The Integrated Engineering Support System

Masanori Hikichi
Yosiyuki Saito

1. Introduction

High-level and complex control systems can now be configured due to the recent highly advanced functions of the control equipment. Consequently, the content of engineering has become large and complex, and hardware costs of the control equipment has decreased. On the other hand, engineering fees, primarily dependent on intellectual work, have increased in proportion to soaring manpower costs. As a result, the portion of engineering fees for configuration of the control system has rapidly increased and has already accounted for half of the system cost. Moreover, engineering tasks which depend on intellectual work cause difficulties in maintaining high system quality in addition to a shortage of system engineers possessing advanced engineering abilities.

To end these situations and improve engineering efficiency, various support tools for engineering tasks have been developed, having positive results.

We will outline the current situation as well as problems to be solved in the engineering support system. Also in this paper we will describe the efforts and future prospects of Fuji Electric.

2. Current Situation and Problems of the Engineering Support System

2.1 Current situation of the engineering support system

Engineering can be defined as a "means and process concerning the life cycle of the control system's configuration". It is generally divided into the processes shown in Fig. 1. In the present situation, however, even if the engineering tasks share the same process, the contents of the tasks differ from each other in their control fields, such as electric control and instrumentation.

Therefore, engineering task is uniquely defined by two factors — the "process" and "control fields". As shown in Fig. 2, the support tools for such engineering task can be clarified with their positioning in a two-dimensional space.

In Fig. 2, support tool 7 supports software design and programming in the B field. But support tool 8 independently supports software design and programming as well as test and maintenance, even though it is also in the same B field. As clearly seen from Fig. 2, current engineering support tools can be expressed as "support for points and lines".

Fig. 1 The engineering life cycle

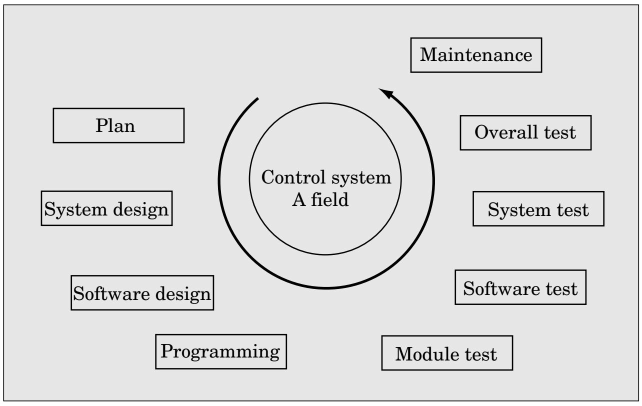
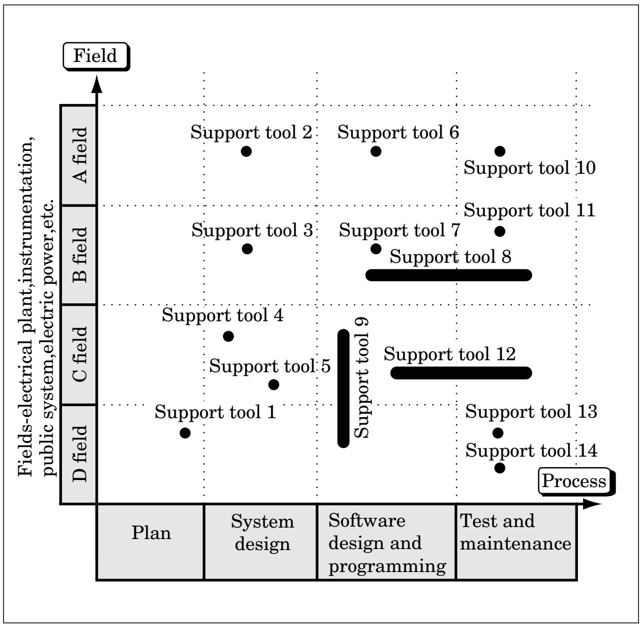


Fig. 2 Current state of engineering support tools



2.2 Current problems to be solved

2.2.1 Adaptation to the EIC-integrated control system

Recent information and control systems closely integrate not only specific control in each control field, but mixed control functions in some control fields (including electrical control and instrumentation). This is represented by the EIC (electric, instrumentation and computer) integrated control system. An integrated support system is highly desired to perform engineering for such a system, as the engineering support system up to now has been difficult to adopt.

2.2.2 Trend from device to system support

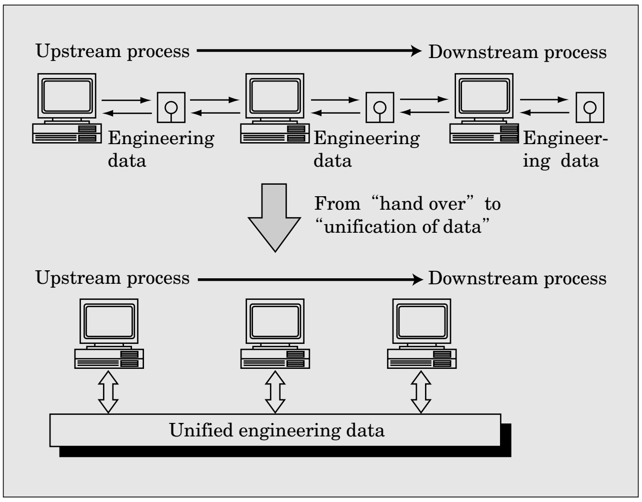
The elements which comprise information and control systems have highly distributed functions. These devices are closely linked to each other, forming a system. In an environment where engineering support for these elements is independently performed without integrated support for the total system, the engineering load increases. Therefore, there is an increasing need for the engineering environment to support the total system.

2.2.3 Information integrity among processes

The current engineering support system supports only a part of the total processes of the upper to lower process. Therefore, plural support systems must be used, each having a specific database for the processing and exchange of engineering data among these systems in order to perform a series of engineering tasks.

The current systems have some problems regarding "management" and "exchange" of information as a large amount of information is generated in the engineering task. Under "management", since information is separated and duplicated then managed in each group, recognition of updated data and information maintenance may be sometimes problematic. Under "exchange", information is not always exchanged smoothly among the groups, and there are some cases in which information is "handed over" to "management" (refer to Fig. 3).

Fig. 3 Unification of engineering information



2.2.4 Improving engineering efficiency and quality

The acceleration of the high-level functions, complexity and increasing software in information and control systems accompany the development of various technologies. These systems require a further improvement in engineering efficiency and quality. Especially required are:

(1) Improving software productivity and quality
(2) Shortening engineering lead time

3. The Integrated Engineering Support System

Fuji Electric has promoted the development of an integrated engineering support system to solve the problems of the support system, described above, and to improve efficiency and quality of engineering. Below is a summary of the integrated engineering support system.

3.1 Integration of the engineering environment

As described above, the current engineering support system consists of "points and lines". Therefore, in the newly developed integrated engineering support system, we achieved integration while aiming at the "support of plane" (see Fig. 4). Features of this integration are detailed below.

(1) An engineering environment able to support all control fields

This environment can unify the configuration of the system, which includes some control field. For example, engineering tasks for electrical control and instrumentation functions with the same user interface can be performed.

(2) An engineering environment able to support all engineering processes

This environment can support all engineering processes, from planning to system design to software design and programming to testing.

Fig. 4 Integration of the engineering environment

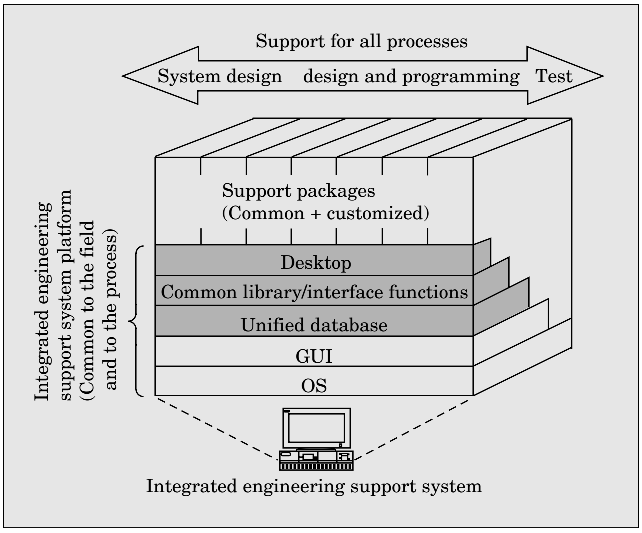
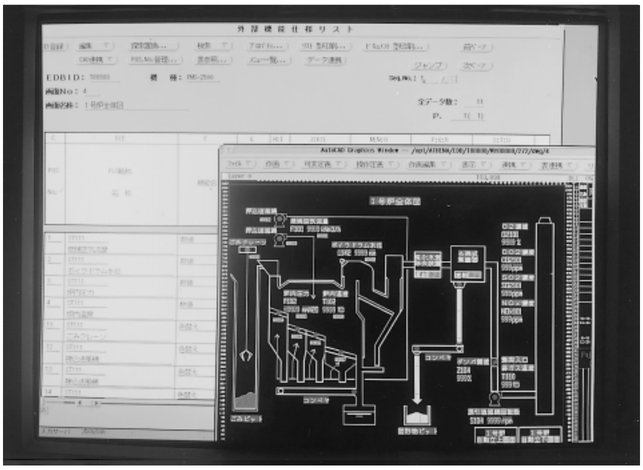


Fig. 5 Example of a worksheet for monitoring and operation function



(3) An engineering environment able to support various types of controllers

With the same user interface, this environment can support the electrical controller, instrumentation controller and operator station for monitoring and operation. An example in Fig. 5 shows a worksheet of the monitoring and operation function.

3.2 Unification of engineering information

It is effective to unify the engineering data to improve work efficiency. Unification solves various problems regarding "management" and "exchange" and contributes to the improvement of work efficiency.

The unification of information was realized by the RDB (relational database) and file server. However, an exclusive work function is required to maintain the integrity of the unified information, and this generally results in decreased work efficiency. Therefore, in this system, the unification of information is realized by minimizing and optimizing the unit of work exclusion.

3.3 Common platform

The hardware, basic software, database and desktop environments are configured as a common platform in all control fields so that all work can be conducted in a single working environment.

In particular, the databases are clearly separated into a common database for all control fields and a specific database for individual fields. The common database is made common up to the data table configuration. As a result, the unification of data is possible in systems having mixed control fields, as represented by EIC-integrated control system.

3.4 High-level function of specification descriptions

The aim of high-level functions is to improve productivity and quality of the control software. One of the factors that obstructs this aim is the human's understanding of the specification and expanding the detail of the system design processes in order to develop a software design specification from the control specification, program and test.

Fig. 6 Improvement of the specification description

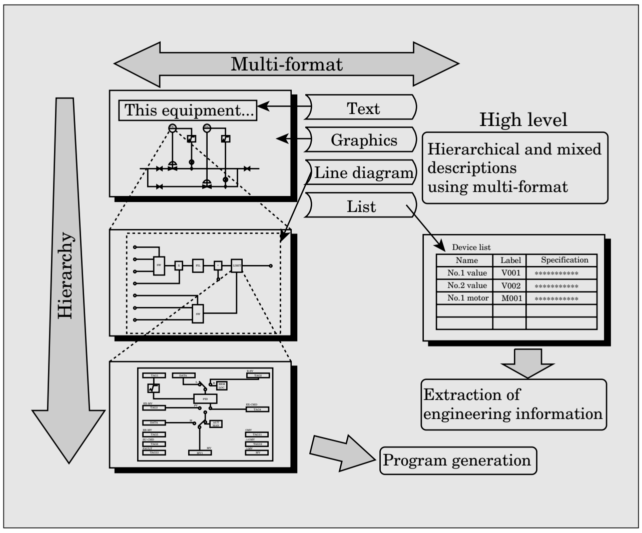
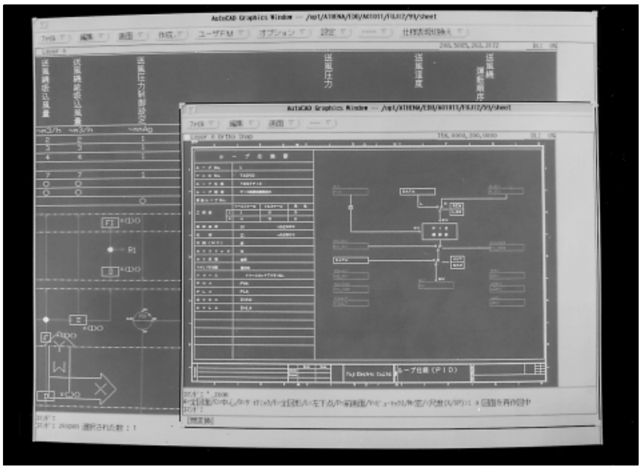


Fig. 7 Example of hierarchical description



Since there are a number of specification expressions and workers involved in the processes, it takes time to understand the specification, and a lack and misunderstanding of information are likely occurrences. These are the factors that obstruct improvement of software productivity and quality.

The integrated engineering support system removes these obstructions and aims to improve software productivity by improving work efficiency and quality by eliminating human error in one series of the works. As a result, the following functions are achieved:

(1) Improvement of the specification description

This is realized by improving expression of the specification description itself. The features introduced are hierarchical description and mixed description using a multi-format (see Fig. 6). Hierarchical description offers the user either a top-down or bottom-up environment. Mixed description improves expression of the specification as a document by utilizing a mixture of descriptions for text, graphics and lists. In

Fig. 7, an example of hierarchical description is shown.

Furthermore, in the conventional support system, the system design process required specified controllers or programs. In this support system, specification of the controllers or program is not required, reducing the user's work load.

(2) Automatic program generation from the specification description

This function automatically generates a program from a control specification, which is a document in the system design process, with an algorithm corresponding to the type of specification description (see Fig. 8).

With this function, the system design process, software design and programming process, and test process use the same expressions of specification. In addition, the human's role in understanding and expanding the specification is minimized. Therefore, software productivity and quality are improved.

There are several types of specification descriptions depending on the control fields, and this support system supports the expressions of data flow, switch flow, time chart, logic table, etc. Figure 9 shows an example of data flow.

In packages such as instrumentation flow and operation flow, the control specifications are made using the specification expressions listed above. A function that automatically generates a program from the control specification is also provided.

(3) Extraction of engineering information from the specification description

An automatic program generating function and an extraction of engineering information in a narrow sense, such as device ordering information, are possible in some specification descriptions, contributing to improved work efficiency.

Fig. 8 Automatic program generation from the specification description

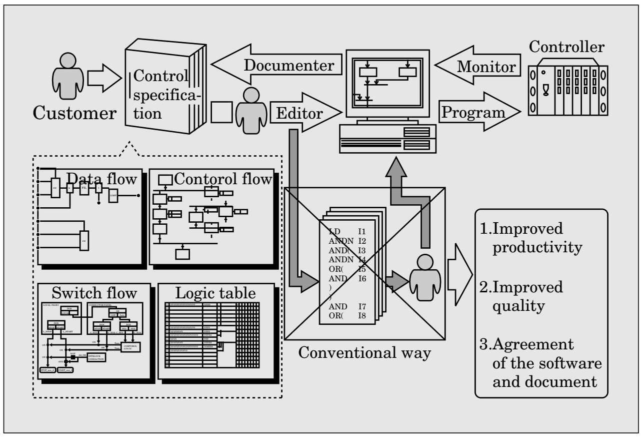
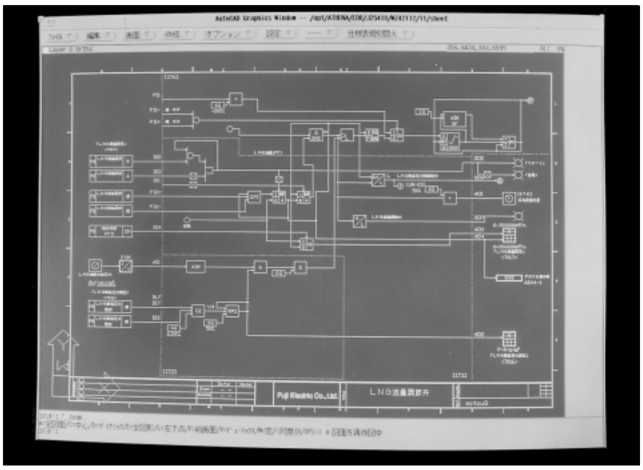


Fig. 9 An example of data flow



3.5 Group engineering environment

Many groups, such as system design, software design and programming and testing, participate in engineering tasks. Most of the work in these groups is occupied by intellectual work. Therefore, efficiency depends on manner in which the work is performed and without unnecessary work.

In the integrated engineering support system, an environment is created in which the users in each group can work closely together. Using unified engineering information, they are connected to other groups under the distributed environments, which are linked to each other via a network.

Such an engineering environment enables concurrent engineering by the groups and has a considerable effect in shortening lead time.

3.6 Software structure

Figure 10 shows the software structure of the integrated engineering support system. The structure has various support packages implemented on a platform of the integrated support system. Interface functions to the platform commonly used by the

Fig.10 Software structure

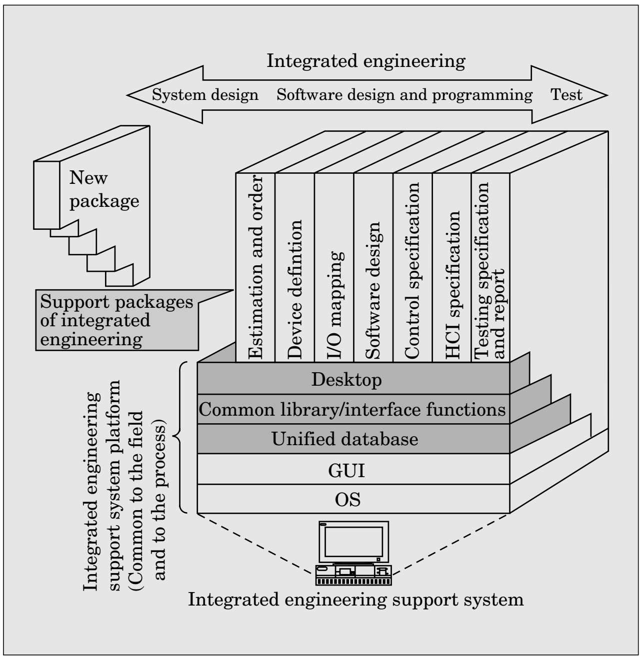
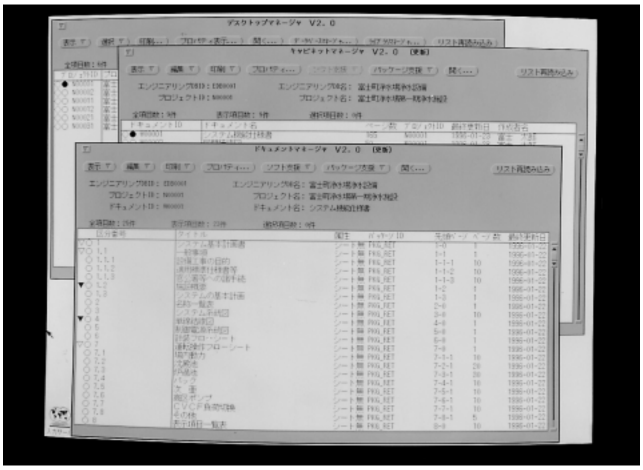


Fig.11 Desktop environment



packages are managed as a common library, improving development of the packages.

Since management of the engineering information is unified among these packages, the user can work regardless of data linkage and data integrity.

3.7 Desktop environment

The desktop environment is an interface between the user and the integrated engineering support system and presents a document management function for the user. In Fig. 11, an example of a screen is shown.

When beginning work, the user selects a project from the desktop environment, displays a list of documents for the project, and selects a desired document. Next, since a table of contents is displayed, the package is automatically started after the user selects the page to edit, and work is begun.

Since the table of contents itself has an editing function, the user can edit the contents of the document to move, copy and delete pages and easily change chapter configuration.

4. Future Engineering Environment Prospects

When considering future trends and prospects for the engineering environment, present ability to solve problems and the development of computer technology cannot be overlooked. After prolonged consideration of these two effects, we foresee following goals for the support system, detailed below.

4.1 From low-level to high-level support functions

From now on, the standard level of each support function will be gradually improved, step-by-step, in the engineering support functions.

For example, the following technical development actions will be taken in the design and test phases of the software:

(1) Support technology for “design”

Automatic design technology will progress remarkably. For example, the function which automatically generates a program directly from the control specification of an upper process document, with an algorithm responding to the format of the specification description, will reach a higher level.

(2) Support technology for “verification”

“Verification” is generally divided into “test” and “analysis”.

“Test” checks the functions of the configured system by trial and error, to verify whether the functions are performing as the designer intended. In this case, a high-level visual simulation, more functional than an actual test, is expected.

“Analysis” deductively and mathematically verifies whether an unsafe situation such as a deadlock or conflict occurs. The results of presently ongoing research are eagerly anticipated.

4.2 From specific to open system architecture

Rapid progress of software technology in personal computers and work stations will further change the architecture of the engineering support system. OLE (object linking and embedding) in Windows[*1] and CORBA (common object request broker architecture) in UNIX[*2] facilitate the configuration of the organically-integrated engineering support system by combining the individual support modules as software components, thus assuring a perfectly open environment. This open system environment enables a link with the software available on the market and realizes a flexible engineering support system that can be easily developed. From now on, many engineering support systems similar to these will begin to appear.

5. Conclusion

In this paper, we have described the current situation, problems to be addressed, the efforts of Fuji Electric and future prospects for the engineering support system. We at Fuji Electric developed the integrated engineering support system based on these prospects.

It is a well-known fact that the engineering support system is vital, and it is not too much to state that the support system determines the capabilities of the information and control system. The technology necessary for improving the support system environment is advancing remarkably. We endeavor to create a system having an improved environment for the user by applying this advanced technology.

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*1 Windows: A trademark of Microsoft Corp., USA

*2 UNIX : A registered trademark of X/Open Company Ltd.