

PRODUCT LIFE CYCLE MANAGEMENT IN A SERIAL PRODUCTION

J. Tavčar and J. Duhovnik

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1. Introduction

In manufacturing companies, products are situated at the very centre of all processes, therefore good product data management throughout the product life cycle is very important. Products are born out of an idea or market impulse and pass through product development and detailing, setting up of technology and manufacturing capacities, as well as distribution and servicing. This journey is completed by their destruction when they are no longer useful (Figure 1). The product life cycle is continually repeated at an ever higher level; therefore it can be illustrated with an ascending spiral. PLM information systems are used for data management throughout the product life cycle. In addition to controlled access to product data, processes such as data exchange, approval etc. are also very important.

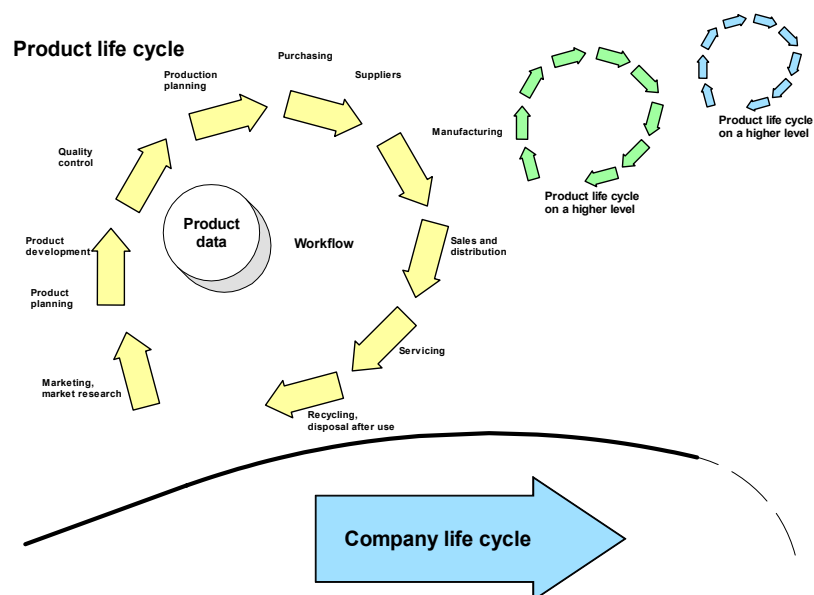


Figure 1. Product life cycle

The product life cycle is associated with the company's life cycle, which is usually longer (a few decades). During the life cycle of any company, a certain amount of time is required to set up the company's infrastructure and manufacturing lines. Development of human resources – i.e. acquisition of qualified personnel – is even more important. Therefore, the association of existing companies and

their capacities into virtual companies is a quicker way to new products. In these times of globalization, a company's ability to be quickly integrated into virtual companies is very important [Bernus 98]. The most vital features in this respect are the company's communication capacity, exchange of data in standard form and adaptability in all phases of the product life cycle.

In order to be able to clearly manage information flows over the entire product life cycle, it is necessary to understand the specific features of communication in individual phases. During the initial stages of the product development, there are many unknown variables, many considerations to be taken into account and harmonized, and many decisions to be made. This part of the process cannot be formalized. Frequent explanations and brainstorming for ideas are required, i.e. a lot of creative dialogue. Only the final results are stored. Later during product development, the collected information becomes more long-lasting in the company and generally better understood. It becomes important to store data in the electronic form - the range of people requiring access to this data also becomes wider. The significance and role of information systems in companies have changed progressively, along with the development of information technologies. First, solutions appeared which covered only individual segments of company business operations, for example material operations, finances etc. Later, software began to cover an increasingly wider range of activities and was renamed from MRP (Material Request Planning) to ERP (Enterprise Resource Planning). In technical departments, the development of CAD software and large amounts of computer files have necessitated the development of PDM systems (Product Data Management). When their functionalities and their range of users expanded, their name was changed to PLM systems (PLM – Product Lifecycle Management).

There are some similarities (but also basic differences) between product development and manufacture. These need to be recognized in order to be able to understand the role and significance of PLM and ERP information systems [Rein 97]. For manufacture, all the necessary information is already available before its beginning; this is by far not the case in product development. During the course of product development, data is collected continually and new information is often discovered that has a decisive influence on the course of subsequent processes. Each instance of product development is usually performed only once and there are several different options, while during manufacture procedures are often repeated. Manufacturing information systems (ERP) are constructed on the basis of initial requirements that considerably differ from those for PLM systems. The main part of an ERP is a database of building blocks and products, which contains descriptions of the basic product data. The software enables monitoring of material operations (in warehouses) and manufacture. Until recently, the use of PLM systems was limited to technical departments. Their basic functionality is to support the storage of and access control to CAD files [DuhTa 00]. Nowadays, their field of applicability has expanded to the entire company structure and its most important suppliers. PLM systems are therefore an efficient product data management tool throughout the product life cycle. In these processes, a company's physical boundaries are not the limits of information flow. The basic user functions of PLM systems include monitoring of the engineering design process and control of subsequent changes, product structure and document management, classification and project management.

The scopes of use of PLM and ERP systems overlap in many areas (e.g. product structure). Graphically supported workflow methods in PLM systems are simpler to use and more user-friendly, while comprehensive management of the components is more detailed in ERP systems. In time, PLM and ERP systems will probably merge into a unified system or at least become highly integrated. A more detailed description of the product development and engineering change processes is given below. Their features are analyzed first, and then an example of a practical solution is given.

2. Engineering change process in serial production of modules

After completed product development, product data are determined in detail and can be changed only according to strictly defined procedures. There should be no hold-ups in the serial production process. Since the correlation between different fields is much higher, the production process must be carefully planned and the communication channels must be provided for. Later product changes (once a product is already included in regular manufacture) cause a chain of corrections and costs related to tool

change, already purchased components, servicing etc. During manufacture, however, processes are clearly defined, therefore they can be automated. Communication via workflow increases productivity and reliability.

A generalized model of the engineering change process is shown in Figure 2. Each change begins with an idea. It is important to ensure an easy collection of ideas and their tracking. In the next step, the idea itself should be transformed into a proposal for a change. The information system plays an important role in arrangement and collection of the required data. Arranging also includes analyzing and testing, if applicable. It needs to be ensured that each proposal is subject to appropriate professional discussion, which, due to economic reasons, can be conducted in several stages. Each change must go through the process of approval, where the consequences of the change are calculated from all perspectives, e.g. in terms of costs and technical feasibility. Once the change has been approved, it should first be provided for changes in documents and their distribution, following which the change needs to be implemented in the production process, servicing etc.

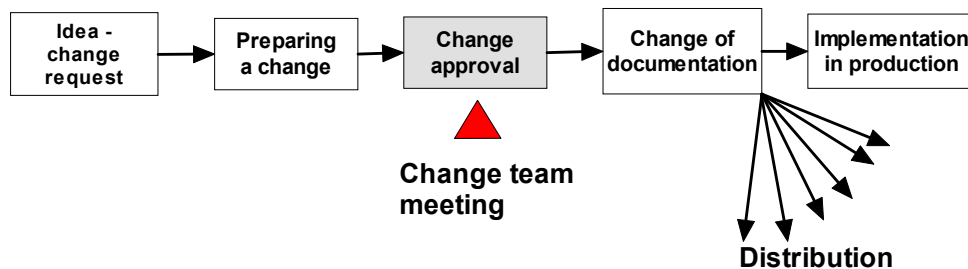


Figure 2. Generalised engineering change process of a product [DuhTa 03]

3. Example from Domel

Domel's main product are vacuum cleaner motors, which are manufactured in over 100 variants, over 4 million units per year. Domel introduced a SAP system (ERP) in order to monitor its products throughout their life cycle. In this company, the product life cycle begins with a developmental project. This applies both to new products and to variants of the existing product range. A project begins with brainstorming, determination of goals and appointment of the project leader. Activities in developmental projects are generally divided to the following phases: planning, prototyping, test series and regular manufacture. The applicable organizational regulation stipulates five milestones on which the assessment of performed work and planning of further activities are based. The overall product development process complies with the requirements of ISO 9001 quality standards and VDA 6.1 automotive standards. Domel's developmental and technological teams are at the core of each project team, while representatives from the quality control, sales, assembly, toolshop, technological and manufacturing departments are included in the assessment and approval of engineering design solutions. During the first developmental phases, the dynamics of changes is very intense.

There are two characteristic phases of product life cycle: product development project and regular manufacture. When developmental documentation is delivered and a decision on regular manufacture has been passed, controlled change management becomes very important. In regular production, each change is associated with high costs, because all processes are highly interrelated. Once the intense dynamics of engineering changes has settled down and the commission has given its approval, developmental documentation can be entered in the SAP information system. Figure 3 shows the approval procedure for SAP documents. The project leader is in charge of entering all design drawings and 3D models describing the new product into the SAP system. He must also make sure that the standardizer prepares records with basic data (MMR) for new building blocks, and links them to documents. Each document is stored in a separate Document Info Record (DIR). In the next step, document approval is performed. A design drawing has various document statuses during its life cycle. Access rights, for example, also vary based on the document's status. In the phase **Under development**, a design engineer can change a 3D model or drawing as much as he wants. Once the

document is completed, a design engineer changes its status to **Prototype**. The document's owner can make changes only if he goes back to the **Under development** phase. Changes in the document status function as electronic signatures. Document status can be changed only by selected users: only standardizer can change the document status to **Under review**, and only head of the product development group to **Issued**. From this stage, the only possible status change is to **Invalid** or to new version (**Revision**). This approach ensures that all issued copies are stored. As soon as a document's status is changed to **Issued**, a TIFF drawing file format is created – this is intended only for viewing and printing. The history of document status changes is also recorded, i.e. their dates and names of the persons who made them. In Domel, originals are no longer stamped paper drawings, but SAP computer files with appropriate statuses.

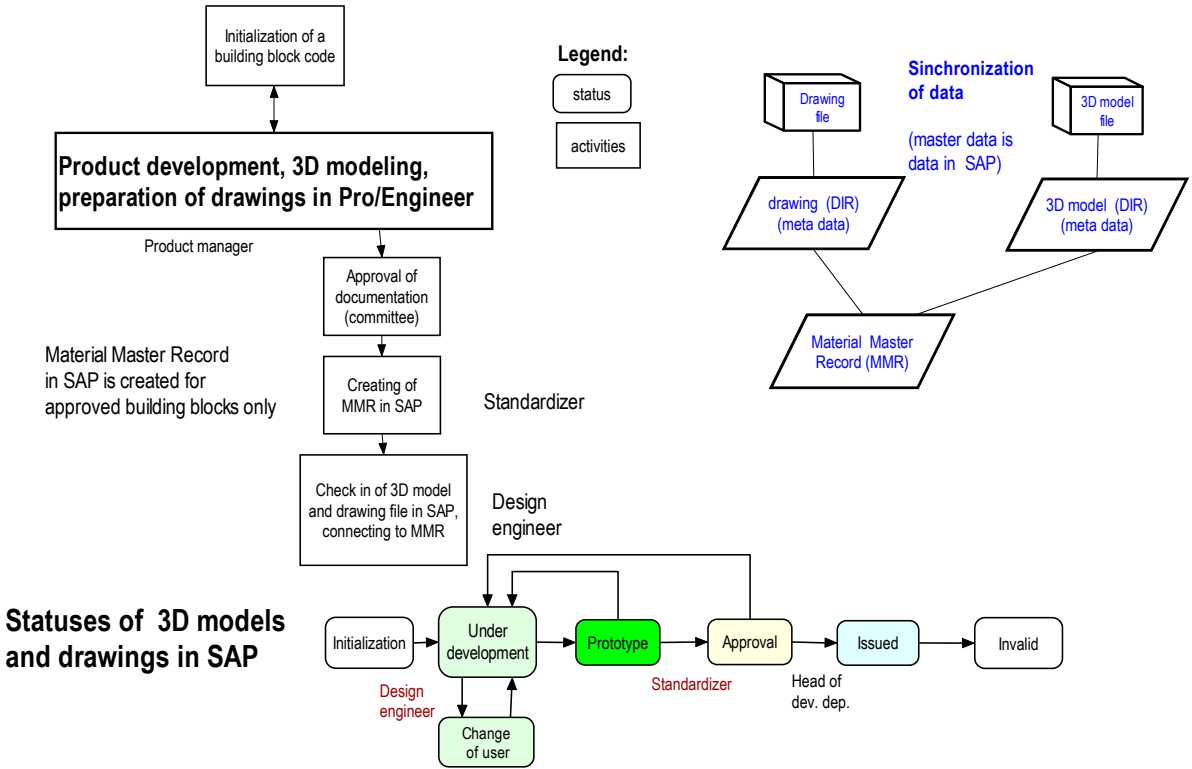


Figure 3. Document approval procedure

3.1 Engineering change process

The procedure of engineering change process is shown on the example of a constituent module – vacuum cleaner motor (Figure 4). In this process, only key points are performed via the information system, i.e. the formal approvals. During the phases of preparation and approval, informal personal communication plays an important role. The engineering change team meets once a week and assesses the proposed changes from all perspectives. The synergistic effects of creative dialogue in a change team cannot be replaced by collecting electronic signatures. The procedure for engineering changes is the same as during documentation issue: the standardizer and head of the design department enter the commission's formal approval in the system. Since approvals are always issued by the same persons, the configuring of workflow was relatively simple. Currently, one of the following options is used: searching for documents waiting for approval on the basis of status or via e-mail within the SAP system. Activation of a SAP module for workflow is currently in preparation. For distribution, Domel uses electronic documentation within the SAP system. Notifications are sent to those individuals who are expected to perform certain tasks. Some users in the manufacture department who always use the

same documents, however, have continued to use paper copies. There is a rule, however, that paper documents are not valid unless the validity of the latest SAP version is checked.

Supporting the product life cycle with e-business makes compliance with ISO 9001 and VDA 6.1 quality assurance standards easier. For example, tracking of changes is important. All corrections which have been made as part of a single engineering change are connected by a single change ID number. In addition, it is possible to see who is working on documentation at any particular moment and more significant events in the document's history are also shown, such as approvals, changes etc.

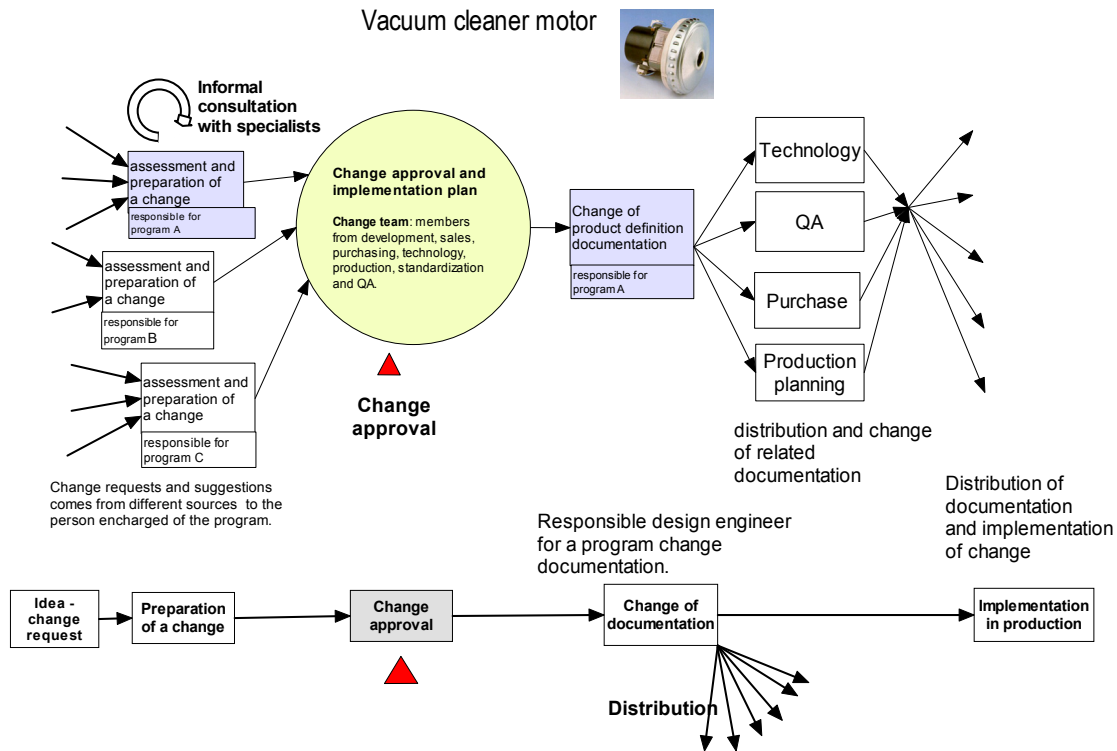


Figure 4. Engineering change process at Domel

Domel is getting ready to start using SAP for the management of its developmental projects as well. This will include employee time planning, costs monitoring and documentation management in all phases of product development. In developmental projects, the number of users is smaller and processes can be very unpredictable. Therefore, these activities have been transferred to the next phase and will be performed once documentation is completed and all the main processes are supported. The priorities in setting up an information system need to be considered. The foundations have to be set first, and then documentation and the main processes are arranged; project management comes later.

4. Conclusion

Good product life cycle management is crucial for successful company operation. Introduction of e-business in companies shortens their response times and increases the clarity of operations. It also opens the door to effective linking outwards. When a company integrates its information system into a sensible whole, doubling of data is reduced and transparency and reliability of business operation increase. Without a clear definition of information flow contents, general e-business programs cannot be used because illogical steps in information flow will quickly occur. It is of vital importance to reasonably integrate those features of product development and manufacture which work to the company's advantage into its information system.

At Domel, we first analyzed the product life cycle from conceptual design to manufacture, with special emphasis on developmental and technological documentation from its creation and approval to use. Due to various technical limitations from the past, the majority of technical documents is still kept and

used in paper form. The purpose of the analysis and renovation was to introduce electronic data storage through the entire product life cycle. A PLM module in the SAP information system enables document storage and distribution (drawings, characteristics, control procedures). It is a large advantage to have bills of materials, material data and the related documents all accessible in one place. Good overview over all changes and controlled access have also reduced the probability of errors.

The engineering changes procedure was also studied in greater detail. Our analysis showed that it is reasonable to transfer only document distribution to the SAP information system, while the decision-making process will continue to take place at work meetings. Changes can now be tracked from any workplace (with appropriate access rights, of course). The requirements of ISO 9001 and VDA 6.1 quality standards are now fulfilled in a clearer and partially automated manner. In manufacturing companies, it is important to recognize the most important processes and support them with appropriate tools and a certain degree of intelligence. In Domel, documents workflow has improved the company's overview over the document status and speeded up engineering changes and document approval procedures. Product development and engineering change processes are crucial for manufacturing companies and well worthy of attention, as was confirmed by the Domel example.

The initial phases of product development were analyzed with particular care. During these phases, the dynamics of changes is intense; therefore, developmental staff needs a tool that should be as close to the CAD environment as possible. A decision was made to implement direct integration between the CAD program Pro/Engineer and SAP. This enabled quicker access to 3D models to those users who need them already during the phase of product development. After review and approval of documents by a mixed committee, formal approvals are given. In this way we have managed to find a good balance of the work requirements with software capability.

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Jože Tavčar, PhD
Domel d.d.
Otoki 21, SI-4228 Železniki, Slovenia
Telephone: +386 4 5117 378, Telefax: +386 4 5117 362
E-mail: joze.tavcar@domel.si