LEAN PROJECT DELIVERY THROUGH DESIGN-BUILD

Presented to Arizona State University DBIA Student Chapter
Co-sponsored by DBIA Arizona Chapter and LCI Arizona CoP
February 24, 2015

In the Beginning…

Why Did San Diego Community College District Start Its Lean Journey?

+ 80 percent

Built Environment

(+1.6M square feet)

Operating Budgets

(-US$46M)

-16 percent

What our team heard?

Let's Think!!!

Current State

Source:

Kent Business School | Centre for Value Chain Research (VCR)

www.kent.ac.uk/kbs/applied-research/vcr

Current State

Future State

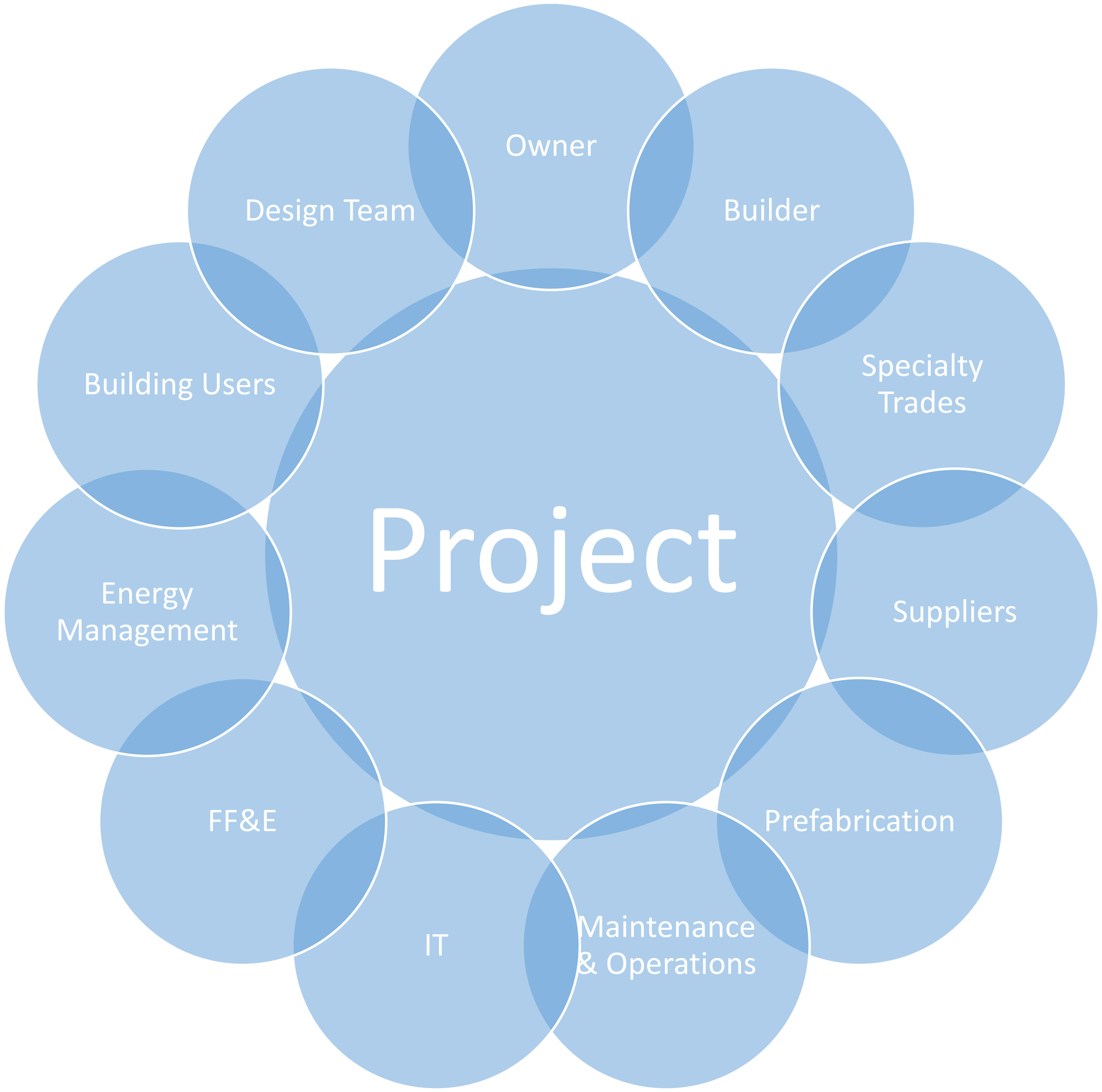
Source:

Kent

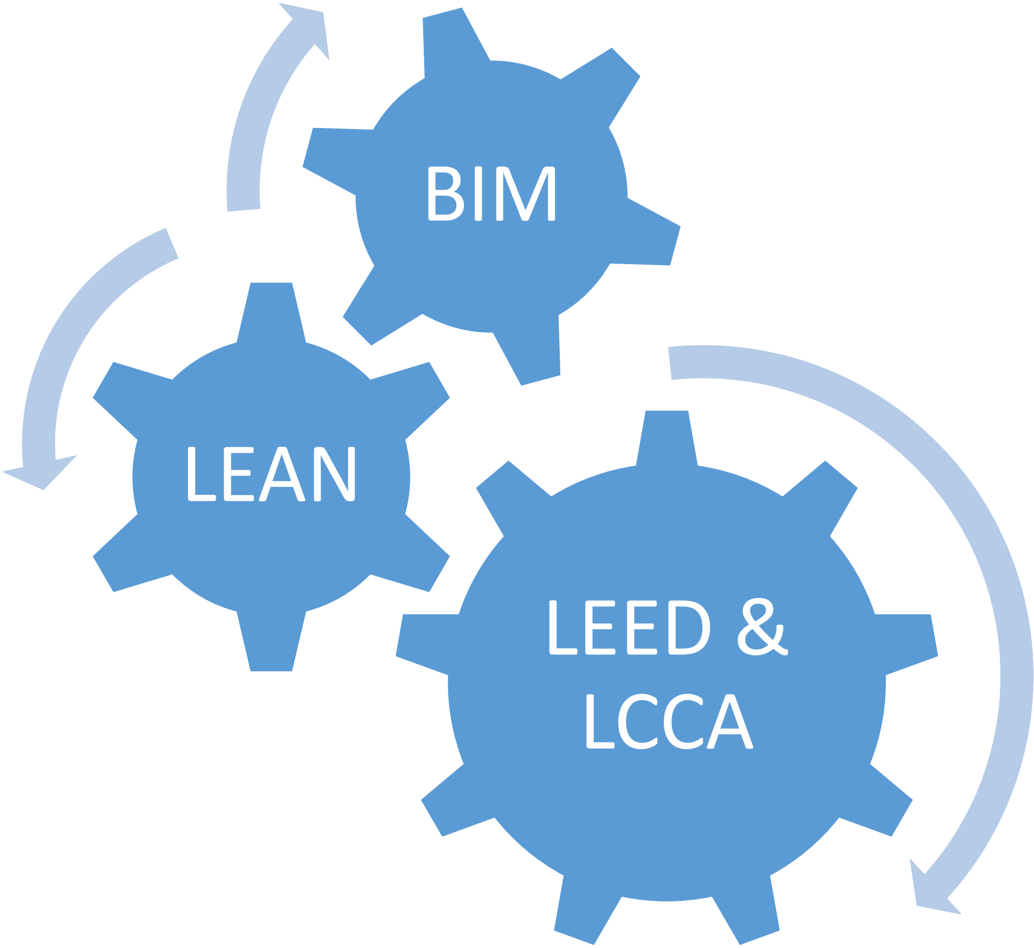
www.kent.ac.uk/kbs/applied-research/vcr

Current State

Desired State



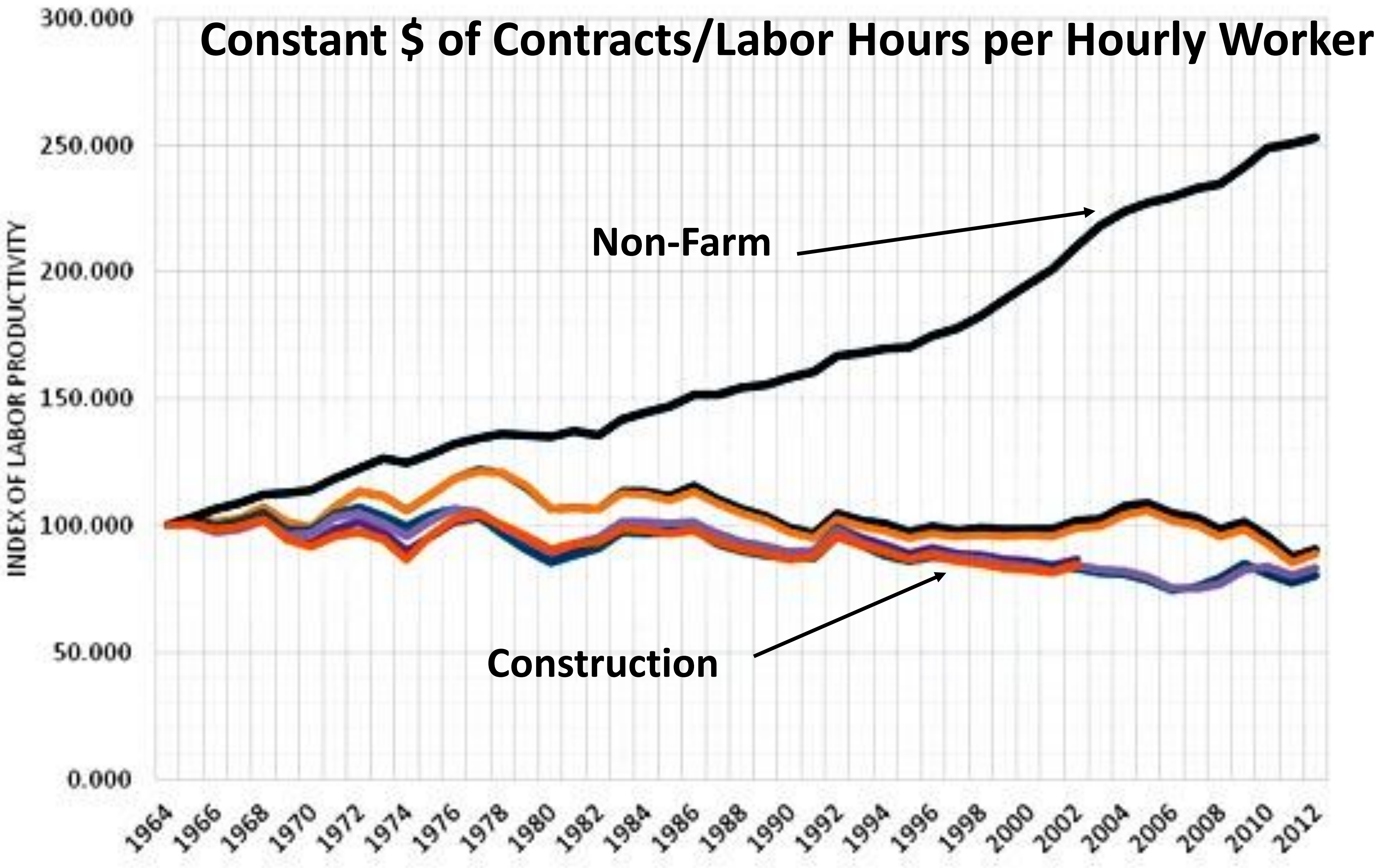
How to Get a Better Project…



Use Design-Build to Foster Lean Behaviors

Lean Fundamentals

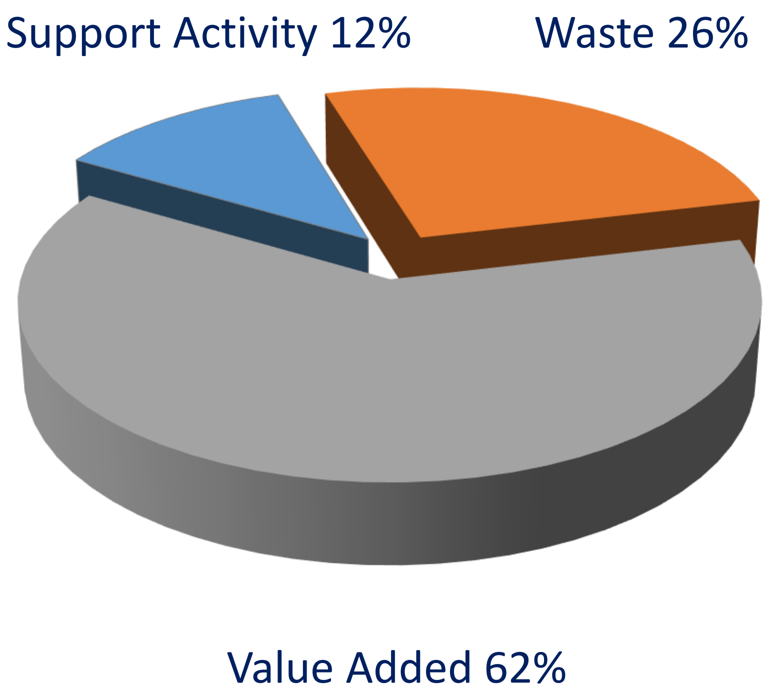
Constant $ of Contracts/Labor Hours per Hourly Worker



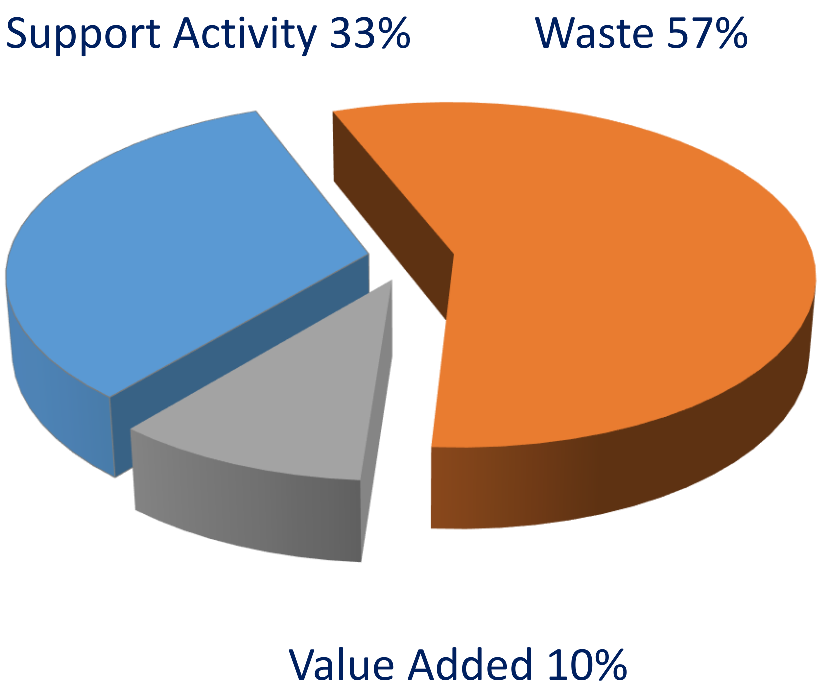
From: Teicholz (2013)

Construction Labor Waste in the U.S.

Current Manufacturing



Current Construction



Source: Construction Industry Institute

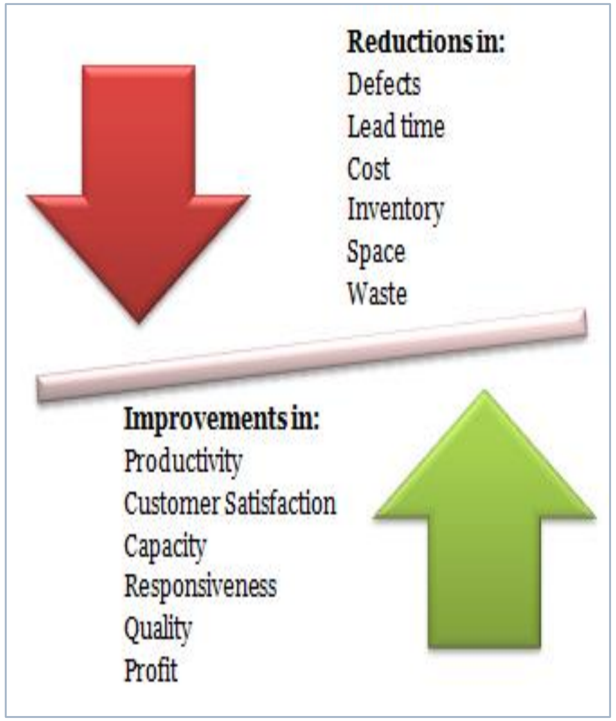
Lean Construction Institute
Transforming Design and Construction

What is Lean Construction?

Lean Construction is a production management-based approach to project delivery to maximize value and minimize waste. - *Lean Construction Institute*

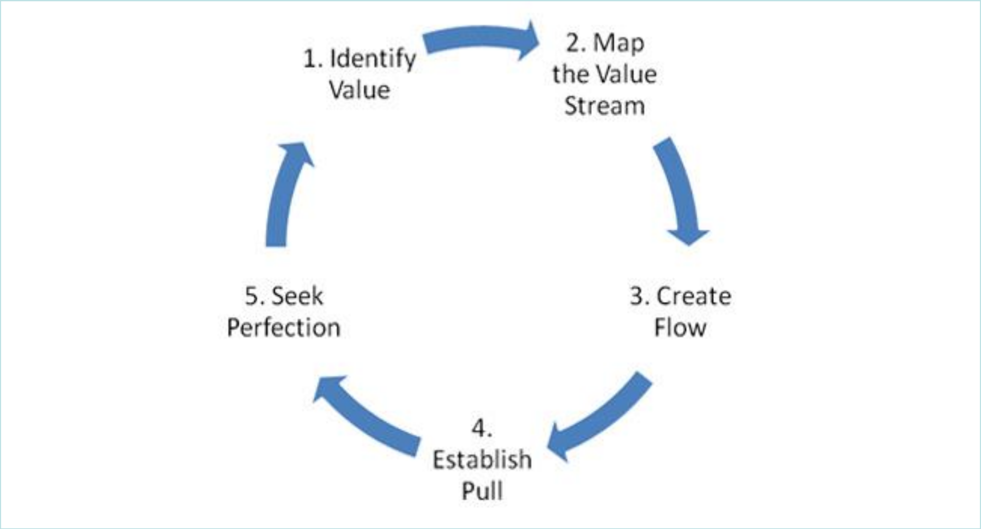
Lean Philosophies

- **Define customer value**
- **Identify and remove waste**
- **Innovate and perfect**



Value

- **Value is defined by the owner**
- **Value is not cost**



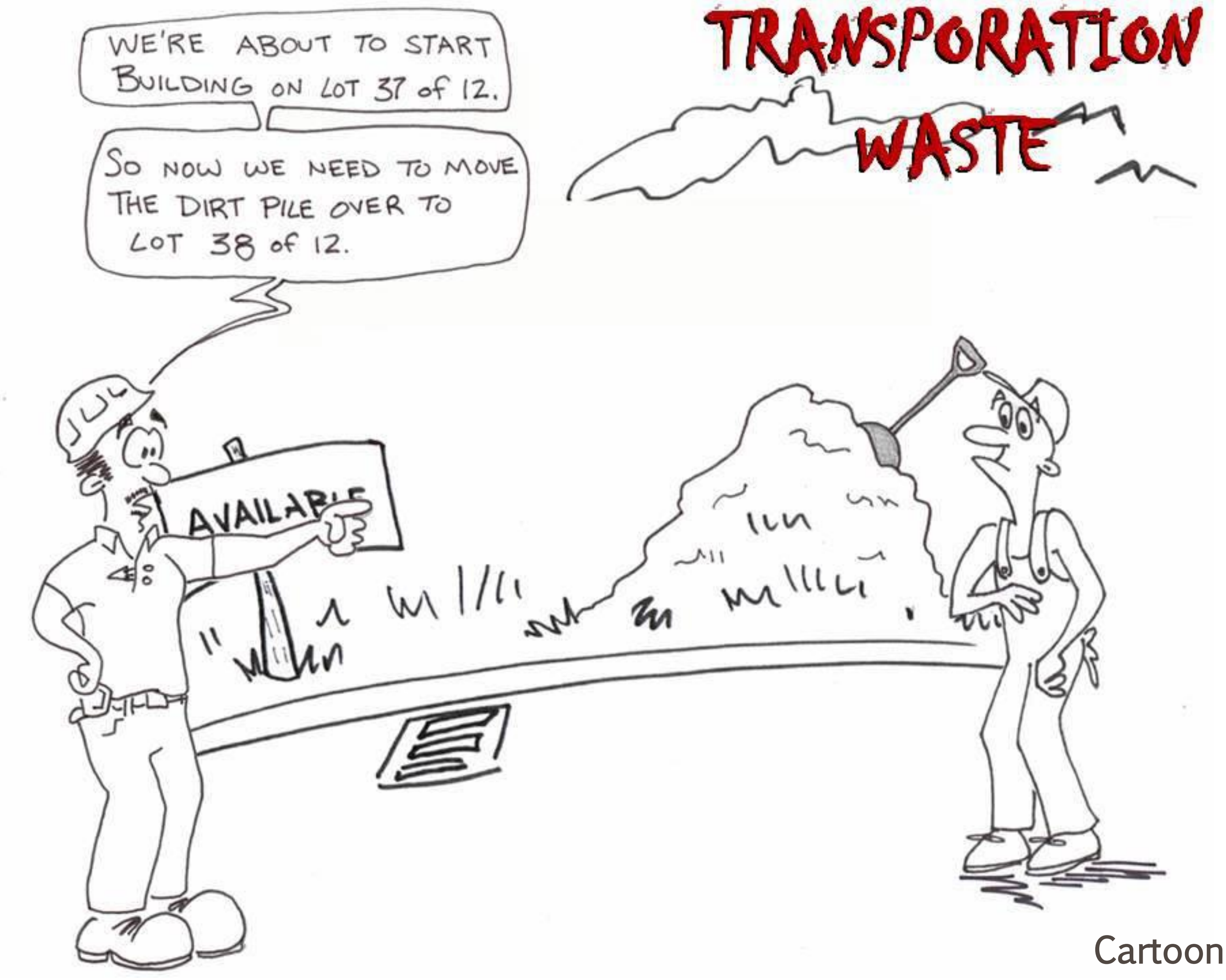
Courtesy: Southland Industries

The Eight Wastes as Defined by Toyota (and Liker)

1. Overproduction
2. Waiting
3. Unnecessary transport
4. Over-processing
5. Excess inventory
6. Unnecessary movement
7. Defects
8. Unused employee creativity

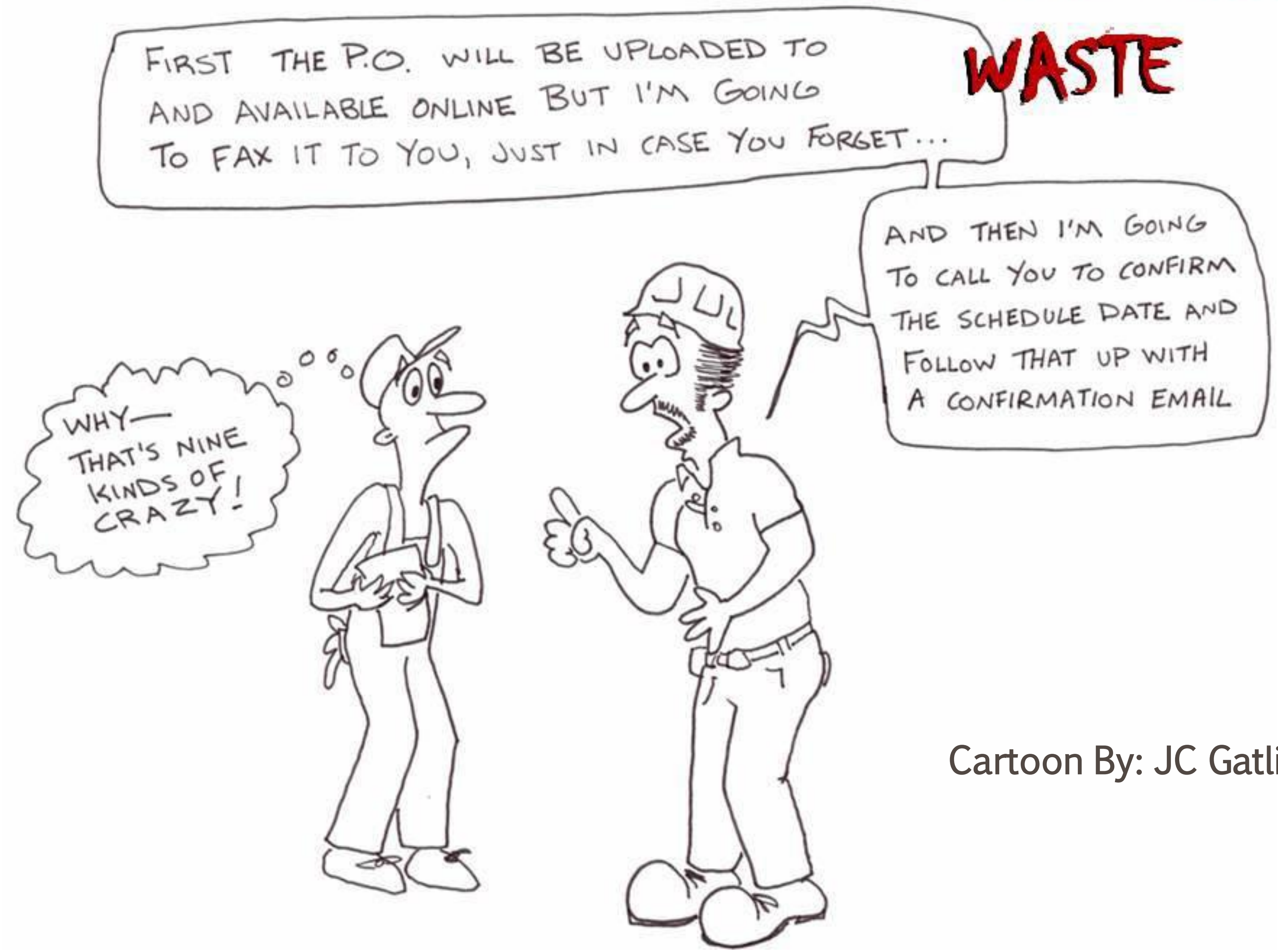
OVER - PRODUCTION WASTE

WAITING WASTE



Cartoon By: JC Gatlin

OVER-PROCESSING WASTE



Cartoon By: JC Gatlin

INVENTORY WASTE


MOTION WASTE
IT'S HERE... TRUST ME. Its IN THE PERMIT BOX NEXT TO THE BLUE PRINTS BEHIND THE DELIVERY TICKETS.
OH WAIT... THAT'S THE NOC. IT'S HERE, SOMEWHERE...
ADDRESS
LOT + BLOCK
©JC Gatlin June 2010

CORRECTION WASTE

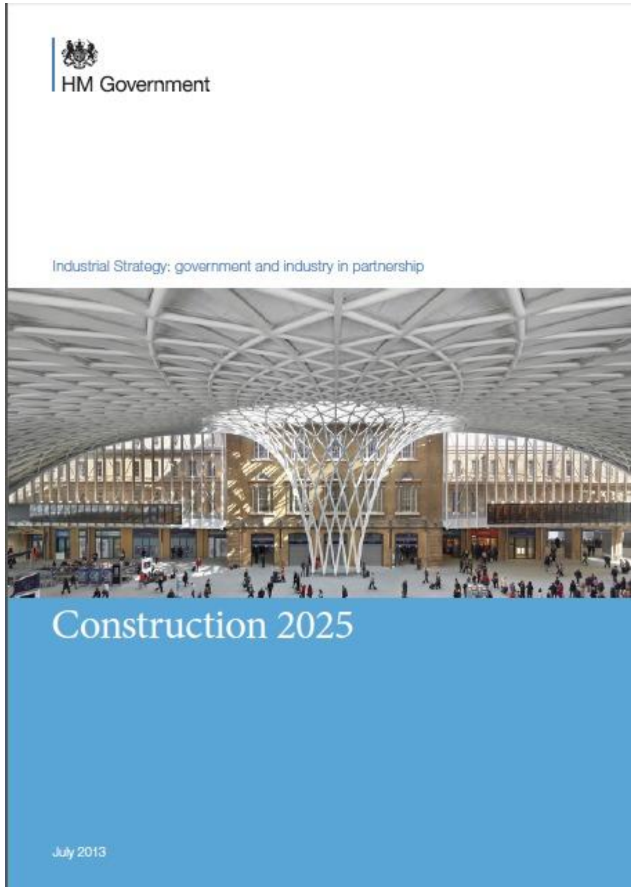
Typical Types of Design Waste:

- Iterative Design
- Rework
- Lack of Coordination Between Disciplines
- Inefficient work flow
- Over design of systems (diversity and factors of safety)
- Poor design that generates waste during construction
- Designing over allowable budget

Typical Types of Construction Waste:

- Rework
- Requests for Information
- Change orders
- Inadequate Resources
- Inefficient work flow
- Workarounds
- Multiple handling of material
- Excess material
- Waiting on supplies
- Waiting on another trade
- Safety losses
- Improper sequencing of work

UK Construction 2025 Goals



https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/210099/bis-13-955-construction-2025-industrial-strategy.pdf

UK Construction 2025 Goals

Lower costs

33%

reduction in the initial cost of construction and the whole life cost of built assets

Faster delivery

50%

reduction in the overall time, from inception to completion, for newbuild and refurbished assets

Lower emissions

50%

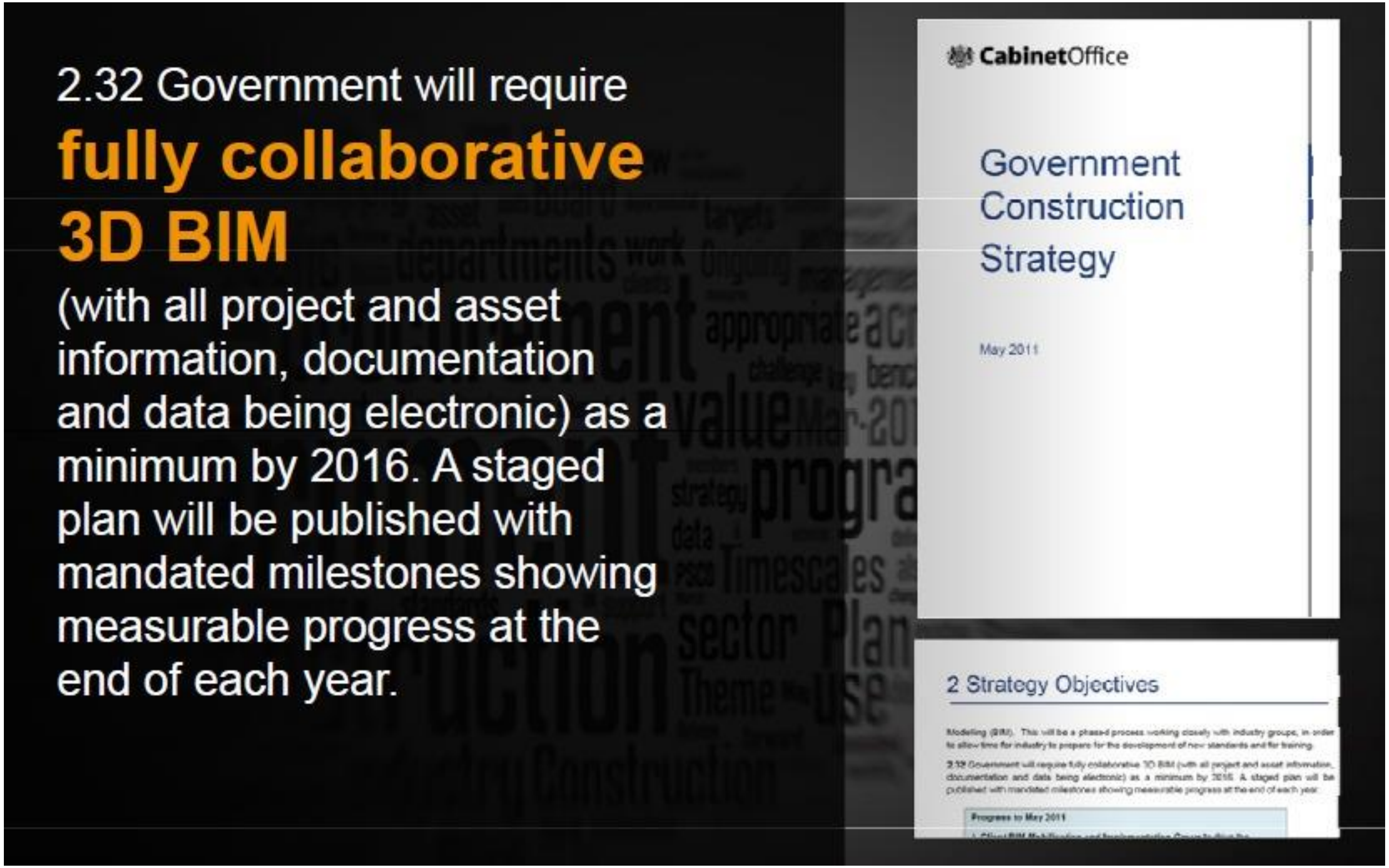
reduction in greenhouse gas emissions in the built environment

Improvement in exports

50%

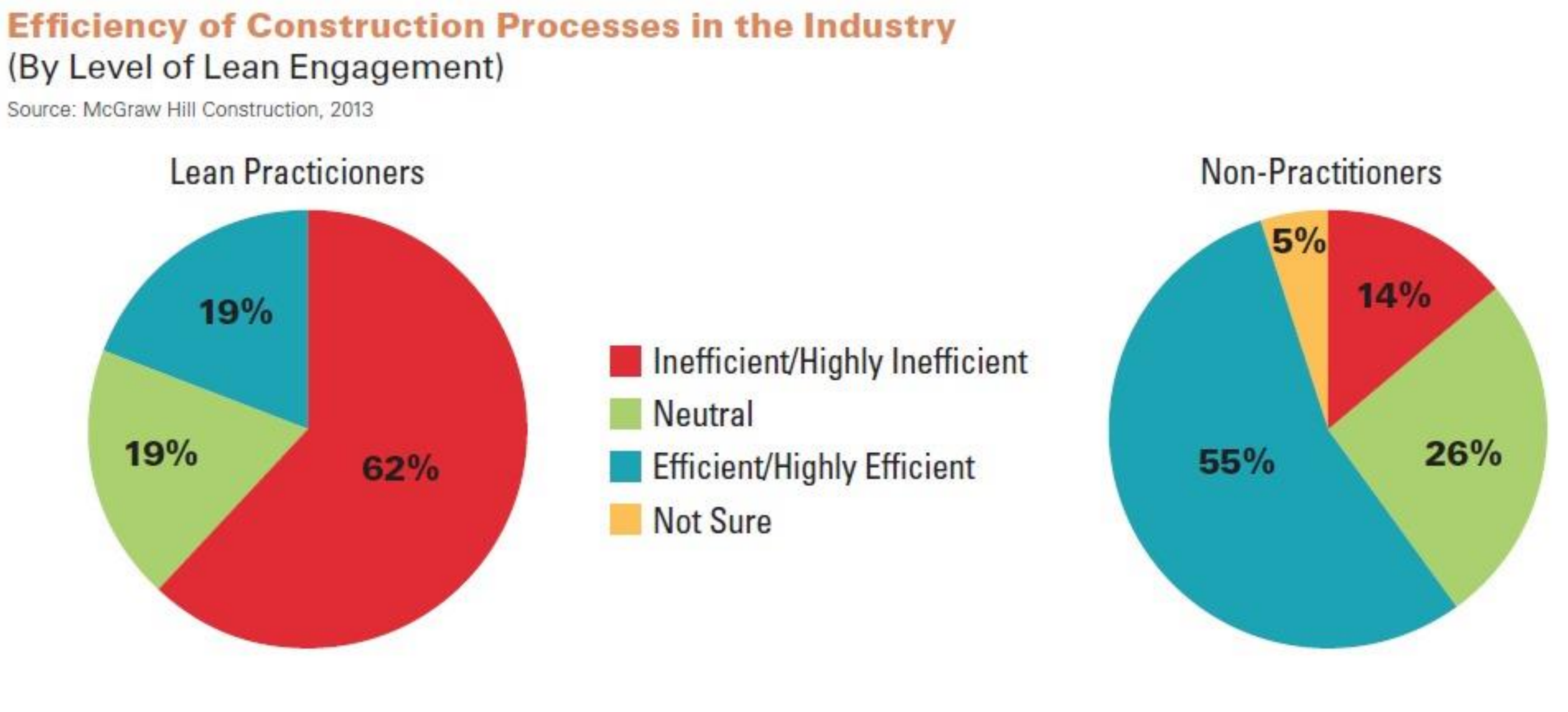
reduction in the trade gap between total exports and total imports for construction products and materials

UK BIM Goals



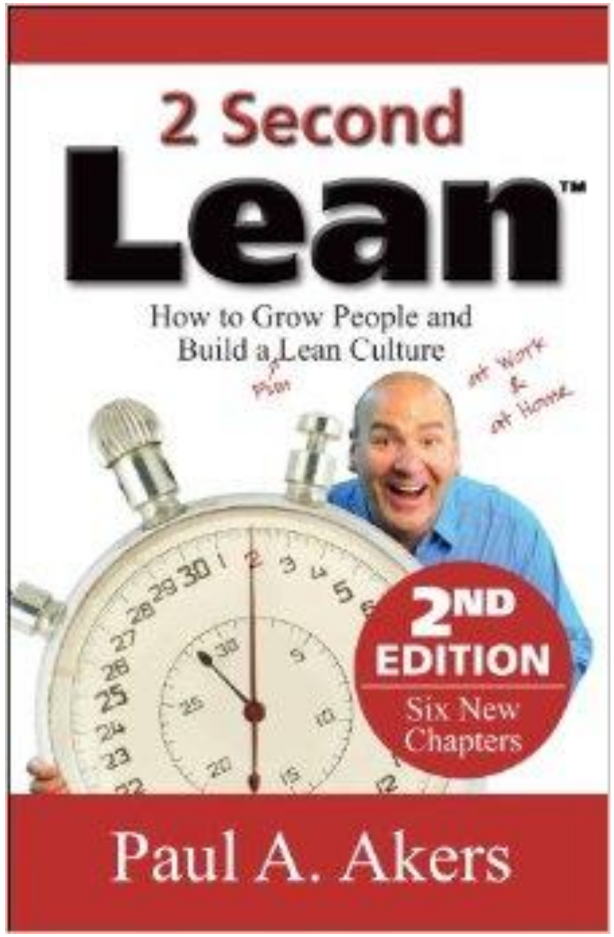
2.32 Government will require
fully collaborative
3D BIM
(with all project and asset information, documentation and data being electronic) as a minimum by 2016. A staged plan will be published with mandated milestones showing measurable progress at the end of each year.
CabinetOffice
Government
Construction
Strategy
May 2011
2 Strategy Objectives

Perceptions of Efficiency in Our Industry



Source: McGraw-Hill SmartMarket Report (2013)

2-Second Lean (A Guide)



“Fix What Bugs You” – Paul Akers

Who is Going Lean?

BROWN

Sutter Health
With You. For Life.

Melbourne Water

SAN DIEGO STATE

UHS

intel

Walt Disney Imagineering

UCSF
University of California San Francisco

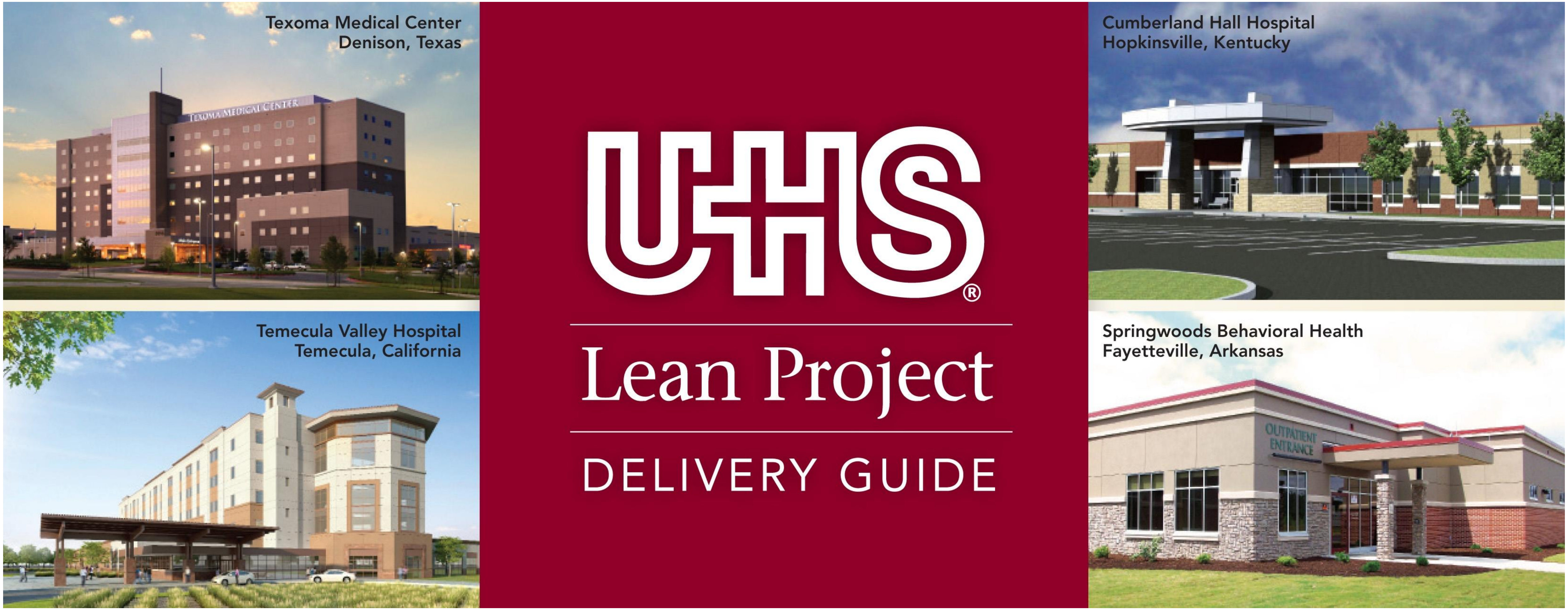
San Diego Community College District

W

Penn
University of Pennsylvania

The University of Chicago

AMGEN



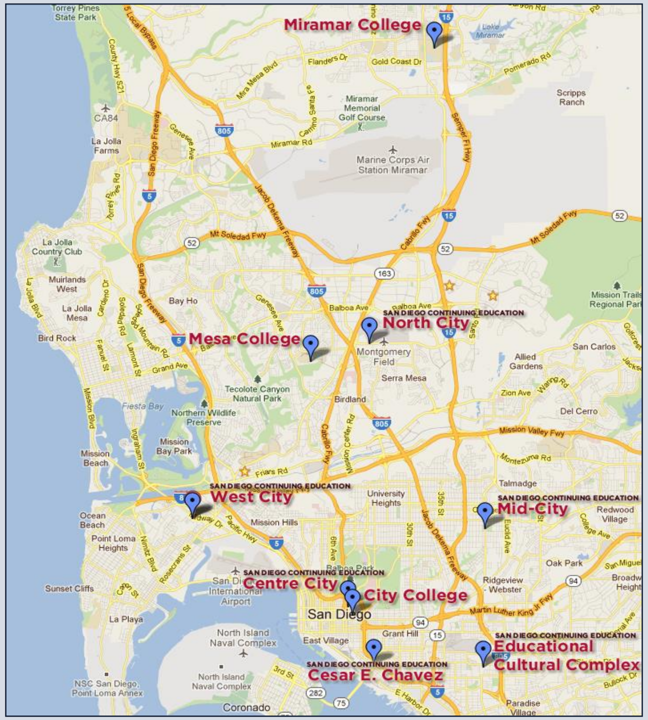
http://www.leanconstruction.org/training/lean-project-delivery-guide/

San Diego CCD Lean Practices

San Diego Community College District (SDCCD)

Overview

- **The Second Largest Community College District in California – Serving 130,000 students**
- **Sixth Largest in Nation**
- **Three Colleges - City, Mesa and Miramar**
- **Six Continuing Education Campuses**
- **$1.555 B Locally Approved Capital Bonds**

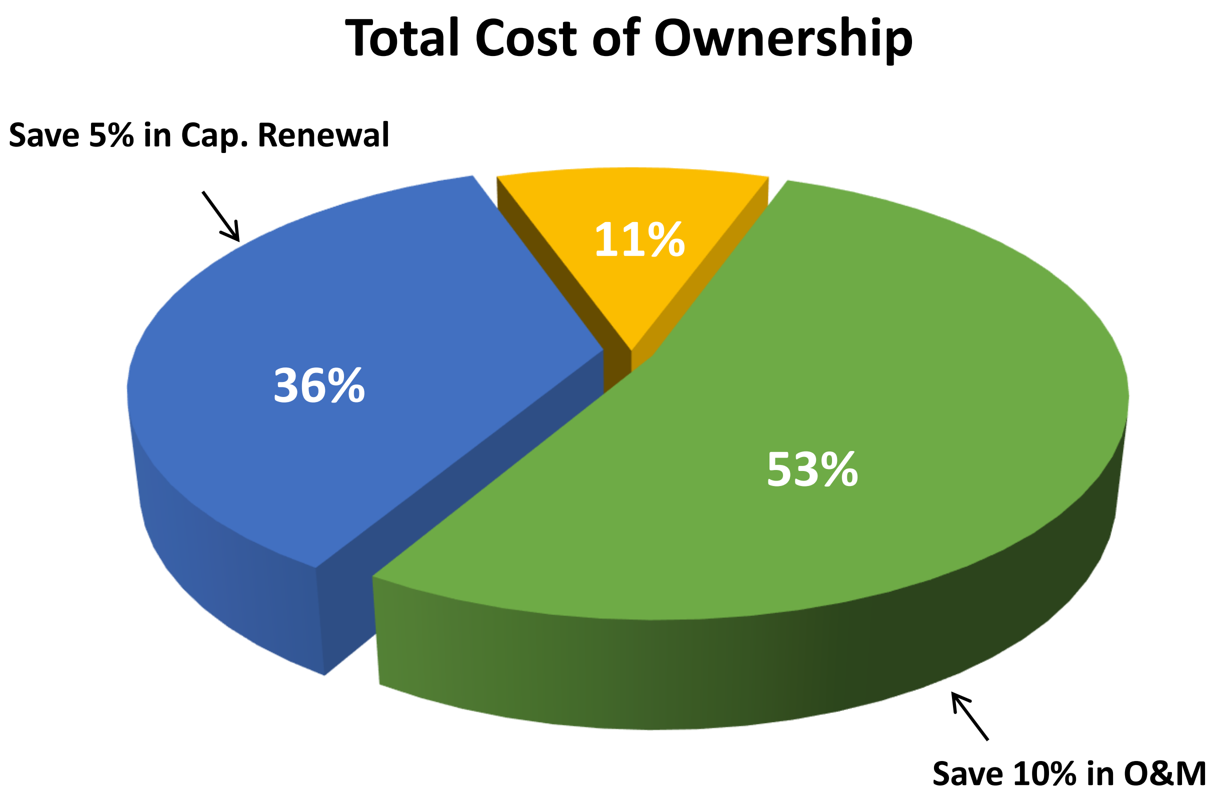


City College **Mesa College** **Miramar College** **Continuing Education**

Total Cost of Ownership

- 50-year design life
- 100,000 square foot classroom building
- Design and construction cost - $30 million
- Capital Renewal: 2% of current replacement value (APPA benchmark)
- O&M Budget $5.69/square foot
- Inflation: 3%

Total Cost of Ownership



Savings

D&C:	$30M	Total	NPV
Cap. R.:	$101M	$ 5M	$1.1M
O&M:	$149M	$15M	$3.4M
Total:	$280M	$20M	$4.4M

Early (and continued) Attitudes Toward Lean

Credit: Lean Construction Institute

- We've tried that.
- We already do that.
- We don't need it.
- It won't work here.
- We don't build cars.
- We're different.
- The other guy needs it, not me.
- We're doing well, so why change?

Use of Lean Tools in Capital Project Delivery

1. Target Value Design
2. A3 Problem Solving and Reporting
3. Set-Based Design
4. Value Stream Mapping
5. Building Information Modeling (BIM)
6. The Last Planner™ System

Defining Values for SDCCD

- Enhance the student experience
- Flexibility in design to accommodate future changes in pedagogy
- Lower total cost of ownership
- Highly energy efficient buildings
- Reduce maintenance and operations costs
- Meet or exceed sustainability objectives

Value-Waste Nexus

- How to create value within fixed monetary constraints?
- Eliminate waste
- Enhance value with the savings from waste reduction

Public Owner Benefits

Reduced Waste in Project Delivery + Sustainable Buildings + Reduced Total Cost of Ownership = Enhanced Value

How to get there?

Design-Build Using Target Costing

Design/Build Statute in California for CCS

- **As of January 1, 2008, Community Colleges can use design build under SB614.**
  - Must be at least $2.5M in value
  - Requires project-specific Board resolution
- **Need to evaluate the project based on five minimum criteria.**
  - Price (10%)
  - Technical Experience (10%)
  - Life cycle cost over 15 years (10%)
  - Skilled Labor Force (10%)
  - Safety Record (10%)

Integrated Project Delivery Charter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Integrated Project Delivery Charter

SDCCD North City Campus Parking Structure

We, the Design Build Team for the SDCCD North City Campus Parking Structure, will be utilizing the Integrated Project Delivery (IPD) model for the design and construction of this project to integrate the people, systems, business structures, and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste and maximize efficiency through all phases of design, fabrication, and construction.

We, the undersigned, agree to achieve this mission by implementing the following objectives:

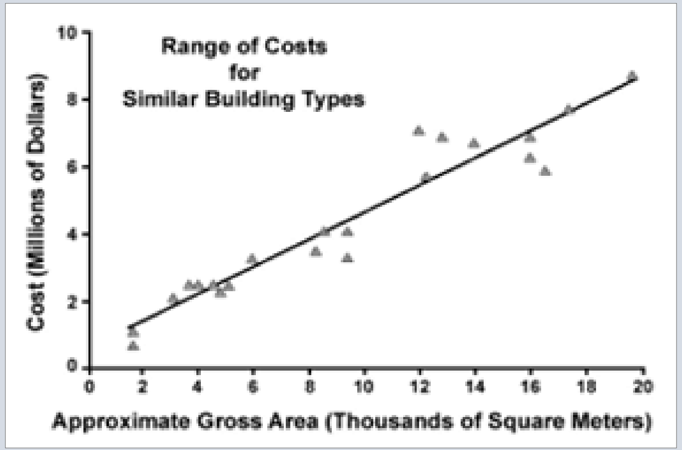
- **Mutual Respect and Trust** – we agree to foster an environment that promotes collaboration, and we are committed to working as a team in the best interests of the project.
- **Mutual Benefit and Reward** – we agree to a shared contingency and a shared savings to breakdown the silo mentality and reward a "what's best for the project" behavior.
- **Collaborative Innovation and Decision Making** – we agree to a team decision making structure where major decisions are made objectively and unanimously.

Legacy Building Services

NTD Architecture

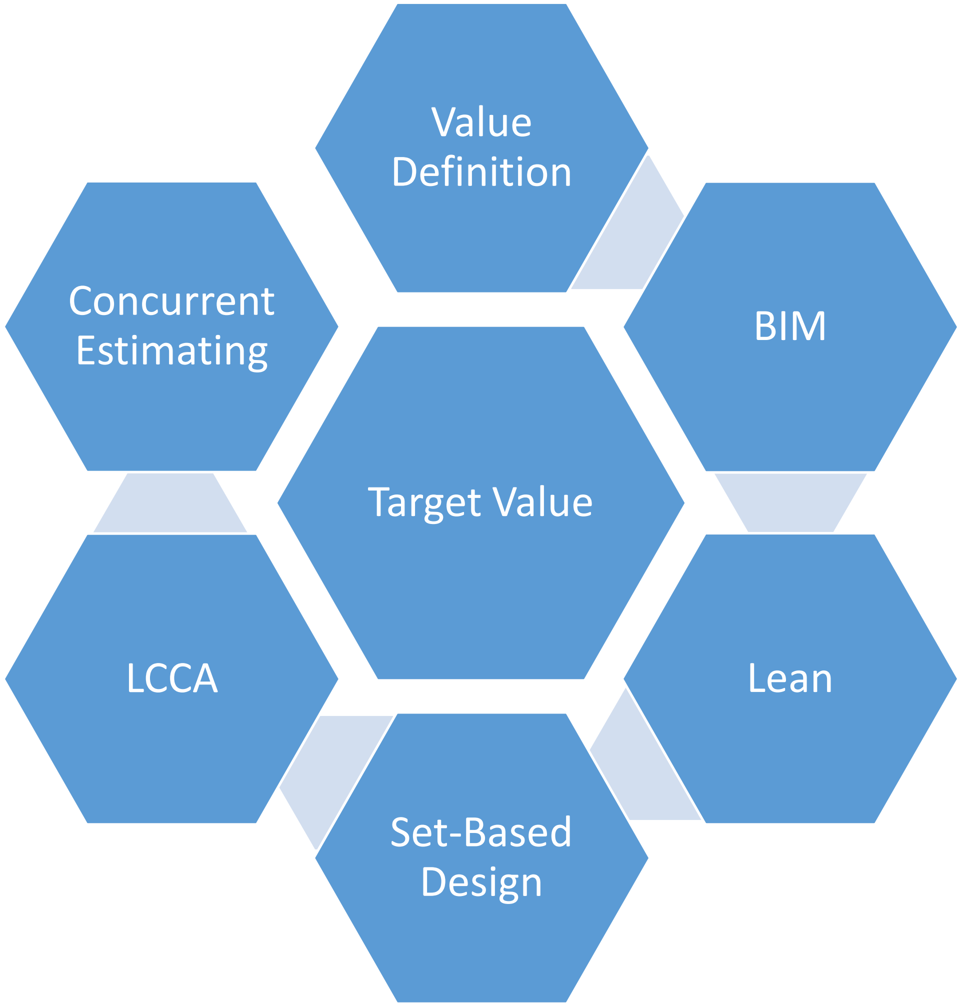
Target Costing - Project Budget Development

- Space Programming
- Space Efficiency
- Targeted Cost Per Sq. Ft.



		SPACE DESCRIPTION	2024 ASF	Quantity	Extended 2024 ASF	Extended 2007 ASF	Variance	2007 Room Nos., Comments
BUILDING	Life Sciences	32-Seat Dry Lecture/Lab-Biology	1,600	x 1.0	1,600	836	764	*supplements* A202
		32-Seat Wet Lab-Biology/Botany	1,728	x 1.0	1,728	1,092	636	*supplements* A210
		32-Seat Wet Lab-Biotech/Microbiology	1,728	x 3.0	5,184	2,048	3,136	*supplement* A204, A231
		32-Seat Wet Lab-Physiology/Anatomy	1,728	x 3.0	5,184	1,834	3,350	*supplement* A226, A206
		32-Seat Lecture/Dry Lab-Life Science (computer)	1,600	x 1.0	1,600	1,053	547	*supplements* A207
		Prep/Stg/Lab Tech Rm (1 per 2 wet labs; 7 wet labs total)	800	x 4.0	3,200	1,232	1,968	*supplement* A203, A205, A226A
		Storage	1,200	x 1.0	1,200	0	1,200	*supplements* A206A, A209, A211
		Marine Biology/Oceanography Lab	500	x 1.0	500	0	500	Aquarium
		Microbiology Culture/Autoclave Room	200	x 1.0	200	0	200	
		Biology/Anatomy Dissection Room	200	x 1.0	200	0	200	
					20,596	**8,095**	**12,501**	
	Physical Sciences	32-Seat Wet Lab-Chemistry	1,728	x 4.0	6,912	3,018	3,894	M201, M202, M203
		Chemistry Lab Instrument Room (1 per 2 labs)	250	x 2.0	500	180	320	M220
		Chem. Prep/Storage/Lab Tech Rm (1 per 2 labs)	800	x 2.0	1,600	1,337	263	M216, M217, M218
		Hazardous Chemicals Storage Room	175	x 1.0	175	120	55	M219
		32-Seat Lecture/Dry Lab-Physics, Physical Science, Geography, Geology	1,600	x 4.0	6,400	2,014	4,386	M204, M205
		40-Seat Lecture/Dry Lab-Geography	2,000	x 1.0	2,000	0	2,000	
		Physics/Physical Science/Astronomy Prep/Stg/Lab Tech Rm	1,600	x 1.0	1,600	1,059	541	M214, M215, M215A
		32-Seat Computer Lab-GIS, Physics, Chemistry	1,600	x 2.0	3,200	0	3,200	
		100-Seat Planetarium	2,500	x 1.0	2,500	0	2,500	
					24,887	**7,728**	**14,659**	

Keys to Target Value



A3 Problem Solving – HVAC Design

A3 No	Title/Theme			Champion	Collaborator	Additional Collaborators		Sponsor	Customer Group	Sign-off
M-001	HVAC System Comparison: Chilled Water AHU, Package DX AC Units and GSHP's			David Dopudja	Don Harrisberger	Jim Horan				
	Discipline	Element	Date Opened	Path Forward Date	Category	*A3 Status*				
	Mechanical	HVAC Systems	12/7/2010	12/13/2010	N/A	Idea Development	Sponsor Identified	A3 Development	Customer Accepts	Integration

Section 1 - Background - Relevance of the topic to CPR Objectives & Values

Comparison of HVAC system options to determine which option has lowest life cycle cost and provides greatest benefit to the facility. Responding to the challenge to improve efficiency, increase reliability, reduce maintenance and help achieve LEED Silver. A facility of this size is typically served by a chilled water (CHW) system with central plant, underground distribution piping and 4-pipe (CHW/HW) air handling units. This analysis will compare the CHW system to systems based on package direct expansion (DX) rooftop air conditioning units and ground source heat pumps (GSHP).

- For the CHW system, heating hot water (HW) is supplied by boilers and pumps in the central plant via underground distribution piping.
- Heating for the package DX system is provided by gas furnaces within the rooftop package units.
- In the GSHP system, heating is provided by the heat pump cycle of the GSHP units. The GSHP system uses a closed loop system of plastic pipe buried in the ground (ground coupled) to allow heat transfer between the earth and fluid flowing through the pipes. This closed loop system transitions to metal pipe within the building(s) where it is connected to the condenser/evaporator heat exchangers in each GSHP unit.

Section 2 - Current Condition

Two 15,000 SF facilities located in San Diego CA. Life cycle cost analysis is for a period of 15 years using a .75% discount rate, a 2% escalation rate and a 1.2% inflation rate. Average energy rates of $0.09 / Kwh and $ 0.61 / therm are used.

Section 3 - Analysis

SHOULD CRITERIA

	Mechanical System Options	Schedule	First Cost	Life Cycle Cost	Efficency	Sustainability	Creativity/Innovation	Flexibility	Community	Maintenace	Total
	HVAC System										
1	Split System	+	+	0	0	0	0	+	0	0	3
2	Package System	+	+	0	0	0	0	+	0	0	3
3	HHW &CHW/ AHU, FCU	0	0	+	+	+	+	0	+	+	6
4	Ground Source Heat Pump	0	0	+	+	+	+	0	0	+	5
5	Water Source Heat Pump	0	0	0	+	+	0	0	0	0	2

+ Meets "Should" Criteria
0 Does Not Meet "Should" Criteria

Section 3 - Analysis

Option	Advantages
Chilled Water (Base Option)	1. Much longer equipment life 2. Much more energy efficient and existing CUP 3. Better temperature control and ability to use 100% OSA 4. Much better zoning options (ability for CO_2 zoning) 5. Much less noise disturbance (chiller and condenser noise distanced from sensitive areas or communities) 6. Less maintenance of equipment outside of CUP
Package/Split DX AC Units (Alternate 1)	1. More available 2. Much less UG distribution piping required (none)
Ground Source Heat Pumps (Alternate 2)	1. More energy efficient 2. Less utilities required (no gas required for heating) 3. More efficient (water source vs. air source) 4. More innovative (LEED point possible) 5. Much less sophisticated maintenance and operation than CHW

Section 4 - Unresolved Issues - Identify any problems or constraints that still exist

Need analysis of existing central plant capacities. Need further input from owner in the weighting of advantages.

Section 5 - Recommendations

Based on the current information at hand the option of chilled and hot water air handlers served by central plant is recommended.

Section 6 - Path Forward/Follow-up

1. Provide existing CUP capacities- Owner
2. Analyze existing CUP capacities - Don Harrisberger
3. Review weighting of advantages with Owner and entire team - Don Harrisberger
4. Confirm CHW (or final HVAC choice) meets budget - Dustin Smith
5. Proceed with /implement CHW (or final HVAC choice) - Don Harrisberger

A3 Problem Solving – Structural System Design

A3 No	Theme / Title			Champion	Collaborator	Additional Collaborators		Sponsor	Customer Group	Sign-off
S-001	Structural System Selection Comparison			Aldrin Orue	Jorge Rivera	Patrick Meek				
	Discipline	Element	Date Opened	Path Forward Date	Category	*A3 Status*				
	Structural	Framing	12/7/2010	12/13/2010	N/A	Idea Development	Sponsor Identified	A3 Development	Customer accepts	Integration

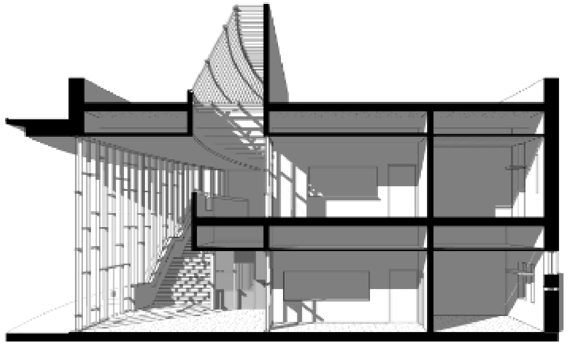
Section 1 - Background - Relevance to Project

Comparison of structural system options to determine which option is the most appropriate and efficient for the facility while meeting project goals of cost, schedule, and aesthetics.

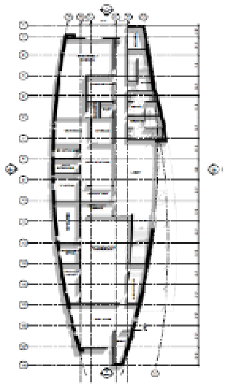
Section 2 - Current Condition

Two-story 15,000 SF facility located in San Diego CA with an open high bay lobby area. A facility of this size and type is typically constructed of a steel frame system due to the many advantages of steel as noted in the following sections below. A comparison analysis with other structural systems will be performed to make sure that advantages from other systems are not overlooked and properly evaluated.

Section 2 - Current Condition - Design



3D Section



Level 1 Floor Plan

Section 3 - Analysis

SHOULD CRITERIA

	Structural System Options	Construction Schedule	Flexibility	Durability (Life Cycle)	Cost	Sustainability	Sound Atuniation	Floor Vibration	Total
	Structural System								
1	Steel System	+	+	+	+	+	+	+	7
2	Concrete System	0	0	+	0	+	+	+	4
3	Masonry System	0	0	+	+	+	0	0	3
4	Wood	+	0	0	+	0	0	0	2

\+ Meets "Should" Criteria
0 Does Not Meet "Should" Criteria

Section 3 - Analysis

Option	Advantages
Steel	1. Lower Cost 2. More Flexible (modifications and attachments) 3. Faster Erection Time 4. Lighter System 5. Much More Accommodating in Architectural Design 6. More Durable Material 7. Better Sound and Floor Vibration Qualities 8. Easier Construction
Concrete / Masonry	1. Shorter Lead Time Required to Erect Superstructure 2. Much More Durable Material 3. Much More Thermal Mass 4. Much More Sustainable (Due to Local Resources) 5. Much Better Sound and Floor Vibration Qualities
Wood	1. Much Easier Construction 2. Shorter Lead Time 3. Much Lighter System

Section 4 - Unresolved Issues - Identify any problems or constraints that still exist

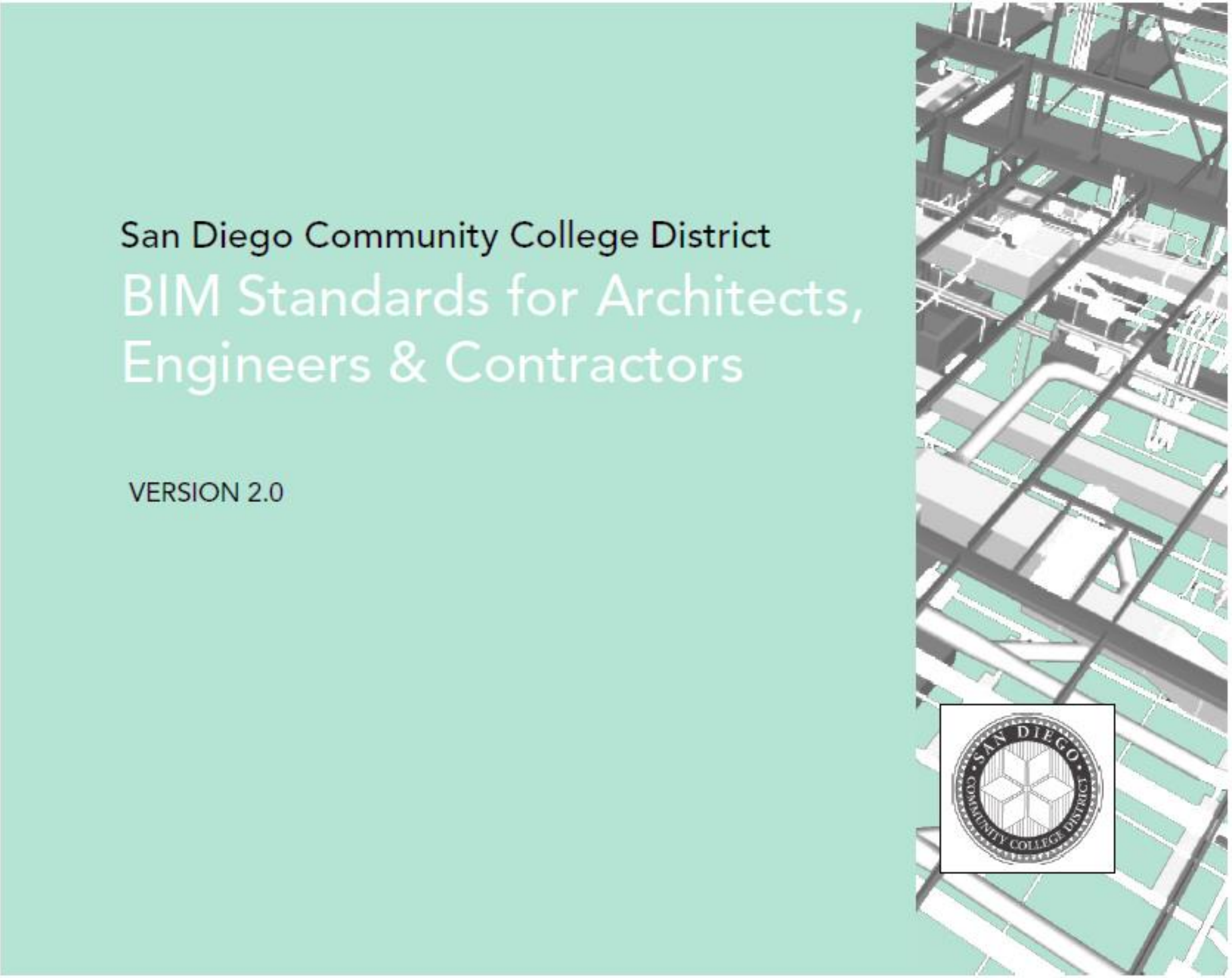
Need structural analysis to determine preliminary steel member sizes to confirm steel option.

Section 5 - Recommendations

Based on the current information at hand the option of a steel structural system is recommended.

Section 6 - Path Forward/Follow-up

1. Structural analysis to determine preliminary steel member sizes- Aldrin Orue
2. Confirm structural steel member sizes with budget - Dustin Smith
3. Confirm structural system selection with entire team and approve A3- Aldrin Orue
4. Incorporate/proceed with structural steel design- Aldrin Orue

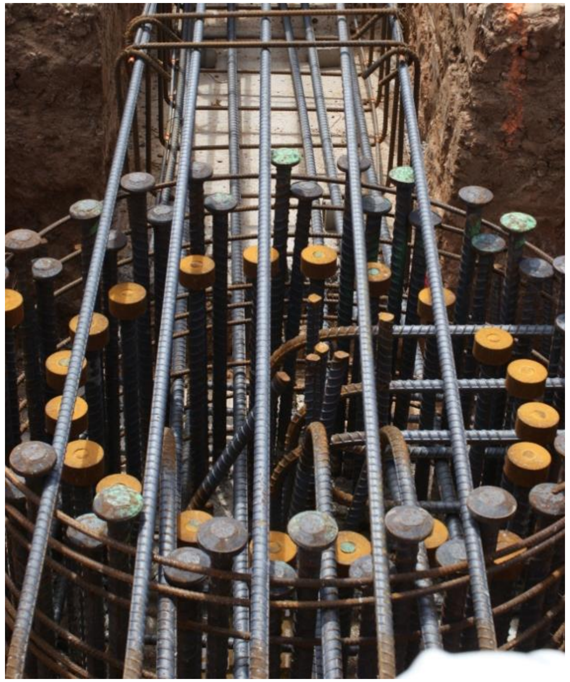

San Diego Community College District

BIM Standards for Architects, Engineers & Contractors

VERSION 2.0

http://public.sdccdprops-n.com/Design/SDCCD%20-%20Building%20Design%20Standards/SDCCD%20BIM%20Standards%20Version%202.pdf

Which Design Would You Want?



Is Critical Path Method Scheduling Obsolete?

Schedule Performance

- SDCCD Experience:
  34 Major Projects with CPM Scheduling
  4 (**12%**) finished on time
- UC System Experience in past 10 years: More than 30% of projects delayed by more than 90 days
- Research by Glenn Ballard and Greg Howell indicated only 54% of planned weekly activities get completed on average.
- Last Planner® pull system – a better way
  (typically 80-90% percent promises kept)

Last Planner® System

Who are the Last Planners?

The foremen and superintendents

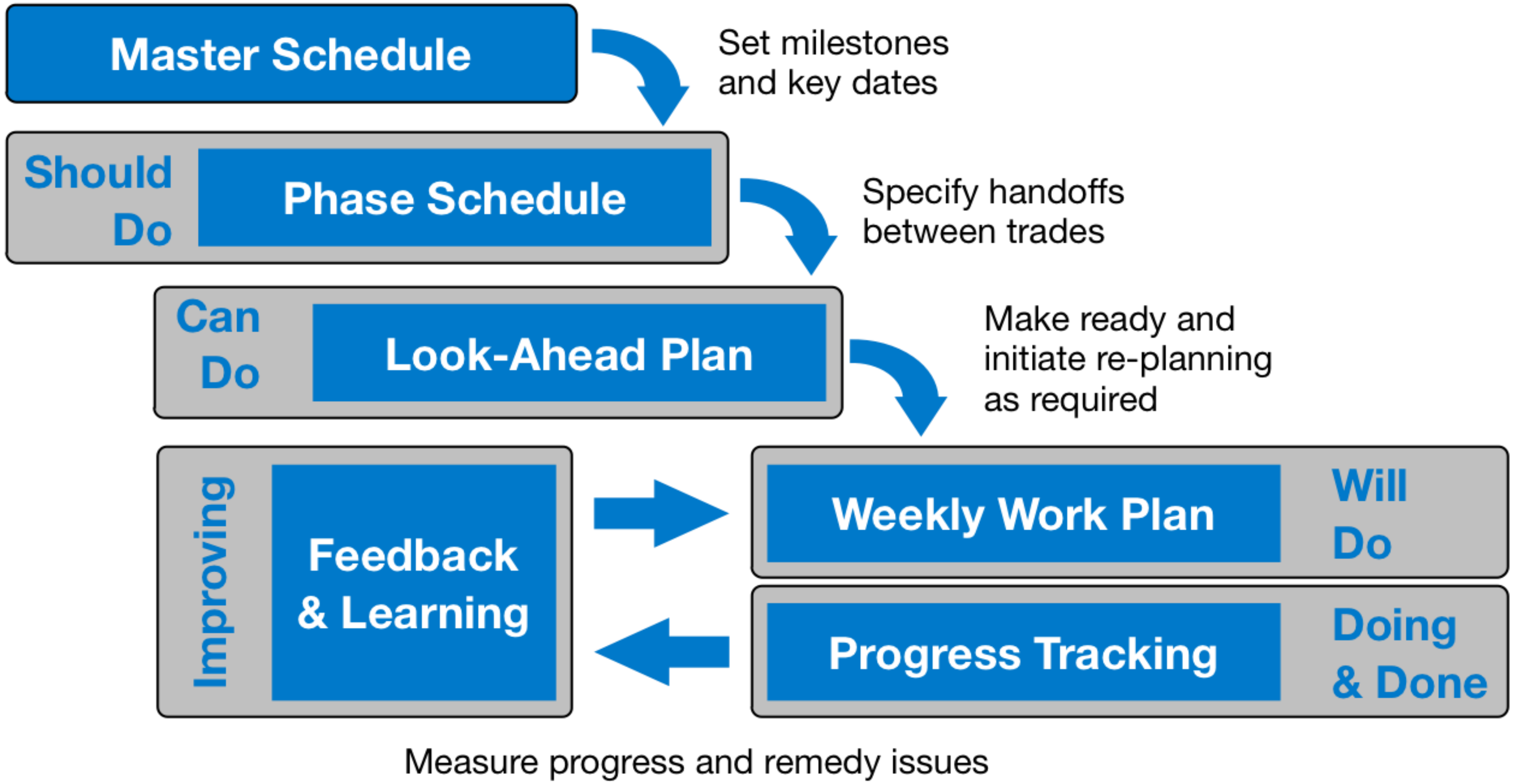
5 Major Elements of System

1. **Master Scheduling** – setting milestones
2. **Phase (Pull) Planning** – specifying handoffs
3. **Make Work Ready Planning** – 6 week look-ahead
4. **Weekly Work Planning**
5. **Learning** - Measure Percent Promises Complete, conduct root cause analysis and act on reasons for failure to keep promises

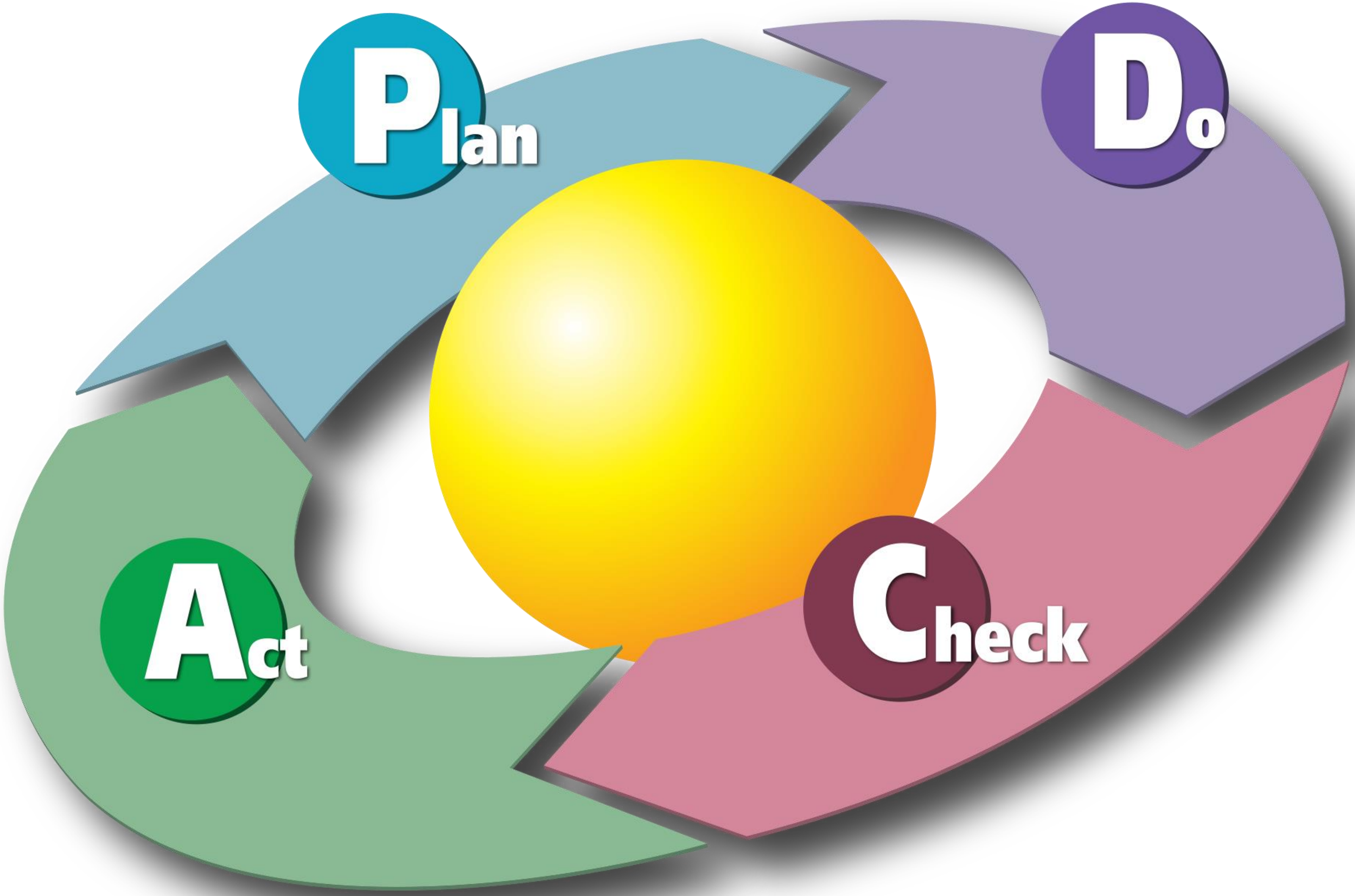
Last Planner® System Principles

1. All plans are forecasts and all forecasts are wrong. The longer the forecast the more wrong it is. The more detailed the forecast, the more wrong it is.
2. Plan in greater detail as you get closer to doing the work.
3. Produce plans collaboratively with those who will do the work.
4. Reveal and remove constraints on planned tasks as a team.
5. Make reliable promises.
6. Learn from breakdowns.

Last Planner System

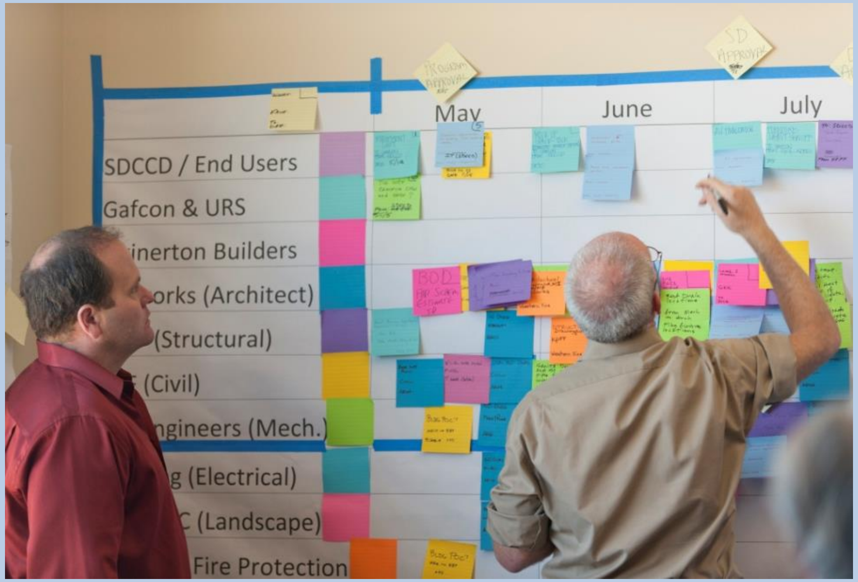


Source: Adrian Smith (2011)


Plan
Do
Check
Act

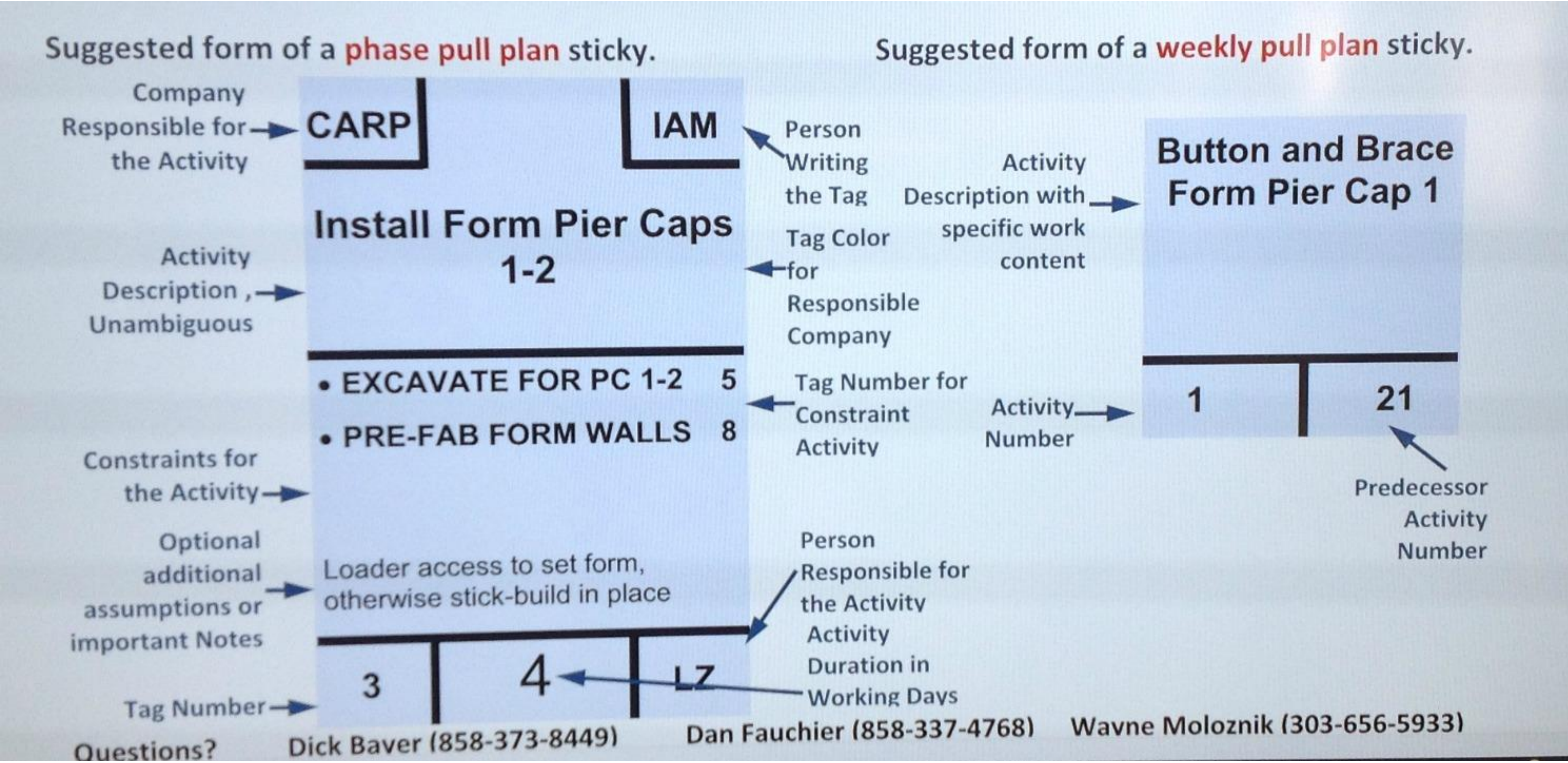
Pull Planning

“Start with the end in mind.” – Steven Covey



Pull Planning Activities


Resp. Party
Preparer
Activity
Constraint 1
Tag #
Constraint 2
Tag #
Tag UID
Total Duration
P3/P6 Act. ID



Suggested form of a phase pull plan sticky.
Suggested form of a weekly pull plan sticky.
Company Responsible for the Activity
CARP
IAM
Person Writing the Tag
Install Form Pier Caps 1-2
Activity Description , Unambiguous
Tag Color for Responsible Company
• EXCAVATE FOR PC 1-2 5
• PRE-FAB FORM WALLS 8
Tag Number for Constraint Activity
Constraints for the Activity
Optional additional assumptions or important Notes
Loader access to set form, otherwise stick-build in place
Person Responsible for the Activity
Activity Duration in Working Days
3
4
LZ
Tag Number
Activity Description with specific work content
Button and Brace Form Pier Cap 1
Activity Number
1
21
Predecessor Activity Number
Questions? Dick Baver (858-373-8449) Dan Fauchier (858-337-4768) Wayne Moloznik (303-656-5933)

Milestone Planning Design Phase

Pull Planning – 6 Week Lookahead

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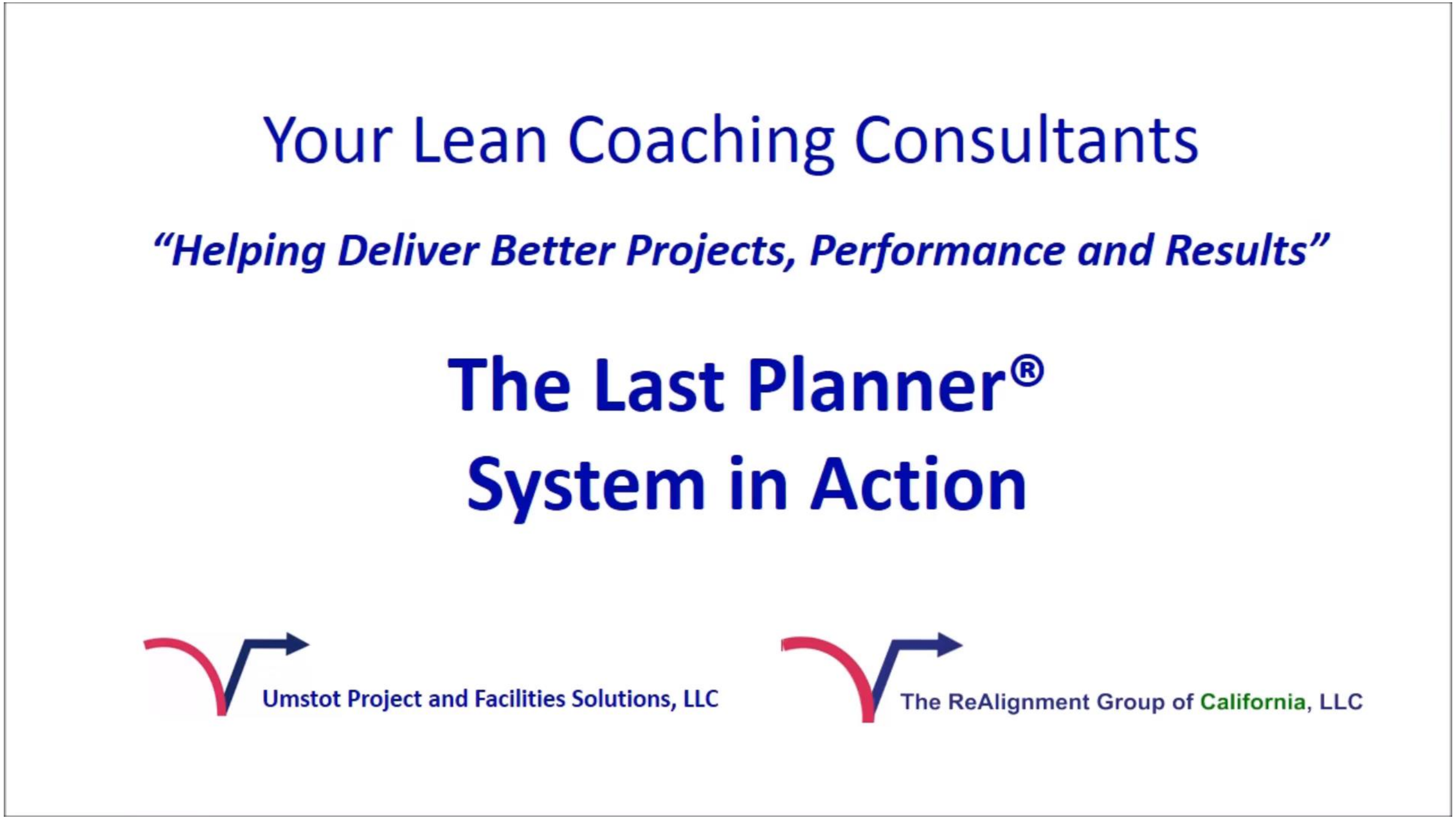
Pull Planning – 6 Week Lookahead

How is the lookahead within Last Planner® different from traditional lookahead schedules?

- Traditional lookahead schedules are used to provide advance notice of activity starts in the service of sticking to a usually quite detailed master schedule.
- Traditional lookahead schedules do not:
  - Shape work flow sequence and rate
  - Match work flow and capacity
  - Maintain a backlog of ready work
  - Develop detailed plans for how work is to be done

Source: LCI (2009)

https://www.youtube.com/watch?v=i4VAyKjMMYg



San Diego CCD Metrics Discussion

Wouldn't It Be Nice If You Could...

Average Savings of $900,000 on each of 15 projects

Reduce Average Schedule Delay by 56 days

Enhance Sustainability Objectives by 44%

Reduce Facilities Maintenance Costs by 53%

By the Numbers – The Database

35 COMPLETED PROJECTS

US$584M CONTRACT VALUE

8000 CHANGE ORDERS

Change Order Analysis

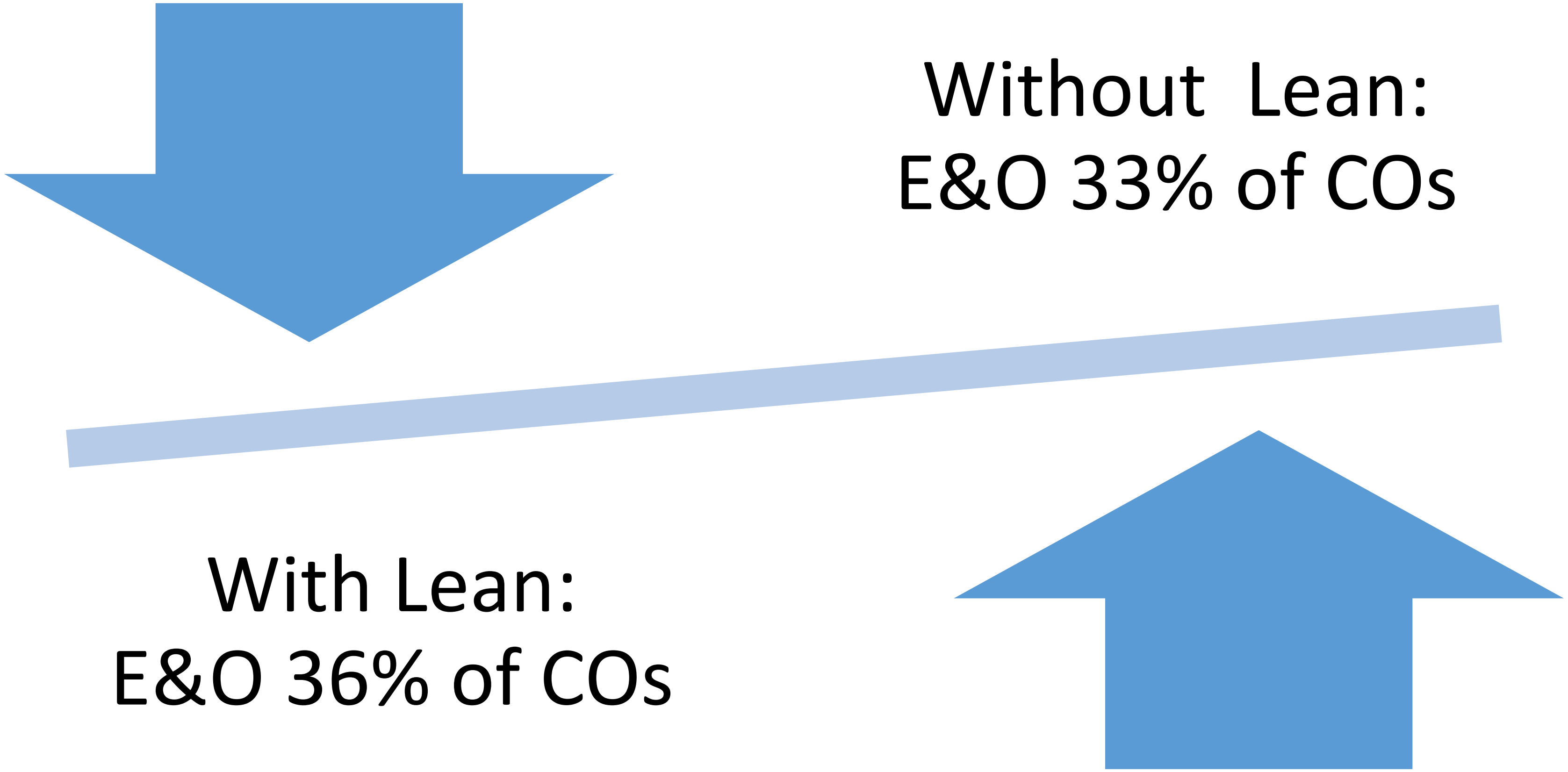
Pre-Lean

- 7.73% Total COs
- 2.99% E&O COs

Post-Lean

- 4.43% Total COs
- 1.88% E&O COs

Interesting Finding



Who is on Time?

Pre-Lean

- 1/19 (5%)

Post-Lean

- 3/15 (20%)

San Diego CCD Schedule Impacts – Lean (with BIM) vs. No Lean or BIM (20 projects)

Average Delay (All Contract Types)

Lean w/ BIM: 25 days (n=8)

Pre-Lean w/o BIM: 80 days (n=12)

Target Costing

11 Projects

Avg. Value:

US$21.8M

83% Met Target Cost; Avg. 7% Below Target Cost

Target Value Design

- Six projects evaluated
- Range of GMP: $4,707,408 to $50,423,353
- Average: $21,768,648
- 5/6 (83%) met target budget
- Averaged 7% under target budget

Target Value Design – Root Cause Analysis

- Lack of contemporaneous estimating and exclusion of specialty trades from early participation in project resulted in project exceeding target budget
- Counter measure: All subsequent projects required presentation of budget first

Potential Sustainability Features

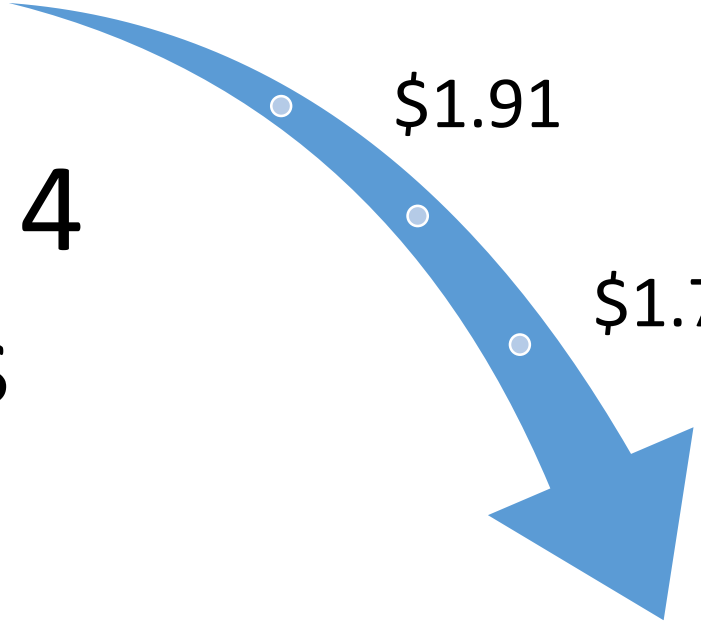
- Higher building energy efficiency
- Extensive use of daylighting
- Use of natural ventilation tied to EMS
- Reduced water consumption
- Use of reclaimed water for irrigation, flushing
- Solid flooring without need for stripping and waxing

Sustainability as a Core Value
LEED Gold Projects

20%	Direct Contract with Architect
26%	Post-Lean
44%	Target Value Design

Value as Reduced Maintenance Costs

$3.93/sq.ft.



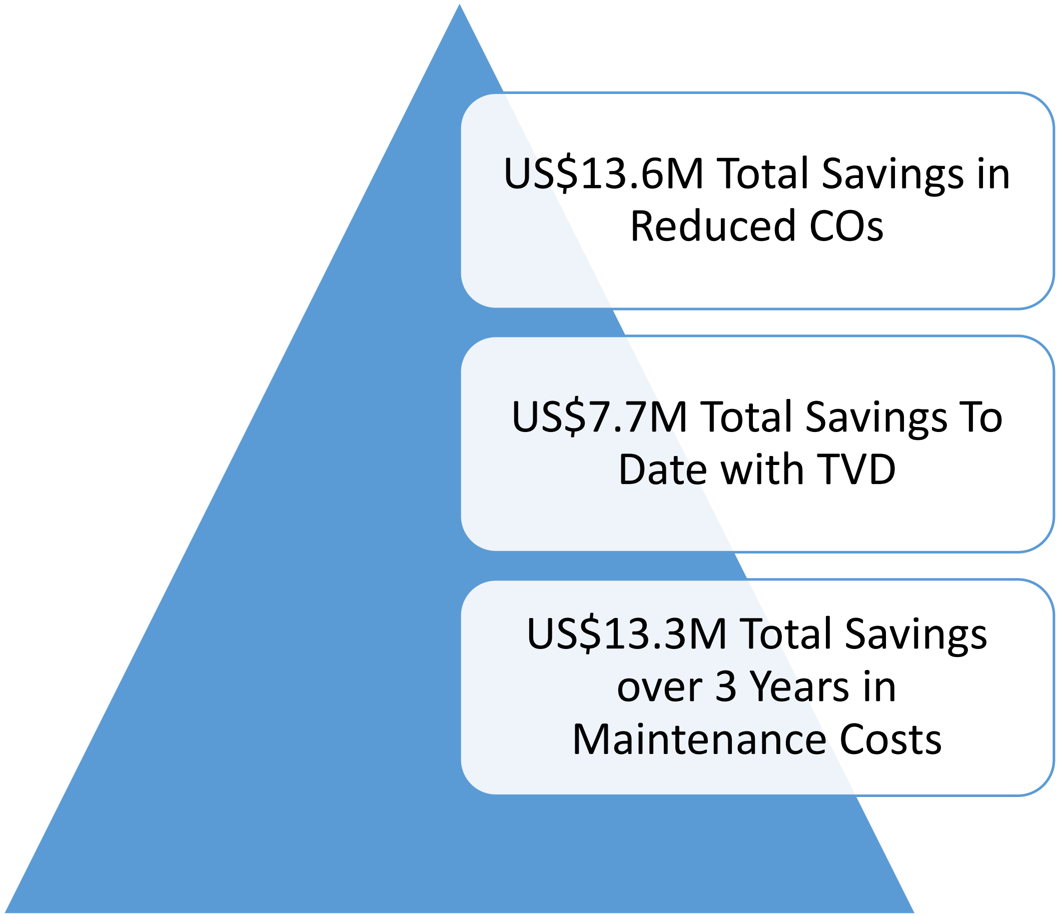
$1.91

Over 4 Years

$1.73

$1.46

US$34.6 Million of Waste Eliminated



Questions?

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