

Convince me or commit me? Avoid the cognitive trap induced by Non-Human Actors in early stages of NPD.

Fabien Jean, Pascal Le Masson, Benoit Weil

► **To cite this version:**

Fabien Jean, Pascal Le Masson, Benoit Weil. Convince me or commit me? Avoid the cognitive trap induced by Non-Human Actors in early stages of NPD.. 21st International Product Development Management Conference, Limerick : Irlande (2014), Jun 2014, Limerick, Ireland. hal-00976059

HAL Id: hal-00976059

<https://hal-mines-paristech.archives-ouvertes.fr/hal-00976059>

Submitted on 6 Oct 2015

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

*21st International Product Development Management conference, Limerick, Ireland,
june 15-17, 2014*

CONVINCE ME OR COMMIT ME? AVOID THE COGNITIVE TRAP INDUCED BY NON-HUMAN ACTORS IN EARLY STAGES OF NPD.

Fabien JEAN^{1,2}
Pascal LE MASSON³
Benoît WEIL³

¹PhDstudent at Centre de Gestion Scientifique, MINES ParisTech

²Full-time affiliation at SAFRAN S.A.

³Professor at Centre de Gestion Scientifique, MINES ParisTech

Contact : fabien.jean@mines-paristech.fr / fabien.jean@safran.fr

60 bd Saint-Michel 75006 Paris France / 2 bd Martial-Valin 75015 Paris France

ABSTRACT

Akrich, Callon & Latour's concept of intersement has been broadly used in NPD. A gap in this theoretical stream of research remains in the difference between human actors' commitment and convincement. The first concerns the enrolment of competent allies while the second concerns arousing top managers' approbation. To address this gap, our qualitative research takes place at SAFRAN, a corporate conglomerate of highly specialised companies. We take the focus of non-human actors (NHA) involved in early stages of NPD analysing 28 NHA of 5 different representational media in 4 different contexts. To characterise NHAs we review the literature on artefacts made within NPD and identify two utmost types (A and B). We find that NHAs which match type A artefacts do better at convincing in prospect of an entry gate to development and that NHAs which match type B artefacts do better at committing in the ideation process. The difficulty for managers is that type A or type B artefacts cannot be recognised according to their representational medium. The consequence is a misunderstanding: some NHA which match type B artefacts create no intersement because type A artefacts were expected, introducing the risk of missing an innovation opportunity. However their failure may not be definitive as managers have the ability to switch from convincement logic to commitment logic. This change in interaction is more probable to happen in informal meetings than in distant artefacts review. Some NHA take advantage of their A-B artefact ambiguity, human actors interact with them by alternating logics, inducing richer decision-making and ideation. We conclude that if managers were aware of the two types of artefacts they could adapt their attitude accordingly and take better decisions. We suggest that managers favour artefacts presentations in informal meetings to favour switching between convincement and commitment logics and avoid the cognitive trap.

EXTENDED ABSTRACT

It has been broadly stressed that the early stages of NPD are critical for radical innovation. Since the absorptive capacity and open innovation streams, it is established that collaboration with other companies, research centres and institutions are key in this phase of the NPD process. Collaboration has been studied through various angles such as the cooperation-competition dilemma, creativity methods (brainstorming, KCP...), intermediaries of the unknown (broker, networker or architect), the emergence of governance mechanisms, the emergence of a common purpose, expectations (eventually generative), mediating technologies with lead users and network creation.

The latter was introduced by Akrih Callon & Latour through the actor-network theory which perceives the innovation process as the building of a network of human and non-human actors through the process of translation. Network perspective or network process perspectives are examples of more recent works which find their theoretical ground in the actor-network theory. They all consider actors involvement in the innovation process through the concept of intersement. We claim that a gap in this theoretical stream of research is in the hinted but left inexplicit difference between the commitment and the convincement of human actors. The first concerns the enrolment of competent allies while the second concerns managers' approbation. They have been said to occur at different time but not sufficiently described to provide with useful knowledge to managers. How should managers convince their top management or commit partners?

To address this gap, our qualitative research takes place at SAFRAN, a corporate conglomerate of highly specialised companies. It is at stake for the group to enact collaboration between companies to provide markets with disruptive innovations. We take the focus of non-human actors (NHA) involved in early steps of innovation. The researcher pursued the analysis of 28 NHA of 5 different representational media in 4 different contexts. To characterise the NHA we take a round at the spread literature on objects made within NPD such as prototypes. We then define artefacts as objects intentionally made within the NPD process and identify two utmost types of artefacts (A and B) in accordance with existing literature. In short, type A artefacts mediate a concept which needs incremental refinement and type B artefacts are too blurry to stand in their present form. We also provide with theoretical instruments from design theories to assess whether human actors receive NHA/artefacts by being convinced or committed. In addition, the longevity of the analysis enables to observe human actors intersement on a daily basis up to 9 months after the artefact was produced.

Findings are that NHAs which match type A artefacts do better at convincing in prospect of an entry gate to development and that NHAs which match type B artefacts do better at committing in the ideation process. The difficulty for managers is that type A or type B artefacts cannot be recognised according to their representational medium, i.e. a text based document can provide with a type B artefact while it was based on a model of type A artefact. We hint that it is the extent of elaboration of the reasoning that embodies a NHA which determines its match with either type A or type B artefact. The consequence is that a quiproquo (misunderstanding) occurs: some NHA which match type B artefacts create no intersement because type A artefacts were expected. They failed at convincing managers who risk missing an innovation opportunity because of a misunderstanding. However their failure may not be definitive as managers sometimes have the ability to switch from convincement logic to commitment logic. This change in interaction is more probable to happen in informal meetings than in distant artefacts review. We also found some NHA of

particular representational media which take benefits of their ambiguity. Being neither type A nor type B artefacts, human actors interact with them by alternating logics, inducing richer decision-making and ideation to occur.

Our contribution is multiple. We study a relevant case of inter-organisational collaboration in early stages of NPD and we diagnose a hurdle to do so, i.e. the cognitive trap of convincing-committing confusion. Using the actor-network theory to do so, we contribute to this stream of research by clarifying the two logic of intersement and by identifying their conditions to occur, i.e. the type of artefact being used. Finally we unify the very spread field of the objects produced in NPD by proposing a name, a common definition and an analytical framework for them.

Perspectives are to confront our findings to different empirical situations. They might differ in a different cultural environment and with other media of representation. The theoretical framework could be reused in quantitative studies to do so.

Managerial implications are that, if managers were aware of the two types of artefacts while collaborating in early stages of the NPD, they could adapt their attitude accordingly and take better decisions of the collective actions required. But before such a change is established in an organisation, we suggest that managers favour artefacts presentations in informal meetings so that they are better able to switch between convincement and commitment logics and avoid this cognitive trap.

LITERATURE REVIEW

COLLABORATION IN EARLY PHASES OF THE NPD PROCESS

It has been broadly stressed that early stages of NPD are critical for radical innovation capacity. Since the absorptive capacity and open innovation streams, it is established that collaboration with other companies, research centres and institutions are key in this phase of the NPD process. Conditions for a successful collaboration have been tackled from various angles that the present paragraph tempts to summarise.

Collaboration capacity is defined as “the actor's capability to build and manage network relationships based on mutual trust, communication and commitment” in (Blomqvist and Levy 2006). Commitment is a broad notion as it has been used in the perspectives (a) of an employee to an organisation in (Swales 2000) or (b) of top management teams to innovation (Daellenbach, McCarthy and Schoenecker 1999), we will then use it as the broadest concept to describe the *willingness of an actor to collaborate with another actor*. The engagement of stakeholders in the innovator's process has been studied highlighting a common purpose as a prerequisite for collaboration (Weisenfeld 2003). Some studies envisage the case where no common purpose is defined (Segrestin 2005) while other propose a method to build this common purpose efficiently (Gillier et al. 2010, Gillier, Kazakci and Piat 2012). It has also been claimed that expectations towards an exploration process should be managed and regenerated (Robinson, Le Masson and Weil 2012). In certain configurations where cooperation-competition dilemma occurs, relational and structural strategies have been found to deal with it (Faems, Janssens and Van Looy 2010). Intermediaries play a significant role which is either broker, networker or architect (Agogue, Yström and Le Masson 2013). The latter involves a specific invitation phase where time, resources and trust issues can be discussed (Ollila, Yström and Agogue 2013). Trust between partners has been broadly studied in the literature but not specifically in the perspective of collaboration in the early stages of NPD (Nooteboom, Berger and Noorderhaven 1997, Rickards 2000, Kohtamäki, Kekäle and Viitala 2004, Bstieler 2006, Bidault et al. 2007, Chen and Wang 2008,

Bidault and Castello 2009, Bosch-Sijtsema and Postma 2009, Muethel, Siebdrat and Hoegl 2012). The higher the trust is between partners, the higher is their involvement in the partnership but not necessarily their creativity (Bidault et al. 2007, Bidault and Castello 2009) while creativity is broadly considered critical in early stages of the NPD process. Knowledge sharing, which is important in the ideation stage (Kelley 2007 p260, Hatchuel, Le Masson and Weil 2009), implies a relationship between partners relying on trust rather than contracts as the latter induces knowledge transactions instead of knowledge sharing (Bosch-Sijtsema and Postma 2009). The

THE ACTOR-NETWORKS APPROACH FOR THE NPD

The actor-networks approach for the NPD tempts to emphasize collaboration as well and depreciate decision making at gates meetings, leaving them as checkpoints (Akrich et al. 2002a, Akrich et al. 2002b, Christiansen and Varnes 2007). Akrich, Callon and Latour (2002a; 2002b) find a significant collaborative dimension in innovation, notably as we may learn from Edison and his capacity to involve “all the allies which will be necessary to transform an entire society” in his process. They claim that the main uncertainty that the innovation manager face is in “the choice of speakers or collaborators who will participate in the innovation’s development”. When collecting ideas among the firm, the possibility to interact with other people should be supported and facilitated to increase the number of high-quality innovation ideas created by individuals (Björk and Magnusson 2009). Employees deliberately bypass formal processes in order to secretly promote their ideas until they are mature enough to be presented to the management (Koch and Leitner 2008). The authors distinguish the intersement between employees to form teams from the intersement of top managers to launch a project. More specifically they occur at different stages of the self-organised NPD process. However it is not clear if both cognitive mechanisms are the same (convincement, persuasion, negotiation); and early stages of NPD have been described as non-linear (Callon 1986, Akrich et al. 2002a) or even chaotic (Cheng and Van de Ven 1996). Entrepreneurs’ reliance on external resources is related to the nature of relationship i.e. transaction-based or collaboration-based (Siu and Bao 2008). In collaboration based relationships the exchange partners maintain a close and comprehensive interaction to facilitate extensive information exchange of tacit and proprietary knowledge for the purpose of strategic development. The transaction-based relationship involves specific resource (goods or services) exchanges based on price. But the main conclusions of this distinction concern the usage of trust and the commitment to relationships. Christiansen and Varnes (2007) hint a shift from planning, preparations and decision making towards co-creation of technology and markets involving intersement of human and non-human actors. We would like to contribute to this move by further exploring this shift revealed in the network process perspective.

Finally, we claim that there is a gap in providing practitioners means to trigger collaboration. More specifically, we argue that Akrich, Callon and Latour who built the theoretical scaffold for many left a confusion that remains a burden in recent studies, namely the difference between conviction and commitment when looking to enact the successful intersement.

It appears that persuading the top management to officialise the development of an idea in a stage-gate process or persuading a brilliant engineer to be part of the

unofficial team are not totally similar in nature. However we lack of explanations in the literature as summarised in Table 1.

Source	Convincing / persuading logic	Committing / enrolling logic
(Akrich et al. 2002b)	“First of all, it is necessary to have a consenting management which is not discouraged by the desperately negative results of the first experiments, and which must be permanently convinced of the long-term interest of the process.”	When listening to such a scientist that I have chosen as collaborator, having confidence in such a marketing specialist, in believing such an opinion poll, in taking up the results presented in such journals, am I becoming involved in a redefinition of my project which multiplies the number of allies that I am interesting, rather than isolating myself more and more?
	“persistent action directed at retailers and households to convince them to buy this storage equipment”	By inventing a high-resistance filament, by introducing a powerful light bulb which consumes little electricity, Edison and his collaborators weaken the position of the companies who provide gas lighting
	Smith claims that it is unnecessary to provide a separate controller for the Mac’s mouse. Nobody believes him. And to convince them, he decides to get back to his office, returning a few days later with a working prototype.	They live there as a family, they work collectively without worrying about regulated working hours
	The marketing people assert that nobody wants the Post-It. Art Fry sets up an experiment, which will prove the opposite. The first prototype created is occasionally, but rarely, sufficiently convincing.	
	Will Lowrey be able to transmit the bankers’ expectations and worries to Edison, and convince him to make his project evolve in such a way as to keep them durably interested?	
	In negotiating the project, in transforming it so that it is convincing to the inside of Menlo Park, they collectively prepare their success on the outside of Menlo Park.	
(Koch and Leitner 2008)	In this manner, more and more people who are convinced of the idea and realize the need for action are attracted, although the idea or invention is still not an official project	After the idea has become more concrete, the inventors try to draw the attention of other individuals to their idea to get support for further pursuit. Thus, the inventors specifically try to attract those people who are considered important for the implementation.
	This process finally leads to the building of coalitions, clusters or even teams around that idea and to the persuading of and negotiating with others to support that idea and to potentially crystallize it into an innovation.	Because the inventors operate outside the formal structures [...]they depend mainly on the support of their colleagues to be able to work on their innovations
	At this point, the inventors, mostly with the support of the R&D managers, present their innovation to the top management and try to persuade them that their innovation should become an official project and thus get organizational resources.	
(Christiansen and Varnes 2007)	This indicates that the template for Internal Product Specification (IPS) is a nonhuman actor that must be accepted by the Business Unit before the trial run can begin.	

Table 1: Convincing and committing logic in the literature using actor network approach in the early steps of innovation

We analyse that in the literature using actor-network approach to tackle the early steps of NPD, convincing and committing logics both appear, sometimes exactly in the same empirical context (for instance building a competent team to develop an idea). We then propose to further understand these two logics and clear up this confusion by answering the following question: *What does it mean for practitioners to commit a potential collaborator or to convince decision-makers?*

METHOD

RESEARCH SETTING: BEGINNINGS OF THE INNOVATION DIRECTORATE AT SAFRAN

Our research is a longitudinal study grounded at SAFRAN, a corporate conglomerate created in 2005. It is compound of 12 main companies which have their own eventually century-long history. Cooperation between companies is very rare because:

- 1) They address different industrial fields (aerospace propulsion, aircraft gears, defence and security).
- 2) In the same field they address disjoint markets as civil aeronautics industry is segmented in closed ATA chapters (e.g. ATA 32 “landing gear” addressed by Messier-Bugatti-Dowty within the conglomerate).
- 3) They are all tier-one suppliers (very few internal contracts).

We believe the SAFRAN case is relevant to our research question because it is at stake for the corporate head to enact collaboration between SAFRAN companies.

The researcher was attached to the Innovation Directorate (ID), a corporate department created in 2011 in order to lead cross-company projects of demonstrator development. Those projects are aimed at utilizing interactions between hitherto separate competences to implement disruptive concepts through the development of full scale demonstrators. Once demonstration has been reached, projects are meant to be handled to one or more companies which will further develop the concept and exploit it on the market. Based on our observations, The process adopted echoes former literature (Rothwell 1992). The researcher was employed at steering the early stages of NPD (before concepts enter a stage-gate process) between the companies and closely worked with ID team.

METHODOLOGICAL FRAMEWORK: INTERVENTION-RESEARCH

The methodological framework for this research is Intervention-Research (Hutchel and Molet 1986). It refers to a qualitative research methodology in which there is a direct and simultaneous involvement of the researcher in a) the concrete construction of reality and b) the construction of a theoretical framework that can help actors make sense of the constructed reality (Hatchuel and David 2007). It shares some concerns with engaged scholarship methodology: “To bridge the gap between theory and practice, we need a mode of inquiry that converts the information provided by both scholars and practitioners into actions that address problems of what to do in a given domain” (Van de Ven & Johnson, 2006 p803). More specifically the theoretical framework described hereupon was specifically proposed in response to our empirical field issues. It was presented to practitioners and validated as a mean to understand their reality and to build future management tools and practices.

DATA COLLECTION: THE ANGLE OF NON-HUMAN ACTORS

Considering actor-network theory, Akrich, Callon and Latour describe the intersement of human and non-human actors in the process of translation leading to innovation (see for instance (Callon 1986)). Human actors and non-human actors (NHA) are considered of equal importance. Focusing on NHA enables to deeply understand network mechanisms and to decline general knowledge for practitioners from a case study but requires a very close contact with the empirical reality (Christiansen and Varnes 2007). We adopt a similar focus in our study. However we do not 'follow the actor' as recommended by (Latour 1987) but try to analyse several NHA at the time to provide more data on a very specific phase of the NPD when NHA acts as boundary objects (Star and Griesemer 1989) to trigger ideation cycles among human actors. For a period of 7 months, the researcher has been playing his dual role of researcher-practitioner (Roth, Sandberg and Svensson 2004) among practitioners, enabling access to precious data by serendipity: while actively participating to meetings and workshops, conversations were recorded to process analysis while taking a step-back with the co-authors.

The contexts of data collection were the followings:

1. An idea contest was organised by the Innovation Directorate (ID). Participants were 48 distributed within 12 companies. A total of 103 ideas were submitted through intranet based technology.
 - a. The ideas were selected by a jury with pre-established criteria (cross-company, originality, feasibility, value for clients, and match with the theme).
 - b. A sub-theme meeting with 5 participants to the contest and 5 DI members occurred.
 - c. Another sub-theme meeting with 5 participants to the contest and 5 DI members occurred.

The researcher participated to the two meetings. Ideas were expressed by their author with one slide presentation (only text) and speech. One of the ideas was already patented and benefited several drawings. One of the ideas was presented with a photograph.

2. DI uses two models of text documents that are reviewed prior concepts enter a stage-gate process. The first expresses the concept while the other formalises its evaluation. Both are based on feasibility and profitability criteria. The researcher had access to 15 expression artefacts and 5 evaluation artefacts. 11 expression artefacts were issued as the next step following a broad collaborative creativity method KCP (see (Elmqvist and Segrestin 2009, Hatchuel, Le Masson and Weil 2009, Ollila, Yström and Agogué 2013, Agogué et al. 2014) for further details on the method). They were all shared on an intranet based platform in order to collaborate.
3. Two meetings to present NHA to both ID top management and companies operational managers were organised. They were organised to decide whether an entry gate should be planned within the research period. These NHA were C-K diagrams. Such NHA based on C-K theory of design have been previously studied as enactive tools for practitioners (Gillier et al. 2010, Hooge, Agogué and Gillier 2012).

4. One C-K based NHA was presented to a company research director. This C-K based presentation had the specificity to explicit the pending questions that ID had at the moment of building this NHA. These questions are meant at facilitating learning and have been added to the C-K formalism inspired by previous studies on questioning in design (Eris 2003). Such questions have been called Deep Reasoning Questions (DRQ) in questions taxonomies (Graesser and McMahan 1993, Eris 2003)

Consequently, we analysed a total of 28 Non-Human Actors (NHA) expressed in 5 media (speech only (no artefact), photograph, patent, text document, C-K diagram) accompanied with an evaluation artefact in few cases.

DATA ANALYSIS: USING NPD ARTEFACTS THEORIES AND DESIGN THEORIES TO UNDERSTAND HUMAN AND NONE HUMAN ACTORS INTERACTIONS

We need a theoretical scaffold to describe NHA features and then link them to the reactions of the human-actors. We then review literature on prototypes in NPD.

When facing the unknown or a complex problem with no answers among competitors, prototyping (building an object) is a helpful reflex in certain organisations (Kelley 2007 chap. 6). Case studies in medicines have shown that experimental systems should generate surprises by embodying both the question and the answer towards an epistemic thing (Rheinberger 1997). If they do not, they tend to be technical objects rather than epistemic things. Stimulators used to spark idea generation have been found to reproduce this serendipity effect more consistently than demonstrators and prototypes in NPD (Ben Mahmoud-Jouini et al. 2013). The identity building of emerging technologies have been interpreted as the co-evolution of two dimensions (technical and usage) from unstable to stable (Gillier and Piat 2011).

New prototyping technologies (e.g. computer simulation versus physical crash tests in car industry) enable to lower the cost of experimentation but can also trigger new learning opportunities (Thomke 2003 chap. 1). Their lower fidelity enable higher rate of problem solving which is crucial in early stages of NPD (Thomke and Fujimoto 2000). The question of the fidelity of the artefact has been raised long ago. In the 1960, Technology Readiness Levels (TRL) developed within NASA improved decision making whether or not integrating a technology to the system being design (Mankins 2009). They provided an evaluation tool of technologies by formalising the gap between current state and the final state of a considered technology. They enabled drastic project management improvements when adopted at Department of Defense (GAO 1999). TRL assessment has been broadly criticised and improved (Moorhouse 2002, Valerdi and Kohl 2004, GAO 2007, Sauser et al. 2008, Mankins 2009, Tetlay and John 2009), but we have very few clues on practices it involves in early steps of the NPD process. Still, we can notice that the TRL evaluation criterion is the environment in which the technology has been demonstrated and that they imply the hypothesis that the goal to achieve is known. Consequently, TRL are not applicable to previously seen stimulators, epistemic things or early problem solving artefacts because they are used before the goal to achieve is defined. However artefacts used at the later stages of the NPD process to evaluate a concept or to demonstrate that specifications are reached (demonstrators and prototypes in (Ben Mahmoud-Jouini et al. 2013)) are suitable for the TRL evaluation logic. High fidelity prototypes are used to integrate all the knowledge acquired previously through lower fidelity prototypes

(Houde and Hill 1997). Lower-fidelity prototypes should focus at Look & Feel, Role or Implementation in exploring designers' questions. In the example of user interfaces, paper and pencil drawings proved to be the most efficient (information gathering vs. cost) prototyping technique (Szekely 1995). It has been claimed that designers should pay attention to the artefact fidelity to the experience being design rather than the artefact fidelity to the end product (Buchenau and Suri 2000). By focusing on prototyping users' experience rather than objects, designers are able (i) to understand the essential factors of an experience, (ii) to explore and evaluate design ideas, (iii) to communicate and share point of views.

Considering fifty experimental aircrafts sponsored by the US governments from the 1940s to the 2000s, it has been said that the first aircrafts (until the late 1970s) were dedicated to exploration while the other (from the 1970s to the 2000s) (Roth, Sandberg and Svensson 2004) were dedicated to prototyping future operational aircrafts, but the detailed review reveals that X-11, X-12 (1950s) and X-27 (1972) were already used as operational aircrafts prototypes (Jenkins, Landis and Miller 2003).

To conclude the literature review, we define artefacts as *intentionally made objects within the NPD process*. This definition has been recently used (Ben Mahmoud-Jouini et al. 2013) and matches the former broadened definition of prototypes. Every company has its own culture of prototyping and managers ascribe specific features to the object they call prototypes (Schrage 1996), we believe the term "artefact" avoids this bias, designate various objects from paper and information technology (cognitive artefacts) to heavy machines, and is more adapted to produce general knowledge despite our definition differs from some previous works (Houde and Hill 1997, Buchenau and Suri 2000, Houkes and Vermaas 2010). We then try to summarise existing literature on artefacts by identifying two utmost types (table 1) to establish a robust conceptual framework.

Source	Type A artefacts	Type B artefacts
(Rheinberger 1997)	Technical objects, experimental conditions (restrict/constrain scientific objects)	Epistemic things, scientific objects (embody what one does not yet know)
(Thomke and Fujimoto 2000, Thomke 2003)	Traditional technologies of experimentation (support learning in traditional ways of long iterations)	New technologies of experimentation (increase opportunities for innovation with higher rate of iterations)
(Houde and Hill 1997)	Integration prototypes (integrate previously acquired knowledge)	Look & Feel, Role, Implementation prototypes (focus a design question)
(Ben Mahmoud-Jouini et al. 2013)	Demonstrators, prototypes (learning on a concept and validate specifications)	Stimulators (trigger creativity)
(Gillier and Piat 2011)	Stable-identity technology (technical and usage dimension stable)	Unstable-identity technology (usage dimension / application unstable)
(Mankins 1995, GAO 1999, Moorhouse 2002, Valerdi and Kohl 2004, GAO 2007, Sauser et al. 2008, Mankins 2009,	TRL 3-9 technologies (demonstrated in various environments until final form)	TRL 1-2 technologies (have no application yet)

Tetlay and John 2009)		
(Jenkins, Landis and Miller 2003)	Incremental test vehicle within an acquisition program (support development)	Testbeds or research tools (explore flight regimes, gather data, mature technology, investigate a phenomenon)

Table 2: Summary of existing literature - two types of artefact are identified

Consequently, all non human actors (NHA) observed within the research period were categorised as type A artefact or type B artefact. The following criteria in accordance with the theoretical framework described here upon were used to ascribe a type (they were not all applied simultaneously depending on their relevance on each NHA):

- Does the artefact call incremental improvement or further research? (Jenkins, Landis and Miller 2003)
- If the artefact represents a technology, does it have a definitive application or not? (Mankins 1995, Gillier and Piat 2011)
- Does the artefact integrate previously acquired knowledge or does it focus and answer a design question? (Schrage 1996, Houde and Hill 1997)
- Does the artefact provide further learning on a concept or does it trigger creativity? (Ben Mahmoud Jouini 2013)
- Does the artefact restrict the investigation or does it embody unknowns? (Rheinberger1997)
- Does the artefact enable learning in a traditional way or does it brings new experimentation opportunities? (Thomke 2003)

Now that we have theoretical scaffolds to describe the Non-Human Actor (NHA), i.e the artefact, we need means to understand if the human actors are being convinced are committed. For this in the analysis of meetings, we need to understand if the human-actor which enters in interaction with the NHA is being convinced are committed. As our meetings were situated in early steps of the NPD process, a design approach is very well suited to understand the cognitive mechanisms which occur. We then use three types of criteria to determine whether the human-actor is being convinced or committed.

- 1) We use behavioural studies (Eris 2003) in design situation to code the questions as either :
 - Deep Reasoning Questions, which entail pure learning on the subject being discussed, the concept proposed and embodied in the NHA. We then assume that human-actors are calling for more knowledge to evaluate the NHA on classical criteria. For instance, when a human actor asked “How much weigh your device?”. The answer provided knowledge to evaluate in what extent would the device add weight on a airplane, increasing fuel burn per hour which is critical for plane makers (clients of SAFRAN companies).
 - Generative Design Questions, which entail suggestions or ask for suggestions to further elaborate the concept by proposing design ideas. We then assume that such questions entail collaboration to the ideation

process. For instance, a human actor asked “what if we put your device in the under belly [of the plane]?”. The question is in fact a suggestion of further elaboration of the concept being discussed.

- 2) We use C-K theory of design to code the suggestions made as knowledge or design idea (i.e. concept in C-K terms). This enable to compare quantitatively which NHA did stimulate ideation cycle best.
- 3) We give the collaborative status of the NHA several weeks after the meetings, when human-actors have decided whether they will be collaborators on the NHA or they will not, i.e. they are enrolled as allies or not.

Concerning the text documents that had not been completed using the evaluation document, we have considered they were received in a convincing mode because their structured had been designed for this. This assumption is very reasonable as the researcher participated a meeting where the structure of the documents were presented by ID to companies delegates (some criteria of evaluation were added which finally lead to value for different stake holders, number of companies involved, access to competencies, technical feasibility and economical profitability). However, we found one counter example which is explained in next sections.

Plus, two versions of results analysis were presented to practitioners. Such collaborative method of results sharing enables further validation and a deeper analysis by the researcher but also ensures a knowledge production more activable for practitioners (Roth, Sandberg and Svensson 2004, Shani and Coghlan 2008).

RESULTS, FINDINGS AND CONTRIBUTIONS

RESULTS OF THE COLLABORATIVE ANALYSIS OF NON-HUMAN ACTORS (NHA) INTERACTIONS WITH HUMAN ACTORS

Hereafter we summarise the results of the analysis. They are further explained in the next section.

N°	Context	Medium	Artefact type	Dominant questioning	Knowledge contribution	Design idea	Status afterwards / decision
D1	Idea contest	speech	B		1	3	ID will organise further elaboration
D2		speech	A	DRQ switched to GDQ	6	4	Idea rejected
D3		speech	A	DRQ	4	2	Idea rejected (not original)
D4		rejected patent + speech	A	DRQ	2	2	Idea rejected
D5		patent extracts + speech	?	DRQ and GDQ iteratively	2	7	ID will organise further elaboration
D6		speech	B	GDQ	5	5	Rejected (not original, no idea)
D7		speech	B	GDQ	2	2	Rejected (not original, no idea)
D8		speech	B	x (no data)	0	0	Rejected

D9		study results + speech	?	DRQ and GDQ iteratively	2	2	ID will organise further elaboration
D10		picture + speech	B	GDQ	1	5	ID will organise further elaboration
T1	KCP creativity method	Text document + evaluation table	A	DRQ	x	x	Passed project entry gate
T2		Text document	B	DRQ	x	x	Hold
T3		Text document + evaluation table	B	both (cf. M1)	x	x	Hold (cf. M2)
T4		Text document + evaluation table	A	DRQ	x	x	Hold
T5		Text document	B	DRQ	x	x	Hold and became redundant
T6		Text document + evaluation table	A	DRQ then GDQ	x	x	Hold, gave birth to T13
T7		Text document	B	DRQ	x	x	Hold (never get attention)
T8		Text document	A	DRQ	x	x	Aborted (lack of resources)
T9		Text document + evaluation table	A	DRQ	x	x	Passed project entry gate
T10		Text document	B	GDQ	x	x	Managed by ID
T11		Text document + evaluation table	B	both (cf. M2)	x	x	Hold (cf. M2)
T12		Text document + evaluation table	A	DRQ	x	x	Passed project entry gate
T13		Text document	B	not yet	x	x	Collaborative redaction in-process
T14		Text document	A	not yet	x	x	To be presented at top management
T15		Text document + evaluation table	A	DRQ	x	x	Passed project entry gate
M1	TM and OM presentation	C-K diagram + speech	both	DRQ and GDQ iteratively	5	3	Various
M2		C-K diagram + speech	both	DRQ and GDQ iteratively	7	7	Various
M3	Research manager presentation	C-K diagram with DRQ + speech	both	DRQ and GDQ iteratively	22	4	further workshop to be organised

DRQ = Deep Reasoning Questions asked to evaluate classic criteria

GDQ = Generative Design Questions asked to suggest design ideas

Table 3: Results of the collaborative analysis of NHA interactions with human actors

FINDINGS OF COLLABORATION-ENACTING NON HUMAN ACTORS/ARTEFACTS IN EARLY STAGES OF THE NPD PROCESS

When a non human-actor (NHA) is presented to human actors of different organisations, human actors interact with it in two different patterns. If the NHA is a type A artefact, the evaluation based on business opportunity and technical feasibility is lead and a decision is taken. This constitutes the basic principle of convincing logic. If the NHA is a type B artefact, the invitees cannot lead this evaluation and imagine further elaboration of the NHA, a collaborative cycle of ideation is started. We found that this collaborative ideation cycle did not happen with text documents whenever they were shared by emails or intranet platform (T1 to T15). We even found cases where the project represented in the text document is put on hold and finally aborted because it could not be properly evaluated, it could not *convince*, and was never used as ideation cognitive artefact (T5 and T7). This phenomenon induces the risk of missing an innovation opportunity. We then make the assumption that NHA which are type B artefacts should be used as ideation stimulators

NHA which are type B artefacts are actually better handled when used as ideation stimulators (D1, D10, T10, D6, D7). The text document evaluated in such a mode is managed by the Innovation Directorate (ID) to further continue ideation cycles on this NHA (T10). Ideas discussed in meetings corresponding to type B have been either rejected after a plain consideration (D6, D7) or recognised of high-potential and are managed by ID (D1 and D10).

This last point reveals the weakness of text-based documents which model structure had been designed to facilitate a rough evaluation: they appear very difficult to handle when the document could not be completed enough to match with a type A artefact and convince. Human actors are left unarmed when facing an NHA which should convince them but cannot. At the opposite informal presentations in meetings enable human actors to ask questions and to make suggestions when the NHA is type B artefact which naturally lead them to commit in the ideation process.

Moreover, we found a key condition to facilitate artefacts evaluation prior engaging in collaboration. This condition is the ability to *switch between convincement and commitment*. As the human actor discovers the artefact he does not know ex-ante what type it is. He does not assume he is about to be convinced or committed. We observe several successfully-managed artefacts which were received in both convincement and commitment logic (D2, D5, D9, T3, T6, T11). A type A artefact which evaluation was negative, did not convinced ID top management, but found a second life when a high potential was revealed as a base for generating new concepts and benefited a new cycle of ideation (T6 and T13).

We found media to express artefacts which are neither pure type A nor pure type B but ambiguous. These NHAs incline human actors to use both logics. The patent is ambiguous as it ensures intellectual propriety on the technology but does not ensure feasibility and profits, it may require deep modifications of the concept (D5). C-K diagrams are ambiguous because they map several alternative propositions at various levels of the concept (M1 and M2). Some propositions may benefit a broad knowledge and convince human actors while others are obviously unexplored and commit more or less human actors in the exploration. The result is a very rich discussion in both ideas and knowledge with several decisions taken at the time. Finally, by adding deep reasoning questions (DRQ) in one C-K diagram, we built a

powerful learning tool for ID, a boundary object between the company expertise and ID managers (M3). This last NHA enabled to exploit the invitee's expertise. It enabled this research manager to contribute to gathering useful knowledge in early stages, but also committed him to further explorations and ideation cycles.

More generally, we suggest that to collaborate in early stages of the NPD process, any NHA embodying a design concept should be presented in informal meetings to avoid a quiproquo (French for misunderstanding) between convincement and commitment logics.

CONTRIBUTION TO EXISTING LITERATURE, LIMITATIONS AND PERSPECTIVES

INTER-ORGANISATIONAL COLLABORATION IN EARLY STAGES OF NPD

Collaboration between different firms in early stages of NPD is under studied from various angles. The SAFRAN case study shows that even among firms depending of the same holding with a willingness to collaborate to produce disruptive innovations, cognitive mechanisms are a hurdle. Using actor-network concepts, we identified relevant non-human actors and pointed out a quiproquo (i.e. misunderstanding) in the interactions logic with this object and potential new allies of the innovator. Trust had been found as an enabler of a collaboration-based relationship between entrepreneurs (Siu and Bao 2008, Bosch-Sijtsema and Postma 2009). We suggest that early stages of NPD have a specific cognitive difficulty due to the convincing-committing potential quiproquo. The risk for practitioners is to arouse evaluation on profitability and feasibility criteria whereas the concept lacks elaboration and/or collaborators.

CONVINCING AND COMMITTING LOGICS IN ACTOR-NETWORK THEORY

Actor-network approach enabled to focus on relevant non-human actors in the SAFRAN case study. But this approach and its derivatives such as network process perspective (Christiansen and Varnes 2007) or network perspective (Borum and Christiansen 1993) suffered from a confusion between convincing and committing logic. Enrolment of collaborators and persuasion of top management were described as separated in time but the difference in the nature of interessement was not explicit (Koch and Leitner 2008). Besides, early stages of the NPD process has been characterised as non-linear (Callon 1986) or even chaotic (Cheng and Van de Ven 1996) which questions their positioning in a linear process. We then clarify these different interessement forms: convincing is about giving sufficient knowledge about a design idea (eventually embodied in a physical non-human actor) so that the potential ally would buy the idea as it is, committing is about giving a stimulator which will trigger targeted ally's creativity (giving design idea suggestions or useful knowledge) and willingness to participate in future explorations. We also suggest that the non-human actors, the artefacts, to convince or to commit are very different and that an imposed form of artefact does not solve the problem (see text-based documents). We also suggest that some of them fail at doing neither convincing neither committing whereas others have the ability to play with the ambiguity between the two logics. The exact conditions to ensure that the right logic is being used/followed at the right moment should be further explored to ensure reproducibility in various management situations.

ARTEFACTS AND DESIGN IN NPD

There is very little literature to help managers to deal with the created objects within the NPD process such as prototypes, storyboards, files. This literature is spread in different disciplinary streams of research. The attempts to build a general framework to think those objects are very few and have little dialog with each other's (Houde and Hill 1997, Thomke and Fujimoto 2000, Thomke 2003, Ben Mahmoud-Jouini et al. 2013). We had an attempt at unifying these rich studies, and it proved to be useful to characterise the non-human actors involved in the process of interestment and network building. More specifically, we defined artefacts as *intentionally made objects within the NPD process* and we defined two utmost types of artefacts in accordance with previous literature. In short, type A artefacts mediate a concept which needs incremental refinement and type B artefacts are too blurry to stand in their present form. The main limitation of our work is the few media of representation studied (speech only, text documents, photograph, patents, C-K diagrams). Further studies should verify our results in different organisations using their own media. For instance, we have seen that the patent has virtuous propriety for collaborating in early stages of the NPD with one example. It should be accessible to provide a broader sample of patent presentations and verify this propriety. More generally, the framework established might be reused for quantitative studies and confronted to new empirical situations.

If we look more in detail which artefacts are a better stimulus in the ideation process, we do not prove that either type B or type A artefacts perform better. However, we suggest that C-K diagrams perform better because they embody a more elaborated reasoning than other media. By following a reasoning step by step with various design alternatives, meetings participants are able to overcome fixation effect more effectively. This leads to a tough contradiction for practitioners which scholars might provide with help: a well elaborated reasoning is a better stimulus in early stages of the NPD process whereas lesser elaborated reasoning need even more collaborative elaboration.

MANAGERIAL IMPLICATIONS

The misunderstanding observed in the SAFRAN case lead to missing potential innovation opportunities instead of elaborating disruptive concepts. Based on our findings, we suggest that practitioners should acknowledge the two types of artefacts *independently of the medium of representation used* (reasoning explain orally, clay model, CAD, text document, storyboard, C-K diagram...). This awareness could prevent the convince-commit misunderstanding, by recognizing and adopting the right logic to deal with new artefacts, i.e. evaluating in view of stage-gate process entry or starting early stages such as inspiration, ideation and concept selection anew. But such a change is long to establish in an organisation, then we suggest as a first step that organisations wishing to collaborate with other organisations in early steps of innovation should organise informal meetings because they will be less exposed to the cognitive trap of adopting the wrong logic: they would be able to switch between logic unconsciously. The next steps of our collaborative research will help SAFRAN managers acknowledging the dangerous convincing-committing quiproquo and may shed further insights to the present paper.

REFERENCES

Agogu , M., S. Hooge, F. Arnoux and I. Brown (2014). "An introduction to innovative design-Elements and applications of CK theory."

Agogue, M., A. Ystr m and P. Le Masson (2013). "Rethinking the role of intermediaries as an architect of collective exploration and creation of knowledge in open innovation." International Journal of Innovation Management **17**(02).

Akrich, M., M. Callon, B. Latour and A. MONAGHAN (2002a). "The key to success in innovation part I: The art of interessement." International Journal of Innovation Management **6**(02): 187-206.

Akrich, M., M. Callon, B. Latour and A. MONAGHAN (2002b). "The key to success in innovation part II: The art of choosing good spokespersons." International Journal of Innovation Management **6**(02): 207-225.

Ben Mahmoud-Jouini, S., C. Midler, V. Cruz and N. Gaudron (2013). Creative artefacts: how stimulators, demonstrators and prototypes contribute to the creative processes ? . 20th International Product Development Management Conference. Paris.

Bidault, F. and A. Castello (2009). "Trust and creativity: understanding the role of trust in creativity-oriented joint developments." R&D Management **39**(3): 259-270.

Bidault, F., J. de La Torre, C. De Rham and M. Sisto (2007). "What makes executives trust each other? The determinants of the Willingness to rely on trust in business partnerships." Creativity and Innovation Management **16**(3): 317-329.

Bj rk, J. and M. Magnusson (2009). "Where do good innovation ideas come from? Exploring the influence of network connectivity on innovation idea quality." Journal of product innovation management **26**(6): 662-670.

Blomqvist, K. and J. Levy (2006). "Collaboration capability–a focal concept in knowledge creation and collaborative innovation in networks." International Journal of Management Concepts and Philosophy **2**(1): 31-48.

Borum, F. and J. K. Christiansen (1993). "Actors and structure in IS projects: What makes implementation happen?" Scandinavian Journal of Management **9**(1): 5-28.

Bosch-Sijtsema, P. M. and T. J. Postma (2009). "Cooperative Innovation Projects: Capabilities and Governance Mechanisms*." Journal of product innovation management **26**(1): 58-70.

Bosch-Sijtsema, P. M. and T. J. Postma (2009). "Cooperative Innovation Projects: Capabilities and Governance Mechanisms*." Journal of product innovation management **26**(1): 58-70.

Bstieler, L. (2006). "Trust Formation in Collaborative New Product Development*." Journal of product innovation management **23**(1): 56-72.

Buchenau, M. and J. F. Suri (2000). Experience prototyping. Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques. New York City, New York, USA, ACM: 424-433.

Callon, M. (1986). *Some elements of a sociology of translation*, Cambridge, MA: The MIT Press.

Chen, M. H. and M. C. Wang (2008). "Social networks and a new venture's innovative capability: the role of trust within entrepreneurial teams." *R&D Management* **38**(3): 253-264.

Cheng, Y.-T. and A. H. Van de Ven (1996). "Learning the innovation journey: order out of chaos?" *Organization Science* **7**(6): 593-614.

Christiansen, J. K. and C. J. Varnes (2007). "Making Decisions on Innovation: Meetings or Networks?" *Creativity and Innovation Management* **16**(3): 282-298.

Daellenbach, U. S., A. M. McCarthy and T. S. Schoenecker (1999). "Commitment to innovation: The impact of top management team characteristics." *R&D Management* **29**(3): 199-208.

Elmquist, M. and B. Segrestin (2009). "Sustainable development through innovative design: lessons from the KCP method experimented with an automotive firm." *International Journal of Automotive technology and management* **9**(2): 229-244.

Eris, O. (2003). *Asking generative design questions: a fundamental cognitive mechanism in design thinking*. International Conference on Engineering Design, Stockholm.

Faems, D., M. Janssens and B. Van Looy (2010). "Managing the Co-operation-Competition Dilemma in R&D Alliances: A Multiple Case Study in the Advanced Materials Industry." *Creativity and Innovation Management* **19**(1): 3-22.

GAO (1999). *Better Management of Technology Development Can Improve Weapon System Outcomes. Best Practices*. United States General Accounting Office.

GAO (2007). *Major Construction Projects Need a Consistent Approach for Assessing Technology Readiness to Help Avoid Cost Increases and Delays. Best Practices*. United States General Accounting Office.

Gillier, T., A. O. Kazakci and G. Piat (2012). "The generation of common purpose in innovation partnerships: A design perspective." *European Journal of Innovation Management* **15**(3): 372-392.

Gillier, T. and G. Piat (2011). "Exploring over: the presumed identity of emerging technology." *Creativity and Innovation Management* **20**(4): 238-252.

Gillier, T., G. Piat, B. Roussel and P. Truchot (2010). "Managing Innovation Fields in a Cross-Industry Exploratory Partnership with C-K Design Theory*." *Journal of product innovation management* **27**(6): 883-896.

Graesser, A. C. and C. L. McMahan (1993). "Anomalous information triggers questions when adults solve quantitative problems and comprehend stories." *Journal of Educational Psychology* **85**(1): 136.

Hatchuel, A. and A. David (2007). *Collaborating for Management Research: from Action Research to Intervention Research in Management. Handbook of Collaborative Management Research*.

Hatchuel, A., P. Le Masson and B. Weil (2009). Design theory and collective creativity: a theoretical framework to evaluate KCP process. International Conference on Engineering Design, ICED.

Hooge, S., M. Agogué and T. Gillier (2012). A new methodology for advanced engineering design: Lessons from experimenting CK Theory driven tools. Proceedings of International Design Conference-Design 2012.

Houde, S. and C. Hill (1997). "What do prototypes prototype." Handbook of HumanComputer Interaction.

Houkes, W. and P. E. Vermaas (2010). Technical functions: On the use and design of artefacts, Springer.

Hutchel, A. and H. Molet (1986). "Rational modelling in understanding and aiding human decision-making: about two case studies." European Journal of Operational Research **24**(1): 178-186.

Jenkins, D. R., T. Landis and J. Miller (2003). "AMERICAN X Vehicles."

Kelley, T. (2007). The art of innovation: lessons in creativity from IDEO, America's leading design firm, Random House LLC.

Koch, R. and K.-H. Leitner (2008). "The Dynamics and Functions of Self-Organization in the Fuzzy Front End: Empirical Evidence from the Austrian Semiconductor Industry." Creativity and Innovation Management **17**(3): 216-226.

Kohtamäki, M., T. Kekäle and R. Viitala (2004). "Trust and Innovation: from Spin-Off Idea to Stock Exchange." Creativity and Innovation Management **13**(2): 75-88.

Latour, B. (1987). Science in action: How to follow scientists and engineers through society, Harvard university press.

Mankins, J. C. (1995). "Technology readiness levels." White Paper, April **6**.

Mankins, J. C. (2009). "Technology readiness assessments: A retrospective." Acta Astronautica **65**(9-10): 1216-1223.

Moorhouse, D. J. (2002). "Detailed definitions and guidance for application of technology readiness levels." Journal of Aircraft **39**: 190-191.

Muethel, M., F. Siebdrat and M. Hoegl (2012). "When do we really need interpersonal trust in globally dispersed new product development teams?" R&D Management **42**(1): 31-46.

Nooteboom, B., H. Berger and N. G. Noorderhaven (1997). "Effects of trust and governance on relational risk." Academy of management journal **40**(2): 308-338.

Ollila, S., A. Yström and M. Agogué (2013). Stepping out of the zone of territorial protection enables open innovation collaboration. 20th IPDM conference.

Rheinberger, H.-J. (1997). "Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube (Writing Science)."

Rickards, T. (2000). "Trust-based Leadership: Creative Lessons from Intelligent Horsemanship." Creativity and Innovation Management **9**(4): 259-266.

Robinson, D. K., P. Le Masson and B. Weil (2012). "Waiting games: innovation impasses in situations of high uncertainty." Technology Analysis & Strategic Management **24**(6): 543-547.

Roth, J., R. Sandberg and C. Svensson (2004). The Dual Role of the Insider Action Researcher. Collaborative Research in Organizations S. Publications.

Rothwell, R. (1992). "Successful industrial innovation: critical factors for the 1990s." R&D Management **22**(3): 221-240.

Sauser, B., J. E. Ramirez-Marquez, R. Magnaye and W. Tan (2008). "A Systems Approach to Expanding the Technology Readiness Level within Defense Acquisition." International Journal of Defense Acquisition Management **1**.

Schrage, M. (1996). Cultures of prototyping. Bringing design to software. W. Terry, ACM: 191-213.

Segrestin, B. (2005). "Partnering to explore: The Renault–Nissan Alliance as a forerunner of new cooperative patterns." Research policy **34**(5): 657-672.

Shani, A. B. and D. Coghlan (2008). Handbook of collaborative management research, Sage Publications Thousand Oaks, CA.

Siu, W.-s. and Q. Bao (2008). "Network Strategies of Small Chinese High-Technology Firms: A Qualitative Study." Journal of product innovation management **25**(1): 79-102.

Star, S. L. and J. R. Griesemer (1989). "Institutional ecology, translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39." Social studies of science **19**(3): 387-420.

Swales, S. (2000). "Goals, creativity and achievement: commitment in contemporary organizations." Creativity and Innovation Management **9**(3): 185-194.

Szekely, P. (1995). User interface prototyping: Tools and techniques. Software Engineering and Human-Computer Interaction. R. Taylor and J. Coutaz, Springer Berlin Heidelberg. **896**: 76-92.

Tetlay, A. and P. John (2009). "Determining the Lines of System Maturity, System Readiness and Capability Readiness in the System Development Lifecycle."

Thomke, S. and T. Fujimoto (2000). "The Effect of "Front-Loading" Problem-Solving on Product Development Performance." Journal of product innovation management **17**(2): 128-142.

Thomke, S. H. (2003). Experimentation matters: unlocking the potential of new technologies for innovation, Harvard Business Press.

Valerdi, R. and R. J. Kohl (2004). An approach to technology risk management. Engineering Systems Division Symposium.

Weisenfeld, U. (2003). "Engagement in Innovation Management: Perceptions and Interests in the GM Debate1." Creativity and Innovation Management **12**(4): 211-220.