CIFE CENTER FOR INTEGRATED FACILITY ENGINEERING

Technology Trends and Their Impact in the A/E/C Industry

Paul Teicholz

WORKING PAPER
Number 2

January, 1989

Stanford University

Technology Trends and Their Impact in The A/E/C Industry

Technology - General

Workstations

Workstations will become ubiquitous (1/desk). They will have sufficient power and graphics capability to enable them to be used for any CAD/CAE function (with the usual caveat for large scale finite element method (FEM) analysis).

Local Area Networks

All workstations will be connected to local area networks that will link members of project teams and staff departments. The LANs will be linked to each other and to wide area networks (WANs) to allow groups to share information with each other and with other data repositories. The speed of these connections will be adequate to permit online interaction regardless of location (with exceptions caused by slower overseas connections and communication problems in some countries).

Database

Database servers on LANs will have adequate capacity (giga bytes) to store the data for large projects. There will be three levels of databases: project, company, industry. The database and knowledge base at each level will be managed by the appropriate server (which may be remote). The project database will have many components under two major categories: engineering and administrative. The former will contain the graphic data, object data and reference data/knowledge for the project. The latter will contain the administrative control systems data/knowledge for the control systems used to manage the project. The role of mainframes as data repositories will decline as large scale servers with adequate channel capacity are developed. Database software and hardware will be developed to permit concurrent update from any workstation (user) that has approval for update for a given type of data. Provisions for controlling and logging updates will become standard so that change control can be carefully managed. Structured Query Language (SQL) will become the standard way to query and update relational databases, but graphical user interfaces will shield users from SQL. Standards will be developed for queries to graphic files that will permit queries from remote and different systems to be processed. Files from different systems will be easily translated to a neutral format in order to be communicated on a batch basis. online interaction between different systems will be handled either by standard interface requests (similar to SQL) or by an expert system interface that "understands" the data schema of each system.

Operating Systems (OS)

UNIX will become the standard operating system for engineering work. The IBM vs AT&T versions will be conformed. OS/2 will become an important OS for administrative applications. There will be difficulties in integrating these two environments until the merits and problems of each are better understood. This will tend to slow the integration of administrative and engineering personnel. My guess is that UNIX will carry the day because it is supported by a larger number of vendors.

Graphics

Graphics will become a standard way to use computers. There will be adequate resolution (at least 1028 x1028) and speed to display and manipulate 3D graphic models in real time. Use of color will become standard. Techniques to interpret stereo 3D will be perfected that will make it easier to have depth perception.

FAX/Scanners/Reproduction/Telephone

The workstation will become a link to all forms of communication & reproduction. These will share a digital communication link that may also handle the LAN in new buildings where fiber optics can replace twisted pairs. This will permit the phone, FAX, reproduction unit (xerox) and scanner to share the same links.

Design

Conceptual Design

The generation of conceptual design from user requirements will remain a major challenge. For plant design, where the rules are perhaps better defined than for other areas (say architecture practice), the use of expert systems may allow quick generation of prototype designs. Space layout (block diagramming) will be facilitated by expert systems that can reason about 3D space. In order to reduce construction cost, the design will reflect the tools and (automated) methods used in the field. All design areas will use the computer for simulation of conceptual (preliminary) designs, i.e. simulating how the design will "work" and the impact it will have on its environment. The environmental impact of a structure will be studied and perhaps presented using simulation models. This will facilitate interaction with the owner and outside agencies (permits, environmental impact, loans, etc.). The data generated during the conceptual design phase will be used to initiate downstream functions.

Detail Design

The process of detail design will be done by fewer engineers using CAD/CAE systems that will automate many of the lower level design functions. Engineering analysis will be completely integrated with the design applications so that analysis and design can be done interactively. Expert systems that are integrated into the design application will check for standards (rules, guidelines, etc.) in such areas as: building codes, company practice, constructibility, operability and maintainability. The end products of detail design will be a 3D graphic database, the object data about the structure (material codes, sizes, weights, etc.) and the knowledge base (specifications) for the project. From this information it should be able to develop a reasonable schedule and cost estimate using expert systems that are tailored to particular types of structures, Eg. high-rise office bldg, ammonia plants.

Construction

Bidding Process

The database created during the detail design process will be used to prepare the cost estimate. The material quantities can be extracted and combined with the construction productivity knowledge of the contractor. This knowledge can be captured in a company database and used with an expert system that will apply this data to a specific project. Estimators will review an estimate rather than starting from scratch. This should speed the generation of a bid and allow more time for thought about alternative work methods.

Procurement

The project database will be used to extract the bill of materials (quantities, descriptions, sizes, etc.). The date material is needed will be defined by relating work packages to schedule activities (also defined in the database). Thus, as changes are made to the design, the corresponding changes can be made to the bill of material and required delivery dates. The process of issuing requisitions and purchase orders will become electronic. Contractors, owners and vendors will use an "electronic market place" to issue and respond to requisitions, issue POs, arrange transportation and perhaps even financing. Standard material codes will be used in the design database to allow easy specification of material and tracking (via bar codes) after the material arrives at the site. Warehouses will use bar code scanners to receive and issue material. Computers will develop picking lists to pick the material for a given work package (perhaps using automated picking systems on large projects). Contractors will expedite material using electronic messages generated by the material system (in addition to the manually generated messages). Vendors will increasingly use their computers to link with the material requirements of the project to allow "just in time" delivery, thereby reducing lay down areas and cash investment in inventory.

Project Control

The project design database and knowledge base become the starting point for the cost, schedule, material control, change order and other control systems. These systems all have a common starting point, and all require a work breakdown structure (WBS) that is tied to the design (though they may not use the same WBS). Thus, changes to the 3D model and associated data will have their corresponding impact on these control systems. Graphic output will be used to relate the feedback from a control system, Eg. to show the activities on the critical path, to show which work packages have the required material on hand, to show the work performed by a given foreman which is over budget, etc. Graphic output will tend to replace printouts as the preferred mode of communication. Expert systems will be used to develop and critique project schedules (networks).

Field practice (work methods)

The use of a 3D model for walkthrough analysis will become standard practice for complex and/or fast moving projects. The same database will be used to control the movement of machines and robots that are used for material movement, pipe bending, fabrication, painting, etc. These tools will have digital controls that are fed from project specific data. Workers will be trained to control and repair these automated tools. There will be less need for unskilled workers and more for workers with robotics and computer user skills.

Facility Management

The "as built" database will become the starting point for the management and repair of the facility. Modifications to the facility over its useful lifetime will be recorded in this database so that the management systems will remain useful. Administrative systems used for normal maintenance, repair and chargeout (billings and rentals) will all be linked to this facility database.

Impact on Organization

Management

Technology will become a significant management issue for management. Some of the major issues will be:

.how to use technology to create a strategic advantage,
.how to organize so as to best take advantage of the capabilities of technology,
.what kind of work force will be needed,
.how to procure, train and retrain this work force (including managers at all levels),
.planning for the cost of technology,
.marketing of new skills and capabilities, and
.creating partnerships with clients and vendors that will exploit the advantages of technology.

Education and training will become significant planning and expense issues. There will be greater emphasis on research and development both within the firm and in partnership with universities. Foreign competition will continue to push the US industry towards greater use of technology.

Architects will increasingly integrate their design practice with other areas that can benefit from integration (planning, interior design, mechanical design, electrical design, facility management, etc.). Partnerships with other firms using the same CAD/CAE technology will be seen as an alternative to integrating these functions within one firm.

Design and construction firms will become more dependent on using and mastering technology. They will have R&D departments with a senior level manager. Owners with large building programs will have similar R&D efforts if they do facility design. Large owners that do not choose to support internal design functions will create partnerships with design and build firms that allow easy and frequent transfer of information (mostly electronic).

Integration of Function

The use of integrated design and construction databases will encourage firms to integrate these functions in order to gain competitive advantage. Architects will tend toward integration of design and engineering analysis (mechanical, electrical, structural). Plant design firms will tend towards design and construct. Alternatively, close partnerships will be formed between companies to allow them to better integrate their systems and thereby achieve greater efficiencies. Contracts will slowly change to permit improved integration and remove current barriers.

Impact on workers

As with other areas of automation, the impact is to favor the skilled over the unskilled worker. Therefore, it will be necessary to have training programs. Because of the large scope of this problem, training will be needed at many levels (union & company). Companies will turn to private industry and two year colleges to help with the training and education of workers.