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MANAGEMENT DECISION SUPPORT BY PLM SOLUTIONS

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ABSTRACT
In this paper research activities at the Institute for VPE to enlarge the focus of Product Lifecycle Management (PLM) solutions toward the support of management decisions are presented. The described approach intends to integrate information sources relevant for the management, to further develop PLM Solution functionalities and to make divided decision processes representable by appropriate workflows.
The integration framework is called Engineering Networks (EN). Engineering Networks consists of Engineering Objects (EO) and Engineering Processes (EP). EO are abstract information carriers to merge geometrical, functional, technological and organizational information entities available in heterogeneous formats, distributed throughout the Enterprise. This information needs to be gathered and processed in order to systematically support cooperative Engineering Processes. Depending on the specific use case different views on the available product data are created and presented via different front ends or applications.
The Management Desktop (MDT) will be a front end to support management. It will be designed to support strategic and operative management decisions in different phase of the product lifecycle.
Requirements for the design of the Management Desktop based on Engineering Networks are amongst others gathered from the investigation of certain fields of application present in industrial application.

Keywords: Product Lifecycle Management, Engineering Objects, Management Desktop, Strategic Management, Product Management, Innovation Management, Design for X, Cross Enterprise Engineering

1 INTRODUCTION
The Support of Management by Product Lifecycle Management (PLM) Solutions is a research field which involves engineering and management aspects. PLM, as the successor of Product Data Management (PDM), evolved from the engineering field and there especially from product development. This paper will focus on the integration of information resources located in product development and management activities. We argue that PLM is an appropriate technology to support management decision processes and propose a research approach to supply managers with processed and aggregated information stemming from engineering.

2 NEED OF ACTION
Today there is a communication or information gap between designers in companies of the discrete manufacturing industry on the one hand and the management on the other hand. Often managers only have very limited time e.g. to decide between several product concept opportunities or to assess a situation a product development project is in right now. The available basis of information is fragmented. That is why a methodology is needed to support managers in decision making in engineering projects.
Figure 1 shows the chart of "Timing and Impact of Management Attention and Influence for a Product Development Project" [1]. It can be seen that the curve of "Possible Impact" (of the management) is high in the very early project phases and declines in the later phases. The curve of "Effective Management Impact" is moving in the lower section during the first project phases and reaches two peaks in the later phases – test, implementation and use.

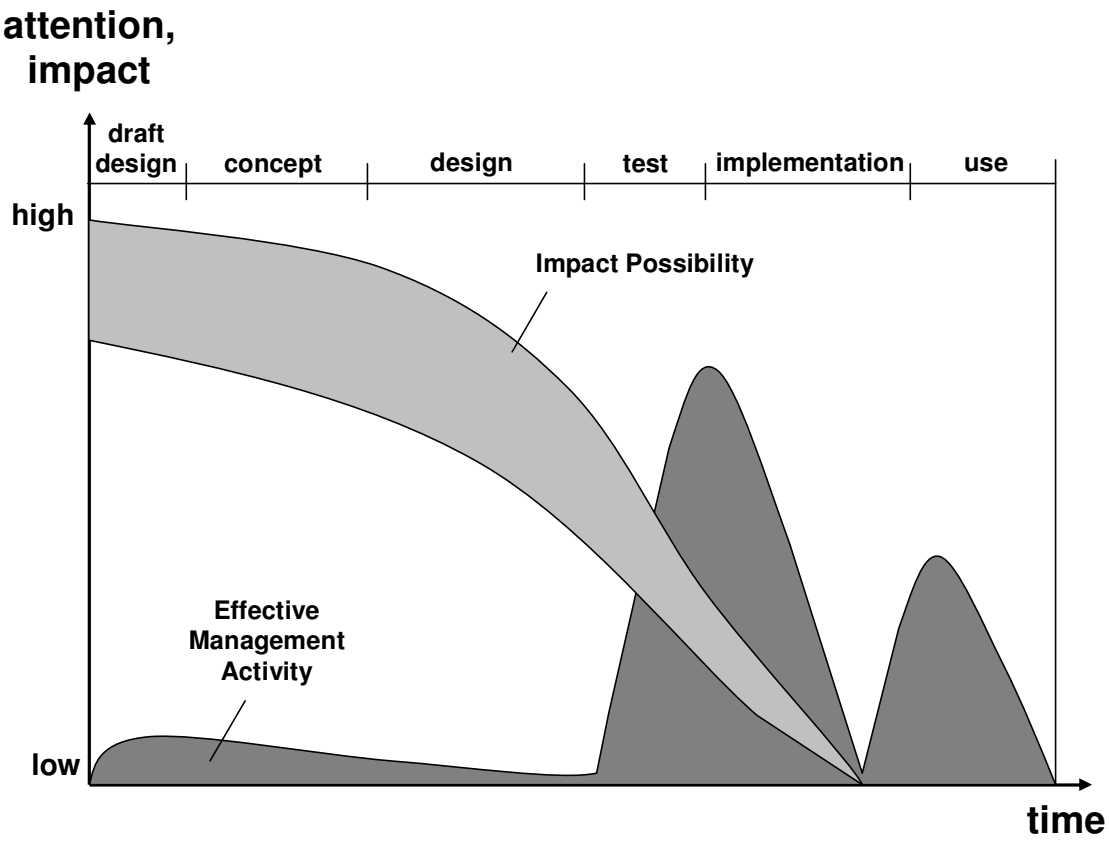

Figure 1 Timing and Impact of Management Attention and Influence of a product design project (in dependence on [1])

To profit of the "Possible Impact" in the early phases of a project and to optimise the "Effective Management Impact" at the same time research activities to develop a methodology that fulfils these requirements will be shown up here. The methodology is called as Management Desktop (MDT) based on Engineering Networks.

3 CONCEPTUAL FRAMEWORK

3.1 Decision Support for Managers

Management activities can be distinct into *normative*, *strategic* and *operative* activities, according to the relation and closeness between those activities and the value-adding processes of a company in the producing industry. While operative management deals with the direct steering of the value-adding processes (e.g. planning and steering of product development projects, optimisation of production processes), strategic management aims to set objectives for the company in the long-run. [18] Evaluation of the current product portfolio by weighting with noted sales figures or the further development of companies offerings by matching the portfolio with market opportunities that can be forecasted are questions of strategic management. Outcomes of normative management are guidelines for the company itself on a high level of abstraction, like the object of the company, decisions about the legal form or setting ethic behaviour directives for the internal cooperation or externally when interacting with stakeholders. [18] Those three levels of management do always exist in parallel. Employees – `managers` - on different hierarchical levels in a companies structural organization accomplish a certain mix of normative, strategic and operative tasks. This mix is not directly linked to the organizational structure of a company. Engineers working on a product development project can for example also be assigned with "management" tasks in the described sense. For example when they decide between different product or component design concepts.

In the context of this paper – decision support for managers – the level of normative management will not be considered in the following. Decision situations of normative management are typically not well structured and they are not closely linked to engineering. The aim of our research activities is, to

further develop PLM concepts and functionalities. Therefore the linkage to engineering tasks is required.
Figure 2 illustrates the relation between the levels of management and the product lifecycle. The product lifecycle is defined herein as a combination of the technical lifecycle (shaded), as it is commonly used in the research field of PLM, and the value-creation chain. Thereby all engineering activities are considered which are processing product related data and their relations to operative and strategic management. Nowadays projects dealing with product development and creation are being carried out in so called virtual enterprises. Processes throughout the product lifecycle phases are distributed across several companies and the relation to partners need to be considered in management activities.

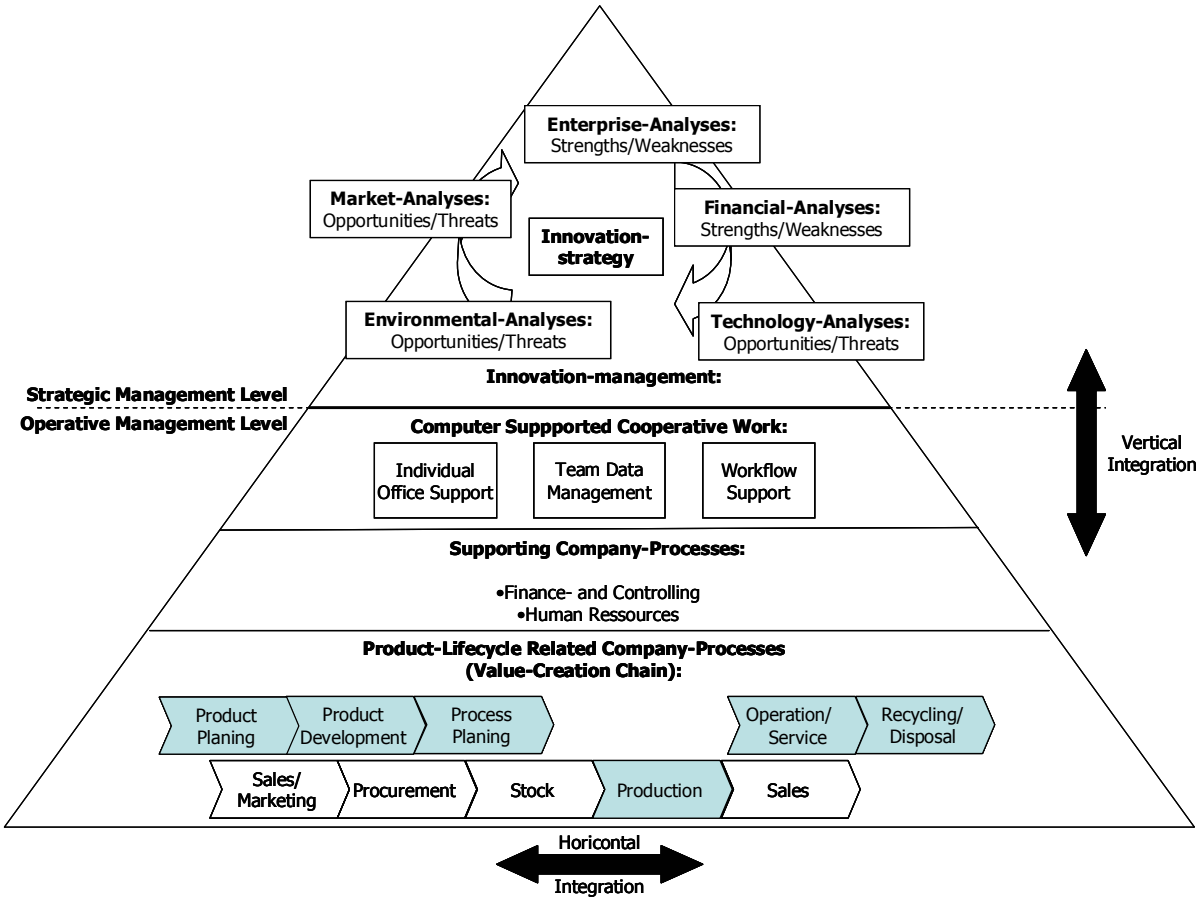

Figure 2 Management Levels and Product Lifecycle

In the upper part of Figure 2 the set up of an innovation strategy and some of the influences that need to be considered during those decision processes of the strategic management are displayed. This symbolizes the product related tasks of the strategic management.
Operative Management is directly linked to one or more process steps of the product lifecycle, while a direct link between the strategic level and the product lifecycle is not required.
The MDT focuses on the support of decisions of operative and strategic management. Therefore the information that is basis for a certain decision needs to be presented in an eligible form.

3.2 Product Lifecycle Management

Matter of the design of PLM Solutions in general is the optimization of product related cooperative business processes by controlling the flow of information and data as well as by integrating specific data processing systems. [17] [9] [11] PLM is not a single technology or software system, but a holistic approach to the integration of information processing throughout the product lifecycle. Information that is spread across two or more systems can be collected, aggregated, processed and presented according to a respective purpose.

In respect to the integration of different IT-systems, PLM solutions can be divided into *horizontally* and *vertically* integrating solutions (cp. Figure 2). While horizontal integration links two or more systems alongside the value creation chain – on the operative management level – vertical integration enfolds both, the operative and the strategic level of action. [16]

In the context of PLM a special example for horizontal integration is the consolidation of two or more engineering domains. The domains mechanical engineering (M), electrical/electronical engineering (E/E) and software engineering (SW) contribute to the development of mechatronic products. In each of these domains specific Legacy and domain specific Local-PDM (L-PDM) systems are in use. One system might be the one used to manage the mechanical engineering data (M-PDM), while the other one is the master in the electrical engineering department (E/E-PDM). The article code (Meta-datum) of the mechatronic products, containing mechanical as well as E/E components is administered by a PLM(-backbone) system above both domain specific solutions, but the referenced data is stored on the operative level and referenced by the superior system.
An example for vertical integration is the extraction of the information about the number of released components of a product at a certain point of time during a product development project. The release figure can be drawn from a PDM/PLM-system, located on the operative level. A key figure calculated from this information could be benchmarked with stored figures from past projects in order to use this datum as one parameter to evaluate the progress of a development project with a project management system on the strategic level.

In Figure 3 typical functions of implemented PLM solutions are listed.

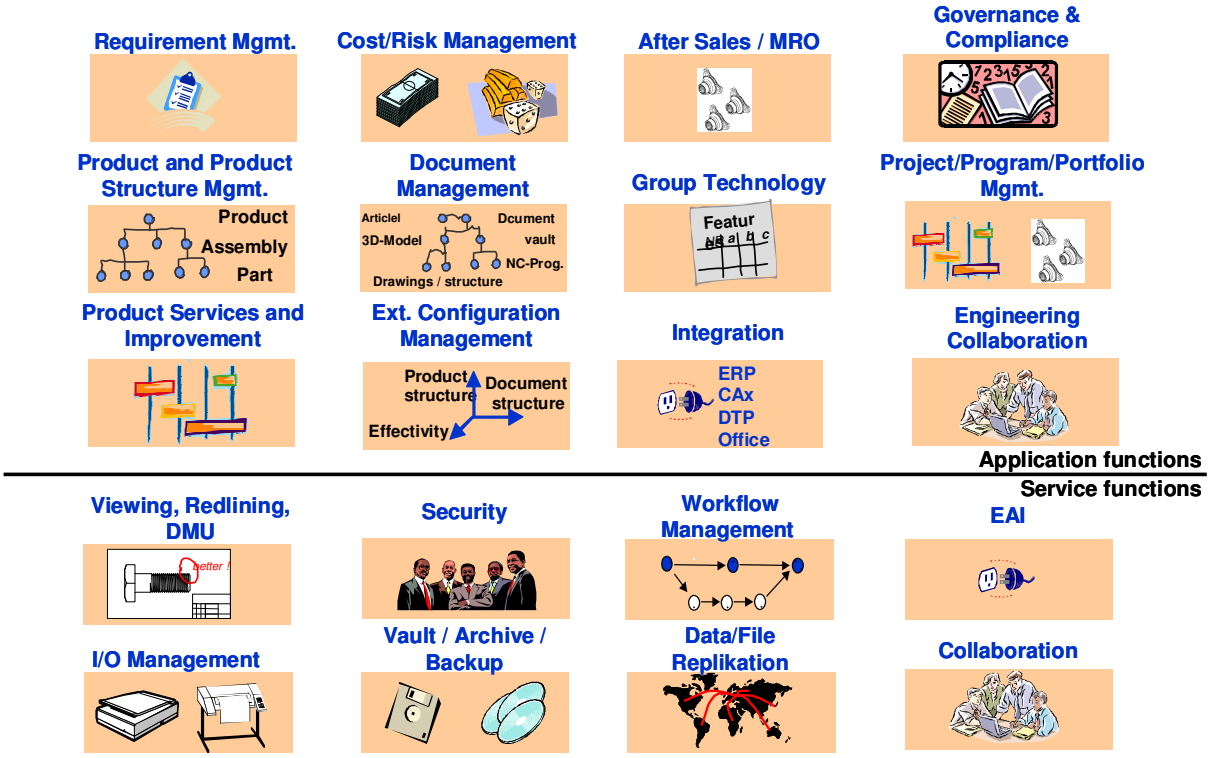

Figure 3 Typical Functions of PLM Solutions

PLM solutions combine different types of functionalities. Beneath functions supporting administrative activities (e.g. configuration management, product structure management, workflow management) functions to support decision making are under development (e.g. project/program/portfolio management, cost management). Some authors argue, that even the direct support of the generation of Product innovations can be offered by PLM.

The direction(s) and extent of integration and the functionality realized in a PLM solution depends on the requirements arousing from the application context it is designed for.

3.3 Management Decision Support by PLM Solutions

The design of PLM solutions according to the requirements of operative and strategic management tasks is a methodology of resolution in order to bridge the information gap between management and engineering.
PLM solutions can offer administrative functionalities. The manager can thereby use more of his capacity to focus on other more creative tasks.
Moreover PLM can integrate the relevant systems and data in order to complete the information basis for certain decisions and to represent divided decision processes.
Finally the functionality of PLM solutions needs to be enlarged, in order to present aggregated information according to the requirements of management.
The intent is to design PLM solutions as integrated Data-Backbone spanning the whole lifecycle and the management levels. The MDT itself combines an application layer upon the Data-Backbone, processing the data according to the required functionality and a Graphical User Interface.

4 STATE OF THE ART

In this chapter examples for tools to support management decision making and the context of usage are outlined: First the Eco-Efficiency Analysis (EEA) is being drafted in the context of Strategic Product Management (SPM). Than a special project management tool supporting is displayed. It can be used for the operative steering of running projects.

One task of the Strategic Product Management is the deployment and implementation of a product policy. This comprises the foresighted planning of the Product-Portfolio and in this context the evaluation of possible product innovations. Ideas for Product Innovation need to be assessed according to different criteria at an early stage of the innovation process. Relevant ideas need to be selected as basis for the proceeding product development. Possible criteria are the compliance with requirements of different stakeholders throughout the lifecycle (e.g. Design for Sustainability, Design for Safety, Design for Manufacturing). That assures the development of products that can be marketed successfully.
Several methods and IT-tools are in use to support those decision making processes. Examples are Portfolio-, Lifecycle-, Lifecycle Assessment- (LCA), Life Cycle Costing- and Eco-Efficiency-Analyzes:
The Eco-Efficiency Analysis is an example for a portfolio based instrument that can be used to evaluate several product concepts and to support decisions between the alternatives. The method has been developed by BASF. It is used by the BASF amongst others to prioritize research projects and to decide about investments in product and process development. [15] [12] [13]
The Eco-Efficiency analysis is a methodology to evaluate different product or process alternatives in a comparative study referring to ecological and economical aspects. As measure for an alternatives environmental impact during its lifecycle a Life Cycle Assesment (LCA) in accordance to ISO 10404ff is calculated considering the input categories *energy consumptio*n, *resource consumption*, *area consumption*, *emissions*, *toxicity potential* and *risk potential*. The Total cost of Ownership (TCO) of the alternatives is calculated from the perspective of the end user to evaluate the economical influence. Both categories are calculated according to a well defined and documented procedure based on input parameters dependent on the analysis subject. [5] [6] One of the overall results is a comprehensive portfolio (cp. Figure 4) integrating both dimensions and giving a quick view on the comparative ranking of the evaluated alternatives. Scenario and sensitivity analysis can be fulfilled by varying boundary conditions and input parameters.

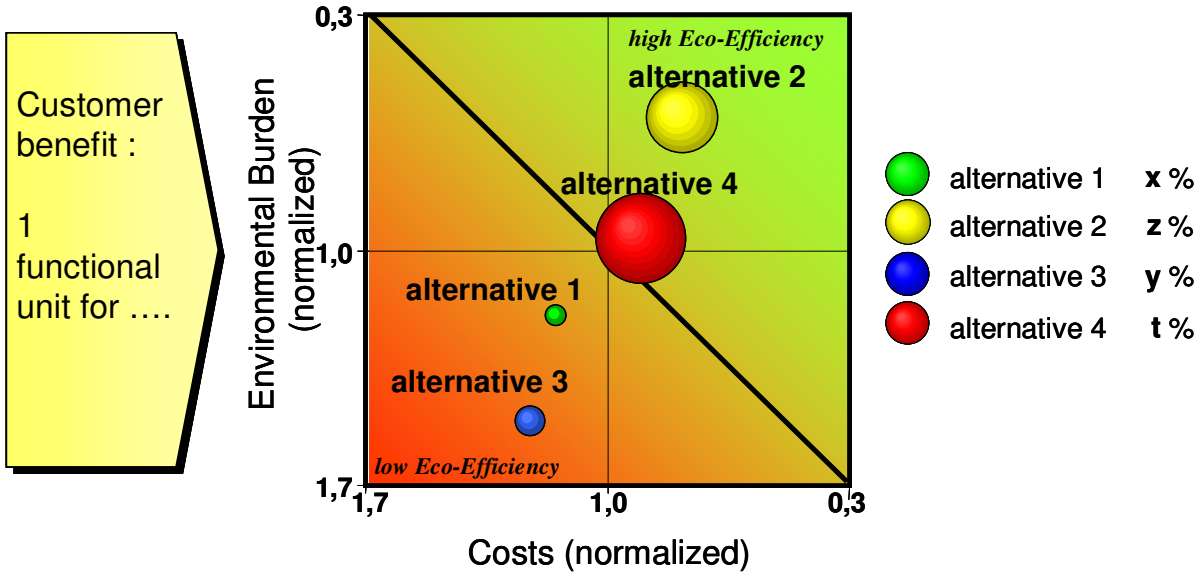

Figure 4 Eco-Efficiency Portfolio Analysis [13]

According to the portfolio-positioning of the product and process alternatives strategic courses of action can be deduced.

An example for support of operative management is a project management tool developed by Magna Steyr based on the method Project-Structure-Plan (PSP). It is a data-bank based system which supports process control and transparency of operating figures [8]. Operating figures are values which represent concentrated information, for example:

- to evaluate processes
- to compare two different operating figures
- or to compare a figure with a benchmark

The tool is involved in a project from the concept phase to the end-of-project phase (EOP).
Up to 1000 target values per project are defined and build the base for the project report with the PSP-tool. The target system is divided in practical functional divisions. These divisions are responsible for a sample of the further defined target values.
Figure 5 shows a screenshot of the graphical user interface (GUI) of the PSP-tool.

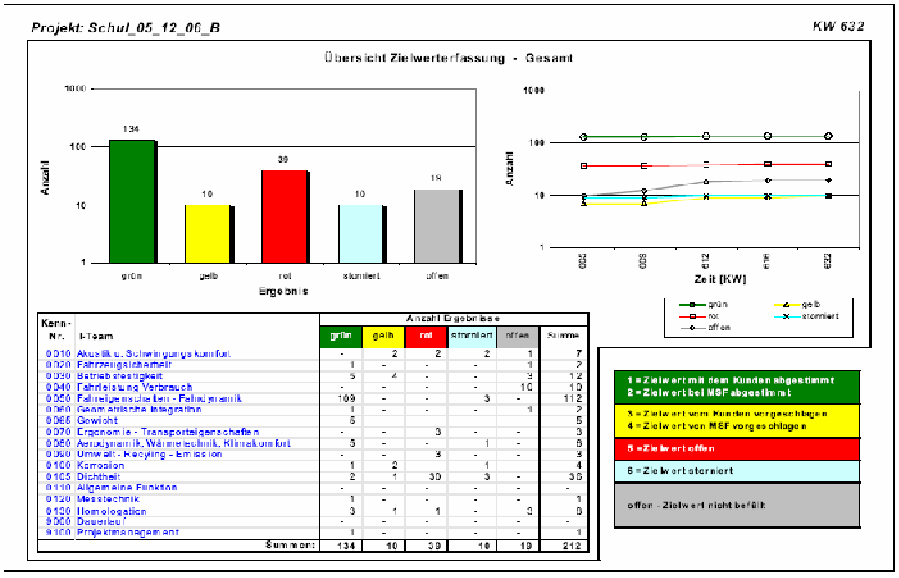

Figure 5 Project-Structure-Plan GUI [8]

In the lower part all functional teams are listed with a quick view on their actual project status and topics. A chart in the upper part visualizes the main topics. The overview is adequate to display the history of a project in an easy to access way. [8]

Figure 6 exemplarily classifies IT-systems relevant for the support of strategic and operative management according to the introduced schema. As displayed above actual PDM/PLM-systems offer functions that support processes spanning different phases of the lifecycle and interfaces to other systems. Enterprice Ressource Planing Systems (ERP) are another class of integrated systems that typically provide information relevant for management activities. It is also shown in Figure 6. The two described tools in industrial use are positioned on the respective management level.

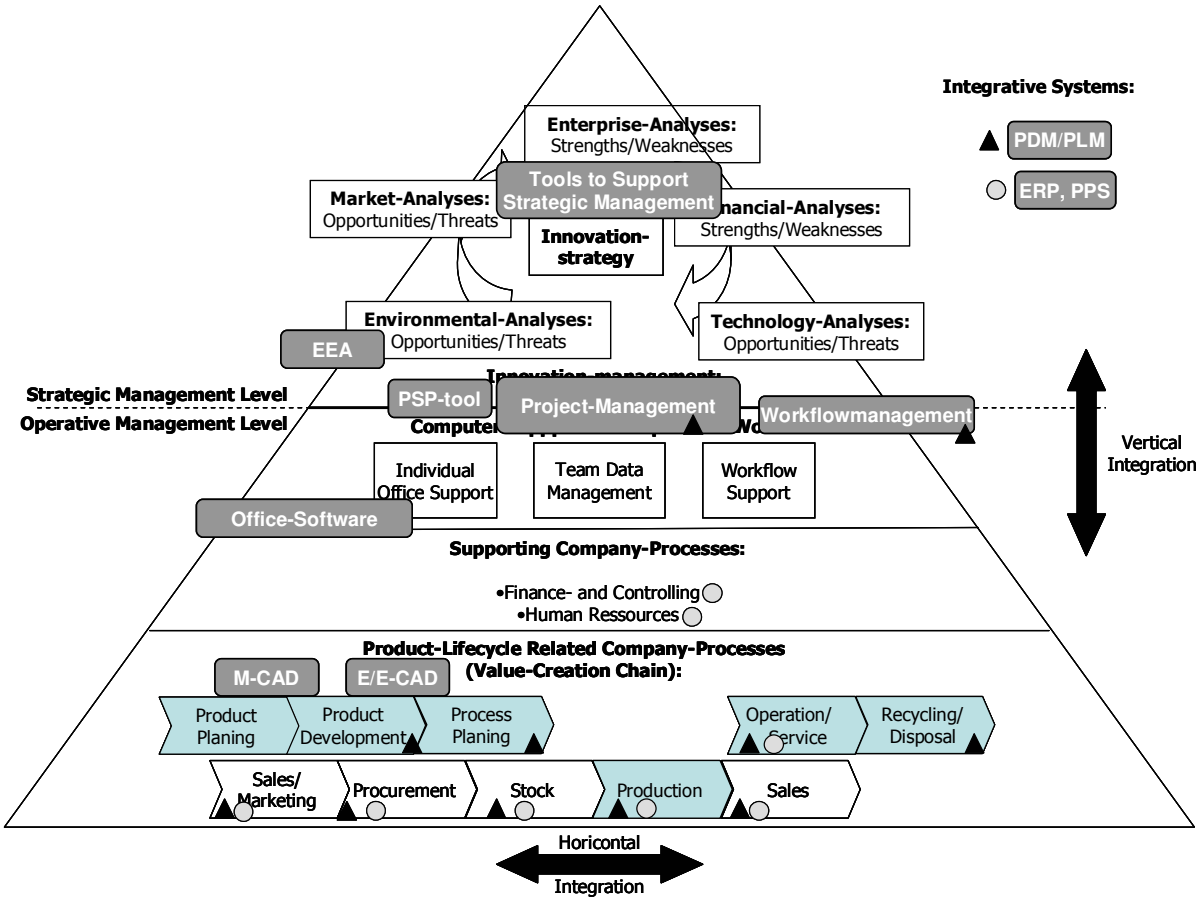

Figure 6 Example Systems relevant for Management Systems

It can be noticed, that nowadays tools like the ones described are usually not well integrated into the companies information processing architecture, but the input, selection and processing of the required data as well as its assessment and evaluation is done to a high extend manually by the user/manager.

5 METHOD OF RESOLUTION: MDT BASED ON ENGINEERING NETWORKS

The methodology under research to enable the design of PLM-backbone solutions supporting management is the "Management Desktop based on Engineering Networks".

The MDT based on EN architecture combines several information processing layers. On the data layer (EN) existing information and data sources are integrated into a federated metadata-schema. Upon the federated data-base system the MDT itself is located on the application layer processing the data and providing functionality to present the complete information base.

Engineering Network aims at the design of a federated metadata-model that comprises all geometrical, organisational, technological and process-oriented product data relevant across the lifecycle.

EN is not designed as a new product data model, but it will integrate existing data-models. This enables the integration of existing legacy-systems and data bases, when designing a company or use case specific PLM solution using the Engineering Network model.

Building up a use case specific PLM solution can be done by instantiating the Engineering Network Metamodell according to a defined set of requirements. Existing information and data sources will be integrated by transforming their local schemas into the federated Engineering Networks schema. The integration leads to a meta-schema that links up to the existing relational, object-relational and object oriented data-schemas.

The elements forming the Engineering Networks model are:
- An **Engineering Network Schema** consists of statical (Engineering Objects) and dynamical (Engineering Processes) entities.
- An **Engineering Object** represents an information element (e.g. an articel, document, function, requirement, sales figure, …), its grafical presentation and all related methods and constraints.
- An **Engineering Process** represents a certain business process related to one ore more phases of the product lifecycle and one ore more management levels. One or more Engineering Objects can be affected by one Engineering Process. Examples for Engineering Processes are business processes of innovation management, portfolio management, configuration management, variant management, project management or release processes.

The MDT will be one possible application based upon an EN-Schema. The MDT will provide the functionality to process the data according to certain decision situations.

Figure 7 illustrates the integration and application layers of the MDT based on Engineering Networks architecture.

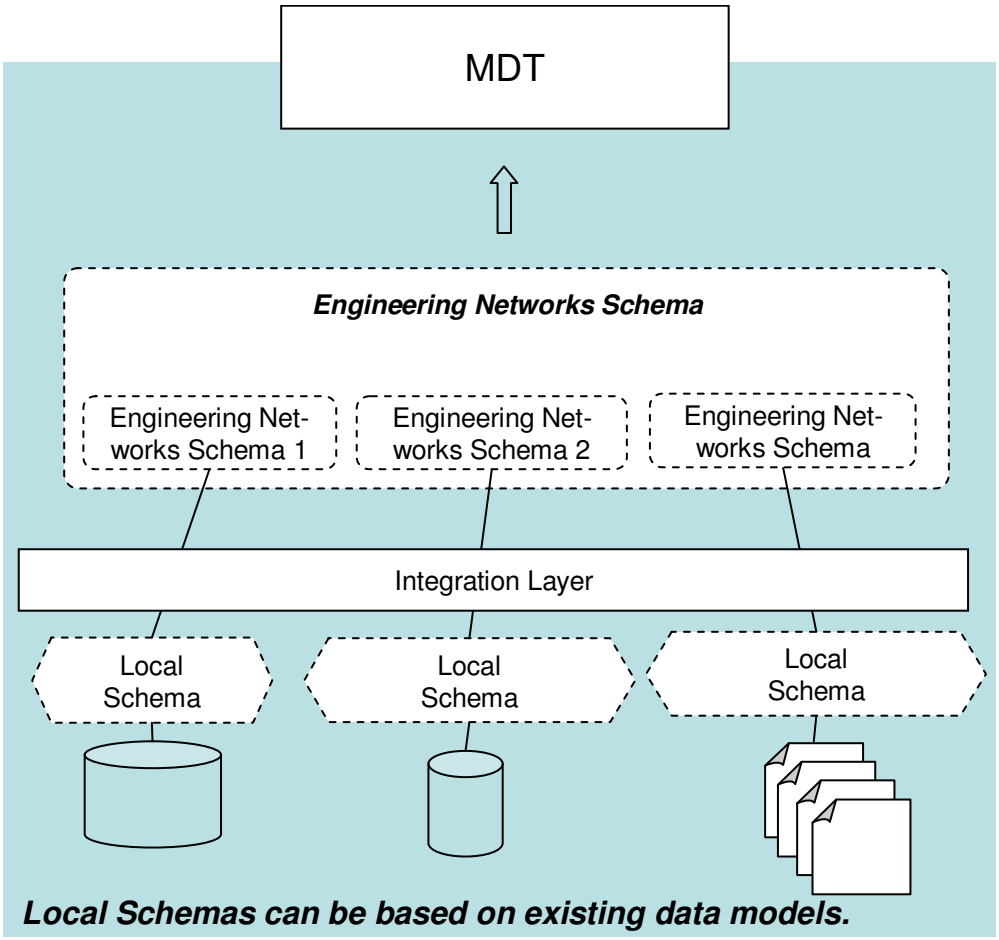

Figure 7 MDT based on Engineering Networks

The Institute for Virtual Product Engineering is working on a research project founded by the German Federation of Industrial Research Associations (AiF). Together with an industrial partner the VPE works out a prototype for an integration method by the further development of object-relational

repository technologies. Using the meta-data repository it will be possible to integrate relational, object-oriented and object-relational legacy- and database systems in industrial use.

6 PRACTICAL EXAMPLES

The described integration methodology is the general architecture of a MDT based on EN. In a certain use case the MDT will be designed according to the requirements in customer and research projects. These requirements need to be analyzed case by case. The analysis phase is not matter of this paper, but for the exemplification in the following two possible use cases are described, how the MDT could be implemented as a tool supporting operative and strategic management.
Examples for the operative Management Support is the use case of a design review meeting (par. 6.1). The evaluation of a product variant portfolio with noted sales figures is an example for strategic decision support (par. 6.2)

6.1 DESIGN REVIEW

An example of practice is the release of an engine of a windshield wiper produced by a supplier in the automotive industry. In this example a German automotive Original Equipment Manufacture (OEM) needs a new wiper engine. The authorized supplier already has designed a windshield wiper engine for a French OEM, but with restrictions of a special surface coating for the three washers. The German OEM doesn't need this special surface, which protects the washers against humidity. The new wiper engine is located directly under the dashboard – in a waterless installation space.
Figure 8 summarizes the boundary conditions and the possible decision alternatives during a design review meeting.

Source: Bilstein

Boundary Conditions:

- Similar motor with three washers is existent
- Washers with surface coating are in productive use

In this situation the manager responsible for this product design project has two different opportunities:

- Use the existing washers
- Start a new component release workflow for three washers without surface coating

Figure 8 Decision Situation during Design Review Meeting

Some of the Information necessary to decide in such a situation is:

- Conditions/Prices for the washers with and without surface coating
- Special quantity discount, in case of using surface coating washers in all engines
- Number of Pieces of the new wiper engine
- Is the usage of washers with coated-surfaces conform to the laws in all marketed countries

If such questions are not answered in time or based on unsure or incomplete information product design changes might be necessary. Product changes might cause extra costs and might cause a miss in fulfilling a contract.

This information is available in different systems inside the company (ERP, SCM, CRM, PDM/PLM) as well as with partners and suppliers or in the internet (standards, patents, market researches, engineering marketplaces). A PLM solution designed according to the Engineering Network methodology could integrate the relevant information sources.
The MDT could support the manager during the design review meeting by processing the information in accordance to rules that are defined product specific. Relevant documents and information can be provided to support the decision by retrieving it from distributed information sources.

6.2 VARIANT PORTFOLIO EVALUATION

A second practical example discusses more strategic aspects. The product manager of a seat-manufacturer needs relevant information to decide which variants of a specific seat should be produced in the future. Therefore different kinds of information are needed: On the one hand data from the sales department about the sales-figures of the last period (available in the ERP-system) and on the other hand data from the design department about product and product structure (usually available in PDM/PLM-systems). Combining this information the manager, in this example, realizes that seats with the criteria “seat normal”, “seat cover textile” and “none seat heater” ca. 58% all configurable products are covered (Figure 9).

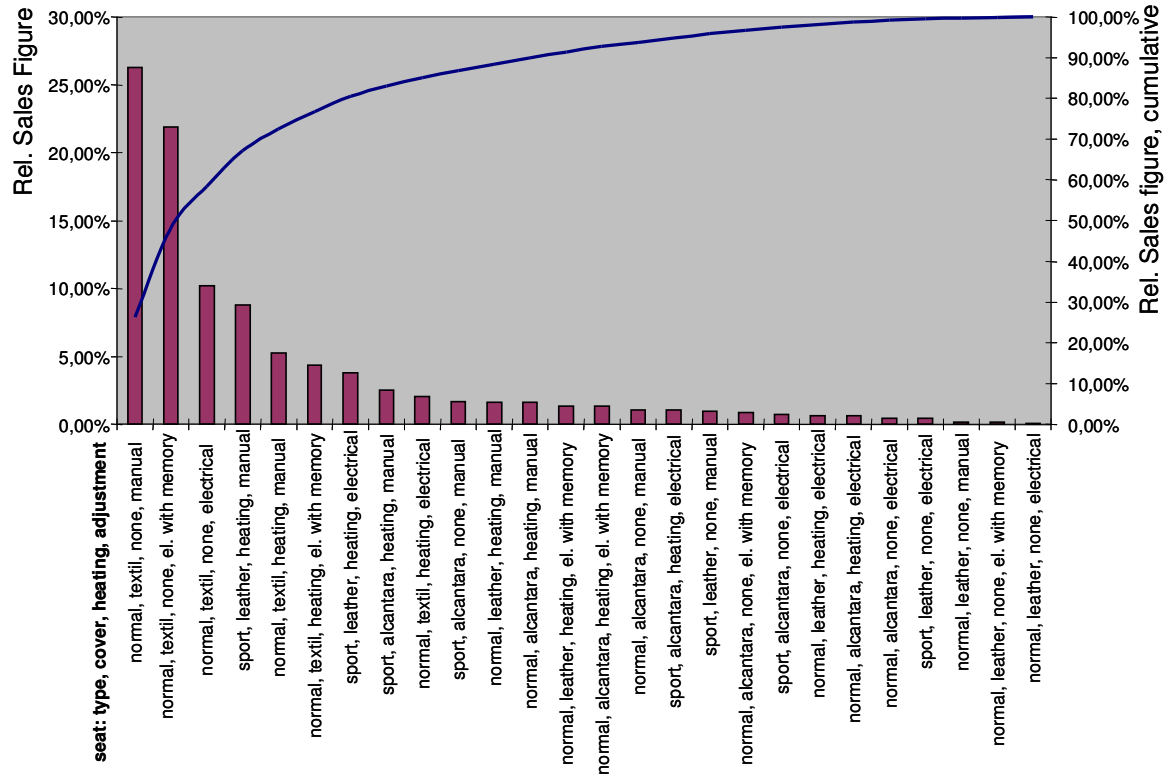

Figure 9 Sales Figure of the varianst of the product structure of the product “seat, front left” cp. [20]

Moreover, 10 of the 26 variants have an expected installation rate of 1% or even less. An optimization of the product portfolio by reducing these 10 variants might be economically interesting for the company.

7 CONCLUSIONS AND OUTLOOK

The Engineering Networks concept for the integration of information relevant for the optimisation of process throughout the lifecycle and spanning the different levels of management is presently under development. It will be a platform for applications like the Management Desktop that can support decision makers of the strategic and operative management. A MDT based on EN will than be instantiated according to the requirements of a defined use case.
Prospective further use cases will be the support of the early phases of the innovation management processes. This comprises the foresighted planning of the Product-Portfolio, of Product-Group specific measures and the management of Product-Development projects.

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