INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED'07
28 - 31 AUGUST 2007, CITÉ DES SCIENCES ET DE L'INDUSTRIE, PARIS, FRANCE

EFFICIENT DECISION-MAKING IN PRODUCT DEVELOPMENT

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ABSTRACT

Product development projects need to be managed in a timely and efficient manner in the present competitive business environment. The authors of this work argue that the commonly used product development models do not fully meet this demand, and the decision-making process needs to be made explicit.

This work mainly focuses on the product development process. Two companies were studied using case study research. The aim of the case study was to identify key factors affecting the decision-making process in product development. The type of collaboration used in these two companies was also investigated in order to identify the influence it had on the decision-making process of each.

The two companies had different views of the decision-making process which were related to their level of development process knowledge. Common factors affecting the decision-making process in product development were divided into ten categories: (1) Handling of requirements, (2) Experience of projects, (3) Organizational aspects, (4) Project management, (5) Top management, (6) Knowledge, (7) Risk management, (8) Information systems, (9) Communication, and (10) Change management.

Keywords: decision-making, product development efficiency, co-operation.

1 INTRODUCTION

In a competitive environment, where products from different vendors often have the same levels of performance, quality and functionality, the process of developing innovative products at a lower cost and within shorter time intervals than competitors becomes increasingly important. In addition, vendors need to be flexible in order to respond to changes in markets and new technologies.

Product development is a complex process, and many aspects influence its outcome. Examples of such aspects include project planning, requirement management, co-operation, knowledge and competence, project management, IT-support, and decision-making. It is argued in this work that an explicit decision-making process is one crucial aspect of efficient project execution. A decision-making process not functioning well may result in unplanned rework, delays and increased uncertainty. Product planning decisions are more closely related to effectiveness while decisions in product development projects are more closely related to efficiency. This study is focused on operative decisions related to the product development process, a process whose aim is to make sure that the product fulfils the defined requirements and targets, within time and budget.

The purpose of this work is to further explore various factors influencing the decision-making process, and how the concept of co-operation may interact with the decision-making process. This knowledge in turn will facilitate a more efficient and stable execution of product development projects. Two companies have been studied using case study research. Three research questions were addressed during the study: (1) What are the companies' views of their decision-making process within product development projects?; (2) What do the companies consider affects the decision-making process during product development projects?; and (3) How does their level of co-operation affect the

decision-making process? A filter was used for interpreting and analyzing the data collected during the case study. The filter was based on Ullman's theory of decision management [1].

There are several interlinked activities that need to be coordinated and managed in order for a product development to succeed, and the decision-making process may be one of the factors that influences the out-put most of all. It is also vital for the entire product development process that all essential decisions and their consequences are analyzed. The appropriate information needs to be available, combined with personnel that have sufficient knowledge and skills to make a well-grounded decision. The decision-making process in product development rests upon three essential aspects: (1) the ability of personnel to manage the decision-making itself; (2) an appropriate organization for decision-making; and (3) the ability to utilize tools for decision-making and the decision-making process. These three aspects served as the adapted filter.

2 THEORETICAL FRAMEWORK

The theoretical framework for this work was chosen from earlier research conducted by Ullman [1], Elfving and Fagerström [2], and the case study which they conducted. Central for this work are the concepts of product development efficiency; information and knowledge management; co-ordination and communication; and decision-making in product development.

In this work, product development is considered a process for the transformation of different stakeholders' needs into output information, which corresponds to a product design suitable for manufacturing. A large amount of information has to be coordinated in the product development process. In addition, the process itself requires and produces a lot of information that has to be managed as a part of the process. An efficient decision-making process and management support is also needed in order to support the project execution. The knowledge and experience related to the product and process will also influence the ability to take balanced decisions.

There is a wide range of factors influencing the outcome of product development [3]. In order to manage product development projects in a collaborative context, 19 factors and five categories were identified by Elfving and Fagerström [2]. Among others, integration, co-ordination, communication, trust, knowledge management and the decision-making process are factors that influence the outcome of collaborative product development projects. Each factor differs in importance, depending on the type of project and the level of collaboration required [2], [4].

2.1 Product development efficiency

Communication and the exchange of information influence decision-making and the execution of the product development process. Efficient information processing and decision-making are important for the task performance of a group.

Two different models related to efficiency will be discussed. The first model comes from the management consultant perspective. The authors Karlöf and Östblom [5] have drawn the following distinction between productivity and efficiency. Productivity relates to the cost per unit produced, while efficiency reflects the customer value in relation to productivity. The customer value may include quality, function, price and service. High overall efficiency is dependent on both productivity and customer value.

The second model originates from engineering design. The authors Duffy and O'Donnell [6] propose a model based on the IDEF0 formalism. The product development function is an activity or number of activities. The control mechanism is represented here as the goal/constraints and resources respectively. The input is represented as knowledge, information and/or data. It is transformed by an activity/activities, resulting in an increase in one or more of these elements, when delivering the output. The efficiency is defined as the difference between input and output, related to the resources (cost). The effectiveness is defined as the relationship between output and the goal/constraints. The performance is the combined measure of effectiveness and efficiency.

The models have some similarities at a general level. Both models have an outer dimension, often referred to as effectiveness. In addition, both models have an inner dimension, related to the process performance, often referred to as efficiency. The overall performance is related to effectiveness and efficiency.

Gate-models are commonly used in industry in order to improve the quality of the process execution. The gate-model can also support the project leader, serving as a road-map and to ensure that no important part of the process is missed. The model will also support internal communication. However, it is argued that the gate-models can also delay decisions, due to waiting and buffering effects. Furthermore, they do not give guidance on how to take decisions. Instead, the decision-making process should be made explicit and support those involved in product development, which will result in a more flexible and efficient product development process.

2.2 Information and knowledge management

Collaboration in product development relies on efficient management of the information exchange. The right information should be available to all involved at the right time [7]. An efficient organization also has to understand information-processing logic and its integration into the total environment in order to make appropriate decisions.

The success of engineering companies is highly dependent on how well product design information is managed and communicated [8, 9]. Engineering designers use information from a variety of sources to undertake a wide range of design tasks. It has been shown that engineers spend as much as 30-35% of their time searching for and accessing engineering design information [10, 11]. When engineers gather information, suppliers are often the mostly commonly used information source. Without access to accurate, up-to-date information, engineers may make mistakes or misjudgments on aspects of the product design. Groups can sometimes make bad decisions by not considering all relevant information and not appraising the full range of options available [12, 13]. It is also common that engineers prefer to use the information they already possess instead of searching for new input. [14].

It is a mistake to equate knowledge and information, and to assume that difficulties can be overcome using information technologies [15]. New knowledge cannot be shared in the same, friction-free way that information is. Efficient handling of IT tools assumes that the organization has a common interpretation of different contexts, which is uncommon. Where a common understanding is lacking, computer tools only allow one to exchange information, not share knowledge. Organizing for exchanges of knowledge has a great deal to do with culture and behavior. As such, it is usually meaningless to begin by investing in software [16, 17].

2.3 Co-ordination and communication

Collaborative product development can be considered a complex activity. The co-ordination of many aspects of a question, together with the interaction of different involved parties and problems, often need to be solved in an integrated manner (i.e. together with a shared basis of information). Communication and the exchange of information will influence the execution of the process. There are many objectives for communication. For example, solving problems, decision-making, integration, exchange of information, access to knowledge, or motivating people are such objectives.

Effective product development requires the co-ordination and communication of market efforts, design and production [18, 19]. Distributed product development stresses the need for efficient communication platforms that support co-operation between multiple actors for the exchange of product development information [20]. Nonetheless, one shortcoming is that product data is handled in a heterogeneous environment, which includes incomplete, redundant and inconsistent product development information [21]. This is a demanding problem within the decision-making process.

Frequent communication also enhances the organizational commitment, leading to individuals that feel they are part of the project. Finally, communication may also reduce the negative effect of rework [22] by eliminating unnecessary activities, while it is also argued that poor communication might result in project failure [23].

2.4 Decision-making in product development

The product development process model which is used defines the actual process, allowing everyone in the development team to understand decisions rationally, and preventing the organization moving ahead with unsupported decisions [24]. However, it is argued that the decision-making process needs to be made explicit as well, to fully support competitive product development.

Explicit decision-making may be applied in different creative activities, from engineering design to business strategies, though they differ in their application. This is possible because of the shared features of decisions which are; the need to distinguish the quality of the decision from the desirability of the consequence; the need to include uncertainty and to value experiments, tests, and other forms of information gathering; and the need to establish preferences for outcomes. NRC expresses this in the following way: *"Recognizing the similarities of all decision processes allows us to use important general insights in applying them; this is particularly true for engineering design"* [25].

Decisions within engineering design can be divided into different categories depending on the nature of the decision. One perspective is activities in the product development process, and Krishnan and Ulrich's "decision framework" includes approximately 30 major areas of decisions at a project level, divided into categories [26]. They found that although different organizations make different decisions during product development, they all make decisions about groups of common issues.

This is true regardless of whether the process follows a traditional product development process [27] or a stage-gate process [28]. All these processes are characterized by the production and distribution of information, interspersed by decisions, and it is the quality of the decisions that determines the time, cost and quality of the result. To be able to manage the decision-making process it is necessary to apply decision management. Decision management is the merger between On-line analytical processing (OLAP), collaboration tools and decision theory. It supports teams, enabling them to make level-headed decisions based on incomplete, uncertain and evolving information. Decision management is used to improve both effectiveness and efficiency of the product development process. O'Donnell and Duffy presented a performance measurement and management model which includes both effectiveness and efficiency but still, in comparison to manufacturing for example, it displays a lack of concrete measurement methods for the product development process [29]. These measurement methods should be further developed in order to support decision-making and learning (knowledge) as well as enabling decision management to better support the development process.

It is also vital to learn from the decisions that are made. Hatamura [30] writes that besides the need for knowing the decision process, it is important to be able to describe and transfer the decision-making process. This is also an important role of decision management.

Ullman [1] (2006) defines decision management as; "Decision management is determining what to do next with the available information, making the best possible choice with known risk as a transparent part of the process, and documenting the result for distribution and reuse". This will serve as the definition in this work. Ullman highlights the important components of managing the decision-making process. These include structured evaluation of existing information, including risk management in the decision-making, and documenting the decision rationale and results. In short, it provides a good overview of how to frame a problem, develop criteria and alternatives, and how to reach a decision. However, it does not provide methods for how to plan and measure the efficiency of decisions in the process, or how to manage the decision-making process in regard to how to identify critical decisions related to success factors in product development.

3 CASE STUDY

A case study was used as the main strategy for collecting empirical data. The aim of the case study was to identify the company perspectives of the decision-making process. Different factors that affect the decision-making process in product development projects have been identified and also discussed with the case study companies. Different principles of collaboration were also investigated in order to see if they affected the decision-making process.

The case study involved two companies, Company A and Company B. The first company was studied during two phases, in 2002 and in 2006, with the aim of studying possible changes at management level and management's view of the decision-making and the product development processes. The second company was studied in 2006 and 2007, with the aim of collecting data in ongoing product development projects and in the related decision-making processes. The aim was to come as close as possible to the studied phenomena.

3.1 Method

Case study research was the preferred strategy to use, since 'how' and 'why' questions were posed. Generally, the case study approach was used as a strategy because it is a qualitative research method suitable for investigating current phenomena in their natural contexts [31] in order to better understand the dynamics of systems [32]. It was also employed because it is a relatively easy way to investigate inter-organizational relationships [33]. A case study copes with typical technical situations, and has the advantage of relying upon multiple sources of evidence. The data collection was, in both cases, made through open interviews, semi-structured interviews, and an overview of project documentation. A literature review was conducted within the fields of efficient product development and decision-making in order to facilitate the identification of interview areas and critical factors in the case studies.

3.1.1 Case Company A

In 2002, the company was located in a mid-sized city in Sweden. At that point, the company had 25 employees but was expected to grow. The core competence was within electronic technology development (e.g., electronic circuit boards for guidance systems). The company had mainly customer oriented product development, meaning that all work was based on customer orders.

During the 2002 study, interviews were made in two rounds. First, interviews were held to further identify interview areas and to complement the data gathered from the project leaders. Second, five project leaders were interviewed, considering eight different product development projects. In total, twelve semi-structured interviews [34] were conducted during the study.

In 2006 the company had grown from 25 to 38 employees. The company was still situated in the same accommodation, but now suffered from lack of space. The company was still expected to grow, and during the year several recruitments were made.

During the 2006 study, in total five interviews were held with, e.g. CEO, Market Manager and Product Development Manager. Just like in the 2002 study, the interviews were semi-structured. The analysis of all the interviews (both in 2002 and 2006) was performed according to Kvale's so-called sentence concentration [35]. The most essential results from the interviews were interpreted and summarized according to this method of analysis. The results from the two studies were compared, looking for risks, opportunities, similarities, and differences between the two. Also, a filter was used for interpreting and analyzing the data, further presented in section 1.

3.1.2 Case Company B

In 2007, the company was located in a small-sized city in Sweden. It had, at the time of the case study, 50 employees and was not expected to grow in the near future. The core competence was within heavy machinery development and manufacturing. Three different types of projects were chosen in co-operation with Company B and included: a full product development project; the revision of a product part; and the development of a new product part. The reason why these types of projects were chosen was due to the different natures of the information processed during their product development.

A three-day study was held in 2006 to identify the decision-making process within the company's product development area. The decision-making and information processes were illustrated with the help of interviews and discussions with, in total, nine people.

In 2007, a total of four interviews were conducted with people from the Board of Directors, the Managing Director, the Market Manager and the Product Development Manager. The documentary information was important during the case study. The collection of data included management documentation such as the product development process model, project plans, and the project documentation system, among others. A background to the case was established, and an understanding of the information system and decision-making process reached, with the help of the documentary information.

During the first analysis of the decision-making process and the information system, the data was categorized into the following: 1. necessary information 2. area of responsibility 3. decisions made and 4. the decision process. This was done in order to assist the second phase with interviews.

The second round of analysis was performed after the interviews. This analysis was carried out with the support of the analysis of the first phase, and Company A's data. Similarities and connections were searched for, and the theory "filter" presented in section 1 was used to scan the data.

4 RESULTS AND ANALYSIS

This section presents the results of the two case studies. A discussion of findings related to theory will follow. Finally, the most important findings are summarized.

4.1 Empirical findings

This sub-section presents the empirical findings regarding the three different research questions: (1) the companies' views of the decision-making process; (2) what factors affect the decision-making process?; and (3) how does the level of collaboration affect the decision-making process?

4.1.1 View of the decision-making process

The two selected companies had different views of the decision-making process due to different levels of decision-making maturity. Company A had a product development model based on generic development activities (e.g., idea generation, concept development, etc). They showed no indication of explicit knowledge of the decision-making process e.g. their main focus was on the requirement specification, estimation of project time and value creation for the customer. Little time was spent on gaining process knowledge. Company B had a product development model based on their information processes, value creating activities and areas of responsibilities. Their focus was on handling the information process in an effective and efficient way. Company B had the view that if decisions are taken in a more efficient way (more rapidly), the development project will be more efficient.

4.1.2 Factors affecting the decision-making process

In 2002, Company A had the following situations in various areas of their development projects. The most essential parts from the case study are presented here.

Poor handling of requirements influenced the decision-making process since missing requirements and/or wrong requirements in specifications lead to exceeded project time (cost) and budget. Also the quality/performance targets were frequently not met due to inefficient handling of requirements.

Their lack of experience in product development influenced the decision-making process, resulting in inaccurate estimation of the necessary amount of hours in offers to customers. This resulted in budget and time over-runs.

Organizational aspects influenced the decision-making process when engineers worked in an unplanned environment across multiple projects. The decision-making at multi-project level was lacking, resulting in a poor resource allocation process and stress in the organization. Furthermore, meetings were held with a clear objective of taking critical decisions, but these were rarely achieved in practice.

Management was responsible for the project selection process and thus also the related decisions. The company did not have suitable decision criteria or risk assessment for deciding which type of customer project suited their organization and their competence. This resulted in a project portfolio with a lot of uncertainty. This in turn led to budget over-runs. Furthermore, on project level top management did not fully trust the project personnel, resulting in unnecessary waiting for decisions to be taken.

In 2006, Company A had grown from 25 to 38 employees. The company's situation in 2006 is presented below:

Handling of requirements had improved since 2002. The company had developed procedures for creating requirement specifications, resulting in more adequate requirements. Improved quality of the requirement specifications supported decision-making.

The product development teams were still to a great extent dependent on top management in product development projects, which delayed decisions and resulted in time over-runs – *"It's a huge problem that we have and I think if we had professional project leaders it would work better because the management would not have to be included quite as much"*.

The product development teams' knowledge of the development process was not fully utilized. The development teams did not have the authority to adjust the process to different projects or to different targets of projects – "*either we use the process model or we don't*". Nor did the teams have a communicated common goal or strategy from top management for product development projects.

Experience from earlier projects influenced the decision-making process positively because the company now had a well documented experience-based check list of all their major project mishaps, which they used for project risk assessment.

Organizational aspects influenced the decision-making process because no structure for assigning responsibility for decisions in projects was available – "*…it works like this - the person doing most of the project work gets to be the project leader*". The company also had difficulties assigning overall responsibility for decisions and decision-making at multi-project level was lacking, resulting in a poor resource allocation process and stress in the organization. Engineers' time was still spread across multiple projects. Another organizational issue, which had become obvious due to their growth, was that development teams were based on team members who shared the same area of expertise.

Risk management influenced the decision-making process positively. The company now had a better ability to assess risks in projects due to the experience-based check list, but at the same time the list was limited to old risks and no process for assessing potential new risks in projects was available.

Information systems influenced the decision-making process negatively, since decisions took a long time, due to difficulties handling project information. No adequate IT solution for managing product information was available. A web-based project portal had been used in one project but with limited approval from the development team.

Communication influenced the decision-making process positively in the early phases and the teams were good at transferring information from sales to engineering – "*In that meeting we try to communicate all that has been said by the customer to the project leader and he can comment on this*". They all sit in the same location so distance is not an issue when communicating internal information. However, the engineers did not communicate continuously with the customers in an efficient way – "*I would like to see more contact between developers and customers*". Informal decisions regarding critical issues that were taken outside formal meetings were not always communicated.

Change management influenced the decision-making process negatively since too much time and effort was put in to develop a "complete" requirement specification – "*… then come preparations for the development project itself and that is a lot about completing the requirement specification*". Too little attention was spent on the continuous process that dealt with negotiation, balancing and updating requirements.

Project Management influenced the decision-making process negatively. Teams were too dependent on the requirement specification (all answers cannot be included) resulting in over-belief in requirements as a support for taking decisions. Also, formal meetings were not based on good decision-making strategy (handling of: uncertain information, risks associated with alternatives, criteria evolution and consensus) resulting in delays in taking decisions.

Company B had the following situation in 2006/2007. The findings presented below focus on necessary information, area of responsibility, decisions made, and the decision process.

Information systems influenced the decision-making process. There was too much dependency on the existing information system which lacked transparency and made it hard to access the right information. There were no structured processes for how to use the IT systems at different phases of development projects or in different departments. This meant that reaching a decision took a long time due to difficulties in handling information between different parts of the organization. Delays were also due to difficulties in providing the right stakeholders with relevant information during product development (information overload).

Organizational aspects influenced the decision-making process since the company had unclear responsibilities in the communication process and thereby also difficulties in assigning decision-basis

responsibility in the decision-making process. Also no project leader with overall responsibility for the main goal of the development process existed.

Project Management influenced the decision-making process negatively since decision basis was difficult to determine for stakeholders when they were developing decision alternatives and making decisions.

4.1.3 The level of collaboration and its affect on the decision-making process

No distinction in levels of collaboration could be seen in the two cases, which meant that no specific level of co-operation could be related to different factors influencing the decision-making process. The findings were instead generic co-operation factors that influenced the decision-making process. Examples of influences on the decision-making process were:

Lack of joint views of decision basis for projects between Company A and customers influenced the decision-making process negatively and lead to rework, budget and time over-draws. Some projects were as much as 60% over budget and 70% over time because of different beliefs about what should be done. Instead of making decisions based on cooperative information between Company A and customers on evolving problems, they tended to rely on answers in the requirement specification alone.

No adequate model or/and method for customer involvement in critical decisions was available and this influenced the decision-making process in a negative way. This made it difficult for teams to asses when to involve customers in the decision-making process, resulting in wrong decisions because of too low customer involvement.

4.2 Analysis

The organizational environment together with overall priorities of the company, influence how decisions are taken in product development projects. The goal, known opportunities and knowledge of the current situation the company is in, act as part of the basis for the decision-making process.

4.2.1 View of the decision-making process

Company A's view of the decision-making process was limited and they showed no indication of explicit knowledge of the decision-making process. They had not thought of the product development process as a decision-production system and therefore did not know how to identify the domain of certain problems in their process e.g. time over-draws were not considered to be related to the length of learning and evaluation time before making decisions, but instead the company thought it was a problem of not having exactly specified the requirements. Related to decision-making theory, the company's view of the decision-making process was rather undeveloped and the ability to handle it in an appropriate way was not possible at that time. Focus on handling the development task time together with the low level of decision-making maturity, gave no opportunity for decision management.

Company B had a better view, or understanding, of the decision-making process. They had the same type of product development model as Company A, but this one also included their product related information processes, value creating activities and areas of responsibilities. Company B had the view that if decisions were taken in a more efficient way (more rapidly), the development project would be more efficient. Company B was successful in producing the right product for their customers (effectiveness) but not at handling product data, so the main issue was increasing efficiency in handling and distributing product data to people making decisions in their product development projects.

4.2.2 Factors affecting the decision-making process

Factors influencing the decision-making process during product development found in the two case studies were divided into ten categories:

(1) Handling of requirements, (2) Experience from earlier projects, (3) Organizational influence, (4) Project management, (5) Top management, (6) Knowledge and information, (7) Risk management, (8) Information systems, (9) Communication, and (10) Change management.

Handling of requirements, change management and communication - When Company A focused on speeding up their development process they looked at incorporating all answers into the requirement specification and on developing an experience-based list of project risks. This resulted in both good and bad results. The focus on the requirement specification made them more successful in gathering the right requirements from the customers but at the same time they did not have a process for requirement changes during development. They relied too much on the requirement list and instead of communicating with the customer when they encountered problems they only looked to the specification, resulting in rework and budget over-runs. The experience-based list of project risks helped them to gradually increase their risk management skills. Company B had an efficient communication process which helped their decision-making process. It enabled decisions to be made despite their lack of transparency in systems handling formal product data.

Experience of projects and Risk management– Company A relied on successfully achieving estimated project time, but their lack of experience resulted in inaccurate estimation of the needed amount of hours in offers to customers, which in turn resulted in budget and time over-runs. This was however improved over time and they learned that different employees' estimations should be multiplied by different factors to be accurate, e.g. one person estimated two days and the project leader multiplied it by three, so increased experience influenced the decision-making process in a positive way. By documenting their experience of major project mishaps some project risks were avoided. This constituted an important decision basis for the projects and influenced the decision-making positively. Company B had a long experience managing development projects within the same area of products which enabled them to intuitively avoid some project risks. Both their experience and intuition of risks impacted the decision-making process in a positive way. However, both Companies A and B did not have a process for discovering new project risks which lead to decreased efficiency of decision-making in some projects. Also, Company B's intuition of risks was limited to two, three persons and meant waiting for decisions to be made which decreased efficiency in the decision-making process.

Organizational influence – Integration of different functions was a recognized need at Company A. However, it was difficult for the company to achieve this at the time. More frequent meetings, involving production and the customers, were one of few suggestions for improved integration. Robust decision theory stresses the need for consensus within development groups but Company A had problems handling large meetings, resulting in ineffective handling of relevant decisions between different functions in the organization. Company A was also striving for better defined responsibilities, both at project and company level, and in 2006 the issue of clear responsibility and authority in the organization still remained (*"//…the condition for good decision-making is that one has authority to make a decision on the matter – that one has one's own responsibilities and doesn't have to run to the manager for all issues that come up…")*. Company B suffered from unclear responsibilities in managing and communicating product related information in the product development process. This resulted in a longer lead-time for product development and was fuelled by the fact that they did not have a project leader with overall responsibility for project success. The lack of responsibilities for information and communication impacted on the decision-making in a negative way.

Management and experience – Management at Company A played in important role in project planning, and their ability to choose projects influenced the decision-making process in projects negatively. By choosing some projects which they did not have any pre-experience or knowledge of, the project teams had difficulties in handling the decision-making within the projects. This was also related to assignment of resources when management generically assessed and assigned the same amount of project time to projects. This resulted in a project portfolio with a lot of uncertainty and in turn led to budget overruns. Furthermore, on a project level, top management did not fully trust the project personnel, resulting in unnecessary waiting for decisions to be made and, as Elbanna and Child [36] write, an insecure environment can influence the rationality of decisions made in projects.

Knowledge – Both Company A and B's knowledge of the development process was not fully utilized since it was not clear to them how to effectively and efficiently use their product development model. This was dependent on management's knowledge of process implementation and communicated common goals and strategy for product development projects. However, Company B was working

hard to continuously improving their knowledge of the development process, resulting in increased efficiency of the decision-making process.

Information systems - Due to difficulties in handling project information and no adequate IT solution for managing product information, the decision basis at Company A was not of the high quality they strived for. Company and project size called for increased use of information systems, but as Davenport and Prusak wrote, it is vital to organize for exchanges of knowledge and this has a great deal to do with culture and behavior. As such, it is usually meaningless to begin by investing in software [16, 17]. It is therefore important to first consider how to build an organization for learning and knowledge exchange when looking at how to become effective and efficient. In 2006, Company B had, on the contrary, too much dependency on existing information systems which they relied upon to provide a decision-making basis for development teams. There was too much information available to be effective. This in turn influenced the decision-making process in a negative way.

Change management – At Company A, the lack of change management influenced the decision-making process negatively since too little attention was spent on the continuous process that deals with negotiation, balancing and updating requirements. This resulted in a decision basis that was not up-to-date and accurate when team members looked for answers in the requirement specification.

Project management - The growth of Company A resulted in a clear understanding of the need for a project leader with the overall responsibility for the main goal of the project (*"We have to have a good project leader, that's something I think we are suffering from here at Company A"*). A leader that is able to make level-headed decisions is vital for project success and Company A suffered by not assigning the overall responsibility to a project leader. In 2006, functions in Company B were not integrated in an effective way, but in 2007 they made some improvements in the information and communication processes, resulting in a more effective handling of product data in the product revision, and new product part development processes. A clear picture of the information process and areas of responsibility for information helped them to communicate in a better manner, resulting in a more efficient decision-making process.

4.2.3 The level of collaboration and its affect on the decision-making process

In both Company A and Company B there were no doubts that the level of collaboration influenced the decision-making process but due to the limited data in the cases no relation between level of co-operation and influencing factors was established.

However, a strong indication of how co-operation affected the decision-making process was shown when the companies expressed the view that their main problem within product development projects was co-operation between departments, customers, and suppliers. This was also confirmed when speaking to other companies in the same geographical area. The problems lie mainly in the shared decision base, in the form of information (product and process information), strategy, and main goal. The increased geographical distance between functions in organizations can lead to difficulties regarding culture and language, thus difficulties in information sharing, which in turn implies repercussions in the decision-making process. However, many of the companies addressed in the region believe in increased opportunities as the product development environment becomes more collaborative. Thus, there are important challenges regarding decision-making in collaborative and distributed product development in the future.

5 DISCUSSION AND CONCLUSIONS

The purpose of this paper was to increase the understanding of decision-making in product development by investigating what the companies' views of their decision-making process within product development projects are; what they consider to affect the decision-making process during product development projects; and how their level of co-operation affects their decision-making process.

The two companies had different views of the decision-making process due to different levels of decision-making maturity. Company A had difficulties handling co-ordination of development tasks which drew attention away from looking at the underlying decision-making process, while Company B shifted focus towards the decision-making process by looking at the related communication process, and viewed an efficient development process as rapid decision-making. The different views of the

decision-making process within product development projects could possibly be divided into levels of decision-making maturity but there are no attempts to make such a division in this study. The different levels of maturity will be investigated in future work.

The ability to distinguish between the communication/information, co-operation and decision-making processes is shown to be an important issue for successful product development. If a company tries to "cure" a problem by focusing on the symptom the result will be failure. A clear conclusion that can be made is that both companies had little or no knowledge of the concept of "decision management," or the opportunities for improvement it could represent.

Co-operation put great demand on communication and information management, a situation which both Companies A and B suffered from. If the division of the different processes (i.e., information, communication and decision-making) is not clear to the involved parties they tend to have difficulties identifying the underlying problem, and focus on solving the symptom instead.

The demanding industrial environment of today pushes companies to increase levels of co-operation (e.g., time pressure and complex products demand higher integration of sub-suppliers), and the authors of this document argue that further research is needed to identify more extensively the factors influencing the explicit decision-making process and related decision management in product development. It is also argued that the conditions for decision-making within distributed product development should be further investigated. This should be done in order to support industries in increasing their efficiency in managing different levels of co-operation and collaboration, and improving decision management in distributed product development. This will also be investigated in future work.

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