Managing Integrated Project Delivery

CMAA
7926 Jones Branch Drive, Suite 800
McLean, VA 22102-3307
Chuck Thomsen, FAIA, FCMAA; Joel Darrington, Esq., Dennis Dunne, FCMAA Will Lichtig, Esq.

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Foreword

A number of old friends (and some new friends) who are thought leaders in program and construction management and in law, have generously contributed their ideas, criticism and original content to the following pages. As you read, I believe you will find some of the most advanced thinking in our industry.

It is highly unlikely that those who contributed to this paper will completely agree with the contributions of the others—or of my own. Early in my career, I noticed that leading professionals had the freshest and most original ideas, believed in them most passionately, articulated them with great enthusiasm—but rarely were in total agreement with others who were equally knowledgeable. Like all of us, they engaged their work with individual conceptions of how the world of design and construction should work. Those conceptions are inevitably tempered with individual philosophies influenced by their unique experiences in our vast, diversified industry and at a more fundamental level, their view of human nature and the behavior of organizations.

It is this diversity of thinking that contributes to progress in our industry. And it is a diversity that the CMAA College of Fellows supports and celebrates.

And so, while this paper is an initiative of the CMAA College of Fellows, it is not a policy statement of the College or of CMAA. It is not a Manifesto.

When new ideas emerge, there is a tendency for true believers to surface, coin new terms, evangelize the concept, market it vigorously, and declare what does and does not qualify as the new ideology. Eventually, there is a danger that they will define it narrowly, the practice will ossify and becomes less adaptable to future change and development.

We will avoid that. While you will find passionate positions on the following pages, CMAA and the College of Fellows have deliberately avoided a position on IPD as a specific contract form or a defined project delivery strategy. Rather, our mission is to provide our members with insights and understanding they can build on and continue our tradition of innovation in the construction industry.

So here are some thoughts about IPD and tools of 21st century project delivery. From these innovative approaches, you may choose what is best for the unique needs of your owners and your project teams—carefully.

Chuck Thomsen FCMAA FAIA
Chancellor emeritus CMAA College of Fellows
charlesthomsen@charlesthomsen.com

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On behalf of CMAA and the CMAA College of Fellows, I would like to thank the people who made this paper possible.

Joel W. Darrington, Dennis D. Dunne and William A. Lichtig wrote the chapter entitled "*Organization, Operating Systems and Commercial Terms*." Will Lichtig and Joel Darrington are lawyers with the Construction Practice Group at McDonough Holland & Allen PC, a full-service law firm headquartered in Sacramento, California, and Dennis Dunne is the 2009 Chancellor of CMAA's College of Fellows. Joel wrote most of the sections on *Project Organization and Commercial Terms*, and Dennis and Will contributed most of the section on *Operating System*. Will is author of the contracts used by Sutter Health for its IPD projects and a nationally recognized leader in the Lean Construction and IPD fields. Joel has considerable experience in construction transactions and over the past few years has worked closely with Will on Lean and other projects. Recently, Joel has also done extensive research on contract incentive programs. In addition, Joel criticized (unmercifully, but helpfully) the chapter on Legal Relationships. Dennis Dunne is a veteran public servant and private sector PM/CM. He is presently involved in a large public sector IPD/Lean enterprise as a consultant and learner (mostly learner he says).

Others have reviewed my writing of the other chapters and provided extraordinarily valuable criticism and contributions. However, if there are errors in those chapters, as there surely must be, it is likely that they are mine.

Mark R. Berry, Esq., was a great help reviewing the chapters on *Legal Relationships* and *Integrated Practice: Process or Product.* Mark is a partner in the Washington, DC office of Peckar & Abramson. He advises and represents contractors and construction managers in the public and private sector. He has served as the head of CMAA's legal committee and he is author of the book "*Construction Management: Law and Practice.*" He is a graduate of the University of Maryland and the George Washington University National Law Center.

John M. McGinty, FAIA, president of McGinty Architectural Consultants, LLP, past president of the American Institute of Architects and a well-known forensic consultant, contributed much thought for the chapter on *Integrated Practice: Process or Product.*

The *Integrated Practice: Process or Product* chapter has also drawn extensively on conversations with Carl Sapers, Hon. AIA, and from his paper entitled "The Liability of Architects and Engineers in Nineteenth Century America," written by Carl and Penny Pittman Merliss. Carl is a an adjunct professor of Studies in Professional Practice in Architecture at the Harvard Graduate School of Design and a specialist in construction law. I have had the pleasure of debating ideas and lecturing to his class annually for two decades. Penny Merliss is a graduate of Harvard Law School (J.D. 1984), the Harvard Graduate School of Arts and Sciences (Ph.D. 1979) and the University of Cincinnati (B.A. 1972). Much of her practice has been concerned with design and construction law.

Kevin A. Delorey is a partner in the Madison, Wisconsin office of Quarles & Brady LLP. He was good enough to share his thoughts on IPD, provide me with contract content from an impressive IPD project and comment on drafts of this white paper. It was Kevin who said of IPD, *"It's too early to put an anchor down."* He's sure right.

Ron Antevy, Chairman of eBuilder, offered criticism and new insights on every page of the section on Project Management Information Systems. I used them all. He was an enormous help.

The section on *BIM* owes much to conversations and an impressive paper by Howard Ashcraft, Esq., titled *Building Information Modeling: A Framework for Collaboration,* printed in The Construction Lawyer, Volume 28, Number 3, Summer 2008. Howard was good enough to discuss the paper at length on a phone call. The Construction Lawyer is the Journal of the American Bar Association's Forum on the Construction Industry. Howard is a Partner of Hanson Bridgett LLP.

Don Russell, FCMAA and 2010 Chancellor of the CMAA College of Fellows, and Bob Wilson, FCMAA Chancellor Emeritus of the CMAA College of Fellows, have read and provided criticism and intellectual input for multiple editions of this document.

Organization, Operating System and Commercial Terms

Joel Darrington, Dennis Dunne and Will Lichtig

Why IPD? What are the major problems for which IPD is proposed as the solution?

Stated briefly, construction projects frequently suffer from adversarial relationships, low rates of productivity, high rates of inefficiency and rework, frequent disputes, and lack of innovation, resulting in too many projects that cost too much and/or take too long to build. Also, projects continue to injure or kill too many workers, and owners are often disappointed with the quality of the end product. IPD, in all its varieties, is structured to address these basic problems.

The basic problem: construction projects are too inefficient, adversarial, and expensive.

All project delivery systems have three basic domains within which they operate: the project organization, the project's "operating system," and the commercial terms binding the project participants. In order for the delivery system to be coherent, the structure in each of these domains must be aligned or in balance. If you attempt to make adjustments in only one or two of the domains, you are likely to produce outcomes that are less than optimal. Think of it as an under-inflated tire—while it's only flat on the bottom, it still makes steering difficult.

Traditional project delivery systems offer a set of solutions in each of these domains. They routinely produce results that continue to disappoint owners and frustrate much of the construction industry. IPD seeks to systematically attack the deficiencies in each of these domains. Each is discussed below.

Project Organization

Tradition projects involve "siloed" structures with fairly rigid hierarchies.

The traditional construction project is organized into three "camps" with diverse interests that sometimes converge and other times are opposed: owner, designer and contractor. Project participants come into their camps at various times during the project, with designers coming on early, construction managers (if any) coming on in mid-design, and general and trade contractors coming on after design is substantially complete. Project communications typically reflect contractual lines, so that a trade contractor's issues flow up to the GC, over to the architect or owner, and if needed, down to the design consultant having the answer. As a result, traditional projects have organizations that resemble silos or chimneys, with each camp organized vertically and separated from each other by contractual walls.

What's the problem with that? It practically ensures that:

Traditional project organizations result in waste, increased cost and time, and more adversarial relationships.

- Design effort will be wasted because information about cost, constructability and owner's non-program preferences only come to the designers, if at all, at a few milestones after substantial design effort has occurred, thereby requiring re-design.
- Construction costs will be higher because general contractors and trade contractors will pad their prices with contingencies resulting from their uncertainty about the meaning/completeness of the design, in which they had little or no involvement. Also, designers will use larger than necessary space factors to give plenty of room for trade installations, resulting in larger buildings than needed. If designers were coordinating with trade contractors from the beginning, they would not need to provide such large space factors.
- Engineering safety factors will be extreme, as the engineers have no assurance concerning the capability and quality standards of the trade contractor who might ultimately be the low bidder. In

order to avoid an underperforming system, engineers often over-design the system's capacity.

- Change orders will result because the constructors first chance to point out problems in the drawings occurs after they have provided their final prices. Additionally, trade contractors who know best how to influence the design in order to improve productivity and constructability are excluded from the design process.
- Relationships will be adversarial and disputes more frequent. Imagine a situation where the party who is alleged to have made a mistake is also the party who decides whether that assertion is valid. That is routinely the position that architects and engineers are in. The contractual structure encourages each party to look to its own interests rather than the interests of the project as a whole. Lack of constructor involvement in the design phase reduces the level of common understanding of the project among the players, resulting in more mistakes, misunderstandings and blame. The stove-piped lines of communication often result in long-distance and arms-length relationships among project participants, hindering collaboration and increasing the likelihood of misunderstanding and mistrust.

In what ways does IPD address these problems?

Integrated teams

Organizationally, all IPD projects share at least one thing in common: construction managers and at least some key trade contractors are involved in the project with the owner and designers from the early stages of design. Thus, these CMs and trade contractors are selected on the basis of qualifications and not on price (although fee percentages may be considered).

IPD projects bring in construction managers and key trade contractors early in the design phase.

Bringing the key constructors together with the owner and the designers from the early stages of the project allow the major players to develop a much higher level of common understanding of the project. This has several salutary effects. The design moves forward with continuous input from the constructors about cost, constructability and value, allowing designers to make better decisions with fewer and less intensive negative loop-backs. This affords the constructors some ability to both influence the design and take some psychological ownership of the design. Perhaps just as importantly, the designers and constructors develop a closer, more productive relationship as they work side-by-side, solving problems together and gaining insight into the other's workings. A new project culture emerges.

Increase your team's integration by physically co-locating members of different disciplines and using Building Information Modeling (BIM.)

Some teams amp up the integration by physically co-locating members of the design and construction team, allowing for the ease of physical proximity to address questions and solve problems. This co-locating process is sometime named the "Big Room." People begin to see themselves more as one team, as they address the common project together, go out to lunch with people from different companies, talk about each other's kids, and make friends. People are much more likely to work out problems with their friends than with strangers.

Building Information Modeling (BIM), discussed more fully in a later chapter, also can assist the effort for an integrated team, as people across disciplines are required to converge around this digital conglomeration of models to figure out how things work together, address clashes and see how the various parts of the project are shaping up. Electronic Project Management Information Systems (PMIS), also discussed later, can provide Information Technology (IT) assistance in achieving integration.

Integrated governance

An integrated team also benefits from integrated governance, and many, probably most, IPD projects use some form of leadership by executive committee, variously called the Core Group, Project Management Team, Management Group or similar designations. Typically, this executive council is responsible for the day-to-day management and leadership on the project and operates on a consensus basis. In some models, the executive council must be unanimous to make a decision, with impasses escalating to senior management review and dispute resolution processes; other models may stipulate that the owner can break impasses, subject to dispute resolution. Most project-related decisions are delegated to the executive council.

Executive committees are always comprised of at least the owner, prime architect and prime contractor or construction manager, and often include representatives of key trades or key design consultants. Make the executive committee too big, however, and management will bog down.

Collaboration is fostered by joint management on a consensus basis.

The executive council members are more than mere managers, though. They are leaders, and their tone and commitment to the project and project delivery method are critical to success of an IPD project.

High-performing teams

The benefits of bringing key constructors and designers into the project early will be minimized if the project players continue to relate to each other in traditional ways. The benefits of IPD will only be realized with a change in culture, in the way team members relate with each other.

Partnering activities and a focus on developing shared processes are often used to aid in the shift to a more open, collaborative culture. The goal is to foster trust among the project participants. The commercial terms can help or hinder the development of that trust, and are discussed more below. Project leaders play a critical role in setting the expectation that team members relate to each other in more collaborative ways. Emphasizing the importance of making and keeping commitments, and tracking the team's performance, helps team members focus on and improve the reliability of their promises. Reliability, in turn, helps build trust.

Involving team members in goal-setting and performance evaluation also helps change the culture to one of increased trust, collaboration, shared learning and esprit de corps.

Some IPD projects create "high-performance" teams that span across disciplines and employers to put the right person in the right function for the project, regardless of employer.

Borrowing from the Project Alliancing model,[1] many IPD projects seek to create a "high-performing team" enlisting the right person for the right function regardless of employer. In effect, for purposes of the project, a virtual "company" is created, but this company is not a legal entity but more like a temporary social organization. People remain employed by their respective companies, but assume one or more roles based on individual skills and project needs, rather than the nature of the employer's business. An electrical trade contractor's senior detailer may be responsible for detailing certain parts of the facility and also volunteer to lead the team's efforts at creating and implementing a communications protocol. The team may ask the

[1] "Project Alliancing" grew out of the experience of British Petroleum in its development of oil fields in the North Sea in the 1990's. BP had repeatedly tried to find a way to develop the Andrew oil field at an economical cost. When traditional construction approaches did not yield an economical solution, BP was driven to find a better way, and helped pioneer a new approach that combined an innovative risk/reward structure with a collaborative project delivery model. The project was delivered £30 million under the estimated maximum price and more than £150 million under BP's original estimate of £450 million (and 6 months ahead of schedule). Its success launched what has come to be called "project alliancing". Australian owners and contractors have become some of the most ardent proponents of alliancing, with a number of public and private projects delivered successfully there.

mechanical design consultant's project manager to lead a special multi-disciplinary design team trying to solve a knotty problem. The CM's scheduling engineer may also sit on the BIM implementation team. These people remain on the payroll and under the supervision of their actual employers, but serve the project in the roles that add the most value based on need and available human capital.

Operating System

Of the various iterations of IPD, few address the "operating system" of a project other than to provide for executive committee governance and constructor-involvement in the design. A closer look at current performance suggests that a re-examination is in order. As described below, Lean Construction or Lean Project Delivery offers a number of innovations on the project operating systems that reduce waste, shorten schedules, increase productivity and quality, and also can improve safety and project relationships. As a result, many IPD projects also embrace and implement Lean Construction.

The current state

Current approaches to managing design and construction are typically based upon a definition of construction management much like the following:

> *Construction Management is defined as the judicious allocation of resources to finish a project on time, at budget, and at desired quality.*[2]

This definition is a reflection of the famous triangle of tradeoffs between Time/Cost/Quality with many supposedly smart people in the industry indicating to their peers (but rarely to the owner) that you can only solve two of the three. Unfortunately this cynical, jaundiced viewpoint is based on practice and experience.

Trust and integrity are required ingredients for improving communications and collaboration.

The essential features of current PM/CM practice are:

- It is activity-based, ignoring the effects of workflow variation on performance.
- It optimizes "performance" at the activity level to increase productivity or point speed.
- It is based on tracking deviations.

[2] Richard H. Clough and Glenn A. Sears, Construction Project Management, John Wiley & Sons (1994).

- It is defensive, managing with the expectation of future claims and disputes.

The 6th annual survey of construction owners by CMAA (2005) reveals:

- Between 40 and 50 percent of all construction projects are running behind schedule (same as previous years)
- The biggest cost impacting construction today is that of inefficiencies built into the way projects are run and managed – not costs of raw material like steel and concrete, or the cost of labor
- More than a third of owners said they felt their project controls were not adequate, citing project management and cost controls as areas most in need of improvement
- "Trust and integrity are required ingredients for improving communications and collaboration"

In the same CMAA 2005 survey the owner' top concerns were listed as:

In conventional projects, each party in the project protects its own turf.

- Each party in the project protects its own turf
- There is little learning and repetitive failures
- It ignores the creation and delivery of value
- Trust and integrity in the construction process
- Coordination/Collaboration among team members
- Improved relationships between contractors, CM staff, Designers, and final users
- A/E consciousness of the cost to build their designs
- Bringing contractors, subs, and suppliers on board during the design phase
- Scope control/communicating a clear work scope
- Providing drawings that are more complete to build the project
- Owner responsibility for the process
- Owner decision-making responsiveness
- Attaining good project definition

Even with all the advances made in the CM/PM world, much of it driven by CMAA through its educational and certification efforts, why is it that the primary concerns of owners remain unchanged year after year? Clearly, the education and skill level of the practitioners of CM/PM services has increased markedly in the last decades, but most of the design and construction results are drearily the same.

In order to ameliorate the basic problems caused by the non–linear, labyrinthine A/E/C world and to provide owners more value, the industry developed a number of palliative workarounds like:

- Value-engineering
- Partnering
- TQM/QFD
- Constructability Reviews
- IT/CAD/PMIS
- Productivity Improvement
- BIM/Computer Simulation

Unfortunately the results from the ultimate score keepers – the owners - haven't fundamentally changed during the tenure of these new "solutions." All of these attempts fail because they operate to relieve symptoms and do not deal with the underlying problems. Sub-optimization is still the result.

Lean construction

Lean is a holistic, value-based approach to creating the built environment. Where almost all current approaches to managing design and construction assume that the process from conception to operation is a linear sequence of events, Lean has been developed to organize and reshape what those familiar with the Architecture/Engineering/Construction (A/E/C) world realize is more like a non-linear labyrinth. Lean seeks to restructure the project's operating system to focus on what adds value and to smooth out the workflow.

A different future state?

A fundamental issue – the inability to reliably predict future success even with a great cast of characters and a desire by all to succeed.

When Lean practitioners speak to groups about this new system concept, invariably many people in the audience listen for a while and then raise their hand and say that they have been regularly practicing most of the principles, behaviors and tools used in Lean. They may go on to cite collaboration, partnering, bringing stakeholders early into the process, and maybe even working in teams.

They will also state that they have been involved in very successful projects when they worked with the right players and used these tools. When questioned further, however, they usually admit that they have been on jobs with virtually the same set of players using the same tools where the results were less than wonderful. And that is a fundamental issue in today's environment – the inability to reliably predict future success even with a great cast of characters and a desire by all parties to succeed.

So, what is new and different with Lean Construction and can it make project delivery more reliable and likely to meet or exceed customer expectations? The initial findings are promising and the following tries to convey why this is occurring.

Lean is founded on the scientific method.

Given that it is a relatively new "operating system," Lean Construction is not easily defined in a sound-bite or elevator speech. It has seen multiple definitions in its evolution.

Because it is hypothesis—and research-based, founded on the scientific method (Plan – Do – Check – Adjust), some concepts, principles and tools are developed and then found to not produce the value expected and are reshaped or discarded. These sub-definitional elements then change and combine, leading to further refinement of the definition.

One definition that seems well suited from a PM/CM perspective was developed by the Lean Construction Institute and is excerpted as follows:

> *Lean Construction is a production management-based approach to project delivery – a new way to design and build capital facilities. . . . Lean changes the way work is done throughout the delivery process. Lean Construction extends from the objectives of a lean production system – maximize value and minimize waste – to specific techniques and applies them in a new project delivery process. As a result:*
>
> - *The facility and its delivery process are designed together to better reveal and support customer purposes. Positive iteration within the process is supported and negative iteration reduced.*
> - *Work is structured throughout the process to maximize value and to reduce waste at the project delivery level.*
> - *Efforts to manage and improve performance are aimed at improving total project performance because it is more important than reducing the cost of increasing the speed of any activity.*
> - *Control is redefined from "monitoring results" to "making things happen". The performance of the planning and control systems are measured and improved.*

> *The reliable release of work between specialists in design, supply and assembly assure value is delivered to the customer and waste is reduced.*[3]

Lean construction is specifically formulated to arrive at all project and program goals without conceding that trade-offs of time, cost, quality, participant satisfaction, or safety are inevitable.

Lean project delivery: New thinking, new tools and new behaviors

Learning Lean is hard work, requiring participants to unlearn many behaviors that worked well in traditional settings.

Lean is a philosophy, culture and discipline with a set of preferred behaviors and a continually increasing repertoire of tools. Learning Lean is hard, disciplined work and requires participants to unlearn many behaviors that worked well in a traditional setting but are antithetical to the Lean experience.

The leader as "the loudest voice" or the "I wind up doing it myself because I can't trust anyone else to do it right" hero personality do not work well in the Lean environment. So, when many of the behaviors that worked in a non-Lean world are stripped away, a new repertoire of tools is needed to replace the dysfunctional ones.

At first, it may seem to some new Lean initiates that they are back attending grammar school. But for most learners, the light turns on quickly and they realize that there really are better ways to contribute, learn and add value. And they find they are having fun too.

The following sections provide a glimpse of some of the most common tools and behaviors used in a Lean environment. This list just scratches the surface of the toolbox that is evolving and developing rapidly in IPD/Lean settings.

Lean tools

Lean tools should only be used when they drive value into, or eliminate waste from, the project. The wrong tool or a tool improperly used creates waste, not value. And as with most useful tools, they require training in order to be used properly and without damaging the project.

Plan-do-check-adjust (PDCA)

At the heart of Lean thinking is the scientific method and the Shewart [4]cycle, also known as the "Plan-Do-Check-Adjust" (PDCA)

[3] Lean Construction Institute, What is Lean Construction? www.leanconstruction.org/whatis.htm.

cycle. The PDCA process is fundamental to lean problem analysis and resolution. PDCA starts with examining an existing process, condition or standard procedure and then refining and improving it to create a new standard. A major element of PDCA is spending adequate time to develop a detailed understanding of the problem to be solved.[5]

PDCA consists of four stages, including:

1. Plan – Investigate the cause of a troublesome condition and create a proposal for its modification or resolution.
2. Do – Perform a test implementation of the plan.
3. Check – Assess the results of the test for effectiveness.
4. Adjust – If the results are satisfactory, modify the original condition or define a new standard procedure. If the results are not satisfactory, refine the plan and repeat the cycle until satisfactory results are achieved. The new improvement becomes the standard, when the process may begin again to attain the next improvement.

While this sounds simple, developing the discipline to deeply engage in this process is counterintuitive to many in the construction industry who always want immediate action. How many times have you heard team members say, "We don't have time for that, we are already behind!" Learning how to better plan to create the capacity for the discipline of PDCA is a major function of the Last Planner System, discussed below.

PDCA sounds simple, but developing the discipline to deeply engage in the process is counterintuitive to many, who are always urgent to move to action.

A3 Reports

An A3 report is a way of organizing and analyzing issues that require the composer to fully engage with PDCA thinking. A typical A3 states the background, the problem, the current state; the future desired state and the proposed counter-measures to get to the future state all on a single, 11" by 17" piece of paper. John Shook, the "A3" guru, has explained the process as follow: ". . . an A3 document structures effective and efficient dialogue that fosters understanding

A3 reports are invaluable for providing a durable record that reflects the knowledge, thought process, and decision recommendation in an accessible format.

[4] Walter Andrew Shewhart (pronounced lke "shoe-heart", March 18, 1892 – March 11, 1967) was an American physicist, engineer and statistician, sometimes known as the father of statistical quality control, W. Edwards Deming said of him: As a statiscian, he was, like so many of the rest of us, self-taught, on a good background of physics and mathematics.

[5] Remember the famous quote from Albert Einstein, "If I had an hour to save the world I would spend 59 minutes defining the problem and one minute finding solutions." Similarly, the quote from Abraham Lincoln, "Give me six hours to chop down a tree and I will spend the first four sharpening the axe."

followed by the opportunity for deep agreement. It's a tool that engenders communication and dialogue in a manner that leads to good decisions, where the proposed countermeasures have a better chance of being effective because they are based on facts and data gathered at the place where the work is performed, from the people who perform it."[6]

While a properly prepared A3 appears very simplistic, it is anything but. A3s are the by-product of a disciplined, collaborative approach to problem solving, with significant work and distillation both by the author and the collaborators. A3s are invaluable for providing a durable record that reflects the knowledge, thought process, and decision recommendation in an exceptionally accessible format. A3s are proof of the old adage, "I wrote a long report because I did not have the time to prepare a short report."

Value Stream Mapping

Using Value Stream Mapping, teams often discover that steps can be eliminated, reorganized, or deferred in ways that improve schedule, reduce time, and improve the quality of the product.

Value stream mapping is an important tool that enables a team to analyze business processes step by step to discover how value is produced, and to identify hidden waste. It allows a team to explore, develop a shared understanding and document both the "current state" of how an operation is performed and the "future state" once that process has been optimized. Simply stated the steps are:

- Identify the target product (deliverable), product family or service.
- Draw a current state value stream map, which shows the current steps, delays and information flows required to deliver the target product or service. This may be a production flow (raw materials to consumer) or a design flow (concept to launch).
- Assess the current state value stream map in terms of creating flow by eliminating waste.
- Draw a future state value stream map.
- Implement the future state.
- Assess and adjust the new process as needed.

When applied to design and construction, it is staggering to see how much hidden waste is buried in operations that are performed in a certain way, "because that's the way we have always done it. " Often, teams discover that steps can be eliminated, reorganized or deferred

[6] John Shook, Managing to Learn, The Lean Enterprise Institute, Inc, Cambridge MA, p. 107 (2008).

in ways that improve schedule, reduce time and improve the quality of the product.[7]

BIM and Real Time Estimating

Building Information Modeling (BIM) is a collection of software programs that help coordinate the design efforts of multiple disciplines and allow for more automated and facile estimation of schedule and cost. While not unique to Lean or IPD, BIM is highly complementary to Lean techniques and an IPD approach.

Architectural drawing and rendering software provides the team the ability to use virtual prototyping to consider possible design solutions. This can help the owner and other stakeholders to visualize and weigh-in on proposed solutions, as well as allow the builders to assess constructability, site logistics and cost ramifications of multiple solutions to influence the design.

Later in the process, BIM allows coordination in 3D and 4D to assist planners, designers and contractors to determine inconsistencies and "clashes" in design. It also ensures that changes in a plan carry through to all of the related items in other plans and budgets. This enables the project team to avoid rework and engage in real-time estimating, as changes to the plans and design occur. For more on BIM, see the chapter on BIM later in this paper.

Target Value Design

Target Value Design (TVD) is a design strategy and process that offers designers an opportunity to engage in the design conversation concurrently with those people who will procure services and execute the design. It focuses on designing based on the articulated project values, which become design criteria rather than mere aspirations. Major aspects of the TVD process include the following:

Target Value Design is a collaborative strategy and process for designing based on the articulated project values, which become design criteria rather than mere aspirations.

- Rather than estimate based on a detailed design, design based on a detailed estimate. The initial detailed estimate is a by-product of the team's initial "validation study," a joint effort of the designers and trade contractors to develop a mutually understood and agreed basis of design, and a trade estimate tied to the basis of design. While the validation study produces the project's "expected cost" – what current best practice would support – the

Rather than estimate based on a detailed design, design based on a detailed estimate.

[7] For a good discussion of the application of Value Stream Mapping to a project's design phase see the AEC bytes "Building the Future" article, "Sutter Medical Center Castro Valley: Case Study of an IPD Project," at http://www.aecbytes.com/buildingthefuture/2009/Sutter_IPDCaseStudy.html.

team then sets a target cost as a "stretch" goal to drive innovation. No longer should an owner, seeing a leap in the estimated price as design progresses, hear the common refrain from a contractor, "Well, now that there are more drawings, I have a better idea what the designer had in mind!" TVD is calibrated to eliminate this waste.

- Rather than evaluate the constructability of a developed design, develop the design based on input on what is constructible.
- Rather than evaluate the constructability of a developed design, develop the design based on input on what is constructible. Don't "draw" without first confirming with the builder that if it is drawn that way it will still be within the estimate and will be safe and productive to execute.
- Rather than design alone and then gather for group reviews and decisions, designers, constructors and users work together to define the issues and produce decisions used by the designers to realize the design.
- Rather than quickly choosing a single solution based upon one person's past experience, use set-based, concurrent engineering concepts to carry multiple solutions far into the design process and narrow choices only at the last responsible moment. Fully research the range of possible solutions, document the developed knowledge, and engage in a decision-making process that disciplines the team to make a decision that is anchored in the facts, rather than the one favored by the dominant personality.
- Rather than have designers and makers working alone in separate rooms, work side-by-side in physical proximity or virtual settings.
- Rather than have designers and makers working alone in separate rooms, work in pairs or a larger group face-to-face. If the project can't afford full-time co-location, develop a virtual alternative, with routine sessions where people are in the same virtual room.

Last Planner System™ / Commitment-Based Planning

Lean project delivery presupposes that project workflow is based upon individuals making and keeping commitments. It seems obvious that each project participant is dependent on others in the project's "network of commitments" to start and finish their work as promised in order to promote the reliable flow of work on the project. When preceding work is not done when promised, it creates problems for the team that is to follow.

Projects are often chaotic, schedules are rarely accurate and many projects are treated as "a commitment-free zone."

On typical construction projects, where only about 55% of items promised to be completed actually are done when promised, this lack of reliability often results in lack of trust and escalating games of "chicken." Because trade contractors want to assure they have plenty of work available when they send crews to site, they delay mobilizing; having been burned historically with false promises that preceding work would be complete on a certain date. General contractors, believing based on prior experience that the trades won't show up on the date they require, start asking the trades to be present sooner. When the trade reviews the site before mobilizing and sees that the work is not ready, they increase their buffer to protect against the unreliability of the GC to predict when the work will be done. Given this, why are we surprised that projects are often chaotic, that schedules are rarely accurate, and that projects are referred to as "a commitment-free zone"?

The Last Planner System™ (LPS)[8] was developed to provide a systematic process of production planning and control that is focused on improving work flow reliability. Its ultimate goal is to allow the "Last Planners" (trade foreman and design captains) to be in position each week to make reliable commitments and keep them. When they are able to do this, workflow becomes more reliable. With more predictable workflow, companies are able to make better decisions about resource allocation, scheduling and coordination. The system, as with other planning systems used on Lean projects, mandates that every participant has a voice with the responsibility to speak up, make and keep promises and say no when it is required.[9]

LPS is also founded on the reality that advance planning never accurately predicts the future, that conditions on projects change, and that plans will need to be changed. It also recognizes that the further removed the planning process is from the date when the work will be performed, the less accurate it will likely be. Finally, it acknowledges that the greater the detail included in the forecast, the more likely it will be wrong. In order to address these issues, LPS performs planning in increasing levels of detail as the time for performance

LPS is founded on the reality that advance planning never accurately predicts the future, that conditions on projects change, and that plans will need to be changed.

[8] The Last Planner System ™ was initially conceived by Glenn Ballard and Gregory Howell and developed by the Lean Construction Institute, which holds the trademark.

[9] Responsibility-Based Project Delivery™, sometimes used in the design phase, is a pull-planning system particularly appropriate for iterative practices often experienced in early design. Responsibility-Based Project Delivery™ was developed by Lean Project Consulting, Inc., which holds the trademark.

gets closer. It also assumes that teams can learn from planning failures and develop strategies to improve their ability to plan reliably.[10]

LPS is a production/workflow control system designed to:

- Empower front-line personnel to make decisions about what work to commit to delivering within a given timeframe
- Improve workflow by ensuring that future work is **READY** when needed by the next performer
- Track Percent Plan Complete (PPC) as a measure of variability in commitment-keeping
- Produce reliable results task by task throughout the project from conception to completion

As noted above, LPS has multiple layers of planning. **Milestone planning** is done as a strategic exercise to confirm at the highest level whether the project can be completed within the overall time allotted. Milestone schedules are prepared based on the key owner schedule requirements and other major project milestones. While this task is often driven by the construction manager or the general contractor, it should involve as many team members as possible to either validate or challenge the assumptions underlying the schedule.

The focus of pull planning is on what each trade or discipline needs from others in order to properly start and finish its work.

The next level of planning occurs in "pull-plan sessions" where the relevant project performers come together to discuss work in a particular phase or needed to meet a particular milestone. A "**phase schedule**" is prepared to address how a milestone is achieved, pulling back from the milestone through necessary major activities that allow one trade or discipline to complete its work in that phase.

The focus is on what each trade or discipline needs from others in order to properly start and finish its work. The phase schedule defines the hand-offs from one discipline or trade to another, assuring that the performer and the customer for each portion of the work agree on the criteria for determining that the work being delivered is fully ready—that is, there are no constraints to the next performer on the project. Each performer must identify their needs

[10] The "principles" underlying LPS can be summarized as follows: "Plan in greater detail as you get closer to doing the work. Produce plans collaboratively with those who will do the work. Reveal and remove constraints on planned tasks as a team. Make and secure reliable promises. Learn from breakdowns." Glenn Ballard, "Production Control Principles," published in the Proceedings of IGLC 17 and available at http://www.ppml.url.tw/IGLC_17/abstracts/Production_development_and_design_management.htm.

and constraints and negotiate with those from whom they need something to accomplish their work. The by-product of the phase planning is a graphic plan showing not just the sequence of work, but detailing the agreement between each "performer" and its "customer" describing what exactly will be provided (sometimes called the "hand-off criteria") and by when.

The next level of planning is referred to as "**Look-Ahead Planning**." The look-ahead window will depend on the project, but is usually a minimum of six weeks. The window should be set to assure that any constraints identified in the look ahead process can be resolved at least the week before the work is planned to be performed.

The look ahead process is also called the "make-ready process" – the focus here is to identify any constraints (obstacles) that would prevent the work from being started <u>and</u> completed as planned. These constraints, which might be submittals, material deliveries, pending Requests For Information (RFI's) or similar items, must be resolved in order to allow the work to be promised and completed. As part of the look ahead process, LPS looks for a reliable promise from a project participant to remove the constraint, reflecting an agreement with the individual identifying the constraint about how and by when it will be resolved.

The final planning level in the LPS is the **weekly work planning** session. This is sometimes referred to as weekly foreman planning. Weekly work plans are used to obtain commitments from the Last Planners of what work will be completed <u>each day</u> during the coming week and to assure coordination between the Last Planners. The weekly work planning process will also identify any "workable backlog" – constraint-free work that is not required to be done this week according to the plan, but which the entire team agrees can be pursued if the team has excess capacity.

During a weekly work planning meeting, the team will make commitments about the work to be completed each day and also review the scorecard from the preceding week of "planned percent complete" – what percentage of the items promised last week were actually completed as promised .

Identifying and agreeing on workable backlog assure that pursuing that work will not injure or detract from one of the other team member's ability to pursue its work. As part of the weekly work-planning meeting, the team will also review the scorecard from the preceding week of "planned percent complete" – what percentage of the items promised last week were actually completed as promised – as well as the reasons for variance. With the goal of improving planning system reliability, the purpose of this review is to identify the root causes of plan failure and to explore what the team might do differently in the future to improve their ability to produce reliability.

A simplified view of LPS is based on the "Should, Can, Will, Did" convention:

SHOULD work is derived from the master and phase schedule.

CAN work is derived from the Look-Ahead Plan and represents what the team thinks can be done.

WILL work is derived from weekly work plans and is work that a performer agrees will be done.

DID work is completed work.

The PPC (Percent Plan Complete) metric is derived by dividing the DIDs by the WILLs.

Implementing LPS also produces collateral benefits. By putting the various disciplines and trades in direct planning conversations, the parties are better able to assure a mutual understanding of the "conditions of satisfaction," thus reducing rework and its attendant costs and delays. This also reduces disputes and claims resulting from the trades stepping on each other's toes (or worse). When the parties come to trust one another more through this process, they are willing to let go of some of the hidden schedule buffers they put into their work schedules as a result of the uncertainty of how others' performance will impact them. Projects move faster and stumble less often.

Retrospectives

Again, focusing on the PDCA cycle, it is important for the team to routinely reflect on project progress and process to assess whether adjustments are in order. Retrospectives are organized, regularly scheduled, facilitated sessions that provide team members the opportunity to assess the effectiveness and efficiency of project process and identify what works and what does not. Retrospectives also allow for team consideration of new approaches to identified problems. Periodically, team members take time to evaluate past activities and identify successes and areas for improvement.

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Lean behaviors

Underlying any successful implementation of Lean Project Delivery are specific behaviors. These behaviors support a change in mindset from individual, personal and contractual achievement to collective, project achievement. They require moving from an attitude of "knower" to one of "learner."

Lean requires moving from an attitude of being a "knower" to one of being a "learner."

Collaboration, trust, promised based management and continuous learning are behaviors required of each individual on a Lean project.

But, as Howell and Ballard point out, it is "relatively easy to contract for the purchase of a thing and relatively difficult to contract for behavior."[11] Cultural change and project leadership are required.

Collaboration

Given the shift in mindset from individual self-interest to a collective enterprise, Lean requires collaboration between all the parties involved in a project. This includes the owner, project manager, the design team, the contractor and operational personnel. Collaboration requires freely soliciting and sharing information and ideas as equals, not as master and subordinate.

Rather than everyone critiquing a proposed solution, collaboration requires engaging the whole team in defining the problem. It is a process by which team members have the opportunity to share with and learn from the talents, experiences and performance of others.

A major shift is to engage the team in collaborating to define the problem, rather than critique a proposed solution. This requires all team members to approach collaboration as a process by which they have the opportunity to share with and <u>learn</u> from the talents, experiences and performance of others. Real collaboration cannot happen without trust amongst the team members and openness to the reality that each of us does not have the best idea for a solution. If an individual believes or behaves like he or she is the "lone genius" in the group, and that collaboration is an opportunity to demonstrate this to the rest of the team, then you have selected the wrong team member!

Trust

Trust, both organizational and individual, is required for Lean Project Delivery. Trust must be a common thread running through the entire program and provides a foundation for collaboration. Trust is essentially a decision each person on the project makes every day to trust the other participants.

Trust is essentially a decision each person on the project makes every day to trust the other participants.

To trust people is to count on their sense of responsibility (or perhaps their sense of integrity), believing that they will choose to act in a trustworthy manner, while recognizing the possibility that they may choose to betray the trust.[12] It is something that can be built intentionally and must be openly discussed.

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[11] Greg Howell and Glenn Ballard, Lean Production Theory: Moving Beyond 'Can Do,' pages 17-23 in Alarcon, L. (ed.), Lean Construction. A.A. Balkema, Rotterdam, The Netherlands (1997); http://www.leanconstruction.org/pdf/beyond-can-do.pdf.

[12] Robert Solomon and Fernando Flores, BUILDING TRUST IN BUSINESS, POLITICS, RELATIONSHIPS AND LIFE, Oxford Press, p. 24 (2001).

Since each participant is asked to focus on project goals and the continuous flow of the project, each must be empowered by his/her company to interweave the short-term goals of the company's contract with the long term goals represented by the project. This requires the company to trust the participant to make important decisions in the project's interest and, simultaneously, the participant to trust that the company's long-term interests are best served by project-first thinking.

When individuals reliably do what they say they are going to do, trust is built.

Trust is realized through fulfilling commitments. Lean projects become a network of commitments that assumes all participants will keep their commitments (i.e., will be trustworthy and reliable). Because policing of individual activities wastes time and effort, team members must rely upon others to honor commitments, including the assumption underlying commitments that the committer has the capability to perform and complete work as promised. When individuals reliably do what they say they are going to do, trust is built.

Promise-based management

Requests and commitments between team members are the basis of communication on a Lean project.

As stated above, requests and commitments between team members are the basis of communication within Lean Project Delivery. Simply stated, one party makes a request and another commits to fulfilling that request according to mutually agreed upon conditions of satisfaction (i.e., both parties understand what satisfaction of the request actually means).

Commitments are tracked from request to completion. When commitments are unfulfilled, the parties renegotiate the commitment, and endeavor to avoid blame and similar counter-productive behavior. When previously made commitments begin to appear unreliable, participants learn to communicate this earlier rather than later, allowing for more flexibility in the team's response. Tracking the rate of commitment-keeping helps people feel accountable and leads to improved reliability of promises.[13]

Continuous improvement

Part of Lean Project Delivery is collecting and sharing information on lessons learned throughout the life of the project and implementing improvements based on those lessons. In Lean terms,

[13] For more information about this topic, see Donald Sull and Charles Spinosa, "Promise-Based Management: The Essence of Execution," Harvard Business Review, April 2007.

this is described as continuous improvement. Continuous improvement adds value to the owner as it affects every area of project development and implementation including site selection, design, procurement decisions, fiscal reporting, safety and quality issues, project delivery methods, material choices, vendor offerings, and operational efficiencies.

Lean Project Delivery includes the documentation of lessons learned, so that all team members have access to and can share information. Numerous tools are used to document lessons learned. Examples include the use of technology, such as Building Information Modeling (BIM) and cost modeling to continuously capture design choices and update budgets. A3 reports, discussed above, also become a valuable library of information for all team members. PMIS and/or social networking software can be used for knowledge management and sharing between team members.

Lean Project Delivery includes the documentation of lessons learned, so that all team members have access to and can share information.

The potential effects of Lean thinking, behaviors and tools

Developing a Community of Practice

A "Community of Practice" refers to a group of people who share a concern, interest or a passion for something they do and then develop further proficiency as they practice and regularly interact. A Community of Practice involves much more than the technical knowledge or skills associated with assuming a task.

A Community of Practice gives members a sense of joint enterprise and identity. They benefit the project with their increased knowledge and skills, adding value to both the owner and the participants.

Organizing around this particular area gives members a sense of joint enterprise and identity. For a community to work, it needs to develop tools, records, routines, vocabulary and symbols that represent the accumulated knowledge of the community. A Community of Practice exhibits the following behaviors and characteristics:

- It has a domain of shared interest as defined by its members. The domain may evolve over time.
- There is community activity that binds members together, such as cooperating, sharing and learning.
- There is a capability developed with a shared repertoire of stories and strategies, thereby leveraging existing practice.

Lean Project Delivery behaviors and tools require collaboration, trust and regular interaction between team members. This often results in the project developing a number of different Communities of Practice focusing on specialized areas such as quality, safety, supply chain, etc. These communities benefit the project because the combined increased knowledge and skills, add value to both owner and participants.

Better project outcomes

Many see Lean Construction as the future of the construction industry. Early adopters appear to be reaping the benefits.

At this point, some are undoubtedly wondering, "So, does it work?" Lean construction is still relatively new, so evidence right now is mostly self-reported and anecdotal. The most comprehensive survey of which we are aware is a 2004 report commissioned by the Construction Industry Institute. While the focus of the survey was not on quantitative outcomes of Lean projects, the report does offer this:

> *Interviews with early adopters of lean construction principles cited increased quality, increased safety, better schedule performance and decreased costs as some of the benefits of starting the lean journey.*[14]

In 2007, Jack Hallman, Global Director of Capital Projects Organization for General Motors Worldwide Facilities Group, noted that GM has experienced notable improvements in projects since implementing lean construction in 2004, including "lower costs, shorter construction cycles, and increased production, safety and product quality." Specifically, Hallman cites a 20% reduction in project completion time.[15]

Others report similar results. Wisconsin-based general contractor The Boldt Co. saw a number of projects improve their schedule performance by 20% once they implemented Lean, as well as striking improvement in productivity, such as a 20-30% improvement in the productivity of concrete work. Graycor, an Illinois general contractor, improved its weekly work productivity from 54% to around 75%.[16]

The theory behind Lean construction is sound and the early results are promising. Many see Lean construction as the future of the construction industry. Early adopters appear to be reaping the benefits.

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[14] James E. Diekmann et al, Application of Lean Manufacturing Principles to Construction, Report to the Construction Industry Institute, Austin, Texas, p. 121 (July 2004).

[15] It's Time for Change – Lean Project Delivery: Eliminating Construction Waste, The VOICE, The Construction Users Roundtable, p. 17 (Summer 2007).

[16] Carly Koprivica, The Coming Revolution, Constructech, p. 2 (August 2002).

Commercial Terms

Traditional contract structures foster local rather than project-wide optimization. This leads to inefficiency and disputes.

As noted above, traditional construction projects are comprised of many two-party contracts that create a vertical chain of relationships that flow back to the owner, but do not interconnect project participants across contractual lines. As a result of this contract structure, each participant operates under commercial terms that provide economic incentive for it to maximize its own interests regardless of whether its actions would hurt other project players or benefit the project as a whole.

Without some different commercial mechanism in operation, a typical trade contract would actually reward a fire protection contractor for running its pipes in the way least costly to the firm, even if that would require the Heating, Ventilation and Air Conditioning (HVAC) contractor to route its ductwork in a way more costly than the savings realized by the fire protection contractor. As a result, the project as a whole suffers.

While some designers and constructors will "do the right thing" in spite of economic incentives, wouldn't it be better to have a set of contract incentives that reward team behavior?

This traditional commercial structure also provides economic incentives that could undercut cooperation, or at best fail to support it. Imagine a scenario where the design of the HVAC system is running over budget, but the plumbing design consultant realizes there is a way to revise the plumbing designs that would be cost effective and also allow the HVAC system to be rerouted in a more efficient way. If the plumbing design consultant is running up against its budgeted hours for the design development phase when it realizes this solution, and the HVAC system as currently designed does not hurt the plumbing designer at all, the economic incentive is for the plumbing designer to keep his head down and remain silent.

Victor Sanvido, then a professor at Penn State University, undertook a comprehensive Construction Industry Institute (CII)-sponsored study of project delivery methods. Among his other conclusions, Professor Sanvido concluded that one of the keys to a successful project is a "contract that encourages and rewards organizations for behaving as a team."[17] In this spirit, IPD projects take a variety of approaches to change the commercial framework of risk allocation and compensation in order to better align the parties' commercial interests with a collaborative approach and overall success on the project.

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[17] Victor E. Sanvido and Mark D. Konchar, Selecting Project Delivery Systems: Comparing Design-Build, Design-Bid-Build And Construction Management At Risk, p. 3 (1999).

Collective risk management

The idea that "the party that can best manage the risk should bear the risk" is largely a fallacy in construction projects.

Traditional commercial terms result in riskier projects. Consider that the common wisdom in construction has been that "the party that can best manage the risk should bear the risk." As a result, traditional construction contracts shift risk among the various participants, and sometimes, despite the common wisdom, the party who bears the risk is the one with the least bargaining power rather than the one best able to manage the risk.

Even more problematic, this risk-shifting principle assumes that there is one, and only one, party that can effectively manage the risk. In many, perhaps most, projects, and especially in the complex projects for which IPD is particularly well suited, the common wisdom is mistaken. The actions of all the various project participants can influence, and be influenced by, what the other players do or fail to do, impacting the risk to each player and to the project as a whole.

Also, events or conditions external to the project players often present risks that impact multiple project participants, who will each vary in the degree to which they can effectively address that risk. This complex web connecting various players and events makes it basically impossible for any one party to effectively manage many kinds of project risks by itself.

Not only is it unfair to make a party solely bear a risk it cannot effectively control, it is also inefficient. If a party is responsible for a risk it cannot effectively control, that unmanaged risk may hurt not only the responsible party but also the other participants and the project as a whole.

The traditional risk-shifting approach provides no commercial inducement to the parties "not at risk" to offer help to the risk-bearing party. Instead, potential helpers have economic motives to view those problems as "someone else's" rather than "ours." This traditional approach results in each party trying to optimize its own part of the project rather than optimizing the project as a whole.

Collective risk management means less risk for the whole project, and thus, less risk for the players to share. It also promotes a collaborative project culture.

IPD offers a better opportunity. Rather than simply shifting risk among each other, members of an IPD team typically agree in various ways to share risk and collectively manage it. By sharing risk, all project participants have a financial stake in effectively identifying and mitigating risks that in traditional projects would be "someone else's problem," leading to a less risky project overall as well as a more equitable approach to risk management. When another's problem will have a direct impact on your bottom line, you are more likely to offer help in solving the problem – promoting an "all for one, one for all" culture with everyone trying to reduce risk in their own way. Collective risk management means less risk for the whole project.

It is important to realize that while the traditional risk-shifting approach seems to protect the risk-shifting party, there are real financial costs in doing so (and it doesn't always work). When someone is allocated a risk that it cannot adequately control, it will seek to protect itself against that risk in at least two ways: (1) up front, by increasing its contract price in order to build in additional contingency to monetize the risk; and (2) later in the project, by engaging in adversarial behavior, such as bringing claims or demanding change orders so as to recoup damages resulting from the risk. Inflated contingencies then get multiplied throughout the supply chain, as contingency gets stacked on top of contingency.

The result is that an owner may either abandon the project as unaffordable or tie up a larger proportion of its funds than is actually necessary to address the project risks. This also results in opportunity costs, since the owner is unable to use those funds for other important goals.

Collective risk management also frees up creativity and energy otherwise spent on defensive behavior.

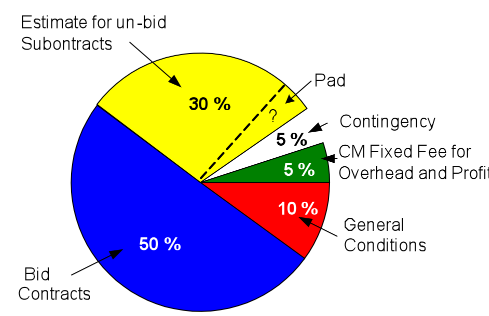
If the parties have a financial stake in most risks, rather than simply shifting them, their commercial interests are better aligned to support collective risk management and to optimize the whole project rather than their own pieces. Typically, the non-owner participants in an IPD project share risk up to a pre-determined point, above which they are not liable. Also, many IPD projects provide some kind of constraint on the players' ability to sue one another. When the project players' liability is limited to a reasonable level, they can then focus more directly on meeting the owner's objectives rather than on protecting their balance sheets. By sharing the collective risk, each player still has "skin in the game" to keep it sharp, but without betting the farm. When the company's survival is at stake, a participant is more likely to take an approach that avoids failure, rather than seeking excellence.

IPD projects use many creative ways of sharing risks and fostering collective risk management. Three common approaches involve sharing the cost-savings or cost overruns against an estimated cost of the work, pooling some portion of the team member's profit and placing it at risk, and/or pooling contingency funds and sharing any amount remaining after project completion.

Painsharing and gainsharing

GMPs are not a great predictor of final project cost.

Typically, when an owner engages a construction manager to provide preconstruction services and then construct the project at risk, the CM is paid its construction costs plus a fee, subject to a Guaranteed Maximum Price ("GMP"). At least as a matter of contract, the owner thinks it has transferred the risk of cost overruns to the CM and that the GMP represents an outside amount of the project cost. However, this is an illusion. In reality, the GMP is only the "first cost," not the "final cost." As the project progresses and the more likely it appears that the constructors will overrun the GMP, the greater will be the temptation for the constructors to act as adversaries and seek to protect their bottom line through claims and change orders. Even if the owner prevails, it still incurs significant transaction costs (e.g., "siege" preparation during construction, lawyers, consultants, and expert witnesses) outside of the GMP in the process.



Owners often want the GMP before construction starts to assure that they can complete the project within their budget. The construction documents may be complete for the early construction tasks but some are often incomplete for later tasks. The CM will bid some of the subcontracts, estimate the cost of the un-bid contracts, estimate the General Conditions and then add in fee and contingency.

Also, the owner pays a price in order to transfer the risk of cost overruns to the CM (and by extension, to the trade contractors). As in any risk transfer scenario, the constructors charge a premium to accept this risk, which takes the form of higher fees and larger contingencies (hidden or explicit). As a result, the owner commits a greater proportion of its project funds to transaction costs rather than construction costs, and the more risky the project, the greater the premium. This is particularly true in those cases where the owner wants the CM to provide a GMP before construction documents are substantially complete, thus requesting a defined price for an undefined product.

Many IPD projects use a compensation model based on shared risk of cost overruns and shared benefit of cost savings.

Many IPD projects choose a different approach to compensation. While they come in different iterations and vary somewhat in how they operate, the general idea is that the project team sets an amount for the expected design and construction cost and then share any cost under-runs or overruns. Thus, the participating team members mutually benefit when project cost savings are achieved and mutually share the risk of cost overruns. (Continue reading below, however, to see how this powerful incentive needs to be balanced with other ones.)

In these painsharing/gainsharing approaches, the owner, designers and constructors jointly develop a mutually agreeable estimate of the anticipated construction cost of the project and devise a system of financial incentives and risk sharing to align the parties' commercial interests to deliver the project within the cost estimate. Some IPD projects set an aggressive cost estimate early in the design process to stimulate innovation in designing cost-effectively. Other IPD projects use target costs as part of the target value design process (see below), but wait until the design is substantially complete to set an "estimated maximum price" that is the basis for painsharing/gainsharing. Either way, the design and construction teams are reimbursed for their project costs and paid a base fee, with the possibility of increased fees under the incentive program.

Pain/gain sharing helps align commercial interests and supports collective risk management.

In addition, the key team members (owner, A/E, CM, major trades) share the risk of cost overruns against the agreed cost estimate, with the owner taking the final risk of cost overruns once the actual construction overrun exceeds some set threshold (which is often set at some or all of the profit from the participating designers and constructors).

By sharing cost overruns or savings, the team's commercial interests are better aligned so that the major players have commercial reasons to mutually support each other in optimizing the project and collectively managing risk. At the same time, the limitation of liability for cost overruns allows the designers and constructors to focus on meeting the overall project goals without unduly focusing on protecting their individual bottom lines.

Cost-sharing incentives need to be balanced with non-cost performance incentives (e.g., quality, schedule, customer satisfaction).

This approach, while containing powerful incentives for cost reduction and project-wide optimization, is not without its own risks. First, because few if any IPD projects actually include all of the dozens of sub consultants and trade contractors in the painsharing/gainsharing program, there is the reality that there will be greater alignment among the major players than among the other players. Without proper leadership and broad enough participation, the close commercial alignment of the major players may be significantly undercut by the more traditional behavior of the non-participating team members.

Also, if the painsharing/gainsharing incentive is not balanced with incentives aimed at non-cost performance goals, the owner may be opening Pandora's Box. Here's what can happen:

The owner typically selects the IPD team based on qualifications and fee percentage before the project is designed. The owner agrees to reimburse the IPD team for design, management, general conditions cost, trade contractor costs and in some cases self-performed construction. Although the owner participates in the development of the construction cost estimate, it is the IPD team that has greater control over these items. The IPD team will get prices from some trade contractors, estimate the cost of the other trades, estimate the general conditions and add one or more contingencies. They must manage the whole to come within the agreed construction cost estimate—and produce an incentive reward. If done right, this of course benefits the owner as well.

However, estimators will certainly be aware of the impact of a painsharing/gainsharing approach. Knowing that prices always have an unpredictable element, they might pad their estimates – creating hidden contingency in addition to the stated contingency line item.

Thus, some amount of the "savings" is likely to come from this hidden contingency rather than from true innovation in design or construction. The larger the padding in the cost estimate, the greater the incentive reward to the IPD team. That is hardly in the owner's interest. Owners in these approaches need to be careful to be closely involved in the formulation of the cost estimate, and the transparency of IPD allows for that. Benchmarking data to help validate or challenge the IPD team's cost estimating can also help.

In addition, if the agreed cost estimate is set before design, it is a clear incentive to compromise the design and reduce scope. Again, owners need to be an active participant in the design process to make sure that design objectives are met. And as discussed below, IPD teams are well-advised to balance the painsharing/gainsharing program with other incentives.

Profit pooling

Profit pooling provides skin in the game to motivate proper attention to project risks, while also providing a cap on liability.

As mentioned above, painsharing generally operates through the mechanism of a pool of profit contributed by each of the participating members of the design and construction team. Often, only the major players participate.

The participating players typically put all or a significant percentage of their profit at risk in a common pool, which is available to pay for cost overruns. Once the pool is exhausted, the owner typically bears the risk of further cost overruns, although nothing would prevent the concept of profit pooling to work with a GMP, with the result that the CM would share the costs of overruns with other project team members up to a point, with further overruns borne by the CM alone (and inevitably passed through to the responsible trades).

If there are cost under runs, some portion is usually added to the profit pool and distributed in accordance with the negotiated percentages in the incentive program. Frequently, the percentages are based on the parties' estimated compensation in relation to the estimated construction cost of the project, although the percentages might be weighted to provide a greater share to the designers, since their raw percentage might be viewed as disproportionate to their influence on project outcome.

The uses and determination of profit pools are myriad. Instead of using them simply for cost overruns, for instance, all or some of the profit pool could be awarded on the basis of performance evaluations against stipulated criteria. Some teams have used the fee pool as an "investment fund" to spend money on one area that saves greater money in another and thus provides greater project cost savings for sharing.

The main purpose is to provide a commercial structure that promotes team behavior rather than simply individual behavior. By requiring at least the major players to share in the risks and benefits resulting from a common fund, the key project players now have financial interest in helping each other. In addition, putting profit at risk gives all key team members—not just the CM—"skin in the game" to keep them focused. Social science suggests that people generally work harder to avoid a loss than to gain a benefit, and painsharing activates that motivation.

Contingency sharing

A shared contingency fund allows for greater cost transparency and collective ownership of mistakes.

All projects have some amount of contingency to cover unpredictable events. It may be hidden as padding within contract prices or cost estimates, or it may be made explicit in a contingency fund. In the cost-reimbursement approach typical of IPD jobs, the contingency fund is generally available to pay for mistakes made by the IPD team. Inexperienced owners will do a double take on this point—*"Why should I pay for mistakes?"* Sophisticated owners, knowing that without an explicit contingency fund there will just be hidden contingency, choose to provide a contingency fund in order to keep costs out in the open and be involved in the fund's management.

Some IPD projects have a contingency fund that if unused is shared by the owner and the IPD team. The convincing thought behind that arrangement is that the IPD Team will treat the contingency fund as its own money—as indeed it is—and manage it wisely. Also, by sharing one common fund, the team is induced to act more collaboratively. These echo the same basic goals and purposes discussed above with regard to profit pooling.

There is another advantage to having a shared contingency pool – reducing the problem of contingency stacking. If everyone hides their contingency in their contract prices, then the aggregate amount of all contingency for the project will be unknown to the team, and is quite likely to exceed the reasonable amount of quantified project uncertainty. By sharing contingency, the total amount of contingency on the project can be reduced, since there is a low likelihood that every participant would need 100% of the individual contingency they may otherwise include in their contract prices.

Some IPD advocates recommend keeping the contingency outside of the incentive compensation pool (i.e., all unspent contingency returns to the owner). That way, the owner will not be tempted to keep the fund too small or to seek to block its use. Also, IPD team members will not be tempted to blame others for mistakes that reduce the potential shared contingency savings.

To provide contingency funds or not to provide – that is the question.

And some IPD proponents advocate eliminating the contingency fund altogether when there is a painsharing/gainsharing approach. This would require the owner to pay for IPD team mistakes as direct construction costs rather than from a contingency. Cost overruns, whether due to mistakes or poor costing, still are shared, so team members retain the incentive to avoid mistakes. Given that IPD team members have their liability limited to their profit pool, why would IPD team members need any contingency? On the other hand, IPD teams may be reluctant to truly risk performing a job with no profit, and without any explicit contingency may simply put hidden contingency into their cost estimates. Owners need to consider the trade-off between transparency and the potential for abuse of contingency.

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Because of the collective sharing of risks and cost savings, the commercial terms in most IPD projects encourage parties to treat the project as a collective enterprise and facilitates moving money across traditional commercial boundaries so that the parties are not discouraged from, for example, investing $100,000 in one party's work to save $150,000 in another's. Thus, the typical IPD commercial terms encourage the team to have an investment or entrepreneurial mindset in creating project value. Again, the goal is to optimize the whole project and not just the individual components.

Incentives

All contracts have incentives. Choose incentives that support your project's most important goals in a balanced way.

All contracts involve incentives. Incentives can be implicit because they are inherent in the way the commercial terms operate, or they can be explicitly stated and addressed in an incentive program. But the choice is not between having incentives or not, it is about which incentives operate on the project team members and how to frame those incentives to communicate what is important to the owner.

In IPD projects, the desire is to provide a balanced set of commercial incentives that address the owner's significant project goals. Nearly all owners will have cost effectiveness as a goal, but many will also have other important goals such as schedule, quality, safety, sustainability, etc. If the commercial incentives are weighted towards cost reduction, then owners may find to their dismay that they get the lower cost they wanted but end up with less scope or quality than initially planned.

Consider the conventional GMP contract. When subcontracted work on GMP projects is competitively bid, the low bidding subcontractors are given incentives to price their work with a sub-optimal margin in order to win the bid. This in turn gives the subcontractor economic incentives to recoup some of that lost profit through change orders or claims. Of course, not all claims are illegitimate, but the contract structure implicitly provides incentives for a contractor to generate change orders in order to realize their profit goals and avoid job losses.

For most IPD projects, the owner seeks to avoid these traditional incentives to adversarial behavior by procuring on the basis of qualifications, and using negotiations, target value design and an incentive program to get value-for-money from the project team in an environment of good will and collaboration.

An effective incentive program focuses on a few key areas that comprise a "successful" project as a whole, keeping these areas in balance so as not to skew the project inadvertently towards one. Examples of key areas used on many projects include cost minimization, schedule, quality, safety, customer satisfaction, labor performance, and planning system reliability.

Care should be taken in selecting performance areas for incentives. Not only should the areas be balanced, they should also consider whether certain areas require incentives at all. Incentives have the potential to create conflict as well as alignment. Every action has a reaction; every goal that affects incentive compensation is a potential source of disagreement. Use incentives wisely for areas of project performance where participants normally need added motivation and to create a complementary set of incentives that keep key project goals in balance.

Most people are not solely motivated by money. Contract incentives should not undermine a performer's non-economic motivations to

Use incentives only for areas that need added emphasis in order to address key project goals in a balanced way.

perform. Social science posits that project participants have basically two types of motivation: economic motivation and intrinsic motivation. Economic motivation arises from compensation terms while intrinsic motivation arises from the performer's own internal values and preferences (such as morality, autonomy, peer approval, loyalty, or reciprocity).

Financial incentives can motivate a performer, but only when he or she feels that the payout is worth the effort. Also, financial incentives can induce the worker to concentrate on the rewarded tasks and neglect other important tasks. Intrinsic motivation, on the other hand, often provides performers with non-economic reasons to perform beyond the bare minimum a contract requires. Since no contract can ever describe every possible action needed for a performer to achieve the owner's goals, both contract incentives and intrinsic motivation are likely to be relevant.

Avoid undermining the team's intrinsic motivations with the financial incentive program.

Social science suggests that in situations where one normally acts as a result of intrinsic motivation, providing economic incentives for that same behavior can displace the intrinsic motivation, sometimes with adverse results. However, contract incentives generally do not undermine intrinsic motivation when:

- The incentive is implemented in a way that makes performers responsible for the means and outcome of their performance. This reinforces their autonomy and helps satisfy the need for self-determination. It also signals the principal's trust and thus improves self-esteem. Among other things, this means that an incentive should not be too prescriptive.
- The principal and performer discuss the results in person. Face-to-face communication signals the principal's respect to the performer, and thus reinforces autonomy and self-esteem. Discussing performance also gives the performer feedback that allows for improvement.
- Performers participate with the principal in mutually setting goals. By involving the performer in the formulation of project goals, the principal enhances the performer's sense of autonomy and communicates respect for the performer as a collaborator.

Also, project context can influence the effectiveness of an incentive program. If incentives are used in the context of an adversarial relationship, the performer may view the incentive suspiciously as a form of exploitation or doubt that the owner will act fairly in making any subjective determinations as to extent of earned incentives. On the flip side, in the context of an IPD project characterized by collaboration and trust, incentive programs can be more successful.

For instance, if there is a change in scope during the project, the IPD team and the owner may need to negotiate a change order to the painsharing/gainsharing threshold that may cause traditional unspoken feelings of an adversarial relationship to surface. If the team has developed a strong set of project relationships founded on collaboration and trust, the team will better handle the negotiation.

Or, when the IPD team suggests a less expensive design alternative in projects with a shared savings feature, the owner may feel that the IPD team is being rewarded to cheapen the project—potentially weakening the collaborative trust that is fundamental to IPD. IPD team leadership needs to be sensitive to these potential issues and be prepared to deal with them productively.

Moreover, it is important to consider who participates in the incentive program, and to what degree. Projects may include some participants in the award fee program (see below), but not in the painsharing/gainsharing program. Or they could have different award fee programs for different types of project players. Some projects require that a certain percentage of the incentive be distributed to craft workers. Not all project players have a significant affect on the outcome of a project – they may appropriately be "bought out" at a fixed price and treated essentially as a commodity. Others, though having a small contract value, may have larger potential impact on the project. Some thought should be given to whether some kind of explicit incentives would help align such players with the larger success of the project.

Goal definition

Incentive programs facilitate goal articulation and project success.

The IPD concept seeks to align a project team with the owner's goals—by stipulating them, defining the metrics for measuring them and providing appropriate incentives for achieving them.

One of the significant reasons that the incentive program in IPD projects works is because it causes the owner, with the help of the IPD team, to develop a clear statement of goals. Attaching money to the message amplifies it.

A project will have many goals. In addition to the classic trio of cost, schedule, and quality, goals might include safety, sustainability, planning system reliability, customer service, local business participation, or minority hiring.

Whatever the goal, it should be clearly defined and achievable.

Award fees

Consider using award fees to balance out incentives based on cost performance.

Besides providing for the possibility of sharing in cost savings, many IPD projects have some kind of bonus system for achieving non-cost goals, often called award fees or satisfaction fees.

Award fee programs greatly vary. Some are funded from project savings and contingency preservation, others by a dedicated fund set aside by the owner outside the construction cost estimate. Some are based solely on quantitative measures, others solely on qualitative measures and some on a mixture of both. Owners may set aside large sums or not-so-large sums. Some particularly clever owners tie the team's ability to share in cost savings to their success in achieving award fees on non-cost performance areas, thus keeping the drive to cut costs balanced with the need to assure client satisfaction in other ways.

Given the great variety, we will provide just a few key principles for consideration. First up—measuring performance.

Clever owners have tied the sharing of cost savings to the team's non-cost performance. For example, the Pentagon Renovation project after the 9/11 attacks used an innovative incentive program that paired painsharing and gainsharing with an award fee program. To participate in the gainsharing, the design-builder needed to have received at least 85% of the possible award fees for non-cost performance.

Projects are made of people, and most people want to be treated fairly and to deal fairly with others. However, traditional economic theory assumes that people act primarily (or solely) out of self-interest. Based on an assumption of self-interest, traditional economists suggest structuring contract incentives to provide either a bonus or a penalty based on a defined quantum of performance, the idea being that self-interested people will expend more than the minimum level of performance to either achieve the bonus or avoid the penalty.

In general, use qualitative rather than quantitative performance goals. Cost performance is a frequent, perhaps universal, exception.

However, social science shows that incentives that depend on fairness (both in terms of the performer's effort and the principal's award) result in better performance than performance incentives tailored to a performer's self-interest, such as mandatory bonuses tied to defined quantitative output. By using a compensation system dependent on fairness, the principal and performer develop greater trust, which reinforces intrinsic motivation. It also benefits the collaborative framework an IPD project seeks to foster.

Why would trust-based award fees result in better performance than award fees based on quantitative results? In trust-based scenarios, both parties act fairly because they know that the other will respond negatively toward unfair treatment, and that would ultimately hurt project performance. Because fairness is not easily quantifiable, the performer makes additional effort to demonstrate her/his trustworthiness.

Consider, however, the results when incentives depend solely on meeting a quantified objective. Such an incentive makes a direct appeal to the performer's self-interest and involves little trust. In general, the performer then provides that amount of effort needed to meet the level of award fee that maximizes its own cost-benefit trade-off. The end result is that a principal will rarely get performance that exceeds the defined quantitative level, and may get much less if the cost-benefit trade-off fails to align with the quantitative goal.

While certain performance goals may be usefully set at a quantitative amount, qualitative metrics generally provide better incentives.

Performance evaluations and payouts

Performance reviews: do them early and often.

One benefit of an award fee program is simply that it requires a formal performance evaluation – too often owners wait until the end of the job to express their (dis)satisfaction. Some owners believe they must get along with the team members so they don't want to alienate them by criticizing them during the project. Likewise, the project team doesn't want to criticize their client. So embedded, reoccurring problems don't get fixed. However, a well designed award fee program forces IPD teams to reflect and share their assessments of current performance, with an eye towards learning and improvement.

Periodic and timely performance evaluation is essential to reinforce good performance and address performance issues. Performance evaluations need to be done frequently in order for the project to be able to take advantage of lessons learned DURING the project, thus promoting continuous improvement.

Award fees should not be subject to dispute resolution. On the other hand, owners need to be transparent, respectful and fair in performance evaluations or risk ruining the project.

An owner who sets an award fee based upon qualitative criteria must stipulate that there is a subjective element in the evaluation and that the owner's decision is final. There should be no dispute resolution process for an award fee. The corollary is that owners must be transparent, respectful and fair in their performance evaluations, or else risk seriously undermining team morale and performance.

Some projects have effectively incorporated self-evaluations as a precursor to the owner evaluation. In many cases, an owner may be able to simply agree with the team member's own evaluation, which would certainly contribute to good project relations, build trust and support the team member's desire for autonomy. Peer evaluations may also be a useful tool in the process, as it would foster team communication and stimulate better performance in order to gain peer approval. However structured, it is essential that the evaluation is done fairly and in a timely manner, such that "lessons learned" can be immediately implemented in the project.

The review could also be reciprocal, with the IPD team reviewing the owner's performance, although this would not impact the award fee determination. Owners could then improve alongside their project team.

Who?

The meetings should include the IPD management committee and the project managers from anyone being evaluated, and could also include the principal executive management of the organization. Developing a brass-to-brass relationship is crucial. The fee-determining person is typically someone senior in the owner's organization – not someone on the IPD management committee.

When should award fees be paid?

The award fees should be determined at the performance evaluations and at least some portion of the earned fee should be distributed to the IPD team periodically. A good approach is to parcel out a portion of the fee as the project progresses and indicate what portion will be earned at the end of the project if the project finishes with current performance.

For instance, the amount of the award fee available for distribution might be as follows:

- 10% at the completion of criteria design
- 10% at completion of detailed design
- 5% at completion of implementation documents
- 5% at completion of foundations
- 10% at topping out
- 10% at completion of building envelope
- 40% at substantial completion
- 10% at final completion

Also, some projects allow unearned fee to be rolled over to subsequent evaluation periods (sometimes to just the next period, sometimes longer).

How much?

Normally, the award fees should not be a windfall. Very large amounts, particularly in a large owner bureaucracy, will attract attention from multiple sources, draw significant pressures to justify paying it and force the owner's management team to justify some subjective decisions.[18]

Even a modest award fee will have a good effect.

Even a modest award fee will still have a good effect. The people working on the project are now conscious that there is a report card. If they earn the bonus, there is clear evidence of their good performance within their organizations. They can tell their top management that the client clearly likes their performance.

Flexibility

Incentives are complex business. What "should" work may not, or it may not work on the next project even if it did on the last. The owner and IPD team should be flexible regarding the incentive program so that they can adjust it mid-project to address changed project conditions. Otherwise, incentives that motivated good behavior under one set of circumstances may motivate problematic behavior under a new set. Also, continuous improvement is just as relevant to the incentive program as to getting the work in place.

The biggest incentive

The prospect of repeat business is a powerful incentive.

Perhaps the biggest incentive has nothing to do with cost savings or award fees. In many cases, at least for projects of serial builders, the biggest incentive is repeat business. Good people want repeat work and will work hard to build or uphold their reputation. The most important issue for any organization is survival. Since the IPD team is selected on qualifications, they know they can be selected again if they deliver a great outcome or have a reputation for excellent client service. Good references and an opportunity for repeat work are far more valuable than making a killing on one project's incentive program. But since repeat work and testimony are unlikely to be a matter of contract, there must be a strong perception that repeat work will follow good performance.

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To sum up, all construction projects need three things to function: a project organization, an operating system and commercial terms. IPD and Lean Construction offer significant improvements in all three areas. Project organizations move from silos to integrated, high-

[18] This is not always true. Lee Evey used a significant award fee in connection with reconstruction of the Pentagon after 9/11. The team earned 100% of the fee.

performance teams. Operating systems move away from linear, waste-laden processes to ones holistically designed to add value, improve reliability, foster collaboration, and continuously improve. The commercial relationships of the major players switch from risk-shifting, self-protective relationships to team-based relationships that align the players with incentives consciously selected to promote collective risk management and whole project optimization. When the project's organization, operating system and commercial terms are harmonized appropriately in an IPD/Lean framework, dramatic improvement can be realized.

Collaboration Software

Chuck Thomsen

The development of Internet communication and web-based databases, with programs structured to the needs of the construction industry provide us with powerful tools to manage information and to communicate. BIM and PMIS help project teams collaborate by pooling information for the use of the project team.

Building Information Modeling

Look inside a construction trailer. There's a plan rack with separate drawings for architectural, mechanical, plumbing, electrical and civil. There are special sets of drawings for landscaping, lighting, security networks, way finding graphics and so on. Shop drawings are in racks, buckets or drawers. Book shelves hold loose-leaf notebooks full of RFIs. Other drawings reflect a change in requirements or corrections to the initial drawings.

Each of these documents describes a piece of the project. None describes it all. Few people have access to a central collection of documents. Information entered in one place may not be replicated (or accurately replicated) in the other places it is needed.

The multiplicity of documents is produced by the multiplicity of contracts. It reflects the many organizations—architects, engineers, consultants, subcontractors and manufacturers—that contribute to the work. And it reflects the sorry fact that our industry has great difficulty integrating these work products.

Building Information Modeling promises to bring huge improvements to the construction industry. There is no technical reason that the sets of design drawings and shop drawings couldn't be integrated into a single electronic model—updated with RFIs and change orders as the project progresses.

There is not an integrated set of drawings to build from. Everybody does separate drawings.

What if the movie industry treated its customers that way? Assume that you went to Blockbuster to rent a movie and got separate DVDs for the parts of the heroine, the hero, the villain, the bit players, the sound track, the scenery, the special effects—and so on. Then you go home and you discover the program is out of sync: the hero swings a punch at the villain and the villain isn't there. Something hasn't been coordinated. So you send Blockbuster an RFI. Blockbuster's policy is to turn it around in three weeks. Then the movie producer changes the plot and distributes updated DVDs.

And shop drawings abound

BIM is a documentation tool, replacing legacy-drafting procedures. But BIM it also a technology for collaboration, an integration tool for our fragmented and specialized building industry and a vehicle for an IPD Team to pool its intellectual capital. As we approach a robust implementation of BIM, it will let us build virtually, before building physically, uncovering problems of sequence, interference and constructibility that trigger change orders and RFIs.

Evolution of BIM

Vector CAD

The first generations of CAD represented buildings with geometry—vector based lines, arcs and circles. A CAD drawing was easy to modify and replicate. It also provided greater precision than pencil on paper. But it was dumb: lines drawn with a computer instead of a pencil.

Object CAD

Then "smart" objects with properties were added. Objects like windows, doors, walls, roofs or stairs had properties that governed their behavior. A window could be pulled from a resource file into a drawing and stretched to fit the required opening. As it was stretched, the panes would grow but the jamb section would not. A user could associate information to the object such as the supplier, part numbers, the finish, the warranty and so on. The drawing objects were "smart." They knew how to behave and what they were.

BIM

From that point, it was a logical step to envision an entire building as a smart object with endless possibilities for algorithms that govern its behavior and associated information. BIM emerged. It's an awesome vision.

BIM characteristics

A BIM model is a digital description of a project.

It may include information such as the physical configuration, programmatic requirements, functional characteristics, specifications, systems performance, supply chain threads, construction sequence, cost or any other information that might be useful.

Plug-ins

Specialized software may be "plugged in" with algorithms that can adjust related building systems if there is a design change. These "plug ins" can include programs for structural and mechanical design. For instance, if a room is enlarged, the size of the structural members can be automatically recalculated and resized. The model adjusts itself. If the building is rotated on the site, the heat gain and loss may be recalculated. Other plug-ins may focus on energy analysis, LEED certification, cost estimating or construction scheduling.

Reports

A BIM model is a database

BIM ideologues will quickly tell you that BIM is not drafting software. It is a database. Drawings are simply one form of report. Like any digital database, a BIM model can produce reports—subsets of information for special purposes. These reports can be in the form of 2D or 3D drawings or an infinite variety of custom alphanumeric reports. The IPD team can tailor reports for specific purposes instead of grappling with a large set of 30" x 40" construction drawings and a fat set of specifications that obscures required information.

For instance, architects can produce a report in 3D and in color, rendered for comprehension by non-technical people. They can deliver drawings for review by entitlement agencies (building permits, accessibility requirements, environmental concerns, aesthetic compatibility or whatever) that address the agency's specific requirements. Assembly details can be produced on site for current construction challenges. Facility managers may access life-cycle, maintenance and replacement information.

4D and 5D models

BIM can include estimating and scheduling capabilities.

BIM can have sequence and construction duration information attached to drawing elements that represent the building systems (4D modeling). A computer program can animate construction progression. A user can input a date to observe current state of completion. The builder can analyze on-site material staging problems, develop phasing plans, improve the sequencing of trade contractors or analyze the cost of construction delays. Cost can also be attached to drawing elements that represent building systems (5D modeling) for estimating and value engineering. The estimate can progress in lockstep with design.

Clash detection

BIM software provides sophisticated "clash detection" routines that indicate when two systems or products occupy the same space.

At the simplest level, pasting shop drawings into a CAD drawing quickly indicates a misalignment or a poor fit. Even in a 2D model, it is obvious if a window doesn't fit between a pair of columns. However, problems are not always that obvious in 2D models. Conflicts are often caused when a building system designed by one consultant interferes with a system designed by another consultant on separate drawings. For instance, if a lighting consultant locates recessed light fixtures on an architectural reflected ceiling plan without checking beam locations on structural drawings, the recessed can may poke into a beam. And we have all experienced a mechanical engineer plotting duct runs that pass through the structural engineers' beams.

Direct fabrication control

BIM models can drive fabrication machinery.

Traditionally, fabricators develop shop drawings based on their interpretation of the plans and specifications. They are checked by the AE. Errors occur at each translation. By pasting shop drawings directly into the BIM model, errors and conflicts are more apt to be detected. Ultimately, a BIM model may include algorithms for CNC[19] direct fabrication of building systems, such as ductwork, curtain wall, millwork. While there are still opportunities for error in these automated processes, they are reduced and often eliminated. Precision is increased and supply chain workflow is shortened.

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[19] Computer Numerical Control refers to computer instructions that drive machine tools used to fabricate components. The technology is labor efficient, accurate, repeatable and facilitates complex forms.

Facilities management

An integrated BIM model is a good bit more valuable to facility managers than typical "as built" drawings. It may contain warranty data, spare parts lists and sources, useful life expectations and maintenance recommendations. It may contain original layouts as well as remodeling and renovation documentation.

BIM as a contract tool

BIM models can augment and clarify agreements.

Although IPD may minimize the contractual silos between the members, it is unlikely that an IPD team will include 50 to 75 subcontractors. Contractual separation will remain for most of the design and construction team. Multiple customized reports from a BIM model will assume important roles as contractual tools. The tools will work both ways—clarifying agreements with both the owner and with subcontractors.

The initial agreement with the owner will likely be a written document, perhaps with some simple diagrams to describe the intended result. As the project progresses, printed reports from the BIM can then augment that original agreement, defining the work for staged approvals just as traditional SD, DD or CD documents have done. However, rendered 3D reports from the model will do a better job of ensuring a meeting of the minds with the owner or users who may lack experience with technical Construction Documents.

The BIM will then become the framework for describing the work to subcontractors. As the design develops, subs will be asked to propose or bid on aspects of the work. When selected, aspects of their technical proposal may become part of the BIM—to be augmented or replaced with shop drawings as their work is developed.

Managing a BIM model

Managing the assembly a BIM model is much like managing the construction—requiring similar knowledge and leadership skills.

Managing the assembly of a BIM model is analogous to managing the assembly of a building. Consider this analogy. A construction manager must understand the technology of construction. But the more crucial job is orchestrating the work of hundreds of organizations—coordinating the assembly of materials on-site with decision-making, sequencing, and supply chain management. Most of a project is built off-site. If the on-site management team doesn't manage the off-site activities there will be delays. Managing the interrelationships is as important as understanding the technology of the work. In the simplest sense, it doesn't do any good for a construction superintendent to know about forming and finishing concrete if the concrete truck isn't scheduled for delivery at the right time.

A BIM model has similar requirements. Managing the development of a virtual construction model requires skills that are similar to managing the real thing. Too often BIM production is staffed with people who understand BIM technology but don't understand how to manage the workflow from multiple sources.

The management job requires setting BIM standards, understanding constructibility and construction sequence, evaluating supply chain data and vetting information that is submitted to be input into the model. But most of all, it requires understanding how to suck this information from multiple sources into an integrated model. The manager must have clout in the organization to get the attention of the extended IPD team to schedule information flow, analysis and problem solving. And since inputs to a BIM model may ricochet through the model, the manager must review and evaluate the accuracy of inputs—just as a CFO ensures that there are procedures to evaluate the inputs of financial information before they are posted to a general ledger.

A BIM model manager requires the support of the IPD management committee who must set policies to adopt the technology, buy and install the software for members who do not have it, train the team, champion the use. Finally, they will need to establish workflows for a BIM process that may be developed by the BIM model manager.

An IPD team needs a BIM manager and an interdisciplinary BIM team staffed with people from member firms. The BIM team integrates drawings from the AEs, subs and manufacturers. They develop 4D and 5D models. They detect coordination problems with clash detection routines. Constructibility reviews trigger design adjustments—made with the collaboration of the AEs. RFIs are anticipated but if collaboration is ongoing it should be minimal. In developing the model, questions surface before construction.

The BIM model manager must be a person with good interpersonal skills to build the collaborative culture required to produce an integrated BIM model. The manager must build trust and networks of personal communication within the contracting team. As with real construction, the more personal contact and the more trust, the more collaboration. BIM allows trust to be built early, well before construction begins. There's an opportunity to allocate model space to each subcontractor to give them confidence that the process will not only find clashes in their systems before they get to the field, but

Building the BIM model requires the same trust and collaboration as building the building.

that the sub will have the ability to model the clearances and working space needed to install their work.

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Architects have typically been the primary source of BIM models, fulfilling their traditional role in developing the drawings and specifications that document the *product*—the description of the design, the intended physical result.

CMs have usually taken the lead in providing project management information (PMIS) systems—gathering and integrating data from the extended project team. These systems have concentrated on *process*—tracking contractual matters such as cost, schedule and quality control; RFIs and change orders.

But now CMs are developing in-house BIM teams and are developing BIM models prior to construction.[20] BIM is not the exclusive territory of the AE—nor should it be.

Eventually, it is likely that an IPD Core Team will build integrated groups to produce integrated documents. Clearly, managing virtual construction will require technical knowledge of both *process* and *product*. Virtual construction will require AEs with product expertise and CMs with process expertise. It will require effective collaboration. IPD will provide the platform.

Ultimately, the IPD Core Team will likely build integrated groups to produce integrated documents.

Dynamic, living and incomplete model

An idyllic vision of BIM is that of a fully integrated and complete BIM model—a virtual representation of the building, available for study before construction begins. It would include construction details, specifications, cost, schedule, warranties, products, systems, construction sequences, off-site fabrication schedules and shop drawings. It would contain 4D schedule data and 5D cost data and be enabled with CAD-CAM instructions for driving machine tools in off-site shops. Wow!

Then, to continue the idyllic vision, the extended IPD Team (AEs, CMs, subs, manufacturers and fabricators) could pour over the model and find construction problems in electronic space before entering the costly physical space of the real world. They would get the change

[20] AGC has published *A Contractor's Guide to Building Information Modeling, Edition One*, that guides contractors in the use of BIM.

orders and RFIs out of the way before construction begins and they would validate the workflow and supply chains.

It's not entirely a foolish pipe dream. Many owners have continuous building programs. They may have prototype designs or at least projects with many similarities. They may have BIM models of building models that can be assembled in various ways for variations in their project needs. They may have in-house staff or continuous relationships with AEs, CMs, subcontractors and suppliers. They can develop continuous improvement for feedback after each project into a prototype BIM model to further refine its value. It's conceivable that these owners could approach that vision.

However, consider the realities of a more typical project. AEs avoid including final details in the Contract Documents so they can maintain competition among multiple manufacturers. Subcontractors, manufacturers and fabricators don't detail their systems until they are under contract. Final construction details aren't available until after products and systems are purchased. And if a project uses fast-track scheduling, complete coordination can't be done in electronic space before construction begins because the design is incomplete.

Furthermore, many subcontractors and suppliers are not BIM literate and those who are may use incompatible software. So the BIM model will be incomplete, augmenting the electronic database with legacy CAD or paper products.

Always limited

For the foreseeable future, a BIM model will be less than ideal. It must be a living, dynamic thing, accepting additions and changes throughout the project's life—continuing to grow after occupancy.

Our vision of BIM far exceeds our ability to implement it.

All the vision of a complete model for virtual construction is possible, and all the capabilities mentioned above are within our technological reach, only some are implemented on any project. A BIM model manager must then decide, given the sophistication of the project team, how far to go.

Barriers to BIM

The ultimate objective is to build an integrated BIM—a virtual building before we make expensive mistakes with concrete, glass and steel. But tradition, contractual separation, archaic laws, technical limitations, interoperability problems and culture hinder us.

Software and hardware constraints

A BIM model theoretically has unlimited ability to hold information. But any practical project model will fall short of what is theoretically possible. Despite faster and faster computers and more efficient software, the model slows down as it enlarges.

Cost practicalities

At some point, it becomes impractical to add detail to the model. We still assume the builder will use some judgment in the field. A drawing doesn't need to show all the nail locations in a wood frame.

Universal adaption

The fruition of BIM will depend on widespread use by designers, contractors and manufacturers. But until trade contractors and manufacturers are operational with BIM, we will limp along with incomplete integration.

Interoperability

Any CM or PM that has managed a program that included multiple architects and multiple CMs has faced the frustrating problems of interoperability in trying to integrate data from different project management information systems. It is hard to share data between Autodesk's Constructware, e-Builder and Meridian's Prolog. The same problem exists with BIM software.

A fully integrated BIM model is a vision, not a reality. At current levels of development, architects engineers, consultants, builders and fabricators may have independent BIM models, legacy CAD systems and legacy paper systems. Those who use BIM software may not use the same programs.[21]

Document signing

The largest part of an architect or engineer's fee is compensation for producing Construction Documents. Then 40-60% of the

[21] The International Alliance for Interoperability (IAI) (www.iai-international.org) functions as a council of the National Institute of Building Sciences (www.iai-na.org) to improve interoperability. The National Institute of Building Science (NIBS) is defining BIM standards. The Facility Information Council (FIC), a NIBS Council, (http://www.facilityinformationcouncil.org/) "provides support for the development, standardization, and integration of computer technologies and software to ensure the improved performance of the entire life cycle of facilities from design, engineering and construction through operation, maintenance and retirement phases."

Construction Drawings are discarded and replaced with shop drawings—about 1-3% of the project cost is wasted.

Integrating shop drawings in a BIM model eliminates this time-consuming and costly redundancy. It also solves problems. If fabricated products don't fit in the 3D space properly, the problem is likely to surface and get fixed.

However, most state laws stipulate that architects and engineers must only sign drawings done under their supervision. So AEs are properly reluctant to sign documents that include drawings prepared by others.

The typical solution for this annoying problem is for an IPD Team to simply produce a sub-set of the BIM model that has been produced under the AEs supervision for the designers to sign. Then the IPD Team calls the integrated BIM model a constructibility set, shop drawings for the building, a quality control document or whatever.

The great vision of BIM is to integrate the designs of the extended project team. It is also the biggest legal problem. How do you track design responsibility.

Although BIM software is useful in documenting the work of a single company, its greater value is that of integrating the work of multiple companies—sharing designs, specifications and information among the extended project team. But sharing blurs authorship and blurred authorship blurs responsibility for the design.

The process of assembling companies necessary to design and build a structure has assumed separate contracts, responsibilities, scopes, liabilities—and separate but clearly allocated and defined risk and responsibility. Statutes, case law and insurance products reflect these contractual silos.

The traditional assumption is that the AEs are responsible for the drawings and specifications. If shop drawings are integrated in BIM the AEs are concerned that they will assume responsibility for their accuracy and the performance of the product. So in project delivery processes with separate contracts, the AE is circumspect about integrating shop drawings. Practitioners and their attorneys partition responsibility by partitioning drawings—balking the development of integrated drawings and crippling the benefit of BIM.

One approach has been to add shop drawing to the BIM model clearly identified in the model as the sub's work. The sub would retain responsibility. However, if the AE and the sub collaborate (a desirable activity) the responsibility becomes unclear.

Until the licensing laws and the insurance industry catch up with technology and practice, it will be necessary for the AE team to print a report from the BIM model that depicts design work that they can comfortably claim has been produced under their supervision. Then they can sign the drawings and obtain required permits. Then the IPD Team can move ahead and integrate drawings as extensively as possible. The BIM can be characterized as a "Quality Control" or a "Virtual Construction" document.

Who pays for BIM and who benefits?

A BIM model improves the design, improves coordination, reveals construction problems and helps the IPD team optimize both product and process. Savings in time, money and grief pay for its cost.

However, in traditional processes the cost of a BIM model is borne by the AE, but the savings benefit multiple sources—the AEs, the CMs, subs, suppliers, manufacturers and, of course, the owner. The cost of building an integrated model surpasses the usual cost of producing typical Construction Documents and so, in projects where AEs are paid a traditional fee, the AE objects to the idea of assuming the total responsibility of managing and developing an integrated model.

However, in an IPD project, the management committee can agree to fund and staff the required effort and the extended IPD Core Team can contribute resources. Since the benefit is to the project, it can be paid for by the project—not by a single project participant.

Legal conundrums

Traditionally, AEs have attempted to retain ownership of the construction documents, although owners, particularly serial builders, have challenged that with increasing frequency.

Intellectual property

In a traditional process with separate contracts, the ownership becomes murky. But with IPD, it is likely that the members of the IPD Core Team will argue that since the BIM model is a collaborative work, it belongs to the members. It can be argued that each of the collaborators has an interest represented by their contribution. They can share it among themselves in parts or in whole—however they agree.

But since the BIM will morph into a useful tool for the facility managers, owners will also want ownership—and in those legal relationships where the owner is a member of the IPD Core Team, they will likely have ownership.

However, it is likely that the IPD Core Team will want a contractual restriction on the owner's ability to use the model for future construction—or permission with indemnity of the IPD Core Team.

Digital information in a BIM Model can be easily copied and reused. Subs, their manufacturers and suppliers may provide proprietary designs to the BIM and may require agreements that prevent fabrication or reuse of the design by others. Confidential processes may be used that must be protected. Access and use of the model must be defined—either in the contracts that form the legal relationship of the IPD Core Team or as BIM management procedures.

The AGC BIM addendum

The AGC has issued a BIM Addendum to their ConsensusDOCS 301. It is a thorough document, clearly written by construction professionals and lawyers who understand BIM and have thoughtful approaches. It's educational and informative. Any construction professional involved in a BIM initiative should understand the concepts.

The Addendum is designed for traditional processes such as design-bid-build or negotiated GMPs and avoids rupturing traditional legal relationships among the owner, architects, engineers, GCs, subcontractors, suppliers and manufacturers. It may be attached to any project contract including sub consultant and subcontractor contracts.

The AGC BIM addendum is for traditional contract structures.

It defines a model as a "Contribution" from one of the project participants.

There are multiple models for analysis, preliminary design studies or renderings.

- A Full Design Model includes architectural, structural, MEP and other design phase models and is analogous to traditional Construction Documents.
- A *Construction Model* includes shop-drawings and related information. It might include information imported from a Design Model or from traditional Construction Documents.
- A *Federated Model* is an assembly of models. The models must maintain their authorship and remain separate. The models can't be interactive: one model must not be affected by a change in another model. They can be linked so they can be used for approvals, coordination, quality control, clash detection, estimating or, ultimately, facility management. However, no one

can change another's model so clear responsibility may be maintained.

To maintain authorship identify and responsibility the Addendum assigns tasks and responsibilities to *The Information Manager* who must control access to the model and record each input, deletion or change with the author's contact information, date, time, etc., and maintain an audit trail of such modifications.

The BIM Addendum also:

- States that if there is a software malfunction, the owner bears most of the risk and that a party to the BIM Addendum may be entitled to a time extension or other requirements.
- Requires that each party agree to waive claims against the other parties to the agreement for consequential damages.
- Requires model users to minimize claims and liability caused the models, by quickly reporting errors or omissions that it discovers.
- Provides rights to the owner to use the model depending on the agreement between the owner and the design professionals.

Each party to the BIM Addendum warrants to the other parties that it has rights to the copyright of its Contributions and agrees to indemnify and hold other parties harmless for claims of third parties claiming a copyright infringement. And each grants the other parties a limited, non-exclusive license to use that party's Contributions.

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The melancholy aspect of the AGC Addendum is that, despite the wisdom of the authors, it is predicated on using powerful integration software for a non-integrated process. Keeping design and construction models separate is inefficient and neglects useful collaboration, construction feedback to designers, quality control and value engineering initiatives. The need to maintain model separation precludes interactive relationships and thereby gives up much of the potential power of BIM. The contractual separation of the key team members creates considerable legal boilerplate and procedural documentation. It is not a Lean process. But that's not the fault of the AGC or the authors of the Addendum. It's our industries burden of tradition.

The need to maintain separation precludes interactive relationships and thereby gives up much of the potential power of BIM.

The BIM Addendum falls short of envisioning an integrated, seamless design and construction process that allows us to build virtually before we pour concrete. But it wasn't intended to do so. And we all recognize that vision is at the top of a long hill to climb. It will be wonderful when we can watch the technical understanding and intellectual energy that went into the AGC BIM Addendum applied to that vision—unfettered by our industry's creaky traditional processes.

What's the design? Who designed it?

The very concept of Integrated Practice distributes the creation of a design across a number of organizations.

- Most owners are serial builders. They create standards and prototypes that they give to AEs and CMs to implement.
- CMs participate in the development of design concepts and affect the design with their recommendations for materials and systems. Constructability and value engineering studies often have substantial affect on the design.
- Manufacturers and specialty subcontractors produce shop drawings that are intended to implement the design intent.
- Manufacturers and software vendors provide 3D or BIM "content" that describes their products over the Internet for insertion into construction documents.
- Design Assist strategies involve trade contractors in the design process.

The design

A singular advantage of digital files is that they are easy to modify and update. So BIM models tend to be living documents—growing through the evolution of the project as the design develops, as clash detection uncovers problems, as field conditions develop, as changes are made and final configurations are adjusted during construction.

And yet designers need to know what they have designed and are responsible for, owners need to know what they approve, contractors need to know what they agree to build, approval agencies need to know what they have approved and inspectors need to know what to accept. The moving train of a BIM model is a problem when there is a static document required for an agreement with a contractor, and approval from an owner or permission from an entitlement agency. Consequently a BIM model must produce reports that define and freeze these categories of documentation.

The designer

In 1857, Otis installed an elevator in a building, something that the manufacturer knew more about than the architect.

Ironically, in 1857, the year the AIA was founded, Elisha Otis installed a "safety elevator" in a New York building. A manufacturer put something in a building that the manufacturer knew more about than the architect. Since then, industrialization and a competitive environment have driven manufacturers to develop more and more sophisticated building products. The result is that architects and engineers include more and more in their design that they did not design and do not fully understand. They rely on the representation of someone else that a product, a material or a system will perform properly.

In 1857, it was an exception to have industrialized products (like the elevator) in a building. When the professions of architecture and engineering emerged, AEs designed building systems: heating, enclosure, partitioning, roofing and millwork systems. Today, most of a building is manufactured off-site from designs produced by manufacturers. Increasingly, AEs design buildings that include technology that the AEs do not understand as thoroughly as the manufacturer. The AE's job has changed. It is to evaluate and integrate systems and products designed by others.

Recently, the AIA distributed an on-line survey to measure the desire for BIM content provided by manufacturers. They asked for interest in partitions, doors, windows, floor coverings, ceiling systems, kitchen equipment, elevators, furniture, electronics, casework, furniture systems and equipment of all kinds for single family residential, healthcare, commercial/retail, multi-unit residential and hospitality, Lab/Hi-tech/Research, K-12 and "other" kinds of projects. This plentiful and commonly used BIM content, available from the manufacturers, contains algorithms and other properties, developed by the manufacturer's designers that may adjust the object as it is installed to a design.

Much design content is available on-line to be downloaded and used in drawings. Much of it will be beyond the ability of an AE to thoroughly evaluate.

Software companies are working on BIM software that will adjust related building systems to design changes. For instance, if window areas are increased (increasing heat loss and gain) the ducts will automatically be resized. If floor plans change the software will check code compliance. If a room is enlarged, the beams will get bigger.

Licensed architects and engineers may not create "Smart systems" and "smart objects". However, AEs will use increasingly sophisticated software tools and embedded objects downloaded from manufacturers. The design may be distributed to different computer systems and used by different participants.

Conceivably, there can be a dispute over the cause of a malfunction in an elevator system. (For instance, did the rails move because the structure deflected or were they improperly aligned during installation?)

However, as industrialization and information technology continue to make more sophisticated systems available to architects and engineers, and present them to the industry over the Internet as smart self-adjusting objects, the problem of tracking responsibility for design components will become more difficult.

Most software contains licensing agreements that protect the software author from liability in its use. While AEs and CMs may place responsibility on manufacturers for the performance of their physical products, they will be unlikely to deflect responsibility for errors produced with the software they use—any more than a taxpayer could blame TurboTax for underpaying income tax.

The responsibility for the elevator problem is far easier to track than a system problem that was designed with smart content downloaded from a manufacturer, adjusted by a CAD operator, modified by owner standards, value engineered by a CM and interpreted in shop drawings by a subcontractor.

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Architects and engineers have traditionally been responsible for the design. At a high level of conceptualization, that will remain true with Integrated Practice. But more often, owners who are serial builders will influence not only design requirements, but design solutions. As the intellectual capital of CMs, trade contractors, manufacturers, suppliers and consultants is added, is it possible for the AE to assume full responsibility for the design?

Or do we need an integrated team to participate in that?

Project Management Information Systems

BIM is sexy. The PMIS is a neglected wallflower.

Like BIM, a PMIS is a web-based, centralized database created and used by the project team. A PMIS is to the process what BIM is to the product. Both are collaboration software: centralized stores of integrated information with rules for access that serve the project team. Both are important tools for collaboration.

BIM is sexy. The PMIS is a neglected wallflower. BIM represents the physical building: the goal, a lighted 3D image on a monitor that is the rewarding culmination of everyone's creative effort. The words, numbers and diagrams in a PMIS don't excite design-oriented AEs or fabrication-oriented builders. Nor are they a high priority for the action-oriented managers of design and construction.

These personalities like the interaction of teams, the intellectual exchange among smart people, the challenge of design and the satisfaction of seeing buildings emerge—on a screen and in the field. They're not thrilled by the chores of methodical documentation. And while people can see their own contribution to a 3D electronic model, it's hard to get job satisfaction out of input into an impersonal alphanumeric database. So, it's difficult to whip up support and convince a team that a PMIS will improve projects.

Overview

This discussion has three sections to describe a PMIS system. It explains its components, reviews its value and discusses some of the challenges of implementation.

Components of a PMIS

The PMIS defines the program and the projects: cost, time, scope and quality. It defines the team: people, organizations and their roles. It helps manage agreements: contracts, permits, approvals and commitments. It manages documents. It produces standard and custom reports. It presents vital signs on dashboards. It guides collaboration and communicates best practices with policies, workflow diagrams and document management.

Values of a PMIS

A PMIS provides information so the team has a common understanding of the facts: a prerequisite for collaboration. It's the cheapest way to gather information because it's only done once. And it's the most reliable way to host information because many eyes scrutinize centralized data and and mistakes are more likely to be found and corrected. It's the first line of defense against political or legal attack. It's a clear window into the project that leaders can use instead of relying on delayed or biased reports filtered through layers of management. It improves performance because it measures it; it's a report card for both team members and management. And most important, it educates the team and makes better managers because it tells true stories.

Information is the input and the output of managers who gather, validate, integrate, record, add experience, make judgments and then give directions.

Challenges of implementation

The voice of authority from a committed owner is essential to a successful PMIS. There's always a bumpy startup while the team adjusts to the routine discipline of entering and sharing information. Some team members will have a hard time accepting change and will neglect the responsibility to provide input. Initially, there will be glitches in the data that provide targets for criticism. Engineering the

The startup is bumpy.

human system to maintain timely and reliable information flow is the hardest part. Success requires support from the top brass.

Interoperability has been a problem but there is progress. PMIS systems can be interfaced with different software used by other organizations to minimize the chores of data entry.

Components of a PMIS

Defining the projects and the team: people, organizations and their roles

A PMIS is built around documentation and communication of project-specific information so most of the engine is devoted to that purpose. Basic project information includes the project location, a current calendar and the project goals.

Projects:
People, organizations, roles, etc.
Cost
Budgets, estimates, VE, payments, etc.
Schedule
Master, push, pull, design, construction, occupancy, etc.
Quality
Scope, requirements, compliance, etc.

There may be web cameras that record on-site activities for public relations or for evidence in case of conflict. There may be general public relations web pages with access for the community, users or other stakeholders.

The PMIS maintains project status from the initial idea for a new facility to it's completion. Such project data may be rolled up for portfolio management and for planning future projects.

As the PMIS develops it will accumulate detailed project information on:

- Cost: Each contract and each project will have the budget, estimates, contract amounts, changes orders, contingencies and forecasts of completion cost. There may be a capital plan with projects scheduled over future years. It may include funding sources.
- Schedule: There will be a master schedule, design schedules, procurement schedules, global "push" construction schedules, short interval "pull" schedules, closeout schedules, occupancy schedules and commissioning schedules. Or there may be a project-specific calendar so the extended project team can coordinate their work. It may display meetings that the user must attend, show deadlines for the user's work products and send automatic reminders. There may be a user-customized calendar for specific responsibilities.
- Quality: Given that most owners choose to define quality as "conformance to requirements," the PMIS may include space programs and other requirements. The PMIS may include procedures for quality control or quality assurance programs, post

evaluation data and include checklists to meet regulatory requirements.

- The team: people, organizations and their roles: Within the PMIS database there is a simple list of the projects with contact information for each company, its key people and their project role. Since so many people deliver a project it makes sense to have a resource where everyone can find everyone else. And it sure helps to know how they fit into the project. A web-accessible database with that information improves communication. That speeds the project. It also adds to the quality of the work. When starting a new project, it helps to know what companies have done similar work and how they performed.

Managing agreements and documents

Nothing happens until there are agreements with someone to do work. Because organizations must work together, interlacing and tracking agreements is a management challenge. Managers must plan who is going to do what, communicate those tasks, make sure there is clear agreement and then track the execution.

The work on a project is created with agreements. In general, there are

- *Contracts*
- *Owner approvals*
- *Agency permissions and permits*
- *Routine commitments*

Agreements: The PMIS records agreements. In general, agreements can be categorized in four major groups.

- Contracts: The PMIS will include a database of the contracts for reference. It will also summarize the scope of work, the financial aspects of the contract and the general terms and conditions. Often problems arise because contracts are negotiated between executives and not explained to execution teams. There are mistakes because people just don’t understand their job. If the scope of work is accessible online it makes it easer for leaders to monitor progress and ensure compliance.

- Owner approvals: The owner’s organization must be managed as well as the design and construction groups. The owner will have policies that govern approvals. They will want to approve designs, change orders, color samples and so on. Some approvals will be contractually required; others will be less formal but important to manage. Accounting must know to schedule cash flow; the legal department must know when to prepare contracts.

- Agency permissions and permits: The project will be constrained by permitting, entitlement and other regulatory agencies. It will help the project team members to have requirements for these permissions online. Many permits have time-based requirements that need a reminder that is triggered by other events or tasks.

For example, a building permit for foundations may not cover the structural frame. If the permit department require 30 days to review the structural design for approval, the system reminds everyone early enough to ensure the design is done on time.

- Routine commitments: Many enlightened managers argue that a project should be viewed as a network of commitments—often verbal and often made in routine coordination meetings. A project culture that places high priority on honoring these routine commitments produces better projects. Recording them in a PMIS adds clarity and importance to the commitment and managers can see that they aren't neglected.

Document management: The PMIS will have a file structure that is the complete project central filing system. It will provide storage, retrieval and distribution of project documentation: written documents and drawings. It will be defined centrally. Folders can be added as projects progress. The system will time-stamp and track document activity. There will be tools to mark up or comment on drawings.[22]

A PMIS filing system is more than a "shared drive" or an FTP site. The team can access and view files without the native software (for instance, an administrator can view a CAD drawing without the CAD software). Like an FTP site, authorized members of the extended project team can access the filing cabinet,[23] but sophisticated multi-level permissions are built into the PMIS. There can be links between documents and other "objects" in the system like cost data or RFI forms.

Standard and custom reports

There are a variety of reports including:

- *Push reports*
- *Pull reports*
- *Dashboards*
- *Summary Roll-up reports*
- *Performance metrics*

A report can be a standard "push" report, a custom "pull" report or a summary "dashboard." They may be on a computer screen, emailed or printed.

Standard "push" reports: Managers must determine who should know what: how to inform and educate the project team and their

[22] Integration of PMIS with BIM systems is a task that requires serious head scratching. As BIM systems receive input from various parties, their contributions need to be logged in. As various parties review drawings their comments must be recorded. Are these tasks part of the BIM system or part of the PMIS? Or will the systems grow together?

[23] As we progress to paperless electronic records, the team must understand that document management includes electronic as well as paper documents.

bosses. They support that responsibility with reports that are "pushed" to the recipients.

Push reports may be routine status information or notifications when action is required. They filter data according to the requirements of the recipient. The objective is to send the right information—no more no less. Sending everything to everybody is nearly as bad as sending nothing to no one. Too much information obfuscates vital signs.

Custom "pull" reports: There's always a new question. A board member may want to know how many companies working on the project are local, a construction superintendent may want to know the number of people on site on a given day or a project manager may want a list of events that reduced a project contingency.

So a PMIS needs a simple tool that allows a non-technical user (with the proper credentials) to "pull" information from the database, arrange it for analysis or import it into spreadsheet, presentation or word processing software. Pull reports may be ad hoc or routine.

Push reports are automatic. Managers don't have to stop to waste time creating them. And because they filter data for the recipient, they communicate more efficiently. Pull reports are custom designed by the user—almost at will.

Dashboards: Too often, the big picture is buried under layers of minutia. To avoid that, the system must present an easy-to-grasp, conceptual view of the program with graphs, diagrams and alphanumeric summaries of vital signs. But if a user is interested, he or she should be able to drill down into the details.

Summary roll-up reports: The PMIS should roll up and summarize both contract and project information into a presentation of information for the entire program. At the program level, a user should be able to view cost, schedule and quality summaries along with the program contingency, cash flow, and other summaries of project information.

In the context of the total program, the PMIS should provide a "Project View" or a "Contract View." Projects are done with multiple contracts, but many contracts are for multiple projects. For instance, "horizontal" procurement of goods and services is common in building programs (e.g., an owner may buy carpet for several projects). So the program needs to provide information "vertically" (for projects) or "horizontally" (the same cost and schedule information for companies working on multiple projects).[24]

[24] As in all database programs, there will be infinite ways to slice and dice the information but normally it will be done within the context of projects or contracts.

Performance metrics: These little indicators of current project health typically include statements of cost and schedule growth, items such as RFI aging, status of approvals, change order resolution and other project-level detail. Many users like to use green, yellow and red "traffic light" signals to color-code these indicators. Then these project results can be filed in historical databases to provide guidelines for planning future projects.

Guiding collaboration with policies and workflow diagrams

A PMIS is a control tool. Owners can prime the PMIS with policy or regulatory requirements that govern the workflow and institutionalize best practices that are specially designed for their organization.

Policies: If team members are to collaborate, they need to know the rules of engagement: how to work together. They must understand the policies that govern interaction, workflow and decision-making—how and when information is passed person-to-person and organization-to-organization. Properly honed, clearly documented but flexible procedures improve the efficiency of the team. People are far more productive when they have a clear idea of what to do.

Policy manuals should be part of a PMIS. After the initial installation of a PMIS, the team can experiment with smart folders, electronic forms and defined procedures. Its harder to do that it first appears.

When these policy and procedures manuals are electronic they can use all the tools of electronic communication like mouse-over pop-up boxes, hyperlinks and animation. They are also easy to access and update because they reside in only one place. And anyone with web access can get to them.

Smart folders and electronic forms: The program manager can set up a PMIS with folders that are programmed to notify specified people when a document is filed. Or electronic forms may be programmed to do the same. That allows managers to design decision-making and control.

For instance, an RFI placed in the PMIS may be routed to the architect and the project manager. The folder can also have a "side car" blog site for discussion contents.[25]

Standards: As owners execute a program, they develop standards to form baselines for continuous improvement. The standards may be for process (contracts, approval requirements etc.) or for product (design guidelines. preferred building systems etc.) They are stored in

[25] This task is harder to do than it might first appear and should not be part of the initial start-up program. See comments under Electronic forms and smart folders, page 76.

the PMIS along with links to the requirements of entitlement and permitting agencies.

Values of a PMIS

The purpose of a PMIS is to help an owner achieve its mission. That purpose can be lost in detail.

The owner pays for the PMIS—and of course, the reason is to improve the building program and ultimately their mission; to achieve higher quality, faster project delivery and lower cost—self-evident values in the quest to improve a competitive position, obtain more facilities with available dollars or operate more efficiently

To be precisely accurate the PMIS does none of these things. What is does do is to inform people so they can make decisions to accomplish those goals more effectively. But sometimes it takes a leap of faith to see the connection between implementing a PMIS and those noble objectives. Sometimes it is lost in detail and procedure.

Here's an explanation of some of those connections.

Information for common understanding: a prerequisite for collaboration

Collaboration requires a common understanding of purpose and the relevant facts. A PMIS will never replace face-to-face meetings, but there's too much information on even the smallest project to hold in our brains. So we need a rigorous, disciplined system. Although people always have some self-interest coloring their attitudes, conflicts subside with shared information. Providing the same information to everyone brings cohesion to the team. There are daily, small decisions that inform the project team about the proportionate values the leaders place on cost, schedule and scope. If the team understands those decisions, they better understand how to make decisions about their own work.

Here's an astonishing reality. If there is no disciplined PMIS, there will be confusion about the fundamentals: budget, schedule and scope. Each will be represented with different definitions and conflicting data in multiple, unrelated documents in different filing cabinets.

The Holy Grail of a PMIS is to replace these different filing cabinets and tons of paper with a centralized, comprehensive, near real-time, web-accessible database of electronic project information, available 24/7. Like BIM, it's a resource for the team, created by the team. The chore of data collection is endured only once and the pleasure of getting accurate needed information is enjoyed often.

The cheapest and most reliable way to document and communicate information

At first glance, one might look at an extensive PMIS and ask, *"Who collects all that data? What a chore! Isn't it costly?"*

The reverse is true. A PMIS reduces the cost of data collection. First, it's data that's always collected—usually repeated by several organizations. Second, with a PMIS the collection job is shared: the PM, the CM, the AE, etc., and then shared by all.

A PMIS saves money because the project documentation process is clearly defined and there is less duplication of effort in implementation.

Without a standardized PMIS, the same data will be recorded multiple times by multiple people in multiple filing cabinets and computers. Collection is inefficient and costly, and the data is inconsistent and unreliable.

With a PMIS, there is only one on-line filing cabinet. Responsibility for data entry is assigned to the appropriate people and those who need and use that information may access it, review it or download it—a far more efficient approach.

Armor for defense against political or legal attack

Projects experience conflict. It may be a lawyer searching for evidence to support a claim, a user who is mad at the director of facilities or a reporter looking for a tabloid story. An abundance of uncontrolled and conflicting documentation provides a target-rich environment for those searching for evidence to support a biased point of view.

Hard project facts are the arsenal of defense. If there are defined project goals and if they are consistently maintained with current data, the owner and the facilities team will have plenty of ammunition for support. If there is a legal challenge, a PMIS will help the owner find facts for support. Typically, paper document storage warehouses have poor search capabilities. A PMIS with centralized electronic documents will lower discovery costs and reduce the time required of executives to assemble exhibits. When there is a dispute, the team with the facts is the odds-on favorite to win.

There is always conflict with big projects. Facts are ammunition.

A window into the project

Any executive who has had the responsibility for a complicated process, implemented by layers of organization, executed by multiple companies, understands how hard it is to know what's going on, what's happened and what's the likely outcome of the current state of affairs. It is difficult to understand progress toward a goal, to know what caused problems and what contributed to success. A PMIS informs leaders about current progress so they can operate the levers of control.

It is hard for leaders to know what is going on with a project.

A PMIS is a management tool for control and collaboration. Control systems require feedback to measure progress so adjustments can be made to stay on track. With all the computers at NASA and all the fixed laws of the physical universe, NASA must still make on-course adjustments to hit the moon. Managing capital building programs is harder because the target may change and we don't have the laws of physics to control the behavior of people and organizations. Leaders must stay in control—not only to stay on course as unpredictable events unfold but also to change course when the destination changes. That means that they must know what's going on.

A PMIS is a management tool for control and collaboration.

Before we had computers, managers had to live with human layers of reporting. Top managers dealt with concepts and left the details of execution to the project managers and field engineers. Field engineers periodically passed information to project managers who passed it to middle managers who repackaged it for top management.

A layered reporting structure has common flaws: reports may be slow, idiosyncratic, filtered, inconsistent or biased. When a program-wide roll-up report is needed, the data needs to be reviewed for consistency at each layer and then consolidated. It's costly: everyone spends time gathering, packaging and reporting—sometimes inventing perplexing formats for each new report.

Centralized, web-accessible management information

Twenty-first century management technology makes these layers of management more transparent. Managers can open their laptop and view the report they want. That's not simply a boon for the top managers, it saves intervening layers of management from non-productive chores.

The technology increases the velocity of information flow. With human layers, the time a piece of paper makes the rounds (and waits for someone who is on vacation or ill) it's usually stale. Putting it on-line in one place for everyone to see provides near real-time response.

As information passes through layers in the organization, it gets distorted. The one-step process of storing information in a central database reduces the chance for it to be corrupted.

Standard formats and definitions

British investors in the 19th century needed to understand the status of their investments in the new world. They developed standard accounting formats for balance sheets and income statements. Today, the Generally Accepted Accounting Principles (GAAP) establish the rules of measurement. Anyone with a basic understanding of accounting can pick up one of these standard financial reports and understand it.

If the IRS let taxpayers invent their own forms to show how they calculated their taxes they would have to increase their audit staff by at least a factor of 10 to understand and decode the tax filings. Ad hoc, individually designed reports on design and construction projects can also create inefficiency and misunderstanding.

The construction industry does not have these standards. If the author invents report formats, they must be explained. Terms will mean different things to different people. Basic words like "budget" or "completion" or "program requirements" or "estimate" will include different components. Documents that contain crucial information will be changed and updated in some locations, not in others. Ad hoc reports presented in author-invented formats will be hard to understand. A spreadsheet will have cryptic column headings understood only be the originator.

So a good manager standardizes formats and definitions that everyone learns to understand at a glance. That increases understanding and saves time.

Security levels

Of course, the window needs shutters. The team members have security levels with defined levels of password protection that control permissions to access, input or change information. Some people will have access to information on their project only, others will have input and read-only privileges, others may modify documents, etc.

Improving performance with report cards

Anyone who has been associated with education understands that measuring performance with report cards motivates students. And it provides clues to parents, teachers and administrators about their effectiveness.

Measuring performance improves performance

The same applies to project teams. What is measured is what improves. For instance, a project may be viewed as a network of commitments to deliver work products that meet given requirements at a given time for a given cost. These commitments may be recorded in the PMIS and displayed in a periodic status report. That will reveal how people meet their commitments and informs project leaders. Knowing that, the firms work to improve their own performance and the leaders know whom to hire for the next project.

A PMIS will be replete with metrics that report progress against the objectives. Hundreds of little scorecards reveal the relationship between the current working estimate and the budget, the aging of RFIs, the status of submittal approvals—and on and on.

Educating management

A PMIS makes better projects. It also makes better managers because it furnishes comprehensive facts about project history. That will educate the project leadership with comprehensive understanding instead of half-truths supported by biased selections of information. Without systematic presentation, people may act (or fail to act) on the wrong information or learn the wrong lessons.

It is natural for us to concoct explanations of outcomes after the fact so we may learn from our experience. However, personal bias and selective memory may lead to a misleading collection of anecdotes. Good records and hard facts help us build true stories.

Owners want experienced managers (either in-house or outsourced) to represent their interests. They want people who understand the industry, understand how to assemble and manage the parts of a design and construction project and can cause the right action.

Valuable experience comes from learning from previous projects and anticipating that similar events might occur. To learn these lessons, leaders must have accurate reports—true stories—about what has happened. So a crucial PMIS function is to enhance judgment by a clear presentation of project activity: the cause and effect of project results.

However, there is some danger in history. Every project presents an unplanned, unpredictable and unique event that requires a non-traditional approach. Again—good data from multiple projects helps reveal the outliers for special attention.

A project involves so many people, is so complex and has so many events that selective information can support different points of view and produce false conclusions. Whether a project is public, institutional or corporate, there will be many voices. There will be users, administrators, lawyers, permitting agencies, the public and perhaps investigative reporters. There will be architects, engineers, consultants, contractors, subcontractors and manufacturers. It's human nature to search for information that supports one's bias. People will filter subsets of facts based on their self-interest—whether it is high-minded professional motivation, serving a personal agenda or controlling a company risk. Consequently, there are frequent incorrect constructions from biased selections of facts. Then someone learns the wrong lesson.

The PMIS will transfer some of the knowledge and experience from the brains of the project teams into a database. As people inevitably leave, get promoted, transfer to another department or go on vacation, they leave knowledge in the database for the benefit of the people who remain.

A PMIS won't eliminate biased viewpoints and self-interest, but it will help. It will define the goals, measure progress, document events and present the final result with standard, objective facts. Routine reports will present honest truth—not apocryphal, selected, self-serving or political stories, but honest, balanced insight into the project realities.

Challenges to implementation

An owner often hosts the PMIS, but if a program manager is the host, the owner must still commit resources, obtain agreement and engage other parts of the owner's organization (typically accounting and legal) to implement the system successfully. And, in most cases, the owner must plan to own and manage the information in the system.

Implementation groups and incremental startup

Think about having inclusive project information at your fingertips: contact information for the players, cost and schedule data for the projects, and workflow for the procedures. You can access up-to-date agreements and monitor their execution.

The categories of information in a PMIS are points on a continuum of managing construction risk, stitched together by software to present the most complete picture to the right people. That's an agreeable state of affairs.

It's easy to get enthusiastic. Ironically, enthusiasm can cause problems; while some people push back against change, others pull too hard. They think of all the lovely things that could be done (many of which we've discussed above) and set out to start, out of the box, with a system so big that they can't get it going. It staggers under the weight of bells and whistles.

The classic mistake is to organize a study group to decide on the total functionality of the PMIS. Each member of the group thinks of a valuable function to include. Each new idea makes the system bigger, the training harder, the politics more difficult and startup thornier. The system fails under the weight of its own ambition.

The reciprocal mistake is *not* to involve people in the process. Without buy-in, resistance increases. But it's better to charge them with developing an incremental approach rather than to design the ultimate system. Some organizations tend to embrace change more easily than others, so the speed of change can be matched to the ability to absorb new processes.

The leaders should provide a long-range vision but conceive short-term milestones. Then people can participate by designing defined parts of the system: startup modules that will provide value to everyone, be easy to do, get everybody in the habit of maintaining online data and give the team a quick win.

The idea is to view the process as a journey, not a destination. There is no ultimate system. Enhancement will be continuous and forever.

A sense of higher purpose

The people who enter the data are not always the people who benefit from it so they may have a hard time understanding its value. They may view the system as management reporting. The vision of an informed, collaborative team may not be clear at first. Somehow, the leader must communicate the important role everyone plays in making it all work—how individual contributions are necessary for success.

An implementation strategy must include time for training the team—along with a little motivational coaching.

There is a relevant quote from Antoine de Saint-Exupery.[26]

> *"To be a man is to feel that one's own stone contributes to building the edifice of the world."*

Entering data into a PMIS may not be contributing to the edifice of the world, but it sure does contribute to the edifice the team is building.

Starting small

But no matter how nimble an organization is, all will invariably suffer when as they install computer systems that automate what has been a human process. There's difficulty while the team adjusts to the new procedures—typically accompanied by grousing from people who resist change. And the grousing is given credibility by the inescapable glitches that are inherent in a system startup.

It won't happen without the boss maintaining a persistent drumbeat of insistence on accurate online information.

Consequently, wise managers start small.

The challenge is people, not technology. A PMIS changes how people do their job. It's a culture shift. That requires executive leadership.

[26] Antoine de Saint-Exupery was the author of The Little Prince, Wind Sand and Stars, Airman's Odyssey and many other works. He was a pilot during the early days of aviation, pioneered air mail over the Andes and was lost on a mission in during WWII.

Starting with the projects and the team

A strategy to install a PMIS may be to start with a little data for all the projects, or a lot of data for a few of the projects.

There are two approaches to implementation:

1. *Start with a few modules for all the projects*
2. *Start with a few projects with all the information modules.*

If the former approach is chosen, projects may initially be identified simply by name with information on the team: the people, organizations and their roles. The details of project accounting, schedules and requirements may come a little later.

A clerical person can enter the original data. Then team members can be asked to update their own profiles and project managers can review the project descriptions. Full-blown cost, schedule and quality information is be added as the team is trained and becomes comfortable with the discipline of routine input.

Conversely, if the latter strategy is chosen, the leaders may choose to implement one or two projects that are staffed with pioneers who are enthusiastic about the system and will be patient with de-bugging the processes.

The next step: agreements and document management

Agreement and document management is straightforward and immediately productive because the team learns how to store and retrieve their files centrally instead of keeping a partial, unofficial sub-set of the documentation on their personal computers. They grasp the concept of the PMIS as a central web-based location for managing agreements and the work products that are the fruit of the agreements.

A PMIS is a good place to put a policies and procedures manual. The first step is simply an electronic version of the paper document in one of the folders. That's easy. More sophisticated user-interfaces (pop-up boxes, hyper-links and animation) can be added over time to make the manual more effective. Ultimately, manuals may be adapted into structured process, electronic forms and smart folders.

Electronic forms and smart folders

Although electronic forms and smart folders may be part of a PMIS, it's best to get the basics working first. Electronic forms are tough to implement and can bog down a startup procedure.

Structured workflow with programmed electronic routing of forms provides managers with a tighter control of procedures but it's harder to do that might appear. It should not be part of the first steps in implementation.

It's not the technology that's tough—it's the people. When a team begins to diagram a workflow in the level of detail that's required for automation, with all the realistic variations, they discover that what they think is a standard process is not. Five people who routinely implement a process will inevitably describe it differently. Then, if there is a group discussion, they will want to change it. The process may vary by project delivery system, by building type, by the amount of money involved or by the group implementing it. After a process is finally defined, it must consider what happens when people who are part of the process are unavailable. If there is reorganization or someone in the chain leaves, the procedures need adjustment. Defining processes is time consuming, political and a big job.[27] If the process is defined without broad stakeholder involvement, the buy-in won't be there and the system will fail.

In the first phases it's best to maintain flexibility in the system so that people can use their judgment and their knowledge of the process to decide how to route information. It's easier to get going and users are less intimidated. With time, the team can begin to automate information flow—gently.

Resistance

PMIS information is updated by project team members who have defined responsibilities to do so. The program manager must create those responsibilities and enforce them. Some of the team, indeed some of the most experienced and capable members, will see the chore of maintaining the PMIS data as "administrivia." They see project information as power, their turf and something they have always been responsible for. They may see their "real" job in traditional light as managing and meeting with people. The PMIS is treated as an afterthought.

Technical support

Resistance may be a cry for help. People procrastinate when they are unsure how to do a task. Some people can go to a training seminar and leave knowing what needs to be done, but most will need additional help. It doesn't work to train everyone once and then move on. Having tech help close by during startup reduces frustration.

[27] There are well-known instances where the installation of a PMIS system failed or was delayed for years because the organization bogged down trying to agree on how they would execute the complex processes that involve multiple people in multiple organizations.

Current information

Some team members will be reluctant to make commitments or enter preliminary information. But a PMIS is collaboration software. It should include commitments, estimates and "guestimates."

Project managers will delay input if they are unsure of the data and that will cause a problem. Here's a common example: a project executive wants to know if a project is on budget. A quick way to check is to look at the current unused contingency. The executive does so and sees a comfortable margin. But the executive remembers that change orders are in the works. A phone call produces something like:

> *"Oh no, we don't have that much left. When we process the latest set of change proposals we will be down to less than 1%. I am waiting to finalize the numbers until we finalize the negotiations."*

And so the project is in trouble but the PMIS doesn't report it and loses credibility as a current source of project information.

Even though a PMIS will accommodate tentative or "estimated" costs that can be adjusted later, people are reluctant to input numbers until they are final. They are likely to prefer to track project information in their personal computer so they can change the numbers without an explanation to management.

Consequently, the information is stale; data is incomplete; project reports are inaccurate. The misinformation leads to embarrassment and planning errors higher in the organization. The PMIS loses credibility. Everyone must accept the idea that "tentative" and "best guess" information is better than no information.[28]

The boss must persuade, cajole, direct and finally order compliance. A good technique is to conduct open monthly project reviews with the project team, based solely on the PMIS reports. Personal spreadsheets are forbidden. That provides a review for accuracy and gets everyone in the mindset that the PMIS must represent reality.

Handheld connectivity

The proliferation of handheld, telephone computers creates new opportunities.

Reports should be formatted and accessible using handheld wireless devices such as a BlackBerry, iPhone or Treo. But what adds even more value than viewing data on a handheld is the ability to collect

[28] One approach is to use a "reserve" category. When a financial event is expected, the best guess is entered against the reserve. By using something less final sounding, such as a "reserve," a "best guess" can be corrected when the event (perhaps a change order) is final.

data—at the source. In traditional workflow information was captured first on paper in the field or in a team member's office, entered into a local computer and then pushed to the central database. Depending on the workflow rules, those steps can take time—perhaps several days. A handheld input device can shorten the process and perhaps provide important early warning to trigger management action.

Interoperability

Problems with interoperability exist within the owner's organization as well as with outsourced companies.

As an owner begins to implement a PMIS, owner groups and outsourced companies will want to receive information from the PMIS to input into their software. And their software will produce useful information to supply to the PMIS. Everyone will want to exchange data without a new round of data entry. It's bad enough the first time and errors always occur in the duplication process.

But each organization will likely have their own software and the software will not be interoperable: the programs don't talk to one another.

So the issue of data transfer among the extended program team (AEs, CMs, constructors) and among the owner's groups (accounting, legal, administration, O&M) will rear its exceedingly ugly head.

Interoperability with outsourced organizations: The owner's management team will want to collect data from the AEs, CMs and vendors for the PMIS. But the firms have standardized on different software. To solve this problem, an owner may decree that everyone on the project use the same software. Sometimes that works but it usually meets resistance. Outsourced companies argue that they have company-wide corporate agreements. License fees are spent and their staff is trained to use their chosen applications. Using the owner's software would require new training and new licenses and create cost.

There are no technical reasons why it can't be done. It often is.

Interoperability within owner organizations: The owner's organization has similar issues. The design and construction leaders want to stay on top of costs, budget work for capital repair and renovation and estimate the cost of potential claims. The administrative, accounting, operations, maintenance, and legal departments also need that information. An obvious thought is that the data should be entered only once for all systems. Not only is it efficient, it's crucial for the PMIS and the other owner systems to agree. If not, executive management in the organization will raise troubling questions.

The Rosetta Stone: Although the software used by an accounting department may not be interoperable with the PMIS software, it's straightforward to write data exchange routines that map and match data fields—as long as the definitions for the numbers are consistent. ("Budget" must mean the same thing to the accountants as it does to the project managers.)

When data exchange routines are used there is a common problem when software is updated to a new version. If data fields change, there will be a need to re-map—but that's straightforward too.

Another approach is to use electronic spreadsheets. Most programs can export and import information to common spreadsheets and word-processing programs. The PMIS manager may simply specify a precise set of data fields and provide spreadsheet templates for organizations to populate. Then users may review the information and approve it for input into their database. That saves keystroking. These common spreadsheet programs reside on everybody's personal computer, are well understood and can work as an information interface within the owner's organization and between the owner and the outsourced companies.

However, there is a brighter light at the end of the tunnel. The industry is working on data exchange standards like aggXML.[29] With them, system can transfer data without data mapping. The approach is similar to the standards that allow users of programs like Quicken or Microsoft money to download payment information from different brokers, checking accounts, credit cards, etc.

The real challenge is a turf challenge.

Turf issues: It's not a technical problem. As data moves from one organization to another, even within the same company, people who are responsible must scrutinize it, approve it and perhaps act on it. The owner's project manager will not allow a CM company to push information into the PMIS without review and approval.

Few CFOs will allow construction professionals to input data directly into their accounting system. They insist (rightfully) on review. A review may be implemented with a structured workflow or with tools that exist within the accounting software. The accounting software

[29] The agcXML is an Associated General Contractors of America initiative. It is an XML schema's for common transactional data such as standard agreements, schedules of values, requests for information (RFIs), requests for proposals (RFPs), architect/engineer supplemental instructions, change orders, change directives, submittals, applications for payment, and addenda.. See http://www.agc.org/cs/industry_topics/technology/agc_xml

may have an incoming information "waiting area" where the information can be reviewed and approved for input. That's good. The attention to detail and accuracy that is characteristic of accountants will be good for the construction professionals who may be more inclined to wag it. Furthermore, some of these groups feel that their data is proprietary. The GCs don't want the owner looking into their databases, and the owner's accounting department doesn't want outsiders having access either.

The owner's project team may be reluctant to provide information to the accounting department. If they are forecasting a funding shortfall or budget issue, they may want to keep it to themselves and try to fix it. If they forecast a healthy contingency remaining on a project they may want to keep it to themselves and use it elsewhere.

There is a timing problem as well. The design and construction group marches to a different cadence than accounting. Information in the PMIS approaches real time. Budgets and estimates start with the facilities group and requests for payments come to the project managers for approval and can be entered into a PMIS promptly and viewed immediately. The design and construction group also monitors the committed costs on a project (e.g., contracts) that typically aren't tracked in accounting. Accounting reports are typically focused on the actual money spent (versus what will be spent), and these reports are usually distributed 2 weeks after the close of a month. That means that data could be 6 weeks old. The operable thought is that accounting reports are history. Construction professionals must look ahead and control events that soon become history.

And so, solving the problem of interoperability between organizations is similar to the challenge of using electronic forms and smart folders. The process must be designed and negotiated providing control to the right people at the right time. The human engineering is more difficult that the technical challenge.

Legal Relationships

Chuck Thomsen

How do you make multiple companies work like one?
…Bruce D'Agostino, President, CMAA

The IPD premise is that design and construction will improve if the designers and constructors align their interests and remove legal barriers to collaboration. And so, as an IPD project begins, thoughts turn to legal structures to support this hypothesis.

If a single company executes a project, and if there is a problem, one part of the company doesn't sue the other. Their financial interest is the same and they find it easier to access material or intellectual resources from within the company that to contract for them from another company.

Although a profit center in a company may be inclined to make self-serving decisions and although a person in one part of the company might get cross at another, employees of a single company are more closely aligned than employees of independent companies working under separate contracts for the same project. When conflict surfaces within a company, an executive is likely to step in and align the team without the cost and delay of litigation.

So in organizing an IPD team, a common intention is to simulate the collaborative and litigation-free characteristics of a single company. (See comments in the chapter on Organization, Operating Structure and Commercial Terms.)

Of course, it can't be done completely. As long as multiple organizations have interests in the IPD Team and those organizations are doing at least some of the work independently, unaligned self-interest will exist. There will never be a contractual vehicle that will replace the need for professionals who have their hearts in the right place. But gains can be made.

Partnering: Prelude to IPD

Traditionally, a project is created by an ad hoc assembly of many specialized organizations, each operating with its own prejudices and self-interest. Each works on its own turf: economically, legally and culturally.

Our management practices have viewed organizational authority, precise contracts, detailed schedules and legal recourse for non-performance as the appropriate tools for knitting together such ad hoc organizations. The theory is that if each does its work satisfactorily, as specified and scheduled, the result will be OK.

It's logical but often disappointing. The problem is that we live in an imperfect world with unpredictable events. And everyone makes mistakes. To often, the result is conflict and legal action. Legal action ricochets. If one party sues another, the defense is to find the plaintiff's mistakes and counter sue. The conflict spreads from there. Since everyone has made mistakes, everyone is open to blame.

During the 1980s, many leaders in the construction industry began to add management philosophies that invoked the soft but essential spirit of collaboration. They recognized that if people on a project team want to help one another, they'd help the project.

Partnering emerged—a process that focuses on building a team, opening channels of communication, installing systems to anticipate and resolve problems and defining project goals for those who must work together. Partnering works. It *does* improve collaboration.

But when problems come up, there are no contractual teeth preventing the partners from getting a divorce. So IPD is a logical evolution—a means to add contractual structures to the spirit of Partnering.

Collaboration is hardly a new idea. In 1427, when Brunelleschi was constructing the Cathedral in Florence, tensions became so great among the artisans that they were made to take an oath to "forgive injuries, lay down all hatred, entirely free themselves of any faction and bias, and to attend only to the good and the honor and the greatness of the Republic, forgetting all offences…"

Such a clause might be useful in an IPD contract.

Dealing with Disputes

A concept in the early Alliancing projects was for each member of the Core Team to agree to not sue other members of the team (often with a list of exceptions for such acts as willful misconduct or egregious mischief).

Joe Horlen, a lawyer and head of the Construction Science Department at Texas A&M questions the practical application of that concept. He says, "Although it is may be theoretically possible in some jurisdictions, it would be likely be no more than a paper tiger if the project fell apart--which is the reason to have a contract in the first place.'

'It would be hard to find a trial court judge who would dismiss a case and limit a party's access to the trial even if they signed a contract to that effect. Access to courts is in the constitution and is taken very seriously by the law, and to waive such access is difficult. Unequal bargaining positions, vague language and many other arguments tend to cause courts to set aside such agreements."

Such a clause in not only questionable in its enforceability, it's a questionable concept. Clearly, many company shareholders would be circumspect about signing away their access to litigation.

However, litigation is expensive, juries don't understand construction and the courts are slow: construction projects can't be put on hold for a few years while a dispute is settled. Usually it just doesn't make sense to take a dispute to court. What does make sense is to develop efficient ways to deal with disputes quickly, and fairly with people who understand the process.

Dispute resolution may progress from a management committee to an executive committee, to a third-party neutral, to mediation—binding or non-binding.

Joel Darrington[30] a lawyer with McDonough Holland & Allen PC who specializes in construction matters points out, "For this reason and others, many IPD projects use dispute resolution processes. They start with the management committee. If they can't resolve the dispute, it may go to a group of senior executives from each of the disputants.'

'From there, disputes may escalate to a third-party neutral for investigation and recommendations, mediation or both. Mediation could be binding or non-binding. If non-binding, then arbitration or litigation would be the forum of last resort to resolve the problems.

[30] Joel Darrington made many helpful edits to this paper.

Anecdotally, very few IPD projects (if any) make it to litigation between the parties, even if technically allowed under the contract."

Choices

The IPD Core Team is assembled from the key organizations that share the risk and reward of executing a project (or a program). It can be two organizations (an AE and a CM), or it could include sub consultants and subcontractors. Normally, the Core Team will be limited to organizations that have a significant role in shaping the project outcomes.

At the start of an IPD project, the owner and the Core Team must agree on a legal structure for Core Team. The technical considerations to ponder are those of liability, taxes, legal authority and administrative cost.

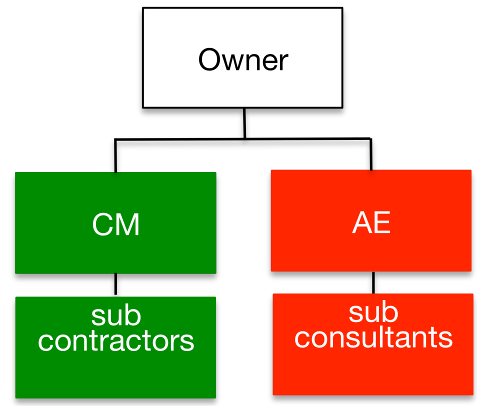
However, an overarching consideration is the effect of the legal structure on the team's culture. The salient question is: what form of legal entity maximizes collaboration and will work for the specifics of the project and the constraints of the owner? (Clearly public, institutional and private organizations will pose vast differences in procurement regulations.)

The common choices Core Team may consider are:

5. Multiple independent contracts (the traditional approach)
6. A single multi-party contract
7. A joint venture (a JV)
8. A limited liability company (an LLC)

Multiple Independent Contracts

An owner could choose to use a traditional approach, contracting with designers and builders independently but still use some of the aspects of IPD.



The traditional approach is for the CM and the AE to have independent contracts with the owner. In itself, it does not contribute to integration, but commercial terms can be added to the contracts to enhance collaboration.

Liability

Unless limitations or transfers of liability are in the contract, each company is liable for its own work and the responsibility is compartmentalized in its own silo of risk and responsibility. Again, as noted above, there also may be clauses (with untested enforceability) that each of the companies sign to limit their ability to sue one another. Dispute resolution provisions can be put in place.

Taxes

Each company pays its own taxes using its own accounting policies.

Administrative cost

Each member manages its own company operations with its existing overhead staff, policies, systems and insurance. Since there is no overarching organization binding the team together, there is no additional administrative cost.

Culture

A multiple-contract structure does not contribute to an IPD culture. However, an owner could establish commercial terms to promote integration such as a shared incentive pool for meeting project goals that would be earned or lost, multi-laterally, by the team. Or, in the case of government contracts that allow award fees but prevent sharing award pools among impendent contractors, the criteria for the award for each contractor could be the same. (A common divisive arrangement is having team members who are rewarded for different goals. Perhaps the most effective part of an incentive pool is that it carries a clear statement of goals and a message from the owner that collaboration is expected and rewarded.)

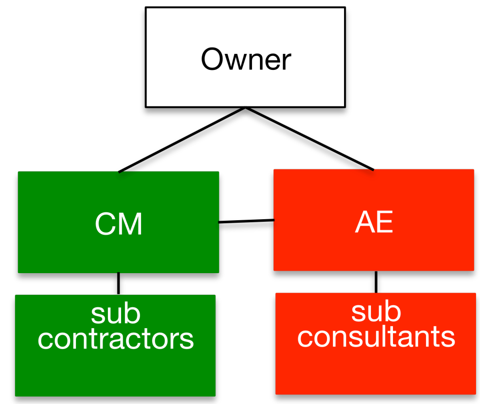
There could be participation in executive committee governance, team meetings ("sustainable partnering") to review everyone's performance, or other aspects of integrated project organization, as long as each of the contracts were coordinated on these points and the parties agreed.

One strategy is to have separate contracts that each reference a common set of project terms and conditions that would help minimize inconsistencies between the contracts.

Single Multi-party Contract

Another possibility is a single, multi-party contract signed by each member of the Core Team (including the owner). Unlike traditional contracts that only define responsibilities to the owner, the multi-party contract defines the duties of each party to one another. The owner pays each party individually.

The payment could be lump-sum or cost-plus, and there could be a target price or GMP. Often, there is a shared incentive plan. See our fuller discussion in the chapter on "Organization, Operating System, and Commercial Terms."



A multi-party contract is signed by each member of the Core Team and defines responsibilities to one another.

Liability

In such an agreement, it is possible to define and stipulate the responsibilities and liabilities of each party within the context of an integrated team that defines liability to the owner.

Some argue that by jointly signing an agreement that provides for pursuing a common project with some shared responsibilities and liabilities, the parties are forming a joint venture and would result in the team members being held jointly liable to a third party. In the spirit of shared responsibility so prevalent in IPD, it is likely that there would be much in the language of the agreements and the actions of the parties to support such an allegation.

The debate has not been resolved, and so far no cases have addressed this issue.

Taxes

Each party will pay its own taxes based on its income and following its standard accounting policies.

Administrative cost

A multi-party contract is likely to be an efficient choice. Each member will manage its operations with its existing overhead staff, policies, systems and insurance. There must be a management committee to coordinate the project and adjust the duties and compensation as the project unfolds. The owner, as a signatory of the multi-party contract, would participate as a member.

Culture

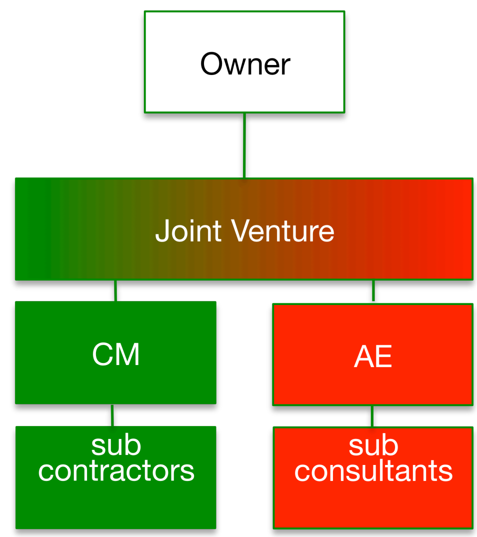
Some IPD advocates would argue that such an arrangement does not go far enough to remove the independent silos of risk and responsibility and that a legal structure that provides a more cohesive organization would be more "integrated."

While there is a unifying management committee and typically a unifying incentive pool that adds to the collaborative culture, the independent silos walls of responsibility intact.

The counter argument is that any organization, short of an independent, fully staffed multi-disciplinary single company, will have independent silos. Even when companies form project-specific entities and become owners, they typically subcontract design and construction management to member companies—again creating silos.

Joint Venture

"Joint venture" is a broad term with shaded nuances in different industries. In the construction industry a JV normally implies a partnership between two or more organizations that combine their resources to do a specific project or program. Normally, there are two contracts. The JV has a contract with the owner that spells out its duties and responsibilities. And the members of the JV have a JV agreement among themselves that spells out their individual duties and responsibilities. The owner pays the JV for the work. The JV pays the members—after deducting JV costs (if any). Normally, the terms of payment to the members of the JV agreement should reflect terms of payment from the owner to the JV agreement. (For instance, if the owner-JV agreement is cost-plus, the JV can pay the members on a cost-plus basis. If the owner-JV agreement has a GMP or target price provision, the individual members of the JV should probably have GMPs or target prices in their agreement with the JV.).



A typical joint venture is uncommon for IPD projects because the CMs don't want responsibility for the AEs design and the AEs don't want responsibility for construction. However, the CM and the AE can contract with a JV with indemnities and GMPs for their respective work and pass savings to the JV. The JV can hold the profit, contingencies and incentive fees and pass it to the AE and CM based on a predetermined agreement. That encourages collaboration.

Liability

Normally there is "joint and several" responsibility stipulating that each member of the JV is responsible to the owner for the entire work. If one party defaults, the remaining partners must assume its responsibilities. Consequently, the total assets of each member are on the line for the successful execution of the agreement.

For this reasons, JVs between AEs and CMs are seldom used for either IPD arrangements or design-build: architects don't want responsibility for construction and contractors don't want responsibility for design.

However, a unique approach is for a JV to do perform none of the work but subcontract design work to the AE and construction work to the CM. Each indemnifies the other. Each works at cost and provide a GMP for their respective responsibility to the JV. If work is done for less that the GMP, the savings accrue to the JV. The JV provides management and executive activities and holds the profit, contingencies and incentive fees to be distributed at a predetermined rate. Now, if the AE can think of ways to help the contractor, it improves the profit, contingency or award pool—and vice versa—certainly in the spirit of IPD.

Most owners would not agree to contract with a JV that had no assets so if the approach in the paragraph above was used, it's likely that the owner would require corporate guarantees. However the AE could guaranteed the typical AE responsibility and the CM could guaranteed the typical construction responsibility to the JV and indemnify one another. Of course such indemnities is worth no more that the assets and insurance of the respective companies.

Taxes

For tax purposes, a JV is seen as a partnership between companies. In a partnership, income flows through the partnership to the partners and the partners are taxed as individuals. Although in many states a JV must file a tax return, profits are normally passed through to JV partners and the JV has zero income. Even if the JV held the profits, they would be distributed to the JV partners. The members of the JV would then file their own tax returns based on their usual accounting policies.

Administrative cost

Although it is possible to distribute all the expenses of the JV to each of the member companies, a JV typically develops a little overhead cost of its own for accounting, entertainment, legal representation, perhaps office space and supplies, etc. So there is usually a minor increase in overhead. It is rare for a JV in the construction industry to have its own employees and to create its own overhead staff, policies and management systems but it is sometimes done.

A JV must have a management committee to direct the organization, make major project decisions, modify the duties, adjust the compensation or handle other administrative or operational decisions as the project unfolds. And the JV may invite the owner to participate as an ex officio member. However, the JV management committee is not the same as the project executive committee that involves the owner as a integral member—that would still be an important part of the project governance.

Culture

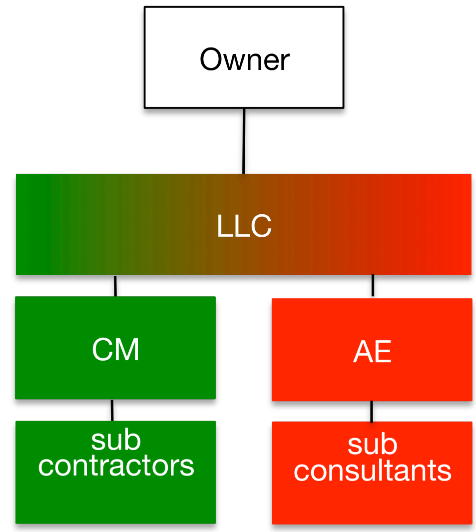
Some IPD advocates would feel that while the "joint and several" responsibility exposes the members to inclusive liability for the entire project, it benefits the project because the members share inclusive responsibility for the result. Collaboration is likely to improve when each partner is responsible for the work of the others.

It's also possible for the JV to develop an integrated team, staffed with employees of the JV member companies, to manage a PMIS and a BIM model. While the AE would sign a sub-set of the drawings for permits, the JV could own the model and assume responsibility for the integrated set—one way to ease some of the concerns that exist with PMIS and BIM integration when there are separate contracts.

Limited Liability Company

Another possible legal structure would be for the Core Team to form a Limited Liability Company ("LLC") to build the project.[31] The ownership of the LLC may be distributed to the IPD Core Team proportionate to the level of effort and cost of the services that each member of the IPD Core Team might provide—and therefore proportionate to the potential profit (or loss) of members. Or it could be distributed some other way, such as the based on the party's ability to influence project outcome or the amount of risk assumed by a party.

The members would agree to divide the work and subcontract it among themselves. The AEs design, the consultants consult, the CMs manage and the constructors construct. Each prime company is reimbursed at cost or at any reasonable predetermined arrangement for their work. At the end of the project, the profits are distributed based on the division of ownership. Non-Core Team members would be contracted either directly to the LLC or subcontracted to prime companies.



An LLC theoritically limits the liability of its members, however a well informed client will require coroporate guarantees. The LLC may limit third party liability.

Liability

If architects, engineers and constructors form an LLC to execute a project, their liability to the owner is limited. That may be in their interest but not in the interest of the owner. Unless the situation is exceptional, a well-informed owner would require corporate guarantees.

While owners an LLC enjoy limited liability for most of their business transactions, the protection is not absolute. State statutes differ, but an owner (either an individual or a company) can be held personally liable if she, he or it injures someone, guarantees a bank loan or a business debt, fails to manage employee withholding taxes properly, is intentionally fraudulent, illegal, or reckless or treats the LLC as an extension of his, her or its affairs. This last exception requires attention. If owners don't treat the company as a separate business, a court might decide that the LLC doesn't really exist, and the owners are doing business individually and are therefore liable for their acts.

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[31] C Corporations, S Corporations, LLPs and LLCs allow the owners to limit their liability to the extent of their investment. However, the members of an IPD Core Team are apt to be companies, not individuals. That excludes LLPs and S Corporations. The C Corporation has a double layer of taxation so that is a discouraging characteristic. That leaves the common choice to be an LLC.

Taxes

The profits of the LLC are passed through to the members. In the context of this paper, the LLC members would be the members of the IPD Core Team. They could distribute shares anyway they agreed to, but one likely approach would be to distribute shares proportionate to their potential risk and economic interests (e.g., their overhead and profit, or their fee) in the project.

Administrative cost

An LLC will require a full set of administrative resources: legal, accounting, human resources, etc., although it's possible for one of the IPD Core Team companies to do these jobs. Nevertheless, there will be additional cost. Significant set-up costs are involved.

The LLC will need to carry its own property and liability insurance. Even though the LLC shields the member companies from liabilities, it must stay in business to execute the project and for some time afterward.

Culture

Many believe that the culture of a single company provides the best integration. That might work if the project is large enough to warrant a full-time staff. That, of course, helps approach the single company ethos, but it takes time and money to create the administrative systems and bureaucracy, and many employees will be hesitant to leave the ladders of their own organization's advancement programs.

Such an approach would be easier for a construction team that might require a full-time project manager, superintendent and field staff for several years. But the design function typically has more specialized talents that move in and out of the project for shorter assignments.

However, in most IPD projects, the more practical approach will be to simply subcontract the required tasks of management, design, construction and administration to member companies. The IPD Core Team could contract with the sub consultants and subcontractors, or the individual organizations could contract with the appropriate sub consultants and subcontractors. That approach would allow the existing accounting and contracting staff in the key organizations to do the administrative work.

The LLC would have two unifying characteristics. Shared responsibility to and with the owner and the sharing of profits/losses would be the basic elements that motivate alignment of the IPD Core

Team. Those same characteristics can exist in any legal structure if structured appropriately.

So there is much to debate about the value of an LLC for an IPD Core Team. Traditionally, owners don't want their service providers to have limited liability. They will want the companies they choose to have their skin in the game with personal or corporate guarantees—negating much of the value of limited liability.

The limitation of liability might still be of some value in a suit instigated by a third party (a slip-and-fall suit, for instance) but the injured party, in spite of a lack of privity might be able to litigate against the architect or other team members anyway.

Most states have extensive regulations covering the bylaws and governance of a corporation that may limit the freedom of the IPD Team members' ability to set up unique management procedures. The participants in other contract structures have broader opportunities to invent their own rules of governance and operation.

A Bit of History

Since much of the thought process surrounding the legal relationships hinges on liability, it seems useful to look at the history of change so that we might understand where we are, connect the dots and think about the future.

From the middle of the 19th century to the middle of the 20th, there was little change in the legal structures of design and construction. The task was simpler. But industrialization and specialization in the industry have brought the need to involve far more organizations in a collaborative endeavor for a far more sophisticated product. Consequently, recent decades have seen innovation by construction professionals and their lawyers. By the time this paper is read it will be incomplete—someone will have invented another approach.

The growth of limited liability organizations

In the 18th century, the concept of an organization that limited investor liability didn't exist. An investor in an enterprise was a partner and personally liable.

But industrialization in the 19th century brought the need for capital. Economic growth required companies to attract funds. It was clear that to do that, it would be necessary to limit the liability of investors to the extent of their investment. The concept of a limited liability corporation emerged and flourished and has taken multiple forms

However, the philosophy of limited liability didn't immediately apply to professionals (architects, engineers, lawyers, doctors). For most of the 20th century, state statutes required professionals to be liable for their work as individuals and precluded them from practicing as a limited liability company. That changed in the last half of the 20th century and a number of limited liability concepts emerged in the statutes.

C Corporations

Until the late 20th century the C Corporation was the only form of a limited liability company. The C Corporation is a business entity that limits the liability of the shareholders to their investment. The number of shareholders is unlimited. Other companies can be shareholders so there can be holding companies and tiers of subsidiaries. C Corporations can be private, controlling the number and selection of owners and the value of their shares, or they can be public with their ownership and the share value controlled by the market.

The C Corporation is an entity and must pay income taxes on its profits. The owners pay individual income tax only on money they receive from the corporation as salary, bonuses or dividends. The shareholders are then taxed for the income produced by the dividends. Although C Corporations are taxed at lower rates than individuals, this double tier of tax will usually take a larger bite out of the shareholder's eventual after-tax rewards from the enterprise than most other forms of business organization. (That may depend on the current tax laws and the tax brackets of the shareholders, and while usually the case, there may be exceptions.)

Some C Corporations routinely bonus all of their profits to owners, using debt to capitalize the business, thus avoiding taxes on profits. It is a practice that may be examined by the IRS

S Corporations

Frustrated by the double tier of taxation, businessmen and professionals persuaded lawmakers that there should be a form of corporation that limited the liability of its investors but avoided taxation cost of the C Corporation. S Corporations are regular corporations that have elected S Corporation tax status. An S Corporation lets the shareholders enjoy the limited liability of a C Corporation but pay income taxes on their personal returns as a sole proprietor or a partner.

The profits of an S Corporation are distributed to the shareholders as cash and/or increased share value, and the shareholders are taxed on the sum of both at ordinary income rates. (If the shareholders leave the money in the company to capitalize operations, increasing share value, it is still considered personal income and taxed.)

Most states follow the federal lead when taxing S Corporations by taxing the business's profits on the shareholders' personal tax returns. However, a few states tax an S Corporation like a regular corporation.

S Corporations impose some limitations. Shareholders must be individuals (not a company) and a U.S. citizen or resident. There may not be more than 100 shareholders. An S Corporation shareholder may not deduct corporate losses that exceed his or her "basis" in corporate stock.

Limited Liability Partnership (LLP)

And then, after creating an S Corporation that was taxed like a partnership, our states created a partnership that had the limited liability of a corporation. The Limited Liability Partnership was created primarily for professionals like lawyers, architects and doctors. It is a partnership, but one that limits the liability of the partners to their current equity participation in the partnership.

Limited Liability Company (LLC)

Not long ago, an S Corporation was the only limited liability organization that did not have the double layer of taxation. But in the late 20th century, adding LLCs expanded the choice. A Limited Liability Company is like a
C Corporation in that it limits the liability of its owners, but like an S Corporation, it can pass income through to shareholders. (However, an LLC or may also elect to pay taxes like a C Corporation.)

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Designing a legal structure for project delivery is about juggling primary considerations of responsibility, risk and collaboration with a secondary tier of considerations: taxation, administrative cost and public liability. It is influenced by significant variations in state laws and case law governing licensing, codes and the formation and operation of legal entities such as those discussed above.

And so a word of caution is appropriate at this point. This document is not a do-it-yourself legal guide. Departures from common practice require examination by experienced construction lawyers conversant with the details of applicable state laws.

What is encouraging is that AEs, CMs and their lawyers are turning away from contracts that focus only on defining and delegating compartmentalized risk and responsibility linearly to an owner. Recognizing that many organizations must work together to produce the project, the focus is on finding on finding productive ways to share risks and rewards and build collaboration. That will make a better game for us all.

Integrated Practice: Process or Product

Chuck Thomsen

As it evolves, as it surely must, will Integrated Project Delivery become a form of design-build—gathering architects and engineers into builder's legal responsibility to deliver a reliable product? Or will it be the reverse—a process that brings the builder into the architect's professional responsibility to provide a Standard of Care and serve the interest of the Owner? Or will it be both? A look back at some legal history of our industry will help illuminate this question.

Since integrating a project teams means integrating the responsibility to deliver a building, it will inevitably be compared to design-build.

A Defect-free Building

Craftsmen built most buildings in Early America. Only a few men assumed the role of a full-time architect before the mid 19th century.[32] Builders, typically masons or carpenters, called themselves architects.

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[32] Notable examples are: Charles Bulfinch (1763-1844), Richard Morris Hunt (1827-1895) and Benjamin Henry Latrobe (1764 1820) .

Early American tradesmen were required by common law to produce "workmanlike" results. As loose groups formed under the leadership of entrepreneurial craftsmen to build a building for a price, 19th century judges made the logical assumption that a builder architect should guarantee the work to be correct.

In Ohio in 1834, an Owner hired a "mechanic" to design and build a house. The chimney flues smoked and the house had to be rebuilt. The court stated that the law required the "mechanic" to build in a workmanlike manner. [33] In another case in 1841, a builder who had designed and built a defective sawmill explained that he had done the work "to the best of his knowledge, skill, and ability."[34]

Craftsmen, who often called themselves "architects" were expected to deliver a "defect free" result.

The court said:

> *"…when a party contracts to do a certain piece of work in his "trade", he is presumed to be both able and willing to do it in a workmanlike manner…the very offer to do the work, presupposes capacity. To say that a builder, after the destruction of the materials, and the expenditure of his employer's means, should be permitted to shield himself from damages, upon the ground that he only contracted to the best of his knowledge, skill, and ability, and that he is not responsible if the work is not done in a workmanlike manner, would be a fraud which the law will not countenance."*

Professionalism and the Standard of Care

But when the craftsman/builder/architect moved out of the mud and rain, obtained degrees from universities, established associations like the AIA, obtained licensing and sought professional status, a new concept, the Standard of Care, emerged.

When architects separated from construction, they sought the status of other professionals and the "Standard of Care" emerged.

As the number of Architects grew in the 19th century, they sought and obtained the status of other professions: law and medicine. They argued that to err is human and their responsibility should not be perfection but instead their work should meet the standard of their peers. Although circumstances, jurisdictions and the predilection of judges differed, most courts agreed that an architect did not guarantee perfect plans, a perfect building or perfect supervision that would deliver a defect-free project.

[33] Somerby v. Tappan

[34] Manuel v. Campbell

Both principles were analyzed and clearly stated by the end of the 19th century.

In a famous New York case,[35] in 1888, a three-judge panel, reviewing a previous decision, stated that an architect when overseeing construction is:

> *…bound only to exercise reasonable care, and to use reasonable powers of observation and detection in the supervision of the structure. He might direct during one of his site visits that portions of the plumbing work be packed in wool, but he would not be required, upon his next visit to the building, to tear apart any brick work that might by then have covered the pipes in order to see whether his directions had been attended to. An architect is no more a mere overseer or foreman or watchman than he is a guarantor of a flawless building."*

However, "Hubert" gave new emphasis to the Architect's responsibility to stay abreast of emerging technology—a responsibility that is on steroids as we enter the 21st century. The justice who first heard the case emphasized that the reasonable skill and knowledge required of an architect should include design documents which incorporate technical learning reflecting:

> *"…new conveniences such as steam heating that becomes the customary means of securing the comfort of the unpretentious citizen. The architect is expected, as a professional, to keep himself abreast of such developments, and as a professional he is not permitted to avoid liability for ignorance of new technology by throwing the responsibility of any errors committed upon the contractor or the owner."*

The words *"would not be permitted to avoid liability for ignorance of new technology"* are galvanizing in light of the technologies that present themselves to Architects in the 21st century—an abundance of technical knowledge light years beyond the ability of a single person to absorb. And it is not only the technology of construction but the technology of collaborative design that must be understood.

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The Standard of Care concept doesn't establish a metric to define an acceptable tolerance for defects. It addresses process. It is a legal term defined in most jurisdictions as:

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[35] Hubert v. Aitken

> *"that same level of care employed by reasonably prudent professionals practicing in the same field in the same area."*

Standard of Care does not speak to the notion of defect-free buildings. Rather it is the recognition under common liability law that professionals (doctors, lawyers and architects) are in the business of exercising learned judgment, based on experience with a body of knowledge, and upon situations and decisions not totally knowable or under their exclusive control.

For instance, a doctor may use the best-known treatment and still lose a patient. Likewise, an architect may specify the correct soils tests, hire good geo-technical and structural consultants and the ground may still heave and displace the foundation. If the architect can show "that same level of care employed by reasonably prudent professionals practicing in the same field in the same area" he or she may avoid responsibility for the cost of the repair. The concept is that professionals are to be held accountable for process, not results.

The Standard of Care is not intended to protect professionals by establishing a threshold of error, allowing minimal defects. Rather it is recognition that because buildings are so complex and unique, design professionals cannot guarantee defect-free buildings.

A professional design does not require that every element of construction, down to the location and length of each nail, be specified in the design documents. Such details are often best left to the skill and discretion of the builder, whose expertise is found in converting a design to the physical conditions of the real world. Buildings, unlike automobiles, are not mass-produced products that present an opportunity to eliminate flaws in subsequent editions.

Therefore, architects and engineers, when designing a unique structure, are not subject to product liability laws. Instead the law places a duty to follow a process based on a body of knowledge and experience. And that process constantly evolves as knowledge grows.

But the basic concept of a professional that is not expected to be perfect remains. In the words of a twentieth century court,[36] architects:

> *" deal in somewhat inexact sciences and are continually called upon to exercise their skilled judgment in order to anticipate and provide for random factors which are incapable of precise measurement. In such*

[36] City of Mounds View v. Walijarvi (1978)

> *circumstances, certainty as to the exact result to be obtained by relying on an architect's plans or supervision is impossible, and perfection is to be neither anticipated nor expected."*

The Spearin Decision

Meanwhile, contractors sought the protection of the law to deliver what the plans and specifications called for even if the result did not suit the Owner's purpose.

Early in the 20th century, the United State Supreme Court held that since a builder agrees to build according to plans and specifications furnished by the Owner (and it can't be shown that the contractor knew that the plans and specifications would produce a defect) the contractor is not responsible for the consequences of defects in the plans and specifications. [37]

The Owner's Responsibility

If a builder builds a flawed design as defined in the plans and if the architect could demonstrate that he or she had used the "*care employed by reasonably prudent professionals practicing in the same field in the same area*." the owner is left with the cost of correction. Even though there is a mistake, the AE is not liable, the builder is not liable and the owner must pay.

Initially, all risk on a building project lies with the owner. A risk not allocated to professionals or builders remains with the owner. Try as they might, owners cannot allocate all risk for building defects or unanticipated conditions to others. Given the inherent common law limitations on liability for both builders and AEs, the owner must assume liability for defects occurring under the Standard of Care concept and the Spearin doctrine. A wise owner will know that we don't live in a perfect world and will have contingencies to protect against the unpredictable.

In most IPD projects, there is a pool of money that recognizes this reality. It is used to pay for the mistakes of the members (just as the contingency in standard cost-reimbursable CM-at-Risk contracts may be used for mistakes). It may also be used for economic efficiency–it may be cheaper for the owner to not pay for a near perfect design when the cost of proceeding with a sufficiently complete design yields sufficient savings to cover any extra costs the builder may incur

[37] United States v. Spearin (1918)

in overcoming missing design information. If unused, the contingency may be returned to the owner or shared. That motivates everyone to participate in checking everyone else's work.

Traditionally, as recognized under law, builders have not been seen as professionals since the craft of building is not assumed to include the level of uncertainty that architects face (a 19th century assumption that has proved increasingly incorrect in the 21st century). The traditional attitude of society (no longer valid) has been that Architects are responsible for defining the best construction technology.

Therefore, if a contractor builds a building exactly as designed and it leaks, it is not fair to hold the contractor liable. However, in the real world, on an almost daily basis, builders see errors in the plans and work out solutions with the architect. One pundit[38] said, "The dirtiest trick a contractor can play on an architect is to build a building exactly as designed!"

As our industry has developed, manufacturers and trade contractors often know more about component design than architects and engineers. So, when there is a problem, owners not knowing who to sue, usually sue everybody involved, including subs.

Centralizing responsibility for results has been a driver for design-build and Bridging. But in many cases, the owner, in spite of lack of contractual privity in a design-build project, can sue the architect directly because of an implied duty based on professional licensure.

Process or Product?

It is yet to be seen if the courts consider IPD to be a design-build process, obligated to deliver a defect-free building, or a professional service expected to provide judgment, wisdom and experience. Since owners are applying the IPD label to many forms of project delivery and are inventing their own contracts terms the decisions will tip one way in some cases, another way in others. It's unclear how Spearin and the Standard of Care concepts will work with IPD contracts. Certainly, different IPD agreements will produce different decisions.

It's possible that a trade contractor under contract to an IPD Core Team[39] would be able to use Spearin concepts and claim successfully

[38] Attributed to Jack Hartray, FAIA, a well-respected Chicago architect.

[39] Whether incorporated, a JV or simply under contract to the CM working under a multi-party contract

that the IPD Core Team had an implied warranty that the plans and specs were correct. However, if a CM working under a multi-party IDP contract held the trade contracts the CM would be unlikely to derive protection under Spearin since the CM had a duty to evaluate the design as it developed.

However, assume that the CM and the AE form an IPD Core Team that is an LLC or a joint venture or operates under a multi-party contract, and assume that subcontractors are under contract to the IPD Core Team. If there is a flaw in the design, does the IPD Core Team have a duty to deliver a defect-free building or do they operate under a Standard of Care. Are they delivering a product or a service?

If the agreement implies the delivery of a product, the AE may owe a traditional Standard of Care to the IPD Team, but the IPD Team may commit to delivery of a defect-free building. However, if liability for project problems is shared among the Members, the AE will share its proportion of the liability for a defect and so will share financial exposure for their mistakes anyway.

A key benefit to the IPD process is that this sharing of responsibilities can be defined among the parties by the project participants, thereby establishing at project inception the expectations and Standard of Care each of the team members owes to the other. The owner is usually a part of the IPD team and can participate in crafting this agreement that spells out the duties of the IPD Core Team Members to one another. So the question becomes what does the IPD enterprise agree to deliver—a defect-free building, or a building of a quality which meets the Standard or Care (or some higher level defined by the IPD agreement itself)?

This collaborative design effort, at the heart of the IPD concept, blurs the line of demarcation between the multiple authors of the design. Since the CM and key subcontractors participate in the development of the design documents, they are unlikely to have any protection under Spearin. Indeed, since the owner is intimately involved in the process and influences many decisions, the owner also assume some ownership in the design.

Undoubtedly some owners and their lawyers will fashion agreements with integrated teams that include fixed prices, GMPs and defined results. Based on the specific language in the agreement such a contract may be interpreted as a design-build agreement to deliver a defect-free product. But certainly, others will fashion agreements that define the process and professional responsibilities, and the IPD team will be expected to deliver a Standard of Care.[40] And there will be substantial gray areas for the courts to deliberate.

However, both AEs and CMs argue that the driving ethos of IPD is professional and that the AE and the CM may both owe the owner a Standard of Care—but not perfection. If history is a guide, that's a likely outcome. CMs appear to be repeating the evolution to professional status that characterized the emergence of architects. Consider this:

- In the mid 19th century, architects separated from the physical act of construction, formed associations (such as the AIA), were hired on the basis of qualifications rather than price, obtained licensing and by the end of the century the "Standard of Care" concept was in place, firmly cementing the role of architects as professionals with professional, not product responsibility.
- In the late 20th century, construction managers separated from the physical act of construction, formed associations (CMAA), were hired on the basis of qualifications rather than price and at least one state requires CCM certification to assume the title of "Construction Manager." And a "Standard of Care" clause is surfacing in some IPD contracts.

History appears to be repeating itself.

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However, even with a Standard of Care applied to the agreement between the IPD Team and the owner, it is likely that the standard will be very high. Since the extended project team can review BIM models the team will be expected to do so. And since physical conflicts can be discovered by clash detection routines, that will be expected as well. So it is likely that if a Standard of Care becomes part of an IPD contract with an owner, the standard will approach "defect-free" anyway.

So it is likely that if a Standard of Care becomes part of an IPD contract with an owner, the standard will approach "defect-free" anyway.

[40] Already, Standard of Care clauses are appearing in IPD contracts.