Present Status and Future Prospects of an Engineering Environment for Integrated Control Systems

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1. Introduction

Influenced by the trends of factory automation system upgrades and a growing need for flexible production systems, information and control systems have become more sophisticated and complicated. Due to this development, engineering has rapidly increased in scale and complexity to accomplish the system's objective. This engineering consists of selecting various hardware components, designing software and then combining the two. Naturally, engineering costs for information and control system have increased to account for a large proportion of the total system cost. Engineering is greatly indebted to human labor, and the shortage of system engineers along with a sharp rise in labor costs have caused a rapid increase in engineering costs, sometimes resulting in difficulties assuring system quality.

An effective method of resolving this situation is to automate engineering. Up to now, various trials have been performed with constant results. However, in view of future development, the present engineering environment for design automation is not enough and must be further enriched.

This paper outlines the engineering environment of information and control systems up to the present and describes the problems, basic approaches to solution, and future prospects.

2. Present Status of the Engineering Environment

2.1 Former engineering environment construction

Since the mid 1970s, the widely spreaded use of controllers mounted with microcomputers and distributed control systems centered around a computer has broadened software application to include control functions. Also, the quantity of software installed in systems has increased. Engineering costs of system construction greatly increased due to the emergence of various control components which are highly distributed, control methods for skillfully linking these components, and the processing of a large quantity of information.

In view of these backgrounds, the "CASE project" has been promoted since 1984, aiming at improving the quality and productivity of engineering in both the narrow sense (drawing up specifications, ordering equipment. hardware design, etc.) and in the broad sense (software development for computers and controllers in addition to the above). In order to achieve the above goals, the CASE project utilizes the following approaches:

(1) to design automation support to improve the quality of the upper process work
(2) to design automation support to secure accuracy in transferring design information to the lower process
(3) to design automation support for the lower process work

To expand and quickly resolve problems for the engineering environment, construction and development of the engineering environment for the individual fields have been planned. Thus, on-site problems can be recognized and then solved by application of this environment.

2.2 Present engineering status of each control field

As a result of the above activities, the application of an engineering environment to each individual field has been firmly established, resulting in improved efficiency and quality of engineering.

The features of main engineering environment for individual fields are follows.

(1) "APEX" for the electric control field

Automatic preparation of list type data for design information from the system design department was realized and is in operation. Data is shared between the software design system for controllers "FPROCES-C" and the sequence CAD system "FE-CAD."

(2) "FIDESS" and "FRENDS" for the instrumentation field

The "FIDESS" prepares an instrumentation loop diagram with the CAD image. Based on this and using tag numbers as the key, an instrumentation data base (e.g. signal names, base scale and unit) is generated. In addition, specifying instrument information for each component links the system with the "KMT" instru-

Table 1 Application status of engineering support tools

Process / Domain	Drawing up of specifications: Equipment drawing, instrumentation flow chart, operation flow chart	Drawing up of specifications: Equipment list, sensor list, interface list	Ordering of equipment	Hardware design: Sequence chart	Software design: Controller software	Software design: HCI software	Testing	⇨ ⇦ Product
Power	SUKSES (telemeter-telecontroller) F-APEX (industrial substation equipment)		FE-CAD Linking system	SUKSES-APEX FE-CAD	FPROCES-C	FPROCES-M	FPROCES-C FPROCES-M Testing tools	MICREX control system
Water treatment	–	CATS	KMT	CATS FE-CAD	CATS FPROCES-C	CATS FPROCES-M		
Instrumentation	FIDESS		KMT	FRENDS FE-CAD	FPROCES-C	FPROCES-M		
Electric control	APEX	APEX	APEX	PMDS FE-CAD	FPROCES-C	FPROCES-M		

ment estimation and ordering system. It is also linked with the engineering data base of the "FRENDS" design system for instrumentation controllers through the instrumentation data base.

(3) "CATS" for the water treatment field

As for the departments of system design, controller hardware and software design, computer software manufacturing, and testing, automatic collection of the department data bases and automated drawing up of related documents have been realized.

(4) "SUKSES" for the power control field

The telemeter and telecontroller SAS series was targeted and position table preparation was automated, linking the SAS and computer data bases.

(5) Common support system "FPROCES"

This tool supports the manufacture and testing of software for controllers placed in lower processes. It consists of "FPROCES-C" for controllers and "FPROCES-M" for HCI equipment. Almost all of the upper process support systems are linked with the "FPROCES."

The application status of engineering support systems in each individual field is shown in Table 1.

2.3 Present problems

As mentioned above, the efficiency and quality of engineering is improving; however, recent progress in information and control systems has posed problems for the engineering environment. These problems are described below.

2.3.1 Necessity of integrating engineering support environments

(1) To cope with integration in the control field

As typically seen in EIC integrated systems, recent information and control systems are not limited to specialized control content for each control field. They increasingly deal with many control fields, including electric and instrumentation control, mixed in a closely linked system. Previous engineering support environments for individual fields have problems of dealing with such integrated systems.

(2) From controller support to system support

Information and control systems consist of varied equipment with highly distributed functions, closely linked to form a system. In an environment where engineering support for this equipment is performed individually and no integrated support for the whole system is available, engineering must bear a heavy load. There is a growing need for an engineering environment with total system support.

(3) To secure consistency of information between engineering processes

Present engineering support systems cover only a part of whole engineering processes. Therefore, to carry out a series of engineering tasks, it is necessary to use two or more support systems, each having its own proper data base, with engineering information exchanged between these systems.

In particular, it is difficult to maintain unification when information modified in a lower process is fed back to the support system data base for the upper process.

2.3.2 Further improvement in engineering efficiency and quality

As previously mentioned, the engineering environments constructed until now have improved engineering efficiency and quality. However, the acceleration of advanced functions, complexity and software application of recent information and control systems that accompany the development of various technologies requires further improvement of engineering efficiency and quality. Particularly desired are:

(1) an improvement of software productivity and quality

(2) a reduction in engineering lead time

3. New Engineering Environments

To solve the problems described above and improve engineering, Fuji Electric is constructing a new engineering environment. The basic concept can be summarized in the following three points:

(1) integration of the engineering environment
(2) advanced support functions for software design and manufacture
(3) realization of a group engineering environment

3.1 Integration of the engineering environment

Integration consists of the following three elements:

(1) To provide an engineering environment that enables unified system construction extending over different control fields.
For example, it is necessary that engineering can be done for both electric control and instrumentation control functions on the same support device, utilizing a similar user interface, and based on of unified, common information.
(2) To provide an engineering environment where all engineering processes can be uniformly supported:
That is, the engineering process — from the drawing up of specifications, ordering of devices, hardware design, software design and manufacture, to testing — has to be done in the same support environment with unified information. This must be performed without awareness of the transfer and unification of engineering information generated in the processes (see Fig. 1).
(3) To provide an engineering environment that enables unified support of various equipment
For example, it is necessary that software design, manufacture and testing of controllers for electric control and instrumentation as well as operator stations can be done on the same support device, using the same type of user interface and based on unified common information.
The most important point in realizing the above is to construct an engineering support system with architecture based on a "unified platform common to control fields, engineering processes and equipment support functions" (see Fig. 2).

3.2 High-level support functions for software design and manufacture

The advancement of support functions aims to improve software productivity and quality for controllers. A major factor that hinders this advancement is "human interpretation of software design specifications from control specifications." A drop in engineering efficiency due to this human factor and a reduction in quality caused by human error during interpretation are serious problems. The point in removing this factor is to achieve automatic program generation from control specifications.

This function automatically generates control programs directly from control specifications, i.e. the upper document, in accordance with an algorithm corresponding to the specification description format (see Fig. 3).

The following are indispensable for realization:

(a) R & D of the control specification description formats
(b) R & D of software usable as components and its synthesis technology.

Engineering information, in a narrow sense, can be extracted from control specifications, which further contributes to improvement in engineering efficiency

Fig. 1 Unified management of engineering information

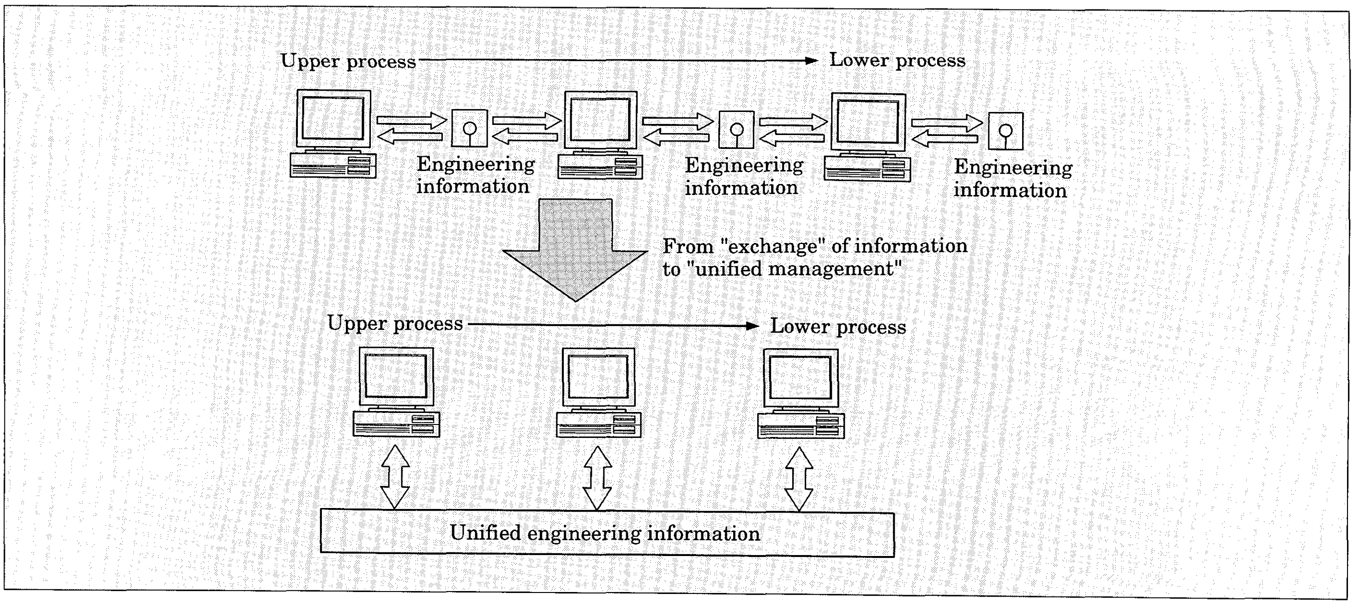


Fig. 2 Basic structure of the integrated engineering support system

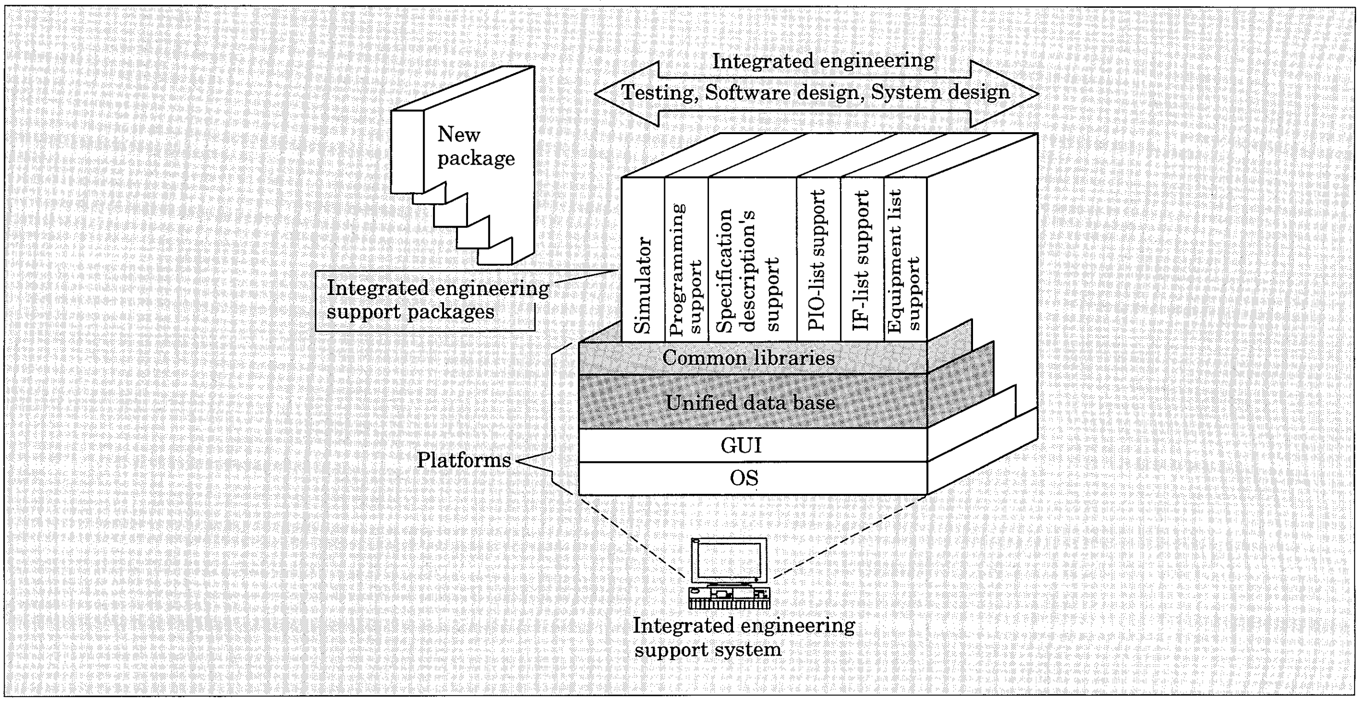
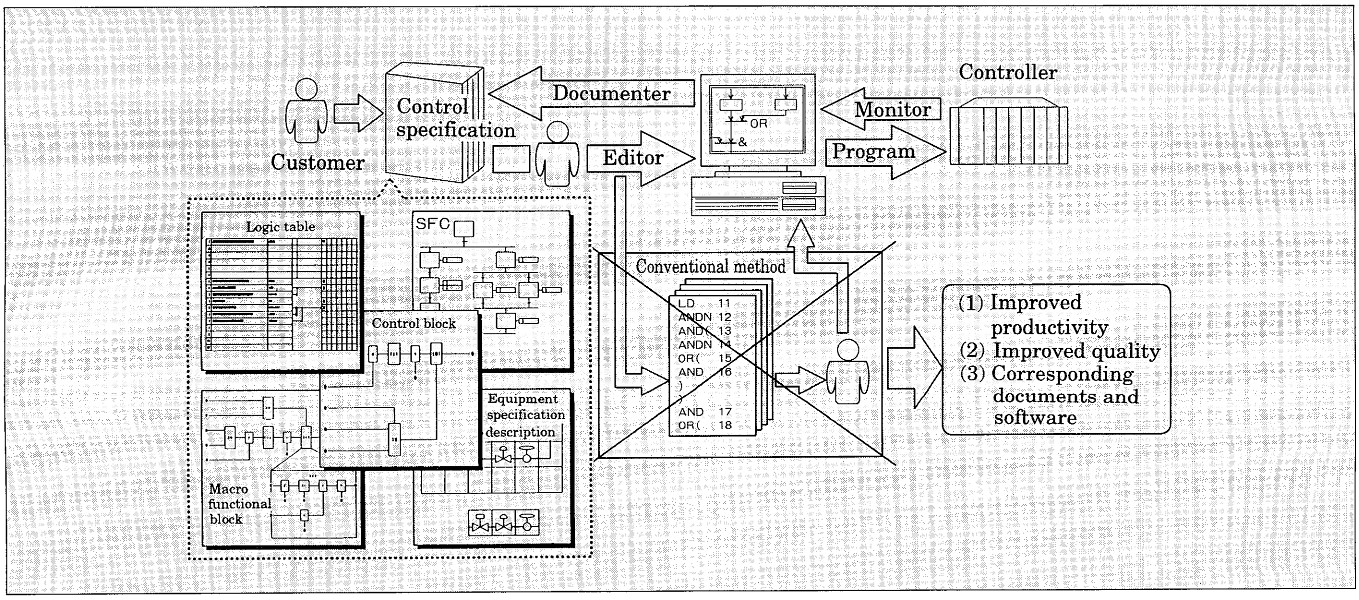


Fig. 3 Automatic program generating function



and quality.

3.3 Realization of a group engineering environment

Engineering is handled by several departments, from preparation of specifications to testing. An engineering environment in which these departments can closely cooperate under unified management will naturary contribute to an improvement in work efficiency and quality (see Fig. 4).

Such an engineering environment enables concurrent engineering by two or more people (concurrent engineering function).

Therefore, its effectiveness in reducing engineering lead time when work load rapidly increases due to information and control systems becoming larger and more complicated is clearly evident.

4. Future Prospects of Information and Control System Support Technology

Support technology for information and control systems continues to progress under the influence of CASE technology for computer software and CAE technology for hardware. A general view of forthcoming major support technology is shown in Fig. 5.

Fig. 4 General view of a plant engineering support system

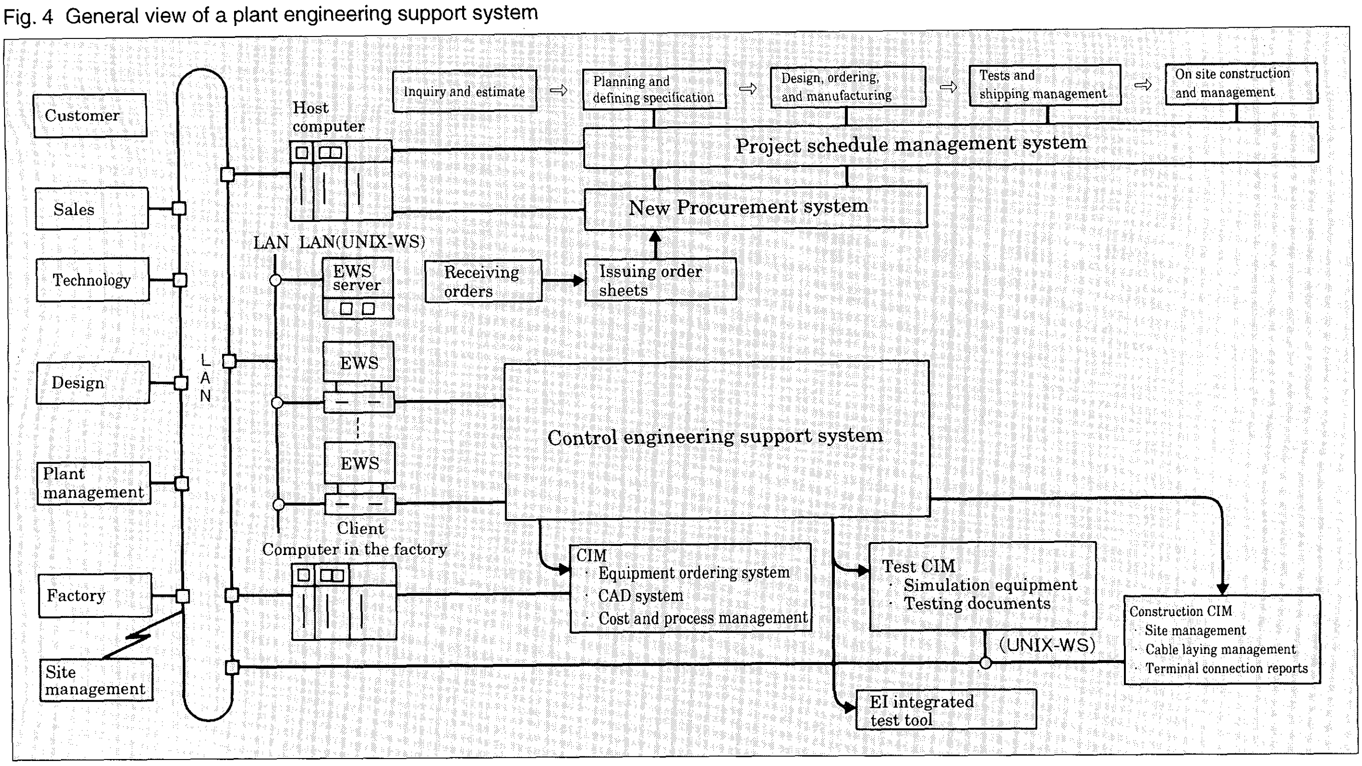
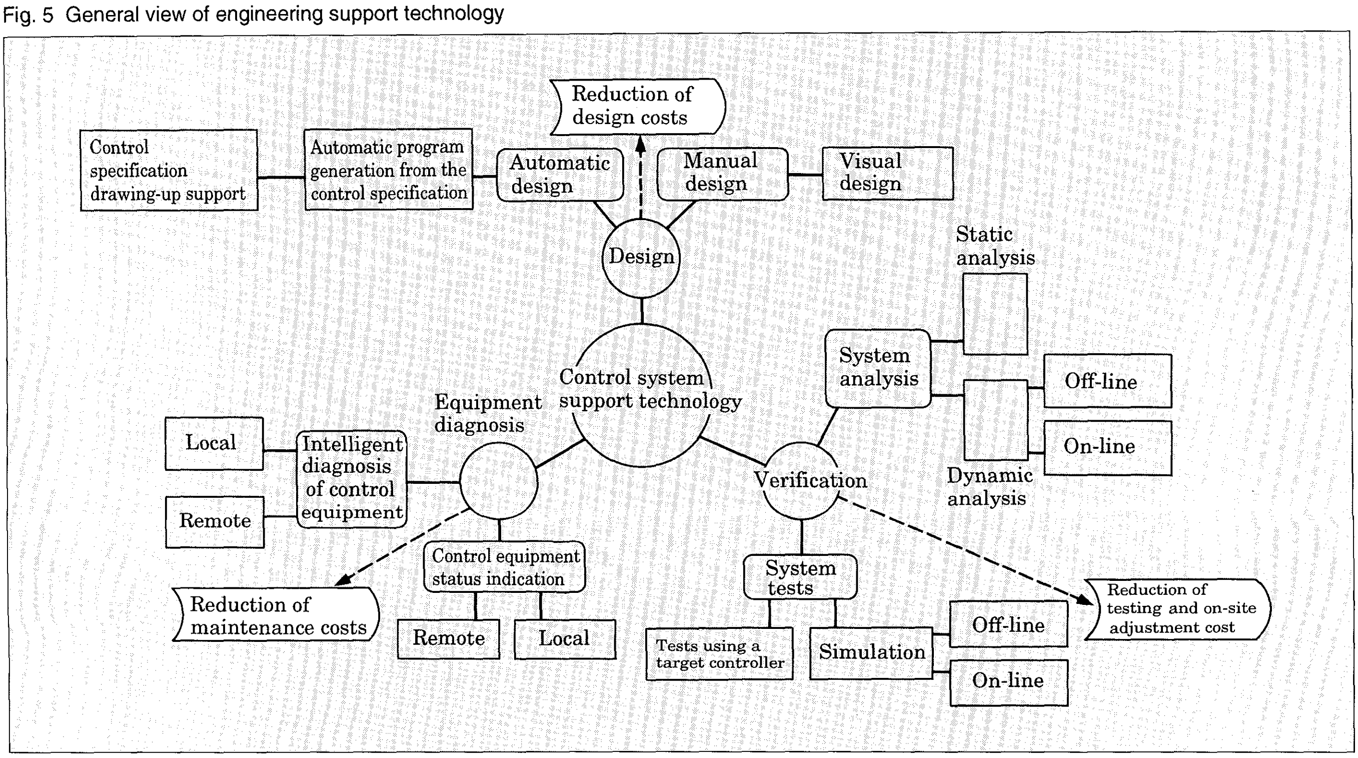


Fig. 5 General view of engineering support technology



4.1 Support technology for "design"

Automatic design technology should make remarkable progress in the future. Necessary extraction of engineering information and software synthesis will be automatically performed on the basis of control specifications determined and described by upper process designers.

Moreover, even the upper process designer's preparation of the control specifications will be supported by automation tools. This will facilitate correction of the specifications easy, and make them free from error. AI and object-oriented technology will be the elements used to achieve this.

4.2 Support technology for "verification"

"Verification" can be roughly divided into "test" and "analysis." "Test" verifies by trial and error whether a constructed system is operating as the designer intended. For this purpose, development of sophisticated visual simulation superior to tests using target controllers is anticipated.

On the other hand, "analysis" verifies deductively and arithmetically. The possibility of the occurrence of a dangerous state, such as a deadlock or conflict. This is a technically difficult hurdle, but when put into practice, enables high quality verification.

The petrinet theory appears to be a promising basic technology.

4.3 Support technology for "equipment diagnosis"

"Equipment diagnosis" technology will progress enough to automatically output not only a report on the condition of a fault but also information on fault origin and what measures should be taken. The methods of applying treatment with knowledge technology and applying analysis can be considered. AI technology and Petrinet theory will be used as the basic technology.

5. Conclusion

The present status and future prospects of an engineering support environment for information and control systems are described.

An engineering support environment is in direct contact with man and has no final state. We will contribute to the sound progress in this field through actively introducing new technology, constantly accumulating improvements, and the continuously developing easy to use systems.