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DECISION BASED KNOWLEDGE MANAGEMENT FOR DESIGN PROJECT OF INNOVATIVE PRODUCTS

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1. Introduction

Knowledge management is necessary to ensure performance in companies. Our approach is developed within the framework of knowledge management systems for design projects of innovative products. These systems must handle the specificity of innovative design projects, like an evolving environment, a specific context and dynamic knowledge and intensive decision-making tasks. On the one hand we denote that existing methods and tools for knowledge capitalisation applied to product development are inaccurate for innovative products. On the other hand, the decision-making process is a main key in the success of innovative projects. The purpose of this paper is to understand, to describe, and to model decision-making flows of this kind of projects in order to specify KM systems that satisfy projects stakeholders' needs. We will validate our models on a case study from PSA Peugeot Citroën Automotive Research and Innovation Department.

The paper is organised as follows: in section 2 we introduce an overview of KM for product development, in section 3 we expose our approach, section 4 and 5 are devoted to the description of our models, section 6 draws out how the model can be used.

2. Knowledge Management for products development

Knowledge management can be considered with several points of view. We chose to retain the largest definition. We consider that Knowledge Management is an organisational process that leads to companies' knowledge optimisation. The purpose of KM is to seek optimisation of information flows and knowledge creation through tools and human relationship like socialisation [Nonaka, 1995]. This knowledge can be tacit, if it's not formalised and if it's not shared between people or it can be explicit, if it's residing in documents, and databases.

We consider that design can be decomposed in three types [Kota, 1991]: routine design, innovative design and creative design. Hence, functional decomposition and structural architecture of the product are built respectively during creative and innovative design in opposition to routine design or re-design that aim to define design parameters in a pre-defined structural architecture. Besides design type, one important area for the characterisation of KM systems for product development is the process in which the system is used. Most KM systems for product design are materialised by tools, built to support routine design in technical processes (requirement analysis, implementation, architectural design, detailed design…) or projects processes (decision making process…). On the one hand these approaches seek to formalise knowledge, considered as an object, collected from interviews with experts and formalised with knowledge engineering methods like MKSM, CommonKADS, KOD, …[Dieng 00]. On the other hand, project memories rely on design rationale capture [Burge, 00] which is not efficient for re-use in “wicked” problems. We observe that if there could be organisational KM Systems for innovative and creative design like expert networks, there are no KM tools to support those activities especially for project processes.

3. K M for design projects of innovative products development

3.1 Design projects of innovative products

Our research focuses on design projects of innovative products, the primary objective of this paper is to set an overall framework intended to specify KM tools for such projects. To this end, we define design projects of innovative products as projects that lead to the design of new products that could become innovation while sold to customers. Those projects can be decomposed in different types of design activities, but they mainly focus on creative and innovative design.

3.2 Hypothesis

The first hypothesis of our research assumes that design projects of innovative products get organised in complex systems. To dread this complexity we propose to use Jean-Louis Le Moigne’s Systemic Theory [Le Moigne 90]. Its finality, its borders, and its subsystems define the innovative project system. One of the main properties of a complex system characterisation is its functional model. According to the Decision-Information-Operation System model, a complex system can be decomposed in three subsystems linked with interactions. The Operation System does the work piloted by the Decision System, which decides for the whole system through the Information System that acts as an interface and a memory.

The second hypothesis characterises the type of knowledge manipulated by such projects. In fact, innovative projects are specific organisations that use various resources. On the one hand, actors of these projects use tacit knowledge, or know-how, which is not specific to innovation and is pre-existent in the enterprise. This knowledge is relevant to routine design and must be covered by KM systems for routine design. On the other hand, in addition to product development such project lead to knowledge acquisition related to the new technologies and materials used by the project. We observe that this knowledge is unsanctioned and not stabilised due to dynamical aspects of innovation [Buckingham 97].

The third hypothesis describes the decision-making process as a key factor of innovative projects. Since most knowledge used in design tasks is not specific to innovative projects, and since knowledge creation highly depends on orientations taken in the projects, we assume that the key factors in terms of knowledge creation are relative to decision. Owing to the decision-making process, the product developed will or not get value for the consumer. This means that decision-making process determines the success of this kind of projects.

3.3 Frame of reference

According to these hypotheses, we propose to focus our research on KM systems that aim to support the decision-making process of projects. As far as our research theme arises from industrial problems, we chose to respect existing firm’s organisation and processes. Consequently we shall limit our work to KM systems materialised by tools design for information processing related to decision-making.

To begin with, we propose some definition. According to Stal [Stal 01], “a decision is a process which leads an actor to answer a question”. In this paper we consider decision-making as a process of information transformation. This process is collective and can be considered as a release mechanism of operational activities. A decision flow is the informational flow from the decision system to the operational system that leads to the answer. A Decision flow is characterised by its source and its target along with the nature of the flow itself (See figure 1).

First we have to understand the decision making process of projects. Then we shall be able to specify KM systems that suit to projects stakeholders needs and projects specificity. We propose in a model based on 2 views. The first view is organisational and leads to the identification of decision processors. The second view characterises the functional aspects of the decision flows and their nature.

4. Decision Processors and Organisation

4.1 Organisational system

The system we study is organised in projects, those projects are articulated and piloted by several committees and authorities. Each project can be considered as a complex system. The goal of the organisational view of flows is to provide a guide for understanding organisational aspects of decision. For that reason we want to identify target (*T-Processors*) and source processors (*S-Processors*) of the decision flow. Those processors can be a single actor or a group of actors, for instance, a designer, a steering committee, and a design team.

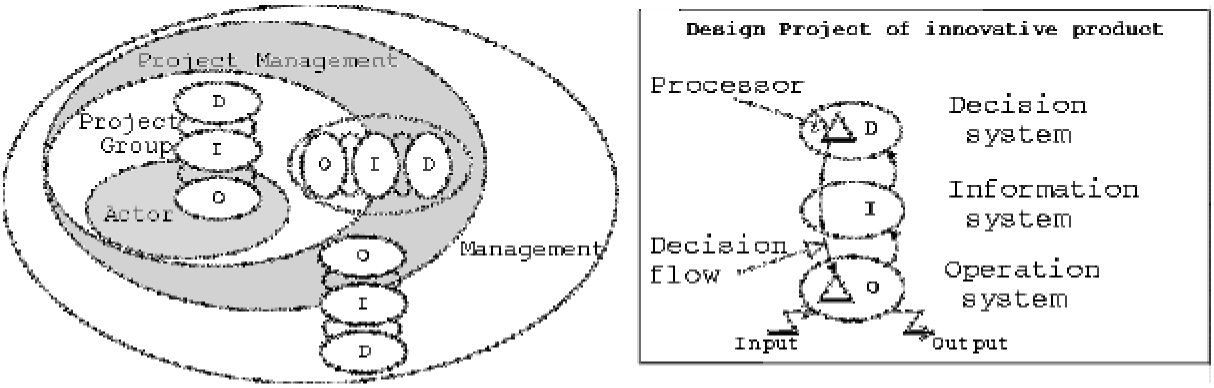

Figure 1. Human organisational system

At first, to locate the processors, we suggest modelling the *human organisational system*. It is made of concentric strata representing different levels of activities related to the projects. The core is the actor, the next level is the project group, and then we find the project management, the management (of the project portfolios, for instance), the enterprise and the outside world.

Furthermore, the processor has to be characterised by its function related to the decision flows. We chose to use DOI representation [Le Moigne 90]. The processor is located in predefined subsystems (D, I or O) as illustrated by figure 1.

We propose to illustrate this by a case study at PSA by referring to table 1. This example is taken from a design project of innovative steering systems which purpose is to design a specific prototype using a new technology, lets call it *Prototype Project*. This project is realised in partnership with a supplier. We identified 5 systems related to this project: the *Prototype Project* system, two PSA projects linked with it, one supplier project, and the management system of PSA (The innovation department management). For each system we propose to fill the table by identifying processors' level and function, a processor is selected in the table if it can take decision, transmit a decision or if receive decision only connected to the *prototype project* activities. For confidentiality reasons, most of the data are hidden and we chose to show only processors related to *prototype project* and PSA innovation department.

Table 1. Processors

		Function					
		Prototype Project			**PSA Innovation department**		
		D-System	I System	O- System	D-System	I-System	O- System
Human Organisational System	Actor	∅	E-mail Intranet	Actor a1 Actor a2 …	N.D.	N.D	N.D
	Project group	Simulation team Architecture team …	E-mail Intranet	Simulation team Architecture team …	N.D	N.D	N.D
	Project Management	Project Manager Steering committee	E-mail	Steering committee	Confidentia l	Confidential	Project Manager
	Management stratum	Not Determined	N.D.	N.D.		Confidential	Confidential

4.2 Matrix of interactions

As far as processors are identified, we have to draw out interactions between processors. We propose to use a square interaction matrix to understand those links. This matrix contains *Target Processors* in rows and *Source Processors* in columns. Those processors are sorted by human organisational system stratum. A decision flow linking two processors is illustrated by a mark in the matrix. This matrix is not symmetric; identifying marks related to a row containing the processor Φ highlights all the source processors emitting decisions flows to Φ.
We propose to illustrate this by a case study taken from the same design project of innovative steering systems as above. We grouped processors by systems (PSA projects, Prototype System, Supplier system and PSA management system). The different areas of the matrix are shown figure 2.

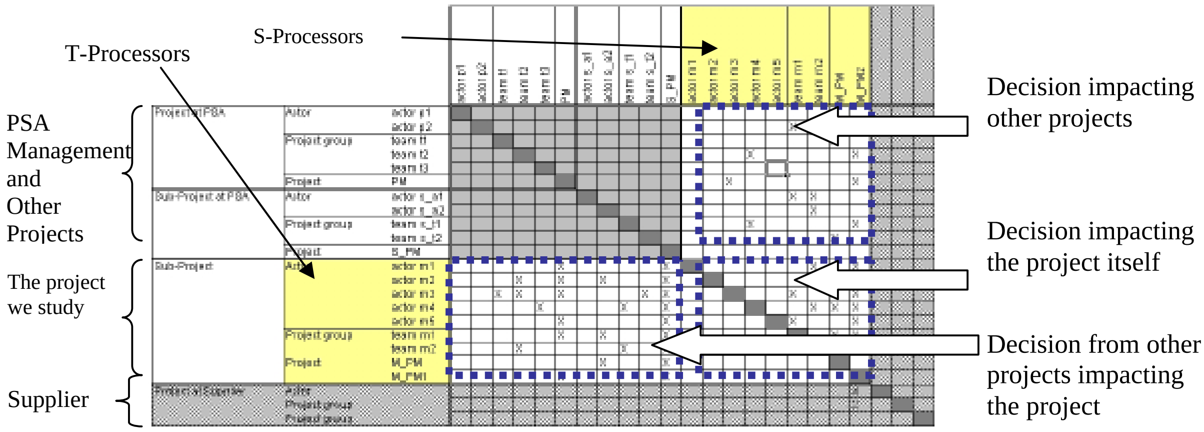

Figure 2. Matrix of interactions

5. Decision flows: nature and function

5.1 Nature

To begin with we propose to identify the object targeted by the decision flow. We use a simple model, considering that a decision-making process can impact either the product to be design, the process supporting that design or the organisation necessary to the project. Furthermore, to refine our description, we suggest observing each element following several points of view, structural, functional and genetic. In this paper we only focus on the product aspects. Organisational and process aspects will be described in future publications. The genetic view of the product focuses on the different technologies used, the functional view describes the functional decomposition of the product and the structural view focuses on the structural element definition of the product. In addition, the nature of the decision must be described. We propose to consider its status, its nature and its value.

- To provide decision state we use *DTL (Decision Time Line)* representation [Stal 01], “the *DTL* includes the decision process from the request to the answer”. The decision state elicits where is the decision information in the overall decision process. The different steps are: apprehending, identification, negotiation, synthesis, capitalisation and transmission.
- The nature of the decision flow is the nature of the information processed. It depends of the product view. It can be requirements, a set of specification, a choice of function, a simple information, a parameter, …
- Then is the explicit value of the information, for example the description of requirements for a function.

5.2 Functions

The decision is the result of a decision-making process. According to Le Moigne’s hypothesis, (from Simon theory), decision-making is intelligence (teleological comprehension) and decision is design (problem solving). We propose, as illustrated figure 3, several terms related to decision-making processes in design projects. *Solution space* is unknown and infinite (for example, functions that can satisfy a new steering systems). *Constraints* restraint the solution space. *Alternative space* is the part of the solution space explored and evaluated by the project. *Solutions* are chosen after an *evaluation* under a set of *criteria*. This is done *in order* to satisfy *objectives* of the project in a specific *context.*

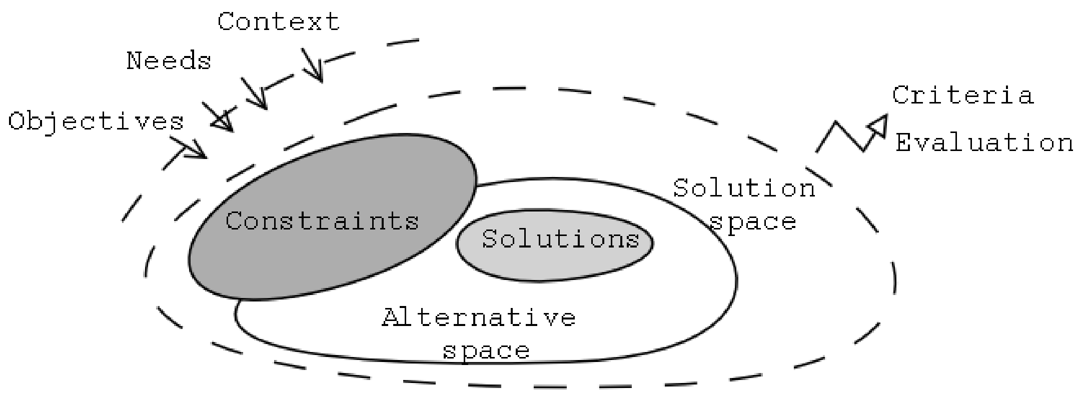

Figure 3. Decision terminology

Concerning design project of innovative products each of these elements (except context and needs) can be the object of a specific decision-making process. The last term to introduce in the notion of *consequence* used to describe the impact of a specific decision-making process on other processes.

5.3 Example

Table 2. Example of decision flow nature and functions

	Structural		Functional		Genetic	
Product	Ref.	PS_10	Ref.	PF_12	Ref	PF_32
	State	Transmission	State	Negotiation	State	Apprehending
	Value	307	Value	3 different set of functions.	Value	Criteria to compare technologies
	Nature	Target vehicle choice	Nature	Choice of Steering function	Nature	Type of Technology
	Object	Solution	Object	Alternatives space	Object	Criteria
	Consequence	PS_13	Consequence		Consequence	

We illustrate in table 2 the three views of the product and different states of the decision-making process applied to the example of innovative steering project described section 4.1. For instance, the flow called PS_10 concerns the structural view of the product (Target vehicle choice for prototype) and deals with a decision that is transmitted (means that the decision is taken) about the final solution, which is 307 car. This decision has consequences on flows PS_13.

6. Decision based Knowledge Management: Conclusion and Perspectives

In this paper we described a framework to analyse decision flows in design projects of innovative products in order to specify KM systems that satisfy projects stakeholders' needs. Our approach rely on a model of decision flows with 2 views, an organisational view which leads to decision processors identification and processors interactions identification and a view that characterises the functional aspects of the decision flows and their nature.

Results about this model application on the PSA innovative steering project will be exposed in future papers but we can already draw out how the models can be used and articulated and how they can lead to general recommendations. The type of KM system to be developed highly depends from de decision activities of the project analysed. To begin with, organisational view should help to identify the main processors in the different levels. This shall lead to various conclusions. For instance, this determines if the project depends of decision-making process of other projects. This identifies if there is the need for one KM system dedicated to the project, several KM systems or a global KM system. Thereafter, helped with meeting minutes, and available documents, the main types of decision flows handled by the project must be characterised with the decision flows function and nature view. This reveals what are the main activities of the projects, for instance, if there are more decisions about functional alternatives on the product than decisions about the definition of criteria to evaluate technologies. This view shows what the KM system must be applied to, this means capitalisation of criteria, alternatives, constraints, … This will also show what must be capitalised at first, by identifying what decision are critical by using what we called *consequence* of the decision identified.

If those models provide a clue to understand decision-making in innovative projects we think that continuing research about these models will demonstrate that they can also be used to formalise decision in order to build a decision based Knowledge Management system.

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