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Use of Information Management Systems from Designers' Perspective

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Abstract

In product development research, studies that aim at identifying best practice methods and processes are often conducted. However, it is also essential to learn about causes for bad practice and to gain understanding about how to avoid it. In complex product development, design engineers have to meet the challenges of increased product functionality but their needs for multidisciplinary integration of information are not sufficiently met by existing information management systems. This prevents the design engineers from working at their full capacity and inhibits the possibilities to get support for innovative and value-adding work. This paper aims at identifying reasons for non value-adding work that is linked to inefficient information support, and especially to the use of information management systems. It can be concluded that designers have difficulties to acknowledge positive effects such as better product quality or lower costs that are connected to the use of information management systems. It is argued that one potential means for improved information integration is by managing a trade-off between standardised and customised IT tools and systems.

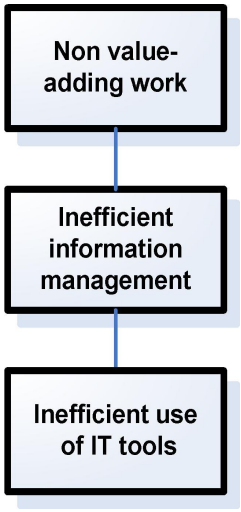
Keywords: Information management, complex product development, lean product development, non value-adding work

1 Introduction

In order to stay competitive when developing complex products, companies continuously have to improve their cost and time efficiency while producing products with higher quality and improved functionality. To manage the complexity, specialised departments have to collaborate in order to effectively meet customer requirements. One effect of the complexity is a significant growth of product data that has to be shared on an enterprise wide level. The need for information integration put demands on organisations to establish formal information channels such as structured IT systems that can handle an extensive amount of information and integrate IT tools, so that engineers they can make use of the available information.

Organisational and product complexity implies that engineers today allocate a high proportion of development time on activities that are not regarded by engineers as value-

adding. Non value-adding work[1] within an organisation serves as a starting point when refining this research approach into partial problems as shown in figure 1. Related research in lean product development focuses on how to enable lean in new product development [2, 3].



According to Chao et al [4] information systems can play a key role in supporting lean product development. Product lifecycle management (PLM) systems has also been addressed as a means to reduce non value-adding work [5]. Therefore, in figure 1 a basic assumption is that inefficient information management can be identified as one source for non-value adding work. When refining the problems further, inefficient use of IT tools[2] can be seen as one explanation for problems with information management in IT systems[3] and is regarded as one key to waste-elimination in complex product development.

Research Purpose

This paper aims at identifying reasons for non value-adding work that is related to inefficient information management. The objective is to investigate in what ways IT systems can support and improve information management among design engineers. The study has focused on two major areas: information sharing and the use of IT tools and systems. In order to explore these issues the following three research questions have been stated:

1. In what ways is information shared within the organisation?
2. How can use of information management systems be encouraged?
3. How can the use of information management systems be more effective?

The need for well-organised information in complex product development organisations has been the subject of related research [6, 7], where it is argued that information managed by computer systems has to be based on the understanding of how engineers work. Although, the user is said to be in focus of most introductions, it is important to gain further knowledge on engineers' attitudes towards use of information management systems in complex product development. The issues of information exchange and collaboration in complex product development and the difficulties with tool and system integration, and diverse traditions within multidisciplinary contexts have to be further researched. This study aims at exploring addressed issues with the objective to gain a better understanding of users' attitudes and needs towards PLM systems.

User Involvement

Even though IT only offers a part of the organisational gain [8], difficulties with successful IT tool support lie in education and commitment [9]. Sutinen et al also suggest several guidelines that are important when addressing the usability of IT tools. Problems concerning tool introduction is also the subject of Ottersten and Balic [7] who prescribe a structured process for successful tool integration. In order for a tool to become easily accepted by users it must fit into a company's existing development process and be easily integrated with tools

[1] Non value-adding work (or waste) is anything other than the minimum required for mission assurance [1].
[2] By IT tools we mean software that is used for specific designing tasks such as CAD and FEM tools.
[3] By Information management system/IT system we refer to PLM system and similar cross-disciplinary software for communication and management of product data. The two terms are used interchangeably.

that are already in use [10]. In addition, presumptive users have to experience a need for an IT tool or system to become motivated users [11]. The importance of tool integration in PLM system as a means to better support product development has been the subject of extensive research [12-15]. Garetti and Terzi [16] present an approach that focuses on organisational change and knowledge management to improve the innovation ability with PLM.

Esrock [17] states that successful technology adaptation and how technology is spread through social systems relies on more than the mere issue of whether there is user access or not to the technology itself. The technology acceptance model recognizes beliefs and attitudes to be an important aspect of technology adaptation [18]. Regarding technology as socially constructed, Askenäs [19] introduces a model that describes the relationship between organisational structure, technology, individuals and the use of technology concluding that technology has both a passive and active role in organisations. Thus, isolated IT-based information systems add little value to the organisation. The true benefits resides within the organisational activities [8].

2 Methodology for Data Collection and Analysis

This paper is based on an interview study that has been carried out in an automotive company. In this study 15 interviews were conducted in March through April 2006. A qualitative investigation method was chosen in order to be able not only to describe the situation but to grasp connections between different technical functions. Semi-structured interviews were chosen to give room for unexpected issues to evolve [20]. The interviews were carried out by the authors and lasted on average for two hours.

The study took on a user perspective (figure 2) addressing information sharing and the use of IT tools and systems. *Information sharing* regarded ways in which the interviewees collaborated and shared information across the company and the extent to which these activities were supported by the available IT systems. *The use of IT tools and systems* addressed designers' willingness to accept and use information management aids. This was done to investigate the information integration and the need for tool and system customisation. The respondents were selected either from the electrical/electronics or the body department in order to include the problems surrounding complex development. The development of the body consists of mainly mechanical engineering but the dependence on the electrical/electronics function makes it necessary to work cross-functional in all stages of the product development. The choice of interviewees grew organically, originating from initial contact persons at the company. The respondents were project leaders, middle managers and design engineers. Both tool experts and ordinary designers were included in the study due to their diverse needs [6].

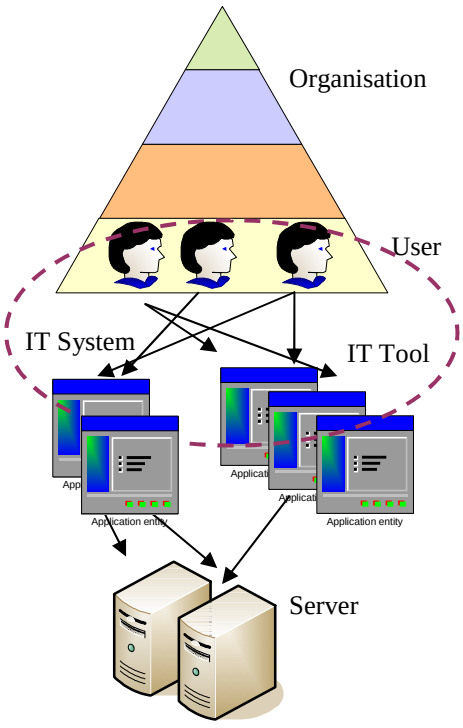


Figure 2 The interface between IT tool/system and user as unit of analysis.

In addition to the qualitative data collection some structured questions concerning the use of IT tools were posed. The interviews were combined with observations on how the

respondents used their IT tools and systems in their daily work. After the data gathering, audio recordings were transcribed and put together in a document in order to code and analyze the material. Verification of the results has to some extent been done by discussing the results with selected respondents and research colleagues. The findings have also been compared to the results of other researchers.

2.1 The Industrial Case

The company taking part in this study is a manufacturer of automotive products and is part of a larger international group. Product development is carried out and managed both in global platform projects and in local development projects for derivatives of the specific platforms. At the time for the study, the company went through changes in the development process adapting to multi-brand platform development. The company was also in progress of implementing a new PLM system.

3 Findings and Analysis

Findings, related to the research questions, and that are seen as potential causes for non value-adding work are categorised in the following two sections. Each presented finding is followed by an analysis that connects the findings with previous research.

3.1 Information Sharing

A general opinion among respondents was that a large proportion of their daily work was spent on searching for information. Three main information searching activities (figure 3) performed by the respondents have been identified from the interviews: formal requests typically made by sending an e-mail or by filling out a form, meetings where information is gathered through an exchange between individuals, and by finding information on their own, for example through searches in databases. The different activities are often performed in parallel and may all include the use of IT tools and systems. However, the last approach does not require the involvement of other people.

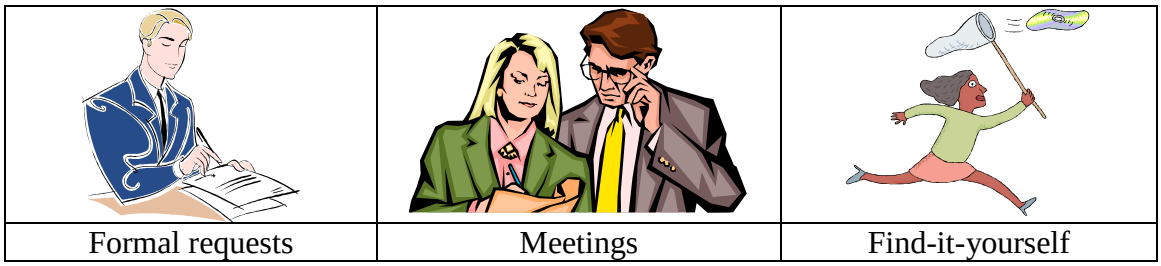


Figure 3 Ways of retrieving information, identified at the studied company.

The majority of the respondents considered personal contacts through meetings to be a shortcut to information and regarded it by far to be the easiest way to get information. Many interviewees even expressed an unwillingness to place formal requests, mainly because this was perceived as a time consuming activity. When it came to the alternative to collect information through the use of IT systems, almost none of the respondents thought this to be a main information source. Findings show that the data often is available but information about where to find it and which tool or system to use is sparse. Difficulties with knowing where to look for information the first time it was needed was emphasised as a usual barrier. The respondents therefore expressed a need for structured ways to learn how to search for information in order to be effective in their database information retrieval.

In contrary to personal contacts, information management systems only require one person at the time to be involved in the information exchange. Hence, information management systems can contribute to reduce the total time spent on information retrieval, and non value-adding work. Information posted in the information management system has to be available to all engineers, regardless of their engineering discipline belonging, in the sense that it is understandable as well as easy to find. Information management systems that support model-based development could make information retrieval easier since requirements and solutions are represented by models (figures, diagrams and geometries) instead of via text based specifications. These models would help design engineers to get more accurate and detailed information that is easy to take in [21].

Meetings

The respondents perceived that they spent too much time on activities that are not value-adding in the sense that they did not contribute to the actual development progress. For example, respondents stated that there are too many meetings and that very few of the attended meetings were meetings where decision-making actually took place. Instead the meetings worked as forums for information sharing. Even though informal agreements were frequently made at these meetings, there was a frustration among interviewees that they did not have the authority to take formal decisions. Although this is the case, respondents continue to attend meetings as a safety measure in order to guard their own department's interests. When a decision can not be reached in one of the appointed fora, it has to be taken to a higher hierarchical level in the organisation, requiring a lot of effort from the involved design engineers since they have to "accompany the issues" and give detailed information to several managers (figure 4). Many of the respondents felt that the ongoing company change towards a more hierarchical decision-making resulted in the feeling of not having control over the outcome of their own work. In addition, they had to rely on managers that they perceived had insufficient information or not enough detailed technical knowledge to make well-based decisions.

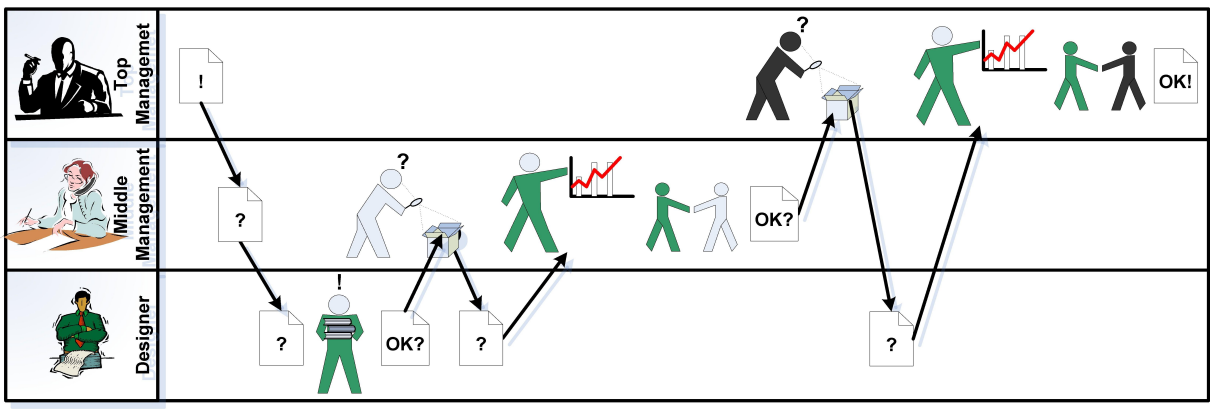


Figure 4 Hierarchical decision-making with delegated responsibilities requires the same information exchange over and over.

It is discussed that one motivation for respondents to attend meetings could be their eagerness to participate, in some way, in the informal decision-making, knowing that when related questions are brought up on several consecutive meetings you have to attend in order to be influential. Bragd [22] states that although a multitude of meetings are held without any formal decision-making, the kind of directions that do take place at these meetings are later to be classified as decisions. One possible measure to overcome non value-adding work connected to time-consuming meetings could be to clearly define organisational roles as well

as responsibilities, enhancing the possibilities to come up with quicker decisions without the need for one designer to convince and inform several co-workers.

Hierarchical decision-making in the studied company could be seen as a necessary outcome of the development of product platforms that requires more synchronisation both within departments and cross departments. Also the cooperation itself requires a more formal terminology used in the information management systems, in cases where collaboration cross-functionally and with global partners is needed. The number of recurring everyday questions that comes with numerous management levels could most probably be reduced dramatically by the use of efficient information management systems. These allow reduction and reuse of information, which makes it possible to relieve design engineers of the overwhelming burden of shovelling information up and down in the company hierarchy.

3.2 Use of IT Tools and Systems

When approaching the interviewees with their use of IT tools and systems respondents addressed three major issues: education, incentives for tool use and adaptation to work procedures.

Education

According to the respondents, when a new IT system was introduced, it was expected that co-workers assisted each other with guidance and teaching. Though, on some occasions key users were given detailed system introduction, and were then supposed to educate other users at their department. A consequence of this practice is that wrongful use and misunderstandings were inherited from user to user. Almost none of the respondents had received any training in information management. Not even the product data management (PDM) system that had been used for 30 years had any courses connected to it. Respondents found it remarkable that there had been no training in the use of PDM systems, whereas for engineering tools such as CAD, experts were educated up to a year, full time. In the 30 year-old PDM system this led to redundant information being stored several times with different names, used by different departments. This makes PDM functionality as for example traceability, virtually impossible to perform.

Research states that problems recurring when introducing IT tools can be overcome through the use of clear guidelines and a structured process [7, 9]. When employed, engineers are given an introduction course to learn about the product development process; if this could be done in combination with the major information management systems used at the company a higher quality of the future data could be assured. By performing education and introducing the future users to the tools, not only does the company acquire a quality control of the information, but also the possibility to show and motivate the future users in how and why the systems help the company produce better products.

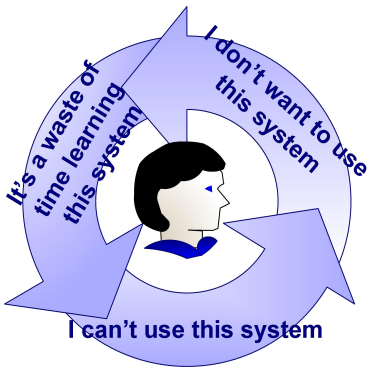


Figure 5 User's reluctance to invest time in adapting to new IT systems.

Incentives for IT Tool and IT System Use

What motivates the respondents to use IT systems? When asked, the interviewees did not instantly connect the use of information management systems with any direct effect on product quality. Any possible connections between IT systems and cost or time expenditures were also perceived as vague, which contributed to an evil spiral where the benefits of the tool/system were not seen. One implication is that presumptive users do not want to spend time learning the system, which leads to that they can not use the system in a way that benefits their work (figure 5). Tools where the benefits of using them are obvious, as for example tools that offer a good product representation by visualisations or tools that have superior functionality compared to the old IT tools, were easier for the respondents to gain acceptance for.

In addition to the users' perception of a technology's usefulness and ease of use [23], the attitude in organisations towards tool use has to be addressed in order to motivate users to use their IT tools and systems properly. Incitements that are perceived to be important when practising a development process [24] should be considered as important when it comes to the use of tools. Thus, it is essential for users to see the connections between IT tools and the needs for tools such as supported work procedures, improved product quality, reduced lead times, increased dependability regarding information, and less administrative work. After all, IT tools and systems are integrated in the product development process.

When introducing a new tool based on a top management decision, it is important to identify to what degree users are receptive to this introduction. Presumptive users are not motivated to use the new tool if it has been forced upon them. Instead, it is argued by the authors that the system introduction can be compared with a sales process. If the majority of the engineers are happy with the specific tools in use, as illustrated left in figure 6, introducing a new tool is going to be difficult, and should involve convincing the user of the need for a new tool. In this case it is important to gain understanding for new tools by getting the designers enthusiastic about the new possibilities obtained by them. In comparison, if the tool users are very disappointed with the current work procedures it is not needed to motivate users but the change itself is a way to achieve motivated users. In this case a quick introduction and even prototype solutions that evolve over time may be incorporated.

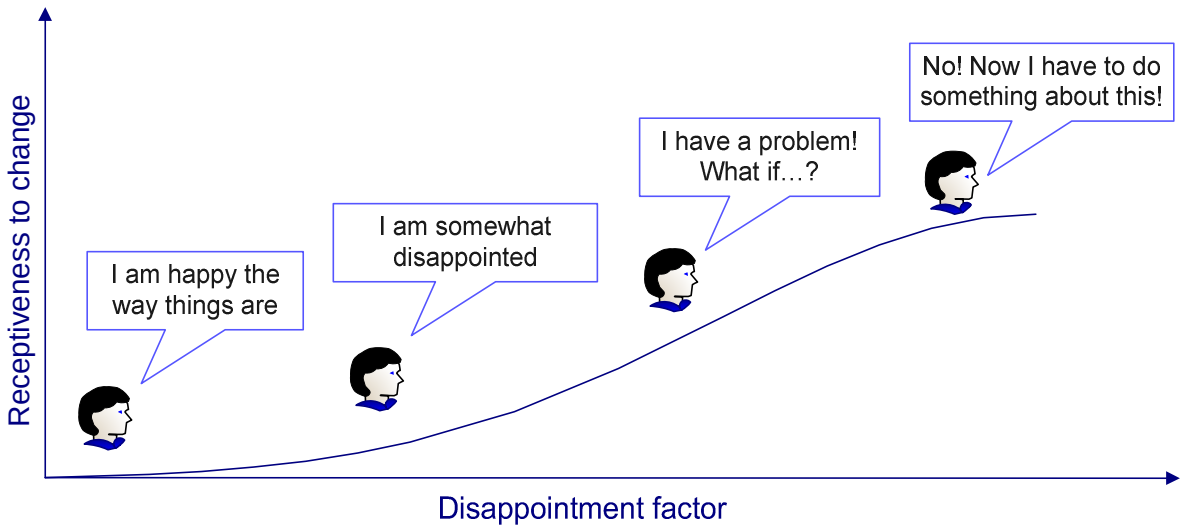


Figure 6 Users' receptiveness to the introduction of an information management system. Inspired by a sales process [25].

Adapting Systems to the User

When introducing a new information management system the interviewees stated that it was very important that existing work procedures were closely considered. It was regarded important that the systems were flexible in the sense that they could be adapted to the product development process, rather than having systems based on static information models that required users to change.

When it comes to user adaptation, the fact that there are clear differences in the way information is used by engineers from different design contexts [6] makes it hard for management to define the design of information management systems to fit all users. The issue of managing the integration of IT tools and systems is addressed by Malmqvist [26] who illustrates how customisation has to be made in order to achieve cross-disciplinary system integration. Clearly, when adapting information management systems in organisations, trade-offs have to be made affecting the organisation, user and IT support. In accordance with the research of Garetti and Terzi [16], analysing the findings shows that it is important to find a balance between customising information management systems and adapting them to over time changes of product development processes. In complex product development where there is a need for multidisciplinary collaboration, a major challenge is to balance the needs of support for both engineering and information management. This trade-off is illustrated in table 1.

Table 1: Trade-off between customisation and standardisation.

High support for engineering	Trade-off	High information management support
Customised information management systems that allow high engineering support	Balance between different stakeholders' interests	Use of the best available standardised information management system for system integration
A bottom-up approach gives support for multi-disciplinary engineering needs	Mixed approaches allows data transparency and adequate engineering support in the organisation	A top-down approach concludes what information that needs to be stored and shared in the information management system
Specialised tools and systems can be chosen for each task	Trade-off between design functionality and system integration aspects	Off-the-shelf products that are known to work together are chosen
Information management systems are based on work procedures	Adapted to the company formal development process	Information management systems are based on standardised product development processes

In line with other research findings [7, 9] the study also shows that the respondents are more willing to adapt to standardised tools if the tools are mapped against existing development processes in an early phase of information system introduction. It is argued that different viewpoints from affected stakeholders have to be recognised early on, especially since the wishes of design engineers often are focused on daily problems, implicating that this viewpoint alone might not be sufficiently visionary to include future organisational and system needs and opportunities.

When considering complex organisations developing complex products, integration problem with system to tool becomes more evident. The gain of having an integrated approach to information management is more accurate data exchange, but the immediate loss is a lower

degree of engineering freedom. Even though tailor made tools can be successfully introduced as a bottom-up approach [27], a balance between work procedures and standards has to be obtained to achieve sufficient tool-system integration in a way that permits the company to be reasonable flexible and cost efficient.

4 Discussion and Conclusions

Reasons for bad practices in the scope of this study are summarised in figure 7, explaining the addressed problems of non value-adding work inefficient information management, and inefficient use of IT tools.

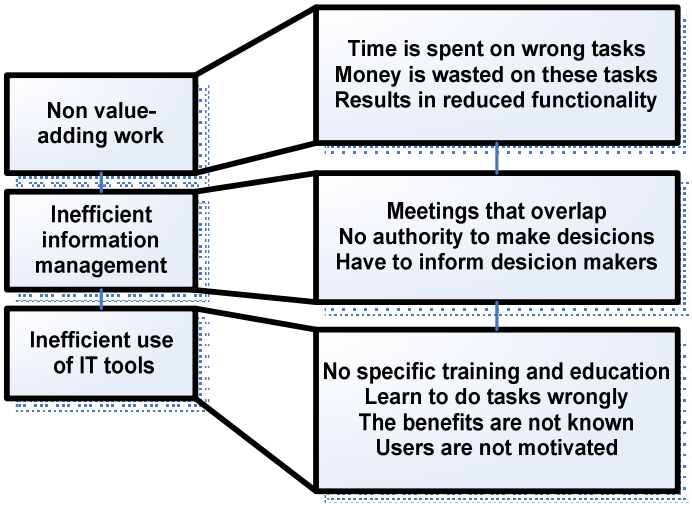


Figure 7 Bad practices from users' perspective.

From the study the following can be concluded:

- Most interviewees found that informal meetings and personal contacts was a shortcut to retrieve information.
- The most common barrier for finding new information, or a new type of information was the problem of knowing where to look for it.

It is the belief of the researchers that accessible information management systems, e.g. knowledge-based systems in connection with PLM systems significantly can improve the effectiveness of retrieving and conveying information. It is argued that the reason for preferring personal contacts is that the procedure of retrieving information via the PLM system is not as well known nor thoroughly established in the organisation. Improved systems that are easier to work with and where the information retrieved can be trusted would reduce this incentive. It is however not argued that information systems should or could replace all types of communication. However, there is a potential for facilitating and formalising a large quantity of the information channels.

- Even though informal decisions and agreements were frequently made at meetings, lack of authority makes it hard to take formal decisions.
- The complexity of the issues and the lack of technical knowledge, in combination with a highly formalised decision process make it necessary for the responsible expert (engineer) to spend a lot of time informing management of technical solutions.

The willingness to attend meetings might be a result of that the engineer is stuck with the responsibilities but lack the proper authorities needed for decision-making. This leads to that a lot of time is spent on pushing information and decisions in the company hierarchy, rather than pursuing with the design work.

- There is a difference in how engineering tools and information management systems are introduced.
- The benefits with information management system are difficult to realise by the engineers working with them.

It can be concluded that the information management systems used today are difficult for designers to connect to positive effects, such as better product quality or lower costs. It is important for management to realise these draw backs, so that designers can be properly motivated. A method similar to a sales process would gain a larger understanding from both the engineers and the management. The sales process makes it possible to understand in what phase the users are and makes it possible to adapt the introduction to their current state of mind, possibly allowing only selective introduction measures among some of the affected users. Another way to facilitate the introduction of new tools would be to customise them, but this has to be done in balance with the needs for standardisation and data information integration.

Trying to manage the different needs and wishes from several users, located at different physical locations and at the same time achieve a well structured PLM system requires an optimal trade-off that in many cases is not to achieve. A realistic approach is to allow IT systems that show a somewhat lower tool as well as information management support, but where the balance offer a solution that can be introduced at a lower cost and at a quicker pace than any of the “optimal” solutions. This balance can be different for different companies and can evolve during time to be more adapted to the organisation and processes.

Future work involves understanding the managers’ view on information management systems. If their view differs from the system users’, this new knowledge could be used to acquire better management support. It is also interesting to further investigate the users’ need in quantitative forms by performing an inquiry investigation. Future work could also include a way to measure and compare the effectiveness of information management within different companies producing complex products.

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