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Abstract

In dynamic business environments, product development projects rarely proceed according to the original plan. It is likely that some changes must be made and plans or goals be redefined to adapt to changes in the business environment. Which changes should the project approve and implement, which ones to reject, and why? Earlier product development literature has largely covered planned decisions and go/no-go decision criteria in line with a phased product development process. Project management literature, in turn, suggests change management processes and practices during the project. Earlier research has not sufficiently covered criteria for change decisions that are needed between product development gates, nor a holistic approach for making such decisions in complex product development projects.

This paper explores decision criteria and change management in complex product development projects. In a qualitative, multiple case setting we characterize change management practices, decision criteria, and managers' experiences with change management in seven complex product development projects within one firm. The results report multiple parallel change management approaches differing in terms of business context maturity, type of change, and IT system use. Operative criteria dominated in the change decisions of the case projects, as opposed to more long-term oriented strategic criteria. The paper concludes with propositions concerning more holistic change management frameworks that would account for contextual contingencies.

Keywords: product development, change, change management, decisions, decision making

Introduction

Projects today seek much wider business benefits than just the reaching of immediate project goals (Shenhar 2001). In product development, this means extending the view from product functionality and project goals to business performance, customer satisfaction, and project portfolio benefits. Typically, such benefits are considered before the project and reconsidered at the decision points – gates or milestones - of the product development process (Cooper 2001).

Various strategy-related decision criteria are being used, to ensure the right focus for projects, and to increase probability for business benefits. Traditional product development decision making literature largely focuses on phase (gate) related decision making (Krishnan and Ulrich 2001) and neglects decision making on changes between the gates. Continuous, non-gate-specific change decision schemes are important, as they suggest flexibility in projects as a response to dynamic business environment.

While the traditional view on project management has considered changes as a negative issue, in an uncertain environment changes are not only unavoidable but they might be prerequisites for successful results. Projects need to be managed flexibly (Dvir and Lechler 2004, Olsson 2006). While gate-related decisions may keep the project focused, changes between the gates help the project to adapt to uncertainty in the business environment (Olsson 2006). There are also other lines of research that – instead of gate-specific decisions – covers changes made continuously upon specific needs throughout product development and other types of projects (Hsieh et al. 2004, Wu et al. 2005, Sanchez and Perez 2004, Hällgren and Maaninen-Olsson 2005, Terwiesch and Loch 1999, Loch and Terwiesch 1999, Dvir and Lechler 2004). Change management, or integrated change control, has an important position in projects' integration management (PMI 2004).

Decisions are made both at gates and upon need concerning occasional changes between the gates. Change decisions require that the change need is identified and its relevance and impacts are properly assessed (e.g. PMI 2004). Different decision criteria have been researched for decisions at gates, but such research is missing for between-the-gates change decisions. Research has not provided solutions as to whether flexibility-oriented change management in a dynamic business environment can be carried out in a robust, controlled manner. The purpose of this study is to explore the use of decision criteria for change requests of product development projects, to identify decision making approaches and change management systems, and analyze their relevance to managers' perceptions of the robustness of such change management.

We first report a literature review on the decisions and decision criteria in product development, and changes and change decisions in projects. Secondly, we introduce the case study setting, research questions, data collection approach, and analysis methods for the empirical study in a complex product development environment. Thirdly, the results of the empirical study are presented. Finally, we discuss the findings in light of earlier literature, and conclude key contributions and ideas for further research.

Literature review

Decisions and decision criteria in product development

Studies in product development management claim that having the right product concept and launching it at the right time and on the right market are among the main factors explaining product development success (Cooper 1999, 2001, Brown and Eisenhardt 1995). Such factors clearly involve making conscious choices on, for instance, what the product is, and when and where to launch. Decision, according to Mintzberg et al. (1976) is commitment for action. In product development, such commitments are made throughout the whole product development process. Earlier literature has focused on decisions regarding project selection, product launch, the flow of decisions on the gates of the product development process, and project termination. Earlier empirical studies have identified and used a variety of methodologies and decision criteria on these different decision points.

Project selection and start decisions concern which new product ideas to pursue and where to invest resources, with an intent to eliminate potential failures as early as possible. A variety of literature covers e.g. project selection, screening of product ideas, and design decisions after the “fuzzy front end” of product development. Also decisions on project portfolio selection and balancing, project selection, and resource allocation focus on this early phase of product development (Archer and Ghasemzadeh 1999, Hansen et al. 1999, Henriksen and Traynor 1999). Decision support models such as optimization models and other analytical methods have been developed and analyzed by many authors (e.g. Calantone et al. 1999, Michalek et al. 2005, Sarkis and Liles 1995, Alarcón and Ashley 1998, Jovanovic 1999, Badri et al. 2001, Liberatore and Stylianou 1995). A variety of criteria have been used to evaluate project and product ideas, e.g. fit with marketing competence, fit with technological competence, pay back time, profit, risks, process effectiveness, customer satisfaction, and uncertainty (e.g. Calantone et al. 1999, Michalek et al. 2005, Badri et al. 2001, Cooper et al. 1997, Englund and Graham 1999, Henriksen and Traynor 1999). Recent literature has particularly encouraged to seek decision criteria beyond the immediate financial benefits and suggested longer-term oriented tools to support decision making, e.g. technology roadmaps (Petrick and Echols 2004).

Product launch decisions concern when and with what product, price and market parameters the product is launched. This has been considered even the single costliest choice in new product development (Di Benedetto 1999, Guiltinan 1999). Studies of product launch largely focus on the success of products under different decision conditions. According to a survey study with almost 300 products, Hultink et al. (1999) reported that market and product type are associated with the type of decision. Decision criteria have not been in specific focus in these studies but, rather, differences between projects have been examined in terms of launch strategy before the decision, and decision content and decision success, after the decision. Hultink and Langerak (2002) reported a survey study of competitive reactions to launch decisions, rather than antecedents to them. Guiltinan (1999) reported a conceptual study on launch strategy and tactics and their relation to demand outcomes. He focused largely on the content of the decisions and actions regarding launch, and emphasized particular features and relative innovativeness of the product as the primary determinants of relative advantage. Di Benedetto (1999) reported a literature review and survey on success factors in product launch. The results largely focus on skills, managerial actions, involvement of different units and cross-functional cooperation rather than decision criteria.

Decisions at product development process gates concern, besides the start and launch decision, any go/no-go type choices during the product development process. Krishnan and Ulrich (2001) made an extensive literature review on product development decisions and identified the following typical decisions during product development projects: concept development, supply-chain design, product design, production ramp-up and launch. These relate directly to phases (Ulrich and Eppinger 2000) or stages (Cooper 2001) in typical product development processes. Earlier research on development gates has examined what the decision criteria are and how they are used at different gates (Hart et al. 2003). Hart et al.'s study prepared their criteria based on Griffin and Page's success factor studies and reported that different criteria are used at different NPD decision gates. They listed 20 different criteria later categorized into market acceptance, financial performance, product performance, and others. Hart et al. carried out a survey study in two countries to identify patterns of decision criterion usage across the product development gates. They did not report significant differences across countries or respondent groups, but noticed that the list of criteria changes as the projects proceed from one gate to another.

Project (or product) termination decisions concern such situations where either internal or external forces of the project cause the project or product to become either irrelevant, unsuitable, unprofitable or even harmful. Therefore, the project must be terminated before its planned end. The later the project is terminated, the more difficult the decision is due to "sunk costs" and commitments made. Especially project termination decisions involve behavioral uncertainty where the risk taking, collaboration and preferences of decision makers come into play (Calantone et al. 2003, Schmidt et al. 2001). Schmidt & Calantone (1998) suggested that for more innovative products this difficulty is even more pronounced than for incremental NPD. While termination decision does not necessarily involve separate criteria, earlier research suggests the use of procedures for monitoring the project on such factors as time, technical advances, market success, probability of technical success, and costs (Balachandra et al. 1996). Balachandra (in Brockhoff 1994) suggests paying attention to early warning signals in projects and responding to them upon need. These studies, however, do not report exactly elaborated criteria and measures which would trigger the termination decision, or help in redirecting the project to avoid termination.

Above, we have listed examples of different criteria (i.e. standards of judgment) used at the different stages of product development process. The identified criteria seem to deal with the same kinds of issues: different product or project performance factors, technology potential, market potential, uncertainties, resources, and longer term opportunities. The criteria appear to differ somewhat across phases (i.e. they evolve), and they seem to depend on the nature of product, innovation, and business environment. According to Hart et al. (2003) such criteria are indeed needed to detect problems, to identify opportunities for solving the problems, and allocate resources and exercise control to improve the chances of project success.

The above literature centers clearly around the given decision points, rather than explains decisions between the decision points. Especially in turbulent environments, product development should occur in dynamic, flexible organizations which can modify their choices even between pre-planned decision points (Calantone et al. 2003, Olsson 2006).

Changes and change decisions in product development

Between the decision gates of the product development process, decisions to project scope, plans and goals may be carried out in the form of change management. Project management and product development literature covers changes and change management from two rather different perspectives. On one hand, uncertainties and changes caused by them are anticipated and prepared for in a broad set of literature concerning risk management (e.g. Chapman and Ward 2002, Chapman and Ward 2004). On the other hand, once changes take place, they and their impacts on the project are considered for instance in terms of configuration management (Turner 1999, Bentley 2002, Bliss 1993, Leffingwell and Widrig 2003), engineering change orders (Hsieh et al. 2004, Wu et al. 2005, Terwiesch and Loch 1999, Loch and Terwiesch 1999), or more general integrated change control (PMI 2004). According to Shenhar and Bonen (1997) change management from both risk and configuration viewpoints is necessary in projects with a demanding (complex) scope and high uncertainty.

Our focus is on changes and (reactive) change management during the product development project, and we purposefully exclude (proactive) risk management. Hällgren and Maaninen-Olsson (2005) additionally differentiate between change and deviation. Deviations represent situations that deviate from any (sub-)plans in the project and they may be positive or negative, large or small. Not all deviations require change at the project level. Changes, in turn, represent realized situations with significant divergence to the project scope or plan.

Changes during product development are troublesome and costly (Turner 1999, Hooks and Farry 2001). However, product development in turbulent industries can hardly avoid changes. Wu et al. (2005) state that “perfect design is unrealistic and thus design changes are inevitable” (also Leffingwell and Widrig 2003). From the perspective of business in uncertain environments, it is rather evident that technical and market changes can never be fully controlled (Brown and Eisenhardt 1995).

Some changes to product development projects are indeed caused by external forces outside the control of the project and even beyond the influence of the customer. For instance, changes may be caused by political, economical, environmental, and third party reasons. Wu et al. (2005) noted in a road construction project environment that changes caused by climate, hazard or civilian complaints are generally hard to control in the designing phase. Customer's needs and preferences may change, market forces may change, and even the original problem being solved may change. The project owner may make strategic decisions on business focus, resources, or entire project portfolio, and such decisions may enforce project-level changes. According to Wu et al. (2005), changes requested by the owner are rather hard to prevent. Very often, engineering change orders are triggered by corrections or additional or updated customer requirements (including features and functionality) and are applied after the product release (Terwiesch and Loch 1999) or during product development (Thomke and Reinertsen 1998, Royce 1998). According to Turner (1999), it is better to change the direction in the project to fulfill customer needs than to stubbornly keep the schedule and cost target and thereby fail to serve the customer.

Other changes, in turn, stem from reasons internal to the project and are largely under the control of the project. Project owner, team members, subcontractors and surrounding actors may request changes due to a variety of reasons (e.g. Wu et al. 2005). For example, if the

project team gains new knowledge about market demand, it may itself suggest additional functionality or features even after initial plans have been fixed.

Dvir and Lechler (2004) investigated 448 projects from various industries and distinguished between two types of changes: plan changes and goal changes. Plan changes were induced by the environment - e.g. strikes, weather conditions, and shortage in resources, outside the control of the project group – and prevented the project from following the original plan. Goal changes related to project scope: they were changes in requirements, or ability to meet them within the available budget and time, or changes in circumstances that impact the necessity of the product. Goal changes might come from uncertainties in customer requirements and business environment.

Literature on change management in projects is rather unanimous concerning the necessity for an integrated way of managing changes. A general change management process typically includes recognizing and justifying the need for change, evaluating the change impact, agreeing or making decisions on how the change is carried out, and implementing the change (different change management processes are presented e.g. by PMI 2004, Hooks and Farry 2001, Leffingwell and Widrig 2003). Some change management process models include proactive risk management, i.e. influencing the factors that cause changes (PMI 2004), and others specifically encourage for the use of a formal change control system to capture changes (e.g. Leffingwell and Widrig 2003).

The above mentioned change management processes either implicitly or explicitly include the need for assessing the relevance of change and deciding on the execution of change. While external forces, such as a strike in the factory, may generate a need to decide on reactive actions to deal with change through plan modification, project goal changes are usually a result of a conscious decision by the stakeholders (Dvir and Lechler 2004). In both cases, project owner and manager may have some level of control: in plan changes decision makers focus their attention to how they will deal with the event, while in goal changes they may even consider the content and degree to which change is acceptable.

The change decision itself has two extreme options. On the one end, the project could deny any kind of change requests, thereby keeping its planned schedule, cost and scope targets. The consequence of this might be product failure as compared to market demand and customer requirements, and low business benefits. On the other end, the project could allow and approve all kinds of changes, in an attempt to ensure fit to market demand and business expectations. The consequence of such flexibility might be schedule delays, cost overruns, and, eventually, failure to close the project. Hooks and Farry (2001) describe change management as the act of balance between being too rigid (automatically rejecting all change) and trying to develop a moving target.

Research on change management currently debates the need for formality in assessment and decision making on changes. While some authors suggest rather formal change-related decision-making (Dvir and Lechler 2004, Ainscough et al. 2003, Yeo 1996) and others promote the use of fairly formal assessment methods e.g. traditional discounted cash-flow and real options (Yeo and Qiu 2003, Olsson 2006), others favor rather fuzzy decision-making (Wu et al. 2003, Hällgren Maaninen-Olsson 2005, Singh and Shoura 2005). The above mentioned studies acknowledged solely the use of financial assessment methods and criteria in change-related decision making. Research has not, yet, considered criteria for change decisions in a more holistic way, as in gate-related decisions.

Change management and criteria for change decisions

In the above chapters, we have summarized two tracks of literature. Firstly, research in product development decision making has largely focused on decisions on the main gates of the product development process: project selection and start, go/no-go decision points, product launch, and project termination. Those studies have promoted the use of strategy-related criteria for evaluating projects and making decisions. Such criteria have included project efficiency, technology potential, market potential, resource availability, longer-term profit potential, and many more. Secondly, research in project change management has examined the drivers for changes, different types of changes, change management process, and different methodologies for change assessment and decisions. This track of literature has largely been driven by construction industries and not, yet, looked into decision criteria for change decisions beyond purely financial criteria in a complex product development environment. What kind of a change management approach and decision criteria are used and needed in complex product development? This entity has not been explained fully in earlier research.

The purpose of this study is to characterize the change management approach, explore the use of decision criteria in the implemented changes of product development projects, and analyze product development managers' experiences with such change management. Our interest is to propose relevant issues to be considered in the change management of complex product development projects. More specifically, our research questions are:

RQ1. How are changes managed in complex product development projects?

RQ2. What are the main criteria for change decisions in such projects?

RQ3. How are the change decisions made?

RQ4. How do project managers and owners, in general, perceive change management in this setting?

In this study, we focus on changes from the project's viewpoint and exclude changes appearing to the individual, to a wider organizational context, and to the customer. We only focus on the external sources of changes, independent on whether they have an impact on the project plan or goals. Furthermore, we limit our scope to changes which one can decide upon. Examples of such changes are additional, changed, removed features and functionalities, changes to the activities in the project, and changes in the planned and agreed resources. E.g. weather conditions as external changes are excluded from our scope, since it is not possible to decide upon them. The impact of a change to the project can be anywhere between low and high, and can deal with one or more elements of the project plan or goals, e.g. scope, schedule, cost, resources, or quality.

Research methods

Research material

For the exploratory study, we employed a qualitative research design and used multiple-case study methodology within one company. The choice of research design was motivated by the "how" type of research questions that encourage towards qualitative designs (Yin 2004). As a research setting, we purposefully selected a complex and uncertain business environment, to best highlight the presence, relevance, and impact of changes. The context is a turbulent telecommunications network business environment.

Within this setting, we selected seven different cases which are product development projects already completed or nearly completed in telecommunications network infrastructure development. Each product typically has up to some tens of customers who are telecommunications network operators. The deliverables, i.e. the products of the case projects have been on the market for several months and are being sold to various customers. The case projects represent different product lines that are later marked with letters A through E. Each product line has the ownership of one or several different products. Each product is developed in form of consecutive releases.

The projects, later referred to in numbers one through seven, represent five different businesses and cover both established and new markets. Projects in the established markets developed new versions of well-established products, each version with additional unique functionalities. Projects in early markets were either the first or second versions of the product. The projects in product line B developed functionalities for both established and new markets. To characterize the nature of the case projects, we estimated the project scope and schedule, project complexity and product complexity as compared to the whole range of projects in the product lines. Our case projects represent medium to large scope in terms of product release nature, project budget and number of people. Regarding schedule, the case projects' schedule ranged from a short to long. Each case project's complexity was estimated in terms of multi-site involvement, external collaboration and the product line maturity, and the case projects represent the low to medium project complexity. Product complexity was estimated in terms of product architecture, product usage in the network and the degree of the product availability, and the case products represent the medium to high complexity products. A summary of the case features are presented in Table 1.

Table 1: Case projects in this study and their relative characteristics.

Project	Product Line	Project size	Duration	Project complexity	Product complexity	Markets
One	A	medium	short	low	medium	established
Two	B	big	long	medium	high	established and new
Three	B	medium	short	medium	high	established and new
Four	C	medium	medium	low	high	new
Five	D	big	medium	low	high	established
Six	D	medium	medium	low	high	established
Seven	E	medium	long	medium	medium	new

Data collection and analysis

Data was collected through interviews with decision makers at both project level and business level. Altogether 11 interviews were made, i.e. one to two interviews per project. All interviewees had worked in the case firm for many years already, and all except two interviewees were male. The project managers (7) were all considered senior personnel and they all had already managed multiple other projects earlier. The interviewees at business level (4) represented different organizational units, such as quality and product management, and had a short to long experience in their current position.

The interview outline focused on change decision criteria and change management within the case projects. In the interviews, we used a characterization of decision criteria, partly based on success criteria presented by Shenhar (2001) and complemented with portfolio and roadmap alignment items. We looked into the following five sets of criteria: project efficiency,

customer impact, business success, preparing for the future and project portfolio (see Appendix 1). Besides the criteria-related questions, the interviews included general questions on change management and its robustness.

A structured interview protocol was used to maintain consistency across respondents and to avoid bias towards the most obvious criterion categories, i.e. those expressed in the formal change management system. In the interviews we asked: Were the impacts of the changes to the following items considered, while making the change decision? The list of potential criteria was used as a template to record the respondents' reported criterion use in a consistent manner. Typically the answer was either affirmative or negative and was followed by additional comments which were typed down. In rare cases the answer was conditional on the source of the change. In some cases, the change was critical for business and its implementation became a question of business survival, whereas in other cases the change was requested by customers. Besides the criterion questions, we asked the respondents' general experiences with change management in the project. These responses were typed down by the interviewee. All interviews were performed by the same person. This ensured that the items were explained in a consistent way. Notes were taken on the answers, and a template on a pre-defined decision criteria was used.

Additionally, we collected project-related documentation and database excerpts on the change log of case projects, and they were used to further analyze the implementation, management and impact of changes. The data was content analyzed, cross-tabulated to show findings across cases, and similarities and differences across cases were sought.

Results

Change management in the case projects

We examined the general change management approach through interviews, analysis of change request templates used in the projects, and final reports of those projects that had already ended. Changes took place in all the cases. Change requests were typically initiated either by the customer directly, by customer through the product manager, by R&D personnel, and by the project team. The projects faced changes in the areas of added or modified functionality, product performance, resource availability, underlying platforms, and architectural, procedural and legal matters.

Based on the data, all case projects used a change management system that consisted of a change management process description, a template to record change requests and consequent actions, and a change control board. Change management processes in the projects included change initiation, evaluation, decision making, and documentation of changes. The case projects differed in terms of how systematic the change management approach was, what kind of decision criteria were used, the applied change request template, and projects' final report template.

The case projects differed in how systematic an approach was used for change management, and to which extent information technology was used in change documentation. Projects two, three, five and six used a highly systematic approach to change management supported with an advanced information system. These projects utilized a common database that includes an integrated change request template, has space for any relevant documentation, and records the change decision as well as chosen actions. Projects one, four and seven also used a predefined

process in their change management, but without much information system support. Instead of a common database structure, these projects stored their change request templates, change assessments, and decisions in project-specific folders in different documents.

The analysis of the case data revealed that the usage of the common database structure was related to product complexity, and the age and the size of the product line rather than other characteristics of the projects. More traditional and bigger product lines with complex products used the common database (product line B and D), whereas newer or smaller product lines with less complex products did not (product line A and E). While also product line C could be considered a traditional product line, it did not use the database system as part of its change management.

Even if all projects used rather similar templates to handle change requests, the projects differed in terms of what decision criteria were included in their change request templates. All of the projects' change request templates contained project efficiency as a decision criterion in some way, and the efforts required to implement the change. However, only the templates of projects one, four and seven included the impact of the change to schedule as decision criterion. Projects two, three, five and six, in turn, treated budget and schedule impacts more implicitly by including them in modified target setting. Customer impacts or business success were typically not recorded through the templates at all. According to the interviews, such factors were considered less formally, as part of discussions preceding and during decision making. Projects in product lines B and D used pre-screening to evaluate the change requests and their business feasibility before actual decision making.

The projects used product-line specific templates for their final report. Again, it appears that the maturity of the business is reflected in the formality and thoroughness of the report template. The more traditional product lines B and D had a more thorough and extensive template which stated explicitly which topics the project report should cover and how. The templates in the projects of these product lines also required the project to record the number of product content changes. In case of project three, the template additionally requested the effort required to implement the change, and in project five, it requested possible changes in resources. Projects one, three, four and seven used a lighter version of a report template with a focus on selected main headings for the report.

Use of decision criteria in change decisions

According to the interview respondents, criteria regarding project efficiency, customer impact and project portfolio are the most explicitly considered when evaluating and deciding on changes. Business success and preparing for the future were considered somewhat less frequently and less consistently.

Project efficiency. All interviewees responded that project scope, project schedule, project budget and product quality are considered when evaluating and deciding on changes in their projects. Interviewees' answers concerning project efficiency related factors show a high level of conformity.

Customer impact. In all the case projects, interviewees stated that product functional performance and fulfillment of customer needs are considered when making change decisions. Since a large part of change requests stemmed from the customers, the impact to customer can even be seen as the driver of change. Almost all case projects additionally

consider the impact to technical product specifications, possibility to solve customer's problems, and customer satisfaction towards the product. Projects differed to some extent in their knowledge of customer's use of the product, and the way in which customer acceptance of the product is treated. In some cases, such factors became apparent only after project completion whereas in others, also preliminary knowledge was available during the project. For example, project seven was only developing its first product and did not consider customer acceptance as relevant before the product launch, while all other projects already had at least one release on the market. Therefore, these customer impact related criteria received mixed opinions in the responses.

Project portfolio. According to the interviewees in all the case projects, the impacts of the changes on technology platform and resource dependencies were considered when evaluating and deciding on changes. A majority of projects also considered the impacts of changes to the product or technology roadmap, development of other products in the same product line, and ongoing development projects in other product lines. Wider impacts to other parts in the company beyond the involved product lines were not considered consistently across the projects. The learning experience for the next project was considered by projects one, two, three, four and five. Some of the interviewees did not analyze the various portfolio-level impacts across the company but, rather, considered the nearest product lines' portfolios only.

Business success. All interviewees were unanimous on using impact to time-to-market as a criterion when evaluating and deciding on changes in their projects. A majority of the case projects considered the impacts of changes on sales volume, business income, and potential growth opportunities. Some projects also considered the impact of the change on the overall leadership position of the company, whereas market share and company brand image were considered only by project three. Such factors were, by the respondents, considered too distant from the project. However, project six considered strongly the product brand image. The projects differed from each other especially in terms of how business success was considered as part of change evaluation and decision making. The more traditional and bigger product lines which employed a more systematic approach to change management had a two-layer approach to decide upon changes, with business success as a screening factor. As projects in these product lines faced a high number of change requests, they had chosen to screen the requests primarily based on their commercial impact before treating change requests in line with the formal change management process. This screening was done by a pre-defined team which, based on its analysis suggested to further evaluate those change requests which had a positive impact on the business success, whereas those which showed a negative impact were not handled any further.

Preparing for the future. According to the interviewees, preparing for the future was not in active use as an evaluation or decision criterion for changes during the project. The majority of the interviewees reported that impacts to future projects and product releases are considered to some degree when evaluating changes, but other future-oriented criteria were not actively considered. Rather, future market opportunities were introduced through roadmaps, strategic planning, and initiation of new projects, i.e. outside the scope of project change management. The product lines had a quite consistent approach to dealing with future strategy and technology opportunities, but not in connection with change management. Only project seven mentioned such criteria as part of change management.

Additional criteria. Some interviewees noticed that changes may generate new risks to the project and concern environmental issues that could also be used as evaluation and decision criteria in changes. However, this was mentioned in the latter interviews only.

The answers of the project manager and the business manager were quite consistent within each project. They were rather unanimous on what evaluation and decision criteria were used in the project's change management.

Decision making approach in change decisions

According to the interviews and project reports, the projects differed from each other in how decisions were made on product scope changes. Three different patterns were recognized across the projects. Firstly, in some projects, change decisions were made by the project team. Secondly, some projects used product line's management board to make decisions on changes. Thirdly, one project split the responsibility on change decisions between project team and product line's management board. These patterns seemed to be related to several change-related factors: the importance of the change, the impact of the change, decision-making culture, and way of operation in the product line.

Projects one and seven had full responsibility for change decisions at the hands of the project team. The project teams approved and rejected changes as part of their general project management. In these projects, the changes were considered as minor. The project teams had the possibility to escalate decision making to the product line management if needed, but such needs did not appear. The projects had high time pressures from the customer. The need to keep up with the original schedule forced the project teams to consciously avoid product scope changes or compensate them by dropping some other features and functionalities. In the cases when features or functionalities were dropped, the scope changes were negotiated with the product line manager.

Projects two, three, five and six used product line's management board to make decisions on changes, with project manager participating in the board meetings. The project teams were involved in evaluating the changes and provided recommendations on their implementation. These projects were active in pre-screening the change requests and their business feasibility (impact on the customer and impact on business success) before submitting them to the management board's decision. Based on its analysis, the pre-screening team made a positive or negative decision on behalf of the management board. In case of a positive decision, management board would consider both whether or not to implement the change, and when. The timing of change implementation may require further analysis concerning the impacts of the change to the project.

Project four had split the responsibility for change decisions between the project team and product line's management board. The role and responsibility of the project manager and team was of higher importance than in projects two, three, five and six. The change decision made by the management board was rather a recommendation than final decision. Instead, the project team used the conclusion of the management board as a basis for its own decision on the feasibility and implementation consequences of the change. The project team was expected to report the status of the change back to the management board.

Other than product scope related changes in the projects were not handled as formally and systematically as those characterized above. For instance, changes concerning resources to

sub-project plans were not analyzed based on the change management process. Furthermore, a fourth pattern emerged - “must-do” type of changes. Major resource changes and some feature and functionality changes were seen as such “must-do” type of changes which were decided higher in the firm’s hierarchy. Therefore, the decision was made actually before the change was even discussed. For some such feature and functionality changes, the projects applied the change management process afterwards in the form of impact analysis.

Managers’ experiences with change management

According to the interviews, change management is crucial both for the project and for the product. As the interviewees put it, “without change management, the projects would have failed”. Most of the interviewees felt that change management brought necessary structure into the project work. A change management process with its decision-making approach and way of communicating changes helped the projects. Also, the systematic approach was said to have improved the project teams’ overall attitude.

However, some interviewees stated that systematic change management involves a danger of becoming too bureaucratic and too heavy especially concerning the approval of changes. In one project, the interviewees said that project team members had purposefully started to avoid making change requests because of the bureaucracy of the change management system. As a result, the project was in risk of developing features and functionalities not needed by the customer. In another project, the interviewees reported that too many changes were being suggested and too much effort was needed to manage them according to the change management system. Many good experiences dealt with the pre-screening of change requests and a two-layer decision making system. The two step approach was seen as a way to decide upon changes in a rapid and straightforward manner, and carry out thorough analyses only for the more significant changes.

Discussion

In the above empirical study we have explored the system of and experiences from change management as well as evaluation and decision criteria for change decisions in a complex product development setting. We have attempted to identify factors particularly relevant to change management in such an environment.

Concerning the first research question of **change management system**, our data showed that even within one company there are multiple different approaches in use. The data indicated that the approaches were differentiated by the maturity of the business context and type of change. The more traditional product lines had a systematic, information technology supported change management system instructing the project teams to very consistent change requests, analysis and reports (with the exception of project three on business line C), whereas the less mature product lines relied also on a systematic but lighter process. On the other hand, while the more operative decisions tended to follow the change management process of the project as such, some strategic decisions by-passed this process. Therefore, the results show that the change management system in the complex product development projects can be considered a combination of (at least) three different approaches, as depicted in Figure 1. These findings give support to Dvir and Lechler’s (2004) study in acknowledging contextual (strategic) reasons for plan changes. The findings also suggest that a single, integrated change control system (e.g. PMI 2004, Hooks and Farry 2001, Leffingwell and Widrig 2003) may be

overly idealistic to suit complex project environments which can operate in different business contexts and face many different types of changes.

Figure 1: Change management system in the case projects covered four different approaches.

In the second research question, **criteria for change decisions** were sought. Decision criteria were apparent in the projects' change request templates, but differed between the traditional and less mature business contexts. This indicates that evaluation and decision criteria do have a central position as part of the overall change management process of the case firm, but they may be quite context dependent. The interviewees clearly emphasized the use of project efficiency, customer impact and some portfolio related criteria, and considered broader business or future criteria as less used in their projects. In general, we found support to similar types of decision criteria as those used in decision making literature (e.g. Hart et al. 2003) and project success literature (e.g. Shenhar 2001). Therefore, it seems that criteria used on product development process gates could to some degree be applied also in change decisions. Again, however, our results indicate a distinction between shorter term, operative level criteria and longer term, strategic criteria, which could possibly be explained by the types of changes implemented in the different projects. However, as our data could not confirm this directly, further research is suggested on the link between types of changes and use of decision criteria.

The third research question concerned the **way of making decisions on changes**. The results suggest that both the nature of change and scope (or impact) of change impacted the way in which change decisions were made. Also the surrounding product line's maturity appeared to relate to the decision making. Changes regarding product scope were handled through the project's change management system, but varied between product lines in terms of whether pre-screening was used and what was the division of responsibility between the project team and product line management board. Four different patterns were identified in the data. Changes regarded as mandatory for the survival of the product line (e.g. major, strategic resource or functionality changes) were decided by the Product Line's management team (line I). In the case that such a decision was done, the change management system was applied to perform a detailed impact study and choose among alternative ways to manage the change. Other product scope changes utilized rather simple decision patterns where either project team (line II and IV, Product line A, C and E) or product line management board (line III, Product line B and D) made the change decision. These different patterns in change decision making are illustrated in Figure 2. The results are in line with e.g. Hällgren and Maaninen-Olsson

(2005) who suggested that different tactics are needed to manage different deviations. Where Hällgren and Maaninen-Olsson's case study distinguished deviations in terms of whether they had occurred before and what kind of knowledge was needed, our study identified the scope (or impact) and nature of the change calling for differentiated change management tactics.

Figure 2: Identified alternative patterns in change decision making.

The fourth research question focused on project managers' and business managers' **change management experiences**. Interview results in this study support the need for systematic change management, earlier proposed e.g. by project management standards (PMI 2004). The results at the same time repeat an earlier concern for the rigidity danger in change management (e.g. Hooks and Farry 2001).

Conclusions

The results of this study raise three issues as main contributions of this study. First and foremost, throughout the discussion section we have identified a distinction between operative and strategic change management. These two levels of analysis were apparent in how changes were managed, decision making criteria, and way of making decisions in the complex product development projects of this multiple-case study. Our data indicated that the more strategic decisions somehow "by-passed" the formal change management system, which may be an inherent characteristic of a dynamic, complex product development environment. Rather than abide by such a by-pass route, we anticipate that strategic changes would require somewhat different a system, possibly a more informal one, than the smaller-scale operative changes. Therefore, we see an evident connection between change management research and strategic decision making research. They could be combined and empirically explored in future studies.

Second, the results suggest that the context in which changes take place seems to have an impact on how changes are and should be managed. In particular, our results raised the maturity of the surrounding business as a relevant contextual factor which was related to the thoroughness of the change management system, use of IT support as part of the system, and also the decision making approach. Therefore, we are inclined to suggest a contingency view

to change management instead of or as part of company or industry-wide standards. On the other hand, the product line, business or company-level system of change management could actually be characterized as a repertory of alternative change management tools and tactics, each designed for different types of change events.

Third, the alternative patterns of decision making that were identified in this study add understanding about the tactical steps in making change decisions. The role of a screening team was highlighted, especially when the number of change requests is significant. A participatory approach to assessing changes and their impacts was experienced as positive by the interviewees, thereby promoting the use of such involving tactics of change management. The position of a screening team in comparison to the project team or the product line management board was not examined in this study purposefully. Due to the perceived importance of such a screening team, according to the interviewees, further study is suggested in the different project roles concerning change management.

These findings contribute to change management and product development decision making research by a proposition to develop more holistic frameworks for change management. Such a framework should cover different changes not only in terms of their source but also in terms of their business context, strategic vs. operative nature, scope, and alternative tactics for their management. Furthermore, we conclude that change management processes may not be as simple and straightforward as indicated in the models presented in earlier literature.

Limitations

The single-company, seven-case setting with a limited number of interviews causes limitations to the generalizability of the research findings. While the qualitative approach itself causes limitations of generalizability, we took several steps to improve the overall quality of the design. For instance, we have described the research procedure, data nature and analysis steps as thoroughly as possible to improve the transparency of the process to readers and reliability of findings. We utilized literature to develop a framework for gathering data and analyzing especially the decision criteria. Additionally, we utilized multiple sources of data – interviews, project documentation and change management templates – to improve the validity of the results.

We are aware that the case projects develop complex products in a limited industry segment, and therefore the results may be limited to that kind of a setting. The projects were a subset of a larger portfolio, and we have tried to characterize their features as compared to the entire portfolio to illustrate the representativeness.

The choice of interviewees may have impacted the results. The interviewees were managers responsible for the projects either from project or business management viewpoint, which may skew the findings towards optimism in the use of decision criteria. Managers may act differently from what they say they do, which is always a concern in self-reported data. The use of interviewees on two different organizational levels on most case projects helped increase the reliability of responses. However, had more interviews been made and some with project personnel, the results could have been somewhat different. More comprehensive research is suggested to test and verify the findings.

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Appendix: Check list used in interviews

Project efficiency

program scope
program schedule
program budget
product quality

Impact on the customer

functional performance of the product
technical specifications of the product
fulfilling customer needs
Solving a customer's problem
The customer's use of the product
Customer's acceptance of the product
Customer satisfaction towards the product

Business success

Commercial impacts: sales volume
Commercial impacts, e.g. money: profit or growth potential
Commercial impacts: timing of market entry
Market share
Company brand image
Company leadership (position) in certain areas (Customer's perception)

Preparing for the future (infrastructure impacts)

Future market opportunities
Future technology opportunities
Ideas for future projects / products
New strategy / change of strategy

Project portfolio

Product or technology roadmap
Technology platform (changes)
Resource dependencies, i.e., resource impacts to the other projects
Development of other products in the product line
Development going on in other product lines
Wider impacts elsewhere in the company
Learning experience for next (more important?) project