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The Information Systems Component of Concurrent Engineering

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Abstract

Concurrent Engineering is an approach to product engineering where product design, planning, manufacturing, and marketing are implemented largely simultaneously with the objective of reducing costs and shortening time to market. A priority and technical requirement in concurrent engineering is the automated flow of product information among interdisciplinary team members. Technological advances in information processing, proliferation of engineering software, and enhancement of hardware and networking capabilities provide the necessary support for concurrent engineering. However, data overflow, information system incompatibilities, and other non-technical problems hamper the smooth implementation of concurrent engineering principles. This paper discusses the significant issues, problems, needs, and current situation of companies addressing engineering information system requirements. Product Information Management systems, frameworks, and networks address these issues and provide new capabilities.

I. Information System Requirements

In 1988, the Institute of Defense Analysis formally defines concurrent engineering as "... a systematic approach to the integrated, concurrent design of products and their related processes, including manufacturing and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle, from conception to disposal, including quality, cost, schedule, and user requirements." [6,p.23]. It can also be broadly defined as the simultaneous design of products and their engineering, manufacturing, and marketing processes [1,7]. It should involve management support, teamwork, consensus, and information sharing. Multidisciplinary teams constitute the core of a concurrent engineering effort. The first requirement for this team is to break down the barriers that exist between specialists. These specialists may come from marketing, sales, purchasing, engineering, and manufacturing, most of whom have no idea of what the other groups do and how they perform [1].

Synergy is the cornerstone of any concurrent engineering effort, and for this to develop, the organization needs information management tools that perform in concert [14,p.10]. Automated access to design and manufacturing data for interdisciplinary teams and administrators has become a technical priority. This data access capability is so central to implementing concurrent engineering that it is rapidly becoming accepted as one of its technical enablers [7,p.96]. In fact, the ability to distribute information is essential to the accomplishment of any enterprise's corporate goals [13]. Enterprise-wide information releases result in fewer engineering changes resulting from producibility and supportability issues. It eases the implementation of the changes that are required. Other issues such as reliability, maintainability, and safety can be addressed before any production commitments are made [15,p.28]. Finally, products cannot be "forced" through the factory since materials cannot travel faster than the information needed to produce the product. Critical time to market ,with its inherent product and process design , is a function of the speed of information [21,p.156].

II. From Traditional Engineering to Concurrent Engineering

Traditional product development follows the sequential engineering process, often described as "over the wall" engineering where each department does its part and then passes its output to the next department, with the presumption that whatever changes or modifications will just be communicated back. Manufacturers used to develop products in a series of steps, starting with design and engineering, then letting contracts for various materials and services before finally going to production [5,p.10]. This results in very long product release lead times, rework, and decreased profitability. Furthermore, US manufacturers started automating in the wrong place, the factory floor. "In their zeal to get automation up and running, manufacturers set in place risky and expensive systems for applications such as material handling, even without considering the links between product design, cost, and quality." [23,p.79]. This situation provided the impetus for concurrent engineering. It was determined that 75% to 85% of eventual product costs are committed during the design phase [6,p.24]. In concurrent engineering, analysis guides rather than validates the design, providing early feedback on product performance and even manufacturability [12,p.66]. Analysis for design helps replace costly and time consuming prototypes. Analytical tools such as CAD and CAM allow prototyping to be accomplished in the computer.

This realization emphasizes the critical need to move data faster and in a form acceptable to the intended users. Current Data Base Management Systems (DBMS) support only one language which may be of use only to a particular department. It takes a critical mass of quality data before engineers will use a new system. People usually reject new approaches if data are insufficient or not easy to use [16,p.82]. On the hardware side, few companies can afford to scrap existing mainframes and minicomputers in the host-based environment. Most companies can only afford to update their engineering workstations once every four or five years [10,p.86]. Most concurrent engineering efforts emphasize the need for implementing client/server architectures. However, many engineers trying to implement concurrent engineering have a hard time trying to keep up with the latest hardware [10,p.78].

Trying to develop a computing environment more conducive to concurrent engineering faces numerous other difficulties. Non-technical issues such as traditional company policies and accounting practices often take precedence over concurrent engineering goals [10,p.78]. The more specific problems and needs of concurrent engineering information management will be addressed in the next section.

III. Computer Application Problems and Needs

A. Problems

In an independent market research study (conducted by Market Reach of Palo Alto, California for Sherpa, Corp., San Jose), 97% of engineering directors and MIS managers pinpointed product information management as a significant problem area in their organizations [18,p.36]. Because of the interdisciplinary nature of concurrent engineering, objectives are sometimes in conflict [14]. What may be good for manufacturing may prove to be fatal for the marketing implementation. The involvement of several designers requires a high degree of collaboration. Early calls for concurrent engineering were thwarted by middle management feifdoms and by the lack of computerized tools which are necessary to initiate and accommodate departmental interactions [5]. The possibility of concurrency can be restricted in varying degrees by the complexity of the process within each subfunction or department. Interactions between downstream activities and upstream activities often lead to design inconsistencies. The product development process which involves the application of synchronous, value engineering, and other knowledge and capabilities becomes difficult to model [14,p.3]. Yet, it provides a challenging and potentially profitable task to accomplish.

The proliferation of engineering software provides a wide array of powerful tools for individual applications. However, this results in an overwhelming abundance of data and information, whether useful or not from such applications [4]. More time is now necessary to browse through all the piles of computer output. Different CAD/CAM systems provide the company with greatly enhanced designing and prototyping capabilities but they are widely dispersed geographically and may span across different departments [7,p.96].

The ability to communicate and understand design proposals is hampered by the limitations of classic design documentation methods and by the enormous difficulty of finding the data for a particular task [15,p.28]. These methods include drawings, numeric computer data, plaster tooling models, and physical mock-ups. The documentation required to emulate even a single product definition typically contains thousands of data items, much of which are not in the desired form or format [16,p.81]. Finally, the lack of a useable central database prevented manufacturing from communicating back to the design engineers. As mentioned earlier, most current computer-based product databases are still too cumbersome to be useful.

The various software packages used in concurrent engineering often require different hardware in terms of graphics capabilities, memory requirements, and other similar considerations. Many organizations face the problem of moving from a host-based environment, where everything is controlled by a mainframe or a microcomputer, to a client/server architecture that is more desirable for the necessary applications [10]. Also, many organizations are repeating the mistakes they have made during the early days of CAD, CAM, and CAE. Data incompatibilities among different vendor's equipment resulted in "islands of automation" [18,p.36] because computer hardware and software could not exchange or communicate information. Today, many manufacturing companies have generally succeeded in achieving effective physical data-sharing within the heterogeneous computing environment. However, each "island" has vendor-specific solutions to their respective environments. This leads to a situation where many "islands" can exchange information, but cannot manage the extracted information once it has entered the new system, creating what are called "islands of control" [18].

B. Needs

The general needs of a concurrent engineering information system were presented in the Prasad, Morenc, and Rangan's [14] article on the research issues in information management for concurrent engineering. "The need for overall coordination, consistency, control and integrity of data, design ideas, and design rationale is critical." [14,p.3]. The challenge is to capture, manage, coordinate, and utilize data, knowledge, and processes generated by the concurrent engineering process. Data must be both internally consistent (values within the designer's context) and externally consistent (data from other departments, subfunctions, etc.)[14,p.6]. The need to accommodate various types of design representations as well as design data makes it necessary for us to deal with different levels of abstraction. Our information management strategy must take into account how the design information is represented in the computer, and how different processes may interact with this information [14,p.11].

An important issue which need to be addressed is the trade-off between having "open systems" and security. "Open systems" is a term designating a seamless flow of information throughout a computer network [21,p.156]. Communication is very important for concurrent engineering. It can include everything from a willingness to share information without a time lag to managing databases. Concurrent engineering requires rapid access to information, but can we feel comfortable about the validity and integrity of continuously updated information which is accessible to a large number of individuals? Can we restrict access or provide partial access to a select group? Bear in mind that the conventional engineering information flow is primarily unidirectional while concurrent engineering requires a multidirectional information flow. It is now possible to set up a file management system that will tell us who was looking at what, when [12,p.62].

A potpourri of other needs are also considered. Concurrent engineering is a management and engineering philosophy which is open to individual interpretation. It will be implemented differently by different companies because of the differences in leadership styles, products, processes, employee abilities, customer requirements, supplier capabilities, etc. [6,p.24] Any attempt for vendors to create information system packages for concurrent engineering must accommodate this reality. Cost models and cost databases must be included in any information system so that design engineers can make economic evaluations rapidly, eliminating further development of economically unfeasible design intentions and prototypes [6]. Companies need tools that can help manufacturing determine assembly problems inherent in a design. Consequently, tools that can communicate those problems back to the designers are also necessary [22, p.80].

Information system managers have to ensure basic connectivity and also move on to interoperability at the application and data structure levels [17,p.38] to facilitate information flow in the proper form. We expect users to be from different disciplines, only few of which are expected to be electronic engineers. Software and hardware products must compensate for this anticipated lack of computer application background. This can be achieved through uncluttered panels, simple instructions, and built-in intelligence designed to anticipate the user's needs. We expect that users do not want to refer to manuals. Furthermore, any features built into products must be easily accessible from the front panel [19,p.116].

The push to introduce standards in writing software and in simplifying network management may ease information systems implementation. International design efforts will simplify the customization of products. Firms implementing concurrent engineering must standardize on standards. There is a big trend towards CAD/CAM standards, thus giving momentum to the implementation of open systems. Improvements in graphics have shielded the engineers from the complexities of operating systems [2,p.159] and have thus boosted productivity. There is still an ever-increasing need to pursue these positive developments.

To summarize the needs, a new technological infrastructure of software application tools, databases, data management facilities, computer platforms, network communications, and standards is necessary to foster a cultural change necessary for the success of concurrent engineering efforts [15].

IV. Available Solutions and Alternatives

A. Product Data Management (PDM)

Many experts believe that the way to provide the missing link between design and manufacturing is PDM [11,p.42]. A PDM system strives to manage and control the flow of information between the two processes. PDM systems alleviate the data overflow which helps coordinate control of data and manufacturing [4,p.60]. Some even claim that if any program can carry the name "concurrent engineering", then it should surely be PDM [12,p.60]. PDM systems provide a way of attaining easy access to vast amounts of data, yet manage changes, many of which are made almost simultaneously [12,p.62]. They also provide a common interface and access to the numerous software tools used in concurrent engineering.

Mills' [11, pp.42-44] article gives the most comprehensive description of the components of PDM:

* Data Base Management Systems - forms the core of virtually all PDM packages. Although many PDM programs are built on top of commercial relational DBMS such as Ingres and Oracle, several others are based on "object-oriented" DBMS.

* Networks and network services - help connect various systems. Electronic mail helps PDM users communicate with one another while standard file formats allow PDM data to be easily and transparently from one system to another.

* User interfaces - helps users to use the full capabilities of PDM's without too much effort. Some offer graphical user interfaces with point-and-click operation to further simplify tasks.

Most commercially available PDM's do the following:

* Data Management: Access, Security, Data transfer, Archive

* Review and Release Management: Procedures and policies for review and release of design data can be encapsulated into a PDM

* Project or Product Management: PDM systems allow project managers to set up hierarchical product structures to bring order to the product design process.

We can say that the focus of a PDM is on managing, controlling, and modelling some of the related activities in the design and manufacturing processes. A PDM system puts all of the files created by CAD, CAE, and CAM under a central authority. It manages the relationships among the various design files, and controls access to them throughout the product life cycle, regardless of the computing platform.[18,p.36].

The markets for PDM systems is still emerging. Other synonymous names used for PDM's are Product Information Management (PIM) and Engineering Database Management (EDM). The most visible manufacturer of PDM's is Sherpa, a California based company that has 50% of the marketshare [11,p.42]. Since PDM's are still at their infancy, companies are groping for ways to implement them successfully.

Sherpa asserts that a pre-condition for any successful PDM is a study of the current workflow. It is presumed that "if you can't simplify the manual process adequately, you can't do it electronically". They are rarely off-the-shelf buys and finding the one that fits all the needs and works with existing equipment can be very difficult [12,p.62]. The following are the reasons why, to varying degrees, PDM systems require customization [11,p.43]:

1. Engineering organizations have widely varying practices and procedures that are encapsulated and altered with PDM.

2. Virtually every engineering organization has a different set of software tools that link to the PDM system.

3. Most engineering organizations have a diverse set of hardware.

One drawback of PDM systems is that most emerging automated PDM systems in the market are vendor specific and highly centralized. They are still unable to traverse the boundaries of distributed or dissimilar computing environments [18,p.37]. Hopefully, this problem can be solved as the technology matures.

B. Frameworks

Frameworks are architectures, building blocks of software and services where electronic applications programs sit. They provide such facilities as common design data management, process management, and common user interfaces. Frameworks can be established to enable electronic design applications to communicate with each other and share data. They require encapsulation or integration of development tools. These can be structure. Companies contemplating or implementing concurrent engineering should seriously evaluate their processes and identify existing problems and areas for potential improvement. The findings should be evaluated with their current software and hardware capabilities in mind. Once it is determined that a better information system is necessary, funds must be provided to choose among the feasible alternatives.

Product Information Management systems offer the most comprehensive package. If this is the desired option, then the level of customization must be determined. If current networks or frameworks exist, possible modifications and enhancements may be sufficient. In either case, the future direction of the company must be taken into consideration. There should be ample room to accommodate future enhancements.

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