

## ARCHITECTURES FOR MECHATRONIC PRODUCT DATA INTEGRATION IN PLM SYSTEMS

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### 1. Introduction

Currently, many large companies have rather separate processes for mechanical, electrical, and software development. The engineers within these branches have had different traditions, terminology and different IT tools to support their work. Indeed, the prerequisites of electrical, mechanical and software engineers differ, but they have a common need to share their information. Lately, demands on tighter integration have emerged through an underlying requirement to produce products that utilise the full potential of all three disciplines, and projects for integrating domain-specific PDM and SCM solutions are underway at many major manufacturing firms. However, choosing the best solution for the task has shown to be more difficult than anticipated, and progress towards integrated PLM solutions able to manage mechatronic development processes has been slow.

The purpose of this paper is to investigate the consequences of alternative PLM system architectures with respect to their ability to support mechatronic product development. In general, the development of a PLM solution suited for a particular firm's needs, requires a holistic approach with a simultaneous consideration of system, process, information and organizational aspects [Svensson, et al. 1999]; [Hallin, et al. 2004]. In earlier work, we have investigated process [Svensson and Crnkovic 2002] and information model [Hallin, et al. 2003] aspects. In this paper, we focus on system architecture aspects, exploring the properties of alternative architectural solutions, in relation to the problem situation at a high technology firm. Specifically, we aim to

- identify basic needs and challenges in the area
- identify principal solutions for data integration between mechanical, electrical, and software tools
- state the advantages and disadvantages of different architectures and
- state guidelines for PLM systems architecture development

The work is based on a case study where the main study object has been a multi-technology system with high software content, studied through analysis of product documentation and interviews with designers.

The remainder of the paper is structured as follows: section 2 discusses related work. Section 3 and 4 presents the research approach and analyses the situation at the studied firm. A number of alternative PLM system architectures are described in section 5 and discussed in section 6. Conclusions and ideas for future work are listed in section 7.

### 2. Related work

The introduction of a new PLM system in a large enterprise requires a holistic approach that regards the existing architectures and the political landscape within the organisation [Svensson et al., 1999;

Hallin et al, 2004]. [Hallin, et al. 2004] stresses the importance of an information focus instead of a systems focus when performing product data integration.

Several information models that act as prescriptions for how to successfully model mechatronic data has been suggested in the past. [Collier 1999] deals with the problems of multibrand platform development and show how these difficulties can be bridged by employing a generic architecture that supports multi-CAD and multi-PDM solutions in one single logical information model. Another approach that shows the possibility to support mechatronic development on a system level is presented by [Hallin, et al. 2003]. However these models do not in detail include software development and it is also questionable if it is ever going to be possible to develop a complete information model. They conclude that the development of domain specific information models is a prerequisite for system integration. The domain specific subsystems would also require a holistic system that connects them on a common integration level to manage common information.

Work into describing the development processes has been undertaken by [Svensson and Crnkovic 2002]. They are describing an approach to integrate PDM and SCM systems where the information about the hardware and software constituents is available and where it is possible to follow the maturity of the product.

The possibilities of data integration have been investigated in a number of related studies. The textbook [Crnkovic, et al. 2003] further describes the problems of PDM and SCM integration. Several cases are described as well as scenarios and approaches for successful integration. [Burr, et al. 2003] have performed a work in where the benefits of CAx/EDM (read PLM) have been investigated. In their work they show that the current integration is failing, resulting in data losses, especially when handovers occur in the development process. Further problems identified have to do with the growing scope of the softwares as they separately support larger areas of the product development process. They further show approaches to integrating product data. Another integration approach that focuses on model based development is presented by [El-Khoury, et al. 2005]. In this paper it is suggested to perform an integration based on PDM system, but extended with model based development in order to better comply with the requirements of mechatronic development.

To summarise this chapter; there is a lot of work being done in the field of PLM, PDM, and SCM integration. However, the current situation and the problems involved in mechatronic data representation have not fully been investigated. Above all it is interesting to more thoroughly investigate contextual factors and limitations such as the influences of historic and political decisions taken depending more on the latest demonstration of a consultant, claiming to have all the solutions, than on the actual engineering needs. This study aims to explore possible architectures for integration of SCM and PDM systems, and to evaluate them individually and against each other from both the engineering and management point of view.

### **3. Research approach**

#### **3.1 The industrial case**

The industrial setting for this study has been a large manufacturer of complex products, with traditional focus on mechanical engineering. The study focuses on a project aiming to improve the support for mechanical, electrical, and software product data integration (Figure 1). In this context a product documentation and system support for the development of an infotainment module (high electrical and software content) has been analysed. The firm's roots in mechanical engineering have given the mechanical engineers fairly good tools and PDM systems to manage their data.

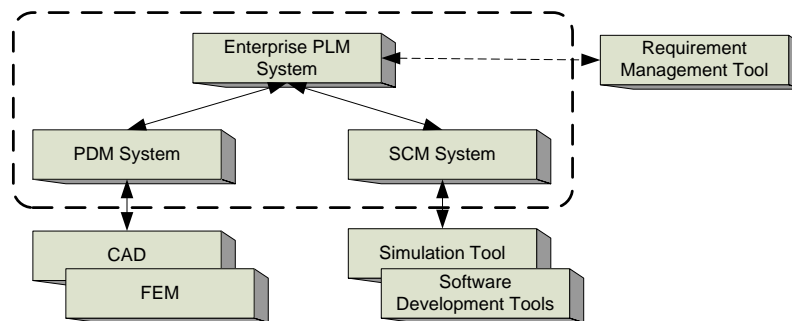
A SCM system on the other hand has more recently been evaluated and taken into practice. This has been carried out as a bottom up initiative. The lack of top management initiative in the introduction of the SCM system can be traced to alliances with other manufacturers, under the same corporate umbrella, where the recently introduced SCM system is not supported.

#### **3.2 Methodology for data collection and analysis**

The main research method of this study is mainly a document review, following documents connected to the development of an infotainment module. The study also involved searches in the company

specific PDM system and several thousands of pages with requirement documentation were investigated in order to map out the links between documents residing in different systems. All in all seven document types representing a chain from customer based properties to the most detailed software requirements and design data were analysed.

In addition, to gain more knowledge about the processes and tools, five interviews with a total of nine respondents have taken place during the autumn 2005. The interviews were conducted as semi-structured discussions with usually more than one respondent present. Topics for the interviews involved information models, requirements management, electrical, and mechanical engineering. These subjects were discussed with the purpose of creating a holistic image of the current PLM situation at the company. The interviews lasted for 2-3 hours. On follow up meetings, the respondents were given the opportunity to comment on the descriptions and conclusions of the researchers.



**Figure 1. The scope of the study involves PDM and SCM integration**

The data collected has been refined and reduced in a systematic way. The first step to reduce the data was when summaries of the meetings were written and diagrams and information models drawn up from the content found in the requirement documents. For the results presented to be credible, transferable, dependable and confirmable [Robson 1993], the findings have been tested in follow-up meetings to the interviews. The analysis also involved comparison with the result of other researchers; a strong correlation would ensure that the conclusions would be generally applicable.

## 4. Findings

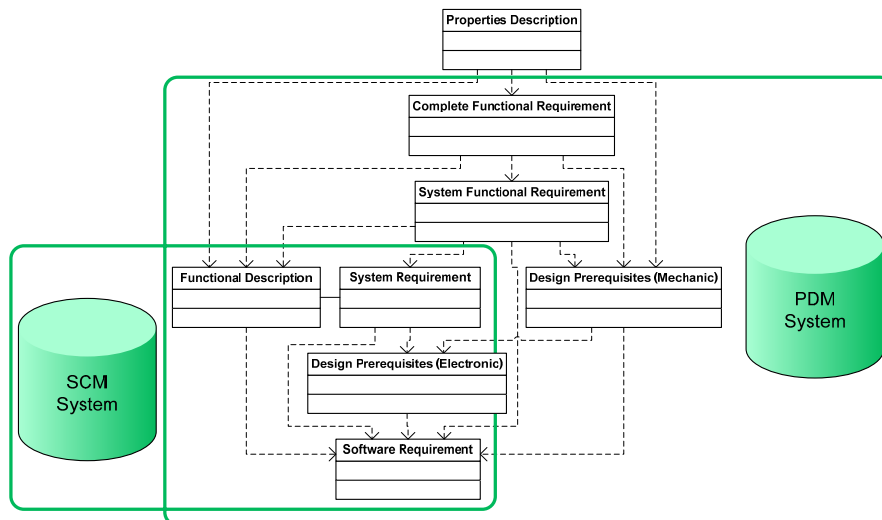
Changes in the company surroundings have increased the pressure to review the way data traditionally was managed. The development of the industry branch into producing more and more complex products finally made it obvious for the management, that the current in-house systems for requirement management and PDM were not adequate. The PDM software and the document based requirement management were getting the job done, but offered little support to the engineers working with them.

### 4.1 Requirement and document management

Documents remain the most used way of communicating requirements within the case company. The requirements are broken down into several requirement types according to the functionality of the product (Figure 2). Eight different requirement types were analysed during the study. The entire document structure is managed in a mainframe computer system. Connected to the requirement documents are also other types of documents describing standards, laws and technical regulations. The links between the specific documents can be very difficult to follow and when one document is changed it can be necessary to perform changes in up to thirty linked documents.

Some inconsistencies and variations between the document types and within the documents that need further explanation were discovered. Whilst the document structure is rather closely aligned to a systems engineering framework, the departments in the firm have been allowed to define their own versions of the document types. These inconsistencies mainly relates to the "System Requirement" document and the "Design Prerequisites" document. The "System Requirements" were stated in a

document that had their functional descriptions broken out and described in a separate document type. The “Functional Description” document contains use cases necessary for describing the software and system requirements found in the “System Requirement” and “Software Requirement” documents. For a software developer it is however also important to be aware of the hardware requirements on the product, described in the “Design Prerequisites” document. All these links to documents made the work difficult especially for the software and electrical engineers.



**Figure 2. The requirement breakdown and their connection to the PDM and SCM tool**

The “Design Prerequisites” documents are documents that not only contain requirements, but also solutions and suggestions in order to offer a complete combination of development material, adapted to each development discipline and for each development group, in a single document. The nature of this document type, to be adopted to each development group, has made it inconsistent in its content. There are examples of both model based documents as well as text based documents, written sometimes as reports and other times as proper requirements. There are not only internal differences between “Design Prerequisite” documents but also that mechanical requirements and electrical hardware requirements are described using the same name, which could be confusing. There is also uncertainty about the hierarchical order between design prerequisites documents for mechanical engineering.

#### 4.2 PDM and SCM situation

The current situation is a situation in change. The company aim has been to replace the current mainframe PDM system with a commercial integrated PLM solution. In parallel to this work, there are ongoing projects with the aim to introduce a SCM system in the electrical and software development. The PDM tool currently in use is showing flaws when it comes to handling data from all disciplines efficiently. The identified problems lie in weak connections towards other systems and applications used in the development. A lack of rules and guidelines concerning naming document types has made the PDM system difficult to work with. It would for the actual engineer be hard to find the proper links to requirements and the connected data if they wanted to, and even harder to trace related requirements and documents. The connection to the document management tool is vague and primary involves tracking document numbers. The current way to handle versions is working for managing mechanical product data, but is not good enough for electrical and software product data.

In a complex development area as electrical and electronics, the work in the PDM system has been even more difficult. Difficulties lie in several layers. On one hand the best tool for each task is wanted, on the other hand historic and supplier relationships have favoured certain integrated solutions.

Management knowledge about the commercially available alternatives has also shown to be limited, and choosing the best tool for the task has been more difficult than anticipated. Triggered by the necessity to handle the increased complexity, the employees in software and electrical development have gained support from the middle management to perform pilot projects with a commercial SCM tool to manage the electrical and software product data.

The SCM system is introduced in parallel to the PDM solution which makes it necessary to manually transfer requirements, documents and files between the systems. Requirement documents concerning electrical and software development is connected to the SCM tool but at the same time the same data is also managed and available in the PDM system (this overlap is shown in Figure 2). This leads to that the requirements that are connected to the solutions in the PDM and SCM systems are represented sometimes only in the SCM systems and sometimes in both of the systems at the same time. Even though it is easy to work with the data in the SCM tool, the migration back to the PDM tool is time consuming because this has to be done manually.

Main actors have various ambitions and emergencies that call for their attention. The need for a better system in electrical development is not clearly seen by mechanical engineers and the organisation as a whole. The future of the system is therefore uncertain, it serves its purpose, but it is not one of the tools prescribed by company standards. The SCM system chosen is also developed and supported by a relatively small firm, which makes it difficult to be accepted as a global standard within the company. There is a problem that the SCM system is becoming part of the organisation that will increase the integration problems when a new enterprise PLM system is introduced. It is also difficult for the mechanical engineers to know what is going on in the SCM tool because they lack access and knowledge about it. The practise of using a SCM tool has however minimised the use of document-based requirements for the electrical engineers. It is also the belief among electrical engineers that the SCM tool is offering better support for their work than the existing commercial PLM solutions.

## **5. Alternatives of architectures for mechatronic product data integration**

Reflecting over the findings and related work it could be argued that the breakdown of requirements at the case company is inconsistent and difficult to work with. This study does however not in detail deal with how to write and manage requirements but more on how to make sure that they are available in the interface used by the engineers and designers in their daily work. The transition from document based to an information model based requirement management system will probably by itself reduce and regulate the current difficulties of requirement relations. To have the requirements broken down according to product functionality is not a problem, but the mixture of solutions and requirements in the "Design Prerequisites" documents is problematic from an information modelling perspective. It is therefore important to extract these documents out of the requirement structure (because they are appreciated by the engineers working with them) and using them as reports connected to the solutions that they are describing.

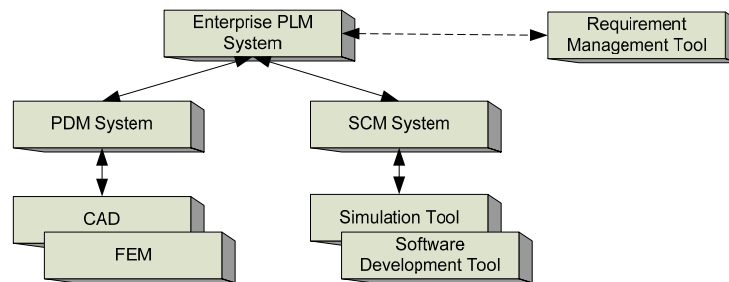
Four major approaches are identified as possible ways to connect the tools used for mechatronic product development. The approaches analysed in this chapter are simplifications, where the focus has been on PDM and SCM integration concepts related to the specific case.

### **5.1 Best-in-class**

The first approach (Figure 3) could be described as a "best in class" system [Burr, et al. 2003], where the most appropriate tool is chosen for each discipline. Integration has to take place on two levels. In the SCM case that will be from the engineering tools whose data is managed via the SCM system, and then on a second level from the SCM system to the enterprise PLM system. Keeping a subsystem for each development discipline makes it possible for that system to be highly supportive of the tools used. Because of this adaptability, the traditions of each discipline can be embraced which is going to lead to less resistance from the product designers since their interfaces towards the enterprise PLM are not changed [Dahlqvist, et al. 2004]. This approach also shows benefits of being flexible and robust; when a tool is declared obsolete it could be replaced without affecting the communication between the other tools and the enterprise PLM system. Difficulties and problems are related to the two integration levels. By having the two levels, the implementation of standards is going to be more difficult to

manage. The communication between the PDM and SCM system towards the PLM system is most likely going to be performed by a standard protocol, but in the subsystem to tool level, it is more likely going to be a software specific protocol. This could result in problems when data shall be identified and shared which could lead to data reduction or data losses [Burr, et al. 2003]. Indirect connections to other systems and in particular the requirement management tool might be inconvenient, however working with standard protocols on enterprise level would ensure to reduce this risk of inaccurate communication between systems.

Connected to the case study this would imply that a commercial PLM system is put in service and either copies or supervises the data from the local databases. This would mean that the mechanical engineers could get an interface towards the software developers and vice versa. The structure allows the use of different information models for both the PDM and the SCM sphere that would make a stepwise integration possible. The current approach with customised document (data) types would be easier to accommodate in this multilayered approach.



**Figure 3. Best-in-class: An integration system collects data from the local management tools**

### 5.2 One system as integrator

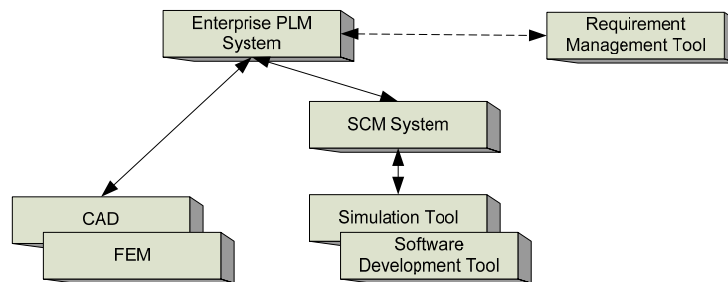
The second approach (Figure 4) would imply (to the current case) that the current PDM system is replaced and the new PLM system takes the role of an enterprise integration system. This is similar to the approach described by [El-Khoury, et al. 2005]. The enterprise level PLM system would then be customised to communicate with the SCM system; sharing information that is important for mechatronic development. This system would reduce the amount of managed data in the mechanical branch and still make it possible to keep the other tools that are giving the electrical engineers and software developers the support they need. A further advantage is the support from PLM suppliers to supply solutions for requirements management, PDM and CAD that work well together. The problem with this type of system is going to be the communication and data sharing between the PDM system and the SCM system. This is similar to the case in “best-in-class” where the communication interface needs to be available to ensure successful integration. In the future this system will be highly PLM system dependent which would make it more difficult to replace it as a CAD integrator.

In the case, this approach would need less initial work if a PLM bundle with integrated CAD tools is chosen. It is still possible to have a stand alone information model for the SCM branch while the over all information model involves the handling of mechanical product data.

### 5.3 All-in-one integration

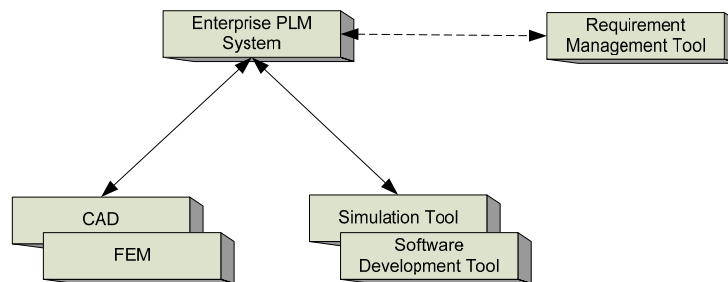
A third approach (Figure 5) would be to remove other types of management systems and integrate them into one supreme system. This approach would be similar to the all-in-one-integration concept [Burr, et al. 2003], or a full integration [Crnkovic, et al. 2003]. In practice this is going to be very difficult to implement because of the differences between the different development disciplines. It would be highly ineffective to let the PDM system take the place as a supreme system and practically impossible to let the SCM system perform the task [Dahlqvist, et al. 2004]. Other problems that might occur is if a new upcoming technology branch is introducing a tool that is not following the standards required by the PLM system, then it is going to be more difficult to integrate it, and you will have to

rely on the PLM vendor to develop support for this. Updates are in general going to be difficult to perform because they will affect all tools connected to the master system. It is also in practice going to be difficult to find a system that is taking in the needs from both mechanical and electrical engineers (and all other stakeholders) to create a truly integrated system.



**Figure 4. One system as integrator: One of the systems takes the role of integrating system**

This would imply, related to the case, that a total reconfiguration of the current information model, which might take years to implement. The development processes would have to be adapted to the new system unless major customisation projects are undertaken to adopt the system to the company's development processes. An alternative is to take a complete bundle from one of the PLM suppliers and try to work around the limitations these bundles might impose on the SCM discipline.



**Figure 5. All-in-one integration: PDM system takes the role of supreme system**

#### 5.4 Peer-to-peer integration

The final approach involves a peer-to-peer communication (Figure 6), where the systems are communicating on an equal basis. This could be related to a loose integration [Crnkovic, et al. 2003]. This approach would require every program to be modified to communicate with every other system it needs to share data with. In this example (Figure 6) there is only three systems represented, but in a real scenario there are several more applications and databases that need to share data. In the case of an update of one system, all other systems connected need to be modified in order to communicate with the new tool. However if a standard is used, this solution could be interesting because of the robustness of only using standalone software. The traffic over the network and the sizes of the product databases could be reduced since server communication is not needed. Control and supervision and error detecting is going to be more difficult when you do not have a server to log activities and make backups. However the freedom to develop domain specific information models is endless, as long as the communication between systems is according to standards.

In the studied case a problem with control and supervision has been identified, for example same name for different documents, this would be even harder to control by this approach.

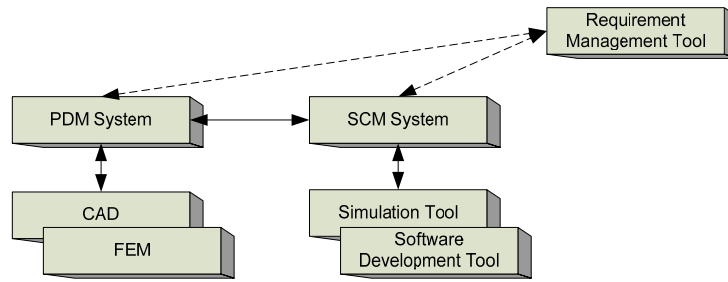


Figure 6. Peer-to-peer integration: Peer to peer communication on an equal basis

Table 1. Comparison of different approaches

Approach 1: Best-in-class	Approach 2 One system as integrator	Approach 3 All-in-one integration	Approach 4 Peer-to-peer integration
<p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>• Best tool for each discipline can be selected</li> <li>• Low introduction resistance</li> <li>• Can replace a subsystem without effect on other subsystems</li> <li>• Can work with standard protocols without involving the specific tools</li> <li>• Reduced risk of inaccurate communication between tools</li> </ul>	<p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>• High support for one of the disciplines</li> <li>• Quite high support for other disciplines as they can keep their existing subsystem</li> <li>• Can be based on PLM supplier bundles</li> </ul>	<p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>• Only one central database used</li> <li>• The tools can reach all data, since they do not require a subsystem to reach the database level</li> <li>• The correctness of the data is assured (only in one place)</li> <li>• Easy to uniformly manage changes and versions</li> <li>• Can be based on PLM supplier bundles</li> </ul>	<p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>• Not dependable on a single software or database</li> <li>• Less server communication</li> <li>• Not dependent on a single supplier</li> </ul>
<p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>• Two communication levels to manage</li> <li>• Loss of data between systems with separated databases</li> <li>• Data can be stored in several places</li> <li>• Complex management when the same data is represented in more than one database</li> </ul>	<p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>• Requires additional customizations for one system to control the other, compared to using a complete bundle</li> <li>• Difficult to replace the tools directly connected to the integration level</li> </ul>	<p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>• Needs heavy customisation or adaptation of tools and processes</li> <li>• Beneficial with tools that uses standard formats</li> <li>• High costs to replace systems and tools (Supplier dependent)</li> <li>• Updates and</li> </ul>	<p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>• Difficult to replace tools unless they are standardised</li> <li>• Difficult to supervise and to control</li> <li>• Difficult to find and correct data errors</li> <li>• Restriction and rights are less</li> </ul>



<ul style="list-style-type: none"> <li>• Can lead to bugs since you add a system on top without revising the existing subsystems</li> </ul>		introduction of a new tool involves the top system	manageable <ul style="list-style-type: none"> <li>• The data is stored and managed by several tools and databases</li> <li>• Every tool has to be customised in order to communicate with other tools</li> </ul>
<b>Summary</b> Controllable integration where the most appropriate tool can be chosen for each branch	<b>Summary</b> A compromise where tools and systems that are difficult to integrate can co-exist	<b>Summary</b> A truly integrated controllable system where data is represented in only one place	<b>Summary</b> A flexible solution where all tools co-exist with a robust but difficult to manage web of databases

## 6. Discussion

### 6.1 Integration or differentiation

The question to ask here is if it is better to have a company integrated system with lower support for the engineering, or if it is better to differentiate the development and have more specialised tools and systems that offers better engineering support. This complexity is illustrated in Figure 7. The challenge lies in how far to take the integration and (related to the case) to replace or integrate the SCM system into the future solution.

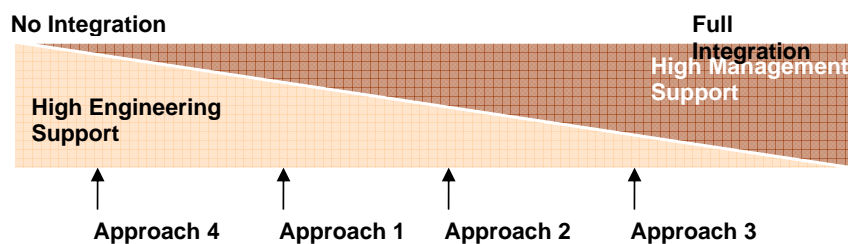


Figure 7. Level of integration

One aspect regarding cross-functional work is the political and organisational aspects of product development. The focus of this study has been on PDM and SCM integration, which seems to at this point be driven by electrical, and software engineers and their management. The understanding from the mechanical department is there, but for them this is not the most prioritised task. This has been evident during meetings when respondents did not have the same view on integration, the need for integration, and why the data needed to be shared. The approaches and commitment has also shown a variation depicting the electrical and software departments as the driving force. A need for integration and communication has become evident as a result of rising problems. Too much differentiation leads to a very specialised and concentrated knowledge where side effects could involve a low grade of invention and synergies between disciplines. Too much integration could lead to that spear point knowledge is lost and that quality problems in the details could arise. The trend in general is probably going to continue to create more and more specialised engineers, but to integrate the way data is stored and managed between departments will facilitate the work for engineers to acquire the product data they need to create modules and components that function well together.

From the engineers and designers point of view a bottom up approach that allows them to have the IT tools and systems that support their work, and that does not require changes of the current process, is beneficial. In their research [Dahlqvist, et al. 2004] concludes that it is easier to perform loose types of integration between tools already in use because it would not dramatically change the way the engineers work. Connected to the results of [Hallin, et al. 2004] this would lead to a compromise similar to “best-in-class”. Best support for the engineering perspective is given when the engineers themselves can choose the tool they want to use; this would lead to a peer-to-peer situation that is difficult to manage. However in contrast to this extreme stands the importance to have access to information from other engineering disciplines, in order to collaborate effectively.

The management perspective (top down) is all about controlling the information within the company so that the correct data is always retrieved when requested. This involves version management, change management and data integrity. High support for these approaches is given by a highly integrated system, where versions and changes are controlled from one central facility. In an approach where several subsystems are involved this is going to be managed by several servers and systems. In a peer-to-peer approach it is going to be very difficult to track the right versions because they are represented in several stand-alone systems. In the Best-in-class and “One system as integrator” approaches use of separated SCM systems it is going to be more difficult to manage versions, because these are represented in both the subsystem (the SCM system) and in the overlying PLM system. The best approach for managing data would therefore be an all-in-one integration approach.

## **6.2 Installation and upgrade possibilities**

In general and with support from [Hallin, et al. 2004] it could be said that the development of domain specific information models are essential for successful integration. If this first step was undertaken the second step of enterprise integration would become easier. The approaches presented in this chapter have different possibilities to be successful because of the installation and supplier support. The bundles available today from the largest PLM suppliers offers a relatively high maturity and are cost effective since they require few modifications. The drawback is that they do not include, to this date, a satisfactory way of managing software and electrical data. The integration approaches available through these systems therefore corresponds to the first and second approaches (Table1).

The fully integrated solution (all-in-one) is today quite immature, concerning the commercial alternatives and if used to its full extent it would require large customisations of the tools (and/or the development process). It seems like the large PLM suppliers are trying to develop bundles where “everything” is supposed to be integrated in one company wide database, but they are not there yet. This trend might also be a problem for the customers due to that the tools are so tightly integrated that there in practise does not exist an option to choose a different tool to be used in parallel with the fully integrated solution.

The loose type of integrations (peer-to-peer) has its potential but is not considered mature for a large company with many tools that need to share data. The future trend towards open source software could make it possible to use more specialised systems that can communicate with other softwares transparently, making this an interesting approach. By avoiding having one single centre that the whole system is dependent upon, that is a rather conservative view on data management, the system will be very robust. The real advantage would lie in the possibility to change and replace systems as a democratic process, where information models, communication methods and other static structures do not pose any threat. The use of standards is a prerequisite for this type of integration though adapting every tool for it would be way too time consuming.

## **7. Conclusions and future work**

When introducing a PLM system there are many factors to take into account. In the case of SCM and PDM integration there exist a number of possible general approaches to how this can be done. In this paper, four major approaches to perform PDM and SCM integration are presented. These approaches span from the integrated approaches with a single PLM system, to a solution where no integrating system at all is used.

This study has concluded that there are advantages and disadvantages with all approaches of integration. In the end it boils down to the prerequisites and aims of the specific company which approach to use. The amount of control, creativity in the processes, and tools and systems in the portfolio will considerably affect the choice of how to perform integration. Things to consider are:

- To what extent can we or do we want to rely on a single PLM supplier?
- Can we accept less functionality in order to get a more integrated IT solution?
- Are there going to be reasons for performing major changes to our system in the close future?
- Do we want to customise our tools and systems to fit the processes, or the other way around?
- Do we need integration with all disciplines or can we manage working with subsystems?

In the studied case an approach corresponding to the “One system as integrator” alternative is being adopted and the “all-in-one” alternative considered. These approaches have a high support from the PLM supplier and that calls for effective tool integration. The main problem is that the chosen PLM system itself is not good enough for managing software and electrical data on a low level. This would mean that it is going to be necessary to integrate the system with an unsupported SCM subsystem, or change the electrical engineers way of working.

This study has been the first step in a series of studies aimed to develop a demonstrator for showing how mechatronic product data efficiently could be integrated and represented in existing commercial tools. Future studies will also involve further interview studies to better map out the engineering perspective and the standards to be used in the communication between softwares. These future studies will also give the study validity by confirming not only that mechatronic product data is represented correctly but that the companies are also focusing on doing the right things.

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