



The American
Institute
of Architects

Project Delivery

an AIA Knowledge Community

The Future of Making Things:

Design and Delivery Innovation in the Digital Age

Phil Bernstein FAIA RIBA LEED AP®

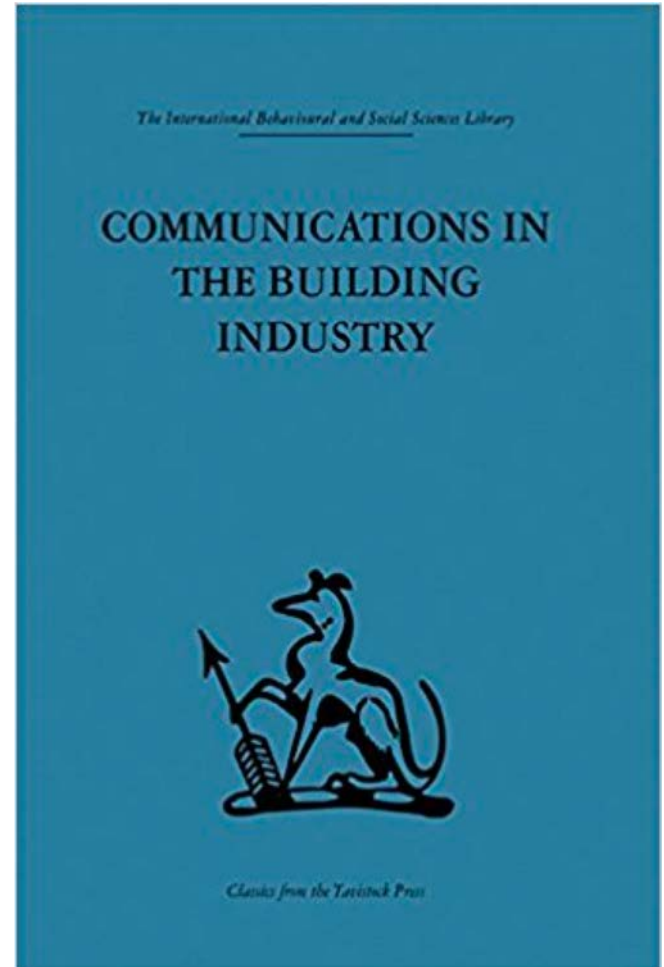
Lecturer in Professional Practice, Yale University School of Architecture

Autodesk Fellow

AIA Project Delivery Symposium | Washington DC | 06 March 2018

Communications in the Construction Industry (Higgin and Jessop, 1965)

“The basic decisions of construction control are often **incomplete or unduly rushed because necessary information is not available sufficiently ahead of time**, or is not complete enough. On many occasions members of the construction team could, but do not, ease this problem by **supplying the data that would facilitate the preparation of fuller and more useful information by others**. Building construction is remarkable among industrial activities for **the lack of detailed information about how it proceeds**. Until more is known there can be no basis for improvement.”



“The Committee concluded that the difficulties experienced in typical construction projects, including those identified by CURT members, are artifacts of **a construction process fraught by lack of cooperation and poor information integration**. The goal of everyone in the industry should be **better, faster, more capable project delivery created by fully integrated, collaborative teams**.”

CURT WP 1202 (2004)



McKinsey&Company

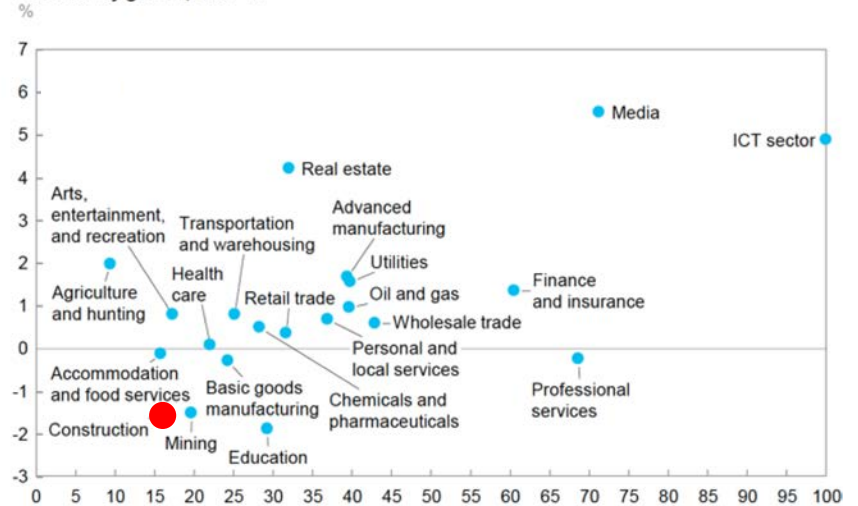
MCKINSEY GLOBAL INSTITUTE

SOLVING THE PRODUCTIVITY PUZZLE: THE ROLE OF DEMAND AND THE PROMISE OF DIGITIZATION

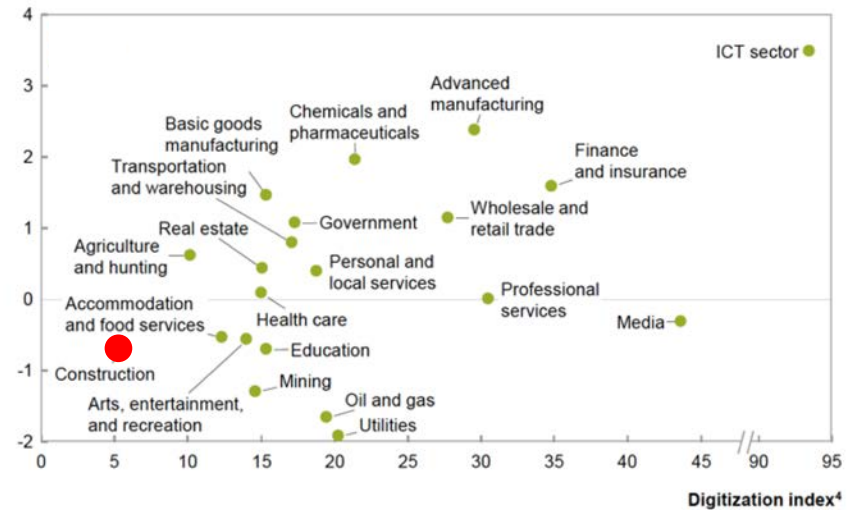
FEBRUARY 2018

United States

Productivity growth, 2004–14²



Europe^{2,3}



McKinsey&Company

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REINVENTING CONSTRUCTION: A ROUTE TO HIGHER PRODUCTIVITY

FEBRUARY 2017

IN COLLABORATION WITH
MCKINSEY'S CAPITAL PROJECTS & INFRASTRUCTURE PRACTICE

MCKINSEY
GLOBAL
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INSIGHT.
IMPACT.

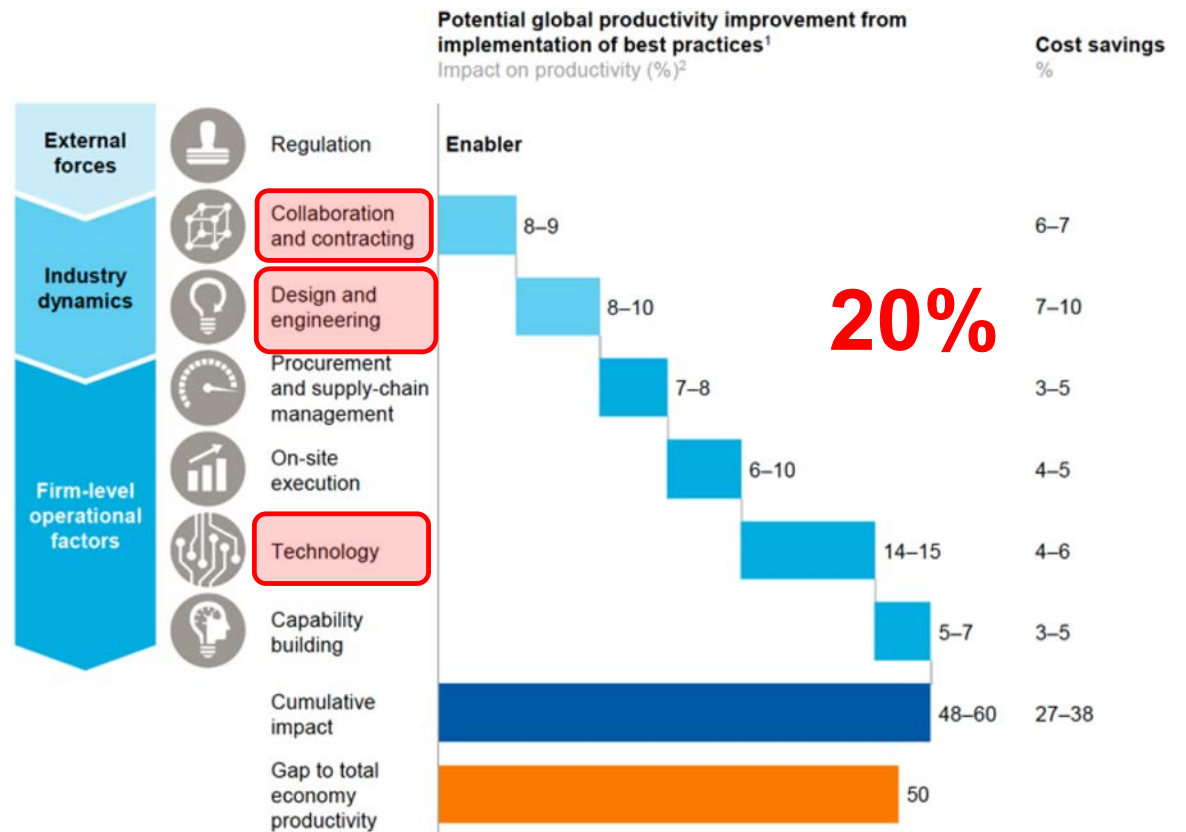


Exhibit E5

Construction can catch up with total economy productivity by taking action in seven areas

Cascading effect

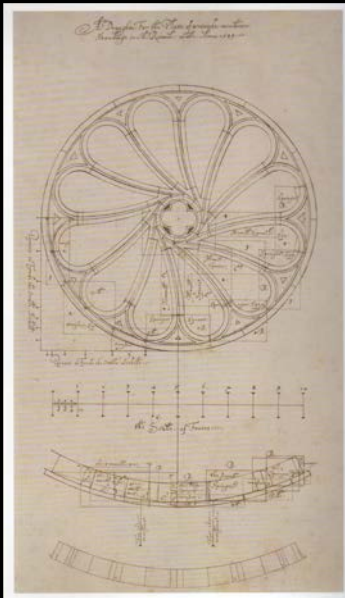
Regulation changes facilitate shifts in industry dynamics that enable firm-level levers and impact



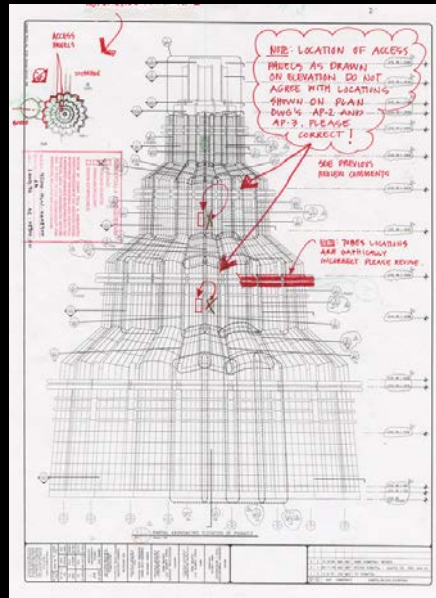
- 1 The impact numbers have been scaled down from a best case project number to reflect current levels of adoption and applicability across projects, based on respondents to the MGI Construction Productivity Survey who responded "agree" or "strongly agree" to the questions around implementation of the solutions.
- 2 Range reflects expected difference in impact between emerging and developed markets.

SOURCE: McKinsey Global Institute analysis

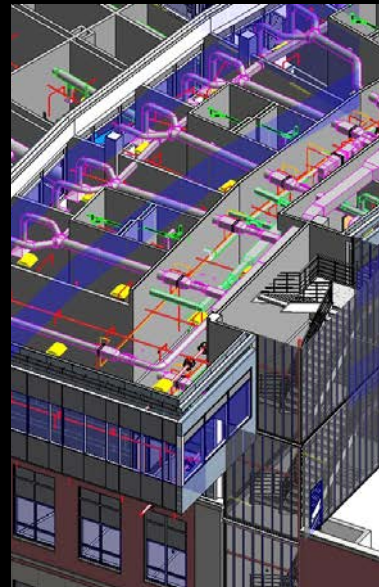
Evolution of Tools and Technologies



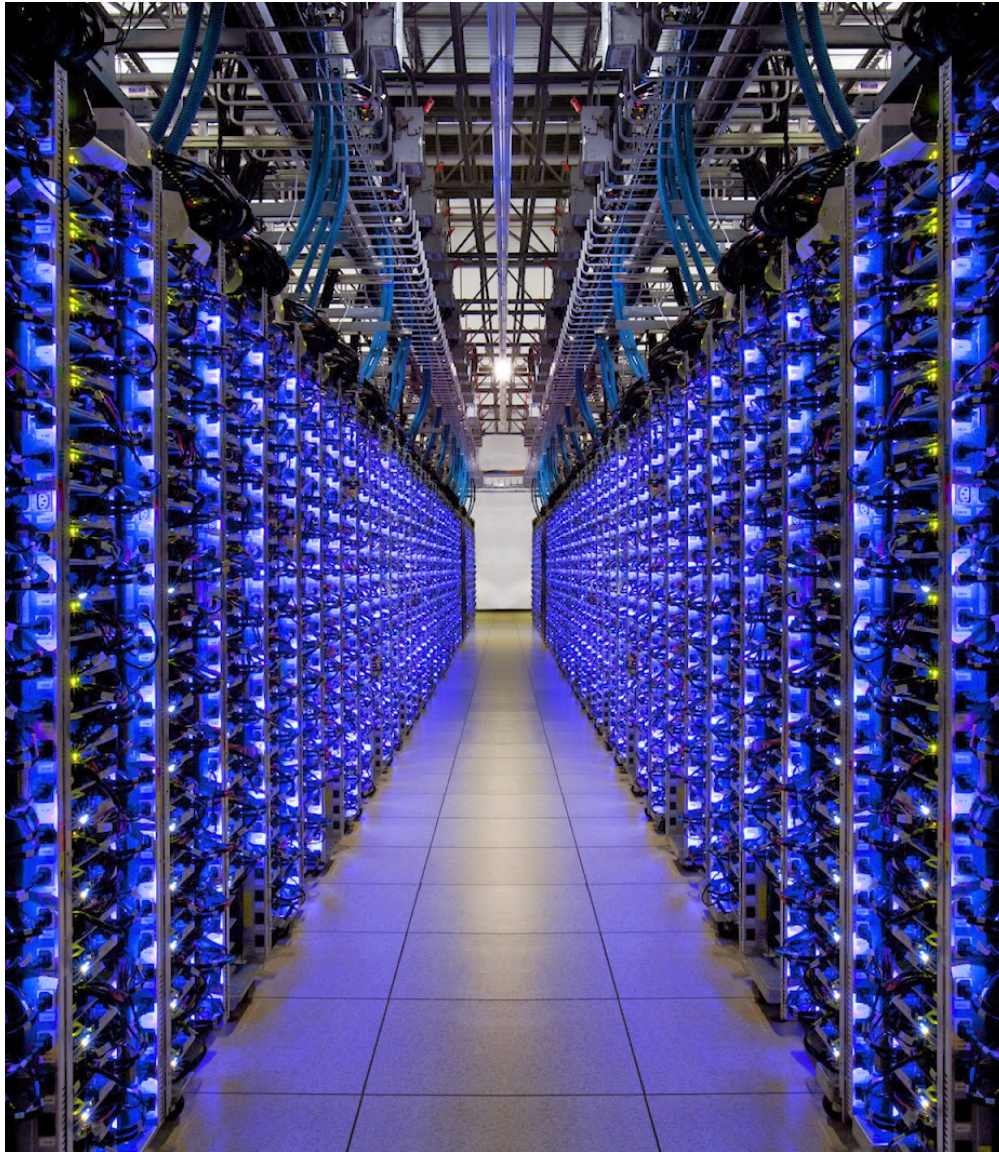
Drawing



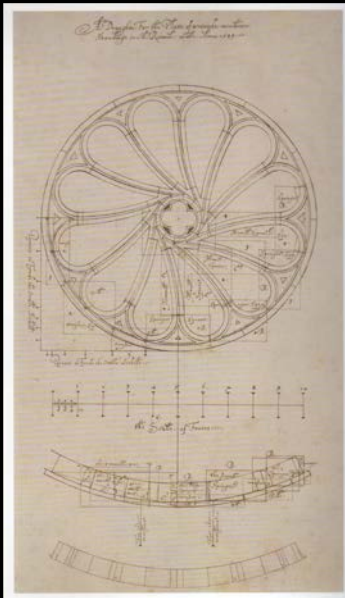
CAD



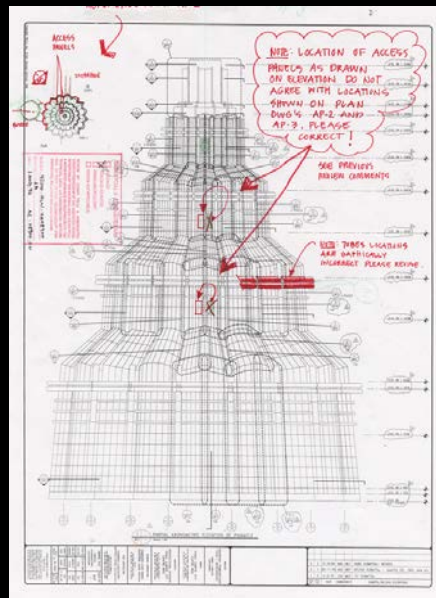
BIM



Evolution of Tools and Technologies



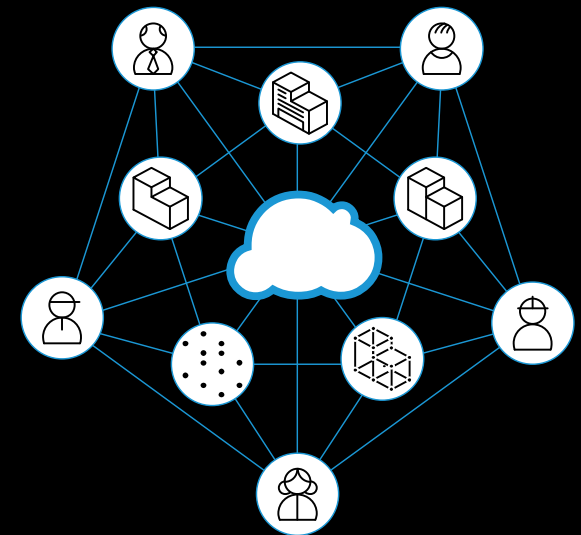
Drawing



CAD



B I M



Connected BIM

A blurred background image showing a group of people in a meeting or collaborative workspace. They are gathered around a table, looking at documents or devices, suggesting a professional or educational setting.

Connected BIM Technologies

Big Data

Computational Design

Simulation / Analysis

Internet of Things

Industrialized
Construction

Machine learning



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EMBODIED ENERGY STUDY: META DATA VS MICRODATA

Image Courtesy of Yale Center for Environment and Architecture

FILTERS

DATA - STUDIES

Growing up in Singapore

VARIABLES

HUMAN/SOCIAL

MEDICAL HISTORY

DEVELOPMENT METRICS

- BMI for age z-score
- Body mass index
- Length/height for age ...
- Head circumference fo...
- Head circumference
- Standing height
- Recumbent length
- Mid upper-arm circum...
- Mid upper-arm circum...
- Tricep SFT for age z-sc...
- Triceps skinfold thicken...
- Weight for age z-score

LAYOUTS



VISUALIZATIONS

Life Cycle



Multi Bar Chart



Line Chart

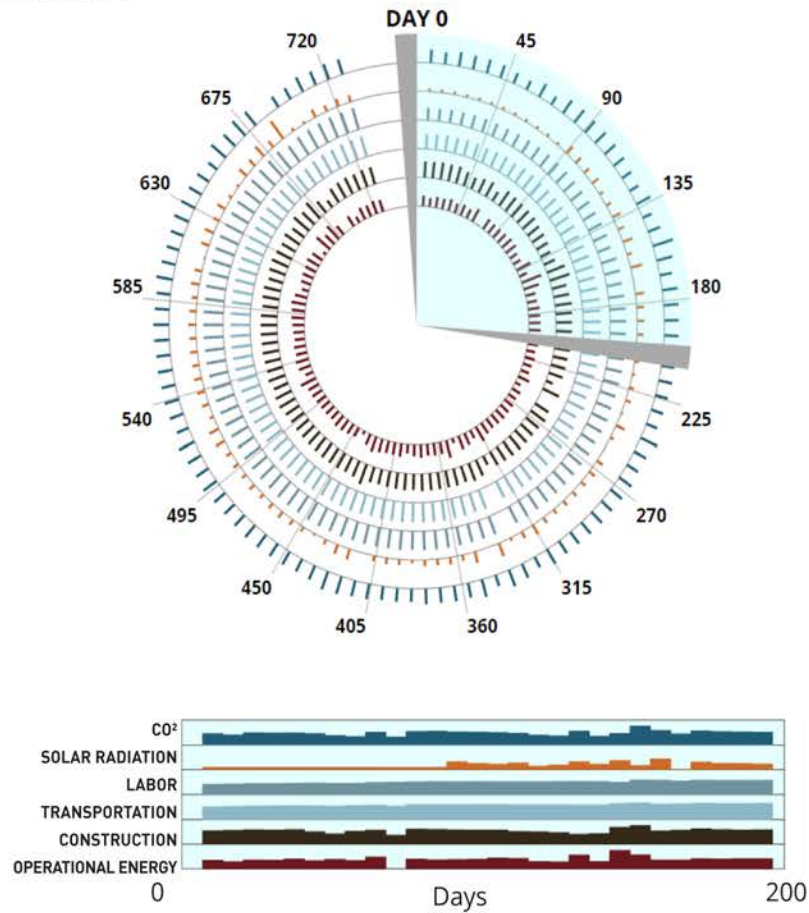


Line Plus Bar Chart



Stacked Area Chart

LIFE CYCLE



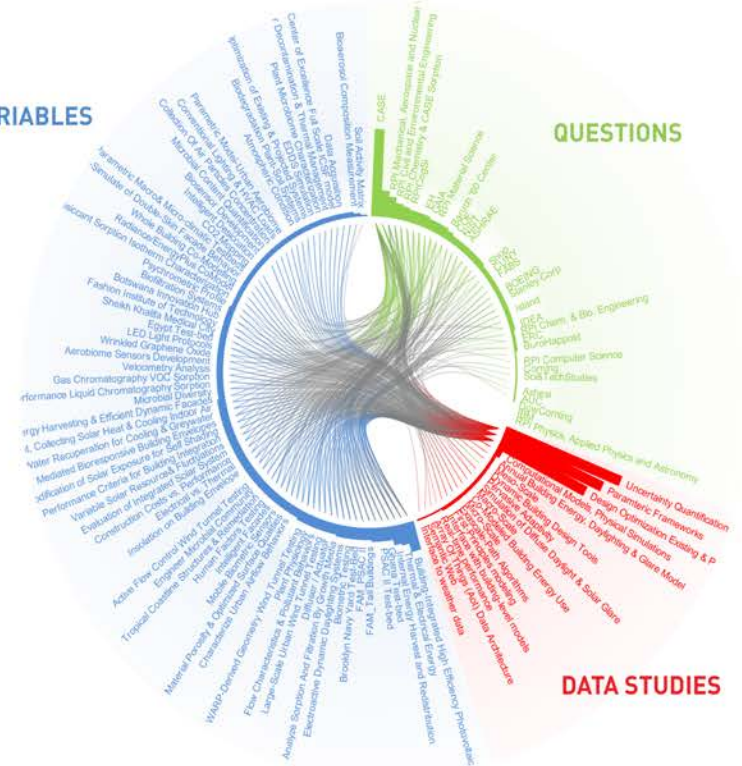
CONCEPTUAL CLUSTER



VARIABLES

QUESTIONS

DATA STUDIES





Connected BIM Technologies

Big Data

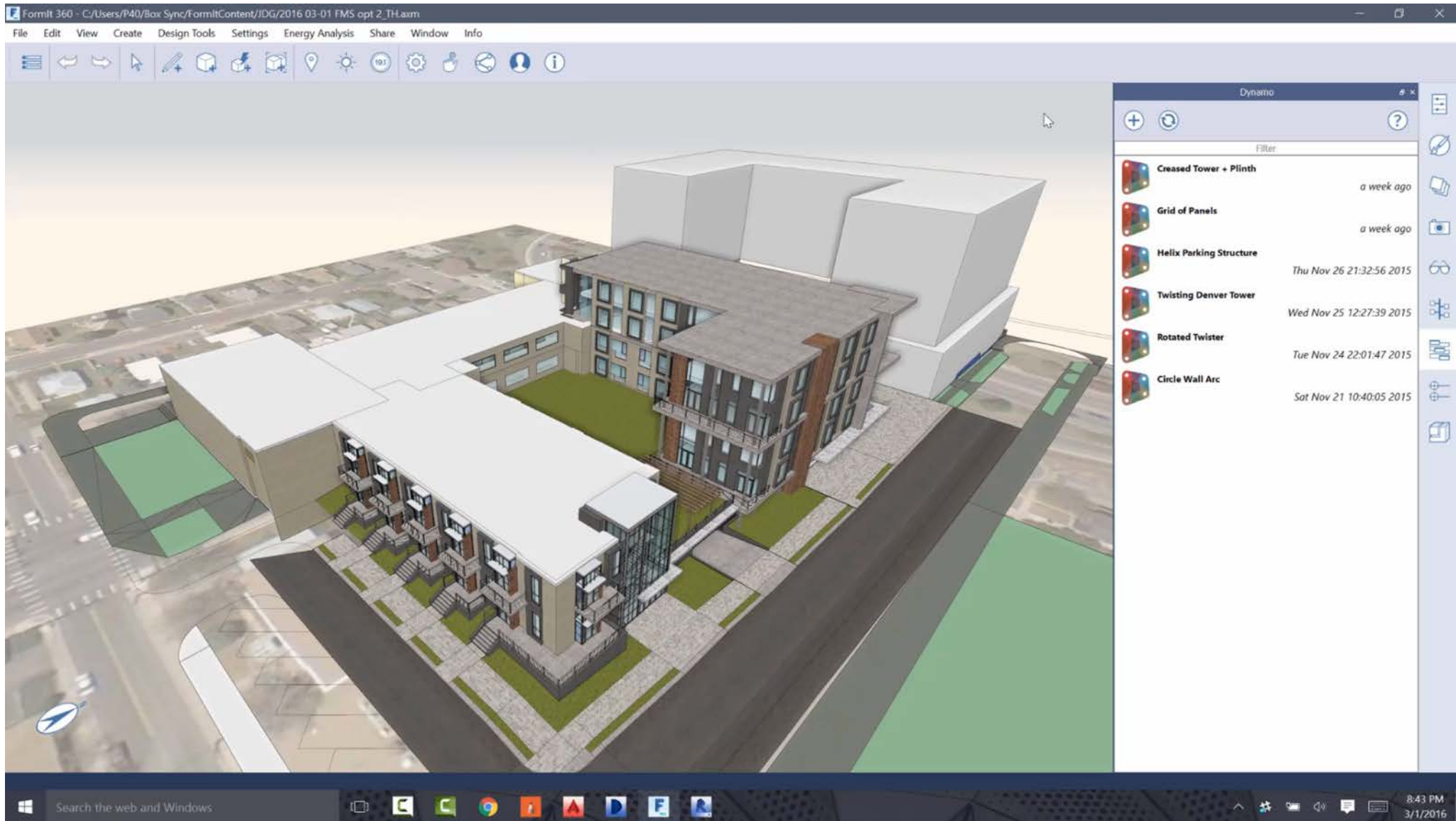
Computational Design

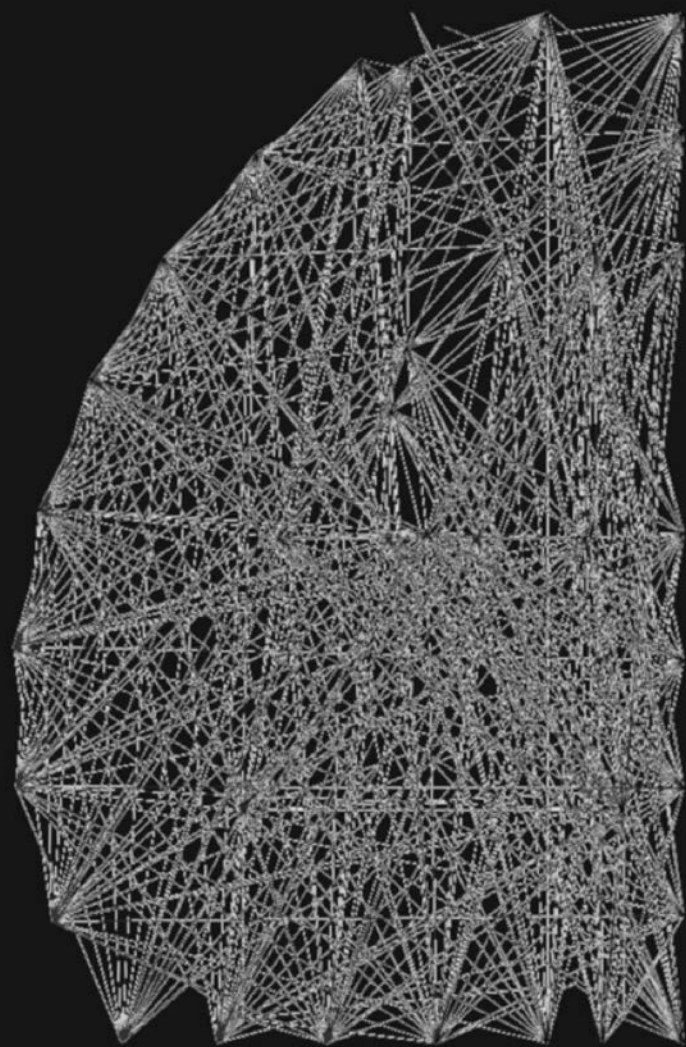
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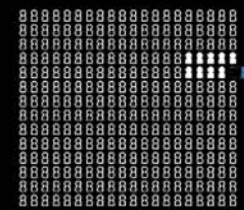
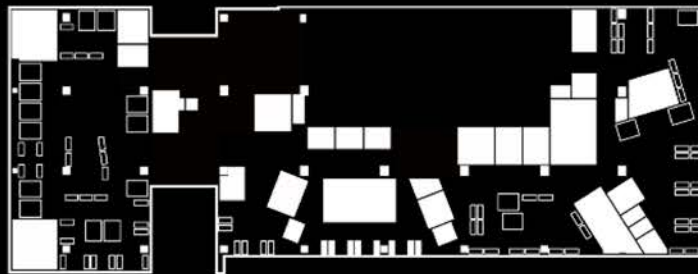
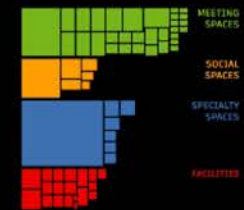
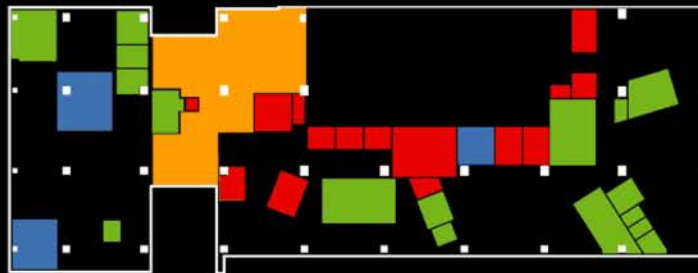
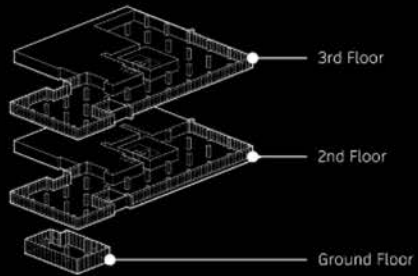
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Connected BIM Technologies

Big Data

Computational Design

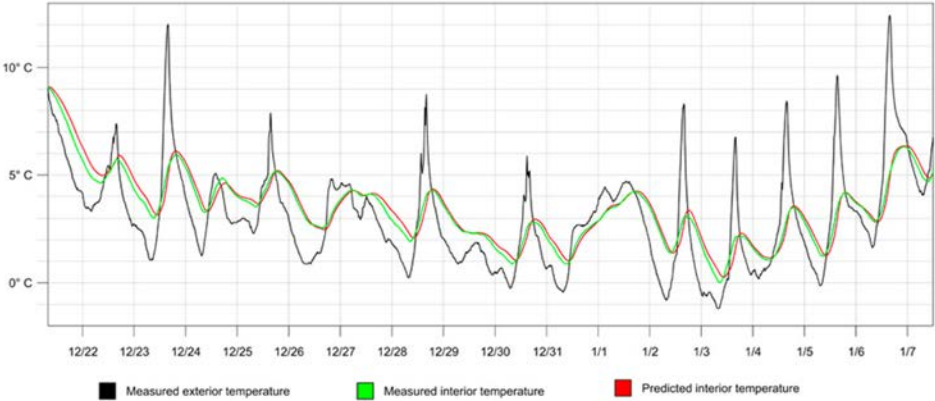
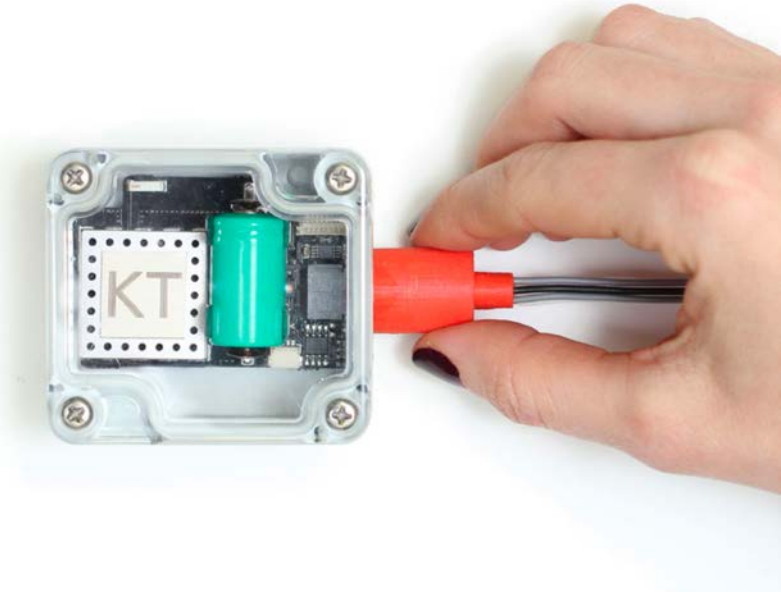
Simulation / Analysis

Internet of Things

Industrialized
Construction

Machine learning

KIERAN TIMBERLAKE





Connected BIM Technologies

Big Data

Computational Design

Simulation / Analysis

Internet of Things

**Industrialized
Construction**

Machine learning





Connected BIM Technologies

Big Data

Computational Design

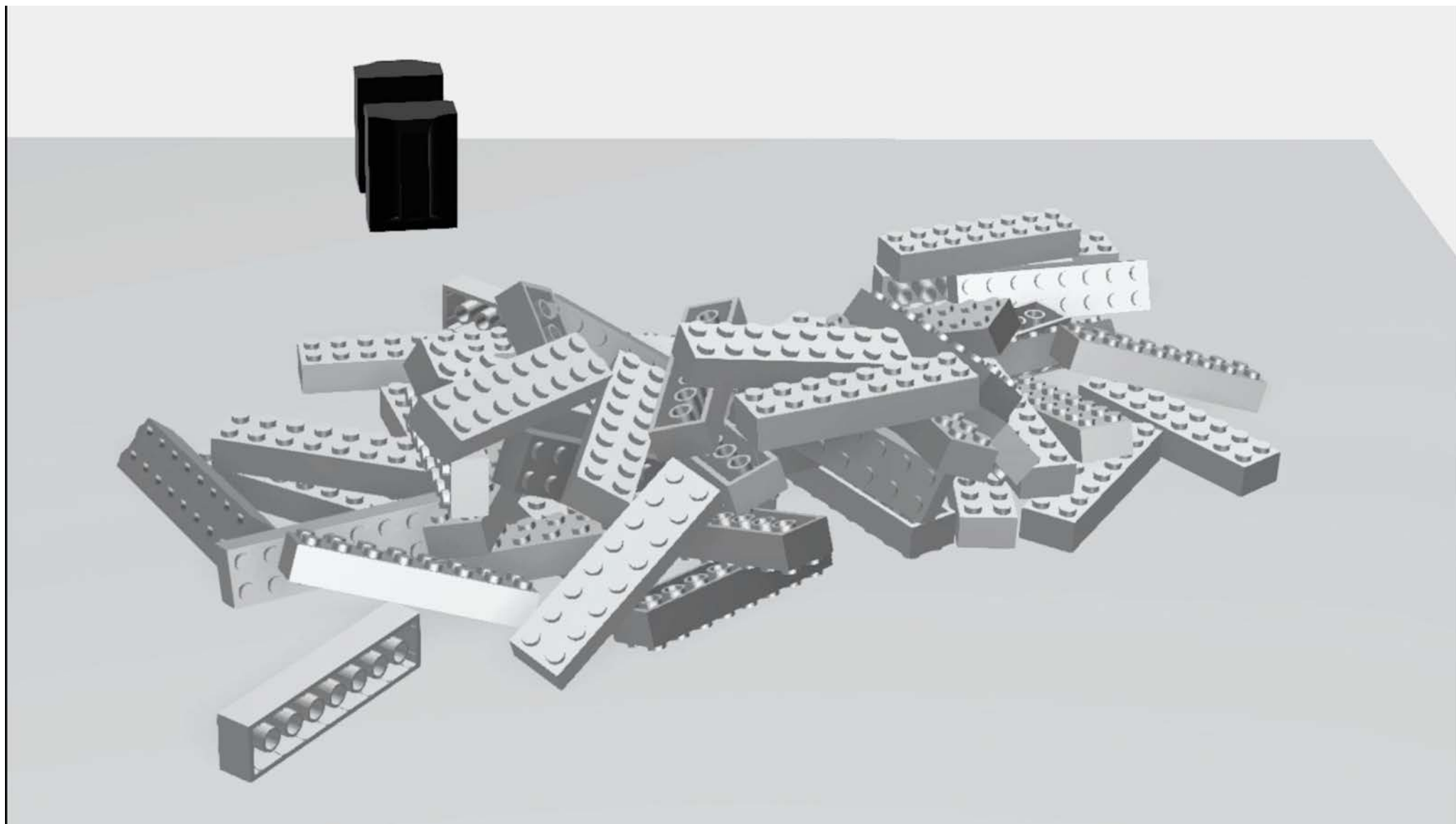
Simulation / Analysis

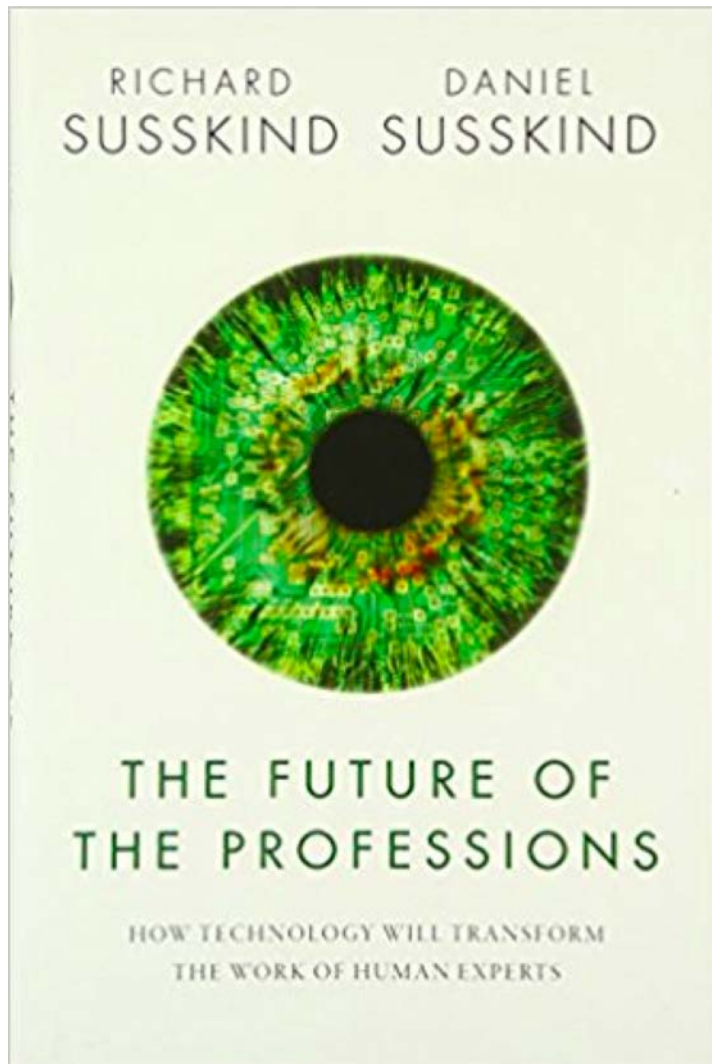
Internet of Things

Industrialized
Construction

Machine learning







“ (W)e are on the brink of a period of fundamental and irreversible change in the way that the expertise of specialists is made available in society. Technology will be the main driver of this change. And in the long run , we will neither need nor want professionals to work in the way that they did in the twentieth century and before.”

Top Causes of Overall Uncertainty for Owners, Architects and Contractors

Source: McGraw Hill Construction, 2014

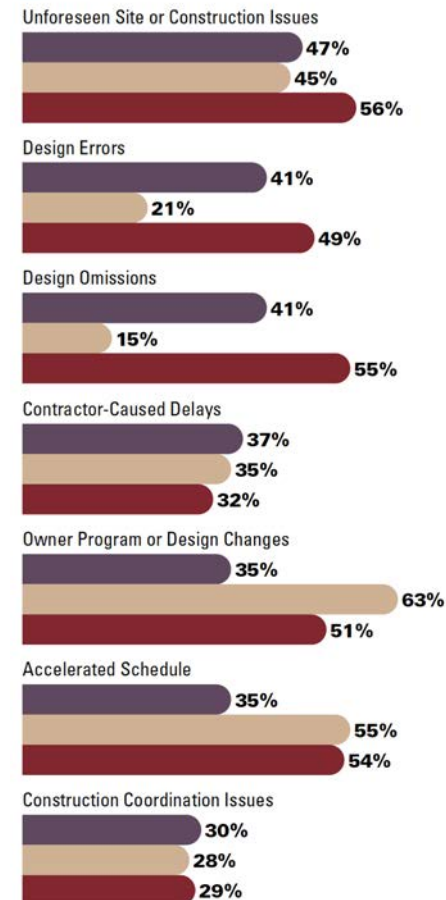
Causes of Uncertainty	Ranking of Causes by Player		
	Owners	Architects	Contractors
Unforeseen Site or Construction Issues	1	3	1
Design Errors	2 (tie)	6	5
Design Omissions	2 (tie)	7	2
Contractor-Caused Delays	4	4	6
Owner-Driven Changes	5 (tie)	1	4
Accelerated Schedule	5 (tie)	2	3
Construction Coordination Issues	7	5	7

Source: McGraw Hill Construction "Managing Uncertainty in Building Design and Construction" Smart Market Report 2014

Top Factors That Cause Uncertainty

Source: McGraw Hill Construction, 2014

■ Owners
■ Architects
■ Contractors



Comparison of Delivery Sequence and Key Decisions


Delivery Typology	Option	Schedule of Design Components, Key Decisions																						
Design - Bid - Build	Standard	PD	SD	DD	CD	PR	C	SC	\$	CA														
	Negotiated Select Team	PD	SD	C	DD	CD	PR	SC	\$	CA														
	Cost Plus Fixed Fee	PD	SD	C	DD	CD	PR	SC	CA															\$
Construction Management	CM - Advisor	CM	PD	SD	DD	CD	PR	SC	\$	CA														
	CM - Agent	CM	PD	SD	DD	CD	PR	SC	\$	CA														
	CM - Constructor	CM	PD	SD	DD																			
Design Build	Standard	C	SC	\$	PD	SD	DD	CD																
	Bridged Design Build	PD	SD	DD																				

Key

 Cost of Construction Determined

 Constructor Contract Determined

 Sub-Contractors Selected

 CM Selected

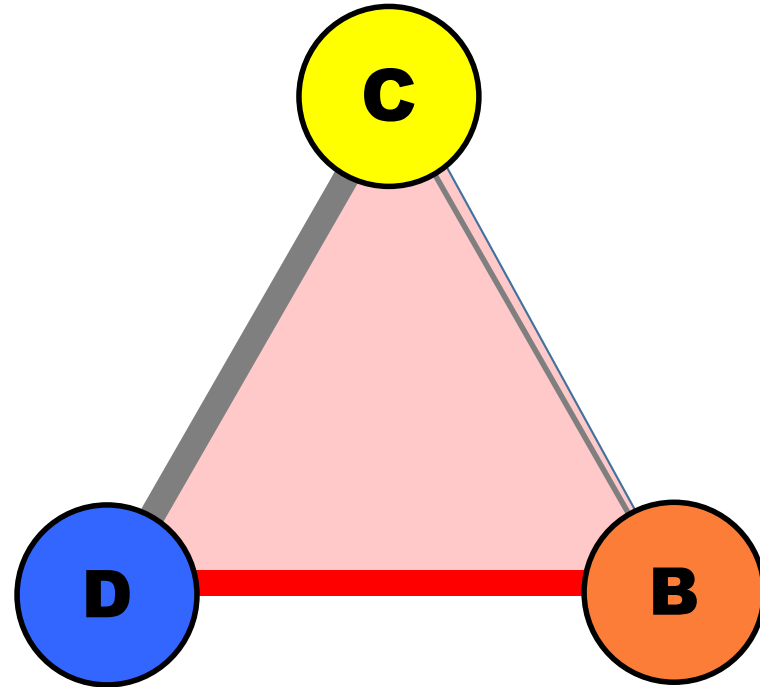
 Design Element

Commodity

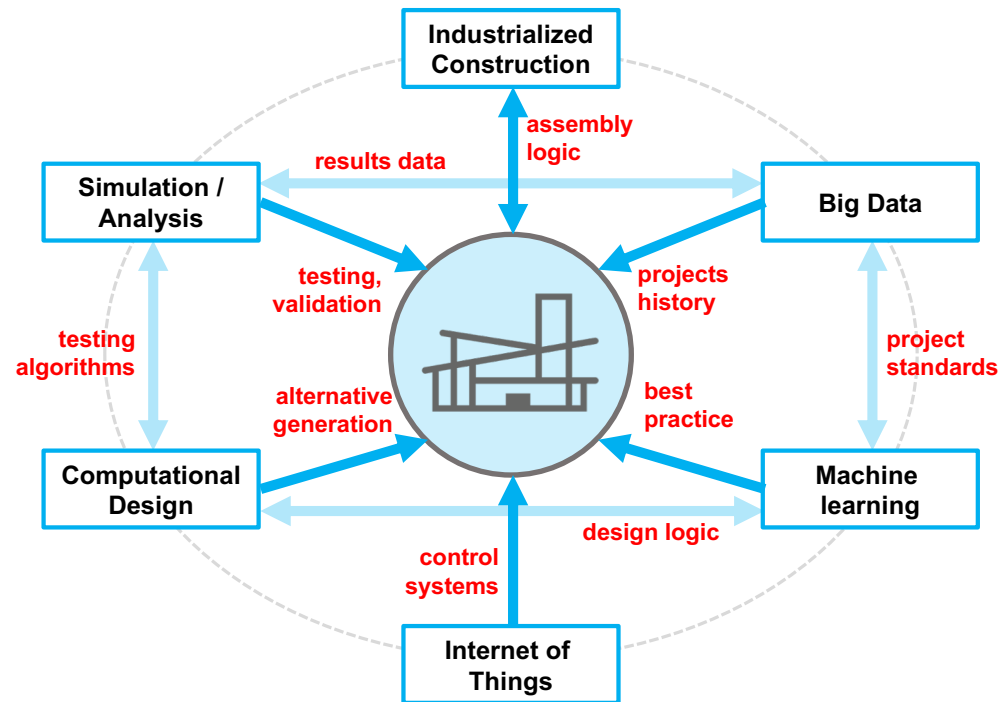
Risk

Standard of care

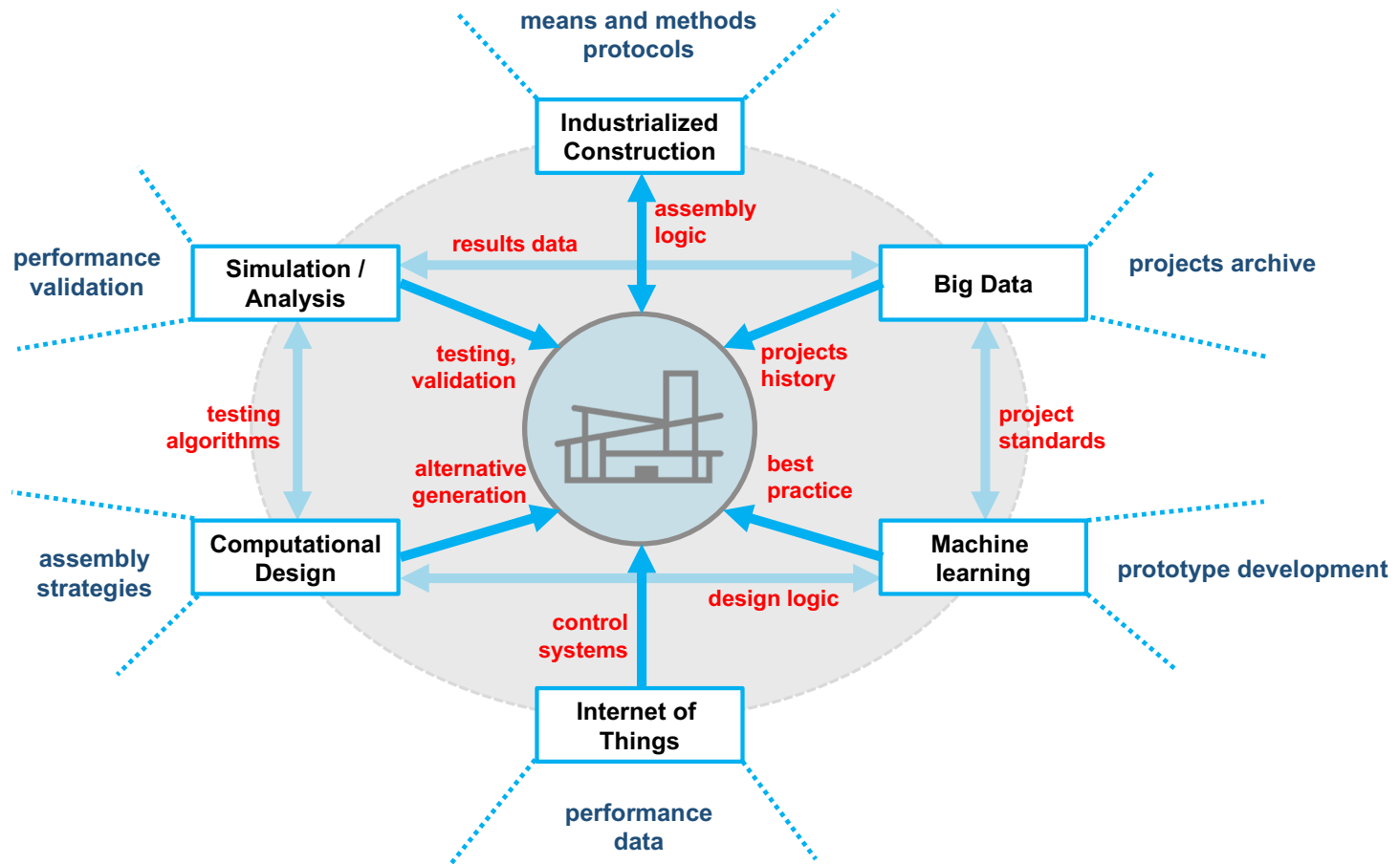
Design \leftrightarrow Making



Design and Construction



Asset Operation

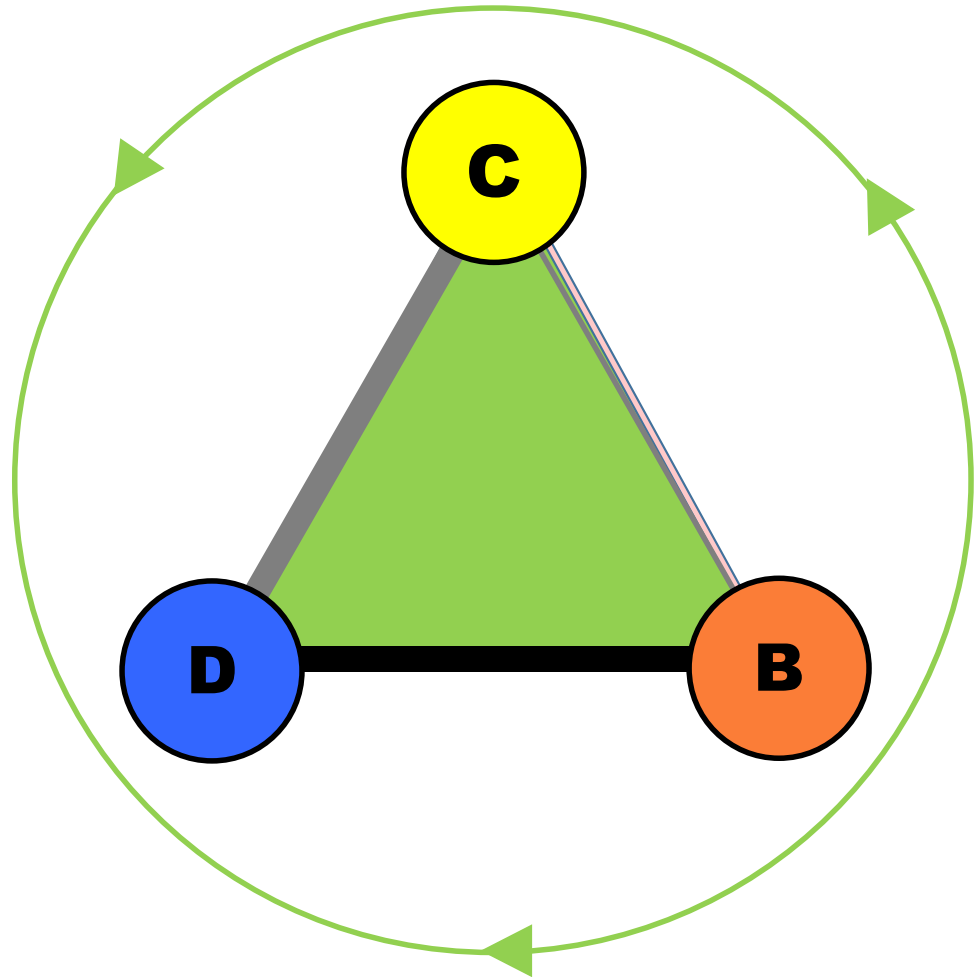


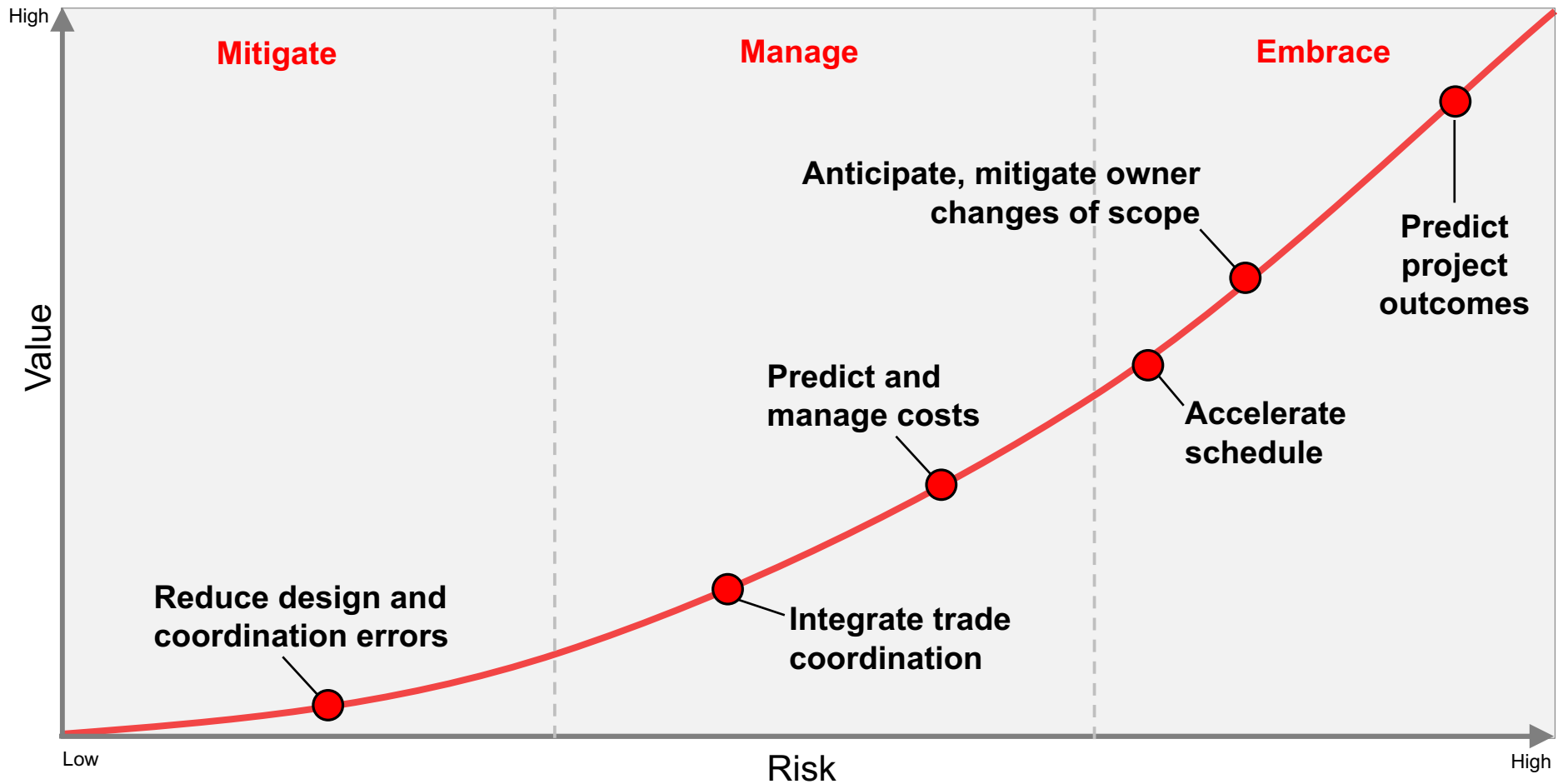
Measurement

Validation

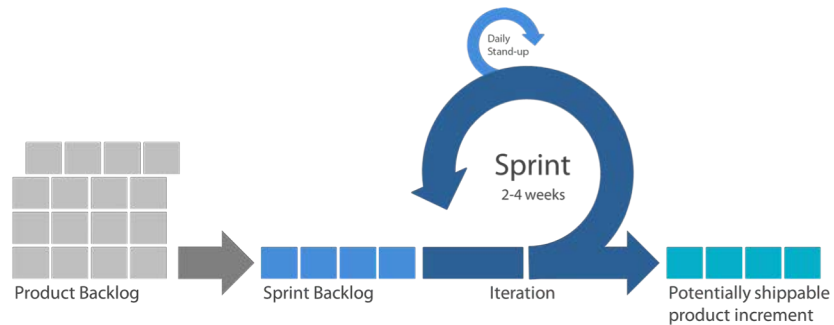
Performance outcomes

Design → Making

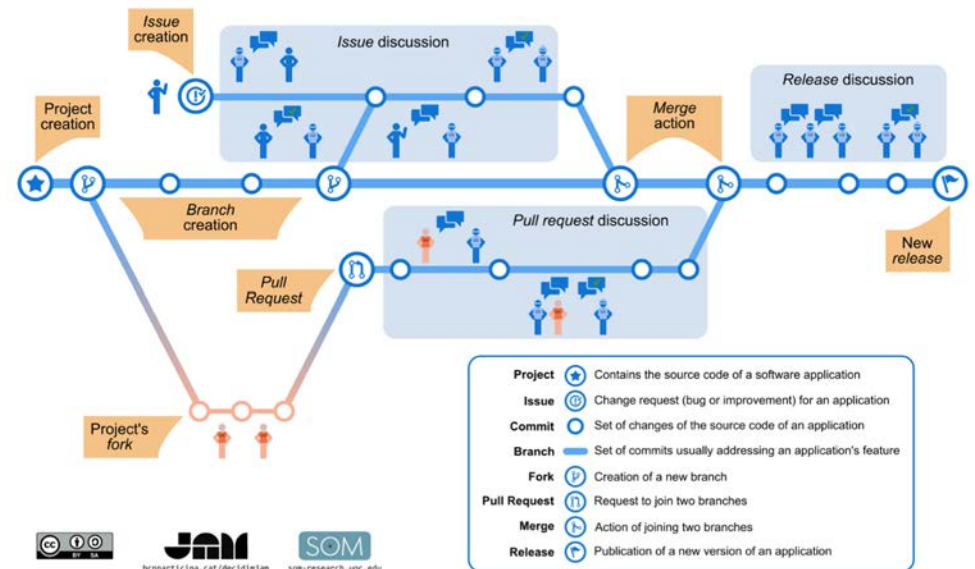




Agile → scrum design



Github content management



“We have to show that good design delivers on the core mission of our partner. It is quantifiable: reducing infections, making recovery times faster, and increasing staff retention.”

**Alan Ricks, Partner
MASS Design**

Interview in Yale School of Architecture CONSTRUCTS Spring 2018

“Design is the major risk...end users create the most change on a project.” (Anna Franz)

“People are more important than contracts.” (Christian Stohler)

“Trust, accountability and collaboration are more important than BIM, collocation or technology.” (Laura Stagner)

“We need challenge-driven project delivery where outcomes create value.” (Barbara Jackson)

“Delivery models don’t matter, but outcomes and process do. Culture drives delivery.” (Patrick Duke)

“CM at Risk really isn’t very collaborative.” (Ed Hansel) ***but “CM at Risk can be collaborative.”*** (James Apodaco)

“Are owners picking the best team or the best proposal? Hopefully it’s both.” (Craig Unger)

“Every team member gets one sacred cow.” (William Thompson)

“We know exactly what we’re building when we build from a model. We’re designing to manufacture.” (Jim Patee)

“ILPD offers better outcomes than traditional delivery methods.” (Andy Rhodes)

“The rigor of our model mitigates our risk. It’s a trust issue.” (Cory Brugger)

“Don’t forget about design, because without the stylist, nobody buys the cars.” (James Coleman)

“With BIM we’re creating a lot of paper, but have we improved the deliverables?” (Robert Otani)

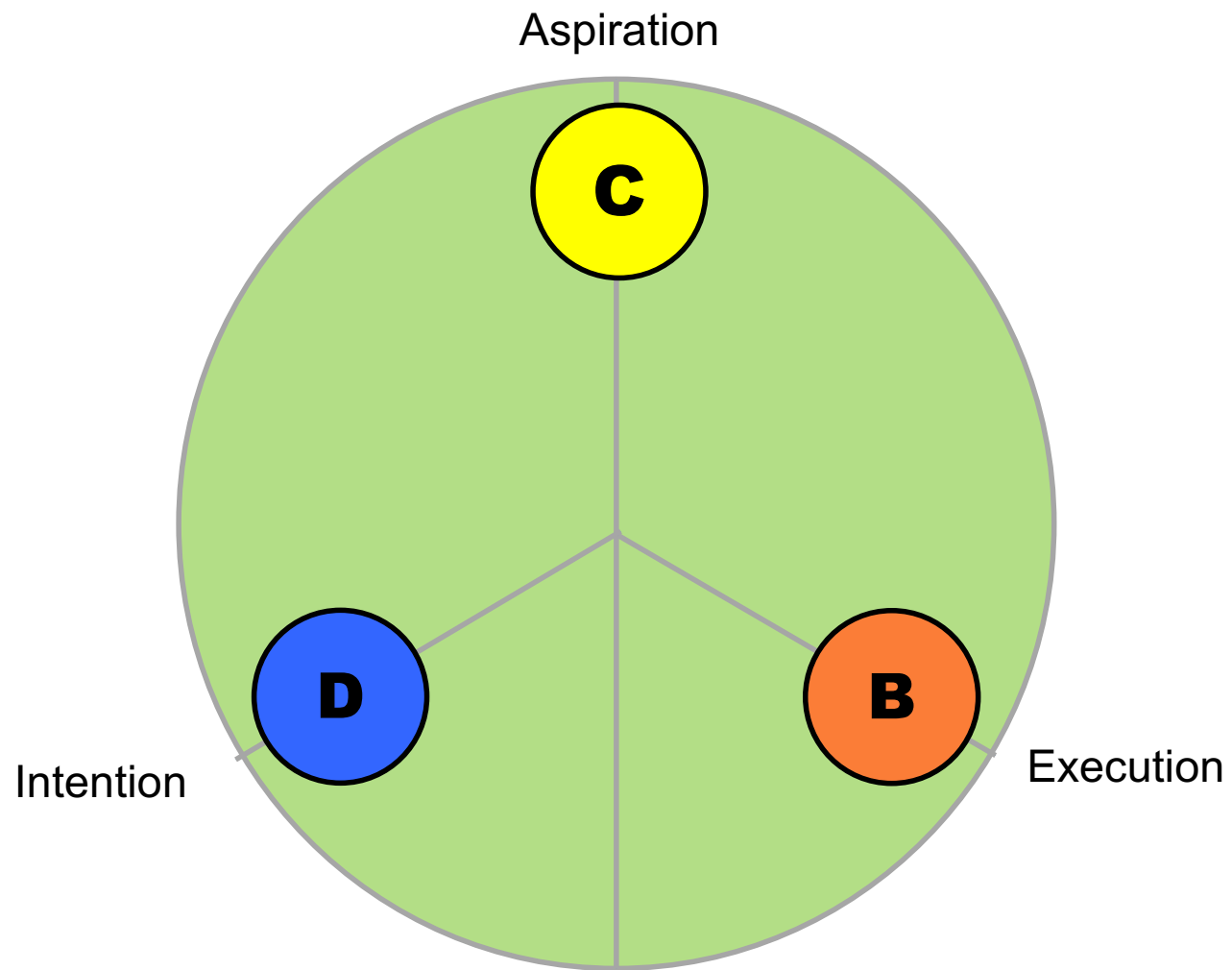
“With 30% precision, there’s no sense in making cost estimates.” (Ari Pennanen)

“Team cohesion and integration are more important to project success than delivery model.” (Keith Molenaar)

“Project delivery systems can create bad behavior.” (Bevan Mace)

The Final Take-Aways

1. Construction may finally be entering an age of innovation.
2. Design and construction are integrating in various ways but culture is still a problem.
3. Technology is opportunistic, but not deterministic.
4. More collaboration and cooperation is better than less.
5. No single delivery model fits all, and we need to be smarter in choosing them...
6. ...but delivery models are constantly evolving, so try to keep up.
7. Design is about iteration, construction is about optimization. Can they co-habitate?
8. We need more data on actual results (help us GSA!).
9. Outcomes are more valuable than commodities, but AEC is primarily transactional.
10. New methodologies need to be socialized across the industry.



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