The value of integrated information in enabling high-performing project teams and buildings

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With lots of input from Dean Reed, Howard Ashcraft, Atul Khanzode, Cynthia Brosque, and others
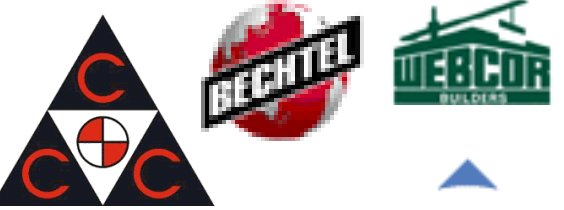
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- **100% funded by industry**
  - **Building owners**
  - **Design and construction companies**
  - **Software and hardware vendors**
- **1988-2000 BIM**
- **2000-2010 VDC**
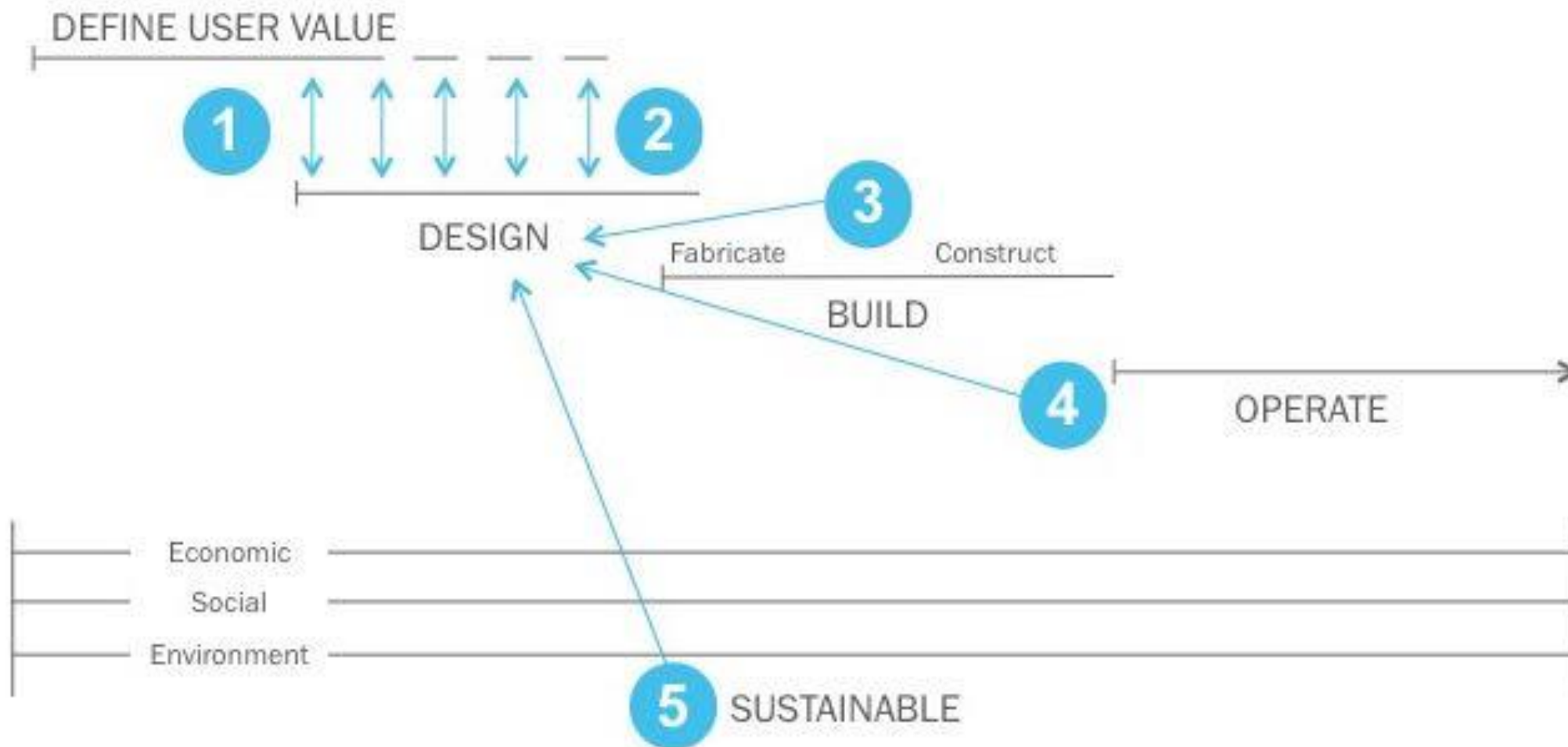- **2010+ Optimize Facility Performance**

My main point at the 1ˢᵗ 5D Conference:
Integrated processes to create high-performing buildings

Are these high-performance buildings?

Image courtesy WDI

http://www.ucsfmissionbayhospitals.org

https://www.edf-re.com/project/roosevelt-wind/
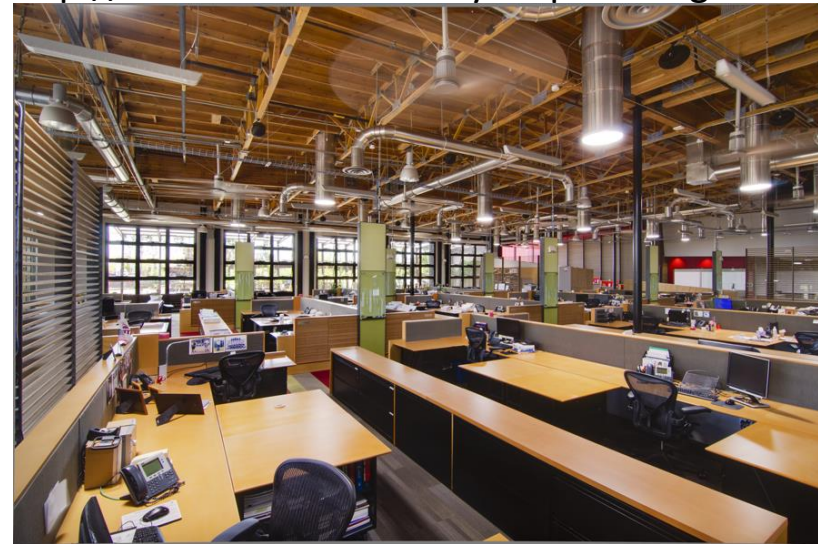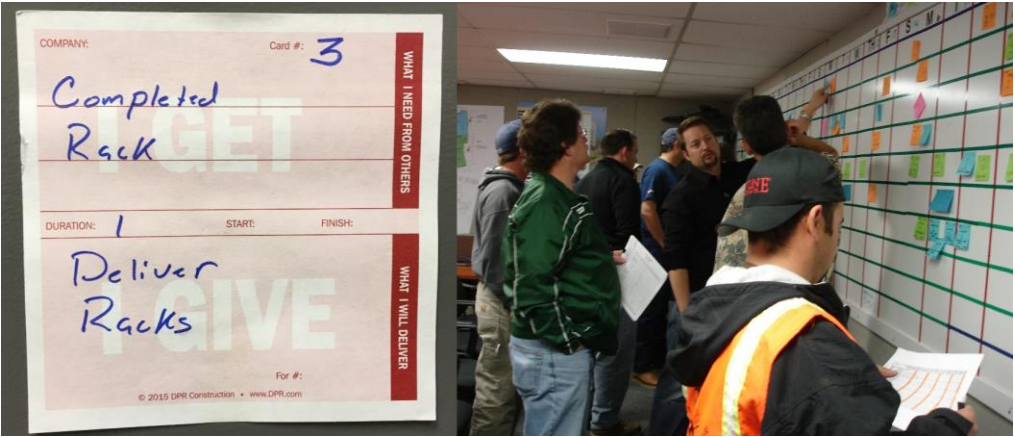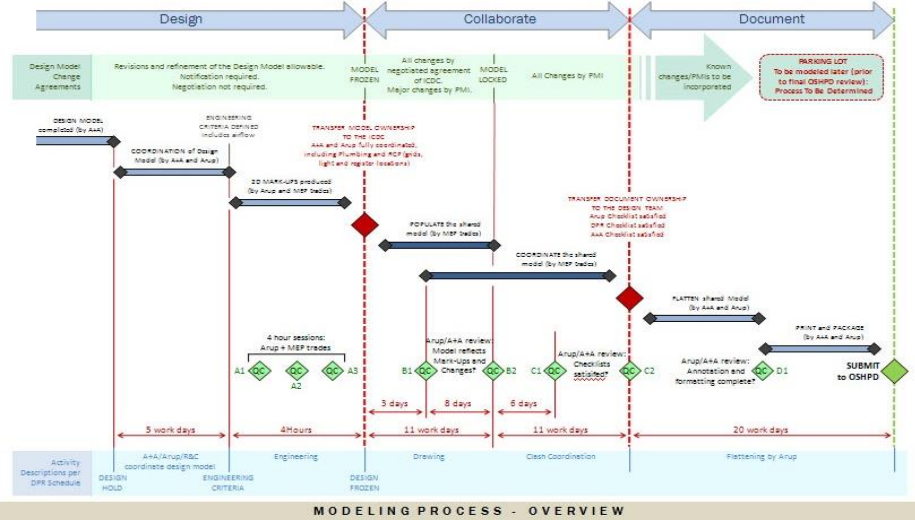

Image courtesy DPR

Are these high-performance processes?

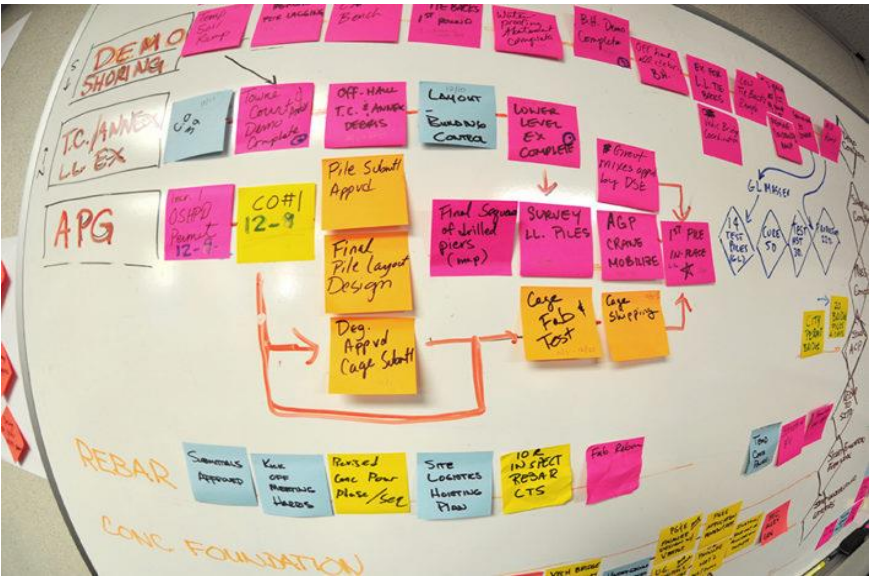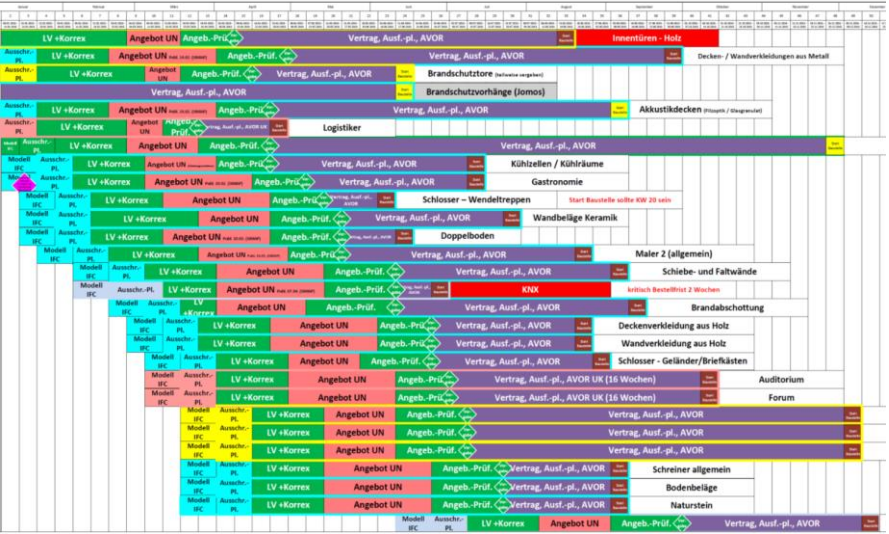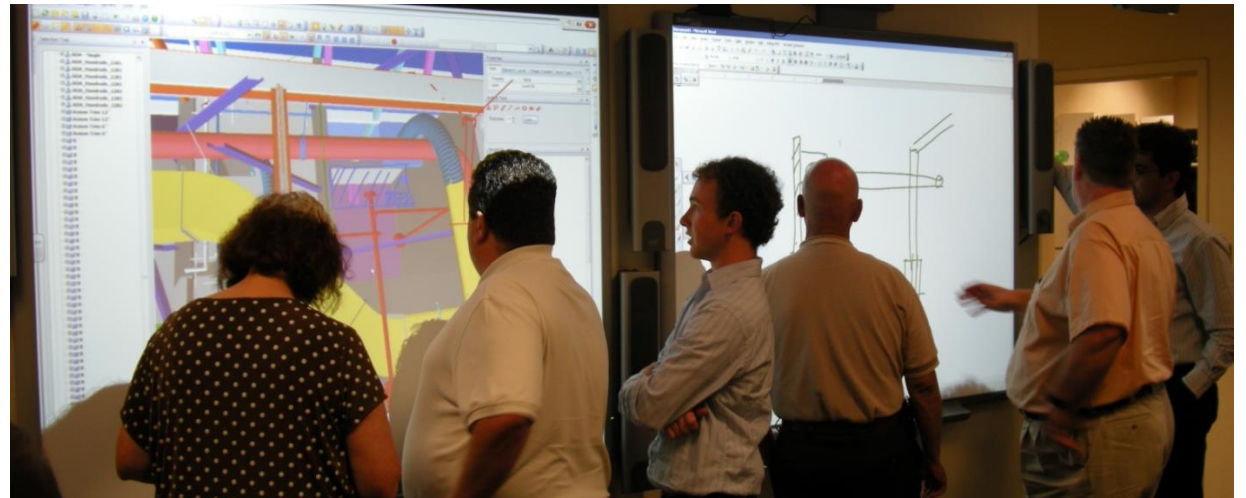Image courtesy DPR

Image courtesy DPR

Image courtesy DPR
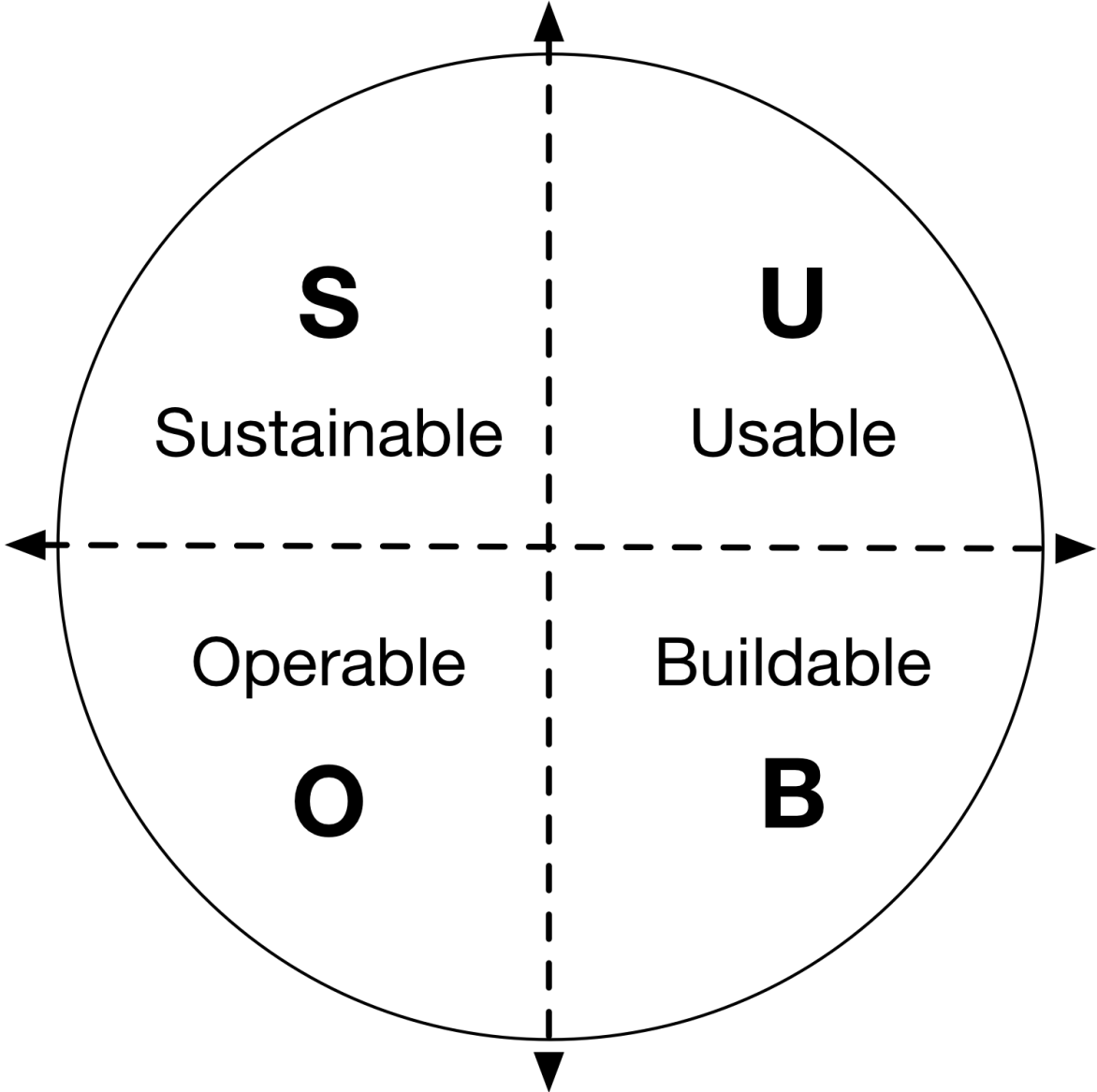

Image courtesy Drees & Sommer

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Are these high-performance project teams?

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It depends on what you are trying to achieve

S Sustainable | U Usable

O Operable | B Buildable

People make projects happen

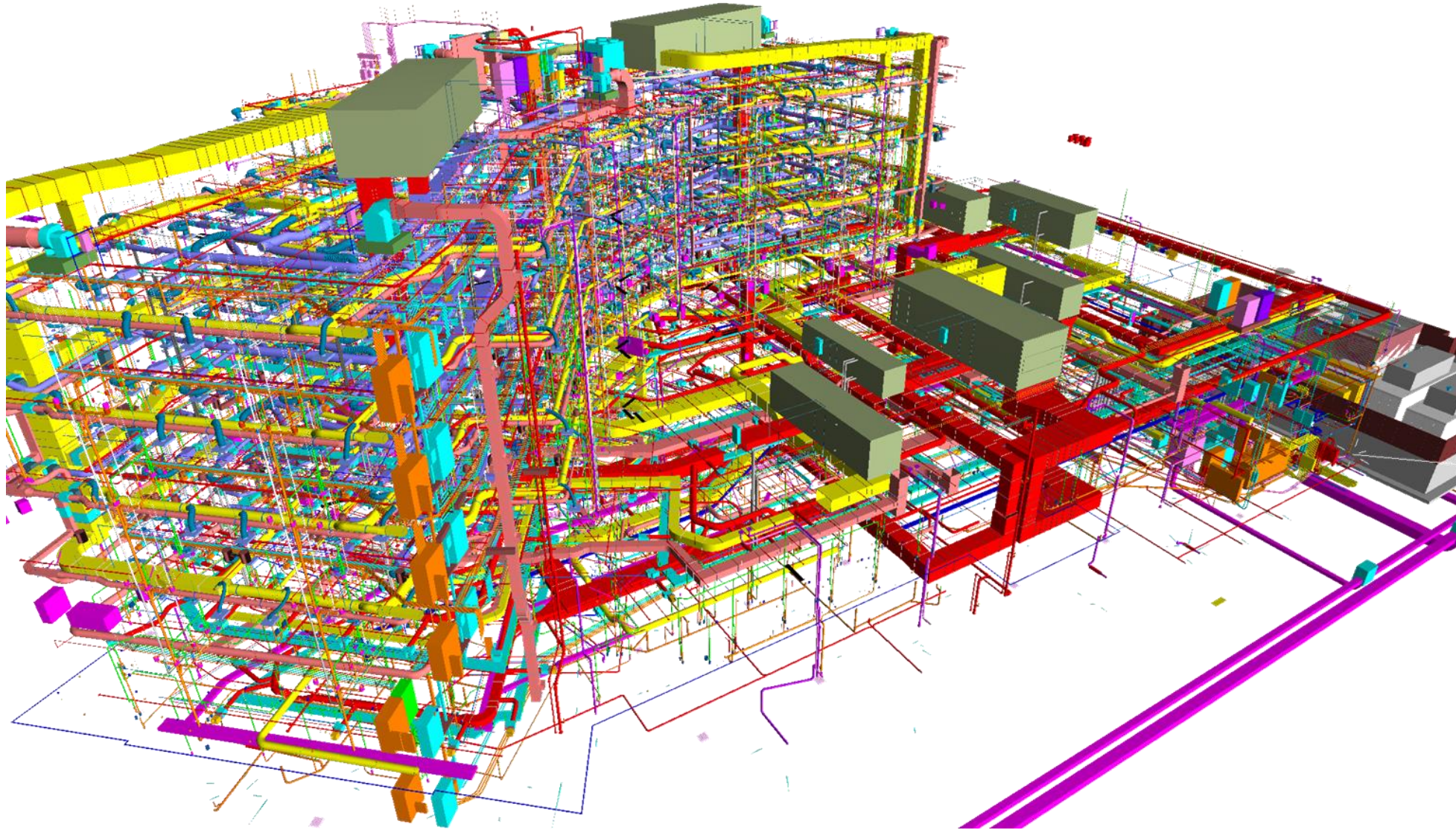# But in 2018, people can only do so much without information
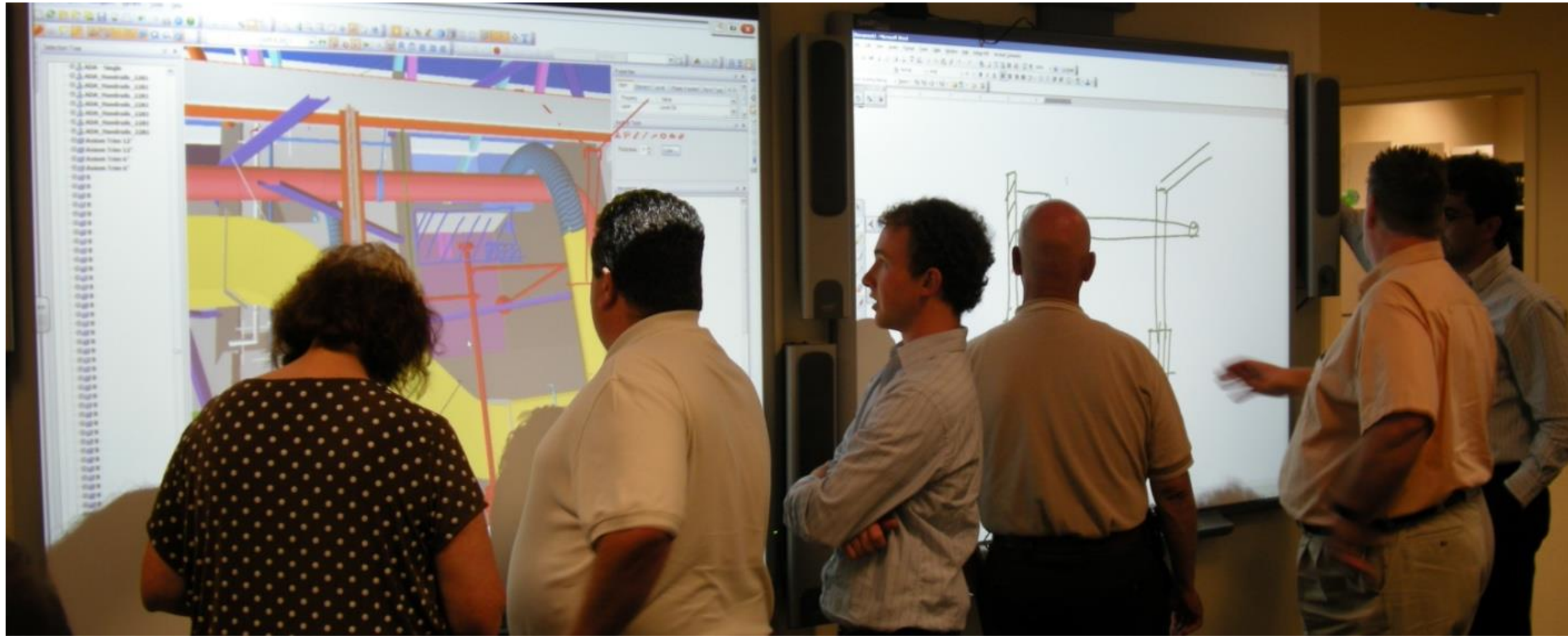
Since our clients buy a product from us, BIM is essential

Picture courtesy DPR

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But the best people and tools will not achieve anything if they are working in a poor workflow
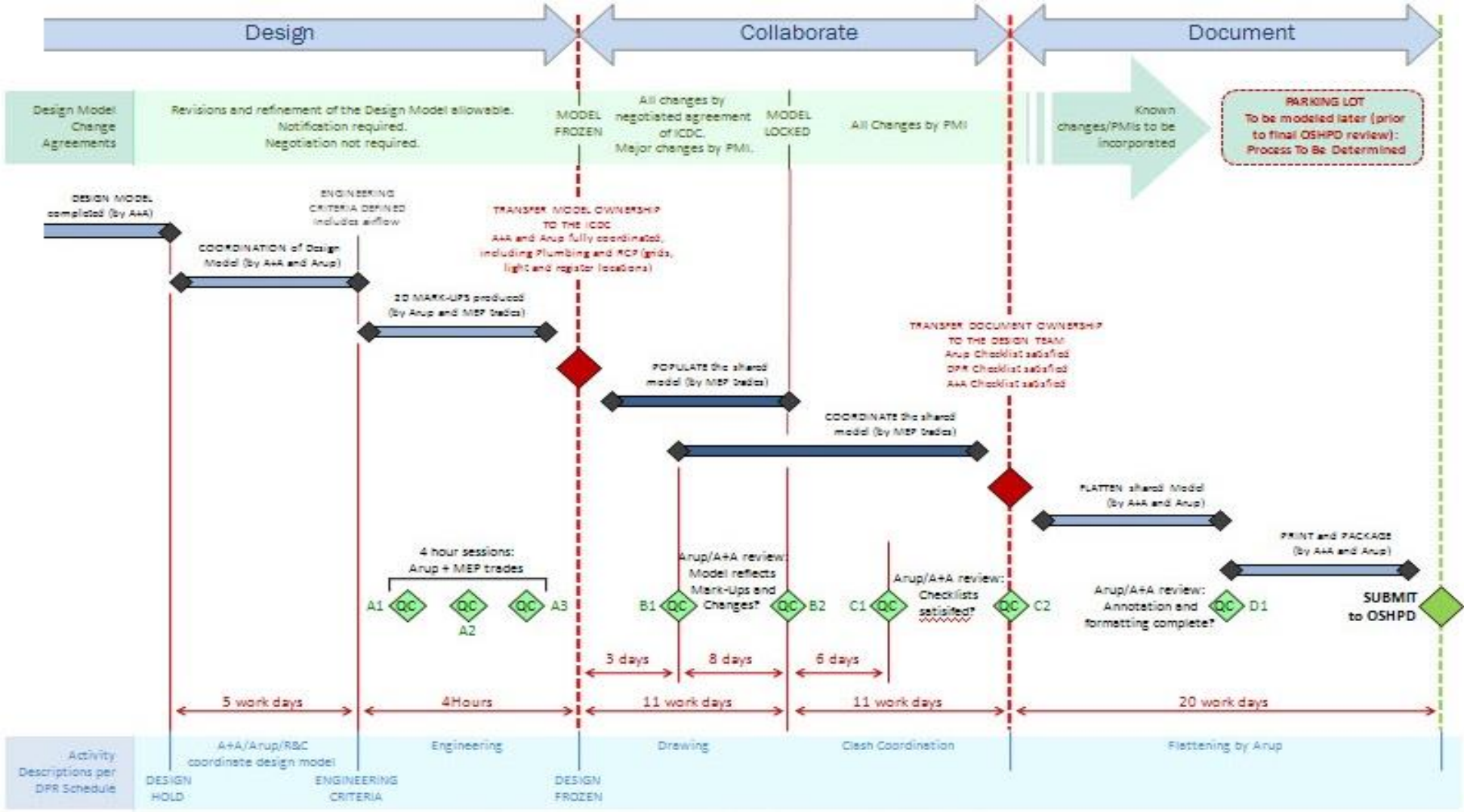
MODELING PROCESS - OVERVIEW

Picture courtesy DPR

Processes are more likely to be followed if they are created by the people working in the workflows
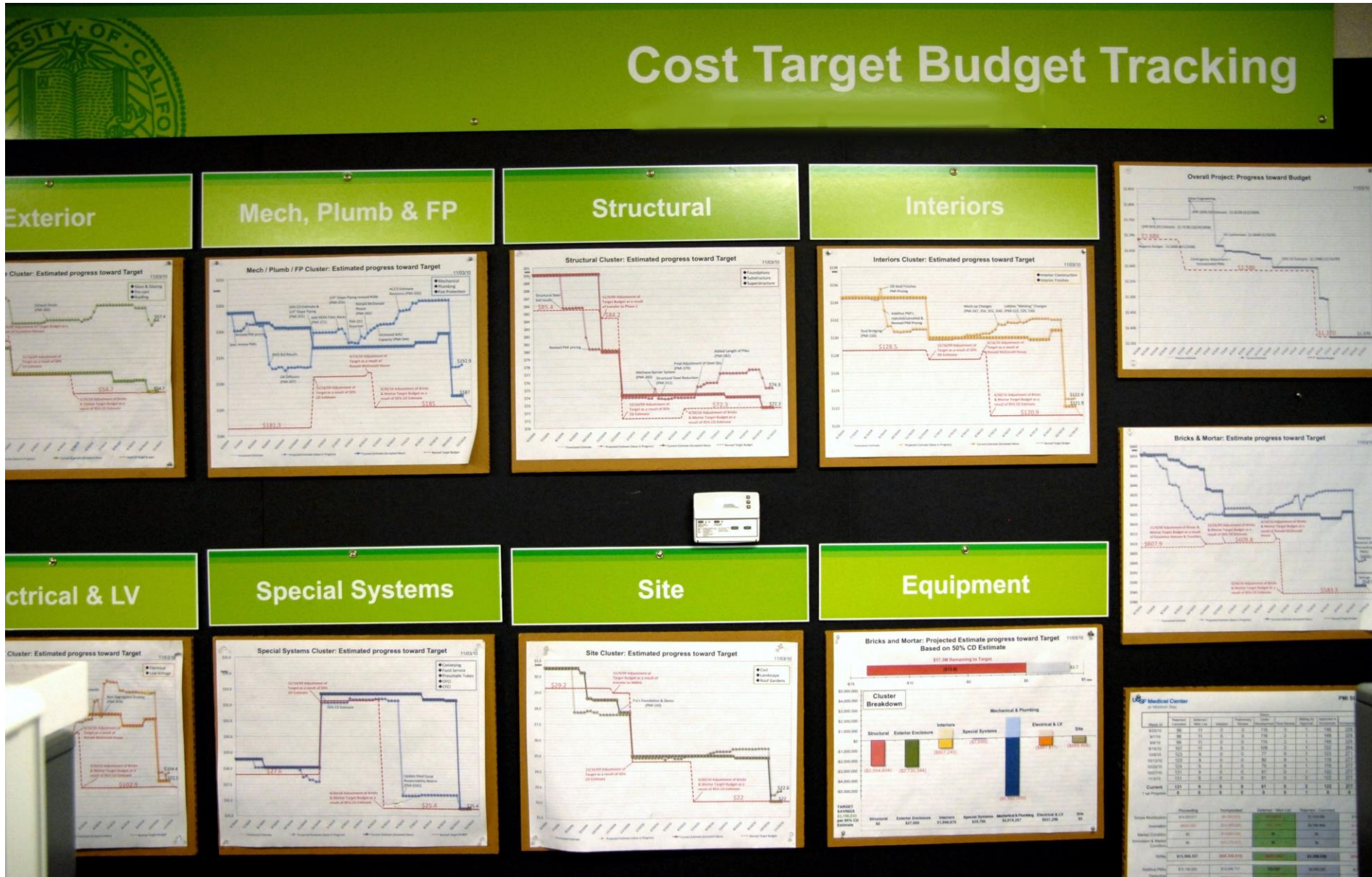
But the best people, tools, and processes won't matter unless they focus on the right things

Picture courtesy DPR

Establish and track project and client objectives

Picture courtesy DPR

Voilà ... this is VDC

Client Objectives

Project Objectives
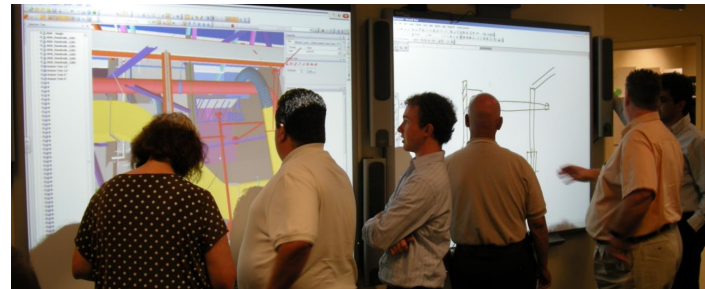
Integrated Concurrent Engineering (ICE)

Building Information Modeling (BIM)
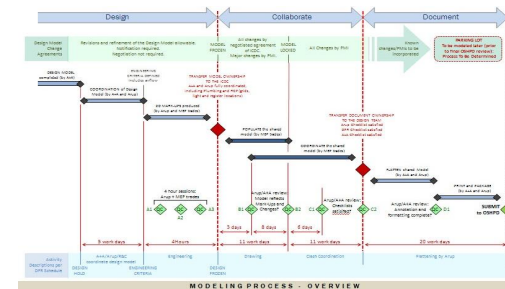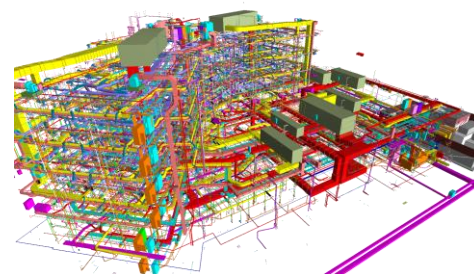
Project Production Management (PPM)

Expect and create high-performing buildings

Martin Fischer | Howard W. Ashcraft
Dean Reed | Atul Khanzode

Integrating Project Delivery

WILEY

PROJECTS	EXAMPLES	FIGURES	FEATURES
50	123	189	33

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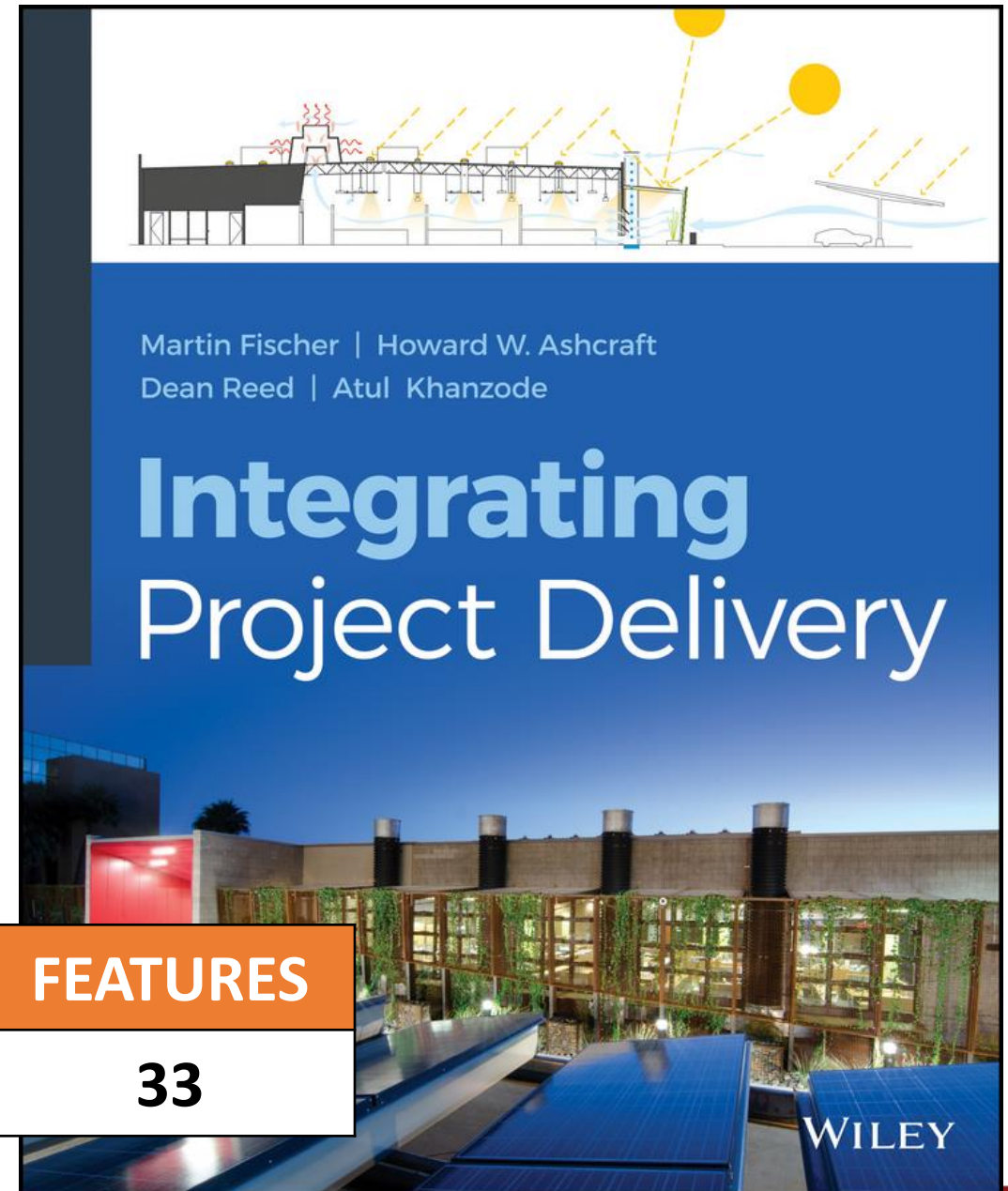
The value of integrated information:
The conceptual perspective

The Simple Framework for IPD
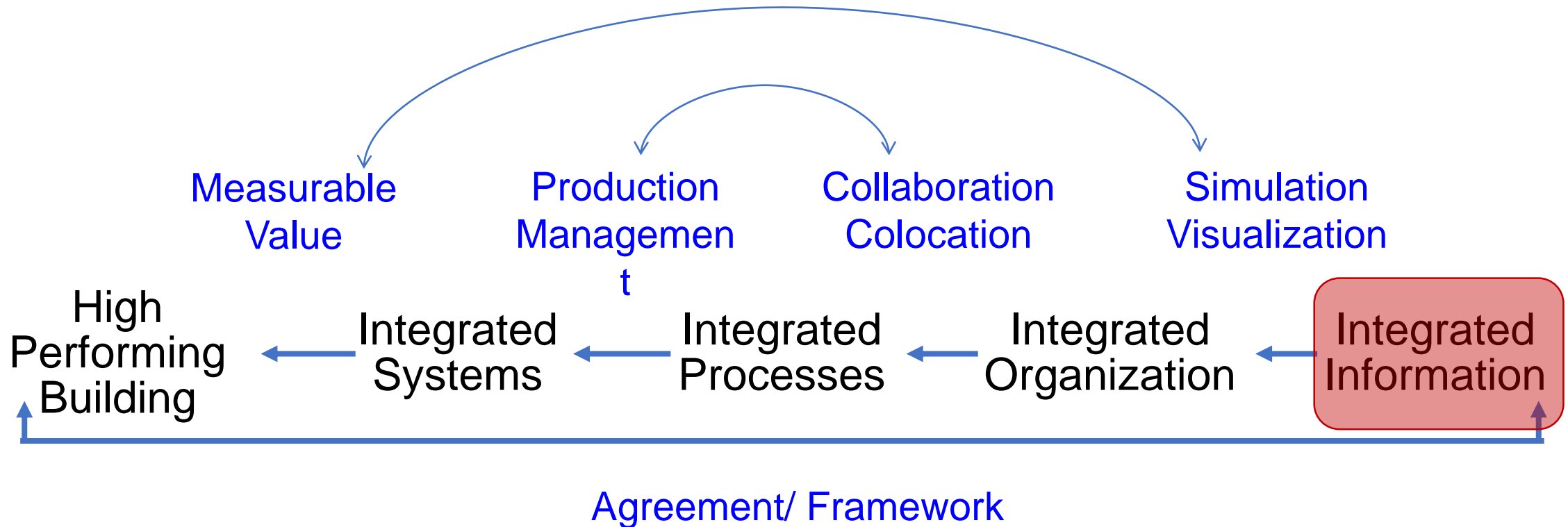
Integration is the key strategy to creating high-performing buildings

Doing your job vs. creating a high-performance building
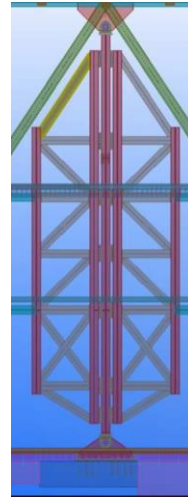
Gigafactory Top Out on Nov. 7, 2016
- 5 Buildings
- 350,000 m2
- 32,000 t of structural steel
- 2,500 t of rebar

All steel and rebar shop drawings from GPLA HD BIM

7 months from first phone call

Greg Luth,
President,
GPLA

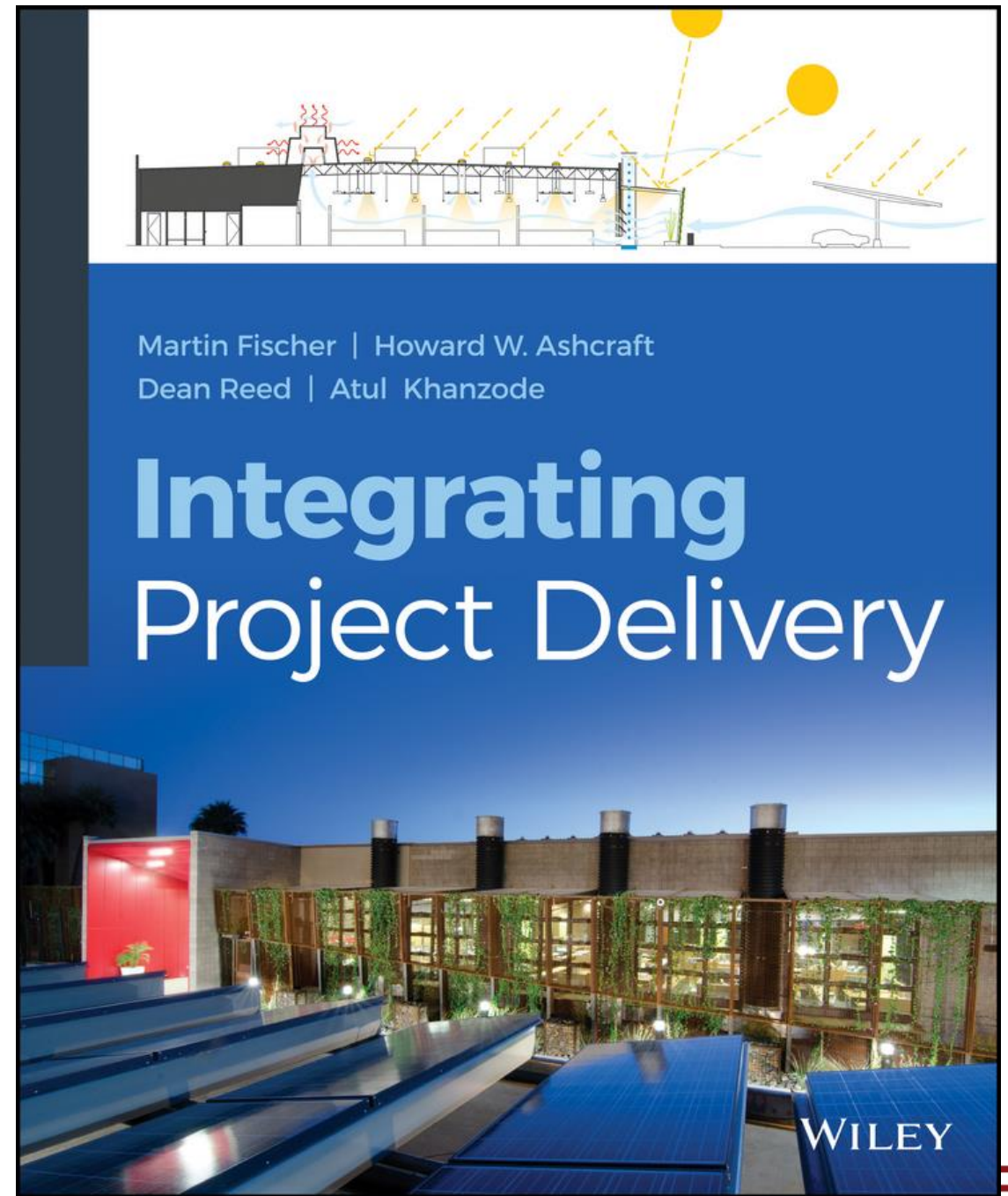"Incomplete design is the source of many of the problems in our industry. In light of the potential offered by the digital revolution, the traditional design process is an anachronism that we can no longer afford."

"My job is to create a high-performance building."

"It is **not** to create a model or a set of drawings."

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The value of integrated information

- Feedback loops
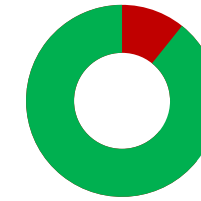
- Optimization

- Predictions

Feedback loops

Are you working for the information, or is the information working for you? Kathleen Liston

BIM-based Quality Management

Pre-defined **QA/QC** checklists attached to **each BIM** object

19 of **20** specifications met

95% **Quality Score** of object
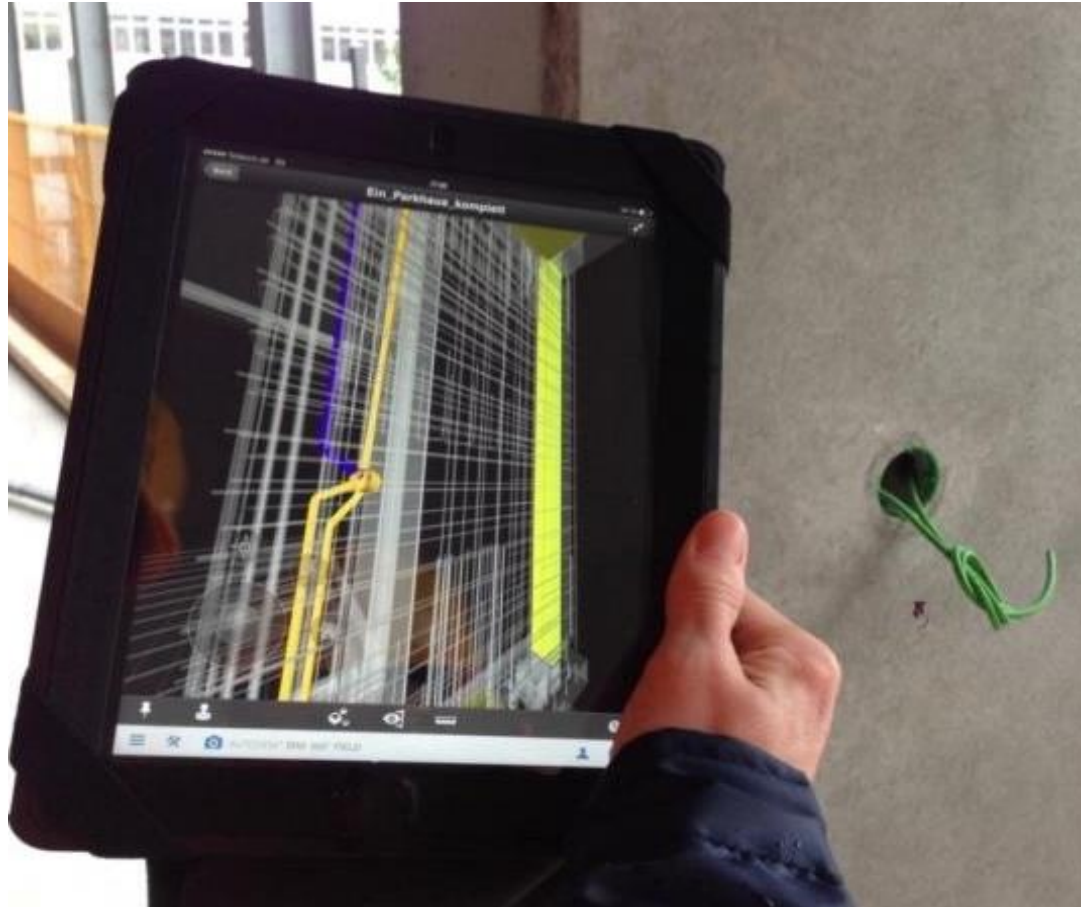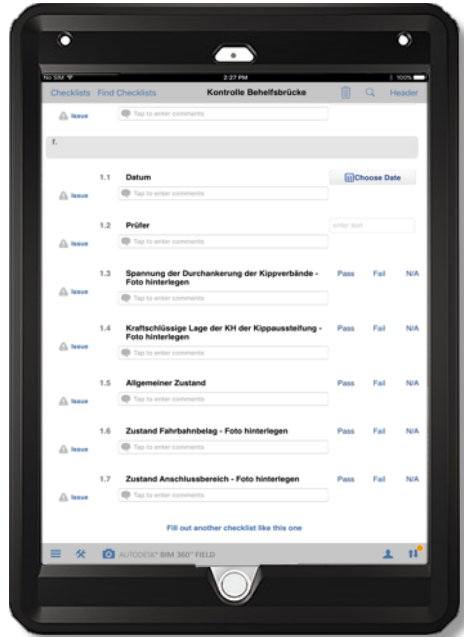
On s'engage et on voit. Napoleon

Current Prototype: Integration of product and process, with Max Schütz

DPR Arizona Team (2017): "We really should have a BIM viewer integrated with our work plans."

Switch between Monthly, Weekly, Daily Planning

7 BIMs from Revit, Tekla, Sketch-Up and Siemens NX

Imports 70+ different CAD formats

Takt Plan

Weekly Work Plan view

Monthly, weekly, and daily planning in one tool

Daily Stand-up view

Monthly, weekly, and daily planning in one tool

Integration of product and process

See **the area** in which you are planning

Ready for construction?

Comment from a construction practitioner: "Many project teams don't have supply chain visibility."

See **what** you are planning

Quick info:
Still **missing shop drawings**!

1 Nov 2018 – 17 Feb 2019

Task 1
20 Nov 2018 – 30 Nov 2018

Num Workers: 4
Quantity: 86
Missing Make Ready Categories: Shop Drawings
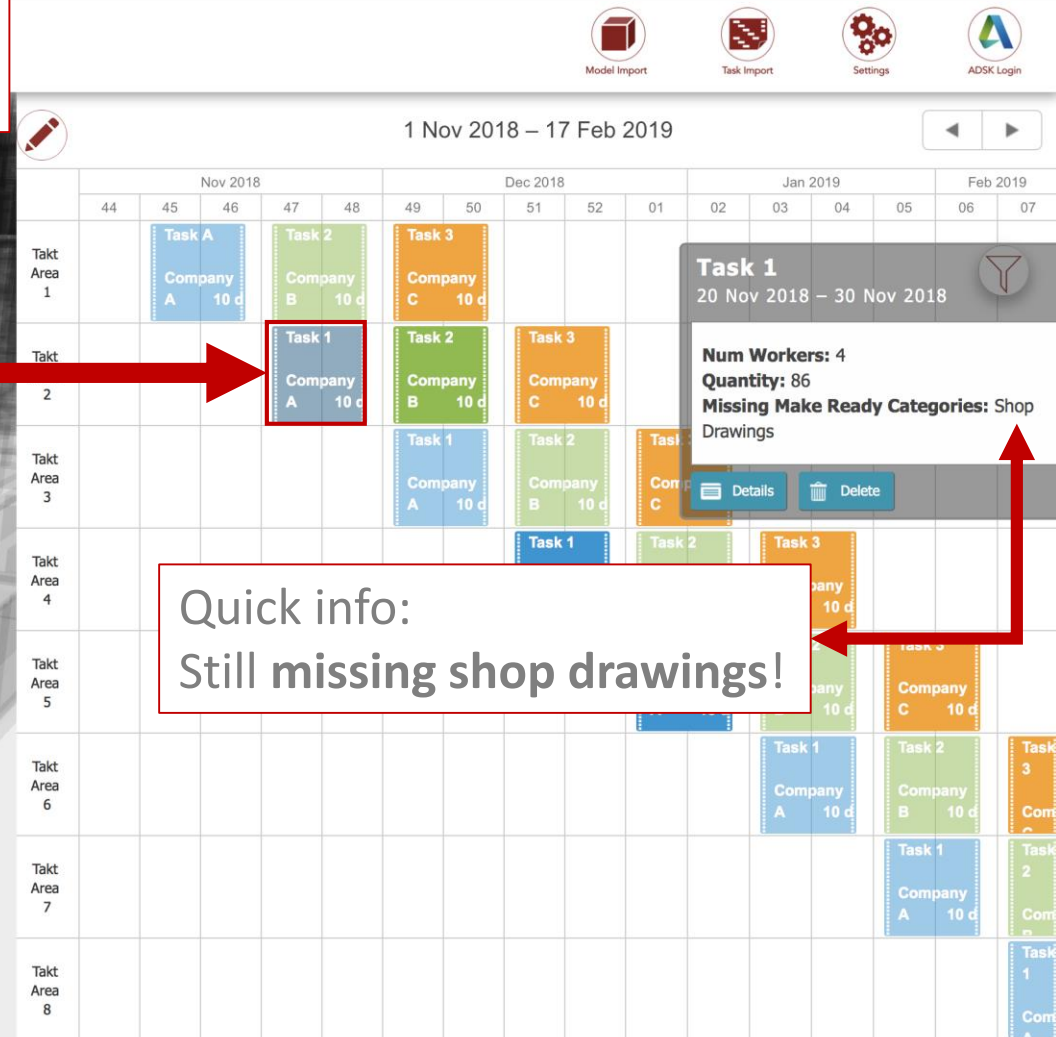
What's missing for building the footings?

Optimization

"The automated execution of processes changes everything."
(Alan Perlis, 1961)

An engineer with today's tools cannot compete with an engineer with the same tools that are connected
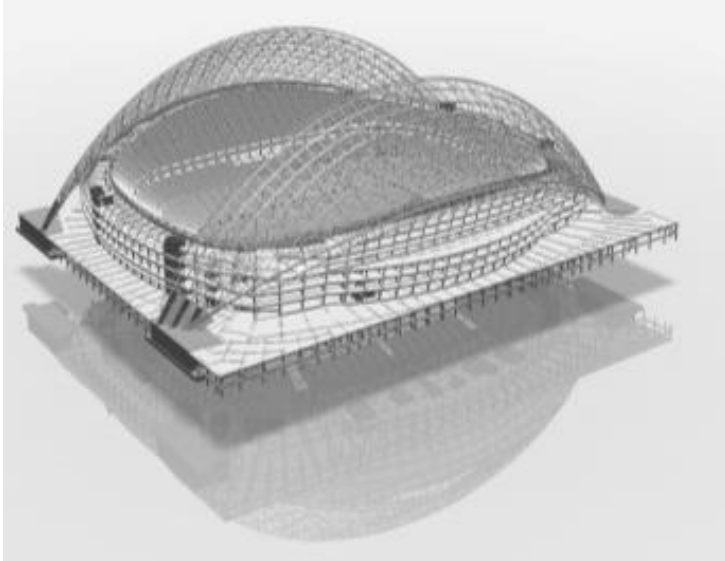
	Engineer with today's tools	Engineer with connected tools
Total steel weight	**2,728 mt**	**2,292 mt**
Cost savings		$4M
# alternatives evaluated	39	12,800
Design time per alternative	4 hours	3 seconds
Total design time	~200 hrs	~200 hrs

Roof truss design for a soccer stadium in the Middle East
Work by Forest Flager and John Haymaker in collaboration with Arup Sports, London

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Optimize across all cost components of a steel frame

Design Cycle Time: 8-24 weeks
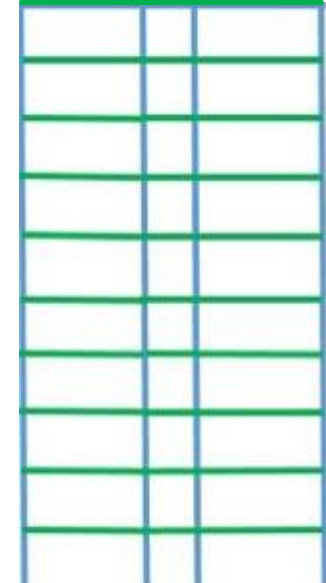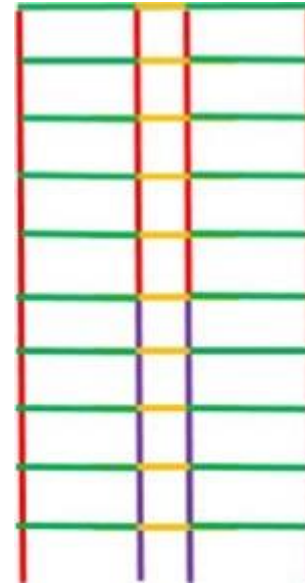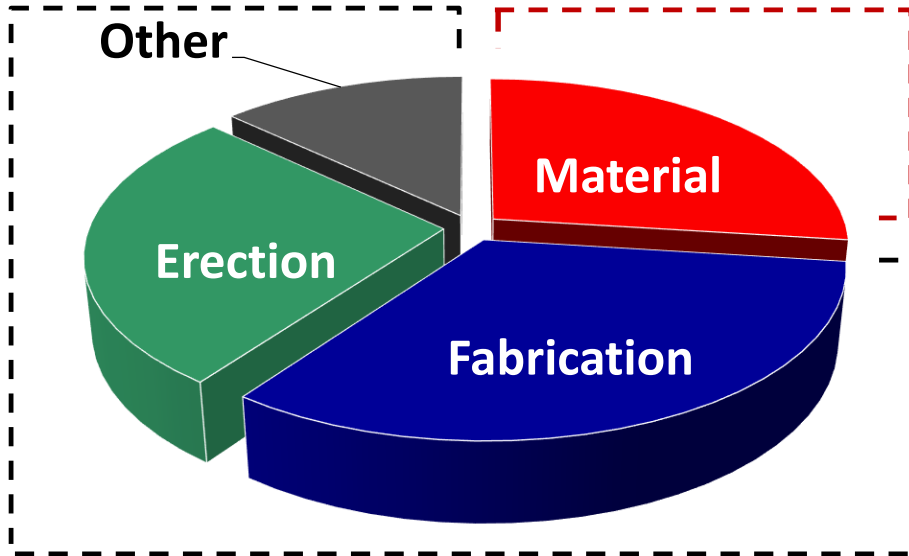
	Original Frame	Value-Engineered Frame
Steel Weight	-	**+8%**
Total Cost	-	**-13%**
Procurement Time	-	**-20%**

Work by Forest Flager, Pratyush Havelia, Henry Hamamji, Filippo Ranalli, Bo Peng, Thomas Trinelle
in collaboration with SOM, Herrick, Autodesk

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Optimizing Constructability to Reduce the Cost of Wind Energy
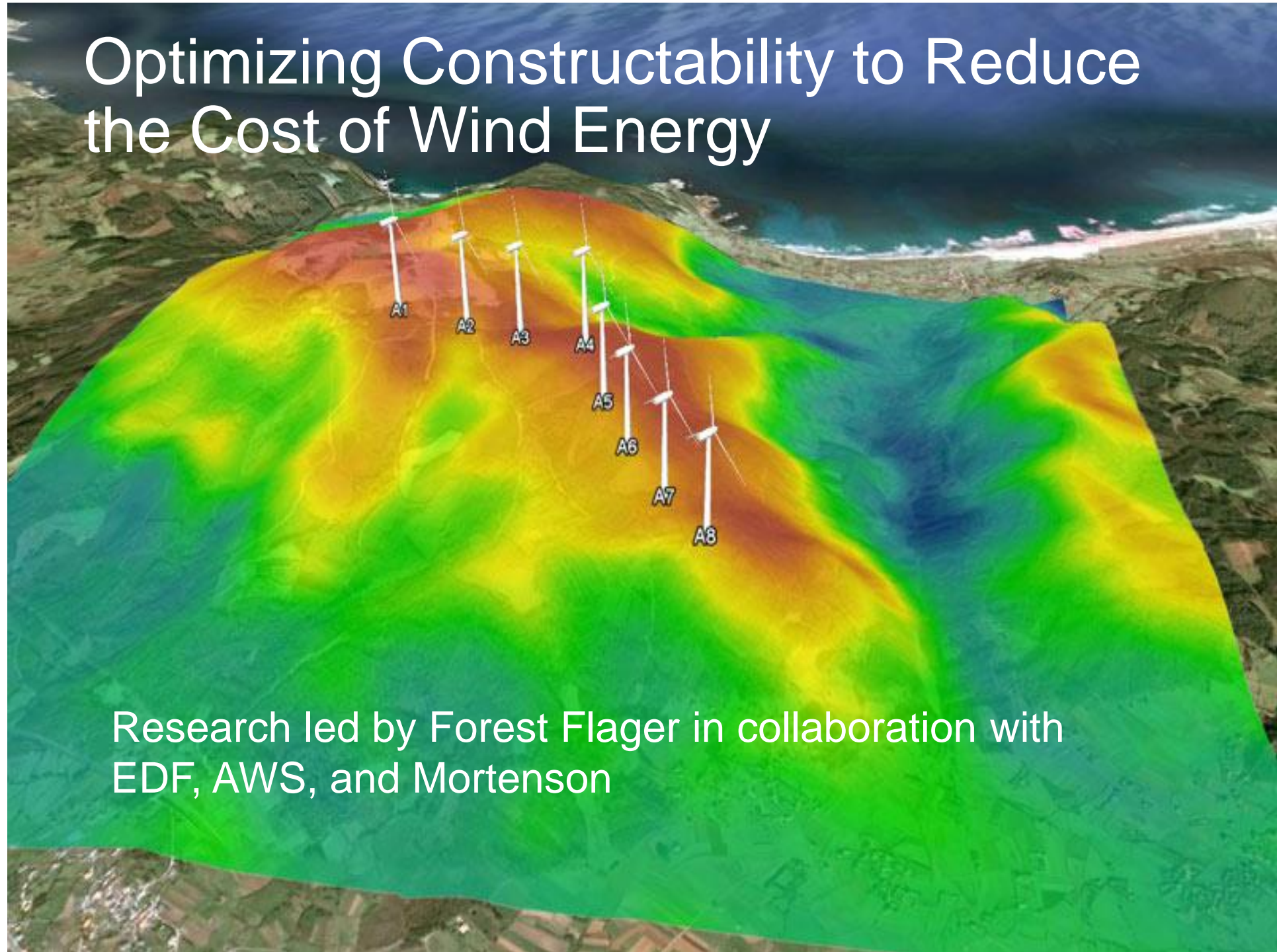
Research led by Forest Flager in collaboration with EDF, AWS, and Mortenson

Roosevelt: As-built, optimized for electricity production only

KEY

▬	= Existing Roads
▬	= Collector System
▬	= New Roads
●	= Turbines
▨	= Buildable Area
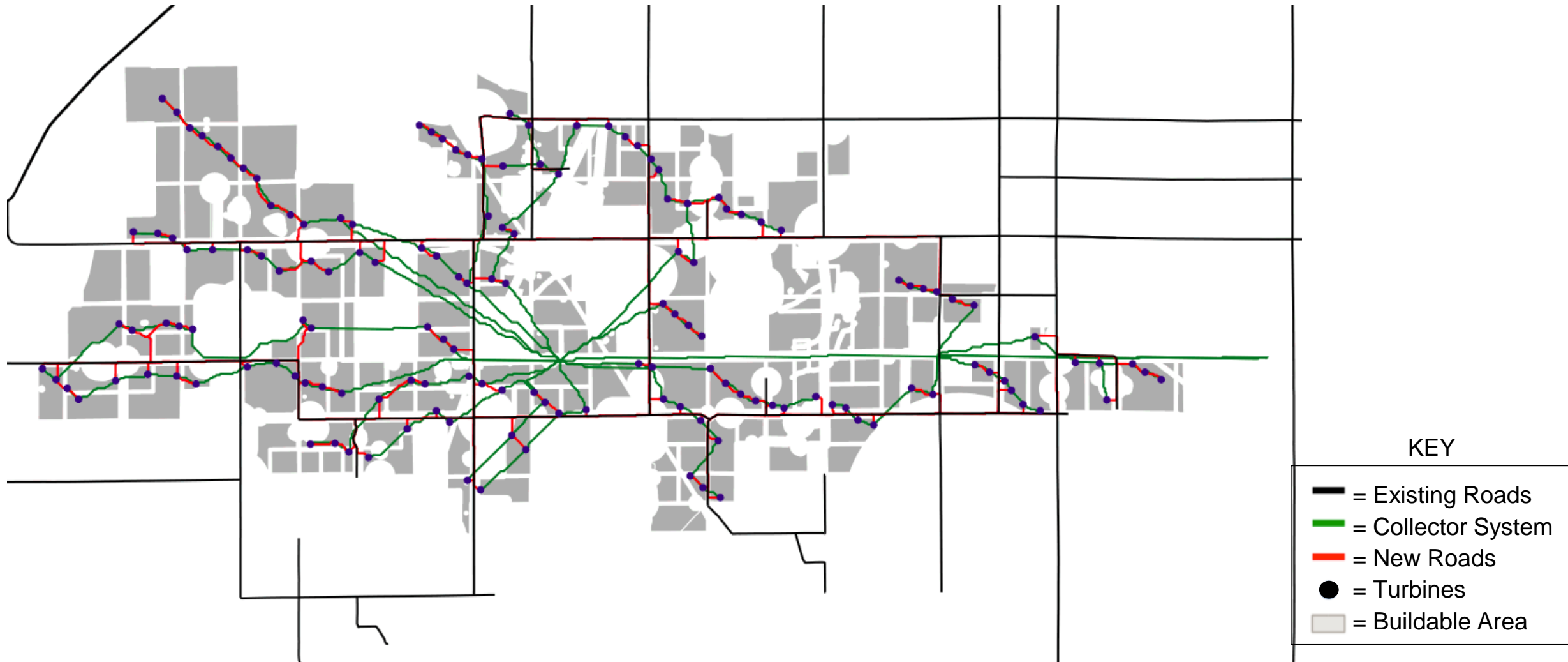
Roosevelt: Turbines with locations optimized for electricity production **and** construction costs

KEY

— = Existing Roads
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— = New Roads
● = Turbines
▨ = Buildable Area
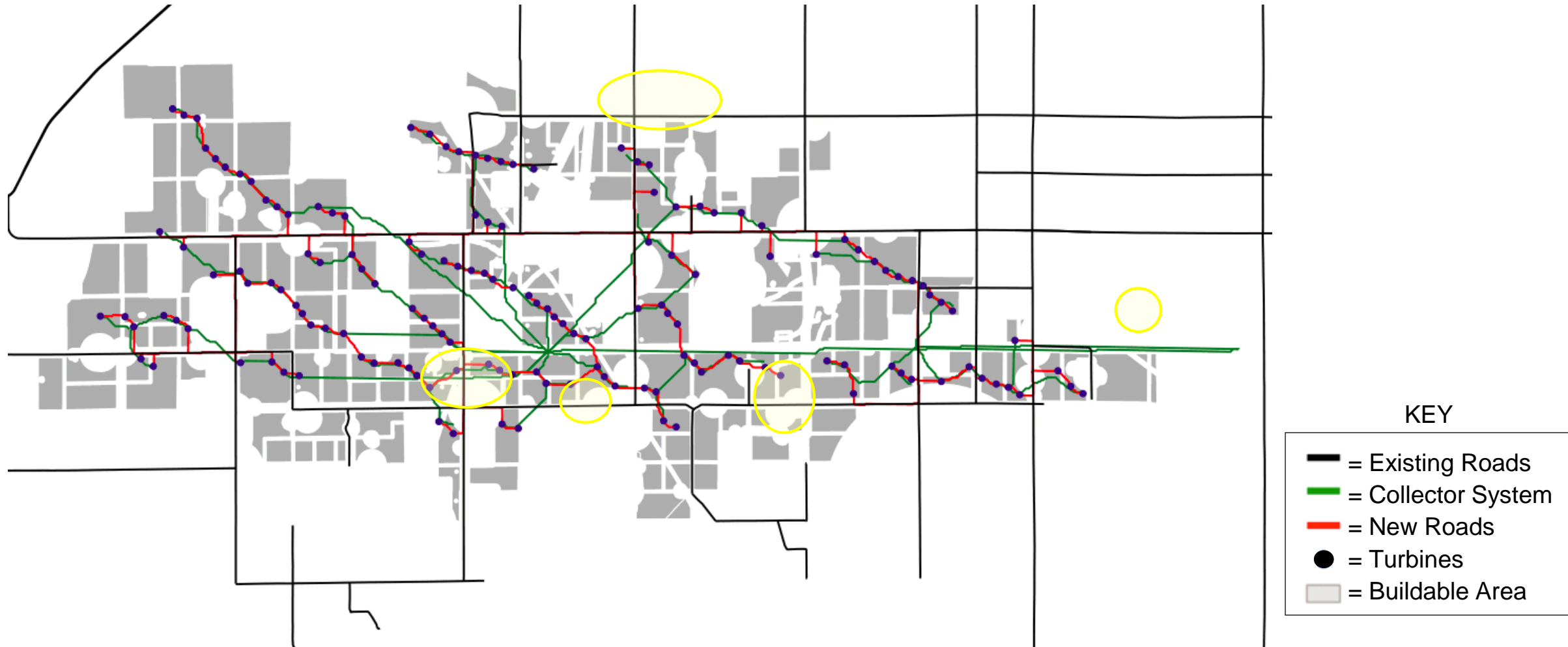
Roosevelt Results

Design Alternative	Construction Cost (M USD)	Net Energy (GWh)	Cost of Energy (USD / MWh)
As Built	90.37	1450	36.28
Optimized Turbine Positions	-6.90 (8.2%)	1448	-0.22 (0.64%)

By combining construction costs and wind data, a wind farm with the same electricity output utilizing 10% less land and requiring 8% less investment capital could have been built.

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In autumn 2017, in the offices of a General Contractor on the East Coast

Meet Jake
- Experienced construction manager
- Scheduling projects for 10 years
- Tools: Primavera, MS Project

Jake won a building project!
- 38-story high-rise
- Cast-in-Place concrete

- Jake used P6 to schedule his project.

- Total duration: 567 days!

"I' m wondering how correct my P6 schedule is though…

Why not run some AI to see what I come up with!"

ALICE TECHNOLOGIES

Construction Information Model (CIM)

- Jake's architect gave him a Building Information Model (BIM) to use for his AI scheduling efforts.

- The BIM was unnecessarily detailed for Jake's scheduling purposes with ~5,000 elements.

- Jake went to his automation team and explained the scheduling scope.

- 2 days later he received a Construction Information Model (CIM) with 1,440 elements.

VS

BIM: 4711 elements   CIM: 1440 elements

Construction Recipes

Effort: 1 week

Step 1 – Run ALICE to replicate the P6 schedule

- CIM Setup: **2 days**

- Construction model set up: **2 days**

- Run simulation: **2 mins**

- Same crew mix & numbers as in P6

- Total duration: **622 days**

- "Ugh… Looks like my P6 schedule was a little optimistic. Lets see what I can do."

High Rise Building Schedule results

● P6   ◆ P6 AI

Duration
622 days

CPM Duration
567 days

Cost x $ 1000 — 42500$, 40000$, 37500$, 35000$, 32500$, 30000$, 27500$

Time in Days — 560, 570, 580, 590, 600, 610, 620, 630, 640

ALICE
TECHNOLOGIES
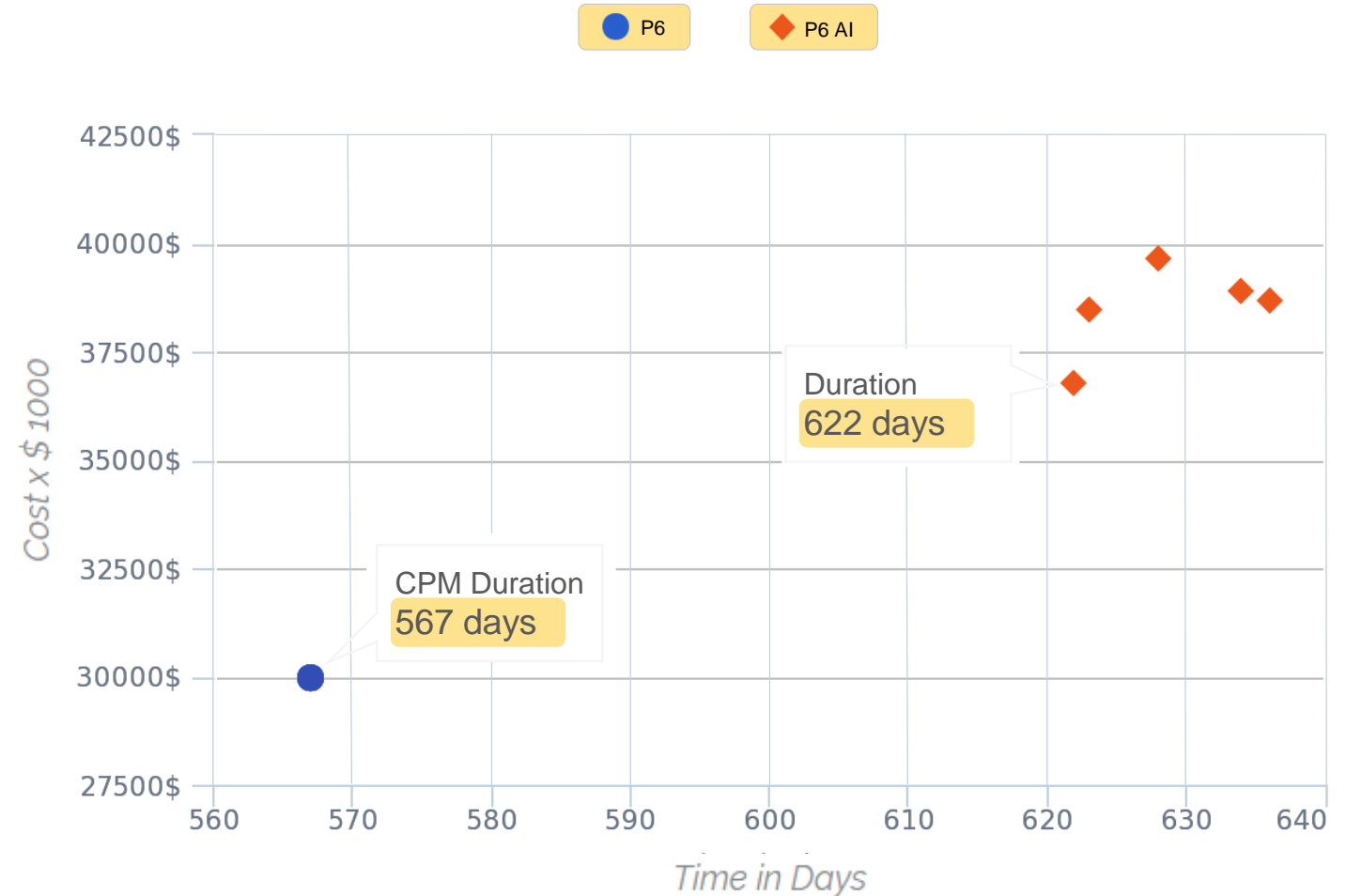
ALICE automatically generates resource-loaded 4D models for each schedule option
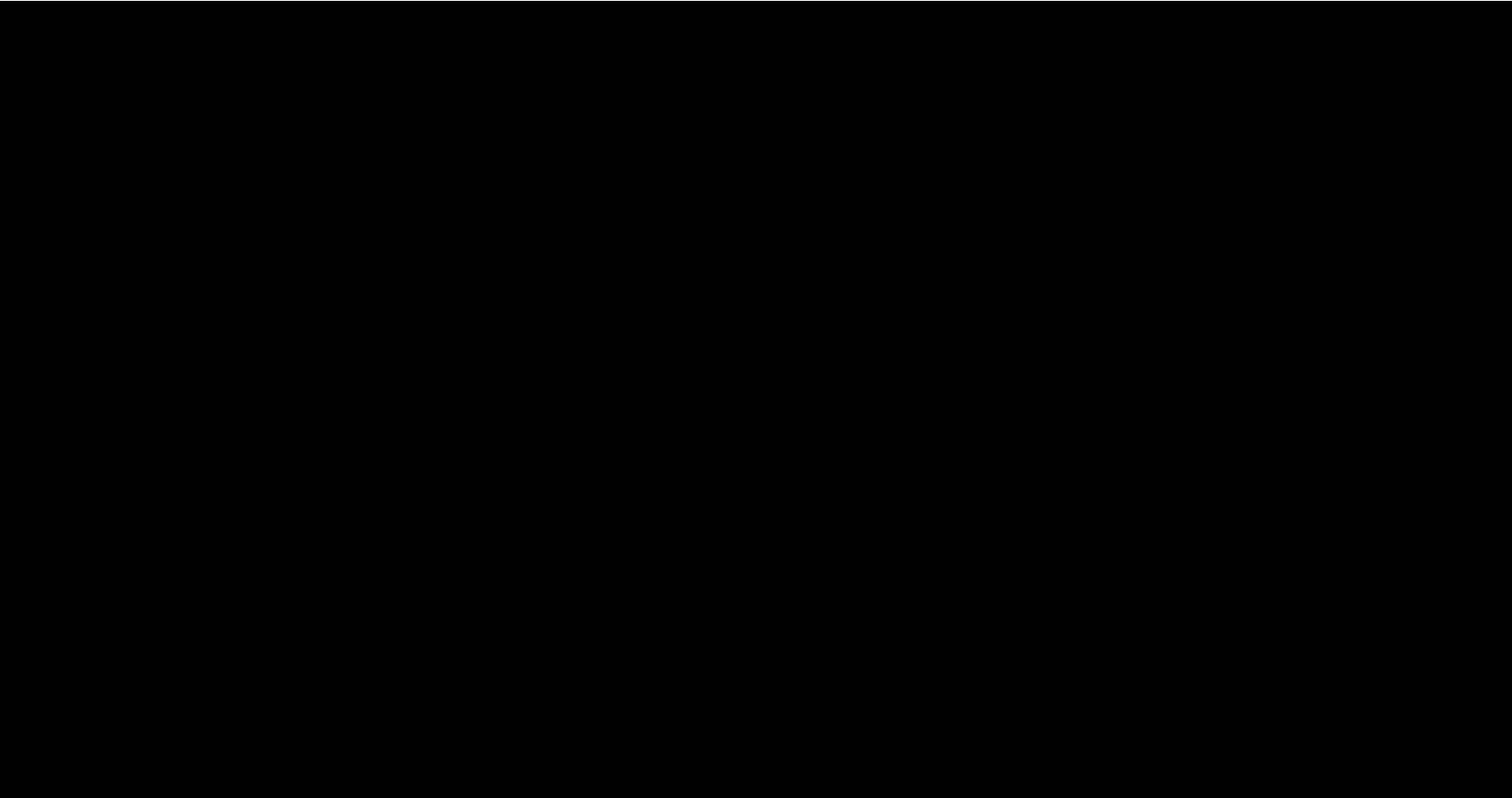
Step 2 – Resequence the façade work

- CIM Updates: Split Ext wall: 4 hrs

- Construction model set up: 4 hrs

- Run simulation: 2 mins
- Changed crew workflow from clockwise to crisscross

- Total duration: 610 days

- "Hmm... I am saving a few days, but it's not enough!"

High Rise Building Schedule results
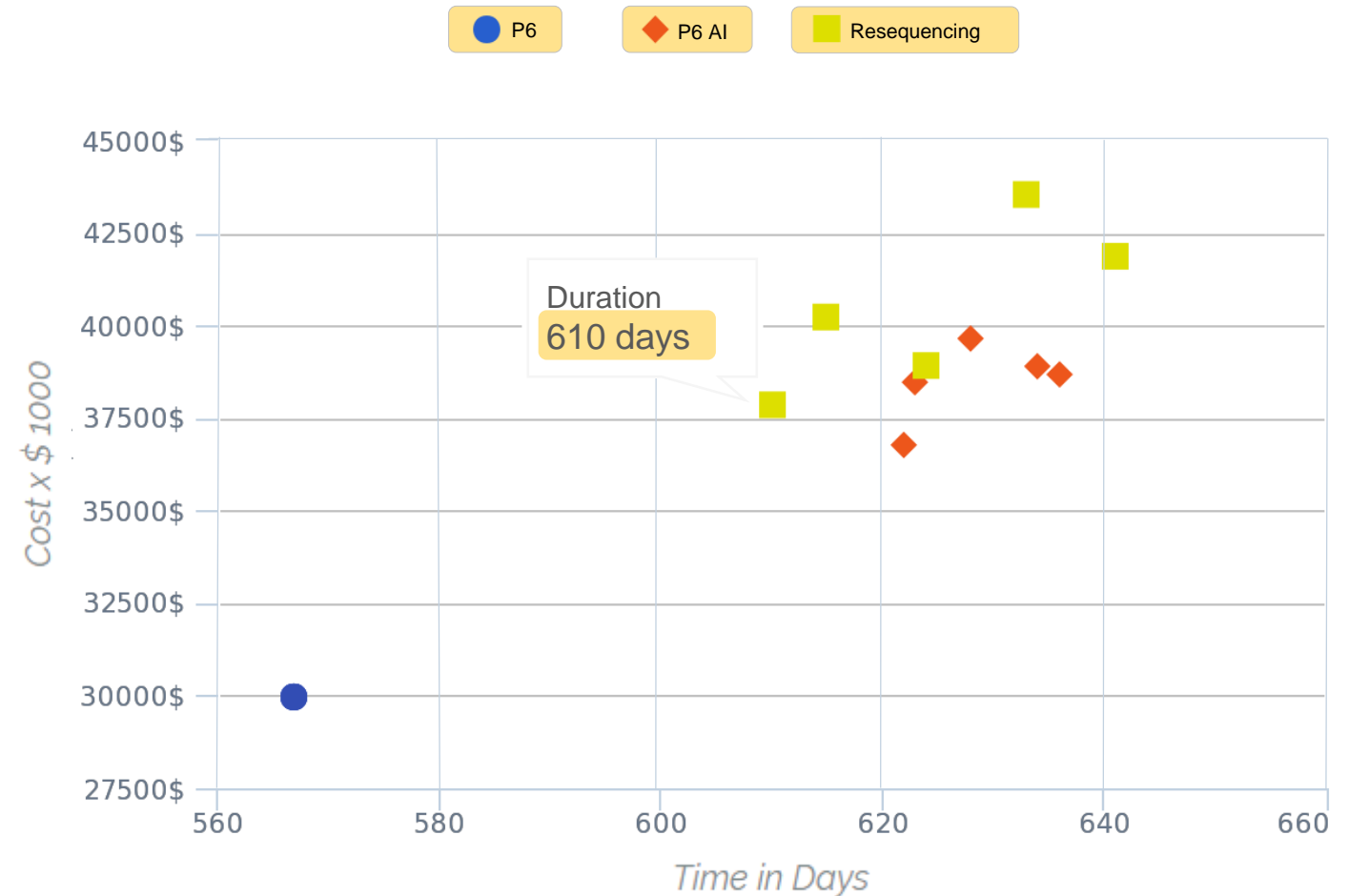
Phase 3 – Increase the number of crews to make sure that work can be done as soon as possible

- CIM Updates: 0 mins

- Construction model set up: 1 min

- Run simulation: 2 mins

- Changed crew mix to 15 crews of each type

- Total duration: 549 days

- "That's cool! But lets find out how many crews I actually need to get the same result…"

High Rise Building Schedule results

Legend: P6 ● | P6 AI ◆ | Resequencing ■ | 15 crews ▲

Chart — Cost x $1000 (y-axis, 25000$ to 50000$) vs Time in Days (x-axis, 540 to 660)
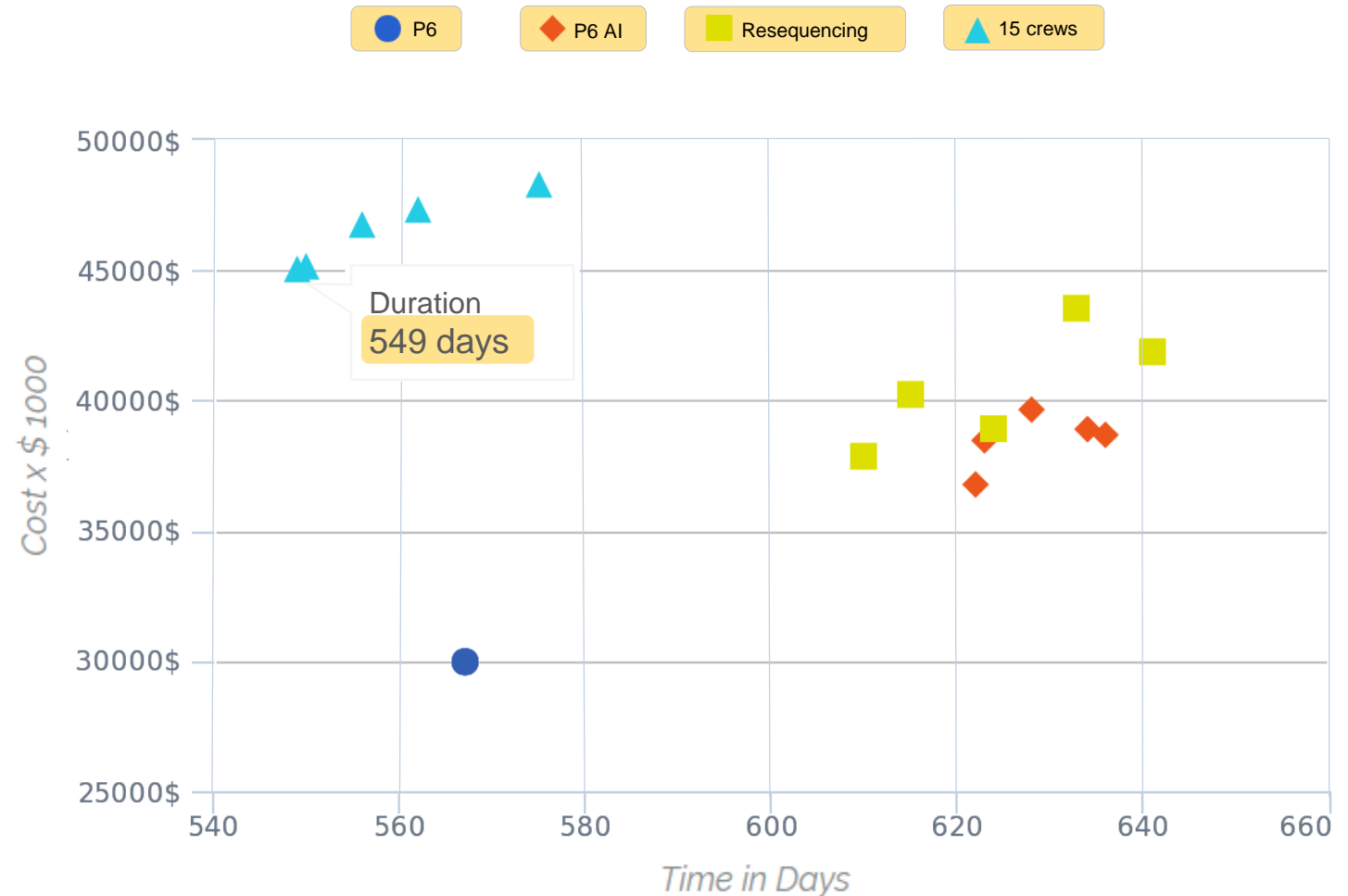
Duration: 549 days

Phase 4 – Balance the crew mix

- CIM Updates: 0 mins

- Construction model set up: 1 min

- Run simulation: 2 mins

- Increased only Carpenter crews to 6 – all other crews remain 1

- Total duration: 549 days

- "Wow! Looks like I need only 6 carpenters to get the same result… cheaper!"

High Rise Building Schedule results

Legend: P6, P6 AI, Resequencing, 15 crews, 6 carpenters

Duration
549 days

Y-axis: Cost x $ 1000 (25000$ – 50000$)
X-axis: Time in Days (540 – 660)

ALICE TECHNOLOGIES

Phase 5 – Study the impact of overtime

- CIM Updates: 0 mins

- Construction model set up: 3 min

- Run simulation: 2 mins

- Everyone works overtime: 6 full-time days per week

- Total duration: 480 days

- "This is great! But I don't want to pay everyone overtime. Plus, the owner asked if we can finish even faster…"

High Rise Building Schedule results

Legend: P6 · P6 AI · Resequencing · 15 crews · 6 carpenters · Overtime

Duration
480 days

Cost x $ 1000 (y-axis): 25000$, 30000$, 35000$, 40000$, 45000$, 50000$

Time in Days (x-axis): 475, 500, 525, 550, 575, 600, 625, 650

In summary

- You can't do anything, e.g., make a decision, without information
- You can't do anything well without good information
- You can't have good information without a shared way to structure it

- The more you do something the better you get
- Doing something in seconds vs. hours or days allows you to get much better much faster or start to do new things

- You can't automate very much without good information

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Your success depends on the quality of your predictions
→ how will you improve performance predictions in 2018

Number of **virtual** buildings considered

Number of **real** buildings considered

Quality of analysis and simulation **models**
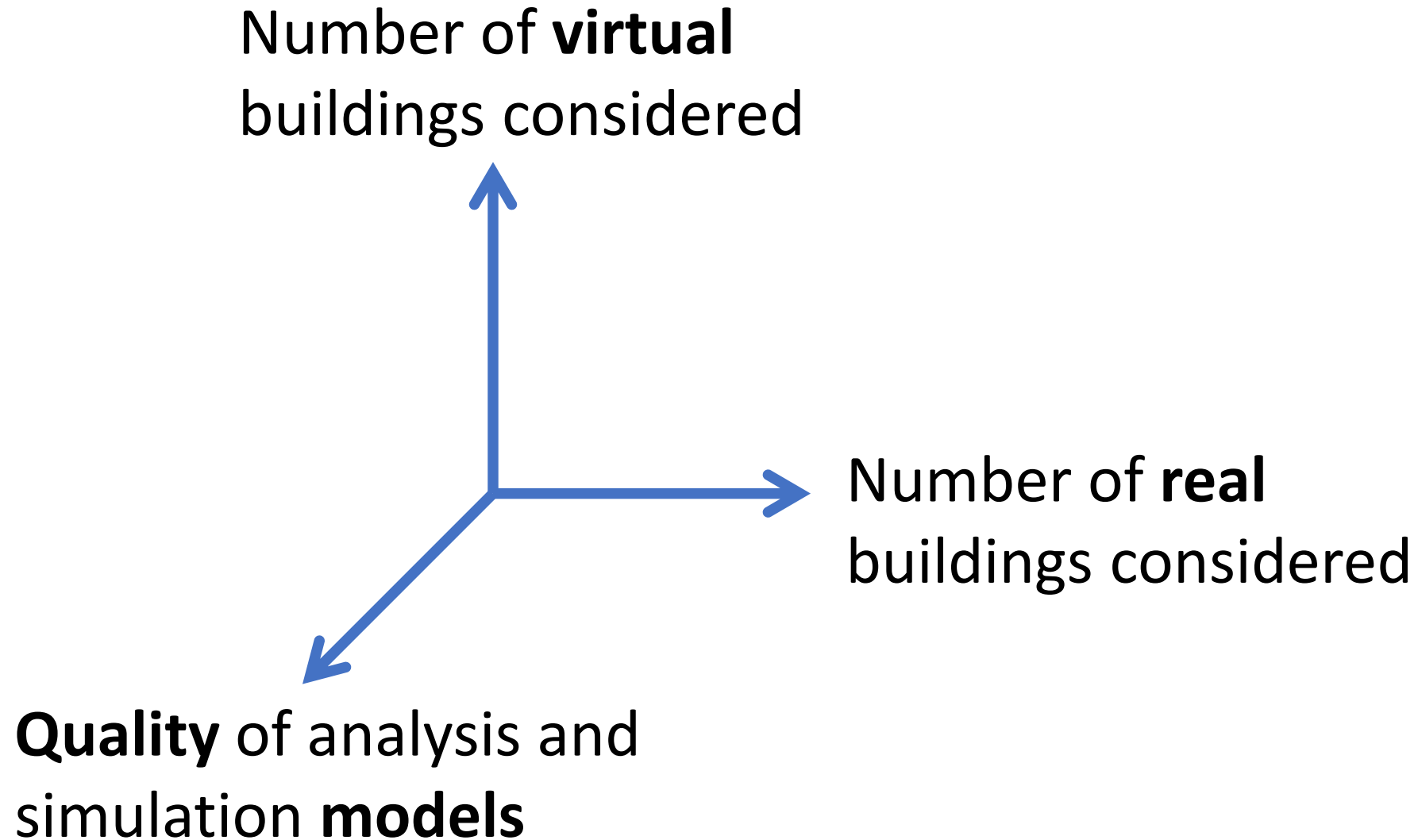
CEOs are proud of their people but wonders whether it's enough

How will you leverage BIM in 2018, 2019, etc.? Why?

Visualization

Information Integration

Automation

Open the whole Eden Valley Medical Center hospital on budget and 30% earlier than typical

Highly reliable construction

Pictures courtesy DPR Construction

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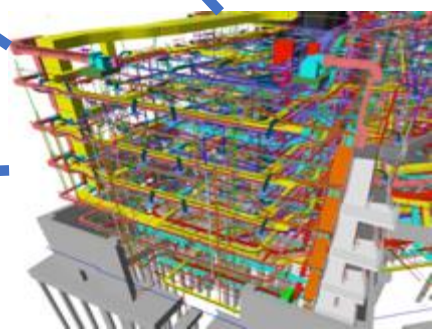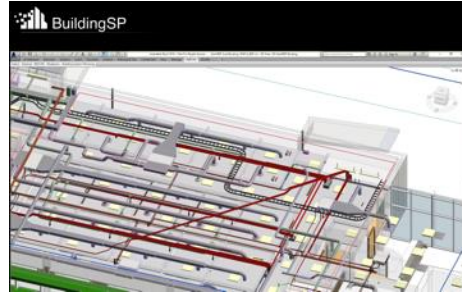
Are you designing and coordinating your buildings manually, object by object?

Picture
Courtesy
of DPR

Or, are you using automated design methods?
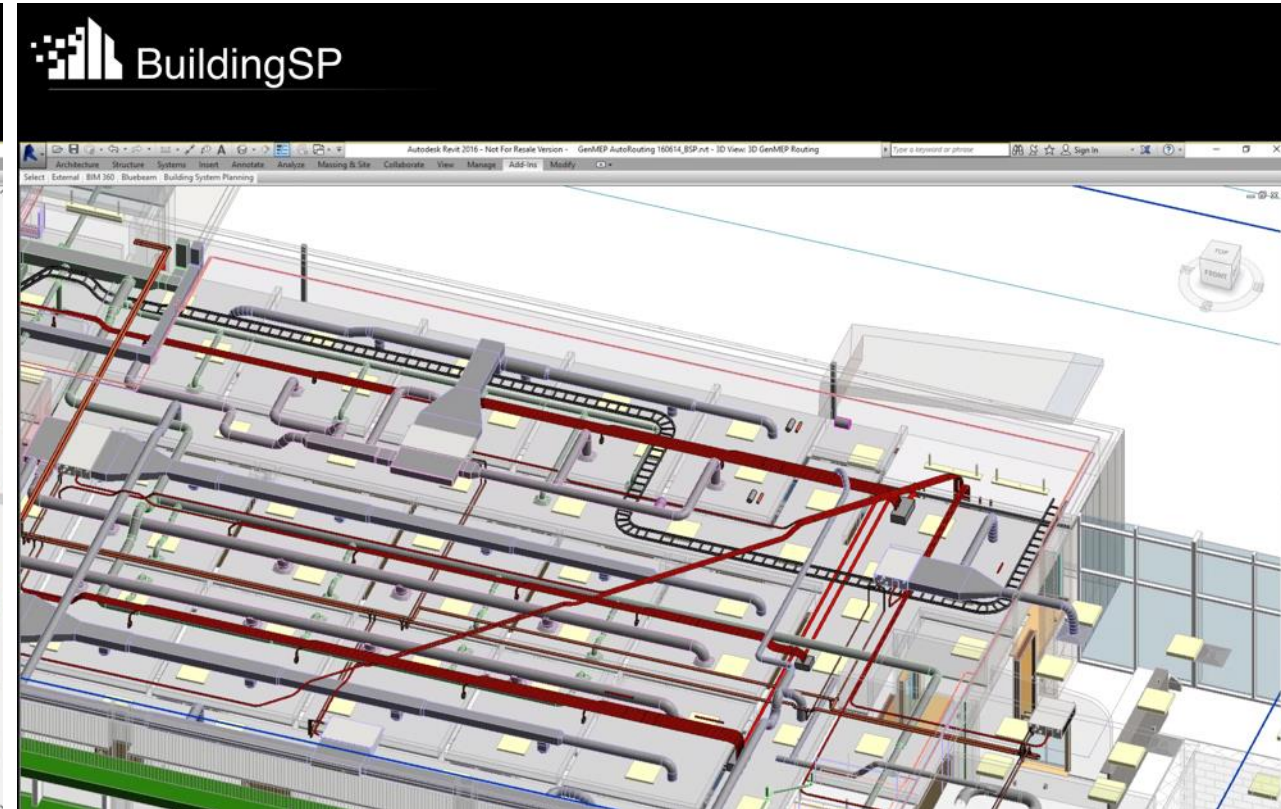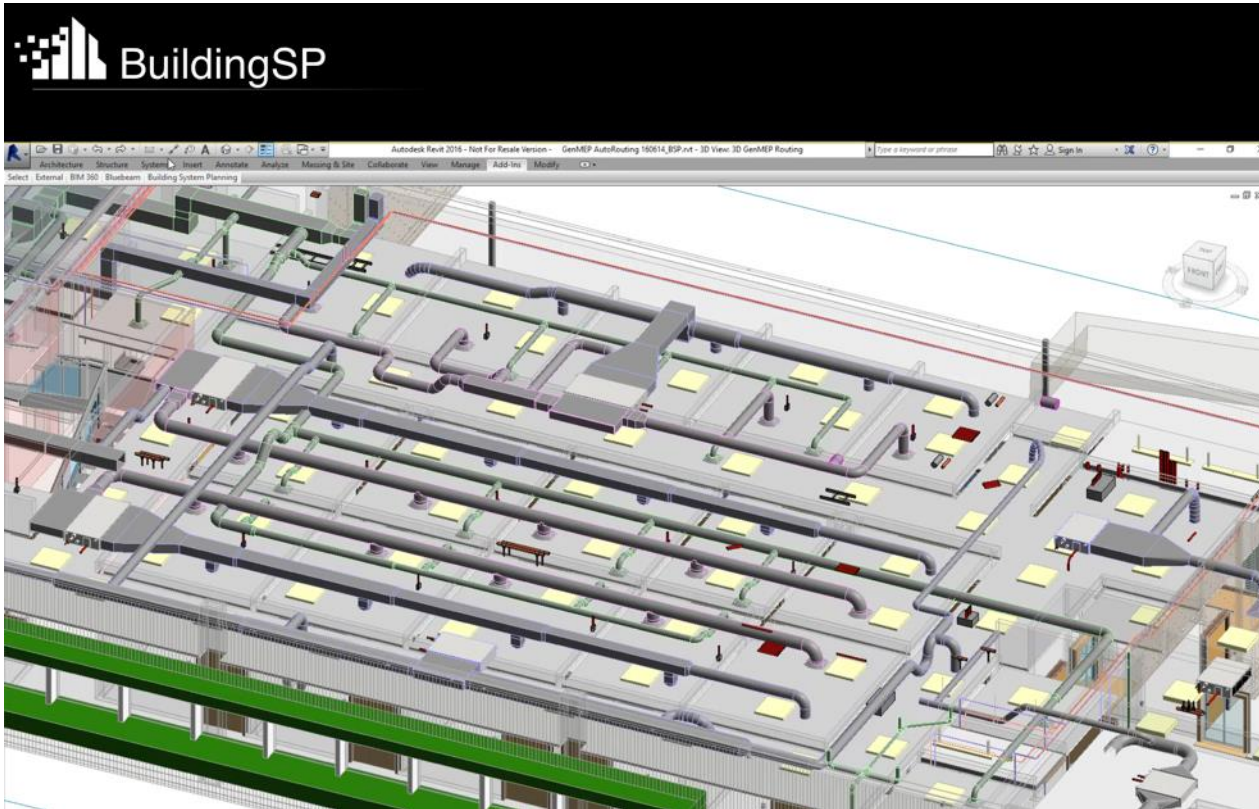
MEP modelers click over 1,300 times per hour when modeling MEP systems

Example courtesy Brett Young, BuildingSP, brett@buildingsp.com

I have made all my generals out of mud.

Napoleon

Executive Program on

"Strategic Leadership in the Dynamic Construction Industry"

with the Stanford GSB

STANFORD BUSINESS GRADUATE SCHOOL OF — Executive Education

DPR CONSTRUCTION

|	SUN, JAN 28	MON, JAN 29	TUE, JAN 30	WED, JAN 31	THU, FEB 1	FRI, FEB 2
6:00 - 6:45 am		*Optional Morning Exercise*	*Optional Morning Exercise*	*Optional Morning Exercise*	*Optional Morning Exercise*	*Optional Morning Exercise*
7:00 - 8:00 am		*Breakfast*	*Breakfast*	*Breakfast*	*Breakfast*	*Breakfast*
8:00 - 9:20 am		**Strategic Leadership: Why it Matters - A Perspective** Burgelman	**Managing Project Supply Chains I** Lee	**Design Thinking** Soule	**Uncovering Our Hidden Assumptions About How to Enhance Organizational Performance** Pfeffer	**Designing your Organization for Agility** Levitt
9:20 - 9:40 am		*Break*	*Break*	*Break*	*Break*	*Break*
9:40 - 11:00 am		**Strategic Leadership: Why it Matters - Analytical Tools** Burgelman	**Managing Project Supply Chains II** Lee	**Design Thinking** Soule	**Overcoming the Knowing-Doing Gap** Pfeffer	**Strategic Leadership of Corporate Innovation** Burgelman, Fischer
11:00 - 11:20 am		*Break*	*Break and group photo*	*Break*	*Break*	*Break*
11:20 am - 12:40 pm		**Dynamic Forces driving Firm Evolution – The Strategy Diamond** Burgelman	**Data Thinking for Construction** Rajagopal	**Connecting the Customer Brand to the Talent Brand** Rao	**Strategic Cooperation vs. Competition** Burgelman, Fischer	**Designs for Corporate Entrepreneurship in Established Firms** Burgelman, Fischer
12:40 - 2:00 pm	*Check-in Schwab Residential Center 12:00pm-4:00pm*	*Lunch*	*Lunch*	*Lunch*	*Lunch*	*Lunch*
2:00 - 3:20 pm	*Optional Campus Tour (4:00 - 5:00 pm)*	**Virtual Design and Construction** Fischer	**Thinking Inside the Box** Levav	**Scaling Up Excellence** Rao	**Optimization and Data-Driven Decision Making** Fischer	**Building Strategic Leadership Capability: What Did We Learn?** Burgelman
3:20 - 3:40 pm		*Break*	*Break*	*Break*	*Break*	
3:40 - 5:00 pm		*Project/Case*	*Project/Case*	*Project/Case*	*Project/Case*	
5:45 - 6:15 pm	*Opening Reception*	*Reception*	*Dinner - Stanford Stadium (5:45 - 7:30 pm)*	*Reception*		
6:15 - 7:30 pm	*Welcome Dinner*	*Dinner*			*Dinner - Fogarty Winery (6:00 - 8:00 pm)*	
7:30 - 8:00 pm						

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You must decide how to allocate your firm's resources when you get back to your office.
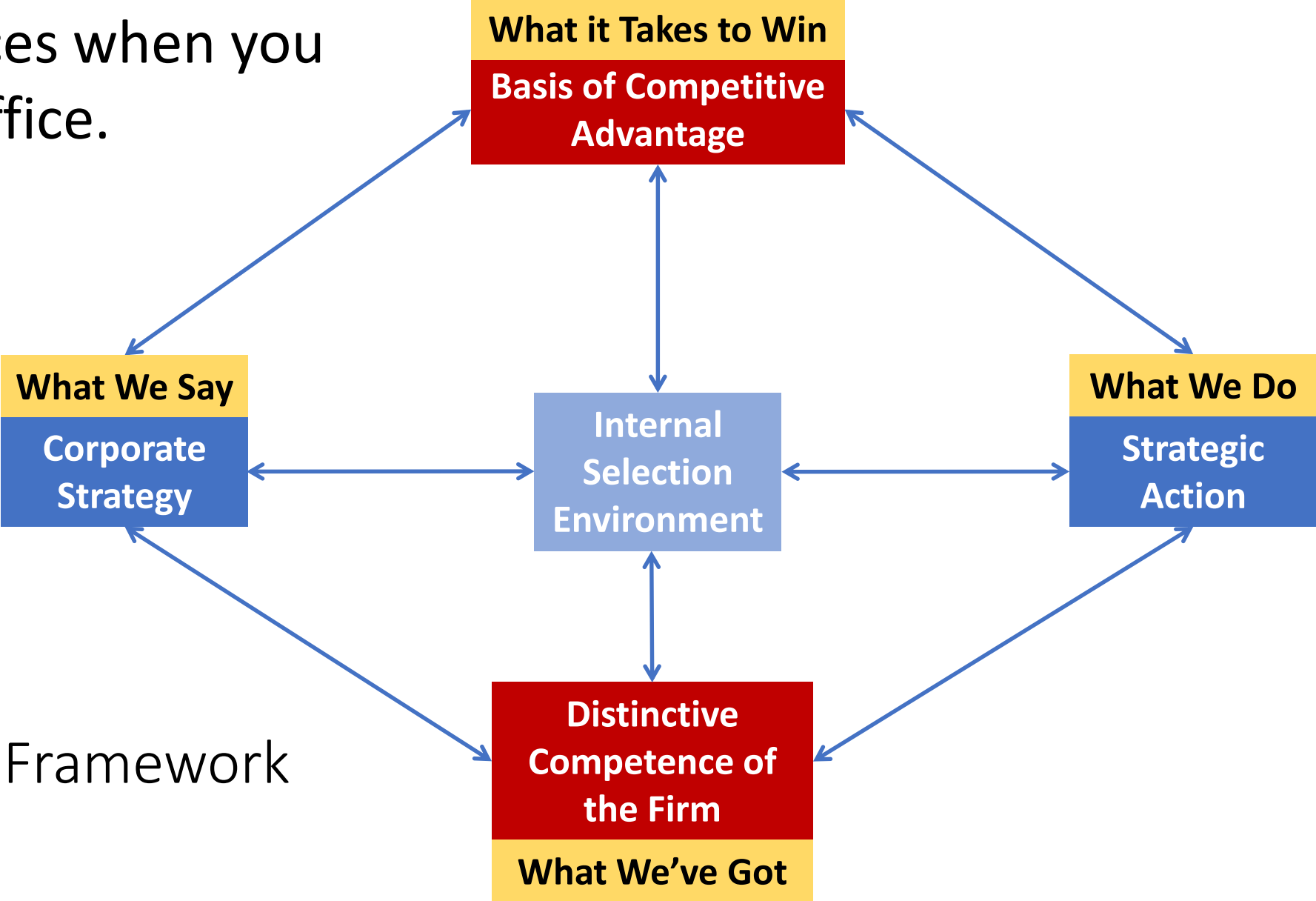
Strategy Diamond Framework

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The Business Perspective
"The 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.

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