

Lean and Prefabrication- A Process Paradigm Shift

Amy Marks

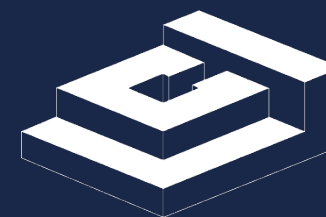
CEO

XSite Modular Consulting

October 17, 2017

CAPTURE AND LEVERAGE THE LEAN ADVANTAGE

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19TH LCI CONGRESS

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LEAN & PREFABRICATION—A PROCESS PARADIGM SHIFT

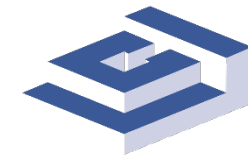
- Industry thought leader on off-site and prefabrication
- Alumna of Harvard Business School and a graduate of the UF
- Chair of the upcoming Advancing Prefabrication Conference – January
- Trainer for Mechanical Contractors Association of America (MCAA)
- Singapore’s Panel of Experts on Construction and Productivity
- Founder of LinkedIn’s Modern Methods of Construction (MMC)
- CoreClarity trainer
- Amy and her team have worked on six of the seven continents implementing prefabrication



AMY MARKS

CEO & Co-Founder





LEARNING OBJECTIVES

- Learn off-site language, definitions and execution strategies
- International trends in prefabrication; Design for Manufacturing and Assembly (DfMA), “pieces and parts” vs. volumetric modular
- Review proven off-site implementation process and how it enhances or challenges current lean process
- Review Element-Centric Target Value Design vs. Trade-Centric Target Value Design
- Pitfalls, best practices and metrics for off-site



Training

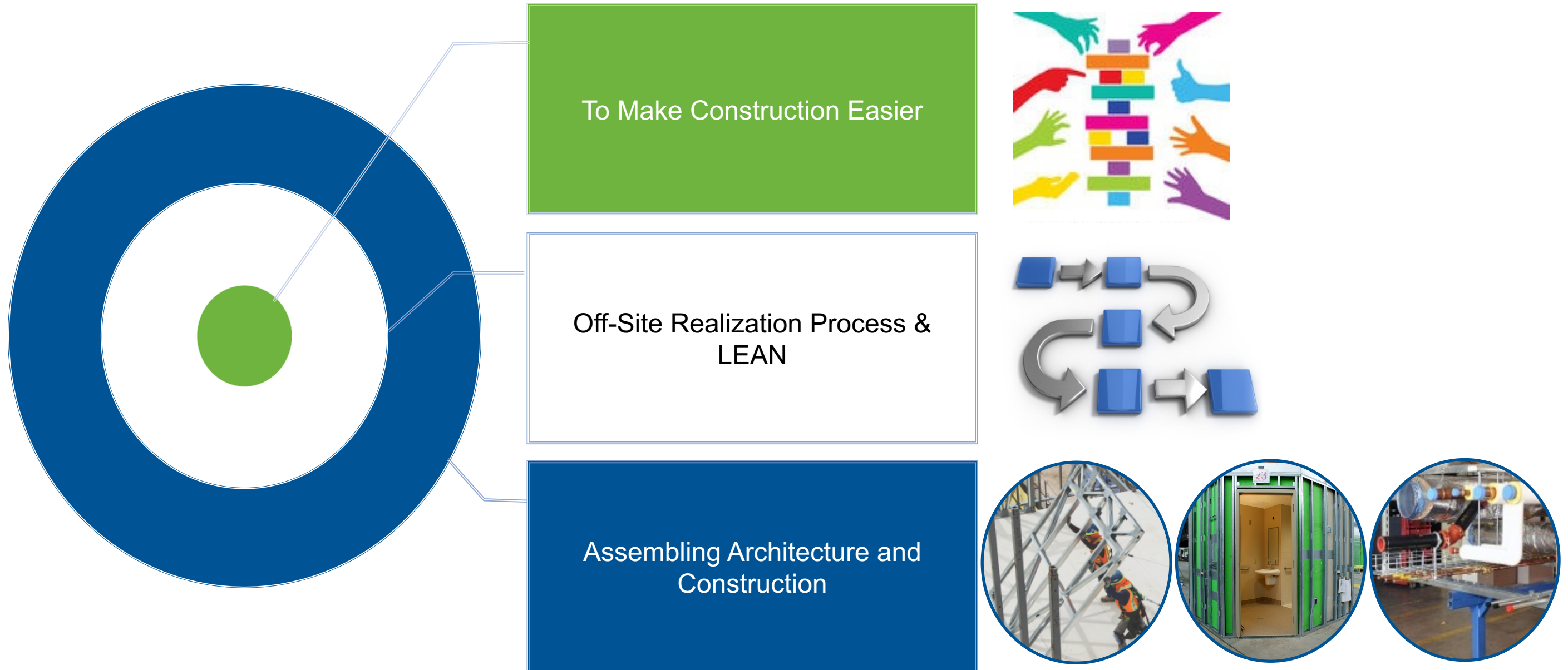


Resources



Plan | Value
Generation

XSITE MODULAR CONSULTING



XSITE EXPERIENCE



Housing



Pods



Industrial



Government



Health
Care



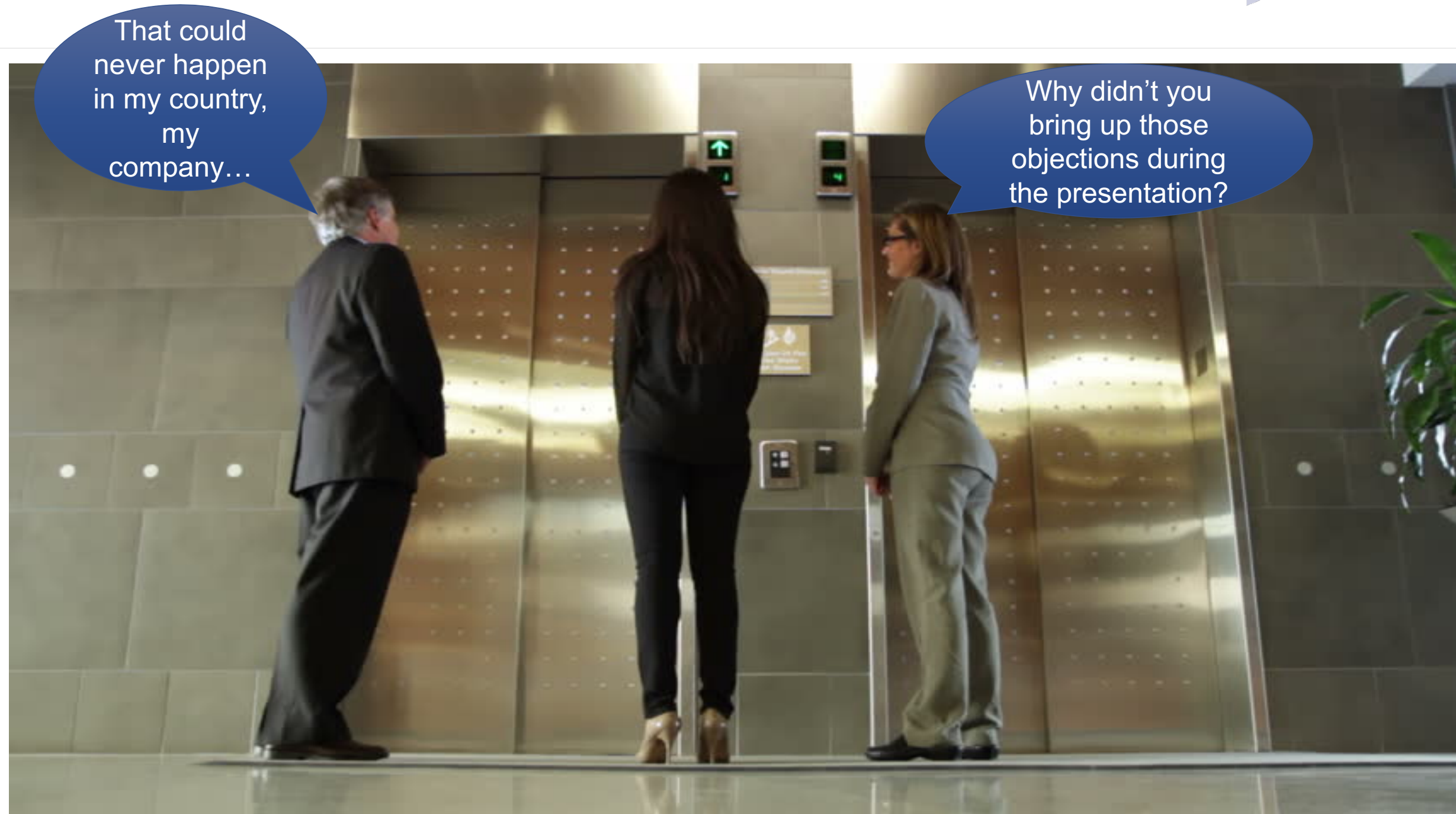
Mission Critical



Education



Hospitality



That could never happen in my country, my company...

Why didn't you bring up those objections during the presentation?

SECTION ONE – WHAT IS OFF-SITE?



OFF-SITE CONTINUUM

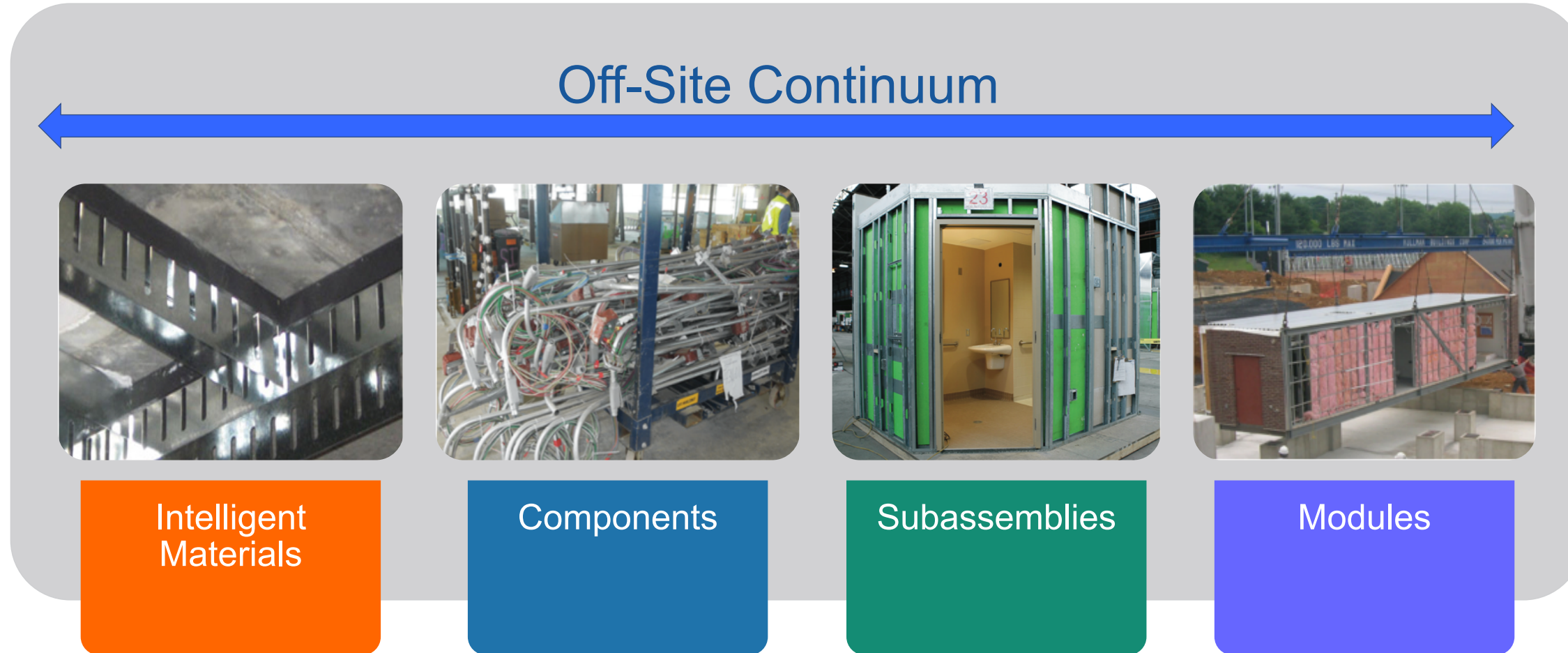
Off-Site is a broad term that encompasses the creation of **building elements** in a **controlled environment** that are transported to their final destination preferably installed on-site using **accelerated assembly** methods.



Built Environment



Training

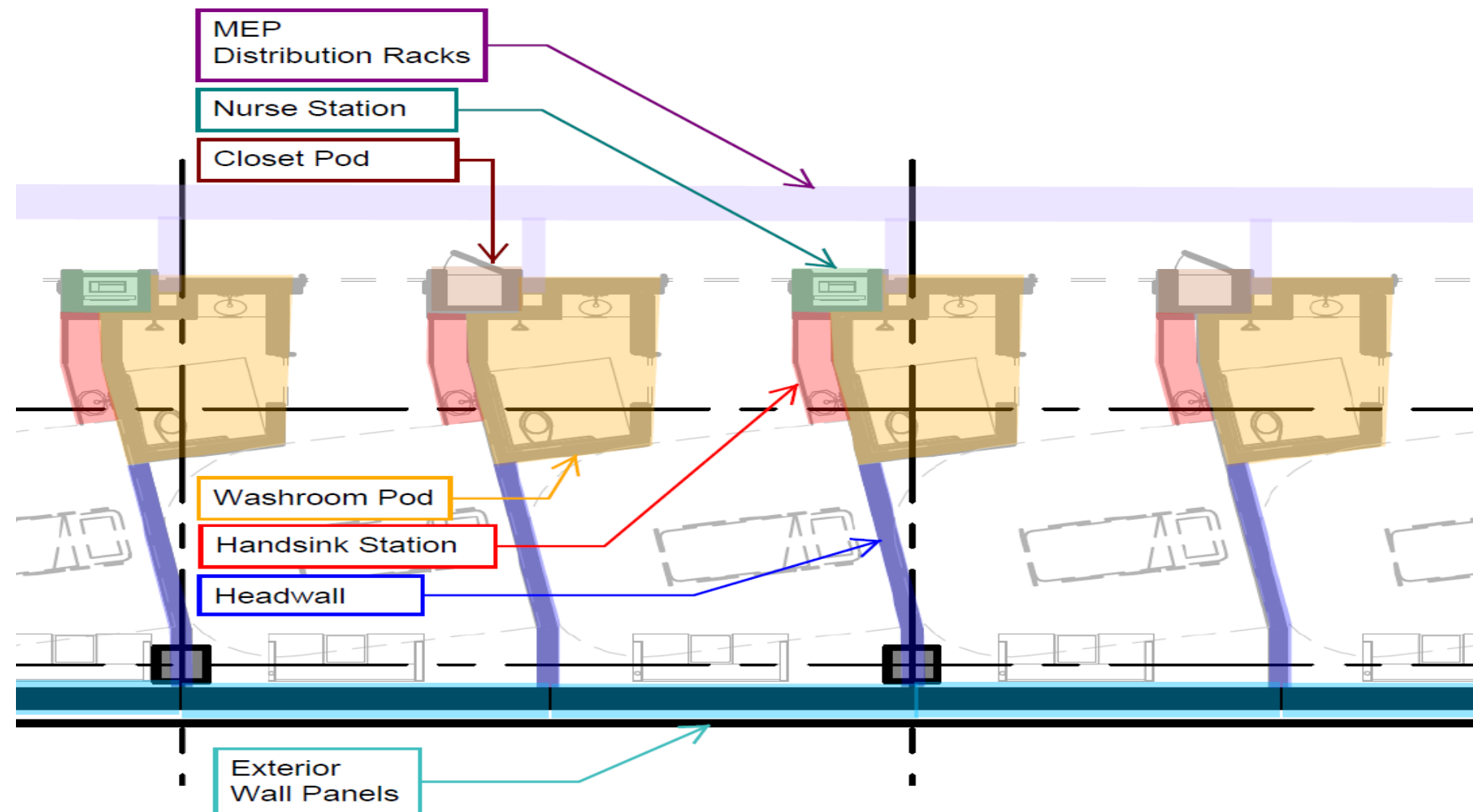


TYPICAL OFF-SITE - CELLULAR

Simple components that are often repeated

Examples include:

- patient bathrooms
- headwalls
- MEP distribution racks
- smart walls
- closets



Built Environment



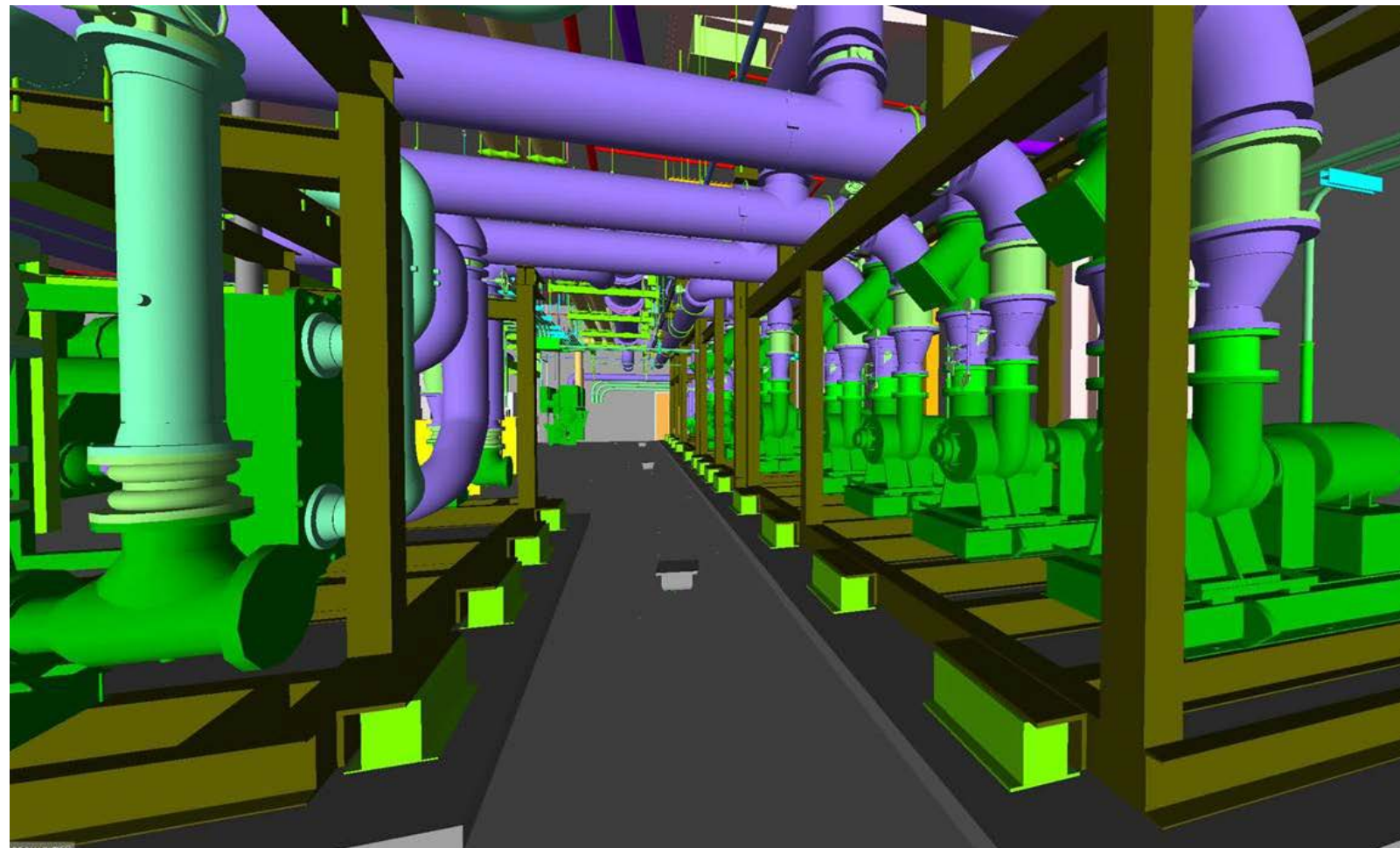
Training

TYPICAL OFF-SITE - TECHNICAL

Complex areas with multiple trades operating in a confined area

Examples include:

- boiler / chiller plants
- mechanical penthouses
- chemical processing skids
- large, complex racks
- elevators



Built Environment



Training

PREFABRICATION BENEFITS

- Less congested site, less manpower to manage on-site
- Safer construction site
- Cost certainty
- Schedule certainty, potentially shorter schedule
- Reduced site disruption
- Best-in-class quality



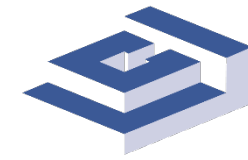
Removal of
Waste



Act | Safety



Optimize the
Whole



PREFABRICATION LONG-TERM BENEFITS

- Build more with less resources
- Cross-project learning = shorter learning loop
- “Standing on the shoulders” of proven designs
- Continuous improvement due to decoupled elements
- Ability to tap into a larger, global supply chain
- Investments today reap future returns



Continuous
Improvement



Optimize the
Whole



BENEFITS – THE BOTTOM LINE

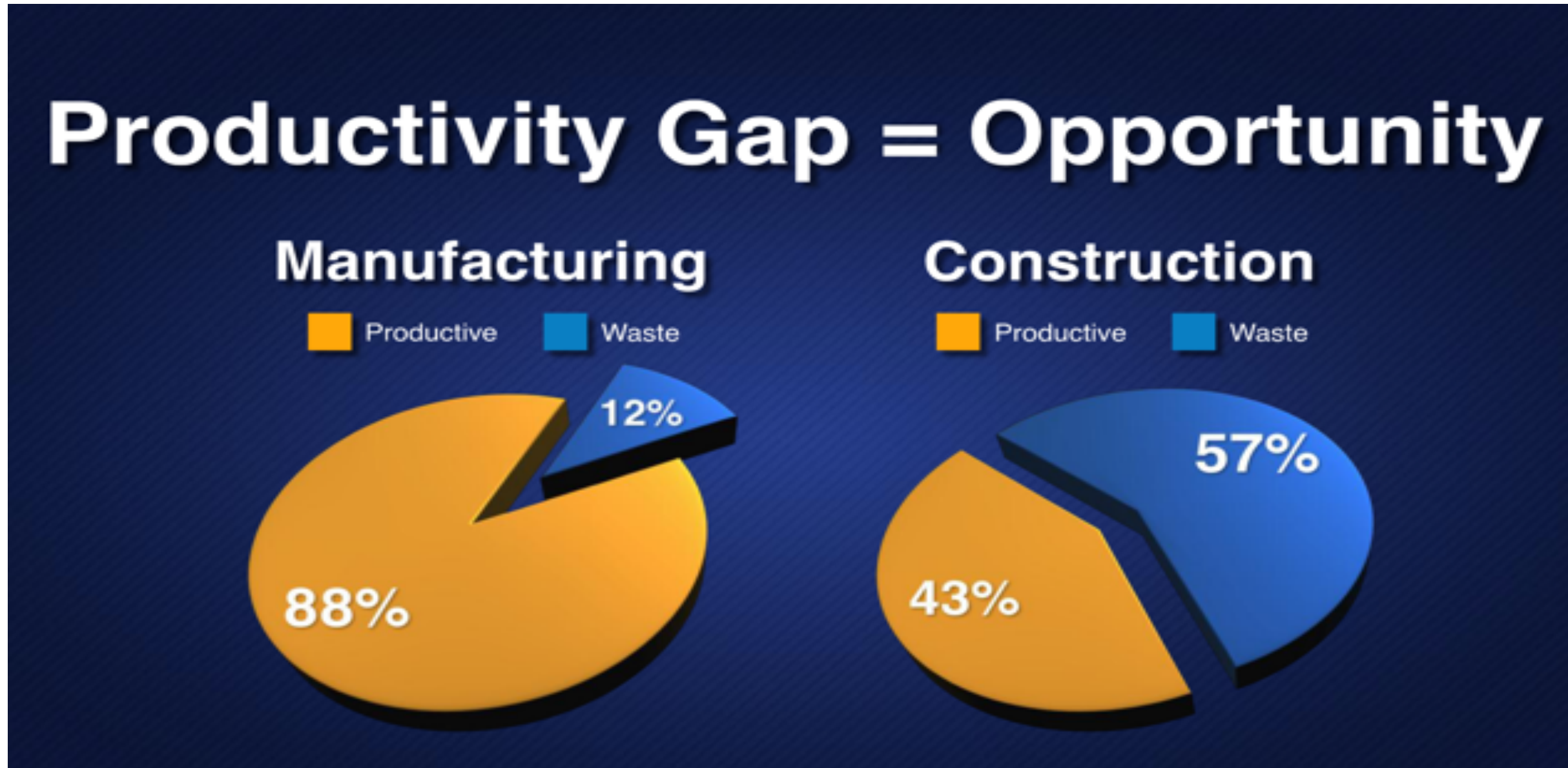
EASIER leads to ...

BETTER & FASTER

Result = MORE VALUE

(potentially cheaper, maybe not)

IT'S ABOUT PRODUCTIVITY




Construction Industry Institute

CONSTRUCTION AND R&D



The construction industry is among the least digitized.

McKinsey Global Institute industry digitization index; 2015 or latest available data

Relatively low digitization  Relatively high digitization
● Digital leaders within relatively undigitized sectors

¹Based on a set of metrics to assess digitization of assets (8 metrics), usage (11 metrics), and labor (8 metrics).

²Information and communications technology.

Source: AppBrain; Bluewolf; Computer Economics; eMarketer; Gartner; IDC Research; LiveChat; US Bureau of Economic Analysis; US Bureau of Labor Statistics; US Census Bureau; McKinsey Global Institute analysis

SECTION TWO – OFF-SITE IS A PROCESS



OFF-SITE PROCESS

- Off-Site is a process, not a decision, with tools and experts just like pull planning or any other Lean method
- Better when it's not a stand-alone method
- It can enhance or enable (modify) the other lean methods



Process
and Flow



Tools



Optimize the
Whole

OFF-SITE PROCESS



Is everyone rowing in the same direction?

THE PROCESS

Off-Site Realization Process (OSR)



Enables and optimizes the use of off-site prefabricated elements

STEP ONE - ALIGN



ALIGNMENT

Step One of the process involves:

- Educating the project team
- Defining value
- Identifying enablers and constraints
- Developing an initial off-site plan



XSITE TEAM AT A COLLABORATION SESSION



Training



Collaboration



Process
and Flow

ALIGNMENT



Consistency
Performance
Lifecycle
User Experience



Client / Owner



Onsite Issues
Quality
Schedule
Competition



Builder



Re-Use
Risk Quality
Productivity



Subcontractor

SYSTEMS APPROACH

A methodology that analyzes performance and interaction of individual systems and how that system affects whole building design and overall performance.

Using a structured process, analyze and select solutions (off-site and conventional) which increase value and reduce waste.



Built Environment



Optimize the Whole



Removal of Waste

SYSTEMS APPROACH

You need to know...

- How building systems interact
- Each systems expected performance
- Sequence of construction
- Contracting and procurement process
- Understanding of available supply chain
- **Structured Process to integrate off-site elements**



Built
Environment



Optimize the
Whole



Removal of
Waste

SYSTEMS APPROACH

- Do we need it?
- How much do we want to decouple it?
- How can it be produced off-site?
- What can we concurrently build?
- Does this assist in turning the project site into an assembly location vs. a construction site?



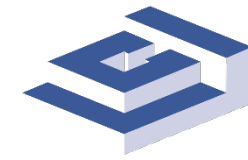
Built
Environment



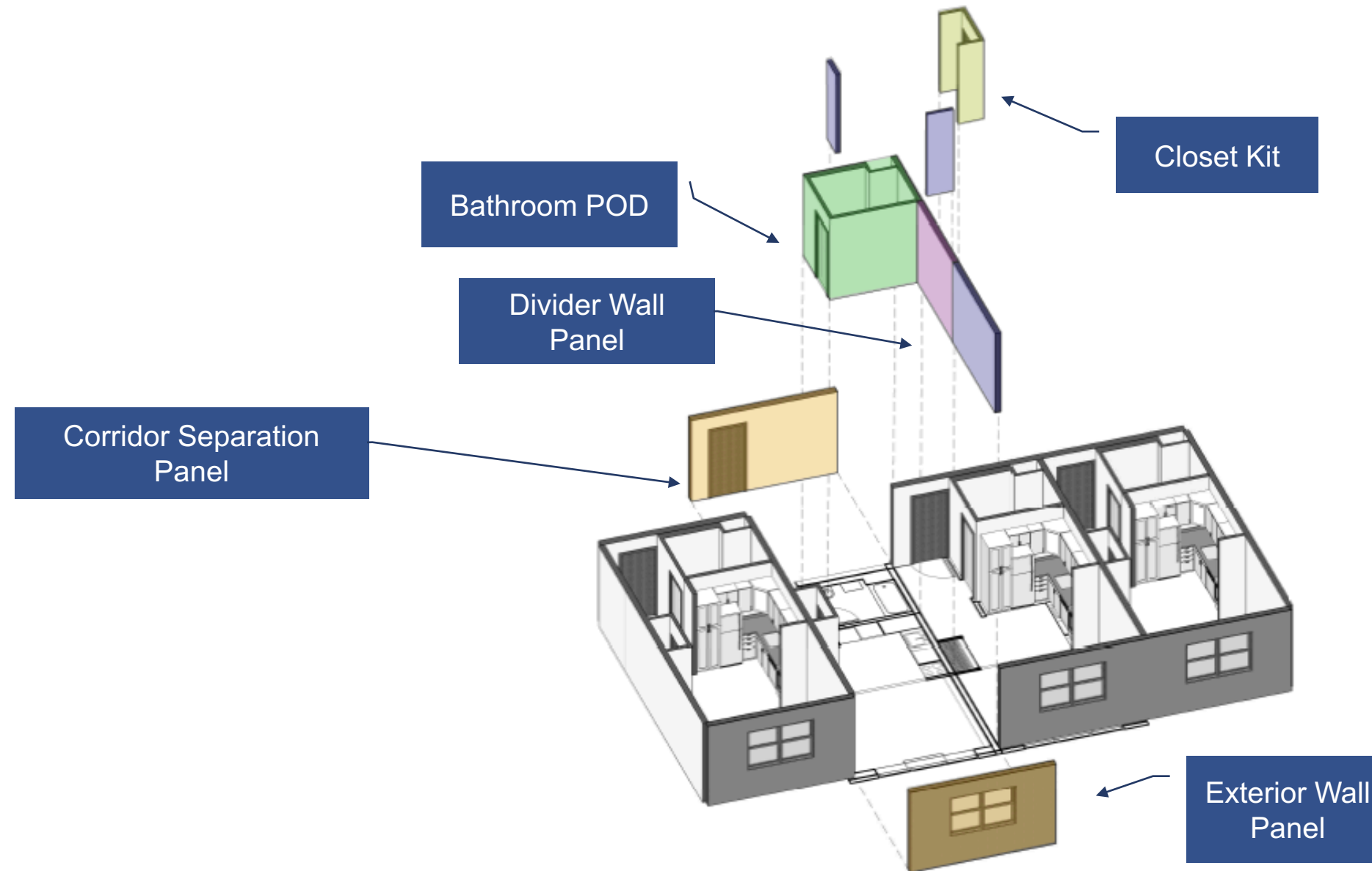
Optimize the
Whole



Removal of
Waste



SYSTEMS APPROACH



Built Environment



Optimize the Whole



Removal of Waste

STEP TWO - PLAN



PLAN

Step Two is Plan

- Dissection Plan - Identify, Prioritize, Categorize the Off-Site Elements
- Score the Elements
- Organize the Teams

#	Total Score	Category (1, 2, 3)	Group	Execution Strategy	
1	9	1	MEP Modules	OSM	Electrical rooms vertically
2	9	1	MEP Modules	OSM	IT rooms vertically
3	9	1	MEP Modules	OSM	CUP Building fully
4	11	2	MEP Racks	SCOSC	Electrical underground
5	10	2	MEP Racks	OSM	Prefabricated boiler generator)
6	10	3	MEP Racks	SCOSC	Prefabricated elec
7	10	3	MEP Racks	OSM	Prefabricated wiri
8	8	1	MEP Racks	SCOSC	Main corridor distr
9	8	1	Operating Rooms	OSM	Simulation ceiling
10	8	1	Operating Rooms	OSM	Operating room ce
11	10	2	Pods	OSM	Non-patient room
12	10	2	Pods	OSM	Enhanced washroc
13	10	2	Pods	OSM	Patient washroom
14	9	2	Pods	OSM	Nurse Server close
15	8	2	Pods	OSM	Nurse charting sta
16	12	1	Shell	OSM	Exterior panelized
17	11	1	Shell	OSM	Integrated conduit
18	11	2	Shell	OSM	Precast stair landir
19	10	1	Shell	OSM	Elevator rooftop o
20	8	1	Shell	OSM	Hung exit corridor
21	9	2	Wall Panels	OSM	Handwash / eyewa
22	8	2	Wall Panels	OSM	Stretcher room he
23	8	2	Wall Panels	OSM	ER headwalls (MI)

TOOLS – KEY ELEMENT SHEET

Bathroom Pod

Major Group Element C Interiors
Group Element C10 Interior Construction

Description
Bathroom pods are completed bathrooms and come with plumbing fixtures and finished interior spaces. These include: casework, countertops, electrical fixtures, bath accessories, finishes and flooring. They are delivered on-site as single 'plug and play' units.

Highlighted Vendors

Trade Impact

01 General Req's	n/a
03 Concrete	n/a
04 Masonry	n/a
05 Metals	n/a
06 Carpentry	Integral framing and drywall
07 Insul. & Roofing	n/a
08 Openings	Integral door and frame
09 Finishes	Integral floor, wall and ceiling finish
10 Specialties	Integral bath accessories
21 Fire Suppression	n/a
22 Plumbing	Integral rough and finish plumbing
23 HVAC	Integral exhaust fan/grill
26 Electrical	Integral rough and finish electric



Key Components

1	Wall & Ceiling Panels
2	Wall Finishes
3	Floor Finishes
4	Plumbing Fixtures
5	Bath Accessories
6	Rough & Finish Plumbing
7	Rough & Finish Electric
8	Door & Frame



Tools

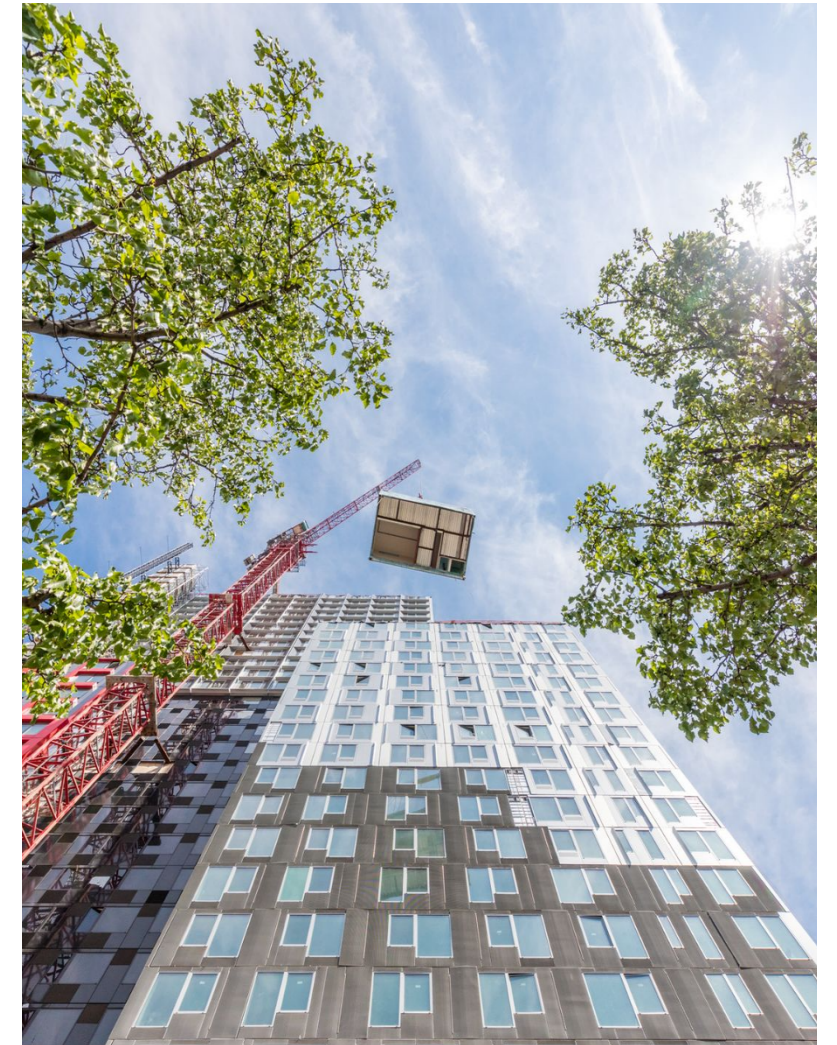
STEP THREE - IDENTIFY



IDENTIFY

Step Three is Identify

- Decide Execution Strategy
- Identify Suppliers
- Contact Suppliers
- Prequalify Suppliers



B2-PACIFIC PARK, BROOKLYN, NYC

STEP FOUR – SELECT



SELECT

Step Four is Select

- Detail the Design Requirements
- Target Value Design (TVD)
- Request for Proposals
- Supply Chain Engagement
- Analyze Proposals



PROTOTYPE INSPECTION



Tools



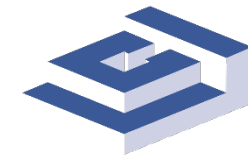
Collaboration



Process
and Flow

STEP FIVE - INTEGRATE





INTEGRATE

Step Five is Integrate

- Onboard the Selected Supplier
- Integrated Design Sessions
- Refine On-Site Construction Sequence and Installation Schedule



OFF-SITE ELEMENT READY FOR INSTALLATION



Built Environment



Optimize the Whole



Process and Flow

DESIGN FOR MANUFACTURE AND ASSEMBLY (DfMA)



Training



Collaboration



Process
and Flow

DESIGN FOR MANUFACTURING & ASSEMBLY PRINCIPLES

1. Modular design
2. Design parts for multi-use
3. Reduce total number of parts
4. Use of standard components
5. Use of intelligent materials
6. Design for ease of fabrication
7. Design for ease of assembly and minimized handling
8. Design for Safety



Training



Tools



Process
and Flow

DfMA PRINCIPLES - VW



Training



Collaboration



Process and Flow



DfMA PRINCIPLES - VW



← 60% of total engineering cost →



Training

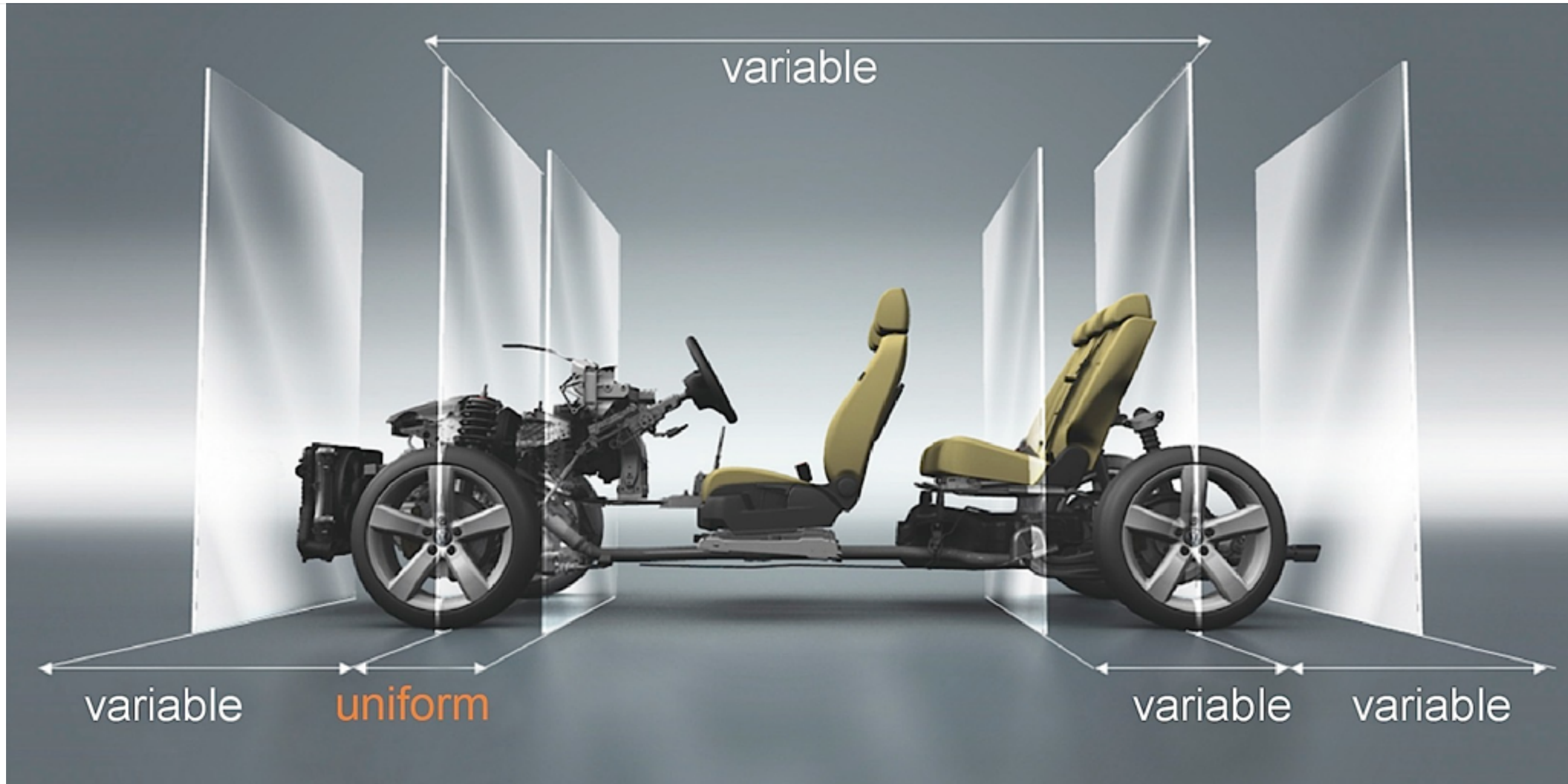


Collaboration



Process and Flow

DfMA PRINCIPLES - VW



Training



Collaboration

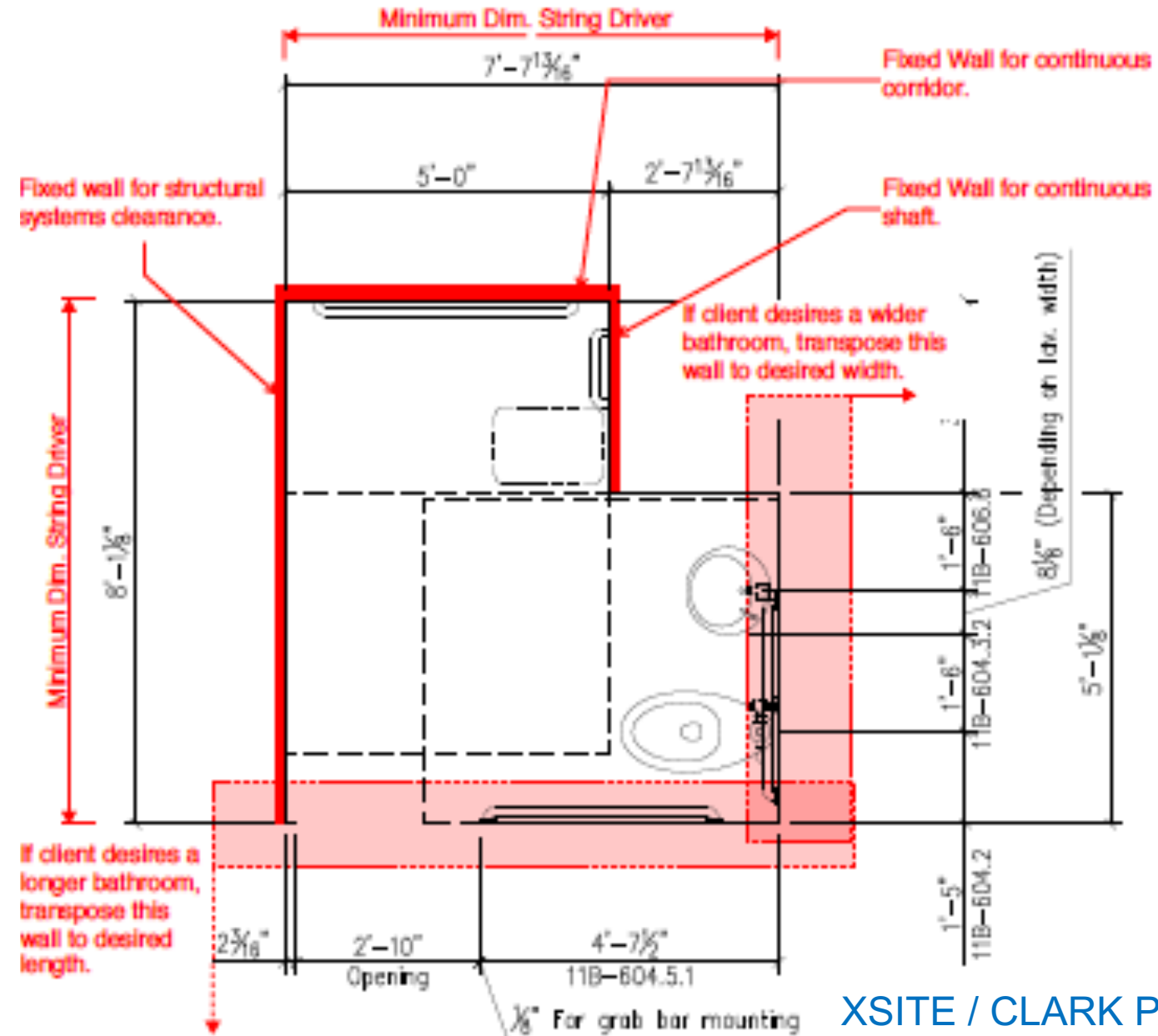


Process and Flow



DfMA PRINCIPLES - PODs

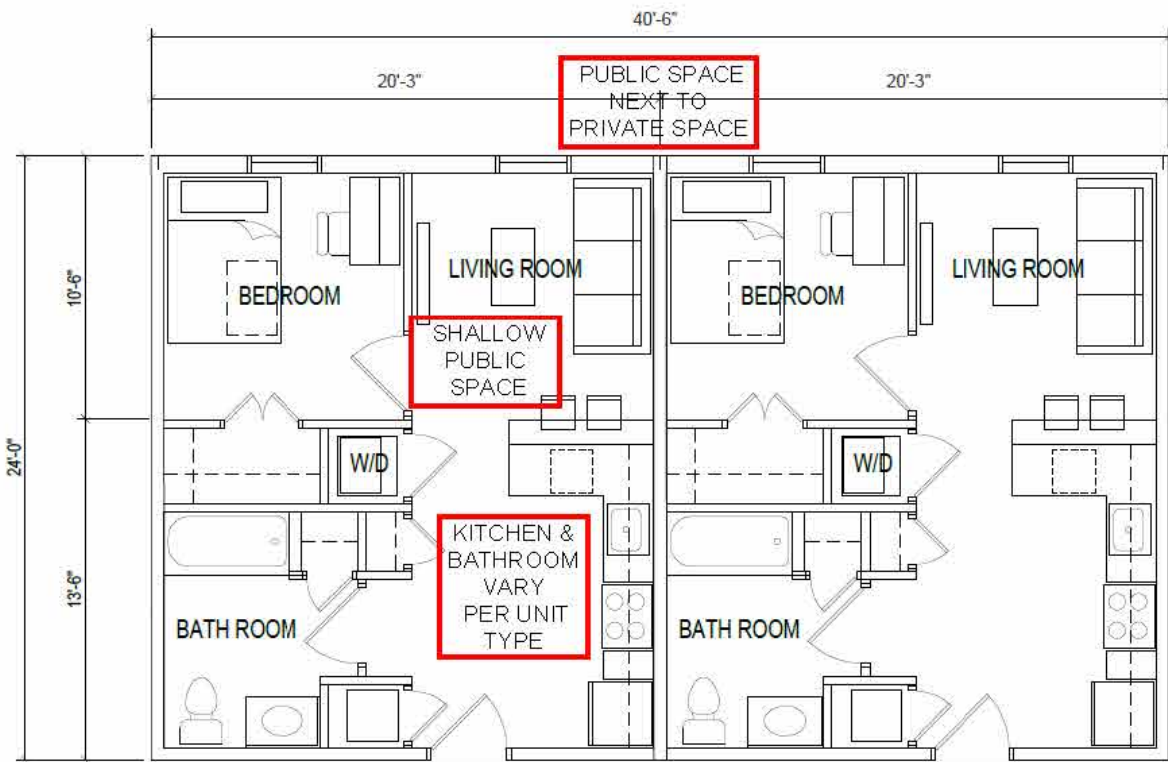
Strategy for expanding upon the base minimum adaptable bath unit to support design of larger bathrooms and continuity of shaft space



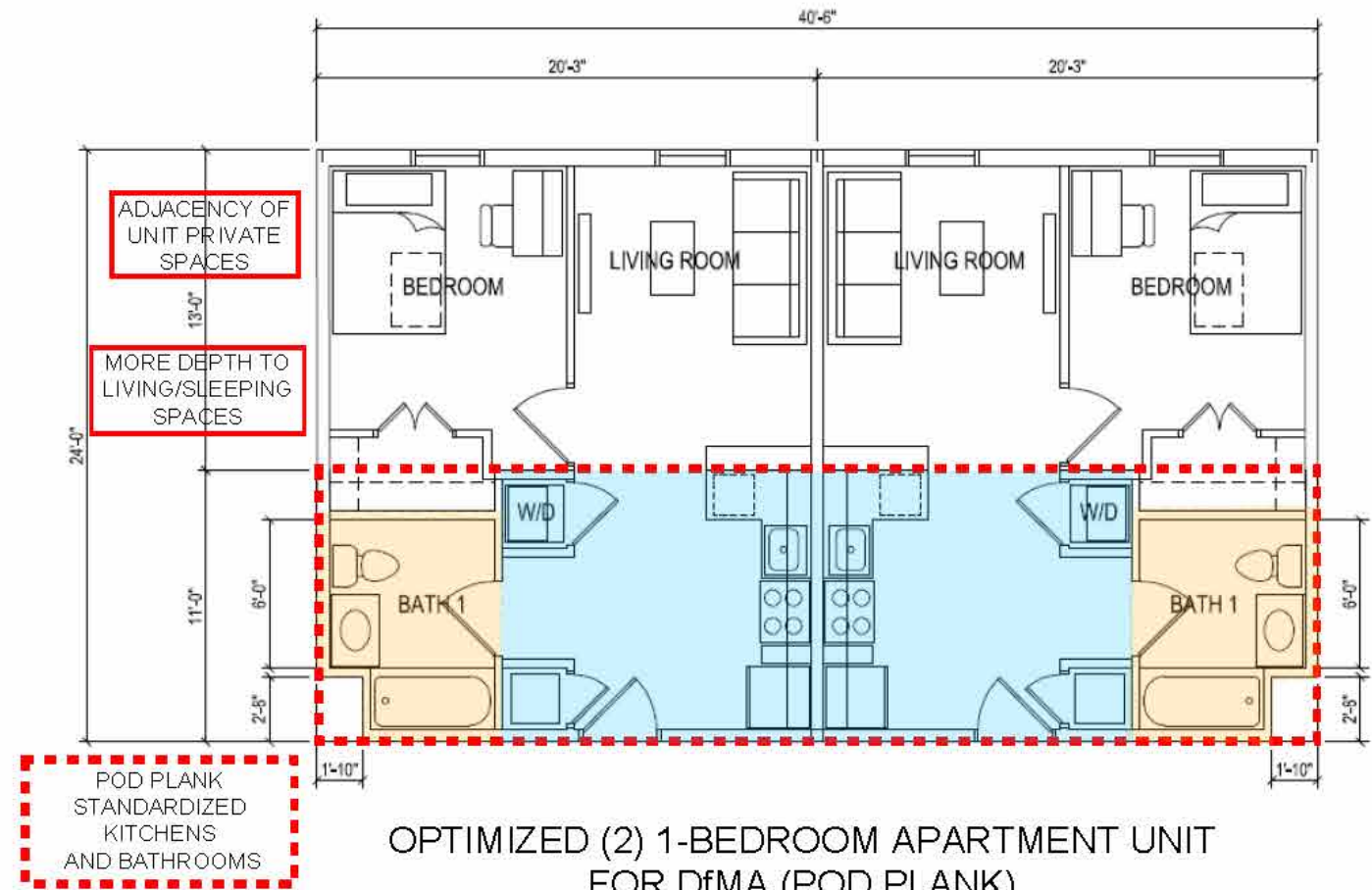
Optimize the Whole

XSITE / CLARK PACIFIC POD PLANK

INSIDE OUT DESIGN



ORIGINAL (2) 1-BEDROOM APARTMENT UNIT



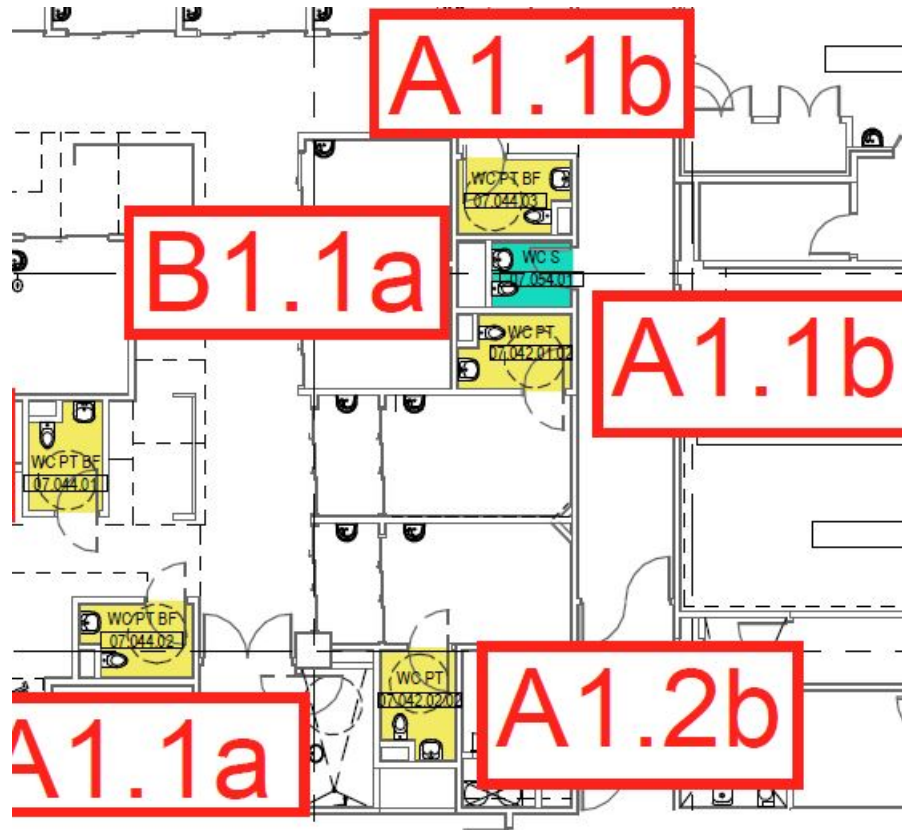
OPTIMIZED (2) 1-BEDROOM APARTMENT UNIT FOR DfMA (POD PLANK)



Optimize the Whole

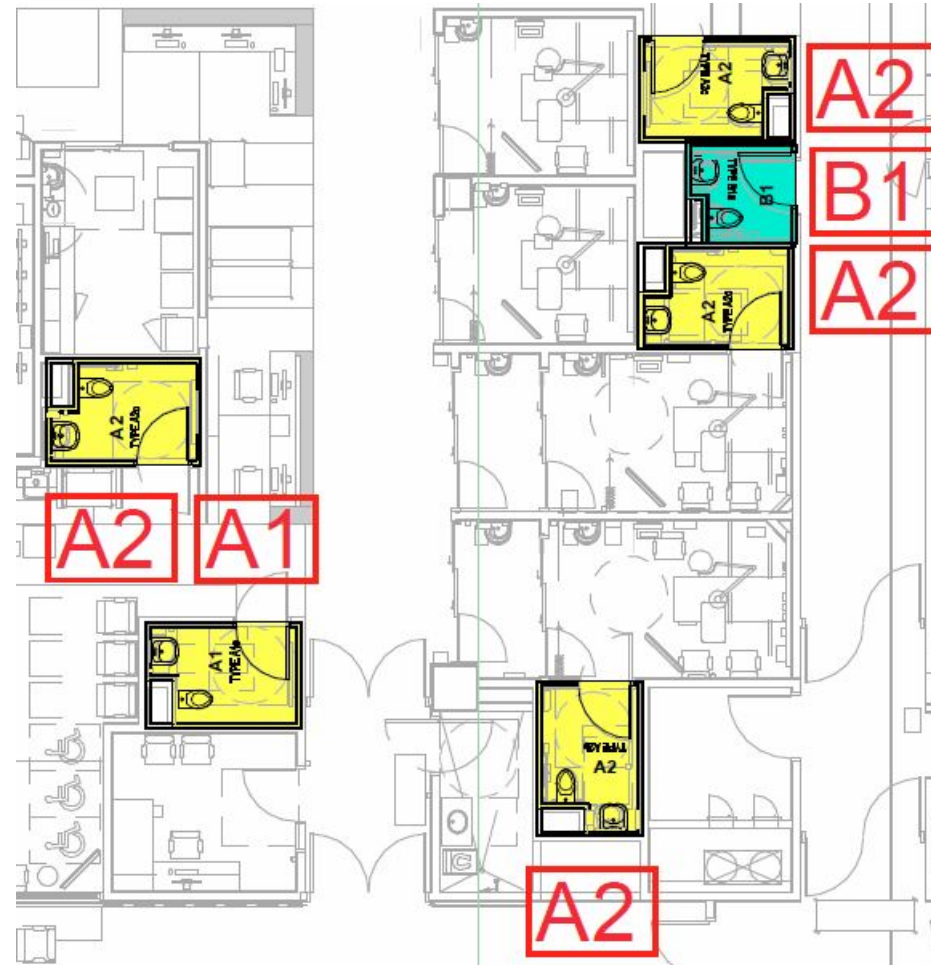
XSITE / CLARK PACIFIC POD PLANK

INSIDE OUT DESIGN



BEFORE standardization
700 individual bathroom pods
99 different types

AFTER standardization
700 individual bathroom pods
5 different types



Optimize the Whole

SECTION THREE – IMPACTS ON OTHER LEAN METHODS

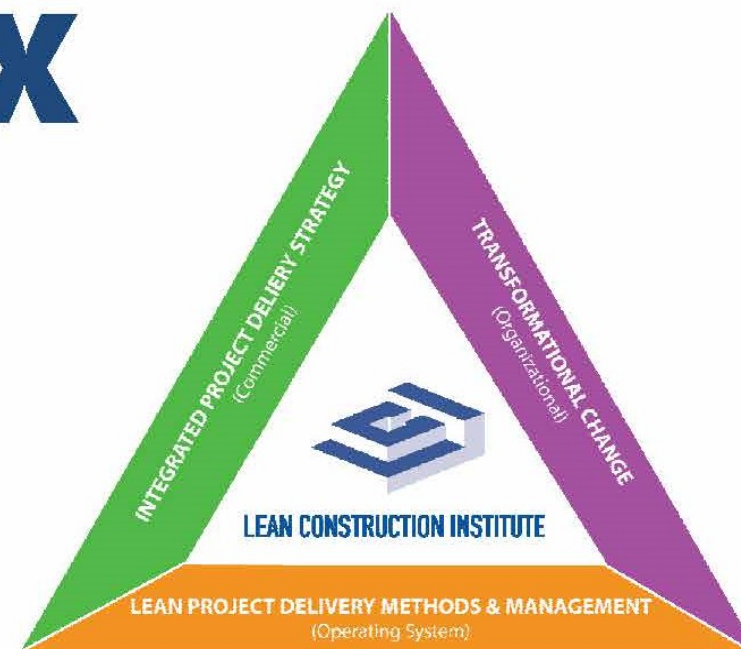


LEAN - EVIDENCE

PROJECTS with **HIGH LEAN INTENSITY**
are **MORE LIKELY** to complete
AHEAD OF SCHEDULE & UNDER BUDGET

3X

2X

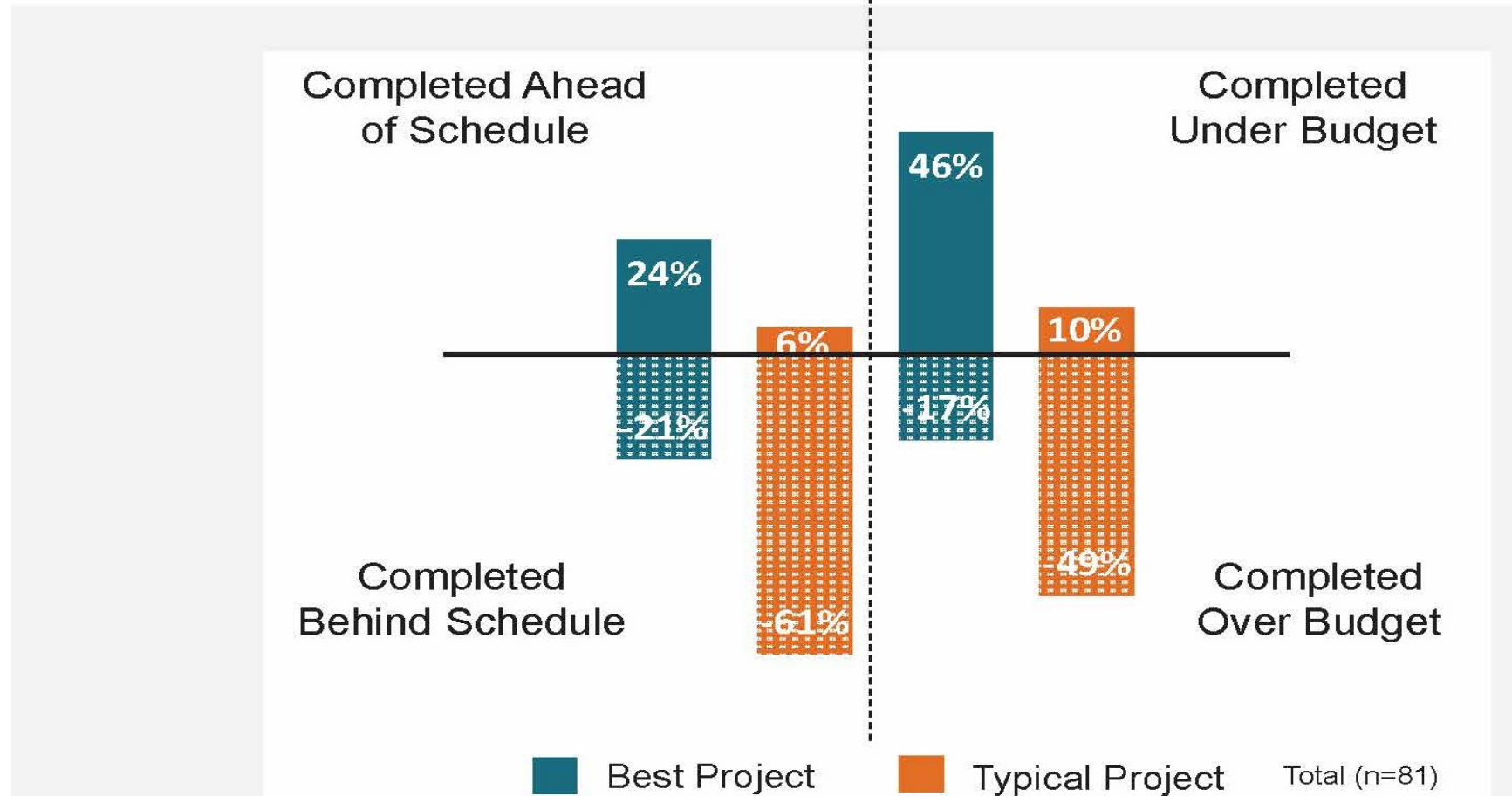


Research

LEAN - EVIDENCE

Satisfaction vs. Value

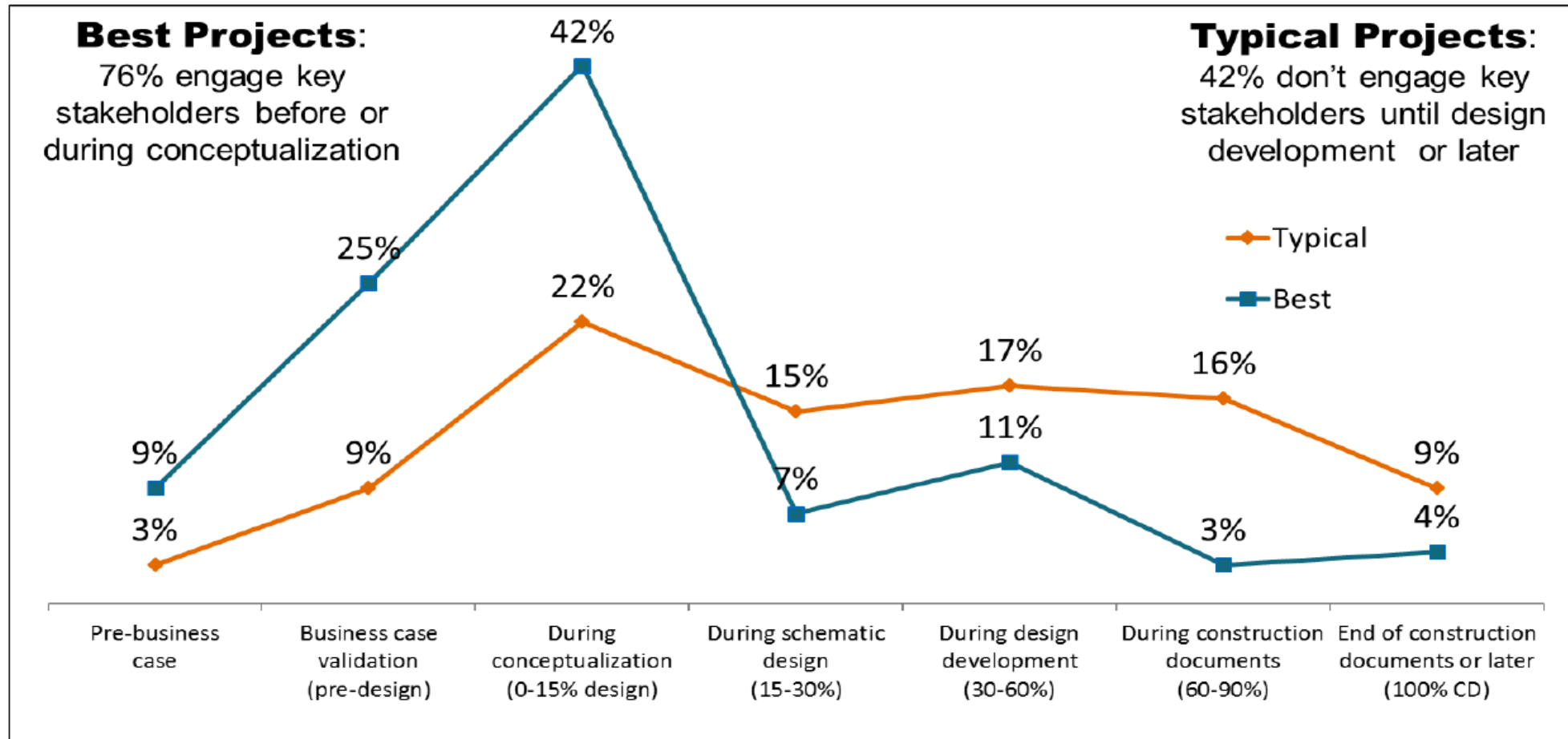
Performance from Approval of Capital Project
(% of Best/ Typical Projects)



Research

LEAN - EVIDENCE

Timing of Key Stakeholder Engagement

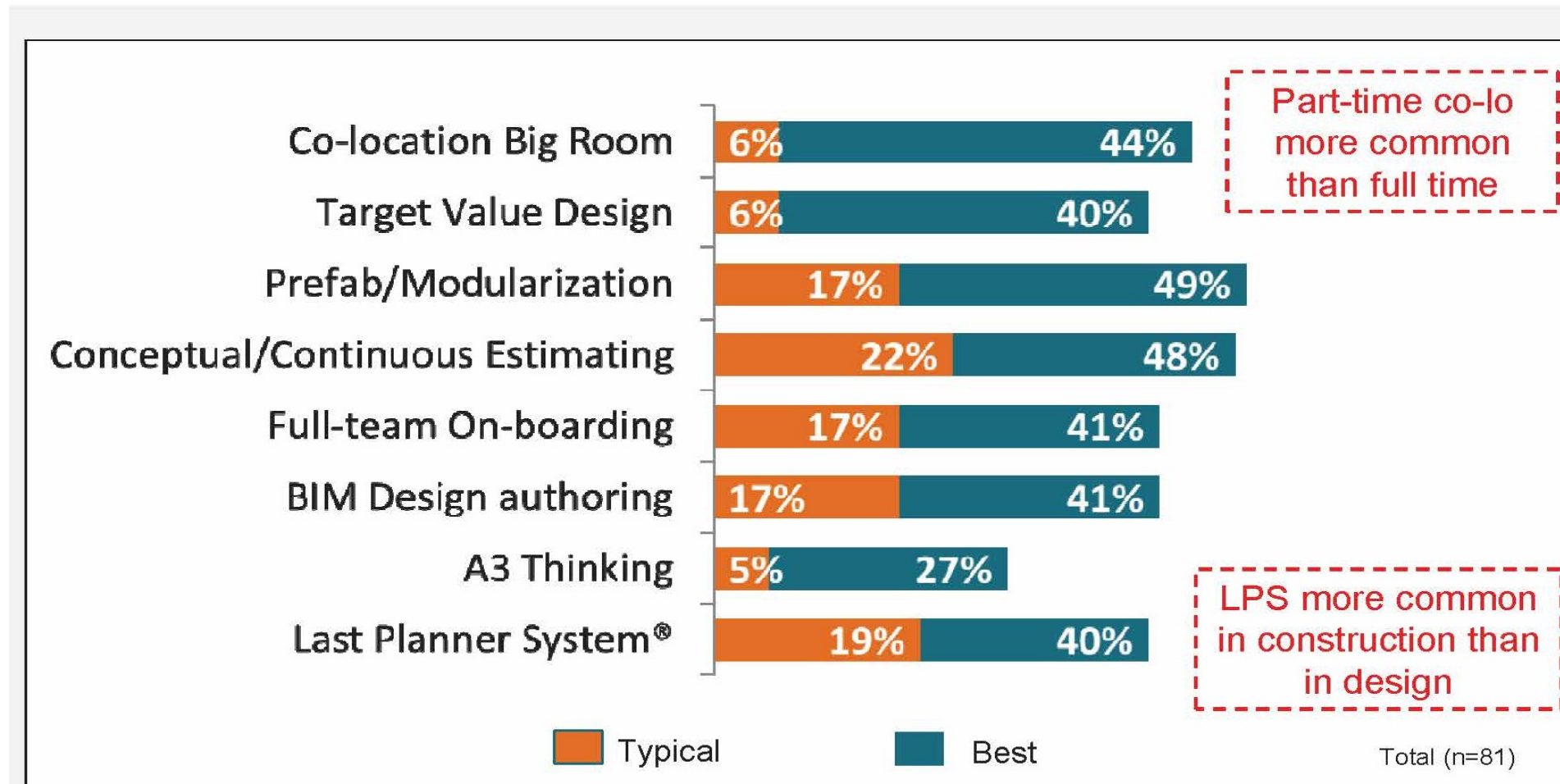


Research

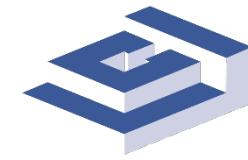
LEAN - EVIDENCE

Learn as a Team

Methods with Most Degree of Difference Between Usage



Research



CO-LOCATION - BIG ROOM

Enhancements

- It's a key premise that the off-site realization process is collaborative
- All stakeholders are present in the big room for off-site element team so it reinforces the need and concept



Collaboration

Modifications

- Some normal design/coordination meetings are replaced by the off-site element team meeting
- Others incorporate the off-site element meeting (or leaders from the team) into larger design/scoping sessions



Respect for
people | Team

PULL PLANNING

Enhancements

- Because the focus is on resequencing the work, pull-planning is needed
- Allows for additional time savings to be identified and realized for prefabricated elements
- Decoupled AND less pieces and parts – cleaner schedules – better work flow – more certainty



Collaboration

Modifications

- During the pull plan, prefabricated elements are identified (usually with a sticker on the sticky note)
- Areas including prefabricated elements are revisited to ensure all resequencing considerations during the session
- Approvals are needed earlier for items within the prefabricated elements



Respect for
people | Team

TVD – ELEMENT- vs TRADE-CENTRIC

Enhancements

- Focuses on performance-based specifications vs. prescriptive specifications
- Places focus on sharing costs as part of the design criteria

Modifications

- Requires target costs for element-based solutions vs. trade focus

Conventional Bathroom



Required Trades: 9
Carpenter, Plumber,
Mech, Elec, Drywaller,
Door, Fire Protection,
Tiler, Painter

Prefabricated Bathroom Pod



Required Trades: 1
Bathroom Pod
Manufacturer

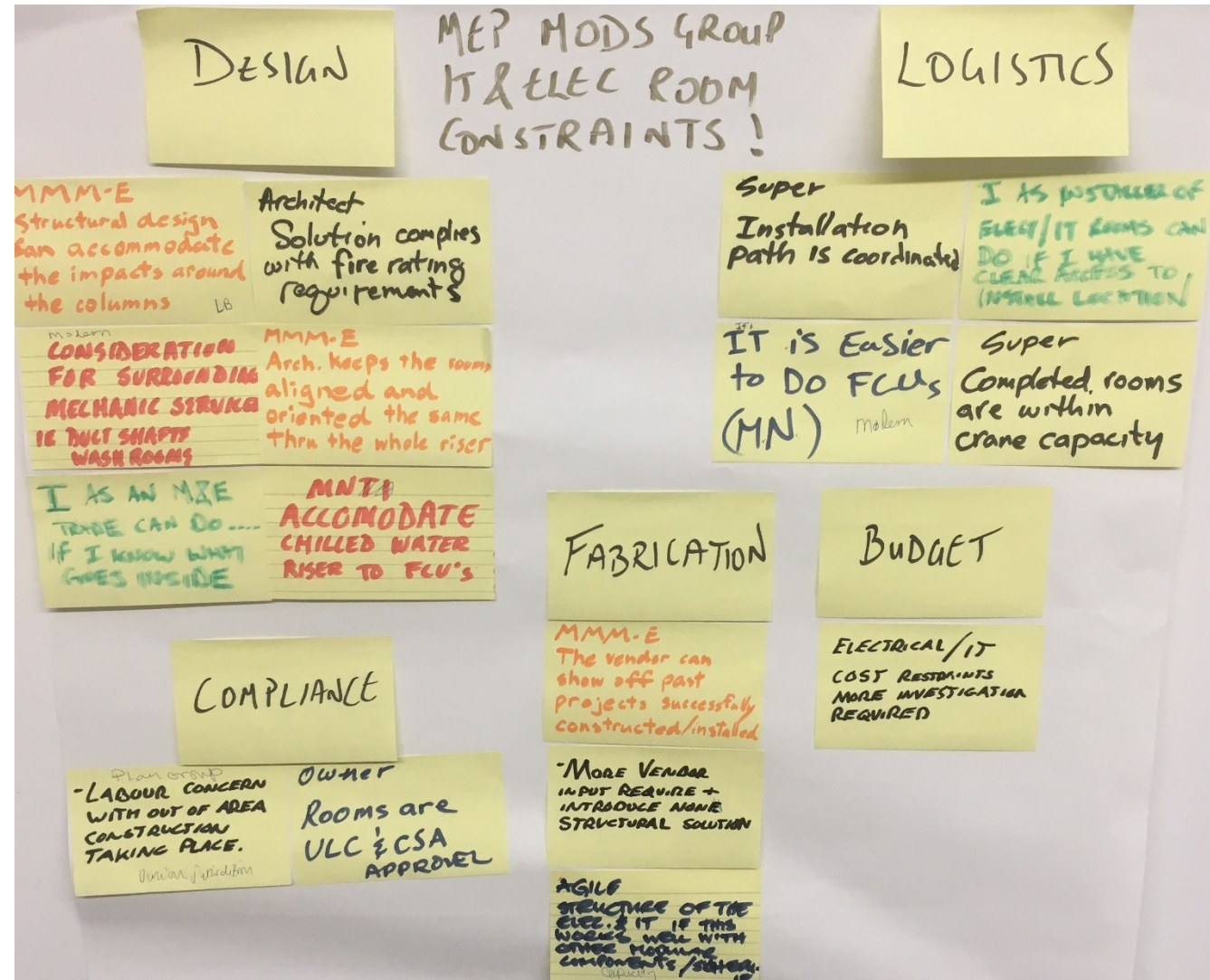
CONSTRAINT LOG

Enhances

- Off-site element teams focus on removing constraints
- I CAN do “off-site element”, IF this criterion is met.

Modifications

- The off-site element team collaboratively removes constraints for the element, not just the responsibility of the project manager



Plan | Value Generation



Collaboration

INTEGRATED PROJECT DELIVERY (IPD)

Enhances

- Collaboration within the off-site element teams fosters better communication and team work
- Focus is always on value to the project and not the individual since many elements are multi-trade
- Prefabrication is more successful in a collaborative environment

Modifications

- Key partners may be different
- Some traditional partners may not want to give up the work that is intertwined within elements
- Elements should be carved out at concept prior to any budgeting or estimates



Plan | Value
Generation



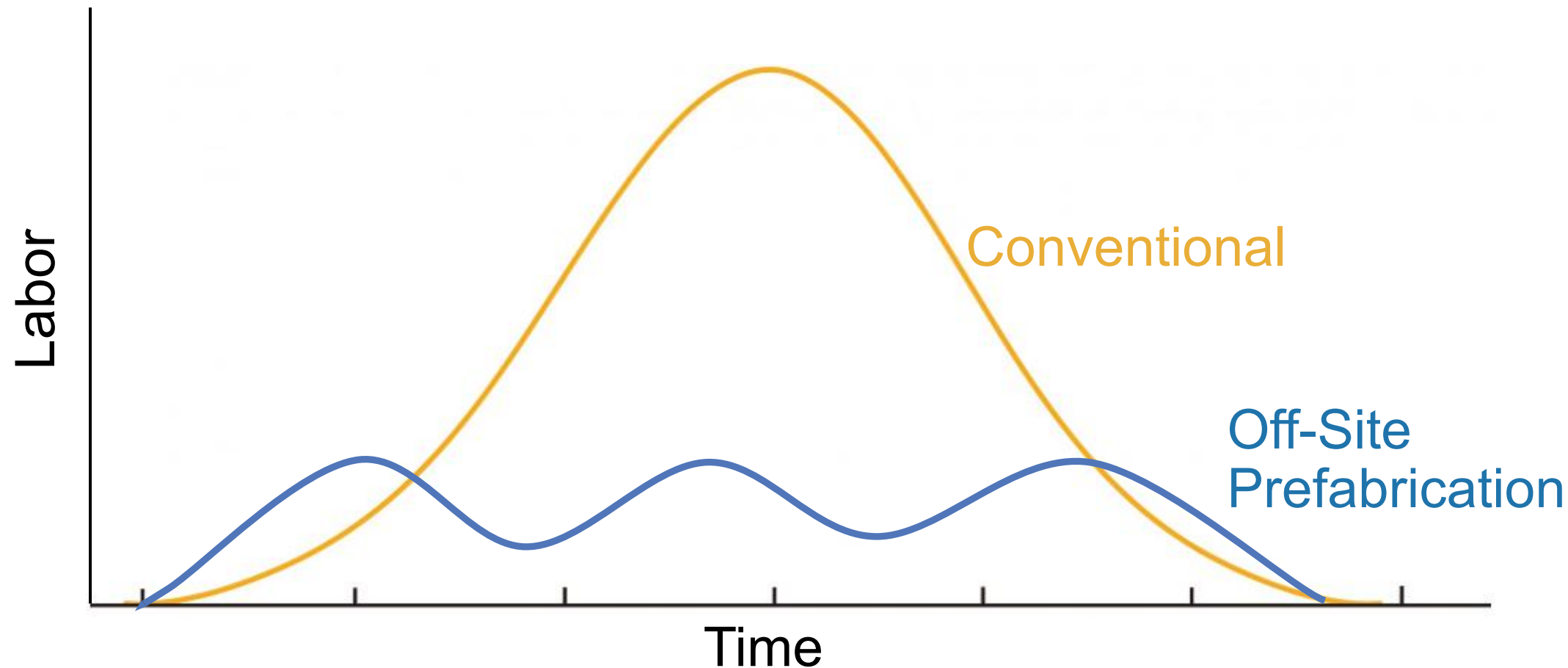
Process
and Flow

SECTION FOUR – PITFALLS, METRICS & CASE STUDIES



METRICS

- Reduced on-site labor
- Balanced, consistent labor

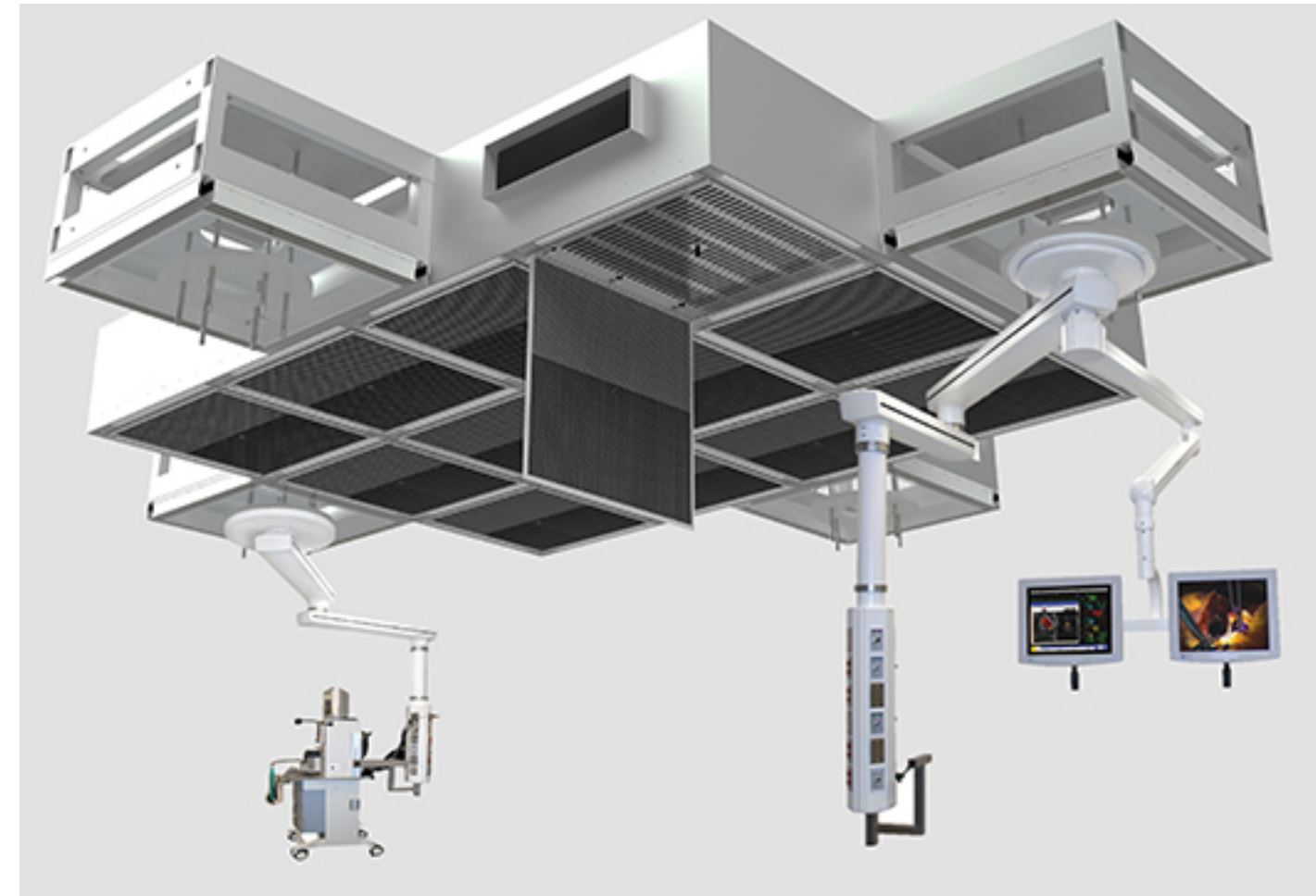


Process
and Flow

Other Metrics:
Schedule certainty
Cost certainty
Punch list
Safety

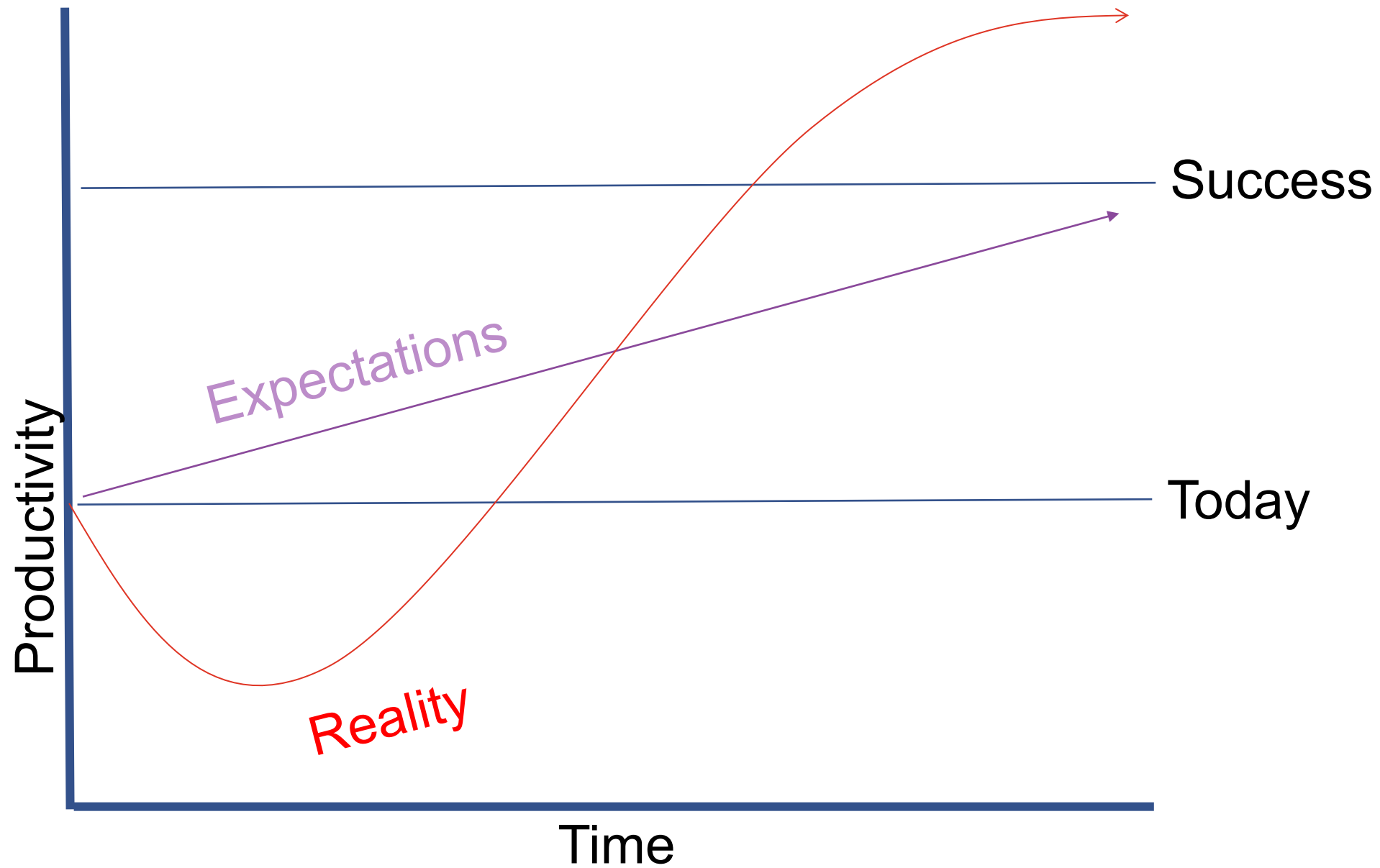
PITFALLS - PREFAB KILLERS

- Late engagement
- The "apples to orange" comparison
- Conventional procurement process
- Lack of Alignment – Why are we doing this?
- Single Element Focus
- Project-Centricity



OPERATING ROOM CEILING FROM SLD TECHNOLOGY

REALITY - THE LEARNING CURVE



Continuous Improvement



Built Environment



Process and Flow



CASE STUDY – LCF

THE MISSION

Help our client reduce its recurring capital costs of construction by:

30%

Provide an integrated project delivery (IPD) approach with a focus on design innovation for a complex manufacturing plant

Identify opportunities to utilize pre-fabrication, pre-assembly, modularization & off-site fabrication

Utilize a target value design (TVD) approach to achieve cost savings from start to finish

A Winning Formula for Lean Construction

Target Value Design + Off-site + Integrated Project Delivery + BIM

OUR APPROACH

Assemble the right (fully integrated) team upfront

The project team (system experts, design team, construction team, off-site experts, and strategic subcontractors) was assembled before any drawings were created. We spent significant time on aligning around our goals and the types of solutions the team would be exploring together. By spending time to align upfront, the design sessions that followed were more focused, productive and efficient.

Look at every angle

The team carefully analyzed the current system design and costs, understanding inputs and outputs, identifying major components, and labor intensive areas. Each specialty group within the team conducted an Initial Dissection Plan (IDP) – a brainstorming session focused on generating as many waste reduction ideas for the project as possible.

Go virtual

Leveraging 3D modeling in a BIM environment enabled the team to help the client visualize the new fabrication model including its new design, work flow and opportunities to leverage off-site throughout the facility. The team would have been crippled without the ability to virtually model possible solutions and new ideas.

OUR RESULTS

It's all about ideas

In total, the integrated team generated over 160 potential solutions and then evaluated the list against possible constraints, potential value, feasibility, cost, scheduling and so on. In the end, 75 improvements were identified as key elements that should be incorporated.

Bigger isn't always better

The team's new Target Value Design reduced the project footprint by 60% and the actual building area by 32%, which will translate into a significant cost reduction.

The bottom line

Leveraging this approach, our integrated team was able to identify a 40% potential cost reduction in the design and construction of these complex manufacturing plants.

For more insight on our Zero Waste strategies and how they can support your project, drop us a note: relentlessallies@balfourbeattyus.com



Research



Resources



Tools

CASE STUDY - LCF

LCF

- > The team developed a repeatable process for PPMOF and incorporated new supply chain partners
- > Six distinct areas of work with a value of approximately \$242M were examined yielding:
 - > 44% cost reduction
 - > 85% reduction of on-site hours
 - > 60% reduction of schedule
 - > 60% reduction in footprint
 - > 38% improvement in costs per capacity

Proof is in the pudding



Research




Resources



Tools

Balfour Beatty
Construction

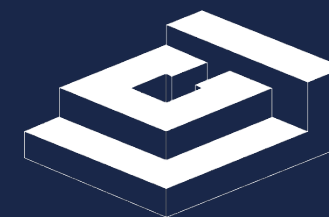
LEAN & PREFABRICATION – A PROCESS PARADIGM SHIFT



*“It is not necessary to **change**.
Survival is not **mandatory**”*

W E Deming

In the spirit of continuous improvement, we would like to remind you to complete this session's survey in the Congress app! We look forward to receiving your feedback. Highest rated presenters will be recognized.



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