System Integration Technology for Construction of CIM

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1. Introduction

CIM (Computer Integrated Manufacturing) is an integrated system that is extremely effective for securing advantages in business competition. An integrated system inplies a well coordinated system which dynamically combines all business activities from order acceptance to delivery and after sales servicing. In order to construct such an integrated system, it is necessary to balance goods, manpower, and information by reviewing in detail the operations of the entire enterprise and the manufacturing processes to be systematized. For the construction of CIM/FA, Fuji Electric systematizes and broadly uses "system integration (SI) technology" to exhaustively review what the appropriate operations and manufacturing processes should be. The manufacturing, operations, and information systems are integrated. Efforts are made to realize improvements in working methods on the field and increase physical distribution as well as automation.

This paper introduces the procedure and technique for planning and constructing the setup of goods, man power and information to solve business problems.

2. Requirements for Construction of CIM

2.1 Objectives of CIM

The following five items can be considered as the main objectives of CIM.

(1) To increase the customer service rate by shortening delivery time.
(2) To enhance flexibility to deal with products of small batch production.
(3) To enhance total productivity by shortening the development period.
(4) To enhance quality by reducing the defect pecentage.
(5) To enhance profitability by reducing cost and opportunity losses.

SI systematizes the business functions of sales, development and design, production management, manufacturing and physical distribution processes in a well harmonized form to achieve the objectives of CIM.

The principal areas of CIM can be classified into three fields: manufacturing (production), information pattern recognition (information), and integrating engineering to realize a dynamic system. Fuji Electric has developed a consolidated structure that permits a well balanced evolution of these three fields to meet customer needs.

2.2 What is CIM integration?

From the viewpoint of computer hardware, CIM dynamically combines the main computer, FA computers, programmable controllers, etc. by a network as shown in **Fig. 1**. From different viewpoint, CIM places each technology (data base, production management system, manufacturing management, manufacturing control, etc.) in each level of a system of hierarchical structure and interfaces the information among these technologies by a network system. The integration here links the data of each technology through one database.

The above can be briefly summarized as follows. "CIM Integration connects unified databases by a pipeline called a network."

3. To Achieve CIM

CIM requires a huge capital investment and a long development period. To promote CIM, it is therefore necessary to determine a firm policy with a clear longterm vision. Fuji Electric carefully considers the following points for construction of CIM.

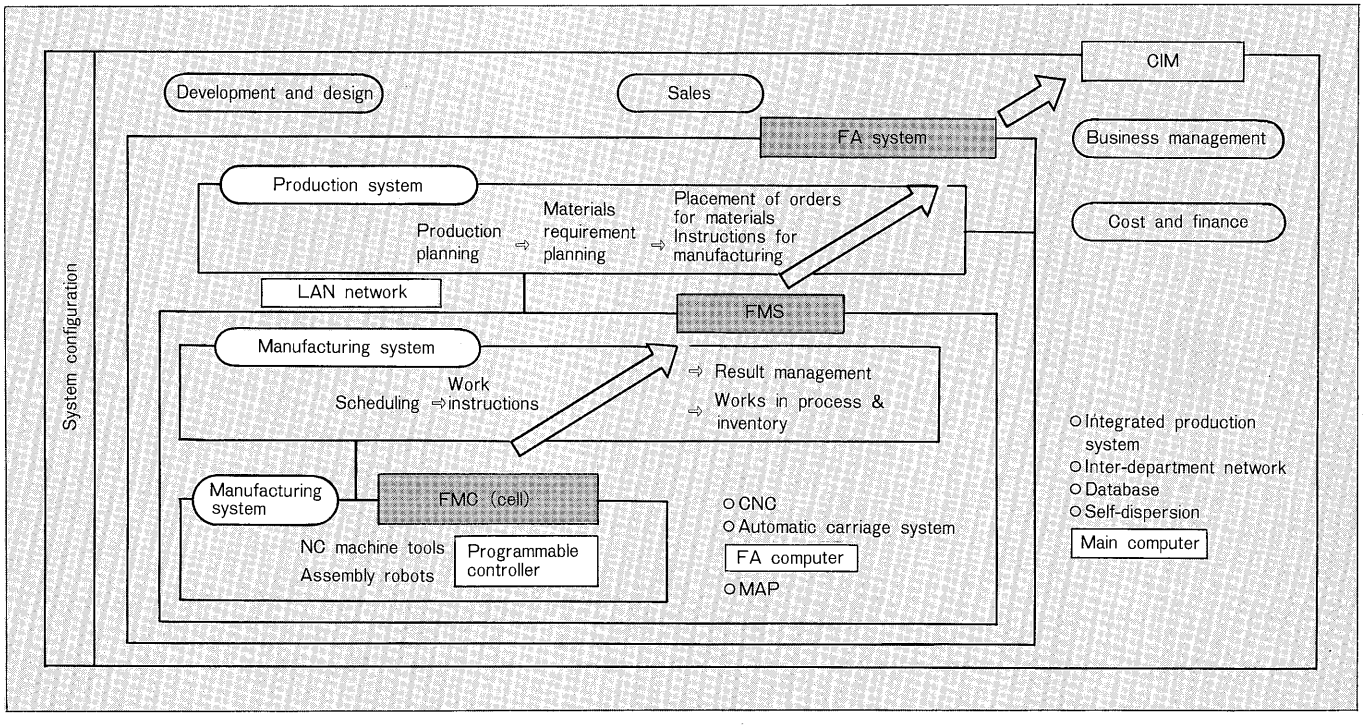
3.1 Construction of CIM optimized for the business

Business characteristics including the environment (competitor status, customer requests, state of relevant businesses, competitive power of products, etc.) that surrounds the business, management strategy, state of factory integration, financial situation, and restriction of human resources are all reflected in CIM. Therefore, CIM should be unique to each business. It is therefore necessary to configure CIM by using a top-down approach.

3.2 Effective use of existing system

The notion that the existing system is entirely abandoned when constructing a new CIM system is false. Efforts are made to effective use existing items as much as possible and to standardize the flow of information between hard-

Fig. 1 Overall configuration of CIM



ware and software.

3.3 Construction of CIM that changes the constitution of the business

CIM fundamentally improves the constitution of the business. Not only it is a technical challenge, but renovation in many aspects is required.

3.3.1 Renovation of operations system

It is necessary to consider the framework of operations of the entire business as an actual system, to analyze it from three aspects, i.e., goods, man power and information, and to then reconstruct the roles (functions) of each department, contents of work and organizational structure. That is, to create structure that permits the departments of sales, development and design, production management, manufacturing, cost/finance and personnel to operate in integrated form. Furthermore, those who are engaged in the operation of the system should be sufficiently re-educated and trained.

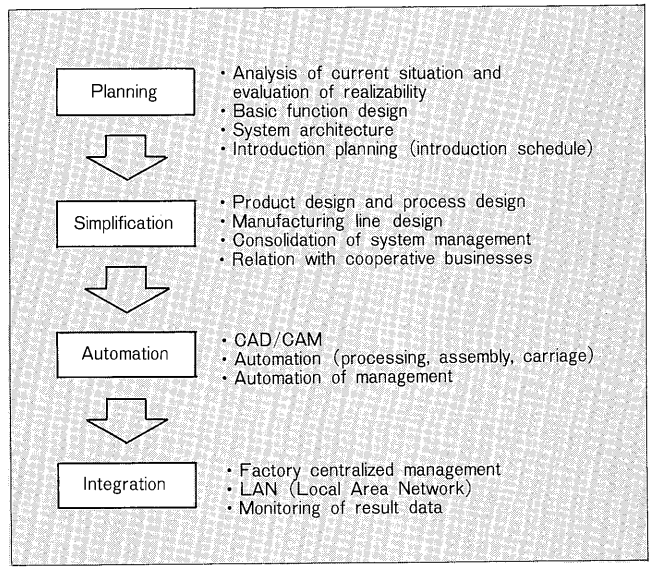
3.3.2 Renovation of the relationship with cooperative business

It is necessary to review and systematize the allotment of functions between cooperative businesses and those internal to the company. Cooperative businesses should be brought up to reduce inventory while maintaining a high level of quality and shortening delivery time.

4. Steps to Achieve CIM

CIM is configurated of multiple subsystems related to various departments such as sales, development and design, production control, manufacturing and cost/finance. (**Fig. 1**) In order to design a "good system" in which these departments are dynamically linked and exhibit sufficient functions, " in a short time" and "at high efficiency", it is necessary to clearly determine the procedure for CIM construction and to skillfully make use of the technologies for system design in accordance with the determined procedure. The steps to achieve CIM are shown in **Fig. 2**.

Fig. 2 Steps to achieve CIM



The steps to achieve CIM are described in this paper based on the experience and know how of system construction cultivated by Fuji Electric over a long period of time.

4.1 Consolidation of conditions for achieving CIM

4.1.1 Improvement and simplification of actual system

The system which functions on the dynamic linkage of goods, man power and information is called the "actual system". Improving the method of production and flow of goods, "simplification" in particular, is necessary to construct an easy to use system, and is the key for realizing a system which will be often used. Fuji Electric and the customer jointly consolidate system requirements for manufacturing by making full use of the technologies for IE analysis and integration of manufacturing. A typical case is introduced below.

(1) Integration of layout of the whole factory and of the working shops.
(2) Improvement of physical distribution systems in the factory.
(3) Improvement of setup and design of one-product-feed production lines.

"Simplification" is realized through such improvements. Furthermore, the control and management systems that support these manufacturing systems are constructed so as to be directly coupled with the manufacturing lines. For example:

(1) Manufacturing preparation system
(2) Manufacturing line control system
(3) Manufacturing system

4.1.2 Automation of the system

Automation is considered for the simplified actual system. Automation of manufacturing processes and information processing are examined in this stage. Typical items considered are as follows.

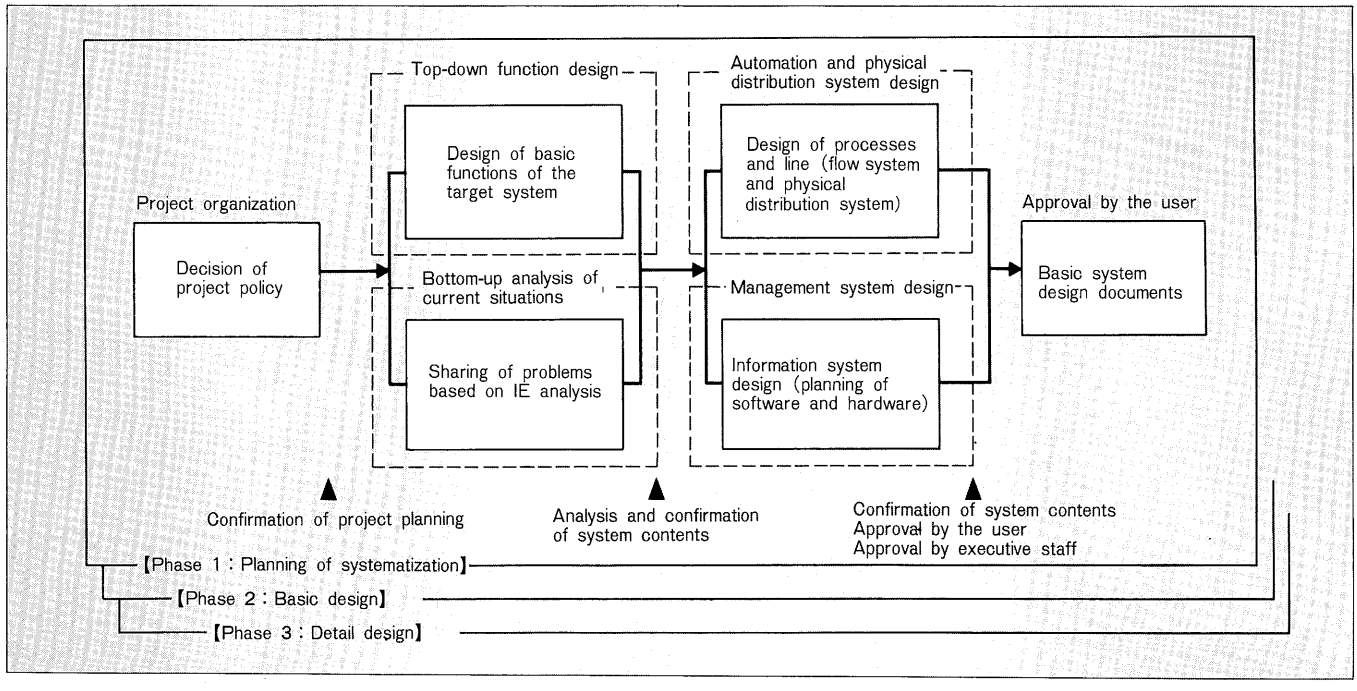
(1) Automation of manufacturing processes (coupled with simplification).
    (a) Automation of processing and assembly
    (b) Automation of material handling
    (c) Automation of inspection and testing
(2) Definition of information required for manufacturing processes.
    (a) Working instruction data and working data (NC program)
    (b) Monitoring information (result data, operation monitoring)
(3) Policy decision for software specifications to determine necessary information and decentralization of processing (self dispersion).
(4) Generation of data model.
    (a) Important interface information between departments
    (b) Necessary information reported to customers and sales department
    (c) Result evaluation information for business management

4.1.3 Integration of the system

The requirements for integration of the system are database unification and construction of a network system. The definition of data requirements for automation and the communication protocol and hardware are considered in this step.

(1) Architecture of the overall hierarchical structure is defined based on data requirements.
    (a) Main computer (business computer, office computer)
    (b) Front computer (FA computer, FA personal computer)
    (c) Cell controller (FA personal computer, programmable controller)

Fig. 3 Working procedure for CIM design



(2) Definition of data transmission and communication method.

Communication protocols are considered for the local area network (LAN) in the factory and the wide area network (WAN) among businesses.

(3) Selection of hardware for integration.

Hardware is selected over a period of time. Decisions are made by paying constant attention to the trends and progress of FA technologies and information technologies.

(4) On site introduction.

Instead of introduction of the whole system at once, introduction is divided into multiple phases and implemented in steps.

4.1.4 Process of design and construction of CIM

It is necessary that CIM be initiated by a top-down approach with a project structure that is suitable for the entire business. The working procedure for CIM design is shown in **Fig. 3**.

First of all, the project policy is determined with the management strategy, target and restrictions clarified. In order to construct a high level system according to the target, instead of a system based on the current situation, "basic functions of the target system" are designed top-down. Hereafter, bottom-up analysis of the current situation is made and items for systematization are clarified. System design for filling the gap between the level of the target system and the level of the current system is the next step. Design of process lines and an information system to support them are implemented in this step, and a "basic system design documents" are created.

The details of the design processes stated above are introduced in the next chapter.

5. Technique for CIM Design and Construction

The CIM design and construction techniques used by Fuji Electric can be roughly divided into two methodologies. (**Fig. 4**) One is the methodology for systematization which is applied through the compilation of system design procedures and design techniques. Another is the methodology for project management.

5.1 Methodology for systematization

5.1.1 Working procedure of system design

System design work is divided into phases, and diversification of the work and setup of the implementation sequence are made according to logical relationships. The documents (system specifications) to be drawn up during

Fig. 4 Organization of techniques for CIM design and construction

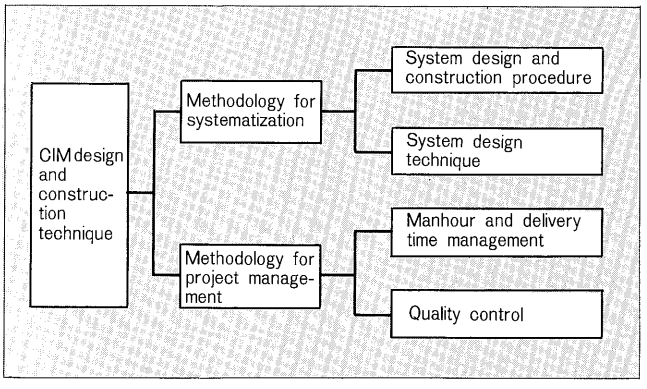
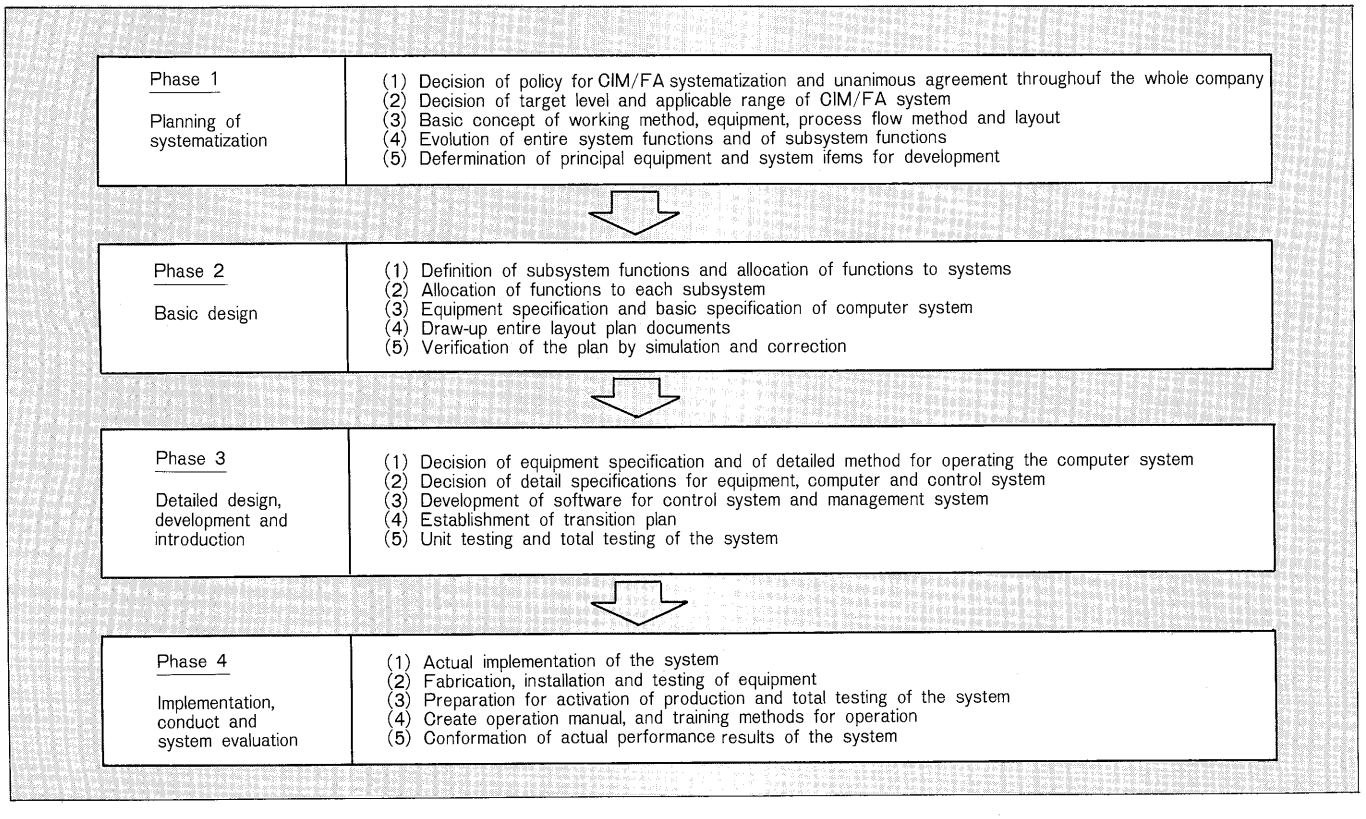


Fig. 5 CIM/FA design procedure



work in each phase are filled out according to specified formats to achieve a specified level of quality.

The working procedure for system design is as shown in **Fig. 5**.

(1) Phase 1: Planning of systematization

Planning of systematization determines the framework of the system to be designed. This is therefore the most important step.

The scale of the system, level of automation, management resources to be input, the structure for realizing the system, etc., are determined from management policy, the target, technology trends, etc. In addition, a definite image of the entire target CIM system is created by making use of all of the relevant production technologies, management technologies and system technologies.

Finally, new technologies and equipment which must be developed to realize this system, and the structure for promotion of the entire project are also confirmed in this step.

(2) Phase 2: Basic design

In this process, the specifications for detailed design necessary for components to be fabricated in phase 3 and afterwards as required to realize the functions of the overall system determined during Phase 1: Planning of systematization, are clarified.

(3) Phase 3 and Phase 4

Phase 3: Detailed design begins upon completion of basic design in Phase 2. The largest problem in Phase 3 is how to dynamically interface the linkage of subsystems.

In Phase 4, actual introduction and operation. It is important that the basic policy of the plan and contents of the system are correctly understood by the user and that the system is connected for actual operation.

Fuji Electric always incorporates an internal scheme for evaluation and formation of the system. This allows early detection of system trouble and permits improvement during system formation.

5.1.2 System design techniques

Design techniques provide the means for design, and are effective when it is linked with the design work procedure described earlier. Design techniques can be classified as shown in **Fig. 6**.

(1) Function analysis

This is defines and describes functions for a specific operation area, and decomposes the functions into more easily understandable management units. This analysis is the most important work for construction of the system.

(2) Data analysis

This is a series of work to define and describe the mutual relation of data based on the function analysis above and determine what data aggregates are present in a specific operations area, and what data items belong to each one of these data aggregates.

(3) Technical architecture

Fuji Electric is attempting to standardize of system structure, program configuration and program structure in order to enhance the productivity of system development, to facilitate maintenance and to enhance quality. Batch architecture and online architecture are available. Online

Fig. 6 Classification of CIM design techniques

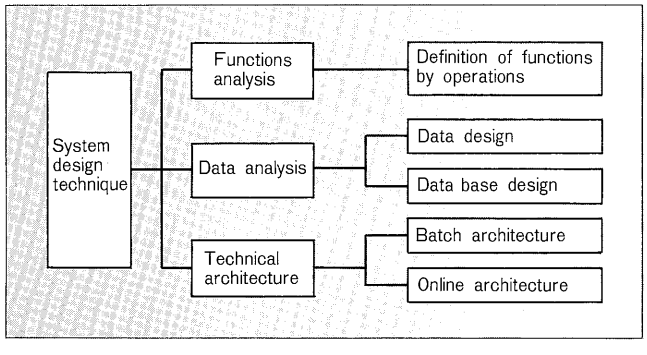
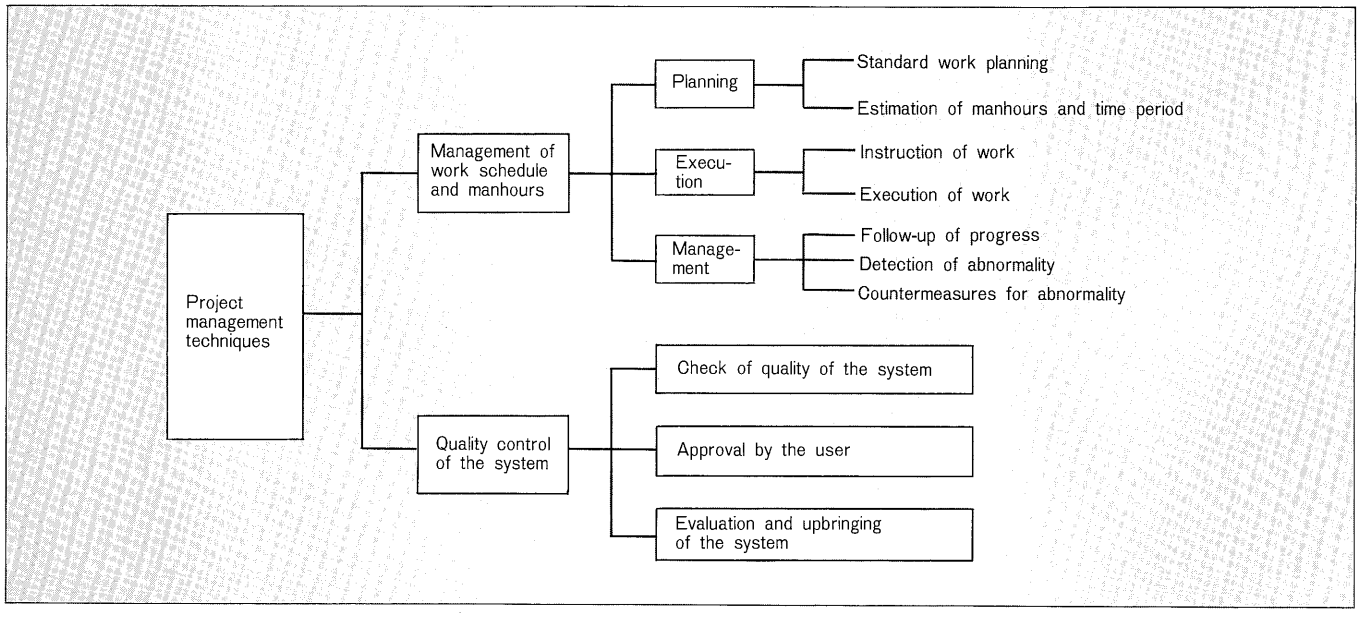


Fig. 7 Structure of project management



architecture in particular is utilized for enhancement of the quality of the system with regard to improved response, recovery management and security management.

5.2 Techniques of project management

5.2.1 Objectives of project management

Project management is implemented with the following three objectives.

(1) To plan so that construction of the system is completed by the delivery time.
(2) To issue instructions so that the work progresses and is completed as originally planned, to follow-up on the progress and to take countermeasures in advance.
(3) To check the quality in each phase to assure that the contents of the system satisfy the target level, and to take countermeasures.

5.2.2 Structure and scope of project management

The structure of project management is shown in **Fig. 7**. As shown in **Fig. 5**, system design is implemented in four phases, i.e., planning of systematization, basic design, detailed design and actual inplementation. Project management is concerned with these four phases, and management check points are established in each phase.

6. Afterword

There are many cases where priority is given to the information system only, and fundamental reform of the manufacturing system and operations system is overlooked. It is the function of SI to throughly relying on plan, estimate, evaluate and execute CIM/FA instead of relying on mere ideas and rules of thumb. Future progress of CIM/FA is dependent on SI. Fuji Electric intends to further strengthen its leadership in this field.