CHAPTER 23

Product Lifecycle Management

GOAL

Understand PLM, why it is crucial for companies to implement, what a PLM system offers, what PDM is and its relationship to PLM, and analyze some PLM and PDM case studies.

OBJECTIVES

After reading this chapter, you should understand the following concepts:

- The current engineering and design practice
- Types of product information
- PLM goal
- PLM benefits
- PLM systems
- PLM enabling technologies
- PDM
- Case studies of implementing PLM and PDM

CHAPTER HEADLINES

23.1 Introduction

Historically, different computer applications evolve to handle separate parts of the product lifecycle. CAD focuses on product design. CAE focuses on product analysis. CAM focuses on product manufacturing. PDM (product data management) handles the management of design and drafting files from conceptualization through detailed design. ERM (enterprise resource management) handles the release of manufacturing data. SCM (supply chain management) deals with synchronizing orders of supplies and material required to make the product, and coordinates production logistics. CRM (customer relations management) brings customer voices and feedback to product design and development.

These application tools and the engineers who use them have always been, to a large extent, standalone and isolated from each other. While this engineering attitude worked in the past, it does not work anymore. The engineering landscape has changed dramatically because the way in which companies work has changed in many ways:

- **Operations occur in distributed facilities.** An organization may have design and manufacturing facilities in different geographical locations.
- **Product design occurs around the clock and around the world.** This prompts the use of the concepts of collaborative design and Web-based communication.
- **Design responsibilities have been decentralized.** This results in concurrency problems. How can designers of a team know and access the latest design changes?

Companies have to change because of the change in business climate and markets where they compete. Markets are fragmented and change rapidly. One strategy for responding to these ever-changing markets is mass customization which attempts to deliver a product of one at or near mass production cost. Mass customization attempts to deliver customized products, one per customer. Interested readers should consult the literature for more coverage.

Companies realize that CAD, CAE, CAM, PDM, ERP, SCM, CRM, and other systems must work together and exchange information at multiple points during the product lifecycle. For example, PDM is the key to maintaining an accurate product definition for complex products, especially those with long lifecycles. ERP can provide valuable manufacturing production and procurement information for designers in the early conceptual stages of product design.

This highlights the critical importance of a continuous exchange of information and the significant value of individual systems working together throughout the entire lifecycle. **PLM** (product lifecycle management) is a framework that integrates all the different facets and activities of a product cycle together.

23.2 Product Information

A product is a complex entity that unifies an organization and its operations. It also generates a wealth of information at different phases of its lifecycle. The organization must

handle and manage product information effectively. At an abstract level, we identify three types of product information: product definition, product production, and operations support. The three types of information must interact with each other continuously to provide effective and current knowledge to all involved teams and individuals in all roles.

Product definition is primarily concerned with managing knowledge as an intellectual asset that is comprised of the product's total definition, including product specifications, conceptual design, part geometry, analysis results, engineering drawings, assembly drawings, and so forth. Thus, product definition encompasses all CAD, CAE, and CAM information.

Activities related to product definition information include:

- **Product configuration management.** As the product design and configuration evolve, the resulting information must be managed in an effective way to ensure its availability on a timely basis to whoever needs it.
- **Change management.** This is a crucial activity. Any change that is made by a member of the product team must be documented and made available immediately. If an organization has offices in different locations, no office should work with obsolete information.
- **Product design and design optimization.** This is a major activity of product definition. All engineering, design, and analysis tools are used here to ensure the proper design and product dimensions.
- **Material selection.** Engineers choose material based on design calculations.

Product production is primarily concerned with the physical operations that are performed to produce the product itself. Activities related to product production information include:

- **Material purchasing.** This activity requires an awareness of suppliers and what they offer. Here, SCM tools should come in handy.
- **Production planning and scheduling.** This is an outcome of the process planning.
- **Equipment design.** Some organizations design their own production equipment in-house. This equipment is highly specialized and is not available off-the-shelf in mass markets.
- **Equipment ordering.** This is off-the-shelf equipment. SCM tools should help decision makers in ordering this equipment.
- **Facilities planning.** Facilities planning must be done before equipment can be installed and operated.
- **Equipment installation and operations.** This signals the beginning of production. This is the ultimate outcome of all of the preceding activities.
- **Maintenance.** Production facilities must be maintained on a scheduled basis to prevent unpredictable shutdowns and failures during critical production times.
- **Manufacturing and quality assurance (QA).** QA tests the accuracy of the production and manufacturing processes. It is an important part of customer satisfaction. QA uses various statistical methods and tools, including Six Sigma.

- **Delivery.** At last, the product can be shipped to customers. Delivery is part of the material handling and logistics problems.
- **Support and customer service.** This activity is the beginning of product revisions and future changes. Customer feedback, field service, and service data often provide a valuable measure of the success of product design and manufacturing.

Operations support includes activities directed at managing finances, human resources, and organizational structure design and management.

The conclusion that we can make now is that a product is synonymous with generating information and managing information. Without information, organizations cannot innovate or create new products; they cannot grow. Therefore their demise and collapse becomes a matter of time. Without information management, organizations cannot compete as their time-to-market lead time becomes excessive. Therefore they cannot make profit nor survive in the marketplace, although they may have excellent products.

Without successful information generation and management, the productivity of individuals and their organizations suffers and declines. Productivity leads to growth, growth leads to profitability, and profitability leads to survival in the marketplace.

Having realized the importance, the complexity, and the heterogeneity of product information, and having realized the importance of its management, the central question can be stated as follows: How can we manage this information effectively? We now can appreciate that the scope of the sum of the product information is much bigger and more complex than the scope of any individual area, including CAD, CAE, CAM, and so forth. One effective answer to the question is PLM.

23.3 PLM Framework

PLM is a framework that attempts to manage product information electronically in a timely manner. It is a vision and philosophy that is built around a digital form of product information. If we can create a complete digital product definition, we have an effective solution to the product information management problem described in Section 23.2.

The main goal of PLM is the creation of a timely communication among all entities and personnel of an organization who are responsible for a product, regardless of their geographical location. Figure 23.1 shows this spirit of communication. The dashed lines in Figure 23.1*a* indicates no or little communication. Without PLM, only suppliers and manufacturing communicate directly, by the virtue of necessity. Figure 23.1*b* shows that PLM fosters and encourages communication at both the physical and intellectual levels among engineering, manufacturing, human resources, suppliers, and customers.

PLM unifies disparate applications that enterprises depend on for daily decision making into one holistic viewpoint. These applications are related to the three types of product information discussed in Section 23.2; they include PDM, ERM, CRM, and SCM. Suppliers are

an integral part of PLM. Even customer feedback from existing product lines can be incorporated into the PLM system. This is the "lifecycle" part of PLM.

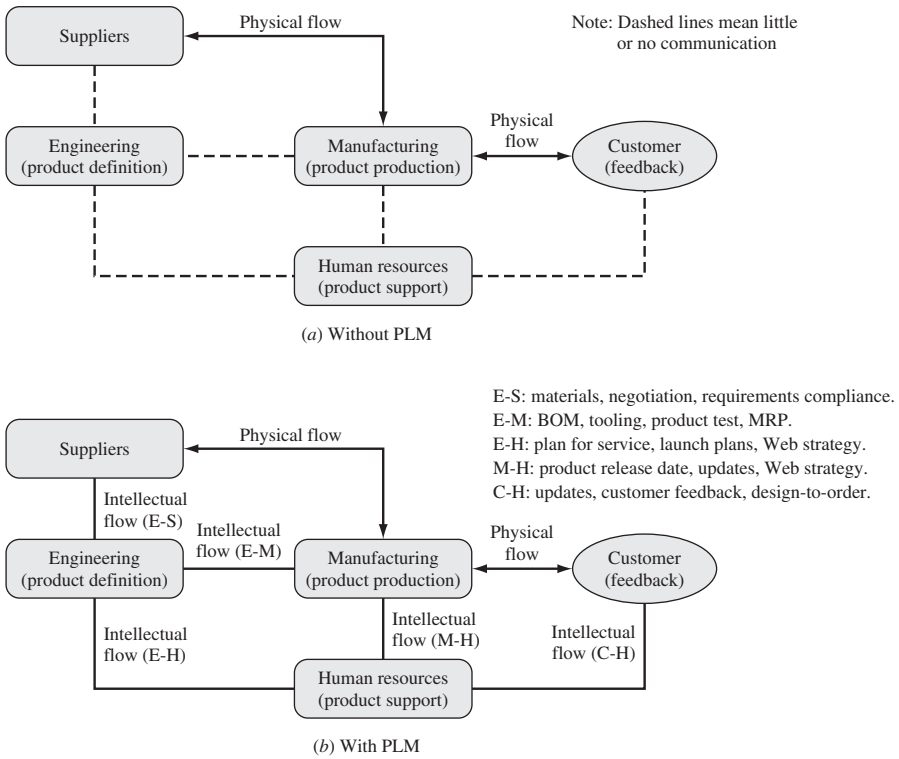

Figure 23.1 PLM framework.

Thus, PLM allows a company to design, analyze, and manage its products from initial conception to retirement. The focus is on the product and its delivery and management from conception to whatever the end of its life is; all done electronically, and in a digital form. In other words, PLM creates a digital product value chain that allows product features, costs, materials, and so forth to be easily and efficiently communicated among all parties involved in a part lifecycle.

Engineering computer applications are morphing today into full-blown PLM tools used by decision makers to increase profits and improve efficiencies across the extended enterprise. PLM enables companies to make better business decisions and deliver greater value to customers, by improving the efficiency of product development processes and the company's capacity to use product-related information.

PLM provides companies with the missing product development link: the ability to truly integrate existing ERM and CRM capabilities with integrated and real-time product information.

By doing so, it brings the informed input of every relevant constituent into a product's planning, definition, design, development, manufacture, sale, movement, support, and even retirement. This kind of rigorous product lifecycle management means that companies are better able to rationalize the design, development, and overall management of their product portfolios.

PLM systems are geared to give enterprises a 360-degree view of all phases of a product's lifecycle, from cradle to grave. From the very first iteration of an idea through its design and development to the manufacturing floor and beyond, PLM systems attempt to incorporate all aspects of a product's costs, features, and functionality into a unified view by combining all manner of data from across the enterprise into the development process as early as possible.

PLM systems work in an enterprise by:

- Providing a single, virtual workspace in which product content, process information, and program status information are fully integrated and under configuration and version control.
- Enabling the precise status of a product at any stage of its life to be accessed and modified through appropriate security protocols, both inside and outside the company.
- Integrating resource information with content creation processes through the connection of workflow and cost information with the product's developmental state.

Unlike so many other enterprise applications, PLM is not a single solution installed from a few CD-ROMs, even though it does involve software and integration tools. Rather, it is a way to reorganize and rethink the entire process of how a company brings products to market. It alters established workflow and integrates business processes. It's a conglomeration of multiple solutions that a company implements and integrates through a common architecture to make all this possible.

23.4 Benefits

PLM fundamentally changes the nature of product development. All parties work collaboratively, particularly while the product's design is still in a position to be influenced. PLM helps companies achieve:

- **Repeatability,** by leveraging intellectual property assets and enforcing standardized, repeatable, and dependable work methods.
- **Lower and steeper learning curves,** through access to the right information for a multitude of enterprise-wide participants, not just engineering.
- **Concurrent work efforts** on different product components, by synchronizing development around object configurations and ongoing changes and updates, something that is impossible to do at any scale without technology enablement.
- **Improved product quality,** by adhering to standards and improving collaboration with customers.

- **Reduced time-to-market,** by reducing the number of engineering change orders, increasing product modularity, and fundamentally altering the method and speed with which information is shared and accessed by employees, from serial/sequential mode to a concurrent one.
- **Reduced total product cost,** by enabling customer product configuration through design-to-order, and by utilizing an integrated approach to product development.
- **Increased product standardization,** by increasing product modularity and encouraging customer input.
- **Improved information exchange,** by increasing collaboration with all parties involved, including customers and suppliers.
- **Increased product customization,** by increasing the generation of product ideas and improving collaboration with customers.
- **Improved predictability,** by reducing the variability in manufacturing processes.
- **Decreased customer response time,** by generating rapid customer quotes through Web technology.

As these benefits point out, PLM is ultimately about even more than getting better products to market faster. PLM can deliver cost-management and revenue-generating benefits as well. PLM can lead to productivity, which leads to growth which, in turn, leads to profitability.

23.5 Implementation

Although many companies like IBM are using PLM systems, few companies outside of the auto and aerospace industries have adopted it across the enterprise. More often than not in today's tight budgetary climate, companies start with one aspect or module of PLM, like a document collaboration suite, on the way to a broader, more comprehensive solution.

In this way, the massive changes an organization may undergo because of PLM can be phased in gradually over time. This lets companies meander toward a solution rather than making a headlong rush toward PLM. Also, with the cost spread out over a longer period, ROI (return on investment) can be more easily measured before the next phase is implemented.

While PLM is aimed at hard-product manufacturers, like automakers, other industries, such as petrochemicals and major pharmaceuticals, also are adopting specialized PLM solutions from niche providers. For the most part, though, PLM is aimed at organizations that produce hard products. PLM is designed to turn the entire extended enterprise into a shared data repository with a common purpose: make a better product, make it faster, and make it for less money.

The four particular areas in which PLM can help resolve long-standing hurdles to innovation, productivity, and profitability are

1. **Knowing which product to pursue.** Companies often expend resources on dead-end ideas before they get the right product completed. By aggregating key insights and capturing known facts, dramatic new approaches to what to do and when to do it are possible.
2. **Long product cycle times.** Margin erosion, excessive discounting, and erratic materials management and inventory profiles are common signs that product delivery performance is too far behind a market window. To do it right the first time and get it done faster requires an unprecedented degree of enterprise-wide synchronization, concurrent development, work management, and data and configuration control.
3. **High product development and launch costs.** High recurring and nonrecurring product costs often indicate an over-reliance on internal solutions, a squandering of resources on developmental dead ends, and a failure to manage evolving insights in a way that allows the true enterprise costs of certain decisions to be determined. Appropriate responses include earlier and more effective collaboration with third parties, integration with enterprise resource information, and the enhanced integration of product-engineering tools. PLM provides a foundation for building these vital links.
4. **Substandard product quality.** Excessive failure rates often point to a breakdown in requirements definition at the front end and weak engineering change-order mechanisms after the problem has surfaced. PLM provides access to key insights early, facilitates bringing the right parties to the table at the right time, and accelerates the ability to process a change when it is required.

23.6 Enabling Technologies

PLM is a framework, vision, and philosophy that encompasses and integrates existing design, manufacturing, and communication technologies. These technologies include CAD, CAE, CAM, PDM, and Web tools. PLM is viewed as an innovation in product development technology. As such, it can be viewed as an extension to current CAD/CAE/CAM/PDM technologies. This view is actually beneficial because it allows us to understand PLM better, and it helps us to put it in context relative to past, present, and future technological developments.

Figure 23.2 shows such a context. It shows the evolution of innovation in product development technology. Four generations are identified over the past four decades. The first generation is 2D CAD and drafting. These early systems were slow, limited by both hardware and software issues at the time.

The second generation is 3D wireframe and surface modeling with limited CAD and CAM applications. These systems were proprietary and closed architecture.

The third generation is what is currently available. Currently, we have standalone systems that support CAD/CAM/CAE, parametric design, associative drafting, and digital prototyping.

The fourth generation has been evolving. Its goal is develop a suite of integrated applications and systems that allow the development and support of a digital product value chain. Fourth-generation systems are based on the PLM framework. An example of a PLM system is Teamcenter from EDS.

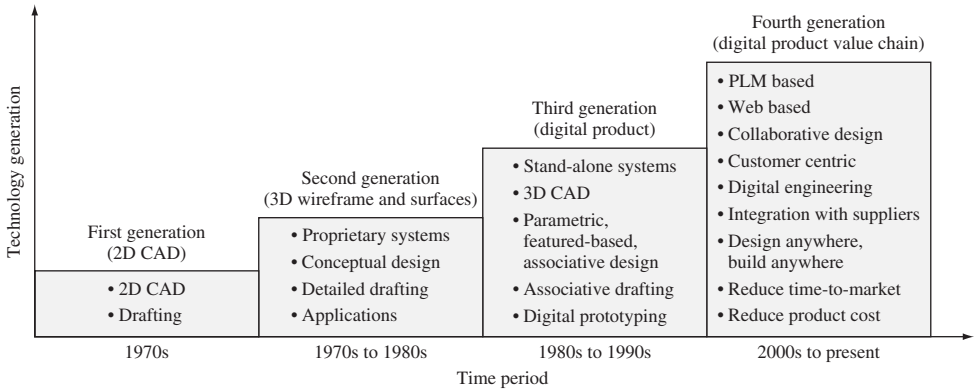

Figure 23.2 Evolution of product development technologies.

23.7 Examples of Business Problems

PLM industrial examples point to reaping substantial benefits and cost savings from the integration of different product technologies. For example, a German automaker uses IBM Thinkpads plugged into automobile dashboards to help dealership mechanics diagnose problems. In the process of diagnosis, the application captures useful service information about the car. That information is transferred back to the car design and manufacturing departments. The integration between the dealership and the car manufacturer saves the manufacturer money on warranty replacement parts, while making for happier and more loyal customers. This results in a win-win situation.

Another example is related to RFQ (request for quotation) in the automotive industry. An automaker has a slow and inconsistent response to customer RFQs. It can take longer than 45 days for a customer to receive a quotation. The reason behind the slow response is a 100-step manual, arcane, nonmeasurable process. The PLM solution is to automate the manual process through workflow, change process, and document management capability. Moreover, the solution provides measurable RFQ metrics via the Web to allow continuous feedback from customers in a timely fashion.

A third example is related to inefficient engineering and manufacturing operations in a company. The company has inefficient engineering throughput, operational deficiencies in design engineering, and lack of availability of the latest, most accurate design data to manufacturing. The root of the problem is the use of multiple CAD/CAM systems and an inefficient engineering change process. The PLM solution is to use only one CAD/CAM system and to use workflow and document management techniques to document, deploy, and control the engineering change process.

23.8 Product Data Management

PDM is an important, if not the most important, PLM enabling technology. Some may think of PLM as the new and more encompassing PDM. CAD/CAM vendors recognize the importance of PDM and offer PDM systems with extensive capabilities. Existing PDM systems include ENOVIA and SmartTeam from Dassault Systems (maker of CATIA CAD/CAM software), iMAN from EDS (maker of Unigraphics), Metaphase from EDS (maker of IDEAS), ProductCenter from AutoCAD, PDMWorks and SmartTeam (from SolidWorks partners), and Windchill from PTC (maker of Pro/E).

PDM software manages, organizes, and controls engineering design information through the transformation from prototype design to a product in full production and then to product obsolescence. Good PDM systems provide flexible product assembly structures, supporting complex relationships between parts, drawings, supporting documents, metadata, and teams.

Current PDM applications employ sophisticated configuration management technology which automatically organizes fragmented product data derived from many sources. With an emphasis on content, meaning, status, and relationships, PDM applications transform product data into product information that can be used reliably within other applications or by users making product data queries.

23.8.1 Motivation

PDM is here out of necessity. There is a lot of engineering data with more being created each day by different groups and teams for a given product. We need PDM because product data

- is subject to different interpretations by different people;
- exists in many different versions;
- is used by many computer programs, running on different computers;
- is stored on many different types of media;
- is used by different people in different functions, at different geographical locations;
- has multiple relationships;
- has to be maintained for years.

23.8.2 Evolution of PDM Systems

PDM systems have been evolving over the years. Current systems combine PDM and collaborative techniques, producing what is known as cPDM, collaborative PDM.

The conception of PDM started when CAD/CAM companies began to see their customers' data management problems. In the late 1980s, they introduced the first-generation commercial PDM systems. Typically, they focused on selling their PDM systems to their existing customers and often used them to leverage sales of CAD/CAM/CAE.

The basis for these PDM systems is the database engine—typically a commercially available relational database management system (RDBMS). The database is used to keep records of parts and related files. The PDM systems then provide the security, file storage,

revision control, classification, notification, and application integration, in addition to facilitating the engineering process.

A common theme among first-generation PDM systems is the focus on the downstream engineering process. These systems have two key capabilities: release management and change management. They manage the initial release of design data to manufacturing and the engineering change order process. These PDM systems enforce very strict engineering procedures to control the product process effectively.

The main focus of first-generation PDM systems is on manufacturing. However, other areas of focus are also needed. The second-generation PDM systems support the entire product lifecycle—from initial concept to product obsolescence, including purchasing and product support. They can support concurrent engineering practices in both a flexible, conceptual design phase and in the better-defined engineering change process. They can also manage several levels of release of a design.

Some systems go beyond managing engineering procedures and manage the engineering process (workflow) as well. Users can share up-to-date, prereleased engineering data, and the flow of that data can be intelligently, yet flexibly, controlled according to a set of rules.

23.8.3 Scope of PDM Systems

A PDM system works at every level and across all divisions within a company, even in facilities located around the globe. It integrates data from different types of hardware and software applications to enable members of a multiperson design team to locate and access project data quickly.

A PDM system also permits project leaders to oversee data better throughout the entire design effort, to ensure that team members are working on the most current version of the design, making only permissible modifications to the design, and are not given access to designs that are outdated, unapproved, or "frozen" for review.

A PDM system provides the project team or work groups with a flexible data management tool for meeting the engineering requirements for productivity and quality. At the same time, management of the entire design effort is improved by providing an advanced query capability for accessing data via common attributes and increasing data security.

By overseeing application-level tasks such as checking and tracking design revisions, authorizations, and drawings, a PDM system provides procedural control over the design methodology by facilitating approvals and notifying team members of a project's status. As a result, it provides the improved internal coordination required to allow companies to implement concurrent engineering and compress the overall product development cycle. It also facilitates a team-oriented approach to product development, therefore compressing the time required to bring new products to market.

23.8.4 Benefits of PDM Systems

PDM allows team members to work collaboratively and to have access to current documents at any time, anywhere. PDM systems help companies to achieve

- **Improved design productivity,** due to immediate access to design documents and changes.
- **Improved design and manufacturing accuracy**, because all changes are approved timely.
- **Fewer design changes,** due to collaborative efforts and instant communications.
- **Better management of engineering change,** because project leaders have electronic control.
- **Reduced development time,** thus reducing time-to-market.
- **Better audit trails,** because all changes are well documented electronically in a centralized database.
- **Improved communications between team members,** because they have instant access to information.
- **Faster customer response,** because customers are part of the product team through CRM.
- **Reduced overheads,** because PDM streamlines operations and eliminates redundancies.
- **A major step toward total quality management (TQM),** because all product data is under the control of one system.
- **Better use of creative team skills,** because PDM makes team members feel like one family.
- **Comfortable and easy use of product information,** because every employee knows where information is and how to access it at any time.
- **Data integrity safeguarding,** because it is all stored in electronic vaults.
- **Better control of projects,** because of the timely feedback from all team members.

23.8.5 Implementing a PDM System

The implementation of a PDM system by companies requires careful planning to ensure the success of their use in the engineering process. We offer the following implementation guidelines:

1. **Expectations.** Identify the needs and requirements. Be realistic about them, as well as being practical about the plans for how to meet them.
2. **Analysis.** Do not overanalyze the product data management problem before starting the project.
3. **Team building.** Get the right people together who understand how information flows throughout the company and know where the biggest bottleneck areas exist.
4. **Requirements.** Determine requirements in a few meetings.
5. **Business comes first.** Focus on business requirements first, not technology.

6. **Who offers what.** Develop a list of vendors that offer potential solutions.
7. **Evaluate.** Choose an evaluation methodology that fits the company style, needs, and time frame.
8. **Decide.** Evaluate how a vendor and its products match up with the company business and technology requirements.
9. **Acquire.** Execute the decision. Ask for references, move on, and buy the PDM system.
10. **Use.** When implementing, focus on incremental projects that scale up.

23.8.6 Software Capabilities

PDM systems range from simple, off-the-shelf packages to complex, tailorable systems that can be further developed to fit a company's requirements exactly. Most PDM systems are custom-built to user specifications.

PDM software integrates with, and partially substitutes for, other software used by engineering organizations such as CAD, document management, engineering document management (EDM), free-text databases, ERP, manufacturing resource planning (MRP), and workflow/groupware.

The engineering content of CAD files, scanned images, and word-processed documents are stored in a secure vault, and free-text indexes may be available for the text documents. Check-in and check-out of documents and drawings is part of a simple change control and document distribution process, which can be elaborated by custom programming, either by using the PDM software's own scripting language or by making calls to its published API.

The software functionality and capabilities a company requires depend on many things, including the type of product, its organization, the systems that are in use, the skills of the people who will support the PDM system, and the progress that has been made toward an effective engineering environment.

Some of the features that the software must provide are flexibility, ease of use, powerful access and viewing tools, strong data vaulting technologies, open architecture, full scalability, rules-based and event-driven nature, availability on a wide variety of platforms, and functionality across heterogeneous networks and client/server configurations.

23.8.7 Software Functions

PDM software can be viewed from three perspectives. From a manufacturer's perspective, it permits management and control of the engineering process information. From a product perspective, it can help organize design revisions, track versions of an evolving design concept, and retrieve archived data and other product-specific information. From a process perspective, PDM software can orchestrate procedural events such as design reviews, approvals, product releases, and so forth.

To satisfy these three perspectives, PDM software must provide the following functions:

1. **User functions**

- *Design release management* provides security and access control, check-in and check-out, establishment of data relationships, global release definitions, user lists, and metadata management.
- *Change management* specifies who approves what, and when. This also includes revision and version relationships and control, baselines, and other configuration management functions.
- *Product structure management* provides parts list and bill of material functions, parts definitions, and parts relationship attributes.
- *Classification* provides tools to search for and retrieve standard parts and existing design data.
- *Program management* creates work breakdown structures and schedules resources.

2. **Utility functions**

- *Communications and notifications functions* handle interactions within the context of the PDM system and provide interfaces to external e-mail systems.
- *Data transport* provides mechanisms to move data among users, as well as applications and PDM functions to and from other products.
- *Data translation* provides access to tools that translate data between applications such as CAD and CAM.
- *Image services* provide a "viewing" capability for reviewing graphical images and may provide redline mark up.
- *Administration* provides functions which enable PDM users to set up, customize, and manage the PDM system.

23.8.8 A Case Study

Some companies such as NEC, Xerox, Texas Instruments, Groupe Schneider, Honeywell, and General Electric have already invested in PDM technology. We offer a case study as an example to see PDM in action.

NEC Mobile Communications Division (NEC MCD) is a supplier of cellular telephones, pagers, and other infrastructure equipment, such as base stations and terminals. It outsources its design and manufacturing operations to subsidiaries who are far from the headquarters.

To improve its ability to track and share product data with its subsidiaries, NEC MCD implemented the Obbligato PDM system, with the goals of creating a more effective design process, better management of engineering information, and enabling work within a distributed environment.

The Obbligato design environment allows for concurrent engineering. It allows, at the same time, NEC MCD mechanical and electrical engineers to refer to each other's designs and

documents, manufacturing engineers to test for design for manufacturability (DFM), and purchasing to readily identify available parts and suppliers. Moreover, Obbligato is also used for managing engineering documents, parts information, drawing information, bill of materials, specification sheets, and customer information.

Some of the outcomes and benefits that NEC MDC has enjoyed from implementing Obbligato include automated functionality, easy access to older files for reference, document management facility that allows data reuse, easy document change by only one person at a time, concurrent viewing of a document by multiple authorized personnel, and the replacement of the inter-company manual delivery system by an electronic distribution system.

PROBLEMS

Part I: Theory

23.1 What is the current business and engineering practice for product lifecycle management?

23.2 What are the three types of product information?

23.3 Describe the PLM framework.

23.4 How does a PLM system work in an enterprise?

23.5 What are the benefits that PLM helps companies achieve?

23.6 How does PLM help innovation, productivity, and profitability?

23.7 List the PLM enabling technologies.

23.8 Find one or two case studies of implementing PLM in industry. Submit a typed report that documents each case as follows: describe the problems that prompted the company to consider PLM, the PLM solution and the system that the company implemented, and the benefits that the company gained.

23.9 Why do we need PDM?

23.10 What are the benefits of PDM?

23.11 List and explain the implementation guidelines for PLM systems.

23.12 List and explain the functions that PLM software provides.

Part II: Laboratory

Use your in-house CAD/CAM system to answer the questions in this part.

23.13 If you have access to a PLM or PDM system, find what it does and how to use it. Apply the chapter concepts to each system to better understand them.