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Operation Management in Construction Lecture #9 Digitalized Production Planning and Control

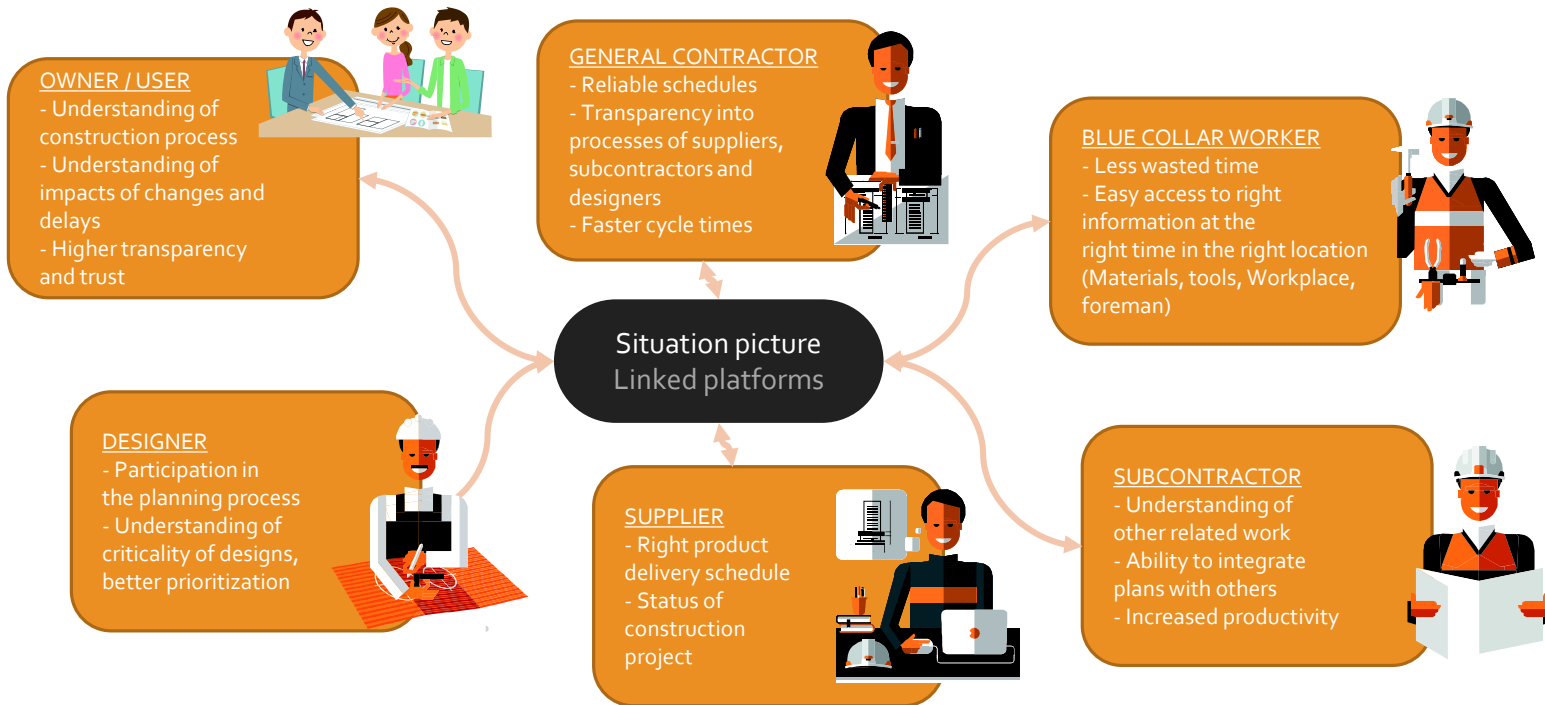## Olli Seppänen
Associate professor

Topics, Lecture #8

- **Learning objectives**
- **How can situation picture be formed digitally?**

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Intended learning objectives for this lecture

- ILO 5: **Students can explain** the significance of work and labor flow and how flow can be achieved in construction
  - *ILO emphasized for digitalization of flow*
- ILO 6: **Students can discuss** how digitalization can be used to guide production planning and control decisions
 - *ILO emphasized*

Real-time situation picture

Real time situation picture

OWNER / USER
- Understanding of construction process
- Understanding of impacts of changes and delays
- Higher transparency and trust

GENERAL CONTRACTOR
- Reliable schedules
- Transparency into processes of suppliers, subcontractors and designers
- Faster cycle times

BLUE COLLAR WORKER
- Less wasted time
- Easy access to right information at the right time in the right location (Materials, tools, Workplace, foreman)

Situation picture
Linked platforms

DESIGNER
- Participation in the planning process
- Understanding of criticality of designs, better prioritization

SUPPLIER
- Right product delivery schedule
- Status of construction project

SUBCONTRACTOR
- Understanding of other related work
- Ability to integrate plans with others
- Increased productivity

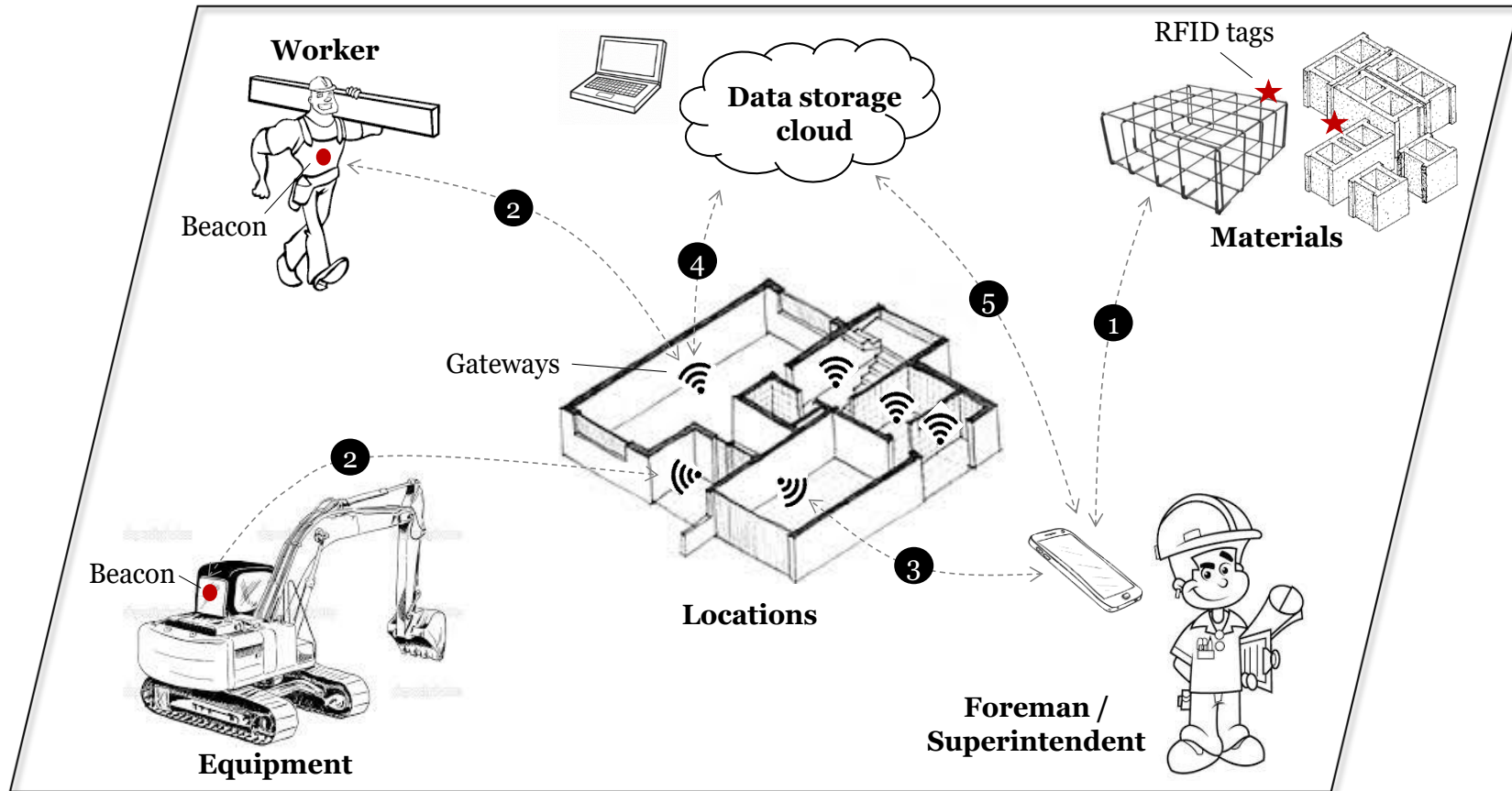# Forming situation picture

Technology has developed:

- **Sensors and positioning are in use**

- **Process has been simplified (e.g. takt production / prefabrication)**

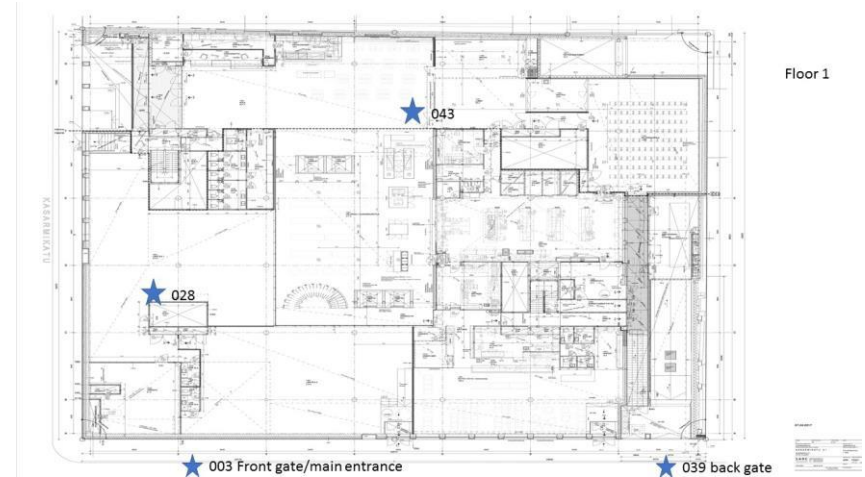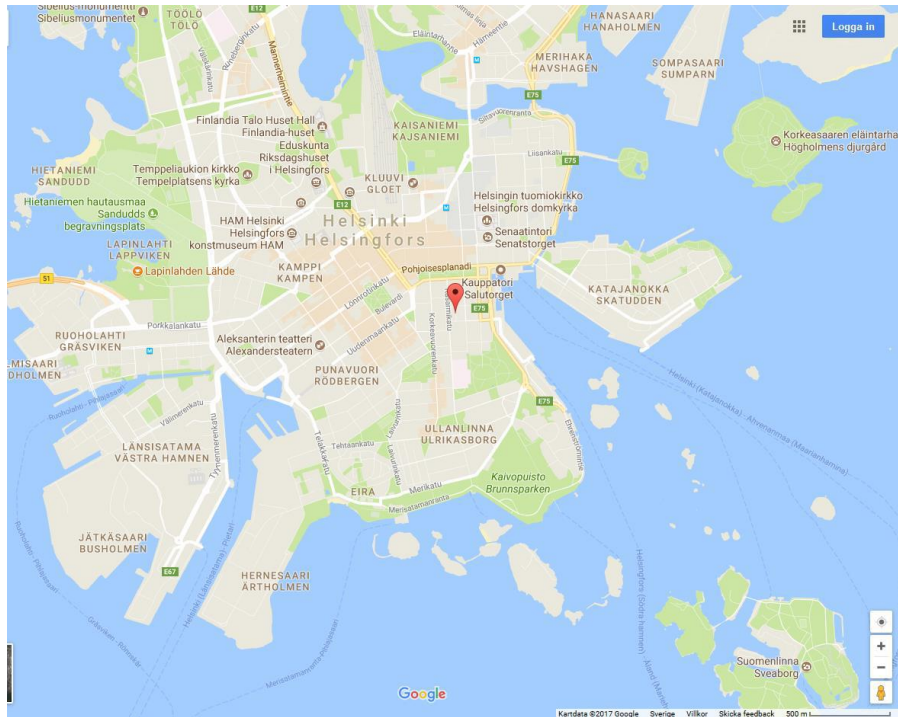- **Digi-engineers collect digital data**
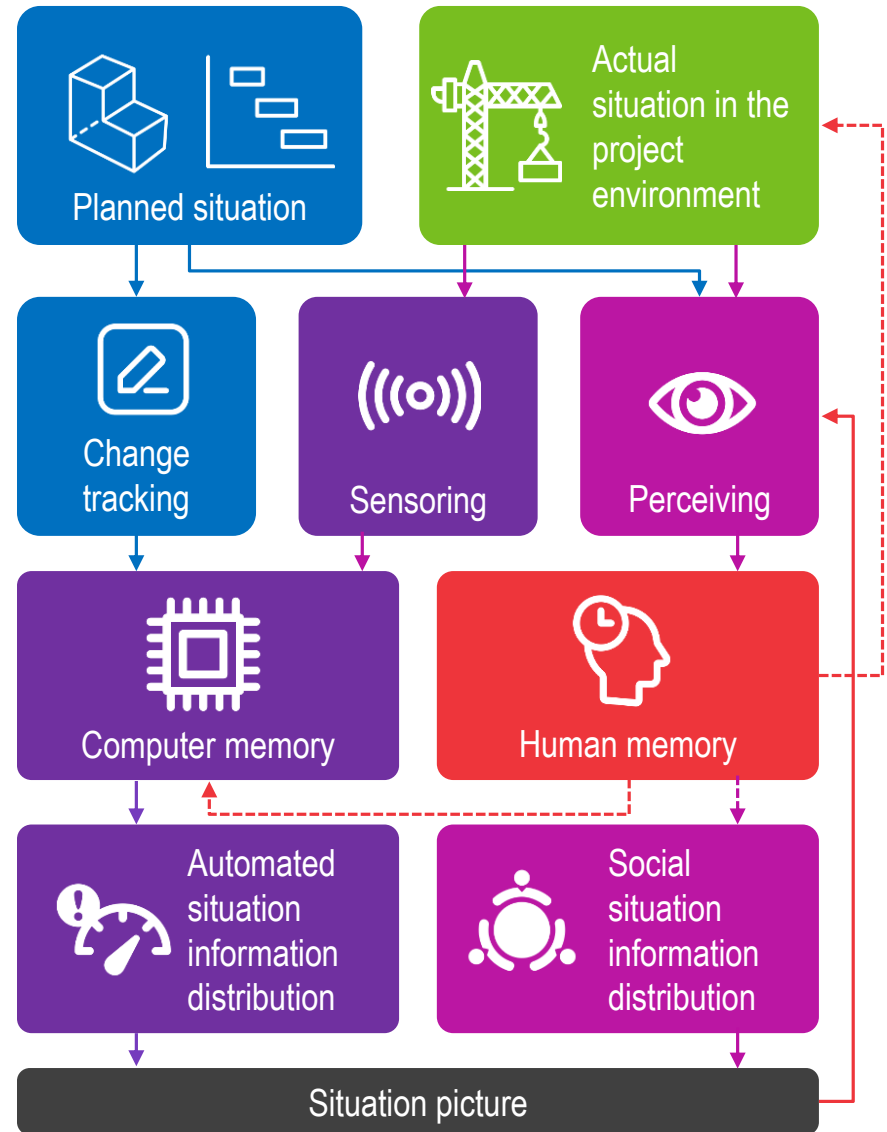
Kärkkäinen et al. (2019)

Real-time position of resources

Example installation (Office building YIT)
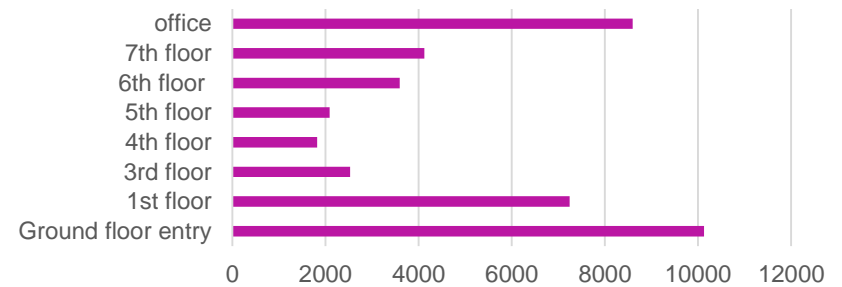
Kiilto factory

Beacon list

Material packages

Example data from positioning

Examples		Material number			
Month	Day	25	26	28	53
6	1	1	1	1	0
6	2	0	0	0	0
6	3	0	0	2	0
6	4	2	2	0	0
6	5	0	1	0	0
6	6	2	0	1	0
6	7	0	0	1	0
6	8	1	1	0	0
6	9	0	0	0	0
6	10	1	1	0	0
6	11	1	0	0	0
6	12	0	0	0	0
6	13	0	2	0	0
6	14	0	0	0	0
6	15	0	0	0	2
6	16	0	0	0	0
6	17	0	0	0	0
6	18	0	0	0	0
6	19	0	0	0	0
6	20	0	0	0	2
6	21	0	0	0	0
6	22	0	0	0	0
6	23	0	0	0	0
6	24	0	0	0	0
6	25	0	0	0	0
6	26	0	0	0	0
6	27	0	0	0	0
6	28	0	0	0	0
6	29	0	0	0	0
6	30	0	0	1	0
	total	8	8	6	4
	sum	7	7	5	3

Location-based time information of workers (minutes)

Project level time information and value-adding

Project level Total time   Project level Workplace   Project level Value-adding

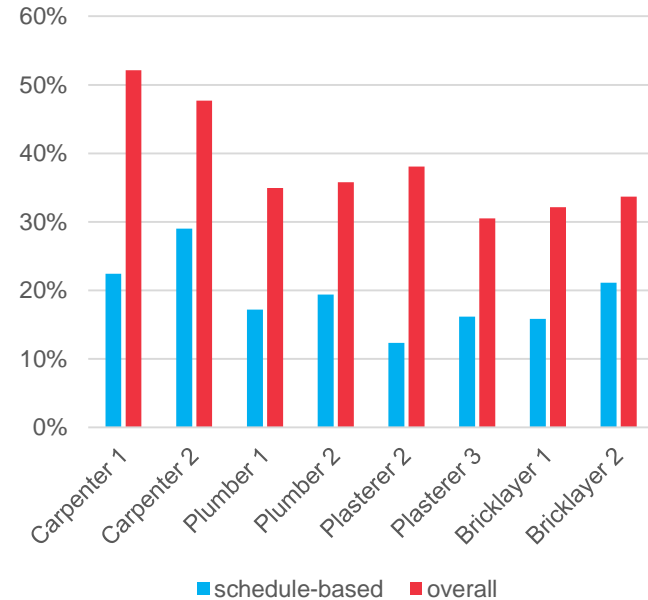Aalto University
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In-door positioning results

- **Workers in a work location more than x minutes at the time**
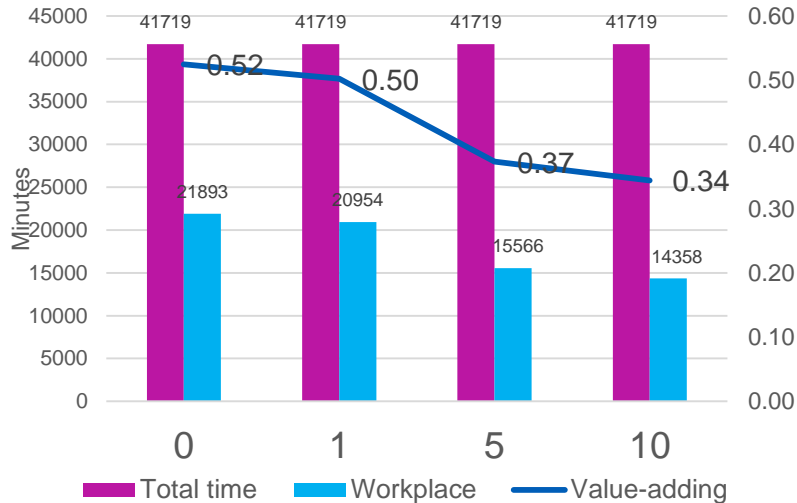
- **Workers in the correct work location**

Waste KPI's based on uninterrupted presence

1. **Presence Index, PI**

   Uninterrupted presence / actual duration
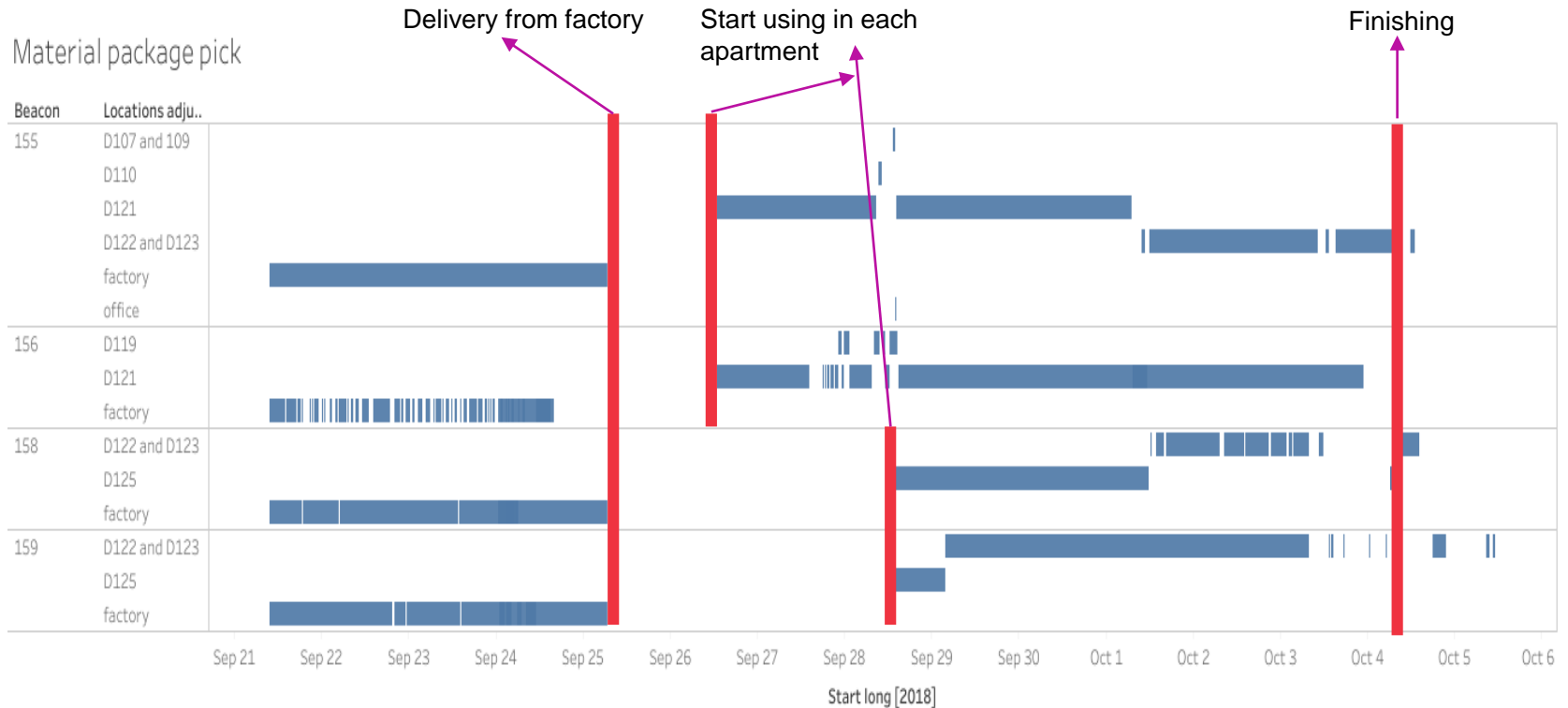
   Measured average 34.5%, large variation

2. **Presence-to-plan, PP**

   Uninterrupted presence / planned duration

   Measured average 33.8%

- Conclusion: worker has to be present just 1/3 of work time in order to achieve schedule objectives

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Material package pick

Possible uses of indoor positioning

Real-time tracking use cases in construction sites

Task status monitoring (compare actuals with the scheduled)	BIM integration for onsite condition check	Safety control	Resource searching

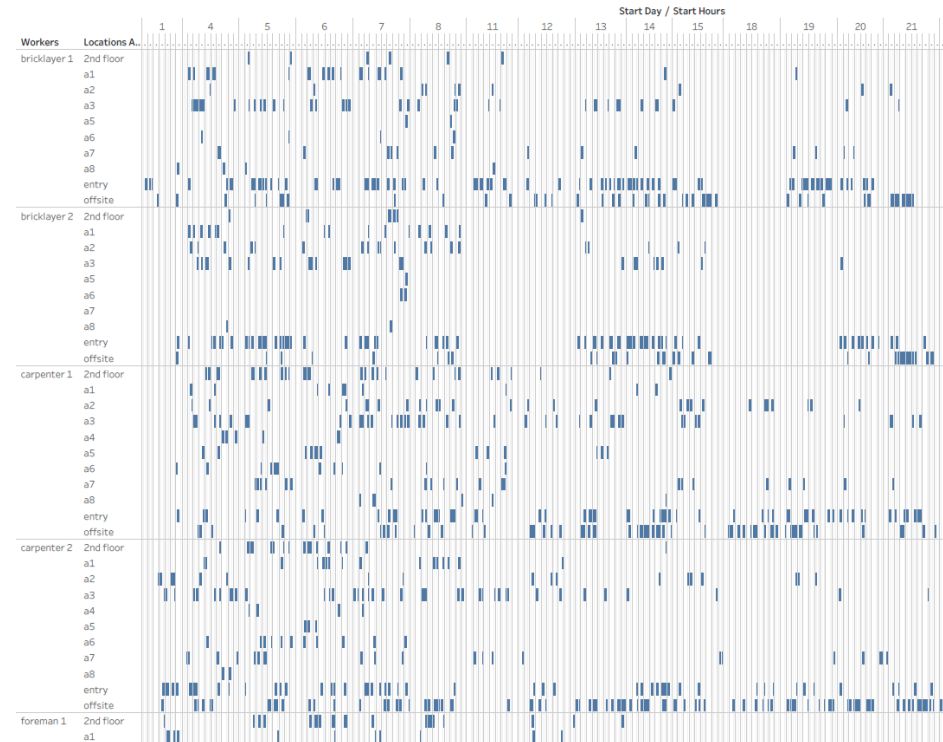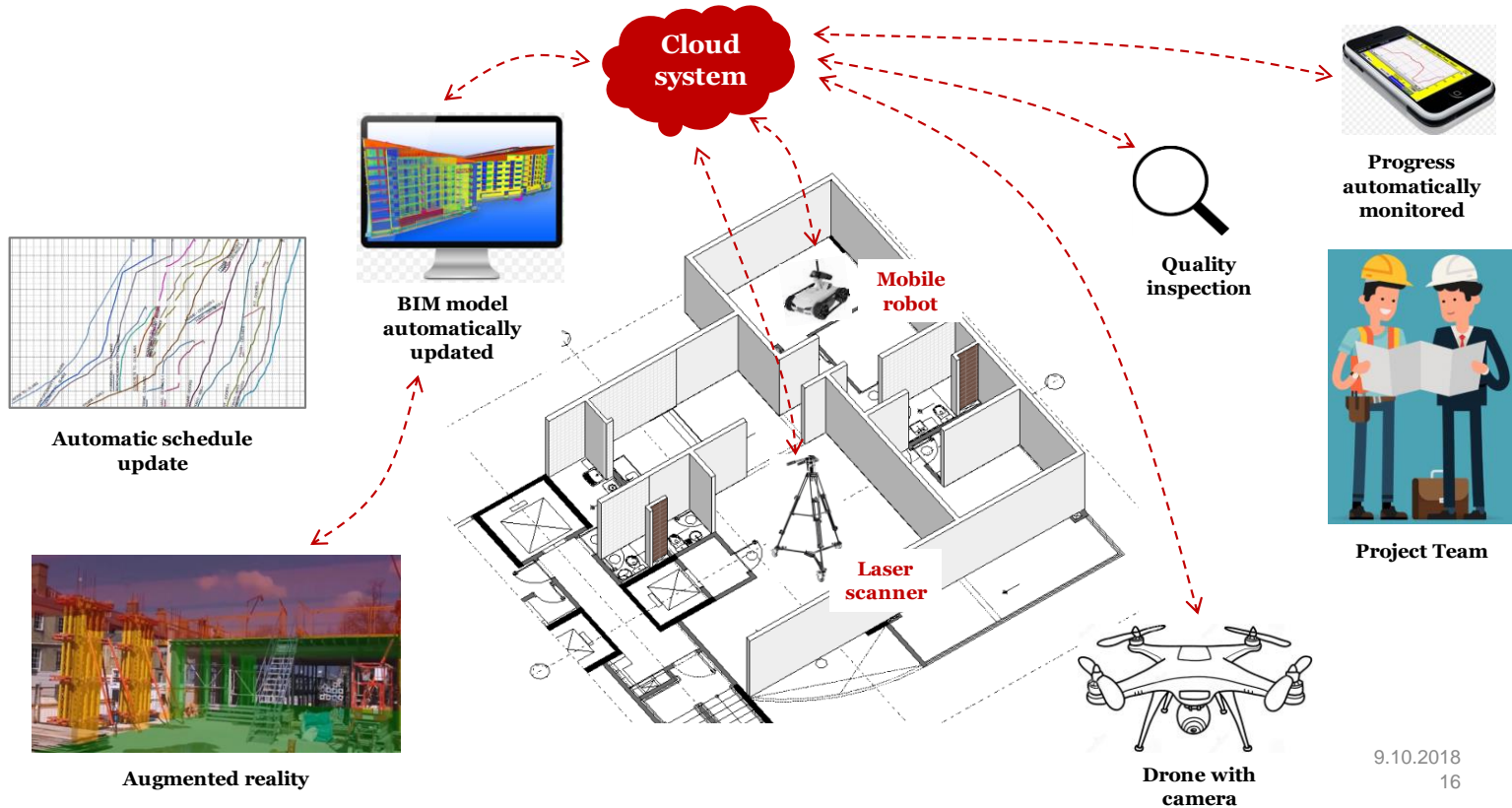| Supervise in real-time workflow compared with schedule	Check if right workers are in the right location performing right jobs	Are all materials, equipment and workers in the right place?	Visualize the work processes in BIM	Authorize workers to enter specific areas	Alert workers in dangerous areas	Locate right material, tools or people for workers in real time

Results related to indoor positioning

- **Real-time, scalable evaluation of value-adding time (~25-35%)**

- **10-20% of worker time in the scheduled locations – but no major delays!**

- **Materials move 8 times before use**

End of video 1

Automated progress through images

Cloud system

BIM model automatically updated

Automatic schedule update

Augmented reality

Mobile robot

Laser scanner

Quality inspection

Progress automatically monitored

Project Team

Drone with camera

9.10.2018
16

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Example: bathroom progress

0. Initial state

1. Demolition

2. Plastering

3. Diamond Drilling

4. Insulating pipes

5. Conduits

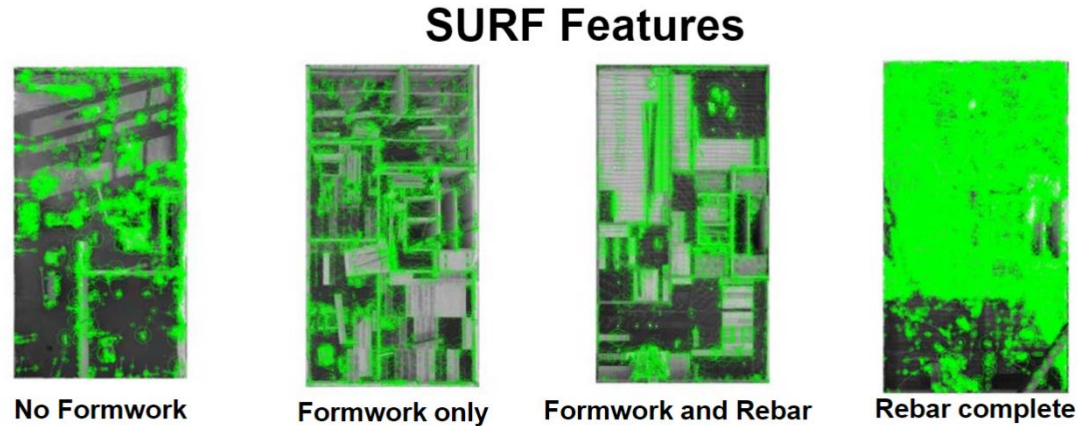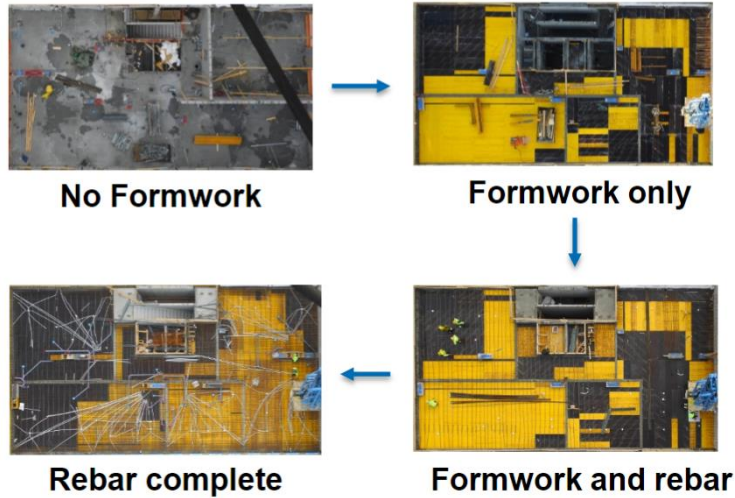6. Water Insulation

7. Tiling

8. Chrome piping

9. Connecting water pipes

10. Final cleaning

Example: crane cameras

Slab state recognition

No Formwork → Formwork only

Rebar complete ← Formwork and rebar

SURF Features

No Formwork | Formwork only | Formwork and Rebar | Rebar complete

Bag-of-visual words

Feature Vector → SVM → Label NF,F,R,Rc

Training Set

- **Small set of images sufficient for training the classifier well**
- **Testing accuracy: 100%**

All images

Label	Count
No Formwork (NF)	39
Formwork (F)	30
Rebar (R)	7
Rebar Complete (Rc)	8

Training Set

Label	Count
No Formwork (NF)	3
Formwork (F)	4
Rebar (R)	1
Rebar Complete (Rc)	1

Example: quality issue detection, 85% accuracy for door frames

Example: concrete element factory

Camera mounted on mobile crane, staircase extracted from images and rebars recognized

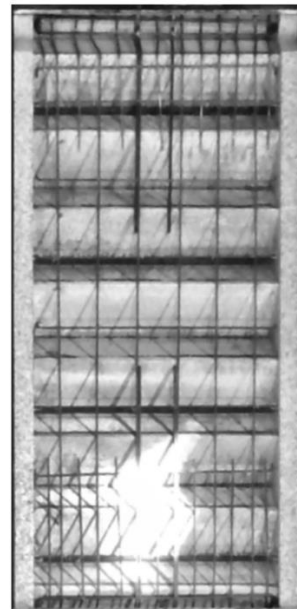Staircase localization: IOU 0.5: 1.0, IOU 0.7: 1.0, IOU 0.9: 0.96

Rebar detection. **F1 score**.

- A1 - A2 – MODIX: **0.79**
- X5 - Y7: **0.69**
- U3: **0.63**

Captured photo

Extracted staircase

Recognized rebars

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Reality Capture conclusions

- **Already now it is possible to automatically evaluate progress and find quality issues from images**

- **The problem is getting enough data to train the algorithms**
    - Images
    - Massive data collection

- **Images form an important part of situational awareness in construction**

Other data collection

- **Other ways to automatically get situation data:**
    - Meeting minutes (text analysis)
    - Communication tools (site WhatsApp etc.)
    - Environmental sensors (concrete drying, humidity, temperature etc)
    - Planning systems
    - Integrating to supplier systems

From data collection to situational awareness?

- Automated data collection results in huge amounts of data
- Data storage needs to be standardized

- Role-specific dashboards are required

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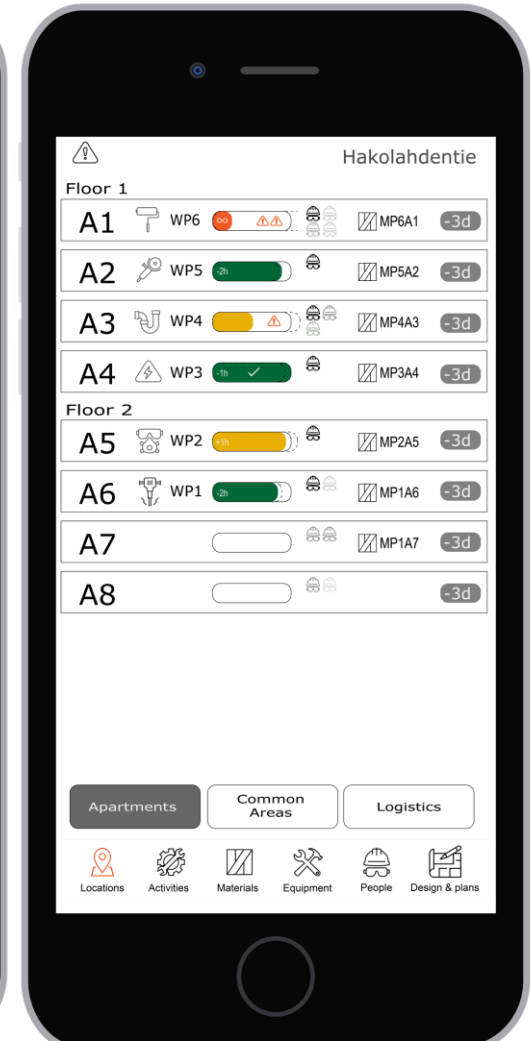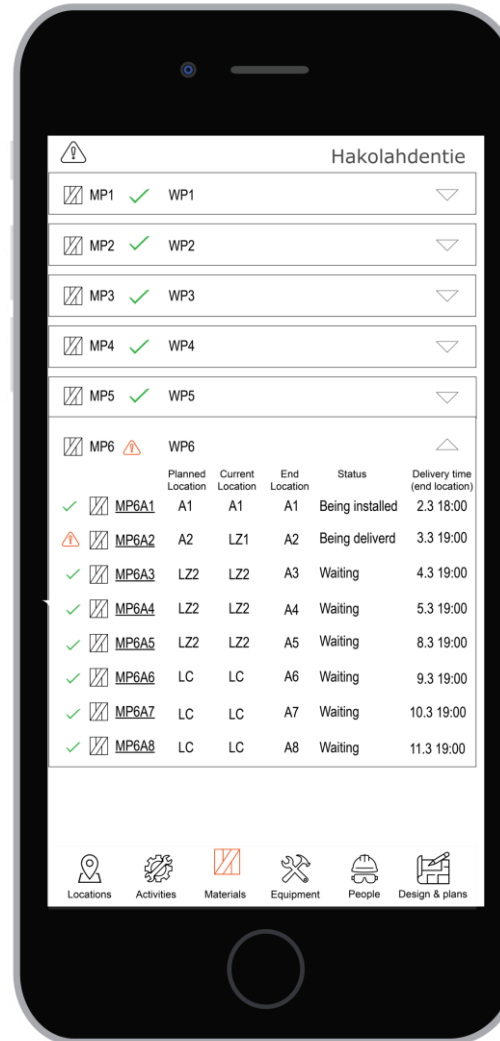
Digital twins of process
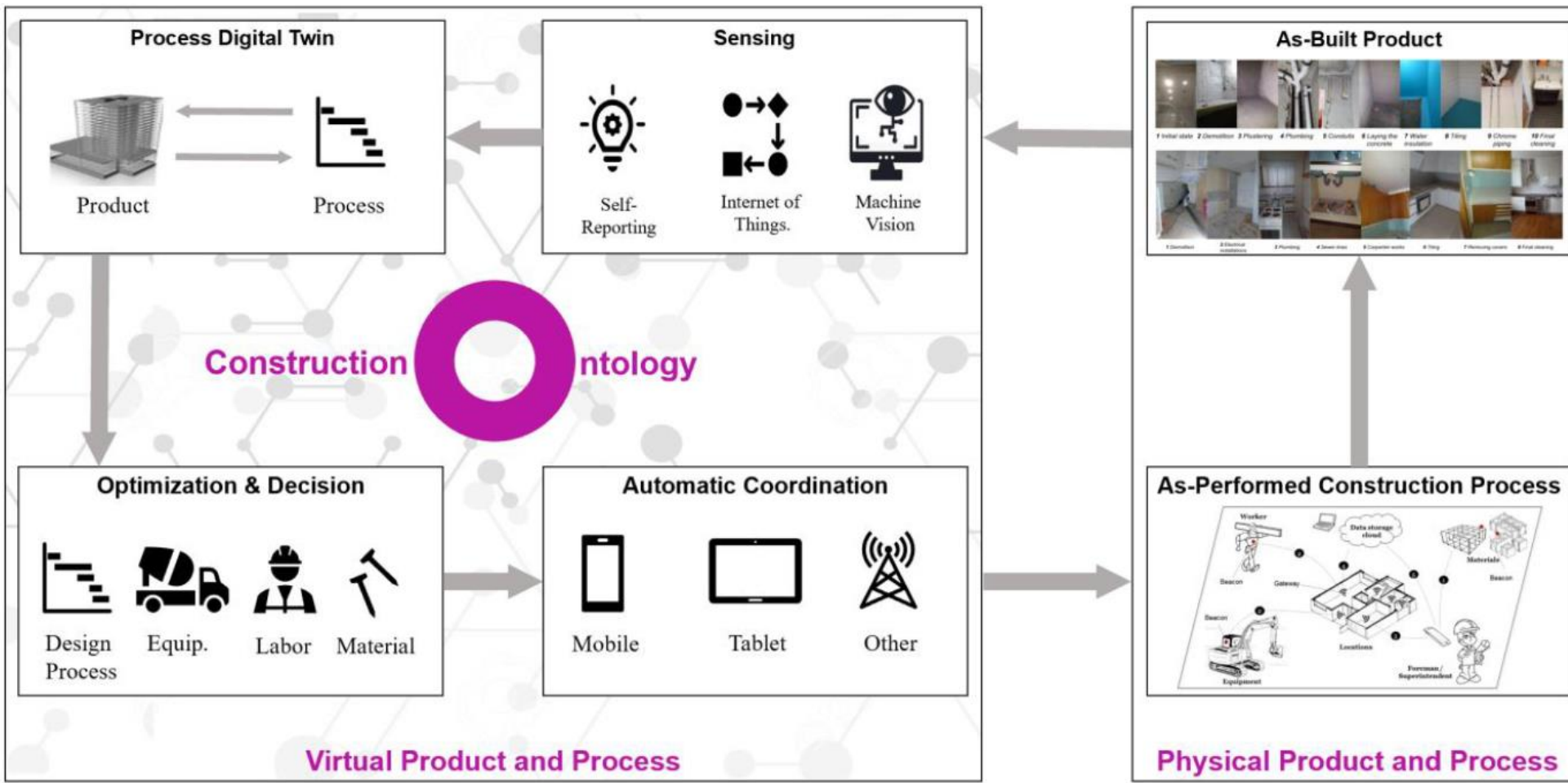
All data must be linked and flow

Design data

Product data

Production data

IoT / Reality Capture

As built data

Distributed common workflow data
- Linking workflows with data across all parties
- Collaborative data creation respecting data ownership
- Sharing based on standard ontologies and formats

Advanced multi-platform tools and services

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Thank you
Questions &
Comments