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From the Editor

Japan's key industries that have sustained the development of the country's economy have been facing serious new challenges over the past few years. The key industries include textiles, shipbuilding, steel, automobiles and electronics. In particular, Japan's heavy industry as represented by steel and shipbuilding has been in the process of transition from maturity to decline stage because of advancing NIES countries as well as the appreciation of the Japanese yen. Therefore, in these industries, the companies, while restructuring themselves as a survival strategy have been taking positive actions to diversify business and advance into new areas such as new materials, information and communication, biotechnology and leisure-time amusement. In the meantime, the production industries including the automobile, home electrical appliance and electronics industries are promoting the transformation of the industrial structure as well as company activities in the realms of technological innovation, information networking, service industries, and market diversification. They are also addressing issues such as the impact of trade friction, the catching-up of the NIES countries, the high yen trend and employment uncertainty. Among other things, market diversification requires a production system for a small quantity of a large number of products. The shortening of the design to production/sales period has become a key strategy in the market competition.

In Japan, NC machine tools and industry robots have been propagated since the beginning of the 1980s, and factory automation has been rapidly achieved with the introduction of automated warehouses and automatic guided vehicles. In the area of design, CAD systems have been installed, and computerization has been promoted in each department centering on computers and communications. However, such departmental computerization has many inefficient aspects from the overall company standpoint. Therefore, it has become increasingly necessary to centralize these functions and to integrate all the functions of planning, development, production, control, sales, physical distribution and services. The concept of CIM has been formed on this principle. The CIM concept was originated in the United States as a method to revitalize the industrial economy, and it aims at achieving a sort of industrial synergism through total optimization of system engineering. In other words, CIM can be regarded as a system concept for the production industry as a whole.

Japan Electronic Industry Development Association (JEIDA) defines CIM as follows:
"A new production system concept to integrate all the areas and functions of business activities by a computer using information as media, for the purpose of total efficiency improvement." This concept was developed out of the necessity to have a mechanism with centralized and

comprehensive efficiency that could penetrate sales, development, production, physical distribution and service in order to achieve a corporate strategy capable of coping with the future business environment. This is not very different from the CIM concept started in the US. Therefore, discussions in this issue are basically based on the JEIDA definition.

Japan's production technology is at the world's top level now, and is supported by high-level information technology. Furthermore, we expect that Japan's CIM will continue to advance in the future with the progress of artificial intelligence technology based on new information technologies such as "neuro" and "fuzzy." However, there is a large number of problems to be solved. For example: a large amount of development investment for the construction of the total system and a long-term development period, automation limitations, maintenance, acquiring system flexibility capable of responding to the changes of the corporate environment, standardization of protocol, training of the system staff, etc. We look forward to the realization of an effective CIM that will be harmonious with human creativity, and that will provide solutions to the above-mentioned problems.

This time, we have explained the basic concept and approaches relative to Japan's CIM situations, and provided actual examples of CIM installations in representative companies. We would like to express hearty appreciation to those who have contributed articles for this issue. We hope this issue will be of value to its readers.

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Towards JIT-based CIM with Human Support

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1. Introduction

Advances in computer and communication technologies have brought the world closer together. We are in an age when events in the U.S. or in Europe reach the cozy confines of our homes in Japan no later than the times when they take place. The trend of the times seems to be an acceleration of the tempo at which user needs diversify and gain in sophistication, and it is now necessary for companies to build systems which can catch up with these changes as quickly as possible.

The sharp appreciation of the yen against the U.S. dollar starting in September, 1985 and friction in U.S.-Japan trade relations have dealt a heavy blow to Japan's export industries. It was to survive this shock that the country's manufacturing industries started to feel an increasing need to switch over from Factory Automation (FA) to Computer Integrated Manufacturing (CIM). Automation and streamlining of operations in isolated plants could no longer deliver goods effectively. Activities in factories scattered far and wide had to be integrated and streamlining efforts or efforts towards higher efficiency had to encompass an entire company or, preferably, all its group affiliates. Today, therefore, the manufacturing industries are gradually moving from factory automation or total factory automation towards computer integrated manufacturing involving an entire company. For company-wide CIM of this nature, it is important to introduce the just-in-time (JIT) concept at all organizational levels of the enterprise, including the marketing, production, and engineering sections.

This paper will deal with the salient features of the just-in-time concept as it is used in production and information control systems and will discuss the issues involved in and the prospects for CIM systems which have human support.

2. The Starting Point of Activities in a Manufacturing Enterprise

Activities in a manufacturing enterprise start from production, which initially depended entirely on tools held in human hands. The products that such efforts yielded were modified according to orders from customers. This process was mechanized and automated when the need arose for large volume sales. In the process, small-to-medium size undertakings grew into companies of middle standing, and eventually into top level enterprises (See Figure 1). This was accompanied by the acquisition of management and systems engineering techniques. Thus, activities in the manufacturing industries today basically center on raising profit margins at the plant level and on the balanced investment of

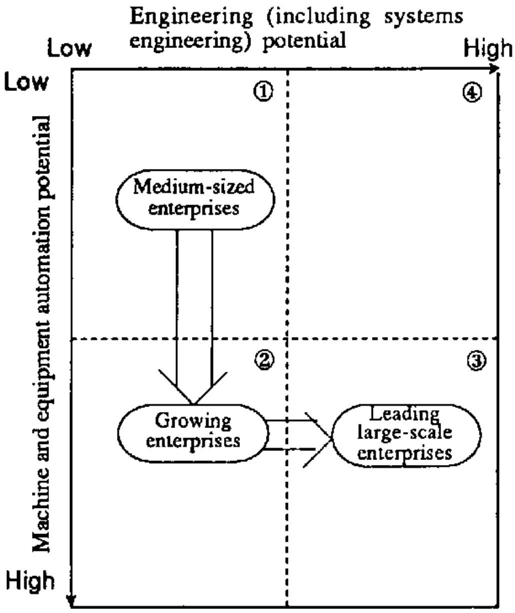


Figure 1 Evolution of companies in the manufacturing industry

profits in research and development as well as in marketing. Factories are of the greatest importance to a manufacturing enterprise, which must seek the cooperation of other areas within its setup to prevent unnecessary production. Factories, on the other hand, must strive to abide by the delivery schedule for orders received by sales people and also must maintain the quality level specified by the engineers. They must also make sure that the factory maintains a trim appearance. Company-wide CIM cannot succeed without such mutual reliance. The interrelationships involved here are shown in Figure 2.

3. Why Human Support-Type CIM?

Various factors account for the severe competition manufacturing companies face vis-à-vis other companies. Thus, in the nineties,

(1) The design and development of new products must be speeded up
(2) Flexible production lines must be built
(3) Training and education systems must be established to maintain high quality.

The importance of the first factor should be apparent from the fact that 80% of the cost of a marketed product is accounted for by the design and development and production engineering departments (See Figure 3). To resolve this problem, CAD/CAM (computer aided design/manufacturing) systems are being used, and attempts are being made to further accelerate the pace of the creative activities of employees by putting CAE (computer aided engineering) into practical use as well. In addition, in order to reduce design and development lead time, concurrent and simultaneous engineering methods have been proposed and implemented (See Figure 4). These new approaches are a departure from the conventional practice of developing new products by executing the necessary steps one at a time. These are technology development approaches which call upon all the concerned departments to simultaneously attend to their roles in parallel.

The second factor, building flexible production lines constitutes the basis for CIM and is, therefore, the most important theme for the manufacturing industry. This calls for:

① Flexibility to allow changes in production line layout and process design
② Automating processes and establishing a realtime information system, all in a multi-process environment
③ Reducing the time required for preparation and replacement of metallic molds, etc.
④ Clarifying the conditions for building flexible mixed-flow assembly lines.

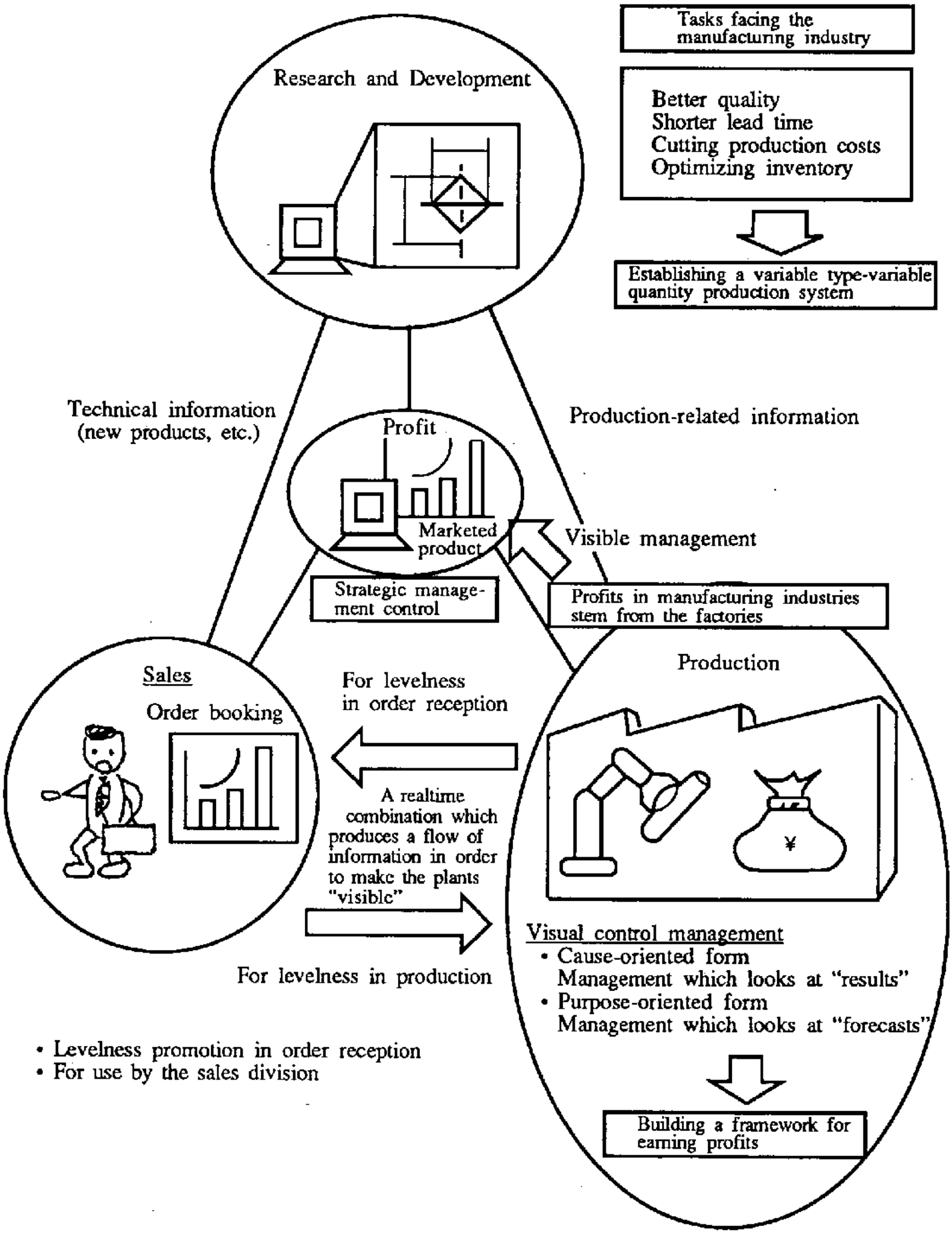


Figure 2 CIM promoted by Yokogawa Electric

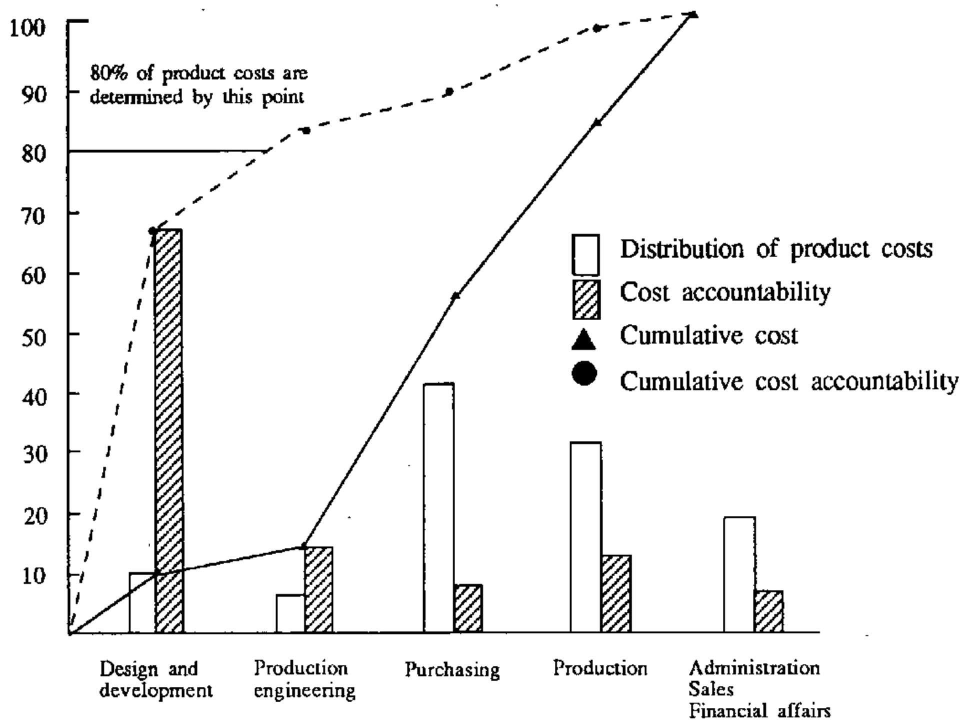


Figure 3 Design and development cost accountability

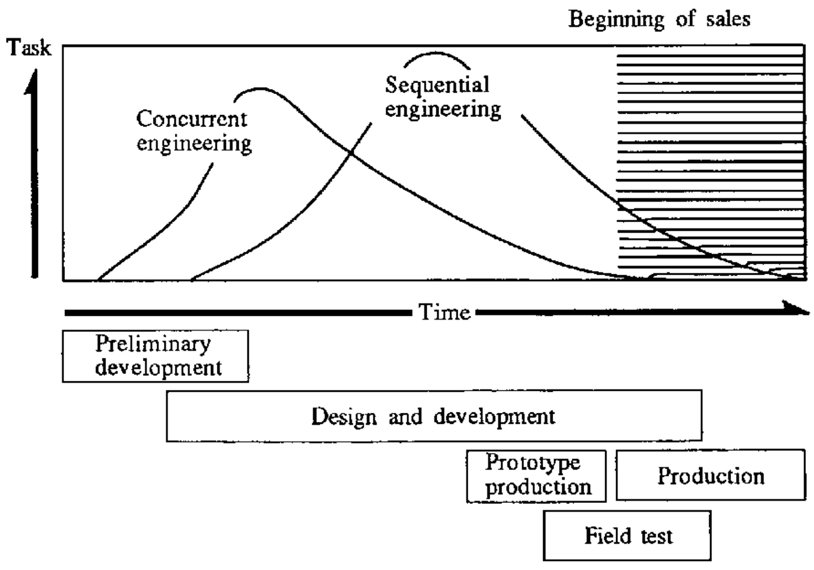


Figure 4 Concurrent and sequential engineering

In addition, a good labor environment is necessary for maintenance of high product quality. However, the prospects for the working environment in the nineties seem bleak. Therefore, strategic investment in training and education is necessary, and each department must implement its own educational plans. The aims of such educational plans include raising worker morale, giving employees a feel for their jobs, introducing them to high technology, and stimulating creativity in their design and development activities.

CIM combined with human support systems constitutes an excellent tool for satisfying these needs.

4. Introduction Procedure of Human Support CIM

4.1 Basic concept

(1) Make clear what the strategic marketed products are and determine on the basis of such products the desired range of CIM applications

(2) Even if the desired CIM application area is already automated, once again review the production, physical distribution, and information control systems on the basis of the just-in-time concept, eliminate unnecessary elements, and then introduce CIM.

4.2 Introduction procedure

The possibility of introducing CIM is studied in detail after fully understanding the concepts of CIM implementation. Once the decision is made to introduce CIM, the procedure must be planned and targets fixed after building a vision of the system based on management strategy. The job must begin after all members have checked the planned procedure.

Step 1

(1) Figure 5 shows the steps to be followed to improve site operations and improve and simplify physical distribution on the basis of the just-in-time concept.
Operations must start with leveling and then take up flow production and finally standardization of jobs in that order. In a multi-process production environment, one must advance from single to one-touch preparation, gradually implementing automation. In this way, a production system is established.

(2) The flow of information must be simplified and standardized. A visual control management system must be created around information related to machinery, physical distribution, delivery, quality, and manual operations. In this way, an information control system is established.

One will encounter some bottlenecks calling for early detection, these being associated with the transition from mixed to single flow production. There are also areas where quick change is necessary. Here, it is advisable to introduce human intervention systems backed by decision support systems. The decision support system must ensure the clarity and accuracy of the information that is needed in the human decision-making related to machines, devices, line conditions, product quality data, parts supply, and inventory status.

Step 2

(1) Establishment of manufacturing information control systems based on single or

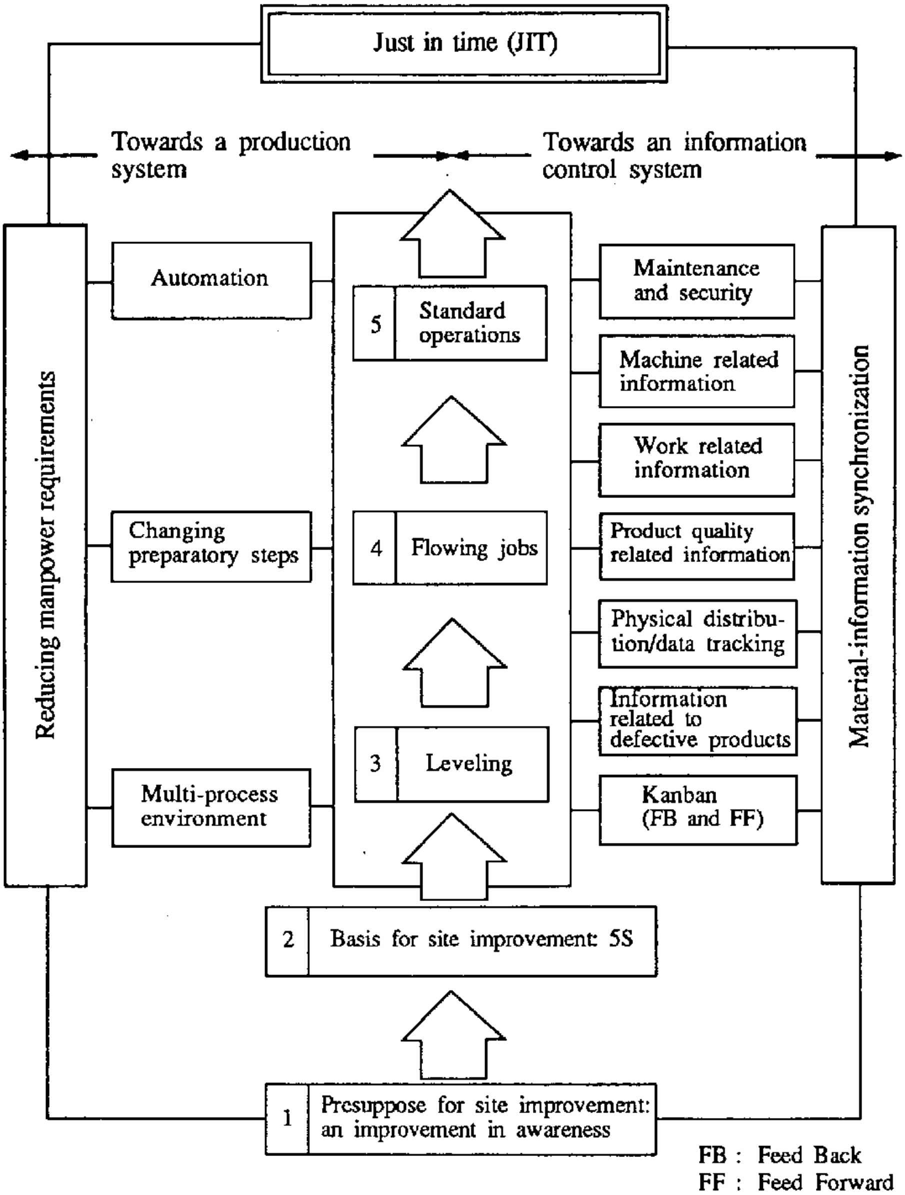


Figure 5 Introduction procedure of the JIT production concept

multiple flexible manufacturing cells (FMC)

(2) Establishment of vertical linkage through a realtime connection between the aforementioned distributed system and the sales and the technical information systems.

Yokogawa's own feasibility study (FS) approach will assure the smooth progress of the operations in step 2. It will also help synchronize materials and information.

Step 3

Step 3 is based on the flexible manufacturing work cells established in steps 1 and 2. It horizontally extends the knowhow acquired in these two steps, and integrates isolated unmanned systems. It integrates all production lines and sales and design activities.

Figure 6 provides a view of the above procedure within the framework of a structural diagram of production lines. In this figure, the unmanned system pyramids represent areas not instantaneously and flexibly adaptable to changes, including changes in the mode of use. However, a flexible production line can be built economically by introducing systems reliant on human discretion for final evaluation and by mutually connecting these with the small unmanned systems into a total system. Determination of the size and range of the small pyramids falls under the supervision of the group leaders at the site. Placing human support systems behind unmanned systems makes it possible to build production lines that are distinct from one another and which are competitive. In other words, the aim as of

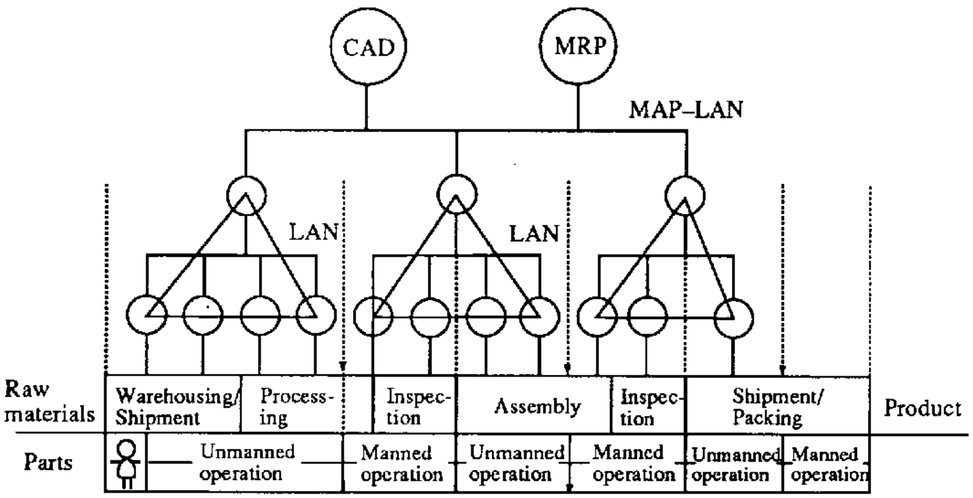


Figure 6 Horizontal extension of a vertically distributed system

today is to build a CIM system which incorporates a human support system. Functions of the human support systems are listed below:

(1) Improving unmanned systems and creating new systems
(2) Machinery and device trouble diagnosis and forecasting and preventive maintenance
(3) Quick response to failures or emergencies
(4) Flexible adjustment if there is a defect in products or if the production schedule must be changed
(5) Intelligent support for autonomous distributed systems
(6) Intelligent differentiation.

4.3 Special features of the horizontal extension of a vertically distributed system

As mentioned in 4.2, this method of building a CIM system offers a number of advantages. The principal advantages are:

(1) Reduced initial investment as well as total investment
(2) Shortening the time required for system building
(3) Easier standardization and maintenance of application software
(4) Easier horizontal extension of the same software
(5) Fewer risks of all the lines stopping, easier restart if there is a partial stopping.

5. Tasks Presented by Human Support CIM

Numerous tasks remain to be attended to in future CIM applications. These are summarized below, from the standpoint of future developments in particular:

(1) A review of cell-level automation, and integration (specifying the range that may be attended to by a single operator)
(2) Introducing general-purpose intelligent machines and devices and, at the same time, synchronized production
(3) Use of "Kanban" combining feedback with feedforward information
(4) Establishment of a production system combining mixed flows into a single stream
(5) Balancing unmanned and human systems
(6) Integrating databases of distributed and independent organizations
(7) Establishing an in-house communication network
(8) Training people capable of creative thinking in top and middle management.

6. Conclusion

We saw above that a CIM drive needs as its basis flexible factory setups free from wasteful activities, and that it is important to develop a sophisticated information control system on this basis. In view of profitability, it is impossible to build a system by using machinery and a computer of current technology, which can simulate the human faculties of quick recognition and judgement. Accordingly, in factory building for the 1990's, flexible production lines can be implemented only by a well-balanced system configuration that can fully utilize current automated machines/devices, computers and communication technologies as well as human characteristics.

Expectations Effect for CIM and Installation Status — Questionnaire Survey —

1. Survey Outline

In August and September 1988, the Japan Electronic Industry Development Association (JEIDA) sent a questionnaire targeted to businesses in general to investigate their needs with respect to CIM. The objectives of the survey were as follows:

1) To identify necessary structures for evaluation of CIM by classifying and consolidating the evaluation items that constitute CIM from the standpoint of needs. And, to understand the differences in requirements for CIM caused by differences in job types, etc. from the viewpoint of structure.

2) To understand the preparation and installation status of the current CIM, to clarify the differences between industry types and to project the future course of events.

Questionnaires were sent to 4,671 company establishments and responses were received from 464 establishments, or about 10%. Out of the 464, responses that did not answer the majority of questions were eliminated, and an analysis was made of 428 responses. The attributes of the respondents are given in Table 1.

(1) Departments of the Respondents: Many respondents belong to Production Technology (25%), Production Planning/Control (20%), Corporate Planning (12%).

(2) Involvement in CIM: 73% of total respondents are involved both in development and utilization. This implies that CIM should not be used simply as is, but should be developed at the same time.

(3) Line of Business: CIM is used most often for electric, electronic and OA related industries (29%), which is followed by machinery, precision machinery and plant engineering (15%), and science, plastics and rubber (11%).
In the analysis of the installation status and future perspective of CIM as given below, the following classifications were used, combining industries for which a small number of responses were given. The industry name which is underlined is used as the name representative of the group.

1) <u>Electric</u>, electronic and OA related industry......................122 responses
2) <u>Chemical related</u> (chemicals, plastics, rubber, glass, ceramic, cement, textile, paper, pulp, petroleum/coal).......................................84 responses
3) <u>Cosmetics</u>, medicine ..... 12 responses
4) <u>Food</u>............................ 24 responses
5) <u>Steel</u>, metal, non-ferrous metal ....

Table 1 (1/2) Number of Responses by Item in CIM User Requirements Questionnaire Survey

	Item	No. of Responses
Establishment or plant of respondent	1. Corporate Planning	51
	2. Marketing, physical distribution	7
	3. Production planning, production control	87
	4. Research, development	13
	5. Design	22
	6. Production technology	108
	7. Other	139
	Omission	1
	Total	428
Involvement with CIM	1. Development of CIM	143
	2. Utilization of CIM	77
	3. Development and utilization of CIM	168
	4. Other	36
	Omission	4
	Total	428
Industry type	1. Electric, electronic, OA related products	122
	2. Textile, paper, pulp	25
	3. Clothing, apparel	2
	4. Chemical, plastic, rubber	45
	5. Glass, ceramic, cement	10
	6. Petroleum, coal	4
	7. Cosmetics, medicine	12
	8. Food	24
	9. Steel, metal, non-ferrous metal	39
	10. Automobile, motor-cycle, transportation machinery	39
	11. Transportation service	2
	12. Stationery, business machine, interiors	2
	13. Print related, publications, newspapers	2
	14. Software	1
	15. Construction	9
	16. Machinery, precision machinery, plant engineering	63
	17. Other	27
	Total	428

Table 1 (2/2) **Number of Responses by Item in CIM User Requirements Questionnaire Survey**

	Item	No. of Responses
Goods & services	1. Consumer goods	86
	2. Durable consumer goods	90
	3. Industry goods	199
	4. Service	9
	5. Other	40
	Omission	4
	Total	428
No. of types of final products	1. Less than 10 types	35
	2. 10 - 49 types	44
	3. 50 - 99 types	39
	4. 100 - 499 types	86
	5. 500 - 999 types	45
	6. 1000 types and over	171
	Omission	8
	Total	428
Production type	1. Primarily mass production	245
	2. Primarily individual production	136
	3. Other	44
	Omission	3
	Total	428
Production planning	1. Primarily after-order production	221
	2. Primarily speculative production	167
	3. Other	38
	Omission	2
	Total	428
No. of employees	1. Less than 100	28
	2. 100 - 499	123
	3. 500 - 999	101
	4. 1,000 - 2,999	108
	5. 3,000 - 9,999	55
	6. 10,000 and over	12
	Omission	1
	Total	428

..........:.........................39 responses

6) Automobile, motor cycle, transportation machinery ....39 responses
7) Machinery, precision machinery, plant engineering.................... 63 responses
8) Other .... 45 responses

(4) Types of Goods/Service: consumer goods 41%, industrial goods 46%, service 2%

(5) Number of Final Products: about 40% responded that the number of products is more than 1,000, as we live in an age of "a large number of product types of small quantities."

(6) Type of Production: mass production 57%, individual production 32%

(7) Production Planning: after-order production 52%, speculative production 39%

(8) Number of Employees: widely distributed, from 100 people to 3,000 people

Furthermore, Table 2 shows a cross tabulation of the industries and other response items given above.

2. Analysis of CIM Evaluation Items

2.1 Level of Expectation for Evaluation Items

Table 3 shows the mean, variance and standard deviation of expectation levels for 56 items that constitute CIM (The levels are shown in five stages from 0 to 4. The larger the number, the greater the expectation.)

Out of the individual items, the following are relatively high with respect to expectation level.

(1) Production lead time (from receipt of order to shipment) can be shortened 2,988
(2) Flow of materials and flow of data (information) can be synchronized..........2,878
(3) Easily responsive to changes in production planning and additional plans 2,721
(4) Joint sharing of database between marketing, design and production can be implemented.................................2,650
(5) Optimum scheduling can be made 2,649
(6) Productivity can be improved........ 2,632
(7) Production system interlocked with marketing can be established............... 2,617
(8) Inquiries on delivery time from users and sales sides can be promptly handled.......... 2,554

From these results, it can be said that the average level of expectation concerning CIM is related to the shortening of flexibility lead time based on centralized control and synchronization of information.

On the other hand, for the following items expectation is at a low level.

(1) R&D expenditures can be reduced........... 1,239
(2) Hiring of talented people for new technology areas will become easier...........1,354
(3) Production after receiving orders will become possible.............................1,533
(4) It will lead to a market size increase 1,570
(5) It will increase market share...........1,579

Table 2.1 Cross Tabulation of CIM User Requirements Questionnaire Survey Based on Industry Type and Involvement of Respondents with CIM

	Item	Dev. of CIM	Use of CIM	Dev. & Use of CIM	Other
Industry type	1. Electric, electronic, OA related products	43	12	54	12
	2. Textile, paper, pulp	8	4	13	0
	3. Clothing, apparel	1	0	1	0
	4. Chemical, plastic, rubber	10	13	19	3
	5. Glass, ceramic, cement	2	4	2	2
	6. Petroleum, coal	2	1	1	0
	7. Cosmetics, medicine	4	4	4	0
	8. Food	4	7	8	4
	9. Steel, metal, non-ferrous metal	12	9	16	2
	10. Automobile, motor-cycle, transportation machinery	19	7	8	4
	11. Transportation service	2	0	0	0
	12. Stationery, business machine, interiors	1	0	1	0
	13. Print related, publications, newspapers	0	0	2	0
	14. Software	1	0	0	0
	15. Construction	3	3	1	1
	16. Machinery, precision machinery, plant engineering	23	8	26	6
	17. Other	8	5	12	2
	Total	143	77	168	36

Table 2.2 Cross Tabulation of CIM User Requirements Questionnaire Survey Based on Industry Type and Goods/Services Type

	Item	Consumer goods	Durable consumer goods	Industry goods	Service	Other
Industry type	1. Electric, electronic, OA related products	10	35	66	2	7
	2. Textile, paper, pulp	17	0	5	0	3
	3. Clothing, apparel	2	0	0	0	0
	4. Chemical, plastic, rubber	7	3	31	0	4
	5. Glass, ceramic, cement	2	2	4	0	2
	6. Petroleum, coal	2	0	1	0	1
	7. Cosmetics, medicine	12	0	0	0	0
	8. Food	23	0	1	0	0
	9. Steel, metal, non-ferrous metal	1	12	23	0	3
	10. Automobile, motor-cycle, transportation machinery	1	16	17	0	5
	11. Transportation service	0	0	0	2	0
	12. Stationery, business machine, interiors	0	1	0	0	1
	13. Print related, publications, newspapers	1	0	0	0	1
	14. Software	0	0	0	0	1
	15. Construction	0	3	3	1	1
	16. Machinery, precision machinery, plant engineering	4	11	43	0	4
	17. Other	4	7	5	4	7
	Total	86	90	199	9	40

Table 2.3 Cross Tabulation of CIM User Requirements Questionnaire Survey Based on Industry Type and No. of Final Product Types

	Item	Under 10	10 - 49	50 - 99	100 - 499	500 - 999	1000 & over
Industry type	1. Electric, electronic, OA related products	7	3	9	27	16	58
	2. Textile, paper, pulp	1	2	3	8	3	8
	3. Clothing, apparel	0	1	0	0	0	1
	4. Chemical, plastic, rubber	2	1	7	7	7	20
	5. Glass, ceramic, cement	3	0	0	1	1	5
	6. Petroleum, coal	0	0	0	2	1	1
	7. Cosmetics, medicine	1	2	2	3	1	3
	8. Food	4	6	2	3	4	5
	9. Steel, metal, non-ferrous metal	6	5	3	6	2	17
	10. Automobile, motor-cycle, transportation machinery	3	9	5	7	1	14
	11. Transportation service	2	0	0	0	0	0
	12. Stationery, business machine, interiors	0	0	0	0	1	1
	13. Print related, publications, newspapers	0	0	0	0	0	2
	14. Software	0	1	0	0	0	0
	15. Construction	2	2	0	1	1	2
	16. Machinery, precision machinery, plant engineering	1	11	7	15	3	24
	17. Other	3	1	1	6	4	10
	Total	35	44	39	86	45	171

Table 2.4 Cross Tabulation of CIM User Requirements Questionnaire Survey Based on Industry Type and Production Type

	Item	Primarily mass production	Primarily individual production	Other
Industry type	1. Electric, electronic, OA related products	65	42	15
	2. Textile, paper, pulp	20	5	0
	3. Clothing, apparel	0	1	1
	4. Chemical, plastic, rubber	35	8	2
	5. Glass, ceramic, cement	6	3	1
	6. Petroleum, coal	4	0	0
	7. Cosmetics, medicine	10	2	0
	8. Food	22	1	1
	9. Steel, metal, non-ferrous metal	20	17	2
	10. Automobile, motor-cycle, transportation machinery	19	15	5
	11. Transportation service	0	0	1
	12. Stationery, business machine, interiors	2	0	0
	13. Print related, publications, newspapers	1	1	0
	14. Software	0	1	0
	15. Construction	2	7	0
	16. Machinery, precision machinery, plant engineering	28	23	11
	17. Other	11	10	5
	Total	245	136	44

Table 2.5 Cross Tabulation of CIM User Requirements Questionnaire Survey Based on Industry Type and Production Planning

	Item	Primarily after-order production	Primarily speculative production	Other
Industry type	1. Electric, electronic, OA related products	74	33	15
	2. Textile, paper, pulp	10	13	2
	3. Clothing, apparel	1	1	0
	4. Chemical, plastic, rubber	11	33	1
	5. Glass, ceramic, cement	5	4	1
	6. Petroleum, coal	0	4	0
	7. Cosmetics, medicine	2	10	0
	8. Food	4	19	1
	9. Steel, metal, non-ferrous metal	31	6	2
	10. Automobile, motor-cycle, transportation machinery	32	4	3
	11. Transportation service	0	0	1
	12. Stationery, business machine, interiors	0	2	0
	13. Print related, publications, newspapers	2	0	0
	14. Software	1	0	0
	15. Construction	8	1	0
	16. Machinery, precision machinery, plant engineering	29	25	9
	17. Other	11	12	3
	Total	221	167	38

Table 2.6 Cross Tabulation of CIM User Requirements Questionnaire Survey Based on Industry Type and Number of Employees

	Item	Under 100	100 - 499	500 - 999	1000 - 3000	3000 - 10000	10000 & over
Industry type	1. Electric, electronic, OA related products	3	22	28	41	22	5
	2. Textile, paper, pulp	0	11	10	2	2	0
	3. Clothing, apparel	0	1	0	1	0	0
	4. Chemical, plastic, rubber	7	21	10	6	1	0
	5. Glass, ceramic, cement	2	4	0	3	1	0
	6. Petroleum, coal	0	0	4	0	0	0
	7. Cosmetics, medicine	1	8	1	1	1	0
	8. Food	4	10	5	4	1	0
	9. Steel, metal, non-ferrous metal	3	8	11	7	10	0
	10. Automobile, motor-cycle, transportation machinery	1	8	9	12	5	4
	11. Transportation service	0	1	0	0	1	0
	12. Stationery, business machine, interiors	0	1	0	1	0	0
	13. Print related, publications, newspapers	0	1	0	0	0	1
	14. Software	0	0	1	0	0	0
	15. Construction	2	3	1	1	2	0
	16. Machinery, precision machinery, plant engineering	2	13	19	21	6	2
	17. Other	3	11	2	8	3	0
	Total	28	123	101	108	55	12

Table 3 Mean, Standard Deviation and Variance of CIM Questionnaire Survey Evaluation Items

Code	Evaluation item	No. of responses	Mean	Standard deviation	Variance
X1	CIM will qualitatively improve product development capability. ...	426	1.810	1.170	1.368
X2	Timely announcement of new products will be made possible. (Development capability can be enhanced by CAD/CAM/CAE.) ...	423	1.969	1.262	1.594
X3	Information on product specifications changes can be quickly communicated to the design/production site. ...	425	2.449	1.230	1.512
X4	Product life cycle can be shortened. ...	427	1.970	1.245	1.551
X5	Inventory of materials/parts can be reduced. ...	426	2.488	1.126	1.267
X6	Work in process can be reduced. ...	425	2.489	1.223	1.496
X7	Inventory of final products can be reduced. ...	426	2.411	1.234	1.523
X8	Procurement lead time can be reduced. ...	426	2.371	1.127	1.269
X9	Preparation time can be shortened. ...	428	2.023	1.038	1.077
X10	Production lead time (from receipt of order to delivery) can be shortened. ...	426	2.988	1.120	1.254
X11	After-order production will become possible. ...	424	1.533	1.224	1.498
X12	Production plans based on process capability can be made. ...	427	2.513	1.091	1.189
X13	Systematized production activities with emphasis on planning instead of demand-on-supplier system can be performed. ...	426	2.401	1.123	1.262
X14	Optimum scheduling can be done. ...	424	2.649	1.014	1.028
X15	Products can be made on schedule. ...	428	2.343	1.080	1.167
X16	A small quantity production of a large number of products can be made. ...	428	2.369	1.235	1.526
X17	Changes in and additions to the production schedule can be done easily. ...	427	2.721	1.057	1.117
X18	Utilization rate of facilities at production site can be improved. ...	426	2.303	1.069	1.143
X19	Production technology capability can be enhanced by optimum production process design. ...	426	2.150	1.094	1.196
X20	Operation of production process will become easier. ...	428	2.488	1.021	1.042
X21	Waste in the plant can be identified. ...	428	2.147	1.053	1.109
X22	Productivity will be improved. ...	427	2.632	1.029	1.059
X23	Bottlenecks in the plant can be understood. ...	426	2.204	1.107	1.226
X24	Quality distortion can be reduced. ...	426	1.885	1.051	1.104
X25	Operational errors can be continuously checked. ...	424	1.675	0.971	0.943
X26	Quick analysis and feedback on quality problems can be done. ...	425	2.275	1.067	1.139
X27	Delivery inquiries from both users and the sales side can be immediately responded to. ...	428	2.554	1.191	1.419
X28	Production system interlocked with sales can be established. ...	426	2.617	1.185	1.404
X29	Information on demand will become accurate. ...	426	2.129	1.196	1.430
X30	R&D expenditures can be reduced. ...	423	1.239	0.972	0.945
X31	Plant expenses can be reduced. ...	428	1.988	1.063	1.131
X32	Direct headcounts (workers in the field) can be reduced. ...	424	1.934	1.122	1.258
X33	Indirect headcounts (controller, purchasing agent, etc.) can be reduced. ...	427	2.215	1.073	1.151
X34	Allocations of employees (the right people in the right places) can be done properly. ...	425	1.694	1.069	1.142
X35	Cost reduction can be done by efficiency improvement and level enhancement of indirect jobs. ...	428	2.463	1.011	1.022
X36	Precision of cost accounting will be improved. ...	427	2.122	1.018	1.037
X37	Precision of price quotation will be improved. ...	427	1.780	1.138	1.294
X38	Intellectual value-added benefits can be increased. ...	423	1.853	1.068	1.140
X39	CIM will be helpful in developing product strategies. ...	427	1.747	1.091	1.189
X40	Marketing enhancement (POS, VAN) can be done. ...	426	1.744	1.247	1.556
X41	Decision making by top and middle management can be done more easily and correctly. ...	428	2.353	0.989	0.978
X42	Integrated risk management across the company can be done. ...	423	1.853	1.096	1.201
X43	Close management of a plant can be done based on corporate business indexes and strategy. ...	426	2.235	1.126	1.267
X44	Waste throughout the company can be eliminated by resource planning. ...	428	2.040	1.022	1.045
X45	Corporate image will improve in the market. ...	425	1.953	1.100	1.210
X46	Market share can be increased. ...	428	1.579	1.036	1.073
X47	Market size will be expanded. ...	426	1.570	1.117	1.248
X48	Morale of employees will be heightened by improvement in the working environment and job quality. ...	424	1.774	0.943	0.890
X49	Hiring of people in new technology areas can be done more easily. ...	427	1.354	1.011	1.023
X50	After-sales service will be improved. (Enrichment and efficiency improvement of service) ...	425	1.584	1.052	1.107
X51	Joint sharing of a database between marketing, design and production departments can be done. ...	426	2.650	1.055	1.113
X52	Expenses for slips, paper, etc. can be reduced. ...	428	2.103	1.086	1.179
X53	Reliability and quality can be improved by collecting the latest field data on a real-time basis. ...	421	2.100	1.112	1.238
X54	Information exchange on common problems in the company can be done more quickly. ...	427	2.340	1.096	1.201
X55	Flow of materials and data (information) can be synchronized. ...	426	2.878	1.076	1.157
X56	Operation of JIT will be made possible through a material procurement network. ...	422	2.043	1.219	1.485

The above results indicate that the introduction of CIM is not necessarily considered to have a direct impact on the improvement of the financial position, such as through a sales increase.

2.2 Extraction of Potential Factors of CIM Evaluation Items

What constitutes the expectations concerning CIM and what are the viewpoints involved will now be examined. In other words, a small number of common factors are sought which are independent of each other and give an overall summary of the 56 evaluation items related to expectations about CIM. In this way, the differences in expectations about CIM by industry can be clarified if a small number of factors (evaluation factors) that provide an overall summary are selected. Table 4 shows evaluation items with a heavy factor load that shows the degree of relationship with the evaluation items, with reference to the six evaluation factors obtained as a result of factor analysis. The resulting interpretation of the meaning of the evaluation factors in relation to evaluation items with significant relationships is as follows:

I. Improvement in Flexibility: This is not limited to manufacturing flexibility, but includes planning/control flexibility and aims at efficiency improvement in the flow of materials such as through inventory reduction.

II. Improvement of Productivity and Quality: This aims at quality improvement and improvement of the utilization rate and productivity primarily from the standpoint of manufacturing.

III. Enhancement of Sales Power: This aims at accurate understanding of information about demand by means of information network enhancement and support for strategy based on this understanding.

IV. Enhancement of Product Development Capability: This aims at timely announcement of high value-added products and shortening of the product development cycle by automation from the R&D to the production technology areas.

V. Enhancement of Corporate Management: This aims at quality improvement of corporate management by joint sharing of decision support for corporate strategy and control information.

VI. Efficiency Improvement of Indirect Jobs: This aims at productivity improvement for clerical and administrative jobs.

These six evaluation factors represent the viewpoints for expectations about CIM, but they do not show the strength of expectations. Therefore, the six evaluation factors have been ranked based on the average strength of expectations based on the relationships between individual evaluation factors and the strength of expectation for related evaluation factors (Table 3). The sequence is as follows:

Flexibility Improvement (I) > Enhancement of Corporate Management (V), Efficiency Improvement of Indirect Jobs (VI) > Improvement of Productivity and Quality (II), Enhancement of Sales Power (III), Enhancement of Product Development Capability (IV).

Table 4 (1/2) Relationship between Evaluation Items and Evaluation Factors

Code	First factor: Improvement in flexibility	Load
X17	Changes in and addition to production schedule can be done easily. ...	0.632
X10	Production lead time (from receipt of order to delivery) can be shortened. ...	0.620
X6	Work in process can be reduced. ...	0.608
X28	Production system interlocked with sales can be established. ...	0.598
X13	Systematized production activities with emphasis on planning instead of demand-on-supplier system can be performed. ...	0.596
X5	Inventory of materials/parts can be reduced. ...	0.594
X12	Production plans based on process capability can be made. ...	0.585
X7	Inventory of final products can be reduced. ...	0.583
X14	Optimum scheduling can be done. ...	0.574
X16	A small quantity production of a large number of products can be done. ...	0.530
X27	Delivery inquiries from both users and the sales side can be immediately responded to. ...	0.530
X8	Procurement lead time can be shortened. ...	0.525
X15	Products can be made on schedule. ...	0.517
X55	Flow of materials and that of data (information) can be synchronized. ...	0.516
X20	Operation of production process will become easier. ...	0.495
X56	Operation of JIT will be made possible by use of a material purchasing network. ...	0.493
X3	Information on product specification changes can be quickly communicated to the design/production site. ...	0.452
X11	After-order production will become possible. ...	0.434
X23	Bottlenecks in the plant can be understood. ...	0.401
X51	Joint sharing of a database between marketing, design and production departments can be done. ...	0.379
Code	**Second factor: Productivity and quality improvement**	**Load**
X24	Quality distortion can be reduced. ...	0.696
X18	Utilization rate of facilities at production site can be improved. ...	0.553
X25	Operational errors can be continuously checked. ...	0.538
X32	Direct headcounts (workers in the field) can be reduced. ...	0.531
X22	Productivity will be improved. ...	0.521
X21	Waste in the plant can be identified. ...	0.515
X31	Plant expenses can be reduced. ...	0.481
X26	Quick analysis and feedback related to quality problems can be done. ...	0.456
X19	Production technology capability can be enhanced by optimum production design. ...	0.448
X9	Preparation time can be shortened. ...	0.419
X48	Morale of employees will be heightened by improvements in the working environment and job quality. ...	0.411
X34	Allocation of employees (the right people in the right places) can be done properly. ...	0.352
X53	Reliability and quality can be improved by collecting the latest field data on a real-time basis. ...	0.326
Code	**Third factor: Marketing power enhancement**	**Load**
X29	Information on demand will become accurate. ...	0.659
X40	Marketing enhancement (POS, VAN) can be done. ...	0.646
X39	CIM will be helpful in developing product strategies. ...	0.615
X46	Market share can be increased. ...	0.600
X47	Market size will be expanded. ...	0.594
X42	Company-wide integrated risk management can be done. ...	0.523
X28	Production system interlocked with sales can be established. ...	0.431
X44	Waste throughout the company can be eliminated by resource planning. ...	0.424
X50	After-sales service will be improved. (Enrichment and efficiency improvement of services) ...	0.378
X45	Corporate image will improve in the market. ...	0.369
X1	CIM will qualitatively improve product development capability. ...	0.348
X11	After-order production will become possible. ...	0.331
X27	Delivery inquiries from both users and the sales side can be immediately responded to. ...	0.323
X4	Product life cycle can be shortened. ...	0.315
X2	Timely announcement of new products will be made possible. (Development capability can be enhanced by CAD/CAM/CAE.) ...	0.294

Table 4 (2/2) Relationship between Evaluation Items and Evaluation Factors

Code	Fourth factor: Product development capability enhancement	Load
X2	Timely announcement of new products will be made possible. (Development capability can be enhanced by CAD/CAM/CAE.) ...	0.544
X1	CIM will qualitatively improve product development capability. ...	0.543
X30	R&D expenditures can be reduced. ...	0.479
X37	Precision in price quotation will be improved. ...	0.430
X4	Product life cycle can be shortened. ...	0.399
X49	Hiring of people in new technology area can be done more easily. ...	0.370
X3	Information on product specification changes can be quickly communicated to the design/production site. ...	0.367
X38	Intellectual value-added benefits can be increased. ...	0.349
X39	CIM will be helpful in developing product strategies. ...	0.269
Code	**Fifth factor: Enhancement of management control**	**Load**
X41	Decision making by top and middle management can be done more easily and more correctly. ...	0.512
X36	Precision in cost accounting will be improved. ...	0.430
X54	Information exchange on common problems in the company can be done more quickly. ...	0.430
X42	Integrated risk management across the company can be done. ...	0.405
X43	Close management of a plant can be done based on corporate business indexes and strategy. ...	0.400
X44	Waste throughout the company can be eliminated by resource planning. ...	0.336
X38	Intellectual value-added can be increased. ...	0.332
X51	Joint sharing of data base between marketing, design and production departments can be done. ...	0.326
X37	Precision of price quotation will be improved. ...	0.304
X49	Hiring of people in new technology areas can be done more easily. ...	0.304
X34	Allocation of employees (the right people in the right places) can be done properly. ...	0.274
X29	Information on demand will become accurate. ...	0.253
Code	**Sixth factor: Efficiency improvement in indirect jobs**	**Load**
X33	Indirect headcounts (controller, purchasing agent, etc.) can be reduced. ...	0.676
X35	Cost reduction can be done by efficiency improvement and level enhancement of indirect jobs. ...	0.614
X52	Expenses for slips, paper, etc. can be reduced. ...	0.551
X31	Plant expenses can be reduced. ...	0.407
X55	Flow of materials and that of data (information) can be synchronized. ...	0.270
X48	Morale of employees will be heightened by improvement in working environment and job quality. ...	0.256
X54	Information exchange on common problems in the company can be done more quickly. ...	0.253

Table 5 CIM Preparation Status : Element System Installation Status: Frequency

Numbers in ( ) are %.

Element system	Not installed	Planning	Preparing	Preparing or planning	Partially implemented	Fully implemented	Partially or fully implemented
CAD	100 (23.5)	17 (4.0)	18 (4.2)	35 (8.2)	247 (58.0)	44 (10.3)	291 (68.3)
CAM	152 (36.2)	44 (10.5)	37 (8.8)	81 (19.3)	173 (41.2)	14 (3.3)	87 (44.5)
CAPP (Process Design)	230 (54.9)	79 (18.9)	40 (9.5)	119 (28.4)	68 (16.2)	2 (0.5)	70 (16.7)
FMS	152 (36.2)	63 (15.0)	23 (5.5)	86 (20.5)	176 (41.9)	6 (1.4)	182 (43.3)
Automated Warehouse	160 (37.8)	48 (11.3)	20 (4.7)	68 (16.1)	170 (40.2)	25 (5.9)	195 (46.1)
Automatic Transport	159 (37.7)	53 (12.6)	25 (5.9)	78 (18.5)	174 (41.2)	11 (2.6)	185 (43.8)
LAN in Plant	108 (25.7)	94 (22.3)	42 (10.0)	136 (32.3)	158 (37.5)	19 (4.5)	177 (42.0)
Real-time Production Control System	82 (19.4)	89 (21.0)	59 (13.9)	148 (35.0)	161 (38.1)	32 (7.6)	193 (45.6)
In-house Information Network	57 (13.3)	71 (16.6)	37 (8.6)	108 (25.2)	225 (52.6)	38 (8.9)	263 (61.4)
Inter-company Information Network	192 (45.7)	57 (13.6)	30 (7.1)	87 (20.7)	131 (31.2)	10 (2.4)	141 (33.6)
Distribution/Physical Distribution VAN	208 (48.9)	74 (17.4)	36 (8.5)	110 (25.9)	97 (22.8)	10 (2.4)	107 (25.2)

3. Installation Status of CIM

As shown in Table 5, the complete implementation of CAD ranks the highest among all element systems. 68.3% of company establishments who responded to the survey use CAD systems, including those with only partial implementation of the system. CAD is followed by in-house information networks (61.4%), automated warehouses (46.1%) and real-time production control systems (45.6%). On the other hand, the least widely propagated system is CAPP (16.7%). The characteristics of installation status by industry are:

(1) Electrical Products Related: CIM installation is most advanced compared with other industries overall. In particular, the installation percentage is high for CAD (86.6%), in-house networks (71.3%) and CAM (64.7%).

(2) Chemical Related: The installation percentage for in-house networks is relatively high (63.1%). This is followed by a real-time production control systems (46.4%) and CAD (42.9%).

(3) Cosmetics/Medicine: The installation of automated warehouses is the highest (66.7%). This is followed by automatic transportation (58.7%) and in-house networks (50.0%).

(4) Food: Overall the installation rate is low. Among other things, the installation rate for in-house networks is the highest (58.3%). This is followed by automated warehouses (41.7%) and automatic transportation (37.5%).

(5) Steel: The installation rate for real-time production control systems is conspicuously high (71.1%). This is followed by in-house networks (66.7%) and CAD (64.1%).

(6) Automobile: The installation of CAD is the highest (79.5%). This is followed by CAM (52.6%) and automatic transportation (47.4%).

(7) Machinery Related: The installation rate for CAD (93.7%) is the highest across all types of industry. FMS (64.5%) and CAM (55.1%) installations have also advanced, though their installation rate is low with respect to other industries.

Industries where CIM installation is high by element system are:

(1) CAD: Machinery Related (93.7%), Electrical Products Related (86.8%), Automobile (79.5%)

(2) CAM: Electrical Products Related (64.7%), Machinery Related (55.6%), Automobile (52.6%)

(3) CAPP: Steel (33.3%), Electrical Products Related (21.8%), Machinery Related (19.4%)

(4) FMS: Machinery Related (64.5%), Electrical Products Related (56.7%), Automobile (43.6%)

(5) Automated Warehouse: Cosmetics (66.7%), Electrical Products Related (59.8%), Machinery Related (52.4%)

(6) Automatic Transportation: Cosmetics (58.7%), Electrical Products Related (57.9%), Machinery Related (47.6%)

(7) LAN: Electrical Products Related (53.5%), Automobile (46.2%), Steel (42.1%)

(8) Real-time Production Control System: Steel (71.1%), Machinery Related (52.4%), Electrical Products Related (48.3%)

(9) In-house Network: Electrical Related Products (71.3%), Steel (66.7%), Chemical Related (63.1%)

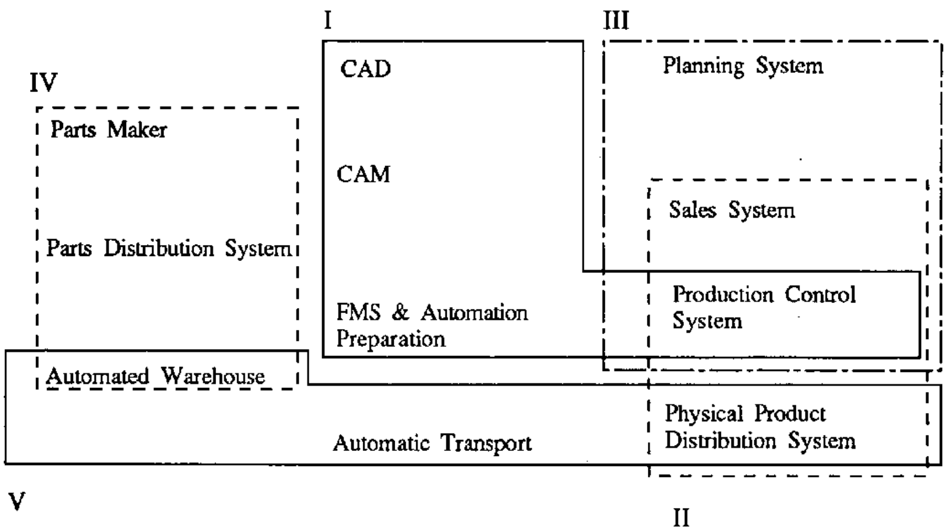
(10) Inter-company Network: Electrical Products Related (44.1%), Automobile (38.5%), Steel (38.5%)

(11) Distribution/Physical Distribution VAN: Cosmetics (33.3%), Food (33.3%), Electrical Products Related (33.3%)

From the survey results, the following characteristics by industry have been found. Electrical products related industries have been promoting CIM in general. Machinery related industries started CIM with design and production areas. Steel industries have installed CIM centering around production control systems. The cosmetics industry has attached significance to the physical distribution system.

4. Future Perspective of CIM

Expectations for CIM greatly differ from one industry to another. This means that images about CIM itself vary from one industry to another. If the eleven element systems of CIM are likened to islands, the five patterns shown in Figure 1 will be an archipelago composed of characteristics by industry. It is believed that links will be further enhanced due to joint sharing of information in the archipelago and moves connecting the archipelagoes will become more active in the future.



Pattern	Industry
I. Design/mfg. link (Product development power oriented) type:	Electrical products related, machinery related
II. Production/sales integration (Downstream oriented) type:	Cosmetics/medicine, chemical related, electrical products related
III. Planning network oriented type:	Steel, electrical products related
IV. Upstream network type:	Machinery related, electrical products related
V. Physical product distribution emphasis type:	Cosmetics/medicine

Figure 1 Pattern Development of CIM Link and Industry Corresponding to Each Link Pattern

If we classify CIM based on the expectations related to CIM, the following three types can be seen:

(1) Product Development Power/Flexibility Emphasis Type
Electrical products related and machinery related industries, which are machining and assembly industries, will be in this category. Above all, electrical products related industries enjoy a high installation rate for each element system, and linkage within each of the five patterns is at high level. The linkage between patterns has been developed, and CIM in these industries is expected to advance as the leader in all the industries of the future.

In the meantime, machinery related industries emphasize enhancement of product development power. Therefore, the installation of individual element systems such as CAD, CAM and FMS has been propagated, but the level of linkage between element systems is not so high. It is anticipated that links between element systems in each of Patterns I, II, III and IV will be enhanced, with advances in individual patterns made in parallel in the future.

(2) Productivity and Quality Emphasis Type
Chemical related, food and cosmetics industries are in this category. In the cosmetics industry, the level of linkage between element systems in each of Patterns II and V is high, as related to production/sales integration and physical distribution of products. In chemical related and food industries, they have strong expectations for marketing capability enhancement, and therefore CIM has not been propagated significantly. It is believed that CIM centering around Pattern II will be rapidly propagated in the future.

(3) Planning System Emphasis Type
The steel industry is a typical one in this group. Even at present, CIM has been developed around a real-time production control system. The level of linkage between element systems in Pattern III, including planning system is the highest.

Expectations other than marketing capability enhancement are high and it is believed that CIM aimed at a network including the planning and strategy level will be propagated in the future.

Honda's Global CIM

Yukio Mieda
Director & Chief Engineer
Honda Engineering Co., Ltd.

1. Company Profile

Honda was established in 1948, and produces and sells 2 and 4 wheeled vehicles as well as a group of general use products divided into three areas-farm equipment, generators and general purpose engines. At home in Japan, the company has three research institutes to develop two- and four-wheeled vehicles as well as general-purpose products and an engineering firm involved in research and development activities related to production technology. We have four factories for producing products and one for producing components.

Since its establishment Honda has firmly stood by its policy to "create products with no parallel anywhere else in the world" and to "serve society and mankind as a whole". We try to develop and market products which please men and women all over the world and, in this way, make a positive contribution to society. In particular, we are active abroad in developing, producing, and selling products matched to the local environment, developed locally, and capable of being manufactured nowhere else. At the same time, from beginning to end we have followed a norm of returning to each country whatever is received from that country. As we set our sights on the 21st century, our company now plans to complete a global network to link together Honda activities all over the world.

2. CIM as a Means to Respond to Customer Demands

Thus, Honda tries to operate close to the customers, delivering products designed and timed in accordance with what our customers want. Honda products, including two- and four-wheeled vehicles and general-purpose products, belong to different genres and they must satisfy the requirements of customers world-wide. This calls for a creative approach in product development, manufacturing techniques, and marketing. It is here that computer integrated manufacturing (CIM) comes into play: it borrows the power of computers to efficiently integrate all types of functions. As for global CIM, this employs communication technologies to overcome global distances. Actually, we at Honda realize that we are now at the entry-level stage in launching this new kind of strategy. This paper will provide a glimpse into Honda's corporate efforts towards global CIM and its future plans in this direction.

As Figure 1 shows, CIM represents two principal streams. One stream involves development of new product types. Here, efforts are concentrated on developing new models consistent with market trends and scheduling the equipment and facilities needed to start off mass-production. This may be thought of as a flow which starts from computer aided de-

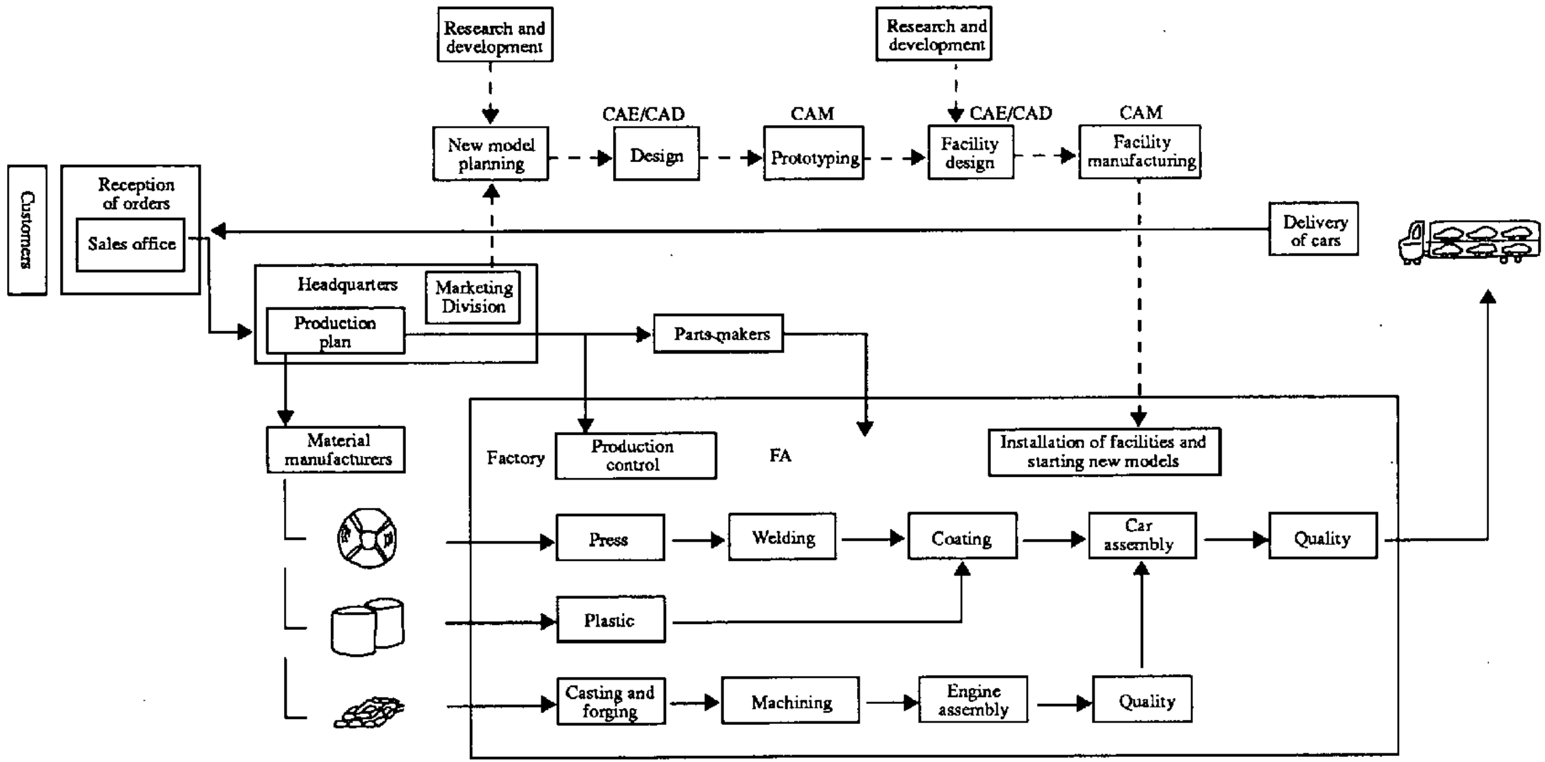


Figure 1. Two CIM Flows

sign, continues through engineering and finally proceeds to manufacturing, that is, a CAD → CAE → CAM flow.
The other stream represents the production of vehicles according to orders received from customers, and includes the entire process up until delivery. The flow here is from production control to factory automation (production control → FA).

2.1 CAD/CAE/CAM in vehicle development

Figure 2 shows the flow of events which originates from vehicle development in HONDA R&D Co. Data like that which appears in Photo 1 is what results once smoothing* is completed. This is the data that eventually represents the master data used for product development. This data takes the form of a reference database and is centrally controlled in R&D and transmitted across communication channels to the departments which need it. It is here that the Honda Highway Network shown in Figure 3 comes into play. After the basic design is over, a number of analyses are conducted. These include strength analysis, shock analysis, aerodynamic analysis, and control stability analysis. The results of these analyses are fed back into the design process.

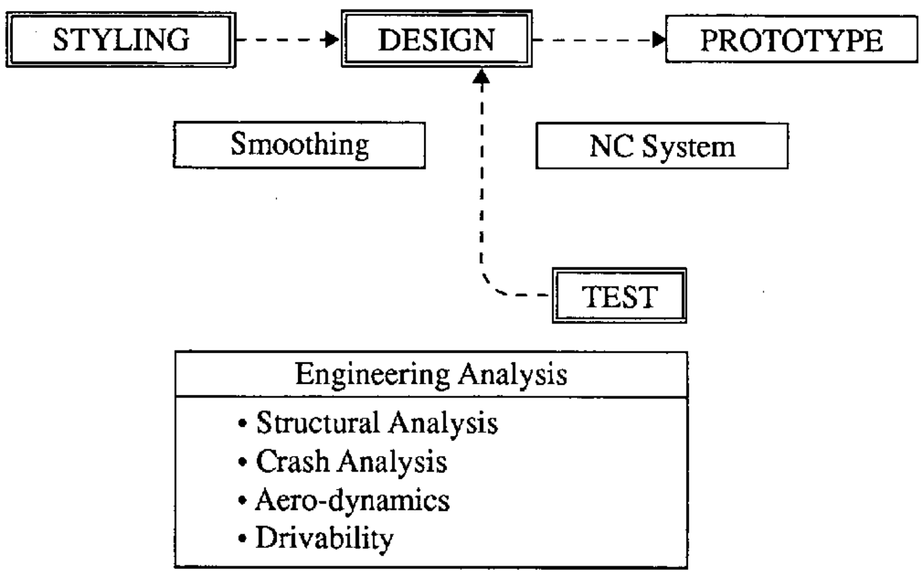


Figure 2. Design Flow in HONDA R&D Co.

* Smoothing: This refers to smoothing of the surface and curve data making up the surface of a car body. Smoothed data is necessary because the original data is formed from clay models or a rough sketch.

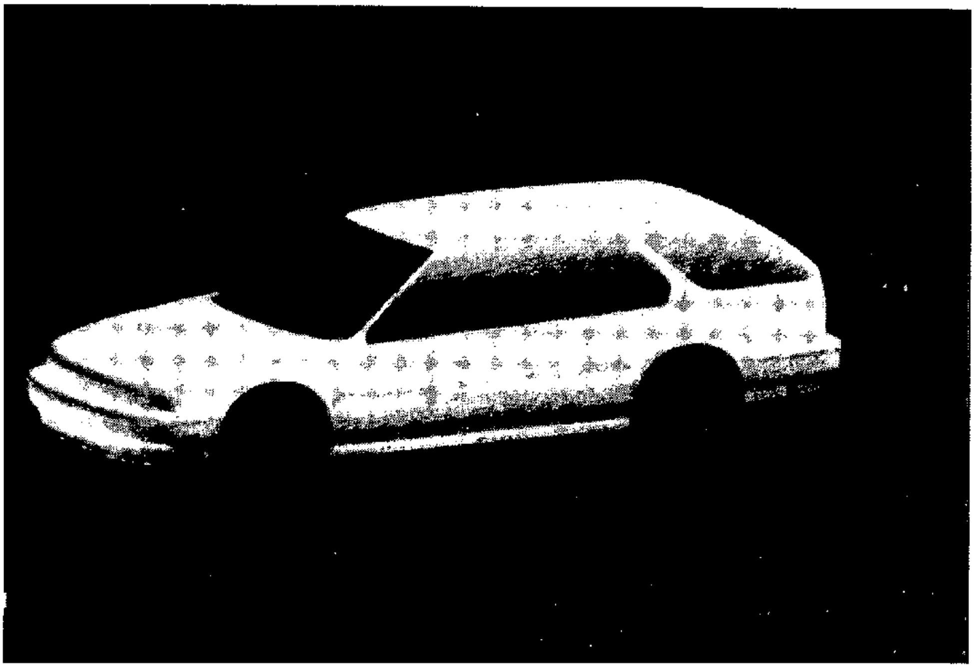


Photo 1. Surface data of Accord Wagon

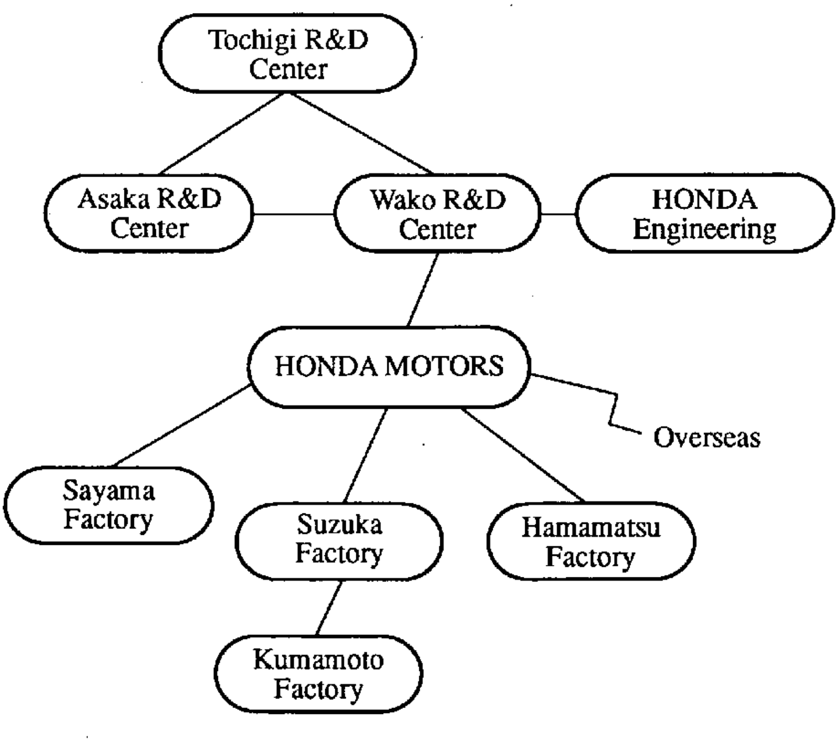


Figure 3. Honda Network Highway

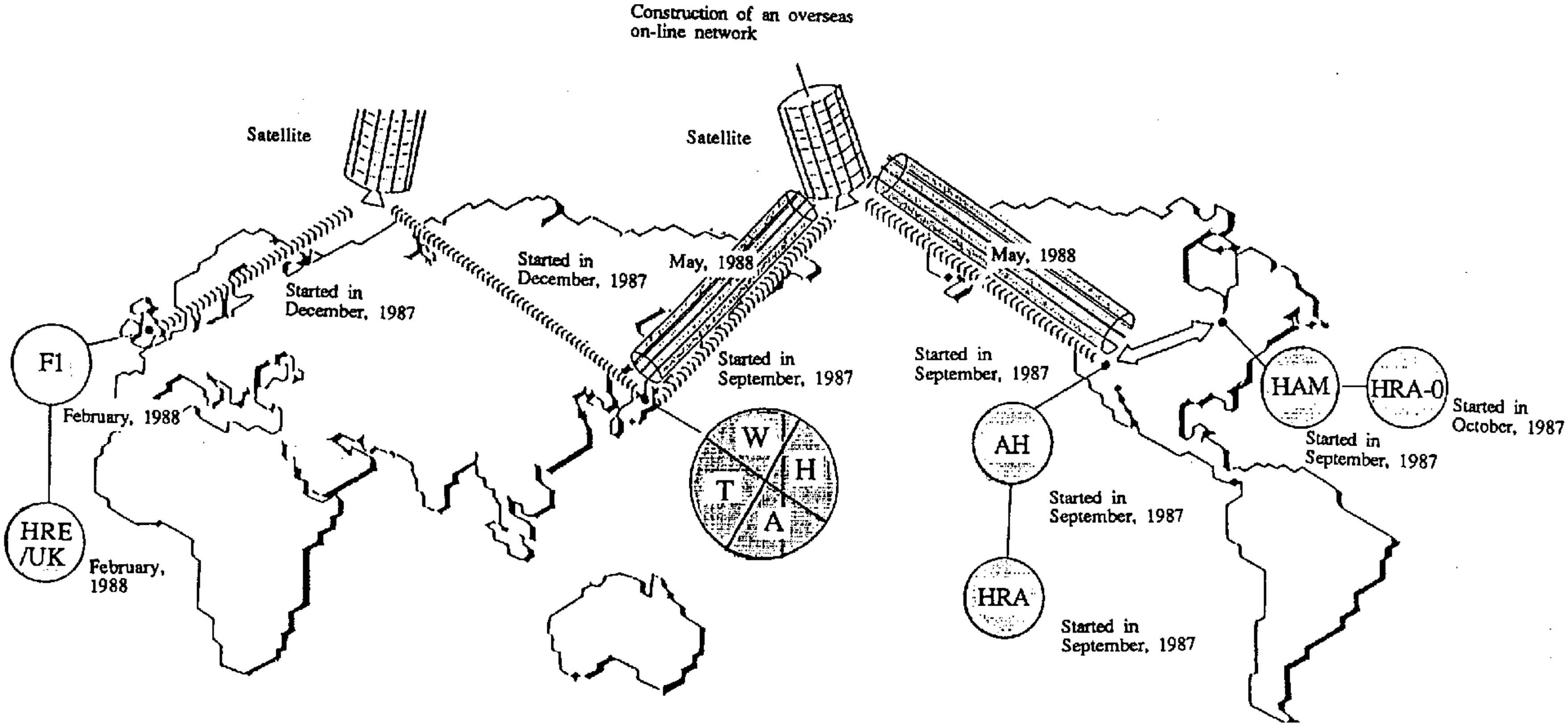


Figure 4 Honda's Global Network

In parallel with this, the same database is used for production of prototype vehicles. Here, too, computer techniques, such as direct numerical control (DNC), are made use of to improve the level of precision and to reduce lead time. A global network is being built, as shown in Figure 4, for efficient database development. The computer system shown in Figure 5 supports the above-mentioned commodity development activities.

2.2 CAD/CAM for production preparation arrangements

Honda Engineering starts a feasibility study on topics such as pressability once a styling and basic design database has been built up in R&D (Photo 2), and feeds information on items presenting problems back to R&D. As soon as a "go" sign is issued following a combined evaluation by sales, engineering, and development (SED), crowning* and other production engineering data is added. At the

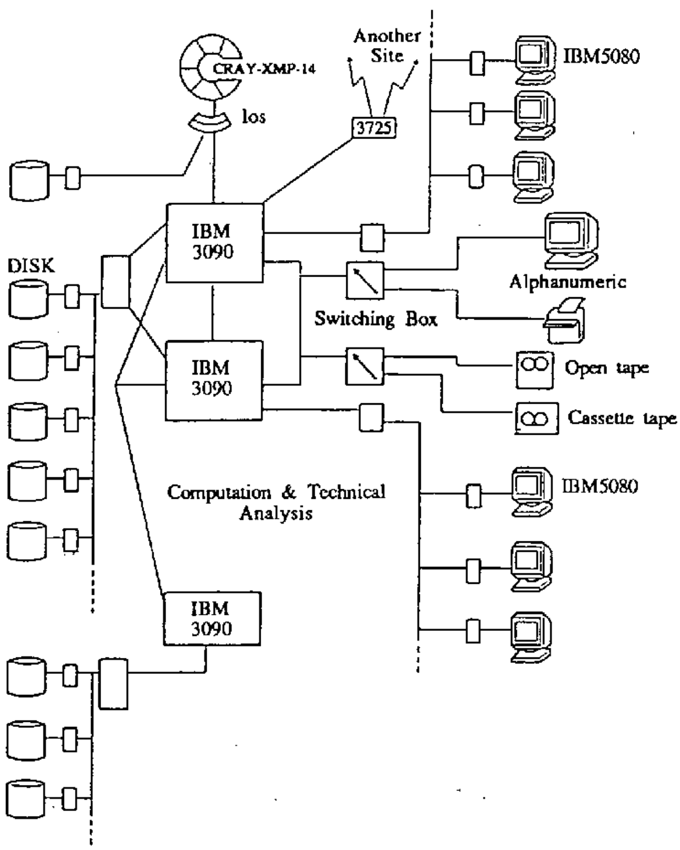


Figure 5 System Configuration

* Crowning: In stamping press, by its very nature, the steel plates are more likely to affect the sharpness of the shape than are the press dies. Crowning — or overcrowning — refers to surfacing metal molds with an eye to this possibility.

same time, die related data is created and metal dies are machined by numerically controlled profilers (Photo 3). A drawing of a bend die is shown in Figure 6.

Similarly, robots and jig fixtures** are prepared (Photo 4) and the special parts for the module machines to process the engine are designed and manufactured. Honda Engineering takes charge of installing the related equipment and starting up mass production both in Japan and abroad, but operates hand in hand with the local factory staff in this endeavor.

2.3 Production control AUT

Small-lot, mixed production has become a necessity today because of diversification and the increase in the number of product types.

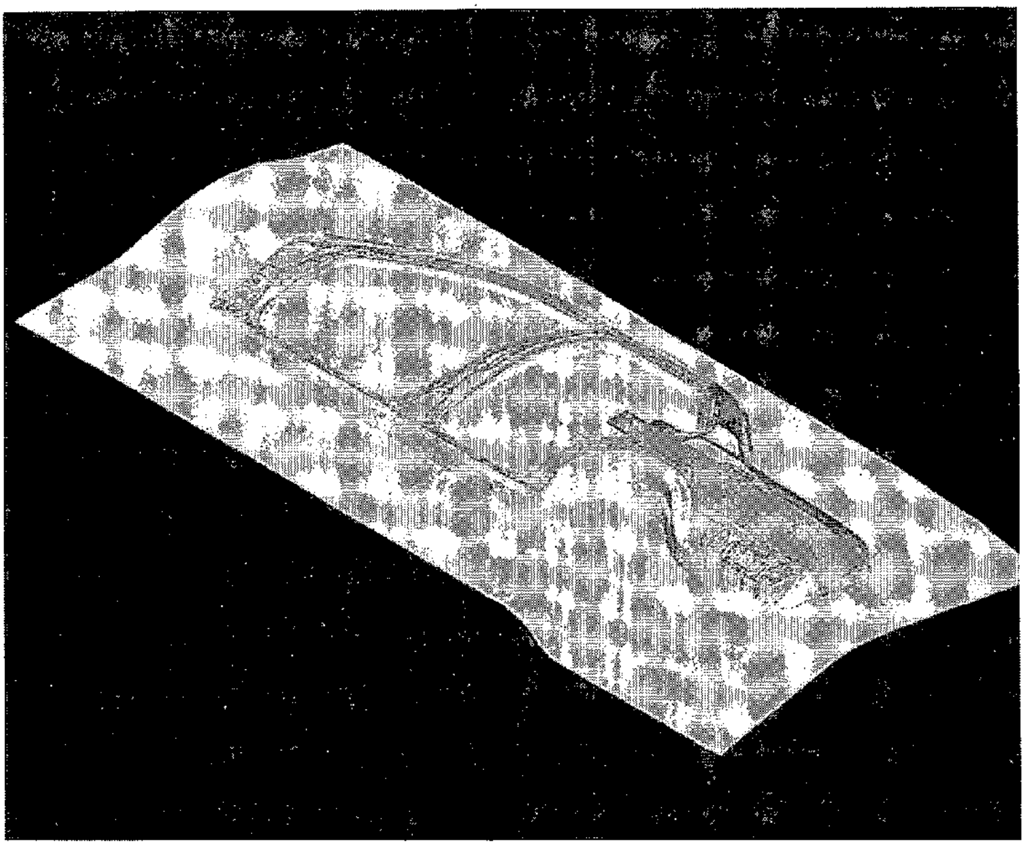


Photo 2. Simulation on pressability

** Jig fixtures: This refers to the welding jig fixtures used to accurately hold welded parts in position so that the robots can complete the welding operation.

Flexible production systems need to be built so that delivery of products built as ordered can be accomplished during, for example, the time it takes a customer to obtain a parking lot certificate. The number of products a plant can handle has to be increased overseas as well, due to the increasing severity of competition. Accordingly, arrangement has been made for supply of parts and technical support to these plants from a number of plants in Japan. Mother plants supporting the overseas factories may follow different approaches in production and production control. Coordination with the control framework in each plant thus becomes necessary.

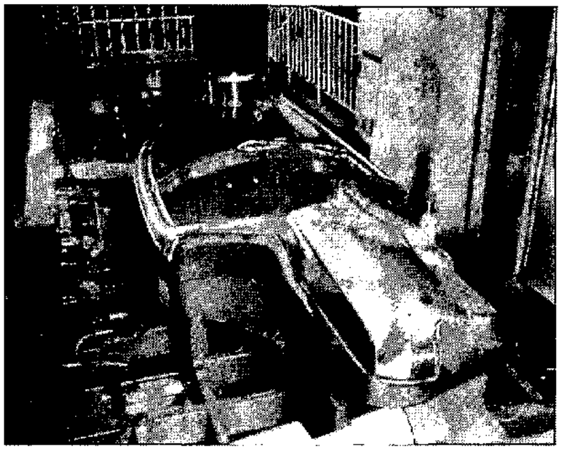


Photo 3. Numerical control die carving machine

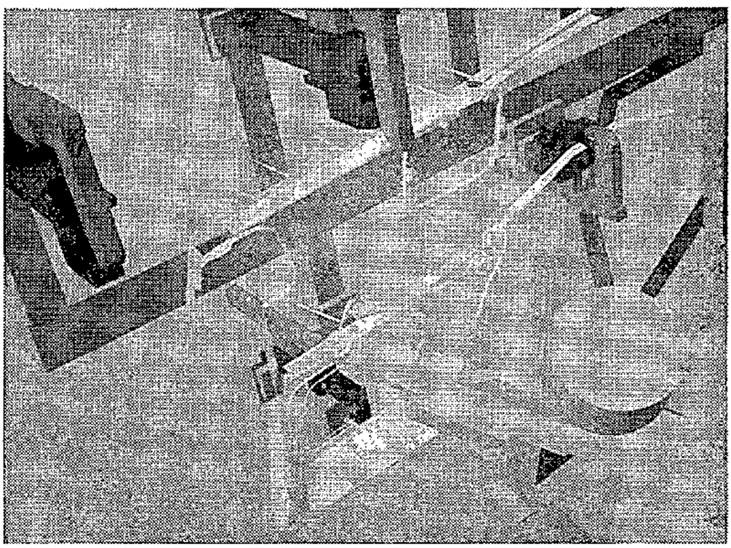


Photo 4. Simulation of robot

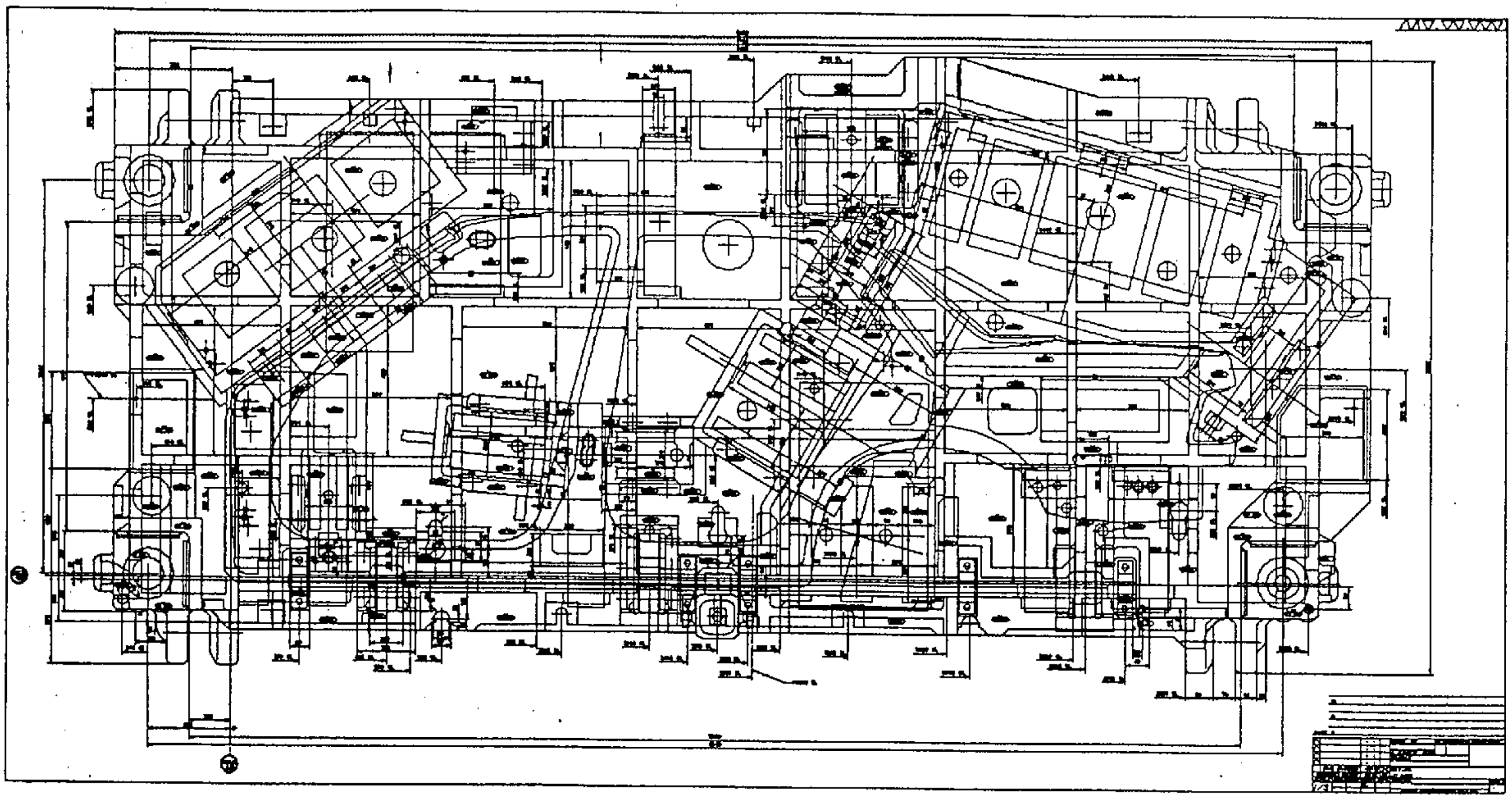


Figure 6 Bend Die Drawing

This is the background against which Honda, in 1984, launched Project AU-T directly under the supervision of management, to "automate" and "totalize" production and related control activities. The aim of this project is to bolster production control from the perspective of efficient management at the corporate level. Its target is to create "a production control system equipped with the latest information processing functions, a system on a par with the highest level of efficiency (from the point of view of speed and cost) attained anywhere in the world." The production concept was based on the following three items:

(1) Market needs oriented master schedule
Definite short-term production plans centering on orders from nearby users.

(2) Synchronized production
Synchronizing production at all manufacturing sites over fixed time intervals (comprising a week's time as of now).

(3) Line balanced production
Leveled production based on balanced efficiency between respective machining areas, involving both the company and its business connections.

Overall planning for the concrete development of a new production control system, was split into three steps as follows:

(1) Step 1
Developing an all-Honda system embodying all principal production area activities, and using the bill of materials thus far used by the different manufacturing sites.

(2) Step 2
Upgrading the all-Honda system by integrating the bill of materials of the different manufacturing sites and using an online network.

(3) Step 3
Further upgrading the all-Honda system through horizontal extension of the domestic system overseas and through adding technical information to the production management system.

Step 1 was completed in August, 1988, and Step 2 in February. 1991.

Accordingly those things which up until then had had their frameworks for production control built and operated on a location-specific, product-specific basis were given a common basis in a unified company system, and came to be operated according to unified rules. The system and the rules are readily intelligible to all related parts makers, overseas production plants, and all concerned Honda departments, and the system is rated highly for its success in raising overall job efficiency. In addition, from its past practice of placing all orders at one time every month, Honda has now switched over to a weekly system. This has resulted in a fourfold increase in the opportunities we have to incorporate user needs in production plans. As for the applications aspect, numerous users have gained access to the Honda database through the approximately 2,000 terminals installed both within the company and outside it, as shown in Figure 7. At present, work is under way to execute the third step, namely to extend the system horizontally overseas.

2.4 Factory automation

Obviously, even if a plant lays down a fine production plan and procure materials and parts just as envisaged in the plan, if it doesn't efficiently produce high-quality commodities, there's no point to it all. For years the

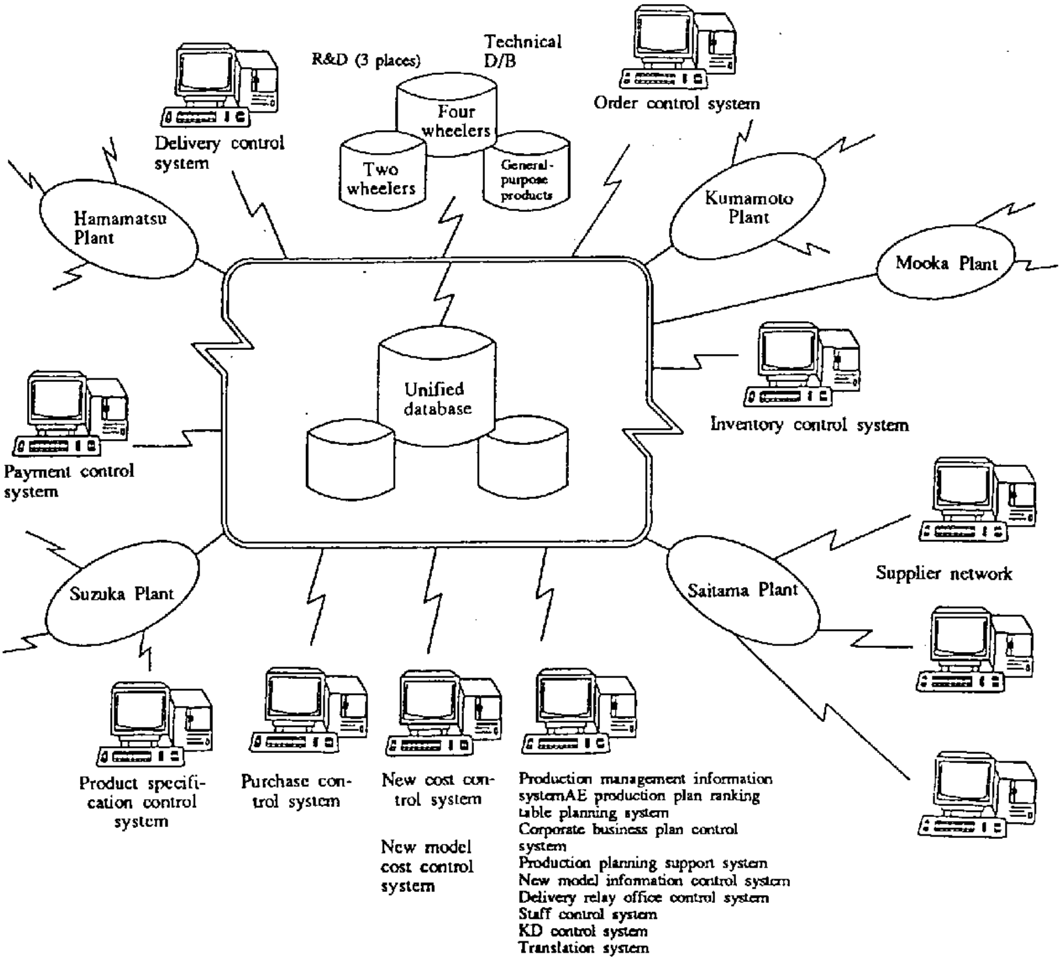


Figure 7 Production Control Application

staff at our production sites and Honda Engineering have been working hand in hand to resolve every constraint encountered on the road to achieving this end. Already, highly sophisticated automated lines for machining engine parts and for welding have been installed and are being run. Honda's new assembly (NA) project is boldly facing the last challenge in this area, namely, making similar strides in the assembly area. This project was launched in an experimental plant in the Suzuka Plant in 1988. The new assembly line emphasizes human dignity and gives priority to achieving better quality through mechanization of "dirty," "difficult," and "dangerous" jobs. The characteristic features of its lines may be summed up as follows:

(1) Combining processes together and substantially reducing their number
The existing 150 processes were condensed into 32 processes.

(2) Large-scale automation
Altogether, 17 processes and 27 machines (adding up to 48 functions) have been automated.

(3) Asynchronous production processes
Use is being made of guided automated trolleys (GAT).

Figure 8 outlines the computer system controlling the entire setup.

The computer is linked directly with the production line. As indicated in Table 1, therefore, particular attention was paid to raising the level of reliability. Again, as Figure 9 shows, machines made by various manufacturers are all linked, from the host computer at the highest level to the controllers at the lowest hierarchical level. The linkages, when established, revolutionized existing concepts. In the absence of past experience, Honda had to follow a trial-and-error approach in the line control which occupied a central position in the scheme. The line control functions were as follows:

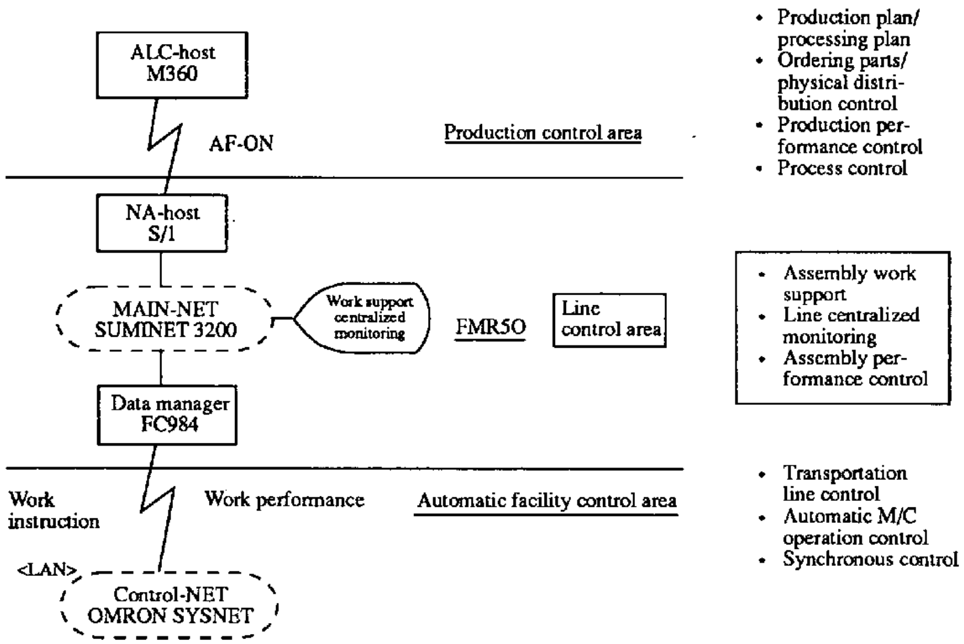


Figure 8. System Overview

Centralized/distributed control of information
Distributed processing
=> Improvement of reliability and distribution of load

- Work/performance information control with intelligent terminals called data managers
- Control information history control and work/performance information control (B/u) with S/1
- Distribution of data processing by making use of LAN functions
- Improvement in the MAN interface by making use of CG technology

Table 1 System Features

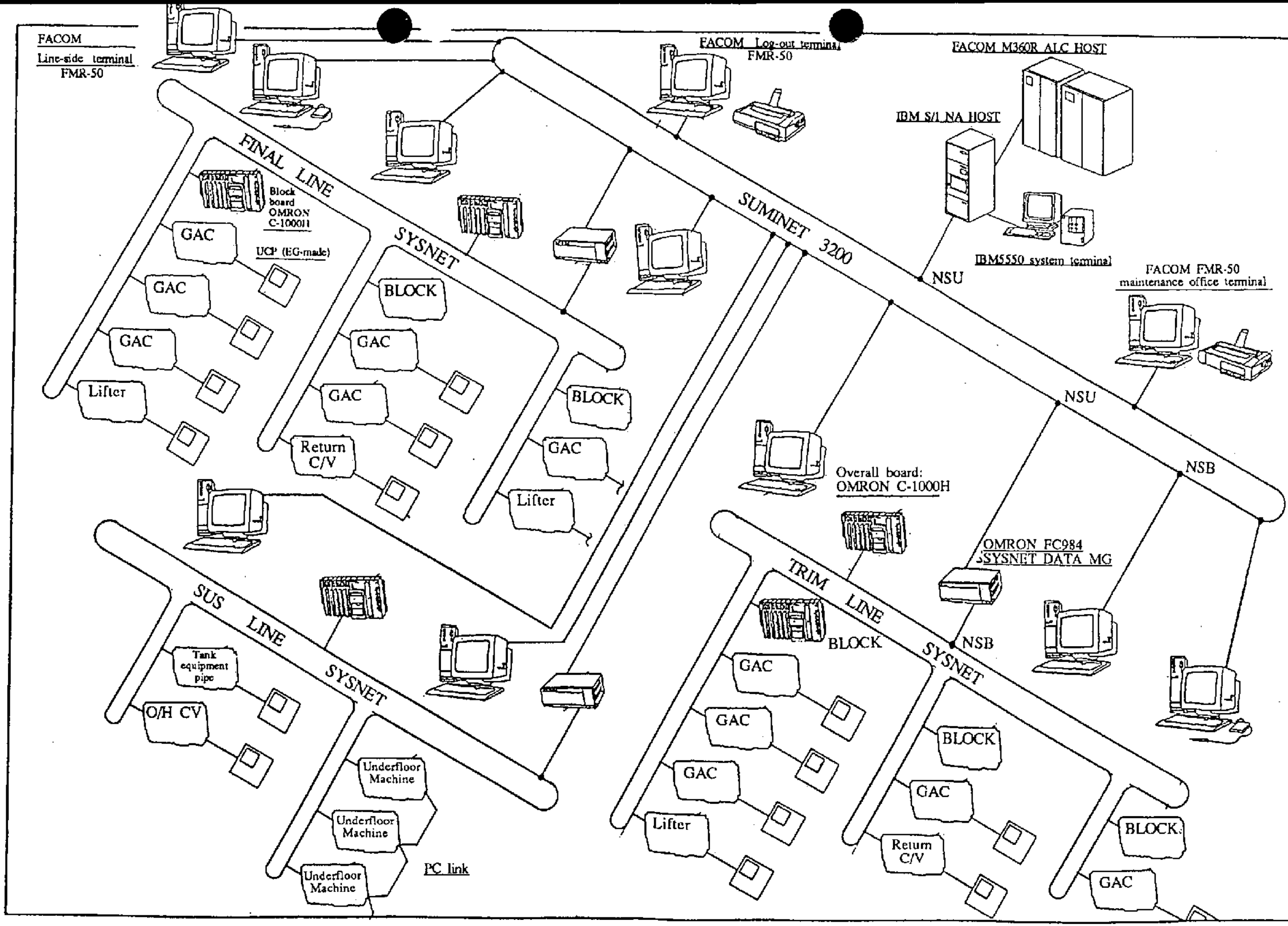


Figure 9 Line System Configuration Image

(1) Support for assembly

1. Production model type collation
2. Allotment of MTCO data to machines
3. Monitoring product quality

(2) Centralized monitoring

1. Monitoring line operations
2. Monitoring production equipment
3. Equipment trouble data control

(3) Monitoring assembly performance

1. Monitoring assembly progress
2. Assembly performance control
3. Quality performance control

(4) System maintenance and control

The experience gained was made use of in the S-No. 3 and HAM No. 3 lines.

3. Conclusion

As already mentioned, according to Honda's own evaluation, the company has yet to progress beyond the starting point in computer integrated manufacturing. Also, CIM represents not a goal but a process. Computer integrated manufacturing is achieved as one strives to efficiently manufacture high quality products while relieving individual workloads, eliminating unnecessary operations, and steadily resolving problems, keeping one's eyes fixed on optimization achieved at the corporate, not the departmental level, for tomorrow, not merely for today. United together, Honda is moving ahead in its CIM drive with these ideals in mind.

Komatsu's FA Systems Construction Aims at CIM

Chiaki Sakamoto
Chief Project Manager
Information Systems Div.
Komatsu, Ltd.

1. CIM System Trends

The CIM concept at Komatsu, Ltd. is shown in Figure 1. If the idea behind CIM is defined as the organic combination of information in the sales, development and production departments for the purpose of obtaining an overall effect, the present emphasis of our company is on the construction of sales/production oriented CIM. In concrete terms, this means the creation of a new system combining sales and production, review of product code structure, construction of a company-wide network, and establishment of new FA factories. By so doing, we are pursuing activities with the objectives of reducing lead time from order receipt to product delivery, inventory reduction and promotion of efficient global operations.

On the other hand, the Development Department is also proceeding with computer system utilization in the area of technological information management, CAD, CAE, etc., and they feel it is necessary to further enhance linkages in the future, particularly with the Production Department.

Out of the above-mentioned systems, in this paper, I would like to dwell on the basic concept used for the construction of the FA systems of our company, based on the idea that the basics of CIM lie in FA.

2. Examples of FA System Construction Using MAP 3.0

In our company, several new FA systems have started full operation in recent years. Out of these, I would like to introduce two system examples that have been constructed using the system technologies of Komatsu Ltd. These systems use MAP 3.0.

2.1 Small Press Plant

(1) Outline of the FA Factory

The primary products produced at this plant are small presses, press brakes and shearing machines, as shown in Figure 2. A total of about 40 machine types are produced here.

Here, all types of information, such as order backlog information, material order placement information, production control information and daily production progress information, are controlled by the computer and are connected by network. You can get production control information about products on order on a realtime basis.

The layout of the factory is as shown in Figure 3. The inside of the factory is divided into several blocks including an automated parts warehouse, sheet metal welding line, machining line, sub-assembly line, painting line and

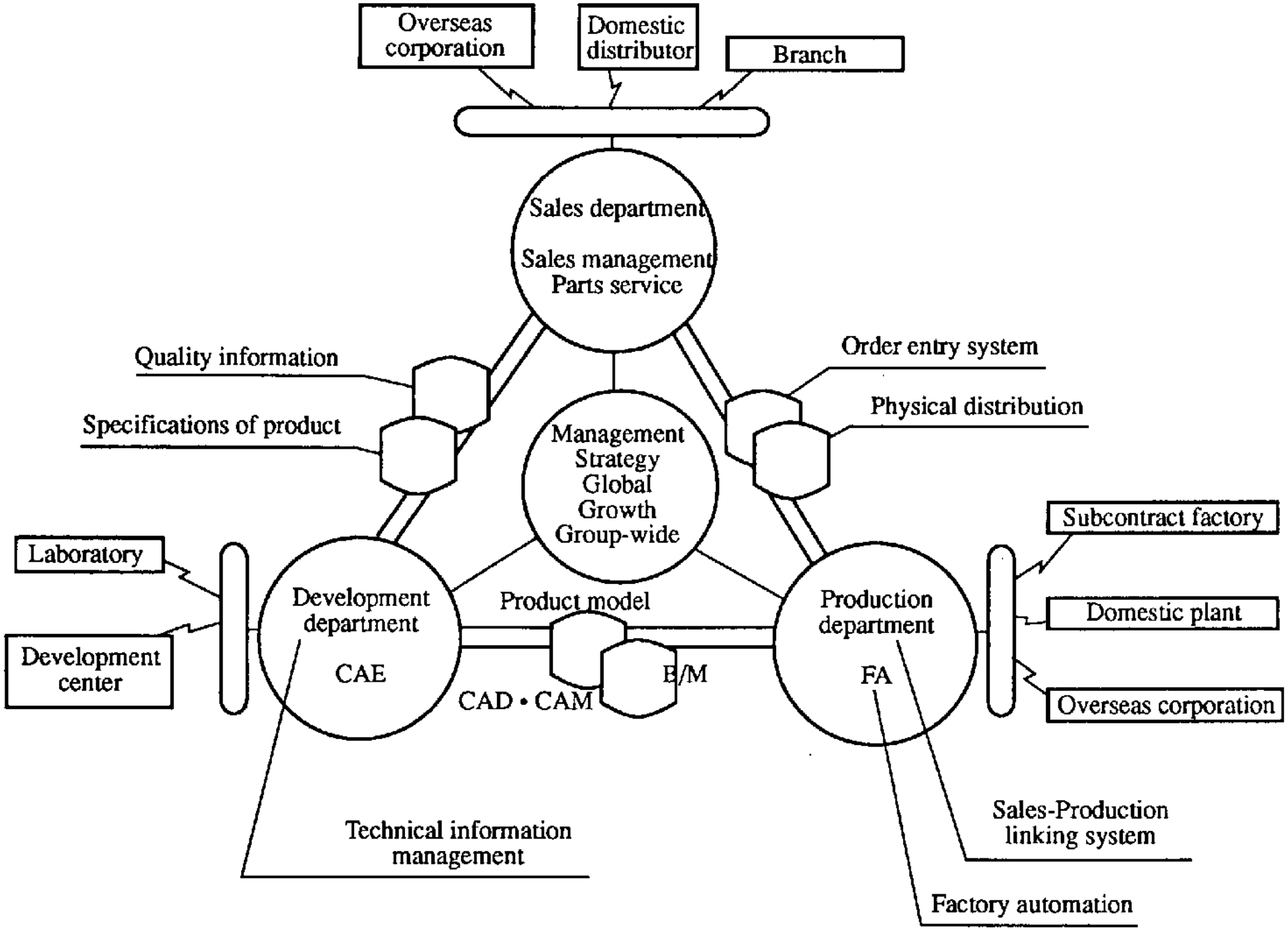


Figure 1 CIM Concept of Komatsu, Ltd.

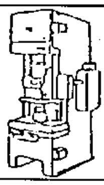
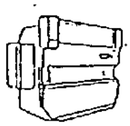
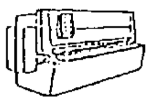
Manufacturing Products	Sketch	No. of Machine Types	Machining Ability
Small-sized Press (OBS) (OBW) (OBP)		11 machine types	110t – 200t
Press Brake (PHS)		12 machine types	110t – 450t
Shear (SHS) (SHF)		17 machine types	4mm – 13mm (sheared plate thickness)

Figure 2 Products for CIM Management

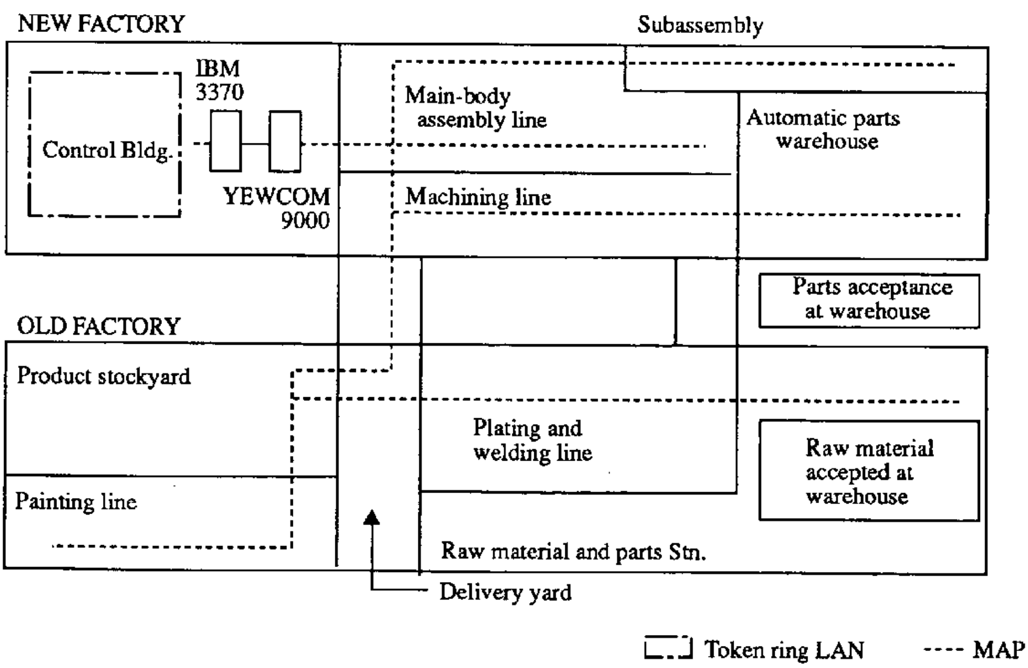


Figure 3 Block Layout Chart

product stock yard. Parts transportation between these blocks is done by AGV (Automatic Guided Vehicle). The parts which are handled on the sheet plate welding line and the machining line are the mainframes for products like small-sized presses, and for transportation of large and heavy items we have come up with new contrivances, such as adoption of a 20-ton AGV.

Parts supplied by subcontractor factories are stored in an automated parts warehouse, and they are automatically provided to the production line in the necessary quantities at the necessary times by computer control. Operational instructions are given by the computer to operators on a realtime basis.

(2) Configuration of the Computer System

Our system configuration is shown in Figure 4. The systems below the plant computer level in Figure 4 are installed at the FA factories. MAP 3.0 is used as the network between the plant computer and area computers.

2.2 Hydraulic Equipment Plant

As you see in Figure 5, this plant produces hydraulic pumps and motors for construction equipments. Here, a large number of FMS (Flexible Manufacturing System) have been adopted, and automatic assembly is more advanced. The size of the total system is significantly larger than that of the small-size press plant that I explained earlier (see Figure 6).

In the area of production control, we have introduced a production method using electronic Kanbans between the assembly line and the machining line.

2.3 FA System Concept

I will now tell you about the concept used in FA system design for the construction of the two FA plants that I have introduced above.

In the development of FA systems, we adopted the following ideas, based on our emphasis on being able to keep abreast of future technological innovations and being able to re-utilize already developed software.

(1) Autonomous, Distributed Systems

Development of individual software will become easier through functional distribution, and the reliability of the whole system will be improved by autonomous processing of trouble shooting at times of failure by autonomous, distributed computers.

(2) Adoption of a World Standard Network

Plants are dynamic entities and continue to change to keep pace with the times. It often becomes necessary to add new functions and to cope with changes of combinations of functions between systems. Thus, we have adopted a standard network. In particular, MAP 3.0 is expected to be the world's standard LAN for factories.

(3) Adoption of an OS and Programming Language which will be Future World Standards

As for the OS, there are no standards in the area of FA/CIM, but we have adopted UNIX because of its expectations for the future.

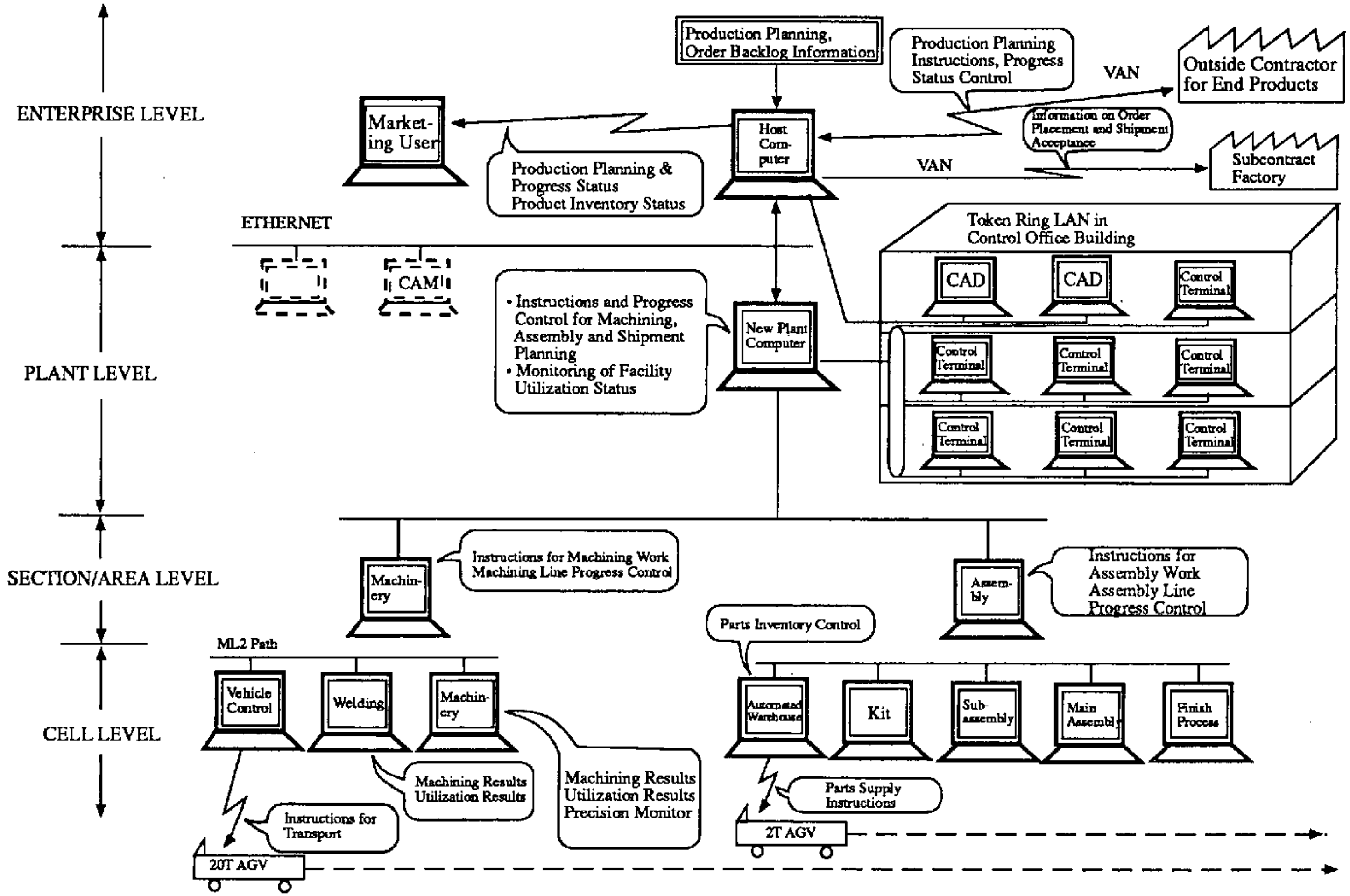


Figure 4 System Configuration

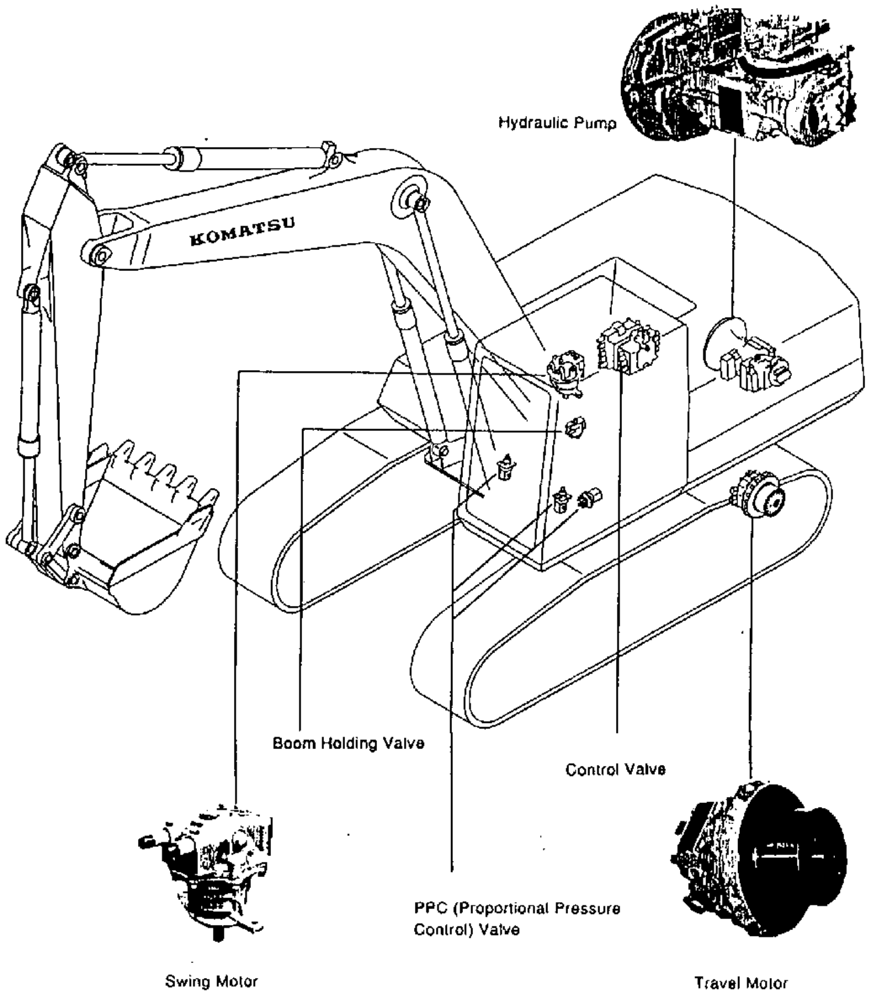
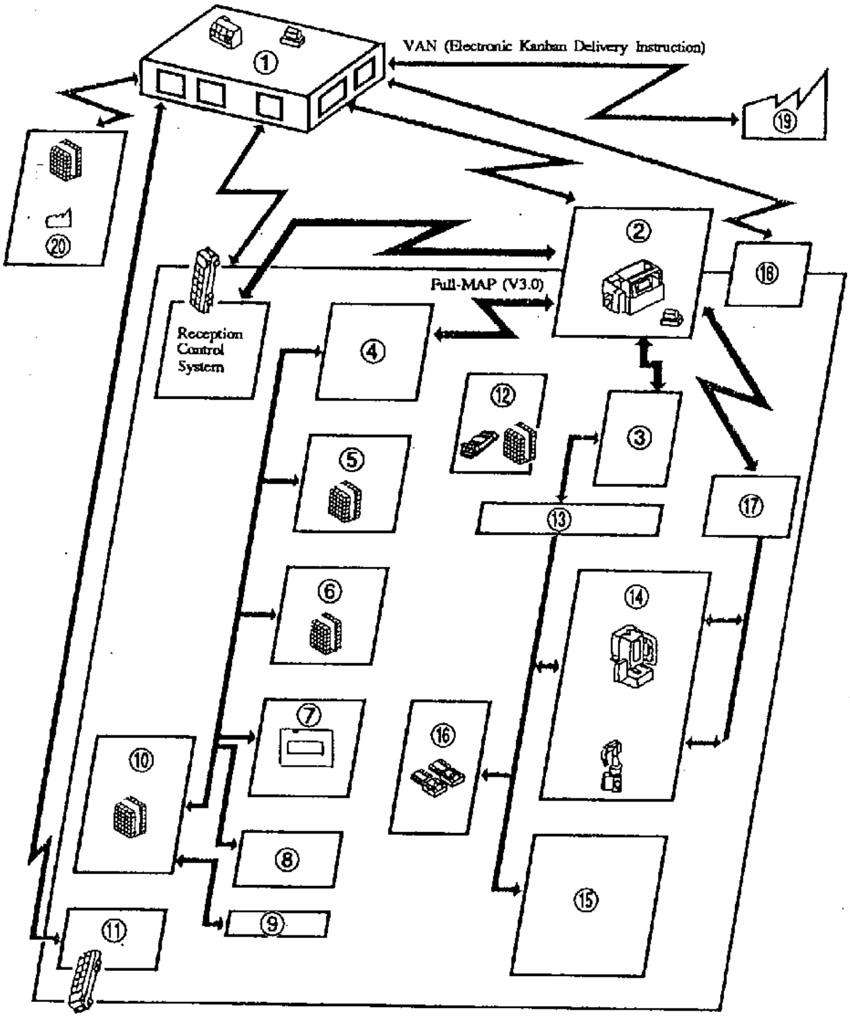


Figure 5 Parts for CIM



① IBM Host Computer for Enterprise
② Plant Computer
③ Machining Area Computer
④ Assembly Area Computer
⑤ Finished Material Warehouse Control Computer
⑥ Small Size Material Warehouse Control Computer
⑦ Assembly Cell Control Computer
⑧ Inspection Cell Control Computer
⑨ Painting Cell Control Computer
⑩ Product Warehouse Control Computer
⑪ Shipping Control Computer
⑫ Raw Materials Warehouse Control Computer
⑬ Machining Cells Control Computers
⑭ FMS Control Computers
⑮ Human Interface Intelligent Display
⑯ Automatic Pallet Changer for AGV
⑰ Equipment Monitoring Computer
⑱ CAD/CAM Computer
⑲ Co-operate Company
⑳ Co-operate Factory

Figure 6 System Configuration

However, we do not have an environment to adopt UNIX in all areas, and in actuality UNIX and other OS coexist in our system.

(4) Separation of Standard Parts and Customized Parts of Software

The software development costs for a total CIM system are enormous. Therefore, re-utilization of already developed software is a serious concern for the future. Therefore, we have decided to separate the standard parts of software that contain fundamental FA mechanisms from the customized parts that meet the specifications of individual customers.

(5) Hierarchical Structure Based on World Standards

When we consider the future trends in computer hardware, we predict that FA computers will be divided into various models specializing in specific areas of application, and we believe that the design standards at that time will be the standards that will be most commonly used in the world. Therefore, when we adopted a hierarchical structure for CIM, we decided to use the standards for the CIM reference model provided by ISO/TC 184.

	Present Status (General CAD/CAM System)	Future (Integrated CAD/CAM System)
CAD	Drawing Preparation (2-dimensional)	Product Model Development (including Drawings)
Linking with CAD/CAM	Explanation of Drawings by Humans	Transmission of Product Model
CAM	Processing Centering on Graphics Information	Processing including Machining/ Delivery Information

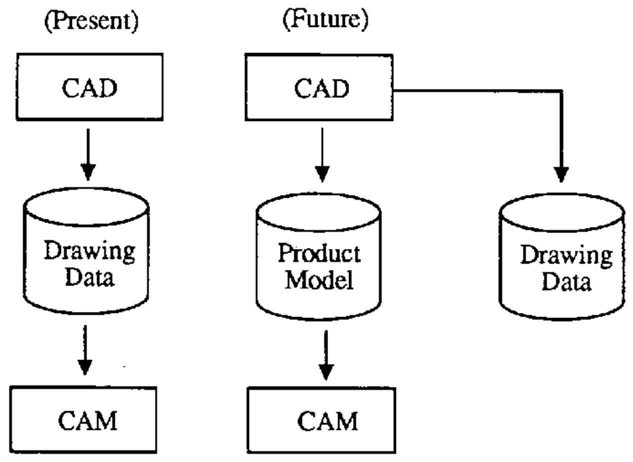


Figure 7 Integrated CAD/CAM

3. Future Development Plans

Information at FA factories is automatically collected and is linked to the new sales/production system that I mentioned at the beginning of this paper. The problem we have is to know in what time cycles we need to collect information from non-FA factories using POP (Point of Production).

Furthermore, true CIM cannot be constructed only with a production control system and an FA system. One big problem out of all of our remaining tasks is the information exchange between the Development Department and the Production Department. As in simultaneous/concurrent engineering systems, we need a system that can be used with innovation of the work involved in development design, production preparations, etc. To give a concrete example, I would like to cite the realization of an integrated CAD/CAM system (see Figure 7). This system has a function to change product specifications into computer data at the CAD stage, and to quickly calculate manufacturing costs when modeling is done.

Current News

* IBM Japan Releases Notebook PC for Wireless Data Communications

Taking the lead in the IBM group worldwide, IBM Japan has developed a notebook personal computer which can be used for outdoor data communications. It will be released in Japan in March, 1991. First, a modem and software for connection between the PC and car phones have been developed, making it possible to use the PC inside automobiles. Next, within the year, radio data communications through the PC from outdoor locations other than inside automobiles will be made possible through a radio data communications company oriented to general public use.

The modem was developed through cooperation with Microcom of the U.S. and other domestic and overseas manufacturers, while the software was developed in cooperation with CSK. It is estimated that the total price, including the PC, modem, and software will fall within the 500,000 yen range.

The number of automobile and portable telephones serviced by NTT and the New Common Carriers (NCCs) reached 786,000 as of the end of 1990. By connecting these telephones to notebook-type computers, employees will be able to call and communicate with company computer centers from the inside of automobiles. Also, sometime in 1991, users will be able to access the services of Nihon City Media, the world's only data communications radio company oriented to the general public. This company has installed antennas in 14 locations within Tokyo's 23 wards. Users will be able to send and receive data using the radio PC via these antennas from any location within the 23 ward area. Since this service poses no limitations on the locations where a PC can be used, it is expected that applications spread to companies in every business area.

* Sony's "Electronic Book Specifications" Adopted by Eight Companies

Eight home appliance and information equipment manufacturers, including Matsushita Electric Industrial, Sanyo Electric, Canon and Ricoh, have decided to adopt "Electronic Book Specifications," the new CD-ROM hardware and software standards proposed by Sony. These standards were jointly determined by Sony and Iwanami Shoten and other publishers with the aim of expanding the CD-ROM market. The impetus for widespread CD-ROM use occurred in July, 1990 when Sony unveiled a low-priced, portable CD-ROM player, the "Data Discman" (58,000 yen), which was soon followed by the release of electronic dictionaries and other software by a number of publishers.

These eight manufacturers plan to be ready to release their own CD-ROM equipment in the summer and fall of 1991, so that Sony will be able to supply ICs and other parts and provide OEM manufacturing, should there be any demand for this. Since Fujitsu has already announced its adoption of these standards, as of now 10 companies now use "Electronic Book Specifications." This amounts in reality to the establishment of a set of CD-ROM standard specifications for general consumer use, and further market expansion can be expected from now on.

* Federation of Bankers' Associations of Japan: Individual Credit Information to be Disclosed to the Individual

In order to promote thoroughness in privacy protection, the Federation of Bankers' Associations of Japan has decided to make individual credit information registered at its Japan Banking Individual Credit Information Center available to concerned individuals with regard to when, by whom and for what purpose their information has been used. The above center was founded in October, 1987, through integrating the information centers established by banking associations in each area of the country. As of September, 1990, the number of member institutions was 2,622, and the total number of individual records maintained was about 33 million. Information regarding repayment of personal loans and arrears and substitute settlements, etc., is registered there, and information is primarily offered in response to inquiries from financial institutions.

The Federation is connected online to the banking associations in each region, and will be able to provide, in response to a request for information disclosure by a concerned individual, request information for the past three months regarding from whom and how many times information has been requested.

Due to strengthening of the retail banking sector, use of individual information has recently been growing because of an increase in personal loans, etc., and the volume of information held at the Individuals Credit Information Center has also grown explosively. Thus, it became necessary to give further consideration to individual privacy protection, and the current policy was adopted. The Federation has received the compliance of affiliated financial institutions, and aims at system completion in August, 1992.

* Fujitsu Enters the SI Business

Fujitsu has embarked into the System Integration (SI) field, a business which involves singlehandedly undertaking everything from system planning and design through actual development, completion and maintenance. SI usually is an operation led by the computer manufacturer involving commissioned development of the integration of systems which has been performed by the systems information department of the customer. For this reason, the contract with the customer and the method used in development have been matters of great importance. In 1990, Fujitsu established and equipped an in-house investigative organization to deal with these problems. As a result, they have completed a development procedure, "SDEM90," which defines a detailed contract system for SI with over 100 items, the "Basic Systems Integration Contract," as well as the operations needed to perform SI. With this procedure, the expenses that will be encountered can be estimated.

Fujitsu has already been engaging in business negotiations, and has concluded contracts with several companies, such as an order of about 3 billion yen for a system for an oil and chemical manufacturer. There are many large-scale systems for which the software alone reaches hundreds of millions of yen, and which exceed one billion yen with the computer included. Fujitsu is aiming at performing SI for about 40 companies in 1991. The SI business has already been energetically developed by IBM Japan, so it appears that rivalry among computer manufacturers will become even more heated from now on.

* NTT Splits Mobile Communications Businesses

In February, 1991, NTT announced the separating off of its mobile communications businesses, which include automobile and portable telephones and paging. Through a general stock meeting in June, 1992, a mobile communications company initially servicing the entire country will be established with 100% investment by NTT, and the car/portable telephone, paging service, shipboard telecommunications and aircraft public telephone operations currently serviced by NTT will be transferred to this company. Also, in order to use frequencies more efficiently and to deal with the increase in new users, automobile and portable telephones will be digitalized.

One year later, this 100% financed mobile communications company will establish eight subsidiary companies for separate regions. The central company will be responsible for the Kanto region as well as for general control, and will exercise overall control of shipboard telecommunication and aircraft public telephone services. From then on, the central company will successively lower NTT's investment ratio, with the aim of listing the company on the stock market five years after its founding.

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