McGraw_Hill CONSTRUCTION

Interoperability
in the Construction Industry

SmartMarket Report
Design & Construction Intelligence

2007 Interoperability Issue

connecting people_projects_products
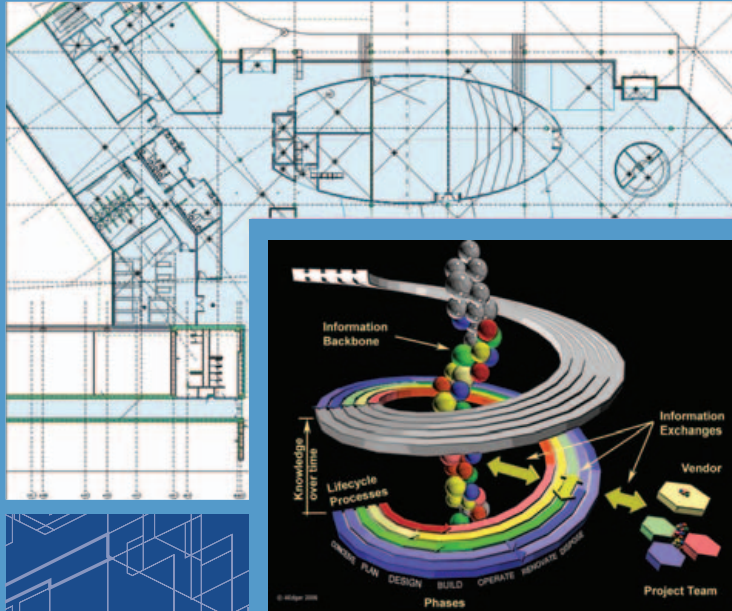
Introduction

Norbert W. Young Jr., FAIA, President, McGraw-Hill Construction
Stephen A. Jones, Senior Director, Business Development, McGraw-Hill Construction
Harvey M. Bernstein, F.ASCE, Vice President, Industry Analytics, Alliances and Strategic Initiatives

Norbert W. Young Jr.

Stephen A. Jones

Harvey M. Bernstein

Undeniably, the construction industry is in the midst of an unprecedented technological revolution. Due to the highly fragmented nature of our industry however, this sweeping change is manifested in thousands of custom and commercial applications being deployed in uncoordinated ways by tens of thousands of firms on over a million projects every year. To quote author William Gibson, "The future is already here, it's just not evenly distributed."

While individual adopters may be enjoying a variety of benefits from these "point solutions," the industry as a whole is being held back from quantum advance because the tools, powerful as they are in their own right, don't pass information seamlessly among themselves. This situation is made even less tolerable because our industry is also rapidly adopting principles and practices of integrated project delivery which strive to eliminate long-standing inefficiencies and avoid oft-repeated problems by sharing knowledge and collaborating earlier in the process with all members of the design, construction and operations lifestyles. As people are learning to work and communicate more effectively for the overall benefit of both their companies and their projects, their IT tools need to evolve to support this new way of doing business.

This McGraw-Hill Construction research study, sponsored by the American Institute of Architects (AIA), International Code Council (ICC), Associated General Contractors of America (AGC), Construction Users Roundtable (CURT), Construction Owners Association of America (COAA), Construction Management Association of America (CMAA), Construction Specifications Institute (CSI), Society of Marketing Professional Services (SMPS), and the buildingSMART Alliance, is intended to capture a variety of perspectives on the current status and importance of interoperability in the North American construction market and potential paths towards solutions. In this way it serves both as a valuable snapshot of where we are today, and as a baseline for understanding and appreciating future progress we will make for our industry by working effectively together.

Norbert Young is a registered architect, with professional affiliations in The American Institute of Architects, the Urban Land Institute, the Construction Specification Institute and the International Alliance for Interoperability, where he served as Chairman of the IAI-NA Board of Directors. In addition, Norbert serves as a trustee of the National Building Museum and is the former chairman of the board of regents of the American Architectural Foundation. He is also a member of the Construction Users Roundtable, a national organization of over 50 major owners focused on providing the "voice of the owner" to the design and construction industry. Norbert is a Fellow of The American Institute of Architects, and in 2005 he received the Edward C. Kemper Award from the AIA for outstanding service to the profession of architecture. In 2007 he received the Henry L. Michel Award for Industry Advancement of Research from the Civil Engineering Forum for Innovation. Norbert is very active in education-related initiatives by serving as vice chairman of the national ACE Mentor program–a high-school level program designed to identify and attract new talent to the design and construction industry. Additionally he serves on the Board of Overseers of his architecture alma mater–Penn Design.

Steve Jones leads McGraw-Hill Construction's initiatives in Building Information Modeling, Interoperability and Integrated Project Delivery as well as developing alliance relationships with major corporations for technology and content. Before joining McGraw-Hill, Steve was a Vice President with Primavera Systems, the world's leading provider of project management software. Prior to that, Steve spent 19 years in a variety of design and management roles with Architecture firms. Most recently he was a Principal and Board of Directors member with Burt Hill, one of the largest architectural/engineering firms in the world. Steve holds an MBA from Wharton and a BA from Johns Hopkins.

Harvey Bernstein, Vice President, Industry Analytics, Alliances and Strategic Initiatives, F.ASCE, oversees McGraw-Hill Constructions' Research and Analytics division. He has served as a member of former Secretary of State Colin Powell's Advisory Committee on Leadership and Management. He currently serves as a member of the Princeton University Civil and Environmental Engineering Advisory Council, the Harvard Joint Center for Housing Policy Advisory Board and a visiting Professor with the University of Reading's School of Construction Management and Engineering in London, England, where he also serves on their Innovative Construction Research Center Advisory Board. He has written numerous papers and reports covering innovation, productivity, energy conservation and green building and co-authored the book *Solving the Innovation Puzzle: Challenges Facing the Design and Construction Industry* (ASCE Press, 1996).

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What is Interoperability?

Definitions of Interoperability

Interoperability is viewed with both a narrow and broad perspective by the construction industry. From a purely technology-based view, interoperability is **the ability to manage and communicate electronic product and project data among collaborating firms.**

However, many build team members also see interoperability at a cultural level. Beyond the technology, interoperability is often defined as the ability to **implement and manage collaborative relationships among members of cross-disciplinary build teams that enables integrated project execution.**

These perspectives are interrelated and can be symbiotic. Interoperability of technology enables efficiency at a practice level. **If all members of a build team can freely exchange data across different applications and platforms, every member of the team can better integrate the project delivery.** Many firms are already moving toward more collaborative teams, especially with the expanded use of design-assist and design-build on projects. As teams become more integrated, they are increasingly demanding technology solutions that benefit those relationships.

Definitions of BIM

Like interoperability, Building Information Modeling (BIM) can be defined from both a technology and process point of view. The National Institute of Building Sciences (NIBS) in its National BIM Standard defines BIM as "a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward." This database contains the physical and functional characteristics of a structure composed of intelligent objects rather than lines, arcs, and text. BIM can render multiple views of data including 2D drawings, lists, text, 3D images, animation, as well as elements of time/scheduling (4D) and cost (5D).

As noted above, BIM is also a way to share data throughout the entire lifecycle of the structure. This data can include the initial design data; geospatial information; financial and legal data; mechanical, electrical, and plumbing (MEP) layout; building product specifications, environmental and energy modeling results; and other information that can be used collaboratively by architect, engineer, contractor, and owner (AEC/O) professionals during the project life cycle and by facilities managers after the project is completed.
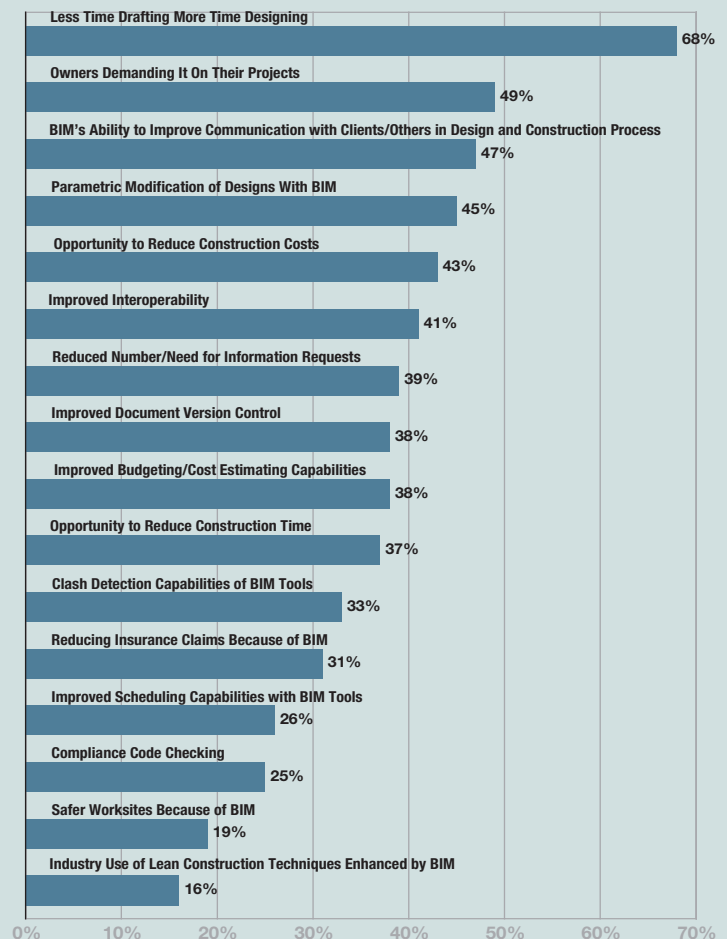
BIM and Interoperability

Interoperability issues are gaining attention with increased use of BIM. In addition to using BIM to create 3D design, these models are a rich database of the physical and functional characteristics of a facility. In order to optimize the use of BIM, it is critical that much of this **BIM data be shared between build team members. As a result, interoperability of technology is an important factor. Re-entering data from a BIM into another application or platform used by the build team creates wasteful and costly duplication.**

The promise of improved interoperability ranks among the factors that have the greatest influence on the decision to use BIM (41%).

Other key factors include:

- Owners demanding it (49%)
- BIM's ability to improve communication among the build team (47%)
- The opportunity to reduce construction costs (43%).

Factors Influencing the Use of BIM

Factor	Percentage
Less Time Drafting More Time Designing	68%
Owners Demanding It On Their Projects	49%
BIM's Ability to Improve Communication with Clients/Others in Design and Construction Process	47%
Parametric Modification of Designs With BIM	45%
Opportunity to Reduce Construction Costs	43%
Improved Interoperability	41%
Reduced Number/Need for Information Requests	39%
Improved Document Version Control	38%
Improved Budgeting/Cost Estimating Capabilities	38%
Opportunity to Reduce Construction Time	37%
Clash Detection Capabilities of BIM Tools	33%
Reducing Insurance Claims Because of BIM	31%
Improved Scheduling Capabilities with BIM Tools	26%
Compliance Code Checking	25%
Safer Worksites Because of BIM	19%
Industry Use of Lean Construction Techniques Enhanced by BIM	16%

Source: McGraw-Hill Construction Research and Analytics, 2007

Costs Associated with Non-Interoperability

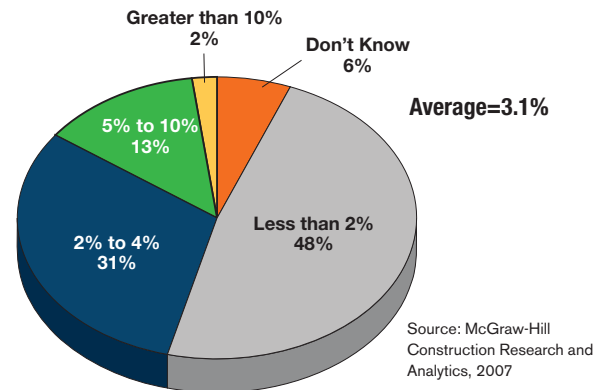The lack of interoperability is driving up costs for the industry. **On average, about 3.1% of project costs are related to software non-interoperability.**

- Nearly half of build team members (48%) believe lack of interoperability adds less than 2% to costs, while 31% estimate it adds between 2% and 4% to costs.
- Thirteen percent report that non-interoperability costs between 5% and 10%, and 2% say non-interoperability adds more than 10% to costs.
- Engineers estimate non-interoperability has the highest impact, adding nearly 4% to costs, while owners estimate it adds 2.5%.
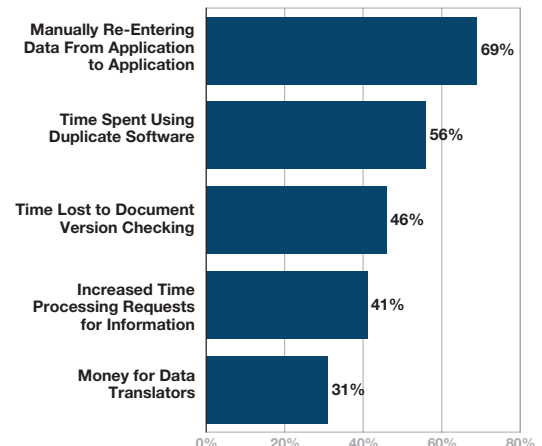
Time spent on overcoming non-interoperability is the primary driver of costs. Manually re-entering data from application to application ranks the highest at 69% with 75% of engineers reporting it as a primary cost. This is true regardless of the type of software used, whether it is 2-Dimensional CAD, BIM, bidding software, or any other application.

Time spent using duplicate software (56%) and time lost to document version checking (46%) are also key cost drivers.

Benefits of Interoperability–Data Sharing

A large majority of the industry would benefit today from interoperable technology. Build team members frequently share data across software applications. Eight in ten report sharing a medium (41%) or high (38%) amount of data.

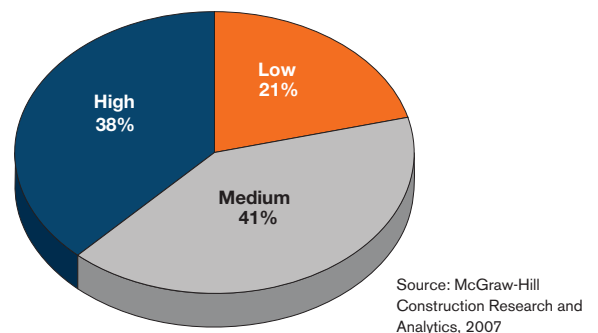**Through interoperability, build teams can reduce waste, speed delivery and cut costs.**

Interoperability eliminates:

- Manual re-entry of data
- Duplication of business functions
- Continued reliance on paper-based information exchange

Interoperability benefits include:

- Increased speed of overall project delivery
- Reduced infrastructure vulnerability
- Greater reliability of information through the lifecycle
- Expanded markets for companies
- Decreased supply-chain communication costs
- Improved to value customers

Total AEC/O Costs of Non-Interoperability

Greater than 10% 2%
Don't Know 6%
Average=3.1%
5% to 10% 13%
Less than 2% 48%
2% to 4% 31%

Source: McGraw-Hill Construction Research and Analytics, 2007

Drivers of Non-Interoperability Costs

Driver	Percent
Manually Re-Entering Data From Application to Application	69%
Time Spent Using Duplicate Software	56%
Time Lost to Document Version Checking	46%
Increased Time Processing Requests for Information	41%
Money for Data Translators	31%

Source: McGraw-Hill Construction Research and Analytics, 2007

Total AEC/O Frequency of Data Sharing

Low 21%
High 38%
Medium 41%

Source: McGraw-Hill Construction Research and Analytics, 2007

Productivity

Productivity levels within the construction industry have been a source of intense debate in recent years. **As construction values have risen to record–high levels, productivity within the industry has come under scrutiny.** Paul Teicholz, Ph.D., of Stanford University suggests that while overall industrial productivity has significantly increased in the United States, construction industry productivity is on the decline. Teicholtz claims that while total non-farm productivity more than doubled between 1964 and 2004, construction productivity dropped by nearly 20% during that time.

However, industry observers, including authors of this report, have argued that the Teicholz study is misleading because it uses labor as the sole measure of productivity. Several factors can influence construction productivity, such as the skill base of the workforce; size, scope and type of project; and site conditions and other environmental factors. Meanwhile, the construction industry is creating more complex structures in less time and with higher quality than ever before. (Bernstein, "Measuring Productivity: A Path to Improving Performance in the Design and Construction Industry").
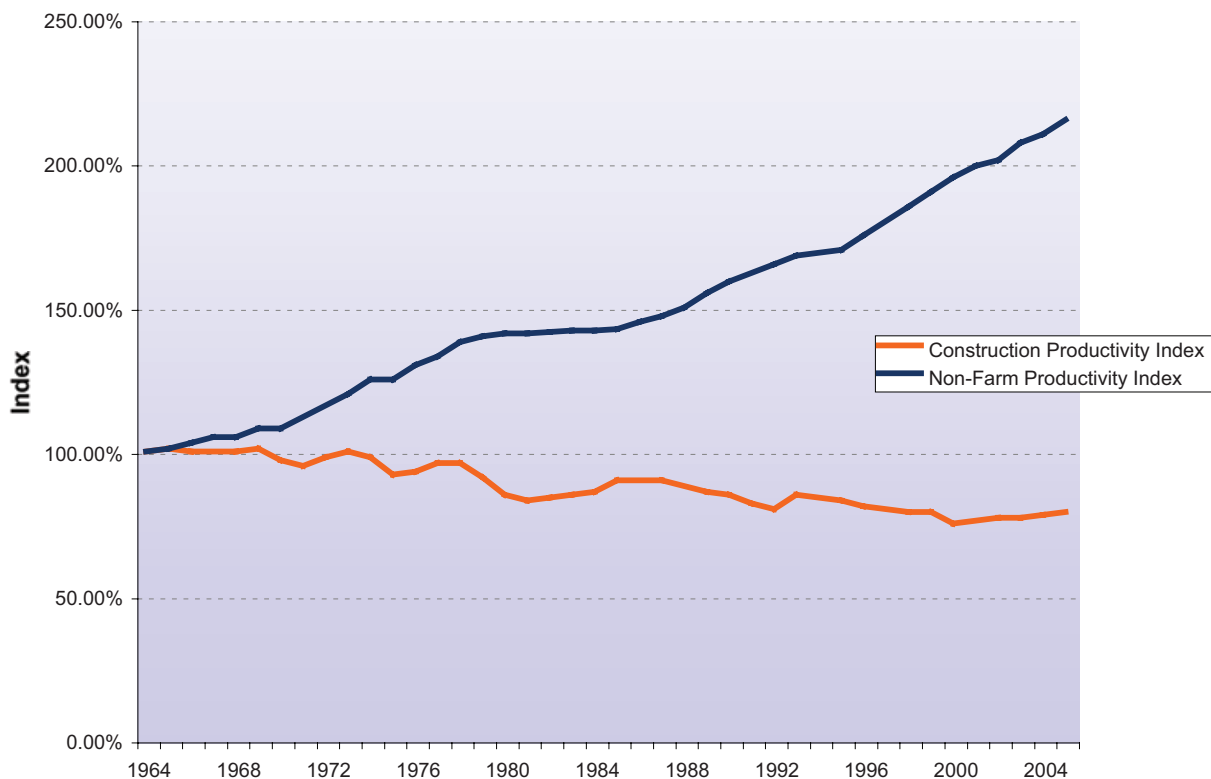
Impact of Interoperability on Productivity

Associated with concerns about productivity, owners and industry groups are troubled by the level of waste resulting from a lack of interoperability. **The industry generally perceives lack of interoperability as an impediment to improving productivity.**

The National Institute of Standards and Technology (NIST, www.nist.org) set off alarms about the issue in 2004, estimating that lack of interoperability costs the U.S. capital facilities market—including commercial, institutional and industrial—facilities $15.6 billion per year. On a global basis, that would equal more than $60 billion. The study estimated that between 0.86% and 1.24% of construction spending is directly related to inadequate interoperability. Owners bore nearly two-thirds of those costs. (Gallaher, O'Connor, Dettbarn, Jr., and Gilday, "Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry," NIST 2004, pp. 6-1–6-3).

The industry perceives that the problem is much greater than the NIST study suggests. On average, build team members surveyed for this report estimate that about 3% of project costs are related to software non-interoperability. Within today's $1.2 trillion U.S. construction market, which represents all construction sectors, such an estimate would equate to $36 billion in annual waste. In the $4.6 trillion global market, that would extrapolate to $138 billion.

Constant $ of Contracts/Workhours of Hourly Workers
Sources: U.S. Dept. of Commerce, Bureau of Labor Statistics

Global Construction Output (2006)
Total: $4.6 trillion

Canada
$156 billion

United States
$1.2 trillion

Russia
$90 billion

Western Europe
$1.4 trillion

Eastern Europe
$73 billion

Asia
$1 trillion

Middle East
$37 billion

North Africa
$28 billion

India
$81 billion

Malaysia
$12 billion

Africa
$70 billion

South America
$101 billion

South Africa
$15 billion

Australia/ New Zealand
$82 billion

Source: University of Reading (Roger Flanagan and Carol Jewell):
data: Asia Construct, EuroConstruct and national statistics

(*All figures are in U.S. Dollars and use January 2007 exchange rates*)

Key Players

There are several key players who generate large amounts of data that need to be shared among build team members during a project's lifecycle. **Within the dynamic, continual exchange of information on a typical project, one team member's data will often affect the work of the entire team, requiring constant updating of facts, figures and analyses.**

Architects
- Generate data related to the physical and functional characteristics of a facility's design.
- Plans and drawings are often updated throughout the project lifecycle, reflecting changes in budget, schedule and design elements.
- Nine out of ten share high to moderate levels of data.
- See software incompatibility as the biggest obstacle to data sharing.
- Estimate that lack of interoperability contributes 3.3% to project costs.

Engineers
- Generate data related to the design of a facility's systems and analysis of its characteristics.
- Data from analysis can often lead to changes in design, affecting schedule and budgets.
- Data from building systems, such as mechanical, electrical and plumbing, are used to detect potential spatial interferences between systems that could lead to costly change orders.
- Three-quarters share high to moderate levels of data.
- See software incompatibility as the biggest obstacle to data sharing.
- Estimate that lack of interoperability contributes 3.6% to project costs.

Contractors
- Generate data related to scheduling, building product quantities, cost estimating and project management.
- Establish and update schedules and costs information that can affect the design of a project.
- Three-quarters share high to moderate levels of data.
- See software incompatibility as the biggest obstacle to data sharing.
- Estimate that lack of interoperability contributes 2.9% to project costs.

Owners
- Need regularly updated data about budgets and schedules as it is adjusted throughout the project lifecycle.
- Require data related to operations and maintenance of a facility for use after a project is completed.
- Seven out of ten share high to moderate levels of data.
- See software incompatibility as the biggest obstacle to data sharing.
- Estimate that lack of interoperability contributes 2.5% to project costs.

Building Product Manufacturers
- Generate data related to building products such as dimensions, weight, appearance, cost, warrantees and future maintenance.
- Data affects costs and design.

Project Lifecycle

Firms and organizations throughout the construction industry are addressing the need for greater efficiency in the building environment by rethinking traditional ideas of project delivery. **Conventional delivery methods have often promoted a divide between build team members, as work is handed off from one member to the next throughout the process.**

Traditional project delivery tends to focus the greatest amount of effort during the construction documentation phase. At this point in the lifecycle, much of the design has already been developed, but input from the construction team about costs and schedule can lead to significant design changes.

Integrated project delivery promotes greater collaboration between build team members earlier in the lifecycle. **As team members work closely together during the design phases, they have a greater ability to impact costs before the project progresses into the construction phases.** While designers continue to be the focus of the early phases, contractors, fabricators and suppliers can provide design assistance to improve constructability and expedite construction.

The emergence of BIM technology is further promoting this shift in the delivery cycle, as team members use modeling tools collaboratively. BIM can speed exchange about model changes between team members and help identify problems, such as system clashes, earlier in the delivery cycle.

In order to reap the full benefits of BIM's ability to promote integrated project delivery, build team members will increasingly need to have interoperable solutions.

Standards

Industry groups and technology providers are experimenting with standards that could establish universally accepted ways of transferring data across different software. Through these standards, technology companies can find common ground where build teams can seamlessly exchange information.

IFC–Industry Foundation Classes

IFCs are used for transferring data that represents the parts of buildings and their relationships to each other. Promoted by the IAI since 1995, several technology providers support IFCs as a data transfer standard. Experiments with its use are ongoing. (www.iai-na.org)

XML–Extensible Markup Language

XML is used for transferring data via the Internet. IAI chartered aecXML in 1999 to establish common schema definitions for AEC/O commodity data. IAI describes it as an "organized briefcase" that "will only include the small amounts of data you wish to transport from one location to another, not your entire office." (www.iai-na.org)

Interoperability Standards

BuildingSMART Alliance, founded in 2006 as an expansion of the International Alliance for Interoperability, is working to define standards of data interoperability. Among its efforts, the group helped establish International Foundation Classes (IFCs), which electronically define elements of a building design in a format that can be shared among applications. IFCs are among several standards currently being promoted by industry groups. As part of its mission, buildingSMART, in partnership with the National Institute of Building Sciences, is promoting open standards and creating neutral ground to coordinate interoperability efforts throughout the industry. In fall 2007, buildingSMART dedicated itself to the goal of eliminating $200 billion in construction cost waste by 2020.

Traditional Design

buildingSMART Design
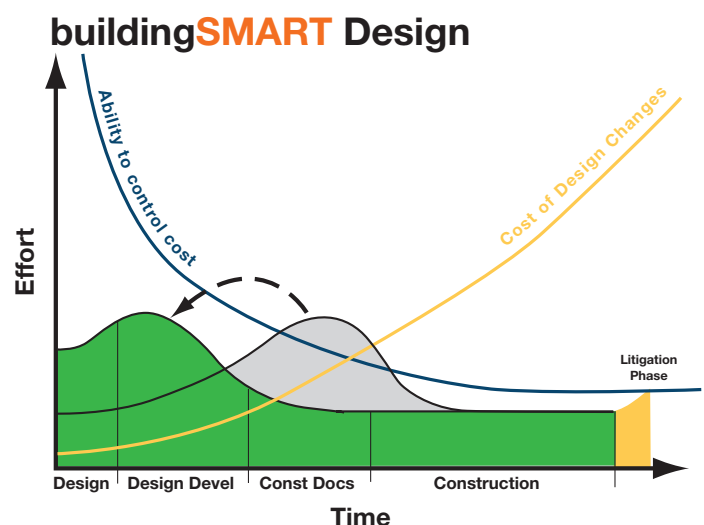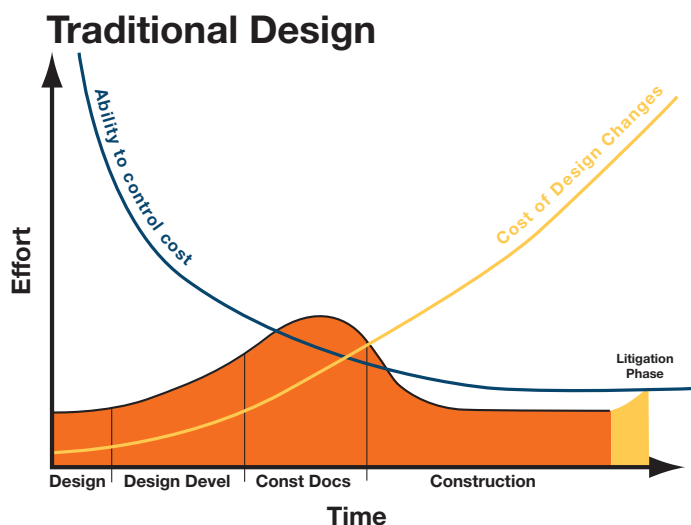
"Earlier Decision Making Improves Ability To Control Costs" – Graphs courtesy of Patrick MacLeamy, President of HOK and IAI International

Industry Groups

Several industry groups are working to promote interoperability, identify the demands of build team members and support solutions. **While they are often working toward the same interoperability goals, these groups are sometimes following different paths to a solution.** Some of these groups include:

American Institute of Steel Construction AISC

AISC has been a leader in promoting digital design and interoperability. In 1999 it launched and funded a multi-year initiative to promote Electronic Data Interchange (EDI) throughout the structural steel industry and thus improve the competitiveness of the material by reducing schedule time needed to get steel in place. **www.aisc.org**

buildingSMART Alliance

This organization is dedicated to improving interoperability in the building industry through such initiatives as promoting the use of open standards that allow data sharing across different software and platforms, and defining standard information exchanges that support specific workflow-use cases. **www.buildingsmartalliance.org**

3xPT Strategy Group

This collaboration of the Associated General Contractors of America (AGC), the American Institute of Architects (AIA) and the Construction Users Roundtable (CURT), addresses interoperability issues as part of its mission toward industry process transformation. **www.agc.org/3xptstrategy**

Construction Specifications Institute CSI

CSI developed the MasterFormat and OmniClass classification systems that help consistently structure project information and now is developing the IFDLibrary an open dictionary of construction terminology to improve interoperability. **www.csinet.org**

Construction Owners Association of America COAA

We support the concept [of interoperability] and believe it has tremendous potential for our industry." (Jack Mumma, COAA President). **www.coaa.org**

Construction Management Association of America CMAA

CMAA conducts an annual survey of owners. This year's survey focused on information technology and its impact on construction projects, particularly the ways technology can be used to improve project collaboration. **www.cmaanet.org**

International Code Council ICC

ICC is developing protocols and software, called SMARTcodes, for presenting code criteria in an interoperable format. SMARTcodes would allow build teams to automatically check building information models for code compliance. **www.iccsafe.org**

Construction Industry Institute CII

CII helped launch FIATECH, a consortium of building industry partners focused on identifying and accelerating the development, demonstration, and deployment of interoperable technology. It developed "Roadmap for Capital Projects" to identify the necessary technologies to deliver its mission. **www.fiatech.org**

Open Geospatial Consortium OGC

OGC is developing standards to improve the exchange of spatial information across different systems and platforms. **www.opengeospatial.org**

Open Standards Consortium for Real Estate OSCRE

OSC is developing e-business standards that enable interoperability among systems used within the real estate industry. **www.oscre.org**

Markku Allison, AIA

Resource Architect **American Institute of Architects AIA**

Interoperability is a hot topic around the AIA these days. Members are increasingly expressing their struggles with data sharing on projects. When trying to translate data between architects and contractors for quantity takeoffs and estimating, for example, teams often run into obstacles. Even when data can be transferred, the results are mixed.

"[Architects] are experiencing frustration from a lack of clear and complete translation of intelligent data," Allison says. "They might try to transfer files between applications and get only partial results. Geometry data might translate, but the intelligent data associated with the geometry might be lost. They get partial results, but because those results are partial that raises question marks about the accuracy. It casts a cloud on the entire exercise."

In some cases, such as mission−critical work, architects and their build team partners "hack away at it until they find a workaround." These can be time- and labor-intensive exercises that don't always prove successful. In the end, teams sometimes have to compromise on data they are able to share. It's a process that often repeats itself with each new project.

"Every time you have a project with a new consultant [who uses] a different software, you spend a lot of time figuring out file-sharing protocols and file-saving protocols," he adds. "That takes a big chunk of time."

Interoperability Market Summary

Interoperability and Data Sharing

Interoperability issues impact the entire building community. **The large majority of build team members frequently share data across a wide variety of different software applications.** A lack of interoperability hampers that exchange, leading to redundant work and a need to invest time and money in non-standard solutions that drive up project costs.
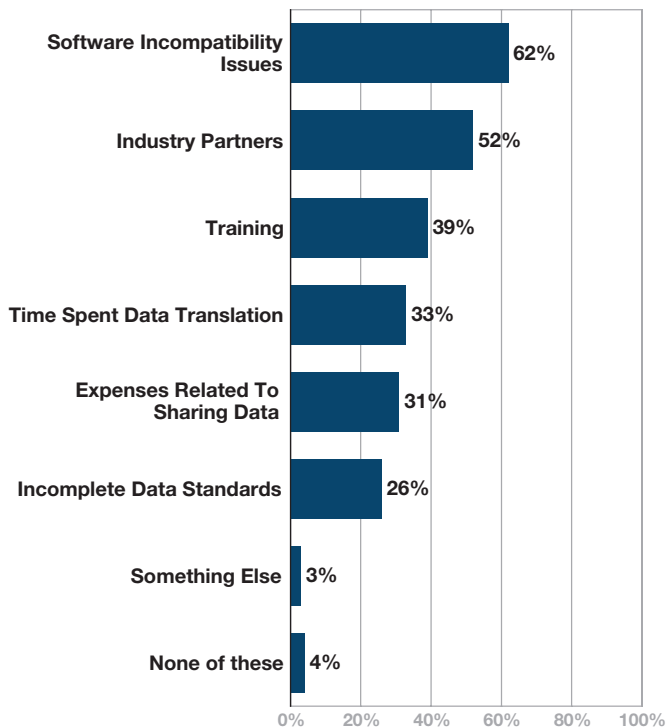
A majority of the industry (62%) lists software incompatibility issues as the primary factor impacting build team members' ability to share information across software.

Although costs play a part in addressing interoperability, they rank below concerns about software and partners. Owners are more focused on data sharing expenses than any other build team member. Among the costs that build team members cite as important are:

- Training (39%)
- Time spent on translation (33%)
- Expenses related to sharing data (31%)

While some industry groups actively promote the development of data standards that could help improve interoperability between software applications, only a quarter of build team members report being concerned about those efforts.
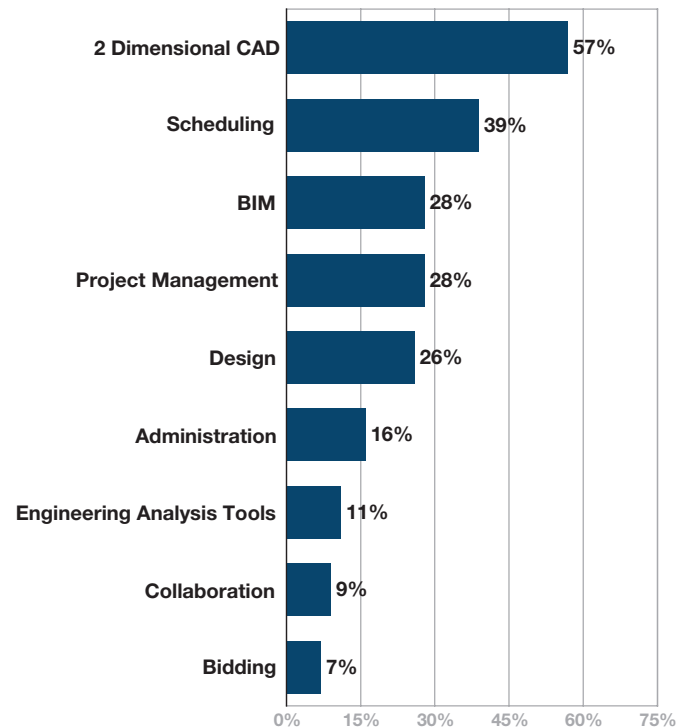
Software Choices

Build teams use a wide variety of software tools to address their needs, whether the task is related to design, management, systems analysis, bidding or any other work. In most cases, these applications are designed to meet the specific needs of particular disciplines, not the industry as a whole.

- The software most frequently used by the AEC/O community is 2D CAD (57%).
- Scheduling software is second on the list (39%), driven by its use among a majority of contractors and owners.
- While some have found success sharing data between 2D CAD and other design-related software like BIM, build team members give data sharing between 2D CAD and scheduling a poor rating. In fact, most software types receive a poor rating for ability to share data.

Factors Impacting Data Sharing

Factor	Percentage
Software Incompatibility Issues	62%
Industry Partners	52%
Training	39%
Time Spent Data Translation	33%
Expenses Related To Sharing Data	31%
Incomplete Data Standards	26%
Something Else	3%
None of these	4%

Source: McGraw-Hill Construction Research and Analytics, 2007

Software Types Used Most Frequently

Software Type	Percentage
2 Dimensional CAD	57%
Scheduling	39%
BIM	28%
Project Management	28%
Design	26%
Administration	16%
Engineering Analysis Tools	11%
Collaboration	9%
Bidding	7%

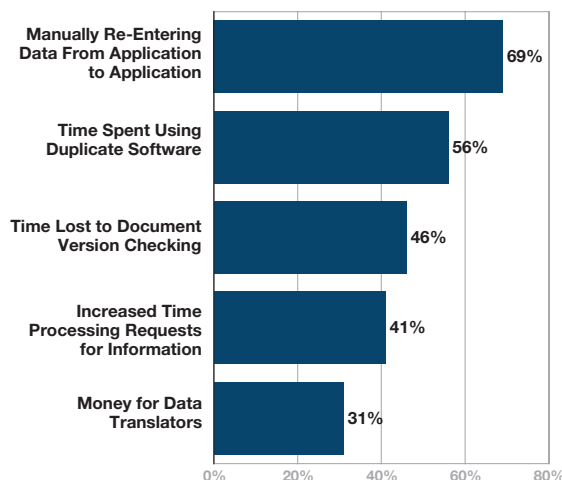Source: McGraw-Hill Construction Research and Analytics, 2007

Cost of Non-Interoperability

Lack of interoperability affects the workflow in the building community and ultimately impacts project budgets. Build teams estimate that interoperability issues contribute 3.1% to a typical project budget.

Build team members regularly invest in a variety of methods to overcome the barriers to data sharing.

- Manually re-entering data from application to application is the biggest cost (69%), as staff duplicates work already completed by other project partners.
- More than half (56%) report that time spent on duplicate software is a major cost.
- Other costs include time lost to document version checking (46%) and increased time processing requests for information (41%).

Potential of BIM

BIM has emerged as a critical catalyst in the effort to create interoperability within the building community.

However, with all disciplines envisioning a place for BIM, **the need for interoperability is heightened as firms invest deeper in its use.** As firms become experts in BIM, they begin to face the limits of its use.

- Software incompatibility issues are seen as having a more significant impact on data sharing by BIM experts (78%) compared to advanced users (72%), intermediate users (58%) and beginners (59%).
- BIM experts see issues with industry partners as a more important factor (56%) than other users.
- BIM experts are much more concerned about incomplete data standards that are intended to improve interoperability (56%) than the group as a whole (26%).

Drivers of Non-Interoperability

Category	Value
Manually Re-Entering Data From Application to Application	69%
Time Spent Using Duplicate Software	56%
Time Lost to Document Version Checking	46%
Increased Time Processing Requests for Information	41%
Money for Data Translators	31%

Source: McGraw-Hill Construction Research and Analytics, 2007

Factors Impacting Data Sharing by BIM Experts

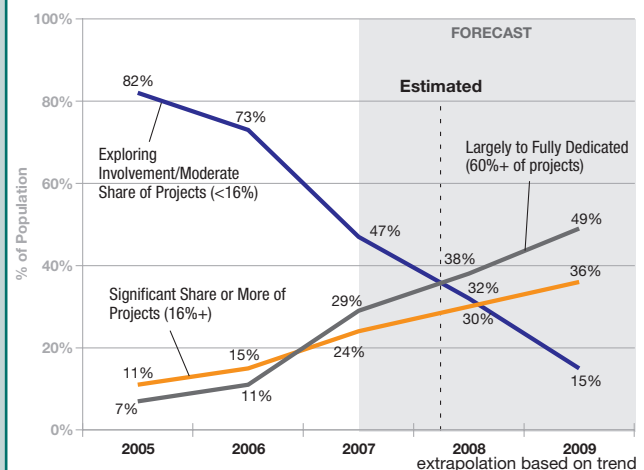| Category	Value
Software Incompatibility Issues	78%
Industry Partners	56%
Training	11%
Time Spent on Data Translation	33%
Expenses Related to Sharing Data	11%
Incomplete Data Standards	56%

Source: McGraw-Hill Construction Research and Analytics, 2007

BIM Tipping Point

While mostly a buzzword a few years ago, the widespread benefits promised by BIM have helped propel its use within the industry. A majority of build team members claim they have used BIM, and a quarter (28%) use it frequently. This rapid adoption of BIM is likely to reach a tipping point in 2008, as the number of build team members who are largely dedicated to its use surpasses the segment still exploring it. **As a significant portion of the industry adopts BIM and explores its uses, concern over interoperability issues will grow.**

While architects are the fastest adopters of BIM, other build team members are close behind and are expected to reach their own tipping points in the coming years. For now, most build teams report limited use of BIM among other team members. Only one quarter of firms using BIM state that all or most firms involved in a project are using BIM. **If a limited number of firms use BIM, the need to seamlessly share data between BIM and other applications being used on the team remains an important issue.**

BIM Demand by Firms

% of Population

	2005	2006	2007	2008	2009
Exploring Involvement/Moderate Share of Projects (<16%)	82%	73%	47%	38%	15%
Significant Share or More of Projects (16%+)	11%	15%	29%	32%	36%
Largely to Fully Dedicated (60%+ of projects)	7%	11%	24%	30%	49%

FORECAST — Estimated

extrapolation based on trend

Demand for Interoperability – Data

Interoperability also has an impact on build teams seeking to collaborate and achieve integrated project delivery. If every member of a team is able to share project data seamlessly with others, work flows more smoothly and quickly. Conversely, any team member who is not able to exchange that data represents a barrier to those efficiencies.

While the industry struggles to find software that interoperates well, some build team members have been reluctant to participate in finding solutions. Over half of build team members (52%) see their industry partners as having a major impact on data sharing.

Data Sharing by Architects

Interoperability is having an immediate impact on the architectural community. Architects share more data across applications and platforms than any other member of a build team. Nine out of ten architects share high (47%) to medium (43%) levels of data. **For architects, software incompatibility is the biggest obstacle to data sharing.**

- As the most frequent sharers of data, architects are the most concerned with software incompatibility, with 69% flagging it as a factor compared to 60% of engineers and 60% of contractors.
- The effect of industry partners on data sharing concerns a majority of architects (55%), more than engineers (48%) and contractors (47%).
- Architects see training (41%) as having a greater impact on efforts to share data than other build team members.
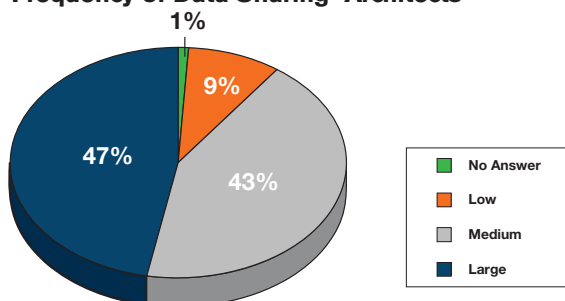
Data Sharing by Engineers

The engineering community is facing some of the broadest challenges with interoperability. Although engineers generate large amounts of data, they are able to share less data across software applications than other build team members. Half of engineers surveyed report that they can only share data at a moderate level. Software incompatibility is faulted as the main drag on data sharing (60%), while the ability to interoperate with industry partners is also a significant concern (48%).
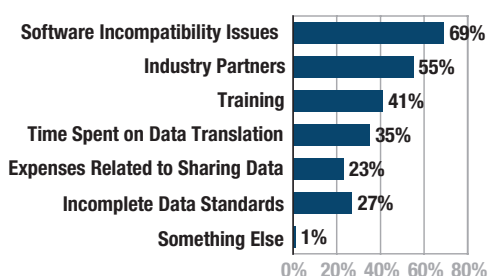
Engineers see incomplete data standards (41%) as a greater barrier to interoperability than any other build team members. As engineers use a wide variety of analysis tools, linking those applications through standards may be seen as a future solution. Engineers are nearly four times more concerned about the effect of incomplete data standards than contractors (11%), and almost twice as concerned as owners (23%).
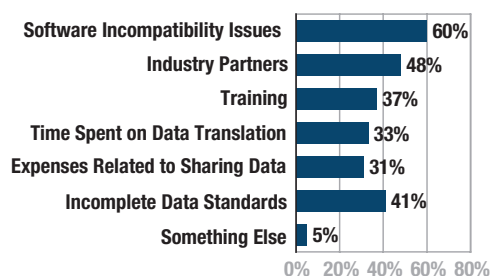
Frequency of Data Sharing–Architects
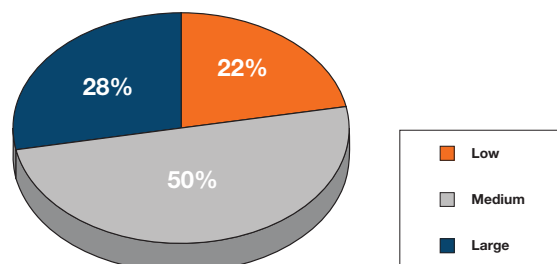
- 1% No Answer
- 9% Low
- 43% Medium
- 47% Large

Source: McGraw-Hill Construction Research and Analytics, 2007

Frequency of Data Sharing–Engineers

- 22% Low
- 50% Medium
- 28% Large

Source: McGraw-Hill Construction Research and Analytics, 2007

Factors Impacting Data Sharing-Architects

Factor	Percent
Software Incompatibility Issues	69%
Industry Partners	55%
Training	41%
Time Spent on Data Translation	35%
Expenses Related to Sharing Data	23%
Incomplete Data Standards	27%
Something Else	1%

Source: McGraw-Hill Construction Research and Analytics, 2007

Factors Impacting Data Sharing-Engineers

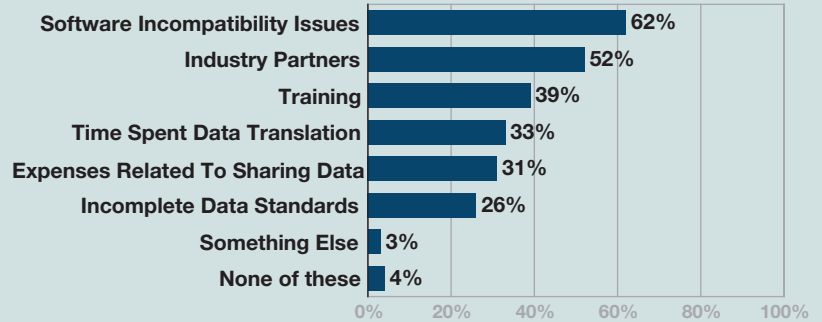| Factor	Percent
Software Incompatibility Issues	60%
Industry Partners	48%
Training	37%
Time Spent on Data Translation	33%
Expenses Related to Sharing Data	31%
Incomplete Data Standards	41%
Something Else	5%

Source: McGraw-Hill Construction Research and Analytics, 2007

Sharing

Frequency of Data Sharing: Total Respondents

Low 21%
Medium 41%
High 38%

Factors Impacting Data Sharing: Total Respondents

Factor	Percentage
Software Incompatibility Issues	62%
Industry Partners	52%
Training	39%
Time Spent Data Translation	33%
Expenses Related To Sharing Data	31%
Incomplete Data Standards	26%
Something Else	3%
None of these	4%
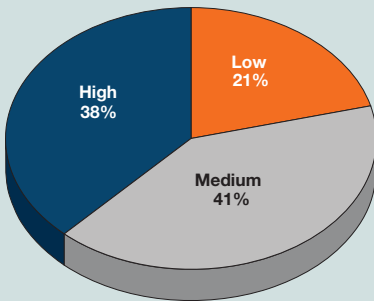
Data Sharing by Contractors

Contractors face a looming need for improved interoperability. Among build team members, they are the most frequent sharer of data after architects. Three-quarters of contractors report medium (35%) to high (40%) levels of data sharing. Along with architects and engineers, they see software incompatibility within their own firms and among other partners as a major obstacle to data sharing. Three out of five contractors see software incompatibility as a factor, while nearly half (47%) say that inability to share data with other partners has an impact on interoperability.

Data Sharing by Owners

Owners ultimately stand to reap the most benefits of interoperability. By reducing waste through improved interoperability, projects can be delivered faster and at a lower cost, bringing higher value to their investments.

Owners also see the potential to inherit more data that could help with facility operations and maintenance, as interoperability could streamline the transfer of data from AEC/O firms to their own software applications once a project is completed. Owners already depend on a fairly large amount of data sharing, with seven in ten estimating that they share at a moderate (34%) to high (38%) level.

As the source of project funding, owners are much more focused than other industry players on expenses related to data sharing (45%), such as buying software or hiring specialized staff to address interoperability.

Frequency of Data Sharing–Contractors

25%
35%
40%

Low
Medium
Large
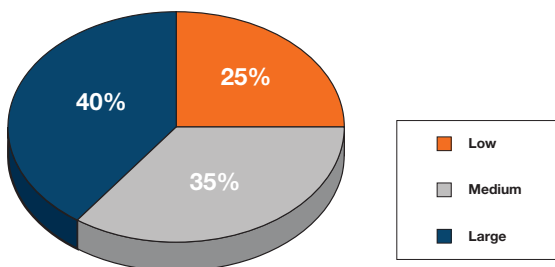
Source: McGraw-Hill Construction Research and Analytics, 2007

Frequency of Data Sharing–Owners
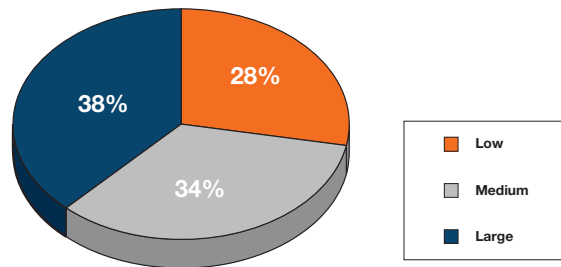
28%
34%
38%

Low
Medium
Large

Source: McGraw-Hill Construction Research and Analytics, 2007

Factors Impacting Data Sharing-Contractors
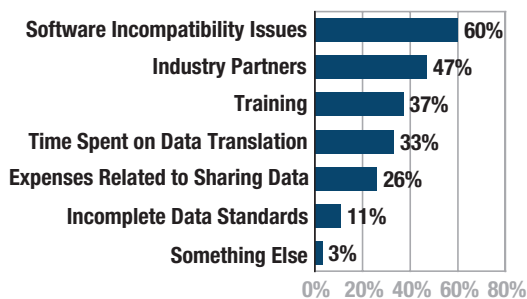
Factor	Percentage
Software Incompatibility Issues	60%
Industry Partners	47%
Training	37%
Time Spent on Data Translation	33%
Expenses Related to Sharing Data	26%
Incomplete Data Standards	11%
Something Else	3%

Source: McGraw-Hill Construction Research and Analytics, 2007

Factors Impacting Data Sharing-Owners

Factor	Percentage
Software Incompatibility Issues	57%
Industry Partners	56%
Training	40%
Time Spent on Data Translation	29%
Expenses Related to Sharing Data	45%
Incomplete Data Standards	23%
Something Else	1%
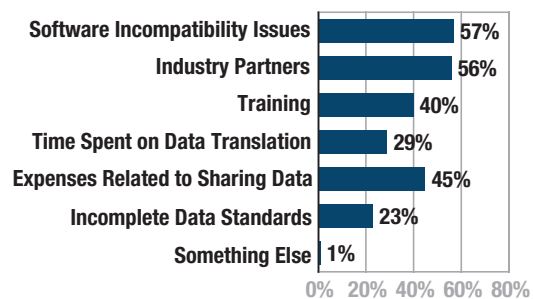
Source: McGraw-Hill Construction Research and Analytics, 2007

AEC/O Industry Software Use

Build team members collectively use thousands of software programs developed by hundreds of technology companies. Because the majority of these programs are developed to work as standalone applications, they are not typically designed to share data with other programs. As a result, build team members re-enter data or search for one-of-a-kind "workaround" methods to simulate interoperability between software programs.

■ 2D CAD is the type of software most frequently used by the industry (57%), particularly by architects and engineers.

■ Scheduling software is also frequently used (39%), particularly by contractors and owners.

■ Although BIM remains an emerging technology, today more than a quarter (28%) of all build team members use it frequently.

Build teams are interested in seeing a broad range of software programs share data seamlessly, particularly 2D CAD, BIM and project management software.

Architect Software Choices

Design software is the natural domain of architects. While 2D CAD remains the software most frequently used among architects surveyed (72%), designers are quickly adopting BIM as a favorite tool. Half of architects (48%) rank BIM among the tools they frequently use.

Architects are experiencing some levels of success with interoperability within the design community. Surprisingly, architects surveyed stated that 2D CAD and BIM share data fairly well with each other as compared to other software packages. As architects are focused specifically on design applications, they may be less aware of a lack of interoperability among other software applications. For example, other build team members say 2D CAD and BIM do not share well with applications such as engineering analysis tools. Very few architects (4%) use engineering analysis tools and may be less familiar with those issues. Despite some successes with design software, the rest of the build team needs to be able to exchange data better with architects.

Engineer Software Choices

Analysis is a prime task of some engineers and naturally they gravitate toward the tools that will help them accomplish those goals. However, only one-third of engineers say they frequently use engineering analysis software. The more engineers carry out analysis by hand, the less interoperable that data becomes.

Engineers are very committed to using 2D CAD (73%), and some are now using BIM frequently (35%). Many use BIM for 3D visualization and clash detection. While 2D CAD and BIM can share some data well, engineering analysis software is generally rated as doing a poor job of sharing data across different applications.
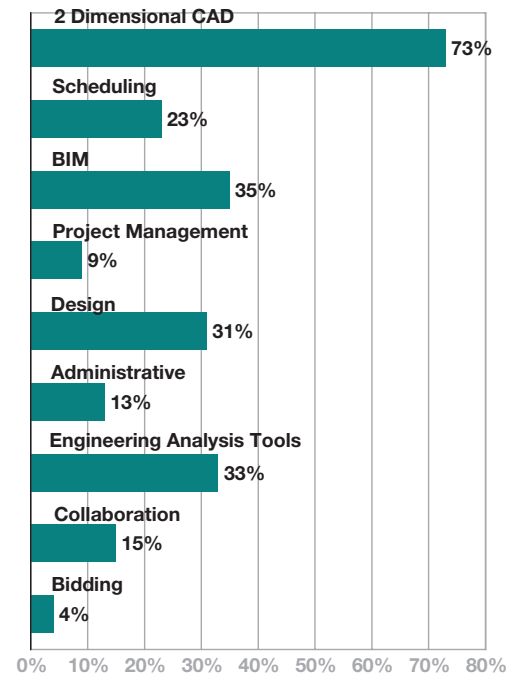
Engineers also require a wide variety of tools to accomplish their work. While one vendor's BIM software might be sufficient for most building architects, dozens of different analysis tools from a variety of vendors are required by members of the engineering community. Consequently in this environment, engineers feel a greater need for data standards to help improve interoperability between software.

Architect Software Use

Category	Percentage
2 Dimensional CAD	72%
Scheduling	24%
BIM	48%
Project Management	13%
Design	40%
Administrative	17%
Engineering Analysis Tools	4%
Collaboration	4%
Bidding	1%
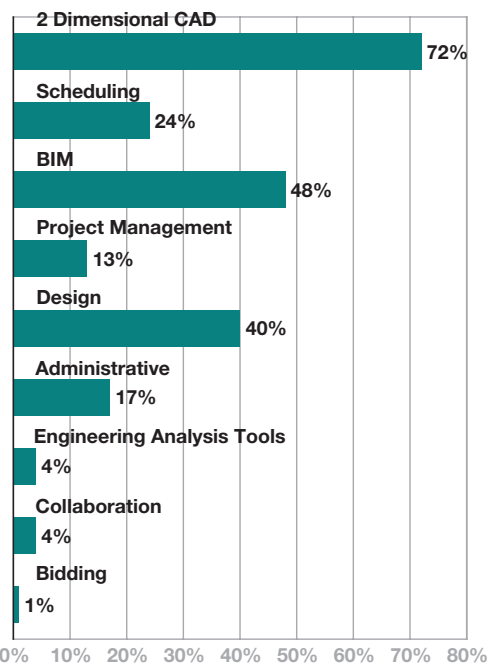
Source: McGraw-Hill Construction Research and Analytics, 2007

Engineer Software Use

Category	Percentage
2 Dimensional CAD	73%
Scheduling	23%
BIM	35%
Project Management	9%
Design	31%
Administrative	13%
Engineering Analysis Tools	33%
Collaboration	15%
Bidding	4%

Source: McGraw-Hill Construction Research and Analytics, 2007

ware Usage

Software Types Most Used–All Respondents

Software Type	Percentage
2 Dimensional CAD	57%
Scheduling	39%
BIM	28%
Project Management	28%
Design	26%
Administration	16%
Engineering Analysis Tools	11%
Collaboration	9%
Bidding	7%
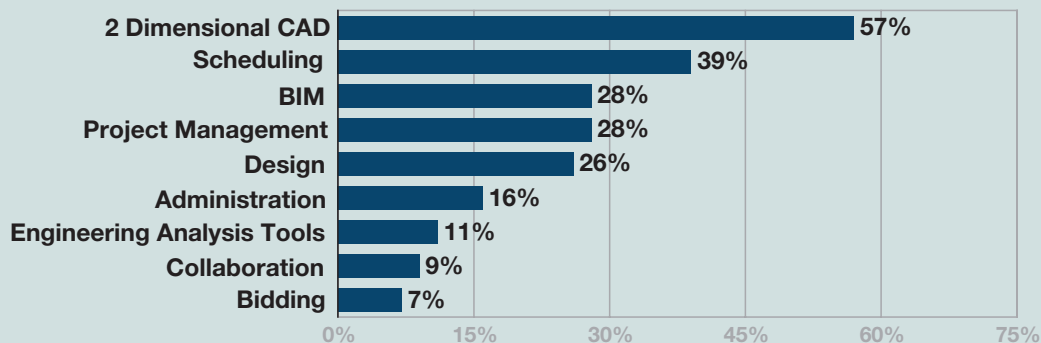
Source: McGraw-Hill Construction Research and Analytics, 2007

Contractor Software Choices

While 57% of all respondents use 2D CAD as their most popular software tool, it is only listed as "frequently used" by 33% of contractors. BIM and CAD are the leading choice of architects and engineers, contractors are primarily concerned with sharing data associated with project management and scheduling software. In general, contractors are less reliant on specific software types than architects and engineers. The software tools most favored by contractors are project management (50%) and scheduling applications (54%).

Owner Software Choices

Owners find it critical to keep a sharp eye on schedules. Scheduling software is frequently used by owners (57%) and many use project management programs (40%). However, owners are frustrated by a lack of interoperability between these applications and other software used by the build team, giving them low marks when it comes to data sharing.

While other build team members have found some success with data sharing across design software packages, owners rely on an array of software outside the design world. Few owners (17%) frequently use BIM, although nearly half (49%) use 2D CAD, often as a way to stay in communication with the build team on project progress.

Contractor Software Use

Software Type	Percentage
2 Dimensional CAD	33%
Scheduling	54%
BIM	13%
Project Management	50%
Design	14%
Administrative	17%
Engineering Analysis Tools	0%
Collaboration	7%
Bidding	14%
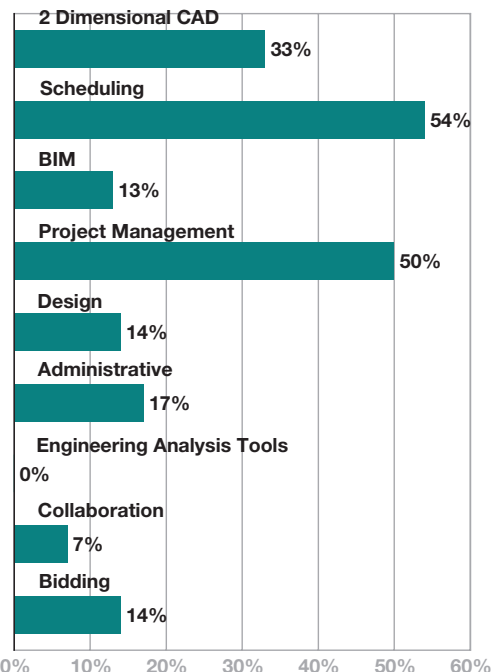
Source: McGraw-Hill Construction Research and Analytics, 2007

Owner Software Use
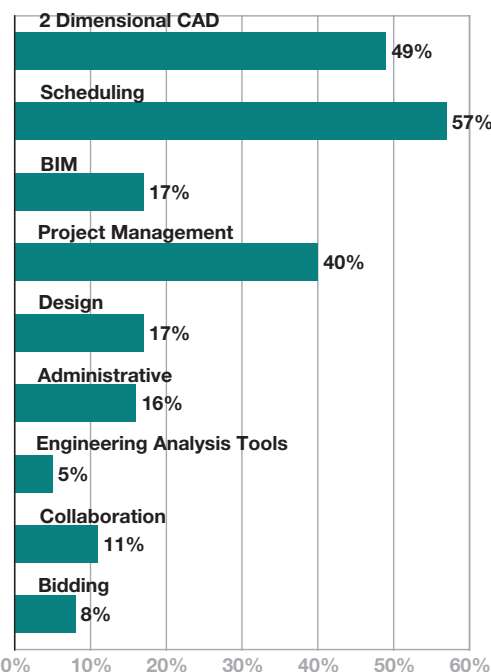
Software Type	Percentage
2 Dimensional CAD	49%
Scheduling	57%
BIM	17%
Project Management	40%
Design	17%
Administrative	16%
Engineering Analysis Tools	5%
Collaboration	11%
Bidding	8%

Source: McGraw-Hill Construction Research and Analytics, 2007

Lack of interoperability affects the workflow in the building community and ultimately impacts project budgets. Build teams estimate that interoperability issues contribute on average 3.1% to a typical project budget.

In addition, survey respondents reported that on average lack of interoperability negatively impacts project scheduling by 3.3%.

Architect Cost of Non-Interoperability

As the most frequent data sharer among build teams, architects are likely to bear the burden of many costs and frustrations related to interoperability.

On average, lack of interoperability contributes more to project costs related to architects (3.3%) than most of the team (3.1% combined average). Three out of five architects estimate that non-interoperability constitutes 2% or more of total project costs with the largest segment (44%) reporting a cost range between 2% and 4%.

Similarly, architects estimate that addressing interoperability issues adds more time to their schedules (3.6%) than most of the team (3.3% combined average).

Engineer Cost of Non-Interoperability

Engineers surveyed have the greatest concern among build team members about the impact of interoperability issues on project costs. Engineers estimate costs are close to 3.6% while the build team as a whole estimates it at 3.1% on average.

Similarly, engineers see interoperability having the greatest impact on schedule with nearly one-third estimating that it adds 5% or more. While all members of build teams report manual re-entering data across programs as contributing the most to costs, more engineers (75%) hold that view than other team members.

Cost of Non-Interoperability–Architects

Average 3.3%

- Don't Know
- <2%
- 2% to 4%
- 5% to 10%
- >10%

Cost of Non-Interoperability–Engineers

Average 3.6%

- Don't Know
- <2%
- 2% to 4%
- 5% to 10%
- >10%
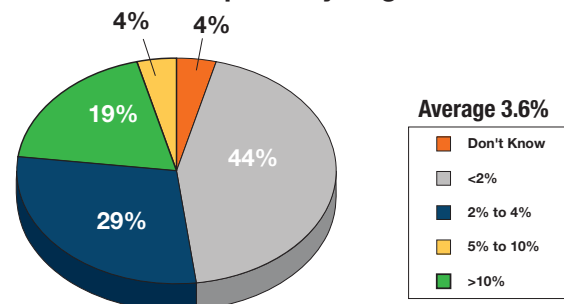
Architect Non-Interoperability Scheduling Impact

Average 3.6%

- Don't Know
- <2%
- 2% to 4%
- 5% to 10%
- >10%
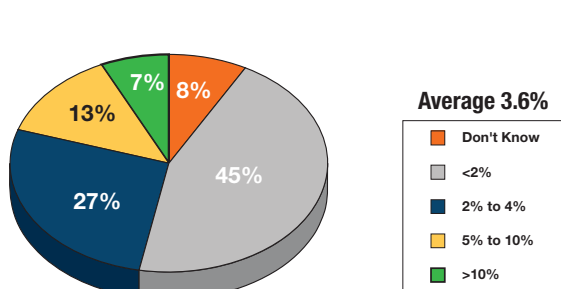
Engineer Non-Interoperability Scheduling Impact

Average 3.8%

- Don't Know
- <2%
- 2% to 4%
- 5% to 10%
- >10%

Source: McGraw-Hill Construction Research and Analytics, 2007

Source: McGraw-Hill Construction Research and Analytics, 2007
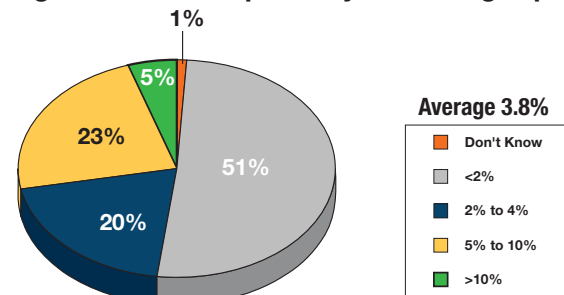
# of Non-Interoperability

Cost of Non-Interoperability–All Respondents

- Greater than 10% 2%
- Don't Know 6%
- 5% to 10% 13%
- 2% to 4% 31%
- Less than 2% 48%

Average 3.1%
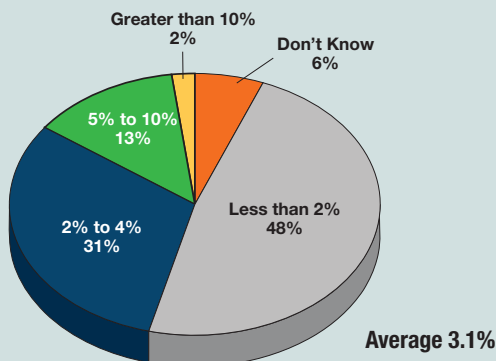
Impact of Non-Interoperability on Scheduling

- 5%
- 5%
- 14%
- 23%
- 53%

Legend:
- Don't Know
- <2%
- 2% to 4%
- 5% to 10%
- >10%
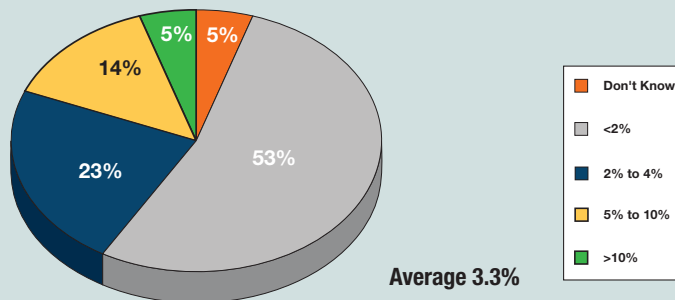
Average 3.3%

Contractor Cost of Non-Interoperability

While non-interoperability issues are a significant concern for contractors, they do not see it contributing as much to the cost of projects as the design community does.

On average, contractors report that non-interoperability costs 2.9% of a project's budget, compared to 3.6% by engineers and 3.3% by architects. Three in five contractors estimate that non-interoperability contributes less than 2% to project cost. This could be tied to the amount of software used by contractors.

Owner Cost of Non-Interoperability

Interestingly, owners only feel that the lack of interoperability contributes on average only 2.5% to project costs. This is lower than the AEC/O total mean (3.1%) and over a full percentage point lower than engineers (3.6%).

Likewise, owners feel that the lack of interoperability only adds on average 3% to the project schedule. This is higher than contractors (2.8%) but once again much lower than engineers (3.8%) and architects (3.6%).

Cost of Non-Interoperability–Contractor

- 3%
- 11%
- 7%
- 20%
- 59%

Average 2.9%

Legend:
- Don't Know
- <2%
- 2% to 4%
- 5% to 10%
- >10%

Cost of Non-Interoperability–Owner

- 1%
- 5%
- 8%
- 29%
- 57%

Average 2.5%

Legend:
- Don't Know
- <2%
- 2% to 4%
- 5% to 10%
- >10%
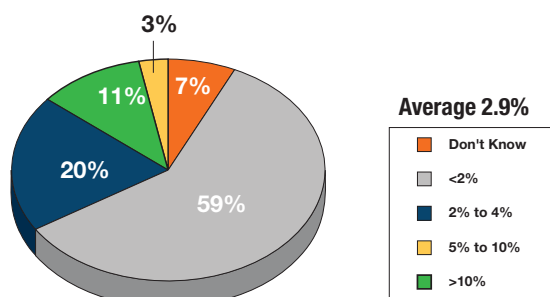
Contractor Non-Interoperability Scheduling Impact

- 3%
- 10%
- 6%
- 20%
- 61%

Average 2.8%

Legend:
- Don't Know
- <2%
- 2% to 4%
- 5% to 10%
- >10%

Owner Non-Interoperability Scheduling Impact

- 5%
- 5%
- 8%
- 24%
- 57%

Average 3.0%

Legend:
- Don't Know
- <2%
- 2% to 4%
- 5% to 10%
- >10%

Source: McGraw-Hill Construction Research and Analytics, 2007

Source: McGraw-Hill Construction Research and Analytics, 2007

Driver of Interoperability

BIM plays a key role in creating awareness of interoperability issues. As build team members create and reference these data-rich models, the advantages of sharing data between disciplines become clearer. With adoption of BIM heading toward a tipping point in 2008, more users of this technology may seek solutions that facilitate data exchange. Competitive pressure could drive this dynamic. Build team members believe their competitors may be adopting BIM more quickly than they are. To avoid the risk of falling behind, more firms will adopt BIM and possibly push its limits to create their own competitive advantages.

An overarching goal of BIM is to create a dynamic model of a building that can be used by the entire build team throughout that building's lifecycle. As a result, BIM drives demand for interoperability. As shown in graph on page 4, a significant portion of build team members (41%) see the promise of improved interoperability as a factor in their decision to use BIM.

Architects and BIM

Architects are the leading champions of BIM. Within a period of a few years, **architects embracing BIM have gone from just exploring the technology to using it on a majority of their projects–a tipping point likely reached earlier this year.** As such, they are the heaviest users of BIM among build team members.

While architects are out in front on this technology, they are also frustrated by the lack of adoption of BIM by other build team members. The lagging use of BIM by industry partners and the costs associated with the technology itself are the main obstacles to architects adopting BIM. In the meantime, other build team members report having interoperability issues between BIM and non-BIM software. As such, **data sharing between architects and the rest of the team is hampered by both the limited use of BIM on the team and the non-interoperability among the various software applications used on projects.**
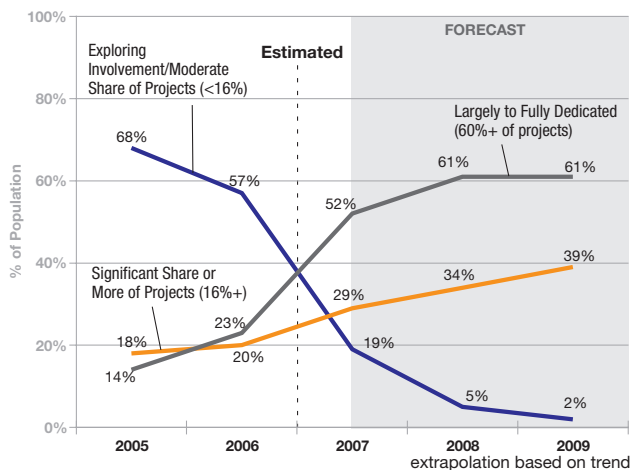
Engineers and BIM

Engineers are rapidly moving toward adoption of BIM. Following in the footsteps of architects, engineers could shift from largely experimenting with BIM to using it on a significant share of projects sometime in 2008–about a year after architects reach their tipping point. Although architects have the highest level of sophistication with BIM, engineers are more likely to report being the only build team member using BIM software on a typical project.

If a firm is the only one using BIM during a project, they will have to rely on data translation across software applications if they hope to achieve interoperability on that project.
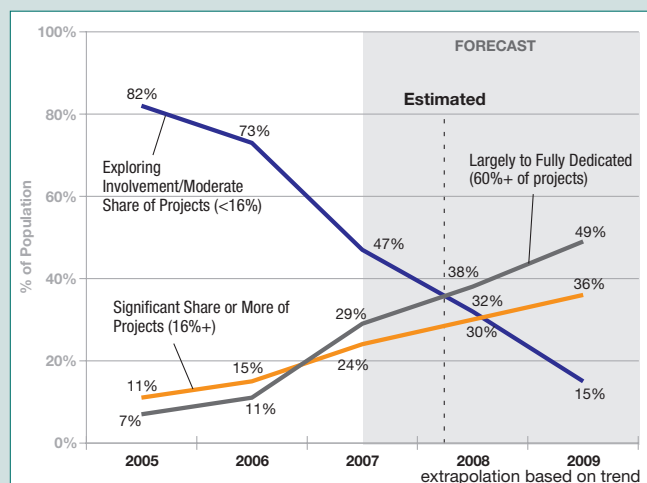
- 80% of engineers who have adopted BIM use it for 3D rendering.
- Half of engineers use it for interference detection.
- Half use BIM for parametric manipulation of designs.
- Nearly half (46%) use it for structural analysis.

Architects

Source: McGraw-Hill Construction Research and Analytics, 2007

Engineers
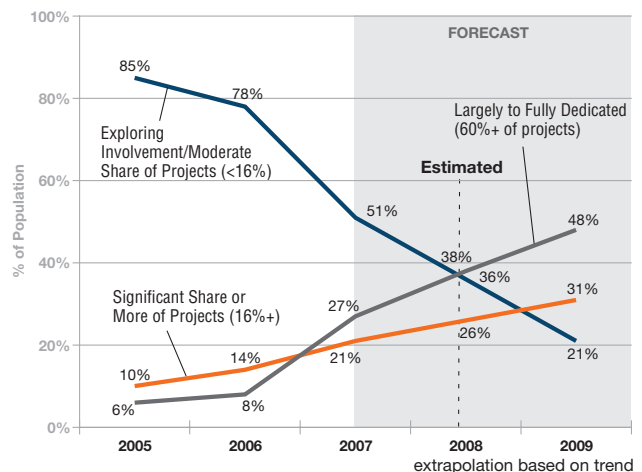
Source: McGraw-Hill Construction Research and Analytics, 2007

BIM Demand by Firms

FORECAST

Estimated

- 82% — Exploring Involvement/Moderate Share of Projects (<16%)
- 73%
- Largely to Fully Dedicated (60%+ of projects)
- 49%
- 47%
- 38%
- 36%
- 32%
- 30%
- 29%
- Significant Share or More of Projects (16%+)
- 24%
- 15%
- 15%
- 11%
- 11%
- 7%

% of Population

2005 2006 2007 2008 2009
extrapolation based on trend

"Interoperability will become more of an issue as we continue to push for the use of new technology, whether it be BIM or any other technology that gets us closer to an integrated project delivery system. Our goal is to be able to develop within the project [build] team an attitude that improves the process by having teams that are fully integrated and cooperative with each other. You need to be able to take advantage of technology that allows the free flow of information from the submittal stage to the operations and maintenance phase. We see interoperability as a challenge to achieving that."

–Ricardo Aparicio
Manager, General Electric
President, Construction Users Roundtable

Contractors and BIM

While the capabilities of BIM help drive interest in seamless data sharing, few contractors have adopted it. Only 13% of contractors count BIM among their frequently-used applications, compared to half of architects and one-third of engineers. Half of contractors have never used it.

Contractors are hesitant to adopt BIM in part because the cost and its limited use by others. As a result, **contractors are lagging other build team members in adoption of BIM.** Contractors are not expected to reach the tipping point until 2009 when the number of firms who have largely adopted BIM surpasses the number still experimenting with it.

Once contractors adopt BIM, they utilize it differently than the design community. Although they consider it important for 3D visualization and interference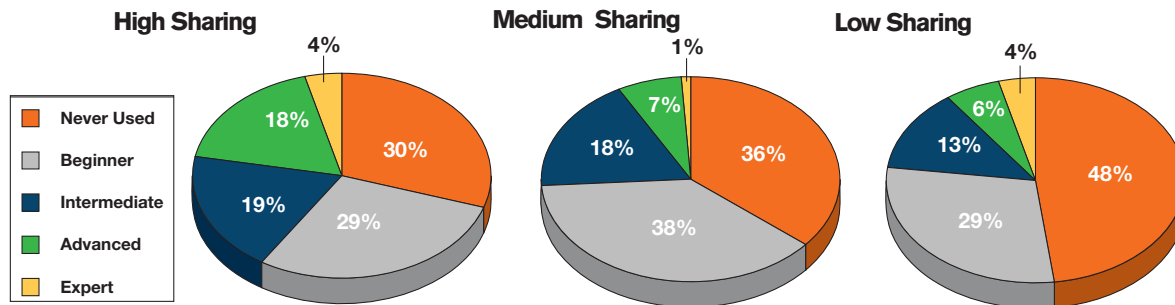 detection purposes, contractors surveyed report that they will more often use BIM for quantity takeoffs, construction sequencing and administration than other build team members.
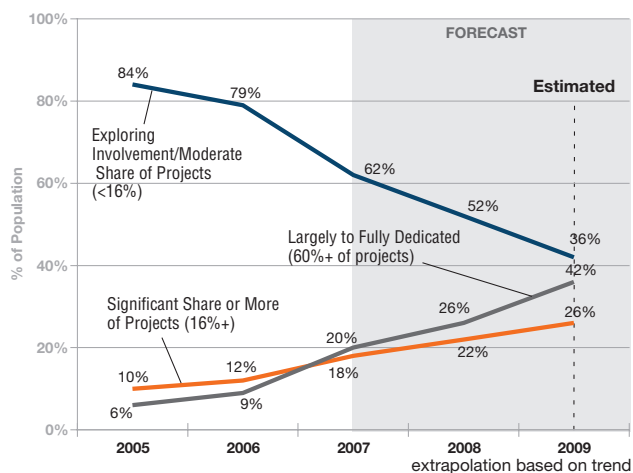
Owners and BIM

BIM represents an opportunity which has not been realized by owners yet. Although few owners currently use BIM, it's of rising interest to them. Nearly half of owners (47%) have never used BIM, but they continue to adopt the technology. **By the end of 2008 the number of owners using BIM on a moderate to significant amount of projects could outpace those who are minimally invested in BIM.**

Beyond their 3D capabilities, these models offer the future promise of providing a critical database of facility information that can be used for operations and maintenance. While that capability has not been realized today, interoperability is a critical factor in the development of BIM, as data will need to be culled from a variety of industry partners, including original equipment manufacturers, for use by owners.

Contractors

FORECAST

Estimated

- 84% — Exploring Involvement/Moderate Share of Projects (<16%)
- 79%
- 62%
- 52%
- Largely to Fully Dedicated (60%+ of projects)
- 42%
- 36%
- Significant Share or More of Projects (16%+)
- 26%
- 26%
- 22%
- 20%
- 18%
- 12%
- 10%
- 9%
- 6%

% of Population

2005 2006 2007 2008 2009
extrapolation based on trend

Source: McGraw-Hill Construction Research and Analytics, 2007

Owners

FORECAST

- 92% — Exploring Involvement/Moderate Share of Projects (<16%)
- 80%
- **Largely to fully dedicated share of projects tipping point projection**
- **Significant share of projects tipping point projection**
- 58%
- 48%
- 43%
- 38%
- 28%
- Significant Share or More of Projects (16%+)
- 27%
- 24%
- 19%
- 16%
- 15%
- 6%
- 4%
- 3%
- Largely to Fully Dedicated (60%+ of projects)

% of Population

2005 2006 2007 2008 2009
extrapolation based on trend

Source: McGraw-Hill Construction Research and Analytics, 2007

BIM Usage and Obstacles to Acceptance

Firms using BIM by Respondent

- Most (57%) build team members report that only a few firms involved in their projects are using BIM.
- Only one-quarter (24%) state that all or most firms on their projects are using BIM.
- Engineers (29%) and contractors (30%) are more likely to report that all or most firms involved in the building team on their projects are using BIM.

Obstacles Affecting Delayed Use of BIM

- According to build team members, too few firms using it (36%), cost (36%), its inefficiency for smaller projects (33%), and training time (33%) are the greatest obstacles in use of BIM software at their firms.

Sophistication with BIM by Sharing Segment

- High data sharers are more likely to think of themselves as being highly sophisticated with BIM software compared to other data sharers.
- Low and medium level data sharers are more likely to have never used BIM software.

Sophistication With BIM by Respondent

- Overall, more than one in three (36%) build team members have never used BIM software
- Architects (43%) have the highest level of BIM sophistication, followed by engineers (35%).
- Contractors and owners are the least sophisticated with BIM software and are the groups most likely to have never used the software.

Sophistication with BIM by Length in Occupation

- Newer entrants in building and construction are more BIM savvy. AEC/O professionals with less than 5 years in the industry had the most expert knowledge in BIM (5%) and the lowest percentage of respondents who have never used BIM (21%).
- Build team members who have had a longer tenure in their occupation are less sophisticated with BIM software. Those AEC/O professionals that have been in the industry for over 10 years had the highest percentage of respondents that have never used BIM (38%).

Obstacles Delaying BIM Acceptance

Obstacle	Percentage
Unclear Roles/Change in Roles of Participants Caused by Introducing BIM on Project	19%
Current Legal Contracts Do Not Address BIM Issues/Proprietary Information Issues	23%
Instability of Electronic Hardware	24%
Lack of Objective Documentation of Benefits	24%
Unresolved Issues Concerning Ownership/Maintenance of BIM Model	26%
Lack of Interoperability	27%
Cost of Software	29%
Training Time Associated with Implementing Necessary Tools	33%
Cost Associated with Implementing Necessary Tools	36%
Too Few Firms Are Using It	36%

Source: McGraw-Hill Construction Research and Analytics, 2007

Firms using BIM Software by Respondents
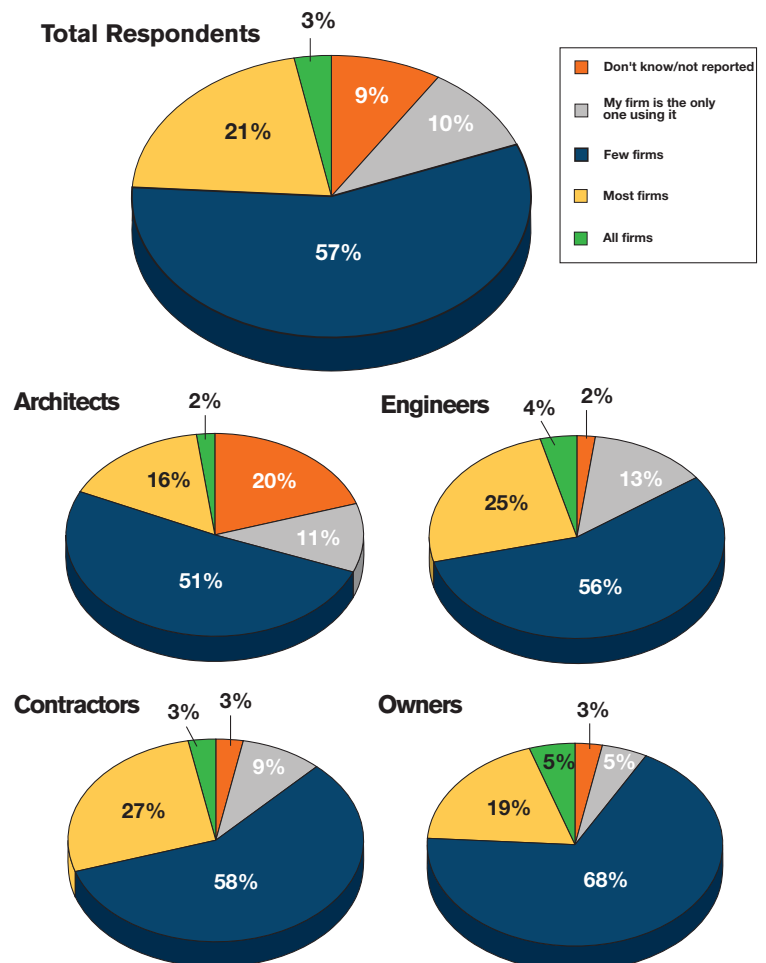
Total Respondents

- Don't know/not reported
- My firm is the only one using it
- Few firms
- Most firms
- All firms

Total Respondents: 3%, 9%, 10%, 21%, 57%

Architects: 2%, 20%, 16%, 11%, 51%

Engineers: 2%, 4%, 13%, 25%, 56%

Contractors: 3%, 3%, 9%, 27%, 58%

Owners: 3%, 5%, 5%, 19%, 68%

Source: McGraw-Hill Construction Research and Analytics, 2007

Sophistication with BIM Software by Sharing Segment

High Sharing

- Never Used
- Beginner
- Intermediate
- Advanced
- Expert

4%
18%
30%
19%
29%

Medium Sharing

1%
7%
18%
36%
38%

Low Sharing

4%
6%
13%
48%
29%

Source: McGraw-Hill Construction Research and Analytics, 2007

Sophistication with BIM Software by Respondent

Total Respondents

1%
3%
11%
17%
36%
32%

Architects

7%
19%
16%
17%
41%

Engineers

4%
12%
32%
19%
33%

Contractors

4% 1% 3%
19%
50%
23%

Owners

1%
8%
13%
47%
31%

- Do Not Know
- Never Used BIM Software
- Beginner
- Intermediate
- Advanced
- Expert
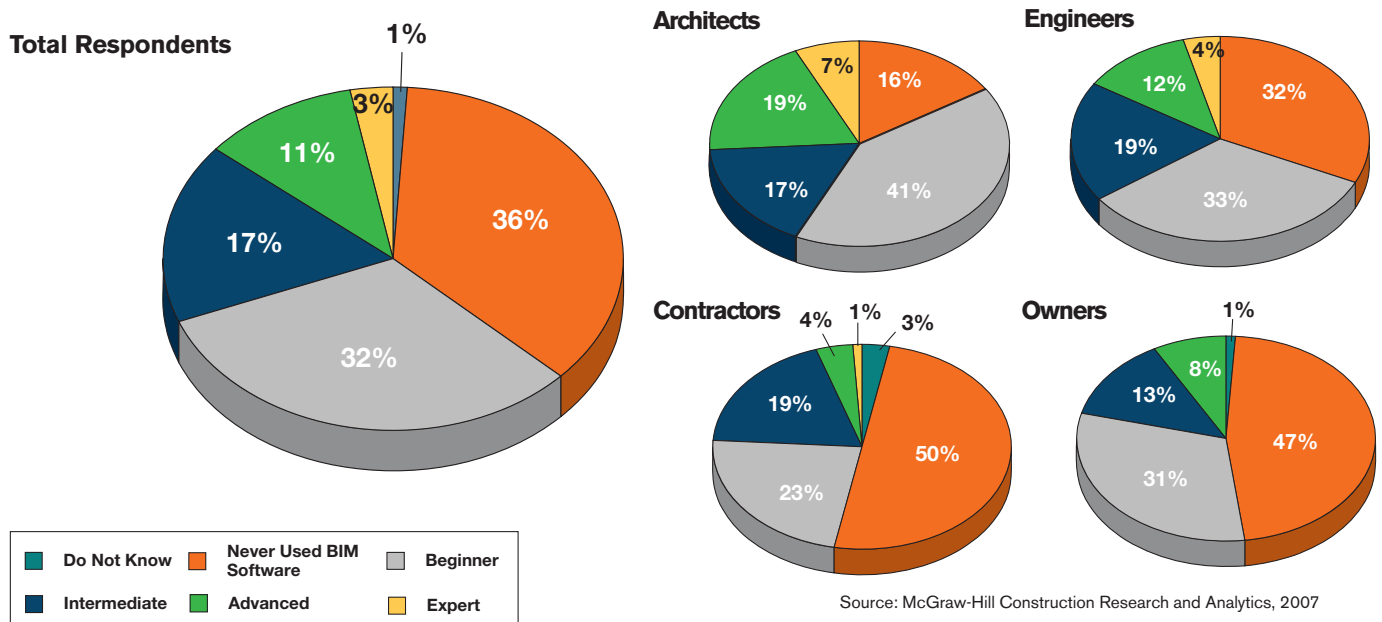
Source: McGraw-Hill Construction Research and Analytics, 2007

Sophistication with BIM Software by Length in Occupation
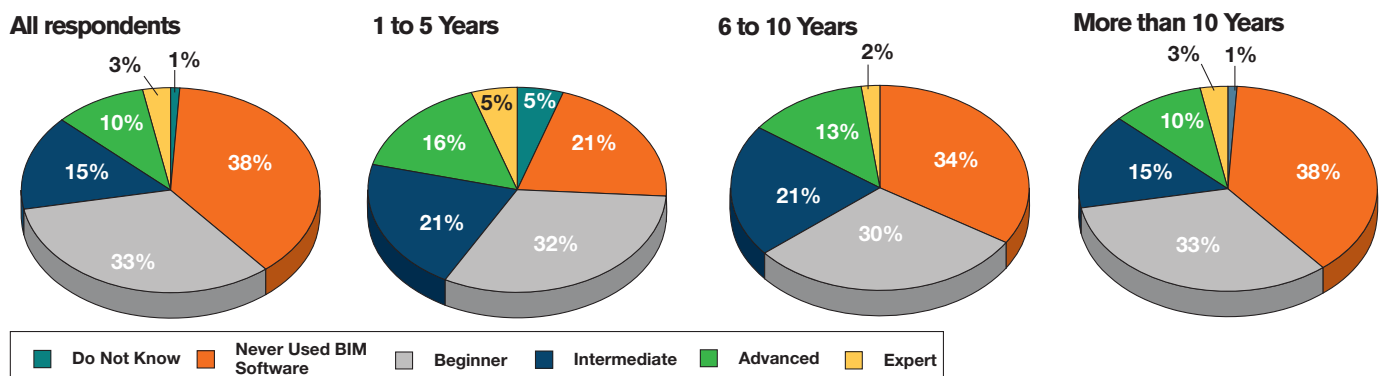
All respondents

3% 1%
10%
15%
38%
33%

1 to 5 Years

5% 5%
16%
21%
21%
32%

6 to 10 Years

2%
13%
34%
21%
30%

More than 10 Years

3% 1%
10%
15%
38%
33%

- Do Not Know
- Never Used BIM Software
- Beginner
- Intermediate
- Advanced
- Expert

Source: McGraw-Hill Construction Research and Analytics, 2007

Code Checking

The ICC is tackling interoperability issues as part of its effort to bring code checking capabilities to building information modeling. The Code Council is developing a system called SMARTcodes, which could be used to conduct automated code compliance checking of electronic building plans. The Council is working with BIM software manufacturers so that SMARTcodes can ultimately be used with model checking software to check BIMs for code compliance before plans are sent to regulatory agencies. **In theory, a BIM that has been auto-checked should pass quickly through the approval process, saving time and money.**

MHC research shows:
- Among all survey respondents, the higher the level of data sharing, the higher both the interest and use in automated code checking
- Few build team members have ever used any automated code processing, but most are interested in the capability.
- Architects show the highest level of interest in automated processing.
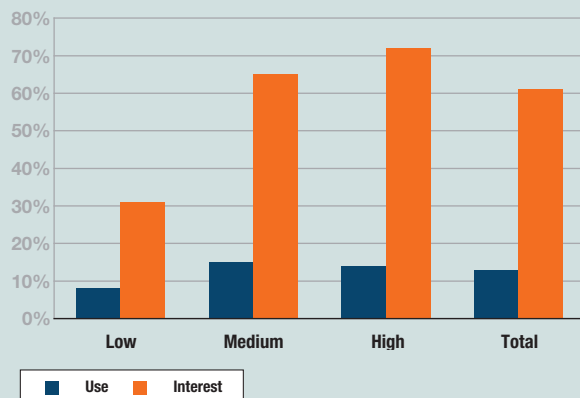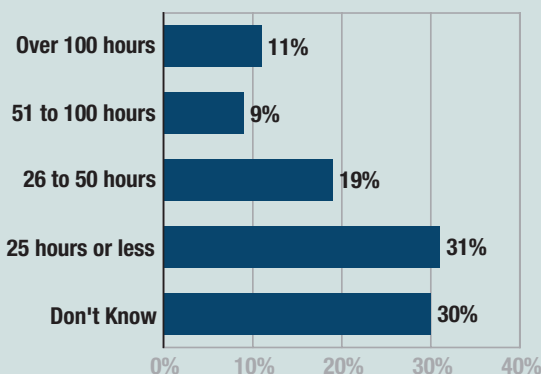
David Conover, senior advisor with the Code Council, says converting the codes to an interoperable format proved easier than expected. The trick is getting those codes to interoperate with existing software and related codes. For example, in order for the process to work, BIM software developers have to define all of the characteristics of a wall so they match up with how the International Codes define a wall.

Code Council efforts also have to be coordinated with those of other industry groups, such as the Construction Specifications Institute and its OmniClass classification and IFDLibrary open dictionary systems for identifying project information. The SMARTcodes system will also incorporate product information from building product manufacturers that provide compatible electronic information needed for code checking. Without the help of product manufacturers, BIM users would have to input information about each product, spending time and money in the process.

OmniClass and the IFDLibrary

Achieving interoperability is dependent on being able to successfully exchange information across a wide variety of processes and systems. In the building industry, given the distributed nature of the teams that design, produce and operate buildings, we need shared information standards to structure data exchanges. With the largely paper-based communications we have traditionally used, we have relied on hierarchical formats. As we transition to model-centric technology, we need to keep evolving our standards to support new requirements. To do this, CSI and CSC (Construction Specifications Canada) along with others are focused on developing OmniClass and the IFDLibrary as comprehensive frameworks for naming objects and establishing their properties to support buildingSmart and Interoperability.

Interest and Usage in Automated Code Compliance Checking by Sharing Segment

Source: McGraw-Hill Construction Research and Analytics, 2007

Time Spent on Code Checking by Sharing Segment
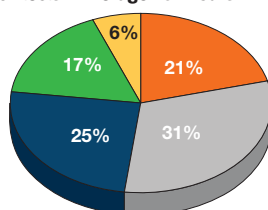

Source: McGraw-Hill Construction Research and Analytics, 2007

Low – Average 38.1 hours
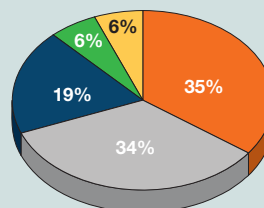
Medium – Average 59.3 hours

High – Average 64.6 hours

Legend:
- Don't Know
- 25 hours or less
- 26 to 50 hours
- 51 to 100 hours
- Over 100 hours
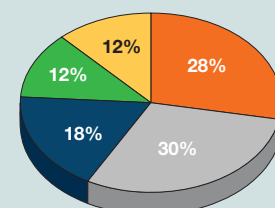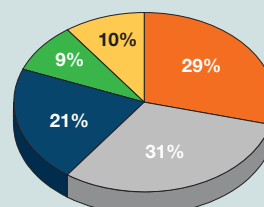
Architects and Automated Code Checking

Architects see great potential in automated code compliance checking. While three out of five build team members are interested in the concept, **architects are by far the most intrigued with 85% expressing interest in the technology**–more than twice as many as contractors (42%). That interest is fueled in part by the fact that architects share data more frequently than other build team members. Nearly half of architects (48%) spend 26 hours or more on code checking on a typical project. Because limited options exist for electronic code processing, such as e-permitting, few architects have used the technology (12%).

Engineers and Automated Code Checking

Engineers appear to be leading efforts to improve the flow of data used for code compliance checking. Engineers are the most likely to have used an automated process for code checking with 21% claiming to have tried it– nearly twice the rate of architects and owners. Engineers estimate spending around 51 hours on code checking on an average project with many (43%) reporting that they invest 25 hours or less to code checking.

Contractors and Automated Code Checking

Automated code checking seems like an ideal cost solution for contractors. After owners, contractors spend the most time per project on code–compliance checking on average (57 hours). Three in ten spend 26 hours or more on code checking, while an equal number report spending 25 hours or less. Despite this, **contractors have the least interest in automated code checking.** While 13% of all build team members have used an automated process for code checking, only 5% of contractors have ever used the technology. In keeping with that trend, a minority of contractors (42%) are interested in automated code checking compared to a large majority of architects (85%).

Owners and Automated Code Checking

Since permitting is of prime importance to owners, code checking is a major issue for them. Owners estimate they spend about 59 hours on code compliance checking on an average project, the highest of all build team members. Almost half (46%) report that code–compliance checking requires 26 hours or more on an average project. Like all build team members, few owners (12%) have used any type of automated process for code–compliance checking. Half of owners are interested in automated code compliance checking–below average for the entire build team (61%).
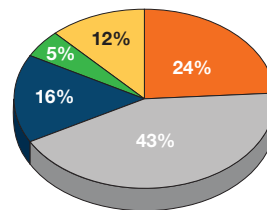
Interest and Usage in Automated Code Compliance Checking by Respondent

Source: McGraw-Hill Construction Research and Analytics, 2007

Time Spent on Code Checking-Total

Source: McGraw-Hill Construction Research and Analytics, 2007
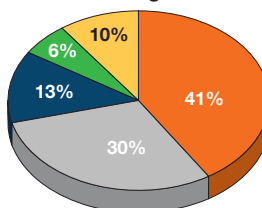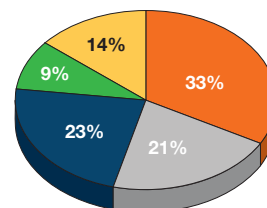
General Motors

When General Motors started planning its next generation of manufacturing facilities in 2000, the company demanded projects that were delivered faster, better, cheaper and safer. While owners and developers typically aim for such lofty goals on their projects, many find their hopes dashed by the limitations of traditional design and construction. So GM chartered a new path, utilizing emerging ideas of virtual design and construction as well as integrated project delivery to find its way.

The plan would require bringing together a variety of software applications to take design concepts from the virtual world to reality. Projects would ultimately be designed entirely in 3D, using electronic data from each build team member that could be fed into a singular model without the use of physical shop drawings. All system interferences would be identified in the model before the construction phase began in order to eliminate change orders. Information would be shared with fabricators so that all fabrication could occur off-site and be delivered just-in-time.

Through trial and error, the team found solutions to its interoperability dilemmas and is well on its way to helping GM see a 25% reduction in key metrics for design and construction.

The plan was implemented in 2004 at two GM projects—the new 2.4-million-sq-ft Lansing Delta Township plant in Lansing, Mich., and a 740,000-sq-ft addition to its Flint V6 Engine Plant in Flint, Mich. Architecture/engineering firm Ghafari Associates of Dearborn, Mich., took the lead as technology integrator on the jobs, finding ways to allow build team members to exchange electronic data seamlessly. The LDT project emerged as a testing ground for the concept, helping the team find solutions and identify weaknesses.

Among the discoveries on LDT was the need to allow companies to use their best-in-class software whenever possible and find ways to make it interoperable, says Robert Mauck, vice president of advanced technologies at Ghafari. "Initially, GM's standard was that all 3D modeling was to be done in MicroStation or Triforma," he explains. "We went back to GM and said, 'If you relax that standard, you'll get—from an interoperability standpoint—the ability to move design data directly to fabricators and subcontractors and let them use their own software, which is typically not MicroStation. Let them use their best-of-practice tools and give us the flexibility to make sure they can get our data and that we can bring the data back into the model.'"

The team implemented the change on the Flint V6 project. Although it would require finding several interoperability workarounds, Mauck says it was worth the effort to make sure that the entire process remained true to the virtual construc-

tion mission. In most cases, the team has found ways to bring data into programs such as Navisworks, for integration and collision detection.

"We'd design something in RAM Structural System and link that to a modeling tool such as TriForma, then leverage detailing efforts by the fabricators and pull that back into the design model," says Samir Emdanat, manager of advanced technologies at Ghafari. "Fabricators would use [Tekla] Xsteel and through the CIMSteel Integration Standards [CIS/2] format we can take any structural model and pull it from one application to another. We pulled all of the detailing models made by the fabricator and used them for all MEP coordination. That was a huge benefit."
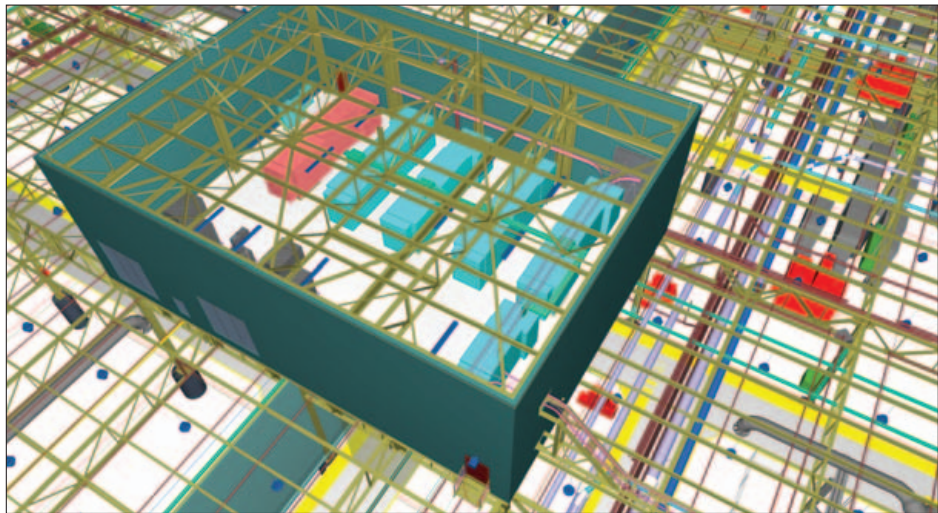
Ghafari Associates uses detailed 3D models to eliminate collisions on General Motors projects before construction starts. Image courtesy of Ghafari Associates

The team used Bentley's ProjectWise system to create real-time server access to the main MicroStation model. Through ProjectWise, team members could "check out" files from the server, work on them and then "check in" the updated files. The system allowed team members to easily track progress.

"Requests for information [RFI] were minimal on these jobs," Mauck says.

Other software on the V6 job included SDS/2 for steel detailing, QuickPen for mechanical planning, InteliCAD for HVAC work and Autocad.

Using the CIS/2 format for data exchange proved critical when working with fabricators. Three weeks from the start of construction on Flint V6, an order for 5,000 tons of structural steel needed to go out or the team would miss a mill cycle. The team met with fabricators to determine the data it would need to quickly identify the details needed for the order. "Because of the CIS/2 format, we were able to exchange information from RAM

Structural System," Emdanat says. "We could give them very accurate analytical models. The fact that they could look into our design model and pull information directly from those models allowed them to issue an order very quickly. Also, they could give early input to optimize the steel for cost."

Although the team was making considerable progress with interoperability, some challenges remained during the Flint V6 project. Emdanat says that exchange standards for MEP applications were lacking. As a result there was some reworking of models that had to be done. Still, the team achieved its goal of 100% collision detection. "We had install-level 3D models before we started construction," he says. "There were no changes at the construction site thanks to the coordination upfront. That helped the schedule significantly."

In fact, the flint plant sped to completion in 9.5 months–27% faster than the 13 months target schedule

The team moved on to improve its practices with other projects for GM in Fort Wayne, Ind. and Pontiac, Mich. Because of a lack of effective workarounds, the contractors agreed to use some of the same design software in order to overcome the lack of interoperability in MEP coordination.

Reducing shop drawings also became a major target. On the LDT project, the team had to create nearly 12,000 steel shop drawings which were exchanged as PDFs and printed documents. On the two new projects, the team wanted to implement a 3D shop drawing review process. Ghafari and the steel fabricator worked with the technology teams at Bentley and SDS/2 to find solutions. "There was nothing in the industry that we could use," Emdanat says. "It was one of the first times where a structural engineer would review a 3D model generated by fabricators. We were relying on the 3D model by the fabricator throughout the detail coordination process. They would submit data in CIS/2 format for coordination and then submit in its entirety in SDS/2 format for us to review. There were no 2D drawings generated at all–No PDFs."

Integrated project delivery proved a key component of making GM's plan work. Bringing in contractors and subcontractors early for preconstruction or design-assist not only helped identify design and constructability issues, it helped establish interoperability demands.

"Every subcontractor operates a little differently," Mauck says. "From the engineering side, if you don't know who's going to be on the team downstream, you have to make assumptions. You run the risk of not having everyone on the team be able to have interoperability. If you're at the same table at the beginning, you resolve those issues."

But build team members aren't the only partners in the process. Emdanat says that as the industry works through its interoperability issues, software vendors are key players in finding solutions.

"Software vendors have become integral to the team," he says. "They understand the potential of a new way of working. They partner with us to make the software do what it's supposed to do and facilitate the exchange formats. With minor tweaks to software, we can get it to do what it's supposed to do. Once you figure it out, it becomes an opportunity rather than a problem."

Jack Hallman
Director of Manufacturing Construction Management
General Motors

General Motors is on a mission to have its capital projects built better, faster, cheaper and safer—and interoperability is a key driver toward those goals. Part of the Detroit-based company's strategy is to be software neutral. Rather than strictly dictating the software that needs to be used, GM expects the firms it works with to use software that coordinates data through applications like NavisWorks.

Hallman says such coordination efforts are an expectation on GM projects, so any firms that work with the company need to be able or willing to work in 3D. "We expect our GCs and major subs to collaborate and help do the design," he explains. "We're not looking for the A/E firm to do it all. We want the A/E firm to coordinate the model with all of the other subs."

Since making collaboration a standard procedure in January 2006, GM has already started reaping the rewards. Hallman says projects are coming in faster and at higher quality. Costs are also dropping thanks in part to the speed of design work; the ability to do more off-site fabrication; just-in-time delivery; and improved workplace organization.

"Happily, our safety has gone up," he adds. "There's less debris, clutter and hazards on site. Those [factors] improve safety."

In the big picture, Hallman hopes to see 3D BIM designs become "living models" that stay with the building long after its completion to help with operations and maintenance tasks. Getting there will require additional levels of interoperability, such as OEMs creating smart objects that can go into models.

"It would be great to see the process set up so that we can get smart objects into the model and that data has the OEM recommendations for maintenance," he says. "Then we can bump that data up and against [our management software] and not have to do that manually."

Ultimately, Hallman says owners have the power to push the industry to overcome its interoperability issues. "We have to be the catalyst to drive the industry to accept these new processes and systems and to learn and be able to navigate these processes and software," he says. "To me it's almost incredulous that people can't see it as a win-win situation. Today, I get projects faster, better, cheaper and safer. And the contractors and A/E firms ought to be able to do more with the same amount of people, which increases their profit margin. It's a win-win and we'd better get people to understand that."

Perspective of the Industry

Jim Bedrick

Vice President, Virtual Building and Design

Webcor Builders

There is no need to sell the benefits of interoperability to Webcor Builders, based in San Mateo, Calif. Bedrick says the company relies on 3D, 4D and 5D models for quantity takeoffs, MEP coordination, schedules and other tasks. In nearly every case, Webcor builds its models from scratch either because few architects and engineers provide models or they can't seamlessly share the data needed to create those models.

"We're redoing a lot of work that's already been done," he says. "If we could avoid that, we could turn around cost information a lot faster and more often to architects."

Although the company has been willing to go it alone in the past, it is now pushing for greater efficiencies. Webcor now requires all MEP subcontractors to provide system models in 3D. Bedrick says the company has tried IFCs and other means of data transfer with some success, but the process needs a lot of honing.

"So far, interoperability hasn't been much of an issue, but we've seen it coming and now we have to address it."

Joseph Burns

Managing Principal

Thornton Tomasetti

Interoperability holds a lot of future promise at New York-based Thornton Tomasetti, but it remains well over the horizon. For Burns, the decision to tackle interoperability issues comes down to a simple matter of productivity.

"How long does it typically take to do a task, and if we use a different process, will it take fewer hours?" he asks. "The sooner you can put your part of the design into the hole to see if it fits, the better."

Often, relying on software translation has not proven to be the answer. "One of the potential productivity gains [of interoperable software] is the speed at which others can understand what you're doing and can respond," he adds. "There's a local level and a global level to that. If I'm the only one using 3D, I could realize local efficiencies because maybe I do analysis quicker for example. But I don't get global efficiencies if no one else uses 3D and I have to reproduce everything in 2D."

In the end, a lack of interoperability can cause the solutions promised by software to be overshadowed by its setbacks. "Throughout history, we had an incredibly interoperable system called paper," he says. "It's a wonderful product because we can all buy pencils and draw on paper and make copies. We had a series of standard conventions on how we drew and people knew what we meant. Today, we've traded that for a system that, while still using the drawing conventions, has electronic underpinnings that involve different systems that don't talk to each other all the time."

Patrick MacLeamy

Chief Executive Officer

HOK

For MacLeamy and St. Louis-based HOK, working collaboratively with contractors, engineers and consultants is smart business. Based in part on MacLeamy's work with the buildingSMART Alliance, HOK has adopted a plan to form project alliances that better integrate team practices on all of its projects. Unfortunately, the more HOK tries to use tools that should help bring those teams together, the more aware the firm becomes of the lack of interoperability in the industry.

"Our whole firm is quite aware of this and working hard at this problem everyday," MacLeamy says. "Everyday, I know what the interoperability issues are and what it costs us in time, money and lack of quality. It's a damn shame."

Among its many goals, HOK hopes to be able to have continuously updated cost estimates, using shared data among team members, so that the firm can ensure a project remains on track. For now, MacLeamy sees contractors forced to take its electronic data—which includes quantities—and re-enter that data into other software or print out HOK's drawings to calculate those quantities by hand.

"It's really dumb what we have to do," he says. "As a result, we don't continuously update our costs, and that creates mistakes. If we end up over budget after all of this work, we have to redraw, and that costs money. Instead of devoting our energy to better design work, we're focused on redrawing efforts to bring the building in at cost. Even worse, if we're over budget, too many times architects and contractors bring the building back at cost by cheapening the building, instead of by designing it right in the first place. No owner wants a cheap building after all of these millions of dollars and hassle."

Those frustrations extend into the engineering arena. HOK has had some success with exchanging data among the primary disciplines, such as structural data, but conducting more detailed analysis has proven difficult.

"If you want to do anything sophisticated, you can't," he adds. "If you want seismic analysis or wind analysis or heat-gain analysis or day-lighting analysis or green-building compliance, you have to have someone re-enter data out of the architects' and engineers' drawings and into another special program. Then after that work, they build another model just for that analysis. In the meantime if you changed your building, the analysis is no good. There's a word for that—stupid."

Perspective of Software Companies

Brad Workman
Vice President
Bentley Systems

What is your opinion of using data standards to improve interoperability?

We support standards. There's a lot that each [software] vendor can do within their own products to support standards. A big part that is often overlooked, and is critical, is the standardization of how the end-user enters the information. We can come up with a standard interchange, but if people don't populate it in standard ways then there's very little the vendor can do.

Why are standards important?

If we have to interface with every cost–estimating third–party product out there, how do we do that? If we as software vendors have to interface with everyone else, it's going to mean X number of interfaces we have to create and that takes a lot of time and effort, and it could be problematic to meet these issues quickly. That's why standards are very important. That is why we need to interoperate with things like IFCs.

What will push the adoption of standards?

We've been pushing IFCs for 10 years and in many cases the vendors have been out in front on this issue. Now that we're starting to see adoption, we're going to have to do a better job of fulfilling it. The vendors are working, but the demand is there too. Until the last few years, we've been out in front of most of the industry. We had IFCs back when architects were using lines, arcs and circles. We'll make a lot of progress in a short amount of time.

Can software vendors solve this dilemma?

Many users have thought that software vendors should be taking the first steps. We've done that, but it needs to be validated in market adoption so that we can respond. We're like our customers are in their businesses—we respond to the market. We, as software vendors, can't be the only leader in that process.

Jonathan Bowman
Manager
Adobe

Would introducing more technology providers to the market and increasing competition help push the industry toward more solutions?

I think it dilutes the effort even further to have more players involved. That just adds more potential issues to the mix. There are applications out there that have been proven over time. If Adobe started in the CAD business, we'd start from ground zero. We'd put in the bells and whistles, but we wouldn't have the experience that these others are providing. The technology companies out there are expert within their own right. By Company A taking the first step and saying it will open up its system, it will force the others to follow. That's the hard part...forcing one of them to step out and say they will adopt this.

Phillip Bernstein
Vice President
Autodesk

What are the main challenges for technology companies trying to improve interoperability?

What's happening now is we have widespread discontinuous adoption of digital technology in the construction industry. That's happening simultaneously with redefinition of the business processes that people are using technology to support. To get to a state of zero friction, you have to have really well-articulated business relationships between pieces of technology that can talk to each other in an appropriate way. A cost estimating program needs to know the amount of and cost of paint, for instance, but it doesn't need to know much geometric information.

How can we ultimately achieve interoperability?

We're in a time of an explosion of technological innovation in terms of the things we build as providers and the things our clients do with our technologies. We're in a time of intensive process and technological innovation. There will be a lot of attempts made to make all of this stuff work together. What's in people's best interest is to be patient as we watch what's happening out there; supportive of the things that work; and dismissive of things that don't work.

"Eventually, the technologies that people like the best will come to the fore. I think there's an unrealistic expectation that somehow the technology providers will by brute force solve these problems top down. That's not how it will work. It will work by people figuring out what they want to accomplish as a business process and then finding the best ways to interconnect them. In a time of explosive innovation, that's how things work.

> *"There's a tendency to reduce this problem to describing interoperability as every single piece of software can understand every single piece of data by all other pieces of software. That's both reductive and not helpful."*
>
> **–Phillip Bernstein, Vice President, Autodesk**

United States Coast Guard

Faced with a post–9/11 environment, budget constraints, and ever-evolving missions, the United States Coast Guard (USCG) set out to overhaul its facility operations in 2004. The USCG created a plan to establish 35 new Sector Command Centers that would unify its group commanders and port operations into combined facilities. Under the traditional planning methods, the USCG mission would take nearly 30 years of combined team efforts to complete with approximately 10 months dedicated to each project.

USCG brought on board Onuma, Inc., of Pasadena, Calif., to create ways to expedite the process and plan for the future. Onuma employed its in-house tools, called the Onuma Planning System (OPS), to develop a web-enabled standardized system that USCG could use to rapidly catalog its facilities and develop future growth strategies. The Onuma system would require significant interoperability to allow data to move seamlessly into the system and ultimately into a format that could be shared during future projects. The team was able to complete planning for the 35 command centers in six months, instead of the 350 months it could have taken under its existing methods.

The evolution of Onuma's OPS began with the expanding use of the Internet in the early 1990s. Initially used as a communications tool between its California and Tokyo offices, the firm eventually began to expand its use into project planning, tapping into interoperable formats whenever possible. The system's speed is fueled by open standards. Just as the Internet expanded through open standards, Onuma is seeking the same for its architecture and planning work. The aim of OPS is to address the full lifecycle of a project from planning through operations and maintenance. It exchanges data using industry foundation classes (IFC). It can also link with geographic information system (GIS) information, transferring data from IFC to CityGML and back.

To populate the OPS system for the USCG projects, Onuma needed to cull large amounts of data about its client's existing facilities. The firm received data in a variety of formats, largely as Excel files and PDFs. Kimon Onuma, president at Onuma, Inc., said that Excel proved to be a very effective format because many people were familiar with it, and as a database tool it flowed well into the OPS database. Data included geospatial information on building and room sizes as well as the office equipment in each room. Behind the scenes, Onuma was creating the building blocks for designing BIMs of the facilities.

The key to the process was keeping it simple for USCG personnel. Onuma wanted data in interoperable formats, but it also wanted to make sure USCG used the tools with which it was most comfortable.

"[Field operators] didn't want to hear about interoperability or BIM," Onuma says. "They just wanted tools to plan for these command centers with a simple web-based interface that allows them to log-in, see the pieces they need to work on and start using the tool. As they work on the project, the system constantly collects site-specific data to populate the database
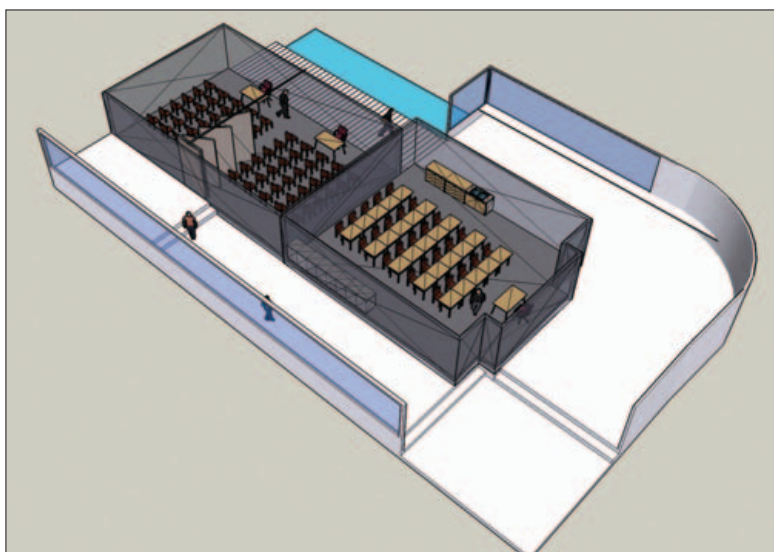
Onuma's OPS system allowed U.S. Coast Guard personnel to easily input data that led to BIM models. Image courtesy of Onuma, Inc.

for later use. The interoperable aspect is that as they are populating it. It's building a BIM by filling in forms that are linked through interoperable standards to BIM software."

Onuma likens the process to the travel web service Expedia.com. The web portal asks customers to fill in simple data, but it doesn't require them to understand anything about the technology behind it. Through the inputted data on Expedia.com, the customer is booked on a flight, all necessary parties are informed, a credit card is billed and the airline makes the necessary preparations for the arriving customer.

After one day of training, planners guided local teams for each command center during a three month period.

"Once we trained them in OPS, they could assemble projects with space and furniture for each project on their own," Onuma says. "After training, we didn't participate in charrettes. They went on their own. We created value as architects in developing a system that trained their architects to interact with the
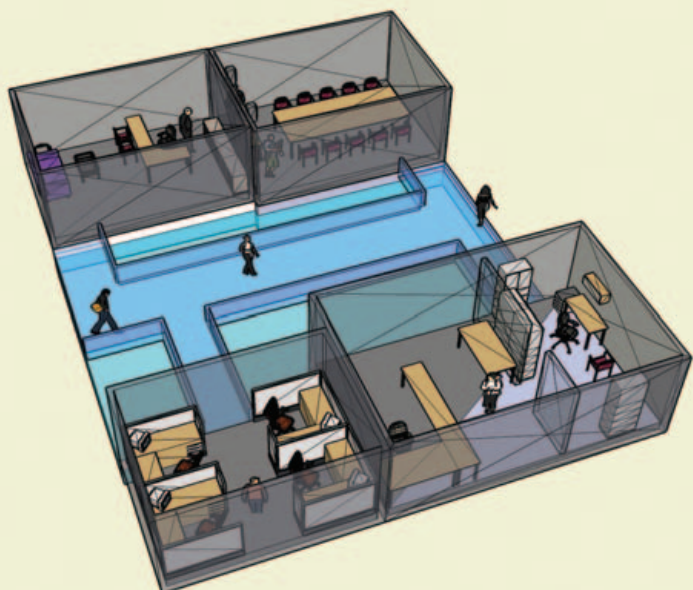
U.S. Coast Guard personnel can update changes to staff, office equipment and other facility attributes, leading to 3D views of its plans. Image courtesy of Onuma, Inc

system using interoperable standards in the background to create their own charrettes. We didn't have to be dragged along as the only people who knew how to use the system."

By empowering the local teams with a standardized web-enabled system, travel expenses that would normally be incurred in the collection process were reduced by $25,000 per command center.

OPS was also linked to GoogleEarth to integrate Onuma's BIM work with GIS data. As a result, USCG can see 3D representations of its facilities as they exist geographically. USCG can then use that data to better understand the geographic relationships between its facilities, including ports and command centers. As a result, USCG can better plan for emergency scenarios where resources need to be quickly redeployed.

The 35 projects have been planned and development of projects is underway. Among the completed jobs is the Sector Command Center at Yerba Buena Island in San Francisco. The project included building a new 1,200-sq-ft command center, renovating 6,000-sq-ft of existing office space and converting 11,000-sq-ft of barracks into new office space. The design development documents were completed in one month using BIM, rather than the 10 months it would take under the traditional system.

In the end, USCG's entire 33-million-sq-ft facility portfolio was inputted into OPS, allowing for at least low-level creation of BIMs for each facility. Nearly 3-million-sq-ft of space was rendered in high detail with Archicad. Onuma created a calculator to allow planners to quickly understand personnel and equipment demands at each facility. Tools were also developed to allow for blast threat analysis and other security tools.

In conjunction with the Sector Command Centers project, Onuma, along with other teams, also helped develop a roadmap for future facilities. The Shore Facilities Capital Asset Management Road Map was used to define USCG's overarching goals and how interoperable technology could be used to achieve them. The plan will guide USCG for years to come as it dedicates itself to finding interoperable ways to expedite its missions. As part of a team that included architects, engineers and other consultants, Onuma needed interoperable methods of data exchange throughout the process.

"The ultimate goal in all of these is determining how we link to lifecycle," Onuma says. "They want to understand what it will cost to maintain these facilities for 75 years. If you don't know that kind of data when making early plans, you could plan for three months before realizing the facility won't work for your needs."

Quick access to information will also help with addressing frequently changing budgets and the effect those have on facility planning.

"You don't have to go back to the report and restart the whole process each time," he says. "You have it in the database for rapid analysis. You can go from always reacting to planning for the future."

Paths to a Solution

Interoperability within the built environment will be achieved through a combination of solutions spurred by people and technology. Changes in how build teams work together and how they identify the tools needed to promote better collaboration are cultural changes that will promote a more interoperable work environment. With demand in place, the technology marketplace will work to deliver those tools and develop future paths to interoperability. Experts within the AEC/O community have identified several of these solutions and are working to achieve them.

People Solutions

Integrated project delivery. While not a direct solution to interoperability, the creation of more–integrated build teams will drive demand for seamless data sharing. A collaborative build team that trades ideas and information early in the process needs easy exchange of data that can be regularly updated across various software platforms. This cultural shift will highlight the need for greater interoperability and the solutions to achieve it.

Client demand. Owners and developers will continue to demand interoperability within build teams in order to reduce waste, speed delivery, and cut costs. Large owners, such as General Motors, are already heavily promoting the need for interoperability on projects. As more owners push for such solutions, primary build team members will rise to meet demand and in turn expect it from their subcontractors and consultants. With widespread demand for interoperable products, the software industry will respond with appropriate solutions.

More Education. A limited portion of the industry–those with the most experience in digital data exchange across platforms–understands the impact of inadequate interoperability. As build team members develop into experts on current data-rich software, they become more aware of the limits of data sharing and see it as a barrier to effective workflow. While industry players could learn these lessons on their own, increased education about interoperability issues will accelerate that awareness and prompt firms to consider those issues as they form build teams and make technology investments.

Metrics to quantify benefits. Creating metrics to analyze the costs and benefits of using interoperable products will drive demand for solutions. If early adopters of interoperability solutions can quantify their successes, other build team members can use those results to justify making investments that improve data exchange. This will accelerate demand for answers to interoperability dilemmas.

"If you consider history, Columbus had a limited view of the surrounding universe and as such could only interoperate with what he saw and could understand. How would his missions have changed if he had additional resources available like Google Earth?"

–Dave Conover
Senior Advisor
International Code Council

"If I was a software vendor I would make sure my technology was the most interoperable in the industry as my competitive advantage."

–Hector Camps
Educator and President
PHI Cubed, Inc.

"We're starting to work with architects and engineering teams who can appreciate the value of interoperability. We'll produce case studies, measure metrics and be open about it. This industry is more driven by fear of losing a competitive advantage than being transformative or innovative."

–John Tocci, President, Tocci Building Companies

Technology Solutions

Open standards. The software industry should universally embrace open standards that will facilitate the seamless exchange of data between applications and platforms. The path to interoperability may not come from a single standard, but a set of standards. While one standard might be effective for certain data–sharing tasks, it may not be the best option for all. A limited group of standards could provide a toolbox of solutions to resolve interoperability issues.

Embrace interoperable software. Build team members should consider interoperability issues when making technology purchases. The ability of technology to exchange data across software and platforms should be weighed among the primary factors for investment. Even if those benefits will not be realized today, they are of emerging importance and could come into play in the near future. Metrics and improved education will help promote this solution.

More competition. The technology marketplace can benefit from fresh ideas about how to create interoperability within the built environment. These solutions could come from new players entering the market and creating competitive pressure to respond to these issues. Technology providers argue that more competition could further confuse the market by introducing more applications and platforms to an environment that already has limited interoperability. However, new competition is ultimately a healthy part of market evolution, resulting in those new ideas being embraced, acquired or improved.

BIM's Place on the Paths to a Solution

Driver of Interoperability

BIM plays a key role in creating awareness of interoperability issues. As build team members create and reference these data-rich models, the advantages of sharing data between disciplines become clearer. With adoption of BIM heading toward a tipping point in 2008, more users of this technology may seek solutions that facilitate data exchange. Competitive pressure could drive this dynamic. Build team members believe their competitors may be adopting BIM more quickly than they are. To avoid the risk of falling behind, more firms will adopt BIM and possibly push its limits to create their own competitive advantages.

Legal Barriers

While use of BIM is on the rise, looming legal issues threaten its use within an interoperable environment. As a new technology, there are limited legal and contractual frameworks to clearly define liability. BIM offers a dynamic exchange of data, yet within the legal community contracts are often established using language based on 2D drawings. In some contract language, if there are discrepancies between electronic files and printed files, the printed files govern. Within a model-sharing environment, data need to flow from one party to the next electronically with all parties trusting their accuracy. Without a framework to allay concerns about indemnity in such an environment, build team members will remain hesitant to collaborate using BIM. (Patrick J. O'Connor, Jr., "Productivity and Innovation in the Construction Industry: The Case for Building Information Modeling," pp.35-41)

"The ability of an owner to reuse data instead of paying to continually recreate or reformat information for new uses during the facility lifecycle is one of the most compelling reasons for owners to advocate for true interoperability: a common international data exchange standard that enables data to be imported and exported by any software system, at any time."

–Renee Tietjen, Senior Architect, U.S. Department of Veterans Affairs

Conclusions

What trends can be gleaned from this research and what do they mean for the future?

Experience Will Breed Awareness and Drive Demand

The rapidly emerging confluence of Integrated Project Delivery and BIM will accelerate users' evolution from enjoying what Joseph Burns of Thornton Tomasetti terms the "local efficiencies" of IT tools inside their firms, to appreciating the "global efficiencies" of multiple firms sharing data and models to work more productively. The clear correlation in the data between experience with IT tools and awareness of the need for interoperability indicates that as more firms become expert at deploying increasingly sophisticated solutions in ever-more integrated project team settings, they will recognize the role of non-interoperability in preventing them from getting the full benefits of integrated teams and of their IT investments. This will increase demand, and as more interoperable solutions come to market, their benefits will create a ripple effect of ever-greater demand and adoption. As Michael Kenig of Holder Construction says, "When the technology systems start to talk to each other and we realize the benefits, only then do we see what we didn't have before."

Owners Increasingly Will Take Leadership Role

This realization is likely to be felt most keenly by owners, who according to the NIST study bear, nearly two-thirds of the cost of non-interoperability. Patrick MacLeamy of HOK, observing that non-interoperability often contributes to the need for redesign and scope reduction to meet budget says "No owner wants a cheap building after all these millions of dollars and hassles." And ultimately, owners accrue the life-cycle benefits of interoperable IT tools. Jack Hallman of GM envisions the power of "living models" to enable the full life-cycle, and insists that owners "have to be the catalyst to drive the industry."

Users Will Lead the Way to Define Tangible Benefits of Interoperability

Companies that tabulate the costs of their interoperability workarounds provide a baseline to measure the financial value of improved interoperability. John Tocci of Tocci Construction says, "We're spending close to seven figures on file conversions." Jim Bedrick of Webcor cites that his company is "redoing a lot of work that's already been done." And Arup's Erin McConahey pays her staff to model other firms' structural design when Arup is designing MEP "because we know we'll have to work around that."

Universal Interoperability between All Applications Will Not Be the Near-Term Solution

For most companies it would be prohibitively expensive to implement and is not where the greatest value lies anyway. As Phil Bernstein of Autodesk puts it, imagining a "state of zero friction" where "every single piece of software can understand every single piece of data generated by all other pieces of software [is] both reductive and not helpful." Ultimately, standards will be developed to guide the creation of more widely interoperable software applications. But in the meantime, software makers will use a variety of approaches (IFC, XML, API) to enable interoperability on a case-by-case basis, led by demand from customers needing to support specific workflows and business benefits. As an example, consider how the runaway success of SketchUp as an early-stage design tool encouraged major CAD companies to facilitate its import into their more-robust authoring tools.

Major Software Companies Will Respond to Market Demand for Interoperable Solutions, But at Their Pace

Brad Workman of Bentley points out, "We're like our customers are in their businesses, we respond to the market." But he is optimistic, saying, "Now that we're starting to see adoption… we'll make a lot of progress [on interoperability] in a short amount of time." Phil Bernstein of Autodesk acknowledges that "the demand for interoperable applications right now exceeds our capacity to achieve it," but offers a more tempered forecast, saying that "we pick and choose the things we think we can be successful at, and they return value to our shareholders. We're not doing this to have fun. We're doing this to make money."

This Environment Will Spawn an Unprecedented Entrepreneurial Opportunity

Armed with cost justification and user requirements, nimble technology firms who do not have the baggage of legacy data structures and installed bases to support can quickly develop targeted solutions that come out of the box ready to interoperate or middleware that enables existing tools to "play nice with others." This second tier of AEC/O software companies may be where the interoperability monster is slain. They can effectively leverage the growing demand for interoperability in a market of relatively slow-responding major providers.

Methodology

The research in this report was conducted through a survey of 75 architects, 75 engineers, 70 contractors and 75 owners (total sample size of 295) between May 29 and June 27, 2007. The "total respondent" category displayed throughout the report represents the four respondent groups combined as the total build team. MHC Research designed the investigation, including the method of survey collection, sample, questionnaire and analysis.

The use of a sample to represent a true population is based on the firm foundation of statistics. The sampling size and technique used in this study conform to accepted industry research standards expected to produce results with high degree of confidence and low margin of error. The total sample size (295) used in this sample benchmarks at a 95% confidence interval with a margin of error +/- 5%. For each of the AEC/O respondent groups, the confidence interval is 90% with a margin of error +/- 10%. Important demographics of the respondent population sampled are as follows:

Respondent Primary-Construction Type
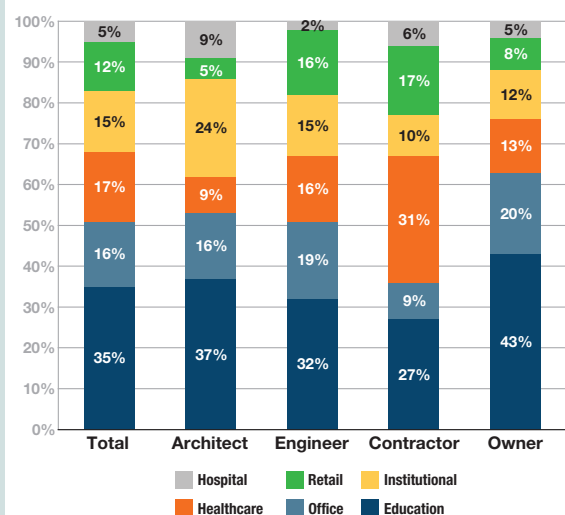
Respondent Primary & Company Size
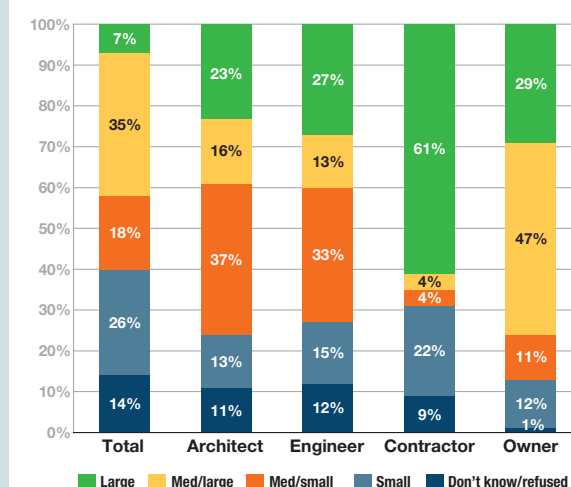
The BIM tipping point analysis is based on Malcolm Gladwell's book, *The Tipping Point: How Little Things Can Make Big Differences*. Using estimates of past, current and future usage of BIM, the tipping point is the inflection where the population turns from less involved to more involved. Because the survey was conducted in mid-2007, 2006 was used for the current year point as it was the most recent complete year for counting projects that used BIM. The tipping point will occur where the blue line projecting low to moderate involvement with BIM (less than 16% of projects) intersects with the orange line projecting significant involvement with BIM (greater than16% of projects), or the grey line projecting large to full involvement with BIM (greater than 60% of projects). Depending on usage rates, the tipping point will vary. Under gradual adoption, as pictured at right, the significant–involvement tipping point is reached first. If the largely to fully dedicated involvement point is reached first, this would represent more rapid adoption.

"Tipping Point" Analysis
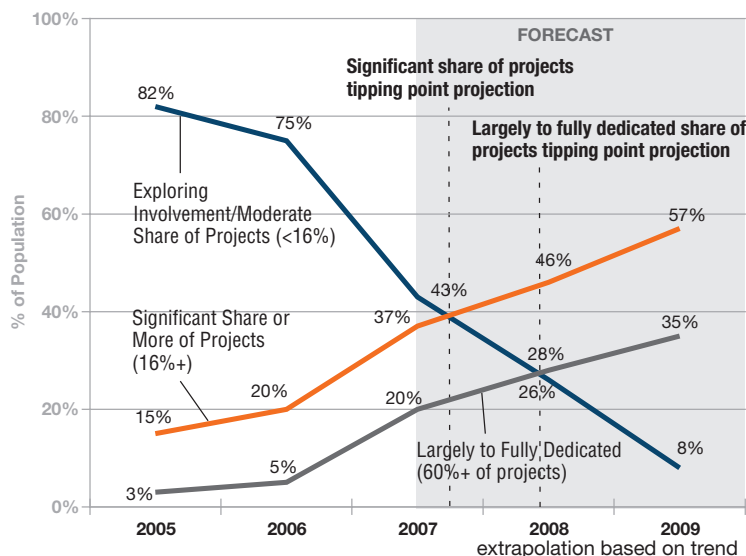
Source: McGraw-Hill Construction Research and Analytics, 2007

Resources & Partners

Organizations, Web sites and publications that can help you get smarter about interoperability

McGraw-Hill Construction
- Main Website: **www.construction.com**
- *GreenSource:* **www.greensourcemag.com**
- Research & Analytics: **www.analytics.construction.com**
- *Architectural Record*: **www.archrecord.com**
- *Engineering News-Record*: **www.enr.com**
- Analytics Store: **www.analyticsstore.construction.com**

Sponsor Websites
- American Institute of Architects (AIA): **www.aia.org**
- International Code Council (ICC): **www.iccsafe.org**
- Construction Users Roundtable (CURT): **www.curt.org**
- Construction Owners Association of America (COAA): **www.coaa.org**
- Associated General Contractors of America (AGC): **www.agc.org**
- Construction Management Association of America: **www.cmaanet.org**
- Construction Specifications Institute (CSI): **www.csinet.org**
- Society for Marketing Professional Services (SMPS): **www.smps.org**
- buildingSMARTAlliance: **www.buildingsmartalliance.org/**

Other Associations & Government Agencies
- FIATECH: **www.fiatech.org**
- National Institute of Building Sciences (NIBS): **www.nibs.org**
- National Institute of Standards and Technology (NIST) report on the cost of not having interoperability: **www.bfrl.nist.gov/oae/publications/gcrs/04867.pdf**
- Open Geospatial Consortium (OGC): **www.opengeospatial.org**
- Open Standards Consortium for Real Estate (OSCRE): **www.oscre.org**

Universities
- Georgia Tech: **bim.arch.gatech.edu/**
- Stanford University Center for Facility Engineering (CIFE): **www.stanford.edu/group/CIFE**

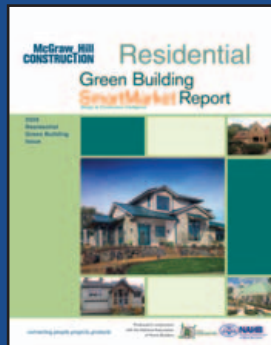# SmartMarket Report
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