2009 BFRL Project Description

Project Title: Virtual Project Data Integration Testbed

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BFRL Program: CONSIAT: Construction Integration and Automation Technologies

Objective: Develop methods, specifications and test cases for evaluating and extending protocols for enabling the exchange, access and integration of construction project data. Investigate the measurement science challenges for improving construction productivity with the integration of information, communication and automation technologies.

Problem:

What is the problem? Although many architecture, engineering and construction organizations have adopted aspects of 3D modeling and information management technologies in the design and project documentation phase of construction projects, the capabilities and benefits of these technologies are not being exploited to leverage potential advancements in cross-functional integration, modularization, fabrication, pre-assembly and construction work packaging. The digital exchange and integration of design models, equipment specifications, construction plans and related information is impeded, in most cases, by the absence of consistent vocabularies, identifiers and encoding formats for data used by the organizations involved.

Industry studies have identified inefficiencies ranging from 25 percent to 50 percent in current methods for coordinating labor and managing, moving and installing construction materials.[1,2] Leading industry groups, such as the Construction Industry Institute (CII),[3] Construction Users Roundtable (CURT) and FIATECH,[4] have identified the critical need for fully integrating and automating construction processes. The measurement science for realizing breakthrough improvements in construction productivity does not exist. Additionally, the enabling measurement science is lacking for enabling automated access to and integration of diverse information systems;

Why is it hard to solve? The problem is hard to solve because the foundational measurement science for semantic analysis and the codification of information requirements into data exchange and integration specifications is missing. Compounding the challenge are the

[1] Tulacz, G. and Armistead, T., "The Top Owners - Large Corporations Are Attempting to Meet the Industry Halfway on Issues of Staff Shortages and Risk," Engineering News-Record, November 26, 2007.
[2] Nimmo, P. and Daneshgari, P, "Ideal Jobsite Inventory Levels to Improve Productivity," Electri'21 Report, 2005.
[3] Construction Industry Institute, *Strategic Plan*, Austin, TX, 2005.
[4] FIATECH, Capital Projects Technology Roadmapping Initiative, Austin, TX, October 2004.

complexity of the building information models and construction projects, the broad mixture of different disciplines and vocabularies which must be accommodated, and the increasing intricacy of specialized software applications and information management practices employed in construction projects.

How is it solved today, and by whom? The problem is not solved. The measurement science required to solve this problem does not currently exist. A few universities[5] and industry organizations[6] are investigating ways to improve interoperability. Other OUs at NIST are working on aspects of these problems for other industries, e.g., electronics, health care and manufacturing. None of these programs have delivered the necessary measurement science to support the semantic analysis and integration for the evolving federated information infrastructure for the construction industry. In Europe and Asia, governments are funding major initiatives[7,8] to advance their industries' capabilities in integrated and automated construction. None of these efforts has addressed the need for the enabling measurement science, performance metrics, and an integrated approach to their application.

Why NIST? This project addresses BFRL's core mission to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology. This project supports the BFRL strategic priority for measurement science for breakthrough improvements in construction productivity and the BFRL core competency in information, communication and automation technologies for intelligent integration of building design, construction and operation. BFRL is uniquely qualified in pursuing this research due to its involvement and understanding of product data standards such as ISO 10303 (STEP), IFCs and CIS/2, its interactions with the International Alliance for Interoperability (IAI), the National Building Information Modeling Standard (NBIMS), many CAD software vendors that have implemented product data models, and end-users of those data exchange specifications and its earlier work on developing and validating date exchange specifications.

Approach:

What is the new technical idea? BFRL will investigate model-based approaches to developing and testing data exchange and integration specifications, advancements in semantic analysis and methods for characterizing and harmonizing construction industry data models and vocabularies. BFRL will develop methods, tools and test suites to validate draft information exchange and integration protocols for different construction project scenarios. BFRL will demonstrate the rigor and value of these new methods and will work with standards organizations to ensure applicability.

Why can we succeed now? With the increased focus on building information modeling, interoperability, and construction productivity, and the increasing capabilities and variety of software applications being used for construction projects, the construction industry is

[5] e.g., Carnegie-Mellon University, Stanford University, Virginia Tech, University of Texas at Austin, University of Waterloo.
[6] e.g., CII, CURT, FIATECH, International Association for Automation and Robotics in Construction.
[7] *Strategic Actions for Realising the Vision of Information and Communication Technologies in Construction (Strat-CON)*, VTT Technical Research Center of Finland, www.strat-con.org.
[8] *European Construction Technology Platform* and *EUREKABuild*, www.ectp.org

demanding reliable and repeatable data exchange and integration. BFRL is collaborating with ITL and MEL to adopt and extend the relevant results from their work to these challenges.

What is the research plan? BFRL will investigate and extend different approaches for semantic analysis, data model characterization and developing data dictionaries for integrating building modeling systems, project execution systems and the evolving federated network of information resources. BFRL has established collaboration and testing agreements with industry organizations to apply this research to accelerating the development, testing and deployment of interoperability and integration methods and tools. BFRL will work with standards organizations to assess the applicability of the developed methods. BFRL will work with the National Academies to conduct an industry workshop on Advancing the Productivity and Competitiveness of the U.S. Construction Industry and will provide support to the National Academies panel as they conduct this investigation and produce a final report.

Recent Results:

Outcome: Published AEX (Automating Equipment Information Exchange) version 2.0 XML schemas for exchanging engineering information on numerous types of mechanical equipment and the corresponding equipment data sheets.
Output: AEX interoperability demonstrations among multiple software applications at numerous industry conferences.
Impact: Hydraulic Institute, American Petroleum Institute/Subcommittee on Mechanical Equipment and American Society of Mechanical Engineers/ ASME B.73) adopted the AEX specifications as the basis for their electronic data exchange standards.
Impact: Electric Power Research Institute adopted NIST methods (AEX methods and schemas) and information handover guidelines for the Advanced Nuclear Technology Program: Configuration Management of 3-D Models, Associated Databases and Documents/Records.

Anticipated Results:

Output: Lipman, R., "Details of the Mapping Between the CIS/2 and IFC Product Data Models for Structural Steel", Journal of Information Technology in Construction, submitted March 2008.

Impact: Industry adoption of the methods and tools for conformance testing enables the reliable selection and integration of new software tools and streamlined processes for breakthrough improvements in construction productivity.

Standards and Codes: The direct impact of the research will be improvements in the measurement for conformance assessment and test suites and files used in the construction industry data exchange standards such as IFC and CIS/2. Staff participates in many committees related to those standards.