Collaborative Decision Making in New Product and Process Development : The Case of Automotive Industry

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STYLE DEFINITION

This part gives an overview of different styles used in this manuscript. The goal of this definition was to make this manuscript easier to follow for the reader.

The body of this manuscript is written using Times New Roman style with police 12. This is an example of this style.

Definition 1. This is an example of style used for definitions proposed by other authors in their work. Every definition will be preceded with the term "Definition number" and will be presented encircled with the simple border. The definitions are numbered and can be found in the recapitulative table.

Definition A. *This is an example of the style used when we are proposing a definition the concepts concerning our research study.*

When we are citing the work of other authors in this manuscript we use this style. The citations are written with Times New Roman, police 11, and italic.

WHEN GIVING AN EXAMPLE ENCOUNTERED DURING OUR FIELD RESEARCH WE WILL BE USING BOOK ANTIQUA, POLICE 12, ITALIQUE AND UPPERCASE.

CHAPTER 1

INTRODUCTION

1

INTRODUCTION

The New Product and Process Development (NPPD) is one of the key processes contributing to the enterprise success and its future development [Marxt and Hacklin 2004]. The first phase of this process is the Project Definition Phase. In this phase, the project team has the mission to define coherent project objectives. This is a very important phase because almost 80% of the product and process are specified in this phase [Whelton, Ballard *et al.* 2002], i.e. 80% of the project resources are committed in this phase. Morris [Morris 1988] states that the main reasons contributing to the project success emanate from the Project Definition Phase.

This phase is also a collaborative decision-making phase. Different actors of the NPPD process, which are experts in various fields of the product development, make collective decisions related to common (joint) fields. In this process, every actor has specific objectives defined for his domain of action. Therefore, the collaborative decision-making is a process where actors have different and often conflictual objectives. Actors in the collaborative decision-making process have also different knowledge concerning the problem as well as different information and points of view. FOR EXAMPLE, ONE OF THE IMPORTANT DECISIONS IN THE NPPD PROCESS IN VEHICLE DEVELOPMENT IS RELATED TO VEHICLE DESIGN. IF WE SIMPLIFY THE CASE, ONE OF THE OBJECTIVES IN THIS DECISION IS TO REDUCE GLOBAL VEHICLE COSTS AND THE OTHER IS TO HAVE AN ATTRACTIVE DESIGN. IN ORDER TO SATISFY THEIR OBJECTIVES, THE DESIGN DEPARTEMENT CAN PROPOSE VERY LOW CARS, WITH HIGH INCLINATION OF WINDOWPANE AND GREATHER GLASS SUPERFICIES. IF THE VEHICLE LINE IS TOO INCLINED, IT MIGHT BE NECESSARY TO WORK ON NEW GLASS MATERIALS WITH HIGHER RESISTANCE. THEREFORE, THE OBJECTIVES OF ECONOMIC DEPARTEMENT CONCERNING THE COST

OPTIMISATION ARE BROUGHT INTO QUESTION. This example illustrates some of the difficulties in the collaborative decision-making that we mentioned.

Due to the complexity of this phase and its duality of nature, the problems related to the Project Definition Phase concern two different axes:

1. The Decision-making axe - What is collaborative decision-making? Who is deciding? What are different roles in this decision-making process? What is influencing the collaborative decision-making and needs to be taken into account? What influences one collaborative decision and what are the consequences?

2. The Project Management axe - What the project team is to do in this phase? How to manage this phase? Is there any mean of control and how to control this phase?

Within this research study, we tried to give some elements of answer to some of the upper stated questions. In order to help the project team in the decision-making phase we have developed a conceptual model of collaborative decision-making. This model is descriptive and the aim of this model is to identify and define the intrinsic elements of collaborative decision-making, thus necessary for the decision-making. The modelling approach used in this study is the systemic approach developed by Le Moigne [Le Moigne 1990] that we will explain further in this manuscript. In this model, we defined the collaborative decision as a system and therefore we have developed four views in our model: Objectives, Transformations, Process and Environment.

The collaborative decision-making model is descriptive. Therefore, the conceptual model of the collaborative decision-making does not have the goal to contribute to the optimisation of decision choice. The choice of using the descriptive approach are following:

- Firstly, in development projects the number of criteria to take into account is constantly increasing. The optimisation methods are not yet so developed to address some hundreds of criteria. Moreover, in most of the cases, there is no optimal solution. FOR EXAMPLE, IN THE PROJECT DEFINITION PHASE IN THE AUTOMOTIVE INDUSTRY, THE PROJECT TEAMS HAVE IDENTIFIED ALMOST 150 GLOBAL CRITERIA USED TO DECIDE IN THIS PHASE. THESE CRITERIA CONCERN THE ENTIRE VEHICLE AND CAN BE DECOMPOSED ON SEVERAL SUB-CRITERIA.

- Secondly, the Project Definition Phase is a phase where project objectives are defined. Hence, in every collaborative decision-making, the project objectives' space is reduces or changed. These objectives are the outputs of the collaborative decision-making. Thereby, the project objectives are changing and dynamic. The fact that the project objectives continually change makes the automation of the decision-making process difficult. Moreover, the fact that the objectives that are

not jet defined at the same time causes the difficulty to define the decision-making criteria.

Consequently, this research work tries to contribute to the clarification of the collaborative decision-making permitting to have a better overview of this process and to help, i.e. to support the project team within it. In this axe, our position is very similar to the one defined in Decision Support field [Shim, Warkentin *et al.* 2002], that is to support the decision makers in this process and no to substitute the cognitive process of the decision makers.

In the axe of project management, we have developed an enhanced project management tool based upon the collaborative decision-making. Some Scientifics have already noticed the inadequateness of some project management tools in the early stages of product development [Louafa 2004]. The developed project management tool consists of three levels: decisional, informational and operational level. This structure is based upon the extended definition of the system developed by Le Moigne (see § 4.2) that we propose in this manuscript. The decisional level concerns different collaborative decision-making processes in NPPD process. The informational level is related to the information concerning one precise collaborative decision. The development of this level is based upon the conceptual collaborative decision-making model. The operational level concerns the operational processes necessary for the product development. This level corresponds to the classical activity network used for the project planning. Up till now, the practice in the project management was to develop the project planning using the product break-down structure. The complexity of the working processes, the deployment of system engineering methodology as well as concurrent design are only some of the reasons that make the project management, organised upon the product break-down structure, difficult. Therefore, we can notice the development of the “process” approaches.

The developments within the decision-making axe and project management axe permit on one hand to increase the robustness of decision in the collaborative decision-making, and on the other the traceability of the collaborative decision-making processes. The decision robustness comes from the fact that the elements required for decision-making are identified: who is deciding, what is decided upon, what is necessary to know to decide, what the decision influences, who is to do what so that the decision is possible. The traceability comes from the identification of flows (decisional, informational and operational) in collaborative decision-making processes. Hence, it is possible to know what are the influencing decisions, required information or previous activities to realise before one decision and what are the decisions that will be influenced, what is the information (output) and what is to be done afterwards.

Our research work has been implemented in the Project Definition Phase in PSA Peugeot Citroen. In the implementation phase, we have worked on the enhancement of the company’s referential project management tool. In the decisional level of this tool, we have identified and

modelled 13 collaborative decision-making processes. The informational level consists of 73 collaborative decisions that were modelled using our conceptual collaborative decision making model. Our industrial application is related to the construction of the decisional and informational level. Nevertheless, this work triggered the reflection about the organisation of the operational level. Hence, the operational level concerns 10 identified operational processes. The elements developed in this tool were identified with regard to the existing enterprise "Know-how" and the company's working culture.

1.1 Lecture Guide

This research study is organised in this manuscript within 5 chapters. The structure of these chapters is presented on Figure 1.1.1, and organised as following:

- Chapter 2: Research Context and Objectives,
- Chapter 3: State of Art,
- Chapter 4: Collaborative Decision Making Model, and
- Chapter 5: Managing Collaborative Decision Making Processes in Automotive Industry.

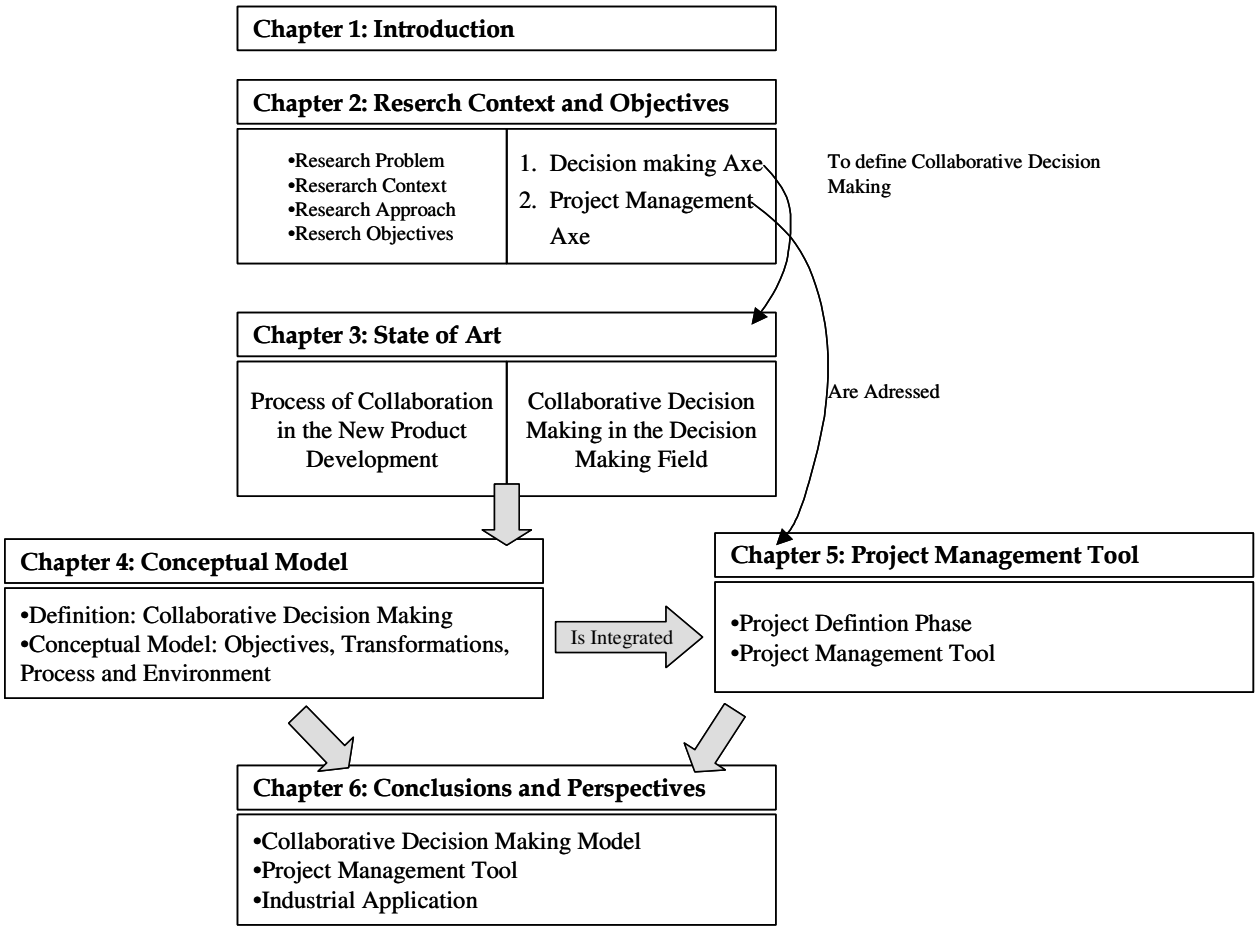

Figure 1.1.1 – Organisation of the manuscript

In chapter 2 we present our research problem and its context. Here we describe two influencing contexts: research and industrial. In this chapter we also expose our research approach: systems approach defined by Le Moigne [Le Moigne 1990]. Objectives that we defined at the beginning of this research study are exposed at the end of this chapter.

Chapter 3 represents state of art or bibliographic study. There are two domains explored in this chapter. The first one concerns definition of working processes that influenced the development of new working condition and introduced changes in organisations: coordination, cooperation and collaboration. The second one is a hart of our study and covers decision-making field. Here we try to give a global overview of the field even though the research literature can be very divergent.

The conceptual collaborative decision-making model is explicated in chapter 4. In this chapter we give also the definitions of different concepts used to develop this model. It is organised in four different views that are defined by the model: Objectives View, Environment View, Process View and Transformations View.

Our research was developed in collaboration with PSA Peugeot Citroen. The Project Management tool based upon collaborative decisions is implemented in the first phase of vehicle development. The application and integration of conceptual collaborative decision-making model in this tool is presented in chapter 5.

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CHAPTER 2

RESEARCH CONTEXT AND OBJECTIVES

2

RESEARCH CONTEXT AND OBJECTIVES

2.1 Introduction

Collaborative decision-making is a decision-making where different actors in the new product development process have different objectives, information and knowledge concerning one problem. The problem of collaborative decision-making was underpinned on the field in the case of new methodology deployment. Based on some field conclusions, that we present in this chapter, we define the problem and develop a conceptual model that was afterwards applied in the automotive industry. The conceptual model was used also as a base for a new Project Management Tool development. The goal of this part is to give a global overview of how the research is constructed, the research and industrial context, as an introduction to further research problem development and positioning.

2.2 Research Problem and Context

2.2.1 Research problem: Collaborative Decisions

Collaborative decision-making is one of multi-actor decision-making. The tendency of transferring decision-making process from individual to group or collective has already been pointed out by numerous literature and case studies [Shim, Warkentin et al. 2002].

In New Product and Process Development process, the collaborative decision-making is the most frequent decision-making process. Therefore, this is an important issue in New Product and Process Development. In our industrial application phase, we had an opportunity to work on collaborative decision-making in vehicle development. Hence, we give examples from our field research in order to illustrate this type of decision-making. The phase where we have applied our research is the first phase of the New Product and Process Development. We will call this phase the Project Definition phase. In collaborative decision-making actors are generally the experts in one precise domain and have specific objectives for this decision-making process. Their objectives concern only one aspect or domain of vehicle development. The point of view and position of one actor in collaborative decision-making are "coloured" by the knowledge and information that he possesses. In this work, we propose the next definition of collaborative decision-making (see § 4.1):

Definition A. *Collaborative decision-making is a collective decision-making where different actors have different and often conflictual objectives in the decision-making process.*

According to the proposition of the possible typology of decisions given by Zaraté and Soubie [Zaraté and Soubie 2004], collaborative decision-making is a synchronous decision-making. In the case of development project, this is the most frequent one. This is for several reasons that represent at the same time are the advantages of this kind of decision-making:

- Collaborative decision-making environment creates favourable conditions for synergy development. This is pointed out as a very important asset [Rose 2000] in every project, multiplying the results.
- Collaborative decision-making involves large number of actors having different knowledge of the problem. Thus in decision-making process a larger number of different aspects is covered, diminishing the unknown and uncertainties.
- For the same reason as in the previous point, the collaborative decision-making is a better-informed process. Every actor has different information, concerning different aspect of the same problem, or the information that is tightly connected.
- Upper statements sustain the possibility of a better-quality decision-making process. As actors have larger knowledge, more information and are influenced by synergy effects, the collaborative decision-making is a process resulting in a larger number of alternatives and thus possibly a decision of higher quality.

This type of decision-making, even though showing great advantages is not without some inconveniences and problems that are to be taken care of:

- Every decision maker has his own preferences concerning the decision. These preferences intervene in the decision-making process, thus altering it.

- Problems of different value judgements that every decision maker has for the same decision. Decision-makers have different backgrounds and different information, and therefore have different value judgements.

- The specificity of collaborative decision is the existence of different objectives in the decision-making process. Every actor has his own objectives that are important to be satisfied or the project may be at stake.

- As collaborative decision-making is a multi-actor decision-making, the problem of post-control is an important issue. Development projects are in the dynamic environment and it is necessary to follow-up the coherence between the chosen solution(s) and developing situations.

The information in our research work is enriched by the field research conducted in collaboration with PSA Peugeot Citroen. This collaboration concerns, as we said previously, the Project Definition phase. This industrial context as well as its characteristics is detailed in the §2.2.3. In the application phase, after an investigation of the terrain, there are several problems concerning the research and its application that were identified. These problems related to this process concern several levels:

- Collaborative decision level: The problem of identifying appropriate information about important decision elements. For example: who are the actors in the collaborative decisions, what are the information that the decision makers need to have in the moment of decision making, what is the level of criticality of information needed, what causes the conflicts in collaborative decisions?

- Collaborative decision-making process level: The difficulty of determination of the influence of collaborative decisions on different activities or decisions that are further in the Project Definition phase. For example: what are the decisions to be made before and after, what are the decisions that will be influenced by the present collaborative decision, i.e. what project objectives will be influenced, what are the activities influenced by this collaborative decision?

- Project level: The difficulties to implement the existing project management methods and tools in the management of this phase. For example: the base of project management is to identify activities constituting a phase in new product development determined by the project team in accordance with project goals. The problem is that the project objectives are not defined and in this phase (see § 5.2), project complexity does not facilitate identification of activities.

2.2.2 Research Problem Emergence

The research concerning collaborative decision-making, presented in this thesis, is based upon conclusions of Master of Science (MSc) research study, conducted in PSA Peugeot Citroën. Work concerned application of new methodology important for New Product and Processes Development (NPPD) process in the field of automotive industry: Systems Engineering.

Introduction of this methodology have caused a development of New Development Scheme of NPPD process. New Development Scheme is a referential document in PSA Peugeot Citroen for New Product and Process Development. It represents, taking into account the time dimension, global development logic and stages of conception (or design), development and industrialisation.

The objective of MSc study was to identify the crucial points in the process of deployment of Systems Engineering. These points represented the problems or difficulties in this process that are to be worked on in order to obtain a significant gain in terms of time and company's performance.

"System Engineering can not be considered as other design methods, but rather as a way to deploy best practices around the entire description of the engineering process" [Lardeur 2003]. It is an engineering approach, based on Concurrent Engineering, for development of complex systems (products), such as aeroplanes or vehicles. Systems Engineering takes into account entire life cycle of one system and is based upon the structural decomposition of systems. Lardeur [Lardeur 2003] states several dimensions of these approaches:

- Interconnection or interrelation of different activities as their results evolve conjointly during the development process,
- Parallel and iterative realisation of these activities, and
- Global integration referring to global optimisation of developed solutions obtained through these activities.

Deployment of Systems Engineering has made New Product and Process Development more collaborative (see § 3.2). There are several definitions of the collaboration process. We have given a short overview in the §3.2.3. Darses and Falzon [Darses and Falzon 1996] define the collaboration close to co-conception. In co-conception the partners develop the solution conjointly: they share the same goals, and contribute to their attainment with their specific competences, and all this with very strong constraints of direct cooperation in order to ensure successful problem resolution. The results of MSc study have pointed out that these changes have influenced not only the working processes, but also the decisional ones. Thus, in the most of NPPD processes, the actors are to decide collaboratively. Based upon these

conclusions, we have defined the problem of the collaborative decision-making and necessity to work on them.

2.2.3 Industrial Context: Project Management and Support

The field research related to this work was conducted in collaboration with one of two automobile constructers in France, PSA Peugeot Citroen. PSA Peugeot Citroen is the sixth most important worldwide enterprise in this domain. Its complexity lies also in the fact that this is one group with two brands: Peugeot and Citroen. Even though each brand has different market target and objectives, the NPPD process for both brands is the same.

Our collaboration was established specifically with SPJ department ("Support ProJets" means project support). This department is responsible for methodology development and project support during the whole NPPD process, i.e. during every phase of project life cycle. Its mission is to help and follow the project team:

- By helping the project team to adopt the best organisation corresponding to the specific phase of NPPD process,
- In order to capitalise knowledge in the domain of project management for further reuse and development,
- As internal consultants, experts of different methodologies and tools necessary for project management, for every phase of NPPD process.

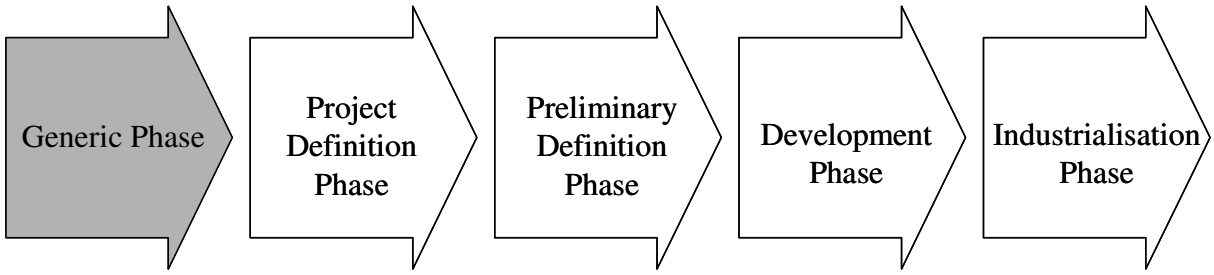

Figure 2.2.1 NPPD cycle in PSA Peugeot Citroen[1]

The collaborative decision-making model, as well as project management application, has been developed for the first phase of NPPD cycle: the Project Definition phase (§ 5.2). The Generic Phase concerns the innovations and is not considered as a "project" phase. In PSA Peugeot Citroen, NPPD cycle is constituted of several phases: generic phase, project

[1] These are not the actual names of NPPD phases. We have translated them in view to keep the meaning of the phase.

definition phase, primary definitions, development and industrialisation. The Project Definition phase is a phase where, through the collaborative decision-making process the most of the strategic decisions concerning the project as well as the enterprise are defined. In doing so almost 80% of the product and process are specified in this phase [Whelton, Ballard et al. 2002]. Product and process specifications represent also an engagement of enterprise resources, which implies the importance and necessity of good quality decision-making process. In his research, Morris states that the main reasons contributing to the project success emanate from the Project Definition phase [Morris 1988].

The Project Definition Phase differs from other development phases because the project objectives are to be defined within this phase. So even though in PSA Peugeot Citroen the "project" culture is well developed and implemented, the project methodology do not offer the necessary solutions for the project management.

2.3 Research Approach and Objectives

2.3.1 Research Approach

Merriam-Webster's dictionary defines epistemology "*as the study or a theory of the nature and grounds of knowledge especially with reference to its limits and validity"*. Therefore, the questions posed by this science are about the nature of the knowledge, the methods and validity of the knowledge. Perret et Séville [Perret and Séville 2003] point out that *"the epistemology consideration is indispensable to a scholar concerned with performing a serious research because it permits establishing validity and legitimacy of one research"*.

In general there are two distinct paradigms related to the engineering sciences: positivism and constructivism [Ahmed 2005; Le Moigne 1990]. The positivists [Thiètart 2003] postulate that the reality has its own existence. The scholars consider that there is no dependency between the research object (the reality) and the subject who is observing him or experimenting. This paradigm is using the objectivity principle: object observation does not change the nature of the observed or experimented object.

The concurrent epistemology is the constructivism. The modern bases of constructivist epistemology were determined by Jean Piaget in Encyclopaedia (Pléîade) "Scientific logics and knowledge" published in 1968 [Le Moigne 1990]. The bases of this epistemology lie in the belief of the scientist that the knowledge is dependent of the observer. The knowledge is conceived by the modeller in his interactions with the phenomenon that he comprehends and develops (conceives) [Le Moigne 1990]. Therefore, the constructivist epistemology is based upon the object-subject dependence hypothesis. In this case, the knowledge is believed to be subjective and contextual.

In our research, we are based upon the systems approach. Systems approach is one of the paradigms of constructivist epistemology. It permits to model one phenomenon comprehended as complex as a system. The notion of the system represent a conjunction of the phenomenon itself perceived globally or by his project and its intern interactions between his active constituents whereof it is a resulting composition [Le Moigne 1990]. In his work, Le Moigne develops his modelling approach: systemic conjunction[2]. It is named "conjunction" because it is based on two modelling procedures: cybernetic procedure and structuralist procedure. In systemic conjunction the concept of general System is defined as *"a representation of an active phenomenon comprehended as identifiable by his project in an active environment, in which he functions and transforms teleologically"[Le Moigne 1990]* (see Figure 4.2.3).There are several theories resulting form the general systems approach: theory of open systems, theory of general system, communication theory, systems theory and organisation theory.

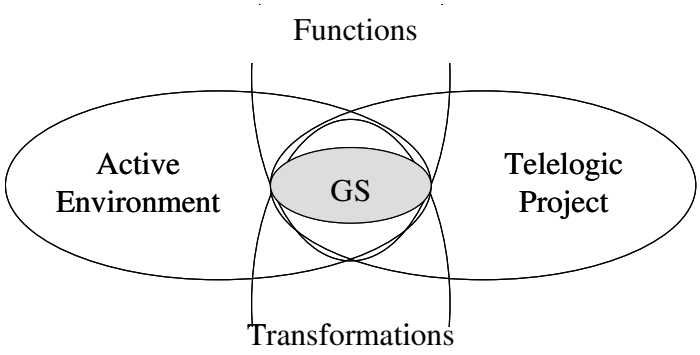

Figure 2.3.1–Systemic conjunction

2.3.2 Research objectives and results

The collaborative decision-making is a complex process with several specificities like: objectives' definition is parallel to the decision-making process, conflict apparition, existence of different values and criteria in the decision-making process (for further insight see §4). Often these decisions do not have optimal solutions because of the large number of criteria influencing decision-making process. In these cases, there is only the possibility to negotiate the most convenient one. Therefore, if we take into account research and industrial context defined respectively in § 2.2.2 and § 2.2.3, we identified two main streams generating the research results (see Figure 2.3.2):

1. Project management oriented,

[2] This is a authors translation of the concept "conjonction systèmique".

2. Decision Support oriented.

Problem related to the Project Definition Phase (§ 5.2) have accentuated the need in the domain of management of collaborative decision-making processes and project. These difficulties have pointed out several needs:

- Global progress monitoring: Project Definition Phase is a phase where project objectives are to be defined. The project team do not have the possibility to evaluate the project progress in this phase because of the problem of activity identification and their relationship definition.

- Process control: Collaborative decision-making is a synchronous decision-making. As it is not a formalised process with the clear definition of objectives, participants, decisions, it is very hard to identify what was decided, what was already effectuated and what rests to be done, and therefore to control this process.

- Accentuation of correction activities: Due to upper mentioned problems (see for detailed information §5.2), the Project Definition Phase is hard to structure and to organise. As the project team has no project trajectory, it is hard to evaluate project evolution and therefore introduce corrections if necessary.

The second research stream is decision support oriented. The relationships in collaborative decision-making are complex and not easily identified. The aim was to develop a decision support tool with several objectives:

- To structure/organise collaborative decision-making: The participants in this process are numerous and therefore it is necessary to have an adequate organisation of this process.

- To identify the elements and information necessary for decision-making: Systems Engineering Deployment introduced activity concurrence. In these conditions, the actors do not necessarily know what are the crucial elements or information for one decision.

- To help decision-makers in this process: The Project team has several tools at its disposal. As the field research revealed (see §5.4.2), there are too many tools developed for the project management. Therefore, the conception and integration of user-friendly and efficient tool was imposed.

In this PhD, we have tried to give an answer for both of these streams. In the case of decision support, we have developed a conceptual model of the collaborative decision-making containing the necessary information about one collaborative decision (see Figure 4.2.2). This model is exposed in detail in chapter 4 of this manuscript. During the application phase in

PSA Peugeot Citroen, we have used this model to represent all identified collaborative decisions. This information is physically stocked in the document called the Individual File.

In order to satisfy the objectives concerning the project management we have developed a project management tool. The structure of this tool is developed on three levels: decisional level, information level and operational level. This structure is represented on Figure 2.3.2. The project management tool is described further in the chapter 5 of this manuscript. In this part we also argument the choice of the structure with reference to operational needs identified on the field.

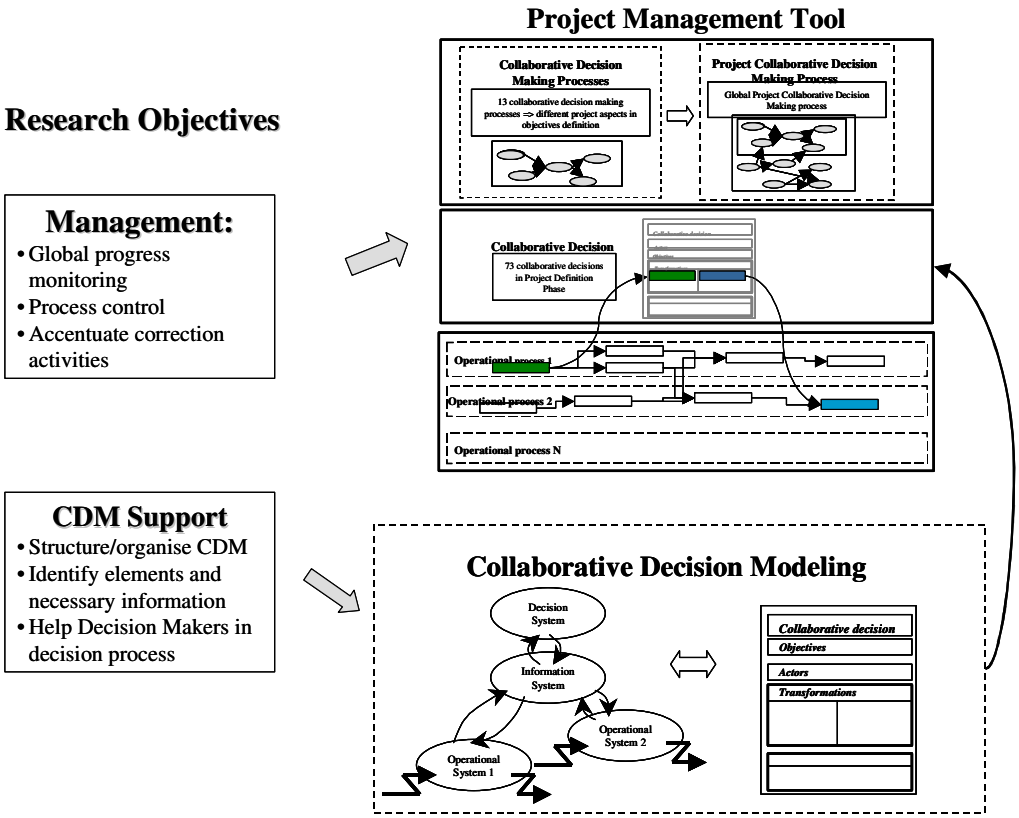

Figure 2.3.2- Research Objectives and Corresponding Results

2.4 Synthesis

In this chapter, we have addressed global frontiers of our research work. Therefore, we have outlined some advantages and problems in collaborative decision-making. Research and industrial context of this PhD work are also presented in this chapter.

In view to these two contexts, we have identified two global domains of our research:

- Decision Support oriented

- Project Management oriented.

We have tried to develop a contribution for each of these two domains. These contributions are incorporated in the Project Management tool that will be presented in the fifth chapter.

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CHAPTER 3

STATE OF ART

3

STATE OF ART

3.1 Introduction

As we already exposed in the § 2.2, the research problem of this PhD thesis concerns collaborative decision-making in New Product and Process Development process. In this chapter, we present the relevant literature for our research work. As the addressed problem is decisions constituting the collaboration process, we find necessary to define on the first place the process of collaboration (because it influences the characteristics of collaborative decision-making) and afterwards the collaborative decision-making. Therefore, this chapter consists of two major parts:

1. The research concerning different situations of collective work - In view to define clearly the collaborative decisions, it is necessary first to give a clear definition of collaboration, as well as to identify the specificities of this process influencing collaborative decision-making. Hereby, we want to define the context shaping the collaborative decision-making. Collaboration is considered to be one of the different situations of collective work [Rose 2000]. We can state also the coordination and cooperation. Therefore, this part contains a literature overview for these three collective work situation, different streams and related definitions (see § 3.2).

2. Research concerning decision-making domain - Decision-making is relatively a large domain. In this part we try to give a global overview of the domain and afterwards to

present the literature relevant to the scope of our research study. In this part we have developed a quantitative and qualitative vision of the domain. Quantitative study of the domain is realised using one scientific provider (ISI Web of Knowledge) with the reputation of having exhaustive scientific databases. It is presented in § 3.3.1.We do not pretend that this study is entirely exhaustive. The aim is to globally represent the field. Afterward we focus on three connected fields (§ 3.4, § 3.5, § 3.6):

- Cooperative and Collaborative decision-making: The organisational decision-making is more and more collective [Longueville 2003; Shim, Warkentin *et al.* 2002; Zaraté 2005]. Therefore, we are often talking about multi-actor decision-making. This field is relatively a new field (see § 3.4), and does not propose a unified vision concerning different collective decisions. In this part, we give an overview related to cooperative and collaborative decision-making, as these processes as often confused (see § 3.4.1).

- Descriptive approaches process oriented: Collaborative decision-making in NPPD process are complex. In vehicle development, there is a large number of criteria used for decision-making. WE CAN GIVE AN EXAMPLE OF PSA PEUGEOT CITROEN, WHERE MORE THAT 150 CRITERIA ARE IDENTIFIED AS NECESSARY FOR THIS PROCESS. This fact makes the usage of analytical methods in decision analysis difficult. Here, we present some of the approaches and identified decision-making processes.

- Decision Support Systems: In § 2.3.2 we identified two research goals. The one concerns decision support and the other decision management. Decision Support Systems (DSS) represent a research field with a certain maturity [Carlsson and Turban 2002; Gachet and Haettenschwiler 2001; Shim, Warkentin *et al.* 2002]. In this part of the manuscript, we give an overview of different systems developed to support multi-actors decision-making.

3.2 Cooperation, Collaboration: New Working Conditions

Responsibility delegation, as well as problems related to information acquisition, exchange and extraction, have also altered organisational decision-making processes [Zaraté 2005]. The basic hypothesis of one decision maker in the decision theory is practically not sustainable. More and more the decision-making processes become the collective ones. We can state several reasons for this: existence of different competences, different knowledge concerning one problem, different information even contradictory ones and geographical dispersion. In order to overcome these problems, the decision-making is increasingly cooperative or collaborative, and the research issues in this domain gain on quantity.

The cooperative or collaborative decision-making is a part of the cooperation or collaboration process. Hence, in order to define collaborative decision-making we find that it is of most importance to define the concept of collaboration. There are several forms of human interaction in the company. Almost everyday we can hear somebody employing the terms such as coordination, cooperation or collaboration. The scientific literature has offered a certain number of definitions identifying conditions necessary for these types of collective work. Nevertheless, some of these definitions are contradictory (see § 3.2.2, § 3.2.3 and § 3.2.4): is collaboration a weaker form of cooperation or a most integrant form?

Cooperation and collaboration are the terms that are *often confused*. They are both defined as human interactions where different actors have common objectives and realise different tasks in order to attain these objectives. Nevertheless, as we will show it in the § 3.2.2 and §3.2.3, there is some discordance in the literature concerning their definitions and difference between these two concepts. First, we will expose a brief survey of different definitions of coordination, because it is considered to be one of collective work situation and because some studies use the concept of coordination in order to differentiate cooperation and collaboration. Therefore, we find necessary to introduce this concept without entering deeper into the subject. Second, we expose different definitions of cooperation and afterwards the collaboration process. In the end, we give a comparison between these two concepts.

3.2.1 Coordination

The research literature shows a certain homogenisation of criteria that determine the coordination. The pre-conditions or the context of coordination is the existence of interdependence between the actors and task sharing between them. The degree of interdependence necessary for coordination is defined differently, as we show it here.

Bareigts [Bareigts 2000] sees the coordination as functioning rules established by one or several actors in view to joint task realization. Rose [Rose 2000] considers coordination in the NPPD process and is more focalised on groups. He defines the coordination as a sum of lows and procedures that assure the group functioning. Coordination includes also resource allocation and access facilitation to different information and knowledge necessary for attaining the objectives. Thomassen and Lorenzen [Thomassen and Lorenzen 2001] develop also "an activity based" coordination model. They "*view coordination as a transfer of information and/or provision of common knowledge amongst entrepreneurs, in order to align the interdependent industrial activities they undertake"*.

Mattessich and Monsey [Mattessich and Monsey 1992] consider the coordination as a more formal interaction than the cooperation. They define the coordination as a formal interaction implying the formal relationships. Coordination also needs compatible missions, some

planning and role division. For them, even though authority rests individual there is an increasing joint responsibility.

3.2.2 Cooperation

The cooperation is a process often confused with collaboration. Hereby, we give an overview of different definitions proposed in the research literature, identifying different preconditions for cooperation as well as differentiation studies related to cooperation or collaboration.

As for coordination, the condition necessary for the cooperation is the existence of activities that are mutually interdependent. Moreover, the additional condition is that actors in this interaction have the common goals [De Terssac and Maggi 1996; Soubie 1996]. De Terssac [De Terssac and Maggi 1996] defines the cooperation as a collective action where all actors have the same goals.

Soubie [Soubie 1996] in his work identifies several conditions necessary for the cooperation to appear:

- The existence of common goals,
- The actors are participating together in the resolution of the problem,
- The existence of the communication tools, and
- The tasks necessary for the problem resolution have to be separable.

Nevertheless, Belkadi [Belkadi, Bonjour et al. 2003] have already noticed that this term was used largely and that there were the cases of its excessive utilisation. In the field of concurrent engineering and design, Béguin [Béguin 1994] considers the cooperation as weaker form than collaboration. The actors are working in parallel but not conjointly.

Zaraté [Zaraté 2005] proposes a more extensive definition of the cooperation. She observes the cooperation in view to develop support systems adequate for this process. For her the cooperation:

- Implies the participation of several agents (human or not) in the resolution of one problem,
- Having common goals:
  - Total: global system point of view,
  - Partial: agent point of view,

- Having the communication tools,
- Where there is a possibility to decompose the problem to be resolved on several sub-problems,
- Where every agent has the competences/knowledge concerning the task realisation and
- Where there is a function of task allocation and allocation control.

In her work, she defines three types of cooperation:

- Complementary cooperation,
- Negotiated cooperation and
- Interdependent cooperation.

Complementary cooperation implies that every agent has a task to execute with regard to his capacities and/or context. The particularity of this type of cooperation is that there are no task interferences. They are independent. *Interdependent cooperation* is when every actor has an independent position to defend or to negotiate. This type of cooperation is based upon the argumentation between different parties. In *negotiated cooperation* every partner has the possibility to negotiate or defend its' position.

Boujut and Laureillard [Boujut and Laureillard 2002] focalise their research on the cooperation between team actors in design processes. They distinguish clearly the concepts of cooperation and coordination. Using the definitions proposed in Oxford dictionary they define "c*o-ordination as 'the harmonious or effective working together of different parts', while co-operation is defined as 'the process of working together to the same end'*." Therefore, as in previous studies, they accentuate the "shared set of goals" as a necessary condition for cooperation apparition. They present a conceptual framework for developing support tools in cooperation process, identifying three levels: tools, actors and organisation. The use of intermediary artefacts in order to foster cooperation process in the design is underlined as an important issue.

Zhuge [Zhuge 2003] based on the work of Tambe [Tambe 1997] points out two types of cooperation: the cooperation in a loosely coupled way and the cooperation on a tightly coupled way. In his research he adopts a cognitive orientation, i.e. he considers the cooperation as a "knowledge-intensive teamwork". Therefore, the actors can cooperate on three levels:

1. Work cooperation: Team members implement task already predefined.

2. Resources cooperation (Information sharing level): Team members communicate and thus share the information.

3. Cognitive cooperation: Team member learn from each other, make abstractions and use the past experience in order to solve the problem.

In management sciences, research studies state also that the cooperation process implies the will to work together or the personal interests of actors in cooperative process (see [Saubesty]). Axelrod [Axelrod 1992] in his work qualifies this relationship as "win-win". Ouchi [Ouchi 1980] on the other hand accentuates the divergence of objectives in cooperation and the necessity of interdependence of actors in order to cooperate.

3.2.3 Collaboration

The etymology of the word collaborate in Latin is "com" meaning together and "laborare" meaning working. The research literature shows little consensus on the matter of definition of this concept as we show it in this part of the manuscript. Nevertheless, there are two conditions pointed out regularly when defining collaboration: the existence of the common set of goals and activity interdependence are pointed out [Darses and Falzon 1996; Rose 2000; Zaraté 2005].

Dillembourg [Dillembourg, Baker et al. 1996] (see [Rose 2000; Zaraté 2005]) affirms that the collaboration depends on mutual engagement of different participants and on coordinated effort to solve a problem that is posed. In the field of support systems for collaborative work, Zaraté [Zaraté 2005] considers collaboration as a less advanced form of cooperative work. In her work, she states that collaboration:

- Implies several agents participation (human or not) in problem solving: from the global system's point of view;
- Having common goals:
  - Total: from the global system's point of view,
  - Partial: from the agent's point of view,
- Having the means of communication: from agent's point of view and point of view of cooperation human/system;
- Every agent having the competences/knowledge for the task realisation: from agent's point of view, having the capacities for problem decomposition on sub-problems: from the global system point of view.

Jassawalla and Sashittal [Jassawalla and Sashittal 1998] explore the problem of collaboration in a NPD (New Product Development) process. Their research work covers a field study in 10 high-tech firms. They compare different cross-functional linkages in NPD process: integration and collaboration. The authors focus their attention on integration and collaboration as important cross-functional linkages, enhancing the efficiency of NPD process. They notice that the both terms commonly refer to *"coming together of diverse interests and people to achieve a common purpose via interactions, information sharing, and coordination of activities"*. Collaboration is, in their opinion, a more complex and a higher intensity cross-functional linkage (see Figure 3.2.1).

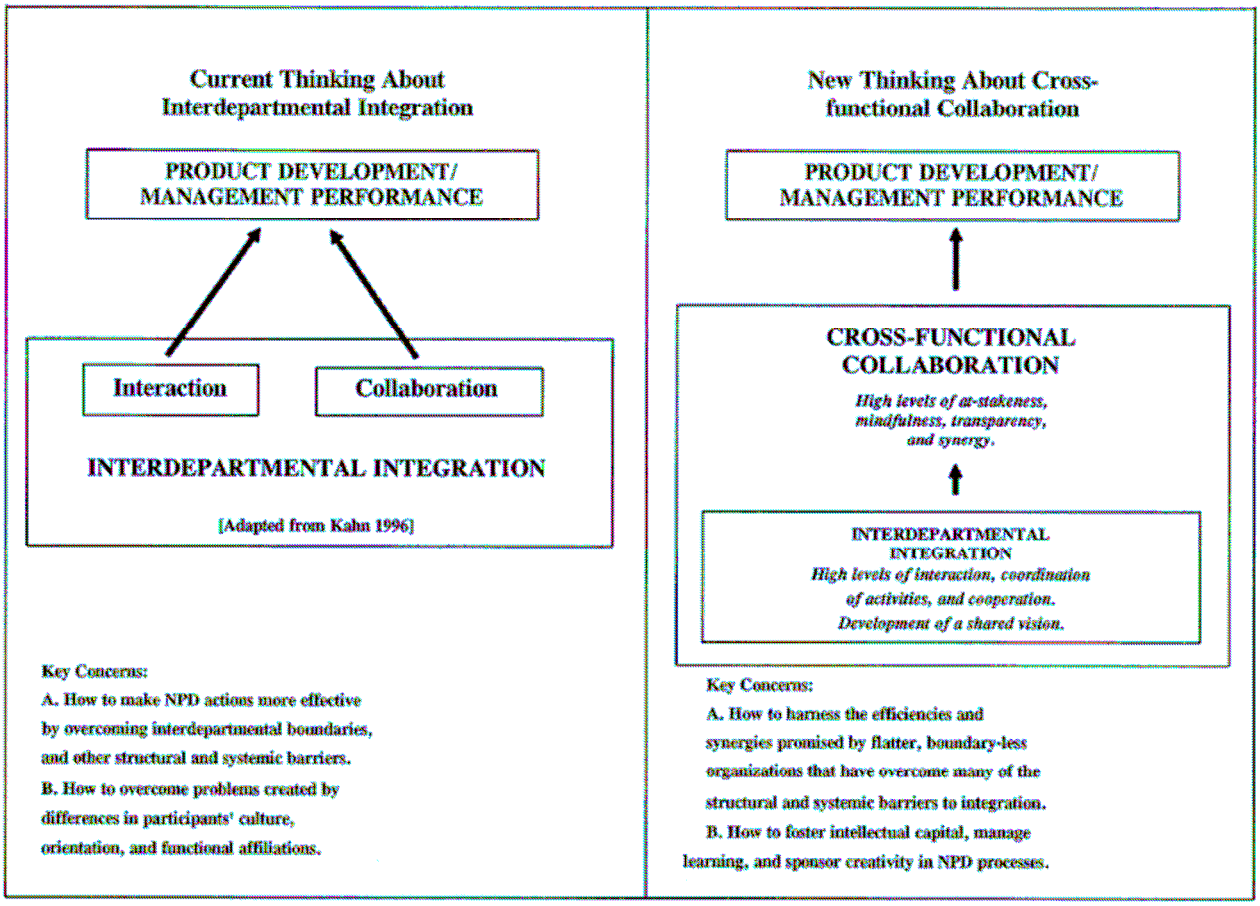

Figure 3.2.1– Integration and Collaboration Differentiation [Jassawalla and Sashittal 1998]

Jasawalla and Sashittal define NPD related cross-functional collaboration as a "*type of cross-functional linkage, which in addition to high levels of integration, is characterized by participants who achieve high levels of at-stakeness, transparency, mindfulness and synergies from their interactions*". In their work they define the upper given key features that collaboration includes at high levels: (a) *at-stakeness*: a condition where participants have equitable interest in implementing jointly developed agendas, and feel equal stake in NPD related outcomes; (b) *transparency*: a condition of high awareness achieved as a result of intense communication and exchange of hard-data that makes the motivations, agendas, and

constraints of all participants explicit; (c) *mindfulness*: a condition where new product decisions and participants' actions reflect an integrated understanding of the breadth, and the often divergent motivations, agendas, and constraints that exist and (d) *synergy*: the accomplishment as a result of cross-functional linkages of NPD outcomes that reflect capabilities significantly beyond those participants individually bring to the process.

Wood and Gray [Wood and Gray 1991] address the collaboration process in generally. Their research work concerns the collaboration "*as an interorganizational phenomenon designed to achieve desired ends that no single organization can achieve acting unilaterally"*. When it comes to the definition of the collaboration, the authors founded a large number of definitions, each of them "*having something to offer and none being entirely satisfactory by itself"*. Some of the given definitions are:

- The definition of Westley and Vredenbourg [Westley and Vredenburg 1991] based upon the definition of Gray [Gray 1989] seeing the collaboration as *"a process through which parties who see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible"*.

- The definition of Logsdon [Logsdon 1991] and Sharfman [Sharfman, Gray et al. 1991] is based upon the Gray's [Gray 1989] definition: the collaboration is *"a process of joint decision-making among key stakeholders of a problem domain about the future of that domain"*.

- Roberts and Brandley [Roberts and Bradley 1991] define the collaboration as "*an interactive process having a shared transmutational purpose and characterized by explicit voluntary membership, joint decision-making, agreed-upon rules, and a temporary structure"*.

Due to this multitude of definitions and different aspects treated in each of them, the authors proposed a new definition including the elements necessary giving answers to questions: Who is doing what, with what means, towards which ends?: "*Collaboration occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to this domain"*.

3.2.4 Cooperation versus Collaboration: Working Definitions

The definitions of coordination and collaboration, respectively given in § 3.2.2 and § 3.2.3, are very similar. We point out that two conditions are identifyied as necessary for both of the processes:

- Interdependence of the tasks,

- Common set of goals for all parties participating in this processes.

However the differences between these two concepts are not so clearly underpinned [Darses and Falzon 1996; Rose 2000; Zaraté 2005]. Darses and Falzon [Darses and Falzon 1996] discuss the differention of cooperation and collaboration in design processes thought the differentiation of co-conception and distributed conception. Authors consider the concept of co-conception very close to the definition of collaboration. In co-conception the partners develop the solution conjointly: they share the same goals, and contribute to their attainment with their specific competences, and all this with very strong constraints of direct cooperation in order to ensure successful problem resolution. The concept of distributed conception is close to cooperation because the actors are working simultaneously but not conjointly. The actors are accomplishing tasks that were predefined and are having their own goals, trying to participate as efficiently as possible in the collective resolution of the problem.

Zaraté [Zaraté 2005] considers cooperation as a form of interaction that is more elaborated than collaboration. For her, the cooperation comprehends also the coordination while the collaboration does not. The coordination is necessary for cooperation. On the other hand, if the members of one group can coordinate themselves, the author observes that then we are talking about the collaboration. In her work, she states that the coordination:

- Has a repartition function and control function of tasks assignment from the global system's point of view,

- Constitutes the cooperation process, the same as the communication.

In his PhD, Rose [Rose 2000] is proposing a synthesis of four different situations of collective work, with their differences and specificities (see Figure 3.2.2): communication, coordination, cooperation and collaboration.

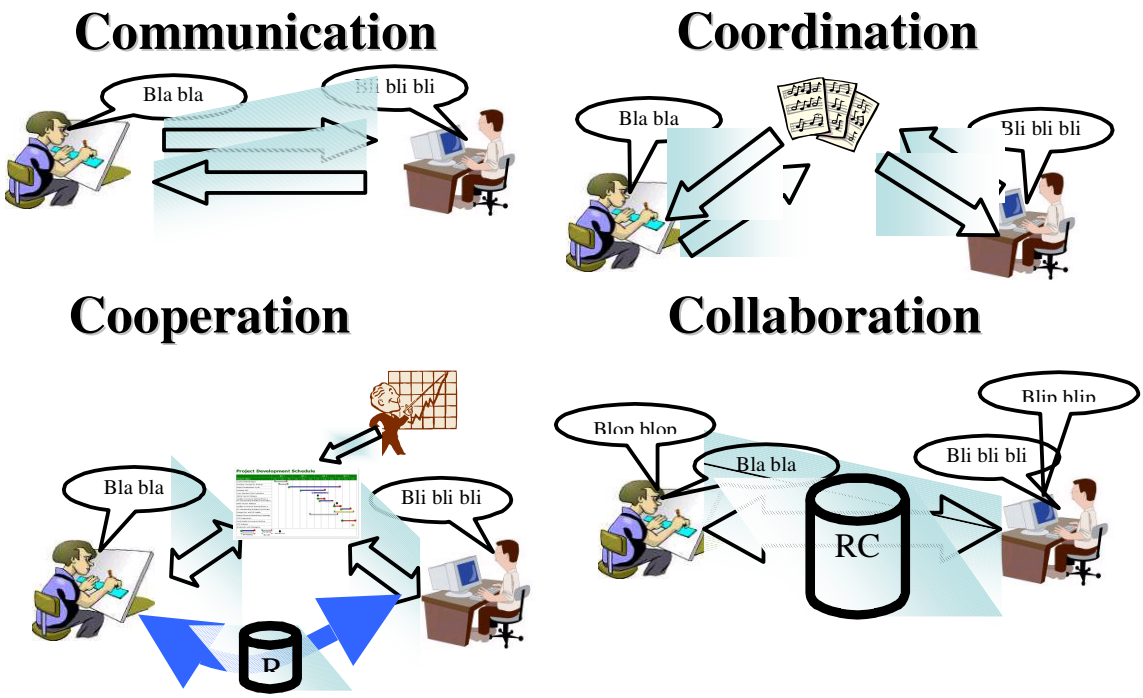

Figure 3.2.2 – Different situation of cooperative work [Rose 2000]

The context of our research is NPPD process. In this research field, the definitions of cooperation or collaboration are homogenous. The definition of collaboration process definitions can be represented by the definition of Darses and Falzon [Darses and Falzon 1996] or Rose [Rose 2000]. Therefore, we consider the collaboration to be a process where different actors have common global goals, where the task realisation is interdependent, i.e. the work of one actor is depending of the task realisation of the other actors. This task realisation is parallel (concurrent). Whilst, the cooperation in the design process is a process where different actors have common global goals but the task realisation in not interdependent, i.e. each actor is able to realise his task without depending directly on other actors in the process. Only the global goals depend on the task realisation of all actors.

3.3 Decision Making

3.3.1 Global Overview of the Domain

Decision-making is a large scientific domain. We have conducted a quantitative study of this field in order to depict the field scope and development. On ISI Web of Knowledge site, we can find 96 071 papers referring to “decision-making” as a key word. The database that we searched contains record from 1956 up till now. If we consider just the articles in journals, there are 82 705 records.

Afterwards, in order to obtain a more refined picture of different disciplines addressing the problem of decision-making, we have conducted the study by the research subject. This study is referring to 10 000 most relevant papers (taking into account the indices of importance of different international journals). Ten most important scientific domains concerned with decision-making problems are presented on the Table 3.3.1

SUBJECT CATEGORY	RECORD COUNT	% OF 82705
OPERATIONS RESEARCH & MANAGEMENT SCIENCE	7344	8.8798%
ENGINEERING, ELECTRICAL & ELECTRONIC	6499	7.8580%
COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE	5378	6.5026%
COMPUTER SCIENCE, THEORY & METHODS	4955	5.9912%
COMPUTER SCIENCE, INFORMATION SYSTEMS	4185	5.0602%
MEDICINE, GENERAL & INTERNAL	3874	4.6841%
COMPUTER SCIENCE, INTERDISCIPLINARY APPLICATIONS	3799	4.5934%
ENVIRONMENTAL SCIENCES	3545	4.2863%
MANAGEMENT	3414	4.1279%
ENGINEERING, INDUSTRIAL	3163	3.8244%
(212 Subject Category value(s) outside display options.)		

Table 3.3.1- Global overview of the domain

Table 3.3.1 contains only ten most important subject areas. Two hundred and twelve subject areas are not represented on this table. Hereby, the study confirms that the decision-making field is a large domain (concerning 212 scientific fields) and that is a transversal question. This table illustrates also that decision-making is an important issue in industrial engineering. Every subject area has its proper problems concerning the decision-making field and therefore uses different approaches to solve them.

3.3.2 Research focus

The subject of our research study is the collaborative decision-making in NPPD processes. If we consider decision-making in organisations, there are several scientific approaches dealing with this problem (see Figure 3.3.1): decision analysis [Carlsson and Fuller 2002; Doyle and Thomason 1999; Keeney and Raiffa 1976] developing different analytical tools for optimal decision-making; in management sciences the observation of decision-making as a human activity (information search in decision-making [Nutt 2005], different decision making styles [Nutt 1986; Thunholm 2004], different influence factors [Fong and Wyer 2003; Sayegh, Anthony *et al.* 2004]); decision-making as a group work (problem concerning the consensus [Esser 1998; Janis 1971; Priem, Harrison *et al.* 1995], conflict in decision-making [Jehn and Mannix 2001; Matta and Corby 1997; Schulz-Hardt, Jochims *et al.* 2002]); studies concerning different types of decisions ([Mintzberg 1976; Stal-Le Cardinal 2000]) focalised on number of actors (individual [Keeney and Raiffa 1976], group [Shim, Warkentin *et al.* 2002], cooperative [Zaraté 2005], collaborative [Karacapilidis and Papadias 2001]) or different fields of decision-making (design [Badke-Schaub and Gehrlicher 2003; Hansen and Andreasen 2004], marketing [Leeflang and Wittink 2000]).

In the § 2.3.2, we underscored two global research goals, i.e. to help manage collaborative decision-making within the scope of project management and to support collaborative decision-making. In View to these stated goals, we focus on three different domains (see Figure 3.3.1) that we previously explained in § 3.1:

- Collective Decision Making (cooperative and collaborative),
- Descriptive approaches used in decision-making theory, and
- Different solutions in Decision Support Systems (DSS).

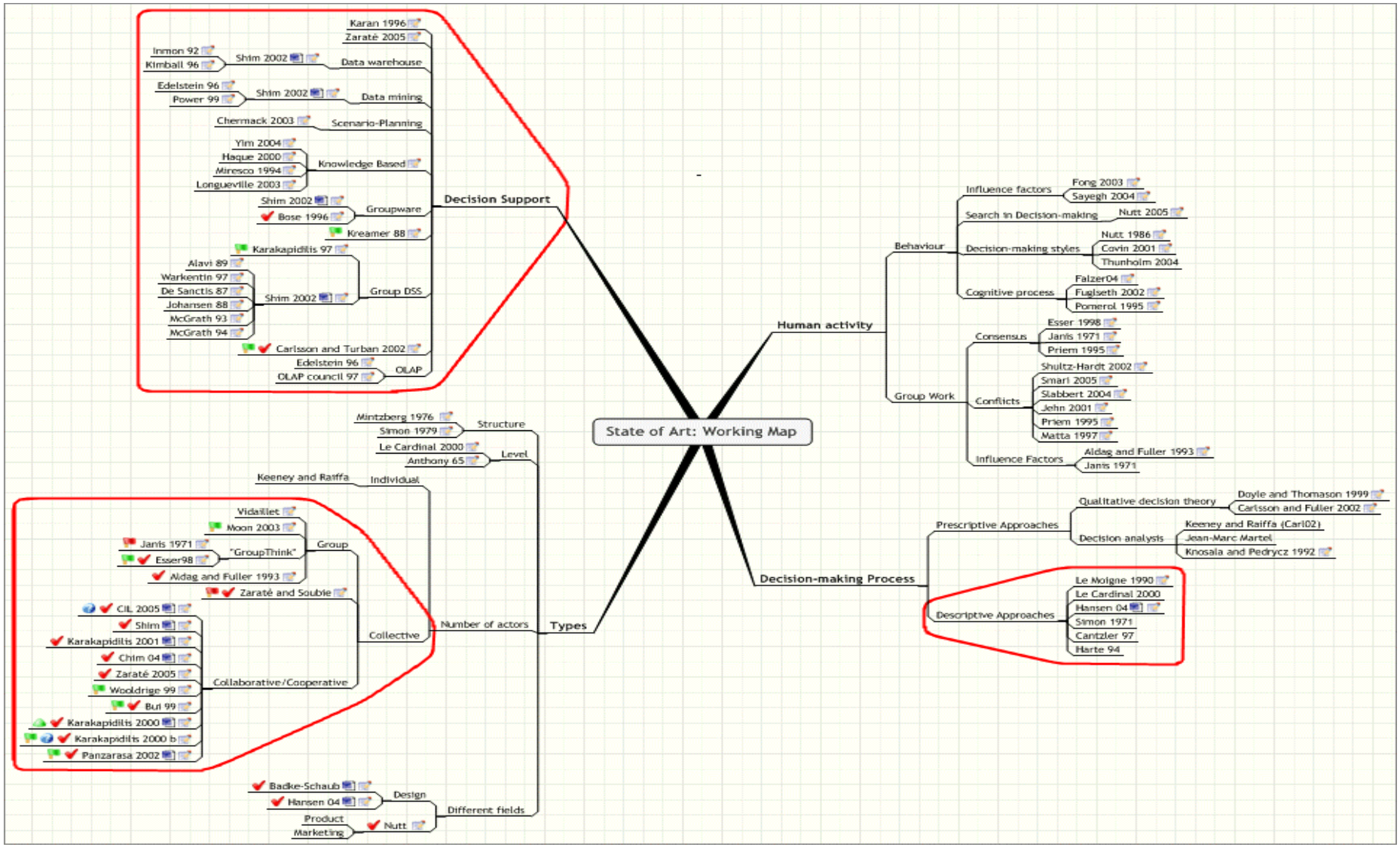

Figure 3.3.1 – "Decision-making" in organisation

3.4 Deciding together: Group, Cooperative and Collaborative Decision Making

Group, cooperative and collaborative decisions represent collective decisions. In last years there have been a shift from individual decision-making to collective decision-making [Longueville 2003; Shim, Warkentin *et al.* 2002; Zaraté 2005]. Therefore, different forms of collective decision-making have become the subject of diverse scientific research. We have conducted a research on development of group, cooperative and collaborative decision-making domains in scientific literature. In view to represent the scientific field, we interested ourselves in the scope of each research problem, as well as their development. Hence, the quantitative study[3] comprehends the publication years and the progression of the research in each research problem (see Table 3.4.1,Table 3.4.2, and Table 3.4.3 respectively).

Publication Year	Record Count	% of 7500
2005	878	11.7067%
2004	713	9.5067%
2003	665	8.8667%
2002	583	7.7733%
2006	583	7.7733%
2001	555	7.4000%
2000	521	6.9467%
1999	476	6.3467%
1998	442	5.8933%
1997	396	5.2800%
(33 Publication Year value(s) outside display options.)		

Table 3.4.1–Analyse of Group Decision Making Domain By Year

The three tables show clearly that group, cooperative and collaborative decision-making are becoming the subjects of growing interest for the scientific community. The quantitative analyse did not take into account the distinction of different subject areas in these research domains. Therefore, the tables represent the global situation integrating different scientific domains, from medical to engineering and artificial intelligence. The numbers of articles founds for each of these domains are: 7500 in the group decision-making domain, 625 in cooperative and 694 in collaborative decision-making fields. The number of publications indicates that the cooperative and collaborative decision-making are recently addressed

[3] www.isiwebofknowledge.com

subjects comparing to the group decision-making. In this part, we give only the short versions of this research. The tables containing all years and percentage are given in the Appendix B.

Publication Year	Record Count	% of 625
2005	81	12.9600%
2004	64	10.2400%
2003	54	8.6400%
2006	47	7.5200%
2002	43	6.8800%
2000	42	6.7200%
1999	41	6.5600%
2001	40	6.4000%
1998	36	5.7600%
1994	32	5.1200%
(15 Publication Year value(s) outside display options.)		

Table 3.4.2- Analyse of Cooperative Decision Making Domain by Year

We can see on the tables that the last four to five years have been essential for the scientific production in these domains. Moreover, we can notice that the interest in these subjects appears during the 90s and is constantly increasing.

Publication Year	Record Count	% of 694
2005	93	13.4006%
2004	86	12.3919%
2006	81	11.6715%
2003	72	10.3746%
2002	63	9.0778%
2001	56	8.0692%
2000	53	7.6369%
1999	48	6.9164%
1998	30	4.3228%
1996	24	3.4582%
(8 Publication Year value(s) outside display options.)		

Table 3.4.3– Analyse of Collaborative Decision Making Domain by Year

3.4.1 Collaborative versus Cooperative Decision Making

In order to define clearly the scope of our study, we searched for a clear definition of collaborative decision-making and different approaches used to support this decision-making. As there are definitions of the process of cooperation and the process of collaboration, it

would be logic to find that the cooperative decision-making is a part of cooperation and that collaborative decision-making is a part of collaboration. It would be also expected these two types of decision-making to be influenced by the specificities of these processes. Nevertheless, the research concerning cooperative or collaborative decision-making and research concerning cooperation or collaboration seems to be little connected. For example, in his overview of the domain of decision support, Shim [Shim, Warkentin *et al.* 2002] considers group support systems to be collaboration support systems. He defines them as systems that "*enhance the communication-related activities of team members engaged in computer-supported cooperative work" [Shim, Warkentin et al. 2002]*. For him the collaboration occurs within the context of cooperative work and is defined as *''multiple individuals working together in a planned way in the same production process or in different but connected production processes''* ([Wilson 1994] read in [Shim, Warkentin *et al.* 2002]). Cil [Cil, Alpturk *et al.* 2005] gives a similar definition. In his work he considers group decision support systems (GDSS) as systems helping a group to work concurrently and cooperatively. GDSS are systems supporting group working on unstructured problems and containing tools that exploit advances in communication to support discussion-oriented tasks in group decision making. For him "*DSS technologies constitute an area that is generally referred to as ''computer- supported cooperative work'' or ''collaborative systems'', which are used to support unstructured problems"[Cil, Alpturk et al. 2005]*.

The fact that the field of cooperative or collaborative decision-making is not yet precisely defined can be explained by its novelty (see § 3.4). This field is developing in the 90's and therefore can be considered as a relatively new field. Nevertheless, the growing amount of research studies shows the need for a clear definition.

3.4.1.1 Cooperative Decision-Making

The field of cooperative decision-making is mostly addressing distributed and asynchronous decision making [Zaraté 2005; Zhang and Goddard 2005]. When addressing likewise defined cooperative decision-making, we can state several research approaches, mostly support oriented:

- Multi-agent Systems,
- Distributed Decision Support Systems.

Here we present briefly the scope of these two scientific fields.

"Multi-agent systems are systems constituted of different "information"[4] processes that are realised at the same time, i.e. of different living agents, using the common resources and communicating between them" [Zaraté 2005]. In his work Bui [Bui and Lee 1999] defines a software agent "*as a program that performs a specific task on behalf of a user, independently or with little guidance. An intelligent agent performs, reactively and/or pro-actively, interactive tasks tailored to a user's needs without humans or other agents telling it what to do"*. The research in the field of multi-agent systems can be illustrated by several studies:

- Bui and Lee [Bui and Lee 1999] propose a framework for building decision support systems using agent technology. They propose taxonomy of agents' characteristics that can be used to help identify agent necessary to support different decision tasks. The authors also propose a life-cycle for cooperative decision support building.

- Pinson [Pinson, Louca *et al.* 1997] in her work develops a general framework for building a distributed decision support systems (DSDSS). The application is developed for strategic planning where "*users intervene as human agents in the solution formation, and strategic knowledge and domain knowledge are distributed in different agents which communicate through various blackboards and message passing"*.

- Vahidov [Vahidov and Fazlollahi 2004] uses agent technology for developing pluralistic multi-agent DSS. He develops a framework where agents are organised in groups according to the phases of the problem-solving process.

As many authors have already pointed out, the decision-making environment has changed [Gachet and Haettenschwiler 2001; Zaraté 2005]. In order to support decision-making the tools have to be able to support decisions in a dynamic environment that is rapidly changing and often distributed. Therefore, distributed decision support systems are defined. *"A* ***distributed decision support system*** *is a collection of services that are organized in a dynamic, self-managed, and self-healing federation of hard and software entities working cooperatively for supporting the solutions of semi-structured problems involving the contributions of several actors, for improved decision-making"* [Gachet and Haettenschwiler 2001]. This definition is based on several assertions:

[4] Information is used to accentuate double notion of "informatique" in French, pointing out that it is an information processing and a computer process.

1. A distributed DSS is not necessarily data intensive,
2. In a distributed DSS, two data units, which are not semantically related can always be physically stored in different storage devices,
3. A distributed DSS takes advantage of decentralized architectures,
4. A distributed DSS can survive on an unreliable network,
5. A distributed DSS enhances mobility,
6. A distributed DSS does not replace face-to-face meetings; it promotes and enhances them.

Zaraté [Zaraté 2005] finds this definition very large and finds necessary to define the software architecture for these systems. Therefore, she proposes a Cooperative Decision Support framework. This Cooperative Decision Support framework is composed of several packages:

- An interpersonal communication management system,
- A task management system,
- A knowledge management tool,
- A dynamical man/machine interactions management tool.

This whole framework is presetnted in the figure.

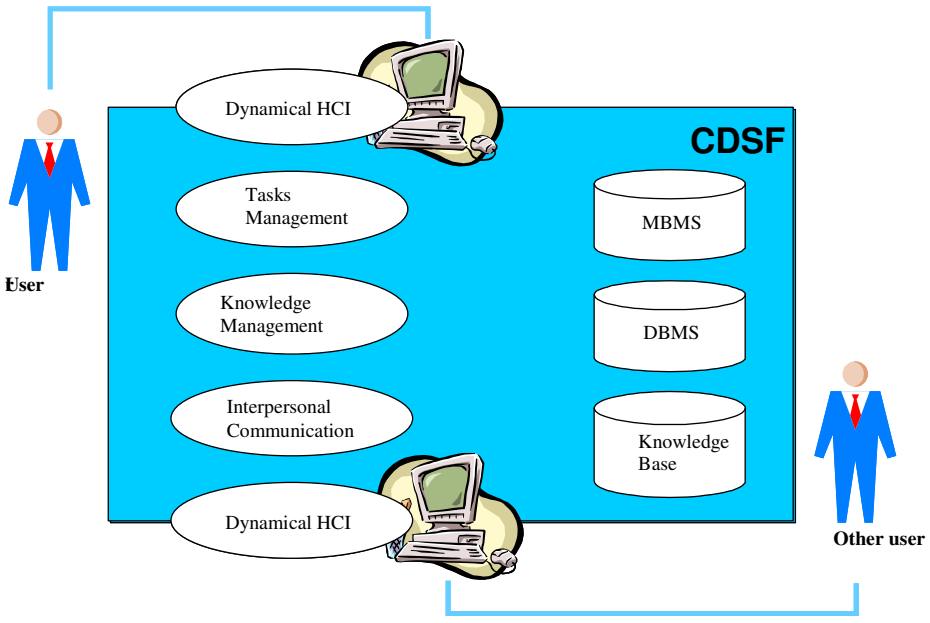

Figure 3.4.1- Cooperative Decision Support Framework Architecture [Zaraté 2005]

3.4.1.2 Collaborative Decision-Making

In the collaborative decision-making field, the situation is not so clear. As we already mentioned, in most of the research studies, the concept of collaborative decision-making is used as a synonym for cooperative decision-making. Hence, the collaborative decision-making is considered to be distributed asynchronous decision-making [Chim, Anumba *et al.* 2004; Cil, Alpturk *et al.* 2005]. However, we can stand out two works, having different research approaches, considering collaborative decision-making as multi-actor decision-making, where actors have different goals. The first is the work of Panzarasa [Panzarasa, Jennings *et al.* 2002] and the second of Karakapidilis [Karacapilidis and Papadias 2001; Panzarasa, Jennings *et al.* 2002].

Panzarasa and Jennings [Panzarasa, Jennings *et al.* 2002] in their research refer to collaborative decision-making as a *"group of logically decentralised agents that cooperate to achieve objectives that are typically beyond the capacities of an individual agent. In short, the collaborative decision-making has generally been viewed and modelled as a kind of distributed reasoning and search, whereby a collection of agents collaboratively go throughout the search space of the problem in order to find a solution"*.

Authors consider collaborative decision-making as a *multi-agent socio-cognitive process*. Thus they incorporate beliefs, goals, desires, intentions, and preferences in what they call mental modelling. Panzarasa and Jennings formalize a model giving the insight in: a) the agents' mental states and processes and b) a range of social behaviours that lead them to solicit, and take part in decision-making process.

The authors also adopt a prescriptive approach in order to give a set of possible actions in every step of collaborative decision-making. The model is developed using *social mental shaping*, the process by which the mere social nature of agents may impact upon their mental states and motivate their behaviour. Their collaborative decision-making model consists of four phases:

- The practical starting-point,
- Group generation,
- Social practical reasoning,
- Negotiation.

This developed model, as the authors state, *"aims at developing the theoretical foundation of collaborative decision-making by using a formal language"*. The authors do not propose a concrete help for decision makers in this process. Moreover, they consider the collaborative decision-making process in an idealised world and not to be iterative. The process is

"socially" oriented and "*captures underpinning motivations and social processes of each stage"*.

Karacapidilis and Papadis [Karacapilidis and Papadias 2001] consider the collaborative decision-making to be an argumentation process. It is a process of "*collaboratively considering alternative understandings of the problem, competing interests, priorities and constraints"*. In this process, every decision-maker has specific goals and therefore can decide to adopt a specific strategy to attain these goals. Therefore, the conflict of interests is inevitable in this process. In addition to these problems, the authors underline the problem of information retrieval. For some decisions the necessary information are missing or the time necessary for information retrieval is too elevated. There is also the problem of different value judgement that has to be taken into consideration.

Karakapidilis and Papadias [Karacapilidis and Papadias 2001] develop the "Hermes" system to support collaborative decision-making. In order to define Collaborative Decision Support Systems (CDSS) they use the definition of Kreamer [Kreamer and King 1988]: *"Collaborative Decision Support Systems (CDSSs) are interactive computer-based systems, which facilitate the solution of ill-structured problems by a set of decision makers working together as a team"*. The objective of these systems is to augment the effectiveness of decision groups throughout information sharing between group members and the computer. The authors indicate two ways of attaining the objective: by removing the communication impediments or by providing techniques for decision structuring.

Therefore they develop the Hermes systems a "*generic active system that efficiently captures users' rationale, stimulates knowledge elicitation and argumentation on the issues under consideration, while it constantly (and automatically) checks for inconsistencies among users preferences and considers the whole set of the argumentation items asserted to update the discourse status*". In this argumentation process, Karakapidilis and Papadias develop the basic argumentation elements: issues, alternative, positions, and constraints representing preference relations.

Nevertheless, we found one study developing different types of decision-making and giving an overview of different support adequate in each of the cases. Pascale Zaraté and Jean-Luc Soubie [Zaraté and Soubie 2004] develop a matrix of collective decisions taking into account two principal criteria: time and place (see Table 3.4.4). In their work, they also give an overview of several supports and their correspondence with different types of collective decision-making.

We then can find different types of collective decision-making process:

	Same time	Different times
Same place	Face to face decision making	Asynchronous decision making
Different places	Distributed synchronous decision making	Distributed asynchronous decision making

Table 3.4.4 - Collective Decision Making Situations

In this table, Zaraté defines four different decision-making types [Jankovic, Zaraté *et al.* 2006]:

1) Face to face decision-making: different decision makers are implied in the decisional process and meet them around a table. This is a very classical situation.

2) Distributed synchronous decision making: different decision makers are implied in the decisional process and are not located in the same room but work together at the same time. This kind of situation is known enough and is common in organisations.

3) Asynchronous decision-making: different decision makers are implied in the decisional process and they come in a specific room to make decisions but not at the same time. The specific room could play a role of memory for the whole process and a virtual meeting point. This kind of situation is well known in the Computer Support of Cooperative Work (CSCW) field and some real cases correspond to it, but for decision making it has no intrinsic meaning for a physical point of view, we cannot imagine decision made in organisation in this way: it is the reason why this case has a grey bottom in Table 3.4.4. For us this case could be assimilated to the next situation. Nevertheless, for an electronic point of view we have to check what are the impacts induced by this particular situation and this case could be seen as a virtual room well known in the GDSS field.

4) Distributed asynchronous decision making: different decision makers are implied in the decisional process and they do not necessarily work together at the same time and in the same place; each of them have a contribution to the whole decisional process.

According to this study, we consider the collaborative decision-making to be face-to-face decision-making. The cooperative decision-making is defined as distributed asynchronous decision-making [Zaraté 2005].

3.5 Descriptive approaches in Decision-Making

It is widely recognised that decision-making field globally consists of two research approaches [Cantzler 1996; Longueville 2003]: analytical approaches and approaches that can be considered to be descriptive, originally coming from cognitive psychology and information processing field.

Analytical approaches are in the same time and prescriptive and descriptive approaches [Carlsson and Fuller 2002]. The origin of these studies is decision analysis (see [Keeney and Raiffa 1976] for additional information) and these studies seek to optimise decision solution, i.e. the choice made in decision-making process. In this field we can cite several studies: Multi-Attribute Utility Theory (MAUT) [Keeney and Raiffa 1976], Soft Decision Analysis approaches using fuzzy logics [Carlsson and Fuller 2002] or Qualitative Decision Theory [Doyle and Thomason 1999]. These approaches are also often criticised [Carlsson and Fuller 2002; Doyle and Thomason 1999; Simon 1978].

Analytical approaches are not of interest in the scope of our study. As we already mentioned in the § 2.2.3, in the Project Definition phase there are more that 150 global decision-making criteria, and some of the decisions do not have optimal solutions. Therefore, we focused on so called descriptive approaches.

The most of the studies in the field of descriptive approaches are coming from the domain of cognitive psychology and information processing domain [Cantzler 1996]. They are focalised on the decision-making process and search to describe it. In this part of our manuscript we expose several studies focalised on the decision-making process.

One of the most cited decision-making processes is developed by Simon [Simon 1977]. He defined three global phases: Intelligence, Design and Choice. Intelligence is the phase of problem search, Design concerns alternative development and Choice involves analysing the alternatives and decision choice for implementation.

Many studies are based upon the work of Simon. Le Moigne [Le Moigne 1990] develops the Canonical Model of decision-resolution process based upon the Simon's definition of the process (see Figure 4.5.1). The working hypothesis adopted in this study is that "the decision can be represented as a work of symbolic computation", same as Simon's. The decision-making process, considered as a cognitive process of problem solving, is constituted of three main phases: Intelligence, Conception and Selection. This model as well as the model of Stal-Le Cardinal (see Figure 4.5.3) that is presented succinctly after, will be detailed in the § 4.5.1.2.

Zaraté notice that there have been changes influencing decision-making process [Zaraté 2005]. Decision-making in organisation is becoming more and more multi-actor. She cites the

work of Gory and Scott Morton [Gorry and Scott Morton 1971] stating that the more one organisation is complex, the less are the chances that the decision will be taken by one single actor. Therefore, participants of one decision-making process have to integrate multiples points of view that are not necessarily harmonic. Due to the rapidly changing environment, every actor in decision-making process has to augment his or her vigilance and information research. Therefore, based upon the work of Simon, she proposes a revisited decision-making process Figure 3.5.1. In this process, the intelligence phase is becoming more complex and more active because of the environment to be taken into account. These changes have also influenced decision-making progress (see Figure 3.5.1).

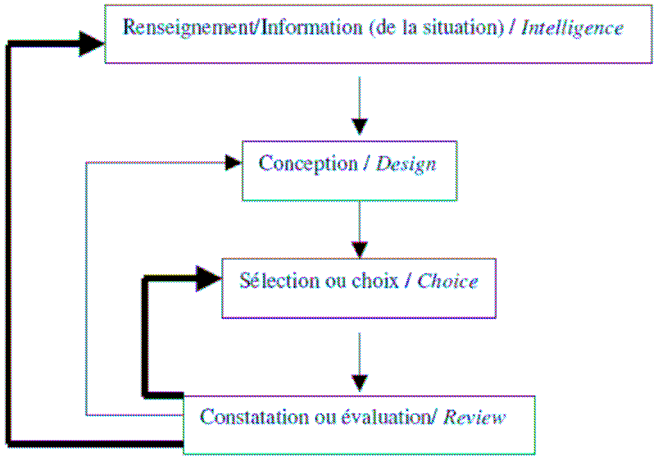

Figure 3.5.1 –Revisited decision-making process [Zaraté 2005]

Stal-Le Cardinal [Stal-Le Cardinal 2000] focuses her work on decision-making processes concerning the choice of actors . Even though the process is developed for the case of choice of actors it tends to be generic for the New Product Development processes. The decision-making process is considered to be a problem solving process where an actor is to respond to a posed question. There are six phases identified in this process: seizure, identification, negotiation, synthesis, capitalisation and transmission (see Figure 4.5.3).

Cantzler [Cantzler 1996] proposes a model of decision-making process in design process. In this model the process is triggered by an event called “stimulus”[5]. The author in this model captures also a “non-decision”. The decision-making process is constituted of four phases:

[5] Concept defined in the cognitive psychology field.

1. Recognise: This phase depends on decision-makers sensibility. The decision maker has to recognise the decision question. The exceptions are urgent decisions that do not need optimisation and justification.

2. Prepare-imagine-design-plan: It is a cognitive process of problem clarification, imagination and alternative identification in order to prepare the results of this phase.

3. Choose-justify-revise-plan: This process produces a decision or "non-decision", as the authors consider it. The problem posed in this phase is how one decision maker can choose between a set of alternatives.

4. Move on-capitalise-valorise: This phase is a capitalisation phase. Generally, it consists of writing a document concerning the decision that was taken, as well as the details concerning the process.

Hansen and Andreasen [Hansen and Andreasen 2004] propose a model of the decision-making process in New Product Development process. The author points out the complexity of decision-making process, because the engineering designers in this process have to:

- Take into consideration consumers' needs and values and to ensure time to market,
- Target the business to create an adequate company profile,
- Find best design solutions and ensure all product life-cycle phases,
- Coordinate all design activity.

The model is proposed upon results of an empirical study conducted by Ahmed [Ahmed 2001], showing that designer do not externalise or structure alternatives in the decision-making process. Therefore, Hansen and Andreasen propose a design decision-making framework. This framework consists of two models:

- Decision node,
- Decision map.

Decision node represents a model of elementary decision-making activity constituted of six sub-activities: specify, evaluate, validate, navigate, unify and decide.

The decision map is a model of the object of decision-making process in design. Authors identify three artefact objects: product, life phase systems (eg. Production or distribution system) and meetings between the product, operator and life phase systems.

3.6 Decision Support Systems (DSS)

Decision Support Systems represent the computer support for decision-making process of complex or ill-structured decisions. This field has developed in the late 60s. The table represents a quantitative analysis of this domain[6]. The key word used was "Decision Support System".

The conclusion that we can make is that this field has certain maturity (40 years of research). The number of research studies is relatively elevated (around 600 publication per year) and is increasingly progressing. This conclusion is not just related to this quantitative study. There are several detailed reviews concerning this field [Cil, Alpturk *et al.* 2005; Gachet and Haettenschwiler 2001; Shim, Warkentin *et al.* 2002].

Publication Year	Record Count	% of 5980
1978	2	0.0334%
1981	5	0.0836%
1982	9	0.1505%
1983	17	0.2843%
1984	29	0.4849%
1985	20	0.3344%
1986	26	0.4348%
1987	15	0.2508%
1988	16	0.2676%
1989	16	0.2676%
1990	47	0.7860%
1991	153	2.5585%
1992	232	3.8796%
1993	213	3.5619%
1994	295	4.9331%
1995	270	4.5151%
1996	278	4.6488%
1997	360	6.0201%
1998	363	6.0702%
1999	363	6.0702%
2000	442	7.3913%
2001	423	7.0736%
2002	428	7.1572%
2003	517	8.6455%
2004	535	8.9465%
2005	546	9.1304%
2006	357	5.9699%
(3 Publication Year value(s) outside display options.)		

Table 3.6.1 –Quantitative study of Decision Support System field

[6] This study was conducted using also the ISI Web of Knowledge (www.isiwebofknowledge.com).

One of the most used definitions of DSS [Zaraté 2005] is the one given by Keen and Scott Morton [Keen and Scott Morton 1978] where DSS implies the utilisation of computers to:

1. Support decision makers in the decision making process in ill-structured tasks,
2. Help rather than remplace decision-makers judgements,
3. Ameliorate the quality of decision making rather than its efficiency.

The original concept of Decision Support Systems evolved from two main areas: the theoretical studies of organisational decision-making conducted by Simon, Cyert, March and others, and the technical work carried out by Gerrity, Ness and others [Shim, Warkentin *et al.* 2002]. The bases used for this concept are Anthony's [Anthony 1965] definition of management activities and Simon's [Simon 1977] description of decision types. For Anthony, management activities consist of: strategic planning (executive decisions regarding overall mission and goals), management control (middle management guiding the organization to goals), and operational control (first line supervisors directing specific tasks). Simon described decision problems as existing on a continuum from programmed (well structured and easily solved) to nonprogrammed (ill-structured and difficult to solve). The custom decision-making process is defined by Simon [Simon 1977] with his three phases: Intelligence, Design and Choice (see § 3.5).

DSS field is rather a large field. Shim [Shim, Warkentin *et al.* 2002] in his work gives an overview of several decision support systems: data warehousing, on-line analytical processing, data-mining, web-based DSS, collaborative systems, virtual teams, knowledge management and optimisation-based DSS. As in our study, we are dealing with collaborative decision-making, one of collective decisions, and it is important to depict the DSS supporting collective decision-making. Therefore, we cite several approaches used in this field.

Herrera-Viedma and al. [Herrera-Viedma, Martinez *et al.* 2005] propose a consensus support system to assist the experts in all phases of the consensus reaching process of group decision-making problems with multigranular linguistic preferences relations.

In order to include the preferences of decision makers in the group decision-making process, Kwock and al. [Kwok, Ma *et al.* 2002] propose a fuzzy multiperson multicriteria decision-making model and structured group decision-making process incorporated in his fuzzy group support system (FGSS).

Zhang et al. [Zhang, Sun *et al.* 2005] address the problem of generation and identification of group decision tasks based on structured group argumentation information. They develop a conceptual model for task generation and identification, and implement it in their prototype of group argumentation system (FBA-GASS).

Jacob [Jacob and Pirkul 1992] proposes a distributed group decision support system (DGDSS) in order to reduce the need for meetings by providing a system that allow the group members to exchange information and expertise on continuous basis.

Zaraté and Soubie [Zaraté and Soubie 2004] discuss the decision support for collective decision-making. Based on the classification of collective decision types (see Table 3.4.4) the authors explore different concepts of DSS and their suitability.

In the case of face-to-face decision-making, the authors consider that classical GDSS represent adequate support tools. In the case of distributed synchronous decision-making, the tools that are efficient are: videoconferencing, telephone meetings and EMS. The asynchronous decision-making authors consider to be inexistent in the organisational decision-making and thus is not treated in their work. In addition, in the case of distributed asynchronous decision-making, the e-mail is considered to be a support, but it supports only the communication. Therefore, the authors propose a new cooperative DSS framework related to this case. The framework for cooperative DSS should have:

- A communication tool,
- A task editor that can divide the problem on sub-problems and sub-tasks, and handle task assignments,
- A repository tool that can record all decisions made before the actual problem solving.

3.7 Synthesis

In this chapter we have explored relevant literature related to two fields: different types of collective work and decision-making field with the special attention given to the definition of collaborative decision-making and its differentiation from cooperative decision-making. In this part we want to underline several points:

- The working conditions are changing. Therefore, the actors are lead to cooperate and collaborate more than before. The organisation decision-making processes are changing, and we are talking about cooperative and collaborative decision-making.
- As there are definitions of the process of cooperation and the process of collaboration, it would be logic to find that the cooperative decision-making is a part of cooperation and that collaborative decision-making is a part of collaboration. It would be also expected these two types of decision-making to be influenced by the specificities of these processes? Nevertheless, the research

concerning cooperative or collaborative decision-making and research concerning cooperation or collaboration seems to be little connected.

- In the most of cases, the cooperative decision-making is defined and asynchronous and distributed decision-making. There are two fields, oriented decision support that particularly address this problem: Multi-agent systems and Distributed DSS.

- The concept of the collaborative decision-making is used as a synonymous for cooperative decision-making. Nevertheless, in recent years we can stand out several studies defining the collaborative decision-making as a distinct type of collective decision-making: multi-actor decision-making where different actors have different goals.

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CHAPTER 4

COLLABORATIVE DECISION MAKING MODEL

4

COLLABORATIVE DECISION MAKING MODEL

4.1 Introduction

Decision-making tends to be more and more multi-actor. In his work, Shim [Shim, Warkentin et al. 2002] exposes the transfer from individual decision-making to collective decision-making. Zaraté [Zaraté 2005] adds that all organisational processes are mutating. *"Organisational processes evolve and tend to a greater participation of actors in decision-making: responsibilities and initiatives are more and more distributed."*

The collaborative decision-making is a one type of collective decisions [Zaraté and Soubie 2004]. Actors in this process are generally experts in one precise domain and have specific objectives in the decision-making process. Their objectives concern only one aspect or domain of the problem. Thereafter, the collaborative decision actors' position and point of view are "coloured" by his own vision and knowledge of the problem. The actor's performance evaluation is based upon his capability to attain objectives in his own domain.

Definition B. *Collaborative decision-making is a collective decision-making where different actors have different and often conflictual objectives in the decision-making process.*

The collaborative decision-making process in the development project is also a very important and efficient way for opinion and information exchange. This aspect of collaborative

decision-making represents its real strength. Opinion divergence and differences in problem definition influence the diversity and richness of generated alternatives and therefore the decision quality. This advantage of collaborative decision is at the same time a source of main difficulties in decision-making process. Some of these difficulties are following:

- Different conflicts: for example between objectives of different actors participating in the collaborative decision-making, preferences and strategies each one of them have related to their own objectives;

- Information acquiring problem: in the decision-making process the existence of too much or no information concerning the problem, or relevant information missing;

- Influences of value judgment: These value judgements depend upon the role and goals of each actor.

In this chapter, we expose an Integral Collaborative Decision Making Model. This model is conceptual and is used for decision modelling and decision support and management. Forstly, in order to explain the model structure, we think that it is necessary to expose different approaches in decision-making research and explain the approach adopted in this study. Secondly, we develop all four existing views of the model: Objectives, Environment, Process and Transformation Views. Before every model view, we give the working definitions of concepts used to develop the view.

4.2 Research Approach

In § 2.6 (“Research objectives and results”), we have already exposed that our research objectives were two-folded:

- Decision-making support for decision makers: to help decision makers in this process by structuring/organising decision-making and identifying the important information or elements to be taken into account during this process;

- Management of the collaborative decision-making processes: to propose to a project team a possibility to monitor the global project progress in collaborative decision-making process(es), to control this decision-making process and thus to open a space where the project team can consider corrective activities.

Le Moigne [Le Moigne 1990] introducing the notion of complexity says *“that it implies the notions of possible unpredictability, of plausible emergence of new and meaning of the phenomenon that we consider complex. For his observer, it (the phenomenon) is precisely complex because it carries potential behavioural unpredictability: it does not postulate latent*

determinism permitting to "a powerful mind" to predict by calculation the future (behaviour) of this phenomenon, even if it is probabilistic."

Therefore, the collaborative decision-making can be perceived as a complex phenomenon for several reasons:

- In collaborative decision-making participating actors have different objectives, knowledge and vision concerning the problem;
- Objectives of the collaborative decision are different than the objectives of each decision maker and represent an aggregation of these objectives;
- Criteria in collaborative decision-making are not homogenous. Every field touched by collaborative decision has his own criteria and the relationships, as well as influences between these criteria and objectives, are not always known (especially in the case of innovative projects);
- Operational processes influencing and influenced by collaborative decision-making are inter-conditional and inter-related. Collaborative decision-making is a a common decision process for two or more operational processes;
- Collaborative decision-making depends on the information, outputs of different operational processes that are continually changing and thus introduce the unpredictability in the decision-making process.

In our research approach, we base upon the systemic theory developed by Le Moigne [Le Moigne 1990] (see § 2.3.1). The systemic theory is known to be adapted in the case of modelling complex phenomenon as the collaborative decision-making.

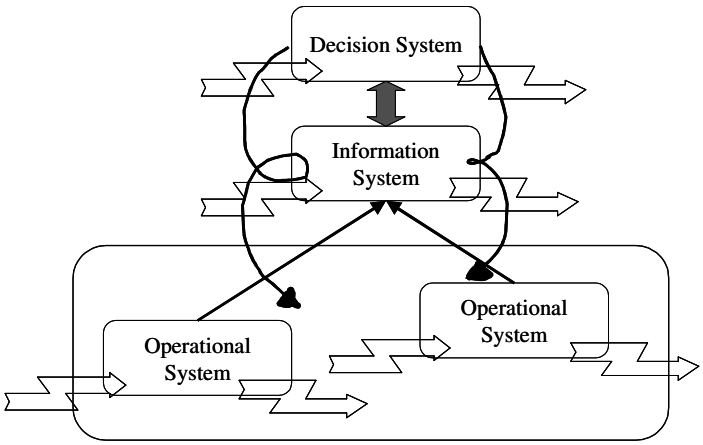

Figure 4.2.1- Proposal of Extended System Definition

The decision-making processes are more and more multi-actor (see §4.1), but not only them. All organisational processes are changing. New Product and Process Development is

particularly illustrative. Systems engineering methodology deployment and constant time racing have conducted to parallel activity realisation. At the same time, in development projects, there are several parallel processes. These processes are dependent. They are inter-related as their results are inter-dependent. Therefore, based upon this change in working conditions we propose an extension of "canonical model of the system (process)" (see Figure 4.2.1).

The specificity of this system is that the decisional system is common for two or more operational processes. The problem that is resolved or decided upon, concerns a joint field of these processes. Therefore, the collaborative decisional system is rather complex due to different relationships between different objectives in collaborative decision-making (Figure 4.2.2).

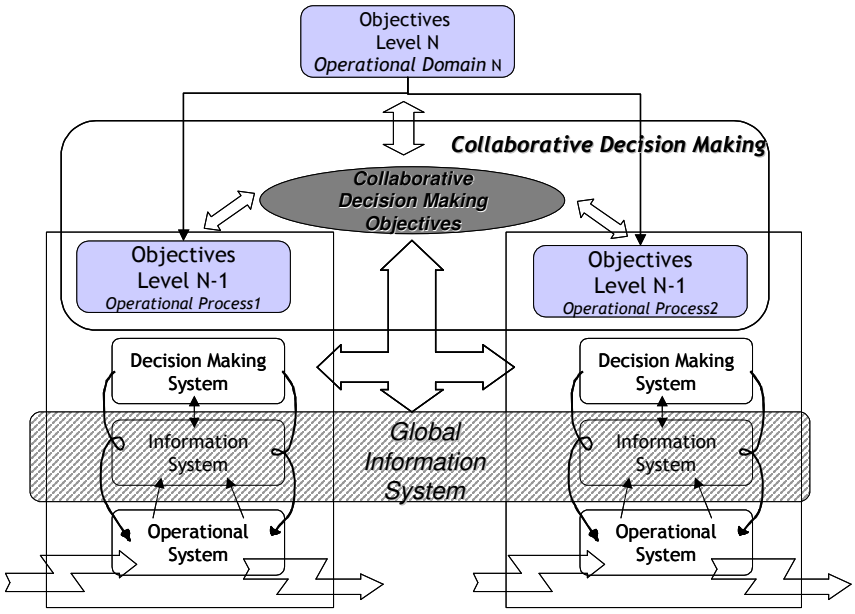

Figure 4.2.2 - Collaborative Decision-Making System

The following definition of the system given by Le Moigne [Le Moigne 1990] represents a base for complex phenomenon modelling. He gives it in a mnemonic way:

Definition 1. General System is a representation of an active phenomenon comprehended as identifiable by his project in an active environment, in which it functions and transforms teleologically (see **Erreur ! Source du renvoi introuvable.**).

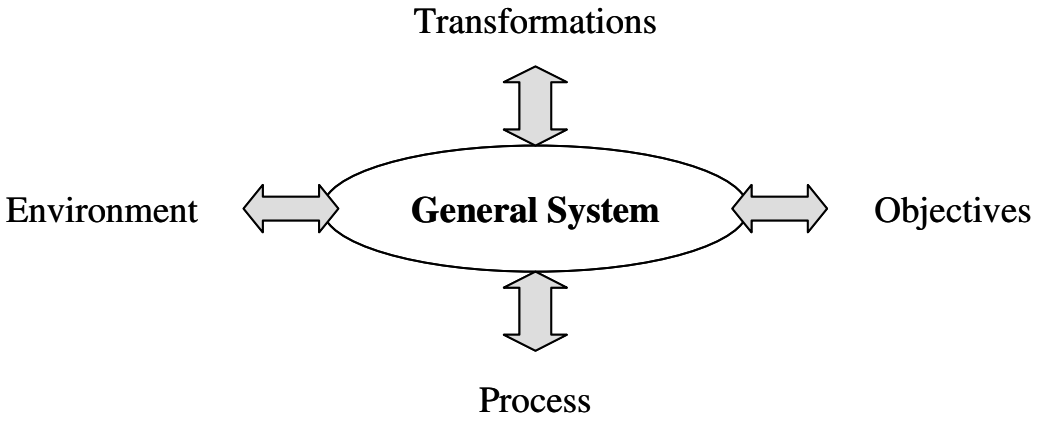

Figure 4.2.3 - Definition of the system [Le Moigne]

We used this definition of the system in order to identify the intrinsic elements and information necessary for good and quality decision-making. Therefore, our conceptual model of collaborative decision-making has four views. These views are not to be taken separately into account. There are links between them that are important for the whole model. This model is also used as a base for the collaborative decision-making process modelling that we used afterwards for the development of project management tool explained further in chapter 5.

We now propose to define these four views: objectives, process, environment and transformations, one by one.

4.3 Objectives

The view "Objectives" concerns different objectives that influence the collaborative decision-making. These objectives represent *"what the system is to attain"*. In this part, we introduce the working definitions of concepts used in the "Objectives" view. Therefore, we give the definitions of objectives but also the resources and preferences because they influence the objectives' definition.

4.3.1 Working Definitions

4.3.1.1 Objectives

In order to model and comprehend relationships between different objectives in collaborative decision-making we find necessary to define objectives. In our research work we base upon the definition given by Le Cardinal [Stal-Le Cardinal 2000]:

Definition 2. An objective is a target that is to supposed to be attained by one project. This target has three-dimensions: quality, cost and delay.

Here, we propose a model of objectives in figure 4.3.1. We developed this model as a conjunction of research definitions proposed to introduce concepts important for the definition of objectives and results of the observation in the field study. The research questions that we posed in order to define the concept of objectives are: what are the objectives, how are they defined, what are the levels of objectives' definition, who is defining them?

Objectives in one project can be defined on strategic, tactical and operational level [Stal-Le Cardinal 2000]. The objective's definition in a development project is influenced by the actor's competences, his personal aspirations and resources that are at the project's disposal. Thomas Durand [Durand 1998] defines three dimensions of competence: savoir, savoir-faire et savoir-être [7]. As it is a cognitive process, the objectives will be ambitious or not with regard to the actors' personal aspirations. FOR EXAMPLE, IF A PROJECT MEMBER RESPONSIBLE FOR MOTOR DEVELOPMENT WANTS TO PROGRESS IN THE COMPANY, OBJECTIVES CONCERNING THE MOTOR WILL BE AMBITIOUS (LESS FUEL CONSUMMATION, LESS NOISE, ETC.). The objective's attainement is also a process of professional acknowledgement.

The car objectives can be unaccepted, accepted or adhered. We were inspired by the study of Aldag and Fuller [Aldag and Fuller 1993] on group decision-making. In their study, they define several decision outcomes like decision acceptance or adhesion. The study revealed that the acceptance or adherence of decision outcomes influence the implementation process. The decision outcomes represent the objectives for the implementation process. The same conclusion was confirmed on the terrain. In function of the degree of objectives' acceptance, the decision-making process will be less or more successful.

[7] The translation of these terms would be: know, know how and know how to (be). Nevertheless, we have found that these terms are being used without translation as they represent well-defined concept. This is also a reason why in this manuscript we chose to leave these terms in their genuine form.

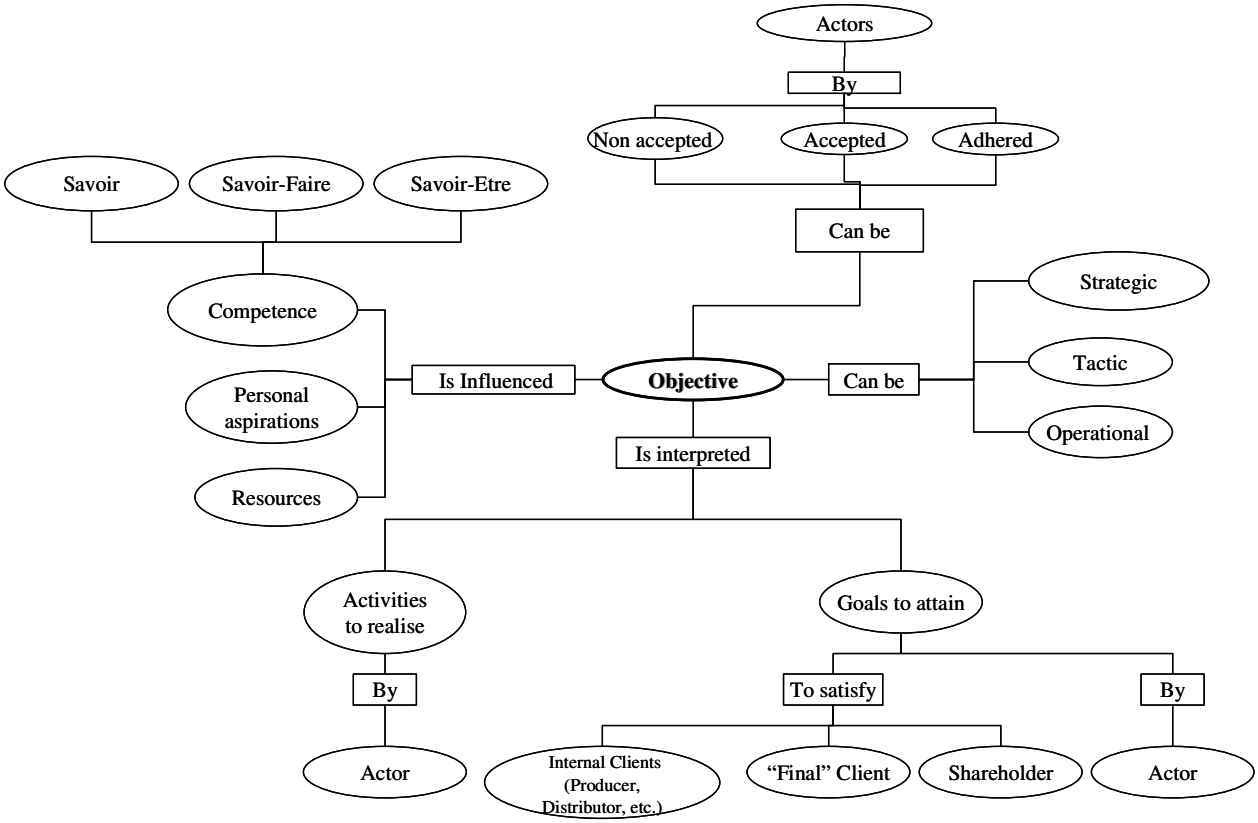

Figure 4.3.1 – Working definition of the objectives

The definition of project objectives is a rational process. Project actors have also to take into account the "resource" constraints. In our research, we consider project resources largely. The definition that we use is the one given by Cantzler [Cantzler 1996]:

Definition 3. Resources are material, software or human means or a set of these, having the capability and proper purposefulness, and the ability to participate to a realisation of shared (joint) aims.

Project objectives also have to take into account the satisfaction of different goals[8]:

- Goals of internal clients;
- Goals of the "final clients";
- Shareholder goals.

[8] In this part it is necessary to define objectives and goals, as these terms can be confusing. We refer to Merriam-Webster's On-Line Dictionary. Objective is "something towards which effort is directed". Goal is 'the state of affaires that a plan is intended to achieve and then (when achieved) terminates the behaviour intended to achieve it3.

We defined the clients by leaning on the systemic approach which is "client" oriented. This definition is enriched with the field observation. Internal clients are actors working on complementary processes like production and project needs to satisfy constraints evolving from this domain that are related to production capacities and organisation. The "final" client is buying the product and the objectives embracing his needs are given by marketing and depend on marketing segmentation. The shareholders are different parties interested in placing their capital in one enterprise. The capital deficit can seriously endanger one company's existence. In order to attain these different goals actors define activities that are most likely to lead to the realisation of these goals.

4.3.1.2 Preferences

The definition of the collaborative decision-making objectives is thus influenced by preferences of different actors in the decision-making process. Panzarasa [Panzarasa, Jennings *et al.* 2002] states that most of the research concerning collective decisions do not take into consideration social or cognitive activities that are very important for this type of decision-making. The authors define them as given: "*Pref (ai, φi, ψi) (ii) means that the agent (ai) prefers the solution φi rather than ψi in the interval ii"*.

Hereby we propose a model and a definition of the actor's preferences in the collaborative decision-making process. As it can be seen in Figure 4.3.2, the preferences depend upon the decision context and are defined according to the competences of the actor.

Definition C. *Preferences are preferable solutions of one actor in a precise decision context. Actor's preferences are considered thought his competences in a large sense (knowledge, background, behaviour).*

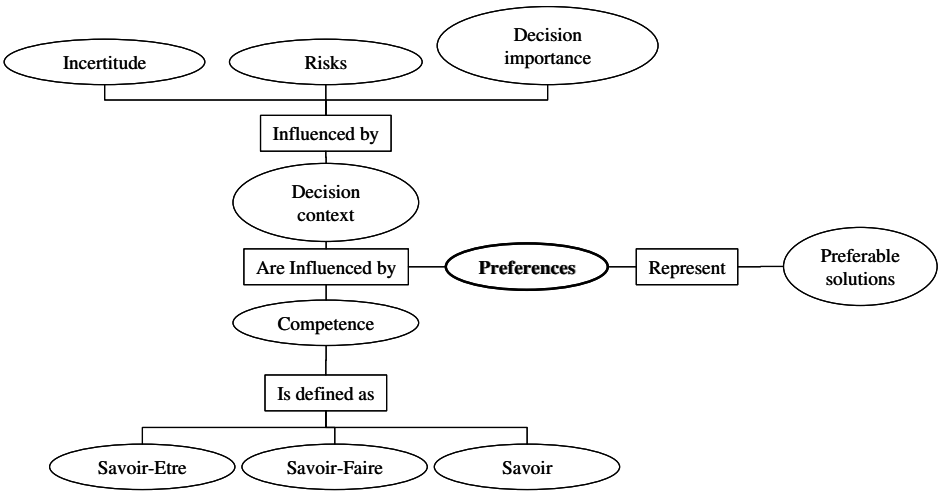

Figure 4.3.2 – Preferences in collaborative decision-making

Janis [Janis 1971] and Aldag and Fuller [Aldag and Fuller 1993] have exposed the importance of decision importance, time pressure (i.e. the risks) and incertitude as antecedences influencing the decision-making characteristics. These antecedences will determine the decision-making context (the notion of context is defined in §4.4.1.2) and therefore the decision-making process. These are not the only antecedents discussed in the literature. We defined them in view to the field research and their utilisation by the decision makers.

4.3.2 Objectives View

The property of objective is a recursiveness: *"one project is decomposable on objectives, themselves decomposable on sub-objectives and so on, until the ultimate level accounting for elementary objective"* [Stal-Le Cardinal 2000]. The project decomposition process is complex and integrated objective on different enterprise levels. FOR EXAMPLE, IN THE OBJECTIVES' DECOMPOSITION PROCESS, THE PROJECT TEAM NEEDS TO EXPLORE RELATIONSHIPS BETWEEN OBJECTIVES: TO TRANSCRIBE DIFFERENT ENTERPRISE OBJECTIVES TO PROJECT AND PRODUCT OBJECTIVES, TO DECOMPOSE PROJECT OBJECTIVES ON SUB-OBJECTIVES AND TO STUDY THEIR FEASIBILITY THROUGH COHERENCE VERIFICATION (SEE FIGURE 5.2.2). This process is complex because:

- It concerns different objectives (enterprise, project and product), themselves concerning different organisation levels;
- These objectives are inter-related;
- The nature of the objective's relationships is not always known because of the constant need for innovation.

The collaborative decision-making objectives are objectives concerning the common field of two or more operational processes (see §4.5.1).These objectives represent an aggregation[9] of the operational objectives of the concerned fields. Therefore, the collaborative decision-making objectives and operational objectives are different for the concerned common filed.

Definition D. *Collaborative decision-making objectives represent a target to be attained by two or more operational processes in the field of joint responsibilities. These objectives can be different from the operational objectives for every process.*

[9] In Concise Oxford English Dictionary, aggregation is defined as "*a whole formed by combining several disparate elements*".

Collaborative decision-making objectives, as well as relationships between different objectives influencing collaborative decision-making, are represented in the Objectives View (figure 4.3.3). The objectives decomposition process creates also a residue that cannot be integrated in operational objectives (level N-1). This is the reason why collaborative decision-making objectives have to incorporate[10] operational objectives of the upper level. In most of the cases, operational objectives of the upper level are considered as constraints in the decision-making process.

As the operational processes are inter-related, the operational objectives are also. The nature of these relationships is not adressed within this research study. This is a very important question because this study can result in the definition of different types of collaborative decision-making, which can conduct to better decision support of this process.

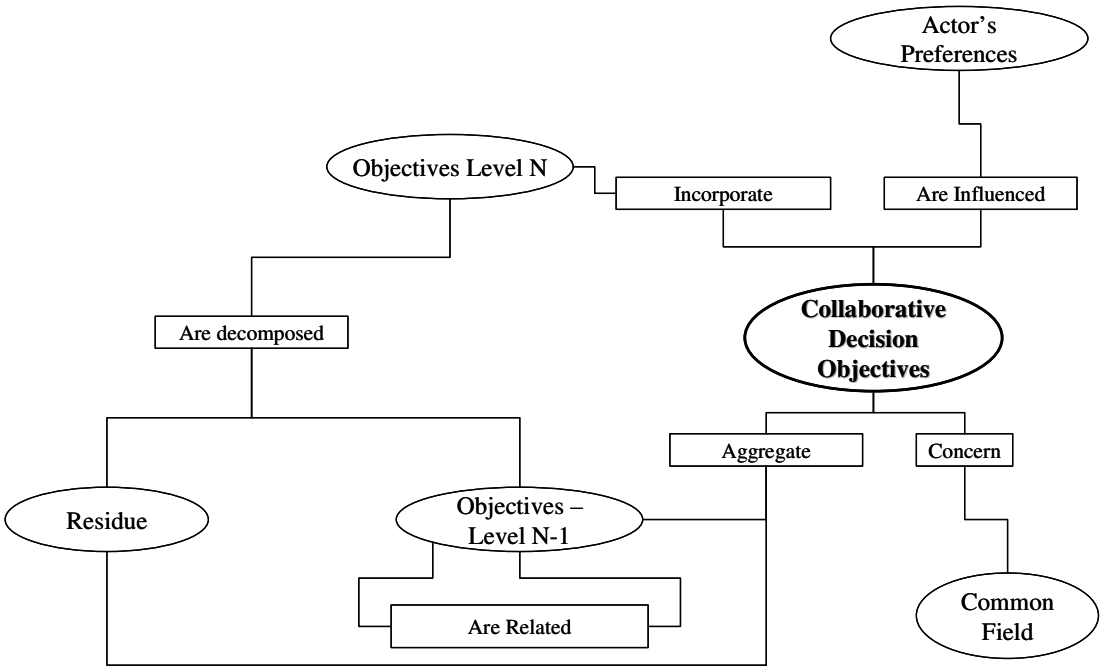

Figure 4.3.3 –"Objectives" View in collaborative decision-making

The collaborative decision-making is also a human process and thus influenced by human behaviour. Collaborative decision-making objectives are influenced by the actor's preferences (see §4.3.3). One actor's performances are evaluated as a degree of operational objectives attainment. This evaluation is result based and generally very positive, but it can also create some problems. FOR EXAMPLE, WHEN DECIDING A STYLE, THE STYLE DEPARTMENT HAS AN INTEREST TO PRESENT AN ATTRACTIVE STYLE. THE OBJECTIVE OF THIS COLLABORATIVE

[10] To incorporate in Merriam-Webster's is defined as "to unite or work something already existent so as to form an indistinguishable whole".

DECISION IS TO DECIDE THE CAR STYLE WITH REGARD TO ITS ATTRACTIVENESS BUT ALSO IT'S FEASIBILITY IN THE GENERAL SENSE. DECISION-MAKERS ARE: THE STYLE DEPARTMENT, THE DESIGN RESPONSIBLE, THE PROJECT MANAGER, AND REPRESENTATIVES OF DIFFERENT ENTERPRISE DEPARTMENTS LIKE MARKETING AND FINANCE. THE DECISION IS TO BE TAKEN IN COLLABORATION WITH THE ENGINEERING DEPARTMENT TO ASSURE THE FEASIBILITY OF THE STYLE CONCEPT. IN REALITY, IT COULD HAPPEN THAT THE STYLE DEPARTMENT CONSIDERS STYLE CONCEPTS AND NOT TO DIVULGATE IT BECAUSE THE EMOTIONAL COMPONENT CAN PREVAIL EVEN THOUGH THE DESIGN DOES NOT CORRESPOND TO BUDGET OR ENGINEERING CONSTRAINS.

4.4 Environment

In this part, we present different environment of the collaborative decision-making. Every environment has multiple relationships with the collaborative decision-making and is influencing this process. In order to introduce the definition of the environement, we need to define the concepts of the context and actor. These concepts are utilised in the modelling of the "Environment" view of the collaborative decision-making model.

4.4.1 Working Definitions

4.4.1.1 Environment

The term Environment is largely used and polysemantic. There are numerous definitions of an environment. In Merriam-Webster's Dictionary, it is defined as *" the circumstances, objects, or conditions by which one is surrounded*". The Oxford Concise English Dictionary states that an environment is *"the surroundings or conditions in which a person, animal, or plant lives or operates"*.

In Wikipedia an **environment** is defined as *"a complex of surrounding circumstances, conditions, or influences in which a thing is situated or is developed, or in which a person or organism lives, modifying and determining its life or character."*

- In biology, ecology and environmental science an environment is the complex of physical, chemical, and biotic factors that surround and act upon an organism or ecosystem.
- Environmentalism is a concern with the preservation of the natural environment, especially from human pollution, and the ethics and politics associated with this.
- In social science, environmentalism is the theory that the general and social environment is the primary influence on the development of a person or group.

- In computing, an environment is the overall system, software, or interface in which a program runs, such as a runtime environment or environment variable, or through which a user operates the system, such as an integrated development environment in which the user develops software or a desktop environment.

Furthermore, in his PhD thesis, Jacqueson [Jacqueson 2002] gives two interesting definitions: the definition of the "Cabinet BECA Environnement" and the definition given in the ISO 14 001. Cabinet BECA Environnement gives this definition: *« Environment is a complex system composed of living and non-living elements, connected by different relationships"*. In the ISO 14 001 (1996) the environment is *"milieu in which an organism functions, including air, water, ground, natural resources, flora, fauna, human beings and their interrelationships"*.

Here we propose a definition of environment used in this study:

Definition E. *Environment is a complex surrounding system, living (actors) and non-living (context), having multiple relationships with the observed object and thus influencing object's behaviour.*

Defined as previously, we can for each environment distinguish its context and actors participating to this environment.

4.4.1.2 Context

The concept of context has been an object of different studies [Longueville 2003; Pomerol and Brezillon 2001]: linguistic, semantic, modelling, philosophies and artificial intelligence. There are several definitions depending on the research and the domain. For Longueville [Longueville 2003], the context is *"something that encircles and gives a sense to another thing"*. In our research we refer to the definition of Hasher [Hasher and Zack 1984]

Definition 4. The context is a collection of relevant conditions and surrounding influences that make a situation unique and comprehensible.

Furthermore, independently of the definition of the context most of the authors agree upon the fact that the context is very important for the decision-making process [Brézillon and Zaraté 2004; Longueville 2003; Pomerol and Brezillon 2001, 2003].

The field of artificial intelligence has been particularly fruitful in the research concerning the context. Pomerol and Brézillon [Pomerol and Brezillon 2001, 2003] suggest that there are three types of context: proceduralized context, contextual knowledge and external knowledge. Their research is human centred and for several reasons that we won't explicit here (see [Pomerol and Brezillon 2001]) their definition is linked to the definition of knowledge.

Ozturk and Aamordt [Ozturk and Aamodt 1998] propose a distinction between an external context and an internal context. Longueville [Longueville and Gardoni 2003] on the other hand adopts a more pragmatic approach defining two types of context necessary to integrate: implicit context and global context.

Brézillon and Zaraté [Brézillon and Zaraté 2004] emphasize the fact that *"making one context explicit can improve in a consequential way interaction among the members of the firm"*. In our research we therefore tried to identify the factors influencing the collaborative decision-making process. Our approach is not human centred as the research in artificial intelligence is. The necessity to explicit the context is also underlined by the difficulty concerning the different points of view in collaborative decision-making.

4.4.1.3 Actor

The collaborative decision-making process is a human process. There are different actors participating in the collaborative decision-making process. In this work, based upon the definition of actor given by Julie Stal Le Cardinal [Stal-Le Cardinal 2000] we propose the following definition:

Definition F. *Actors are humans being a part of enterprise resources and can be identified by his role and his competences.*

The influence of the group structure and the roles that actors have in the group decision-making have already been the object of several studies [Aldag and Fuller 1993; Makaras 2003]. Therefore, we identified the roles to support this complex decision-making process. Every role assigned to one actor implies certain responsibilities and activities [Castelfranchi and Falcone 1998].

4.4.2 Environment View

Three different environments influence collaborative decisions in New Product and Process Development: Decision environment, Project environment and Enterprise environment (see figure 4.4.1). We identified these three environments with regard to the influences of different systems in the NPPD process observed on the field. Each of these environments, as we already defined in §4.4.4.1, is identified by its context, determining the influencing factors of collaborative decision-making, and different actors relevant for collaborative decision-making. It is important not to see these environments as separate and distinct entities (see figure 4.4.1). Our objective is to identify the most pertinent elements influencing the collaborative decision-making and thus essential to take into consideration while deciding.

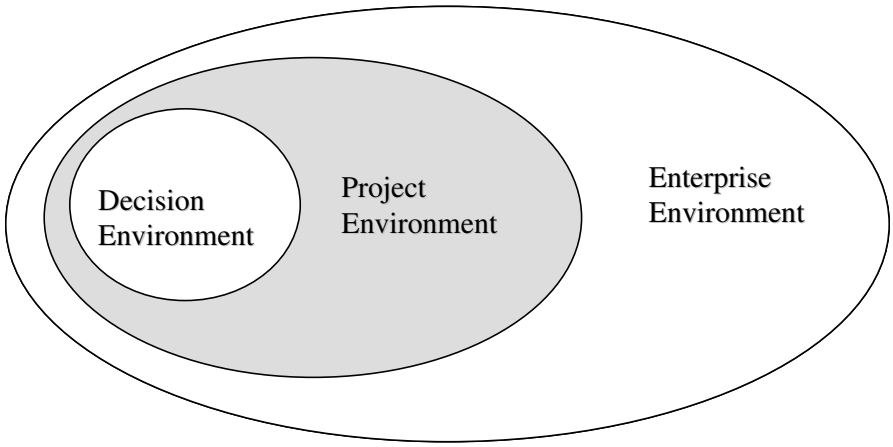

Figure 4.4.1 – Three different environments influencing collaborative decision-making

In view to the definition of the Environment as well as different environments identified, we propose an Environment View (see Figure 4.4.2).For every environment, we identify the corresponding context and participating actors. Therefore, the Decision Environment is identified by the decision-making context and the actors participating in the collaborative decision-making process. This environment is influenced by the Project Environment, equally defined by Project Context and Project Influence Groups. The Project and Decision Environments are influenced by the Enterprise Environment, identified by its context and actors.

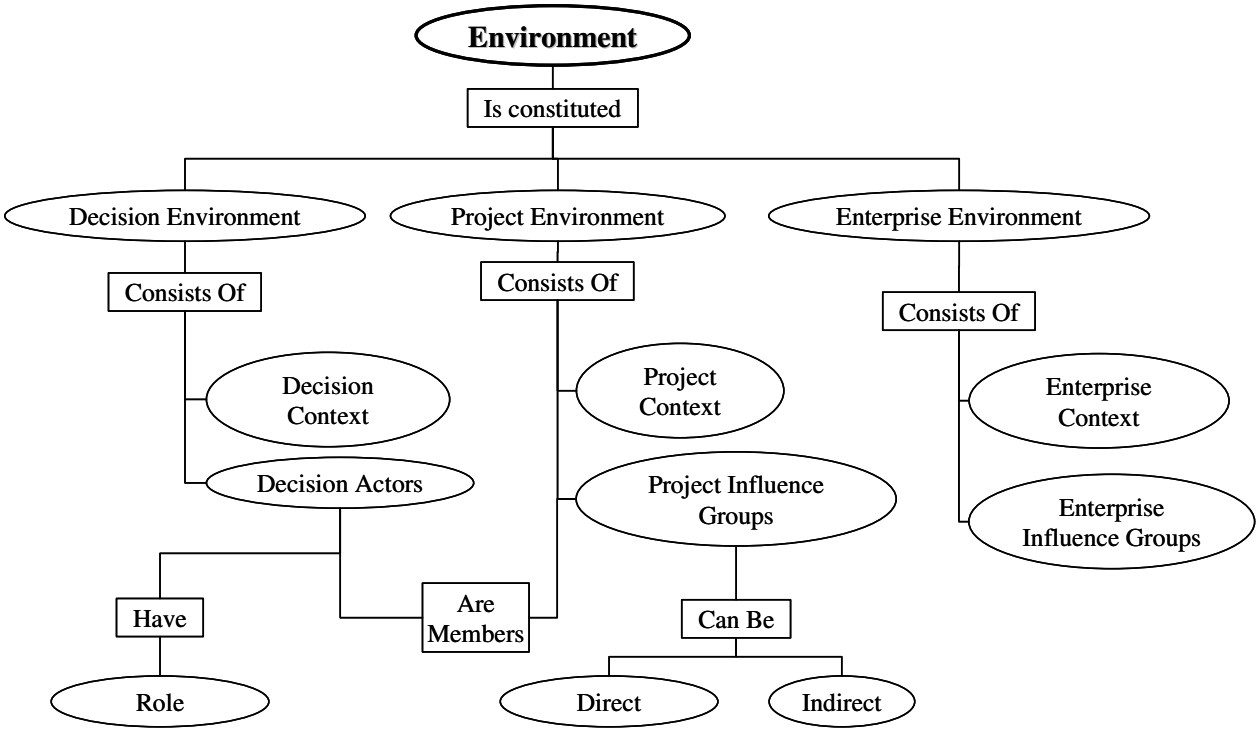

Figure 4.4.2. "Environment" View in Collaborative Decision-Making Model

The Decision Environment is constituted of the Decision Context and Decision Actors. According to the definition of context given in § 4.4.1.2, we identified three factors influencing collaborative decision-making that constitute the Decision context:

- Decision-making risks,
- Uncertainties and
- Decision importance.

The homogenous vision concerning these three factors is important for collaborative decision-making. As collaborative decision-making is subject to different value judgments, different decision-making criteria and different decision objectives, it is necessary to "negotiate" or determine these factors in view to have a better vision concerning the problem. FOR EXAMPLE, THE DECISION CONCERNING THE VEHICLE STYLE DOES NOT IMPLY THE SAME RISKS FOR STYLE DEPARTMENT AND FOR ENGINEERING DEPARTMENT. IF A STYLE DEPARTMENT DRAWS A SPORTS CAR, WITH SHARP LINES AND VERY CLOSE TO THE GROUND, FOR ENGINEERING DEPARTMENT JUST A QUESTION OF WINDSHIELD CONCERNS THE RISKS OF PRODUCTION TECHNIQUES: IS IT POSSIBLE TO PRODUCE A WINDSHIELD WITH A HIGH RESISTANCE AND WITH THE HIGH INCLINATION ANGLE.

Decision Actors are persons participating in the collaborative decision-making process. We identified three types of Decision Actors in view to the degree of participation, observed and identified on the field, in collaborative decision-making:

- Collaborative decision-making pilot,
- Decision makers and
- Contributors.

A *Decision making pilot* is a person responsible for the collaborative decision-making, i.e. the decision in question contributes to the objectives' definition within the domain of his responsibility. The pilot is also a person being in the best position to define the values of factors of the Decision Context and has the lawfulness in front of the project team for an overall acceptance of these values. *The decision makers* are project members having knowledge and information necessary for collaborative decision-making. The collaborative decision-making pilot and decision makers are members of the groups of direct influence (see Project Environment Actors) on collaborative decision-making, because they are deciding the solution of the problem.

The contributors are project members detaining the information important for the clarification of certain aspects of collaborative decision-problem of making but do not have the

responsibility to decide on the solutions (the domain of their responsibility is not directly concerned). They are members of project groups of indirect influence because they are not deciding but are brining a clarification to the problem.

In the *Project Environment*, the Project Context is mostly determined by the project typology. The importance of one collaborative decision will be different in different projects. FOR EXAMPLE, CERTAIN DECISIONS CONCERNING INNOVATION ASPECTS DO NOT HAVE THE SAME IMPORTANCE IF THE VEHICLE PROJECT HAS THE OBJECTIVE TO REPLACE THE VEHICLE WITH A LARGE PART OF THE MARKET AND INFLUENCES THE ENTERPRISE IMAGE OR IF THE OBJECTIVE IS TO DEVELOP A VEHICLE FOR A NEW MARKET NICHE. IN THE FIRST CASE, THE INNOVATION ASPECTS ARE OF MOST IMPORTANCE BECAUSE THE PRODUCT DIFFERENTIATION WILL BE DONE WITH REGARD TO THE INNOVATION ASPECT, WHILST IN THE SECOND CASE IT IS IMPORTANT TO DEVELOP A VEHICLE CORRESPONDING TO CUSTOMERS NEEDS.

Project Environment Actors can be members of:

- Direct Project Influence Groups or
- Indirect Project Influence Groups.

Project Influence Groups are different decision-making groups [Longueville 2003] in the project development. The terms direct or indirect refer to their implications on collaborative decision-making. If the decision is in their responsibility and concerns the field that they are to develop, then we call these groups *Direct Project Influence Groups*. If the decision does not concern their field of development and the actors of these groups do not have the knowledge to decide upon the problem, we call them *Indirect Project Influence Groups*. Nevertheless, there is never an entire independence of development fields. Indirect Project Influence Groups can detain clarifying information without which it is impossible to have a global view of the problem.

Enterprise Environment concerns globally the enterprise and all departments working with the project on the product and process development. Enterprise Context relates to directives given by different enterprise departments. These directives reflect enterprise strategic orientations. Each department give its directives to the project. Depending on the project, some of them are more important that others which are considered to be “standard”.

Actors in the Enterprise Environment are members of the *Enterprise Influence Groups*. The influence that these groups will have upon collaborative decision-making depends mostly upon the importance of strategic orientations for the project. If these orientations are decisive for the project, then they become the constraints.

4.5 Process

The "Process" View represents the process of collaborative decision-making. Before we present our proposition of the process, we give a global definition of the process, as we use it in this manuscript. We find also necessary to present different definitions of the decision-making process proposed in the literature.

4.5.1 Working Definitions

4.5.1.1 Process

The concept of process can be defined as given [Matheron 1989]:

Definition 5. A process is a sequence of activities for a given time interval, and triggered by certain conditions.

In systemic epistemology, Le Moigne [Le Moigne 1990] states that the characterisation of one activity or function can be done recursively and that it passes through the notion of the process. A process is defined by its practice and its result.

Definition 6. Process is the conjunction of one temporal transfer S (displacement in a time: for example a transport) and one temporal transformation F (morphology modification: for example transformation of flour and water in bread).

This definition represents a canonical process model. It can be presented as in figure 4.5.1.

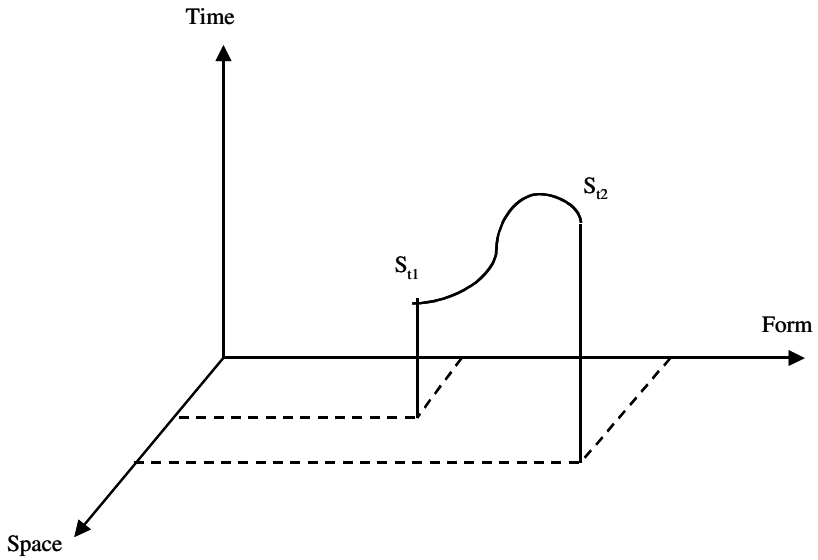

Figure 4.5.1 – Canonical Process Model [Le Moigne 1990]

Le Moigne's process definition implies the existence of resources, material or human (see §4.3.1.1) to enable the process. This aspect of a process is very important with a growing knowledge of resource limits. The utilisation of resources has to be optimised and planned and therefore we incorporate this aspect into Process View of collaborative decision-making model.

4.5.1.2 Decision Making Process

The decision-making process has been a subject of numerous studies. We will give a brief overview of some studies that we thought to be of importance for our research work. For more information about the research work concerning the decision-making field, see §3.3.

The decision analysis represents a descriptive and prescriptive approach [Carlsson and Fuller 2002]. The object of this paradigm is to maximise the utility of one decision (outcome) for the decision-makers of a given problem. Keeney and Raiffa [Keeney and Raiffa 1976] define a five step decision-making process:

1. Pre-analysis,
2. Structural analysis,
3. Uncertainty analysis,
4. Utility or value analysis and
5. Optimisation analysis.

The major critic of this process is that it is based on the hypothesis of one decision maker, which is, as we already mentioned, unsustainable in the new working conditions.

One of the biggest influences on decision-making research comes from cognitive psychology and the information processing theory which has been developed by Herbert Simon [Simon 1977; Zaraté 2005]. Simon identified four phases of the decision-making process: *Intelligence, Design and Choice* (see § 3.5). Many studies are based upon this work. Le Moigne [Le Moigne 1990] developed his Canonical Model of the decision-resolution process based on the Simon's definition of process (figure 4.5.2). His work is based upon the hypothesis that "the decision can be represented as a work of symbolic computation", same as Simon's. The decision-making process, is considered as a cognitive process of problem solving, and can be constituted of three main phases:

1. Intelligence: This is the process of the construction of the decision-making problem. It concerns creation of symbols representing a diagnostic of one situation. The diagnostic is a cognitive dissonance between projected and actual directions.

2. Conception: This is a process where different action plans or strategies are elaborated as possible solutions to the problem posed in the process of Decision Intelligence.

3. Selection: This process represents a comparison process of evaluations of the elaborated plan or strategies.

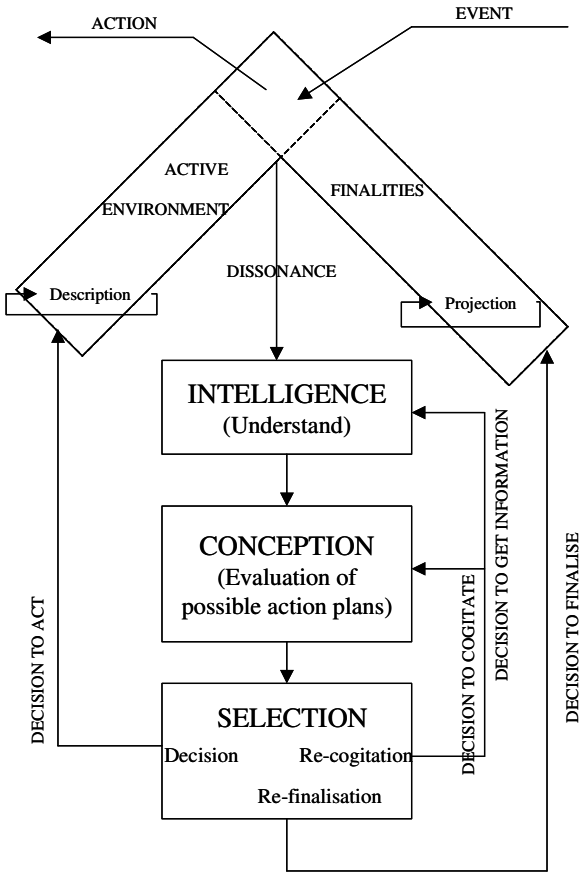

Figure 4.5.2 – Canonical Model of Decision-resolution process [Le Moigne 1990]

Zaraté [Zaraté 2005] explores the decision-making process in different working conditions. With the introduction of new technologies, decision-making processes change. People are working asynchronously and decisions are made by several decision-makers, not necessarily in the same time and on the same place. In these conditions, Zaraté observes that the phase of intelligence and design are more frequently visited as a consequence of a constantly changing environment. In the Decision Intelligence phase, actors have to search for a multitude of information but also to evaluate the pertinence of this information for one decision.

Stal-Le Cardinal [Stal-Le Cardinal 2000] focuses her work on decision-making processes concerning the choice of actors . Even though the process is developed for the case of choice of actors it tends to be generic for the new product development processes. The author considers the decision-making process as a problem solving process where an actor is to supposed to respond to a posed question. This process is constituted of six phases (see Figure

4.5.3). The relationships between them are purely logic and do not have any spatial or temporal dimension.

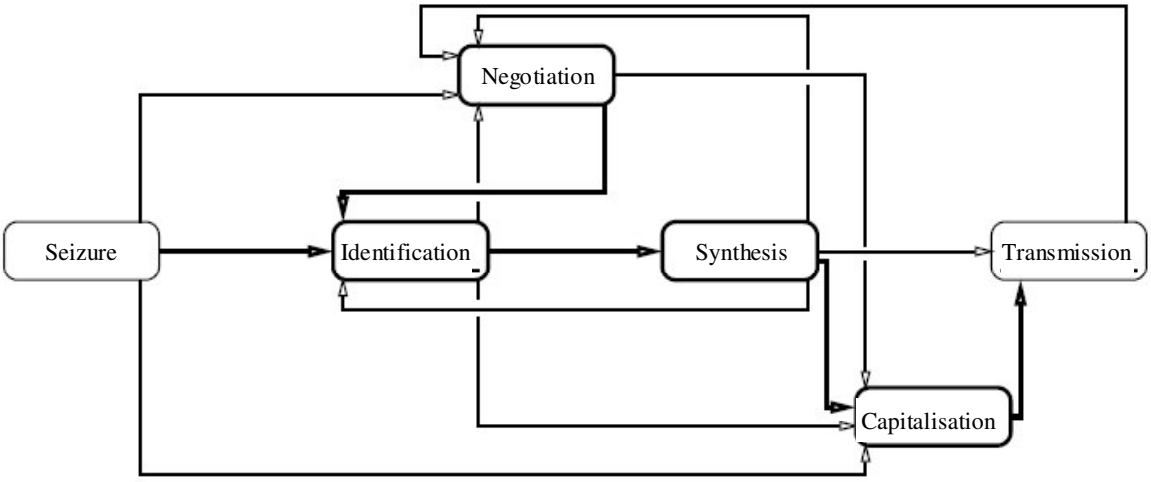

Figure 4.5.3 – DTL (Decision Time Limit) [Stal-Le Cardinal 2000]

There are six phases in this generic decision-making process:

1. Seizure: This is the initial phase of the decision-making process. In this process the decision maker takes into account the given information about the problem and is trying to understand it, as well as the process objectives. This phase is a binary phase, i.e. it is accomplished as soon as the decision maker understood and accepted to reply to the posed question.

2. Identification: It is the phase of the decomposition of objectives on sub-objectives as well as identification of necessary resources/actors. In this phase, the decision makers develop the possible strategies for problem resolution without actually giving a concrete response to the problem.

3. Negotiation: In this phase the objectives and the resources that are necessary for their realisation are negotiated. After this phase, the phase of identification is required in order to adapt the strategies for new negotiated objectives.

4. Synthesis: This is the evaluation phase of possible task results determined in the phase of identification. The decision-maker's model optimises and simulates the possible solutions in the search for the optimal one.

5. Capitalisation: The capitalisation phase is related to the transformation of the information of orevious phases in a reusable form.

6. Transmission: This is a phase consisting of the transmission of the made decision as well as the criteria used in the decision-making.

The presented theories permit to comprehend the nature of the decision-making process. This knowledge is a base for our development of the Process View. Confronted with the reality of the field research and the specificities of collaborative decision making it helpes modelling the collaborative decision-making process (§ 4.5.2).

4.5.2 Process View

The Process View represents the process of the collaborative decision-making. This view is developed upon the definition of the general decision-making process given by Simon [Simon 1977]and Le Moigne[Le Moigne 1990]. Furthermore, it is refined with the information of actual collaborative decision-making on the field. Collaborative decision-making is a complex human-interaction and human-cognition process. There are several specificities of this process:

- In collaborative decision-making there is no optimal solution. The solution has to be negotiated with all collaborators.

- This process is subject, besides the problem of information gathering, to the problem of “getting the good information on time”. The NPPD processes are multi-actor processes. Therefore, the decision-making depends on the work of other collaborators or decision makers.

- The complexity of the collaborative decision-making introduces the problems of coordination and task assignments.

Therefore, we have identified 3 general phases (considering the Canonical Model of Decision-resolution process Figure 4.5.2) of the collaborative decision-making process: Identification of the need for decision-making, Decision-making phase and Implementation and Evaluation. As we stated in § 4.5.1, this process is based upon the presented decision-making processes and the set of information gathered during our field research.. Here we explain the process globally.

The Process View is described in Figure 4.5.4. In the model we underline as in § 4.5.1, that every process implies the utilisation of the resources, human or material (see Figure 4.5.4) in §4.3.1). The collaborative decision-making process is mostly a human process. Nevertheless, sometimes in order to make a decision, it is required to use a digital mock-up or physical mock-up. These resources have also to be planed.

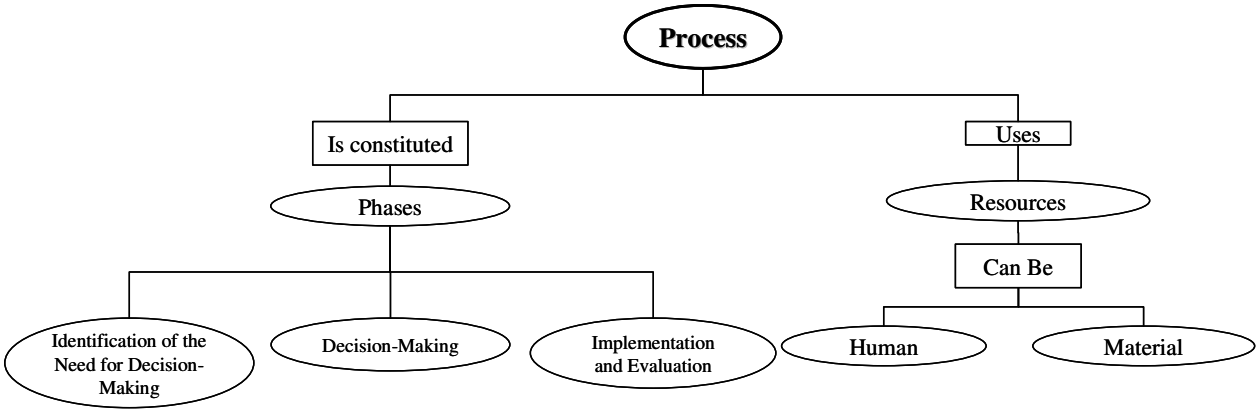

Figure 4.5.4 – Process View

The *Identification of the need for decision-making* is an initial phase of the collaborative decision-making process. It starts when one of the actors identifies the problem that has to be treated with other collaborators and is blocking further progression of the development. Then the actor has to identify the pilot of this decision and the actors concerned. This is also a phase of the preparation for decision-making. In view to the decision-making process, every actor concerned prepares required information.

The *decision-making phase* is the negotiation phase of the solution for the problem. At the beginning it is of most importance to negotiate or discuss the objectives. Objectives are one of the possible sources of conflict in decision-making. Harrington [Harrington, Soltan et al. 1995] states that the conflict can be anticipated if a situation is recognised as a source for potential conflict. That is why the conflicts that are issued from objectives have to be made apparent and discussed. Maximising just one solution does not necessary mean that it is convenient for the whole product, in this case the vehicle. Afterwards, it is necessary to generate and discuss the possibilities of solutions. Every actor in the decision-making process has specificobjectives, thus, a consensus has to be reached before the next phase can be started.

The *Implementation and Evaluation* phase is initialled with the reached consensus concerning the solution. As in the model given by Le Moigne (see Figure 4.5.2) there are several possible decisions:

- Decide to act according to the solution.
- Decide to rethink about the solution. This is possible if there is enough time in the provisional planning.
- Decide to get more information about the problem. The NPPD process is an innovation process and sometimes it is required to get more information. Nevertheless, the time margin is also in this case a preponderant factor.

- Decide to renegotiate the objectives. The objectives are given by enterprise departments. Therefore, if there is no possible solution or consensus, the actors have to renegotiate the given objectives. Even though this decision may seam time lost sometimes it is better to renegotiate that to continue.

After the solution has been made, the project team has to elaborate the implementation plan for the given solution. This implementation plan is diffused to all actors concerned. The collaborative decision-making pilot is the person who organises regular feedbacks and if there is any problem in the implementation, there is a possibility to reiterate and initiate the first or the second phase.

4.6 Transformations

The "Transformations" View has the aim to incorporate different states of evolution of one collaborative decision-making system. Therefore, we give on the first place the definition of the transformation. Afterwards, we present the transformations identified in the collaborative decision-making process.

4.6.1 Working Definition

In the definition of the process (see Figure 4.5.1), Le Moigne indicated that the notion of process implies two types of transformation:

- Spatial transformation T-S,
- Form transformation T-F.

The spatial transformation concerns a change in a Time-Space referential and the form transformation concerns a change in the Time-Form referential.

The notion of the transformation has a double meaning. At the same time it refers to the change and result, i.e. the "process" and what is being "processed". As the collaborative decision-making is an information processing, we propose the following definition of transformation in the collaborative decision-making process:

Definition G. *Transformation is a conjunction of an information change and its result and can be spatial (transfer of information) or form transformation (transformation of the information into new information).*

As the collaborative decision-making process is presented in the Process View, in the Transformations View we will consider the transformations resulting from this process.

If we consider the collaborative decision-making as a system, we can identify four transformations in the global system as indicated in Figure 4.6.1.

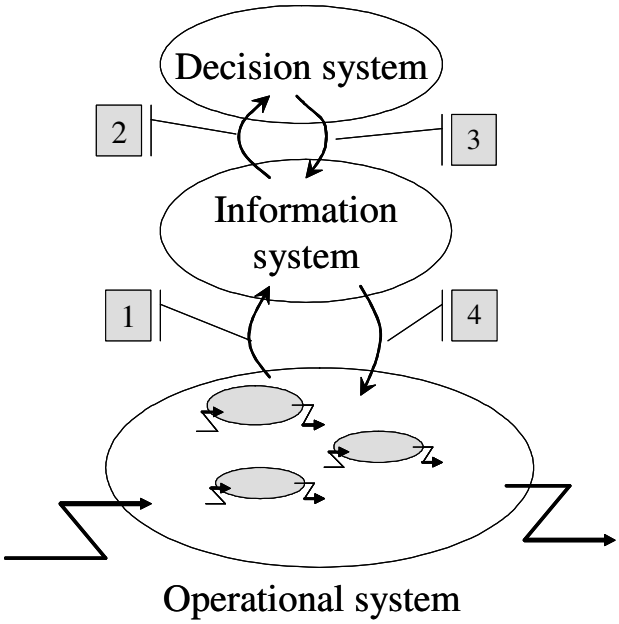

Figure 4.6.1 – Different transformations in collaborative decision making.

These transformations can be divided into two groups: preparatory transformations and implementing transformations. Transformations one and two are preparatory ones, and three and four are implementing ones.

The preparatory transformations are transformations that are required in order to dispose with elements necessary to decide upon. There are two transformations:

1. Transformations from the operational system into the information system,
2. Transformation from the information system into the decision system.

The implementing transformations are transformations related to the implementation of the decided solution. Transformations three and four correspond respectively to:

1. Transformation from the decision system into the information system,
2. Transformation from the information system into the operational system.

The transformations represented in the Figure 4.6.1 are incorporated in our conceptual model of collaborative decision-making. The model of the transformations view is presented in the next part of the manuscript, § 4.6.2.

4.6.2 Transformations View

The Transformations view has the objective to permit the actors in the decision-making process to follow and manage this process. As we said previously (see § 4.6.1), there are two groups of transformation: preparatory transformations and implementing transformations (see Figure 4.6.2).

The preparatory transformations represent the base of the decision-making process. The transformations are the elements necessary to take into account in the decision-making process. In our definition of the system, they are considered as inputs for the system. In order to present them, we can define them as:

1. Information from the information system and the base for the decision making,
2. Required activities of the operational system enabling collaborative decision-making.

This identified information includes all necessary elements for problem consideration. Without this information, there is no possibility for decision-making. These information are characterised by:

- Name: the name of the information or the document containing the information.
- Responsible: the role of the actor that is responsible for the information.
- Storage: the place where the information is stored and can be found.
- Criticality: the conjunction of the probability that the information will be provided on time and the importance of the information for the decision-making.

The operational system's activities are grouped into a preparatory plan. They represent what is to be accomplished before the decision, so that the decision-makers dispose with sufficient elements for decision-making. The preparatory plan is characterised by:

- Activities: activities in different fields of the NPPD process that are to be accomplished.
- Responsible: the role of the responsible of the activity.
- Objective: the objectives of an activity.
- Criticality: the conjunction of the probability that the activity will be accomplished on time and the activity's importance for the decision-making.

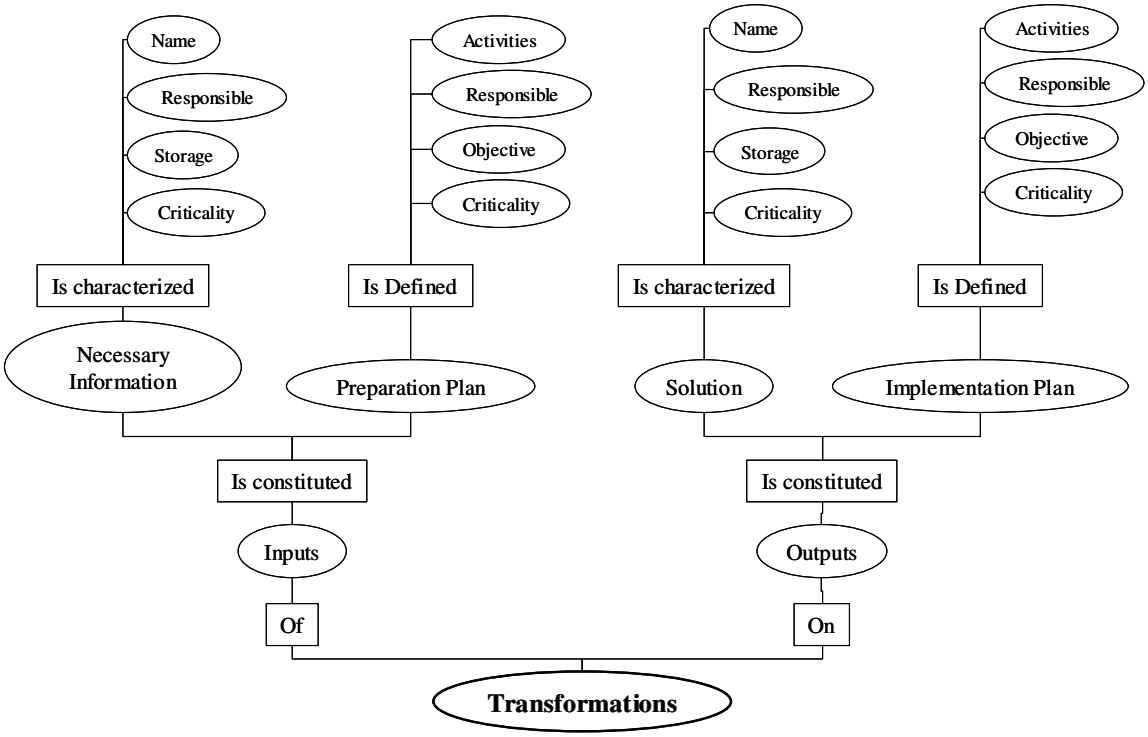

Figure 4.6.2 – Transformation View

The implementing transformations concern the implementation of the chosen solution. Due to the multitude of actors and collaborators, it is necessary to define them as they are the base for implementations and realisation of the solution. These transformations are considered to be the outputs in decision-making model. In our model, they are defined as:

- Information of what has been decided in the decision-making process and transferred into the information system,
- Activities to be accomplished in order to realise the decision.

The information in the implementing transformation concerns the solution that has been decided. As the information in the preparatory transformations, they can be characterised by their name, the role of the responsible, where the information is being stored and its criticality.

Operational system's activities are grouped in the implementation plan. This plan represents what is to be done. It is also defined with activities in different fields of the NPPD process, the responsible of the activities, its objective and criticality.

4.7 Synthesis

In this chapter, we presented the conceptual model for collaborative decision-making. This model has been developed using descriptive approaches of the decision theory. The theory used is the systemic theory developed by Le Moigne [Le Moigne 1990]. We propose the definition of collaborative decision making as a system. Therefore, we develop four key concepts of one system: environment, objectives, transformations and process. Every concept of the system's definition is developed in the special view of the conceptual collaborative decision-making model. This model comprehends the crucial elements for collaborative decision-making support in the NPPD process:

- *Objectives View* – Different objectives in collaborative decision-making, relationships between different objectives and actor's preferences.
- *Environment View* - Decision, project and enterprise environments, actors participating to these different environments, different groups of influence in collaborative decision-making.
- *Process View* - Three global phases of the collaborative decision-making process, identification of the need for collaborative decision-making, decision-making and implementation and evaluation.
- *Transformations View* – Preparatory transformations and implementing transformations permitting the effective follow-up of the process.

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CHAPTER 5

PROJECT MANAGEMENT BY COLLABORATIVE DECISION MAKING PROCESS MANAGEMENT

5

PROJECT MANAGEMENT BY COLLABORATIVE DECISION MAKING PROCESS MANAGEMENT

5.1 Introduction

The field research and development within the scope of this PhD Thesis was done in collaboration with PSA Peugeot Citroën, as we already mentioned in chapter 2. PSA Peugeot Citroën is the sixth vehicle constructer group in the world. This industry application is a specific collaboration with the SPJ (Support ProJet) department. The SPJ's mission is to assist the project management team in the entire NPPD process: from Project Definition phase up to Production phase, i.e. Project Realisation phase. The centre of interest of this collaboration was the first phase of this process: the Project Definition phase.

In this, fifth chapter, we give a detail description of the project management tool that we developed. In the §5.2, we explain the Project Definition phase, the context of this phase and problems encountered by the project team, in order to illustrate the complexity of project management in this phase. Afterwards, we present our approach, used in the field research. In the end, in the §5.4, we expose the project management tool, the incorporated options and granularity levels.

5.2 Project Definition Phase

New Product and Process Development (NPPD) is one of the key processes contributing to enterprise success and future development [Marxt and Hacklin 2004]. Identification of the client needs during the market research phase represents a starting point for the Project Definition phase. In PSA Peugeot Citroen, the Project Definition phase is the first phase of NPPD cycle. This phase is characterised by numerous relationships between different actors contributing to the NPPD process and a considerable uncertainty issues to be dealt with.

The Project Definition phase is also a phase where, through the collaborative decision-making process, most of the strategic decisions concerning the project as well as the enterprise are defined. In doing so, almost 80% of the product and process are specified in this phase [Whelton, Ballard et al. 2002]. Product and process specifications represent also a commitment of enterprise resources, which implies the importance and necessity of good quality decision-making process. In his research, Morris states that the main reasons contributing to the project success emanate from the Project Definition phase [Morris 1988]. These research results only confirm the importance of this phase for the entire NPPD process.

The Project Definition phase is very complex because:

- It is a phase where all aspects of one project are to be defined,
- Project organisation and management are set up throughout the fulfilment of functions, assigned to every project team member,
- It is a phase of convergence of project objectives through the collaborative decision-making process,
- Management bases, as well as the motivation of project team, are built up progressively throughout this phase.

During this phase, the project team is constructed and integrated progressively. The project manager has to create a strong cohesion between team members, which is a condition sine qua non for the project success. The mission of the project team consists of defining coherent project objectives with regard to the constraints related to the enterprise and the market. In order to do so, the team members are working with different enterprise departments on one hand and extended project team on the other.

At the very beginning of this phase, different enterprise departments give the global guidelines for the definition of project objectives to the project team. Some of these departments are following: marketing, production, innovation, strategy, development and design. The given guidelines represent the transcription of strategic orientations of the enterprise, given by different fields. The project team has also to take into account the results

of market segmentation and targeting, as well as to integrate the client needs (figure 5.2.1).The relationships between different objectives in the decomposition process are very complex (see Figure 5.2.2).

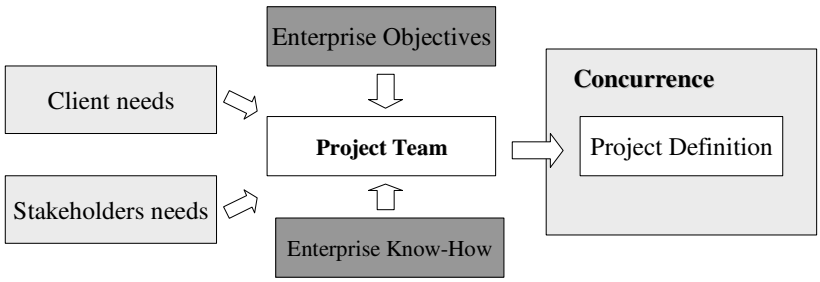

Figure 5.2.1 - Project objectives definition context

To accomplish its mission, project team, based on these global orientations, has to decompose project objectives in order to discern their global incoherence and to propose the coherent ones. In this process, project team relies on different enterprise knowledge poles. These departments detain an expertise in one field or aspect of project development. The process of definition of project objectives is very delicate because of hardly obtainable balance between the enterprise ambitions, representing the vision of the future, and the existing knowledge in the enterprise. This balance is obtained and elaborated through the collaboration and negotiation process, progressively converging to precise definition of project objectives.

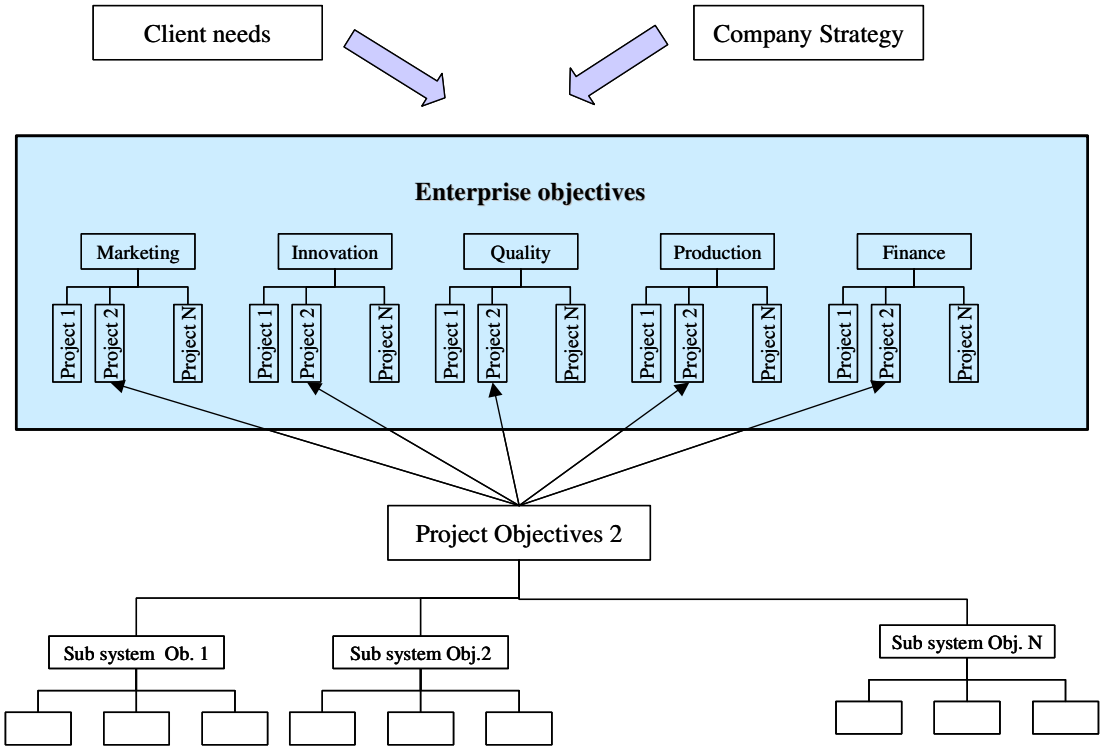

Figure 5.2.2 - Relationships in the process of decomposition of objectives

The industrial application have given us the possibility to identify and to model this process (see Figure 5.2.3). There are five activities in this process: Integration of enterprise objectives, Decomposition of project objectives, Feasibility examination, Evaluation and hypothesis integration and Project Objectives' Cohering.

In the *integration of enterprise objectives* activity, the project team has to take into consideration the objectives assigned to the project by different enterprise departments. These objectives are given separately for every domain of action. The project team has to integrate these objectives and to propose a space of possible hypothesis for the definition of project objectives. Thereby defined objectives refer to the global vehicle level.

The *decomposition phase* concerns the decomposition of the global project objectives, given on the global product level, on the performance objectives of different sub-systems, themselves decomposed on sub-objectives, and so on. The objectives' decomposition is done according to the systems engineering methodology. The difficulty of the project team in this phase is to determine the adequate decomposition level: the objectives have to be as global as possible and adequate to evaluate in the feasibility study.

The *feasibility examination* is an activity of verification of the possibility to realise the given performance objectives. As the development projects are innovative projects, it is hard to evaluate the feasibility. The difficulty lies in the feasibility determination for the assigned time delay based upon the existing enterprise know-how. The outputs of this activity are different solutions spaces of the given performance objectives.

In *the phase of evaluation and hypothesis integration*, the project team evaluates the coherence between the identified solution spaces and project objectives. The project team has to integrate in this reflection the consideration of different relationships between project objectives.

In *the project objectives cohering phase*, after the evaluation of preliminary project objectives, the project team is to reduce the space of project objectives, taking into account the evaluation of the hypothesis based upon the feasibility study. Therefore, the new cycle of the project definition can start until the refinement is adequate for the identification of global project objectives' coherence.

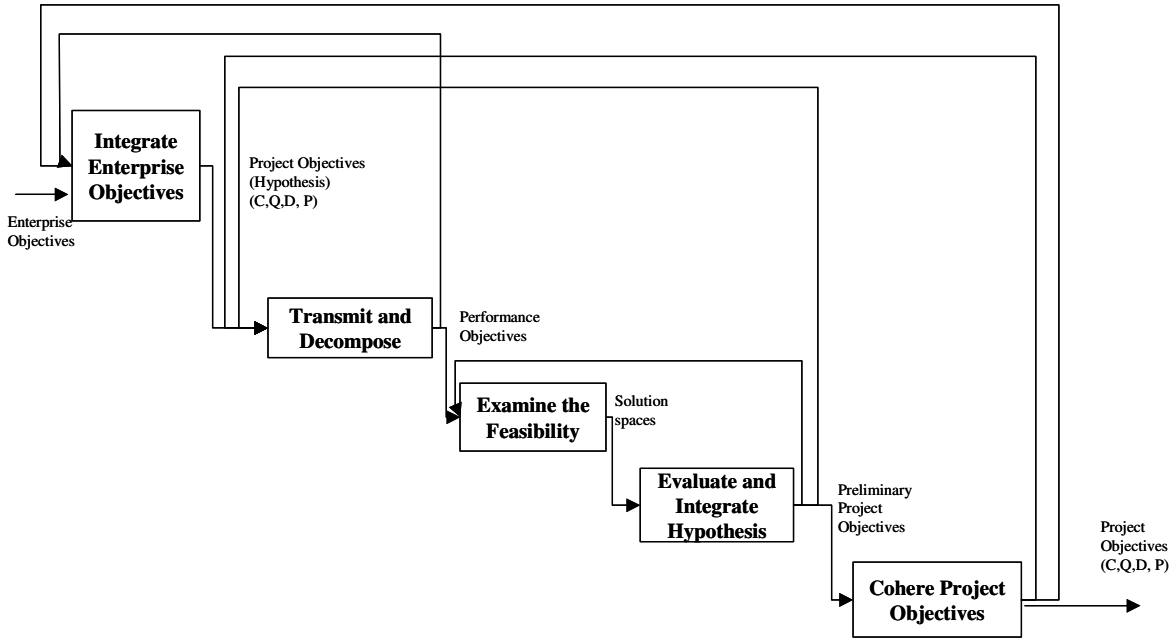

Figure 5.2.3 - Process of project objectives definition

The difficulty of this phase lies in the fact that there are over 150 objectives to monitor on the global level. The correlations between these objectives are not often determined, so there is no certainty in how the changes of one objective will influence the other. Furthermore, the Project Definition phase is crucial for innovation introduction. In this phase, the project team has to decide what are the innovations to be incorporated in the vehicle development. This innovation introduction increases even more the difficulty of identification of possible correlations between project objectives.

The process of project objectives' definition of is also a collaboration process between the enterprise departments and different knowledge poles (see Figure 5.2.4). The responsibility for the project results is project teams', but in order to do so, the project team has to create the cohesion between these two levels. Every step of this process is done in collaboration and negotiation with one or both levels. As enterprise departments have a strategic vision concerning one field, thus having the global overview, and the knowledge poles have more operational vision involving feasibility, different problems can arise: conflict apparition, incomprehension due to different backgrounds and language used, difference in points of view concerning the same problem, different objectives to attain.

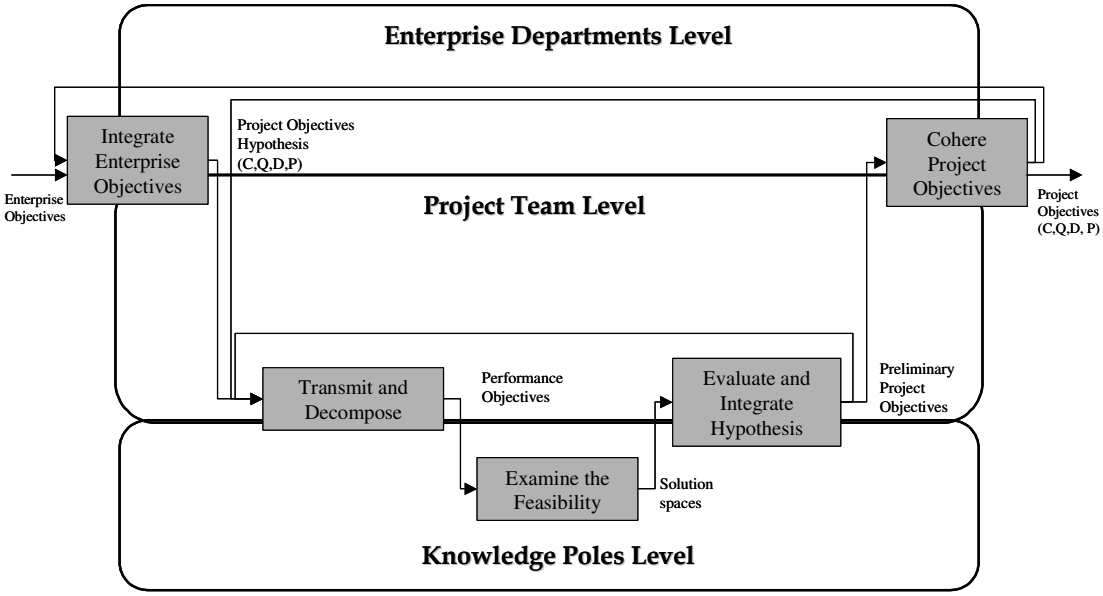

Figure 5.2.4 - Collaboration between different levels in the process of objectives definition

5.3 Project Complexity and Project Management Problems in Project Definition Phase

The project complexity is the concept often used, but not many studies address the definition of this concept [Baccarini 1996]. Baccarini [Baccarini 1996] defines the concept of project complexity as *"consisting of many varied interrelated parts' and can be operationalized in terms of differentiation and interdependency"*. Therefore, we consider the vehicle development projects as complex projects. Some of the difficulties related to complex projects and that influence the project success underpinned by Baccarini are the problem of project objectives and goals defining [Morris and Hough 1987] and the problem of project planning, coordination and control requirements [Baccarini 1996; Bubshait and Selen; Melles, Robers *et al.* 1990].

Project management methodology's starting point is a clear definition of project objectives. Based upon these objectives, the project team is to develop different approaches used in project management (quality management, economic optimisation, risk management), as well as project management tools (planning, indicators table). This is clearly opposite to the Project Definition phase needs. During this phase, the project team defines project objectives and so the existing approaches and methodologies are hardly applicable. This statement is in accord with Louafa [Louafa 2004] that in complex projects the limits of existing project management tools are accentuated.

Moreover, the problem of project planning and coordination induce the problem of project control. FOR EXAMPLE, THE ONLY EXISTING CONTROL WITHIN THIS PHASE WAS POSSIBLE AT THE VERY END OF IT, AND ON THE UPPER MANAGEMENT LEVEL, I.E. SENIOR DIRECTORS COMPANY

LEVEL. DURING THIS PHASE, THE PROJECT MANAGER DOES NOT HAVE ANY INSIGHT IN THE GLOBAL PROJECT PROGRESS RELATED TO CONVERGENCE AND COHERENCE OF PROJECT OBJECTIVES AND THUS THE POSSIBILITY TO INTRODUCE THE CORRECTION ACTIVITIES. THE CONTROL POINT WAS AT THE END OF THIS PHASE WHERE PROJECT TEAM OBTAINS A "GO OR NO GO" DECISION FROM THE TOP MANAGEMENT. IN THE CASE OF "NO GO" DECISION THE TIME DEADLINE FOR THE VEHICLE DEVELOPMENT IS AUTOMATICALLY INCREASED. THIS AUGMENTATION CAN BE UP TO SEVERAL MONTHS. THIS DELAY IS NOT ACCEPTABLE IN CURRENT CONDITIONS WHERE A GLOBAL COURSE FOR TIME REDUCTION IS ONGOING. There is another danger concerning the control problems. The Project Definition phase influence and determines the project success. If there is no control of validity of project objectives, the whole project is in stake.

The Project Definition phase is also a decision-making phase, more precisely the collaborative decision-making phase. Collaborative decisions are made by different actors participating in the process of definition of project objectives that have different and often opposite project objectives. ONE OF THE EXAMPLES OF THIS CONFRONTATION IS A DECISION CONCERNING DESIGN STYLE OF PEUGEOT 407. THE PROJECT TEAM HAD A CHOICE BETWEEN TWO DIFFERENT STYLES, A STRONG STYLE WITH SPORT LINES AND LESS SPACE ON THE BACK OF THE VEHICLE OR A STYLE LIKE RENAULT VELSATIS WITH MORE SPACE BEHIND. In the project every actor is responsible for one part or aspect of the vehicle development and thus has vision and knowledge "coloured" by the information of its own field. The decision makers have also different priorities concerning the decision values and alternatives. Hence, the collaborative decision-making represents a rich way for decision alternatives' generation and helps the project team in the identification of decision impacts, but these advantages are also the source of the potential problems. In the Project Definition phase, the problems related to collaborative decision-making and project management concern several levels:

- Collaborative decision level: The problem of identifying the appropriate information about important decision elements. For example: who are the actors in the collaborative decisions, what are the information that the decision makers need to have in the moment of decision making, what is the level of criticality of information needed, what causes the conflicts in collaborative decisions?

- Collaborative decision-making process level: The difficulty of determination of the influence of collaborative decisions on different activities or decisions that are further in the Project Definition Phase. For example: what are the decisions to be made before and after, what are the decisions that will be influenced by the present collaborative decision, i.e. what project objectives will be influenced, what are the activities influenced by this collaborative decision?

- Project level: The difficulties to implement the existing project management methods and tools in the management of this phase. For example: the base of project management is to identify activities constituting a phase in new product development that project team determines in accordance with project goals. The problem is that the project objectives are not defined and in this phase, project complexity does not facilitate this identification.

5.4 Industrial Application

5.4.1 Research approach

As we already said in the § 5.3, the Project Definition phase is a collaborative decision-making phase. That means that the entire phase consists of numerous decisions to be taken by different actors in: enterprise departments, project team and knowledge poles. The project team and specially the project manager did not have any tool or application necessary to manage and control project progression in this phase. The goals of the field research done in PSA Peugeot Citroën that we determined conjointly with the SPJ department were:

- To identify the operational needs concerning the Project Management of the Project Definition phase,

- To develop a support tool for project management knowing that the whole phase is collaborative decision-making phase and that the project team needs a support tool for decision-making also.

The theoretical knowledge and operational problems were complementary in the research process. The theoretical concepts gave us a base for identifying possible project management tools and applications and vice versa. While developing the application, we had an insight on actual operational problems of project team, and globally in project management, and thus we were able to improve the research results and application. One of the points that we insisted upon is to develop a tool adapted to the needs of the project team who will use it in the future. This approach is the same as the approach developed and described in the PhD Thesis [Lardeur 2003; Longueville 2003], presented in the figure 5.4.1. This integrated approach proposes a conjoint development of methods and tools, which are mutually nourished with the results of other.

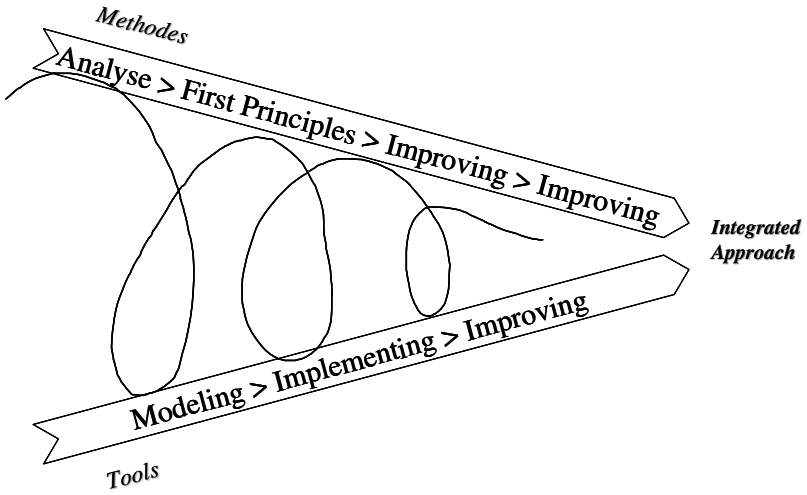

Figure 5.4.1 - Integrated approach methods and tools

5.4.2 Field research

The first objective of our field research concerns the identification of project team operational needs in the field of project management. The goal of this study was to identify the existing methodologies and tools applied in this field in order to determine the requirements for the new tool development. The issues that we wanted to address in this study are: is it necessary to develop a new project management tool or to upgrade an existing one?, what are the features that are essential for project management knowing that every project team has his own management and coordination rules? and who will be using this tool?. Therefore, we decided to conduct two studies (see Figure 5.4.2):

- A study of existing methodologies and tools in Project Management field in the Project Definition phase, and
- A study of project team operational needs.

The study of existing methodologies and tools was done on one hand by conducting a research within existing documents and on the other by interviewing members of SPJ department. In PSA Peugeot Citroën the knowledge management is an important issue and thus the study of existing documents was fruitful. The SPJ department is responsible for knowledge management in Project Management field. Most of the information is stocked on the intranet. The problems encountered in this study concern the information extraction: great quantity of information, different degree of information detail and utilisation of proper and specific vocabulary.

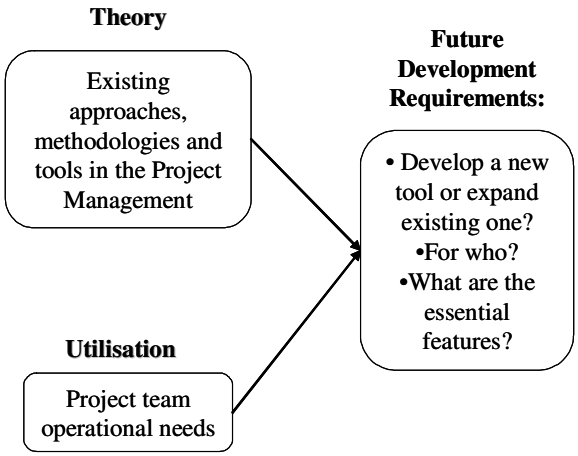

Figure 5.4.2 - Research approach used in the field study

The study of existing documentation was complemented by information from the interviews. Most of methodologies and tools were developed or managed by SPJ. That is why the document research was complemented with the interviews of SPJ team members. As they are also the field support for project team, they were an important source of information concerning the utilisation and problems linked to these methodologies and tools.

The study of project team operational needs was more difficult to conduct. The problem is that the project team is generally occupied and a large study mobilising a great number of project team members was not possible. In order to obtain this crucial information, several persons were interviewed: SPJ team members who are project support and responsible for the development of the referential project *planning* tools. These actors have a responsibility to capitalise Project Management knowledge in this phase as well as occurred problems. Therefore, the operational needs of project team were identified indirectly.

5.4.3 Research Results and Conclusions

In order to have a coherent vision of the methodologies and tools used, we organised the resultsof the study of existing methodologies and tools in one table. The content of this table cannot be presented in this manuscript due to the confidential clause signed with the PSA Peugeot Citroen. In the table, the rows concerned different project management methodologies. In the columns, we identified: methodology objectives, the team members responsible for the methodology application, methodology results, tools used for the methodology application, necessary information in methodology application and upgrading possibilities that were not exploited.

The results revealed a lack of appropriated tools for project manager giving a global overview of the phase, as well as the crucial points for the project management, important to assure the project success. Furthermore, there was no support for the collaborative decision-making. The

only document referring to this issue included the partial information of the collaborative decisions identified in the Project Definition phase. We identified several problems concerning this document:

- The information contained in the document represented a good base but was very partial and needed to be upgraded to fit current situation,
- The modelling was not rigorous (for example the same relationship between decisions was not modelled equally),
- The documents were written in MS Word and thus permitted neither interactivity nor the phase management.

The study of project team operational needs revealed two important points:

- In the project management there is no methodology or tool addressed to project manager with whom he will be able to follow and control project progress, but in terms of maturity progress of project definition,
- There is a multitude of methodologies and tools contributing to project management in different ways, but the operational needs indicate an overcharge of team members and a search for a delimitation of number of tools used.

Even though these two points may seem contradictory, these two conclusions are in fact complementary. The responsibilities in the project management are precisely divided within the project team. Each team member has the responsibility over one project domain, as we already noted. FOR EXAMPLE, THE QUALITY MANAGER HAS HIS OWN QUALITY AND RISK MANAGEMENT METHODOLOGIES AS WELL AS CORRESPONDING TOOLS. THUS, HE HAS A SPECIFIC VIEW CONSIDERING THE PROJECT. The tools of every team member concern the overview of only one or few project aspects and can introduce the incomprehension between the team members. Thus, in the project team, there are numerous representations of the state of the project but due to this multitude of points of view, the global overview of the project is missing.

Based upon the conclusions of these two studies, the study of existing methodologies and tools and the study of project team operational needs, we decided to upgrade the referential project management tool developed in Microsoft Project. The use of this tool is PSA Peugeot Citroen is not just “planning” oriented, but represents an organisation tool used by the project team.

5.5 Project Management Tool: Management of Collaborative Decision Making Processes

The referential project management tool developed in Microsoft Project is an important tool in PSA Peugeot Citroën. This is practically the only tool connecting all team members. It is used by the Planning Manager and the Project Manager for the management and activity coordination of the whole project team.

The information available in this tool concerns different project activities organised in different sub projects. For every activity, there is the information about the necessary completion time as well as its beginning and its end. As vehicle development projects are big, the number of activities is elevated. IN THE REFERENTIAL TOOL THERE ARE OVER 800 GLOBAL ACTIVITIES FOR THE TIME BEING. WE CAL THEM "GLOBAL" BECAUSE THESE ACTIVITIES CAN BE DECOMPOSED AND THEIR COMPLETION TIME IS BIG. FOR SOME OF ACTIVITIES THIS TIME IS UP TO 3 MONTHS. Thus defined activities are necessary, but this definition bothers the project control and coordination.

The problem of the referential project management tool is that the activity links are inexistent in this tool. Therefore, the crucial information concerning the critical path is not available. There are several reasons that influenced this condition. First, even with 800 activities, which is a minimum for projects as vehicle development, there is a question of visibility. We already evoked that some of these activities last for 3 months. In this case it is necessary to decompose them and to introduce links between them. Second, the links between activities are time links and some project teams find them very restraining. They need an option to introduce logic links between activities without necessarily moving or changing dates or activity times.

As we already exposed in the § 5.4.3, after the field research we decided to upgrade the referential project management tool. Our objective was to develop a tool that helps the project manager to have a global overview of the project progression and to identify the crucial points for the project success. This tool also supports the project team's collaborative decision-making process.

Therefore, we propose a tool structure organised on three levels: Decisional level, Informational level and Operational level (see Figure 5.5.1). The decisional level considers the collaborative decision-making processes of one project. The informational level is based upon the conceptual collaborative decision-making model and thus, incorporates the intrinsic elements of one collaborative decision. The operational level considers the operational processes of one project. We explain each of these levels further in this manuscript.

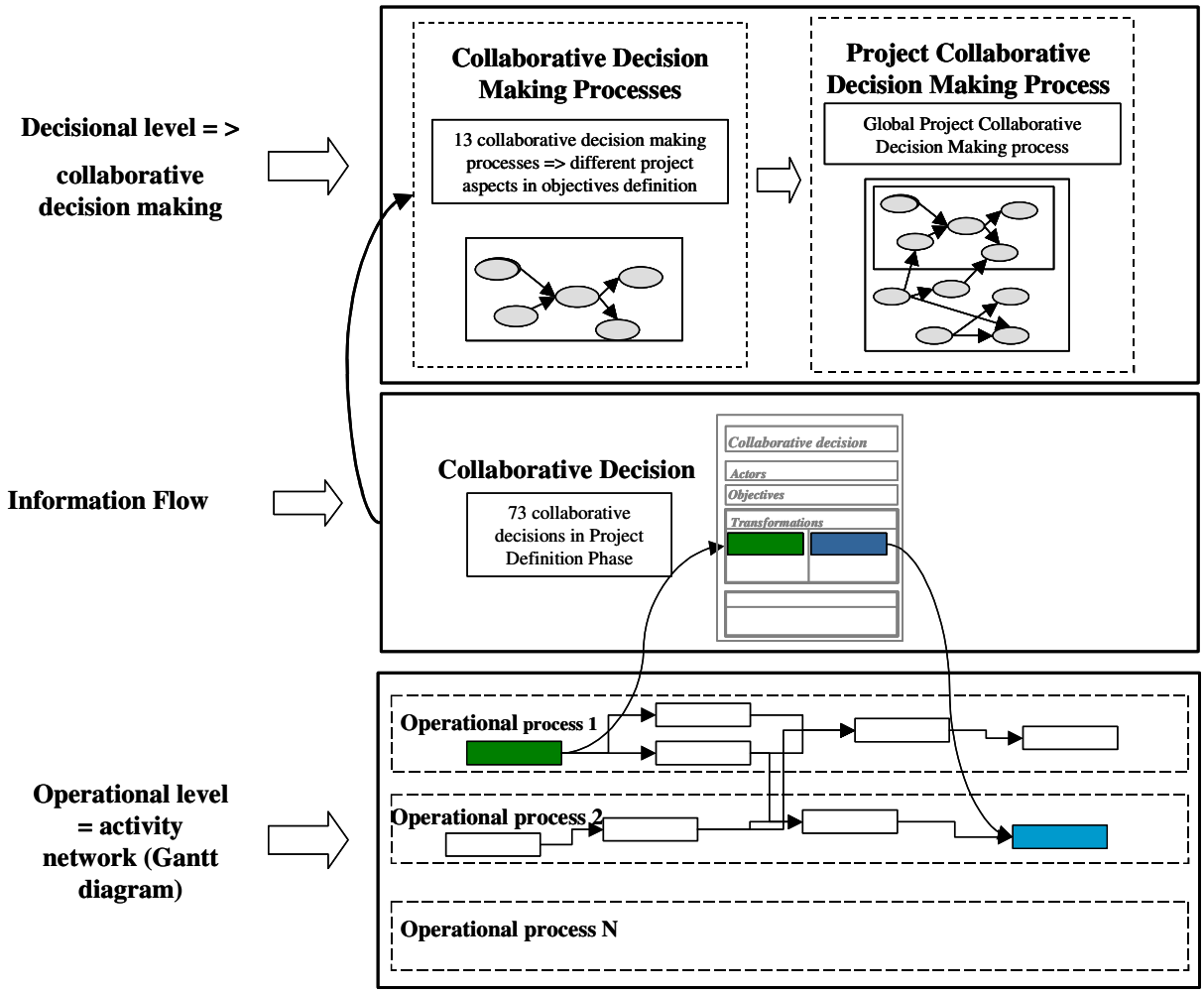

Figure 5.5.1 - Different Views in the Project Tool

5.5.1 Decisional level

The decisional level concerns the collaborative decision-making processes in the NPPD process. These collaborative decision-making processes are represented by the sequence of different collaborative decisions. The relationships between collaborative decisions can be direct or indirect (see Figure 5.5.2). The relationships are direct when the output of one decision is the input of another and indirect when the output of one decision influences the input of another.

The collaborative decision-making processes contribute to the progressive definition of one project aspect or field, i.e. the project objectives in one project domain are progressively defined in this process. In the decisional level, there are 13 different processes identified. In our research we have not addressed the question of the classification of collaborative decision-making processes. Their definition was elaborated with regard to the PSA Peugeot Citroen culture and know-how. FOR EXAMPLE, ONE OF THE PROCESSES IS CALLED "PURCHASE". THIS PROCESS CONCERNS THE DEFINITION OF THE SUPPLIER POLITICS. IT IDENTIFIES THE

COLLABORATIVE DECISIONS TO BE MADE IN ORDER TO DEFINE THE PROJECT OBJECTIVES IN THIS FIELD.

Even though we have modelled the collaborative decision-making processes separately, the relationships between them are not forgotten. Therefore, for every process we identified the links with other processes. These processes all together constitute the global project collaborative decision-making process, integrating all project development aspects. The advantage of thereby presented processes lies in the fact that it is possible to obtain an overview of just one process or a global overview of the project collaborative decision-making process. This global project overview is very important for the project manager because it contains the information of the crucial points and the project progression path, which help him in the project management.

The decisional level is represented in the project management tool in a separate view. This view is nevertheless related to other standard view proposed in the MS project: Gantt, WBS, budget. In this view, as we implemented this tool in MS Project, the decisions are represented as milestones, because this software does not permit the manipulation of other concepts other than activities or milestones. The relationships used for the collaborative decision-making process are the relationships as the disposal in the MS Project.

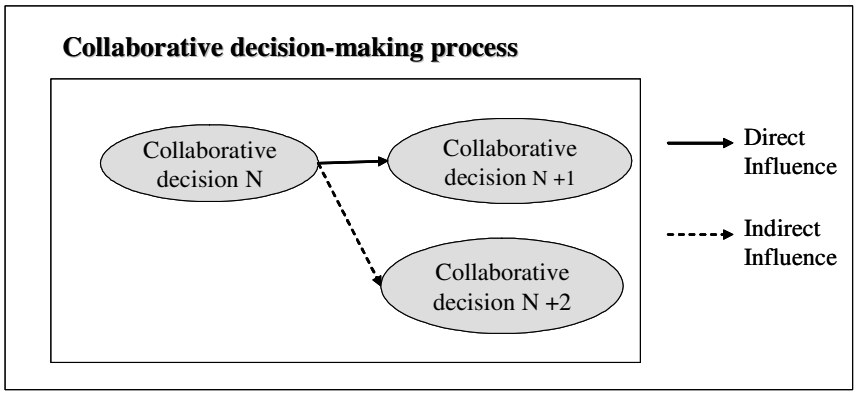

Figure 5.5.2 - Direct and indirect influences in collaborative decision-making process

5.5.2 Informational level

The Informational level concerns the information of one collaborative decision. This level is developed using the conceptual model presented in chapter 4. According to this conceptual model, we have created a document called "the Individual File" (see Figure 5.5.3). The information contained in this file concerns all four views of our conceptual model and thus the information concerning one collaborative decision-making. However, the document does not contain all the information we identified as necessary for collaborative decision-making. The problem lies in the difficulty in information retrieving or extraction. FOR EXAMPLE, RELATIONSHIPS BETWEEN PROJECT OBJECTIVES AS WELL AS THEIR INTERDEPENDENCIES ARE

VERY DIFFICULT AND COMPLEX TO DEFINE. IN THE PROJECT DEVELOPMENT, TEAM MEMBERS ARE USING THE LIVING ENTERPRISE KNOWLEDGE TO DEFINE THEM, BUT FOR THE MOMENT, THERE IS NO SUPPORT CONTAINING EXPLICIT INFORMATION. FUTURE DEVELOPMENTS WILL CONSIDER THIS LACK IN ORDER TO IMPROVE AND FACILITATE DECISION MAKING FOR THE PROJECT TEAM.

The first part of Individual File concerns different types of actors in the collaborative decision-making. There are collaborative decision-making pilots, contributors and decision makers. The presented definition of types of actors in collaborative decision making is important because every actor type defines the role and the responsibilities within the collaborative decision making [Karacapidilis and Papadias 1998b] and can contribute to the decrease of conflicts in decision making process. The pilot is a team member responsible for the definition of project objectives decided in collaborative decision-making. The contributors in the collaborative decision-making are the team members who produce the inputs necessary to make a good decision but do not participate in collaborative decision-making process, because the problem of collaborative decision does not concern or influence directly contributors project activity field. The decision makers are the team members that are responsible for the project objective coherence and their own objectives are directly concerned and influenced by the outputs of collaborative decision.

The central part of the Individual File concerns transformations and corresponding activities of contributing operational processes. These information and activities are essential for quality decision-making on time. If they are not available when the project team has to decide project objectives, the degree of uncertainty can be endangering project success. That is also, why we have connected this part to risk management. For every input, output or activity to be realised, we defined and integrated in the Individual File the concept of criticality. The criticality is a notion of the risk of obtaining the information on time. It is calculated accordingly to risk management methodology applied in PSA Peugeot Citroën. The quality manager, who evaluated and includes these risks in the risk database specially designed for risk management.

In this part, we also wanted to exhibit eventual conflicts in the collaborative decision-making. We are based upon the hypothesis that exposing eventual points where conflicts can outbreak will diminish them [Harrington, Soltan et al. 1995]. Therefore, we insist on the transparency of individual objectives of every actor. These objectives are highlighted in this part of Individual File along with the activities of each actor. The aim was to give the project manager an overview of possible objective incoherence and out breaking conflicts. The conflicts related to objectives' incoherence is just one of possible conflict types in collaborative decision-making.

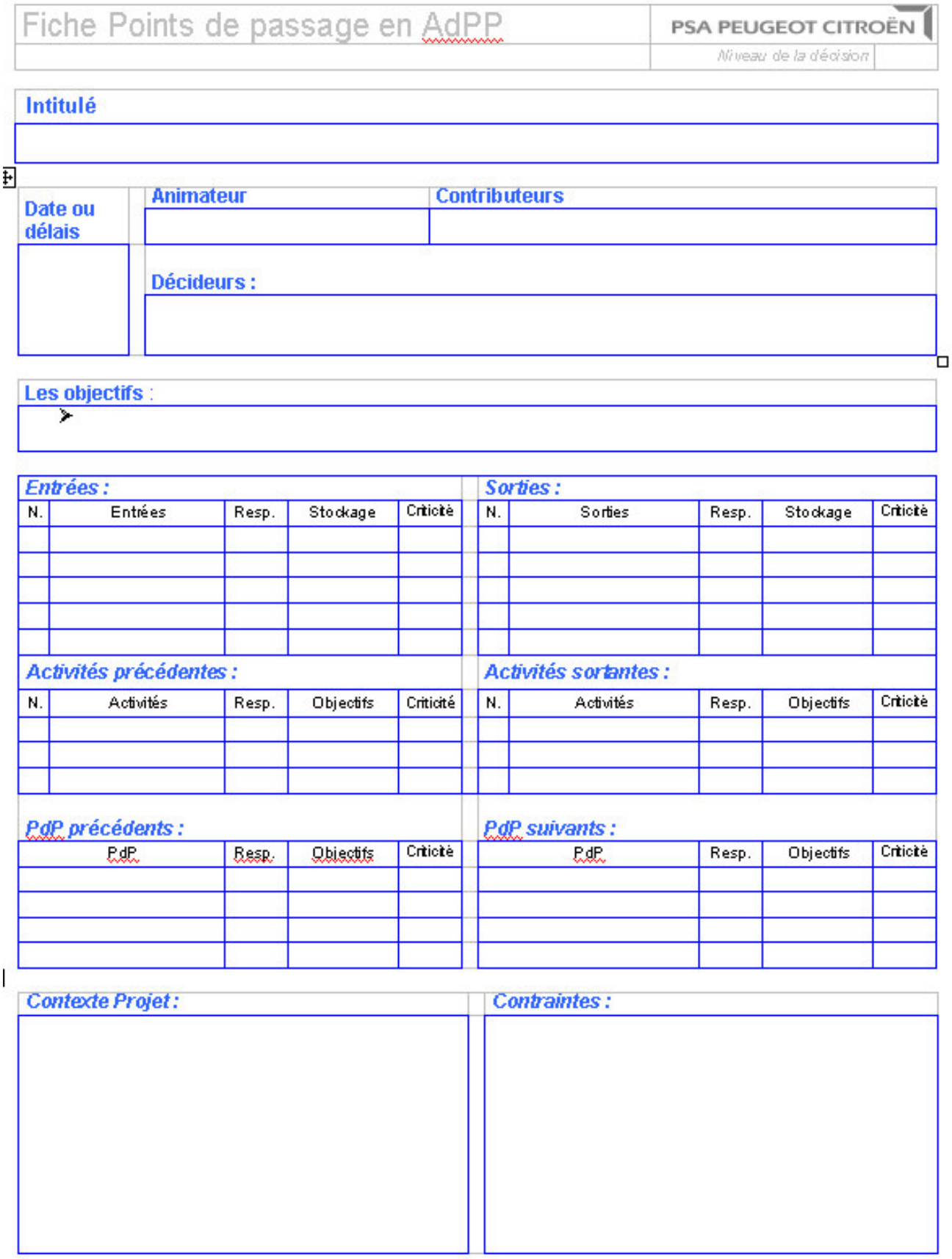

Figure 5.5.3 –Individual File

We identified and modelled seventy-three collaborative decisions for the whole Project Definition Phase. The decisions are identified using the knowledge of the Project Definition phase. FOR EXAMPLE, ONE OF THE DECISIONS OF THE PURCHASE PROCESS IS THE DECISION CONCERNING THE "MAKE OR BUY" POLITICS. IN THIS DECISION, THE DECISION MAKERS DECIDE IF IT IS BETTER TO EXTERNALISE THE PRODUCTION OF SOME PARTS AND WHAT ARE THE PARTS THAT ARE NOT "STRATEGIC" AND CAN BE PRODUCED BY A SUPPLIER.

5.5.3 Operational level

The organisational level concerns the operational processes in the NPPD process. We have not worked directly on the construction and organisation of this level. Nevertheless, the developments of the decisional level and the collaborative decision-making modelling have triggered the internal reflection related to its organisation.

The operational level organisation was influenced by the adopted Product Breakdown structure, which is very standard in the project management methodology. But due to the project complexity the project team has pointed out the necessity to work by "process". Therefore, in this level, 10 operational processes were identified. Their definition is based upon the enterprise know-how.

5.5.4 Contributions

The referential project management tool has been implemented in Microsoft Project software. The tool is already used by the project team for project management. Here we cite some of the advantages of this tool:

- The tool helps in the construction of the project trajectory and the organisation of the project in the early stages of NPPD, like the Project Definition Phase. The global Project Collaborative decision-making process presents a global overview of the phase progress. The crucial points to be resolved are identified in this tool.

- The tool also contributes to identification of activities to be realised, thus the project planning and control.

- Different levels and granularity representation constitute a complementary and coherent project image. Each view in the tool is adapted to the operational needs of one project team member. Project actors and their corresponding views are presented in Figure 5.5.4. The central point that permitted us to identify and homogenise the information in different views is the collaborative decision modelling used to create the informational view (Figure 5.5.4). The advantage is that all the actors can have the coherent vision of the project and its progress.

The project management tool is already used by project team. The feedback from the project team is that the tool is concise and permits the project organisation and planning. One project team is constitutes of minimum 15 members.

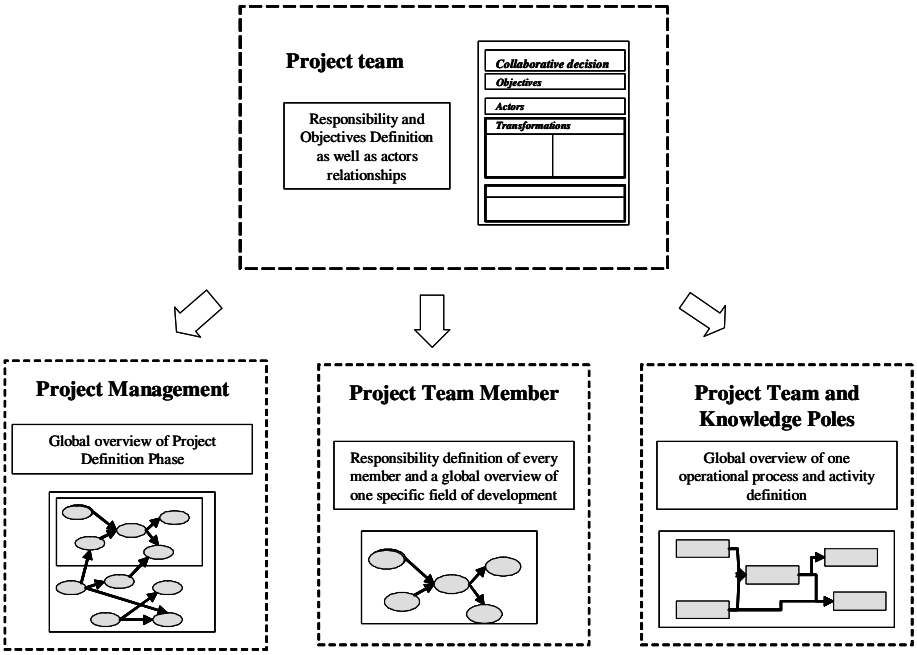

Figure 5.5.4 - Different project presentation adapted to different project actors

5.5.5 Limits of Developed Tool

The project management tool has also some limits:

- Interactivity can be better: The implementation of the tool in MS Project has a consequence of restricted interactivity. The links between processes, decisional, informational and operational, are manual, so the user has to know exactly what to do.

- Knowledge management: in generally, there are more than one project at the time. The new information, activities or decisions concerning one project have to be introduced manually in the reference tool. This is an important issue because there is a possibility that the enterprise know-how will be lost because of the great quantity of information.

- Manipulation of elements other that activities or milestones: In Microsoft Project there is only a possibility to introduce activities or milestones. So when introducing the decisions, we had to be very prudent because of possible confusions. That is why in PSA Peugeot Citroën one person is responsible for project support in utilisation phase.

- Integration of the dynamic aspect of decision-making: Even though the collaborative decision-making process integrates the dynamic aspect of one decision, this aspect is not incorporated in the tool.

5.5.6 Development Perspectives

In view to the limits identified in § 5.4 and the experience in the implementation phase, we can stand out the following possible development perspectives:

- Create a new software that supports the project management in complex projects: Our application with different views introduces a degree of flexibility in project management. This is not enough. Project team need a working tool taking into account every actor needs, a relative simplicity in the exploitation and different visualization of the project (decisional view, operational view, informational view, etc.).

- Develop a new project management method: In this paper, we have presented existing lacks in the project management methodology in the project with high complexity, having big project teams, etc. The identified problems give an opening for a reflection and development of different approaches in project management. For example, create a new way for project organising and control based on identifying the decisions to be made and their correlation to the project objectives definition.

- Create a collaborative decision making support system: In the field research, we have identified a great operational need for the information and identifying all the necessary elements for good decision-making. Thus, development of the exhaustive collaborative decision-making supporting system can be a conceivable solution.

5.6 Synthesis

Our research on the collaborative decision-making is applied in PSA Peugeot Citroen. This collaboration addresses specially the first phase of the NPPD process, the Project Definition Phase. In this chapter, we have shown some of the difficulties of collaborative decision-making, as well as in project management. In order to overcome these difficulties and to help (support) the project team, we propose a new project management tool based upon the collaborative decision-making modelling. The development of this tool incorporated also the results of the study related to the project team operational needs.

The project management tool that we propose is constituted of three different levels: decisional level, informational level and operational level. The decisional level concerns the collaborative decision-making processes in the NPPD. The informational level concerns the information of one decision and the operational and the operational level, the operational processes necessary for product development.

We have underlined some of the advantages of this tool:

- The tool help to construct the project trajectory and thus to organise the early phases in the NPPD;
- The tool contributes to the identification of activities to be realised, and therefore the project management and control;
- It helps the project team to have a coherent vision of the project. For every team member, the project management tool contains an adapted view corresponding to his or her roles and responsibilities.

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CHAPTER 6

CONCLUSIONS AND PERSPECTIVES

6

CONCLUSIONS AND PERSPECTIVES

The research study presented in this manuscript concerns the collaborative decision-making in the New Product and Process Development. The collaborative decision-making is one of the types of collective decisions. It is a face-to-face decision-making where different actors have different and often conflictual objectives in the decision-making process.

In our research study we have identified two research axes: the decision-making axe and the project management axe. Our research study is applied in the Project Definition phase in the automotive industry, PSA Peugeot Citroen. In view to our research axes and the implementation in PSA Peugeot Citroen, we organise our conclusion in three parts, each of them presents the respective contributions, limits and perspectives. The first part concerns the conceptual model, the second the project management tool and the third is related to the industrial application.

6.1 Collaborative Decision Making Model

We have shown that the collaborative decision-making is a complex process. In order to define and support this process, we have posed the following questions: What is collaborative decision-making? Who is deciding? What are different roles in this decision-making process? What is influencing the collaborative decision-making and needs to be taken into account? What influences one collaborative decision and what are the consequences?

6.1.1 Contributions

In view to the questions posed in our research work, we addressed the issue of the collaborative decision-making definition. In chapter 3, "State of art", we have shown that there is no coherence concerning the definition of this concept in the literature. Moreover, the collaborative decision-making in considered differently in the NPPD field and the decision-making field. Within this work we propose a definition of the collaborative decision-making in the NPPD process, and therefore we contribute to the clarification of different decision types proposed by Zaraté and Soubie [Zaraté and Soubie 2004]. In adittion, an overview of the comparative study of collaborative and cooperative decisions is given in this work, as well as their different consideration in the NPPD field and decision support field.

In order to satisfy our research objectives defined in the § 2.3.3, i.e. to support decision-makers in the decision-making process, we propose a conceptual model of collaborative decision-making. The proposed model contains the intrinsic elements of collaborative decision-making. We developed this model using the systemic approach developed by Le Moigne [Le Moigne 1990]. As we consider the collaborative decision-making to be a system, the conceptual model has four distinct views:

- View "Objectives": This view identifies different objectives that exist in the collaborative decision-making, as well as their relationships.

- View "Environment": In this view we represent three environments that influence the collaborative decision-making (decision, project and enterprise). We also identify the actors participating and influencing these environments.

- View "Transformations": This view concerns the preparatory and implementing transformations in the collaborative decision-making. Preparatory transformations refer to the elements influencing the collaborative decision-making, whilst the implementing to the elements that are influenced by the collaborative decision-making.

- View "Process": This view presents the process of collaborative decision-making. This process has three phases (identification of the need for decision-making, decision-making and implementation and evaluation) and integrates the resource utilisation.

Therefore, the information is these four different views of the conceptual model contribute to the clarification of the question of collaborative decision-making definition.

Moreover, the identification of the decisions, information and activities that influence the collaborative decision-making, as well as that are influence by the collaborative decision-making, contributes to the clarification of two posed questions: What is influencing the

collaborative decision-making and needs to be taken into account? What influences one collaborative decision and what are the consequences?

Thereby, our conceptual model and its implementation have contributed to the increasement of the decision robustness and the traceability of the collaborative decision-making process. The information contained in the model identifies the element required for the decision-making: who is deciding, what is decided upon, what is necessary to know to decide, what the decision influences, who is to do what so that the decision is possible, thus contributing to the decision robustness. We contribute to the traceability by identifying different flows (decisional, informational and operational) in collaborative decision-making processes. Hence, it is possible to know what are the influencing decisions, required information or previous activities to realise before one decision and what are the decisions that will be influenced, what is the information (output) and what is to be done afterwards.

6.1.2 Limits

The collaborative decision-making model is a generic model referring to the collaborative decisions in the NPPD process. In this model, we have not discussed the problem of relationships between the objectives that influence the collaborative decision-making. It is possible that by identifying the different types of relationships or different configuration of objectives' relationships, the collaborative decision typology can be defined. Therefore, the question of appropriated management or tools can be posed.

The collaborative decision is also a "fat soil" for conflict apparition. The problems concerning the different conflicts and the possibility to manage these conflicts within the decision-making process are not addressed in this model.

6.1.3 Research Perspectives

With regard to the research limits, one of the perspectives that we consider is the development of collaborative decision-support system. We proposed a conceptual model of collaborative decision-making, but we find important to work on the whole system in order to propose a dynamic, user-friendly system supporting interactively decision-makers in this process.

We have pointed out that the types of project objectives' relationships have not been addressed in the model. Defining the typology of relationships can contribute to the definition of collaborative decision-making typology, and thus, the definition of adequate tools for decision support.

Another question that we consider important is the question of decision-making conflicts. The literature related to different conflicts and conflict management is relatively large[Barki and Hartwick 2003; Jehn and Mannix 2001; Matta and Corby 1997; Schulz-Hardt, Jochims *et al.*

2002]. We find necessary to work on the identification of different conflicts in this process, so that adequate methods for their management can be integrated into the collaborative decision-making process.

We also think that it is important to work on the evaluation of the decision performance. We have not addressed this issue in our conceptual model. However, we think that is important to develop a support tool permitting this evaluation in order to identify the possibility to introduce the correction activities on time.

6.2 Project Management by Collaborative Decision Making

The first phase in NPPD process is the Project Definition Phase. This is the phase where the project objectives are defined. This is also the collaborative decision-making phase. In § 5.2 and § 5.3, we have exposed several problems of project management due to the complexity of this phase. As it is the collaborative decision-making phase, the problems related to the project management are following: How to organise this phase? How to manage it? Is there the possibility to control and how to control it?

6.2.1 Contributions

In view to the objectives of project management, we proposed an enhancement of the project management tool. The proposed project management tool is organised on three levels: decisional level, informational level and operational level. The decisional level represents the collaborative decision-making processes in the NPPD process. The informational level concerns the information of one collaborative decision. The operational level consists of different operational processes necessary for product development.

In the early phases in the NPPD process where the project objectives are not yet defined, the project team is unable to identify what is to be done. The collaborative decision-making processes represent the crucial points that the project has to assure in order to guarantee the project success. As the decisions are interrelated in these processes, the development of the decisional level contributes to the organisation of early phases. Moreover, the decisional level represents the project trajectory enabling the management of this phase.

For every collaborative decision, we defined the roles and responsibilities of every project actor. This information enables the project control by the project manager because he knows who, when and what is to do in the project.

6.2.2 Limits

The collaborative decision-making processes are dynamic processes. In the project management tool this dynamic aspect of the decision-making process has not been addressed. If some conditions change, then the decision has to be repeated and the relationships in the decision-making can be changed. This is an important aspect of the decision-making process, but in complex projects, as the vehicle development projects, to introduce this dynamic aspect can be expensive and time consuming. It is important to find an adequate balance between there two contradictories.

6.2.3 Research Perspectives

In our research, we have integrated new management elements, the decisions and the information, in the project management. However, we have not addressed the question of integration of these elements into the global project management methodology, as risk management or cost optimisation. Therefore, we find necessary to work on the elaboration of new project management methodology that incorporates management elements other than activities or milestones.

6.3 Industrial Application

The research work presented in this manuscript has been implemented in PSA Peugeot Citroen. During this implementation phase, we have worked on the enhancement of the referential project management tool used in this enterprise. The tool was implemented in Microsoft Project, used by all project teams. It is now used for project management.

6.3.1 Implementation

In order to help the project team to manage the Project Definition phase, we have work on the enhancement of their referential tool. The enhanced tool has several views: decisional, informational and operational. In the decisional level, we have modelled 13 collaborative decision-making processes (some of them are innovation, design, industrialisation). The informational level, containing the information related to one collaborative decision, is constituted of 73 collaborative decisions. The identification of these decisions was done with regard to the existing “know-how” of project management in the Project Definition Phase. The development of the decisional and informational level has triggered the reflection about the organisation of the operational level. Thus, the new organisation is “process” oriented and is organised in 10 operational processes necessary for the product development.

6.3.2 Limits

We identified two limits in implementation: one related to the software utilisation, Microsoft Project, and the other related to our conceptual model. The referential project management tool was developed in the Microsoft Project environment. This software imposed some constraints in the deployment phase. In this tool, the decisional and informational levels are represented apart. Therefore, when a user wants to switch from one view to another, he has to do it manually. The tool does not have the flexible links between different views. This can be an important issue in the utilisation phase.

The second limit concerns the implementation of our conceptual model. The conceptual model was used to model 73 identified collaborative decisions. While modelling, we have noticed that some information was not easy to retrieve. In some cases, the information was inexistent. This problem is a consequence of distributed localisation of knowledge in the enterprise.

6.3.3 Development Perspectives

The implementation phase has pointed out the need for the development of project management tools that are more flexible than existing ones, and most of all that permit the utilisation of other management elements as decisions or information.

Moreover, we have noticed that the project management is becoming more “process” oriented. Today, on the market, the project management support and process support are proposed separately. In our opinion, it is important to develop a tool integrating the option of these separated softwares.

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APPENDIX

APPENDIX A

A.1 Group Decision Making

Research study on group decision making:

Publication Year	*Record Count*	*% of 7462*
1965	4	0.0536%
1966	4	0.0536%
1967	4	0.0536%
1968	2	0.0268%
1969	2	0.0268%
1970	7	0.0938%
1971	3	0.0402%
1972	4	0.0536%
1973	6	0.0804%
1974	5	0.0670%
1975	5	0.0670%
1976	3	0.0402%
1977	7	0.0938%
1978	2	0.0268%
1979	5	0.0670%
1980	3	0.0402%
1981	7	0.0938%
1982	4	0.0536%
1983	11	0.1474%
1984	4	0.0536%
1985	7	0.0938%
1986	8	0.1072%
1987	9	0.1206%
1988	7	0.0938%
1989	6	0.0804%
1990	23	0.3082%
1991	183	2.4524%
1992	188	2.5194%
1993	209	2.8009%
1994	304	4.0740%
1995	288	3.8596%
1996	363	4.8646%
1997	396	5.3069%
1998	442	5.9233%
1999	476	6.3790%
2000	521	6.9820%
2001	555	7.4377%
2002	583	7.8129%
2003	665	8.9118%
2004	713	9.5551%
2005	878	11.7663%
2006	545	7.3037%

A.2 Cooperative Decision Making

Publication Year	*Record Count*	*% of 620*
1990	2	0.3226%
1991	14	2.2581%
1992	18	2.9032%
1993	23	3.7097%
1994	32	5.1613%
1995	21	3.3871%
1996	29	4.6774%
1997	30	4.8387%
1998	36	5.8065%
1999	41	6.6129%
2000	42	6.7742%
2001	40	6.4516%
2002	43	6.9355%
2003	54	8.7097%
2004	64	10.3226%
2005	81	13.0645%
2006	42	6.7742%

A.3 Collaborative Decision Making

Publication Year	*Record Count*	*% of 693*
1991	9	1.2987%
1992	10	1.4430%
1993	12	1.7316%
1994	17	2.4531%
1995	16	2.3088%
1996	24	3.4632%
1997	22	3.1746%
1998	30	4.3290%
1999	48	6.9264%
2000	53	7.6479%
2001	56	8.0808%
2002	63	9.0909%
2003	72	10.3896%
2004	86	12.4098%
2005	93	13.4199%
2006	80	11.5440%

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The research work exposed in this manuscript has already been object of several publications:

- Jankovic, M., J.-C. Bocquet, et al. (2006). "*Management of the Vehicle Design Process throughout the Collaborative Decision Making Modeling"*. Integrated Design and Manufacture in Mechanical Engineering - IDMME06, Grenoble, France.

- Jankovic, M., J.-C. Bocquet, et al. (2006). "*Integral Collaborative Decision Model in order to Support Project Definition Phase Management"*. International Design Conference - Design 2006, Dubrovnik, Croatia.

- Jankovic, M., P. Zaraté, et al. (2006). "*Collaborative Decision Making: Complementary Developments of a Model and an Architecture"*. 21st European Conference on Operational Research - EURO XXI, Iceland.

- Jankovic, M., P. Zaraté, et al. (2006). *"Collaborative Decision Making: Complementary Developments of a Model and an Architecture as a Tool Support."* Journal of Decision Systems **13**(1/2004 - Submitted).

- Jankovic, M., P. Zaraté, et al. (2006). "*Complementary Aspects of a Conceptual Model and Architecture Tool for Collaborative Decision Making"*. Workshop of the EWG-DSS, London, United Kingdom.

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Résumé :

Ce travail de thèse s'intéresse à l'étude des décisions collaboratives dans le processus de conception de nouveaux produits. Les contributions de cette thèse sont focalisées principalement sur la compréhension des décisions collaboratives et leurs spécificités par rapport aux autres types de décisions collectives, ainsi que la gestion des processus de prise des décisions collaboratives dans le cadre du management de projet. Nous proposons un modèle conceptuel de décisions collaboratives. L'objectif de ce modèle est double : identifier les éléments relatifs à l'aide à la décision mais aussi aider au management des processus de prise des décisions. Ces éléments sont représentés au sein de ce modèle conceptuel et organisés en quatre vues (Objectifs, Transformations, Environnement et Processus). Le modèle a été utilisé pour développer l'outil de management de projet chez PSA Peugeot Citroën. Il a été appliqué dans la première phase de conception, la phase de définitions des objectifs d'un projet. La mission de l'équipe projet dans cette phase est de définir les objectifs du projet tout en incorporant différentes contraintes de l'entreprise et le marché. L'outil est organisé en trois niveaux : le niveau des processus des décisions collaboratives, le niveau d'informations et le niveau des processus opérationnels. Il permet à l'équipe projet de :

- Gérer le projet dans la phase de définition des objectifs ;
- Suivre le progrès global de cette phase ;
- Avoir une meilleure visibilité de la convergence des objectifs ;
- Organiser la prise des décisions collaboratives.

Mots Clés: décisions collaboratives, processus de conception, management de projet

Abstract :

The PhD Thesis deals with the problem of collaborative decision making in the New Product and Process Development. The contributions of this thesis are focalized on the definition of collaborative decision-making and their specificity with regard to other types of decision-making, as well as the management of collaborative decision making in the project. In our work we propose a conceptual model. The objective of this model is double: to identify the elements necessary for decision making but also to help decision makers in this process. The identified elements are organized in four different views of the model (Objectives, Transformations, Environment and Process). This model is used for the development of the project management tool in PSA Peugeot Citroen. This tool is implemented in the first phase of New Product and Process Development named the Project Definition Phase. This tool is organized on three levels: decisional level, information level and operational level. This tool permits to the project team to:

- Manage the project in the Project Definition phase;
- Follow the global progress of the project;
- Have a better visibility of the objectives convergence
- Organize the collaborative decision-making.

Keywords: collaborative decision-making, new product and process development, project management.