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Managing Uncertainty and Expectations in Building Design and Construction

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Transforming Design and Construction

SmartMarket Report

McGraw Hill Construction

President

Kathryn E. Cassino

McGraw Hill Construction Research & Analytics/ Industry Insights & Alliances

Vice President, Industry Insights & Alliances

Harvey M. Bernstein, F.ASCE, LEED AP

Senior Director, Research & Analytics

Burleigh Morton

Director, Research Communications

Michele A. Russo, LEED AP

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Managing Uncertainty and Expectations in Design and Construction SmartMarket Report

Executive Editor

Harvey M. Bernstein, F.ASCE, LEED AP

Editorial Advisor and Chief Author

Stephen A. Jones

Editorial Director

Michele A. Russo, LEED AP

Managing Editor

Donna Laquidara-Carr, LEED AP

Senior Director, Head of Marketing

William Taylor

Creative Manager, Media

Juan Ramos

Art Director

Alison Lorenz

Contributing Art Director

AD-BOUTIQUE, INC.

Terumasa Yamada

Contributors

Bruce Buckley

Deborah Snoonian Glenn

Katharine Logan

Research Project Manager

Susan Barnett, MRA, PRC

For further information on this
SmartMarket Report or for any
in the series, please contact:

**McGraw Hill Construction
Research & Analytics
34 Crosby Drive, Suite 201
Bedford, MA 01730**

1-800-591-4462

MHC_Analytics@mcgraw-hill.com



About McGraw Hill Construction

McGraw Hill Construction's data, analytics, and media businesses—*Dodge, Sweets, Architectural Record, and Engineering News-Record*—create opportunities for owners, architects, engineers, contractors, building product manufacturers, and distributors to strengthen their market position, size their markets, prioritize prospects, and target and build relationships that will win more business. McGraw Hill Construction serves more than one million customers through its trends and forecasts, industry news, and leading platform of construction data, benchmarks, and analytics.

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Introduction

Perfection is a baseline expectation when you purchase a product. But as experienced owners of building projects know, design and construction is an imperfect process with a variety of inherent uncertainties. Given that reality, what can project teams do to identify, anticipate and mitigate the conditions and factors that drive uncertainty, and how can owners adjust their expectations of project team performance to align with reasonable, achievable metrics that truly benefit the project?

These are the core questions behind this *Managing Uncertainty and Expectations in Building Design and Construction SmartMarket Report*, produced by McGraw Hill Construction in partnership with the AIA Large Firm Roundtable. Key findings of this research with owners, architects and contractors include:

- Owner-related issues, such as accelerated schedule, unclear project requirements, lack of direction and involvement, and program or design changes, are cited as the leading drivers of uncertainty on building projects.
- While only 7% of owners believe perfect construction documents are possible, design errors and omissions are still considered highly impactful sources of uncertainty. On average, owners say they expect to pay somewhere between 3%–5% added cost on a building project due to these issues, and consider anything up to 6% to still be acceptable as “good performance.”

- Better communication and integration among project team members scores as the most effective approach to reducing the causes and impacts of uncertainty.

The objective for this initiative is to advance the level of shared understanding among owners, design professionals and construction firms about the mutual challenges they face in building design and construction. This will help to shift the conversation from blame and recovery for unanticipated problems to proactive and collaborative ways to reduce their occurrence and to performance metrics that foster these behaviors.

In addition to the AIA Large Firm Roundtable, McGraw Hill Construction wishes to thank the other industry leaders who provided support and guidance to this research in order to bring this important study to the market. Those organizations include the premier industry partners of AIA, Autodesk and DBIA; and industry partners AGC, Graphisoft and the Lean Construction Institute.

For more detail on the methodology of this report, please see pages 59–60.



Stephen A. Jones
Senior Director
McGraw Hill Construction



Harvey M. Bernstein
F.ASCE, LEED AP
Vice President
Industry Insights & Alliances
McGraw Hill Construction

Stephen A. Jones leads MHC's initiatives in BIM and how emerging economic and technology trends are transforming the construction industry. Active in numerous industry associations (including the buildingSMART Alliance, the BIMForum, Construction Users Roundtable, Alliance for Construction Excellence and Charles Pankow Foundation), Jones frequently speaks at events around the world on the business impact of emerging technology and trends. He also hosts MHC's ENR FutureTech and

High Performance Construction events. Before joining MHC, Jones was a vice president with Primavera Systems (now part of Oracle), a global leader in project management software. Prior to that, he spent 19 years in creative and management roles with top design firms, most recently as a principal and Board of Directors member with Burt Hill (now merged with Stantec), one of the largest A/E firms in the U.S. Jones holds an M.B.A. from Wharton and a B.A. from the Johns Hopkins University.

Harvey M. Bernstein, F.ASCE, LEED AP, has been a leader in the engineering and construction industry for over 30 years. Currently, he has lead responsibilities for MHC's market research group, including MHC's thought leadership initiatives in areas such as commercial and residential green building, BIM, information mobility, innovation and global construction markets. Prior to joining MHC, Bernstein served as President and CEO of the Civil Engineering Research Foundation. He has written hundreds of papers covering

innovation and sustainability and currently serves as a member of the Princeton University Civil and Environmental Engineering Advisory Council and the National Building Museum Board of Trustees. He is a visiting professor with the University of Reading's School of Construction Management and Engineering in England. Bernstein has an M.B.A. from Loyola College, an M.S. in engineering from Princeton University and a B.S. in civil engineering from the New Jersey Institute of Technology.

Introduction

The AIA Large Firm Roundtable is pleased to present *Managing Uncertainty and Expectations in Building Design and Construction SmartMarket Report* as lead sponsor for this industry study.

The Large Firm Roundtable, founded in 1984, includes leaders of the largest North American-based architectural and A/E firms. The Roundtable is committed to advancing the interests of design firms and clients of all types and sizes. We undertake periodic research about industry issues and best practices.

While it's generally acknowledged that the design and construction process isn't perfect, there has been a lack of real data about what uncertainty to expect and how to manage it well. As a result, even top-performing project teams sometimes end their work with conflict and strained client relationships. After discussing this issue for several years, the Large Firm Roundtable decided in 2012 to move forward with this research project. We commissioned McGraw Hill Construction's Research & Analytics group to conduct the work.

We believe the study findings will help owners, architects and builders manage today's projects more effectively and improve our industry's performance in the future. This report is intended to be an educational tool for every member of the project team.

This project has included financial sponsorship and active participation from many other groups across the design and construction industry—leading owners, architectural and engineering firms, construction contractors, technology firms and professional organizations. We are grateful to these partners for their support.

I would like to thank the Roundtable's steering committee for this project: Jay Halleran, Assoc. AIA, managing principal of NBBJ; Ralph Hawkins, FAIA, chairman of HKS; James Bearden, AIA, CEO of Gresham Smith & Partners; Craig Williams, AIA, principal and chief legal officer of HKS; and Tim Twomey, AIA, vice president and deputy general counsel of RTKL. This project has been led for the Roundtable by Clark Davis, FAIA, former vice chairman of HOK and principal consultant with Cameron MacAllister Group.

This study may lead to additional research about some of the topics presented here. We look forward to your comments and invite others to join us in our future work.



Bryce D. Pearsall, FAIA
Chair, AIA Large Firm Roundtable
Chairman, DLR Group

AIA Large Firm Roundtable 2014

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Bryce D. Pearsall, FAIA, is chair of the AIA Large Firm Roundtable and chairman of DLR Group, which has integrated design offices throughout the U.S. and abroad, and a passion for design in the built environment. During his time as three term LFRT Chair, the LFRT has led valuable initiatives supporting architectural firms, our partners in the building industry and most importantly our clients—building owners and users. Bryce received his Fellowship in the American Institute of Architects in 1998 and is an advocate for the value of design, leadership and the profession at all levels. Additionally he serves on the Board of Directors of The American Architectural Foundation, the American Institute of Architects National Board Advocacy Committee, as Chair of the Iowa State University College of Design Advancement Council and as a Governor on the Iowa State University Foundation.

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Construction at the World Trade Center site,
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Executive Summary

Owners, design teams and contractors contend with many types of uncertainty as they produce building projects on strict schedules and budgets in a dynamic environment of frequent change. In this context, is it realistic or even possible to expect flawless execution of error-free documents?

This research examines the parameters of that question, including the causes of uncertainty, reasonable expectations for performance by various parties and effective means of mitigating uncertainty to improve outcomes for everyone.

Top Causes of Uncertainty

Perspectives vary between owners, architects and contractors on the relative importance of key drivers of uncertainty on building projects.

Unforeseen site conditions is among the top three factors cited by all parties. Architects and contractors zero in on owner-driven changes and accelerated schedule (also owner-related), while owners and contractors both point to the design team (design errors and design omissions). All parties rank the contractor-related factors (contractor-caused delays and construction coordination issues) relatively lower as drivers of overall uncertainty. While each party certainly cares about the causes it is responsible for, the general trend is to weight other parties' causes as being more significant.

Other findings related to uncertainty include:

- **Unclear project requirements at the outset** is identified by all parties as the top driver behind owner-driven changes.
- Contractors cite a much higher frequency of five types of **design errors and omissions** in final construction documents than architects perceive.
- **Individual trade contractor performance** is the top-named reason for **construction coordination issues** by all parties, led by the general contractors (67%).
- Despite their direct responsibility for these issues, higher percentages of contractors cite **scope gaps among prime and subcontracts** (41%), and **lack of thoroughness of preconstruction planning, estimating and scheduling** (33%) as leading causes of uncertainty than either the architects or the owners do.
- Although almost one third (32%) of general contractors believe that trade contractors benefit the most from uncertainty, about half of architects (47%) and owners (50%) believe that general contractors do.

Top Causes of Overall Uncertainty for Owners, Architects and Contractors

Source: McGraw Hill Construction, 2014

Causes of Uncertainty	Ranking of Causes by Player		
	Owners	Architects	Contractors
Unforeseen Site or Construction Issues	1	3	1
Design Errors	2 (tie)	6	5
Design Omissions	2 (tie)	7	2
Contractor-Caused Delays	4	4	6
Owner-Driven Changes	5 (tie)	1	4
Accelerated Schedule	5 (tie)	2	3
Construction Coordination Issues	7	5	7

Expectations and Performance

While most owners (86%) report a high level of satisfaction with quality on their projects, fewer are highly satisfied with cost (63%) and schedule (64%), regardless of owner size or project complexity.

The **ability to develop a set of documents that meet the owner's program requirements and are constructible within budget** is unanimously cited as the most-valued metric for design team performance, followed by the **ability to work with other team members to solve issues and not escalate to the owner**, which is the number one metric for construction team performance.

While only a fraction of the industry believes it is possible for the design team to create a perfect set of final construction documents on a reasonably complex project, surprisingly, architects with that opinion (13%) outnumber owners (7%). That said, a significant percentage of owners (21%) believe it is reasonable to expect perfect documents, and almost three quarters (73%) say it is reasonable to expect perfect performance from the construction team.

Most owners (80%) say they expect to face added costs from design errors and omissions on their future projects, and on average they feel that a 3%–4% range is reasonable for non-negligent mistakes.

Opportunities for Performance Improvement

Clearer direction from owners (79%), and more active leadership by owners (68%) are the top-cited mitigating elements. Nearly two thirds (64%) identify **best value or other team selection criteria not based primarily on low fee** as very important.

Reinforcing the value of tighter designer/builders collaboration, **more integration between design and build parties during design and construction (77%), more time for design firms to participate in coordination (66%) and clearer definition of deliverables between parties during the design process (67%)** all rank among the top five. Also, the **use of BIM by entire project team (50%) outranks the use of BIM by single firm (32%)**, further emphasizing the greater value of collaborative efforts.

Owner contingencies are a traditional method of mitigating design and construction risk, although owners' policies and practices generally do not embrace transparency or leverage standard approaches.

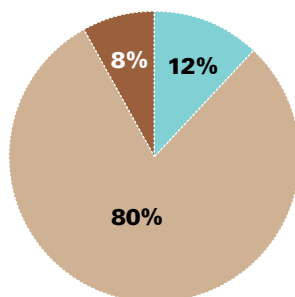
- **Most (81%) always have a project contingency, but just under a quarter (24%) have a standard risk assessment process to determine the right amount.**
- **Only about half (51%) always tell architects about a contingency, and only around a third (37%) always tell contractors. While a quarter (25%) never tell their architect, even more (37%) never tell their contractor.**
- **Only about a third (37%) allocate contingencies into separate project risks.**

Expected Cost Impacts of Design Mistakes on Future Projects (According to Owners)

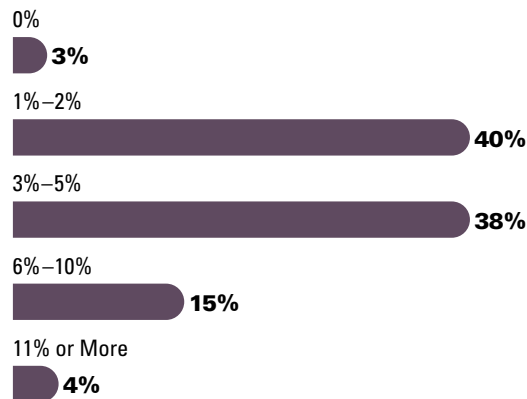
Source: McGraw Hill Construction, 2014

Expects Future Projects to Be Completed With No Added Costs Due to Design Mistakes (According to Owners)

- Yes
- No
- Not Sure



Level of Additional Costs Accepted as Normal (According to Owners Who Anticipate Additional Costs)



Recommendations

Observations and Recommendations

The survey results and interviews with the project's Owner Advisory Group (OAG) yield a number of observations and recommendations to help project teams minimize the causes and impacts of uncertainty, establish appropriate performance expectations and improve building project outcomes for everyone. Some highlights are included below.

Imperfection Is Inevitable

The findings in this study are clear that expecting flawless execution of error-free drawings on building projects is not realistic. Only 1% of owners surveyed say they've ever even seen a perfect set of drawings, and great projects are certainly possible without them. As to contractor perfection, one OAG member aptly puts it, "Construction is not an exact science... so it's not that there's an issue, but how the contractor recovers from that issue."

This makes the critical point that performance expectations must shift from a zero-defect baseline to an informed and realistic acknowledgment of an acceptable range of reasonableness for the impact of imperfection, tailored to each project. And effectiveness in dealing with imperfection is a more valuable metric than frequency of committing it.

Change Orders Are Not Inherently Bad

To that point, while about half of the surveyed owners favor using the number of change orders as a performance metric, neither design nor construction respondents support it, nor does the OAG. One of those owners notes that the term has gotten "a negative connotation because it generally has a cost associated with it. But change orders come from many different places. Some are good and benefit the end product. It's not enough to just judge it on the number." Another uses them simply as "a way to adjust contracts up or down as needed" during the process.

Owners should revisit how they view change orders and consider more appropriate metrics aligned with activities that avoid and mitigate the uncertainty-related problems that underlie changes.

Looking Deeper at Owner-Driven Causes of Uncertainty

The top drivers of uncertainty-related problems, according to the survey results from architects and contractors, are owner-driven changes, and the need for clearer direction from owners, as well as more active leadership by owners. OAG advice on these types of issues includes the following:

REALISTIC EXPECTATIONS ABOUT OWNERS

Design and construction teams need to understand that their owner clients are often dealing with a range of internal stakeholders (boards, finance officers, administrators, end users, operations staff, etc.) and dynamic external forces (market changes, regulations, technology advances, etc.). Thus, they can't always be expected to provide perfect information at the outset, nor always control scope, budget or schedule changes during the project. As one OAG member says, "Change is

going to happen no matter how much work you put in upfront."

DESIGN TEAM IMPACT ON OWNER CAUSES OF UNCERTAINTY

On programmatically intense buildings, it is unrealistic to expect all owner stakeholders to understand design and construction well enough to provide perfect guidance. So design professionals should make the effort to understand more about what end users will really be doing in the building (e.g., technical, workflow, operating requirements) before, as one owner says, "they start getting people excited about where spaces are going to be." Such better-informed design is less likely to generate disruptive stakeholder changes and more likely to increase owner satisfaction. As another owner says, "Before you draw one thing, finalize the value propositions so you know what you're answering, instead of what you think we want."

Similarly, they cite the disruption caused by designers “not knowing the [cost] ramifications of [the] design before show[ing] a pretty drawing” to owners or regulatory officials, causing what one refers to as the “terrible process of ‘value engineering’ to basically identify what we aren’t going to get [that] our users are all excited about.”

On a positive note, several owners foresee what one calls “a big opening for the architectural community to step up and help out” by providing greater leadership and evolving toward a deeper relationship with owners that he calls a “trusted advisor, participating a lot more and a lot sooner, really doing an integrated project design around that client’s mission and that client’s culture.” He predicts it can be “a whole new paradigm for the architectural world, not a transaction based on ‘You tell me what you want and I’ll tell you how it’s going to be,’ but more of an ongoing, participative process where they’re continually helping you get to where you need to go.” He believes that in this less prescriptive role, architects will need to “get comfortable that their design’s going to

get messed up a little bit, but it’s going to certainly be more functional as it moves forward.”

CONSTRUCTION TEAMS ANTICIPATING RATHER THAN REACTING TO PROBLEMS

The OAG members express little patience with experienced construction teams that don’t identify uncertainty-related problems in advance that they should have seen coming. One owner says “I tell them, ‘Don’t tell me it’s new when you’ve dealt with this your entire career.’”

Instead, they value construction teams that anticipate issues and will initiate the tough conversations early to avoid crises later. For example, to prevent cost conflicts related to scope, one owner tells contractors, “When something comes up that isn’t part of what you signed up for, raise your hand and say right there and then ‘No cost, maybe cost or definitely cost.’”

Another says, “a really high-performing construction team has not only people who are excellent in the field with communication and coordination for what’s happening now, but somebody [who is] looking several weeks or

“Start early, integrate quickly and work together as a whole so you know what you’re getting into.”

months out, going through the documents and the plan to identify things that may become issues later. And then have those conversations as early as possible so that it’s not a crisis later. If something requires input from the owner to sort out some uncertainty, bring it up in a spirit of having an equal seat at the table. Everybody is a professional. Let’s not let the project suffer because we don’t want to surface something for a group conversation.”

A third extols the benefit of “open dialogue [with contractors] from start to finish, asking the right questions as you work through it. If the contractor is proactive saying, ‘We’re concerned about this,’ then the owner can say, ‘No, I think you’re going forward in a good fashion.’ Or the owner can go to the contractor saying, ‘We’ve got four other jobs with the same inspector, he keeps doing this, can you guys think this through as you move forward?’”

Communication, Collaboration and Integration: Early, Open and Often

Expanding the focus to the whole project team, the

research findings show that more integration and better communication are the most effective mitigating factors against overall uncertainty. One OAG member succinctly puts it that “documents don’t take the place of communication,” continuing that “if communication is better, coordination would be better.” Another’s formula for mitigating uncertainty is to “start early, integrate quickly and work together as a whole so you know what you’re getting into.”

Integration can take many forms, from full-on IPD (integrated project delivery) to less intensive approaches applicable within other more conventional project delivery methods. For example:

- On design-bid-build projects, some OAG members are finding success by engaging trade contractors in a Design Assist role, either for a fee or as a guarantee of being able to bid the job, to review cost and constructibility of documents prior to finalization. One owner says “Though not 100 percent, we’ve had very solid success to the point

where now we always do it.”

- One has a new, but “highly successful” Term Agreement program, where he bids out on-call, indefinite quantity contracts to a number of collaboration-oriented design and construction firms, then forms ad hoc integrated teams from within the group to collaborate on small, quick projects.

A primarily design-bid-build owner recommends collaborating intensely on submittals to avoid unanticipated problems in the field, such as “a sub looking at you and saying ‘I forgot to order it.’” He explains the process: “Within the first three months [of construction], we take the mechanical, electrical, plumbing, building controls, fire protection and usually elevator subcontractors and their suppliers, and basically lock them in a room for a week with the architect and engineers to make them coordinate their submittals completely. When they’re finished, they’re stamped by the architect and engineer, and everyone can go order their stuff and know it’s coordinated.” And the owner has less risk.

On a cautionary note, highly integrated projects can run a special risk. As one very experienced IPD owner says, “When everyone shares responsibility, no one’s really responsible. So you have to watch that.”

Managing Risk Through Contingencies

Contingencies are widely used to buffer financial uncertainty. The survey results show most (81%) owners carry them on all their projects, although they generally do not share information about them with their teams and typically do not have a standard method for establishing their amounts, either by category or as a whole.

While most OAG members do not share contingency information, primarily because as one says, “It’s a constant fight [about] why I’m not letting them use that money,” several others are finding success through creative approaches to sharing information about, and sometimes the unused portion of, their contingencies.

- One owner shares the complete project pro forma, including contingency, with the major team members.

He finds that this awareness successfully increases everyone’s sense of fiscal responsibility without needing IPD.

- Another, when using IPD, engages all members in establishing the contingency, which is then openly drawn down by all parties to deal with the impacts of uncertainty, and the remainder is shared. This transparency incentivizes all parties to act frugally.
- A third, working in a design-bid-build environment, gives the general contractor a 2% contingency specifically for subcontractor change requests, agreeing to split the unused portion 50/50. This motivates aggressive negotiation of changes on his behalf, driving their total cost as low as 1%, and it provides a well-earned incremental fee for the general contractor.

Many OAG members have a standardized way to establish contingencies, typically dialing a starting percentage up or down based on their experience with specific factors that will affect a particular project. One OAG member has developed a formal Risk Register, a spreadsheet listing all the ways uncertainty might impact a project.

It is “organized by the categories of spend. The chances of it happening are this, and the total value is that, which gives you a risk score.” The total score informs his setting an appropriate contingency.

Until owners feel their teams are displaying more diplomacy around spending contingencies, secrecy about their amounts is likely to remain standard industry practice. However, owners should definitely follow the lead of OAG members in developing more informed ways to establish contingencies, based on real-world experience and project-specific risk factors.

Benefits of Technology

The findings cite that BIM is effective in mitigating uncertainty through virtual coordination and digital fabrication. All firms should embrace the best technologies for their area of the industry. For more information on BIM, including the Level of Development standard, see the BIMForum link in the Resources section on page 61.

Conclusion

In all, the study findings affirm Peter Drucker’s conclusion that “a problem anticipated is a problem half solved.” ■

Data: Introduction

McGraw Hill Construction has conducted extensive research over the past few years on construction industry trends that are changing the ways in which design and construction projects are conducted. The SmartMarket Reports that are based on this research—including a series on building information modeling (BIM), the use of different project delivery systems, the adoption of lean building approaches, the impact of improved information mobility and the wider use of prefabrication and modularization—all focus on ways in which the industry is evolving to improve productivity, quality and profitability.

However, despite the continuing advancement of tools and approaches, building design and construction teams still frequently face unanticipated problems that negatively impact quality, cost and schedule. While in an ideal world, the uncertainties that create these problems would be understood, anticipated and addressed collaboratively and proactively by the project team, the focus is more typically on assigning blame for unmet expectations and determining responsibility for recovery.

The purpose of the research on uncertainty and performance expectations presented in this SmartMarket Report is to:

- Identify which aspects of uncertainty have the most negative impact, what their causes are, and what tools and processes are available to project teams to reduce their occurrence and mitigate their impact.
- Understand the varying perspectives of owners, designers and contractors on their own and each other's level of performance, what the most meaningful aspects of performance are and how they should be measured, and how all parties can more productively align around reasonable expectations.

In addition to the owner, architect and contractor perspectives captured in the main survey research, McGraw Hill Construction conducted in-depth interviews with an Owner Advisory Group comprised of seven innovative owners, each specializing in a different building type. Their commentary on the broader research results provides experienced insight into how the industry can best capitalize on these findings.

The goal of this research initiative is to provide objective data and experienced perspectives as a context for entire building teams to engage in constructive, informed conversations about realistic performance expectations and to consider practical ways to address the factors that drive uncertainty, so that they can both reduce its occurrence and mitigate its impact.

Note About the Data

The data in this report are based on a survey conducted from April to May 2014 with 155 owners, 82 architects and 78 contractors. The initial screening process was conducted by phone, and the survey itself was conducted online.

Respondents were screened in part based on their involvement with complex projects. For more information on the survey methodology, see page 59.

In addition to the quantitative study, interviews were conducted with seven owners widely recognized as leaders in the construction industry. Their responses to the issues raised in the broader survey are represented in a series of short articles interspersed throughout the data. For more information on the owners included in this discussion, see page 60.

Data: Understanding Uncertainty

Top Factors That Cause Uncertainty

As the first phase of this research, over 1,500 owners, architects and contractors were presented with a list of factors and asked to select the one that causes the greatest uncertainty on building projects. Listed below are the top seven causes of uncertainty identified by these respondents.

- **Accelerated Schedule**
- **Owner-Driven Program or Design Changes**
- **Design Errors**
- **Design Omissions**
- **Construction Coordination Issues**
- **Contractor-Caused Delays**
- **Unforeseen Site or Construction Conditions**

Interestingly, responsibility for all but one of these seven disruptive factors can be said to align closely with a particular project team member.

- **Owner:** In most cases it can be fairly said that the owner is in control of a decision to implement an **accelerated schedule** and for generating **owner-driven changes** during the project process.
- **Design Team:** Similarly, the design team rightfully can be seen as having control over **design errors** and **design omissions** in the final documents.
- **Contractor:** Along the same lines, the contractor would be the party perceived as most responsible for **construction coordination issues** and **contractor-caused delays**.
- **Player-Neutral:** Only **unforeseen conditions** are neutral, not caused by any one party.

It is also important to note the other factors that scored relatively low among respondents regarding their impact on uncertainty. These include:

- Team Formation Process
- Project Delivery Method
- Renovation (versus New Construction)
- Project Complexity
- Regulatory Permitting Process

None of these factors was selected as having the greatest impact on increasing uncertainty by more than 7% of any respondent type, so they are not included as a focus of this report.

Understanding Uncertainty

Overall Impact on Uncertainty

Respondents rated the relative impact of each of the seven major drivers on overall uncertainty. Comparing the total rankings with those of the separate architect, contractor and owner groups reveals an interesting pattern. The chart, at right, shows the percentage of architects, contractors and owners who rated each factor as having a high or very high impact.

The neutral factor, unforeseen site or construction issues, ranks highest overall (47%), with an especially strong vote from contractors (56%) who often bear the brunt of dealing with those situations in the field.

The two owner-associated causes, owner-driven changes (47%) and accelerated schedule (45%), rank a close second and third in the percentage of total respondents who find them to have a high impact on uncertainty. Yet only about one-third (35%) of owners agree that these are top causes of uncertainty, starkly contrasting with the high percentage of architects who regard them as highly impactful (63% and 55%, respectively).

- Owners primarily involved with healthcare projects are most reluctant to identify owner-driven changes (29%) or accelerated schedule (19%) as top causes.
- On the other hand, the impact of owner changes and accelerated schedules are acknowledged most by large owner organizations (38% and 42%, respectively) and those doing mostly office projects (42% and 39%, respectively).

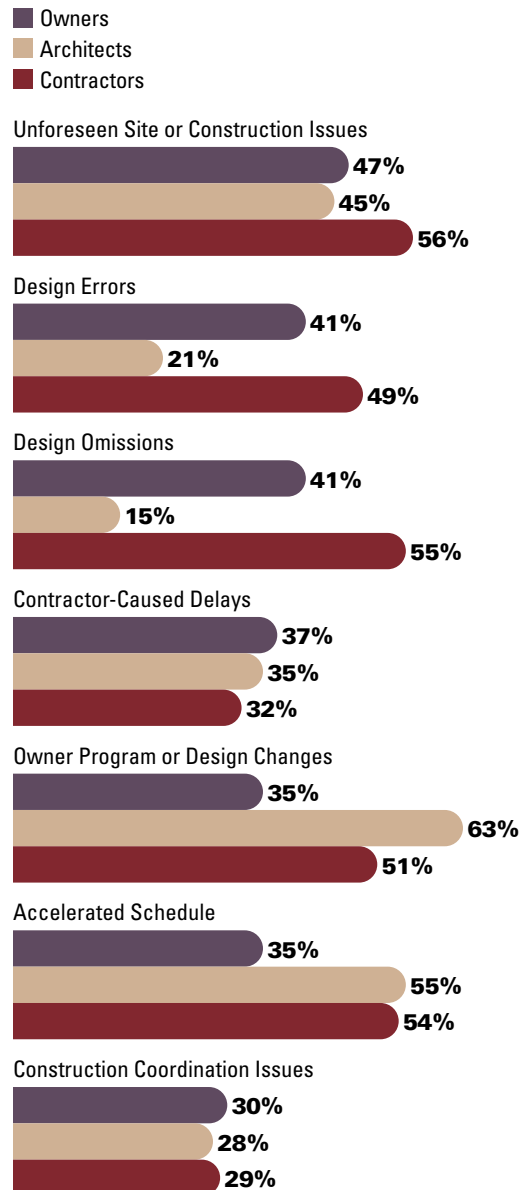
The architects' two issues, design omissions and design errors (both 37%) ranked next overall.

- Although architects surely are concerned about the impact of design omissions and design errors, they do not cite them as highly (only 15% and 21%, respectively) relative to other concerns, particularly owner-driven changes (63%) and accelerated schedule (55%).
- Office-project owners feel most strongly among all owner types about the negative impact of design errors (55%) and design omissions (61%).

The contractor-related causes, contractor-caused delays and construction coordination issues, ranked as the least impactful overall, selected by just 35% and 30% of all respondents, respectively. Unlike owners and architects, the contractors' ratings of these issues were very similar to the totals.

Top Factors That Cause Uncertainty

Source: McGraw Hill Construction, 2014



Almost half (47%) of small contractors cited contractor-caused delays as having a high or very high impact on uncertainty, perhaps because they may typically work on smaller projects with shorter schedules, where delays have a more pronounced impact.

Understanding Uncertainty

Causes of Uncertainty

With Greatest Impact on Quality, Cost and Schedule

To look deeper into the impact of these causes, owners, architects and contractors were asked to identify which of the seven top factors has the greatest impact on each of three key metrics: quality, cost and schedule.

Similar to the findings about overall uncertainty, each party views factors controlled by others as being the most impactful.

This consistent lack of alignment demonstrated below between owners, architects and contractors about these extremely important aspects of project control, execution and team performance highlights a challenge of perceptions within the industry. One of the key objectives of this research is to quantify the magnitude of these differentials, so that the problems related to uncertainty can be understood, openly acknowledged and effectively managed in a constructive dialogue, rather than dealt with passively through contracting strategies that assume perfection, avoid and transfer risk, and too often result in unmet expectations, costly claims and litigation.

Factors With the Greatest Impact on Project Quality

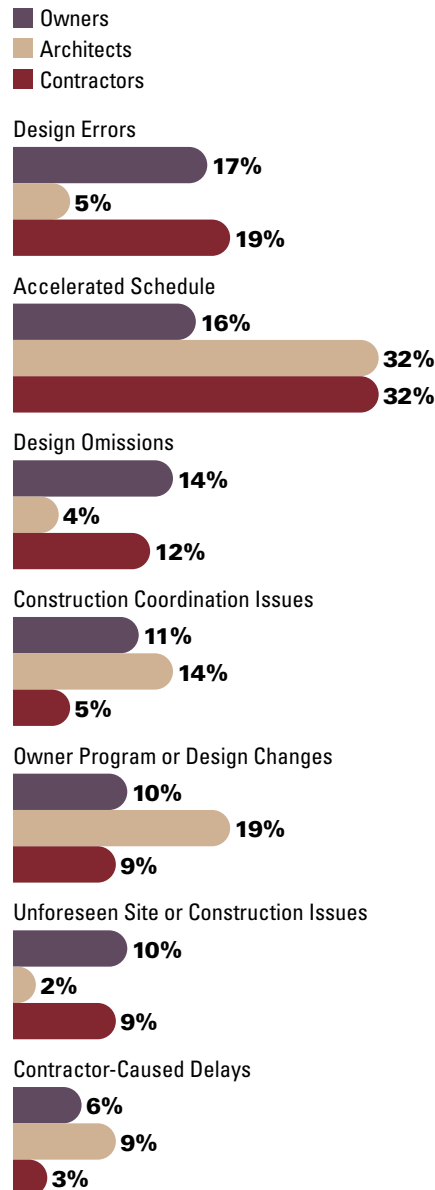
ACCELERATED SCHEDULE AND OWNER PROGRAM OR DESIGN CHANGES

24% of all respondents cite accelerated schedule as the most important cause of uncertainty that can impact project quality. However, the variation between parties' responses tells a deeper story.

- Nearly one third (32%) of both architects and contractors weigh in for accelerated schedule as the top factor.
- Only half as many (16%) owners choose accelerated schedule, in spite of the fact that owners are typically in control of the project schedule.
- The trend repeats itself with owner program or design changes, where twice as many architects (19%) name it as the most impactful factor, than do owners (10%).

Cause of Uncertainty With Greatest Impact on QUALITY

Source: McGraw Hill Construction, 2014



Understanding Uncertainty

Causes of Uncertainty With Greatest Impact on Quality, Cost and Schedule

CONTINUED

DESIGN ERRORS AND OMISSIONS

Design errors is the most-cited factor by owners (17%), especially those doing mostly office projects (27%). It is also named by a significant number of contractors (19%). However, it is top-ranked by only 5% of architects.

Design omissions is similar, with even fewer (4%) architects selecting it compared with contractors (12%) and owners (14%). Midsize owners (those who spend \$50M–\$100M annually on construction) feel strongest (27%). This should not be interpreted to mean that architects are unconcerned about design errors and design omissions, just that they feel other factors have a greater impact on quality.

OTHER FACTORS

Although the two factors contractors control are lowest-rated among the group, a similar pattern appears. Only 5% identify construction coordination issues as most impactful compared with owners (11%) and architects (14%), and only 3% point to contractor-caused delays compared with owners (6%) and architects (9%).

Factors With the Greatest Impact on Project Cost

OWNER PROGRAM OR DESIGN CHANGES

Owner program or design changes is considered most influential, with 26% of the total selecting it as the factor with the greatest impact on project cost. But again, **the interesting part of the analysis is in the dramatic variance between parties' perspectives, where architects (44%) strongly cite it as the most impactful, while only a third as many (16%) owners agree.**

This misalignment is at the heart of the need for early, open and constructive dialogue about how such changes need to be managed. There is much less misalignment on accelerated schedule.

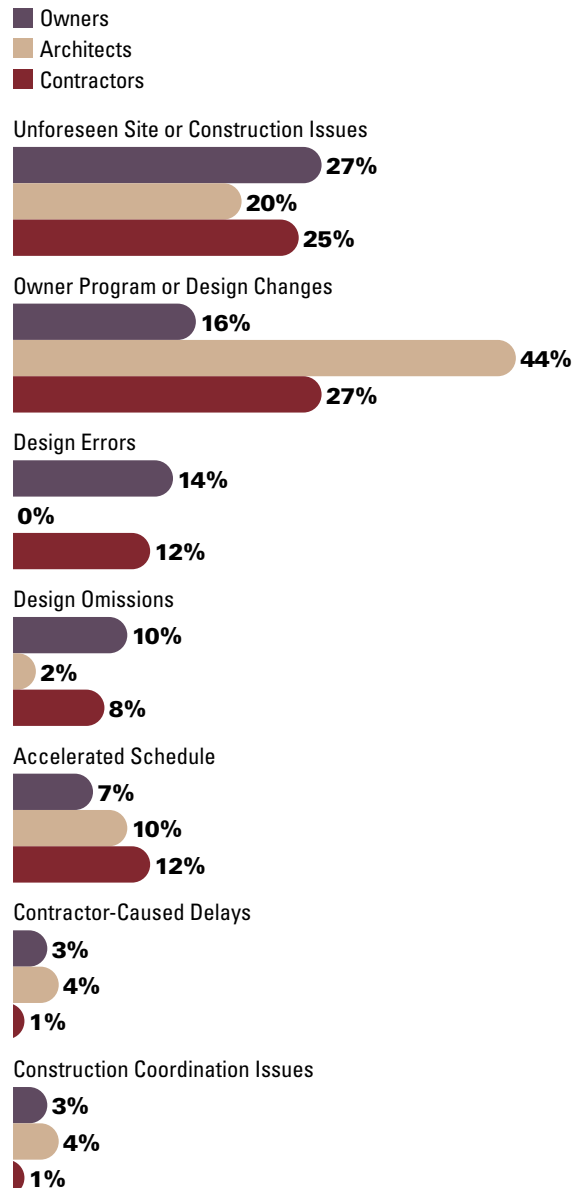
DESIGN ERRORS AND OMISSIONS

No architects select design errors as the most impactful factor on cost, and few select design omissions (2%). Instead, architects favor owner program or design changes as noted above (44%) and unforeseen conditions (20%).

Interestingly, only about 10% of contractors and owners select one of those as the most impactful on cost, which tends to substantiate the architects' perspective.

Cause of Uncertainty With Greatest Impact on COST

Source: McGraw Hill Construction, 2014



Understanding Uncertainty

Causes of Uncertainty With Greatest Impact on Quality, Cost and Schedule

CONTINUED

OTHER FACTORS

Contractor-related factors—construction coordination issues and contractor-caused-delays—again scored lowest among the group, but even though everyone's numbers are small, the tiny percentage of contractors (1% for both factors) is also again the least.

Factors With the Greatest Impact on Project Schedule

Unforeseen site or construction issues is the unanimous top factor impacting project schedule, especially for owners (25%), but after that a similar pattern of conflicting perspectives appears between the parties.

ACCELERATED SCHEDULE AND OWNER PROGRAM OR DESIGN CHANGES

Owner program or design changes again has more than twice the percentage of architects (31%) who consider it to be highly influential compared with owners (14%). Accelerated schedule shows a similar gap between contractors (17%) and owners (8%).

CONTRACTOR-CAUSED DELAYS AND CONSTRUCTION COORDINATION ISSUES

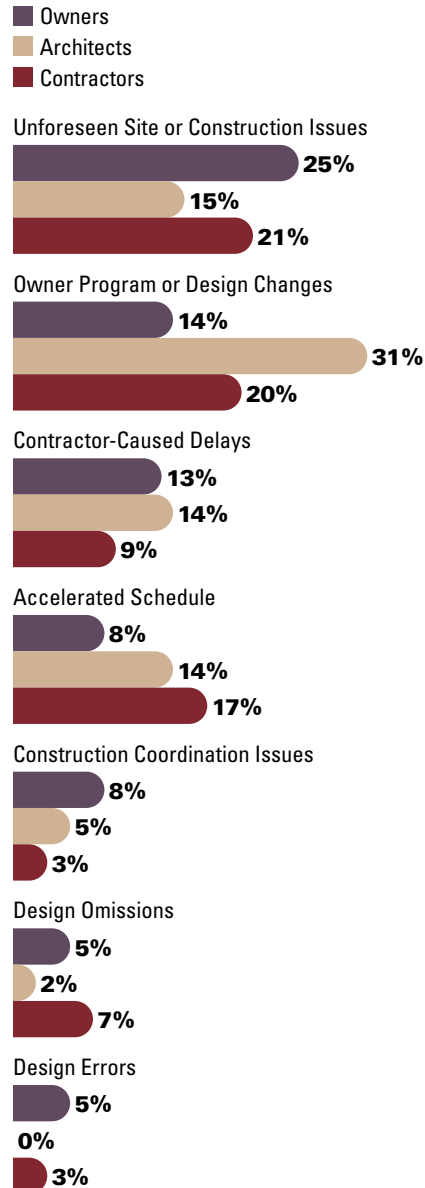
Because schedule compliance is considered to be much more aligned with contractors than architects, their factors (contractor-caused delays and construction coordination issues) rank higher in this category relative to their ranking for impact on quality or cost. However, as in those other instances, noticeably fewer contractors name them as the most important factor than the architects and owners do.

OTHER FACTORS

The percentage of all respondents selecting design omissions (5%) and design errors (3%) is the lowest of any factors, and again, fewer architects (2% and 0%, respectively) point to them than do the other parties.

Cause of Uncertainty With Greatest Impact on SCHEDULE

Source: McGraw Hill Construction, 2014



Owner Insights on Uncertainty Data Findings

Alignment on Most Impactful Causes of Uncertainty

As to the differing perspectives of owners, architects and contractors on which factors impact uncertainty, **Boyd Black, University of Chicago**, sums it up well for this project's Owners Advisory Group (see page 60 for more information), saying "We probably all thought that in our intuition, but now we have data to support that it's pretty extreme." **Don Vitek, Whirlpool**, adds, "I think the magnitude [of difference] is surprising."

Chuck Hardy, GSA, sees these results as a reflection of the industry's unwillingness to examine causes and make real changes. "I think it's a skewed perception and it's troublesome. That's what's driving the legal profession." His interpretation is that each party "feels they are somewhat out of control in the areas where they're blaming others." But he insists that they "do have control, [they're] just choosing not to assert it. There are ways, whether it's earlier planning or a much more trusted advisor role [by the design team] that make it more productive than just saying, 'Well, we've just got to continue down this path.'" He advises that when a problem occurs, "fast rewind, and ask 'What could we have done before we ever got to this place that would have at least potentially mitigated us [from] even having this conversation?' We tend not to look at things that way. It's always just 'How can we best solve the reality we have today?' rather than trying to retool."

He continues, saying, "What's great about this report is that it really codifies with numbers and

"Owners grow a little numb, maybe even callous, to shortening schedules and budgets without adjusting the program."

information, where people actually see themselves. Now the question is, 'Are we just going to sit and live with this, or are we going to do something about it?' And if so, what do we do? How do you shift these numbers in positive directions? Which ones can you change?"

Accelerated Schedule and Owner-Driven Changes

The group concurs that owners need to improve their practices related to owner-controlled factors.

- **John Moebes, Crate & Barrel**, shares the perspective that "owners grow a little numb, maybe even callous, to shortening schedules and budgets without adjusting the program. We've been guilty ourselves of arbitrarily taking two weeks out of our fastest schedule and expecting everyone else to adjust to that. Yet we know that unless we adjust the program and find systems or techniques that really fit that reduction in time, there's going to be a problem later."
- **Vitek, Whirlpool**, says, "Maybe it's denial. If you make a change it's like 'Oh, this can't be a big change,' but the owner might not get that it has more repercussions than they imagine."
- **Jerry Lea, Hines**, says it most directly: "I really think the owner is the source of most of the evils."
- **Craig Russell, Disney**, however observes "once we've locked down our design, the percentage of impact from discretionary changes is low single digits, while

non-discretionary ones are often 2–3 times more."

Design Errors and Omissions

While the group acknowledges that perfect documents are not a reasonable expectation, they concur with the research results that assign a high impact to problems caused by imperfection. Having practiced architecture for many years, **Moebes, Crate & Barrel**, accepts the imperfection, but he encourages design teams to be forthright about it. "There just never seems to be a design error, even in things like roofing and flashing or other things where it's just clearly been designed wrong, where the design professional, whether it's an architect or an engineer, just nods their head and says, 'Yeah, that ball got past the goalie on that one.'"

Contractor-Caused Mistakes and Coordination Issues

Continuing that thought, **Moebes, Crate & Barrel**, says that in his experience, "Contractors are a little bit more up front saying, 'Yeah, that was built wrong. We'll go handle that with the subcontractor.'"

As to the research finding that GCs say trade performance is the biggest problem, **Vitek, Whirlpool**, asks, "Does that come [from] a breakdown in the field by the trades installing the work, or is the breakdown really in the supervision of those individuals by the coordinating general contractor?" ■

Frequency/Impact Analysis of Causes of Uncertainty

While one cause of uncertainty may occur frequently but have relatively low impact, another may not occur often but have a major impact when it does. Conducting a frequency/impact analysis is one way to prioritize which causes will be the most beneficial to address for mitigation.

Focusing on the aspect of project cost, respondents were asked the following two questions related to each of the top seven causes of uncertainty:

- How frequently does each cause occur on your projects?
- What is the typical percentage impact on cost?

These responses were normalized and multiplied, then scaled into a range of 1-100, resulting in a frequency/cost impact index score for each one.

The analysis clearly indicates that owner-driven program or design changes (84/100) is the most impactful cause on cost, and by a significant margin.

This makes sense because these changes are reported to occur, on average, on almost two thirds (60%) of projects. Over one third (36%) of contractors and one quarter (26%) of owners say owner-driven changes always occur, with 40% of healthcare owners reporting it taking place on all their projects. Since these changes must be accommodated, they often have an unavoidable budget impact.

Design omissions (59/100) is the next highest ranked cause, likely because omissions are reported to occur, on average, on half of all projects (54%) and carry the potentially major implication of discovering missing project scope after a budget has been established. Interestingly, half of the contractors (48%) claim omissions occur on every project, while none of the architect respondents claim omissions occur more than half the time, with the majority (84%) saying design omissions occur one quarter of the time or less.

The next three factors cluster within a few points of each other:

- **Construction Coordination Issues (53/100)** often cause expensive rework. The use of BIM is making a major contribution to reducing both the incidence and severity of coordination problems. For more information on the use of BIM to manage uncertainty, see page 49.
- **Unforeseen Site or Construction Issues (51/100)** are always a potential cost problem. As such they are an excellent candidate for a reasonable owner contingency and a well-established change management process.

Frequency and Cost Impact of Top Causes of Uncertainty

Source: McGraw Hill Construction, 2014

Top Factors	Index (1–100)
Owner-Driven Changes	84
Design Omissions	59
Construction Coordination	53
Unforeseen Conditions	51
Design Errors	50
Accelerated Schedule	38
Contractor-Caused Delays	37

- **Design Errors (50/100)** are reported as occurring less frequently than design omissions, therefore appearing lower among the index scores.

Accelerated schedule (38/100) and contractor-caused delays (37/100) benefit from relatively low reported frequency across all the respondents' project experience.

This frequency/impact analysis clearly indicates that reducing owner-driven changes will be the most effective way to mitigate the impact of uncertainty on project cost, followed closely by fewer omissions in design documents and better coordination.

Drivers/Frequency of Most Impactful Causes of Uncertainty

The frequency/impact analysis identified owner-driven changes, design omissions and coordination issues as the most impactful causes of uncertainty (see page 17). To effectively address these, it is important to understand more about them. The following pages share specific research findings on their causes and frequency.

Drivers of Owner Program or Design Changes

Unclear project requirements from owner at outset is the most important driver overall, rated as being of high or very high importance by the most respondents (71%). There is significant variation between the perspective of contractors (85%) and the owners themselves (59%), reflecting a theme throughout the research of each party's reluctance to acknowledge the relative importance of drivers/causes that are most closely under their control.

This differential in perspective repeats with the next two most important drivers:

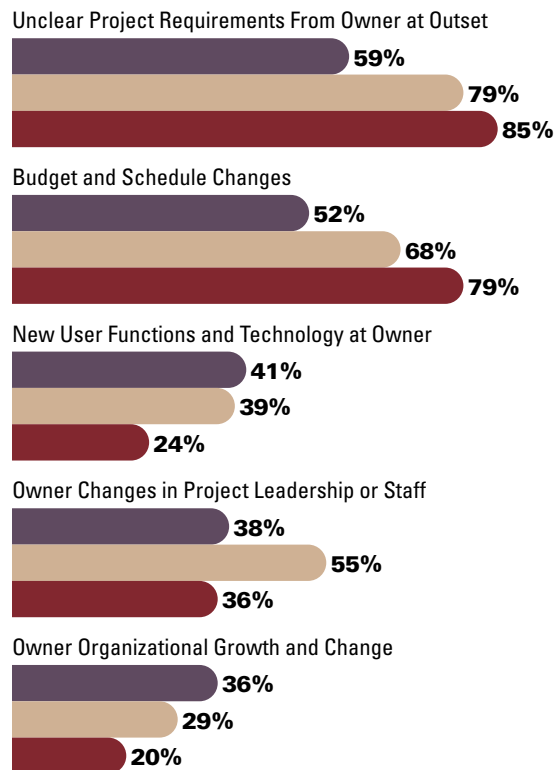
- **Budget and schedule changes (63%) is cited by far more contractors (79%) than owners (52%),** which makes sense because contractors are tasked with managing those elements, although owners are typically the source of them.
- **Owner changes in project leadership or staff displays a similarly deep variance between owners (38%) and architects (55%).** This kind of change could be more impactful for architects because it can be disruptive to the design process, whereas owners may feel staff turnover on their side is a normal part of business, therefore not as important.

Though less significant overall than the first three drivers, **owners are more willing than architects or contractors to identify two drivers—new user functions and technology at the owner and organizational growth and change at the owner—as top drivers for program or design changes.** These findings may be influenced by the fact that these drivers are often initiated from elsewhere in the owner organization, external to the project leadership or staff itself, but must be dealt with by them directly.

Important Causes of Owner-Driven Changes (According to Those Who Rate Them Important/ Very Important)

Source: McGraw Hill Construction, 2014

■ Owners
■ Architects
■ Contractors



Understanding Uncertainty

Drivers/Frequency of Most Impactful Causes of Uncertainty

CONTINUED

Frequency of Types of Design Omissions and Design Errors

Rather than exploring the causes of design errors and omissions, the research focused on determining the frequency of occurrence of four specific types.

It is important to note that while architects are typically responsible to the project team for the quality and completeness of the full set of construction documents, design omissions and errors can occur in the documents of any of the design professionals (engineers, specialty consultants, etc.), not just the architects.

With half (50%) of all respondents citing it, lack of coordination among disciplines in contract documents is top on the list of common problems. Striking here, though, is the huge variance between the low frequency reported by architects (27%), and the far higher perception by contractors (81%), who, it could be argued, have an educated opinion because this directly influences their responsibility of coordinating the trades.

The disparity between architect and contractor perceptions of frequency continues through the final three issues:

- **Gaps or Discrepancies in or Between Contract Documents:** Architects (21%), Contractors (68%)
- **Constructibility Issues of Proposed Design Solutions:** Architects (12%), Contractors (55%)
- **Errors in Calculations, Details, Dimensions:** Architects (8%), Contractors (44%)

Respondents were given the ability to write-in other issues related to design errors and omissions they see occurring at a high frequency. **Incomplete/unclear/incorrect details or designs is the top among all those responding (51%) and especially among owners (59%).**

While it is tempting to dismiss these differences as just the routinely opposing views of architects and contractors, quantifying this significant degree of misalignment points to the need for more focus on expectations, perceptions and alignment about how design team performance should be measured, and what amount of uncertainty-related variance from perfection should be considered reasonable, normal and acceptable in construction documents.

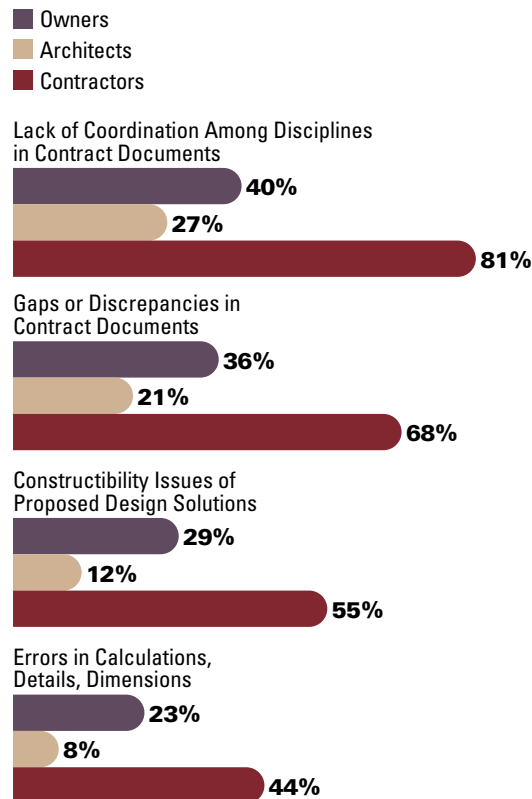
Drivers of Construction Coordination Issues

In most cases, a higher percentage of contractors identifies most of the factors included in the research as contributing with high/very high frequency to

Specific Design Errors or Omissions That Occur Frequently

(According to Those Who Rate Them as Occurring Frequently/Very Frequently)

Source: McGraw Hill Construction, 2014



construction coordination issues than architects or owners. These findings probably reflect an acknowledgment of their responsibility for construction coordination and their strong feelings about its drivers.

67% of general contractors say that individual trade contractor performance is the most frequent driver of coordination problems. Far fewer owners (42%) cite this, which is understandable because they typically leave day-to-day trade contractor management to the general contractor. However, more of the large owners (48%) identified this issue, likely reflecting a higher degree of awareness on their part.

Understanding Uncertainty

Drivers/Frequency of Most Impactful Causes of Uncertainty

CONTINUED

Responsibility for the next two falls squarely on the shoulders of contractors, and to their credit, they represent the highest percentage of respondents citing them as highly impactful:

- **Scope Gaps Among Prime and Subcontracts:** All respondents (35%); contractors (41%)
- **Lack of Thoroughness of Preconstruction Planning, Estimating and Scheduling:** All respondents (28%); contractors (33%)

Misinterpretation of design/technical documents places the onus of responsibility on the construction team rather than finding fault with the documents. 35% of architects and 41% of contractors rate this highly, with owners (20%) pulling down the average likely because in most cases they would be unaware of the issue occurring.

Underperforming/unqualified/inexperienced staff, subs and team was not included in the main survey, but it was brought up frequently by respondents when asked about other factors that frequently cause design errors and omissions. This factor is focused more on the lack of properly skilled personnel than the previously discussed factor of individual trade contractor performance, which reflects a company-level assessment.

Concerns about staff could be tied to the growing workforce shortage in the industry, and can potentially drive many kinds of uncertainty on projects. Interestingly, architects (43%) and owners (29%) perceive this more frequently than contractors (20%). Since these could be considered subjective measures, it raises the issues of performance expectations and perceptions related to the construction team—and points to a need for fair and open discussion early in a project about how performance should be measured to reduce this misalignment, clarify expectations and establish transparent measures to define “good performance.”

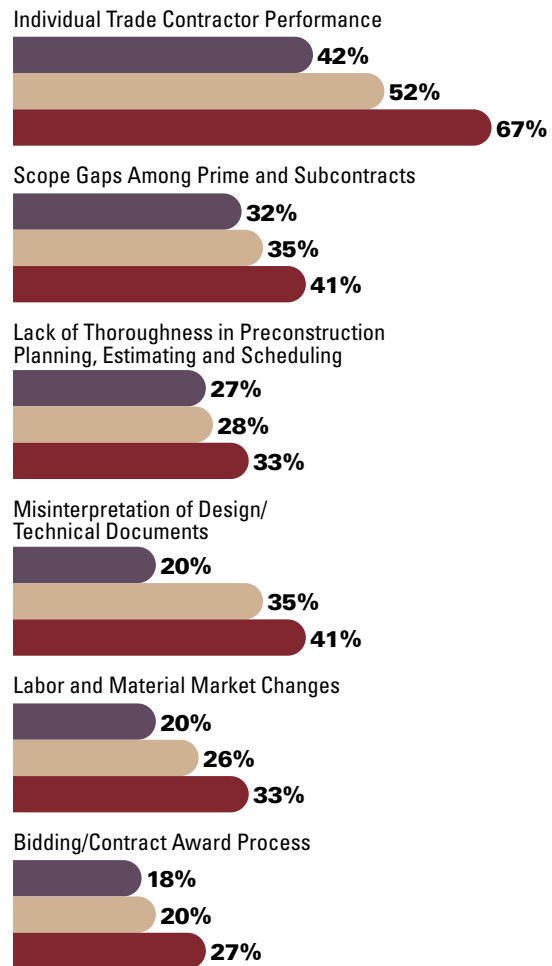
The bidding/contract award process, along with labor and material market changes, receive the fewest designations of high impact, but contractors are about 30% more vocal than the average for each.

Miscommunication between teams was also noted among the other factors independently cited by respondents (41%). It is the only factor where architects lead (50%), likely because design professionals can be one of the teams referred to and thus are aware of the impact.

Factors Frequently Contributing to Construction Coordination Issues (According to Those Who Rate Them as Occurring Frequently/Very Frequently)

Source: McGraw Hill Construction, 2014

■ Owners
■ Architects
■ Contractors



Understanding Uncertainty

Perceived Business Advantages of Project Uncertainty for Team Members

While uncertainty can be seen as a root cause for all manner of problems on building projects, it is possible that some parties may stand to benefit from it. As the saying goes, "Where's there's mystery, there's margin."

To explore this issue in the research, respondents were asked if they believe that uncertainty creates a business advantage for one or more team members.

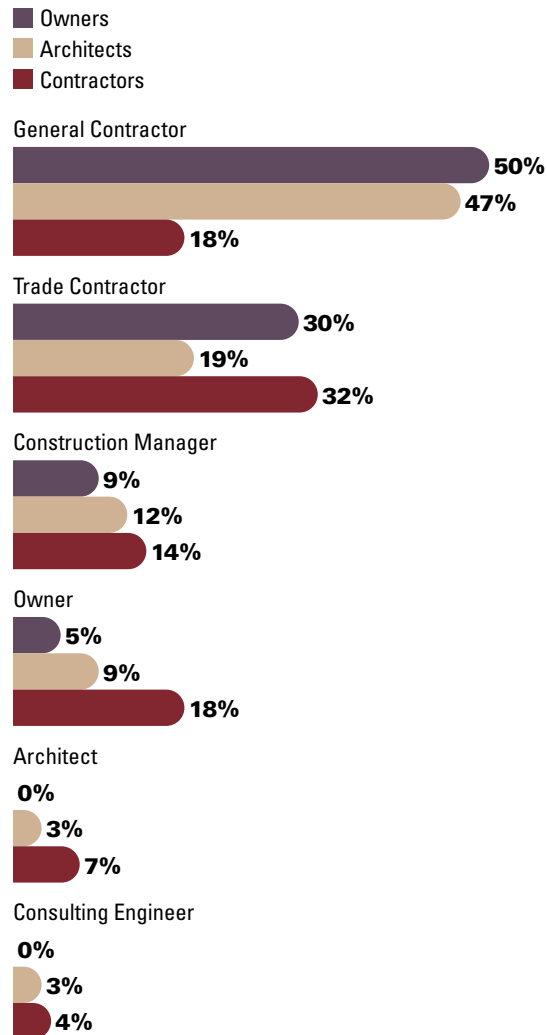
- Only a third (33%) of all respondents and 39% of architects believe that one or more parties are benefiting from uncertainty.
- Owners generally perceive that a single player benefits from uncertainty the least (28%), although large owners are well above average (38%), perhaps indicating a relationship between total dollar volume of projects and perception of advantage.
- Meanwhile, a large percentage of the group (31%) isn't sure, indicating that a significant slice of the industry is on the fence about this matter.

Those who replied positively were shown a list of six company types (owner, architect, consulting engineer, construction manager, general contractor, trade contractor) and asked to identify which one gets the greatest business advantage from uncertainty.

- Half of the architects (47%) and owners (50%) pointed to the general contractors, while only 18% of general contractors themselves agreed, repeating a familiar pattern in these overall finding about uncertainty.
- Trade contractors were the next most-cited group, with general contractors (32%) and owners (30%) leading the way. Architects (19%) pulled the average down significantly, perhaps reflecting less direct exposure to the day-to-day business aspects of the trades, which are traditionally handled by the general contractor.
- Interestingly, a significant number of contractors (18%) say that owners gain business advantage from uncertainty. This may be because of a perception that when owner-related problems occur, owners sometimes deflect responsibility and hold others most responsible, a behavior that aligns with other findings in this research.
- The other company types received generally low citation as potential beneficiaries. The firms least perceived to benefit are the architects (3%) and consulting engineers (2%), an important acknowledgement by the broader industry.

Team Member Who Gains The Greatest Advantage From Project Uncertainty

Source: McGraw Hill Construction, 2014



The varying perspectives among the key parties about causes and impacts of uncertainty point to the need to better understand expectations and perceptions about performance.

Owner Insights on Uncertainty Data Findings

Causes of Owner-Driven Changes

LACK OF UPFRONT PLANNING AND UNCLEAR PROJECT REQUIREMENTS

The members of this project's Owners Advisory Group (OAG, see page 60 for more information) had a variety of perspectives on these issues.

- **Chuck Hardy, GSA**, points to the extended gestation period of many federal projects. "We often plan far too soon for a project that we get the bill for later. The alignment was clear when we did the study five years ago and confirmed when we submitted for funding three years ago. Now we're starting design, but things have changed. I don't think you're ever going to get away from having changing project requirements [in that situation]. But if you can understand why they're changing, then you can manage to them."
- **Don Vitek, Whirlpool**, faces the opposite situation in a fast-moving corporate environment. "It's not unusual for us to be asked to completely scope out something and commit to a number and a delivery time frame with very, very little information. Then we're charged with delivering on a schedule that is extremely difficult to achieve. That's just kind of the way it is in corporate America these days."
- **Jerry Lea, Hines**, says as a commercial developer they do their best to "predict what the market wants, but [project teams] have to be ready to adapt midstream" when market changes force project changes. He continues that "we say

"I don't think uncertainty really benefits anybody."

[in our contract] that we want them to include normal and customary changes that are reasonable for them to address. But if the changes are unreasonable, then we've got to pay for them. We're going to be fair about it because if we're not, they won't be there next time for me."

- **Eric Miller, Sutter Health**, feels it is important to "do a good job gaining understanding on what the terms of satisfaction are for a project." If that has been done, he agrees there is a reasonable limit to the changes owners should expect a team to anticipate. "When the changes stack up, and it's all these little things that add up to hundreds of thousands, sometimes millions of dollars, it's difficult to look [the project team] in the eye and say, 'You should have thought of all of them.'"

CHANGES TO OWNERS' PROJECT STAFF

John Moebes, Crate & Barrel, thinks "isolating changes in owner project staff [as a cause of uncertainty] is important. I've seen a lot of that staff-cycling-through-the-project thing, especially with landlords and developers. Generally the owner's project manager knows the most about the project and stakeholder needs. When you lose that person and get a new replacement—if you get a replacement—the project AEC team can really be leaderless. I think that's a huge Pandora's box for uncertainty, and [negative impact on] cost and schedule. It's something the owner side of industry needs to do better."

DESIGN TEAMS' ROLE IN CAUSING OWNER CHANGES

Boyd Black, University of Chicago, believes that design firms often have a hand in causing what can appear to be owner-driven uncertainty by their tendency to establish and perpetuate a culture of change during design. "Design is a very iterative process, and each step along the way you're making refinements. [Design teams are] always looking to make another tweak that'll make it a little bit better. Some are still making design changes during construction. But that generates a culture that change is okay, and the users experience a design that's constantly in flux. So, why should they feel that they can't make suggestions to refine and improve design without the design team immediately saying 'You're changing things'? My response is 'Well, yeah, but you changed a whole bunch of stuff last week.' The culture of change either needs to be avoided or better managed."

He also sees that a lack of sufficient depth in programming can end up driving owner changes that could have been avoided. "I think architects and engineers can provide incredible leadership by drawing out the information from owners that they need to make more fully informed recommendations before they start getting people excited about where spaces will be, or what the building will look like. Really understanding all the [technical, workflow and performance] criteria that need to be met and testing it at a relatively detailed level, so that when we do start design and we do

start placing these different elements in the building, we understand the implications not just from a spatial organization standpoint but from a performance standpoint. Because I don't think the owners, in many cases, understand enough about design and construction to really give clear direction all the time. So as design goes on, owners say, 'Oh, I didn't realize that. Well, that won't work.' And then the architects say, 'Well, that's a change.' Well, yeah, it's a change, and it's an owner change, but if the design team had a deeper understanding of the full implications of the design on the user's operations, there wouldn't need to be a change. I think that's a huge opportunity for architects and engineers to demonstrate true leadership on projects, true value."

INEXPERIENCED OWNERS CREATE MORE UNCERTAINTY

All of the group members cite inexperience as a major cause of owner-driven uncertainty. **Hardy, GSA**, makes the comparison that "people who aren't typically engaged in this industry are much like someone who is dealing with new IT in their office. It's that happiness that 'I'm going to finally get what I need, and it's going to be perfect.' And they expect it to work magically, but their expectations are much higher than reality."

Frequency of Errors and Omissions

The OAG members commented on the difference between contractors' and architects' perceptions about the frequency of errors and omissions.

- **Lea, Hines**, says although "design teams aren't doing the same quality of documents [they used to], we also find that contractors and subcontractors have begun to get a little lazy. We typically will not have an architect's or engineer's representative onsite full-time, because the contractors quit doing their job. Instead of looking at the drawings, they'll just ask the architect, 'Where do I find the detail on this? What's the answer to this question?' It's clearly on the drawings or in the specs, but they don't want to bother to look for it."
- **Hardy, GSA**, observes that architects tend to focus documentation effort on design intent, because "if I care about it, I'm going to put more detail into it." That leaves other aspects less thoroughly defined, yet he sees trade contractors expecting to use the documents "almost like instructions to build an airplane model from a hobby shop, saying, 'I'm going to build it just like it says. Every piece will fit. Everything's going to go together, and it's going to be a happy place.' But life doesn't work that way."

- **Vitek, Whirlpool**, concurs that "the contractor expects perfection and 100% clarity on drawings, but you never get that. And architects expect well-informed contractors [who] can interpret drawings where needed to fill in the gaps. I think that's reasonable if it's not taken too far."

There are strong feelings about the value of integrating construction knowledge into design documents. **Miller, Sutter Health**, notes, "I'm finding the pushback from contractors to be 'If that darn professional'—it doesn't matter, architect, mechanical, whatever it is—'knew what it took to install this, they wouldn't draw it that way.'" He, like others, involves contractors earlier because "the open conversation, the open platform, the Big Room, whatever you want to call it, has helped that. The conversation drives documents that are constructible."

Hardy, GSA, forecasts that further blurring of the traditional lines between design and construction will impact business models. "How much of the design is actually being done by the detailers in shop drawings and not by the architect? While our fee structures, our logic and everything has the architect as the master of those, a lot of it is migrating to the sub community. So I think there has to be a realization of how design is really getting done right now, and that it will likely result in a fee realignment. Not a lessening of fees, but allowing architects to spend more money on what they're good at, which is the design intent. And let the subs and GCs spend money on what they're good at, which is the detailing and the implementation of that design intent."

"If that darn professional ... knew what it took to install this, they wouldn't draw it that way."

Causes of Coordination Issues and Contractor Errors

Commenting on the research finding that general contractors think trade contractor performance is the leading cause of coordination issues and construction errors, **Miller, Sutter Health**, identifies internal discontinuities within the trade contractor as a driver. "The biggest issue usually is that the person who estimates and does the detail is not the person [who] leads the installation. The superintendent or job foreman walks in the first day and says, 'That's impossible. You can't do that.' But I have to say, 'Here's a mirror, start looking, because you're now talking to your own team. That's within your own dance.'"

Offering another perspective, **Moebes, Crate & Barrel**, points to the common use of a design-bid-build delivery system as an underlying cause. "You've got a lot of placeholders and straw man systems in your model that really can't be coordinated until the actual sub-trade shows up. And most of the industry is relying on a design-bid-build type of project delivery that holds the sub-trade to the very end. But by that point the designers have spent so much of their fee that they don't want to have to re-coordinate, and the owner's already procured documents, so no one wants to change anything. You've got so much industry standard practice that seems to work against having really good coordination with the sub-trades that, although I think it's right to point to the sub-trades, it's wrong to really tar them too thickly because it's the way the industry works."

Vitek, Whirlpool, puts it most simply. "If communication is better, coordination would be better."

Who Benefits From Uncertainty?

Moebes, Crate & Barrel, speaks for the entire OAG when he says "I don't think uncertainty really benefits anybody." **Miller, Sutter Health**, adds, "No one really wins in uncertainty. No one does. Your owner's checkbook is never large enough, and your contractor's appetite for doing work for free is never going to be there."

Although the research shows most respondents believe contractors are the most frequent beneficiaries of uncertainty, **Chuck Hardy, GSA**, thinks pointing to general contractors is a troublesome sign. "It further encourages the misperception that a change order is a good thing for them—that they're making money on them." He believes a more nuanced view is that "trade contractors and

smoother?' The general contractor is [being blamed for poor] preplanning and has to deal with all the trade coordination and disruption in the schedule. And the owner's going, 'Where am I going to get money for this? What am I going to do?' I think at the end of the day, architects, owners and general contractors are really linked on a project. And I think all of them equally are pained by uncertainty and change."

Craig Russell/Disney makes the point that many owners, such as his organization, "are interested in long-term relationships with design and construction companies." He continues that "If we feel that another party was materially advantaged on a particular project because of our own inability to get our act together, it will work counter to the spirit of maintaining that long-term relationship." ■

"If we feel that another party was materially advantaged on a particular project because of our own inability to get our act together, it will work counter to the spirit of maintaining [a] long-term relationship."

construction managers are the ones [who] don't have liability in the bigger picture. And as change comes, and uncertainty is added, and scope is added, the trade contractor and the construction manager are expanding their contracts." Meanwhile he says, "the other three [architect, general contractor and owner] are having real issues because for an architect, it's 'Why didn't you think of this earlier, and why can't I have this

The Cost of Imperfection:

Reducing Error-Induced Uncertainties

Some valuable research has been conducted into the question of the cost of imperfection on projects, but far more research is needed for a full, quantitative understanding of this issue.

Virtually all buildings will have unanticipated changes during construction. Some—although fewer than is widely thought—are due to design errors and omissions. Others are due to unexpected site conditions, freak weather, contractor modifications of construction materials or methods, or other sources of havoc. Typically, owners handle the prospect of these uncertainties by adding contingencies to their budgets, but in today's business climate, many owners express a shrinking tolerance for uncertainty-driven cost overruns, no matter what the scale.

What level of uncertainty is reasonable to expect on construction projects, particularly with regard to errors and omissions? How much do changes typically cost? And how can projects keep rates of error down?

Baseline Rates of Change and Error

According to a 2012 study by Dougherty, Hughes and Zack summarizing statistics from more than 25 papers covering 359 building and infrastructure projects, the direct costs of rework from design errors and omissions alone range from 0.5% to 2.6% of total construction cost.¹

Factor in all other reasons for rework, and direct costs range from 4.03% to 6.05%. Add indirect costs on top of that, which are often not tracked, and Dougherty, Hughes and

Zack calculate that the direct costs of rework balloon by 80%, bringing total costs of rework for changes from all factors to 7.25% to 10.89%.

And these numbers are on the rise. In studies conducted between 2002 and 2011, costs of rework as a percentage of cost of construction run at more than twice the costs in studies from the previous decade. Reasons suggested include "the lack of skilled, qualified craft labor," and the expectation that teams today "do more, faster, with less." More study is needed, however, to understand this trend and to develop strategies to reverse it.

Variables Affecting Rates of Error

Variables associated with rates of error include project size, complexity, location, delivery method, time frame and certainty around project parameters, although there are relatively few quantitative studies. Researchers in all disciplines call for more investigation in this area, and the largely qualitative conclusions in the literature often add little to common sense.

DESIGN ERRORS AND OMISSIONS

Changes due to errors and omissions typically account for a higher percentage of cost on larger projects—although some research suggests this trend goes into reverse when project budgets top \$100 million.

PROJECT COMPLEXITY

Project complexity also operates as a risk factor for error, but industry literature tends to define "complexity" loosely. In addition, although the prediction makes sense intuitively, few numbers are available to back it. A couple of 1999 studies attribute higher rates of errors and omissions to retrofits, which might be considered a type of complexity: one expert puts the rate at 5% for retrofits, compared with 2% for new construction; another study sets a 1.0% base rate for new construction, with 1.5% for additions and 2.5% for renovations.²

INTERNATIONAL PROJECTS

International projects carry a higher percentage of cost changes due to errors, compared with domestic projects, according to the Dougherty, Hughes and Zack study, which cites figures of 2.1% for international projects and 1.7% for domestic. No studies examining possible regional differences within the U.S. were found.

PROJECT DELIVERY SYSTEM

Qualitatively, researchers across all disciplines consider design-bid-build (DBB) projects apt to produce more errors overall because of their sequential nature and the resulting separation of project expertise into silos. But empirical data to support that expectation are rare, and a counterexample, a 1999 study of projects completed for the automotive industry, sets DBB as a baseline,

1. Dougherty, Jason M., Hughes, Nigel and Zack Jr., James G., "The Impact of Rework on Construction & Some Practical Remedies," prepared for the Navigant Construction Forum, August 2012. 2. Automotive Industry Action Group (AIAG), "Guidelines for Improving the Accuracy of Architect/Engineer Construction Documents," April, 1999. 3. *ibid.*

and adds a cost-of-error markup to other delivery methods: 0.5% to construction management, and 1.0% to design-build.³ In 2012, researchers at the University of Colorado and Penn State University began work on a database correlating project performance with delivery method. Work on the project is ongoing.

OTHER FACTORS

Other factors that make intuitive sense as predictors of error include fast-tracking and initial uncertainty around project budget or goals. Researchers across disciplines share an expectation that these factors will correlate to a higher incidence of error, but there are no prominent, well-known studies or project data supporting the expectation.

Strategies to Cut Rates of Change and Error

Two themes emerge from studies of strategies to reduce the costs of change and error: better communication via technology and better communication on a human level between members of the project team.

BETTER COMMUNICATION VIA TECHNOLOGY

The technology-themed version of better communication calls for more extensive and smarter use of building information modeling (BIM) and digital design tools. These are preferred because they allow all parties working on a building—owners, architects, contractors, specialty trades, fabricators and others—to access and interact with design information that is up-to-date, accurate and trackable.

BETTER COMMUNICATION ON A HUMAN LEVEL

The human-themed version of better communication calls for more effective communication and collaboration among project team members. In particular, the tendency to avoid difficult conversations about potential conflicts at the outset of a project, when all parties want to present themselves at their best, consistently correlates with higher rates of change.

TEAM MEMBERS LEADING THE DRIVE FOR IMPROVED COMMUNICATION

Studies conducted by groups representing design professionals suggest benefits from designers' continuing contribution to the project team throughout construction.³ A position paper by an owner's group calls for owners to lead "the creation of collaborative, cross-functional teams comprised of design, construction and facility management professionals."⁴ And most studies agree that owner expectations and buy-in are crucial to reducing costs of change.

From a contractor's perspective, strategies for avoiding changes and cost overruns include:

- Continuous involvement of a building's end users
- Getting a design freeze prior to construction
- Having the owner appoint a "project czar" as the sole source of contact with the contractors and the sole entity who can approve changes
- Third-party biddability, constructibility and operability reviews to reduce uncertainties

- Reviews of change orders on owners' past projects to avoid repeating the same mistakes

Need for Additional Research

To get a true picture of the sources and costs of errors and omissions, however, more quantitative study tracking changes and their causes is needed. This tracking needs to occur during—rather than after—construction. In the meantime, owners and contractors may take comfort from studies indicating that design errors and omissions are responsible for a smaller portion of the costs of change than they probably think. ■

3. Two studies conducted by the American Consulting Engineers Council (ACEC): ACEC, "Client Expectations of Perfection," prepared by the ACEC Risk Management Committee, 2005 and ACEC, "The Cost of Perfection in Public Works Projects: A Design Professional's Perspective," Revision 2.10, 2006. 4. Construction Users Roundtable (CURT), "Collaboration, Integrated Information and the Project Lifecycle in Building Design, Construction and Operation," prepared by the Architectural/Engineering Productivity Committee of CURT, WP-1202, August 2004.

End-User Engagement

Mozilla Headquarters

MOUNTAIN VIEW, CALIFORNIA



Mozilla employees work in an open environment with no private offices, so offices are designed with numerous collaborative and conference room spaces.

When architecture firm MKThink began developing concepts for Mozilla's new Mountain View, California, headquarters, the firm not only sought to meet the expectations of company executives and facilities personnel, but the entire staff. Through extensive engagement with all 260 employees, the team ultimately created a design that increased employee efficiency, minimized wasted space, improved building performance and eliminated the need for significant post-occupancy alterations.

The 54,000-square-foot-project relocated Mozilla headquarters from an existing location in Mountain View to a new one in the area. Jonas Kellner, senior associate at MKThink, says the strategy enabled the team to not only gather important information on potential facility usage, but it also improved employee buy-in about the new location.

"Some of the staff was concerned about losing the downtown office," he says. "Part of the desire for the client was to make the staff be part of the design process and engage them in that before we started construction. By the time the design

was done, staff members felt ownership in the design. It would help them understand the decisions we made in the design process. It gave users a chance to provide input on a level that was unprecedented in modern construction."

The user-engagement strategy for the new Mountain View project grew out of Mozilla's past work with MKThink. Mozilla, which has built 11 facilities in the last three years, has used MKThink on its projects around the world. "To us, MKThink is more than just a design team, they study our culture," says Rob Middleton, director of workplace resources at Mozilla. "We have a very open-source-natured culture. Everyone here at Mozilla has an opinion, and their opinion is valued. So we wanted to take what we've learned elsewhere and actively engage our employees to have input in creating their culture. We know the things that we think worked and didn't work, but let's hear from our employees directly."

The team first used a strategy of surveying its employees and studying how facilities were utilized during a project they conducted in San Francisco. For the Mountain View project, the team chose to pursue even more direct engagement with employees. The strategy included online surveys, in-person group and individual interviews, presentations to the entire staff and email exchanges.

User Engagement

The process was structured around a series of three "brown bag" lunch sessions with staff. Employees who couldn't attend in person were able to connect via online conferencing. During the first session, Kellner

CONTINUED

Mozilla Headquarters

MOUNTAIN VIEW, CALIFORNIA

says the team explained the process and announced that employees would receive a brief online survey. The team followed up with a questionnaire about how and where employees carried out work, their opinions on existing workspaces and other related questions. The team also did an in-office study to observe how spaces were used at the previous facility. Focus groups were set up with team managers and their team members to gather additional team-specific information. The team also set up a wiki page where presentations and results could be posted, in case anyone wanted to reference them later.

The team presented survey results at the second brown bag session, at which they were able to discuss the findings openly with users. "This gave us talking points," Kellner says. "We could say, 'You guys said you want a slide [between floors], but you also say you want more conference rooms. Which would you want more?' People started to understand trade-offs. 'Do you want a bigger gym or bigger desks?'"

Based on the collective input, the team began to hone its designs. At the third brown bag session, the team presented design ideas and solutions to concerns. "By the end, we got a lot less comments and emails; that was indicative of this entire process," Kellner says.

One significant finding from the team's survey process involved the staff's use of conference rooms. Mozilla staff works in a open environment with no private offices. As a result, staff needed to have access to collaborative and private spaces when needed.

Kellner says that at its existing facilities, staff generally remarked that there were not enough conference rooms. Additionally, in-office studies showed that conference rooms were often occupied by only one or two people at a time. The team also remarked that staff may not know when conference rooms were available on short notice.

In response, the design team created more than 60 unique "team spaces," including 37 conference rooms. The conference rooms range in size from large spaces that can accommodate approximately 20 people down to video phone booths that can fit up to two people. Video conferencing is available in every room, but the technology used in those rooms ranges, depending on space requirements. Middleton says this translated into a significant budget savings for Mozilla. "Instead of building a 10-person conference room with \$60,000 in video conferencing capability, [we] could scale that down and put three four-person media rooms in the same amount of space, where the technology is only \$12,000 per room."

User engagement continued during construction. Contractor BNBuilders installed cameras at the project site so Mozilla staff could monitor progress. "We collaborated with the owners to create a Twitter [account] and Facebook page, so [employees] could see inside everyday and could comment on the project," says Tony Castillo, project manager at BNBuilders. "They became part of the project. That was a big hit."

Although some value engineering was required, Middleton says no functionality was lost in the process. In fact, the completed project required no significant post-occupancy alterations, an outcome for which Middleton credits the team's user-engagement process. "A lot of times, people don't understand what they need until things are built, and then they want to make changes. We've had no additional modifications since we moved in, which is somewhat unheard of." ■

Project Facts and Figures

Architect
MKThink

Type of Project
Tenant Fit-Out in Class A
Office Building

Size
54,000 sq. ft. over 2 stories

Start
October 2013

Completed
April 2014

Overcoming Uncertainties

**End-user outreach helped
determine facility needs.**

- All 260 employees were surveyed and engaged in in-person meetings.
- Resulting design addressed employee efficiency, minimized wasted space and improved building performance.
- Conference room designs met needs and saved money.
- No post-occupancy modifications were required.

Data: Performance

Expectations and Metrics

Perceptions of Owner Satisfaction

Architects and contractors were asked how often they believe their projects meet owners' expectations about quality, cost and schedule, while owners were asked how often they find that their expectations are met.

The marked differential of perspectives between owners and their project teams on three critical aspects of owner satisfaction reveals the need for much more clarity about performance expectations and more standard methods for consistently measuring them.

Meeting Quality Expectations

Alignment among players is closest on the subject of quality, where nearly all architects (99%) and contractors (97%) feel they meet owners' expectations with high frequency, and a solid majority (86%) of owners agree. It appears that BIM plays a role, because more (93%) of the owners who employ BIM on their projects report this high satisfaction with quality, compared with those who do not (84%). Only 2% say they are always disappointed in the quality they receive from their project teams.

Meeting Cost Expectations

Perceptions are less well aligned relative to meeting owners' cost expectations.

- Fewer than two thirds of owners (63%) cite a high frequency of satisfaction.
- Most contractors (91%) and architects (85%), on the other hand, believe they are frequently satisfying their clients.

While only 1% of contractors confess to a low frequency of meeting cost expectations, a much higher percentage of owners (7%) say their cost expectations are not met.

Among types of owners, the greatest percentage of highly satisfied owners are among those in healthcare (74%), while the least are in education (56%). This may reflect the difference between healthcare project teams, which are frequently comprised of highly specialized designers and builders who are selected through a qualifications-based process, versus the large percentage of education project teams that are formed through public bid processes.

Meeting Schedule Expectations

The greatest misalignment between the parties occurs relative to schedule.

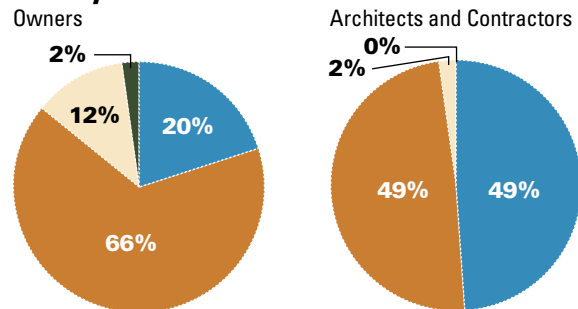
- A high proportion of architects (90%) and contractors (87%) believe they are hitting the mark frequently.

Frequency With Which Projects Meet Expectations

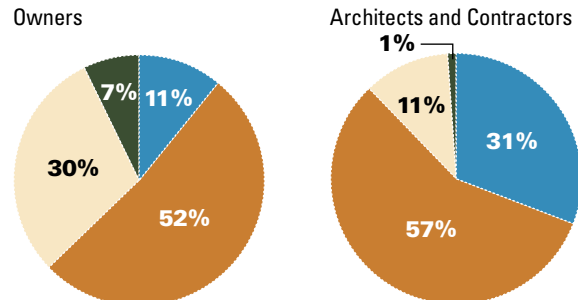
Source: McGraw Hill Construction, 2014

- Always Meet Expectations
- Frequently Meet Expectations
- Sometimes Meet Expectations
- Infrequently/Never Meet Expectations

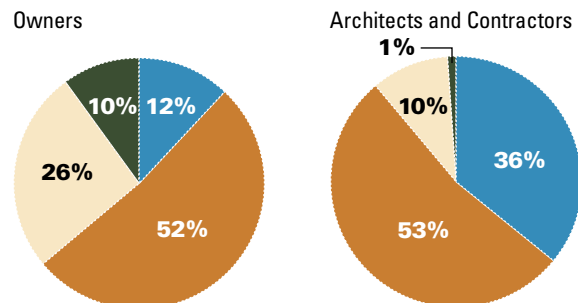
Quality



Cost



Schedule



- Less than two thirds (64%) of owners agree. In fact, a significant percentage (11%) say they are rarely satisfied.

In general, the findings among owners are consistent across organization size, project types and the degree of complexity of their projects.

Effective Criteria in Measuring Design Team's Performance on Project

Owners, architects and contractors are in relatively close alignment on the rank order of metrics that should be used, but some interesting variations of emphasis are also evident between parties.

The ability to develop a set of documents that meet the owner's program requirement and that are constructible within budget is cited by a large majority of each party as the single most important metric for a design team. This reinforces the view that the documents are the foundational deliverable upon which much of the success of the project depends.

A close second is the ability to solve issues by working with team members and not escalate to owner, with over three quarters of architects (83%), contractors (77%) and owners (78%) citing it as very important. This points to the shared appreciation of a collaborative approach to issue resolution, in contrast to more adversarial practices.

Applying metrics based on design errors and omissions—including the percentage of construction cost due to design errors and omissions, the number of design errors and omissions, and the percentage of contingency used due to design errors and omissions—is less widely supported by any of the parties. In fact, most owners acknowledge that perfection in documentation is neither possible nor reasonable to expect (see page 31).

Only about a quarter (28%) of architects favor a metric for number of change orders on a project, probably because there is a wide variety of factors that can generate change orders, many of which are unrelated to design team performance. **However, it is interesting to note that almost half (46%) of owners designate it as an effective metric to apply in their measurement of design team performance.**

Effective Criteria in Measuring Design Team

Source: McGraw Hill Construction, 2014

■ Owners
■ Architects
■ Contractors

Ability to Develop Documents That Meet Owner's Program Requirements and Are Constructible Within Budget



Ability to Solve Issues Working With Team Members and Not Escalate to Owner



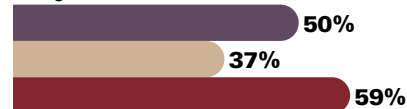
Number of Design Errors and Omissions



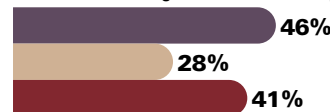
Percentage of Construction Cost Due to Design Errors and Omissions



Percentage of Contingency Used Due to Design Errors and Omissions



Number of Change Orders on a Project



Expectations Regarding Construction Documents

Possible to Have Perfect Construction Documents

Only 10% of owners, architects and contractors believes that it is possible to have a perfect set of final construction documents on a reasonably complex project. Interestingly, owners (7%) represent the smallest portion of this group, while architects (13%), who reasonably should be the least willing to take this position, actually make up the largest part of the group.

Among that small group of respondents who believe perfect documents are possible:

- Twice as many concentrate on commercial projects than institutional work, probably reflecting the typically higher complexity level of institutional projects.
- There are more small owners (those that spend \$10 million to \$50 million annually on construction) than larger owners, perhaps because their projects are often less complex.

As an inquiry into the past experience of the group who believe perfect documents are possible, the owners (7%) and contractors (10%) were asked if they have ever seen a set of perfect construction documents, and the architects (13%) if they had ever produced one. The responses (15%, 17% and 18%, respectively) show that reality has fallen far short of the ideal in their actual experience.

Since it was not stipulated that the documents had to be related to a "reasonably complex project" as in the question about the possibility of perfection, these probably reflect some past experiences with relatively simple projects that were completed without incident.

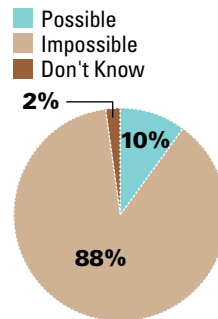
Reasonable to Expect Perfect Construction Documents

Just the owners were asked if they believe it is reasonable to expect to have a perfect set of final construction documents. Although only a few (7%) believe it is possible to produce perfect documents, three times as many (21%) say they think it is a reasonable expectation.

This seeming contradiction is illuminated by comments made during individual interviews with members of the Owner Advisory Group, where several stated that although they understand perfection is not possible, they would typically not openly acknowledge that position and will instead always hope for it.

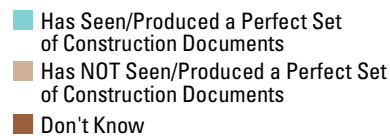
Possibility of Perfect Construction Documents (According to Owners, Architects and Contractors)

Source: McGraw Hill Construction, 2014

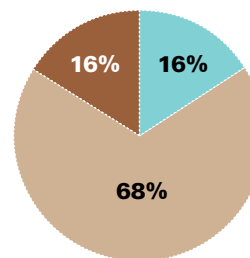


Experience With a Perfect Set of Construction Documents (According to Owners, Architects and Contractors Who Believe Perfect Documents Are Possible)

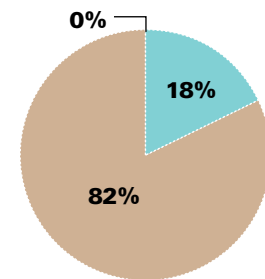
Source: McGraw Hill Construction, 2014



Owners and Contractors

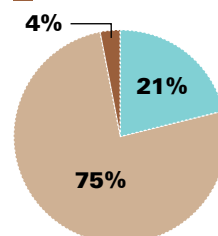
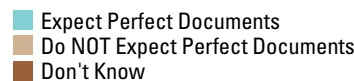


Architects



Expectation That Perfect Documents on a Complex Project Is Reasonable (According to Owners)

Source: McGraw Hill Construction, 2014



Expectations About Cost Impacts of Design Team's Performance Issues

Most owners (80%) say they fully expect to encounter added costs on their future projects that will be caused by design mistakes.

When asked how much additional cost caused by design mistakes (as a percentage of total construction cost) they would accept as normal, owners' responses range from 0% to over 20%, but the average is 3%–5%.

- **Only a few owners (3%) hold the line at 0% budget impact being acceptable.**
- **Less than half (40%) believe 1%–2% is the acceptable range.**
- **A similar percentage (38%) believes 3%–5% is an acceptable expectation.**
- **The remainder (19%) would accept upwards of 6% added costs.**

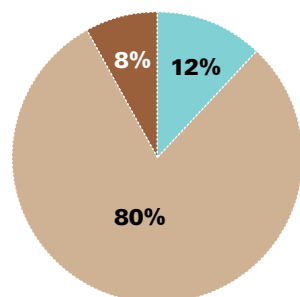
The fact that eight in 10 owners (80%) say that they fully expect added costs from design mistakes firmly resolves the question that imperfections of this nature are well within reason. While the majority (53%) express the belief that a normal percentage cost impact from these issues is 3% or greater, the results across all owners show a wide variance, from 0% to over 20%. These findings suggest another opportunity for an open and informed team dialogue, based on specific aspects of a project early in the process, to develop alignment that will avoid conflict later.

Expected Cost Impacts of Design Mistakes on Future Projects (According to Owners)

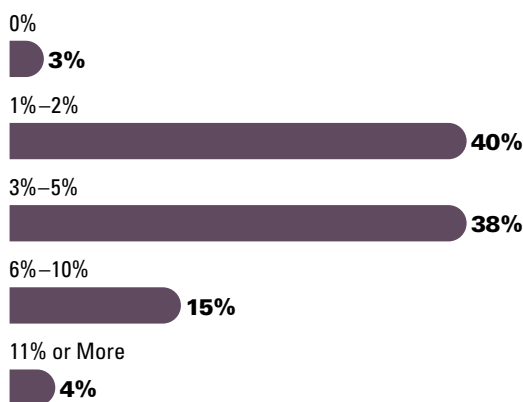
Source: McGraw Hill Construction, 2014

Expects Future Projects to Be Completed With No Added Costs Due to Design Mistakes (According to Owners)

- Yes
- No
- Not Sure



Level of Additional Costs Accepted as Normal (According to Owners Who Anticipate Additional Costs)



Criteria for Measuring the Construction Team's Performance

Similar to the inquiry about design team performance, all respondents were asked which metrics should be used to measure the performance of a construction team.

- **The results show there is relatively close alignment between the parties on the rank order of metrics that should be used.**
- **There is also more commonality among owners, architects and contractors on the importance of each one than with the design team metrics.**

The ability to work with other team members to solve issues and not escalate to the owner ranks as the top metric favored by all the parties. This collaborative behavior is an important tactical way of dealing with the impacts of uncertainty as they manifest themselves on projects, but it requires an appropriate culture on the project team and the discipline not to default to self-protective measures when challenges arise.

Hard metrics make up the rest of the top five, reflecting the more quantitative nature of the work performed by the construction team. There is general alignment between the parties on the order of importance, especially since the option of no errors due to negligence ranks last overall, reinforcing the point that perfection is not an expected industry standard.

Interestingly, although measuring the number of change orders on a project ranks last among contractors (17%), it is second-highest rated among owners (52%). This differential is similar to the large number of owners (46%) who rate this as an appropriate metric for design teams' performance, versus far fewer architects (28%). (See page 30.)

The reasoning may be similar in each instance, in that architects and contractors both likely believe there are many causes of change orders that are not in their direct control.

Best Criteria for Measuring the Performance of the Construction Team

Source: McGraw Hill Construction, 2014

- Owners
- Architects
- Contractors

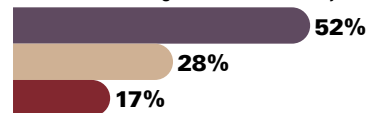
Ability to Solve Issues Working With Team Members and Not Escalate to Owner



Percentage of Construction Cost Due to Construction Errors



Number of Change Orders on a Project



Percentage of Contingency Used Due to Construction Errors



No Errors Due to Negligence



Expectations Regarding Construction Team's Performance

Possible to Have Perfect Performance by the Construction Team

Similar to the questions addressing expectations of perfection in construction documents, respondents were asked if they believe it is possible for a construction team to deliver perfect performance. **Whereas only about 10% of respondents expressed the belief that perfect documents are possible, significantly more (average 24%) feel perfect performance is achievable by a construction team.**

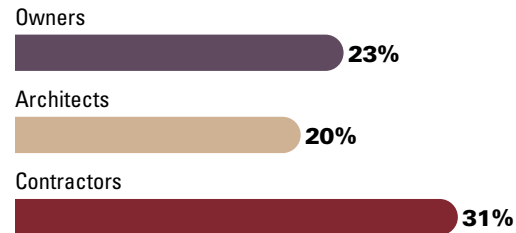
Interestingly, 31% of contractors say that perfect construction performance can be delivered. This optimistic stance by the party most responsible for delivering perfect construction performance significantly outpaces owners (23%) and architects (20%) and, in fact, aligns with the higher percentage of architects than owners who believe perfect documents are possible. (See page 31.) In both cases a trend is emerging where owners may hold lower expectations of perfection than the parties who would appear to be most responsible for delivering it.

Reasonable to Expect Perfect Performance From the Construction Team

When owners were asked if they think it is reasonable to expect the construction team to deliver perfect performance, far more (73%) expressed assent than did with perfect documents (21%). This clearly demonstrates that owners hold the construction team to a higher threshold of performance expectation than the design team. This seems to convey a general sense by owners that the types of uncertainty dealt with by design teams may rightfully produce a wider margin of acceptable error than they are willing to expect from builders.

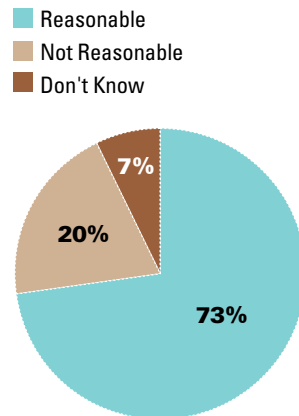
Believe Construction Team Can Have Perfect Performance

Source: McGraw Hill Construction, 2014



Reasonable to Expect Perfect Performance by Construction Team (According to Owners)

Source: McGraw Hill Construction, 2014



Owner Insights on Performance Expectation Data Findings

Owner Satisfaction

The Owner Advisory Group (OAG, see page 60 for more information) believe that the variance between owner and architect, engineer, contractor (AEC) team ratings of owner satisfaction with quality, cost and schedule have to do with perspective and attitude.

Don Vitek, Whirlpool, suggests that “although the project was delivered on the agreed-upon revised schedule, maybe the owner agreed on it reluctantly and still got beat up by senior management because it was later than what was promised. That could leave a bad taste in the owner’s mouth,” even though the AEC team felt they met schedule.

Chuck Hardy, GSA, further explains that while quality is a softer metric that can be finessed somewhat in discussions with top management, cost and schedule are tougher. “We’re making commitments internally that can’t be easily moved. Architects and contractors are saying, ‘We handled this uncertainty as perfectly as we could, mitigated the risk as best we could,’ but time or cost was still added. And these are hard numbers that owner project teams and their hierarchy upwards don’t like to take into the board to explain what happened.”

John Moebes, Crate & Barrel, believes that owner experience impacts satisfaction. “As satisfaction falls off, I would look at the level of sophistication of the owner.” **Jerry Lea, Hines**, agrees and also thinks happy teams create happy owners. “We get good value for what we pay for, in quality, cost and schedule. We staff the job during construction with a pretty seasoned team that goes

“We have found if it’s a good job for the contractor, it’s a great job for us.”

into it with the attitude of, ‘I want to help the contractor succeed.’ We have found if it’s a good job for the contractor, it’s a great job for us.”

Design Team Metrics

The OAG’s comments on design team metrics support the research findings about the primary importance of good documents and collaborative behavior, over hard metrics about changes and contingencies. As **Hardy, GSA**, puts it, “If you hit those top two, the others will come in line.”

Eric Miller, Sutter Health, more directly relates document quality to construction cost impact. “When it comes to work that was missed, if I spend a buck with an architect, I’m going to spend fifteen dollars with a contractor to fix it.” So his focus is on “creating a complete set of documents up front, so that you don’t have that expensive circle of change.”

Another slant comes from **Lea, Hines**, who differentiates between his metric for design, which is, “Has the building been successful from a leasing standpoint?” and production, where “it’s not only the quality of the drawings but it’s getting them done on time.” His perspective on the metric about avoiding finger-pointing with contractors: “I’ve seen that before, so I always insist architects have a strong project manager to put a stop to it. They’ll take [the contractor] aside and say, ‘You won’t do that again. You’re going to work as a team, or we’ll get you replaced on the job.’ They just won’t stand for it.”

Thinking in a larger context about measuring design team value, **Boyd Black, University of Chicago**, expects them to be thinking on the owner’s behalf about the entire project process, not just the design. “It’s an opportunity to demonstrate leadership by considering, for example, ‘How do we make sure that the campus is as little impacted as possible during the project?’ Generally, the quality of the design itself is easier to deal with. It’s the quality of the process, the quality of the experience, that we look for.”

Perfect Construction Documents

The Owner Advisory Group generally agrees that perfect construction documentation is an unrealistic expectation.

■ Although **Lea, Hines**, believes “in general today drawings and specifications aren’t as good as they used to be,” he also admits, “I don’t think I’ve ever seen a perfect set of drawings. I would love to.”

■ **Craig Russell, Disney**, says perfect documents could be “possible if you have all the people who are going to build it foresee all the outcomes and plan together to create a perfect, zero-defect design.” But, he continues, “I’m not talking on the first project. I’m talking on the tenth project, where this team is extraordinarily high functioning and can think through the project very well together.” Otherwise, “do I think it’s reasonable? No.”

- **Black, University of Chicago**, adds, "We sometimes joke here that the only time we get even close to perfect construction documents is as-builts."
- Though perfection is elusive, **Hardy, GSA**, captures a common belief among the group that "the expectation should always be that you're going to get the best set ever, if not perfect." Although he adds that, "it's the owner's responsibility to determine the requirements" for document quality and clarity. He feels owners "train [design teams] into what is an acceptable level of documentation." And if they let their vigilance slack on a project, the "next project most likely will follow that lesser set."

Most are focused on how to deal with the inevitability of imperfection. **Vitek, Whirlpool**, states it succinctly: "Documents don't take the place of communication." To that point, **Lea, Hines**, extols the benefit of his firm's hands-on approach. "I think the industry standard for errors and omissions on drawings is probably in the 5% to 7% range. Ours is less than 2%, and we track this on every job. We hire good consultants, then we look over their shoulder and try to help them. The idea is, 'Let's try to get the most complete and coordinated set of drawings we can.'"

The Cost of Imperfection

The average impact of design imperfection is cited by owners in the research as typically 3% to 5% of construction cost. In general, the Owner Advisory Group members focus on what **Miller, Sutter Health**, calls a "range of reasonableness" that is appropriate to each project.

"Generally, the quality of the design itself is easier to deal with. It's the quality of the process, the quality of the experience that we look for."

- **Hardy, GSA**, believes "if we're 3% to 5% close to perfect on our drawings, I think that is probably a good number."
- **Moebes, Crate & Barrel**, who does "seven or eight stores a year," believes the cost of imperfection correlates to owner experience. "For us, it's probably less than 3%." But less frequent builders, such as mall developers he deals with, "are seeing more impact and certainly have more E&O issues."
- **Miller, Sutter Health**, who involves contractors early to help improve design, is more pointed. "If it exceeds 3% to 5%, I start hunting. We've invested a lot of money in preconstruction, and I have difficulty believing after multiple months and a lot of iterations, that you have more than a 3% to 5% wiggle on your total cost to deliver."
- **Russell, Disney**, reminds us that "sometimes it's a design error, not a designer error," meaning that a well-intentioned element of the design simply didn't work out in the field. "Everybody kind of owns that one."

Construction Team Performance Metrics

The top metric for construction teams identified in the research is collaborative problem-solving, followed by other quantitative metrics on construction errors and change orders. **Hardy, GSA**, agrees with that priority. "Once the contractor gets into the driver's seat, it's a great metric. If they're

doing number one right, most of those others would be minimized." He fully expects problem-solving from contractors. "Owners are hiring contractors because they're the subject matter experts in construction. They get a set of drawings that shows the design intent," and he expects them to "solve some of the anomalies in the drawings and the design to meet the expectations of the owner."

Construction errors are generally less of a problem for the group. **Lea, Hines**, recalls, "We see them, but it's not common. We've had contractors lay out the job and get it wrong. Sure, they make mistakes. Nobody's perfect." He focuses more on evaluating the quality of a contractor's service. "I think through it in stages. In preconstruction: 'Did they work with us in finalizing the design effectively, or did they play any games?' In construction: 'Did they manage the subcontractors?' Even some good contractors put a staff out there that doesn't know how to manage the subs effectively." He continues, "The biggest place we see contractors fall down today is in close out and commissioning, especially when they're real busy. They start sending their top people off to the next job, which is an event of default in our contract. The systems today are so complicated to commission that you've got to be paying attention or you're going to be in trouble."

Regarding the use of change orders as a metric:

- **Vitek, Whirlpool**, thinks the term has gotten “a negative connotation because it generally has a cost associated with it. But change orders come from many different places. Some are good and benefit the end product. It’s not enough to just judge it on the number. Is a 100 change order project worse than a 20 change order project? I’m not sure you can say that.”
- **Moebes, Crate & Barrel**, adds, “Less sophisticated owners tend to always see a change order as a negative. They feel like they’re getting preyed upon. And a lot of architects feel the same way. Owners who build a lot realize a change order is just the way you adjust a contract up or down. We show everybody the [construction] contract and say, ‘Yeah, some of the stuff isn’t covered in the scope, and there’s going to be a change order to handle that.’ But it’s not meant to pillory any of the designers or set up the contractor later. We’re just up front with saying, ‘This is how the job’s going to run.’”
- **Hardy, GSA**, agrees. “If I tell a project team, ‘Your metric is number of change orders,’ they’ll just start grouping change orders. Instead of individual ones, they’ll have one huge one. It’s a metric that I don’t put a lot of credence in.”
- **Lea, Hines**, addresses it by reducing the incentive. “We don’t pay an additional fee on change orders unless I really change the scope of the job. The contractors put what fee they want for that in their initial bid. So there’s not a big incentive for the contractor to ask for change orders.”

Perfect Construction Performance

The OAG members largely agree that it is more reasonable to expect perfect execution by contractors.

- **Moebes, Crate & Barrel**, says, “With retail builders that goal of perfect [construction] could be real because we build so much, and the quality of what we build is directly associated [with] the brand experience for the customer.”
- **Miller, Sutter Health**, believes, “As long as I define what perfection is, I think they should hit it. When you look at [MEP work] in its installed condition, it’s a piece of artwork. You’re almost embarrassed to put sheetrock over it. That’s the way you want it. And when I walk down that finished hall at the end of the day, it should look damn near perfect.”
- **Vitek, Whirlpool**, makes a different point, that “construction is not an exact science. Everybody wants it to be, but it’s not. So it’s not that there’s an issue, but how does the contractor recover from that issue? I would expect performance at a very, very high level for a team that reacts and responds well to uncertainty.”

Offering another perspective, **Russell, Disney**, feels that often, “execution is imperfect as a result of the design. I would say three out of four problems in the field are not because of field personnel imperfection. They track straight back to design.”

To address this, Disney is implementing integrated project delivery (IPD) contracts with incentives and profit pools where he expects “near-perfect design,” and contractors who say, “Okay, I understand this job exactly. I helped you design it. Now I will hold myself accountable for performing its execution at a very high level of quality.” ■

“Documents don’t take the place of communication.”

A Successful Balance: Integrating Design-Build Speed, Owner Control and Workplace Safety

Camp Pendleton Replacement Hospital

CAMP PENDLETON, CALIFORNIA

The Navy's new hospital at MCB Camp Pendleton, a landmark facility serving 70,000 active-duty and veteran members of the military and their families, faced an aggressive construction schedule from the start. Funded under the American Recovery and Reinvestment Act of 2009, the project came with a hard expiration date on its financing. In response, the Navy departed from its traditional design-bid-build preference for project delivery and instead awarded the project on a design-build basis.

The new hospital was completed in 49 months from start of design: well below the Navy's typical completion time frame of five to seven years for a hospital project and six months ahead of the project's own schedule.

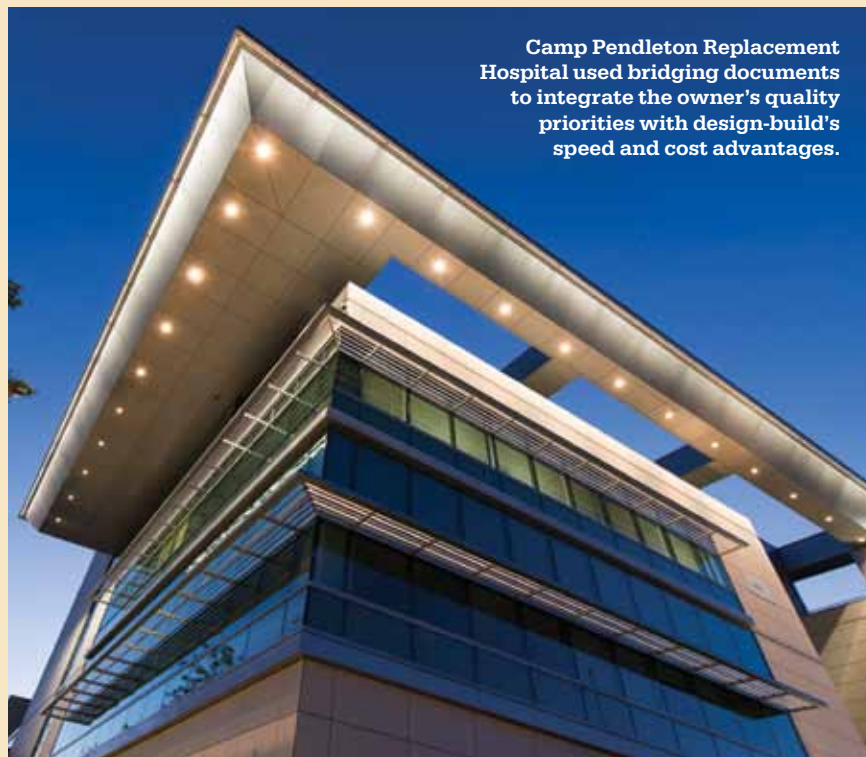
"By any industry standards," says David Williams, R.A., senior project manager for NAVFAC Southwest, "we were at least 30% ahead of schedule for a project of this complexity and magnitude."

And at a contract cost of \$447,300,000, the project came in more than \$80 million below the Navy's \$530,000,000 budget.

Bridging Uncertainty

Design-build's speed and fixed cost often come at the price of a reduction in owner control. To mitigate this, before issuing its RFP, the Navy retained HDR Architecture to develop a set of documents that would outline the project program, generate a design concept, describe adjacencies within the hospital and generally spell out the project the Navy wanted.

To ensure these bridging documents embodied the Navy's



Camp Pendleton Replacement Hospital used bridging documents to integrate the owner's quality priorities with design-build's speed and cost advantages.

expectations, a multidisciplinary integrated team of representatives of medical staff, patient groups and Navy stakeholders collaborated with HDR on a guiding charter of themes and goals for the project and reviewed iterative documentation of the emerging design.

The bridging documents, which were developed to a 30% completion level, became the basis of the Navy's comprehensive RFP and a fixed requirement of the bid. The bridging documents not only secured the Navy's priorities, but they provided bidding teams with a high level of certainty as to what the project entailed, while leaving the engineering and construction detail open to them to maximize.

The result, says Thomas Todd, AIA, vice president at HDR, was "a

successful balance of design-build advantages and owner control."

After award of the contract to a joint venture (JV) design-build team of Clark Construction Group and McCarthy Building Companies, with HKS Architects as the project architect-of-record, the Navy kept the bridging team intact and co-located at Clark/McCarthy's site trailers, where they continued to provide oversight throughout the documentation phase.

"We focused heavily on this issue of co-location," says Williams, attributing to that strategy alone a significant measure of the project's savings in both time and cost.

Make Haste Slowly

To get the project out of the starting blocks as fast as possible, the JV

Camp Pendleton Replacement Hospital

CAMP PENDLETON, CALIFORNIA

team broke the project into discrete packages: site work, structural with minimal mechanical, central plant, parking structure, and the exterior and interior design of the hospital. For each package, the team developed a schedule that would allow construction to proceed before the project was fully designed.

For all its haste, the process of documentation and construction was far from pell-mell. A master plan provided a clear and reasonable path from breaking ground to handing over the hospital, and field leadership for each major phase brought key subcontractors together to break up the master plan into daily activities the team could follow, monitor and remedy if any aspect of the work began to slip.

The Navy instituted an approvals process of intermediate submittals consisting of three submissions before the final permit drawings. At each interval the owner provided feedback, which enabled the team to develop the design in close alignment with owner expectations.

To improve the print-review-design process, designers and reviewers met a week prior to each review and flipped through the forthcoming submittal page by page. When the reviewers began their work, they were familiar with what they were looking at, and conversations with the designers were fresh in their minds. In reverse, when the reviewers completed their review, they met with the designers again and ran through the same page flip, explaining their comments. This process enabled the designers to address a concern on the spot and it distilled the real issues for action, which were then written up into formal comments.

"It took a bit of convincing," says Carlos Gonzalez, P.E., vice president at Clark, "because these conversations added time up front. But they avoided rejected final submittals or incorrect designs that would have resulted in construction changes later."

By the end of design, 99% of cost items were accounted for, and construction changes amounted to less than 2%.

Increased Safety for Increased Certainty

On a project with a health-based mission, worker safety becomes a matter of project integrity. "The Navy provided great leadership on this," says Gonzalez. "From day one, they were not afraid to stop work or slow down until we could demonstrate that we could do it safely. Their unwavering commitment to safety empowered us to follow along."

The project built its exemplary safety record day by day, with initial orientations to safety, weekly site walks by a joint government-contractor safety team looking for ways to improve, monthly meetings to review and recognize safety-based behaviors, and a parade to celebrate the first million work hours without a loss-time incident.

"The success I'm most proud of," says Gonzalez, "is safety." In 2.6 million hours worked at Camp Pendleton, the number of DART (days away, restricted or transferred) and lost-time incidents was zero.

Outstanding Overall

At the conclusion of the Camp Pendleton contract, the Navy provided a performance evaluation to the joint venture, which

Project Facts and Figures

Owner

NAVFAC Southwest

Architect

HKS Architects, Inc. and HDR Architecture, Inc.

Construction Manager/

General Contractor

Clark/McCarthy Joint Venture

Project Type

Hospital with central utility plant and parking structure

Size

■ Hospital: 518,000 square feet

■ Central Utility Plant: 21,000 square feet

■ Parking: 546,000-square-foot parking structure and 1,000 stall surface parking lot

Design Start

September 2009

Construction Completion

October 2013

Project Results

■ Schedule: Finished 6 months ahead of schedule

■ Cost: Project budgeted at \$530,000,000 but came in at \$447,300,000

■ Safety: Zero lost time and zero DART injuries in 2.6 million hours worked

■ LEED: Gold certification

reflects implicitly on the team's strategies for managing expectations and uncertainties. The verdict overall: outstanding. ■

Claims Consultant Perspective

Advances in construction methods and collaborative tools can help project teams identify potential issues and reduce risks. Relationships between team members are critical in that effort, enabling better communication and collaboration.

Uncertainties can be costly, and sometimes they lead to disputes and claims. While many traditional causes for claims remain the same, some consultants say that advances in construction methods and tools can help reduce the risks.

Roy Cooper, vice president and leader of Construction Claims Services at Arcadis, says analyzing projects from a claims perspective at an early stage can go a long way toward identifying and avoiding costly risks. Enhanced schedule reviews, for example, can make a significant difference. Nearly all claims that his group encounters have an “element of time,” he says, where issues affect construction schedules. Cooper suggests that project teams should view projects “not from a purely nuts-and-bolts scheduler’s standpoint,” but a claim’s perspective.

“This is different [from] your typical schedule review,” he says. “We’re taking a harder look at it. What is in the schedule that can bite us down the road on claims?”

Cooper says that qualitative risk assessment—where potential risks are identified—and quantitative risks—where potential costs of risks are estimated—have been traditionally difficult for owners to execute. However, advancements in technology, such as scheduling software and building information modeling (BIM), are making it easier.

Richard Martone, managing

director of PMA Consultants, says that schedule claims are traditionally the most difficult to resolve, but advanced schedule control systems enhance opportunities to avoid issues or mitigate them quickly.

“We see that sophistication from both contractors and owners; contractors in terms of preparing and submitting schedules and owners in terms of evaluating those [schedules] and commenting on them,” he says.

Collaboration and Communication

Collaboration and communication among team members are critical when trying to reduce uncertainties on projects, says Frank Guita, senior vice president and managing director of the Americas Claims and Consulting Group at Hill International. More collaborative delivery methods and tools like building information modeling can help in this effort, Guita says.

“By the intent of the process, BIM is collaborative,” he says. “In the traditional design-bid-build delivery model, you can have islands of self-interest. When you go down a BIM road, you’re in a collaborative environment, and that starts to connect those islands.”

Guita adds that through such collaborative techniques, teams can identify conflicts and problems early. “The number one cause of construction disputes we see is problems or defects with contract documents,” he says. “BIM starts to

break that down. You do things in the model that catch many of the things that lead to problems in the field.”

Still, working in BIM can have its downsides from a claims perspective. “The risk lines can get blurred when you get into a BIM environment,” he says. “If there is a problem, it gets more complicated to figure out who is responsible.”

The increased complexity of projects—from both a technical and organizational standpoint—can increase the risk of disputes as well. A project may have numerous stakeholders on the owner’s side, each with a particular set of project requirements and expectations. Likewise, large projects often require joint ventures of design and construction teams, where each member may have a unique perspective. “In a joint venture, contractor X might think differently than contractor Y and contractor Z,” Cooper says. “Imagine if a dispute comes up: One might want a fight, and the other wants to kiss and make up. The owner doesn’t know if they should bring flowers or boxing gloves.”

Regardless of the means and methods used on a project, Cooper says dealing with potential risks on projects comes down to relationships between people. “Half of the battle is about the people,” he says. “If we work out the relationship issues, then we have a better chance of avoiding or mitigating and resolving disputes early.” ■

Data: Opportunities for Performance Improvement

Importance of Four Major Mitigating Elements

To begin the process of identifying what practitioners should concentrate on in order to have the greatest positive impact, respondents were asked to rank four major potentially mitigating elements in order of their likely effectiveness in reducing all types of uncertainty in the building design and construction process.

- **Documents:** Detailed construction drawings with no significant errors or omissions
- **Early Collaboration:** A collaborative approach with involvement by the entire project team in early design
- **Issue Resolution:** Clear process for project team members for dealing with issues that arise during design and construction
- **Shared Liability:** A collaborative approach with shared liability across the project team

Error-Free Documents

Error-free documents rose to the top as the dominant desire, with half of all the respondents (48%) saying that if such documents were possible to produce, they would certainly be the most important mitigating element. Only a few (9%) rank error-free documents as least important (i.e., not among their top three choices).

Although it has been well-established in the findings that perfection is not a realistic expectation, the unanimity among architects, contractors and owners on this point reinforces the importance of construction documents as the foundational element on which much of the success of the rest of the project depends.

Early Collaboration

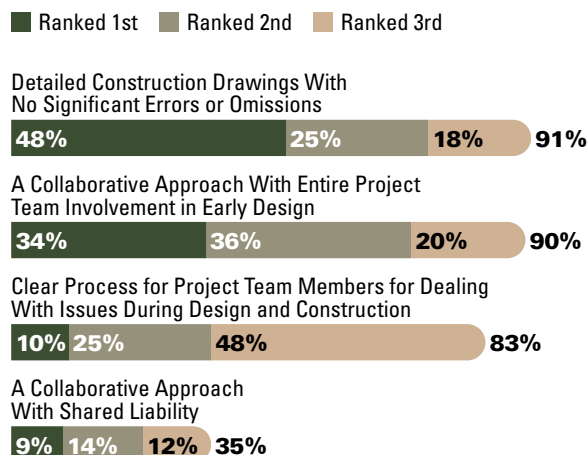
34% chose early collaboration as most important, although a similar proportion (36%) placed it second on their list, underscoring its subordinate position to error-free documents. Respondents who are involved in a high proportion of healthcare work felt especially strongly (41%) about the value of a collaborative approach, likely reflecting the growing popularity of it in that market sector.

Issue Resolution

The support for a clearly defined approach to issue resolution ranks much lower, with only a few (10%) citing it as most important and half (48%) placing it third on their list. Contractors seem least supportive, with 31% not even including it among their top three, almost twice the average (17%) among all respondents. This may be because many contractors feel that they already have a

Top Ranked Factors for Reducing Uncertainty (According to Owners, Architects and Contractors)

Source: McGraw Hill Construction, 2014



satisfactory issue resolution process and that other mitigation strategies are more important for reducing uncertainty.

Shared Liability

Shared liability receives the smallest level of support (9%) as the most promising mitigation approach. Nearly two thirds (65%) of all respondents exclude it entirely from their top three, led by architects (78%), who most likely feel that they have the least amount of control over the riskiest aspect of a project. Conversely, contractors show the most overall support for shared liability as a means to mitigate uncertainty, with half (52%) including it among their top three. This may indicate a desire by contractors for design professionals to accept more of the risk on a project, as well as showing that contractors have an interest in exploring new ways to structure business arrangements around risk and liability to reduce the impact of uncertainty.

Opportunities for Performance Improvement

Effectiveness of Specific Factors on Reducing Overall Project Uncertainty

To provide greater detail in identifying the most effective ways a project team can address and manage uncertainty, respondents were asked to rate 13 specific factors as to their impact on reducing the overall level of uncertainty in the building design and construction process. The chart shows the top nine factors selected by at least 50% of owners, architects or contractors who rated each factor as either having a high or a very high impact, but the analysis below looks at all 13 factors. Several themes appear in these responses.

Importance of the Owners' Role

Two of the top three factors cited by all respondents relate directly to the owners' role on projects.

- **Clearer direction from owners ranks first with most (79%) of the total respondent pool**, and rates even higher (89%) among architects. Project complexity influences this factor somewhat, with over eight in 10 (83%) of the respondents who do mostly complex projects citing it as highly significant, versus fewer (73%) of those who rarely do complex projects.
- **More active leadership by owners, a closely related factor, is third overall, with over two thirds (68%) citing it as having high or very high impact on reducing uncertainty.** Large owners and architectural firms weigh in even more emphatically—at 77% and 83%, respectively. This is likely because their large and complex projects often involve especially high levels of uncertainty and thus would be likely to benefit most from active owner involvement. Indeed, respondent experience with project complexity does impact preferences, where over two thirds (76%) of those doing mostly complex work identify active owner involvement as critical, versus just over half (51%) of those involved primarily in simpler projects.

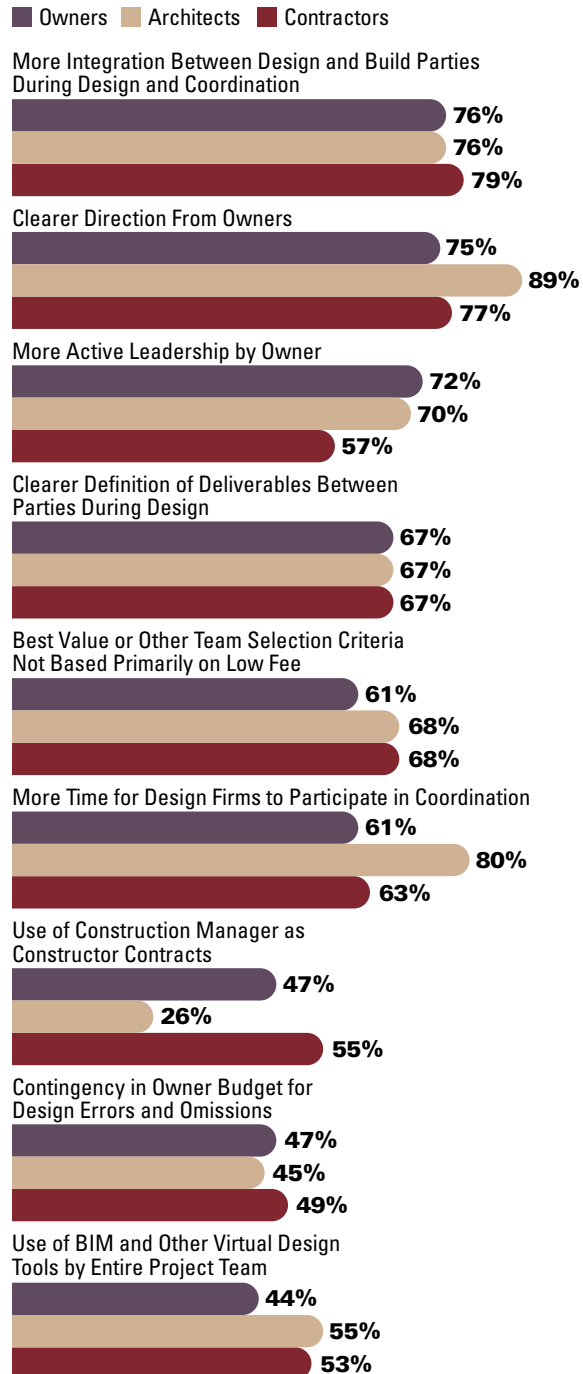
Integration and Collaboration:

Three of the top five factors highlight support for better collaboration among all parties, a theme that appears repeatedly in this research.

- **More integration between design and build parties during design and construction is deemed impactful by over three quarters (77%) of all respondents.** Especially appreciative are the large contractors (91%), probably because of their experience with benefits of greater integration on their relatively large and complex projects. To that point, significantly more of the respondents who do mostly complex projects (83%)

Top Factors That Reduce Project Uncertainty

Source: McGraw-Hill Construction, 2014



Opportunities for Performance Improvement

Effectiveness of Specific Factors on Reducing Overall Project Uncertainty

CONTINUED

identified this factor as very important than those doing mostly simple projects (67%). This is also reflected among owners, where many more from the education (82%) and healthcare (77%) sectors cite it than office project owners (62%).

- **More time for design firms to participate in coordination garners high votes from two thirds (66%) of all respondents.** It is particularly supported by architects (80%), and also by the large contractors (74%), reinforcing the value of tighter designer/builder collaboration as an effective risk reduction strategy. Three quarters (75%) of BIM users weigh in with high support for this, versus just over half (57%) of non-users, reflecting its valuable role in coordination. And among owners, the strongest support is shown by the large organizations (65%) and those in healthcare, where the benefit of coordination proves especially valuable.
- **Clearer definition of deliverables between parties during the design process is cited by identical percentages (67%) of architects, contractors and owners,** identifying it as a high priority initiative for the industry with unanimous support. Owners in the healthcare sector (74%) and the larger contractors (73%) show above-average enthusiasm. Interestingly, three quarters (74%) of owners with small (less than \$50 million annually) building programs cite this, versus fewer (62%) of the largest owners (greater than \$100 million annually), perhaps indicating a greater perceived need for structured project processes in that portion of the market.

Team Formation and Project Delivery Approach/Strategy

Five of the cited factors relate to how teams are formed and what approaches and strategies they use for managing the delivery process. For more detailed information on the use and perceived value of many of the delivery systems mentioned below, see the 2014 *Project Delivery Systems SmartMarket Report*.

- **64% of respondents believe Best Value or other team selection criteria not based primarily on low fee can have a major impact on reducing uncertainty as the project moves forward.** Owners, who might be thought to be most resistant to alternative team formation approaches, are only slightly less enthusiastic (61%). More of the large contractors (74%) cite this approach than the smaller ones (59%), likely indicating a preference to be evaluated for their resources and experience, and to be paid fairly for it. Interestingly,

that proportion is reversed among architects, where more small firms (71%) favor this as an important factor than the large firms (60%), perhaps reflecting that more fee-based bidding activity typically occurs among those smaller firms.

- **Use of construction manager (CM) as contractor is favored by almost half (44%) of all respondents. Over half (54%) of healthcare owners cite it, as do 55% of the contractors, especially the larger ones (61%) who are more likely to understand its value.**
- **Although the use of integrated project delivery (IPD) contracts is an emerging trend still in its early stages, over a third (37%) rate it highly, with contractors (41%) leading—and even more notably, large contractors (45%). Similarly, large architects (50%) greatly outnumber small ones (23%) and many more healthcare owners (46%) identify it as a top contributor than office owners (25%), probably reflecting the difference in actual IPD experience between the two groups.** This statistic will be interesting to watch in future research as IPD use evolves and more completed project metrics are made public.
- **The use of design-build contracts, while only cited by about a third (31%) of the total population, receives high marks from contractors (42%),** perhaps reflecting greater experience with its benefits than architects and owners. This finding is also consistent with the results of the 2014 *Project Delivery Systems SmartMarket Report*, which showed that contractors favor design-build over other delivery systems to achieve most project benefits. Project complexity also impacts preferences for design-build, with 44% of healthcare owners indicating their belief that it is a valuable contributor to reducing uncertainty versus just 25% of the respondents who rarely do complex work.
- **Use of lean design and construction principles, though only scoring high among a quarter (26%) of all respondents, received top ratings from a larger percentage of contractors (33%)—especially the larger ones (40%),** again likely due to their more extensive experience with the considerable benefits of lean. The 2013 *Lean Construction SmartMarket Report* revealed that a high percentage of the industry are still unfamiliar with lean practices, suggesting that as familiarity with this approach grows, it may be more widely recognized for its impact on reducing project uncertainty. See page 58 for more information from lean practitioners on the benefits they have experienced from its use.

Opportunities for Performance Improvement

Effectiveness of Specific Factors on Reducing Overall Project Uncertainty

CONTINUED

Use of Building Information Modeling (BIM)

Two of the factors reported by the survey respondents identify the influence of BIM on reducing uncertainty.

- **Half (50%) of all the respondents believe the use of BIM and other virtual design tools by the entire project team significantly reduces uncertainty.** As a sign of its positive reputation even among non-users, a third (32%) of the respondents who are not currently using BIM still give it a high rating. Owners overall are slightly less convinced (44%), although size matters because over half (51%) of the large owners (those spending more than \$100 million on projects annually) cite this factor. Also, large contractors show above-average support (62%). These findings reflect the fact that currently, BIM tends to be used by larger companies on larger projects.
- **Overall, fewer (32%) see the use of BIM and other virtual tools by a single firm as highly important.** Interestingly, while over half (55%) of large architects do feel BIM by a single firm is important, only a quarter (24%) of contractors agree, perhaps acknowledging the growing, successful use of BIM by GCs and multiple

trade contractors in an integrated approach on projects and a sense that just one firm modeling does not provide the same degree of benefit.

McGraw Hill Construction has conducted extensive research on the business value of BIM in the U.S. and beyond that demonstrates the advantages BIM provides in reducing uncertainty. The findings are published in a series of *SmartMarket Reports*, including the *Business Value of BIM in North America SmartMarket Report* and the *Business Value of BIM for Construction in Global Markets SmartMarket Report*. For more information on those findings, see page 49.

Importance of Budget Contingency

Almost half (47%) of all respondents identify contingency in the owner budget to accommodate design errors and omissions as being important to reducing uncertainty.

The results show very little variation between owners, architects and contractors, providing a high degree of alignment on this issue. For more information on contingencies used by owners, see page 52.

Mitigating the Seven Top Factors That Cause Uncertainty

Seven key causes of uncertainty were studied in the Understanding Uncertainty section of this report. (See pages 11 to 24.) To examine mitigation potential from another angle, respondents were asked to rate the relative effectiveness of 13 specific factors on those top causes of uncertainty.

The Mitigation Matrix on page 45 summarizes these findings. The matrix is organized, left to right, by primary responsibility for the causes:

- Owner-Related Issues (Owner-Driven Changes and Accelerated Schedule)
- Design Team-Related Issues (Design Errors and Design Omissions)
- Contractor-Related Issues (Construction Coordination and Contractor-Caused Delays)
- Unforeseen Conditions, for which no specific party is primarily responsible

The number scores in the matrix are the percentages of all respondents that rated a particular factor as having either high or very high mitigating impact on each specific cause of uncertainty. Color coding indicates six tiers of perceived effectiveness ranging from red (scores above 80%) to purple (scores below 40%).

Top Five Strategies for Mitigating Risks

BETTER COMMUNICATION AMONG ALL PROJECT TEAM MEMBERS

Better communication among all project team members in early stages of the project is clearly identified as the most impactful factor versus every one of the top causes of uncertainty. This underscores the main objective of this research, which is to encourage an informed and open dialogue as early as possible in a project. Such an

Opportunities for Performance Improvement

Mitigating the Seven Top Factors That Cause Uncertainty CONTINUED

approach allows a team to acknowledge and manage uncertainty and its impacts, rather than relying on contracting strategies that avoid and transfer risk, and operating under the prevailing patterns of misaligned and often unrealistic performance expectations.

GREATER LEADERSHIP OR INVOLVEMENT BY OWNER IN ALL STAGES OF DESIGN AND CONSTRUCTION

Greater leadership or involvement by owner in all stages of design and construction follows as the second-most important factor for all respondents. This is especially true regarding accelerated schedule (83%) and owner-driven changes (81%), which is not surprising since these causes are so closely related to owners.

Interesting variances occur between the scores of the three parties for this factor.

- **Owners' scores are consistent with architects and contractors on the topic of owner-driven changes.**
- **However, owners have noticeably less regard for the impact of accelerated schedule (70%) than contractors (90%) and architects (88%).**

This difference in perspective may stem from owners' belief that in most cases an accelerated schedule is identified early in the process and is the responsibility of the design and build team to plan for and execute against, requiring no special level of owner involvement. By contrast, owner-driven program or design changes are often surprises to the rest of the project team, and they

Impact of Strategies on Mitigating the Seven Top Causes of Project Uncertainty (According to Owners, Architects and Contractors)

Source: McGraw Hill Construction, 2014

■ Scores Above 80 ■ Scores 70 to 79 ■ Scores 60 to 69 ■ Scores 50 to 59 ■ Scores 40 to 49 ■ Scores Below 40

	Owner-Driven Changes	Accelerated Schedule	Design Errors	Design Omissions	Construction Coordination Issues	Contractor-Caused Delays	Unforeseen Conditions	AVERAGE
Better Communication Among All Project Team Members in Early Stages of the Project	88	96	94	88	93	79	79	88
Greater Leadership or Involvement by Owner in All Stages of Design and Construction	81	83	78	71	59	53	73	71
Use of Team-Based Alternative to Design-Bid-Build	64	70	75	71	72	49	65	67
Appropriate Contingency Dedicated to This Issue by Owner	79	70	73	48	54	57	79	66
Use of BIM	53	64	76	69	76	47	55	63
Shared Liability Across the Project Team for Problems Created by This Factor	48	59	71	62	63	53	58	59
Use of Lean Design and Construction Practices	28	48	32	31	39	32	28	34

Opportunities for Performance Improvement

Mitigating the Seven Top Factors That Cause Uncertainty

CONTINUED

therefore merit closer involvement by and leadership from the owner to manage with the least disruption.

USE OF TEAM-BASED ALTERNATIVES TO DESIGN-BID-BUILD

Ranking third overall, the use of a team-based alternative to design-bid-build is viewed as most impactful related to design errors (75%). This probably stems from the sometimes adversarial culture of a design-bid-build project, where design errors are often sources of great contention. Unfortunately, fewer owners (62%) rate it highly, which points to a need to help owners understand the potential benefits of team-based alternatives.

HAVING AN APPROPRIATE CONTINGENCY DEDICATED TO SPECIFIC ISSUES

Having an appropriate contingency dedicated by the owner to the specific issue in question ranks fourth overall and is seen as especially relevant to these four issues:

- **Owner-driven changes (79%) not surprisingly garners a top rating from more architects (83%) than owners (74%),** highlighting the need to discuss in advance how these will be managed (re: professional time as well as construction budget) when they occur.
- **Unforeseen conditions (79%) shows a similar diversity of perspective between contractors (96%) and owners (76%),** understandable because contractors have to directly contend with the cost impact on a project. The average is pulled down by architects (67%), who are typically least directly affected.
- **Design errors (73%) earns consistent ratings across all three parties,** indicating a general consensus on its importance.
- **Accelerated schedule (70%) is again led by contractors (79%) over owners (65%),** reinforcing owners' relative reluctance to implement extraordinary measures related to it.

USE OF BIM

Use of BIM ranks fifth overall and is most closely aligned with design errors (76%) and construction coordination issues (76%), two areas where a model-based process is particularly effective.

It scores lowest (47%) with contractor-caused delays, which may be because many of these kinds of delays are typically not directly related to the design, so models are not perceived as being effective for mitigation. This may change as more trade contractors, fabricators

and suppliers engage in integrated, model-based construction processes.

For more information on the value of BIM in reducing project uncertainty, see page 49.

Additional Strategies for Mitigating Risk

SHARED LIABILITY ACROSS THE PROJECT TEAM

In sixth place overall, shared liability across the project team for problems created by this factor scores high with less than six in 10 overall (59%), but it is rated relatively well for design errors (71%), especially among owners (78%).

Although this finding could be interpreted as a desire by owners to avoid and transfer risk and liability to other members of the project team, it can also be seen as an opportunity to engage with owners in a constructive dialogue related to alternative team structures such as integrated project delivery, where liability and reward are shared among participants in a collaborative environment.

USE OF LEAN DESIGN AND CONSTRUCTION PRACTICES

Half (48%) of the respondents identify the use of lean design and construction practices as an effective mitigating factor for uncertainty caused by an accelerated schedule. This makes sense because of the powerful schedule-oriented elements of lean (e.g., pull planning, etc.), and its focus on all parties making and keeping commitments in an open and integrated process.

Compared with all the factors, the relatively low scores returned for lean likely reflect unfamiliarity rather than informed negative judgment. This is supported by the findings published in the McGraw Hill Construction *Lean Construction SmartMarket Report*, which quantifies the low general awareness level in spite of the outstanding benefits.

For more information about how lean construction practices mitigate uncertainty on projects, see page 58.

Owner Insights on Mitigating Uncertainty Data Findings

Owner Leadership-Related Factors

Most of the Owner Advisory Group (OAG, see page 60 for more information) agrees that their role is critically important to mitigating uncertainty.

- **John Moebes, Crate & Barrel**, states it clearly: “An informed and active owner solves a lot of problems in the project. You can have really great contractors, sub-trades, architects and engineers, but if the owner isn’t driving that project well and responsibly, they’ll be hamstrung.” He also wishes “more architects would become owners because I think they’re some of the best trained people to be owners and lead construction.”
- **Craig Russell, Disney**, makes the important point that because they “pick the team and decide on the strategy for the project, owners have ultimate responsibility for the outcome of the project.”
- **Don Vitek, Whirlpool**, is committed to early and consistent owner involvement. “I encourage teams to share issues or questions with me early. Don’t try to prepare everything to the utmost degree before our first review. Show me design iterations, or get into some of the construction details so that I truly understand the dynamics. Otherwise there’s a lot of churn that is not value add at all.”
- **Chuck Hardy, GSA**, is also “a hundred percent behind the need to get better at our planning and our direction, so what we’re giving people is clear.” But he also highlights the importance of experienced contractors and architects to support the owner,

“An informed and active owner solves a lot of problems in the project.”

by “getting people who have lived through and dealt with some of these issues out there solving problems, and not just pointing out problems” for the owner to solve.

- **Boyd Black, University of Chicago**, agrees, saying, “We don’t always have the expertise to ask all the right questions to make sure we have a really solid basis of design or owner project requirements document.” He feels that this is a great leadership opportunity for design teams to help owners be more successfully engaged.

Integration-Related Factors

Moebes, Crate & Barrel, observes that “there’s still resistance [to integration] because people are afraid of scope shift or liability shift. And for architects, there’s a lot more you have to know on an integrated team. But when I look at some of the architects that we work with now and the sheer amount of means and methods that they know and they’re not afraid to talk about, it’s staggering compared with what it was 10 years ago. I think we need a message to younger architects coming into the industry now about integration, and what they could and should do as they start and advance their careers that would make integration better and more achievable.”

Craig Russell, Disney, believes “co-participation provides the logical opportunity to reduce duplicative work” between the design and construction team members. “The

contractor defines the final outcome through shop drawings and the work installed in the field, and the designer can’t read the contractor’s mind regarding exact means and methods that will be employed to achieve the design intent.” He favors an integrated approach whereby teams assign responsibilities to the parties best-suited for them in advance. This avoids uncertainties caused by duplicative efforts and “definitely reduces field changes.”

One of the leading proponents of integrated project delivery (IPD) in the U.S., **Eric Miller, Sutter Health**, recalls, “We went into integrated project delivery to be able to predict cost and predict how long it was going to take.”

However, through that process Miller came to realize that designers and builders have typically “never really looked at each other’s work, ever. Now as we watch the groups work together and do the conflict resolution, they’re all getting smarter. They’re all starting to realize that even though their job is tough, there are other jobs out there that might be just as tough. They’re starting to be a little more respectful.” But there are drawbacks as well. “Any time you bring multiple people together, it takes more time. When you get 10 people in a room, time is spent on things that aren’t always productive.” He also finds “gaps ... occurring as we start sharing responsibility. When everyone shares responsibility, no one’s really responsible. So you have to watch that.”

Owners shared other ways they achieve the benefits of an integrated approach.

- **Jerry Lea, Hines**, says, “We can’t do real IPD. But by bringing contractors in to review the design drawings for feedback, I’m trying to get that benefit without the IPD contract.”
- During design development **Black, University of Chicago**, sends RFPs to select key trades to be design assist partners. “But we don’t find all trade contractors are up to the challenge yet.” He also integrates the AEC team with facility operations about things like potential shutdowns, to engage their practical expertise in the project.

Hardy, GSA, believes the results of this research show that “we need to continue to push what I was going to call ‘the conversation’ [about greater integration], but in fact, we need to stop the conversation and begin the action. I think it was George Patton who called it the ‘Ready, aim-aim-aim mentality.’ We need to actually do something about this.”

Team Formation and Project Execution-Related Factors

Miller, Sutter Health, says, “Unfortunately, the traditional delivery method sets everybody up to spend an inordinate amount of energy watching how much it costs to install what you said you could install. It’s focused on piecemeal. And breaking that mindset is extremely difficult.” To shift that paradigm, he does a lot of GMP (guaranteed maximum price) projects as well as IPD. “What I’m finding is that the contract has less

“What I’m finding is that the contract has less to do with it than the attitude of my staff.”

to do with it than the attitude of my staff. Now that my PMs have had a taste of integrating, being involved and working together as a team, the contract is less important. They know the benefit of getting parties together early so they’re doing it on every contract because the predictable outcome is improving.”

Hardy, GSA, agrees that personnel are a critical element to project delivery strategy. “With limited resources, we have to do better at tying team selection to project delivery selection, because everybody isn’t skilled in the same sets. It’s a lot easier to change the delivery method you choose than to suddenly make [different] people appear. You’re dealing with the staff you have, so play to their game. At the end of the day, it’s the personnel who are going to deliver and drive the best solution.”

Alternative approaches are gaining support among some of the owners:

- **Craig Russell, Disney**, has successfully garnered internal support for IPD, often a difficult hurdle. “Happily, we have some extraordinarily enlightened contracts people who see the significant promise to our sustained practice [being] much better off [by] going that way.”
- **Vitek, Whirlpool**, addresses uncertainty by doing a lot of design-build, noting, “the primary reason for that is to have the responsibility in one place versus two and tying it together contractually.”

- **Black, University of Chicago**, has recently started using term agreements with architects, engineers and contractors who “get the idea of working collaboratively together” for small projects on tight budgets and time frames. “We meet with our client together. Then we tell the team, ‘Here’s the budget and schedule. Work together and get it done.’ The projects that we implemented it on so far are going better than anticipated.”

- Lean construction is also gaining traction. **Russell, Disney**, is influenced by the ride systems vendors on his projects. “They are manufacturing thinkers from aerospace and automotive, and have been working in a much more lean way for a long time. Comparing it to building construction sometimes makes me feel like we’re incredibly backward.” **Hardy, GSA**, agrees: “Forward-thinking last planner and lean activities are just not as common in the industry as they should be.”

Moebe, Crate & Barrel, cautions against overreliance on any of these approaches as a cure-all. “I collectively refer to that as ‘whiz bang,’ and whiz bang can’t solve a bad owner or no owner involvement—or if you don’t have good team chemistry. If anything, it can probably make it worse. If we don’t have the right team, good things just won’t happen.”

BIM-Related Factors

All of the OAG members are engaged with BIM. Their comments are included in the sidebar on BIM and Uncertainty on page 49. ■

BIM and Managing Uncertainty

McGraw Hill Construction has tracked the growth of building information modeling (BIM) through the SmartMarket Report series since 2007. Since then, the number of North American companies that have been involved on a BIM project increased from 28% to 73% and is still growing, while almost all companies surveyed globally report increasing their level of BIM implementation once they've started.

Use of BIM to Address Uncertainty

Contractors from 10 different regions were surveyed for the 2014 *Business Value of BIM for Construction in Major Global Markets SmartMarket Report*. Many findings relate to reduced uncertainty.

- **Four out of the top six BIM benefits reported by contractors are related to reducing uncertainty:** (#1) reduced errors and omissions in construction documents; (#2) improved collaboration with owners and design firms; (#4) reduced rework; and (#6) better cost control/predictability.
- **The top three preconstruction BIM activities help reduce uncertainty:** multi-trade coordination, visualization of design intent and modeling for constructibility evaluation.
- **The top three construction phase BIM activities also help address uncertainty:** model-driven layout in the field, model-driven prefabrication and status/progress monitoring.

Uncertainty-reducing benefits also scored well among the owners, architects, engineers and contractors

“If teams are coming [into the project] like-minded around BIM, it definitely helps reduce the overall uncertainty” — Owners Advisory Group.

surveyed for the 2013 *Business Value of BIM in North America SmartMarket Report*.

- **Reduced errors and omissions is the top BIM benefit among all respondents, and reduced rework is named top by contractors.**
- **Fewer claims and litigation grew by 40% as a BIM benefit from 2009 to 2012**

Owner Perspectives

BIM is also demonstrated in this SmartMarket Report to be an important tool for reducing uncertainty on complex projects. 93% of project owners who use BIM on their projects report a high level of satisfaction with project quality, versus non-BIM owners (84%).

In addition, 50% of all respondents to the research in this report believe that BIM reduces overall uncertainty when used by a full project team; and its reputation precedes it because almost one third (32%) of owners not using BIM also agree about its efficacy for reducing uncertainty.

In fact, every owner in the Owner Advisory Group reports that BIM is being used on their projects, and in some cases their internal staff is developing BIM capabilities. Their comments on the effectiveness of BIM to reduce uncertainty include the following.

- **One notes that both the integration enabled by BIM and its growing use by contractors are positive trends.** “We’ve seen really, really good benefit when major subcontractors such as piping and HVAC use

modeling from the primary design team to do their design in BIM as well.” He continues that BIM is “very beneficial not only to get a better coordinated set of drawings, but it’s a great tool for the contractors. I think every contractor we use now, if they don’t get a BIM model, they’re going to do one anyway.”

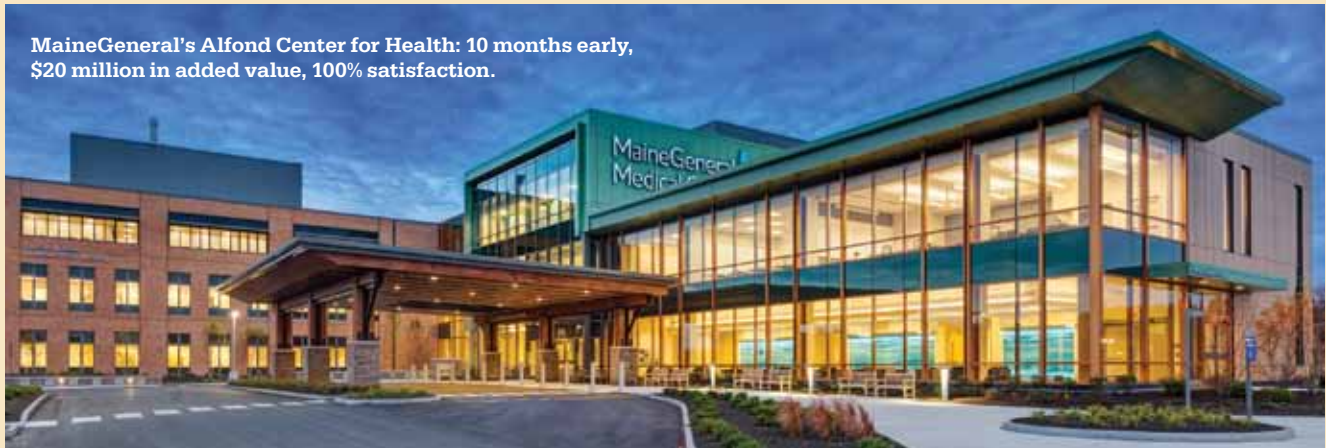
- **Another perceives that “depending on whether you’re an architect, contractor or owner, you’re using BIM for different intentions, and I think we need to get better aligned around the intentional use of BIM”.** But he continues, “I agree wholeheartedly that if teams are coming [into the project] like-minded around BIM, it definitely helps reduce the overall uncertainty”.
- **One owner cautions that “An [inexperienced] owner saying [to an inexperienced team] ‘I want 10 more pounds of BIM on that project’, is not going to help that project.”**
- **Lastly, one owner whose internal staff uses BIM, shares that, “the number of people [using BIM at their company] always locked to their computers now is quite high. You don’t have the same sort of unit cohesion within your team that you really need”.** As a result, he says, “We’re doing a lot more social management to get the BIM people up out of their cubes and talking. [It’s] an interesting sociological problem that we’re trying to manage more effectively.” Asked how, he says, “We’re having more lunches.” ■

Project Culture Fostered by Integrated Project Delivery (IPD) Is Key to Success

MaineGeneral Medical Center's Alford Center for Health

AUGUSTA, MAINE

MaineGeneral's Alford Center for Health: 10 months early, \$20 million in added value, 100% satisfaction.



Ten months ahead of schedule, some \$20 million returned to the project in value-added savings, LEED-HC target exceeded by a full level, over 90% in-state workforce, and 100% owner satisfaction across a list of measurable items: by any standard, MaineGeneral Health's newly completed Alford Center for Health got a lot right.

Owner, architects and construction manager unanimously attribute the project's success to a delivery process that generated a culture and a set of strategies for establishing expectations, holding to them and managing uncertainties that could have otherwise undermined them.

Cultivating a Culture

"The biggest project of my life, and I'm going to do it a different way than I've ever done a project before? I must be crazy!" Chuck Hays, CEO at MaineGeneral Health, remembers saying to himself when he committed to an integrated project delivery (IPD) process. "But it was the best thing I've ever done. I'd do it again in a heartbeat."

Under the IPD contract, team

members waived their right to sue one another. They put into place an umbrella insurance program that covered everything and everyone, and rolled the insurance premiums into the project costs. The insurance structure generated, in effect, a firm aligned to the project good.

"It's an inspiring way to work," says Ellen Belknap, president of SMRT, architects to the project with TRO Jung|Brannen. "It allowed us to take our armor off. When you're not protecting your turf, you release the energy spent finding fault, and you just solve the problem."

Co-location in a Big Room environment throughout design and construction completed the integration of the project team and incubated the advantages of the IPD process.

Expectations for Project Quality

As a road map for the project, the IPD documents articulated a set of conditions of satisfaction, such as bringing the project in under budget and adding value to the outcome; maximizing the employment of local labor and local subcontractors;

achieving LEED Silver certification or better; using evidence-based design, standardization in prototypical rooms and products, and LEAN process improvement techniques; and completing the project on schedule. The team identified five priorities or "lenses" for decision-making in pursuit of these objectives: patients and families, physicians, staff, safety and cost.

"It wasn't something you wrote down and walked away from," says Steve Evers, principal at TRO Jung|Brannen. Every meeting started with a reiteration of the project mission and guiding principles, and the priority lenses were applied to every decision.

Throughout the project, an iterative process of communication and consultation with stakeholders kept quality and expectations on track. The team engaged interdisciplinary user groups in lean processes to maximize spatial and procedural efficiencies, for example, and generated BIM models, cardboard mock-ups and full-scale mock-ups of key project components for user groups to approve.

MaineGeneral Medical Center's Alford Center for Health

AUGUSTA, MAINE

Schedule

In construction manager Robins & Morton's near-70-year history, which includes over 1,200 healthcare projects in the last 10 years alone, the Alford Center for Health's construction finish rate of 25,600 square feet per month stands as the firm's record. The team completed the entire design and construction process 10 months ahead of schedule, saving the owner some \$1 million in financing costs per month. Key to this achievement were lean methodologies, prefabrication and the IPD process.

Among its suite of lean methodologies, the team used pull planning to develop the project schedule. Evers describes this approach as "a constant pull of information following the sequence of activity on the site." Production of drawings was structured around three sets: footprint, core-shell and floor plan. Once issued, each set was considered locked, so that construction could proceed while the remainder of the project continued in design. Issuing architectural drawings ahead of engineering inevitably entailed what Evers calls "pain points," which the team managed by staying staffed up through construction to coordinate as issues arose.

Early involvement of subcontractors boosted the drawing schedule, saving time on design development by allowing project details to be generated as shop drawings. Subs also collaborated in developing the construction schedule, so that it represented what the trades themselves had said they could do. Daily stand-up meetings onsite facilitated coordination

and workflow, and weekly work plans signaled any aspect of the project that was veering off track, so team members could address impediments promptly.

Standardizing more than 250 headwalls and 170 inpatient bathrooms also enabled them to take advantage of prefabrication which sped up the work and helped level the workforce curve. In particular, prefabrication of 52,382 square feet of exterior wall helped meet an aggressive schedule to get the building closed in before Maine's winter set in.

To speed decision-making across the project, the project implementation team had full authority to implement any decision with which they all agreed. Only controversial decisions were referred to the senior management team. "Decisions could be made onsite," says Hays. To retain ultimate control of the project, the owner held a right of veto over any decision; but with that came the understanding that a veto would open up discussion on schedule and cost.

Cost

The IPD structure motivated all parties to control project costs. "A lot of our fee was at stake," says Robert Gambrell, senior vice president at Robins & Morton. "It drives people to help solve a problem—not out of greed, but out of pride, because your partners expect you to perform."

The subcontractors' presence at the co-location site gave the team a strong handle on costs, and allowed a process of Target Value Design, as opposed to after-the-fact value engineering. Every two weeks the team downloaded design changes,

Project Facts and Figures

Owner

MaineGeneral Medical Center

Architect

TRO Jung|Brannen and SMRT

Construction Manager

Robins & Morton

General Contractor

HP Cummings

Size

640,000 square feet

Construction Start

August 2011

Construction Completion

August 2013

Cost

■ Project: \$312,000,000

■ Construction: \$224,000,000

LEED Certification

anticipating LEED-HC Gold

Results

■ Financing Costs Saved:
\$10,000,000

■ Value Added Savings:
\$20,000,000

■ Schedule: Completed 10
months early

■ In-state Labor Force: 91%

updated estimates and worked out solutions to maximize value within budget. The concept of a change order became irrelevant, and the contingency pool went unspent.

As a result of the integrated process, the design and construction of the Alford Center for Health became, says Belknap, "not so much managing uncertainty, as maximizing opportunity." ■

Contingencies as a Means of Mitigating Uncertainty

The topic of budget contingencies as a potential mitigating factor for many of the aspects of uncertainty appears frequently throughout the research.

To baseline the current practices related to contingencies, owners were asked:

- How frequently they have contingencies
- How frequently they share information about contingencies with the project team
- If they employ a standard risk management process to establish contingencies
- How frequently portions of contingencies are allocated to separate project risks

To contrast with those responses, architects and contractors were asked how often they establish contingencies and how frequently they are aware of owners' contingencies.

Percentage of Projects With Contingencies

As can be seen in the chart at right, there are differing perspectives on the share of projects that carry contingencies.

OWNERS

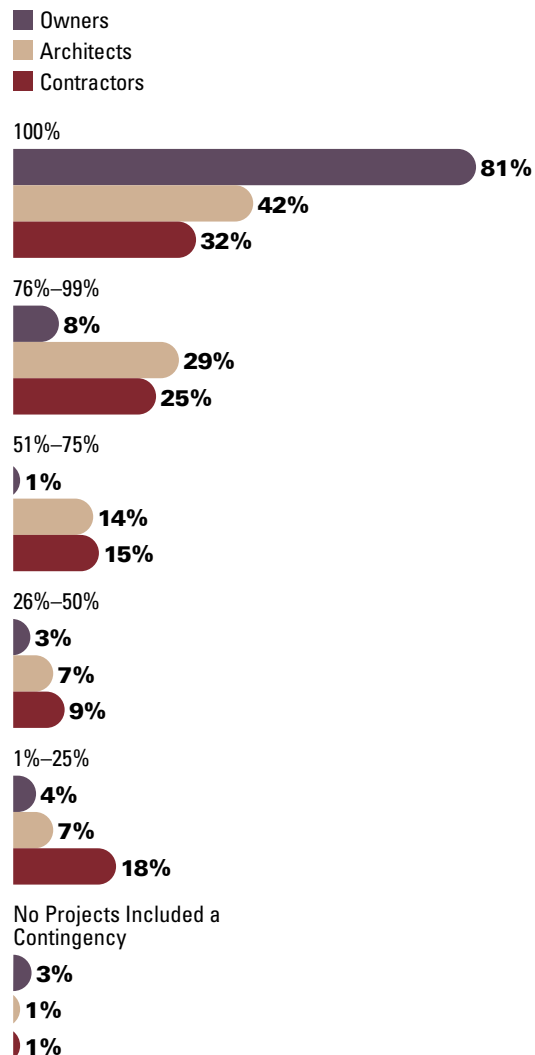
- On average, almost all owners (97%) have contingencies on at least some portion of their projects.
- Most owners (81%) have contingencies on every one of their projects.

ARCHITECTS AND CONTRACTORS

- Nearly all architects and contractors (99%) report at least some portion of the projects they work on carry a contingency.
- Far fewer architects and contractors have them on all their projects. For architects, only 42% report that all their projects carry contingencies; 32% of contractors report the same.

Percentage of Projects That Included a Contingency Conducted in the Last Five Years (By Player)

Source: McGraw Hill Construction, 2014



Opportunities for Performance Improvement

Contingencies as a Means of Mitigating Uncertainty CONTINUED

Owner Communication With Teams About Contingencies

As can be seen in the chart at right, the existence of contingencies is often held confidential by owners, which may explain the disparities in the frequency with which firms report that their projects have contingencies (see page 52).

- 51% of owners always tell their architect, but only 37% always tell their general contractor.
- On the opposite end of the scale, 25% of owners say they never tell their architect, and 37% say they never tell their contractor.
- On average, owners share contingency information with their architects a little over half the time (58%) and with their contractors 43% of the time.

Allocation of Contingencies

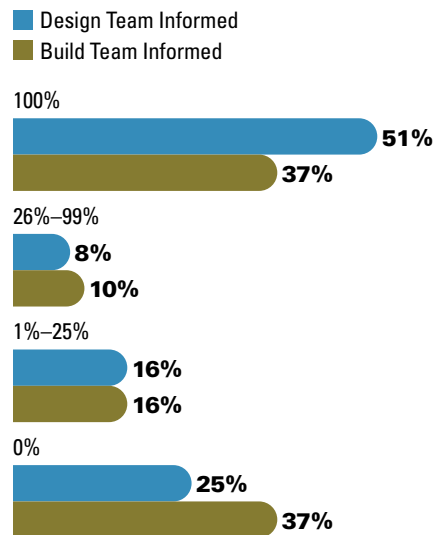
The processes for establishing and managing contingencies vary significantly for owners—24% have a standard risk assessment process to determine a level of contingency for a particular project, and only 37% allocate a contingency into separate project risks.

As can be seen in the chart below, among those who allocate for separate project risks, unforeseen site or construction issues typically receives, on average, the largest allocation (30%), with owner/scope changes (20%) and design issues (20%) trailing.

The findings about contingencies offer an important opportunity to bring a great deal more structure and process to contingency setting and management in a constructively collaborative environment.

Percentage of Projects on Which Owners Inform Design Team or Build Team About Contingencies (According to Owners)

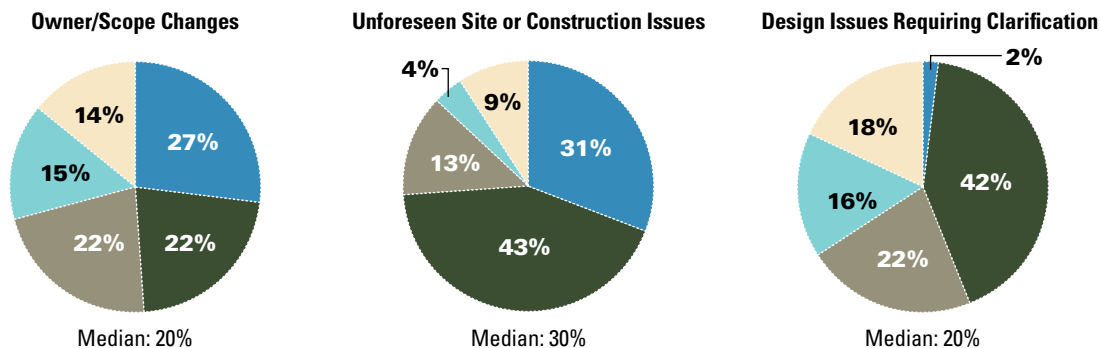
Source: McGraw Hill Construction, 2014



Allocation of Contingencies by Owners (According to Owners Who Allocate Contingencies Into Separate Risks)

Source: McGraw Hill Construction, 2014

■ More Than 40% ■ 21%–40% ■ 11%–20% ■ 6%–10% ■ 5% or Less



Owner Insights on Mitigating Uncertainty Data Findings

Contingencies

All of the Owner Advisory Group (OAG, see page 60 for more information) members use contingencies.

- **Don Vitek, Whirlpool**, always carries “a project contingency outside of what the contractor or design builder has.”
- **John Moebes, Crate & Barrel**, relies on contingencies for “the unforeseen condition in the field, or what we call ‘the aberrant inspector’ who throws something at you that is not even in the code and causes a cost issue.”
- **Chuck Hardy, GSA**, adds that “from an inside-the-owner’s view, a contingency is seen as [part of] the project cost. If they manage the project within that cost, it’s a success. So they’ll track that like it’s the last glass of water they have in the desert.”

Telling the Project Team About a Contingency

Although they have contingencies, most say they do not share details about them with project teams. **Boyd Black, University of Chicago**, sums it up when he says, “I found it to be a constant fight with the design team why I’m not letting them use that money.” **Hardy, GSA**, agrees: “It’s like saying you have a couple weeks to float on the schedule. Those couple weeks will get filled.”

Moebes, Crate & Barrel, takes a radically different approach by sharing his entire project budget, including contingency numbers with the design team, general contractor and main sub-trades. “We only started doing this two years ago. It’s kind of a twist on IPD [integrated project delivery]. There’s not a

“From an inside-the owner’s view, a contingency is seen as [part of] the project cost. If they manage the project within that cost, it’s a success. So they’ll track that like it’s the last glass of water they have in the desert.”

three-party contract with shared savings on risk and reward, but we’re showing everybody exactly what our number is and how that number is moving. So if there’s an error or omission, or unbought scope or something, we’re showing everyone how that’s affecting our number and how it’s coming out of our overall project contingency.”

He says this creates an interesting shift in attitude. “The first time we showed them exactly how much money we had in the pro forma budget to do a store and made it clear we can’t exceed that, I thought they would like that level of transparency. But I think it made them all a little bit more nervous because we suddenly made them responsible. Not accountable. We’re accountable. But responsible. When the owner doesn’t reveal that contingency, then everyone’s just blissfully in the dark.”

Eric Miller, Sutter Health, goes even further on his IPD projects. When setting contingencies he “maintains a separate owner’s bucket as well as a shared team bucket.” Starting within guidelines that address project size and complexity, he then works with the team to set the shared contingency “because it’s one bucket of money that they all draw down. If they don’t draw it down, a percentage of it goes back to them, which can increase their profit to a capped level. So I use contingency more as a carrot than a stick.” But he is still learning how to

calibrate this kind of incentive to get the desired results. “If I put that just ahead of them, I can get them to run for it. If I put it too far ahead of them, they’ll ignore it.”

Subcategories of Contingency

Most of the OAG members do not subdivide the contingency into separate categories of risk.

Moebes, Crate & Barrel, says, “We’ve tried to, but then you end up just moving the money around.”

Jerry Lea, Hines, however, always carries a contingency specifically for non-negligent design issues. “We take 3% of the construction contract amount and give that to our [internal staff] construction managers in the field to manage the normal errors and omissions type change orders that occur on any job.” He expects them not to use it all, though. “We’ve been tracking this for the last few years, and the actual is less than two, but to make sure we have enough, we typically carry three. Of course if it is an unusual project, a big renovation or something, then that metric will change.”

When Hines acts as a development manager for a third-party client, there is often an educational process required regarding design contingencies. “They don’t understand that if you try to make an errors and omission claim against an architect for something that isn’t negligence, you’re wasting

your time. Unless they are truly negligent in the standard of care in the industry, you're going to have to pay for whatever that thing is. We're doing a project right now where I am struggling to get them to understand that minor coordination is just a fact of life and they're going to have to pay for it. Some owners just don't understand the business well enough to get that they need a contingency."

He also carries a separate construction contingency "for the risk of being a general contractor, and being responsible for all the subs and delivering the project on time. I explain that it is not the risk for errors and omissions in my drawings because I have my own contingency to deal with that." But he uses market pressure to keep their pencils sharp. "When the contractor bids to us, I tell him, 'If you need a contingency, include it in your price and tell me what it is.' And he's in competition, so he's got to think about how much contingency to add that won't cost him the job."

Recently he has developed a way to have contractors also take on the risk of errors and omissions in the drawings, without an IPD contract. "Anytime you can create an alignment of interest, then you're more likely to succeed. So, for any issues that aren't a legitimate scope change, instead of contractors just passing through the subs' claims for additional cost, I say, 'I'm going to give you a separate 2% contingency to cover those kinds of costs. And at the end of the job, whatever isn't spent, I'll split with you, 50/50.' Now, they are negotiating the hell out of those subcontractor change order claims. Because every dollar that they push back on the sub, they get

"Some owners just don't understand the business well enough to get that they need a contingency."

50 cents of. So, on those jobs our change orders are less than 1%." He began this process in Houston, but it has now spread nationally. "I've got contractors around the country who have heard about this, and they're saying, 'Cut me in on some of that.' And every time we've done it, we spend less than half of the [3% budgeted] contingency, and the general contractor has gotten a nice fee increase. We started out at 2.5%, and today we're tracking between 1% and 1.5%. So if I can take the 3% that's in my budget, and off-load that risk to the contractor for 1% to 1.5%, I've done a pretty good job."

Standard Process to Establish Contingency

The Owner Advisory Group varies in how they establish contingencies.

- **Craig Russell, Disney**, says his contingencies are totally project-specific. "Our projects aren't the most technically complicated things in the world, but they're very complex from the standpoint of the number of moving parts and disciplines and details. We'd love to say [our process of establishing contingencies] is scientific, but it ends up being a wonderful blend of science and art."
- **Chuck Hardy, GSA**, on the other hand, says, "GSA has a standard with set numbers for new construction and renovation."
- **Eric Miller, Sutter Health**, developed a Risk Register, which

is a simple matrix of uncertainty factors that might cause problems and estimates of their cost impacts. He assigns a probability to each one based on the specifics of the particular project, then calculates a risk score. He uses the risk score to determine the right contingency for each project.

- **Boyd Black, University of Chicago**, creates a customized contingency management plan when the budget is developed that reduces by phase through design, and again through the riskiest parts of construction.
- **John Moebe, Crate & Barrel**, assigns a contingency quickly "for the sort of project we've built 20 or 30 times" and then adjusts it for special conditions. "With a seasoned team, I might reduce it a little bit, or dial it up for a new team member, an unusual design or a location with high seismic [activity] or aberrant inspectors." ■

Utilizing Design-Build-Bid to Minimize Uncertainty

Crate & Barrel

UNITED STATES

In 2008, Crate & Barrel deployed a new method for delivering retail projects at locations throughout the United States. Dubbed “design-build-bid,” the process utilizes multiple-prime contracting between the owner and key specialty contractors with an integrated approach early in the design process. That phase is followed by a traditional design-bid-build method, where a general contractor is hired under a stipulated sum contract for the remaining portions of the work.

In bypassing the traditional hierarchical relationships among design teams and construction teams, John Moebes, director of construction for Crate & Barrel, says the company has realized significant savings on budget and schedules, while reducing many of the uncertainties on projects.

“We looked at the design-bid-build process and said, ‘We think there are certain elements of our buildings we could improve on if we rejigger that process,’” he adds.

Although Crate & Barrel has a recognizable brand and look, each of its stores is unique. Although common elements are used, there is no prototype design for entire stores. In the past, the company used traditional contracting between it and an architect as well as a construction manager. Moebes said the company wanted to embrace an integrated project delivery (IPD) ethic, but without the three-party contracts used on many IPD projects. Instead, Crate & Barrel targeted specialty contractors that could have a direct impact on a project’s critical path.

One of the first opportunities pursued was structural steel. “In the traditional approach, the owner

works with an architect and comes up with a structure from the design side and engineering side,” he says. “You wait until that process ends, then you start a new process with the general contractor and the steel fabricator. They are taking part of your time and money to deliver that to you.”

In-House Design Process

Early in the process, Crate & Barrel prepares a schematic design model in-house to show design intent and obtain internal approvals of the overall concept. Concurrently, the structural engineer is released to begin reviewing the schematic design model and establishing a preliminary foundation, upper-level and roof-framing plan, including brace frame locations.

From there, other key disciplines can be involved, modeling MEP,



Rendering of a new Crate & Barrel store in Sarasota, Florida, scheduled to open Fall 2014.

Crate & Barrel

UNITED STATES

exterior skin and other critical components. The teams work together in BIM to help with coordination and visualization. Create & Barrel reports that failure of spatial visualization on its part is the root cause of the majority of the owner change orders on previous non-BIM projects. This process allows owner stakeholders to approve proposed concepts with confidence and avoid adjustments in the field during construction.

From there, the project architect can assume full control of the owner's model to develop higher levels of detail.

Although Crate & Barrel has early and direct engagement with key engineers, the company expects those engineers to have an ongoing relationship with fabricators. Moebes says this presented an initial challenge because most structural engineers aren't used to this process. "We kept hearing contractors tell us that the structural system [designed by the engineer] wasn't particularly practical and they would have to spend extra time on it," he says. "Since engineers aren't [typically] partnered with fabricators, they don't know much about what makes a steel structure expensive."

This process allowed the structural team to have early discussions and come up with best-value propositions on dozens of aspects of Crate & Barrel projects. "They did it in a way that gave best value to us and gave them better profitability," he says. "It was about finding the most efficient options for all parties."

Since then, Moebes says Crate & Barrel has seen its average structural steel needs on projects drop from around 200 tons each to around 150

tons. Crate & Barrel claims that its structural steel costs dropped 38% between 2005 and 2009.

Rob Rutherford, president of SteelFab, Charleston, S.C., a steel fabricator that has worked with Crate & Barrel since it began this new process, says he sees a greater "push for innovation" by working directly with Crate & Barrel. "They are outside-the-box thinkers, always trying to think of a better, smarter, faster way to do things," he says. "[Moebs] takes every step in the process and challenges us to streamline something or make it simpler."

Because SteelFab and its engineering partners have worked with Crate & Barrel regularly for more than six years, Rutherford says the team has a relationship that helps reduce uncertainty. "It's amazing how little conversation has to happen sometimes," he says. "When you work consistently together on projects like this, you're always on the same wavelength."

Rutherford says that SteelFab is now regularly part of the early design development process for Crate & Barrel projects. "We're on a project with them now where the steel and HVAC will determine if this project happens or not," he says. "We need to have this building designed, planned and evaluated from a cost standpoint before it becomes a project. What we do is part of making the business case for a project."

One of the most recent advances for Crate & Barrel is to take over shipping of its construction materials. As a retailer, shipping is a core competency for Crate & Barrel, and Moebes says that

including shipping in its process reduces costs and improves reliability. "With our customers, we guarantee the stores get product," he says. "We take every measure possible to make sure product gets to customers on time and in good condition. The construction industry doesn't do that very well. Materials are needlessly damaged or needlessly lost. With steel we took some of our supply chain, logistics knowledge and applied it to shipping structural steel. You might put [materials] in a container and ship it. You might ship via barge or train. That's a retail approach to shipping that saves money." ■

Project Facts
and Figures

Owner

Crate & Barrel

Type of Project

Retail Stores

Budget Benefits

After instituting its design-build-bid delivery method, Crate & Barrel's average costs in 2009 compared to 2005 were:

- Hard Costs: -58%
- Structural Steel: -38%
- Framing and Sheathing: -53%
- Concrete: -56%
- HVAC: -55%
- Plumbing: -59%
- Electrical: -65%
- Fire Protection: -65%
- Finish Carpentry: -71%

Lean Processes to Reduce Uncertainties

By driving waste out of projects, users of lean construction methods aim to reduce project uncertainties. Collaboration and communication through the use of a variety of practices and tools have helped improve predictability, tighten schedules and align expectations.

With the goal of increasing value by driving waste out of projects and improving predictability, lean construction takes dead aim at project uncertainties and expectations. A highly collaborative process, lean seeks input from key team players early and often, using a range of principles and practices.

Collaboration

"In the lean strategy, the earlier you engage a full team, the better situated you are to add value and drive waste out," says Bevan Mace, vice president at Balfour Beatty Construction.

Mace says value stream mapping is a key element of the lean process that addresses the needs of owners while considering the flow of design and construction. "If you're involved early in the business case stage for a project, you are able to determine the critical drivers; not just for construction but for operations," he says. "Design and construction is waste to an owner. They have a business need and want to use the facility, so you minimize that design and construction period."

Bernita Beikmann, principal and director of lean strategy at HKS, says a collaborative strategy that includes early engagement of key team members can reap significant benefits, including reduced errors, more accurate budgets and more predictable scheduling.

"Lean allows you to have the conversations you need to have to overcome constraints," she says. "You can accomplish more from a schedule perspective if you have everyone from the team working together and an owner who has an understanding of when they need to make decisions. That includes [the owner] asking questions about the information that they need to make those decisions."

Beikmann says engagement between the design team and key subcontractors can be particularly effective when trying to drive value. "On a traditional project, you often don't get a chance to talk to the people who are building it—it's forbidden," she says. "If I have a conversation with a drywall contractor on the constructibility of a certain design detail, there's a better chance I can give the owner what they want for a price that the owner can afford, as opposed to us just focusing on the owner's needs and fulfilling that without understanding the complications with building it."

James Barrett, national director of integrated building solutions at Turner Construction, says lean tools, such as the Last Planner system, can significantly reduce uncertainties during construction. In addition to setting milestones and identifying conflicts, the system does regular look-ahead planning and measures percent completion of plan to determine if schedules are slipping and need adjustment.

"With Last Planner, you're trying to drive out uncertainty of outcomes," he says. "The biggest challenge is the uncertainty between trades. As jobs have gotten more complex by nature of the buildings and systems, that uncertainty is the greatest hindrance to achieving schedule. Lean addresses that. Using Last Planner, [percent of plan complete] is a reflection of someone's ability to deliver something when they say they will deliver it."

Results

On a 1.9-million-square-foot retail and warehouse complex in North Texas, Turner created a Punchlist Prevention Program using the Last Planner System to develop critical punchlist milestones and quality tracking metrics. As the team progressed through the various turnovers, they focused on continuous improvement, reducing the number of punchlist items from 7.1 per 1,000 square feet to 3.9 per 1,000 square feet.

Turner has also seen the benefits of applying Target Value Design. The Northeast Georgia Medical Center project team of Turner, HGA and Perry Crabb delivered \$3.6 million in savings at the time of GMP contract finalization by utilizing Target Value Design. Last Planner is also being used on the project, which Turner credits for enabling the team to tighten the schedule and put them on track to deliver the 350,000-square-foot facility two months early. ■

Methodology:

Managing Uncertainty and Expectations Study Research

This study was conducted by McGraw Hill Construction to investigate the levels of uncertainty and related costs experienced on building construction projects in the U.S. More specifically, this research sought to explore the following:

- Causes of uncertainty and their impacts
- Contingencies used to account for uncertainties
- Expectations of team members during the design and construction process
- Mitigation factors that players use to compensate

The research was conducted between April 22nd and May 27th, 2014, using an initial phone module to screen respondents followed by an online survey among those who qualified.

Survey Participants

315 construction professionals across three firm types—155 owners, 82 architects and 78 general contractors—took part in this research. The total sample size has a margin of error of +/-5.5% based on a 95% confidence interval.

The sample list was drawn from McGraw Hill Construction's Dodge Database.

Quota groups were established to achieve target representation by:

- Firm Type: architects, GCs and owners
- Primary Project Type: commercial or institutional
- Owner Project Type: sectors include education, healthcare (hospital and non-hospital), office and other (amusement, hospitality, multifamily and retail)

- Owner Firm Size: across three size categories
- BIM Involvement: at least some with such experience

SCREENING CRITERIA

- **Architect:** Currently works at architecture, architecture/engineering or multidisciplinary (with architect as lead) firm.
- **GC:** Currently works at firm that is general construction/general contractor or multidisciplinary firm (with contractor as lead).
- **Architects and General Contractors:** Has worked on at least one building project over \$10 million in construction value in the past five years, and fulfills one of the following criteria for responsibility at their organization for new building and renovation projects:
 - Direct project involvement
 - Familiarity with multiple projects
 - Working knowledge of factors that impact project uncertainty
- **Owners:** Approximate average total value of all company's building construction projects over the last five years is \$10 million or more, and fulfills one of the following criteria for responsibility at their organization for new building and renovation projects:
 - Direct project involvement
 - Client responsibility on all projects
 - Familiarity with multiple projects
 - Working knowledge of factors that impact project uncertainty
 - Currently employed (but not in the automotive or energy/public utility industry)
- **Architects, General Contractors, and Owners:**
 - At least 80% of firm's construction projects over the last three years were a combination of commercial and institutional

- At least some proportion of firm's projects in the last five years are highly complex
- Respondent knows if company uses BIM software
- Respondent's company is headquartered in the U.S.

Analytic Variables Used in the Analysis

In addition to the analysis by the three player groups, periodically we also include references to differences by the following variables:

- **Type of Primary Project:**
 - Commercial (n=101)
 - Institutional (n=214)
- **Owner Project Type:**
 - Education (n=48)
 - Healthcare (n=31)
 - Office (n=31)
 - Others (n=45) (Includes amusement, multifamily, hospitality and retail.)
- **Percentage of Highly Complex Projects:** Defined as involving highly customized design solutions that are systems-intensive with detailed technical requirements.
 - <=50% (n=102)
 - 51%-99% (n=137)
 - 100% (n=76)
- **Owner Company Size:** Defined by average total project value in the past five years.
 - \$10M to <\$50M (n=59)
 - \$50M to <\$100M (n=27)
 - \$100M+ (n=69)
- **General Contractor Firm Size:** Defined by total value of projects in 2013.
 - <\$50M (n=30)
 - \$50M+ (n=46)
- **Architect Firm Size:** Defined by 2013 billings.
 - <\$5M (n=49)
 - \$5M+ (n=31)

Methodology:

Owner Advisory Group

McGraw Hill Construction conducted 90-minute telephone interviews in July and August 2014 with an Owner Advisory Group, consisting of recognized leaders from seven different building types: education, government, healthcare, hospitality/amusement, manufacturing, commercial office and retail. These owners shared their perspectives on the survey results and offered examples from their experience to expand upon the findings. Selected comments appear in Owner Insights articles throughout the data.

Boyd Black
Assistant Vice President
for Capital Project Delivery
University of Chicago

Under Boyd Black's direction the Capital Project Delivery group manages design and construction at the university. Mr. Black is currently a member of the Society of College and University Planners, the US Green Building Council (USGBC), the AIA Center for Integrated Practice Leadership Committee, the AGC Industry Advisory Council and is a current board member and past president of the Board of the Construction Owners Association of America.

Charles Hardy
Chief Workplace Officer
GSA Public Buildings Service
Charles Hardy serves as Chief Workplace Officer at GSA Public Buildings Service. Prior to joining this position in 2011, Mr. Hardy served as the director of design and construction for GSA's Public Buildings Service, Great Lakes Region, where he led the agency's ARRA operations in six states.

Mr. Hardy serves as an ex-officio board member of the Construction Managers Association of America and as a trustee for the Construction Users Roundtable.

Jerrold (Jerry) P. Lea
Executive Vice President
Conceptual Construction
Hines

Since 1981, Jerry Lea has been responsible at Hines for consultant selection and contract negotiations, budgeting, scheduling, management of consultants' designs, and contractor and subcontractor bidding and negotiations for over 100 million square feet of office buildings, retail complexes, hotels, sports facilities, clean rooms, performing arts theaters and museums. Mr. Lea is an honorary member of the AIA, a member of The Rice Building Institute Founding Board of Directors, a former chairman of the USGBC LEED Core and Shell Committee and a former member of the USGBC LEED Steering Committee.

Eric Miller
Director of Project Management
Sutter Health

Eric Miller manages construction over multiple hospitals and medical foundations in the East Bay and Peninsula Coastal areas. Prior to this position, he served in administrative positions at Kaiser Permanente and the San Francisco Department of Public Health. During this same time, he also served as instructor for John O'Connell Community College in San Francisco, teaching adult classes for Local 39 hospital engineers.

John Moebes
Director of Construction
Crate & Barrel

John Moebes joined Crate & Barrel as the director of construction in 2006 and manages all capital construction projects. Prior to that, he was an associate principal at Good Fulton & Farrell Architects in Dallas where he oversaw the firm's development and use of workflow technology. He is recognized as a leader in the use of Internet-based project management tools, building information modeling and digital document review to improve project performance.

Craig Russell
Chief Design and Project
Delivery Executive
Walt Disney Imagineering

Craig Russell is responsible for the design, engineering, production, installation and project management functions for Walt Disney Parks and Resorts projects around the world. In addition, he shares responsibility for WDI's legal, contracts, facilities and operations teams. He also currently sits on the board of the LEAN Construction Institute.

Don Vitek
Director, Global Real Estate
Program Management
Whirlpool Corporation

Don Vitek has worked in all aspects of real estate management, including operations, analysis, transactions, and design and development projects to date exceeding \$750 million. He is currently responsible for developing new facilities and/or major expansions for the company on a global basis, resourcing and performance management for the Global Real Estate team.

Resources

Organizations and websites that can help you get smarter about managing uncertainty and expectations on building projects.



McGraw Hill Construction

Main Website: construction.com

Dodge: construction.com/dodge

Research & Analytics:

construction.com/dodge/

dodge-market-research.asp

Architectural Record: archrecord.com

Engineering News-Record: enr.com

Sweets: sweets.com

SmartMarket Reports:

construction.com/market_research

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Founding Partner

AIA Large Firm Roundtable

Premier Industry Partners

American Institute of Architects: www.aia.org

Autodesk: www.autodesk.com

Design-Build Institute of America: www.dbia.org

Industry Partners

The Associated General Contractors of America: www.agc.org

Graphisoft: www.graphisoft.com

Lean Construction Institute: www.leanconstruction.org

Research Partners

American Subcontractors Association: www.asaonline.com

Construction Management Association of America: cmaanet.org

Construction Owners Association of America: www.coaa.org

Construction Users Roundtable: www.curt.org

Mechanical Contractors Association of America: www.mcaa.org

National Electrical Contractors Association: www.neca.org

Sheet Metal & Air Conditioning Contractors' National Association: www.smacna.org

Other Resources

BIMForum: bimforum.org

buildingSMART alliance: www.buildingsmartalliance.org

Charles Pankow Foundation: www.pankowfoundation.org

International Risk Management Institute: www.irmi.com

National Institute of Building Sciences: www.nibs.org

National Institute of Building Standards and Technology: www.nist.gov

■ Design and Construction Intelligence

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www.construction.com/market_research

