Delivering Better Projects through Fostering Lean Construction and Integrated Project Delivery Behaviors

BY

DAVID UMSTOT, PE, CEM

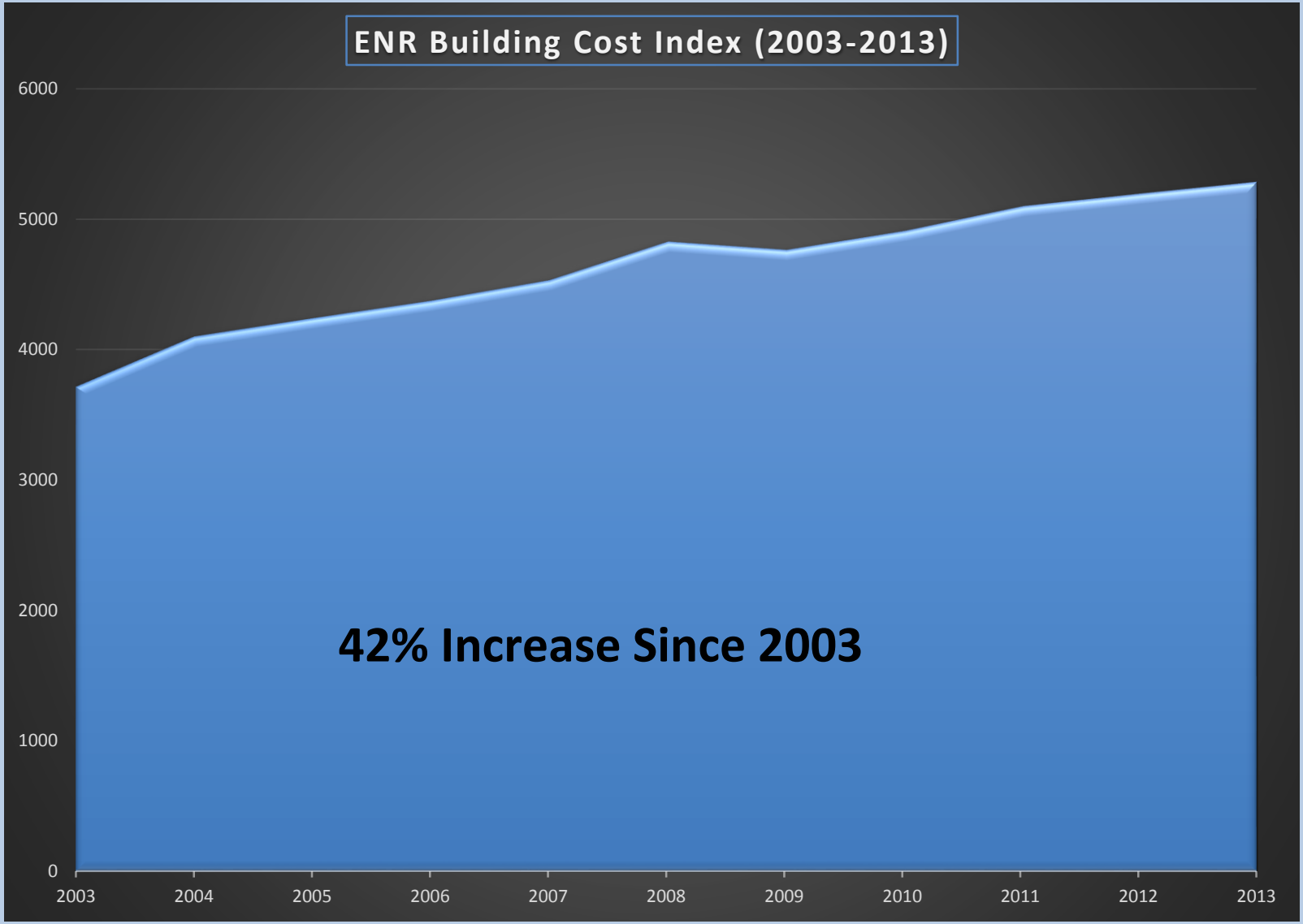
UMSTOT PROJECT AND FACILITIES SOLUTIONS, LLC

Presented to Rising CM Conference
October 26, 2013
Las Vegas, NV

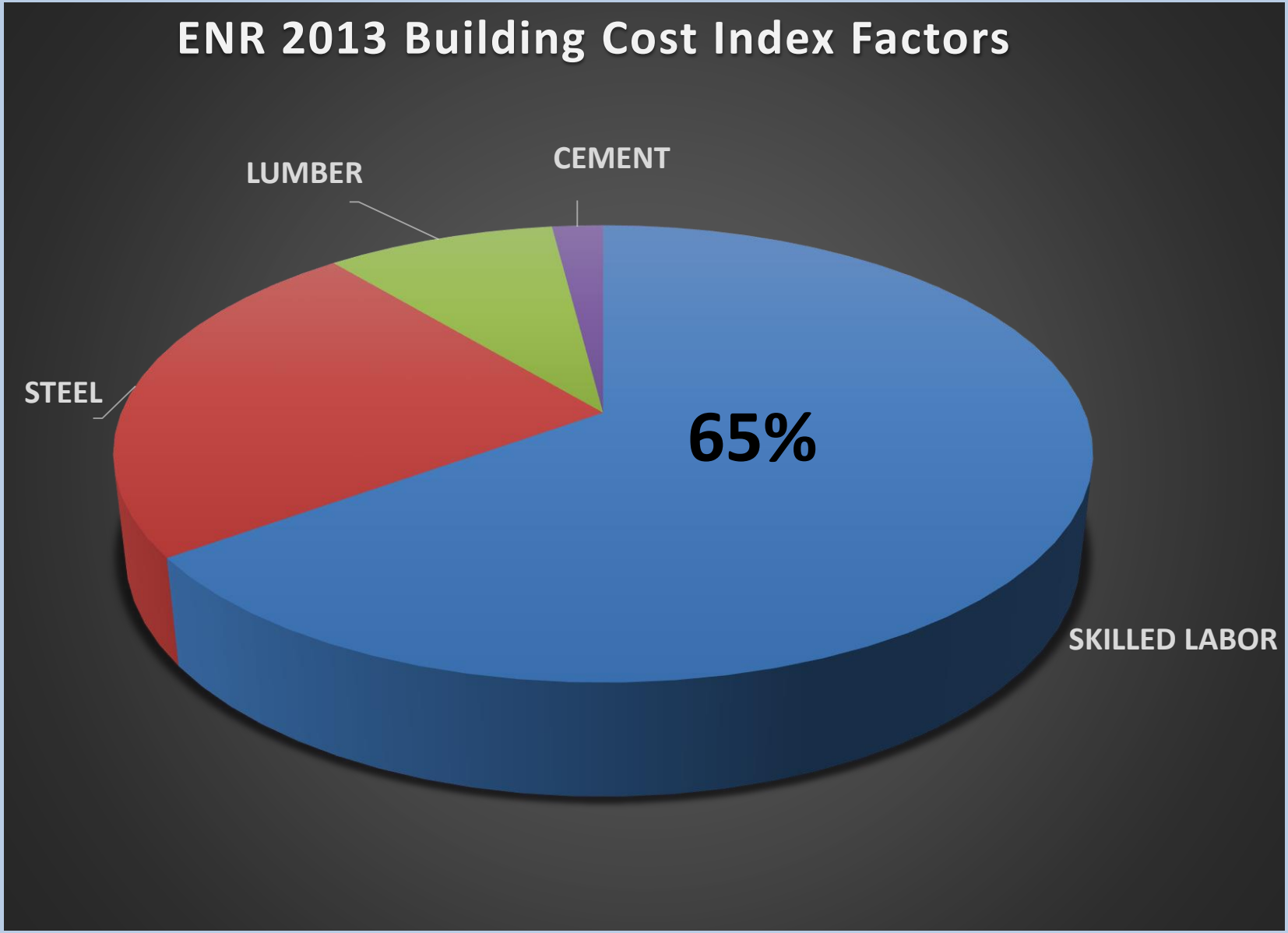
#COAA

Lean Construction
A World View – Extreme Lean!

https://www.youtube.com/watch?v=rwvmru5JmXk

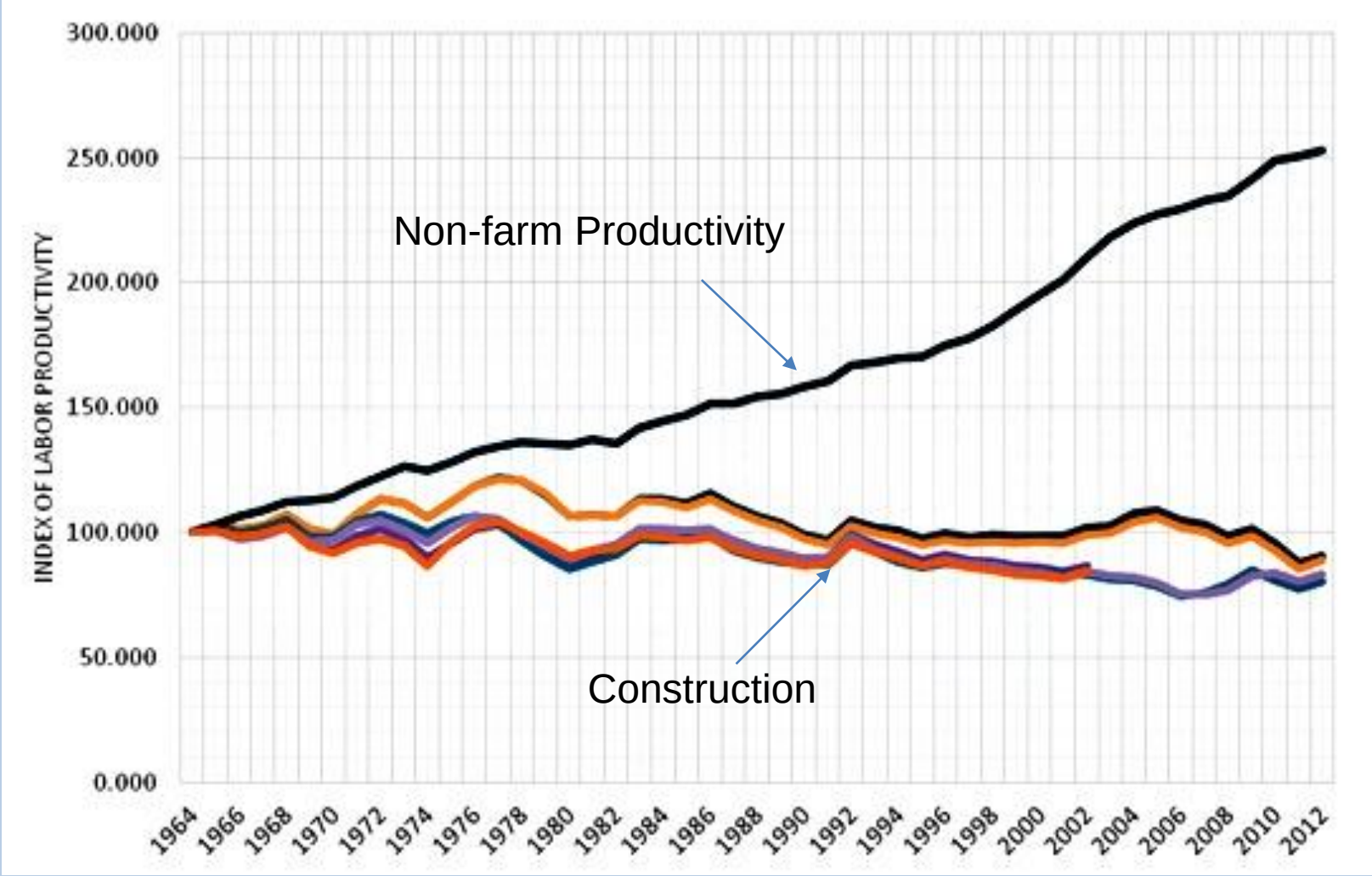


Source: ENR, 30Sep2013



Source: ENR, 30Sep2013

Index of Construction Labor Productivity 1964-2012



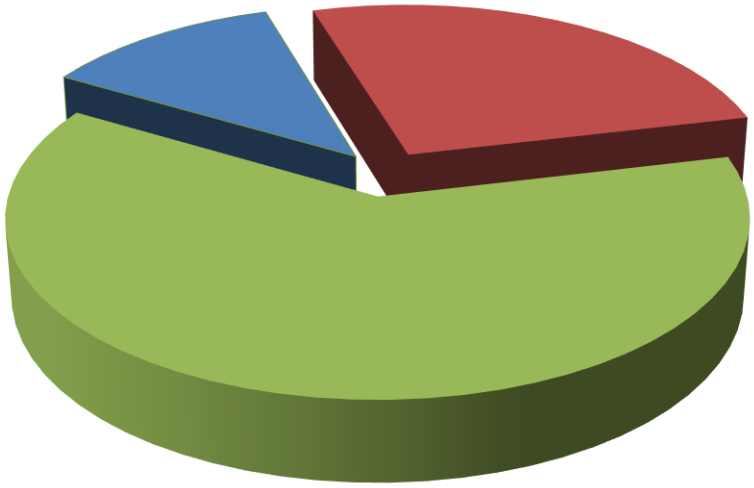
From: Teicholz (2013)

Construction Waste in the U.S.

Current Manufacturing

Support Activity 12%

Waste 26%

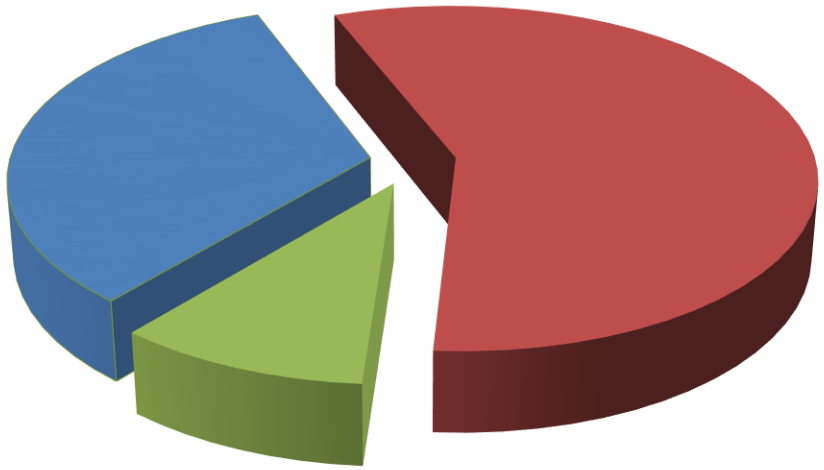


Value Added 62%

Current Construction

Support Activity 33%

Waste 57%



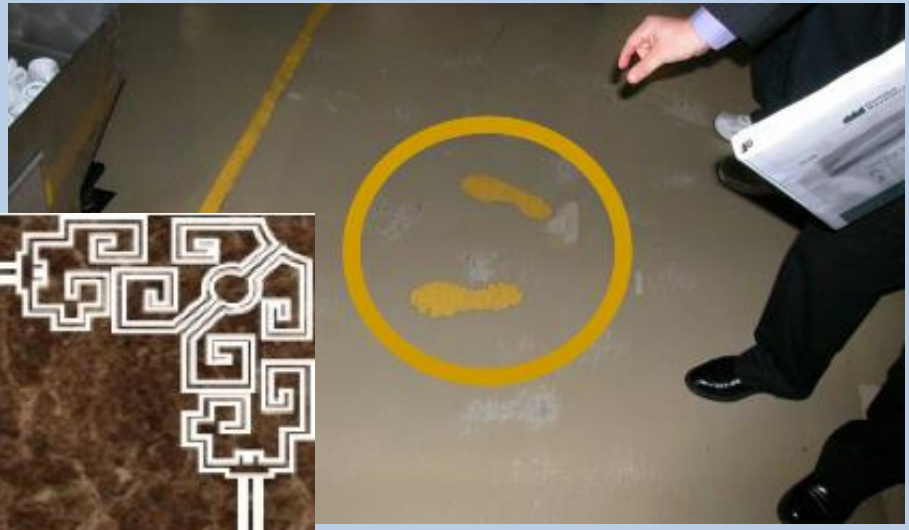
Value Added 10%

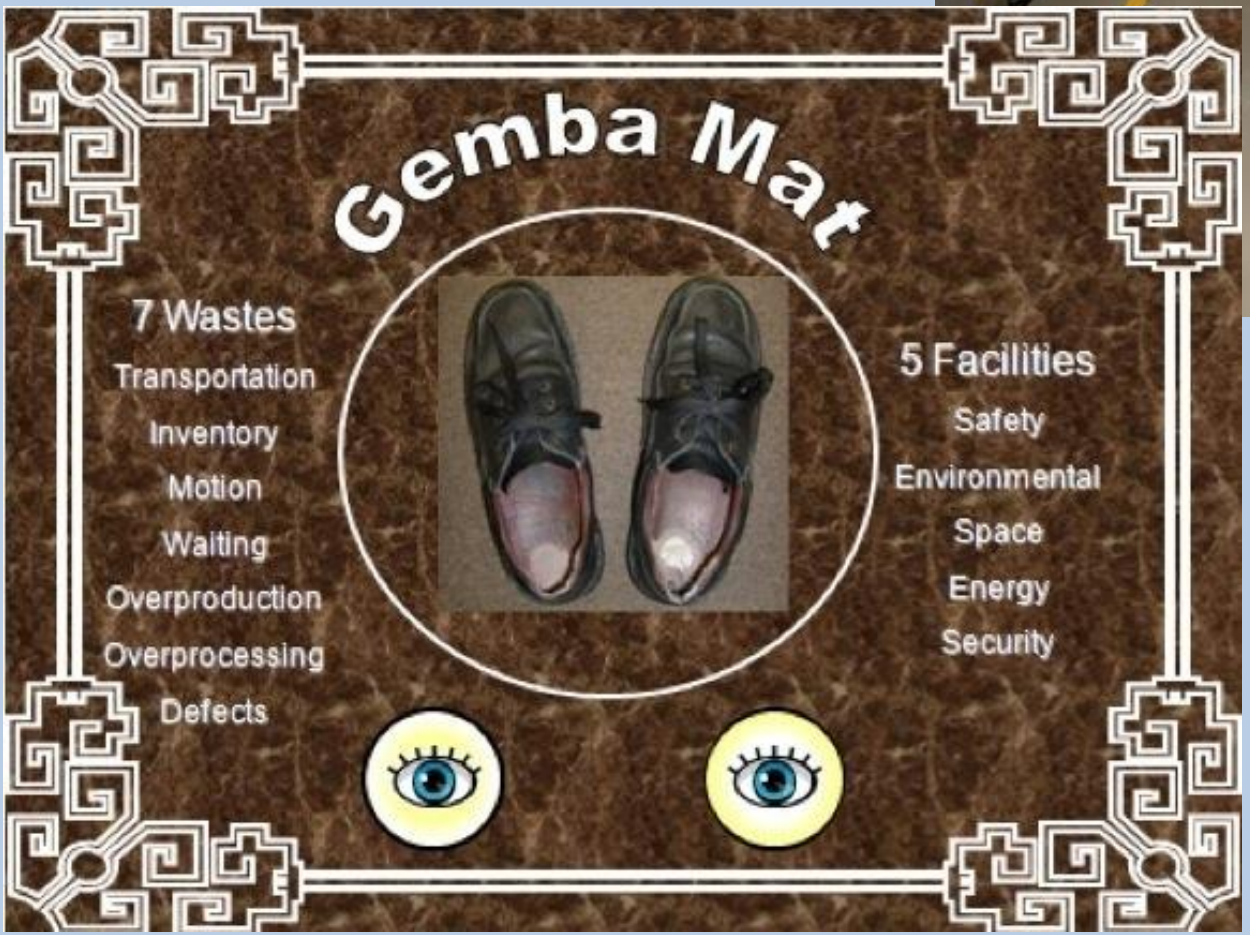
Source: Construction Industry Institute

Awareness Test

https://www.youtube.com/watch?v=Ahg6qcgoay4

Ohno Circle (Open Your Eyes)





The Eight Wastes as Defined by Toyota (and Liker)

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

Typical Types of Construction Waste:

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

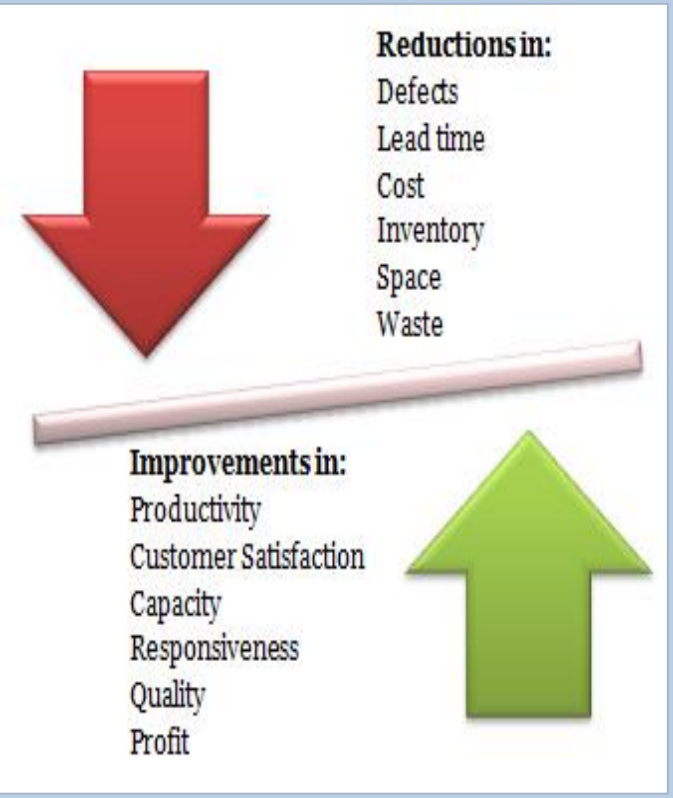
WHAT LEAN IS NOT…

- What We've Always Done
- A Singular Tool
- A Workforce Reduction Method
- A Quick Fix
- A Cost Cutting Method
- A "Manufacturing" Program
- A Project
- A Quality System
- A Passing Fad – Program Of The Month
- Someone Else's Job

Courtesy of The Blair David Co.

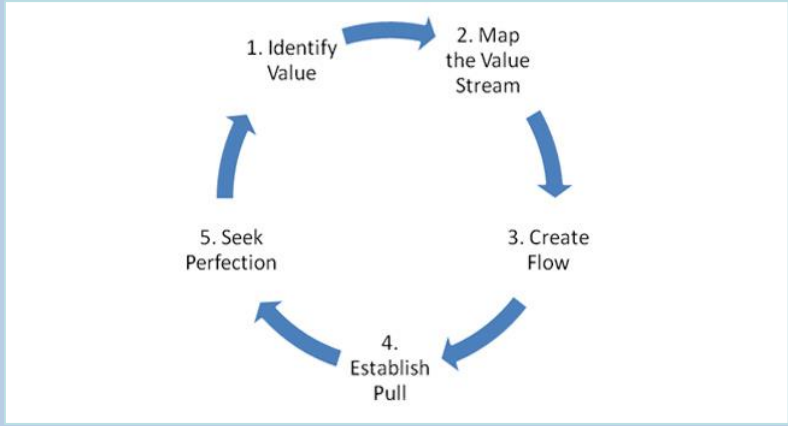
Lean Philosophies

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



Value

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



What is Lean Project Delivery?

Shared principles:

1. Optimize the Whole
2. Collaborate, Really Collaborate!
3. Continual improvement/pursuit of perfection
4. A focus on delivering value
5. Allowing value to flow
6. Creating pull production

The priority for all construction work is to:

1. Keep work flowing
2. Reduce inventory of material and tools, and
3. Reduce costs

Who is Going Lean?

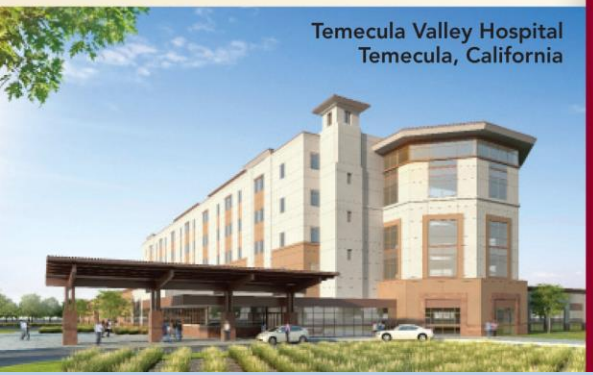
UHS

Sutter Health
With You. For Life.

Walt Disney Imagineering

UCSF
University of California
San Francisco

AMGEN



UHS®

Lean Project

DELIVERY GUIDE

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

Why Go Lean? (From UHS Lean Project Delivery Guide)

Fundamentals of Lean:

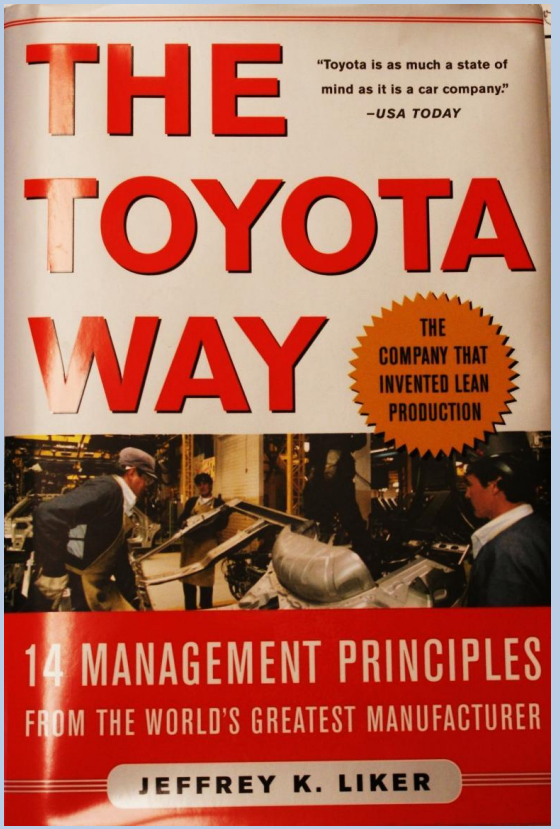
- To understand *value from the customer's perspective and to only* take *actions which deliver that value*
- Waste is disrespectful
    1. to humanity – squanders scarce resources
    2. to individuals – adds work
    3. to clients – adds cost/time/aggravation
- Become a leaning organization through relentless reflection and continuous improvement as a team. Status quo is never acceptable.
- Lean is about inspiration and empowerment. People are empowered to affect decisions and the work itself which not only delivers better projects, but leads to heightened satisfaction for all.
- Lean is about developing *principles that are right for your* organization & diligently practicing them to achieve high performance.

Why Did San Diego CCD Go Lean?

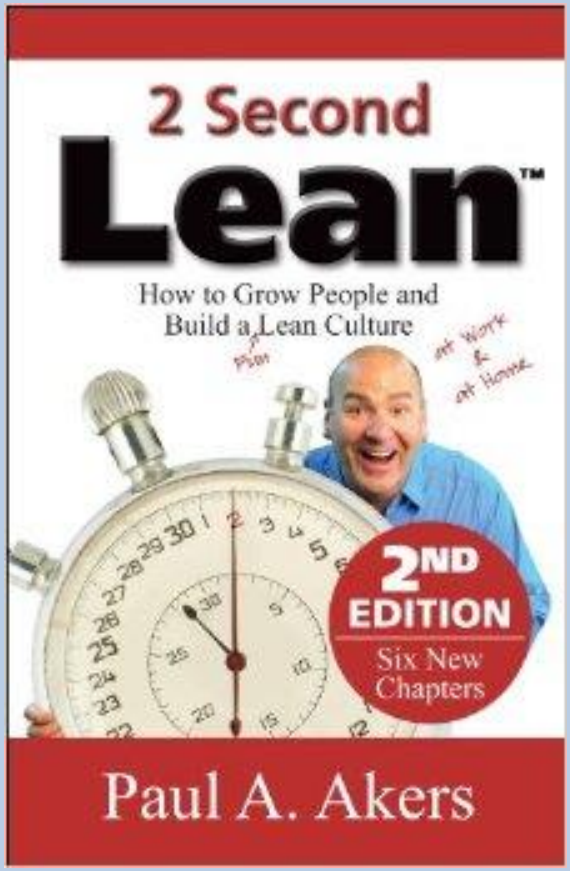
- Reduced operating budgets of **$46 million** over four years (-16%)
- Increased built environment footprint of 1.3 million square feet (+65%)
- Capital funding from locally approved and funded general obligation bonds

San Diego Community College District

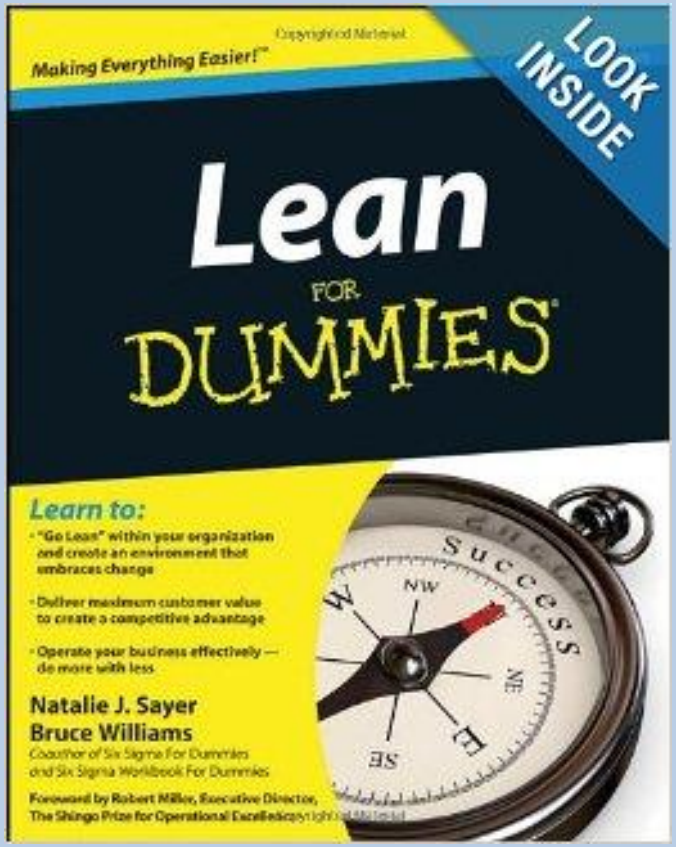
Practicing the Toyota Way Business Principles



Additional Lean Resources



"Fix What Bugs You." – Paul Akers



"Think of Lean as a fitness program for your business."

Early (and continued) Attitudes Toward Lean

- 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?

Credit: Lean Construction Institute

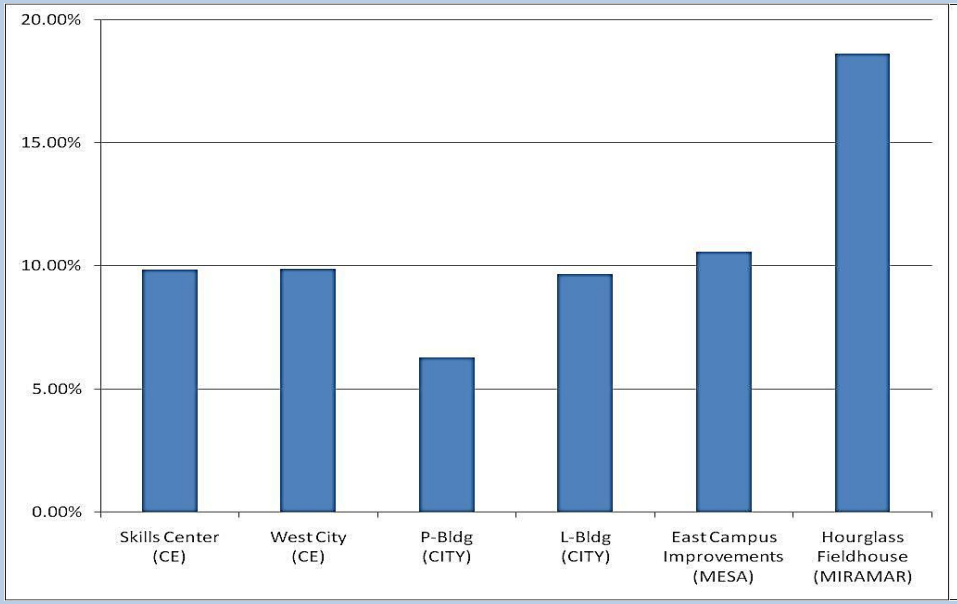
San Diego Community College District

Schedule Performance

Traditional Design-Bid-Build

Change Order Rate
Average = 10.8%

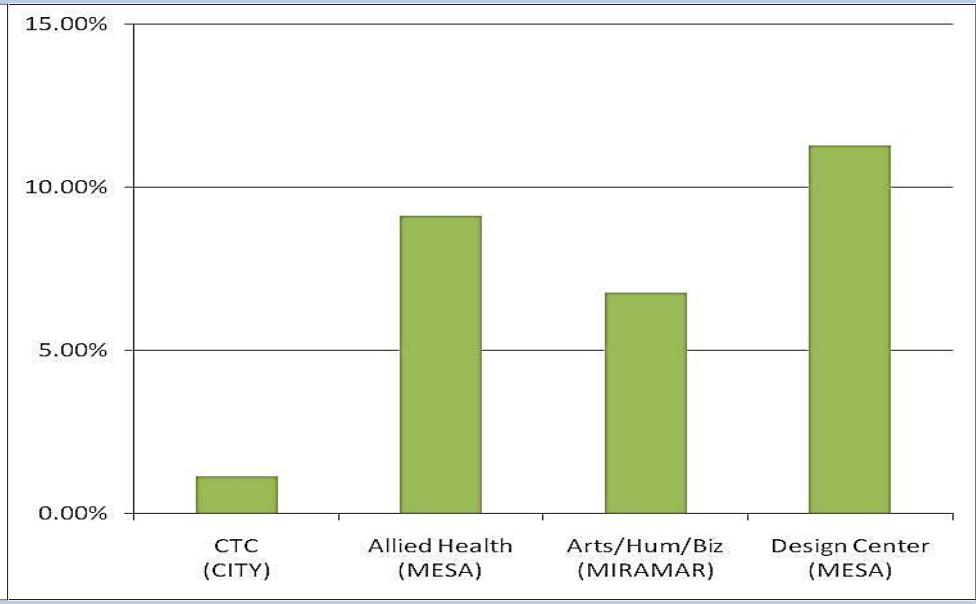
Project Delay
Average = 43.5 Days



CM Multiple Prime

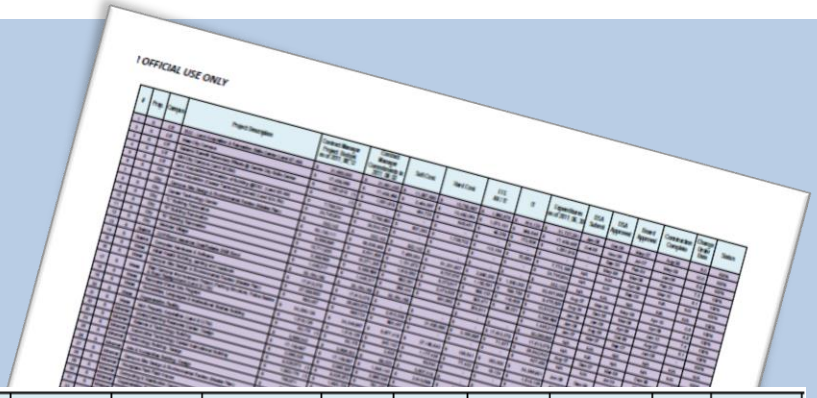
Change Order Rate
Average = 7.1%

Project Delay
Average = 19.5 Days

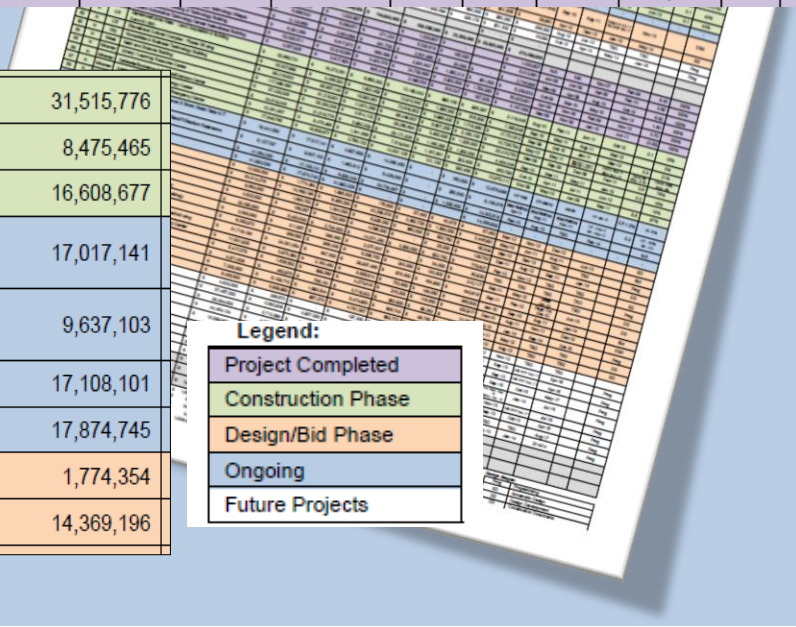


San Diego Community College District

$1.6B at a Glance



#	Prop.	Campus	Project Description	Contract Manager Project Budget as of 2011_08_12	Contract Manager Commitments to 2011_09_02	Soft Cost	Hard Cost	FFE AV / IT	IT	Expenditures as of 2011_06_30	DSA Submit	DSA Approved	Board Approval	Construction Complete	Change Order Rate	Status
1	S	CE	ECC - Land Acquisition & Relocation Skills Center (Land $7.4M)	$ 31,650,000	$ 31,681,400	$ 11,297,890	$ 10,782,697	$ 1,560,878	$ 614,124	$ 31,737,281	Jan-06	Oct-06	May-07	Aug-09	8.0	100%
2	S	CE	West City Campus	$ 17,409,369	$ 17,409,369	$ 2,484,567	$ 13,482,064	$ 1,073,191	$ 369,546	$ 17,409,495	Oct-05	Nov-06	Jul-07	May-09	10.0	100%



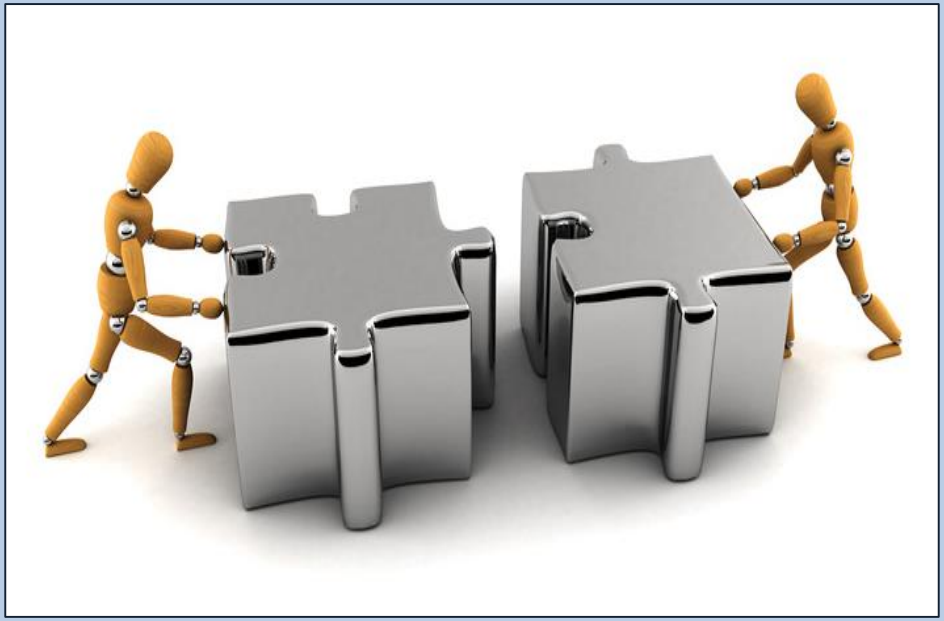
Miramar	Cafeteria/Bookstore & Student/Campus Center	$ 34,519,245	$ 31,515,776
Miramar	Aviation Maintenance Technology Center	$ 10,251,857	$ 8,475,465
Miramar	Parking Structure #1 & Police/Emergency Center	$ 17,848,765	$ 16,608,677
City	Infrastructure - Central Plant /Sewer & Storm Drain/ Data & IT projects	$ 19,441,050	$ 17,017,141
Mesa	Infrastructure - Fire Lane/Central Plant/IT/Stadium Restrooms	$ 8,127,797	$ 9,637,103
Miramar	Infrastructure Phase II	$ 41,564,305	$ 17,108,101
District	Proposition N Program Management	$ 41,992,026	$ 17,874,745
CE	Fire Science / EMT Training Facility	$ 13,000,000	$ 1,774,354
City	Science Building	$ 54,014,278	$ 14,369,196

http://www.aia.org/ipdg

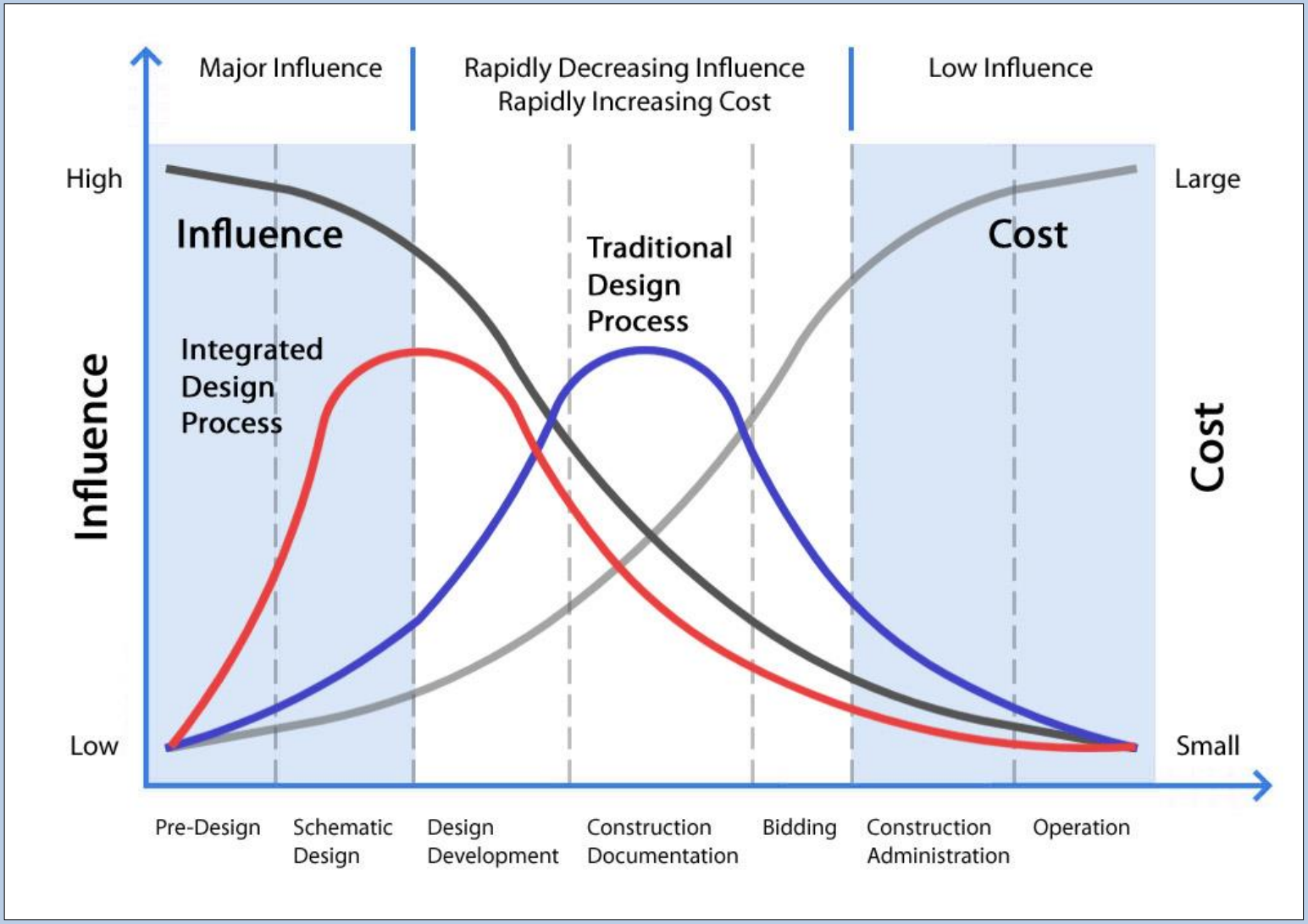
IPD – What Is It?

- Project delivery approach that integrates people, systems, business structures, and practices to optimize project results, **increase value to the owner, reduce waste and maximize efficiency** of project delivery.

- Distinguished by **highly effective collaboration** among the owner, prime designer and prime constructor **commencing at early design through project completion**.

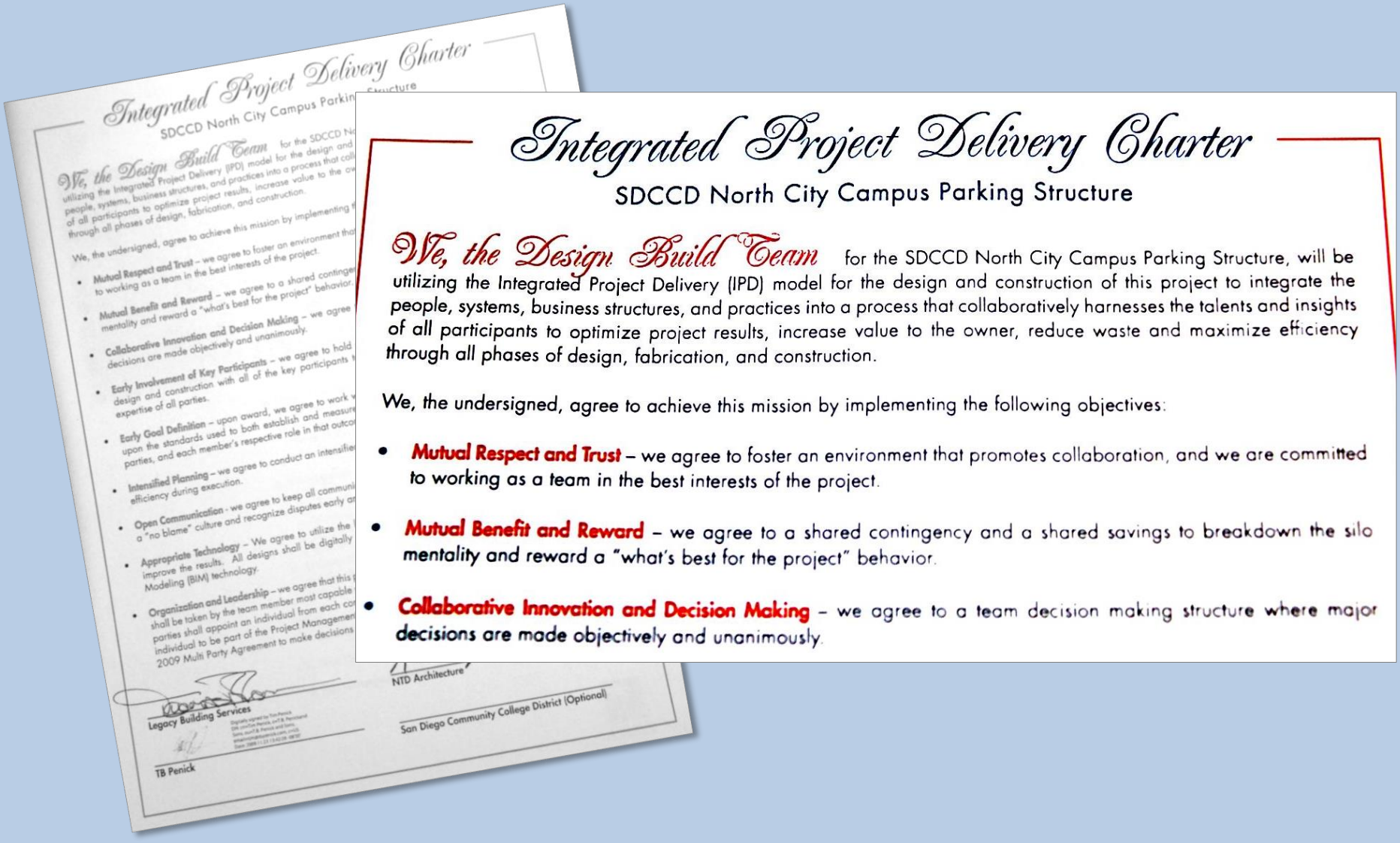


IPD – Why Do It?



MacLeamy Curve

IPD-ish Projects at SDCCD



Integrated Project Delivery Charter

SDCCD North City Campus Parking Structure

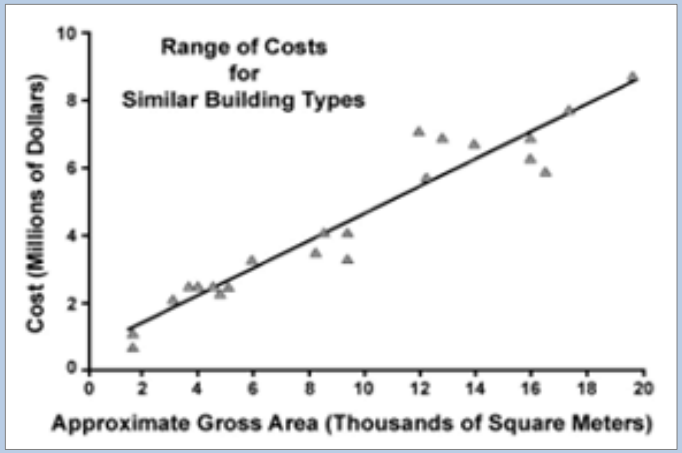
We, the Design Build Team for the SDCCD North City Campus Parking Structure, will be utilizing the Integrated Project Delivery (IPD) model for the design and construction of this project to integrate the people, systems, business structures, and practices into a process that collaboratively harnesses 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.

Target Costing – Project Budget Development

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



BUILDING		SPACE DESCRIPTION	2024 ASF	Quantity	Extended 2024 ASF	Extended 2007 ASF	Variance	2007 Room Nos., Comments
	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**	

A3 Report for HVAC Set-Based 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 Reporting System Design – Structural

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

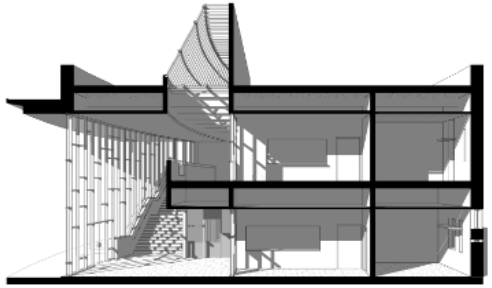
Section 1 - Background - Relevance to Project

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.

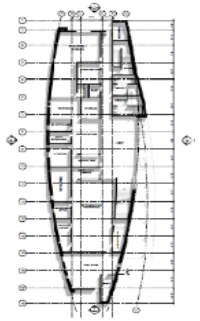
Section 2 - Current Condition

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 Attuniation	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.

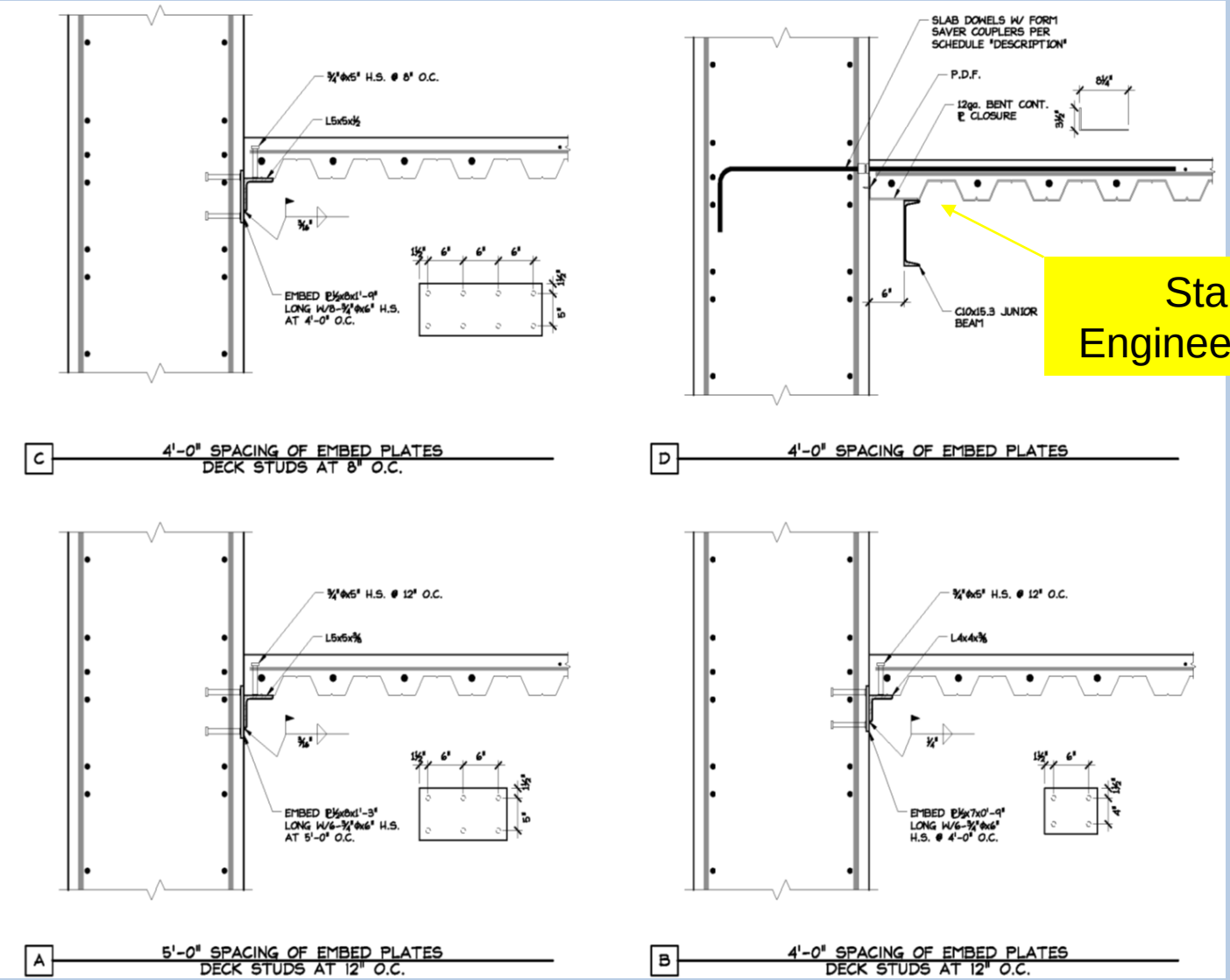
Section 5 - Recommendations

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

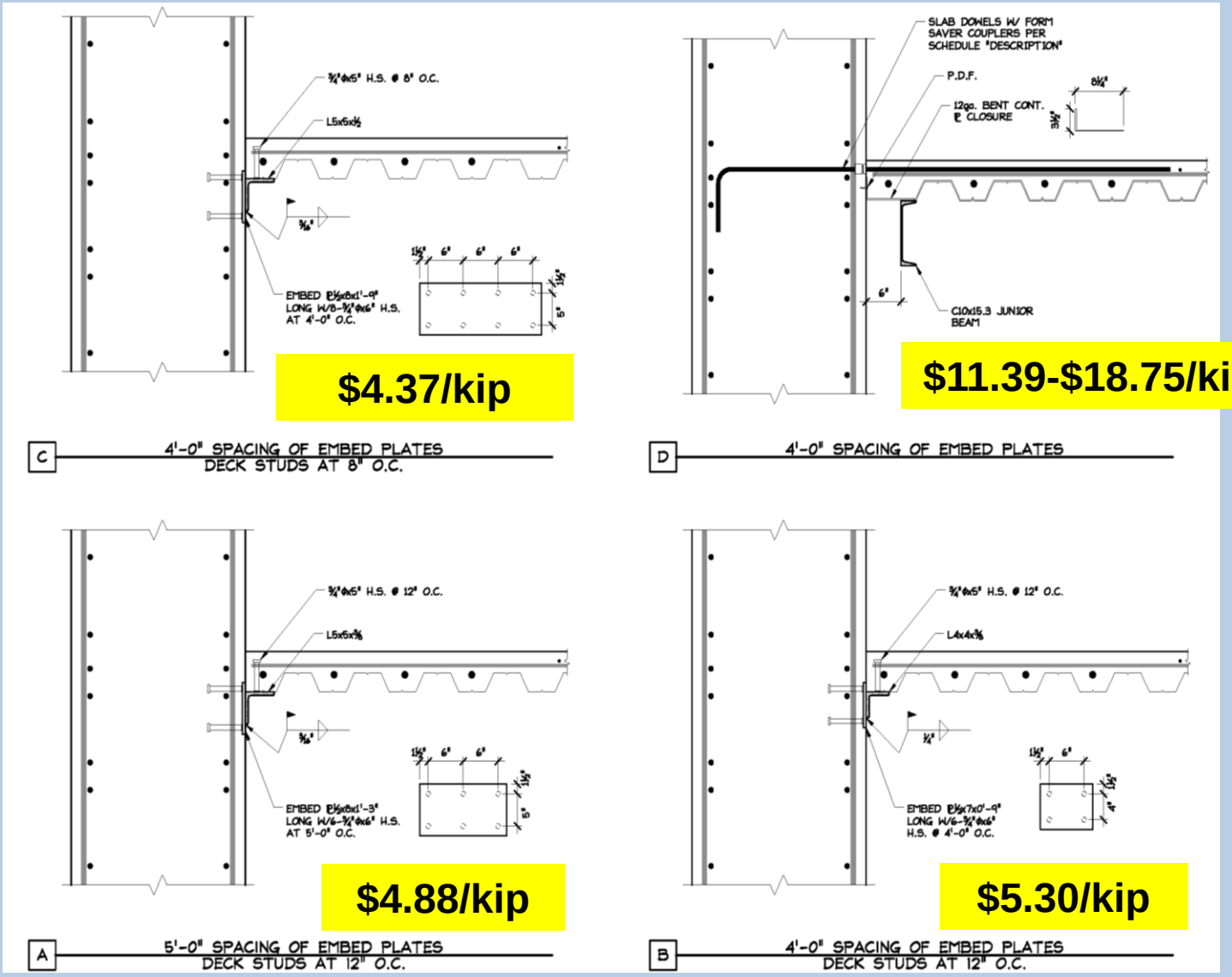
Set-Based Design – Connection Example



Standard Engineering Detail

Courtesy: Tipping Mar

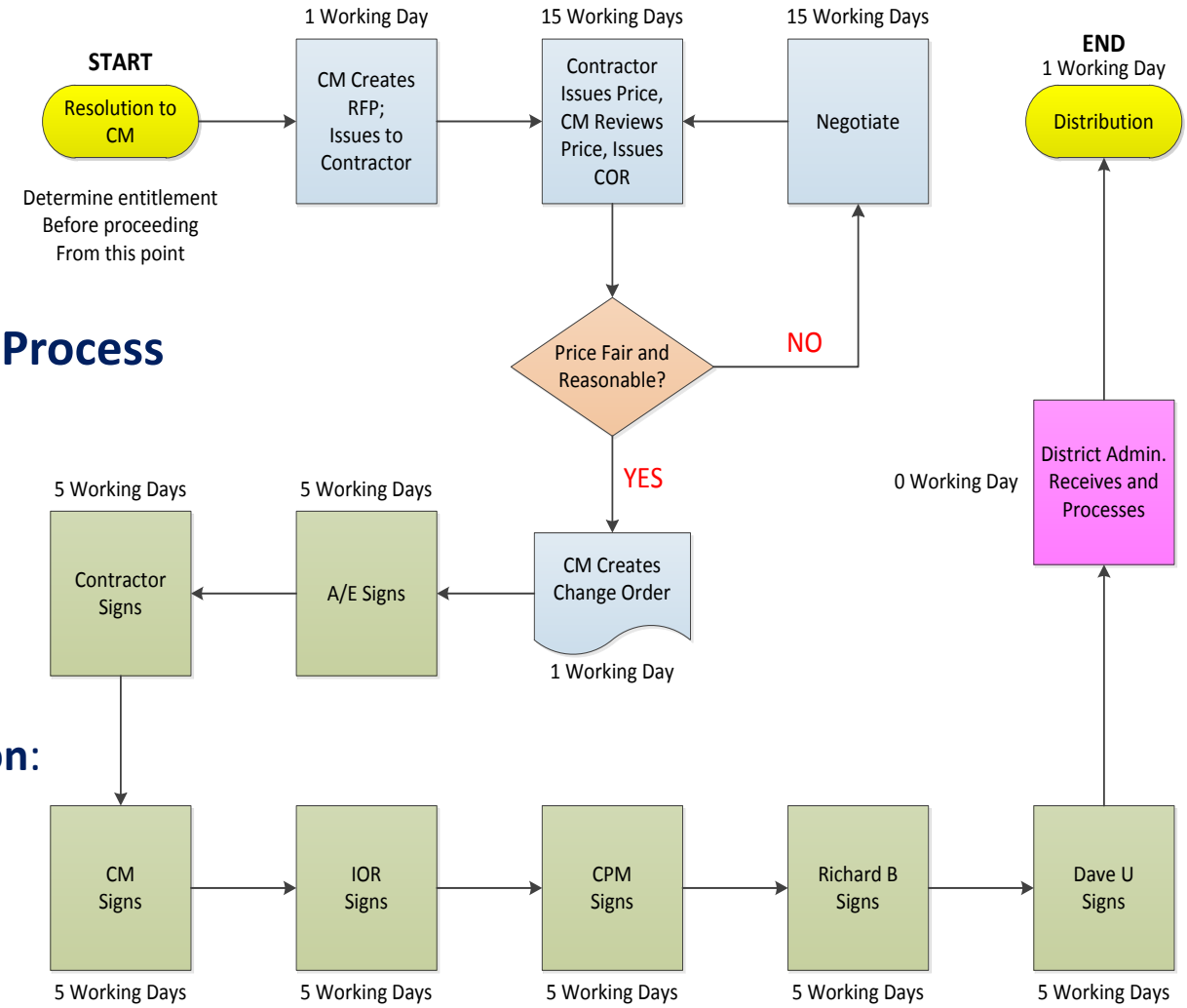
Set-Based Design – Connection Example



Courtesy: Tipping Mar

Value Stream Mapping – Change Order Process

Old Change Order Process



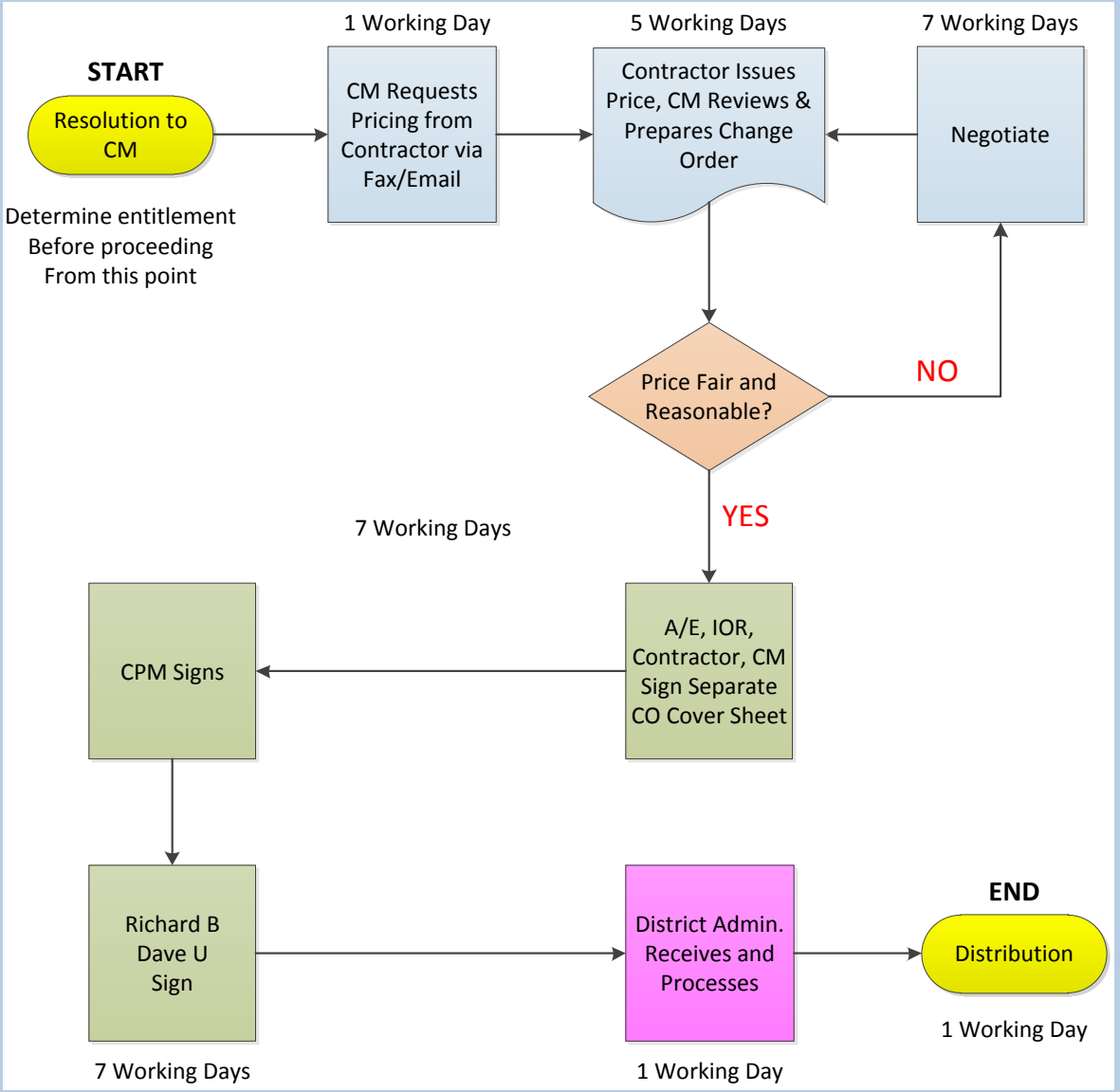
Total Process Duration:
67 Working Days
With Negotiation

Value Stream Mapping – Change Order Process

New Change Order Process

Effective January 2011

Total Process Duration:
28 Working Days
With Negotiation



Is Critical Path Method Scheduling Obsolete?

Schedule Performance

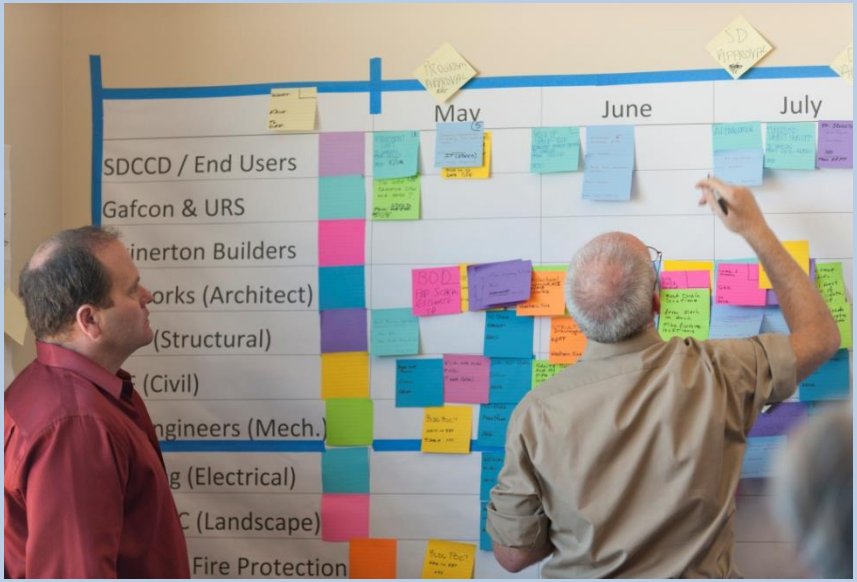
- SDCCD Experience:
  30 Major Projects with CPM Scheduling
  3 (10%) finished on time

- Research by Glenn Ballard and Greg Howell indicated only 54% of planned weekly activities get completed on average.

- LastPlanner™ pull system – a better way (typically 80-90% percent promises kept)

Pull Planning at SDCCD

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



Pull Planning in Action

https://www.youtube.com/watch?v=QcF7bRo57aY&feature=plcp

San Diego Community College District

Pull Planning Workshop

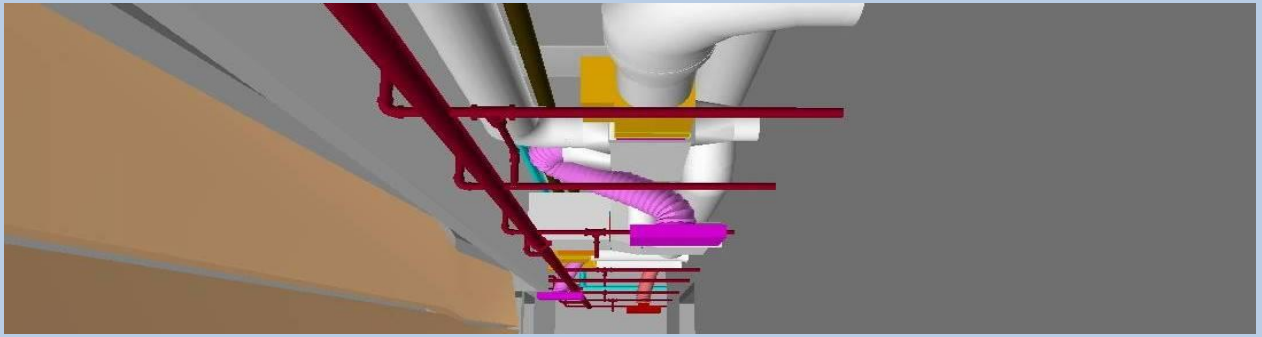
https://www.youtube.com/watch?v=6N3oV6tV8d4&feature=youtu.be

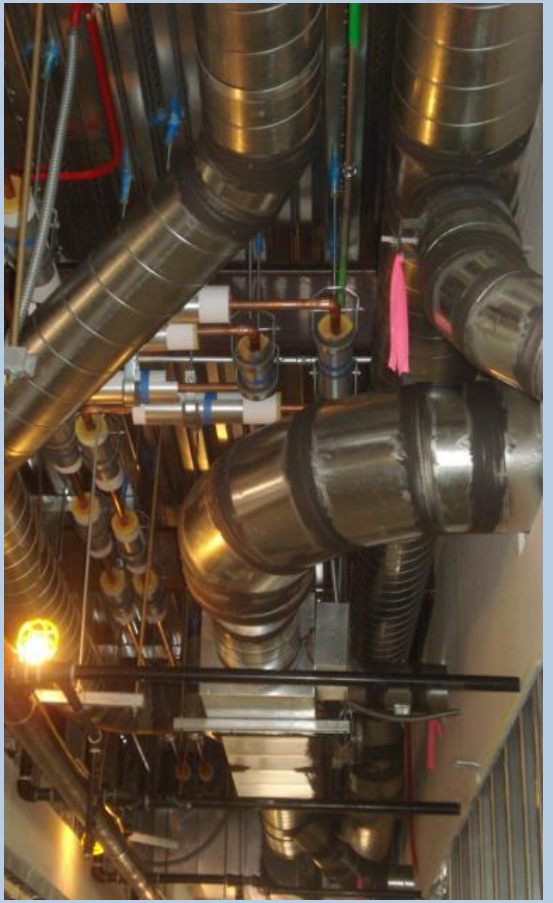
SDCCD Change Order Metrics – BIM vs. No BIM

Change Orders

	Errors & Omissions	Total
BIM:	1.1%	4.1%
No BIM	3.3%	8.6%

(All Contract Types)



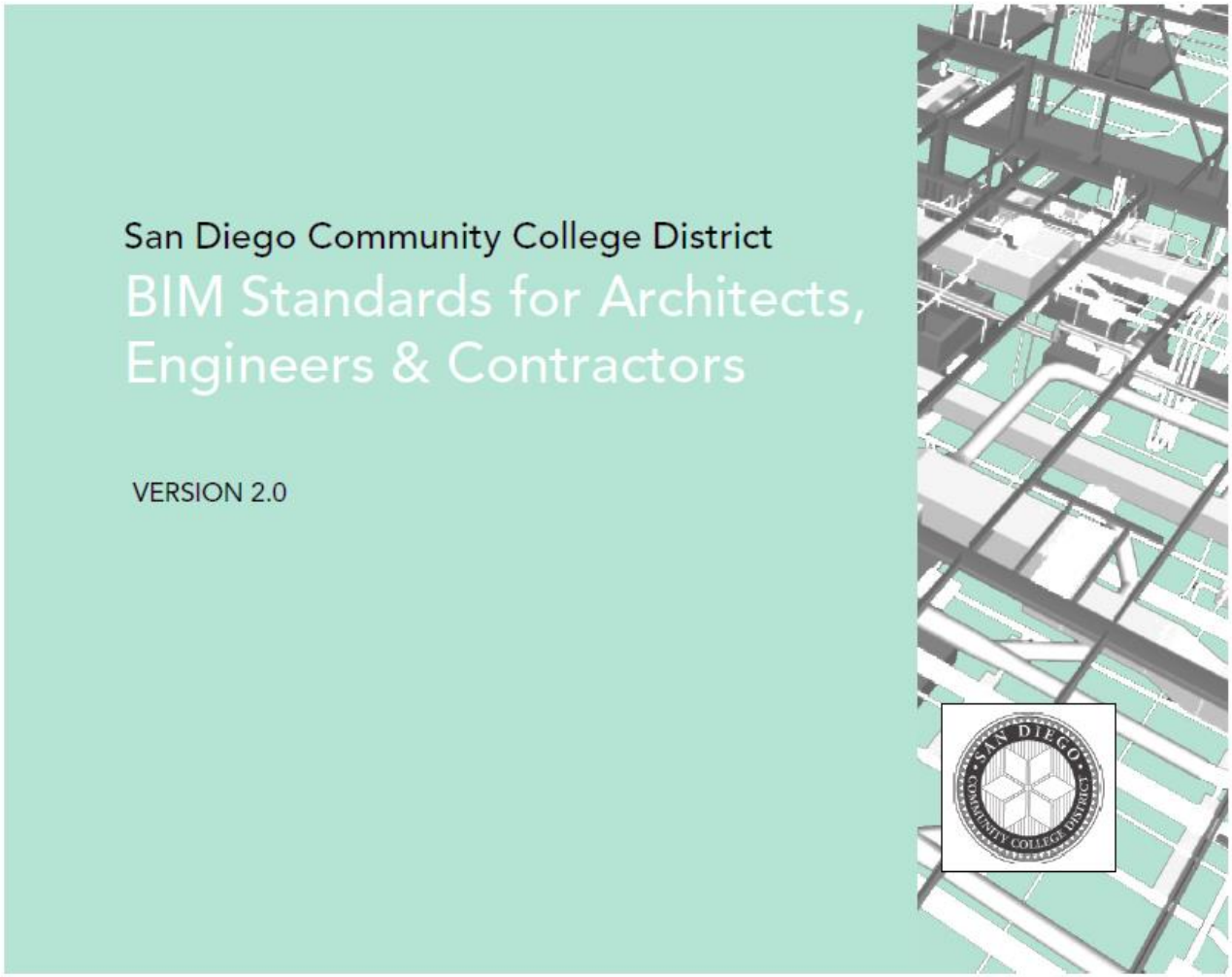


SDCCD Schedule Impacts – BIM vs. No BIM

Average Delay (All Contract Types)

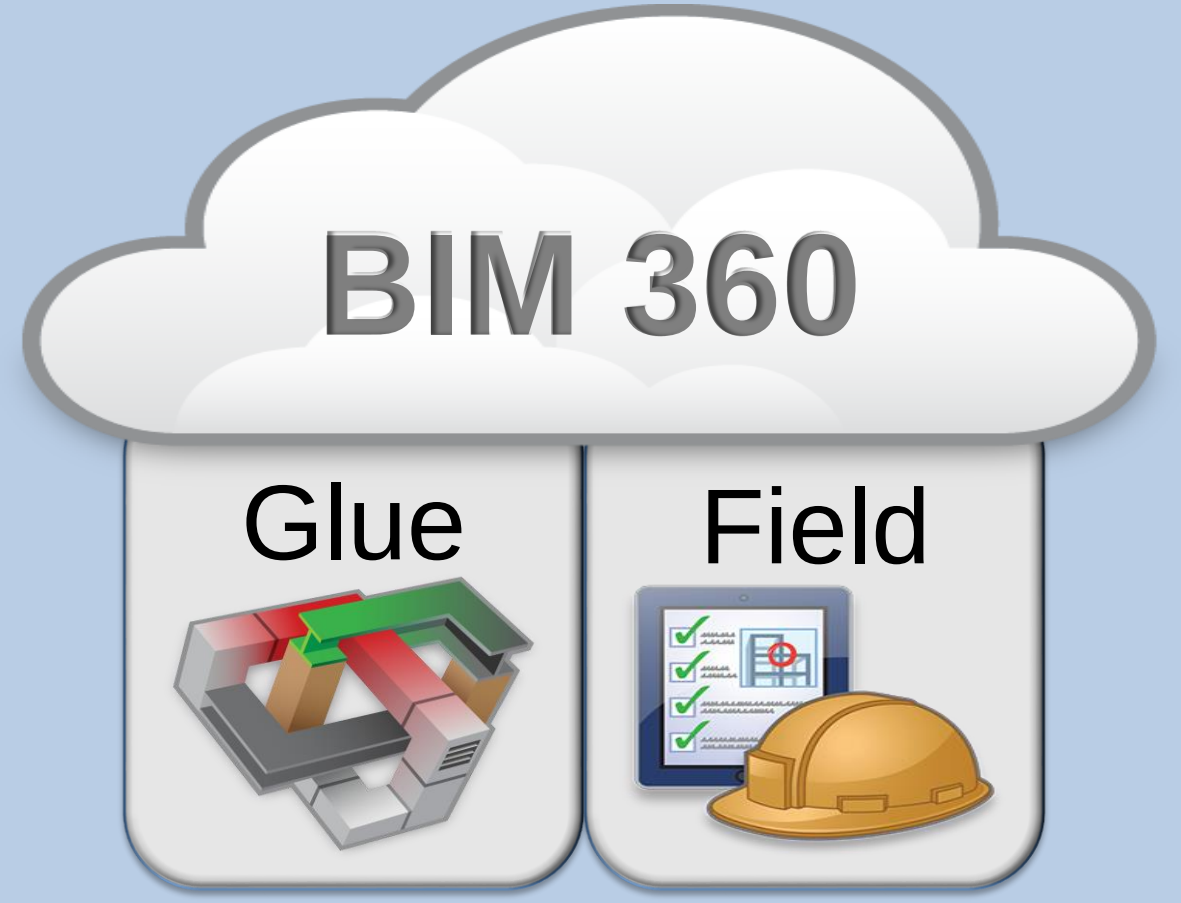
BIM: 24.5 days

Without BIM: 79.6 days



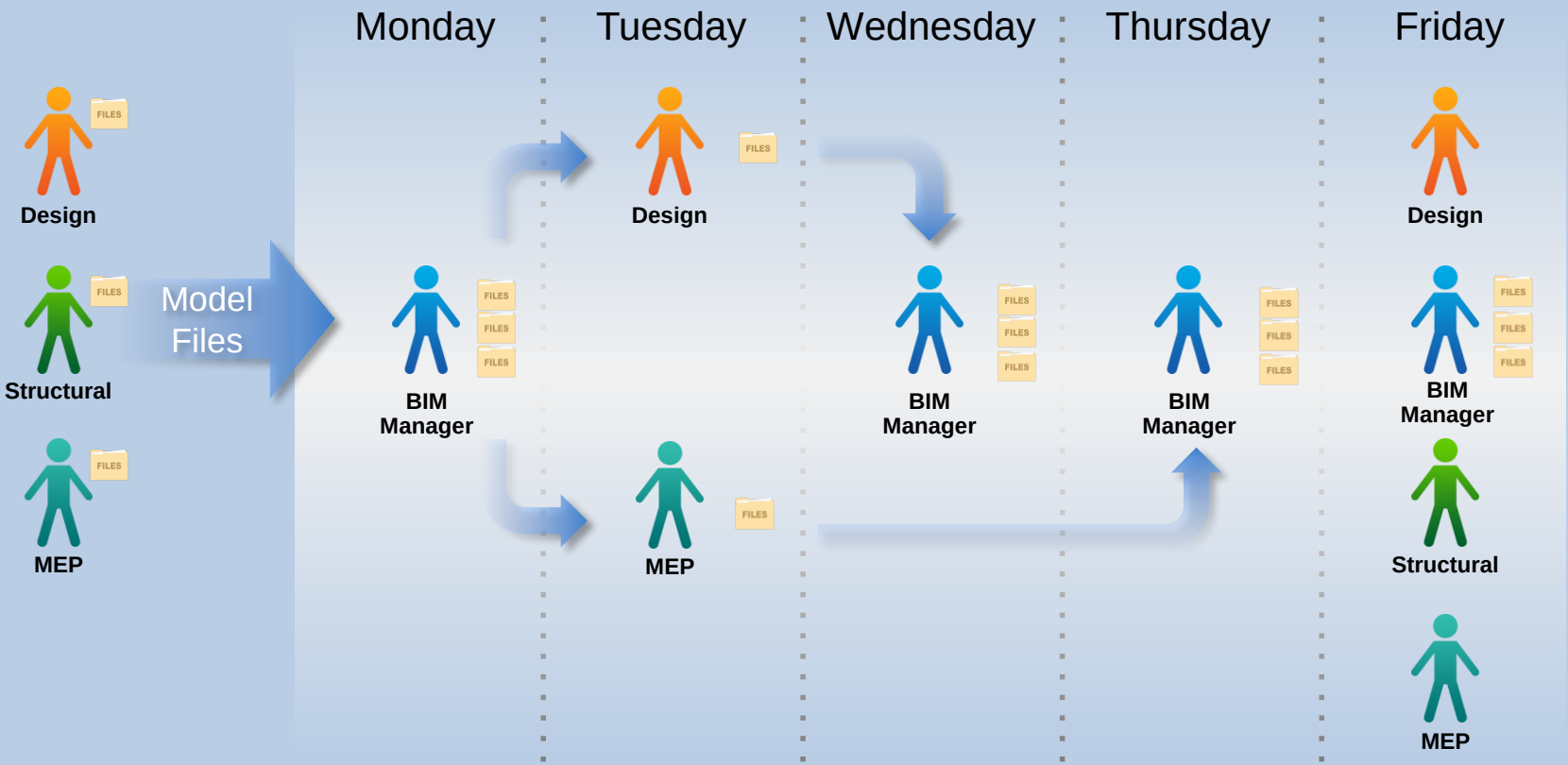
http://public.sdccdprops-n.com/Design/SDCCD%20-%20Building%20Design%20Standards/SDCCD%20BIM%20Standards%20Version%202.pdf

Autodesk BIM 360



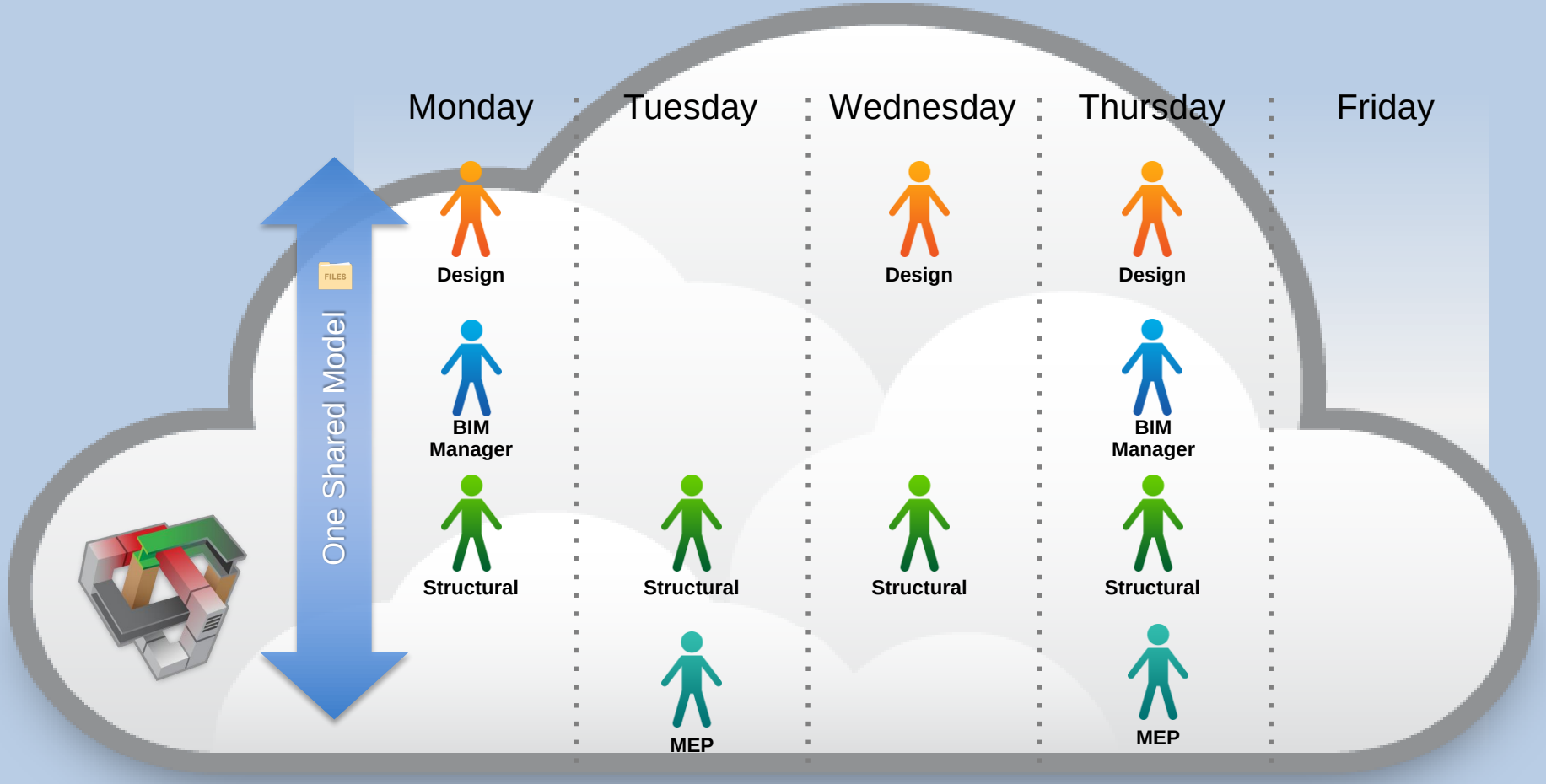
Courtesy: Autodesk

A Typical Week in a Coordination Process



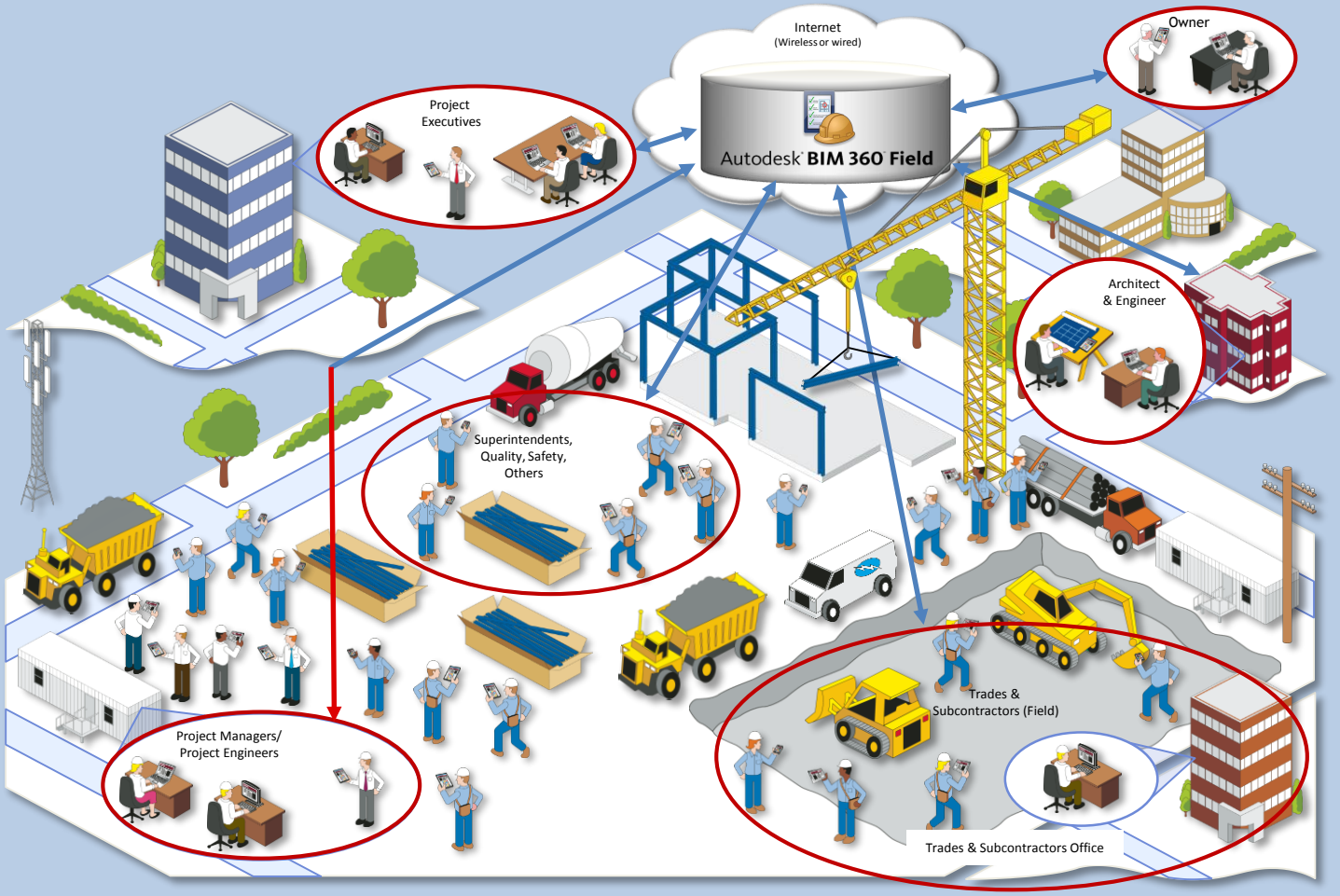
Courtesy: Autodesk

A Week in a Glue-Enabled Coordination Process



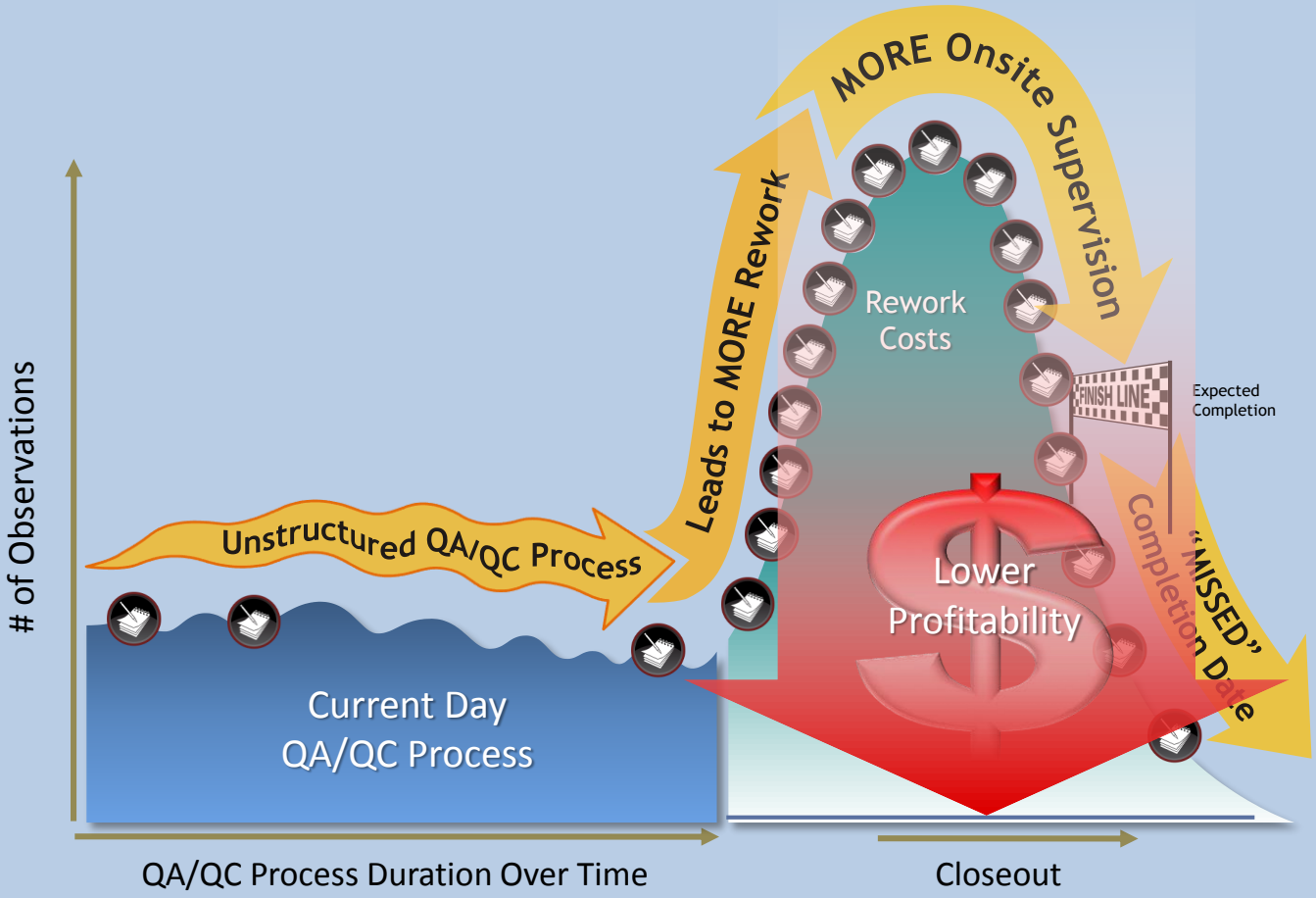
Courtesy: Autodesk

Autodesk BIM 360 Field: Management… *Everywhere*



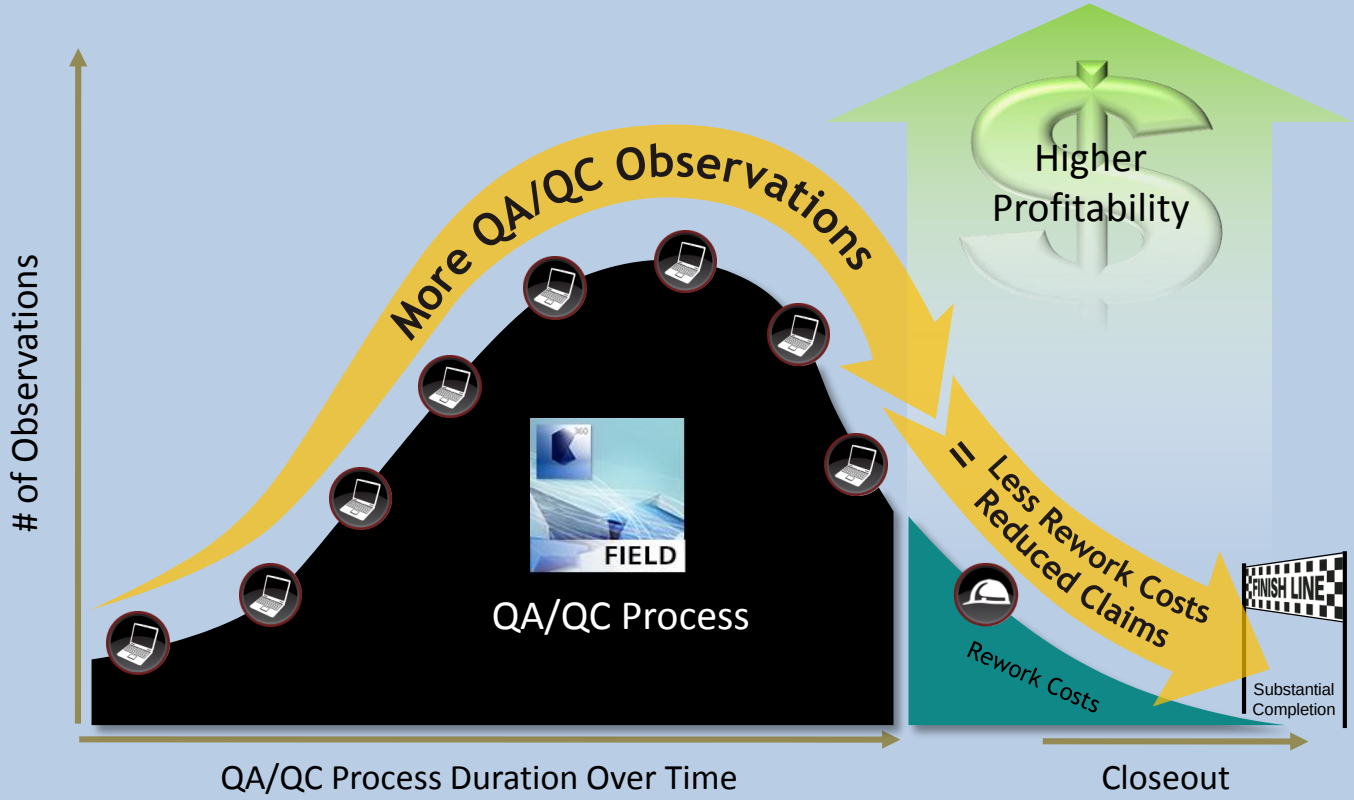
Courtesy: Autodesk

Current QA/QC Process



Courtesy: Autodesk

BIM 360 Field – Structured QA/QC



Courtesy: Autodesk

Patrick MacLeamy, FAIA, Chairman and CEO, HOK
-- “Buildings are Assembled Not Built”

SDCCD Structure and Skin Pre-Fabrication Trends

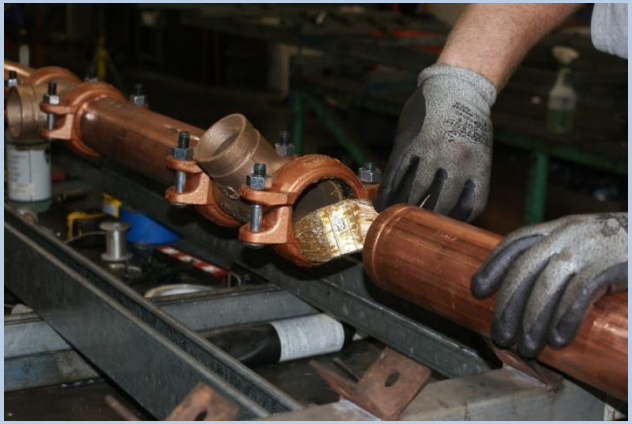
Exterior skin – Mesa College Math & Science Building

Columns and Double Ts – City College Arts & Humanities Building

Off-site Pre-Fabrication Trends on SDCCD Projects

Mechanical systems off-site racking – Mesa College Math & Science Bldg








Pre-fabrication warehouse – University Mechanical & Engineering

Questions?

David Umstot, PE, CEM

Umstot Project and Facilities Solutions, LLC

david.umstot@umstotsolutions.com

www.umstotsolutions.com

(619) 201-8483