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LORAN-T

Development and Application of a Newly Integrated CAD System

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ABSTRACT

Taisei Corporation (President : Yasuo Satomi) completed the development of the LORAN-T CAD system (Long Range Architectural Networking in Taisei) and is now using it for practical applications. Since April 1986, the Design and Proposal Division, the Building Construction Division, and the Information Systems Department of the Business Planning and Administration Division have been jointly working on the development of LORAN-T to its successful completion. LORAN-T is an integrated CAD system for building design with an architectural semantic model. It is used to serve those in programming and schematic design, planning, contract design, drafting, cost estimation and construction work.

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INTRODUCTION

With conventional CAD systems, it was necessary to repeatedly enter data because architectural design, structural design and utilities equipment design were either loosely integrated or not integrated at all. We faced many obstacles when trying to transfer data to different fields and in the latter stages when dealing with cost estimation and construction work.

Taisei believes that LORAN-T will change its traditional view on CADs for building designs. The newly-developed LORAN-T CAD system consists of an integrated three-dimensional (3-D) architectural semantic model database containing total building information on architectural, structural and utilities equipment designs. This integration, both vertically and horizontally, contributes not only to overall efficiency but also to the overall design quality.

Vertical integration is the relation among the phases of building design such as programming and schematic design, planning and contract design. Horizontal integration is the relation among the design areas such as architectural, structural and utilities equipment designs. In this way, data matching is maintained, overlapping of data entry is avoided and data transfers are speeded up. Thus, Taisei engineers can view a three-dimensional shape of underdesigning buildings at any time during the design process. We believe this will greatly contribute to the overall design quality.

Another advantage is that data can be easily shared with the design, the cost estimation and the construction departments through the intra-company network. Before starting construction, construction engineers can three-demensionally figure out the details of architectural, structural and utilities equipment designs. Therefore, we believe LORAN-T will shift CAD from that of being a auxiliary tool to that of an important tool. As an auxiliary tool CAD could only support partially the building design. But through LORAN-T, CAD becomes an important tool that supports not only the entire design phase but also the construction phase by utilizing design information systematically and quickly based on a consistent design construction system.

LORAN-T Features

1. The ability to share information among various design fields from the design phase to the cost estimation and construction phases by means of a common architectural database.
2. Once data is entered, it is automatically transferred (without overlapping) to be used for drawing, analysis simulation and cost estimation.
3. Large amounts of data such as machine catalogs, equipment specifications and general data, is included in the system.
4. Engineering Work Stations (EWSs) are distributed as unified units and connected to drafting CAD systems. Through the intra-company network, Engineering Work Stations can exchange data with other drafting CAD systems.
5. Through the intra-network system, other related systems (general-purpose computers, personal computers and graphic work stations) can also be effectively used.
6. By integrating the existing programs with newly developed programs, LORAN-T can easily be adapted to any program which will be helpful for future technological innovations.

LORAN-T System Configuration

This system is divided into the following categories.

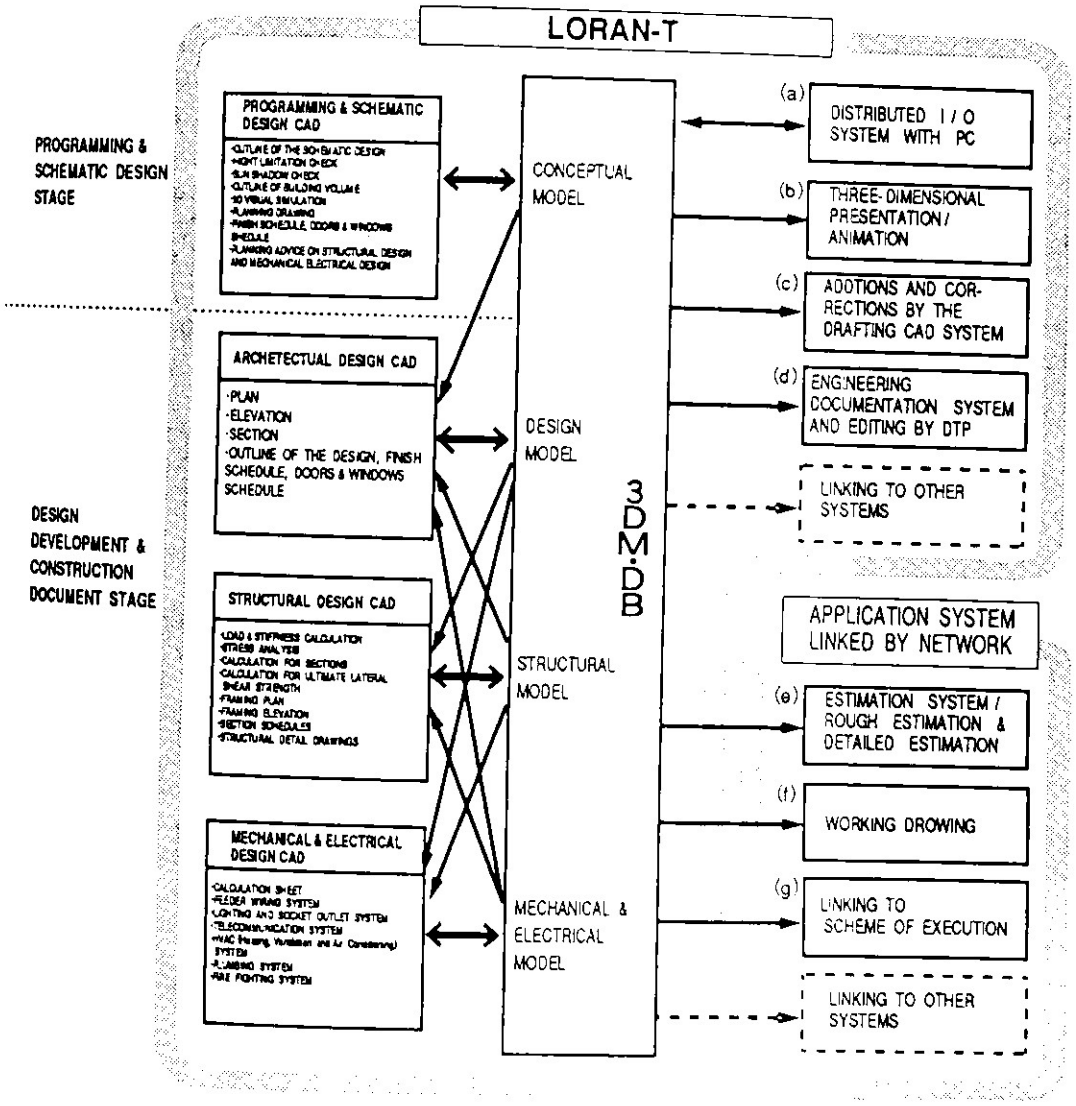
Ⓐ **Architectural CAD system by Engineering Work Station** (VAX/STATION 3100)

This is the trunk of the system. By gradually using upgraded Engineering Work Stations, integrated design can be achieved, from initial design phase to construction document phase. High-level design information can be produced and applied by being linked with several systems mainly used in the design division.

The network connects various Engineering Work Stations as a unit while keeping them properly distributed and connected among each other.

Ⓑ **Application system linked by network**

The system extracts the necessary data from the design information, then arranges and transfers the data to the related sections such as the cost estimation and construction departments through the network. Thus, the former problem of overlapping building data entries has been eliminated. As a result, the basis for applying CIC has been established. Taisei intends to expand gradually the linked application system such as construction CAE, CAM, construction robots.



Major subsystems

A-1 System using Engineering Work Stations

(1) Programming & Schematic Design CAD

For the programming & schematic design phase, LORAN-T includes SPIRIT, a system already in practical use at all of our branch offices. (The total number of SPIRIT-based applications between September 1983 through 1989 was 10,000.) The schematic design phase is linked with SPIRIT to develop schematic drawings, including basic plans. With this system, various planning simulations are possible, including space-requirement, cost estimation, and land spacing. Data produced in this phase are transferred to the Architectural design CAD via a common data base.

(2) Architectural Design CAD

The design model is put into the common data base to make it available to the Structural and Mechanical & Electrical design CAD. At the same time, based on the input, this system performs various evaluations and simulations, such as room-size calculations, evacuation calculations, precise-cost estimation, and automatically produces the drawings and documents necessary to prepare an application for construction approval (plan, elevation, section drawings, list of interior and exterior finishes, list of fittings, design specifications, etc.). With this system, special fields of concept development and structural and utilities equipment design can be integrated, based on a common architectural semantic model, so that sufficient compatibility is maintained and quick adaptation to design changes becomes possible.

(3) Structural Design CAD

Using the Structural design CAD, an experienced structural engineer adds structural components and attributes in an architectural semantic model to complete a structural model. With this system, it is possible to obtain the necessary data from the common data base at any time. The system has various structural-calculation programs which make possible to conduct detailed and precise simulations. The results of the simulations are automatically added to the structural model. It is also possible to produce structural calculation documents and structural drawings.

Thanks to the completion of this system, structural calculations and drafting work can now be conducted simultaneously, with no time lag. And prior to actual construction work, it is possible to perform a three-dimensional check on potential interference between structural components and equipment and to examine space extensions and the balance of the structural components.

(4) Mechanical & Electrical Design CAD

Based on the architectural semantic model that has a common-data structure shared by the design, structure, and utilities equipment fields, this CAD system can directly incorporate detailed data about mechanical and electrical equipment in a short time, while avoiding extra work after obtaining the basic architectural design. It can calculates various load factors related to the building under consideration, and accordingly develop the most appropriate mechanical and electrical equipment systems. It also determines the specifications of such equipment and parts. As a result, this system can produce mechanical and electrical drawings, calculation documents, and three-dimensional perspective drawings of equipment integrated with structural components.

This process contains a series of mechanical and electrical equipment design activities, including various calculations. This has been achieved not only by the employment of good, reliable application software, but also by the unique structural models and the systematic use of a huge general data set.

A-2 **System linked to EWS (mainly used in the design division)**

(a) Separate data input and drawing output by multiple personal computers

In the transition period before an Engineering Work Station is installed for each engineer, a number of inexpensive personal computers are installed and connected by a computer network system, and they are used exclusively for data input (Architectural design CAD and Structural design CAD) and for the output of drawings (structural plan).

(b) Visual three-dimensional presentation and animation

The architectural semantic model produced on Engineering Work Stations can be transferred to a three-dimensional display system to make a three-dimensional presentation and animation. At the same time, design simulations, including color control and analytical engineering simulations, including interference evaluations, can be conducted. Thus, advance evaluations are possible at any design stage.

(c) Additions, corrections, and editing by transferring to the drafting CAD

Drafting data can be transferred to GDS (General Drafting System) and a PC-based-CAD system by means of "MUSIC" which is a unique transfer system developed by Taisei Corporation in order to produce more detailed drawings as finalized plans. These drawing production activities can be performed in both decentralized and centralized ways.

(d) Standardized documents, such as structural calculation documents, can be submitted to the engineering documentation system for final editing. Finished documents based on the common data base can be produced automatically. In addition, this system performs a desktop publishing function, which can revise documentation formats and combine and edit drafting, image, and text data sets.

B. **Application systems linked to the network**

(Linked to systems used in the stages subsequent to the design process)

(e) Integrated cost estimation system

This system aims at combining a conventional cost-estimation method, based on hand-written drawings made in the architectural and utility equipment design phases, with calculations based on the data transferred from the common data base. With personal computers widely used at the construction sites, it is possible to obtain various forms and ledgers. The system is also linked to on-site accounting systems. When using the data transferred from the common data base, the quantitative calculation work, the so-called "pick-up" calculations, can be reduced by as much as 70%, and labor utilization become more efficient. The range of calculation is also expanded to include both rough and detailed estimates, thus providing support for quick cost estimation at the design stage.

(f) Production of execution documents (execution drawings, work schedules, and other application and registration forms)

With Engineering Work Stations, building data can be transferred via the computer network to the systems dedicated to execution work such an working-drawings production system. With this system, the work necessary for preliminary building data input (70% to 80% of the entire work load) can be almost entirely eliminated.

LORAN-T System Environment

Planning, architectural design, and analytical programs, as well as cost estimation systems were mostly developed originally by Taisei and have been put to practical use. The system environment is conceptualized as one in which duplicated data is eliminated, while at the same time making use of the above software packages flexibly in designing work. For the LORAN-T system, needs in the design process were carefully examined to develop our own system environment.

The following are the basic requirements for the LORAN-T system.

1. Arechitects and engineers can design a building through interactive data processing.
2. Design projects are accomplished through team effort.
3. Members of a design-project team, those in charge of architectural, structural and utilities equipment design, should be able to work at separate and distributed working stations.
4. Multiple cases and versions of building data should be available, and can be referred to, and their progress can be examined instantly.
5. A project data base should contain not only three-dimensional geometry data, but also attributes of building components and space configurations, so that special requirements and building components can be modified easily while maintaining overall integrity and coordination.
6. The newest data should be available regarding standard specifications, (doors and windows, finishing materials, utilities equipment catalogue data, etc.) and these data should be maintained properly and can be referred at any time, anywhere in the network.
7. Drafting data and documents are obtained from the three-dimensional model data base, and can be submitted to outside processing and other CAD systems to obtain the final version of a drawing. Data exchange and management system is necessary for this purpose.

Primary functions of the system environment are as follows :

(a) Three-dimensional architectural semantic model and object-oriented data base
(b) Distributed data processing by Engineering Work Station
(c) Project data base management
(d) General data base management
(e) Graphic data processing
(f) Drafting and documentation output
(g) Three-dimensional presentation, animation

The construction industry in Japan has just started employing Computer Integrated Construction systems and the level of its practical applications is still low when compared to other industries. However, labor shortage is a common problem in the entire construction industry, from the design phase through actual construction work, and it is expected that Computer Integrated Construction will soon be widely used. LORAN-T was developed foreseeing such urgent needs, and aims at establishing an expandable project data base that can meet such future needs. A configuration model of a planned building, information on the attributes of structural components, environmental information, and administrative information are defined as a project data base. Furthermore, common reference information necessary for producing project data is defined as a general data base. LORAN-T has employed a kernel-based data base, which has been jointly developed by Mitsubishi Real Estate Co. and Mitsubishi Electric Co. with the three-dimensional architectural semantic model. Taisei added its expertise as a general contractor to make a project data base for this system.

By the year 2000, Taisei intends to improve the new generation of CAD systems by applying key technologies (database, networks, etc.) for system construction and to apply practical Computer Integrated Construction, for example, data transmission to robots in the construction field.