Improving Green Building Construction
in North America

Guide to
Integrated Design and Delivery

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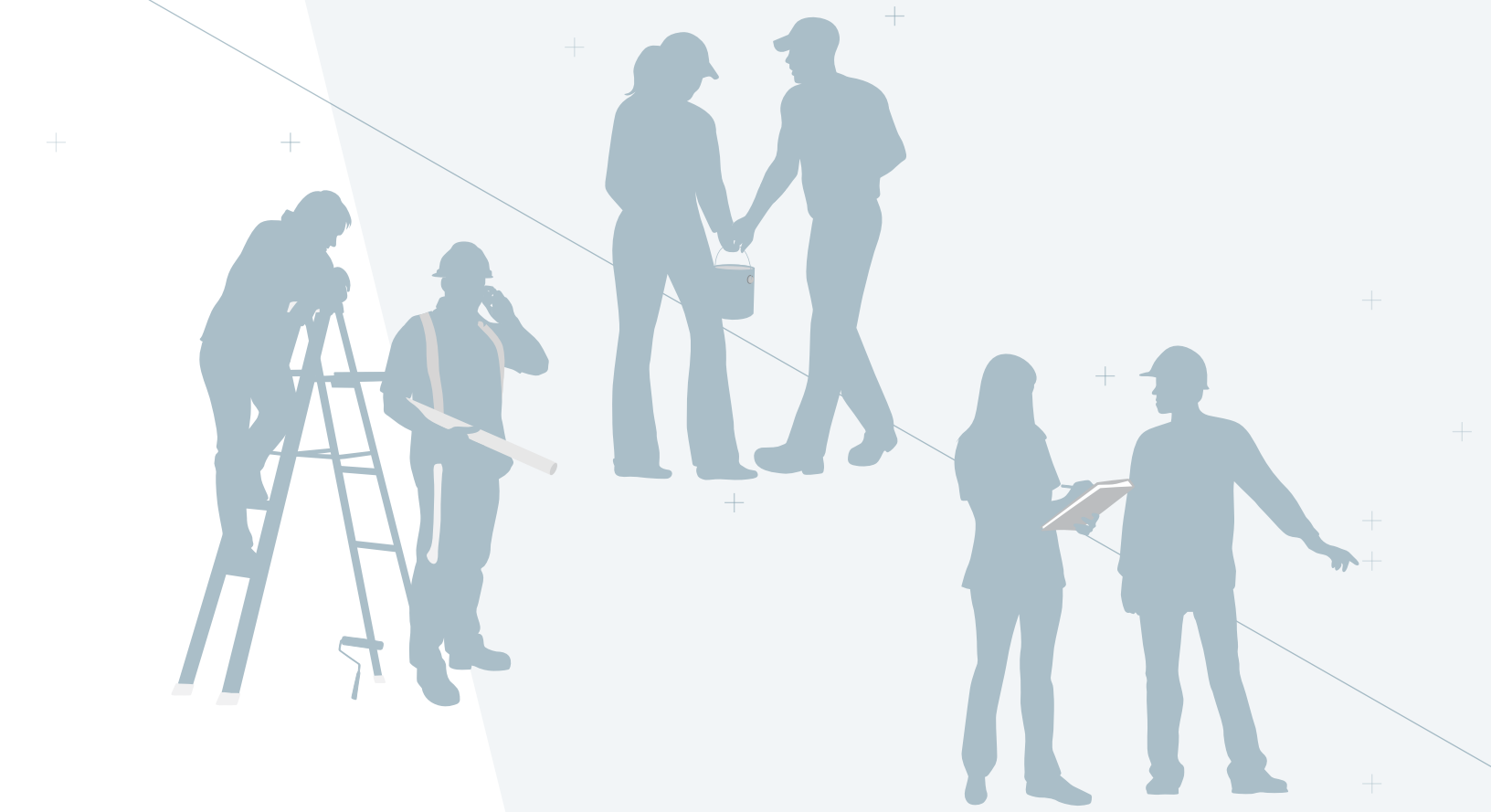
Improving Green Building Construction
in North America

Guide to **Integrated Design and Delivery**



Contents

Table of Figures

Acronyms

AIA	American Institute of Architects
BIM	Building Information Modeling
CEC	Commission for Environmental Cooperation
CLT	cross-laminated timber
HVAC	heating, ventilation, and air conditioning
IPD	Integrated Project Delivery
LEED	Leadership in Energy and Environmental Design
RFI	requests for information

Abstract

Environmental impacts of buildings and the costs of construction projects can be significantly reduced through the use of an integrated design, delivery and operations process. The definition and application of this building approach, however, varies widely across industry sectors and regulatory jurisdictions in North America.

This guide, which draws on the 2013 report by the Commission for Environmental Cooperation (CEC), *Improving Conditions for Green Building Construction in North America: Enhancing Capabilities of the Green Workforce*, outlines five main steps for success in implementing an integrated design and delivery process.

Based on current industry approaches, it highlights best practices and tools for 10 workforce sectors, and is supported by seven case studies and more than 50 reference documents. Guidance presented in this document was developed in part through interviews with more than 30 industry professionals and in consultation with internationally renowned experts working in Canada, Mexico, and the United States.

This guide is intended to introduce building practitioners to tested methods for incorporating deeper levels of integrated design and delivery into their construction projects. It can also help all stakeholders concerned in meeting their goals for constructing better and greener buildings.

The **Commission for Environmental Cooperation** (CEC) is a trilateral organization through which the governments of Canada, Mexico and the United States collaborate, with input from civil society, on the conservation, protection and enhancement of North America's environment.

Introduction

Background

Green building practices have the potential to save energy, save money, and improve the quality of human habitat across North America. They can also contribute to water conservation, more efficient use of raw materials, and ecosystem health, around the globe. The Intergovernmental Panel on Climate Change has singled out the building sector as having the most cost-effective opportunities for reducing carbon emissions—in fact, many building-related opportunities are cost-neutral, or even cost-positive to the building owner (Levine et al. 2007). Despite this plethora of opportunities, only a small fraction of new construction and existing building renovation projects in North America actively deploy green solutions, and even fewer embrace approaches that can integrate those solutions into a project deeply and holistically enough to achieve the dramatic resource efficiencies potentially available to them.

In 2013, the Commission for Environmental Cooperation (CEC) released the report *Improving Conditions for Green Building Construction in North America: Enhancing Capabilities of the Green Workforce*. It highlighted the need for a new paradigm in the way building projects are delivered, in order to enable the kind of innovations that result in meaningfully greener buildings. In particular, the 2013 report suggested that recognizing a broader group of stakeholders within the sustainability debate calls for a shift in perspective that would acknowledge the world as a complex dynamic system and be founded on holistic, flexible strategies. This new perspective must embrace a whole-systems view as a necessary, valuable means of better understanding the roles and relationships of stakeholders.

Drawing on that, the CEC commissioned this guide to help practitioners in ten workforce sectors implement a more integrated approach to establishing a highly collaborative working environment in which shared values and goals are readily accessed as drivers for project decisions. By allowing such values as energy efficiency or sustainable purchasing to come to the fore, project teams can typically discover much greater capacity to reduce the environmental impact of the built environment.

Guidance presented in this report was developed through interviews with over 30 industry professionals and in consultation with internationally renowned experts working in Canada, Mexico, and the United States (US). The results of those interviews were then refined in a day-long workshop with a core team of the most advanced practitioners and teachers of deeply integrative practices, resulting in a draft guide that was revised based on review comments from the original interviewees and others in the field.

This research has established that a well-organized integrated design, delivery, and operations process has the ability to deliver deeply green buildings at lower costs, and case studies supporting this were obtained from each country. Approaches for achieving integrated teams, however, vary widely by industry sector and by country and are not well distinguished or defined.

This report is designed to meet the pedagogical needs in all these contexts; by establishing a common understanding of best practices and referencing specific tools, it is intended to enable practitioners to achieve deeper levels of integration that will accomplish meaningful results, both for the environment and for the building industry.

Integrated Design and Delivery

The building industry has long suffered from a lack of integration among industry sectors. Business-as-usual leads different firms and individuals to enter into a project in phases and take responsibility for only what falls in their area of expertise or responsibility: architects and engineers are responsible for planning and design, contractors are responsible for constructing the building or structure, and building owners are left to deal with the outcome. This assembly-line approach very rarely works to create a building that is optimized as a system. Rather, the final product often underperforms and may not even meet the needs of the owner.

Over the years, different approaches have been developed to help building professionals execute a construction project more collaboratively. These include: Partnering, Integrated Design Process, Lean Design and Construction, Integrative Process, or Integrated Project Delivery. Each approach has helped project teams achieve higher levels of success by encouraging some level of integration among the responsibilities of the various team members. This guide distills the key tenets of these various approaches, under the blanket term "integrated design and delivery," to help project teams achieve the kind of integration that will have transformative and tangible effects.

To get there, this guide outlines five main steps, which are supported by several case studies, expert comments, reference documents, and specific guidelines for each expert group.

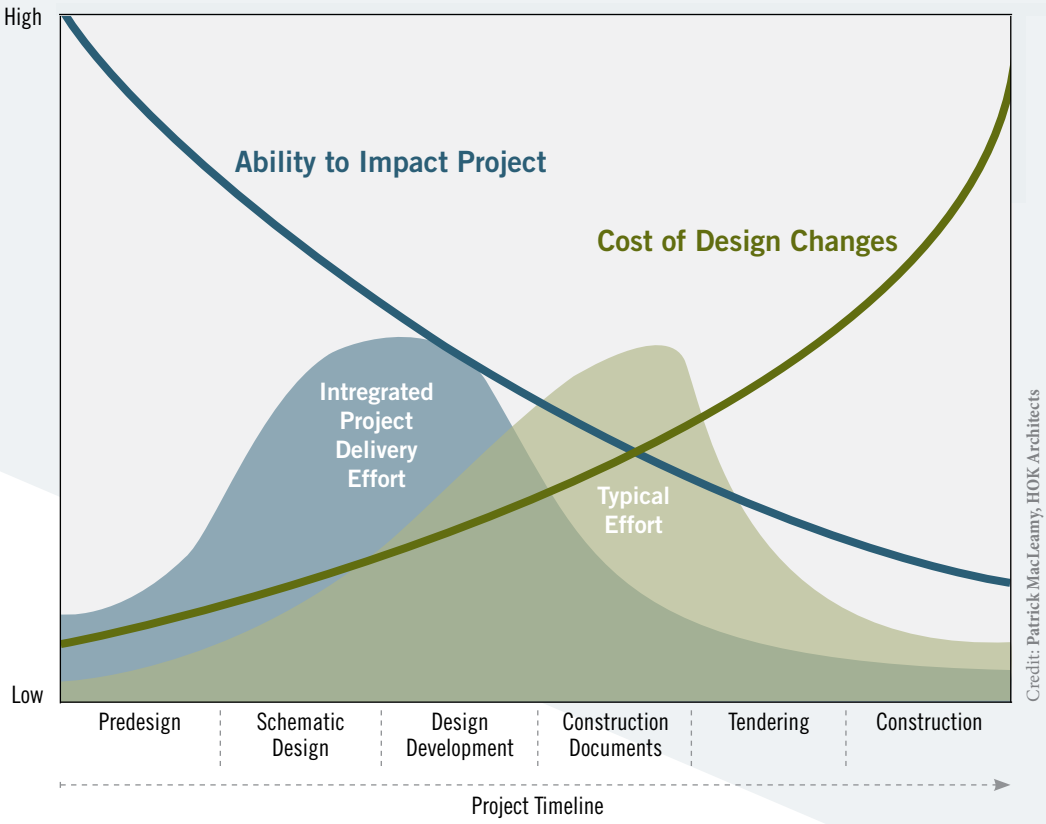
Why increase integration?

1. **Integrated teams agree on a clear path forward before construction starts.**
   - Key team members are selected before the design phase.
   - The team defines project goals and maps responsibilities for going forward together.
   - Input from multiple disciplines helps find the best solutions.
2. **Integrated teams achieve greener buildings.**
   - System efficiencies are discovered through identifying synergies.
   - Waste and redundancy are avoided through better coordination, thus reducing material, energy, and water use.
   - Contractor and trade input during design increases cost predictability, which protects green features from being cut during construction.
3. **Integrated teams save the owner money.**
   - Construction costs are weighed from the beginning.
   - Fewer changes are made later in the design process, when they become most expensive.
   - Fewer Requests for Information (RFIs) and change orders are placed.
   - Embedded contingencies and variable costs are reduced.

An integrated team generally spends more time and energy making decisions early in the project, when the ability is highest to affect the project positively. Results include making fewer changes down the road, when changes become more expensive (Figure 1) (Wilson 2014).

> **"What creates the difference between a frustrating project and a fulfilling project? Everyone we've talked to mentions education, alignment around purpose, reduced ego, and clear direction."**
>
> – Bill Reed, Regenesis Group

Figure 1: Cost and effort of design changes as project progresses



Shortcomings of the traditional design-bid-build approach:

- Projects take longer to complete since all the design work needs to be finalized before the contractor is procured.
- Knowledge is lost in the hand-offs between project phases.
- Adversarial relationships develop because separate contracts create competing incentives for team members.
- Any cost savings from selecting contractors based on the lowest bid are offset by extra costs incurred in change orders, construction rework, litigation, or reduced quality.
- Performance outcomes in terms of energy and water efficiency and occupant comfort fall far short of what is cost-effectively achievable.

The problems in numbers:

- 30 percent of projects do not meet schedule or budget (FMI Corporation 2007).
- 7–11 percent of construction costs are spent on rework, which causes delays (Zach 2013).
- 92 percent of project owners say architectural drawings are insufficient for construction (FMI Corporation 2005).
- 37 percent of materials used in the construction industry end up being sent to the landfill (Kristine Fallon Associates, Inc. 2012).

> **“By fixing our linear and non-holistic process, which is fraught with redundancy, we can start to significantly downsize or eliminate a building’s mechanical systems.”** – John Boecker, 7group

Integrated Design and Delivery in Canada, Mexico and the United States

In the US and Canada, “integrated design” sometimes stands for a vague concept of interdisciplinary collaboration that is limited to the design stage, or it can signify a very deliberate, collaborative process that extends through construction and into building operation. It is in the latter sense that we will consider it in this report: as an integrated management, design and construction practice adapted from certain modern managerial-production systems that are widely used to structure a more deliberate process.

One of these systems, Lean Construction, was derived from the Lean manufacturing principles, which emphasize value for the customer, tightly controlled process flow, and emphasis on perfection, pioneered by Toyota. This production management approach has now developed trademarked techniques to maximize value and minimize waste in construction, through organizations like the Lean Construction Institute, which runs workshops, hosts conferences, and is responsible for the development of training programs to educate practitioners in both Canada and the US. Lean construction practices, based on the Lean principles, will recur in the discussion below.

Another very influential source helping to solidify and define integrated practices is the Leadership in Energy and Environmental Design (LEED) Standard, a green building standard used internationally, that awards project teams which have worked together to identify opportunities to save energy and water early in design.

Furthermore, specialized multi-party contracts have been adopted in the US and Canada to formalize integrative efforts, although use of such contracts is still very rare and typically limited to very large, complex projects, especially in the healthcare sector.

These sources of guidance, however, are only utilized in select domains, with little crossover. Interviews with practitioners in the US and Canada revealed that terminology and practices differed greatly between different disciplines, creating confusion and opening the door for companies to use terms like “integrated design” for marketing without changing current practices. This suggests that there is great opportunity to influence practice in these countries by simply laying the groundwork for a common understanding of what true integration entails.

In interviews with Mexican practitioners, respondents generally expressed a much more consistent understanding of integrated practices than their colleagues to the North, but they also had a much more limited approach—mostly just involving the contractor team in the design process. Lean practices were not cited as a basis for implementation and most practitioners expressed a need for more guidance on the process.

Research suggests integrated approaches have recently been introduced in Mexico, largely through greater exposure to the LEED Standard. A small number of practitioners are practicing deeply integrative processes, but to the knowledge of the authors at the time of this report, no projects in Mexico had used a multi-party contract. These findings suggest that a resource outlining specific steps to deeper levels of integration, and consolidating tools that already exist, could greatly benefit Mexican building professionals.

Achieving Integrated Design and Delivery

The success of an integrated project is highly dependent on the caliber of the team. The core of the team is usually the architect, the engineer, the contractor, and the owner, with design consultants and trade subcontractors included as needed. Tips on how to select a strong team are described for each expert group.

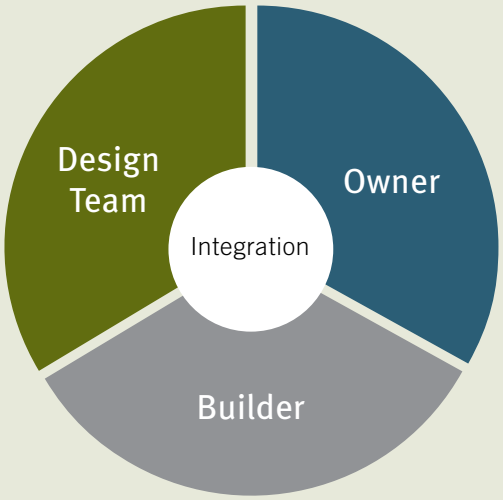
> [Integrating a team] **is not just pulling together a multi-disciplinary team, although that is an important first step. It means that each person in the room needs to have both the right expertise and the right posture. Without both, you can still end up with just another building.**
>
> – Laura Lesniewski, BNIM

STEP 1

ALIGN VALUES

Before delving into pre-design, integrated projects begin with a kick-off meeting to explore values. Such a meeting may last several hours or even several days, depending on the size and complexity of the project, but the team members must explore the values that underlie the project and agree in their alignment to them. This represents a first step in establishing common ground for the project and developing the deep-rooted working relationships that will be necessary (Figure 2). With this understanding as a basis, the team can begin to work together, negotiate a contract, and communicate effectively.

Figure 2: A kick-off meeting brings together team members from various project phases



Examples

- Daylighting/Energy Analyst
- Commissioning Agent
- Landscape Architect
- Civil Engineer
- Planner
- Architect
- Structural Engineer
- Mechanical, Electrical, Plumbing (MEP) Engineer
- Building Users
- Owner
- Community Members
- Facilities Manager
- Planning Staff
- Operations and Maintenance Staff
- Cost Estimator
- Mechanical, Electrical, Plumbing (MEP) Contractor
- General Contractor
- Construction Manager
- Product Manufacturers

Credit: 7group and Bill Reed 2009.

> **“While energy is important, I am increasingly interested in the potential of the reframing of health and well-being of the whole (people and place) as the overarching goal, and understanding other targets as evaluation metrics for achieving this.”** – Jennifer Cutbill, Intern Architect, Dialog Design

Questions for the project team (7group and Bill Reed 2009):

1. What are you trying to accomplish by building this project?
2. After it is built and occupied, what will define its success? What will have been achieved?
3. How will the project continue to evolve as a contributing member of its community and place?

These should be the results of a well-conducted kick-off meeting:

- A project driven by values is more likely to result in a green building because human health and ecological wellbeing are topics nearly everyone cares about.
- Exploring values will help participants consider the broader impacts of the project, expanding its possibilities.
- Values address the “why” of the project, which helps unleash aspiration and creativity; greater things become possible.
- The exercise of developing a statement of shared values creates a foundation that makes joint decision-making easier and also builds trust, which is essential for effective collaboration.

Important:
Aligning around values is easier if individuals have the buy-in and authority to speak for their organizations. If an individual commits himself to a set of values, but higher management dismisses this commitment as merely goodwill, then tensions can begin to arise in the project when the team member is called upon by the other members to act on those values.

Case study: Lion’s Gate Wastewater Treatment Plant (see p. 59)

STEP 2

ALIGN GOALS

In an integrated design and delivery project, team members mutually define the desired outcomes of the project and work together to set performance goals. These goals should reflect the integrated nature and open-ended potential of an integrated project. In other words, whereas conventional goals are different for each team member, integrated goals are shared and project-centric.

One way to jump-start the goal-setting process is through the "touchstone exercise" outlined in *The Integrative Design Guide to Green Building* (7group and Bill Reed 2009). Each team member answers the question, "What are the key needs this project must address?" and the selection and ranking of performance goals can be handled through discussion or an actual vote. The sequence is as follows:

1. Owners come in with certain needs and aspirations.
2. Team input enhances those needs based on shared values.
3. Team collectively translates general needs into specific, measurable performance goals.

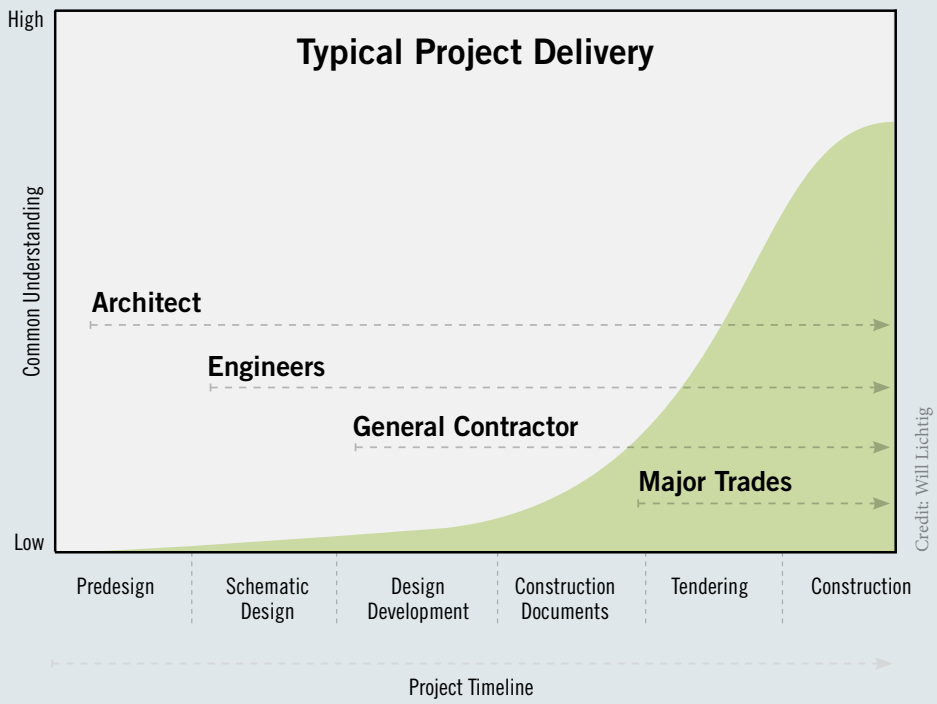
The results of the touchstone exercise can be used to prioritize performance targets as well as form the basis for the "Owner's Project Requirements" document, which details the functional requirements of a project and the expectations of how the completed building will be used and operated. These goals are then used to generate a "Basis of Design" document, which describes in general terms how the goals will be achieved in the project. Alternatively, goals may be documented in project team charters, conditions of satisfaction, or project goal agreements.

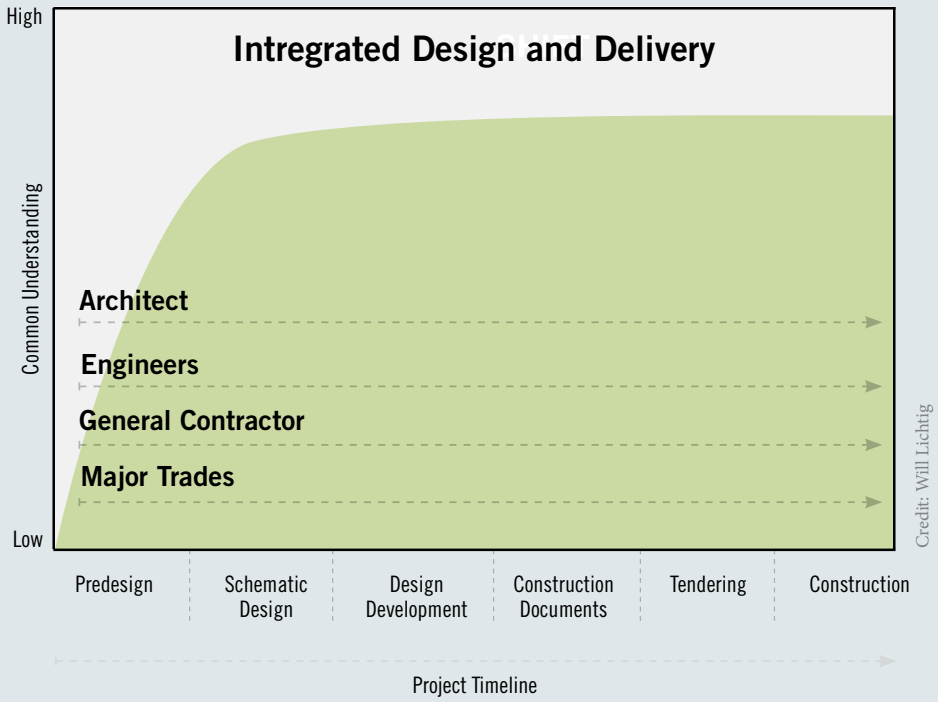
Advantages of aligning goals (Wilson 2014):

- All team members go through the same learning curve together at the beginning of the project (Figure 3).
- The team and the project can proceed much more quickly and efficiently and there is reduced risk of misunderstandings and missteps.
- Team members can assess if they truly have the capacity to deliver what is being asked, instead of signing on and finding out too late that they might not have the needed expertise.
- The owner will feel in control and happy.
- The architect will avoid redrawing.

Case study: Edith Green–Wendell Wyatt Federal Building (see p. 57)

Figure 3: Common understanding of a project team throughout the duration of a project





STEP 3

SELECT A BUSINESS MODEL AND CONTRACT STRUCTURE

Selecting a Model

It might be possible to create alignment with a really great team and pursue an integrated process with a conventional design-bid-build business model, but risk management and financial terms ultimately determine how businesses and firms relate. If these structures don't also change, it will be difficult to extend integration beyond a select group of people to the organizations for which they work. Even in alternative delivery models, like Design-Build or Construction Manager at Risk, those committed to an integrated approach end up expending energy to circumvent status quo policies, which is not impossible but is also not the easiest course. Integration is most likely to succeed if it is the path of least resistance, from both an individual and a corporate standpoint, which is accomplished by aligning incentive structures with this new way of engaging—something best achieved with an Integrated Project Delivery contracting approach.

The choice of contract structure is typically driven by the owner. However, pursuing an integrated contracting model may be suggested by any stakeholder. Integrated Project Delivery aligns incentive structures by contractually linking two or more parties' risk and profit. These contracts typically include three distinct mechanisms for sharing the financial risk and benefits in a project.

Mechanism 1: Base Fee, with Contingent-on-Success Profits

- Parties agree to a base fee covering each party's direct costs (either lump sum or cost-plus with a maximum).
- Owner creates a separate shared incentive pool so that participants receive their share of profit if performance goals are met.

The parties agree to a base fee that is not linked to actual material, labor, or project costs. Profit is awarded based on achieving predetermined project goals, such as meeting schedule, target cost, green performance, or quality goals. The approach encourages a team to work more efficiently and shift work amongst themselves so that the most capable party handles each job, because no one needs to fight for project scope in order to maintain profit.

Results:

- Parties have an incentive to reduce variable costs in order to increase overall project profit margin, instead of rack up additional billable time.
- Team members have an incentive to care about the success of the overall project, rather than just deliver their piece, and are more likely to share expertise.

Case study: Barus and Holley Hall, Prince Laboratory Upgrade (see p. 54)

Mechanism 2: Variable Costs, without a Cap

- Costs for labor, materials, and equipment do not have a cap.
- Overruns affect everyone, through the loss of shared profits.

The owner agrees to pay, without any cap, for the variable costs (e.g., costs for labor, materials, and equipment—everything excluding profit). There are limitations on change orders and there is the ability to draw from the shared profit pool if there are overruns beyond the target cost. Uncapped variable costs help prevent small cost overruns from derailing the entire project and keep the team intact so that it can make up the loss by finding savings in another area.

Results:

- Contingencies are reduced.
- A collaborative atmosphere is retained even through project disruptions.

Mechanism 3: Limits on Change Orders

- Risks are solved by the team, rather than by giving individuals the right to issue claims, pursue litigation, and change orders.
- This move reduces pricing contingencies and schedule disruptions and saves everyone from spending time in legal maneuvering.

To ensure that the contingent-on-success profits and unlimited variable costs aren't an unfair advantage for the builder, the general contractor and subcontractors are prohibited from issuing change orders citing design errors or omissions. An integrated team should have far fewer problems in the first place, but when issues do arise, this forces the team to resolve problems quickly and efficiently on their own.

Case study: Rocky Mountain Institute Innovation Center (see p. 61)

Key elements of sharing risks and rewards:

- Each party will only receive its share of profit if the project successfully meets the goals established in Step 2.
- Each party also agrees not to sue another for design errors, omissions, or delays (unless there is true negligence).
- Waiver agreements facilitate collaboration and cut costs.
- Fiscal transparency (historical profits, overhead, and build-up of hourly rates) of the team increases trust between the owner, the design team and the construction teams.

Case study: Mosaic Center (see p. 60)

Selecting a Contract

Integrated Project Delivery (IPD) contracts give all those who participate in the risk and reward structure (at minimum the owner, architect, and general contractor) joint project control, which ensures that those who are accepting the risk have a voice in the decision-making.

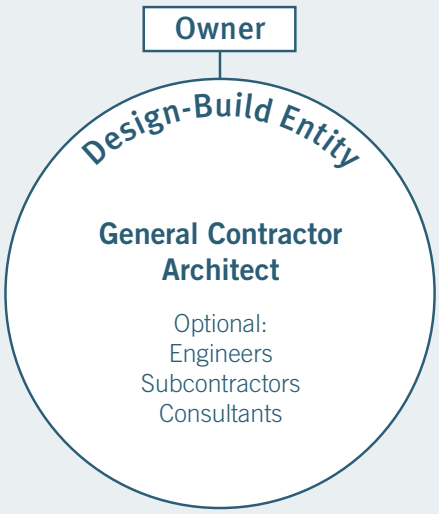
This is accomplished in one of two ways:

1. **Multi-party contracts** bind the owner, architect, and general contractor together in the risk and reward structure, and sub-agreements are added for subcontractors and consultants so that they share in the portion of the at-risk compensation but have limited or no voting rights at the management level (Figure 4).

2. **Poly-party contracts** bring more team members into the shared risk-reward structure, and all members have a vote or veto power on major decisions. In addition to the owner, designer, and builder, key participants may include mechanical, electrical, or plumbing contractors if they can provide valuable input about constructability and cost. Depending upon the project, steel erectors, framers, curtain wall contractors, major equipment vendors, and others may similarly be key participants (Ashcraft n.d.).

Figure 4: Multi-party contract structure

Figure 5: Integrated Design-Build contract structure



Credit: Wilson 2014.

IPD contracts further support integration because they require:

- joint project control, including the owner,
- early involvement of key participants, like trade subcontractors and consultants,
- jointly developed and validated goals, and
- liability waivers.

IPD contracts are not adopted equally between the US, Canada and Mexico. The US has publicly available IPD contracts that can be adapted to various projects. These include the ConsensusDocs 300 and the American Institute of Architects' (AIA) C191. Canada currently does not have a standard form of multi-party contract for IDP projects, but the Canadian Construction Documents Committee is currently working on a standard form, relying heavily on AIA precedents. IPD projects have been carried out in Canada, however, using custom contracts. In Mexico, multi-party contracts are not currently part of integrated practice, although practitioners do engage with integrated design through the Leadership in Energy and Environmental Design (LEED) rating program.

Troubleshooting: IPD doesn't apply to my project because...

... it is a small project with a limited budget.
Solution: The IPD business model can be scaled up or down based on the number of stakeholders. The financial benefits apply to smaller projects too.

... the construction start date is uncertain or dependent on further fundraising.
Solution: A small team of generalists-specialists can develop well-rounded programmatic goals and a rough design until other participants can be hired. A project can start IPD once it raises the needed funds. This kind of rolling acquisition is how most projects happen in reality—while it would be great to have a fully formed team at the very start of a project, a project can be a successful IPD without it (see: the Mosaic Center case study, p. 60).

... the owner is unable to be a strong participant in the predesign process.
Solution: A modified "design-build" contract with shared risks and rewards might offer more familiarity and relieve the owner of the responsibility of participating in the design work (Figure 5). However, the owner would not receive a share of the savings if the project comes in under budget—that would go to the design-build team, for its efficient work—and relinquishes some control over outcomes.

... it is a public project that is restricted to low bid by local, state, or federal statutes.
Solution: incorporate other integrated aspects, such as collaborative decision making, early involvement of key participants, and metric-based decision making, while using more traditional contracts (see Edith Green–Wendell Wyatt Federal Building case study, p. 57).

Negotiating

In some cases, financial incentives can disrupt an intrinsic motivation to act more collaboratively, as might be the case if the team is driven solely by the goal of creating a green building. To mitigate this possibility:

- Conduct an alignment workshop before negotiating the contract.
- Approach contracts as a license for creative freedom, not a prescriptive set of conditions.
- Reiterate jointly developed values throughout the project and at important transitions.

Case study: Mosaic Center (see p. 60)

STEP 4

PLAN THE ROADMAP

Once the team has settled on a business and contract model, the team agrees on a procedure for frequent and effective collaboration. One outcome of the kick-off meeting should be to identify the subteams in charge of organizing and executing specific tasks, and assign responsibility for tracking progress in relation to green performance goals. Team members may work on the respective issues of their specialty separately but reassemble for a deep discussion with the whole team at targeted points. The team develops a project roadmap for each period of time between each meeting and schedules smaller meetings for targeted subgroups where there are likely to be synergies. The *Integrative Process (IP) ANSI Consensus National Standard Guide* (Institute for Market Transformation to Sustainability 2012) offers a model for establishing this process and direction for preparing each workshop and selecting collaborating teams. For example, in the Oregon State Capitol Renovation project (Oregon Legislature 2013), the team divided into cluster teams called site, structure, enclosure, interior construction, other furniture, fixtures and equipment, and mechanical, electrical, and plumbing/information technology. Planning the approximate number of meetings results in more accurate fees and establishes clear expectations for what 'integrative' actually means. Assigning the preparation work that must be done before each meeting helps to avoid duplicated efforts and spell out individual responsibilities.

- Agree on a method for frequent and effective communication.
- Identify subteams for specific tasks.
- Schedule whole group meetings strategically to iterate and find synergies.

Lion's Gate Wastewater Treatment Plant (see p. 59)

> **"Architecture firms that have followed their project roadmap report 30–35 percent less time spent in the construction/documentation phase."**
>
> – John Boecker, 7group

Team Communication
While the team develops the project roadmap, it is also a good time to establish communication norms so that the necessary people are included in making decisions. These norms might include establishing rules about communications made via email or in-person, using Web-based project management tools, or using a joint work location. Co-location has been found to generate significant time and cost savings, but if full co-location is not possible, compromises include co-locating for part of the week or allowing consultants to work on other projects while they are in the shared space.

- Fully co-locate if possible.
- Establish clear communication protocols.
- Consider Web-based management tools or hosted intranets.

Rocky Mountain Institute Innovation Center (see p. 61)

Using Building Information Modeling
Building Information Modeling (BIM) is a set of digital design and execution tools that can be shared by a team, saving time and money. According to a 2007 Stanford study, BIM provides an estimated 40 percent reduction in unbudgeted changes, provides cost estimates within three percent of traditional estimates (but generating the estimate 80 percent faster), results in contract savings up to 10 percent with the use of clash detection, and reduces project time by seven percent (CIFE 2007). If it is set up appropriately, BIM also facilitates performance simulations that are important for verifying that the project is on track to meet green goals.

> **"Building Information Models are platforms for collaboration; they lead naturally to intensive communication and interdependence."**
>
> – Howard Ashcraft, Hanson Bridgett LLP

STEP 5

FOLLOW THROUGH

Once the project team has agreed on values and goals through early alignment workshops (in steps 1 and 2), chosen an appropriate business model and a contract structure (in step 3), and agreed on a roadmap for implementation (in step 4), it is ready to implement methodically the project process and follow through to project completion.

Methodical Discovery and Implementation

Before engaging in schematic design, teams need to complete an early analysis of the interrelationships among project systems and how each individual's role relates to the other team members' roles.

- Analyze interrelationships among project systems *before* schematic design.
- Analyze anticipated water and energy demands.
- Perform early-design-phase simulations to predict actual loads.
- Identify opportunities for design choices to reduce high-impact loads and/or meet them with on-site, renewable resources.

This step is outlined by the Integrative Process LEED credit (US Green Building Council 2015).

Sustaining the Collaboration

A concerted effort is required to maintain the necessary high level of collaboration in an integrated team. A facilitator may be needed for the length of the project, to sustain the collaboration and ensure that the team reaps the benefits of its earlier cost and time investments.

- Designers and builders come with various levels of skill and experience in collaborative work: ongoing coaching, facilitation, and support are essential to maintaining a high-functioning team.
- The bigger and less experienced the team, the more intensive and hands-on the facilitation has to be.

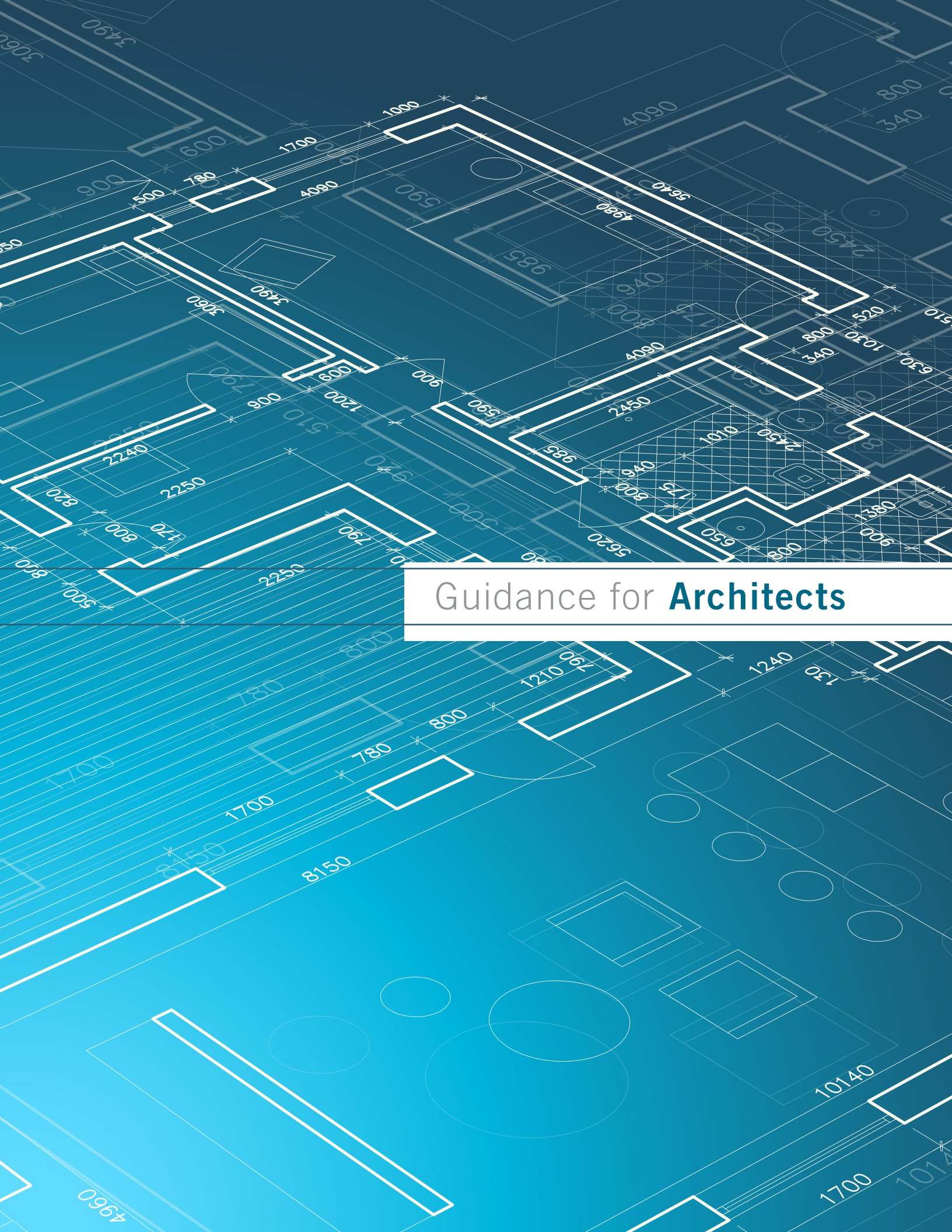
Construction and Operation

Ensuring that the values of the project are passed down into construction and operation is one of the biggest challenges—and often where poorly integrated teams mistakenly take short cuts and inadvertently compromise green performance. Including the building operator in the design team and reviewing roles and responsibilities with the builder's teams helps ensure continuity, and coordinating the commissioning schedule with the construction schedule helps to efficiently verify performance targets.

There is no final step in an integrated design and delivery project. The operations team must be trained at the end of construction, but tracking performance and monitoring key performance indicators continues for the life of the building.

- Review with the builder's team their roles and responsibilities before construction.
- Coordinate commissioning: the installation of all systems by the builder is subject to performance goals, and commissioning is incorporated into the construction schedule.
- Verify the training of the building operations team.
- Roll a percentage of performance savings into operations optimization.
- Establish standard operating procedures that provide continuous feedback.
- Communicate the building's green features and performance goals to occupants to gain their support and buy-in.

Case study: Lion's Gate Wastewater Treatment Plant (see p. 59)



Guidance for **Architects**

Role to Play in an Integrated Approach

When using an integrated design and delivery approach, the architect is asked to make a significant departure from his usual way of doing business. One important difference is the presence of the owner as a team member at the predesign phase. This means that the responsibility of controlling communication with the owner will be partly replaced with coordinating with the contractor and educating the whole team about the significance and interconnectedness of design decisions. Other responsibilities include:

- **Welcome cross-disciplinary input during early design.**
- **Engage contractor and key trades so that they understand key design decisions.**
- **Educate the owner about alternate options that might lead to higher performance.**

Opportunities

Use of a collaborative model during the design stage may be seen by some architects as a burden and a disruption to the problem solving that they are trained to do. It may also feel restrictive to some architects, who are used to taking the lead. However, in most cases, implementing full alignment, changing the business model, and adopting an IPD agreement will be worth the time invested.

Following performance requirements set by the whole team instead of just specific details provided by the owner will give the architect more freedom to innovate and create. From the beginning, trades and contractors can provide information about the effectiveness and constructability of alternate concepts, which will help architects choosing systems and layouts iteratively to efficiently achieve the project goals. The architect can feel confident suggesting ideas that might meet or exceed the initial performance goals while staying on budget and resulting in fewer surprises during construction.

> **“We are seeing a shift from a siloed approach to trans-disciplinary approach, but we need to ultimately get to a transcendence that operates across boundaries.”** – Jennifer Cutbill, Dialog Design

Integrated design and delivery might feel cumbersome or repetitive. But if implemented at all levels you'll see:

- **more leeway for creative design;**
- **quality feedback on the effectiveness and constructability of alternate concepts;**
- **whole-team commitment to the project's overall success, including green performance; and**
- **fewer changes in construction that alter design.**

Initiating an Integrated Project

The architect is well positioned to initiate an integrated design and delivery approach because, as a trusted voice for the owner, he can usually propose an integrated approach before the project is too far along. It is helpful to clarify how integrated design and delivery benefits all parties and to give examples from projects already realized. If the owner is hesitant about the process, it may be helpful to suggest an integration consultant or facilitator for the project.

Key Points:

- **Propose integrated approach as early as possible.**
- **Make the case by appealing to the owner.**
- **Suggest a facilitator, if needed.**

Selecting the Team

The success of an integrated project is highly dependent on the caliber of the team. For that reason, the architect will have a vested interest in the other parties that are selected for the team. The architect can suggest to the owner that he or she ask for proposals from pre-assembled teams, instead of individual parties. That would allow the architect to submit a proposal with a contractor with whom he already has a good working relationship and who ideally has experience with integrated design and delivery approaches.

Leading Integrated Project Delivery expert Howard Ashcraft compares creating an integrated team to a corporate merger (Ashcraft 2011). In a successful merger, members from different firms create a single organization with a common culture that reflects their beliefs and values. Choosing team members or partnering with firms with which the owner has a strong working relationship helps ensure cultures are complementary rather than antagonistic.

If it is not possible to advocate for hiring a firm with which the architect already has an established rapport, the architect would ideally select firms who have demonstrated an ability to adapt to a new system and make a strong commitment to a culture of collaboration.

If you can, work with those you know or with whom you have done previous integrated projects. If you do choose new partners:

- **select for competency and capacity, and**
- **prefer team members with an interest in collaboration.**

Selecting the Team: In the Interview

The architect can demonstrate a capacity for collaboration even without prior experience on an integrated design and delivery project. Capacity for collaboration can be demonstrated by emphasizing experience with Lean design and construction, or integrated design, and by describing ways in which the party adapted to more collaborative projects.

Key Points:

- **Emphasize consideration of an individual's prior experience.**
- **Specify claims: Ask, "How did you collaborate differently on that project than on others?"**
- **Engage contractor and key trades as early as possible.**

Overcoming the Learning Curve: Co-learning and Joint Decisions

Integrated design and delivery has a steep learning curve, but from existing case studies it is clear that once a team successfully completes one integrated project, that team will be much more efficient on successive projects (case study: Lion's Gate Wastewater Treatment Plant, p. 59). It is the architect's role to foster a culture of collaboration and to be persistent in engaging all participants. For the team members, adjusting from being "the expert" to being a "co-learner" will be possible only in an environment of collaboration, where suggestions and openness are encouraged.

> "[Integrating a team] **is not just pulling together a multi-disciplinary team, though that's an important first step. It means that each person in the room needs to have both the right expertise and the right posture. Without both, you can still end up with just another building.**"
>
> – Laura Lesniewski, BNIM

Key Points:

- **Teams that have done one or more truly integrated project(s) are likely to be successively more efficient on others.**
- **Learning how to make joint decisions is a skill.**
- **Fostering a spirit of collaboration is everyone's responsibility.**

Taking the Role of Educator

As seen in steps 1 and 2 above, integrated projects are structured to deliver on the values and goals that the project team establishes. If sustainability objectives are not established, the architect might have to educate the team about those benefits. Associating green features with reduced operational costs and reduced time to market may help to make sustainability part of the conversation. The authors of *The Integrative Design Guide to Green Building* (7group and Bill Reed 2009) suggest that working with "nested systems" helps bring sustainability objectives to the surface. Examining how a project affects the primary systems within the whole of the environment—defined as habitat, water, energy, and materials—reveals the relationships between smaller and larger systems.

Key Points:

- **Integrated projects will deliver only on the values and goals that are expressed.**
- **If sustainability values are not already a focus, you might have to play the role of educator in order to bring those goals to the surface.**

> **“BIM is an attitude for how information is exchanged.”**
>
> – Phil Bernstein, Autodesk

Utilizing BIM

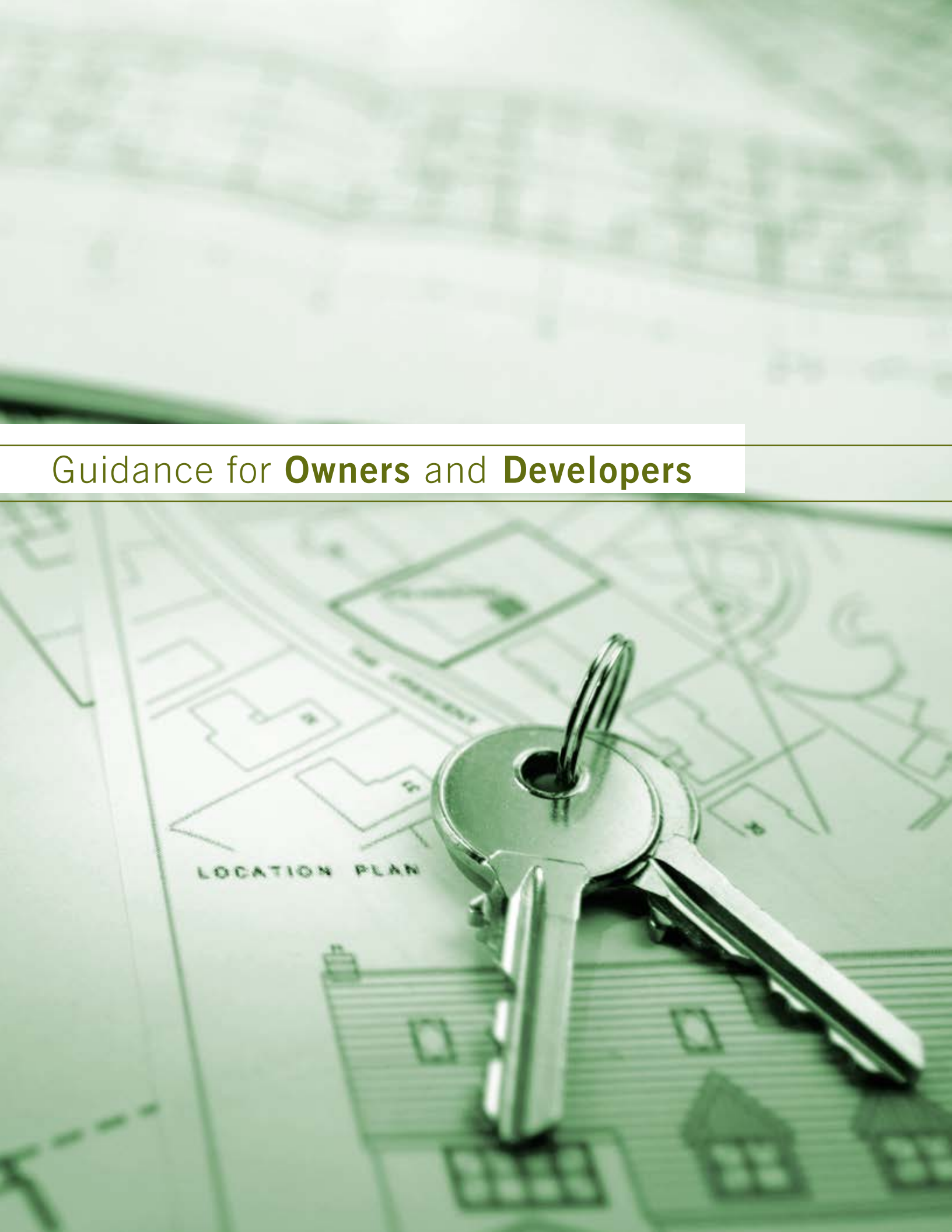
Over 70 percent of architects use BIM, according to a Smart Market report (Smart Market Report 2012). However, many limit the use of these software tools to creating 3-D renderings and understanding the performance and cost of a near-final design (Malin 2007). Architects can use BIM more economically—and help ensure sustainability goals are incorporated into the project—by doing simple box models to evaluate the energy performance of different conceptual designs before schematic design has even begun, looking at factors like massing, orientation, and percentage of glazing. Such models would be done using energy modeling programs before moving into full-fledged BIM design tools.

BIM can also be used as a communication tool to drive collaboration among team members. With the development of cloud-based BIM servers, multiple users can access a BIM model and changes made will appear for the other users in real time.

Key Points:

- **Utilize BIM to compare alternate concepts, not just to model performance of final design.**
- **Use the rich data sharing as a collaboration tool.**

Guidance for **Owners** and **Developers**



Role to Play in an Integrated Approach

Integrated design and delivery has to-date mostly been an owner-driven process, with the owner or developer requiring this approach from the outset, beginning with the team selection. In integrated projects, the owner will take a more active role in selecting and engaging with the project team. An openness to a new business model, which often requires more investment upfront, and to a high level of engagement throughout the process, is crucial for success.

Key Points:

- **Initiate an integrated approach.**
- **Commit to staffing decisions and engaging differently with staff.**
- **Embrace new financing models and invest more money upfront.**

Opportunities

Although employed at a very high level on relatively few projects, owners who have pursued integrated design and delivery approaches report better outcomes in terms of value and cost (Ashcraft 2013). The owner becomes an influential partner in the design process and helps establish the project's values and goals during steps 1 and 2 of the Guide. If sustainability objectives have been established, integrated teams also have higher potential to deliver those outcomes and the owner will be more confident of getting a project that is truly green. The integrated design phase requires the teams to think about the full potential of a project (in step 1), which often results in qualitative improvements. For example, The Sarah E. Goode Academy achieved LEED Gold even though it was programmed for LEED Silver (see p. 63). Moreover, owners often experience benefits in costs and schedule. In *Integrated Project Delivery: The Owner's Perspective* (Ashcraft 2013), multiple owners in projects of different scales had projects come in ahead of schedule and under budget. The Mosaic Center (see p. 60) was five percent under budget and five months ahead of schedule at the time this report was written.

> **"Our facilities are LEED Gold, net zero, etc., and we attribute most of that to hiring teams that were best integrated and were able to incorporate energy goals."** – Shanti Pless, National Renewable Energy Laboratory

Integrated design and delivery provides:

- **what you want, because your voice is heard throughout the process,**
- **better outcomes in terms of value and cost,**
- **the potential for exemplary energy savings and occupant comfort at no added cost, and**
- **teams that are innovative and creative.**

Initiating an Integrated Project

Integrated design and delivery is often an owner-driven process because the owner assembles the team and sets the project parameters. Whether drawn to integrated design and delivery out of frustration with current methods, out of interest in a value-based approach, or based on an early recommendation from a member of the project team, the owner must be willing to take the lead in requiring collaboration as a parameter and committing to that requirement all the way through the process.

Initiating an integrated project requires owners to recognize that:

- **Integration is often an owner-driven process.**
- **It requires leadership and commitment.**
- **It requires efficient and clear decision pathways.**

Selecting the Team

The biggest decision the owner will make in a construction project is selecting the team. The success of an integrated project is highly dependent on the caliber of the team; the owner will have a vested interest in choosing parties that are committed to an integrated approach and that work well together. That means judging all parties—including the general contractor—on quality and character rather than on lowest cost.

As Oscia Wilson writes in her book, *The Owner's Guide to Starting Integrated Building Projects (*Wilson 2014*)*, "When a building team is hired through the lowest bid process, construction is erroneously treated as an interchangeable commodity, as if one team is as good as any other. The small savings gained with this tactic disappears if the general contractor lacks the experience or sophistication for the project, or if the team doesn't work well together, doesn't share ownership towards the project goals, or feels resentful at being forced to low-bid a project at a possible loss."

It is also best to work with those who have experience with integrated design and delivery projects and who have worked together before. However, because relatively few individuals have that experience, the owner might have to weigh candidates' capacity to work in an integrated fashion. The owner could engage a trusted builder first and then work to find an architecture firm that's complementary, or vice versa.

Leading Integrated Project Delivery expert, Howard Ashcraft, compares creating an integrated team to a corporate merger (Ashcraft 2011). In a successful merger, members from different firms create a single organization with a common culture that reflects their beliefs and values. Choosing team members or partnering with firms with which the owner has a strong confidence in their ability to work collaboratively helps ensure cultures are complementary rather than antagonistic. It may be in the owner's interest to engage the subcontractor and key trades to provide accurate cost and constructability feedback to the architect.

Select all partners based on quality. Work with those you know if you can, but if you do choose new partners:

- **select for competency and capacity,**
- **prefer team members with an interest in collaboration, and**
- **engage the contractor and key trades as early as possible.**

Selecting the Team: In the Interview

If it is not possible to select a firm with which one already has established rapport, the selection should be based on the prospective firm's capacity to adjust to a new system, its demonstrated ability to adapt to and commit to a culture of collaboration, and experience it has had with Lean design and construction, or integrated design. The owner should beware of candidates who claim that integration is "in their DNA" or that "they have always worked that way," because that suggests a misunderstanding about the extent to which an integrated design and delivery process differs from the conventional model. A track record of sustainable design performance, such as applying the American Institute of Architects' 2030 Commitment, also helps differentiate teams interested in valuing final outcomes.

Key Points in interviewing:

- **Interview teams rather than individual firms.**
- **Make selections based on an individual firm's prior experience.**
- **Probe claims. Ask, "How did you collaborate differently on that project than on others?"**

Overcoming the Learning Curve: Managing the Team

The owner must be willing to participate actively and engage all the way through construction; committing to the process and reinforcing the notion that collaboration and early alignment really is a requirement for the project. Even after design, it is essential to have someone representing the owner onsite to make decisions about construction. Owners typically report that integrated projects require more of their time, but that the additional time is worth it in the end (Ashcraft 2013). Furthermore, the added time is often a different kind of engagement that is intellectually stimulating and fulfilling, rather than time spent simply fighting battles (see the Mosaic Center case study, p. 60).

The owner will have to be clear about expectations while also being open to being challenged by the group. This may allow the team to fulfill needs that go beyond the owner's expectations. Whoever is the internal champion for integrative design and delivery within the owner organization may have to overcome significant management resistance. In tough economic times, executive managers can push hard for low-bid procurement and may be hesitant to try a new approach. By referencing successful projects and demonstrating effectiveness in practice, the internal champion can get beyond this resistance. However, as mentioned in step 1 above, aligning the organization internally and defining clear decision pathways before pursuing an integrated project will help to prevent those problems in the first place.

Key Points in being a successful manager:

- **Integrated design and delivery is not a spectator sport: How fully is your organization ready to engage in the process?**
- **Being clear about expectations is of even greater importance in performance-based contracts.**
- **Ensuring internal alignment helps avoid managerial resistance.**

Utilizing BIM

BIM models can be very useful during post-construction if they have been created with that use in mind. Thus, the owner needs to plan and communicate to the design team how he/she might use these 3-D, data-rich models to improve operations and maintenance once the building is constructed. Some of these uses might include transferring the as-built data into the facility management system, running ongoing analysis of operational capabilities, or using the models to support future renovations. This would require specifying requirements for interoperability and an as-built model up front. For an easy reference, the owner should look for BIM programs that have been verified compliant with the Construction Operations Building Information Exchange (COBIE).

Key Points:

- **Decide early on if and how you might want to use a 3-D, data-rich model of your building after occupancy.**
- **Specify up front your requirements for interoperability.**
- **Consider including in the project requirements an accurate as-built model to be completed after construction.**

Building on Lean Practices

With the mantra of "maximizing value while minimizing waste," Lean design and construction practices encourage collaboration as a means to efficiency and provide an entry point into integrated design and delivery because of some of their overlapping principles. To that end, many Lean practices could be useful tools in an integrated project: The Last Planner® System consists of layers of increasingly detailed schedules that help create a more reliable production schedule during construction, created by "collaborative pull scheduling;" Just-in-time Delivery offers a system that minimizes materials waste and storage problems; and Root Cause Analysis offers a collaborative problem-solving tool. These tools and more may all be incorporated into the construction process, but a focus on early alignment and participatory input in early design is still needed to ensure that they are successful.

Examples of key Lean practices to implement:

- **Last Planner® System**
- **"Pull" planning and production**
- **Just-in-time Delivery**
- **Root Cause Analysis**

Guidance for **Manufacturers**

For the purposes of this Guide, the stakeholder category of manufacturers includes those who might participate in an integrated project in the capacity of a product development specialist or product representative.

Role to Play in an Integrated Approach

In an integrated project, manufacturers may provide on-hand product knowledge to a design team to ensure complementary systems and cost-effective solutions for healthy and sustainable materials use. That expertise could save hours of research for the design and specification team. In some cases, the manufacturer's expertise could enable a product or product system to be enhanced, based on the needs of the project. Since integrated teams are also better positioned to utilize prefabrication services, the manufacturer may have the competitive edge in this market that promises to shift a larger percentage of the construction budget to manufacturers. More widely, the practice of involving manufacturers in a design process would provide market feedback that might be useful for product innovations.

For integrated projects, manufacturer participation offers:

- **on-hand building science and product knowledge,**
- **input on how systems will integrate together, and**
- **the ability for products to be designed and enhanced to meet project needs.**

Opportunities

The integrated design and delivery process offers an opportunity to establish a closer relationship with owners and to understand their product needs. As part of the team, the manufacturer will be called upon to share his product knowledge, as well as to sell complementary products as integrated systems. For example, the company Tremco has led the way in this area with its Proglaze Engineered Transition Assembly System, which markets sealants, membranes, primers, and flashings (all its own products) compatible with insulation and sheathings of other manufacturers as one, integrated, whole product (Yost and Atlee 2012). The details are backed with extensive research to ensure compatibility for optimal energy savings and moisture management, which is likely to appeal to integrated teams who understand the importance of each part working together as a complete system. The effort also saves architects, specifiers, general contractors, and trade subcontractors the time and research they would usually put into figuring out how the assembly would best perform—a service that owners are currently likely willing to pay a premium for and eventually might grow to expect.

Integrated projects provide manufacturers with:

- **a closer relationship with owners—the ability to understand their needs and build relationships,**
- **opportunity to share building science knowledge and contribute to a higher-performing building, and**
- **a chance to sell products as they are intended—as a part of integrated systems.**

> **"Owners are getting smarter about Lean and IPD and requiring that expertise more and more to participate in the project. If we weren't going down this path, we would be excluded from the market."**
>
> – Robert Tibbling, Assa Abloy

Selling One's Expertise

As of yet, very few projects have been proactive in bringing product representatives on board early in design, so the role one might play in integrated design and delivery will depend on his ability to make the case for his involvement. Some of the arguments that might be appealing to the project team revolve around having added product knowledge at the table. Manufacturers can help engineers choose complementary systems, help specifiers weigh performance statistics, and help owners get more value for their money. Once a project is completed successfully, partnerships develop and it is easier to rely on demonstrated value.

Having deep product knowledge at the table helps the design team:

- **choose complementary systems,**
- **weigh performance stats, and**
- **achieve more value for the cost.**

Supporting BIM

Providing high-quality, data-rich 3-D objects for use in BIM can increase a product's chance of being specified and reduce the risk of being substituted out. These objects should be visually appealing, for rendering purposes, technically precise, and include data in open-formats for use in quantity take-offs (i.e., a detailed estimate of the materials and labor to complete a construction project) and simulations—for example, finish materials must have accurate light reflectance characteristics for use in daylight modeling, and envelope materials must include thermal characteristics, such as heat transfer and storage (*AEC Magazine* 2013). Products must also be complementary to the use of BIM by operations and maintenance staff, allowing the ability to capture in-operation data that can be entered into the model.

Key Points:

- **Provide data-rich 3-D objects for designers to place in their model.**
- **Support high-performance green goals by including performance data for simulations and data aggregation.**

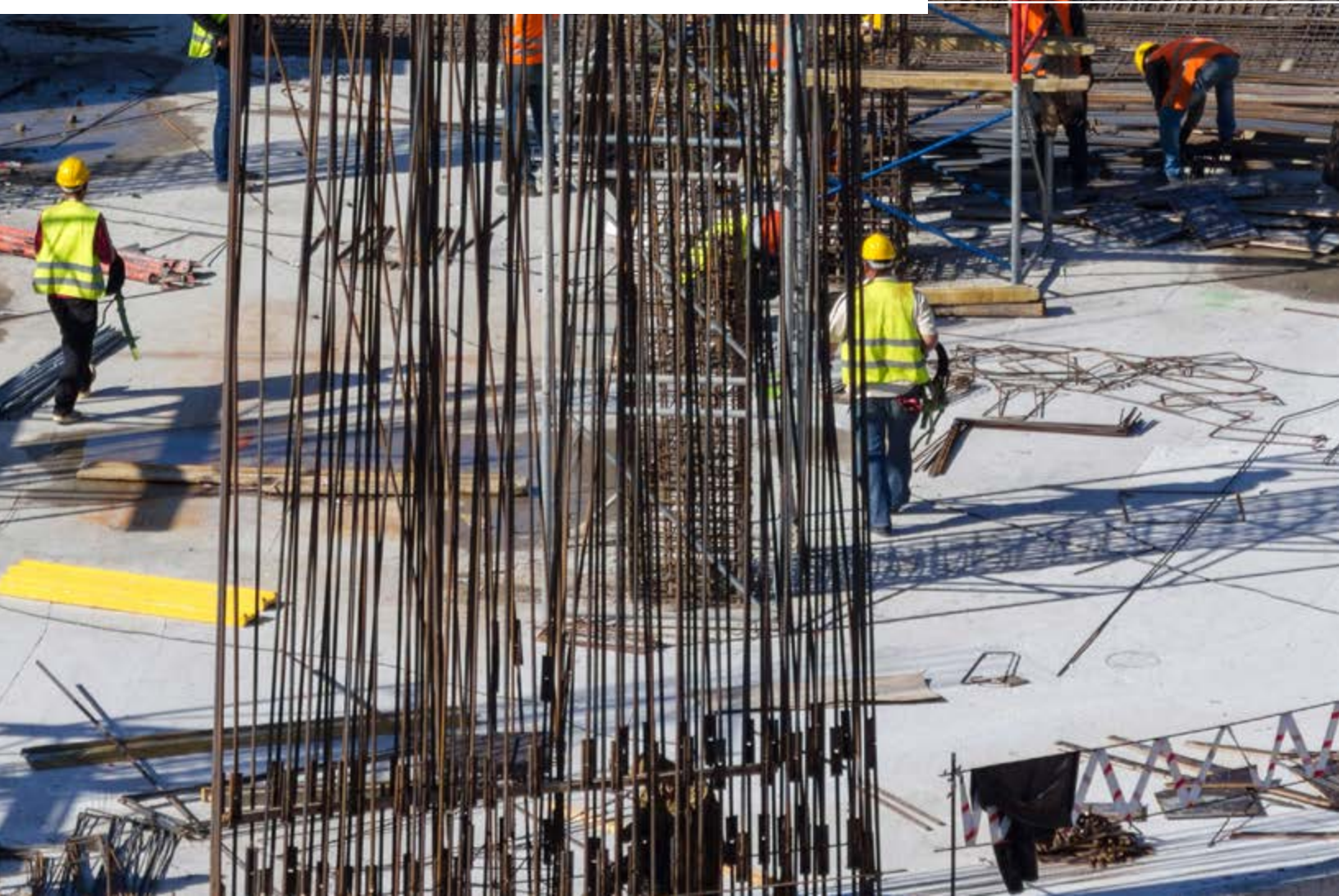
Building on Lean Practices

With the mantra of "maximizing value while minimizing waste," Lean design and construction practices encourage collaboration as a means to increase efficiency and provide an entry point into integrated design and delivery because of some of their overlapping principles. They also support the efficient use of materials, which is an important sustainability objective. In construction, typically the entity purchasing products, the entity installing the products, and the entity responsible for waste disposal are often entirely different companies, so waste occurs in the hand-offs. An integrated approach can optimize these activities by applying certain Lean practices related to products, like Just-in-time Delivery, or taking more responsibility in other stages of construction, like committing suppliers to take back construction waste.

Examples of key Lean practices to implement:

- **Lean practices, as applied to construction, can play an important role in delivery of supplies, e.g., Just-in-time Delivery.**
- **The aim of "maximizing value while minimizing waste" encourages collaboration throughout the delivery process.**

Guidance for **Trades**



For the purposes of this Guide, "tradespeople" are defined as those who create, assemble, and install the elements that become a building. The final outcome of any project often relies on them.

Role to Play in an Integrated Approach

One of the main principles of integrated design and delivery is to involve the trades early in the design process in order to ensure that construction documents are complete, changes that might improve installation and maintenance are identified, and that all tradespeople begin construction with a full understanding of the systems they are asked to install. This is particularly necessary on green projects, where systems are carefully detailed for optimum performance and new technologies may be implemented. Having that feedback also reduces change orders and delays once the project moves into construction, which ultimately cuts costs (case study: Barus and Holley Hall, Prince Laboratory, p. 54). Not only does a greater understanding of design decisions help ensure that building features will be installed and assembled as intended, but the input that tradespeople can offer during design will help ensure that project documents are complete and avoid problems during construction.

Experienced, involved tradespeople can:

- **Offer design input using knowledge about how systems are installed.**
- **Provide input on constructability and installation processes.**
- **Remain vigilant to quality throughout construction to ensure green and other performance goals are achieved.**
- **Minimize change orders and delays once construction begins.**

The Trades Already Know the Value of Early Involvement

Many tradespeople are familiar with looking at architectural drawings and will know if they won't work or that they lack detail. These errors or omissions also lead to rework, for which the trades are held accountable. A study found that the estimated cost of rework typically accounts for 7 to 11 percent of total construction costs and frequently causes delays (Zach 2013). Those numbers do not include flawed installations that are not reworked. Any slight penetration of a critical barrier, or a valve installed upside down, can cause the most expensive system to underperform and, in the case of a green building, might cause the whole building to fall short of its performance goals.

Selling One's Expertise

Although early trade involvement is critical, the owner or general contractor may be hesitant to pay for the "extra" time. Tradespeople may have to make the case for their early involvement by demonstrating the value they bring to the table. In such cases it is helpful to emphasize experience in any project management or facilitation training that would be valuable in fostering coordination and communication between different trade groups. Those skills demonstrate an ability to act in a collaborative fashion. An owner or contractor pursuing integrated projects is also likely to be interested in performance testing skills, since it is increasingly common for the trades to test the performance of the systems they install, even before commissioning (CEC 2013).

> **"We kind of laugh at the integrative design process, because we've known all along that we are the ones that make it work—the drawings don't make it work. It's best to get us involved as early as possible."**
>
> – John Sullivan, UA Plumbers Local Union No. 1

The Integrated Building and Construction Solutions (IBACOS) sample "High Performance Scopes of Work" (Yost 2010) offers performance testing checklists that are sequentially linked to ensure that nothing gets missed in the handoffs between trades, and that can be a powerful tool for enhanced coordination. Those checklists are relevant to contractors working in residential foundation, framing, windows, drainage plane, air sealing and insulation, and heating, ventilation, and air conditioning (HVAC).

Exceptional expertise that you as a tradesperson might offer a project:

- **Emphasize any project management or facilitation training.**
- **Offer performance testing before commissioning process.**

Building on Lean Practices

With the mantra of "maximizing value while minimizing waste," Lean design and construction practices encourage collaboration as a means to efficiency and provide an entry point into integrated design and delivery because of some of their overlapping principles. They also support the efficient use of materials, which is an important sustainability objective. To that end, many Lean practices could be useful tools in an integrated project: The Last Planner® System consists of layers of increasingly detailed schedules that help effect a more reliable production schedule during construction, created by "collaborative pull scheduling;" Just-in-time Delivery offers a system that minimizes materials waste and storage problems; and Root Cause Analysis offers a collaborative problem-solving tool. These tools and more may all be incorporated into the construction process, but a focus on early alignment and participatory input in early design are still needed to ensure that they are successful.

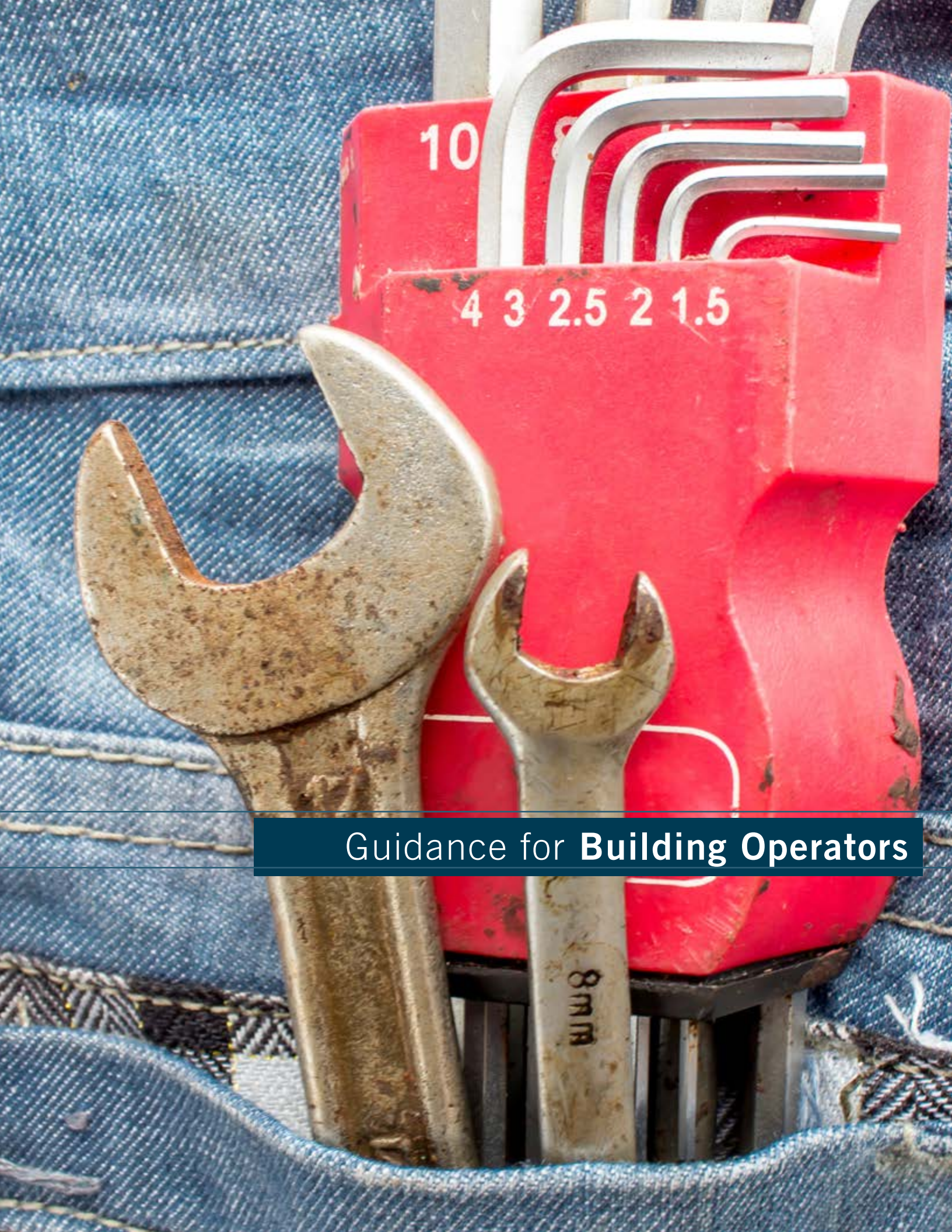
Examples of key Lean practices to implement:

- **Last Planner® System**
- **"Pull" planning and production**
- **Just-in-time Delivery**
- **Root cause analysis ("5 Whys Analysis")**

Tools to Manage Obstacles

Integrated design and delivery will not prevent all possible obstacles and project-specific challenges that may arise, but it will help teams find solutions collaboratively without grinding to a halt. Lean construction offers some tools for managing obstacles, getting to the root of a problem, and finding the right person to find a solution. The "5 Whys Analysis" technique helps a team find the reasons for a problem by formulating a "why" question five times in response to each answer. This may be particularly useful to help identify who should be involved in finding a solution, since so many players have had a stake in the project by the time construction begins. (A short primer on the 5 Whys Analysis can be found at Six Sigma 2015.) Another tool, the "Constraint Log," helps keep track of challenges and holds certain players accountable for resolving a problem by a certain date. This ensures the project keeps moving forward, and that obstacles are resolved as they develop (Lean Construction Institute 2015).

- **5 Whys Analysis: The problem-solving technique used to dig for the root cause of a condition by asking "why" successively (at least five times) whenever a problem exists, in order to get beyond the apparent symptoms.**
- **Constraint Log: A list of constraints, with identification of an individual promising to resolve the item by an agreed-upon date. Typically developed during a review of the Six-Week Look-Ahead Plan when it is discovered that activities are not constraint-free.**



Guidance for **Building Operators**

For the purposes of this Guide, the category of "building operators" includes facility managers, superintendents, and custodians—those who are in charge of making the building function during occupancy.

Role to Play in an Integrated Approach

If included early in design, building operators can provide feedback about how occupants might react to certain design features, or offer recommendations for optimizing building operation and maintenance. At minimum, building operators will know more about the building they will manage and will carry knowledge of the project's values into occupancy. Building operators ultimately make sure that a building designed to be green actually has lower environmental impacts.

As an operator, take steps during the IDD process to prepare yourself for your future responsibilities:

- **Learn about the building you'll be held responsible for.**
- **Provide feedback about design features that might not work for occupants or that you think will be too difficult to manage.**
- **Ensure that the values defined in design, and any green performance goals those values have generated, extend into practice.**

Opportunities

Without proper tools, support and necessary resources to operate the systems well, green, high-performance buildings can underperform. For the operator, taking part in creating the building and ensuring that the building design enables efficient and simple maintenance will be highly beneficial when the project is finally completed. Understanding any decisions made on alternate concepts will help building operators understand how the building is supposed to function and what ends it achieves. Since integrated projects are based on values, operators will share in a sense of ownership for what the building does for the community or for the environment, which will help guide how the project lives after its construction.

As an operator, wouldn't you like to:

- **"be handed" a building and already know how it works?**
- **know that the approach to operations is being thought about early in design rather than when it is too late?**
- **be a part of creating a building you'll be responsible for?**

> **"Operations** [personnel] **have a right to be able to see their job as continually making a building better—not just making sure it runs."**
>
> – Barry Giles, BuildingWise

Selling One's Expertise

The value building operators could bring to early design is widely acknowledged by owners and architects. Owners typically want their operators involved because, as people who are familiar with the organization and its functional demands, they can represent the owner's needs. Architects also appreciate operators' involvement because the building is much more likely to perform well when the operators fully understand the building's design features, and this in turn makes the design team look good. These benefits put the building operator in a strong bargaining position. The team may be willing to adjust their meeting times to accommodate operators' busy work schedules, for example (case study: Barus and Holley, Brown University, p. 54)

Particular expertise that you as the operator can offer a project:

- **Only you can provide practical feedback on occupant behavior.**
- **As the person in charge of the building, it is especially important for you to know its features and how it is supposed to perform.**

Utilizing BIM

BIM models can be very useful to utilize during occupancy if they have been created with that use in mind. A study conducted by the US National Institute of Standards and Technology estimated that US$0.23 per square foot of managed facility space is wasted by owners and operators each year (Gallaher 2004). Reasons could include warranty repairs done at the owner's expense, the labor involved in filling out Computerized Maintenance Management System databases, or the labor expended in researching existing conditions. A BIM program designed specifically for building operators can automate the creation of equipment inventory lists, populate facility management systems, and reduce redundancy in the maintenance data. This will allow building operators to focus on pre-emptive maintenance and optimizing of systems, instead of "putting out fires."

However, a design team might not build BIM models for that capacity if the intent to use the program post-construction is not expressed. Building operators should decide on and communicate to the design team the way they might use these 3-D, data-rich models to improve operations and maintenance. Some of these uses might include transferring the as-built data into the Facility Management System, running ongoing analysis of operational capabilities, or using the models to support future renovations. This would require specifying requirements for interoperability and an as-built model up front. A good start is to look for BIM programs that have been verified compliant with the Construction Operations Building Information Exchange (COBIE).

Key Point:

- **If a BIM model will be used to manage the building, make sure the model is built to support that function.**

Tools to Manage Obstacles

Integrated design and delivery will not prevent all possible obstacles and project-specific challenges that may arise, but it will help find the right solutions, even if construction is already complete. As mentioned in step 3 of this Guide, integrated project teams are often linked in a risk and reward structure in which their payment is tied to the fulfillment of performance goals. The owner can still hold the project team responsible for resolving issues the building operator may find, such as a malfunctioning system or a building that is falling short on its green performance targets.

If those problems do arise, Lean construction offers tools to help find solutions. The "5 Whys Analysis" technique helps a team find the reasons for a problem by formulating a question five times in response to each answer. This may be particularly useful to help identify who should be involved in finding a solution, since so many players have had a stake in the project by the time construction begins. Another tool, the "Constraint Log," helps keep track of challenges and holds certain players accountable for resolving a problem by a certain date. This ensures progress is made and that issues are resolved as quickly as possible (Lean Construction Institute 2015).

- **5 Whys Analysis: The problem-solving technique used to dig for the root cause of a condition by asking "why" successively (at least five times) whenever a problem exists, in order to get beyond the apparent symptoms.**
- **Constraint Log: A list of constraints, with identification of an individual promising to resolve each item by an agreed-upon date. Typically developed during a review of the Six-Week Look-Ahead Plan when it is discovered that activities are not constraint-free.**

Guidance for **Financial Professionals**

For the purposes of this Guide, the financial professionals sector includes those responsible for the evaluation, transactions, and financing of real estate, including investors, realtors, appraisers, and lenders.

Role to Play in an Integrated Approach

Integrated projects have much to gain by including parties from the financial sector in early alignment workshops. If implemented more often, involving financiers in integrated design and delivery might drive new financing models tailored to the approach's higher upfront costs and lower embedded risk. The role of financial professionals in an integrated approach is to learn about the new business models in order to understand the risk and reward structures. Being included in the design stage also gives financial professionals a broad understanding of a specific project's green design features and potential savings from operations costs.

Including financial professions early in the process is a benefit. They:

- **Better understand how an integrated process affects risk.**
- **Facilitate early upfront investment.**
- **Recognize increased value of integrated projects in appraisals.**

Opportunities

For the financial industry, integrated design and delivery projects may appear risky, but there are some compelling reasons why financial professionals should be paying attention to integrated design and delivery projects. If projects implement the collaborative risk and reward structures into their contracts, the chance of litigation is greatly reduced. Based on available case studies, projects that follow the process are more likely successfully to come in on schedule and under budget (Ashcraft 2013) and achieve a green, high-performance building, which, in appraisals and loans, is increasingly recognized as a value. However, these opportunities will only be translated into the finance world if financial professionals can attest to these outcomes from direct experience.

New is usually risky, right? Not in this case:

- **Get a better understanding of the value of a property, including how green performance and certification can enhance that value.**
- **Make educated decisions about risk.**
- **Mitigate long-term resiliency issues that might put investments at risk.**

> **"The finance people need to be brought into the story so that they begin to understand why this** [integrated design and delivery] **is a good investment."** – Chrissa Pagitsas, Fannie Mae Multifamily

Selling One's Expertise

Most likely, a project team will approach financial professionals because of the benefits that the owner has to gain. Benefits include receiving better terms, based on a fuller understanding of how design decisions are expected to affect operational savings; and improved financial decision-making, by better integrating sustainability factors at each step of financing. Even if involved on the periphery of the project, financial professionals will take away just as much from the alignment process as those in the project team.

Get involved! Sell your expertise:

- **Argue that you might be able to offer better terms if you understand design decisions and projected savings.**
- **Explain that financiers have to incorporate sustainability at each financing step, and so, if that is a driving value of the project, one needs to be aware of it.**

Overcoming the Learning Curve

Mastering the terms and language of integrated design and delivery is essential, especially because "integrated finance" has different meanings from "integrated design and delivery." A glossary is included in this report, and case studies offer a view into how these ideas are applied. It is important to understand that project teams also need time to adjust to an integrated design and delivery approach. Case studies show that after successfully completing a first integrated project, a team will become successively much more efficient and skilled at delivering high-performance projects cost-effectively (case study: Lion's Gate Wastewater Treatment Plant, p. 59). For this reason, outcomes may vary from project to project at first, but as teams become more experienced and the approach is more widely adopted, real estate professionals may see a noticeable difference between projects that took an integrated approach and those that did not.

Key Points for financial professionals considering integrated construction projects:

- **Learn the language.**
- **Have patience: integrated teams produce more reliable results as they become more experienced.**

Guidance for **General Contractors**

> **People will still instinctively play the blame game, but in a true integrative process, teams have to take ownership of a problem. It's a matter of getting teams to function differently.** – Dave Kievet, Bolt Company

General contractors are responsible for the construction of a project. They typically subcontract out much of the work, while playing a management and coordination role.

Role to Play in an Integrated Approach

General contractors are usually responsible for completing a construction project on budget and on schedule. They manage the sequencing and integration of the trade subcontractors and support the work of the commissioning agent. In an integrated approach, the general contractor is usually selected early in design to provide cost and constructability input. It is important that the contractor engage in the alignment workshops in order to understand the expectations around collaborating during design and avoid change orders during construction.

As the project contractor, you have a vital role:

- **Provide cost and constructability input during design.**
- **Support owner and team values and goals throughout construction.**
- **Collaborate with the owner, architect, and engineer to solve problems.**

Opportunities

The current way of doing business often puts contractors in a tenuous position. In design-bid-build projects, contractors are given just a week or two to estimate the cost of a design that has taken thousands of man-hours to conceive. Then they are handed construction documents that are likely to have at least a few errors, omissions, or ambiguities. Addressing those problems takes time and money, which makes the owner unhappy. Then, contractors are liable for making sure that all the trades and subcontractors complete their tasks properly, though in many cases, there is no time or resources to communicate how their work is supposed to interact as a part of the larger system or to share the project's green goals.

Integrated design and delivery requires more upfront work from contractors during the design stage, but will save time and frustration down the line. Having been involved from the outset in the alignment and design workshops, contractors can ensure that the construction documents include the level of detail they will need and they develop a full understanding of the project's scope and design for when construction begins. This preparation work prevents change orders and delays and saves time usually set aside for the bidding process. Contractors can also advocate for the early involvement of the trades, which will reduce the risk of installation mistakes, therefore lowering the contractor's liability.

Appreciate the differences IDD makes from design-bid-build construction:

- **Collaborate in the creation of construction documents that are actually sufficient for construction.**
- **Face fewer change orders and delays.**
- **Feel confident that subcontractors and trades are all on the same page.**

Initiating an Integrated Project

Integrated design and delivery is sometimes viewed as an owner-driven process, but increasingly contractors are initiating an integrated approach. Some contractors who have developed a reputation built around Lean construction now market a specialty in integrated design too. Pitching those services as common practice to owners could help educate them about the potential benefits. In an integrated design and delivery approach, contractor selection is based on qualifications and collaboration skills (just as for the architect), rather than on the ability to deliver the project at lowest cost. The model recognizes that bids are often just a best guess, based on sparse information that does not take into account the many factors that could influence construction. In order for the entire team to jointly agree on the project goals, scope, and target cost, the owner needs to select a contractor that it trusts can deliver the best value—not one that picks the lowest number. That means owners who understand this concept will likely welcome the contractor (especially one they've used before) proposing a new way to go forward with a project.

An example of a contractor-initiated integrated project is the Mosaic Center case study (p. 60).

Key Points for a contractor contemplating initiating an integrated approach:

- **Integrated design and delivery is sometimes viewed as an owner-driven process, but it does not have to be.**
- **Approach owners with whom you have a positive, long-lasting relationship.**
- **Demonstrate the value of selecting the contractor for quality and potential instead of for lowest-cost bids.**

Selecting the Team

The success of an integrated project is highly dependent on the caliber of the team. For that reason, the architect will have a vested interest in the other parties that are selected for the team. The contractor can suggest to the owner that he or she ask for proposals from pre-assembled teams of firms, instead of individual parties. That would allow the contractor to submit a proposal with an architect with whom the contractor already has a good working relationship.

Leading Integrated Project Delivery expert Howard Ashcraft compares creating an integrated team to a corporate merger (Ashcraft 2011). In a successful merger, members from different firms created a single organization with a common culture that reflects their beliefs and values. Choosing team members or partnering with firms with which the owner has a strong working relationship helps ensure cultures are complementary rather than antagonistic.

If it is not possible for the contractor to advocate hiring a firm with which they already have an established rapport, the contractor would ideally select firms who have demonstrated an ability to adapt to a new system and make a strong commitment to a culture of collaboration. This applies to both a design partner and trade subcontractors. The same process that allowed the contractor to be selected based on quality and attitude rather than low-bid should also apply to the trades. Demonstrated creativity and persistence will go a long way to help team members who have not worked together before overcome the hurdles of an integrated project.

If you can, work with those you know or with whom you have done integrated design and delivery before. If you do choose new partners:

- **favor partners with competency and capacity, and**
- **prefer team members with an interest in collaboration.**

Selecting the Team: In the Interview

Contractors must demonstrate their capacity for collaboration, even without prior experience on an integrated design and delivery project. This can be demonstrated by emphasizing experience with Lean design and construction or integrated design, and by describing ways in which they adapted to projects that are more collaborative. It is useful to engage subcontractors and key trades at this stage, to receive the benefits of having accurate cost and constructability feedback and an aligned team going into construction.

Key Points in selecting the project team:

- **Carefully consider the individual's prior experience.**
- **Examine claims: Ask, "How did you collaborate differently on that project from on others?"**
- **Engage key trades as early as possible.**

Overcoming the Learning Curve: Co-learning and Joint Decisions

Existing case studies show that once a team successfully completes a first integrated project, it will become successively much more efficient on others (case study: Lion's Gate Wastewater Treatment Plant, p. 59). For the team members, adjusting from being "the expert" to being a "co-learner" will be possible only in an environment of collaboration, where suggestions and openness are encouraged. The contractor must foster a culture of collaboration and be persistent in engaging all participants. If all players stay committed through the full process, they will be much more efficient when working together again on the next project.

- **Teams that have done one or more integrated design project(s) are successively more efficient on others.**
- **Learning how to make joint decisions is a skill.**
- **Foster a spirit of collaboration by encouraging trade partners to speak up.**

Utilizing BIM

In 2012, the percentage of contractors using BIM surpassed that of architects, with 74 percent of firms doing so (Smart Market Report 2012). BIM software helps identify where ductwork would run into structural members and aids in visualizing the final components so that fewer errors and misunderstandings result. Models can also be used in the prefabrication of systems across various trades, which reduces labor onsite, increases quality, and creates a safer work environment. Timing and weather data layers in the model also enable the contractor to compare various sequencing options. BIM models can be used as a collaboration tool because they require a high degree of trust and communication between the contractor and the design team. At each iteration, where design features are added or changed, it is useful to run a clash detection scan and resolve issues with the team as they arise. During construction, the model should be maintained and act as an orientation point for subcontractors and trades.

Key Points in getting the most from BIM:

- **Use the model to support multi-trade prefabrication.**
- **Run clash detection scans concurrent with design iterations.**
- **Maintain modeling during construction.**

Building on Lean Practices

With the mantra of "maximizing value while minimizing waste," Lean design and construction practices encourage collaboration as a means to efficiency and provide an entry point into integrated design and delivery because of some of their overlapping principles. They also support the efficient use of materials, which is an important sustainability objective. To that end, many Lean practices could be useful tools in an integrated project: The Last Planner® System consists of layers of increasingly detailed schedules that help create a more reliable production schedule during construction, created by "collaborative pull scheduling"; Just-in-time Delivery offers a system that minimizes materials waste and storage problems; and Root Cause Analysis offers a collaborative problem-solving tool. These tools and more may all be incorporated into the construction process, but a focus on early alignment and participatory input in early design are still needed to ensure that they are successful.

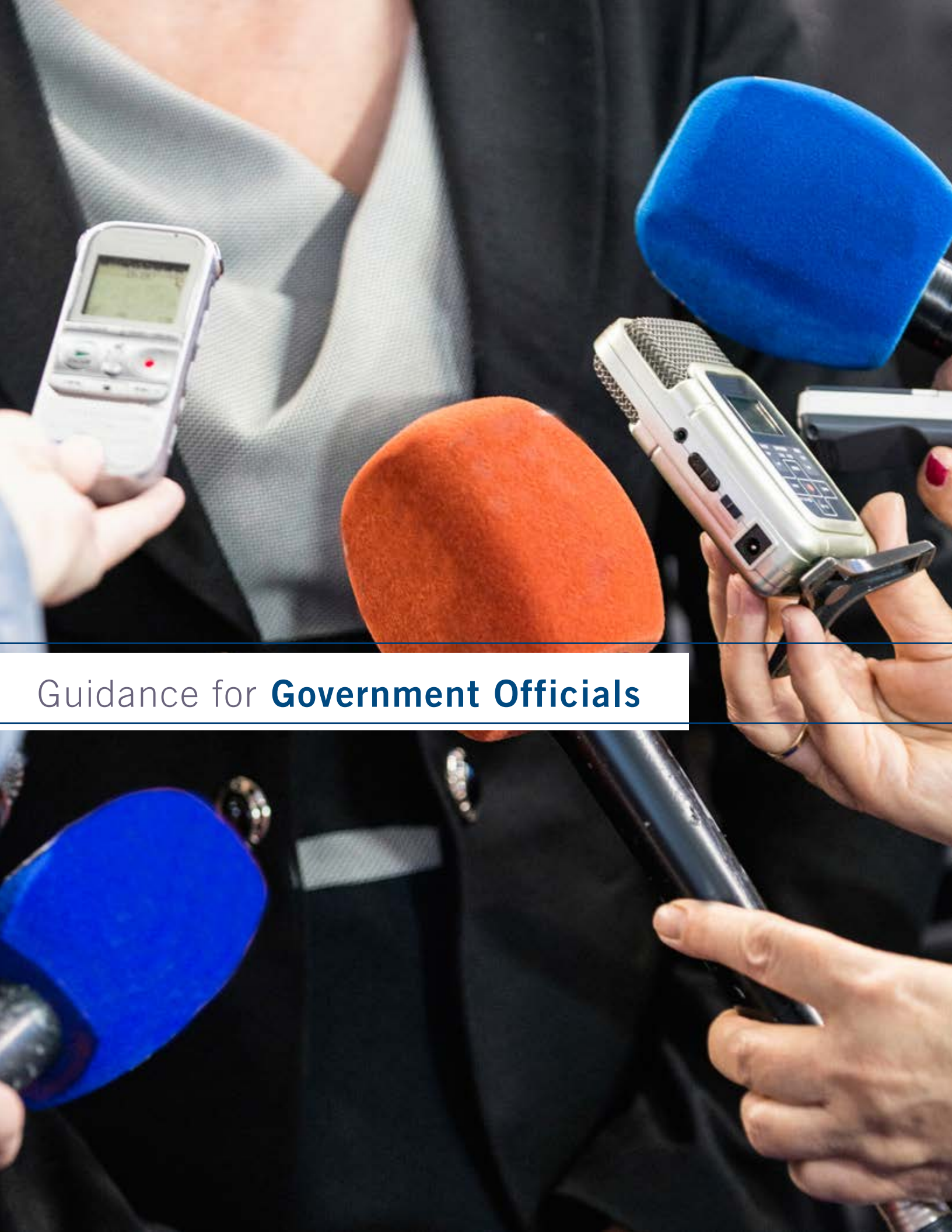
Examples of key Lean practices to implement:

- **Last Planner® System,**
- **"pull" planning and production,**
- **Just-in-time delivery, and**
- **Root Cause Analysis (the 5 Whys Analysis).**

Tools to Manage Obstacles

Integrated design and delivery will not prevent all possible obstacles and project-specific challenges that may arise, but it will help find solutions collaboratively even if construction is already complete. If those problems do arise, Lean construction offers tools to help find solutions. The "5 Whys Analysis" technique helps a team find the reasons for a problem by formulating a question five times in response to each answer. This may be particularly useful to help identify who should be involved in finding a solution, since so many players have had a stake in the project by the time construction begins. Another tool, the "Constraint Log," helps keep track of challenges and holds certain players accountable for resolving a problem by a certain date. This ensures progress is made and that issues are resolved as quickly as possible (Lean Construction Institute 2015).

- **5 Whys Analysis: The problem-solving technique used to dig for the root cause of a condition by asking "why" successively (at least five times) whenever a problem exists, in order to get beyond the apparent symptoms.**
- **Constraint Log: A list of constraints, with identification of an individual promising to resolve each item by an agreed-upon date. Typically developed during a review of the Six-Week Look-Ahead Plan, when it is discovered that activities are not constraint-free.**



Guidance for **Government Officials**

> **We are deceiving ourselves by saying that low-bid is how we deliver value, but in many ways we have been so bound by our contracts.**
>
> – Mark Palmer, City of San Francisco.

Government officials can engage with integrated projects in their roles as code officials, planning and zoning staff, and policy makers. Government agencies might also be owners seeking a method of procurement for a public project.

Role to Play in an Integrated Approach

Code officials and planning and zoning staff may be peripherally involved with integrated projects through the permitting process. In order to balance environmental performance and their public health and safety concerns, they need to have a deep understanding of the health and safety benefits of green features. Government agencies can also act as owners interested in integrated design and delivery approaches for their public works projects. Since most jurisdictions have policies that require contracts to be awarded based on the lowest bid, policy makers have a role in reforming that legislation. Adopting state or provincial versions of the Brooks Act or following Colorado's lead by adopting legislation similar to its Integrated Delivery Method for Public Project Act would greatly help remove these barriers.

Key Points:

- **Keep an open mind about the approach and remove policy barriers.**
- **Gain deeper understanding of how green building can positively affect health and safety.**

Opportunities

Public project owners might be interested in the value, cost, and schedule benefits that private owners are reporting from using integrated design and delivery approaches. As outlined in *Integrated Project Delivery: An Owner's Perspective*, multiple owners in projects of different scales have had projects come in ahead of schedule and under budget (Ashcraft 2013). For example, Bellevue Hospital in New York was completed three months early and cost US$30 million less than initial project estimates. Since the entire team's interests were aligned with the project goals, the outcome was more predictable, and the owner can be more confident of having gotten a project that meets its needs.

For code officials, integrated projects bring greater opportunities to provide input early and thus avoid what can sometimes devolve into adversarial relationships. When designers and builders know what potential issues they must navigate, they reduce the likelihood of being blindsided by a code issue after money and time has already been invested.

As one responsible for the public's health and welfare, officials might also find relevant the approach's potential to realize buildings that have less impact on the environment and that serve public health interests. The alignment process set out through this approach (steps 1 and 2 of this Guide) encourages the project team to think about all that a project has the capacity to achieve rather than make a checklist of a set of narrow goals. This opens the possibility for qualitative improvements. For example, the Sarah E. Goode Academy achieved LEED Gold even though it was programmed for LEED Silver (see case study, p. 63). As team members, officials can participate in setting the targets and benefit from creative and innovative input from the team.

Key Points:

- **Integrated design and delivery results in reduced costs, less waste, and compressed construction schedules.**
- **Increased value translates into public health benefits.**

Initiating an Integrated Project

Many government agencies require that construction projects engage in a competitive bidding process and select contractors based primarily on cost. Professional services, however, such as the architect's contract, are granted on a qualitative basis. This approach limits using one contract for both services unless granted by statutory authority. A committed agency might be able to find solutions to those limitations and incorporate at least some aspects of integrated design and delivery. Some alternative delivery methods, for example, might already provide one the statutory authority to incorporate IPD principles (Gehrig 2010):

1. **Design-Build Authority:** If an agency has design-build authority, then it is permitted to award a single contract for a contractor to design and construct the entire project. This allows the agency to bring trade contractors into design early and tie compensation to project outcomes.
2. **California's Infrastructure Finance Act (California Code §5956):** This applies only to fee-producing facilities, but gives broad authority to the agency for awarding a contract to do any combination of study, planning design, construction, development, financing, maintenance, improvements, repairs or operations. Rather than being selected based on lowest cost, teams are selected based on demonstrated competence and fees are determined by competitive negotiation.
3. **Lease/Lease-back:** This authority only applies to school districts or community college districts. The public agency leases land to a contractor and the contractor constructs the facilities and leases the building back to the agency until payments account for the costs of the project. In this arrangement, the agency is free to select a contractor on any basis.
4. **Energy Service Contracts:** These contracts allow public agencies to purchase electric or thermal energy, but can also apply to the renovation or construction of facilities using those services. This allows an agency to award a single contract for all phases.
5. **Public-Private Partnerships:** These contracts give public entities the option to contract with private companies to provide certain services, which can include design and construction. These are performance-based contracts, which help encourage integration.

These options may not allow the full incorporation of integrated design and delivery principles, but they allow profit to be tied to project performance, and most give authority to do a single contract. Alternatively, in the US, a project can always apply for a variance to contracting restrictions under the rationale that the project will be a pilot project for new processes (National Association 2010). This step might ultimately be important proof of concept for regulatory or statutory reform. Some public agencies are not subject to design-bid-build restrictions at all. These sometimes include local county water districts or transportation authorities. Furthermore, some states, including Colorado and Arizona, have adopted statutes that specifically give authority for IPD projects. If these options do not apply, it is still possible to incorporate the behavioral aspects of integrated design and delivery while making use of more traditional contracts (see Edith Green–Wendell Wyatt case study, p. 57).

Public projects are sometimes restricted to design-bid-build, but there are ways around. You might find some flexibility with:

- **certain agencies not subject to design-bid-build restrictions (county water districts, etc.),**
- **design-build,**
- **the Infrastructure Finance Act (CA),**
- **lease/lease-back, or**
- **energy service contracts.**

Guidance for **Engineers**

This category includes civil, electrical, mechanical, structural, and plumbing engineers—those typically responsible for the technical aspects of a project. Engineers focusing on other systems are addressed under "Specialty Consultants."

Role to Play in an Integrated Approach

Building engineers design the systems and are responsible for the technical aspects of a project. In an integrated project, these experts translate the expressed values of the project, such as sustainability, into systems that will achieve those aspirations. Engineers have to ensure that the components of a high-performance building integrate together well.

Key Responsibilities:

- **Integrate systems**
- **Translate values into high-performing systems**

Opportunities

Most engineers understand that deep collaboration with architectural designers is essential if the building's form is to fulfill its function. Integrated design and delivery allows engineers to work concurrently with the architects as strategies emerge. This is especially important for sustainability strategies, which often depend on efficient mechanical systems integrated into complementary envelope and structural designs.

Key Points:

- **Be on a level playing field with architectural designers.**
- **Work with the architects and contractors to achieve form meeting function.**
- **Collaboratively explore design options that can achieve high-performance green goals in cost-effective ways.**
- **Receive constructability input from the contractor and trades.**
- **Save the project money by passing schematics to the contractors and letting them work out the details in the shop drawings.**

Overcoming the Learning Curve: Co-learning and Joint Decisions

Integrated design and delivery has a steep learning curve, but from existing case studies it is clear that once a team successfully completes one integrated project, that team will become successively much more efficient on others (case study: Lion's Gate Wastewater Treatment Plant, p. 59). It is the engineer's role to foster a culture of collaboration and to be persistent in engaging all participants. For the team members, adjusting from being "the expert" to being a "co-learner" will only be possible in an environment of collaboration, where suggestions and openness are encouraged.

Key Points:

- **Teams that have done one or more truly integrated project(s) are likely to be successively more efficient on others.**
- **Learning how to make joint decisions is a skill.**
- **Fostering a spirit of collaboration requires active effort.**

> **“The engineer is responsible for roughly half of the sustainability features of the building. If there is a disjointed process between the architectural drawings and the engineering, then sustainability becomes much more of an add-on feature.”**
>
> – Peter Rumsey, Point Energy Innovations

Taking the Role of Educator

As seen in steps 1 and 2 of this Guide, integrated projects are structured to deliver on the values and goals that the project team establishes. If sustainability objectives are not discussed, the engineer might have to educate the team about those benefits. Associating green features with operational costs reduction and reduced time to market may help make sustainability part of the conversation. The authors of *The Integrative Design Guide to Green Building* (7group and Bill Reed 2009) suggest that discussing “nested systems” during step 2 of the Guide helps bring sustainability objectives to the surface. Examining how a project affects the primary systems within the whole of the environment—defined as habitat, water, energy, and materials—reveals the relationships between smaller and larger systems.

Key Points:

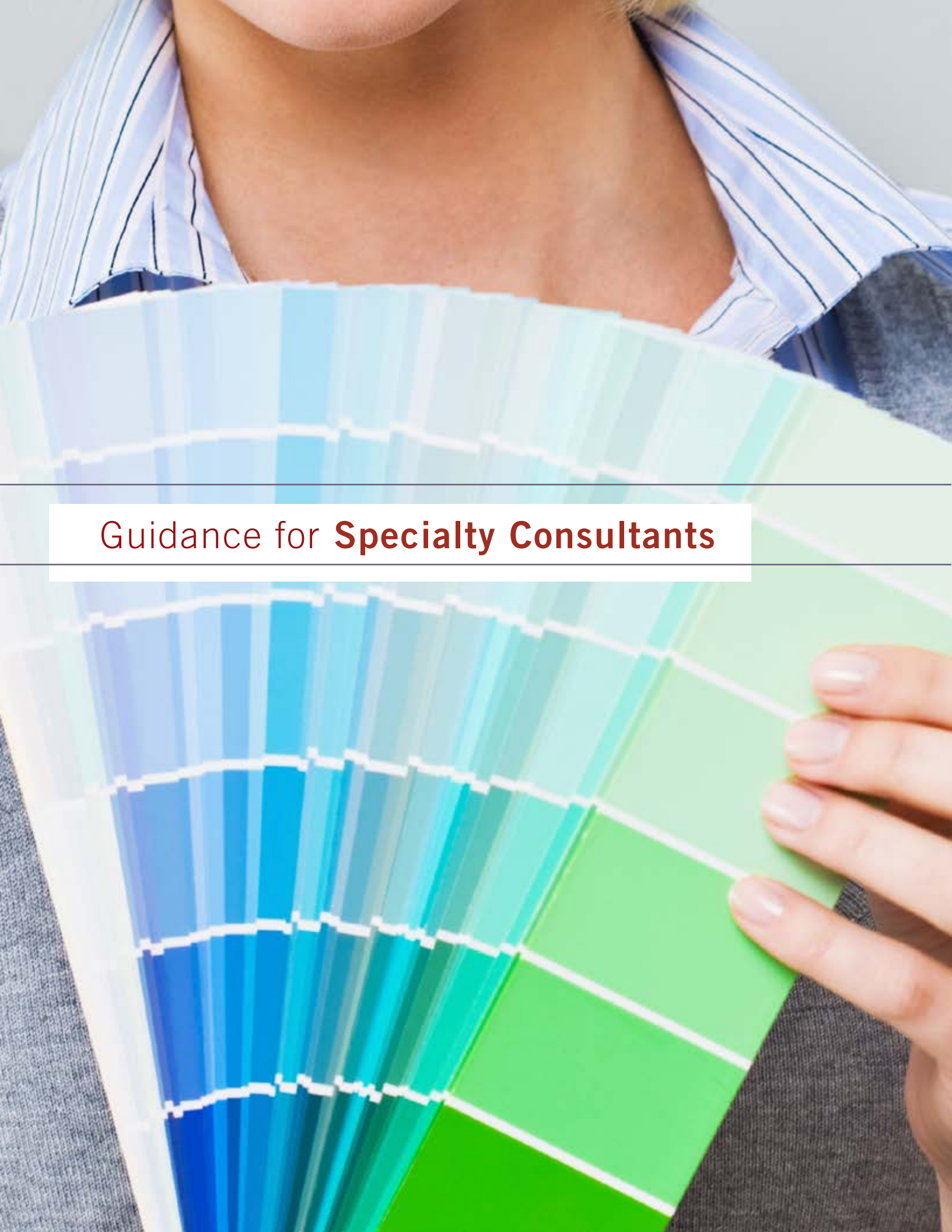
- **Integrated projects will only deliver on the values and goals that are expressed.**
- **If sustainability goals are not already a focus, you as the engineer might have to serve in the role of educator to bring those goals to the surface.**

Utilizing BIM

Over 67 percent of engineers used Building Information Modeling tools in 2012, according to a McGraw-Hill Construction report (Smart Market Report 2012), though adoption has lagged behind the rate of architects and contractors. This may be partly because data for technical systems is more rare and manufacturers are just beginning to provide information that is searchable and able to be indexed. Nevertheless, engineers who use BIM rate it as highly valuable (Smart Market Report 2012) and architects are beginning to demand those skills as part of team selection. Sharing BIM models brings the highest rewards by allowing for the seamless integration of systems and ensuring that systems get installed as intended. With the development of cloud-based open BIM, multiple users can access a BIM model and changes made will appear for the other users in real time.

Key Points:

- **Sharing a model with architects allows for seamless integration of systems.**
- **If developed appropriately, BIM can reduce the effort needed to simulate building performance, therefore allowing the team to iterate more rapidly through design options to achieve the most cost-effective and greenest solutions.**
- **Clash-detection features help ensure that systems get installed as designed.**



Guidance for **Specialty Consultants**

Specialty consultants are individuals and firms whose participation in a project depends on the project scope and the extent of need for their expertise: interior designers, landscape architects, energy consultants, enclosure consultants, lighting consultants, commissioning agents, cost estimators, etc. Other types of consultants that might fall into this category include: land-use planner, energy auditor/rater, envelope consultant, building forensics expert, acoustical engineer, habitat specialist, and audio/visual consultant.

Role to Play in an Integrated Approach

Specialty consultants can advise on any aspect of the building, or sometimes help facilitate coordination through the design and construction process. Although they each have an area of specialty, in an integrated approach they also provide added value by improving connections between systems. Depending on the breadth of their role and the goals of the project, a specialty consultant may need to be included in the same risk and reward structure as the architect and contractor.

Consultants Know the Importance of Integration

Consultants often understand the importance of early collaboration and alignment. In a project team, specialists are challenged to find ways to integrate their perspective into the design and to ensure that other building features support rather than thwart the integration of their work. This is done most easily during early design.

> **"I've been involved in meetings with the architect, owner, and contractor but it's more productive when everyone is around the table—structural engineer, mechanical engineer, etc."**
>
> – Andrew Dey, Andrew Dey Consulting, owner's representative and lender's agent.

Opportunities

Integrated design and delivery is not yet a perfect science. Project complexity—in terms of cost and technical detail—will govern the specifics of the process roadmap, the IPD contract type, and the extent to which the project can invest in helping the team overcome the learning barrier. Identifying the right approach at this stage most likely requires an independent facilitator, which may be a role the specialty consultant could learn to fill. Consultants for one specific aspect of the system, like the building enclosure or the daylighting strategy, are unlikely to be included in a shared risk and reward contract unless the project is very big and their role is deemed critical to the project's success. However, working directly and collaboratively with all parties will make their work much easier.

Key Points:

- **Projects may need an independent expert to facilitate choosing the right approach, which could be a new role for you to fill.**
- **If you're responsible for a specific aspect of the project, the collaborative environment will make your life easier because you can work directly with all parties, and be free to advocate for all the integrative elements that are needed to make the project successful.**

Taking the Role of Educator

As seen in steps 1 and 2 of this Guide, integrated projects are structured to deliver on the values and goals that the project team establishes. If sustainability objectives are not discussed in steps 1 and 2, the specialty consultant might have to educate the team about those benefits. Associating green features with operational cost reduction and reduced time to market may help make sustainability part of the conversation. The authors of *The Integrative Design Guide to Green Building* (7group and Bill Reed 2009) suggest that working with "nested systems," during step 2 helps bring sustainability objectives to the surface. Examining how a project affects the primary systems within the whole of the environment—defined as habitat, water, energy, and materials—reveals the relationships between smaller and larger systems.

Key Points:

- **Integrated projects will only deliver on the values and goals that are expressed.**
- **If sustainability goals are not already a focus, consultants might have to serve in the role of educator in order to bring those goals to the surface.**

Overcoming the Learning Curve: Co-learning and Joint Decisions

Integrated design and delivery has a steep learning curve, but from existing case studies it is clear that once a team successfully completes one integrated project, that team will be much more efficient on successive projects (case study: Lion's Gate Wastewater Treatment Plant, p. 59). It is the consultant's role to foster a culture of collaboration and to be persistent in engaging all participants. For the team members, adjusting from being "the expert" to being a "co-learner" will be possible only in an environment of collaboration, where suggestions and openness are encouraged.

Key Points:

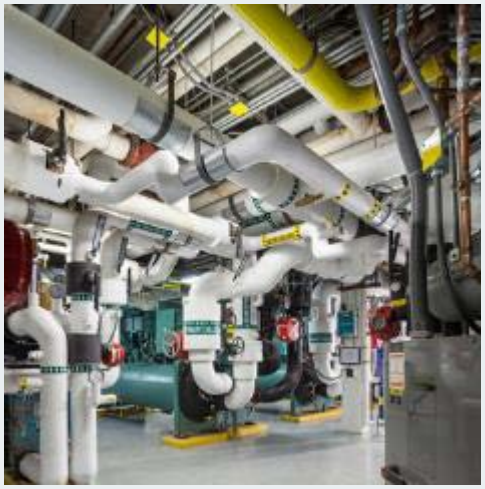
- **Learning how to make joint decisions is a skill.**
- **Fostering a spirit of collaboration is essential.**

Utilizing BIM

For specialty consultants like enclosure, lighting, or mechanical systems specialists, sharing BIM models brings the highest rewards, by allowing for the seamless integration of systems and ensuring that systems get installed as intended. With the development of cloud-based, open-source BIM, multiple users can access a BIM model and changes will appear for the other users in real time. For consultants facilitating an integrated approach, BIM can provide a tool for true collaboration early in design and orient a discussion about future expectations of facility management practices, which often get overlooked. Not only does the tool provide a picture of how intersecting systems will perform, it can become the basis for operations improvements or future renovations. If used for this purpose, the tool can give the design team a sense of continuity.

Key Points:

- **Sharing a model with the team allows for seamless integration of systems.**
- **If developed appropriately, BIM can reduce the effort needed to simulate building performance, therefore allowing the team to choose more rapidly among design options and achieve the most–cost-effective and greenest solutions.**
- **Use the software as a collaboration tool.**



Case Studies

Source: Brown University, Facilities Management

Barus and Holley Hall, Prince Laboratory Upgrade, Brown University

Location: Providence, Rhode Island
http://www.brown.edu/Facilities/Building_Brown/projects/bh/

When Brown University embarked on an upgrade of the Barus and Holley building—a seven-story laboratory, office, and classroom building that had largely gone unrenovated since it was built in 1965—its initial goals were mainly to fix what was broken. The project's priorities were to upgrade the mechanical systems, including installing a new fire alarm system, rehabilitating the elevators, converting the ventilation system to 100 percent outside air and incorporating heat recovery, replacing chiller plant and cooling towers, and replacing the electrical switchgear. However, the university chose this project to implement its very first Integrated Project Delivery contract, and the efficiency and collaboration of the team allowed for much deeper application of green retrofits. Brown University realized savings of US$1.2 million on a US$12 million project budget, which was applied to a thorough study of the inter-relationships between the mechanical systems and a highly technical analysis of the hot water system that will save water and energy for years to come.

> **"Having the subcontractors at the table during the initial phases, offering their input on the best way to construct, was by far the biggest contributor to our cost savings."**
>
> – Thomas Cousineau, project manager at Brown University

Because the team worked closely together it was able to identify creative ways to provide added sustainability value at no extra cost, such as installing energy recovery for toilet exhaust (which was simple because they were already doing so with the ventilation system) and replacing two old air handling units with just one and purchasing a spare motor for back-up. As the work progressed, team members also discovered issues that they could fix and, because they were incentivized to care about the project as a whole rather than just their scope of work, they were more willing to take on those easy fixes. For example, the team ended up replacing six leaking water riser valves and stopped leaks from a manhole into the adjacent Prince laboratory's electric room.

The biggest obstacle was getting the necessary approvals in a timely manner, according to Cousineau, so the team switched to having principals' meetings every two weeks. That worked well but reinforced the need for an active, engaged owner and responsive decision makers. At the start, the project strongly engaged the operations staff, "but it was difficult to keep them involved due to the frequency of meetings," says Cousineau. Eventually the team realized they could be more engaging by relating to the staff's own values. At this particular project, notes Cousineau, "the actual building occupants won't notice much of a change except perhaps in more reliable systems." The team realized that the operations staff people "were basically the owner, as the new equipment was really for them." Changing that message became a theme for the project.

Possibly because of the strong input from operations staff, the University decided to keep its share of savings within the project and invest in other, more long-term items. The project team's efficiency paid for spare paint jobs, revising the sequence of operations for the high-temperature hot water system, and a "cross-connection investigation" to understand the interrelationships between different systems for future work.

Overall, "though it took some effort to get everyone to understand the new contract and its ramifications," says Cousineau, in this case, "it is what allowed the team to truly collaborate. What had been one of the biggest energy hogs on campus is now a model of efficient systems."

Key integrated design and delivery strategies emphasized by the project team:

- **Gaining internal buy-in from management or board**
- **Holding a team goal-setting workshop, including key participants like the general contractor and trades**
- **Using a multi-party contract**
- **Having profits tied to performance**
- **Limited use of change orders**
- **Waived liability**
- **Achieving fiscal transparency**
- **Participation and training of operations and maintenance personnel**

Centro Internacional de Exposiciones y Convenciones WTC

Location: Mexico City, Federal District
http://www.exposwtc.com/

Source: México es cultura/La Cartelera nacional

The World Trade Center in Mexico City set some aggressively green goals from the beginning of its renovation discussions, especially for energy use and sustainable purchasing, hoping to achieve the impressive green certification of LEED Gold. Alignment and communication practices that the project team borrowed from integrated design and delivery helped the team reach those goals, according to Alejandra Cabrera, the director of *Sustentabilidad para México A.C.* (Sume), which assumed the role of project manager. In fact the project achieved certification in a matter of 18 months.

It was Cabrera's first time working on a project aiming to achieve LEED certification, and a project kick-off meeting, in which the whole team "set goals and duties" and made sure everyone knew their specific responsibilities, was invaluable. The entire team agreed to rules for going forward; every member was included in all communications, mail, and appointments having to do with the project, and a weekly check-in meeting was scheduled for "talking about the advances of the project, reporting on achievements, and giving the LEED AP the necessary project documentation." The team made sure to include the maintenance manager in the kick-off meeting discussion, and even though it was difficult to convince him to participate at first, Cabrera reports it was "worth every inch of stress." These steps might sound elementary but Cabrera argues that developing and forming an efficient team is essential to staying aligned and integrated throughout the whole process, instead of starting off strong and then fading or breaking apart as the project goes along.

Because the project team was agile and responsive to suggestions of each member, it was able to come up with some creative solutions to help update parts of the building that had been constructed 20 years ago. The team chose to waterproof the roof with a reflective, biodegradable membrane and, with input from Philips and Osram, procured low-mercury lamps. Without the efficiency achieved through integrated design and delivery principles, some of these green features likely would have been cut to keep costs down.

Key integrated design and delivery strategies emphasized by the project team:

- **Using a jointly developed process roadmap**
- **Participation and training of operations and maintenance personnel**

Edith Green–Wendell Wyatt Federal Building

Location: Portland, Oregon
http://gsa.gov/portal/content/252613

Source: US General Services Administration

The Edith Green–Wendell Wyatt building in Portland, Oregon, is LEED Platinum–certified, having been overhauled to achieve an expected 50 percent reduction in energy use compared to its performance pre-renovation. The project is also expected to reduce potable water use by 60 percent—primarily by using rainwater for flush fixtures. Those are amazing improvements, from an environmental perspective, that could not have been achieved without an extremely integrated team functioning at a high level.

To add another level of complexity, the building is a federal project that is subject to low-bid restrictions, eliminating the possibility of an integrated project delivery contract. So how was this team able to integrate and achieve such successful outcomes? Patrick Brunner, project manager for the US General Services Administration, proved that "where there is a will, there's a way." As a federal project, the project was required to use a Guaranteed Maximum Price structure. The contracting model that conformed to that structure while offering the most flexibility was a "Construction Manager as Constructor" model. Brunner spent extra time and effort interviewing those who responded to the Request for Proposals and tried to personally visit potential contractors and suppliers at their locations or went to see previous projects they had completed. Once the right team was assembled, Lisa Petterson, principal at SERA Architects, recalls that Brunner came in and said, "the contract can't do this, but let's all sign this one-page agreement as a working understanding of how we'll proceed." The team agreed on an open checkbook policy, for financial transparency, and then developed principles for acting collaboratively and making joint decisions.

One of the proactive steps they took as a part of this policy, according to Petterson, was that during construction the design field team was located in the same space as the general contractor. For subcontractors, "one of the biggest impediments to getting their job done is access to information." According to Petterson, the conventional process usually goes like this: the subcontractor has to figure out what's missing, write the Request for Information, get it to the contractor, who gets it to the architect, who passes it to the engineer, who goes to the supplier. "The whole process takes three and a half weeks, and that's if you understood the question."

So instead, the team maintained an "open door policy" during business hours, where anyone could ask questions. "That hurt our [short-term] productivity but helped our overall project delivery," says Petterson. As a result, this project had just 855 formal Requests for Information, compared to 6,000 on a typical similar project, and many times they were "just confirming information for the paper trail," says Petterson.

The collaborative environment also paid off because it allowed the project team to better adjust to unforeseen challenges. After pricing out the designed 2-foot-wide exterior sunshades, the material supplier made the suggestion that they could utilize the material more efficiently if the shades were narrowed to 18 inches. The architects went back to the drawing board and found that with a slight adjustment they could pull the shades away from the wall by 6 inches and get the shading they needed. "It only took us one day to figure out how to make that work," says SERA Architects Associate Principal Lisa Petterson, "and we saved the project millions of dollars."

Source: US General Services Administration

Another slight change of direction occurred when tenants began signing on after design was complete and demanded their own local server capacity. The project team had been intending to monitor and control the servers from a different location to maintain valuable usable space in the building [and to more easily reach energy use intensity (EUI) goals], but the tenants made their needs clear. According to Matthew Braun, project executive at Howard S. Wright (the project's general contractor), the team developed the solution to co-locate all the servers in the basement, rather than have them on every floor. This required gaining buy-in from the tenants since they had to pay more, but it allowed the team to maintain the building's original EUI goal because the centralized system enabled them to use heat recovery. A 100-ton heat recovery chiller now serves the server room and is big enough to accommodate future growth. "In a non-integrated team, the whole project would have been delayed while we figured out where and how we were going to locate and manage the servers," says Braun. Instead, they were able to add the entire system after all the original mechanical and electrical infrastructure had been installed, and the project moved along as planned.

The project team generated enough savings to pay for one more year of professional services, which they used for operations and maintenance training and extensive post-occupancy surveys—an added value that often gets left by the wayside. After a project that saw such success, Brunner argues that what's most important is a project team that "collectively believes in pushing to do something better." He sees the contract form "as a tool" and hopes that something like a three-party agreement can be developed for federal use, but "it will never be a silver bullet," he says. "It's the constant care and feeding and raising the bar—the constant forming, reforming, and storming—that make the magic."

Key integrated design and delivery strategies emphasized by the project team:

- **Gaining internal buy-in from the management or board**
- **Using an alignment workshop to tap into common values for the owner and team**
- **Holding a team goal-setting workshop, and including key participants like the general contractor and trades**
- **Using shared Building Information Modeling (BIM)**

Source: US General Services Administration

Lion's Gate Wastewater Treatment Plant

Credit: Miller Hull Partnership

Location: Vancouver, British Columbia
http://www.metrovancouver.org/lionsgate

The story of the Lion's Gate Wastewater Treatment Plant proves that input and iterative collaboration between multi-disciplinary experts can allow teams to find synergies that an individual would not discover by himself. When Metro Vancouver was required to upgrade its wastewater treatment plant to a secondary facility—one with much more advanced filtration requirements, necessitating an entire new facility to be built at a different location—the agency wanted to do so in a way that advanced its sustainability objectives of reducing energy costs, carbon footprint, potable water use, and environmental impact.

In pursuing an integrative design approach from the outset, the team produced a design that accommodates sewage heat recovery, and biogas generation, and reclaims water and nutrients—the result of a systems approach to water, energy, and nutrients ensuring that this plant will generate new resources from what is typically treated as waste. It's an exemplary model of how integrated teams driven by values can achieve higher levels of sustainability than a typical team can.

The agency had been watching the development of another wastewater plant, the Brightwater Treatment System in the Seattle area, which had also pursued an integrative process, and so Lion's Gate selected John Spencer, of CH2M Hill, who had been the project manager on the Seattle project, to serve as engineer. It also hired Bill Reed and John Boecker to facilitate the integrative process that had been described in the 2012 *Integrative Process (IP)–ANSI Consensus National Standard Guide* (Institute for Market Transformation to Sustainability 2012).

Their experience helped the team overcome some of the initial learning curve, and has kept the project on track in terms of cost; one good indication being that, to-date, Lion's Gate has had a total of just three contract amendments, while the Brightwater project amassed 42 within the first two years. Even so, the architecture and engineering teams still had some trouble communicating initially. The engineering team, especially, was eager to begin designing and had difficulty understanding why the specifics of a project were not being discussed even after three team workshops.

The project broke through that resistance when the architects realized that the engineers did not intend to use the whole site for the mechanical systems. They had been working hard to make the most efficient use of the space in order to give the architects more to work with. Similarly, the engineers were surprised to learn that the architects were willing to work within certain constraints and were not expecting the engineers to bury all the tanks or hide them away for purely aesthetic reasons. The key, according to the owner, was that the team had the discipline to push through the full alignment process and did not try to get rid of the facilitators after the first workshop. By trusting the process—and trusting itself—the team succeeded in reaching a deeper level of engagement itself, and greater potential for the facility.

The owner now plans to go forward with a design-build delivery model, using the schematic design that it says could not have been conceived otherwise and that has received wide acceptance with its operations and maintenance staff.

Key integrated design and delivery strategies emphasized by the project team:

- **Gaining internal buy-in from management or board**
- **Using an alignment workshop to tap into common values for the owner and team**
- **Using a jointly developed process roadmap**
- **Participation and training of operations and maintenance personnel**

Source: Mosaic Center, Dennis Cuku

Mosaic Center

Location: Edmonton, Alberta
http://themosaiccentre.ca/

Owners Dennis and Christy Cuku set extremely high green goals for their new office space in Edmonton, Alberta. Their aspirations included LEED Platinum, and being certified net-zero energy by the International Living Future Institute, and their integrated team will likely deliver what's needed for those ambitious green certifications.

But these achievements weren't always such a sure thing. Halfway through design, C$2 million already spent, and six months used primarily to "build the project culture" for their new office space, the two also decided to try a full Integrated Project Delivery contract. It was a risk to spend more money negotiating a new contract instead of proceeding with design but Howard Ashcraft, who managed negotiations of their contract, assured them "IPD retrofits" are actually quite common and often reach the same level of success as projects that use IPD from the outset.

It turned out that at that stage it was not too late for the project to benefit from the input that the contractor and consultants could provide. Adopting the contract forced the team to take a good look at how construction would actually proceed, and seeing that the design would probably run over budget, the design team "started taking out unnecessary nooks and crannies that the architect had originally specified," says Dennis Cuku.

The contract negotiations were also beneficial in supplementing team development and the goal setting that had already begun. The team had developed a vision of success, a list of project objectives, and a decision checklist, but the values matrix facilitated by Ashcraft "really empowered them to make decisions by weighing the outcomes against the six core values," says Cuku. "Once it was birthed, I didn't have to touch it anymore. That is the real value of the IPD process from an owner's perspective. You don't want to have to be onsite everyday, dealing with personality and design issues."

The team has been so effective and self-sufficient that the project is expected to come in five percent below budget and five months ahead of schedule, proving that integrated design and delivery is particularly effective at delivering green buildings within budget. But there are still things Cuku learned through the process. He wishes that he had included a few more people in the core IPD team, including some early key trades because there were some individuals who weren't totally aligned with the direction of the project and as a result were "difficult for the rest of the IPD team to accept into the project culture." To that point Cuku suggests, "I think there needs to be a personality checklist for choosing partners. This process is not for everybody. You have to be willing to collaborate and be part of a team."

Key integrated design and delivery strategies emphasized by the project team:

- **Gaining internal buy-in from management or board**
- **Using an alignment workshop to tap into common values for the owner and team**
- **Holding a team goal-setting workshop, and including key participants like the general contractor and trades**
- **Use of multi-party contracts**
- **Having profits tied to performance**
- **Limited use of change orders**
- **Waived liability**
- **Achieving fiscal transparency**

Rocky Mountain Institute Innovation Center

Location: Basalt, Colorado
http://www.rmi.org/rmi_innovation_center

Integrated design and delivery enabled the Rocky Mountain Institute (RMI) to push the boundaries of green with their Innovation Center in Basalt, Colorado. This project is striving to become one of the most energy-efficient buildings in the US and to invent completely new green building strategies in the process. Integrated design and delivery is helping RMI do that by building trust within the project team and opening opportunities to talk constructively about risk.

The innovation center is expected to achieve an energy use intensity of just 16 kBtu per square foot, partly due to a completely passive heating and cooling strategy—the only mechanical systems are for ventilation and localized backup heating. That's only possible in the coldest climate in the lower-48 states of the US by designing to "adaptive comfort" thresholds, which identify an expanded range of temperature set points for human comfort that takes into account all six factors that make humans feel hot or cold (air speed, air temperature, humidity, activity level, clothing level, and radiant surface temperature). Designing for a space that can fluctuate between 18 and 28 degrees Celsius, instead of 21 and 24 degrees Celsius, offers more possibilities for how a space can be built and enables the team to significantly downsize (or eliminate) mechanical systems, according to RMI's Chris McClurg, "but there is always the fear of what if it doesn't work?" Given that the space needed to work for the organization's growing numbers and the project team's profits were dependent on the final outcome of the whole project—not just on delivering their scope—the team "had to find a way to talk openly about that risk."


Source: ZGF Architects

RMI hired a consultant to facilitate the workshop for negotiating the IPD contract and make sure everything was clearly presented. Then they put strict processes in place to make sure the goals were clear and decisions would be communicated. The team set up a modified pull planning system for the design phase: setting up weekly consultant meetings to solve issues that arose. The design team was split geographically between Portland, Oregon, and Colorado, and looking back, without the constraints of that dual location, they might sometimes have fallen back to a more conventional way of working, says Kathy Berg, of ZGF Architects. But the group continued to have more conversations about how they wanted to engage differently and "'let's be more IPD' became a kind of code phrase for acting more collaboratively," says Cara Carmichael, the project manager at RMI.

With an effective process in place, the team developed the trust necessary to handle the risks that accompany innovation. The team completely rethought past heating and cooling strategies, according to John Breshears, president of Architectural Applications. Instead of worrying about the whole space, the team focused on passively heating and cooling just the most highly occupied zones; each person will have their own Hyperchair, a desk chair that provides heating and cooling directly to its occupant.

Source: ZGF Architects

Another design decision that the team attributed to their integrated process is the use of cross-laminated timber (CLT). The project had constraints balancing the budget versus the building height and CLT helped keep a high floor-to-floor height for maximizing daylighting while allowing for distributed mechanical systems. "Having the contractor there helped us understand how CLT could help shorten our scheduling, since much of the material is prefabricated," says Breshears. And, using this material, the design team determined that they could use straight stairs without landings, saving valuable floor space.

In addition to all the tangible outcomes from pursuing an integrated process, the collaborative work environment affected the project team on a personal level, too. "In a very good way, this has been one of the most frustrating projects I have ever worked on," says Berg. "We constantly had to ask ourselves 'Are we trying hard enough?'"

"We built such open relationships," says McClurg. "I wish we could do it all again. How many people can say that about a project they've worked on?"

Key integrated design and delivery strategies emphasized by the project team:

- **Using an alignment workshop to tap into common values for the owner and team**
- **Holding a team goal-setting workshop, and including key participants like the general contractor and trades**
- **Use of multi-party contracts**
- **Having profits tied to performance**
- **Limited use of change orders**
- **Waived liability**
- **Achieving fiscal transparency**
- **Using shared Building Information Modeling (BIM)**
- **Lean project management**

Sarah E. Goode STEM Academy

Location: Chicago, Illinois
http://goodestemacademy.org/

The Sarah E. Goode STEM Academy of the Chicago Public Schools (CPS) will use much less energy and let much more daylight into its classrooms solely because of the influence of an integrated team. This unique project serves as a direct comparison to a conventional process, showing that integration improves green outcomes when sustainability is an expressed project goal.

The design process for the new Sarah E. Goode began with a prototype that prescribed much of the design: the site plan, building massing, structure, and orientation, programmatic adjacencies, and elevations. Despite these narrow constraints, CPS and the Public Building Commission of Chicago (PBC), which manages project development for CPS and other city agencies, wanted the project to achieve LEED Silver certification. Luckily, PBC includes an eco-charrette as part of their standard process, and sustainability consultant Helen J. Kessler, of HJKessler Associates, and PBC sustainability manager Deeta Bernstein used that opportunity to introduce the principles of integrative design and explore design options.

Their stated goal was to improve energy performance while lowering first cost and providing a good learning environment for the students. Using the mantra from the 2012 *Integrative Process (IP)–ANSI Consensus National Standard Guide* (Institute for Market Transformation to Sustainability 2012), "Everybody Engaging Every Issue Early," Kessler helped the team focus on the relationships among systems, using an holistic, iterative, non-linear process. She challenged the team to think outside the box by asking, "How can we improve on the performance of the prototype without changing the floor plan or the location on the site?" Several core goals came out of the discussion: increase the amount of daylight, simplify construction, reduce cost, implement a more effective HVAC system, and engage the community. The charrette included all members of the design team, including architect Jennifer Costanzo, principal of STR Partners, the mechanical engineer Sachin Anand, of dbHMS, and the landscape architect Terry Ryan, principal of Jacobs/Ryan Associates, as well as representatives from the school system and outside stakeholders.

After multiple iterations that considered the costs and benefits of a ground-source heat pump system instead of the standard rooftop packaged mechanical system with variable air volume distribution, the team chose the heat pump option, which eliminated both a rooftop penthouse and extensive ductwork throughout the building. In this case it was

Source: Public Building Commission of Chicago

discovered that the ground-source heat pumps, which one normally thinks of as costing more than standard systems, actually cost less. This solution also allowed for reduction of the floor-to-floor height and therefore of the overall building height. The team then used an iterative daylight and energy modeling process to decide how much to enlarge the windows in the classrooms to maximize daylight. The hollow-core slab structure was swapped out for a more standard steel deck with concrete topping, allowing for greater flexibility and ease of construction.

Conveniently, another school that was based much more closely on the original prototype went out to bid at the same time as the Sarah E. Goode STEM Academy, providing a real-world cost comparison. The Goode School design reduced construction cost by over two percent while reducing energy use significantly and providing an improved learning environment.

Another result of the project was how it changed each individual's mindset. PBC's sustainability manager became a "believer" that the integrative design process really works and that one really can deliver green while lowering first cost. The architect, Jennifer Costanzo, also became a believer: "I thought that since we were working from a prototype, the charrette would be a waste of time. But then the owner actually suggested meaningful changes," she later told *Chicago Architect Magazine* (Petersen 2014).

And then sometimes one just gets lucky: the school principal, who had not been directly engaged in most of the design discussions, happened to sit in on a construction meeting and heard that the project was just a couple of points shy of achieving LEED Platinum. Not knowing much about LEED, the principal asked, "What is this 'Platinum' thing, and can't we do that?" Kessler had never gotten CPS to approve a thermal comfort survey before, so that hadn't been on the table. But with the principal's support, the survey and a couple of other operations-related credits were approved. Now students are working on the thermal comfort survey, and the project has been certified Platinum.

Key integrated design and delivery strategies emphasized by the project team:

- **Holding a team goal-setting workshop, and including key participants like the general contractor and trades**
- **Participation of operations and maintenance personnel**

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Glossary of Terms

Base fee: The portion of compensation guaranteed to the supply team, regardless of project outcomes. This can either be structured as a fixed fee/lump sum or as a cost-plus with a maximum and may or may not include a profit margin under an IPD contract (Wilson 2014, 69).

Building Information Modeling (BIM): A digital representation of physical and functional characteristics of a facility, which is a shared knowledge resource for information about a facility, forming a reliable basis for decisions for design and construction, operations, or demolition (National BIM Standard US 2015).

Change order: Written orders to the contractor signed by the owner, architect, and contractor, issued after execution of the contract, authorizing a change in the work or an adjustment in the contract sum or contract time (Maginnis Law 2011).

Charrette: An intensive workshop in which various stakeholders and experts are brought together to address a particular design issue (Todd 2013).

Cost contingency: An allowance factored into the estimate, designed to cover items of cost which are not known exactly at the time of the estimate but which occur on a statistical basis (Jelen and Black 1983).

Energy use intensity (EUI): A metric that expresses a building's energy use as a function of its size or other characteristics. It is usually expressed as energy per square foot per year (Energy Star, n.d.).

First cost: The prime cost, or the direct cost in terms of materials and labor involved in producing a commodity, such as a building.

Guaranteed Maximum Price (GMP) structure: A type of contract where the contractor is compensated for actual costs incurred and a fixed fee up to a not-to-be-exceeded ceiling price. Some public agencies require GMP clauses.

Integrated Design Process (IDP): A framework in which project team members from all disciplines work together early and often throughout the project design process (Cole and Hatten, n.d.).

Integrated Project Delivery (IPD): According to the AIA California Council (2014), "Integrated Project Delivery (IPD) is a project delivery method that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction. The Integrated Project Delivery method contains, at a minimum, all of the following elements:

- Continuous involvement of owner and key designers and builders from early design through project completion,
- Business interests aligned through shared risk/reward, including financial gain at risk that is dependent upon project outcomes,
- Joint project control by owner and key designers and builders,
- A multi-party agreement or equal interlocking agreements, and
- Limited liability among owner and key designers and builders."

Integrative Process: A framework in which all project team members are engaged in an intentional process of discovering mutually beneficial interrelationships and synergies between systems and components, in a way that unifies technical and living systems, so that high levels of building performance, human performance, and environmental benefits are achieved" (Institute for Market Transformation to Sustainability 2012). An integrative process attempts to shift fragmented, dominantly technical perspectives to whole-systems thinking (7group and Bill Reed 2009).

IPD-ish: Compared to full IPD projects that employ multi-party contracts, IPDish approaches treat IPD as a philosophy, often using some level of shared risk and reward (Tepfer 2013).

Lean design and construction: A production management–based approach to project delivery that extends the objectives of a lean production system (maximize value and minimize waste) to specific construction management techniques. (Lean Construction Institute 2015).

LEED AP: A professional LEED credential an individual obtains to specialize in one or more of five LEED rating system categories. (US Green Building Council, n.d.).

Mental model: The worldview through which an individual operates (7group and Bill Reed 2009).

Partnering: A formal management process in which all parties to a project voluntarily agree at the outset to adopt a cooperative, team-based approach to project development and problem resolution to eliminate—or at least reduce—conflicts, litigation, and claims (US General Services Administration 2015).

Project Roadmap: A schedule and task spreadsheet template described in the Integrative Process ANSI Standard (MTS 2012).

Pull planning system: A method of advancing work when the next-in-line customer is ready to use it. A "Request" from the customer signals that the work is needed and is "pulled" from the performer. Pull releases work when the system is ready to use it (Lean Construction Institute 2015).

Pulse Model: The Integrative Process model, outlined in the ANSI standard, of research, analysis, and meetings on a repeating cycle that progressively approximates and refines the design solution.

Quality assurance: The planned and systematic activities implemented so that quality requirements for a product or service will be fulfilled (ASQ 2014).

Quality control: The observation techniques and activities used to fulfill requirements for quality (ASQ 2014).

Request for Information (RFI): A procedure used in the construction industry in cases where it is necessary to confirm the interpretation of a detail, specification, or note on the construction drawings or to secure a documented directive or clarification from the architect or owner.

Specifier: Someone who draws up specifications for a building project that define the qualitative requirements of materials and products to ensure that everyone understands the product requirements (Betts 2000).

Supplemental References

Listed here are the writings and resources that were especially helpful in the preparation of this Guide. This bibliography is by no means a complete listing of all the works consulted, but it indicates the substance and range of the research conducted and is intended to key resources for those who wish to learn more.

Featured Resources

Ashcraft, Howard. 2013. *Integrated project delivery: The owner's perspective.* Hanson Bridgett LLP. <www.cisc-icca.ca/getmedia/598988de-03df-4a4e-b13a-e074f74d7723/The-Owner_s-Perspective.aspx>.

This excerpt from an upcoming textbook, *Integrated Project Delivery: Theory and Practice,* explores an owner's motivation for pursuing an IPD project and presents advice for managing project partners and responding to skepticism both within and outside an owner organization. The chapter is based on interviews with 14 owners who undertook IPD projects themselves.

Highlights:

- Demonstrates perceived benefits from an owner's point of view.
- Explains what it takes to organize and initiate an integrated project.

Institute for Market Transformation to Sustainability. 2012. *Integrative Process (IP) ANSI Consensus National Standard Guide 2.0 for Design and Construction of Sustainable Buildings*. Institute for Market Transformation to Sustainability and American National Standards Institute. <http://webstore.ansi.org/RecordDetail.aspx?sku=MTS+2012%3a1>.

This integral resource defines a framework for practicing Integrated Design. The guide covers recommended practices for steps to take, from predesign all the way through operations and performance feedback.

Highlights:

- Proven framework for how to manage the flow of people, information, and analysis.
- Answers the question of who to involve and when.
- Lists outcomes and performance measurements that should be completed at each stage of design and construction.

The "pulse model" promoted in this guide is fully explained in this resource, as is the Project Roadmap. An outline of the Integrative Process is available for free to the public here: <www.sevengroup.com/storage/7group%20Integrative%20Design%20Process%20Outline.pdf>.

Lean Construction Institute. 2015. Glossary. Accessed 14 February 2015. <www.leanconstruction.org/training/glossary/>.

Highlights:

- Contains glossary of key terms.
- Offers on-demand training and education programs.

US Green Building Council. 2015. LEED integrative process credit. Accessed 11 March 2015. <www.usgbc.org/node/2613097>.

Highlights:

- Helps teams capitalize on interrelationships between systems.
- Forces teams to start early: perform an energy modeling analysis and water budget analysis before schematic design.

Wilson, Oscia. 2014. ***The owners' guide to starting integrated building projects.*** CreateSpace Independent Publishing Platform. 134 pp. http://boiledarchitecture.com/how-ipd-compensation-works/.

This book is a wonderful, short, approachable introduction to the components of Integrated Project Delivery for any audience, but it also offers owner-specific guidance, such as discussion points to use to win internal buy-in within the owner organization, specific advice for issuing the Request for Proposals (RFP), and suggestions for finding funding sources. Wilson's book has greatly influenced this Guide's stance on whether IPD contracts are always necessary or beneficial for an integrated project.

Highlights:

- Section on discussion points to win internal buy-in within owner organizations.
- Advice on "what to do if you can't do IPD."
- Owner-specific guidance on issuing the RFP, defining funding sources, and identifying the owner chain of command.

Tepfer, Sara. 2013. ***Realizing next-generation green; Project delivery and cost management strategies for high-performance buildings.*** American Institute of Architects. <www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab100073.pdf>.

This collection of four case studies provides insight into what integration strategies are most effective in high-performance projects, namely collaborative decision-making, early involvement of key participants, and metrics-based decision-making. The report also explores why projects are not pursuing IPD in its truest form, instead more commonly forgoing the multi-party contracts. One of the suggestions is that real benefits are being achieved using IPD as a driving philosophy, so project teams are happy making small changes rather than betting on large paradigm shifts, even if the latter would bring greater rewards.

Highlights:

- IPD projects are rare; true IPD projects are even more rare.
- However, even "IPD-ish" approaches have resulted in successful and cost-efficient projects.
- IPD can be a flexible and approachable tool.

Additional Resources

***AEC Magazine*. 2013. BIM for manufacturers**. July 2013. Accessed 20 May 2015. <www.aecmag.com/comment-mainmenu-36/567-bim-for-manufacturers->.

This article argues that manufacturers should be providing Building Information Modeling libraries for their products so that these can be subjected to virtual testing during design. The article also outlines BIM component suppliers and indicates which might be most usable for manufacturers.

AIA Minnesota. 2012. *IPD case studies*. School of Architecture – University of Minnesota. American Institute of Architects. March 2012. <www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab093703.pdf>.

This report outlines 12 case studies of projects that implemented some level of IPD. This set of case examples documents a wide range of team experience. A survey of 127 participants in these projects reveals several take-away conclusions, including that teams with more experience or that benefitted from previous professional relationships had a stronger understanding of IPD principles and, consequently, the team's learning curve was less steep. Many of the projects attribute substantial cost and scheduling benefits to the integrated approach. Unique to this report is a project matrix, in which the basic size and cost of each project was related to the IPD strategies that were chosen to be employed. This is a particularly good resource for individuals seeking real-world examples of how different IPD strategies have influenced outcomes and it makes a strong case for employing multi-party contracts.

AIA California Council. 2014. *Integrated project delivery: An updated working definition*. Version 3. American Institute of Architects. Accessed 20 May 2015. <www.aiacc.org/new-ipd-pdf-form/>.

AIA's most recent stance on the definition of Integrated Project Delivery "draws a line in the sand" by officially declaring that multi-party or interlocking agreements are needed for a project to be called IPD. This resource also contains tables demonstrating the benefits of IPD compared to other delivery models.

This paper is based on the assumption that the negotiation of an IPD contract is not separate from the collaborative process, but rather is one of the first exercises that tests how a team works together and the practical approach to the contract negotiation matters. <https://www.boiledarchitecture.com/wp-content/uploads/2014/10/2014-07-15-IPD_DEFINITION.pdf>]

AIA. 2012. *An architect's guide to integrating energy modeling in the design process*. American Institute of Architects Energy Modeling Working Group. Accessed 20 May 2015. <www.aia.org/practicing/AIAB097932>.

AIA National, AIA California Council. 2007. *Integrated project delivery: A guide*. Version 1. American Institute of Architects. <www.aia.org/groups/aia/documents/pdf/aiab083423.pdf>.

This guide from the American Institute of Architects describes the principles of Integrated Project Delivery and provides guidance for setting up an integrated project. Although a possible integral resource for architects, given its attention to approaches at every stage of design, its position on the type of contractual agreements suited for IPD is now outdated with regard to the AIA's updated working definition of IPD.

Ashcraft, Howard. 2011. *IPD teams: Creation, organization, and management*. Hanson Bridgett LLP. <http://www.hansonbridgett.com/Publications/pdf/~/media/Files/Publications/IPD-Teams.pdf>

This document gets to the root of why we might seek collaboration in the first place: to discover better, more creative solutions that could not be invented by an individual. But only effective teams bring this greater potential, so Ashcraft outlines how to properly create, manage, and motivate a team. This resource might be particularly useful for an owner or facilitator in charge of fostering a collaborative culture, but is also important for any participant in an integrated project.

Ashcraft, Howard. 2010. *Negotiating an integrated project delivery agreement*. Hanson Bridgett LLP. <www.hansonbridgett.com/~/media/files/publications/negotiatingintegratedprojectdeliveryagreement.pdf>.

Ashcraft, Howard. 2008. *Building information modeling: A framework for collaboration.* Presented to the Society of Construction Law International Conference, London, England, 6–7 October 2008. <www.zeidlerpartnership.com/ianfairlie/2011-05-15_Collaboration/BIM_A_Framework_for_Collaboration_by_Howard_Ashcraft.pdf>.

Ashcraft reviews how the business and legal structure of IPD helps design and construction teams utilize BIM models to their fullest potential, primarily by removing the liability concerns that usually accompany sharing such detailed information.

Ashcraft, Howard. N.d. *The IPD framework.* Hanson Bridgett LLP. <www.hansonbridgett.com/Publications/pdf/~/media/Files/Publications/IPD_Framework.pdf>.

A must-read for anyone seeking to understand how IPD is structured to promote better project outcomes. This document describes the difference between a multi-party contract and a poly-party contract and contains an appendix that shows why traditional contracts undermine collaborative objectives.

AGC of America. N.d. *Contractors' guide to BIM.* First Edition. The Associated General Contractors of America. <http://www.tpm.com/wp-content/uploads/2013/02/AGC_Guide_to_BIM.pdf>.

This guide is an introduction to BIM for general contractors, including how to pick a BIM tool, how to conduct the process, and what responsibilities fall under its scope.

ASQ. 2014. Quality assurance vs. quality control. American Society for Quality. Accessed 20 May 2015. <http://asq.org/learn-about-quality/quality-assurance-quality-control/overview/overview.html>.

BC Green Building Roundtable. 2007. *Roadmap for the integrated design process.* Busby Perkins+Will and Stantec Consulting. <www.greenspacencr.org/events/IDProadmap.pdf>.

This early document on the integrated design process covers practices in British Columbia and Canada and is split into two sections, for novice and advanced practitioners. The document emphasizes that an integrated design process revolves around mindset, but does not address the extent to which a different business model or contract is desired or needed. The process it sets forth most closely resembles the Integrative Process ANSI standard referenced in this guide, showing strong correlations between thinking in the US and Canada on this subject.

Betts, Gary. 2000. Construction documentation specifications. *The Architect's Handbook of Professional Practice.* 13th Edition. John Wiley & Sons.

BIM Forum. 2015. Introduction to levels of development specification. Accessed 7 January 2015. <https://bimforum.org/lod/>.

This resource helps practitioners identify and articulate with clarity the content and reliability of BIMs at various stages in the design and construction process. This could be particularly important for an integrated team in order to be able to share BIM models, understanding to what level certain details are still not final.

Boecker, John. 2014. Integrative process and IPD Web meeting. *BuildingGreen Inc.,* and Commission for Environmental Cooperation. Accessed 20 May 2015. <www.youtube.com/watch?v=mDEXxo929ds&feature=youtu.be>.

CEC. 2013. *Improving conditions for green building construction in North America: Enhancing capabilities of the green workforce.* Montreal: Commission for Environmental Cooperation. 46 pp. <www3.cec.org/islandora/en/item/11387-improving-conditions-green-building-construction-in-north-america-enhancing-capabilities-en.pdf>.

A precursor to this Guide, the CEC green workforce report reviews education and training opportunities in North America. The need for more education about integrated delivery models is emphasized in this report.

CIFE. 2007. *VDC USE in 2007: Significant value, dramatic growth, and apparent business opportunity.* Center for Integrated Facility Engineering Technical Report #TR171.

Cole, Jeff and Michael Hatten. N.d. *Integrating energy engineering and performance modeling into the design process.* BetterBricks. <www.betterbricks.com/graphics/assets/documents/Performance_Modeling_FINAL-WEB.pdf>.

Consigli Construction. 2014. ***Optimizing collaboration: The power of co-located teams.*** Accessed 20 May 2015. <www.consigli.com/2014/10/14/customizing-collaboration-the-power-of-co-located-teams/>.

These case studies from the construction firm Consigli help make the case for co-location and offer guidance on how best to foster collaboration in a co-located tam.

The Construction Management Association of America. 2012. ***An owner's guide to project delivery methods.*** <https://cmaanet.org/files/Owners Guide to Project Delivery Methods Final.pdf>.

This guide contrasts the benefits of Integrated Project Delivery with those of Design-Build, Construction Manager at Risk, and Design-Bid-Build, from an owner's perspective. IPD offers all of the advantages of a DB or CMAR project, according to this report, while also alleviating tensions related to the completeness of design, setting the target cost, and holding the contractor who participated in design responsible for problems that arise during construction.

The Construction Users Roundtable. 2010. ***BIM implementation: An owner's guide to getting started.*** <www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab085571.pdf>.

This resource, endorsed by the American Institute of Architects, serves as a practical guide to help owners develop a BIM implementation process. The paper is divided into three sections—Project Pre-Planning, Design and Construction, and Operations and Maintenance—so that owners can employ BIM processes at whatever stage they find themselves.

Costanzo, Peter. 2014. Sustainable facilities management: Bridging the gap from BIM to building operations. The BIM Hub, 9 December 2014. Accessed 20 May 2015. <https://thebimhub.com/2014/12/13/sustainable-facilities-management-bridging-the-gap/#.VVzGgU3JD2Q>.

This quick post describes the difficulties of usefully applying BIM data in the operations phase and makes recommendations for the kind of decisions needed early in design in order to enable an easier transition.

Day CPM Services. 2013. ***Oregon State Capitol renovation project.*** 3 June 2013. <www.oregonlegislature.gov/mp/Documents/IPDPresentation.pdf>.

This presentation gives a high-level overview of how an integrated design and delivery approach was implemented in the Oregon State Capitol Renovation Project using a CM/GC. This resource gives insight into how subteams, or "cluster groups," are formed and work together between whole-group meetings.

Egan, John. 1998. ***Rethinking construction: Report of the Construction Task Force to the Deputy Prime Minister John Prescott, on the scope for improving the quality and efficiency of UK construction.*** Department of Trade and Ministry. United Kingdom. <http://constructingexcellence.org.uk/wp-content/uploads/2014/10/rethinking_construction_report.pdf>.

FMI Corporation. 2007. ***Eighth annual FMI/CMAA survey of owners: The perfect storm—Construction style.*** <www.cmaafoundation.org/files/surveys/2007-survey.pdf>.

FMI Corporation. 2005. ***Sixth annual FMI/CMAA survey of owners.*** <www.cmaafoundation.org/files/surveys/2005-survey.pdf>.

Gallaher, Michael et al. 2004. ***Cost analysis of inadequate interoperability in the U.S. capital facilities industry.*** August 2004. National Institute of Standards and Technology. <http://fire.nist.gov/bfrlpubs/build04/PDF/b04022.pdf>.

Gehrig, David. 2010. ***IPD Video series—Part 6.*** Hanson Bridgett LLP. July 2010. Accessed 20 May 2015. <www.hansonbridgett.com/Publications/videos/ipd-video-part6.aspx>.

IISBE. 2004. ***The Integrated design process.*** International Initiative for a Sustainable Built Environment. <http://iisbe.org/down/gbc2005/Other_presentations/IDP_overview.pdf>.

This paper outlines the integrated design process as defined by the Canadian C2000 program and explains how these of approaches are stronger if supplemented by supporting business models and contracts.

Jelen, F., and J. H. Black. 1983. *Cost and optimization engineering.* Third Edition. McGraw-Hill Book Company, pp. 456-457.

Kristine Fallon Associates, Inc. 2012. BIM for owners—Background and strategies for success. *Movement for Innovation Industry Reports and Economist Magazine* <www.tn.gov/finance/OSA/documents/KFAtoIndustry9.27.12.pdf>.

Lesniewski, Laura, and Bob Berkebile. 2013. Sustainable design and construction, integrated delivery processes and building information modeling. *Sustainable Built Environments*, pp. 634–652.

This paper presents a brief history that helps to explain the fragmented nature of the building industry in its context and then points to lean thinking and BIM as drivers that will provide a path to truly integrated projects.

Maginnis Law. 2011. Oral and written change orders in construction contracts. 8 April 2011. Accessed 20 May 2015. <www.maginnislaw.com/2011/04/oral-and-written-change-orders-in-construction-contracts/>.

Malin, Nadav. 2007. Building information modeling: Transforming an industry. *BuildingGreen, Inc*. Accessed 20 May 2015. <https://www2.buildinggreen.com/article/building-information-modeling-and-green-design>

This section of an article on BIM technology helps explain how BIM is simultaneously an enabler and a driver for integrated projects.

McCracken, Courtney J. 2013. *The effect of project delivery process on energy performance in buildings.* M.A. thesis, Center for Environmental Studies, Brown University.

This thesis research provides a good literature review of the theorized benefits of Integrated Project Delivery. Though this investigation of three school districts does not demonstrate a statistical correlation between project delivery method and energy use, the author suggests more early adopters with "visionary owners" are likely needed to prove the concept.

Molenaar, Keith, and Nathaniel Sobin. 2009. *Sustainable, high performance projects and project delivery methods: A state-of-practice report.* The Charles Pankow Foundation and the Design-Build Institute of America. <http://www.dbia.org/resource-center/Documents/Sep2009ReportPankowDBIA.pdf >.

This study explores the impact that project delivery methods have on the owner's ability to achieve sustainability goals. The study does not specifically analyze integrated project delivery, but its findings indicate that success rates favor those project delivery methods that do not seek pricing before selection, and that projects which achieved gold or platinum LEED certification were twice as likely to have assigned, during procurement than during design, the responsibility for achieving project sustainability objectives—two major features of integrated design and delivery projects.

National Association of State Facilities Administrators et al. 2010. *Integrated project delivery for public and private owners.* <www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab085586.pdf>.

Given the statutory limitations of pursuing multi-party contracts, this resource presents the argument for why public owners may want to pursue full IPD—even if they have to obtain an exception or variance claiming the project as a test project. This resource also reviews other variations public owners can pursue if they currently have political or cultural barriers that they cannot overcome.

National BIM Standard US. 2015. Frequently asked questions about the national BIM Standard-United States™. 13 February 2015. Accessed 20 May 2015. <www.nationalbimstandard.org/faq.php>.

Pennsylvania State University. 2012. *BIM planning guide for facility owners.* Version 1.0. Computer Integrated Construction Research Program. Pennsylvania State University, University Park, PA. April 2012. <www4.fm.virginia.edu/fpc/ContractAdmin/Documents/BIMPlanningGuide.pdf>.

This guide acts as a resource for facility owners to more effectively integrate BIM into the organization and lifecycle of a facility.

Quigley, David. 2013. ***Achieving spatial coordination through BIM: A guide for specialty contractors.*** Mechanical Contractors Association of America, Inc., Mechanical Contracting Education and Research Foundation, The National Electrical Contractors Association Inc., New Horizons Foundation, and Sheet Metal and Air Conditioning Contractors National Association. <www.mcaa.org/mepguide/M29PDF.pdf>.

This guide specifically targets how BIM applies to MEP contractors, calling for integration with the design team as a necessary component.

Roberts, Tristan. 2013. Energy modeling: Early and often. *BuildingGreen*. <www2.buildinggreen.com/article/energy-modeling-early-and-often>.

7group and Bill Reed. 2009. ***The integrative design guide to green building: Redefining the practice of sustainability***. Hoboken, NJ: Wiley.

A seminal resource for integrated design and delivery, this book explains the philosophy that underpins integrative design and provides first-hand anecdotes from the experts at 7group and Bill Reed. Much of the content of the ANSI Integrative Process was drawn from this book, and readers will also find itemized tasks and descriptions of group exercises that they can employ on their own projects—some of these examples are referenced in this guide.

Sheffer, Dana Alice. 2011. ***Innovation in modular industries: Implementing energy-efficient innovations in US buildings.*** PhD diss., Stanford University. <https://gpc.stanford.edu/sites/default/files/d013_0.pdf>.

Sive, Ted. 2009. ***Integrated project delivery: Reality and promise. A strategist's guide to understanding and marketing IPD.*** Society for Marketing Professional Services Foundation, July 2009. <www.tedsive.com/docs/Sive_White_Paper_IPD.pdf>.

Recognizing that IPD needs wider market adoption, this resource helps firms attract owners interested in integrated projects, celebrate and share their own stories of success, and reliably convey team capabilities. This is a great resource for anyone who wishes they could put together an integrated design and delivery project, but lacks like-minded owners. Sive argues that even without a clear market demand, teams can be developing their capacity and selling the concept to the market.

Smart Market Report. 2012. ***The business value of BIM in North America.*** <http://images.autodesk.com/adsk/files/mhc_business_value_of_bim_in_north_america_2007-2012_smr.pdf>.

This survey reports market adoption of BIM by workforce sector, revealing very different usage rates between architects, engineers, contractors, and owners.

Teicholz, Paul. 2013. Labor productivity declines in the construction industry: Causes and remedies (Another look). *AECBytes Viewpoint #67*, 14 April 2004. <http://www.aecbytes.com/viewpoint/2013/issue_67.html>.

This analysis of construction productivity shows a decline over 20 years despite improvements in tools and technology. Industrial productivity, by contrast, has sharply risen.

USDOE. 2012. ***How-to guide for energy-performance-based procurement: An integrated approach for whole building high performance specifications in commercial buildings.*** Department of Energy, National Renewable Energy Laboratory. <http://apps1.eere.energy.gov/buildings/publications/pdfs/rsf/performance_based_how_to_guide.pdf>.

This report relates lessons learned from the National Renewable Energy Laboratory's recent campus expansion, which includes assembling an integrated project team.

US General Services Administration. 2015. Partnering. Accessed 20 May 2015. <www.gsa.gov/portal/content/100822>.

Wilson, Oscia. 2014a. IPD for small projects. <http://boiledarchitecture.com/ipd-for-small-projects/>.

This blog post explains how IPD contracts can work for small projects and what benefits they bring to projects with a limited budget. Though successful examples are still rare, Wilson argues that small projects need not steer away from this contracting model.

Yost, Peter and Jennifer Atlee. 2012. Tremco: Getting the devil out of air and water details. *BuildingGreen.* Accessed 20 May 0215. <https://greenspec.buildinggreen.com/article/tremco-getting-devil-out-air-and-water-details>.

This article demonstrates how complex products demand a certain level of integration with other systems in order to function properly, and how the manufacturers that have recognized this are benefitting by providing solutions attractive to project teams pursuing high-performance projects.

Yost, Peter. 2010. High performance scopes of work. *Green Building Advisor*. <www.greenbuildingadvisor.com/blogs/dept/green-communities/high-performance-scopes-work>.

This article discusses the origin and creation of the high performance scope of work checklists, which are useful tools for coordination between trade contractors during construction.

Zach, James. 2013. Professional development: Avoid construction rework. Accessed 20 May 2015. <http://epubs.democratprinting.com/article/Professional+Development%3A+Avoid+Construction+Rework/1300169/0/article.html>.

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