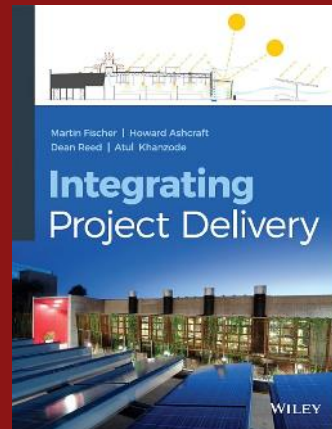


Die berufliche Weiterbildung im Wandel: Welches Angebot braucht der Markt?



Martin Fischer, Stanford University
Kumagai Professor of Engineering
Professor, Civil & Environmental Engineering
fischer@Stanford.edu



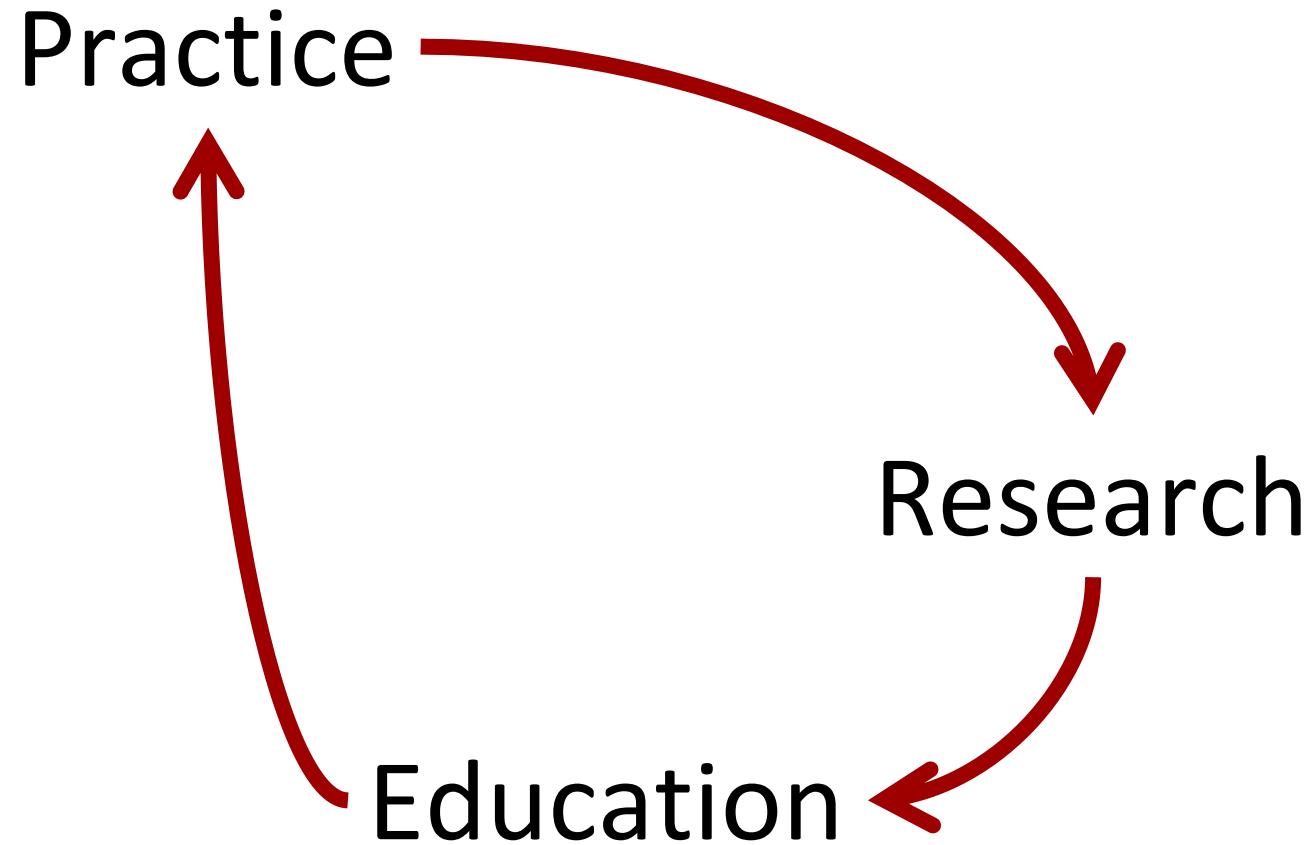
Stanford
Center for Professional Development



CENTER FOR INTEGRATED FACILITY ENGINEERING

“CIFE invents the next practice of designing, constructing, and operating the built environment.”

The CIFE community accelerates the cycle of innovation from practice to research to education to practice, and so on



The **combination of emerging digital technologies** creates **unprecedented opportunities** for **supporting project teams** in creating high-performing buildings

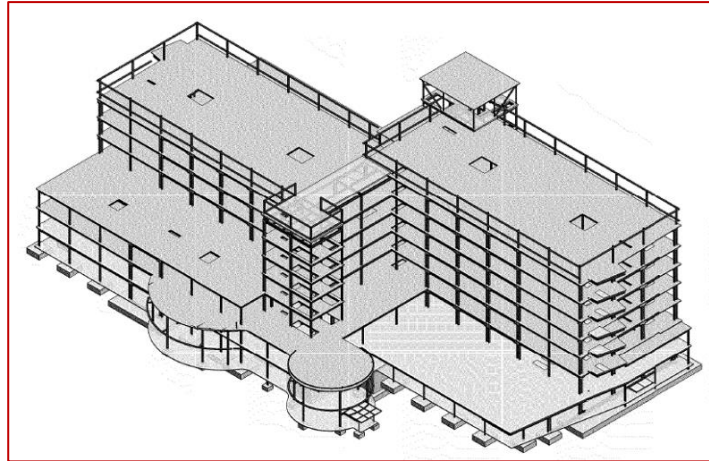
- *Mobile*
- *Cloud / Parallelization*
- *Location / Dimensional Control*
- *Machine Learning / Artificial Intelligence*
- *Robotics / Additive Manufacturing*
- *Internet of Things (IoT)*
- *Virtual Reality / Augmented Reality*
- *Etc.*

The **combination of emerging digital technologies** creates **unprecedented opportunities** for **supporting project teams** in creating high-performing buildings

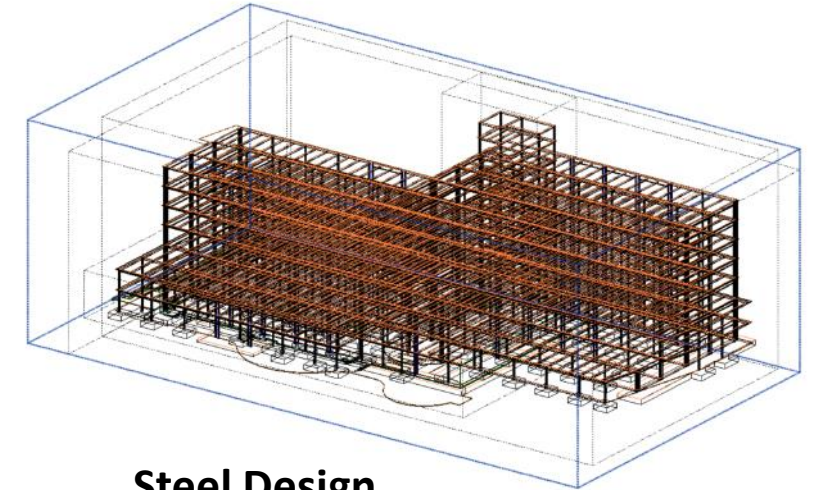
- *Mobile*
- *Cloud / Parallelization: **Cost-optimal structural design***
- *Location / Dimensional Control*
- *Machine Learning / Artificial Intelligence: **GPT for natural language interface and aligning information***
- *Robotics / Additive Manufacturing: **robots on site***
- *Internet of Things (IoT): **IoT crane hook***
- *Virtual Reality / Augmented Reality*
- *Etc.*



Creating a cost-optimal structural design



Analytical Model



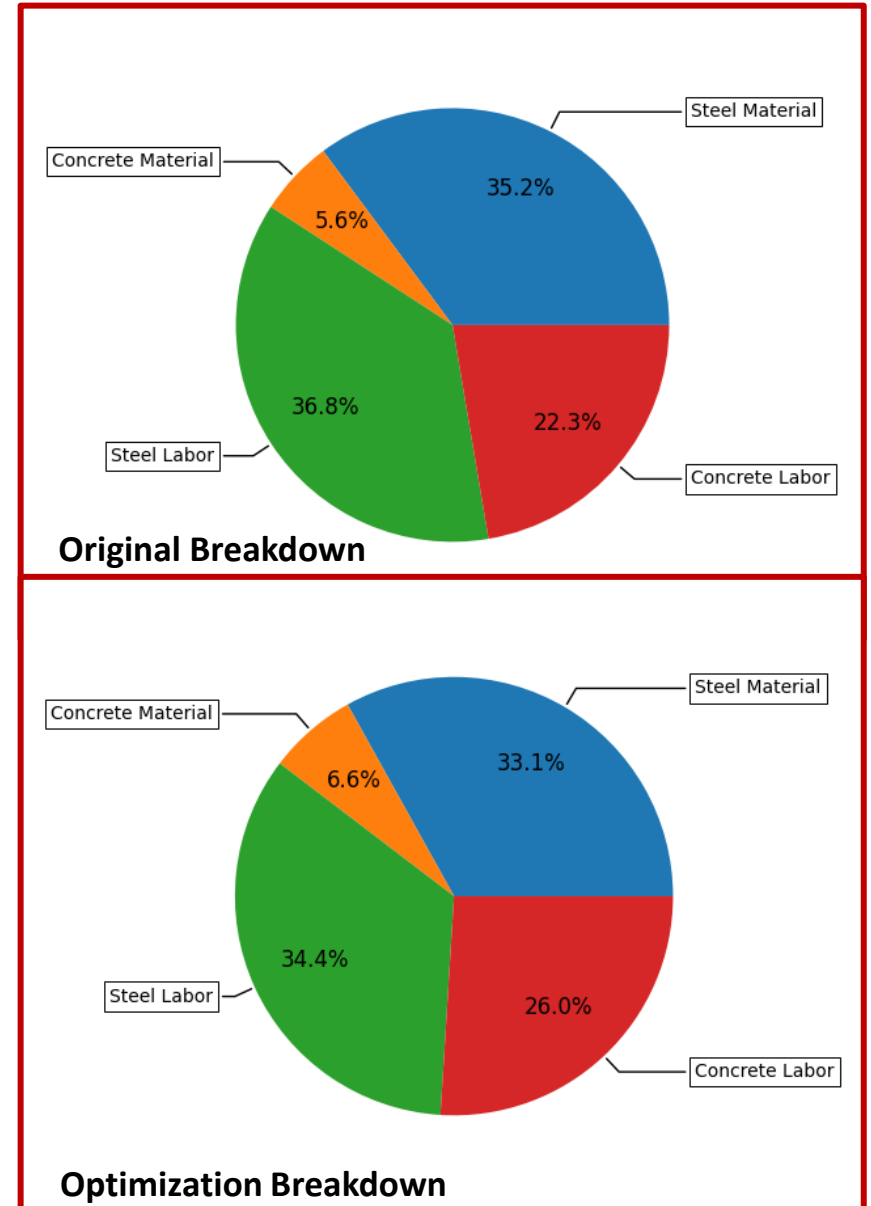
Steel Design



With Filippo Ranalli and Eduardo Miranda, CEE

Creating a cost-optimal structural design

Metric	Optimization	Original	Difference
Design Time	1 hour	~weeks	
Steel weight [kips]	1,712	1,705	0.4%
Concrete weight [kips]	6,276	6,276	0.0%
Number of studs	7,100	17,946	-60.4%
Cambered beams	389	362	7.5%
Unique sections	48	51	-5.9%
Number of shear bolts	3,876	8,954	-56.7%
Shear tab stiffeners	0	501	-100.0%
Doubler plates	57	29	96.6%
Gravity material [\$]	1,117,086	1,138,324	-1.9%
Gravity Labor [\$]	1,827,933	1,862,342	-1.8%
Lateral material [\$]	189,499	203,157	-6.7%
Lateral labor [\$]	293,003	291,882	0.4%
Connection material [\$]	131,630	298,412	-55.9%
Connection labor [\$]	127,989	285,060	-55.1%
Total Costs [\$]	3,687,172	4,079,179	-9.6%



Emerging GPT technology opens new opportunity

Many digital tools have been developed to support construction activities. However, they still:

Require extensive resources to train and educate practitioners (e.g., BIM)

Require tedious manual processing of raw data into useful information

Case 1: BIMS-GPT

The screenshot shows the Genie interface with a chat window on the left and a 3D model of a pump in the center. The chat window contains the following text:

Genie Conversation My Rules My Skills Cheatsheet Configuration Log out

Save Conversation Log

can you show me all the pumps and their attributes?

ChatGPT: A: I have found 14 pumps in the BIM database. Each pump has a unique component ID and type, and is located in room 06-470. The pumps are part of different building systems such as Hydronic Return, Hydronic Supply, and Power. Would you like me to provide more information on a specific pump?

who is the manufacturer of pump 14569?

ChatGPT: A: The manufacturer of pump 14569 is PACO.

do you know where I can find the specification for pump 14569?

ChatGPT: A: I have found one record for pump 14569 in the BIM database. It is located on level 6 in room 06-470 and is part of the hydronic return and power systems. The specification can be found in the file path: S:\Submittals\Pumps\KP_KPV_Internet_74005.pdf.

Input your query here.

Pump - Base Mounted [54-3229]

Identity Data	
Type Name	100 Base Mounted
Image	
Comments	
Mark	100
LocBuilding	100-01-000
LocFloor	5
LocRoom	100-01-000-05-170
LocSite	NA
MSB - Manufacturer	PACO
MSB - Model	300A 700 kW
MSB - MGI	MSB-MSB-000-000-000
Equip Sppt	CONFIDENTIAL-000-000-000-000-000
MSB - Installation Date	0/0/2020
Warranty Start Date	0/0/2020
MSB - Serial Number	0000000000
Equipment Type	Pump
Asset Tag	Asset

With Junwen Zheng

Case 2: AIMS

The screenshot shows the AIMS Automated Invoice Management System interface. The top navigation bar includes: Home, Submission, Checking, Drafting, Billing Report, Scope Details, and Automated Invoice Management System.

Invoice Detail

Vendor Name: Testing vendor
Description of Work (Scope): Foundations Labor
Invoice Total: 1165
Invoice Date: 4/7/2020
Status: annotated
Project Accountant Decision: Choose your option

Review Comment

SAVE

Qty	Material	Mfr Part# / Description	Unit Price	Extended
250	Rockwood	400 x US26D - Wall Stop-	\$4.74	\$1,185.00

Requested By: Stephen
Customer Purchase Order#: 2991

REMIT TO:
Kelley Bros
75 Remittance Drive
Suite 8203
Chicago, IL 60676-6203

KELLEY Bros
ESTABLISHED IN 1933

INVOICE 7-112764
Order Number: 7-2026411
Invoice Date: 4/7/2020
Job Name: Wall Stops Legoland
Acct#: 76600

Phone: 607-734-8884
Fax: 607-734-4518

Sold To: SUREPODS LLC
2300 PRINCIPAL ROW, SUITE 101
ORLANDO, FL 32837

Ship To: SUREPODS LLC
PO# 2991
2300 PRINCIPAL ROW, SUITE 101
ORLANDO, FL 32837
Tel: 407-669-7034
Fax:
Ship Via: Direct from Vendor

Sub Total: \$1,185.00
Tax:
Invoice Total: \$1,185.00

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GPT enables rapid development of a natural language interface for BIM

(a) -> search for building objects on L6

CIFE ChatGPT: A: I have searched the BIM database for building components on Level 6. The retrieved results include 1652 General Components, such as Ducts for Return Air and Exhaust Air systems. The component_id and type, location, and building system are available for each record.

(b) -> can you show me all the pumps?

CIFE ChatGPT: A: I have found 14 pumps in the BIM database. Some examples include component ID 14569 and 14601, both located on level 6 and used for hydronic supply and return systems. Other pumps have different system types and locations.

(c) -> Do you know where I can find the specification of pump 14569?

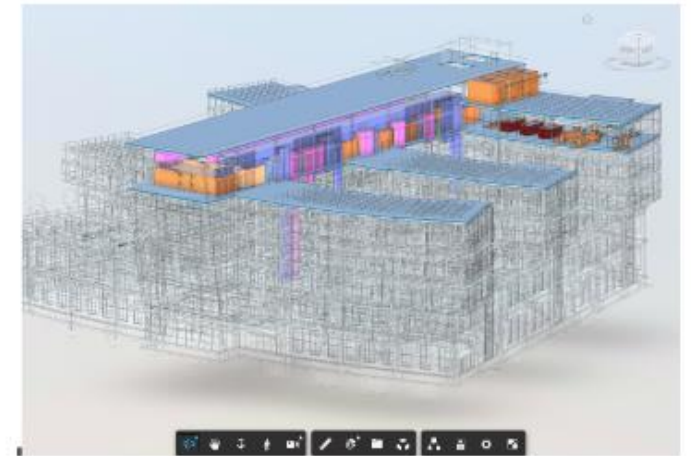
CIFE ChatGPT: A: I have found one record for pump in the BIM database. The pump with component ID 14569 is located on level 6 in room 06-470 and is part of the hydronic return and power systems. The specification can be found in the file path
\$\\Submittals\\Pump\\KP_KPV_Internet_74005.pdf.

(d) -> please explain me how the hydronic supply and return systems works in a building

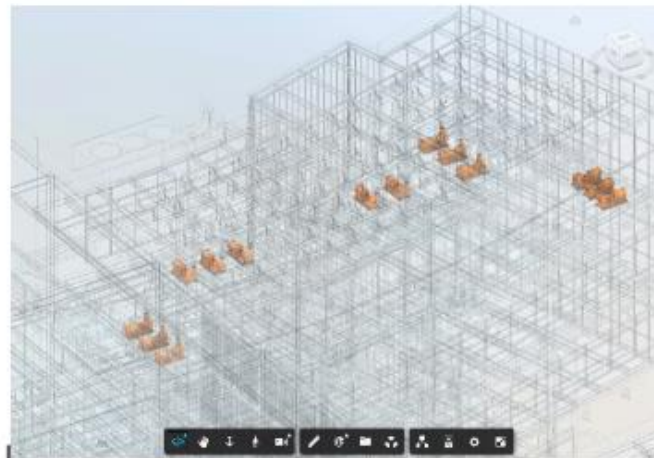
CIFE ChatGPT: A: Hydronic supply and return systems are used to circulate hot or cold water through a building to provide heating or cooling. The supply system delivers hot or cold water to the building's heating or cooling units, while the return system carries the water back to the source to be heated or cooled again. These systems are commonly used in radiant floor heating, baseboard heating, and chilled beam cooling systems. The components of these systems include pumps, valves, pipes, and heat exchangers.



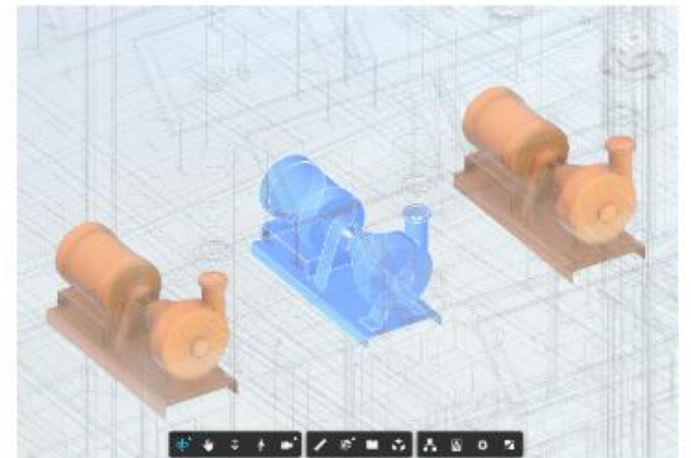
(initial)



(a)



(b)



(c)

GPT AIMS (Automated Invoice Management System)

Vendor Name: Testing vendor
Description of Work (Scope): Foundations Labor

Invoice Total: 1185

Invoice Date: 4/7/2020


Status: annotated

Project Accountant Decision

Choose your option

Review Comment

SAVE 



KELLEY Bros
ESTABLISHED IN 1986

Kelley Bros, LLC
1220 S Main St
Elmira, NY 14904

Phone: 607-734-8884
Fax: 607-734-4518

INVOICE 7-112764

Order Number: 7-2026411
Invoice Date: 4/7/2020
Job Name: **Wall Stops Legoland**
Acct#: 76600

Sold To: SUREPODS LLC

2300 PRINCIPAL ROW, SUITE 101
ORLANDO, FL 32837

Ship To: SUREPODS LLC
PO# 2991
2300 PRINCIPAL ROW, SUITE 101
ORLANDO, FL 32837
Tel: 407-859-7034
Fax:
Ship Via: *Direct from Vendor*

Qty	Manuf	Mfr Part# / Description	Unit Price	Extended
250	Rockwood	400 x US26D ~ Wall Stop~	\$4.74	\$1,185.00

Requested By: Stephen
Customer Purchase Order# : 2991

REMIT TO:
Kelley Bros
75 Remittance Drive
Suite 6203
Chicago, IL 60675-6203

Sub Total: \$1,185.00
Tax:
Invoice Total: \$1,185.00

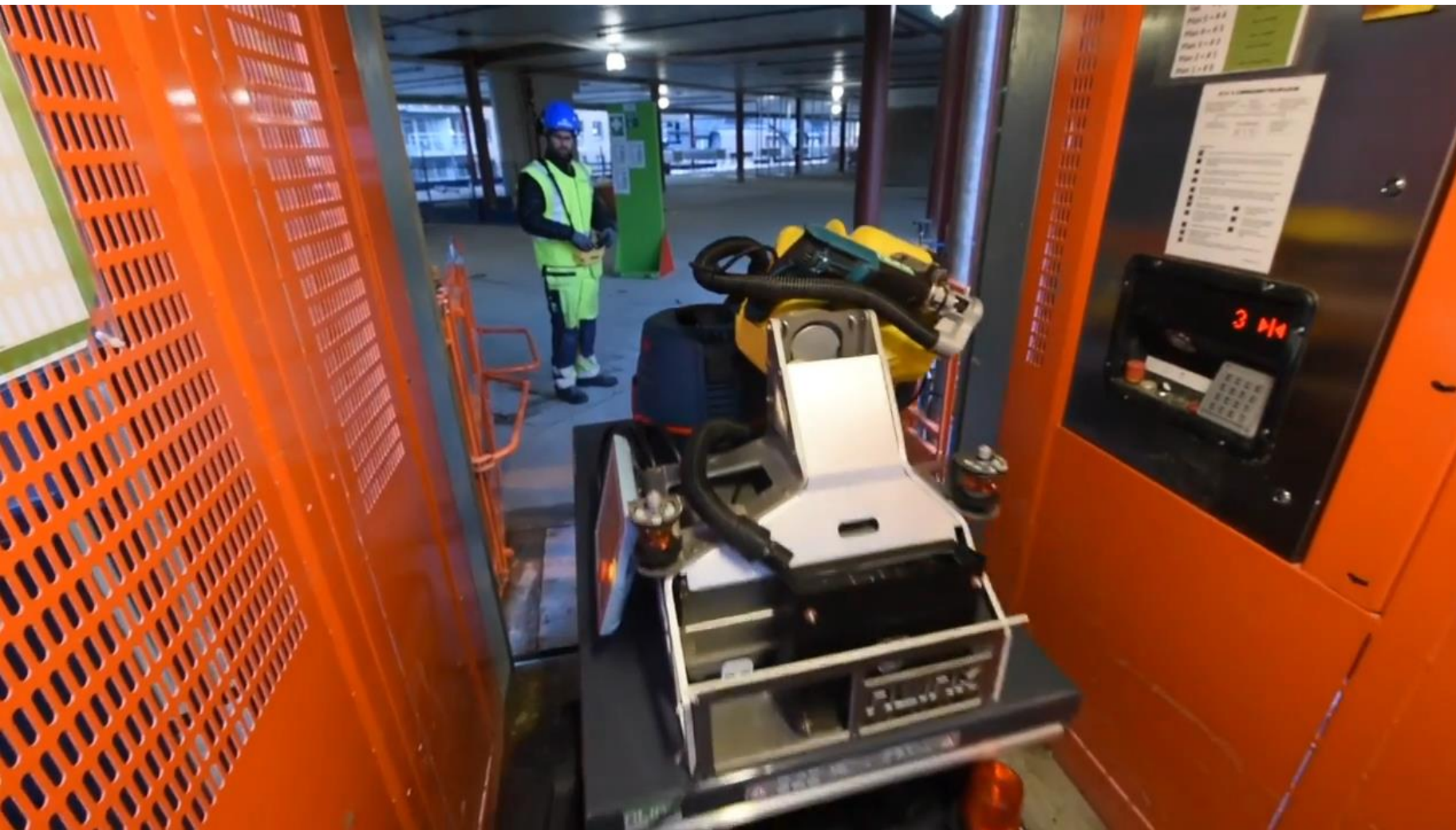
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CIFE has studied 20 robots with 15 GCs in 8 countries



With Cynthia Brosque

Robotic drilling saved time and improved health and safety for four subcontractors



Reduced task time by 11%

Cut muscle strain hours from 60% to 1.3%

Reduced rework from 5% to 3%

Improved accuracy from 10 mm to 3.3 mm

Collected 10 kg of dust/1000 holes which saved 3 h of cleaning per zone (750 m²)

Increased total costs by 13%

Crews using robots on site experienced these performance impacts

Objective	Impact
Safety	25-100% improvement
Quality	20-90% improvement in accuracy 22-100% reduction in rework
Schedule	90% reduction to 50% increase
Cost	84% reduction to 100% increase



With Yan-Ping Wang

How many parts can we install tomorrow?

Sequence of Parts to Install in the next-day Look-ahead Schedule (LAS)



Early Finish

Crews & crane time is wasted
(~\$1,000 / hr per crew)

Late Finish

Crews & crane work overtime
(~\$1,500 / hr per crew)

Trucks on standby
(~\$150 / hr per truck)

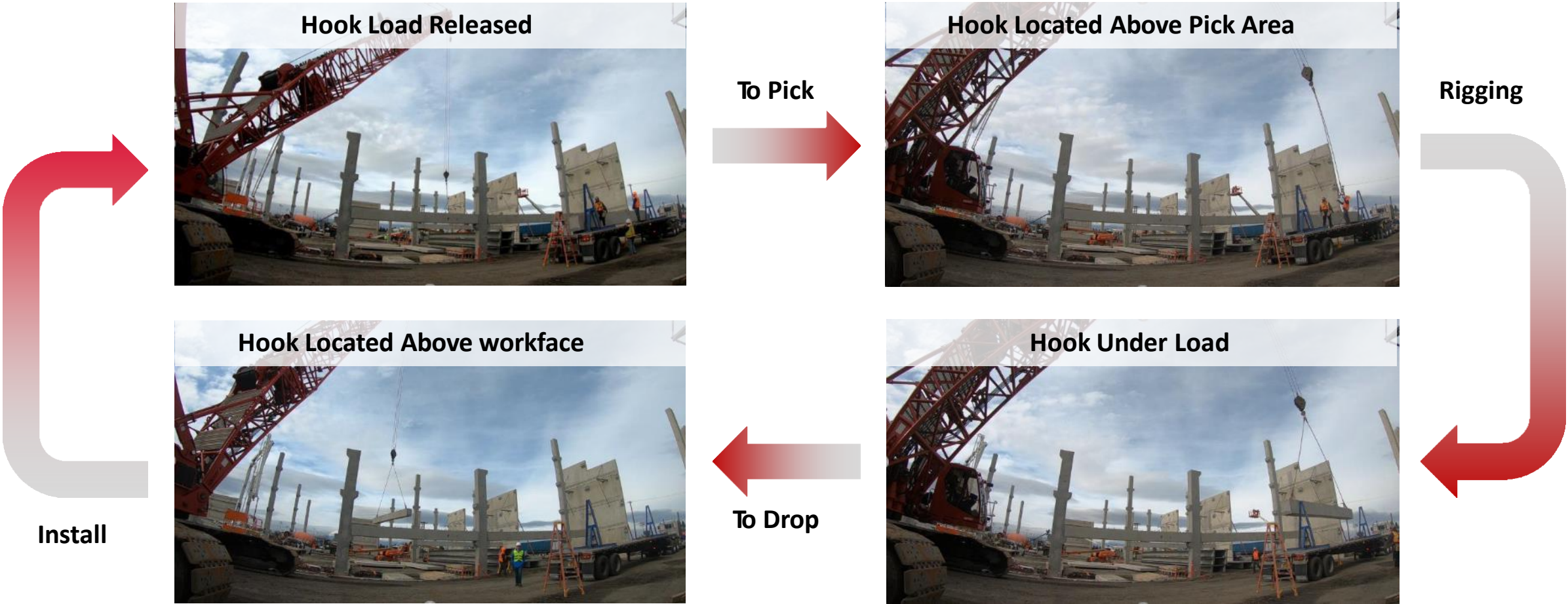
Delivery / production rescheduled
(~\$1,200 / hr per rescheduled part)

Time

← Workday Duration →

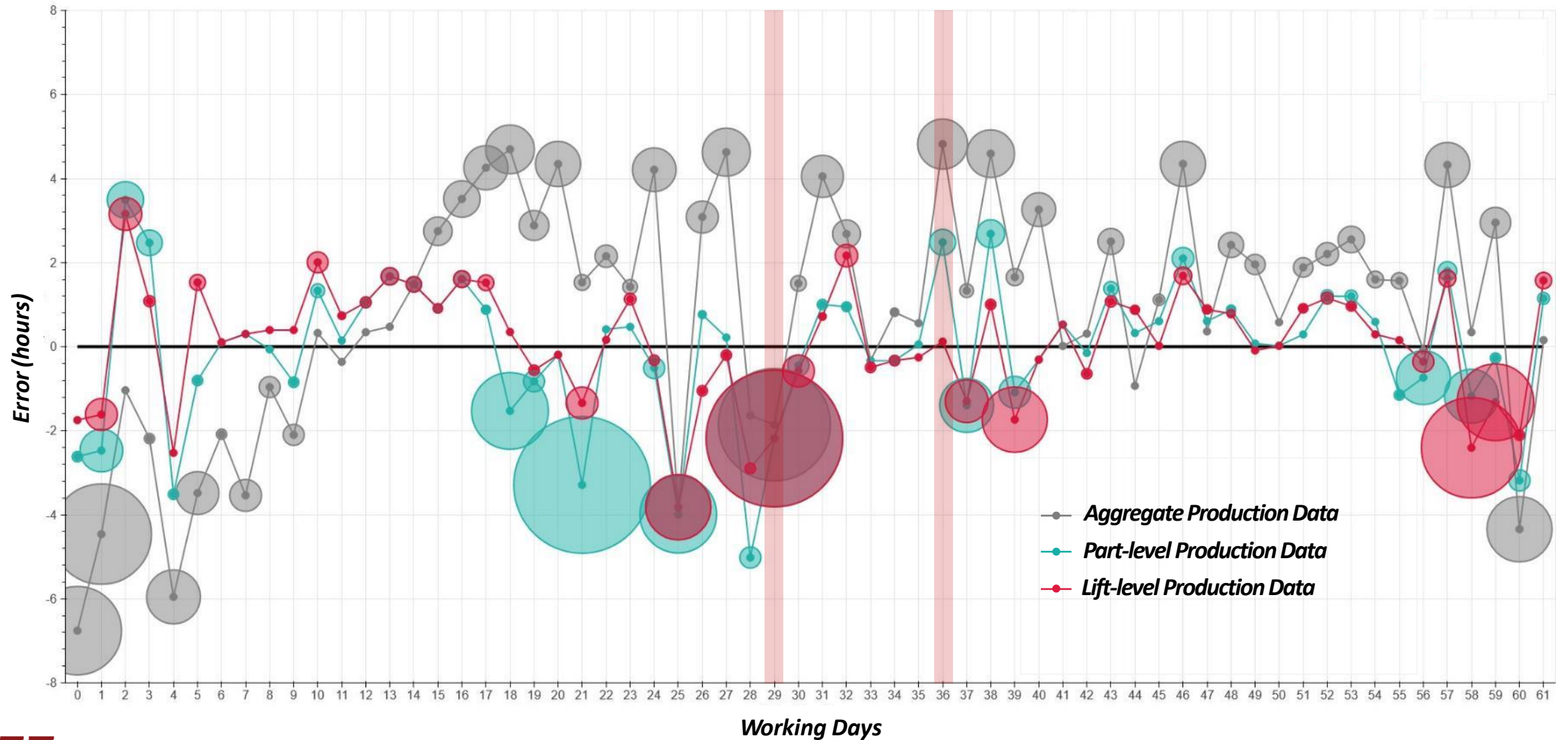
Activity duration data collection

Total Cycle Time = To Pick + Rigging + To Drop + Installation



Collected data from 2,487 crane lifts over 2 precast parking lot construction projects

Using the detailed data enabled better prediction of the parts to order for tomorrow



Impact on the Project

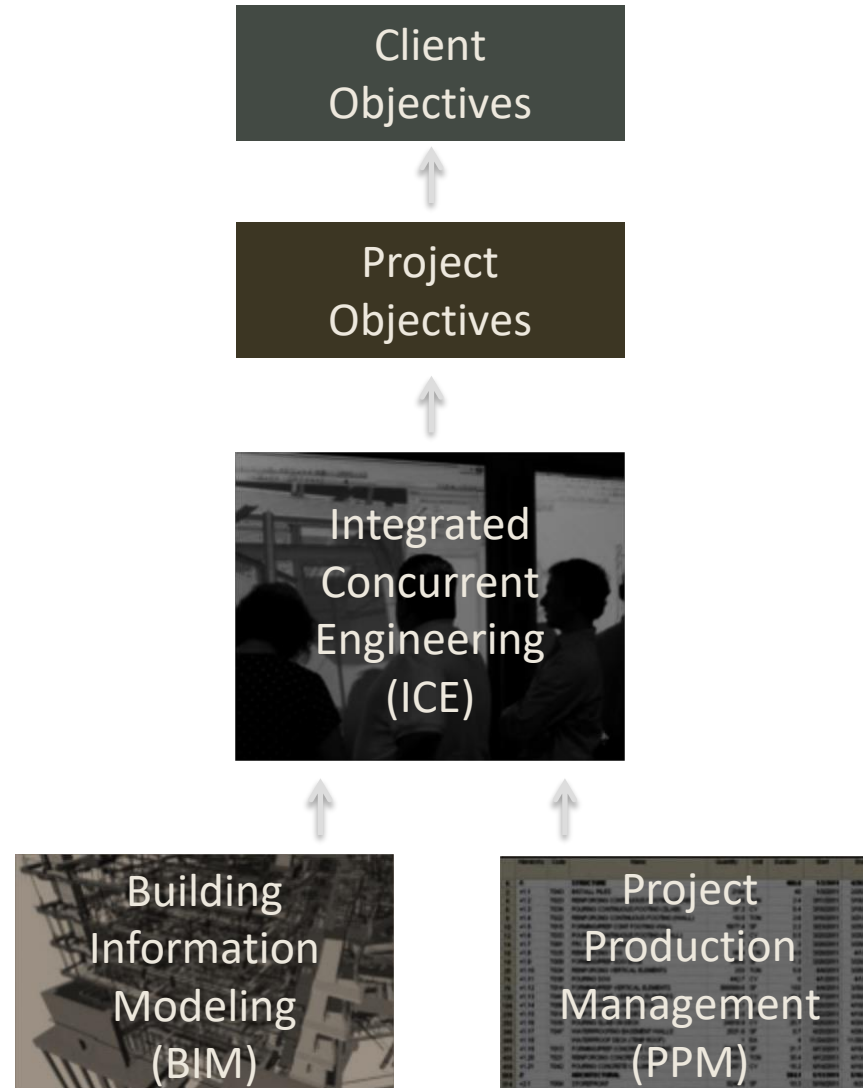
Forecast error reduced by ~50%

Daily effort to update the look-ahead schedule reduced from 2 hours to 1 minute

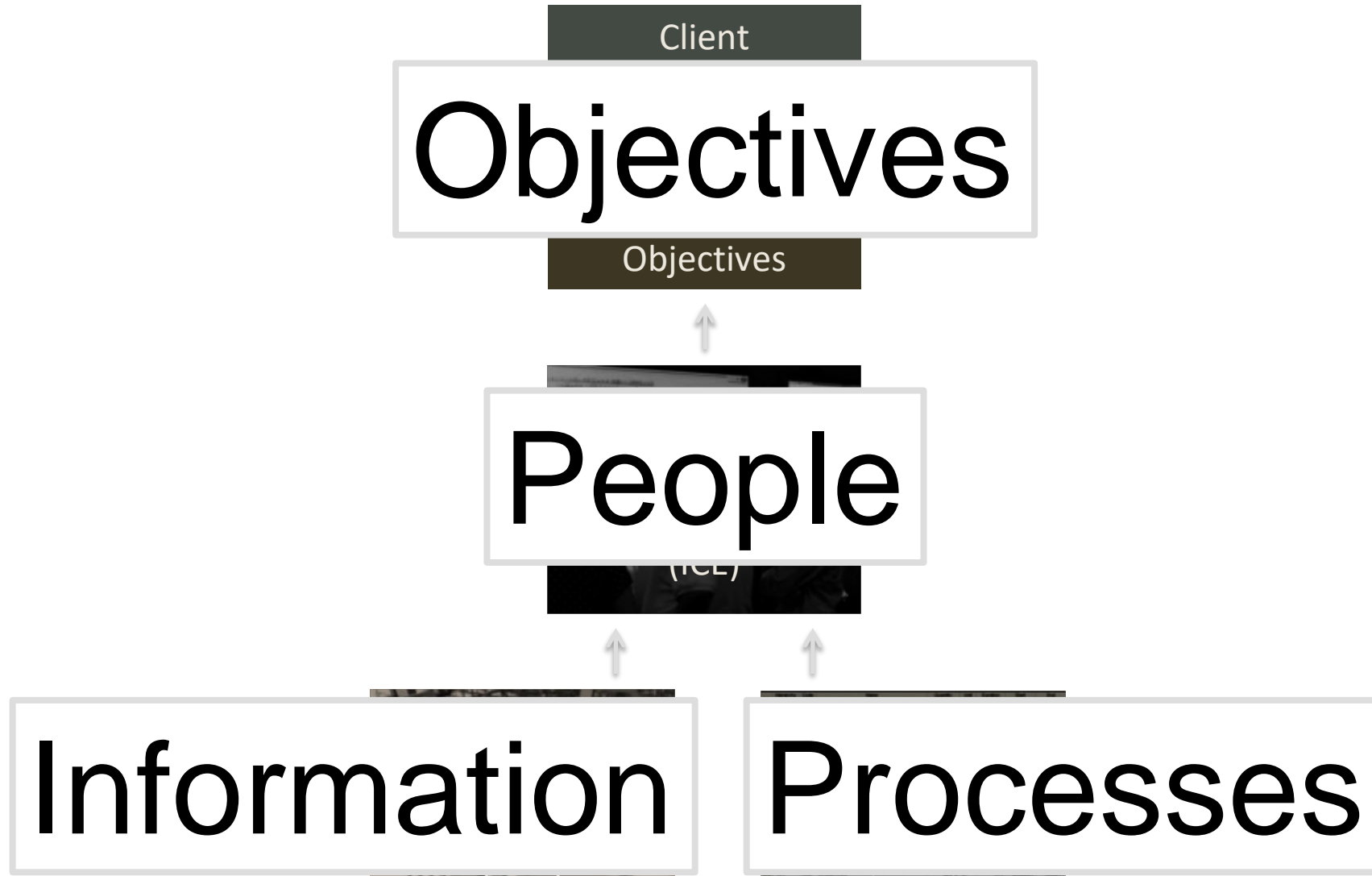
Professional education

- Strong concepts
- Common vocabulary
- Learn by doing
- Diverse
 - All roles
 - All functions
- Large scale

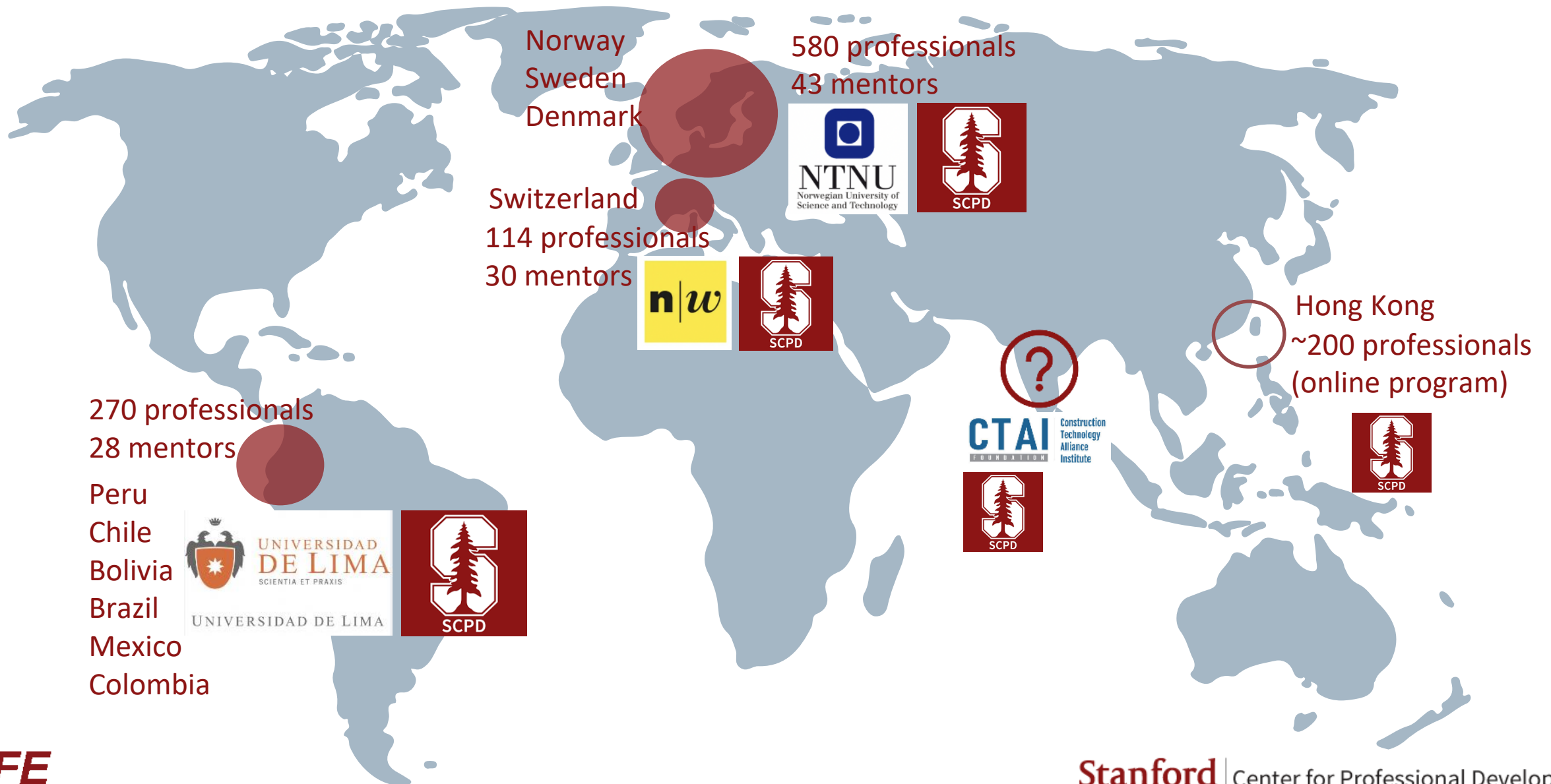
VDC (Virtual Design and Construction) Framework



VDC Framework



~2,000 VDC certified professionals around the world



Recent Large-Scale VDC Programs

NTNU in Norway



FHNW in CH



ULima in Peru

“VDC helped reduce construction cost by 30%”

Lidl is a German grocery chain with 13,000 stores around Europe and the US

Max Tran was hired as a senior project developer in Lidl Sweden to change how they establish new stores

Tumba

Månedsrapport #6
Dato: 02.03.2023

Tillägg/ändringar
till #6

Max Tran
Senior Projektledare
Lidl

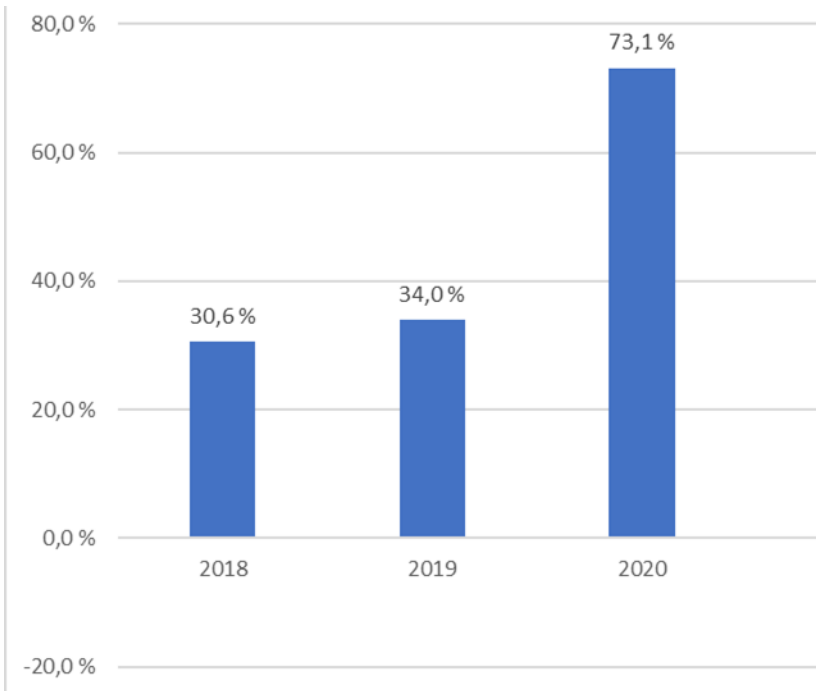


Project execution does not support business strategy



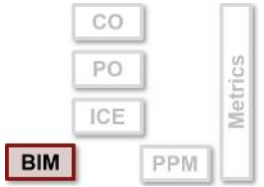
Plans to expand from 200 to 300 shops within 3-5 years

Avg construction cost above ground €/m² with targets



Mastermodel as starting point for all new projects

3D PDF visualization for executives



Mastermodel at LOD 350



Copy



Project n



Update

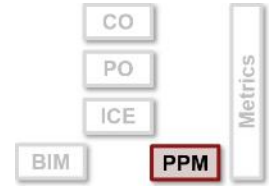


Δ Improvements

Decision latency: 75% < 1w, 82% < 2w, 94% < 3w

Revised decisions < 3%

Dramatically reduced design duration

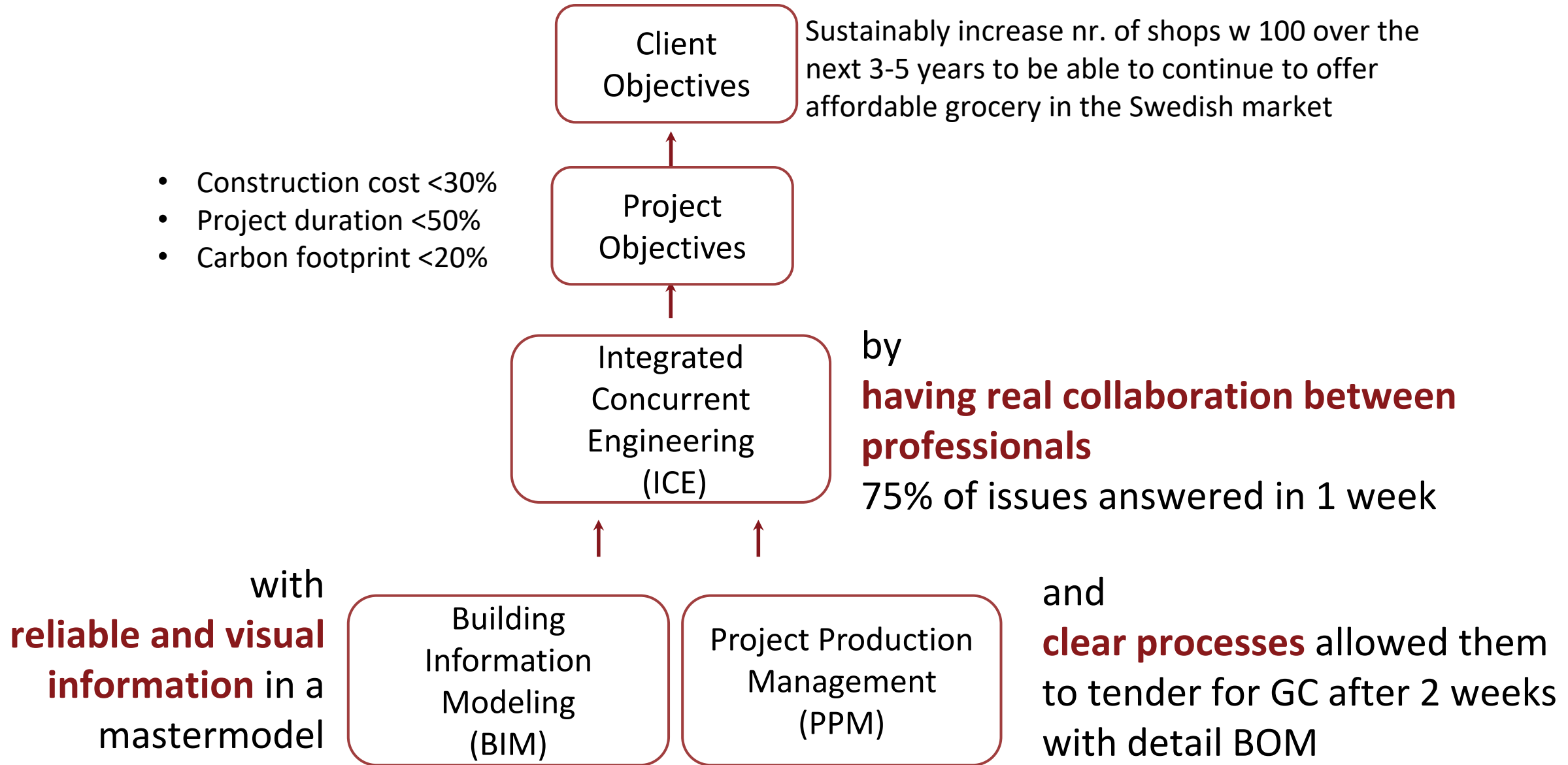


- Design duration **2-3** weeks
→ tender for GC
- Cost of design reduced from 3,0 mSEK to 0,5 mSEK (**-84%**) per project
- Cost of improvements to master design model 3,0 mSEK/year
- Tender with detailed BOM (Bill of Material) from BIM
- Reduced variability on bids from **+/- 50%** to **+/-3%**

Kanaler				
Dimension	Aggregat	Material	Längd (m)	Plåtarea, rekt
Cirk. kanal, Aluzinkplåt				
315	LB02	3	5.7 m	0.0 m ²
Cirkulär kanal				
80	CL01	1	2.8 m	0.0 m ²
80	CL02	1	3.8 m	0.0 m ²
100	LB02	1	1.6 m	0.0 m ²
125	CL01	1	8.2 m	0.0 m ²
125	CL03	1	0.3 m	0.0 m ²
125	LB02	1	7.8 m	0.0 m ²
160	CL02	1	14.1 m	0.0 m ²
160	CL03	1	4.7 m	0.0 m ²
160	LB02	1	22.0 m	0.0 m ²
200	CL01	1	2.4 m	0.0 m ²
200	LB02	1	31.8 m	0.0 m ²
250	CL02	1	4.2 m	0.0 m ²
250	CL04	1	1.7 m	0.0 m ²
250	LB02	1	31.6 m	0.0 m ²
315	LB01	1	0.0 m	0.0 m ²
630	LB01	1	74.0 m	0.0 m ²

Kanaldetaljer			
Produkt	Dimension	Isolering	Antal
Lindab LBXR	300x500-300x500		1
Lindab LDR	1820x900-1400x700		1
Lindab LEPR	1100x700		1
Lindab LORU	200-300x100		1
Cap			
Lindab EPF	125		2
Lindab EPF	160		2
Lindab EPF	200		2
Lindab EPFH	315		6
Lindab ESU	200		1
Lindab ESU	630		3
Lindab LEPR	300x500	-V403	1
Lindab LEPR	500x300		1
Elbow			
Lindab BFU	250-250		1
Lindab BFU	315-315		1
Lindab BFU	315-315	-K403	4
Lindab BFU	630-630		3

VDC Framework – Lidl Sweden

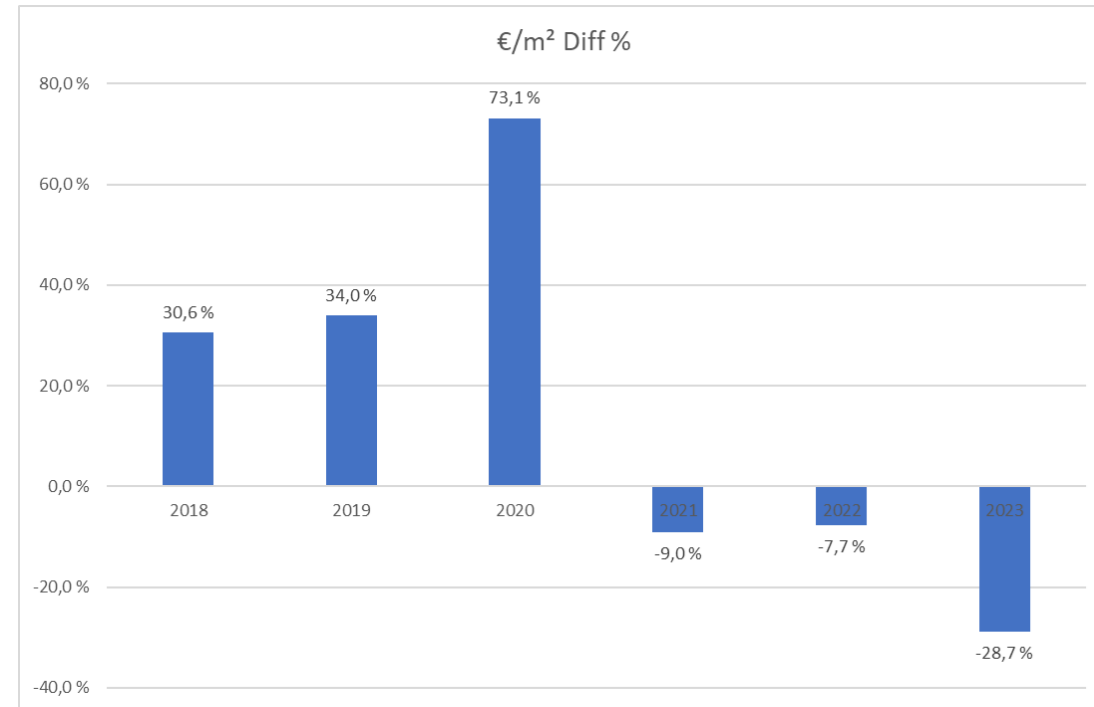


Project execution now supports business strategy



Expand from 200 to 300 shops within 3-5 years

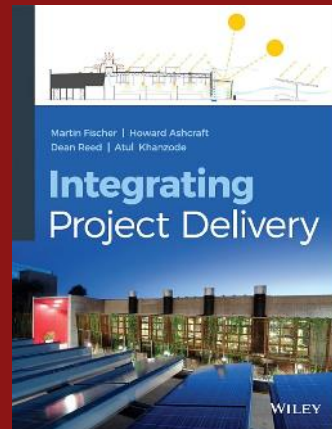
Avg construction cost above ground
€/m² is now 30% below target



Die berufliche Weiterbildung im Wandel: Welches Angebot braucht der Markt?



Martin Fischer, Stanford University
Kumagai Professor of Engineering
Professor, Civil & Environmental Engineering
fischer@Stanford.edu



Stanford
Center for Professional Development