AN EXPLORATORY STUDY OF THE SPECIFICATIONS PROCESS IN A CUSTOMER-SUPPLIER COLLABORATIVE NEW PRODUCT DEVELOPMENT

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Abstract

In this paper we focus on the collaborative process of definition of specifications of a complex product. The aim of the paper is to improve the understanding of the specifications elaboration process and particularly the interactions between customer and supplier project teams. A case study has been analyzed to precise the collaborative definition of specifications through respective contributions of the client and the supplier team members. We have described the interactions between customer and supplier project teams by combining a collaborative concept development process with the formalism of the blueprint method in order to highlight the roles of each company. Our conclusions pointed out three patterns, (1) the degree of interactions between customer and supplier project teams vary in the upstream phases of the New Product Development process, (2) the use of narrow-based definition of specifications enables to increase the trust from the customer towards the supplier, and (3) the collaborative specifications definition process is seen as a co-evolution approach, where needs, specifications and architecture evolve in parallel.

Keywords: Collaborative design, Early design phases, New product development

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1 INTRODUCTION

The supplier can be a source of significant advantage on the customer development process particularly in terms of the potential innovation that might be injected into a new offer generation (Brem and Tidd, 2012; Handfield et al., 1999). In management literature, Early Supplier Involvement (ESI) is defined generally as a form of vertical cooperation in which manufacturers involve suppliers at an early stage in the New Product Development (NPD) process (Bidault et al., 1998). Supplier involvement in NPD can take the form of a variety of configurations (Petersen et al., 2005): the simple consultation of suppliers about customer design ideas (white box), the joint development of an outsourced product (grey box), or the delegation to the supplier of full design responsibility for an outsourced product (black box). These two last configurations are qualified of *collaborative design with suppliers* (Le Dain et al., 2011) because the supplier has a real responsibility in the design activity of the customer. For black and grey box engineering, the customer provides initial list of specifications concerning the product or service to be developed by the supplier. The later will be in charge of the design process starting by clarification of the design problem, including concept generation and ending with the manufacturing ramp-up.
Previous researches have highlighted the importance to redefine the role played by the specification in *collaborative design with suppliers*. Instead of a closed document, the specification becomes an intermediary object (Boujut and Blanco, 2003) between both parties (Karlsson et al., 1998). In this respect, Nellore and Söderquist (2000a) suggested to consider "a broader definition of the specification process, where the written document called the specification is seen as an open arena for joint discussion and negotiation between the OEM and the suppliers" (p.529). For theses authors, the broad-based definition of specifications not only includes a list of requirements but also takes into account the process for defining the specifications. The specification process has been defined by Zhang and Swirski (2002) as the validation of customer requirements and supplier solutions. Both customer and suppliers have to understand the specifications, each other's capabilities and the resources needed (Nellore, 2001). Some authors have also highlighted that the specification process brings in multiple functions such as technical, marketing, production, purchasing. Karlsson et al. (1998) identified in their study of automotive suppliers some problems in language translation as well as in harmonization because the different layers of specification are created by different people. It is the reason why Nellore and Söderquist (2000a) suggested that "the role of specifications in outsourcing decisions help in connecting the different functions and people together" (p.539). The product development process can be seen as a flow of specifications and that this highlights the need for improved communication between all involved actors — external and internal (Nellore et al. 1999). Both knowledge base and technical competences of customer and suppliers can determine the content and the context of this specifications flow (McGovern and Hicks, 2006). In this respect, "if there is to be co-generation of specification, then the specifications have to be collaborative and thus not restrict the input of the suppliers" (Nellore and Söderquist, 2000b, p.260).

While previous studies have focused on the mediating role of the specification in co-development and the importance of the supplier participation in the specification process, the operational process of the collaborative elaboration of specifications between customer and supplier project teams is relatively unexplored. Nellore et al. (1999) have proposed a specification model for product development, detailing the main steps and deliverables for generating specification in automotive industry. These authors have identified the potential role of the supplier in the inputs of the model, without detailing the process and collaborative activities performed by both the customer and the supplier. Abe and Starr (2003) have defined a *design structured teardown process* that illustrates the initial writing and the evolution of specification. These authors have defined tasks and outcomes for each step of the process, without taking into account collaborative situations.
The aim of the paper is to improve the understanding of the collaborative specification process and particularly the exchanges between customer and supplier project teams. More particularly, the research question addressed is "*How customers and suppliers interact in the collaborative specification process?"*
In the next section, we present the background of our model of customer-supplier exchanges process around the specifications that has served our analysis of the case study. Next the methodology and the

case study are described. We finally discuss the results and draw some conclusions and future research avenues.

2 BACKGROUND

In this paper, we focus on the upstream phases of product development process proposed by Ulrich et al. (2011). These early phases concern notably the elaboration of the project plan, the elaboration of concepts and initial drawings of a solution. But these authors do not precise in their process when the suppliers have to be involved. In the cases of black box and grey box or of *collaborative design with suppliers*, the on-time involvement of suppliers is performed during the generation and development of concepts (Le Dain et al., 2011).

The aim of the paper is to describe the exchanges around the elaboration of specifications between customer and supplier project teams in the upstream phases of a product development process. In this paper, we have developed a conceptual model representing the exchanges between a customer and a supplier during the elaboration of specifications. This conceptual model is based on the *collaborative concept development process* described by Langner and Seidel (2009) and the blueprinting method illustrating by Fliess and Becker (2006). In the following we describe these both contributions and then we present our new conceptual model.

In the upstream phase of NDP, the customer project team has to select the supplier who will be integrated in the project. For describing this selection process, we adopt the *collaborative concept development process* proposed by Langner and Seidel (2009). This process is divided into three distinct phases: *exploration phase*, *competition phase* and *engagement phase*. It proposes a framework to understand the supplier selection and the roles taken by Original Equipment Manufacturers (OEM) (the customer) and by suppliers during each phase. The authors have developed their *collaborative concept development process* from two empirical studies conducted in the automotive industry. They compared two case studies concerning the development of a novel convertible roof by two distinct OEM and their own suppliers. Differences between both OEM reside in the initial experience in convertible roof. The initial experience relates to past design experiences and the employment of engineers specialized in this area (Langner and Seidel, 2009). The first OEM had high initial experience, and the second had low initial experience. Authors have highlighted that the relative detail of specification and the relative degree of specification change are related to the initial experience of the OEM.

The first phase of their process is the *exploration phase*, in which activities of initial concept ideation, exploration of concept alternatives, primary concept selection and specification setting are performed. This phase is primarily driven by the customer company. Then a second phase has been defined, -*the competition phase*-, where activities of feature development within specifications and development of working model are performed. In this phase the supplier proposes a first solution to customer specifications. In this phase suppliers are consulted and they are put into competition. But the manner to request proposals from suppliers is not detailed in this *collaborative concept development process*. The main locus of these activities takes place in the supplier company. At the end of the *competition phase*, the supplier is chosen by the customer. A third phase, the -*engagement phase*-, concerns the joint activities performed by both the customer and the supplier project teams. It concerns activities of identification of target conflicts and concept optimization.

In the process proposed by Langner and Seidel (2009), activities performed by each actor are not described in detail and how each actor uses the specifications as a mediating object is not clarified. For this reason, we propose to combine this process to the blueprinting method illustrated by Fliess and Becker (2006). These authors have decomposed a co-development process by using the blueprinting method on twelve case studies. They have used the formalism of the blueprinting method to represent activities in a co-development project. The representation has clearly identified the activities performed by the customer project team, by the supplier project team and by both project teams. It has been able to distinctly discern the effort of the customer and the effort of the supplier during the development process. Furthermore, Fliess and Becker (2006) have represented on their blueprint the link between the activities. It enables to understand the exchanges and the workflow between the customer and the supplier project teams. However the representation includes all the co-development process (from needs to industrialization) and does not specifically focus on the specification process.

Finally, based on this background, we proposed a conceptual model describing the exchanges between the customer and supplier encountered in the upstream phases of the NDP project and related to the specification process (Figure 1). The model proposed is called *collaborative specification process model* because we focus in this paper on the specification process, and not only on the concept development. This model distinguishes the activities conducted in an autonomous way by each actor and the joint ones. It also integrates the three steps of the collaborative concept development process introduced by Langner and Seidel (2009). The model proposes an integration of the locus of each phase namely the exploration phase, the competition phase and the engagement phase and the customer's and supplier's activities highlighted by Fliess and Becker (2006). As illustrated in Figure 1, the exploration phase is a phase mainly driven by the customer, while the competition phase is held by the supplier. In the engagement phase, both the supplier and the customer perform activities.
Furthermore we have taken into account on the Figure 1 the flow of specifications defined by Langner and Seidel (2009) for each phase. In the first phase, specifications are set. Next, suppliers develop features based on these specifications. After the supplier chosen, target conflicts are identified based on supplier proposals.
Finally, we have represented exchanges between supplier and customer with arrows. This makes reference to conclusions of case studies performed by Langner and Seidel (2009) in which the high exchanges during the exploration phase and the competition phase have been identified. The effect of the initial experience on the exchange intensity is not represented on the Figure 1 because it represents the generic model (without distinction on the initial experience of the customer).

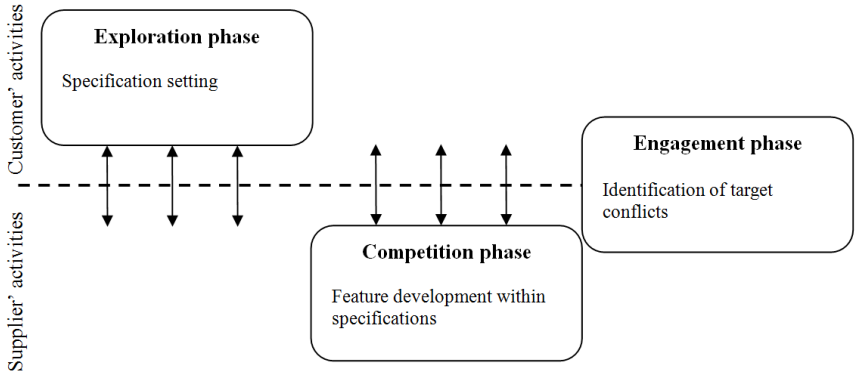

Figure 1. Collaborative specification process model in upstream phase

3 METHODOLOGY

The purpose of this paper is to contribute to the understanding of the collaborative specification process. The exploratory nature of our research lead us to use the case study approach, as the most appropriate means of investigating a how question (Yin, 2009), i.e. *How customers and suppliers interact in the collaborative specification process?*
The unit of analysis used in this paper is the co-development project of a Box between the customer that we will call ENERGY Company and its supplier called COM Company. The Box development is a part of a development program dedicated to a new energy management solution for Buildings market.
ENERGY Company is a French worldwide company, global specialist on energy management, with a market share of 24 billion euro and 160,000 employees in the world. ENERGY Company strategy has moved in the last decades from developing products to developing product and services. COM Company is a worldwide French company with a market share of 1.2 billion euro and 4,200 employees. This company is the European leader on the broadband markets.
Data was collected from various sources: daily observations, interviews and documentation. The first author of the paper is working 3 days per week in ENERGY Company and has been able to observe the project and hence collect data through field notes. We have conducted semi-structured interviews in order to let the chance to the interviewees to explore new issues during discussion. Objective of the semi-structured interviews was to explore and to detail the activities performed during the specification process and the document exchanged with the supplier project team. Moreover semi-structured interviews gave the opportunity to the respondents to report their feedbacks on the

difficulties and the best practices encountered during the specification process. We have interviewed multiple time several functions in ENERGY Company, like four times the program manager, twice the project manager, four times the purchasing leader and twice the technical leader and the architecture leader. Duration of interviews has been around two hours, during which notes have been taken. In more of the interviews, we have had access to official project documentation (contracts signed between both companies, the different versions of the list of specifications, the Marketing Needs, the proposals of the suppliers), and to the multitude of presentations during all the life cycle of the project. Furthermore we have observed project teams during key meetings. We have next analyzed data in order to capture relevant information about the exchanges between the client and the supplier. We did not have the possibility to interview directly the supplier team, but we had access to files provided by the supplier. The various sources of data collection enabled a triangulation approach (Yin, 2009).

3.1 Case description

The co-development project of a Box was a strategic project for ENERGY Company. It is addressed to small and medium buildings markets. The aim of the project is to provide a Box and an Application to the customers to give them the opportunity to monitor and to control energy consumption of their buildings. Small and medium buildings can be industrial buildings, like manufactures, or commercial buildings, like supermarkets. This kind of buildings consumes energy (electricity, water, gas), has its own environment (temperature, hygrometry) and its own constraints (e.g. the freezers of supermarkets cannot be switched off during the night). By using the Application, clients are able to know at every time every day the energy consumption of their buildings. Moreover they can be alerted in case of a non-planned peak of consumption. They are also able to manage electrical devices of the buildings in order to reduce the energy consumption and consequently to reduce the energy bill.
The Box proposed by ENERGY Company to provide control and monitoring of energy consumption is based on three main features: a physical component (a Box), a Remote Service Platform (RSP) which is similar to a Cloud and an Application. The Box is installed in each building of the client. Each building is either ever equipped with multiple sensors (gas, electricity, water, temperature, humidity), or if sensors are missing ENERGY Company can install them. Sensors are connected to the Box either by a physical cable or wirelessly. The Box centralizes all data coming from the sensors. Then the Box sends these data into the RSP. The data sending is realized either by using the Internet connection of the client (Ethernet or Wi-Fi) or by using GPRS thanks to a SIM card installed in the Box. The data are next stocked in the RSP, transformed to graphs by the Application. The client can get access to the Application and hence visualize graphs of energy consumption of its building.
ENERGY Company has been the integrator and is selling the Box with its own brand. ENERGY Company had a low initial experience in the development of such boxes and in radio connectivity. This is why ENERGY Company has called on COM Company to develop the Box and the GPRS connectivity. COM Company has been responsible for the development of some features of the Box: the wrapper of the Box, the firmware and the integration of all components that formed the Box. COM Company has been selected by ENERGY Company for its expertise and experience in the development of such boxes, as well as for its expertise in the radio connectivity.

3.2 Results

The description of the co-development project of the Box is based on the model proposed (Figure 1). It follows the three phases of the collaborative concept development process (namely the exploration phase, the competition phase and the engagement phase), plus a description of activities conducted in an autonomous way by each actor and the joint ones. Moreover, the exchanges between ENERGY Company and COM Company has been described for each phase.

3.2.1 The exploration phase

First of all, ENERGY Company's team has participated to the activity of definition of the *Marketing Needs*. *Marketing Needs* document expresses Use Cases (corresponding to the needs from the market), the Business Model, the scope of the projects, the own constraints of ENERGY Company and the need of competencies. Twelve months have been necessary to write and validate this input. The *Marketing Needs* document has then been used to define the *Request For Proposal* (RFP) to be sent to the potential suppliers. The RFP contained elements that allowed ENERGY Company to situate the Box

in its environment: inputs required of the Box, like the number and the type of sensors, outputs required of the Box, like the way of connectivity, and constraints, like the maximal volume of the Box.
In parallel to the creation of the RFP, the ENERGY Company's architecture leaders have worked on the definition of an *initial architecture* of the Box. They expressed their concept and started the translation of *Marketing Needs* into *initial specifications*. Based on their knowledge and experience on previous projects, architecture leaders have proposed a first architecture of the Box based on these *initial specifications*. For example, they proposed type of connectors that link physically sensors into the Box.
Then, six potential suppliers have been selected in the supply base of ENERGY Company. This activity has been performed by the purchasing leader. Potential suppliers have been chosen on the known capabilities of developing and producing such Boxes, as well as their capabilities in connectivity devices. Some meetings have been organized between ENERGY Company's project manager, purchasing leader and those potential suppliers. These meetings have enabled ENERGY Company to present their needs to the suppliers based on the *Marketing Needs* previously identified. Both companies have discussed about potential suppliers capabilities to develop and produce the Box. It happened that two potential suppliers were not able to ensure the production of high quantity of boxes. Furthermore one potential supplier was not able to master all types of connectivity devices required by ENERGY Company. Finally, a shortlist of three suppliers has been selected by the ENERGY Company's project team and validated by Top Management of the company.

3.2.2 The competition phase

Firstly, the RFP has been sent to the shortlist of three potential suppliers identified in the exploration phase. These three potential suppliers have answered to the RFP by creating and writing *proposals*. Each proposal has then been analyzed by ENERGY Company project team. Many meetings of exchange have occurred between the ENERGY Company and each of the three potential suppliers' project teams. These meetings have been able to clarify the needs of ENERGY Company, to precise some requests in the RFP and to ensure the well understanding of needs by potential suppliers. In this phase ENERGY Company project team has respected the equity between the three potential suppliers, by passing the same time of meetings with each of them. And in case of a changing of needs, ENERGY Company has prevented all potential suppliers. About six months have been required from the sending of RFP and the reception of the different suppliers' proposal. The three potential suppliers had to understand the RFP sent by ENERGY Company and to pass time to develop and write their proposal. ENERGY Company's team have evaluated each potential supplier on the base of some criteria such as the quality of the proposition made, the financial wealth of the potential suppliers, the Business Model proposed by potential suppliers and the historic of relationships between ENERGY Company and them. Then the project team has proposed a ranking of the three potential suppliers from results to the evaluation of these criteria. Finally ENERGY Company Top Management has selected COM Company to develop the Box and the radio connectivity.
Secondly, in parallel to the supplier selection, the *initial architecture* of the Box has evolved due to potential suppliers' proposals. Each proposition made by the three potential suppliers has been able to question, internally in ENERGY Company, the *initial architecture* proposed by architecture leaders. The initial architecture of the Box has evolved into a *consolidated architecture*, taking into account technical solutions proposed in suppliers' proposals.
Thirdly, the architecture has been the base for the co-definition of specifications activity (see the next section), where ENERGY Company and COM Company teams have jointly defined the final architecture and where the supplier has brought its own expertise on it. We have observed that the purchasing leader of ENERGY Company has reviewed the *consolidated architecture*. She has commented the consolidated architecture document in order to evaluate if the proposed architecture let the chance to the supplier to express its all expertise in technical choices, or to be more precise on some specifications or constraints. For example, it has been identified in Marketing Needs that the Box required a Human Machine Interface. The ENERGY Company architecture leaders have made a technological choice by using LCD Display to fulfill this need. The purchasing leader has commented this choice by proposing to remove this technological choice in order to let the chance to the supplier to make his own choices.

3.2.3 The engagement phase

As we have presented in the previous section, discussions between the three potential suppliers and ENERGY Company have been able to ENERGY Company project team to revise its initial description of the box architecture and thus propose a consolidated version. This consolidated architecture has been the initial input for the collaborative activities performed with COM Company.

On one hand, there has been the co-definition of the Box specifications activity. It has been able to both companies to share their own constraints, to ensure the alignment of the objectives of the project, to ensure the well understanding by COM Company of the needs of ENERGY Company, to write *collaborative specifications* and to prepare the definition of the *functional architecture* of the Box. An example of constraints is that the box is installed in electric panel of buildings. All constraints linked to electric panel, like electro-mechanical constraints, were unknown by COM Company. This specific environment is the expertise of ENERGY Company. The co-definition of the specifications of the Box has been performed during a three weeks workshop. An example of co-definition of specifications has cited by the Program Manager of ENERGY Company. It concerned the definition of the Central Processing Unit (CPU) of the Box. ENERGY Company project team, based on the experience of the company and its own supply chain, has made a choice of a brand and a type of CPU. Nevertheless, during the workshop, COM Company has explained to ENERGY Company that the CPU chosen was not suitable for the Box specifications for some reasons: energy consummated by the CPU was too high and the CPU was not enough powerful for this application. Consequently COM Company has proposed another CPU and ENERGY Company has accepted to modify the specification.

Based on the *RFP*, the *consolidated architecture* document and the *collaborative specifications* of the Box defined during the three weeks workshop, COM Company has made a detailed proposal of a functional architecture. It has consisted of two fifty pages document where the detail of all what will be developed has been written, including the costs, the resources and the development time.

On a second hand, the exploration phase has comprised the contracting process includes drawing up and signing the *Engineering Agreement* and then the *Development Contract*. The signature of an *Engineering Agreement* has been a demand of COM Company. This agreement has been able to justify the payment for the time to pass to perform the activity of co-definition of specifications of the Box, the development of a *functional architecture* and the initial engagement of ENERGY Company concerning the production of the Boxes by COM Company. The second contract signed has been the *Development Contract*. This contract has summarized the engagement taken by the ENERGY Company (in terms of needs, payment, and production engagement) and the engagement of the COM Company (in terms of functional architecture, costs, and delay).

4 DISCUSSION AND CONCLUSION

From the empirical insights, we propose some adaptation of our initial collaborative specification process model. We define a *consolidated collaborative specification process model* (Figure 2). In this section, we discuss these suggestions in the light of previous academic results. The Figure 2 comprises arrows that represent the exchanges between customer and supplier project teams. Furthermore we precise on the Figure 2 the main activities performed and the documents created and exchanged between both project teams.

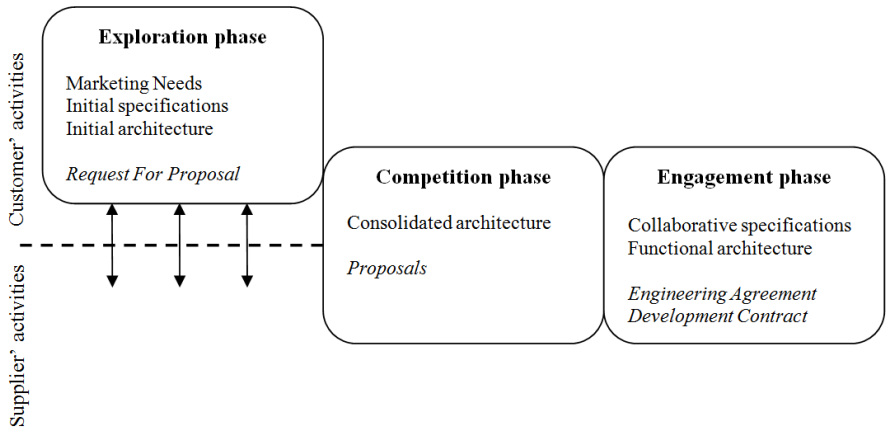

Figure 2. Consolidated collaborative specification process model in upstream phase

Firstly, this three step model is applied in the upstream phases of a development process, where needs and specifications are described. We have observed that activities performed in the exploration phase are still held by the customer and they concern the definition of *Marketing Needs*, *initial specifications*, *initial architecture* and the preparation of the *Request For Proposal* (Figure 2). Furthermore Langner and Seidel (2009) have pointed out the change of relative detail of specification in the exploration phase. In the case of the OEM with a Low Initial Experience, the relative detail of specifications was low at the end of the exploration phase. In our case, ENERGY Company has a low initial experience in development of Box. From our case study we have noted that the degree of initial specifications was low. The definition of specifications was uniquely due to the past experience of the company. That corroborates the conclusions from Langner and Seidel (2009). In the *exploration phase,* most exchanges have been related to the exchanges between customer and supplier project teams in the activity of the definition by the customer of a shortlist of potential suppliers. We have observed that exchanges between customer and suppliers in the exploration phase are limited. We conclude that in this phase the relative involvement of supplier by the customer is lower, that is corroborating the conclusions from Langner and Seidel (2006). In the *competition phase*, we have pointed out that the relative degree of specification change was high due to supplier proposals. By developing and writing proposals, the three potential suppliers have contributed to the refinement of specifications by the "Low Initial Experience" ENERGY Company. In our study we have observed that the *competition phase* has enabled to intensify the exchanges between ENERGY Company and suppliers. Thanks to the proposals from the three potential suppliers, ENERGY Company team has been able to refine the *initial architecture* into a *consolidated architecture*. In the Langner and Seidel (2009) three step model definition, the locus of the competition phase is held by the supplier. Our observations have shown that, in more of the proposals from the suppliers, there was an important work done by ENERGY Company team to refine the architecture and to prepare the engagement phase. Consequently, we conclude that the locus of the activity is not only in supplier place, but also in the customer place. The competition phase is doing in collaboration between customer and supplier project teams (Figure 2). The *engagement phase* has started with the signature of an *Engineering Agreement*. It has been able to formalize a first engagement of both companies and to align companies on the financing of the engagement phase. This third phase has seen the activity of co-definition of the Box specifications. We have highlighted that both companies have brought their own competencies and constraints and they have discussed during a three weeks workshop. This activity has been considered as crucial by interviewees in order to ensure the alignment between both project teams. In the engagement phase the relative involvement of supplier by the customer has been high, and activities have been performed in collaboration between customer and supplier project teams (Figure 2). We have observed that the relative degree of specification change was high. The strong collaboration between customer and supplier project teams has led to the co-definition of specifications. Following this co-definition of specifications, the supplier has been able to propose a functional architecture. Furthermore this functional architecture has been the base to write the *Development Contract* and like that to formalize the strong engagement of both companies.

Secondly we have noted in the *competition phase* that the purchasing leader has reviewed the consolidated architecture proposed by ENERGY Company architecture leaders. Her role of evaluation of the narrow-based definition of requirements (Nellore and Söderquist, 2000a) has been crucial for the co-definition of specifications of the Box activity. It has been able to let the chance to the supplier to make its own technological choices. We consider this practice as a real added value on the specification process, because it increases the trust from the customer towards the supplier. But we can discuss the role taken by the purchasing leader. Why the architecture leaders' did not take into account this "broad-based approach" during the definition of the architecture? They potentially could take into account the supplier capacity to make technological choice, and to bring his expertise on it. The role of the purchasing leader has also been to check the understandability of the architecture and of the constraints expressed by architecture leaders. In some words, the purchasing puts herself in supplier's place.

Thirdly, the evolution of Marketing Needs, specifications and architecture observed in the specification process can be connected to a co-evolution approach (Dorst and Cross, 2001) of problem solution. Many loops between customer and supplier have been able to ensure the alignment and the well understanding of both teams on the objective and needs of the project. We have highlighted the

evolution of the architecture, from the initial architecture proposed by architecture leaders of the customer, to the functional architecture defined supplier project team.

To conclude this paper we noted that the collaborative specification definition process caused a variation of the degree of exchanges of customer and supplier project teams in the upstream phases of the development process. We proposed a conceptual model based on two contributions coming from the literature: the *collaborative concept development process* and the blueprinting method. We next applied with model into the co-development of a product between a customer and a supplier. With this case study we clearly identified the exchanges between the customer and the supplier in the different phases of the elaboration of specifications: the exploration phase, the competition phase and the engagement phase. The first phase is mainly concerned by the customer, where needs and initial architecture of the product are defined. Then in the second phase customer and supplier contributed together to the consolidation of the architecture. Finally, in the third phase we highlighted the collaborative contribution of each firm to the elaboration of specifications and the functional architecture. We have pointed out the degree of specification change and the contribution of the expertise of the supplier into the definition of specifications. The involvement of supplier in the specification process is able to improve the customer needs by the supplier, and to benefit of the supplier expertise as early as possible. To extend this exploratory study we propose to study the specification process of other collaborative projects to enrich the model proposed.

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