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TARGET VALUE DESIGN

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1. Introduction

Newnes, et al. [2008] explores the problem of predicting whole life cost for low volume, complex products. Construction is mentioned, but only electrical systems and components are addressed. This paper explores the problem in construction, with a study of target value design (TVD), the name given to an adaptation of target costing from manufacturing's product development [Cooper and Slagmulder 1997] to construction projects [Macomber et al. 2007]. Although cost estimation is a part of TVD, the objective is rather to cause than to predict.

Construction projects are a type of product development, differentiated primarily by the products that are developed, which are rooted in place and hence unique at least as regards location [Ballard 2005a]. This location uniqueness is often supplemented by customer uniqueness. This building, bridge, or factory is typically designed and constructed for a specific customer. It is very rare that products are produced ahead of customer demand or that multiple copies of product designs are produced. Further, apart from housing, product architecture tends to be integrated as opposed to modular, increasing the coordination challenge in design. Historically, construction projects have also had the following characteristics:

- Projects have been structured as sequential processing systems, with each specialist brought onto the team only when their specific task is to be performed.
- Design has been produced with a focus on meeting customer functional requirements, then costed, resulting in rework to reduce cost within budget.

Sequential processing and design-driven cost were also characteristic of manufacturing's product development until the 1980s. Innovations in product development such as target costing, concurrent engineering, and supply chain management came later to construction. For example, the first successful application of target costing in construction was reported in Ballard & Reiser [2004] about a project completed in 2002. In a comparative study of product development and construction projects, Zika-Viktorsson, et al. [2003] found that "…social processes requiring conceptual co-operation and communication were less pronounced in the construction projects investigated." This difference is tentatively attributed to the difference in the nature of the work in the two project types, but the authors recognize the possibility that the difference is rather a function of the way the projects are organized and managed.

This paper reports on the phenomenon of target value design (TVD) in projects dedicated to the design and construction of healthcare facilities. Its findings support the view that construction projects, despite their differences in products and relationship to the customer, can benefit from the same innovations in organization and management that have emerged in manufacturing's product development. However, the peculiarities of construction projects could well be relevant to trends in manufacturing, as the drive for customization increases. We return to this latter consideration in the conclusions and recommendations for future research.

The paper consists of a description of target value design and its component phases, project definition and designing to targets, a review of key projects in the development of TVD and the performance of TVD projects, an account of commercial terms, current research to further develop the methodology, and finally a conclusion and recommendations for future research.

1.1 Target value design

Target value design is the name given to the adaptation of target costing to construction projects by Macomber, et al. [2007]. Process benchmarks for TVD were published by UC Berkeley's Project Production Systems Laboratory in 2005, with a revision in 2009 [Ballard 2005b], [Ballard 2009]. TVD is used to structure and manage the project definition and design phases of construction projects with the goal of delivering value to customers within their conditions of satisfaction, which typically include cost and time, but may include other conditions as well.

TVD begins in the project definition phase, starting with the development of a project business case and culminating in a funding decision. Subsequent to funding, the focus of TVD shifts to the process of designing to targets; i.e., what the client wants in order to accomplish their purposes, and the conditions that must be met in order for that value to be realized. After design is complete, TVD continues steering toward targets in preparation for and during construction, with emphasis on process design and execution.

1.1.1 Project definition

At the heart of TVD is the practice of setting project budgets based on the worth to the client of the asset to be constructed. Ability to finance may be a limiting factor, requiring a reduction of the budget below what the client is willing to spend, resulting in the client's allowable cost for the project—what they are both willing and able to spend to get the asset.

As shown in Figure 1, the next step is to benchmark the project market cost, expressed as an interval estimate. If the allowable cost (AC) is greater than or equal to the upper end of the interval estimate, the project budget is set equal to AC. If AC is below the upper end of the interval estimate, the project budget is set at that upper end.

When there is a gap between what the client's allowable cost and the market cost, a decision must be made if to proceed with the project. That happens in two steps. The first is a subjective assessment by the client as to whether or not the gap can be overcome without modifying the project scope, what is to be designed and constructed, or if an alternative scope meets their business requirements. If the decision is made to continue, the next step is to engage the key members of the project team to validate the client's business case; i.e., to decide if the gap can be overcome, or perhaps to identify or develop better means for accomplishing client purposes than in the current project business case.

For building projects, the team typically consists of the architect, key design engineers, the construction manager, and key specialty contractors. In the case of a hospital, the structural engineer, mechanical engineer, and electrical engineer would usually be on the team; along with the steel fabricator and erector (or the corresponding concrete specialists), the mechanical contractor, and the electrical contractor. Others may be appropriate, depending on the specifics of each project.

Team members are engaged on professional service contracts, paid from an expense account. If the project is eventually funded, these expenses can be capitalized. The pre-agreement among the client and the project team members is that the budget will be the boundary between painsharing and gainsharing (see Figure 2). A fixed fee will be negotiated with each company on the project team, with some or all that fee at risk. If the actual cost of the project, adjusted for any approved change orders, exceeds the budget, the fees of team members will be used to pay that cost overrun up to the pre-agreed percentage, which has thus far been 25%-100%. This provides the client money to pay for roughly a 10% budget overrun, but any costs in excess of that amount must either be recovered from insurance or borne by the client. Obviously, clients will enter into this type of arrangement only with companies and individuals they trust, both as to competence and character.

As opposed to trying to pay the least for each project, the client relies on gainsharing incentives to drive innovations in performance, which has proven effective in reducing costs over time.

A business plan validation study may take as little as three weeks and as long as three months, depending on the size of the project. The study operates from programmatic data, supplemented typically by a massing model with functions allocated to spaces, but no further design. Narratives are produced specifying the basis of design for each building system; e.g., structural, HVAC, plumbing, power, lighting, etc. An estimate of the cost to design and construct is produced and a decision is made if to recommend funding the project with its current scope or to modify the scope in order to stay within the allowable cost.

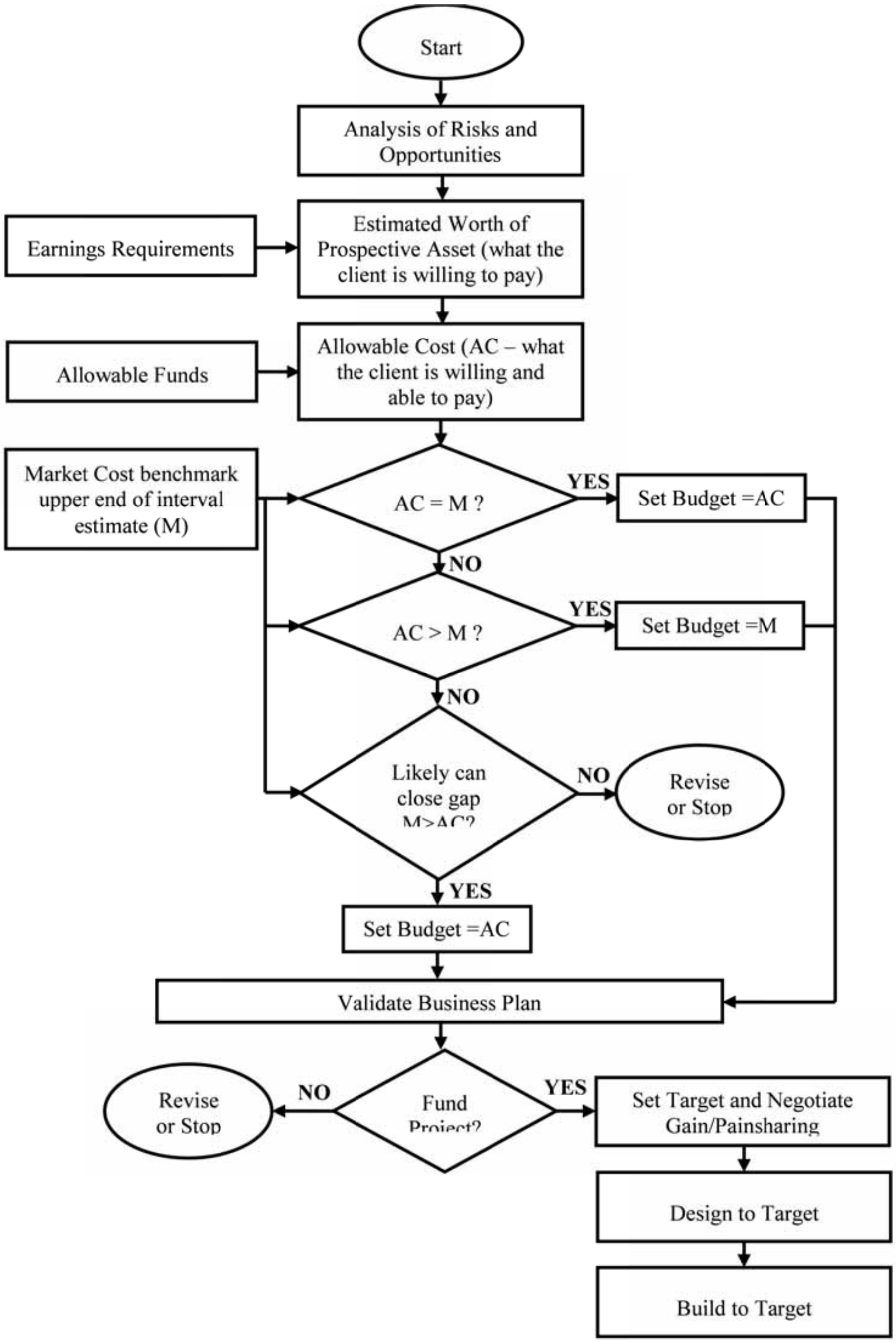


Figure 1. TVD process

If the recommendation of the project team is to fund and if that recommendation is accepted, the next step is for the client to set a target cost lower than the budget and to negotiate an agreement how to share the cost savings with members of the project team. However, if there is still a substantial gap to be overcome between budget and the market benchmark, setting of a more aggressive target is deferred until project financial feasibility is assured.

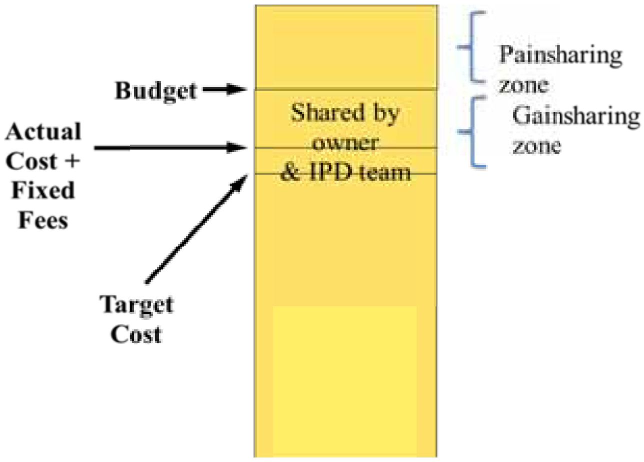


Figure 2. Basic commercial model

That deferral of setting a target cost below budget is what happened on Sutter Health's Cathedral Hill Hospital Project in San Francisco. As shown in Figure 3, the project was funded by the client even though the expected cost produced by the validation study was $60 million above the $911 million allowable cost for construction (the complete project was expected to cost $1.7 billion in total). It took 14 months before the expected cost matched the budget. Once it was sufficiently below budget, a target cost was set $70 million below and a gainsharing agreement made between the client and the members of the project team that were in the risk pool. The $70 million was determined by adding up the estimated cost of additions to the project scope the client would fund from cost savings; e.g., providing patient lifts in all hospital beds rather than the limited number funded in the budget.

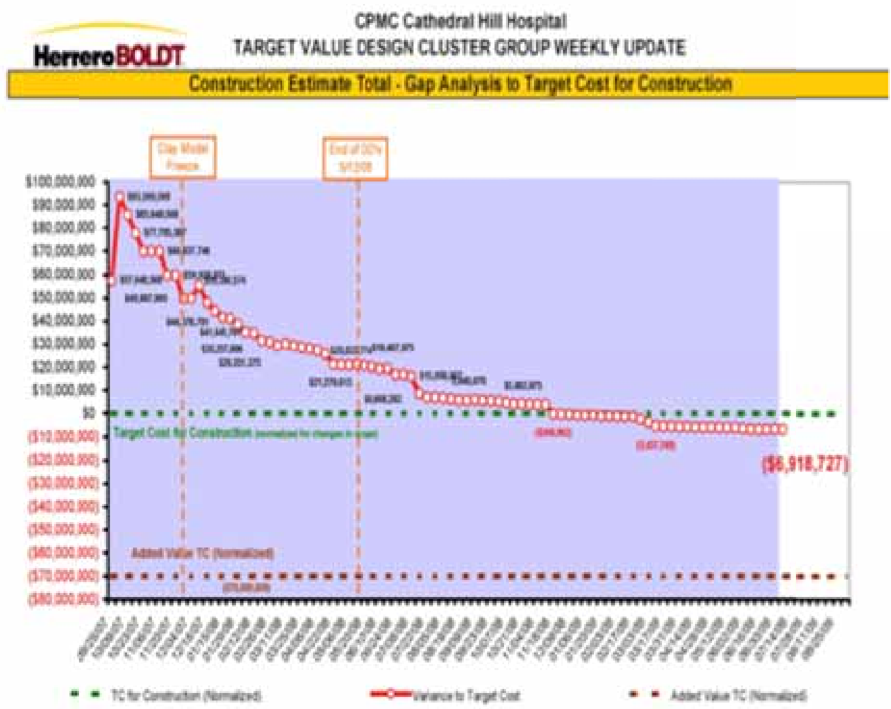


Figure 3. Estimated cost—Cathedral Hill hospital project

1.1.2 Designing to targets

The following recommendations regarding Designing to Targets are from the 2009 P2SL Process Benchmark for TVD:

1. Target scope and cost are allocated to cross-functional TVD teams, typically by facility system; e.g., structural, mechanical, electrical, exterior, interiors,
2. TVD teams update their cost estimates and basis of estimate (scope) frequently. Example from a major hospital project during the period when TVD teams were heavily in design: estimate updates by each cluster at most every three weeks.
3. The project cost estimate is updated frequently to reflect TVD team updates. This could be a plus/minus report with consolidated reports at greater intervals. Often project cost estimates are updated and reviewed in weekly meetings of TVD team coordinators and discipline leads, open to all project team members.
4. Co-location is strongly advised, at least when teams are newly formed. Co-location need not be permanent; team meetings can be held weekly or more frequently.

Substantial changes in roles and behaviors are required from conventional, amounting to a cultural change and requiring strong and dedicated leadership. As an example, consider Sutter Health's 5 Big Ideas:

1. Collaborate, Really Collaborate: It's not enough to 'play nice' and be polite. What's wanted is to work together productively, making the best use of everyone's capabilities.
2. Optimize the Whole: As opposed to the reductionism traditionally seen in work breakdown structures, recognize that not all parts of a project can be optimized simultaneously, consequently, it's necessary for money to be able to move across organizational and contractual boundaries in search of the best project-level investment.
3. Tightly Couple Learning With Action: Lean is a learning system in which learning comes from experiments (intended deviation from process) and from breakdowns (unintended deviation from outcomes).
4. Projects as Networks of Commitments: Most people take their promises seriously. If they did not, human collaboration would be impossible. Yet promises are neither solicited nor made in traditional project management. Plans are mutual commitments among those whose actions are specified in the plan. Commitments are made person-to-person between 'suppliers' and 'customers', creating a web that can be modeled as a logic network.
5. Increase Relatedness: Effective collaboration is conditioned by trust and confidence, which in turn are generated by reliable behavior (not least, doing what you say you will do; keeping your promises) and by seeing others as people like and unlike yourself.

1.2 How TVD differs from traditional construction practices

Basing project budgets on estimates of the worth of the asset to be constructed has not been widely practiced in the construction industry, perhaps in part because of differences in project organization from product development. When a Toyota or a DuPont develop new products, that is largely done by their own employees. When they build a new process plant, that is largely done by contracting for design and construction services from third parties. This transaction context and organizational boundaries have contributed to an adversarial relationship between the parties, and a corresponding reluctance on the part of the buyer to reveal what they are willing to spend, fearing the plant's cost will be inflated.

Engaging key members of the project team to validate the buyer's business case has been equally rare. This may also be rooted in the contracting relationship between the parties, with the buyer not trusting the suppliers to act in the buyer's interest. As noted above, the prospect of painsharing, suffering reduced project profit margin, aligns the commercial interests of buyer and suppliers, and prevents the project team endorsing a project business plan that cannot be delivered.

Designing to targets might be assumed to be standard construction industry practice, but the facts are otherwise. Common practice is rather for design to proceed without cost or schedule feedback for rather long intervals of time, resulting in rework of the design to get back on budget or program, or even reductions in quality or scope of the asset to be constructed.

Cross functional design teams, the elemental organizational unit during the design phase of construction projects, are also uncommon in the industry. Common practice is rather for the various design specialists (architects, structural engineers, mechanical engineers, etc.) to operate at arm's length, meeting only to assess status and agree next steps, and not to co-create design. Even more rarely are constructors brought into the design phase as full-fledged members of the design team, valued for the relevance of the design criteria they embody, as opposed to serving as cost estimators or as reviewers of design documents already produced to assess buildability.

Contractual and organizational features of Target Value Design are directed to aligning commercial interests and integrating the project organization to support these changes in practice. Methods and tools are also critical in this regard, among them nD models (commonly referred to as Building Information Models in the building sector of the construction industry) set based design, A3 reports and Choosing by Advantages.

The use of computer modeling has a long history in the industrial sector of the construction industry, but only within the last ten years has its use spread throughout all sectors. In some regions of the world, even complex projects are being designed in 2D, but those exceptions are rapidly shrinking.

Set based design was identified as a key to Toyota's product development success in papers by Ward et al. [1995] and Sobek et al. [1999]. Toyota was found to produce more prototypes and to keep them alive longer than their competitors, yet to complete projects faster and produce better quality and more product variety. This led Ward et al. to title their 1995 paper "The 2nd Toyota Paradox" and to propose a radical reduction in rework as the solution to the puzzle. Practitioners of Target Value Design have published a number of papers on the application of this set based approach to construction projects; e.g., [Mar 2012] and Parrish et al. [2010].

A3 reports and their role in the decision making process has been well described in the literature, and has been taken up largely intact by those using Target Value Design (see [Sobek and Smalley 2008] and [Shook 2008]). An addition to product development practice is the use in construction of Choosing by Advantages, a method for evaluating and selecting from alternatives with multiple criteria [Suhr 1999]. The method is integrated into A3 consensus decision making, providing support for recommendations.

2. Performance of TVD projects

There has been as yet no comprehensive identification of TVD projects nor collection of performance data, so we are limited when evaluating their performance. Table 1 lists 16 TVD projects, 13 of which have measured their actual or projected cost performance to be 15% under the market benchmark.

In the remainder of this section, three TVD projects are described that were critical in the development of the methodology.

2.1 U.K. Ministry of defense housing projects

The first application of target costing to construction appears to have been the U.K. Defence Ministry's two housing projects reported in Nicolini et al. [2000]. That attempt to apply target costing is said to have failed because the U.K. contractors had so lost touch with making, as opposed to buying, that they no longer understood cost, but only price [Nicolini et al., p. 318].

2.2 Tostrud Fieldhouse project

The first successful application of target costing in construction appears to have been the Tostrud Fieldhouse Project at St. Olaf's College in Northfield, Minnesota; with Boldt Construction as the lead company in a design-build contract structure, and completed in 2002 [Ballard and Reiser 2004]. The funds for the project were donated by the Tostrud family, so there was relatively little focus on target setting. However, the project did provide valuable experimentation in designing to targets. The following recommendations from the 2009 P2SL TVD Process Benchmark were initially validated on the Tostrud Fieldhouse Project:

1. The cost, schedule and quality implications of design alternatives are discussed by team members (and external stakeholders when appropriate) prior to major investments of design time.

2. Cost estimating and budgeting is done continuously through intimate collaboration between members of the project team—‘over the shoulder estimating’.
3. The Last Planner®[1] system is used to coordinate the actions of team members.
4. Targets are set as stretch goals to spur innovation[2].
5. Target scope and cost are allocated to cross-functional TVD teams, typically by facility system; e.g., structural, mechanical, electrical, exterior, interiors, … (Table 2)

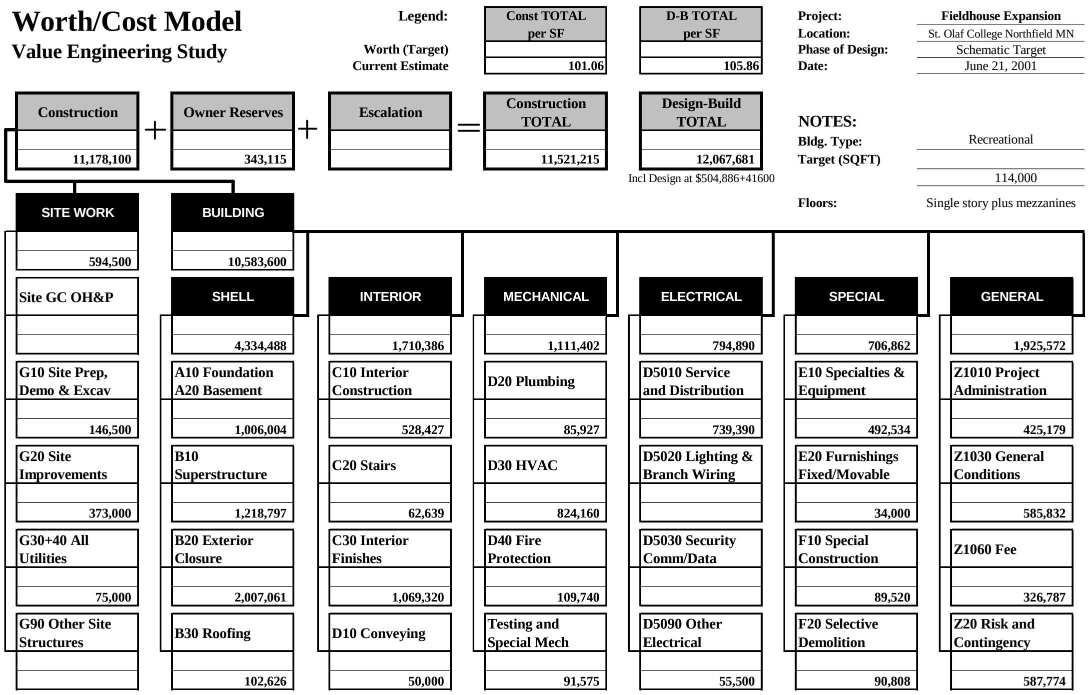
Table 1. Cost performance of 16 TVD projects [Tommelein et al. 2011]

Ref	Project Size	Date Completed	Market Cost (Benchmaked or Expected)	Target Cost Set for Designing	Final Cost (or Current Estimate if below Target)	Market Unit Cost / SF	Target Unit Cost / SF	Final Unit Cost / SF	Improvement in % (Realized or Targetted)
1	114,000 SF	Aug-02	$ 13,533,179	$ 11,645,250	$ 11,716,836	$ 158		$ 103	35%
2	230,000 SF	Nov-07	$ 22,000,000	$ 18,900,000	$ 17,900,000	$ 96		$ 78	19%
3	105,230 SF	Nov-08			$ 40,887,342			$ 389	0%
4	75,362 SF	2006	$ 13,600,000	$ 13,100,000	$ 11,200,000	$ 180		$ 149	18%
5	231,966 SF	In construction	$ 309,000,000	$ 229,514,852	N/A	$ 1,332	$ 989		26%
6	925,000 SF	In construction documents	$1,109,895,176	$ 960,958,000	N/A	$ 1,200	$ 1,039		13%
7	869,000 SF	In construction documents	$1,812,000,000	$ 1,586,000,000	N/A	$ 2,085	$ 1,825		12%
8	233,050 SF	In design development	$ 312,703,815	$ 295,486,733	N/A	$ 1,342	$ 1,268		6%
9	107,000 SF	In design development	$ 281,000,000	$ 250,000,000	N/A	$ 2,626	$ 2,336		11%
10	477,000 SF	In construction documents	$ 210,000,000	$ 189,017,000	$ 187,557,000	$ 440		$ 393	11%
11	368,882 SF	Dec-09	$ 98,000,000	$ 94,000,000	$ 89,200,000	$ 266		$ 242	9%
12	101,992 SF	In construction	$ 163,294,171	$ 108,324,655	N/A	$ 1,264	$ 1,062		16%
13	430,000 SF	Mar-09			$ 153,300,000			$ 357	
14	138,000 SF								
15	220,587 SF		$ 45,500,000			$ 206			
16	30,000 SF	Oct-10	$ 14,500,000		$ 13,700,000	$ 483		$ 457	18%
								average	15%

The target cost for the project, $12,067,681, was allocated to the TVD teams, each of which had representatives from the client, the architect, the construction manager (Boldt), and the relevant design engineers and specialty contractors. As an example of allocation, the Site Work TVD team was given a target cost of $594,500. As a result of discovering unexpected soil conditions, the expected cost for site work exploded to $1,100,000. A combination of project contingency and funds transfer was used to cover the additional cost, with $300,000 coming from contingency and the remainder from target cost underruns by the mechanical and the electrical TVD teams. This highlighted the importance of structuring commercial terms and relationships so that money could move across contractual and organizational boundaries as needed to meet project objectives.

4 Last Planner is a registered trademark of the Lean Construction Institute and names a method of production planning and control designed for projects.

Table 2. Worth/Cost model (from Ballard & Reiser 2004)



Comparative evaluation of projects is difficult because the number of variables potentially impacting performance are so numerous, with multiple interdependencies difficult to understand. This case provides one of the best opportunities for comparative evaluation. Carleton College, another small liberal arts college in the same city, had built a similar facility only two years earlier. As shown in Table 3, comparison revealed that St. Olaf's Fieldhouse took 10 months less to design and build, at 2/3 the cost per square foot compared to Carleton's Recreation Center.

Table 3. Fieldhouse comparison (from Ballard & Reiser 2004)

	St. Olaf Fieldhouse	Carleton College Recreation Ctr
Completion Date	August 2002	April 2000
Project Duration	14 months	24 months
Gross Square Feet	114,000	85,414
Total Cost (incl. A/E & CM fees)	$11,716,836	$13,533,179
Cost per square foot	$102.79	$158.44

2.3 Sutter Fairfield medical office building

Sutter Health committed to deliver its capital program using Lean Project Delivery in late 2003. In 2005, the first application of target costing was made on Sutter Roseville's Acute Rehabilitation Center Project, resulting in on-budget performance in a period of very strong price inflation. This outcome reversed the previous trend at Sutter Roseville Medical Center, where the three previous projects had to return to the Sutter Health Board of Directors between two and four times for additional funds. This outcome encouraged further development of the TVD methodology, which was next used on the Sutter Fairfield Medical Office Building Project.

As shown in Figure 4, benchmarking against similar completed projects, the market cost for the Fairfield facility was estimated to be $22 million. A target cost was set at $18.9 million (in this case, target cost was set equal to the allowable cost). The cost at completion was $17.9 million; approximately 19% under market.

Figure 4. Sutter Fairfield medical office building (The Boldt Company 2008)

This was the first Sutter Health project to use the Integrated Form of Agreement (IFOA), a type of relational contract [MacNeil 1985], developed by William Lichtig, outside counsel, then with McDonough, Holland & Allen in Sacramento, CA. [Lichtig 2006]. The IFOA is a multi-party agreement, signed by all companies that are in the risk pool, sharing gains and losses.

Sutter Fairfield was also the first project where an important anomaly was discovered; namely, the project cost estimate decreased during project execution. According to industry practitioners, the opposite normally occurs; as design becomes more detailed, the cost estimate increases. Sutter Fairfield also provided another data point in support of the second anomaly in TVD projects—they consistently underrun market benchmark costs.

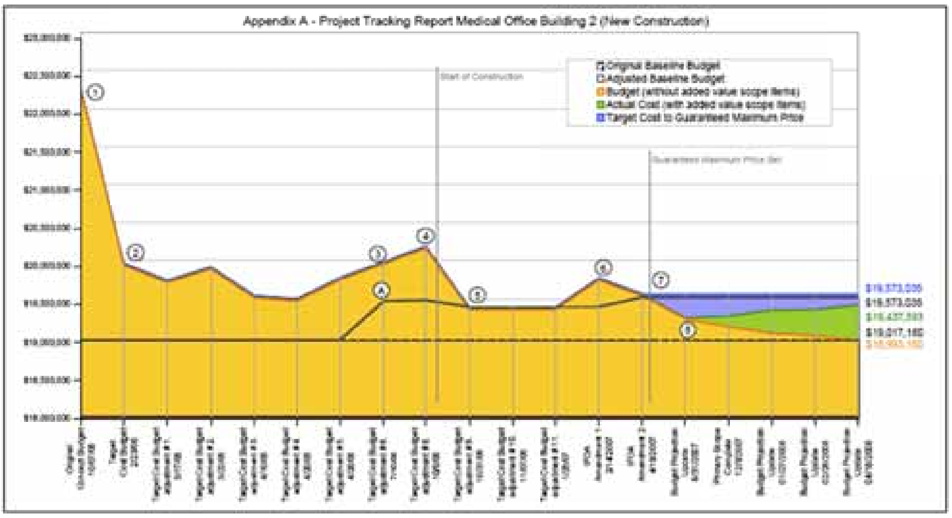


Figure 5. Sutter Fairfield cost estimate history (The Boldt Company 2008)

As shown in Figure 5 (Cost is in gold, Contingency is in blue, and Savings expended on value-adds is in green), the cost estimate trended downward through design and construction, ending $1 million below the project budget. Most of that $1 million was spent adding features to the facility valued by the client.

3. Commercial terms in target value design

Compensation for service providers that are members of the risk pool, whether design or construction professionals, is through reimbursement for the costs of work and project overheads, plus a negotiated fixed fee and the opportunity to increase profits through gainsharing. Over time, more and more team members are being included in the risk pool. If any are excluded whose work is interdependent with that of risk pool members, there is a risk that they will not devote the same level of effort, and thus be constraints on project performance.

As illustrated in Figure 2, targets for performance improvement, whether in cost or value delivered, are not expressed in project budgets, but rather in separate targets, supported by gainsharing/painsharing agreements. Project performance is judged relative to budgets and schedules. Setting budgets and schedules as stretch goals has traditionally been done in pursuit of paying least cost, but increases the risk of project failure. TVD provides an alternative means for continuous performance improvement without unnecessary risk, and creates the means, integrated teams with aligned commercial interests, for reducing the probability of risk events occurring.

The budget (this could also or alternatively be the schedule, a sustainability rating such as LEED points, or other condition of satisfaction) is the boundary between painsharing and gainsharing in a TVD arrangement. Setting that boundary based on the client's allowable cost incurs the least risk. It cannot be reduced without violating the client's business case. If cost at project completion is greater than budget, the design and construction companies in the risk pool sacrifice some or all their fees to pay the overrun. If the project is completed below the budget, members of the risk pool increase their fees by some percentage of the cost underrun.

This limits the cost risk borne by service providers and provides the client a financial buffer equal to the sum total of fees at risk, perhaps 5-10% of total project cost. Admittedly, the client bears the risk of catastrophic loss; cost overruns greater than the fee buffer and any applicable insurance. No TVD projects to date have exceeded their budgets, hence there is no empirical data on the risk clients are assuming. The TVD methodology involves a change in strategy, from risk shifting to collaborative mitigation of the probability of risk events occurring. However, TVD has a short history and there will undoubtedly be failed TVD projects that will test the industry's acceptance of this new approach to project delivery[3].

4. Whole life target value design

Research is now underway to further improve the effectiveness of the TVD methodology by extending it to whole life costs and benefits of the constructed assets [Ballard 2008]. The costs involved in construction projects range from the cost for designing and the cost of constructing (together amounting to the capital or first cost), then the cost to operate and maintain the physical facility (commonly referred to as life cycle costs), and finally the costs and benefits of asset use. Figure 6 illustrates the differences in relative costs, strongly suggesting that design should be oriented to life cycle and whole life costs, and certainly to whole life benefits, which must be sufficiently large to pay for all the costs and allow for profits.

However, potential returns on investment are compelling only if the investment can be made. Hence, getting the most from available funds is essential for delivery of greater value to customers.

This whole life TVD research has as its objective reducing the constraints on value generation. That is to be accomplished by 1) allowing project budgets, allowable costs, to change during design in response to the forecast impact of design alternatives on whole life costs and benefits, and 2) by developing means for financing these investment opportunities. The projects within the research program are:

1. Develop and validate methods for modeling whole life costs (operations cost models) that can be used to determine allowable costs.
2. Develop and validate methods for benchmarking market costs that are more accurate than current methods.
3. Develop and validate methods for linking product models to operations cost models to forecast the impact of design alternatives on whole life costs and benefits.

3 BAA's Terminal 5 Project at Heathrow Airport posed the risk of catastrophic loss at the corporate level. The estimated cost for the project approached the net worth of BAA. Their response was to assume all risk, set the project budget generously (so it actually contained financial contingency), and agree to split cost savings with their framework suppliers. Critics claim they spent more than they should have, but the project was completed within budget and catastrophic loss was avoided.

4. Develop and validate methods for financing these investment opportunities, so project budgets can be adjusted to the allowable costs that result from innovative design alternatives. This will include descriptive research to assess financing options and obstacles in different construction industry sectors and project types.

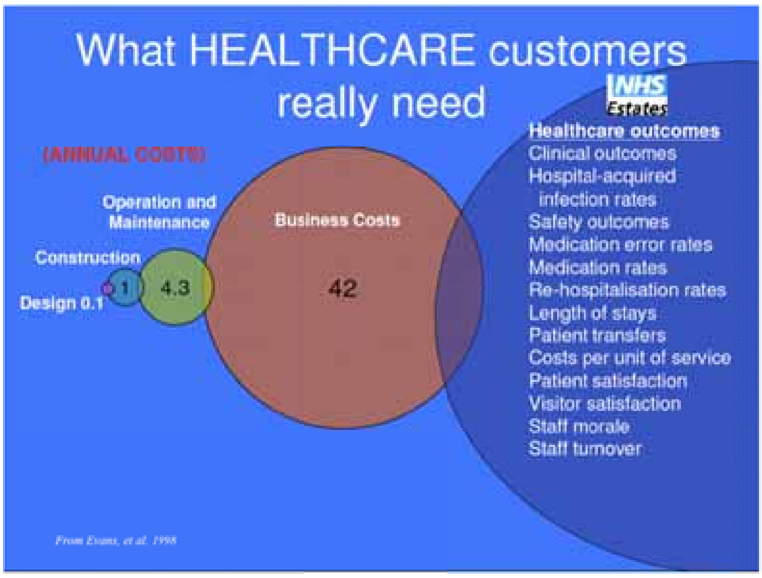


Figure 6. Relative costs (from Evans et al. 1998)

5. Conclusion

Construction projects using the target value design methodology have been presented to show that product development methodologies such as target costing, concurrent engineering and supply chain management can be beneficially applied to the management of construction projects despite their differences. Behavioral differences noted in the literature, such as that reported by Zika-Viktorsson, et al. [2002] may well be the result not of the ineluctable differences between product development in construction and in repetitive manufacturing, but rather the result of differences in the way construction projects have traditionally been structured and managed.

Target value design is a project management methodology that has been widely adopted in U.S. healthcare. Two anomalous and beneficial features of TVD projects are 1) estimated cost falls during the course of project execution, and 2) projects are completed substantially under market costs. Current research is underway to extend its application beyond healthcare and education to other construction industry sectors and to other project delivery approaches than the Integrated Project Delivery[4] [Cohen 2010] that has been most frequently used on TVD projects. Research is also underway under the title, Whole Life Target Value Design, to reduce the obstacles to generating greater value for customers and for service providers. Collaborators in these research initiatives are welcome.

Future research is also needed on the opportunity to learn about ‘mass customization’ from construction’s product development, which is predominately dedicated to the delivery of value to a specific customer(s) in specific circumstances.

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