Measuring the generative power of an organisational routine with design theories: the case of design thinking in a large firm

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MEASURING THE GENERATIVE POWER OF AN ORGANISATIONAL ROUTINE WITH DESIGN THEORIES: THE CASE OF DESIGN THINKING IN A LARGE FIRM

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ABSTRACT

This article studies how a large firm uses Design Thinking (DT) as a core process in specific design and development team whose mission is to bridge the gap between unidentified market needs and business units research & development effort. We analyse two cases where new concepts were developed and promoted to business units for implementation by following DT methodology. Our study shows that the DT routine reveals some generative power to explore the user perspective, yet it appears uncontrolled when it comes to generate a wider variety of ideas and knowledge challenging the design ecosystem ontology omitted and made invariant through user-focus hence it faces difficulties to engage with stakeholders and other organisational routines for an enhanced creativity and organisational change.

Keywords*: innovation, design thinking, aerospace, routines, change management.*

1. INTRODUCTION

Design Thinking (DT) as a design toolbox has raised a lot of interest over the last twenty years among businesses looking for innovation systematisation beyond traditional decision-making and product development paradigm (Liedtka, 2015). When it comes down to exploration and exploitation (March, 1991; O'Reilly & Tushman, 2013), DT is appears as a ready-made creativity and strategic tool managers (Lee & Joo, 2015; Lockwood, 2010; Rhinow & Meinel, 2014). In less than twenty year, DT has left quite a large footprint in the industry, being extended from the works of David Kelley and Tim Brown at IDEO (Brown, 2008), becoming a way of managing (Martin, 2009), and it is now being showcased in several large firms across the world.

1.1 A TOPIC OF INCREASING INTEREST WITH A GRADUAL DEFINITION CONSENSUS

As a consequence, an increasing amount of scholars try to understand its origin, scientific background and in-practice use (Bauer & Eagen, 2008; Buchanan, 2008; Carlgren, 2016; Cooper & Junginger, 2009; Efeoglu et al., 2013; Kimbell, 2012, 2011; Rauth, Carlgren & Elmquist, 2014). DT has been introduced in the management field and in firms as change management means (Brown & Katz, 2011; Brown, 2009, 2008; Dunne & Martin, 2006; Lockwood, 2010) whilst "democratising" design and fostering design as a practice with a set of decontextualized tools. Yet, it remains unclear to grasp the impact of DT, and what it fully becomes when turned into a firm practice practice (Carlgren, 2016; Lee & Joo, 2015; Rauth, Carlgren & Elmquist, 2014; Seidel & Fixson, 2013).

1.2 DESIGN THINKING SEEN AS A SET OF ROUTINES

Recent works have put forward a framework to identify DT as an organisational routine in its various forms (Carlgren, Rauth & Elmquist, 2016) which we will refer to. Moreover, as a design method, its performance, impact on the organisation, knowledge management, remain to be clarified and it is only very recently that its contribution in terms of cognitive bias reduction for decision-making process has been brought to the fore (Liedtka, 2015) among other 'soft facts' (Schmiedgen et al., 2016).

1.3 THE DYNAMICS OF ROUTINES: GENERATIVE POWER OF DESIGN THEORIES AND METHODS

In the routine literature, several features and dynamics are discussed to explain macro organisational dynamics (Zollo & Winter, 2002), to highlight coordination mechanism (Jarzabkowski, Lê & Feldman, 2012; Spee, Jarzabkowski & Smets, 2016) and reveal the generative power of routines, in conjunction with organisational exploration (Cohendet & Simon, 2016; Deken, Carlile & Berends, 2016; Pentland et al., 2012). This generativity usually refers to the performance of the routines being able to resource themselves, to recombine, select and evolve in novel routines, which refers to the phenomenon of having a routine being able to manage collective acceptance to build new rules.
In a separate but close field, design theory literature has already elaborated along with contributions from cognitive psychology what generativity is, based on formal theory of design. This contributed to analyse generativity from a cognitive and a social perspective: knowledge expansion and conceptual exploration (Agogué, 2014; Agogué, Le Masson & Robinson, 2012; Hatchuel et al., 2013, 2011; Hatchuel, Le Masson & Weil, 2009; Hooge, Béjean & Arnoux, 2016).
Generativity, beyond common and unwieldy analytical metrics for innovation (Schepurek & Dulkeith, 2013) appears to reflect exploration dynamics and probably is an adequate criterion to value design method and routines in organisations specially related to innovation and hence diving into the unknown.

Consequently, we question DT from the routines and design theories perspectives and address the following question: Is DT routine demonstrating a generative power in terms of generated ideas, knowledge but also in terms of collective engagement to explore new disruptive paths at the design and business level?

1.4 PURPOSE AND SCOPE

We first propose to elaborate a framework to measure generative power of DT routine when embedded in an organisation – this measurement will be derived from design theory. And we test it on one "reference case", well-known to all experts in DT before testing it on real cases. Our laboratory case is the IDEO's shopping cart design for the ABC Nightline TV documentary. We have chosen to investigate how DT has been used for two separate topics – waste management and turnaround time – on board of aircrafts. The two projects were conducted within a large aeronautics equipment manufacturer, Zodiac Aerospace, by a dedicated team requiring cross-business-units collaboration and challenging dominant designs and product fixation.
Our contribution to design management and organisational studies is two-fold. First, we aim at highlighting potential factors contributing or not to the generative power of design thinking and its routine. We carefully look for knowledge structures, practices and artifacts that would or would not elaborate new design paths avoiding lock-ins. Second, we would like to show the limited and unruled generative power of DT and the challenge it faces to have an organisational impact. We will then propose improvements

as we believe it could be revised notably its performance related to generativity and transformational power to avoid the method to become just another management fad (Deserti, Rizzo & Cobanli, 2016; Seidel & Fixson, 2013).

2. THEORETICAL BACKGROUND

2.1 DESIGN THINKING

Beyond the works of (Buchanan, 1992; Dewey, 1958) considering design as a *liberal art* and (Simon, 1995) taking design as a core discipline, the Design Thinking we are interested in is the human-centred problem solving methodology, "fostering creativity" as explained by Hasso Platner in the preface of (Plattner, Meinel & Leifer, 2016). It is inspired by the way *traditional* designers (industrial designers, stylists, architects) think transposed into a consulting toolbox (Brown, 2009; Lockwood, 2010; Powell, 2016). We base our understanding of DT from the works of (Bauer & Eagen, 2008; Brown, 2008; ParisTech, n.d.; Stanford, n.d.), which segment DT in three main phases which we will refer as: Launch & Exploratory phase, Conceptual & Prototyping phase and Proposal phase.

DT is now well frame-worked despite its plurality in large firms (Carlgren, Rauth & Elmquist, 2016; Kimbell, 2012, 2011), making it easier to identify when embedded beyond IDEO's service. Its embeddedness and appropriation by the businesses still raises several questions (Carlgren, 2016; Rhinow & Meinel, 2014) challenging it as the "next competitive advantage" (Martin, 2009).

DT is framed with the unit of analysis of organisational routines (Feldman et al., 2016; Feldman & Pentland, 2003) by identifying several themes – user focus, problem framing, experimentation and diversity – rallying mindsets, practices and techniques hence promoting ostensive and performatives aspects.

2.2 QUESTIONING ITS IMPACT

As DT is gradually being used across the industry, since it is seen by executives as a ready-made routine among "ways to look at their businesses because they've seen that the seemingly pragmatic, linear, analytical, quantitative approach of business thinking has not yielded the hoped-for results" (Lockwood, 2010).
It is an attempt for businesses to get away from the exploitation regime, and favour exploration, yet it may not have a long lasting effect as said by Continuum's founder Gianfranco Zaccai in (Lockwood, 2010). It is a trial to play around with organisational ambidexterity (O'Reilly & Tushman, 2013).

DT's methodology has been praised its brainstorming qualities (Sutton & Hargadon, 1996), its "knowledge broker" and emulation through empathy values for organisations (Hargadon, 2002), the latter being corroborated in (Carlgren, 2016, 2013; Carlgren, Elmquist & Rauth, 2014; Hargadon, 2002; Seidel & Fixson, 2013). Despite efforts made to link DT with engineering activities (Beyhl, Berg & Giese, 2014; Beyhl & Giese, 2016, 2015), and the role of some artefacts such as prototypes (Beyhl & Giese, 2015; Gabrysiak et al., 2010), we can highlight the naturalistic approach of DT. Users are well studied but do not take an active role in the (re-)design process compared to works of

(Kristensson, Magnusson & Matthing, 2002; Magnusson, Matthing & Kristensson, 2003) therefore some design features could perhaps be omitted. Some potential limits are then identified from the depth of the user perspective brought into the design exercise.

In the same line of thought, several works from the design theories' field have offered detailed explanation of features a design process should tackle from a cognitive and a social perspective in (Hatchuel, Le Masson & Weil, 2009; Hooge, Béjean & Arnoux, 2016): idea generation, knowledge expansion which echoes earlier works on creativity in psychology (Amabile et al., 1996; Paulus & Yang, 2000), on organisation dynamics (Dougherty, 2008; O'Connor & DeMartino, 2006; Zollo & Winter, 2002) whilst stressing the social dimension of design and creativity is key to understand how effective design can be as shown in (Akrich, Callon & Latour, 1988; Seidel & Langner, 2015; Sosa & Gero, 2003). In addition to that, the use of C-K Theory (Hatchuel & Weil, 2002), has been proven as being a very useful theory to show the extent of a design exercise, fixation effects/path-dependence and depth/width of exploration (Agogué & Kazakçı Osman, 2014). The purpose of this approach is to measure the design effort compared to a given C-K referential done before or in parallel to the experiment to measure the cognitive and social effort linked to the exploration of knowledge and concept spaces, hence revealing the generativity of the process. This methodology has already been applied to the fields of cognitive psychology and technology strategy in the seminal works of (Agogué, Le Masson & Robinson, 2012; Elmquist & Le Masson, 2009; Le Masson et al., 2012).

Along the same footsteps, we can look at performance criteria from the routines literature, which refers to generativity with similar semantics. Change, flexibility, entanglement and interdepences are explained at the light of routines (Feldman & Pentland, 2003; Howard-Grenville, 2005; Jarzabkowski, Bednarek & Spee, 2016; Leonardi, 2011; Spee, Jarzabkowski & Smets, 2016) and as a potential source of novelty (Deken, Carlile & Berends, 2016). A simulation model in (Pentland et al., 2012), puts forward the generative mechanics of routines inspired from evolutionary models (variation, selection) whilst highlighting the link with macro-level phenomena. (Cohendet, Llerena & Simon, 2012; Cohendet & Simon, 2016) explains how creativity is enhanced and new routines generated by endogenously recombining sub-routines encoded in the business when efficiency guidelines overcome creative flexibility. In other words, this literature field relates to the generativity as the effort for a social group to generate new knowledge or organise for future reference to work on, which relates to a kind of dynamic capability.

For our study, we then choose to relate to generativity in the broadest sense: we will pay close attention to the generation of new ideas, new knowledge areas at an individual and collective level to clarify the forces at work in the DT routine, as we see there is a gap in the literature to explain what makes a creative routine generative in a large firm.

Consequently, we question DT from the routines and design theories perspectives: Is DT routine demonstrating a generative power in terms of generated ideas, knowledge but also in terms of collective engagement to explore new disruptive paths at the design and business level whilst breaking away from pre-existing routines?

3. METHODS AND RESEARCH SETTINGS

3.1 RESEARCH DESIGN

This study relies on an ongoing three year collaborative research started in 2015 with the French aerospace original 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. This peculiar team presents certain flexibility, and managerial patterns that differ from the rest of the Innovation/Design/Research&Technology teams. We benefit from a unique position to understand how a historic aerospace group such as Zodiac Aerospace tries and evolves new organisation settings and innovation methods 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 expansion, technological transfers, and innovation from the airships, inflatable boats, seats, electronics equipment, power supply, lighting, cabin lining and lavatories. In a global standardisation movement activities were consolidated and corporate functions have been created to support business units (BU). It is in that perspective that the SDT was created: have a close contact with the market and feed BUs with proposals to further develop. The team is constituted of 8 permanent engineers/designers delegated by BUs for three years maximum, and still dedicate 50% of their time to their unit of origin. They report to a local manager, who actively contributes to the team creativity effort and facilitates discussions with BUs and reports to the group business development director.

3.3 DATA COLLECTION

This research is a qualitative study where the first author is hosted at the Group Innovation Direction of Zodiac Aerospace and has full access and regular discussions with the SDT.

In order to understand the routines and the design effort in the DT methodology applied to a design brief or embedded in an organisation, we propose to first start with an analysis of the famous IDEO's Shopping cart well documented in the ABC Nightline show (Case 0). We propose then to use the same analytical lens on the two cases from Zodiac Aerospace. See Table 1 for the collected data.

In case 1, the main author followed the project and its leader since its launch in September 2015 until the final handover discussions with BUs between January and April. A final analysis was reported to the SDT manager, providing a fresh look over this first Design Thinking project.
Case 2 started closely before the last handovers of the first project, and was led by a different project leader, who had observed and partially participated to the previous. Some returns on experience where taken on board, yet only minor changes were made to the Design Thinking approach such as a better timing of exploratory phase. No feedback was given by the author to the team on this project.

Table 1 - Data description

	Case 0	Case 1	Case 2
Description	IDEO's Better Shopping Cart	ZA Better Waste Management for the aircraft	ZA Optimised Aircraft Turnaround Time
Project length	One week	6 months	8 months
Organisational entities involved	IDEO team (designers and engineers)	ZA mixed background (several BUs, working groups of designers and engineers)	
Data sources	ABC Nightline TV documentary	All documentation produced during the project and formal/informal discussions with project participants (12 interviewees)	

3.4 ANALYTICAL LENS

As introduced in the theoretical background, we will discuss DT routine, and question its impact from a design theory perspective as it provides the broadest sense of the generative power of design effort, and can be transposed to a routine.
First, we will refer to the framework elaborated in (Carlgren, Rauth & Elmquist, 2016) to clearly identify the routine of DT embedded in the organisation (see Table 2). We will refer to it only in the case of Zodiac Aerospace, as for IDEO's case, DT is in its purest form. Second, we will use the design framework in (Hatchuel, Le Masson & Weil, 2009; Hooge, Béjean & Arnoux, 2016) to highlight the design effort in terms of idea generation and knowledge expansion (Table 3) from a cognitive and social perspective.

In order to fill in the design framework four main cells we have executed the following:

1. **Cognitive/Idea Generation** – A C-K referential was elaborated ex-post based on the exploratory phases of DT as per (Agogué, Le Masson & Robinson, 2012). 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 can ideate across the semi-conductor industry see (Le Masson et al., 2012). So we feel confident that we did not minor exaggeratedly the DT exercise.
2. **Cognitive/Knowledge Expansion** – As stated earlier, the C-K referential will help comparing the knowledge solicited by DT and the related cognitive effort.
3. **Social/Idea Generation** – With the help of data collected, interviews, we observe techniques used and group dynamics to generate and select new ideas.
4. **Social/Knowledge Expansion** – Along the same line of thought as the previous cell, we report the way knowledge is handled to promote ideas and build consensus around the creative effort, in addition to the fit with stakeholders' knowledge basis and routines.

Table 2 - Characteristics and framework in (Carlgren, Rauth & Elmquist, 2016)

Themes	Principles/Mindsets	Practices	Techniques
User focus	• Empathic • Curious • Non-judgemental • Social	• Seek to understand latent needs and pain points of users (empathize) and let this understanding guide all work • Use a qualitative, context specific approach in user research. • Involve users in ideation, prototyping, testing	• Ethnographic research • Informal meetings with customers • Accumulate user stories and anecdotes • Journey mapping, empathy map, persona • User feedback sessions
Problem framing	• Unconstrained thinking • Comfortable with complexity and ambiguity • Open to the unexpected	• Challenge and reframe the initial problem to expand both problem and solution space • Synthesis of research insights: finding patterns, framestorming (ideation to find alternative problem formulations)	• 'How-might-we-questions' • 'Five why' • 'The problem statement' (Point Of View), 'painstorm', 'FOG' (fact, opinion, guess)
Visualization	• Thinking through doing • Bias towards action	• Make ideas and insights visual and tangible to externalize knowledge, communicate and create new ideas • Visually structure data • Make rough representations • Provide experiences to enable understanding	• Creation of rough physical mock-ups by using e.g. paper, card-board, glue and foam, Lego, or any available artefacts • Sketching, storyboarding • Storytelling, role-play, video • Writing 'ugly code', wireframes
Experimentation	• Curious and creative • Playful and humoristic • Optimistic and energetic • Learning-oriented • Eager to share	• Work iteratively (divergent, convergent) • Converge based on a diverse set of ideas • Prototype quickly and often to learn • Test solutions quickly and often: share prototypes with users and colleagues • Fail often and fail soon	• Brainstorming techniques • Creation of flexible and physical space that supports experimentation and visualization
Diversity	• Integrative thinking • Open to differences in personality type/background • Democratic spirit	• Create diverse teams and let everyone's opinion count • Collaborate with external entities • Seek diverse perspectives and inspirations (variety of fields, broad research) • Take a holistic perspective into account	• Personality tests • Conscious recruitment • Analogies, study visits • '360° research': white space analysis, benchmarking, past failure and success, pattern recognition, demographics, etc.

Table 3 - Analytical framework and examples of criteria value

	Cognitive	**Social**
Idea generation	**Cover the whole conceptual potential of the initial concept *("problem formulation")*** *Classical method:* brainstorming *Criteria:* fluency *Issues in the literature:* limited expansions (similarity, based on limited knowledge base) *Method improvements:* mix divergent thinking/convergent thinking personalities, trained facilitator (filtering and orienting divergence)	**Involve and support people in a rule-breaking process** *Classical method:* brainstorming *Criteria:* well-being, participants satisfaction (i.e. fell comfortable in idea generation) *Issues in the literature*: production blocking (social anxiousness, perceived expertness, missing recognition) *Methods improvements:* status auction, electronic brainstorming
Knowledge expansion	**Enable relevant knowledge activation, acquisition and production** *Classical method:* participative workshops *Criteria:* variety and overlapping *Issues in the literature:* limited performance because of close-world condition *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** *Classical method:* consensus building methods *Criteria:* expert agreement Issues in the literature: conflict, difficulty to accept variety of skills, knowledge distribution *Method improvement:* no pressure to accept particular perspective, make the customer be positive (prepare acceptance)

4. RESULTS

We first represent IDEO's case, and to explain to understand how we fill the framework, see Table 4, Table 5 and

Table 6, which compiles all three cases. Afterwards, Zodiac Aerospace's cases are presented, also taking into account the organisational routine dimension, followed by our analysis.

4.1 TEST CASE ON IDEO'S SHOPPING CART (IDEO)

We proposed to test our analytical framework on the well-known case of IDEO's team working on a new shopping cart by using there DT methodology. The case configuration here is different from Zodiac Aerospace as DT is not embedded in any firm, it is an external intervention with little feedback and promotion to potential client and users.

4.1.1 IDEA GENERATION

Cognitive dimension

The team lead by Peter Skillman, with David Kelley's supervision and authority guide the eclectic group composed of engineers, designers, linguist and marketing etc.

Themes for the groups are given following the deep dive, with an emphasis on overall safety/theft; they reflect a certain limitation in the concept exploration, closing the path for other designs. For instance, at one point the leader says "If [the cart] doesn't nest, we don't have a solution" Peter Skillman.

The generative power is rather low despite the combination of professionals, and user input assimilated to experts ("The trick is to find these real experts. The people who are really getting the info are out in the field meeting with people." David Kelley).

Social dimension

The brainstorming has strict rules and the leaders have an important role in guiding the exercise, all members have their say, and propose their ideas freely to discuss their attributes.

A vote is organised to narrow down the number of ideas generated, and recombination of concepts' features happens at the very end for the final design proposal.

However, beyond the team level, concept legitimacy is partially given thanks to user empathy: there is a surprise effect when shop assistants are confronted to the new design as it may redefine their whole work and traditional routine: e.g. the hand-held scanner can be seen as a threat to the cashier's position at that time. This performative aspect is not well handled by DT, due to the reduced exploration.

4.1.2 KNOWLEDGE EXPANSION

Cognitive dimension

Team members are encouraged to go out and meet all traditional users whilst acknowledging some alternative uses when the cart is taken out of its supermarket environment (barbecue, carrying). Yet, some rules inherent to the cart and the supermarket are not challenged nor identified in the process: What about using the cart up to the car's boot? Following the user's shopping experience down to the refrigerator? Should the provided plastic bags be considered as the sole option? Etc.

The user focus, expands the members' knowledge yet, and his immediate concerns whilst letting a whole knowledge space hidden.

Social dimension

All members share their knowledge through stories, drawings and prototypes, allowing everyone to be on the same level despite their different background.

The last stage – promotion/testing of the design – ends up on a weak note: it considers that the design as it is, a detailed actionable prototype, should entail a development project for a cart manufacturer, but many aspects still remain unanswered: strong diversification needed from the cart manufacturer to start working with more plastic materials, electronic devices to be closer to supermarket operations, and marketing value and fitness goes beyond 'user consultation' as a whole ecosystem of routines and values are to be elucidated.

Finally, we would like to quote Kelley, who partially reveals the conception of DT when applied or embedded to a firm: "It is one thing to be able to do a product once in a while, but if you can build a process where you can routinely come up with great ideas. That's what the companies really want". He calls for creativity systematisation and exploration dynamic of the organisation by emphasising the conceptual effort without specifying generative mechanism or organisational compatibility.

4.2 SDT CASES (ZA1, ZA2)

SDT's two project leaders were trained to DT in their studies or career. We go through the main themes of the routine as described in Table 2 (Carlgren, Rauth & Elmquist, 2016): User-focus, Problem Framing, Visualisation, Experimentation, and Diversity. Due to time constraints and re-consideration of their own work as the design exercise move forward the team leaders and the SDT manager decided to have some overlap with the main three movements of DT, see below, in Figure 1.

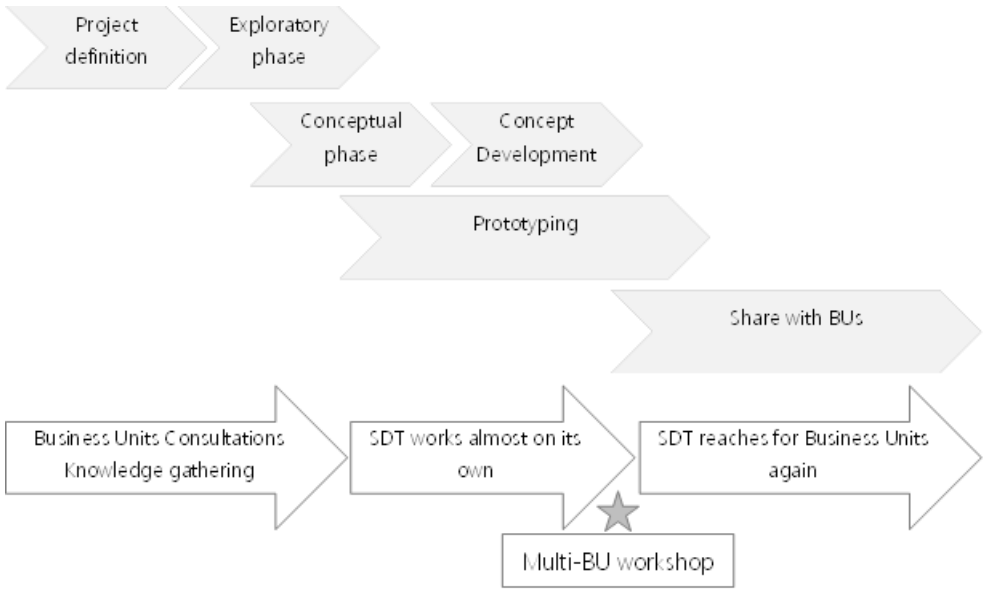

Figure 1 - SDT's DT methodology

Problem framing

The projects definition was a collective choice made at SDT after a year of work, and weekly creativity sessions on different topics chosen by team members. The topics were selected for enabling BUs to tackle users' issues whilst exchanging with fellow units.

User-focus and Diversity

The exploratory phase consisted of background research, collecting data from BUs, and topic's stakeholders. The result was presented in the form of a mind map of the documented topics in alignment with overall product portfolio. The report is shared to participating BUs for knowledge gain, and to have feedback for SDT to gear the DT focus.

Problem framing, experimentation and visualisation
The conceptual phase is made of several creativity sessions between SDT members and occasionally invited BUs or corporate employees, and in case 2 a group of engineering students trained to DT. Those sessions brought around 200 ideas that are classified and sometimes merged together and reformulated when similar. Ranking follows criteria reflecting: alignment with business strategy, customer value, added value compared to the existing and user value. In parallel SDT added a subjective note representing how far-fetched ideas are. A final shortlist follows: a top 10 along with specific lists of 5 to 10 concepts for each BU, i.e. suitable for their specific product portfolio.

Visualisation and experimentation
Prototyping happens quite early in the process, during the first sessions, drawings are made, discussed with others, and low fidelity prototypes are made on the spot. During the concept development and iterations between SDT and BUs, several 3D renderings are discussed with engineering/marketing/design teams.

Problem (re-)framing and another theme in the DT routine: social acceptance
The multi-BU workshop is a specific creativity session held after the concepts ranking and first development iteration. It is the first time SDT presents their concepts. Representatives of the concerned BUs attend and work around a tailored theme considered as the core topic by SDT's members and manager.

Finally, the promotion to BUs is carried over several months to pitch the ideas with physical meetings, multiple design iterations on the presented concepts whilst taking into account comments from the several parties.

This step goes beyond simple feedback. Indeed, SDT has to 'sell' internally their proposals for BUs to further develop. SDT is considered to succeed when a BU takes the lead on a proposal, and one metric, yet without a given objective, is the number of provisional patent applications.

4.3 SUMMARY OF RESULTS

Table 4 - Summary of results – LAUNCH AND EXPLORATORY PHASES

	Case	Cognitive	Social
Idea generation	IDEO	- Topics opening an innovation field identified by team leaders: better shopping cart - Several themes are quickly identified for exploration: safety, shopping practices, checkout, searching products	- New topic to work upon with eclectic group - Members have a history of DT practice - Everyone feels concerned by the project as they all have some experience and already have ideas of improvements
	ZA1	- The Waste Management topic is identified as major issue on board of aircrafts - Business Units are somehow related to the issue and could contribute to it	- The team had already briefly explored the topic - DT was seen as a strong value-add by the team and the manager to try another method to promote SDT's work to the whole group - Some concepts are extracted from business units revealing some isolated ideas
	ZA2	- The Turnaround Time subject is seen as a critical point for airline operations where Zodiac Aerospace can contribute through their equipment	- The team had already briefly explored the topic - DT had been used in the previous case, the team was rather happy with experience and took into account some points to improve (quicker exploration, better technical details in proposals)
Knowledge expansion	IDEO	- Team leader encourages to go out for the deep dive and meet the users, seen as experts on the field - 'Extreme users' are investigated	- A first discussion helps to define a set of themes to work, consensus is built by sharing experiences - Knowledge is carefully shared between members
	ZA1	- Following DT methodology, team members are encouraged to collect information from their desk and meet with waste stakeholders ranging from passengers to airports - The report raises interest among business units' contacts	- Team leaders encourage to share the acquired knowledge quickly between each other and redirect towards other potential interviewees or topics when something is felt worth investigating further - A full report is issued and shared with business units
	ZA2	- Following DT methodology, team members are encouraged to collect information from their desk and meet with all stakeholders impacted by turnaround time ranging from passengers to airports operations - The report raises interest among business units' contacts	- Team leaders encourage to share the acquired knowledge quickly between each other and redirect towards other potential interviewees or topics when something is felt worth investigating further - Some knowledge areas to discarded for being out of the company's business scope - A full report is issued and shared with business units

Table 5 - Summary of results – CONCEPTUAL & PROTOTYPING PHASES

	Case	Cognitive	Social
Idea generation	IDEO	- The team is fragmented in groups to work a selected topics following exploratory phase input - Concepts are reviewed, voted, and recombined at a later stage to convert into a single solution	- All members come up with many ideas, and have to be refocused on some selected topics chosen by team leaders to avoid dispersion and stop the ideation - High involvement of members - Some existing design rules are kept constraining some wild ideas
	ZA1	- The team organises several creativity sessions, mixing drawings, rapid prototyping, around selected themes formulated after the exploratory phase - All concepts are reviewed and ranked - A shortlist of ideas is issued	- High involvement of members with once in a while participants external to SDT and directly concerned by the project - A final workshop is organised with all business units' contacts to recombine over already elaborated concepts
	ZA2	- Identical to ZA1	- Identical to ZA1
Knowledge expansion	IDEO	- All ideas are carefully discussed and tested through tacit knowledge produced	- Team leaders had to reframe the problem and stress knowledge areas previously identified to further develop the concepts
	ZA1	- All ideas are discussed and iterated over between members - Some deception was felt by SDT members after the multi-BU workshop, they expected to have more breakthrough ideas - Concepts are ranked and grouped to match known product lines, and business units' activity	- No specific intervention from leaders or manager to expand knowledge to other areas - Multi-BU workshop is organised around two themes already worked on by SDT after presenting exploratory phase output and shortlist of ideas
	ZA2	- All ideas are discussed and iterated over between members - Concepts are ranked and grouped to match known product lines, and business units' activity	- Identical to ZA1

Table 6 - Summary of results – PROPOSAL PHASE

	Case	Cognitive	Social
Idea generation	IDEO	- The final concept is refined through recombination of best features in the theme, no further expansion nor comparison to other solutions	- The final solution is presented to some users in the supermarket environment for feedback, and tested with team members on the field - For shop assistants, a surprise effect is noticed suggesting the value chain is modified
	ZA1	- Some improvements are made to some of the shortlisted ideas selected by business units - New renderings, more technical details have to be provided	- The shortlist of selected concepts are promoted to business units, and a secondary shortlist is presented in line with their product portfolio - A stretch from existing design but would require some level of rule breaking, - Poor enthusiasm from business units
	ZA2	- Identical to ZA1 for the contacted business units	- Identical to ZA1 for the contacted business units
Knowledge expansion	IDEO	- The hand scanner seems to be the only feature that remains to be worked on, but very little concern is shown on all the knowledge remaining	- No further development axis is highlighted
	ZA1	- The team leader visits business units and organised several meetings to discuss iterations over selected concepts - More technical detail is requested - Business units are in a "wait and see" position, the value is not yet fully grasped - The stretch from their dominant design requires a better acquaintance of other business units	- Provisional Patent Applications are considered to encourage business units to work on the solutions - Budget lines are missing for business units, they do not seem to have enough resources available to implement - Working between business units is considered as rather complicated exercise
	ZA2	- Identical to ZA2 for the contacted business units	- Identical to ZA2 for the contacted business units

4.4 CASES' INTERPRETATION: LIMITED COGNITIVE AND CONCEPTUAL EXPLORATION LIMITING ORGANISATIONAL IMPACT

4.4.1 KNOWLEDGE LEFT ON A SIDE

The exploratory and the conceptual phases to study knowledge clusters directly pointed by users, some topics out of user's scope where deliberately left on a side, like in the case no.2, as some areas where considered out of Zodiac Aerospace's scope (business held directly by airport operators) and others not even mentioned. With the help of the C-K referential, we revealed white spaces, which show that compared to the chosen design paths and knowledge areas, there is up to 60% of the knowledge that was solicited.

In case 1, for instance, waste in the aircraft was not apprehended from another angle: bacteria and viruses; it was partially revealed during the preliminary exploratory phase, but quickly discarded as not being raised by users. In addition to that, "time-constraint" and "not having the right tools" was raised across case 1&2, yet it does not prevail from contouring missing knowledge, not directly seen through users.

User-focus promotes primary concerns, or sometimes secondary, but other constraints are omitted whereas they could open new paths far from traditional design.

Table 7 – Design effort a cognitive/individual perspective

	Cognitive perspective
Concept coverage	- Up to ~60% coverage - Very path dependent and some sideways exploration with the help of with "What If scenarios" in conceptual phase, challenging existing designs
Knowledge expansion	- Up to ~60% of knowledge is presented (Case1: areas not even in the radar ; Case2: white spaces were identified and omitted) - Tacit knowledge with prototyping - Main acquired knowledge comes from user empathy, other knowledge such as new technologies or new functions are scarce - New distant knowledge appears almost serendipitously with need-pair solutions - User knowledge is interpreted into a design brief

The new knowledge that is constituted has the following pattern (see Figure 2):

- User empathy provides elements to revise existing designs and reconsider close functions without challenging their nature
- Distant knowledge is reached only during 'What-ifs?' sessions, which by reshuffling the card allow members to imagine different environments, use cases and designs calling for personal knowledge extracted from fiction or for recurrent group ideas (e.g. the 'sushi-belt' for any purpose, robots, or a "magic thing that makes life easier" etc.). Some realistic concepts were shortlisted and require further investigation for BUs for having changed the ecosystem. These ideas that appear in a serendipitously fashion, echoes works of (von Hippel & von Krogh, 2015) on need-solution pairs.

Finally, the strong user-focus reveals a pre-fixation in the design process: a preconceived ecosystem. The users do inform on the existing ecosystem, yet DT takes it for granted. DT seems to have encoded in its routine that the ontology of the problem is invariant; knowledge is not fundamentally re-ordered during the design exercise, as shown in Figure 2.

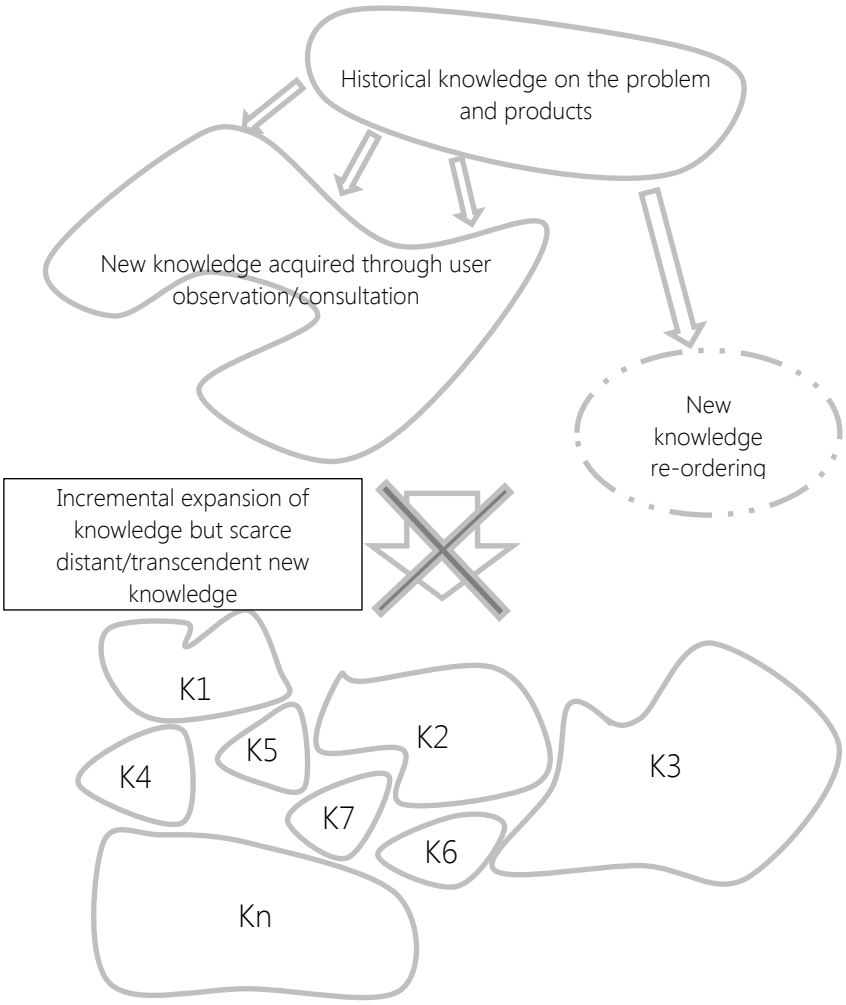

Figure 2- Knowledge expansion pattern with no re-ordering

4.4.2 A CERTAIN PATH-DEPENDENCE

In correlation with knowledge structure we have observed a certain path-dependence due to the restrictions of user-focus and business scope. In Figure 3, the dotted lines and circles represent the unrevealed areas, most of the knowledge developed the hereditary path we see on the left which stays close to dominant designs, some deviations branch out of the main path showing how user focus and experimentation opens optimisation and recombination possibilities over existing designs.
Among distant concepts, in the "unexplored" area, some ideas where highlighted during creativity sessions but mostly forgotten because requiring further research was needed to appreciate the concepts with the relevant missing knowledge.

As some particular knowledge items are not collected, there is no "push" force to neither create extreme design paths nor probe the ecosystem. Only some "what-ifs" scenarios built on shaky grounds break existing rules but are hardly selected for being out of the preconceived problem framing.

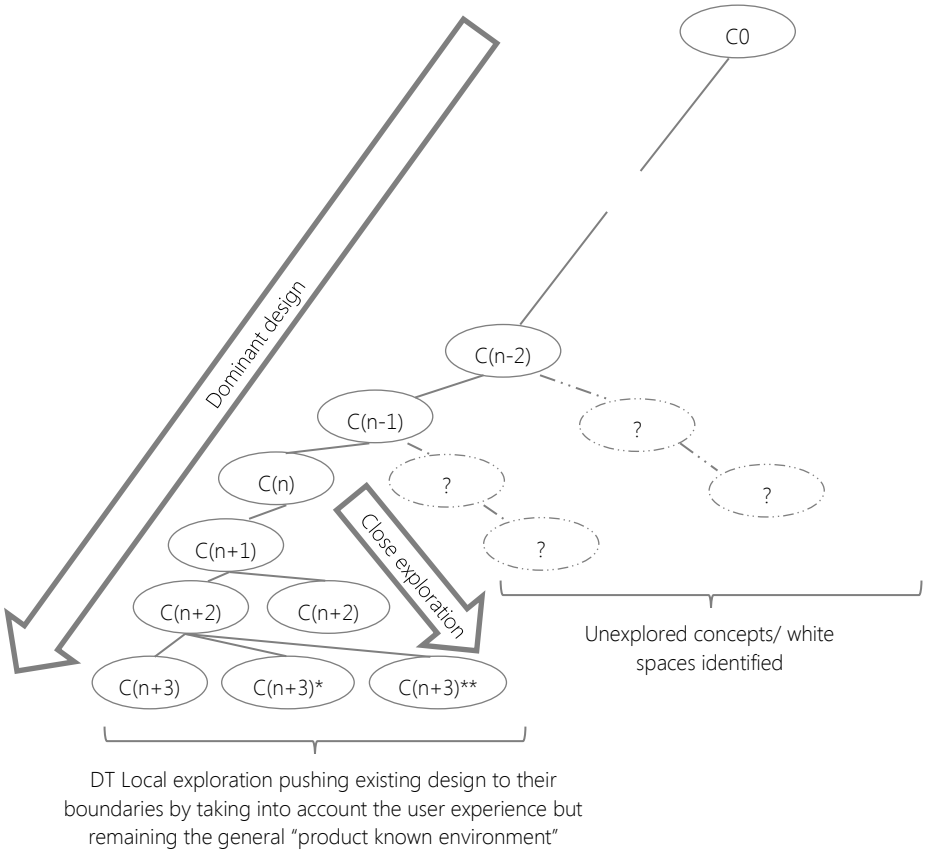

Figure 3 - Concept development pattern

4.4.3 THE STRUGGLE TO PROMOTE IDEAS TO BUSINESS UNITS

Beyond the cognitive dimension, SDT has to promote concepts to BUs for further development.

Two SDT members have stressed that "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". Here, they pinpoint the dilemma of having creativity/flexibility challenging efficiency dogma (O'Reilly & Tushman, 2013); and DT already constrains them:

- To remain close to established product design fixation
- To struggle to ground edge designs challenging the existing ecosystem implicitly defined by consulted users

The SDT admitted that they remained at a very conceptual level and that discussions with BUs were complex since they were requesting more technical details and customer value proof and struggled to articulate interdependence of the proposal with the existing state of the art. Despite difficulties, the SDT have opened the BUs' eyes to user concerns and potential improvements.

The SDT who seeks at shaping valuable proposals bridging aircraft manufactures/airlines and Zodiac Aerospace know-how, seems to struggle to match the

level of performance requested by BUs. The effort required goes beyond the pure proposal of creative ideas.

The routine implemented by SDT wants to break the existing ostensive aspects of the overarching business routines such as the business scope, and techno-structure imposed which reflect how products are designed in partially isolated clusters. This segmentation is historically linked to serial acquisitions, the group standardisation, and to the fact that engineering is ruled by the aircraft manufacturer along with airline specific demands, following Air Transport Association chapters which siloes equipment and systems.

Consequently, the performances developed by SDT face the exploitation wall raised by daily BUs operations, hence facing questions from BUs' contacts: "Who is paying for the development work? Who is paying the intellectual property? I don't have a budget line for this action." Questions that have shy answers, in case 1 only one budget line for the coming financial year of one BU reflects the will to study one proposed concept. SDT's exploration and BUs' exploitation have different temporalities.
When facing reluctance, SDT choses to protect worthwhile ideas with provisional patents with sponsorship from group corporate management, thus complexifying SDT's action, as BUs willing to develop may be hard to find and to bend to perform the work.

DT by providing a list of concepts that are pre-fixated by the ecosystem actually fits pretty well with the BUs' ontology, yet there is a misfit when DT provides borderline concepts revising design rules, knowledge and organisational dynamics, its technostructure and settled routines. Those issues are apparently not controlled in the DT methodology.

5. DISCUSSION AND CONCLUSION

Our study shows that DT has a limited generative power due to several factors:

- Knowledge collection through user focus draws a design path closely ramified from existing dominant design whilst omitting and not controlling other paths challenging the design ecosystem
- The search for users information feeds reveal a hidden bias where the ontology appears invariant by default and encoded in DT routine
- These fixations make the impact of novel edgy concepts for the pre-fixated ecosystem effortful as the rule breaking process is hard to understand for the organisation.

As a routine DT is not showcasing a strong generative power and appears to misfits the organisation.

Generativity is not an end in itself, as extreme cases of generativity would imply extreme flexibility for the organisation and market. DT does an incredible work at exploring the user knowledge and exploiting for enhanced or new functions it but some of its generativity appears uncontrolled. As the ecosystem is pre-fixated, DT omits the possibility of using technology to modify the environment, modulate the organisation and its routines to perform the design exercise. Problem formulation is perhaps too narrowed and should embrace a larger scope as concept promotion is challenging.

One axis of development of DT would be to refine its problem formulation and extreme user research steps. Preliminary studies should enlarge the perimeter to alternative use cases to address the possible alteration of the design ecosystem and the organisational implications. This process should not be left to "What-If" scenarios which only provides need-solution pairs (von Hippel & von Krogh, 2015) easily discarded or disturbing for final developers as its origin is ill-defined.
This openness at the start should be stopped at some degree and should take into account organisational barriers to gain in design fluency when it comes to challenge existing rules.

As we mentioned, knowledge structure and path-dependence for concepts appear to be limiting factors for DT to go full scale in the organisation and emphasise, stimulate the creativity of BUs. The "Change by design" promise (Brown & Katz, 2011) is not kept as its own uncontrolled generativity. User-empathy does not seem good enough to articulate interdependences in a large firm at a cognitive and social level.

Overall, if a creative routine should be designed to bridge the gap between exploration and creativity, we would be looking at phenomenon such as the one of a messenger RNA conveying genetic information from DNA to the ribosome for expression of encoded genes. A creative routine, would feed from pools of knowledge, a given ecosystem, encode the essence of it, into several performances and then reinterpret these within the organisation, and if possible with variations, selections, if we refer to (Pentland et al., 2012). Design Thinking still has a few features to articulate and develop to succeed its organisational embedding.

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