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IDENTIFICATION OF PROMISING CONNECTING-POINTS BETWEEN PRODUCT LIFECYCLE - AND PROJECT MANAGEMENT

Roelofsen, J.[1]; Anwander, C.[1]; Lindemann, U.[1]
(1) Institute of Product Development, Technische Universität München

ABSTRACT
Today´s product development usually takes places in a project organization. But the "worlds" of product data and project management are not linked good enough yet to enable optimal development cycle times, cost and product quality. There are software tools implemented that support the handling of product data and others that support project management but the link between both is not implemented satisfactory up to now. This contribution takes a look at possible connection points between both worlds from three different points of view. It wants to give a hint on where a connection between Product Lifecycle Management and project management would have the most positive effects but does not introduce an interface between both types of software tools.

Keywords: Product Lifecycle Management, Project Management

1 INTRODUCTION
Product development is usually carried out in projects. Thus there is a need to link project information to product information in order to enable fast product development and high product quality. Up to now there is no satisfactory link between product development and project management information implemented even though the handling of product data and project data is supported very well by software tools. There are even some approaches to link both types of tools in overall PLM-software but these still do not support product development optimally.
This contribution takes a look at both Product Lifecycle Management (PLM) and project management tools from three different points of view in order to give a hint on how to connect the development and project management world best. The goal is to enable a better usage of project information for the product and its lifecycle during development and to use product information for a more efficient project management.
The result is not an interface for two software tools but a theoretical examination of the most promising connection points between those two types of software support.
To do so, the functions of product lifecycle management tools and project management tools are analyzed and compared. The second step is to analyze the product development process as well as the project management process and have a look at how these processes are related to each other.
Based on this analysis the process steps are identified in which an information exchange is crucial for optimal product development.
The third view is an object oriented one. Objects that are essential for development and project management are defined and their relation to each other is analyzed. For this a structural analysis based on a Dependency Structure Matrix is applied.
From these three points of view the most promising connection points between the PLM and project management world are derived and hints for a more efficient product development are given.

2 DEFINITION OF TERMS
Before the analysis of PLM and Project Management Software is carried out, definitions of the terms Project Lifecycle Management (PLM) in comparison to Product Data Management (PDM) as well as the term Project Management are given as they are used in this contribution.

2.1 PLM and PDM

The product lifecycle consists of all phases of the product life from the first idea for a product to its disposal or recycling. The product lifecycle consists of the phases: planning, product development, production engineering, production, assembly, sales, use, maintenance, recycling/disposal [1]. Product Lifecycle Management according to this definition [2] includes all activities that are necessary to administer a company´s product during its lifecycle. During a product lifecycle a huge amount of data, documents and information is generated that calls for tools supporting the generation as well as the administration of this data [3].

Main point of interest in Product Lifecycle Management is thus the product and its related processes.

Product Data Management (PDM) concentrates on data concerning the product that are generated within the company, it does not take into account information about product use, maintenance or recycling. The focus of PDM-solutions is put on the administration of CAD- and other product data mainly in product development and connecting those data to production engineering and production.

In contrast to that PLM takes into consideration all phases of the lifecycle starting with strategic product planning [4]. Most PLM-tools base on PDM-solutions that are expanded by new functionalities so as to enable a support of the whole value-added chain in the company and beyond [2, 3, 4, 5]. Some of these added functions are amongst others configuration management, requirements management and requirements tracking. [4].

One of the advantages of PLM systems is that product information is available to company members as well as suppliers independent of its actuality or point of origin. The result of the implementation of a PLM-system in a company is a continuous cross-functional information flow for all tasks concerning the development, sale, maintenance and recycling of a product [3].

2.2 Project and Project Management

The project definition in DIN 69901 puts a lot of emphasis on a project being predominantly characterized by its uniqueness of boundary conditions. These boundary conditions are amongst others target settings, limited time, budget, workforce and a project specific organization [6]. From this result the main criteria for a project that comprise of a clear task definition, a defined duration with fixed deadlines, an allowed budget and clear cut responsibilities [7, 8].

Project management according to the aforementioned project definition is understood as the sum of all executive functions, organization and management tools that are necessary to carry out a project. [6] These are activities concerning project definition, planning, control and the end of a project [7]. Project management thus aims at guaranteeing a successful project completion in time meeting quality requirements and the required costs.

Project management can be seen as one part of PLM but this aspect is not integrated sufficiently yet.

It deals with organization and administration of project information in the first place, whereas PLM is rather focused on the product. It can be explained by these different points of focus that the concepts of Project Management and PLM systems are different. Project management deals with the optimization of a process whereas PLM deals with efficient information administration. In order to integrate project management into PLM it has to be found out how the product influences the project process and its organization and vice versa.

3 ANALYSIS

In this chapter first the approach towards the analysis of PLM and project management support is described and afterwards the findings of all three points of view (function, process and objects) will be displayed.

3.1 Approach

The approach applied in this contribution is based on the consideration of how to use synergy potentials of project management and PLM as good as possible. Both concepts are highly complex and thus relations between the concepts are hard to identify. This contribution wants to identify and understand possible links between the systems. A deeper insight into the relations between PLM and project management shall help to extract reasonable links for the information exchange of these systems. Recent publications and dissertations as well as the expertise of an industrial partner that sells process and project management software and the according consulting services are the basis for this analysis.

In order to identify possible links both kinds of systems will be analyzed on a conceptual level concerning different points of view. The first view concentrates on the functions implemented in the concepts, the second one deals with the interrelation of their processes and the third view the relations between product- and project specific objects are displayed. These relations are analyzed via a Dependency Structure Matrix. The results of a discussion with a number of industrial participants are illustrated and compared to the findings of this analysis. Finally the points of view are brought together and conclusions regarding an optimal connection between Product Lifecycle and project management are drawn.

3.1 Functional view

In order to be able to analyze PLM and project management systems regarding their functions both kinds of systems have to be modeled on the same level of detail. The functions of both types of system are described in various dissertations (as e. g. [7, 8, 9, 10, 11, 12, 13]). To the functions identified for PLM-systems belong ([10, 11, 12, 13]):

- Requirements Management
- Configuration Management (Product Structure Management)
- Administration of Documents
- Data Protection
- Reporting
- Workflow Management
- Change Management
- Communication Management
- Project Management
- Quality Management
- …

The functions identified for project management software include amongst others ([6, 7, 9]):

- Configuration Management (Project Structure)
- Reporting
- Resource Management
- Project Controlling
- Quality Management
- Risk Management
- Multi Project Coordination
- …

The functions of both systems are compared to each other. What is noticed first is that project management is seen as one function of the PLM system. This is in line with the requirement of a PLM-system spanning the whole product lifecycle, but as was pointed out at the beginning of this contribution and was confirmed in the discussion with industrial partners, the integration of project management into PLM is not realized satisfactorily in practice yet.

There are some functions that occur in both systems, but have different focuses. But still integration on a functional level is seen as relatively easy.

Based on the connection of both functional models and the assumption that project management is a PLM-function the thought arises to create an overall concept that integrates project management into PLM on an abstract functional level. The integration in this case takes places in those functions that occur in both systems.

One of these integrated functions could be a common target- and requirements management, the definition of project targets on the project management side and requirements management on the PLM side can be integrated into one function as they strongly relate to each other.

Another function of interest is the reporting. Reporting on the project management side is used to survey the progress and results of the project. These reports are used for the preparation of important decisions concerning the project. On the PLM side reports and documents are generated that document results and are used for the product´s safeguarding. They consist mainly of product information. These functions are the same regarding the content of the functions but up to now they are separated in terms of data and software implementation. Thus they should be integrated to lead to better matching of product and project information.

Taking a further look at the similarities of both systems reveals other interesting aspects: the collaboration management that is part of both systems is another common function that could be integrated easily as the same kind of information is handled here.
There are other functions that have very similar names but deal with different kinds of information, that is project oriented objects in project management and product oriented objects in PLM. To these belong quality management, configuration management and administration of documents. But still there are some promising possibilities of functional integration in this area in a common goal- and requirements management, reporting, quality management, configuration management and change management.
A common reporting that could spread a bridge between product and project view is the main point of interest in this view. Requirements, configuration and change management can be carried out more effectively if integrated as changes and decisions concerning product oriented objects influences project oriented objects and vice versa.
Besides the common functions there are as well some functions to be found in PLM that should be regarded in project management as well. These are for example release management, status management and data backup. A potential for optimization is seen if the functions archiving, release and status management as well as workflow management were integrated and used commonly for the description of the product as well as the project. Release management for example consists of the releases of documents, products and projects. In order to be released the object has to pass certain states. As both points are used to manage the product and the project, these functions should be integrated as well.
There are two approaches regarded that take a functional view on both PLM and project management system. Mesihovic [10] takes a look at how to support project management by PDM-Data. In accordance with this analysis Mesihovic suggests to use the product structure to support project management. Product and project structure management are part of the function called “configuration management” in this contribution. Saynisch [14] as well sees configuration management as the central point of interest in order to achieve a product oriented project management. The suggestion in this case is to expand existing engineering and project management methods by integrating a cross-functional configuration management.
The results from the functional point of view show, that a functional integration of project management and PLM is possible on the basis of already existing functions in both systems.
A common structural management for example could be implemented by connecting the product structure as it is found in the PLM system to the project structure used for project management. This would lead to a direct connection between e.g. due dates for documents or milestones and the product part or module in question. This way project management could better influence the working level and raise the engineers` awareness for the importance of managing product development in a project.
From the development engineer`s point of view, it could be a decrease of the “unwanted” reporting work if documents and states would be updated automatically. A connection of product and project structure could thus lead to more effective and efficient product development.

3.2 Process view

After taking a look at the functions implemented in PLM and project management systems the processes these tools are used in will be analyzed. There will be given a short outline of the structure of both processes. Afterwards the connection and relation between the processes will be analyzed based on the process descriptions.
The product development process consists of the phases

- Product Planning,
- Product Design,
- Production Engineering and
- Start of Production.

In some cases the monitoring of the product in production for the first few months is seen as part of the product development process as well. In parallel to the development process project management takes place. The project management process is composed of the phases:

- Project Definition,
- Project Planning,
- Project Control and

- Project Close-Out.

During the elaboration of this work, both processes were displayed graphically in detail and the resulting Gantt-charts were analyzed as to where information exchange is essential. In this contribution less detailed graphs are shown that allow seeing the main points of interest.

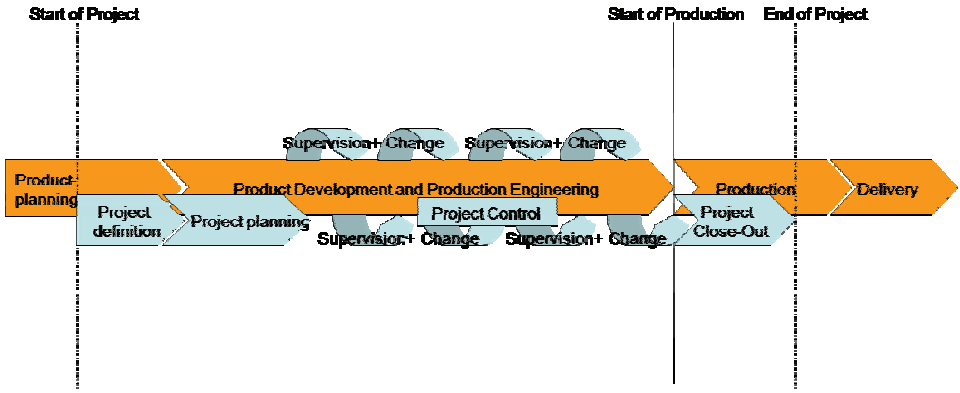

Figure 1. Product Development and Project Management are carried out simultaneously

As can be seen in figure 1, product planning usually starts before a project is officially defined, that means first ideas are collected and selected before an actual development project is started.
Planning the project then takes place in parallel to product planning and the beginning of the development phase. During product development and production engineering the project is controlled constantly and a short time after the start of production the project is closed. During product development there are continuous changes and adaptations started by project management that have influence on the product developed. Product development and project management are closely related to each other during this phase. Shortly after start of production both project control and development are ended and the phases of production and project closure are started.
After analyzing the relation of the processes concerning the process flow and connection between those, the question arises, which process steps need information from the parallel process steps and whether one partial process relies on the results of the parallel process in order to fulfill its task.
This will be analyzed in the following. The objects discussed are shown in figure 2.

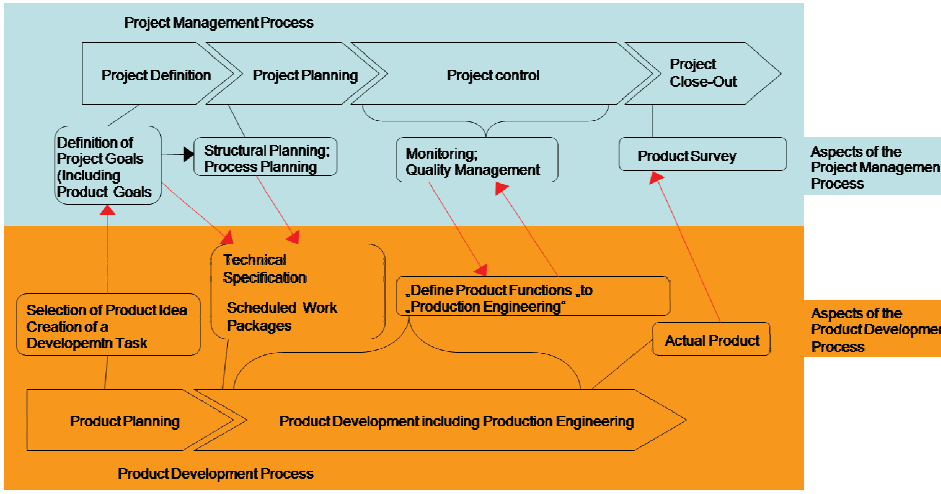

Figure 2. Information exchange between product development and project management process

During the product planning phase the product idea is selected. Financial and technical requirements are derived here as well. It would be an advantage if these requirements could directly be used for the definition of the project goals, as the information could be used without further effort and the information consistency would increase. Furthermore a complete consideration of all known product information up to that point as well as complete knowledge documentation could be enabled.

Next the project and product objectives are determined during the phase of project definition. These objectives are documented in the specification of the product.

This definition of objectives builds the basis for the product development project and is thus important for the project manager as well as the engineers. This leads to the recommendation that an interface should be generated between PLM and project management that enables a common, coherent and complete specification that can be used by all project participants. The consistent documentation and administration of project and product targets would support project control and product development so that both sides would benefit from such an interface.

The scheduling that defines time and sequence of the work packages is generated during process planning on the project management side. The results that have to be delivered at the end of single process steps or in order to pass a milestone or quality gate are necessary to control project progress, but are created concerning the product. Thus here lies a possible connecting point for product and project world as well. Based on a target-performance comparison the current project situation is analyzed during the phase of project control. If e.g. a sub-assembly is not yet as mature as planned due to technical problems the project manager has to react to this discrepancy possibly by adding more personal resources. In order to communicate the measures taken to the right persons, information exchange between product and project level is necessary. This reciprocal connection is present during the whole development and project control phase.

These are just some examples for the need for information exchange between project management and product development process. More examples can be found in Kerley et al. [15] in which a case study for the integration of life-cycle engineering into a design process was analysed.

The conclusion is drawn that an interface is required that enables the exchange of process information. This kind of interface would have to deal with the generated results regarding the product on the one hand and information about changes and measures taken on the project side on the other hand. The conceptual design of such an interface should as well consider the findings of Bitzer et al. [16] concerning the influence of process characteristics on the selection of a PLM architecture.

Up to now product information is stored and administered in PLM systems in a level of detail and in types of data that are not suitable for project management. To make this already existing information available to project management is essential for a true integration of PLM and project management.

3.3 Object view

The analysis to this point was focused first on system functions and second on processes of PLM and project management. Now the relations between product oriented and project oriented objects shall be dealt with. Objects from project and product side are chosen and their relations to each other are illustrated in one model.

The method for modeling this system has to meet certain requirements. These are:

- It has to be able to show the dependencies between the objects
- All interdependencies have to be depicted
- The model has to stay comprehensible
- It has to enable the identification of direct and indirect correlations of the objects

In order to handle the large number of relations identified that link the objects, these are analysed in a Dependency Structure Matrix (DSM). Moreover an analysis of dependencies by a DSM and its corresponding graph meets all requirements mentioned above.

The DSM is an analysis method that has many possible applications in product development as is discussed by Browning [17].

All objects are arranged symmetrically in the rows and columns of a matrix. The matrix shows for each of the objects if it has an influence on another one or not. The selection of objects used for this analysis is based on terms that are often used in literature dealing with product development or project management. It has to be mentioned that the objects analyzed are just a selection and there is no claim that this selection is exhaustive. Figure 3 shows part of the analyzed matrix.

The matrix consists of 30 different objects. It was filled by a group of experts and afterwards a tool that can be used to identify amongst others clusters or circles in a DSM was applied for analysis. While the matrix was filled during a workshop (that is a cross was put into the field where one object influences the other) the reasons why a dependency was deduced were documented for each dependency. This shall provide a better understanding and reproduction of the results gained from this method application.

		Deadline	Project Cost	Production Cost	Project
		6	7	8	9
Product Describing Document	1			X	
Process Describing Document	2	X	X		X
Product	3			X	X
Project Status	4				X
Product Status	5				X

Figure 3. Excerpt of the analyzed matrix

First the results of the analysis of the graph corresponding to the matrix will be displayed. The tool used to analyze the matrix can produce the graph corresponding to a matrix as well. This was examined for distinctive features. An accumulation of project oriented objects was detected in one part of the graph and the product oriented objects were accumulated on the other side of the graph. The center of the graph is built by a zone in which project and product oriented objects mix.

These elements of the graph are possible connecting points as the graph could be divided in a project and a product oriented part. This hints towards the fact, that most elements are connected within their domains and just the elements of the central zone are important for linking product and project level. The elements identified in the central zone are:

- Project Status
- Project Manager
- Review
- Product Describing Document
- Product Status
- Product
- Specifications

It is noticeable that the elements review and specification that were identified as promising connecting points already in the other two views occur again in this analysis.

After the inspection of the graph the matrix itself is analyzed concerning clusters. Clusters are groups of elements that are all interrelated to each other [18]. A change in one of the elements of a cluster thus results in changes of all other elements of the cluster. The analysis of the matrix revealed some clusters. One for example connects “product”, “product quality” and “test”. These are all product oriented elements and thus do not hint on a necessary connection between product and project level. The second example comprises of the project oriented objects “process describing document”, “project change” and “project forecast”. Here the same conclusion can be drawn as for the first cluster. All clusters but one consist of elements from one level. This cluster is built by the objects “product”, “function” and “review”. This review calls for a connection of product and project level or can be seen as a possible starting point for the development of a concept for an interface respectively.

It is assumed that the high interconnectivity within the single levels is met by the already existing specific software tools.

A second analysis of the matrix was carried out in which product and project level were regarded as different domains and thus the matrix was transferred to a multiple domain matrix (MDM). In this MDM the influence the product has on the project and vice versa is regarded. The findings of the first analysis were confirmed but the possible connecting points were completed by the objects project manager, engineer, technical problem and product describing document. As up to now there is only one categorization of the objects into project and product oriented objects, the next step to analyse these according to the categorization introduced by Vidal et al. [19]. This categorization into attributes, objects links and events will hopefully confirm the results gained up to now.

6 RESULTS AND RECOMMENDATIONS

The analysis of project management and PLM according to three different points of view showed some interesting results that are displayed and discussed in the following. The findings from function, process and object analysis are connected to each other in order to gain an overview of the most promising aspects for the integration of project management and PLM. The most important point regarding function and process view (that lead to very similar results) is the demand for support in the definition of product and project objectives as well as the identification and administration of requirements. A link between function and object view can be realized by assigning system functions to certain objects as for example the support of the project manager and the engineer by the function collaboration management. All three points of view show that an adequate review process is crucial for the integration of project management and PLM. Another important result from the analysis is that the communication between project manager and engineer should be improved or better supported.

As a result from all three points of view can be derived that common functionalities in requirements and goal management and a common review process are the most promising starting points for an integration of product and project level. Moreover the roles of the project manager and the engineer and the support of their communication were identified as very important.

But still the review process remains the most promising and supposedly optimal starting point for product and project level integration. The implementation of an intelligent review process would probably lead to a large improvement in product development and project management. This review process has to show product and project objectives intelligibly and different views and levels of detail

of information have to be provided for different users. In such a review process the product maturity could be monitored as well.
The results generated in this work were demonstrated and discussed with a group of industrial partners during a workshop that dealt with the connection of PLM and project management.
The industrial partners agreed that in practice project management and PLM solutions are not integrated sufficiently yet. Many of the workshop participants had the opinion that it would be of great use if the degree of product maturity would be used and displayed in project management software. This confirmed the analysis result that the review process or the control of the work progress respectively, is an important connecting point between product and project level. But as many of the ideas presented and discussed were seen positively, still a discussion was raised on whether a further automation of administrative processes in product development would be accepted by the people working on a project.
Finally it can be stated that PLM as it is implemented in practice and PLM as it is defined in theory e.g. by Sudarsan et al. [20] still shows significant difference. In practice PLM mostly consists of a number of independent software tools that are rarely linked to each other. This is still far away from the optimal idea of PLM providing everyone working on a project with the information he or she needs out of one overall system that administers all information available in a company. Review processes are often seen as a problem, as they cause extra work for the engineers but the benefit of this extra works does not become clear to them. Often on different levels of management different kinds of reports are requested, which adds to the extra work already done. The automatic generation of reports thus was seen as desirable by the industrial partners, as the generation of redundant information can be prevented by this as well.
In conclusion it can be said that after the discussion during the industrial workshop that the connection points identified in this analysis meet the demands expressed by the industrial partners. These points should thus draw special attention when implementing an interface for PLM and project management solutions.

7 CONCLUSION AND OUTLOOK

After the identification of promising connection or integration points of PLM and project management these have to be used for the implementation of a software interface or alternatively used for the generation of a better support of project manager and engineer in terms of methods.
The next point to be carried out is the analysis of real reporting processes. At the moment there is work going on regarding the development of a new reporting process at a company, which uses the findings of this work and wants to develop them further. Especially the links between the different objects is regarded here. The results are used as well by a partner company that develops software solution for process and project support.

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Contact: J. Roelofsen
Technische Universität München
Institute of Product Development
Boltzmannstraße 15
85748 Garching
Germany
+49 89 289 15156
+49 89 289 15144
roelofsen@pe.mw.tum.de
www.pe.mw.tum.de

Julia Roelofsen is a research associate at the Institute of Product Development at the Technische Universität München, Germany. She works on a research project that deals with the situation specific configuration and adaptation of development processes as part of the research alliance FORFLOW.

Carolin Anwander studied mechanical engineering at Technische Universität München (Germany), majoring in product development and ergonomics. Her M.Sc. thesis, a cooperation of ACTANO GmbH (Munich, Germany) and the Institute of Product Development at Technische Universität München, dealt with promising strategies for integrating project management into product lifecycle management. She now works as a design engineer at KSB AG (Pegnitz, Germany).

Udo Lindemann is a full professor at the Technische Universität München, Germany, and has been the head of the Institute of Product Development since 1995, having published several books and papers on engineering design. He is committed in multiple institutions, among others as President of the Design Society and as an active member of the German Academy of Science and Engineering.