Lean Construction Institute - Qatar

المعهد القطري للتصميم والتشييد الفعّال

Transforming the Built Environment

تغيير بيئة تصميم وتشييد المشاريع

Reducing Project Time and Cost Overruns Using TVD and the LPS®

Webinar Facilitator

Open to Public

Free Webinar

Earn 2 CEUs

Dr. Glenn Ballard
Co-founder of IGLC, LCI, LIPS, and P2SL
Research Associate, Project Production Systems Laboratory
University of California, Berkeley

Electronic Certificates of Attendance will be issued

Date: July 1, 2020 | Time: 7:00 - 9:00 PM

@Lciqatar @Lean Construction Institute - Qatar

Causes of projects completing over budget/over time

- External events outside the project's control
- Selecting suppliers of goods or services that are incapable or self seeking
- Using contract terms that drive perverse behavior
- Setting unachieveable project targets
- Failing to coordinate actions in pursuit of project targets

Objectives of the webinar

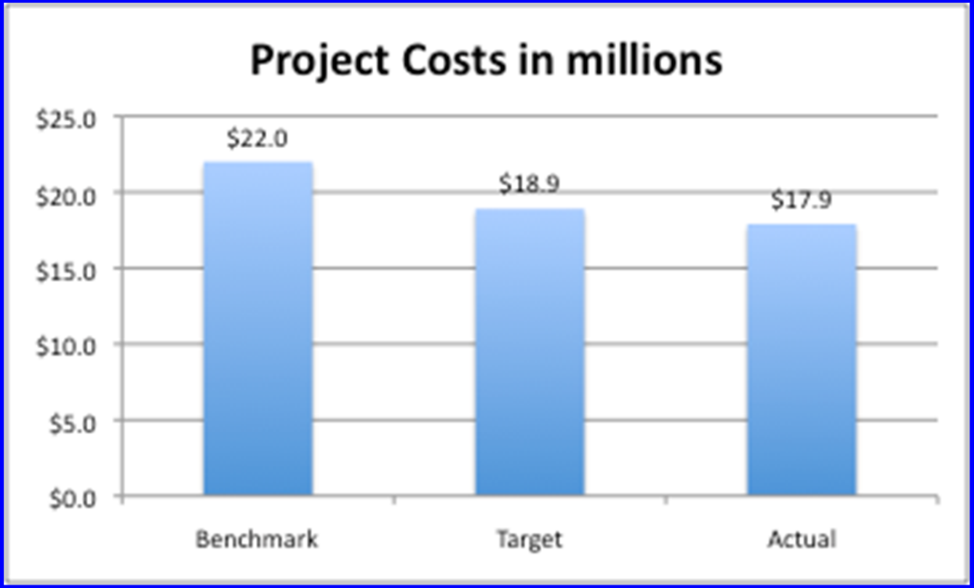
1. Describe how Target Value Delivery works
2. Describe how the Last Planner System works
3. Show how they impact construction project performance

Target Value Delivery

Outline

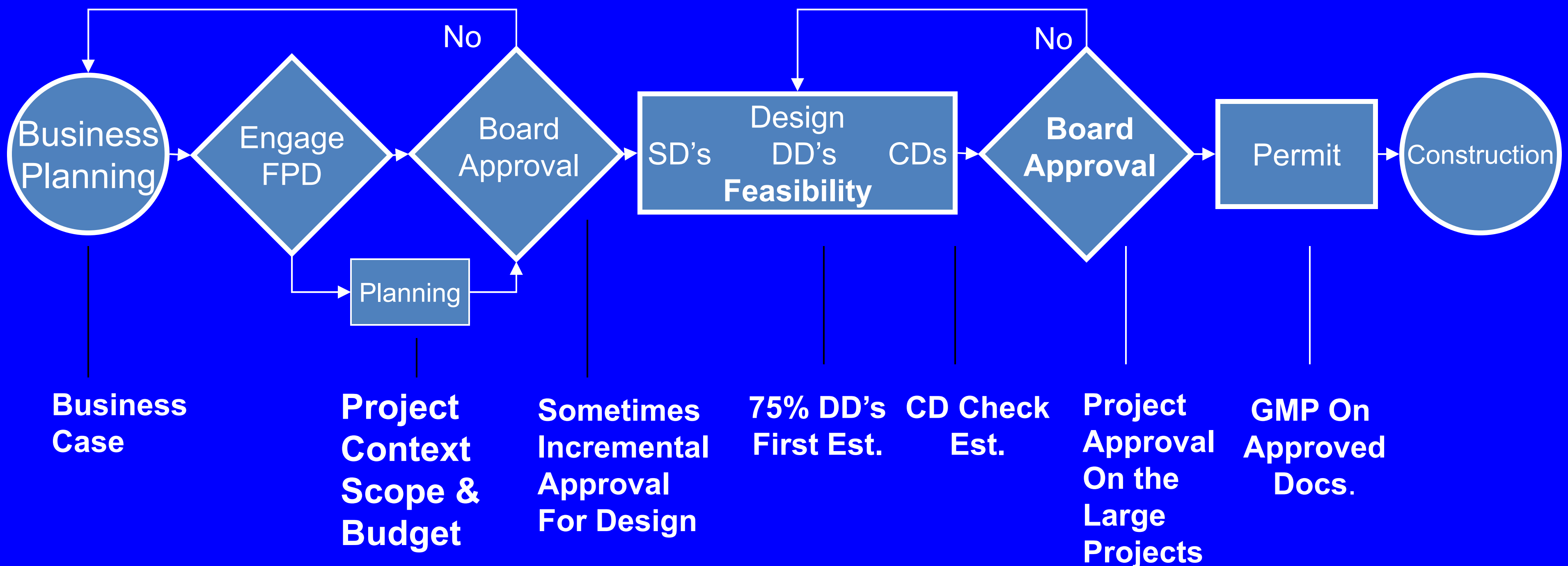
- What is Target Value Delivery (TVD)?
- Where did TVD come from?
- How do projects set targets in TVD?
- How do projects steer to targets in TVD?
- How well does TVD work?
- Key Points/Discussion

Sutter Fairfield Medical Office Building



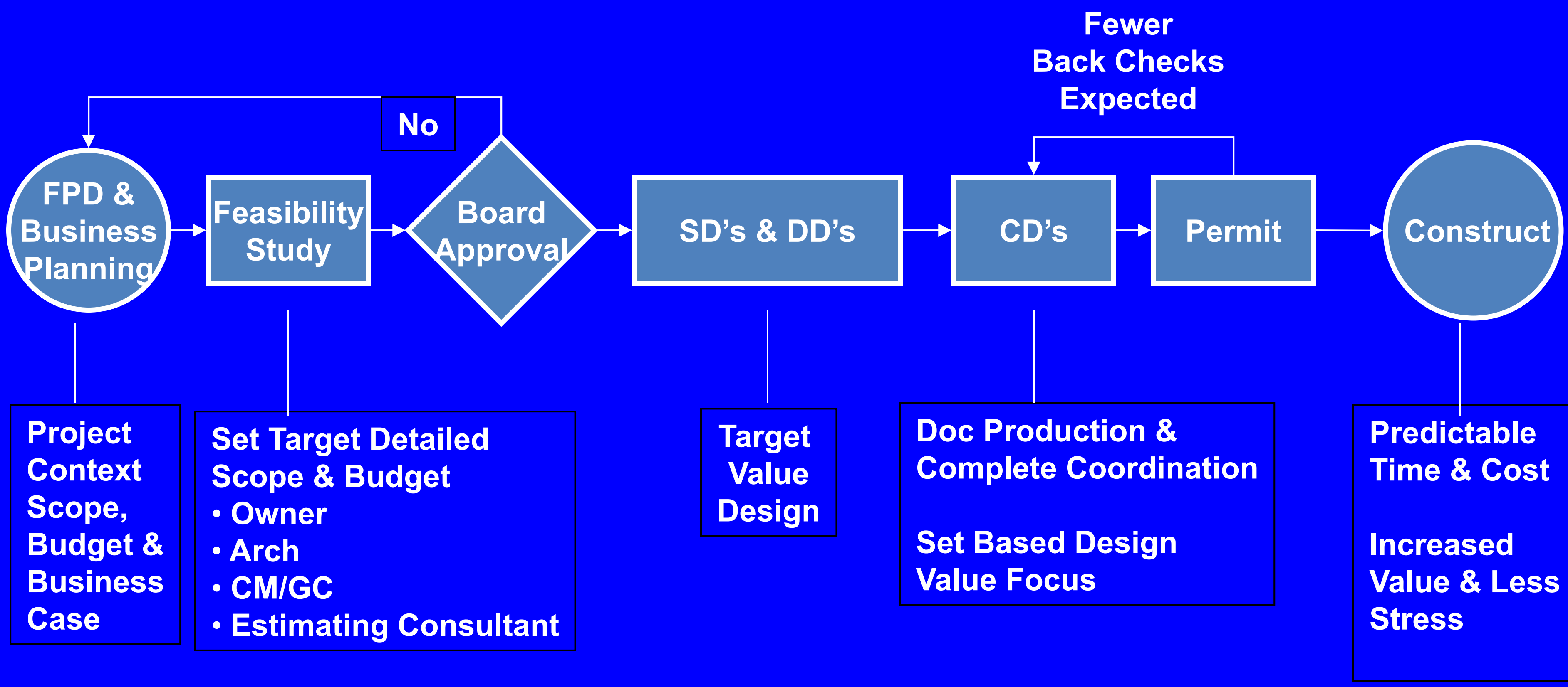
Cost at completion was 5.2% below target and 18.6% below market.

Sutter Health Old Process



From a presentation by Sutter Health's David Long, 2005

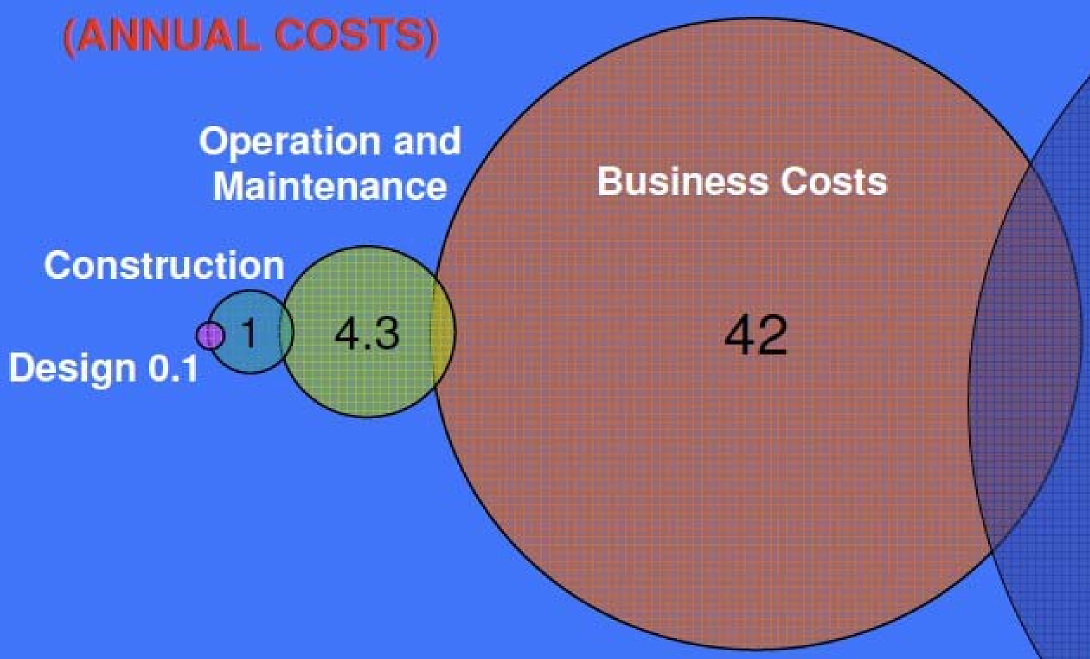
Target Value Design Process Flow



From a presentation by Sutter Health's David Long, 2005

What HEALTHCARE customers really need

NHS Estates



Healthcare outcomes

Clinical outcomes
Hospital-acquired infection rates
Safety outcomes
Medication error rates
Medication rates
Re-hospitalisation rates
Length of stays
Patient transfers
Costs per unit of service
Patient satisfaction
Visitor satisfaction
Staff morale
Staff turnover

From Evans, et al. 1998

Target Value Delivery Process for Capital Projects

Develop project business plan

↓

Validate the project business plan

↓

Set targets for what's wanted and conditions of satisfaction

↓

Steer design to targets

↓

Steer construction to targets

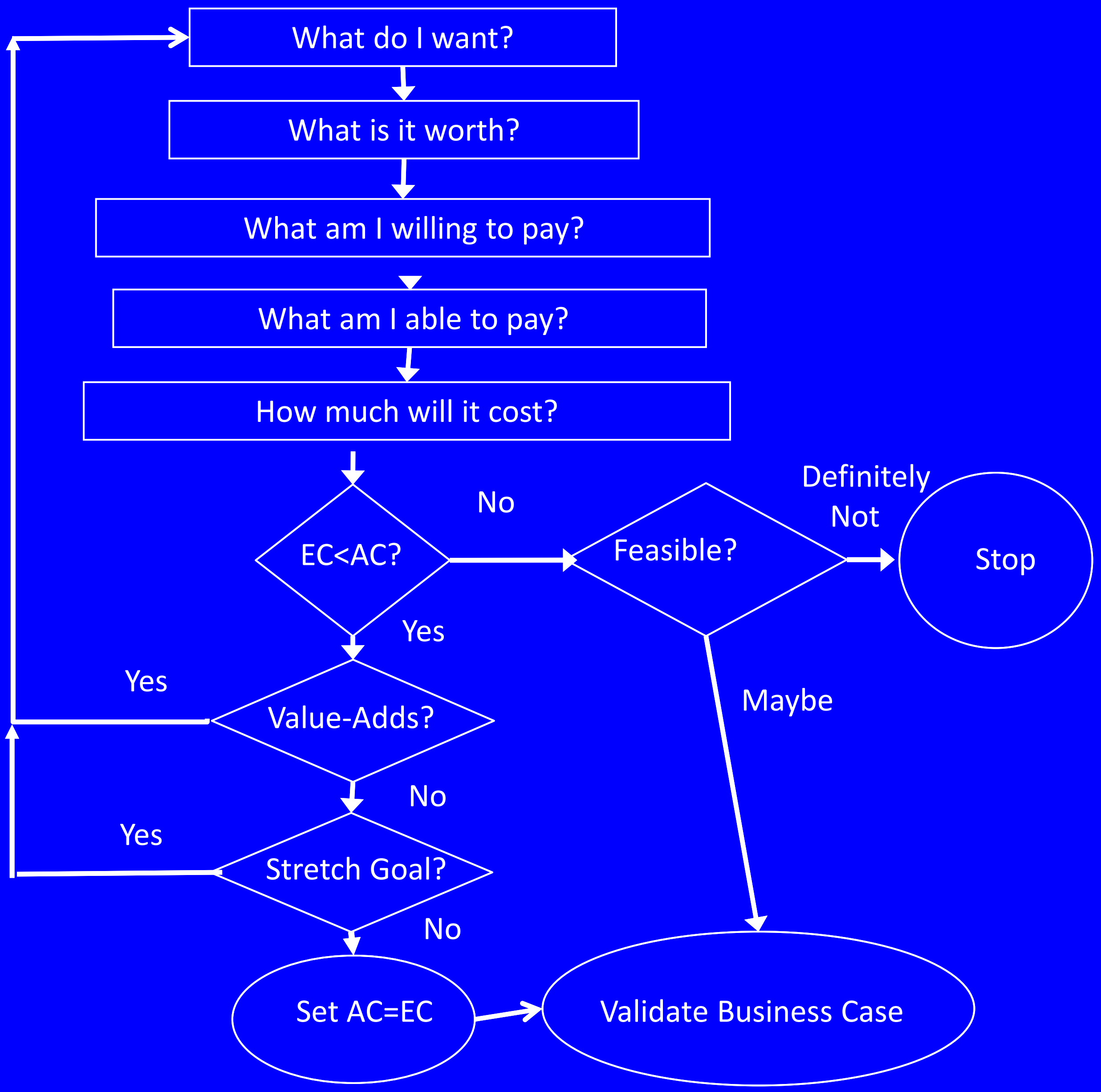
In moving from an idea to a go/no go decision, several key questions are asked and answered

A. What benefits are wanted from the project?
B. What is the lowest acceptable ratio of benefits to costs? (allowable cost)
C. How does this project compare to others as an investment alternative? – except for projects that are mandatory for the continued existence of the client
D. Given the risks and uncertainties, can this project be completed successfully?

Answering those questions involves producing and assessing a business case, and producing and assessing a project execution plan against risks and opportunities

Allowable Cost (AC): what I am willing and able to pay.

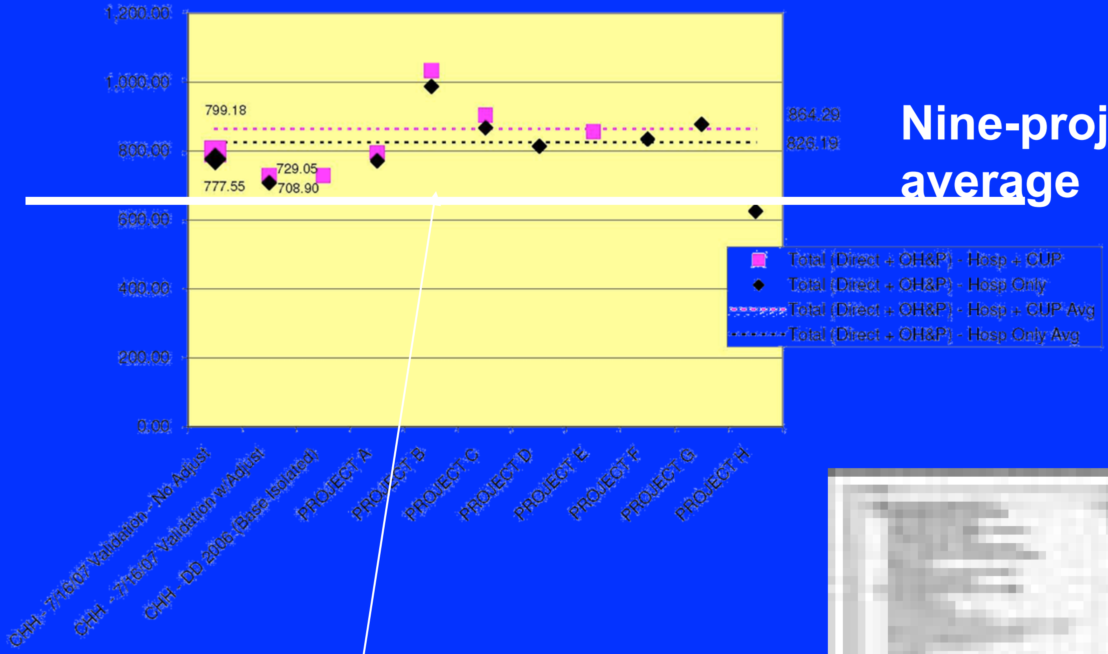
Expected Cost (EC): what it would cost based on the market.



Alternative methods for conceptual estimating

- Benchmark against similar projects
- Develop a building information model from the voice of the customer, then cost the model.

Setting the target cost and project schedule



Nine-project marketplace average

Target set 14% 'below' marketplace

Haahtela's Cost Model

What is it?

A software for producing building information models that takes input from the voice of the customer and produces an estimated cost for what's wanted.

How does it work?

By embedding algorithms and formulas used by architects and engineers to move from 'I want to be able to hear a pin drop from any seat in the theater' to the costs of impacted components and systems. Change the requirement and the estimate changes accordingly.

How well does it work?

- Average cost at completion of 39 projects = 1% under the conceptual estimate.
- Range: From -15% to +11.8%
- Average under: -3.66%. Average over: +3.32%
- Standard deviation = 4.9%

Target costing information model

Same information as design uses

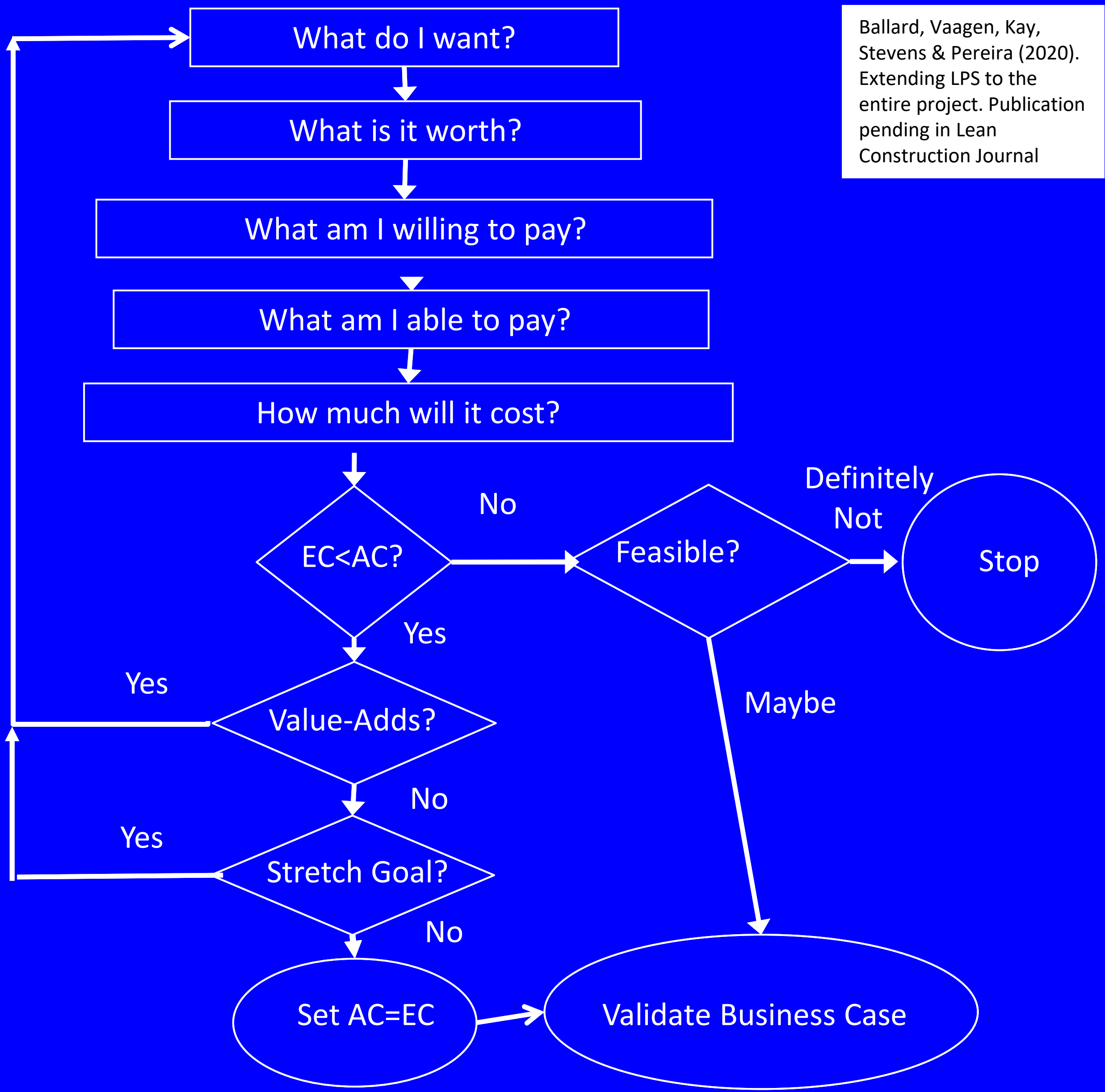
Number of luminaries needed is based on required lighting

N= ExA/(FxnxUfxMf)
where
E is illuminance required
A is size of the space
F is efficiency of the lamp
n is number of lamps in the luminaire
Uf is a certain factor (dealing with the absorption of surfaces)
Mf is a factor (dealing with probability that lamps work)

Modeling one of many possible design solutions enables counting the number of luminaries (or size of main switchboard, or…) and then applying cost to quantities and types of products to be purchased.

Allowable Cost (AC): what I am willing and able to pay.

Expected Cost (EC): what it would cost based on the market.



Ballard, Vaagen, Kay, Stevens & Pereira (2020). Extending LPS to the entire project. Publication pending in Lean Construction Journal

Grau, D., Cruz-Rios, F. and Sherman, R., PROJECT VALIDATION–A NOVEL PRACTICE TO IMPROVE VALUE AND PROJECT PERFORMANCE. (Available at Google Scholar)

Key Points

A. The natural target for built environment projects is to provide the customer acceptable net benefits in use of the asset.

B. Targets are set for what's wanted (benefits) and constraints on their delivery (cost, location, time…).

C. Setting cost targets is done through analysis of the gap between allowable and expected cost.

D. Expected cost is typically estimated by benchmarking.

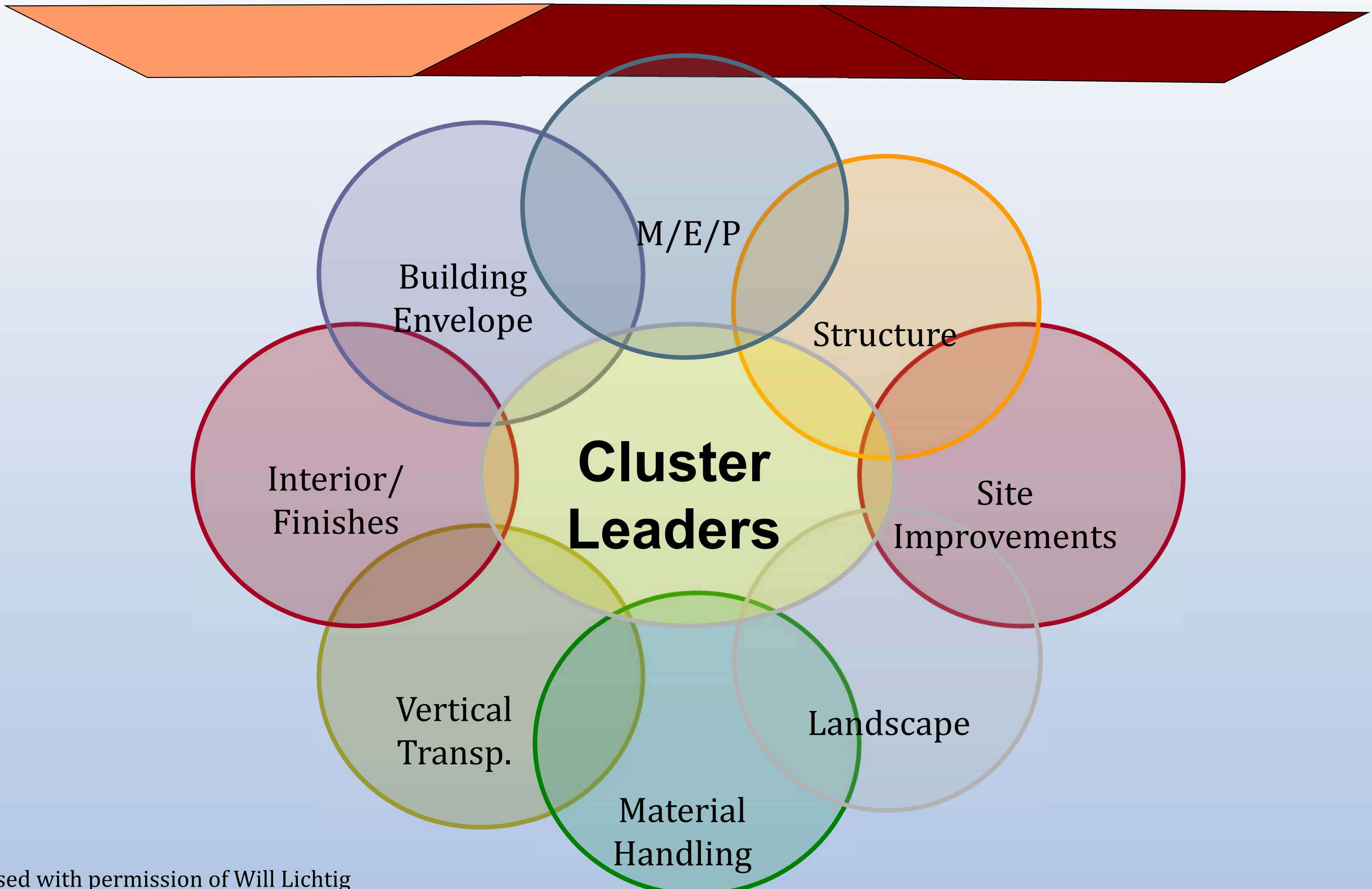
E. An alternative way of determining expected cost is to build a model from the voice of the customer and cost that model.

F. Go/No Go decisions are made by producing a project execution plan and assessing if the project can be completed with acceptable risk.

Some Questions You May Have

- Why not try to pay the least for what you want? Trying to pay the least tends to result in paying more than you would otherwise—mainly from perverse behaviors.
- Wouldn’t it be better to first design, then cost? With no target cost to meet, designs tend to be produced that exceed what clients are prepared to pay, resulting in rework and often extended project durations.
- Is it always appropriate to design for the whole life of the asset to be constructed? Yes, even for a developer who intends to sell or lease rather than use themselves. The benefits to be acquired increases the market value of the constructed asset.
- Why set an allowable cost before estimating what it will cost to get what you want? Gap analysis involves comparing an expected cost to the allowable. You only change the allowable cost when convinced that it is infeasible.

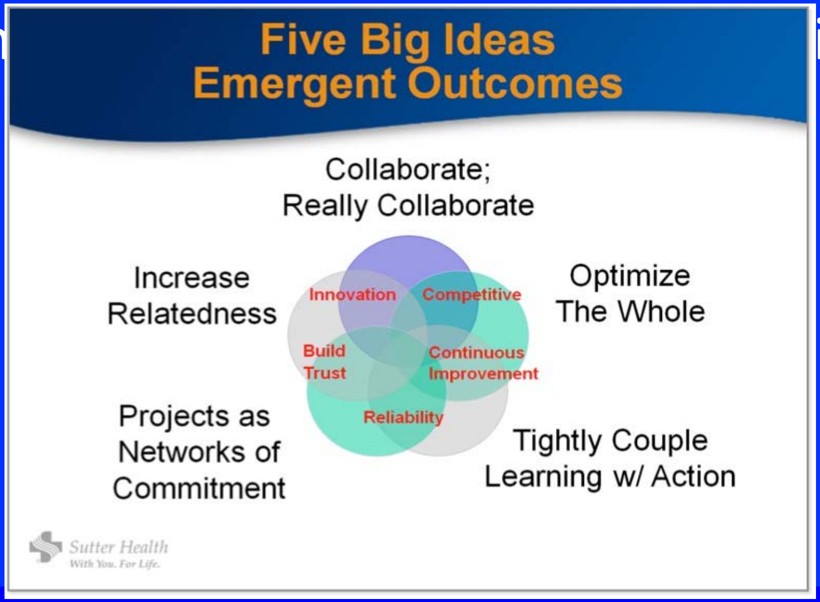
Organization for Steering Design to Targets



used with permission of Will Lichtig

Steering Design to Targets

1. Allocate the target cost to systems, subsystems, and components
2. Have cost modellers provide cost guidelines to designers up front, before design begins.
3. Incorporate value engineering/value management tools and techniques into the design process.
4. Use com ing to the extent feasible.



Target Cost Model

Legend:	Const TOTAL per SF	D-B TOTAL per SF
Worth (Target)		
Current Estimate	89.33	94.12

Project:	Fieldhouse Expansion
Location:	St. Olaf College Northfield MN
Phase of Design:	Schematic Target
Date:	June 21, 2001

Construction	+	Owner Reserves	+	Escalation	=	Construction TOTAL	Design-Build TOTAL
9,840,302	+	343,115	+		=	10,183,417	10,729,883

Incl Design at $504,886+41600

NOTES:

Bldg. Type:	Recreational
Target (SQFT)	114,000
Floors:	Single story plus mezzanines

SITE WORK — 594,500

Site GC OH&P	
G10 Site Prep, Demo & Excav	146,500
G20 Site Improvements	373,000
G30+40 All Utilities	75,000
G90 Other Site Structures	

BUILDING — 9,245,802

SHELL — 4,334,488

A10 Foundation A20 Basement	1,006,004
B10 Superstructure	1,218,797
B20 Exterior Closure	2,007,061
B30 Roofing	102,626

INTERIOR — 1,710,386

C10 Interior Construction	528,427
C20 Stairs	62,639
C30 Interior Finishes	1,069,320
D10 Conveying	50,000

MECHANICAL — 1,111,402

D20 Plumbing	85,927
D30 HVAC	824,160
D40 Fire Protection	109,740
Testing and Special Mech	91,575

ELECTRICAL — 794,890

D5010 Service and Distribution	739,390
D5020 Lighting & Branch Wiring	
D5030 Security Comm/Data	
D5090 Other Electrical	55,500

SPECIAL — 706,862

E10 Specialties & Equipment	492,534
E20 Furnishings Fixed/Movable	34,000
F10 Special Construction	89,520
F20 Selective Demolition	90,808

GENERAL — 587,774

Z1010 Project Administration	
Z1030 General Conditions	
Z1060 Fee	
Z20 Risk and Contingency	587,774

To design for value delivery…

- understand how the facility will be used, at occupancy and after, before designing.
- understand owner client conditions of satisfaction for delivery of the facility; economic, environmental and social impact.
- link what's wanted and owner conditions of satisfaction and keep them linked when either changes—don't let scope and cost drift apart.
- set stretch goals in scope, cost or time to spur innovation.
- align commercial interests with delivery of value to the owner.
- design to target values and conditions of satisfaction—do not design, then cost.

	St. Olaf College Fieldhouse	Carleton College Recreation Center
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

Sutter Health's 2012 Report

- Since they launched lean in 2004, Sutter Health had completed 22 'lean' projects > $10 million, some much larger, but no acute care hospitals.
- "Lean" mainly referred to use of target value delivery and last planner
- None over budget or time
- All 'fit for purpose'
- Average 3.4% under budget
- Average 15% under market

Eden Medical Center Replacement Hospital

- $309M Project Budget
- 130 licensed beds, 223,000 SF
- Completion: 3Q 2012

Performance – Eden Medical Center

- Completed under budget 6 months early
- No compromise to space program or sustainability goals
- Construction rework 15-80% less than trade baselines
- Productivity 5-20% greater than trade baselines
- Mechanical/Plumbing installed exactly to the model 99% of the time
- Fewer RFI’s, Change Orders and failed inspections than Sutter ‘legacy’ projects

Eden Medical Center – adherence to the model

Key Points

1. Steering to targets in design requires a budget that allocates the total project target cost to systems, subsystems and components.
2. Steering to targets in construction requires a budget that allocates costs to work packages
3. Steering is done through feedback. Designers still design, but within constraints.
4. The TVD fundamental rule is that only the buyer can change targets.
5. TVD has consistently been used to deliver projects to targets or better.

We have ten minutes for comments and questions. If we run out of time, send me your questions and I will try to answer them

gballard@berkeley.edu

The Last Planner System of Planning & Control

Glenn Ballard

July 1, 2020

Construction Weekly Work Plan

1 WEEK PLAN

PROJECT: Pilot

FOREMAN: PHILLIP

DATE: 9/20/96

ACTIVITY	Est	Act	Mon	Tu	Wed	Thurs	Fri	Sat	Sun	PPC	REASON FOR VARIANCES
Gas/F.O. hangers O/H "K" (48 hangers)			XXXX Sylvano, Modesto, Terry	XXXX						No	Owner stopped work (changing elevations)
Gas/F.O. risers to O/H "K" (3 risers)					XXXX Sylvano, Mdesto, Terry	XXXX	XXXX	XXXX		No	Same as above-worked on backlog & boiler blowdown
36" cond water "K" 42' 2-45 deg 1-90 deg			XXXX Charlie, Rick, Ben	XXXX	XXXX					Yes	
Chiller risers (2 chillers wk.)						XXXX Charlie, Rick, Ben	XXXX	XXXX		No	Matl from shop rcvd late Thurs. Grooved couplings shipped late.
Hang H/W O/H "J" (240'-14")			XXXX Mark M., Mike	XXXX	XXXX	XXXX	XXXX	XXXX		Yes	
Cooling Tower 10" tie-ins (steel) (2 towers per day)			XXXX Steve, Chris, Mark W.	XXXX	XXXX	XXXX	XXXX	XXXX		Yes	
Weld out CHW pump headers "J" mezz. (18)			XXXX Luke	XXXX	XXXX	XXXX	XXXX	XXXX		Yes	
Weld out cooling towers (12 towers)			XXXX Jeff	XXXX	XXXX	XXXX	XXXX	XXXX		No	Eye injury. Lost 2 days welding time
F.R.P. tie-in to E.T. (9 towers) 50%			XXXX Firt, Packy, Tom	XXXX	XXXX	XXXX	XXXX	XXXX		Yes	
WORKABLE BACKLOG Boiler blowdown-gas vents -rupture disks											

Linbeck Next Stage Development

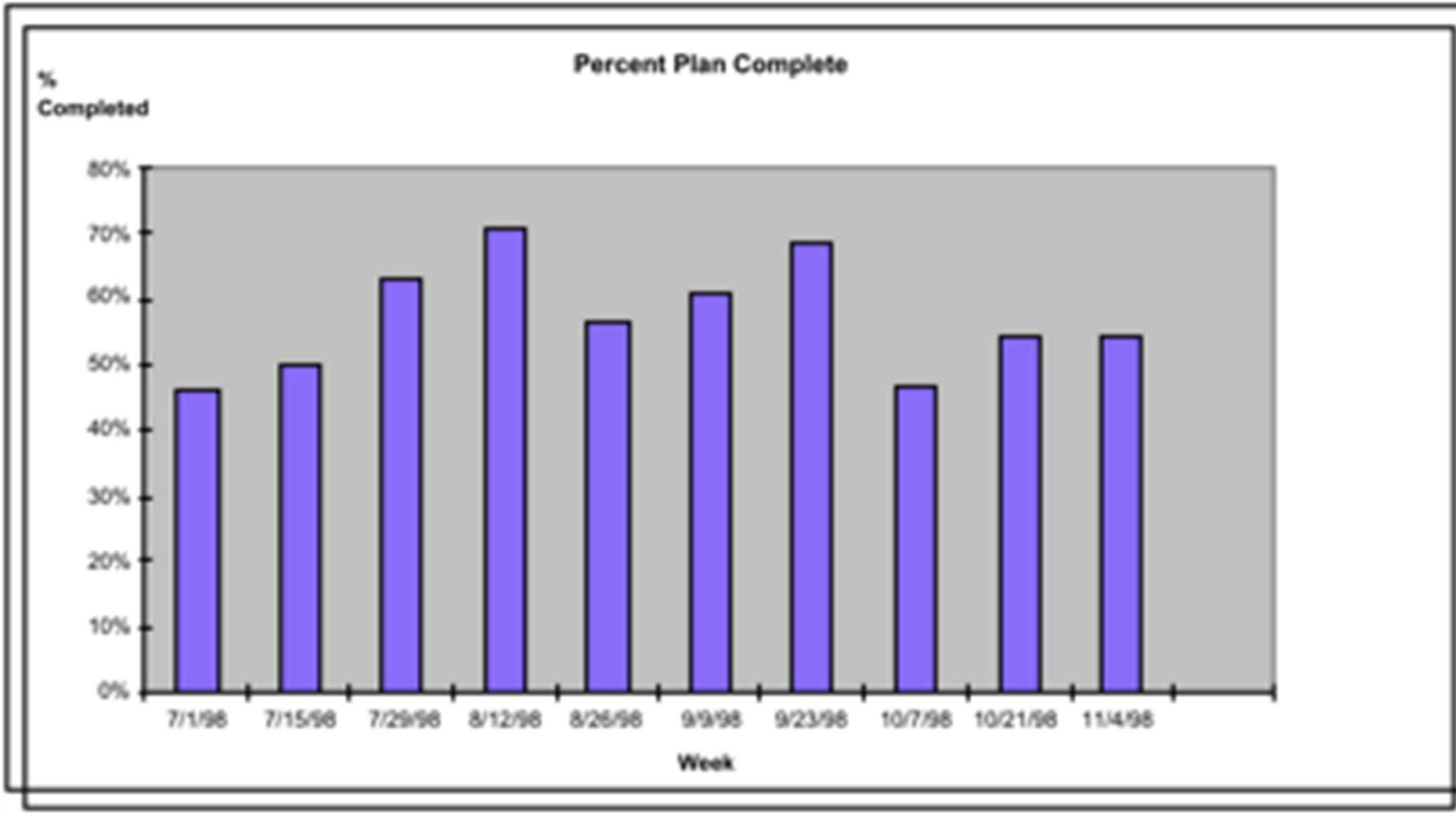
The Texas Showplace

Action Items Log

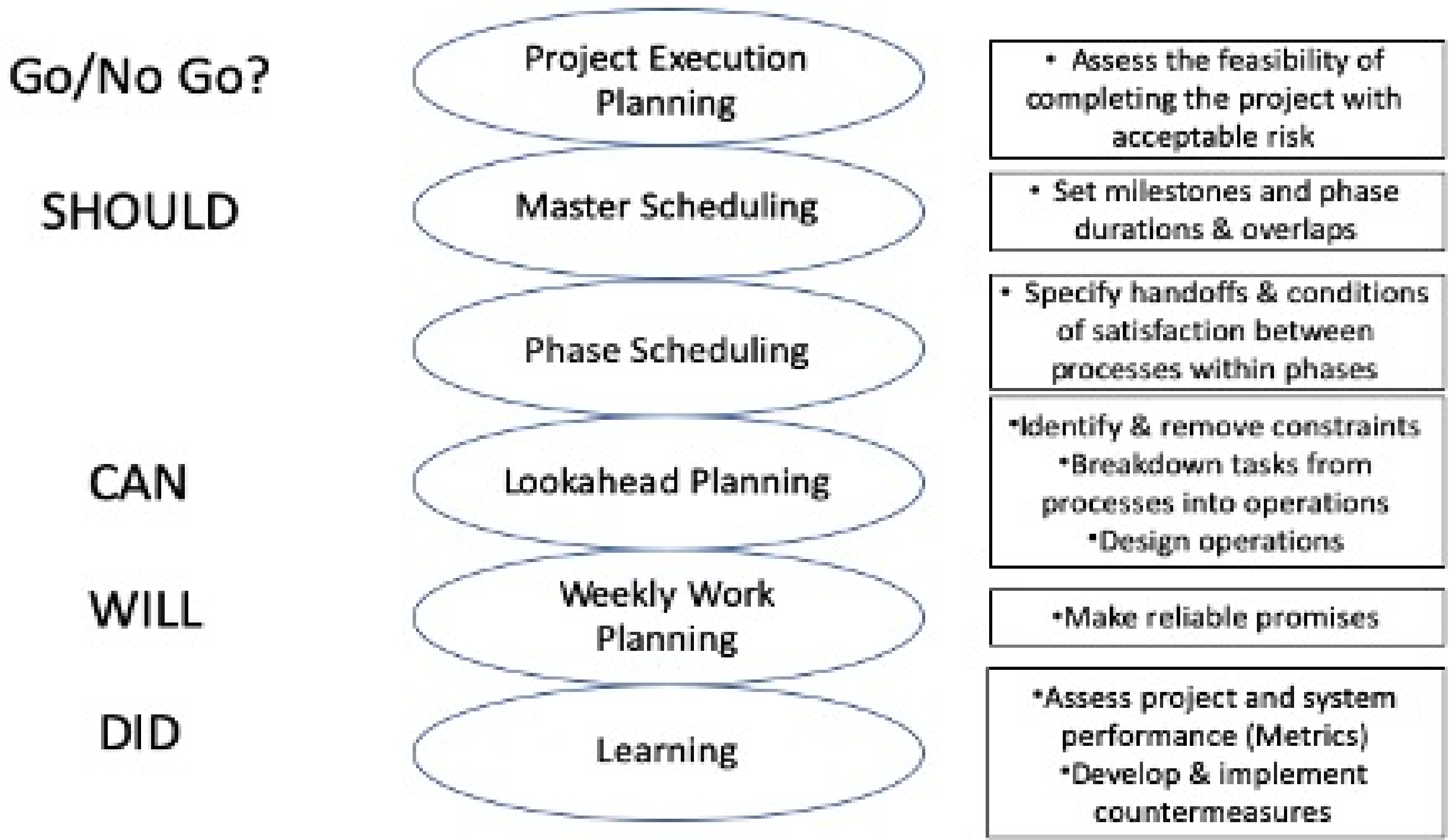
As of December 2, 1998 Project Progress Meeting Revised: 12.14.98

Date Originated-Item No.	*Item Description*	*Action By*	*RNC*	*Date Required*	*Date Completed*
A. Site/Civil					
	Texas Accessibility Standards:				
AA07.01.98.01	• Provide TAS requirements to ELS	HA		07.07.98	07.07.98
AA07.01.98.02	• Identify preliminary and final TAS review process.	ELS		07.14.98	07.14.98
AA07.01.98.03	Resolve building storm/sanitary *site collection points* and pipe inverts; still lacking inverts. *Coordinate profiles with water line surrounding building to be deeded to City.*	CHPA/HA/ *LCC/TSPH*	2	07.10.98 07.31.98	08.02.98
AA07.01.98.04	Develop site and parking lighting *compatible with Lone Star Race Park* for site plan submission for Planning and Zoning approval *(Control Road "B").*	TEE/*FE/ HA*	6	07.14.98 08.12.98	08.12.98
AA07.01.98.05	Provide color rendering for submission for Planning and Zoning review/approval; resolve landscape issues (IA07.01.98.05).	ELS	7	07.14.98 07.27.98	07.27.98

Next Stage PPC: Design Stage



Last Planner System of Planning and Control



Why extend the Last Planner System to manage the entire project?

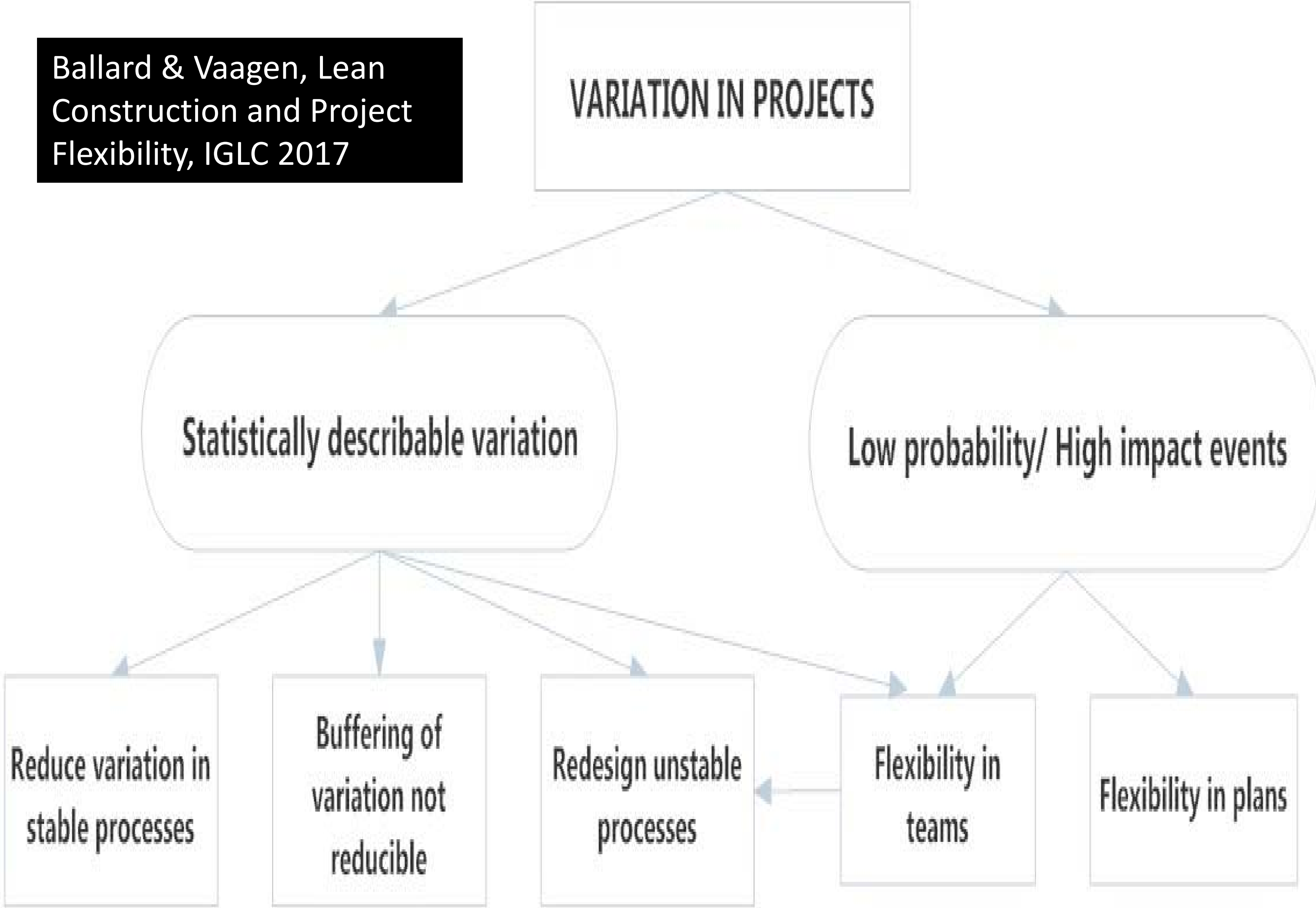
We had three concerns with current practice:

1. *failure to involve the right people in planning*
2. *being overly deterministic in the face of uncertainty*
3. *over reliance on the ability to predict probability of occurrence of risk events."*

- Use pull planning to produce project master schedules.
- Incorporate alternative pathways in project schedules.

[2020 Current Process Benchmark for the Last Planner System of Planning and Control, available at p2sl.Berkeley.edu. See for more information about forming project execution plans and using them to evaluate project feasibility.]

Ballard & Vaagen, Lean Construction and Project Flexibility, IGLC 2017



Increasing Flexibility in Plans is done by:

- Postponement—e.g., planning in greater detail as time for execution draws nearer; making decisions at the last responsible moment
- Hedging--developing or buying an ‘insurance’ to offset potential losses or gains. Examples are:
  - From *Set-based design* -- develop a fallback alternative design in case it is needed to meet the Last Responsible Moment (Ward, et al., 1995).
  - Embed alternatives in project master and phase schedules.

Flexibility in Teams is increased by:

- promoting psychological safety; feeling safe to speak truth to power, to make suggestions, to request feedback, to expect help when mistakes are made, to perform experiments.
- cultivating the habits and skills of creating your own future—applying the Last Planner principle that work is planned by those who do the work.

Countermeasures for poor quality of work plans and schedules

1. Master schedules are kept at milestone level of detail
2. Phase schedules are developed by those with direct responsibility for doing the work being scheduled, filling in the gaps between milestones in the master schedule, phase by phase, and
3. Scheduling is done at more detailed levels nearer in time to scheduled execution—the rolling wave approach: project-phase-process-operation-step.

Master Scheduling

Master schedules should be at milestone level because *forecast error increases with the length of the forecast period and the level of detail.*

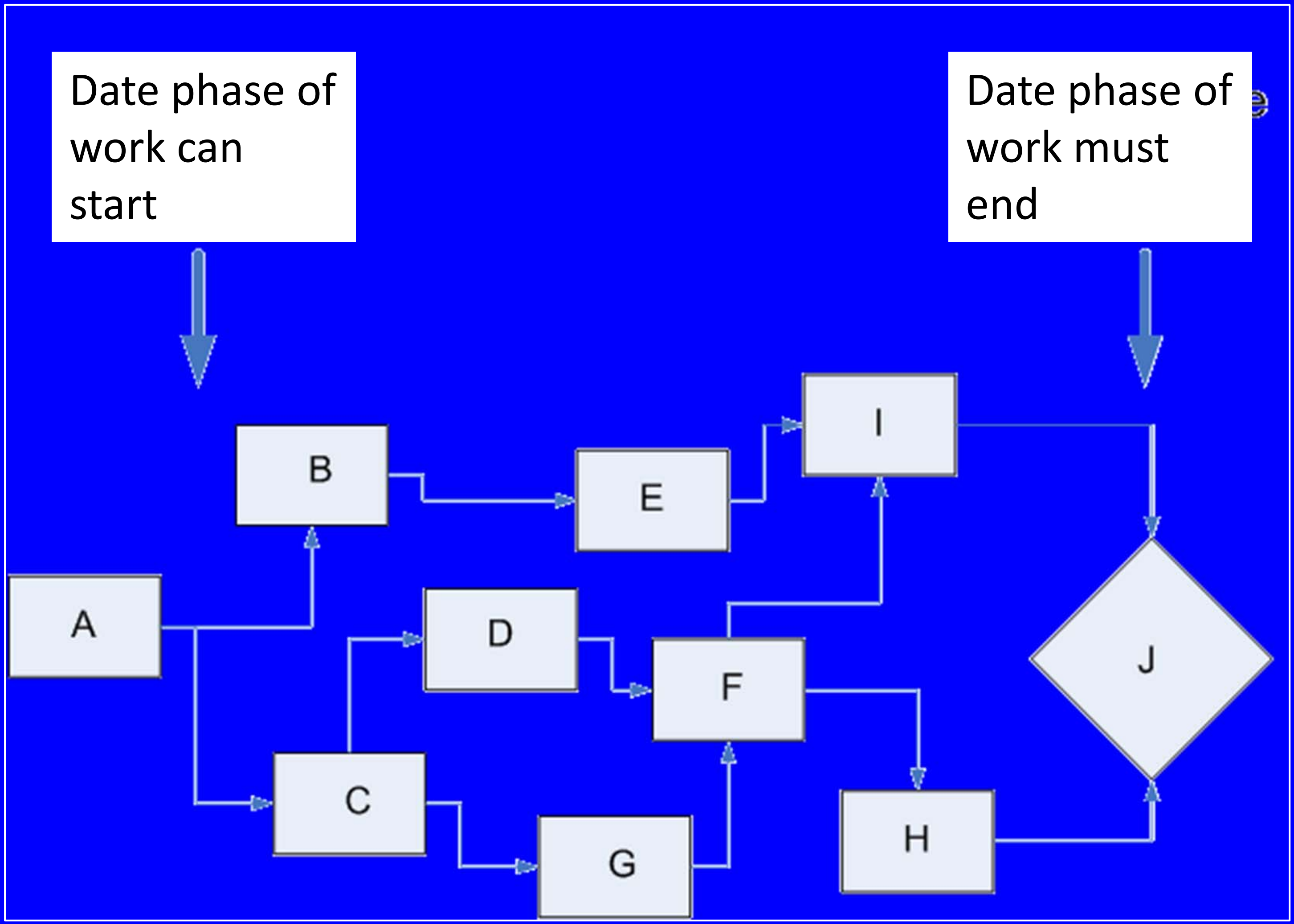
Pull Planning

Courtesy of Alan Mossman

Phase Scheduling (pull) Process

- Define deliverables and scope—what will count as successful completion.
- Develop logic network using backward pass.
- Apply unpadded durations to activities.
- Re-plan as needed to generate a schedule buffer (float) to absorb expected variation in durations.
- Allocate the schedule buffer to critical and variable activities.

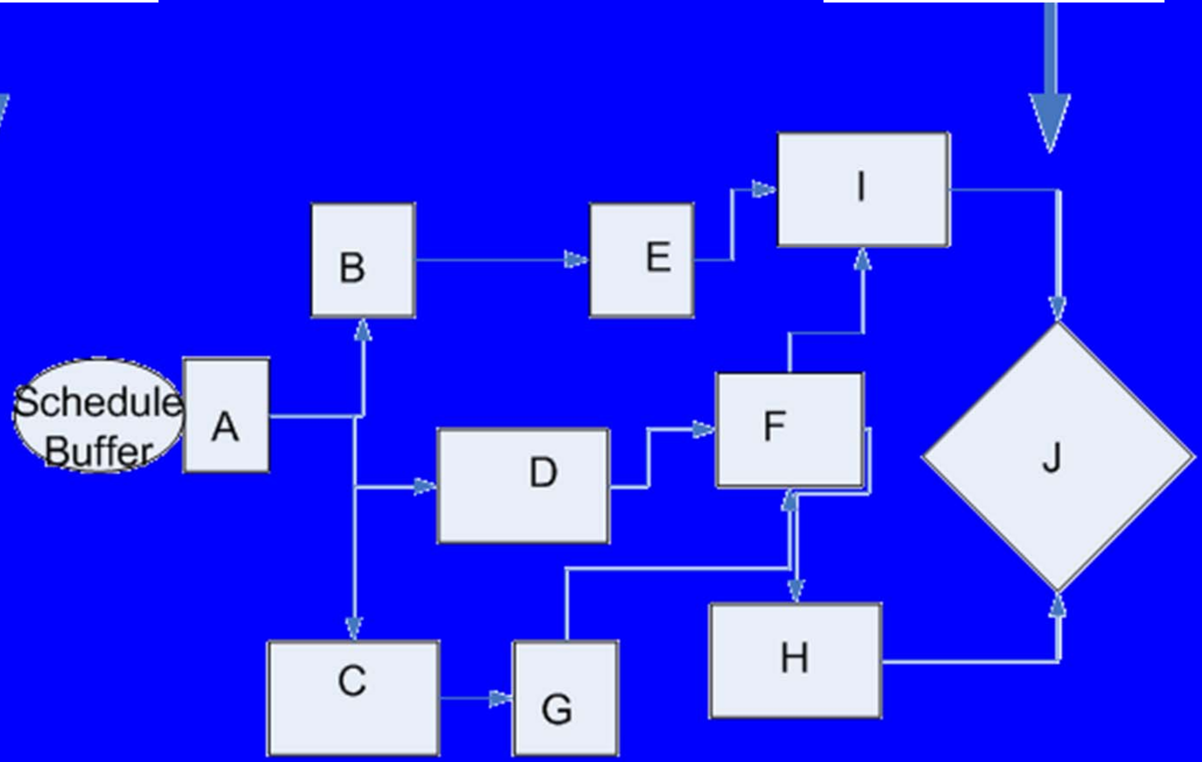
The First Attempt



Shrunk and Buffered Against Variation

Date phase of work can start

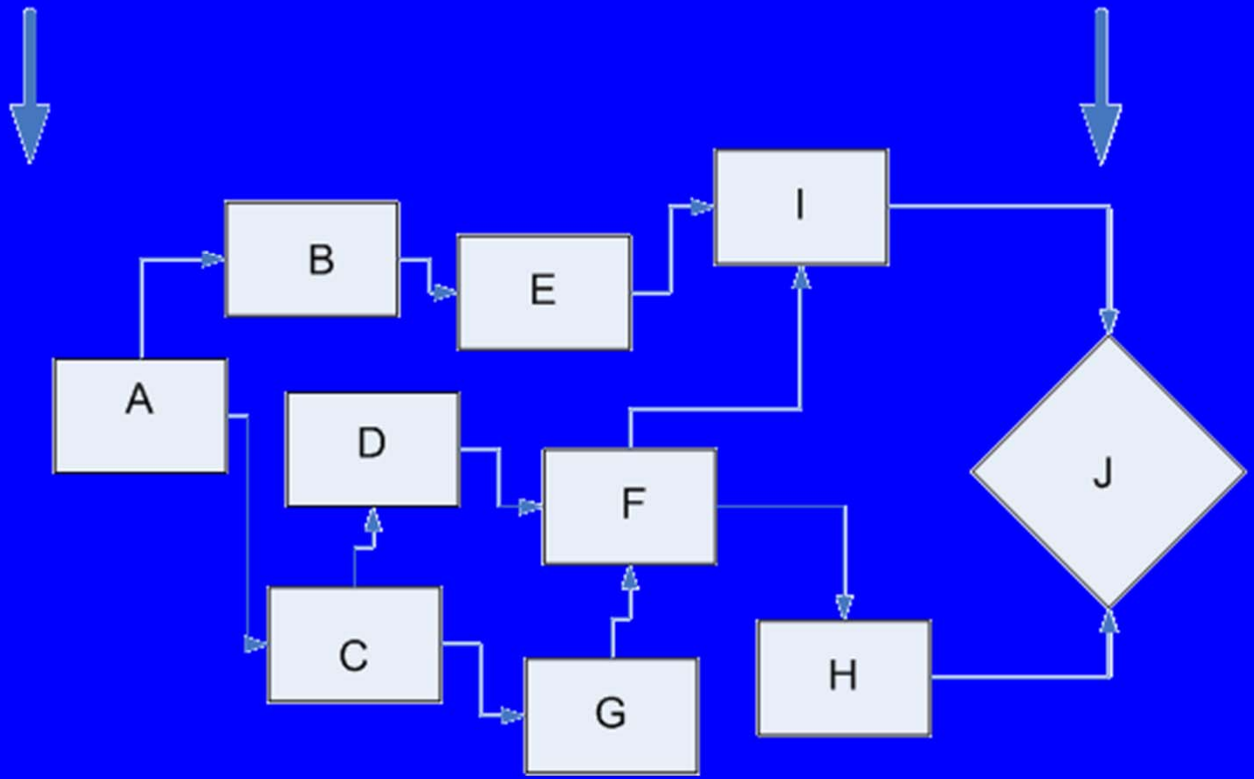
Date phase of work must end



After Schedule Buffer is Distributed

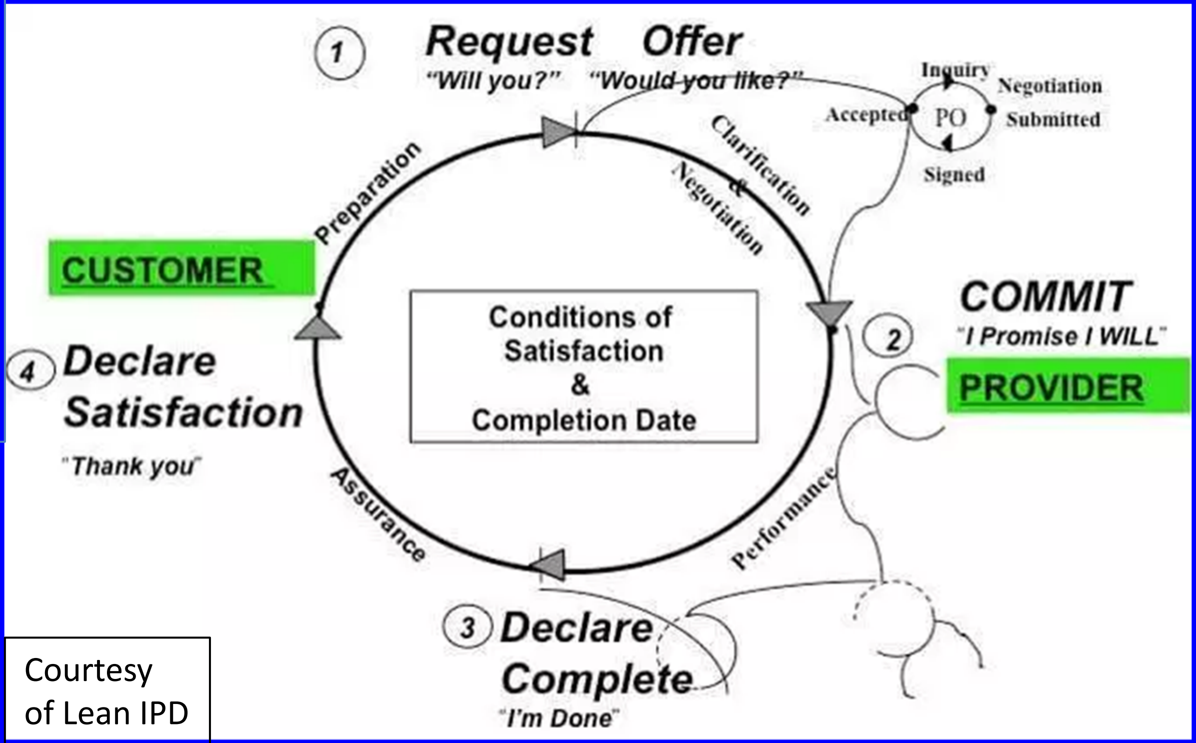
Date phase of work can start

Date phase of work must end



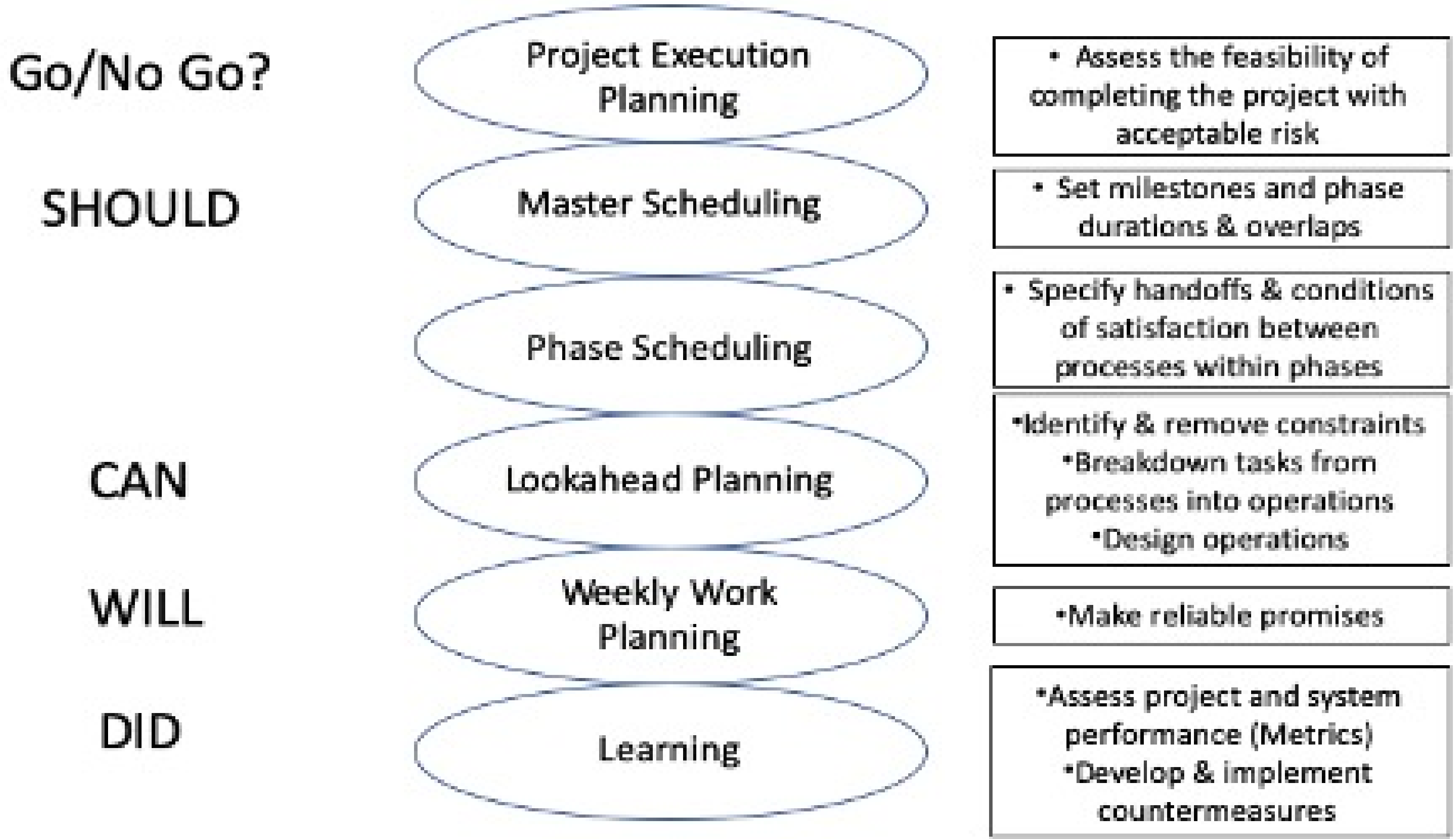
Reliable Promising Cycle

1. Request
2. Clarification
3. Negotiation
4. Commitment
5. Performance
6. Declaration of Completion
7. Declaration of Satisfaction

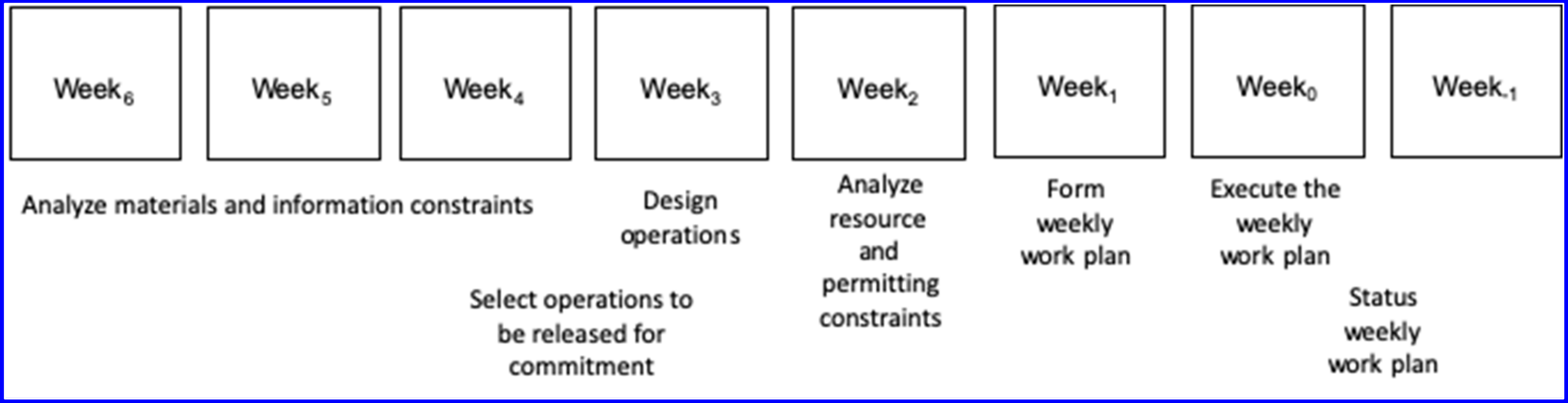


Courtesy of Lean IPD

Last Planner System of Planning and Control



Making Tasks Ready to be Released for Commitment



Identify & Remove Constraints

Project name:_______________

Last Planner-Lookahead

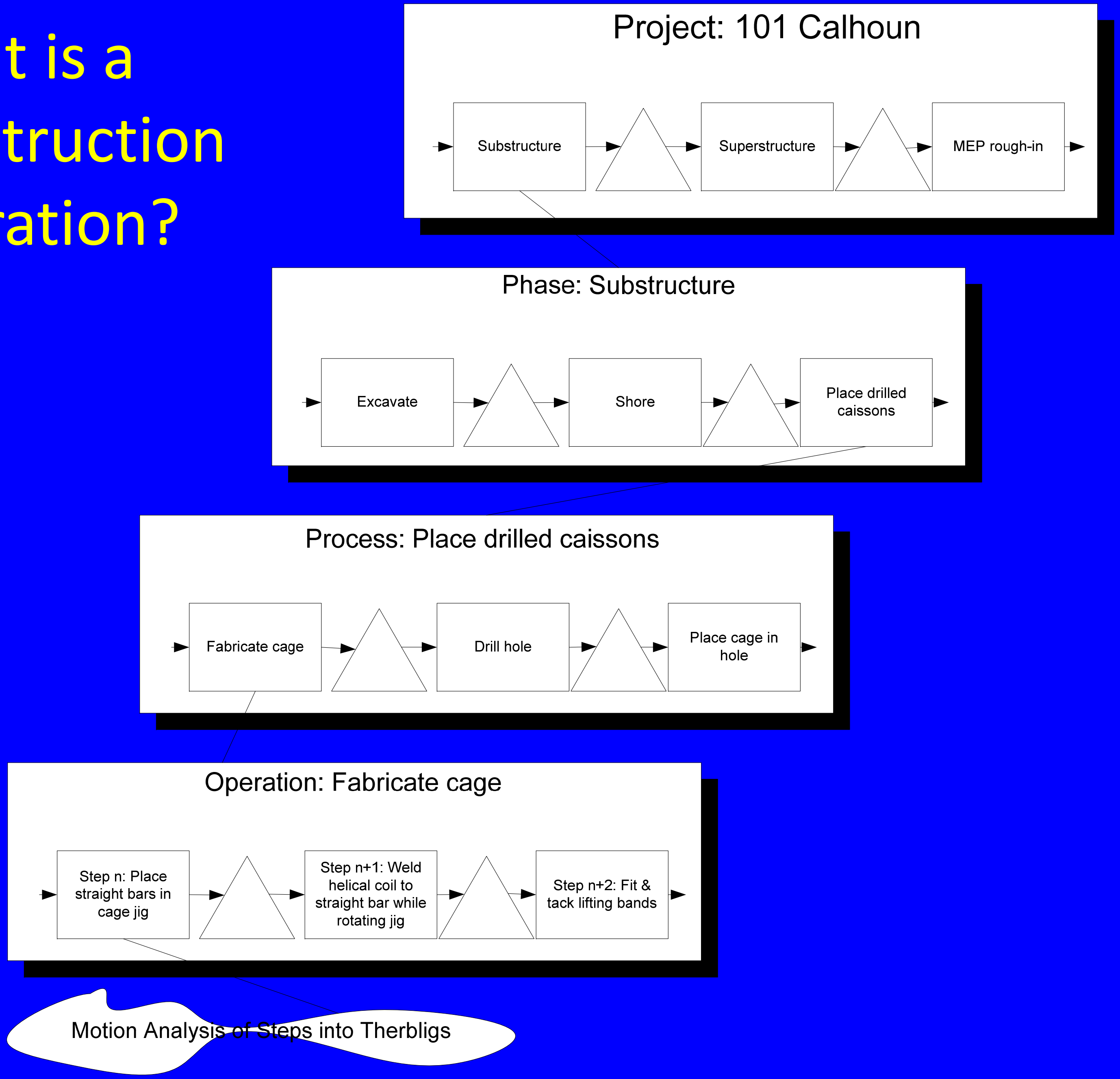
Constraints Analysis

Prepared by: _______________

Run Date:

Activity ID	Activity Description	Planned Start Date	Responsible Party	Contract / Change Orders	Design			Materials	Labor	Equipment	Prereq Work	Space	Sound?	Comments
					AE Complete	Submittals	RFI's							
11	Rebar erection for 1st floor columns 5,6,7,8	1/15/2007	Rebar-sub	X	X	X	X	Delivery Mon AM	X	X	X	X		
12	Electrical inserts/rough-in for 1st floor wall w1	1/15/2007	Electrical Sub	X	X	X	X	X	X	X	X	X		
13	Formwork for 1st side for 1st floor wall w1	1/15/2007	GC	X	X	X	X	X	X	X	X	X		
14	Mechanical penetrations in 1st floor wall w1	1/15/2007	Mechanical	X	Shop Dwg approval	Puddle flange (Seal)	X	X	X	X	X	X		
15	Strip formwork for columns 1,2,3,4	1/15/2007	GC	X	X	X	X	X	X	X	X	X		
16	Electrical inserts/rough-in for columns 5,6,7,8	1/16/2007	Electrical Sub	X	X	X	X	GI couplers	X	X	X	X		
17	Formwork for 1st floor columns 5,6,7,8	1/17/2007	GC	X	X	X	X	X	X	X	Inspection	X		
18	Formwork for 2nd side for 1st floor wall w1	1/16/2007	GC	X	X	X	X	X	X	X	Inspection	X		

What is a construction operation?



How are Construction Operations Designed?

- Virtual prototyping
- Physical prototyping (mock-ups)
- First run studies (for repetitive operations)

What is a Construction Operation Design?

- Operations designs are an explicit, detailed plan for how a specific task will be done, developed collaboratively with those who will do the work.
- Operation designs typically involve a process diagram, a crew balance chart and a dimensioned diagram of the work area showing movements of workers, materials, and equipment.
- Design criteria for operations are safety, quality, time and cost (SQTC).
- Plan-Do-Check-Act (PDCA) is used to test and improve the capability of designs to perform to SQTC criteria.

First Run Studies at PDVSA's PARC (1994)

Sub	Before	After	% Improvement
Ata	3 supports/day	22 supports/day	600%
Costa Norte	54" dia. pipe in 4 hr-19 min	...in 32 min	700%
Den Spie	1 wire/5 min.	1 wire/3 min.	70%
Distral	10 isos/week	15 isos/week	50%
DSD	0.087m/min.	0.9 m/min.	800%
Formiconi	2.75 mh/LM	1.72 mh/LM	50%
Piaca	1 column/hr	3 columns/hr	200%
Rivaco FM	1 siding/13 min.	1 siding/8 min.	60%

From "PARC: A Case Study", by Ballard et al., IGLC1996

Design Operations

HerreroBOLDT
Joint Venture

Herrero Boldt
2100 Oakdale Avenue
San Francisco, CA 94124-1516

415-824-7675 phone
415-824-7674 fax

Memorandum to BIM Champions March 11, 2008

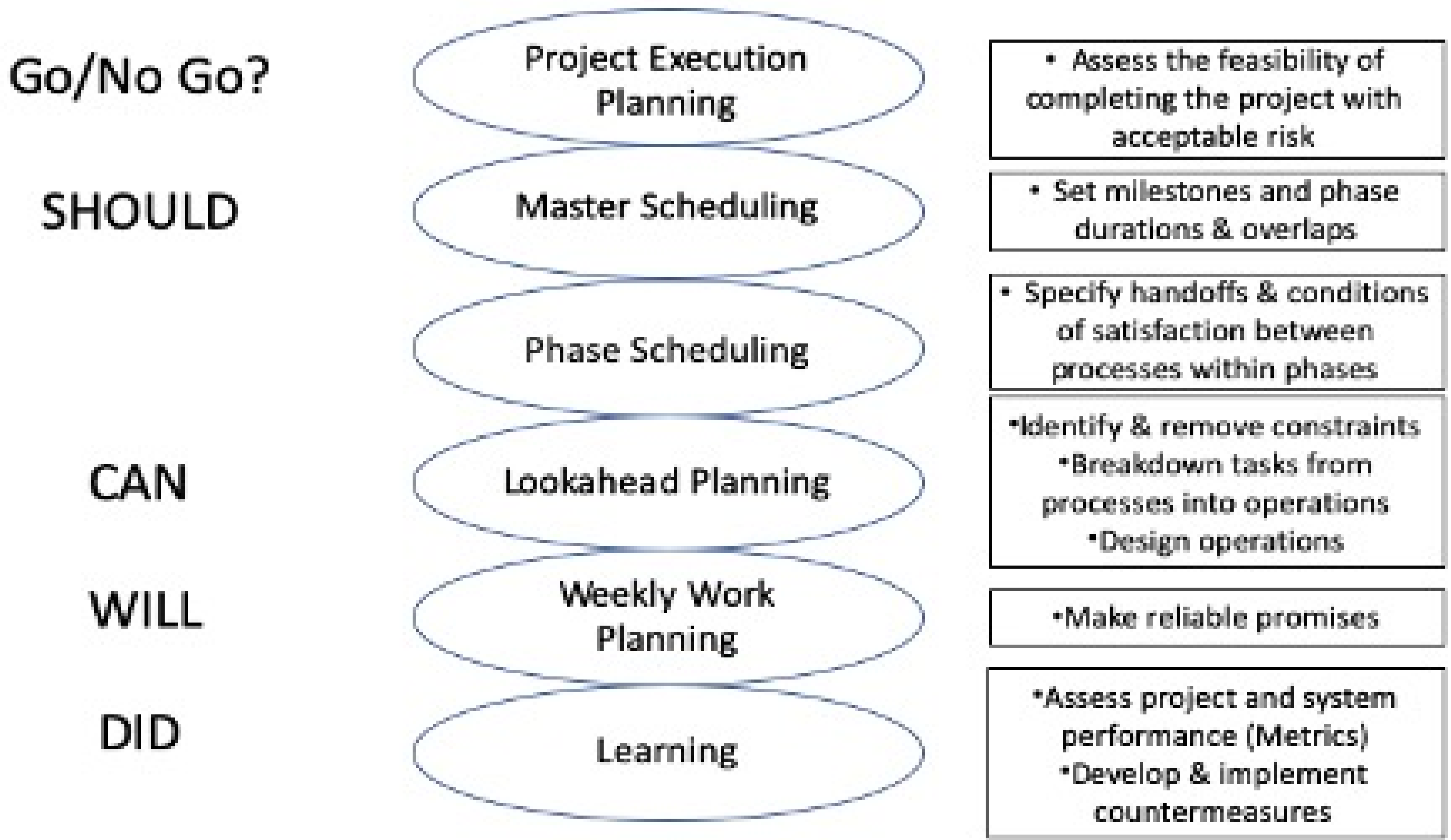
Lessons Learned from BIM Stress Test #2 – Navis Import and Printing Test

The following notes were supplied by each of the test participants based on their individual results. Please take time to review all items, identify solutions to each problem, set a date to have the solution resolved and assign a responsible party.

Ted Jacob Engineering Group, Inc

1. The insertion point of all model were not exactly the same. A universal reference point should be established for all trades to use.
2. Define color scheme to identify individual service in NavisWorks model for all trades.
3. The ceiling grid lines were missing from the architectural DWG 3D model.
4. The other important systems such as Fire Sprinkler System, Cable Tray, and Pneumatic Tube were missing form the coordination model.

Last Planner System of Planning and Control



Matching and DID with WILL: Reliable Promising

Rule: Include in daily work plans only tasks that are:

- Defined to convey what performers need to understand
- Sound
- Sequenced (critical tasks first)
- Sized to the capacity of performers

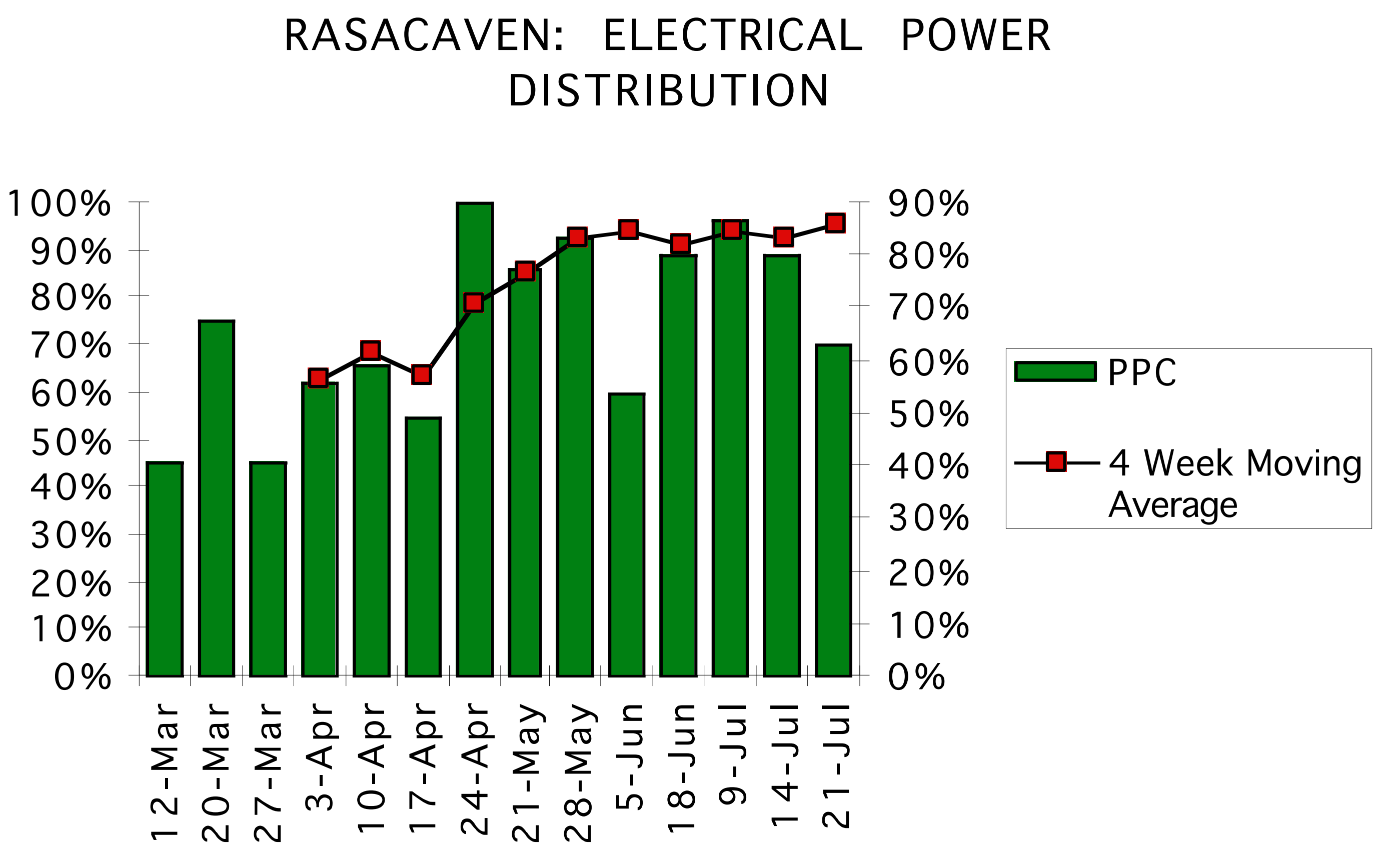
Construction Weekly Work Plan

1 WEEK PLAN

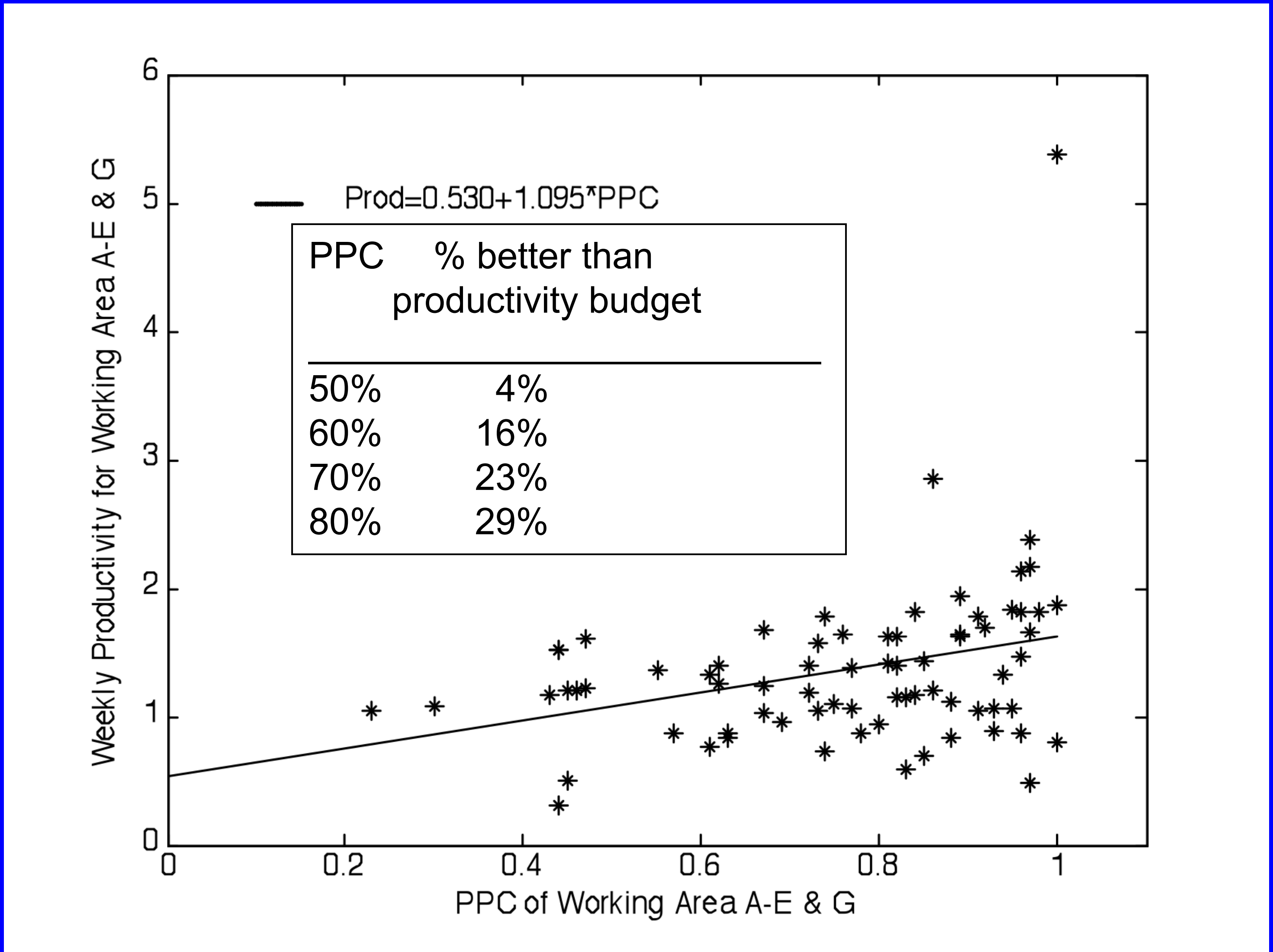
PROJECT: Pilot | **FOREMAN: PHILLIP**

DATE: 9/20/96

ACTIVITY	**Est**	**Act**	**Mon**	**Tu**	**Wed**	**Thurs**	**Fri**	**Sat**	**Sun**	**PPC**	**REASON FOR VARIANCES**
Gas/F.O. hangers O/H "K" (48 hangers)			XXXX	XXXX						No	Owner stopped work (changing elevations)
			Sylvano, Modesto, Terry								
Gas/F.O. risers to O/H "K" (3 risers)					XXXX	XXXX	XXXX	XXXX		No	Same as above-worked on backlog & boiler blowdown
					Sylvano, Mdesto, Terry						
36" cond water "K" 42' 2-45 deg 1-90 deg			XXXX	XXXX	XXXX					Yes	
			Charlie, Rick, Ben								
Chiller risers (2 chillers wk.)						XXXX	XXXX	XXXX		No	Matl from shop rcvd late Thurs. Grooved couplings shipped late.
						Charlie, Rick, Ben					
Hang H/W O/H "J" (240'-14")			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		Yes	
			Mark M., Mike								
Cooling Tower 10" tie-ins (steel) (2 towers per day)			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		Yes	
			Steve, Chris, Mark W.								
Weld out CHW pump headers "J" mezz. (18)			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		Yes	
			Luke								
Weld out cooling towers (12 towers)			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		No	Eye injury. Lost 2 days welding time
			Jeff								
F.R.P. tie-in to E.T. (9 towers) 50%			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		Yes	
			Firt, Packy, Tom								
WORKABLE BACKLOG Boiler blowdown-gas vents -rupture disks											


RASACAVEN: ELECTRICAL POWER DISTRIBUTION
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
12-Mar
20-Mar
27-Mar
3-Apr
10-Apr
17-Apr
24-Apr
21-May
28-May
5-Jun
18-Jun
9-Jul
14-Jul
21-Jul
PPC
4 Week Moving Average

Impact of PPC on Productivity



Graphic courtesy of

Extemin: 27th annual mining conference, Arequipa, Peru

We Learn From…

- Experiments: Intended deviations from process
- Breakdowns: Unintended deviation from outcomes

Traditional vs Last Planner

Traditional	Last Planner
1. Planners plan and doers do	1. Planning is done collaboratively
2. Thermostat model of control (reactive)	2. Control is proactive (making ready) and reactive
3. Inconsistent learning from plan failures	3. Systematic learning from plan failures
4. Scheduled tasks are pushed onto doers without regard to readiness	4. Doers are required to commit only to ready tasks
5. It is assumed that planning produces perfect plans	5. It is assumed that all plans are forecasts and all forecasts are wrong

Last Planner Fundamentals

WHAT	HOW
A. Testing project feasibility through project execution planning.	A. Pull planning & stochastic planning
B. Detailing the phases between master schedule milestones	B. Pull planning
C. Making scheduled tasks ready in lookahead planning	C. Constraints analysis, Task Breakdown, Operations Design, Replanning
D. Selecting tasks for daily and weekly work plans	D. Commit only to tasks that are well defined, sound, sequenced and sized

Last Planner Fundamentals

WHAT

E. Making handoffs reliable
F. Learning from broken promises
G. Measuring planning system performance
H. Measuring project performance

HOW

E. Reliable Promising
F. 5 Whys, Prevent-Detect-Correct-Analyze, Plan-Do-Check-Act
G. Percent Plan Complete, Tasks Made Ready, Tasks Anticipated, Commitment Level
H. Milestone Variance, Percent Required Tasks Complete, Commitment Level

Key Points

1. Systems executed by people are social as well as technical.
2. As opposed to the traditional view that people are what screw up otherwise perfect systems, people are what make systems work.
3. Reliable promising is the social glue in human systems.
4. But you can't make a promise if you can't say "no".
5. And being able to say "no" requires accepted rules of behavior to which everyone in the system can appeal.
6. Last Planner is an example of a management system that integrates the technical and social.

We have a few minutes for comments and questions. If we run out of time, send me your questions and I will try to answer them

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