How the Last Planner System is used in Target Value Delivery

Glenn Ballard

Introduction

Target Value Delivery (TVD) and the Last Planner System (LPS) are two of the primary tools used in Lean Construction. Understanding how they work together is needed to use both properly. The Last Planner System began its life in 1991 as a system for planning and control of production on projects. The 2020 Current Process Benchmark describes the Last Planner System's current form, which is to be the planning and control process for both project and production. Target Value Delivery is a process for setting project value and cost targets prior to design, then steering design and construction to those targets. TVD was adapted from Toyota's product development process in 2002, but its roots are deeper, extending at least as far back as Henry Ford in the 1910s. A book titled "Target Value Delivery of Building Projects" (Ballard and Morris, 2023) scheduled for publication by the end of 2023, will do the same for Target Value Delivery. The book reports on research that began in 2016 by the Project Production Systems Laboratory at the University of California Berkeley. This research found that TVD is better than traditional forms of project delivery and its functions and methods can be learned and used by everyone. This is supported by the TVD book with descriptions how clients, cost management consultants, architectural/engineering companies, and general contractors use TVD.

I will first describe how targets are set in TVD, then outline how steering is done, followed by examining the role LPS plays.

How Value/Cost Targets are set in TVD

Presuppositions

1. A first presupposition (initial assumption) of TVD is that project target value can be set prior to design, based on the objectives for the project. Value targets are needed for achieving those objectives.
2. A second key presupposition is that an allowable cost can be set based on expected benefits from hitting value targets.
3. A third key presupposition is that cost can be set for achieving value targets by regressing from the functional program to a facilities program capable of delivering desired functionalities within constraints, then costing that facilities program to produce a probable estimate of cost (expected cost).

Table 1 and 2 are from the TVD book. They describe the functional program and the facilities program for a project.

Functional Program	Description
• **Functional Outcomes**	Quantitative performance statements: for example, number of procedures to be performed, students to be taught, maximum response time (for buildings such as fire stations), gross operating margin.
• **Qualitative Requirements**	Adjectival quality statements for example: grand, economical, top of the line Success measures: 100% up-time, meets needs 80% of the time, achieves LEED gold
• **External Conditions**	Factors external to the program for example: site conditions, existing building conditions (renovation) overall remoteness, availability of skilled labor.
• **Irreducible Uncertainty**	Uncertainty within the program requirements, for example: quantitative uncertainty, long range outcome changes. Also includes unresolved uncertainty.

Table 1: Functional Program (Ballard and Morris, 2023)

Functions to be performed and qualitative characteristics of the building are drawn from the client answering the question "what's wanted?" External conditions and uncertainties must be identified and managed to deliver desired functionalities and capacities.

Facility Program	Description
• **Spatial Program**	Quantitative measure of number, type, and size of assignable (function) rooms, allowance for non-assignable spaces (corridors, restrooms, elevators, etc.), allowance for structural area.
• **Qualitative Requirements**	Space performance narrative, measurable requirements (acoustics, lighting, etc.) and qualitative statements. Often referred to as a third key presupposition is that cost can be set for achieving value targets by regressing from the functional program to a facilities program capable of delivering desired functionalities within constraints, then costing that facilities program.
• **External Conditions**	Impact of external conditions, such as anticipated foundation design, site grading, material selection.
• **Irreducible Uncertainty**	Uncertainty within the facility requirements, for example, quantitative uncertainty in un-assignable area, space utilization, extent of daylighting access, floor plate efficiency.

Table 2: Facility Program (Ballard and Morris, 2023)

Moving from the functional program to the facilities program is done by regressive thinking; i.e., looking for what provides the desired functions. Regressive thinking proceeds by finding and assessing currently known design solutions, using simulation and/or benchmarking. When none of these solutions are fit for purpose, designers must create new solutions using abduction (creative thinking). The simulation tool developed by Finland's Haahtela Group in their use of TVD is described in the TVD book in this way: "What's wanted (target values) and the cost of providing what's wanted (target cost) are determined prior to design by creating through simulation, a model of the building from the voice of the customer, then costing the materials, components and services needed to construct that building. The simulation model is fully detailed, buildable, and capable of supporting desired functions at desired capacities, but is not what will be constructed, leaving designers free to create designs that deliver target values within the target cost."

How Projects are Steered to Value/Cost Targets

"In TVD current best practice, once targets are set, multiple alternatives for building systems and components are generated using **Set-Based Design**, then evaluated against factors relevant for differentiating them using **Choosing by Advantages**. The total importance of advantages of each are determined (the benefits they offer), then evaluated against their cost. If none of the alternatives is found to deliver their part of target value, design's job is not yet done, regardless of cost. If target values are achieved, but at greater than target cost, designers continue striving for ways to achieve target values at lower cost using **Value Engineering Methods**" (From TVD in Building Projects)

To the three methods in **bold** in the above paragraph must be added a fourth: how design is organized on TVD projects. Table 3 and Table 4 were provided by the Boldt Companies. It shows the Leaders, Members, Coaches and Estimators in Innovation Teams for Site/Civil, Shell & Core, Fit Out, etc. Individuals are color-coded by company. It is apparent that the teams are multi-functional and include trade partners (specialty contractors-color coded black).

	Site & Civil	Shell & Core	Fit Out	[illegible]	Medical Equip & Technology Hardware	Technology Systems	Production / BIM	Communications	Connected Delivery	Permit Team
Leader	David Mortensen	Brian Russell	[illegible]	[illegible]	Andy Lewis	[illegible]	Pete Selmo (Production) Graham Ryan (BIM)	Daniel Perschbacher	Graham Ryan	Angel Ortiz
Co-Lead	Brian Russell	Brian Frey	Marya Graff	Bob Poppi	Terry Hensler (Equip)	Mike Neely	Angel Ortiz	Nick Loughrin	Angel Ortiz	Pete Selmo
Coach	Nick Loughrin	Daniel Perschbacher	Daniel Perschbacher	Daniel Perschbacher	Nick Loughrin	Nick Loughrin	Nick Loughrin	Daniel Perschbacher	Nick Loughrin	
Team Members	Darren Maas	Graham Ryan	[illegible]	Angel Ortiz	Darren Maas	Jake Haugh - Security	Mike Neely	Sam Sievers	David Mortensen	[illegible]
	Bryan Frey	Angel Ortiz	Carley Acosta	[illegible]	Marya Graff	Bob Bell - Tech (IMS)	Matt Wade	Jackie Gauger	Brian Russell	Matt Wade
	[illegible]	[illegible]	Graham Ryan	[illegible]	[illegible]	Justin Reynolds - Tech (IMS)	Carley Acosta		[illegible]	[illegible]
	Bob Szczepaniak	[illegible]	[illegible]	Brittany Hanson	Bob Bell - Tech (IMS)	Bob Popp	[illegible]		Daniel Perschbacher	
	Angel Ortiz	Bob Szczepaniak	Bryan Frey	Tim Kehoe	Kevin Erwin	Marya Graff	Bryan Frey		[illegible]	
	Mike Neely	Mike Neely	[illegible]	Adrienne Carlson	CHW IT Rep	[illegible]	[illegible]		Bob Szczepaniak	
	Jake Haugh	Matt Wade	[illegible]	Todd Olsen	[illegible]	Adrienne Carlson	TP's		Pete Selmo	
	Matt Wade	Carley Acosta	[illegible]	Bob Szczepaniak	[illegible]	Joe Leinen	[illegible]		Nick Loughrin	
	Carley Acosta	Future Trade Partners	[illegible]	[illegible]	Brittany Hanson	Nate Wheeler	[illegible]		Andy Lewis	
	Future Trade Partners		[illegible]	Mike Schickert (Electrical)	Tim Kehoe		Bob Popp		[illegible]	
			[illegible]	[illegible] (HVAC)	Adrienne Carlson		Brittany Hanson			
			Klas Bergheda	[illegible] (HVAC and Plumbing)			Tim Kehoe			
			[illegible]	Mike Neely			Adrienne Carlson			
			[illegible]	Joe Leinen			Todd Olsen			
Target Value Estimator	Chris P.	Chris P.	Chris P.	Bob P.	Andy Lewis	Bob P.	Chris P.	N/A	N/A	N/A
KEY:	CHW	Cannon	Boldt	[illegible]	[illegible]	[illegible]	Trade Partner			

Table 3: Innovation Teams (courtesy of the Boldt Companies)

The Innovation Teams apply LPS—they participate in pull planning sessions to create phase schedules, they do lookahead planning to make scheduled tasks ready to be performed, they commit to 2-week work plans and when a committed task is not completed as planned, they search for countermeasures and test them at the next instance of that task. A template for LPS use by Innovation Teams (color-coded) is shown below.

To better understand the importance of LPS to TVD, here is a true story from a 7000 seat, fully enclosed amphitheater, courtesy of Linbeck Construction. The project averaged 61% PPC (percent plan complete) during its design phase. The Site/Civils team was best at 78% PPC so I asked them to select five of their plan failures and analyze them using 5 Whys. Here's what they found:

1. Site/Civils assumed City requirements for traffic analysis were the same as before.
2. MEP (mechanical, electrical, plumbing) did not understand Site/Civil's requirements for drainage, resulting in a Site/Civils plan failure.
3. Site/Civils assumed soil conditions were known and did not allow time for testing.
4. Same as #1 above.
5. Confusion over who had what responsibility.

All five failures were the result of not understanding something critically important-as opposed to mistakes in calculation or otherwise within the design act. The fundamental causes of non-completion were failure to follow two LPS processes: the reliable promising process and learning from experience.

How well do TVD projects perform using LPS, Innovation Teams, Set-Based Design, Choosing by Advantages and Value Engineering methods?

Table 5 reports the cost savings achieved on a complex multi-year program for designing and delivering various types of out-patient facilities for Advocate Aurora Health in the United States. Here are the measured cost savings: 2016-0.5%, 2017-9.2%, 2018-18.9%, 2019-14.5%. Estimated cost savings for 2020 and 2021 were forecast and later confirmed at 16% and 18%. These savings are for the entire program. More important over time is the cumulative effect of adjusting cost standards annually for each building type in the program. In addition, there were improvements in fitness for purpose and speed of delivery. A more detailed report is included in Ballard and Morris (2023).

What does LPS do to support TVD?

Apart from the functions performed in Project Definition, all remaining LPS functions are performed in Target Value Delivery, both in design and in construction:

- Pull planning is used to detail generation and selection from alternatives for the design of building systems and each sub-phase of design and construction.
- Lookahead planning is used to make scheduled tasks ready to be executed, through constraints removal and collaborative design of work methods (virtual prototyping, physical prototyping, first run studies). •
  Commitments are made through the reliable promising process.
- Broken promises are analyzed to find and test countermeasures.
- Participation in LPS planning and learning helps create the culture of intense collaboration needed to support innovation and continuous improvement.

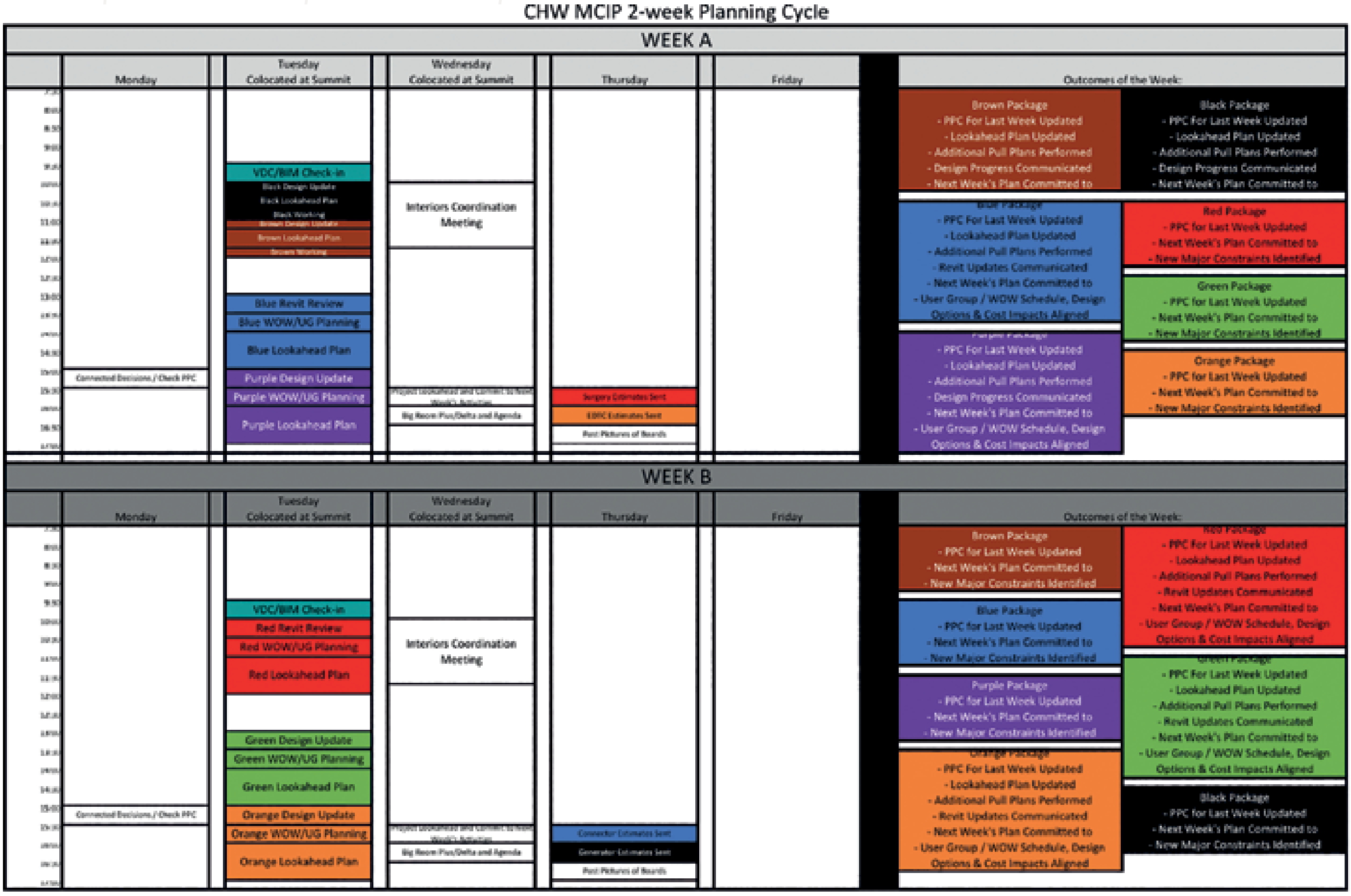

Table 4: Template for Innovation Teams use of LPS (courtesy of the Boldt Companies)

AAOC Program Statistics Normalization Summary — AdvocateAuroraHealth, HDR, IMEG, BOLDT

Baseline Project Comparables			
Project Type	Project Date	Project Cost $/SF	Project Name
A-Ground Up	6/20/2016	$335	Condell (cost)
A-Ground Up	6/20/2016	$344	Condell (model)
B-White Box TI	4/18/2017	$316	North Broadway (cost)
D-White Box TI		TBD	North Broadway (model)
C-MOB TI	4/18/2017	$316	North Broadway (cost)
D-Renovations		TBD	TBD
E-Other		TBD	TBD
F-Small/One-Off		TBD	TBD

Year RESULTS	Year	% Savings
2016 Average	2016	0.5%
2017 Average	2017	9.2%
2018 Average	2018	18.9%
2019 Average	2019	14.5%
2020 Average	2020	16.0%
2021 Average	2021	18.0%

All Projects

Summary of RESULTS: All Projects

Project Name	Project Year/Date	% Savings to Comparable	Project Type	Normalized $/SF	Comparison $/SF	Comparable Project
Condell	Jun-16	2.7%	A-Ground Up	$335	$344	Condell (Model)
Sequoia	Jul-16	-1.6%	A-Ground Up	$335	$330	Condell (Model)
Huntley	Jul-17	4.6%	A-Ground Up	$338	$362	Condell (Model)
Des Plaines	Aug-17	11.9%	A-Ground Up	$310	$352	Condell (Model)
Oak Lawn	Mar-19	13.3%	A-Ground Up	$333	$384	Condell (Model)
Mundelein	Nov-18	9.8%	B-White Box TI	$280	$311	North Broadway (cost)
South Holland	Mar-17	0.0%	B-White Box TI	$312	$312	North Broadway (cost)
Lombard	Jan-18	12.2%	B-White Box TI	$283	$322	North Broadway (cost)
Sykes	Jan-18	23.3%	B-White Box TI	$247	$325	North Broadway (cost)
Imani Village	Dec-18	17.2%	B-White Box TI	$283	$341	North Broadway (cost)
West Dundee	Feb-19	17.1%	B-White Box TI	$278	$335	North Broadway (cost)
Lake View	Jul-18	16.7%	B-White Box TI	$277	$333	North Broadway (cost)
South Downers	Sep-16	1.0%	C-MOB TI	$305	$308	North Broadway (cost)
Crystal Lake	Sep-17	16.9%	C-MOB TI	$265	$319	North Broadway (cost)
Randall Road	Oct-18	3.5%	C-MOB TI	$314	$332	North Broadway (cost)
Irving & Western	Feb-19	20.3%	C-MOB TI	$258	$330	North Broadway (cost)
Delavan Addition	Mar-20		A-Ground Up	$433	$395	Condell (Model)
Des Plaines Addition	Apr-20		A-Ground Up	$415	$393	Condell (Model)
Highpointe	Jul-20		B-White Box TI	$258	$320	North Broadway (cost)

Summary of IN PROGRESS: All Projects

Project Name	Project Year/Date	% Savings to Comparable	Project Type	Normalized $/SF	Comparison $/SF	Comparable Project
Burbank (Budget)	Feb-20	-12.1%	B-White Box TI	$385	$343	North Broadway (cost)
Burbank (Current 12/8/20)	Mar-21	16.0%	B-White Box TI	$303	$360	North Broadway (cost)
Burbank (Target)	Mar-21	20.1%	B-White Box TI	$288	$360	North Broadway (cost)
Good Sam Growth (Budget)	Mar-22	19.3%	B-White Box TI	$297	$368	North Broadway (cost)
Lake Villa (20200317)	May-21		A-Ground Up	$400	$405	Condell (Model)
Lake Villa (Target)	Mar-22	18.2%	A-Ground Up	$349	$418	Condell (Model)
Naperville (Budget)	Oct-20	16.1%	B-White Box TI	$303	$368	North Broadway (cost)
Naperville (Current 10/28/20)	Feb-21	15.1%	B-White Box TI	$303	$357	North Broadway (cost)
Naperville (Target)	Feb-21	20.1%	B-White Box TI	$285	$357	North Broadway (cost)
Park Ridge (Budget)	Apr-22	2.4%	B-White Box TI	$350	$360	North Broadway (cost)
Park Ridge (Allowable)	Mar-22	31.3%	B-White Box TI	$256	$372	North Broadway (cost)
Park Ridge (Target)	Mar-22	21.0%	B-White Box TI	$291	$360	North Broadway (cost)
Dreyer Naperville Reno (Budget)	Apr-22	21.8%	B-White Box TI	$292	$372	North Broadway (cost)
Dreyer Naperville 35.8k (Budget)	Feb-22	21.1%	B-White Box TI	$293	$371	North Broadway (cost)
Dreyer Naperville (Target) 30,420 & 4,300 Shell	Feb-22	21.0%	B-White Box TI	$294	$371	North Broadway (cost)
Six Corners TI (Budget)	Feb-21	12.9%	B-White Box TI	$312	$357	North Broadway (cost)
Six Corners TI (17,890 SF Target)	May-22	22.0%	B-White Box TI	$288	$369	North Broadway (cost)
South Elgin (Budget)	Nov-22	10.1%	C-MOB TI	$356	$322	North Broadway (cost)
Algonquin (Budget)	Mar-22	11.5%	C-MOB TI	$326	$369	North Broadway (cost)
[illegible] (Budget)	May-22	-8.7%	C-MOB TI	$403	$369	North Broadway (cost)
Batavia Addition (Budget)	Jan-22	4.5%	B-White Box TI	$352	$369	North Broadway (cost)

Table 5: Cost Savings over 5 years (courtesy of HDR Architecture & Engineering)

References

Ballard, G. and Morris, P. 2023. Target Value Delivery of Building Projects. Cambridge Scholars Publishing. Publication Pending.

Ballard, G. and Tommelein, I.T. 2021. 2020 Current Process Benchmark for the Last Planner System of Project Planning and Control. Lean Construction Journal.