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ELECTRONIC SIMULATION IN CONSTRUCTION

Construction Industry Institute

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Electronic Simulation in Construction

**Prepared by
The Construction Industry Institute
Electronic Simulation in Construction Research Team**

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Executive Summary

Owners, engineers, construction managers, and contractors face numerous problems throughout the life cycle of a project (i.e., planning, design, construction, start-up, operation, and maintenance). These problems include:

- Lack of comprehensive scope visualization and design review
- Constructability, maintainability, and operability issues
- Quality and safety issues
- Cost and schedule control problems

The main purpose of this research was to identify, analyze, and evaluate the current use of interactive electronic simulation in construction. The results highlight the benefits, limitations, and barriers of electronic simulation in heavy industrial construction, and also establishes the state-of-the-art, state-of-practice, and the state-of-R&D for electronic simulation in construction.

The Electronic Simulation in Construction Research Team believes that many areas and practically all types of projects could significantly benefit from the use of electronic simulation. The research team developed a decision aid to assist users in selecting the most appropriate electronic simulation technology for their use. That is described in CII Implementation Resource 154-2.

With 92 percent of survey respondents agreeing that electronic simulation technology adds value to the project management process, it will remain an important field of review, consideration, and implementation facing CII membership.

Introduction

Purpose

The purpose of this research was to identify, analyze, and evaluate the current use of interactive electronic simulation in construction (ESIC). Electronic simulation includes the following:

- *Spatial Visualization (3D-Static)*, which is the use of 3D CAD systems/tools for spatial visualization and analysis in contrast to simple 2D rendition. Example: 3D-Model Review
- *Virtual Interactive Environment (3D-Dynamic)*, which is the use of visualization systems/tools to present 3D objects or project plans into computer generated interactive virtual project environment for visualization, simulation, and analysis. Example: Animated 3D-Model Construction Sequence
- *Construction Process Simulation (mathematical models)*, which is the use of mathematical models/tools to simulate system interactions with an objective to forecast impacts, and determine activity bottlenecks, resource requirement, and productivity of the system or process. Example: Monte Carlo-based models, MicroCyclone, Stroboscope, and Symphony.
- *Integrated Simulation Environment*, which is the integration of 3D-Static, 3D-Dynamic, mathematical simulation models (as well as other project management software and databases) into an unified framework. This is done in a way that achieves seamless data transfer between the different systems and databases for the purpose of overall project management.

Objectives

The specific objectives of this research were to:

- Determine and evaluate existing technologies involved in interactive electronic simulation in construction.
- Develop procedures and recommendations on when to use and how and what type of technology to use.

Method/Approach

The research team believes that owners, engineers, construction managers, and contractors can strongly benefit from the use of electronic simulation in construction for mitigating the problems such as the ones mentioned earlier. The analysis of the data has been organized in an information matrix format for easy access and understanding. This information has been further analyzed to develop a decision aid for effective application of electronic simulation in construction.

To establish the state of electronic simulation in construction, an extensive review of existing literature and supplier product information was conducted, followed by three different questionnaire surveys and two case studies. Finally, the results obtained from the research were used to develop a decision aid to assist users in selecting the most appropriate electronic simulation technology for their use.

Assumptions/Constraints

The results of this research represent a “snapshot in time” of the-state of technology. The technology is rapidly changing and developing with additional improvements made by suppliers driven by the increased demands of the marketplace for more intuitive and functional solutions and systems. The software simulation developments over the past two decades have been driven primarily by the industry direction to what process needed the improvement. Initially, simulation programs and tools where developed to handle process technologies, then a period of extensive efforts were deployed to deliver systems and software improvements in the engineering design work process, more recently industry applications focusing on materials management and improved procurement processes have become more widely used. It is now recognized that the integration of all of this information will benefit the construction industry significantly. Technology suppliers are now beginning to address the specific requirements of an integrated engineering, procurement, and construction project work environment.

Data Analysis

Questionnaire

The questionnaire described earlier was mailed to all CII member companies. Forty responses were received from 28 companies, with six companies providing multiple responses. Multiple responses from a single company were distinct, as they were specific to the office that responded to the questionnaire. Figure 1 illustrates the level of usage of 3D CAD systems, Virtual Reality/Visualization Systems, Mathematical Simulation Systems, and Integrated Systems as indicated by the survey data.

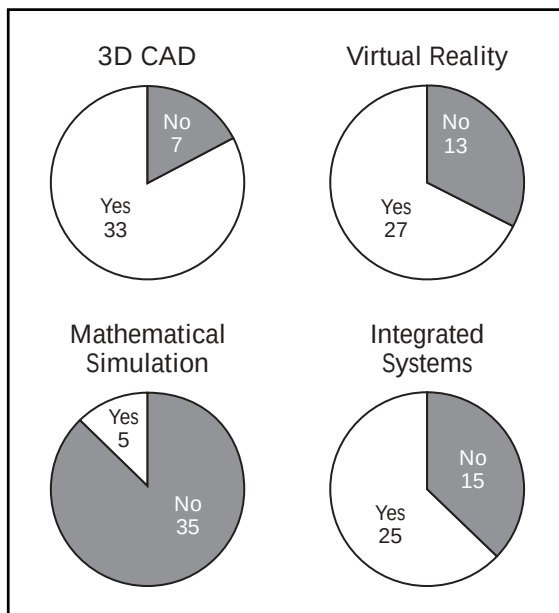


Figure 1. Level of Usage of Different Systems

Types of Organizations Responding

Different types of organizations responded to the questionnaire. Respondents included owners, architects/engineers, construction management contractors, construction contractors, consulting companies and others agencies such as government research labs, maintenance service providers, and design management specialists.

Types of Projects Performed by the Respondents

The primary project types performed by the responding companies included general building construction, transportation, manufacturing, industrial process, petroleum, power, environmental, and telecommunications. Other project types were chemical, gas processing, pulp and paper products, R&D materials, air vehicles, space vehicles, information technology, munitions, directed energy, sensors, propulsion, human effectiveness, warehousing, distributed facilities, biotech, food facilities and processes, and special purpose buildings.

CAD System Usage

CAD systems were used by about 82 percent of the respondents to the questionnaire. Intergraph (PDS) and AutoCAD were the most commonly used software by the respondents. See Figure 2 for the CAD products used. The Other category includes Pipe Master 3D on top of MicroStation, CADPIPE, Solid pipe designer, and MK 3D pipe plus.

Virtual Reality/Visualization Tools Usage

In this category, 67 percent of the respondents used some form of virtual reality/visualization tool. Around 38 percent of the respondents used Walk-through/3D design review while 27 percent used Digital cameras. See Figure 3 for the types of products used. The Other category included piping layout and structural analysis.