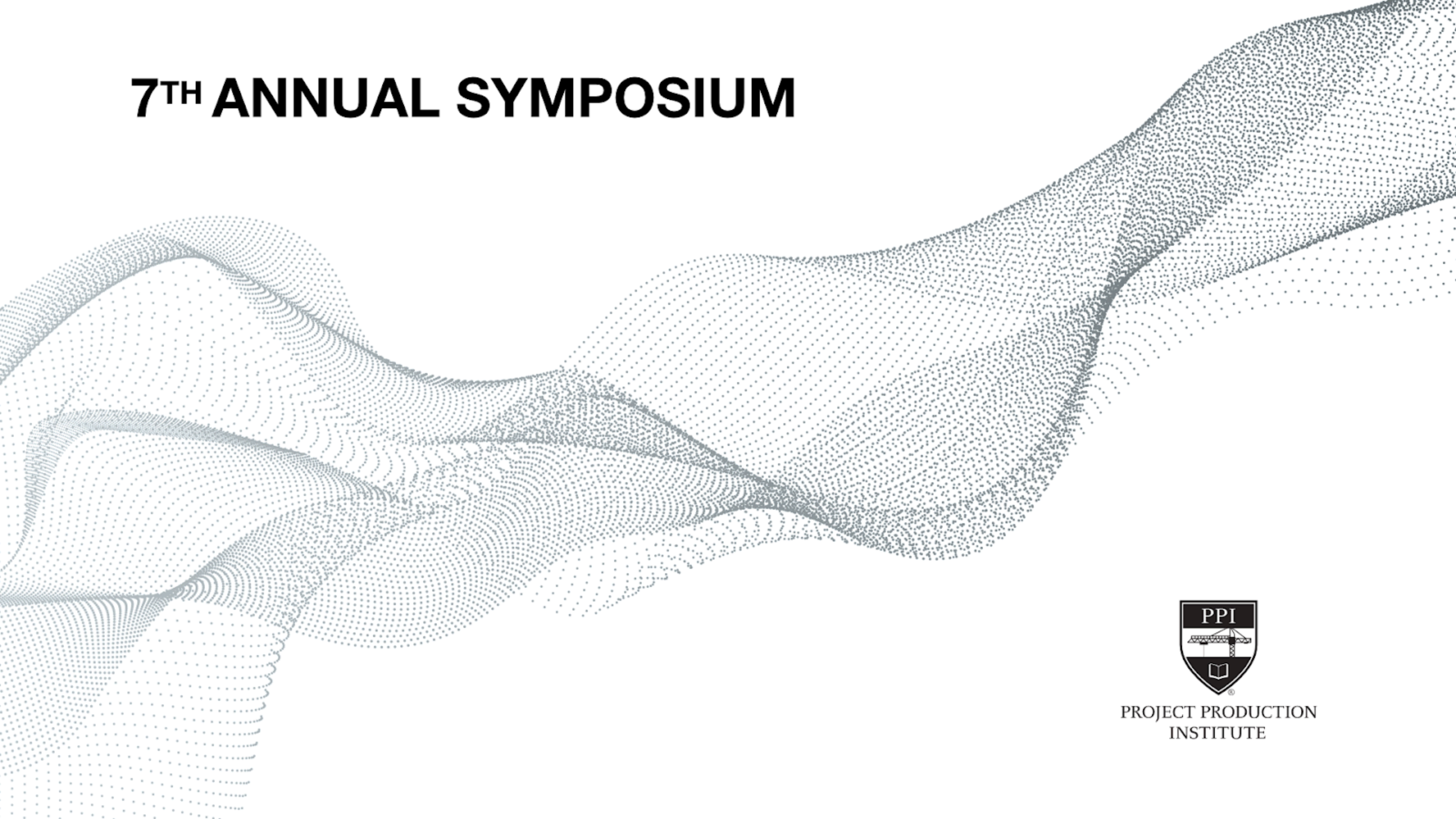
7TH ANNUAL SYMPOSIUM

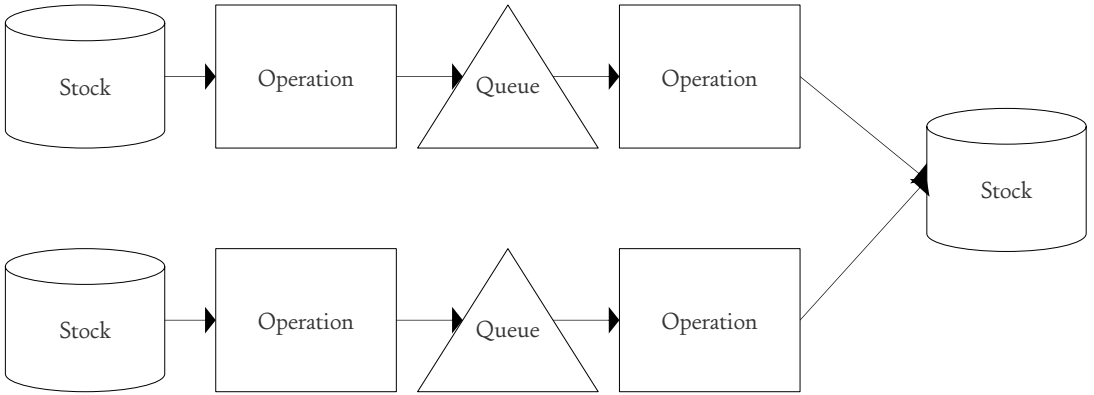


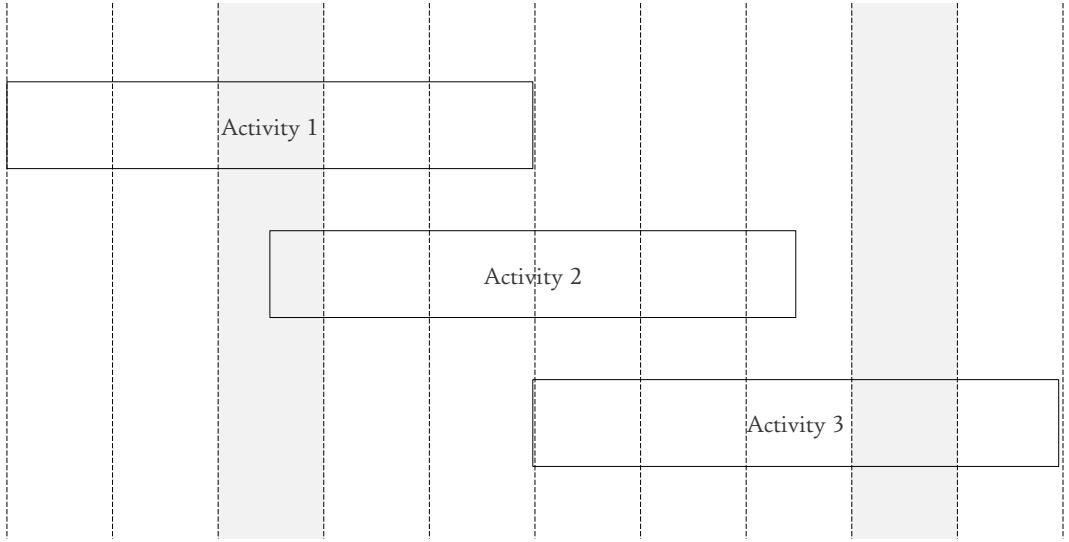
PROJECT PRODUCTION
INSTITUTE

Datacenters

Integrated Design & Construction

PROJECT PRODUCTION INSTITUTE





Emphasis on WHAT & HOW

rather than WHO & WHEN


Artificial Intelligence
Machine Learning
Simulation
Optimize
Analytics
OPERATIONS SCIENCE
Mixed Reality
IoT
4D Visualization
Control
Reality Capture
Robotic Process Automation

Time-to-Market

Competition for Market Share

Lack of Supply Network

Source: Alphabet/Google/Aerial Innovations

Datacenter Construction - Market Numbers

“AWS pioneered cloud computing in 2006”

"2019 total market: $64.20B, 8.5% CAGR”

“In the third quarter of 2019, hyperscale capex data center spending exceeded $31 billion, up 8 percent year over year.”

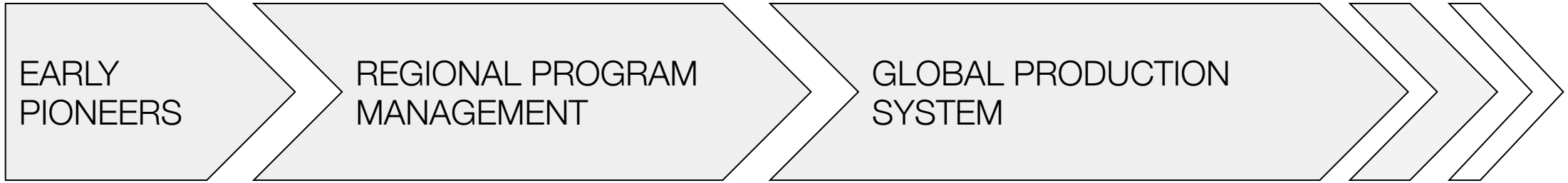
	Amazon (AWS)			Microsoft (Azure)			Google (GCP)		
	2018	2019	2020e	2018	2019	2020e	2018	2019	2020e
Cloud Rev ($B)	$25.7	$34.9	$46.1	$10.0	$16.3	$23.6	$2.5	$4.3	$6.7
Cloud Rev Growth	47%	36%	32%	82%	62%	45%	135%	70%	55%
*Market Share	67%	63%	60%	26%	29%	31%	7%	8%	9%
CAPEX ($B)	$21.9	$26.5	$30.5	$11.6	$13.9	$14.9	$25.1	$26.8	$32.6
CAPEX growth	11%	21%	15%	43%	20%	7%	91%	7%	22%
Customers	Netflix, GE, Salesforce, Expedia, Adobe, Intuit, Kellogg's, Philips, BP			Walmart, Ford, NBC, Geico, T-Mobile, Daimler			Snap, Home Depot, Colgate, Disney, eBay, Spotify		
Other Key Metrics	69 Availability Zones within 22 geographic regions			Available in 140 countries and 54 geographic regions, with plans for 4 more			61 Availability Zones within 20 regions. Available in 200+ countries & territories.		

*Note: Market share is among "Big 3" (AWS, Azure, GCP)

*Note: Google does not disclose exact Google Cloud revenues or the mix between G Suite and GCP. However, it has stated on the 2Q19 earnings call that Google Cloud annual run rate was >$8Bn. For 2Q19, we assume the mix is roughly 50:50 between GCP and G Suite, or about $1Bn each. The above table only includes GCP.

Source: Jefferies

Approach over time



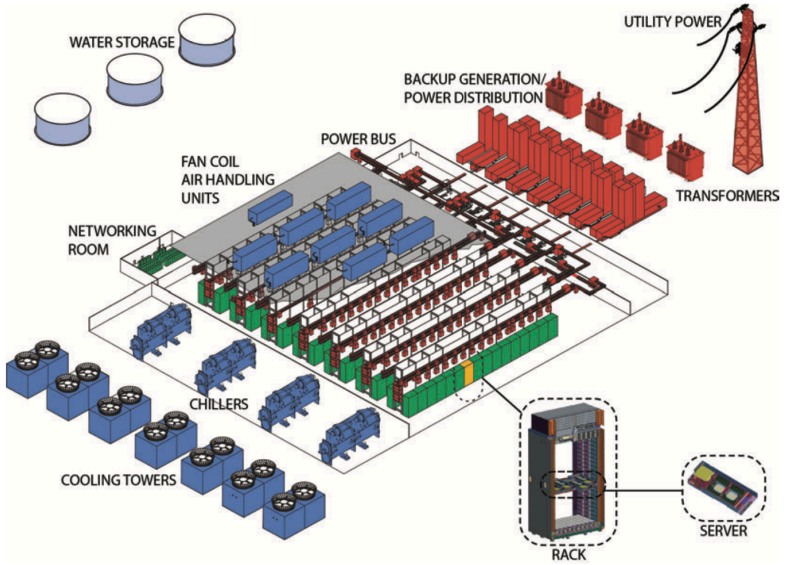
Datacenter Project as Production System

Global Product Architecture

Configuration-based Design

Industrialized Project Delivery

Source: Google Earth. Google Datacenter, Council Bluffs, IA



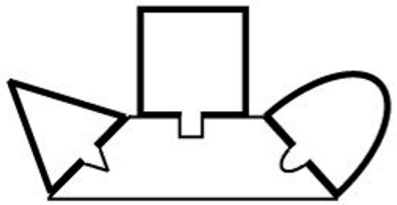
Source: The Datacenter as a Computer

Source: Alphabet/Google/Aerial Innovations

Product Architecture

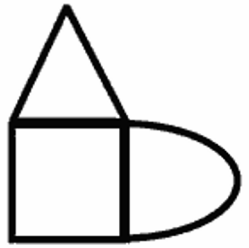
The arrangement of functional elements into physical chunks
which become the building blocks for the product or family of products.

- Eppinger & Ulrich



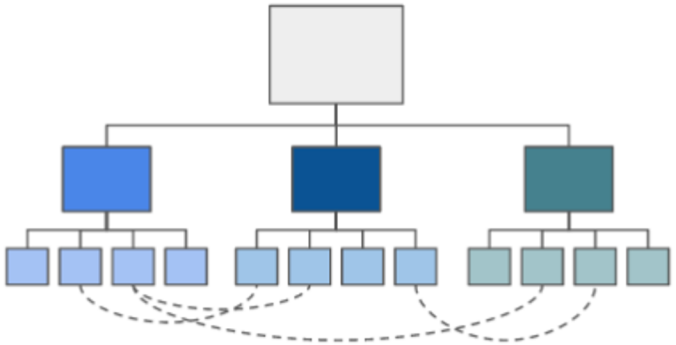
Slot-modular architecture

Bus-modular architecture



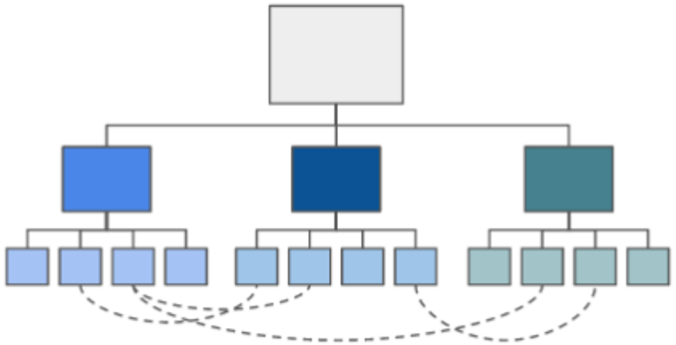
Section-modular architecture

Product Architecture



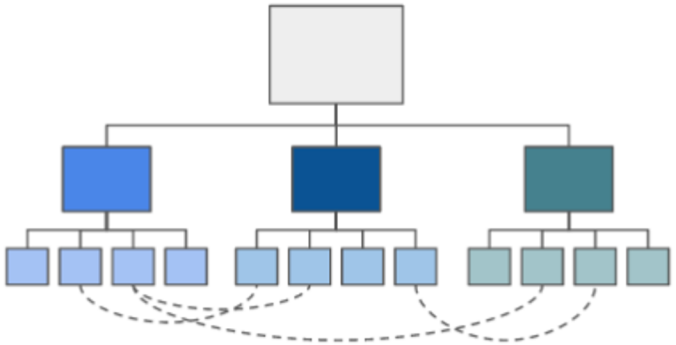
Product Architecture

Source: Volvo



Product Architecture

Source: Joe Breezer / Smithsonian



Product Architecture

Source: Joe Breezer / Smithsonian

Source: IBIS Bikes

Industry Standard Interfaces

110mm / 148mm BOOST wheel width
Conic Headset 44mm / 56mm
Bottom Bracket BB92, ISO, …
ISCG05 Mount
Seat tube collar 34.9mm, M6x1mm x 15mm
Wheelsize 27.5, 29, 26
…

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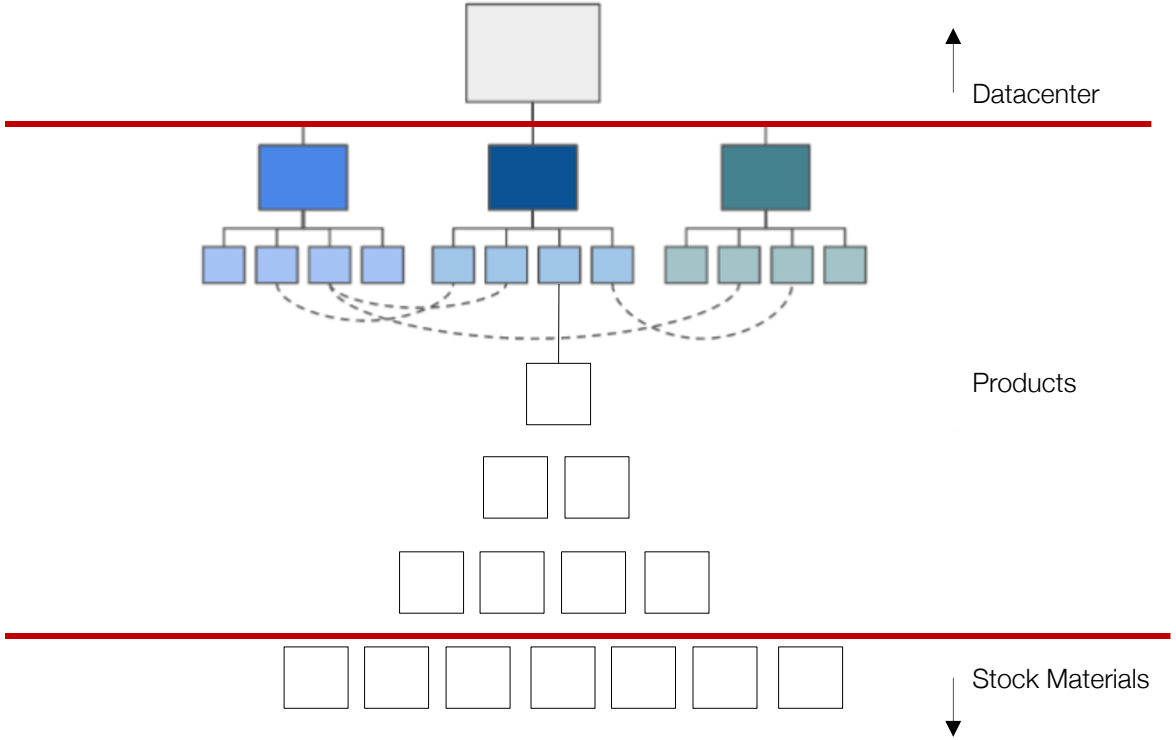
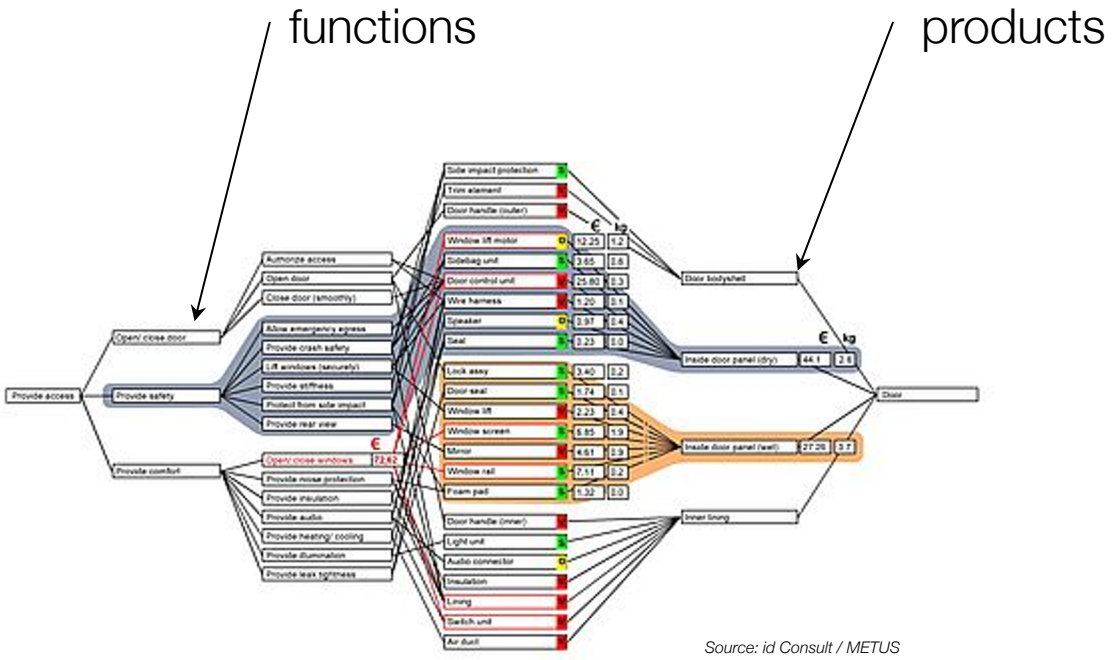
Product Architecture

Source: Alphabet / Google

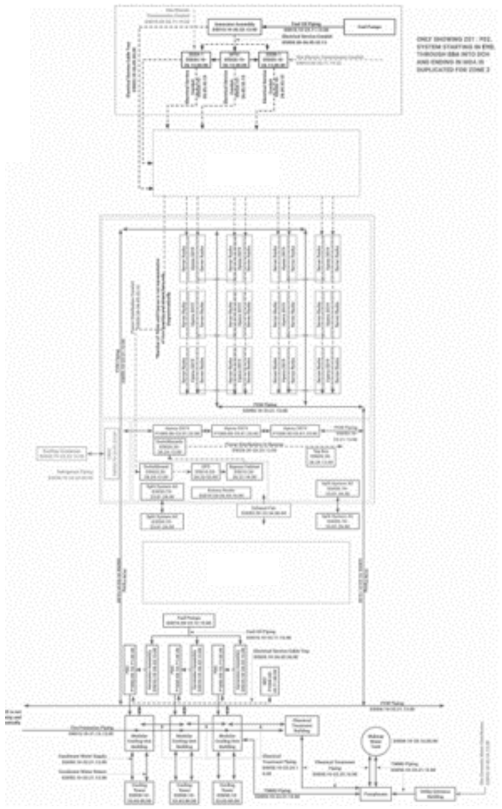


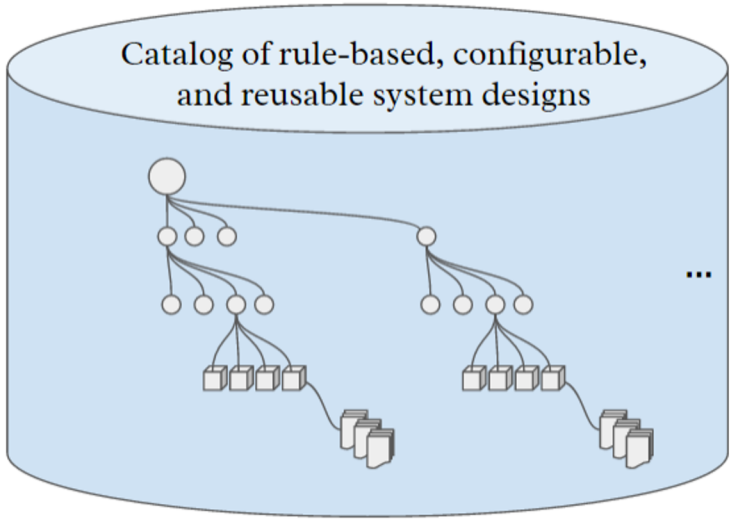
Product Architecture



Source: id Consult / METUS

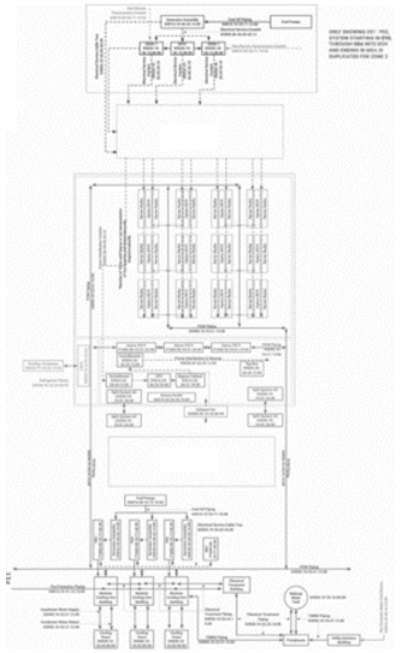
Configuration-based Design

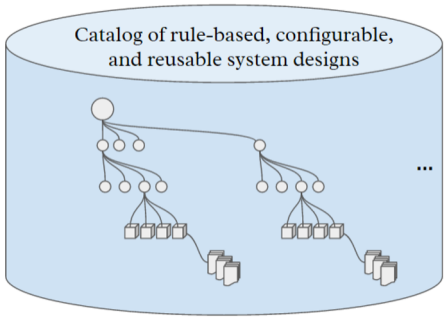




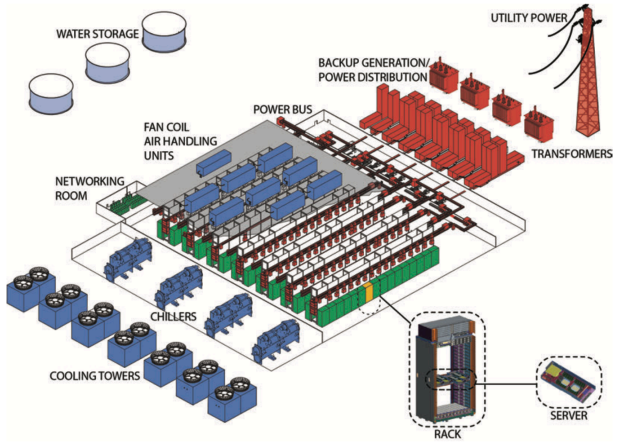
PLM System

Configuration-based Design





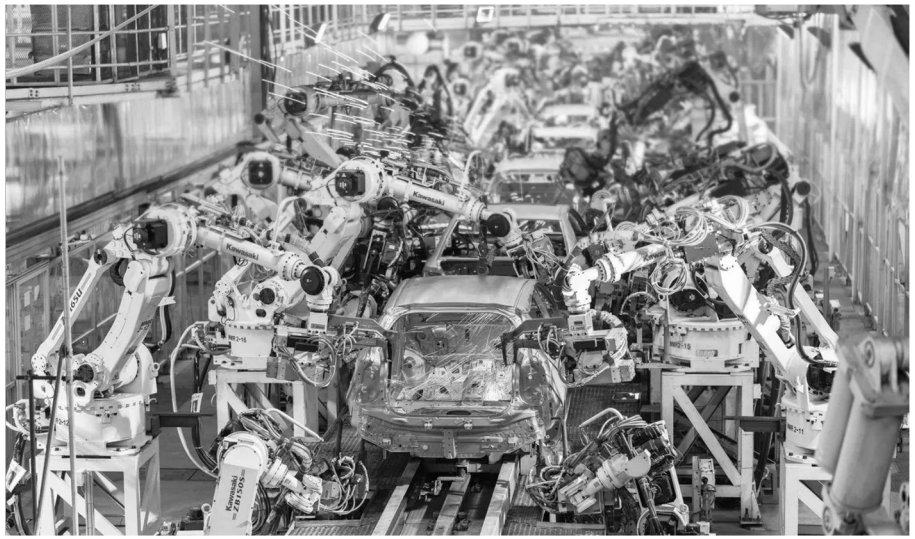
PLM System



DATACENTER IN A DAY

Industrialized Project Delivery

Documents + Schedule + Resources



Product Design + Process Design + Capacity + Inventory + Variability

Datacenter Production System

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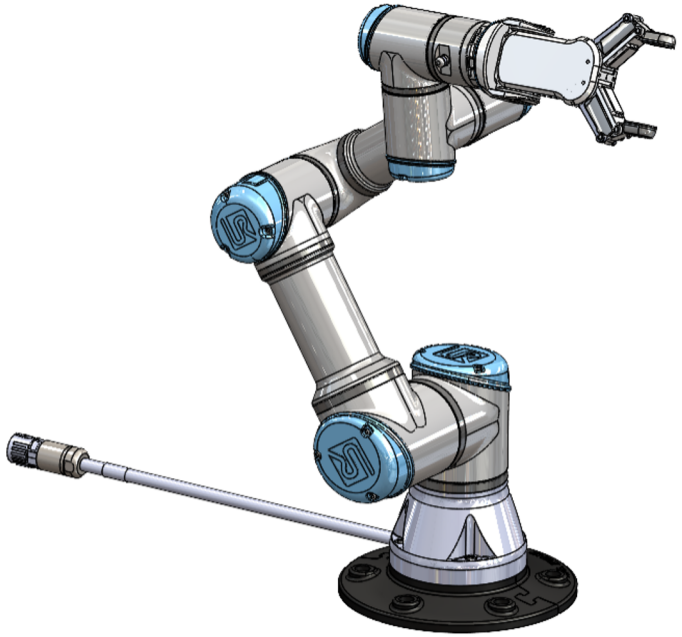
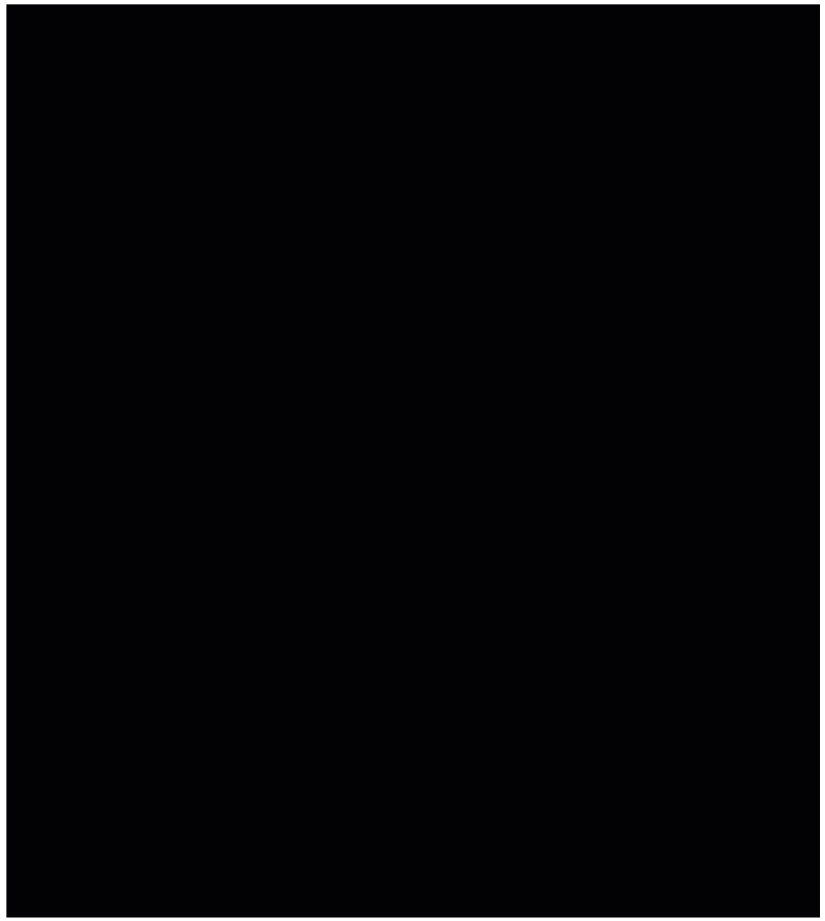
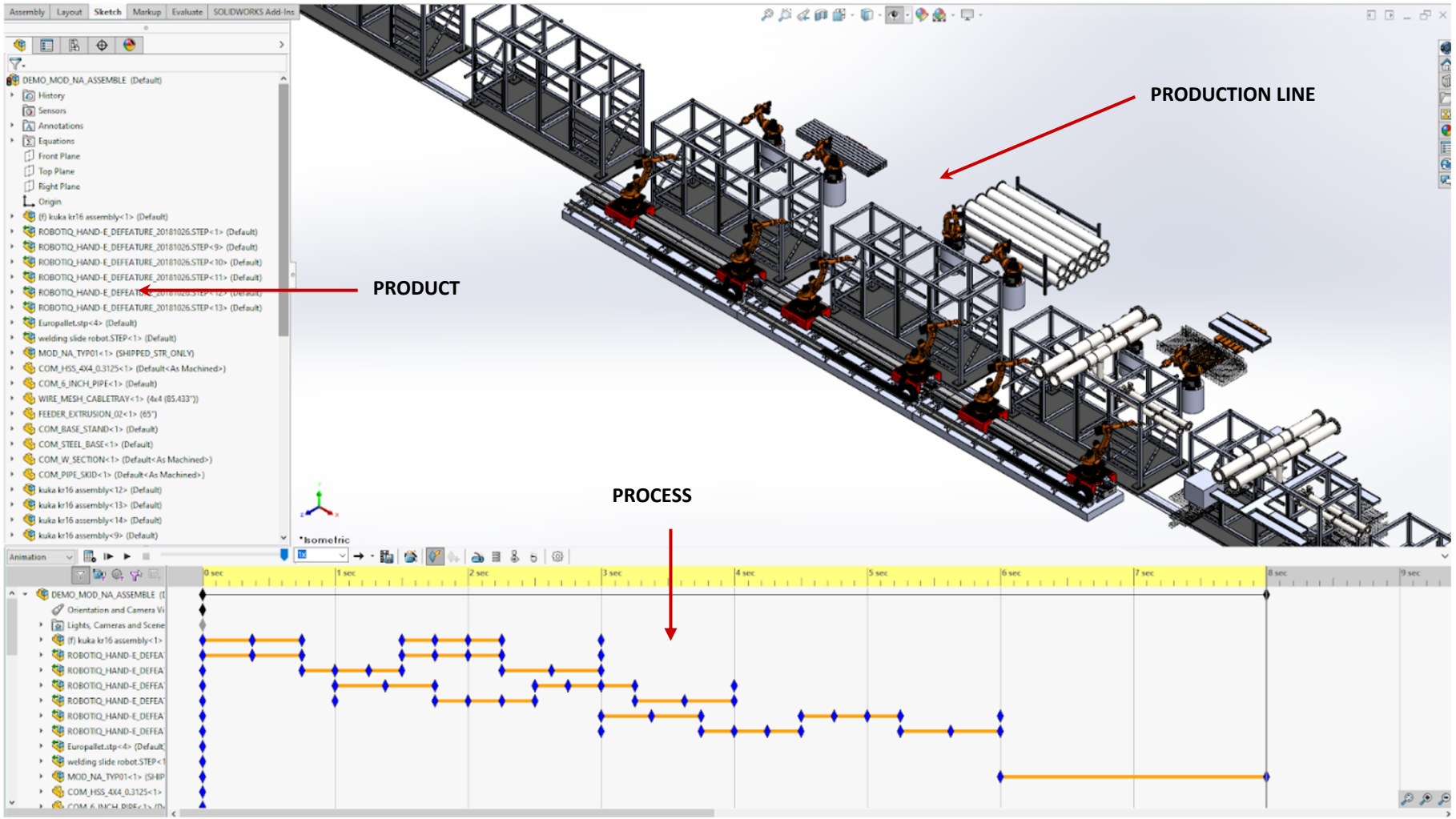
Industrialized Project Delivery





Industrialized Project Delivery



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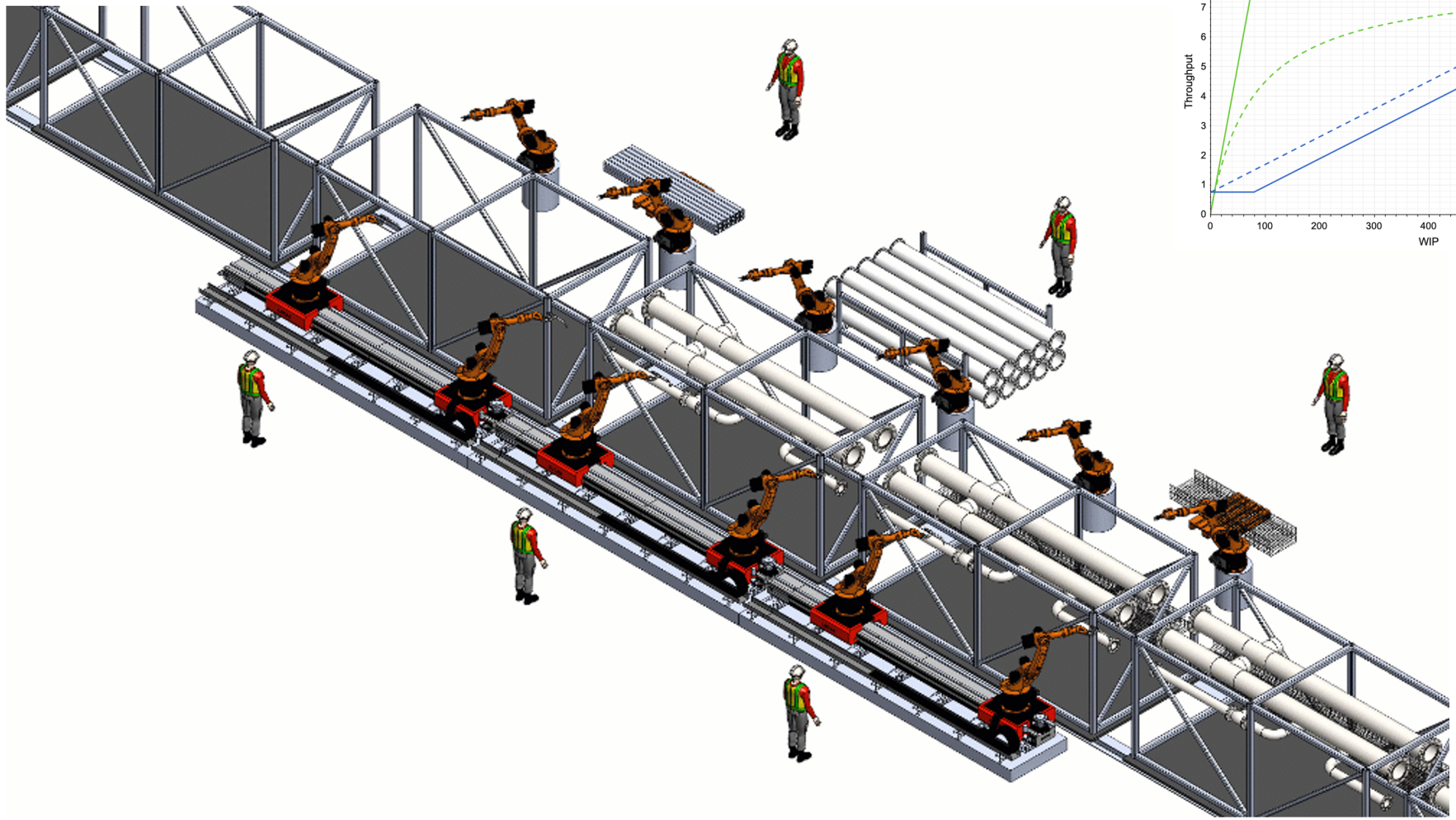

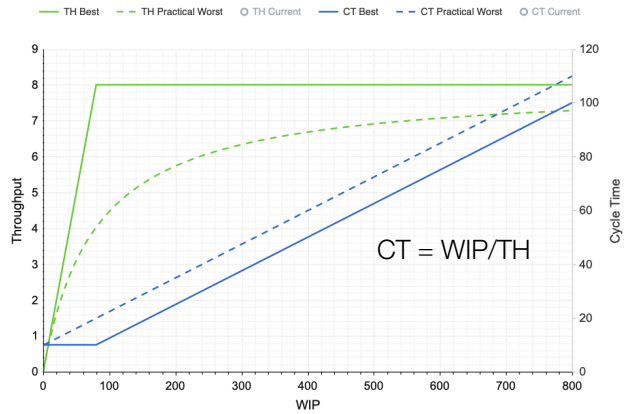

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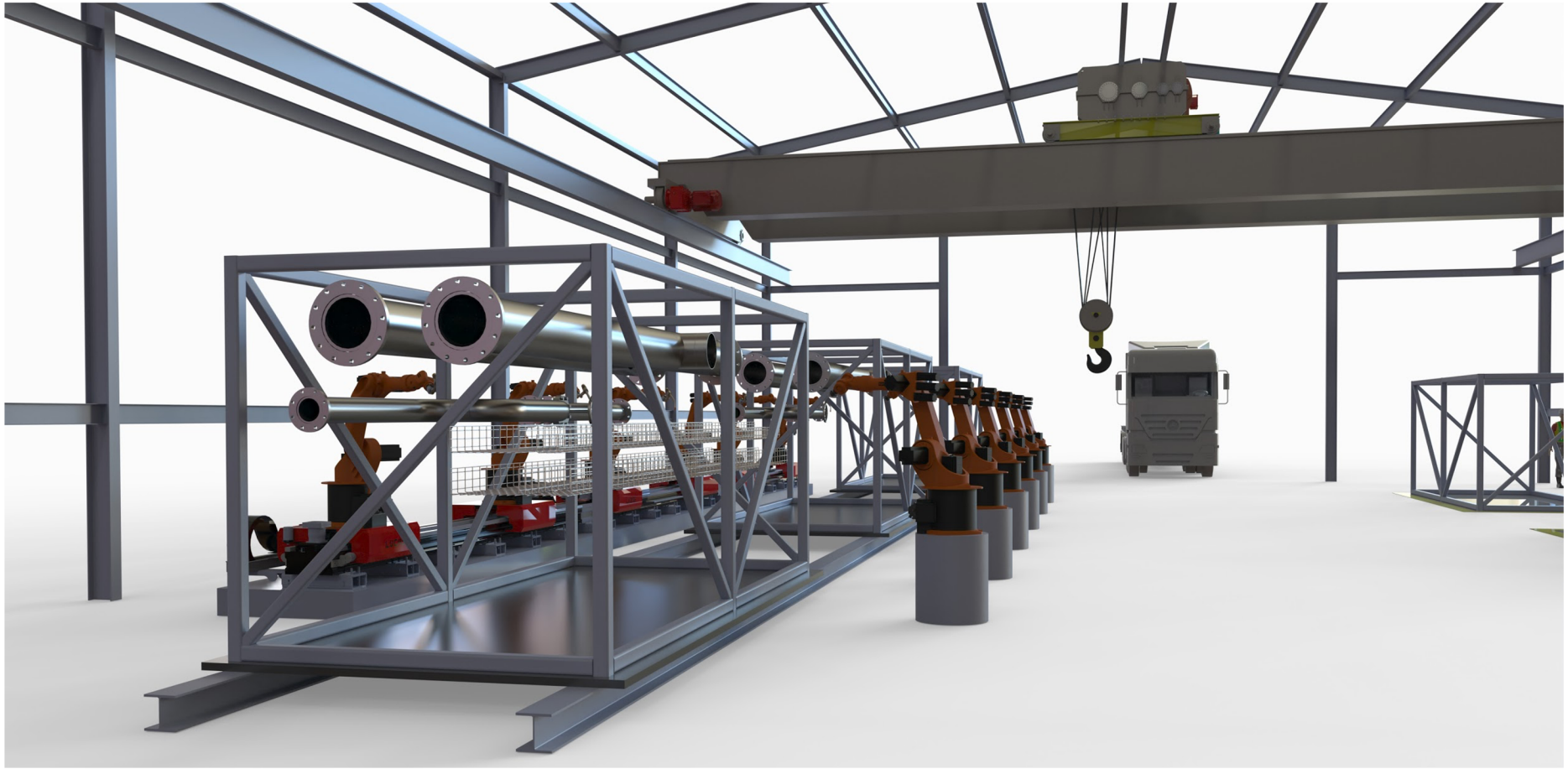

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Questions