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# Innovate to decide : Modelling and experimenting decisional ambidexterity to manage the metabolisms of the innovative organization

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# INNOVATE TO DECIDE: Modelling and experimenting decisional ambidexterity to manage the metabolisms of the innovative organization


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# Résumé

Cette thèse de doctorat a lieu à un moment critique de l'histoire du groupe Zodiac Aerospace venant atteindre les limites de la croissance externe par acquisitions dans des marchés de niche. Alors, dans une perspective de croissance interne, ce conglomérat de PMEs établit des activités d'exploration au sein de chacune de ses entreprises. Ces explorations promettent alors de dépasser les limites et les performances de l'exploitation des niches occupées (March 1991b). Cette ambidextrie organisationnelle bien qu'elle soit bien appliquée se heurtent à de nombreuses difficultés d'ordre stratégique ayant trait au design organisationnel, à l'empreinte marché et à la nature du contrôle opéré par la holding sur les différentes PMEs.

Cette thèse discute ainsi la manière dont nous cadrons, gérons et gouvernons les projets d'exploration dans un conglomérat de PMEs contraint par les défis de l'exploitation. Zodiac Aerospace est en effet un terrain de recherche adapté puisque que certaines études de cas d'ambidextrie mettent en évidence des pratiques a priori irrationnelles ou incompatibles. Nous y avons déployé un dispositif de recherche-intervention. Cela est d'autant plus stimulant qu'elles semblent dépasser les performances promises par les différentes formes d'ambidextrie étudiée dans la littérature. Nous avons été alors en mesure de démontrer cette anomalie par rapport à trois modèles d'ambidextrie synthétisés d'une revue de littérature exhaustive : adaptative, interactive et encapsulée.

Ces modèles d'ambidextrie explicitent comment l'exploration est soutenue par des processus de recherche, reconnaissance et même de génération de nouveaux problèmes, besoins et solutions. Différentes hypothèses sont émises sur les modes d'organisation de cette exploration par rapport à l'exploitation en termes d'action collective et cognition de l'environnement. Par exemple, le modèle **d'ambidextrie adaptative** propose de séparer structurellement les deux régimes afin de résoudre efficacement un problème donné. Ce dernier devrait être alors défini par le top management (March 1991b; O'Reilly and Tushman 2004). Le **modèle interactif** donne une dimension plus contextuelle à la manière

dont les problèmes sont (re-)définis et étendus localement grâce à de nouvelles mises en relation (Benner and Tushman 2003; Gibson and Birkinshaw 2004; O'Reilly and Tushman 2007; O'Reilly and Tushman 2011). Cela offre la possibilité de travailler la charnière entre l'exploration et l'exploitation fluidifiant la transition d'un régime à l'autre (Cohendet and Simon 2016; Nonaka, Hirose, and Takeda 2016; Simon 2006). Le dernier modèle vise un tout nouveau problème entraîné par une exploration générative **encapsulée** dans un projet débouchant a priori sur une exploitation encore inconnue. Le projet peut alors devenir organisation ou changer localement l'organisation existante (Brown and Eisenhardt 1997; Galbraith 2010; Lenfle 2008; Lenfle and Loch 2010; Turner and Lee-Kelley 2013).

Cependant, ces trois modèles d'ambidextrie évitent, à part pour la question cruciale de l'allocation des ressources, le conditionnement de l'exploration par l'exploitation. En d'autres mots, l'exploration ne fait que se heurter aux contraintes de l'exploitation afin de sélectionner ce qu'il est possible d'incorporer au sein des activités d'exploitation. Le risque principal est alors d'avoir une exploration interminable manquant de s'ancrer dans l'organisation hôte (Lenfle 2016). Seul le modèle interactif propose d'affiner l'articulation entre les deux régimes permettant de retravailler la sélection localement. Cela est d'autant plus critique que les réunions de sélection ou de décision sont plus en réalité des lieux où la valeur et le sens se font (Christiansen and Varnes 2007), tout comme pour les enjeux de pilotage en forte incertitude et par manque d'expertise (Loch, Mähring, and Sommer 2017; Sommer, Loch, and Dong 2009; Sommer and Loch 2004). Cette interaction met ainsi l'accent sur la notion de **métabolisme** entretenu par les échanges sur la valeur des connaissances, des concepts et des décisions soutenant un changement organisationnel (Hatchuel, Weil, and Le Masson 2006; Segrestin et al. 2017).

**Par opposition** avec la pensée habituelle de la gestion de l'innovation et des théories de l'organisation, nous démontrons qu'il est plus génératif de structurer au préalable **une exploration en la conditionnant par les connaissances de l'exploitation**. Cela s'oppose à l'idée que l'on devrait séparer et isoler les activités d'exploration afin de ne pas les brider par les contraintes d'exploitation. Nous montrons que certaines explorations ne sont pas générées (ou ne sont pas désirables pour l'exploitation) parce qu'elles se heurtent à un filtre de sélection et de pilotage ultérieur. Elles ratent ainsi des concepts plus attractifs et génératifs pour une exploitation future.

Par conséquent, la connaissance de l'exploitation n'est plus simplement vue comme un filtre sélectif en référence à la fatalité de la transition exploration-exploitation. En revanche, l'exploitation est utilisée comme une connaissance nécessaire et préalable afin de gérer l'exploration. Puisque la connaissance de l'exploitation peut être considérée comme infinie, et qu'elle résulte d'un ou plusieurs processus décisionnels, nous proposons d'en suivre une synthèse suffisante : des paires de décisions et critères décisionnels. Cela constitue

un reflet du design organisationnel et ses différentes contraintes, et incorpore au passage les enjeux de la sélection des explorations vus par l'exploitation. Il s'agit aussi intégrer autrement la suspension du processus décisionnel que par la séparation exploration/exploitation.

De nouvelles situations décisionnelles peuvent être alors envisagées dépassant les limites de l'exploitation et désirant une situation meilleure que celle entretenue par l'exploitation actuelle. L'exploration de nouvelles connaissances est alors pilotée par la conception de décisions et de ses critères devant être testés vis-à-vis de ce que l'exploitation est désormais capable d'embarquer.

Cette nouvelle dynamique entre exploration et exploitation est baptisée **ambidextrie décisionnelle**. Plutôt que de sélectionner pour l'exploitation, nous gérons l'exploration de sorte à dépasser l'exploitation compte-tenu de son processus décisionnel. Cela repositionne l'ambidextrie autour du rôle pivot de la décision afin de gérer l'inconnu, de la même manière que James March avait conditionné l'exploration et l'exploitation autour d'une situation de résolution de problème. De plus, nous permettons de sauver l'ambidextrie dans le sens où cette notion a dérivé à travers plusieurs disciplines (Wilden et al. 2018) et a soulevé de nombreuses ambigüités sur ses capacités managériales et processus décisionnel (Benner and Tushman 2015; Birkinshaw and Gupta 2013; Gupta, Smith, and Shalley 2006; O'Reilly and Tushman 2013).

Ce modèle d'ambidextrie a permis de révéler chez Zodiac Aerospace des schémas qui restaient incompris. L'ambidextrie décisionnelle a expliqué les faiblesses et les difficultés rencontrée par les prémisses d'une **gouvernance de l'innovation** nécessitant un soutien et un outillage adapté. Cette gouvernance avait en effet réussi à lancer et gérer des projets d'exploration intégrant spécifiquement des contraintes d'exploitation, par exemple : un projet à développer entre les lignes organisationnelles des PMEs, ou encore, éviter les choix technologiques connus. Ces projets avaient mis en évidence des **inconnus désirables** fédérant divers acteurs du conglomérat de PMEs mais aussi à l'extérieur du groupe autour d'une **mission commune** dépassant les effets de fixations propres aux organisations et aux processus décisionnels. Ces concepts n'étaient accessibles qu'en jouant avec le conditionnement de l'exploration par l'exploitation.
Finalement, afin de clarifier les règles de gouvernance jouant avec les connaissances de l'exploitation pour une exploration plus générative et pour un changement organisationnel durable, nous avons contribué avec une communauté de managers et ingénieurs à la mise à jour des procédures Gestion de l'Innovation du système qualité s'inscrivant dans une démarche d'excellence opérationnelle.

Ce travail sur l'ambidextrie contribue aux littératures en gestion des projets d'exploration,

gestion de l'innovation et ambidextrie en théories des organisations. Il permet aussi de revenir sur l'article de James March en 1991 ayant introduit à travers un modèle de simulation l'intérêt de définir une exploration par rapport à une exploitation. Il avait ainsi discuté un conditionnement entre les deux régimes autour de l'organisation de la résolution d'un problème donné dans un but de dépasser les limites de la rationalité limitée de l'exploitation. Nous éclaircissons l'émergence et les dimensions critiques des pratiques de la conception au-delà de l'ingénierie. En effet, avec les enjeux de l'intensification de l'innovation et de la gestion de l'inconnu, nous proposons de conditionner les deux régimes autour du processus décisionnel. Il devient alors nécessaire d'innover, et plus précisément de **concevoir pour mieux décider**. Cette conception de la décision permet alors de gérer et soutenir la **métabolisation de l'exploration dans les organisations**. Ce changement organisationnel induit n'est rendu possible que par le conditionnement par les connaissances d'exploitation comme ressource de conception et langage commun. On guide ainsi l'exploration de nouvelles connaissances cherchant à être décidables dans une exploitation améliorée mais encore inconnue.

# Abstract

This PhD thesis is set at a crucial moment in the history of Zodiac Aerospace group which had reached the limits of external growth through acquisitions in niche markets. In a perspective of internal growth and competitive advantage, this conglomerate of SMEs created exploration activities hosted in each firm. It raised several strategic issues relative to organizational design, market footprint and also the nature of control operated by the group holding on different SMEs.

The thesis discusses the way in which we frame, manage and govern exploration projects in a conglomerate of SMEs constrained by exploitation challenges. Zodiac Aerospace is a stimulating research ground for collaborative research as it revealed cases of ambidexterity having poor results for exploitation. Even more surprisingly, it also outperformed models of ambidexterity with a priori irrational or incompatible practices. We were able to demonstrate this anomaly with respect to synthesized literature models of ambidexterity: adaptive, interactive and encapsulated.

In all three models the issue of how exploration is supported by processes searching, scouting or even generating new problems, needs and solutions. Different assumptions are made on how to organize them with respect to collective action and environment cognition. For instance, the **adaptive model** places the structural separation between both regimes to efficiently solve a problem, which should be defined by top management (March 1991b; O'Reilly and Tushman 2004). The **interactive model** gives a more contextual dimension to problems which may be redefined and extended locally as new relationships are made (Benner and Tushman 2003; Gibson and Birkinshaw 2004; O'Reilly and Tushman 2007; O'Reilly and Tushman 2011). It opens the possibility of having a refined work on the hinge between exploration and exploitation for better transitioning (Cohendet and Simon 2016; Nonaka, Hirose, and Takeda 2016; Simon 2006). The last model targets a whole new problem driven by a generative exploration **encapsulated** in a project leading to an a priori unknown exploitation. The project may become the new organization or locally

change the existing organization (Brown and Eisenhardt 1997; Galbraith 2010; Lenfle 2008; Lenfle and Loch 2010; Turner and Lee-Kelley 2013).

All three models however avoid, besides resource allocation, conditioning exploration by exploitation. In other words, exploration bumps into exploitation constraints to select whatever is possible to be incorporated by exploitation activities. Decision-making is suspended for exploration to take place, separated from exploitation. The main risk is having never ending exploration failing to anchor in the host organization (Lenfle 2016). Only the interactive model offers the idea of refining the hinge between both regimes allowing to modify locally the selection criteria. And selection and decision meetings are rather a place of sense-making (Christiansen and Varnes 2007) and steering patterns in high uncertainty without expertise (Loch, Mähring, and Sommer 2017; Sommer, Loch, and Dong 2009; Sommer and Loch 2004). This interplay puts an emphasis on **metabolisms** driven by discussing knowledge value, concepts, decisions and relationships which sustain organizational change by avoiding the duality of process & structure (Hatchuel, Weil, and Le Masson 2006; Segrestin et al. 2017).

**In contrast** with usual thoughts of innovation management and organization theory, we demonstrate that it is more generative to structure **exploration by conditioning it with exploitation knowledge**. It opposes to the idea that we should separate and isolate exploration activities to avoid being contaminated by exploitation. We show that some explorations are simply not generated (or are not desirable for exploitation) because they bump into a selection filter and missing more attractive and generative concepts for future exploitation.

Consequently, exploitation knowledge is no longer seen as a selective filter when dealing with the transition from exploration to exploitation. But instead, exploitation is used as necessary and **prior knowledge** to manage exploration. As exploitation knowledge is rather infinite, and results from a decision-making process. We can then rely on decisions & criteria pairs to summarize exploitation knowledge, which also reflects organization design and constraints. It also allows to loop back with the exploration selection challenge. We integrate differently the suspension of decision-making than just forcing the exploration/exploitation separation.

New decision situation can be designed overcoming exploitation limitations and aiming for a situation better than exploitation. Decision-making is then suspended for **decision-designing** overcoming the separation and non-conditioning. Exploration of new knowledge is then steered by the design of decisions and criteria which should be tested against what exploitation is actually capable of taking on-board. Consequently, generating exploration projects given this knowledge management will help driving and managing organi-

zational metabolisms which induce change.

This new dynamic with respect to exploration and exploitation, is called **decisional ambidexterity**. Instead of simply selecting for exploitation, we manage exploration to do better than exploitation given its decision-making. It proposes to re-position ambidexterity around the pivotal role of decision-making in order to manage the unknown, in the same way that (March 1991) conditioned exploration with exploitation around a given problem-solving situation. Furthermore, it also allows to "save ambidexterity" in the sense that this notion has drifted across different literature fields (Wilden et al. 2018) and had raised numbers of ambiguities on its managerial capabilities and decision-making (Benner and Tushman 2015; Birkinshaw and Gupta 2013; Gupta, Smith, and Shalley 2006; O'Reilly and Tushman 2013).

This model of ambidexterity allowed revealing patterns at Zodiac Aerospace which were so far misunderstood. It explained the weaknesses and difficulties of sustaining and tooling decision ambidexterity for its early stage **innovation governance** which however had still managed to launch projects specifically targeting exploitation constraints (e.g. in-between business units' boundaries, known technological choices). These projects highlighted **desirable unknowns** federating several actors from the conglomerate's SMEs and outside the firm around a **common purpose** overcoming fixation effects embedded in organizations and decision-making. These concepts were not reachable when avoiding the mutual conditioning of exploration and exploitation.
Finally, in order to clarify the governance rules fiddling with exploitation knowledge (mainly decision-making) for a more generative exploration and sustainable organizational change, we contributed to the update of Innovation management procedures for the quality management system in a perspective of operational excellence.

This work on ambidexterity contributes to the literature on exploration project management, innovation management and ambidexterity in organization studies. It also allows coming back to James March's seminal article on 1991 which already introduced the concept of conditioning between exploration and exploitation but around problem definition. We also clarify the emergence and crucial dimensions of design practices beyond just design engineering. With innovation intensification and the challenges of managing the unknown, we propose to condition such ambidexterity around decision-making, which implies in the end to innovate to decide and drive the metabolization of exploration.

*Puisque ce mystère nous dépasse, feignons d'en être les organisateurs*
*Les mariés de la Tour Eiffel*, Jean Cocteau

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*Mario Le Glatin*
*Paris, December 2018*

# Publications

## Journal Papers

- (Le Glatin, Le Masson, and Weil 2017b) - Mario Le Glatin, Pascal Le Masson, and Benoît Weil (2017b). "Generative action and preference reversal in exploratory project management". In: *CERN IdeaSquare Journal of Experimental Innovation* 1.2, pp. 39–46. DOI: 10.5170/cij.2017.539
- (Le Masson et al. 2018) - Pascal Le Masson et al. (2018). "Designing Decisions in the Unknown: A Generative Model". In: *European Management Review*. ISSN: 17404754. DOI: 10.1111/emre.12289
- Attempt to submit a version of the papers on Design Thinking to *Creative Innovation Management Journal* - resubmission in progress.

## Conferences papers

- (Le Glatin, Le Masson, and Weil 2016) - Mario Le Glatin, Pascal Le Masson, and Benoit Weil (2016). "Measuring the generative power of an organisational routine with design theories: the case of design thinking in a large firm". In: *6th CIM Community Workshop - 25th Anniversary of the Creativity and Innovation Management journal*. Potsdam
- (Le Glatin, Le Masson, and Weil 2017a) (with Proceedings) - Mario Le Glatin, Pascal Le Masson, and Benoît Weil (2017a). "Decision design and re-ordering preferences: the case of an exploration project in a large firms". In: *Proceedings of the 21st International Conference on Engineering Design (ICED17)*. Vol. 7. August. Vancouver, Canada, pp. 81–90
- (Le Glatin et al. 2018) - Mario Le Glatin et al. (2018). "Design Paradigm in innovation management - analysing and extending design thinking methods with design theory". In: *R&D Management Conference*. Milan, Italy
- (Le Glatin, Le Masson, and Weil 2018) - Mario Le Glatin, Pascal Le Masson, and Benoît Weil (2018). "Can Ambidexterity kill innovation? A case for non-expected utility decision-making". In: *EURAM 2018*. Reykjavik, Iceland

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# Introduction

> *[...] organizational adaptation requires both exploitation and exploration to achieve persistent success.* (March 1991b, p. 205)

Organizing collective action has taken different structures and used different means to channel its effervescence. Over the last decades with increasing interest on innovation management, several models have been prescribed in order to support firm's innovation. An overwhelming concern for exploration (Wilden et al. 2018) and its means have been the centre of attention to counter limitations of exploitation such as path-dependence, bounded rationality, cognitive biases and other myopic behaviours.

Designing an ambidextrous organization has become mainstream for managers. Academics have studied the topic in-depth through several units of analysis to understand how it can contribute to innovation and firm's competitive advantage. It has given ideas for implementations, and contingencies to be aware of, but has spiralled around the paradoxes of balancing exploration and exploitation (Benner and Tushman 2015; Birkinshaw and Gupta 2013; O'Reilly and Tushman 2013). However, organization design and allocation of resources to sustain two separate regimes aimed originally at organizational learning (March 1991b). The drift towards innovation necessarily have encountered other practices such as exploration project management. Is the original perspective on learning and adaptation compatible with innovation management?

Moving beyond problem-solving, adding uncertainties and more significantly addressing the unknown are the signature of innovation management. Novelty is generated and managed through an arsenal of practices and methods that can be seen in marketing, strategic analysis, design reasoning and theory (Le Masson, Hatchuel, and Weil 2017). These practices are enclosed within projects (Lenfle 2008, 2016) or portfolios(Maniak and Midler 2014).
However, ambidexterity promotes a separation between exploration and exploitation and it is more generally discussed for organizational dimensions of time and structure support-

ing a regime and the other. Consequently, the unknown occupies a different place and is related to in different ways when seen from innovation management through exploration projects or seen from organizational ambidexterity and its foundations. Over time, and with evolution of practices and constructs in literature, the separation of regimes could now be in conflict with generative processes driving the exploration and exploitation of the unknown.

Ambiguities on the meaning of ambidexterity, exploration and exploitation have been spotted and extensively discussed in (Gupta, Smith, and Shalley 2006). Having a common definition of these constructs appears critical. At the light of what ambidexterity has become over the years for organization studies, performance and innovation, (Birkinshaw and Gupta 2013) stress the discomfort caused by how exploration and exploitation are considered with respect to ambidexterity, and the seminal model on organizational learning and adaptation.

> *On several occasions in seminars and at conferences I have had debates with colleagues about how the notion of ambidexterity might be reconciled with March's (1991) view that exploration and exploitation are mutually incompatible. My response is quite straightforward. March (1991) provided a theory to explain his observation that exploration and exploitation represent self-reinforcing patterns of learning. I agree with this observation. However, I don't believe he is saying that it is impossible for organizations to overcome these self-reinforcing patterns; he is just saying that it is extremely difficult. This is where ambidexterity comes in. Essentially, ambidexterity provides a normative perspective on how organizations function. It says that managers are making choices and trade-offs among competing objectives, and when they do their job well they override the organization's tendency to go down the path of least resistance. For example, they might actively push one objective ahead of the other for a limited time, or they might find creative ways of delivering on two objectives at the same time* (Birkinshaw and Gupta 2013, p. 293)

The underlined extract highlights the potential divergence and necessity to reconsider the separation between exploration and exploitation, its meaning and how it can be conditioned one another. Indeed, both should be performed, they bear different mindsets that are not sustainable on their own for the firm, but should be kept separate and balanced in sequence or in parallel. Cross-contamination between exploration and exploitation jeopardizes firm's performance and potentially underlying forces driven by innovation pushing the performance frontier drawn by both regimes. Given new practices of innovation management driving exploration regime, we should also help clarifying where the unknown lies and its impact with respect to the dichotomy encouraged by ambidexterity.

Our PhD manuscript starts with this perspective: designing an ambidextrous organization will separate exploration from exploitation activities through different means. If the firm is not able to sustain the innovation effort to explore and exploit, who is to blame? Should we consider the firm is not doing it well enough? Or should it be the model of segregating exploration from exploitation?
Such questions are legitimated by the issues and ambiguities raised in the literature in recent years, and we propose to come back to the origins of such model of ambidexterity, and the dichotomy exploration/exploitation. Starting of again with the seminal article (March 1991b) will allow confronting the original perspective of organizational learning and adaptation with the contemporary issues of innovation management. This literature has also created a place for exploration engines: exploration project management (Lenfle 2008) for instance put the emphasis on managing the unknown, generative processes.
We suggest testing original foundations and hypotheses to discuss the validity of the ambidexterity models given new practices of innovation. For instance, such exploration projects develop requirements, engineering capabilities that are new to established and mirrored organizations (Colfer and Baldwin 2016). Project-based organizations supporting new product development will face several challenges such as decomposition and integration (Sosa and Mihm 2008), but as interdependencies are reconfigured with innovative design, dynamically mirroring product engineering with the organization becomes critical to sustain learning and adaptation in the long run. In other words, the unknown brought by exploration projects and generative processes can be at odds with the assumptions made in implementing ambidexterity.

The PhD journey was hosted by Zodiac Aerospace offering an industrial context to study their concern for organizational ambidexterity and their innovation practice. This conglomerate of SMEs built over more than a century has been the grounds for numerous designs, products and technologies that have largely contributed to the structure of the aviation industry. With raising uncertainties on the future of the market, designs, technologies and qualification/certification requirements, and the pressure to maintain and optimize legacy products, ZA designed an ambidextrous organization. However, they have had difficulties in the implementation and several exploration project raised controversies for business units and top management. Since not all projects could be considered as failures, with also a concern on the notion of failure and performance (Elmquist and Le Masson 2009), we were in a position to discuss the prescribed model of management and actual practice.
Several case studies were identified to study their practice, its course of action and try to understand it given literature models of ambidexterity and managing the unknown. These cases were proposed by managers and engineers who had open management issues with their projects.

In this PhD thesis, we will then closely study the implementation of an ambidextrous organization and its impact on sustained innovation. The development in management of exploration project, of the unknown and generative processes will also bring a new light on the original purpose of separating exploration and exploitation: organizational learning and adaptation. The organization design with the underlying *mirroring hypothesis* will necessarily be challenged as project dynamics will interfere with intra-organizational boundaries, inter-organizations and inevitably with strategic management.

The sections below provide a starter to the manuscript. First, we explain the industrial request specifying the nature and preliminary formulation of the management issue faced by the Chief Technical and Innovation Officer of Zodiac Aerospace. Second, we further detail our opening research questions which will guide us through the literature review (part 1, p.45). Third, in the last section, the synopsis is pictured showing the overall structure of the PhD thesis.

# 1 An industrial request: Zodiac Aerospace struggling with exploration projects and ambidexterity

## 1.1 Conglomerate of SMEs and a group holding

The thesis was conducted at the Technical & Innovation Direction of Zodiac Aerospace (ZSA, holding). Established in 1896, this large industrial group of 75 entities designs, develops and manufactures aeronautical equipment for aircraft/helicopters manufacturer and airlines. These are scattered across 100 facilities across the globe and mainly centralized in Europe and North America. In the last couple of decades, some facilities were established in cost-competitive countries for the serial production of some entities.

The group of SMEs where each of them with a few hundreds employees each, equating to a total of 35,000, have their own responsibility and performance logic. A light group holding of 200 employees with several support functions have the challenge to manage the sometimes competing SMEs due to the market structures and build up synergies targeted by the executive committee.

The management directives are cascaded down to the pool of business units grouped in so-called "divisions" and branches with a Master Plan (*Hoshin Kanri* planning) synthesizing the strategy. However this broad strategic plan is largely adjusted by the individual business units as their autonomy is driven by operational concerns faced locally in their line of business. The group holding controls the BUs through several reporting channels, the major one being Profit & Losses; so beyond the control dimension, the corporate staff serves as the flag holder of the Zodiac Aerospace brand, representing BUs for key accounts and suppliers at the top management level, in addition to external functions: institutions,

certification authority, research councils and public funding schemes.

## 1.2 An entrepreneurial history closely linked to the historical roots of the aircraft industry

Since 1896, the history of ZA has developed numerous innovations at the time when the aviation industry was building up in Europe and in North America. These largely contributed to aircraft safety, aircraft components and later to systems and cabin equipment. Today as the market has largely settled and rationalized with safety and certification frameworks, several novelties and radical improvements have also reached the market thanks to long-term partnerships with aircraft manufacturers and airlines.

However, BUs are looking for new growth catalysts as they face growing uncertainties on future aircraft architectures and kick-off date. In parallel, the world fleet continues growing but mainly for legacy aircraft with occasional marginal improvements, and a symmetric requests for substantial decrease in (re-)development costs. A macro-economic side-effect is the growing concentration of equipment and system manufacturers: main competitor of ZA (B/E Aerospace, very similar structure and market footprint) was acquired by Rockwell Collins (equivalent of Thales group) who is currently being acquired by United Technologies Corporation. Along the same dynamic, ZA has been very recently acquired by Safran group.

## 1.3 Increasing uncertainties and novel unknowns for intra/inter-BU exploration projects

After splitting the former Zodiac group in 2007, between Zodiac Aerospace and Marine & Pool Activities, the current corporate team has largely developed its intervention starting off with counselling and support in order to back up the performance of exploitation activities (Quality, Cost and Delay) but also value exploration and competencies regeneration for future prospects: expert network, scientific and technical council (ZSTC), expert review (technical audit for NPD), creation of an R&T function, evaluation of technology maturity level (Technology Readiness Level), creation of technology/production road maps (TRM/PRM) challenged by top management, lobbying and external funding, transverse future technologies, and intellectual property.

Given raising uncertainties on exploitation certainties such as aircraft architecture and integration, or new program, and airline demanding frequent changes, several exploratory projects and sometimes key programs have gained visibility for the corporate teams. Overall, ZA has been developing organizational ambidexterity locally in business units and at the corporate level.

The Technical and Innovation Direction along with the Executive Committee are in a position to try out management innovations with respect to these projects (intra/inter BU) that appear to regenerate organizations in a large internal pool of agents, tools, competencies, processes and organizational structures. The challenge for the Innovation Direction was to overcome the limitations of the market-pull dynamic of aircraft manufacturers and airlines. Several techno-push projects had been identified by BUs and top management, these were promoted and steered through a committee called "Multi-BU". For more "short-term concerns" associated with the anticipation of user and client needs, two special teams where created near assembly lines of Airbus and Boeing. The aim of these teams is to capture potential future needs, deal with a portion of the technical support addressed to their BUs of origin, formulate new concepts and tests these with airlines and aircraft manufacturers.

Projects were launched using these platforms, among several other R&T topics within each BU, and they raised technical barriers, issues associated with institutional barriers (certification, client/user desirability), and collaboration between BUs. Overall, they have caused difficulties in transitioning between exploration and exploitation. Some of them have been considered as (partial) successes, others as failures, questioning what makes innovation performance. But given the demanding constraints of exploitation in the aircraft industry, and the mirroring by BUs and their internal organizations, the projects' trajectories question the organizational fit, boundaries and their capability to sustain such potential innovations.

This organizational context, individual histories of entrepreneurship and SMEs' collective history, framed by a strong *dominant design*, we wonder what is the managerial perspective regarding intra/inter-BU projects, and the first questions that come to mind would be the following:

- What are the benefits of organizational ambidexterity for exploration projects within a conglomerate of SMEs?
- How is the innovation effort challenging the performance frontier set by exploration and exploitation balance?
- What are the implications of organization design for exploration project management?
- How is the corporate and local management dealing with these potentially conflicting trends (exploration project management and ambidexterity)?

These questions were originally raised in the early stages of the PhD journey. They touched upon a critical idea: is Zodiac Aerospace not good enough to develop an ambidextrous

organization? As it has been stressed in our preliminary introduction to the literature, we have some arguments to believe that perhaps ZA could actually be applying the models appropriately. So, it is rather an invitation to reconsider the underlying assumptions and implications of ambidexterity, and separation of exploration from exploitation.

# 2 An invitation from literature: ambidexterity revisited by innovation management evolutions

## 2.1 Organizational ambidexterity - separating and balancing exploration and exploitation

Zodiac Aerospace has been developing an ambidextrous organization with several means: dedicated departments to exploration (e.g. R&T, innovation, design, advanced concepts) within BUs, autonomous team, group-level initiatives to foster exploration, committees discussing and deciding on exploration project management at the light of strategy, corporate leadership and sponsorship.

The BUs have been gradually establishing project-based organizations to support the delivery of legacy products/services and NPD based on customer demands. Along with the rationalization trend of the market, major customers such as aircraft manufacturers and airlines have been prescribing specific ways to manage programs and projects along with equipment qualification and certification. BUs require maintaining their knowledge, competencies over long periods of time to satisfy clients along the value chain during the lifetime of the products and the aircraft (from a few years to several decades). Exploitation performance is thus achieved in reinforcing these routines with a spirit of continuous improvement (March 1991b).

Yet, as threats of uncertainties and unknown are seen for the future of the ecosystem, several innovative projects try to anticipate and shape what ought to be designed for the future aircraft platforms or airline retrofits to keep up with the competitive advantage. Consequently, they require building creative dynamic capabilities (Nonaka et al. 2014), and regenerative dynamic capabilities (Ambrosini, Bowman, and Collier 2009) to sustain repeatable patterns of innovation inspired by the historical entrepreneurial spirit of BUs. These patterns largely contribute to exploration regime. The literature (Birkinshaw and Gupta 2013; Gupta, Smith, and Shalley 2006) has stressed it may not be on the same continuum of exploitation, but perhaps in an another dimension. However, it is recognized these should coexist and be balanced; which reinforces the idea of separation between the two: non-conditioning of both regimes.

It becomes then critical to understand how dynamic capabilities, fed by innovation prac-

tices, can contribute to shifting the performance frontier set by exploration and exploitation to solve efficiently the problem worked out by agents in the firm. How is organizational learning and adaptation actually sustained? Key representatives of the ambidexterity literature (Benner and Tushman 2015; Birkinshaw and Gupta 2013; O'Reilly and Tushman 2013) have questioned the *how* inviting more qualitative research and micro-foundational approaches. Indeed, innovation-driven exploration will rely on numerous practices trying to shape the unknown and generative processes that may be stretching beyond the seminal problem-solving defined by James March.

For instance, the challenge of building these capabilities will have a stake in the strategic intent and organization design that is directly linked to the decisions (Birkinshaw and Gupta 2013) made along the project management and design steps taken in the radical innovation process. It also potentially contributes to redefining problems to be solved by agents in the firm, thus repeatedly updating (March 1991b) model. More precisely, in terms of problem-formulation, engineering design efforts mobilized in the exploration regime will necessarily reveal and challenge interdependencies from technical standpoint but also from an organizational perspective (Colfer and Baldwin 2016). Aiming for the unknown to reformulate problems goes however beyond search-based model of exploration may compromise what exploitation is capable of performing.

## 2.2 Managing the unknown for organization studies

These limitations encourage us to consider the management and design of underlying dynamic capabilities and organizational fit to support these exploration, or simply innovative projects as they glide across the conglomerate. It channels then the PhD journey through another literature field mainly concerned by project management and managing the unknown. Overall, it could be considered as an encapsulation of practices in another regime of collective action differing from organization studies.

With the development of project management and other contemporary approaches to innovation management, the attention and locus of innovation is relocated at a meso-level: not centred on the individuals and not necessarily seen managed at the organizational level. Project-based management (Galbraith 2010; Turner 2009) and other organic views that could be traced back to (Burns and Stalker 1961) bring another perspective. Calls have been made in major journals on challenges the field should address (Bakker et al. 2016; Söderlund, Hobbs, and Ahola 2014; Söderlund and Müller 2014; Sydow, Lindkvist, and Defillippi 2004). Projects have been studied for being a flexible and convenient vehicle for exploration and innovation practices (Midler, Killen, and Kock 2016), innovation management can be historically linked to project management (Davies, Manning, and Söderlund 2018; Lenfle and Loch 2010, 2017). However, putting aside the normative view of project management (e.g. Project Management Institute), the nature of exploration

project management and the encapsulation of generative processes (e.g. Design Thinking, creative problems-solving, C-K theory, etc.) raises numerous questions on organizational ties compared the host firm, the risk of spin-off ad-hoc patterns. These contingencies are crucial for a conglomerate of SMEs where organization design reflects engineering design and its constraints (Colfer and Baldwin 2016).

So, the contributions of the project management literature encourages us to study the perspective and impact of portfolio and program management for exploration, for organization design and strategy (Gemünden, Lehner, and Kock 2018; Hobday 2000). More generally, it is another way of discussing organizational ambidexterity, and its coexistence in a firm such as Zodiac Aerospace. For instance, these projects re-discuss aircraft equipment and systems technical constraints, as well as corresponding BUs' organizational boundaries. We must also stress here the pressures related to the dominant designs, the lock-ins, and path-dependence associated to these products in the market and how the BUs are organized internally given a mirror hypothesis. The crucial issue being how the corporate team of ZA (Group Innovation Direction, CTO, ZSTC along with the ExCom) steers, organizes, manages these projects as they tend to revise individually not only the design/engineering dimension of the products, but the underlying organizations and ecosystems (environment, institutions) whilst playing within the group strategy and market footprint. Exploration projects consequently moderate the organizational learning, design and adaptation brought initially by the separation of exploration and exploitation.

## 2.3 Preliminary Research questions

Zodiac Aerospace practice of innovation, organization design, strategic management and engineering bring new questions to be answered given this preliminary literature review at the light of conditions imposed by the industrial context. This early formulation of our research questions will guide through the literature review (part 1, p.45). We invite the reader to consult the identified research gap and associated research questions in chapter III (p.121). Further advice on reading is given in the *Reading tips* box on p.41, the synopsis is presented in the following page.

- What are the implications of enforcing the non-conditioning of exploration and exploitation for organizing ambidexterity?
- How is organization ambidexterity understood from the perspective of exploration project and project-based management?
- How comparable is the foundational model of (March 1991b) with today's approaches to innovation management?
- What is the organization design and change associated to exploration project management?

# 3 Thesis outline and synopsis

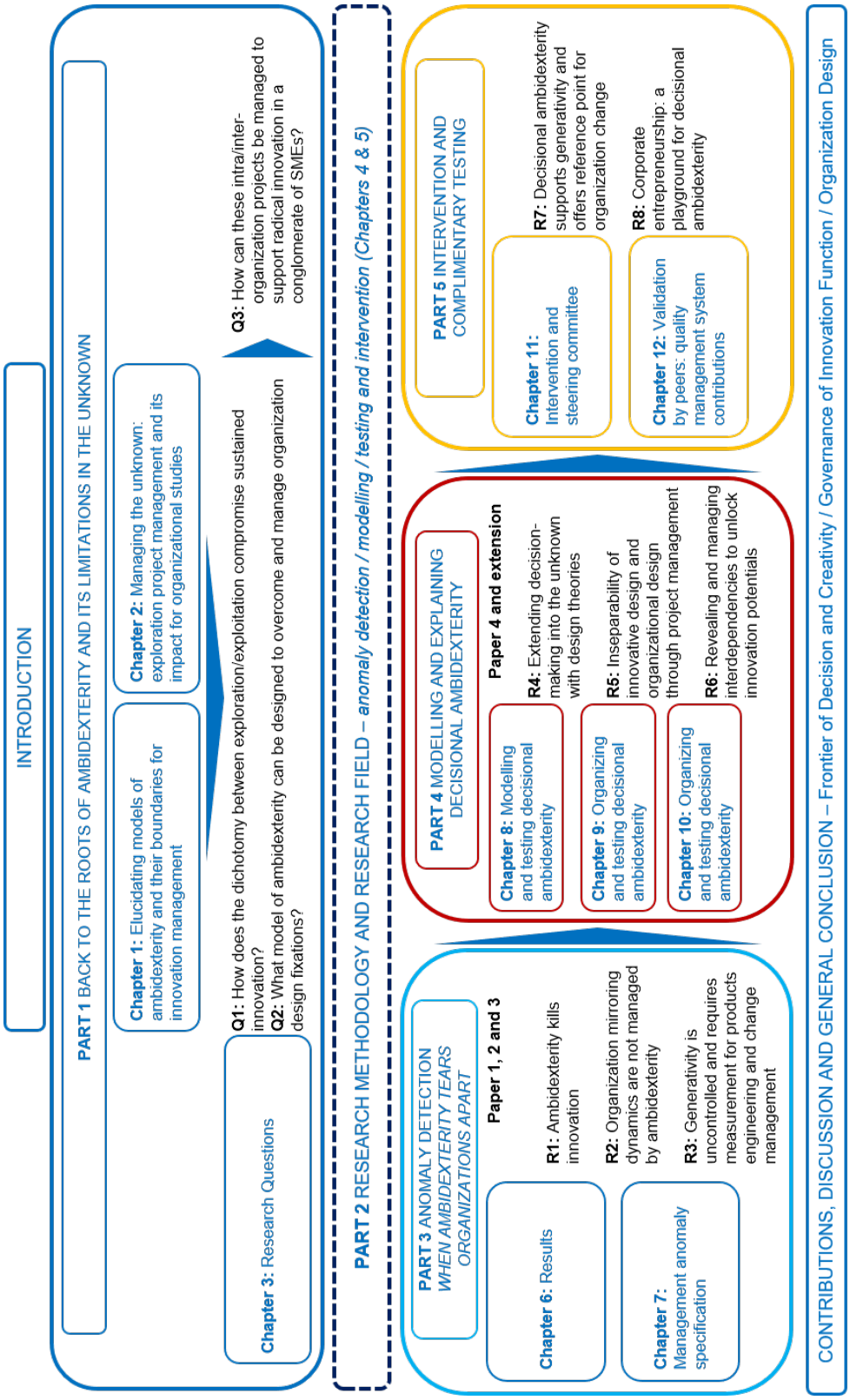


**Figure .1:** Thesis' synopsis

# Reading tips

**Reading tips** We encourage the reader to first consider the master table of content to have a global picture of the thesis. The introduction gives a second overview of the agenda of the thesis and opening questions.

First, before each part a grey text box hold a summary of the upcoming chapters with keywords and results and followed by a table of contents.

Second, the literature review in part 1 (p.45) ending with the research questions chapter III (p.121) will help the reader understanding the research gap and the origins of the anomaly.

Third, we invite to look at the research trajectory conducted by the PhD candidate, the research context, the anomaly detection method and the cases' description. See Part 2, p.133.

The anomalies presented in Part 3 (p.211) provide requirements for a new model (chapter VII, p.237) that is then presented and detailed in Part 4 (p.249). It allows us finally to provide foundations for legitimate researcher's intervention, see Part 5 (p.299).

**Note to the reader:** You will probably notice that starting off with the methodology sections, we will make reference to a character simply named *The Researcher* or *The PhD Candidate*. This choice was made because the methodology was written first and *he* was quickly referred to as being part of the research management, as if he were an instrument. When reaching the model testing and associated interventions, you may feel that the narrator, *We*, gets closer to the *The Researcher*.

**Conseils de lecture** Nous encourageons le lecteur à considérer d'abord la table des matières principale pour avoir une vue d'ensemble de la thèse. L'introduction donne un deuxième aperçu de la feuille de route de la thèse et des questions préliminaires.

Tout d'abord, avant chaque partie, une zone de texte grise contient un résumé des chapitres à venir avec les mots-clés et les résultats, suivi d'une table des matières.

Deuxièmement, la revue de la littérature en partie se réfère à la littérature. (p.45) se terminant par le chapitre questions de recherche III) (p.121) aidera le lecteur à comprendre les lacunes de la recherche et les origines de l'anomalie.

Troisièmement, nous vous invitons à examiner la trajectoire de recherche du doctorant, le contexte de recherche, la méthode de détection des anomalies et la description des cas. Voir Partie **??**, p.**??**.

Les anomalies présentées dans la partie 3 (p.211) fournissent les exigences pour un nouveau modèle (chapitre VII, p.237) qui est ensuite présenté et détaillé dans la partie 4 (p.249). Il nous permet enfin de jeter les bases d'une intervention légitime du chercheur, voir Partie 5. (p.299).

**Note au lecteur:** Vous remarquerez probablement qu'en commençant par les sections méthodologiques, nous ferons référence à un personnage simplement nommé *The Researcher* ou *The PhD Candidate*. Ce choix a été fait parce que la méthodologie a été rédigée en premier et *he* a rapidement été désigné comme faisant partie de la gestion de la recherche, comme s'il était un instrument. Lorsque vous accédez aux tests du modèle et aux interventions associées, vous pourrez sentir que le narrateur, *Nous*, se rapproche du *Le Chercheur*.

# Part 1

# Back to the roots of ambidexterity and its limitations in the unknown

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**Outline** In this first part, we propose to conduct our literature review to clarify the preliminary research questions formulated in our introduction. The aim is to have a theoretical model to discuss our case studies.

The first chapter (I, p.51) addresses a historic paper on balancing exploration and exploitation for organization learning (March 1991b). It has fed several streams of literature including innovation management, organizational structure and performance and behavioural literature. We propose to examine the assumptions made on the Marchian problem-based model. We cover the emphasis put on *exploration* at the light of the unknown. In other words, one of the major stakes of innovation management. We will raise several issues questioning the validity of models of ambidexterity. The developments in design theories and reasoning allow stressing the challenges imposed by generative processes as they address the unknown and how adaptive processes and interactionist perspectives manage it.

In the second chapter (II, p.85), we have a close look at literature where the unknown is at the centre of the discussion. It lets specifying a different coordination mechanisms where generative processes can be encapsulated: exploration projects. We discuss, at the light of *generativity*, how project management addresses exploration regime and its setting in an organizational context: organization design and change management. It allows to loop back with the original challenge of organizational learning and adaptation.

Several limitations and aporia are identified in the literature by the community encouraging us to formalize our research questions given a common theoretical model with associated descriptors (chapter III, p.121): **a non-mutual conditioning of exploration and exploitation**. This portrait will allow us to test it on adequate case studies (chapters IV and V).

**Aperçu** Dans cette première partie, nous proposons d'effectuer notre une revue de littérature afin de clarifier les questions de recherche préliminaires formulées dans notre introduction. L'objectif est d'avoir un modèle théorique pour discuter de nos études de cas.

Le premier chapitre (I, p.51) commence par un article historique sur l'équilibre entre exploration et exploitation pour l'apprentissage organisationnel (March 1991b). Il a alimenté plusieurs courants de littérature, notamment la gestion de l'innovation, la structure et performance organisationnelle, ainsi que la littérature comportementale. Nous proposons d'examiner les hypothèses formulées à l'aide du modèle de March fondé sur les problèmes. Nous nous attardons sur l'*exploration* à la lumière de l'inconnu. En d'autres termes, l'un des enjeux majeurs de la gestion de l'innovation. Nous poserons plusieurs questions sur la validité des modèles d'ambidextrie. L'évolution des théories et du raisonnement en matière de conception permet de mettre l'accent sur les défis imposés par les processus génératifs lorsqu'ils abordent l'inconnu et sur la façon dont les processus adaptatifs et les perspectives interactionnistes le gèrent.

Dans le deuxième chapitre (II, p.85), nous examinons de près la littérature où l'inconnu est au centre du débat. Il permet de spécifier un mécanisme de coordination différent où les processus génératifs peuvent être encapsulés : les projets d'exploration. Nous discutons, avec la notion de *générativité*, comment la gestion de projet aborde le régime d'exploration et sa mise en place dans un contexte organisationnel : conception organisationnelle et gestion du changement. Elle permet de revenir sur le premier défi de l'ambidextrie : l'apprentissage et l'adaptation organisationnelles.

Plusieurs limites et apories sont identifiées dans la littérature par la communauté nous encourageant à formaliser nos questions de recherche à partir d'un modèle théorique commun avec des descripteurs associés (chapitre III, p.121) : **le non-conditionnement mutel de l'exploration et l'exploitation**. Ce portrait nous permettra de le tester sur des études de cas adéquates (chapitres IV et V).

Chapter I

# Elucidating models of ambidexterity and their boundaries for innovation management

In this first chapter of literature review, we propose to start discussing the seminal paper by James Gardner March published in *Organization Science* in 1991 entitled: "Exploration and exploitation in organizational learning" (March 1991b). We, of course, put this article into perspective with the flourishing streams of literature which have rooted their assumptions in the problem-based and decision-making background mobilized by J.March.

The introduction of the manuscript highlighted that the streams of literature of organizational ambidexterity could be revisited by developments in innovation management, such as exploration project management. This preliminary assumption is induced by the limitations raised by several authors in the field of ambidexterity, specially on the how to achieve such model (Benner and Tushman 2015; Birkinshaw and Gupta 2013; O'Reilly and Tushman 2013). And it is also backed up by the organization studies dimension challenging project management (Bakker et al. 2016; Söderlund, Hobbs, and Ahola 2014; Söderlund and Müller 2014; Sydow, Lindkvist, and Defillippi 2004) and more specifically exploration project management, tightly linked to innovation management literature (Davies, Manning, and Söderlund 2018; Lenfle and Loch 2010, 2017).

The several challenges, in the literature briefly discussed so far, point at the tensions and fuzziness at the crossroads of innovation management and organizational studies. More precisely, the original assumptions of *exploration vs. exploitation* for organization learning and adaptation may be now in conflict with the engines of innovation: managing the

unknown through project management. The unknown has gained ground over time up to the point where models of ambidexterity may no longer be valid. It is this interaction between ambidexterity and the unknown that will guide our literature review. We are keen on understanding what happens at the potential edges of ambidexterity's validity domain. We propose then to start anew with the foundational paper (March 1991b) on which literature piled up.

The notion of exploration and exploitation were typified in the well-defined situation of problem-solving and associated decisions to balance off these two constructs for organizational learning and firm competition for survival and primacy. The first section (1) elaborates on the model and its boundaries as defined by J.March. These boundaries have separated it from the unknown, whereas it has been feeding streams of literature in innovation management, organizational structure and performance.

The second section (2) discusses the latter with the emergence of the *organizational ambidexterity* construct and prescription of organizational designs supporting innovation. Limitations identified by major researchers in the field are reported opening the debate on the micro-foundations of ambidexterity.

Finally, the third section (3) looks at generative processes and their contributions to exploration and exploitation. It allows us to extend the behavioural roots of problem-solving and decision-making with design reasoning.

# 1 Balancing exploration vs. exploitation: an incomplete model?

In (March 1991b), James March presents a model supporting a Schumpeterian view of a firm's sustainability with an organizational learning perspective: exploiting old certainties or exploring new possibilities. The firm is described as a system, where choices are made within the organization to engage in exploration or exploitation.

> *[..] maintaining an appropriate balance between exploration and exploitation is a primary factor in system survival and prosperity.* (March 1991b, p. 71)

The trade-off discussion is developed with a reference point taken in rational models of choice. A decision problem is then composed of: a set of states of nature $S$ from which consequences are envisioned $X$ with associated probabilities $\mu$, a cost function $c : x \in X \rightarrow y \in \mathbb{R}^+$ and the decision-maker is requested to build up decision function $d : s \in S \rightarrow x \in X$. Several axioms are necessary to support the theory depending on the model used, and the simplest version can be found in (Wald 1945, 1949), corresponding to basis on which (Savage 1954) and (Raiffa 1968) have developed in management education (Fourcade and Khurana 2013; Giocoli 2013).

But before considering the decisional dimension, it is worth noting the conception of action: problems *appear* to the agent, who then calculates accordingly given previous statistical learning from the past and additional information available on the spot. The calculation is seen as suboptimal given the limited/bounded rationality of the agent and the collective in an organizational context (Simon 1955). The organizational behaviour is then focalized on the agent, its beliefs and interactions with others and available information. It allows then envisioning the contribution to the performance and survival of the firm as beliefs evolve and the environment changes.
These features have been stressed in a recent review literature published in *Strategic Organization* (Wilden et al. 2018) among other evolutions of the constructs of *exploration* and *exploitation* following March's seminal article. With an exhaustive dataset and data-mining methods, they have observed the evolution of the range of keywords initially proposed by March for exploration and exploitation (see Fig.I.1 and I.2).

> *Exploration includes things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery, innovation.*
>
> *Exploitation includes such things as refinement, choice, production, efficiency, selection, implementation, execution.* (March 1991b, p. 71)

The review points out the notion exploration has gained more attention: please note the difference in scale (y-axis), it is astonishing! It reinforces the importance of exploration

to balance out biases of exploitation, but we should also keep in mind that exploitation should also be maintained to a certain extent (Birkinshaw and Gupta 2013). Co-existence is key to the performance and survival of the firm.

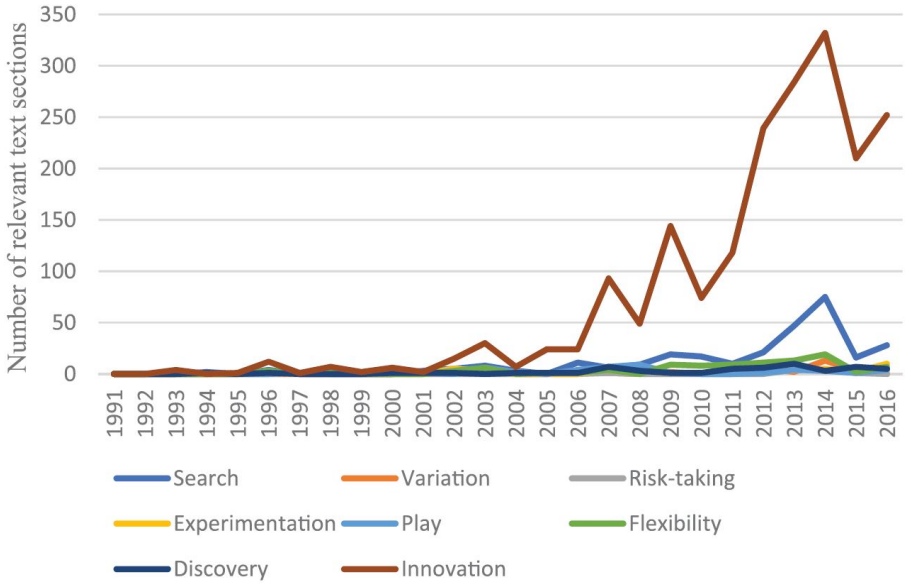


**Figure I.1:** Evolution of exploration keywords since (March 1991b)

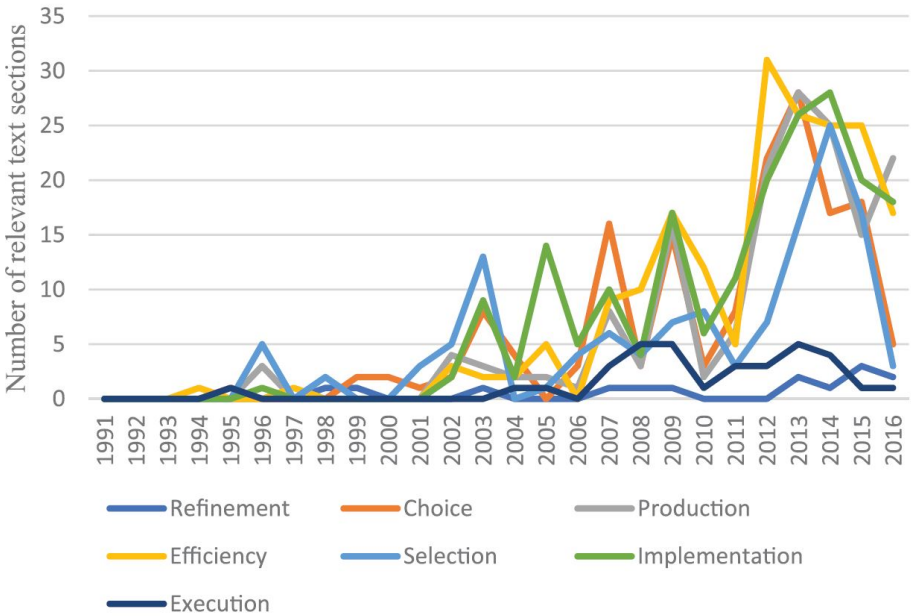


**Figure I.2:** Evolution of exploitation keywords since (March 1991b)

In (Wilden et al. 2018), they show the trade-off dilemma has drifted across several clusters of management literature with a recent emphasis on ambidexterity, organizational structure and performance (see section 2) and innovation management (see section 3). Several

calls for future research are made to contribute to reconsider the organizational behaviour roots, extensiveness and micro-foundations of the constructs of exploration/exploitation, and their articulation with organizational boundaries (e.g. intra-organizational or across organizations).

These issues are discussed in the following sections. But before starting to discuss the topics raised in the literature, we propose in the following paragraphs to question the underlying hypotheses made on exploration and exploitation. We focus then on the separation enforced between the two and how it contributes to organizational learning, behaviours at work and the issue of sustaining the balance for performance and survival.

## 1.1 Adaptive processes supporting organizational learning

The adaptive processes that are framed by *given* problems will call for numerous mechanisms ranging from "rational models of choice", "theories of limited rationality", "organizational learning and evolutionary models of organizational forms and technologies" (March 1991b, p. 72). Within the information-processing paradigm, the notion of "search" is mobilized to understand to which extent decisions should be made to consider *given* alternatives and available information to organization action. As it is stressed, the decision model is quickly jeopardized with the observational capacity of the agent not being able to acknowledge new alternatives, sure thing principle[1], or uncontrolled externalities:

> *The problem is complicated by the possibilities that new investment alternatives may appear, that probability distributions may not be stable, or that they may depend on the choices made by others* (March 1991b, p. 72).

This unobservability reinforces the limitation to adaptive process which should be optimized because of bounded rationality and theories of satisfying (Simon 1955) in addition to anchoring effects and other cognitive biases revealed by the works of Amos Tversky and Daniel Kahneman in their prospect theory (Kahneman and Tversky 1979; Tversky and Kahneman 1974). In the field of theories addressing the unknown, to go beyond available information and knowledge, theories of creativity with the support of cognitive psychology have emphasized similar phenomena: fixation effects (Smith, Ward, and Schumacher 1993; Ward 2007). But the bridge remains to be built between these two separate fields of research where theories and experimentations means do not yet synergize.

The targets associated with the problem (pre-)framing define a reference frame to value learning and knowledge management. Organizational learning has stressed the importance of *refining* alternatives and *inventing* new ones. Exploration precedes or augments exploitation and will have antagonistic effects on the performance of decision-making (e.g. skills improvement to execute existing alternatives)(Levinthal and March 1981). This

[1] Sure-thing principle: (Savage 1954, p. 21)

viewpoint on learning performance preconceives its criteria and the organizational ties between the exploration and exploitation regimes. It tends to hide the complexities associated with multi-scale phenomena at the individual, social and organizational levels as specified by J.March himself on balancing out the two regimes. Organizing an appropriate decision balancing exploration and exploitation becomes critical.

In the tradition of adaptive process, the proposal from evolutionary theories introducing the notions of *variation* and *selection* is then quite seducing. J.March describes the purpose of these regimes and limitations by proposing the garbage-can decision process as a reservoir to protect from externalities and the unknown(Eisenhardt and Zbaracki 1992):

> *Effective selection among forms, routines, or practices is essential to survival, but so also is the generation of new alternative practices, particularly in a changing environment.* (March 1991b, p. 72)

The adaptation speed and the prior exploration/exploitation of appropriate practices will make a difference in the environment. Again, a structural or a sequential view of managing exploration and exploitation is suggested to take place at different levels: individual, organizational and social. For the organizational learning perspective, the interactions between individuals and the organization, and the competition for primacy between organizational (sub-)groups will contribute to the exploration/exploitation trade-off and vice-versa. The presented model is robust enough to cover several streams of literature and include some of the multi-scale complexity.

Now, on the value of both regimes, J.March gives further indications on the necessity to separate them. Exploration is presented as a sacrifice and vulnerable because of overarching performance criteria derived from exploitation. The exploration valuation framework is exploitation-driven, as if on the same continuum:

> *Compared to returns from exploitation, return from exploration are systematically less certain, more remote in time, and organizational more distance from the locus of action and adaption.* (March 1991b, p. 73)

It reinforces the antagonistic effects of deciding of the allocation/division of resources to one of the regimes. The exploitation reference point also complexifies the understanding and efficiency of exploration during its refinement towards exploitation. Exploration is pictured as rather complex and fuzzy, highly uncertain and should be transformed into more systematic regime, like exploitation to perform better:

> *Reason inhibits foolishness; learning and imitation inhibit experimentation. This is not an accident but is a consequence of the temporal and spatial proximity of the effects of exploitation, as well as their precision and interconnectedness.* (March 1991b, p. 73)

These views tend to emphasize paradoxically the orthogonality of exploration activities with respect to exploitation still triggering antagonistic effects for a given performance valuation reference. At the light of this model we could synthesize in the figure below:

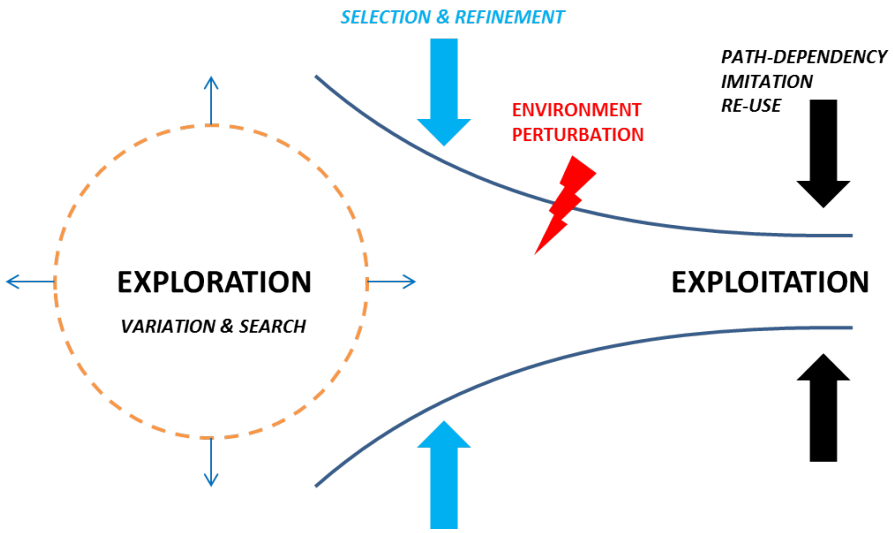


**Figure I.3:** Schematics of exploration and exploitation trade-off

Despite hiding several details of the model, the figure highlights the adaptation perspective and the learning required channelling the organization at the light of changes in the environment. It is a temporal representation, but it could also be picture in parallel, showing exploration oriented in certain directions usually blinded by exploitation.

> We ask several questions echoing the limitations mentioned by J.March and the exhaustive literature review (Wilden et al. 2018) relative to the learning mechanisms and experimentation (discovery). The search-based model should enable reaching full rationality in opposition to its boundedness. As suggested in (March 1991b), foolishness could be driving force. We must then clarify the behaviours, their categories with respect to problem-solving, search and decision-making.
>
> Is it required to sustain the separation and balance between exploration/exploitation? How predictable are the discovery patterns? What are the spatial and temporal parameters to play with to balance out ambidexterity?

## 1.2 Learning with respect to foolishness, novelty and creative logics

In order to study learning mechanisms, James March along with other great researchers have extensively studied the sociology of organizations and some, if not most, have taken a close look at engineering activities (Dong, March, and Workiewicz 2017, p. 8). Engineering departments among other functions in the firm have created over decades design and engineering rules, set of established practices required to support product development

and manufacturing. Engineering has been one of the major epicentre of novelty and also the baseline for daily exploitation. It is a place of tension and balance for exploration and exploitation regimes. Learning, imitation and forms of rationalization are deployed in such context to sustain exploitation regime. The knowledge management gravitates around and deals with the established rational model organizing collective action.

In an evolutionary perspective, efficiency can be improved with a better selection with respect to the production of such engineering organizations. Imitation is one sub-activity with the risk of converging on sub-optimal selections. Ways of controlling this convergence must be envisioned such as bringing novel knowledge, or in a network theory perspective, slightly disconnecting agents (Dong, March, and Workiewicz 2017, p. 8). Encouraging novelty becomes critical and J.March recalls that most novelties fail, leading to the promotion of the garbage-can decision model appropriate for unstable environment paired with a selection process. Benefits of others experimentation can also be drawn fostering vicarious learning (Riedl and Seidel 2016).

> *If you're going to engineer an evolutionary process, you have to work on improving selection, and you have to work on improving novelty.* (Dong, March, and Workiewicz 2017, p. 9)

Novelty is odd and uncertain, and this failure rate calls for some *technologies of foolishness* by opposition to exploitation behaviours ruled by established technologies of model-based rationality (Dong, March, and Workiewicz 2017; March 2006). Rational models have misspecified the organization of action due to numerous difficulties: uncertainty and the unexpected (Shackle 1949), causal complexity, preference ambiguity (Camerer, Loewenstein, and Rabin 2004; Slovic 1995) and strategic interaction (Chia 1994; Eisenhardt and Zbaracki 1992; Pettigrew 1977) just to name a few. So, other models with feedback means have developed to adapt continuously, to counteract myopic behaviours (Levinthal and March 1993) and surprise effects associated to incompleteness of previously mentioned models of rationality. Yet, these models may not reach a global optimum (Barron and Erev 2003; Brehmer 1980; Carroll and Harrison 1994).
These problem-based modelling approaches will frame the behaviour of the algorithm with certain boundaries and will not facilitate discovery of other domains. We can all picture a robot hitting a wall in a infinite loop with the hope to minimize the distance to the objective behind the wall despite having numerous sensors. Limitations of the agent bound its rationality because of numerous biases, but also the environment minors the performance of adaptive processes for being too complex, endogenous, subjective and contested (March 2006, p. 205). Experimentation is then required to put the robot in a position where novelty can be observed and gradually understood given pre-conceived rules. In that perspective, the novelty-search algorithms (Nguyen, Yosinski, and Clune 2015) applied for robots to adapt like animals in a resilience mode (Cully et al. 2015).

This sets the frontier of problem-solving perspective and possible decisions, but leaves potential ones undiscovered due to bounded rationality.
The complexity rises when considering unusual experiences compared to existing knowledge basis and rational model as discussed in by Raghu Garud with a narrative perspective (Garud, Dunbar, and Bartel 2011). In the following extract, J.March plays with the edges of the model and the necessity to *generate variety*, but we can expect this generativity is limited to the landscape of bounded rationality and search:

> *The first central requirement of adaptation is a reproductive process that replicates successes. The attributes associated with survival need to be reproduced more reliably than the attributes that are not. The second central requirement of an adaptive process is that it generate variety.* (March 2006, p. 205)

However, creative logics or generative processes in a broader and weaker sense (Epstein 1990, 1999) are required to bring variety to the process and add up to the existing knowledge (bounded and unbounded). But again, it goes beyond search/discovery and is rather associated with novelty and the reaching for the unknown.

Exploration regime in its quest for variation, requires alternative mechanisms such as organizational slack, randomness, *errors* of adaptive process parameters and other mechanisms shifting the performance frontier with objectives derived from intuition of a leader. J.March makes then a case for foolishness and some *kind* of irrationality compared to the normative technologies of rationality established in the organization:

> *The designers of adaptive systems often proclaim a need for deliberately introducing more of them to supplement exploration. In their organizational manifestations, they advocate such things as foolishness, brainstorming, identity-based avoidance of the structures of consequences, devil's advocacy, conflict, and weak memories (George, 1980; George and Stern, 2002; Sutton, 2002). They see potential advantages in organizational partitioning or cultural isolation, the creation of ideological, informational, intellectual, and emotional islands that inhibit convergence to a single world view (March, 2004). Whereas the mechanisms of exploitation involve connecting organizational behaviour to revealed reality and shared understandings, the recommended mechanisms of exploration involve deliberately weakening those connections.* (March 2006, p. 207)

The numerous failures of rational models and their technologies are *utopian* (March 2006, p. 209):

> *It is argued that the link between rationality and conventional knowledge keeps rational technologies reliable but inhibits creative imagination. This char-*

> *acterization seems plausible, but it probably underestimates the potential contribution of rational technologies to foolishness and radical visions.*

It encourages then the "heroism of foolishness" to support exploration and the use of technologies of rationality as a baseline to enhance exploration, and avoids pure irrationality. This last sentence blurs the boundaries of exploration and exploitation, let it be on the same continuum or in two orthogonal planes. It is a thin-wall domain defined here pushing the debate down the line of functional stupidity in organization (Alvesson and Spicer 2012), pure irrationality in (Brunsson 1982) and his subsequent works, or the role of opportunism and reliability (Foss and Weber 2016; Lumineau and Verbeke 2016).

> *Exploratory foolishness may sometimes be desirable, and technologies of rationality may be important sources of exploration; but the use of rational technologies in complex situations is unlikely to be sustained by the main events and processes of history.* (March 2006, p. 211)

The main question we can ask ourselves so far is **how collective action should be organized in such domain of foolishness tangent to irrationality**. And not managing appears almost clearly out of question due to the necessity to balancing the exploration regime to reach a global optimum with an enhanced adaptive process. We have reasons to worry as several authors have described the variety of learning behaviours (Garcias, Dalmasso, and Sardas 2015) at the light of learning/performing paradox (Smith and Lewis 2011); or even the systematic violation of management rules contributing to learning (Mangematin et al. 2011).

How do we articulate it with learning mechanisms and overall knowledge management? How could we turn such *deviant* behaviour into resources or at least start building dynamic capacities that will support innovation? Foolishness could contribute to unbounding individual and collective rationality, but perhaps also extend into the unknown. It remains unclear in the model and proposals made by J.March.

## 1.3 Shifting the performance frontier with innovation

The seminal paper of 1991 review (Wilden et al. 2018) addresses two research gaps related to the re-connection with behavioural roots and supporting capabilities required for exploration/exploitation (Wilden et al. 2018, p. 11):

> *How do behavioural tendencies of managers, such as the risk propensity of executives, relate to a firm's ability to explore versus exploit? How do individual tendencies to explore versus exploit interact with environmental trends at the institution, industry, and country levels?*

*How do capabilities that support exploration and exploitation emerge and become embedded in organizational routines? Are there differences in the dynamic capabilities required for executing exploration versus exploitation? Which dynamic capabilities are required to overcome path dependencies in exploitation?*

As we have stressed in the previous paragraphs, enhancing adaptive processes with novelty-driven processes supporting exploration may lead to numerous difficulties when trying to reconnect with exploitation regime: routines, rules and practices. The nature of exploration could otherwise fall in the domain of behaviours based on foolishness or rationality.

In a behavioural perspective, it is crucial to understand what facilitates the allocation of resources for such activities. The underlying decision-making process must be clarified. Decisions are seen as trackers and reflections of the organizational life, and some of these are consigned into technologies of rationality. Agents in the firm develop associated routines that are rationally bounded and they consequently struggle to reach global optima on an objective Pareto front as pictured in the Fig.I.4. The previous subsection highlighted that agents are bounded in a biased knowledgeable space; exploration allows them to reach statistical optima on the Pareto front. Foolishness could perhaps contribute to the search vector for exploration, and it remains unclear if it contributes to generative processes broadly, into the unknown.

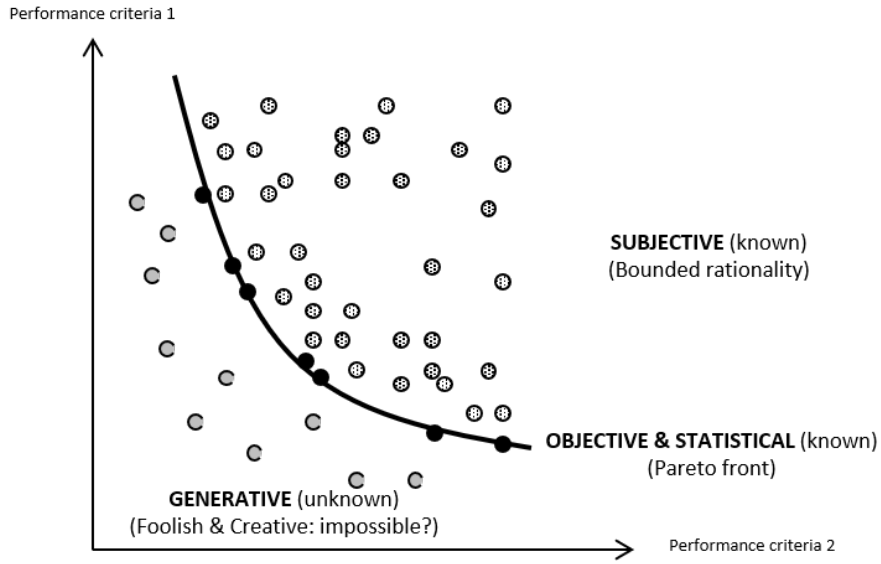


**Figure I.4:** Schematics of behaviours

The tension created by exploration behaviours interfere with existing routines and rational models that could be expressed in terms of performance criteria delimiting the Pareto front: foolishness creates an exploitation oddity, an unusual experience (Garud, Dunbar,

and Bartel 2011) that encourages to revisit the Pareto front definition or even the performance framing (x and y axes).

Giovanni Gavetti (Gavetti 2012) pinpoints the ability to overcome focal behavioural bounds and reach for cognitively distant opportunities. Instead of paying attention to local collective action, he focuses on strategic leadership that would be able to manage such stretch. Such kind of system thinking elevated at the leadership level would encourage to revisit the strategic agency and governance of collective action. If one has attended J.March leadership classes or read (March and Weil 2003), one could find such behavioural leadership with fictional characters as Don Quixote: foolishness benefits his journey in some ways.

The concept of behavioural strategy (Powell, Lovallo, and Fox 2011) proposes also to integrate the views of reductionist, pluralist and contextualist research. Despite the attractiveness of such consolidated and holistic construct, management requires to design concepts that explain collective action in organizations and at best would be actionable in practice. As suggested by the authors, it is as the crossroads we can build a comprehensive understanding.

So, in order to make a case for supportive capabilities required for exploration and exploitation, and combination of both, the behavioural perspective calls for some architectural design of adaptive systems for the organization as mentioned by J.March. The contribution of innovative practices, generative processes or how they are impacted remains to be clarified. It is a limitation of the problem-based view.

It also invites us to deeply understand the mechanisms of both exploration and exploitation and the associated dualism (Farjoun 2010). The paradoxical tension between regimes describes the adaptive system performance with an inverted U-shape between the degree of adaptiveness and the frequency of turbulence of the environment(Posen and Levinthal 2012). It prescribes then adjustments to the organization sustaining exploration and exploitation, and questions where and how arbitration should be made. How should be structured the firm? How does leadership should design accordingly to support innovation and performance? What makes exploration and what makes the tension points when exploiting its outcomes?

Overall, we could say that we have two major models, one that would be structural and another one more processual. To organize collective action in the firm, it is also crucial to keep an eye on learning patterns, if exploration or exploitation contributes to core rigidities and incompetencies (Dougherty 1995; Leonard-Barton 1992).

# 2 Organizational ambidexterity: organizing unbounded problem-solving

In this section, we propose to cover the stream of literature focused on the approach to capture behavioural roots through organizational structure and design. Some hints of this research program can be found echoing portfolio project management or program management, and coordination & communication means deployed across the organization in relationship with learning mechanisms when competing for primacy (March 1991b, p. 84):

> *Similarly, multiple, independent projects may have an advantage over a single, coordinated effort. The average result from independent projects is likely to be lower than that realized from a coordinated one, but their right-hand side variability can compensate for the reduced mean in a competition for primacy. The argument can be extended more generally to the effects of close collaboration or cooperative information exchange. Organizations that develop effective instruments of coordination and communication probably can be expected to do better (on average) than those that are more loosely coupled, and they also probably can be expected to become more reliable, less likely to deviate significantly from the mean of their performance distributions. The price of reliability, however, is a smaller chance of primacy among competitors.*

The literature on organizational ambidexterity made the effort over several decades to capture the relationship between the constructs of exploration and exploitation with respect to several other observables: different level of analysis within the firm, influence of the environment, leadership and many more (Birkinshaw and Gupta 2013; O'Reilly and Tushman 2013). The numerous variables are usually studied through quantitative methodologies with surveys and databases. Correlations and patterns are then derived in relationship with the firm's performance and innovation. Ways of organizing ambidexterity are typified with different impacts given a set of control variables centralizing most of debates in the field, and may have led to contradictions because of control variables.

We first review the different forms of organizational ambidexterity and influence of performance and innovation, and what are the capabilities addressed in such domains. Second, as the core issue remains the management of competing objectives, we analyse the literature on paradoxes and how it contributes to organizing collective action. Finally, given the extant literature and limitations raised by the community of researchers we come back to the underlying mechanisms and the necessity to understand the micro-foundations of exploration and exploitation and nuances that may have been omitted.

## 2.1 Structural, sequential and contextual ambidexterity

The word "ambidexterity" preceded the seminal paper of (March 1991b) in *The ambidextrous organization: Designing dual structures for innovation* (Duncan 1976). The concept was introduced for organization design to improve innovation capabilities. It makes an assumption on the innovation process seen in two sequential phases: initiation and implementation. Robert Duncan stresses the behavioural dimensions (resistance model mainly) and the decision-making associated to the innovation process. The so-called **structural ambidexterity** is designed to facilitate the management of ill-structured problems posed by innovation[2]. Given several behavioural features analysed, three conditional rules are prescribed for the organizational structure given the nature of innovation (uncertainty, radicality, need). Merging the literature of dynamic capabilities and organizational ambidexterity (O'Reilly and Tushman 2007) also emphasizes the importance of senior management to oversee the trade-offs of exploration/exploitation and the translation of *sensing, seizing and reconfiguring* (Teece 2007). Simultaneity is achieved by the structural organization of exploration and exploitation. The dynamic capabilities emerge from the contribution of senior management being able to oversee the overall reconfiguration of both regimes: a strategic intent with clear vision and values and the necessity to have ambidextrous leadership. This attraction for leadership and senior teams is given because of the risk of ambiguity of capabilities (O'Reilly and Tushman 2007, p. 190):

> *What is needed is the identification of specific senior team behaviours and organizational processes/routines that allow firms to manipulate resources into new value creating strategies. Ambidexterity as a dynamic capability is not itself a source of competitive advantage but facilitates new resource configurations that can offer a competitive advantage*

This way of organizing is given for high strategic importance and operational leverage by opposition to other configurations: independent business unit, internalization/subcontracting and spin-off. It is an answer to the ad-hoc/spin-out emerging business see in the innovator's dilemma (Christensen 1997). The critical dimension of this stream is the contribution of a potential ambidextrous leadership from the top management and middle management (Benner and Tushman 2003; Benner and Tushman 2015). However, its nature and means of action are not specified.

The **sequential ambidexterity** approaches the question of innovation and continuous change with. The sequential approach is more influenced by a continuous change perspective (Brown and Eisenhardt 1997). Brown and Eisenhardt bring the nuance of change in a more dynamic and continuous way contrasting with punctuated equilibrium. When

[2]We remind to the reader the language used in that time was of course very different from what management studies has become now. We may refer of course to the narration and analysis of innovation management by (Burns and Stalker 1961) explaining organic and mechanistic structure with a strong background from sociology of organization applied to new product development.

considering the shift from exploration to exploitation (the opposite is rarely mentioned), they emphasize the importance of experimentation and light structure (*semi-structure*). It is a *weaker* form and blending the edges of the short burst of radical/discontinuous change in between long periods of incremental change[3]. Focusing on processes and systems allows to have an alternative approach to the structural dimension of ambidexterity:

> *Continuously changing organizations are likely to be complex adaptive systems with semi-structures that poise the organization on the edge of order and chaos and links in time that force simultaneous attention and linkage among past, present, and future. These organizations seem to grow over time through a series of sequenced steps, and they are associated with success in highly competitive, high-velocity environments.*(Brown and Eisenhardt 1997, p. 32)

**Contextual ambidexterity** brought another modulation that tends to merge the structural dimension with the punctuated equilibrium by (Gibson and Birkinshaw 2004, p. 209):

> *contextual because it arises from features of its organizational context. Contextual ambidexterity is the behavioural capacity to simultaneously demonstrate alignment and adaptability across an entire business unit*

The influence of context opens up the perspective on organizational ambidexterity by considering the boundary condition of the construct: environment dynamics. It also moves away from the trade-off allocation problem by *simultaneously develop[ing] these capacities by aligning themselves around adaptability* (Gibson and Birkinshaw 2004, p. 221). The interplay between adaptability and alignment is placed at the individual level, calling for paradoxes at the local level, in addition to support from senior management.

The three models described try to organize in different way the separation and balance between exploration and exploitation. The non-mutual conditioning is maintained: exploration and exploitation regimes happen in sequence, in parallel and at different levels and contexts.

Systematically, top management and its leadership is required to oversee and manage the balance, in addition to enabling some level of flexibility for transitioning dynamically. Yet, it does reveal the actual practice and implementation.

## 2.2 Limitations of organizational ambidexterity models

Authors have also highlighted the push from academic reviewers during their publishing process. Their qualitative study would indeed bring more depth to the construct of ambidexterity and separation between exploration/exploitation. They were encouraged to

[3]Nowadays, such pattern could be associated with the concept of Agile management experimented and formalized in software development

embrace the literature of organizational ambidexterity with (Birkinshaw and Gupta 2013, p. 288):

> *Interestingly, our original focus in this paper was not on ambidexterity per se. Our specific interest was in the tension between an organization's capacities for alignment and adaptability, and in the role of organizational context to help it achieve an appropriate level of balance between the two. In developing the paper, we came across ambidexterity as one possible framing for our work, and we leaned heavily on Adler and colleagues (1999) in our theorizing. But it was actually the editor, Marshall Schminke, who had the bright idea to describe the phenomenon we observed as contextual ambidexterity, as distinct from the more structure-oriented approach to ambidexterity that Duncan (1976) and Tushman and O'Reilly (1996) had described.*

In contrast to the amount of quantitative studies, the extensive literature reviews conducted by major authors (who have contributed with detailed qualitative or mixed studies (Benner and Tushman 2003; Gibson and Birkinshaw 2004)) in the field have called for further qualitative research and trying to surface underlying processes supporting ambidexterity in action (Birkinshaw and Gupta 2013, p. 332):

> *How they actually do this is seldom addressed in the research on ambidexterity but is at the core of the leadership challenge. What do the interfaces of the old and new need to look like? How can leaders manage the inevitable conflicts that arise? More qualitative and in-depth studies are required to answer these questions.*

It is a call to reconnect with behavioural roots and to better specify the practice of exploration/exploitation and its management beyond pure trade-off as if they were on the same continuum. Quantitative studies have failed in specifying such phenomena:

> *Although the results are not completely consistent across studies, in general they confirm that structural ambidexterity consists of autonomous structural units for exploration and exploitation, targeted integration to leverage assets, an overarching vision to legitimate the need for exploration and exploitation, and leadership that is capable of managing the tensions associated with multiple organizational alignments* (O'Reilly and Tushman 2013, p. 328)

> *At a high level of abstraction, it is easy to claim that firms shift structures between exploitative and exploratory modes—but what would this mean at ground level? Major structural transitions can be highly disruptive. What does it mean to go from exploitation to exploration, or the reverse? Here the research is not fine-grained enough to provide much insight.*(O'Reilly and Tushman 2013, p. 327)

> *We know some organizations are more ambidextrous than others, but for this insight to be valuable we have to take a more detailed look at the way they make their decisions, who gets involved in those decisions, and how those decisions are implemented. For me, this is one of the areas where ambidexterity research has the most potential. There is, for example, some research looking at decision processes in top management teams (Smith & Tushman, 2005) and how executives embrace paradox (Andriopoulos & Lewis,2009), but I would like to see a lot more.* (Birkinshaw and Gupta 2013, p. 293)

It is interesting to note the interest of leadership, which had raised as a reaction with respect to the *awakening of the machines* that Herbert Simon dreamed of. Stanley Stark (Stark 1963) in his review on creative leadership mentions the work Philippe Selznick's of administrations through leadership (Selznick 1957), here is a stimulating extract:

> *Why did Professor Selznick write this particular essay? And why did he title it Leadership in Administration? Any reply to the first question should include, I believe, a statement to the following effect: he wrote it as an intuitivist supplement, corrective, or antithesis to the formalist essay that Herbert A. Simon titled Administrative behaviour. And any reply to the second question should include, I believe, a statement to the following effect: leadership in the old-fashioned sense, which stood so high with the intuitivist likes of Plato, Carlyle, and Weber, stands very low in the world of scientific empiricism; in Administrative behaviour... the word leadership itself cannot be found in the heading of a single chapter, chapter section, chapter subsection, or anywhere in the index. ... My guess is that Professor Simon would wonder much, and that Professor Selznick would find it exceedingly difficult to satisfy him. But we must satisfy him if we are ever to convince him that at any given time the computer is not doing all the thinking that middle or upper managers do. For example, when he says that "we will have the technical capability, by 1985, to manage corporations by machine" (1960, p. 52), are we entitled to smugly retort, "Sure, but what about leading, creatively leading—a la Selznick—by machine?" if we cannot reach agreement on what Professor Selznick means? It is one thing to say to Professor Simon— "You've left creative leadership out of your social psychology and out of your machine" — and another to demonstrate that he has omitted a piece of reality.*

Leadership is presented as a counterforce and extension of bounded rationality and technologies of organizing to reach optima. The decisions, the vision given by leadership remains to be specified.

When comparing the structural and processual models (Benner and Tushman 2015; Birkinshaw and Gupta 2013), the contextual approach encourages to look at the business envi-

ronment, not only at business unit level but in a more general perspective. With innovation management, organization may have to adapt in different ways, as it can shift the performance frontier of exploration and exploitation. Mary Benner suggests the innovation locus (Lakhani, Lifshitz-Assaf, and Tushman 2013) having shifted and being shaped in different ways (e.g. open innovation, community-based, exploratory partnerships), the ambidextrous organization should be revised as the adaptive process may no longer rely on *models based on cost minimization, local search, hierarchy, power, control of contingencies, and extrinsic motivation* (Benner and Tushman 2015, p. 508). It is interesting to note that this in-between concept, sheds a fresh light on fixations and path-dependency of some constructs that are showing limitations.
Similarly, in (Gupta, Smith, and Shalley 2006, p. 699), the system design with its engineering background on modularity (Henderson and Clark 1990) brings another way of contextualizing ambidexterity given the system architecture and innovation. Exploration activities can be conducted locally for a module, and exploitation can carry on in others as long as interfaces remain stable. The coupling between modules may also an obstacle to such approaches as explained in (Benner and Tushman 2003, p. 247).

> Exploration and exploitation non-mutual conditioning may be then challenged by innovation practices and loci. The decision-making and managerial capacity (e.g. leadership) are not fully elucidated in the literature and would require fine-grained qualitative research.
>
> Another way of considering the balancing of the dichotomy between exploration and exploitation, is to look at how the literature on paradoxes have nurtured a way of managing collective action (Smith and Lewis 2011). It would allow considering the antagonistic effects with different main performance criteria (generation of alternatives, and efficiency of choice).

## 2.3 Managing with paradoxes

The organizational ambidexterity literature with its organization adaptation for innovation and efficiency plays with translation of the underlying adaptive process articulated with exploration/exploitation. Researchers in the field have already stressed its limitations and calls for future research. Their synthesis calls for forms of ambidextrous leadership (O'Reilly and Tushman 2007) or at least a crucial involvement of senior management to oversee forms of structural/sequential/contextual ambidexterity. For a manager it will imply then allocating resources for a regime or the other in different ways in space and time. From a behavioural perspective, the manager will bear the paradoxes associated with the co-existence of these regimes or inversely will manage other individuals with such paradoxes (Papachroni, Heracleous, and Paroutis 2015).

Due to multiplicity of studies, their nature, their unit of analysis, the triggered paradoxes would be of different types when looking at the critical literature review of (Gupta, Smith, and Shalley 2006) in their special research forum. For instance, the definition of exploration and exploitation may depend on the unit of analysis chosen in the studies (multi-scale problem), the continuity or orthogonality of the two constructs, the system dimension opposed to organization and individual, interpersonal learning, tacit knowledge, inter-dependencies and local/distant search. They also specify that learning mechanisms associated with exploration or exploitation may of be different nature, as it was confirmed in (Garcias, Dalmasso, and Sardas 2015). Paradoxes then bring the promise of blending the dichotomy in a distributed way dependent on context.

For instance, (Leonard-Barton 1992) reveals the paradox of new product development managers having to rely on existing core capabilities and still avoid associated core rigidities: e.g. values, skills and knowledge, managerial systems and technical systems. Paradoxes for project management were handled with different strategies associated with adaptive limitations: abandonment, recidivism, reorientation and isolation.
But paradoxes can also be embraced to manage a firm specially for senior management (Smith and Tushman 2005) who can overview the numerous organizational tensions (Smith and Lewis 2011). Teams arrangements, communication, leadership coaching contribute to adopting and managing the paradoxes in a *dynamic equilibrium* in order to avoid the fatality of cyclical patterns associated to paradoxes. For instance, (Smith and Lewis 2011, p. 392) proposes that some individuals with cognitive/behavioural complexity and emotional equanimity are likely to accept paradoxical tensions instead of defending. It is an invitation to dig into the constraints to better twist the paradoxes into managerial action. The unit of analysis to cope with organizational tensions may also be translated in different action registers as demonstrated in (O'Dwyer, Sweeney, and Cormican 2017) with project portfolio ambidexterity. CEOs are found to be using practices based on paradoxes to drive performance and innovation in firms (Fredberg 2014).

However, despite the attractiveness of paradox theory as an alternative to contingency approaches, the work of Linda Putnam in (Cunha and Putnam 2017) addresses the potential paradox of a success trap for this vigorous literature: the paradox of the paradox. Two issues retained our attention: the imprecision of the word and the paradox reversibility while being a problem/tool to manage. For our concern, as we question the possibility of actually organizing collective action through the paradoxes of ambidextrous tensions, its practice may become very diffuse and hard to grasp. Furthermore, the tensions created by these *stretch goals* (Sitkin et al. 2011) may be favoured in some organizational contexts but it also raises the question of the ambidextrous individual able to cope with such *double binds* (Holmqvist and Spicer 2013). The concept of double-bind thinking, introduced by

Gregory Bateson (Bateson et al. 1956, 1963) may encourage some kind of schizophrenia or at least high level of stress among individuals subject to such organizational tensions. Others may be more successful. Such unbalanced performance for ambidextrous strategy and leadership encourages to dig a little further into the cognitive level.

For instance, in (Laureiro-Martínez et al. 2015), magnetic resonance imaging is performed on individuals to identify brain regions supporting the decision-making associated with exploration/exploitation and its trade-off. The findings include the awareness of the environment of decision-making, the influence of emotion and attention, the sequencing and switch of the two regimes, and learning mechanisms. The authors insist on the fact that their results do not encourage any form of selection and hiring but rather on the training.

Similarly, the contributions of the MIT's System Thinking department's director Peter Senge (Senge 1990) is suggested in the discussion of (Leonard-Barton 1992, p. 192). He calls in his paper for heuristics associated with leadership styles supporting a generative learning instead of adaptive learning. The leader could have new roles to support the tensions and organizational learning; leader as a designer, teacher and steward. The associated skills and management tools should then be developed, and would allow extending the model of adaptive learning with creation process in the continuity of coping mechanisms with a broader system thinking. This view of managerial action recalls also the works of (Starbuck 1983) considering organizations as action generators. So, instead of relying on the individual skills to cope with cognitive ambidexterity and associated strain, the focus could be shifted toward methods, practices and management technologies as well as organizational routines.

Finally, the paradox approach may leave us without clear means of understanding the practice of organizational ambidexterity, as it tends to distribute the paradox on multi-scale and phenomena fashion.

By following the lines suggested for future research in the ambidexterity literature reviews referenced previously, we propose to take a closer look at the decision-making process for exploration, exploitation and its trade-off. It may for instance document what is expected from leadership specially if they engage in generative practices shifting the frontiers of exploration and exploitation. So far, we have highlighted that macro-level analysis may be insufficient and rather too contingent, hence our need to explicit the underlying mechanisms.

# 3 Deciding to innovate: micro-foundations of ambidextrous organizations?

In this final section of the chapter, we propose to analyse the literature on decision-making supporting exploration and exploitation. First of all, the necessity of managing the adaptive process through exploration and exploitation was presented as a necessity to cope with externalities and sustainability. Along with the firm's performance, innovation management has become the central focus of ambidexterity as it contributes to exploration/exploitation impact and trade-off.
The firm's management decides then to innovate to feed the adaptive process with exploration regime which then requires to be transferred to exploitation purposes. We have stressed that these two regimes can structurally co-exist, be sequenced dynamically and more importantly may be shaped in different ways depending on the unit of analysis (organization, system and individual/cognitive).

Relying on the decision-making process in a *neo-Carnegie way* (Gavetti, Levinthal, and Ocasio 2007), i.e. looping back with the behavioural roots of (March 1991b), encourages to specify decision-making with respect to exploration, exploitation and its balance. Decisions are considered as legitimate unit of analysis. It is tracker of sociology of organizations (Crozier and Friedberg 1977; March 1991a; Pettigrew 1973), perhaps even an artificial construct (Laroche 1995) for which we should perhaps prefer organizational action.

> Without opposing decision and course of action, we will have to look at the impact of risk, uncertainty and the unknown as we tasked ourselves to regard adaptive process with respect to innovation management. The following paragraphs will aim at clarifying the nature of decision-making in our chosen field of study and how it handles the dichotomy and balance of both exploration and exploitation.

## 3.1 Uncertainty and the unknown

In the assumptions made by (March 1991b), the problem space given to the firm to adapt to survive was set beforehand: exploration was a means to search for alternatives not considered by exploitation in the given problem space. However, the previous paragraphs on organizational ambidexterity and the focus on exploration preceding exploitation, gave several hints that the search could be more complex than the one originally defined by James March. Several keywords challenge what makes adaptiveness such as: unusual experiences, new locus of innovation with open innovation, environment awareness, system thinking, differences in learning mechanisms for exploration and exploitation and the adjective generative.

Originally, the problem space involved statistical and optimization dimensions for the decision-maker. In other words, statistical learning and subjective beliefs that could be modelled in terms of probabilities. We are in the realm of risk-taking and uncertainty. The consequences of decisions are known but the probability of happening is not known. The search-model of exploration consists in looking at other consequences and decisions to enlighten the decision-maker by having the global picture of the problem instead of being bounded. By referring again to earlier definitions (Levinthal and March 1993, p. 105), the research developments suggest that exploration encourages to specify the regime of generation or generativity of new knowledge in its broadest sense: *[exploration] the pursuit of new knowledge, of things that might come to be known* and *[exploitation] the use and development of things already known.*

If new knowledge is generated by experiences (changing environment) or deliberate experimentation and action, the rational choice theory reference[4] is no longer fully valid as we force the set of possibilities to become larger and potentially reconfigured (Hey 1983). We enter the realm of the unknown or unknowledge as suggested by G.L.S Shackle (Frowen 1990; Shackle 1949).

In the field of operations research, (Ozdemir and Saaty 2006) proposes to add a variable labelled "Unknown" with uncertain probability; the model can then be used for decision-making and take into account the perception of the unknown. In other words, the "other" states of the universe of probabilities are integrated, so it means really re-examine the full extent of the theoretical, objective and unbounded problem by opposition to the rationally bounded one.
It is not an actual theorization of the Unknown as we have defined it: states of nature and decisions that we are fully unaware of it but that only action can reveal. The dynamic dimension of decision-making naturally updates the sets of choices, consequences, and utility function but decision theories rarely focus on this feature because of potential problems of dynamic consistency, modelling complexity and preference revelation given choices made (Chabris, Laibson, and Schuldt 2006; Machina 1989).

The timing issue dragging behaviours such as patience and impulsivity are not really our concern despite being also part of life in organizations. We are rather interested in what could be willingly generated in a static frame: changing belief, new decision.

Coming from a decision problem to another invites us to consider the generative function that allows the transfer between the two. It is an expansive projection by opposition to traditional projection reducing the scope (se Fig.I.5 below). In other words, it is not reducing uncertainty over time with numerous means of actions (Sommer, Loch, and Pich

[4] we refer here to subjective expected utility theories

2008). Instead, shifting from a problem to another increases uncertainty temporarily before further experimentations can be performed (e.g. testing). Likewise, the need-solution pairs developed in (Hippel and Krogh 2016), stresses the existence and discovery of new problems and opens a field for how to behave in such unknown landscape.

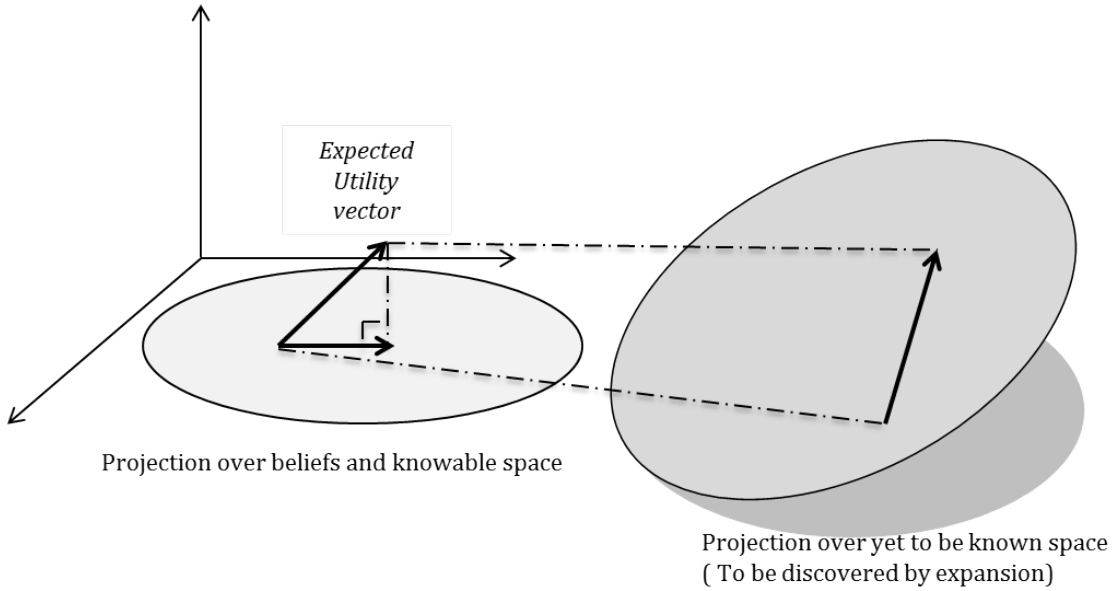


**Figure I.5:** Schematics of the knowledge expansion

Such behaviour has been studied in cognitive psychology where the avoidance and search for the unknown can be channelled through the curiosity and regret (Dijk and Zeelenberg 2007). Based on information-gap theory (Ben-Haim 2006), it proposes a first step to consider known unknowns (Rumsfeld 2002a,b), but double unknowns again are not part of the equation. The case of Black Swans (Taleb 2007) and the types of uncertainties associated with knowledge categories can bring a new light on the decision-making process (Faulkner, Feduzi, and Runde 2017). It helps defining with more clarity the boundary conditions of expected-utility theories which presuppose what is known and uncertain, compared to other theories such as non-expected utility ones (Machina 1989, 2010; Quiggin 2014; Starmer 2000). But, they still lack in sensing and seizing double unknowns despite revealing a number of interesting behavioural features that could contribute to the generation of new knowledge and choices. They refer to phenomena such as: preferences reversal, dynamic inconsistency, anticipation, optimism/pessimism, regret, that call for mathematical models that are not additive in the classical sense [5].

[5] It is worth mentioning that in the cumulative prospect theory, the original formulation violated the fundamental transitivity. They managed accommodating the axiom by changing the integral measure with weights and still allowing reversal as in Allais' paradox and other oddities

The literature on decision-making with respect to exploration and exploitation, stresses the importance of generative learning and the frontier with the unknown.

Decisions and search of new alternatives can be of different nature, hence changing the nature of exploration and consequently of future exploitation. We must study in more detail the edges of the Pareto front and its potential crossing.
We propose then to study the interplay between search relieving bounded rationality (known) and generation of new knowledge reconfiguring problem formulation and solving (unknown).

## 3.2 Generative processes: creativity, engineering and design

Exploration distinguishes itself from exploitation by introducing a way of reasoning that is quite challenging for it. We propose to take a closer look at the generative phenomenon and how it is translated in practice to support exploration.

The idea of generating alternatives with a background of theory of creativity was introduced by the works of Robert Epstein. He proposed a *weaker* definition of creativity, namely generativity, to study how animals would engage in creative problem solving (Epstein et al. 1984). With his colleagues, he put forward that pigeons would engage in actions helping them to gain insight to solve the problem in a novel way. In that sense, we are close to the novelty-search algorithm mentioned previously (Cully et al. 2015; Nguyen, Yosinski, and Clune 2015). Generativity is the distinctive feature of design theory and practices. Designers engage in jotting, sketching, drawing, writing and speaking (Brun, Le Masson, and Weil 2016; Ferguson 1992; Goel 1995; Goldschmidt 1991). All of the tasks, that could also be seen as micro-decisions, contribute to idea generation.

With the emergence of brainstorming (Osborn and Rona 1959) coming from advertisement and the large contributions of cognitive and group psychology (Amabile et al. 1996; Guilford 1967) numerous managerial practices have been prescribed to support innovation in organizations (Amabile 1988). Our aim is not to make an exhaustive survey of available practices, but rather to identify the performance discriminants of generative processes supporting exploration and eventually efficiency exploitation. It will help us in better understanding what causes and follows a generative process, i.e. the "operator" that supports the discovery of new knowledge, that allows making our way through the unknown.

### 3.2.1 Design Thinking

In the last two-three decades, Design Thinking has become the centre of attention for numerous companies and consultancy firms (IDEO, Continuum). Looking back at its origins at Stanford's School of Engineering, the director of Product Design (Faste 1994) stresses the need to teach young engineers to ambidextrous thinking:

> *The gestation of Ambidextrous Thinking has occurred both in a College of Visual and Performing Arts (Syracuse University) and a School of Engineering (Stanford University). Thinking in the former setting is often characterized as being soft and fuzzy, in the latter, cold and hard. These characterizations are impediments to understanding the nature of design process. The central mission of Ambidextrous Thinking is simply to acquaint engineering students with the full range of their human potential in order to encourage a more balanced and potent approach to problem solving. In so doing it demonstrates the important connections between these seeming opposites.*

Several techniques are taught to students to deal with reasoning trespassing traditional analytical thinking:

> *Many of the techniques pioneered in this class are showing up in local research and design firms. Examples include mind-mapping, scenario improvisation and story-boarding. I believe there is more to this than the efficacy of the techniques students are bringing with them to the work place. With the introduction of electronics, increasing numbers of products are as much about the design of desired behaviours as they are with the delivery of utilitarian function. Sole reliance on analytical skills will not guarantee engineering success in the increasingly consumer oriented marketplace, nor will it help engineers process the overwhelming amount of information that they will be facing in their careers*

Design Thinking has evolved in a methodological toolbox to democratize design to all individuals in a wide variety of contexts (firm, public institutions, associations and classrooms). It tends to challenge design as a profession (Kimbell 2011, 2012). However, its underlying generative processes can be coded to explain engineering in its globality (Mabogunje, Sonalkar, and Leifer 2016). It is powerful and can be hosted in firms to stimulate new product development at its frond end, but still raises the question of its performance (Schmiedgen et al. 2016). The task is rather complex as performance criteria considered for tame problems (in exploitation) are ill-suited for the wicked problems at stake (Buchanan 1992; Rittel and Webber 1973).

Focusing on the generative phenomenon *per se*, or in its simplest form "idea generation" (fluency), we should pay attention closely enough to what supports generativity in the

design (thinking) process. For instance, (Sonalkar, Mabogunje, and Leifer 2013) introduced the *Interaction Dynamics Notation* to track "concept generation" and a comparison is made against Linkography (Goldschmidt 2014). Their research method stresses how crucial the expression of an idea is for the individual and inter-personal relations engaged in the design process. Works in cognitive psychology from (Smith, Ward, and Schumacher 1993; Ward 1994; Ward 2007) have also stressed the decisiveness of knowledge categories to stimulate idea generation with the notion of *fixation effects* It creates a potential performance reference point for exploration. Such anchoring could be associated with boundedness, and requiring a search for other alternative, but also the limitations of search in a given problem space.

### 3.2.2 Design theories and design engineering: rules and fixations

Other approaches originating also from an engineering background have developed theories to frame the design reasoning in different universities across the globe under the umbrella of the Design Society. Currently, C-K theory (Hatchuel and Weil 2009) has managed to be general enough to explain other design theories and practices (Agogué and Kazakçı 2014; Hatchuel, Le Masson, and Weil 2011; Le Masson, Dorst, and Subrahamanian 2013). Considering design theories, with respect to creativity and innovation management (Le Masson, Weil, and Hatchuel 2017) also allows extending design theories domains where engineering and product design have been lacking (Eppinger 2011). So using design theories as a reference tool to measure generativity could be an appropriate instrument. Tracking design fixations relating to cognitive fixation effects was studied and modelled with C-K theory (Agogué, Le Masson, and Robinson 2012; Houdé 1997; Le Masson, Hatchuel, and Weil 2011).

The capacity to avoid fixations, potential traps associated with exploitation, associated routines, and heuristics appears as a crucial performance criteria of the generative processes supporting exploration. The power to defixate will be hold as key to value the richness, usefulness of exploration.

However, this performance may be seen as self-destructive or antithetical for exploitation. They may generate concepts and knowledge pushing decision-making to its limits and complicating learning mechanisms. Indeed, these generative processes may be seen as upstream processes, in the fuzzy front end (Brown and Katz 2011; Leifer and Steinert 2011) for design thinking, as it is the case also for innovative design practices by opposition to systematic design (Pahl and Beitz 2007) or rule-based design (Le Masson, Hatchuel, and Weil 2011).

Returning to home base by avoiding spin-off and fully ad-hoc devices mentioned in organizational ambidexterity encourages to think of how beliefs and utility (value) are managed

to reach the end decision to innovate. The organizational learning calls for a third loop of learning (Leifer and Steinert 2011), or a meta-learning (Lei, Hitt, and Bettis 1996) extending the single/double-loop learning (Argyris and Schön 1978; Levitt and March 1988). Both favour reconfiguring the system in a wider perspective. It would not be incrementally, nor just between elements, but rather with underlying categories and descriptors.

In a tangent approach and still without considering the screening issue, researchers in design management have largely insisted on the vitality of the creation of meaning to support innovation management through design practice (Verganti and Dell'Era 2014). In that perspective, we rally the notion of dynamic punctuated equilibrium (Brown and Eisenhardt 1997), where the exploitation is relieved from strictness to explore with a semi-structure through different means of experimenting. The necessity of a temporal or structural handover is blended in the process. This "objective" of meaning and stabilization is also clearly described in the works of Carliss Baldwin with the design rules (Baldwin and Clark 2000). Rules can then be used as criteria for decisions, and organize design activities around these.

### 3.2.3 *Homo Faber/Deux ex machina*: Designing mutations

In a perhaps slightly outdated practice (Kesselring, Fritz (VDI 1942) stemming from an earlier version of systematic design (Pahl and Beitz 2007), German engineers looked at decision-making for product design where the design process is punctuated by technical and economical evaluation enhanced by research and idea generation and ad-hoc decisions. He proposes that it is a means of developing products and also coming up with technical mutations. The biological analogy is derived from evolutionary theories:

> *Finally, the following interesting analogy between the divine act of creation in nature and the human act of creation in the technology should be noted. In both cases, from time to time, there is a discontinuity, apparently without a demonstrable relation to what has gone before, something new. We call this a "biological mutation" and mean by it the realization of a divine idea, the other: "technical mutation", meaning the sudden appearance and the first realization of a human idea. Just as it is one of the great tasks of biology to investigate the emergence of mutations in their field, so for us it must be one of the top guidelines to explore the preconditions for the emergence of ideas.*[6]

[6] Author's translation: "Schließlich sei noch auf folgende interessante Analogie zwischen dem göttlichen Schöpfungsakt in der Natur und dem menschlichen Schöpfungsakt in der Technick hingewiesen. Im einen wie im anderen Falle entsteht von Zeit zu Zeit unstetig, anscheinend ohne nachweisbare Beziehung zu Vorangegangenen, etwas Neues. Wir nenen das eine: "biologische Mutation" und verstehen darunter die Verwicklichung einer göttlichen Idee, das andere: "technische Mutation" und meinen damit das plötzliche Auftreten und die erste Verwicklichung einer menschlichen Idee. Ebenso wie es eine der grossen Aufgaben der Biologie ist, das Zustandekommen von Mutationen für ihren Bereich zu erforschen, so muss es auch für uns zu den obersten Richtlinien zählen, die Vorbedingungen für das Auftreten enuer Ideen zu ergründen."

In his paper written during his time at Siemens, he does not develop the importance of models design to value ideas' technical/economical dimensions contributing to the decision process. The idea remains seductive, as he departs from a classical evolutionary perspective by the fact he intends to generate mutations. The origin of the mutation, and its actual process remains to be specified.

> So far, we have insisted on the necessity to have generative processes supporting exploration in the sense they should generate alternatives. Fluency is key.
>
> Second, the ability to defixate is important to value alternatives differing from those at reach in exploitation regime. Methods and models are required to support such process that is not as straightforward due to biases and heuristics.
>
> Third, a corollary, to counter isolation of exploration (March 1991b), generative processes should look at avoiding concepts being a wildcard in the game of exploration/-exploitation trade-off. Specially for decision-making and the meaning creation as the beliefs and utilities may be twisted depending on the course of action and life of the concept in the firm.
>
> Furthermore, we see that exploration can be of two different orders and interacting with exploitation in the realm of what is known but also with the unknown. Such interplay brings new complexities for decision-making due to problem-formulation. It raises also new questions for organizational learning and adaptation.

### 3.3 Organizing ambidexterity through interactions

Managing generative processes, managing design and its impact on exploitation routines (problem-solving, decision-making) requires overcoming the core performances of fluency and defixation. In (Dong, March, and Workiewicz 2017; March 1991b), he advocated that the volume of ideas, technologies, ventures is a necessity in the spirit of technologies of foolishness without explaining the tension and selection between explored and exploited alternatives. So far, we have developed through the literature the necessity to manage the trade-off of exploration/exploitation, and each regime individually, with an emphasis that the trick lies in exploration and its transition. Generative processes would be the engine of exploration and simultaneously complexify its articulation with exploitation. We have specified that deciding to innovate implies revisiting the decision-making process. How could this distance be reduced? The question becomes then how to manage generativity and how to manage design.

### 3.3.1 Managing design

The role of the leader as a designer had already been introduced (Senge 1990), and recent works have also stressed that managers should not be only focused on decision-making but perhaps should be designers (Boland and Collopy 2004). If the firm is fully design-oriented do we avoid decisions? Either way, collective action will be organized in some way and will contribute to the purpose of the firm.

The locus of Design in the firm and interactions with other departments is rather critical to understand its impact. When surveying the role of industrial design in British firms (Gorb and Dumas 1987), Angela Dumas in her years at the London Business School's Centre for Design Management, revisiting the notion of design given by Simon's definition where Design departs from Science: *Everyone who designs devises a course of action aimed at changing existing situations into preferred ones* (Simon 1996). Instead of only focusing the artificial dimension of design, i.e. development of an artefact, A.Dumas and P.Gorb insist on the system of artefacts and how individuals interact with such system. Design's definition is extended to take into account the managerial and behavioural dimensions:

> *a course of action for the development of an artefact or a system of artefacts; including the series of organizational activities required to achieve that development*

They show that design occurs in a silent form already across the firm despite not being recognized as such: professional designers, design department etc. If design exists in a diffuse way across, so it means that we could have a way to articulate the generative processes' outputs with existing routines as individuals engage in design in their own way and domain. For Design Thinking practice, several tools used that fall in the categories of need-finding, idea generation and idea testing (Seidel and Fixson 2013) will bring limitations and support other practices. Anyhow, several ad-hoc management tools and practices have to be implemented to link this exploration practice with product development for instance (Beyhl, Berg, and Giese 2014; Beyhl and Giese 2015).

The role of prototyping appears crucial to implement Design Thinking (Holloway 2009; Stigliani and Ravasi 2012). Klaus Krippendorff largely contributed to the importance of artefacts and the associated semantic turn (Krippendorff 1989). In a similar way, Angela Dumas (Dumas 1994) stressed the importance of relying and building *totems* through metaphor-making in product development as it can engage the 'silent designers' (Dumas and Mintzberg 1989, 1991) to revisit the decision-making process altogether around these totems. Based on a case on shoe design, here is a totem example:

> *The result is a set of slides, caricatures, and words that represents the product family - this is the totem. Most of the shoe manufacturer's teams produced*

> *totems consisting of a phrase and a slide, or a slide and a caricature. While totems can include several slides, caricatures, and phrases, it is important that they combine to form a simple and memorable metaphor, and this is often best achieved with just one or two phrases and images.*

Referring to totems call for a (too) short digression on the works of Emile Durkheim (Durkheim 1915). He reveals how religion is social phenomenon, pushing aside the traditional sacred dimension on the back seat, and insisting rather on the collective consciousness built around totems. If we allowed us such detour, it is because of the works of André Orléan on the notion of "value" in economics (Orléan 2011). He proposes that the value should not be considered as a substance in itself driven by work value and subjective utility in economics models, but rather stemming from the market economy where producers and buyers (exchangers) meet to trade goods. So it is the circulation that makes value and meaning.

### 3.3.2 Managing meaning and making sense of the unknown

These notions of meaning and value around the unknown shaped by generative processes encourage to manage generativity through its social dimension that crystallizes around the decision-making, the learning, the sharing and the diffusion.

One could then engage design in the firm through the cultural impact (Buchanan 2015) by supposing that design is more mindset enhancing daily concerns. The trick is also to reach out for all *silent designers* if we follow the spirit of democratizing design and creativity. Design Thinking has proposed that the empathy building for users could support a design thinking culture within the firm (Elsbach and Stigliani 2018). Based on the literature on organizational routines, the trick is also to be able to frame Design Thinking within the firm. It appears crucial (Carlgren, Rauth, and Elmquist 2016) as it can become in many different forms and relying on different set of tools. Several themes can be identified: User focus, Problem framing, Visualization, Experimentation and Diversity. They all involve principles, practices and mindsets. The latter will contribute to its culture which can be even more enforced through management education and wide training programs (Dunne and Martin 2006; Martin 2009). Yet, reaching institutionalization may not be the only key to let innovative design develop and be sustainable in the firm due to key players: silent designers (Dumas and Mintzberg 1989). They are those who engage in some generative processes on a daily basis with, for, or against rational-based technologies (management technologies, routines, communication channels, meetings, gates etc.).

Furthermore, making decisions and their formalization may be not key in early phases of generativity because of the lack of shared understanding and belief. The middle-ground be-

tween generated concepts and social system is the place where they simultaneously shape each other (Akrich et al. 2002). Individual will gradually gain interest (*intéressement*) that can eventually sustain innovation management, without focusing on the rationality of decisions (Mintzberg and Westley 2001)[7]. This analytical lens leads to how sensemaking (Weick, Sutcliffe, and Obstfeld 2005) can contribute to managing the unknown.

In the case of product innovation, some works have stressed the sensemaking for product innovation showing that its system have different dynamic compared with non-innovative contexts (Dougherty et al. 2000). For instance, they stress that tensions are created in through different themes: framing of knowledge (new) links, tensions across product/business/strategy ventilating sense and knowledge across all levels of the firm. Making decisions on innovation would be a fallacy where people actually look for approval and rather building sense interactively (Christiansen and Varnes 2007). This viewpoint insists that innovation management should create the means to support such interactionist action to sustain learning mechanisms and handling novelty from exploration to exploitation. In other words, the creation of meaning, the sense-making and associated learning triggered by generative practices rely on a certain **ecology of generativity**. We derive the notion from the ecology of creativity described in (Cohendet, Grandadam, and Simon 2009; Harrington 1990) but also the case of managing technical experts in science-based firms revisiting the concept of epistemic communities by creating diversity (proto-epistemic societies) in (Cabanes 2017).

In (Stigliani and Ravasi 2012), they refer to *prospective models of sensemaking* driven by design thinking practice (Continuum agency) but unfortunately it considers only the design process without calling for the generativity for the client or the designed object for end-users. We can actually question the usefulness as the CEO of Continuum stated in (Lockwood 2010, p. 20):

> Q:I would think that afterward they might fall back to their more analytical thought processes. A: Oh, that's absolutely true. But it's progress, even if it's like taking two steps forward and one step back. In some cases, they may even have a natural tendency toward design thinking, but it has been sup- pressed because of the way things are traditionally done in corporations. Q:I wonder if there is any concrete way to evaluate the prevalence of design thinking or design as a competitive strategy in to- day's organizations. Do you have any recommendations for how we might assess this? A:That's a great question. I don't know how you would measure it, though. You know, that's kind of the essence of the value of design thinking: You start to value things you just can't measure. If you try to measure what you can't measure...

[7]Note: we are in a position where action gains in importance and leaves decision in the dark or at best as an ex-post social representation (Laroche 1995)

Undoubtedly, generative processes rely on several practices, heuristics and learning mechanisms that include a social dimension to create meaning, make sense, that could perhaps in the end lead to decisions once interest and beliefs are settled. A sister approach is also addressed with the sensemaking perspective in a crisis mode (Berthod and Müllerseitz 2016) with the notion of managing the unexpected (Weick 2011) and highly-resilient organizations (Sutcliffe and Christianson 2012). But it is unfortunately a case for high uncertainty and extreme level of adaptiveness.

Finally, we have seen that there are ways of explaining how the unknown could be used as a driver to create meaning and gradually make sense of the novelty. Totem, metaphors, desirable futures can used to organize innovation. But still, by being "pre-decision" it avoids the decision-making and some behavioural dimensions of exploitation. Inversely, if were to follow this interactionist perspective we struggle to identify the handles to manage exploration.

What are the useful, necessary articulations and interdependencies to work on? Should we only rely on generating *enough* and hope that some will go through this ecology of generativity?

This probe onto decision-making for innovation, playing on the balance and performance of exploration and exploitation tends to reinforce the dichotomy between the two. It shows from the organizational adaptation and learning perspective that generative processes can occur *upstream* or in a distributed way. In any case, they emphasize the antagonistic effects of exploration and exploitation. The modes of collective action can take different shapes (linear and/or interactive), but still rely on managerial personae to separate and balance both regimes.

# 4 Chapter conclusion: limiting assumptions on the extension of generative processes

In this first chapter of literature review, we started with the seminal adaptive model (March 1991b) that was largely extended in the literature of organizational ambidexterity. As the model is now reaching out for innovation management with the tensions of exploration and exploitation, we proposed to discuss this initial setting with management of the unknown. Several writings indicate that the constructs of exploration, exploitation and ambidexterity require clearer definition and understanding to prescribe practices due to the nuances brought by impact of the chosen unit of analysis (individual, social, organizational and system) as well as contingent factors. This ambiguous stretch is due to the gap created by models, derived from problem-solving, currently applied to new contexts and knowledge drive by innovation and the unknown. Is it still conceivable to separate exploration from exploitation in the unknown?

Given the behavioural roots of this work, we got to the point of discussing the literature on decision-making with respect to the unknown that is addressed by the evolution, emphasis and drift of the construct of exploration. Reaching out for innovation reconsiders the search-based model of adaptive processes, so that exploration is no longer just a regime ensuring that the system is adapted enough to the unbounded problem at stake. Indeed, novel alternatives and consequences are generated dynamically expanding the problem domain with unknown probabilities.

We then focused our attention on the generative phenomenon that supports this problem shift, expansion and potential reconfiguration. Theories, tools, methods and practices exist to support such phenomenon. Most of them could be labelled under the Design umbrella, but also many other are more *silent*. Generative processes take place in an ubiquitous fashion when compared to rational models supporting exploitation. The emergent nature of novelty, preceding problem formulation and solving, and making decisions, pushed our reasoning down the lines of interactionist and network perspectives supporting the creation of meaning and collective sense-making. These approaches are definitely complementary and fill the gaps left by a pure decision-making in firms.

Relying on a rather linear perspective of innovation through **adaption** could be a first approach to organize generative processes for exploration and balancing out exploitation for learning and adaptation. The organization learns and adapts

from generated mutations in the Known or Unknown[8]. The edge between what is known and unknown challenges the nature of the non-mutual conditioning between exploration and exploitation.

It encourages the training of leaders to develop their ambidextrous thinking and manage their teams accordingly. The second approach sees innovation in a more networking perspective through **interactions**. It would promote the design of spaces, networks and interactions means by management executives. This in-between perspective gives more room to the generative phenomenon so that they could then support an ecology of generativity.

One could argue for non-interventionist management, but we made the assumption that we would steer the *performance of the generative process*: fluency and defixation, and the organizational impact and sustain. The first criteria is more related to the standalone practice reduced to the individual or the design team, whereas the second calls for the diffusion, learning and regeneration of the organization subject to the generative phenomenon.

At last, we have taken a micro and then a macro perspective to sustaining organizational learning and adaptation through ambidexterity and innovation. We have elucidated the thought process of the individual (decision and design) and its organization in a broader sense. The interactionist view describes also the social dimension. If we use again the biological metaphor, one the axioms of ecology is that the success of a unit is measured by the number of descendants. Transposed to our generativity, we can question what the unit means for generative phenomena as they can localized and linearized (design department, exploration-dedicated unit), or be distributed (we are all designers!). We could then envision a generated concept (a prototype, a product, a technology, a function etc.) or consider a colony of generated concepts that have something in common and for which individual sacrifice is the norm (portfolio, program, product line etc.).

We believe then that in a firm context, there are also other action means to sustain generativity and an efficient interaction with exploration and exploitation. We propose then to look at other ways of managing the unknown mainly through project management. By doing so, we can overcome the several limitations addressed in this chapter for models of ambidexterity through adaptation, interactions and their management. Projects, by encapsulating management activities, are indeed a device that sometimes can be the equivalent to small firm, or business unit, or sometimes just a piece in a larger puzzle.

[8]mutations are usually regarded as responses to a change in the environment

# Chapter II

# Managing the unknown: exploration project management and its impact for organizational studies

*Unitas multiplex: l'unité de, dans la diversité.*
*La Méthode: La Nature de la nature*, Edgar Morin

In the previous chapter we have exposed models of ambidexterity. We have insisted on the role of ambidexterity and how it would rely of adaptive and interactive processes. Both of these play with an agent-based and socio-organizational views of the firm to sustain organizational learning. They contribute to the balancing of exploration/exploitation by offering room for generative processes.
Generativity, an engine of innovation, will shift the performance frontier of exploration and exploitation. The adaptation relies more on the constructs of exploration/exploitation and a linear perspective of innovation. Whereas, the interactionism brings a networking perspective whilst stressing the emergent nature of generative processes through creation of meaning and sensemaking. Both place a different emphasis on decision-making organizing collective action in the firm. However, as we stressed the invasive role of the unknown through innovation management, the assumption of separating and balancing exploration vs. exploitation may be shattered.

In this chapter, we propose to tackle another action mode where the unknown occupies a key place. It is less linear or distributed that the previous models of ambidexterity. Seen from the firm level and system level, it is **encapsulated**. We will consider the literature on project management through the lens of researchers who rethink project management

as practice reveals new challenges (Svejvig and Andersen 2015) which also lead to critical management studies (Cicmil and Hodgson 2006).
Projects are seen as appropriate devices to cope with turbulent environments (Ekstedt et al. 1999), they can also stimulate learning and creativity to support complex products development (Hobday 2000), and the project-based organization is regarded as efficient for information sharing and knowledge management (DeFillippi 2001; Silver 2000). It is even more important to deal with the notion of projects as they have been institutionalized extensively in firms through the Project Management Institute and the Project Management Book along with certification for practitioners. Overall, it makes of project management a stimulating candidate to perform ambidexterity.

Our concern is what happens when these projects and its management try to shape the unknown, specially because it has this encapsulated mode of dealing with exploitation and exploration. We are then more inclined at looking at the adaptive mode of project management rather than optimizing models for projects (Davies, Manning, and Söderlund 2018). However, we still see how the fields of innovation and project management could be cross fertilized at little further at the light of generative processes and managing the unknown.

> The first section will cover the literature on exploration project management (1), then we will look of the organization design of projects (2) and finally we will have a close look at change project management and strategic project management that is heavily contingent to environment perception (3).

# 1 Exploration project management, radical innovation and corporate entrepreneurship

It is largely established that institutionalized project management comes with a certain faith in instrumental rationality, objectivity, reductionism and expectations of universal validity (Cicmil and Hodgson 2006; Ika and Hodgson 2014, p. 1182). Traditional projects are framed, needs and requirements are captured into objectives allowing to breakdown the project into work packages and tasks. Usually, these are mirrored by an organization (*work breakdown organization*). Gates track the progress against criteria agreed upon from the beginning or by mimicry in-between them. The strongest assumption is that the course of action is driven by risk management (risk registers) and uncertainty reduction towards the objective. Change control boards are used to deal with several uncertainties or additional demands.

However, most of choices and states of nature are known and usually uncertain. It is largely the case of (new) product development process. Several fallacies are known already (Thomke and Reinertsen 2012) revealing some of the dangerous rational myths behind project management (Boxenbaum and Jonsson 2017). Of course, several add-ons were made to the traditional project management methodology (waterfall model): scrum and agility (Takeuchi and Nonaka 1986) or diamond approach to deal with contingency, novelty and complexity (Shenhar and Dvir 2007). As several schools of thoughts (Söderlund 2011) can be found in project management, we propose to focus our discussion on the tension with innovation management. We will tend to fit with this line of thought as it considers the association of strategic management with the launch of exploration project by firms. In other words, it contributes to firm's survival and performance.

Finding articles and books that openly discuss the place of the unknown in management is a complicated task. There are very few publications on the topic, usually the word has a secondary position leaving on the front seat other keywords such as innovation, radical innovation, entrepreneurship or simply high uncertainty or at best unforeseeable uncertainty. We will leave aside the notion such as unexpected or surprise as we are concerned by the deliberate action of heading into the unknown for a desirable future. In (Svejvig and Andersen 2015), we would fit in the category of *Complexity and Uncertainty* and *Broader Conceptualization*, which necessarily echoes the contingency, behavioural and decision schools of thought as we have been developing an interest for neighbouring research discipline: innovation management. As explained in a recent and critical literature review (Davies, Manning, and Söderlund 2018), these two disciplines have evolved over decades and they explain why/how these two have failed to learn from each other. We propose to follow this path and bring additional light to these teachings with the question of managing the unknown through project management.

In this first subsection, we will address the issue of project management facing high uncertainty or dealing with the unknown. We will then characterize the features of such management with respect to the host organization and finally how it deals with generative processes.

## 1.1 Exploration project: organizational oddity

As stated previously, we are interested in discussing at the edge of project management and innovation research: exploration project (Lenfle 2008). They differ and destabilize the optimizing model of traditional *plan and execute* that one could see in development processes. It cannot also be reduced to an adaptive model as presented in the previous chapter. It embeds features that call for proactivity. Several principles are defined to support his new project category:

1. The need to set up a specific entity to manage the exploration
2. The emphasis on the central role of tests (prototypes, testing, customer trials, etc.) in the management process
3. The emphasis on the need for concurrent exploration which must concern both concepts and knowledge
4. The management process must take into account these two different dimensions of performance: the value of the products and accumulated knowledge
5. The management tools used must allow a reformulation of the objectives along the way

As we can see, some features are derived from adaptive models inspired by contingency theory (Shenhar and Dvir 2007) but it brings insight from innovation management that call for a mode of action continuously shifting (Brown and Eisenhardt 1997). It also relies on innovative design practices (Hatchuel et al. 2010; Le Masson, Weil, and Hatchuel 2010, 2017). By developing this experiential approach (Eisenhardt and Tabrizi 1995) and based on the works of (Loch, Meyer, and Pich 2006), the exploration strategy consists in multiplying probe and learn steps, the projects outcomes are hard to grasp as the action mode challenges heavily optimization and adaptive model. Trial and error can be complemented by selectionism. Careful balance of these two strategies may contribute to overall performance depending on complexity and unforeseeable uncertainty (Sommer and Loch 2004).

The distancing of the projects can be seen as an organization oddity (Lenfle 2016). The author proposed that with the support of design theories and design management, the

concurrent exploration of knowledge and concepts could help support the project variables: objectives, risks, capabilities to be developed. Projects are indeed very stimulating loci where technology and system meet knowledge management (Silver 2000) thus bearing critical capabilities for the firm. As these are used as experiments in its broadest sense (Thomke 2003), they can also absorb shocks and risks that a traditional new product development process wouldn't (Brown and Eisenhardt 1997). Yet, the strangeness of the project requires careful management of the unknown dimensions of the project: e.g. potential organizational ties through communities contingent to the expansion made into the unknown.

In the field of innovation management, we could not avoid the works of Gina O'Connor (O'Connor 2016)[1]. First of all, in this literature, projects are seen as devices for innovation, and they usually are synonymous with product development. Using them as unit of analysis, project timelines are made to articulate the link with breakthrough innovation. Exploration is the centre of attention, and emphasis is put on the actual creation process (path creation, regenerative dynamic capabilities (Ambrosini, Bowman, and Collier 2009)). As for the previously quoted works and others (Beaume, Maniak, and Midler 2009; Maniak, Midler, and Lenfle 2007), the organizational ties are not discussed in much depth despite the strategic dimension of these projects heavily challenging functions of existing products (concepts and knowledge). For example, the rich longitudinal studies (O'Connor 2016) show how the projects are hosted by several business units or departments, and sometimes, end up establishing a proper entity on its own. To counter ad-hoc behaviours, she calls then, beyond the necessary support of top management during the exploration process, for a proper institutionalisation thus avoiding only relying on innovation champions.

> Exploration project may have the tendency to float across organizations as they encapsulate several innovative practices challenging exploitation. They bring new experiences, they engage in action, which potentially allows pushing the performance frontier of exploration. It does contribute to ambidexterity with antagonistic effects for exploitation certainties: evaluation of objectives, contributing teams and resources and established knowledge.
> Before coming back to the organizational and institutional issue, we would like to focus on the mechanisms that potential regenerative dynamic capabilities should address as the exploration projects glide across an organization in the hope for a landing field so they can actually plan the plan and execute the plan.

[1]Please note the more recent chapter in the Handbook of Research on New Product Development published in 2018 is exactly the same. Only the title of the chapter differs: "Institutionalizing an innovation function : moving beyond the champion" instead of "Institutionalizing corporate entrepreneurship as the firm's innovation function: reflections from a longitudinal research program"

## 1.2 Difficulty of transitioning

The contingency stressed in the work of Sylvain Lenfle and Christoph Loch can be confirmed through several other works presented in a special issue (Midler, Killen, and Kock 2016). It reinforces the perspective that traditional optimizing models are insufficient for innovation (Davies, Manning, and Söderlund 2018). Contextuality is necessary to understand the complexities, the successes and the failures of projects. For instance in (Akkermans and Oorschot 2016), they explain how small feedback loops between project phases and concurrency (Maniak et al. 2008) can reduce risks and delays. The importance of coordination is also stressed in the alleged decision gate in product development (Christiansen and Varnes 2007) where stakeholders are rather networking instead of making decisions.

However, numerous practices and myopic behaviours can be found like in the case of mega projects. Their fragility (Ansar et al. 2017) show the absence of learning on the methods and tools used to conduct such large projects. Stage-gate mode also tend to fail quite too often when following the iron triangle of Quality Cost and Delay of standard project management (Sethi and Iqbal 2008). This encourages to rethink constantly what makes the performance of the project, the evaluation criteria used along the trajectory as it was stressed in (Lenfle 2008, 2016). The same authors also through a tremendous historical effort on project management insisted that originally the root of project management (Lenfle and Loch 2010, 2017) where closer to innovation management as also stressed by (Davies, Manning, and Söderlund 2018). So the notion of failure against an optimizing framework, which is also the exploitative regime discussed in the previous chapter, encourage the re-articulation of the performance for exploration projects (Elmquist and Le Masson 2009).

As the innovation management research has (mainly) developed the adaptive model with respect to project management, the over-emphasis on these models had a tendency of not considering enough optimizing "constraints" such as planning, execution and exploitation [2]. It is then key to understand how the contingency is managed but also how this distance is engineered within projects and by stakeholders or the projects' governance.

Several hints can be found in the literature such as: sensemaking of risky and loss of control (Iacovou and Dexter 2004), terminating projects (Green, Welsh, and Dehler 2003), modelling with real options theory (Lint and Pennings 2001), also mapping risk-tolerance (Kwak and LaPlace 2005) and escalating commitment relative to the project (Ross and

[2]Remember J.March's quote on using technologies of rationality: (March 2006, p. 209): *It is argued that the link between rationality and conventional knowledge keeps rational technologies reliable but inhibits creative imagination. This characterization seems plausible, but it probably underestimates the potential contribution of rational technologies to foolishness and radical visions.*

Staw 1993). The encapsulated model of managing the unknown and dealing with risks and uncertainty, as a vehicle for innovation, continuously defy the working reference for the host firm. As the practice shows, shifts are made and references are made against the original concepts as shown in (Seidel 2007) across multiple contexts.

> For an exploration project to find a landing spot we see the constant performance re-evaluation challenges and stress test against exploitation constraints. The problem can also be turned upside down by ensuring the existence of large net to catch the exploration effort and make sense of it. They may have learning and adaptive mechanisms differing the rest of the organization (Lundin and Midler 1998), or expecting to have a full projet-based organization. So, what are then the underlying mechanisms that drive expansions in project's scope? Is there a way directing it and control/measure a *distance* with respect to exploitation ?
>
> These are very *engineering-oriented* questions but we force these questions as it has been stressed that the models of ambidexterity have enforced the non-mutual conditioning between exploration and exploitation. So coming from the project management perspective, and its encapsulation mode, we propose to study if ambidexterity is discussed differently given evolutions of innovation management.

## 1.3 Generative processes in project management?

Since we are focused on innovation management and project management as they contribute to separation of exploration and exploitation, we propose to discuss the underlying mechanisms driving the exploration effort: mainly generative processes.

Design theories and design management have been solicited by researchers already (Lenfle 2016) for instance, and (O'Connor 2016) refers to the management concept of "regenerative" dynamic capabilities developed by (Ambrosini, Bowman, and Collier 2009). In the behavioural school (Söderlund 2011), the place of creativity is discussed in several contributions, but still remains secondary compared to other aspects of project management. Our focus is not specially on notions such as creative climate, even though it may contribute positively to the project conduct, specially compared to tools and frameworks induced by management theories aiming at reducing variation (Ekvall 1993; Ekvall 2000). We are rather interested on the actual creative process and methods that we tasked to label in its weaker form: generativity.

In (Harrison and Rouse 2015), feedback sessions in creative projects (industrial design and modern dance) reveal several moves used by designers and feedback providers. The feedback provided two kind of signals: *excavations* and *adjustments*. It thus fed an adaptive mode for designers to bring back previous concepts and refinements to the prototypes.

Such approach calls for a deeper value management in the spirit of what was discussed in the previous chapter on how to formalize design practices. For instance, (Gillier, Hooge, and Piat 2015) manage the value exploration and measure the "distance" of the concept shift and novel knowledge (Seidel 2007). In the same vein, cases of exploration project management show how to build legitimacy around novelty with stakeholders (Hooge and Dalmasso 2015) and management value creation and value realization (Maniak et al. 2014). Design Thinking was proposed to be blended with project management to enhance value and change management (Ben Mahmoud-Jouini, Midler, and Silberzahn 2016). All of these approaches bring additional depth to the interactive model and extending the project's requirement for greater quality. Within the project team (Holmquist 2007), an evaluator can play the role to channel continuously the project evaluation criteria and bring a systematic reflection which acts as *catalyst* for transformation.

Similarly to ambidexterity literature, the role creative leadership in project management is identified as a way to manage generative processes and its challenges for exploration. (Bech 2001) stresses the proximity of project management and project leadership, which can facilitate employee creativity, support the emergence of the leader's vision and organize collective creativity (Mainemelis, Kark, and Epitropaki 2015). Recent works also have put the emphasis on the different leadership figures (Ezzat, Le Masson, and Weil 2017) including traditional ones such as the visionary and the animator, but brings a novel perspective with the *defixator* role. The leader brings the practice of defixation (Ezzat et al. 2017) to creative team management with minimal executive feedback so that team members can generate concepts avoiding fixation effects.

Generative processes in project management as shown here tend to constantly orchestrate value of novelty by circulating concepts and meaning, or by comparison with some reference point. High constraints and pressure in the iron triangle can also be a trigger for creativity to reach such objectives or stretch goals (Maier and Branzei 2014). But others have also put forward the violation of project management rules (Mangematin et al. 2011) as a means to support learning. Hacking can be then encouraged to mitigate more efficiently risks associated with delay and uncertainties as common project rules tend to increase risks (Olin and Wickenberg 2001). Rule bending and redefinition can be adjusted not only to generate better course of action sustaining project's (dynamic) performance and also exploration guided by systematic rule breaking such as *skunkworks* (Bommer, DeLaPorte, and Higgins 2002).

Such generative processes are referred as non-routine work in the framework of organizational routines (Obstfeld 2012). An echo of the *silent designers* introduced by Angela Dumas and Henry Mintzberg. A creative project is defined in such context as:

*An emergent trajectory of interdependent action initiated and orchestrated*

> *by multiple actors to introduce change into a social context If organizational routines are viewed as trajectories of interdependent action through which organizations generally get things done, then creative projects are the means by which they get new things started*

Placing the generation of routines into creative projects allows D.Obstfeld to reconsider the interaction with adaptive model introduced by James March through the *garbage can model*. He shows the extension of the adaptive model where informal choices brought by creative projects differing from the search of organizational routine. Whilst keeping the idea to economize cognitive effort, one can rethink the theorization of interdependent action including organizational routines and generative processes. One can do so by stressing the emergence of novel choices (not found by search) but through creative effort:

> *This expanded consideration of combinatorial elements underscores the importance of knowledge articulation as a means for linking problems to solutions, people to ideas (i.e., either problems or solutions), and enlisting people to participate in unfolding action trajectories*

In the figure below (II.1), the impact of the interdependent action is represented and insists on the nature of the direction of such non-routine work (stable, incremental, radical and architectural):

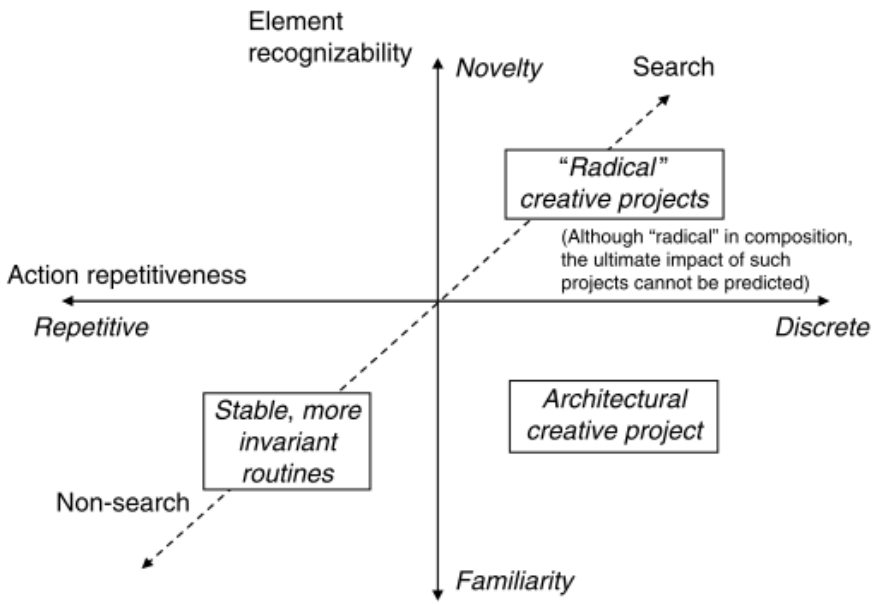


**Figure II.1:** Two dimensions of interdependent action (Obstfeld 2012)

Research on the middle-ground present cases of how such routines emerge and creative projects contribute to it. It reveals the different roles endorsed by the project manager: sense-maker, game master, web-weaver, and flow-balancer (Simon 2006). Later research

conducted in the game industry also demonstrated how a creative project, in corporate entrepreneurship perspective, is managed to recombine routines and rethink the new product development process across the firm in addition to deliver a novel product radically changing the traditional identity of the games developed (Cohendet and Simon 2016).

The role of the leader is also emphasized in (Adler and Obstfeld 2007) with a channelling effort on the project team by bringing additional insight on the direction of *creative search* supporting exploration. By revising Dewey's philosophy, the importance of impulse (affect) in addition to intelligence and habit drivers, allows placing their respective impact on project, deliberation and routine levels (see Fig.II.2)

| Forms of collective activity ⇒<br>Components of individual conduct ⇓ | Project | Deliberation | Routine |
|---|---|---|---|
| Impulse | +++ | + | + |
| Intelligence | + | +++ | + |
| Habit | + | + | +++ |

**Figure II.2:** Influence of individual behaviour on collective action (Adler and Obstfeld 2007)

The proposed analytical lens allows thinking what is to be managed and the nature of the articulation of the generative processes in project management and the interdependence with organizational routines for instance. Despite having a different background, we cannot avoid discussing the works of Hirotaka Takeuchi and Ikujiro Nonaka, with the use of ambiguity and metaphors (Dumas 1994) to build and drive project teams (also referred as knowledge teams); e.g. "Tall Boy" for the Honda Civic and "Rugby Player in a Dinner suit" for the Honda Accord (Clark and Fujimoto 1990; Nonaka 1991). Whilst developing the knowledge management and learning, later works of I.Nonaka have introduced the management concept "*ba*" (literally meaning "place", not necessarily physical):

> *What differentiates ba from ordinary human interaction is the concept of knowledge creation. Ba provides a platform for advancing individual and/or collective knowledge. It is from such a platform that a transcendental perspective integrates all information needed* (Nonaka and Konno 1998)

By developing an interactive approach to learning, socialization, externalization, combination and internalization of processes (SECI model), it helps describing what contributes to the dynamics of knowledge management enact the common place of *ba*. In (Krogh, Ichijo, and Nonaka 2000), numerous qualitative studies support this view enabling knowledge through creation of rich context, building communities and supporting knowledge exchange. They insist on numerous pitfalls such as a too strong focus on generating

knowledge, thus accentuating the articulation, interdependence and circulation of knowledge rather than on quantity. It opposes to the view on the generation of alternatives in J.March's model discussed in the previous chapter (March 2006).

Such perspective is further developed in the managing flow and introducing also an ancient Greek concept of wisdom *phronesis* insisting on the virtue of thinking of the context and judging value. These processes sustain in their view creative dynamic capabilities by opposition to adaptive ones at a meso-level (Nonaka, Hirose, and Takeda 2016). Their demonstration and conceptualization goes further in order to propose the image of a fractal organization as a reflection of these knowledge dynamics supporting creative dynamic capabilities (Nonaka et al. 2014), as multiple "edges" are managed on multiple direction. Relying on the fractal idea, raises the question of the pattern to be repeated to support. What is the actual action logics driving this dynamic capability?

Finally, we have covered how the encapsulation of generative processes in projects contribute to adaptive or interactive models at the project level and with stakeholders. However, the organizational dimensions are not addressed specially in the spirit of organizational ambidexterity, despite still considering the separation of exploration and exploitation but with some modulations (e.g. hacking).

Creative projects have a temporary nature (Bakker et al. 2013) imposing time frames over the project teams and stakeholders determining tasks and team processes. After having illustrated the nature of generative mechanisms in exploration and/or exploration project management as a means to substantiate innovation management, we must clarify the organizational ties supporting such trajectories.

At this point of the literature review, it is important to note that these ties were not as present with meta perspectives of the adaptive model and the interactive model, since projects are used as experiments for the whole firm, as an ambidextrous offshoot in an organization that should be preserved for exploitation performance.

## 2 Project-based organization supporting ambidexterity

In the previous section, we extensively discussed the nature of exploration project management and its engines such as creativity, generative processes, non-routine work, rule bending, but also their limitations and difficulties to loop back to an exploitation regime. The key feature of the exploitation of exploration project requires a continuous management of performance and valuation as the project battles through the unknown.

In innovation management literature, along with the strong contingency theoretical background that could be traced back to (Burns and Stalker 1961), the notion of organic structure supporting innovation in new product development led to the conceptualization of the matrix organization where projects and product developments can pool resources sustained by departments and units (Galbraith 1971, 2010). It is the preferred mode to *integrate cross-functional resources and knowledge to cope with high uncertainty, complexity and change* (Davies, Manning, and Söderlund 2018). These notions blended to the point where projects became fully associated with the concept of organic and flexible ways of organizing. Originally, in the detail of the Tom Burns and Georges Stalker, the organic structure was defined based on one case study and by contrast with the mechanistic cases (Hannan and Freeman 1989):

> *It is instructive to note that Burns and Stalker found only one instance of an organic structure in a situation in which this should have been the appropriate form of organization. Their book is essentially an analysis of why organization that ought (sic) to change to organic systems fail to do so, even when there is high agreement among their managers that they should move in that direction*

The advice given by T.Burns and G.Stalker should be treated carefully. On the other side, the matrix organization has more cases to support the interaction between the functional structure and projects. In (Galbraith 1971), the transition from a functional form to the other is detailed also with the transitioning with a task force to cope with delays, and contingent factors are highlighted encouraging a form or the other. The level of complexity and reconfigurability can be increased to such height calling for careful management of careers, opportunities and reconfigurable decision forums in addition to satisfying changing client demands across the globe or just in identity and customization (Galbraith 2010). We also point out the fact that the change is conducted in a dissociate way to the actual organizational life, i.e. as for organization design for ambidexterity.

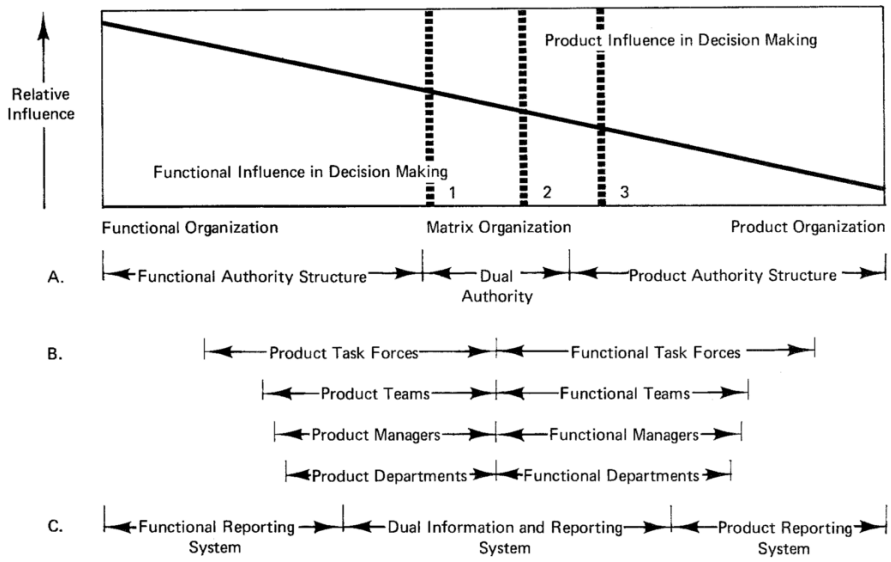


**Figure II.3:** Functional-matrix organization transition spectrum (Galbraith 1971)

It is then crucial for exploration project and generative processes to understand how efficient matrix organizations are to support these projects but also sustain innovation and regenerative dynamic capabilities of such organization. As we have shown, the leadership figure was rather present, putting a lot of weight of its shoulders and probably requiring training and management tools that still require to be elucidated as revealed in the first chapter on paradox management.

Here, we would like to discuss the organization design and studies domains required to support the project management we are interested in. The research community organized around journals such as the *Project Management Journal* or *International Journal of Project Management* have released numerous articles around the project-based management with Rodney Turner's lifework (Turner 2009), but also with a special issue (Söderlund and Müller 2014) in PMJ, another in IJPM (Söderlund, Hobbs, and Ahola 2014) and also two in Organizational Studies (Bakker et al. 2016; Sydow, Lindkvist, and Defillippi 2004). They raise several challenges around theoretical model, methodologies including a lack of practice-based research to enhance theoretical models.

Firstly, we will discuss the organizational ties of exploration projects compared to the host firm. The mirroring hypothesis between engineering design rules and organization design will give us some ground to understand where generative processes are rooted and the necessary renewal for exploration projects. Secondly, we will naturally address the topic of ad-hoc patterns, as exploration may lead to weighing the anchor. Finally, we will deal with the concept of portfolio and program management for exploration.

## 2.1 Mirroring hypothesis and renewal of resources and competencies

In a matrix organization where projects are kicked off and requiring resources in functional departments, exploration projects will request competencies that may be off the charts. As a reference point, one can imagine that the firm has settled its engineering for product development and that it may even have developed modular engineering for improved efficiency (MacCormack, Baldwin, and Rusnak 2012). The mirroring hypothesis tested in (Colfer and Baldwin 2016) shows the congruence between product architecture and organization. It also reveals the interest in having a partial mirroring or the capacity of breaking the mirror for strategic competitive advantage. In a normative perspective (Colfer and Baldwin 2016, p. 716) they advise that:

> *The designers of technical systems are boundedly rational—they cannot know or do everything. Thus, organizations are needed to carry out complex design and production processes. For system architects and organization designers, the design challenge is to create a technical architecture and corresponding organization that together are capable of carrying out complex tasks and solving problems that may come up along the way*

The static view is of course enlightening, but mirroring dynamics are not explicit. In the weakest form, they present the mirroring trap, i.e. the failure of supporting ambidexterity, which can be countered by partial mirroring where knowledge boundaries are broader than operational task ones. It brings some slack to the alternatives and interdependencies in product architecture, yet there is a risk of 'early' modularization causing failures because of lack of system understanding. Due to the complexity and high rate of change, the system knowledge will be necessarily incomplete, so they recommend (Colfer and Baldwin 2016, p. 724):

> *In such cases, organizational processes that deviate from strict mirroring are likely to be beneficial in terms of technical performance, competitive advantage, and the accumulation of valuable knowledge and capabilities. A "partial mirroring" strategy can be an effective way to explore and understand latent interdependencies that are not apparent under the current technical architecture. Furthermore, if the stakes are sufficiently high, firms may go further, overturning the current architecture for their own strategic advantage. Strategic mirror-breaking, if successful, can bring about wholesale changes to industry structure.*

Exploration projects will tend to play in partial mirroring organization where latent interdependencies may be challenged. It would imply technical and engineering issues, at a modular or even call for architectural innovation (Henderson and Clark 1990). The temporary organization supporting the project may be then in conflict with the established

mirroring organizing.

In a very recent detailed literature review, Maxim Miterev, Rodney Turner and colleagues bring the link with the organization design and project-based organization. For instance, in (Miterev, Engwall, and Jerbrant 2017) they warn us (through practice-based research) on threats of isomorphism mechanisms (mimicry, coercion and normative) against temporary-organization supporting one-off projects dealing with high uncertainty (see below Fig.II.4).

| Isomorphic Mechanisms | Specific Mechanisms | Affected Temporary Organization Design (TOD) Dimensions | | | |
|---|---|---|---|---|---|
| | | Structure | Strategy | Process | People |
| Coercive | Prescriptive guidelines and frameworks | + | + | + | + |
| | Project management assurance system and internal audits | + | | + | |
| | Expectations of steering group members | + | + | + | |
| Mimetic | Post-closure and lessons learned reports | + | | + | |
| | Sharing of approaches within formal communities of practice | | | + | |
| | Informal networking within unofficial groups/coalitions of managers | + | + | + | + |
| Normative | Influence of professional associations | + | | + | |
| | Influence of popular management models and wider societal norms | | | + | |
| | Influence of industry-specific norms | | + | + | |
| | Similarity of the managers (due to HRM practices) | | | | + |

**Figure II.4:** Isomorphic pressures on project-based organization (Miterev, Engwall, and Jerbrant 2017)

The goal rationality of such organization is then questioned specially in a context of interrelatedness of temporal organization with a host/established functional organization in addition to institutional fields. They advocate that isomorphic pressures may vary depending on industrial sectors but that *skunkworks* projects may be required to escape such pressures of project-based organization. Institutional entrepreneurship is seen as an another perspective to further understand how novel practices countering pressures can be institutionalized in firms.

Following the idea of extreme forces of reconfigurability (Galbraith 2010), the project-based organization identified as a proper organization form calls for a renewal of organization design as discussed in (Miterev, Turner, and Mancini 2017). It resurfaces the contingency of numerous managerial phenomena and the links with wider unit of analysis in organization studies and design. In a rationally bounded perspective, (Simon 1967) gave his definition of organization design with the adaptive model associated to decision-making and information processing:

> *[Organizational design] is to investigate the information flows that are essential for accomplishing the organization's objectives, then examine what these information patterns imply for organization structure*

Therefore, the issue is that introducing adaptive, interactive, and generative processes that may be encapsulated or not, should be translated into design rules given a ratio-

nal goal (Burton and Obel 2018). The matrix form compared to the unitary one was a way to deal with adaptation. It could lead, depending on places and flow, to support exploration-related interactions. Can organizational rules be generative? Are there design rules unlocking interdependencies? Can the temporary organization support organizational generativity?

In (Van de Ven, Ganco, and Hinings 2013, p. 396), the authors trace the evolution of organization design evolving from "*contingency to configuration, to complementarity, and to complexity and creative theories of organizing*". The question of organizational fit is then treated with whole new perspective: *generative fit* (Avital and Te'eni 2009). The suggested rules for generative designs should be evocative, open-ended and adaptive. It is worth mentioning that their notion of adaptation embeds the concept of re-invention which goes beyond the notion we have chosen stemming from J.March's view[3]. Quoting (Barry 2011, p. 9), Andrew Van de Ven, in the spirit of managing as design (Boland and Collopy 2004) and thinking of organizations as design (Romme 2003), proposes to follow up the emergent role of professional designers, or architects as they blend several disciplines:

> *perhaps a more unified organization design school will emerge, where "delight, deliver, and deepen" all come together using bits and pieces from both orientations. To be successful thought, this new OD [organization design] will require a lot more than asking executives to brainstorm, prototype, and otherwise "get creative". Coming up with effective organization designs that deliver, delight, and deepen will require training along the lines that designers get years of learning how to reframe organizational problems into evocative questions, finding inspirational networks alongside solutional ones, creative and aesthetically sophisticated experimentation, and working with multiple mediums and representational forms. It will also require systematic testing over time, to see where and how these innovative designs work, and don't work. Clearly OD is heading towards a new chapter, perhaps its most interesting and inventive one yet.*

Despite being an open invitation for future research, the hints given to support such generative design rules for the organization remains quite unclear and again bring back contingency theories to front seat with numerous interactions (Van de Ven, Ganco, and Hinings 2013). Such contextuality is confirmed in (Turner, Maylor, and Swart 2015) bringing an analysis of project management with organization ambidexterity literature stressing the dynamics between human, social and organizational capital. Or even with (Winch 2014) proposing three domains of project organizing: project-based firms, projects/programs,

[3](Avital and Te'eni 2009, p. 352) defines the generative fit for information systems as *the extent to which the functionality and process support of a (computer) system are designed to complement and enhance one's innate generative capacity in a particular task-driven context. Therefore, generative fit enhances the human resources needed in the production of new, ingenious, task-driven output configuration*

and owners/operators. Their interactions stress the interfaces of governance, resources and commercial domains.

When considering exploration project management, or at least, management contributions integrating complexity and contingency theory (Shenhar and Dvir 2007), it is worth pointing out the managerial implications are very short on what should be done regarding the structural and social dimension of project-based management. At best, (Asquin, Garel, and Picq 2007) identifies the risk of loosing knowledge and competencies in project-based organization because of lack of expertise and human resources to cope with reconfigurability. And in (Aggeri and Segrestin 2007), project management methods were studied for their negative effects on collective learning, and the critical implication for innovation department.

Finally, in one of the chapters of the Cambridge Handbook of Organizational Project Management, (Pollack 2017) proposes to reconsider change management and project management given a recent volume of the Project Management Institute entitled 'Managing Change in Organizations: A Practice Guide'. He underlines the risks of not fully integrating change in management of portfolio, programs and projects, may lead to change being a simple option. However the challenge, is on the different perception of action in both fields.

> Change management puts emphasis on communicating change, instead on the definition and control of the change project delivery. What is the contribution to exploration project to organizational ambidexterity? Such cleavage on the encapsulation of exploration with respect to established organization raises then several questions on the by-products of the related generative processes on the organization structure.

## 2.2 Risk of ad-hoc: epicormic shoot and no generative learning

The previous paragraphs show the tendency of project management to require a temporary organization. Thus, it pushes further the notion of matrix organization and potential decentralization as it requires more flexibility, reconfigurability, scalability. It is a means to deal with higher levels of uncertainty and potentially integrating the unknown.
In that perspective (Hornstein 2015) makes a call to merge organizational change and project management, as project should be seen as proper organizational change initiative in order to integrate also technical, social and behavioural issues. Otherwise, he recognizes that an increasing number of project management enquiries are integrating change elements focusing mainly on the process rather than on the contingent dimensions. It has, then, a very different assumption on organization design compared to organizational ambidexterity.

(O'Reilly and Tushman 2007) proposed to resolve the spin-off strategy of the innovator's dilemma by adopting an organizational design supporting structural ambidexterity given high strategic importance and operational leverage (see Fig.II.5). Such design allows then balancing exploration and exploitation, transferring, organizing learning given the crucial role of top management's leadership overseeing such global picture.

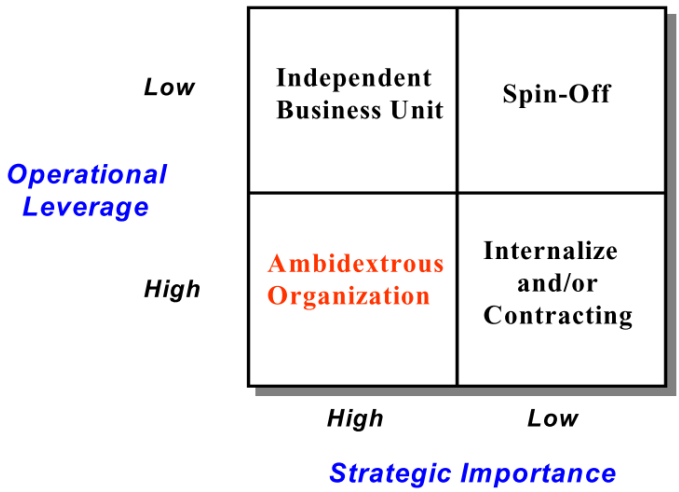


**Figure II.5:** Managerial action given operational leverage and strategic importance (O'Reilly and Tushman 2007)

By comparison with (Christensen 1997), where the focus is on organization's value and organization's processes, considering the operational leverage allows thinking of the host organization supporting the team targeting the radical or disruptive innovation. It creates the tension to find a *generative fit* between the project's exploration and exploitation needs and constraints (e.g. high entry barrier, technical complexity and certification). Of course, it is not an end per se: (Engwall and Svensson 2004) calls for *cheetah teams* as an extreme version of agile and reconfigurable projects that could be launched to cope with urgent and unanticipated issues. This offshoot of a project creates anyway some sort of paradox regarding the embedded nature of projects (Sydow, Lindkvist, and Defillippi 2004).

The question could become then how centralized should the encapsulation of exploration and adaptation be. As studied in (Siggelkow and Levinthal 2003) (de/)centralization is nor right or wrong but rather they advocate a temporary decentralization to support exploration and adaptation. They propose to play around interdependencies of firm activities addressed by such temporary structures to increase the performance of exploration and exploitation. When considering the acquisitions of technologies as an exploration enabler, (Puranam, Singh, and Zollo 2006) points out the criticality of synchronization of the organizational shift with the technological maturity. The notion of interdependence becomes

key again as an exploration project may disrupt *epistemic interdependencies* (Puranam, Raveendran, and Knudsen 2012).

However, the literature tends to stress mainly the importance of governance and resources to steer these projects (Turner and Müller 2017; Winch 2014). Even when managers don't fully understand projects (Loch, Mähring, and Sommer 2017), they are critical to discuss underlying models and overcome crises to generate new alternatives. Contingency perspectives will also stress the determinism of project trajectories given history and context (Engwall 2003). So, to avoid thinking that projects are simple tools, the unit of analysis should be elevated to the thinking of temporary-organization as discussed in the previous paragraphs (Packendorff 1995). It could avoid the shortcomings of the 'one-off' project.

Another perspective, inspired by design, will tend to blend design reasoning and theories to re-thinking organizations (Romme 2003). Embedding generative processes across the organization as general mindset and practice could enact *design-oriented organization* (Hatchuel, Weil, and Le Masson 2006). The design-oriented organization would aim at systematically creating positively deviant projects and programs that rely on (generative) dynamic capabilities of the firm. It gives a fresh look on intrapreneurship and corporate entrepreneurship, as generative design rules across the firm would support such projects. It echoes the works of Phanish Puranam quoted earlier, and still require further case studies and detail to fully embody such models.
Thinking of generative processes across the firm, (Adler 1995) reveals the dynamics of coordination tasks and mechanisms during a product development's life cycle (project framing, design & development and manufacturing). The interdependencies revealed by differences in the degree of novelty and degree of fit will call for different coordination mechanisms (standards, schedules, mutual adjustment and teams):

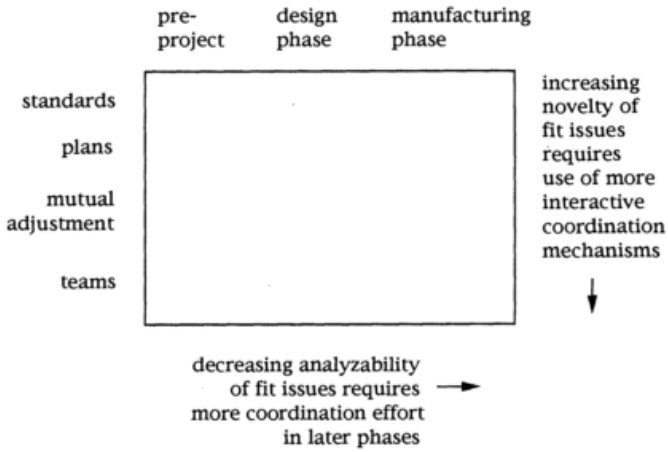


**Figure II.6:** Interdependence of coordination mechanisms (Adler 1995)

Considering project for exploration and exploitation underscores its strategic dimension for the firm as discussed in (Adler and Obstfeld 2007), and pictured below:

| These ⇒ drive these ⇓ | **Exploration** | **Strategy** | **Exploitation** |
|---|---|---|---|
| **Exploration** | One exploratory project sparks another | Strategy sets the direction of exploration | Experience in exploitation activities throws up problems and opportunities for exploration |
| **Strategy** | Exploration opens up new strategy options | Strategic action creates strategic options | Operational improvements through refined exploitation create new capabilities and open up new strategy options |
| **Exploitation** | Exploratory projects can create new processes and routines for exploitation operations | Strategy shapes the priorities of exploitation-oriented operations | Accumulation of exploitation experience drives habit formation and learning curve |

**Figure II.7:** The intertwining of exploration, strategy, and exploitation (Adler and Obstfeld 2007, p. 40)

Consequently, the risk of ad-hoc (temporary) organization supporting an exploration project could easily become real as interdependencies slip away. Poor stakeholder management where legitimacy building is key (Eskerod 2017; Hooge and Dalmasso 2015) could accentuate the phenomenon. Governance, for inter-organizational and multi-level perspectives, is necessary (Sydow and Braun 2018) to address the traditionally implicit technical/social/organizational interdependent facets in temporary organization.
Projects calling for inter-organizational/departmental support show the crucial role of *concurrent platform innovation process* supporting the temporary-organization of radical exploration project: e.g. electric car developed in a traditional combustion car company (Von Pechmann et al. 2015). However, as the industrial context may be subject to a high rate of change, a full projectification of the firm (Beaume, Maniak, and Midler 2009), the (feedback) learning with functional department is rarely, if not never, addressed with the respect to legacy engineering or other mirrored features of the organizational structure.

An exploration project in a more or less developed project-based organization can then lead to a spin-off. The fact that innovation managed and encapsulated in exploration projects raises significant questions for organizational coherence and design for ambidexterity. Be it permanently ad-hoc or temporary organization driven by architectural innovation (Henderson and Clark 1990), the image of the epicormic shoot in plant biology is quite seducing. Wouldn't it call for the co-existence of exploration feeding from exploitation?

It is (perhaps) a positively deviant part of a tree that grows in a place where it is not really supposed to be (e.g. tiny branch on the lower tree trunk, instead of on the ground or on a fully developed branch). It feeds from established resources, but perhaps it makes some sense at higher unit of analysis as discussed for project-based organization.

As a matter of fact, it may be too reductive to consider projects not as ephemeral but rather by trying to making them more permanent (Müller-Seitz and Sydow 2011). Such non-termination can also be sustained by learning mechanisms in-between projects in time (Hartmann and Dorée 2015) but also in multi-project perspective as we discuss in the following paragraphs. This added time-scale and synergy, calls for some kind of organizational metabolism if we carry on with the biological analogy. Metabolism would refer to what comes out or is at the heard of interactions between processes (projects) and structures (organization designs).

## 2.3 Portfolio and program management for exploration

Whilst taking the assumption we are in a project-based economy and project-based organization, where the matrix form is further developed with high levels of reconfigurability (Galbraith 2010), the notion of portfolio and program management allows revisiting the risk of the ad-hoc, the spin-off, and the epicormic shoot with respect to the host organizational form. For instance, by extending (Hobday 2000), (Gemünden, Lehner, and Kock 2018) defines a project-based organization insisting on the different levels of management that should be aligned and integrated so that it can be declined around structure, value and people management (see Fig.II.8):

1. management of single projects
2. management of the project landscapes
3. leadership of the project-oriented organization

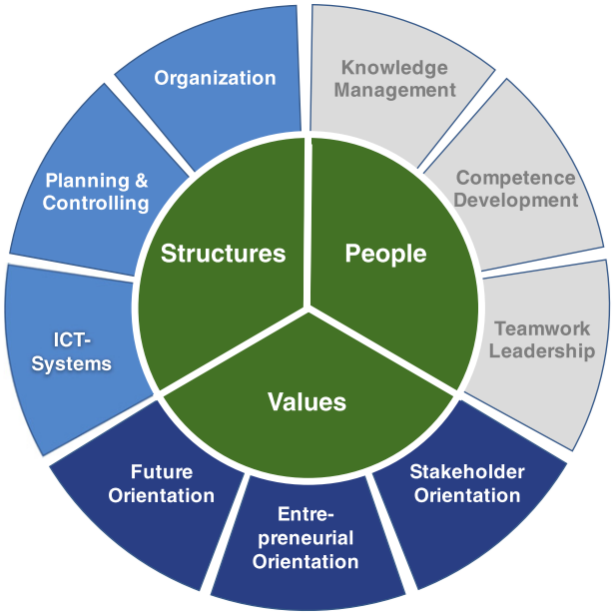


**Figure II.8:** Model of the project-based organization (Gemünden, Lehner, and Kock 2018)

This ecology of projects makes then a lot of sense and may sustain innovation as described in (Von Pechmann et al. 2015). It considers a projectified firm (Renault), where radical projects will be systematically launched through the interactions of strategy, programs and projects organized in a temporary manner and fully serviced by functional departments. The network of projects can also be seen as fishing net for value management (Laursen 2018) which can be organized with a multi-lineage approach of product development (Maniak and Midler 2014).

The strategic management will tend to balance the control and open/emergent approach of this multi-project management (Kopmann, Kock, and Killen 2017), and tend to encourage the establishment of a dedicated function, potentially requiring an institutionalization of innovation (O'Connor 2016). Robert Burgelman in (Burgelman 1983) had questioned whether "structure follows strategy" or "strategy follows structure". He proposed new analytical lens insisting on the interactions between strategic behaviour, corporate context and concept of strategy to blur the lines between a purely induced strategy by top management and the emergence of autonomous strategic activities. This projectified view of the firm with exploration and exploitation taking place on multiple levels and directions is quite in line with R.Burgelman's perspective. And it departs from the models of ambidexterity, except for the contextual which blunt the edges of the non-mutual conditioning between exploration and exploitation.

In this ecology of projects, introducing the concept of trajectory (Aubry and Lavoie-

Tremblay 2018) - which can also be found in the works of Rémi Maniak and Christophe Midler on Renault - allows studying the interaction between projects and (project-based) organization design over time. With an interactionist approach, sensemaking and reflexivity was accounted before decisions associated with organization design. Monique Aubry suggests that further understanding should be developed around the sensemaking supporting learning between projects and project managers as it will feed the governance and leadership embodying the strategic management.

The notion of *program* becomes quite stimulating to support this kind of system thinking. It is defined by the International Project Management Association and the Project Management Institute as follows:

> *a set of related projects and required organizational changes to reach a strategic goal and to achieve the defined business benefits* (IPMA) *program as a group of related projects, subprograms, and program activities that must be managed in a coordinated way in order to achieve benefits that may not be obtained if they are managed individually* (PMI)

Compared to the portfolio and multi-project management, programs emphasize the link between the projects whilst giving also more weight to strategy, stakeholder management and complexity (Patanakul and Pinto 2017). The strategy/execution of the program involves then political work, flexibility and managing interdependencies targeted and revealed by the criticality of uncertain technologies developed along the way and to be integrated. The program also develops a certain bureaucracy to administrate the portfolio with a Program Management Office.
Risk management and change control are among their main tasks. Learning mechanisms can also be centralized through lessons learnt through project delivery. When discussing, for instance, corporate venture capital investments (Keil, Zahra, and Maula 2016), they put forward factors influencing learning benefits for exploration and exploitation. Entrepreneurial opportunities of the incumbents should be articulated with skills and ideas showcased by start-ups, at it gives way to previous generated opportunities or even generate further opportunities for entrepreneurship. The portfolio level gives more context and contrast to pool opportunities. It constitutes most of the program governance contributing to exploration and exploitation organizational learning as transactions are made with start-ups.

The governance of portfolio of projects, seen as a program, and with project-based organization gives more weight to a change project (Gareis 2010). The change management could then be fully embedded in the project, instead of seeing it as a different management. However, the tendency is to operate a dichotomy making change a project and a technical project (e.g. product development), instead of embedding change within the

project. In a literature review on program management (Martinsuo and Hoverfält 2018), Miia Martinsuo develops propositions for future research on change program management towards organizational capability as it has been moving from the traditional plan & control approach as it integrates value management, synergies across programs, stakeholder management in addition to a means to succeed in the organization's environment.

Finally, we have seen that unit of analysis of the portfolio of projects, and more specifically, the notion of program management gives more weight to the strategic management of the underlying projects. This concern with respect to the project-based organization would then emphasize the triad: structure, the value and people management.

What it also stressed is that there is a governance of such pool of activities that is slightly shifted compared to the functional structure as it answers directly to the environment through clients, instead of "only" dealing with standards, regulations and sustaining a body of knowledge. It gives then more weight to the project-based organization and generative fit to be managed as exploration projects develop their yet-to-be known trajectories.

Consequently, as ambidexterity could be managed at the program level to potentially metabolize projects with organizations, we must now precise the role of environment perception. Understanding the environment will allow anticipating adaptation and thus adjust the program for change. To metabolize could then refer to the dynamics of interactions between projects, and how it contribute to organizational change.

# 3 Change project and the environment

In the previous section, we have discussed the organizational dimension of project management and its implications for exploration projects supporting generative processes as a means for innovation management. We have shown that the literature in the field has come to a point where project-based organization, seen as temporary organization, and an extension of matrix organization, are state-of-art to support innovation management. However, the literature reveals numerous limitations and has made repeated calls to further merge the teachings of organization studies and design to better understand the value management, human resources management as well as interdependencies in between departments and (temporary) organizations. We have also pointed that detailed work from engineering and design management were able to address these *epistemic interdependencies* and introduce notions such as *generative fit* to support congruence in innovation management. These elements could play a role in organization metabolism for ambidexterity.

The encapsulated nature of the projects allows more flexibility and potential reconfigurability that can be sustained through appropriate governance, in a more efficient way than traditional centralized and functional organizations. Of course, such concern is rather contingent to the maturity of technology, the market rate of change, task complexity and environment turbulence.

The notion of environment is perhaps easier to look at, seen from the project perspective, as it concentrates collective action in a project team. The adaptive model takes into account the environment by defining what is external to the adaptive system. And the notion of environment becomes more blurry with interactionism as the notions of boundaries in a network may be hard to delimitate unless one is able to cluster. Where does the firm's environment start? How is it observed and managed?

This section will consider how the project-based management regards the environment, with also a concern for the way in which the environment is discussed in the adaptive and interactionist models. We have made the assumption of the projectification of firms. And so far, we have seen it can relate to ambidexterity models discussed in the previous chapter depending on the level of analysis and viewpoint (structure, process, social and system). To discuss these topics, we propose to draw from system theory and developments by Maturana and Varela (see for instance the analysis of images of organization in (Morgan 2006)). They introduce the concept of *autopoiesis* which interprets differently the frontier between system and environment applied to biology. They introduce the idea that a system interacts with the environment by thinking of it as a reflection and part of its own organization[4]. The principles of autopoiesis (self-generation) are based on auton-

[4]The definition of the environment becomes relative to each system, i.e. there is no external observer

omy, circularity and self-reference. The cognition of the "environment" is constituted of patterns of variations and reference points reflecting its own organization mode, so that the environment is organized as an extension of itself.

> Firstly, we will start by looking at the way in which the environment is responded to. Secondly, as projects and organizations will tend to organize their extension in the environment, we will look at the open innovation literature and its implications for project management. At last, we will consider how the firm can reorganize or regenerate itself to constantly address these patterns of variations engaged between the system and its "environment".

## 3.1 Responding, exploring, and exploiting to the environment

The teachings from previous experiences can encourage some kind of responses to prepare in some way to the environment dynamics. Among the variety of pre-emptive strategies (Macmillan 1983), timing to offer to the market a new concept (product, service, feature, architecture etc.) through careful project management is crucial, as it comes with its set of advantages and disadvantages (Lieberman and Montgomery 1988; Lieberman and Montgomery 1998). As described by Lieberman, several firm's resources will be of different nature depending on the strategy (pioneer or follower) and the decision to enter at a certain rank the new market. The created value space will be dependent on luck and dynamic capabilities (Teece, Pisano, and Shuen 1997).
It is dependent on numerous control variables, so given the tone of our literature review, we propose the case where the market or operational ecosystem's dynamics are pretty stable with long development lead times. There are no visible threats of new entrants due to high entry barriers and strong dominant design (Abernathy and Utterback 1978). In those markets, the long term strategy is to be able to be ready when the new dominant design comes out (Christensen 1997; Macmillan 1983). It becomes then complex to support the necessity to invest into resources and dynamic capabilities for a risky and uncertain course of action.

Having slack resources appear crucial to innovate, yet the relationship between these two would be curvilinear (Herold, Jayaraman, and Narayanaswamy 2006; Nohria and Gulati 1996). The inverted U-shape relationship between slack and innovation pushes the optimization game on extremely complex grounds as it is also dependent on multiple control variables (Nohria and Gulati 1997). It is also stressed that the nature of slack resources (absorption and rarity) will have a different effect on product exploration/exploitation given the (non-)existence of ecosystem's threats (Voss, Sirdeshmukh, and Voss 2008).
By referring to prospect theory (Kahneman and Tversky 1979), they build upon the concept of framing and anchoring to explain the moderating effects of the environment per-

defining "boundaries"

ception on the nature of available resources[5]. Their research was further developed to show different patterns of exploration/exploitation relative to the environment (Voss and Voss 2013). They propose that the balancing of the two modes could be conducted along the dimensions of the product and the market. They emphasize the known paradoxical myopic behaviour of large established firms having the resources but not implementing ambidexterity for product development, and they also confirm the need for sustained market ambidexterity for long-term growth. The latter can also be directly linked to the failure of stage-gate models in project management as described in (Sethi and Iqbal 2008) which tend to make beforehand strong and stable hypothesis on the environment. It questions again the actual practice of product ambidexterity, and ways of sustaining exploration/exploitation through project management, since the ambidextrous organization design may not be observed in the same way.

The necessity to change the organization comes from the cognition of a change in circumstances. One could also develop the need to adapt further by exploring yet to be known alternatives and generating new knowledge. Relying on real options theory for instance, (Fredberg 2007) encourages to think of the importance of the generation of options along the product development process. Bringing design theory closer to real options allows then coping with high uncertainty and turbulence of the environment, but also stresses how the new choices and their value should be positioned in the real options tree. This pattern recalls the notion of pre-emptive strategies (Macmillan 1983, p. 17) with the idea that one should shape one's luck:

> *"Good generals make their luck by shaping the odds in their favor and by being able to spot and rapidly capitalize on every emergent opportunity created by the mistakes of their opponents, or by the good fortune they have helped to shape"*

Before jumping to tricking the new environment's odds, the adaptive model can still bring some valuable subtleties. By developing the canonical bandit (Posen and Levinthal 2012) - extending James March's model - Hart Posen and Daniel Levinthal develop the idea that environment change decreases the rewards of exploratory efforts at accumulating knowledge (inverted U-shape between the optimal degree of adaptiveness of the search strategy and turbulence frequency).
So organizing change may induce a renewed focus on exploiting old knowledge, beliefs and opportunities. For instance in (Jansen, Van Den Bosch, and Volberda 2006), ambidexterity is studied in relationship with organizational antecedents such as centralization, formalization and connectedness. Such search strategies supporting organizational adaptation will reflect the conception of environment's dynamism and competitiveness, i.e. a set of

[5] A rare case of the theory's takeaways outside of finance (Barberis 2013), as this nonconventional theory remains rather complex to be fully deployed despite its modelling of future cost/benefit reasoning.

actions conditioned by knowledge mapping of the (believed-)world (Posen and Levinthal 2012, p. 598). However, the results of Justin Jansen and colleagues, may be considered insufficient as the organizational choices such as decentralization and environment dynamism will encourage exploration. Nevertheless, the example of the General Motor's car in (Posen and Levinthal 2012) shows the greater exploration was not beneficial as they ended up with a poor new-environmental fit because the turbulence devalued existing knowledge and also devalued the chances of returns associated to generating new knowledge. They consequently insist on the *finesse* of such nuances of exploration/exploitation and the unknown (Posen and Levinthal 2012, p. 599):

> *The challenge for organizations is the ex-ante assessment of the magnitudes of these two competing forces.*

The modes of exploration and exploitation do reveal that the non-mutual conditioning of both could be revisited. At least, exploration project management does bring a new flavour to adaptation and engagement with environment. Consequently, the role of strategic leadership for exploration and exploitation can then naturally be linked to the influence of environmental dynamism (Jansen, Vera, and Crossan 2009). Still in the line of thought of ambidextrous models, it places the emphasis on leadership and top-management role to cope with such organizational challenges. But isn't there an approach in between to cope with organizational metabolism?

These takeaways again encourage to promote the simultaneous thinking and implementation of managements of project and organizational change as discussed in previous paragraphs (Hornstein 2015; Pollack 2017).
Relying on the product development literature and project management, we find how different adaptive arrangements can be made at the product design level. (Sanchez and Mahoney 1996) develop the knowledge management supported by modular product architecture reflected in organization design. It reduces the cost and difficulties of adaptive coordination. The environment dynamism and turbulence can then easily be coped with as long as the architecture remains stable: the firm will remain flexible with the modules' boundaries. Leaving a loose structure (Nogueira and Raz 2006) will then prove beneficial against turbulent environment specially if teams can (re-)organize the product design. Such perspective is even further developed with the idea of fractal organizations (Nonaka et al. 2014) by considering multiple interfaces at the project level (Nonaka, Hirose, and Takeda 2016). These meso-foundations allow reconnecting with the locus where knowledge is generated and managed, and the creative side of dynamic capabilities taking place at the team-level and organized my middle management.

In a similar vein, whilst insisting on interdependencies and drawing from practices of product design and engineering, system engineering can considerably provide an enhanced

perspective on the governance of project-based organization in complex environments. (Locatelli, Mancini, and Romano 2014) proposed to shift to a *system-based*, and thus a *system governance*, with for instance naturally embedding the system thinking and supporting the re-use of system elements. The role of project management offices in governing performance appears then crucial to prepare environment responses. For instance, a temporary entity ("transition support office") can be designed to conduct change with permanent entities by addressing paradoxes and challenges in order to support a learning process in the project-based organization (Aubry, Richer, and Lavoie-Tremblay 2014). Adapting to the change of circumstances can then be addressed by directly managing the adaptation of project rules (project management office) and product/system design.

> These logics of engagement with the environment can be pushed even further by considering the move to work closely with the origins of some of these turbulences in the supplier-client relationship by moving from a settled project management (co-development) to a more exploratory context (co-innovation) (Maniak et al. 2008). It avoids the caveats of traditional logics of reacting to change.
> In (Colfer and Baldwin 2016) - when discussing the mirroring hypothesis - echoes of the fractal organizations of I.Nonaka can be found with a call for collaboration across firm boundaries as a means, to deal with *epistemic interdependencies* (Puranam 2012). The simultaneity of project management (through product development) and organizational change (in the form of change project) is then reinforced. It encourages opening the boundaries of innovation in a project-based organization, or even in a adaptive model perspective. The generation of new alternatives, new knowledge by interacting with the environment can then be fully embedded in the project in order to value the exploitative or exploration dimensions.

## 3.2 Freeing, exploring and exploiting innovation

Coming back to (Kline and Rosenberg 1986) showcasing a linear model of innovation, it becomes challenging to withstand it against open innovation. Indeed, its complex nature will bring several changes to the market, the social context and product system. Reinforcing the interdependencies of the technology and economic realms, the authors naturally call to open the innovation black box (economist view) and the process of technologist. They have a tendency to forget the market environment and its dynamics. The open innovation then encourages to find the origin of such dynamics and place the product development effort over such domain.

The role of lead-users (Hippel 1986; Hippel 2005) can be rallied support ideation and valuation of new concepts. Bringing user input, supplier relationship but also manufacturers (Franke 2014; Hippel 2007) can then support innovation management for the firm up to an extreme point where innovation is fully taken care of by users (Hippel 2016). Freeing in-

novation tends to fully open economists' black box, it severely challenges transaction costs and incomplete contracts perspective such as (Aghion and Tirole 1994) where innovation is simply described through patents and funding. See figure below:

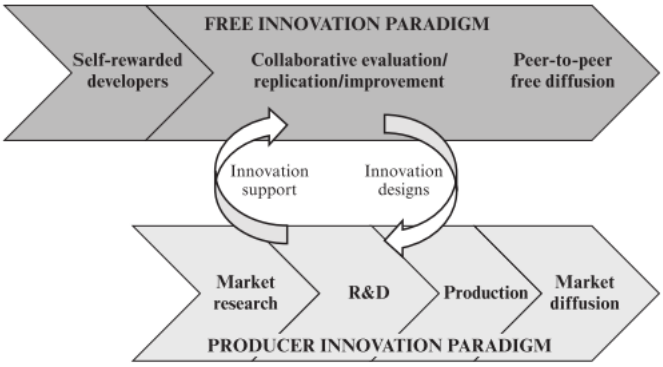


**Figure II.9:** The free innovation paradigm and the producer innovation paradigm (Hippel 2016)

Maintaining the interactions between the two paradigms can also be organized as a means to manage the environment by collaboratively making sense along the design with users themselves. It can create new requirements and eventually new products (Hewing and Hölzle 2014; Kristensson, Magnusson, and Matthing 2002; Magnusson, Matthing, and Kristensson 2003). In a similar way, the design-driven perspective of innovation management, (Verganti and Dell'Era 2014) calls to identify and work with *interpreters* that could be better identified through a wider system thinking, better understanding of the whole value chain and environment awareness. We could then think of exploiting such potential innovation sources for the organization.

The new loci of innovation (Lakhani, Lifshitz-Assaf, and Tushman 2013) create tensions to contour the organizational boundaries, and they propose instead to approach this difficulty of opening/closing boundaries by addressing the decomposition of tasks and the knowledge distribution supporting problem-solving. It stresses again the role of leadership to perform the associated strategic decomposition, as a means to decide of organization designs. The (strategic) decision-making comes back to the front seat or at least shifting the attention to collaborative problem framing (and decomposition) with some added uncertainty. Even with common generative practices, the structure and formulation of complex problems are crucial (Kavadias and Sommer 2009), implying the importance of mediators creative leadership or adequate design management tools to regulate group dynamics (Ezzat, Le Masson, and Weil 2017; Ezzat et al. 2017). The collaboration means imply careful co-design practices (Berger et al. 2005) and partnering.
Indeed, it has also been clarified how the role of co-creation enhances exploration/exploitation learning in project-based organization (Eriksson, Leiringer, and Szentes 2017).

Moving to a "private-collective" model of innovation as in the case of open-source software domain (Hippel and Krogh 2003) allows shifting the paradigm from the traditionally private and closed producer (Baldwin and Hippel 2011). Consequently, this new regime of exploitation/exploration of the environment deeply challenges the conditioning of both constructs. The blur is stronger if one considers that the entry-level of open-innovation practices in firms consists in managing a pool of established and potential suppliers to be more vigilant to changes coming from the downstream value-chain.

> This shift in the locus of change management encourages to revise the nature of choices to be made to support innovation management at the light of the environment turbulence, and organizational boundaries nuances.
> How should organization prepare and organize such loci of innovation? How should executives build up and regenerate competencies given the multiple project trajectories?

## 3.3 Competence building: nesting innovation and organizational metabolism?

The nature of dynamic capabilities could be split into two adaptive and creative ones according to (Nonaka, Hirose, and Takeda 2016). They also need to be tailored and designed to address such turbulence and complexity. These routines (Zollo and Winter 2002) embedded in the firm may be subject to path-dependency, requiring to regenerate the dynamic capabilities themselves; as the latter represent the ability to renew competencies in order to sustain the environmental fit (Teece, Pisano, and Shuen 1997). This recombination or regeneration of a higher level deeply questions the means to achieve this extraction from potential lock-ins (Bessant, Stamm, and Moeslein 2011).

What appears critical for such capability enabling the "renewal of the renewal" of competencies supporting organizational adaptation, could be seen in the management of the unknown. The open innovation context showcases numerous proxies channelling the innovation effort (Howells 2006), so the participation to intermediation allows addressing collectively the risks and opportunities of generating new knowledge and accreting it (Agogué et al. 2017). For instance, by connecting, ad-hoc networks are created to collectively commit to innovation, creation of legitimate place for collective innovation (not a shared vision), sharing an agenda of open issues and questions before sharing knowledge and potential answers.
The case of the semi-conductor industry, joining forces to address the unknown, reveals how they constitute a new path through clever road-mapping activities supporting the generation of knowledge (Le Masson et al. 2012). These phenomena also require a specific analysis to understand the structuration process taking place in such networks (Sydow et al. 2012) where hierarchy is replaced by heterarchy reconsidering the leadership role around collective roadmap activities: e.g. creation and gap filling (Lange et al. 2013; Müller-Seitz and Sydow 2012).

Partnering with other firms are effectively a means to explore novel fields, but the underlying cooperation relies on necessary coordination mechanisms as well as cohesion. This mix was identified as crucial to support collective action (Segrestin 2005). It also reveals critical questions on the legal framework supporting such open-ended processes thus avoiding rigidities and formalism of traditional business contracts. The lack of identification and tooling for path-dependence and path-creation, be it collective or not, can lead to a standstill as it is the case for orphan innovation (Agogué, Le Masson, and Robinson 2012) and under-performing technologies biased by government-led incentives (Nemet 2009).

Consequently, understanding through a relational and interactionist lens, the management of genuine uncertainties, and the unknown in such partnerships, alliances and networks becomes critical. It requires also to distance from pure governance or contractual perspectives despite being crucial, not only to reduce the costs and uncertainty associated with incomplete knowledge (Sydow, Müller-Seitz, and Provan 2013). For instance, the existence of collectives such as the famous Lunar Society of Birmingham (1765-1813) exhibits the capacity to organize beyond the firm's boundaries into the gaps of the ecosystem left by the unknown (Le Masson and Weil 2014). Such groups materialize the links between science and industry, in order to collectively define new problems, address what is invisible, in contrast with the existing. Interfering in such way "into" the firm's environment allows guiding the action logics towards what is potentially manageable with potential innovators (Neyer, Bullinger, and Moeslein 2009). Sociotechnical imaginaries can thus be managed to stimulate the ecosystem at stake (Hooge and Le Du 2016) echoing at higher level the use of metaphors to drive radical product development. This approach is relieved from the flexibility and dynamic responses expected from the firm as they generate a new space in its networks (Grant 1996).

Now, the idea of the higher level capabilities called *regenerative dynamic capabilities* (Ambrosini, Bowman, and Collier 2009, S15) could perhaps be embodied as it frames how firms "*might modify and extend their current dynamic capabilities*". But this third-loop of learning (Leifer and Steinert 2011; McClory, Read, and Labib 2017) shows the issue of iterating the looping process as path-dependency looms again at different loop levels. The pattern can reach for the *hyper-environment* by promoting a change of leadership and external change agents. The trick comes from the environment cognition seen at different management levels or for different activities. Hence, it is critical to master the ability to identify the fixation effects associated with the product design, the environment, institutions but also organization design.

By reconsidering the importance of action for human cognition (Barsalou 2016), we have another argument in favour of the role of design or generative processes in general. Action allows a better understanding of the environment's perception and its dynamics. The

notion of *cognitive fit* (Martignoni, Menon, and Siggelkow 2016) between mental-model of the decision-maker and the strategic environment, can then be studied to see if it contributes positively/negatively to exploration.
They show that cognitive style (simplifier vs. complexifier) will be better suited for different hierarchical levels (respectively lower and upper). The decision-making for strategic leadership should rely on a complexifier cognitive style in an inter-organizational context and high uncertainty levels (and inversely):

| | **External Interdependencies** | **Internal Interdependencies** |
|---|---|---|
| **Overspecification** | Slight overspecification can be beneficial for low complexity.<br>Overspecification is in general not very harmful in the long run. | Overspecification is very harmful for all levels of complexity. |
| **Underspecification** | Underspecification is very harmful for all levels of complexity. | Underspecification can be beneficial, especially for high complexity. |

**Figure II.10:** Effects of misspecified mental models on exploration (Martignoni, Menon, and Siggelkow 2016, p. 2561)

The performance perception combined with the interdependence representation, will then contribute to more or less exploration which in return should encourage a more or less efficient choice in the real performance landscape. However, this association should be carefully handled, as we have also stressed that too much exploration does not guarantee stationary payoffs (Posen and Levinthal 2012). So the direction of generative processes could be guided to inquire and interfere with the environment. Evaluating objects at the frontier of a knowledge domain also reveals several biases consistent with prospect theory and bounded rationality (Boudreau et al. 2016): lower scores for closer domains, and the more novel prospects are associated with lower evaluations. It marks again the edges of optimization and search models, and leaves room for generative processes supported by design reasoning to articulate performance ands its renewal.

Coming back to the decision of exploring and exploiting, several parameters are to be considered: guiding exploration project and engaging with the environment, loci of innovation, but also the project-based organization change. Structure and processes are off-balanced by project trajectories. Since, we relied on several biological analogies. The concept of metabolism could be another way of formulating these management parameters.
The word extends and stresses the meaning of *metabole* which means *change* from the Greek $\mu\epsilon\tau\alpha\beta o\lambda\eta$, itself derived from the prefix *meta-* (with, communal, in between, after)

and the noun *bole* (throw, cast and also wiggle or dance[6]). So coming back to other introduced borrowed words (ecology of generativity, epicormic offshoot and mutation), the metabolism is a *process* that is rather in between organs and physiology.
For instance, the immune system, among other metabolic "devices", generate numerous leucocytes (white blood cells) thanks to DNA variations in order to create cells that are potentially able to fight against threats detected in the body. It shows the capacity of creating deviant cells (different DNA) which should be eliminated per se, but that needed to potentially generating the adequate defence (Hallé 2004, p. XX). This small example gives an idea of the different nature of metabolism by opposition to other processes operating in a organic system.

Finally, a developed environment cognition properly building capabilities supporting innovation faces the daunting task of generating choices and selecting them to probe interactions, interdependencies that are potentially distributed across several loci of innovation. Sustaining organization metabolism, embedding innovation practices and organization change, could be a side-effect managed by exploration management. These metabolisms could then contribute to organizational ambidexterity.

A gap between exploration project management and models of ambidexterity has been widening. As a matter of fact, the original aim of organizational learning and adaptation was founded on a different assumption of organization design. Project management and project-based organization bring new dynamics that are not fully compatible as described so far with previous models of ambidexterity. Several roles such as intermediaries, roadmaps, sociotechnical imaginaries, and gap-filling are potential clues to guide the cognitive fit and generative fit.

Nevertheless, we are left with several unanswered question on the management of fixation effect relative to cognition, the decomposition of tasks, the update and extension of representations and organization design. These questions will also have different weights and change in nature depending if they are considered at the project level, the program level or its governance. We consequently underline the complexity of metabolism but also the importance to manage them to sustain ambidexterity and innovation practices. Otherwise, these practices could be phased out given their assumptions.

[6] latin: *ballare*

# 4 Chapter conclusion: projects as generative vehicles unsettling organization learning and design

In this second chapter of the literature review, we started by looking at projects as vehicles to search for novelty. It introduced an encapsulated way of dealing with collective action and ambidexterity. The unknown is at the heart of and encapsulated in projects. The separation between exploration and exploitation is addressed with new concerns for organizational learning and adaption. This perspective brought a new way of thinking of adaptation and interactions with the environment. The projectification of economy and the refinements of the matrix organizational form have put to the fore temporary organizations creating ties for project-based management. Such temporary structure may not be fully phased with underlying functional organization that takes care of legacy product designs, associated knowledge management and control of technical and organization interdependencies as they are mirrored.

The generativity associated with exploration projects may push the temporary organization to a point where ties may be hard to understand and justify. Projects may then float and anchoring them implies high levels of reconfigurability of the organizations whilst taking on board value management and numerous contingencies. The notion of *generative fit* becomes quite handy to merge design management closer to organization design.

Moreover, the project-based organization requires careful management to handle multiple projects at once, which should not be considered as isolated phenomena. The refinements brought by portfolio management and program management allow stretching the collective action encapsulated in projects in a more easier way towards innovation and strategic management. We have also stressed that the history of project management is actually closer to innovation than to optimization-inspired methods. The governance associated to this unit of analysis reveals the environment cognition, and the associated *cognitive fit* to be maintained. The subsequent allocation of resources, decomposition of tasks, problem formulation and strategic decision-making become rather complex as it can be addressing several loci of innovation.

The systems engineering and tradition of detailed product development literature have had the tendency to specify the way in which design issues are dealt at technical level but also at the organizational and social level. The importance of interdependencies and the way in which temporary organizations or project

management offices or even governance could play with raises intriguing perspectives to conduct collective action for innovation management. Not only twisting technical interdependencies play a major role for product development but with the organizational partial mirroring the change management comes closer to actual project management. The nature of decision-making that we had addressed in the first chapter takes now a whole different colour.

Finally, the encapsulation of generative processes in project management brings a different perspective of organization design and sustainable innovation management. Advanced forms of the matrix organization with temporary organization supporting project management or even change project, raises numerous issues on the way the generativity of product design practices can be conducted simultaneously with the dynamics and change requirements of the host organizations. The tensions identified not only fall dramatically into the realm of contingency and difficulties to conduct managerial action, but it raises the potential impact of fixation effects and interdependencies which are usually targeted by efficient generative processes. Drawing from complexity theory, fixation points and interdependencies knots could be viewed as attractors where collective action anchors and burgeons. Consequently, it would be interesting to see how projects can be driven by shifting these attractors whilst managing their influence area.

The following chapter will review our findings made in the literature in order to synthetically specify the three presented models and our research questions.

# Chapter III

# Research Questions

*In the fields of observation, chance favours only the prepared mind.*
Louis Pasteur

In our literature review, we have taken sides with the critical approach of stress testing a founding paper with evolutions of innovation management, project management but also with refinements of generative processes brought by design reasoning, theory and engineering design.
James March's seed coming from problem-solving (March 1991b), has spread from a concern of organizational learning developing an adaptive model to being the fertile ground for ambidexterity and innovation. The dichotomy operated between exploration and exploitation regimes has fed numerous studies, with more emphasis on the role of exploration, and confusion around what embodies really this two constructs. The articles (Birkinshaw and Gupta 2013; Gupta, Smith, and Shalley 2006) were critical in discussing the non-mutual conditioning of exploration/exploitation as introduced by (March 1991b). They sketched the idea that the divide between these two may have changed in nature. They also encourage to think of it on two separate dimensions and avoid only considering it as two ends on a same continuum.

In less than 30 years and approximately 20,000 citations, the adaptive process of organizational learning rooted in a search-based model of problem solving has been largely superseded with what innovation management has become and its diverse approaches. The models, we have studied based on the literature review address part of these evolutions whilst still being all equally present in research and practice.
We have taken a stance regarding how generative processes challenge exploration vs. exploitation and see how they contribute to models of ambidexterity and how they are encapsulated in different modes of collective action such as project management. The notion of exploration is quite pervasive, and usually aims at supporting sustainable innovation. However, by considering input from design theory and reasoning, we have shown

the numerous limitations, tensions left to how coordination and collective action should be conducted. For example, when considering the biology metaphors used in the literature and introduced in the review: adaptive evolution calls for mutation and selection, interactions call for an ecology of generativity, encapsulation in projects may lead to epicormic shoots at odds with organization design. The latter allowed questioning the nature and the management of organizational metabolism.
The management load comes then in different ways for leadership, or top management, middle management and agents, and raises in complexity when dealing with the loci and nature of generativity. Management prescriptions have had the tendency to call for advanced decision-making, cognition and action.

As these three pivoting dimensions are quite recurrent, we propose to have an enlarged vision of decision-making. Inspired by the neo-Carnegie research agenda (Gavetti, Levinthal, and Ocasio 2007, p. 531), we propose to stick with foundations "*behaviorally plausible, decision-centred perspective on organizations*". The stress test driven by design reasoning and theory will support such effort. The research program tailored at Centre for Scientific Management in Mines ParisTech started off from a former tradition of studying implementation and performativity of operational research tools and methods (Segrestin et al. 2017). Later, it constituted itself as an extension of H.Simon's work: design theory and expandable rationality (Hatchuel 2001). Our literature review at least brings forward the originality of looping back with origins and more 'traditional' management issues as design theory and innovation management have constituted its own path.

> We propose to first clarify the models of ambidexterity and management of the unknown studied in our literature review with the following descriptors: model of coordination and collective action and the innovation potential of attraction covering the nature of generative processes, environment cognition and organization design.
>
> These description elements will help us formulating our research questions and preliminary hypotheses to set a course for the methodology part and results.

# 1 Model description categories

First of all, we should start by clarifying the descriptors enabling a clearer comparison between models as these were introduced all along the literature review. We had started from James March's seminal paper (March 1991b) and methodological literature review (Wilden et al. 2018) with a concern for organizational learning, rationality and foolishness, and its contribution to innovation management. Diving into the literature of ambidexterity allowed giving another flavour to the dichotomy of exploration/exploitation with some concern for organization design, resource allocation, dynamic capabilities and paradoxes. As the question of implementing ambidextrous organization and prescribing sometimes heavily contingent recommendations, we proposed to look at the decision-making and the contributions from generative processes challenges. The second chapter, studied the projectification of the economy and how innovation management could be encapsulated. Embedding generative processes in the case of exploration-dedicated project, raised numerous questions on the organization hosting such projects, reconsidering the matrix and organic forms. Finally, the associated organization design and decisions to be made accordingly permit rethinking the environmental and cognitive fits in cope with change.

Another approach to our literature review and derived models would be then to identify what are the designated **models of collective action**. In other words, it is the way in which the models are prescribed and translated into managerial action. It embeds several hypotheses and sets a manageable course of action. The second dimension to medidate - due to the complexity induced by potentially distributed generative processes across the firm and organization structures - would be the **innovation potential of attraction**. We suggest to break it down in three. The first sub-category concerns **generative processes** and their 'performance'. The latter cannot be fully isolated per se as it has been extensively discussed throughout the literature review, we propose to consider the second category: **environment cognition**. And finally, the last sub-category is the organization design. The concern for attraction is inspired by complexity theory in the sense that 'chaos' can temporarily 'organize' itself around near-point-of-equilibrium. Consequently, it allows us to add a concern for how standalone generative practices will engage with the environment and simultaneously mirror what is necessary in the **organization design** to support its own generativity.

In the same vein of the two previous chapters, we propose to picture our dimensions and sub-categories by considering their 'edges' revealed by the challenges sustained by the unknown and its management. It delimitates the three models on those edges, which have been pointed out by the stress test of design theories against innovation management, organization studies and project management.

## 1.1 Model of collective action

All of the research discussed in the literature review addressed in some way how action should be carried out to support their model. Sometimes, the recommendation was quite 'meta' allowing it to be transferrable to different research domains, sometimes it was more centred on the agent (decisions, responsibility, cognition, relationships) and in other cases it was quite abstract with constructs such as dynamic capabilities.

The loci of generative processes and their organization is depicted in the way individuals, teams and organizations will contribute and interfere with it. The drive and control of such generative forces is placed on different management tools and individuals. The effort is placed on the relationships and knowledge interplay (Hatchuel 2011; Segrestin et al. 2017).

## 1.2 Innovation potential of attraction

The innovation potential of attraction will be constituted by different sub-categories contributing at different levels of the firm: individual, technical, systemic, social and organizational.

### Generative process

The generative processes come in different practices, more or less formalized or even institutionalized. They have different generative engine, leading action in different directions and contributing to the valuation process in different ways. The innovation potential will come from the novelty, the fluency and also defixation power (Agogué, Le Masson, and Robinson 2012; Houdé 1997; Le Masson, Hatchuel, and Weil 2011; Smith, Ward, and Schumacher 1993; Ward 1994; Ward 2007). The attraction comes from the way in which a group of individual participate to the joint generative effort.

It is also crucial to understand the nature of fixation effects and interdependencies addressed, and of course what is taken for granted in the exploration process. The behavioural aspect appears critical as it involves what bounds rationality, and what can expand it, and the tools and methods used to support such constraint or effort. Specification of mental models and performance beliefs to drive generativity will be key as they address potential *epistemic interdependencies* (Puranam, Raveendran, and Knudsen 2012).

### Environment cognition

The environment cognition relates to the generative processes locus and its engagement into its environment. It considers mainly how the system is shaped and how it regards its

own extension with 'environment'. Different devices and mechanisms can be imagined to prepare for uncertainty and the unknown.

Not only it targets the perception and decisions made to cope with the environment, but also how action occurs purely as a means to engage with the environment and deal with uncertainties and the unknown. The *cognitive fit* with elaboration of mental models will support the appropriate *environmental fit* (Martignoni, Menon, and Siggelkow 2016; Posen and Levinthal 2012). The innovation potential of attraction will be supported by how the system's extension into the environment is managed through the generative process, implying some level of awareness that is taken into account by different individuals (agents, middle/top management).

**Organization design**

Organization design was addressed in different ways in our literature review. The forms adopted by the firm were seen as important to support generative processes but it is also key to understand what contributes to the implementation of outputs. Moreover the beliefs and alternatives supporting the organization designs will be closely to product development with the *mirroring hypothesis* in mind.

As the organization design is supposed to be the result of a change to better respond to the environment, this potential never-ending process for turbulent and complex environment calls for a certain *generative fit* by opposition to the traditional *organizational fit* (Avital and Te'eni 2009; Van de Ven, Ganco, and Hinings 2013). The innovation potential of attraction here is then expressed by considering what make the structures to reshape around a proposed or even sketched new organizational design.

Overall, the organization design will support the generative processes, engaging with environment if they metabolize through structure and processes of the organization. Relationships and knowledge will dynamically evolve in parallel.

## 2 Research questions and preliminary hypothesis

The portrait made with our descriptors and models drawn from the literature review reveal the assumptions made by these and their potential limitations. These mainly appear since we tasked ourselves to use design theory and reasoning to stress test several foundational approaches made at the edge of the literature in innovation management, organization theory and project management.
First, we propose to address that the fact that the original construct of balancing of exploration/exploitation may have suffered to a point where ambidexterity could severely jeopardize innovation management (Birkinshaw and Gupta 2013; Gupta, Smith, and Shalley 2006; Wilden et al. 2018). Such perspective is also valid for project management as the tension of exploration/exploitation typifies the nature and course of action of projects in the firm, and the associated temporary organization (Lenfle 2016).
Second, it is almost unthinkable to fully discard such concept. So, we propose to revisit the notion of adaptive process, along with interactive and encapsulated models, at the light of generative processes. We should, in a way, reconsider nuances between exploration and exploitation, their definitions to regenerate ambidexterity behaviour across the firm (cognition, product development, project) and ambidextrous organization. More specifically, the relationship between product design and organization design (Colfer and Baldwin 2016), and the importance of *epistemic interdependencies* could reveal ways of properly overcoming and managing organization design fixations, thus enabling the hybridisation of project and change management.
Third, if we manage to regenerate such construct with the fresh teachings of design theory and reasoning, we should of course be able to validate it. We should then also specify the new regime of collective action supporting it.

Based on the descriptors and the projection of our three models derived from the literature, we can identify several areas of commonalities. The dichotomy is usually enforced between exploration and exploitation, with of course, different value frames and performances. These modulations emphasize the paradox of dealing with both no matter the unit of analysis (middle/top management, organization design, project, resources, routines, etc.). There is a **non-mutual conditioning between exploration and exploitation** presented across the literature streams.
For instance, as exploitation picturing bounded rationality, exploration could be driven by foolishness or irrationality. Chaos could then perhaps provide some input for exploitation, but the role of exploitation providing some grounds for exploration is rarely, if not never, discussed (Wilden et al. 2018). Only James March sketched a possibility of nuancing the dichotomy (March 2006, p. 209)[1]:

*It is argued that the link between rationality and conventional knowledge*

[1] quoted in chapter I

*keeps rational technologies reliable but inhibits creative imagination. This characterization seems plausible, but it probably underestimates the potential contribution of rational technologies to foolishness and radical visions.*

Such cleavage is also enforced in the nature of project management for exploration and the required organizational ties. Interactionism blurs the dichotomy but instead raises numerous questions on the management and control of organization design, identity and change direction.

In order to sum up, we propose to define a common model of non-mutual conditioning between exploration and exploitation regimes. It is declined over the four descriptors introduced earlier.

The innovation potential of attraction specify the non-mutuality between the product design and development for radical innovation and organization design. The mirroring hypothesis pictured a static view of the mutuality, but we are interested in the change process.

Despite the interactionist perspective stressing the reciprocity sustained through circulation of concepts, the emergent nature of value, recombination of routines, the role of artefacts and metaphors, it is not very clear how the managerial action is achieved to balance and control design fixations and epistemic interdependencies. Especially, they don't necessarily review the separation of both regimes and how it could be articulated differently. So there is also a non-mutual conditioning of coordination and collective action across the different level of analysis.

| General features of a model of **non-mutual conditioning** between exploration/exploitation | |
|---|---|
| **Model of coordination and collective action** | 1. Not necessarily on the same continuum, exploration and exploitation call for two dissociate action regimes.<br>2. Balancing is left as a paradox at different levels of analysis: structure (centralization, distribution), time and individuals. |
| **Generative processes** | 3. The nature of generative processes supporting exploration appears quite free, random and sometimes even foolishness-based.<br>4. Generativity of the product development may not be sustained by (temporary) organizations (floating issue).<br>5. The performance and reference are light structured: reduced to a selection issue or sometimes to complex interactionist phenomenon. |
| **Environment cognition** | 6. One-way interaction: Environment to Organization.<br>7. The environment structures the response, nature and distribution of generative processes.<br>8. The environment is used to augment the product development requirements. |
| **Organization design** | 9. Organization design is pre-conceived or uncontrolled.<br>10. Organization design creates gaps for managing generative processes and the dynamics of their organizational ties. |

**Table III.1:** Model of non-mutual conditioning of exploration and exploitation

### RQ1: How does the dichotomy between exploration/exploitation compromise sustained innovation?

First of all, the difficulties raised by generative processes challenging organizational forms and action regimes supporting innovation, encourage us to specify: **What are the characteristics of exploration project management floating between intra-organization and inter-organization settings?** It appears crucial to understand the underlying mechanisms and tension points where generativity strikes against organization boundaries and rules. Our interest is in linking the design theories and product development with such concern to contribute to questions raised in the literature (Gavetti, Levinthal, and Ocasio 2007, p. 532):

> *how organizational rules and routines interact with formal and informal decision-making structures is an important unanswered question that must be answered to develop a more integrated theory of organizations*

Due to the separation operated by exploration and exploitation to support organizational learning, and limitations addressed by interactionist and project management literature, the construct of ambidexterity may have been outdated by practices and literature refinements in innovation management: **Does the dichotomy of exploration/exploitation jeopardize innovation management at the light of generative processes?**

As suggested in the literature, nuances could be disentangled between the exploration and exploitation regimes, so we could ask ourselves: **How generative processes contribute to exploration struggle with exploitation constraints (design rules, fixation effects, interdependencies)?**

Finally we can summarize our first target into:

> **How does the dichotomy between exploration/exploitation compromise sustained innovation?**

As the reader can guess, we propose to reveal a management anomaly with respect to predictions of the literature models of ambidexterity. The prescribed non-mutual conditioning between exploration and exploitation clashes with generative processes specifically targeting the unknown. Exploration projects have a means to encapsulate the management of the unknown, and consequently drive innovation, but they can fail in the long run because of ambidextrous organizations.

Furthermore, organizations design as well product engineering fixations are not fully overcome through exploration project management nor ambidexterity itself.

### RQ2: What model of ambidexterity can be designed to overcome and manage organization design fixations?

If exploration/exploitation dichotomy's construct could actually kill innovation, we need to tackle the underlying behavioural foundations in order to disentangle associated difficulties. A first hint would be to deeply revisit the way decision-making is constructed due to the interference of generative processes supported by design reasoning and theory.

Several rules, fixation effects and **epistemic interdependencies**, which are representative of formal and informal patterns of exploitation, could be directly addressed by exploration activities. More precisely, they could be among the requirements and be the purpose of generative processes to sustain innovation in the firm.**How could organization design and change be simultaneously managed along a radical innovation project?**

The **environment cognition** and the associated (mirrored) **organization design** bearing new product development projects reveal their design rules, fixation effects when challenged by generative processes. The **ecology of concepts**, **organization mutations** and **epicormic shoots** triggered and challenged by exploration activities as knowledge-interactions dynamics are constantly strained (Hatchuel 2011): **How does it metabolize with innovative design, organizational concerns and strategy?**

We propose then to synthesize these questions and first assumptions into:

> **How can ambidexterity be revisited to overcome and manage organization design fixations?**

By opposition with anomalies, we naturally explore what the mutual conditioning between exploration and exploitation can bring to exploration project management. The underlying problem-solving foundation will be revisited by design theories, where the unknown is its second core after knowledge, will help revealing so far hidden variables. Rooting decision-design on fixations and interdependencies will facilitate generation of alternatives and concepts. Such generation will then effectively work on product design and organization design.

This modelling effort will necessarily require testing with further case studies but also experimentation. Given their context, the researcher's intervention, where generativity is driven be decision-design, will raise several questions on contingent organizational routines, dynamic capabilities, as well as interactions and reconfigurations supporting organizational change.

### RQ3: How can intra/inter-BU exploration projects be metabolized in the organization to support radical innovation for the conglomerate?

The previous two questions encouraged the detection of an anomaly in the practice of innovation management and the design of a new model reconfiguring and extending the domain of validity of the ambidexterity construct. We consequently need to think of the managerial action of the new model.

Since, we will propose to root our research in the field offered by a conglomerate of SMEs evolving the aircraft equipment market (Zodiac Aerospace), we propose to emphasize the organization design and behavioural approaches arising from the inter-organizational relationships. Thus, it heavily challenges the edges of interactive and encapsulated models, as organization structures tend to be the by-product of product development.
Finally, our last research question can be summarized into:

**How can intra/inter-BU exploration projects be metabolized in the organization to support radical innovation for the conglomerate?**

Following the modelling effort, the associated testing and intervention, provide means of actions to work (organization & product) design fixations to surface interdependencies. Disentangling such knots offer a new lens driving organization change and product innovation. New interactions are created and routines are recombined through the generation of alternatives and concepts relying conditioned by exploitation. Overall, these dynamics contribute to organizational metabolisms.

# Part 2

# Research methodology

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**Outline** In this second part, we explain the methodology used to tackle the limitations identified in the literature and start answering our research questions.

The first chapter (IV, p.141) explains the intricacies of **intervention research** and how the original research project defined with Zodiac Aerospace evolved. At the light of the descriptors and models derived from the literature review, the identified limitations encourage to prepare for a potential **anomaly detection**. We consequently specify the implications of such agenda and the required analysis level.

The research journey is specified in order to understand how the PhD candidate came across developing a critical thinking to reflect on observations and analysis of case studies. We synthesize the usefulness and implications of several steering committees, article writing in addition to academic confrontation. We insist on their contribution to the definition of an analytical lens required to make sense of an anomaly and propose a new model, requiring further testing.

The second chapter (V, p.173) portraits the research context and offers some history on aircraft industry in order to understand what Zodiac Aerospace has become. A synthetic overview is given of its innovation management and stresses some difficulties that were originally reported in the research project.

Finally, several cases are selected and presented. We explain how they contributed to article writings and overall methodology: anomaly detection, theoretical modelling, validation, intervention and further validation.

**Aperçu** Dans cette deuxième partie, nous expliquons la méthodologie utilisée pour s'attaquer aux limites identifiées dans la littérature et commençons à répondre à nos questions de recherche.

Le premier chapitre (IV, p.141) explique les spécificités de la conduite d'une **recherche-intervention** et comment le projet de recherche original défini avec Zodiac Aerospace a évolué. À la lumière des descripteurs et des modèles tirés de la revue de littérature, les limites identifiées incitent à se préparer à une potentielle **détection d'anomalie**. Nous précisons par conséquent les implications d'une telle feuille de route et le niveau d'analyse requis.

Le parcours de recherche est précisé afin de comprendre comment le doctorant a développé une pensée critique pour traiter les observations et analyses des études de cas. Nous y synthétisons l'utilité et les implications de plusieurs comités de pilotage, la rédaction d'articles en plus de la confrontation académique. Nous insistons sur leur contribution à la définition d'un niveau d'analyse nécessaire pour rendre compte d'une anomalie et nous proposons un nouveau modèle, nécessitant des expérimentations contrôlées.

Le deuxième chapitre (V, p.173) présente le contexte de la recherche et propose un historique de l'industrie aéronautique afin de comprendre ce que Zodiac Aerospace est devenu. Un aperçu synthétique de sa gestion de l'innovation est donné et souligne certaines difficultés qui ont été signalées à l'origine dans le projet de recherche.

Enfin, plusieurs cas sont sélectionnés et présentés. Nous expliquons comment ils ont contribué à la rédaction des articles et à la méthodologie globale : détection des anomalies, modélisation théorique, validation, intervention et validation ultérieure.

# Chapter IV

# Methodological approach and research journey

In this chapter, we present the methodology deployed over the three years of the PhD thesis. The methodology relies on an intervention-research approach (Hatchuel and David 2008) facilitated by the CIFRE contract (*Convention Industrielle de Formation par la REcherche* - Industrial Convention of Training through Research).

First, in section 1, we introduce the principles of intervention-research in management. Then, in section 2, we present the data collection process with the associated analysis based on the literature model. We follow an anomaly detection methodology in order to formulate a new model that was tested during the last stretch of three years of the research program through validation and application within ZA.
The final section 4 portraits the position of the PhD candidate within the firm.

# 1 Principles of intervention research in management

The Intervention Research in Management (IRM) has been elaborated over several decades of research partnerships at *Centre de Gestion Scientifique* (Hatchuel and David 2008).This approach has proven efficient in revealing the intricacies of complex managerial situations specially in the innovation management field with the multiplicity and novelty of interactions, decisions, knowledge flows in project and strategy management. IRM relies on two pillars: a **collaborative protocol and theoretical perspective**.

The aim is not to solve a definite problem proposed by an organization. The theoretical setting can actually be rather dull at the beginning despite bearing a certain potential. Nonetheless, a dialectic between *established-theories-in* use and *contextual-established-in-use* allows improving models of action. The point is nor to perform change management, but rather to gain an understanding of theories-in-use, their performativity and how models of thought can evolve within the business. This continuous monitoring between academia and industry through the PhD candidate enables uncovering a real research issue supported by:

- Pre-conditions
  - partner with a pioneering logic
  - open management issue free interviews
  - contractual commitment to a research issue
  - support of an academic team with research potential (PhD directors/supervisors and research lab)
- Monitoring principles
  - Free interviews
  - Warranted isonomy[1]
  - Confidentiality of all individual interviews
  - Capacity to create new empirical material
  - Controlled design
  - Management innovations evaluated as rational myths

Given this set of conditions and practices, the outputs emerge naturally following the dynamic and symmetric feedback supported by the PhD candidate through his meetings, steering committees with academia and industrial colleagues. It implies testing models of thought, frameworks drawn from the literature, and models grounded on field data based on the case studies conducted.

[1]from the Greek *isonomia* = *iso-* (equal) and *nomos* (the order of the world). Ability to discuss freely theories-in-use through steering committees and prepared meetings

## 1.1 Initial management issue formulation

Originally, the PhD research program was designed to address the topic of economic performance of design at Airbus Aircraft. At that time, the PhD candidate was already working within Zodiac Aerospace [2]. The program discussed how design activities of project and program management could be valued by alternative means to project objectives. For instance, it raised that traditional learning mechanisms between projects were hard to track such as spill-overs (Cohen and Levinthal 1989), and how learning could be managed from a project to another in an efficient manner. The performance dimension, its definition and underlying value management was central for the topic. Today, as the PhD project was not launched in July 2015, it was put on hold and is currently being dealt by a PhD fellow at CGS (Agathe Gillain).
As this PhD subject would not come to life in its original form by 2015, we proposed to re-allocate the project to Zodiac Aerospace. With the support of the Group HR management, a new sponsor was to be found: Thierry Rouge Carrassat, Chief Technical and Innovation Officer for Zodiac Aerospace. Several meetings were organized between the PhD Directors and the CTO to provide information on the company, its history, its context, innovation management practices and how the PhD program would be framed by IRM methodology.

The topic was adapted, it discarded part of the economic performance axis: the topic recentred around the old dilemma of market-pull vs. techno-push. ZA presented several cases trying to overcome the growing rationalization of market-pull by aircraft manufacturers and airlines. For instance, they had two development teams close enough to market prescribers in order to try to anticipate market-pull trends and formulate proposal of new products/services that could federate several BUs for more added value.
Furthermore, as business units were highly profitable in their respective niche-markets covered over the history of acquisitions, corporate management had been sponsoring techno-push initiatives. These were steered through a *Multi-BU committee* showcasing a mix of top-down and bottom-up approaches.
Another salient feature was the history of acquisitions and expansion since the establishment of the company in 1896. Zodiac Aerospace was a conglomerate of SMEs with individual responsibility for each BUs grouped based on market segmentation and technology proximity into so-called: business lines, divisions and branches.

For further details on the how the PhD program was formulated, you can refer to the Appendix A6. It is a clean copy of the submission made to the ANRT (*Agence Nationale pour la Recherche et la Technologie*) - the agency sponsoring the CIFRE PhD Programs nationwide.

[2] supervising a testing laboratory of Zodiac Interconnect UK following his MSc in Aeronautical Engineering

## 1.2 Phases of IRM

Intervention research can be split into different phases that do not necessarily represent a linear story in the research journey. The phases are the following: feeling of discomfort, rational myth, intervention and research, portraying a set of logics and change process.
Starting with this *feeling of discomfort* with respect to the open management issues identified, the researcher in an abductive fashion starts generating hypothesis on raw data collected through open interviews with a wide variety of actors across business units.
The investigation is followed by the definition and gradual elaboration of a *rational myth.* This myth reflects as a potential model, and reference to rely on to explain and coordinate collective action. As exposed by Bachelard in his thesis "*Essai sur la connaissance approchée*" (Essay on approximated knowledge) (Bachelard 1927) to explain scientific knowledge development and constructivist epistemology:

> *The order of sensibilities does not necessarily follow the salient features, what we could call the dynamic topography of our experience. We indeed have little agreement with the simplification of the prior phenomenon of every scientific development. We think the primordial features stand out by themselves and establish themselves forcibly to our study through their generality. Nevertheless, sometimes it is the accident and not the general that is explanation principle to the point where problems should be overturned to restore the generality to the phenomenal features the spirit had represented in special meaning.* [3]

It should not be mistaken for serendipitous discoveries but his work stresses the importance of experimentation, seen as the *contact between Thought and Reality* which is the only way of specifying the mode of existence. The knowledge is thus approximated by a movement of conjunction from Thought to Reality, which are supported by means of *intervention and interaction.* The gradual and often non-linear shaping of knowledge allows the researcher to *portray a set of logics.* Up to this phasing, the purpose of the researcher is mainly to explain and bring to the surface the rationality mobilized in the collective action. In that regard, we adopt an *ordinary* perspective of rationality (Boudon 2012). We avoid the potential patchwork and associated burst of the notion of rationality, and stunning relativism that social sciences can sometimes produce. Of course, we cannot pretend to discard existing theories that explain collective action through according to different research programs (Lakatos 1980): utility, materiality, mechanistic or cognitive.

[3] Translation by the researcher: "L'ordre des sensibilités ne suit pas nécessairement les traits saillants, ce qu'on pourait appeler le *relief dynamique de notre expérience.* On est bien en effet peu d'accord sur la simplification du phénomène préalable à tout développement scientifique. On croit que les caractères primordiaux ressortent d'eux-mêmes et s'imposent à notre étude par la seule force de leur généralité. Parfois cependant, c'est l'accident et non le général qui est principe d'explication au point qu'il faut renverser les problèmes pour restituer la généralité à des caractères phénoménaux que l'esprit avait schématisés dans un sens spécial."

The methodological individualism required to reveal the *set of logics*, and *rational myth*, tends to adopt a cognitive approach to understand social phenomena which are the implications of the individual actions inspired by reasons. It is a means of avoiding pitfalls as explained by R.Boudon (Boudon 2012): solipsism, psychologism, procedural knowledge and programmatic approaches, dispositional variables, restrictive axiomatic such as rational choice theory and expressive rationality (Frega 2010). So, we tend to look for how these reasons are shaped within and without context. We also identify the research program Max Weber's proposition in his treatise on the Sociology of Religion (Weber 1946, p. 280):

> *Not ideas, but material and ideal interests directly govern men's conduct. Yet very frequently the 'world-images' that have been created by 'ideas' have, like switchmen, determined the tracks along which action has been pushed by the dynamic of interest*

The researcher in his generative search will then test his evolving understanding with the field through different *intervention and interaction* devices, acting as measuring devices and testing: interviews, questions with given semantics, presentations of models, steering committees, discussions with supervisors. And finally, there is a need for predictability in the new understanding built by the researcher which comes in the form of a *change process*. This change occurs mainly from the understanding of *Reality* of the studied domain. It does not necessarily imply the implementation of new management tool, or rationality organizing collective action, but rather a learning process due to the scientific understanding. We will come back to this in the section 2, as we propose a methodology of anomaly detection.

## 1.3 Data collection

The vast majority of data was collected in the group Zodiac Aerospace through the variety of interactions with actors of the firm. Given the nature of our research, a diverse sample of data type was sourced across the research ground.

From the beginning of the PhD journey until the end, a large sample of resources: meeting minutes, presentations, TRL assessments, technology/product roadmaps, project statements, project & program documentation stored on local networks, intranet, etc.
Another set of data was gathered through active participation to workshop, seminars, meetings where sometimes where the researcher was invited for observation and we must add data collection with varying degrees of intervention: writing workshops, working groups, interviews, project meetings and seminars.

# 2 Anomaly detection and modelling

As we will present in the following sections and following chapters (Chapter V), we have a small-sample research contained in a large conglomerate of SMEs. The different phases of IRM tend to overlap and provide feedback between themselves. Overall, we have the three main categories of logics interacting with each other(Dana and Dumez 2015):

1. Deduction
2. Inference
3. Abduction

Given the sample size and in order to provide meaningful results for academia and practice, demonstrating a case of anomaly is key from a statistical standpoint (Siggelkow 2007). The purpose is to carefully observe a counter-example to the models extracted from literature (Part 3), then propose a new model explaining the phenomenon and extending existing theories (Part 4). In this section, we present how we mobilize the idea of comprehensive research (Dana and Dumez 2015; Dumez 2016) to elicit counter-examples of existing models in the literature and design a new one. There are three main risks associated highlighted by the method:

1. Abstract actors or being of reasons
2. Circularity
3. Equifinality

These three major risks will serve as a baseline to promote counter-factual reasoning with the elucidated anomalies by putting the effort on creating a typology, stress mechanisms between levels of analysis through a set unit of analysis, and proposition of a new concept redefining and extending existing theories.

## 2.1 Detecting an anomaly in management

One of the movements of a comprehensive research (Dana and Dumez 2015) can be seen as a modulation of deductive research. The selected literature and associated models tell us what to observe when scouting the research ground, with a risk of being trapped with circularity. The first step consisted in analysing theoretical frameworks relating to ambidexterity, exploration project management, strategy management and organizational design/studies in face of the unknown. It is also a way of rephrasing the elaboration of the *rational myth* and *set of logics portrait*. Based on the literature review (Part 1), we were able to select several of these frameworks which are key to identify a phenomenon unknown to academic literature in contrast with the synthesised model of **non-mutual conditioning of exploration/exploitation**.

The analysis requires to extract typologies and mechanisms of phenomena observed in the selected literature that shed light on the anomaly. The descriptors are introduced to stress issues and limitations already identified in the literature. It will also facilitate the instrumentation to describe the purpose of our research questions, hence the anomalies and their implications (Part 3).

We have selected the common descriptors: **model of coordination and collective action**, **innovation potential of attraction** (*generative processes*, *environment cognition* and *organization design*). The literature review aimed at stress testing major models of ambidexterity in order to see that the construct had drifted overtime and locally *delaminated* as innovation management had evolve to embrace the unknown specially with exploration project management. These were analysed with inputs from design theories and reasoning embodying generative processes. Several assumptions and limitations were identified with the help of the descriptors as presented in the research questions (p.121).

> In the first chapter (VI), a first batch of results from selected case studies (see Table V.1 p.205 in section 3) will be presented revealing anomalies. This is based on the chosen descriptors and synthesized version of the anomaly detection articles.
> In a second chapter (VII), we will then have to further specify these anomalies revealing in more detail the limitations and underlying assumptions found in the literature review (see research questions p.121).
> Finally, the anomaly detection should lay the requirements to build up a new model revisiting and extending literature models in order to explain the abnormal phenomena.

## 2.2 Data analysis

We must mobilize a unit of analysis that opposes inference and abductive logics. The first calls for explanations, typologies and mechanisms the selected literature will allow us to observe. The second is more independent from the literature and tends to extract what the research ground can "tell us" through the variations observations and interactions/interventions. The two are far from being independent in practice, there is a constant confrontation bore by the researcher himself echoing a declination of the Hawthorne Effect.

The two different sets of data allow us to confront the two logics separately over the collected documentation and the variety of field notes (interviews, meetings and workshops participation). The unit of analysis is crucial to elicit the articulation between the levels of analysis (from the individual to the organization/ecosystem) and associated mechanisms evolving through the timeline of the case studies. So, we would tend to have a 'mesoscopic' approach as the typologies drawn from the literature review, in association with event-system theory invite us to play on different levels and temporalities (Griffin and Ragin 1994; Griffin 1993; Morgeson, Mitchell, and Liu 2015). The other benefit is that it forces

the researcher to disentangle black-boxes that may have been contoured in the literature such as *abstract actors* and *beings of reason*.

We propose then to explicit the selected descriptors (see chapter III, p.121) over time as the decision-making and action is engaged by actors (designers, engineers, managers, etc.), within projects and within committees. We then suggest to look at the time-sequence of the following derived descriptors:

- **decision/problem space design**: decision and problem formulation is extracted from documentation and conducted interviews for the different surveyed selected projects. The input from design theory from a methodological standpoint also helps to envision a large decision/problem space which was discussed with interviewees (as the possible course of action).
- **actual made decisions**: recorded from project history, documentation and interviews
- **engaged course of action**: recorded from project history, documentation and interviews
- **organization design**: supporting (temporary) organizations were found in project documentations and interviews and also directly observed.

As an example, if we propose to represent a project management for a standardized product development, the descriptors allow us to show the linear and supposed stability that is adapted through risk management procedures. The figure IV.1 below gives an idea of how this would be done.

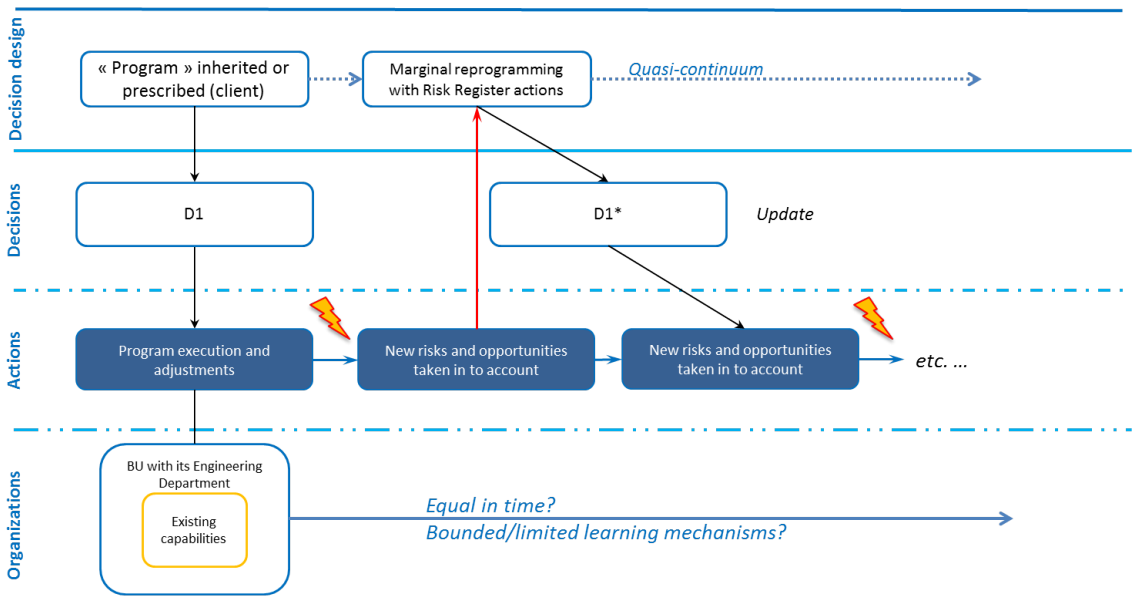



**Figure IV.1:** Derived descriptors representation for a *traditional* development project.

This analytical lens remains very useful to draw the project trajectory, its coordination mechanisms and collective action. However, we must stress that it may also become chaotic as real life management, and interaction with the environment and organizations is not without obstacles. So we must highlight these obstacles and specify what the literature models of **non-mutual conditioning between exploration and exploitation** would have predicted compared to the actual course action depicted with our descriptors.

**Note:** In order to specify and make sense of these obstacles, numerous control variables can of course be added as we have discussed in the literature review to counter contingencies and concomitant phenomena. Adding them may raise model's fitness with data but not necessarily up to a point of reaching perfect congruence from a statistical viewpoint. Consequently, we will address some of common control variables and clarify how influential they could have been or not in order to make a case for the anomaly as easily as possible.

## 2.3 Modelling: Naming, explaining and testing

Finally, the anomaly detection encourages the researcher to formalize a new model mitigating some perspectives addressed by the research questions and the observed phenomena. The novelty invites *naming* the phenomenon based on traces left by academics or practitioners to weave a model from it.
The new model is introduced in Part 4, it should be *free-standing*: plausible on its own due to the showcased logics of the conceptual argument (Siggelkow 2007, p. 21). Despite being backed by the cases, it also requires elevating the model from the idiosyncrasy of the cases themselves.

Our model will support a novel explanation of the anomalies presented in the chapters VIII and IX in Part 4. The validity of the model is presented in chapter X and in Part 5 through the different ways in which the researcher intervened in the research ground: contributions to projects and management procedures. For IRM phasing, it corresponds to the establishment of a new *rational myth* proposing a new way of organizing collective action. The support and reaction to this experimentation is detailed in the two chapters where the model was experimented and validated by peers. Moreover, this experimentation of the model validates the status of the model as a building block providing an understanding of complex mechanisms, laying a path along the research questions perspectives for a future theory with exploratory hypotheses (Part 6).

Now, we have specified the different descriptors to detect the potential anomalies, we need to be able to compare models derived from literature with the case studies. We propose then in the following paragraphs the adaptive, interactive and encapsulated models. They represent different models of ambidexterity as we have seen throughout our literature review along the chosen descriptors.

The **adaptive model** is mainly concerned with responding to the environment by organizing the firm in a way that it is a priori capable to answer to potential changes. The generative processes such as radical innovation are then structured by the organization design and environment cognition.

The **interactive model** tends to deepen the contingencies of generative processes by stressing the importance of relationships, emergent new ones so that new routines can be recombined through the open-ended network dynamics. The organization design are shaped to the complexity of relationships tied through generative interactions.

The **encapsulated model** brings a more 'organic' view by framing generativity with the scope of a project supported by a temporary organization also tied functionally to resource-providing organizations. The change dynamics of the (temporary) organization are the mirror's image of the net of projects engaged with the environment and program office/governance's strategic input.

### 2.3.1 Adaptive model: coping with the environment's dynamics

In the adaptive model, what is critical is the way in which the adaptive process rooted in problem-solving, and by-extension decision-making (probabilities on solutions), moved from organizational learning with a concern for exploration and exploitation regime to being a key construct to think the firm's innovation performance in addition to having competitive advantage. Mutations of the organization structure and process are the answer to environment changes. Variation and selection should be then managed to ensure an efficient exploration.

The other salient feature is that it tends to prescribe organization design with different level of analysis that should be the responsibility of top management as they are considered among the few to bring system thinking and thus conduct strategy. The underlying foundations such as decision-making and dynamic capabilities building remain quite obscure (Birkinshaw and Gupta 2013) and may lead to complicated managerial action.

| | **Innovation potential of attraction** | | |
|---|---|---|---|
| **Model of coordination and collective action** | Generative processes | Environment cognition | Organization design |
| Top management and leadership are the corner stone shaping the adaptive processes supporting innovation management. They oversee organizational learning and relationships balancing exploration and exploitation. Selection, valuation and strategic decision-making is their responsibility. | Generativity is supported by search-based processes to discover missing alternatives hidden by bounded rationality. Foolishness or simple landscape searching can uncover unbounded rational alternatives. The overall product development process tends to be by-product of the ambidextrous organization. | The environment offers the alternatives to the decision-maker and seeker. High levels of flexibility and capabilities are required to respond quickly enough to changes. Search-based behaviour help to prepare and build up capabilities to cope with the environment. | The firm should balance its organization structurally, sequentially or contextually (different levels of the system) to support exploration and exploitation regimes. Ambidextrous organizations are the norm, and the careful balance is chosen depending on the environment dynamics observability. |

**Table IV.1: Adaptive** model descriptors

### 2.3.2 Interactive model: enabling an ecology of generativity

The interactive model approaches the issue in a far more contingent way. The circulation of concepts and interactions with artefacts contribute to the exploration regime and simultaneously to the exploitation effort as stakeholders take part in the process. The decision-making has a tendency to be left on the back seat, as the engaging action with others will allow addressing uncertainties and the unknown. Yet, organizing open innovation, or freeing innovation raises the question of problem formulation and deciding of its decomposition in the network of interactions.

The organization boundaries can be easily blurred by the numerous engagement of agents and artefacts with the environment. It naturally reveals numerous question on the governance, if not control, of such fractal organizations as the identity and purpose of the products being developed could bring heterogeneity and incoherence.

| | **Innovation potential of attraction** | | |
|---|---|---|---|
| **Model of coordination and collective action** | Generative processes | Environment cognition | Organization design |
| Middle management and individuals (designers and silent designers) bear the interactions. Spaces, occasions and artefacts should be designed. Top management may be involved to shape networks and relationships. Decision-making and problem framing may be required to be decomposed and distributed by top management. | Interactions between agents and artefacts support circulation of meaning, create and manage value. Metaphors, desirable concepts are used to drive coordination and cohesion for radical innovation. | Flexibility is supported by the network and favours open innovation to reach out for new design requirements. Reaching out for the full value chain and extending it to user-designers allows shaping future environments. It is a means to formulate and solve problems. | Network and distributed design. Open/close boundaries on multiple fronts, potentially fractal. Organization tends to be a by-product of the product development processes in the network. |

**Table IV.2: Interactive** model descriptors

### 2.3.3 Encapsulated model: challenging organization design and learning

The encapsulation of generative process into projects and the management of a portfolio with a program elevate the interactive perspective by putting the emphasis on strategic management, an enclose collective action, as well as a potential issue of governance and temporary organizations.

The temporary organization supporting the project-based management also relies on functional departments providing key resources and knowledge management. The organizational learning and organization ties of projects floating across these organizations can induce difficulties that encourage to think of change management with the scope of a given project, instead of a separate activity.

| | **Innovation potential of attraction** | | |
|---|---|---|---|
| **Model of coordination and collective action** | Generative processes | Environment cognition | Organization design |
| Project management and/or program management lead innovation. Project management office preserves project management rules. Program governance may frame projects with a roadmap and other strategic management input. | Practices, methods are embedded in project/program. Resources are drawn and requested depending on novelty. | Perception and action engaged locally, at project level and with possible oversight from program governance. Learning between projects is key to build awareness. | Projects shape temporary organizations relying on functional departments. The boundaries move according to environment interactions and may be governed by program management and office. Temporary organization tends to be a by-product of the product development processes supported by the portfolio of projects. |

**Table IV.3: Encapsulated** model descriptors

# 3 Research Journey

In this section, we present the research journey over the three years corresponding to the IRM phasing and its modalities. The researcher took part in several Steering Committees with the firm and PhD directors, as well as numerous Academic confrontations which have participated to the evolution of perception of literature frameworks and gradual specification of a new *rational myth*. The figure below gives a global picture of the journey over several dimensions:

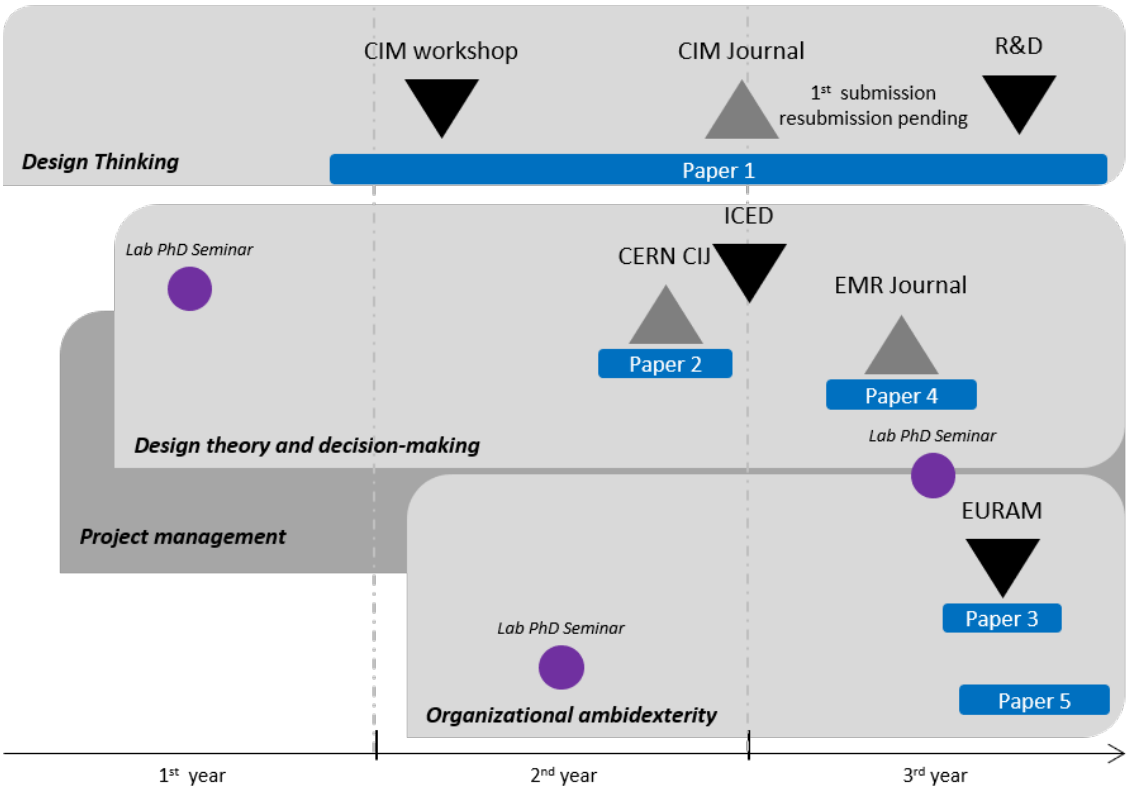



**Figure IV.2:** Research Journey

## 3.1 Steering committees

In order to elaborate the different phases of IRM, several steering committees were organized on a quarterly basis with the academic and industrial supervisors, in addition to weekly interactions with both separately.

The first set of meetings gave a frame for an open discussion (*isonomy*) around a proposed model of action, framework projected over the data collected on several case studies. Presentations and discussions allowed testing hypothesis, different narratives, and semantics taken from literature models. Two major meetings were organized with the CTO, R&T, engineering and business development managers, in addition to PhD Directors. Otherwise

10 other steering committees were held with the CTO and PhD supervisors to keep track of the *open management issue*.

The second set of meetings were perhaps less formal as the challenge was to update PhD supervisors as frequently as possible on the collected data and analysis made. In a more personal way, it was the occasion for the research to test extreme hypothesis or simple extrapolations in order to explore the boundaries of the domain of the models taken from the literature or grounded in the data. Practically, it implied testing narratives, semantics from different literature streams to test how the supervisors would project themselves in the understanding built by the researcher. It is a dual learning process for both sides.

## 3.2 Academic confrontations

The research had the occasion to participate to a range of academic activities: thesis presentation at the laboratory, presentation for the annual PhD candidates meetings of the CNRS research unit (UMR 9237), presentation at seminars, conferences and journal submissions with peer reviews.

| ***Lab presentations*** | |
|---|---|
| **First Year** | *February 2016* - First case studies results |
| | *April 2016* - Design Thinking and design theory case studies |
| | *June 2016* - First year Thesis status |
| **Second Year** | *September 2016* Literature review on decision-theory/making |
| **Third Year** | *March - May 2018* - 3 Thesis presentations |

**Table IV.4:** Academic interactions - Lab presentations

| ***Seminars*** | |
|---|---|
| **First Year** | |
| **Second Year** | *February 2017* - "Travail et créativité : une approche croisée à l'international" organised by Yanita Andonova & Emmanuel Sevignac |
| | *April 2017* - Thesis Presentation Chalmers University |
| **Third Year** | *March 2018* - Thesis presentation PhD Seminar |
| | *June 2018* - EURAM PhD Colloquium |

**Table IV.5:** Academic interactions - Seminars

| ***Conferences*** | |
|---|---|
| **First Year** | |
| **Second Year** | *October 2016* - 6th CIM Community Workshop |
| | *January 2017* - 10th SIG Design Theory Conference |
| | *August 2017* - ICED Conference |
| **Third Year** | *June 2018* - EURAM Conference |
| | *July 2018* - R&D Management Conference |

**Table IV.6:** Academic interactions - Conferences

During the three years, the researcher engaged discussions with several researchers to learn more from their publications and research interests. It was the occasion to present the research project, results of case studies and trying to find echoes with their works. The table below offers an overview in a chronological order:

| ***Management researchers*** | |
|---|---|
| Pierre Couronne | Former Professor at *Université de Lille 3* and at *ISAE SUPAERO-Toulouse*, we had several discussions on the nature of design engineering and its contribution to management. His concern regarding the PhD project was seen from the angle of human resources and organization theory. His input was very helpful during the first months when trying to make sense and preliminary assumptions on the first cases analysed at ZA. |
| Gilles Garrel | Professor of Management at *Conservatoire Natinal des Arts et Métiers (CNAM)* - we had a first open exchange and shared a course together for the MSC in Entrepreneurship organized by *Ecole Polytechnique* on bio-technologies. The purpose of this exchange was to share some insights on Zodiac Aerospace cases. He shed light with perspectives on project management and strategic management. He shared some experience on cases and ongoing research in creative (game and circus) and sport equipment industries. |
| Lisa Carlgren | Post-doc at *Chalmers University* - I had the occasion to review her EURAM 2016 submission, so we took time after the conference to discuss her research. Several insights on Design Thinking and its relationship to organization routines and strategic management were discussed. The discussion helped clarify the multiple impacts of design thinking (method) and design reasoning in general and the relative issues of framing (Carlgren, Rauth, and Elmquist 2016). |
| Georg Von Krogh | Professor of Management at *ETH Zürich* - Discussion on the nature of need-solution pairs (Hippel and Krogh 2016) and the managerial action required to identify them and sustain an ecology of creativity. He suggested the reading of the edited books of Mark Runco and referring also the works of Robert Epstein. |
| Emmanuel Marcon | Professor of Management and Business Intelligence at *IAE Poitiers* - The exchange occurred following a PhD seminar on business intelligence organized by PSL University. Given his research and interactionist approaches on information gathering and processing, we had some debate on decision-making and its limitations. He encouraged the reading of (Oury and Schmidt 1983) on the place of "vigilance" in economics. It allowed feeding a new approach to the paper submitted at ICED 2017 by insisting on the economy of project management and decision-making. |
| Laurent Simon | Professor of Management at *HEC Montréal* - Short meeting arranged during a visit to Montreal following ICED in Vancouver. After presenting the research conducted at ZA, he presented his research at Ubisoft (Cohendet and Simon 2016; Simon 2006). Whilst keeping a concern for organization routines, he gave reasons to work on how concepts are 'forked' during design processes (traceable through in C-K but not necessarily explained in detail) and these emergent micro-decisions are managed collectively. His concern echoed the criticality of linking design theory and management with organization theory, which we have addressed in the literature review. |

| *continuation of table*IV.7 | |
|---|---|
| Marine Agogué | Assistant Professor of Management at *HEC Montréal* - Short meeting arranged during a visit to Montreal following ICED in Vancouver. The discussion pointed out the design of decisions, and how the decision theory and design theory could be experimented in laboratory environment, or at least tracked in project management. |
| Florence Charue-Duboc | Professor of Management at *CRG-Ecole Polytechnique* - Several critical comments were made during my PhD status presentation, at $i^3$ 2nd year PhD Seminar (May 2017).<br><br>**It marks a key turning poing in the thesis**. Indeed, the purpose of the presentation was to try to show the anomaly. The presentation went awfully bad, but I took it as a weakness for not having the appropriate descriptors. As the notion organizational ambidexterity was discussed, the presentation was criticized for not nuancing enough the dichotomy between exploration/exploitation. |
| Laure Cabantous | Professor of Management at *CASS Business School, University of London* - The researcher was consulted for her work on decision-making with Alberto Feduzi (Feduzi et al. 2016). She raised interest in the cases in the decision-making practices of ZA and encouraged having a closer look at strategy-as-practice stream of research and legitimation with the firm. |
| Katharina Hölzle | Professor of Management at *University of Potsdam - d.school* at editor for CIM Journal - Following the CIM Community Workshop in Potsdam (November 2016) and gathered feedback, a submission was made to the CIM Journal. A first round of reviews pointed at several weaknesses of the submitted article including the multi-level analysis.<br>Several months later, during a visit to Mines ParisTech, we took some time to discuss the paper. Misunderstandings were cleared out and together with Sophie Hooge, we had time to elaborate on the use of design theory and reasoning (practice and methodology) to understand the build up of dynamic capabilities sustaining innovation management in addition to conduct management research. |
| ***CGS researchers*** | |
| Sophie Hooge | Assistant Professor - On several occasions, we had the opportunity to discuss the shades of ambidexterity and how ZA cases proved new practice requiring management tools and support. Her knowledge of the car industry was used as a reference to explicit how different the aircraft industry is, and the features brought by my research compared to literature on exploration project management and radical innovation. |
| Cédric Dalmasso | Assistant Professor - During the last 6 months of the PhD, he was referred to for two articles co-authored on ambidexterity (Garcias, Dalmasso, and Sardas 2015) and high uncertainty project management (Hooge and Dalmasso 2015). Not being so engaged with design theory and reasoning as other researchers in the lab, but more familiar with decision-making, project management and organization studies, his feedback was very helpful in clarifying my narrative. |
| Philippe Lefebvre | Assistant Professor - His courses on organization design and organization studies, and his research on engineering departments, were enlightening to test the anomaly detection and the models revising decision-making and organization design. |

| *continuation of table*IV.7 | |
|---|---|
| ***Mathematics researchers*** | |
| Pierre-Henri Wuillemin | Assistant Professor at *LIP6, Université Pierre & Marie Curie* - When surveying literature on decision theory, a theoretical graph model (pyAgrum) was found to simulate decision problems. A meeting was set to discuss how the developed Python code could be extended to designing decisions, or at least simulating the effect of surprises. The main output was that the nature the probabilities and underlying algebra should be revisited to properly simulate such behaviour unless sticking multivariate decision-making. |
| Matthias Troffaes | Associate Professor at *Durham University* - Another Python model was found in the field of imprecise probabilities (Improb), thus opening an opportunity to model the design of alternatives and states of nature. However, again the model proved insufficient to model the design by a decision-maker. |
| ***Psychology researchers*** | |
| Anaëlle Camarda & Mathieu Cassotti | Post-doc at *Université Paris Descartes* and *CGS Mines ParisTech*; Professor at *LaPsyDé, Université Paris Descartes* - Following discussion with Marine Agogué, the idea of combining the experimental protocols of decision-making and creativity was discussed but reveals numerous obstacles as they have epistemic differences. It remains an open topic. |

**Table IV.7:** Academic interactions - Discussions with researchers

## 3.3 Evolution of the *rational myth* contributors

In this subsection, we propose to cover the literature journey of the researcher. We briefly present how the modelling effort came around over which literature was mobilized, in addition which articles were presented at conferences and sent to journals. The elaboration of the *rational myth* and *set of logics portrait* is not a linear process. So the following paragraphs are an *ex-post* viewpoint of the PhD journey. We have taken the liberty to make three categories for which articles were written and presentations made on various occasions to test literature models on case studies.
As the reader will see, they do not follow the literature review chapters (I and II), instead they follow the PhD candidate through the three years and how he tested several frameworks to engage with academia. The researcher made a first effort regarding the literature around the construct of "decision-making" "design thinking" before going into the field "organizational ambidexterity" and ramifications.

### 3.3.1 Decision-making

Through the case study at ZSSM, we had the opportunity to study the decision theories in order to explain the project management. Data was presented in a way that it encouraged the decision-making study: the story was told as sequences of events with commitment to decisions, beliefs and their representation in several documents.

**Rational theories of choice -** As we will see later, we proposed to test the validity of rational models of choice, where rationality is seen as instrumental(Boudon 2012). Large reviews of decision theories were executed: from the ones based on *maximum expected utility* to modulations made between the 1950s to early 1990s with models discussing the underlying axiomatic and formulation mathematics. The works of Allais, Kahnmenan, Tversky, Machina, Camerer, Giocolli, Quiggin, G.Klein, Slovic, Regenwetter and Gilboa were paramount in the field.
Debates on rationality, coherence between decision, beliefs and action were covered to understand how the construct of decision-making was considered in different literature domains ranging from economics, management to philosophy. It was also the occasion to make a detour through mathematics with decision models using multi-criteria approaches and imprecise probabilities.

**Irrationality in decision-making -** The question of not being able to expect, changing the notion of utility to deal with the way decisions are made, led the researcher to dive into the way what makes irrationality and how the decisions are constructed. So the perspective of ex-post construction of decision to justify the course of action, and deviance according instrumental rationality was addressed.
Yet, as we were looking to bridge a gap with design theories, considered as a change of paradigm, we were looking for ways in which rationality could be preserved and still extend decision-making with design theories without falling in the trap of leaving model-out-of-domain phenomena to dispositional variables such as irrationality or constructs determined by ad-hoc phenomena such as Bourdieu's *habitus*. One could refer to the books of Christophe Morel on absurd decisions, and the works Nils Brunson for their perspective on irrationality and absurdity. However, the researcher was more inspired by the works of Richard Bronk on the importance of imagination and creativity in markets (Bronk 2009) as a means to propose extensions and deep revisions of outdated models of Thought explaining Reality.

> The last two paragraph led to an article presented at the International Conference on Engineering Design (Le Glatin, Le Masson, and Weil 2017a) and to a parallel submission to CERN IdeaSquare Journal of Experimental Innovation (Le Glatin, Le Masson, and Weil 2017b) (see appendix A2).

**Strategy management and politics of decision-making -** Similarly, studying the role of strategy-making, strategy-as-practice, encouraged the researcher to find ways of formalizing decisions in a different way. The works of Crozier, Fredberg, Pettigrew, Sfez were key to test other frameworks were the role-playing is mobilized. The researcher discussed with Laurent Simon, who referred also to Laure Cabantous for further debates on decision-making and emergent strategies. The difficulty for the researcher was to make

sense of the observations. Some of decisions taken were not coherent with the course of action or beliefs. Violations of rationality axiomatic could be highlighted but as the outcomes were mitigated and questioned utility and performance, a different model was to be found to add details to known phenomena or substantiate anomalies in a novel model. A turning point was reached with a detour through the literature of routines and organizational ambidexterity. Indeed, stimulating papers with a sociological perspective written by Fanny Simon and Albéric Tellier with the *event system theory* of Frederick Morgeson and *event-structure analysis* of Larry Griffin.

### 3.3.2 Design Thinking

As two case studies were based on the use of Design Thinking (DT) methodology, in-depth literature review was conducted to understand its origins, evolution and complementarity with other design perspectives in literature: design studies, design theories and creativity.

**Design Thinking in organizations -** The place of a creativity methods, supporting the Fuzzy Front End and a subsequent efficient NPD, has been largely studied in the past decades starting with creative problem solving, brainstorming, and more recently with Design Thinking methodology. Since it came through practice mainly, several academics starting in d.schools (Stanford and Potsdam) but also Swedish researcher centres, worked towards positioning DT with respect to engineering, creativity and innovation management and organization studies also.
However, as design in general is usually seen as a confined activity confined to engineering, or perhaps strategy, or even organizational design, several barriers were faced when trying to framing and valuing DT as part of an ecology of routines in the organization.

**Design Theory and engineering -** From the perspective of design theory, design science, and engineering, reaching out for their impact of the organization was not a easy task. But, as the field appeared more structured, it helped as reference to position DT and try to reach out for organizational issues.

**Design-Oriented Organization -** In the tradition of works of design theories and the importance of management devices in organization, embracing post-Simonian paradigm, the works of design-oriented organizations for innovative capabilities (Andy Dong, Armand Hatchuel). They place design as a generalized activity taking place at all levels of the organized, hence requiring to be carefully managed to sustain firm's regeneration.
This literature complements existing literature on dynamic capabilities and organizing for radical innovation (O'Connor, Dougherty, Leonard) but also the contributing organizational routines needed to support these: knowledge management, valuation, power and legitimacy.

The last three paragraph led to an article presented at 6th Creative Innovation Management Community Workshop at University of Potsdam d.school (Le Glatin, Le Masson, and Weil 2016). The latter was adapted after having some input of several researchers for a submission at Creative Innovation Management Journal. The paper had taken different frameworks in the literature whilst trying to bridge the difficulty to link design theory literature with organization, and catch Design Thinking in between. The editorial along with the reviewer highlighted several weaknesses of the paper and asked to resubmit.
After several months of maturation, the researcher had the opportunity to engage discussion with one of the editorial board members. Katharina Hölzle insight was crucial and we realized we are addressing the same issue despite the PhD candidate's clumsy writing. Therefore, an extended abstract had been submitted for the R&D Conference in Milano (2018), and the re-writing of a full article for the conference (Le Glatin et al. 2018) but also for a clean resubmission to CIM Journal (see appendix A1).

### 3.3.3 Organizational ambidexterity

As mentioned earlier, in the same way that the duality between market-pull and techno-push was first addressed by the research project, the researcher inquired on the model of ambidexterity. The motivation for such topic started when trying to formalize a portfolio of case studies, and projects observed at the intra/inter-BU level.

**Organizational perspective -** These projects were hard to label in the organizations. The belonging and having appropriate management tools appeared critical to interviewees and attendees of the PhD steering committees. They acknowledged that projects all along where not fully exploration nor fully exploitation. Consequently, the researcher looked for literature items that would touch upon this grey zone contributing to strategy and competitive advantage. Luckily, in recent years (2013-2015), several authors such as Tushmann, Birkinshaw, O'Reilly pointed towards the necessity to study decision-making and managerial capabilities to better understand the translation of ambidexterity at a micro-level, beyond top management and environment perspectives.

**Exploration vs. exploitation of routines -** Since ambidexterity can be approached in two main different ways. Besides the organizational one, the other stresses the nature of routines and they should be coordinated in a global way for organizational learning. In 1991, March's proposes a more behavioural approach by considering problem-solving, theories of choice, evolutionary theory and information-processing. This echoes the decision-making issues mentioned earlier with an *a priori* irrationality.
The cases encouraged to conceptualize the possibility of switching between modes, but also to find a middle ground avoiding the dichotomy. In other words, a new kind of rationality

where absurdities and anomalies can be resolved, hence blurring the artificial separation between exploration and exploitation or even forcing them to be over a same continuum.

**Project Management -** Finally, during the last stretch of the PhD journey, we reached out to project management literature. Recent research on exploration project management and the role of the unknown in such situation, have amended the literature with new ways of addressing the tension between exploration and exploitation. The works of Loch and Lenfle are now a cornerstone in the field. Since the organizational studies were key for the research, naturally we were drawn towards the role of matrix organization, adhocracies, and more generally temporary-based-organization in the field of project management. It was a means to loop back with organizational design and by which means the organization supports these projects: resources, routines and dynamic capabilities.

> To test the understanding of the literature and its limitations, the researcher also engaged in a critical presentation during a PhD Seminar (June 2017) encouraging to clearly position the analysis and explain how the described phenomena differs from the literature models. It was a turning point in the journey since it encouraged the understanding of presented anomalies and design of a new model resolving them. The notion of *decisional ambidexterity* was clarified and extended also with the contribution to European Management Review article (Le Masson et al. 2018) (see appendix A4).
>
> In addition, a full article was sent to EURAM 2018 Conference (Le Glatin, Le Masson, and Weil 2018) (see appendix A3), a synthesis for the Doctoral Colloquium was submitted. Finally, another working paper will be submitted to future conferences (see appendix A5).

## 3.4 Paper writing and case studies

The several discussions, debates and literature reviews were key to formalise reasoning into several papers. These are summarized and reformulated here in the manuscript and can be extensively consulted in the Appendix. The associated case studies are briefly presented in the following chapter.

In the previous methodological sections, we have explained the intent to demonstrate an anomaly. Three papers were written for this common objective with different streams of literature. They are based on three major cases representing the variety of innovation management. These are presented in Table V.1 (p.205).

Then a theoretical paper offers a model to reconcile with the anomaly. Compared to published version (appendix A4), we propose in this manuscript an extension that is then discussed in the last paper of this thesis (see Table V.2, p.206).

# 4 Role and position of the researcher - Intervention Research

In this section, we explain what were the activities and relations of the researcher but also employee of the firm. We explain the mission of the Innovation Direction and how the researcher took part in it. We also cover daily activities, main drivers of integration with respect to the management issue at stake in the research project, and peculiarities.

## 4.1 Being part of the Innovation Direction

The Innovation Direction was created in 2013, following the creation of the Zodiac Scientific and Technical Council (ZSTC) by Thierry Rouge-Carrassat. He had been in charge of engineering departments and the general management of business units. In parallel, several discussions with the Group Human Resources benchmarked how Research & Technology or Research & Development was organized. Among the surveys, it was decided to establish an "Experts Career" program that would value technical careers besides the traditional management one and the program management (ZA-H-5003 Expert Technical Career Path Standard). This dual ladder model (Allen and Katz 1986) was largely inspired by the car equipment manufacturer Valéo. Thierry Rouge-Carrassat had also previously established a dedicated R&T within business unit.

The CEO, Olivier Zarrouati had decided to create a Group Technical & Innovation Officer, and Thierry was offered the opportunity. With the support of a consulting firm, management tools were introduced to offer BUs means of managing the nascent dedicated R&T activity. Previously, these were part of more traditional engineering activities designing products for client demands, but induced high risk. A separate process and structure was proposed to mitigate risks between an upstream/exploratory set of activities compared to more downstream/exploitative ones taking place in client programs (new product development).

The management tools consisted in what is almost a standard for aeronautics after having being one for the Department of Defence in the United States of America: Technology Readiness Level and Technology Road maps (Mankins 2009). Airbus and Boeing, in addition to the institutions such as public funding schemes, certification authorities have been in the past decades gradually introducing the concept of technology readiness assessment in 9 levels. Some discrepancies between scales can sometimes be observed such as Boeing's being longer one (see Boeing's procedure PRO-5157 - Technology and Application Readiness Criteria (Issue March 21, 2007)).

| Level | Definition |
|---|---|
| TRL1 | Scientific research has resulted in the observation of basic principles for a given concept, these begin to be translated into more applied R&T. |
| TRL2 | Technologies are identified for a given concept, and more than one application/environment is identified. Still speculative, no experimental proof or detailed analysis to support the conjecture. |
| TRL3 | Applied research is initiated. Analytical studies to set the technologies into given environments, and lab based studies to physically validate predictions = proof-of-concept. |
| TRL4 | Elements must be integrated to establish that the "pieces" will work together to achieve concept enabling levels of performance for the system. Low-fidelity, lab environment |
| TRL5 | Fidelity of the elements being tested increases significantly. They must be integrated with reasonably realistic elements for testing. |
| TRL6 | A major step in the level of fidelity of technology is demonstrated. A prototype is tested with the actual whole system application or only similar to the planned application but with the same technologies. |
| TRL7 | An actual system prototype demonstration is expected in a operational environment. The prototype should be near or at the scale of the planned operational system. |
| TRL8 | True system development, and full integration. |
| TRL9 | The system is fully operational and in-service, it may included some final fixes if applicable. |

**Table IV.8:** TRL scale definition - DoD/NASA and ZA-Quality Standard 1090

### 4.1.1 Mission definition

The researcher arrived in late July 2015 in the newly created team: a CTO delegate for the Americas from the start in early 2014, the Director of Intellectual Property had been recruited in October 2014 and the Director of R&T European funded programs in May 2015. An additional member was delegated at the Institute for Technology Research in Toulouse (*IRT Saint-Exupéry*) in charge of the department of Electrical Systems. In the following months, an experienced project manager would be hired to take care of a national program for metal additive layer manufacturing, joined by a PhD candidate based in an university laboratory in Orléans (*Ecole Nationale Supérieure de Mécanique Aéronautique*). The team was rather young in the group except for the CTO and the one based in Toulouse, we were then all discovering the intricacies of the group. We would share a lot of information and thoughts on what we would discover as we held meetings across business units.

In December 14, 2015, team's mission was defined, despite all being already being autonomous in their functions (project management, patent management, funding and R&T management support):

- Lead the development of a long term technological vision with associated tools & processes
- Manage efficiently the expertise and IP, develop relevant internal & ex-

ternal partnerships and secure funding to ensure a sustainable road map

- Lead the development of a long term technological vision with an associated sustainable road map
- Manage efficiently the expertise and IP, develop relevant internal & external partnerships and secure funding by applying required tools & processes

### 4.1.2 PhD Candidate in Innovation Management position

The researcher would report to the CTO as he would potentially benefit from the feedback from field work, analyses and model creation and testing. Bi-weekly meetings were organized to keep track of what the researcher was conducting, and potentially answer to his questions and test hypothesis.

On several occasions, the PhD Candidate took some of the CTO's tasks. These were quite varied but all served the research project in some way or another. The table IV.9 offers a glimpse of the different activities (see below).

| Activities | Description |
|---|---|
| TRL procedure | *October-January 2016* - Support Zodiac Seats France to implement the TRL assessment procedure and the management of technology handover between R&T and Development Engineering activities. Appropriation of the definitions given in the existing group procedures was mandatory and required further details and adaption to the local engineering context.<br>The several workshop days organized for the R&T and Development Engineering departments helped the identification of a case study. Frequent discussion with managers for innovation management related issues, led to providing a training session on Innovative Design methods. |
| ZAOS Program Management | *March-July 2016* - Within the Zodiac Aerospace Operation System launched in 2016 as part of the Quality Management system. It established a common baseline for all business units to support program management activities. Several workshops were held by Operational Excellence team and the researcher contributed to stressing the link with R&T activities.<br>It was also the occasion to get to know several other program managers and directors from across the firm and gain familiarity with the program management activities |
| Strategy Management Review | *June 2016* - A review for the Cabin Branch on Technology and Product Roadmap was scheduled and the researcher represented the CTO to collect feedback on ongoing projects and communicate messages from the CTO |
| ZAOS Develop & Sustain | *November 2016 - March 2017* - In the same way to the Program Management process, the parallel and supporting process of Developing and Sustaining products and services was defined. A baseline was created for all BUs and the researcher took the responsibility during workshops to synthesize, challenge and write the "Design & Develop" process.<br>It was a key turning point to be fully comfortable with the processes and BU practices. The experience contributed to clarify the understanding of the decision-making process and *rational myth* for development engineering activities. |
| CORAC meetings | *November 2017 - February 2018* - For a topic related to connectivity and aircraft operations, the Council for Research in Civil Aviation (*Conseil pour la Recherche en Aviation Civile*), the CTO invited the researcher to follow-up on these meetings where the main French aeronautical firms propose projects contributing to the given topics.<br>Besides representing one of the only company relevant for aircraft cabin equipment, the content of the meetings largely contributing to the understanding of how firms showcase their strategy and perception of innovation in their ecosystem. |
| ZAOS Innovate | *November 2017 - April 2018* - In a similar way to Program Management and Develop & Sustain processes, a new set of procedures were defined to fit the ZAOS framework. The researcher took the lead of the activities dedicated to technology roadmaps and innovation management, to propose extensions of earlier versions of procedures based on the case studies analyses and research journey. |
| R&T Managers meeting | A colleague of Zodiac Interconnect Europe launched a series of meeting dedicated to share practices, issues and knowledge on technology domains for R&T managers based in France. The researcher participated to these meetings to discuss their topics, present and test hypotheses built during the last year of the PhD journey. |

**Table IV.9:** Tasks not directly related to the research project

## 4.2 First steps and gaining autonomy

From August to November 2015, the time was dedicated to gain acquaintance with several business units, understand the purpose of the Technical and Innovation Direction, as well as try to reveal potential *open management issues* for case studies supporting the research project.

### 4.2.1 Being introduced by the CTO

The first month was fully dedicated to open discussions with several managers (engineering, marketing, sales), technical experts and project managers part of the middle management of BUs across the group. Meetings were held in the corporate headquarters in Plaisir where several BU representatives have offices, as well as several other video-conferences. The CTO had sent an email introducing the researcher's PhD project to the ZSTC community, as well as key experts and managers who have a rather dense network within their business unit or across others. In total, 15 employees were consulted. Not all of them contributed equally to data collection. They were from 8 different business units all from middle management and Direction committees.

The researcher received a warm welcome from all interviewees who were curious in finding what he could bring to their daily concerns. As these first meetings were quite open, the setting was about having them tell stories about their work, their projects, difficulties, good practices and general management topics. They were in a favourable setting to disclose valuable signals feeding a *feeling of discomfort* guiding the *rational myth* sensing.

### 4.2.2 First intervention: TRL assessment tool

As the researcher was gradually being identified, recognized in the R&T community, the R&T Manager of Zodiac Seats France (ZSFR) reached out for support on the implementation of the TRL assessment, before reconsidering the TRM structuring. The request originated from a demand of funding scheme who steers carefully the progress of portfolio of projects. TRL targets had been given and several debates occurred on the understanding of their definitions, so they needed support on providing accuracy to definition baseline given in the ZA procedure and justify the TRL assessment through a proper tool.

Four workshops were organized with the support and input of the CTO for the first meetings. The researcher had benchmarked several business units beforehand following the round of open interviews, and other aeronautical firms for examples of TRL assessment use. Based on the latter, a draft created by the researcher served as a basis for discussions with R&T stakeholders at ZSFR to propose an update TRL assessment tool.

A by-product of this intervention, a new ZA procedure was re-issued to share the updated baseline definition with detailed tool to support other BUs. The TRL was seen as an evaluation and not necessarily associated with gates to be passed. Such perspective fed many debates on the maturity assessment of systems or designs since technologies would be integrated in a given product at some point. Thus, it also encouraged the revision of the complementary procedure on *Technology Roadmap definition, creation and sustaining* and its articulation with Product Roadmaps.

Subsequently, the relationship established with the business unit led to the identification of a case study on the engineering of a modular platform for business class seat (see case description p.198).

### 4.2.3 Master courses for literature frameworks

In parallel to the Zodiac Aerospace integration, during the months of September-October, several courses were taken in the Design Engineering curriculum of Mines ParisTech organized by the chair of Design Theory and Methods for Innovation to confirm learnings on design theories, innovation management, epistemology of management sciences and organization studies.

These courses were taken in the perspective of gaining robustness over certain topics related to the *feeling of discomfort* originated from the open management issues faced during the first set of open interviews. It was also a means of trying different *set of logics portraits* to explain first batch of observations and further observations through *intervention and interaction* in the form of case studies.

### 4.2.4 Surveying BUs for topics

As explained briefly, a first intervention was the opportunity to identify a first case study at Zodiac Seats France on the engineering design of a modular platform of business class seat. The rest of case studies were mostly identified following the first interviews and validation with the CTO. He played an important role in challenging the interest of the case studies and serve as liaison with the managers at stake.

For instance, the case identified at Zodiac Sensing and Systems Management (ZSSM, former Intertechnique, and now called Zodiac Fuel and Control Systems) came around as the CTO proposed to study a case of a technology developed from scratch, above TRL6 and about to be integrated in a Boeing aircraft program. The intent was to study a case of success despite numerous difficulties along the way. A first interview was set with the R&T Manager. The history of the project was told, but the narrative did not reflect anything special besides collaboration issues with Boeing and unfavourable conjecture due

to commercial litigation concerning other ZA business units. However, the manager had mentioned another potential case study he quickly presented. The researcher looked for feedback from the CTO and concurred to the idea that this other case would perhaps reveal more stimulating management issues than the bumpy road of the other project's trajectory. Another interview was set to dig deeper and try to grasp the manager's motivation (see case description p.197).

In another case, the CTO introduced the researcher to the Airbus Development Team for on-going projects and invited him to several other meetings held by the Executive Committee to follow up on the concepts, projects and several debates related to the activity domain and associated innovation management issues (see case description p.200).

The regular attendance to Executive Committee meetings for strategic technologies and product/service concepts (see case description of Multi-BU meetings p.203) also led to the acquaintance of other managers who had a deep interest in understanding the performance and success of their ongoing projects (see case description p.202)

The CTO's guidance through bi-weekly meetings focused on discussing the researcher's analysis, modelling, and collected data. These interactions were key for the research trajectory in addition to the autonomy of the researcher having built his relations/network across business units.

### 4.2.5 End of PhD and autonomy

During the second half of the PhD, as several case studies were ended but required further analysis and modelling, the researcher had already established regular contact with several R&T Managers or Director of Engineering. Naturally, the researcher was requested for his contributions to TRL assessment and TRM definition, as well as procedures written for the Zodiac Aerospace Operational System (ZAOS) (see Table IV.9).

Nonetheless, the researcher was gradually acknowledged among these managers for his input on innovation management. For instance, the case study and intervention for Zodiac Oxygen Systems Europe (ZOSE, see section 3.1.1) was proposed by the R&T manager. He had started an internal program to anticipate evolution and disruption of pilot oxygen masks to complement the benchmark made by the marketing department. Creativity sessions were considered and the researcher assisted the R&T team to organize them and capitalize on the design efforts made as well as with the evaluation. In parallel, an internal open innovation challenge had been organized by the ZSTC, of which one topic concerned the comfort and functions associated to the pilot protection against the risks of hypoxia. Consequently, the researched helped transcribing the open innovation outcomes into an innovative design mapping based on C-K theory.

Furthermore, the initiated program was carried on and partially translated into an answer to a call for partners in the European funded program: Clean Sky 2. Airbus was leader of the topic reviewing the future pilot oxygen mask. A team was put in place at ZOSE and started designing concepts dealing with the ill-defined problem presented in the program. The researcher was invited again to help formalizing the efforts made and explain their design process. The challenge was to gradually explain how to address highly uncertain and unknown parameters in their design process and discussions with the principal partner/client (Airbus).

The researcher was called to provide internal training, recognized by HR department, for the R&T department of Zodiac Seats France. The training consisted in an introduction to design theories, design regimes and a workshop to practice. Another example, during the PhD writing, the researcher had the opportunity to contribute to an innovative design initiative at Zodiac Electrical Power Systems. Beyond the design issue, in the same way as in the ZOSE case, the researcher intervened and tested models based on his research, as part of the process of testing the *set of logics* and the *change process*.

## 4.3 Advantages and risks of intervention research for the study

The position of the researcher, as an executive PhD given the CIFRE convention, exposed him to valuable insight on open management issues but also some potential *contamination* of data collection.

### 4.3.1 Catching CTO's political influence and complaining

Being hosted at the Innovation Direction and studying the topic of innovation management opened many doors in business units and corporate meetings. It was quite easy to gather information during the first round of interviews and the subsequent interactions with engineers, designers and managers, as well as interventions in business units.

On some rare occasions, some interviews were hard to manage as the speech being held was very negative (complaining). The dialogue had to be redirected towards proposing solutions, alternatives or different management philosophy to deal with. And sometimes, the closeness to the CTO was tentatively tried to put a word or find backup. Of course, these are dimensions of daily life in organizations and reflect a certain situation, but for the role of the researcher, it can complicate the activity of separating a clean analysis from one that is contaminated by potential superfluous details. For instance, the question of irrationality and absurdity of decisions or lack of understanding of strategies of some managers were hard cases that could have been quickly put into the quarantine of useless collected data. Yet, the role of the researcher is to propose hypotheses, new models that can explain Reality and be predictive in some way.

### 4.3.2 Being consulted for multiple and varied topics

As mentioned, in a previous section on gaining autonomy, the researcher had new opportunities to study cases, following Jacques Girin's "opportunistic methodology" and also introduced in the comprehensive methodology as expressed by Hervé Dumez.

For instance, as new procedures had been written by the researcher for the TRL assessment, the Internal Audit Team quite often relied on him to provide appropriate recommendations to BUs. It was the occasion for the researcher to bring additional information when interacting the concerned R&T manager and try to probe the field in search for critical events, shifts in their speech, or simply new projects catching one's attention: new design/technology embarking a organizational change.

# 5 Chapter synthesis

In this chapter, we have presented the research journey over the last three years. We covered how intervention research was implemented at Zodiac Aerospace emphasizing the different movements of participating to the firm's activities, studying them and also gaining in reflexivity with academic activities including meetings, seminars, presentations, conferences and article writing.

Besides the overarching research methodology, the literature review highlighted several limitations and potential anomaly which were partly confirmed through several interactions and difficulties faced by the researcher in his academic interactions. We proposed how to address the anomaly and the associate effort to name and model the novel phenomenon. We put to the fore descriptors and synthetics models (adaptive, interactive and encapsulated) to instrument the anomaly detection.

Finally, we have also indicated several other activities of the researcher in the firm and how fruitful the environment and interactions were to facilitate the original research agenda and disentangle the *open management issue* with colleagues concerned by the topic.

# Chapter V

# Presentation of the research field and justification of case studies

In this chapter, we start by presenting the aviation industry market and specially the context of equipment manufacturers with current challenges for this ecosystem (section 1). We insist through its history the nature of constraints, their formalization and how the industry professionalized over time.

Then, we continue by introducing our research ground and the specificity of Zodiac Aerospace and how relevant it is for our research questions (p.187). The organization structure of this conglomerate of SMEs and history of acquisitions is described in order to provide enough context for the reader to grasp engineering and marketing challenges.

Finally, we will briefly present the selected cases (section 3) before diving into the analysis in the following parts 3, 4 and 5. We explain the contribution of each case to our research methodology and to article writing.

# 1 Aviation industry market

The aviation industry started off with many successful and failed attempts since the eighteenth century. It is only after the 19th century industrial revolutions that investors and influencers started promoting the development air balloons, Zeppelins and gliders along with engine-powered aircrafts.

In this section, we develop the establishment and evolution of this market, the challenges associated with product development, its perspectives, and the position of a large equipment manufacturer such as Zodiac Aerospace.

Sources used for this section range for courses taken by the researcher during his studies in aeronautical engineering (ISAE-SUPAERO), the Museum of Conservatoire National des Arts-et-Métiers, public domain documentation (Airbus/Boeing market forecasts and EASA/FAA documents) and internal documentation provided by the communication office of Zodiac Aerospace.

## 1.1 A global sector for an increasing traffic

### 1.1.1 Pioneering, establishment and consolidation

It is usually recognized that the first flight of a fixed-wing powered-aircraft was the *Éole* in 1890, developed by Clément Ader with the support of the Péreire family - who had previously financed part of Hausman's renovation. His works were an application of discoveries and theoretical models formulated earlier in the century by George Cayley (first fixed-wing glider and formulation of drag and lift forces and the usefulness of cambered wings[1]).
The French Military Ministry had gained interest in his engineering efforts who encouraged further experimentation with the support of the ministry's engineering departments, a council of professors and the establishment of a school of "*aircraftery*"[2].

The subsequent developments led to *Avion II* and *Avion III* (see Fig.V.1), the army had plans for observation and bombing. Several experiments were conducted to master the aircraft. However, with the crash of *Avion III*, the difficulties to explain what lessons could be drawn, and the secrecy imposed by the Army, left C.Ader without any further financial support to continue the trial-and-error process started. As explained by himself in his book (Ader 1907), he may have started too early and it would have been preferable to work publicly. It then abandoned the legacy of the *Éole* and his larger project of contributing to the National Defence through the founding of a school for aviation.

[1] see his treatise *On Aerial Navigation*, 1810

[2] *Ecole d'Avionnerie*: see for instance the letters exchanged between Clémenter Ader and Generals Billot and Laurent in (Ader 1907)

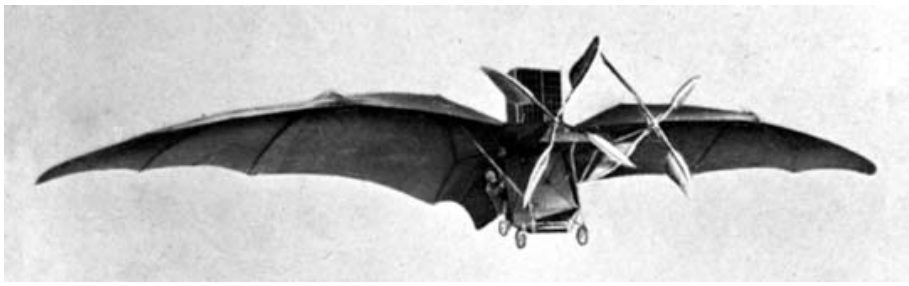


**Figure V.1:** Clement Ader's *Avion III* in 1897

Clément Ader's project would be fulfilled later by Colonel Jean-Baptiste Roche when creating the Superior School of Aeronautics and Mechanical Construction in 1909, now known under the name of ISAE-SUPAERO (Toulouse)[3]. But another trend had gained more visibility in parallel to development attempts of rotating/fixed-wing aircrafts: hot air balloons had been developed starting in 1784 with the *Intrépide* flying over the Versailles castle with Montgolfier brothers[4].

Several "research companies" (*Société d'Études*) were established to develop airships with the support of investors (a key venture capitalist at that time was Henri Deutsch de la Meurthe), politicians, and academics from different institutions (Aéro-club de France, Science Academy, Engineering Schools such as Mines ParisTech, Ecole Polytechnique and St Cyr). For example, here are a few key names: Grands Ateliers Aérostatiques du Champ-de-Mars by E.Surcouf in 1880, later renamed Société Astra who would manufacture Wright brothers' aircraft under licence and Société "Mallet, Mélandri et de Pitray" in 1896 (later named Zodiac in 1911)[5]. They had an industrial vision for these applications that were the hype in that time in World Exhibitions. Along with air races and numerous experiments, applications for the Army and Transportation were also targeted as use cases. They had been validated for instance during the American Civil War with the Union Army Balloon Corps[6].

[3]For more details, see the history written by Claude Rosetti: `https://www.isae-supaero.fr/fr/isae-supaero/Institut/hisis-l-histoire-illustree-de-nos-ecoles`

[4]First flight with animals in front of the court of Louis XVI in Versailles on 19 September 1783; and first manned flight with Jean-François Pilâtre de Rozier on 21 November 1783 over Paris by the Castle of La Muette for the crown prince: Louis XVII

[5]We must specify here that in 1909, Maurice Mallet *et al.* developed a standard biplane that flew over 70km on December 9, ten months after Blériot XI crossed the English channel (approx. 40km)

[6]One could even refer to the novel of Jules Verne *The Mysterious Island* where the characters escape from the siege of Richmond, Virginia with an air balloon.

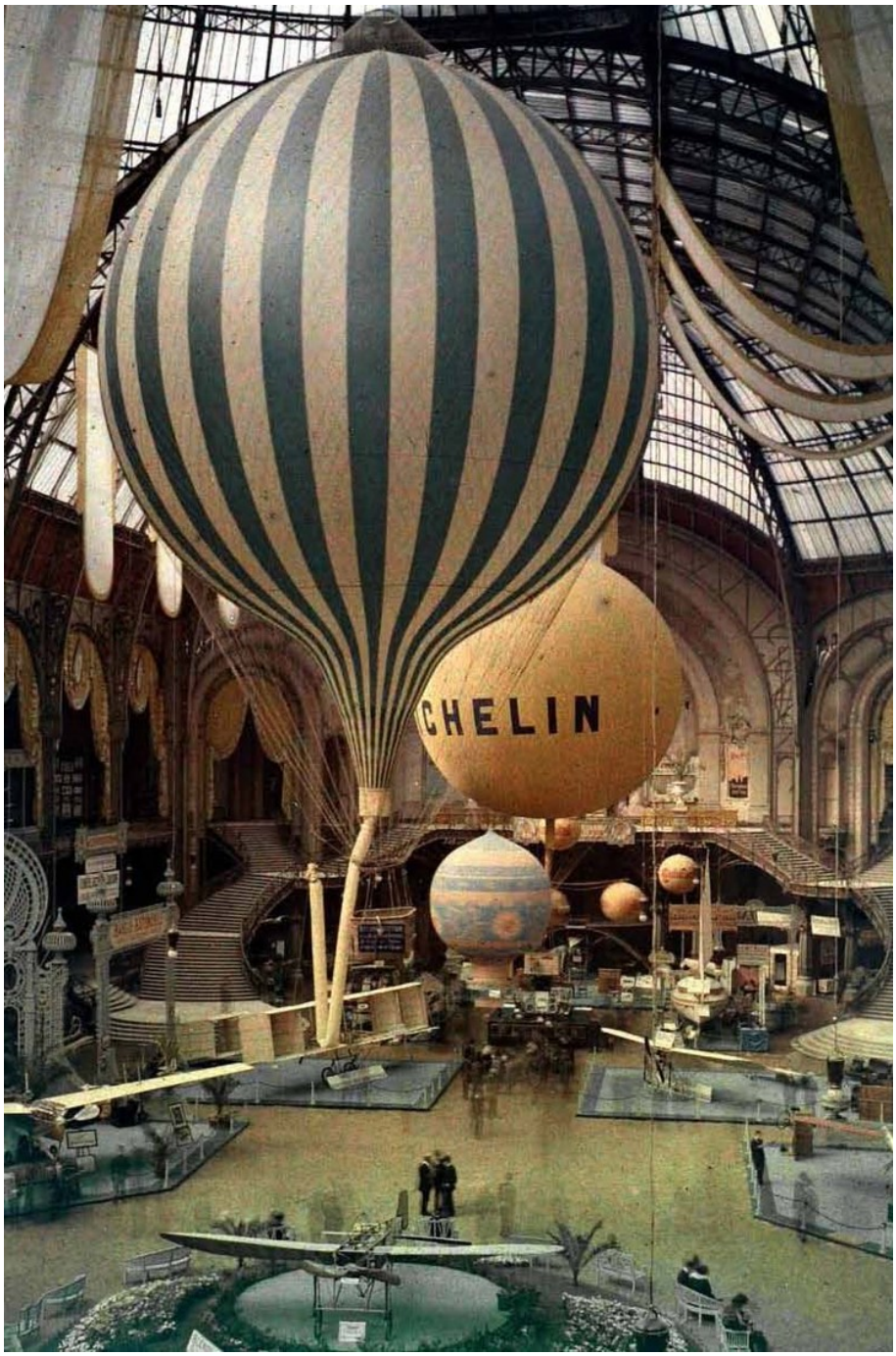



**Figure V.2:** Exposition Universelle "Zodiac" airship in 1909

Besides airships, technology transfers and alternative approaches where developed during the same period such as the effort of Alberto Santos-Dumont with the famous 14bis (1906) and Demoiselle (1907) fixed-wing aircrafts, Henry Fabre (first seaplane in 1910) and Coanda's first alleged jet engines (ducted air fan with combustion chamber in 1910), *Appareils d'Aviation Les Frères Voisin* (est. 1906, later split and integrated into what would become *Gnome&Rhône* est. 1905, i.e. SNECMA/Safran Aircraft Engines) and

*Blériot Aéronautique*, a constituent of today's Airbus along with former Dassault Aviation (*Société des Avions Marcel Bloch*, est. 1929) who had merged with pioneering work of *Bréguet Aviation* (est. 1911).
Of course, the list is not exhaustive, but we would like to stress the numerous links tied by inventors and investors across several decades of experiments, partnerships and industrial settings. And similar stories could also be presented in other countries of Europe and North America.
The frenzy was also channelled by the founding of companies such as *Compagnie générale transaérienne* (est.1908 by Blériot) *Compagnie des Messagers Aériens* (founded in 1919 by Bréguet, Blériot, Renault and Caudron) and *Compagnie Générale Aéropostale* (est. 1918, by Pierre-Georges Latécoère) who created a market to sustain an emerging industry besides military applications. The former would then be acquired by growing competition, mergers to become Air France for instance.

The premises of the aviation industry was a collective effort of engineering where a dominant design was gradually established discarding airships for reliability issues. Different architectures with engines moving from the back (pusher) to the front of the fuselage (tractor), different profiles for lift and drag trade-offs ("canard configuration", box-kite) and steering/stability equipment (box-kite, dihedral, rudders, ailerons), fixed wheels or idlers, etc.

> The value of the "*aircraftery*" took decades to be demonstrated with trials made by a community of pioneers who thrived from building in parallel an ecosystem and organizations supporting their product designs: Army, influential investors, mutual investments and self investment in the creation of market (e.g. mailing and transportation), academic institution creation, learned societies, associations and federations. This is a crucial aspect to emphasize as the setting of the market was not a linear process, nor the lonely process of several pioneers who demonstrated the superiority of product design.

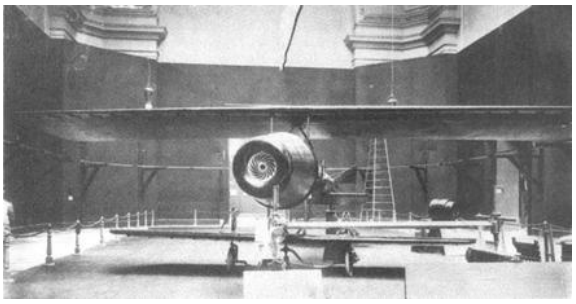
### 1.1.2 A turning point: jet age

Following major improvements made during and after World War I (WWI), the jet era would finally come to existence despite first tentative steps made by Henri-Marie Coanda in 1910. The latter being marginalized during the second exhibition of the International Aeronautic Salon in October 1910 against standard designs and persisting doubts/controversies on the actual airworthiness of the aircraft and the engine (ducted air fan or actual jet engine). The figures below show the Coanda-1910 (V.3a) versus the two dominant designs of that time: airships and unshrouded propellers aircrafts (V.3b and V.3c).
As several records would be broken by aviators (distance, time and speed), aircraft designers and manufacturers would also compete in engineering novel engines, optimising

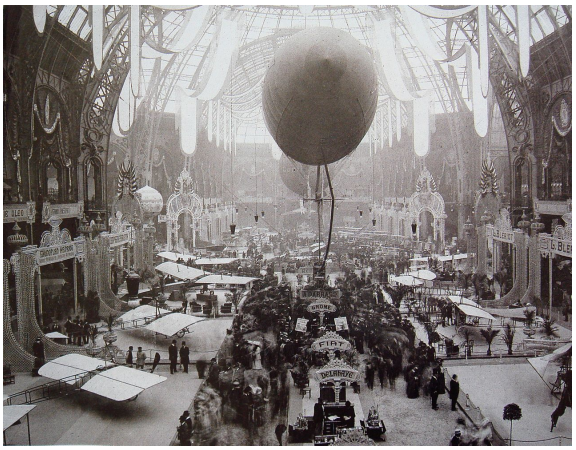
propellers, materials, in addition to wing and fuselage designs. For instance, one can recall the success of *Blériot XI* when crossing the English Channel against Antoinette aircraft, encouraging its promotion during the 1st Paris Air show (see Fig. V.3b).

Conceptual models and theoretical efforts were made by physicists and engineers building upon the earlier works of George Cayley in the 19th century. Besides the need for pilot training such as rudimentary "*tonneau Antoinette*", wind tunnels were built to formalize design parameters in addition to testing facilities sponsored by the army. For example, Gustave Eiffel wind tunnels built in 1909 in Paris (Champ de Mars) (Barr 1992; Gallant 2002) contributed not only to mechanical engineering for buildings but also to aerodynamics. Air Transportation would only start to exist with several routes of airships in North America and Europe, but with WWI bombers converted for passengers, the first airlines were created and dedicated aircraft designs such as the Farman Goliath F60 derived from the F50 bomber (see Fig. V.4). With increasing speeds, optimization of turbo-propellers, sonic speeds can be reached at the propellers tips, so shrouded configurations can be beneficial encouraging the development of ducted-fan and then turbofan, a kind of jet engine.

Advancements in jet engines became a major architectural innovation for heavier-than-air aircrafts (Henderson and Clark 1990). It sets a milestone in the development of long haul flights and commercial aviation. It would be hard to say that it was unexpected for established industrial players. However, it raises the issue of perception and cognition of change in product design (incremental, radical, architectural and modular) and the ecosystem deals with the emergence of this shifts.



**(a)** Fig1



**(b)** Fig2

**(c)** Fig3

**Figure V.3:** First dominant designs before jet-era

The onset of the jet era occurred with the commercial aviation intensification, flight routes tailored supporting a wider phenomenon usually dubbed "globalization". Distances are shortened, leisure is democratized for wider categories of population, with major emphasis put on the efficiency of engines for airlines operations.

The frequency and variety of aircraft missions across the globe also raised numerous evolutions for safety and robustness. Redundancy is the baseline for most aircraft systems (operational). Several other architectural innovations can be listed in the evolution such as the elimination of the Flight Engineer in the cockpit as a side-effect of development of electronics and digital commands.

**Figure V.4:** Farman's F60 aircraft for 12 passengers in 1919

## 1.2 Market order and segmentation

### 1.2.1 Major players and market organization

The market is mainly organized by aircraft manufacturers who integrate the systems and equipment (co-)designed by suppliers. It is hardly impossible to avoid the prescription mechanisms associated to Boeing and Airbus, and marginally by Bombardier, Embraer and increasingly Irkut and Comac. Several mergers of engineering services and manufacturers consolidated what Boeing and Airbus are today. For instance, Boeing absorbed McDonnell Douglas, Airbus is the result of the merger of Sud Aviation and Nord Aviation to become first Aérospatiale. Forces were joined, redistributing the roles of among historic roles: airframers, structural part engineering and aircraft integration.

Overall, the market can be seen as an oligopoly for systems and equipment manufacturers. The whole being layered to meet the integration requirements of the aircraft manufacturer. See Fig. V.5 for further details.

**Figure V.5:** Schematics of market organization

After numerous series of mergers and acquisitions at all market levels, the number of players has reduced drastically. This consolidation has put a certain order and hierarchy in market relationships, encouraging players to by-pass some players to gain insight.
One can refer for instance to the mapping built by Grundman Advisory from 1993 to 2016. A few more can be added such as Safran acquiring Zodiac Aerospace and United Technologies Corporation (UTC) with Rockwell Collins (who recently acquired B/E Aerospace). The very large mapping (pdf format) can be accessed on Grundman's Advisory news section: *Aviation Week publishes Grundman Opinion, "A map of aerospace mergers and acquisitions"*[7].
Given this context, airlines undergoing changes in demographics, population displacement, market design (e.g. hub structure) have evolving requirements for aircraft missions: longer routes, multiple stopovers across a continent, low maintenance etc. The aircraft manufactures perform a preliminary proposal to meet their key customers (major airlines).

Aircrafts can be categorized in now three groups: short/long haul, and currently business magazines tend to introduce the concept of "middle-of-market". Below, Fig. V.6 shows along two *performance criteria* the three sets of aircrafts. Despite visual and alleged similarities between short/long haul aircrafts, physics, design rules and systems' architectures do not allow a simple rule of three. Aircraft programs are spanned across roughly a decade in average (from the early designs to first delivery) mobilizing several suppliers in a co-development process and requirements cascaded down along the hierarchy of product/service design.

[7] `http://grundmanadvisory.com/?news=aviation-week-published-grundman-opinion-a-map-of-aerospace-mergers-and-acquisitions`

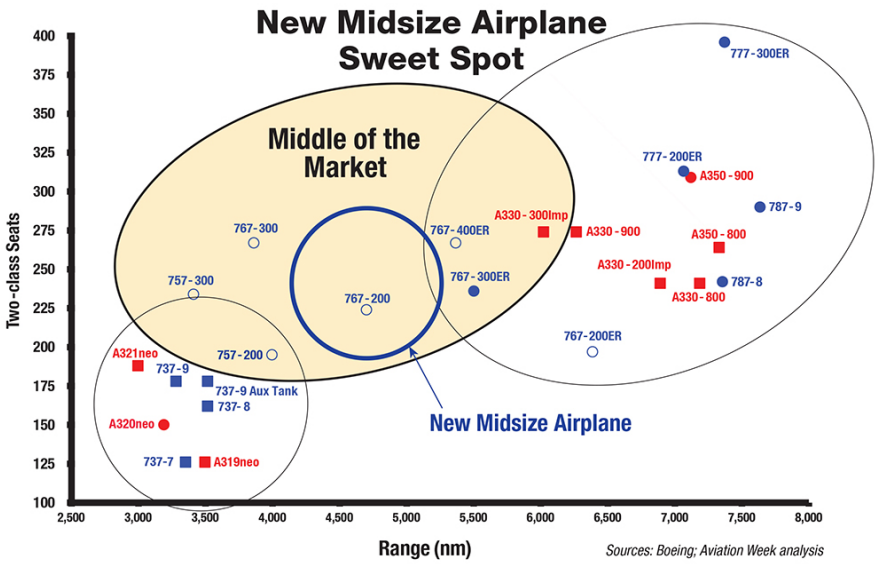



**Figure V.6:** Aircraft Market Segments

Among suppliers, as most players are conglomerate of SMEs, these follow in broad strokes the perimeters given by the ATA chapters (Air Transportation Association). The classification is originally intended for engineers and technicians performing repairs and maintenance duties on aircrafts. Aircraft systems are covered from ATA no.20 to 92. For example, ATA 44 corresponds to Cabin Systems, where one can find the following sub-systems:

- 44-00 General
- 44-10 Cabin Core System
- 44-20 In-flight Entertainment System
- 44-30 External Communication System
- 44-40 Cabin Mass Memory System
- 44-50 Cabin Monitoring System
- 44-60 Miscellaneous Cabin System

As one can see, it does not cover for instance several "monuments" found in the cabin: seats, class dividers, lavatories, galleys, etc. ATA follows a system architecture description and the cabin domain should be seen as an area sanctuarised by airline for customization and branding. Naturally, it has more players specialized equipment certified by Technical Standard Order (TSO, see below for further details).

### 1.2.2 Importance of safety and regulations

First safety regulation can be associated with a publication of the Paris Police headquarters dating from April 23, 1784. It followed the flight of the hot air balloon built by the Montgolfier brothers in late 1783 for King Louis XVI at Versailles castle:

> *It shall be unlawful to manufacture and lift off balloons and other aerostatic machines with heaters using wine spirit, fire crackers and other flammable materials and orders that all other aerostatic balloons may not take-off without permission. Such permission shall only be granted to people with recognized experience and capability...*

From the early delays, the approach to aircraft safety came as insurance for justifying on one hand what objects were safe and reliable according to a set of standardized criteria and on the other hand the how and the who required to design, develop and sustain these objects.
Despite some differences between the rules established for North America and Europe - Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) respectively - they ensure airworthiness[8] along four main domains:

- Monitoring Safety issues
- Product Certified & Checked
- Safety Rules & regulations
- Approved Organizations

These topics are declined in the certification process that is recognized with the issue of Type Certificate for the aircraft and associated scope covering critical systems and equipment (e.g. electrical power generation and distribution). In addition, almost standalone equipment such as engine have their own Type Certificate and "*less critical*"[9] equipment with Technical Standard Order (TSO); so they can be qualified and certified with a relative independence from the aircraft manufacturer.

The general process is described in the Fig. V.7 pictures the phases until the release of a form (e.g. EASA Form-1/FAA 8130-3) validating the conformity of the manufactured/repaired product given an extensive list of justification documents issued by Design,

[8]Definition: the capability of an aircraft to operate safely with respect to its crew, its passengers, on-board goods and outside environment (air traffic and other people including on-ground).

[9]Note: The reader should not consider that there are different levels of criticality but rather that in order to ease the development, qualification and certification, some equipment are not necessarily queued in the qualification process of the aircraft but as interdependencies are mastered in the integrating aircrafts the certification process can be carried "separately" even though several features are still adjusted through changes requested/submitted between manufacturer and supplier.

Manufacturing and Maintenance activities. The figure also insists on the fact that airworthiness is maintained throughout the life of the product, meaning until it is dismantled and removed from the aircraft fleet.

**Figure V.7:** Certification Process

The certification and crucial airworthiness aspect, a more technical set of requirements are addressed by system/equipment/technology/material-specific standards. These are issued by several regulatory bodies such as SAE International (Society of Automotive Engineers) issuing Aerospace Recommended Practice (ARP), EUROCAE (European Organization for Civil Aviation Equipment), RTCA (Radio Technical Commission for Aeronautics) issuing standards for instance "Environmental Conditions and Test Procedures for Airborne Equipment", MIL-STD from the US Military Standard, etc. Qualification and design processes requirements are largely compliant with these standards in addition to customer requirements.
Last but not least, the International Organization for Standardization (ISO) has greatly contributed to the standardization of processes with ISO9100 / AS9100 (Aerospace Basic Quality System Standard).

## 1.3 Challenges and future changes

The market is rapidly growing based on surveys and forecasts made by Boeing and Airbus on yearly basis. Asia-Pacific countries are greatly contributing to this trend with legacy aircrafts being retrofitted in major American and European countries despite several external shocks.

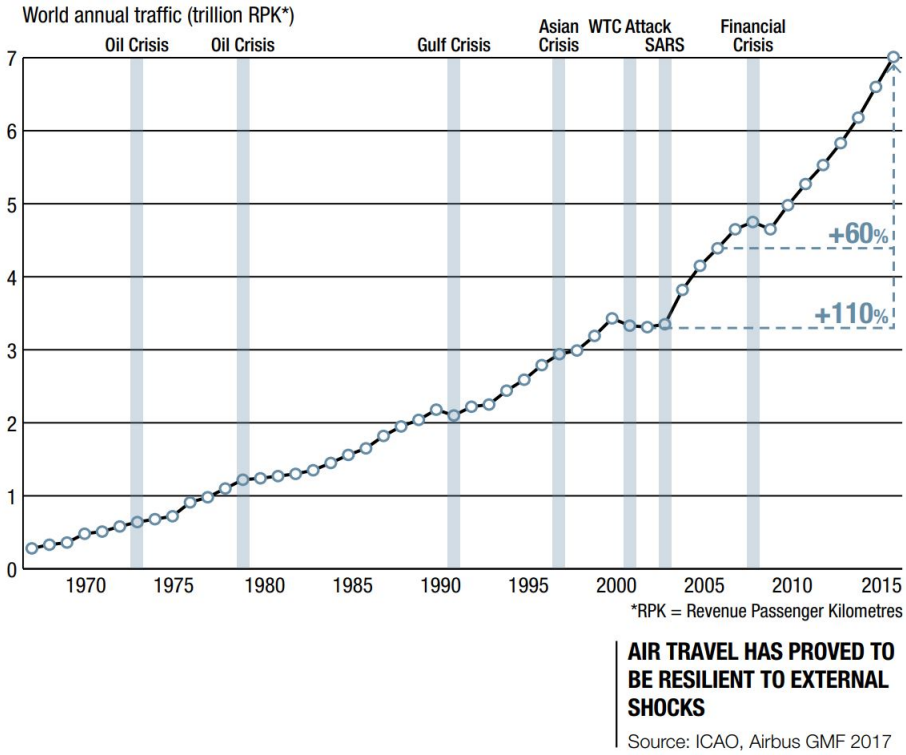



**Figure V.8:** World Annual traffic evolution - Airbus Global Market Forecast 2017

35000 aircrafts will be delivered by 2036, among which 13000 are for replacement and the rest being actual new deliveries growth. Traffic will keep on increasing with rate per annum from 2.5% between advanced countries up to 6.2% between emergent countries taking most of the traffic share (40%). Finally, several other trends can be foreseen with environmental considerations, passengers demographics and changing urban mobility.

### 1.3.1 Greener aircrafts

The rising awareness of human's activity on Earth has also encouraged the aviation industry to develop means of reducing its greenhouse effect share. For instance, from the viewpoint of fuel combustion, optimizing engines with a criteria such as number of passengers per kilometre per litre of kerosene in addition to emitted $CO_2$ and $NOx$ particles per number of passengers per kilometre. Tremendous engineering efforts were made to enhance the efficiency of the combustion chambers, engine sections (fan, compressor and turbines) and overall architecture (by-pass). These efforts are still on going with open-rotor engine. Taxiing of aircrafts could also be changed to avoid burning fuel with electrical drive in landing gears or pushback car integrated on taxiing rails.

Other architectures such as delta wing for commercial aircrafts and V-formation flight (inspired by geese flying patterns) have been imagined by industrial actors. These approaches also tend to think the overall aircraft and its integration within the airspace

and airports. Incremental innovations however can be designed by using lighter materials while guaranteeing strength. For instance, marginal improvements on wingtips or using composite materials for the skin of wings and fuselage reduce overall weight. Nevertheless, these replacement are not modular as it dramatically reduces the electromagnetic shielding required against thunderstorms or simple electromagnetic interferences. Shielding should then be improved across wirings and harnesses needed for fly-by-wire systems[10] and several other electricity powered devices.

A greener aircraft does not only imply optimization along several green-performance-indicators exploiting the dominant design, nor replacing some features, but also has a greater impact on the architecture of the aircraft itself and sensitivity to the evolutions of the aircraft integration (e.g. airport, air traffic patterns, flight route demands, etc.)

### 1.3.2 Passenger demographics and trends

Passengers through airlines interaction the evolution of the market. Passengers are more and more observed and consulted by airlines, aircraft manufacturers and equipment manufacturers. Beyond traditional satisfaction survey, creativity sessions and ethnographic observations in "labs"[11].

Currently, the expectation of passengers are changing. Let us take, for instance, the evolution of seats in the cabin. Historically, no distinction existed. Then with the gradual democratization, class segments were created: first, club and economy. The club disappeared to be replaced by the idea of a business class, with now sometimes dense business class, reducing the size of the first that aims for a hotel-like experience. These nuances should also be declined depending on culture and flight routes across the globe.

Ageing population is another concern for cabin layout including: seating and lavatories. Reduced mobility of certain categories of passengers also causes several issues for seating, movement along corridors and reaching for different cabin areas. Seats architecture and access are modified, additional equipment to assist are also designed.

So called *millenials* emphasize the rising ubiquity of (Internet) connectivity on mainland and ground transportation. Airlines have been gradually shaping the business model of connectivity with new suppliers and services providers offering solutions guaranteeing an almost continuous connectivity. From traditional shared displays hanging over seats, to seat-centric inflight-entertainment, the passengers are now also willing to connect to existing solutions: in-flight connectivity (Wi-Fi and entertainment server) supported by

[10] replacing traditional manual mechanical flight controls

[11] See for instance the experiment lead by Airbus $A^3$ in California to test their modular cabin concept for refurbished freight aircrafts called *Transpose*

antennae and ground/space relays, and active/passive displays for mirror casting personal device content or accessing airline provided content.

These novelties being transferred from an evolving society and use cases where aircraft experience may appear old fashioned. They bring numerous uncertainties to a professionalized and highly constrained engineering. New product development may then fit the given architecture but may also encourage the generation of ad-hoc solutions and reconfiguration of (epistemic) interdependencies.

### 1.3.3 Urban mobility

Finally, another major trend is the regain in urban mobility. The reducing flight times and connecting time at stopovers, has dramatically reduced distances across the globe. Combining this trend with city expansion, road and general public transportation can become saturated to point where other means must be developed. In cities of high inequalities such as Sao Paulo, helicopters are an efficient alternative to travel across the city avoid traffic jams for those who can afford. Social imaginaries tend to contribute to urban mobility effort on adapting aircraft to fly safely through the city skies. Science fiction works in literature and movies have embodied these ideas for more than a century.
However, it is gradually becoming a reality with Unmanned Aerial Vehicle's technologies developed in the past two decades. Automation, algorithmic robustness, and mastering of flight dynamics for quadcopter designs for instance were key in addressing the scaling of remote control devices to civil/military applications, and up to autonomous taxi.

In the last 5 years, several initiatives, usually referred as Passenger Drones, were launched. In China, *eHang 184* flew early 2018, in Germany, *Lilium* is being developed, in Dubai and Germany the *Volocopter* was developed and test flights were conducted, Airbus has two concepts developed in two different centres: a traditional vertical-take-off and landing (VTOL) called *Vahana*, and a modular solution combined with car *Pop.Up*. These passenger drones enable on-demand air transportation expanding the horizons of taxi fleets and personal/public transportation with safer means of flight travel that are not reachable with traditional light aviation airworthiness.

The evolution of the market order and segmentation given the highlighted trends encourage equipment manufacturers to carefully reconsider the way products and services are developed. In the following section, we develop how projects and programs are managed given the aviation history depicted previously. Its professionalization has established rules, processes and structures to support new product development which we will address at the light of several novelties, increasing uncertainties and the need to innovate, i.e. managing the unknown.

# 2 Zodiac Aerospace Innovation Context

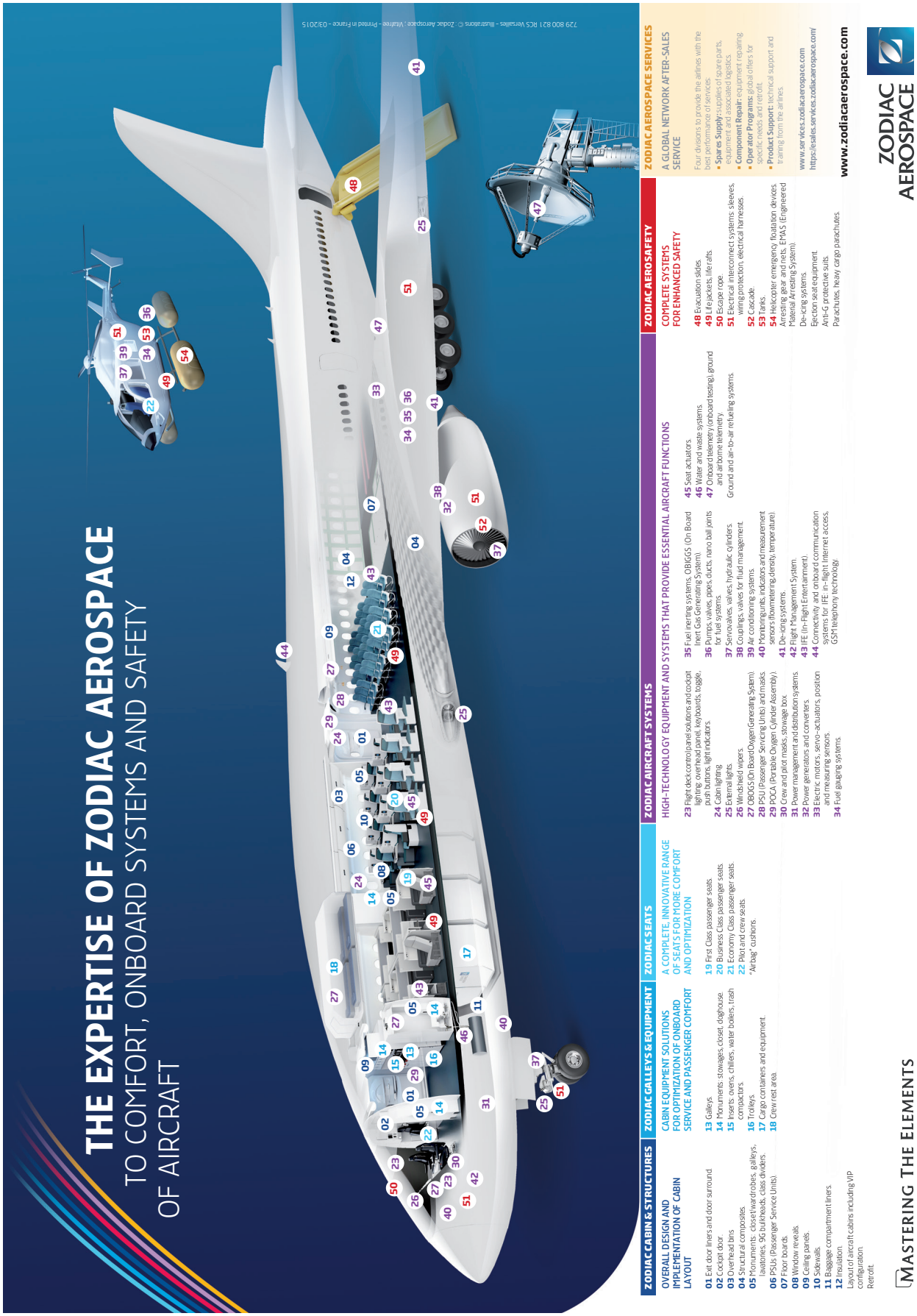
In this section, we propose to present the context of the research project offered by Zodiac Aerospace. We cover its overall organization, its history, examples of major innovations in the aviation industry and how R&T and Innovation are managed across the group of SMEs.

## 2.1 General organization: conglomerate of SMEs

The thesis was conducted at the Technical & Innovation Direction of Zodiac Aerospace (ZSA, holding). Established in 1896 by Maurice Mallet, the venture initially targeted airship and fabric engineering. It has now turned into a large industrial group of 75 entities designing, developing and manufacturing aeronautical equipment for aircraft/helicopters manufacturer and airlines. These are located over 100 facilities across the globe and mainly centralized in Europe and North America. In the last couple of decades, some facilities were established in cost-competitive countries for the serial production of some entities.

The group of SMEs where each of them, with a few hundreds employees each, equating to a total of 35,000, have their own responsibility and performance logic. A light group holding of 200 employees with several support functions have the challenge to manage the sometimes competing SMEs due to the market structures and build up synergies targeted by the executive committee. As shown in the following page, we present the variety of Zodiac Aerospace products that can be found on an aircraft. The segmentation by branches dates from 2015, but the current status is a merge between Cabin & Structures and Galleys & Equipment (now called Zodiac Cabin), and Aircraft Systems and Aerosafety (now called Zodiac Aerosystems). Most equipment is represented by a single business unit, overlap is rare between entities. For example, in the kitchen area (galley) the configuration is the following with all separate engineering departments, standards and regulations and sales channels:

- The galley structure (frame, panels and fixtures) is developed by Zodiac Galleys Europe/US
- The inserts (oven, boilers, coffee makers, bun warmers and ice containers) are developed by Zodiac Electrical Inserts Europe/US
- The trolleys designed by Zodiac Air Catering Equipment
- The lavatories are composed of the lining/decorative elements (Zodiac Airline Interior Integration) and of toilet seat and underlying water & waste systems (Zodiac Water & Waste Systems)


THE EXPERTISE OF ZODIAC AEROSPACE
TO COMFORT, ONBOARD SYSTEMS AND SAFETY
OF AIRCRAFT
ZODIAC CABIN & STRUCTURES
OVERALL DESIGN AND IMPLEMENTATION OF CABIN LAYOUT
01 Exit door liners and door surround.
02 Cockpit door.
03 Overhead bins
04 Structural composites.
05 Monuments: closet/wardrobes, galleys, lavatories, 9G bulkheads, class dividers.
06 PSUs (Passenger Service Units).
07 Floor boards.
08 Window reveals.
09 Ceiling panels.
10 Sidewalls.
11 Baggage compartment liners.
12 Insulation.
Layout of aircraft cabins including VIP configuration.
Retrofit.
ZODIAC GALLEYS & EQUIPMENT
CABIN EQUIPMENT SOLUTIONS FOR OPTIMIZATION OF ONBOARD SERVICE AND PASSENGER COMFORT
13 Galleys.
14 Monuments: stowages, closet, doghouse.
15 Inserts: ovens, chillers, water boilers, trash compactors.
16 Trolleys.
17 Cargo containers and equipment.
18 Crew rest area.
ZODIAC SEATS
A COMPLETE, INNOVATIVE RANGE OF SEATS FOR MORE COMFORT AND OPTIMIZATION
19 First Class passenger seats.
20 Business Class passenger seats.
21 Economy Class passenger seats.
22 Pilot and crew seats.
"Airbag" cushions.
ZODIAC AIRCRAFT SYSTEMS
HIGH-TECHNOLOGY EQUIPMENT AND SYSTEMS THAT PROVIDE ESSENTIAL AIRCRAFT FUNCTIONS
23 Flight deck control panel solutions and cockpit lighting: overhead panel, keyboards, toggle, push buttons, light indicators.
24 Cabin lighting.
25 External lights.
26 Windshield wipers.
27 OBOGS (On Board Oxygen Generating System).
28 PSU (Passenger Servicing Units) and masks.
29 POCA (Portable Oxygen Cylinder Assembly).
30 Crew and pilot masks, stowage box.
31 Power management and distribution systems.
32 Power generators and converters.
33 Electric motors, servo-actuators, position and measuring sensors.
34 Fuel gauging systems.
35 Fuel inerting systems, OBIGGS (On Board Inert Gas Generating System).
36 Pumps, valves, pipes, ducts, nano ball joints for fuel systems.
37 Servovalves, valves, hydraulic cylinders.
38 Couplings, valves for fluid management.
39 Air conditioning systems.
40 Monitoring units, indicators and measurement sensors (flowmetering, density, temperature).
41 De-icing systems.
42 Flight Management System.
43 IFE (In-Flight Entertainment).
44 Connectivity and onboard communication systems for IFE: in-flight Internet access, GSM telephony technology.
45 Seat actuators.
46 Water and waste systems.
47 Onboard telemetry (onboard testing), ground and airborne telemetry.
Ground and air-to-air refueling systems.
ZODIAC AEROSAFETY
COMPLETE SYSTEMS FOR ENHANCED SAFETY
48 Evacuation slides.
49 Life jackets, life rafts.
50 Escape rope.
51 Electrical interconnect systems: sleeves, wiring protection, electrical harnesses.
52 Cascade.
53 Tanks.
54 Helicopter emergency flotation devices. Arresting gear and nets, EMAS (Engineered Material Arresting System).
De-icing systems.
Ejection seat equipment.
Anti-G protective suits.
Parachutes, heavy cargo parachutes.
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A GLOBAL NETWORK AFTER-SALES SERVICE
Four divisions to provide the airlines with the best performance of services:
▪ Spares Supply: supplies of spare parts, equipment and associated logistics.
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## 2.2 A history of complementary niche strategy

Zodiac Aerospace, actually stems from the separation with Zodiac Marine. The former Zodiac Group had been expanding between seas and skies with technology transfers from air balloons to inflatable boat[12], and several other extensions playing on complementarities to expand its footprint.
The history of mergers and acquisitions, leaving aside the former Zodiac Marine group of entities, can be traced back to the seventies with EFA (Parachutes in United States) reopening the aeronautics branch as shown in the figure below (Fig. V.9). The main drivers for acquisitions, as explained on Zodiac Aerospace corporate presentation, are synthesized into five key principles:

1. Diversifying in businesses with a high technological content, through internal and external growth
2. Favouring niche markets to rapidly attain leader positions
3. Ensuring steady growth in earnings per share
4. Supporting customers over the long-term through a strong after-sales activity
5. Aligning our operations with the Principles of the Global Compact

The first group of acquisitions intended to gain stronghold in the aircraft safety systems market whilst still developing some related marine activities around rubber coated fabrics (Kléber Industries), flexible tanks (Superflexit), parachutes (EFA, Parachutes de France) and arresting/evacuation systems (Air Cruisers, Aerazur). The family shareholders' trust put in the newly appointed CEO Jean-Louis Gérondeau. He led an external growth strategy helping the financial recovery and building a strong position in the aircraft equipment market. The strategy was then extended with several other niche markets (mainly oligopoly) with high added value justified by complex engineering know-how complying with safety and airworthiness regulations. For instance, early nineties was the entry into the aircraft seating (Weber Aircraft, Sicma Aero Seat), water & waste systems (Monogram/MAG Aero and Avon) and oxygen devices as well as sensing and systems management (Groupe Intertechnique).
Overall, we have more than 40 acquisitions since late seventies which enabled diversification around the inflatable boat decaying market with sport and leisure perspectives. But mostly, the group regained a leadership position in the aircraft equipment market by federating numerous SMEs.
As told by Olivier Zarrouati[13] during an open interview in May 2018 conducted by the PhD candidate:

[12]Hence, the genericization of the Zodiac trademark, rubber coated fabric inflatable boats made also famous by military boats and the Atlantic ocean crossing of Alain Bombard
[13]former CEO from 2007 to 2017 who more than doubled the revenues and tripled the stock price

> *We scouted our environment for niches with high added value, after a selection process, we would then make sure that new business unit will be able to perform and hold its position in the market. When it comes then to innovative concepts, the trick is really to make sure they understand the value of novelty on their own and not by forcing it by top management.*

This mindset was also confirmed by a separate interview made with the Vice President of the group, Maurice Pinault, former CEO of Zodiac Marine activities.

**Figure V.9:** History of acquisitions by Zodiac Aerospace

## 2.3 Feats of engineering

The history of Zodiac Aerospace has left several landmarks in the domain of engineering. Starting the nascent airship venture, engineering know-how was developed for fabric engineering and sewing techniques. Then, when redeveloping the company in the aircraft market over less than three decades, the group developed its competencies in complex engineering for aircraft systems, and material and stress engineering for cabin equipment.

### 2.3.1 Technical fabric and associated technologies

The airship industry at the wake of the $20^{th}$ century required not only building an understanding of models of flight mechanics but being able to design, engineering and manufacture robust fabric assemblies. Standards of quality or test engineering were being gradually established. Tensile strength of a piece of a fabric was crucial but sewing techniques was an even more critical feature of these assemblies. Advanced Sewing techniques were required for overall resistance to aerodynamic forces (lift and drag) and associated designs.

With growing competition in an established market of inflatable boat, Zodiac Aerospace managed to expand these competencies with the parachute industry, inflatable boats, airbags, emergency evacuation systems (slides, life rafts) and arresting systems (nets and harnesses on runways). Several of these high skilled work can also be observed in weaving

and braiding techniques for conduits and hoses for harsh environments. The developed industry thus greatly differs from clothing industry with safety and airworthiness standards that imply a wide spectrum of physical variables (temperature, tensile in static/dynamic modes). It has greatly contributed to the unique position in a quasi-duopoly with strong commercial and technical bonds with aircraft manufacturers (Airbus, Boeing and McDonnell Douglas).

Zodiac Aerospace has dominated the market of Parachutes, aircraft arresting and evacuation systems and also part of the market associated with braided/woven products. Unique technologies were developed to remain competitive in several areas: flexible fuel tanks, open sleeves for electrical harnesses and net arresting systems.

### 2.3.2 Composites materials and cabin equipment

Early nineties, the Zodiac group had been developing the leisure and sport marine domain to expand the inflatable boat market (Zodiac, Avon and Bombard product lines). Their entry into the aircraft seating market was done through Weber company who also had several engineering and manufacturing capabilities in aircraft parts and synergies with its former conglomerate Walter Kidde and Company Inc who had sold the business to a largely diversified British conglomerate (Hanson PLC) [14]. Kidde had also a foot in the inflatable boat market during the war effort. A similar move was operated with SICMA in France, which had been developing aircraft structural part, seats and also skis and tennis rackets.

Engineering could be then developed in the domain of material engineering. Structural parts for pilot, crew and passenger seating were developed and kept leadership by meeting and developing further safety and certification requirements with authorities. The rest of the cabin would then require similar technical capabilities for stress and flammability constraints.

All cabin interiors and galley's area require qualification and certification competencies to package for instance kitchen appliances to airworthiness standards. All of which also requires to withstand severe static and dynamic mechanical testing which are complex to monitor and use for further design of assemblies and parts. Furthermore, standardization is not common in this market because of market volumes and changing demand of airlines looking for unique branding opportunities.

[14] British Owner Sells Weber Aircraft for 85 Million, LA Times, 1992, 7th October

### 2.3.3 Aircraft systems

At the end of the $20^{th}$ century, the group continued to settle its position in other fields of the aircraft equipment market. Monogram (MAG Aerospace) and Groupe Intertechnique were acquired. They had respectively developed themselves in the field of water & waste systems engineering and embedded systems for aircraft operations (computer, printed circuit boards, fuel gauging systems, oxygen masks and control systems). These two first acquisitions were a key advantage to secure market niches. Added value is accomplished through complex system engineering, functional robustness and secured certification capabilities for further product development. It was the occasion to combine engineering competencies into the creation of a business unit in the field of airbags for automotive industry with inflatable technical fabric and precise control electronic systems.

Later, these activities would be complemented by several power electronics generation and distribution (ECE, Zodiac Electrical Power Systems), wiring parts/systems and hydraulic, servo-control and ducting systems. The underlying SMEs acquired on such domains had been building their field first through components and quickly grew into engineering of sub-systems and full systems in order to cover regulation and certification domain. Several breakthroughs can be mentioned such as inerting systems for fuel tanks, oxygen regulators, or even metal fabrication in harsh environments.

## 2.4 Today's R&T and Innovation: an oddity for innovation management?

### 2.4.1 ZSTC and Experts Network

Established in 2010 by the managing director of former Intertechnique group (covering former Aerotechnique group of activities, i.e. Fuel & Control Systems and Oxygen Systems), the Zodiac Scientific and Technical Council (ZSTC) gathers engineering managers and R&T managers equally representing the variety of activities in the group. It was created for four main objectives:

- Prepare technological evolution for the decade ahead and reinforce synergies: long-term Technology Road Map were created to fit market & sales perspectives to feed product lines.
- Value technical experts across the company: expert career path created with Human Resources for engineers preferring a technical career instead of one dedicated to management[15].

[15]Note: this career path implied a more traditional management of teams until reaching managing director and escalating the hierarchical line. The project and program management was at first outlined as a comparison (Hölzle 2010) but never formalized by Human Resources. Several cross-overs would occur between programs and traditional management. The projectification of business units would somehow blur their differences despite sustaining the importance of both functions and projects in the matrix.

- Reinforce relationships with academia, start-ups, innovative suppliers and potential partners: incentives to host PhD candidates in R&T departments, collaborative research programs, *TechnoDays* seminars to gather people around common topics (e.g. composite materials, electronics, systems engineering, etc.).
- Reinforce Intellectual Property protection and management, as well as R&T management practice (guidelines and procedures)

The council creation was supported by the Vice President of the group (Maurice Pinault) for its strategic leverage:

> *It is a major leverage of growth for the Group such ours which designs and manufacturers the most complex systems and that is required to meet regulation constraints and quality & safety requirements increasingly harder. In 2010, we created the ZSTC to improve the performance of our technological research, to gather necessary resources for our competitivity and foster the development of cross-cutting innovation with high added value.*[16]

The joint effort contributed to encourage transversality through some major disciplines for the group such as material flammability, power electronics, systems engineering and composite material engineering and manufacturing. *TechnoDays* have been organized for these topics, experts were nominated locally in business units, and through round of interviews experts gain different status degrees of the career path:

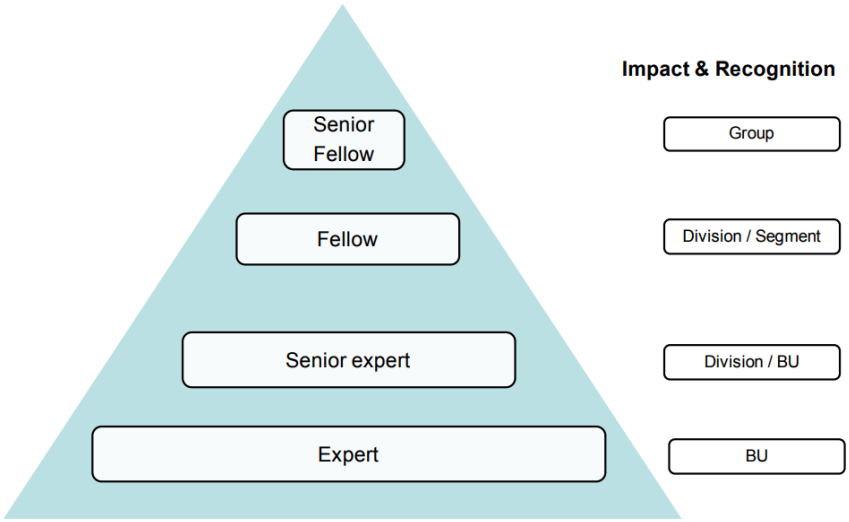


**Figure V.10:** Distribution of experts by status and technical domain - Zodiac Aerospace Human Resources Standard ZA-H-5003

[16]Translated by the author: "C'est un levier majeur de croissance pour un Groupe comme le nôtre qui conçoit et réalise les systèmes les plus complexes et qui doit répondre à des contraintes réglementaires et à des exigences de qualité et de sécurité toujours plus fortes. En 2010, nous avons créé le ZSTC pour améliorer l'efficacité de notre recherche technologique, disposer des ressources nécessaires à notre compétitivité, favoriser le développement d'innovations croisées à forte valeur ajoutée."

### 2.4.2 Late Creation of R&T function through TRL assessment

Given this initial background and internal efforts made in the business units Zodiac Fuel & Control Systems to constitute a dedicated R&T Team (in 2012-2013), workshops were organized with the support of a consultancy firm to define and implement technology road maps (TRMs) for all business units. With a bottom-up approach validated by top management strategy, road maps were fed with marketing and sales data picturing the future markets and technologies were identified to enable and facilitate potential market access. Aircraft and equipment manufacturers had been implementing the notion of Technology Readiness Level (TRL) which streamlined the road-mapping.

Guidelines were subsequently written to support the rollout of this new language and practice. Business units were then able to provide and use a maturity assessment canvas for the technologies in development and the road ahead for integration. The president of the ZSTC was then appointed Chief Technical Officer (CTO) of the Zodiac Aerospace group, a new position created by the CEO. His role consisted in gradually institutionalizing the R&T function in business units, supporting them for public funding opportunities and auditing the practice of R&T and innovation management (TRL assessment, TRM, patent application and PhD subjects).

## 2.5 An innovation locus where exploration project management and organizational design clash

So far, we have portrayed in the previous pages the history of aircraft engineering, the establishment of design rules and the acquisitions strategy of Zodiac Aerospace. Several key features can be listed characterizing the innovation context for Zodiac Aerospace (see below).

- An industrial ecosystem at stake with increasing uncertainties and unknown due to strong segregated rigidities mirrored by engineering, safety and regulations but facing potential radical transformations of architecture
- Complexity and difficulty to master a full system (architecture and components) - myopic behaviours
- Architectures defined in a contingent manner by the ecosystem raising uncertainties and the unknown shifts
- Urge to innovate for strategic competitive advantage in the wake of a radical change
- A consolidated market made of conglomerate but without being traditional divisional firms
- Autonomy and responsibility of individual SMEs but the necessity to orchestrate their interdependencies to innovate

- Projects situated in a intra-BU and inter-BU context challenging product/service design and organizations simultaneously
- A light corporate team dedicated to innovation with several relay networks (professions, experts)

Zodiac Aerospace presents a distributed innovation management with an ongoing standardization for processes (Quality Management System) and to some extent structures (R&T department separated from Development Engineering). Each BU has its own responsibility and dedicated financial reporting. They all face their own market segment with the associated professionalisation but also the urge to embrace uncertainties and the unknown to innovate.
This situation encourages to understand the place in the (aircraft) system architecture, the interfaces, the interdependencies and knowledge yet to be discovered to guide exploration and consider synergies with other BUs. It is a concern for top management as they worry about the strategy of this portfolio of SMEs.
The CEO and VP[17] have stressed the idea the intent was to secure the niches in the long run, but still develop their own capabilities to prepare the future. They specified the importance of branch directors to oversee the portfolio of business units to build a sustainable strategy for them. Top management had for instance launched several initiatives they considered to be key for the group or gave a place for bottom-up projects.
For example, transversality was gradually being organized with communities of experts, TechnoDays, (in)formal communities of practice for engineering and R&T managers at the BU or division level.

Top management also decided to launch projects and places were novel products and services could be developed *in-between* the organizational boundaries or just seen as strategic for the whole group. A fuel-cell project was launched, hosted by a business unit with the prospect to developing this technology for the aircraft equipment market with perspectives on electricity, water and heat management. Two teams were set near aircraft manufactures: one near Airbus and the other by Boeing. These teams were composed of several engineers, designers and managers from different business units. They dedicated 50% of their time to technical support for their BU of origin; the rest was dedicated to business intelligence and innovation management. Workshops, prototyping, and presentations were regularly organized by the team to generate concepts sometimes in partnership with clients, users and also representatives of BUs.

The gradual rationalization of the R&T and Innovation activities since 2010 with the establishment of R&T and Innovation management within each BU was supplemented by an effort coordinated by top management to the develop even more radical design of

[17] Open interviews conducted by the author in May/June 2018

products and services. The former tend to address incremental innovation, sometimes radical ones aimed through a path punctuated by several steps to test their environment. For instance, long term projects are part of partnership agreement funded by institutions such as associative, national or international Research Councils. The latter were a means for the Executive Committee to protect existing niches from more radical concepts.
In these specific case raising strategic interest, such project were addressed in a different *locus* breaking away from the existing and protected organization design: the multi-BU committee was rather convenient. Otherwise, the Business Unit being is considered as an indivisible unit. It encourages the development of alternative approaches: fostering exploration topics, steering committees for valuation and strategy, and project management.

# 3 Case studies selection

## 3.1 Brief case description

Below, we present the different case studies conducted at Zodiac Aerospace and that where discussed in five different articles in Appendix. Due to organizational dimension of innovation management of this conglomerate of SMEs, and the organization design, we propose to split the cases in two categories: intra-BU and inter-BU. The trajectory of studied projects were, in fact, more or less contained within the perimeter of a business unit, market segment, qualification/certification requirements. Other cases were deliberately set in between these boundaries or across with top management sponsorship.

### 3.1.1 Intra-BU cases

**Icing conditions detection** The first impulse originated in the early 90s with the concern a former CEO - Intertechnique group (now Zodiac Fuel and Control Systems) - and with the crash of an ATR72 in the U.S.A due to ice accretion on wings. A project manager and engineer (who would eventually become the R&T manager), developed an ultrasonic sensor for wing's skin to detect ice and measure icing-protection fluid dilution ratio. It allowed participating to several test campaigns, to gain a reputation in the field for safety and airworthiness (DGAC, EASA, Transport Canada), and develop two versions of the technology with the support of funding (SPAé, European Power Optimized Aircraft) and synergies with pending product development (e.g. computer electronics for A380). A first patent was applied.

Early 2000s, the technology is compared in test campaigns with the monopoly's solution (Goodrich, former Richmond; mechanical oscillator). It proved its efficiency on the ground but not for flying conditions due to several technical limitations compared to competition's: no defrost, complex wing installation and high costs. Furthermore, Airbus did not support the development as their aircraft (A380) is not sensitive to icing. Airworthiness institutions were indeed specifying icing conditions types and aircraft sensitivity.

However, regional aircraft manufacturers such as ATR and Bombardier were pushing former Aerazur entity (now Zodiac Elastomer Europe) and Intertechnique for an integrated ice detection and ice protection system. With the support of several engineers recruited in previous years, they developed a solution tested again with the support of Airbus as the icing conditions detection regulations were evolving. Three test campaigns were conducted with convincing results from an alternative technology (thermodynamics and Peltier effect) overcoming

the previous limitations.

Despite an aircraft program request for proposal and with uncertainty and potential surprises in airworthiness evolutions, the recently established icing conditions team at Intertechnique pivoted towards an unfamiliar technology for the BU (laser optics). Parallel studies were conducted, and the R&T manager had participated to technology evaluations with FAA and Transport Canada. In addition, strategy and business development managers had considered potential acquisitions to definitely break the monopoly.

Finally, in 2011 a new project on uncertain laser technology was launched within a CleanSky program. And more recently, a second project was launched, with CleanSky2, forking the technology concept developed so far and extending the airworthiness validity domain.

**Note:** The researcher came around this case with the support of the CTO and R&T manager who explicitly mentioned the need to specify the nature of this projects at odds with other R&T and Engineering Departments activities and with BU management. The project was seen as an unidentified object despite having legitimacy in the airworthiness, safety fields and among aircraft manufacturer engineering departments. The generative processes needed to be further specified to understand the nuances of its innovation potential of attraction with respect to the engineering department, knowledge and organization design.

**Business Class Seat platform** This case is an outcome of a recurrent topic at Zodiac Seats France: standardization and modularization of seat architecture to facilitate product development. Indeed, airlines demand for seats change every 5-10 years, including cabin reconfiguration for seasonal passengers flows, and they request a short development cycle of about 2 years, compared to the 10 years (approx.) for an aircraft. However, the seat is absolutely critical in passenger safety with severe qualification and certification requirements in association with increasing demands for airline/passenger customization and ergonomic design. Despite the beneficial prospects of platform engineering for economy and business class seats, the rhythm of product development and complexity in conjunction with optimized resources hadn't left many opportunities to develop such

project.

Separated from development engineers, a recently constituted R&T department was tasked to study the modularization of a business class seat for easier packaging and certification. A large exploration (patent, design options, architectures, technologies etc.) was considered and selection of design concepts were made based on product development criteria and support of several engineering, operations and marketing stakeholders. Further stress simulation and testing was required, but following the bid award from a demanding airline, the subsequent design and development was driven by customer requirements and its design studio.

Several difficulties were discovered late in the development raising questions on the maturity of the design and certification requirements such as increased difficulties associated with the joint qualification of seat and shell and inclusion of airbags. Delays were unfortunately accumulated with numerous quality problems due to technical compromises.

Despite the exploration quality, exploitation issues had to be dealt with. The project trajectory that aimed at developing a business class seat platform was compromised.

**Note:** The research was introduced to such product development case as he was supporting the R&T department in formalizing the TRL assessment and associated management. The Director of Engineering and R&T managers were intrigued and disturbed by the design choices and integration issues, requesting a deeper understanding of the coordination and collective action model, as well as how the innovation potential of attraction of the platform was managed.

**Hypoxia protection - researcher's intervention** The R&T department was preparing mid-2017 a participation to CleanSky2 program with Airbus as a partner in order to propose new radical solution to protect pilots from hypoxia. The need emerged from the necessity (safety) requiring a pilot to wear the emergency oxygen mask when alone in the cockpit. Such requirement is however hardly compatible with the required comfort of extended use due to emergency design

of the mask (high levels of stress, smoke in the cabin, emergency manoeuvre).
.
The team was originally constituted of R&T engineers, and then after 6 months, they were stretched over the traditional engineering department dedicated to product development leaving only one R&T member. Numerous brainstorming and design sessions with the support from an external design studio contributed to a wide and in-depth exploration.

In parallel, an internal "Open Innovation Challenge" organized by the ZSTC for which one of the two topics was improving ergonomics of the oxygen crew mask. The researcher had then proposed a C-K mapping to position and value the concepts proposed by ZA participants. In addition to the acquaintance with the R&T and Engineering manager for other purposes, the researcher was requested to support the project team in selecting concepts, and guiding them before the first proposal to the CleanSky2 partners.

It was the occasion to work on the decision-making and the design of alternatives and states of nature, as well as embedding the organization design required to support the innovation effort expected in the project. The dichotomy of exploration/exploitation could then be revisited and nuanced within this project. It enabled the proposal of novel ways to organize collective action within and around the exploration project.

### 3.1.2 Inter-BU cases

**Airbus Development Team - Design Thinking cases** The ADT is sponsored and monitored by the C-suite for strategic management purposes. The team was tasked to provide technical support for several BUs and to generate concepts that would feed on unmet user needs by gaining a better knowledge of real use cases of ZA products. The team is constituted of 8 permanent engineers and designers delegated by BUs for three years maximum, and dedicating half of their time to their BU's sales/technical support. They report to a local manager who actively contributes to the team creative effort and facilitates discussions with BUs. He reports to the group VP of Strategy and Business Development as well as the Chief Technical Officer.

The Design Thinking (DT) methodology was chosen to promote the user-centric approach, explore usage, share gathered knowledge, and ideate for and with relevant BUs. ADT's two project leaders were trained to DT at Stanford's d.school,

and other members were trained in other institutions. A design and creativity spirit was largely promoted by the local manager as well as the members themselves. The projects phasing completely covered DT's enactment themes (Carlgren, Rauth, and Elmquist 2016).

Both cases addressed transverse topics where many BUs are concerned in some way or are actively part of the value chain. The first topic dealt with waste managed onboard aircrafts. The second topic tackled the optimization of aircraft turn around time (i.e. between landing and take-off). Several users and extreme users can be searched and studied to build empathy and also the technical/market knowledge from the different BUs is tightly interfaced around both topics.

In order to fit the scope of work of the ADT, the team shared knowledge with BUs to keep them up-to-date and build legitimacy all along the DT process. A "Multi BU workshop" was organized for problem-reframing and further ideation and prototyping with BUs. A final selection process was defined based on DT criteria and ZA's strategic intent: customer value, technical feasibility, passenger experience, group strategic alignment, in addition to a separate ranking for "creative sparks". The selected concepts were then approved by the Group VP of Strategy. Thereafter, they were shared again and promoted to business units who could potentially host their development in their renewed product lines.

**Note:** the researcher had first visited ADT in Toulouse, since it was recognized as one of the new loci of innovation in ZA. Interested by the PhD project and with several pending problems regarding concept appropriation by BU, the local manager accepted and invited his colleagues to provide relevant project documentation and interviews to gain an understanding of the projects driven by Design Thinking.

**Lower deck** As several projects had been launched as well as numerous ideation sessions at ADT, the researcher had presented his analysis of the two Design Thinking cases in March 2016. Among the conclusions, the C-K mapping and project trajectories had revealed the recurrent topic of using the aircraft lower deck (cargo area) as a means to embody several concepts enabling solutions for waste management and aircraft turn around.

The local manager had also a hunch for such topic as it had been quite recurrent in the three years of existence of ADT, including a provisional patent application with a former intern. As the team was about to be renewed, he decided to request the former intern to come back and support a new project dedicated to the lower deck use.

A first market study was launched with a consulting firm to evaluate airline's ticket yield management in addition to fleet evolution and maintenance dates, to envision the size of lower deck market in addition to its integration. The latter was critical as it implied modifying the aircraft's cargo area for passengers without disrupting airlines' operations. The technical feasibility of this retrofit was studied first by an external engineering firm and then deepen by an internal BU dedicated to certifying specific aircraft customization. In parallel, concepts were tested with several airlines' executives, and the overall business case was discussed with ZA Executive Committee board.

The project proved to be a success as several key client (airlines and Airbus) formalized requests for proposals and project development framing is ongoing (see announcements during last Aircraft Interiors Exposition in Hamburg 2018). Moreover, several BUs are willing to take ownership of the project.

**Note:** This project has to be read at the light of the Design Thinking projects conducted at ADT and other projects followed by closely by the ExCom.

**Connected Cabin** The raising interest for connectivity and Big Data for aviation industry had made its way into Zodiac Aerospace. Such topic was a perfect fit for Zodiac Inflight Innovations who developed inflight entertainment solutions and communication devices as well as Zodiac Data Systems (antennae and inflight test equipment). The topic was rather convenient for another BU such as Zodiac Air Catering Equipment whose market value chain extends from the aircraft galley area to catering services delivering the trolleys to aircraft doors.

Two members of the ZSTC, affiliated to Zodiac Inflight Innovations started pitching the idea in front of the Executive Committee to launch a project on Big Data services centred around an enhanced cabin with connectivity hardware enabling machine to machine communication and management. After two rounds with the support from a member of the ExCom in charge of their business branch,

they managed to precise the project scope, potential business case, and needed resource to develop a prototype to probe the market at 2017 Aircraft Interiors Exposition in Hamburg.

A team was constituted with engineers from different BUs providing equipment for the cabin and who had an interest in constituting the connected cabin and developing associated services. The project moved on quickly with bi-weekly reporting meetings followed by the VP of Strategy and Business Development, and numerous side meetings. Moreover, the ExCom made an open statement to investors that a project was being launched to value aircraft connectivity. A cabin prototype was manufactured with built-in connectivity features and scenarized for airlines. It put forward the benefits of retrofitting hardware and software providing value-added services smoothing airline operations and client experience and satisfaction.

The prototype enabled collecting valuable feedback from potential clients and following the exposition the project did not continue.

**Note:** The researcher came around this case as he knew the two ZSTC members and regularly attended ExCom meetings relative to technology and innovation. They were keen on having him following the progress of the project and keep track of concepts generated along, even before the budgeting agreed by ExCom. This case benefited from the same context and sponsorship as the Lower deck. Consequently, we can contrast them and nuance their respective innovation potential of attraction.

**Multi-BU committee** **Note:** The researcher was regularly invited by the CTO to attend ExCom meetings relative to technology and innovation. These meetings were usually labelled Multi-BU meetings following the interest of former CEO (Olivier Zarrouati) to have a top-down approach urging new projects (such as the Fuel Cell briefly exposed earlier) and also to offer space to projects originating in one or multiple BUs bearing a strategic importance. All of these projects addressed new markets, gaps in between market segments by bringing forward new technologies or new product concepts.

This case is approached not necessarily on the technical, engineering or marketing content of the projects steered by the MBU committee, but rather on the way decision-making was conducted by individuals and teams attending these meetings. ExCom members were all present with leadership from the CEO and VP of Business Development and Strategy. The meetings were prepared by the MBU Director, also called Director of Large Projects (*Directeur des Grands Projets*) with the support of the Director in charge of product roadmaps. The job involved monthly reporting of the projects to the mentioned VP as they would be subsidized by top management budget (stemming from fees collected by the holding on BUs).

The meetings occurred in average every quarter, sometimes punctuated by other meetings in between for projects requiring an urgent strategic decision: commercial support for business development, group strategy relative to overall market positioning and budget.

The Committee operates as an alternative locus of (radical) innovation compared to in-house R&T and Product Development activities in BUs. It emphasizes the interest of corporate management for entrepreneurship across the group. It also differs from the ZSTC and members of the Innovation Direction whose role leans towards support (processes and tools) and networking for knowledge domains sustained by experts.

## 3.2 Associated paper writing

| Anomaly detection papers | | |
|---|---|---|
| **1** | **Design Thinking for innovation management**<br>The purpose of this paper is to study the adoption of Design Thinking methods for multi-BU and B2B2C context. Design Theories are used to track generativity of the design practice: user fixation and learning metabolism supporting innovation management.<br>Presented at 6th Creativity Innovation Management (CIM) Community Workshop, first submitted and rejected Spring 2017 to CIM Journal, reformulated for R&D Management Conference 2018 and resubmitted to CIM journal with substantial modifications compared to first version. | **Airbus Development Team**<br>**Case 1:** Waste Management (6 months)<br>**Case 2:** Turn Around Time (8 months)<br>12 interviews for each case, field notes and full access to project documentation. |
| **2** | **Decision-making in exploration project management**<br>In this article directly submitted to CERN IdeaSquare Journal of Experimental Innovation (2017), after a round of reviews for ICED 2017, we presented an exploration project conducted over more than a decade. It showcases the project's timeline and what could be considered as an irrational due to a preference reversal. We propose instead to extend the notion of rationality with the existence of generative actions and the deliberate will to reverse preferences. These are seen as means to manage the unknown. Departing from optimization, design and generative processes can support this extension and exploration. We consequently introduce the notion *decisional ambidexterity*. | **Zodiac Fuel and Control Systems**<br>**Case:** Icing conditions detection system (one decade, and additional background history)<br>8 interviewees consulted several times, field notes and full access to project documentation |
| **3** | **Organizational Ambidexterity and innovation management**<br>This paper addresses the hypothesis that organizational ambidexterity (OA) can kill innovation. The first version called for the importance of decision-making to understand the operationalization of OA as mentioned by researchers in the field. We propose to leverage non-expected utility decision-making based on Paper 2, but in reality with the feedback from the research community we also recentred the presentation on problem-solving as originally discussed by James March seminal paper (March 1991b). We stress the aporia of segregating exploration from exploitation for a meaningful exploration as generativity is otherwise biased and reduced. The latter revealed being crucial to manage the unknown and consequently to innovate.<br>Presented at EURAM 2018 Conference Innovation SIG and will be rewritten based on valuable collected feedback. | **Airbus Development Team and Zodiac Seats France**<br>**Case 1:** Waste Management (6 months)<br>**Case 2:** Business Class Seat Platform<br>12 interviews for case 1 and 10 interviews, in addition to field notes, full access to projects documentation. |

**Table V.1: Anomaly detection** - Case studies and written papers

| | | |
|---|---|---|
| | **New model** | |
| **4** | **Designing decision: managing the unknown**<br>This article discusses the need to overcome the decision paradigm by embracing design theories to extend the latter to the unknown. Four archetypes of decisions based on design paths are presented corresponding to different forms of collective action: learning, performance and organization. Compared to the published paper, we extend the model with organizational theories by integrating organizational constraints and hypothesis in the decision design reasoning to generate and execute alternatives/decisions to be managed in exploration/exploitation modes.<br>Presented on several occasions by Pascal Le Masson, debated with the researcher over the PhD's second year. After a first round of reviews, a modified version is in press in the European Management Review. | **Theoretical paper**<br>The traditional thought experiment of the decision to go out with an umbrella/hat given the weather belief is used. |
| | **Model validation and intervention** | |
| **5** | **Ambidextrous decisions and corporate entrepreneurship**<br>Given the anomaly and the proposed model, we will present two cases that can explain their success and failure. These have a corporate entrepreneurship taste and present features relating to decisional ambidexterity, managing the unknown and organizing for it. One case appears to have the right set of practices to succeed in its innovative design and associated management whereas the other one struggles. The comparison allows justifying the usefulness of the new model and ways to implement certain practices. It is a working paper to be submitted by the end of 2018 to conferences (to be determined) | **Airbus Development Team, Connected Cabin and Multi-BU committee**<br>**Case 1:** Aircraft's lower deck (1 year)<br>**Case 2:** Connected cabin (10 months)<br>Field notes, minutes of meetings, 6 interviewees each consulted on multiple occasions and full access to projects documentations, meeting minutes, in addition to input from former CEO and VP. |

**Table V.2: Modelling and intervention** - Case studies and written papers

# 4 Chapter synthesis

After having globally presented the general research methodology of the PhD journey for the research questions refined over the last three years, we have described in this chapter the actual research context.

The history of the aviation industry, its emergence, and its gradual organization and segmentation with the numerous original actors explain the dynamics of today's market and positioning of players such as Zodiac Aerospace.

This firm has developed specific innovation capabilities through several decades of acquisitions, extending its market footprint. In the last decade, we presented how centralization and gradual homogenization, new coordination means and collective action patterns emerged to cope with the unknown to be managed for future aircraft programs and markets. We exposed also the difficulties for top/middle/local management to address the challenges imposed by exploration project management with respect to the underlying organization designs and market segmentation.

Finally, we introduced the case studies conducted at Zodiac Aerospace and how these led to published and presented articles in journals and conferences. These papers fit with the methodology of anomaly detection, theoretical modelling and empirical testing. We explain how the other cases support the researcher's intervention, testing and experimentation.

# Part 3

# Anomaly detection - when ambidexterity tears organizations apart

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**Outline** In this third part, we present our first set of results addressing the first two critical research questions. We propose to shed light on an anomaly revealed by the different selected cases at Zodiac Aerospace and the comparison between the actual course of action, its controversies and predictions expected from the **adaptive, interactive and encapsulated** models.

The first chapter (VI, p.217), through three different case studies, highlights the difficulties rising from organizational ambidexterity. Generative processes black-boxed in projects perturb the edges of models relying on a non-mutual conditioning between exploration and exploitation as this separation is no longer valid the unknown. We reveal biases and fixations effects deriving from the dichotomy that paradoxically jeopardizes the exploration and the exploitation regimes themselves. It also severs sustained innovation. We find that generative processes are fixated by organization designs, consequently creating tensions for middle/top management and strategic coherence.

These results are a reformulation of three articles addressing these cases with their own specific literature. The Icing Condition detection case (p.197, is examined through the lens of decision-making, preferences reversal, and exploration project management in (Le Glatin, Le Masson, and Weil 2017b), available in appendix A2. The Design Thinking cases hosted by the Airbus Development Team are discussed through the teachings of design theory (C-K) by focusing on the generativity of the method with respect to these exploration projects, see (Le Glatin, Le Masson, and Weil 2016; Le Glatin et al. 2018), available in appendix A1. Finally, ADT cases and Business Class seat platform are presented in (Le Glatin, Le Masson, and Weil 2018), see appendix A3. It suggests to consider non-expected utility theories and limitations of organizational ambidexterity.

The second chapter (VII, p.237) then proposes a baseline for the following modelling part (4, p.249) as we need to find an extended model capable of explaining with better clarity the observed phenomena. As we tasked ourselves earlier on, we adopt a behavioural approach used to define modelling requirements based on the limitations observed in our case studies.

**Aperçu** Dans cette troisième partie, nous présentons notre première série de résultats portant sur les deux premières questions de recherche. Nous proposons de mettre en lumière une anomalie révélée par les différents cas sélectionnés chez Zodiac Aerospace et la comparaison entre le cours réel de l'action, ses controverses et ses prévisions attendues des modèles **adaptatifs, interactifs et encapsulés**.

Le premier chapitre (VI, p.217), à travers trois études de cas différentes, souligne les difficultés qui découlent de l'ambidextrie organisationnelle. Les processus génératifs cloisonnés dans les projets perturbent le domaine de validité des modèles en s'appuyant sur un non-conditionnement mutuel entre exploration et exploitation car cette séparation n'est plus valable pour l'inconnu. Nous révélons les biais et les effets de fixations qui découlent de la dichotomie qui paradoxalement met en péril l'exploration et les régimes d'exploitation eux-mêmes. Elle compromet aussi une innovation durable. Nous constatons que les processus génératifs sont fixés par les conceptions organisationnelles, ce qui crée des tensions pour le management intermédiaire/supérieur et la cohérence stratégique.

Ces résultats sont une reformulation de trois articles traitant de ces cas avec leur propre littérature spécifique. Le cas de la détection des conditions givrante (p.197, est examiné sous l'angle de la prise de décision, de l'inversion des préférences et de la gestion des projets d'exploration dans (Le Glatin, Le Masson, and Weil 2017b), disponible dans l'annexe A2. Les cas de Design Thinking accueillis par l'équipe de Airbus Development Team sont discutés à l'aide des enseignements de la théorie de la conception (C-K) en se concentrant sur la générativité de la méthode déployée dans ces projets d'exploration, voir (Le Glatin, Le Masson, and Weil 2016; Le Glatin et al. 2018), disponible en appendice A1. Enfin, les cas ADT et la plate-forme de siège de la classe affaires sont présentés dans (Le Glatin, Le Masson, and Weil 2018), voir annexe A3. Cet article suggère de tenir compte des théories d'utilité non-espérée et des limites de l'ambidextrie organisationnelle.

Le deuxième chapitre (VII, p.237) propose ensuite un cahier des charges pour la partie suivante de modélisation (4, p.249) car nous devons trouver un modèle étendu capable d'expliquer plus clairement les phénomènes observés. Comme nous l'avons souligné plus tôt, nous adoptons une approche comportementaliste pour définir les besoins de modélisation en fonction des limites observées dans nos études de cas.

# Chapter VI

# Results

In this first batch of results, we task ourselves to demonstrate an anomaly in the presented case studies by opposition to the literature models in our research questions chapter (III, p.121). The results are presented in the same fashion for the three selected case studies. They are also detailed in different articles in the Appendix.

Systematically, we present the trajectory of the project where we stress what appears to be a *weak signal* with respect to generative processes at stake. It appears as an obstacle for collective action, something that has created a management issue for involved designers, engineers and managers. We then propose to use the **adaptive, interactive and encapsulated** models to **predict** what could have been the course of action. It will serve as a reference point for the actual course of action and detect the anomaly with more precision as explained in the methodology section (p.146).

We first present the analysis of the *Icing conditions detection* case (see description, p.197). It reveals what could be considered as absurd or even irrational decision-making as depicted in (Le Glatin, Le Masson, and Weil 2017a; Le Glatin, Le Masson, and Weil 2017b), can be accessed in the appendix (413). The product ends up in a paradoxical tension between the developed technology, its legitimacy and the organizational anchoring.
Second, we present another case of platform engineering exploration for aircraft seat design: *Business Class Seat platform* (see description, p.198), which has been analysed in (Le Glatin, Le Masson, and Weil 2018) and that can be accessed in the appendix (p.423). The trajectory reveals a transitioning for exploration to exploitation regime with several difficulties questioning the efficiency of both exploration and exploitation.
Third and finally, we analyse *Airbus Development Team - Design Thinking* cases (see description, p.200). The *performance nature* of generative processes is at the heart of this case as discussed in (Le Glatin, Le Masson, and Weil 2016; Le Glatin et al. 2018)

and that can be accessed in the appendix (p.397). Again organizational ambidexterity is challenged by specificities of generativity causing several complications to enable a sustainable innovation management.

# 1 Icing conditions: misunderstood entrepreneur or absurdity?

## 1.1 Trajectory of the project

As described previously in the methodology sections (see p.197), the case was suggested to the researcher for analysis as the R&T manager had managed the project from the beginning and had increasing pressure on the conditions of exploitation after the years of exploration and financial constraints to continue exploration.

The figure.VI.1 below, gives the chronology of the project as it was developed over more than two decades. The sequence can be followed through the numbers at the corner of several boxes and years highlighted at the bottom. The arrows indicate sequence and causality operating for actions, decisions and the design of decisions. It is, of course, a condensed view of the history of the project but we can stress the nature of exploration (disrupt monopoly), when exploitation (client request and market opportunity) could have occurred and when exploration was launched again.

The vertical dotted line is the critical part in the project trajectory. A first exploration was carried out by the project team looking for alternative solution overcoming limitations known of the monopoly's solution. They scouted the field, several test campaigns were conducted with the support of national laboratories and aircraft manufacturers. These were proven successful despite some caveats as the first technology developed addressed only ice detection on ground. However, another solution was developed with further test campaigns. Regional aircraft manufacturers were looking for an alternative solution to the monopoly and possibly for an integrated system: detection and protection from ice. Restrictions were looming over regional aircrafts as they were statistically known more sensitive to icing conditions.

Surprisingly, instead of going for this aircraft program and system/product development between ZFCS and ZEEU that was at hand's reach, the current technology development were stopped altogether. Exploitation promises were discarded, in order to launch a new wave of exploration addressing yet to be specified icing conditions: new undefined regulations, scientific knowledge on icing conditions, and appropriate technology. We propose then to zoom on this key moment of the project history that balances exploration and exploitation in order to make sense of it through the lens of literature models.

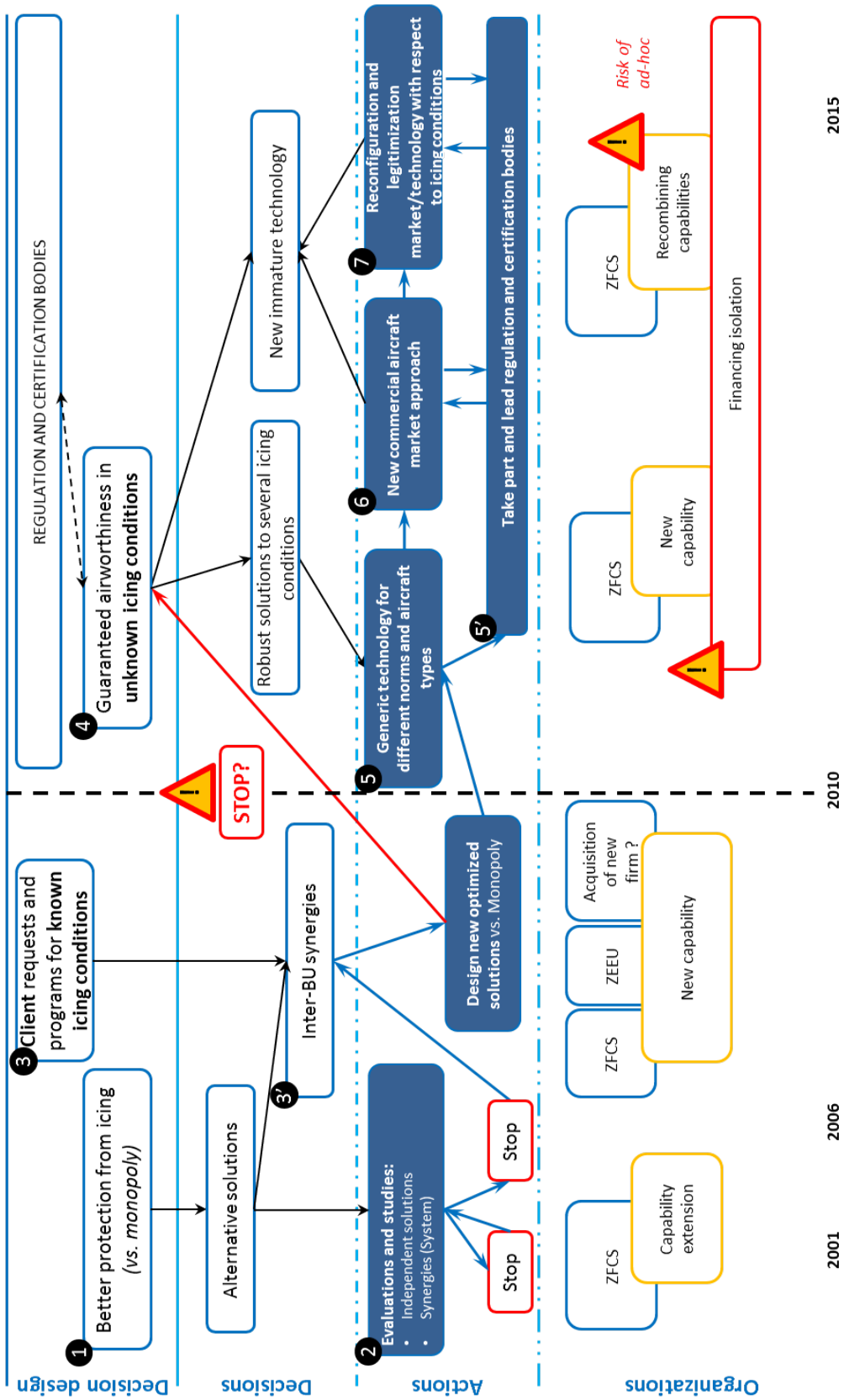


**Figure VI.1:** A constituted path challenging BU strategy and organization ties

## 1.2 Models' predictions

| Predictions of the adaptive model | |
|---|---|
| **Model of coordination and collective action** | BU management and group top management were involved in key decisions (search direction for technology development, patenting, business acquisition, etc.). **Prediction**: BU management could have selected the program opportunity with the development of the system between ZFCS and ZEEU as a means to set a first foot on the monopoly for future learning promises in the new environment. |
| **Generative processes** | The exploration was rich in finding existing alternatives but generating new ones that are undecidable is not considered by adaptive models. **Prediction**: The exploration movement should have been gradually adapted to fit exploitation constraints. Make or Buy strategy for the detection technology (e.g. acquire Vibrometer firm) in order to bring value added with an integrated system (detection and protection) by opposition to a standalone solution. |
| **Environment cognition** | Interactions were created with laboratories, test facilities and potential clients to guide the search direction: overcome limitations of monopoly's solution. **Prediction**: Wait for the environment to stabilize and prescribe new requirements on icing conditions regulations, which can make the generated concepts decidable. |
| **Organization design** | R&T team dedicated to exploration, spatially isolated from engineering department. It was identified as a new standalone product line. The development engineering was familiar with systems engineering. **Prediction**: The exploitation could have been conducted for the icing conditions detection and protection system between ZFCS and ZEEU. Resources were available. |

**Table VI.1: Adaptive** model predictions for icing conditions detection project

| Predictions of the interactive model | |
|---|---|
| **Model of coordination and collective action** | R&T engineers and managers created and made sense of the surveyed technologies. Meetings were organized with middle and top management to structure future course of action. **Prediction**: Middle and top management allow and enable further interactions to gain awareness and act accordingly. |
| **Generative processes** | Test campaigns, studies and meetings were conducted and shared among engineers and managers. Presentations are held with management to envision new positioning. **Prediction**: The appropriate sense and knowledge could have eventually captured through subsequent interactions. R&T manager could have then refined the new meaning emerging from further exploration. |
| **Environment cognition** | Numerous interactions with clients, laboratories and potential clients were conducted to address uncertainties of icing conditions and required technologies. **Prediction**: Shape new networks, lead-users and unknown interpreters to gradually design new technologies for icing conditions. Continue developing open innovation practice. |
| **Organization design** | The exploration team had expanded beyond the ZFCS boundaries and gradually gaining recognition. **Prediction**: This open innovation should have easily shaped a fully autonomous product line as the legitimation process is carried out. Perhaps even a new BU (ad-hoc) could be created. |

**Table VI.2: Interactive** model predictions for icing conditions detection project

| Predictions of the encapsulated model | |
|---|---|
| **Model of coordination and collective action** | The exploration was seen as sequenced projects probing alternatives' validity and success. The overall icing condition detection theme could be considered as a program but without the management structure, despite having a governance with middle and top management sessions.<br>**Prediction**: Road-mapping activities to pave the way for future projects. |
| **Generative processes** | Each specific project encapsulated design and engineering practices to refine the selected alternatives.<br>**Prediction**: These trial-and-error projects proving the technology, regulation and market landscape should continue until an appropriate fit is crystallized. |
| **Environment cognition** | Each project engaged with clients and test facilities, and they allowed building upon each other.<br>**Prediction**: Each project will explore the environment in a given direction and contribute to future projects. For instance, the program could have enforced the exploitation opportunity to sustain further exploration on the side. |
| **Organization design** | The projects relied on R&T engineers and request additional resources if needed.<br>**Prediction**: Transferring the project to the development engineering to develop the integrated system would have been possible due to system related knowledge. |

**Table VI.3: Encapsulated** model predictions for icing conditions detection project

## 1.3 Anomaly: market legitimacy for the market but no organizational support

| Actual course of action | |
|---|---|
| **Model of coordination and collective action** | The team conducting exploration didn't support the exploitation opportunity but rather continued exploration. They handed over some R&T engineers to develop "on the shelf" the first version of the explored product, whilst further exploration continued shaping the unknown (norms and regulations, and aircraft integration and safety) |
| **Generative processes** | The exploration was guided by a future prospect of exploitation: safety norm evolution and associated icing conditions typologies. They willingly reversed preferences by choosing a highly uncertain technology, but managing the environment legitimacy in parallel. |
| **Environment cognition** | The environment is shaped by the R&T manager constituting a collective path for the market: deciding regulation's scope and application, steering scientific discoveries and applied research on icing conditions, and specifying norm and technological performance. |
| **Organization design** | The projects managed by the R&T team were rather autonomous with partnerships and funding agreements. They gained autonomy up to a point where developing a product required to hand over some R&T engineers to the Product Development department. |

**Table VI.4:** Actual course of action for icing conditions detection project

What our descriptors reveal is that the conducted project does partially fit some of the models with an emphasis on the interactive and encapsulated models. The team engaged with the environment's actors and pushed the trial-and-error pattern to ensure the legitimation of the developed technology as well as the primacy/leadership of the newly reconfigured icing conditions detection market.

However, we see that the exploration is guided by exploitation constraints that still requires to be fully settled and designed. The project is at odds with organization design as they have evolved in autonomy and developed capabilities so far unmatched by legacy engineering departments. Top management, despite having sponsored the exploration, still tries to keep the BU *together* and avoids having a spin-off. As the technology is not fully mandatory for existing heavy-body aircraft (statistically proven by manufacturers), it still requires to make a case for itself beyond small/regional aircraft market. The BU strategy is thus challenged by this market re-orientation and the lack of technology-market fitness.

### 1.3.1 Lone irrational entrepreneur?

One could argue the R&T manager used foolishness (March 2006) to refuse the first exploitation opportunity benefiting from synergies with another BU. He is however a sane spirit in a sane body.

The adaptation of technology is performed dynamically with the environment being shaped by managing safety regulation and norms as well as technology legitimation. Exploration of technologies and product concept are guided by generating and refining alternatives of what exploitation (regulation and standard) could be.
The non-mutual conditioning of the regimes is compromised, but brings new hopes for exploitation. As discussed in (Le Glatin, Le Masson, and Weil 2017b), see appendix A2, preferences were reversed, representing a violation of rational theory of choice, but at the same time allowed uncovering prospective alternatives requiring a contingent environment management.

This entrepreneurial effort is not isolated, it was sustained through a rich engagement with the environment, learning for the R&T team, but also support from BU management and top management.

### 1.3.2 New BU for ZSSM?

This offshoot generated by the R&T team dedicated to icing conditions detection was established as a young product line. The issue for top management is the absence of a clearly defined market for heavy-body aircraft, which are the *norm* for other products in the BU.

It is probably the paradox of this exploration project and the autonomy gained through open innovation practice, path constitution and funding schemes. It is abnormal for the three models, as the top management sponsored the emergent strategy from the beginning, and steered the process along the way as a strong technological advantage could be

developed to overcome the monopoly.

In the end, exploitation is shifted from its standard belief and conception to market the product, from a marketing and engineering standpoint. In fact, the prototype developed and tested by R&T implies a lot of rework for development engineering, in terms of robustness, quality and manufacturing engineering. Nevertheless, the prototype can also be seen as a means to support learning of the new technology so far unfamiliar to the engineering department.

Creating a new BU appeared out of the equation. BU management preferred to capitalize on the exploration and develop the new technology on the shelf. They also allowed with external funding to let the new technology version to be further explored as the norms and regulations being co-managed by the R&T manager have created new slots requiring applied research and product development to ensure aircraft safety and airworthiness.

# 2 A seat platform: poor exploration management?

## 2.1 Trajectory of the project

As described previously in the case presentation (see p.198), the researcher was encouraged to have a closer look to this seat design after we had organized several meetings and workshops to support the BU in implementing their own management tools and practice to evaluate TRL for R&T projects and support handovers with Development Engineering. This Business Class seat platform project, not only raised the assessment issue for isolated technologies and its integration, but rather emphasised the criticality of design robustness as a system to meet requirements.

The figure VI.2 below, gives the chronology of the project as it was developed over more than two years. The sequence can be followed through the numbers at the corner of several boxes and years highlighted at the bottom. The arrows indicate sequence and causality operating for actions, decisions and the design of decisions. It is a condensed view of the history of the project but we can stress the nature of exploration (platform envelop definition and selection) and the shift towards exploitation requested by a demanding client.

The vertical dotted line is the critical part in the project trajectory. A first exploration was carried out by the project team looking for alternative solution overcoming limitations of packaging and certification for business class (BC) seat. Several options were found in the market (patents, competition benchmark) and they designed several alternatives before elaborating criteria with BU stakeholders to decide on the concept. They ended up with a seat architecture sharing a frame with neighbouring seat (like a bench) supporting their own load and a shell providing volume and several valuable BC features. The modular design puts the emphasis on the seat lower frame as being the core on which all other modules would plug in (foot rest, backrest, shell, etc.).

This is when sales and program management teams saw the attractivity of the product with a greater living space which seduced a demanding client. The concept design was then selected by the client and further refined with their own design studio. However, this shift from exploration to exploitation revealed several complications in the design architecture. For instance, the 3 legged seat and the load of both seat and shell packaged together as whole for certification (i.e. airworthy and safe for passenger) raised the mechanical engineering complexity. This a priori successful balance from exploration to exploitation came out to be quite disastrous: quality issues, delays, engineering cost overruns, and jeopardized seat platform.

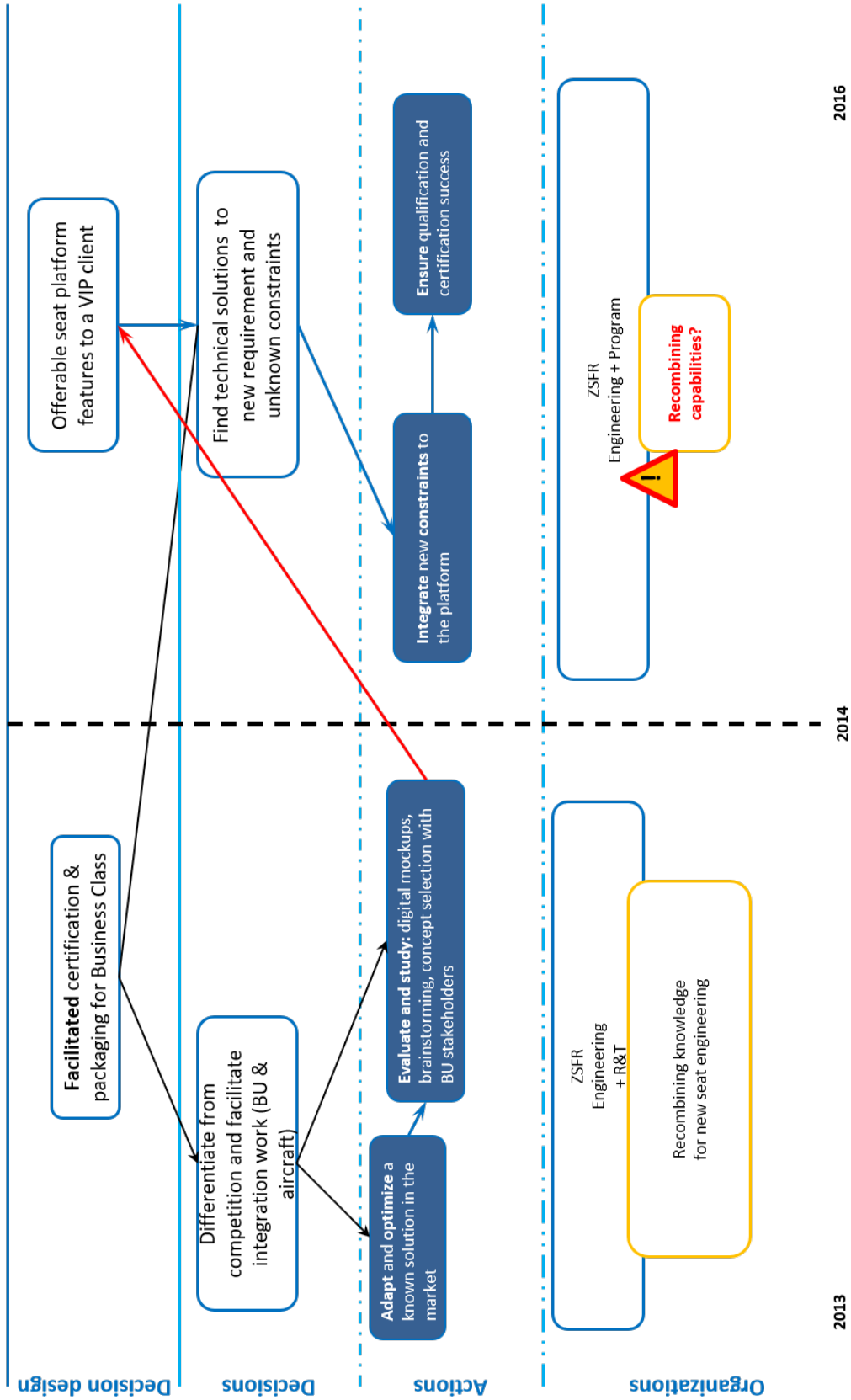


**Figure VI.2:** A jeopardized platform engineering

## 2.2 Models' predictions

| Predictions of the adaptive model | |
|---|---|
| **Model of coordination and collective action** | Sales, Engineering and Strategy managers took part in balancing out exploration and exploitation effort.<br>**Prediction**: Management would actually encourage exploitation of the explored alternatives and subsequent decision-making (concept selection process ) |
| **Generative processes** | The exploration was rich in finding and generating alternatives, ensuring enough room for engineering to develop a solution.<br>**Prediction**: Once the concept is selected, the uncertainty reduction mindset of development projects would be applied to meet client requirements and product early-specifications (modularity). |
| **Environment cognition** | The technology and patent scouting was rich and allowed finding *white spaces* to develop new solutions. Known issues for packaging, aircraft integration and certification-ease were used to design alternatives.<br>**Prediction**: Once a client can make a demand fitting existing offer (preliminary design), the exploitation should be launched and further development would be based on adapting the course of action. |
| **Organization design** | R&T team dedicated to exploration and isolated from engineering department. They were tasked to create a new product concept based on modularity and new requirements.<br>**Prediction**: When exploitation requirements are given, the project should transfer its resources to development engineering. |

**Table VI.5: Adaptive** model predictions for BC seat platform project

| Predictions of the interactive model | |
|---|---|
| **Model of coordination and collective action** | R&T engineers and manager designed digital mock-ups, coordinated with stakeholders to select concepts.<br>**Prediction**: Middle and top management pushes the mock-up and prototypes among department to learn by doing and meet requirements along the development process. |
| **Generative processes** | Tests, simulations and meetings were held around digital mock-ups to refine and generate choices.<br>**Prediction**: The mutual interactions between individuals and prototypes during presentations, and client meetings will gradually ensure a smooth uncertainty reduction. |
| **Environment cognition** | Demonstrated awareness and scouting of the environment through presentations and consultations with BU stakeholders (engineering, marketing, packaging, certification).<br>**Prediction**: Added requirements will be identified through interactions with client and prescribers (design studio). In exchange, the proposed seat platform features will be discussed and mutually adjusted. |
| **Organization design** | The initial R&T project spreads beyond the R&T team boundaries with involvement and consultation of different stakeholders.<br>**Prediction**: Depending on the evolution and definition of requirements, the necessary resources will be found and support the product design. The Engineering department may have to be reconfigured to fit the modular design. |

**Table VI.6: Interactive** model predictions for BC seat platform project

| Predictions of the encapsulated model | |
|---|---|
| **Model of coordination and collective action** | The exploration project had a concern for platform engineering feasibility and an exploitation target (packaging, ease certification). Middle management as well as BU management supported the initiative.<br>**Prediction**: The project would be part of a product line or stream of projects, and eventually a program for business class seat platform. |
| **Generative processes** | The design practice to define the seat platform made an effort to define the minimum and common features required for modularity. The selection criteria also shaped the design of alternatives.<br>**Prediction**: As new requirements would be demanded by the client, the project would gradually adapt and propose variations to the platform. |
| **Environment cognition** | The project reached out for unmet needs from value chain and aircraft integration to extend the project's requirements.<br>**Prediction**: The client's project would define new requirements and induce constraints that would have to be adjusted to the R&T project's specifications. |
| **Organization design** | The projects relied on R&T engineers and request additional resources if needed.<br>**Prediction**: Transferring the project to the development engineering to develop the seat platform would require to temporarily find resources in engineering departments to solve conflicting requirements. |

**Table VI.7: Encapsulated** model predictions for BC seat platform project

## 2.3 Anomaly: a rich exploration jeopardized by a demanding client

| Actual course of action | |
|---|---|
| **Model of coordination and collective action** | The exploration is guided by exploitation objectives. The shift is capitalized by the client and its requirement. During the actual product development, mechanical engineering issues were faced due to novelty/unfamiliarity of the product for development engineers. |
| **Generative processes** | Careful exploration was conducted with criteria for selecting them defined with BU stakeholders. The complications faced by exploitation activities raise numerous questions on the evaluation of generated/selected alternatives. In the end, the platform design is no longer modular and the client's product becomes specific and has generated cost overruns. |
| **Environment cognition** | After exploring the environment to define the platform, the client and its design studio imposed requirements forcing the platform design to be adapted. The built-up awareness for exploration is reduced and non-negotiated with the client (imposed requirements). |
| **Organization design** | The project gradually moved from R&T to Engineering, but also had to come back to some R&T engineers to solve complications in mechanical engineering practice. The Engineering Department struggled to meet requirements. |

**Table VI.8:** Actual course of action for BC seat platform project

This comparison shows that the actual course of action is far more complex and raises again numerous obstacles the literature models would not have fully grasped. For instance, the decision-making process organized during the exploration phase was used not only to select a platform design, but also as a basis to generate new alternatives in between decision meetings.

The transition from exploration to exploitation was seen from the angle of the client who identified a feature (increased living space and leg space) in the platform seat (with its enhanced packaging and certification). However, the difficulties were treated by the Engineering department requiring to call back R&T engineer to support them. There is then an overlap of the influences between exploration and exploitation.

### 2.3.1 Lack robust design practice between R&T and Development?

One could argue that the engineering is overall of poor quality. It is an argument hard to sustain as the BU is one of the market leaders and pioneered several designs. Moreover, the product development is conducted in short time period (2 years approximately) and it requires a lot of flexibility within engineering departments to support the design and development. The researcher had the occasion on multiple occasions to witness the density of relationships and knowledge sharing within a project's scope.

Together with the Engineering Director, ex-post reviews were conducted to evaluate the maturity and robustness of the design during the exploitation phase (client's program gates). It revealed that the several mechanical issues relating to the interference of the platform design and client requirements were understood late in the development process. The researcher found that traditional product development (i.e. no modularity) relies a lot on the physical testing conducted quite late in the process due to parts availability[1]. However, simulation test engineers had flagged several flaws of the design, but were not heard by development engineering preferring to witness the physical test, whereas they were by R&T engineers during the exploration phase.

Finally, it is not a complete failure as teachings have been transferred to R&T team and advanced concept team (group of internal designers and engineers) to study again the possibility to develop a new modular design, with more emphasis on the shell design. Another topic on modularity was also launched by the R&T team approaching the concept differently, for instance, not in seat-centric way.

### 2.3.2 Too early exploration/exploitation transition?

One could also argue the project was handed over to quickly to the engineering department. However, it is not really the case as the selection of concepts was made collectively and interactively with BU stakeholder. The client's request for proposal and bid award was an actual great opportunity to value the exploration phase conducted by the R&T team.

[1] It is almost a *religious* moment for engineers and the client who is sometimes invited. People come to witness the first dynamic crash test as it were a major milestone in the qualification process which validates design choices

What is perhaps missing is the weakness in countering the demanding client's request which have pushed the physical limits of the platform design. Why not using the client's opportunity and constraints to develop in parallel a full platform design instead of trying to keep some complicated associated features (e.g. totally new compact seat kinematic)?

The exploration and exploitation were put on a same continuum, being perhaps overlapped at the beginning of the project. Later, it unfortunately over-complexified the product design and development, to a point where the innovation effort in the platform design is killed by switching to a normalized exploitation regime. When discussing with engineers and managers why some alternatives had been discarded (designed by the researcher with C-K Theory, see (Le Glatin, Le Masson, and Weil 2018) and appendix A3), signs of regret were identified explaining the difficulty to identify and articulate the exploration/exploitation divide earlier in design practices.

# 3 ADT/Design Thinking: resistance, death valley and organizational misfit by design?

## 3.1 Trajectory of the project

The last case we are presenting here is the synthesis of two projects managed by the Airbus Development Team (see p.200). The researcher had the occasion to analyse two projects led by two different members (engineer and designer) who had been trained to Design Thinking. The other ADT participants had been also introduced, if not trained to it, like it was the case of ADT's manager. The latter had given access to all documentation available on their server and requested his colleagues to save some time for my interviews. The team had been tasked to generate proposals valuing BU's know-how and combined synergies in the form of Multi-BU projects. They usually referred to the recurrent argument of the *not-invented here syndrome* or *resistance to change* to explain the absence of follow-up by BUs to develop their generated concepts.

However, they stressed some cases where BUs were thrilled by having opened their eyes to the competencies of sister BUs in the group, unlocking interdependencies between products that are usually hidden by market segmentation and sales channels. The projects based on Design Thinking adapted the method to have BUs not only learn from user knowledge, but also to have multi-BU design workshops.

As presented in the Appendix A1 (p.397), the cases were analysed with the help of C-K design theory in order to understand the performance of the generative processes in the projects and their impact for BUs (ADT's mission). The C-K mappings were synthesized from control groups of students from Mines ParisTech. The figure VI.3 below shows the synthesis of the projects' trajectory. Both design briefs (Better Waste Management and Turn Around Time Optimization) followed the same pattern as they had defined a methodology canvas adapted from their practice, experience and Design Thinking.

Our focus is on the output of the projects as they come to a standstill. If Design Thinking may not be the key to everything, it is worth understanding the relationship between the nature of generative processes and their organization impact: concept appropriation and development by business units.

In the appendix A3 (p.423), this transition from exploration to an absence of exploitation is analysed. Below, we propose rephrasing it with descriptors and models' predictions derived from our literature review. The trajectory is summarized in figure VI.3, and they strech over less than a year (approximately 8 months).

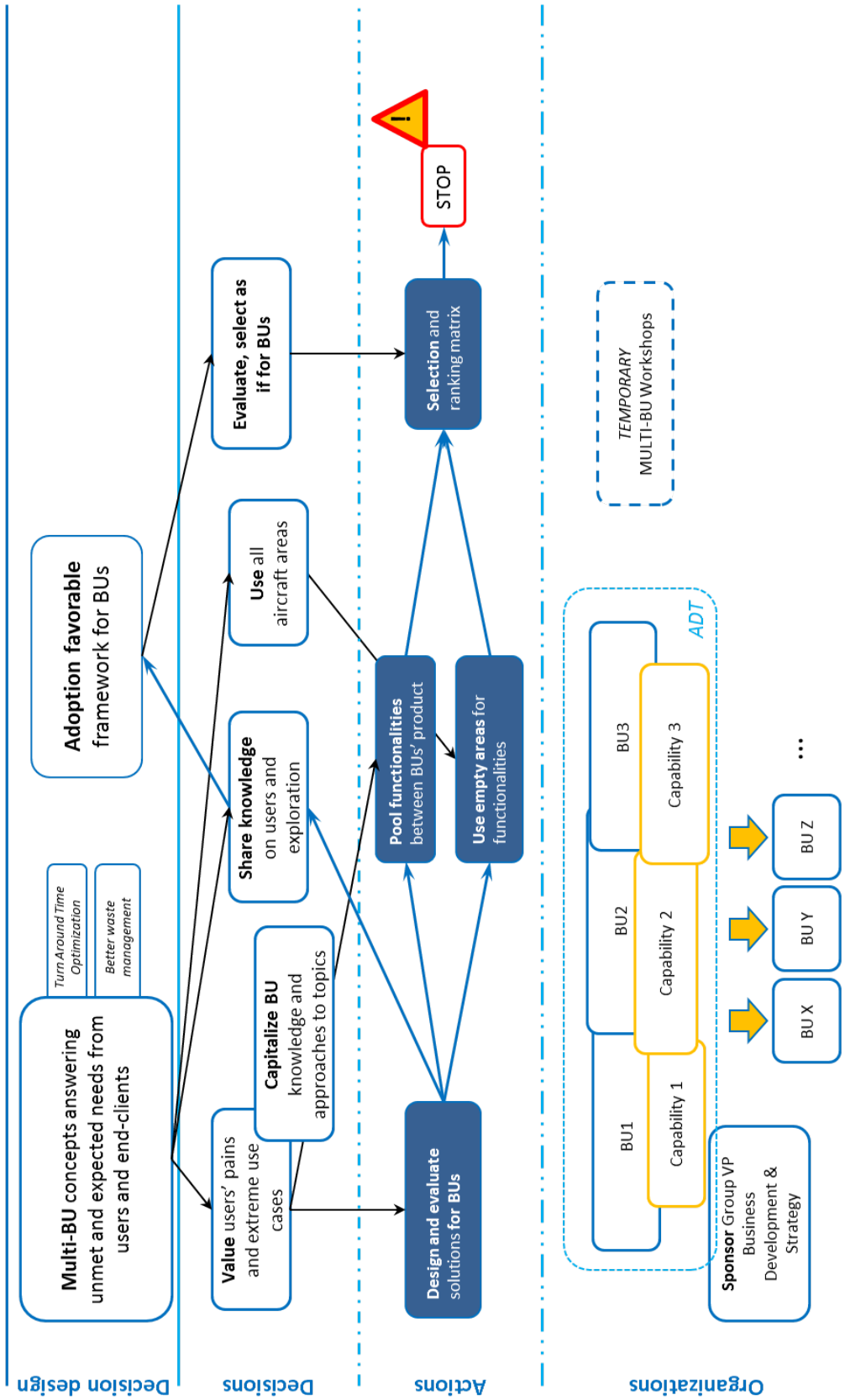


**Figure VI.3:** A constituted path challenging BU strategy and organization ties

## 3.2 Models' predictions

| Predictions of the adaptive model | |
|---|---|
| **Model of coordination and collective action** | ADT manager leaded the balancing of exploration and exploitation prospects (BU's interests). Sponsorship from the VP of Business Development & Strategy. Workshops were organized to balance out concepts and their rework.<br>**Prediction**: Leadership and top management identifies how the concepts can fit BUs' strategies. |
| **Generative processes** | The exploration was supported by Design Thinking generative power driven by user empathy and extreme user cases.<br>**Prediction**: As user/client value is supported by Design Thinking practice, the product development (exploitation) should naturally occur. |
| **Environment cognition** | The environment and value chain was scouted with the help of Design Thinking and other ADT's activities such as previous projects and technical support.<br>**Prediction**: The newly explored environment should ensure enough decisional/problem-solving background for BUs to engage in exploitation of concept proposals. |
| **Organization design** | ADT team is an example of contextual ambidexterity organized at the group level. The exploration is delocalized, interactions with relevant BUs are maintained along the exploration process (for organizational learning).<br>**Prediction**: Exploitation of proposed concepts will be slightly adapted to the products design as they may require contractual development between BUs. Organization design should mirror the product as they have accepted and participated to the concepts' user/client value. |

**Table VI.9: Adaptive** model predictions for ADT/Design Thinking projects

| Predictions of the interactive model | |
|---|---|
| **Model of coordination and collective action** | ADT members and BUs correspondents, at stake with project's topic, are in continuous contact to share knowledge and co-design concepts.<br>**Prediction**: Middle management should naturally embrace the concepts as meaning is created and circulated. Top management will sponsor the initiative due to emergent strategic interest. |
| **Generative processes** | Users and observation studies provided the foundations to generate concepts and solve existing or non-existing issues creating justified value-added. Co-design sessions with BUs also contributed to it in addition to knowledge sharing.<br>**Prediction**: The gradual sense-making and demonstrated client value should ensure concept appropriation and development. |
| **Environment cognition** | BUs' environment knowledge was integrated as well as extended by scouting.<br>**Prediction**: The explored environment with new conceptual alternatives extends the network for BUs and allows them to build system thinking. |
| **Organization design** | The exploration project used internal ADT resources and progressively solicited BUs' resources for exploration.<br>**Prediction**: The proposed concepts may call for an intra-BU or inter-BU development depending on the interactions with existing BUs' product architecture. BUs should then align as value is demonstrated. |

**Table VI.10: Interactive** model predictions for ADT/Design Thinking projects

| Predictions of the encapsulated model | |
|---|---|
| **Model of coordination and collective action** | The exploration projects were part of the overall ADT's program of making boundary-spanning proposal for BUs to develop intra and/or inter BU products. **Prediction**: The sum of projects would potentially generate organizational learning for BUs, if not, create product development opportunities through top management program governance and sponsorship from VP of Business Development and Strategy. |
| **Generative processes** | The Design Thinking, combined with ADT's experience and Practices, supported the exploration effort, in addition to the ADT overarching design brief. **Prediction**: The generativity would be driven by user observation and BUs segmentation to create the appropriate associations. |
| **Environment cognition** | The generative processes have encoded the need to scout the environment by targeting user experiences. **Prediction**: The exploration projects would open a new and demonstrated product development environment for BUs. |
| **Organization design** | The exploration projects rely on ADT's resources and handover to BUs after selection. **Prediction**: Transferring would imply technical documentation to fit BUs available resources or identify new ones. |

**Table VI.11: Encapsulated** model predictions for ADT/Design Thinking projects

### 3.2.1 Anomaly: client value demonstrated but no NPD

| Actual course of action | |
|---|---|
| **Model of coordination and collective action** | The exploration is guided by exploitation objectives (user pains) that are potentially in-between BUs boundaries. |
| **Generative processes** | The generativity is supported by Design Thinking and added practices (multi-BU co-design workshops). The assumption is made that the user and client value being demonstrated, the concepts will naturally trigger their product development. The generative process is naturally fixated by users (encoded in design method). |
| **Environment cognition** | User experiences and BUs' environment are scouted. Design Thinking mainly develops concepts fixated by the existing environment. When crazy concepts are generated, they are adapted to what a BU would develop without considering capabilities (re-)generation of the environment (product standards, certification, sales channels). |
| **Organization design** | When crazy concepts are generated, they are adapted to what a BU can develop without actually considering new or recombination of capabilities within the BU or with other BUs. |

**Table VI.12:** Actual course of action for ADT/Design Thinking projects

The comparison of the actual course of action with the models' prediction reveals again the necessity to understand the micro-foundations of exploration and exploitation, and their balance. The generative process practice of Design Thinking gives an idea of the direction of generativity and how it tries to build to innovation potential of attraction through demonstrated user and client value.
However, none of the business units were interested in actually committing to pushing

the concepts further. They had accepted the concepts and recognized their interest and client value. They had even co-designed the concepts with ADT members, validated by VP Business Development sponsorship.

The exploration opened the path to new knowledge and better awareness of the environment and system thinking. Opportunities of connecting BUs together, through concepts revisiting interdependencies, were identified as they would be usually hidden behind their traditional market and product perspective. Nevertheless, the models fail in explaining why the concepts are not developed by BUs as we discuss below.

### 3.2.2 Co-design, acceptance and no follow-up

The *non-invented here syndrome* could be of course flagged as being the main reason for BUs not accepting to making these concepts their own. Indeed, no project lines were added to the budget by Business Unit. Only one added a line, but with zero budget, meaning they would perhaps consider a paper study. The *death valley* argument (Markham et al. 2010) is also not really valid as BU can budget the project, and budget consolidation is discussed with group CTO, ExCom and each BU manager to decide how they size the budget with support from the holding's budget.
What is even more surprising is the fact that engineers, designers and managers from BUs participated to co-design workshops with other BUs. They legitimized and made sense of the concepts themselves in addition to welcoming the shared knowledge on users and value chain.

### 3.2.3 Exploring alternative aircraft spaces

Finally, the concepts generated with Design Thinking, as presented in appendix A1 (p.397), were designed as if for BUs wouldn't change. Moreover, the decision process to rank and select concepts in order to be promoted to BUs reinforced the stability of existing boundaries and engineering capabilities, as well as markets domains.
In some other cases, concepts generated through *What Ifs? scenario* allowed relieving some operational constraints (e.g. passengers storing their personal luggage in containers, passengers participating to waste sorting). These concepts unlocked interdependencies between aircraft equipment and engineering as seen in C-K reference mapping. However, the concepts were promoted as if BUs could just adapt them, without emphasizing the radicality of the new perspective implying deep reconfiguration of engineering design, system architecture and market positioning.
We have overall a good example of ambidextrous organization with a supportive top management leadership, a valuable generative process, deep interactions at different management levels. But, our literature models fail to explain the absence of further product development or even re-use of a feature in their technology and product roadmaps.

# 4 Chapter synthesis

Based on the methodology designed for our research questions, we have taken each case individually by identifying a critical snapshot in the project trajectories where the adaptive, interactive and encapsulated models where used for predictions. By categorizing these with our descriptors, and comparing them with the actual course of action, we have spotted anomalies and discussed their justification.

Firstly, we have demonstrated the fact that ambidexterity actually kills innovation, which answers our first research question. We have also managed to specify the different obstacles revealed by the analysis supported by design theory and engineering bringing the necessity for an micro-approach to the balancing of exploration and exploitation. Several biases and fixations effects stem from the *non-mutual conditioning* between these two regimes, which appears to be no longer valid in the unknown and high uncertainties.

Secondly, we have also stressed that the black-boxing of generative processes within projects can later create controversies for middle/top management as well as strategic coherence. Indeed, the separation of exploration from exploitation at the organizational levels tends to bring and reinforce **organization design fixations**. It does not encourage taking them into account within generative processes to value the necessary change dynamics among resources nor the routines supporting engineering practices.

Finally, these results, specified in different ways through intra and inter BU cases, give several hints to try to overcome the literature models' limitations to design an extended model reconciling with the observed anomalies. Our aim would be to reconnect the ambidexterity models with the unknown since innovation management has developed in ways that the original non-mutual conditioning has lost ground.

# Chapter VII

# Management anomaly specification

In this chapter, we propose to synthesize the anomalies highlighted by the cases' results of the previous chapter before listing the requirements to design a new model extending the literature models of non-mutual conditioning between exploration and exploitation, in order to understand the observed phenomena.

The first feature raised through the descriptors and the comparison between models' prediction is perhaps the continuity and orthogonality of exploration/exploitation that is dealt at different levels: generative processes, coordination mechanisms, environment cognition and organization design. So, we confirm the nuances expressed in (Gupta, Smith, and Shalley 2006). What is perhaps more surprising and natural at the same time is the fact that exploration can be based on exploitation characteristics. However, the cases show these can be beneficial or counter-productive for innovation management, thus requiring an careful management to counter the forces of traditional models of ambidexterity.

The second aspect is that we can assert that ambidexterity kills innovation. It is of course a bold statement, but the meta-language of exploration/exploitation tends to ignore the micro-foundations of collective action such as decision-making and generative processes (Birkinshaw and Gupta 2013). The actual implementation of ambidexterity, be it contextual, structural or sequential, induces numerous complications dealing with exploration/exploitation regime separation for practice. More specifically, it appears to be incompatible with practices where the unknown is effectively managed.

The cases show they follow organizational ambidexterity, but at the same time, have mitigated efficiency when it comes to exploration or exploitation standalone. Radical innovation is not really achieved for the originally intended exploration project, despite

having several other valuable takeaways (Elmquist and Le Masson 2009). There is tendency to leave exploitation routines as a static reference point, as a fixation effect, and let exploration free float in other directions without carefully managing the search and generation directions.

Organization design being constricted by certification and market constraints, generative processes and organization ambidexterity clashes to support this enclosed change calling for a support of organizational metabolism and potential *regenerative dynamic capabilities* (Ambrosini, Bowman, and Collier 2009). Despite appropriate interactionism, we have seen that practices are not sufficient to sustain generative processes into a full settlement organizations. At best, in the case of the icing conditions detection, the settlement is partial as the alignment with BU management and Engineering department remains controversial. Consequently, reconsidering organization design supported/supporting generative processes appears crucial, as it probably implies considering the mirroring of the engineering efforts.

Consequently, we would propose some requirements extending the literature models presented previously. These where limited to non-mutual conditioning of exploration and exploitation. This extension is crucial since the observed phenomena tends to show dynamics sustained at the level of engineering design practices challenging the coordination of exploration/exploitation conditioning and the management of its innovation potential of attraction.

We propose to simply name this extended model by considering the **mutual conditioning between exploration and exploitation** as a means to overcome the fixation effects which are managed at the engineering design, organizational and environment levels.

# 1 Synthesis of anomalies

The three cases presented in the previous chapter have insisted on different limitations of the three proposed literature models of non-mutual conditioning between exploration and exploitation:

- **Adaptive model:** the search-based assumption of exploration is overstretched by generative processes of different nature and locus. Exploration is guided by uncertain or unknown (i.e. to be designed) exploitation constraints as cleverly managed in the icing conditions detection case. Whereas, it can also be a lock-in despite valuable generativity on the user experience domain, as several fixation effects of existing business units are not revisited as presented in the ADT's cases.
- **Interactive model:** creation of meaning and value circulation among (silent) designers around meetings and prototypes are not sufficient to sustain radical innovation and the associate unknown gradual shaping. The business class seat platform shows the interference and conflicts arising from the exploration/exploitation handover and agenda differences. It would require a management of deeper learning mechanisms. Exploration and exploitation are unfortunately both jeopardized.
- **Encapsulated model:** As already stressed in the literature on project-based management, the need to link project trajectories with underlying organizational ties, resources and routines is even more critical at the light of exploration projects searching for exploitation landing fields. Learning and change management tend to be dissociated in exploration and exploitation regimes.

Below, we stress the anomalies raised by the cases compared to the synthetic model portrait in the research questions chapter (p.121). As the reader will notice, some anomalies are reformulations further specifying the limitations already raised in the literature.

Then, we come back on the different observed anomalies based on the models predictions by comparison with the actual course of actions. We start then disentangling these anomalies before formulating our new model requirements.

| | **Non-mutual conditioning** | **Mutual conditioning** results |
|---|---|---|
| **Model of coordination and collective action** | 1. Not necessarily on the same continuum, exploration and exploitation call for two dissociate action regimes<br>2. Balancing is left as a paradox at different levels of analysis: structure (centralization, distribution), time and individuals. | 1. Exploration is driven by exploitation characteristics, sometimes with loss of control.<br>2. Leaving the balancing as a paradox leaves innovation unmanaged. Balancing exploration and exploitation can be managed through sensemaking around prototypes and meetings, but does not address the change management properly (partial or dynamic mirroring) |
| **Generative processes** | 3. The nature of generative processes supporting exploration appears quite free, random and sometimes even foolishness-based.<br>4. Generativity of the product development may not be sustained by (temporary) organizations (floating issue).<br>5. The performance and reference is light structured: reduced to a selection issue or sometimes to complex interactionist phenomenon. | 3. Generative processes are partly directed if not biased by exploitation constraints and not necessarily managed carefully.<br>4. Generativity may indeed require radical organizational learning and change but is not properly managed at the engineering design practice level.<br>5. Performance is not necessarily discussed nor sanctioned but appears as a conscious struggle that goes beyond selection process or sensemaking |
| **Environment cognition** | 6. One-way interaction: Environment to Organization.<br>7. The environment structures the response, nature and distribution of generative processes.<br>8. The environment is used to augment the product development requirements. | 6. The environment may be actively managed to legitimize the innovation potential.<br>7. Generative processes do not (systematically) address and leverage fixations by the environment.<br>8. The environment awareness does augment design requirements but struggles in identifying the mirroring organization change. |
| **Organization design** | 9. Organization design is pre-conceived or uncontrolled.<br>10. Organization design creates gaps for managing generative processes and the dynamics of their organizational ties. | 9. Organizational ambidexterity conflicts with design and engineering organizational mirroring.<br>10. Organization design is isolated by exploration/exploitation dichotomy. |

**Table VII.1:** Model of non-mutual conditioning of exploration and exploitation and synthesized case results

## 1.1 Generativity biased by exploration/exploitation dichotomy

First of all, it is important to note again that our research agenda set from the beginning was to use advances in design reasoning and theory to understand how generative processes and associated management of unknown allows revisiting innovation manage-

ment and the major construct of ambidexterity. The cases presented earlier show how the models black-box the nature of generative processes and their interferences with several managerial dimensions such as: coordination mechanisms, environment cognition and organization design.

Angela Dumas with Henry Mintzberg (Dumas and Mintzberg 1989) had stressed the importance of *silent design* occurring across the organization. The cases reveal how these distributed design activities can be framed and segregated by what exploration and exploitation are in an ambidextrous organization.
In the cases of the business class seat and ADT, the generative processes had used clear exploitation characteristics to base their exploration: seat packaging, integration and certification issues, and user pains. It is used as a reference point, but at the same time when balancing out exploration/exploitation, the generative processes require an extreme adaption to exploitation organizational constraints despite having made a strong effort on the cognitive and interactive dimensions. The exploitation is conducted as if a simple extended or new list of requirements had been given to the engineering departments. Risks can be assessed, as well as maturity, but these registers are unfortunately rather static. They may not capture and manage *epistemic interdependencies* accordingly (Puranam, Raveendran, and Knudsen 2012).

Exploration efforts are then potentially biased by the non-mutual conditioning. And inversely, the exploitation is heavily burdened by exploration features that lack articulation with generated novelties.

## 1.2 Killing sustained innovation capabilities

The nature of unknown, its management and generativity have been underestimated in how they collide with adaptive, interactive and encapsulated models. They stretch the boundaries of these management models and challenge their viewpoint of collective action. The radical innovation intent is severed by their limitations.

For instance, among the expected capabilities, the role of leadership, top management and governance is stressed as being crucial. However, the actual practice and implementation is rarely discussed in detail. The different cases showed how management layers took an active role in projects trajectories. Valuable practices were implemented ranging from sensemaking, decision-making to sponsorship. These were meant to balance the contradictions of exploration/exploitation trade-offs and the results are partially successful and riddled by controversies.

The icing condition detection case creates a critical tension between its business environment legitimacy and BU strategy and Engineering appropriation. Following the retirement

of the R&T manager, the researcher had relayed his idea of licensing the technology to an external firm capable (adequate cost-structure) to develop and industrialize it for small aircrafts. This move would be a means to actually set a foot on the aviation market, make a case for it before fully demonstrating its usefulness for heavier aircrafts enhancing flight safety. Again, such emergent strategy would be possible by fully considering separation nor balance of both, as they explore and exploit interconnected fields.

### 1.3 Ignoring organization design and its engineering design mirror

Organizational ambidexterity had highlighted ways of structuring the balancing of exploration/exploitation adding different typologies on how to sustain a competitive advantage. Oddly, separating it in space, time or leaving it in context, brings some organization design into play but only by sketching the organic dimension of it. For example, the centralization of ADT at the group level or creation of a standalone R&T team are fully prescribed. It still leaves numerous ties among members with exploitation activities and extended environment constraints. However the black-boxing of generative practices into these organic systems ignores the risks associated with the potential need for reconfiguration of stakeholders ties. Thus, the dynamics induced by design practices require, not only a partial-mirroring by organizations, but rather a mirroring dynamic.

For instance, the required adjustments, in terms of engineering capabilities to engineer a seat platform architecture, require a mirroring organization (Colfer and Baldwin 2016). The change is not addressed within generative process and with *integrators* contributing to *interdependence shift* (Stan and Puranam 2017). The managers in charge of the projects were acting as integrators. In the case of the seat platform, they a priori managed to articulate the integration for the Engineering Department and were later called back for further support. The same goes for ADT: numerous sessions were organized during the exploration but also after concept selection to follow up and adapt the preliminary designs trying to facilitate the integration. As specified in the limitations section (Stan and Puranam 2017, p. 1058): *A significant weakness of this study is that it does not provide direct evidence for the micro-mechanisms of how integrators help to cope with interdependence shifts—only that they do (and that these effects are visible even at intermediate performance stages).*

The idea of a triple-loop of organizational learning (Leifer and Steinert 2011; McClory, Read, and Labib 2017), and the regenerative capabilities point in that direction. But as they engage in a recursive pattern, as discussed in the literature review, it appears crucial in the case studies to frame the organization of collective action with practices that are tightly linked to generative processes. In a more successful way, the icing conditions detection case shows how future exploitation constraints (regulation and norms) are shaped to support the technology search and selection.

# 2 Specifying requirements for a new model of ambidexterity

Coming back to our research questions (p.121), we have stressed how organizational ambidexterity can severe radical innovation practices embodied by different generative processes. One could say that it is the fault of organizational culture, but we have pointed in ZA's presentation (see p.187), there are no signs of bad intentions raising barriers again these radical innovation in the cases presentation and results. Several practices and management tools were used to circulate emergent value among stakeholders, including collective decision and co-design workshops.

So, our first assumption would be to put the emphasis on the micro-foundations. The nuts and bolts of generative processes and interactions with value management, action and decision-making would be absolutely critical to embody ambidextrous management. It fits the behavioural foundations of March's agenda (Gavetti, Levinthal, and Ocasio 2007) and it lies at the crossroads of design theory and reasoning which can be understood as science extending H.Simon's work (Hatchuel 2001; Simon 1996). Considering everyone as a designer in its own way and practice, generating actions, interacting with other (silent) designers and artefacts, could be a means to think of generative processes among all of these organs and processes, which call for a meta-process such as metabolism (Hatchuel, Weil, and Le Masson 2006; Segrestin et al. 2017).

> Among our descriptors, we could then propose to consider what could be explained by a metabolism. We consequently need to target what contributes to such phenomenon that is neither structure nor traditional process. Deriving from our observed and justified anomalies, we propose to recentre organizational ambidexterity around decision-making by bringing in the teachings of design theory at that level as well as organizational design.
> We would then embed some sort hacking of the constraints and biases induced by exploitation/exploration non-mutual conditioning. Moreover, it will bring a dynamic mirroring hypothesis as a means to reflect the organizational change supporting the generative engineering design.

## 2.1 Generative process and ambidexterity micro-foundations

From the beginning of our literature review up to the cases analyses, we have discussed the course of action, decision-making and generative processes. We have justified how organization ambidexterity can kill sustained innovation management.
So, we have to come back to foundations of the exploration versus exploitation model whilst also keeping in mind the limitations and perspectives identified in the interactive and encapsulated models.

The model's extension we propose to address in the following part (4, p.249), should then almost start from a similar reasoning introduced in the foundational paper (March 1991b). However, the dichotomy of exploration and exploitation should be fully revisited by considering **a mutual conditioning** of both regimes as it was sketched by the practices highlighted in the projects' trajectories.

The nature of problems, their (re-)formulation and solving should be reworked around the uncertainty and unknown management. Decision and problem management should be enhanced by generative processes. For instance, in (Le Glatin, Le Masson, and Weil 2017b) (appendix A2, p.413), we associate the possibility to deliberately play around the reversal of preferences to push decision-making into the unknown. We have proposed to call such pattern **decisional ambidexterity**.

Such practice should aim at identifying fixation effects and their (epistemic) interdependencies. This **technology of organizing** should support creation of meaning, value management, engineering and a baseline for coordination and collective action.

## 2.2 Generative processes and organization design

The free-floating of exploration projects, as they look for organizational ties, should also think through the lens of design theory and reasoning. The idea of design-oriented organization (Hatchuel, Weil, and Le Masson 2006) already pointed in that direction. We need to specify with more clarity the organization design, as we have seen that assumptions of temporary organization or project-based organization tend to hide the complexities of changing engineering design briefs in exploration project management.

Design theories and reasoning are usually discussed for products and services, but one could consider the organization, its resources and routines as concept-enabling-knowledge for design. So, the key requirement of the model is to avoid black-boxing generative processes, as we have seen they expand onto several management dimensions. We should then put the emphasis on potential **organization design fixation** that are not naturally part of the engineering design practice, nor traditional project management. These are usually discussed in change (project) management and organizational change but would probably benefit from richer synergies if embedded in actual project management (Hornstein 2015; Pollack 2017).

Consequently, our **model of mutual conditioning between exploration and exploitation** should also aim at managing an organizational metabolism necessary to sustain organization re-design as a necessary condition supporting the innovation potential of attraction of - so far black-boxed - generative processes in exploration project management.

# 3 Chapter synthesis

Thanks to the previous chapter, we were able to identify literature models' weaknesses and several hints given by the case studies. The synthesis of results reveals, through tracking of generative processes in projects trajectories, that there is in fact a conditioning managed or left uncontrolled between exploration and exploitation.

First, we propose to return to the micro-foundations of organizational ambidexterity as generative processes interfere with several management dimensions depending on their generativity. Some are indeed more or less fixated by exploitation constraints, and some are actually actively used to generate concepts. Therefore, focusing on the model of action, decision-making and generative processes would be a means to specify how managers, individual and (silent) designers should interact with such constraints to manage the generativity of their practice embedded in projects.

Second, the case studies results encourage to focus on the dynamics of the mirroring hypothesis, as the generative processes may challenge to some extent interdependencies that can be catastrophic to exploration value and subsequent exploitation. Radical innovation fostered by generative processes may indeed be fixated by organization design, thus winking at bringing organization design as concept enabling knowledge supporting product design practices. Change management could be then brought at the level of product project management and the underlying generative mechanisms.

Finally, we have a requirements baseline to continue our journey to design a **model of mutual conditioning between exploration and exploitation**. We have new grounds extending the studied literature models and reconnecting ambidexterity with its behavioural foundations at the light of the teachings of design theory and thinking.

# Part 4

# Modelling and testing decisional ambidexterity

# Part Contents

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**Outline** In this fourth part, we propose to define and detail a model extending the literature models presented earlier by specifying the criticality of **mutual conditioning between exploration and exploitation**. We do so by reconnecting with the behavioural foundations of ambidexterity such as decision-making, and by enhancing it with design theory. It allows embedding at a micro-level the generative processes and articulate its generativity with cognitive, social, systemic and organizational dimensions.

The first chapter (VIII, p.255) synthetically reformulates the article published in *European Management Review* (Le Masson et al. 2018) which can be consulted in the appendix A4 (p.463). We develop the concept of **decisional ambidexterity** which considers the capability of designing decisions. It is based on the results of the previous part (3, p.211) and more specifically the peculiar decision-making process identified in the Icing Conditions Detection case (Le Glatin, Le Masson, and Weil 2017b), available in appendix A2. We outline a new approach of making decisions by integrating design theory which effectively embraces the unknown. We gradually explain why we gain more insight on cases presented previously with anomalies.

The second chapter (IX, p.269) complements the previous one by emphasizing our concern for the organizational impact of generative processes as they may be black-boxed within projects and departments but still ripple across organizations. This feature was stressed by the intra/inter-BU dimension, thus encouraging us to nest organization design at the level of engineering design and decision-making in exploration project management. We use again the previous anomalies and explain how decisional ambidexterity allows reconciliation. By doing so, we insist on redefined micro-foundations of ambidexterity and associated **technology of organizing** required to avoid biases and fixations effects which are usually made silent through the non-mutual conditioning between exploration and exploitation.

The last chapter (X, p.283) aims at testing the model of decisional ambidexterity which has encoded the mutual conditioning between exploration and exploitation. To do so, we rely on two inter-BU cases, the Lower Deck and Connected Cabin projects. The first, hosted at ADT, shows how such ambidexterity is developed by a manager whilst keeping in background the Design Thinking cases[1]. The second, in a similar context, reveals another project rooted in several BUs stressing in contrast the essentiality of managing the organizational design within engineering practice and problem-formulation.

[1] No project is an island (Engwall 2003)

**Aperçu** Dans cette quatrième partie, nous proposons de définir et de détailler un modèle prolongeant les modèles de littérature présentés précédemment en précisant la criticité du **conditionnement mutuel entre exploration et exploitation**. Nous le faisons en renouant avec les fondements comportementalistes de l'ambidexterité, comme la prise de décision, et en l'enrichissant de la théorie de la conception. Elle permet d'ancrer à un niveau micro les processus génératifs et d'articuler leur générativité avec des dimensions cognitives, sociales, systémiques et organisationnelles.

Le premier chapitre (VIII, p.255) reformule synthétiquement l'article publié dans *European Management Review.* (Le Masson et al. 2018) consultable en annexe A4 (p.463). Nous développons le concept d'**ambidextrie décisionnelle** qui considère la capacité de concevoir des décisions. Il est basé sur les résultats de la partie précédente (3, p.211) et plus spécifiquement sur le processus décisionnel tout à fait particulier identifié dans le cas de détection des conditions givrante (Le Glatin, Le Masson, and Weil 2017b), disponible en annexe A2. Nous esquissons une nouvelle approche de la prise de décision en intégrant la théorie de la conception qui embrasse efficacement l'inconnu. Nous expliquons progressivement pourquoi nous obtenons plus d'informations sur les cas présentés précédemment avec des anomalies.

Le deuxième chapitre (IX, p.269) complète le précédent en soulignant notre préoccupation pour l'impact organisationnel des processus génératifs car ils peuvent être mis dans une boîte noire au sein même des projets et des départements mais peuvent en même temps avoir des répercussions dans le reste des organisations. Cette caractéristique a été soulignée par la dimension intra/inter-BU, ce qui nous encourage à positionner le design organisationnel au niveau de l'ingénierie de la conception et de la prise de décision dans la gestion des projets d'exploration. Nous reprenons les anomalies précédentes et expliquons comment l'ambidextrie décisionnelle permet une réconciliation. Ce faisant, nous insistons sur la redéfinition des microfondations de l'ambidextrie et des **technologies de l'organisation** associées et nécessaires pour éviter les biais et les effets de fixations qui sont habituellement rendus silencieux par le non-conditionnement mutuel entre exploration et exploitation.

Le dernier chapitre (X, p.283) vise à tester le modèle d'ambidextrie décisionnelle qui a encodé le conditionnement mutuel entre exploration et exploitation. Pour ce faire, nous nous appuyons sur deux cas inter-BU, les projets Lower Deck et Connected Cabin. Le premier, hébergé chez ADT, montre comment une telle

ambidextrie est développée par un manager tout en gardant en arrière-plan les cas de Design Thinking[2]. Le second, dans un contexte similaire, révèle un autre projet enraciné dans plusieurs BUs soulignant par contraste l'importance de la gestion du design organisationnel dans la pratique de l'ingénierie et la formulation des problèmes.

[2]Aucun projet n'est un îlot (Engwall 2003)

# Chapter VIII

# Modelling and testing decisional ambidexterity

*Laws should only provide a basis for self-fulfilment.*
Paul Klee

In this first modelling chapter, in the same fashion as described in the beginning of our literature review, we propose to come back to a canonical model that requires to be enhanced by generative processes. James March in his seminal paper had consciously declared the boundaries of his model (March 1991b); yet these very same edges are heavily challenged by the evolutions of innovation management which have gone beyond the perimeters of the ambidexterity models relying on the non-mutual conditioning between exploration/-exploitation. Generative processes such as design practices taking place for radical innovation, ripple throughout decision-making, collective action, coordination mechanisms and organizations.

Based on the management anomaly specifications and the mirroring requirements needed to design a new model, we propose to synthesize the article published in the European Management Review (Le Masson et al. 2018) (see appendix A4, p.463). The developed model allows clarifying the heuristics associated with **decisional ambidexterity** (Le Glatin, Le Masson, and Weil 2017b) (see appendix A2, p.413). Furthermore, it gives some grounds on the designing of decisions and to set a new frame for collective action.

We discuss which extensions are made on the traditional assumptions on problem-solving and rational theory of choice thanks to the teachings in design theory. We can then revisit some stimulating constructs previously identified in our literature review discussing the performance of the decision design relating to the *innovation potential of attraction* and underlying useful methods and heuristics.

All along the modelling effort in the following section, we make several references to the previous detected anomalies. We do so in order to explain how the new model allows gaining new insights. We also refer to the gap-filling between former models and the new as we also tasked ourselves to keep coherence and a sense of continuity when coming from the known to the unknown.

We start by coming back to the original model of (March 1991b) with its foundations in problem-solving and choice of alternatives. We extend the canonical framework of decision-making into the unknown with the support of C-K design theory.

Then, we discuss the performance of the decisions designed and made. It invites to think beyond traditional expected utility theories of choice.

The first partial representation of the model is pictured on p.266 and the table VIII.1 (p.267) gives a comparison with the synthetic model of non-mutual conditioning between exploration and exploitation.

# 1 Designing decisions: decisional ambidexterity for organizational metabolism

In the introduction and premises of our literature review (chapter I, p.51), we presented the trajectory of the agent-based model of James March, creating the construct of exploration and exploitation to sustain organization learning and fighting for supremacy (March 1991b). The starting point being problem-based - and consequently decision-making by adding a pinch of uncertainty - allows considering the bounded rationality of agents limited in their daily routines, and requiring exploration, i.e. search-based patterns looking out for overlooked alternatives already present in their decision space.

The issue of the decision creation is rather left aside by only promoting the garbage-can decision model and foolishness as a means to improve the generation of novelty, beyond pure selection issues. Without discarding altogether a potential contribution from foolishness and irrationality, starting from the canonical model of decision theory such as (Wald 1945, 1949)[1] where an agent picks up an alternative among those offered to her, consequences $X$ are known depending on the outcome of the states of nature $\Theta$. The (statistical) decisions ($d : s \in \Theta \rightarrow x \in X$, $d \in D$) are calculated based on costs of consequences ($c : x \in X \rightarrow y \in \mathbb{R}^+$) and the states of nature weighted by degrees of probability $\mu$. The theory predicts the existence of an optimal choice minimizing costs.

Using design theory, such as C-K theory (Hatchuel and Weil 2009), for its generality can be used onto the canonical model $(D, \Theta, c, \mu)$ which can be complemented by statistical learning $L$ drawn from previous experiences and sampling $(D, \Theta, c, \mu, L)$. We also address the issue of simultaneous problem formulation and solving, conceptualized in need-solution pairs (Hippel and Krogh 2016) who encouraged the use of design theory to identify and generate these pairs.

## 1.1 Mobilizing design theory for decision paradigm

The dominant design stemming from the decision problem is the optimum choice in the acknowledged set of choices, beliefs, states of nature and cost function. Using C-K theory gives a starting point formulated by a model of knowledge that can be considered as the state of the art, and the decision broken down into the given environment $\Theta$ and optimal decision maximising expected utility $d_{MEU}$ (minimizing costs). We then have a first branch on the concept space, and a first knowledge sub-space.

[1] It is considered as foundational for decision-theory, as (Savage 1954) derived his model from it, as well as the management variant of (Raiffa 1968). In (Giocoli 2013), the model's trajectory over time is drawn showing the structuring role of Bayesian probability theory, as well as its diffusion in management education (Fourcade and Khurana 2013).

Naturally, the Wald's model gives it own parameters that can be hacked by design. The set of decisions $D$ and the states of nature $\Theta$ can be then re-designed. Generativity, like in the experiment where pigeons generate new action to solve a problem (Epstein et al. 1984; Epstein 1990), will play on the generation of new decisions, as well as altering the states of nature. It differs from trial and error in the way that it deals with novelty, ill-defined problems, by matching stimuli and actual transformation of the behaviour required to deal with (generated) new situation.

In a very simple way, we are interested in managing the operators $D \to D*$, which generates and reconfigures decisions, and $\Theta \to \Theta^*$ which integrates new states of nature, changes the world's description, semantics and changes the posture of the decision-maker with respect to these states. The cost function $c$, and beliefs $\mu$ will subsequently have to be redefined or simply extended to the new range.

Coming back to the figure show in the literature review (p.61), copied below, we push the model beyond the Pareto front. As the operators generate new possibilities, revisiting performance criteria which are the tip of the iceberg of the transformations of $D$ and $\Theta$.

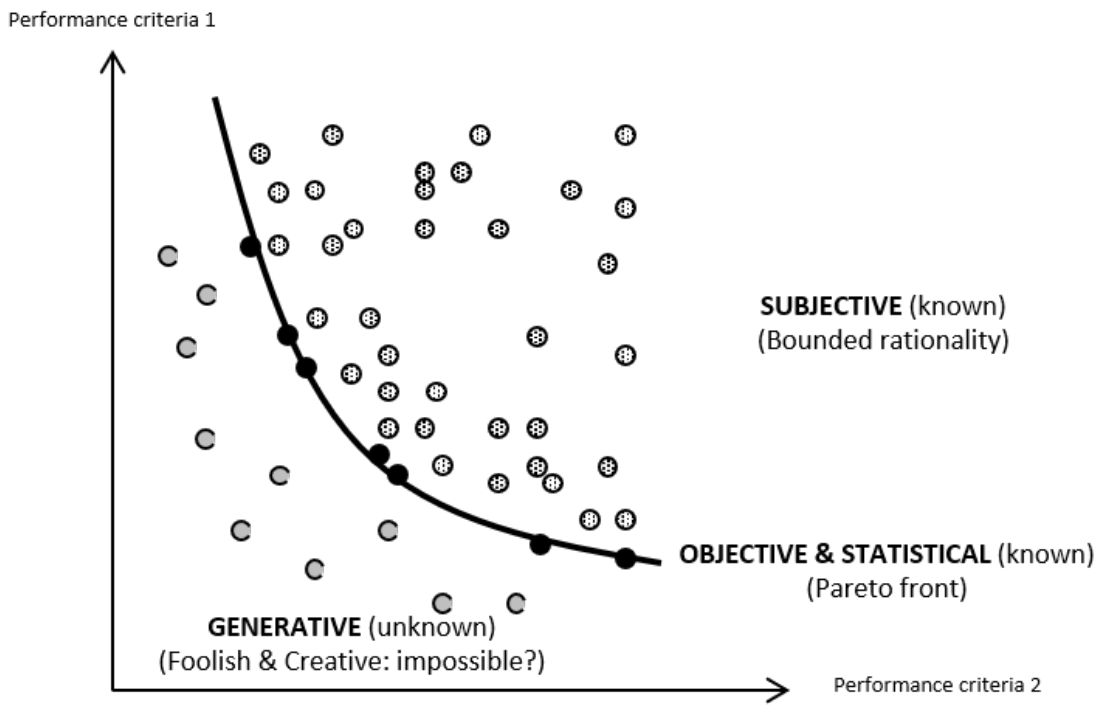


**Figure VIII.1:** Schematics of behaviours

## 1.2 New decision categories

Firstly, beyond the optimum decision $d_{MEU}$, the decision-designer can try to push the optimization even further for a given chosen state of nature $\theta_i \in \Theta$. We have then a **new**

**wishful decision by optimization** ($d_{opt}$). It could be a simple functional improvement added for one feature that could be constrained otherwise by the realization of one outcome in the spectrum of consequences.

> Optimizing makes the assumption that a lot of parameters have been identified and locked, so that gap to be explore between what is boundedly known and what is yet to be known is clear. It could be considered as the simplest and predictive form of transitioning between exploration and exploitation.

Secondly, the uncertainty associated to the considered states of nature $\Theta$, the decision-designer can study the envelop of available alternatives $D$ so that he can add a new decision which minimizes costs for all contingencies: **new wishful decision by genericity** ($d^{gen}$).

> In the Business Class seat, we can label some of their decisions aiming at developing a platform for a modular product line. The exploration of existing possibilities (benchmark) and the generation of new alternatives both encompass a new wishful decision by genericity.
>
> We can also argue that when the client program selected the explored product design, the exploitation regime performs a regression towards optimizing as if the preliminary platform design would be robust enough for a full development and uncertainty reduction. Some knowledge areas had indeed not been fully uncovered. So, in a *post mortem* analysis, we have a better understanding of what could have been managed differently to maintain the exploration and exploitation effort and their mutual conditioning.

Now switching to the design heuristics, instead of leaving $\Theta$ fixated, we can work on redesigning the states of nature.

Thirdly, we can try to change a single state of nature in order to force the redesign of decisions. Considering an unknown (i.e. out of the domain) state of nature that may have a devastating impact on consequences can be one way. Or one could simply just slightly shift a not very likely state of nature. The idea of the *What If?* scenario in Design Thinking methodology addresses this perspective. However, one can also target the most certain knowledge which hides fixation effects; it tackles the *sure thing principle* (Savage 1954, p. 21). Following the same fashion, deliberately reversing preferences can force the design or the concern for an unknown state of nature which may favour the reversal; as discussed in our paper (Le Glatin, Le Masson, and Weil 2017b), also in appendix A2. We are then designing a **new wishful decision by best choice hacking** ($d^{alt}$). For

example, if the decision problem was to choose between known several technologies and associated performance, one could try reversing the order and try to design a situation where it would work.

The Icing Conditions Detection case can be interpreted in that way since considering an unknown safety regulation evolution was to be shaped by the R&T manager to justify the new performance of the technology in the new spectrum.

Exploration effectively relies on exploitation constraints to generate new alternatives. It could be also considered as coming *out of the blue*, in a serendipitous way, as an externality or as need-solution pair (Hippel and Krogh 2016). But at least, the model allows linking them back to the dominant designed decision, since we can play on the decision space and states of nature.

Finally, we can reproduce systematically all pieces of certain knowledge. By doing so, we explore the full extent of fixation effects considered on knowledge usually requested or made implicit in decision-making. So we end up with a **new wishful decision by all choices hacking** ($d^*$).

In the Design Thinking cases, shifting the concepts in aircraft areas, where BUs are not dealing with the design brief, falls into the category of all choices hacking. Clearly, it highlights that the exploration has gone out of the boundaries of what classical search-based model would have delivered. Such hacking insists on the fact that exploitation won't be conducted nor balanced by ignoring the new created interplay. Frontier between product designs can be totally re-discussed to shape the new environment (e.g. lower deck, integration between equipment in galley area, passengers loading their luggage, etc.).

Overall, the different decision categories one can design, offers a new mapping for the decision-maker to envision the course of action. By becoming a decision-designer, the design reasoning on alternatives allows, not only understanding the consequences of avoiding the conditioning between exploration and exploitation, but also to envision the efforts required in terms of knowledge management. Consequently, it enables starting to reconciliate the risks of floating of exploration project management with the organizational learning originally hoped with (March 1991b) model.

## 1.3 Knowledge value

The different decisions categories, by simply relying on Wald's canonical decision model, show the extension $D$ and $\Theta$ spaces. The transformation operated by design theory comes with consequences on the value $c$, beliefs $\mu$ and learning $L$. These are redefined by composition of $D \rightarrow D*$ and/or $\Theta \rightarrow \Theta^*$.

The most stimulating feature from a standard statistical probability view is that adding a new decision, or new state of nature, flattens existing probability distributions. In other words, we **increase global uncertainty**. And we do it so that it is even more accentuated that it could perturb a search-based model since we are extending the spaces we are relying on. From a rational choice theory, it is, of course, unacceptable but the operators in between the old and the new spaces take in the possibility of design, it is not an externality.

In the Icing Conditions Detection project, when they reversed their preferences for a highly uncertain technology, they opened a new environment to be shaped. The potential risk was reallocated, raising uncertainties but also made former alternatives less interesting despite being more certain in a different setting.

Learning can be organized for such purpose. Seen from the development engineering department, the prototype tested on aircraft is not to be considered as a traditional exploitation. Instead, it should be seen as an *exploitation exploration* where the unfinished engineering work offers the opportunity to acknowledge and reconfigure engineering rules around the new technology and system.

We consequently endogenize the unknown by design. Not only are we are building up awareness but also we are anticipating it by systematically designing and prospectively managing unknown decisions and states of nature. We are in line with the idea of bringing vigilance (Oury and Schmidt 1983), opportunism (Lumineau and Verbeke 2016), reliability (Sutcliffe and Christianson 2012) to the front seat, by turning the decision-maker into a decision-designer. The underlying assumptions have been weakened to leave room for design theory to unveil its potential on its sister theory.

The concept of *phronesis* (Nonaka, Hirose, and Takeda 2016), which we discussed in the literature review, could be then further substantiated with the way a manager makes and design decisions. It is a means of organizing collective action: creating simple coordination mechanisms around certain knowledge that can tweaked collectively by stakeholders, mobilizing (silent) designers around problems that can be systematically ill-defined by themselves, and simply overseeing the course of action with other reference points given

by the decisional mapping.

In the BC class seat platform project, the early stages of concept selection and generation with BU stakeholders were an actual case of blending the exploration with the exploitation constraints. However, this effort was biased when the project was transferred to program management as if fit for development. Instead, it could have been the occasion to continue exploitation knowing and managing learning for a continuing and parallel exploration. This awareness is however only realized in the aftermath and not along the transition nor the exploitation project management.

This decisional ambidexterity consequently also gives an **extended risk assessment** register, richer than traditional practices seen in project management. But, in the same fashion we did, we could manipulate the risk register which is used, transferred and adapted in between projects as a representation of the dominant decision design framing (a priori) collective action in project's trajectory.
The modelled technology of ambidexterity can give room to the stretching caused by encapsulated generative processes and still letting them be managed.

# 2 Performance of decision design

The described approach of simply applying a generativity theory to a foundational canonical model puts the emphasis on the transformation operators rather than on the dichotomy of exploration and exploitation regimes. These operators offer a systematic way of exploring given exploitation references. The dichotomy and non-mutual conditioning are left aside by a constant articulation of interdependencies of exploration and exploitation. So, it is not the set of elements and their nature that counts, but rather the relationship engaged between them that is to be managed. In that regard, we move beyond duality of the regimes (Farjoun 2010).

> The performance of both exploration and exploitation will be dependent on the quality of the generative operators. It implies the collective effort of designing the fit of decisions, and identifying, acknowledging and managing fixations effects and underlying interdependencies.
> It is crucial to *measure* and characterize the distance between what exploitation can achieve on its own path and the different explored and designed decisions can otherwise. Learning and adaptation take a different twist with the cognitive fit and design fixation effects.

## 2.1 Beyond the fit: moving and designing target

The paradoxes of opposing two competing objectives becomes rather secondary or even transparent, by adopting the design and elucidation of interdependencies between decisions and states of nature. All the ties justifying exploration can be derived from exploitation, and conversely the exploitation can be justified by a reference enlarged by exploitation.

The constant generative search is rooted in exploitation, and exploitation is inversely valued through exploration. The pattern is similar to the novelty-search algorithm (Cully et al. 2015; Nguyen, Yosinski, and Clune 2015) designed for robots to improve their resilience, but we improve such heuristics by considering that the problem is also re-formulated, as if the underlying algebra was reconfigured.
For instance, not only has the robot a performance objective (reaching a given point in space), the novelty-search algorithm will generate new movements in two dimensions without knowing the terrain. But, it will only operate with the possible actuators available and their performance range. It is also crucial to reconsider the actuators framing the range and nature of alternatives. This is what we achieve with our operators.

Conditioning exploration by exploitation, can be considered actually quite natural but let us remember that numerous design and creativity methods encourage to liberate con-

straints and be careful with brief formulation. *Thinking out of the box* also requires starting by defining the box itself.

In the icing conditions detection project, opposing the technology alternatives imposes to value them against a given system, integration and regulations. Reversing the preferences, encourages to reconfigure the value framework: new system, new integration constraints and new regulations. The problem reformulation is built upon an exploitation constraint and target on the move. Consequently, a fraction of the project management is driven towards ensuring the target is managed to satisfy preferences reversal.

## 2.2 Overcoming biases and fixation effects

The performance of exploration will be seen through the generativity of the design practices. These will be valued relatively to reference points which can be previously generated decisions or potential decisions. But as the end game is to be able to decide and organize collective action for these, it would be even more practical to set the reference on exploration points.

We have discussed exploitation and *weak* exploration natural reliability, path dependency, can not only be biased due to bounded rationality but also can be fixated due to lack of understanding of environment awareness, system thinking and organizational design.
Newly generated concepts may be indeed challenging epistemic interdependencies which will have to be carefully managed when these are revealed by directly concerned decision-makers. It is then preferable to have them actively dealing with the (re)-design practice of these interdependencies and their rationality that was contextually established and fixated.
As James March partly addressed it (see quotation below (March 2006, p. 209)), he gave a few hints on how the produce of exploration, be it foolish or not, would eventually become rational and exploited could be used as a basis for exploration. We believe that our model allows elucidating this mutual conditioning and how to exploit it for exploration and vice-versa. This complement to the separation between exploration and exploitation had been omitted in the original model (March 1991b) as noted in our literature review. It underlines the natural interaction between what makes exploration and exploitation. However, it doesn't imply necessarily a continuum nor orthogonality, but rather multiple relationships to be surfaced and managed.

> *It is argued that the link between rationality and conventional knowledge keeps rational technologies reliable but inhibits creative imagination. This characterization seems plausible, but it probably underestimates the potential contribution of rational technologies to foolishness and radical visions.*

In the Design Thinking cases, an external observer, unfamiliar with the history of aircraft cabin equipment and stringent standards & regulations, could easily consider product designs, interfaces and usage totally foolish. Different value networks taken from other user experience (passenger, cabin crew) will confront to rationally developed products and services.

Anchoring the exploration to exploitation provides a playground to relieve constraints faced by dominant designs, promoting new interactions with users, or even hacking altogether how things are done and envision a new environment (e.g. lower deck, passenger boarding). However, the learning associated with the defixation is to be further explained as it unlocks several interdependencies that are not self-evident when just showcasing concepts or prototypes.

The performance is discussed in different ways and through action engaged in the decision-design process. Adaption model is left close enough to optimizing decision and richer exploration can be achieved by challenging beliefs, preferences order and states of nature. Interactions can be managed around these parameters. And the encapsulation can be tracked and positioned with respect to learning challenges.

Finally, not only the distance is generated away from a dominant design, fixation points and ingrained interdependencies, but it is also key to enable the constant transformational dialog between these two.

Performance of decision design is then substantiated through the heuristics presented earlier and the necessity of interacting through them. It will target multiple parameters in engineering design and constraints.

## 2.3 Model synthesis

Below, the figure VIII.2 represents, with C-K formalism, the different designed decision categories and the knowledge used. We specify the different **wishful decisions** and the enabling knowledge hacked to design new decisions and new states of nature.

Following customs in C-K theory, the dominant design is left on the left of the concept tree where we have put the wishful decision by optimization ($d_{opt}$). A variation to the optimization can be then to design by considering a wishful decision by genericity ($d^{gen}$). It considers as many states of nature possible by defining an envelop of consequences that the decision should be ready to address. Then, hacking the states of nature, opens a new branch with two new designed decisions categories: wishful decision by best choice hacking and all choices hacking. The first tackles what could be the dominant, what is

more obvious, the sure thing principle. The second shifts the decision problem in a new environment.

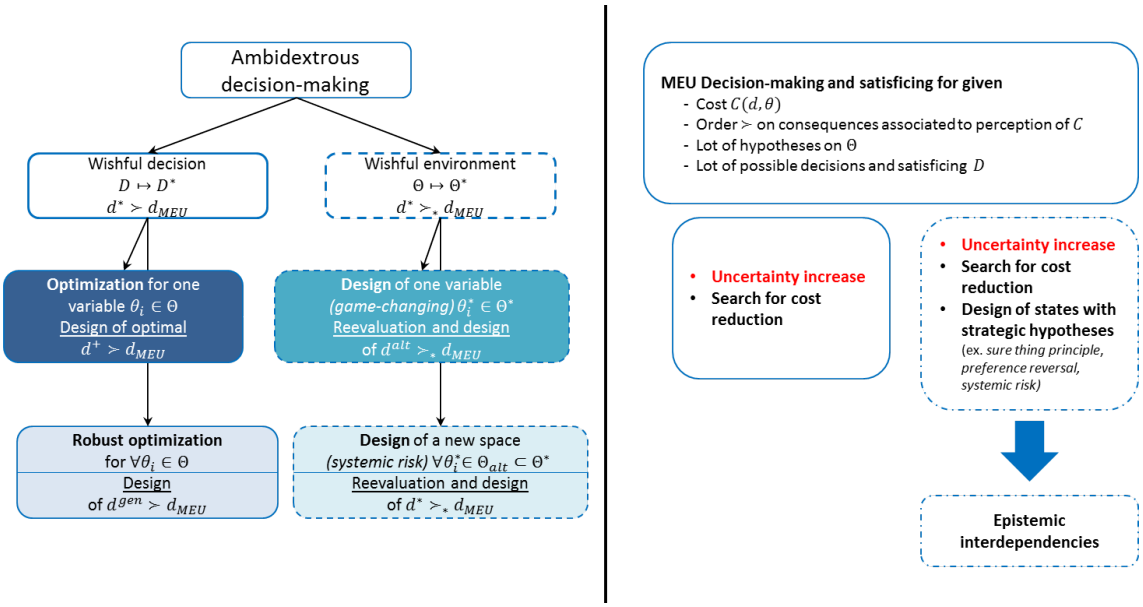


**Figure VIII.2:** Ambidextrous decision-making by deciding into the unknown with design

The table VIII.1, brings the comparison between the newly designed model of mutual conditioning of exploration/exploitation and the former derived from the literature. Several items have to be further specified given the chosen descriptors used for the anomaly detection. We have discussed the fixation effects and necessary anchoring to exploitation parameters facilitating the management of exploration. The mutual conditioning between exploration and exploitation will channel learning, dealing with interdependencies. Therefore, it will also require looking beyond the cognitive dimension of decision-designing. Organization design, the mirroring dynamic as well as action modes organizing *decisional ambidexterity* will have to be taken into account to fully cover the anomalies identified with all descriptors.

These incomplete model features presented in the following table will be discussed in the following chapter IX. The organizational metabolism can then be discussed in more detail to sustain organizational change and learning.

| | **Non-mutual conditioning** | **Mutual conditioning** extended model |
|---|---|---|
| **Model of coordination and collective action** | 1. Not necessarily on the same continuum, exploration and exploitation call for two dissociate action regimes.<br>2. Balancing is left as a paradox at different levels of analysis: structure (centralization, distribution), time and individuals. | 1. Exploration and exploitation are mutually used to support extended decision-making.<br>2. The balancing paradox is dealt by design operators valuing mutual benefits of exploration and exploitation. It is organized through interactive decision-design practices.<br>(**To be completed. See next chapter**) |
| **Generative processes** | 3. The nature of generative processes supporting exploration appears quite free, random and sometimes even foolishness-based.<br>4. Generativity of the product development may not be sustained by (temporary) organizations (floating issue).<br>5. The performance and reference are light structured: reduced to a selection issue or sometimes to complex interactionist phenomenon. | 3. Generative processes target the exploration/exploitation bone of contention and associated decision-making.<br>4. Generativity is articulated around design fixations and interdependencies for better interactive value management with other (silent) decision-designer.<br>5. Performance is repositioned on the transformative feature of decision-design where its criteria are redefined.<br>(**To be completed. See next chapter**) |
| **Environment cognition** | 6. One-way interaction: Environment to Organization.<br>7. The environment structures the response, nature and distribution of generative processes.<br>8. The environment is used to augment the product development requirements. | 6. The environment is managed through decision-design.<br>7. The decision-design addresses environment-induced fixations.<br>8. The environment awareness developed through decision-design targets also (potential) interdependencies and future exploitation features.<br>(**To be completed. See next chapter**) |
| **Organization design** | 9. Organization design is pre-conceived or uncontrolled.<br>10. Organization design creates gaps for managing generative processes and the dynamics of their organizational ties. | **See next chapter** |

**Table VIII.1:** Model extension

# 3 Chapter synthesis: designing decisions for cognitive ambidexterity

We have used the requirements listed in the previous chapter after detecting and specifying the anomalies in several cases. We have then proposed to start anew by coming back to the beginning of our literature review.

The canonical model of decision theory (Wald 1945, 1949) is mobilized to consider the problems-solving with uncertainty described in the seminal paper (March 1991b). As we had repeatedly tested the edges of the literature models of non-mutual conditioning between exploration and exploitation, we have used the teachings of design theory to extend decision theory into the unknown.

It allowed specifying different decision categories and heuristics playing with decision problem parameters and formulation. The model proposed an **extended risk management** as the uncertainty is increased by design but at the same time uses exploitation core specified by fixation effects, biases of bounded rationality and interdependencies to ground exploration and manage its generativity and value.

We have also made reference to the previous anomalies and made sense of them with the help of the decision ambidexterity. They fall into several designed decision categories in the unknown and they let clarifying what has been missed or what was in the blind spot of models of ambidexterity.

The following chapter complements the gaps left in the model's description as we had specified several organizational descriptors to detect the anomalies. We will define further decisional ambidexterity with our concern for strategic management and organizational learning and change.

# Chapter IX

# Organizing and testing decisional ambidexterity

*The more any quantitative social indicator is used for social decision-making, the more subject it will be to corruption pressures and the more apt it will be to distort and corrupt the social processes it is intended to monitor.* (Campbell 1979, p. 85)
Donald T. Campbell

In this second modelling chapter, we have to fill in the gaps for the model requirements we have defined for ourselves at the end of the anomaly detection chapter VII (p.237). The definition and specification of decisional ambidexterity in the previous chapter addressed some of the descriptors used earlier in our methodological approach. The organizational dimension was not fully discussed as we have mainly stressed the decision-designing to revisit the mutual conditioning between exploration and exploitation in order to start anew with organizational ambidexterity.

Recalling our review on project based management, interactionism and organization design, we will build upon limitations previously identified to complete our decisional ambidexterity model.

First, we discuss the question of simultaneity where (exploration) project management should consider also the change management (Hornstein 2015; Pollack 2017). It will enable us to take into account the mirroring hypothesis (Colfer and Baldwin 2016) and its dynamics as fixation effects and interdependencies are seen in engineering design and organizational dimensions. Second, we will come back to concept organizational metabolism (Hatchuel, Weil, and Le Masson 2006; Segrestin et al. 2017) allowing overcoming the iterations of traditional double bind of structure and processes.

# 1 Beyond dichotomy: simultaneity

The different cases presented in the anomaly detection chapter revealed several tensions associated with the encapsulation of generative processes and their potential free-floating across organizations (Lenfle 2016). Decisional ambidexterity allows focusing on the micro-foundations of exploration/exploitation dichotomy: revisiting the decision-making by considering decision-design permits touching upon one of the key aspects of coordination and collective action organizing for innovation. The way action is engaged, the way decisions are made, and the way organization members network (Christiansen and Varnes 2007) can be captured through the decision-design in the C-K formalism.

The transformation, due to exploration, or the one faced in exploitation because of the unexpected, can imply an active role for decision-designers as they play on states of nature, the degrees of beliefs and the cost functions will be redefined. Consequently, at the project management level depending on the framing imposed to the decision-design and the underlying engineering brief, the interdependencies can be controlled or even avoided depending on the aimed independence level. The latter will contribute to the innovation potential of attraction at the organizational level: how business units will host, support, redesign their organizations or recombine their capabilities for such projects. As we remember, we are not interested in spin-off and other ad-hoc phenomena, we want the organization to regenerate itself "within its boundaries" by relying on its organizational metabolism.

> We start discussing the implications of decisional ambidexterity for project management, as it will design decisions at the project level that can quickly address several interdependencies reaching out for permanent organizations. Then, the mirroring hypothesis gives an idea of the relationships behind revisited design rules and interdependencies and their organization. Modularity/genericity is an answer corresponding to one decision category but doesn't allow getting a full picture.

## 1.1 Project management: product or organizational change?

### 1.1.1 Uncertainty/Unknown buffer to manage the ecosystem relationship

We had specified that the project-based organization was probably an efficient way of organizing the firm to face uncertainties. Projects can be seen as uncertainty buffers (Davies, Manning, and Söderlund 2018, p. 971):

> *integrate cross-functional resources and knowledge to cope with high uncertainty, complexity and change*

However, we remember that when pushing this form into the unknown reveals several difficulties that are exacerbated in cases where the organization's identity and boundaries

are tied by market rigidities tightly linked to product engineering. Zodiac Aerospace is a proper example of such pattern.

The Icing Conditions Detection case was a vehicle to shape the unknown, an example of decisional ambidexterity, by playing on preferences' order to value the unknown and manage the ecosystem. It built its own autonomy through public funding and legitimation with key industrial players. It allowed more flexibility compared to a traditional exploration that would have been fully hosted by an engineering or product development department with a functional form.
Just like in the two other cases analysed previously, the projects were sponsored by middle and top management, sometimes even having a key isolated position from other routines. It gives freedom to operate.

The relationship to the environment and the ways projects engage with it relocates organizational adaptation and learning at the project level in a temporary organization, whereas organizational ambidexterity would have a tendency to materialise it in a permanent organization.

In a sense, enforcing institutionalization (O'Connor 2016) of innovation function or organizational ambidexterity could be dangerous for the firm's cohesion and coherent action. Specially, if it is not sustained by clear managerial action and engineering at the project level that clearly embeds the change management and adaptation to the environment.
Decisional ambidexterity allows then reconciliating this change of locus.

### 1.1.2 A vehicle for change: which manageable parameters?

The necessity of change appears as the interdependencies have shifted (Stan and Puranam 2017). It is deep down what makes management a reality. Organizing collective action is necessary only at the wake of novelty forcing a transformational experience.

If the project brings some novelty through decisional ambidexterity it will rely on existing interdependencies (exploitation) to generate new alternatives. The mutual conditioning is required to surface and manage interdependencies.
When discussing the interface between design and manufacturing activities in (Adler 1995), the author targets the cruciality of coordination mechanisms around interdependencies defined by the new product development. Mutual adjustment and interaction models will vary depending on the analysability of product/process fit. It is key to be able to reflect the organizational change required for the engineering interdependencies as they will be directly used as springboards to articulate the mutual conditioning between exploration and exploitation.

As new decisions are designed along projects trajectories, they can phase out compared to established organizations. It forces to conform the project to the host and permanent organization. It can even (implicitly) consider that the host or integrating BU would not change.

In the Design Thinking projects, as well as the BC seat platform, when transferring the designed products and made decisions, they faced the exploitation regime in permanent organizations with established engineering design rules. The learning and organizational change was not on the menu of the project nor handover with the redesign of decision-making.

For instance, ADT did try to refine designs, but it was rather an optimization effort instead of playing on states of nature to envision the required change in engineering constraints, product interfaces, standards, regulations, market segmentation, business models, etc. For the seat platform, the learning and design rules evolution came after relying on late and repeated mechanical tests which confirmed previously discussed but underestimated numerical simulations.

In order to embed the organizational change management within project management (Hornstein 2015; Pollack 2017), we must then clarify how the engineering interdependencies and fixation effects are dealt with at the organizational level. In (Stjerne and Svejenova 2016), the work at the boundaries of temporary organizations lets overcoming the dialectics of temporary and permanent organizing. It brings a multi-level perspective we propose to channel through decision design: decisional ambidexterity.

## 1.2 Mirroring hypothesis: a static view

We had identified in the literature the mirroring hypothesis (Colfer and Baldwin 2016). We could a priori use decisional ambidexterity in exploration project management that considers existing product design architecture as a starting point. It would involve a number of design rules reflecting the managerial technology. Behind the scenes, sensemaking interprets and adapts to make actual practice (Christiansen and Varnes 2009) giving some flexibility to the rules. So the (partial) mirroring is obtained through established technologies of organizing which can have different levels of independence, hence clustering the sub-organizations for product sub-systems.

### 1.2.1 Modularity

Modularity and loosed coupling (Sanchez and Mahoney 1996) can then be the purpose of decision-design in order to be able to adapt easily and reached strategic flexibility. Instead of being seen as an adaptation to the environment turbulences, it could also be actively co-designed from the product engineering perspective. Having such approach to modularity could also be envisioned temporarily before reintegration (Siggelkow and Levinthal 2003).

In the BC seat platform project, the aim was to define an architecture and organize modularity. However, such effort was not reached and practices of exploitation took over. The existing interdependencies as well as evolving standards with the modularity choices taken were not made clear to stakeholders to redefine its mirroring.

Platform engineering, or designing a *wishful decision by genericity*, is an exploration effort as per which exploitation constraints and parameters can be built upon to define new design rules, and consequently organize engineering departments, manufacturing as well as supply chain.

Therefore, in the knowledge space defined in our C-K modelling of decisional ambidexterity, it would be useful to add the organizational partial mirroring of interdependencies as these will require to be transformed due to the product engineering practice. These are decision parameters that can be resurfaced and explicitly related to organization design.

### 1.2.2 Stress testing: absorbing uncertainty/unknown?

The perspective of modularity and genericity, which is one of the decisions $d^{gen}$ in our model, brings the possibility of managing double unknown situations (Kokshagina et al. 2016) specially through adapted portfolio management. In a similar way, (Hooge et al. 2014), and closer to our concern for decision-design, they showcase the anomaly of willing designing a generic technology to bridge a gap between distant fields and technologies, by opposition to the common evolutionary strategies. Difficulties are raised regarding the sophisticated organizational patterns, and capacity to reuse and connect existing technologies.

Consequently, when considering how the mirroring of interdependencies enacted by members of the organization, the knowledge mobilised in decision-design will require a precise understanding of the levels of independence between elements, boundaries and purpose of each group of other decision-designers involved.

Genericity and modularity will allow absorbing uncertainty quite easily, but once the unknown slips through sub-systems, their inter-relationships are heavily discussed. Decisional-ambidexterity should then be able to specify and support these dynamics. In that sense, the mirroring hypothesis is too static and perhaps only looking at robustness and adaptive flexibility as the unknown is usually seen as exogenous.

# 2 Endogenizing the unknown: dynamically designing projects and organizations

Decisional ambidexterity encourages then to fully endogenize the unknown into project management to address how it can be shaped into organizations through the dynamics of interdependencies mirroring exploitation product engineering.

We then propose to make organization design part of the decision-design model with underlying interdependencies and fixation effects. It will help specifying the nature of decisions covering contingencies that may lie in the intricacies of interdependencies. These should effectively be redesigned depending on the generativity of processes used to propose new alternatives. The latter being one of the issues at stake revealed by the biases induced by organizational ambidexterity and its model of non-mutual conditioning against innovation initiatives.

The model of **decisional ambidexterity** for mutual conditioning between exploration and exploitation focuses now on decision-designing as well as organization. Consequently, this **technology of organizing** that simultaneously aims at supporting innovation project management and change management, will spread out and ripple through established processes and structures and hence contributing to the **metabolism of an innovative organization**.

We first discuss organization design in the unknown and how to overcome organization design fixations. Generative learning sustained through decision design can support disentanglement of interdependencies and fixations. Then, we introduce the necessity to overtake the duality of structure and processes. We focus on how decisional ambidexterity can sustain organizational metabolism.

## 2.1 Organization design in the unknown and against organizational fixation

Organization design requires to be thought differently at the light of decisional ambidexterity, as we force to bring the unknown and its management at the level of projects and interactions around decision-making, now decision-designing. The potential of transfor-

mation and attraction, channelled through extended decision spaces, gives a new flavour to the organization design features specially for interdependencies and fixations effects.

### 2.1.1 The unknown organization design

The difficulty for standard organization design is when considering unknown information of unknown value, as the necessity to establish relationships between agents is hard to justify (Puranam, Raveendran, and Knudsen 2012). And it is not only by having people together that they will be able to solve new problems, let aside formulating new problems themselves. When trying to foresee the future of organization design when facing the unknown, the importance of having a new method for normative field becomes critical (Puranam 2012). The methodology developed over several decades in design theory and reasoning can fortuitously support such initiative.

By considering the importance of action, interaction and decision in organizations, we can centralize such key phenomena into organization design. The contributions of (silent) decision-designers continuously referring to exploitation will help valuing exploration and vice-versa. The multiple interactions required to make sense of decisions, product design and engineering design rules become quite attractive for organizational studies.

For the Design Thinking projects, concepts wouldn't fit BUs or even multi-BU prospects. Engineering rules had to change, product lines and BUs respective boundaries were contested through the designed and selected concepts by ADT, group VP of Strategy and Business Development, and during multi-BU workshops. The confrontation and adaptation would only rely on a separation of exploration/exploitation regimes. Generative processes were guided by product design objectives, as well as environment perspectives (user value and empathy) but failed to address the potential organization redesign.

Placing the unknown right at the centre of organization design can probably overcome caveats of simple solutions or adjustments that only have a concern for: balance of hierarchical control, individual autonomy and spontaneous cooperation (Keidel 1994). A **technology of organizing** could then substantiate the *generative learning* (Senge 1990) by deriving from the decisional ambidexterity model. Such device could help have a better understanding of required organization design and its *generative fit* (Avital and Te'eni 2009; Van de Ven, Ganco, and Hinings 2013).

Learning can then be overseen in our model as it will have to be challenged as interdependencies will be unlocked, reinforced or reconfigured depending on how the decision-designers explore exploitation and exploit exploration.

### 2.1.2 Managing interdependencies and organization fixation effects

In the context of meta-organizations (Gulati, Puranam, and Tushman 2012) and also open-innovation, rethinking of organization design can not be seen as fully transposed to problem/task decomposition by leadership (Lakhani, Lifshitz-Assaf, and Tushman 2013). We have seen that the identity of organization can be so strong due to engineering and regulations, that problem formulation in exploration project management can escape from the attraction of organization competence. So, trying to keeping it together, and build new coherence through the transformation triggered by design activities, requires to shift the locus of change down to the micro-level of interdependencies and fixation effects.

In the Icing Conditions detection, the BU manager ended up having a valuable exploration project recognized in the industrial ecosystem but at odds with the organization. Again, we have a case where the exploration was driven by several expansive decisions changing the game but the interdependencies with systems engineering mastered with the business have to be reworked. The transferred unfinished but flight tested product should be seen as a learning device rather than fit for development.

Fixation effects could be associated to the state-of-art in product development, and the gradual convergence towards a common consensus, which may be biased.

> The constitution of new path will have to emerge through the interactions created by discussing the value of designed decisions and concepts anchored to dominant design. These interactions will support the organization change that is required to support new business development (Simon and Tellier 2018): resources and development of capabilities mobilized around a project. It confirms the networking dimension that can be organized around alleged decision meetings (Christiansen and Varnes 2007).

## 2.2 Sustaining metabolisms: regenerating the organization

As discussed in the anomalies specification (chapter VII), embedding change management within project management calls for phenomena rippling across structures and processes, as we propose to do with centrality of action, decision and design for organizing. The biological metaphor of metabolisms allows targeting "processes" that are tied by the double bind of structure and processes. It puts the emphasis on the *actionable knowledge* and relationships (Segrestin et al. 2017), instead of separating management of structure and process. The constructs of regenerative capabilities and recombination of routines in organization can be then further substantiated with decisional ambidexterity and organizational metabolism.

### 2.2.1 Regenerative dynamic capabilities

The difficulty associated with the innovation function distributed across projects (Gemünden, Lehner, and Kock 2018) goes to the distributed nature of capabilities. Making the sum won't be representative of the overall capabilities available in underlying host functional departments. However, by considering they will be organizing their trajectory around decision-design with supplying departments, other business units, as well as external players, can create a pivotal force for stakeholders to understand in which direction change should occur.

> For the BC seat platform project, in the early stages of defining the extent and features of genericity, several stakeholders took part in designing concepts, even marginally, but also to designing what had to be decided. The sense made out of those meetings, and its contribution to generating alternatives, represents a capability to regenerate seat engineering. Unfortunately, a similar effort was not sustained when switching from exploration to exploitation due to a strong divide enforced by ambidexterity.

As teams and organization will cope with these different temporalities, first locally at the project level, and then at the program level (Simon and Tellier 2016), it gives us confidence on the value of our model. Temporary-organizing will reach a meta-equilibrium during when designing-decisions, as they make sense and rethink the new coordination mechanisms supporting the new product development. We contribute then to the idea of having regenerative capabilities (Ambrosini, Bowman, and Collier 2009, S15) supported by decisional ambidexterity.

### 2.2.2 Recombining routines

In a similar way, the idea of recombining routines (Cohendet and Simon 2016) fostered by a single project, can be the occasion to rethink product design rules that have been fixated for some time. In their case, they specify the importance of meetings held, prototypes and proof of concepts that were tailored and managed by project manager to make a case for a radical product concept, at odds with exploitation regime. Resurfacing interdependencies and design fixation with such practices can be a means to make tacit the designing of decisions and learning mechanisms that can be mapped with C-K theory as we did in the previous chapter.

What is also stimulating here is that, innovation management does necessarily have to supported by additional routines. Within a set of routines, they can be reconfigured to create *more* value, as if the scales and units changed in nature. It is what we tried to picture with the Pareto front and reaching out for alternatives (see p.VIII.1).

In Design Thinking cases, some concepts actually implied recombining routines across business units who were traditionally segregated by the market and engineering standards. Focusing on the product and design rules would only force adaptation, whereas the obstacle was rather on elevating interactions on the how and its legitimacy for users, but also the remaining effort: change in sales pitch, market channel, one-time qualification, evolving standards and certification forms, etc.

Finally, it would be such contextuality that could be associated with contextual ambidexterity but detailed in its interaction modes (Birkinshaw and Gupta 2013). It would now make more sense with the limitations on the nature and dichotomy of exploration/exploitation regimes discussed in the very same paper and in (Gupta, Smith, and Shalley 2006).
The networking effect (Christiansen and Varnes 2007) can easily be structured around the dialogue interdependent and fixation knots. It encourages channelling the access to (distant) knowledge, legitimize the mutual conditioning between exploration and exploitation (Simon and Tellier 2011). But here again, we insist on the technology of organizing collective action through decisional ambidexterity facilitating the grounding of such interactive patterns.

So far, we have proposed then to embed the organization design within our decisional ambidexterity. We have emphasized the need to organize the decision-design around exploitation constraints such as interdependencies and fixation effects, not only at the product engineering level, but also at the organizational level. Routines and capabilities can be articulated around the designed decision to sustain the *metabolism* triggered by associated concepts.
These elements contribute to making its *innovation potential of attraction* dragging along not only a cognitive fit, but also an organizational generative fit.

## 2.3 Full model synthesis

We have then specified the interest of having organization design embedded in the designing of decisions, by considering that organizations are part of the knowledge required to enact decision concepts. Consequently, we propose simply to represent in the C-K formalism what makes decision and its hypotheses with organizational ties and mirroring: interdependencies and fixation effects. They are the translation at the organizational level that can be easily disturbed by generative processes: i.e. where tension and anomalies come from between models of ambidexterity and exploration project management. In other words, we insist once again on the link between actionable knowledge and relationships, and how it can metabolize innovation in the organization with its structure and processes.

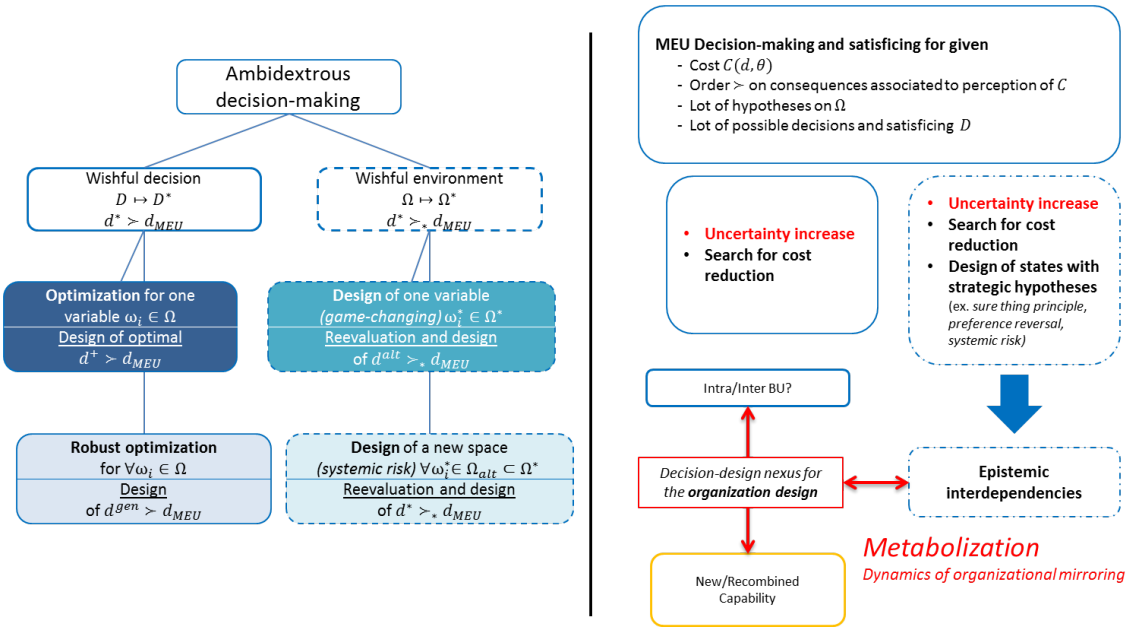


**Figure IX.1:** Decisional ambidexterity: decision-designing and organization design

Listing the engineering design fixations, interdependencies and built-in product architecture, will help addressing the regenerative dynamic capabilities and recombination of routines required to manage the organizational metabolism. The change management will then be steered through the inter-relationships bearing generative learning triggered by the collective decision-designing. It is again the mutual conditioning of exploration and exploitation which allows simply measuring change.

In the following table IX.1, we can complete the model synthesis with the descriptors derived from previous literature review. We remember the synthetic literature model of non-mutual conditioning enabling its comparison with decisional-ambidexterity model which blends the conditioning between exploration and exploitation. It allows overcoming biases induced by organization ambidexterity and its limitations such as neglect of organization design fixations revealed by exploration project management.

| | **Non-mutual conditioning** | **Mutual conditioning** extended model |
|---|---|---|
| **Model of coordination and collective action** | 1. Not necessarily on the same continuum, exploration and exploitation call for two dissociate action regimes<br>2. Balancing is left as a paradox at different levels of analysis: structure (centralization, distribution), time and individuals. | 1. Exploration and exploitation are mutually used to support extended decision-making.<br>2. The balancing paradox is dealt by design operators valuing mutual benefits of exploration and exploitation. Decision-designers interactively unlock and manage (new) interdependencies and (organizational) design fixations. A form of governance may be required to orchestrate and sustain such practice. |
| **Generative processes** | 3. The nature of generative processes supporting exploration appears quite free, random and sometimes even foolishness-based.<br>4. Generativity of the product development may not be sustained by (temporary) organizations (floating issue).<br>5. The performance and reference is light structured: reduced to a selection issue or sometimes to complex interactionist phenomenon. | 3. Generative processes target the exploration/exploitation bone of contention and associated decision-making.<br>4. Generativity is articulated around design fixations and interdependencies for better interactive value management with other (silent) decision-designer.<br>5. Performance is repositioned on the transformative feature of decision-design where its criteria are redefined. Managing the organizational mirroring of interdependencies and fixations is part of the performance assessment. |
| **Environment cognition** | 6. One-way interaction: Environment to Organization.<br>7. The environment structures the response, nature and distribution of generative processes.<br>8. The environment is used to augment the product development requirements. | 6. The environment is managed through the design of decision to realize designed states of nature.<br>7. The decision-design addresses environment-induced fixations.<br>8. The environment awareness developed through decision-design targets also (potential) interdependencies, future exploitation features, and organization design fixations induced by environment. |
| **Organization design** | 9. Organization design is pre-conceived or uncontrolled.<br>10. Organization design creates gaps for managing generative processes and the dynamics of their organizational ties. | 9. Organization design is simultaneously managed with decision-design in project management as it has explored exploitation interdependencies and fixations.<br>10. Relationships and actionable knowledge are concurrently managed through decisional-ambidexterity thus embedding the organizational change management. |

**Table IX.1:** Model extension

# 3 Chapter synthesis: decisional ambidexterity and organization design

This chapter has extended the first version of decisional ambidexterity model with our concern for organization design and change management. We are then able to satisfy the requirements defined in chapter VII.

We re-use the idea of simultaneity of change management with project management (Pollack 2017) to endogenize the unknown further with decision-design perspective. Organization design and regenerating capabilities were included as knowledge elements required to generate new decision concepts and enabling the organization of collective action supporting them. We can then manage a metabolism sustaining innovation effort through organizational change. Our model should be considered as basis for **technology of organizing** to orchestrate and channel interactions for decision-designers contribution to exploration project management and dynamically mirrored organizational change.

The anomalies were discussed at the light of decisional ambidexterity. The case studies reveal several features of decisional ambidexterity and why they were misunderstood given models of ambidexterity.

Consequently, we have a full model of mutual conditioning between exploration and exploitation capable of explaining the descriptors reconciling with the identified literature models' limitations: model of coordination and collective action, and the innovation potential of attraction (generative processes, environment cognition, organization design).

# Chapter X

# Test cases: the Lower Deck and the Connected Cabin

*Everyone who designs devises a course of action aimed at changing existing situations into preferred ones.*
Herbert A. Simon

We have established a new model to reconcile the original construct of ambidexterity with the evolutions innovation management. By revisiting the canonical model of decision-making with design theory, decisional ambidexterity allows us to endogenize the unknown within a technology of organizing collective action to metabolize innovation across the firm. The performance is supported by the interactions between decision-designers revealing interdependencies and their reconfiguration. The value management unfolds as the project trajectory may be manoeuvred away from technical, organizational and environmental fixations. Exploitation dimensions are used to sustain a generative and grounded exploration.

The model was first built on a simple agent-based foundation, and since we tasked ourselves several requirements defined in contrast with anomalies, we made use of the mirroring hypothesis to discuss the necessary organizational change. This transformational process we propose to link with organizational metabolism, is an embodiment of the recombination of routines or regenerative dynamic capabilities. Therefore, it reflects the generative learning expected by (temporary) project-based organization and its boundaries with permanent organization. Otherwise, project will float across the organization.

Consequently, we propose to test our model of mutual conditioning between exploration and exploitation. To do so, we use two case studies conducted at Zodiac Aerospace. We extend the preliminary testing and understanding gained in the two previous chapter when defining our model. The anomalies became understandable as the model of decisional

ambidexterity gives a larger framework to make sense of decisions and concepts that are otherwise labelled as absurd or irrational.
The first project stems from the Design Case studies hosted by ADT we have analysed in the anomaly detection chapter. As explained, in the case presentation (p.201), the project was launched after ADT manager decided to further conceptualize the recurrent idea of using aircraft's lower deck. It was also notified by the researcher in 2016 when presenting his first analysis of the design thinking cases.
The second project originates from two members of the ZSTC with a history of entrepreneurship and innovation. They had reasons to launch a project on aircraft connectivity given their experience on telecommunications, satellites, antennae and onboard computers. It was set as a proper MBU project justifying its value proposal to the ExCom (see case presentation on p.202).

Both cases are comparable in the sense they were sponsored by the ExCom, offered budget and internal/external network support to find answers, contour their ill-defined problems and test the concepts (on slides, digital mock-ups and physical proof of concepts). We use the same analytical lens and descriptors introduced in our methodological chapters enhanced with the logics of decisional ambidexterity (decision categories, learning, organization design). Comparing these two cases will allow testing further our model by gaining an understanding that is missed with models of non-mutual conditioning between exploration and exploitation.

In the first section, we present the Lower Deck project, its trajectory and present the several patterns phased with decisional ambidexterity. In the second section, we discuss the Connected Cabin project, which, despite benefitting from an equivalent context and support, fails to sustain a decisional ambidexterity. The project unfortunately regresses towards biases of traditional models of ambidexterity, hence killing its innovation potential of attraction.
These two case studies give us a richer understanding of what decisional ambidexterity can achieve in reconciliating logics of exploration project management with a renewed organizational learning and adaptation rooted in generative logics.

# 1 Lower Deck: from design feature to value space

## 1.1 Trajectory of the project

As presented in our case presentation (see p.201), the project of Lower Deck started due to the accumulation of concepts generated in several projects over two years at ADT. Among them, many had the recurrent idea of using the aircraft's lower deck. A first provisional patent application process was started mid-2014 (see patent no. US20170233058A1). Late 2015, the patent was made public and made quite an impact with numerous critics coming from specialized blogs, magazines and newspapers[1]. The Design Thinking case studies started in 2015 and what continued over 2016 also made use of the lower deck in various ways.

The researcher had identified the pivotal role of this a priori underused aircraft area to enable concepts that cross over BU boundaries. In parallel, ZA's CEO, during an interview conducted in May 2018 by the PhD candidate, told the concept had already been discussed during ExCom meetings previous to the project formalization. The case seemed justified to them as they had insights on the declining freight market: an increasing empty space in the lower deck was then available. Finally, a project was kicked off and took the concept on its own mid-2016 and directly managed by ADT manager.

Several dimensions were addressed simultaneously. Firstly, an underlying mechanical stress study was conducted: the CTO contracted an engineering consultancy firm to evaluate the technical and safety feasibility of using the lower deck for passengers seating and other airline ancillary revenues. Secondly, the support of group business development directors in charge of airlines accounts offered a way to engage talks with key airline representatives (*interpreters* (Verganti and Dell'Era 2014)). It was the occasion to probe airlines interest and gradually contour client value. Thirdly, later 2016/early 2017, the VP of Strategy (ADT manager's director) contracted another consultancy firm to dig into the ticket pricing model (yield management) and airlines operation cycles in order to economically value lower deck's use cases but also find time frames when the aircraft lower deck could be modified without disrupting aircraft's operations. Finally, a last study was contracted internally with two business units familiar with tailored aircraft modification (VIP, movies, medical care, etc.) for a preliminary design and engineering specification to adapt the lower deck for the different use cases. Early 2018, a new patent application was made with more critical claims specifying the value of the concept refined over time (see patent no. WO2018037268A9). And the global concept was finally revealed to the public with Airbus as a sponsor and co-designer during Aircraft Interior Exposition in

[1]For instance see DailyMail Online brief on December 8, 2015: *Just when you thought they couldn't get any more seats on board: Aerospace company designs lower-deck cabin with vending machines and display screens instead of windows.*

April 2018. A partnership agreement was signed between Airbus and Zodiac Aerospace to develop the product.

What is rather surprising in this project trajectory is the fact that the lower deck feature was first used in several concepts and systematically discarded by BUs who participated to previous projects (including those supported by Design Thinking practice). Concepts were discarded despite having justified user and client value, and having raised some technical difficulties through complimentary meetings with engineers and designers. However, once the lower deck was turned into a proper value space looking for use cases, it gained much more momentum, specially from business unit managers. They indeed requested to host the project in their branch of activity.

The figure X.1 below gives a synthetic view of the project trajectory including the previous Design Thinking cases. Given the decisional ambidexterity model we can specify the nature of decisions designed.

### 1.1.1 Problem inversion of Design Thinking cases

Firstly, we can see that some decisions started from an enhanced optimization, moved towards hacking several choices extending concepts in between or outside BUs boundaries. Some of these were triggered by user input and *What If?* scenarios. The Lower Deck feature was one of them ($d^*$). However, once the concepts are selected, ranked, sponsored and promoted to BUs, the generative effort is reduced to an optimization: finding the best fit for BUs without changing engineering capabilities, or at best marginally by incrementally modifying existing products (new requirement). The issue is also that this optimization and biased adaptation is mirrored by underlying interdependencies and fixations.
For instance, using a waste chute and sorting mechanisms in the lower deck could be developed by Zodiac Inserts who developed the trash compactor (a trolley locked into the galley area). The latter corresponds to a given certification and qualification process. Zodiac Galley could also have considered the product development given its specialty on panels and fixtures withstanding stress and loads, as well as water and electrical circuitry integration (also another certification/qualification process). Finally Zodiac Cargo, who develops containers would be appropriate to develop the relevant container lodged in the lower deck providing the sorting and extraction of waste. It is a potential multi-BU project which always calls for another requirement partly mastered by another BU. It could be developed by each BU individually as technologies are similar or at reach. The incentive to work together would only come if they had a real client demand and/or a change in certification and qualification. Moreover, the concept requires reconsidering airline operations and purchasing policy, so training and change of practice is required in the sales pitch.

Secondly, the induced organizational and environmental phenomena were not really addressed in the Lower Deck project premises. The problem was turned inside out to make the choice hacking more visible. So, instead of forcing the BU congruence, it gave a whole new flavour to the innovation potential of attraction as described in Table X.1 below. Meetings held with the ExCom insisted heavily on the technical advantage that should be designed, since they were rather confident on the client value and market attractivity. The discussions were oriented to ensure the development of a turnkey solution as well as competitive advantage against the footprint of aircraft manufacturers. In other words, they shifted the concept towards having an empty shell. The value space guaranteed its technical feasibility, with the prospect of a separate qualification and certification process. Consequently, BUs could articulate their products in this new space, without worrying about their engineering and organization design fixations, and focus on regenerating their products for this new value space.

### 1.1.2 Regenerative capability through design formulation

The Lower Deck became rather modular and generic for several BUs who needed to develop new design capability to fit requirements evolution. It encouraged the adaptation to the newly designed environment. Instead of forcing the fit to each specific BUs, the problem inversion, allowed attracting them to provide use cases.
Decisional ambidexterity reveals the importance of project management and corporate entrepreneurship interactions steering the project trajectory where the novel value is not forced onto an a priori independent BU, but rather on formulating a concept design that attracts them to grow. It moves them away from their fixations by creating *generative fit* (Avital and Te'eni 2009), thus supporting the regenerative capability expected from them. The organization design was not clearly discussed during project meetings, but the decisional ambidexterity allows us to formulate the idea that product engineering embedded how interdependencies could be unlocked. Otherwise, a non-mutual conditioning would focus only on numerous other explanations: leader as champion, acculturation to the lower deck prospect. Perhaps yes, but it does not make it manageable and does not give much directions to guide collective action and engineering design practice.

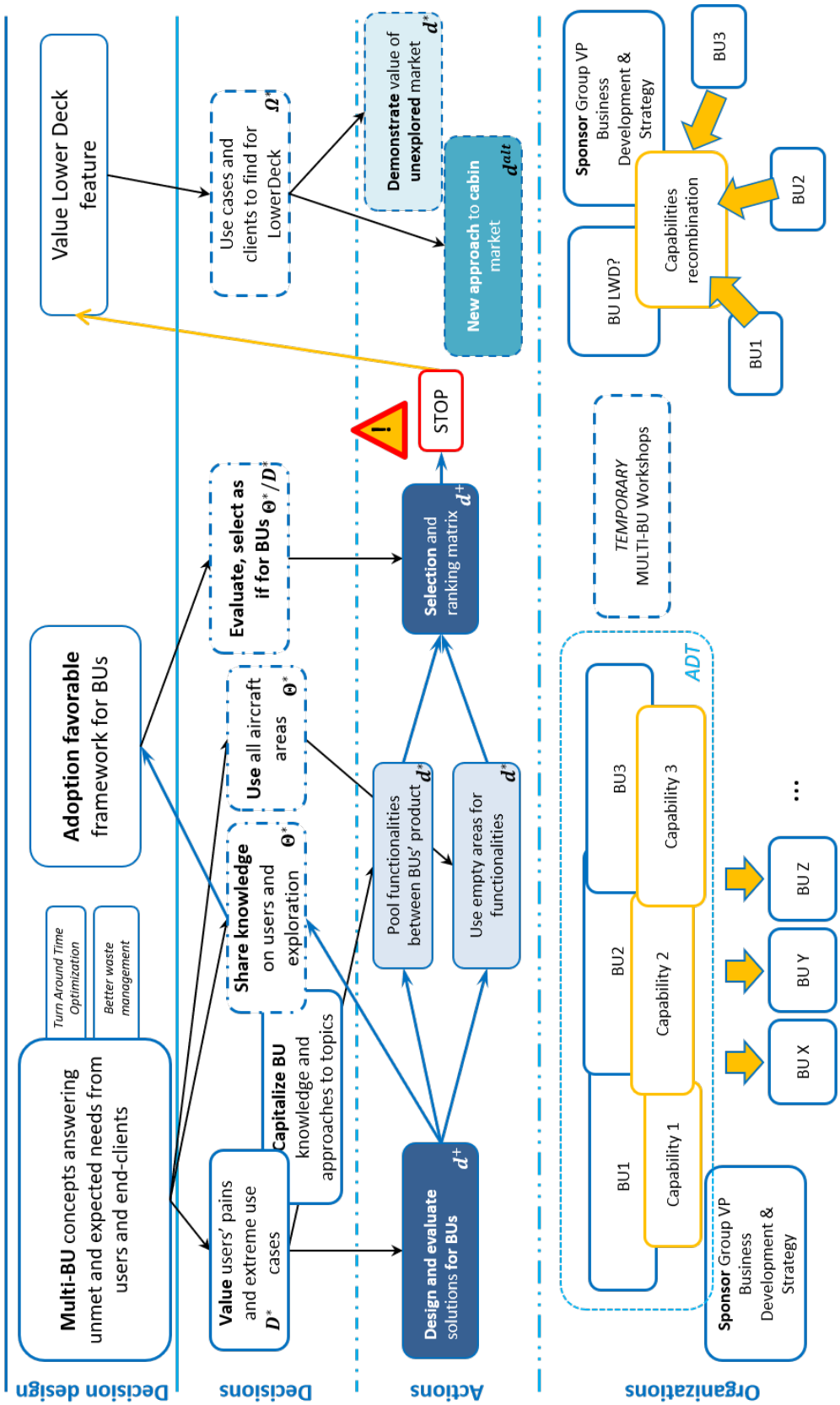


**Figure X.1:** From a feature to value space: inversing the lower deck problem

## 1.2 Decisional ambidexterity analysis

| | **Non-mutual conditioning** | **Mutual conditioning** extended model |
|---|---|---|
| **Model of coordination and collective action** | Lower deck exploration could be fully conducted separately to create a new business unit. | Lower deck business case is tightly articulated around the unlocking of underlying interdependencies that were not addressed in previous projects. It allows preparing exploitation and coordinate BUs around a host concept and value space. |
| **Generative processes** | *Non Applicable* | The conceptualization builds upon limitations raised by BUs. Demonstrate value through actionable knowledge on how to exploit the concept (technical and use cases propositions). BUs don't have to worry for the engineering of what could be common to other BUs, as the concept already determined those interdependencies. |
| **Environment cognition** | *Non Applicable* | The environment is managed with concept tested among potential clients, engineering qualification and certification to ensure passenger and cabin crew safety. The environment is shaped to welcome BUs future engineering effort. ExCom sponsored the engineering effort, qualification/certification constraints, and ensured the concept would crystallize and secure the market creation (technological advantage). |
| **Organization design** | The new BU or spin-off is a possibility, **but** pending discussions consider encouraging the regeneration of the cargo and container BU. | The organization design is integrated in the conceptual exploration as interdependencies and fixations ingrained in BUs are unlocked. BUs do not see it as a an *add-on* to their existing products, but rather as a value space to project onto. The Lower Deck may be integrated by a BU (cargo and container) hosting the contributions of other BUs combined with engineering capabilities for aircraft modification BU. Relationships are now built around the knowledge of enabling the cargo area for a multitude of use cases. |

**Table X.1:** Model extension

# 2 Connected Cabin: project mode and proof of concept?

## 2.1 Trajectory of the project

The project was initiated by two members of the ZSTC (see presentation p.202) who started testing the idea of addressing the trending topic of Big Data and Aircraft Connectivity. The topic had already triggered the development of in-flight connectivity with satellite antennae and ground antennae, including the ongoing product development by Zodiac Data Systems specialized in providing tele-measurement devices for testing and monitoring. In September 2016, the first summit dedicated to aircraft connectivity, *Smart Plane*, was hosted in parallel as a chapter of the major *World Satellite Business Week* in Paris. The topics were gradually gaining importance in the industrial ecosystem. However, already in late 2015, during a ZSTC meeting, the two members pitched the idea on how Zodiac Aerospace, as a group, could set a foot on this emergent market.

As pictured in figure X.2 below, they originally presented the idea of creating connectivity platform providing value-added service for predictive maintenance and airline operations. The claim was grounded on the fact that Zodiac Aerospace was a legitimate player to provide such integrated solution as the group covers the full extent of the cabin and several other key equipment in the aircraft systems. Their knowledge on tele-transmission with the products developed within Zodiac Inflight Innovations (fast growing player in the inflight entertainment market) allowed them to consider connectivity solutions between equipment so far isolated and managed by independent systems. The concept would thus overcome rigidities for airline operations and consequently passenger discontent.

Several meetings were held with the ExCom in order to have full support of top management so that middle management would allocate resources in order to demonstrate the value proposal and business case of such project. The discussions were complex and frustrating as the board of directors was asking for what would make Zodiac Aerospace legitimate beyond market footprint. They were asking for a technology differentiator, something that would ensure the market niche[2]. For instance, the CEO would have preferred to have Zodiac Data Systems to develop a technology (antenna, computer, etc.). In the end, the board was gradually convinced that the key was to be able to manage an ecosystem of industrial players rather than the hardware by making a direct comparison to Apple iPhone's development. They allocated budget to the project so that BUs could allocate time to their engineers and managers. The former CEO also communicated to investors on the project's kick-off.

Soon after late 2016, a whole project team was tasked by the ExCom to build a demon-

[2]this information was drawn from Multi-BU meeting minutes and CEO's interview conducted on May 7, 2018

strator for the following Aircraft Interior Exposition (AIX, April 2017). The design effort was driven towards making a *Minimum Viable Product*: a scenario was drawn with several pieces of equipment showing the benefits of cabin connectivity for airline operations and passenger experience. The proof of concept embodied in a full scale mock-up was modelled to show integration capabilities and synergies. Numerous workshops were held in different location to stage gate the project and track the progress of sub-projects around the connectivity backbone.

During an internal show with airlines organized by of one the major cabin BU in California, they had the occasion to probe some potential clients to provide feedback to the ongoing demonstrator design. It was also used to narrow down the questionnaire used during AIX. The exposition was a success, leading airlines executives came to visit and experience the product along with ZA's top management. Several critical comments came regarding known preoccupations in the market: data ownership, intellectual property, compatibility and standardization among industrial players.

What is quite impressive is AIX aftermath. Every BUs complimented each other, went back to their businesses. And several emails exchanged between project's members, including R&T, Marketing and Engineering managers of respective BUs, revealed how perplex they were on the project's termination. They wouldn't understand why the ExCom and other BUs wouldn't continue with the project. Several other factors can be taken into account: e.g. change of priorities for ExCom concerned with Safran's acquisition (but it didn't slow nor stop the lower deck project), and European funded projects on small connectivity technology block at BU-level but reduced scope.

### 2.1.1 Regression to the mean

By contrast with the lower deck project, and given the similar context, the project's gained momentum raises the question of how efficient the project's output was. Of course, pure continuity of the project cannot be always requested, but the takeaways are scarce. The major one still keeping a system thinking on the value chain can be seen for Zodiac Catering Equipment, but they already had an agenda on passenger experience, cabin crew and airline/caterer operations before the project.

The figure X.2 shows how the genericity and platform concept was originally pushed forward in a newly managed environment. Decisional ambidexterity quickly reveals that there was some regression to the mean (Kahneman 2011) or concept shifting towards a reference point (Heath, Larrick, and Wu 1999). This drift is unfortunately stuck due to organization fixation and interdependencies relatively to their product engineering and market segmentation.

### 2.1.2 Proof of concept to trigger a full-scale multi-BU project?

As we also stress in table X.2, the organization design was left aside and uncontrolled. So, each respective BU would work on recombining their engineering routines to think of the new platform for cabin connectivity. The proof of concept targeted the added requirement of using a communication bus and protocol (wired or wireless). The decisional ambidexterity highlights the need for an organization-design-oriented proof of concept supporting the original intent and sustaining the regeneration of capabilities among BU.

At some point, the CTO notified the researcher that the project was in "project mode". This comment clearly criticizes the limitations of encapsulation and its tendency for not considering enough change management and organizational learning and design. Decisional ambidexterity can also be used to discuss the proof of concept activity embodied by the physical demonstrator, scenario/storytelling, and associated prototyping activities to embody the scenario/storytelling. It allows indeed to formalise choice hacking, environment management, design of states of nature, designing by referring to BU (organizational) fixation effects. In the Connected Cabin demonstrator prototype, we can actually extrapolate what else could have been done to sustain the original concept. For instance, beyond the hardware add-one for existing products, exploiting the constraints of the connectivity topic could have been explored: bandwidth allocation and use, protocol, confidentiality and property. The hardware is of course important, but it corresponds to a retrofit activity, and it is made possible only after crossing qualification/certification/acceptation barriers. These are high-level and system constraints but they can easily shadow engineering ideas. Decisional ambidexterity proposes to generate and segregate alternatives to identify such control variables and actions to realize concepts.

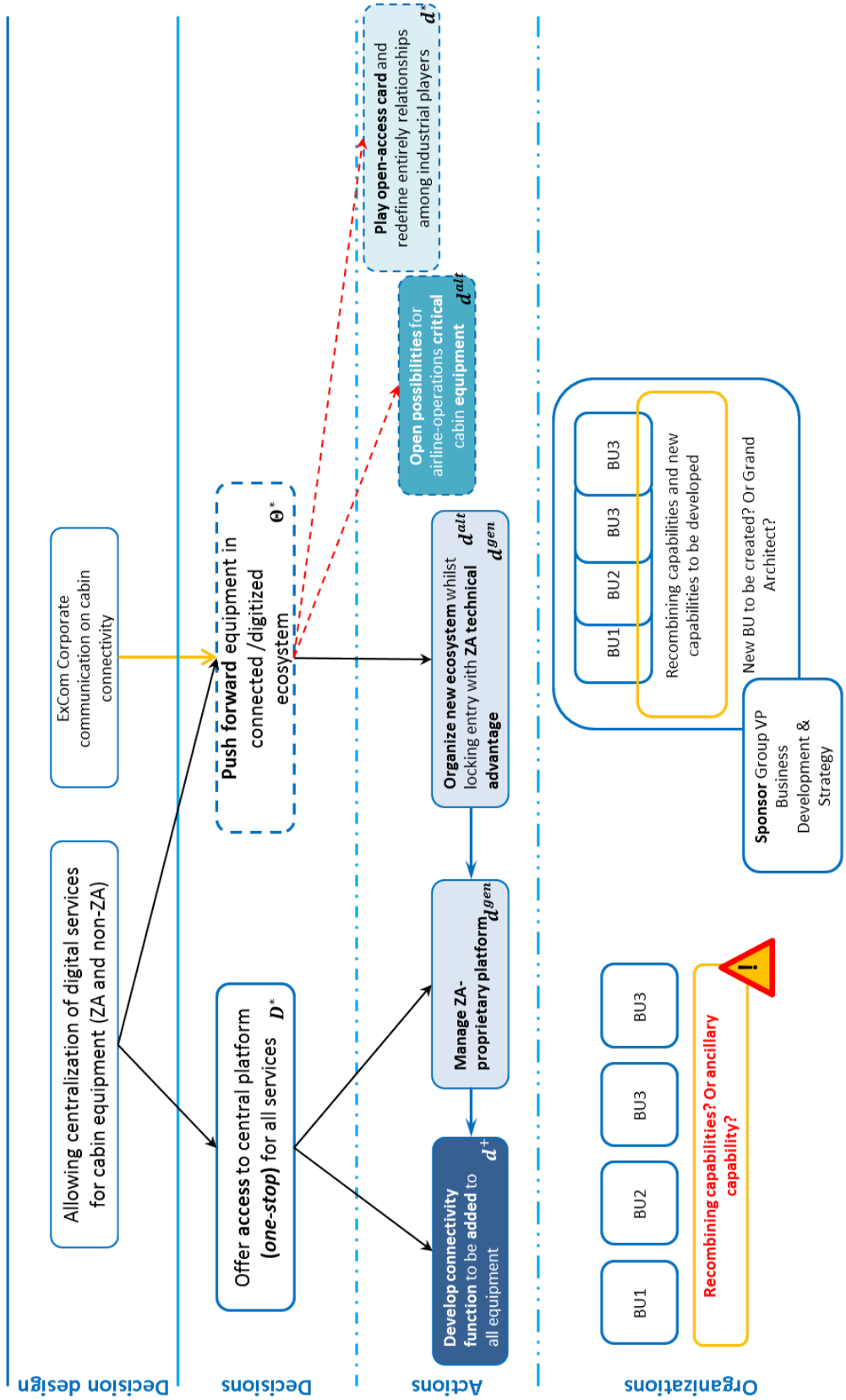


**Figure X.2:** From platform management and ecosystem reorganization to added function

## 2.2 Decisional ambidexterity analysis

| | **Non-mutual conditioning** | **Mutual conditioning** extended model |
|---|---|---|
| **Model of coordination and collective action** | Exploration is conducted by a temporary team relying on delegated resources. | Exploration initially targets a new platform approach for cabin equipment exploited in ZA. The equipment connectivity and associated system is used as an input to pool data in a centralized core system. |
| **Generative processes** | The purpose of the project drifts as the project's main output becomes a proof of concept for AIX 2017. | Hacking all choices to wish for a new industrial ecosystem organized around ZA integration capabilities. New connectivity solution, services for airline operations. |
| **Environment cognition** | The demonstrator and prototyping activities do not overcome fixations and locked interdependencies. | Original intent is to act as a platform leader for the ZA equipment and competition. Request from ExCom to have a key technological advantage to secure the new market. |
| **Organization design** | The project gradually moves away from the concern of articulating the technology with BUs engineering capabilities as the proof of concept mainly emphasizes the need for an added connectivity feature to all pieces of equipment. | Original project's mission was to federate a service platform for connectivity with BUs benefiting from added-value equipment enhanced by data. BUs would then need to regenerate their capabilities for *servitization*. |

**Table X.2:** Model extension

# 3 Chapter synthesis: a reconciliatory model for ambidexterity

In this model testing chapter, we have presented two comparable cases steered by the ExCom in the form of multi-BU projects. The mutual conditioning between exploration and exploitation in our model of decisional ambidexterity allows understanding the logics of generative processes and its innovation potential of attraction. They had similar coordination mechanisms as they were encapsulated into projects but the actions engaged to make a case for the proof of concept bended the project trajectory and organizational change in different ways.

The organization metabolism would not be activated given some constraints on engineering capabilities, standards and regulations as well as market segmentation. The literature models of non-mutual conditioning would indeed explain some patterns in the two cases. Consequently, we can formulate the result that the collective action of decision-designers requires to be organized on multiple levels with the appropriate heuristics and technology of organization. The common purpose, or task formulation, frames also the capabilities of the project, its reach and potential of attraction across organizations. We then back up the validity of our model of decisional ambidexterity.

The Lower Deck project had a strong emphasis on securing the concept feasibility and market access, the virtual mock-ups was rather a means to formalize, update the concept's model and communicate. However, in the Connected Cabin project, the demonstrator became almost an end in itself up to a point the designed generic decisions where gradually biased by strong organizational fixations and locked interdependencies. It reduced the wishful platform engineering to simply adding a function requirement to each equipment. The one-stop shop for all aircraft equipment manufacturers was reduced to an isolated add-on feature for existing and fixated BU-engineered equipment.

The two presented cases had similar management sponsorship, and corporate entrepreneurship spirit. They reveal the subtleties of decisional ambidexterity and the nature of generative effort, its management to avoid the limitations of organizational ambidexterity. The interactions with designed decisions, designed artefacts and steering committees appears key to manoeuvre the project's trajectory but also regenerate capabilities among BUs to support the project-based management.

In the following part 5, we will address the contributions made by the researcher. Several opportunities were seized to test *in vivo* decisional ambidexterity and further proof of validation were provided by interactions with peers within Zodiac Aerospace.

# Part 5

# Intervention and complementary testing

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**Outline** So far, we have proposed a new model reconciling with the detected anomalies symptomatic of the limitations found in our literature review as we forced the tracking of the unknown's management and induced effects across organization. Decisional ambidexterity considers the mutual conditioning between exploration and exploitation to actually use as an action generator through the design of decision. The pivotal role of decision-designing in the unknown, for networking, sensemaking or organizing collective action was demonstrated with our two comparable case studies.

The first chapter (XI, p.305) deals with an *in vivo* case where the researcher actively contributed to the project's trajectory by distilling and adapting the decisional ambidexterity model. Zodiac Oxygen Europe was working on a new pilot oxygen device project within the CleanSky2 program and with Airbus as partner. We expose how the researcher intervened and the results of such intervention. Moreover, we come back on the Multi-BU Committee steered by the Executive Committee where the PhD candidate repeatedly attended over 2,5 years. It was a management device that represented several features of decisional ambidexterity.

The second chapter (XII, p.319) looks at another output of the researcher when participating to the global program of operational excellence: Zodiac Aerospace Operational System. Several procedures were written for Product Development and Innovation. We present the improvements brought by the researcher offering a place for decisional ambidexterity. Furthermore, we add some input regarding several side workshops held by R&T managers who regularly exchanged on innovation practices in their respective BUs. The researcher had the occasion to test and validate his ideas with them.

**Aperçu** Jusqu'à présent, nous avons proposé un nouveau modèle conciliant les anomalies détectées avec les anomalies symptomatiques des limites relevées dans notre revue de littérature en s'efforçant le suivi de la gestion de l'inconnu et des effets induits dans toute l'organisation. L'ambidexterie décisionnelle considère le conditionnement mutuel entre l'exploration et l'exploitation comme un générateur d'action à travers la conception de la décision. Le rôle central de la prise de décision dans l'inconnu, pour la mise en réseau, la création de sens ou l'organisation d'actions collectives a été démontré par nos deux études de cas comparables.

Le premier chapitre (XI, p.305) traite d'un cas *in vivo* où le chercheur a activement contribué à la trajectoire du projet en distillant et en adaptant le modèle d'ambidexterie décisionnelle. Zodiac Oxygen Europe travaillait sur un nouveau projet pilote de dispositif à oxygène dans le cadre du programme CleanSky2 et avec Airbus comme partenaire. Nous exposons la façon dont le chercheur est intervenu et les résultats d'une telle intervention. Par ailleurs, nous revenons sur le Comité Multi-BU piloté par le Comité Exécutif où le doctorant a participé à plusieurs reprises pendant plus de 2,5 ans. C'était un dispositif de gestion qui représentait plusieurs caractéristiques de l'ambidexterité décisionnelle.

Le deuxième chapitre (XII, p.319) examine un autre résultat du chercheur qui a participé au programme groupe d'excellence opérationnelle : Zodiac Aerospace Operational System. Plusieurs procédures ont été rédigées pour le développement de produits et l'innovation. Nous présentons les améliorations apportées par le chercheur offrant une place à l'ambidexterie décisionnelle. De plus, nous ajoutons quelques contributions concernant plusieurs ateliers parallèles organisés par les responsables de R&T échangeant régulièrement sur les pratiques d'innovation dans leurs BUs respectives. Le chercheur a ainsi eu l'occasion de tester et de valider ses idées avec eux.

# Chapter XI

# Intervention and steering committee

Keeping up with our research agenda, now that we have validated our model with two comparable case studies, we engage with the presentation of how the researcher intervened in the firm to test *in vivo* the model of decisional ambidexterity. It allows us to further specify the subtleties of the model and the management requirements revealed by the mutual conditioning between exploration and exploitation.

We show how the project trajectory was set and guided with design of decisions constantly articulated with fixations and interdependencies so that the engineering practice encapsulated in the project could be largely grounded and supported by stakeholders. Furthermore, we exhibit how this R&T funded project aiming for a potentially new product embedding TRL6 technologies, managed its organizational ties to find sufficient echoes inducing the regeneration of engineering capabilities enabling future new product development.

We come back on a management device we often referred to inter-BU cases such as the Design Thinking cases, the Lower Deck and the Connected Cabin. The Multi-BU committee, created in 2012 by a former CEO, was an opportunity to foster top-down projects as well as some bottom-up projects requiring strong sponsorship enabling corporate entrepreneurship.
It is not a case study comparable to others, as it cannot be identified as project on its own. However, it is rather a *governance body for radical innovation*. This locus of innovation within the conglomerate of SMEs can be analysed through the lens of decisional ambidexterity and we propose to specify some of its characteristics.

This chapter further tests our model of decisional ambidexterity and continues justifying

its validity to extend models of ambidexterity and exploration project management presented in the literature review. These series of arguments provide us strong foundations to go into the following chapter XII (p.319) where we present the researcher's contribution to the quality management system for *Design and Develop* and *Innovation* processes (EN9100).

In the first section, we start by presenting one of the researcher's intervention at Zodiac Oxygen Systems Europe for a funded exploration on hypoxia protection device for pilots.

In the second section, we give more detail on the Multi-BU management with respect to decisional ambidexterity. It is not an intervention but it clearly shows the importance of heuristics at work to design decisions.

# 1 Hypoxia: probing and structuring the ecosystem interdependencies

The case presentation on p.199 gave a first global picture of the project's trajectory and context. The specificity of this case is that the researcher actively participated to the project on the R&T manager's request.

Below, we propose to present what was specifically done to implement heuristics of decisional ambidexterity and its induced effects. We picture the trajectory with the global descriptors in Figure XI.2, as well as the phenomena relative to model of coordination and collective action, and its innovation potential of attraction.

## 1.1 Organizational context and project target

The Zodiac Oxygen Systems Europe (ZOSE), whose Engineering and Product Development board is common with its twin sister BU in the United States (ZOSU) is one of the two market leaders in pilot, cabin crew and passenger oxygen masks in addition to oxygen tanks. In the past decades, with ageing patents, an increase of replacement parts providers with an *Parts Manufacturer Approval* (PMA), the risk of obsolescence and market share losses became higher to the point that Engineering Director included it in its roadmap and practices the necessity to think of market regeneration.

One of ZOSE flagship product, EROS mask (see Figure XI.1 below) along with an equivalent product offered by the competition (B/E Aerospace), are provided to aircraft manufacturers on catalogue. They are issued with a TSO (Technical Standard Order) that allows to certify a piece of equipment with sufficient autonomy over the aircraft manufacturer. It induces then several design rules with associated qualification standards.

The equipment was originally developed upon transferred and licensed technologies from the US to support equipment design and supply for Dassault (Darrieulat 1993). Later, in the 1960s, the engineering department developed its own capabilities and winning its contracts on its own. In a pure entrepreneurial spirit, Georges Gutman, then development engineer, created a oxygen regulator solving several limitations such as having oxygen on demand, making breathing more comfortable.

**Figure XI.1:** EROS Pilot Oxygen mask

Improvements were made including the innovation of having an expandable/retractable harness to adjust with the single push of a button the mask to any face whilst guaranteeing a perfect fit and air tightness. Smoke and fire protection with fogging prevention were also developed with a fixed or removable lens attached on the oro-nasal piece.

Given a historical and established dominant design, market players have put on the top of their priorities the urgency of reinforcing safety and preparing for the unexpected with new designs. Indeed, several threats of obsolescence due to ageing patents had been identified, and the aviation ecosystem was concerned by some isolated cases of hypoxia[1], usually due to other equipment failure. A CleanSky2 project, with Airbus as partner, made a call for proposal considering the new safety regulation requiring extended mask wear whenever a pilot is alone on duty in the cockpit.

It was then a proposal to rethink the ergonomics and features of the oxygen mask for this new restrictive requirement. Indeed, several feedback had pointed out that pilots were not following the rule because of the discomfort caused by the mask on their face. However, ensuring a pilot safety, whilst alone in a cockpit, is a first step before removing the copilot position. The flight engineer was removed several decades ago, so it appears to think of one-man cockpit before even examine unmanned commercial aircrafts.

## 1.2 Project trajectory

As explained in the case presentation (p.199), the researcher had first proposed a C-K mapping of the Open Innovation Challenge in order to position the proposed concepts relatively to the dominant design. And, as he was familiar with the R&T manager who was first in charge of the project, he was requested to support their exploration and their

[1]See for instance Helios Airways Flight 522

methodology.

They had already been working for 6 months on the project. Several brainstorming sessions, workshops with industrial designers were held and digital mock-ups had been generated. However, they were confronted with a dilemma. They were expected to provide a product concept to Airbus: a product requirement had been issued largely inspired by the general pilot oxygen mask but with some changed words calling for innovative design. For instance, the word *mask* was replaced by *device*, the adjective *disruptive* had been added on some requirements, and they also referred to a future cockpit without clearly specifying its characteristics.

The researcher supported them in clustering their previously generated concepts, and in creating meaning around new product categories. The clustering was eased by the use of C-K theory. But, more importantly, the researcher insisted on the team's ability to discuss the future decision of committing to a product design and development. So, the interactions with the client should explicitly rely on the extent of their design effort provided and their capabilities, as well as the necessity to discuss fixations and interdependencies. They were encouraged to present the design method, the clustering and how they made sense of the uncertainties and the unknown surrounding the ill-defined problem.

The figure XI.2 below shows the trajectory of the project. Initially, the concept could have been simply an extreme optimization ($d^+$) of the existing mask. It was a simple and easy way to identify action necessary for legacy products. It would allow anchoring to the dominant design and established product roadmap.
The necessity of wearing the mask for extended periods of time actually ensures that before an actual emergency, the pilot is wearing the mask in a standby mode, so the researcher pushed forward the nuance of prevention to counterbalance the emergency mode. It created a category discriminant to make sense of the generated concepts through brainstormings and industrial design.
Consequently, it allowed to consider two other concepts to decide that would fall under genericity ($d^{gen}$) and alternative situation ($d^{alt}$) as they wished for an evolving regulation where the nuance between prevention and emergency is specified. Finally, since the future cockpit is yet undefined, the potential threat of a guaranteed air tight cockpit would make oxygen mask pointless ($d^*$)? Furthermore, without fully exploring such disruption, they took into account nearby equipment that could be integrated with the oxygen device ($d^{alt}$).

All of the designed decisions where mapped through C-K with the project team input, and iteratively discussed so that they would gain in familiarity with the model. The researcher also encouraged to come up with means of avoiding isolation of the project within the engineering department. The project manager also repeatedly came to ask specific questions

to the researcher at the beginning as the heuristics were not made clear enough; so some short sessions were quite randomly set at the beginning with him and his lead engineer, to give some guidance to think of the different decisions categories and the required engineering design.

In the following subsections, we offer more detail on the benefits of decisional ambidexterity and its practice through the researcher's intervention.

## 1.3 A conservative client asking for radical innovation

### 1.3.1 Paradoxical request

We stated that the team was facing a dilemma when the researcher was called. The request made by the client was a mix of encouraged innovative design, but at the same time heavily constrained by mimetic requirements from existing dominant design. It created a lot of confusion and they were quite lost on ranking critical to quality requirements. They also doubted on the client for knowing what they were expecting from the product design.

The request was already ambidextrous in itself but perhaps in the wrong way as it was prescribed in an almost client-supplier relationship (Airbus to ZOSE). The team had the expectation that Airbus knew their need, and symmetrically ZOSE would engineer whatever is physically possible as long as it sustains and extends the product line. Reaching out for methodical innovative design, managed value management and project-based concern for engineering capabilities are clearly formulated despite being an open-ended exploration project funded by CleanSky2 program.

> This is where decisional ambidexterity can help specifying the nuances between pure exploitation (prescription, engineering and development) and exploration.
> Decisional ambidexterity overcomes paradoxical tension of non-mutual conditioning.

### 1.3.2 Exploiting for exploration

From the perspective of C-K theory, having such specified dominant design makes it easier to build the rest of the concepts. So, the researcher did it whilst also re-using some of the mapping made for Open Innovation Challenge. The researcher then encouraged the project members to anchor the value of the generated concept to established requirement by specifying the distant and its nature.

It allowed to make a design document presenting three main concepts categories, with a digital mock-up each, stressing how they came about these options. The researcher had insisted on the necessity to explain their method, their line of thought and its decision parameters so that they could better discuss underlying hypotheses that Airbus may be

deliberately or not hiding: interactions with other projects, cockpit elements, physical constraints, or just a vision for their future cockpit.

It has also forced Airbus to be more specific and answer questions that they did not expected to. For example, several debates gravitated around the head clearance (i.e. distance between the cockpit sealing and pilot's head top) as some design features encouraged the use of surrounding space for prevention. The concepts considering the integration with other cockpit elements such as the seat (engineering knowledge and capability exist at Zodiac Seats France), forced Airbus to solicit FAA/EASA to start thinking carefully about potential evolution of regulations.

## 1.4 Opening the project routines to the organization

### 1.4.1 Stress-tested proof of concepts

The concept categories presented and the design method were really helpful in discussing the unknown fraction of the project, but also key to articulate the interdependencies of the future product and technologies. Due to the nature of the requirements demanded by the client, several interdependencies could have been easily challenged.

With the project manager's support, the researcher encouraged the need to specify ripples caused by different generated features. The purpose was to find knowledge interactions and conjunctions triggered by the designed decisions. The manager organized open weekly meetings inviting several representatives from quality, purchasing, testing, prototyping, repair shop and other engineering sub-units. The aim of these sessions was to identify fixations held by these sub-organizations and the interdependent ties maintained by their engineering or management practices. Consequently, the project team was able to specify further the different concept categories.

### 1.4.2 Looking for organizational echoes

Nevertheless, the most stimulating side-effect of this practice was not the manoeuvre of the project trajectory to provide a well-defined and methodological approach to the client to co-explore the unknown. It was the reflexion of these practices in BU sub-organizations. The interactions organized around decision parameters, product design features and requirements were the occasion to regenerate their capabilities.

The Engineering Director launched several side mini-projects within some of his engineering units to address radical changes in product architecture. These have proven the technical feasibility of some features envisioned in the decision categories, and some opened new perspectives for product lines. For example, the air regulator has always been integrated in the oro-nasal piece because of pressure losses between the system and mouth/nose.

Distancing the regulator through a hose was unimaginable however interactions during the open-meetings to update and consult BU stakeholders and prototyping allowed reconsidering its engineering and interfaces between sub-units. It also invited them to think of product systems and cockpit integration differently, and opened possibilities to change the engineering organization.

And finally, despite having been made fun of at the beginning of the project by other BU members, some of the originally generated concepts were indeed seen as coming out of the blue. These concepts were in the end grounded with exploitation regime and the distance created by exploration was sustained by knowledge identification, generation, and initiated organizational, generative learning and change. Decisional ambidexterity helped stimulating organizational metabolism.

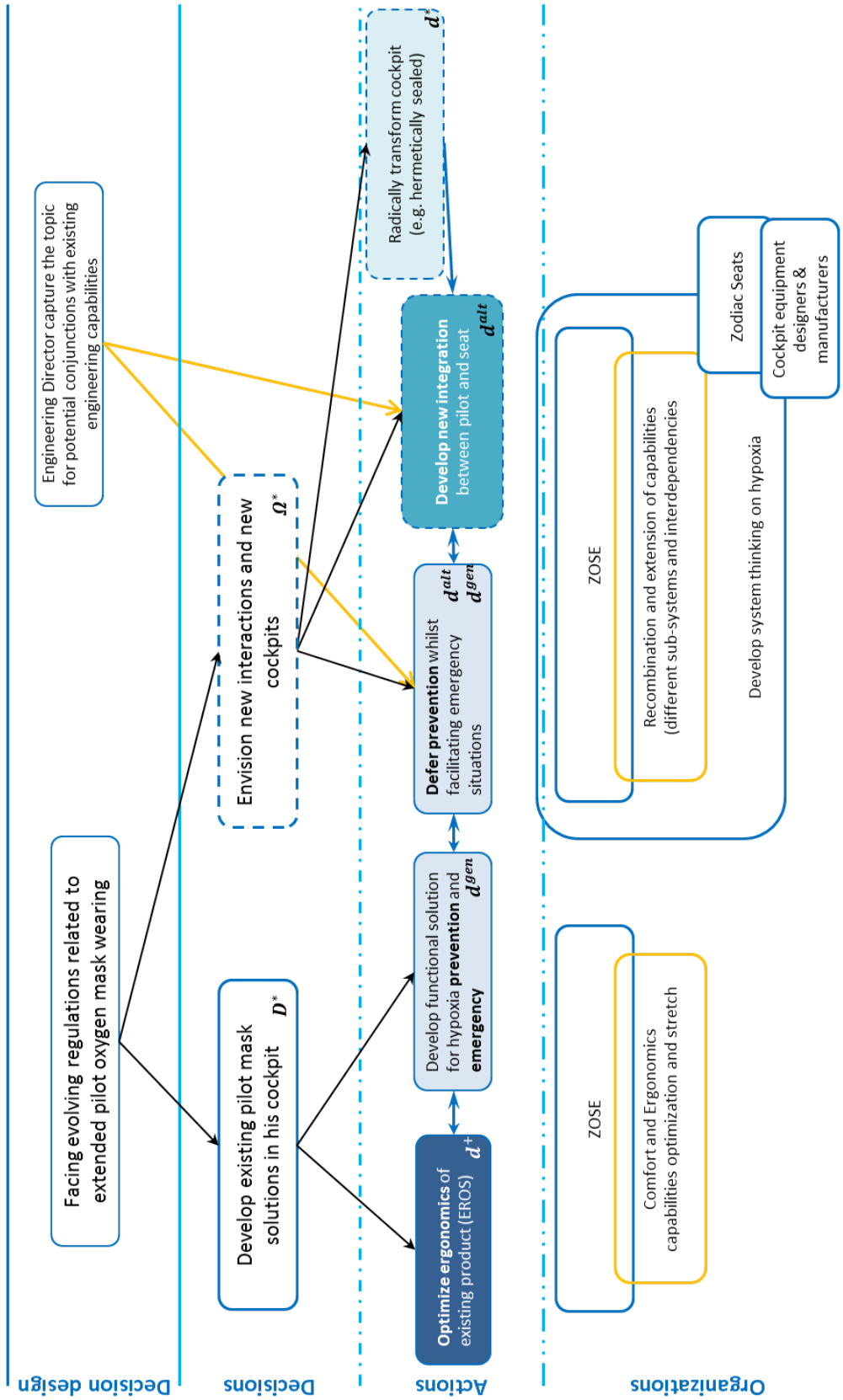


**Figure XI.2:** From decisional tension to satisfy requirements to organizational echoes

## 1.5 Decisional ambidexterity analysis

| | **Non-mutual conditioning** | **Mutual conditioning** extended model |
|---|---|---|
| **Model of coordination and collective action** | Originally, the project was organized in a non-mutual conditioning fashion. An upstream and isolated project from exploitation regime. | The research-intervention with a practice of decisional ambidexterity emphasized the absolute necessity to make explicit reference to exploitation parameters to generate alternatives and design concepts into the unknown. The project team mirrored the patterns with client and BU departments. |
| **Generative processes** | The first sessions aiming at framing the scope and generating concepts were conducted without a clear conditioning with exploitation regime. The direction of search and generativity was ambiguous and encourage the R&T manager to look for methodological advice. | Decision ambidexterity was practiced with clustering of concepts through C-K theory, definition of decision categories. It helped framing previously generated concepts and organize further exploration based on exploitation features and hacking constraints. |
| **Environment cognition** | At first, the exploration environment was defined by Airbus with a paradoxical and ill-defined problem. Several issues relative to certification, and acceptation by pilots but struggled in formulating concepts to the client. | Decisional ambidexterity practice allowed clarifying means of collective action to gradually uncover unknown environments (certification evolution, client needs, system integrations) since they addressed the nature and importance of interdependencies (head clearance, prevention/emergency, seat and cockpit, etc.). |
| **Organization design** | At first, the project was isolated from the rest of the BU and could have been kept out of product development portfolio even to a point of creating a new product line. This risk of incoherence for the BU competencies and market segmentation was sensed by the R&T manager who was more inclined to regenerate. | Working on the mutual conditioning of exploration by exploitation parameters helped organizing learning and disentangling interdependencies, and organization design fixations. For instance, the air regulator is integrated in the oro-nasal piece, and both are mirrored two engineering sub-units working tightly. Questioning it through the designed alternatives, opening the project to stakeholders, and prototyping, facilitated the launch of an internal side project to think of how it could be made and integrated differently. It encouraged to work other engineering interdependencies with other engineering sub-units. |

**Table XI.1:** Model extension

# 2 MBU Committees: a steering committee looking for purpose

The Multi-BU committee was established by the ExCom to launch top-down projects as well as to offer a place for bottom-up initiatives. It was created in 2012 hosting to steer key projects whose strategic interest was acknowledged by the ExCom. For instance, the fuel cell development was initiated by the former CEO as the greener aircraft initiative became more and more important in the aviation sector. A project team was constituted and hosted by Zodiac Oxygen Systems Europe as a potential growth driver and technology transfers. The project aimed at developing the technology for aircraft use with the promise of having multiple sources to be reuse across the aircraft (electrical power, water and heating). The project was conducted in partnership with two aircraft manufacturers and funded by European programs.
The MBU committee also hosted numerous other projects that would call less for a new BU, but rather insist on inter-BU collaboration; others were rather intra-BU bearing a strategic interest as it was developing a *game-changing* technologies.
As we explain, in the case presentation (p.203), the committee with its quarterly meetings was a locus of innovation to give a chance to entrepreneurial spirit[2].

> We propose to discuss some features of this MBU activity at the light of decisional ambidexterity, since it hosted several projects we have discussed previously such as the Lower Deck and the Connected Cabin. We specify the nature of the discussions held in these meetings, the impact of project's trajectory and how it relates to decision-designing.

## 2.1 Organizational context and ecosystem

First of all, it is important to understand that the MBU committee was set at a time when the homogenization of the conglomerate of SMEs was barely starting. The re-branding of business units was starting and the rate of mergers & acquisitions was diminishing.
The business units were exploiting their respective niches, and ZA as a group already covered a wide range of equipment and systems across the aircraft. The former CEO as well as other ExCom members, are all engineers and have a propensity for technical discussions. Niches were segregated with a variety of technologies, with high entry barriers. BU managers and the ExCom helped identifying M&A targets to be the first entrant to gain a strong foothold on these markets. The pattern had been reproduced across all existing ZA market segments.

[2] Among ZA values, Entrepreneurship is put to the fore in order to honour the historical fits of engineering of several engineers and managers, but also to cultivate it. As it is usually acknowledged among managers, people will be given the occasion to pitch their concepts and given the opportunity to demonstrate its value for the firm

The ExCom, as reported by the former CEO, wanted to leave a strong responsibility at each BU level, with Profits & Losses reporting, a certain financial autonomy with a holding consolidation. They avoided imposing projects to BUs. The MBU committee was then a means to drive exploration for BUs through technological development. Some technical barriers (engineering, certification, market interest, supply chain, etc.) would be extensively studied so that one or several BUs would take it onboard. If necessary they arbitrate on the project's allocation depending on how the ExCom judges the BU capacity to sustain the development. The former CEO also saw the MBU as a management device to overcome the limited *bandwidth* of BU and Divisions managers. It is also the role of branch executives (ExCom members) to seize and support these initiatives.

## 2.2 Managing exploration added value for the conglomerate

The committee was a locus for discussion, where top management met with middle management, engineers, designers and marketers. All ExCom members were former engineers, including middle management and BU managers. As confirmed by the former CEO, he encouraged debate on the quality of models and input data used to make decisions on the technologies, products to be developed. The VP of Business Development and Strategy would usually question the Intellectual Property and aircraft manufacturers' risk of claiming primacy. The former group CEO and branch CEOs would dig into the details of the project, questioning engineering topics, partnerships, competition, market shares, suppliers and potential launch customers.

Whenever they felt the model was stress-tested enough given their knowledge on the topic or insight they had from their interactions with other executives inside/outside the firm, they would delegate the responsibility to the BU.

## 2.3 Advantages, conditions and limitations - former CEO's feedback to the researcher

Among the limitations we can find in the MBU device, some can be seen by reflecting on the difference between two cases such as the Connected Cabin and the Lower Deck. These two show that despite benefiting from the same context, they did not hold similar results. Of course we could go on listing numerous reasons, but they were treated alike during MBU and additional ExCom meetings. In other words, the same discussion on hypotheses, input data and modelling was heavily challenged by board members. Such pattern has been reported for executives not familiar with topics (Loch, Mähring, and Sommer 2017), but here, the ExCom is made exclusively of engineers who have cultivated over their careers a deep interest for technologies and applied sciences. They also have market and ecosystem knowledge through other firm's corporate governance participation and external networks (consortia, group of industrial partners, conferences, etc.). For

example, the former CEO had good knowledge for both topics before they were launched as actual projects:

- For the lower deck, he was aware of the decline of the air freight and its share in commercial cargo area. He was already convinced by the market interest and value for airline yield management, to the point that when the results of the market study were presented, he cut through the presentation to address technical and engineering issues. He would be more interested in securing the concept on that issue to gain autonomy from aircraft manufacturer and raise the entry barrier as they knew competition (B/E Aerospace) had been consulted for a similar project.
- For the connected cabin, he challenged a lot the value proposition as he was asking for proof of legitimacy for ZA to organize such service market platform. In an interview in May 2018, a year after the AIX 2017, he told the researcher he tried to encourage Zodiac Data Systems BU manager to develop a technological advantage securing the nascent market. It was another way of scouting for different scenarios and testing the fixations of different BUs as well as interdependent engineered product between BUs.

Despite having same discussion goals to *define what makes rationality* collectively with project representatives and potential stakeholders, it appears that the steering committee could benefit from a technology of organizing, by opposition to *fostering a culture of curiosity and sound debate*[3] to sustain innovation.

It appears then that several conditions can only be surfaced through engineering design, project-based management and change management and its active management around a model such as decisional ambidexterity. Interactions and networking are not sufficient. Indeed, the former CEO recognized the interest of having a practice to specify the model testing, rationality testing practice on countless occasions. He was very receptive to the decisional ambidexterity model and even felt it was natural. The formalization is a real plus for a set of heuristics that may not be acknowledged by everyone. Otherwise, he believes that it is a widespread practice which counters procedural practices fixating rationality. He also insisted on the danger of such mechanistic models of thought (e.g. rational choice theory, operations research) which can be the best way to go to the wall.

[3]The words in italic are extract of the former CEO's interview conducted on September 4, 2018

# 3 Chapter synthesis: a reconciliatory model for ambidexterity

We show in this chapter how the researcher intervened in a project to seed decisional ambidexterity. It reveals the significance to understand the practice of design reasoning, modelling and formalization to discuss the potential decisions and its categories. Coming back to the Multi-BU committee we referred to in previous chapters, we also reveal how some behaviours and practices relate to decisional ambidexterity and how it could further benefit from it.

The researcher specified several different heuristics and supported the team to effectively address the decision-design to address the difficulty faced when dealing with a paradoxical request putting in tension exploitation regime and exploration incentives. The work conducted with them allowed to translate the engineering design work with its mirroring for client relationship management, product integration and internal engineering capabilities and organization design. The methodological approach constantly addressed the mirroring dynamics of the unknown in order to support generative learning and capabilities regeneration.

The Multi-BU committee with the heuristics and culture fostered by the ExCom can be considered from the perspective of decisional ambidexterity. It wasn't a decision meeting place, but rather networking (Christiansen and Varnes 2007). However, this networking benefited some systematic debate on the modelling, hypothesis, problem formulation and value management. It allowed to sustain a culture of curiosity and generative learning developing vigilance for project management. But, we also point out that the debates held in these meetings could also have benefited from a technology of organization where decision-design could have been better structured. For instance, we would have helped to systematically address the interactions and the disentanglement of interdependencies in order to overcome (organization) fixations effects rising from the conglomerate of SMEs sustaining their respective niche markets.

Finally, in this chapter we have given further proof that the model of decisional ambidexterity helps in managing the mutual conditioning between exploration and exploitation, supporting decision-making in the unknown for innovative design and interrelated change management.

# Chapter XII

# Validation by peers: quality management system contributions

*The heart of a good work is a puzzle and an idea.*
Andrew Abbott

In the previous chapters, we have given further proof of the usefulness of a model of mutual causality between exploration and exploitation: decisional ambidexterity. The role of decision-designers and the technology of organizing are sustained by interactions with the decision-design in the unknown, mapping, categorizing oriented towards by interdependencies and fixation effects. We have also sketched by contrast the usefulness of having an engineering-oriented approach to it: considering methodological approaches and objects to effectively organize collective action.

We present in this chapter several other contributions of the researcher to adapt process management and existing R&T and Innovation practices in Zodiac Aerospace. The initiative was part of a global program on Quality Management System and for Operational Excellence following issues encountered by a few BUs. The CTO was the process leader for *Design & Develop*, a key process for *Program Management*. He fought to have an *Innovate* process, which finally was allocated by the Chief Operations Officer despite not being directly linked with operations in the short term.
It was an occasion to reinforce the value of innovation practices as potential contributor and enhancer to operational issues. In other words, we can think that operational issues faced in manufacturing engineering and quality engineering, can be rooted in design choices. This processual view can then be seen as an occasion to work around the mutual causality between exploration and exploitation, instead of only separating an innovation process and management as a totally isolated regime compared to other organizational concerns.

The diagram below (Fig.XII.1) gives a global picture of the 3 main pillars (Drive, Execute, and Support).

**Figure XII.1:** Zodiac Aerospace Operational System: 3 main pillars sustained by 13 major processes

In the first section, we start by presenting the procedures written for the ZAOS with the researcher's contributions. They cover the *Design & Develop* and *Innovate* processes. The first defines a traditional new product development, a representation of an exploitation regime, with a strong influence from the optimization of project management. The second process is then seen as upstream, and the researcher tried to distil it in the model of decisional ambidexterity.

Then, we discuss the feedback gained from several R&T managers community workshops where the procedures were reviewed and where the researcher had the occasion to discuss his model of decisional ambidexterity. Similarly to the ZAOS procedures, these contributions show the issues of surfacing an organizational metabolism against the duality of processes and structure.

# 1 Group procedures: Design & Develop and Innovate

Following some quality and delay issues, corporate teams had launched programs of *operational excellence* across the group. Originally, it was formalized in key requirements for operations (supply chain, manufacturing, industrialization, customer management). Later, it was formalized into an update of the quality management system to prescribe a set of key principles and procedures. The movement initiated for critical process then moved "upstream" to tackle *Design & Develop* and *Innovate*.

The researcher had first participated to the *Program Management* procedures writing to identify how R&T activities could be articulated (TRL assessment for risk management, technology acquisition and integration and multi-BU projects). Then, an even more active contribution was made to *Design & Develop*. It was an occasion to contribute and gain sufficient knowledge on exploitation regime. Consequently, it helped formulate proposals for management devices instilled by decisional ambidexterity in *Innovate* procedures.

> We present the linear view of designing and developing products in the ZAOS. It is part of a more global processual perspective of the exploitation regime that tries to avoid referring to organization structures. Innovation is then placed as an upstream process, we discuss its interface and assumptions.
>
> Then, we show the *Innovate* procedure and how the researcher tried accommodating decisional ambidexterity by introducing the governance construct for road-mapping activities.

## 1.1 Design & Development procedures

In the figure below, we present the overall process of *Develop & Sustain* with inputs/outputs from other processes, as well as suppliers and customers of different processes: Design & Develop, Perform industrialization, Perform maintainability engineering for repair, and Maintain continued airworthiness.

The overall perspective of designing and developing makes several assumptions on the linearity of the process. Customer have need, voiced to the business unit through bidding teams and programs framing the undertaking waterfalled to different underlying processes (see figure.XII.1). As we see below in Figure.XII.2, the suppliers/customers in bold purple letters are other processes providing and expecting actions and deliverables (note: circular references are possible because of iterations).

PROCESS CARD

**Develop and sustain**

**Responsibilities & Authorities:**
Group Process Leader: Group CTO
Process Owner (in the Company) : Engineering Director

**Process Objectives:**
Develop competitive quality products & processes, according to customer and applicable requirements

| Suppliers | Inputs | Process | Outputs | Customers |
|---|---|---|---|---|
| Authorities | Regulations on Product Certifications (incl. updates) | Design and develop<br>Perform industrialization<br>Perform maintainability engineering for repair<br>Maintain continued airworthiness | Development plan (PBS, technical risks & issues, opportunities)<br>Up-to-date status on deliverables, NRC & RC, risks, issues and opportunities | MANAGE PROGRAMS |
| MANAGE PROGRAMS | Customer technical specifications & standards<br>Statements of work<br>Program charter<br>Program management plan (OBS, WBS, planning, resources)<br>Program assumption pack<br>Specification & standards changes<br>Engineering change requests | | Industrial files (3D/2D drawings, BOM…)<br>Means and tools, work instructions, process flows diagram, FAI report | PLAN & PRODUCE |
| PROCURE | Approved supplier list<br>Supplier Obsolescence plans | | Purchased part demand (including technical specifications) | PROCURE |
| | | | Qualification/Certification outputs | Customers/Authorities |
| Suppliers | Material & component specification / data sheet<br>Qualification documents | | Chemicals products & processes | SUSTAIN INFRASTRUCTURE |
| INNOVATE | Mature Technologies<br>Technology roadmaps | | Diagnostic procedures<br>Maintenance procedures<br>Technical data & means definition | SUPPORT CUSTOMERS |
| SUPPORT CUSTOMERS | In-service reliability data | | Root cause analysis and corrective actions to in-service incidents | Customers/Authorities<br>SUPPORT CUSTOMERS |

**Indicators**
- Performance Metrics
  - Qualification/Certification success rate
  - FAI Success Rate
  - OTD on drawings / deliverables
- Monitoring Metrics
  - % reworks on eng. drawings
  - % chemicals with hazardous substances

**Communication / Monitoring**
- Design Reviews
- Program Reviews
- Configuration Management Reviews
- TRL (Technology Readiness Level) Gate Reviews

**Resources**
- ERP + PLM (Product Lifecycle Management) Tools
- Engineering Drawing Management Tool
- Laboratory Means
- Simulation tools

**Skills/Competencies**
- Engineering Knowledge (product & process)
- ZA Design Organization Standards
- Product Certification

**Figure XII.2:** ZAOS - Design & Develop process card (SIPOC view)

Given several inputs and interactions with other processes, responsibility, accountability, support, consultation and information are distributed among functional activities (jobs), with some overlap, interactions but with a global movement forward, the sub-processes are the following:

- Create Technical Proposal
- Analyse Customer Needs & Capture Requirements
- Perform Preliminary Design Analysis
- Create Detailed Design Data
- Perform Verification and Qualification
- Obtain or Support Certification
- Configuration Management

This exploitation regime is heavily dependent on the client's demand and makes the assumption the client knows to some extent how to formulate requirements to a congruent business unit (bidding and engineering team) capable to discuss and support in the formulation of engineering specifications and rules to conduct product development.

Numerous debates during writing workshops (for program management, develop & sustain, as well as innovation) took place because of differences in organization design. The struggle was hard to adopt the view of the quality management system which enforces a strong processual view. The process should be high-level enough to be transposable between business units. The compromise found to avoid specificities was to add some depth to the processes for organizations to better identify with maturity matrices.

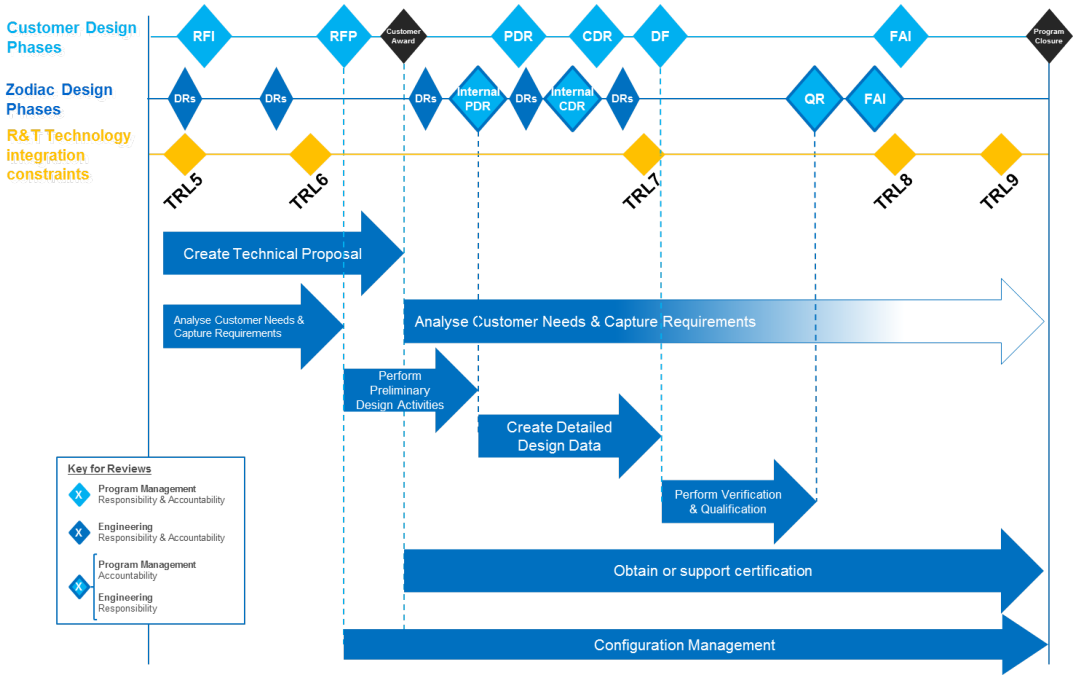


**Figure XII.3:** ZAOS - Design & Develop sequential view

### 1.1.1 Project-based management principles

Project management principles are induced by the framing and management of overarching programs. They impose the breakdown of the activities in work packages supported by team. Resources are picked among whatever organization is in place following the matrix-form (Galbraith 1971).

Resources are allocated depending on customer requirements and derived specifications. What is rather surprising in the writing of these activities and responsibilities is the implicit reference to the necessary competencies and capabilities to continuously be able to develop new products and cope with adaptation to change

### 1.1.2 R&T and Innovation interface

As we can see in the previous figure, they have linearized the R&T activities, through the TRL assessment (Mankins 2009). It corresponds to a stage-gate equivalent (Cooper

2007). Of course, such linear and adaptive view is more appropriate for incremental innovation. Product development and engineering refers to a pool of technologies capable of being integrated as the TRL freezes the integration environment to measure the technology maturation. So, if the engineering rules for products remain stable enough and that these are made clear, it can be considered that maturity assessment will filter and perhaps bring adjustments to technologies.

Consequently, when it comes to major innovations initiatives, they would originate from another process that necessarily challenges or even by-passes traditional adaptive and maturation processes. From the researcher's viewpoint and as discussed on multiple occasions with the CTO, the quality management system had to sanctuarise these processes in *Innovate*. Indeed, *Design & Develop* restricts its scope to a traditional exploitation regime with its lot of hypotheses on nature of risks, certainties, fixations and marginal correction of biases & heuristics.

> The structure of the ZAOS, with the cross-referencing of processes of different nature, forces to build coherence between them as well as delimiting their perimeter. The scope and the risk of leaving activities unmanaged was taken care of by the ZAOS project team. On some occasions, it was also circumvented by using maturity matrices to provide additional detail on how activities can be conducted with underlying competencies and capabilities.
>
> Overall, *Design & Develop* describes the exploitation regime fed by some optimizations that can be decided as they improve product design & development with technologies capable of being integrated.
>
> From the decisional ambidexterity perspective, it provides enough ground to envision designing decisions capable of changing products, their development and required capability. Since, we face a traditional model of ambidexterity, decisional ambidexterity model is bound to be upstream but encourage to disentangle fixations effects and interdependencies.

## 1.2 Innovate procedures

The *Innovate* process was the last in being written in the ZAOS program. Some place had been made already for incremental innovation with more traditional R&T activities focusing on technology maturation made available to product development and program management.

A preliminary round between the CTO, his North America delegate, the Intellectual Property director, and the PhD Candidate was organized to provide an overall framing. This

original draft helped giving some directions to the writing workshop participants. The main issue was defining whether or not the process should consider product design and innovation, in addition to technologies. And more common to other processes in the ZAOS, sub-processes and topics were reallocated and articulated differently under the umbrella of the agreed main processes after several iterations:

- Define, Implement and Maintain Product & Technology Road maps
- Manage Research & Technology Projects
- Manage patents and create patent landscape

*Innovate* complements what exploitation doesn't cover. In other words, it feeds exploration regime. It is regarded *upstream* to provide technologies to improve continuously product along its roadmap. However, the group quickly insisted on approaching the subject with additional processes catching other forms of innovation. It was necessary due to the variety of products, sometimes relying on several common technologies (material, composite, flammability, electronics, EMI, etc.), and due to the value of design and layouts for cabin and seats equipment.
Consequently, the working group had to precise the articulation of other innovation streams and practices contributing to exploration and differing from the linear, continuous and adaptive view of innovation.

PROCESS CARD

**Innovate**

**Responsibilities & Authorities:**
Group Process Leader: Group CTO
Process Owner (in the Company) : R&T Manager

**Process Objectives:**
Drive Innovation to enable competitive & mature technologies which reach market & customers needs in due time

| Suppliers | Inputs | Process | Outputs | Customers |
|---|---|---|---|---|
| MANAGE COMPANY | Product line strategy<br>Internal customer needs<br>Vision for the future<br>R&T budgets | Define, implement and maintain Product &Technology RoadMaps<br>Manage Research & Technology projects<br>Manage patents Create Patent Landscape | Technology RoadMap (TRM)<br>Product RoadMap (PRM)<br>Vision Boards, animations, posters etc. (strategy communication) | MARKET & SELL<br>DEVELOP & SUSTAIN<br>PROCURE<br>Management |
| Customers | Customers expectations and trends (OEM, MRO, Airline & Pax)<br>Travel trends, Industry trends<br>Competitor Behavior | | Mockups, demonstrators<br>New customer experiences | MARKET & SELL<br>Customers |
| MARKET & SELL | Business development plan,<br>Must win list<br>Products and services plan<br>Industrial trends<br>Market Intelligence | | Disruptive, breakthrough, and Incremental Technologies (TRL6 target) and Product/Services concepts<br>Engineering Design Data, Methods & Processes | DEVELOP & SUSTAIN |
| Laboratories, Universities Start-ups, Suppliers, Industry Partners | Research findings<br>New technologies<br>Concepts | | Utility Patents, Design Patents, Trade Secrets, Idea Creation, Rights to IP | MARKET & SELL<br>Management |
| Patents offices (e.g., European, American)<br>Project Teams/ZA employees | Intellectual Property guidelines<br>New ideas, concepts & inventions<br>Published patents | | Freedom to operate opinion<br>Industry standard participation (Creation, Comment, Participation Approval) | |
| Regulatory Agencies & Institutions (e.g., EASA, FAA, SAE) | Aerospace standards/ rules, EHS standards & trends | | | |

**Indicators (ZAOS & FOCUS)**
- TRL Milestones adherence (up to TRL 6)
- # of ideas which have reached TRL 6 and effectively implemented in a development
- # Utility patents applications
- External funding
- R&T budget variance (**FOCUS**)

**Communication / Monitoring**
- TRM (Technology RoadMap) Reviews
- TRL (Technology Readiness Level) reviews
- Strategy committees
- ZSTC (Zodiac Scientific & Technical Council)

**Resources**
- PhD, External funding, labs , Technical Expert Network, Suppliers, IRT (Technology Research Institute)

**Skills / Competencies**
- Engineering knowledge, Innovation culture
- Patent Process knowledge

**Figure XII.4:** ZAOS - *Innovate* process card (SIPOC view)

As we show, in the following paragraphs, decisional ambidexterity explains the nature of these innovation streams contributing in more complex ways and differing from traditional models of ambidexterity.

### 1.2.1 Revisiting the innovation funnel

In order to provide a basis for discussion, the researcher used traditional ways of representing innovation. The famous funnel implies uncertainty reduction through a stage-gated with an hypothetical target and environment. It is rather fixated. He then proposed to use its parameters and assumptions to show that other innovations, differing from technology maturation could be considered:

- Technologies and Products can be created but do not have yet a market
- Markets can be created but do not have yet a product or technology

These two simple statements encourage after defining what the funnel is[1], to envision other scenarios and concepts to be decided. The figure XII.5 below incites to revisit the innovation funnel, not only to show the necessary feedback loops between gates to reach an a priori defined target, but also to show the porosity of the funnel and its elasticity/plasticity as new decisions rule its scope and curvature.

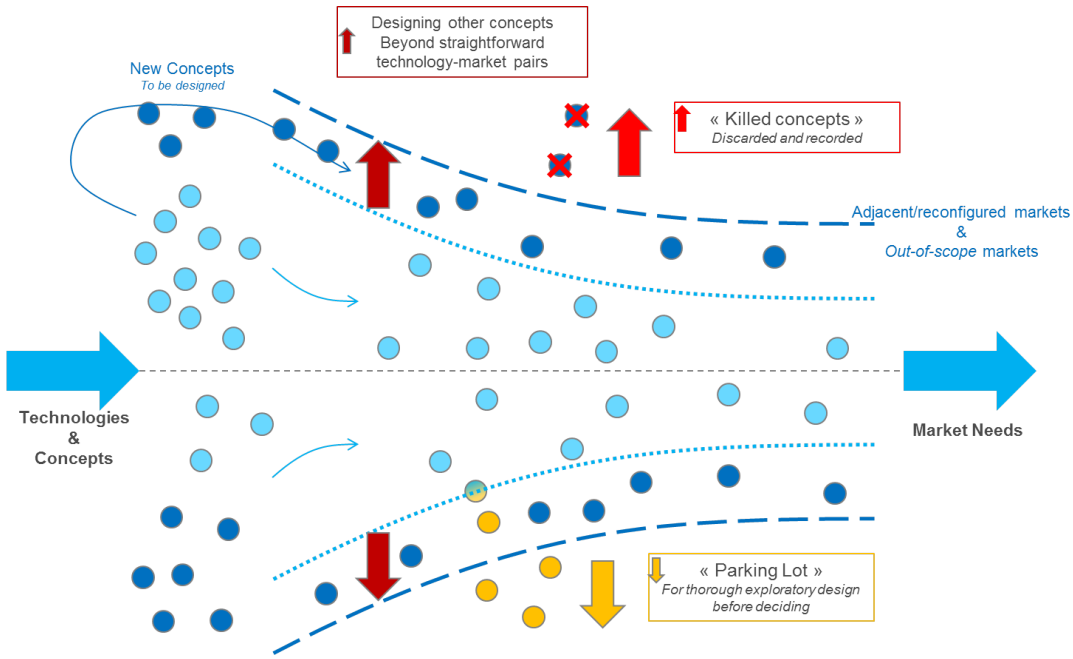


**Figure XII.5:** Extending the Innovation Funnel with Decisional Ambidexterity

The colour code identifies different types of concepts relying on a specific decision-making. The light blue refer to technologies and (design) concepts that can fit the environment and adjust with existing engineering design rules.

[1] what the box is, to think out of it and it in comparison to

Dark blue is for new concepts that tend to modify the shape of the funnel. Some can be fully discarded (red-cross) because they are decided to be out of scope, e.g. they require escalating decision and involve strategic discussions challenging the overall model of business or firm's identity.
Others may be left in a *parking lot* (yellow) as the decision requires deeper value management to understand how to generate a future fit with organizations: e.g. the lower deck project.
Otherwise, the dark blue concepts may require to search or support suppliers in developing technologies, or inversely searching or co-innovating with customers and users to shape the future market. The Icing Conditions Detection project revealed several features of this interplay between technology and market design.

### 1.2.2 Decision-design and Innovation governance

Introducing such interactions touching upon organizational metabolism, the writing team had to provide a means to manage such decisions. They relied on existing practices, i.e. road mapping activities for technologies and products.
First, the group included the product road map as part of *Innovate* whereas in the past it was absent and only focused on technologies (R&T). It allowed to be more representative of *less* business units who focus rather on design features (cabin and seats), besides common topics such as materials.
Secondly, the main issue raised by writing workshop participants was the handover between innovation teams and product development and sales/marketing. The issue was not the handover dossier nor technical items, but rather to have some buy-in from them. Moreover, enforcing a top-down was not necessarily the solution according to participants' experiences.

With the CTO, they proposed to introduce a governance body to orchestrate the alignment and change of roadmaps for technologies and products. The American colleague (CTO's delegate for the Americas) was not very comfortable with it as it has a stronger meaning than in France (more related to the firm's Board). Nevertheless, due to the weight and twist they wanted to give to this management of decisions and concepts, they kept it. The procedure asks to organize meetings with BU stakeholders, invited experts from the group (if relevant), and the group CTO. Interactions in meetings are encouraged then to discuss what can change for the funnel and in between roadmaps. The point is to discuss what makes decision and position concepts accordingly. Experts can bring additional knowledge. And the CTO can spot opportunities outside of the BU, or find connections for multi-BU projects.

In other words, we insisted on the innovation potential of attraction, resurfacing rules for decisions on product engineering and development, in order to fit to them or redesign them

with according knowledge and organizational change. The word metabolism wasn't used but the interactions and the management device through this governance body is here to support such phenomenon.

> The *Innovate* process defined as complement to the exploitation regime in *Design & Develop* offers a first to reconsider a reductive model of ambidexterity for R&T activities and articulate other innovation streams. Decisional ambidexterity is used to condition exploration by exploitation parameters and constraints usually represented through a funnel.
>
> Given the obstacles reported by R&T managers and innovation practitioners, they proposed to work on the articulation of their activities with exploitation regime. Bringing interactions and managing them around fixations effects and interdependencies through the lens of *decisional ambidexterity*, allows to propose new means of actions for existing objects such as road maps. The decision design is distilled in the process and embodied by *governance* of roadmaps during meetings.

# 2 Approach and validation with R&T Managers

Former *Aérazur* group of business units had their own quality management system and shared common practices as well similar technologies (fabric, composite material, injection moulding). When the R&T activities had been gradually established in 2013, they had set up an exchange group with the recently appointed R&T managers. In late 2016, after a year without meetings, the group was set up again, and enlarged to other business units in France, i.e. not restricted to former *Aérazur*. The researcher was already known to these managers, had worked with them on their management practice, and had consulted them to collect input for innovation procedures update (before and during ZAOS project).

They held five meetings between 2017 and 2018 to discuss several topics:

- Key Performance Indicators for R&T management
- Handover between R&T and other BU stakeholders
- Expertise and technologies knowledge access across BUs
- Decision-making and design practices for R&T and advanced concepts

The agenda was set by the main organizer and the researcher. The group was consulted beforehand to adjust according to their interests and were requested to present their perspective on agenda's topics.

> Below, we share feedbacks collected through the five workshops organized by the R&T managers community. The researcher consulted this group of people outside the procedure writing workshops.
> The researcher tested also how decisional ambidexterity could be adapted to the process management perspective of the new quality management system in addition to complementary methods and practices.

## 2.1 Rethinking evaluation of concepts

Several projects hosted in BU's respective R&T departments struggled to beyond TRL6, i.e. the gate beyond which the Product Development engineering should take over. All BUs had a history of numerous product innovation, technology development, and most had been successful before delimiting an up-stream activity (R&T, Innovation or Advanced Concepts). Of course, many other projects had failed or led to high risks taking when developing products for clients.

As we have stressed earlier, TRL assessments consider environment being fixed, so entering the evaluation is made for a given target with its integration assumptions. Several discussions were oriented on how the environment could be shaped to create a generative

fit, as they agreed it couldn't be so deterministic for some technologies and products.

Following three meetings, one of the R&T managers reported he had several TRL6 technologies waiting to handover to product development and industrialisation. He had organized several meetings with stakeholders, but industrialisation and operations wouldn't show up; after several attempts, projects went further with the support of a salesman. Such initiatives led to tensions between departments despite having verbal and signed agreement following the organized meetings (email and signing sheets).
Consequently, he proposed to create an interface for such meetings. The idea of having management device to channel interactions was acknowledged crucial. They made the parallel with brainstormings without a proper coach: rules and isolated brainwriting give voice to all ideas. An Excel spreadsheet was formalised to decide on concepts interest. Criteria were defined and given a weight by BU stakeholders. The objective was first to decide on the interest and value of concepts. However, the second underlying objective was to envision the possibility of reviewing some criteria (with a poor value or ranking) in order to identify what had to change in the BU to enable the decision: engineering rules, client relationship, use cases, suppliers, technical feasibility, manufacturability, etc.

> They managed to emphasize the cruciality of discussing what makes decisions for R&T and innovation concepts to better work out the articulation with exploitation regime. Paradoxically, decisional ambidexterity applied heuristics developed during the meetings allowed reconnecting innovation streams with the gaps created by traditional models of ambidexterity.

## 2.2 The augmented Proof of Concept

During one of the meetings, they also took the opportunity to discuss the Hypoxia Protection project. The several practices of opening the project were presented such as discussing digital and physical mock-ups with stakeholders.

The point was to try to test the idea of revisiting the traditional proof of concept as defined in a TRL assessment. A prototype presented to stakeholders to check pre-defined criteria could lead to a standstill. So, they debated over how they could discuss the evolution of criteria thus enabling other concepts.
To do so, the researcher proposed to work on what an engineering model is. He took an external example (aircraft engine) which can be described with simple equations at a certain order in functional analysis. He insisted on specifying assumptions and impacts on engineering rules, interfaces between sub-systems and organization mirroring. Consequently, they could discuss how simple variations on equation parameters could radically engineering rules and organization. For instance, one can shift from a turbojet to a tur-

bofan by playing on inlet cross section, and shift even to open rotor turbofans by making the cross section infinite. The first shift has a strong impact on mechanical gear and shaft system. The second shift changes the physics altogether, since part of the engine is unducted, so propellers' equations have to be integrated. Such simple tricks in the model handling ripple out through an engineering organization as well as for an entire business unit and environment.

> The discussions with R&T managers revealed their interest but also the difficulty to transpose to their BU and engineering the method. Indeed, formalizing their practice hasn't been done systematically across the group and over the years. However, it also leaves some slack as well as risks and opportunities to innovate around the non-totally-explicit models of engineering. Such setting gives room for high levels of reconfigurability but with threats of leaving interdependencies and fixations in a blind spot.

## 2.3 "What If?" to articulate strategic intent and organization design

Finally, the researcher discussed hacking to value emergent strategies. One R&T manager was very receptive and presented us his way of designing his strategy. His business unit has been facing market share losses and difficulties in opening new markets because of lowering entry barriers (known technology) and regulations.
New growth opportunities had to be found and these would be out of the aircraft industry. Sticking to the history of technology transfers and genericity to different systems integration, he developed alternatives. The methodology formalizing technology roadmaps definition and creation was used to identify hackable parameters. Indeed, he acknowledged presenting to his managing directors highly uncertain Net Present Value calculations and business models. However, his presentations aimed at showing how they could become true or less uncertain by identifying means of action to uncover the share of unknown. Another representative from another BU, shared a history of business plans requested by his local financial director who systematically requested them. He used these models to show the absurdity of such planning per se, and twisted to identify what had to be redesigned internally or in the environment to enable the business cases.

The meeting's participants acknowledged such practices. In some way or another, they had performed similar hacking in their own fashion and with variations. For instance, one relied on formalized business plans for his financial director not only to "cheat" and gain his approval, but also to point at where the effort should be put to make these cases come true. As for the previous modelling effort for engineering and organizing, they stressed the difficulty in transposing across BUs. The R&T managers were more keen in having a set of heuristics and method to adapt and apply them to their specific practice.

There is no *one best way* so it encouraged the researcher to find generic enough. We didn't take the time to introduce decisional ambidexterity as it has been formalized here in the thesis' manuscript or in Appendix A4.

> The meetings held with R&T managers from the French BUs were rich in debate to discuss management issues. During these meetings and the evolving agendas, we tried to test some declinations of decisional ambidexterity before its actual formalization.
>
> We see that they came with their own practices and tricks to overcome limitations of traditional models of ambidexterity. However, they report on the difficulties to have a systematic way of playing on fixations effects and interdependencies to value their project's portfolio. In other words, it encourages to work on a *baseline* that would help them to reconciliate the tensions between the models organizational ambidexterity and exploration projects.

# 3 Chapter synthesis: decisional ambidexterity enhancing process management

In this chapter, we have presented how the researcher contributed to the quality management system through the *Design & Develop* and *Innovate* processes. We tried to accommodate decisional ambidexterity within the processual perspective and it reveals some difficulties circumvented by the introduction of the notion of *governance* for road-mapping activities.

The discussions during workshops with the R&T managers from French BUs reveal also the complexity for them to implement approaches extending limitations of traditional models of ambidexterity. They recognize the results of the thesis, they identify with patterns of decisional ambidexterity, but still struggle to implement or develop their own *technology of organizing*. The disentanglement of fixations effects and interdependencies is complex and perhaps even chaotic. However, the interactive meetings proposed in the procedure to discuss and design decisions opened some possibilities, as some colleagues had implemented similar practices or were about to.

Our work trying to collect and propose means of formalizing decisional ambidexterity is not finished despite having tested ideas of implementation. The logics appear quite normal to them, as it was also recognized by the former CEO and discussed for the Multi-BU committee.

This chapter closes our work at Zodiac Aerospace and our testing of the decisional ambidexterity supporting its validation as an extension of models of ambidexterity. As shown here, it provides means of action to avoid the limitations we had extensively discussed in previous chapters when starting the PhD journey. The following chapters will discuss what we have achieved so far before concluding this thesis.

# Part 6

# General conclusion and discussion

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**Outline** In this concluding part, we come back on the PhD journey outcomes. We synthesize our main results and contributions and we open up with discussions and future research perspectives.

The first chapter (XIII, p.343) sums up the results and contributions of this PhD thesis. The model of decisional ambidexterity provided a new insight on designing decisions. Whilst supporting the innovation management through decision-design, decision-designers use exploitation to condition and steer exploration for generative processes and potential decisions. This mutual conditioning between exploration and exploitation offered new perception to reconnect new practices in innovation management such as exploration projects with organizational learning and adaptation, i.e. the original intent of ambidexterity. We also reveal how the design and decision, targeting fixation effects and interdependencies in product innovative design, are enablers of organizational change. Overall, our model allows extending ambidexterity's validity into the unknown.

The second and final chapter (XIV, p.351) opens up our discussion towards future research perspectives. We have, for management purposes, worked on the shift from decision-making to decision-designing. This novel perspective is tasked to weave new concepts (states of nature and alternatives) around interdependencies and (organizational) design fixations in order to reshape the nature of interactions. Consequently, it opens several new perspectives. The rationality and behaviour of the individual/collective stand on different assumptions and epistemologies when they are seen from the lens of cognitive psychology for decision theories and creativity theories. Organization design may as well be revisited by avoiding to focus on a target organization but rather focus on underlying dynamics of interactions, metabolisms and organizational constraints to generate alternatives, designs and prototypes. We thus propose an *Organizational Design Thinking*, and several ideas for new valuation and management tools for exploration project management.

**Aperçu** Dans cette dernière partie, nous reviendrons sur les résultats du parcours doctoral. Nous synthétisons nos principaux résultats et contributions puis nous ouvrons le débat avec des discussions et perspectives de recherche futures.

Le premier chapitre (XIII, p.343) résume les résultats et contributions de cette thèse. Le modèle de l'ambidexterie décisionnelle a fourni une nouvelle perspective sur la conception des décisions. Tout en soutenant la gestion de l'innovation par la conception de décisions, les concepteurs de décisions utilisent l'exploitation pour conditionner et orienter l'exploration des processus génératifs et des décisions potentielles. Ce conditionnement mutuel entre l'exploration et l'exploitation offrait une nouvelle perception de la nécessité de reconnecter les nouvelles pratiques de gestion de l'innovation, comme les projets d'exploration, avec l'apprentissage et l'adaptation organisationnels, c'est-à-dire l'intention originale de l'ambidexterie. Nous révélons également comment la conception et la décision, en ciblant les effets de fixation et les interdépendances dans la conception de produits innovants, sont des facteurs de changement organisationnel. Globalement, notre modèle permet d'étendre la validité de l'ambidexterie dans l'inconnu.

Le second et dernier chapitre (XIV, p.351) ouvre notre discussion vers de futures perspectives de recherche. Nous avons, à des fins de gestion, travaillé sur le passage de la prise de décision à la conception de la prise de décision. Cette nouvelle perspective est chargée de tisser de nouveaux concepts (états de la nature et alternatives) autour des interdépendances et des fixations (organisationnelles) de la conception afin de remodeler la nature des interactions. Par conséquent, elle ouvre plusieurs nouvelles perspectives. La rationalité et le comportement de l'individu/collectif s'appuient sur différentes hypothèses et épistémologies lorsqu'ils sont considérés sous l'angle de la psychologie cognitive pour les théories de la décision et les théories de la créativité. La conception organisationnelle peut tout aussi bien être revisitée en évitant de se concentrer sur une organisation cible, mais plutôt sur la dynamique sous-jacente des interactions, des métabolismes et des contraintes organisationnelles pour générer des alternatives, des concepts et des prototypes. Nous proposons donc un *Organizational Design Thinking*, et plusieurs idées pour de nouveaux outils d'évaluation et de gestion de projets d'exploration.

# Chapter XIII

# Main contributions and results synthesis

Our PhD journey had started from a literature review questioning models of ambidexterity at the light of the unknown. Innovation management puts an emphasis on generating novelties, practicing innovative design, and using methods who actively embrace the unknown. Since implementing an ambidextrous organization has become rather common - and it was rooted on the assumptions of (March 1991b) model - academics have recently notified the risk that the separation between exploration and exploitation could bear numerous complexities requiring further qualitative studies (Benner and Tushman 2015; Birkinshaw and Gupta 2013; Gupta, Smith, and Shalley 2006; O'Reilly and Tushman 2013). Over the years and with developments in innovation management, the unknown has conquered the grounds of ambidexterity and its problem-based foundations.

We have addressed these open statements and calls for research by revealing several projects in a conglomerate of SMEs, Zodiac Aerospace. These cases were somehow at odds with predictions of ambidexterity models. Indeed, exploration projects, which actively engage with the unknown, stretch beyond what the non-mutual conditioning between exploration/exploitation is capable of explaining. We have shown that ambidexterity can effectively kill innovation as it enforces organization design conformity and a reductive adaptation to exploit explorations. In the case of ZA and its engineering and marketing conditions, we explain such phenomenon by product/organization design fixations and interdependencies that are partially ignored and left unmanaged.

Consequently, we have proposed a model revisiting the foundations of exploration/exploitation. With the help of design theories staging generative processes, we were able to address the design of decisions, leading to decision-making and coordination of collective action. Decisional ambidexterity relies on the *mutual conditioning between exploration and exploitation* to generate alternatives and states of nature laying the ground work for in-

teractions on: the nature of decisions, and models of thought ruling decisions, engineering and organization design. Working out organization/product design fixations and interdependencies, with the dynamic mirroring of engineering, provides additional knowledge to elaborate on the potential decisions framing collective action.
The ambidexterity re-developed in our model is placed back at a behavioural level with decision-design seen as a *naturally* managed and interactive process perhaps even more salient than actual decision-making (Christiansen and Varnes 2007). We were able to reinterpret the management anomalies of ZA with a better understanding of organization design fixations and interdependencies that were more or less managed and targeted in the management of exploration project.

Finally, two other projects and the study of a management device (Multi-BU Committee) enabled testing the model. We thus confirmed the value of previously hidden variables and offered new predictions. We then had opportunities to test in vivo decisional ambidexterity with several heuristics and practices with an exploration project. Moreover, we formalized some of them in the quality management system procedures for Innovation and Development. These practices were also validated and complemented by interactions with the community of R&T Managers.
All in all, the last stretch of the PhD journey allowed to touch upon the organizational metabolism and how decisional ambidexterity could sustain the associated generative interactions around decisions and organizational change.

In this chapter, we come back on the main contributions of this PhD thesis with respect to the literature we have surveyed from the beginning and discussed during our modelling effort (Part 4).

Decisional ambidexterity brings an extended view of decision-making by actively managing the design of alternatives. It brings several decision categories which reveals different action regimes and means of coordinating collective action. Exploration project management can consequently be revisited through this model. We propose to have systematic ways to sustain innovation with a hacking philosophy.

Decisional ambidexterity offers a way of resurfacing organization and product design fixations, as well as interdependencies. By doing so, exploration projects can actively target learning, knowledge management, and we could even say unknowledge management since we are concerned by innovative design. Furthermore, the organizational mirroring of product engineering is embedded through the decision-design process. Consequently, the associated organizational change, competencies evolution and generation, organization redesign are naturally mirrored as potential categorized decisions are envisioned.

# 1 Decisional ambidexterity for exploration project management

Our modelling effort on ambidexterity an its organization started anew with the foundational work of James March (March 1991b). His original intent for organizational learning and adaptation was based on problem-solving and the bounded rationality of agents exploiting routines or exploring new ones. The balance of both regimes was a starting point for a rich literature on ambidexterity in organizational studies, strategic management as well as innovation.

Over time, the construct was transposed to different research fields in management and prescribed in practice. However, innovation management kept developing whilst showcasing generative processes and a keen interest to managing the unknown. The valuable literature review of (Wilden et al. 2018) gives an overview of the trajectory of the ambidexterity construct. Several key academics have also made their own assessment on their contributions to the field (Benner and Tushman 2015; Birkinshaw and Gupta 2013; Gupta, Smith, and Shalley 2006; O'Reilly and Tushman 2013). They all come to the conclusion that the relationship between exploration and exploitation requires deeper qualitative studies to better understand the implementation of ambidexterity. Its decision-making and managerial capabilities have remained blurry. Placing exploration and exploitation on a same continuum or not could be understood in different ways depending on units of analysis (Gupta, Smith, and Shalley 2006). Furthermore, innovation was seen as a potential driver shifting the performance of exploration and/or exploitation.

At the light of these calls for research, we have studied how the models of ambidexterity relying on the assumption of the *non-mutual conditioning between exploration and exploitation* would behave in the unknown. The idea was to test whether or not this strong hypothesis based on problem-solving would hold true in the unknown. Several units of analysis were based on adaptation or interactionism provided frameworks for management. The prospects of exploration project management (Lenfle 2008) was a good candidate to reconnect with innovation management and the increasing projectification. Managing the unknown is one of its main drivers and given an exploitation regime ruled by a project-based organization, we identified in the literature potential shortcomings for organizational learning (Lenfle 2016) and change (Hornstein 2015; Pollack 2017).

Given the heavily constrained environment of Zodiac Aerospace, this conglomerate of SMEs offered a rich research field to question the validity domain of ambidexterity in the unknown. Several exploration projects and practices were studied revealing anomalies and opportunities to experiment with a reconciliating model of ambidexterity.

## 1.1 Avoiding killing innovation in a constrained environment

We have shown that ambidexterity, with its underlying model of *non-mutual conditioning between exploration and exploitation*, can actually kill innovation. The cases reported by Zodiac Aerospace present a wide range of exploration projects, relying on different generative processes. Despite having the a priori required elements to transition these projects, go to market or have business units take over initiatives, they would be considered as failures with no tomorrow for exploitation, learning, adaptation, competitive advantage. Some would only score a few partial points.

These anomalies of ambidexterity can only be understood by reconsidering the frontier of problems and decisions in the unknown. Design theories and reasoning bring a new language for decision-making, problem-formulation and problem-solving. The model **decisional ambidexterity** provides a new understanding of generative processes, environment cognition, organization design, as well as collective action. It allows tracking decisions and their design along a project's trajectory.

We have illustrated that an exploration project can succeed in developing a new product, in a new market, and have several business units taking a stake in the innovation process to regenerate their organizations. A careful work of designing decisions and understanding what makes the decision come true is required through design of the states of nature: market, environmental constraints, norms, standards, users' acceptance, etc. These heuristics of decision-designers provide them with means of action enabling the materialization of their innovation effort.

## 1.2 Hacking philosophy: the decision-designer

The philosophy of designing decisions can be related to hacking. Indeed, applying design theories to decision theories offers new degrees of freedom on a highly normative model of action. The decision-designer does what everyone does: we choose from readily accessible alternatives induced by path-dependency and fixation effects, and if we have or imagine the consequences, we may be willing to generate new alternatives and scenarios where we would be as satisfied or even more satisfied.
Of course, this satisfactory level overcomes and twists bounded rationality (Simon 1955). We would, in fact, extend our rationality by engaging in actions embodying what is necessary to realize designed decisions. Instead of choosing A or B given C or D, one can optimize consequences given a certain belief, but one can also find a generic solution fitting all outcomes and beliefs. Or one could even totally aim for different comparable alternatives in another scenario. One could finally aim for *less* comparable alternatives as we mix up other value networks in different scenarios.

Optimization, genericity, and wishful decision by hacking one or all states of nature sets different courses of action for project management. The hacking is performed given parameters identified in the originally given exploitative situation. It helps rooting, nurturing and making sense of the exploration stretch. Conditioning is no longer seen as reductive, it is instead expansive when designing.

These statements were tested and validated by practices, discussions, and accepted in process management procedures. But, they still raise numerous questions on a synthetic technology of organizing to channel interactions on the design of decisions and commitment. The need is perfectly natural: we are tricking probability theory with a conditioning that in reality implies hacking. Uncertainty is increased but we counter it with means of action reconfiguring relationships and knowledge.

It is rather stimulating to think of our modelling effort as a means to reconnect the rational augmentation hoped by Herbert Simon with the foolishness and Romantic views of leadership by James March. A conscious and rational model of thought led by design theory and reasoning could occupy this grey zone. In other words, our research results targeted the relationship between rationality and foolishness in (March 2006, p. 209):

> *It is argued that the link between rationality and conventional knowledge keeps rational technologies reliable but inhibits creative imagination. This characterization seems plausible, but it probably underestimates the potential contribution of rational technologies to foolishness and radical visions.*

In this PhD thesis, we developed this bone of contention with the mutual conditioning between exploration and exploitation. Decisional ambidexterity, with its decision-design and decision-making in the unknown, offers a means to rationalize and sustain foolishness in a way. It cools down a romantic view of decision-making and collective action in organizations, but we offer in return manageable risks and opportunities sustaining imagination and creativity in markets (Bronk 2009).

## 2 Decisional ambidexterity for organizational ambidexterity

Our research made a specific focus on the encapsulated fashion of project management. It was a means to discuss managing the unknown with a clear view of how collective action was coordinated and the assumptions made from an organizational standpoint. Project management was demonstrated to be historically linked to innovation management (Davies, Manning, and Söderlund 2018; Lenfle and Loch 2010, 2017). It gave us a baseline to discuss the relationship between project-based and temporary organization (Bakker et al. 2016; Söderlund and Müller 2014; Sydow, Lindkvist, and Defillippi 2004;

Turner 2009) and exploration projects (Lenfle 2016).

The "deconstruction" path taken from the model of exploration/exploitation (March 1991b), who took us to discussions on organizational studies, leadership and strategic management, is now taken backwards to reconnect the encapsulated way of separating exploration and exploitation with organizational learning and adaptation. The new perspectives on organization design in (Avital and Te'eni 2009; Puranam 2012; Van de Ven, Ganco, and Hinings 2013) and change management (Hornstein 2015; Pollack 2017) bring additional perspectives on *where* projects could interfere. The cruciality of epistemic interdependencies is flagged as they allow reconnecting with engineering design and its mirroring hypothesis (Colfer and Baldwin 2016).

We were interested in organizational learning and change prospects that tend to be regenerative. This specific feature is given by the heavily constrained environment of Zodiac Aerospace, with numerous design rules, standards, norms, and business units mirroring market segments with associated engineering for certified products. The ecosystem has rather settled after numerous acquisitions and consolidations. Business Units have their specific niches and playfields, and are grouped in divisions and branches for an Executive Committee. Creating spin-offs appeared out of the equation. It would force (re-)generative learning (Senge 1990) and mirrored organizational change to overcome core rigidities and incompetencies (Dougherty 1995; Leonard-Barton 1992).

## 2.1 Organizational learning articulated by exploration/exploitation mutual conditioning

We have shown cases where learning was kept isolated from exploitation because of non-mutual conditioning assumptions. Exploration projects had however played an active role in cultivating learning and opening new innovation fields. Some projects even relied on a clear hacking philosophy of exploitation regime with preferences reversal for instance.

Learning was also inhibited because of generative processes and project management not systematically taking on board organization design and environmental dimensions. Exploration would be conducted for an *iso-exploitation* regime and it would expect that operational organizations would learn from exploration during hand-over. Despite clever and prepared interactions for transitions, most projects would not articulate (enough) the exploration-exploitation mutual conditioning.

Two cases and an intervention allowed however to better identify learning mechanisms around problem-formulation, value space and open discussions on future decisions. Decisional ambidexterity model played a crucial role in forcing learning and shaping the unknown to enable decisions-making. Means of actions can be derived and a sense of

direction is given for learning. Learning of engineering design rules and absorption of new knowledge engage decision-designers in the reconfiguration of organization's knowledge management. This generative learning around decision-design would then require new relationships to be tied.

## 2.2 Organizational adaptation and change driven by unlocking fixations and interdependencies

The studied exploration projects were all potential emergent strategies from intra or inter BU perspectives. They addressed potential competitive advantage and adaptation to the environment. However, we have seen that organizational ambidexterity could potentially inhibit their prospects. Decisional ambidexterity model surfaces the criticality of organization design fixations and interdependencies to steer exploration projects. Otherwise, projects may float and disconnect from host organizations.

Two contrasted cases revealed the importance of problem formulation and managing value around what business units are capable of deciding given their engineering capabilities. Conceptualizing the mirroring hypothesis (Colfer and Baldwin 2016), through the design of decisions and organization design knowledge, forces to merge change management with project management. It encourages also to find means (e.g. prototypes, management tools, decisions committees, business models, etc.) bearing the reconfiguration of relationships and knowledge through novel designed decisions.
As we have shown in the researcher's intervention and other contributions to Zodiac Aerospace, the categorization effort in concepts and designed decisions offer handles on interdependencies and organization design fixations. These channelled interactions with an effort on engineering models and mirrored organizations. They triggered side-projects and valued positively projects that would otherwise be simply considered deviant. We insist again on the fact that exploration is richer and more performant by referring to exploitation. It sustains an elasticity and plasticity in the conditioning between exploration/exploitation offering room for organizational metabolism to thrive.

# 3 Chapter synthesis: decisional ambidexterity, a model for strategic innovation management

This penultimate chapter portraits our main results and contributions. The management anomaly detection revealed and confirmed several limitations of models of ambidexterity relying on the non-mutual conditioning between exploration/-exploitation. The separation can effectively kill innovation instead of letting it positively shift the performance frontier of both regimes. As innovation emerges from the unknown, its management in exploration projects is the ground for innovative design and strategic decisions/actions.

In a constrained environment, extremely path-dependent context and threatened by the unknown, exploration appears more performant and sustainable in the long run if it is mutually conditioned by exploitation. Decision-designers can actively play with different decision categories where hacking is performed on exploitation parameters generating alternatives and action roadmaps to accomplish designed decisions.

Decisional ambidexterity allows reconciliating with the drift of organizational ambidexterity. The initial foundations were on problem-solving, but with organization studies and strategic management, it overstretched towards innovation management. The construct changed in nature up to the point that separating and balancing may no longer be valid for innovative design practices and managing the unknown.

We consequently provided a novel way of reconnecting to the behavioural foundations of exploration *versus* exploitation by working on their mutual conditioning. It provided us means to sustain innovation efforts, as well as organizational learning and adaptation. Resurfacing organization and product design fixations and interdependencies allowed articulating novelty and steer generativity to simultaneously drive product development and organizational change.

# Chapter XIV

# Discussion and perspectives for decisional ambidexterity

In this final chapter, we open up our conclusion for discussions on our model of decisional ambidexterity and research perspectives. We have so far reworked the conditioning between exploration and exploitation. This modulation allows reconnecting models of ambidexterity with managing the unknown. It holds true that exploration and exploitation should be mutually conditioned in a constrained environment with rules, norms, regulations, path dependency sensitive to potential threats of disruption. It avoids deteriorating both regimes. It actually supports a sustainable generativity, organizational change and design.

The developed model of decisional ambidexterity tries to reconnect decision theories with design theories. We have shown how the unknown could be integrated. With the rising projectification of firms and the economy, exploration projects heavily discuss organizational learning and adaptation. Organizational ambidexterity and design implemented by top management should then be reviewed at the light of meso-level analyses at work in projects driven by decision-design and the unknown.

However, designing decisions, from the standpoint of cognitive psychology and even behavioural economics, can be seen as paradoxical. For decision-making on one hand, research agendas have studied and modelled the influence of biases and heuristics (Kahneman 2011; Kahneman and Tversky 1979; Tversky and Kahneman 1974). Moreover, different dispositional variables, such as stress or positive emotions and other conditioning settings can be added to measure their influence (Cassotti et al. 2012).
On the other hand, psychology of creativity has been driven by how individuals and groups generate ideas. Instead of decision biases, they would discuss fixation effects and its inhibitory control (Cassotti et al. 2016) on generativity.
These two research streams stand on different grounds. They rely on different perspectives

of rationality and use different experimental protocols. How could we provide a general model of generation of alternatives, their selection and commitment? How should experiments be conducted to grasp design during decision tasks? Like decisional ambidexterity providing a "unifying" framework, we would wonder about a unified theory of generativity and choice. Or at least, we are curious about pushing both models towards a common asymptote where uncertainty becomes unknown and where the unknown becomes uncertain.

We have considered hacking practices for decision-designers. All *silent designers* in organizations (Dumas and Mintzberg 1989, 1991) could then offer new means of collective action for corporate entrepreneurship and radical innovation (O'Connor 2016). Not only is institutionalizing innovation necessary to recognize the phenomena and avoiding ineffective risk taking, but it can also be sustained with *technologies of organizing.* The importance of valuation tools and methods when designing decisions would be critical to manage exploration projects but also for organizations.

The idea of an *Organizational Design Thinking* would be quite stimulating. Common design thinking methodology will be fixated by users and a given ontology of operations in the ecosystem. Tackling users pains and building empathy helps generating concepts where users can easily adopt, interact with and open new perspectives.
Could we imagine a decision-design methodology where the purpose is to promote concepts that systematically address what will federate organization around a common purpose? It would be a sort of positive *no-man's land* that drives learning and change, instead of fighting for primacy or against inertia.
The valuation methods would be critical to target the cracks between organizations and to generate such concepts targeting organizational constraints and drivers. The Lower Deck project would appear as a suitable example by contrast with the Connected Cabin (see chapter X, p.283).

Finally, our concern for valuation tools and organizational design thinking brings us to discuss a renewed organization design: *generative organization design.* In the literature, we have pointed at several authors inviting to rethink this research topic.
The modelling effort concretized into decisional ambidexterity took organization design as knowledge to generate new concepts and keep an eye on mirroring dynamics. There would not be any target organization design since we focus on engineering design and decisions. For open innovation, problem formulation and solving will be driven through a decision-design practice. Partnering with users, suppliers, integrators and even competitors would have a different twist. Separate and interconnected agendas could support different decision categories engaged with the environment.
If designed decisions drive organization re-design, what would be the managerial action

in such context? What is the governance of such distributed and generative innovation function?

Firstly, the decisional ambidexterity model developed in our thesis and in two articles (Le Glatin, Le Masson, and Weil 2017b; Le Masson et al. 2018) raises several questions and perspectives on how the frontier can be bridged between cognitive psychology for decision-making and creativity. The theoretical implications are critical for both fields when pushing their models to a common asymptote of unknown/uncertainty. It questions also experimentation means to think of decisions upon generated and given choices.

Secondly, the spirit of hacking we have promoted around decisions, interdependencies and organization/product design fixations effects, encourages to rethink valuation methods and methodology to drive exploration project management in a cluster of firms. An *Organizational Design Thinking* would help formalizing methods specifically targeting organizational learning and adaptation around concepts carefully designed based on existing exploitation regimes in organizations.

Lastly, we reconsider the concept of generative organization design with the reconfigurability driven by innovative design in engineering projects. We discuss also how the engineering design practice can embed the concern to overcome and manage organization design fixations.

## 1 A bridge between decision and generativity

When facing a decision task, alternatives are given to the decision-maker. However, we have brought forward that in the course of action, rational choice of theory has several limitations (Le Glatin, Le Masson, and Weil 2017b). One could be *irrational* with respect to several paradoxes that can be embraced in prospect theory for instance (Kahneman and Tversky 1979). Reversing preferences in time or willingly complexifies the understanding of decision-making (Camerer, Loewenstein, and Rabin 2004; Chabris, Laibson, and Schuldt 2006; Machina 1989; Slovic 1995).

For decision theories stemming and extending the works of Abraham Wald (Fourcade and Khurana 2013; Giocoli 2013; Savage 1954; Wald 1949), inconsistency or intransitivity are violations of rationality. A simple way of accepting such violation is the integration of new information in time. Otherwise, considering that the decision-maker generates new decisions and actions, to gain information given a bounded problem, unsettles rational theories of choice.

## 1.1 Bounding and unbounding problems

Rational theories of choice, operational research and refinements brought by cognitive psychology have taken a rationally bounded perspective on agents. A problem would be predefined, the agent will struggle to oversee the full landscape and will follow the *path of least resistance* and be biased. However, the perspectives from creativity theory or generativity theory (Epstein et al. 1984; Epstein 1990, 1999) tend to unbound problems or at least reformulate them. New decisions can be designed and engaged given problem parameters; it was the case for pigeons solving their problem. In a more ill-defined setting, design can not only optimize, find generic solutions or recombine, it can also revamp altogether the problem at stake.

The question for us would be to understand what are the parameters that would trigger the need to design instead of simply deciding. Is it comparable to risk aversion/seeking behaviours? The major difference is when designing, an active interaction is engaged with the environment instead of a passive one expecting for the states of nature to reveal. The decision-designer would hope to generate new knowledge and tie new relationships.

The issue is with the very construction of probabilities. Imprecision and fuzzy sets could be a first patch. Unfortunately, they do not model the reconfiguration and complete revaluation of alternatives and states of nature. Even if a theoretical effort is required for theories of behaviour, extending for instance prospect theory with design reasoning, we could also turn towards experimentation's means.

## 1.2 Differences in experimental protocols

Our interest would be in the inhibitors and triggers for designing decisions. Some situations could be intolerable for decision-making, perhaps they could support the generation of other alternatives countering a priori consequences. Moral judgement and ethical behaviour could be an exciting approach to unlock the deliberate will to design decisions instead of deciding.

For instance, the trolley problem extensively studied by Judith Thomson (Thomson 1976, 1985, 2008) could be an interesting baseline to discuss the design of new alternatives and what could trigger it. This problem also concerns autonomous driving (Bonnefon, Shariff, and Rahwan 2016). The matter is given in an iso-environment for the car, whereas it could be perhaps even more stimulating to think of autonomous cars actively protecting pedestrians (i.e. not just with shock absorbers, sensors to detect the variety of obstacles and pedestrians and deciding).

The difficulty in approaching experimentation at the frontier of decision and creativity is

the protocol and briefs given to the decider/designer. It may totally inhibit one or the other whereas we would be more curious about the comings and goings between the two.

Since the *Centre de Gestion Scientifique* has a partnership with the *LabPsyDé* of Descartes University, we already had several discussions on these topics with Anaëlle Camarda and Matthieu Cassotti. We had some ideas for moral judgement, studying the anchoring effects of Kahneman and Tversky with respect to design, but also biases for negative conditioning and asking for information like in Wason's experiment (Houdé and Moutier 1996; Wason 1960).

### 1.3 Reexplaining behaviours: biases, heuristics and hacking

Furthermore, designing decisions in the unknown encourages the decider to interact and interfere with his beliefs and states of nature. Biases and heuristics could contribute to the dominant design and fixation effects. However, decision hacking with genericity and wishful decisions reveal another behaviour providing a more positive and pro-active feature of rationality.

With the increasing number of practices promoted in start-up environment, we wonder how we could study in more detail the behaviours associated with effectuation (Agogué, Lundqvist, and Middleton 2015; Sarasvathy 2001), lean start-up (Blank 2013; Ries 2011), growth hacking, incompleteness by design (Garud, Jain, and Tuertscher 2008) and platform strategies (Gawer and Cusumano 2014). The practices could easily be explained with decision-design and they could also benefit from research on cognitive psychology around the heuristics developed to make and design decisions in entrepreneurship and early-stage decision-making.
These comments are also valid for finance in venture capitalism and private equity. From early-stage to A/B/C/D rounds, investments are also promising grounds to understand the logics of decisions, information gathering and influence on strategy through corporate governance bodies. Hopefully, some answers will be found in the PhD results of Laure-Anne Parpaleix (*Centre Gestion Scientifique*, Mines ParisTech, and CIFRE contract with BPI France).

## 2 Organizational Design Thinking and management devices

The model of decisional ambidexterity offers a valuable basis to track and explain projects. It can also be used to derive means of actions and valuation practices. However, it would be interesting to reconnect with existing methodologies and management tools providing valuation for decision-making and action.

Methods like platform engineering and Design Thinking were referred to in two case studies. The first has a strong logic on economic evaluation with modularity benefits (Sanchez and Mahoney 1996). The second builds on user empathy and generative practices incorporating such knowledge. We have revealed that both were minored by outdated models of ambidexterity. However, it would encourage to *engineer* heuristics and valuation methods in order to steer their generativity countering the limitations of organizational ambidexterity. In the philosophy of hacking, we would prefer thinking of Judo or Aikido moves where light imbalances are turned into an advantage. It echoes the *phronesis* (Nonaka, Hirose, and Takeda 2016), and *sensing, seizing and reconfiguring* of (Teece 2007). This economic vigilance would use organization design fixation effects and valuation tools to guide Design Thinking and platform architecture. This vigilance would consequently guide exploration project management.

## 2.1 From user pains and needs to recombination of organizational routines

The divergent and convergent phases, with multiple feedback loops of Design Thinking could also be driven by organizational design. We have shown that their fixations can be hard to overcome because of external biases, so it is worth endogenizing such constraints to generate new alternatives and concepts.
For instance, the Design Thinking cases, by comparison with the later Lower Deck project, show the importance of problem formulation, concept positioning, decision enablers and value space. These elements were part of the *innovation potential of attraction* descriptor. The Lower Deck project formulated a concept that would overcome several limitations:

- BUs will struggle to see the value of working around a common purpose
- BUs will takeover the full project for primacy
- BUs engineering and marketing departments may not able to value learning and adaptation to a whole new environment
- BUs will prefer waiting for the clients to manifest new use cases and new ecosystems interdependencies, instead of proposing new ones

The Lower Deck built upon the lessons and attempts of previous projects, where it was a design feature or enabler for other functional objectives. However, by managing its value temporarily in a empty space unoccupied by BUs, the concept managed to create sufficient attraction for business units to federate along a common purpose of learning and recombining their engineering routines. Indeed, constraining certification and market demand were shaped in a way that organizational barriers can be lowered.

In other words, an *Organizational Design Thinking* would specifically target what organizations can't do on their own. However, it is not a simple technology to be outsourced

and integrated. The Connected Cabin project highlighted these limitations. Instead, the concepts aim for reconfiguring interdependencies between BUs, engineering rules and interfaces, as well as the ecosystem. It is not driven by organization pains, but it would focus on existing organization design and routines. One could then search for *cracks* left by interdependencies and design systematically what BUs can't do by themselves. We would be thrilled to study these areas with Lisa Carlgren (Chalmers University) and Katharina Hölzle.

## 2.2 Valuation methods: innovation potential

A means to drive the generation of concepts and potential decisions could also around valuation methods. The mutual-conditioning between exploration and exploitation would inspire us to look simply on existing tools and devices. Relying on *net present value* calculations, business plans and real options could offer numerous opportunities for designing new alternatives and concepts corresponding to hacked valuation methods.
For instance, if several scenarios are presented for a business plan (e.g. pessimistic, nominal and optimistic), one could design alternatives offering them complementary background and comparison. But, the designed decisions could help to think of what should be done for the most favourable scenario. This design practice forces to interact differently with the formalism expected from valuation methods. Problems are inverted. In that perspective, we hope the PhD works of Agathe Gillain (*Centre de Gestion Scientifique*, CIFRE contract at Airbus) will provide some answers on the economic performance of R&D investments with respect to learning strategies for example.

One of the members of the R&T community had reported developing a selection tools for concepts. Not only would it filter them based on criteria agreed with stakeholders, but they also planned in having a derived scoring that would warn decision-makers to reformulate some concept's acceptance. In other words, besides filtering, some concepts would trigger to imagine of different states of nature and criteria to accept them. Consequently, it forces stakeholders to review their department's capabilities, knowledge and relationships across interfaces.

All in all, our perspective on valuation is that decisional ambidexterity and the hacking philosophy promoted with decision-design in the unknown, could support exploration project management. What is even more exciting is that we would use exploitation frameworks to articulate the exploration regime and generative processes. The distance between the two regimes could be measured through this clever conditioning with performance criteria traditionally used. It would avoid isolation between the two as they would use a common language and management tools but have a different relationship to these artefacts.
The intervention for Hypoxia Protection project revealed the usefulness and generativity of such heuristics applied to product conformity matrices (e.g. house of quality) and technical

feasibility and performance (e.g. physical measures). In the sociology and ethnography literature, we would also look for echoes of this dual relationship with management devices for exploitation nurturing exploration and preparing its acceptance. It could offer new actions means for marketing as the level unknow heavily contests existing relationships. For instance, the works of Liliana Doganova (Centre for the Sociology of Innovation, Mines ParisTech) on the performativity of valuation devices could be revisited with generativity practices. This concern for exploration project valuation could also be refined in the future with the ongoing works of Svenja Sommer, Kathrin Möslein and Sylvain Lenfle.

# 3 Generative organization design and governance

For this final section, we will address organization design and governance based on the previous discussions. The cognition, interaction and valuation conveyed in decisional ambidexterity opened stimulating areas to reflect on. Earlier in the manuscript, we had taken a keen interest on organization design and its practice. The conglomerate of SMEs, Zodiac Aerospace, had stressed this dimension for engineering, marketing, market arrangements and group strategic decision-making. Since, the field is willing to renew itself (Barry 2011; Van de Ven, Ganco, and Hinings 2013), we propose to discuss its relationship with generative processes at work for the Innovation function.

The influence of managing as design (Boland and Collopy 2004), as discussed in our literature review, can be bring a different viewpoint on organization design (Romme 2003). The place given to generative processes scattered across the firm, like the existence of *silent designers* (Dumas 1994; Dumas and Mintzberg 1989), can easily allow us to think of design-driven organizations. It doesn't necessarily mean that the firm focuses on design services, nor that design methodologies are institutionalized such as firms having embraced Design Thinking, C-K Theory.

However, we would rather be leaning towards a weaker form of design reasoning distributed across the firm, cultivated by the mutual conditioning between exploration and exploitation. In other words, we would not organize collective action for a target organization design. We would instead prefer offering the management tools and managerial philosophy through a specific governance for innovation. The organization will design *itself* through clearly managed devices, decision-design and a overarching governance body overlooking this fractal organization (Nonaka et al. 2014).

## 3.1 Governance of Innovation function - problem re-formulation

Having a simple rule and heuristic constantly challenging and designing decisions could be used as a pattern to generate organization designs in non-deterministic fashion. Problems are constantly reformulated and solved but without relying specifically on leadership or

top management as suggested by (Lakhani, Lifshitz-Assaf, and Tushman 2013).

A culture of design and decision would be formalized through the dual relationship of mutual-conditioning of exploration/exploitation regimes. Re-articulating the decisions and problems vertically, among internal stakeholders but also with the *exterior*, raises questions on the nature of innovation function's governance. The writings for the ZAOS *Innovate* process addressed such heuristics around the overly famous innovation funnel. We realized that beyond the institutionalization of the innovation function (O'Connor 2016) and associated practices reported by R&T managers and in projects, having a governance body for innovation could emphasize the strategic importance of concepts and their associated decision-design scoping. The Multi-BU committee could have been a corporate example. Problems being reformulated and solved by managing the unknown would require to re-engineer interdependencies echoing its organization design mirroring.

We would encourage to continue these discussions with Dominique Laousse, Head of Foresight and Innovative Group at SNCF. He recently defended his PhD at the *Centre de Gestion Scientifique* under the supervision of Sophie Hooge and Armand Hatchuel. Looking back on the deployment of the innovation function at SNCF, he proposes a staged analysis: from institutionalization, to industrialization (with innovative design projects derived from C-K theory - DKCP) and up to organization and governance. This governance topic reflects also the works of Blanche Segrestin, Kevin Levillain and Armand Hatchuel on purpose-driven companies. Some teachings could possibly be drawn from the ongoing PhD thesis of Jeremy Levêque on firms' *mission drift*.

## 3.2 Governance of Innovation function - design-oriented organization

This extreme reconfigurability organized around a new relationship to decision-making by decision-design could perhaps preliminary perspectives to the multi-dimensional organizations (Galbraith 2010). However, there is no target organization design managed and prescribed. Local action through projects, designed decisions and a governance body would sustain new relationships with the environment. This generativity theory of organizing (Van de Ven, Ganco, and Hinings 2013), clearly endogenizes change management in project management (Pollack 2017).

Furthermore, it places the unknown at the heart of management. Managers transfer, solve, and formulate problems that those who report to them can't solve given their knowledge and relationships. A governance body, dedicated to the unknown through decision-design, would manage its cognition of the environment and strategic health check-up. These perspectives were foreshadowed in the works of Henri Fayol (Fayol 1916). It is worth pointing out that many would only retain the control and regulation roles of Fayol's management principles (Hodgson 2004; Olin and Wickenberg 2001; Turner

and Keegan 2001), whereas he would also insist on strategic knowledge management, relationships with the ecosystem and scientific work (Hatchuel, Le Masson, and Weil 2002; Hatchuel and Segrestin 2018). These practices and heuristics would enact a design-oriented organization (Hatchuel, Weil, and Le Masson 2006) giving a different flavour to the *generative fit* (Avital and Te'eni 2009). Finally, these concerns would encourage to reconsider the place of entrepreneurship and innovation within the organizations with emergent strategies synonymous with design (Drucker 1985).

# 4 Chapter synthesis: decisional ambidexterity, a model contributing to perspectives opened in literature

In this final chapter, we have opened the discussions towards extensions of our work. We proposed to do so by articulating them with key readings already solicited in our literature view. Several stimulation perspectives are offered to connect this thesis work with ongoing research and historical writings.

We started with the cognitive psychology and behavioural concern for our model of decisional ambidexterity. The decision-design needed to extend decision-making in the unknown calls for future research on theoretical models, mathematical foundations discussing the definition of probabilities. A complex task is also ahead of us to experiment and study the comings and goings between designing and deciding. Some leads around moral judgement could be a starter for our prospects.

The concept of *Organization Design Thinking* equipped with relevant value management tools would also be a stimulating area of research. We would extend Design Thinking methodologies to interactively foster generativity around exploitation and organization design fixations. Exploration projects would target what business units are not able to do. These organizations would then find a common purpose for working together. Furthermore, using common language of exploitation and its limitations could be used in favour of exploration projects and value management.

Last but not least, the previous perspectives encourage to avoid thinking of Organization Design as a practice aiming for an organization target. Instead, the role of generativity in projects quickly challenges potential strategic decisions requiring more than institutionalization: a governance body dedicated to the innovation function. Problem reformulation would be nurtured by the mutual conditioning between exploration and exploitation. It would orientate the whole organization altogether towards design: a generative organization design. Governance would embrace strategy design, intrapreneurship and organization's regenerative capabilities through the overarching vigilance of decision-design.

# Part 7

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# Bibliography


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# Part 8

# Appendices

# Appendix A1

# Paper 1: Design Thinking for innovation management

**Abstract** Design thinking (DT) unfolds quickly as a method for managing innovation, beyond traditional decision-making and product development paradigm (Liedtka 2015). DT success appears as a symptom of the emergence of a design paradigm in innovation management (Boland and Collopy 2004; Le Masson, Weil, and Hatchuel 2010; Gruber et al. 2015; Seidel and Fixson 2013; Ben Mahmoud-Jouini, Midler, and Silberzahn 2016). Here lie the potential limits of DT because it is presented as method, inspired by a profession, and its theoretical foundations require further grounding (von Thienen et al. 2018). Consequently, casting DT into design theory will reveal some flaws as well as its potential because it will also reveal ways to expand DT into a new generation of techniques to support the metabolism (Hatchuel, Weil, and Le Masson 2006) of innovative firms and ecosystems. In this paper, we propose to use design theories frameworks to analyse cases of DT-in-use in a large firm to reveal its generativity and defixation capacity. We explicitly show the extent of learning metabolisms and potential user fixations encoded in the DT method. It encourages proposing ways of extending with other techniques to validate and support the potentials of DT as it has been developed through decades.

**Purpose** The purpose is to study the adoption of Design Thinking methods for multi-BU and B2B2C context. Design Theories are used to track generativity of the design practice: user fixation and learning metabolism supporting innovation management. Presented at 6th Creativity Innovation Management (CIM) Community Workshop, first submitted and rejected Spring 2017 to CIM Journal, reformulated for R&D Management Conference 2018 and resubmitted to CIM journal with substantial modifications compared to first version.

# Design Paradigm in innovation management – analyzing and extending design thinking methods with design theory


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## 1. Introduction

Design thinking (DT) unfolds quickly as a method for managing innovation, beyond traditional decision-making and product development paradigm (Liedtka, 2015). An increasing amount of scholars try to understand its origin, scientific background and in-practice use (Bauer & Eagen, 2008; Buchanan, 2008; Carlgren, Rauth, & Elmquist, 2016; Cooper & Junginger, 2009; Kimbell, 2011, 2012). Referring to "how designers think", DT as a method has been introduced in the management field and in firms as change management means (Brown & Katz, 2011; Dunne & Martin, 2006) whilst "democratizing" design and fostering design as a practice with a set of decontextualized tools.

Hence DT success appears as a symptom of the emergence of a design paradigm in innovation management (Boland & Collopy, 2004; Gehry, 2004; Gruber, de Leon, George, & Thompson, 2015; Le Masson, Weil, & Hatchuel, 2010; Seidel & Fixson, 2013; Weick, 2004). Here lie DT weaknesses as well as DT potential. Its limits because DT is presented as a method, inspired by a profession, and its theoretical foundations remain unclear so that casting DT into design theory will reveal some flaws, as we show in this paper. Its potential because projecting DT onto design theory will also reveal ways to expand it into a new generation of techniques to support the metabolism (Hatchuel, Weil, & Le Masson, 2006) of innovative firms and ecosystems, as we also show in this paper. These are two main contributions of the paper. The demonstration will unfold as follows.

In a first part, we present some elements of design paradigm. The design paradigm appears in several strategic and policy areas. It draws a re-discussion of what is a product, what is a decision, what is an organization, what are learning loops (Leifer & Steinert, 2011). It is now widely recognized that design activities are the engine of innovation, be it engineering design, industrial design or architectural design. There is also agreement that the scientific analysis, modelling and evaluation of design regimes are poorly captured by classic models such as production functions, decision making theory, or even Simon's problem-solving theory (Dorst, 2006; Hatchuel & Weil, 2002; Rittel & Webber, 1973; Schön, 1990). Applied to design, these notions result in persistent 'anomalies' and controversies. But research has contributed to reconstruct a basic science, design theory, that accounts for the unique phenomena of design, namely generativity, and is comparable in its rigor, foundations and potential impact to decision theory, optimization and game theory (Hatchuel & Weil, 2009; Kazakçı & Tsoukias, 2005; Sharif Ullah, Rashid, & Tamaki, 2012). Design theory opens a unique opportunity to support the development of breakthrough models of creative rationality that offer new grounds for management and organization in creative economies (Hatchuel, Starkey, Tempest, & Le Masson, 2010; Le Masson, Weil, & Hatchuel, 2017).
Casting DT into the « design paradigm » (Mabogunje, Sonalkar, & Leifer, 2016) is a way to overcome the flaws in language that brings confusion between design as a profession (industrial design) and design as a fundamental regime of action (Le Masson, Dorst, & Subrahamanian, 2013). Actually: design was embedded in diverse professions (industrial designers, engineers, architects...) and was also studied with different approaches: practices, organization and also design

theory. The design paradigm provides analytical framework to go beyond these incomplete, fuzzy or even misleading partial approaches.

In a second part we present an analytical framework that helps to study DT from the point of view of its generativity and its capacity to help designers be defixated. We use this framework to present hypothesis on how to extend DT methods, relying on design theory and innovation management. It suggests that DT method is a potential enabler for defixation against users, their operational ecosystem and a facilitator for firm regeneration through valuation practices.
In a third part we disconfirm the hypotheses on a structured set of cases: we first study a set of several DT exercises made in two cases within a large conglomerate of aircraft equipment manufacturers and we invalidate on these cases the enablers described in the second part with the help of design theory.

We continue with a discussion on the ways of extending DT by techniques supported by design theories. And finally we conclude by examining how these results contribute to our understanding of the new management of innovation in a design paradigm.

## 2. Literature review

### *2.1 Design paradigm*

Beyond the works of (Buchanan, 1992; Dewey, 1958) considering design as a *liberal art* and taking design as a core discipline (Simon, 1995), the Design Thinking (DT) we are interested in is the human-centered problem solving methodology: "fostering creativity" as explained by Hasso Platner in the preface of (Plattner, Meinel, & Leifer, 2016). It is inspired by the way professional designers think (industrial designers, stylists, architects) and transposed into a methodology (Brown, 2009; Lockwood, 2010). The pioneering education curriculum launched in Stanford's Mechanical Engineering department in the 1950s is facing "a pendulum effect" between practice and theory (von Thienen, Clancey, Corazza, & Meinel, 2018), to which we are willing to contribute with design theories. As it all started with pragmatic methodological approaches (creative thinking, visual thinking and ambidextrous thinking) and nowadays teachings and practice as shown by recent research among d.schools and partners (Mabogunje et al., 2016): there is a need to further back up what has been achieved to improve the understanding of DT in-use (Leifer & Meinel, 2015) and in organizations (Carlgren et al., 2016). The former meta-perspective quoted hereafter appears no long self-sustainable given the diffusion of DT in design engineering practices and organizations:

> "M8) Common DT Teaching Belief: Creativity education is a practical matter; it does not need to draw on explicit creativity theories" (von Thienen et al., 2018, p. 37)

So, beyond the teaching issue, if we adopt a design-driven innovation (Verganti & Dell'Era, 2014), DT thinking performance appears critical for the organization. However, this notion requires to be modulated as we break apart from classical models from traditional information procession and Simon's problem-solving theory (Dorst, 2006; Hatchuel & Weil, 2002; Rittel & Webber, 1973; Schön, 1990). Design theory proposes to reconstruct a basic science that accounts for the unique phenomena of design, namely generativity (Glaser, 2017; Hatchuel, Le Masson, Reich, & Subrahmanian, 2018). Generativity differs from creativity as it is less restrictive, in the sense it makes reference to the ability to produce "novel" solutions, i.e. which could not have been defined (Hatchuel, Weil, & Le Masson, 2013). It differs also from optimization (Epstein, 1999). It is in its rigor comparable to performance-like metrics in decision theory, optimization and game theory (Hatchuel & Weil, 2009; Kazakçı & Tsoukias, 2005; Sharif Ullah et al., 2012).

### *2.2 Design Thinking "performance"*

DT's methodology has been praised for its brainstorming qualities (Sutton & Hargadon, 1996), its "knowledge brokerage" and emulation through empathy values for organizations (Hargadon, 2002). The latter has been corroborated in (Hargadon, 2002; Seidel & Fixson, 2013). Efforts have been made to add ad-hoc practices to DT to articulate with engineering activities (Beyhl, Berg, & Giese, 2014), and to value the role artefacts such as prototypes (Beyhl & Giese, 2016). Nevertheless, framing was needed to understand DT's enactment in organizations through several sets of thematic routines (Carlgren et al., 2016). If the method aims at being more than ideation (Dong, Kleinsmann, & Snelders, 2017; Hatchuel et al., 2006) and confined fuzzy-front-end activities (Leifer & Steinert, 2011), DT should probably embrace in its design process the determinants of its landing in the organization and strategy (Boland & Collopy, 2004). It raises several potentials and limitations that need further clarification with the support of design theories.

The figure below represents with a general design theory, C-K (Hatchuel et al., 2013), the *coding* of DT process. Besides the state-of-the-art being challenged, four main movements are supported through user empathy and highly divergent practices:

1. Survey user pains, user experience to challenge existing technical solutions (specifications, requirement, needs)
2. Survey extreme-user, and alternative scenarios where the product/service is "hacked" highlight new requirements enhancing ergonomics
3. Based on the exploration, the problem is reframed, with multiple design shifts compared to existing solutions, as revealed by the functional approach and later prototyping (converging phase)
4. What-If Scenarios, or "Dark horses" can take place at the pinnacle of divergence to ideate by releasing constraints

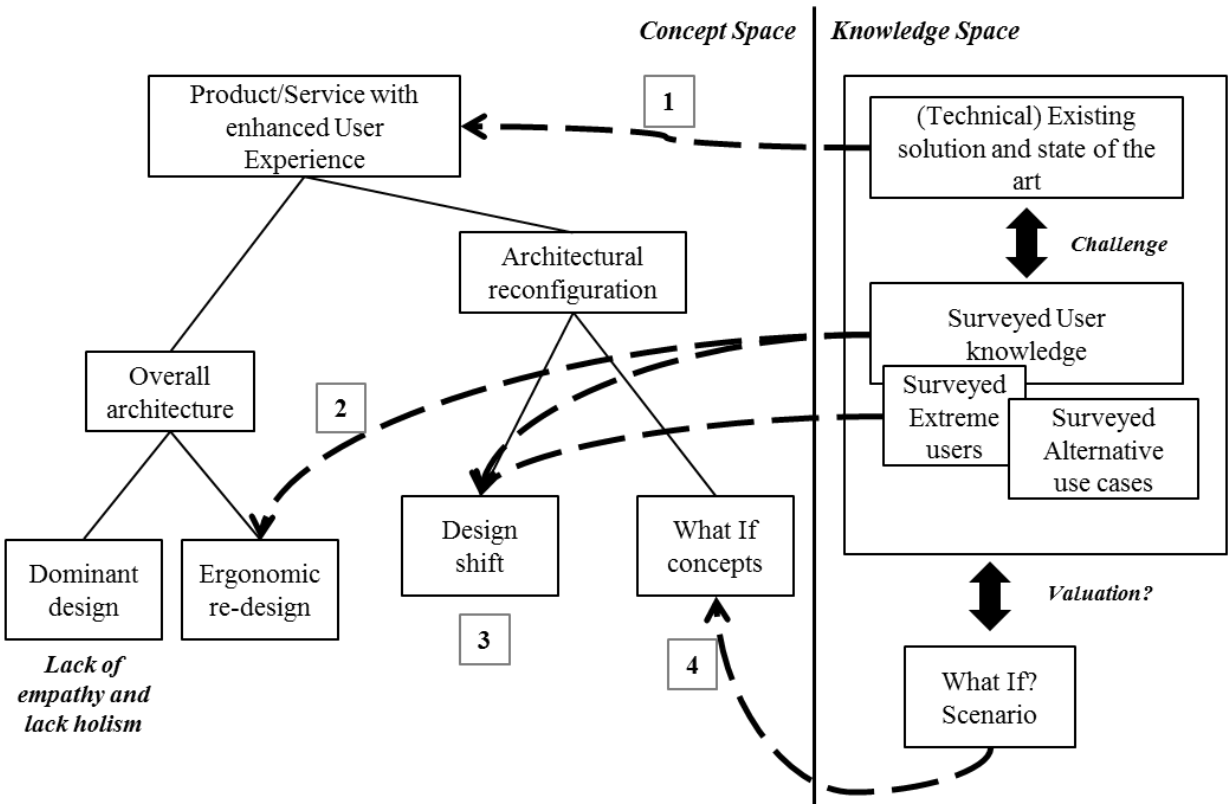


Figure 1 - DT process seen with C-K design theory

*2.2.1 User fixation and dominant design*

One of theme for which is DT is praised is its user empathy. Despite the in-depth study, users do not take an active role in the (re-)design process compared to other approaches (Kristensson, Magnusson, & Matthing, 2002). As shown in Fig.1, besides studied use cases, new ones are generated through "What-If scenarios". The extent of user-driven approach is complemented by the strategic view of the designer in its *problem framing* because users have limited knowledge for novelty (Gehry, 2004). Moreover, the lead-user innovation literature (Urban & von Hippel, 1988) presents a potential path for efficient and novel product development. In order to contribute to DT's three main criteria (desirability, feasibility and viability), practices supporting the distancing from user fixation need better characterization. Some works (Mabogunje et al., 2016) have already tried codifying DT verbal exchanges but we are aiming at projecting them on a given reference proposed by design theories.

It also raises the question of how radical and disruptive we expect the concepts and prototypes to be. In the field of cognitive psychology, one may expect a certain anchoring effect (Tversky & Kahneman, 1974). Finally, with respect to the ecosystem and environment changes, it appears also necessary to measure DT's capacity to change the identity of the designed object beyond user anchoring. Some of these shifts can bear a strategic need for radical innovation (Seidel, 2007; Stan & Puranam, 2017).

**Hypothesis 1:** DT helps fighting against user fixation.

*2.2.2 Learning metabolisms: a valuation issue?*

If we make the assumption that resources are not a limitation, thus avoiding the Death Valley (Markham, Ward, Aiman-Smith, & Kingon, 2010), we expect high levels of sponsoring and commitment to resource allocation to support sustainable innovation capabilities such as dedicated methods (O'Connor, 2018). DT can then apply and support innovation management (Martin, 2009) specially with a strong methodology mobilizing an innovation culture. From a knowledge management perspective, the underlying design activities should then support learning mechanisms beyond organization structures and processes (Cohendet & Simon, 2016). It has been shown that DT's enactment will play with 5 themes: User Focus, Problem Framing, Visualization, Experimentation and Diversity (Carlgren et al., 2016). The concepts partitioning and knowledge categories in Fig.1 encapsulate the latter themes. They are probably sufficient to support the underlying *intéressement* with this translational perspective (Cohendet, Parmentier, & Simon, 2017). It calls for strong features where DT is potentially performant at (Brown & Katz, 2011; Sutton & Hargadon, 1996): Sharing the idea, Looking for allies, Seducing, Convincing, Valuating, Building legitimacy, Manifesto/Codebook, Boundary objects and prototypes (Cohendet et al., 2017). More specifically, through knowledge brokerage (Hargadon, 2002) and the role of prototypes (Beyhl & Giese, 2016), we can stress their potential contributions to the ***Convincing*** and ***Valuating*** participating to the learning metabolisms of the organization (Hatchuel, 2011) in addition to strategy management; where value management, decision-making and political moves are key.

Despite the promise of change by design (Brown, 2009), we would like to evaluate these determinants of "creativity landing" as they probably require ad-hoc processes inspired from change management and organization design as discussed previously. Could it be endogenised in the process of DT? Are there specific designed *Boundary Objects*? How can DT's enactment themes support innovation capabilities in design-oriented organizations (Dong et al., 2017; Hatchuel et al., 2006)?

**Hypothesis 2:** DT will sustain learning metabolisms against fixations built by organizations

## 3. Methodology

### *3.1 Research design*

In order to test our hypotheses and the call for theoretical support reported in the literature, we propose to mobilize a design theory reference capable of stressing the generative and defixation capacity of DT. These two dimensions will also stress how the method can support learning metabolisms given the generated ideas and explored knowledge. Given the mirroring hypothesis (Colfer & Baldwin, 2016), marketing, technical and organizational inputs should be reported in order to value the reach and extent of the design effort. From a pure methodological viewpoint, we must emphasize that invalidating the hypotheses will be more meaningful than sampling for confirmations. It invites us then to explain the disconfirmation and propose improvements.

We need reliable cases where the DT was applied by the book, in order to extract relevant data in order to measure generative power at cognitive and social levels as introduced in the literature review. We proposed to build C-K reference tools with control groups made of students from Mines ParisTech trained to C-K theory unaware of the extent of the DT exercise. They were provided with the exploration phase knowledge of the DT cases.

This study relies on an ongoing three year collaborative research started in 2015 with the French aerospace equipment manufacturer Zodiac Aerospace. This paper is based on the analysis of two main industrial cases of a specific development team (SDT) whose objective is to be as close as possible to an aircraft manufacturer and airlines in order to design innovative offers covering the full range of Zodiac Aerospace portfolio. We benefit from a unique position to understand how a historic aerospace group such as Zodiac Aerospace tests its innovation capabilities with an innovation method such as DT to face a market where some cards are reshuffled between equipment/system suppliers to win new contracts compared to the traditional established market order.

### *3.2 Research context*

The company has a long history of external growth, technological transfers, and innovation from the airships, inflatable boats, seats, electronics equipment, power supply, lighting, cabin lining and lavatories. In a global effort to make synergies across activities and existing market segmentation, corporate functions were created to support innovation in business units (BU). The purpose is to promote boundary spanning activities (Tushman & Katz, 1980) and reconfiguration of business models (Massa & Tucci, 2014).

Most BUs are in a business-to-business-to-consumer configuration. Approaching end-users appears necessary to understand the value of designed equipment, and by-passing traditional market relations. The SDT was created by the

Group VP of Strategy and Business Development. It is sponsored and monitored by the C-suite for strategic management (O'Connor, 2018). The team is constituted of 8 permanent engineers and designers delegated by BUs for three years maximum, and dedicating half of their time to their BU's sales/technical support. They report to a local manager, who actively contributes to the team creative effort and facilitates discussions with BUs and reports to the group VP of Strategy and Business Development as well as the Chief Innovation Officer.

The DT methodology was chosen to promote the user-centric approach, explore usage, share gathered knowledge, and ideate for and with relevant BUs. SDT's two project leaders were trained to DT at Stanford's d.school, and other members were trained in other institutions. The projects phasing completely covered DT's enactment themes (Carlgren et al., 2016). So we are confident that the method was well integrated and practiced by the team.
In order to fit the scope of work of the SDT, the team along the process shared knowledge with BUs to keep them up-to-date and build legitimacy. A "Multi BU workshop" was organized during the process for problem-reframing and further ideation and prototyping. A final selection process was defined based on DT criteria and ZA's strategic intent: customer value, technical feasibility, passenger experience, group strategic alignment, in addition to a separate ranking for "creative sparks". The selected concepts were approved by the Group VP of Strategy, and then shared and promoted to business units who would potentially host their development in their renewed product lines.

## *3.3 Data Collection*

The first author is hosted at the Group Innovation Direction of Zodiac Aerospace and has full access and regular discussions with the SDT: the projects evolution detailed follow-up and interviews. See Table 1for the collected data.
In case 1 (Better Waste Management), the project ranged over September 2015 until the final handover discussions with BUs between January and April 2016. In this case, one main dominant design is established in the ecosystem and is mastered by one business unit of Zodiac Aerospace.

Case 2 (Optimized Aircraft Turnaround Time) started closely before the last handovers of the first project, and was led by a different project leader, who had observed and participated to the previous. Some lessons learnt - mainly regarding timing of exploratory phase - were taken on board. Here, there is no single dominant design, but rather several ones contributing to the turnaround time and concerning several business units interfaces.

| | **Case 1** | **Case 2** |
|---|---|---|
| **Description** | ZA Better Waste Management for the aircraft | ZA Optimized Aircraft Turnaround Time |
| **Project length** | 6 months | 8 months |
| **Organizational entities involved** | ZA mixed background (several BUs, working groups of designers and engineers) | |
| **Data sources** | All documentation produced during the project and semi-structured and informal discussions with project participants (12 interviewees for each case) | |

Table 1 - Data description

## *3.4 Analytical framework*

We will use the C-K reference tool in (Agogué, Le Masson, & Robinson, 2012; Hatchuel, Le Masson, & Weil, 2009; Hooge, Béjean, & Arnoux, 2016) to highlight the design effort in terms of idea generation and knowledge expansion from a cognitive and social perspective (see Table 2). This approach is based on the fact that we are not able to compare the design effort to an average result, or any other statistical method (e.g. Torrance Test), and several limits were raised relating to the reliance on judges (Magnusson, Netz, & Wästlund, 2014) or by reference to functional analysis (Shah, Vargas-Hernandez, & Smith, 2003). In order to fill in the framework's four cells we have executed the following:

- **Cognitive/Idea Generation** – Background knowledge on the organization, products and market was provided to the student control group. A small bias can be seen here as the referential was not done in real-time, yet it has been proven that the exercise can largely cover what all experts combined could ideate across the semi-conductor industry see (Le Masson, Weil, Hatchuel, & Cogez, 2012). So we feel confident that we did not minor the DT exercise.
- **Cognitive/Knowledge Expansion** – The C-K reference will help comparing the knowledge solicited by DT and the related cognitive effort.
- **Social/Idea Generation** – With the help of data collected, interviews, we observe used techniques and group

dynamics to understand how ideas are shared within and outside the team. We paid closed attention to how the concepts were positioned compared to the dominant designs mastered by the existing business units (Abernathy & Utterback, 1978).

- **Social/Knowledge Expansion** – Along the same line of thought as the previous cell, we report the way knowledge is categorized to promote ideas and build consensus around the creative effort, in addition to the fit with stakeholders' competencies, their regeneration (Hatchuel et al., 2006) and interdependences associated with mirroring hypothesis (Colfer & Baldwin, 2016).

| | Cognitive | Social |
|---|---|---|
| **Idea generation** | **Cover the whole conceptual potential of the initial concept ("problem formulation")**<br>*Classical method:* brainstorming<br>*Criteria:* fluency<br>*Issues in the literature:* limited expansions (similarity, based on limited knowledge base)<br>*Method improvements:* mix divergent thinking/convergent thinking personalities, trained facilitator (filtering and orienting divergence) | **Involve and support people in a rule-breaking process**<br>*Classical method:* brainstorming<br>*Criteria:* well-being, participants satisfaction (i.e. fell comfortable in idea generation)<br>*Issues in the literature:* production blocking (social anxiousness, perceived expertness, missing recognition)<br>*Methods improvements:* status auction, electronic brainstorming |
| **Knowledge expansion** | **Enable relevant knowledge activation, acquisition and production**<br>*Classical method:* participative workshops<br>*Criteria:* variety and overlapping<br>*Issues in the literature:* limited performance because of close-world condition<br>*Method improvement:* wisdom attitude, learning during the process (on uses, on existing products), competence building (on out of knowledge base) | **Manage collective acceptance and legitimacy of rules (re)building**<br>*Classical method*: consensus building methods<br>*Criteria:* expert agreement<br>*Issues in the literature:* conflict, difficulty to accept variety of skills, knowledge distribution<br>*Method improvement:* no pressure to accept particular perspective, make the customer be positive (prepare acceptance) |

Table 2 - Analytical frameworks and example of criteria value

# 4. Results

## *4.1 Summary of results*

For confidentiality reasons, only some concepts are shown and knowledge is anonymized, see Figure 2 and Figure 3. We have obtained a coverage ratio of 30-40% (number of grey/white tree leaves). Several areas are partially addressed and the associated knowledge is omitted due to a strong fixation on the use cases and not redefining interactions in the operational ecosystem. Despite the lessons-learnt application by the project leaders between cases we do not observe major differences in pattern in the C-K reference tool.

| | Cognitive | Social |
|---|---|---|
| **Idea generation** | • Numerous concepts are issued at the end of the process selection is made according to several criteria: value consideration and BUs strategic aspects.<br>• The concepts are mainly aligned with existing business lines and design rules except for some concepts that cross over organizational barriers. This extension is very valuable to regenerate existing design rules.<br>• However the existing operational ecosystem is barely challenged meaning concepts conform to existing use cases, and fixates use case scenarios.<br>*Up to 40% coverage* | • The group is strongly federated and very creative and opened to exploration<br>• Concepts are mainly in line with existing designed equipment in BUs, except for some design features and functions that become interdependent with another BU design activity, thus implying co-design activities and difficulties to apprehend from the BUs perspective<br>• The BU anchoring is not guaranteed and provokes a creativity crisis: the stakeholders are not able to develop further the promoted concepts despite their implication in the process |
| **Knowledge expansion** | • Knowledge regarding business, clients and users is aggregated and shared to support idea generation.<br>• Technical breakthroughs are required through user focus.<br>• "What-Ifs" scenarios generating crazy concepts do not articulate enough with the background knowledge | • Defining and launching multi-BU collaboration over product designs redefining engineering and marketing routines appears extremely complicated for stakeholders<br>• Despite clever concepts proposed to BUs several points are not easily addressed: further information to |

| | | |
|---|---|---|
| | needed to link them with existing designs and markets.<br>• Some deception was felt by SDT members after the multi-BU workshop, they expected to have more breakthrough ideas<br>• BUs stakeholders struggle to understand interface with other BUs required for DT concepts due to the lack of knowledge to imagine the required evolutions<br>*Up to 40% coverage* | be gathered, link between BUs, design rules, business model design etc.<br>• Provisional patents application were considered to encourage further development within BUs<br>• Not a single concept is proposed for individual BU innovation budget (supported by Group Top Management) |

Table 3 - Summary of results

## *4.2 C-K reference tools*

The following C-K reference tools built with the students allowed to represent visually with respect to the dominant designs (left branch of the tree): the number of generated ideas, variety, originality and knowledge mobilized for them (value, robustness) (Le Masson et al., 2017). The latter is crucial to understand how knowledge is articulated to support learning metabolisms. Whereas the first features help characterizing the distancing means from user fixation and associated dominant design.

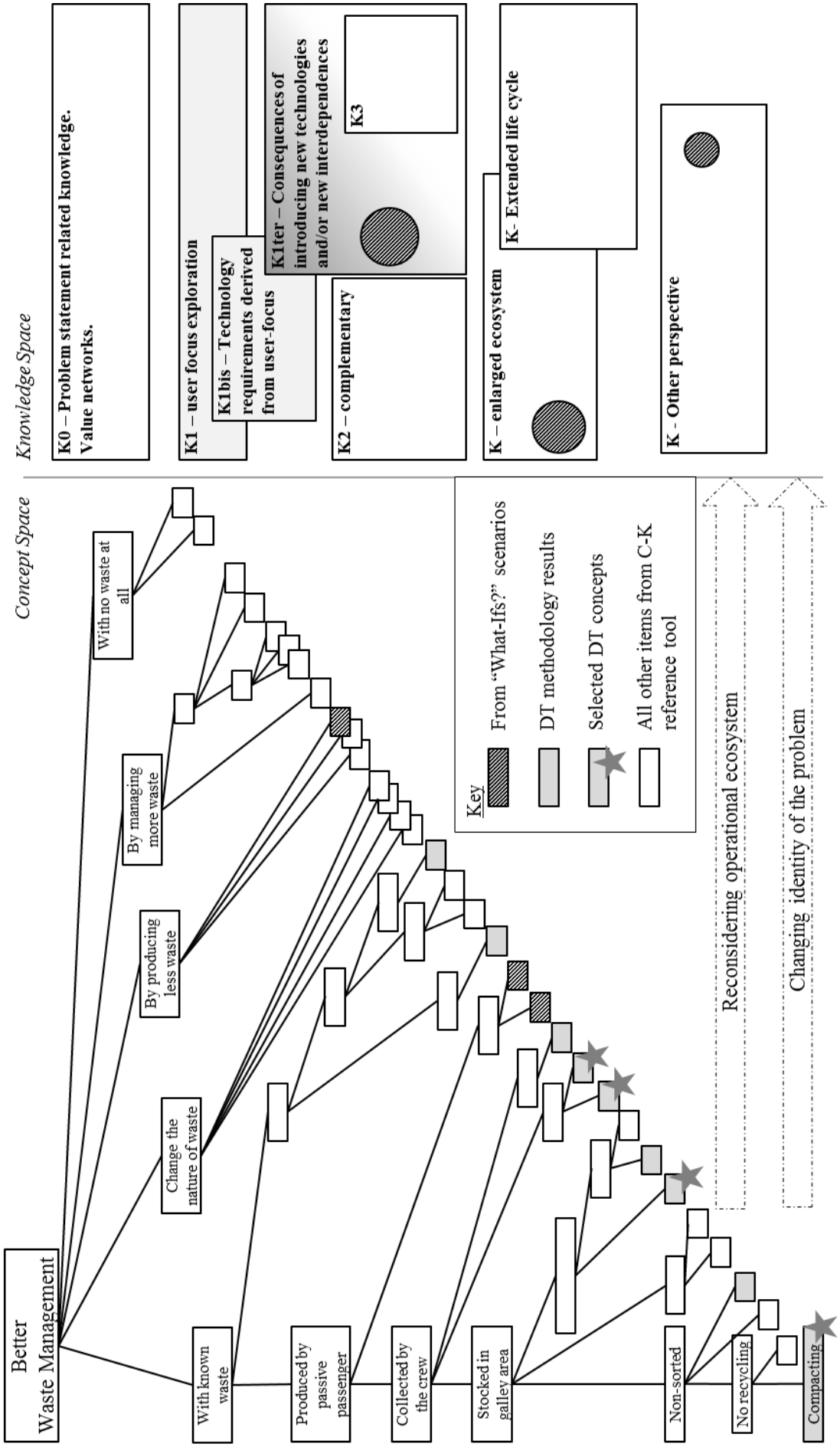


Figure 2 - Better waste Management reference tool

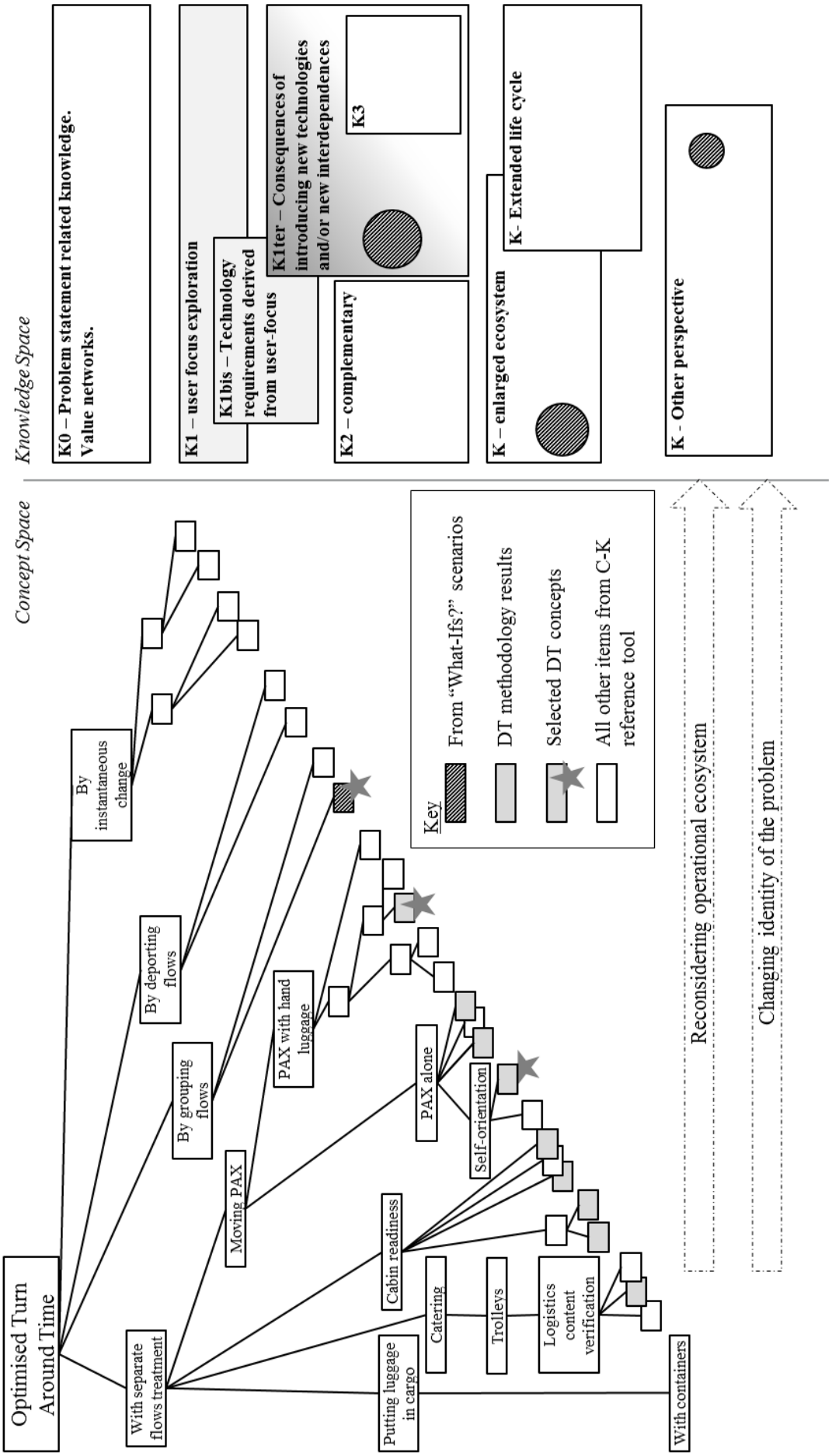


Figure 3 - Turn around Time reference tool

## *4.3 Hypothesis disconfirmation*

### *4.3.1 User fixation to be controlled*

The strong user-focus reveals a pre-fixation in the design process: a preconceived operational ecosystem. The users do inform on the existing ecosystem, and surprisingly opens a path for technology development, but without too much detail on potential interdependencies to-be-discovered. Use cases require a technology development of unexplored or unfamiliar knowledge areas. For instance, the use of the aircraft cargo area was a conceptual comfortable detour to provide solutions. But, unfortunately the method did not address these domains despite requiring further valuation efforts especially for feasibility and viability. Could it be another project to be launched?

Nevertheless, there is a concentration of concepts close enough to the dominant design. Potential paths that would move the business lines boundaries and help envisage other ecosystems are not properly explored. The exploratory and the conceptual phases orient towards knowledge clusters directly reflecting user observation, and marginal topics out of user's scope were deliberately left on a side despite revealing an alternative exploration strategy tackling the ill-defined problem with a different perspective. For instance, in case 2, businesses held today by airports were discarded for being out of Zodiac Aerospace's scope, whereas they could have been informative: boundary conditions and design rules leverage. It could at least provide ground for justifying the value of proposed concepts. It seems rather impossible to innovate on new use cases or explore unknown path away from the user observation. The DT method appears to channel design effort only through user cases within range of sight.

### *4.3.2 Learning metabolisms to be expanded*

With the C-K referential, we have revealed white spaces showing the non-exhaustiveness of DT in exploring and mobilizing useful and distant knowledge. For example in case 1: bacteria and viruses related to waste management, the value of waste, or even gaps addressed by concepts that require throwing a bridge over between business units. It shows that several knowledge areas unaddressed (see "K2-complementarity" or "K-enlarged ecosystem" in Figure 2&3). In that perspective, participants and leaders often reported "having time constraints" and "not having the right tools" regarding missing knowledge as requested by client business units and as revealed by the C-K reference tool. It is a call for providing further methods and refinements to built-in knowledge management (e.g. mappings, presentations and prototypes).

On the other hand, DT offers a way to catch new knowledge through "what-ifs?" scenario-making providing new ideas, and associated knowledge away from user-exploration: most of ideas being then drawn from recurrent ideas coming from other design projects, collective imaginaries and science fiction (robotics, internet of things etc.). Those elements are by the way mainly detached from user focus and their pattern recalls a serendipitously fashion, echoing (von Hippel & von Krogh, 2016) on need-solution pairs. Therefore, DT only provides distant knowledge/concepts through an uncontrolled process of "what-ifs" scenarios biased by collective imaginary.
When trying to valuing the concepts, convincing BUs, SDT members have stressed:

> *"It is hard to promote new challenging design for them as they run on daily basis on client programs. Challenging everything is a risk for us to be seen as the crazy ones in the business"*

And BUs' project managers raised questions regarding concepts that would fall between organizational lines and market segmentation:

> *"How do we split the work with the other BU for the design and development? Who is paying for the development work? Who is paying the intellectual property? I don't have a budget line for this action."*

The paradox is that resources existed: top management (CEO and VP of Strategy) were willing to budget these projects, but BUs were not convinced enough to integrate these into their roadmaps despite having participated to the design effort and validated the concepts. The Non-Invented-Syndrome or similar biases do not hold either as some of these concepts came back to interest them at a later stage. For instance, the conceptual detour of using the aircraft cargo area was originally rejected, but it emerged again during the same financial year as a standalone project in a corporate entrepreneurship fashion (Burgelman, 1983). It stood as a whole value potential (Maniak, Midler, Lenfle, & Pellec-Dairon, 2014) for which BUs' *intéressement* started manifesting. Therefore, we stress DT's weaknesses and lack of control of learning metabolism to sustain innovation capabilities despite holding great potential as revealed by design theory.

## 5. Discussion and conclusion

We have shown so far DT strengths and limitations as we project it on design theories constructs such as generativity and defixation. The user empathy first triggers a need for technology breakthroughs recalling a different approach to lead-users (von Hippel, 1986), but at the same time can be source of strong fixation and difficulty to break away from dominant designs. Moreover, DT proves efficient in covering to some extent the design space but in an uncontrolled manner.

Knowledge domains are not systematically addressed for further exploration or "creativity landing". Using general design theories such as C-K, or parameter analysis that keep a stimulating relationship with functional analysis (Kroll, 2013) could help supporting knowledge management for DT and measuring distance to user fixation and dominant designs. By extension, reconsidering interdependences imposed by the ecosystem, and BUs are not fully mobilized to support learning metabolisms. The landing of these innovative concepts is not fully prepared through convincing and valuation.

Of course, user-defixation and learning metabolisms against fixations built by organizations are not specific claims made by DT, but suggestions we can draw from the innovation management literature and design theories. It is not an end in itself, but an area where DT can gain in performance as suggested in the results.

Figure 4 proposes an extension of the C-K mapping with the formalization of knowledge and concepts supporting the "control" of generativity depending on the strategic intent attached to the DT exercise. Stressing the four main design sub-processes between the knowledge space and concept space, could help steering the generativity and defixation capacity not only to support a strategic intent but also identify value potential (unplanned strategic concepts). It calls also for careful design of technical and organizational prototypes (boundary objects) to support the regeneration of competences and BU altogether.

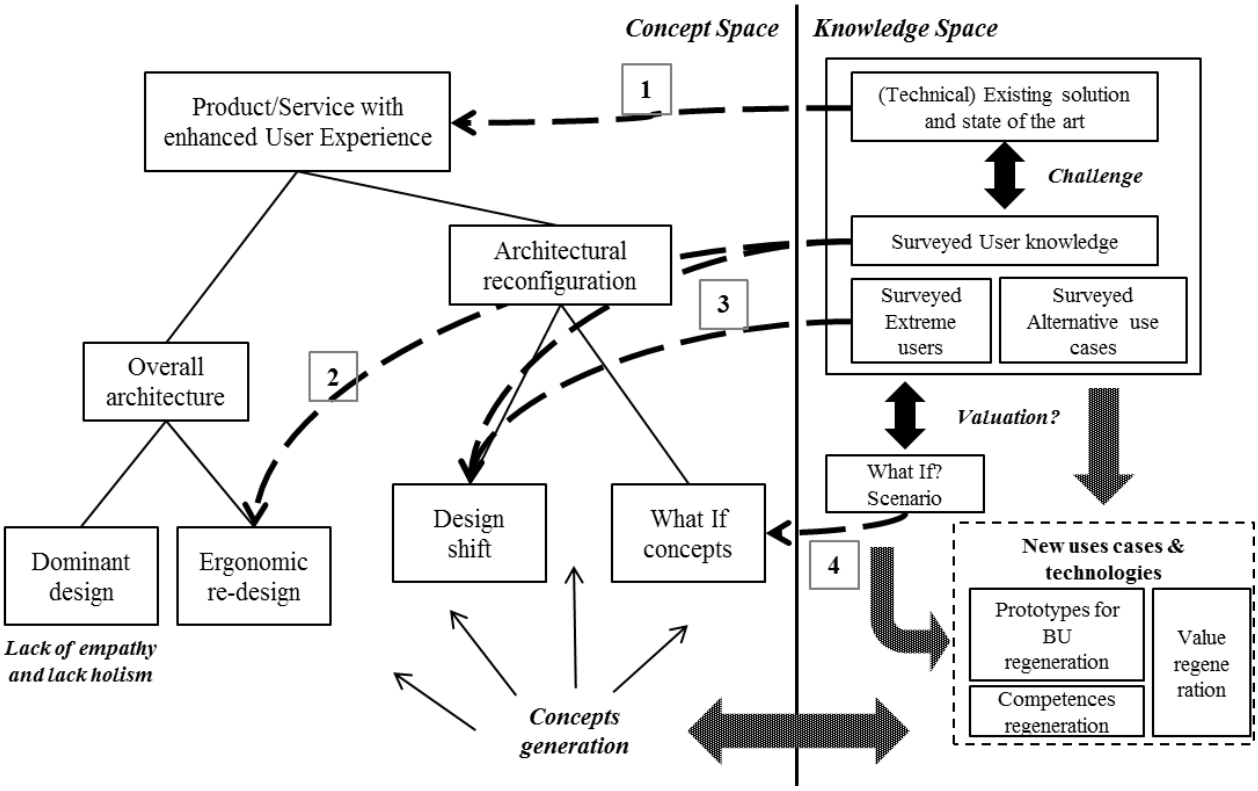


Figure 4 - Controlling and extending DT's generativity

In that perspective, we contribute to the perspective of supporting the management of DT with design theories and "designerly thinking" (Johansson-Sköldberg, Woodilla, & Çetinkaya, 2013; von Thienen et al., 2018). We concur with the idea that if DT aims at becoming more that front-end NPD activities, it should be supported by several other practices endogenising innovation and change management (Hornstein, 2015; Midler, Killen, & Kock, 2016).

Here lies a crucial topic for innovative design and building innovation capabilities in organizations. It is also an area where design theories are lacking and where DT and other practices could contribute through its enactment in organizations through methods in-use clarified by theory. Organization and its routines are usually seen as a by-product of a product design effort, especially in static way; see for instance the mirroring hypothesis model (Colfer & Baldwin, 2016; MacCormack, Baldwin, & Rusnak, 2012). Consequently, DT adaptation in an organizational context with its enhancements on generativity and defixation capacity can help understanding how organizations are redesigned simultaneously to sustain these projects through detailed value management.

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# Appendix A2

# Paper 2: Generative action and preference reversal

**Abstract** Organisations trying to innovate, despite being naturally encouraged to use project management and associated rational theories of choice, will necessarily experiment in some way or another due to the high levels of uncertainty and the unknown to be discovered. Exploratory project management may face situations requiring a constant reconfiguration of beliefs and hypotheses as a reaction to external factors. In this paper, we propose to discuss the existence of a generative rationality breaking away from classical decision theory by deliberately reversing preferences and designing decisions.

**Purpose** In this article directly submitted to CERN IdeaSquare Journal of Experimental Innovation (2017), after a round of reviews for ICED 2017, we presented an exploration project conducted over more than a decade. It showcases the project's timeline and what could be considered as an irrational due to a preference reversal. We propose instead to extend the notion of rationality with the existence of generative actions and the deliberate will to reverse preferences. These are seen as means to manage the unknown. Departing from optimization, design and generative processes can support this extension and exploration. We consequently introduce the notion *decisional ambidexterity*.

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***ORIGINAL ARTICLE***

# Generative action and preference reversal in exploratory project management

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***ABSTRACT***

Organisations trying to innovate, despite being naturally encouraged to use project management and associated rational theories of choice, will necessarily experiment in some way or another due to the high levels of uncertainty and the unknown to be discovered. Exploratory project management may face situations requiring a constant reconfiguration of beliefs and hypotheses as a reaction to external factors. In this paper, we propose to discuss the existence of a generative rationality breaking away from classical decision theory by deliberately reversing preferences and designing decisions.

*Keywords: decision; design; project; innovation; preferences reversal; rationality; generative.*

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## INTRODUCTION

With the hope for innovation, firms launch projects facing high uncertainty and the unknown. They do it to a point where we can wonder how rational their decisions can be regarding the necessity of exploitation and availability of resources (March, 1991a, 1991b). The associated project management depending on the complexity and the well definition of the objectives, may not be fully adequate as it has been highlighted by several academics (Shenhar and Dyir, 2007, Lenfle, 2016, Lenfle, 2008, Elmquist et al., 2009). Experimentation appears crucial to test hypotheses about the ecosystem and technology development as in situations of double unknowns (Loch et al., 2006) or unforeseeable uncertainty (Loch et al., 2008) with trial-and-error approaches.

It is well known that project management is mainly influenced by decision theory specially for early stages (Söderlund, 2011) and the case of applying Stage-Gate like processes may not be as beneficial for radical innovation (Sethi and Iqbal, 2008, Jean et al., 2015) as is forecasting for large project management (Durand, 2003, Ansar et al., 2016).

Decision theory as practice (Cabantous et al., 2010, Cabantous and Gond, 2011) and its performativity within organisations raises important questions on the underlying rationality expected from exploratory project management. Experimentation in organisations and its *ex post facto* exploitation of project's history through the lens of decision theory is an occasion to question the axioms of expected utility theory (von Neumann and Morgenstern, 1944, Tsoukas, 2010).

During 20th century, key contributions and critics were made to the rational theories of choice with paradoxes, heuristics and biases (Allais, 1990), Schakle's unknowledge and its surprise potential (Frowen, 1990) and naturalistic decision-making (Kahneman and Klein, 2009). Axioms were challenged but remained untouched such as the transitivity of preferences (Regenwetter et al., 2011). Two types of inconsistency could occur: the first is a temporal one based on observed choices, and who has been extensively studied; the second questions rationality itself and related preferences ordering (ibid.). Here, we will only discuss the second.

In exploratory project management, potential surprises may occur, managers may take a certain course of action, and make decisions accordingly or not (Langley et al., 1995). So, preferences are evaluated in situation of high uncertainty, ambiguity and of gradual discovery of the unknown. They can be probably challenged in order to make the best decision according to a given performance criteria.

In this paper, we would like to discuss the phenomenon of preference reversal in project management as a signature of a manager's generative action to design and engineer a novel decision playground. We demonstrate that an experimental project management in the unknown cannot be fully explained by a classical decision-making process but rather by a generative decision process: action and decision design. We rely on a case study in a large aeronautical equipment manufacturer who had the incentive to break a monopoly whose offer was questioned by aircraft manufacturers and by aeronautical safety regulations.

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The demonstration is supported by an *ex post* construction of Bayesian diagrams (beliefs in states of nature, their relationships, and utilities) to understand their preferences constructed from several interviews and extensive project documentations. The theoretical choice based on maximum expected utility derived from probabilities and preferences is then compared to the actual course of action.

## THEORETICAL BACKGROUND

Decision theory from its beginning and throughout its evolution has evolved with a set of axioms which hold a certain view of rationality: transitivity, independence and completeness; hence leaving little room to expansive behaviours that one would expect from a manager in exploratory projects.

### Decision theory and developments

A large stream of the economics literature puts the emphasis on deriving economic agents' behaviours from observed choices and by doing so introspection is avoided as much as possible (Samuleson, 1938). The works of Wald (1949), Von Neumann & Morgenstern (1944) and Savage (1954) are in line with this approach. Despite strong debates brought up by Ellsberg (1961) and Allais (1990), and breakthrough discoveries of prospect theory to embody psychology (Kahneman and Tversky, 1979), economics mostly rely on former theories except for the case of finance to some extent (Barberis, 2013).

Consistency or transitivity of preferences can be discussed from a temporal perspective, considering that the decision-maker may not want the same things all the time, but this approach mainly relies on a methodology requiring deducing preferences from actual choices, with the support of mixture models for instance (Regenwetter et al., 2011). Without getting into this debate, we would prefer to challenge preferences with the construct of decision in organisations as seen from management (Cabantous and Gond, 2011, Tsoukas, 2010, Langley et al., 1995, Laroche, 1995). In other words, the manager in charge of his exploratory project actions makes decisions in a way that may differ from theoretical perspectives: the sets of alternatives may not be represented, courses of action may be taken and then crystallised into a decision for the organisation to make sense of the commitment (Weick, 1995).

In that perspective, the rationality expected from the decision-maker may be different from the normative and perspective one given by theories of rational theories of choice. This rationality and the circular relation between thinking, acting, and deciding may require more than 'satisficing' (March and Simon, 1958) as managers deal with unknowledge (Frowen, 1990) and unknown states of nature (Hey, 1983). For instance, discovery and challenging hypotheses through disconfirmation or counterfactual strategies (Wason, 1960, Feduzi et al., 2016), and naturalistic decision-making relying heavily on expert intuition and quick action (Kahneman and Klein, 2009, Klein, 1984) considerably question the notion of rationality and the link between acting and deciding.

Rational theories of choice may be insufficient to make a full account of experimental practices to manage projects in the unknown.

### Innovative project management

Generative processes as observed by R. Epstein while studying creativity of pigeons (Epstein, 1990), or the notion of action generators in organisation (Starbuck, 1983) can be captured by an expandable rationality (Hatchuel, 2001) that integrates the role of action and design as means to grow one's body of knowledge and alternatives to validate and choose from; instead of optimizing and choosing from finite given sets according to available information.

Consequently, with generative behaviour, the very notion of uncertainty and expected utility need a constant update and can then be completely reconfigured in situations of ambiguity, complexity and unknown as already shown in several studies (Lenfle, 2016, Loch et al., 2006, Loch et al., 2008, Ansar et al., 2016).

In Fig 1, from the regime of objectivity and subjectivity, generativity introduces divergence, the possibility of exploration and experimentation. By doing so, generative behaviour in innovative project management can introduce *a priori* loose objectives due to the unforeseeable uncertainties (Loch et al., 2006, Loch et al., 2008) and potential surprises (Frowen, 1990, Shackle, 1952, 1955) to be tested. The management may require features varying from traditional uncertainty reduction project management (Shenhar, 2007, Lenfle, 2008, Takeuchi and Nonaka, 1986): inclusion of new parameters to avoid surprises and higher uncertainty, flexibility, learning, inquiry, value of *failed* projects (Elmquist and Le Masson, 2009), revealing interdependencies (Ben-Menahem et al., 2015). By generating new actions and new decisions, the decision-maker is challenging objective and subjective value of the available parameters, his understanding of the ecosystem's dynamics (Tidd, 2001) and preferences. It calls for a certain vigilance, constant update and inquiry, recalling features of naturalistic decision-making.

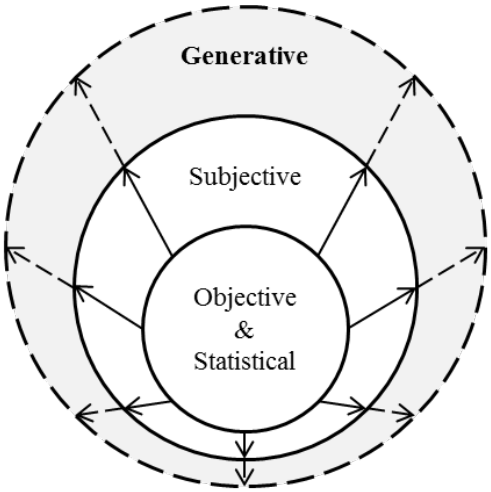


**Fig. 1.** Three fields of decision-making

### Two complementary models

A generative model of decision-making extending rational theories of choice would then incorporate the possibility to reverse preferences and design decisions. By opposition to the classic rational model, if a deviation is observed for not committing to the maximised expected utility course of action, one could assume a psychological bias (subjectivity) or action to engineer the design (generative rationality).

### Research questions

From our literature review, in situations of high uncertainty, unknown and experimentation in innovative project conduct, we may question the link between action and decision in exploration, and the associated rationality of the manager.

We propose to have a closer look at the issue of the order of preferences in exploratory project management with respect with generative behaviours:

(i) Can decision-making in exploratory project management be explained through rational theories of choice?
(ii) How generative behaviour relate to decision-making, beliefs and preferences?
(iii) How the generative model makes sense of the course of action?

## METHOD AND DATA

Our methodology consists in constructing *ex post facto* two *virtual* milestones and understanding the decision-making process in exploratory project management with Bayesian nets/Influence Diagrams, using Netica™ software. We position ourselves in the observer reconstructing strategic decision as reported by Tsoukas (2010): considering these as normative and performative features of project management in organisations (Cabantous and Gond, 2011).

### Contrasting rational and generative decision models

The situations were recreated according to discussions with the project manager; decision models were elaborated on the base of the history of project management and interviews with several stakeholders, hence feeding the methodology as per mathematical theory (Koller and Friedman, 2009). The decision models were realised with the input of stakeholders and validation by project manager.

The diagrams represent states of nature with probabilities (yellow boxes) and costs/utilities (diamond boxes and expected utilities in purple boxes). They were evaluated from the interviews with ranked verbal judgments, and secondary material such as presentations and project statements, business cases and expenses in order to match Wald's approach of decision-making model. The maximum expected utilities were then computed.

With the two constructed rational decision diagrams and suggested optimal decisions, we can oppose these to the actual course of action of the project.

### Research Data

We conducted a case study of the Icing Detection project carried over 15 years at Zodiac Aerospace (Z) business unit dedicated to sensing and system management and making its strategy to enter a monopolistic market.

The original situation consisted in tackling the safety issues related to the icing phenomena, which implied ice removal by any means or its detection. Regulations had then evolved to enhance safety. Aircraft manufacturers were considering a potential upgrade of their anti-ice systems and ice detectors, thus reconsidering the monopoly. At the group level, Z could provide anti-ice systems with another business unit (Za), or internally (Zi) could work on sensing systems in line with their own core business. In addition, Z has a long history of mergers and acquisitions, so an acquisition of a business in the ice detection market was considered.

Overall, 8 interviewees were solicited with semi-structured interviews to trace the history of the project, the different initiatives, beliefs, preferences and actual decisions taken at different stages. Full access to the project documentation including expenses was granted. Interviewees were consulted twice, except for the manager who was consulted six times to fine tune the decision diagrams based on the input collected from the other interviewees (20 interviews in total).

## RESULTS

### Situation 1 – discovering and understanding

The first situation projected the team at the early stages of the project: the aim was to break a monopoly whose technology was criticized for not being sufficient and not meeting the evolving requirements of icing conditions detection due to the understanding that the phenomenon was more complex and causing aircraft to crash.

With the support of public funding and interest from an aircraft manufacturer, Zi did a first study to detect ice on wings before take-off (critical phase) with available internal competencies. Technical difficulties in terms of equipment integration left however the project on a dead-end. Consequently, a wide technical survey was conducted to evaluate ice detection alternatives (patents, laboratories, businesses), and synergies with Za for anti-ice systems to answer to a request for proposals from an aircraft manufacturer. Moreover, an acquisition was considered to enter the market and provide similar technology to the established monopoly. This is reflected in the interviews and project documentation (SWOT analyses, scenario planning etc.).

The diagram (Fig.2) reflects the beliefs and preferences for the project after the first failed study, and considering a wide range of scenarios to break the monopoly with a given technology and strategy for icing phenomena.

*Not following the optimal choice*

In the absence of on-the-shelf mature alternatives, it is interesting to highlight the ecosystem's solution was to offer a service of chemical spray at the airport, before take-off, to avoid ice formation on wings and partially satisfying regulation evolutions (FAR 25 App C). This reinforced the dead-end of the first developed technology.

Despite having commercial incentives, synergies, an envisioned acquisition to go to market quickly and match with maximised expected utility, the project took another course of action. A foreign business offered a patented technology for ice detection and, instead of buying it, the manager consulted his expert engineer who told him he could come up with a solution bypassing the patent and build up competences internally.

*Generative rationality – inconsistency and engineering the decision*

Consequently, what is constructed as a strategic decision by the project (anti-ice system) in accordance with available capabilities, beliefs and utility maximisation, it turned out to be discarded for less profitable decision (ice detection). The course of action reveals inconsistency as the decision was to keep opened alternatives instead on jumping on the optimal.

### Situation 2 – engineering an *irrational* decision

The second situation at a later stage (Fig.3), we find Zi's project into the field of icing conditions detection as the likelihood of detection appears higher than the removal, and more utility is expected from choosing keeping this option.

*Rational theory of choice lacks in explanations*

The action of the manager with his expert engineer that appeared as an out of scope opportunity changed the decision situation. This generative action becomes an irrational decision considering the preferences and beliefs presented by the project manager and his team.

*Generative rationality: ability to engineer the decision*

The generative behaviour then consisted in opening a new space they had to design and in managing the suboptimal decision construction. They took the lead of a EUROCAE working group; a consortium tasked to "update the In-Flight Ice Detection System (FIDS) Minimum Operational Specification ED-103-2016, and provide recommendations on the feasibility to standardize In-Flight Ice Crystals Weather Radar Long Range Awareness Function - 2016" (EUROCAE website). The aviation industry ecosystem concerned by icing conditions, could gradually build their own path and collectively uncover the unknown (Sydow et al., 2012, Lange et al., 2013). Moreover, public funding campaigns supported the ecosystem effort to understand the icing phenomenon and associated technologies.

### Making sense of the situation with the generative model

Constructing the decision reveals the inconsistency in the decision-making process as preferences are reversed. This reversal occurs because an action was taken to generate a new decision playground. It is only then that the decision is engineered and sustained by an active role played in the ecosystem to endogenise new parameters (Loch et al., 2006). The generative action looks at reducing uncertainty by projecting the decision on a larger state to manage, as seen by comparison of the two diagrams.

The manager who presents beliefs, preferences and scenarios to take a decision and commit to it, is also capable to act and design the decision *a posteriori*. A feature discussed in the literature questioning the theoretical rationality of the decision-maker as the tension between acting and deciding may challenge transitivity of preferences.

We have shown the decision model fails to grasp the subtleties of a generative action, exploring the expanded decisional context, provoking a reconfiguration of preferences and value networks.

Furthermore, the traditional objective of maximising the expected utility does not match the actual dynamics of the exploratory project management as action can be

taken to generate new decision situations and to recompute expected utility. The generative behaviour is driven by another sort of criteria than optimizing and uncertainty reduction.

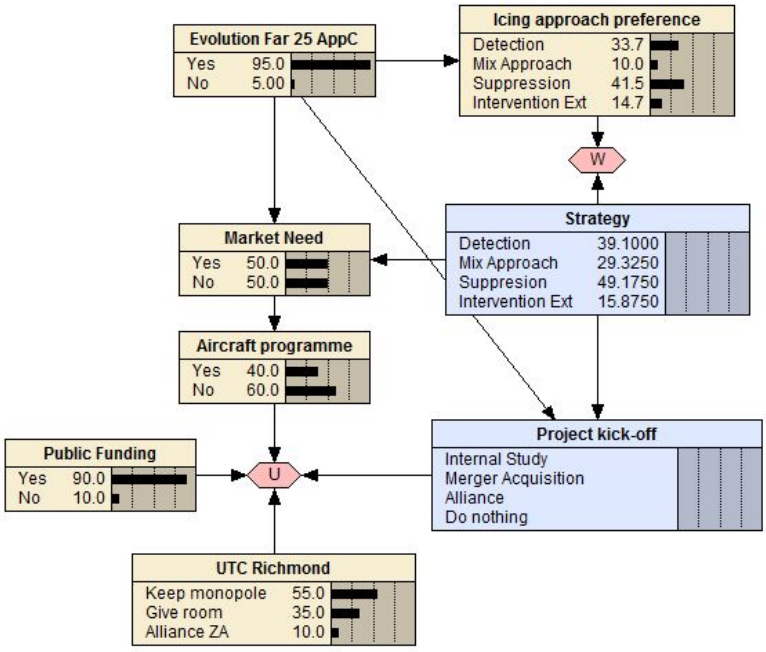


**Fig. 2.** First decisional setting: Beginning the exploration and challenging rational decision

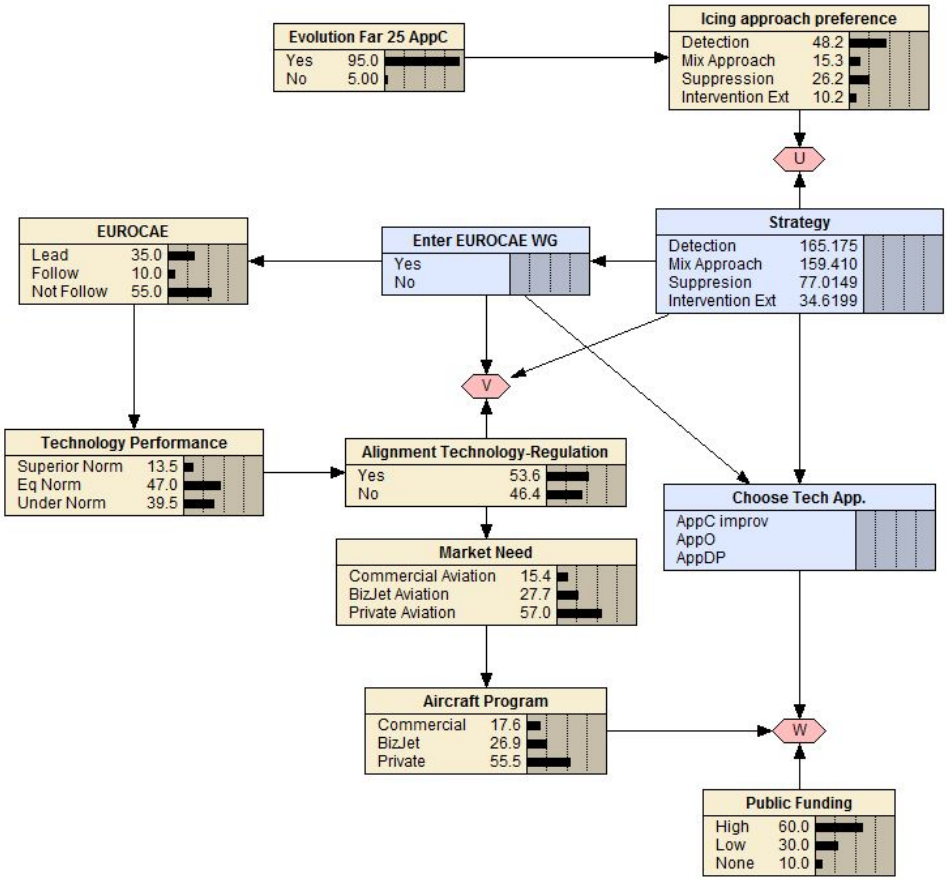


**Fig. 3.** Second decisional space: Expanded and reconfigured decisional space following an irrational decision

## DISCUSSION AND CONCLUSIONS

First, we have shown that rational theories of choice are not fully appropriate to explain exploratory project management as its need for inquiry reveals the possibility to re-order preferences. This discrepancy appears as the construct of decision diagrams, reflecting the normativity and performativity of its underlying theories for project management cannot grasp the importance of generative action to engineer a reconfigured and expanded decision playground. The origin of this generative action is not fully understood. Further research should be conducted to fully understand why and how this occurs, and how it is linked to the level of uncertainty, ambiguity and the unknowledge.

Second, we have also identified that generative behaviour challenges preferences and underlying hypotheses as it is triggered by a criteria different from maximising expected utility based on available knowledge.

Third, the generative action that interferes with the expected continuity of the two decision situations reveals the engineering of the second decision situation as an inquiry process to endogenise the unknown, and reduce uncertainty. This pattern can only be explained by a generative rationality.

We relate to the result that exploration or at least generative patterns are of another kind (Lenfle, 2016) and must be managed in a different way as it has been demonstrated by studies on ambidexterity (Raisch et al., 2009, O'Reilly and Tushman, 2013).

Generative action which triggers the engineering of new decision situations with potential preferences and beliefs interference differs from the works of Feduzi *et.al* whose purpose is about comprehensiveness of a decision situation with different inquiry methods (Feduzi et al., 2016) or the exploration of state space in double unknown configurations (Feduzi and Runde, 2014). Experimental studies within an engineering and user-driven environment such as IdeaSquare@CERN could be conducted to provide further confirmation of this phenomenon.

Deriving from Wason's (1960) inference matching bias (Houdé and Moutier, 1996), simple experiments could be designed mixing orthogonal protocols from creativity theories (generation) and decision theories (selection) to highlight the capacity of participants to trigger the need to generate novel value spaces (abduction) differing from given utilitarian and biased reasoning. The implications for scientific management where the distribution/coordination of decisions/actions are crucial, as the effort to manage generativity for decision-making would endogenise the prospective twist of scientific discovery into society's challenges (a given objective). This behaviour has, at its own scale, proven rather efficient for novelty-search algorithms in robotics (Mouret and Clune, 2015, Stanley and Lehman, 2015) as they avoid the dead-ends of traditional performance criteria.

The management of the tension between decision (optimization) and design (generation), calls for a certain reflexivity of the decision-maker and we propose to call it decisional ambidexterity. The role leadership (Schneider et al., 2012, Ezzat et al., 2017) to generate and engineer extended decision situations for potential greater benefits and risk mitigation as observed by Henri Fayol (1916) and Burns & Stalker (1961).

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# Appendix A3

# Paper 3: Can ambidexterity kill innovation?

**Abstract** The academic construction of ambidexterity articulated around notions such as exploration, exploitation (J. March 1991) has been flourishing over the years with a strong background in organisational theory to explain levels of performance and innovation. However, they have also made a call for in-depth studies to understand managerial capabilities such as decision-making (Birkinshaw & Gupta 2013; O'Reilly & Tushman 2013; Benner & Tushman 2015) supporting the tension of competing objectives. In this paper, we show that organisational ambidexterity can kill innovation as the underlying decision theories are not fully supporting the nature of decision required in regimes such as contextual ambidexterity (Gibson & Birkinshaw 2004). Two case studies from the aircraft cabin equipment industry are presented and analysed at the project management level with descriptors from organisational ambidexterity and decision-making. We propose to look at unconventional decision theories, considering non-expected utilities such as potential regret of imagined prospects, as a means to support management tools enabling ambidexterity at the decisional and contextual levels. First, we show that common decision models based on expected utility encoded in management tools mobilised for contextual ambidexterity can fail to support innovation. Second, we propose that a non-expected utility, such as potential regret of imagined prospects, serves the management of competing exploration/exploitation objectives. Third, the case studies help contouring a management tool extending observed attempts to sustain or extend contextual ambidexterity through unconventional decision-making.

**Purpose** This paper addresses the hypothesis that organizational ambidexterity (OA) can kill innovation. The first version called for the importance of decision-making to

understand the operationalization of OA as mentioned by researchers in the field. We propose to leverage non-expected utility decision-making based on Paper 2, but in reality with the feedback from the research community we also recentred the presentation on problem-solving as originally discussed by James March seminal paper (March 1991b). We stress the aporia of segregating exploration from exploitation for a meaningful exploration as generativity is otherwise biased and reduced. The latter revealed being crucial to manage the unknown and consequently to innovate. Presented at EURAM 2018 Conference Innovation SIG and will be rewritten based on valuable collected feedback.

# Can organisational ambidexterity kill innovation? A case for non-expected utility decision making

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## Abstract

The academic construction of ambidexterity articulated around notions such as exploration, exploitation (J. March 1991) has been flourishing over the years with a strong background in organisational theory to explain levels of performance and innovation. However, they have also made a call for in-depth studies to understand managerial capabilities such as decision-making (Birkinshaw & Gupta 2013; O'Reilly & Tushman 2013; Benner & Tushman 2015) supporting the tension of competing objectives. In this paper, we show that organisational ambidexterity can kill innovation as the underlying decision theories are not fully supporting the nature of decision required in regimes such as contextual ambidexterity (Gibson & Birkinshaw 2004). Two case studies from the aircraft cabin equipment industry are presented and analysed at the project management level with descriptors from organisational ambidexterity and decision-making. We propose to consider unconventional decision theories, considering non-expected utilities such as potential regret of imagined prospects, as a means to support management tools enabling ambidexterity at the decisional and contextual levels. First, we show that common decision models based on expected utility encoded in management tools mobilised for contextual ambidexterity can fail to support innovation. Second, we propose that a non-expected utility, such as potential regret of imagined prospects, serves the management of competing exploration/exploitation objectives. Third, the case studies help contouring a management tool extending observed attempts to sustain or extend contextual ambidexterity through unconventional decision-making.

**Keywords:** decision, project management, design, ambidexterity, management tool

# Can organisational ambidexterity kill innovation? A case for non-expected utility decision making

## 1. Introduction

In the aircraft cabin market, cabin equipment manufacturers are pulled by two out of step dynamics: aircraft manufacturers providing a platform and airlines with brand management and continuously retrofitting cabin for improved passenger experience. With this two-speed setting and stringent safety regulations, deciding to pioneer with innovative products/concepts for a greater competitive advantage (Rumelt et al. 1994) becomes key despite having few players in the market to share the demand volume – a quasi-duopoly. As dominant designs (Abernathy & Utterback 1978) are rather settled in the aircraft industry but following improvements in safety and the search for stronger/lighter materials for CO2 emissions reduction, deciding which design choices should be made to offer to the market becomes rather complex as one offer is highly interdependent of other designs that may not be fully controlled.

What are the decisions to be made to preserve a competitive advantage envisioned through exploration for an effective exploitation? In this paper, we show these strategic questions for an industrial group could be supported by unconventional decision theories and their translation into management tools supporting the tension of competing ambidextrous objectives. Literature in organisation theory has described the (dis-)advantages of being a first-mover or early follower (Lieberman & Montgomery 1998), along with the forms of organisational ambidexterity to adopt depending on product class uncertainties (Benner & Tushman 2015). Here, with the strategic and survival background of ambidexterity (O'Reilly & Tushman 2013) and calls for studies on managerial capabilities, we propose to study what happens at the project management level with a perspective from decision theories

considering the unknown and non-expected utility (Feduzi et al. 2016; Faulkner et al. 2017; Starmer 2000) and design theories (Hatchuel & Weil 2002) to understand design choices in relationship with the body of knowledge and appropriate management tools (Labatut et al. 2009; Labatut et al. 2012; Segrestin et al. 2017; Hatchuel & Molet 1986).

The research relies on two cases studies of exploratory project management conducted in a large equipment manufacturer specialised in aircraft cabin equipment. The cases differ in nature and practices and thus allow giving a global picture of the decision-making process and forms of organisational ambidexterity. The main result of the research is to empirically show that *ad-hoc* decision making processes to articulate innovative design activities for product development in a mode of contextual ambidexterity creates a paradoxical tension as valued exploration prospects are regretted and, separately (Birkinshaw & Gupta 2013; O'Reilly & Tushman 2013) exploration/exploitation performances are degraded. The subsequent result is a call for a proper management tool (Segrestin et al. 2017; Moisdon 1997) based on non-expected utilities – decisional ambidexterity (Le Glatin et al. 2017) – supporting the contextual ambidexterity constructed by (Gibson & Birkinshaw 2004) in order to gradually uncover the unknown (Feduzi & Runde 2014) associated with exploratory projects as practice reveals senior/middle management are only partially prototyping and experimenting potential instruments with scarce resources.

Management tools taking into account (non-)expected utilities could support the decision-making process for pioneer/follower strategies and also dynamically consider the tension between simultaneously competing objectives of exploration and exploitation. Instead of opposing and forcing a transition from exploration to exploitation and vice-versa on a same continuum (Birkinshaw & Gupta 2013), we advocate a regime of where both of them are dynamically coupled to generate knowledge and generate choices to enhance dynamic capabilities (Lakhani et al. 2013; O'Reilly & Tushman 2007).

## 2. Literature review

### 2.1. To Pioneer or to follow early

In the field of strategic management, the question of competitive advantage being core (Rumelt et al. 1994), one of the key feature of building a competitive advantage is to fight for primacy and sustain the first-mover configuration. Among the variety of pre-emptive strategies (Macmillan 1983), timing the offer to the market a new concept (product, service, feature, architecture etc.) is crucial, as it comes with its set of advantages and disadvantages (Lieberman & Montgomery 1998; Lieberman & Montgomery 1988). As described by Lieberman, the decision to enter at a certain order the new market and value space created will be dependent on luck and dynamic capabilities (Teece et al. 1997). Here, we propose to discuss the case where the market or operational ecosystem's dynamics and competitiveness are pretty stable. In the aircraft cabin equipment, there are no visible threats of new entrants due to high entry barriers and strong dominant design (Abernathy & Utterback 1978). The long term strategy is to be able to be ready when the new dominant design comes out (Macmillan 1983; Christensen 1997) and to be able to fit the prescribed architecture (Sanchez 1995; Sanchez & Mahoney 1996). If in addition, new product development costs are high due to stringent regulation constraints, such as in aerospace, it becomes rather complex to support the necessity to decide on exploration and exploitation activities into resources and dynamic capabilities for a risky and uncertain course of action (Jansen et al. 2006) due to intermediate environment moderators (Jansen et al. 2009).

### 2.2. The case for ambidextrous organisation

The dilemma when competing for primacy may be replaced by the debate of strategic nature of exploration/exploitation trade-off (J. March 1991), and literature's refinements (O'Reilly &

Tushman 2013, p.332; Birkinshaw & Gupta 2013, p.294) show there may be other observables when considering these two patterns: multi-level analysis, boundary conditions and other descriptors such as senior leadership and firm's ecosystem. Those recent reviews on in the organisational ambidexterity field have addressed future perspectives requiring "qualitative and in-depth studies"(O'Reilly & Tushman 2013, p.332) on how allocation of resources are balanced, how choices are made, who is responsible for those choices, what are the consequences (Birkinshaw & Gupta 2013, p.296), and how conflicts are managed. For instance in (Lavie et al. 2010) when considering different ambidexterity forms (structural, sequential and contextual) features are highlighted such as: "proactive management is essential", "management provides a supportive infrastructure". Yet, several underlying challenges are not addressed.

At the intra or inter-firm level, organisational ambidexterity was correlated with how exploration/exploitation regimes should be balanced across mergers & acquisitions, alliances and internally (Stettner & Lavie 2014). Others have also looked how ambidexterity is dealt with leadership skills (authority in decision-making, formalisation, cross-functionality, and connectedness, intent, vision) (Mom et al. 2009; O'Reilly & Tushman 2011), is supported by knowledge inflows (bottom-up, top-down, horizontal), or is linked with organisational features (centralization, formalisation, connectedness) and environmental moderators (competitiveness and dynamic) (Jansen et al. 2006).

In their reflexions on their decade award (Benner & Tushman 2015; Benner & Thushman 2003), they call for a review of extant theories as there is a shift in the locus of innovation: new forms of association for a given organisation, increasing complexity and modularity (Lakhani et al. 2013; Sanchez & Mahoney 1996). They maintain their former article's critique of the limitations of process management adoption (TQM, Lean, ISO 9000, and now design thinking, ERP systems, balanced scorecard, rapid prototyping, lean startup, etc.) and

associated risk for exploitation and exploration. It is then crucial to be able to stress in which ways those processes are taken on board in relationship with innovation transitions, organisational structures and senior/middle management culture and decision-making.

The decision pattern behind the support, generation of knowledge, generation of decisions for exploration/exploitation activities has highlighted the gap between decision theory and decision-making in organizations (March & Shapira 1987). Probabilities and preferences may not be as clearly stated and calculated as stated in descriptive/normative views of decision theories (Cabantous & Gond 2011). Others have argued that decision are made *ex-post facto* (Langley et al. 1995; Tsoukas 2010; Laroche 1995; Cabantous & Gond 2011), i.e. after conducting the actions for legitimacy.

The question of how, who, and what are the ins and outs of decision-making for ambidexterity becomes crucial due to difference in nature of tasks performed separately (Tushman & O'Reilly 1996), sequentially (Brown & Eisenhardt 1997) or contextually (Gibson & Birkinshaw 2004). As a matter of fact, the construct of contextual ambidexterity for successful firms came from a large survey revealing a tight link between ambidexterity, performance and organisational context but the underlying decision-making practice is not spelled out as explained by the author (Birkinshaw & Gupta 2013, p.293). In practice, managers tend to rely on different processes or methodologies such as business score cards, business model canvas (Osterwalder/Strategyzer) or Strength Weakness Opportunities Threats analyses (SWOT) and others go for design thinking methodology(Brown 2008) requiring ad-hoc practices to feet existing organisation routines (Carlgren et al. 2016; Carlgren 2016; Beyhl et al. 2014; Beyhl & Giese 2015; Beyhl & Giese 2016). In the oil industry, cases of decision trees as standalone management tools (Moisdon 1997) or even scenario making (Loasby 1990) have been reported. However, we found little research on the type of management tools to support decisions that go beyond risk and uncertainty, namely the

unknown. The place of management tools as unit of analysis has indeed been recorded in several approaches linked with the place of artefacts in organisations (Labatut et al. 2009; D'Adderio 2008; Labatut et al. 2012; Hatchuel & Molet 1986).

### 2.3. Decision with (non-)expected utility

Exploration/exploitation activities as two different self-reinforcing patterns of learning (Birkinshaw & Gupta 2013; J. G. March 1991), call for different managerial capabilities including decision-making to oversee the relevant tasks beyond organisational design (Smith & Tushman 2005). Starting from Black Swans (Taleb 2008) and double unknown situations (Loch et al. 2006; Loch et al. 2008), a series of articles having been discussing decision making and innovative project management (Feduzi et al. 2016; Feduzi & Runde 2014; Lenfle 2016), or in other words ways of conducting exploration (Lenfle 2016; Lenfle 2008). Framing the unknown with respect to risk and uncertainty (Faulkner et al. 2017; Runde 1998; Knight 1921) reveals where decision theories fail to support exploratory project management or even to describe the difficulty of endogenising unknown parameters at a decision gate. Unimagined events, by opposition to events regarded (im-)possible, lie outside of most conventional and unconventional theories of choice (Starmer 2000). It is also a case for unknowledge and surprise potential by G.L.S Shackle (Shackle 1955; Shackle 1952; Frowen 1990) as reported by Richard Bronk in his chapter "Imagination and creativity in markets" (Bronk 2009): "Choice is in a very real sense amongst products of imagination and invention" (p.218).

In an instrumental view of rationality (Boudon 2012), with an agent deciding to invest for future prospects implying a competitive advantage or cost reductions dependent on deep hypotheses (potentially challenged by Black Swans, such as the sure-thing principle(Savage 1954)), one may wonder what decision tools can support such extreme commitment.

Reaching out for high uncertainty and the unknown raises challenges that are already hard to address in complex risk management (Ansar et al. 2016) where prediction, collective decisions, and learning through time (even at the ecosystem level) appear almost impossible.

However, cases of unknown management have been reported in literature with a design perspective (Kokshagina et al. 2016; Hatchuel et al. 2010; Le Masson et al. 2012; Loch et al. 2006). There are strategies that consist in using intermediaries (Agogué et al. 2017) or ecosystem's vehicles to build a path for the industry (Sydow et al. 2013; Lange et al. 2013) such as in the semi-conductor industry where the common purpose was to go beyond Moore's law due to physical limits being reached in other road-mapping activities.

An approach to deciding in a context where innovation incentives are low, and where the operational ecosystem is rather pushing for exploitation behaviours, could be in non-expected utility theories as convention rational theories of choice are insufficient (Starmer 2000). The idea developed by several academics is to relax several axioms that are violated through experimentation (Heath & Tversky 1991; Cabantous 2007). Those shortcomings may be then backed up by organisational practices (Heath et al. 1998) in the same way operational research was implemented and refined over the years (Hatchuel & Molet 1986). Stretching goals (Sitkin et al. 2011) given by a charismatic leader (Ezzat et al. 2017) can also be seen as an exploration vector into the unknown, paradoxically for firms that can least afford those. Considering that a decision maker uses ambiguity or have support from the ecosystem to discover the unknown, models of decision based on regret could be an alternative for strategic management: what is the cost of not committing to a designed course of action? Models proposed by (Loomes & Sugden 1982; Loomes et al. 1989; Loomes & Taylor 1992) considers the possibility to have preferences reversal, cycle of preferences and raise the question of regret estimation compared to experienced regret (Sevdalis & Harvey 2007). Yet, we would

like to take the discussion further down the line of risk and uncertainty and consider the domain of the unknown: imagined and designed prospects to innovate.

## 2.4. Management tools to support decisions in the unknown

Considering that decisions may be imperceptible depending on their consequences' appreciation or paradoxically highly praised (Chia & Nayak 2012; Chia 1994), or even highly perturbed (Taleb 2008), making decisions in the unknown becomes a question of design (Hatchuel et al. 2001). The difficulty for organisation is of course to manage the tension between a decision model and another. As (Starmer 2000) specifies, having a general theory of choice whose special cases are the classical theories appears crucial for the scientific continuity. In experimental management situations, it could call for a "decisional ambidexterity" (Le Glatin et al. 2017), i.e. being able to deliberately reverse preferences to generate decisions that allow exploration while keeping exploitation constraints and meet economic performance criteria. Designing decisions, beyond designing possible states of nature (Feduzi et al. 2016), comes with a price since it requires "the proactive use of techniques to enhance robustness, resilience, preparedness" as to extend the probabilistic approach and engineering design to face risks (Maes & Dann 2017, p.28). As such approaches would imply listing, imagining all sorts of courses of actions and associated gains/losses; we may question the practicality of its implementation with heavy-weight learning practices and resources. The idea that it can be programmed or turned into business operations is quite attractive and avoids falling into the "myth of the entrepreneur as tragic hero in the large corporation" (Burgelman 1983, p.241). It also helps to understand the place for a new management practice of augmented decision-making in an organisation as it is the case with the emergence of new design rules in engineering department: "*generative bureaucracy"* (Hatchuel, Garel, et al. 2009). It echoes how a possible transition from structural to contextual

ambidexterity could be conducted (O'Reilly & Tushman 2013, p.504) and a detailed look on decisions addressed in contextual ambidexterity but where associated research hasn't revealed its full potential (Birkinshaw & Gupta 2013, p.293).

Finally, we propose to have a "management tool" approach (Segrestin et al. 2017; Moisdon 1997; Labatut et al. 2009) to contour the articulation between (non-)expected utility decision making and organisational ambidexterity. Armand Hatchuel's work (Segrestin et al. 2017) has contributed to the idea that learning and organisational dynamics are tightly bound, proposing a theory of collective action where in a post-decisional paradigm design-theory-based management tools – such as C-K theory (Hatchuel & Weil 2002) – can coordinate knowledge and relationships. In this perspective, the issue of managing ambidexterity from the perspective of unconventional decision theories embedded in a management tool could allow endogenising the unknown, its discovery process and deal with the tension of competing objectives of exploration and exploitation to support the regeneration of the existing based on threats and opportunities valued by non-expected utilities such as regret. This instrument would be an instrumentation of a dynamic capability to explain and support underlying dynamics of contextual ambidexterity (O'Reilly & Tushman 2007; Birkinshaw & Gupta 2013).

## 2.5. Research questions

Based on our literature review, we propose to discuss the following questions:

- Why decision models underlying organisational ambidexterity can fail?
- Can potential regret of imagined prospects support a better tension management between exploration and exploitation objectives?
- What management tools could support decisional ambidexterity?

## 3. Methodology and data

This research relies on a case-study analysis (Eisenhardt 1989; Yin 2009) with a logic of anomaly (Siggelkow 2007) of two product concepts for aircraft equipment developed by Zodiac Aerospace (ZA). Data was investigated through analysis most of projects documentation and semi-directive interviews with the projects teams and stakeholders among the business units.

### 3.1. Validity of the case-study context: aircraft industry's ambiguous incentives for radical innovation and ambidexterity

The aircraft industry in the last decade has been facing a shift in the nature of uncertainties forcing market players to change their strategy. First, the major aircraft manufacturers seem, for now, to stop proposing completely new aircraft platforms. Previously, platforms would imply the alignment of design strategies for a least a decade naturally feeding suppliers' income and engineering effort. Markets would be granted easily between the few major players in a quasi-duopoly configuration. A particular feature of the cabin aircraft market is that it a business-to-business-to-consumer (B2B2C) situation; the consumer being the airline (aircraft operator) with its pilots, cabin crew and its end-customers (passengers). The airline's dynamics, its marketing and brand management has shorter cycles (5 years) than aircraft platform engineering (10-20 years). Naturally, cabin equipment manufacturers would play on both grounds to have supplier-furnished equipment (SFE; on aircraft manufacturer's approved catalogue) and buyer-furnished equipment (BFE; directly bought by airline and installed before aircraft delivery). A dominant design (Utterback & Abernathy 1975; Abernathy & Utterback 1978) is then imposed on an architectural level (interfaces and contingent cabin elements) stabilising certain specifications. Orders and subsequent engineering design efforts are then mainly driven by airlines and their possible design office looking for differentiation

and to retrofit their fleet's cabins. So despite strong demand for developing new product & service concepts for an enhanced passenger experience, the product development conducted by the equipment manufacturer remains locked by a set of design constraints given by the aircraft platform architecture and other uncontrolled interfaces. For instance, design briefs are usually distributed separately and taken care of by different cabin equipment manufacturers, which complexifies the choices to be made to meet expected modularity (Sanchez & Mahoney 1996; Sanchez 1995)

Second, the safety regulations and industrial standards reinforce the dominant designs with highly stringent constraints to protect passengers from potential wounds that may occur in regular flight situations, but also from fire and impact (head, neck and body injuries). Public funding opportunities exist to meet with those requirements by developing new materials and designs. And it is reinforced by most of the whole industrial effort (Abernathy & Utterback 1978). However, the European Aviation Safety Agency (EASA) has recognized in 2015 the certification had become far too demanding and costly; and it should become in the coming years 'risk-based' whilst guaranteeing same safety levels. It would imply a shift in the Design Organisation Approval (DOA) and more room for innovation as long as safety is maintained.

Consequently, as the incentives to radically innovate are ambiguous, cabin equipment manufacturers work on optimizing their cost structures to deliver orders (logic of exploitation (J. G. March 1991) with top-down inflows of knowledge (Mom et al. 2007) and a series of mergers & acquisitions have started to consolidate and create synergies and economies of scale. See for instance recent series from B/E Aerospace, Rockwell Collins and United Technologies Corporation. Moreover, alliances exist in the context of joint research programs to support incremental innovations (Lavie et al. 2011) through public funding structures. A review of the past years' issues of Aircraft Interior Magazine and Aviation Week gives also a taste of steadiness of cabin products architecture, despite numerous incremental innovations

(additional functionalities from connectivity and *Internet Of Things*, new stronger/lighters materials, mood lighting, etc.). Some radical concepts have emerged from several players relating to new uses of cabin space (see for example: Airbus $A^3$ Transpose proposal for a modular cabin, urban mobility or supersonic flight return). Yet from an industrial readiness viewpoint those concepts may lie quite far in the future, adding to the uncertainty and unknown of what would be the next architecture for the aircraft industry.

### 3.2. Relevancy of the two projects for contextual ambidexterity and their descriptors: cabin waste management and business class seating

The cases were selected from two different units of ZA in the cabin equipment domain as they are representative of the nature of projects conducted in the organisation. ZA has a long history and track record of successful innovations in the industry. Numerous awards were granted for product designs and several innovative airlines rely on ZA capabilities.

*Cabin Waste Management (case 1)*

The project was initiated internally by a standalone team, hosted by group management, whose purpose is "to make boundary-spanning proposals" as requested by the ZA's Vice-President. The team reports to Business Development director and is constituted of 7 designers and engineers with several years of experience from different ZA business units. The "cabin waste management" topic was identified through their regular contacts they have with aircraft manufacturer and airlines in their local industrial ecosystem. The methodology of Design Thinking (Brown 2008) was deployed by d.school educated team members and used with additional project management features (Ben Mahmoud-jouini et al. 2016). In addition, several workshops were organised to share discovered user and internal knowledge for bottom-up and horizontal knowledge inflows (Mom et al. 2007), and to create social acceptance among their internal clients: marketing and engineering department of business

units relevant for cabin waste management. A lot of effort was put into the user value exploration and knowledge gained through Design Thinking methodology; these takeaways were presented and shared with topic-concerned business units. The concepts were ranked, selected by the team members and validated by the Vice-President, and were all presented to relevant business units for further development with their support. These internal clients are mostly organised with traditional engineering activities for SFE/BFE as explained above, and R&T activities mainly addressing incremental innovation and a few disruptive concepts with tight bounds with airlines aiming for differentiation.

Overall we have a separate structure in charge of exploration through user and customer empathy to create synergies between business units on federating concepts, with an objective of exploitation for cross-business-units product development. A ambidexterity mode that we could identify as contextual at the firm level (Gibson & Birkinshaw 2004) with a deep concern for the variety of sources to innovate from (Benner & Tushman 2015; Lakhani et al. 2013). In addition to that, the team manager thanks to his experience in the company has a dense network (connectedness) and with his team are able to identify what has to be addressed in different business units to formalise and meet centralisation routines (Jansen et al. 2006).

*Business class seat platform engineering (case 2)*

Initially, the project started as a Research & Technology (R&T) initiative to design a new business class (BC) seat architecture that would facilitate packaging and installation activities for the internal engineering purposes and final assembly line operators. The team generated numerous alternatives and the possibility to define a generic platform for BC seat emerged. The core element would meet the initial brief but require to define further the genericity envelop to allow future module sub-assemblies design. As the modularity was worked out (Baldwin & Clark 2006; Sanchez & Mahoney 1996), sales & marketing were in discussion with a client (airline) who had requests meeting some specifications of the *in progress* BC

modular seat design. R&T and Development Engineering resources were then allocated to support the bidding and customer requirements definition with the airline and third-party design office. Traditional engineering practice for BC aircraft seating industry is very much customer-driven for branding and differentiation purposes. Usually, one would speak of "bespoke" seats and forces designs to be reinvented for almost each BFE airline retrofit opportunity. In a way, the organisation is not fully mechanistic (Burns & Stalker 1961) despite strict regulations and imposed quality and project practices standards. Along the development, complexity increased as the product was to be fitted on a new aircraft platform for the engineering team. The platform's variability influences directly through determining parameters such as cabin floor fixtures and cabin volumes. Furthermore, safety regulations evolution demanded additional and more demanding testing, requiring the design to gain in strength and integrate adapted features.

Here, we have an internal exploration regime isolated from operational activities but flexible to feed the R&T team with valuable knowledge for the modular design and its strategic intent for the business unit (Sanchez 1995; Sanchez & Mahoney 1996). When it comes to exploiting, we have a rather internal sequential mode (Brown & Eisenhardt 1998) but the team is reshaped – in an internal change perspective – to integrate the product development mode, so we also have a flavour of contextual ambidexterity (Gibson & Birkinshaw 2004). Moreover, exploitation of the modular architecture is performed with costly flexibility requirements as customer's design office, aircraft platform and safety regulations adding to the design and engineering complexity. This openness required from the team echoes the displacement of the locus of innovation (Benner & Tushman 2015).

*Rich cases for contextual ambidexterity and managerial capabilities*

The two projects are then relevant for: (a) decision pattern generated by managers for exploration/exploitation transition in order to pioneer or to adapt quickly enough with novel

product/service concepts, (b) generation of rich and numerous concepts to decide on their expected utility for the business and (c) understanding of *a posteriori* valuation of (non)chosen concepts for further exploitation/exploration.

### 3.3. Descriptors for decision-making in support of exploration/exploitation

In order to track the decision pattern to commit to the development of certain product/service concepts, we used a C-K mapping (Hatchuel & Weil 2002; Hatchuel, Le Masson, et al. 2009; Hatchuel et al. 2016) rooted by the dominant designs traditionally engineered by business units. This allowed us to *measure* were the proposed concepts where situated and which ones were selected compared to dominant designs (Magnusson et al. 2014; Hooge et al. 2016). Valuation and selection were recorded in documents and questioned during interviews, for instance we searched for reasons why some concepts or design paths were discarded and simultaneously we asked for the positive arguments that may not had been formalised as we were looking for signs of regret. In other words, we were looking for which different/unseen states of nature could support the enactment of certain concepts despite given underlying hypotheses; the idea was then to look for signs of ambiguity requiring further design activities to change the decision situation.

Exploration activities were then detailed through the C-K mapping and the *ad-hoc* decision-making and mobilised managerial capabilities to articulate the transition to exploiting concepts for product development. The interviews allowed us also to understand the valuation of selected concepts, their relevancy for day-to-day business, and signs of regret and prospects for further exploration.

### 3.4. Data collection

Both projects were investigated with the same data collection process. The authors had full access to project documentation and several interviews were conducted with project teams and stakeholders. A reverse engineering approach helped building the history of the projects with the support of several drawings, presentations, meeting minutes with validation from team members. The purpose was to trace which decisions were made that influenced the selection of concepts design for the clients. As explained in the previous paragraph, C-K mapping were used and helped to formalise valuation parameters: positive/negative for exploration and exploitation and where regret was stressed.

## 4. Results

### 4.1. A selection bias despite a rich exploration

Both projects despite their different nature and organisational context:

- Case 1: aiming for high user-value products/services unaddressed or ill-addressed by existing dominant designs;
- Case 2: aiming for a modular design development for a line of products.

Numerous concepts were proposed and referenced in a C-K mapping. Five groups of concepts were carefully detailed by the team over 9 design paths for the B/C seat project. For the waste management project, 12 groups of concepts were designed by the team over 33 options. In both cases, the additional group of concepts were envisioned thanks to C-K theory as it helps with simple heuristics in the concept space to partition concepts into new ones, it is also part of the reference tool (Hatchuel, Le Masson, et al. 2009; Hooge et al. 2016). The difference in number comes from the fact that the design briefs were tackling different portfolios of products so that larger combination or at least links could be made between them; so in the

B/C seat case the problem was isolated to a standalone equipment (seat) with no interaction except for the passenger and the cabin floor as they were aiming for high modularity within their design space sanctuarised by safety regulation, certification standards and organisational boundaries in the industrial ecosystem. Whereas in the waste management case, concepts were designed by taking into account the full variety of equipment in the cabin (galleys, inserts, trolleys, lavatories, seats, cabin dividers, etc.).

In case 1, a ranking spreadsheet was defined by the project team based on the trio: Desirability, Viability and Feasibility. The categories were amended by value propositions relevant to the waste management topic and a category relating to ZA's scope. Scoring was conducted by members, individually, business units as potential candidates to develop concepts were identified. A final round of selection and valuation was discussed by the Vice-President, as he is the chief party for the team's activity. Emphasis was then stressed on strategy as concepts were in between organisational lines and would require close collaboration between existing business units to address topics that are at the frontier of their design space and engineering scope. For example, by opposition with today's sales channel and design requirements prescription, inserts/trolleys/galleys are designed and engineered by different business units. Some concepts identified looked indeed for synergies between these quasi-independent pieces of equipment for greater user-value as justified by the empathy developed with cabin crews. All concepts were supported by strong user-value and effective interest from airline personnel; yet all required a certain level disruption with existing design & engineering rules, marketing perspectives and organisational boundaries. Selected concepts, with emphasis on the Vice-President's shortlist, were presented to business units' managers and engineers, with strong background knowledge to justify and remember the value and potential of concepts as seen in previous workshops. However, despite recognition of the user-value and airline's discourse, most of concepts were discarded even those close

enough to dominant design. To safeguard concepts and buy some time, some concepts were transformed into provisional patent applications before business units would effectively start working on these. Even though the decision-making took into account criteria stemming from exploration and exploitation, it seems the selected prospects were not suitable enough to lead to new product development or clear further exploration activities for business units despite supported strategic views and user-value recognition by all stakeholders.

In case 2, R&T engineers deeply explored the constraints behind the packaging and installation issues of B/C seats. The design approach turned into the necessity to have a central and modular base frame for all sub-elements of the seat. Options were considered and discarded based on existing patents and designs in the seating market. All five concepts were turned into digital mock-ups, underwent several redesigns based on numerous meetings and valuation from team members (engineering, industrial design and marketing); a shortlist of preferred concepts also underwent numerical crash test as it is the main determining criteria. However, the design had some interesting features in terms of clutter and greater freedom for customization and living space design which raised a lot of interest among marketing/sales team. The project was discussed with a major airline that awarded a contract for a new aircraft platform (i.e. new interface to be designed and layout arrangement considerations given aircraft manufacturer). By doing so, the project became prescribed by the airline's requirement, so the proto-modular approach and exploration was cut short by a product development management. Consequently, the product was halfway between modular equipment and bespoke B/C seat (dominant design). This hybrid unfortunately raised several engineering issues that demanded a lot of resources allocation to deliver the product on time. It implied new design and engineering rules that revealed unexpected mechanical behaviours and mitigation issues as specifications were gradually frozen by the customer. In addition, a new safety regulation was imposed which translated into higher constraints on certain design

parameters. So, the genericity and robustness/resilience (Maes & Dann 2017) that originally aimed by the project was partly jeopardised by a reallocation to short term exploitation objectives. We had then here an exploration activity with strategic intents for modular design that would also have the engineering and marketing activities to be reshaped to the designed modularity (Sanchez & Mahoney 1996; Lakhani et al. 2013). Nevertheless, as a potential lead-user (von Hippel 1986) had awarded a contract where the modular concept could fit, the exploration efforts were channelled into a bespoke design without leaving enough room to benefit from the original modular intent and that lead to an ill-defined concept which may be have complicated engineering activities to meet the requirements.

### 4.2. Paradoxical signs of regret to avoid forcing exploration into exploitation

With the support of the C-K mapping and interviews, we questioned why some design options were not selected or why some hypotheses were not challenged to open new design paths. These underlying assumptions were ranging from design rules taken for granted, to product interfaces up to regulations/certification constraints where we have a stake in it. Those discussions raised several comments such as: “They are short-term NPV driven so they won’t see the value of projects without clients and taking more than a couple of years” (NPV = Net Present Value). Paradoxically, business units sincerely acknowledge the potential of presented concepts in several terms: high user-value, desirability, user pain removed, harmonisation between products, avoiding reinventing the wheel, non-recurring cost reduction, etc.

In case 1, the team developing the concepts was rather disappointed that some of the ideation sessions they had with business units were not as creative as those conducted on their own. As a matter of fact they were very close to the dominant design, or fixated by their designed products (Agogué et al. 2014; Gillier et al. 2016). Some concepts were transformed into provisional patent applications, yet no budget allocation was made by business units to isolate

resources to work on these worth of interest concepts. In parallel, the team reported that two concepts were on display at trade shows by minor competitors; they were incremental innovations that remained very close to dominant designs. However, some features of concepts were kept alive and disseminated across business units thanks to the team manager whose place in the organisation and network across the industrial can circulate ideas. But above all, he extracted from this project and previous ones, a recurring generic concept that could be twisted to address different federating topics for the ZA business units. It has a potential to generate new use-cases for passenger experience and crew activities, but also goes beyond the ZA established design space. A new project was launched including technical investigation and market testing with airlines to test viability of the concept. By doing so another round of exploration activities was launched for the team with clear exploitation objectives as potential airlines customers were kept in the loop, with buy-in from business development activities. Senior management was crucial as resources were allocated in a disconnected way from business units to support exploration and channel discussions with airlines.

In case 2, the case for a modular BC seat is recurrent topic for program management, marketing and design/engineering departments, and yet it was never done properly on any seating class. The net present value evaluation was made and despite there is no doubt that the first modular product development is more expensive than a one-shot development, it reduces non-recurring cost in the long term for the product line stemming from the modular approach as the engineering effort is conducted. The authors performed a rough calculation based on the cost evaluation methods for program management and despite the launching investment; it is financially more interesting to do so compared to the average budget variance of the actual product development. The latter is being usually attributed to customer requirements changing (contract management) and other engineering mitigation issues. Moreover, we must stress the

fact that it appears that no single player in the aircraft seating business has offered a full modular seating solution for business class. The modular design is then forced into exploitation without being able to carry its original strategic intent for the firm and the industrial ecosystem. The business unit has as a matter of fact launched again projects on modularity as the exploitation regime was not able to insulate sufficiently the valued explorative features (e.g. non-recurring costs balanced over novel product line). We have found traces of modularity projects for more than ten years in the firm without a proper outcome.

Finally, in both cases, we show that the transition from exploration to exploitation with the support of an *ad-hoc* decision-making processes reflecting the way tension are managed between competing objectives was not fully satisfactory. Selected prospects, and non-selected ones, were left on a side or partly jeopardised. Only some features were extracted to feed knowledge inflows for the business units or a potential new cycle of exploration activities thanks to key managers. It appears in some way the benefits of ambidexterity did not outweigh the costs (O'Reilly & Tushman 2013, p.333); or it didn't at least for one transition. Regarding the team in case 1, it has been greatly reduced after 3 years of existence, so their exploration activities have taken another flavour. The modularity topic for BC aircraft seating is present in every roadmap with a readiness level below 3 (Technology Readiness Level). We may ask ourselves what could have been done to really outweigh the costs and value the extent of exploration/exploitation transition.

### 4.1. Contouring a management tool

As explained above, interviewees did report regret for not being able to promote further their initial intentions through existing management tools such as accounting and reporting systems. Some concepts or features leave traces after they have been discarded in the

decision-making process and resource allocation. These become part of the design and engineering body of knowledge in respective business units with no guarantee of surfacing again. Identified prospects not being exploited *per se*, or with some rework by business units become regret for their originators. During interviewees they struggled to justify clearly what was missing to better articulate the transition. They all reported that it had such strategic weight for the firm that it should be treated at a higher hierarchical level. The question of timing as first-mover was discarded, as the market dynamics tends to guarantee market shares; rather they stressed the high uncertainty associated with interfaces that may not be as easily controlled: market prescription with its design language, regulation evolution and other equipment design footprint.

Both cases reveal an absence of a real practice to support a decision-making that does not fit operational constraints (mainly short-term profitability), and dominant designs. Paradoxically, a strategic move from the competition, a customer or unexpected events may dramatically change valuation of a project shaped to the operational decision-making. By not being able to think of other forms of utility or go beyond delay devices such as provisional patent applications, or even other forms of contract management to safeguard some design choices, their efforts transform into regret. The high uncertainty and unknown are here associated with engineering design parameters and market prescription dynamics. They are also given as exogenous parameters and sometimes hidden as underlying hypotheses that are not being revised as part of dominant design situation.

In case 1, due to the team being at the corporate level and not being backed up by operations such as manufacturing facility, they have put a lot of effort into translating, reworking the selected concepts and outputs of their user-exploration through Design Thinking to trigger a genuine decision to invest on the concepts specially after the final handover with the Vice President’s input. The aim was to complement what expected utility for exploitation could not

foresee and try opening paths for future decisions to be made on their prospects. In case 2, the original modular design was not able to be safeguarded through the exploitation phase, and may have complicated meeting customer's requirements. So it didn't even benefit a proper learning on modular design for R&T and Development teams.

In other words, the concepts being forced through the ambidexterity transition with available managerial capabilities diminished the performance for exploration and exploitation separately. Yet, it also gave birth to bricolage activities (Cabantous et al. 2010, p.582) to support and adapt their prospects for utilities that are not able to clearly state given the available conventional management tools, as they appear to be *a posteriori* in the realm of regret.

Moreover, verified competition threats, technical systemic threats, high levels of uncertainty and unexpected events, these ecosystem parameters are only discovered on the spot and fed into a risk management tool. We may ask ourselves if it would be preferable to pay the price of the unknown when it becomes observable by existing means rather than to extend and allocate resources from the awareness and potential regret built through the early stages of exploratory projects.

## 5. Discussion and conclusion

First, we have elucidated an *ad-hoc* decision making process occurring on top of exploration activities when trying to push designs into an exploitation regime. It is a means of sensemaking (Weick et al. 2005) for the team involved in the exploratory project and associated design efforts. This process comes with a strong selection bias anchored by the dominant design (Abernathy & Utterback 1978) thus altering forms of utility associated to the objects of decision making. Second, regret, as a non-expected utility (Quiggin 2014; Loomes & Sugden 1982) is reported as teams following modes of ambidexterity. Selected exploratory

prospects were skewed when being treated as exploitation objects. Third, the cases have shown that despite recognised potential value and ex-post regret, teams struggle to find support among management tools. They make attempts to value their prospects in different ways but still struggle to find an efficient exploration/exploitation articulation with existing and *ad-hoc* decision-making processes as they try to have their prospects in a state where regret may be valued for high uncertainty and unknown factors and avoiding pure exploitation or exploitation. We advocate that performing ambidexterity by the book may kill the innovation held within exploratory prospects due to the absence of unconventional decision-making processes in management capabilities. These prospects should rather be managed in a *quantic state* that is neither exploration nor exploitation but a dynamic orchestration to benefit from exploitation for exploration and vice-versa. It may be a branch out, refinement or differentiation from contextual ambidexterity (Gibson & Birkinshaw 2004), as we are not putting exploration/exploitation "as poles on a continuum". They are on two separate dimensions for which trying to reach contextual ambidexterity requires reviewing decision theories encoded in management capabilities. By opposition, bi-stability of exploration-exploitation may prejudice a separate regime on its own.

## 5.1. Deciding with other utilities

The cases show it is rather complex to formalise non-expected utilities such as regret and make a case for these in the organisation. They face a long history of management tools that are a mirror of rational theories of choice (Keeney & Raiffa 1979; Raiffa 1968; Fourcade & Khurana 2013). Consequently, extreme uncertainties and unknown parameters are not fully endogenised in the decision-making process. Endeavours are made in *divergent* phases through different practices such as Design Thinking or envelop characterisation for modular and robust design, but these are partly jeopardised by exploiting reflexes encoded in the

organisation. Other attempts were made to keep some of the projects alive long enough whilst hoping they would find a home. But whilst surveying the business units, only hints of the original prospects remain, or where started again altogether like in the case of seat modularity.

Tools such as net present value calculation do not take into account the unknown or at least means of uncovering unexpected events. They only consider identified risk taken formalised by experience, "lessons-learnt" and other forms of learning. Unfortunately, they do not reflect in any form ways of uncovering and endogenising the unknown, forcing to challenge the order of preferences, underlying hypotheses. They don't even consider future prospects as long-term planning. Conversely, having public funding to support R&T activities or consortia (Sydow et al. 2013; Le Masson et al. 2012) are means to create decision situations that are unconventional compared to expected utility models (Le Glatin et al. 2017).

## 5.2. Managing the tension of competing objectives

As discussed in (Birkinshaw & Gupta 2013; O'Reilly & Tushman 2013) deciding if one should invest more in exploitation or exploration for better performances, the debate may not lie in a continuum between two patterns. They advise that allocated projects should be measured on two different scales, but it still leaves open the question of the transition between a regime and another. The five whys remain opened questions as there is no clear understanding of managerial capabilities set in motion for such transitions. In this paper, we have endeavoured to show examples of contextual ambidexterity in the complex strategic environment of aircraft cabin equipment. It appears pushing concepts through a regime to another may be not satisfactory. We proposed with concern for extended decision theories, that non-expected utilities could support a *quantic state* for concepts where they contribute to the two competing objectives simultaneously; to avoid forcing a state or another. It is not a matter of incubation and structural separation as proposed by several authors (Tushman &

O'Reilly 1996; Christensen 1997), but rather a question of internal regeneration of the organisation (O'Reilly & Tushman 2007), or internal change management, through management tools supporting non-expected utilities decision theories.

The case of making decisions based on non-expected utility allows covering rational theories, as a special case, in addition to other forms of utilities such as regret (Starmer 2000) with the possibility for instance to reverse preferences. By extending the endeavours reported in the different cases, hints of what a management tool supporting their collective action would essentially raise awareness on the unknown and its value:

- Positive: increasing returns for immediate exploitation, optimising resource allocation, considering lobbying and marketing activities, designing imagined favourable situations
- Negative: Black Swans and systemic disturbing elements undermining dominant designs

In (Macmillan 1983, p.17) several pre-emptive strategies are discussed around the idea that one should shape one's luck: "Good generals make their luck by shaping the odds in their favour and by being able to spot and rapidly capitalize on every emergent opportunity created by the mistakes of their opponents, or by the good fortune they have helped to shape". This approach largely echoes Shackle's viewpoint notably with the idea of potential of surprise (Shackle 1952). It also adds to the idea that one will design the next decision situation based on more favourable consequences that can also be designed. Economic vigilance is then required to dynamically change the course of action or at least to design in a robust and resilient manner to avoid being disturbed by the unknown. It is in that sense that forcing concepts into one of the two ambidextrous regimes and managing the transition, may lead to unnecessary costs and budget variance, especially in a context where there is shift in the locus

of innovation (Benner & Tushman 2015) and the generation of choices and knowledge are made through different modes (decentralisation, open innovation, alliances) and moving organisational boundaries (Lakhani et al. 2013).

A management tool dedicated to ambidexterity, as a cognitive extension for decision-making (Heath et al. 1998), that would keep and value the tension of exploration/exploitation without forcing the transition, could then allow the following:

- Identification of mixed projects that contribute simultaneously to competing objectives on a Pareto front by considering (non)-expected utilities. Consideration on how the frontier could be shifted: architectural innovation for instance (Birkinshaw & Gupta 2013).

[Insert here Figure 1]

- Using exploitation opportunities to nest exploration prospects features
- Driving exploration prospects with exploitation objectives, as a reference point to design from (Heath et al. 1999)
- Repurposing of design features across project portfolio as utilities differ in nature and time among projects
- Regeneration of organisational rules (design, engineering, sales and marketing)

### 5.3. Perspectives

The portrait given in the previous may rise questions on what sort of organisation could support such management tool. Yet, calls have been made such to understand forms of continuous innovation (Steiber & Alänge 2013) for instance with a case for Google Inc.. However, we may question why the allocation of resources for “Pet Projects” for exploration contributes to its overall performance (exploitation and exploration separately), as its core

business has mainly become internet advertisement in parallel to a proliferation of numerous products/services that struggle find a place in our markets and societies.

In contrast with our aircraft industry cases, the automotive industry has been practising modular design in a high competitive and dynamic context, and cases of multilevel integration of exploration units (Mahmoud-Jouini et al. 2007). Parallels could be drawn to understand the importance of connectedness within the firm, and alliances with suppliers and customers to support exploration and exploitation. In the space industry, project that do not really fit and circulate through the organisation also reflect the difficulty to manage the competing objectives (Lenfle 2016) and its "floating nature".

Forms of organisations such as adhocracy (Mintzberg & McHugh 1985) are possible bearers of such management tool, yet in an internal change perspective, we believe it could be encoded deeper in organisational routines as an augmented version of common operational concerns as in the idea of a *generative bureaucracy* for instance (Hatchuel, Garel, et al. 2009). The tight relationship between the topics of organisation theory such as the different modes of ambidexterity as decision models encoded in management capabilities tends to support the idea it cannot remain a standalone theory as the nature of decisions is a determining factor.

Finally, this constant renewal recalls lean start-up modes (Ries 2011; Blank 2013) and effectuation (Sarasvathy 2001) as it can be implemented in the start-up environment where organisational rules and routines are far from being settled. However, there is a gap with our discussed cases situation with no strong incentive from the ecosystem, rather long economic cycles, strong dominant designs, and yet crucial threats and opportunities for first mover and early follower.

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## 7. Figures and tables

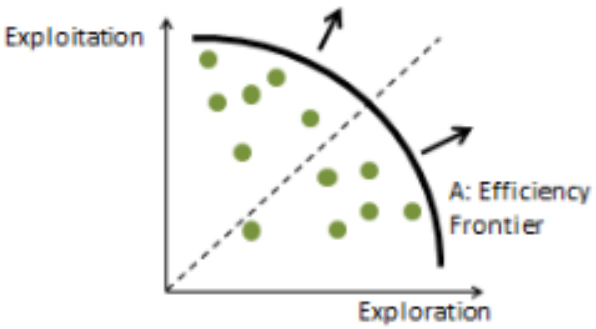


Figure 1 - Different Approaches to Managing Ambidexterity (Birkinshaw & Gupta 2013, p.295–Fig.2)

# Appendix A4

# Paper 4: Designing decisions in the unknown

**Abstract** This study examines how design theory enables to extend decision-making logic to the 'unknown,' which often appears as the strange territory beyond the rationality of the decision-maker. We contribute to the foundations of management by making the unknown an actionable notion for the decision-maker. To this end, we build on the pioneering works in 'managing in the unknown' and on design theory to systematically characterize rational forms of action in the unknown. We show that action consists of designing decisions in the unknown and can be organized on the basis of the notion of a 'decision-driven design path,' which is not yet a decision but helps to organize the generation of a better decision-making situation. Our decision-design model allows us to identify four archetypes of decision-driven design paths. They enable us to discuss the variety of known organizational forms that managers can rely on to explore the unknown.

**Purpose** This article discusses the need to overcome the decision paradigm by embracing design theories to extend the latter to the unknown. Four archetypes of decisions based on design paths are presented corresponding to different forms of collective action: learning, performance and organization. Compared to the published paper, we extend the model with organizational theories by integrating organizational constraints and hypothesis in the decision design reasoning to generate and execute alternatives/decisions to be managed in exploration/exploitation modes.
Presented on several occasions by Pascal Le Masson, debated with the researcher over the PhD's second year. After a first round of reviews, a modified version is in press in the European Management Review.

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# Designing Decisions in the Unknown: A Generative Model

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*This study examines how design theory enables to extend decision-making logic to the 'unknown,' which often appears as the strange territory beyond the rationality of the decision-maker. We contribute to the foundations of management by making the unknown an actionable notion for the decision-maker. To this end, we build on the pioneering works in 'managing in the unknown' and on design theory to systematically characterize rational forms of action in the unknown. We show that action consists of designing decisions in the unknown and can be organized on the basis of the notion of a 'decision-driven design path,' which is not yet a decision but helps to organize the generation of a better decision-making situation. Our decision-design model allows us to identify four archetypes of decision-driven design paths. They enable us to discuss the variety of known organizational forms that managers can rely on to explore the unknown.*

*Additional supporting information may be found in the online version of this article at the publisher's website.*

**Keywords:** unknown; design theory; decision theory; generativity

## Introduction

In a paper recently publish in *Science* (Bonnefon *et al.*, 2016), the authors study how an algorithm should 'decide' when confronted with a question such as 'If the brakes have failed, should the driver system of the car kill the pedestrians crossing the street or save the pedestrians by crashing the car into a wall, thereby killing the occupants of the car?' One can immediately understand the dilemma, and can be tempted to find an alternative option that is unknown to date, but would definitely surpass the two options presented.

This example underlines a basic issue in management science: rational choice is often taken as a given, but there are sometimes 'unknowns' that are beyond rational choice and could deeply influence the rational choice. Hence, the general question is can one extend decision-making to the unknown to rationally support the creation of options?

This issue has largely been addressed by research in strategic management and risk management (Wideman, 1992; McGrath and MacMillan, 1995, 2009; Pich *et al.*, 2002; Cunha *et al.*, 2006; Loch *et al.*, 2006, 2008; Mullins, 2007; Weick and Sutcliffe, 2007; Sommer *et al.*, 2008; Rerup, 2009; Feduzi and Runde, 2014; Feduzi *et al.*, 2016). The issue of the 'unknown' is famous both in professional circles (Wideman, 1992) and in the work of decision-theory scholars (Miller, 2008). Studies have contributed to clarifying what is 'unknown' in relation to decision-making: decision-makers are confronted with 'the unknown' when they are *confronted with alternatives and events that were not imagined and taken into account before and still might impact them to a considerable extent by radically changing their decision situation*. More formally and more precisely, it has been shown that 'the unknown' corresponds to a type of situation that cannot be handled by the theory of decision-making (Loch *et al.*, 2006). The issue is *not* related to decision bias (a phenomenon that has largely been investigated), but to generation bias (a phenomenon that is, formally speaking, not included in decision theory).

As will be shown in the literature review, studies have described and addressed the challenge of managing the unknown: they have contributed to clarifying the goal of generating an improved decision situation and meeting the challenge of overcoming generation bias by presenting multiple ways to generate specific alternatives. However, they have failed to develop a systematic approach to the unknown and a structured map of the paths in the unknown that could contribute to improving the decision situation. Without such a formal framework, they tend to return, more or

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less implicitly, to 'decision-making in conditions of uncertainty.' Typical examples can be found in (Sommer and Loch, 2004; Loch *et al.*, 2008): in these papers, the authors explain that the issue stems from the fact that, in a decision situation, the actors cannot know all of the possible alternatives and states of the world, and explain that managing in the unknown consists of *discovering or generating* new alternatives and new states of the world. However, in the following paragraphs of the papers, the model they use is actually a *restriction* of an *ideal* set of alternatives and events, which is no longer a model of extension, but rather a model of *restriction*, which is well-known in decision theory. This restrictive approach precludes an analysis of all facets of the *generation* of alternatives and states of the world.

Hence, the aim of this study is to follow the program outlined by Loch *et al*. (2006, (2006, 2008) and (Feduzi and Runde, 2014) to develop normative models that can provide 'the standards for comparison and evaluation that are fundamental to the progress of both descriptive and prescriptive work' (Feduzi and Runde, 2014: 269). We are seeking *a model for the generation of new states of the world and new decision alternatives*. That is, we propose a formal model of the *extension of decision-making theory to the unknown*, or simply a model of 'decision design' in the unknown. The requirements for such a model can be listed: this extension should be formally consistent, it should contain the decision logic, it should help characterize and understand critical phenomena that occur when actors are confronted by the unknown, and it should lead to a discussion of a new organizational logic related to the unknown, making sense of the multiple forms and notions that have been identified in contemporary management of innovation and could actually be related to different types of 'management in the unknown.'

As will be described in the literature review, one of the key issues in such a research program is to develop a *model of generativity that is adapted to decision-making*. This is possible because of the great advances in recent years in the field of innovation management, wherein researchers must analyze situations where collective actions, organizations, and strategies consist of addressing the issue of previously unknown products, services, business models, and competences. Hence, the findings of recent studies on innovation management, and more precisely those on design theory for innovation management provide us with a model of generativity. Can it be applied to decision-making? In this study, we show how models of generativity developed for innovation management can actually be used for *decision design in the unknown*, that is, the generation of 'better' decision-making situations, and thus can enrich the field of decision-making in the unknown.

This paper follows a classical construction: literature review, methodological approach, construction of the model, results of the model, and discussion. Hence in the next part, our literature review identifies a twofold gap that should be bridged by a formal model extending decision theory to the unknown: (1) the model should formally (systematically) account for the various ways of 'broadening' a decision space; and (2) the model should help characterize the performance of this process in terms of 'comprehensiveness' (Feduzi *et al.*, 2016) and 'offsetting cognitive biases' (Feduzi and Runde, 2014). As we will show, while decision theory helped characterize 'selection bias,' our model should help characterize 'generation bias.' In the third part, we present our method and, in particular, explain why it appears fruitful to rely on design theory to model the extension of the decision-making framework to the unknown. Research has enabled the development of a basic science, design theory, that accounts for the unique phenomenon of design, namely generativity, and is comparable in its rigor, foundations, and potential impact to decision theory, optimization, and game theory (Hatchuel *et al.*, 2018). As a consequence, today, design theory appears to provide a promising way to model the generation of a better decision space from a given one. In the fourth part, we construct a formal model that extends decision theory to the unknown and present its main implications. In the fifth section, we present the results, i.e. we show how this model bridges our twofold gap. In the final section we discuss the results and present our conclusions.

## Literature review

### *The unknown as a limitation to classic decision theory*

As noted in (Buchanan and O'Connell, 2006), the history of decision-making could be considered to begin with prehistory. However, it was only after World War II that models of decision-making were progressively formalized and integrated into a general framework. Recent historians' studies have enabled us to understand the 'rational choice' movement that unfolded at the end of World War II and during the Cold War (Erickson *et al.*, 2013).

One of the greatest achievements was the formulation of a general theory of statistical decision-making under uncertainty, first by Wald (1939, 1950a, 1950b), which was then extended to the so-called subjective expected utility theory (SEUT) by Savage (1951, 1972), and also codified in management science by Raïffa and Schlaifer (1961) (see in particular the in-depth analysis of 'how homo economicus became Bayesian decision-maker' in Giocoli, 2013).

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According to this model, the decision-maker has to choose one alternative from among a set of available alternatives (actions) and each alternative will have certain consequences depending on which of the possible 'states of the world' occurs. These consequences have a certain 'cost' (or utility), and the decision-maker is able to assign a (subjective) degree of probability to each state of the world. In this condition, the theory predicts that there is a choice that optimizes the expected utility (i.e. minimizes the expected costs).

These studies propose a formal decision model that takes into account a certain type of 'unknownness,' namely, one that can be codified in probability terms. Economists have long been aware of the possibility of 'unknowledge,' or 'unknownness,' or uncertainty (Keynes, 1921/1973, 1937; Knight, 1921; Shackle, 1949, 1979, 1983). Uncertain events and uncertain consequences of choices were considered to be unknowns, but statistical decision theory under uncertainty integrates many of these 'unknowns'. This theory contributes to taming a certain type of unknown, namely, the type that can be reduced to uncertainty, that is, to subjective probability. This progress is illustrated by a series of papers published in the 1990s on the notion of 'unknowledge' in economics and in Shackle's work (Frowen, 1990b): the contributors show that certain types of 'unknowledge' identified by Shackle (Frowen, 1990a; Lachman, 1990; Loasby, 1990) can be integrated into decision theory (Hey, 1990). However, these works also show that one critical type remains: the 'residual hypothesis,' namely, the 'potential surprise,' the event that cannot be formulated and taken into account in the various states of the world. This is one type of unknown that is beyond the bounds of decision theory under uncertainty.

### *Challenging the unknown as a research issue in decision-making*

One consequence of formal statistical decision theory under uncertainty is the capacity to draw a line between uncertainty, which is manageable using decision theory, and the unknown, seen as the 'new frontier' to be explored by decision-making theory builders. The problem of the unknown (or unknown unknowns (unk-unks) or black swan events) has attracted considerable attention in the management literature in recent decades (Wideman, 1992; McGrath and MacMillan, 1995, 2009; Pich *et al.*, 2002; Cunha *et al.*, 2006; Loch *et al.*, 2006, 2008; Mullins, 2007; Weick and Sutcliffe, 2007; Sommer *et al.*, 2008; Rerup, 2009; Feduzi and Runde, 2014; Feduzi *et al.*, 2016). Of course, there are various understandings of exactly what unk-unks are, as explained by (Feduzi and Runde, 2014): authors can speak of 'events' or 'states,' and the term unk-unk 'extends variously to black swan events, unpredictable surprises, unimagined events, unexpected events, unforeseeable events, rare events' (Feduzi and Runde, 2014: 270). Following Feduzi and Runde (2014), we use a broad definition of the unknown that is relevant from the point of view of the decision-maker as modeled by statistical decision theory under uncertainty: (i) the decision-maker actually takes into account the states of the world, which are described with the minimum of detail that enables his/her to compute the cost associated with the consequence of his or her actions in the states of the world. Hence, when one speak of 'unk-unk' in relation to an 'isolated event' that has critical consequences, this implies, from a decision-theoretic perspective, that some *states of the world are unknown*; (ii) moreover, when the decision-maker uncovers unk-unks, he or she will also reconsider his or her initial set of actions. Further, the innovator or creative leader is described as being capable of imagining original, previously unknown courses of action (Nutt, 1993, 2000; Adner and Levinthal, 2004; Mintzberg and Waters, 1985). This implies, again from a decision-theoretic perspective, that *some actions are unknown*.

Hence, *from the decision-theorist perspective*, one can generally consider that the *unknown refers to all data relating to a decision-making problem that are not known by the decision-maker and that will impact the decision*. A decision-making problem can be 'broadened' or 'reframed' if one generates unknown states of the world or unknown alternatives that could change the decision. Thus, in this study, we address what we call the 'decision-challenging unknown': self-evidently, we are not interested in an unknown that would have no impact on the decision. The issue then is to identify the relevant unknown: can we know more about this decision-challenging unknown?

### *Early attempts to extend decision-making theory to account for the unknown*

Very early on, the theory of statistical decision-making was the subject of multiple critics that opened the way to exploring an extension of the decision-making framework. From the Carnegie School of Business perspective (represented by Simon, 1947, 1955; March and Simon, 1958; Cyert and March, 1963, and more recently by Levinthal, 1997; Gavetti & Levinthal, 2000, 2004; and Gavetti *et al.*, 2007), Simon (1955) describes the decision-maker as a 'satisficer' who cannot obtain *ex ante* all the detailed and well-structured information required by the theory of decision-making under uncertainty, and thus cannot act as predicted by the theory and so develops a search

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procedure that only leads to a 'satisficing' solution, rather than the optimal one. A second stream of work, involving the so-called behavioral decision theory, studied the nature of deviations that affect decision-makers (Edwards, 1954; Edwards, 1961; Tversky and Kahneman, 1974; Kahneman and Tversky, 1979; Bazerman and Moore, 2013).

Both streams of research studied facets of the process of hypothesis *construction and generation*. The studies in behavioral decision theory uncovered biases in the generation process: being attracted by too favorable hypotheses, we fail to generate alternative hypotheses, or we generate very similar ones (Fischhoff *et al*., 1977; Mynatt *et al*., 1993). The Simonian approach goes as far as working on models of thoughts describing discovery, addressing the issue of some forms of unknown beyond the known (Simon, 1977; Simon and Kulkarni, 1989), challenging Karl Popper's claim that 'there is no such thing as a logical method of having ideas or a logical reconstruction of this process' (Popper, 1959: 31–32; Simon, 1973).

In relation to generativity, the studies opened a new pathway to overcoming one of the critical limitations in decision-making theory: how to *construct* the 'residual hypothesis' (Shackle, 1983), that is, the list of alternate states of the world, and even the associated list of actions (Feduzi *et al*., 2016). Many of these studies were largely descriptive in nature, but also led to more prescriptive work aimed at developing techniques to assist the decision-maker to improve the quality of their decision-making. Some techniques are cognitive exercises that are recommended to enable the decision-maker to broaden the decision-making frame: 'consider the opposite' (Lord *et al*., 1984), or 'consider any plausible outcome for an event,' not just the opposite (Hirt and Markman, 1995), or take advantage of the variety of evaluation attributes when evaluating choices to screen alternatives and generate new ones (Miller, 2008; Larrick, 2012). Derived from Wason's (1960) discovery task, some methods systematize a process of alternative generation, either by disconfirmation (or eliminative induction, i.e., a Popper-style falsification; Popper, 1959; Farris and Revlin, 1989a, 1989b) or by counterfactual reasoning (Farris and Revlin, 1989a; Feduzi *et al*., 2016). Some methods are more organization-intensive, relying on a combination of alternative generation and knowledge acquisition. Hence (McGrath and MacMillan, 1995) examined the discovery-driven planning method, whereby decision-makers can discover alternatives and are told to keep a checklist to ensure that each assumption is flagged and tested as the process unfolds. Loch *et al*. studied complex learning processes involving parallel experimentation and selectionism (Loch *et al*., 2006), while Schoemaker (2008) proposed a method relying on forecasting and scenario planning.

*Two key issues from a decision-making perspective*

These studies identify two key issues that helped us to formulate our research questions:

1. *The design of a decision space as a new model of thought*. The studies characterize actors that not only decide, but also *design* the decision space. Of course, they *will* have to decide. Further, initially they are facing a decision-making problem, but instead of 'deciding,' they first engage in a 'generation' phase in which they switch from the initial problem to an extended one. Then, the issue becomes: how can one model this generation phase that transforms the initial decision space into a better one? The studies propose techniques to change the decision space, but there is no systematic approach to generativity. Hence, the first research question is: can one model the generation of a better decision space, i.e. can one model 'decision design in the unknown,' and, in particular, *how does a formal model of decision design help characterize the different directions of generativity?*
2. Rethinking performance criteria: *introducing comprehensiveness and generativity*. In examining the design of a better decision situation, the studies characterize what 'better' means. Two main ways to characterize the performance of the design process emerge. Some studies tend to increase the 'comprehensiveness' of the decision space, meaning 'the extent to which an organization attempts to be exhaustive or inclusive in making and integrating strategic decisions' (Fredrickson and Mitchell, 1984). Various empirical studies show a positive relationship between comprehensiveness and the performance of the firm (Eisenhardt, 1989; Priem *et al*., 1995; Miller, 2008). Another stream of studies considers that achieving full comprehensiveness of the decision space is less of an issue than resisting negative biases. These biases include 'functional fixedness,' 'satisficing,' 'selective perception,' 'concreteness,' 'anchoring,' 'availability,' 'confirmation bias,' 'predecisional distortion,' 'framing,' 'accessibility,' and 'focalism' (see Larrick, 2012: 461). More generally, we emphasize that this literature contributed to a great shift from the study of 'selection bias' (a classic focus in studies on decision-making) to 'generation bias' (for a synthesis, see (Cassotti, 2015)). Hence, there are criteria to evaluate how the generation phase led to improved decision quality. However, there is no systematic relationship between the techniques proposed in the studies and their performance. Hence, a second research question arises: *how does a formal model of the generation of a decision space increase comprehensiveness or defixation in the*

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*generation of alternatives, i.e. how does it help to deal with generation bias?*

### *Learning from innovation management: extending the decision framework*

To answer these questions, we rely on the results of recent studies on innovation management. The issue of the generation process has long been identified in innovation management studies. Innovation management has previously been influenced by decision theory, but also more recently by 'decision-challenging unknowns.' We summarize these two approaches below to show how they contribute to our twofold research question.

At the end of the, 19th century, Charles S. Peirce, who was working for the US Coast Survey, proposed to undertake research on the basis of the value of uncertainty reduction (Peirce, 1879; reproduced in, 1967 in *Operations Research*, 15, pp. 643-648). This risk-reduction approach was progressively extended to other innovation skills, for example, marketing was seen as a profession that was able to increase market knowledge to reduce market uncertainty. Some researchers went as far as applying option pricing methods based on the theory of decision under uncertainty developed in finance studies to the pricing of so-called 'real options' (Perlitz *et al.*, 1999; Fredberg, 2007). The decision-making framework was also used for new product development and planning (see, for instance (Clark and Fujimoto, 1991; Thomke and Fujimoto, 2000; Kerzner, 2013), and for the economic evaluation of projects and project portfolios with market and technology uncertainty. Assimilating a new product development (NPD) project to an investment, it was possible to apply the tools and techniques developed for corporate investment to NPD projects: return on investment, net present value (NPV), and expected utility.

In recent decades, building on the studies on 'exploration' (March, 1991), another stream of research has analyzed the logic of generativity in innovation management. The authors of these studies have proposed organizational models to enhance exploration capacity in a systematic way, using either a 'modular' process model (Sanchez and Mahoney, 1996; MacCormack *et al.*, 2001), wherein exploration and creativity can occur at the level of 'modular components' that are loosely coupled to the platform (Gawer, 2009), or a 'concept shift' process model (Seidel, 2007), whereby designers can explore a product concept not only in the fuzzy front-end phases but also later in the process, achieving a concept shift by modifying the concept's components. Numerous studies on radical and disruptive innovation have enabled researchers to characterize, analyze, describe, and prescribe the generative processes that help to deal with the unknown in a large variety of situations. They have proposed new criteria for evaluating the generation phases (see, for instance, Elmquist and Le Masson, 2009), and a large variety of new processes to deal with the unknown: new types of project management (Lenfle, 2016), new forms of competence management and value management (Hooge and Dalmasso, 2015), new ways to interact with the firm's environment through open innovation (Chesbrough, 2003) and open innovation in the unknown (Agogué *et al.*, 2017), new ways to acquire knowledge through absorptive capacity (Cohen and Levinthal, 1990; Lane *et al.*, 2006) and absorptive capacity in the unknown (Le Masson *et al.*, 2012a; Kokshagina *et al.*, 2017b), and new types of collaboration at the ecosystem level to face the unknown (Le Masson *et al.*, 2012b; Lange *et al.*, 2013).

As recently synthesized by (von Hippel and von Krogh, 2016), one of the critical issues addressed by studies on innovation management is related to the generation of 'need–solution pairs,' that is, finding creative solutions and discovering new needs. This corresponds to the generation of alternatives and various states of the world. However, these works focus mainly on the generation phase, which is also called the 'creativity' phase, and are only loosely connected with the decision-making issue. From an ambidexterity perspective, some authors even consider that they should be intentionally separated so that the decision criteria do not pollute the generation phase, that is, creating a generation bias by focusing too much on feasibility, marketability, and, more generally, existing dominant designs (Duncan, 1976; March, 1991; Tushman *et al.*, 1997; Andriopoulos and Lewis, 2009; Birkinshaw and Gupta, 2013). From a more interactive ambidexterity perspective, some authors suggest that there should be some form of overlap and interaction. However, questions remain, because it is not always clear how the *initial* decision space stimulates the generation process. Many studies consider an initial generation phase that ends with an evaluation phase wherein a decision occurs. Maybe the generation phase could be better *driven* by the initial decision data, and would help overcome (and not cause!) the generation bias?

### *Research questions*

Innovation management studies have enriched our knowledge, but have failed to resolve our twofold issue:

1. Modelling decision-making with generative options: can one model the generation of a better decision space, and in particular, how does this formal model help characterize the different directions of generativity, and does it help articulate creativity and decision-making? (RQ 1).
2. Designing performance-driven strategies consistent with the unknown: how does a formal model of the

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generation of a decision space increase comprehensiveness or defixation in the generation of alternatives, i.e. help decrease generation bias? (RQ 2).

Von Hippel and von Krogh (2016) suggest that we should rely on formal models of generativity, such as C-K design theory (C for Concept, K for Knowledge), to better characterize generation processes, performance, and organizational facets. We follow that path in the rest of this paper.

## Research method: integrating a model of generativity into the design of new decision spaces.

As noted in the literature, there are many studies on techniques to improve decision-making situations. However, the research gap is to propose a formal model that can *systematically* characterize the different ways to improve a decision-making situation. Hence, this paper is largely formal. This formal model helps to address cognitive biases and organizational issues. One of the consequences of this is that the paper relies on some mathematical symbols and formulae that may discourage some readers. We have tried to overcome this issue by keeping the equations to a minimal level and having one red thread example that should be considered as a simplified illustration of the general case treated formally. The technical details are presented in the Appendices that are available upon request from the editor. Our modeling research can be described in three steps as follows.

Step 1: from decision-making to the generation of decision spaces.

The general method followed by the Carnegie School and some of the strategic decision-making literature uses the classical model of individual decision-making under uncertainty as a benchmark, and analyzes how the 'real' decision-maker (or a behavioral model of the decision-maker) is often biased, and how some techniques might increase comprehensiveness or de-bias the decision-maker and help him or her to move closer to the 'ideal' situation (see Figure 1). This approach tends to underestimate the fact that, in this process, the so-called 'decision-maker' is actually *not* deciding, and the type of thought required from him or her during the process is *not* decision-making in the strict sense of decision theory. He or she is actually *generating* a new 'decision situation,' that is, the actor is actually following *generation reasoning*, and the generation is applied to a certain object that is not a new product (product innovation process) or a new service, business model, or idea (ideation process); it is applied to a decision space. In this study, we focus on this generation process.

Our method is as follows. We consider a given decision situation, apply a formal model of generativity, and analyze how this formal model modifies the decision problem (see Figure 1).

Applying this method raises two methodological issues: (1), what is our generative model? Below, we justify why we rely on C-K design theory; and (2), what is our model of a decision situation? Below, we justify why we select the Wald decision model as a model for the decision situation.

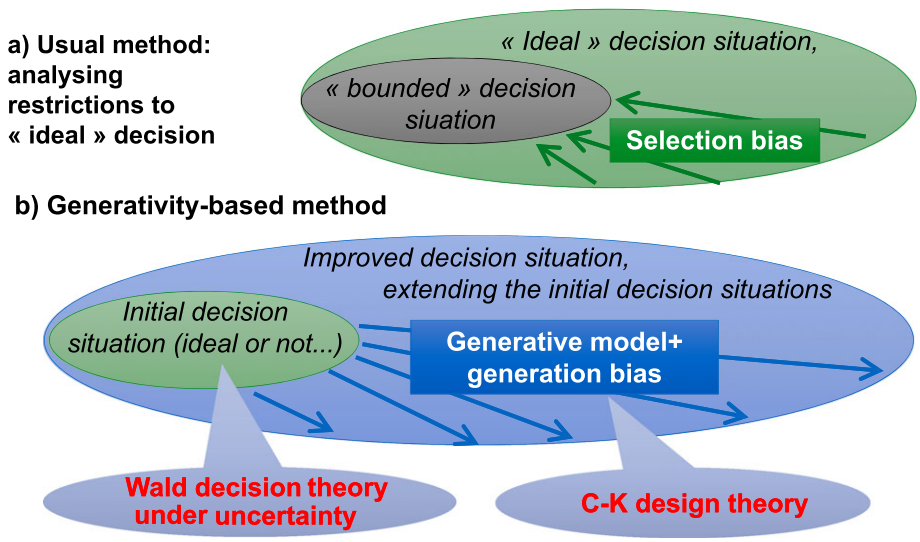


**Figure 1** Method: from the study of selection bias to the study of decision-oriented generativity [Colour figure can be viewed at wileyonlinelibrary.com]

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Step 2: introducing a formal model of generativity: concept-knowledge (C-K) design theory.

Regarding the first issue mentioned above, we rely on design theory. Research on design theory has contributed to the development of a basic science that accounts for the logic of generativity and is comparable, in terms of its structure, foundations, and impact, to decision theory, optimization, and game theory.

Today, design theory is a powerful academic field with several competing and complementary theoretical proposals, particularly the C-K design theory that we use in this study (Hatchuel and Weil, 2009). Some critical properties of design theory, in particular C-K design theory, are of particular interest in relation to our research questions.

Design theory considers a variety of forms of *generativity*. Formal models of design theory such as general design theory (Yoshikawa, 1981; Tomiyama and Yoshikawa, 1986), axiomatic design (Suh *et al.*, 1978; Suh, 1990), a coupled design process (Braha and Reich, 2003), infused design (Shai and Reich, 2004a, 2004b), and C-K design theory (Hatchuel and Weil, 2003, 2009) can all be characterized by their capacity to account for a form of generativity, as shown in (Hatchuel *et al.*, 2011a). In particular, it has been shown that C-K design theory is more generative than Simonian approaches that aimed at modelling generativity but were 'unfinished' (Hatchuel, 2002). These theories have progressively evolved to become independent of professional languages and traditions. As a consequence, design theory appeals as a powerful integrative framework that can account for all activities involving generativity. In particular, studies have shown how design theory can account for generativity in engineering as well as in science (Hatchuel *et al.*, 2013) and art (Le Masson *et al.*, 2016a,b). *For our purposes, it appears that design theory is a model of generativity that is sufficiently general to be applicable to a decision problem.*

From a cognitive point of view, design cannot be reduced to a learning process or an experimental knowledge production process. Its departure points are the very powerful 'desirable unknown' or 'concept' (the 'C' in C-K design theory); that is, incomplete proposals that guide us towards the emergence of new values, uses, and identities of objects (e.g., products, services, processes, and business models) and new knowledge. Applied to a decision problem, it becomes possible to consider that, given a certain decision problem, a concept is the design of an improvement to the decision situation. The theory describes the process of *formulating and structuring this concept* and designing different ways to obtain better decision situations. *Hence, C-K design theory seems to be applicable to decision problems, and can help characterize, in the C-space, the variety of unknowns related to a decision problem.*

Concepts emerge from multiple heterogeneous knowledge (the 'K' in C-K design theory) resources, where K can be a decision problem. A design process uses $C_0$ and $K_0$ as inputs, and results in new concepts and knowledge at the end of the process, that is, new decision problems, as well as new unknowns. This means, in particular, that a design process creates knowledge. Hence, knowledge is both an input and an output of a design process. Thus, C-K theory helps to characterize the type of knowledge that must be gained in relation to certain types of unknowns. Hence, it also helps to characterize *the variety of processes that are required for exploration and knowledge creation to design new decisions.*

Last but not least, recent works on the cognition of creativity have enabled the characterization of fixation in design situations relying on the C-K design theory framework. Hence, C-K design theory serves as a reference for the generative process, and it is possible to characterize the biases associated with this reference (Hatchuel *et al.*, 2011b; Agogué *et al.*, 2014; Crilly, 2015). *Hence, we have the capacity to identify generation biases.*

As a consequence, C-K design theory appears as a formal model of generativity that can be applied to a decision situation as follows: $K_0$ is the decision situation to be improved, while $C_0$ can generally be written as 'design a better decision situation' (partially unknown). The design process will uncover the range of partially unknown decision situations that can be designed from the initial one (here we address research question 1). It is then possible to compare the newly created decision situations with the initial one and determine how much better they are. Fixation analysis, enables us to see not only the increase in comprehensiveness, but also the performance in term of de-biasing (here we address research question 2). Hence, we have a method that enables us to address the two research questions.

Step 3: maintaining Wald's formal model of decision-making within an extended generative perspective.

To apply this method, we need a formal model of a decision situation. As noted above, there are several candidates. Studies on strategic decision-making tend to refer to Savage's decision theory (Dean & Sharfman, 1996; Pich *et al.*, 2002; Feduzi and Runde, 2014; Huang & Pearce, 2015; Feduzi *et al.*, 2016). However, in this study, we rely on Wald's model. There are several justifications for this choice.

Savage's model is actually a generalization of Wald's model. Thus, what do we stand to lose by relying on

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Wald? The main claim of Savage's decision theory is that if agents' preferences and beliefs are consistent (in the sense specified by Savage's axioms), these preferences may be represented by the expected utility formula, whereas Wald considers that the loss function and the beliefs are provided by the agent. As noted by Giocoli, the reference historian of decision theory, 'Savage's theory is first and foremost a normative guide to the formation of consistent beliefs' (Giocoli, 2013: 74). Relying on Wald, we consider that the belief and loss functions are *given*, and do not consider how they can be revealed by the choices made by the agents. By doing this, we avoid the question of whether the consistency rules required by Savage's axiomatic can be applied effectively.

Wald's model not only served as the foundation for Savage's model but was also the foundation of Raiffa and Schlaifer's (1961) model, which has been widely acknowledged in the management literature (Giocoli, 2013). Wald's analytical framework has been implemented in decision trees, which are still taught in many business schools and are the backbone of many studies on strategic decision-making (e.g., studies on real options). Hence, Wald's model can be considered as the operational basis of decision theory.

Wald developed his theory with the aim of providing an integrated framework for statistics, and in doing so he provided a model for making decisions in the face of uncertainty. For Wald, 'a solution to a statistical problem must instruct the statistician about what to do, i.e. what particular action to take, not just what to say' (Giocoli, 2013: 13). Hence, Wald's model is one of *action*, which suits our purposes.

We could also rely on a Simonian model of 'bounded decisions.' This path has already been largely explored, in particular with a view to finding ways to get closer to the optimal choice (as defined by Wald). Since the part of the path from 'bounded' to 'ideal' has already been widely discussed, we prefer to focus on the part between 'ideal' and 'extended ideal.' Using the 'ideal decision' as the starting point helps us to focus the generativity process on the phase that has been least explored until now.

To conclude, we apply C-K design theory to Wald's decision-situation model (the next section), and this formal approach provides answers to our two research questions (the following section).

## A comprehensive and generative model for designing decisions in the unknown: properties and evaluation

In this part, we apply C-K design theory to Wald's decision-situation model. Our aim is to identify the possible extensions of decision theory using design theory. Following the C-K framework, we first identify precisely the 'decision model' that is in $K_0$, which reminds us of the basics of Wald's statistical decision theory. Then, we describe the C-space and the expansions (see Figure 4 for an overview).

### *Background: Wald's statistical decision theory and $K_0$*

Wald formulated the basic decision problem as follows (Ferguson, 1976; Giocoli, 2013;). There are four components: (1) the available actions; (2) the states of the world (also called states of nature), one of which is the true one (the parameter space); (3) the loss function (also called the cost function) measuring the loss to the statistician if he or she takes a certain action when the true state of the world is given; and (4) an experiment, whose goal is to help the statistician to reduce the loss and whose results (called observations) depend on the true state. A decision function is a rule associating an action with each possible experimental outcome. The available decision functions are evaluated according to the expected loss their adoption may cause under the various possible states. The statistician's task is then to choose the decision function capable of minimizing the expected loss. Wald was able to solve this problem in very general terms by adding some additional ingredients: there is a loss function defined over each pair (state of nature and action), and the experimenter may have *a priori* distribution over the parameter space (belief about the states of nature, modelled with Bayesian formalism).

It is worth noting, after Gilboa (2009: 40), that Wald uses a Bayesian approach in the strict sense of statistics: 'Anything that updates a prior to a posterior based on evidence is referred to as 'Bayesian' while in economics the term refers to a more demanding ideological position, according to which anything and everything that is not known should be modelled explicitly in a state-space model and be subject to a prior probability'. Of course, in this study, we stick to Wald's approach and carefully avoid the economics position that hides the issue of the unknown or, said differently, codifies unknowns systematically in an a priori distribution (usually called uncertainty), which is a considerable restriction.

Wald's result (presented formally in Appendix A-1) is extraordinarily general: given the learning capacities L, *a priori* belief $\mu$ about states of nature $\theta_j$ in $\Theta$, the set D of alternatives $d_i$, and the cost function C ($d_i$, $\theta_j$), there is always an optimal choice function to identify the optimal decision $d_{opt}$ inside the set of all known decisions D.

Let us take a very simple example: the raincoat/hat decision problem (see Figure 2). This is actually the example given by Savage when he discussed Wald's theory in his famous article (Savage, 1951). This example was used to show how Wald's theory, which was initially

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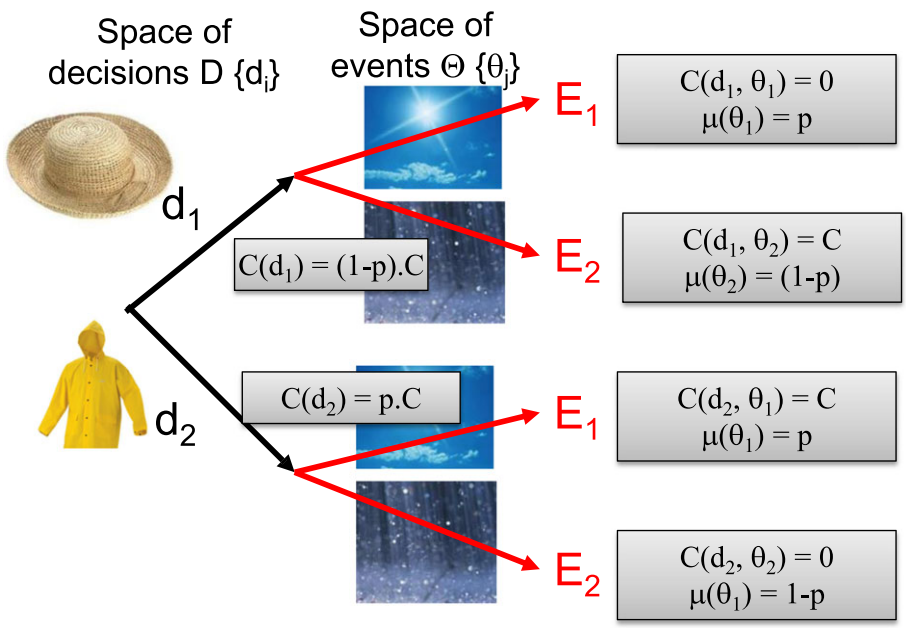


**Figure 2** Decision tree for the raincoat/hat case (simplified: without sampling) [Colour figure can be viewed at wileyonlinelibrary.com]

thought of as a generalization of statistical problems, could be applied to simple everyday decisions.

The possible decisions are: $d_1$, take a raincoat on a walk; $d_2$, take a hat on a walk. The states of nature are: $\theta_1$, there will be rain during the walk; $\theta_2$, there will be sun during the walk. The beliefs are the probability of rain during the walk $\mu(\theta_1 = 1, \text{rain}) = \mu(\theta_2 = 0, \text{no sun}) = p$ (for instance 50%) and the probability of sun during walk $\mu(\theta_1 = 0, \text{no rain}) = \mu(\theta_2 = 1, \text{sun}) = 1\text{-}p$. The costs are, for instance, $C(d_1, \theta_1) = C(d_2, \theta_2) = 0$ and $C(d_1, \theta_2) = C(d_2, \theta_1) = C > 0$ (cost of taking a hat and it rains or cost of taking a raincoat and it is sunny).

Without sampling, the expected costs are (1-p).C for $d_1$ and p.C for $d_2$. If $p>50\%$, then choose $d_1$; if $p < 50\%$, then choose $d_2$ (given the limited space, we do not include the sampling case (see Appendix A-3)).

### *Generating new concepts of decisions (C-space): casting decision-making theory into design theory*

Following the method presented in the previous section, given Wald's statistical decision problem in $K_0$, we actually *design a better decision situation* using C-K design theory.

In C-K design theory, the design process begins with a knowledge base K and concepts C. Knowledge $K_0$ is: D, the set of decisions $d_i$, Θ, the set of states of the world $\theta_i$, and $C(d_i, \theta_j)$ and $\mu(\theta_i)$, which can be seen as 'properties' of $d_i$ and $\theta_j$. There are even definitional properties, *since $\theta_i$ and $d_j$ only 'exist' in the problem through C and $\mu$*. L(d, X) models the way to learn with X on $\theta_i$ to decide $d_j$, namely, how beliefs evolve by sampling.

The concept $C_0$ is: *from the given problem characterized by (D, Θ, μ, C, L), design a better decision situation*.

From this initial situation, the C-K design process leads to several better decision situations. The details of the construction of these better decision situations are presented in Appendix A-1. Below, we present the main features that are deduced from this construction and illustrate them using the raincoat/hat case.

Let us begin with the illustrative case. From the initial decision situation (see Figure 2), C-K design theory leads to the graph shown in Figure 3. In C, there are several concepts of better decisions. Note that even if we added some pictures, these are only concepts of decisions, that is, what is designed is a decision situation (not a product) represented by a decision tree, where some branches have yet to be fully designed to become an actionable decision. Here, we briefly describe Figure 3.

To design a better decision situation, C-K theory prescribes that we should rely on knowledge in $K_0$. Hence, we can think of designing a new decision d* in D. For instance, this can be to take another accessory that is better than a hat. This can simply be 'a better hat' that provides a bit of fun, even in the rain, hence the cost of having such a hat in the rain decreases (symmetrically, one could also design a better hat in the sun or a better raincoat in the sun or a better raincoat in the rain).

Then, C-K theory prescribes that we should use other pieces of knowledge (from $K_0$) to design new options. The knowledge on belief can be used: can one design a new decision that would be good *regardless of what one believes*, that is, an accessory that would be equally effective as a hat in the sun and a raincoat in the rain?

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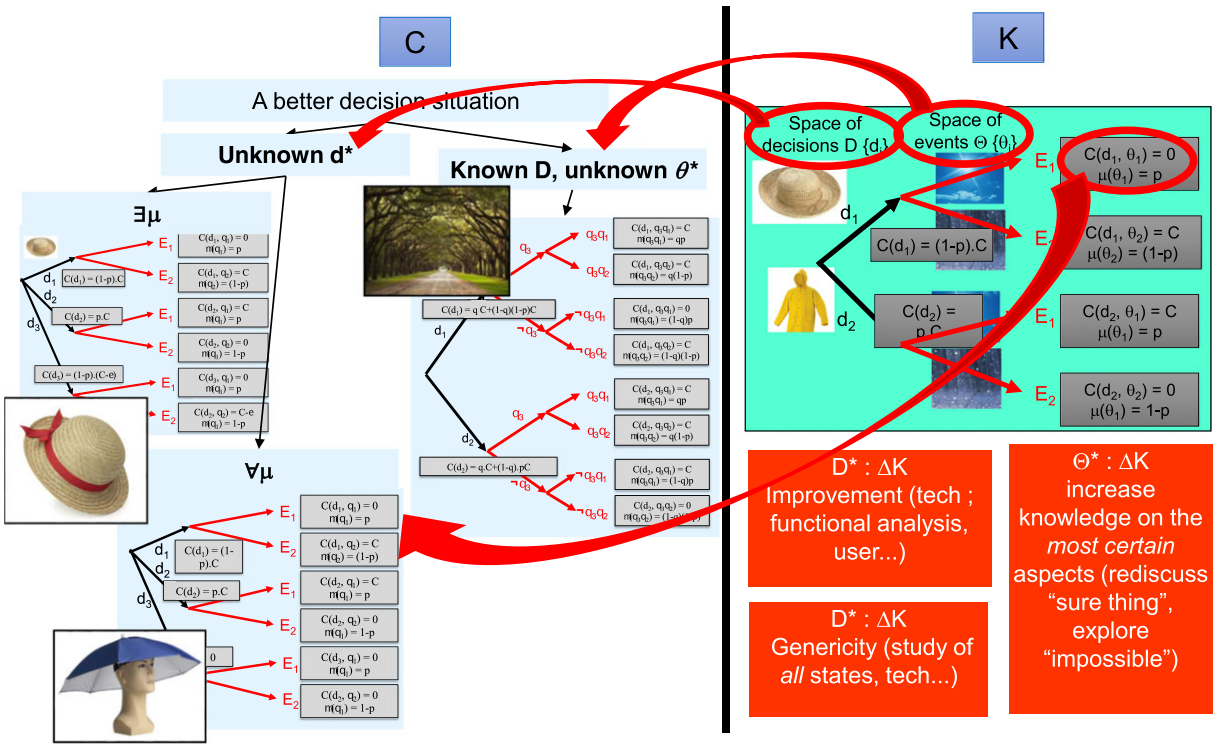


**Figure 3** Extension of the raincoat/hat decision situation to the unknown – design paths toward a better decision situation are represented in the C-space; knowledge expansions appear in the K space. The red arrows represent the attributes of the initial knowledge (D, Θ and μ) that are used to generate the new design paths [Colour figure can be viewed at wileyonlinelibrary.com]

We are now dreaming of something that could be called a 'raincoat-hat' that might not yet exist, but might be able to be created! This 'chimera' is represented by the illustration in Figure 3.

Finally, C-K theory prescribes that we should use a parameter that has not yet been used: design a better decision situation by using knowledge *on the space of events*, namely, by designing a new event! Of course, it might sound strange to suggest that we 'design a state of nature,' but we should keep in mind that from the Bayesian perspective, the state of nature is actually the representation of nature by the decision-maker. Hence, we can proceed with this hypothesis and imagine what new states of nature can be designed. For instance, one can look for a state of nature that would increase the costs of all known decisions, namely, hat or raincoat. Driven by this 'unknown state', one can consider that there are trees all along the walk that protect us from both the rain and the sun, making the hat and the raincoat useless accessories. In this case, we have added a new state of the world that changes the decision situation (other examples are given in Appendix A-1).

This example illustrates the main features that appear in the formal construction of the extension of a decision situation to the unknown. Let's summarize now these features (a detailed demonstration is presented in Appendix A-1):

- We systematically identify all possible ways to generate new decisions d* that improve the decision situation, while keeping unchanged the states of the world. d* is better than the known decisions $d_i$.
- In particular, one design path generates a *generic* decision, that is, a decision that is good for *all* states $\theta_i$ of Θ. $d^*$ is different from all combinations of $d_i$ in D and addresses all known $\theta_i$, i.e. $d^*$ is generic to all $\theta_i$. Note that 'generic' is strongly different from generative. Generic refers to the logic of 'generic technology' (Hooge et al. 2016, Kokshagina 2014, Le Masson et al. 2016b) or general purpose technologies (Bresnahan & Trajtenberg 1995, Joerges & Shin 2018): these are specific types of innovation solution that can address a large set of applications. A generic decision is hence a decision that is robust to several states of the world.
- The design paths will necessarily create new knowledge, and the learning process is guided by the design path: either it is led by $d_{opt}$, the optimal decision in the initial decision situation, or it is led by the systematic study of all $\theta_i$ to obtain a generic solution.
- The 'decision designer' can also create new decision situations by designing new states of nature $\theta^*$. This is a generalization of the Bayesian approach from a belief in the probability of the occurrence of known states of the world to a belief in new, previously unknown

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alternatives. The associated unknown might be either desirable (increased value) or undesirable (decreased value).

- The new state $\theta^*$ is a new dimension added to $\Theta$. One important property is that it is generated by questioning the 'sure thing' or the 'impossible,' and not by reducing uncertainty.
- $\theta^*$ increases global uncertainty and might change the initial hierarchy between decisions $d_i$.

Using C-K design theory, we have systematically generated an extension of a Wald decision model under uncertainty. We can now analyze how this newly constructed decision-design model answers our research questions.

## Findings and results: generating new types of decisions and revising states of nature

We obtain results in relation to our twofold research question: how to characterize the types of unknowns considered as directions of generativity (with associated value and type of knowledge to be explored) (RQ 1), and how to characterize the performance of the process of extending the decision situation to the unknown (RQ 2).

*Types of unknowns corresponding to different directions for generativity (RQ 1).*

Based on the model, we are able to identify, in the decision-challenging unknown, what we call decision concepts or *decision-driven design paths*. These are not decisions; they are decision-driven directions for the generation of a better decision situation. A decision-driven design path is still partially unknown, but it has two critical properties:

1. one knows more about the value associated with it (how much it will change the initial decision situation, measured in terms of expected utility); and
2. one knows about the knowledge that should be explored for the generation of the associated decision situation.

This a critical contribution: it becomes possible to *orient and stimulate* the generation process using decision-driven knowledge. In other words, knowledge about the decision situation does not necessarily restrict the generation of new decisions.

The model enables *four types of decision-driven design paths* (see the synthesis in Figure 4 and Table 1). The first two can be characterized as 'wishful decisions':

1. decision-driven design path, type 1: *new wishful decision by improvement* (Hatchuel *et al.*, 2011a) (unknown decision $d^*$, exploration driven by $\theta_{j0}$). This consists of designing a new decision $d^*$ as a variation of decision $d_{opt}$, which was initially identified as the best one. The design process is driven by a desire to reduce the cost of a specific $\theta_{j0}$, $C(d_{opt}, \theta_{j0})$. The value of the unknown is given by $C(d^*, \theta_{j0}) < C(d_{opt}, \theta_{j0})$ and knowledge creation is driven by $\theta_{j0}$. This is the most self-evident extension.
   Note that the value of knowledge is *not* in risk reduction (as in the basic model of decision under uncertainty) but in *cost* reduction associated with the new pair $(C(d^*, \theta_{j0}))$ (the probability associated with each state remains unchanged). In other words, we have a new way to value knowledge creation: decision theory under uncertainty provides a very interesting way to value knowledge creation through risk reduction; in this decision design, one can value knowledge creation in terms of the cost reduction induced by the newly generated alternative.

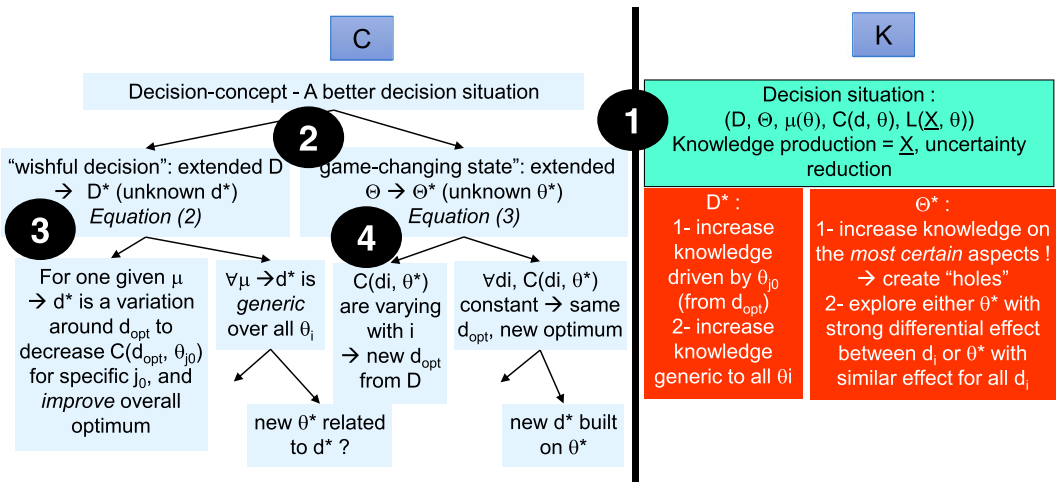


**Figure 4** Decision design in the unknown. C shows the new decision-making situations after $d^*$ or $\theta^*$ extension. K shows the knowledge creation strategies associated with the design of $d^*$ and $\theta^*$. Numbers 1 to 4 indicate the possible fixations [Colour figure can be viewed at wileyonlinelibrary.com]

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**Table 1** Decision design in the unknown: the main features of the four decision-driven design paths (first column: reference = reduction in decision theory)

| | *Reference: learning in decision theory in uncertainty* | *New, wishful decision by improvement* | *New, wishful decision by genericity* | *New, decision changing state by best choice hacking* | *New, decision changing state by all choices hacking* |
|---|---|---|---|---|---|
| Unknown? | No unknown, only uncertainty | New decision d* | New decision d* | New state θ* | New state θ* |
| Driver for the exploration of the unknown | Learning based on risk reduction (sampling to change the belief from a priori to a posteriori) | Better than the (initially) optimal one $d_{opt}$ on at least one state of the world $\theta_{j0}$: $C(d^*, \theta_{j0}) < C(d_{opt}, \theta_{j0})$ | Better than all decisions in all possible states $\forall i, \forall j\ C(d^*, \theta_j) < C(d_i, \theta_j)$ | Explore the 'most certain knowledge', the 'impossibles' associated to the best decision $d_{opt}$. | Explore the 'most certain knowledge', the 'impossibles' associated (systematically) to all decision $d_i$ |
| Value of knowledge | Decrease expected costs | Not in risk reduction, but in decision improvement | Not in risk reduction, but in genericity | Not in risk reduction but in identification of new specific risk | Not in risk reduction, but in identification of new systemic risk |

2. decision-driven design path, type 2: *new wishful decision by genericity* (unknown decision $d^*$, *independent of all* $\theta_i$). This consists of designing $d^*$ as a *generic* alternative that is better *whatever* the state $\theta_i$. Knowledge creation is driven by this genericity, either independent of all $\theta_i$ or driven by features that are common to all $\theta_j$.
   Again, the value is not in risk reduction. The *value of the knowledge creation is all the higher that* $d^*$ *is independent of all* $\theta_i$. *The value of the knowledge lies in the new interdependence of* $d^*$ *and* $\theta_i$ (in terms of costs $C(d^*, \theta_i)$). Note that this form of extension is not really examined in the literature on the unknown in strategic management; it is more common in the literature on platforms and the management of generic technology (Bresnahan and Trajtenberg, 1995; Gawer, 2009; Kokshagina *et al*., 2017a). We can see how the systematic framework unifies different types of unknowns and different types of exploration strategies.

The two other decision-driven design paths rely on the design of a new state of the world that will change the decision situation. We call them design paths toward a decision-changing state.

3. decision-driven design path, type 3: *new decision-changing state by 'best-choice hacking'* (unknown state $\theta_i^*$, exploration driven by having a differential effect on $d_i$). This consists of designing $\theta^*$ as a new dimension of the states of the world that changes the hierarchy between decisions $d_i$. Knowledge creation is driven by investigating the most certain knowledge (sure thing) and by the search for the most order-changing state (heterogeneous $C(d_i, \theta^*)$). The value of knowledge relies on *new interdependencies* between $d_i$ and $\theta^*$ (in terms of expected costs $\sum_{j=1\ldots n+1} C(\theta_j, d_i)\mu^*(\theta_j)$ ). This corresponds to 'uncovering unk-unks' by studying the *robustness of a single solution* (for instance, the dominator, i.e. the best one). In particular, this corresponds to the try-and-learn processes described by (Loch *et al*., 2008). Additionally, it helps orient the exploration process: the model shows that these 'best-choice hacks' can be found when looking at the most certain knowledge. The model does more than merely facilitate broad exploration; it prescribes that we should *focus on the most certain knowledge*, in other words it recommends that we look at impossible states (those that are certain not to occur) and not at the probably possible ones. Again, this underlines the fact that the issue is not in uncertainty reduction, but in unknownness exploration.

4. decision-driven design path, type 4: *new decision-changing state by 'all-choice hacking'*

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(unknown state $\theta^*$, exploration driven by having a systematic effect on all $d_i$). This consists of designing $\theta^*$ as a new dimension of the states of the world that does not change the hierarchy between decisions $d_i$ but changes the overall value. Knowledge creation is still driven by investigating the most certain knowledge (sure thing), but it is also driven by a search of the non-order-changing states (homogenous $C(d_i, \theta^*)$). The value of knowledge relies on *new interdependencies between* $\theta^*$ *and existing* $d_i$ (in terms of expected costs $\sum_{j=1\ldots n+1} C(\theta_j, d_i)\mu^*(\theta_j)$). This also corresponds to 'uncovering unk-unks,' this time through a parallel exploration. However, this is a parallel exploration where the generator looks for systematic conditions that will impact *all* solutions, either positively or negatively. Hence, the model leads us to focus on the hidden interdependencies that make all known states and all known decisions work together (e.g., one designs the 'walk under trees' situation by trying to find a case where, regardless of the decision between a hat or a raincoat and the state of nature, i.e. rain or sun, the pair decision state will be bad).

We synthesize these four decision-driven design paths in Figure 4 and Table 1. The model shows the four archetypes, but combinations are of course possible. In particular, the generation of a new alternative can lead to the generation of new states (at a new level in the tree, see Figure 4) and the generation of new states of the world can lead to the generation of new decisions (see Figure 4).

*Characterizing performance levels by types of generative biases (RQ 2)*

The model underlines a general increase in comprehensiveness. In each branch, there is a gain in D and/or Θ. This is possible because the generation model retains the decision logic. It does not end with a list of 'ideas,' but each branch retains the decision-making formalism. In particular, this means that in each branch, it is still possible to compute the best solution according to Wald's model. One simple consequence is that the decision models that are already in place in a company are preserved and enriched by the generativity process.

However, one should note that between the initial and final states, there might be some surprising changes. For instance, the model shows that the value of the best decision might be *lower* after the generation process. This is linked to the fact that the generation process actually leads to a *transformation of unknownness into uncertainty*, thereby increasing uncertainty. One direct consequence of this is that the expected value of the best alternative cannot be taken as an indicator of the increase in comprehensiveness. Thus, we should look for other indicators of performance improvement.

Another indicator of the performance of the generativity process is the capacity to map fixation and defixation areas. We now show how the model sheds light on the generation biases associated with the process of extending a decision situation to the unknown.

*Overcoming bias in favor of uncertainty and against the impossible.* The decision-design model helps to overcome a first-generation bias that comes from the distinction between decision under uncertainty and generation under uncertainty: individuals and teams might tend to represent themselves as *deciding* under uncertainty instead of *generating*. Technically, referring to Figure 4, it means that they tend to stay in K instead of going to C. In K, they produce knowledge for uncertainty reduction, and they are certainly not producing knowledge that enables them to rediscuss sure things. Many studies have discussed this type of bias: business plans based on optimal NPV expectations, project management dealing with uncertainty instead of unknownness (Lenfle and Loch, 2010), the dangers of misleading expectations in technology development (Borup *et al.*, 2006; Geels and Raven, 2006; van Merkerk and Robinson, 2006), and decisions in relation to innovation projects (Elmquist and Le Masson, 2009).

*Overcoming bias in favor of problem solving and against environmental exploration (problem finding).* If one supposes that a team is designing an innovative solution, a second fixation appears in relation to the alternatives $D^*$ vs $\Theta^*$. Some teams will be tempted to look for new decision alternatives $d^*$ and will neglect the possibility of designing (discovering) new states of the world $\theta^*$. This might be the case for engineering departments that design products when external conditions Θ are given by the list of requirements. Conversely, some teams might be tempted to design new $\theta^*$ for a given list of possible decisions D. For instance, this might occur when a commercial department tries to find new markets without changing the firm's technologies and products. In general, one tends to see a bias in favor of problem solving and against environmental exploration, which corresponds to problem finding. (von Hippel and von Krogh, 2016) examine multiple studies that underline the risk of fixation on a problem that is not well formulated and is not regenerated (von Hippel and Tyre, 1995; Sieg *et al.*, 2010; Sieg, 2012). By mapping both processes, the model contributes to overcoming fixation.

*Overcoming bias in favor of optimizing for one known condition and against the design of generic solutions.* Suppose a team is designing a new decision $d^*$: there

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is a possibility of fixation on designing $d^*$ that optimizes $d_{opt}$ on one (or a couple of) $\theta_j$ ; the team will hardly consider designing a $d^*$ that is independent of external states of the world, i.e. external demands. That is, there is a fixation on designing specific, targeted products/services instead of designing generic solutions (Hooge *et al.*, 2016; Le Masson *et al.*, 2016a; Kokshagina *et al.*, 2017a).

*Overcoming bias in favor of increasing robustness of one known solution and against the discovery of systemic risk.* Suppose a team is now designing new states of the world $\theta^*$: there is a possibility of fixation on testing whether $d_{opt}$ is *robust* under alternative conditions $\theta^*$. Hence, one is looking for specific $\theta^*$ where $C(d_i, \theta^*)$ are so different that they could change the hierarchy of decisions. Teams and individuals will less readily explore situations that *systematically* impact the overall value (and would ultimately lead to a new $d^*$ associated with $\theta^*$), that is, the investigations to uncover systemic risk are hindered by generation bias (Loch *et al.*, 2008; Lenfle and Loch, 2010).

We can see how many well-known tensions, dilemmas, or biases in innovation management can actually be mapped as generation biases in an extended decision-making framework.

## Discussion and conclusion.

This study contributes to innovation management and the foundations of management science. Methodologically, it shows how progress in innovation management and design theory enables us to formally approach the question of the extension of decision-making to the unknown. Subsequently, the study proposes a model of decision design in the unknown with a clear rationality model and explicit performance. The main features are summarized in Table 2, which compares the model of decision under uncertainty with that of decision design in the unknown.

Based on the proposed model, this study contributes to the twofold issue of the unknown in decision-making: (1) the paper identifies a structure of the decision-oriented unknown based on four contrasting types of actionable unknowns called decision-driven design paths and clarifies how each type relates to a particular logic of decision-oriented generativity, with a specific value and specific types of knowledge expansion (synthesized in Table 1); and (2) the study identifies the performance associated with the exploration strategies, this performance being assessed in terms of defixation, that is, the capacity to overcome generation bias. We synthesize this contribution in Table 2. This raises two discussion topics that also indicate directions for further research.

*The potential contribution to Artificial Intelligence (AI) of the new model of decision-oriented generativity*

The structure of the unknown was obtained through a formal approach. Before discussing further organizational issues, it is interesting to note that a formal approach can also have intrinsic value. Today, decision theory is implemented in many algorithms (particularly in AI approaches) and leads to significant dilemmas. One example is the study we referred to in the Introduction (Bonnefon *et al.*, 2016): how should the algorithm 'decide' (*in the strict sense of a formal decision-making model*) when confronted with a dilemma such as 'If the brakes have failed, should the driver of the car kill the pedestrians crossing the street or save the pedestrians by crashing the car into a wall, thereby killing the occupants of the car?'

Formally speaking, this dilemma can be avoided by extending decision-making to the unknown, and our model indicates four design paths. This induces a question: can one implement an algorithm that corresponds to these four design paths to enable a machine to generate a new path? Interestingly, recent progress in AI (in particular on novelty searching or MAP-Elite algorithms) is enabling machines to invent new behavior when confronted with unexpected events (see Lehman and Stanley, 2008; Cully *et al.*, 2015). Our model of decision design in the unknown might make it possible to systematize the analysis of all the

**Table 2** From decision model to decision-oriented generativity model: a new rationality model and associated performance

| | *Model of decision under uncertainty* | *Model of decision design in the unknown* |
|---|---|---|
| Rationality model | If there is: - a set D of decisions $d_i$, - a set $\Theta$ of probable states of nature $\theta_j$, with a belief function $\mu$, - and a cost function $C(d_i, \theta_j)$ (and a learning function L) → then there is an optimal decision diopt that minimizes cost function | If there is D, $\Theta$, $\mu$, C – but the optimal decision is not desirable,<br>→ Then there are four decision-based design paths to generate a better decision situation that extends the given one and this better decision situation:<br>-New, wishful decision by improvement<br>-New, wishful decision by genericity<br>-New, decision-changing state by best choice hacking<br>-New decision-changing state by all choices hacking |
| Performance | Overcome selection biases | Overcome generation biases |

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design paths that a machine might generate and/or analyze the possible generation biases in generative algorithms.

*Revisiting organizational issues raised by the unknown.*

The question of managing in the unknown is one of the critical issues of management science. Since the 1960s, management science developed rational models of action with *uncertainty*. The development of the theory of decision under uncertainty provided then management with 'the basic disciplines that underlie the field of business administration' according to Bertrand Fow, the Director of Research at Harvard Business School in his preface to the reference book 'applied statistical decision theory' of Raiffa and Schlaifer (1961). The theory of statistical decision-making provided an integrated framework that could account for choices between known alternatives, taking into account uncertain events. Moreover, the models were able to place a clear value on uncertainty reduction endeavors (leading to option theory and later to real options), and this also led to powerful organizational models in which expertise, knowledge, and competences appear as core resources for dealing with uncertainty (see, for instance, the classical synthesis of organizational forms by Mintzberg (1978, 1979). Recent studies by historians and economists on the origins of decision-making in economics have led us to think that decision theory under uncertainty was one of the notions that was born in management before being applied to economics (Giocoli, 2013). Following these works, decision appears as a general pattern in decision-based organizational language:

- There is a clear managerial goal, namely, to select the best decision by overcoming selection biases.
- There are two main types of actors: decision-makers and experts, the latter making systematic preliminary investigations to prepare the ground for rigorous, objective decision-making by the former.
- There are techniques and instruments for evaluating alternatives (such as expected NPV) and there is a value ascribed to knowledge resources: knowledge reduces risks (e.g. R&D and marketing studies) and reduces selection bias, enabling a decision that is as close as possible to the optimal choice for a given actor. (see table 3, second column).

Since the unknown is seen today as the type of situation that cannot be handled by the usual decision-making framework (Loch *et al*., 2006), it implies that the unknown might represent a situation in which organizations are at their limit. When organization theory is at its limits, should one rely on the market when facing the unknown? Some studies, particularly in economics, follow this track and analyze open innovation, contests, crowdsourcing, start-up development, or ecosystems strategies as ways to deal with the unknown (e.g., Terwiesch and Xu, 2008). Other works (e.g. Wideman, 1992; McGrath and MacMillan, 1995, 2009; Pich *et al*., 2002; Loch *et al*., 2006, 2008; Cunha *et al*., 2006; Mullins, 2007; Weick and Sutcliffe, 2007; Sommer *et al*., 2008; Rerup, 2009; Feduzi and Runde, 2014 Feduzi *et al*., 2016) suggest that managing in the unknown leads to the development of *new formal models of rationality* that take into account the unknown and that are related to new forms of organizations. In that sense, managing in the unknown is the new frontier of management science.

This study has followed the latter approach by presenting a formal model of rationality to generate a structured mapping of exploration trajectories in the unknown (four decision-driven design paths). Even if

**Table 3** How the model of 'decision design in the unknown' helps underline some differences between 'decision based' organization and 'decision-design based organization'

| | *Some features of an organization based on decision under uncertainty* | *Corresponding features in a organization based on decision design in the unknown* |
|---|---|---|
| Management (leadership, processes, competences, organizations…) | Principle: organize to select the optimal decision by overcoming selection biases | Principle: organize to generate a better decision situation by overcoming generation biases |
| | Organization and capacities: *decision makers & experts* – experts gather relevant data to check D, Θ, μ, C and learn in order to reduce risk (R&D, marketing, etc.); | Organization and capacities: *capacity to generate pathes*: 'exploration', 'dynamic capabilities', 'ambidexterity', 'innovation function',… *manage multiple coordinated explorations*: 'agile', 'flexible', 'open', 'co-', 'platform based', 'flexible', 'parallel / sequential',… |
| | Quality process and techniques: systematic preliminary investigation + decision based on rational criteria (rely on techniques to evaluate cost function: NPV, etc.) | Quality process and techniques: systematic actions to generate new decisions and new representation of states of the world + governance of the explorations. Requires a mix of valuation techniques and generation techniques. |
| | Value of knowledge: risk reduction and selection bias reduction (as close as possible of the optimal choice) | Value of knowledge: improved optimal choice *and* improved representation of states of the world – generation bias reduction |

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it is beyond the scope of this study to analyze all of the implications for organizations, it is important to identify some consequences related to organizational capacity that are associated with the formal framework (see Table 3, third column): The extension of the model of decision under uncertainty to a model of decision design in the unknown leads to a discussion of the related generativity capacities in the organization. These capacities echo well-known notions in the literature such as dynamic capabilities (Teece *et al.*, 1997; Eisenhardt and Martin, 2000), ambidexterity (Duncan, 1976; Tushman and O'Reilly III, 1996; Birkinshaw and Gupta, 2013), agile and flexible development (MacCormack *et al.*, 2001), and parallel/sequential learning (Loch *et al.*, 2006):

- Similar to the decision model for decision capacities, the generativity model induces *quality criteria* in relation to generativity capacities: There is *a clear managerial goal of generating a better decision situation by overcoming generation bias*.
- This leads us to distinguish the capacity to *generate a new path and the capacity to manage multiple coordinated explorations*. The former should enable a systematic exploration of new decisions *and* new states of the world, while the latter should organize and control generation biases, in particular by covering the four archetypal decision-oriented design paths.
- There is a *value ascribed to knowledge resources*: knowledge reduces generation biases and generates improved choices.

This analytical framework, deduced from the generativity model, might help us to characterize the quality of generativity capacities and provide formal grounds and criteria for analyzing the notions evoked above: dynamic capabilities, ambidexterity, agile and flexible development, and parallel/sequential learning.

To conclude, this study aims to contribute, at least partially, to a revision of the foundations of management science by exploring the logic of the unknown in management science. The unknown is the new frontier for management and organizations. Since organizations struggle to manage the unknown, they are tempted to rely on the market to deal with situations involving too much that is unknown. Our study shows that innovation theory and design theory can provide us with formal models that help us to think about and characterize the logic of managing in the unknown. This model of decision design makes the unknown actionable via decision-driven design paths that orient the generation of *better* decision situations and help to overcome dilemmas and generation biases. It is interesting to note that these generation biases might actually be caused by management science itself. This means that, in a sense, these formal models also contribute to protecting management science from its own fixation![1]

More generally, this study contributes to the large body of work confirming that management is no longer limited to the decision-making paradigm, but is already in a post-decisional, generativity-based paradigm wherein models of collective action in the unknown are the new frontier. These studies contribute to making management science one of the few disciplines that is able to scientifically address the issue of the unknown, its language, its structure, and its specific logic of action. They contribute to the repositioning of management science as the discipline underlying the construction of a desirable unknown.

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## Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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# Appendix A5

# Paper 5: Ambidextrous project management and corporate entrepreneurship

**Purpose** Given the anomaly and the proposed model, we will present two cases that can explain their success and failure. These have a corporate entrepreneurship taste and present features relating to decisional ambidexterity, managing the unknown and organizing for it. One case appears to have the right set of practices to succeed in its innovative design and associated management whereas the other one struggles. The comparison allows justifying the usefulness of the new model and ways to implement certain practices. We would propose this comparison to reveal the paradox or instead, we would insist from the beginning on the direction and nature of decision-design practices. The notion of ambidexterity in the unknown could be useful to explain the phenomenon. It is a working paper to be submitted by the end of 2018 to a conference We will naturally adapt literature depending on the audience, but we would like to aim for Academy of Management (Technology & Innovation Management) or EGOS.

**Research data** We use the data mobilized for our decisional ambidexterity model testing.
**Airbus Development Team, Connected Cabin and Multi-BU committee**
**Case 1:** Aircraft's lower deck (1 year)
**Case 2:** Connected cabin (10 months)
Field notes, minutes of meetings, 6 interviewees each consulted on multiple occasions and full access to projects documentations, meeting minutes of Multi-BU committee, in addition to input from former CEO and VP.

# Appendix A6

# Original Research Program

**Abstract** This document aims at describing the intentions for the research project entitled "Techno-marketing and innovative design: organising value exploration and competencies renewal". We describe here the context of the project, its objectives and how we will organise the research. This document is attached to the request package for the PhD CIFRE program made in collaboration with Zodiac Aerospace and l'École Nationale Supérieure des Mines de Paris (Centre for Scientific Management / Centre de Gestion Scientifique).

The project intends to study in depth the duality techno-marketing, the new shapes it takes when it comes to ally user-driven innovation and techno-push innovation, and the organisational and economic challenges these shapes imply for design/engineering in engineering offices. Based on recent breakthroughs in the field of design theories, which allow modelling the interactions between rule creation and rules' structures, our scope of work will let us analyse the possible organisational forms, identify specific management needs et develop management tools suited for this user-drive/techno-push (in terms of performance, evaluation, process structuring etc.). This study will then permit reinforcing the economic and management dimensions of the C-K design theory, studying the double logics of market-pull and techno-push where they can be very contradictory in some cases and complementary at other times, investigating different ways of evaluating the economic performance of design capabilities and studying the emergence of organisation forms which at the frontier between systematic design and innovative design try to "rule" the design activity.

# Techno-marketing and innovative design: organising value exploration and competencies renewal

Mario LE GLATIN

## Abstract

This document aims at describing the intentions for the research project entitled "Techno-marketing and innovative design: organising value exploration and competencies renewal". We describe here the context of the project, its objectives and how we will organise the research. This document is attached to the request package for the PhD CIFRE program made in collaboration with Zodiac Aerospace and l'Ecole Nationale Supérieure des Mines de Paris (Centre for Scientific Management / Centre de Gestion Scientifique). The project intends to study in depth the duality techno-marketing, the new shapes it takes when it comes to ally user-driven innovation and techno-push innovation, and the organisational and economic challenges these shapes imply for design/engineering in engineering offices. Based on recent breakthroughs in the field of design theories, which allow modelling the interactions between rule creation and rules' structures, our scope of work will let us analyse the possible organisational forms, identify specific management needs et develop management tools suited for this user-drive/techno-push (in terms of performance, evaluation, process structuring etc.). This study will then permit reinforcing the economic and management dimensions of the C-K design theory, studying the double logics of market-pull and techno-push where they can be very contradictory in some cases and complementary at other times, investigating different ways of evaluating the economic performance of design capabilities and studying the emergence of organisation forms which at the frontier between systematic design and innovative design try to "rule" the design activity.

## 1. Context

Zodiac Aerospace – aeronautical equipment supplier with worldwide reputation with leadership in different market linked to cabins, embedded systems and aircraft safety – came to MINES ParisTech to set up a PhD (CIFRE program) led by the corporate technical direction focused on Innovation which main goal is to drive an innovation strategy across the group.

The subject « Techno-marketing and innovative design: organising value exploration and competencies renewal» is in line with the ground-breaking strategy set in place by Zodiac Aerospace since 2012. The objective is more focused on the cabin interiors domain, to throw off the shackles of the regulatory framework in order to integrate passengers' feedback and offer global solutions for aircraft manufacturers and airlines. Setting up multi-disciplinary structures close to aircraft manufacturers was a first step. They allow elaborating innovative concepts that are going beyond Zodiac Aerospace's current product lines.

This aeronautical industrial actor with its client-supplier or assembler-equipment manufacturer relationship is looking to renew its technical competencies in an environment where we have platforms close to our clients. It is about wanting to innovate for our customers first, for the *business unit* "cabin interiors furnishing" and then try to reach out to the rest of the group. We would like to co-innovate in order to regenerate design/engineering methods in the group. It is a

very original approach whereas an overview in literature shows that we have a priori two possible ways and that are almost contradictory to tackle Zodiac Aerospace's challenge: user-driven and techno-push.

### 1.1. First approach: *user-driven*

The first approach consists in organising the design activity with a strong orientation towards the market, and a careful listening to the client. Identifying and getting closer well-identified clients intersects the *lead-user* strategy proposed in (von Hippel, 1986) and (von Hippel, 1988). In a strong technological environment, the approach is expressed by the identification the principal ordering customers with distinct needs, who are used to foresee future needs for the rest of the market. As their demand is ahead of time, these lead-users can be the source of new concepts. Zodiac Aerospace is in that sense getting closer to specific customers: look for the innovation and future market needs by aircraft manufacturers. The underlying forces are those of co-innovation, which is beyond co-development (Midler, et al., 2007), and we also encompass the open innovation approach (Chesbrough, 2003) where the usual design canvas is opened to larger public with internal and external stakeholders.

Industrial actors and the automotive industry for instance have tried different methods to collaborate on subject such as engineering. Beyond the just in-time philosophy, with suppliers fully subjugated and a strong accent on operational constraints rather than design/engineering (Cusumano & Nobeoka, 1997), the industry tried to move the centre of gravity towards innovation for more differentiation on the markets. And we must underline the fact that it was the suppliers who actually brought innovations, rather than the car manufacturer who is mainly integrating and selling to the final customers. Despite a close contact with the customer, the manufacturer will not necessarily see potential disruptive innovations for the final customer that are normally seen at the supplier level. Collaborative platforms were then set up between manufacturers and suppliers around the integration of equipment, and notions such as co-design and co-development emerged (see (Prahalad & Ramaswamy, 2004) and (Hout & Stalk, 1993)). This collaboration which surpasses the buy off the shelf behaviour implies a tight sharing between engineers particularly and a better knowledge of the usage of the design equipment. Engineers are then assigned at the customer's facility (or close to it) in order to develop the required products (see collaborations described in the PhD thesis (Laigle, 1994)). Depending on the industrial environment, and the life cycles, the team made of assigned engineers and integration engineers can turn quickly into a development office, hence overshadowing different exploration fields and potentially innovative since the demand is strongly centred on optimised and rapid solutions.

In this collaborative frame, we may wonder about the knowledge sharing for the client-supplier relationship, and notably if the sharing structure is efficient in this co-development context (Merminod & Le Dain, 2014). Moreover, it raised the issue of the paradox of embeddedness by (Uzzi, 1997) for the assigned engineers. The works from 1996 put forward the negative effects of a strong collaboration/integration in inter-company and market visibility perspective: a great homogeneity would then weaken stakeholders against the market. Thus, even though a good cohesion would be a priori an advantage for better client-supplier collaboration in terms of technical issues, design and innovation, the homogeneity would be also a break to creativity and cross business units' innovations diffusion. To a degree where the innovative design regime we are aiming at would be compromised. Albeit, this first approach does

answer the marketing side of the issue: tight collaboration with the clients.

### 1.2. Second approach: *techno-push*

The second approach to Zodiac Aerospace's challenge would be to focus on innovation via a techno-push. The emphasis is placed on an internal work at such a level where the client is almost forgotten. Literature seems to put forward a « grey box » organisation where the supplier works deeply on his products, his value and skills space to come up with technological platforms with a high generic power. (Meyer & Lehnerd, 1997). It involves performing a crucial study of the internal methods and design theories show that to reach an innovative design regime, it would be preferable to adopt a design structure based on *General Purpose Technologies* (GPTs) (Bresnahan, 1996). These technologies are characterised by their omnipresence, a continuous technical and economical enhancement and innovation facilitation. A generic technology allows as well to be transferred to different market segments and potentially create new ones. A genuine example can be the technology of internal combustion. In the cabin interior domain, Zodiac Aerospace could then restructure itself around GPTs in order to gain from a high genericity and the breaking of existing design rules, in order to explore value and renew skills.

In this frame of mind, an innovative risk management is needed specially when it comes to project portfolio (Cooper & Kleinschmidt, 2002) and as it was suggested in the PhD thesis (Kokshagina, 2014) when we face the situation of designing in double unknown situation (market and technology). On a similar topic, the article (Felk, et al., 2010) tackles the issue of strategic efficiency for GPTs in fast changing markets. The authors have already laid some foundations of technical projects management, and it allows reaching out considerations that more than technological ideas on how to organize around GPTs and finally underline a project and management approach in a broad way.

This layout of engineering offices needs also a certain level of retreat which opens the perspective of design rules regeneration, techno-push, sustained innovation and probably differentiation on the markets. We must also highlight that the genericity could be then transposed to other business units.

By contrast with the first approach, we could guarantee the technical side of the challenge and the value exploration organisation in parallel with the skills renewal.

### 1.3. Subject's challenges

We see that the two approaches suggested by the literature, offers two ways to tackle the problematic presented by Zodiac Aerospace. Nevertheless, the group is looking for a model that could marry both trajectories which are uncommonly combined and almost contradictory.

Indeed, the combination is rather complicated on different aspects: the employee in a user-driven or customer-oriented innovation perspective will rather try to adapt as much as possible to the client whereas the techno-push logic will tend to escalate in genericity and to abstract itself from too specific customer needs; from the intellectual property viewpoint, the developer will tend to possess the technologies but on the other hand the co-development will seek sharing; from a strategic management standpoint, the techno-push logic consists in claiming an autonomous strategy (platform leader) whereas co-development tends to isolate dyads or even competing ecosystems; from the project management perspective, the double logic may lead the protagonists to have diverging objectives for a same project; finally in terms of professions, we are looking at having a coexistence in a same system: an innovative marketing, capable of

satisfying the present customer and considering the renewal of his requirements specifications, and on the other hand an innovative engineering office capable of using its current resources to develop suitable products for the direct clients and to be able to benefit from the platform interaction in order to deeply revise its rules basis.

For all these reasons, it seems rather complicated or even contradictory to combine both logics - and at the same time: knowing how to make it could be the key for a generative and innovative design, as well as robust and capable of adding value.

The subject of this PhD thesis is precisely about helping to surpass these apparent contradictions and to build up a new model combining user-driven and techno-push.

The subject is equally more promising that as we are about to see, recent breakthroughs in design theories and a better understanding of organisations focused on designing in an innovation regime allow to grasp the stakes and the adequacy of combining techno-push and user-driven, and to better analyse the relevant management needs and consider the development of adapted management tools.

## 2. Objectives

The theoretical developments in design sciences, with notably the C-K Theory (*Concept-Knowledge* explained in (Le Masson, et al., 2014)) allow us today to have solid understanding of generative logics at work in contemporary industrial design environment. In particular, they have put forward from formal and empirical point of view that contemporary innovative design requires not only the breaking of forms rules in systematic design but also the development of a new family of rules allowing them to gain from the generative potential of an adjusted systematic design. Each process has its own requirements (cognitive, organisational, economic, etc.)

From the design theories perspectives, the user-driven processes appear to be as particularly promising in order to re-discuss design rules – because based on the uses it permits to break certain design rules, properly established sometimes for the markets and clients that have evolved. And the techno-push process or the development of GPTs is the occasion to unfold new rules applicable to larger scope of application.

Design theories grant the possibility to understand the stakes implied to articulate these two processes.

Furthermore, the C-K theory offers an analytical frame for design activities that can be very useful to breakdown novel organisational structures or to follow-up on experimentation and the efficiency of new implemented methods (see for the numerous publications on that matter)

This is why the C-K theory; with its concept-knowledge duality, will be a major advantage to map the techno-marketing platform and interactions with the client.

The tracking of this analytical frame with the support of thorough studies will allow raising the relevant management needs. This should ideally be followed with the set-up of adapted processes to the model of co-innovation that is looking at promoting genericity and a regime of innovative design across business units within Zodiac Aerospace.

The study whilst confronted to both strategies well-documented in literature, will try to open a third approach centred on innovation inter/intra-companies. Instead of pulling back to develop GPTs and breaking design rules, Zodiac Aerospace is getting closer to customers in a co-development approach in order to trigger a value exploration and the renewal of skills not only for

the confronted business unit, but also to spread across the group with the impulse from the corporate innovation direction.

The research can also engage in enhancing the model of concurrent engineering with adapted management tools. These will also have to set up an adequate management platform to palliate the issues of project management in a collaboration environment: the roles of each individual, the knowledge sharing, the project objectives, the projects' performance measurement, and the intellectual property management. There will be also a feedback for the supplier which will have to be smartly conducted in order to spread out the new design rules and developed technologies to other business units. The potential management tools suggest also to be able accept an alteration in the judgement and the running of engineering offices by the clients, but also by the strategic committee of the company.

For same level inter-company collaborations in a co-innovation effort or in a R&D partnership, literature already raise several issues related management and legal aspects: (Bidault, 1994), (Segrestin, 2005) and with the support from C-K theory (Gillier, 2010) and (Gillier, 2010). We will also have to make good use of these studies so that we can look into the client-supplier relationship different from two actors on the same market.

These are all elements that we need to be able to develop and formulate into an economic and managerial dimension for the concerned engineering offices.

It aims at filling a theoretical and practical gap which leads to sense an original model for innovative design regime in a collaborative client-supplier relationship.

As a result, we have several questions we will be dealing with:

- How do we distribute the work and define the perimeter of responsibilities for each individual within these techno-marketing platforms?
- How do we organise a techno-push and the diffusion of new design rules for a group-scale innovation with the support of techno-marketing platforms?
- How do have buy-in from operational teams when it comes to accepting new concepts stemming from new rules (social adherence issue)?
- How do we evaluate the concepts in order to stick with the most relevant? We should be able to weigh these with criteria that go beyond return on investment.
- How do we manage the projects and keep track of their efficiency from the concept phase up to development?
- How do we manage intellectual property rights in these hybrid configurations?
- How do we proceed with the personal in these platforms compared to their company origins (concept of belonging, informal trading inter-companies, etc.)?

## 3. Expected results

The research should help making progress on multiple fields:

- Coming back on the opposition between user-driven and techno-push, and if possible reveal new articulations between these two logics.

- From a design theories perspective: to see how we articulate the reconsideration of forms rules with the creation of new ones.

- From an organisation point of view: to observe how at the interface between systematic design and innovative design appear new organisational structures that are looking at ruling the design methods.

- From a (economic) evaluation standpoint of design capacities: to develop models, tools and analysis allowing the description of the variety of economic efficiency forms and to enrich classical criteria (Net Present Value, etc.), which have shown their limits for innovative design.

## 4. Research organisation

As a first step, a full immersion in the company seems necessary in order to have a deep understanding of the company culture and its history related to engineering offices, marketing teams and client relationships. A map of relationships, and decision tree would be a substantial way to apprehend the organisational issues and the concurrent engineering challenges. Moreover, the analysis with the support of the C-K theory of some major applications in engineering offices would give a first evaluation of the exploration processes and the design methods in the targeted offices.

As a second step, after having a good grasp of the work environment, understanding the way the solutions, designed by our engineering offices, are integrated by the clients may highlight potential performance indicators of the current exploration and design processes.

These two first phases of data collection will have to be theoretically supported, and nourished by previous studies in the C-K theory framework and its relevant tools (KCP method, V2OR for instance), but also with the company history and its organisational evolution.

As a third step, and at this research level, we should have an extensive understanding of the existing organisation, and the gaps that have to be filled. We could then define a new organisation with adequate management tools and start an experimentation phase. The latter will have to be strongly supported and framed in order to react quickly and propose adjustments to the redefined platforms. If these trials and their corrections are proven to be positive we will then consider deploying on a larger scale.

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## RÉSUMÉ

Il est devenu courant de développer une *organisation ambidextre* dans une entreprise pour garantir un avantage compétitif dans son environnement. Cette perspective trouve ses racines dans le modèle de James March (1991) ayant la vocation de soutenir l'apprentissage organisationnel par des mécanismes adaptatifs entre agents. Ce modèle ancré dans la tradition du *problem-solving* propose une approche comportementaliste palliant les biais et heuristiques de la rationalité limitée.

Par opposition avec les modèles de la littérature étudiant l'équilibrage entre les activités d'exploration et d'exploitation (ambidextrie), nous démontrons que l'exploration peut être plus générative si elle utilise les contraintes d'exploitation comme connaissances préalables à la génération de concepts. Ceux-là reposent sur un conditionnement positif par les paramètres des processus décisionnels contribuant à l'exploitation. De nouvelles situations décisionnelles sont ainsi conçues plutôt que de se contenter d'une traditionnelle sélection des explorations. Ce modèle – ambidextrie décisionnelle – permet de réaliser des projets capables d'explorer des conditions dépassant les limites et performances de l'exploitation.

Une recherche intervention chez Zodiac Aerospace permet de rendre compte de ce nouveau modèle. Il étend ainsi la notion d'ambidextrie organisationnelle dans l'inconnu, plus adaptée au management et gouvernance de l'innovation, tout en précisant la gestion des métabolismes organisationnels nécessaires aux changements des organisations dans un conglomérat de PMEs.

## MOTS CLÉS

ambidextrie, exploration, exploitation, décision, projet, organisation, innovation

## ABSTRACT

It is now common knowledge to develop an *ambidextrous organization* in a firm to guarantee a competitive advantage in its environment. Such perspective is rooted in James March's model (1991) whose purpose is to sustain organizational learning through adaptive mechanisms between agents. This model anchored in the tradition of *problem-solving* offers a behavioural approach coping with biases and heuristics of bounded rationality.

In contrast, with literature models studying the balance between exploration and exploitation activities (ambidexterity), we demonstrate how exploration can be more generative if it uses exploitation constraints as prior knowledge to generate concepts. These rely on positively conditioning them by decision-making parameters contributing to exploitation. New decision situations are designed instead of traditionally selecting explorations. This model - decisional ambidexterity - allows building up projects capable of exploring conditions overcoming limitations and performances of exploitation.

A collaborative research conducted at Zodiac Aerospace allowed revealing such new model. It extends organizational ambidexterity into the unknown, more adapted to innovation management & governance, whilst precising how to drive organization metabolisms inducing change among participating organizations in a conglomerate of SMEs.

## KEYWORDS

ambidexterity, exploration, exploitation, decision, project, organisation, innovation