Conceptual Design, BIM and Interdisciplinary Collaboration

By William C. Manion, AIA

A basic premise of a building information model (BIM), as defined by the *National BIM Standard-United States®* (NBIM-US™), is "collaboration by different stakeholders at different phases in the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder."

For BIM projects in the United States, does that basic premise hold true during the concept-design phase?[1] Historically, concept design has primarily been the responsibility of the architect. It is during concept design when decisions have the largest impact on project direction.[2][3] Is collaboration a goal? What degree of collaboration do BIM participants perceive is achieved during the concept design? And, what are perceived impediments to collaboration?

These were some of the research questions addressed as part of a Masters thesis for the University of Cambridge (UK) Interdisciplinary Design for the Building Environment (IDBE) Programme. The research was exploratory, rather than confirmatory; however, it provided insight into the perceptions and behaviors of a group of experienced BIM practitioners in the Mid-Atlantic area of the United States. Interesting findings emerged, and the author proposed a program of follow-up research. To appreciate the benefit collaboration brings to the design process, it is helpful to first understand the increased complexity of design and the terms "teams" and "collaboration."

The Increased Complexity of Design

Over the past 50 years, requirements and expectations for building performance have increased. Building regulations have expanded from concerns for fire and life safety to include water quality, air quality, energy conservation, accessibility, sustainability, health and other concerns. Congress expanded performance demands even further when it defined a high-performance building in H.R. 6, the Energy Independence and Security Act of 2007 (EISA).[4]

In response to these increased requirements and expectations, the design process now incorporates special consultants and new technologies. Multiple stakeholders represent diverse values and interests, bringing multiple goals and criteria that are connected, interdependent and adaptive. They focus not only on the individual performance of the multitude of components and systems that make up a building, but also the interrelationships of these components and systems. As the standards for performance increase, interdependence and adaption become more significant, and design problems become more complex.

Working Group	Team
Strong, clearly focused leader	Shared leadership roles
Individual accountability	Individual and mutual accountability
The group's purpose is the same as the broader organizational mission	Specific team purpose that the team itself delivers
Individual work products	Collective work products
Runs efficient meetings	Encourages open-ended discussion and active problem-solving meetings
Measures its effectiveness indirectly by its influence on others (such as financial performance on the business)	Measures performance directly by assessing collective work products
Discusses, decides and delegates	Discusses, decides and does real work together

Figure 1: A comparison between working groups and teams shows distinct differences.

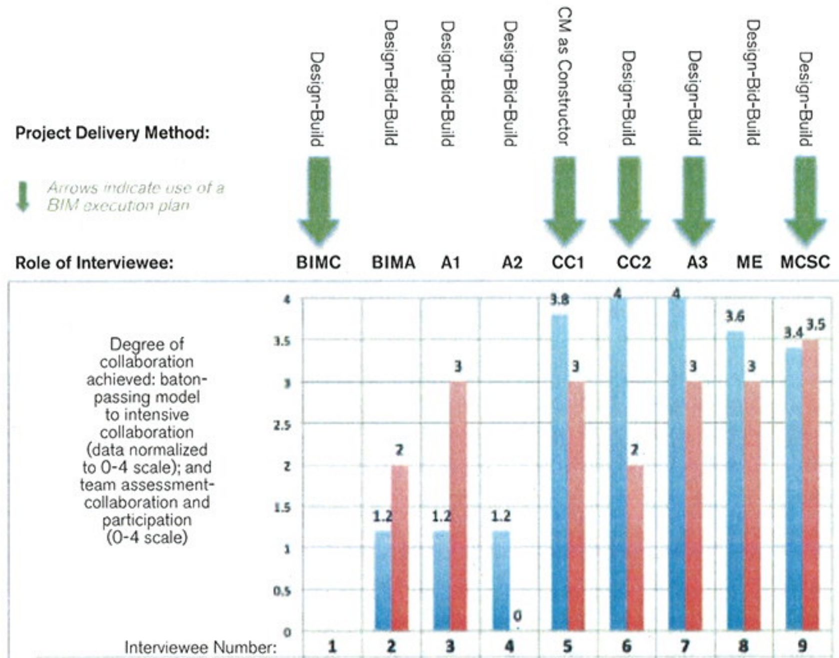
Complex problems are different than high-dimensional or complicated problems. A complicated or high-dimensional problem consists of many interconnected parts that work in a predictable pattern, such as a mechanical watch. Complex problems, on the other hand, exhibit an ability to adapt and often are unpredictable. Cities and economies are complex. A system is complex "if it consists of diverse agents who are connected, and whose behaviors and actions are interdependent and adaptive."[5][6] Increased complexity drives professionals to change the way they approach building design. When solving complex problems, it is beneficial to employ the collaboration of teams of specialists to jointly solve the problem.

The term *team* is often confused with *working group (see "Figure 1,"[7] opposite page)*. Frequently, teams are defined as groups of people with complementary skills who are committed to a common purpose and hold themselves mutually accountable for its achievement. Mutual accountability enables a team to perform at levels beyond what can be achieved by working groups.[8] Research studies have identified at least three basic types of teams:

- **Tactical teams** strive to execute a well-defined plan. A tactical team's collaboration process is highly focused on tasks, with an emphasis on role clarity, well-defined operational standards and accuracy.
- **Problem-solving teams** strive to resolve problems and require trust. A problem-solving team collaboration process focuses on issues and separates people from the problem. The process emphasizes a consideration of the facts (rather than opinion), suspension of judgment and thorough investigation.
- **Creative teams** strive to make something new, think of new possibilities and question assumptions. They require autonomy. A creative team collaboration process focuses on exploring possibilities and alternatives.[9][10]

Although teams often contain blends of different types, one dominant focus usually prevails.

Sometimes, the term *collaboration* is confused with coordination or



Interviewee Number:	1	2	3	4	5	6	7	8	9
Most Recent Project: baton-passing model to intensive collaboration (0-4 scale)		1.2	1.2	1.2	3.8	4	4	3.6	3.4
Most Recent Project: team assessment-collaboration and participation (0-4 scale)		2	3	0	3	2	3	3	3.5

LEGEND

Role of Interviewee:
BIMC = BIM Consultant
BIMA = BIM Manager Architect
A = Architect (total of 3)
CC = Construction Contractor (total of 2)
ME = Mechanical Engineer
MCSC = Mechanical Construction Subcontractor

Definitions:
In a **baton-passing model**, a complete brief is prepared; the architect designs the built form, which is passed like a baton to various engineering and other specialists to make sure the end result will be structurally sound and environmentally habitable.[11]

Intensive collaboration involves the regular presence and intervention of engineers in the ongoing design process, as opposed to many offices in which engineers intervene only at the end of the process to execute the plans of the designing architect.[12]

Figure 2: Research results illustrate interviewees' perception of collaboration and participation.

cooperative behavior. Collaboration is a means for specialists to share and combine their knowledge, extend their individual cognitive and emotional capabilities and jointly develop solutions. Collaborative interdisciplinary design *teams* have the potential to solve more complex design problems than individuals or the traditional *working groups* that sequentially pass facets of design from discipline to discipline.

Collaborative interdisciplinary teams simultaneously apply each individual specialist's knowledge to assist the entire team in understanding the range and complexity of a project. The cognitive diversity of the interdisciplinary team members provides different perspectives, heuristics, categories and biases that contribute insight into the problem and help overcome conceptual blocks;[6] the different experiences of members expand the team's intuition and judgment. Additionally, collaboration assists in managing the emotional intelligence of individual members, particularly in perceiving and responding to emotions outside of the team.[13][14] For collaboration to be effective, team members must commit to the process, contribute value to the effort and be individually and collectively responsible for the work product.[8][15]

Collaboration as a Goal

During the research study, in-depth, individual, face-to-face, semi-structured interviews with experienced BIM practitioners provided important information on the self-perception of teams and collaboration, based on recent projects. All interviewees felt collaboration was a goal during the concept-design phase of their projects. Although they gave varying reasons why they felt collaboration

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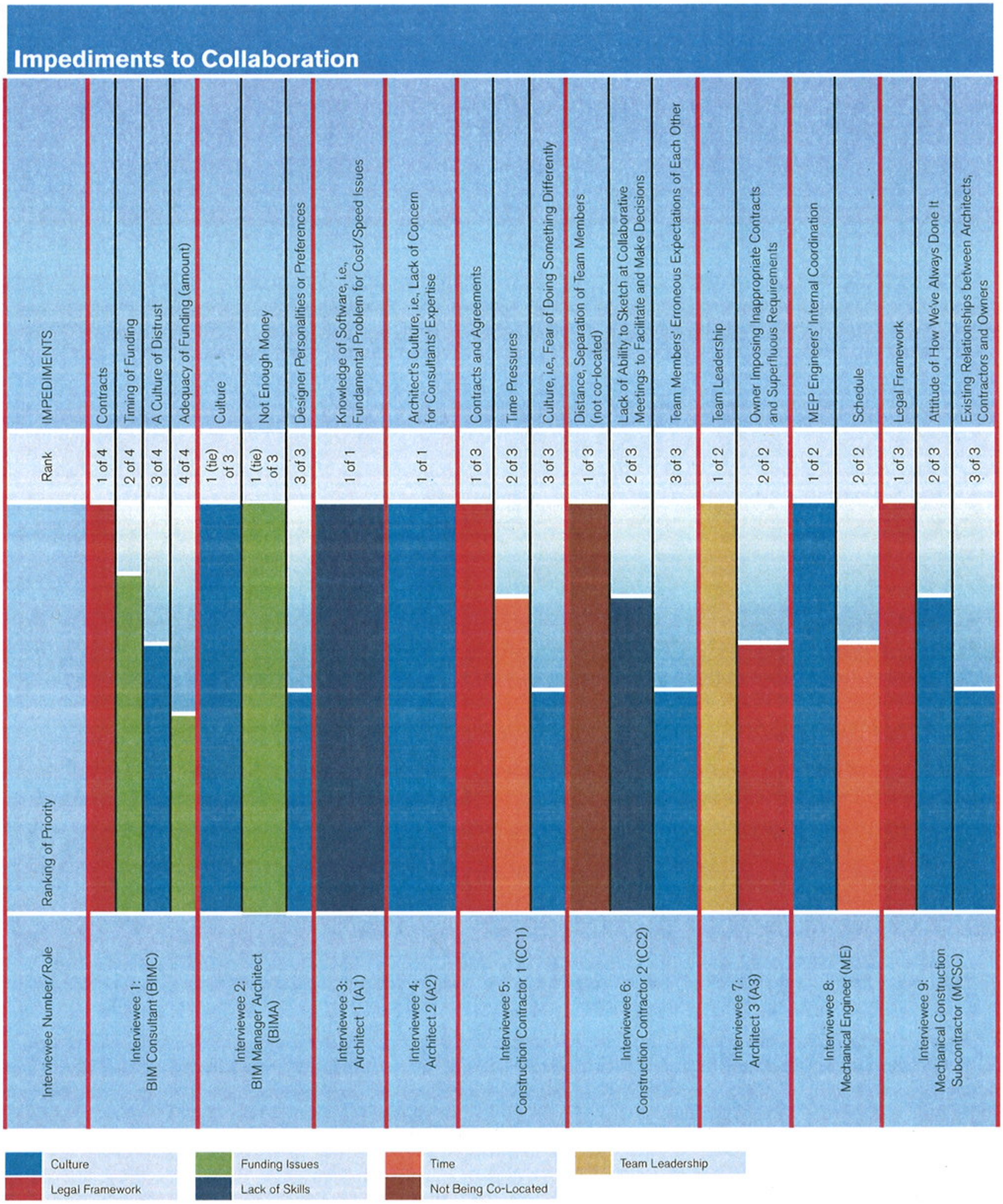

Figure 3: BIM participants involved in the research study point to a number of impediments to true collaboration.

was important, participants generally believed that collaboration resulted in improved design. More than half of the interviewees rated their teams as achieving collaboration on their most recent project. One interviewee stated that they could achieve more collaboration if they utilized a BIM execution plan (BEP) and a project delivery method with early contractor involvement. Survey findings *(see "Figure 2," page 31)* supported that proposition.

However, only five (55.5 percent) of the nine interviewed BIM practitioners said they use, or usually use, a BEP. For those interviewees that did use BEPs, the contents and organization of the plans varied. Teams that used BEPs had a BIM consultant and/or early involvement of the contractor. Authors of these BEPs were the contractor, subcontractor or contractor/architect team; when involved in a project, a BIM consultant prepared the BEP. No BEPs were solely authored by architects, design engineers or other stakeholders.

Although a majority of the interviewed BIM practitioners perceived they had achieved collaboration, later interview discussions revealed that the actual extent of BIM collaboration during concept design was limited to the architect, structural engineer, contractor and some construction subcontractors. In these instances, collaboration was directed toward coordinating components and construction of the building, and not toward developing the design concept for the building. In addition, some BIM practitioners expressed disappointment that mechanical, electrical, plumbing (MEP) engineers generally did not perform BIM energy analysis during the concept design—a time when an analysis would have the greatest impact on the direction of the building design. Other BIM practitioners stated that, during concept design, BIM collaboration and analysis with other design consultants (such as landscape architects, civil engineers and lighting consultants) was limited or nonexistent.

Impediments to Collaboration

During the research, BIM practitioners offered 22 impediments to collaboration, which were grouped into seven categories: culture; legal framework; funding issues; lack of skills; time; not being co-located; and team leadership. The majority (73 percent) of impediments were culture-related impediments (nine mentions); other top impediments related to legal framework (four mentions) and funding issues (three mentions). For more specifics, see "Figure 3" *(opposite page)*.

Limitations of the Research

The information obtained through this research applies only to this sample of interviewees; more general conclusions are only propositions. Reported behavior was not necessarily actual behavior, and correlation did not necessarily imply causation. There may be related factors that were not discussed by the interviewees.

In Closing

For this study:

- The collaboration and performance ratings were generally higher for teams using BEPs and project delivery methods with early contractor involvement.
- The projects with BEPs were projects with project delivery methods with early contractor involvement. None of the Design-Bid-Build projects used BEPs.
- The prime author of the BEPs was a contractor or a BIM consultant.
- Impediments to collaboration cited by the interviewees were culture; legal framework; funding issues; lack of skills; time; not being co-located; and team leadership.

These findings raise several questions:

- Are BEPs and early contractor involvement increasing team collaboration, or are expectations for collaboration

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managed/expectations lowered to what can be achieved and/or solely for the needs of the plan's author?

- Are BEPs adequately addressing the different types of collaboration required during concept design?
- Do the different phases of a project require unique, but coordinated BEPs?
- Do designers and other stakeholders share the same expectations for the concept-design process? Prior research has found that the conceptual-design models of engineers tend to be prescriptive, multiphase procedures, while architects tend to view the conceptual-design models as more broadly defined stages. There is a tendency to rely on the "experience" of the designers to "know how to design."[16]
- On BIM projects with BEPs, is there a shared understanding of the concept-design process? Can a BEP or multiple BEPs resolve differing conceptual-design models of the various stakeholders?

Finally, the research author suggests testing the findings from this research with observational studies and larger surveys.

BIM provides a shared knowledge resource to achieve an important end goal: creating better, more sustainable, high-performance buildings. To realize the promises of BIM, however, additional research is needed to better understand BIM and collaborative design processes. JNIBS

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