Abstract

Purpose: To review the state-of-the-art of Lean Project Delivery (LPD), to show the relationship between LPD and integrated design and delivery and to propose further stages of development, research and practice.

Method: Description and analysis of action research & learning in current practice.

Findings: In the context of Lean Project Delivery with Target Value Design (TVD) projects are completed below market cost—so far as much as 19% below and expected cost falls as design and construction progresses.

Limitations: this work is based on a limited number of linked cases in the US over the last 10 years. We suggest the ideas are applicable far more widely.

Implications: there is still more development and research required to develop effective leadership models for integrated design and delivery, create whole of life Target Value Design, to create significant bodies of evidence to guide the design of many building types and to further develop the Lean Project Delivery System.

Value for practitioners: initial indications are that the methods described work together to deliver significant benefits for owners/clients/end-users and create a more satisfying experience for most designers and constructors.

Keywords: Target Value Design, lean construction, lean project delivery, allowable cost, target cost, value, evidence-based design, A3, set-based design, collaboration, early constructor involvement, integrated form of agreement, integrated project delivery, value management.

Introduction

The idea of integrated design and delivery is not new — the UK Emmerson Report of 1962 noted that “in no other industry was the responsibility for design so far removed from the responsibility for production”. While there has been a shift since then toward more integrated procurement of construction, it has been piecemeal, partial and is still far from the norm, particularly in public sector design and construction.

Many in the public sector believe, usually erroneously, that public procurement rules outlaw integrated design and construction procurement while others actively pursue
integrated procurement paths such as PPP & PFI\(^2\). As the Economist noted recently “Conventional procurement has too often been a litany of overruns and delays, and it does not create an incentive for contractors to consider maintenance costs. If the PFI brings in construction on budget and time, and upkeep is cheaper, then it is likely to offer value for money” (Economist 2010)

Others see technology as a barrier (e.g. inter-operability problems) or a solution (e.g. clash detection and virtual construction) to integrated design & delivery. In a recent issue of AEC Bytes, a blog, (7 Apr 2010) Randy Deutsch reminded his readers of GSA’s Charles Hardy’s statement “BIM is about 10% technology and 90% sociology”. Deutsch went on to assert “ninety percent of what has been written, analyzed and studied about BIM so far is the technology. While the 10% technology works itself out,” he continued, “we would as an industry do well to turn our attention toward the 90% that we share, the sociology of Integrated Design.”

The two pillars of the Toyota Production System are illustrated in Figure 1. One is about process and the other about people. Technology is implicit. Of course technology is important to Toyota — what is significant here is that it is always in service to people and to the processes that enable them to deliver value to their customers.

![Figure 1: the two pillars of the Toyota Way](source: Toyota 2001)

Our purpose in this paper is to describe action research on a number of related and integrative collaborative processes that we believe enable teams using Building Information Modelling (BIM) and virtual construction to integrate design and delivery of projects. The principal processes are:

- Lean Project Delivery
- Evidence-based Design
- Set-based Design
- Target Value Design

Lean project delivery emerged in the 1990s and the other three areas are more recent. Target Value Design is a method used within Lean Project Delivery. Evidence-based design also belongs to Lean Project Delivery, and, like Set-based Design, is more a strategy than a method. It is our contention that they all enable integrated design and delivery. Other processes are mentioned in the paper and issues relevant to the skills and knowledge management elements are noted in passing.

Just as invention of the aerofoil enabled the development of aerodynamic theory (Alexander 1974) we believe that the practice of lean and integrated project design and delivery is advancing ahead of scholastic research and that crucial experiments are to be found in practice. Sociological, ethnographic and psychological studies of these design and

\(^2\) Public Private Partnership & Private Finance Initiative (a sub-set of PPP)
delivery processes will help develop our understanding of how people interact with technologies that are integral to those processes and how the industry can make a step-change in productivity.

**why is integrated project design and delivery important?**

Figure 3 provides a high level view of the design-bid-build process (top) and an integrated delivery process below. In the top process constructors don’t come aboard until the design is substantially complete – then the ‘explosion’ as constructors struggle to make sense of the design, make it buildable and try to compensate for its limitations. The vertically shaded background represents the extent to which the whole team understands what the client wants and how the project will deliver it.

By contrast, in integrated design & delivery processes constructors join the team at or very soon after the start, they develop their understanding of client need and how it will be satisfied with the designers and are able to develop a cost-effective production process alongside the design. Potential benefits of this approach are summarised in table 1.

![Figure 3: comparison of historic and integrated project delivery timelines](image)

Figure 3: comparison of historic and integrated project delivery timelines (after Eckblad *et al* 2007) & their impact on the development of a shared understanding of the project by the whole team—vertical hatching (Lichtig 2007). Lichtig suggests that *shared* understanding may never reach 100% in the historic approach as users often find the completed facility different from what they wanted or expected. The integrated model is intentionally shorter than the historic one as that tends to be what happens. The two small graphs to the left of each diagram are “MacLeamy Curves” (CURT 2004, 4)
Table 1: Potential benefits of Integrated, Lean Project Design & Delivery

| For clients | • Easier to link design options to business objectives  
|            | • Improved value and a higher quality product  
|            | • Greater potential for lower cost construction & operation  
|            | • Reduced energy cost of use  
|            | • Facility delivered faster with higher quality so able to begin payback sooner  
| For designers | • Less rework, minimises iteration  
|             | • Relationships, conversations & commitments are managed  
|             | • Decisions at last responsible moment  
|             | • Easier to create excellent green buildings  
|             | • Easier to design to target cost  
|             | • reduced design documentation time  
| For constructors | • Better integrated design < less rework, lower costs, faster completion  
|                | • More buildable, logistics considered from outset  
|                | • Relationships, conversations & commitments systematically managed  
|                | • greater construction process reliability and cost certainty  

We explain how these benefits arise in the rest of the paper.

**Lean Project Delivery**

Lean project delivery builds cooperation in the context of a single integrated team involving the owner, architect, constructor and other critical players as *equals* in the pursuit of a shared goal.

Figure 4 shows the Lean Project Delivery System™, LPDS (Ballard 2000)

Figure 4: The Lean Project Delivery System™, LPDS (Ballard 2000)

Figure 4 shows the Lean Project Delivery System model. Designed to support a new and better way to design and build capital facilities, it captures both the linear and the iterative nature of the design and construction process and recognises the importance of certain aspects of design and construction happening in parallel rather than sequentially. A post-occupancy evaluation module links the end of one project to the beginning of subsequent ones. (Each element is briefly explained in Ballard 2000; see also Ballard & Howell 2003a).

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3 Lean Project Delivery System is a trademark of the Lean Construction Institute www.leanconstruction.org
value

Value is the *raison d’etre* for the lean project delivery process and it is in large measure what distinguishes lean project delivery from historic delivery processes. It is the client, or more usually the *client system*\( ^4 \), that defines value. It will be different for each client system and each project. Value can be expressed in a variety of ways - for a university it might include some combination of student and faculty experience, flexibility to allow for changes in research projects and technologies - represented by circle D in Figure 5.

In Figure 5 each circle is in proportion to the relative price, or return, so that if the initial price of design is 1 unit and construction is 10 the price of maintaining the building for 20 years will be between 30 & 50 units, the users operating costs - heating, cooling, salaries, etc - will amount to between 150-300 units. Finally D, the economic and other benefits delivered by those who work in the building will be between 300 & 2000 units. There is a range because the actual numbers depend on the uses to which the building is put — a school or a hospital will have a different return to say a factory or an office — and it is suggested that an office in the City of London or in Manhattan will differ from an office in the suburbs.

Figure 5: Understanding value in design: Output value (D) in relation to first cost (A + design cost) and whole life cost (A+B or A+B+C) - Diagram based on an idea from Don Ward, Constructing Excellence & Anne King, BSRIA, data from Evans *et al* (1998), Hughes *et al* (2004), Ive (2006) and others

The purpose of design is to create a structure or building that enables whatever is in D (in healthcare and in education for example it includes the items listed in Table 2) — yet how often do architects get to know what D is, let alone have the information they need to design to optimize it — the latter is the role of evidence-based design (EBD), the subject of a later section.

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\( ^4 \) client ‘system’ includes the end-users, those who will approve payment, the technical buyers (construction specialists) and their advisors. For many projects, particularly larger ones, government agencies and neighbours often have an input to the definition of value. (Salvatierra-Garrido *et al* 2009)
Table 2: Healthcare and educational outcomes

<table>
<thead>
<tr>
<th>HEALTHCARE OUTCOMES</th>
<th>K-12 SCHOOL OUTCOMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical outcomes</td>
<td>Less truanting</td>
</tr>
<tr>
<td>Hospital-acquired infection rates</td>
<td>Better test scores &amp; exam results</td>
</tr>
<tr>
<td>Safety outcomes</td>
<td>Improved behaviour &amp; social skills</td>
</tr>
<tr>
<td>Medication error rates</td>
<td>Staff retention</td>
</tr>
<tr>
<td>Medication rates</td>
<td>Parental involvement</td>
</tr>
<tr>
<td>Re-hospitalisation rates</td>
<td>Employer recognition</td>
</tr>
<tr>
<td>Length of stays</td>
<td>Community integration</td>
</tr>
<tr>
<td>Patient transfers</td>
<td>Economic regeneration</td>
</tr>
<tr>
<td>Costs per unit of service</td>
<td>Community use</td>
</tr>
<tr>
<td>Patient &amp; Visitor satisfaction</td>
<td></td>
</tr>
<tr>
<td>Staff morale &amp; Staff turnover</td>
<td></td>
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</tbody>
</table>

set-based design

Set-based design (Ward et al 1995, Sobek et al 1999, Kennedy 2004, Morgan & Liker 2006, Ward 2007) enables a range of discipline specialists, including constructors, to develop a set° of possible solutions to product design and production design problems and then to decide at the last responsible moment°. Deciding at the last responsible moment allows the project team time to develop a number of design options in parallel and then choose between them with agreement among stakeholders. All of which reduces the need for later rework.

Figure 6: Set-based design dialogue (after Sobek et al 1999)

Figure 6 illustrates the kind of dialogue that might happen between designers and constructors. In practice there are many more than two parties around the funnel - architects, structural engineers, services engineers, façade engineers as well as specialist constructors and the lead constructor. Each has a point of view that can contribute to the

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5 source: National Health Service Estates (UK)
6 what is critical here is the development in parallel of a number of design options - it is sometimes called concurrent engineering - in contrast to point based design where a number of options may be considered but only one is developed at a time.
7 The last responsible moment is an important if subjective concept best identified through a collaborative planning process and then regularly reconfirmed.
optimisation of the project as a whole. These are some of the stakeholders that need to agree.

Faced with complex decisions, often on a daily basis, choosing an effective decision-making method is important as \textit{methods \& decisions \& actions \& results}. Defined by civil engineer Jim Suhr, \textit{Choosing by Advantages} (1999) is a simple, easy to use system that can help individuals and teams make good decisions consistently and show how the decision was arrived at - it includes an audit trail (for an example see Parrish & Tommelein 2009). The system helps avoid common mistakes in decision making - e.g. double counting - by focusing only on the valued advantages of the alternatives\textsuperscript{8}.

To enhance the transparency of set-based design & Choosing-by-Advantages processes, the \textit{A3 process} (Shook 2008, Sobek & Smalley 2008) is an effective way to ensure the widest level of collaboration in and commitment to decisions and to document the decision process and consequent learning so it can be used to create a library of research and ideas for current and future projects — a contribution to knowledge management.

The A3 process and Choosing-by-Advantages together support the idea that \textit{decisions be made slowly with consensus so that whatever is decided can be implemented fast} (Liker’s principle 13 (2004)).

\textbf{evidence-based design}

Supporting set-based design, evidence-based design (EBD) exists to help designers make a connection between design and the outcomes that owners want from their buildings. Data from an \textit{architect or owner with an axe to grind may not be the most reliable}. EBD research seeks to establish causal relationships between design decisions and desired corporate outcomes. Still in its infancy, EBD is most fully developed in healthcare where evidence from clinicians is available and meta-analyses are possible.

Choosing to use EBD is a commitment to basing design (generating, evaluating, selecting from alternatives) on the best available evidence, and to actively search for and create that evidence. Hence it can be said to be a commitment to \textit{research-based design}.

As Rybkowski reports (2009), the publication of Roger Ulrich’s 1984 \textit{Science} paper “View through a window may influence recovery from surgery” marked the beginning of the EBD field. Ulrich analyzed the recovery records of forty-six surgical patients assigned to one of eight rooms. The recovery rooms were identical in all ways but one. On each floor, windows of half of the rooms faced a brick wall, while half faced a natural scene (Figure 5).

\textsuperscript{8} unlike the \textit{Analytic Hierarchy Process}, a currently supported method in academia, \textit{Choosing by Advantages} does not weight factors or values. Refusing to weight values goes hand-in-glove with engaging stakeholders in the decision-making process. Their values all have equal relevance. The focus on the advantages of alternatives provides an environment in which qualitative valuation can be included, unlike return-on-investment calculations, which require that all valuations be monetizable. \textit{Choosing by Advantages} is used by the Society of American Value Engineers (SAVE)
Figure 7. Floor plan of hospital showing patient rooms facing foliage & those facing brick wall. From Ulrich (1984), reprinted with permission from AAAS.

By systematically controlling for a range of other factors, the forty-six patients were matched into twenty-three pairs. Comparison of recovery rates indicated statistically significant differences; patients whose windows faced foliage had

- shorter postoperative stays,
- received fewer negative evaluative comments in nurses notes, and
- took fewer potent analgesics than their matching counterparts.

Ulrich’s results showed that it was possible to measure health benefits and financial consequences of design decisions.

The challenge now is to extend EBD to other building types.

**gluing it all together**

Figure 4 includes the key elements of a lean project delivery process — some will be seen in historic project delivery environments. What is distinctive about lean project delivery is the way all the elements work together

The three domains in Figure 8 are present in all projects. In Lean Project Delivery there is a concerted effort to get the three domains working together for the good of the project and the client. The elements that populate the three domains on a lean project are likely to be different from those used on historic ones — an operating system like Last Planner, relational rather than transactional commercial terms (see below) and a collaborative organisation with integrated, high performing teams and open and integrated governance.

What is important is to ensure that the elements in these three domains work well together both within and between domains.
In a 2005 paper, Owen Matthews and Greg Howell, a Florida based constructor, listed four problems with the ‘traditional’ contractual approach:

- **Good ideas are held back** - late involvement of specialist constructors deprives the design team of the opportunity to develop innovations with those who will deliver the project.

- **Contracting limits cooperation and innovation** - ... the system of subcontracts that link the trades and form the framework for the relationships on the project ... detail exactly what each subcontractor [is] to provide..., rules for compensation, and sometimes useful, if unrealistic, information about when work [is] to be performed. The 20 to 30 page subcontracts mostly [deal] with remedies and penalties for noncompliance. These contracts [make] it difficult to innovate across trade boundaries even though the work itself [is] frequently inter-dependent. (It is hard to have a wholesome relationship ... when you have a charge of dynamite around your neck and the other holds the detonator.) Of course, horse-trading always takes place..., but for “equal” horses. Trading a small increase in effort by one contractor for a big reduction for another, a horse for a pony, [is] almost impossible.

- **Inability to coordinate** - ... no formal effort to link the planning systems of the various subcontractors, or to form any mutual commitments or expectations amongst them. Project organizations looked like 20 or more rubber balls, representing subcontractors, all tethered to a single point by long elastic bands. When the connection point [is] jigged, the balls jigged in all random directions colliding with each other in unusual and unexpected ways.

- **The pressure for local optimization** - each subcontractor fights to optimize their performance because no one else will take care of him. The subcontract ... and the inability to coordinate drives us to defend our turf at the expense of both the client and other subcontractors. Remember that everyone on the project other than the prime contractor is a subcontractor. These subcontractors frequently, in their life outside of the subcontract, may be generous, caring and professional. However, since right or wrong is defined by the subcontract, more often than not, they take on a very legalistic and litigious stance becoming an army where the rules of engagement are “Every man for himself.”

That is the context for what follows:

**commercial terms**

As noted above, in the words of Darrington et al [2009] “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.”

Traditional contracts are transactional. Construction is effected through relationships that encompass a myriad of transactions which is why lean constructors prefer to work with relational agreements that recognise the reality of what needs to happen for successful project delivery. There are now a number of different relational-type agreements:
Integrated Form of Agreement for Lean Project Delivery (IFoA) (USA)\(^9\)
AIA C191-2009 Standard Form Multi-Party Agreement for IPD (USA)\(^10\)
ConsensusDOCS300 (USA)\(^11\)
PPC2000 & PPC2000 International (UK)\(^12\)
Alliancing Agreements (Australia)\(^13\)

Relational agreements create a collaborative system with shared responsibility for managing risk and shared pain/gain tied to the amount of value generated by the end product.

The Integrated Form of Agreement requires the use of lean methods and Last Planner. None of the others do, though there are some in Australia who are keen to do so. The Terminal 5 Agreement used for the construction of London Heathrow’s Terminal 5 was another example (as yet unpublished) of a relational agreement. From 1999 BAA required the use of Last Planner on all its projects.

Encouraging collective sharing of risks and cost savings, relational agreements enable parties to treat projects as collective enterprises, optimizing the project as a whole and enabling the movement of money across traditional commercial boundaries so that it is possible to trade a horse for a pony — i.e. for one trade partner\(^14\) to spend €50k so that another can save €200k. This fosters an entrepreneurial mindset aimed at creating project value and allowing all to share in the savings.

**insurance**

One potential issue with relational agreements is insurance. If each party to a relational agreement is required to have its own insurance and there is a claim during design or construction, an insurance company could force parties to sue one another in order to trigger insurance coverage, threatening relationships.

At Heathrow Terminal 5 the general contractor (who was also the client, BAA) took out a single project insurance that covered all parties and then worked actively with them to manage risk.

A recent, unpublished Australian Alliance Agreement (there is no standard form yet) states a clear intent to procure professional indemnity, public liability and works insurance for the project as a whole. Other insurances are the responsibility of the several parties.

PPC2000 International places responsibility for insurance of the project and the site on one member of the partnering team on behalf of the whole, but still expects each party to have third party and professional indemnity insurance (s.19).

\(^12\) [http://www.ppc2000.co.uk/buypcc.htm](http://www.ppc2000.co.uk/buypcc.htm) 17apr10
\(^13\) there is no standard form Alliance agreement - work is under way in Australia to create one.
\(^14\) Lean practitioners tend to talk about *constructors* and *trade partners* rather than contractors and subcontractors as, within a relational contract, there are no sub-contractors — everyone is a party to the same relational agreement.
Article 7 of AIA C191-2009 refers to “integrated insurance products .... ... structured to provide adequate coverage at reasonable cost, striving to avoid duplication in coverage or exposure gaps.” (our emphasis).

S.21 of ConcensusDocs300 expects each party to have their own insurance and S.32 of the IFoA (v 9, 2009) requires “Architect and Architect’s consultants [to] purchase and maintain insurance” and in Exhibit 5 states “Contractor and its Subcontractors shall procure and maintain insurance ....” Will Lichtig, author of IFoA, reports that Sutter Health is pursuing insurance that will cover risks for professional errors and omissions and commercial general liability from an integrated provider. The intention is that the policy will be written so that the parties will not be required to sue one another in order to trigger coverage.

We would like to see further inter-disciplinary research in this important area to establish which insurance models and practices will most effectively and economically enable the parties to a project to optimize the project as-a-whole.

operating system

Lean project delivery works when individuals make and keep commitments - it doesn’t work without it. Trust and relationships develop on the basis of reliable promises. The Last Planner® System15 LPS (e.g. Ballard & Howell 2003b; Macomber Howell & Reed 2005)), is a commitment management system and its principal metric is PPC, a measure of planning quality, which is the percentage of promises (to do work on or before a specified day) completed when promised. A study by Liu & Ballard in 2008 showed a significant correlation between PPC and productivity in US engineering construction and in the same year Gonzalez et al demonstrated the same relationship in house building in Chile.

LPS was designed to improve the planning process in project-based production and create a more reliable production schedule. It does this by recognising that it is only worth doing detailed planning for a short period (a week or a day) and the people most suited to do it are those who will do the work - these are the last planners that give the system its name. The planning that last planners do is done within the context of higher-level plans that they have contributed to. These layers of increasingly detailed schedules and involvement create a context in which it is possible for the last planners to make and keep promises.

There are five key collaborative conversations that together make up the Last Planner System (Mossman 2009). Each brings its own benefits. When all are working together they reinforce each other and the overall benefits are greater. The key conversations are:

- **Collaborative pull-scheduling** — creating and agreeing the production sequence (and compressing it if required)
- **MakeReady** — Making activities ready so that they can be done when we want to do them.
- **Collaborative pull-based Production Planning** — agreeing production activities for the next day or week and making promises about when they will be completed
- **Production Management** — monitoring production to help keep all activities on track
- **Measurement, learning and continual improvement** — learning about and improving the project, planning and production processes by studying reasons for late delivery and activities that went better than expected.

15 Last Planner is a registered mark of the Lean Construction Institute www.leanconstruction.org
Last Planner works in construction and design. There are also Last Planner derivatives developed especially for design such as Responsibility-based Project Delivery™ and the Design Delivery System™\textsuperscript{16}. The existence of these and other proprietary processes is evidence of practice leading academia.

With the Last Planner commitment management process as its kernel, the lean operating system uses a range of other systems in support. We have already mentioned the A3 process and Choosing by Advantages. Building Information Modelling BIM is vital as it enables a range of conversations around virtual prototypes (Virtual Design & Construction VDC) and exploration of the possibilities of off-site fabrication as well as eliminating many assembly issues before they get anywhere near site. Virtual First Run Studies (Nguyen 2009) and Virtual Value Stream Mapping\textsuperscript{17} can help to establish safe and effective assembly sequences during design. We discuss Target Value Design below.

**organisation**

In addition to the commercial terms that encourage teamwork and an operating system that requires teamwork, an organisation that supports the formation of effective project-level teams is needed to enable the team members to become advocates of the project no matter who pays their salary.

Creating a unified project culture from individuals who come from and at the end of the project will return to a diverse range of organisational cultures is challenging. How can we create a team of project advocates from individuals who owe allegiance to many different organisations - a superteam\textsuperscript{18}?

Factors assisting the creation of a unified project culture include:

- **Co-location** - bring all the key players together for the duration of a larger project and for continuous periods of 3-5 days at regular intervals on smaller ones

- **Integrated governance** — Manage the whole team jointly — on the San Francisco Cathedral Hill Hospital project, a core team of five — the Sutter Health Program Manager, the Sutter Health affiliate (end-user), lead designer, lead constructor, and concrete constructor — provide project governance; at Heathrow T5 staff were given roles that befitted their skills irrespective of who paid their salary. One reason effective governance (leadership) is so vital is that roles and responsibilities are changing. This new way of working challenges existing boundaries and needs project team members with different skill sets to work in different ways. Significant and continuing investment of time and thought from the project leadership team is essential.

- **Align aspirations** — do things that simultaneously move the project forward in social or technical terms and build mutual understanding, respect and a shared vision and culture. The Study-action Team\textsuperscript{19} approach is one way to do this (Hill et al 2007).

- **Practice supervision** — to develop people (e.g. mentoring and coaching), develop processes and enforce the use of proven processes. Particularly important is how

\textsuperscript{16} Responsibility-based Project Delivery RbPD is a trademark of Lean Project Consulting www.leanproject.com; Design Delivery System DDS is a trademark of The Change Business Ltd www.thechangebusiness.co.uk

\textsuperscript{17} for a discussion of Value Stream Mapping reality see Rother and Shook 1999

\textsuperscript{18} Colin Hastings et al, (1986) Superteams: A Blueprint for Organisational Success Fontana. For a summary see www.thechangebusiness.co.uk

\textsuperscript{19} Study-action Team is a trademark of Lean Project Consulting www.leanproject.com
supervisors behave in response to breakdowns—do they seek the guilty or seek the cause? (For deeper discussion of this topic see Mann 2010, 91-94; Ryan & Oestreich 1998; Dekker 2006; Abdelhamid et al 2009)

In all the recent projects discussed here owners/clients representatives are actively involved in project leadership. Sometimes, as in CHH, the eventual user is involved too. This link to the customer appears to us to be important.

What we see is that leadership (or project governance) is important for making integrated design and delivery work and, more particularly, that consistency of leadership is crucial (e.g. leader standard work Mann 2010, 37ff).

Table 3: conditions to help create a high performing team on the Cathedral Hill Hospital Project as reported by Long et al 2007.

<table>
<thead>
<tr>
<th>CREATING A HIGH PERFORMING TEAM</th>
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<tbody>
<tr>
<td>• Commitment to deliver value</td>
</tr>
<tr>
<td>• Create an environment for learning</td>
</tr>
<tr>
<td>• Challenge paradigms</td>
</tr>
<tr>
<td>• Make decisions effectively</td>
</tr>
<tr>
<td>• Design for change free construction</td>
</tr>
<tr>
<td>• Embrace innovation</td>
</tr>
<tr>
<td>• Environment of trust, honesty and continuous improvement</td>
</tr>
<tr>
<td>• One owner voice</td>
</tr>
<tr>
<td>• Implement Lean Project Delivery and lean leadership</td>
</tr>
<tr>
<td>• Planning process that is based on Network of Commitments</td>
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</tbody>
</table>

Commercial terms, operating system and organisation concern the soft aspects of construction - people and processes - the bits that are hardest to research, hardest to make money out of and hardest to get right. And this is not about fitting the people to the technology - its about designing the technology to work with the people.

The second Egan Report (2002) set a target for 20% of UK construction projects by value to be undertaken by integrated teams and supply chains by 2004, 50% by 2007. We believe that this didn’t happen because the commercial terms, the operating system and the organisation were never aligned with this aim.

Target Value Design

As Darrington et al (2009) note 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. Within the TVD process, design is based on detailed estimates, rather than estimates waiting for a detailed design. This requires new skills - the ability - and willingness - to provide estimates on the basis of incomplete & conceptual designs.

One of the earliest examples of TVD was St Olaf College Fieldhouse where a close approximation to ‘redoing the same project with a different method’ occurred when a different contractor built another fieldhouse with similar specification for a private college in the same city. As Ballard and Reiser (2004) note, the St. Olaf Fieldhouse delivery team integrated Lean Construction principles and practices including target costing and Last Planner. Table 4 shows the comparison.

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20 Network of Commitments is an integral part of the Last Planner commitment management system.
Table 4: Comparison of St. Olaf Fieldhouse and Carleton College Recreation Center (after Ballard and Reiser 2004)

<table>
<thead>
<tr>
<th></th>
<th>St. Olaf College Fieldhouse</th>
<th>Carleton College Recreation Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract type</td>
<td>Design-Build</td>
<td>Design-Bid-Build</td>
</tr>
<tr>
<td>Lean construction</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Last Planner</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Completion Date</td>
<td>August 2002</td>
<td>April 2000</td>
</tr>
<tr>
<td>Project Duration</td>
<td>14 months</td>
<td>24 months</td>
</tr>
<tr>
<td>Gross Square Feet</td>
<td>114,000</td>
<td>85,414</td>
</tr>
<tr>
<td>Total Cost (incl. A/E &amp; CM fees)</td>
<td>$11.7m</td>
<td>$13.5m</td>
</tr>
<tr>
<td>Cost per square foot</td>
<td>$102.79</td>
<td>$158.44</td>
</tr>
</tbody>
</table>

The Target Value Design process has developed considerably since then.

Figure 9 shows the key stages of the TVD process. It is the primary methodology used to manage the definition and design phases of the Lean Project Delivery System.
After initial project pre-planning by the owner, the TVD process starts with a project definition phase so now we will review the four phases of the Lean Project Delivery Process (Figure 4) in the context of Target Value Design and using the elements we have already introduced.

**project definition**

The project definition phase seeks to establish a shared understanding of the business case for the proposed building or structure, an allowable cost and time, and to ensure that the project is doable within that cost and time. This process involves the client system in building a picture of the activities they envisage in the new facility — it may even involve the improvement of existing processes so that the new building is able to accommodate them from day 1.

**Figure 10: the Project Definition Process** (after Ballard, unpublished)

Figure 10 is a flowchart of the project definition process. Notice that it starts with purpose—something that some clients seem unwilling to share with their project teams. Without understanding purpose, project team members will find it difficult to visualise the benefits, outcomes and interests (‘D’ in Figure 5) that the new facility will enable.

The client system will let the project team know when project definition is complete — it will be when they feel that the team has the necessary understanding of what is required. Once the project team are clear about the client system’s interests and the need for the
facility and how much the client is willing to pay for it - the allowable cost. Baseline expectations are explored for ends (what’s to be delivered) and constraints (typically time and cost), and the team attempts to validate whether the ends can be provided within the constraints so that they can commit to the design and delivery.

The target value for a project is a statement of the interests that the client system wants a new facility to address. It is rare that client systems are able to articulate their interests from the outset - they often need help to do that in conversations with the project team. As conversations progress interests may change. That is a reason to keep design options open to the last responsible moment.

If the client decides to fund a plan validation study, key members of the team that will deliver the project if funded (architects, engineers, general contractor, specialty contractors, suppliers) are engaged through professional services contracts to work with the client to improve and validate the business plan. The client says “I want X within constraints Y.” The validation study, conducted by the team (including the owner, designers and constructors) that will build the project if approved, determines whether or not that is possible or advisable. What’s wanted may change through consideration of new alternatives or through better understanding the consequences of what’s desired. It is essential to align ends and constraints so design can create means to match. This is high level value engineering\(^2\) (VE) done at the earliest stage in the project when it can have the greatest effect. VE continues throughout the project.

In the course of the project, whenever ends, means or constraints get out of alignment, they must be realigned or the project cannot be managed. That does not mean resisting change, but is rather a way of understanding how to manage change.

**lean design**

Macomber *et al* (2008) suggested nine practices that together help create the conditions for a design process to deliver the target value within the client’s target price:

- Engage deeply with the client to establish the target value.
- Lead the design effort for learning and innovation.
- Design to a detailed estimate.
- Collaboratively plan and replan the project\(^2\).
- Concurrently design the product and the process in design sets (see above).
- Design and detail in the sequence of the customer who will use it.
- Work in small and diverse groups to support learning and innovation.
- Co-locate design team members in a big room.
- Review and reflect throughout the process.

If the project business plan is validated and the owner goes forward with the project, the team works to create what’s wanted at an expected cost less than or equal to the allowable cost. Some teams set themselves stretch goals to promote innovation, for example, setting target cost lower than allowable cost in order to fund scope & value additions.

On the Sutter Fairfield Medical Office Building the user’s representative had no prior experience with TVD so, according to Rybkowski (2009), it was not surprising that he

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\(^1\) In the UK value engineering is known as value management

\(^2\) use of Design Structure Matrices can help avoid delay, rework and out-of-sequence design, Pull-scheduling will then help with the detail — see Last Planner in operating system above.
challenged the process only three months in after receiving professional service invoices earlier than anticipated and the project estimated cost was higher than the allowable. In a tense meeting, Mike Tesmer, Director of Preconstruction Services, Boldt Company, explained that low early estimates on most design-bid-build projects tend to increase later as details are added to the design. By contrast, he argued, initially high estimates on the Fairfield project would probably drop as progressive *value engineering* trade-offs by the full professional team early in design allowed them to agreed design details and minimize contingency. To illustrate his point, Tesmer sketched a diagram (Figure 11) explaining how the two delivery systems differ.

![Figure 11: The Tesmer Diagram (after Rybkowski 2009, 140)](image)

Figure 11: The Tesmer Diagram (after Rybkowski 2009, 140)

Figure 12 shows the reality of what happened subsequently.

![Figure 12: project estimates over time for the Sutter Fairfield MOB Project](image)

*Figure 12: project estimates over time for the Sutter Fairfield MOB Project*

[Project completed in 25 months, despite 3 month construction start delay. Target cost ($18.9m) was set 14% below market ($22.0m). Actual cost ($17.9m) for original scope was 5% below target and 19% below market. Additional scope ($0.45m) represented by vertical hatching.]

Design proceeds within the integrated team. There is a weekly schedule of formal meetings - TVD, weekly work planning, etc - and between these, ever-changing groups meet formally and informally to explore design problems of mutual interest and develop design solutions.
Some have suggested that the reduction in cost achieved so far on CHH is attributable to the recession. Figure 14 shows the US Army Corps of Engineers building cost index for the relevant period. In the time that the CHH team have reduced their estimate of out-turn cost to around 15% below market, the Corps of Engineers index has risen by 3%.

Constructors are integral to this free flowing but purposeful process. It is they who are best able to assess the prices for constructing the design and to negotiate alternative designs that might be built more cheaply while maintaining the designer’s concept.

Figure 13 shows how, by using TVD with SBD & EBD, the estimated cost of the original scope changed over time - it is reviewed every two weeks - and how, when the estimate dropped below the target cost of construction, the project team began applying TVD, SBD to the list of items that were not part of the original scope but were on the client’s wish list — and the expected cost of these items fell too. This is in complete contrast to what happens in Design-bid-build situations when bids come in above the allowable cost. What then tends to happen is that scope is cut and the client is later disappointed with the compromised facility as the expectations created in design are not met. TVD creates the possibility for client delight e.g.:
Completed in 2006, the $13.1m Shawano Clinic is an outpatient facility with exceptional diagnostic capabilities, in part because of target costing. The project team delivered the project almost 15% below budget, itself 4% below market, and 3.5 months ahead of schedule, generating 70 additional days of clinic revenue equivalent to nearly $1m additional revenue for the owner and added service capability in imaging beyond the initial scope.

It is tempting to think that only constructors are at-risk when it comes to pricing - but that’s not true. Constructors may be best placed to make and commit to prices - but everyone, even the designers, have an interest in helping them do it well as all share in the pain if constructors price too low and, if they price is too high, the client suffers - money left over that they could have used to expand the scope.

Another benefit from early constructor involvement is that the production system — how the work and its parts will be fabricated and installed — can be designed alongside the facility design and there is plenty of time to plan for off-site fabrication of elements and in the process reduce the number of personnel required on site (a safety bonus\textsuperscript{23}) while potentially building faster with higher quality.

**lean supply**

Because the production system is designed alongside the facility design, lean supply planning can begin then too. All the key players are already on board and involved in the design so they can plan logistics, prefabrication and the like.

The overall focus on making reliable promises is invaluable here. Real relationships develop around the project and it is difficult to renge on a promise in the context of a real emotional relationship. Unreliability is one of the few grounds for removing someone from a project using lean project delivery. For more on this element of LPDS see O’Brien et al (2008)

**lean assembly**

At the Lean Construction Institute (LCI) Congress in 2008 there was much talk of “going slow to go fast”. This was a reference to the amount of planning that the practitioner presenters were talking about. Time spent planning enables the design process to ‘go faster’ and ultimately the build to go faster too. It is no accident that the overall integrated process in Figure 3 is shorter than the historic version - that is the general experience.

A high level of planning continues on site - all the Last Planner conversations listed above are just as important on-site as in the design office or big-room.

Because all involved are joined into the same contract, with shared risk and reward, the team is able to continue to drive the cost down as that will increase everyone’s margin far more than local optimisation is likely to increase the margin of any one player. .

Taken together all these elements help teams deliver ahead of schedule and below budgets that are already set below market. In traditional design and construction processes loaded with a cushion of surplus time, money and/or materials owned by the

\textsuperscript{23} It is also an opportunity to use Safety by Design and Prevention by Design http://www.designforconstructionsafety.org 3may10
supply chain not the customer so customer has no chance to influence the use and
distribution of that contingency

Table 5 shows the range of projects that have been or are being delivered using TVD. The
list is dominated by hospitals for historical reasons rather than because the strategy is
particularly suited to the design of medical facilities.

Table 5: examples of clients using TVD

<table>
<thead>
<tr>
<th>OWNER/CLIENT</th>
<th>PROJECT(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Childrens Hospital, Seattle, WA</td>
<td>Childrens’ Hospital</td>
</tr>
<tr>
<td>Chinese Hospital, San Francisco</td>
<td>New Hospital</td>
</tr>
<tr>
<td>Sacred Sisters of Mercy, St Louis, MO</td>
<td>SSM Cardinal Glennon; SSM St. Clare</td>
</tr>
<tr>
<td>St Olaf’s College, WI</td>
<td>Fieldhouse</td>
</tr>
<tr>
<td>Sutter Health for itself and on behalf of affiliates in Northern California</td>
<td>San Carlos Hospital; Fairfield MOB; ARC Roseville; — Use TVD on all current projects Cathedral Hill Hospital; Cathedral Hill MOB; St Luke’s Hospital; Castro Valley Medical Centre;</td>
</tr>
<tr>
<td>ThedaCare, WI</td>
<td>Various</td>
</tr>
<tr>
<td>Universal Health Services</td>
<td>use some form of TVD on almost all projects; currently beginning a $140m full TVD project for completion early 2013</td>
</tr>
<tr>
<td>University of California San Francisco</td>
<td>Medical Center; Cardiovascular Research Center</td>
</tr>
</tbody>
</table>

Integrated Project Delivery

Lean Project Delivery (LPD) is Integrated Project Delivery IPD\textsuperscript{24}. IPD as interpreted by the American Institute of Architects (AIA) is not LPD. Organizational integration was included as an essential feature from the first LCI white paper on LPDS (Ballard 2000). Contracts and commercial terms were not specified. According to Cohen (2010), AIA’s most recent definition describes IPD as ‘a project delivery method distinguished by a contractual agreement between a minimum of the owner, design professional, and builder where risk and reward are shared and stakeholder success is dependent on project success.’

Cohen’s report Integrated Project Delivery: Case Studies describes six cases, three of which actively aligned lean project delivery, commercial terms, operating system and organisation. Table 6 summarises Cohen’s criteria for project inclusion.

Table 6: Cohen’s criteria for project inclusion in his 2010 report

<table>
<thead>
<tr>
<th>ESSENTIAL CRITERIA</th>
<th>DESIRABLE BUT NOT ESSENTIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>• early involvement of key participants</td>
<td>• mutual trust and respect among participants</td>
</tr>
<tr>
<td>• shared risk and reward</td>
<td>• collaborative innovation</td>
</tr>
<tr>
<td>• multi-party contract</td>
<td>• intensified early planning</td>
</tr>
<tr>
<td>• collaborative decision making and control</td>
<td>• open communication within the project team</td>
</tr>
<tr>
<td>• liability waivers among key participants</td>
<td>• building information modeling (BIM)</td>
</tr>
<tr>
<td>• jointly developed &amp; validated project goals</td>
<td>• lean principles of design, construction &amp; operations</td>
</tr>
<tr>
<td>• co-location of teams</td>
<td>• transparent financials</td>
</tr>
</tbody>
</table>

Table 7 is a further summary of the differences between Lean IPD & historic DBB delivery.

\textsuperscript{24} IPD a trademark of Westbrook Air Conditioning & Plumbing, Box 5459, Orlando, Fl 32855-5459. they have granted LCI the right to use it in trade.
Table 7: comparison of IPD and historic project delivery approaches - features — after AIA 2007 & Vanguard 1999; from www.thechangebusiness.co.uk & www.leanconstruction.org.uk

<table>
<thead>
<tr>
<th>INTEGRATED/LEAN PROJECT DELIVERY</th>
<th>HISTORIC PROJECT DELIVERY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning, continual improvement, engaging with reality</td>
<td>CULTURE</td>
</tr>
<tr>
<td>Systems thinking; Optimise the whole; encourage, foster &amp; support multi-lateral open sharing &amp; collaboration</td>
<td>THINKING</td>
</tr>
<tr>
<td>Outside-in: act on the system to improve it for customers (helped by those working in it).</td>
<td>MANAGEMENT ETHOS</td>
</tr>
<tr>
<td>Integrated with work; based on data</td>
<td>DECISIONS</td>
</tr>
<tr>
<td>Related to purpose, capability &amp; variation</td>
<td>MEASURES</td>
</tr>
<tr>
<td>Based on demand, value &amp; flow; open, collaborative &amp; integrated team of key players formed at the outset &amp; added to as the stakeholder group grows</td>
<td>ORGANISATION DESIGN</td>
</tr>
<tr>
<td>Concurrent &amp; multi-level; high trust &amp; respect</td>
<td>PROCESS</td>
</tr>
<tr>
<td>Shared openly &amp; early</td>
<td>KNOWLEDGE &amp; EXPERTISE</td>
</tr>
<tr>
<td>Collectively managed, appropriately shared</td>
<td>RISK</td>
</tr>
<tr>
<td>Team success tied to project success; value-based</td>
<td>COMPENSATION &amp; REWARD</td>
</tr>
<tr>
<td>Digitally based, virtual; Building Information Modelling (3, 4 &amp; 5D); Short-term planning e.g. Last Planner</td>
<td>COMMUNICATION TECHNOLOGY</td>
</tr>
<tr>
<td>What matters to them? - Understanding their human &amp; technical concerns.</td>
<td>ATTITUDE TO CUSTOMERS</td>
</tr>
</tbody>
</table>

Issues for further research

In research we would like to see:

- studies drawing on the TVD experience in Finland and UK as well as the US
- studies to extend the idea of TVD to embrace whole-of-life value – this might involve a variable allowable cost so that project teams can negotiate tradeoffs between first cost and the costs and benefits of the use of the facility.
- more Action Research approaches\(^ {25} \) that will help us to understand ‘what cannot be seen’ (Pavez & Alarcon 2008) and enable us to be much more aware of the needs of the people in our industry.

\(^ {25} \) http://en.wikipedia.org/wiki/Action_research describes a range of sources
An understanding of who benefits from waste in the end-to-end design &
construction process.
Exploration of the way that technological advances can be adapted to people so as
to help all involved in creating our built environment to deliver safer, greener,
better, faster and cheaper design and construction.
Studies to broaden the scope for Evidence-based Design EBD
Socio-technical studies of the application of Set-based design
Social and ethnographic studies of BIM & VDC and the leadership required to make it work
Inter-disciplinary studies of insurance models that support IPD
Studies of the impact on site-based production of designing product and
production system together
Studies to explore the applicability of these ideas outside the US.

In the blog quoted earlier, Deutsch (2010) suggested “BIM and Integrated Design offer an
opportunity for the profession and industry to transform itself in ways unseen in over a
century.” As Deutch recognises, this will affect the way those entering the profession are
taught. Is it, he asks, still reasonable to assume “that students pick [BIM] up as though it
were any 3D software”, and that they can, as if by osmosis, understand “how to work
effectively with others in a BIM environment?”

In Academic environments we would like to see disciplines learning together for at least
some of the time so that they understand and appreciate each other’s skills, knowledge
and jargon.

We have technology, we have processes, commercial terms, operating system and
organisation (all of which can be improved)— what we now need is more research to
establish whether or not this is already a better way to build in a range of settings and for
a wider range of project types — and, if it is better, how it can be improved.

In his 1962 report Sir Harold Emmerson reminded his readers that a 1950 UK Building
Working Party - The Allen Report – recommended that those entering the building industry
should take a common course of study for an initial period. Perhaps the time has now
come for integrated education for built environment professionals.

Conclusions
We have described learning in practice around a number of collaborative processes that
enable integrated design and delivery of projects in the built environment in the US.
We believe that these are robust processes that could be used in other contexts and with
certain other building types.
These inter-related and collaborative processes are integral to Lean Project Delivery. A
number of these processes have been developed by or with practitioners and it is
practitioners who are developing the skills and the leadership to get them working
together.
Strong leadership that involves members of the client system appears to be critical for
making this work.

Two outcomes of TVD look to be repeatable (at least within healthcare and education):
1. Projects are completed below market cost—so far as much as 19% below.
2. Estimated out-turn cost falls as design develops.
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References

Note: All papers from International Group for Lean Construction (IGLC) conferences since 1996 are available at http://www.iglc.net

http://www.aia.org/contractdocs/AIASS77630 9apr10


Ballard, Glenn & Greg Howell (2003b) An update on Last Planner Proceedings IGLC11, Blacksburg, VA


http://www.aia.org/about/initiatives/AIAB082049 9apr10


www.economist.com/world/britain/displaystory.cfm?story_id=15731336 5Apr10

Emmerson, Sir Harold (1962) Survey of problems before the construction industry: The Emmerson Report HMSO for the Ministry of Works


González, Vicente, Luis Fernando Alarcón & Fernando Mundaca (2008) 'Investigating the relationship between planning reliability and project performance', Production Planning & Control 19(5) 461-74


Hill, Kristin, Christine Slivon & John Draper (2007) Another approach to transforming project delivery: Creating a shared mind Proceedings IGLC-15, Michigan, USA


Ive, Graham (2006) Re-examining the costs and value ratios of owning and occupying buildings Building Research & Information 34(3), 230-245


Lichtig, Will (2007) Creating a Relational Contract to Support Lean Project Delivery presentation to the Lean Construction Institute Relational Contracting Meeting Chicago, IL June 14-15


Mann, David (2010) Creating a Lean Culture: tools to sustain lean conversations. 2edn. CRC Press

Matthews, Owen & Greg Howell (2005) Integrated project delivery An example of relational contracting. Lean Construction Journal Vol 2 #1 April 2005 www.leanconstructionjournal.org 1may10


Mossman, Alan (2009) Last Planner: collaborative conversations for reliable design and construction delivery


Parrish, Kristen and Iris Tommelein (2009) Making design decisions using Choosing by Advantages. Proceedings IGLC17 Taipei, Taiwan


Rother, Mike & John Shook (2009) Learning to See: Value stream mapping to add value and eliminate muda. Lean Enterprise Institute, Brookline MA


