Broadening the Perspective of Technology in Architectural Practice

October 19, 2012 | Stanford, CA
Stanford University Center for Integrated Facility Engineering

KEYNOTE

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Director, Center for Integrated Facility Engineering
Stanford University

Broadening the Perspective of Technology in Architectural Practice is registered with AIA CES.
Online + Components: **TAP101912W**
Stanford CIFE Live Event: **TAP101912S**
Questions? Contact tap@aia.org

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Martin Fischer

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and (by courtesy) Computer Science
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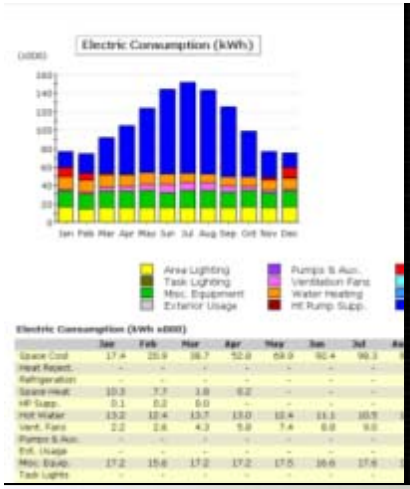
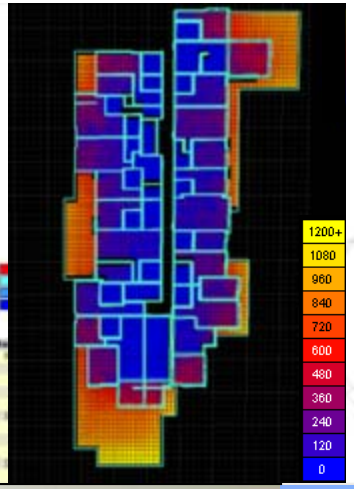
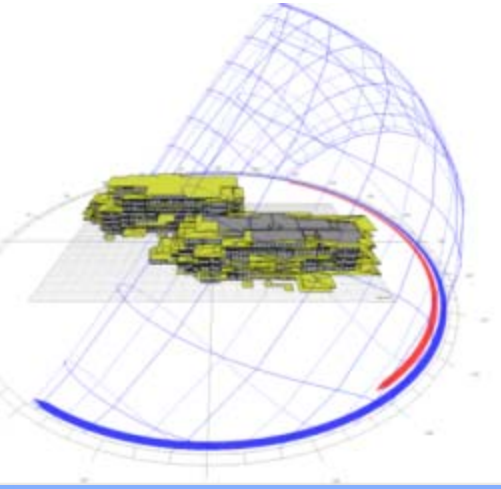
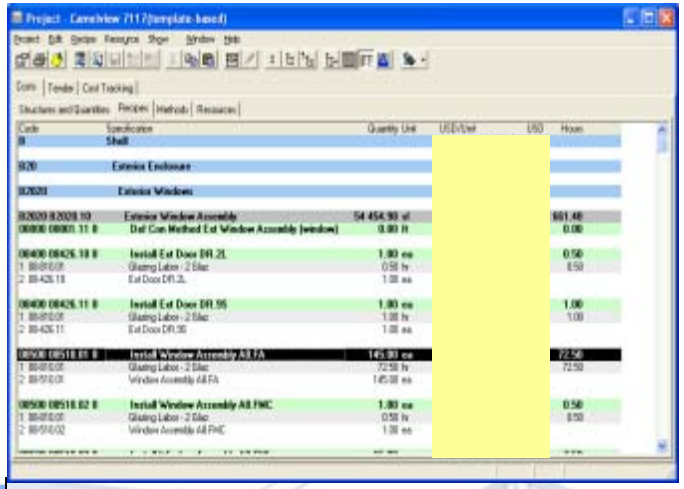
Additional Roles:

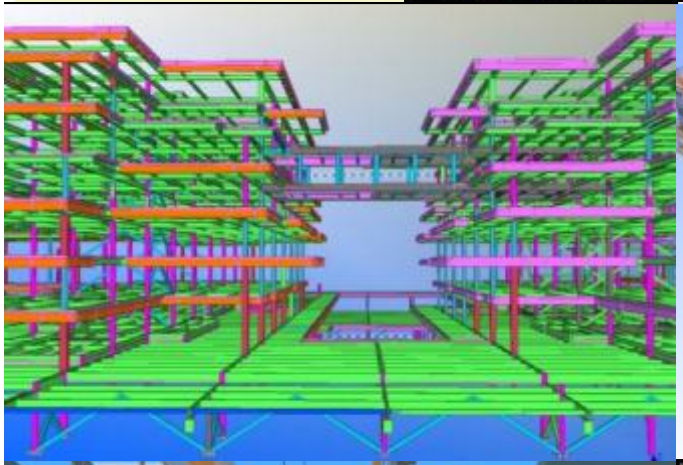
- Senior Fellow, Precourt Institute for Energy
- Lead, Building Energy Efficiency Research, Precourt Energy Efficiency Center (PEEC)
- Affiliated Faculty, Woods Institute for the Environment
- Affiliated Faculty, Emmett Interdisciplinary Program in Environment and Resources (E-IPER)
- Foreign Member, Royal Swedish Academy of Engineering Sciences

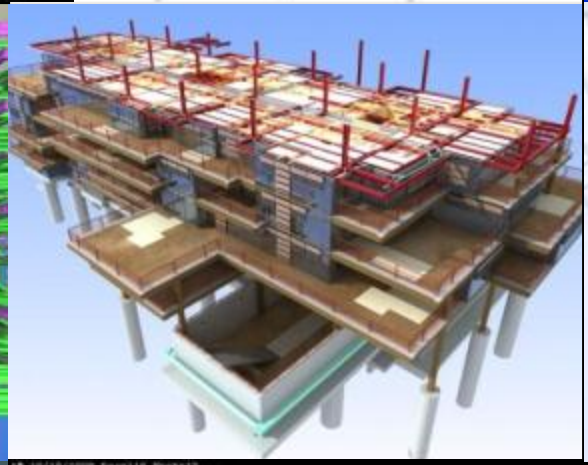

Electric Consumption (kWh)
Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
HP Pump Supp.

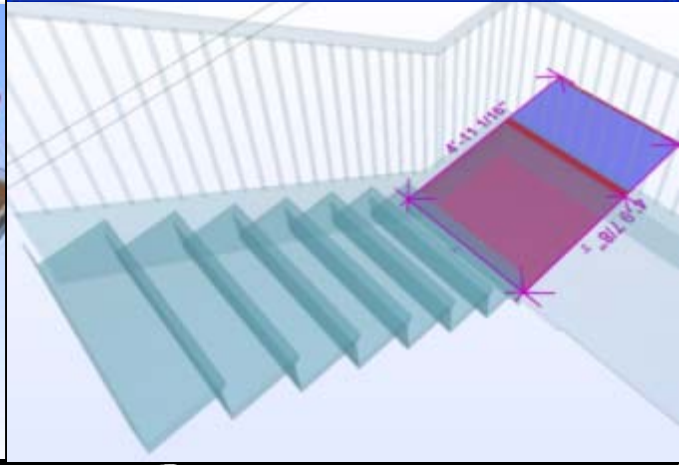

1200+
1080
960
840
720
600
480
360
240
120
0

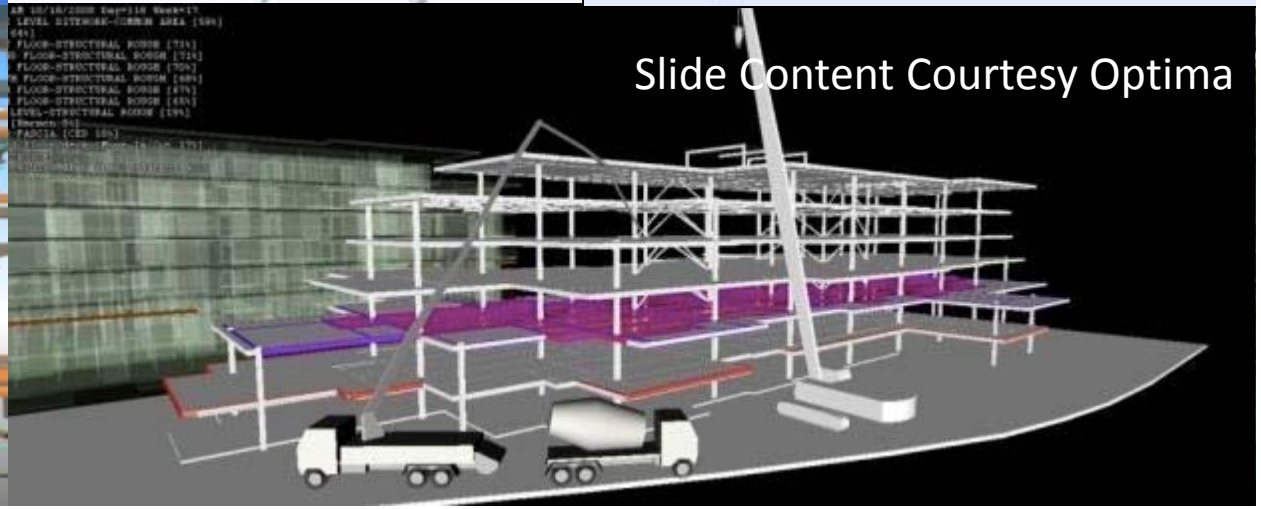




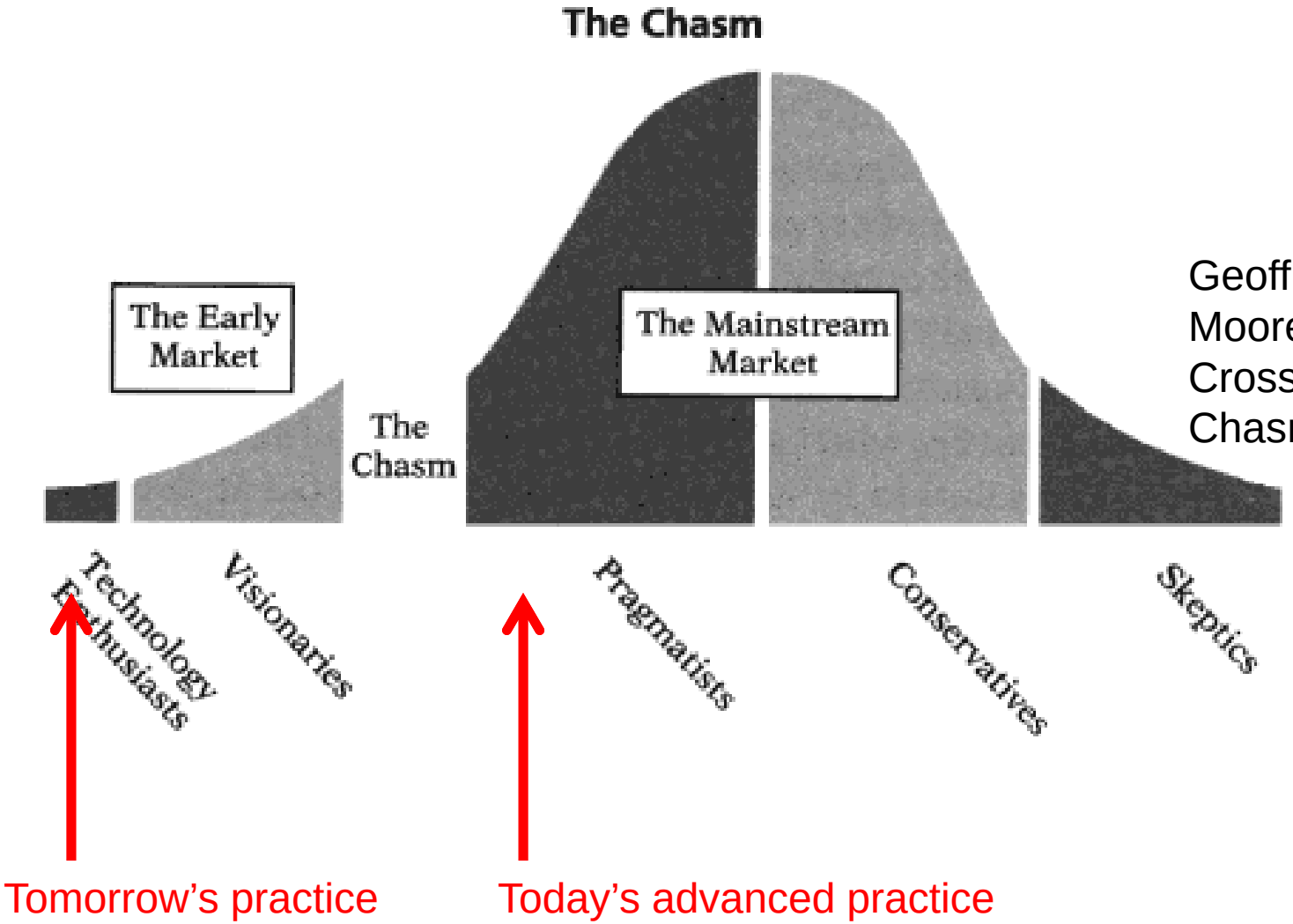







Slide Content Courtesy Optima

VDC practice is becoming mainstream: What is creating the next chasm?

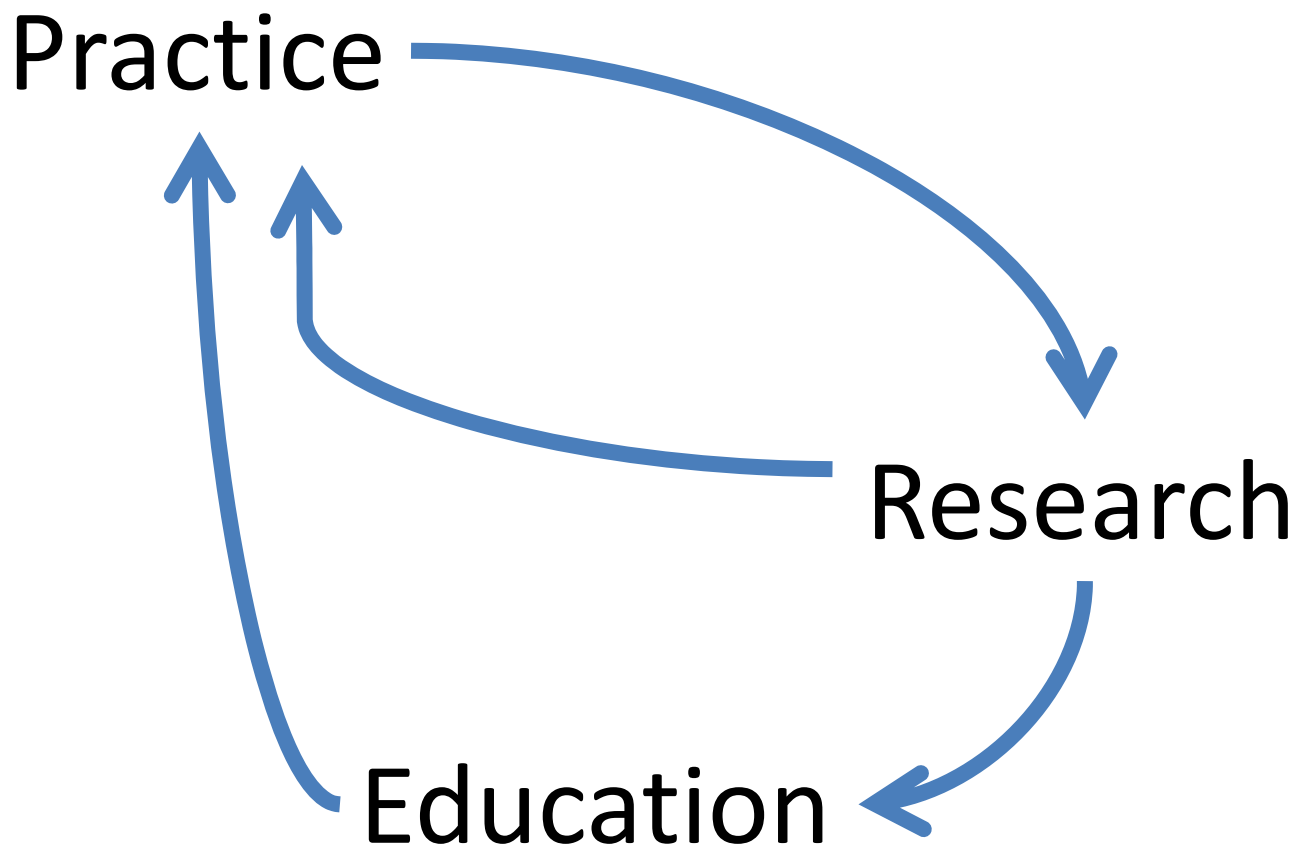


Geoffrey Moore, Crossing the Chasm

CIFE Development and Background

- 100% funded by industry
  - Building owners
  - Design and construction companies
  - Software and hardware vendors
- 1988-2000
  - Building Information Modeling (BIM)
- 2000-2010
  - Virtual Design and Construction (VDC)
- 2010+
  - Integrated Facility Engineering
  - Breakthrough performance

The CIFE community (industry, academia) invents the next practice together



How much do you want to earn per hour?

More than 11.9 cents?

1 hour of computing in the cloud costs 12 cents.

What can you do with 3.5 Million data points per day for a building?
(Y2E2 Building Stanford)

Or 500 Million data points per day for a campus?
(Microsoft Puget Sound)

Global trends that will affect the AEC industry dramatically

- Computing is (almost) free
- Computing is mobile
- Data are abundant
- “What you see is what you get” is today’s good practice
- Projects must be economically, environmentally, and socially sustainable
- The world is flat

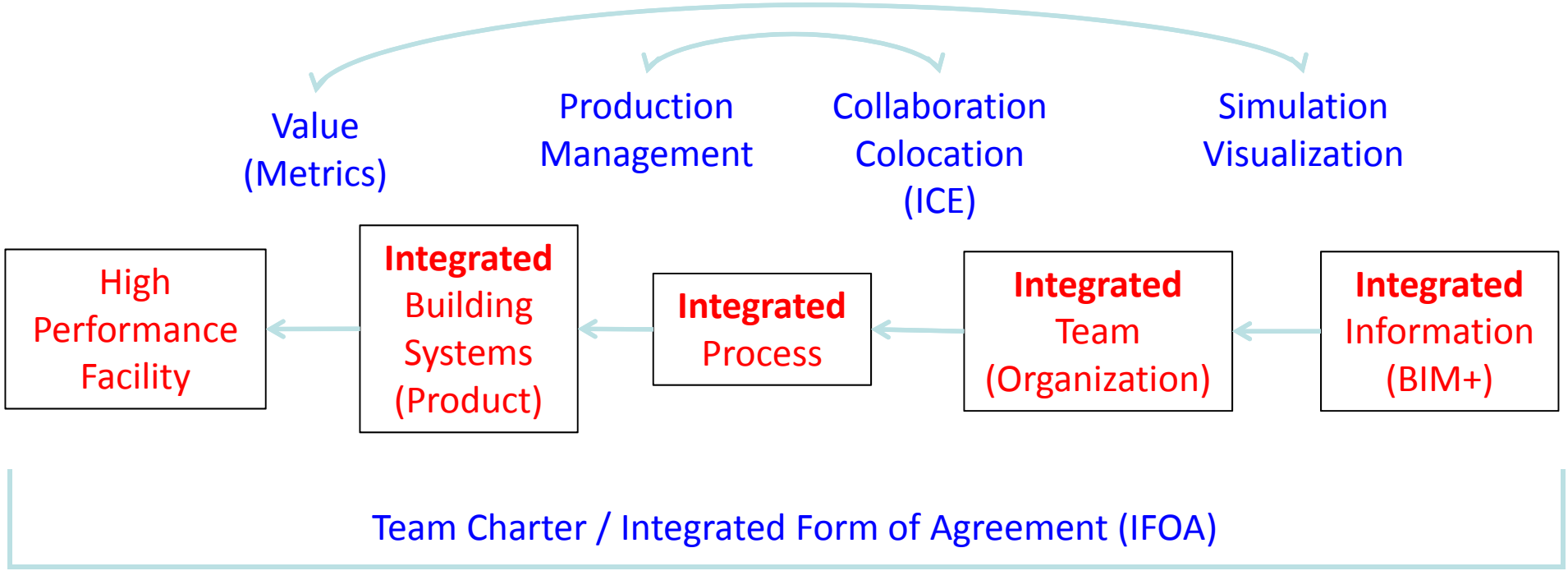
➢ All this is normal for today’s high school students

Project teams must deliver a high-performing building with high reliability. Such a building …

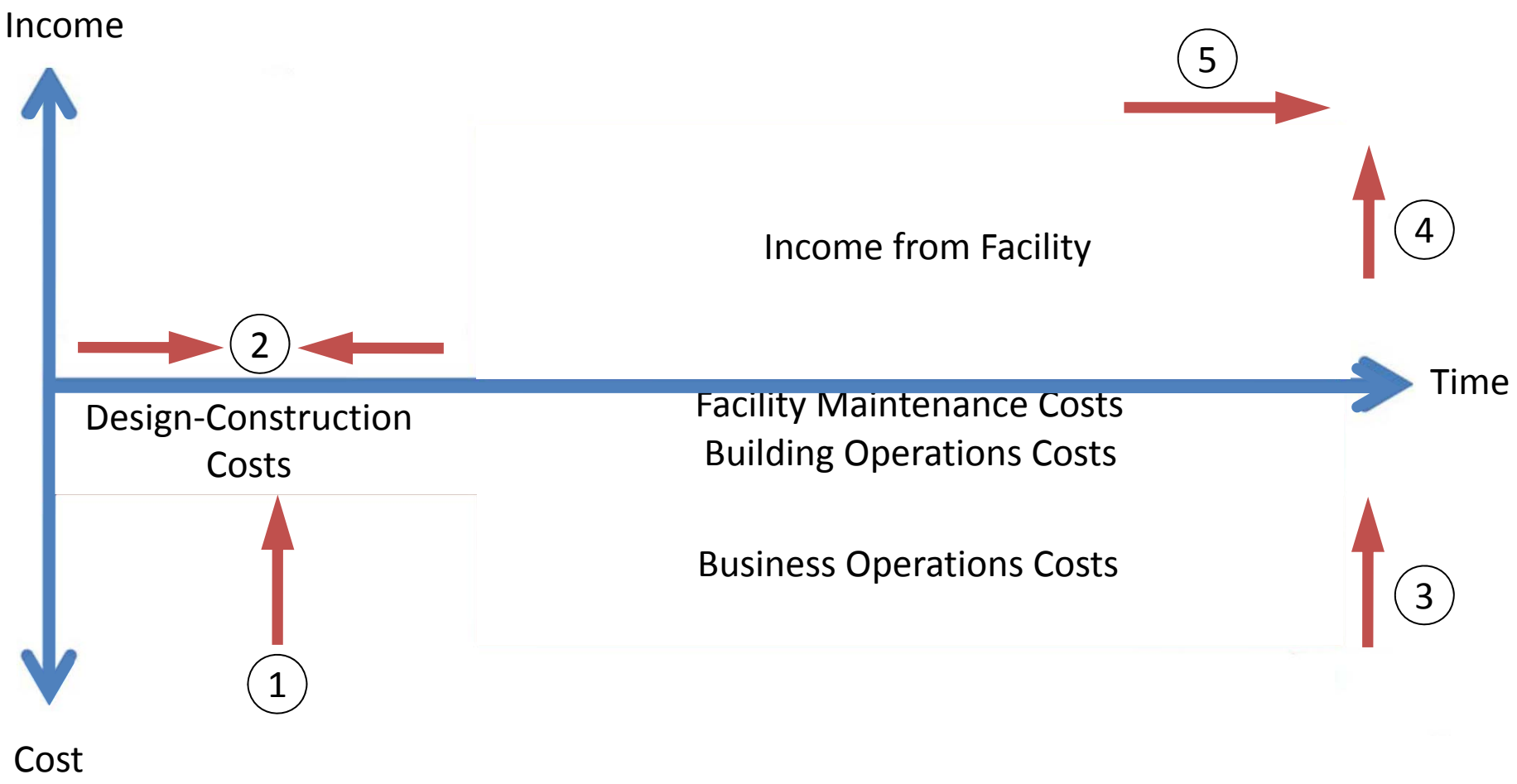
- is buildable
- can be operated efficiently
- makes the users of the facility productive
- enhances its environmental and social context

- and contributes to learning how to do it even better next time.

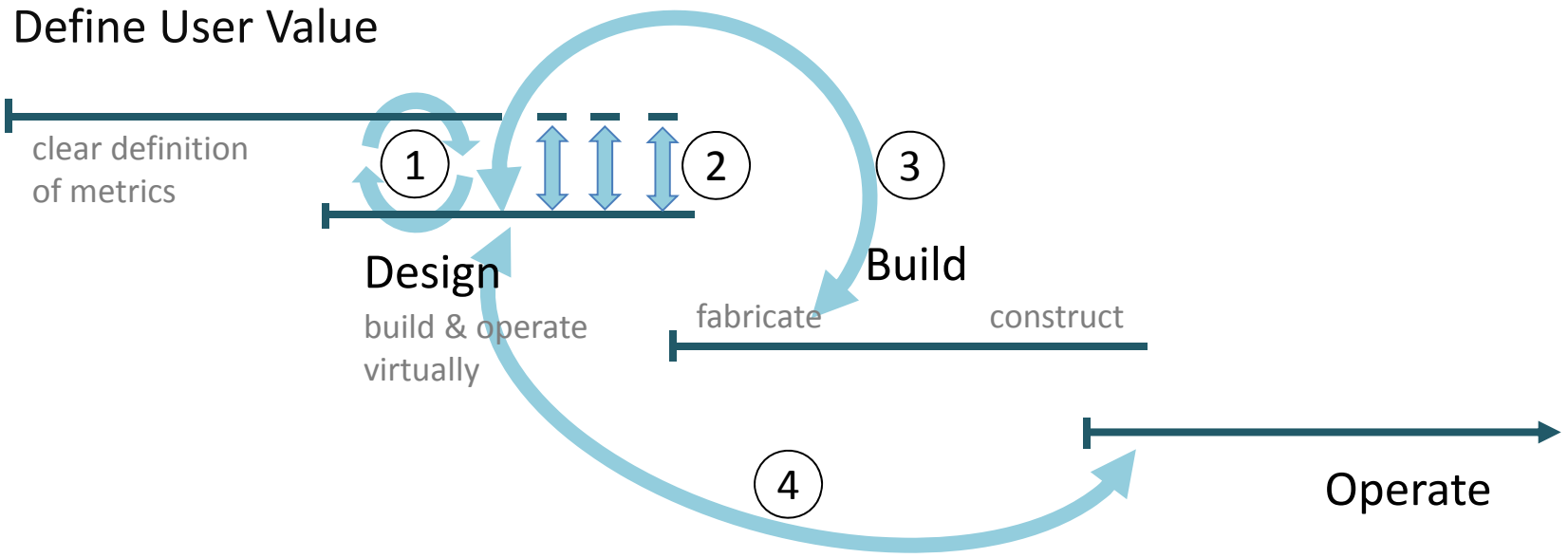
To achieve high-performance facilities, we need a strategy and methods for integration



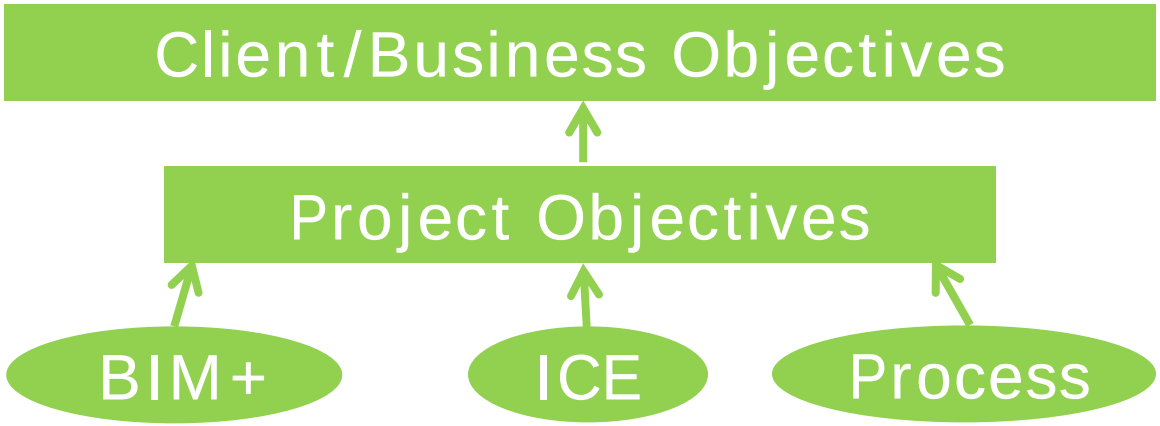
- A facility functions as a whole.
- We must break up a project into clear controllable work assignments.
- How to make sure that the performance of the whole facility does not suffer because of everyone's optimization efforts at the task level?

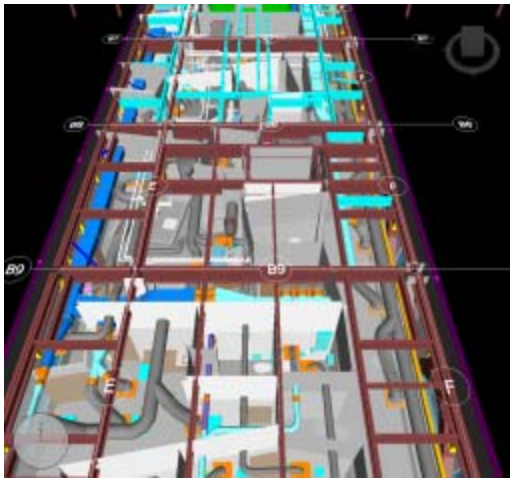

Income
5
4
Income from Facility
2
Time
Design-Construction Costs
Facility Maintenance Costs
Building Operations Costs
Business Operations Costs
3
1
Cost

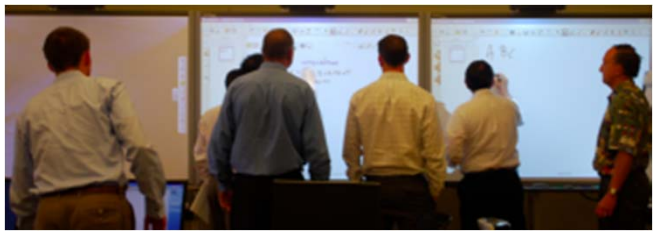
Process Integration

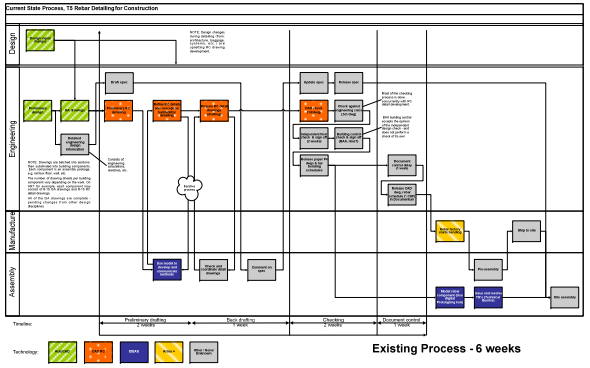


Virtual Design and Construction (VDC)







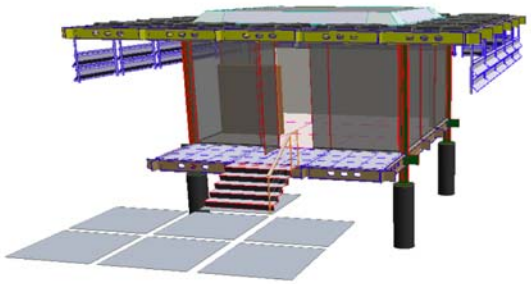


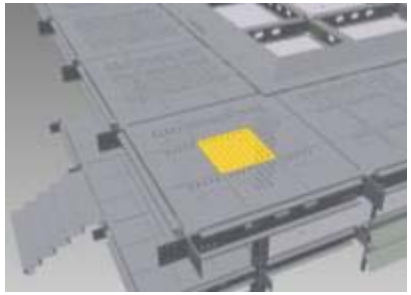
BIM is the first technology that combines data and visualization

Social Interface with Stakeholders

Snapshots courtesy Optima

Visualization





Conceptual project planning & design	Design	Procurement	Construction	Start-up	Operations

Data

Interface with Engineering and Project Control and Management Systems

Visualization - Integration - Automation

3 Levels of BIM

1. **Visualization (manual integration)**
   - Model and visualize all “expensive” elements of the product, organization, and process
   - Get input from team members and stakeholders when it matters
   - Incrementally enhance project objectives
   - Pay for with project funds

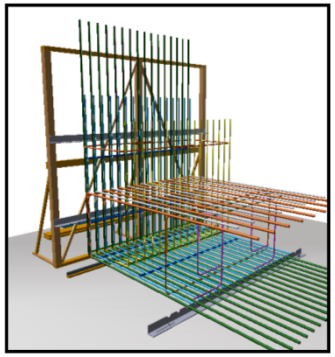
2. **Integration (computer based)**
   - Building information models “interoperate” between disciplines and connect to other data sets (cost estimates, schedules, etc.)
   - Single data entry
   - Requires corporate, multi-project support

3. **Automation**
   - Automated design and (CNC) manufacturing
   - Do high-quality work really fast all the time
   - Enables breakthrough project performance
   - Requires corporate, multi-project support

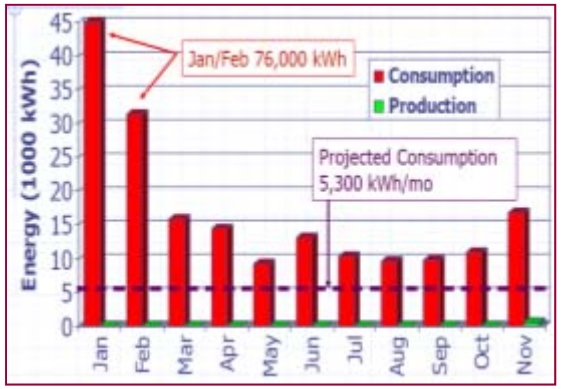
Past → Present → Future

- Yesterday's practice:
  YCASWYG
  You can't always see what you get

- Today's practice:
  WYSIWYG
  What you see is what you get



- Next practice:
  WYMIWYG
  What you model is what you get
  performance



Scofield 2002

Sutter Medical Center Castro Valley, CA, USA – $320 Million

PRESENTATION FOR:

BIM VISION, STRATEGY AND IMPLEMENTATION CONF., ABU DHABI| DECEMBER 13-14, 2011

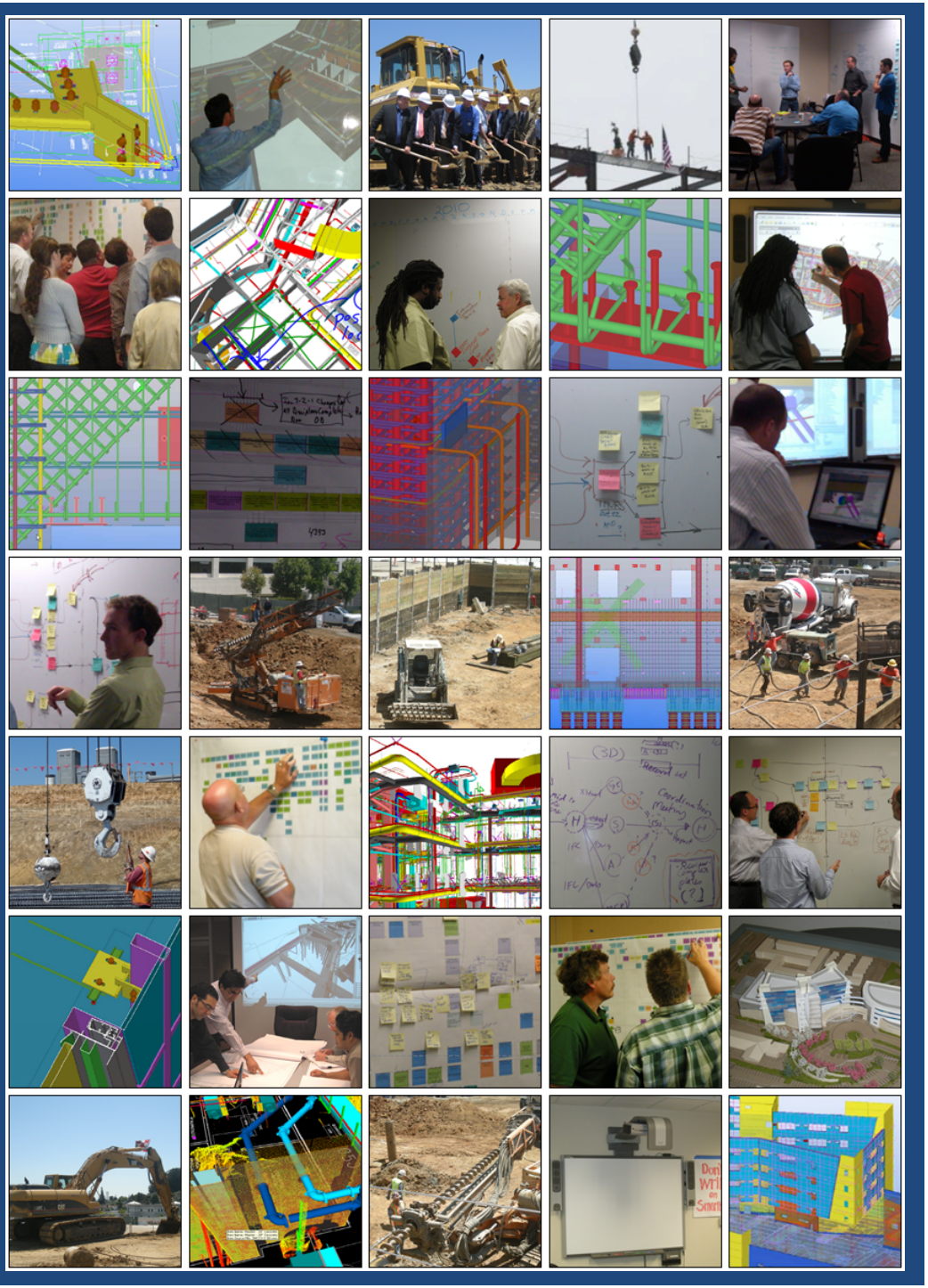
DPR CONSTRUCTION

Where Ambitious Owners with Ambitious Projects Need Ambitious GC's to Focus

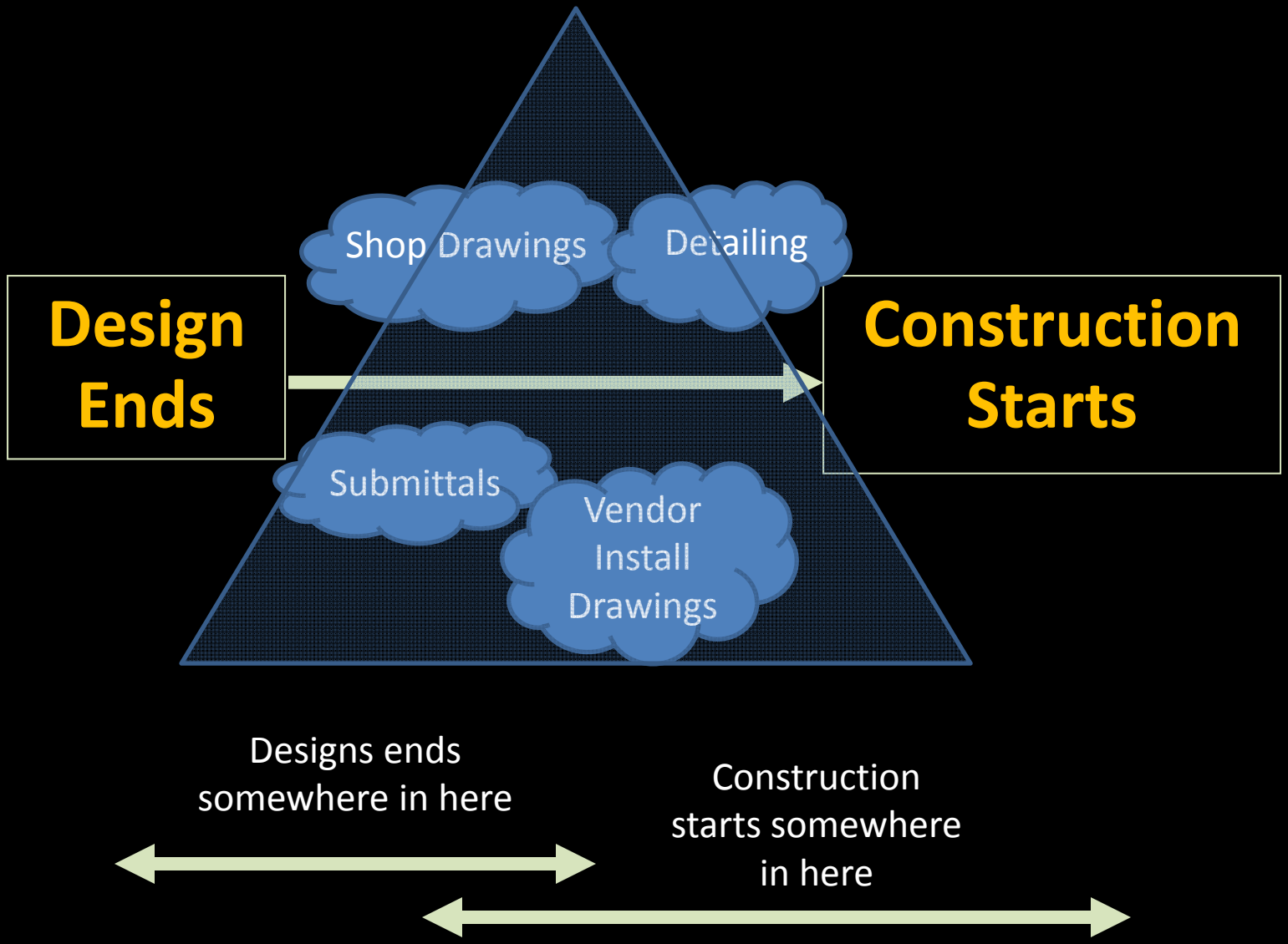
A tentative informed guess about the future of project delivery by

Digby Christian,
Senior Project Manager at Sutter Health
for the
Sutter Health Eden Medical Center Project

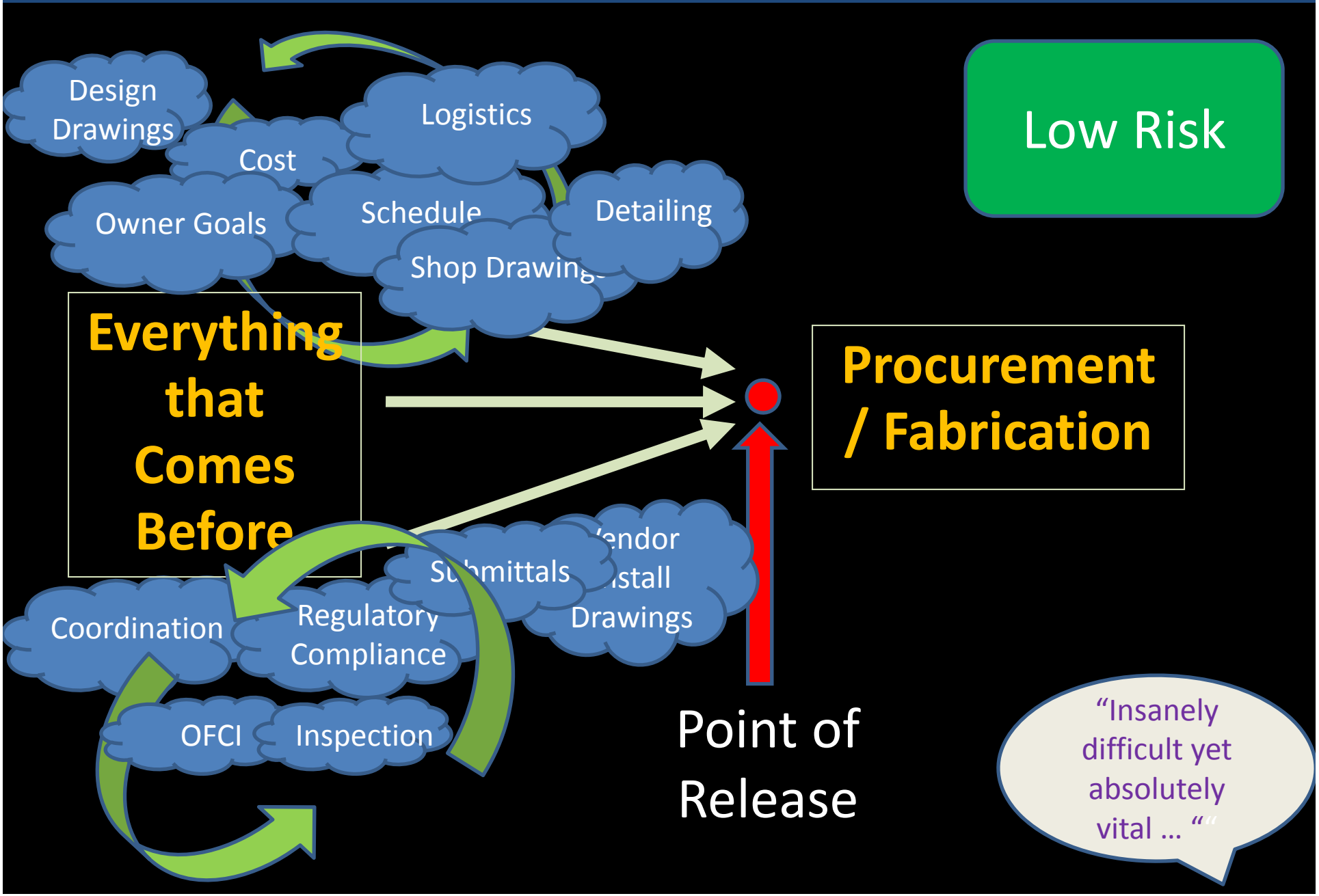
DPR Quarterly Meeting
April 25, 2012



2. The Bermuda Triangle of Project Delivery



4. Point-of-Release Strategies

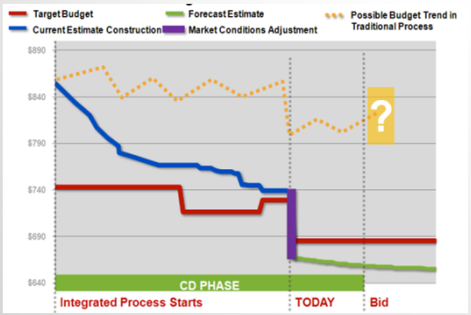


4. Point-of-Release Strategies

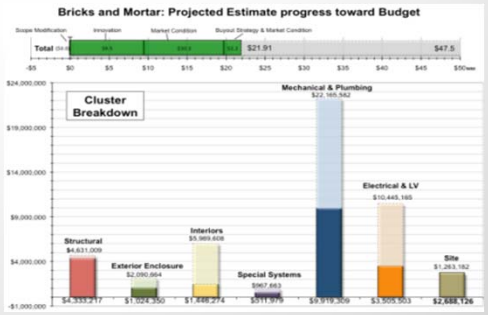
You guarantee certainty of scope, budget, and schedule for the owner

if you can find a way to release procurement, fabrication and installation with zero risk of rework, fully informed by cost and schedule

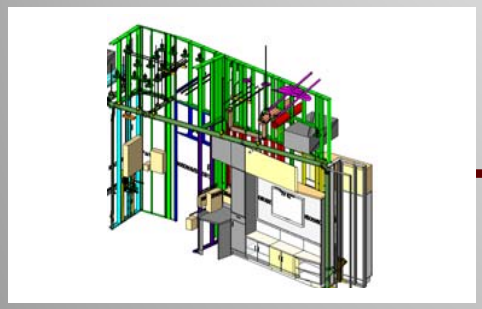
5. Conclusion



Process Metrics



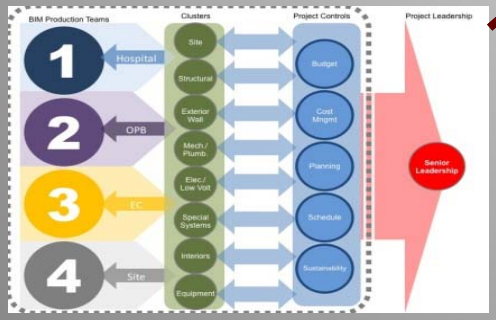
Target Costing



Design Assist Process

Virtual Building Tools

Design the “Big Room”



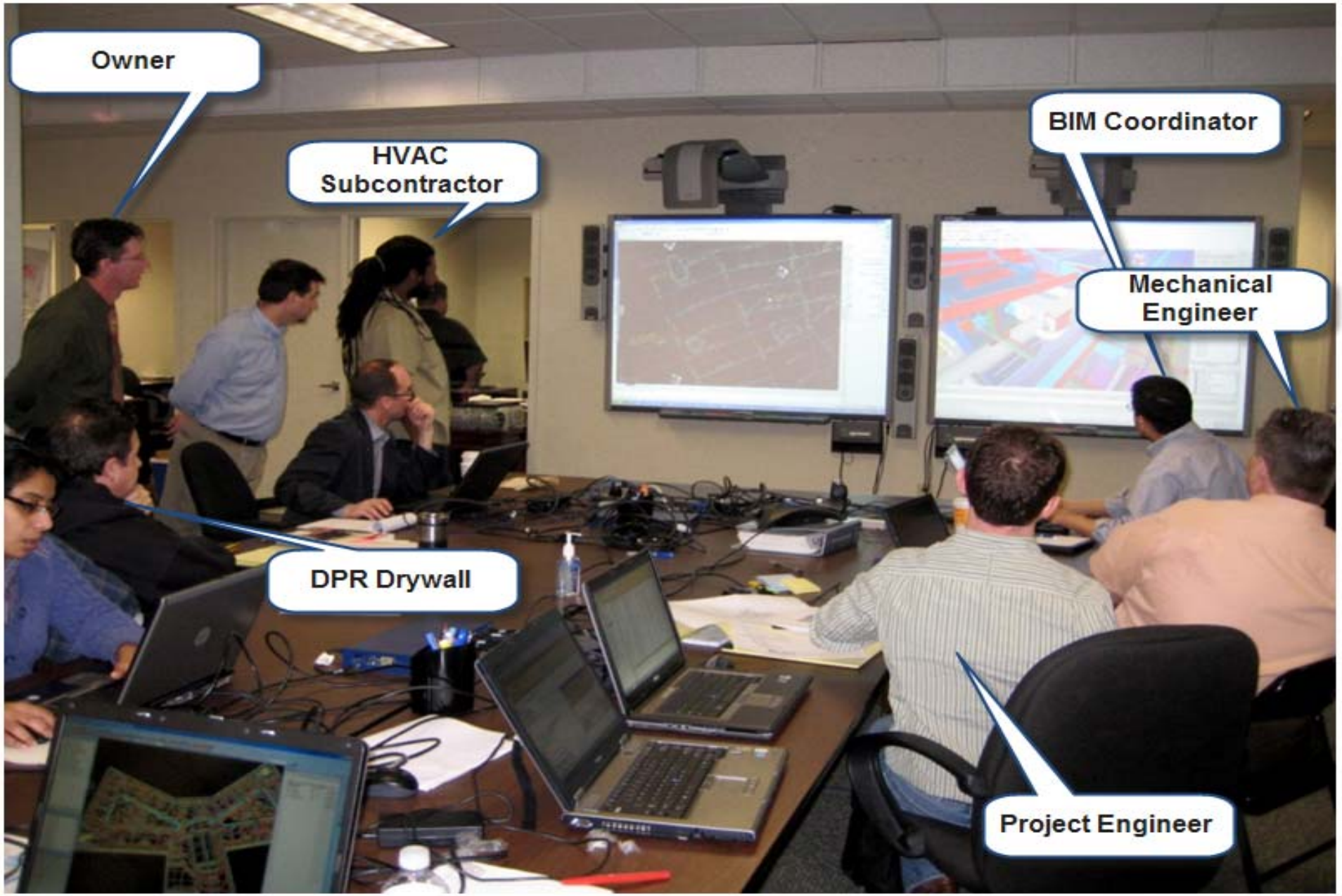
Virtual Company

Collaborative Planning

Big Room

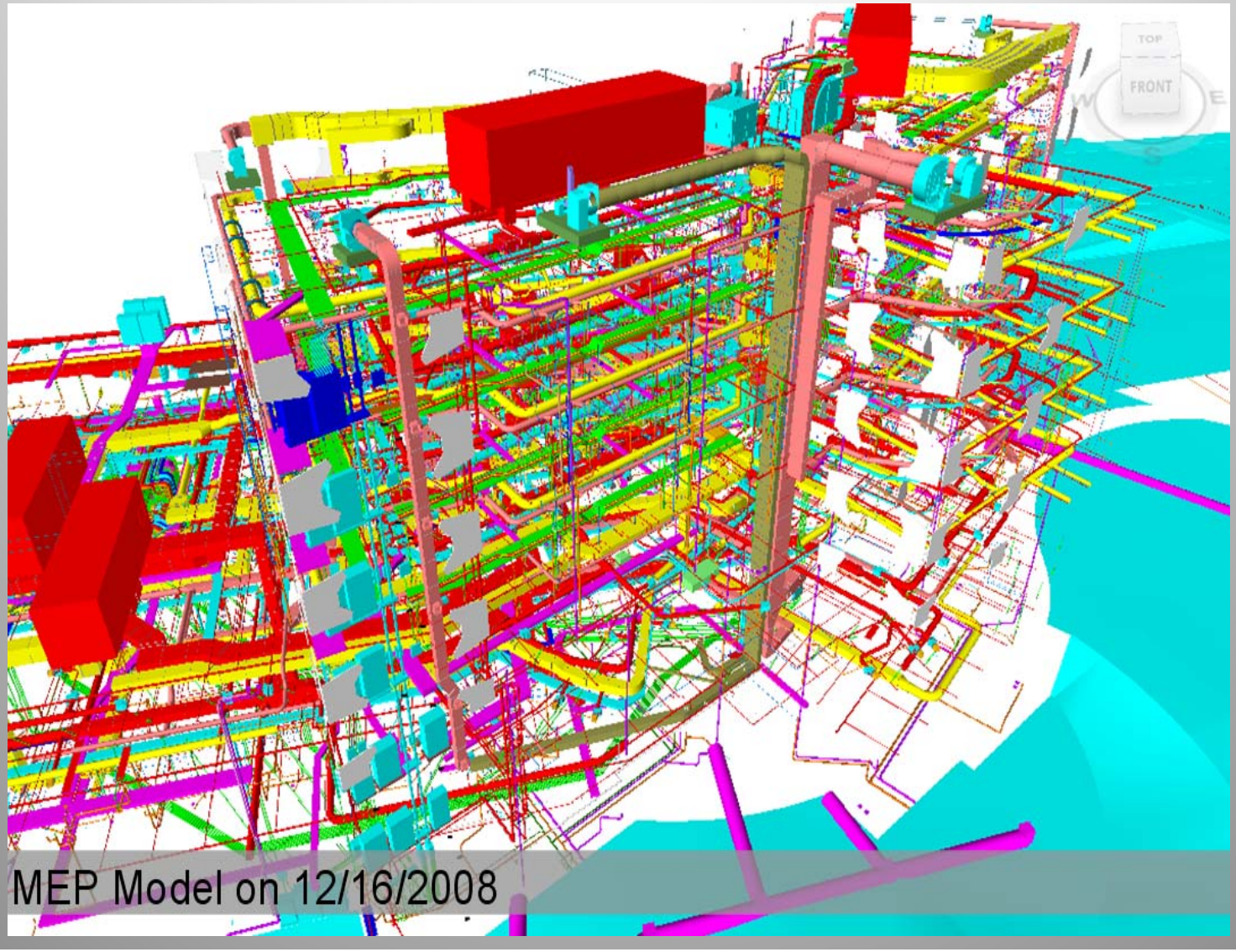
PUBLIC, TRANSPARENT PERFORMANCE METRICS

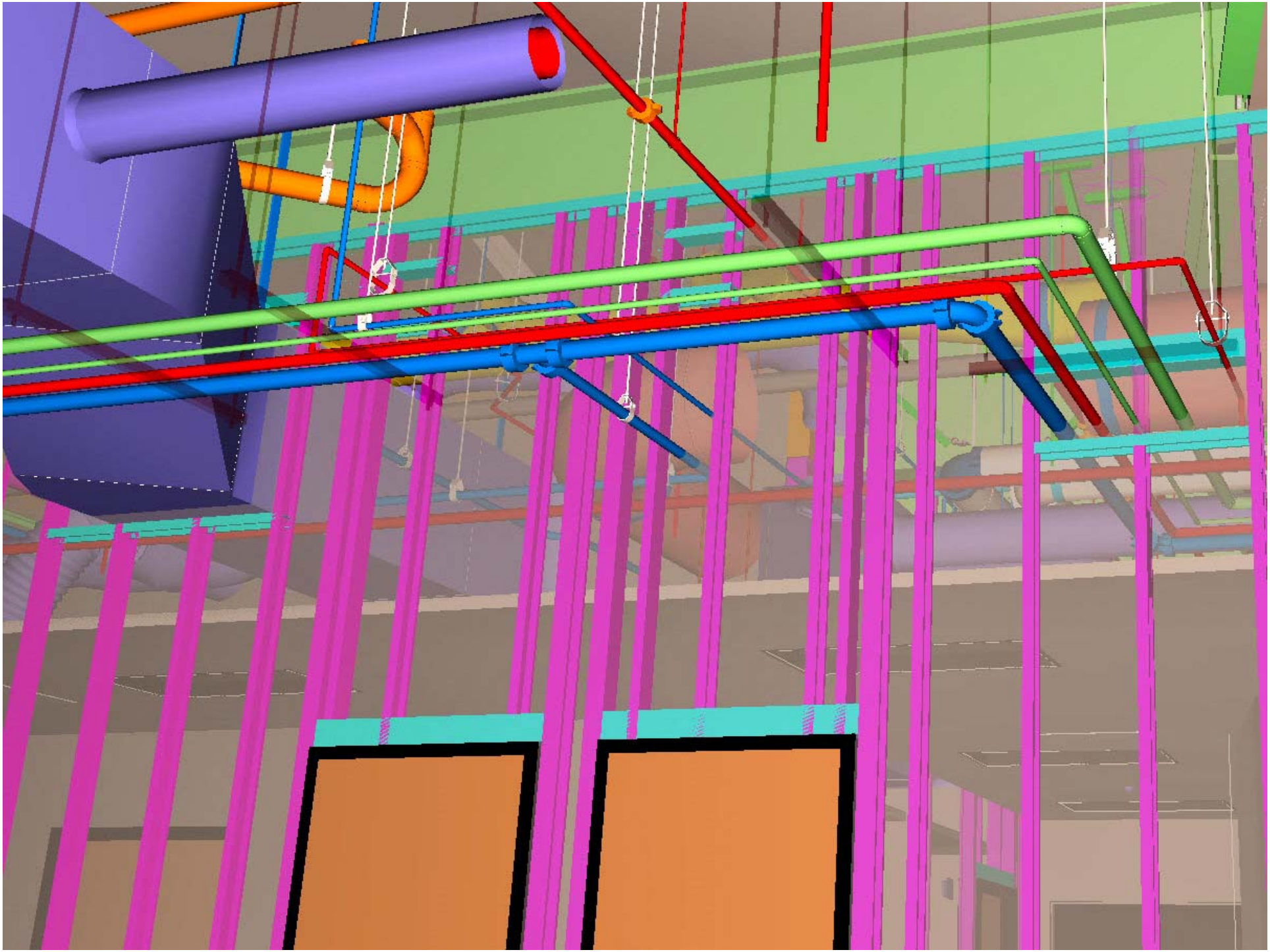
Team organized to work together with BIM



Very Detailed Process Mapping – Every 2 weeks

Everything above 1.0 cm was modeled in 3D





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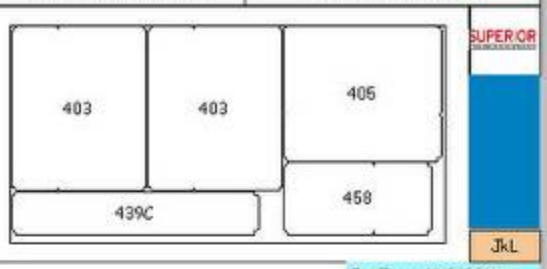
JOB: 84035 | PICK #: 34D

Used: 119.18 x 57.91 | Stock: 120.00 x 60.00



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Material: GALV x 26

SHIP: 5/4/2011

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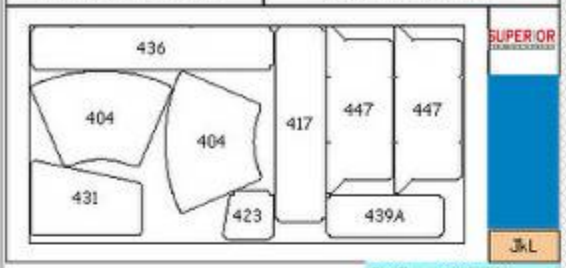

In Shop: 4/13/2011

Material: GALV x 26

SHIP: 5/4/2011

NC #: 2443

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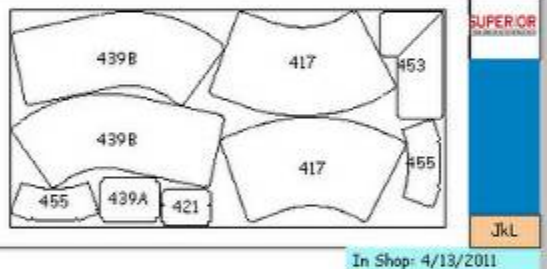

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Material: GALV x 26

SHIP: 5/4/2011

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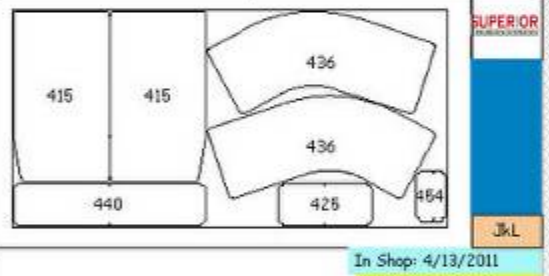


In Shop: 4/13/2011

Material: GALV x 26

SHIP: 5/4/2011

NC #: 2445

JOB: 84035 | PICK #: 34D

Used: 119.86 x 59.66 | Stock: 120.00 x 60.00

In Shop: 4/13/2011

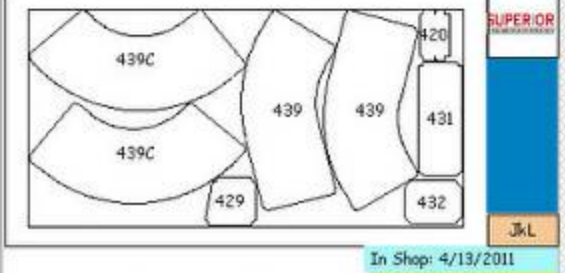
Material: GALV x 26

SHIP: 5/4/2011

NC #: 2446

JOB: 84035 | PICK #: 34D

Used: 119.88 x 59.73 | Stock: 120.00 x 60.00



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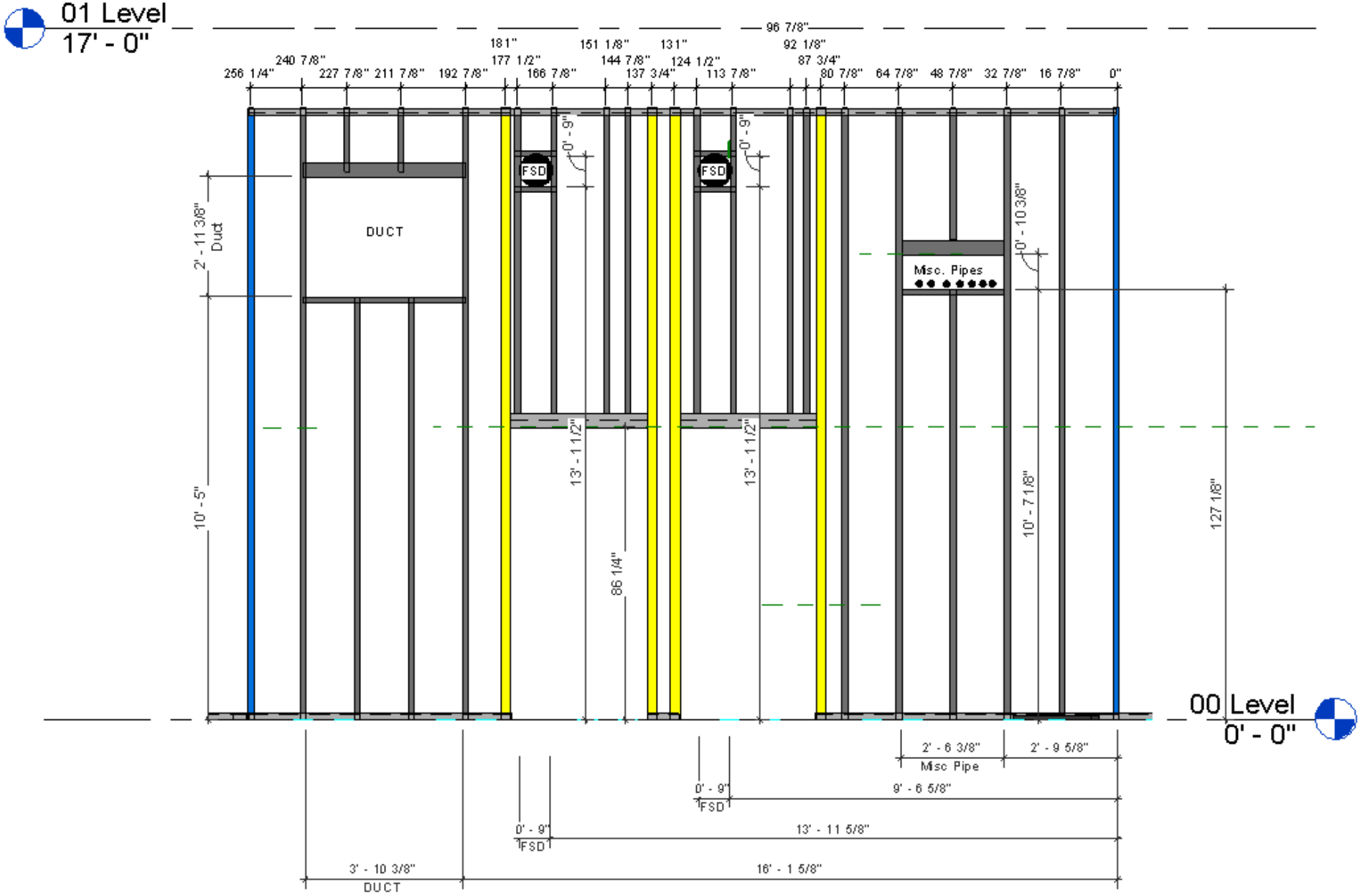
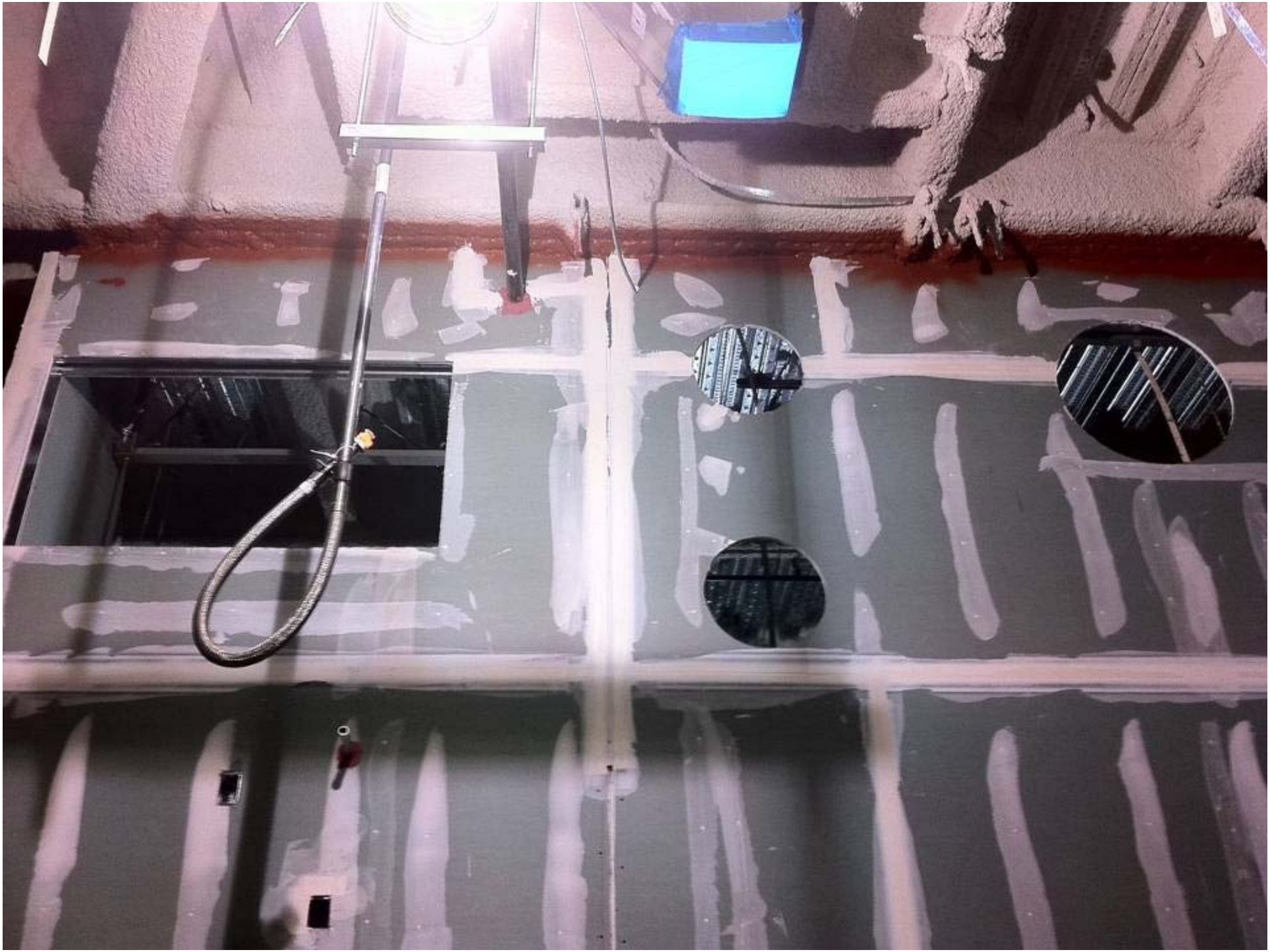
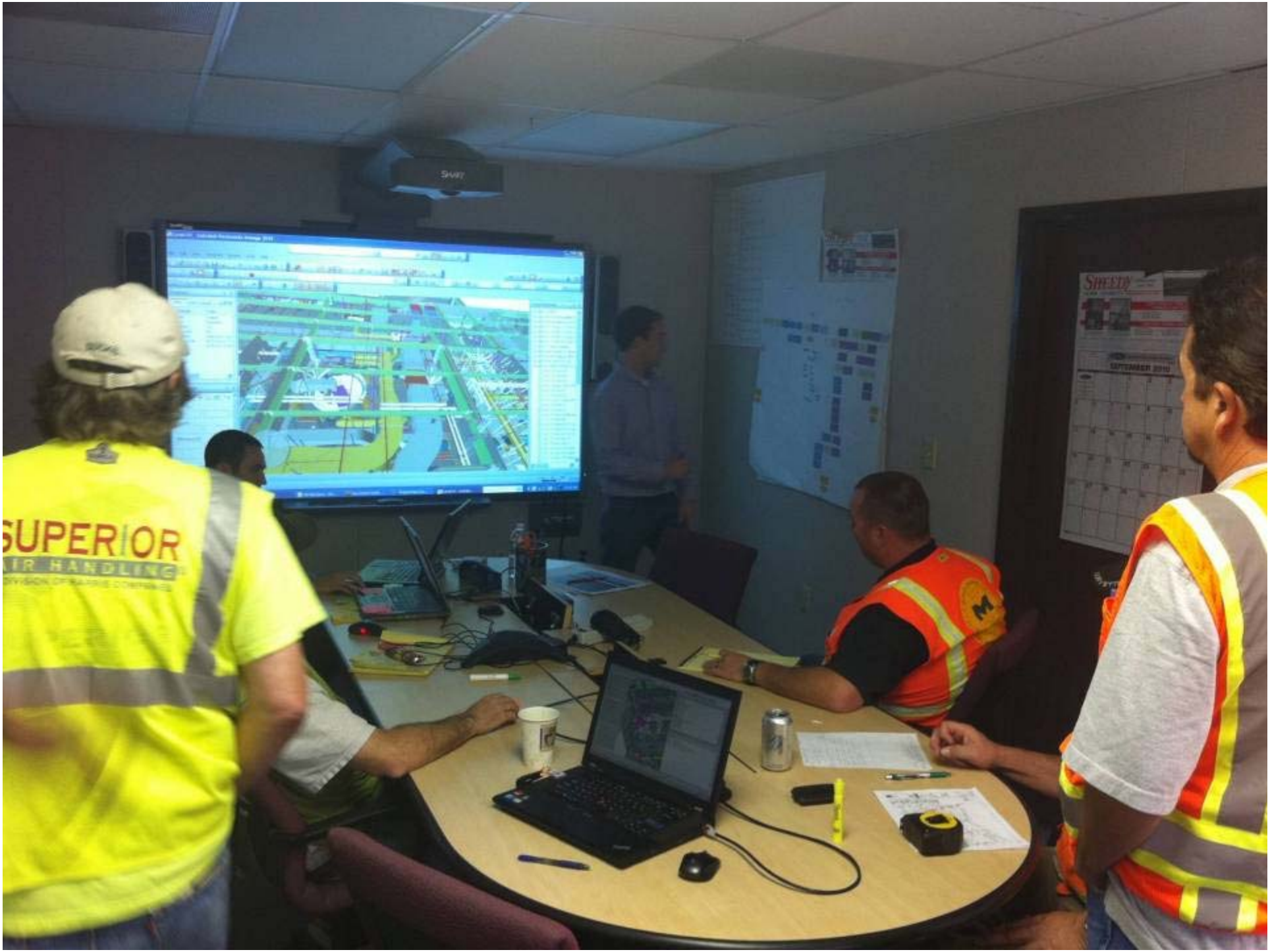
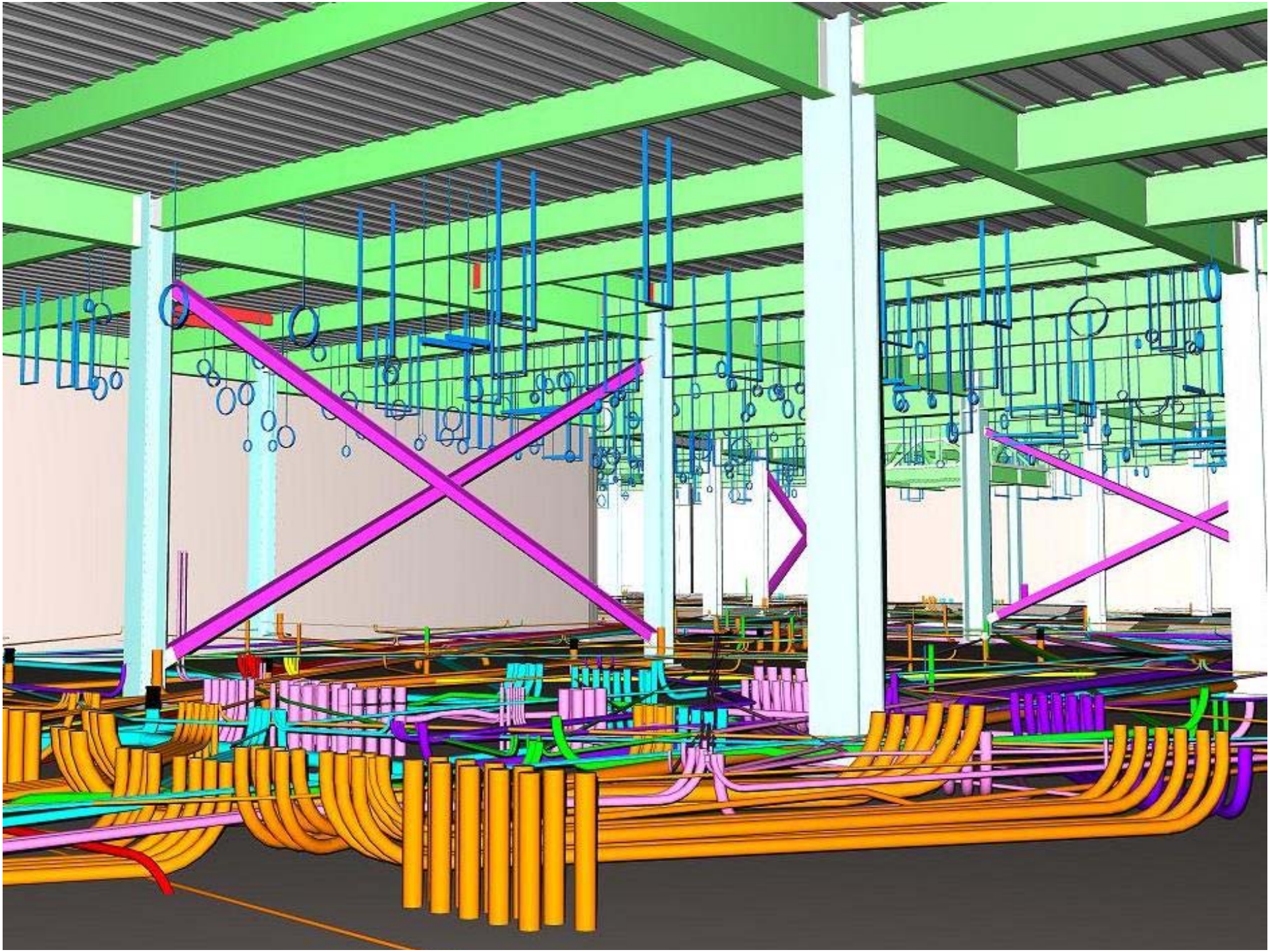
Material: GALV x 26

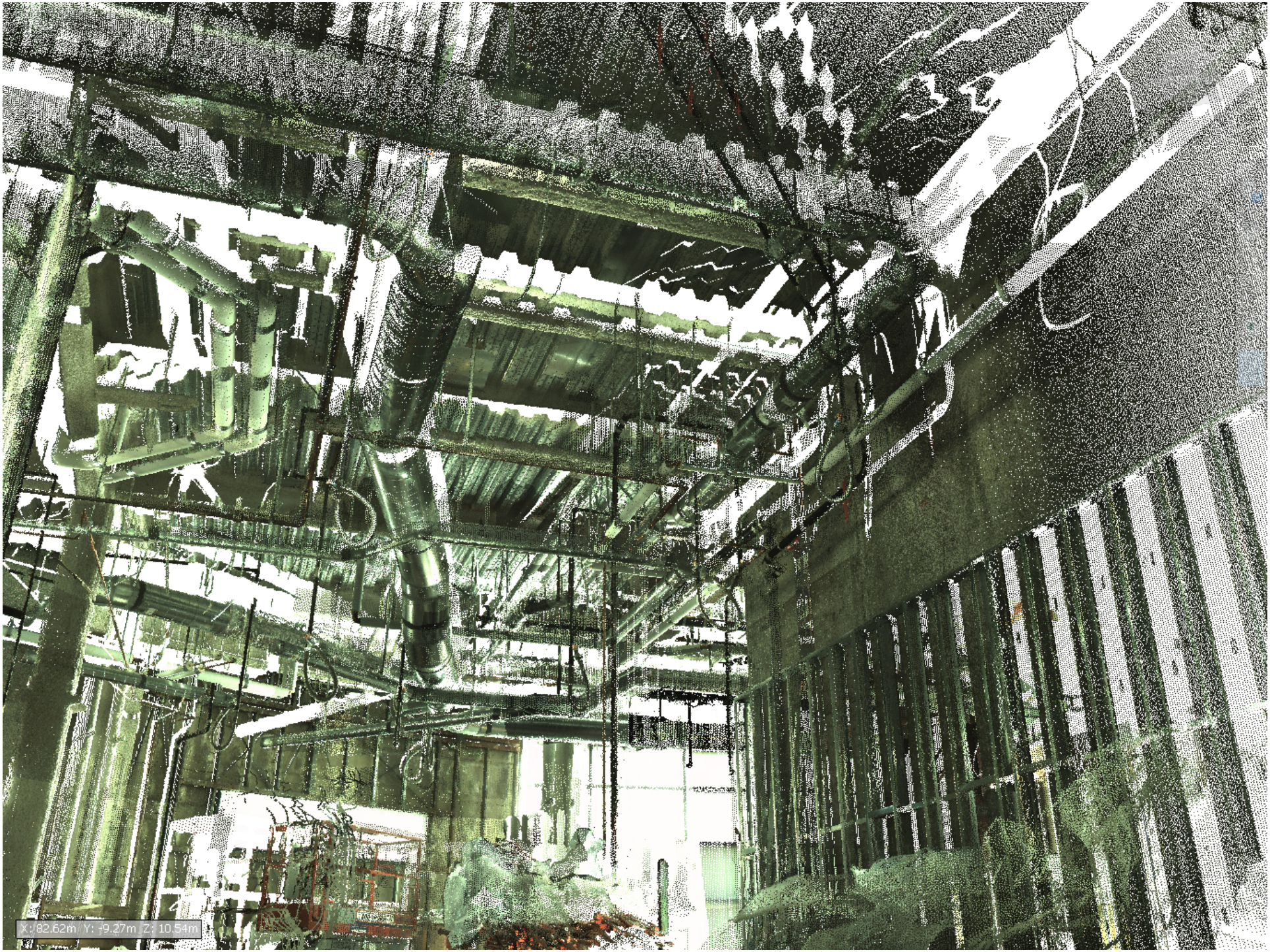
SHIP: 5/4/2011


01 Level
17' - 0"
96 7/8"
256 1/4"
240 7/8"
227 7/8"
211 7/8"
192 7/8"
181"
177 1/2"
166 7/8"
151 1/8"
144 7/8"
137 3/4"
131"
124 1/2"
113 7/8"
92 1/8"
87 3/4"
80 7/8"
64 7/8"
48 7/8"
32 7/8"
16 7/8"
0"
DUCT
FSD
FSD
0' - 9"
0' - 9"
Misc. Pipes
0' - 10 3/8"
2' - 11 3/8"
Duct
10' - 5"
13' - 1 1/2"
13' - 1 1/2"
86 1/4"
10' - 7 1/8"
127 1/8"
00 Level
0' - 0"
2' - 6 3/8"
Misc Pipe
2' - 9 5/8"
0' - 9"
FSD
9' - 6 5/8"
0' - 9"
FSD
13' - 11 5/8"
3' - 10 3/8"
DUCT
16' - 1 5/8"




SUPERIOR
AIR HANDLING

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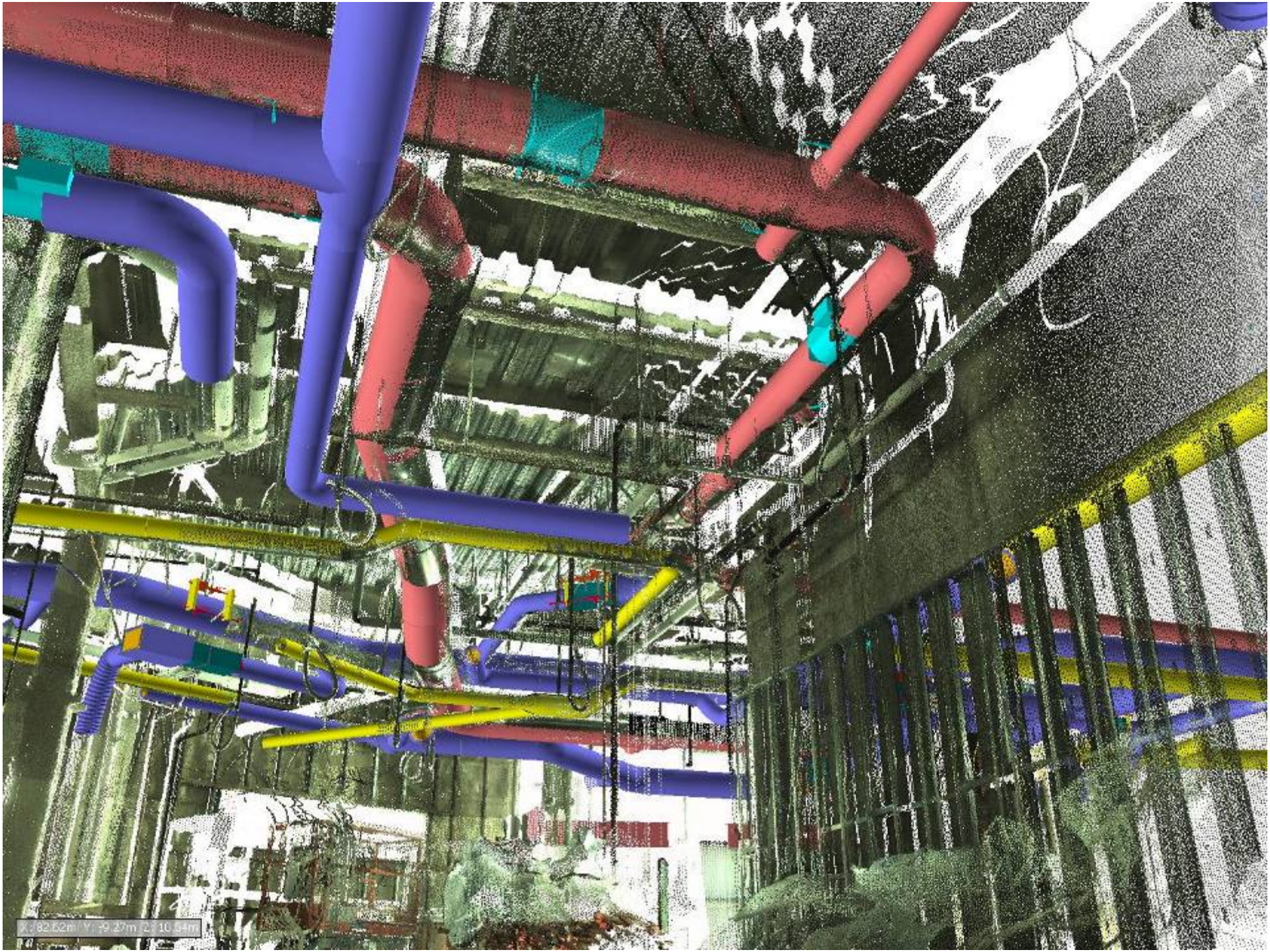


The Business Perspective

“Automated execution of processes changes everything.”

(Alan Perlis, 1961)

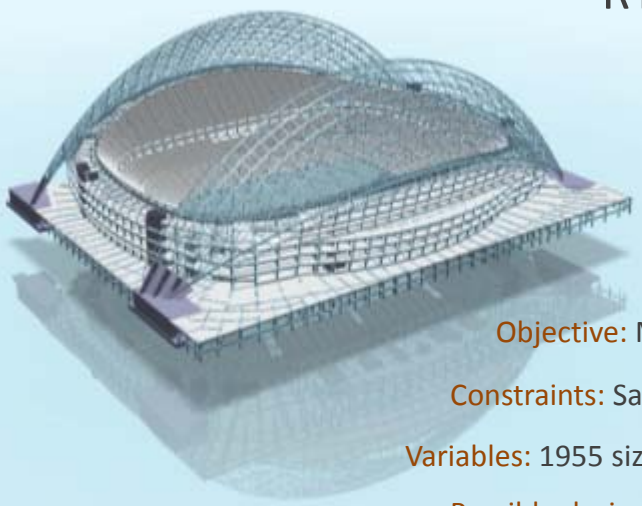
The Scientific Perspective

“Science is knowledge which we understand so well that we can teach it to a computer; and if we don't fully understand something, it is an art to deal with it. Since the notion of an algorithm or a computer program provides us with an extremely useful test for the depth of our knowledge about any given subject, the process of going from an art to a science means that we learn how to automate something.”

(Donald Knuth, Computer Programming as an Art, CACM, Dec. 1974)

Reducing the Cost of Steel Structures Using Computational Design Optimization

Forest Flager / Martin Fischer



Design Problem

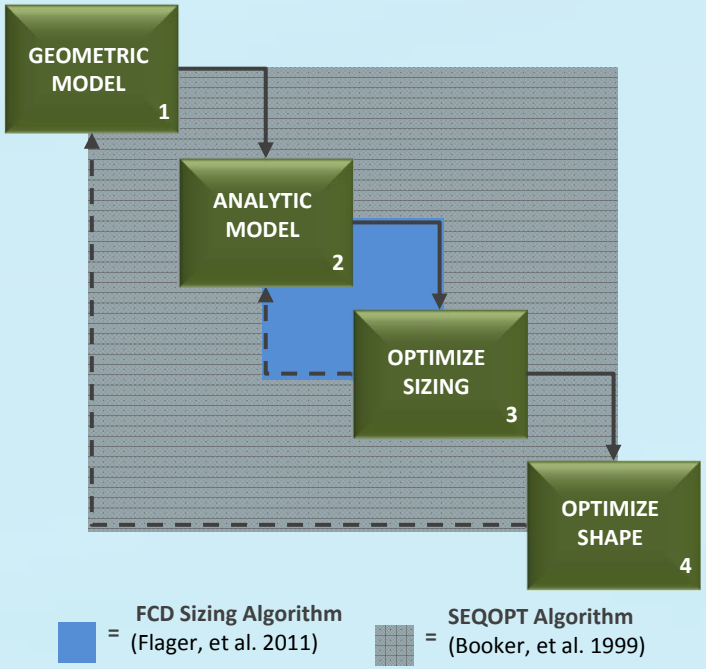
Objective: Minimize steel weight

Constraints: Safety and serviceability

Variables: 1955 size and shape variables

Possible design alternatives: ~ 10^{2435}

BiOPT Method



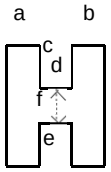
Case Study Results

	conventional design method	FCD (128 cpu) design method
PROCESS		
Design cycle time	4 hrs	3 sec
Alternatives evaluated	39	12,800
Total design time	216 hrs	151 hrs
PRODUCT		
Total steel weight	2,728 met t	2,292 met t
Est. cost saving (USD)	-	$4 M (-19%)

- Orders of magnitude reduction in design cycle time
- Evaluation of a greater number of design alternatives
- Improved product quality

Case Study: Overseas Housing Development

With Lepech/Flager/Basbagill



SCOPE

(1)Housing buildings
● substructure ● shell ● interiors ● services

OBJECTIVES

(1)Minimize life-cycle cost

(2)Minimize carbon footprint

VARIABLES

(1) Number of buildings: 3 - 4

(2) Number of stories: 5 - 8

(3) Building footprint: H-shape

(4) Building orientation: 0-360°

CONSTRAINTS

(1)Gross Floor Area (GFA): 1,500m^2

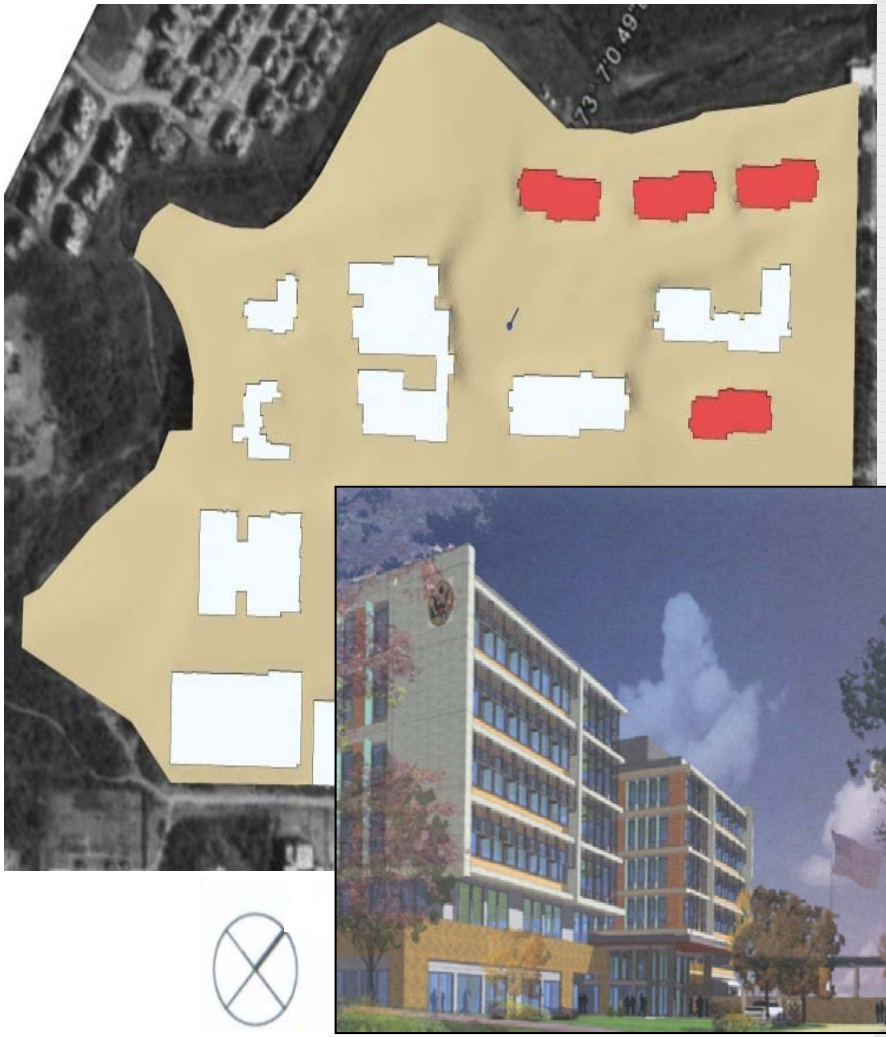
(2)Distance to site perimeter: >20m

(3)Distance between building: >20m

DESIGN SPACE SIZE

Possible design configurations: 1.46E11

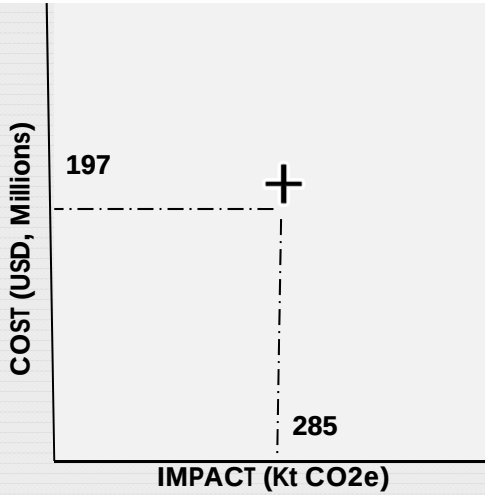
Base Design



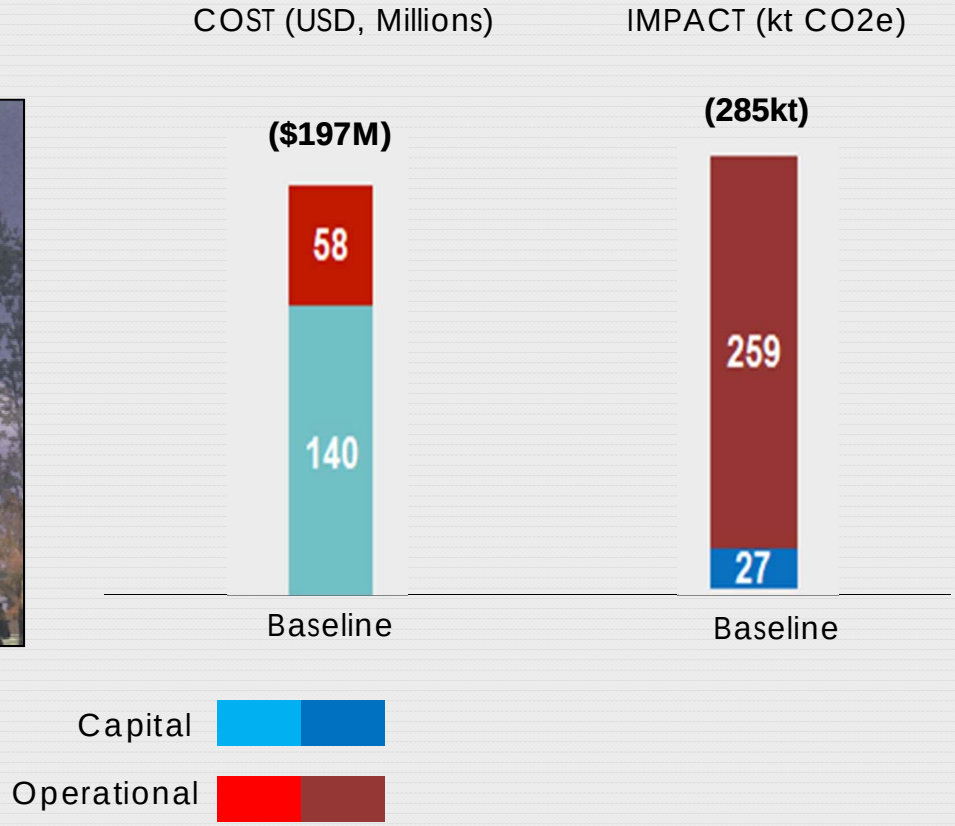
Configuration

Number of buildings: 4

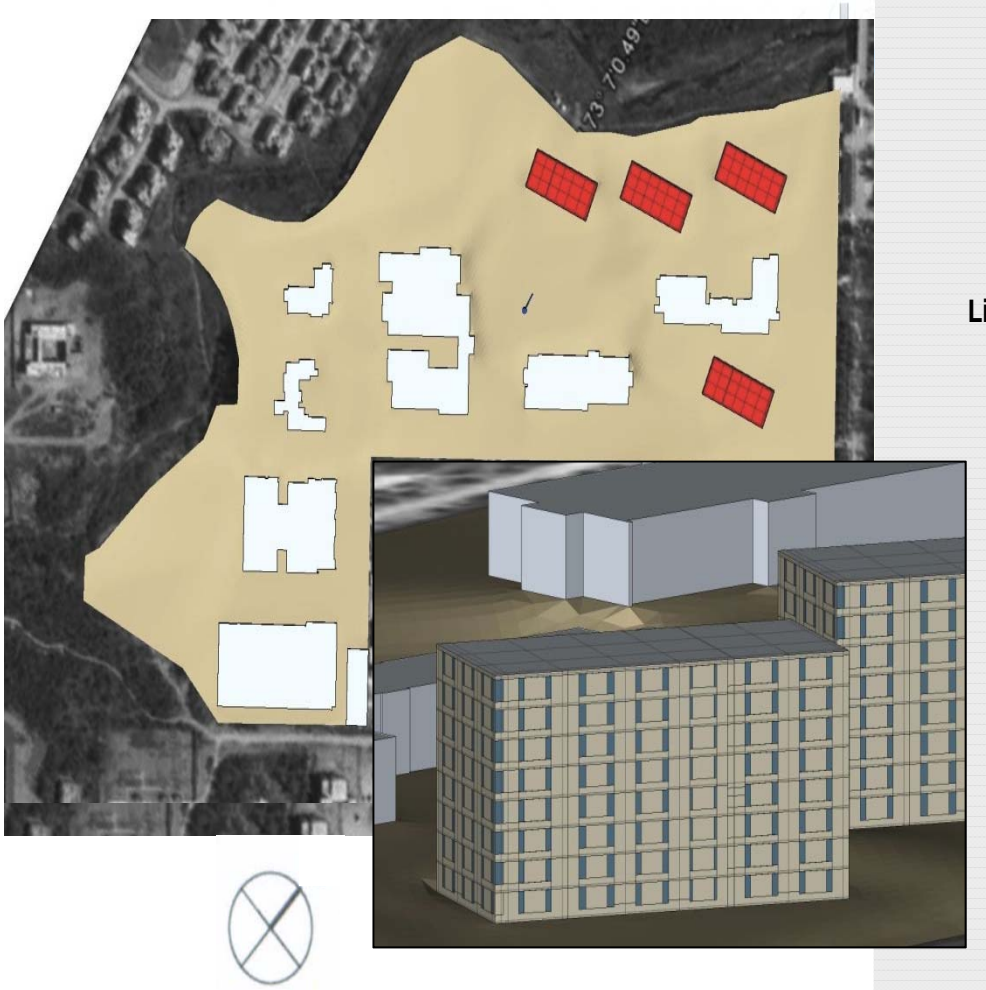
Number of floors: 8



Life-Cycle Performance



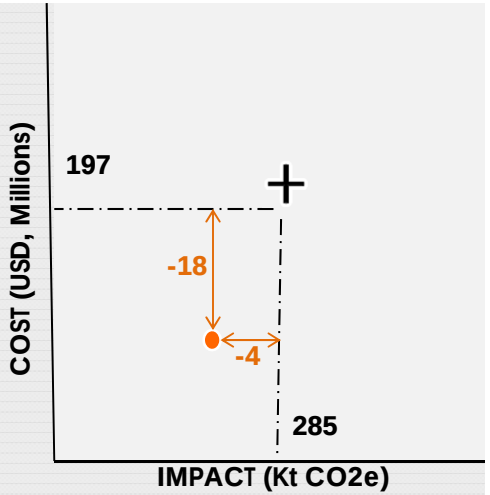
Reduced Cost Design



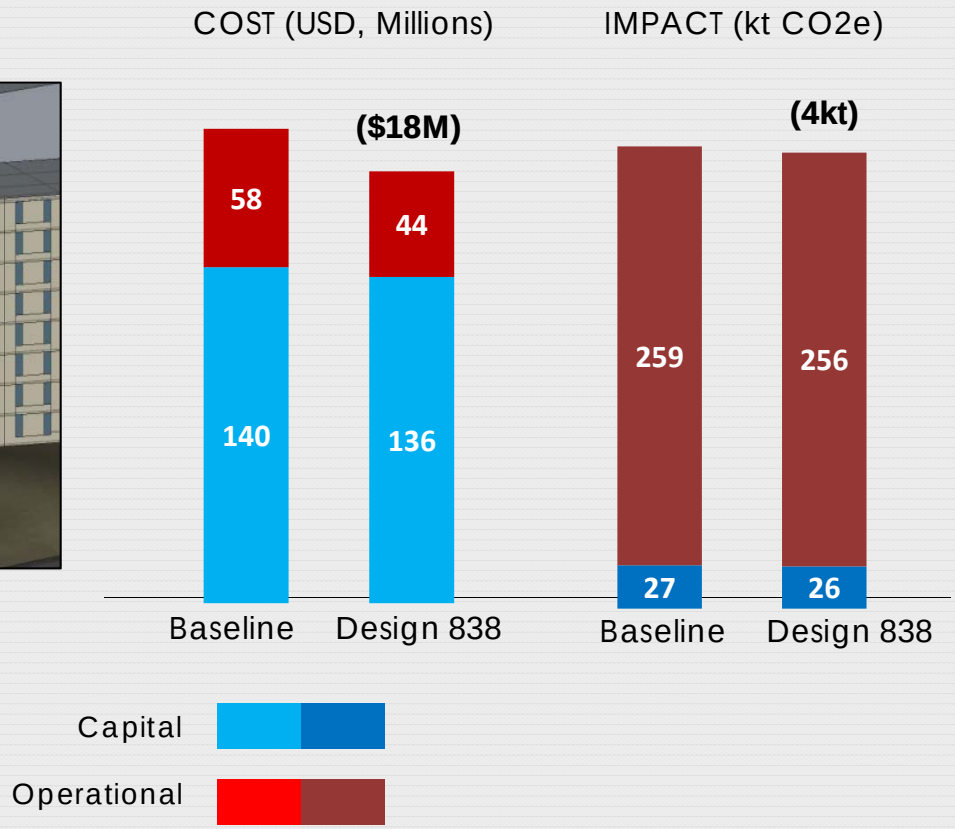
Configuration

Number of buildings: 4

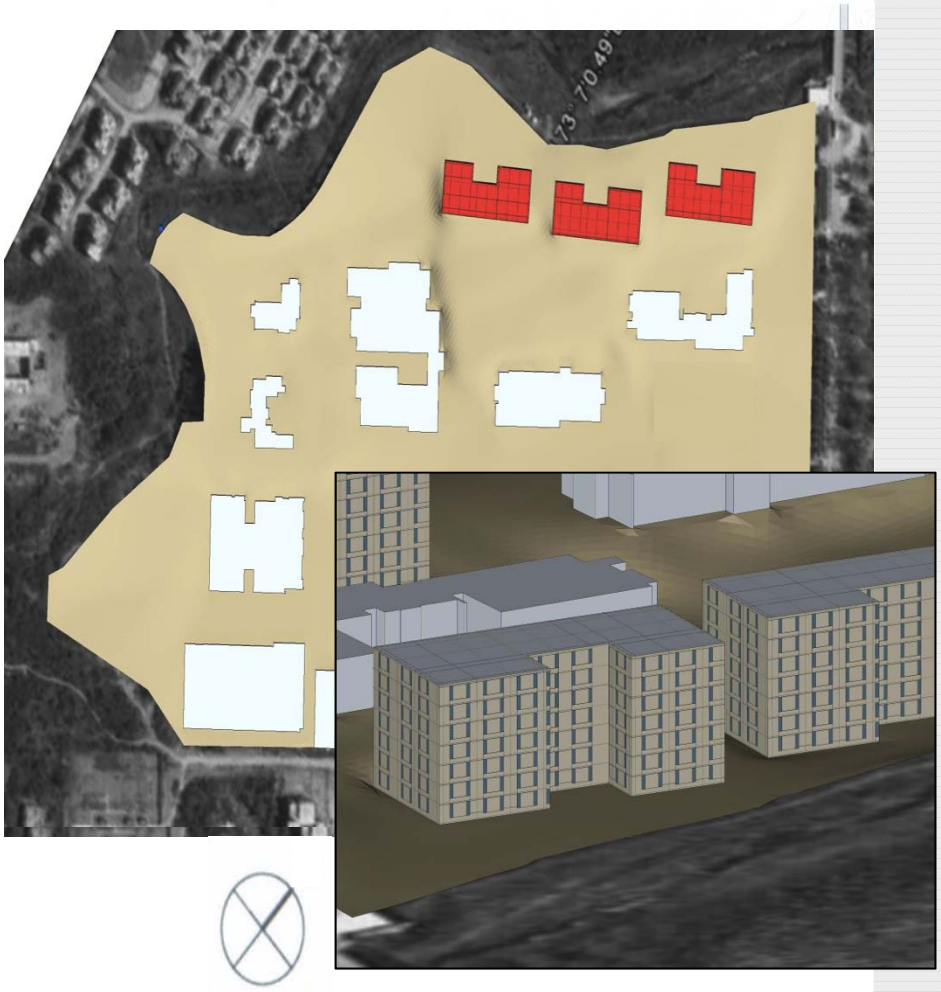
Number of floors: 8



Life-Cycle Performance



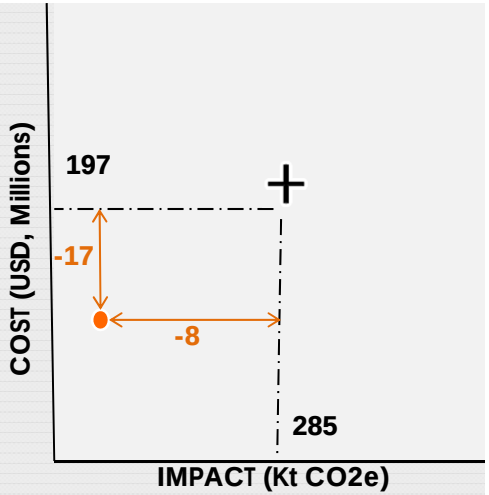
Reduced Carbon Design



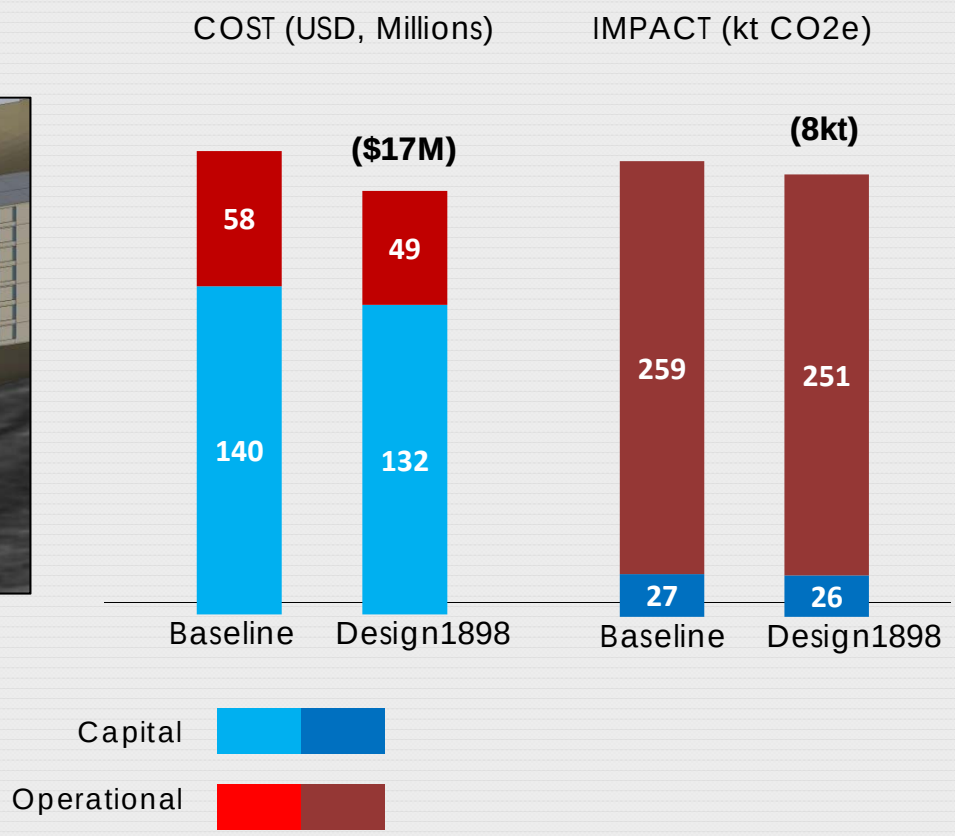
Configuration

Number of buildings: 3

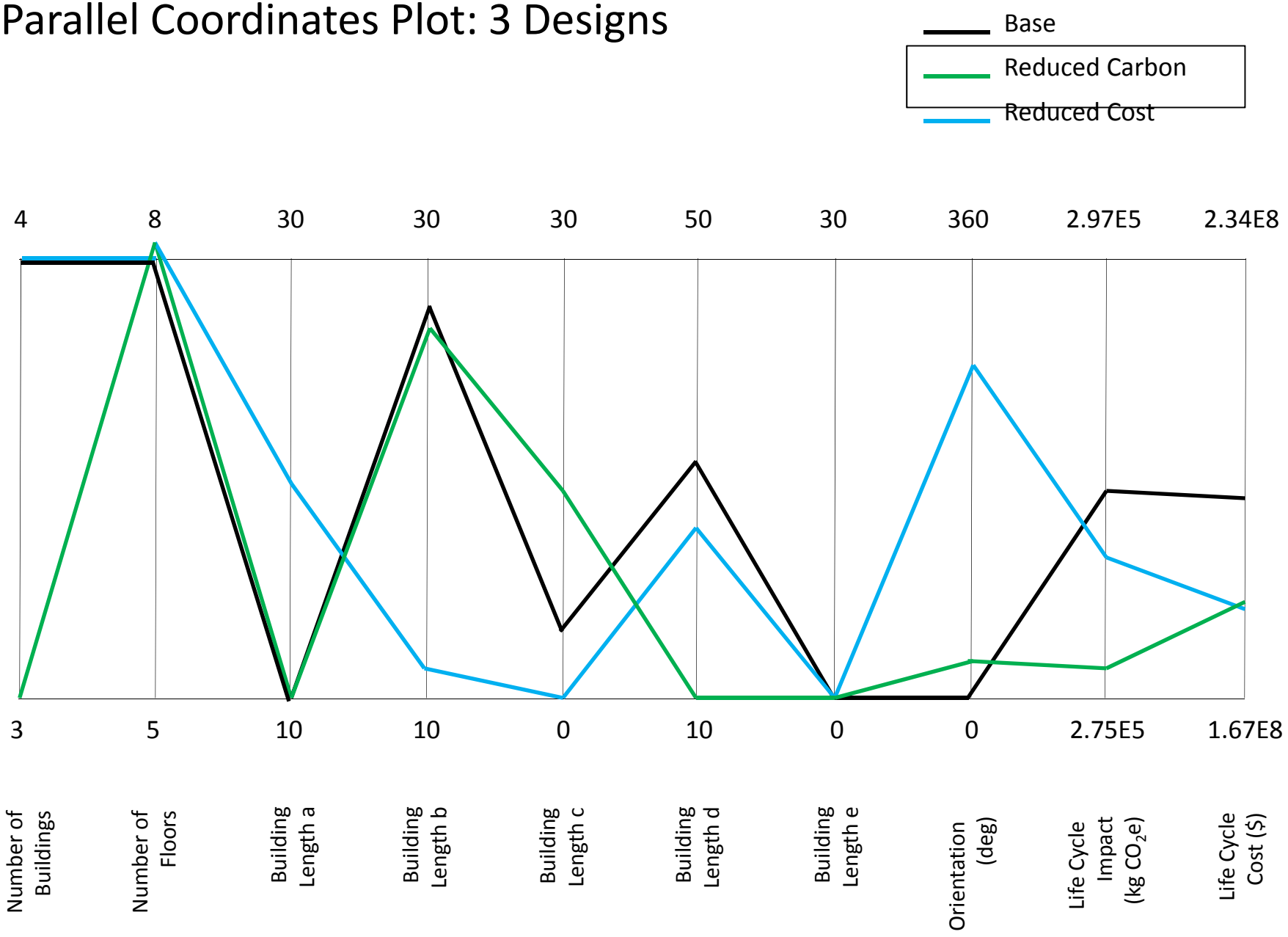
Number of floors: 7



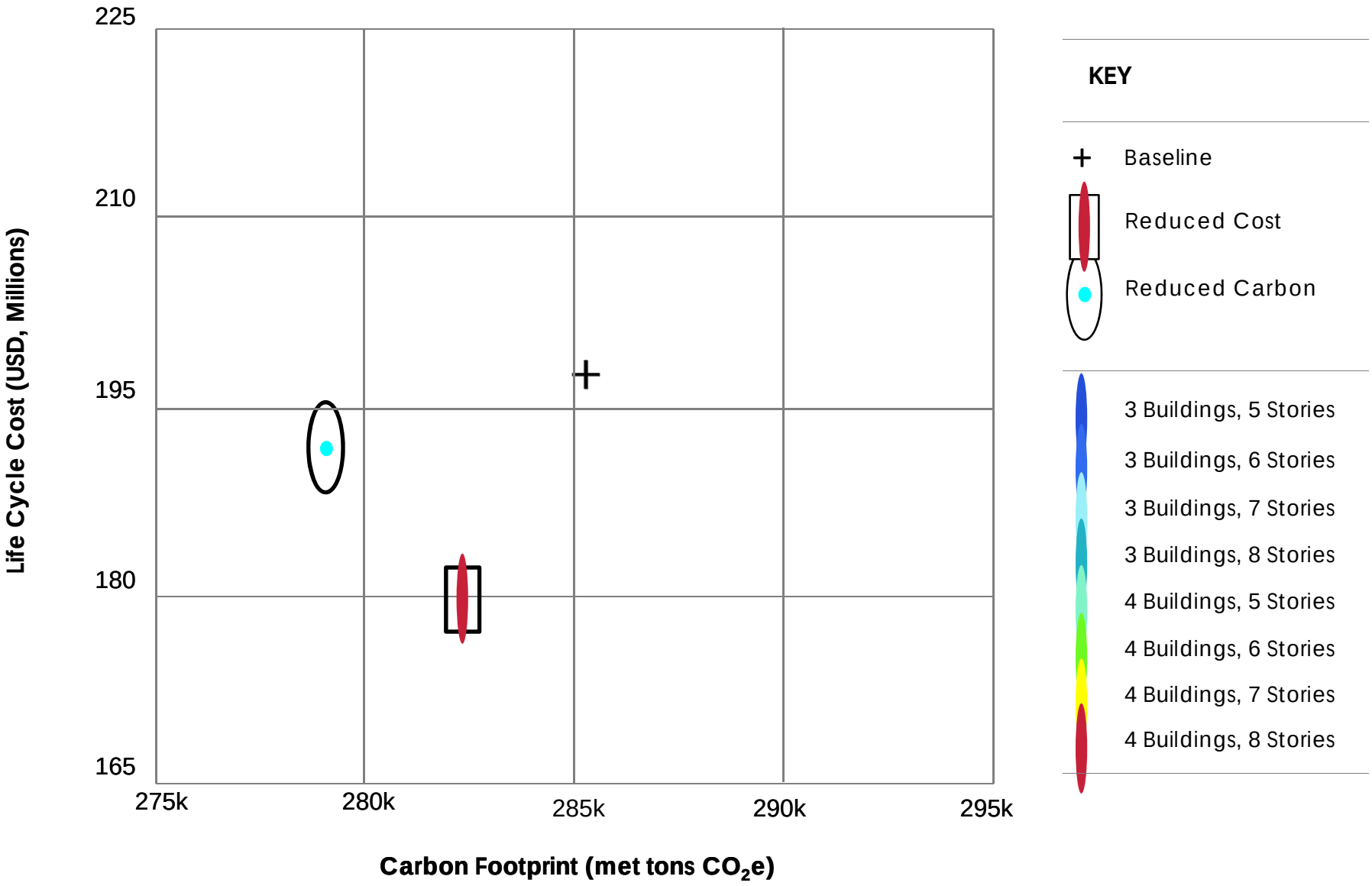
Life-Cycle Performance



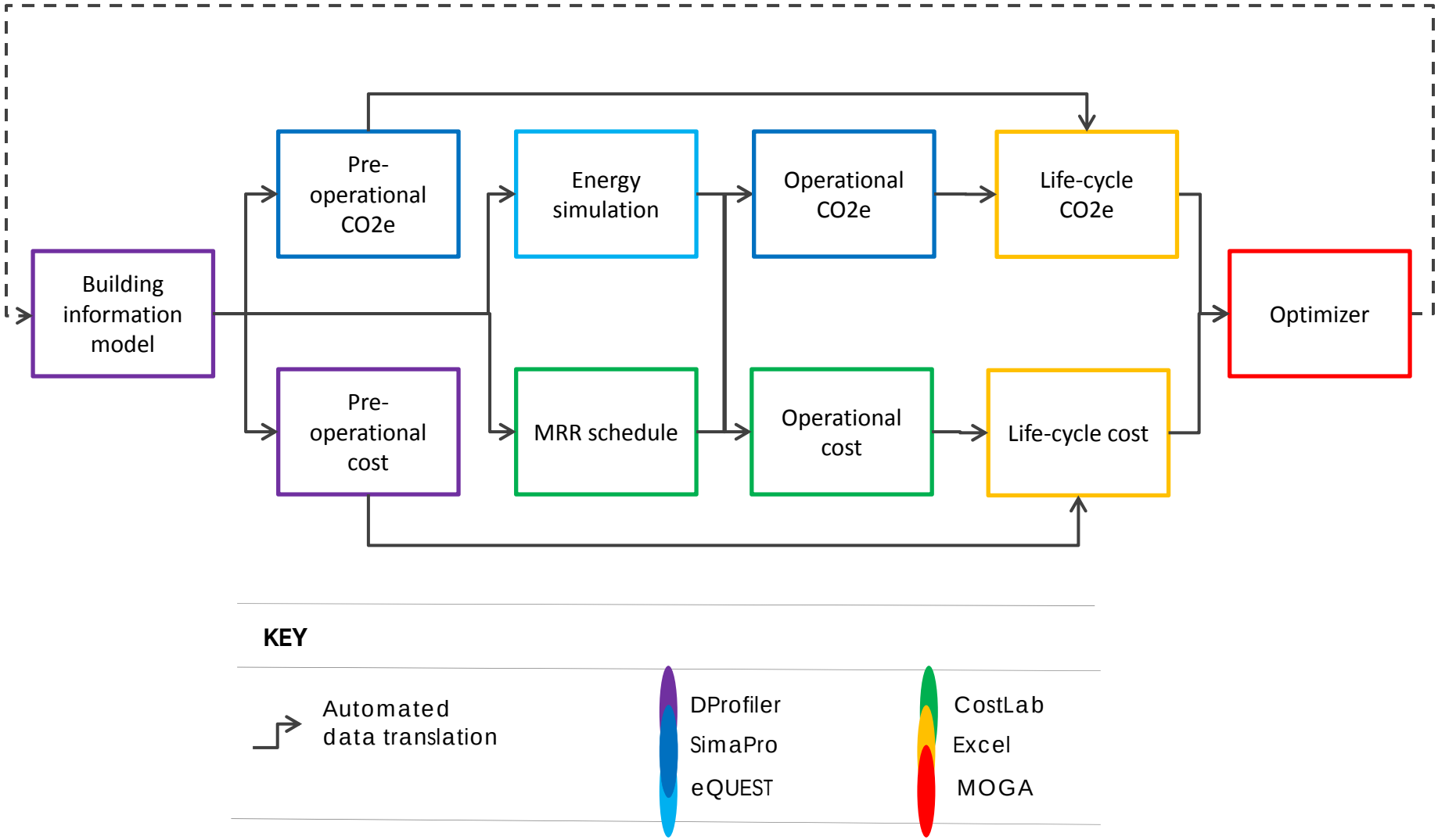
Parallel Coordinates Plot: 3 Designs



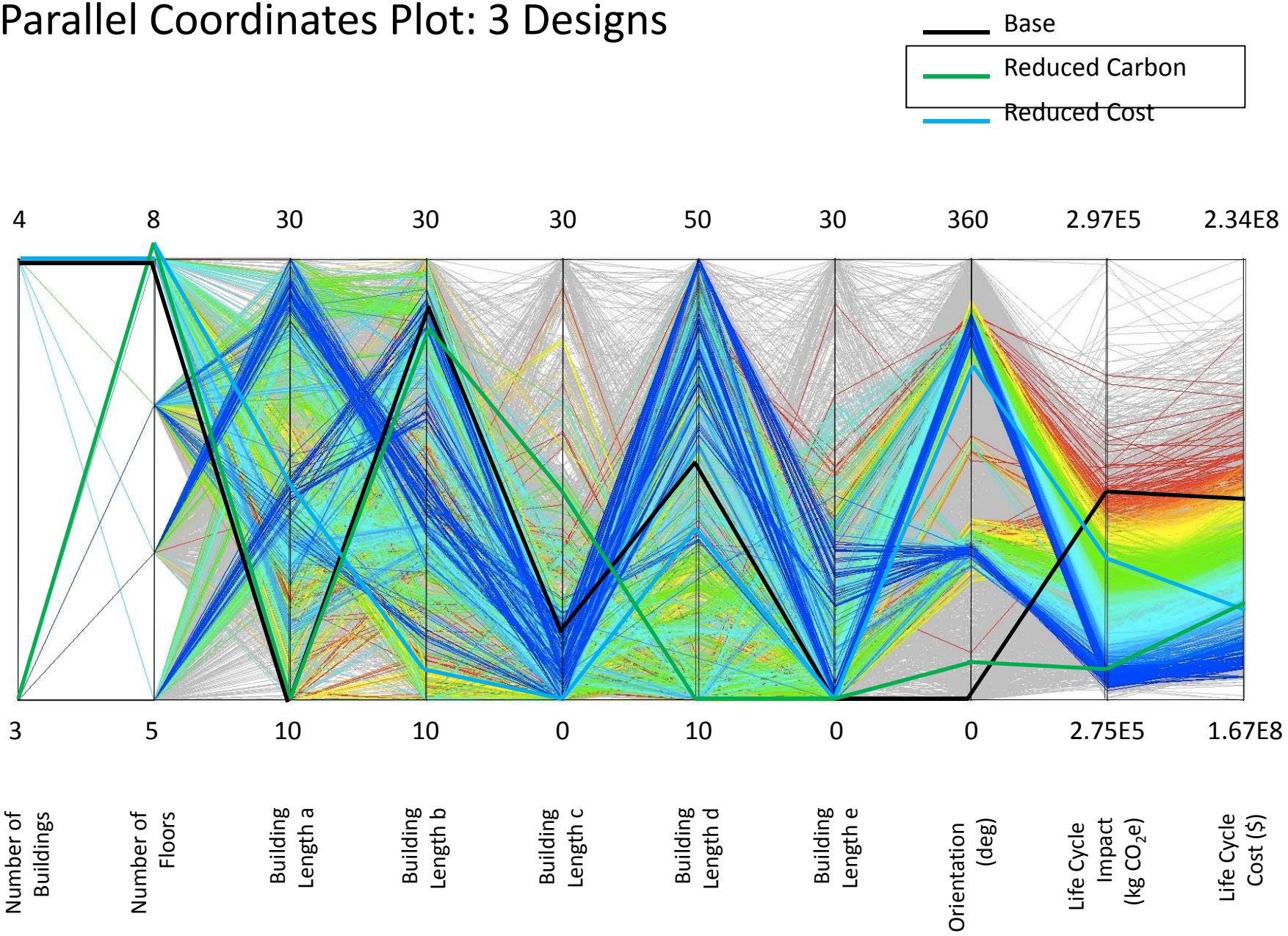
Life-Cycle Cost vs. Carbon Footprint: 3 Designs



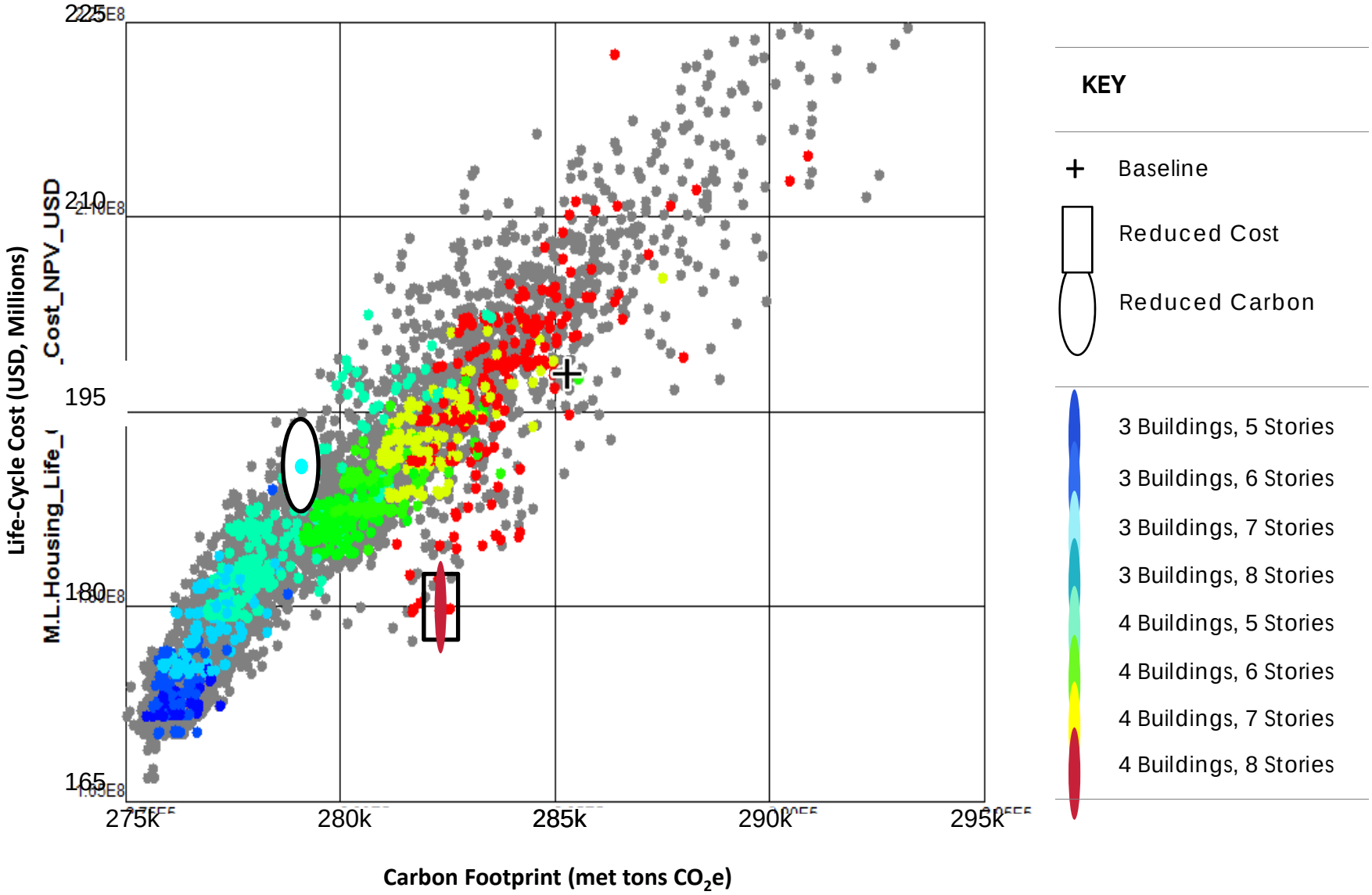
MDO Design Method



Parallel Coordinates Plot: 3 Designs

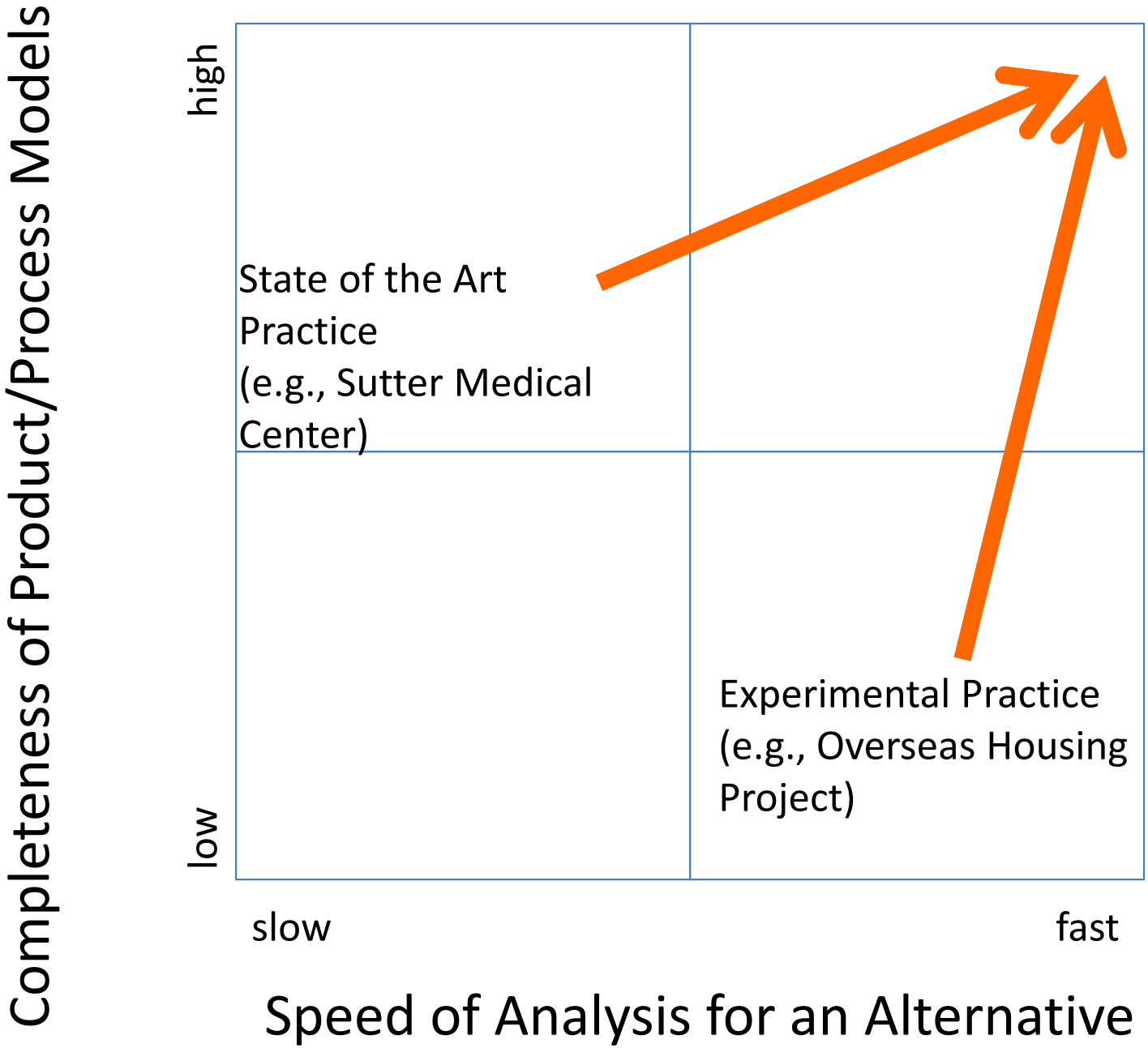


Results: Life-Cycle Cost vs. Carbon Footprint

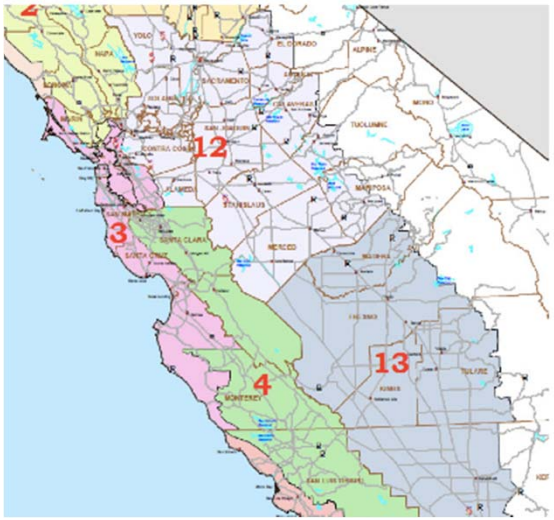


Comparing Performance of Conventional Design Process with MDO (Multi-disciplinary Optimization)

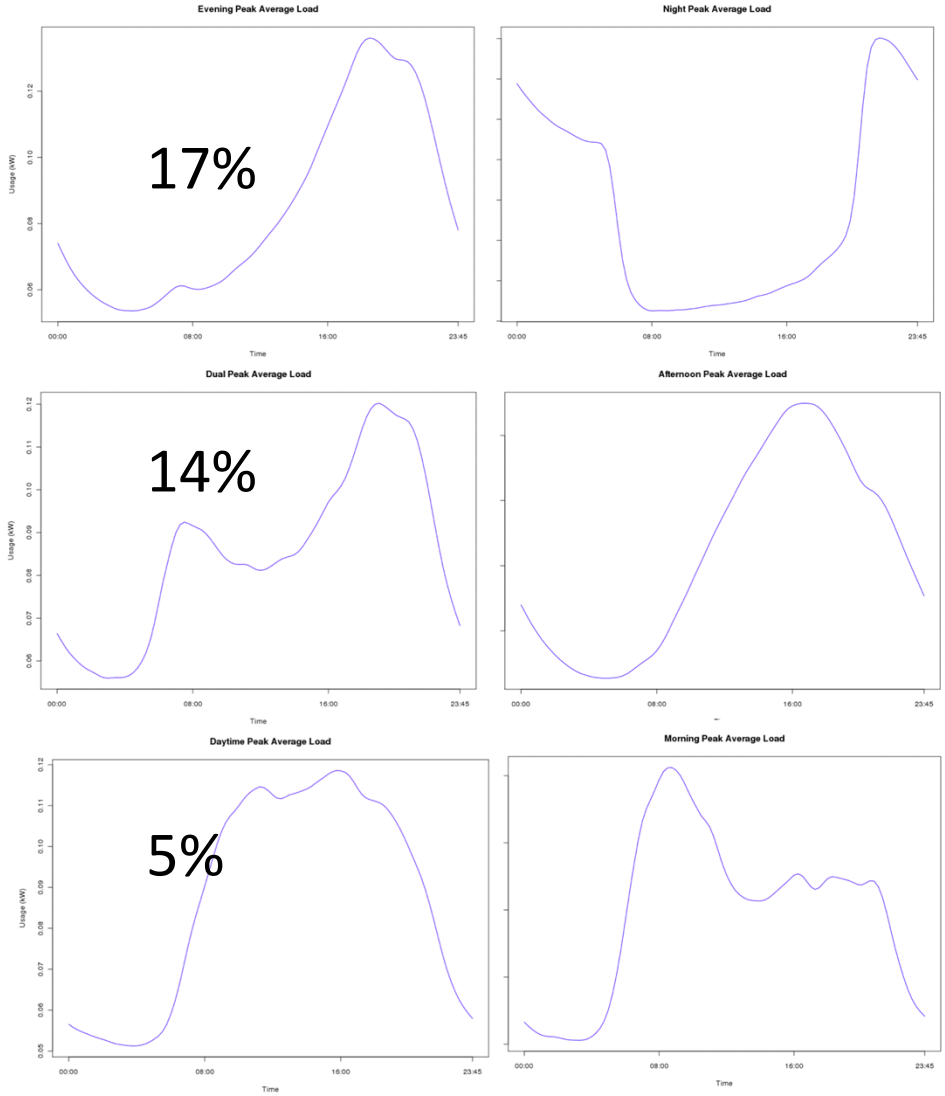
	Conventional	MDO
Set-up time	**60 hrs**	**140 hrs**
Design cycle time	**34 hrs**	**11 sec**
Alternatives evaluated	**3**	**21,360**
Total design time	**162 hrs**	**210 hrs**
Life-cycle cost savings (USD)	**-**	**$27 M**
Carbon footprint reduction (CO_2e)	**-**	**10 kt**


Completeness of Product/Process Models
high
low
State of the Art Practice (e.g., Sutter Medical Center)
Experimental Practice (e.g., Overseas Housing Project)
slow
fast
Speed of Analysis for an Alternative

Smart meters show energy consumption of households (homes + occupants)



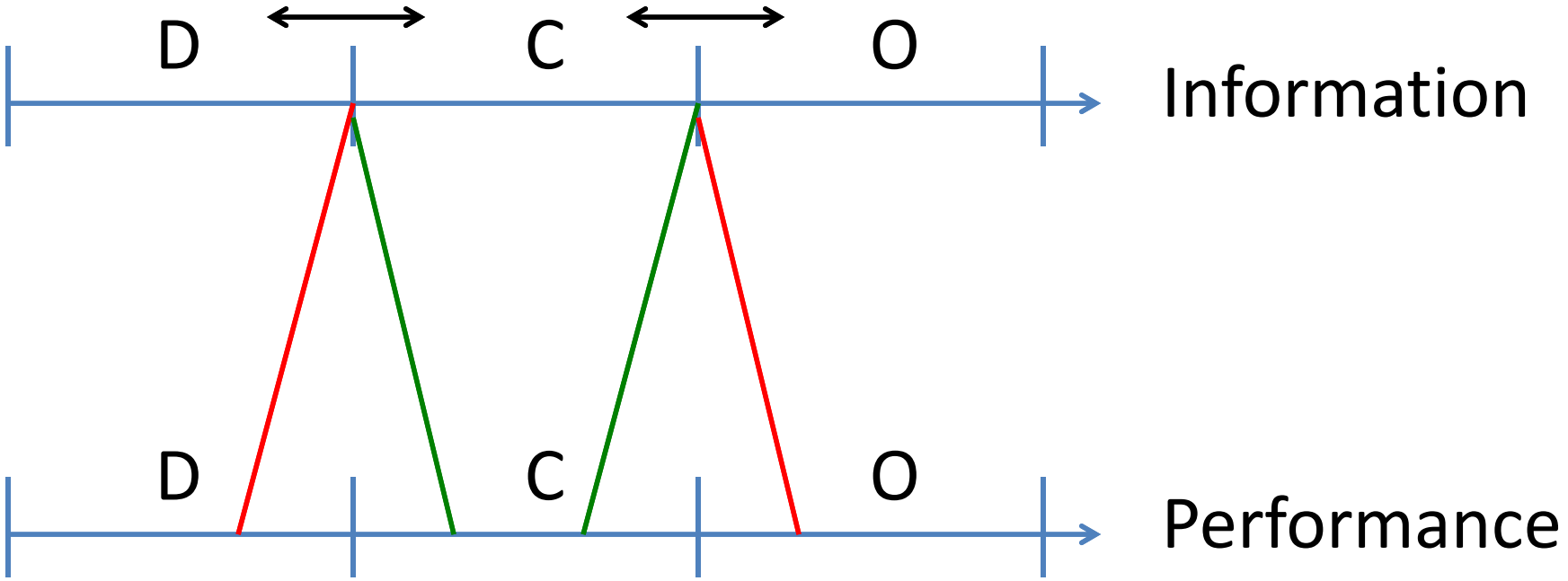
- Climate zones 12 and 13
- 8,337 households
- 43 weekdays
- (June-July, 2011)



Brian Smith, Jeff Wong and Ram Rajagopal,

A Simple Way to Use Interval Data to Segment Residential Customers by Energy Usage for Program Targeting

Who will “guarantee” what?



I have made all my generals out of mud.

Napoleon