AUTODESK WHITEPAPER

Improving Building Industry Results through Integrated Project Delivery and Building Information Modeling

Within the building industry there is a growing interest in integrated project delivery (IPD) and the role building information modeling (BIM) can play in promoting integration among building professionals and improving design outcomes. This whitepaper examines IPD and considers its impact on the building industry—and how BIM is central to process changes that IPD will bring.

The list of new projects based on alternative delivery methods mediated by digital design grows daily as designers, builders and owners increasingly move towards IPD. Professional organizations such as the American Institute of Architects (AIA) and the Associated General Contractors of America (AGC) are establishing putative standards, disseminating guidelines and facilitating discussions within their memberships that highlight successful projects and consider the obstacles to adoption.

This paper presents a brief overview of IPD, reflects on how IPD stems from current challenges facing the building industry, and presents the perspectives of three key members of an integrated project team: owner, architect/engineer, and contractor. The paper includes observations on ways that technology—particularly technology that supports the BIM process—will catalyze significant changes in the way the building industry works. The paper concludes with a consideration of the impact IPD is likely to have on practice going forward.

[Note: In 2007, Autodesk sponsored a series of executive roundtables throughout North America on the subject of IPD. The roundtable events brought together architects, engineers, builders, educators and building owners to examine the issues and opportunities of IPD. The events included various speakers from education and industry whose expertise and experience with IPD exposed the participants to its best practices. The source of much of the information in this paper is from those presentations and subsequent roundtable discussions.]

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Introduction to Integrated Project Delivery

The manufacturing industry has long used concurrent engineering practices coupled with digital product prototypes to control product outcomes. At companies like Boeing and Toyota, product teams comprised of the various disciplines collaborate—from the outset—on all facets of a product's lifecycle to ensure that the emerging product design includes the desired characteristics that are needed to bring a product to market. Their product development processes rely upon information-rich digital models that are used for product design as well as manufacturing, field support, and so on.

Integrated project delivery, enabled by BIM, is based on a similar strategy: cross-functional project teams collaborating on a building's design, construction, and lifecycle management for optimized owner outcomes—using collaborative, model-based technology as a platform.

The American Institute of Architects (AIA) defines IPD as "a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction."[1]

IPD is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.

According to the AIA's *Integrated Project Delivery: A Guide*, the defining characteristics of IPD include:

- Highly collaborative processes that span building design, construction, and project handover.
- Leveraging the early contributions of individual expertise.
- Open information sharing amongst project stakeholders.
- Team success tied to project success, with shared risk and reward.
- Value-based decision making.
- Full utilization of enabling technological capabilities and support.

Although the traditional design-bid-build delivery method is still the most widely used form of project delivery, alternate approaches such as design-build, or construction management at risk—driven in large part by owners seeking to break away from 'low bid' and 'lowest first cost' limitations—are quickly gaining traction and moving the industry towards a more integrated approach for project delivery.

In its 2007 *Environmental Scan*, the AIA commented that alternate delivery models are already causing architects to practice in more collaborative ways with builders, subcontractors, and fabricators[2]. The high adoption rates of BIM is also a bellwether of trends in project delivery, as it is a core enabling process for the enhanced collaboration that IPD demands. In its 2006 *Firm Survey*[3], AIA reported that on average 40% of firms surveyed who had 50 or more employees used BIM. Explorations in IPD will not be far behind.

BIM is an integrated process built on coordinated, reliable information about a project from design through construction and into operations. By adopting BIM, architects, engineers, contractors and owners can easily create coordinated, digital design information and documentation; use that information to accurately visualize, simulate, and analyze performance, appearance and cost; and reliably deliver the project faster, more economically and with reduced environmental impact.

Like sustainable design and digital fabrication, integrated project delivery is the result of a convergence of opportunities brought about by technology and business process innovation—and is inspired by the strong desire of the building industry for more predictable, accurate and responsible outcomes.

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1 *Integrated Project Delivery: A Guide*, Version 1, AIA and AIA California Council, 2007.

2 *Environmental Scan Summary*, American Institute of Architects, June 2007.

3 *The Business of Architecture, the 2005-2006 AIA Firm Survey*, American Institute of Architects, 2006.

Challenges to Practice (Drivers for IPD)

What are the industry issues that are fueling the integrated project delivery trend? A convergence of forces seems to be moving the AEC industry in the direction of integration—based on economics, productivity and nature of current owner design requirements. These issues include:

A shift toward globalized work processes: The building product supply chain is becoming heavily globalized, making cost predictions more complex and demand for building materials more unpredictable. Outsourcing[4] and shifting demographics are globalizing the workforce as well—fueling the need for new competencies relating to collaborative processes while simultaneously creating a new set of potential competitors worldwide.

The need for increased productivity and low margins: Declining construction productivity[5] is diminishing the ability to execute building projects reliably and profitably—and is frustrating the demand for more controlled building outcomes.

The demand for sustainability: Sustainable building design hinges on the ability to gain insight into construction outcomes through analysis, prediction and optimization of the design to reduce environmental impact through reduced energy consumption, carbon footprint and use of fresh water. As a result, sustainable building standards are expanding and evolving[6] to address performance-based assessments that encompass a building's entire lifecycle.

The increasing complexity of buildings themselves: Building projects themselves are increasingly complex endeavors; driven by ever more dramatic building forms, complicated supply chains, new project delivery standards, regulatory restrictions, project interactions amongst large teams of project specialists, and owner demands.

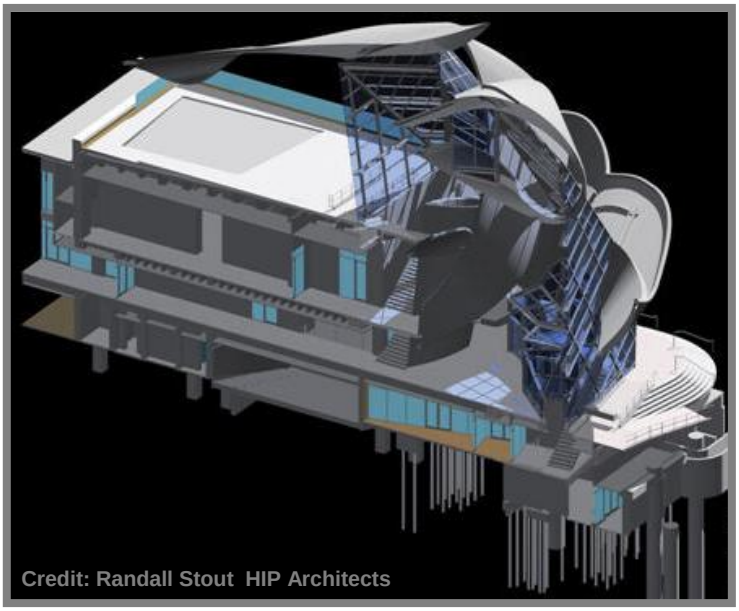

Figure 1:

Building project complexity, relating to building forms (such as the one shown here), supply chains, construction strategies, regulatory restrictions, project interactions, and owner demands continues to rise—fueling the need for IPD.

[4] The 2006 AIA Firms Survey reports that more than one-third of surveyed firms that work on international projects indicated that they typically team up with an in-country partner and two-thirds of the firms that use in-country partners use them for construction documents.

[5] Center for Integrated Facility Engineering (CIFE), Stanford University, "Labor productivity index for US construction industry and all non-farm industries from 1964 through 2003", Data sources: U.S. Bureau of Labor Statistics U.S. Department of Commerce.

[6] The Leadership in Energy and Environmental Design (LEED) standard, a widely used whole-building standard developed by the U.S. Green Building Council (USGBC), was recently expanded in December 2007 to include residential construction (LEED for Homes).

Practice Responses (Opportunities for Innovation)

In response to these drivers, we are witnessing fundamental changes within the building industry's design and construction processes, which include:

Collaboration: Technology—particularly BIM and web-based project management software—has created a solid platform for an improved, more efficient means of collaboration between all the parties involved in project delivery and is enabling the trend towards integrative digital collaborations characterized by strategic partners with shared outcomes, risks and gains.

Representation: Today's means of project representation are moving from 2D drawings to digital models, where representation occurs simultaneously with analysis—changing the design process from representational (based on static, abstract representations of a design) to performative (based on desired outcomes).

Analysis: When design representations become performative, they enable rapid design inference—understanding the analytical ramifications of design decisions *as* they are being made—with analysis being performed by designers as an integral part of the design process. This approach is in stark contrast to more traditional "rule of thumb" evaluations of designs as they evolve.

Standards: As building codes are updated to consider building performance, there is an increasing obligation of designers to provide higher degrees of insight regarding building outcomes. In some instances, owners define technology standards to realize opportunities for increased project and data flexibility.

Fabrication: Digital fabrication techniques blur the distinction between design and production. As this occurs, design sensibility regarding constructability shifts—giving rise to extensive pre-fabrication, mass customization, and factory-produced building components. Digitally fabricated building components further reduce the pressure on field construction productivity.

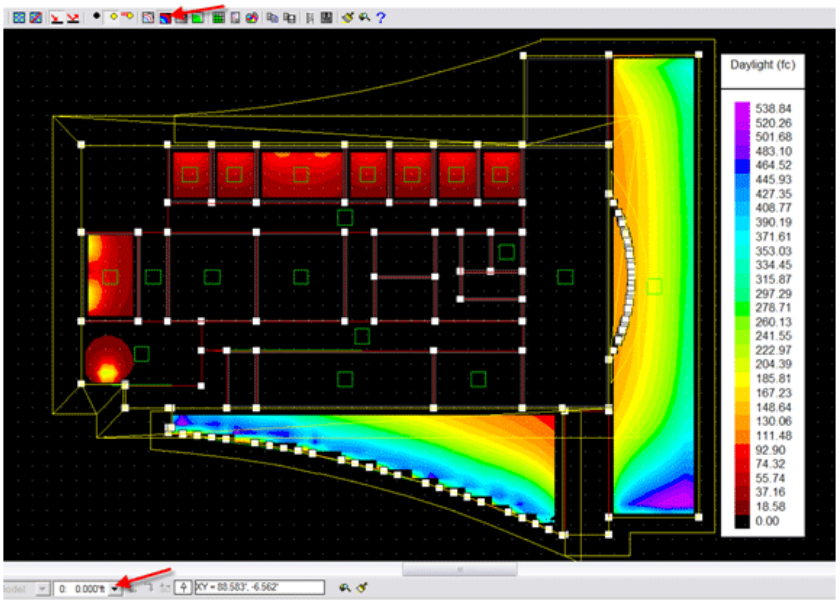

Figure 2:

Understanding the analytical ramifications of design decisions—as they are being made—is being accomplished through the use of digital models coupled with specialized analysis solutions, such as the daylighting analysis shown here, performed using software from Integrated Environmental Solutions (IES) Ltd.

IPD in Practice

A basic principle of IPD is the reliance on knowledge integration. Given that IPD encompasses highly collaborative processes that rely on the collective expertise of the extended project stakeholders (including designers, builders, subcontractors, and owners) contributed throughout the design process but particularly in the early stages of design, the ramifications of design decisions can be understood and thereby increase the likelihood of project success.

The resulting increase in project knowledge creates a better understanding of a project earlier in the design process, enabling owners and their IPD team to more effectively assess their project options and consider how to align them with their business goals. This should, in theory, result in a project that more accurately reflects their requirements. Satisfying owner demands is at the heart of the IPD process.

What Do Owners Want?

Owners are becoming more definitive in their demands for more reliable results in the AEC process. Articulated by the U.S. General Services Administration[7] (the largest owner of commercial space in the country) and by organizations such as the *Construction Users Roundtable* (CURT), owners are looking to the building industry for changes in these areas:

Improved decision-making: Reduce poor design decisions by using digital models and electronic design visualizations during design and construction.

Improved contract documentation: Reduce the level of unknowns in contract documents—eliminating the use of the RFI process to "fill in the gaps". Leverage BIM to reestablish accuracy and precision, and improve the level of construction cognition and assembly understanding on the part of the architects, engineers, and owners.

Improved preconstruction estimating: Reduce the level of guesswork and inefficiency in preconstruction estimating by leveraging schematic design take-offs generated in the BIM process. Leverage the use of multiple pricing models by the contractor and reuse as-built digital models in new markets.

Improved procurement and scheduling: Reform procurement and project scheduling through the use of time modeling (sometimes known as 4D modeling) and cost modeling techniques—eliminating job-site slowtime/downtime and improving sub-trade coordination, overlap and phasing.

Improved coordination: Reduce the number of field coordination errors by integrating the design models of the major design disciplines early in the design process and using clash detection software to facilitate interdisciplinary design coordination—thereby solving coordination issues virtually rather than in the field.

Improved cost-efficiency: Reduce cost impacts of coordination errors, incorrect fabrication, and improper installation by adopting a pre-fit workflow from the designer to the sub-contractor and enforcing greater installation precision. Reduce the use of overtime labor and premium charges for recouping project schedule lost to these unnecessary errors. Reduce spending in general conditions, insurance, and carrying costs by optimizing project schedules that will result in faster construction.

[7] The U.S. General Services Administration (GSA) now requires the delivery of spatial BIMs for all major federal building projects that receive design funding in FY2007 and beyond.

Improved closeout documents: Transform the archaic quality of closeout documents, particularly traditional as-built/record drawings, by migrating to a BIM-centric approach for *all* project documents. Transition the digital model generated during design and construction to facilities management, allowing the owner/operator to use it for building lifecycle management.

How Do Architects, Engineers and Builders Respond?

Architects, engineers and builders are responding to owners' demands by adopting new processes, forging collaborative partnerships, and utilizing new technologies. All companies are facing competitive pressure and challenges to practice (as outlined above) to produce cost-effective, high quality designs and finished construction projects. Companies are responding by considering the opportunities offered by more collaborative business models—including moving towards IPD. Changes that are occurring include:

Embracing internal change: Increasingly, AEC firms are transitioning to collaborative processes built on the use of a digital models to inform and progress the project design and to aid construction. These processes are characterized by increased involvement of project planning, communication, and risk management in a comprehensive and open manner during design and construction.

Creating collaborative partnerships: New partnerships (including proactive, timely owner engagement) that rely on collaborative digital models to facilitate decision-making are creating a new breed of construction/lifecycle-minded designers and design-minded builders who together are managing the project with process and outcome metrics—and putting increased emphasis on the consideration of value and cost.

Leveraging new technologies: New tools and technologies are key enablers of the integration of design practice and construction. These include:

- BIM design tools - providing platforms for integrated processes built on coordinated reliable information and resulting in enhanced coordination, fewer RFIs and change orders, and less rework.
- 3D and 4D visualization - enhancing scope definition, stakeholder engagement, and decision making.
- Model-based analysis - using BIM-based data and digital analytical tools to understand project energy consumption, structural performance, cost estimates and other inferential reasoning from the design while it is underway.
- 4D modeling - coordinating construction and increasing the reliability of schedules.
- Fabrication from 3D models - resulting in elimination of shop drawings; better tolerance, lead time, and safety; and faster field assembly.
- Model-based bills of materials (BOMs) - providing faster, more accurate takeoffs for cost estimating, energy analysis, etc.
- Laser scanning - capturing existing (as-built) conditions that can be combined with BIM to provide reliable as-built models.

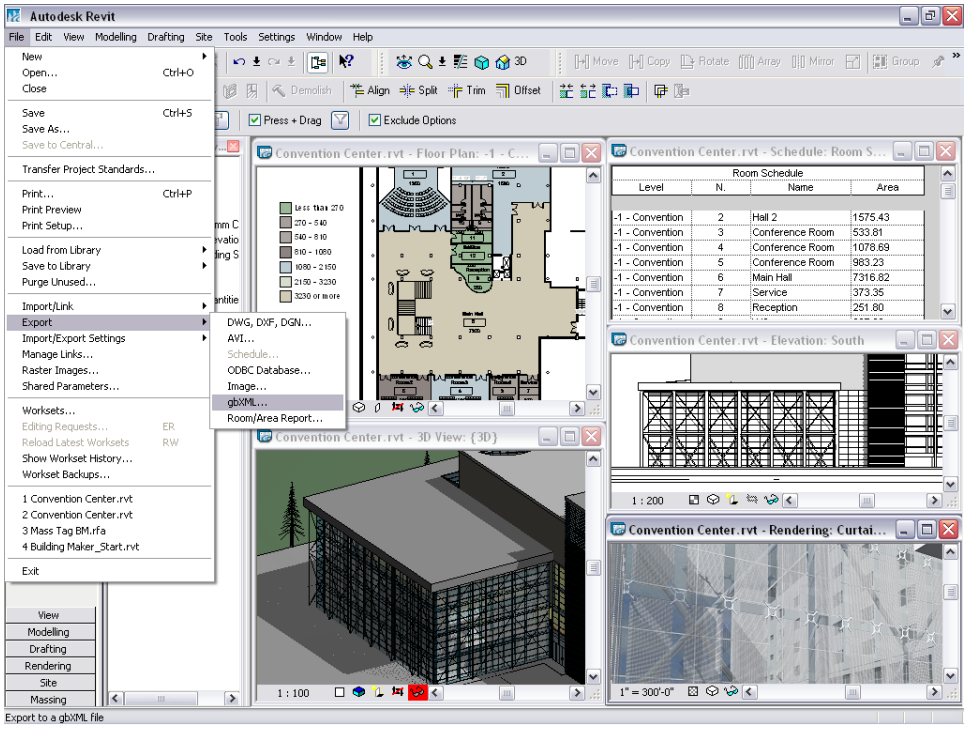

Figure 3:

New technologies (such as Revit, Autodesk's purpose-built BIM solution shown here) are key enablers of the shift towards integration in practice and construction.

Future of Practice

Given the trends cited above, what are the implications of IPD for the building industry? What might be the impact of this method of project delivery on the practical, day-to-day business processes manifest in contracts, workflows, interactions, and decisions of building professionals as they execute projects? And what affect might it have on education and enabling technology? Consider the following changes:

Contracts and Relationships: The relationships of the players in an integrated project delivery team are fundamentally altered, which requires—and will give rise to—new forms of standard contract documents that address important issues such as compensation, risk allocation, and intellectual property. Changes in business models, scopes of services and deliverables will redefine the relationships of the interested parties around measured outcomes, shared risks and shared rewards.

Regulation: With the rise of integrative concepts and methods there will be fundamental changes regarding professional standards of care and how the building process is regulated. Indeed, the meaning of professional licensure itself will change as the boundaries between design and construction blur. What will it mean to "design" and what will constitute competence when processes are integrated and digital information created collaboratively is the basis for construction and fabrication? What is the new meaning of "responsible control," the primary lever of design professional responsibility in the building process?

Workplace: Flexible project structures coupled with collaboration technology will facilitate the integration of global, extended project teams and allow organizations to find talent anywhere and shift work to remote locations as needed—increasing the overall flexibility of the building industry's workforce.

Project process: Traditional project phases will be adjusted and refined to accommodate an integrated project team and their project participation. Construction insight ("means and methods') will be deployed early in the design process resulting in decisions regarding *what* will be built made in concert with decisions about *who* is going to build it and *how* it will be built. A more thorough building design—rigorously analyzed and imbued with construction knowledge—will result in a shorter documentation phase that is repurposed for the delivery of design information, in whatever form necessary, to accelerate building construction. That information will be organized for the benefit of the builder, who will be an active participant in its creation.

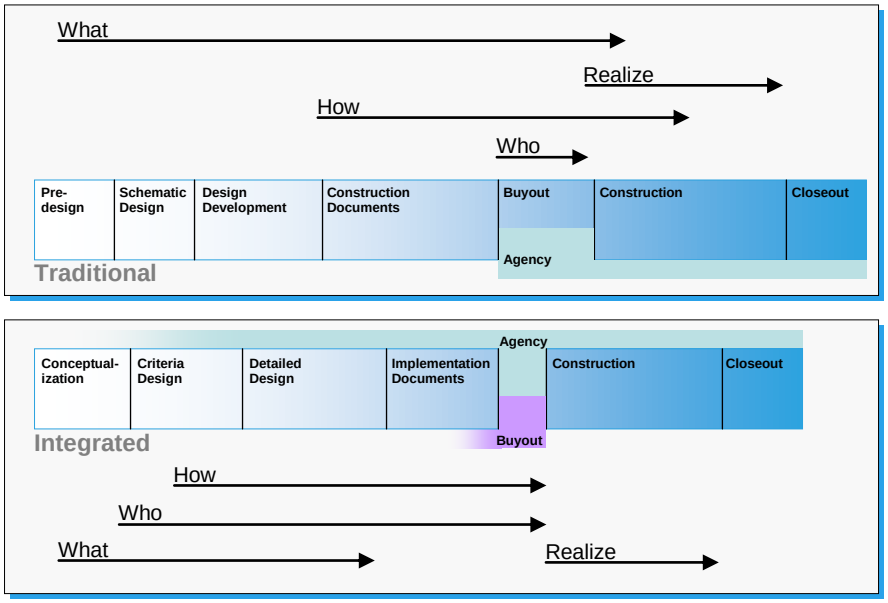

Image: AIA California Council

Figure 4:

Traditional project phases are adjusted by IPD. Construction insight deployed early in the design process results in decisions regarding *what* will be built made in concert with decisions about *who* is going to build it and *how* it will be built. [Image from the AIA California Council's document *Integrated Project Delivery, A Working Definition].*

Education: The curricula of architecture and engineering schools are generally isolated from those of adjacent building disciplines. Architectural, engineering and construction programs rarely intersect, and curricular relationships between design and business education are (in the main) non-existent. As the building industry becomes more integrated, the education of future professionals will no doubt follow suite with altered curricula that reflects the increasingly large footprint of building design and construction.

Technology: How will technology be affected by these trends? The early success of using digital models to quickly iterate alternatives and understand their ramifications will spawn a new generation of analysis technologies that are deeply imbedded in design technologies. With the rise of IPD there will be a burgeoning market for (and therefore rapid acceleration in the development of) enabling technology that is aligned to advance integration throughout the building design, construction and management continuum. Advances will be based on the increasing capabilities of processor speed, storage capacity, widespread availability of broadband connections, larger and more precise displays, and digitally controlled fabrication equipment.

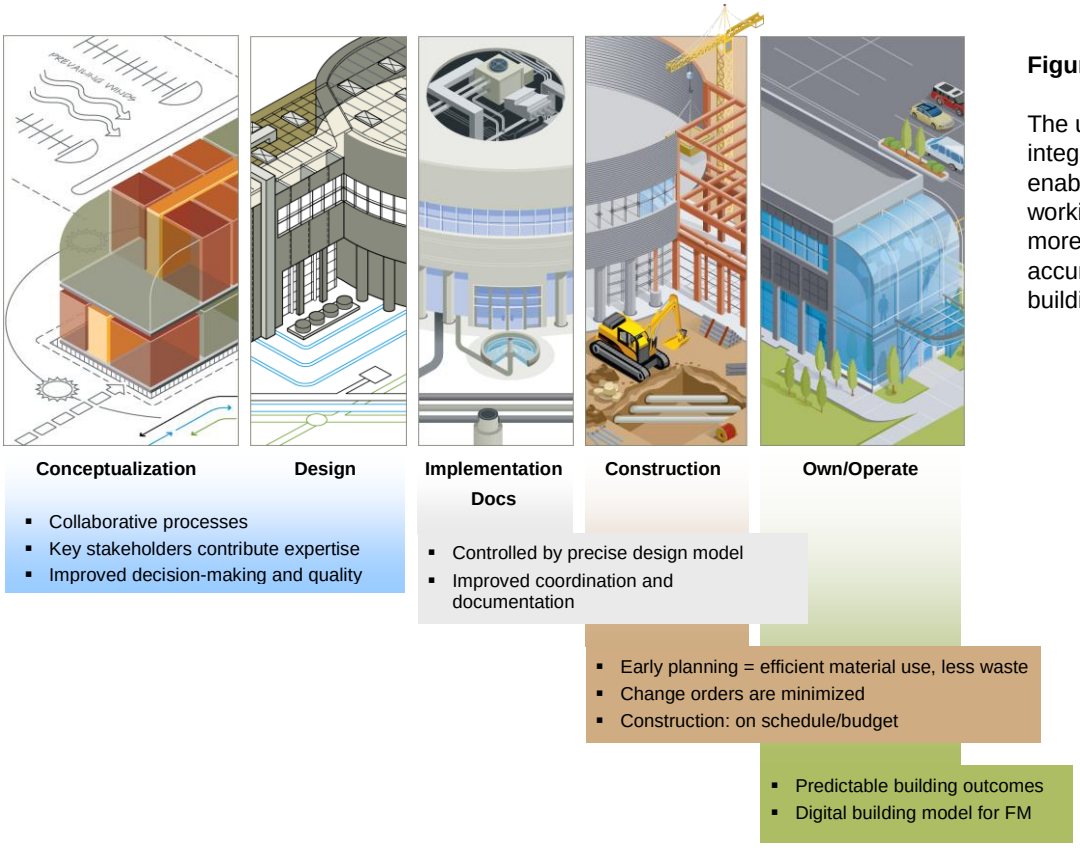

Figure 5:

The use of BIM in an integrated environment enables new ways of working that result in more predictable, accurate and responsible building outcomes.

Summary

Integrated project delivery is upon us—already in use in some form on many projects and the source of intense discussion for everyone in the building industry. BIM solutions enable IPD and can deliver dramatic advances in building technology, but the full potential of BIM will not be achieved without adopting structural changes to existing project delivery methods. Key issues regarding compensation, contractual relationships, risk allocation, and so forth can be overcome.

Greater awareness, owner mandates, and industry initiatives are critical to the widespread adoption of new delivery methods. Autodesk, in its ongoing commitment to improve our built environment, is committed to bringing about the necessary changes—in technology and outlook—to help make integrated project delivery a reality for the building industry.

Afterword

In the summer and fall of 2007, Autodesk sponsored a series of executive roundtables throughout North America on the subject of integrated project delivery. The purpose of the roundtables was to help attendees—and Autodesk—better understand the state of the design profession with regard to IPD and the potential role of BIM in this emerging delivery model. Through open dialogue and a critical examination of the principles and techniques associated with IPD, Autodesk's goal was to support the building industry in its efforts to improve building outcomes.

The six roundtable events—held in Atlanta, Boston, Calgary, Chicago, San Francisco, and Toronto—brought together groups of architects, engineers, builders, educators and building owners in a series of educational sessions to examine the issues and opportunities of IPD. In total, the roundtables were attended by over 200 executives, many of them principals or owners.

In addition to Autodesk presenters, the events included various speakers from education and industry whose expertise and experience with IPD exposed the participants to its best practices. The events concluded with roundtable discussions regarding the implications of, and barriers to, IPD—thus enabling the participants to evaluate its competitive advantages and potential obstacles in the context of their own practices, workflows, and organizations.

The roundtable discussions asked the participants to consider and confer on these topics:

- What are the drivers for practice change?
- What are the implications of this new integrative process, including its potential benefits for the building industry?
- What are the opportunities to impact the advancement of IPD?

Although the specific conclusions reached during these roundtable discussions varied from event to event, overall there were several main themes regarding IPD that emerged:

- The participants were witnessing varying levels of IPD adoption in the industry—within their firms, their competitors, their partners, and their clients—and the overall sense was that IPD is still an evolving approach for project delivery.
- There is still a high degree of concern regarding risk in relation to IPD and the close partnerships it necessitates.
- Many participants felt there was a need for those within the industry to assimilate new competencies—skills relating to collaboration and information management across peer organizations for example—to support IPD.
- And finally, perhaps the most prominent issue raised during these roundtables was the need for new legal frameworks to match new IPD approaches.

Appendix A

The questions below are put forward to the reader to promote awareness and provoke dialog regarding IPD. Similar questions were the basis for the roundtable discussions that occurred in conjunction with the series of IPD events sponsored by Autodesk in 2007. A new series of events are planned for 2008, and questions such as these—and the issues they raise—will be integral to the discussions that take place during those roundtable proceedings.

- What would your firm consider the greatest risk to entering into an integrated delivery process?
- What benefits would make it worthwhile to accept this sort of risk?
- Would your firm enter into a single multi-party agreement including owner, architect, and contractor?
- Would your firm accept a fee structure based on an open book reimbursement?
- What organizational changes and staff training would be needed for your firm to work successfully in collaboration with your counterparts?
- What collaboration tools would be needed to support a collaborative team relationship of this type?

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