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Defense Technical Information Center
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RE: ONR Grant N00014-92-J-1925

In accordance with the terms of the above-referenced grant, enclosed please find a copy of my report of The First CIRP International Workshop on "Concurrent Engineering for Product Realization," held June 27-28, 1992, in Tokyo, Japan.

I appreciate ONR's support, which made a great different in the number of U.S. participants able to attend the workshop.

Sincerely,

Stephen Lu

Stephen C-Y. Lu
Professor of Mechanical Engineering
Computer Science, Beckman Institute
and the Director of KESRL

encl: As noted

c: Mr. J. Oberg, M&IE Business Manager

DRAFT

ABSTRACT.

The First CIRP International Workshop on "Concurrent Engineering for Product Realization", held 27-28, June, 1992, in Tokyo, Japan is summarized. In addition to the workshop summary and results, some background information about CIRP (International Academy of Production Engineering Research), the organization which provided the technical sponsorship to the workshop, is also included.

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INTRODUCTION.

The First CIRP International Workshop on "Concurrent Engineering for Product Realization" was held on 27-28, June, 1992, at the Surugadai Memorial Hall, Chuo University, in Tokyo, Japan, right after the IFIP WG5.3 International Conference POLAMAT'92 (see a separate report on POLAMAT'92). The workshop was organized by CIRP (in French: College International pour l'Etude Scientifique des Techniques de Production Mecanique; in English: International Academy for Production Engineering Research) Scientific Technical Committee in Design (STC-DN), and was sponsored by IFIP Working Groups WG5.2, WG5.3, and WG5.8. This two-day, invitational workshop drew 67 researchers and practitioners in the field from 15 different countries in North America, Europe, and Asia. The distribution of industrial and academic participants was about 31% and 69% respectively. The U.S. Office of Naval Research (ONR) provided partial travel support to some U.S. delegates to this meeting.

Developing useful, reliable, and economical products is the most challenging task in the engineering profession. Due to the increasing complexity of products and intense competition in the world market, product development practices have changed from being "centralized" to being "distributed". The centralized approach relies on broad expertise from a few individuals. It is relatively easy to manage, but not effective for highly complex products. The distributed approach deals with complexities by dispensing different product development functions to a team of engineers, with each contributing their special expertise to the product specifications. This practice allows complex products to be developed, but is very difficult to manage. As a result, it prolongs the development time and often results in sub-optimal product quality and value. The situation worsens as products must incorporate non-engineering expertise to be competitive, and are developed by teams of engineers and managers from different organizations located at remote sites.

Recently, the concept of Concurrent Engineering has been proposed as a potential means to improve the product development (also called "product realization") practice. The idea is to simultaneously satisfy the functionality, reliability, produceability, and marketability concerns, to reduce the product development time (i.e., lead-time) and cost, and to achieve higher product quality and value. This new product development approach emphasizes simultaneous consideration of various product life-cycle concerns at early stages to increase the competitiveness of products. Therefore, it is also called "simultaneous" or "life-cycle" engineering. It is important to note that the essence of concurrent engineering is not just to simply strive for real-time, parallel, and simultaneous actions in product development. Rather, it requires a seamlessly integrated, highly cooperative, fully communicating, and systematically coordinated "team approach" to solving complex "system problems" in product development. More specifically, the concurrent engineering challenges can be translated into the following four categories: 1). integration of complementary engineering expertise, 2). cooperation of multiple competing perspectives, 3). communication of upstream and downstream concerns, and 4). coordination of group problem-solving activities.

Although there have been many reports/papers describing research and development efforts/results in this area over the past several years, there have been very few open forums where researchers and engineers can exchange lessons and experiences to build a systematic framework that can define the scope and directions of future research and technology development. The Workshop was intended to serve as a common forum for establishing a fundamental framework for the research and application communities of this newly emerging discipline. The Workshop goal was to provide an opportunity for researchers and practitioners from different parts of the world to examine this developing issue from cultural, organizational, and technical perspectives. By identifying current issues and future directions in this Workshop, it is expected that a basis can be established for Concurrent Engineering for Product Realization, offering many challenging research and development possibilities for production and information processing technology.

The idea for the Workshop began about two years ago through discussions among several members of the CIRP (International Academy for Production Engineering Research). CIRP has more than forty years of history and is the most prestigious international organization for production research (see the Section on Facts About CIRP). Its membership comes from over 38 countries and is through nomination and election by its General Assembly. The key planning members of the workshop were:
- - F. Kimura (University of Tokyo, Dept. of Precision Machinery Engineering)
- - T. Kjellberg (Sweden, Royal Institute of Technology)
- - F. Krause (German, Berlin Fraunhofer Institute for Production Technology)
- - S. Lu (U.S.A, University of Illinois)
- - G. Olling (U.S.A, Chrysler Corporation)
- - T. Sata (Japan, Vice President of Inst. of Physical and Chemical Research)
- - N. Suh (U.S.A, Head of Mechanical Engineering Department - MIT, former Assistant Director of Engineering at the National Science Foundation)
- - V. Tipnis (U.S.A, President of Synergy International, Inc.)
- - M. Wozny (U.S.A, Director of RPI Design Research Center)
- - H. Yoshikawa (Japan, Vice President of University of Tokyo, Chairman of Scientific committee/Japan IMS)

The organizers shared the opinion that it was necessary for a selective group of scientists and engineers from different countries to meet once a year in an open forum to discuss intensively the current practices, basic definitions and technical challenges, available technologies and computer tools. The first workshop, co-sponsored by CIRP and IFIP (International Federation of Information Processing), was held in Japan in conjunction with the IFIP WG5.3 Conference (PROLAMAT '92) hosted by the University of Tokyo. The follow-up workshops will be held annually in either the United States or Europe.

WORKSHOP SUMMARY.

Workshop participants began exchanging their ideas and views on the subject about one month before the meeting took place. Short position papers were submitted by participants, stating their specific interests and concerns within the subject area. These papers were sent to all invited participants before they departed for the meeting.

The two-day workshop was planned with minimal time devoted to formal presentations, allowing ample opportunities for discussions and debates. Four two-hour sessions were scheduled for each day. Only the first session on the first day was allocated for short presentations by four selected industrial participants. The speakers were selected from four different industries (computer, aerospace, automotive, and electronic) in U.S.A and Japan, and they were specifically asked to speak about the impact and challenges of concurrent engineering in their respective industries. The purpose of these presentations was to develop a common background on the industrial needs and perspectives of the technology to stimulate and better focus our workshop discussions.

These 20 minute presentations were given by:
1. Dr. Frank Lynch of Digital Equipment Corporation, U.S.A.
2. Mr. Roy March of The Boeing Company, U.S.A.
3. Dr. Gus Olling of The Chrysler Corporation, U.S.A.
4. Mr. Kimio Inagaki of NEC Corporation, Japan

Dr. Lynch began his presentation by showing the role of corporate knowledge (both managerial and technical) in supporting the world-class product development practice in the computer industry. He emphasized the importance of viewing knowledge as an asset in a corporation, and suggested several different ways to manage this critical asset in a concurrent engineering environment. He explained some technical details of Digital's initiatives in developing an intelligent computer system that can help to manage the knowledge asset. He concluded the presentation by pointing to some critical issues and challenges that both managers and engineers must face in developing and deploying concurrent engineering technology to industrial practice.

The presentation by Mr. March focused on the special characters of the aerospace industry and how/where concurrent engineering can play an important role in meeting new challenges of the industry due to changes of political forces around the world. He used the new U.S. Department of Defense and the Boeing Company as an example to illustrate a new kind of product development requirement that challenges the company's ability to shorten the product development time in building new military aircrafts (for the post cold-war era). Instead of the old-fashioned way of "order-then-develop-then-build", the new requirement will be "develop-then-order-then-build". He indicated many challenges, including vendor-supplier relations, in product development practice to meet this new requirements.

The new product development challenges, strategies and implementation plans in the Chrysler Corporation were outlined by Dr. Olling in his presentation. As an automotive company that must produce complex products of high quality and large volume in a very competitive and dynamic world market, concurrent engineering brings different meaning and challenges than those found in other types of industries. He explained Chrysler initiatives in bringing all business and engineering data and tools all into one integrated computer environment as a way to support concurrent engineering that can shorten the product development lead time and improve the product quality.

Instead of focusing on specific company strategies, Mr. Inagaki presented a recent product development case at NEC where the company needed to develop a new laptop computer within 90 days in order to meet the hazard of loosing market shares due to the introduction of a new laptop by the competitor. In contrast to other presentations which stressed the importance of new technologies, Mr. Inagaki described a very human-oriented and experience-centered approach to concurrent engineering. He explained how NEC quickly drew management and engineering expertise from previous computer development projects in the company to organize a "tiger-team" that had full authority over all aspects of the product development project. An innovative "backward scheduling" technique was used, and strictly exercised, to insure that the product would meet the 90-day target (otherwise, the market share would be lost and a major change in marketing strategy would be required). This case study clearly pointed out that the success of the project team (i.e., they developed a new laptop computer from scratch within 90 days) was mainly due to (1). a high urgency of the target, (2). a highly motivated group with clear incentives, (3). a strong experience base from related products, (4). a highly cooperative team with full authorities over their decisions, and (5). a strictly enforced backward scheduling approach. Mr. Inagaki's presentation stimulated many discussions among workshop participants on those more human-related issues of concurrent engineering such as management, experience, incentive, and authorization.

The second session in the morning was organized as a group brain-storming session where participants were asked to suggest critical issues that needed to be further discussed in the workshop. Based on the input from participants, two sub-groups were formed to focus on (A). infra-structural requirements, and (B). enabling technologies of concurrent engineering. Sub-group A was to identify those high-level intra-structural issues critical to the success of concurrent engineering, and to transform (i.e., map) these issues into a set of technological requirements. Sub-group B was to focus on defining a set of enabling technologies that could address those intra-structural and technological requirements identified by sub-group A.

Workshop participants were asked to join one of the sub-groups based on their interest and expertise. The afternoon sessions of the first day were devoted to sub-group discussions on these two subjects. During the first session on the second day, each sub-group reported back to the whole workshop about the progress and status of their discussions in order to better coordinate the continuing discussions. The afternoon was devoted to sub-group final reports and synthesis of workshop results (see the next section on Workshop Results). The last hour of the workshop was spent on drawing comments/feedback from participants about the workshop's technical theme and discussion format.

All participants felt the workshop was successful (with respect to the goals that were set forth for it) and expressed high interest in continuing participation of such discussions in the future. They felt that the flexible and open format was effective to allow a wide range of issues to be covered. However, it was felt that the two-day workshop was perhaps too short to engage in elaborated discussions/debates of those identified issues. Suggestions were made on possibly a longer workshop and/or more thorough idea-exchange before the workshop in the future. Participants also liked the inter-disciplinary nature of the group, and suggested ways to involve more industrial and international attendees in the future. They all expressed a strong interest to be continuously involved with this international group to advance the research, development, and application of the concurrent engineering approach in the product realization practice.

Finally, the workshop organizing committee reported on follow-up actions to this workshop. The workshop results would be written by the committee and sent to all participants for review. The approvedreport would be submitted to the sponsoring organizations (e.g., CIRP, IFIP, and ONR/USA) for circulation. Formal publication of these results in international journals would be pursued. Continuing communication among workshop participants would be organized and encouraged. Planning of future workshops (in different parts of the world) will take place.

WORKSHOP RESULTS.

(This report on Workshop Results was co-authored by F. Kimura, T. Kjellberg, F. Krause, S. Lu, and Mike Wozny.)

Introduction:

The goal of a concurrent engineering system for product realization is to produce products that meet given cost, function, and quality requirements, as rapidly as possible (lead time). It was realized by the workshop attendees that concurrent engineering is a multi-perspective issue involving complex inter-play among cultural, organizational, human, and technological aspects. Cultural, organizational, and human solutions needed for concurrent engineering require new technological support; at the same time, new technologies will not be successful without serious consideration given to their implications on cultures, organizations, and humans.

To facilitate and focus our discussions, two sub-groups, one concentrating on those infra-structural (cultural, organizational, and human) issues of concurrent engineering and the other emphasizing those enabling technologies in response to infra-structural requirements, were organized in the workshop. This report summarizes and integrates discussion results from these two sub-groups. We expect that these issues will be developed further in follow-on workshops.

The four major sections of this report cover the following key questions extensively discussed in our workshop:

I). What are the key infra-structural requirements for the concurrent engineering approach to be successful in industries?

II). What are the new technological needs that can be derived from the above infra-structural requirements?

III). What are the necessary attributes of enabling technologies that meet the above technological needs?

IV). What are the critical enabling technologies that are needed by implementation of concurrent engineering in industrial practice?

(I). Infra-Structural Requirements of Concurrent Engineering:

(I.1). MANAGEMENT OF CHANGE. The success of future product realization systems will depend on their ability to handle change. Change, at all levels, is now a way of life, and it must be carefully managed, whether it occurs at high strategic levels or low process characteristic levels.

There is no unified approach to understanding and modeling change in its various contexts. One can start at the strategic level where overall configuration is important. The next level involves organizational change, including the evolution and structure of teams. The more technical aspects involve product and process change characteristics such as tractability, measurability, repeatability and configurability. Culture also is an important, but poorly understood element in managing change.

(I.2). AVAILABILITY OF INFORMATION. Concurrent engineering implies the sharing of information. Teaming is one means of sharing. However, existing technical approaches for sharing information are very primitive. They are governed by the state of computer communications and database technology, not the state of concurrent engineering principles.

No theories or models exist that provide a foundation for information sharing, however, concepts such as cooperative problem solving show promise. Functions which enhance collaborative participation involve the critiquing of designs, the planning and execution of design changes, the recording of design rationale, and the maintenance of agendas, unfinished business or division of responsibility. Why does the performance of a team that works effectively face-to-face in a conference room degrade significantly when its members must communicate via computers located in separate rooms? What is lost? What does it take, technologically, to make this virtually co-located team effective again; in fact superior?

(I.3). DEEP COMMON UNDERSTANDING. Making information available does not solve the problem unless one can act on it. Thus, information must be timely and meaningful. Information is meaningful when there is a common framework for understanding.

There are no theories today which provide useful models for accommodating, for example, different points of view, different disciplines, and various contexts in a product realization system. Although management is perhaps correct in implying that effective cross-functional teaming is primarily a management, and not a technical problem today, the basic issue is that teaming or common understanding is not well understood. What are the essential team qualities that enable a group of experts, with different backgrounds, personalities and goals, to develop and produce a new product in the shortest possible time? If we understand these qualities, then computer tools can be developed which support teaming in a meaningful way, making the product realization system significantly more efficient and cost-effective.

Emerging concepts, such as convergence and collaborative thinking, where each individual of a group builds up an understanding of specialized knowledge from all other group members in such a way that his/her expanded knowledge allows him/her to completely understand the needs and goals of all the other members, show promise. This new collective mindset allows all team members to grasp the cost of each other's activities, providing insights which result in a much deeper level of cooperative work.

Another key aspect of deep understanding is informal human networking, where workers have such a high level of confidence in each other that they can communicate highly reliable planning information well in advance of normal schedules. Again, no models exist for such networking.

(I.4). RISK AND UNCERTAINTY. A successful rapid product development system, by its very definition, requires design decisions (for product or process) to be made very early in the cycle when only incomplete information is available. Extensive experience and highly skilled judgment are required to make such decisions today because current models for representing such incomplete information and assessing its risk are inadequate. Various concepts such as interval analysis, impact and risk assessment, and neural representations require further research.

(I.5). AVAILABILITY OF COMPETENT WORKFORCE. Sophisticated product realization systems require a sophisticated workforce. Shorter and shorter cycle times will force workers to learn new technologies, procedures and skills more quickly. This short ramp-up time for people will change the way workers are selected, educated, trained, and rewarded. For example, instead of paying workers for the specific task they are performing, we can pay them for their skill level, regardless of current task, thus incentivising workers to continue to develop new skills. The more skill an individual has, the more adaptable he or she is to meet future unexpected needs, assuming the skills are in areas of future importance. Innovative education, training, measurement and reward theories and techniques are essential for successful future product realization systems.

(I.6). INTEGRATION. Concurrent engineering deals with creating an infrastructure which makes the enterprise more responsive. A responsive company must get the product right the first time. The shorter lives of products today simply do not leave time to correct design errors, nor to redesign products for lower cost or higher quality. Most of the profits from a successful product are realized early after its introduction.

A responsive enterprise requires global or integrated thinking. When one thinks globally, former CAD measures of productivity, such as "engineering drawing through put" (drawings per unit time) are simply inadequate for the big picture, and must be replaced by measures such as "number of engineering changes", or "time for ramp-up to volume production". There is no adequate modeling methodology which allows one to evaluate trade-offs in such global measures.

(I.7). STANDARDS. Since much of the data dealing with product realization is technical in nature, the ability to effectively use cross-functional teams on a regular and extensive basis across an enterprise will be hindered until the data exchange problem is solved, i.e., until all users can communicate "transparently" across technologies and methodologies. Today, most CAD tools run separately, the models and representations are incompatible, and the user interfaces and databases are inconsistent.

Although there are many technical and bureaucratic problems associated with any evolving standard, the rapid development of the proposed ISO STEP standard is essential if concurrent engineering is to achieve its potential in rapid product realization.

(II). Technological Requirements for Concurrent Engineering:

Given the above infra-structural requirements for a concurrent engineering system for product realization, this section describes the resulting technological requirements.

(II.1). INFORMATION ARCHITECTURE. The computer-based information architecture must have the following attributes: It must accommodate a distributed computing environment, with the appropriate levels of security, based on open networking architecture to allow teams to work transparently, i.e., unhindered by the low level computer workings. The workstations should have a common interface structure so that users can move from one computer application tool to another with minimal learning, i.e., allowing the user to concentrate on the tool and not the interface. The architecture should allow all the tools to be integrated in a way that minimal effort is required to move from one tool to the next. This also implies that the appropriate supervision and release mechanisms are in place which track the progress of the design.

(II.2). DECISION ARCHITECTURE. This topic involves the overall strategy of how teams or groups of teams interact and make decisions when designing a product, and how the evolving design information is managed. One can envision a suite of utilities to enhance collaboration, such as a cooperating multiple agent inferencing network, based on agents representing functional islands of expertise. These agents cooperate with each other in a client-subcontractor mode, interacting on a demand basis requesting/providing services, with no predetermined flow of information and no dominant players. Each agent performs its function and informs associated agents of its solution. The associated agents check for constraint violations.

Such systems are useful for collaborative participation of teams in critiquing designs, planning and executing design changes, recording design rationale, maintaining agendas of unfinished business such as evaluations of designs, suggestions about goals and constraints of design changes, effects of proposed changes on other aspects of the design, changes under consideration or implementation, and the divisions of responsibility.

One can extend the above concept of intelligent agents to include brokering agents that have knowledge about specific services on the network and negotiate for services needed to complete a given task.

(II.3). MANAGEMENT OF PROJECTS. Key issues that must be considered in this area are: multiproject planning and control, project breakdown structure, scheduling, cost estimating, performance measurement, progress reporting, corrective actions, organization, and finally resource allocation.

(II.4). MEASUREMENTS. Measurement Techniques are needed at all levels, from the strategic enterprise level down to the real time human team worker on the factory floor. Measurements involving the effectiveness of teaming concepts, as well as cross functional departmental interaction (e.g., number of engineering change orders) are especially needed for concurrent engineering.

(II.5). MODELING METHODOLOGIES. Five major classes of methodologies are needed. This first involves information methodologies such as EXPRESS, where the information model can be implemented directly into a database (or object base) schema. The next class involves modeling of physical processes, including simulation as well as models useful in the manufacturability evaluation of in-progress designs. The third class involves methodologies for setting strategic and business goals, which will model enterprise-wide characteristics. The fourth class involves methodologies to model organizational structures, in order to determine what type of organization best fits the desired responsiveness or other goals. The final need is a methodology to model human behavior, since most effective manufacturing environments involve a carefully orchestrated interplay between humans and machines.

(II.6). MIGRATION STRATEGIES. The long term success of a *concurrent engineering* based product realization system is its ability to evolve to new hardware and software platforms, new tools and new networks. Most companies have large investments in computer systems, databases, and trained personnel which cannot be cost-effectively changed every time new enhancements appear. Consequently, techniques are needed for migrating existing environments to new enhancements. Utilities are needed which encapsulate existing tools so that they can be embedded into new environments with minimal alteration. Utilities which allow distributed environments to be easily reconfigured, including intelligent routing of existing software tools are also needed.

(III). Attributes of Tasks/Functions for Concurrent Engineering Enabling Technologies

In the following discussions, the term "technology" is used to describe both "tasks" or "functions" to be performed in a concurrent engineering environment, and "systems" or "modules" which are able to carry out those tasks and functions. A list of required attributes for those tasks and functions that concurrent engineering enabling technologies must meet is first presented. Then, a list of systems and modules of concurrent engineering enabling technologies is included.

To describe processes which run under the goal of concurrency for product realization, it is helpful to define attributes of needed tasks and functions. These attributes are collected to characterize the needed enabling technologies. The following non-exclusive list of attributes are presented without an order of importance: incomplete/uncertain, heterogeneous, interval, parallel, open, time-based, and shared. The single attributes can be interpreted as follows:

(III.1). INCOMPLETE/UNCERTAIN. With this attribute, it is indicated that processes in concurrent engineering have to deal with incomplete and uncertain information. Although current engineering systems must also handle incomplete and uncertain cases, concurrent engineering adds more serious demands on these situations. Early communications between downstream and upstream information are very important to concurrent engineering. Information at early stages often lacks details and complete specifications, and many different types of information must be communicated in parallel. Their communication mechanism and representation will be very different from that of current engineering. The ability to handle incomplete and uncertain information is a big difference in concept to sequential processes. It is advisable to look to various knowledge processing tools for its realization.

(III.2). HETEROGENEOUS. The influences on decisions for product realization are manifold. Information can differ in content, representation, relation, and structure. It indicates also that decisions for such complex processes as product realization need knowledge from different related sources and domains. In a concurrent engineering environment, information in both data and knowledge forms, with different levels of abstraction, must be handled effectively to support communication and coordination. Such a heterogeneous information base makes it difficult to evaluate, interpret, and integrate in the right way and in conjunction with the other information.

(III.3). INTERVAL. This attribute has two meanings. One is the incremental availability of information, whether it is complete or incomplete. Unlike traditional single value systems, intervals do not force engineers to make unnecessary commitments to value specifications prematurally. They leave room (degrees of freedom) for others to fill in, avoiding many costly iterations at later stages. Such a ``least commitment" approach to problem solving is a very critical and desirable characteristic of concurrent engineering. The second meaning of interval reflects time dependencies, indicating whether synchronization happens or not, and helping to improve coordination among engineering teams. It also implies that the product realization process does not have to be a fully continuous one in practice.

(III.4). PARALLEL. This is a time characteristic of concurrent engineering. It describes a time overlap of one or more tasks. Although not all engineering tasks can be parallelized, the demand of shortening times for product realization makes parallel processes necessary in concurrent engineering. These processes can be performed locally or distributed. Keeping track of these kinds of processes demands new project structures and new project management methodologies. The term ``parallel" also has a second meaning in concurrent engineering in that it indicates the multiple competing perspectives of product life-cycle concerns must be considered in parallel rather than incorporated sequentially as with the case of traditional approaches.

(III.5). TIME-BASED. This attribute makes visible the demand of shortening of product realization times. Tasks themselves have to be shortened, but there are also dependencies to other tasks which run in parallel. Keeping track of those complex dependencies which vary with time is a very critical task in concurrent engineering. In fact, most decisions in a concurrent engineering environment are intrinsically time-based. The questions of scheduling, backward scheduling, and project management have to be solved. In this context especially synchronization efforts between different project teams have to be made.

(III.6). OPEN. This is an attribute which describes architectures of the concurrent engineering environment. The architectures needed for concurrent engineering have to be open in the following sense. It is necessary to have the ability to include additional functionalities. This must be possible under the time constraint of parallelism. It has to include local and distributed activity. It has to be able to work with heterogeneous knowledge and information systems. It has to be able to include existing system modules as well as future ones. The demand for interfaces with other engineering systems is also high. Standards for data formats, procedural interfaces, and networks are imperative.

(III.7). SHARED. Goals, tasks, knowledge, data, etc. must all be shared to achieve the goal of concurrent engineering. Here, it is necessary to describe shared resources as knowledge bases, information bases, networks and the distribution of work. It can include distributed work and has a strong impact on teaming (both real and virtual) by advanced information technology.

(IV). Concurrent Engineering Enabling Technologies

The concurrent engineering enabling technologies are put together under the organization of an architecture (see Figure 1). A reflection of the systems needed and their relation is shown in this figure. It consists of the human as the center which has access to a Decision Support System (DSS), a Virtual Teaming Support System (VTSS), a Concurrent Product Life Cycle Modeling System (CLCM), and a Time Responsive Intelligent Information System (TIIS). All these components are to be organized with respect to the infra-structural requirements identified by sub-group A.

The human is centered in this architecture, for the fact that it is seen as the overall measure and driving force, as well as the controller of the functions which are performed. The emphasis of this human-centered architecture is seen as a new feature compared with conventional systems for product development support.

(IV.1). DECISION SUPPORT SYSTEM (DSS). The Decision Support System allows engineers to effectively use information for/from the team and individuals, thus making decisions more profound. As in the product life cycle, it is very difficult to handle and evaluate all available facts. When these facts are controversial, the DSS is seen as a tool for providing sound proposals which can be based on multi-criteria evaluations, on simulation, or on feedback. The DSS also has to support decisions about the product development process itself, keeping track of decision rationale and histories. In this sense it also has to contain synchronization and project management capabilities. It seems to be useful to have additional capacity for project management available. The reason for that is the complexity of parallel work which especially is difficult to manage under flexible degrees of parallelism. As decisions have to reflect the cooperation with suppliers and customers, they have to get access to the DSS capabilities.

(IV.2). VIRTUAL TEAMING SUPPORT (VTSS). As one human cannot provide all the knowledge and skills needed in the processes of product development, it is essential to be able to work in teams. For group work it is a need to have personal contact or at least to have a virtual co-location. This is the root for demanding a Virtual Teaming Support System. The features needed are for messages, and for human interaction by means of voice, text, and graphics. It is for sharing knowledge, for analyzing problems, for cooperative decision making and problem solving. The requirements for virtual teaming technologies in concurrent engineering go far beyond the capabilities of those electronic meeting systems currently available. They must support team interactions which could be distributed or centralized, synchronous or asynchronous, technical or administrative, involving both people and machines.

(IV.3). CONCURRENT PRODUCT LIFE CYCLE MODELING SYSTEM (CLCM). Geometric modellers and product modellers will still be a basis of future modeling systems in concurrent engineering. But the demands go beyond the available possibilities. For concurrent engineering it is necessary to have modellers available which can meet the modeling requirements at all phases of a product life. The different influences of the product, the production process, the usage and recycling have to be taken into account. Also the market, the customer, maintenance and repair have to be modeled. These modellers will be product dependent; therefore, demands arise for open architectures. As these modeling functions will be performed in a team, they have to be sharable as well.

(IV.4). TIME RESPONSIVE INTELLIGENT INFORMATION SYSTEM (TIIS). To support the systems described already, it is necessary to have a storage and a retrieval of information available which can be used by different users simultaneously, under time constraints of parallel work, and in synchronization. Another need is to handle information in an intelligent way. This feature can cover several demands such as having the needed information available at the right place in the right time, distributing information to the right members of the team, gathering information in such a way that it is of further use for product life cycle modeling. It has to process information and knowledge not only for storing, but also for output and understanding. The ability to present information for multiple perspectives and levels of abstraction is very critical here. The system has to document for long term, but it also has to be fast in response even for very old information. It has to work not only with company owned sources, but also with suppliers.

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FACTS ABOUT CIRP.

CIRP: ITS AIMS, STRUCTURE AND ACTIVITIES

The early days

In the late 1940s it was becoming increasingly clear that the development of new production techniques was being hampered by the lack of appropriate analysis methods. There was evidently an urgent need for fundamental research to be undertaken in this area, It was realized that, in view of the importance and scale of the problems to be tackled, only international cooperative action would be effective. A meeting was held to discuss these problems, which was attended by Messrs E. Bickel (Switzerland), D.F. Galloway (UK), P. Nicolau (France) and O. Peters (Belgium). It was decided that efforts should be made to bring together research workers studying the application of scientific methods to production technology. This initiative led to the foundation of the International Institution for Production Engineering Research (CIRP) IN 1951.

Present day activities

Today, CIRP is increasingly turning its attention to the use of computerized methods for manufacturing control. In particular, automation, robotics interfacing and the computer integrated factory of the future are all subjects which are receiving detailed consideration, Much of CIRP's work is now concerned with applying a systems approach to manufacturing, with the communication requirements of the CIM environment and with the role of people in future manufacturing processes.

Aims

CIRP's principal aims are:

- - to promote international collaborative research into manufacturing processing methods, including the enhancement of production efficiency and quality of work;
- - to establish regular contacts between research workers and hence provide a forum to stimulate information exchange;
- - to convene conferences to discuss the results of promising research and to ensure their publication in an industrially useful form.

CIRP's activities are concerned with promoting the highest levels of scientific research and as such its policies are strictly non-commercial. CIRP members are all internationally recognized scientists and engineers dedicated to common goals. The organization is fully independent and not restricted to national interests.

The membership is divided into three categories:
Active members, generally directors of former directors of major production engineering laboratories;

Corresponding Members, research workers with recognized credentials who have the potential to become active CIRP contributors and collaborators;

Associate Members, companies or research institutions that support the aims of CIRP and that maintain an interest in the organization's activities.

Organization

At present, CIRP has about 250 active and corresponding members representing some 36 different countries, All the members have been co-opted into the organization after making significant contributions to production engineering research, The unique contribution that CIRP makes to manufacturing research is acknowledged by many of the world' s leading companies and research institutes, who provide active support through the associate membership scheme. CIRP also maintains close contact with international organizations such as ISO, UATI (Union of International Technical Associations), UNESCO and UNO. The technical activities, conferences and publications of CIRP are just one side of the multifaceted organization. There is, of course, a human side too. Relationships built up over the years ensure that CIRP is not only known for its scientific standards, but also for its friendliness and collegiality. All this and more make CIRP a truly unique organization- a world leader in production engineering research.

Scientific and Technical Committees

The Scientific and Technical Committees (STCS) ate the groups responsible for coordinating the collaborative research projects run by CIRP. The knowledge generated in each field of activity is distributed by publications and conferences to the manufacturing community at large. The main activities of the STCS are:
- -collecting and analyzing bibliographies to document the state-of-the-art in particular areas of manufacturing;
- -publishing synthesis reports on important technical problems;
- -organizing seminars and meetings on specialist topics;
- -preparing internationally accepted terminology to aid understanding and promote more precise scientific definitions;
- -contributing to the work of the International Standardization Organization (ISO);
- -surveying the state of the art of research being carried out in different laboratories in the world;
- -studying and promoting the development of important new techniques and technologies'
- -organizing cooperative research projects, comparative testing, standardization of methods etc.

At present, ten STCS are in existence:
A -Assembly
C -Cutting
DN -Design
E -Physical
F -Forming
G -Abrasive Processes
M -Machine Tools
O -Optimization
Q -Dimensional Metrology in Quality Assurance
S -Surfaces

To support these activities an 11th STC (D) had been formed with special responsibility for the publication of the CIRP dictionaries on production engineering. The dictionaries include the terminology and definitions of manufacturing parameters formulated by the individual STCS above. The specific fields of interest covered by the ten major STCS are outlined below.

Assembly (A)
- -Techniques, processes and equipment for the assembly and handling of parts, including design for assembly and the application of industrial robots.
- -Terminology and symbols used to describe assembly and handling operations.

Cutting (C)
- -Processes and techniques used to shape components by material removal (turning, milling etc.), including the processes of chip formation, the physical laws governing the wear of cutting tools and the factors influencing surface finish.

Design (DN)
- -Conceptual and innovative processes in engineering design.
- -Design for economic manufacture, coordination with manufacturing.
- -Computer -automated systems and the integration of technological and

economic methods.
- -Interfacing of CAD/CAM systems.
- -Databases for CAD systems.

Physical and Chemical Machining (E)
- -Research into material removal processes of a physical, physico-chemical or chemical nature, such as electro-discharging machining (EDM), electrochemical machining (ECM) and the use of high energy laser, electron and ion beams.

Forming (F)
- - Processes in which components are shaped by plastic deformation, including pressure joining and separation techniques such as stamping, shearing etc.
- -Application of the theory of plasticity to industrial forming processes with reference to Tribology and materials engineering aspects.

Abrasive Processes (G)
- -Research into material removal processes using hard abrasive grains such as grinding and finishing, attention is largely focused on the mechanics of grinding and the economics of abrasive processes.

Machines (M)
- -Design, manufacture and use of manufacturing equipment, including the study of performance related factors, such as static and dynamic behavior, efficiency and resistance to wear.
- -Control of production processes and the application of new materials.
- -Automation, interfaces and control systems.

Optimization (O)
--Techniques for economic, technical and human optimization of overall manufacturing systems.
- -Design for production, factory equipment selection and lay-out, numerical and adaptive control, application of computers to manufacturing, information technology and human factors in production engineering.
- -advising the other STCS regarding the optimization of manufacturing systems.

Dimensional Metrology in Quality Assurance (Q)
- -Development and application of measuring techniques to be used for quality control procedures, involving the measurement of size, shape and positional relationships in manufactured components and assemblies.
- -Nanotechnology processes and equipment.

Surfaces (S)
- -Research into the geometrical, physical and chemical properties of the workpiece surface in relation to the production process concerned. This has involved the preparation of a CIRP standard for measuring roughness parameters and collaborative projects on measuring surface hardness, residual stresses and crack detection on workpiece surfaces.

Human Aspects of Production Engineering

Process in production engineering depends mainly on the development and application of new scientific knowledge. However, in order for progress to be achieved, the related human and sociological aspects also have to be taken into account. From its inception in 1951, CIRP has always striven to understand the interaction between manufacturing technology and the human dimension. The Round Table held every year during the General Assembly has frequently dealt with the environmental and human problems associated with manufacturing industry. This has involved discussion of:

- -The coordination of research between universities, government institutes and industry;
- -the economic, social and environmental impact of the computer-controlled factory;
- -evaluation of the education and training given to manufacturing engineers.

In addition, the following special task forces have been instituted. Education and Training which deals with the important and difficult problems of teaching the new technologies involved in computer-integrated manufacturing systems. Developing countries, which examines how new technologies can be applied to less industrialized countries. Technology Assessment, which analyses the human and social aspects associated with the introduction of new technology.

General Assembly

Each year, the General Assembly of CIRP is held in one of the home countries of the respective members. During the General Assembly, Which lasts one week, papers are presented on a range of topics including keynote speeches on state-of-the-art, also covering work done by CIRP members over the years. The collaborative research programs of the STCS and working groups are also discussed at this time. The meeting affords a unique opportunity for participants to update their knowledge of the developments taking place in manufacturing industry. The General Assembly is organized as follows.

Opening Conferences : national contributions organized by representatives of the host country which deal with the prominent achievements of local industries and the contributions made by key industrialists and academics.

Keynote papers: : state-of-the-art papers, often written by joint authors, which summarize the technical and scientific aspects particular areas of manufacturing, Moreover, the final results of collaborative research are generally presented in the form of keynote papers.

Technical papers: some hundred and fifty technical papers are presented and discussed each year covering the latest research carried out by CIRP members.

Round Table : an open forum discussion on issues of general interest. Following an introduction by recognized experts, attempts are made to establish a consensus view on a particular subject. Wide-ranging, topical and sometimes controversial issues are discussed in these sessions. Themes for the Round Table discussions are proposed by the STCS with the final selection being made by a committee of STC Presidents and Secretaries.

Scientific and Technical Committees: the STCS meet during the later part of the General Assembly to discuss the results of the collaborative research programs in detail.

Publications

CIRP Annuals :
700 pages in two annual volumes:

- -volume I contains all the technical papers presented at the General Assembly (about 150);
- -volume II contains synthesis reports such as: keynote papers, surveying the state-of-the-art of particular areas of manufacturing; technical reports, summarizing the major results of collaborative research conducted in the STCS; text of the Round Table discussions; conferences of general interest held during the period of the General Assembly; progress reports of the STCS.

CIRP Dictionaries
The dictionaries are written by CIRP members who are actively involved in research, They contain equivalent terms for the various production processes in English, German and French. A comprehensive list of the subjects covered in the dictionaries is available form the CIRP Secretariat.

Proceedings of CIRP seminars
- -Annual Manufacturing Systems Seminar;
- -Working Seminar on Computer-Aided Process Planning (1985);
- -Working Seminars of the different STCS.

CIRP Technical Reports :
- -Unification recommendations;
- -Register of laboratories.

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