White Paper

1999 BERKELEY-STANFORD CE&M WORKSHOP: DEFINING A RESEARCH AGENDA FOR AEC PROCESS/PRODUCT DEVELOPMENT IN 2000 AND BEYOND

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The REALLY BIG Vision

Perhaps as no time before, the new millenium provides exciting opportunities for advancing fundamental changes throughout the entire product life cycle of constructed facilities. Revolutionary advances in technologies and the globalization of world markets are creating new economies. In turn, traditional business models are rapidly eroding to accommodate these changes. We as construction researchers must provide the vision and create the path for reshaping our industry to insure continued success in the new economy.

While this white paper focuses in the area of Construction Information Technology, I want to emphasize the critical need for appropriate environments for creating new knowledge. Much of the new economic models being created involved extensive collaboration of multi-faceted participants. We too, as a construction research community require a collaborative environment if we truly desire to move our industry forward. I propose that discussion begin on the development of formalized opportunities for collaboration. The development of National Centers of Excellence in Construction located throughout the U.S. could provide the appropriate environments for researchers of many disciplines to collaborate in the areas of project life cycle. These centers should be on-going, broad-based think tanks, attracting participation from a variety of industry and academic disciplines. O.K. maybe this is too large of first step. Perhaps a two-week summer institute where we come together for discussion of ideas is a more palatable start.

Now, on to a more focused vision….

The BIG Vision

Construction Information Technology will play a significant role in the creation of globally integrated engineering – construction workflow and collaborative environment. While CIT research in the areas of visualization, intelligent systems, process/product models, standards, and integrated environments continues at a furious pace, the implementation of CIT, particularly integrated environments, varies tremendously within our multifaceted, fragmented industry. Current trends within the Engineering-Procurement-Construction (EPC) arm of our industry suggests that the technical challenges of integrated environments are well on their way to being overcome.

Within the EPC, there is tremendous activity and advancement being made in the areas of automation and integration. Whether it is called Enterprise Product Process, Virtual Process Management, Product Process Management, or Fully Integrated and Automated

Project Processes, general trends are evident from listening to industry leaders and observing the focus at industry conferences during the past year. These trends include:

- Linking process Engineering and Conceptual Design w/ Plant Design:

  The integration of process models, cost estimates, and plant configurations conducted during preliminary design phases with 3D plant design systems provides improved understanding of design proposals. This results in increased collaboration among process designers and engineering disciplines.

- Integration of Preliminary Design Systems w/ Detail Design Software

  Reuse of preliminary design information during detailed engineering propagates continuity of design assumptions and improves accuracy of data throughout the detailed design process.

- Plant Life Cycle Computer Data Preservation

  Preserving full life cycle plant data improves operations, maintenance, and retrofit processes as well as future capital expenditure decisions. Currently there are no formal, accepted methods of documenting and storing life cycle plant data.

- Data Centric Approach

  Current integration efforts are focusing on data centric structures. As these systems mature and are implemented, changes in workflow philosophies will be required. Additionally, associated data and content management efforts are increasingly becoming central investment themes.

The trends in integration throughout the design process will continue to be a focus among EPC companies. The life-cycle focus will continue to extend integration efforts into construction and maintenance phases. These include:

- Data Warehousing
- Standards for Data Exchange
- Intranet/Web Applications

These trends and the overall movement in integration and attendant advances in information technologies will require organizations to pay particular attention to required changes in workflow and organizational issues.

The emergence fully integrated and automated projected processes created though IT will not only change the technical aspects of construction information technology, they will fundamentally change traditional business and economic models within the construction community. No longer will the flow of information be measured in bytes or bandwidth, but as Phillip Evans notes, information will now be unbundled from its physical carrier.

This separation of information and physical carrier has profound implications to the construction industry. Traditional hierarchical structures and proprietary information systems will cease to exist, as we know them. This in turn will change the vary nature of how construction projects are designed and constructed.

Correspondingly, the fundamental roles of engineers, designer, architects, and constructors will change. As John Voeller describes, interchangeable engineers, experts at a distance, and "net" designers will become integral participants in future design-construction organizations.

Fueled by advances in information technology, exciting and fundamental change in construction processes and organizations is guaranteed. This workshop and the vision of its participants will play a vital role in leading the change to a reshaped, integrated construction community.

A First Step

To address the vision of fully integrated and automated project processes, I have conceived a long-term career agenda entitled the Construction Information Technology for the 21st Century (*CIT 21*) project. The project's agenda is to investigate how the broad range of emerging technologies can and should be integrated into the construction industry, study the impact of such integration on communication, productivity, and processes, and provide state of the art knowledge transfer through innovative curricular development.

EnVISION is a specialized project developed within the larger *CIT 21* vision to specifically investigate the potential impact of web-based 3 dimensional (3D) animation of construction processes on project control. While scaleable to all aspects of project control, EnVISION focuses on public sector owner control of design-build projects.

Current methods of controlling public projects for design-build have been adopted from traditional project control techniques developed in the 1970's (Fleming 1983). The rapid increased use by public sector agencies, acute interest at the national level, availability of advanced technologies, and previous research indicate a critical need for developing new paradigms of project control for design-build projects. The proposed research contributes significantly to this need.

The goal of this study is to integrate and extend previous research in design-build and emerging technologies to develop a web-based 3D visual project control system (EnVISION) while addressing the goals of the larger *CIT 21* project. Specific research and education objectives include:

- Develop, test, and implement a new project control paradigm for public sector projects.
- Develop web-centric client server project control dissemination system.
- Identify critical control criteria which benchmark project performance and value added.

- Determine appropriate levels of granularity for 3D representation of construction projects.
- Analyze the impact of visualization on project control.
- Develop an integrated construction engineering and management curriculum.

Linking the "Vision" to Education

Many engineering educators share a vision for the future which includes dramatic restructuring and extensive use of new and emerging technologies. Restructuring in other areas such as corporate business and the military has often been driven by technological change (Ambach 1991, Hammer and Champy 1993). The same potential exists for engineering education.

Long term U.S. competitiveness in engineering hinges on successful incorporation of technologies into core engineering curriculum. Often, such incorporation does not allow modification of existing practices, only rework of existing models of communication, data, curricula, teaching, and learning. Recent work in educational technology demonstrates that merely adding technologies to a classroom does not ensure improved learning and understanding (Dwyer, Ringstaff, and Sandholtz 1991). The problem is much larger than awareness and access. Understanding how students learn engineering and developing technology-based curriculum to encourage meaningful learning are critical.

My overall educational plan is to develop an integrated curriculum for the construction management program in the Department of Civil, Environmental, and Architectural Engineering. Using existing curricula as a foundation, the new curriculum will integrate the research results using emerging technologies into an integrated learning environment for undergraduate and graduate students. The curriculum will provide students with continuity among topics and tools introduced in a number of different classes. I envision developing a curriculum which provides a "cradle to grave" continuum for student learning of the construction process.

CIT 21 will create rich conceptual understandings in project planning and control as it expands resources and hands-on problem solving situations available to students. EnVISION will be the foundation of meaningful problem solving mirroring actual project planners and controllers domains.

The underlying theoretical perspectives driving the cognitive emphasis of *CIT 21* are influenced by Piaget (Inhelder & Piaget, 1958) and Vygotsky (1978). These constructivists consider that to know is to construct knowledge through effort to make sense of one's interactions with the world. Under this concept, focus should be placed on the ideas and understandings students bring to the learning situation and the mechanisms that determine the pace of cognitive processes. The *CIT 21* project incorporates this ideology in the development of curricular units which recognize students' intuitive ideas in project planning and control, provides a series of problem solving activities that help students integrate related concepts and encourages appropriate inquiry and questioning

through prediction-making and reflection activities. Two mechanisms which guide this process are collaborative and project-based learning.

The education link emphasizes knowledge integration. Traditional engineering instruction (much like our research models) commonly encourages the over specialization of ideas rather than the integration of related ideas. This leads to compartmentalization of knowledge and often the belief that engineering courses and real life engineering are not governed by the same principles. *CIT 21* at the curriculum level and EnVISION at the course level will explicitly address the integration of theory and experience.

Well, that's the Vision Thing. If you've got this far, Thanks! I would truly like to see a National agenda established which provides adequate resources and collaborative environments for the construction research community.