Chapter 8 – Challenges of product management in manufacturing industry

This chapter examines the challenges in the separate fields of the manufacturing industry from the product management point of view. At the same time, a survey of the various fields of the industry is created from a slightly wider perspective. There are three case examples in this chapter that look into three very different product environments and the special features or demands in such businesses for product management:

- A (bulk) product to be manufactured in great volumes
- A product that is customer-specifically configured or customized
- A unique engineering product

These different product environments can also be referred to the traditional tri-fold division of products in the manufacturing industry, into A, B and C categories (figure 34).

- Category A – build to order or build to stock (BTO/BTS) no design work or engineering needed.
- Category B – usually build to order, a little engineering or use of mass customization is needed.
- Category C – always build to order. The product is built strictly according to the unique needs of the customer and a very large amount of design work is needed.

Challenges of product management in the engineering and manufacturing industry

Life cycle thinking, value added services and after sales

Capital goods manufacturers in particular have lately been looking for new business opportunities in services, and especially from after market services which last through the life cycle of the product. This trend is seen as the interest of traditional manufacturing companies in offering their customers different value added services

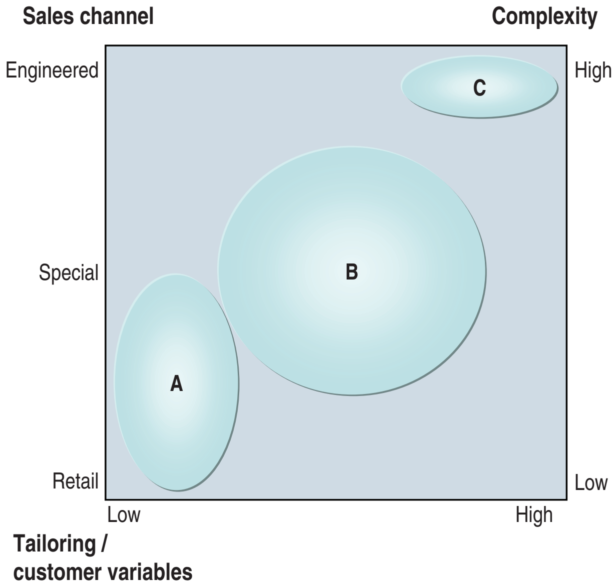

Figure 34. Product categories and their positioning.

on a much wider front. The objective of the service trend is to cover the whole life cycle of the product with services, which, especially for capital goods, can cover as much as 30 years or more. Terms often heard in this context are Life Time Service and PLM, or product life cycle management, which is usually a precondition for offering life cycle services. The management of the whole life cycle of products and closely related services is becoming a central factor in certain fields of industry. The objective of companies is to offer customers a traditional tangible product with more customer-specific services built around the product. This must be done better than before, with more productized services in order to create new business and growth with these services and to increase sales. In addition to PLM and Life Time Service, the name Extended Product is also sometimes used in some connections to emphasize the service perspective tied to the actual product. Service functions can be connected to the concept of the extended product before the manufacture and delivery of the product but the services mainly appear following delivery.

From these new service concepts, capital goods manufacturers are looking especially for even cash flows and better predictability of business and sales, but also for independence from the cyclic trends affecting many industries and a closer and tighter customer relationship. Figure 35 illustrates the impact of Life Time or pre and after market services on the revenue of a company in a capital goods field. This illustration presents the cumulative value of the services tied to the actual product. At the same time, one can see the balancing effect of the cash

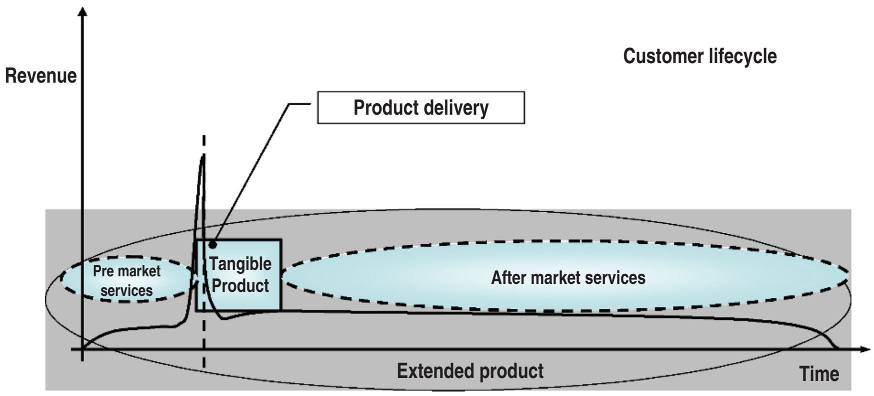

Figure 35. The concept of extended product and services.

flow from the service on the sales of the company. In addition to product sales, the goods manufacturer is sometimes ready to go so far as to deliver the capital goods to the customer on a small or even zero percent margin merely in order to get the maintenance contract for the device for the next 10 years. This can be considered a good example of the importance of services.

Clear and common features can be perceived for the whole capital goods industry in the area of services and especially after sales services:

- Aiming for the a better knowledge of the hardware that has been installed by the customers
- Aspiration for highly standardized, value added services
- Quick and easy availability of product data from the customer interface, utilizing the Internet and wireless technologies
- Anticipating maintenance work and remote diagnostics
- Renewals, modernizations and updating of old devices an important part of the business
- e-Commerce and use of the Internet as the sales channel for services
- XML data format increasingly used in transmission of product data between companies in the after sales value network

One of the most significant possibilities in the area of value added services is anticipating maintenance and remote diagnostics. The most modern information technology, wireless and landline networks make preventive and predictive maintenance possible in many types of environment: in buildings, in production plants, in mines and in forests. Many customers are ready and willing to pay for this. Above all, they are ready to transfer more responsibility for the maintenance of their production equipment to the equipment supplier or to the supplier's maintenance partner. This is natural because suppliers usually have the best expertise on the devices they deliver and a lot of filed information about the operation and performance of the devices at several separate customers, in different environments and in different problem situations.

There has been a movement away from the "We'll fix it when it goes wrong" maintenance model, to an anticipatory operation using remote diagnostics. Important information on the functioning of machines and devices in the field is gathered in real time by the information processing systems of the customer and supplier. In this way, the supplier or maintenance partner can continuously monitor the condition of the device and react quickly to problem situations. On the other hand, the supplier's aim is also to utilize its knowledge of the clientele and of the installed device base and to create incomparable surplus value for their customers. In this way, suppliers are able to offer better value to customers in the form of new services and also get additional sales and keep their present clientele.

A typical operations model concerning maintenance, spare part and repair services used to involve the customer making a failure report on the problem, by telephoning or faxing the supplier. Now the information can be moved through modern information networks. The particular strengths of remote diagnostics include the interactive element and the availability of real time data. The utilization of remote diagnostics is one possibility in after sales, making the comprehensiveness of the services offered to the customer very important. The whole does not function if the services have been split into small separate tasks.

The precondition for the delivery of an efficient remote diagnostics service is a direct data communications link, landline or cordless, between the service supplier and the customer. The information to be transferred is often confidential so it is crucially important to ensure that external parties cannot access the information. In other words, information security is one of the key questions in this area. Furthermore, the supplier can compare the problems experienced by different customers in different situations and in separate environments, based on the operation information. This allows suppliers to intensify the recorded use of customer devices and processes to develop their products.

A precondition for all these new value added services, e.g. expert services to be delivered both as pre and after market service, is the equipment and service supplier's functional product management. Suppliers must be able to control the whole documentation of the products they deliver, possibly with product structures dating to the periods of planning and engineering (as designed), production (as built), delivery (as delivered) and maintenance (as maintained). This makes it possible to know each customer's hardware and the hardware's software environment and to offer new services to the customer. In key position is the ability to control the product data electronically at different stages of the product's lifecycle (table 4) through the whole order-delivery process so that the necessary information is available and easily updated from the customer interface through the information networks.

Around the world, the strongly spreading trend of lifecycle management has brought plenty of new terminology, of which PLM is a good example. PLM refers to the wider frame of reference of product data management, and particularly to its life cycle element. CIMdata defines the term as follows: "Product Life Cycle Management – PLM – is a group of systems and methods with which the developing, manufacturing and management of products will be made possible at all the stages of the life cycle of the product."

Overall, one can say that the boundary between goods production and service production is disappearing little by little. An increasingly large share of the sales volume of international industrial enterprises is in information and services rather than industrial products. Companies themselves try to increase the share of services in order to add more value and to be less sensitive to economic fluctuations in their turnover. On the other hand, customers also want to have comprehensive solutions in which the provider of the product also arranges the financing, installation, maintenance, etc., of the product. A service trend can be clearly seen, and as the growth in the share of maintenance, marketing and R&D personnel in industrial companies increases so the number of production staff decreases. One can still add to this vision of the development trend of the future that the production of these services are made possible at a practical level only by the use of information processing systems which support product lifecycle management.

Traceability

Traceability can be roughly divided into two different areas: the traceability of the product process and the traceability of the order-delivery process. In the product process, traceability is concerned with the planning of the generic product, its creation process and the tracking of the actual development process. Traceability

Table 4. The role of product lifecycle management in various lifecycle phases of the product and order delivery processes.

Lifecycle phase	**Concept planning design and engineering**	**Launch ramp up and volume production**		**Service, support, maintain**	
PLM role	**Design data mgmt**	**Productizing**	**Production change mgmt**	**After sales**	**Support**
• **PLM functions**	• Item mgmt • Structure mgmt • Document mgmt • Interfaces to design tools • Support for workflow mgmt • Support for change mgmt • Design collaboration • Sourcing	• Item mgmt • Structure mgmt • Document mgmt • Integration to ERP • Change mgmt • Sourcing • Support product transfer to other/ multiple sites • Support for program mgmt	• Integration to ERP • Change mgmt • Document vault • Component mgmt • Approved supplier mgmt • SCM • Version mgmt • Collaboration	• Document vault • Item mgmt (spares, etc.) • Structure mgmt • Data retrieval • Re-use of components • Maintenance • After sales services support • Change mgmt	• Document vault • Item mgmt (spares, etc.) • Structure mgmt • Document mgmt • Data retrieval • Support for product mgmt in all lifecycle phases • Provides easy access to all information to all concerned

in the order-delivery process is about the tracking of an individual product unit's production and delivery to the customer.

The basic functions of a PLM system are item management, structure and document management and change management. These features are able to satisfy almost perfectly the demands set on the traceability of the product process. All the changes that have been made to the plans, designs, product documentation, items and product structure, the reasons for the changes and background factors are recorded in the PLM system. If necessary, the whole version history of the product can be easily retrieved using basic PLM functions, from the whole design lifecycle of the product. However, it is considerably more difficult to trace an individual product somewhere in the order-delivery chain: the traceability that is related to the order-delivery process. To carry out the tracking of the order – procurement – production – delivery processes, i.e. to attach a sales order for a product to the product's procured parts and components, assembly structures and production and delivery lots, is difficult with current information processing systems, mainly because very few companies make sufficient IT investments to achieve this. In addition to this, the integration of information is difficult in several sections of the supply chain. It is quite a task to integrate the information on each component, component delivery, and part assembly with the product delivered to the customer. In spite of this, functional solutions exist alongside weighty reasons, such as product liability, which has increased significantly. A better knowledge of delivered products is necessary in order to solve the problems of product traceability, to offer comprehensive value added services to customers, and to manage the quality of the products and the processes and risks involved with both.

Next, we will concentrate especially on the traceability of an individual product. The profitability of a product and the profitability of the company can be greatly weakened by the large quality costs resulting from the birth and progress of a faulty or low quality product in the supply chain. In some cases, products of this kind can end up with the customer. It is usually estimated that quality costs materialize from direct material waste, from wasted part manufacturing and assembly work, from returns of products, from claims, from repairs under guarantee and from decrease in the value of the trademark. Furthermore, increasing product liability can cause costs in terms of possible liabilities for damages. The quality of a product and the processes closely related to its production and delivery can be improved by improving the traceability of the order-delivery process and the traceability of an individual product. The progress of faulty products in the supply chain can be prevented at an early stage to minimize the costs caused by faulty products that have already been delivered to sales channels or to customers and even to create new business opportunities.

Traceability is a part of the company's risk management, in addition to normal quality development. The present ability of a company to track the products delivered by it can be measured by answering roughly the following questions: Can you withdraw exactly those individuals, which contain a faulty component or a wrong software version from the market? Can you trace them in the supply chain (i.e. discover where they are)? Does the recall have to be made with iterating margins of certainty by estimating the products that have been made by the company in a certain period and advertising the matter in a newspaper or even in broadcast news? How much time and work is needed to find the right period? Is it possible to serve a customer in the after sales market by delivering software updates or fault corrections pro actively even before the customer notices the matter, to say nothing of starting to present claims?

Usually a large amount of the traceability information related to an individual product and to its production and testing processes is gathered during the production of industrial goods. However, the information is usually shuttered inside one company or even inside a certain production unit on several different information-processing systems. In order to arrange the extensive traceability of an individual product it is essential to connect all needed pieces of traceability information to each product and to the customer to whom the product has been delivered.

Most of the traceability information for the order-delivery process is created during the transport, distribution, and procurement of the components, and during the manufacture and maintenance of the product. The information can include, for example: component lots, product structures dating from the period of manufacturing, sales, delivery or maintenance, the serial numbers of the components of the product structure, the testing information on completed individuals or assemblies, or the versions of software installed in the products (figure 36). In many cases also the status, performance, maintenance, and testing data on production machinery is allocated to certain precision parts or products. In addition to performance information, other information defined by quality regulations or standards can be allocated to completed products. A good example of this kind of traceability information is a high-pressure valve. The design documentation, specifications and certifications about the materials used, cast lot, cast number, heat-treating, and the test results from the pressure tests on the finished product must be attached to the valve. Collecting this information into a complete and unbroken chain from the procurement of the individual parts and materials to the delivery and maintenance of the completed product makes the traceability of individual products possible. Furthermore, much time, resources and money, which would otherwise be expended on upgrading the information and analyzing products, is saved and it is possible to offer valuable feedback to product development on the products that have been made.

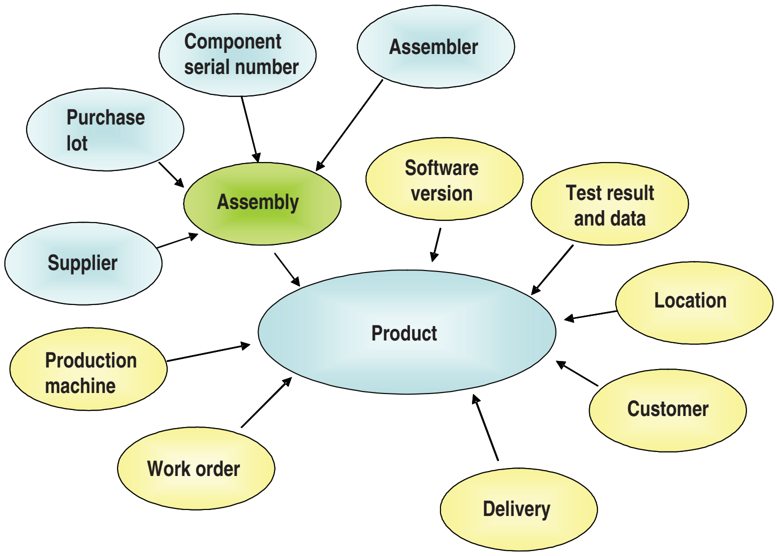

Figure 36. Information related to the traceability of the individual product.

Inside the company, there are usually several separate information systems – for sales, procurement, production, logistics and maintenance – which manage the business operations in question. These systems are typically responsible also for the collection of traceability information. Still, each of these systems manages only its own small part of the jigsaw puzzle. Such systems include, for example, specialized information processing systems for maintenance management, procurement, reception, testing and warehousing of procured parts, inventory management and production control. In other words, the biggest problem is not the need to collect the information, but the ability to connect the collected information into a unified totality that can be utilized, for example, in data warehousing and data mining.

In addition to the scattered information, and the information automation islands of these specialized systems, the real problem is their inability to allocate the information to purchase orders, work orders, production lots and individual products or vice versa. There is a need for information processing systems that can gather the information created during the production and after sales processes so that the information can be allocated to an individual product and to a customer. The information exchange between systems must be emphasized in this context.

One key section in the traceability chain is also the operation of each company and the role of the company as a part of a network of companies. There is usually a large group of companies operating in the supply chain of a given product. These companies should be able to exchange the necessary traceability information. The network can include maintenance partners, dealers and affiliated companies. This holds true especially of the after sales of capital goods where the equipment suppliers are moving closer to their customers, talking about life cycle services, and utilizing traceability information to make services available to the customer. In this context, the customer is seen not only as a buyer of new products, spare parts or maintenance services but also as someone who will continue to buy turn-key services throughout the whole life cycle of the product. The product's supplier can take responsibility for a device for its whole life cycle in return for a service fee. Knowing the installed device base becomes very important in this kind of service. The information must be managed so that it is possible to offer this kind of life cycle service to the customer cost-effectively and with a high level of quality.

Figure 37 shows an example of the utilization of data mining in connection with the collection of traceability information. The illustration presents supplier-specifically the division of faults that have been perceived during the acceptance inspection of the procured components used in production of certain product.

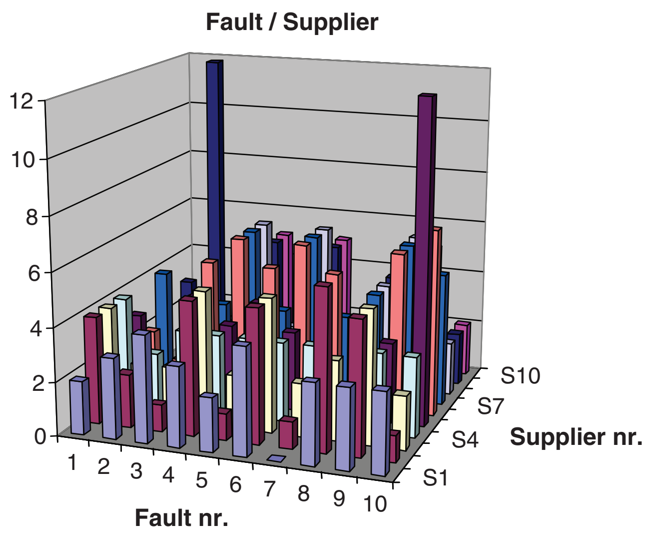

Figure 37. Division of perceived faults between separate suppliers.

Special challenges of product management in the high tech industry

Companies in the high tech industry have to meet the special challenges of product management in their own territory. These challenges result from the special character and nature of the products, from the general development of the technology and from the strong networking of the design and production functions in high technology companies. One can say roughly that nearly all the products of the high tech industry consist of software and different kinds of electronic components and mechanical parts. Merely connecting these three very different worlds, flexibly and well, into one functional entity is a big challenge. The production and design processes of software, electronics and mechanics are quite different, as is the life span of these three different elements.

In the field of high tech, the life cycles of products and components are growing shorter. At the same time, products utilizing the latest technology must be brought to market more quickly than before and in accordance with customer demands and wishes. This pressure, with the broad spectrum of different technologies and quick development of technology, has led companies operating in the high tech field to form partnerships and broad sub-contracting networks. In these networks each actor has specialized in some particular part, subsection, design, or production operation within the narrow field of its core expertise. The network is connected together only by the product, which is common to all the actors. Data on the common product (documentation, product structures with their components, components with their specifications and suitable manufacturers, product changes and technical specifications) must be communicated quickly, faultlessly, and automatically between the different companies in the network. This communication is crucial to the individual companies and to the entire network and it largely determines the competitiveness of the entire network on the global scale and in the more competitive markets.

Technological development has accelerated. The short life cycles of different components and the constant development of software bring a new dimension to product management. The compatibility and convertibility of separate components and software versions is a difficult problem, which must be solved for each product. Another special challenge set by fast development and shortened life, is the increased uncertainty of procuring electronic components. The availability of components can be bad and can change very quickly. Furthermore, the delivery time for special components may be very long compared with the turnaround time of the production process of the actual product.

The networked company structure contains a huge developmental potential when each actor develops into an expert in its own field. However, the big challenge lies in the quick transfer and distribution of information in the network so that every company in the network can operate flexibly, based on real-time and up-to-date product data. The simultaneous increase in product changes increases the challenge. The distribution and transfer of information, in addition to technological challenges, involves a question that is quite basic for the whole network and to which a clear answer must be found. The ownership of the information in the network must be decided, and information security problems solved, before a seamless and fully functional cooperative network can exist.

Case 1: Electronics manufacturer

The sample company from the electronics industry – Bit-shop Plc. (an invented name) – is an international electronics manufacturer. Bit-shop manufactures domestic appliances either under its own brand name or directly under the partner's brand as part of a bigger set of devices delivered by other manufacturers. The products are sold and delivered to Europe-wide markets. The products consist essentially of standard electronic components, mechanical parts and pieces of software.

The company has operations at four sites, two of which are in Finland, and two in Central Europe. Product development and production have been divided across the sites in such a way that some product lines are designed and made in one site only and others at all the sites. Additionally, one contract electronics manufacturer makes products ready for distribution, i.e. for sales packing (box build). Some of the software used in the products is made by Bit-shop; the rest is delivered by another company, which has specialized in software development. The products made by Bit-shop are not especially tailored but restricted change of the products is possible, when necessary, following the basic principles of mass tailoring.

Efficiency as a goal

The strongly increased international competition of the 90s created pressure inside the company and provided the impetus to develop product management. The intensification and streamlining of the operation of its main processes had been the biggest challenge to the company over the last few years. The products were good, but it took too long and required far too much labor to bring them to market. In other words, the productivity of the product design had not evolved in the desired way during the 90s. It was also too slow and expensive to make changes to products at later stages in the life cycle; in other words, the company was unable to achieve the best possible margin for its products in the market. The development objective was to facilitate the management of product data and product versions and to accelerate product development and the volume production ramp up processes significantly. Furthermore, preconditions had to be created for a considerable increase in contract manufacturing, even on a worldwide scale. One objective was also to improve customer service and to respond to fast changes in market demands. To achieve these goals Bit-Shop launched a PLM development project.

When the project was launched, they decided to nominate one full-time project manager. His task was the planning, management and carrying through of the project. Furthermore, it was decided that a clear framework for the whole project should be made by deciding the objectives of the development work and drawing up a coarse progress plan or Road Map. This was made in a common workshop, with the top management of the company, in order to get the necessary commitment and set targets for the development work.

The management of the company set the following primary objectives for the PLM project

- The throughput time of product development, i.e. Time to Market must be shorter. Furthermore, the ability of the company to estimate the actual time needed to introduce products to the market must be made more accurate.

- The effectiveness of product processes must be increased. In improving effectiveness, special attention has to be paid to the harmonization of processes in all offices. The preconditions to develop effective sourcing must be improved, as well as the ability to work flexibly in cooperation with the contract manufacturers.

- Ability to answer the changing demands of the customers and the market faster and more effectively and in a more customer-oriented fashion than before.

Indicators

Clear and simple indicators were set for the above-mentioned objectives so that it would be possible to estimate the real success of the project and direct development needs for the future.

Objective 1

- Turnaround time from stage 0 of the product development to stage 5, in other words from acceptance of the first product concept to NPI, according to the development project model of the company (a gate model).

- Throughput time accuracy; the estimated time for product development throughput at stage 1 and the accuracy of the estimate at stage 5.

Objective 2

- Hours used in product design for the same product family from stage 1 to stage 5. The change in used design hours compared to earlier products of the same product family.

- Number of product changes made at stages 1–5 of the product process and turnaround time of the individual change compared with the situation earlier.

Objective 3

- Number of ECR/ECO and turnaround time of product changes implemented after stage 5 of the product process.

According to the framework set by the management of this company the initial planning and fast startup of the project was to be the next task of the project manager. The Road Map or progress plan of the project contained four stages, with the first stage lasting eight months and the following three stages six months each. The following separate and simultaneous tasks were seen as the base of the project:

- Definition of PLM system requirements and refining of processes and of product data for the system implementation

- Planning of the needs for organizational change management

- Choice of the system supplier; inviting tenders, going through the tenders, reference visits

A project manager was responsible for overall management, but a heterogeneous team from different parts of the company was collected to take responsibility for individual tasks. The content of the progress plan for the actual project was as follows:

Stage 1: (8 months)

- Items, documents and structures managed within sphere of the product management in five product lines and on one site
- System support and change management for the product process
- An ERP interface with manual file exchange

Stage 2: (6 months)

- Interfaces to mCAD and eCAD systems with semiautomatic file transfer, in other words utilizing the export/import features in the systems
- Electronic information exchange with the contract manufacturer through XML format on one site and limited access to the product data for two partners (software and hardware planning)

Stage 3: (6 months)

- ERP interface automation based on XML and Roll Out of the stage 2 implementation of the system, in other words deployment in all other offices

Stage 4: (6 months)

- All chosen partners, limited access to the product data
- Distribution of the product data to all the chosen parties
- Publication of the product data to the customer interface through extranet
- Customer service channel to extranet for product support, claims and change requests

Starting the project

The project was quickly started in all three of the above-mentioned areas. The large task of going through all the item and document information in the legacy systems and defining future processes related to these was begun immediately. It was decided to do this as an internal project within the company. The external experts were asked only to comment on the work briefly in its final stage. In connection with reference visits performed in connection with the choice of software, solutions for item and document control and connected processes carried out by other companies were also studied.

With the aid of a consultant specializing in change management, a comprehensive change management plan was made for the organization to carry out changes in ways of working and thinking. However, most of the actual change management was done within the company, using its own organization and managerial resources. A change management plan was drawn up with the consultant, the starting situation was estimated, and tasks were distributed at each stage of the actual project.

For the choice of software, a very short description of the entire project was drawn up, covering the company environment, and the required properties of the product lifecycle management system. This description was sent, together with requests for tenders, to four technology suppliers or their implementation partners. The main objective was to get the most commensurable offers possible from all the suppliers in order to compare the offered solutions and their costs. Furthermore, an attempt was made to arrange reference visits, with each supplier, to companies in the same field. The decision on the choice of technology was made based on:

- Reference visits
- Lifespan costs (TCO – Total Cost of Ownership) of the system
- Amount of deployment work
- User friendliness
- Impression gained of the technology supplier's future

It was important for Bit-Shop that the supplier should have a similar view to their own concerning the future of the field and the general technological development in the area of PLM applications. Furthermore, it was decided to use a separate system integrator in the deployment work.

Execution of the project

The company moved into a new era in the management of product lifecycles in the autumn of the year 2001, when the first stage of the project was completed. The deployment of the PLM project differed considerably from all the company's earlier development projects, including the ERP implementation project, in terms of its scope, the new processes brought into use, and the new modes of action introduced. Now the whole spectrum of product lifecycle management was brought into use at one go, though at first only at one site. All the product data, items, structures, documents, and related software were brought within the scope of the system. The system allowed paper based processes to be transferred immediately into an electronic form. One great advantage of the move to electronic documents was the ability to see the information in real time. Uniform modes of action in the company's departments and simplification of core processes could be clearly seen.

The product lifecycle management was made to cover all the sub-processes of item management during the whole lifecycle of the items, from establishing a new item to the process of killing the old item, the approval procedures for new products and the change processes of products in production. In addition to physical components, in this case an item refers also to the software installed in the products and to documents connected to the items describing the products and defining the assemblies or their manufacturing and actual assembly work (e.g. assembly instructions).

Concerning physical components, a more systematic way was introduced to control the component knowledge of the company. A new issue was the control of sourced standard components and the item numbering schemes for these items as well as the management of the manufacturers and suppliers of these sourced components. In the first stage of the project, the company's product development processes were also connected to the ERP system. In the first stage of the PLM project a semiautomatic data transfer mechanism, over which new elements could be built later, was carried out. XML format was used, as well as the existing export/import features of PLM and ERP-systems.

The better management of change processes was especially important. Change management immediately informed the people who needed to see the effects of the change. This accelerated reaction and gave more time for carrying out the actual changes. The changes did not come as a surprise. The beginning of electronic product lifecycle management required considerable initial exertions in specifying product data. In other words, the absolute first task was to specify what constituted product data in which context. Other very laborious tasks included cleaning the item data, retrieving and sorting documentation, determining processes, preparing instructions, and providing user training so that the effectiveness of the operation would not decrease when the system was brought into use in the company. In the example company, the number of PLM users would be 200 in the first stage of the project, and the product lifecycle management system would have about 700 users in the third stage of the project.

In the next stage partners came along

The second stage in the PLM project began when the use of the PLM application at the first site had become routine. In the next stage the first partners, the design subcontractors, would also become users of the system. The objective was to increase the ability of the company to react to changing situations and to ease the routines of information retrieval and transfer within the company. With external partners, the goal was to reduce the mistakes taking place in data transfer between the partners. The idea was also to reduce the work required for serving design partners and to decrease the amount of manual re-entering of information into the information systems by the partners. The partners became better able to fetch the information they needed for themselves and to add information directly into the PLM system. In other words, the objective was really to increase the productivity of the design work.

The project had passed the first stage. However, it was decided that it would proceed according to the steps outlined in the Road Map with a maturing period of three months between stages. This would allow the expertise of the organization to develop as users adopted the new modes of action. The short maturing period would also increase the readiness of the organization to move on to the following stage of the project. During the maturing period, more end users would be trained so that everyone's expertise would be raised to the same level. At the same time, the functionality of the processes that had been brought into use would be studied and small adjustments could be made before the totality was spread to cover the operations of the whole company. Concerning the realization of PLM objectives one could say that the turnaround time of the product process would probably shorten significantly; the effectiveness of the operation processes would improve. This was not merely the outcome of new electronic processes but the outcome also of good change management and training and of new operations models. Many things could be learned from the first stage of the project, but one fact in particular was perhaps clearest; the strong input of the organization into change management was worthwhile. The organization was extremely excited about PLM and willing to learn new modes of action. Success in this area was naturally affected also by the fact that it was possible to redeem expectations with clear and simple operations models and with a sufficiently user-friendly application.

When designing the project, the demands and the actual amount of work in defining new modes of action related to the creation and maintenance of items and documentation in the whole company was underestimated as well as the labor needed to go through the existing item and documentation base. External consultants and reference visits were very helpful in this work. The appeal to so-called best practice models solved differences in views between the separate item and document "schools" inside the company. Nobody had to give in.

In terms of project costs, the schedule and the amount of external work had kept extremely well so far. This was mainly because the implementation had been almost perfectly based on existing technology. In other words, the existing properties and features of the acquired standard software package were used. The implementation partner's experience in carrying through projects of this kind was also a great help. It was decided however to add the maturing period of three months to the schedule between the stages of the project, at least for the first and second stages.

Case 2: An engineering product

The Project Workshop Plc. (name invented) is an international company that delivers energy production plants and turbines as turnkey delivery everywhere in the world according to the principles of a project product. The design, manufacturing and delivery of the products are always unique but observe certain similar basic creation and delivery process principles. Usually the products vary in the functions, size and capacity of the plant. The company has product development, engineering and manufacturing activity at three European sites. The company also uses a number of subcontractors and partners – especially in design and manufacturing operations – in all stages of delivery. The company does not operate at all in the field of after sales and maintenance. These services are bought from local service providers. Therefore, the biggest area of expertise for this company is in planning and design, project management competence, and the efficient management of sub-contractors and suppliers. Furthermore, a few special manufacturing stages can be included in the areas of core expertise. In the spring of 2000, the company launched a development project aimed at developing product lifecycle management. The objectives of the project were set as:

- Improving the quality of planning and engineering and reducing planning changes and errors in the late stages of delivery
- Improving the productivity of planning and design
- Reutilization of existing and faultless standard design solutions
- Quicker turnaround time in design and engineering
- Better ability to serve the end customer, by distributing information to the customer at all stages of the project

Situation at the beginning of the project

It was decided to begin the actual project, after first setting objectives, by studying the present state of product lifecycle management in the company and identifying its biggest problem areas and challenges. It was decided that exact plans would be made for the beginning and content of the development project based on this study.

The current state of affairs was surveyed at all three sites so that differences between the current situations of product lifecycle management at each site could be clarified. The survey was carried out by interviewing key persons from the company in engineering, design, manufacturing, sourcing, marketing and IT services. The preliminary survey was conducted by a consulting company offering expert services in product management. About 30 days of external work were needed to carry out the survey. The result of the survey had been expected. The results are presented briefly below.

Management of items

The item base of the company and the item coding scheme were quite comprehensive for all production materials related to the company's own manufacture as well as for sourced parts, components, and installation tools. The computer and embedded software installed in the product was not itemized, however. There was an adequate standardized and uniform description documented for the structure of the item code at the company level. Currently the management of items was carried out in the company's ERP system. The grouping and classification of the items had been based on the product structure hierarchy according to the system, assembly, sub-assembly principle, even though ERP systems could not support the structure hierarchy due mainly to a lack of structure management features in the system in question. The structure and management of the assembly and work drawings had been concentrated, with the quality documents, in a separate document management system. For regulatory reasons, paper versions of documents were filed in the drawing archives, and these were considered the official versions of the documentation and were used as the originals for accepted drawings. The operative documents were also recorded on network drives according to the index structure defined in the quality system.

Problems often appeared when – as was too common at present – the official paper document did not correspond to the version in the file. An attempt was made to secure the entirety of the information by an agreement that the person who had made the original drawing would also make any changes. The versioning of documents had been carried out alphabetically; the first version was A, the second B, then C, D and so on. A conscious attempt was made to avoid linked documents. Both Finnish and English were used as document languages. The management of documents coming from subcontractors was problematic because the material contained a large amount of CAD documentation using several different formats due to the different documentation systems used by the subcontractors and because the subcontractors' documents had not been included within the current document management system. The ERP system and the document management system covered, among other things, the quality manual, administrative documents, documentation on customer projects, and production and delivery documents. The document management system processed only the metadata for the documents; there was no link or connection from the current system to the actual document files.

Approval of documents

The inspection, approval, and release of drawing documents were manually acknowledged with a pen on the paper originals but no information about these measures was recorded in the document management system. In other words it was not known, from the project management point of view, who had accepted or released the documents and when. This caused big delays because it was always necessary to wait for the distribution of final versions. The distribution of documents was based on distribution lists and carried out on paper through the internal post.

Management of the product structure

The company's products had slightly different product structures for the bidding stage and for the production stage, mainly because the coarseness level of the product in the first stage was little different. The part lists for the production stage were found from the drawings of each part assemblage. The exact traceability of raw materials and sourced components in the product was important because in certain cases various authorities and external auditing institutions were interested. The supplier did not participate in the management of the life cycle of the product after the actual delivery. A product guarantee was granted for one year, during which time the supplier was responsible for repairs under guarantee. The previously mentioned single-level hierarchy in item management caused problems in the structure management of the product because in principle all the parts were at the same level and because the product was typically quite complex.

Information system environment in use

The intranet integrated all the company's sites into one entity. The network made possible the connections between the separate units and the utilization of common servers and network drives and common databanks. The information system environment was quite scattered in terms of the software in use for the production and maintenance of product data.

There were several CAD systems in use. Indeed nearly all the design functions had their own systems. This was because the separate fields of design and engineering had very different needs. For historical reasons, each of these areas had formed its own special systems. Furthermore, the company's IT strategy had been to choose, instead of a general system, a specialized system for each separate design function. In addition to this, a lot of the design and production had been outsourced to different subcontractors and to contract suppliers. In this situation, the principal also had to pay attention to the applications used by its subcontractors, which increased the amount of software in use. The great amount of software made its integrated use very difficult because the wide spectrum of software made the reuse and transformation of data difficult.

Integration of information processing systems

As stated earlier, each part of the company had its own system. There were four different in-house CAD systems in engineering, ERP was responsible for material management, and there was a special dedicated system for delivery project management. The transfer of product data succeeded only between separate CAD systems. Data transfer between systems contained many shortcomings, which caused the formation of overlapping product data and a lot of manual reworking. Some different sites had information processing systems in common, but the operations models differed significantly from each other.

Standard design solutions

The company had started a design standardization project to increase the use of tried and trusted, high-quality design solutions. The standard solutions involved successful planning solutions and empirical information, with which:

1. An attempt was made to avoid re-creating existing solutions, which ought to be utilized more in the design work.

2. The throughput of planning was accelerated.

3. Design productivity was improved.

4. Quality was improved and stabilized.

5. Mistakes were avoided.

6. Turn-key deliveries were facilitated and task definitions and the operation of sub-contracting became easier.

7. Manufacturing, material sourcing and warehousing were facilitated.

8. The number of bought and manufactured items was reduced.

The objective – a standard structure that could be reused as such – remained unchanged.

A generic standard product “1” was created for structural solutions and assemblies of proven value. Good and suitable structures and assemblies were recorded on product 1 as reusable drawings and part lists. The list of filed solutions was also recorded in the document management system. The company had to use standard structures, in accordance with its modes of action whenever this was possible. The accepted standard solution contained ready elements of three kinds:

1. **A model drawing** – demonstrating the content and manner of representation required of the drawing in question

2. **An assembly** – representing the entire model at a suitable scale

3. **A SOP** (Standard Operating Procedure) – describing the mode of action, an approach or method used by the company in certain tasks

Frame of reference for product management

In addition to the goals and targets set to improve the productivity of design and engineering, three other starting points were set for the development of product lifecycle management:

- More of the manufacturing of the product and its parts would in future be moved to the sub-contractors. Product management would have to help with this.

- More and more product data would be translated into an electronic form.

- The objective was to transfer responsibility for large totalities to the subcontractors so that they would become turnkey suppliers instead of being only part suppliers.

Considering these starting points, the product lifecycle management system had to be able to serve as an efficient tool for implementing these objectives. It should furthermore, be possible to control the data flow of the whole order-delivery process much more effectively than at present, using product lifecycle management. Change management was difficult for many sub-contractors, who could not utilize the principles of concurrent engineering (CE) in the desired fashion over a sufficiently broad area. Information security was also a concern owing to the networked environment.

Problem sections of the product management

Based on the survey report, the company regarded shortcomings in document management as the biggest problem in the area of product management. The availability of the information would have to be improved and information retrieval made much more efficient and flexible. The document management would have to cover and contain more document groups. It would have to be handy, efficient, and able to control the actual documents as well as the metadata. The current system could not do this.

Other special needs were:

- Chronological management of the information. The product lifecycle management system should be able to handle and distribute information on traceability, design history, and document-related change information.
- It should be possible to verify information by comparing it with the original. There should be less overlap in product data.
- The subcontractors' access to the databanks would have to be clarified. In this area, a SOP would be drawn up and a clear frame of reference set for information security.
- The product lifecycle management system should make possible the integration of design and ERP systems, so that the synergic advantages of the integrated use of systems could be fully utilized.
- It should be possible to implement the hierarchical management of product structures.
- Improved ability to use files and transfer them between the separate system applications.

Developing product lifecycle management in project workshop Plc.

The company was quite satisfied with the result of the preliminary survey: there were many areas to develop but also a lot of opportunities to improve the effectiveness of the operation while keeping an eye on the set objectives. A successful project would considerably develop the operation of the whole company. As a basis for the PLM implementation, it was decided not to apply all the possible properties of PLM. It would be better to focus on selected areas. The survey information suggested that the deployment of the PLM system would be profitable for Project workshop Plc. The deployment work and the adaptation of the system could begin with certain features, on a marked off operation field. In the long term, over a five-year period, product lifecycle management would come to cover the operation of the whole company as well as the closest sub-contracting networks for the selected areas.

When the survey work had been completed, a cross organizational team was collected to carry forward the project. The planning work for the project began from the AS IS analyses. At the same time, the whole team analyzed the possibilities and advantages of applying each area of PLM. For the implementation, an investment analysis was made with ROI (Return of Investment) calculations for the deployment project.

Management of documents

The management of documents would be one of the most important application areas for the product lifecycle management system in the company. It would allow a significant benefit to be obtained from a moderately small input. On the other hand, this would require that both the metadata and the actual data content be managed by one system. In other words the present operations model and software, the document management system in which the system controlled only the metadata, would have to be given up.

The centralized management of documents could be effectively used to develop information retrieval and filing methods, which would then increase the effectiveness of the design work significantly. The successful utilization of the standard design solution project would require efficient and easy retrieval of information. It would be possible to develop the internal cooperation of the design organization with external parties – the subcontractors – in a more rational direction by using the PLM system and the results of the standard design solution project together. In this way, it would be possible to build a real self-learning organization, which would learn by utilizing the results of functional document management. It would also be easier to develop the management of multi-page design documents through centralized document management. For example, the drawings and related part lists could be made up as one document irrespective of which software had been used to create the documents in question or where they were actually located in the company's information processing system.

Product lifecycle management would help with the problematic management of the subcontractors' document material. PLM solutions based on Internet technologies could be used to build a functional solution to the management of the networked sub-contracting environment. Because both design and manufacturing were carried out in this case by sub-contracting, it was extremely important that the information be made to go flexibly through the whole chain of operations. In other words, the right version of the necessary information would have to be quickly retrievable irrespective of the physical location of the person needing the information. Furthermore, the customer and subcontractors would have to be able to make controlled changes to the designs and to accept and inspect ready designs in order to find the best and most reasonable solutions for each design. On the other hand, this would mean that new problems concerning information security and user privileges would have to be solved.

A well-functioning information connection could also be formed between different parts of the company. In this case, the information processing system could help to level out the workload peaks of design and engineering through internal sub-contracting and to increase the synergy between the separate company sites. It would then be possible to utilize the results of the standard design solution project in the whole company, irrespective of location. Figure 38 depicts the operation of the design network roughly as it was originally and as it could be with the help of flexible document management. The idea of the scheme was that the product lifecycle management system should utilize Internet technologies.

Internet technology allows information to be updated by different parties in the network, with all parties having their own viewing rights, thus securing the flexible and free progress of information throughout the network. The principal does not have to act as the distributor of information or sacrifice a huge contribution of work to serve all parties. The co-ordination of the operation, the creation of operations models, and the management of the sub-contracting network remain the principal's task. In this scheme, a connector represents an information connection which functions in both directions, SA is the engineering subcontractor, TA, the subcontractor for production, A, an auditor and AS a customer. B is naturally Project workshop Plc.

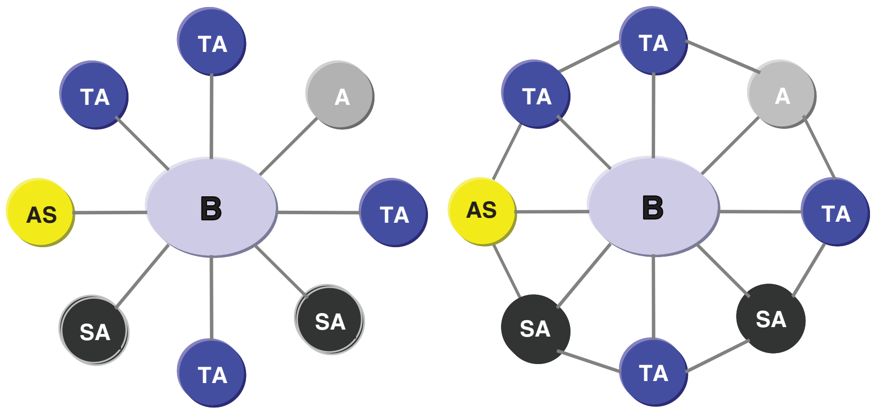

Figure 38. Operation network for product design and the connections between the separate members of the network before and after deployment of the product lifecycle management system.

The management of user privileges is essentially connected to the application solutions described. The user privileges for employees are controlled by the system, as well as the privileges for all other parties within the system. The system provides each user with a personal profile. This profile determines what the user can do within the system. This functionality can also be used to build workflows. The subcontractors can be given rights to create or update information or only to look at documents created by another party in the process of creation, checking, acceptance, and release of information.

Management of the product structure

The company's management of the product structure was originally almost non-existent because the management procedure contained only a single-level hierarchy. All items for a product were in the same group. For the deployment of a PLM system, a functional generic product structure first had to be created. It was essential that a product could be divided logically into suitable totalities, which could be collected as structures, which would at least serves co-operation between design and production.

Change management and workflows

The company was operating in a highly networked environment. In addition to its own design organization, some external parties were very deeply involved. The subcontractors and partners in various areas, the auditor and the customer are important from both the definition and execution point of view of the design. The change management tool with workflows would be used so that the subcontractors, the auditor, the customer and the company's own production could be connected to the design. With the assistance of the product lifecycle management system, the auditor and customer could electronically deal with the compulsory approvals and inspections of the designs and design changes in preparation.

The change management tool could be used to gain significant advantages especially concerning turnkey deliveries by using the Internet user interface to the PLM system. The use of the change management tool could reduce the costs caused by bad flow of information and uncontrolled changes. The advantages of an Internet user interface would also include independence of equipment and operating system, which would be very advantageous in terms of price and ease of maintenance. The same PLM application hosted by the principal could be used by the subcontractors, by the customer and by the auditor. The management of this kind of totality could be carried out using the standard workflow features of a PLM system. The auditor or the customer would simply be defined in the workflow as one of the parties required to accept the document in circulation before the principal of the design subcontractor could release it. Likewise it would be possible to use the company's and the subcontractors' expertise more effectively than before. Production know how could be delivered to design and engineering through a request for comments, for example from the internal and external manufacturing parties. For example, the following categories would be included in the workflows:

(a) **Approval:** For example a design change (Engineering Change Order – ECO) delivered by e-mail or a proposal for a design change (Engineering Change Request – ECR) is delivered for acceptance to the department head or to an outside auditor. The workflow does not continue until the person in question has acknowledged his own approval of the document. The receipt can also be conditional, in other words can depend on some certain detail.

(b) **Commenting on or inspecting proposed changes:** ECOs are delivered for comment, if necessary, by a project and manufacturing work planner or subcontractor. The workflow does not continue until the party in question has indicated its opinion of the matter under change or development.

(c) **Providing information:** Information about the work under change or development is transmitted to those parts of the organization concerned in the matter. In this case, for example, the delivered document does not require any measures and the workflow proceeds according to schedule.

The actual design work can begin when sufficient information is available; when approval has been received for the action to be taken; when the persons in question have given their own views as the basis of the design work. The design proceeds iteratively through the product lifecycle management system, the focus growing steadily sharper as the work progresses. Management of the workflow can be handled in the same way as in the change process.

The advantages and development potential brought by the product lifecycle management system

At the planning stage of the PLM-project, objectives were originally set in such a way that the project could be divided into three development projects of approximately equal size. The objectives could be reached by developing communication and cooperation between the separate departments of the organization and external interest groups. Developing the transfer of files and the conversion of different formats would improve the utilization of work that had already been done, and the work done by the interest groups could be better utilized without manual stages. This was especially important when attention was being paid to the numerous document creation applications, i.e. the CAD systems. Connecting the PLM and ERP systems would increase the automation of data transfer and accelerate the manufacturing and sourcing processes. The quality of the operation would be developed by reducing design information mistakes due to bad communication and incomplete or late information transfer. One of the most important viewpoints in this context was that more advanced product management would make possible a radical reduction of every kind of unnecessary and non-value-producing work.

We have seen earlier how work can be better utilized; information retrieved more effectively; design changes made more rationally and with fewer mistakes; and benefits obtained from existing applications. On the other hand, the product lifecycle management system could not in itself improve the operational effectiveness of this company; only its progressive and reasonable use in everyday work would improve the company's operations. The core task for this kind of system is to provide a new tool with which to break through separate organizational interfaces and to remove physical distances in the organization as well as to enable the intensification of the work in organizations, companies and networks.

Product lifecycle management can help to overcome difficulties in daily work and bring many opportunities to develop the rationality and cost efficiency of

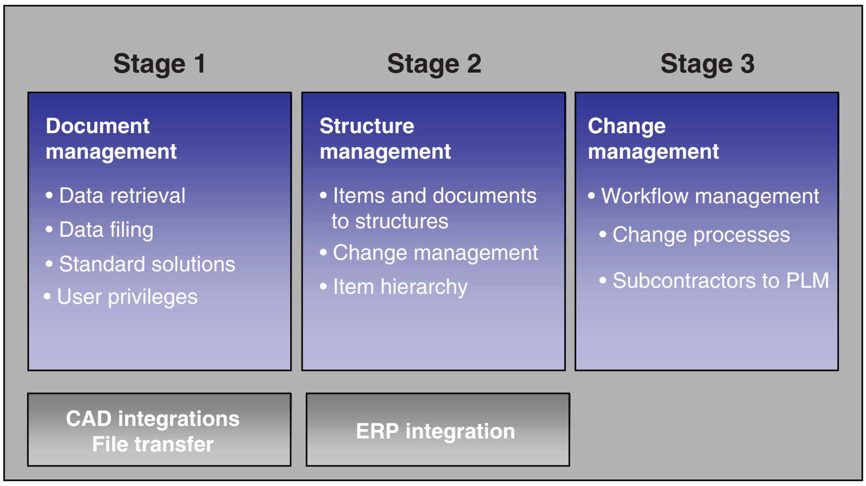

Figure 39. Order of deployment of product lifecycle management features at Project Workshop Plc.

the whole order-delivery process. Still it is difficult to measure the results of development operations in the most important indicators of the business world: euros or dollars. A PLM investment is very expensive both internally and externally. The organization has to really commit to the PLM deployment and make use of plenty of external help. According to preliminary plans, the PLM project for Project Workshop Plc. would be based on three different stages and totalities (figure 39):

- Management of documents
- Management of the product structure
- Management of changes

Pilot

When the plans had been completed, the project proceeded to the following stage. The expertise of the organization was regarded as defective in the area of product management, so it was decided to carry out a pilot study or simulation of the project on a small scale, in one office but on genuine production material.

The functionality of the product structure created to develop product management, the “cleaned” pilot items, and the connection between documents and items were tested using a commercial product lifecycle management system. The implementation of the pilot documentation in question under the control of the PLM system took place in such a way that the documentation in electronic form – in this case all 2D drawings, part lists, schemes and technical specifications – were gone through, collected and saved to a network drive. Metadata was then created for each document item in the PLM system. The information used for the metadata attributes included: name, number, document type, version, revision, creator, format, file vault name (in other words a reference to the location of the actual document file), and the recommended viewing and editing application. All documents, which consisted of several pages and belonged to one particular document item, were connected and a metadata card containing the information mentioned previously was created manually. When the actual file was connected to the item and its metadata card, the original file was deleted from its original position and moved, under system management, to the file vault. The history of actions later performed on each document – viewing, editing, output, etc. – was recorded in detail in the history log. At this stage, the material had been taken within the sphere of document management.

The adoption of change and structure management requires the creation of a product structure on the system and joining the individual items to the structure. A product structure was then added to the system. For each object in the product structure, an item was created on the system with the following attributes: name, number, type (product, assembly, part, material, component, or document), version, revision (if necessary, dozens of attributes could be created for the items). Furthermore, the relation of each item to other items, in other words parent–child relationship, was defined for each item to create the hierarchy of the product structure. It was then possible to connect the actual document items to the product structure. The system now knew all the items in a certain structure. The system therefore knew how changed objects – a particular assembly, for example – were related to other objects in the same structure.

Experiences of the pilot

In the pilot, each legacy data load stage was performed manually. In other words, all the metadata were fed into the system from the keyboard. This required a lot of routine work, but its success was immediately clear.

When a product lifecycle management system is brought permanently into use, the method described above is not suitable because there can be dozens of different products with tens of thousands of items in each. Feeding legacy information into the system is usually carried out by mass loading, using suitable data migration software, with Microsoft Excel and Access, or by writing the necessary loading program. However, the preparation of this mass charging of the database usually requires a great deal of work because different places have to be searched for the necessary information, which has to be massaged into a suitable form and gone through thoroughly to ensure its validity. Before this, the relations between the separate components and assemblies must be carefully analyzed.

The information is imported into the system in a way that is similar to creating new design information in a normal production environment: filling out a metadata card for each item. The input of the metadata can also be automated according to certain parameters. Alternatively, the metadata can be imported for example via CAD integration. It is also possible to include pre-filled fields, following some suitable logic.

When a plan for the manufacture of a new product was made in Project Workshop Plc., a list of the drawings to be created was made at the same time. This list was then updated according to the progress of the design work. With the adoption of product lifecycle management, the drawing list was replaced with an "empty" product structure (i.e. a structure without content) to which each document would be connected immediately upon completion. In this way, the creation of product data could be very carefully controlled from the outset of the system. The work and resources required for performing this design task could be effectively distributed, and the progress of the design process could be followed in real time without separate reporting. The system could simply be asked for detailed reports on the state of each item and its related documents for a given product or project.

When the advantages brought by the product lifecycle management system were estimated from experience gained with the pilot material, it could be seen that significant advantages had been obtained. The advantages are generally very clear in this kind of production environment, in which different work processes, the structure of the product and design tasks, the creation of documentation and changes made to the product must be controlled simultaneously. It is quite clear that a more complex product, made in a networked environment, requires a considerable amount of product management work. With the product lifecycle management system, a steady foundation is obtained for this work and much automated help is gained. At the same time, a frame is defined for the cooperation of the whole network, the advantage of which comes out as speed, rationality of operations and fewer mistakes. A lot of work is needed to import existing product data into the system. When a system is already up and running, it will require a little additional information input from the performer of each task, but the acquired advantages will still overcome the trouble of the extra work. In this case, the use of the pilot material showed that deployment of the system was easy and rectilinear but that the preparatory work was important to the success of the work.

What next?

In spite of the successful pilot and in spite of good experiences from the project, future tasks remained unsettled because the project financing needed to carry out a sufficiently comprehensive operational change was not obtained. Progress was stranded on the unsuccessful selling of the benefits inside the organization. The PLM team was unable to sell the project to a highly placed executive sponsor and the necessary support for the first stage was not forthcoming from the uppermost level of management. Furthermore, the general market situation affected the carrying out of all investments.

A clear and comprehensive plan for the use of information technology is necessary irrespective of the size and branch of the company. The plan must provide a broad view of development operations in the short and long term. What will be done in the coming year – in the next three or five years? The arrangement and development of product lifecycle management should be included in this plan.

The deployment of a PLM system is not just a project fraught with problems related to information technology. It is not enough to install an application and train the users. It is about examining and developing internal processes and defining modes of operation. Naturally, a lot of work is needed to define the functions of the system to be used and adapting processes to the organization. For this reason, it is extremely important to collect a heterogeneous group from the organization and operation network to sketch the development of product lifecycle management for the whole operation network. This group has to include not only the development staff and leaders but also the end users of the system. Furthermore, management must commit to all major development projects at the earliest possible stage.

Case 3: Capital goods manufacturer and customer-specifically variable product

This section studies the experiences of a capital goods manufacturing company that makes mass-customized devices for the metal industry. A PLM system was brought into use in the company during the year 2000. The turnover of the business unit that adopted PLM was about 60 million euros per year. The company began systematically to develop product lifecycle management in the late 1990s. In the background was the strong growth of the business during the years subsequent to the depression of the early 1990s. The volume of business had more than doubled in less than four years and it was no longer manageable using the old methods. The company had fallen into a vicious circle of deteriorating product data: the flow of information was slow, and the information was scattered in different systems and on user PCs. It was so difficult to find information that employees simply continued to develop personal saving and retrieval methods. The situation was getting worse and heading in the wrong direction. For some time, the company had been following the development of product lifecycle management systems. It was clear that the deployment of PLM had been one of the most significant change factors during the last few years in the field of manufacturing industry. The time was ripe for the company to launch a PLM project. The management team chose PLM as the strategic success factor of the future. Before the final system was chosen, in the summer of 1999, the present state of product lifecycle management and the worst problem areas had already been studied with the help of a consulting company. Employees were interviewed during the analysis and they presented the following wishes:

- Separate application islands must be connected.
- Current system tools must be utilized more effectively.
- Mass customization should be expanded.
- Management of documents must be developed.
- Management of changes must be developed.
- Unnecessary work must be avoided.
- The customer must receive the right information.
- Hassle must be removed.
- Existing product data should be utilized.
- Items must be cut and standardized.

The different alternative PLM systems were gone through and were carefully considered. Reference visits were made to other companies to search for the right approach and to gain from their experiences. Once the choice had been made, a decision in principle was made that no tailoring would be done to the application. This was one of the best individual decisions made in the project. It is relatively common, and indeed sometimes justified, to tailor applications to meet the customer's special requirements. However, the starting point for the project in this company was that the operation of the product lifecycle management system should not be so special that it could not be adapted and made more versatile by changing modes of action. One background factor to this decision was experience from an earlier ERP project. In that ERP project, the tailoring – the so-called necessary changes – had become a burden. The users of untailored PLM system were able to take advantage of new versions of PLM system programs much sooner. The product lifecycle management system has been updated once or twice yearly depending on the need for the new properties brought by each new version.

Breakthroughs on subprojects

A PLM project is a large project, which must be carefully designed and must be divided into small subprojects. Some typical subprojects include, for example, the definitions of processes and modes of action, the creation of databases, parameterizations, definitions of links between PLM and other information processing systems, the building of those links, the grouping of items and item transfers, the transfer of old documents, the creation of document templates, the creation of manuals, user training, and so on. The list of work to be taken into consideration is a long one.

It should be clear that a full-time project manager is necessary. A regularly assembled steering group is also needed for the successful completion of a large – or even a small – project. The steering group of the example company included a representative and program manager from the supplier as well as, from the customer company, a PLM project manager, the director of R&D, the production director, IT experts, and a representative of the sales department. The number of experts participating part-time in the project varied depending on the stage of the project.

Controlled entry of documentation into the system

Perhaps one of the most distinctive features of a PLM system is the management of documents. Special attention must indeed be paid to document management. Only separately defined documentation should be moved into the PLM system, which must be kept in good order. It is essential to provide a clear answer to the question: what is product data? The metadata on documents must be standardized and the purpose of the documents must be clear within the company.

The example company made a mistake at the beginning of the project. In the ecstasy of the project, all kinds of documentation were moved into the system, not all of which fulfilled the definition of product data. Furthermore, some of the processes to which the documentation was connected were less than obvious. When documentation expanded, it became difficult for users to find documents unless they knew how to use the right search conditions in the right way. At the beginning of the project, the company did not fully understand the power of product structures. When document management features with the right product structure links are built in a controlled way, it is not difficult to find the information wanted by the user even from a large mass of documents. Currently, a product object serves as one cornerstone of the PLM system. About 40 standard products have their own product cards for which the standardized documentation related to the product in question, has been established and connected to the uppermost level of the product structure. The other core object is a project object. All product development projects, as well as many other projects, have their own project hierarchy in PLM where the created documentation is connected. CAD models and drawings, and related items, have also been connected amongst themselves. Overall, the PLM system will contain about 20,000 documents by the beginning of the year 2003, about 17,000 of which will be CAD models or drawings. New documents accumulate quickly, at a rate of about 500 pieces per month.

The business processes determine

Organizations and management models have been conveniently changed in the company simultaneously with the deployment of PLM over the last two years. Common to these changes is the fact that department limits have been exceeded and accustomed modes of action have been changed. The processes of the company and the responsibilities of organizations are physically concretized as documents, items and product structures, so it is natural that the spheres of responsibility of departments have also been critically examined. Information technology cannot usually be used to solve problems unless a clear change takes place simultaneously in processes and modes of action. As is well known, a mess is not worth automating.

Rome was not built in a day either

Characteristic of the modern world is the speed of change and the fact that everything is supposed to happen in a moment. True enough, speed can indeed often be measured in money, and it is an important element in the competitive ability of companies. To accelerate processes, companies invest in new systems, such as product lifecycle management. In the system suppliers' advertising, the ease and speed of deployment of PLM are among the most central arguments. One hears of projects lasting only a few months. However, the advertising may create the wrong image of how quickly or slowly the course of a big ship can be changed. Even if the system could indeed be set up technically in a few weeks, changing the culture and modes of action within the company is a challenge that will not necessarily be overcome in a few months. When the big wheel has at last been made to turn, it seems that the changes are bigger than anyone would have guessed and that they are not at all restricted to product development or production. In order for change to occur in a controlled fashion, the project group will still have a lot of work to do even when the system is technically functioning.

Guidelines for the future

It has been said that a PLM project is never ready and there is some truth in this assertion. Companies live from their products and their services, and new things are happening all the time. There is a lot of work in the management of documents, items, structures, versions, variations, configurations, workflows, and life cycles. The deployment of a PLM system merely provides a good base for continuing development. Management of all the company's key information lies in the databases with Internet interfaces and networking with other companies, making actual electronic business possible. In the network of the electronic business, the one that commands the internal processes of the company succeeds best.

Summary

- The management of the life cycle of products and related services is becoming a central factor in the manufacturing industry. The objective of many companies is to offer customer-specific products and after sales service, to create new business and growth, and to increase sales with these services.

- Capital goods manufacturers seek an even cash flow, better predictability of business and sales, independence of cyclic trends from new service concepts around the product as well as perfect grasp of their customer base.

- Traceability can be roughly divided into two different areas: traceability of the product process (the creation and maintenance process of the product) and traceability of the order-delivery process (the delivery process of individual products).

- In the field of high tech industry, the special challenges of product lifecycle management are strong networking of companies, data transfer between companies, short life cycles of components, and fast development of software.