




CURT

THE CONSTRUCTION USERS ROUNDTABLE

"THE OWNERS VOICE TO THE CONSTRUCTION INDUSTRY"



**Collaboration,
Integrated Information,
and the Project Lifecycle
in Building Design,
Construction and
Operation**

WP-1202
August 2004

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Collaboration, Integrated Information and the Project Lifecycle in Building Design, Construction and Operation

Presented by the Architectural/Engineering
Productivity Committee of
The Construction Users Roundtable (CURT)

WP-1202 August 2004

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Notice:

The purpose of this publication is to make available to industry the results of research and common owner practices. The information is provided solely for the individual consideration and education of CURT members and the industry. The publication does not necessarily represent the views of every CURT member company on this topic. The booklet is offered as an informational publication only. CURT intends only to synthesize current thought and trends concerning the topic. Neither CURT nor its committees make any warranty as to the completeness regarding the materials. Readers are encouraged to further research the topic before relying exclusively on these materials. Each CURT member and other readers of these materials are free, acting in its own discretion and its own perception of business self-interest, to reject or adopt the recommendations in whole or in part. Adoption and/or reliance upon these recommendations is strictly voluntary.

The Mission of The Construction Users Roundtable (CURT) is to promote cost effectiveness for owners doing business in the United States by providing aggressive leadership on issues that will significantly improve project engineering, maintenance and construction processes, thereby creating value for the owners.

1. Abstract

The Architectural/Engineering (AE) Productivity Committee, comprised of representatives from the architectural, engineering, construction, building management, and operations, technology and building products industries, was convened by The Construction Users Roundtable (CURT) to address the perception of inadequate, poorly coordinated AE drawings and the resulting difficulties in the field. (For a list of CURT AE Productivity Committee participants, see page 14.)

Building owners, particularly those represented within CURT, regularly experience project schedule and cost overruns. As a result, CURT has directed this task force to evaluate how alternative processes—namely, use of information technology combined with changes in project structure and delivery processes—might address these issues. In its initial incarnation, this task force was asked to exclusively address the question of coordination, errors and omissions, and similar quality challenges in AEC documents and processes. After much discussion, it was agreed that these issues are symptoms of the larger issues identified in this paper, and that the larger root causes of quality issues with the AEC production process would be best addressed with the recommendations contained in this paper.

The goal of everyone in the industry should be better, faster, more capable project delivery created by fully integrated, collaborative teams. Owners must be the ones to drive this change, by leading the creation of collaborative, cross-functional teams comprised of design, construction, and facility management professionals.

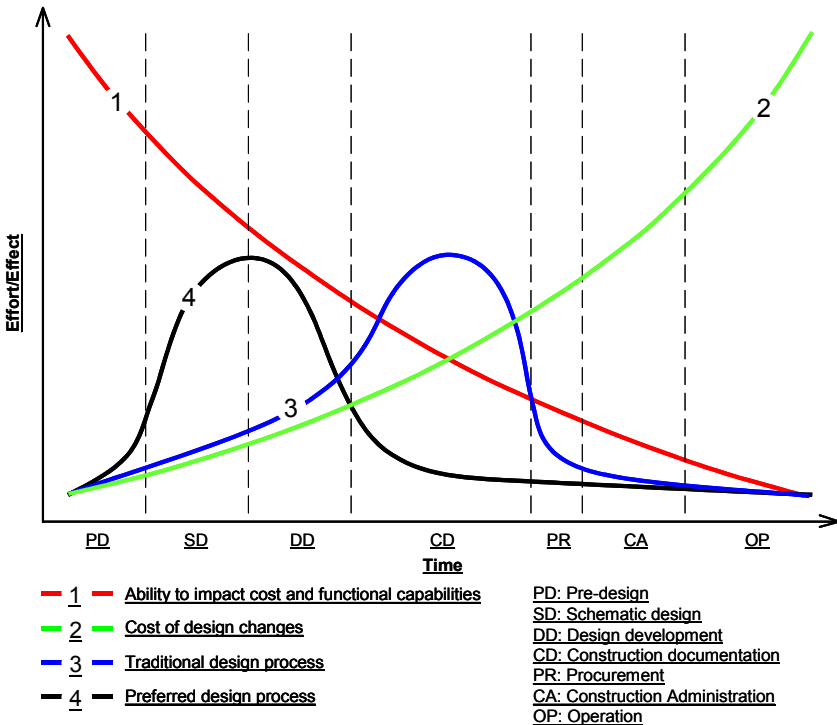
The Committee concluded that the difficulties experienced in typical construction projects, including those identified by CURT members, are artifacts of a construction process fraught by lack of cooperation and poor information integration. The goal of everyone in the industry should be better, faster, more capable project delivery created by fully integrated, collaborative teams. Owners must be the ones to drive this change, by leading the creation of collaborative, cross-functional teams comprised of design, construction, and facility management professionals. Toward that end, the Committee makes four recommendations and articulates a vision of the future. The following recommendations have been endorsed by CURT as a framework for articulating new policy, procedures, and standards for the construction industry.

2. Recommendations

The Committee proposes the following four elements of a new policy framework for CURT:

1. **Owner Leadership: Owners, as the integrating influence in the building process, must engage in and demand that collaborative teams openly share information and use appropriate technology. CURT should establish policy and procedures for implementing change in the AEC industry and encourage other building owner organizations to join the effort:**
 - ▲ Owners are generally unaware of—or actively discourage—full project collaboration as described here, and the AEC industry has failed to communicate the benefits of new processes like those recommended by the Committee. This inertia is caused in part by long-standing industry traditions, combined with the fragmented supply chain that characterizes most building projects. For example, in traditional building projects, design and construction teams form, execute a project, and then dissolve, rarely working together as a whole again. Thus, in addition to every building being unique, every project team is unique. That means learnings from a project are only carried forward in a fragmented way to the future projects.
 - ▲ Frequently deferring to traditional approaches and roles, owners delegate responsibility for organizing and driving project processes to other parties and have not been assertive in demanding new, improved processes that yield better results.

Opportunity: Owners driving full collaboration through information sharing early in the project process are most likely to achieve the desired outcomes: fast, efficient, effective, and cost-bound buildings. Such collaboration shifts the bulk of analysis, design, and decision-making earlier in the design process, giving the collaborators maximum opportunity for good decisions. This concept is shown in the following diagram.



Owners driving full collaboration through information sharing early in the project process are most likely to achieve the desired outcomes: fast, efficient, effective, and cost-bound buildings.

The diagram illustrates four important concepts about the relationship of design effort/cost (Y axis) and the traditional phases of design and construction (X axis), with each concept depicted by a different type of line:

- ▲ The red line (line 1) represents the team's decreasing ability to affect project variables such as cost, schedule, and functional capability as the project progresses.
- ▲ The green line (line 2) shows how the cost of making changes dramatically increases as the project progresses. In the manufacturing industry, it is generally accepted that these costs increase ten-fold as you transition from design to procurement to fabrication.
- ▲ The blue line (line 3) represents the distribution of design effort in a traditional building project, when design information is developed most substantially in the construction document phase.
- ▲ The black line (line 4) suggests a new distribution of design effort under a full collaboration model, where substantial information is collected, integrated, and documented earlier in the design process due in part to the input and collaboration of all stakeholders. The red line depicts the critical concept of earliest possible decision-making to maximize the ability to effect change and minimize the potential cost of design changes (particularly those caused by mis-integration of design information).

Opportunity: Early depiction, analysis, and decision-making in the building process are the best hopes for improving the conditions that lead to the recommendations implicit in the red line. Using the enabling possibilities of technology to document, visualize, integrate, and coordinate project information, dramatic possibilities for improvement in the building process could include:

- ▲ Accountability: Selecting the proper collaborator to make and implement project decisions supports collective responsibility for project success.
- ▲ Project scope: Conducting early analysis of design strategies and understanding resulting implications stabilizes project scope and large-scale decisions accordingly.
- ▲ Schedule: Virtual buildings created in a fully collaborative environment support construction sequence, means and methods, and procurement evaluation, yielding better schedule analysis and decisions and, as a result, faster construction.
- ▲ Quality: Early decision-making supports proper allocation of resources, more accurate cost modeling, and results in more integrated designs of higher quality.
- ▲ Reduced cost: Building information models created by fully collaborative teams create the best chances for finding expensive mistakes; optimizing systems, materials, and other design strategies; and reducing the costs of building and building operations.

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- ▲ Performance/sustainability: Digital design information assembled early provides the maximum opportunity to understand the effects of material selection, energy consumption, site impact and supports optimum decision-making in related issues.
 - ▲ Operability and maintainability: Digital design information that supports construction has an extensible life that can support building operation, management, and ownership.
2. **Integrated Project Structure**: The building process cannot be optimized without full collaboration among all members of the design/build/own project. CURT and other owner organizations should establish policies that support such collaboration. Issues to address include:
- ▲ Current project organization, characterized by operational silos between design, procurement, construction, and ownership, is a barrier to collaboration, because each participant optimizes for its own interest rather than that of the overall project.
 - ▲ Risk aversion, framed by current legal and insurance requirements, drives this non-collaborative behavior dramatically.
 - ▲ Current contract models, based on traditional practices, institutionalize non-collaborative approaches, perpetuating standards that do not value collaboration.
 - ▲ Business models and related compensation to the parties do not encourage or support collaboration. For example, digital design information that could directly support cost estimating, preparation of shop drawings, or fabrication is intentionally omitted by the design team in order to minimize liability exposure.

Opportunity: Expanding project teams to include designers, contractors, suppliers, manufacturers, facility managers, etc., with all participants adopting a systems approach to project execution, would result in true collaboration in the best interest of the project. (For a provocative discussion of such an approach, see *Refabricating Architecture*, by Kiernan and Timberlake [McGraw Hill 2004].)

Project collaboration must be characterized by open, timely, and reliable information sharing.

3. **Open Information Sharing:** Project collaboration must be characterized by open, timely, and reliable information sharing. CURT should advocate the establishment of procedures and protocols to achieve this end. Issues to address include:
 - ▲ Project information, bound by current standards of practice, remains in individual silos established by project participants (see page 3) and does not effectively cross boundaries between design, fabrication, and construction or building operation. Current delivery methods require the recreation of project data at each transition in the project lifecycle, and sharing such information is discouraged.
 - ▲ The fragmented nature of building projects—where design and construction teams form for a single project and then dissolve—emphasizes the discontinuous nature of the building design and construction supply chain and discourages steadily increasing project knowledge.

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- ▲ The AEC industry lacks broadly adopted standards for organizing and sharing comprehensive project information during a building project. While certain standards have been developed (such as IAI IFCs), their adoption has been slow, and thus benefits have not been demonstrable to building owners.
 - ▲ Current technology is optimized for individual project procedures and tasks, rather than for providing digital data that can support the entire building lifecycle.
 - ▲ Current liability management standards and resulting practices discourage integration of project information for numerous reasons, including the reluctance to share unresolved or incomplete information prior to formal release.

Opportunity: Better, faster, and more cost-effective projects can be achieved by eliminating artificial boundaries between team members to promote full information sharing. This will require adjusting current risk allocation and compensation models to allow more flexible arrangements for collaboration that fairly balance responsibility with compensation. Once barriers to sharing are eliminated, earlier and smarter design decisions will yield better, more accurate deliverables and cost models. Data transaction standards, supported by building owners, will begin to benefit the industry in general and owners in particular. Systems design will improve with early inception during project conceptualization, better coordinated design strategies will come into focus faster, and less time will be spent in the field resolving conflicts resulting from information partitions. Kiernan and Timberlake refer to the concept of “joints” between design and fabrication elements. The more individual, partitioned elements of design and construction there are, the more intersections required, and the higher likelihood of mis-coordination or mis-fitting.

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4. **Virtual Building Information Models:** Effectively designed and deployed information technology will support full collaboration and information sharing and will lead to a more effective design/build/manage process. CURT should endorse establishing technology-based project lifecycles that optimize the creation, interaction, and transport of digital information throughout the building process.
- ▲ Collaboration technologies, supported by endorsed industry standards, are new in the building industry, and should be supported to drive widespread adoption. Without adoption, these technologies will not reach maturity and, therefore, will not be able to support full collaboration with digital design data.
 - ▲ Existing data standards for digital project collaboration are not widely adopted nor tested. Such standards should be encouraged and validated.
 - ▲ It is generally accepted that as much as 30% of the cost of construction is wasted in the field due to coordination errors, wasted materials, labor inefficiencies, and other problems in the current construction approach. (For further information on this analysis, see www.m4i.org.)
 - ▲ Current technologies focus on solving discrete project tasks, and lack of substantive interoperability limits the ability for digital building information to support the building lifecycle. While there is limited interoperability within individual project silos (design, build, and manage) there is no project-wide standard for distributing and consuming project data.

Opportunity: Adjacent industries such as manufacturing demonstrate that technology can support full project collaboration, but technology providers must respond to the demands of the marketplace. Technology creates multiple avenues for improved project understanding and integrated design, manufacturing, and construction through model-based virtual prototyping. Creating “digital buildings” that can be resolved and coordinated, and using the resulting building information to discover and eliminate errors, will achieve the goals of delivering faster, cheaper, and more suitable buildings.

3. Vision Statement

The AE Productivity Committee envisions a building environment substantially changed in the future, where building projects are undertaken by deeply collaborative teams that include all disciplines that contribute to project fruition, and where better, faster, more capable buildings are the norm rather than the exception. This new building environment, where owners demand higher-performing AEC teams, requires fundamental changes and is characterized by the following:

- ▲ Owners are fully engaged in the virtual design process and are empowered to make informed decisions early, using building information models and collaboration technologies as a decision-support system. Such systems, created to maximize understanding early in the project, are comprised of building models from which construction documentation is extracted. Vital building information achieves continuity throughout design and construction by persisting in the building information model, and decisions are facilitated using representations that owners understand (as opposed to the traditional tools of orthographic projections like plan, section, and elevation).

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- ▲ Virtual design, analysis, fabrication, and construction become the standard approach for building much the same way 3D parametric modeling and the resulting digital information are the backbone of modern manufacturing processes.
 - ▲ Information created by the collaborative team flows quickly, effectively, and freely amongst project participants, each of whom shares a stake in the outcome and shares in the resulting rewards. Impediments to information sharing are thus shattered by new standards of care, contracts, and business models. (This approach mirrors characteristics of the Project Alliance delivery model currently being tested in Australia.)
 - ▲ Digital information created by the collaborative team flows throughout the lifecycle of the building project, emanating from the building information model that has virtually constructed the building before construction commences and supports its operation throughout its life. The information permeates every aspect of the building's lifecycle.
 - ▲ Building infrastructure systems are designed concurrently with architecture (rather than using linear, asynchronous design), and the two are integrated with fundamental design intent.

CURT has adopted this vision of the future and supports the efforts to establish the necessary framework procedures and standards (including standard performance specifications and measurements of success) to test and validate these recommendations. These actions will create the opportunity for necessary change in the building industry.

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4. Moving Forward

The AE Productivity Committee suggests that these recommendations form the basis of further study under CURT leadership. Recommendations 1 and 2 should be further studied, evaluated, and documented by the Committee. Recommendations 3 and 4 should be delegated to adjacent co-participants (such as professional associations and/or technology and product providers) under appropriate Memoranda of Understanding.

Members of AEC Productivity Committee

Gertraud Breitkopf, Chairperson	General Services Administration (GSA)
Micheal Alianza	Intel Corporation
Norman Koonce	American Institute of Architects (AIA)
James Dinegar	American Institute of Architects (AIA)
Richard Allen	Gadsby Hanna – representing American Society of Civil Engineers (ASCE)
Patrick Natale	American Society of Civil Engineers (ASCE)
Harry Mashburn	Mashburn Construction -representing Associated General Contractors (AGC)
David Lukens	Associated General Contractors (AGC)
David Harris	National Institute of Building Sciences (NIBS)
Ric Jackson	FIATECH
Martin Fischer	Center for Integrated Facility Engineering (CIFE) – Stanford University
Patrick MacLeamy	HOK
Ashok Raiji	Arup
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William Skinner	A/E Data Integration
Gregory Bentley	Bentley Systems
Brad Workman	Bentley System
Philip Bernstein	Autodesk
Jason Winstanley	Autodesk
Mark Sawyer	Graphisoft USA
Norbert Young	McGraw-Hill Construction - representing International Alliance for Interoperability (IAI)

Construction User Roundtable Publications

The purpose of developing Construction User Roundtable (CURT) publications is to disseminate recommendations, guidelines, and reports developed by the Construction Users Roundtable. CURT is focused on improving the cost effectiveness of the U.S. construction industry. These publications have been developed from the point of view of owners or users of construction services. Efforts by all segments of the industry, however, are vital if major improvement is to be the result.

This publication is one of a series from committees or study teams addressing a problem area.

Findings and recommendations of The Construction Users Roundtable are included in publication series classified as White Papers (WP), Reports (R), or User Practices (UP). In addition to these classifications, CURT publications are numbered based on the category of the topic:

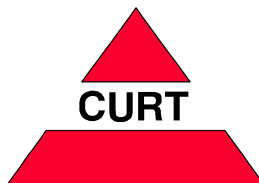
Category	Number Code
Constructability	011 to 099
Contractor Management	101 to 199
Cost	201 to 299
Interface Management	301 to 399
Workforce/Industrial Relations	401 to 499
Material Control	501 to 599
Purchasing	601 to 699
Quality	701 to 799
Safety	801 to 899
Security	901 to 999
Strategy	1001 to 1009
Work Planning and Scheduling	1101 to 1199
Technology/E-Sourcing	1201 to 1299
Special Projects	2001 to 2099

Examples:

WP-1201: A CURT White Paper on Reverse Auction

R-402: A CURT Report on Tripartite Initiatives

UP-801: A CURT User Practice on Construction Safety in Contractor Prequalification



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