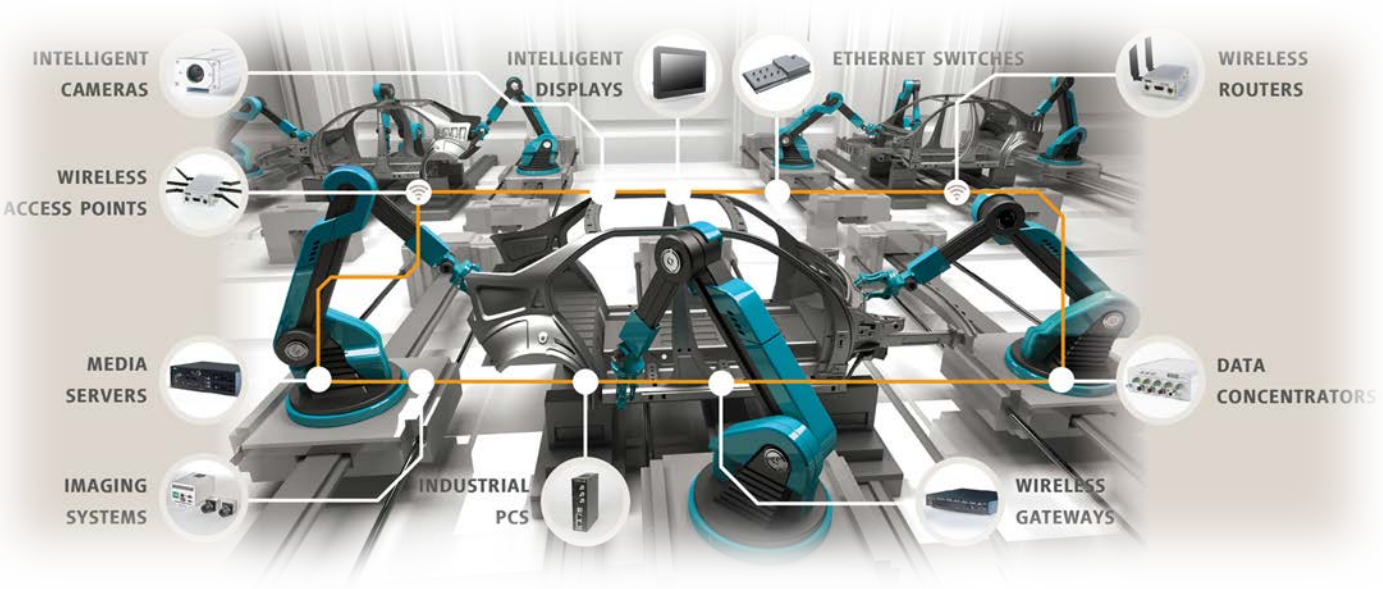
THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

RESEARCH INSTITUTE
FOR SUSTAINABLE URBAN DEVELOPMENT
可持續城市發展研究院



Construction Industrialization: Research & Development

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The Hong Kong Polytechnic University

Presentation at CEDD Annual Concrete Seminar 2018

9 May 2018

1. The Past


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2. The Present

Construction matters for the world economy

... but has a long record of poor productivity

Construction-related spending accounts for **13%** of the world's GDP

...but the sector's annual productivity growth has only increased **1%** over the past **20 years**

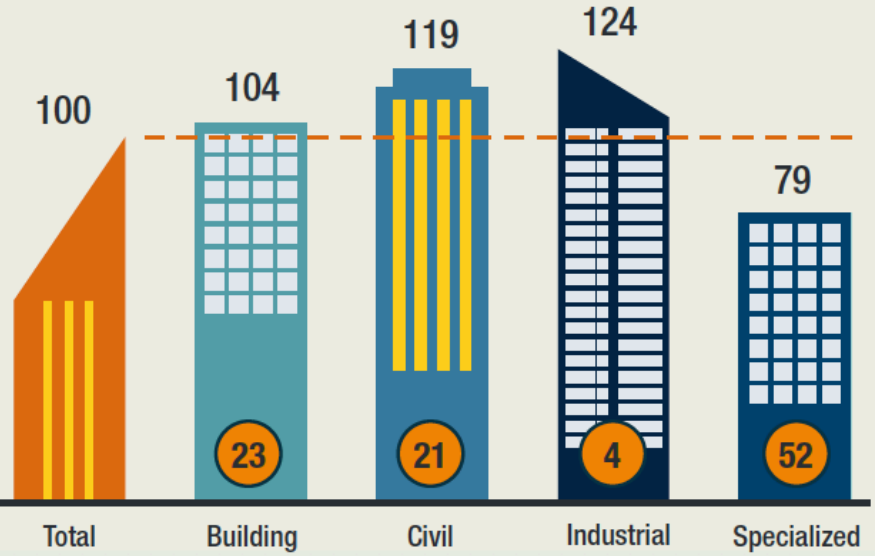
$1.6 trillion **of additional value added** could be created through higher productivity, meeting **half the world's infrastructure need**

Construction is a sector of two halves

Fragmented specialized trades drag down the productivity of the sector as a whole

Construction productivity by subsector
Value added per employee, indexed total sector=100, 2013

● % of construction value added



Source: McKinsey & Company, 2017

Construction Industrialization

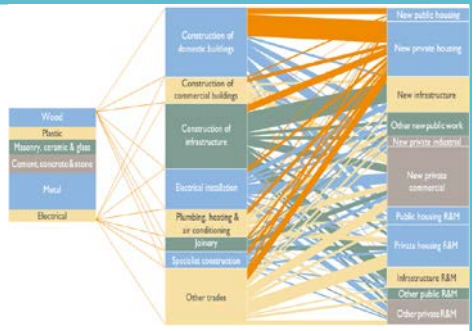
1. Prefabrication
2. Mechanisation
3. Automation
4. Informatization
5. Customisation

3. The Challenges

Challenges in Construction Industrialization

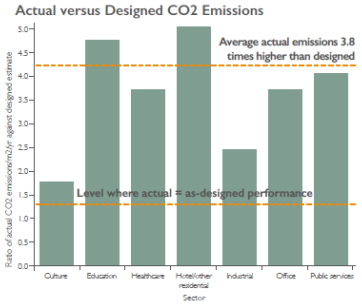
Economy: *Inefficient Resources Allocation*

- Supply Chain Confusion
- Multiple transactions and Multiple on-costs
- Repetitive and non-standardized Design
- Excess Capacity in Prefabrication Manufacture Sector
- Lack of circular economy strategy in control the cost of labor, material, machine, equipment



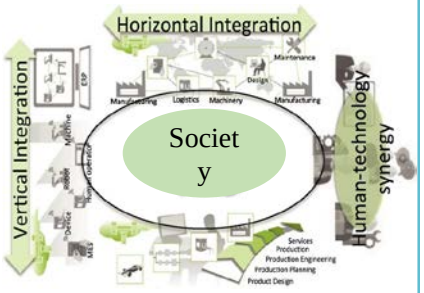
Environment: *Pollution, Waste and Energy Consumption*

- Transfer the noise, dust, waste from site to plant
- Building energy consumption accounts for 20% of the total energy consumption in China*
- Carbon emission
- Lack of using renewable energy and material



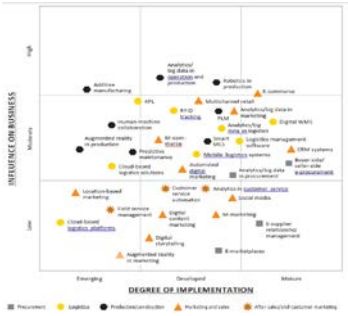
Society: *Disconnection of Stakeholders in Global Value Chains*

- Low level of customization
- Low level of servitization
- Low level of horizontal integration among different stakeholders



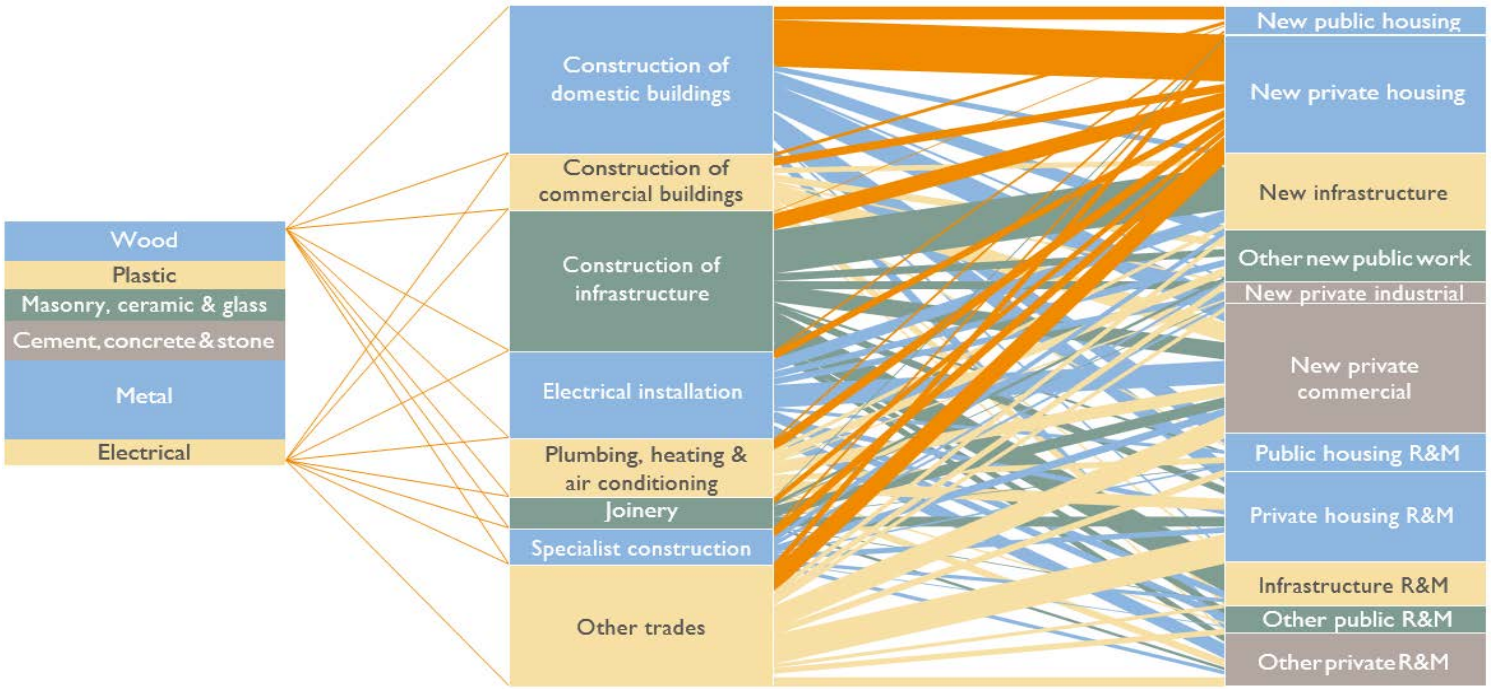
Technology: *Fragmentation of Real objects, Information, Processes*

- Lack of interoperability among software, tools and systems
- Lack of ability of awareness, autonomy and communicativeness in each physical objects.
- Lack of advanced material for additive manufacturing
- Low level of automation and numerical command
- Low level of machine to machine communication
- Disconnection between physical environment and virtual platform



Economy: *Inefficient Resources Allocation*

- **Supply chain management**
- Multiple transactions and multiple on-costs
- Repetitive and non-standardized design
- Excess capacity in prefabrication manufacture sector
- Lack of circular economy strategy in control the cost of labor, material, machine, equipment



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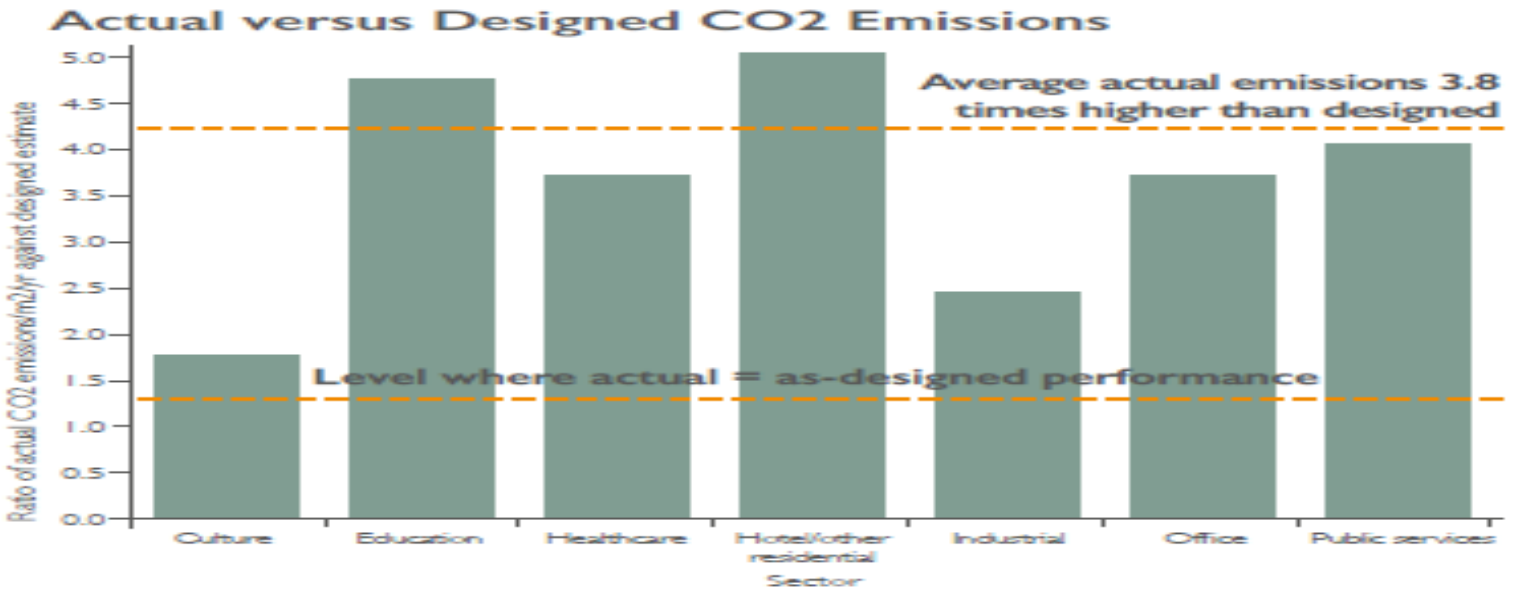

Data Source: Chinese Building Energy Research Report (2017)
Image Source: Innovate UK, Building Performance Evaluation Programme: Findings from non-domestic projects (2016)

Society: *Disconnection of Stakeholders in Global Value Chains*

- **Lack of mass customization**
- Without geo-demographic driven solutions
- Without virtual workforce
- New occupations and unskilled labor
- Lack of policy support

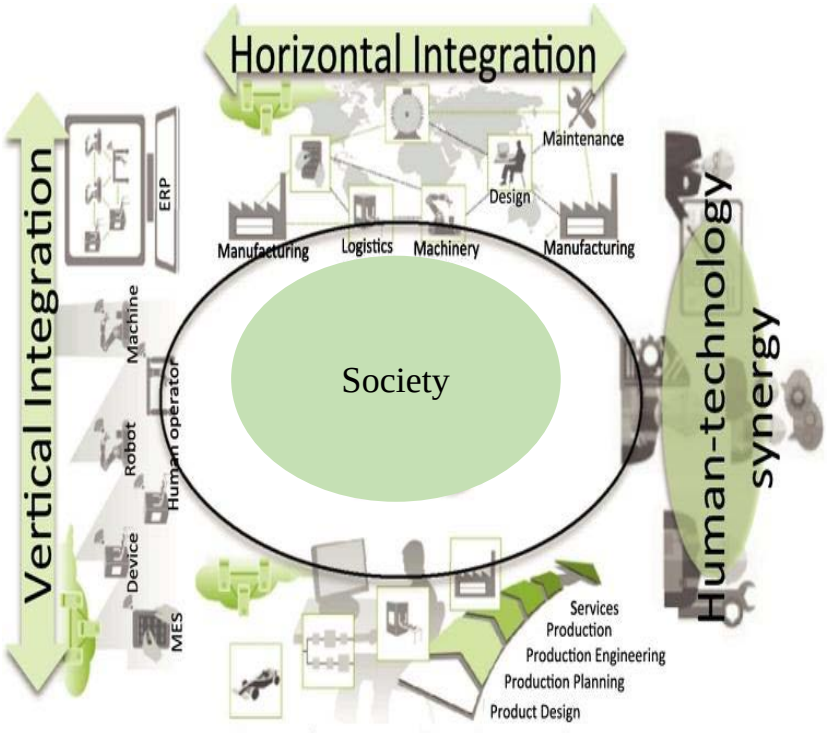

Image Source: Marques, M., Agostinho, C., Zacharewicz, G., & Jardim-Gonçalves, R. (2017). Decentralized decision support for intelligent manufacturing in Industry 4.0. Journal of Ambient Intelligence and Smart Environments, 9(3), 299-313.

Technology: *Fragmentation of Real Objects, Information, Processes*

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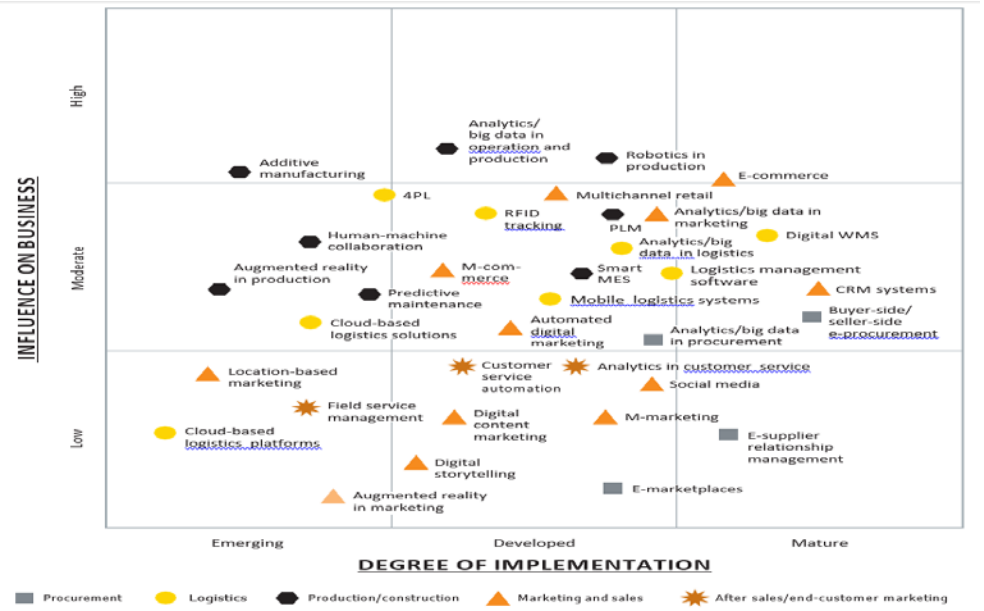


Image Source: Desk research, interviews, Roland Berger

4. The Future

SMART CONSTRUCTION OBJECTS

- Capture real-time data of **precast elements**
- Share real-time data among **major stakeholders**

RFID Reader

Android Phone with Developed Apps

RFID Tag

NFC Tag

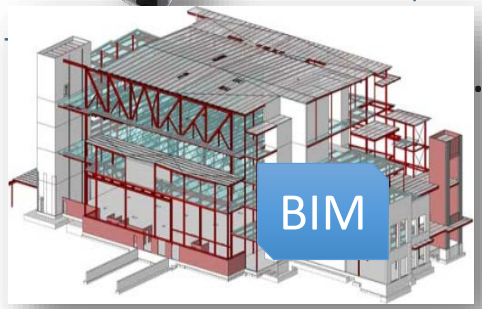
IoT + Prefabrication

Problems to address:

- Coordinate different stakeholders
- Schedule precast in very small site
- Update BIM model with real data
- Detect misplacement of precast concrete

....

Construction Physical Internet



The Hardware

- RFID tag
  - UHF tag encapsulated in strong plastic shell
- Bind on steel before casting
- Read from hand-held reader
- Reader sends data to cell phone through Bluetooth
- Staff cards are used for authenticate (via NFC) instead of username/password for mobile app

APP to Read from Hardware

Function menu

Sign in with staff Card

1. Receiving (optional)

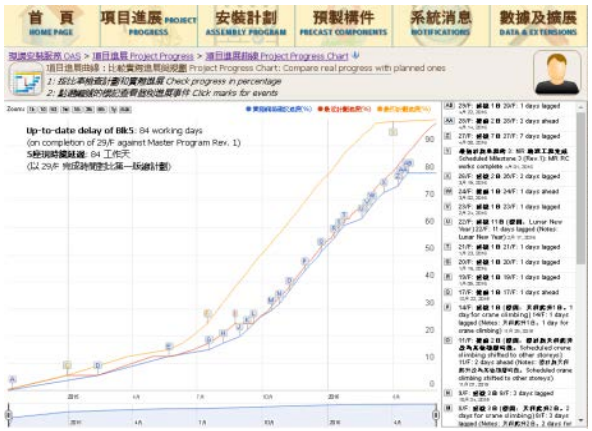
3. Inspections (optional)

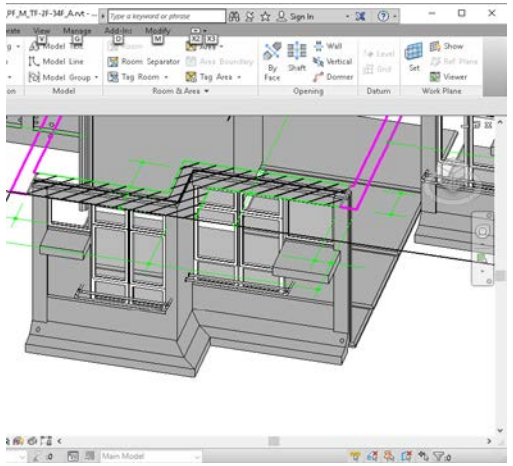
2. Erection with guides

- Login with staff card
- Water-proof mode
- Lock screen when operating

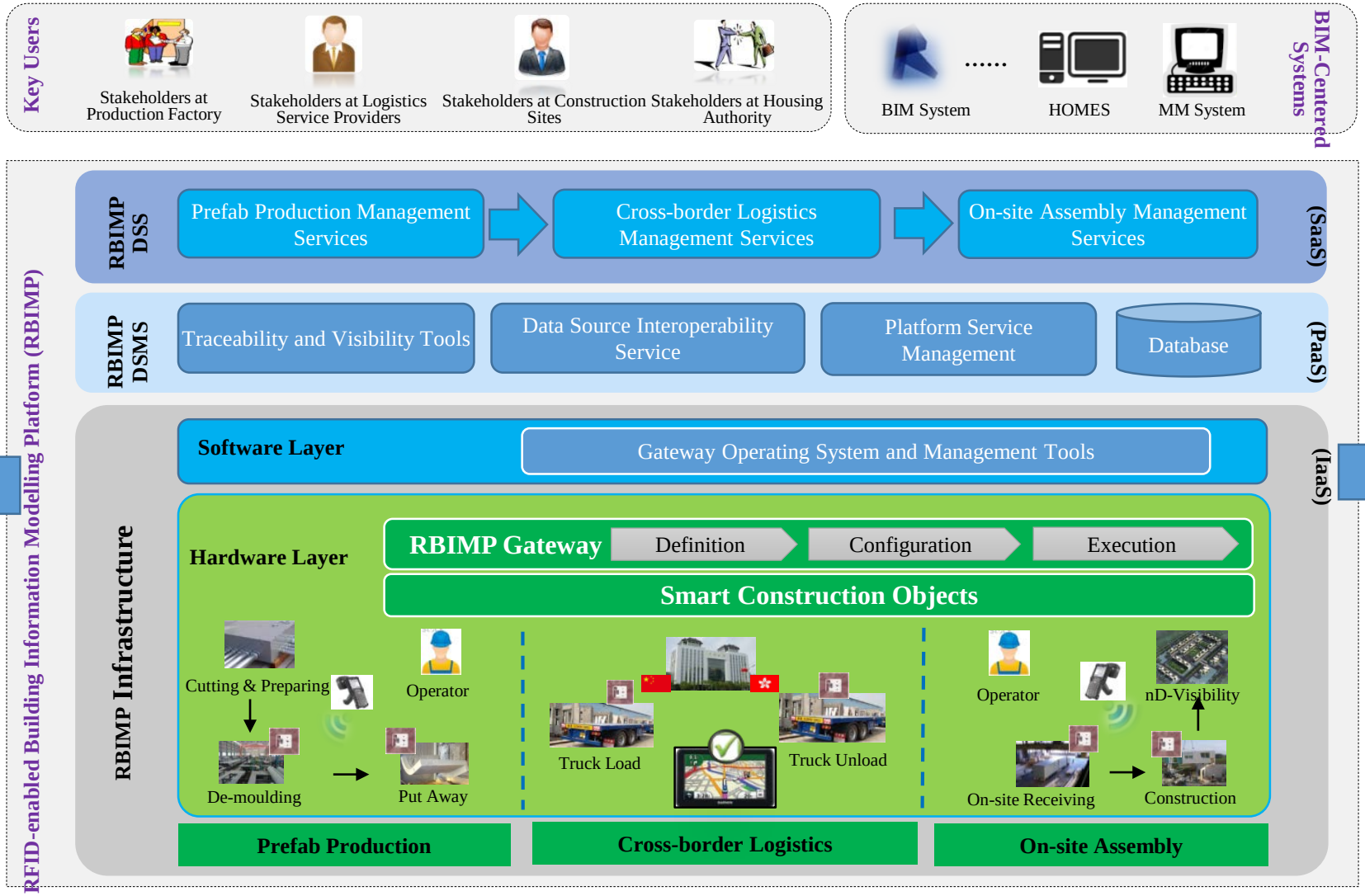
SMART DECISION SUPPORT

- Coordinating orders for **major stakeholders**
- Anticipating problems in **supply chain management**





Platform Structure



RFID-enabled BIM Platform for Prefabricated Housing Production

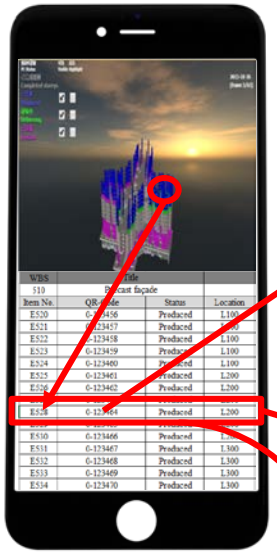
Service 1: a prefab manufacturing service for managing and searching prefabricated components from factory, buffer and laydown area in a more prompt and efficient manner by adopting QR code/barcode/RFID technologies.

Background

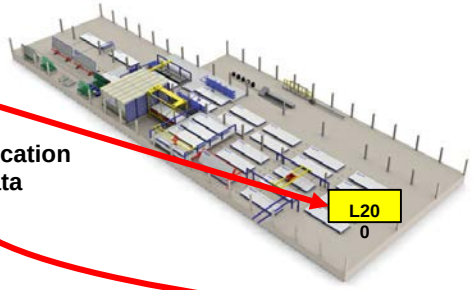
Scenarios

Focus Area

Research Plan



3D shape & specification data



Location Data

Productivity indicators:

- Stock management (e.g. number of precast components/assets not been correctly selected , number of precast components/assets not been prepared for pickup)
- Production lead time (e.g. time to locate precast components and corresponding position, delays in logistics activities waiting for precast components)

The availability of prefabricated components in factory

RFID-enabled BIM Platform for Prefabricated Housing Production

Service 2: a cross-border logistics service to facilitate the prefabricated components to be traceable and delivered just in time.

Background

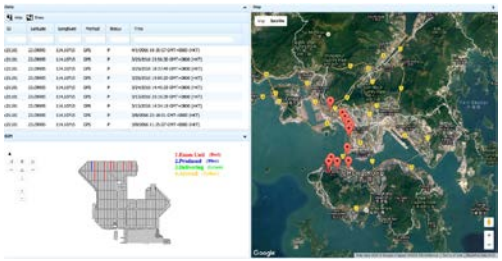
Scenarios

Focus Area

Research Plan

(1) Vehicle scheduling and task allocation

(2) Vehicle real-time traceability



Productivity indicators:

- Vehicle scheduling (e.g. time to arrange tractor to arrive in factory/buffer/laydown area, number of errors in matching tractor and trailer)
- Task allocation (e.g. time to allocate the driver)
- Accuracy and frequency of the vehicle tracking

RFID-enabled BIM Platform for Prefabricated Housing Production

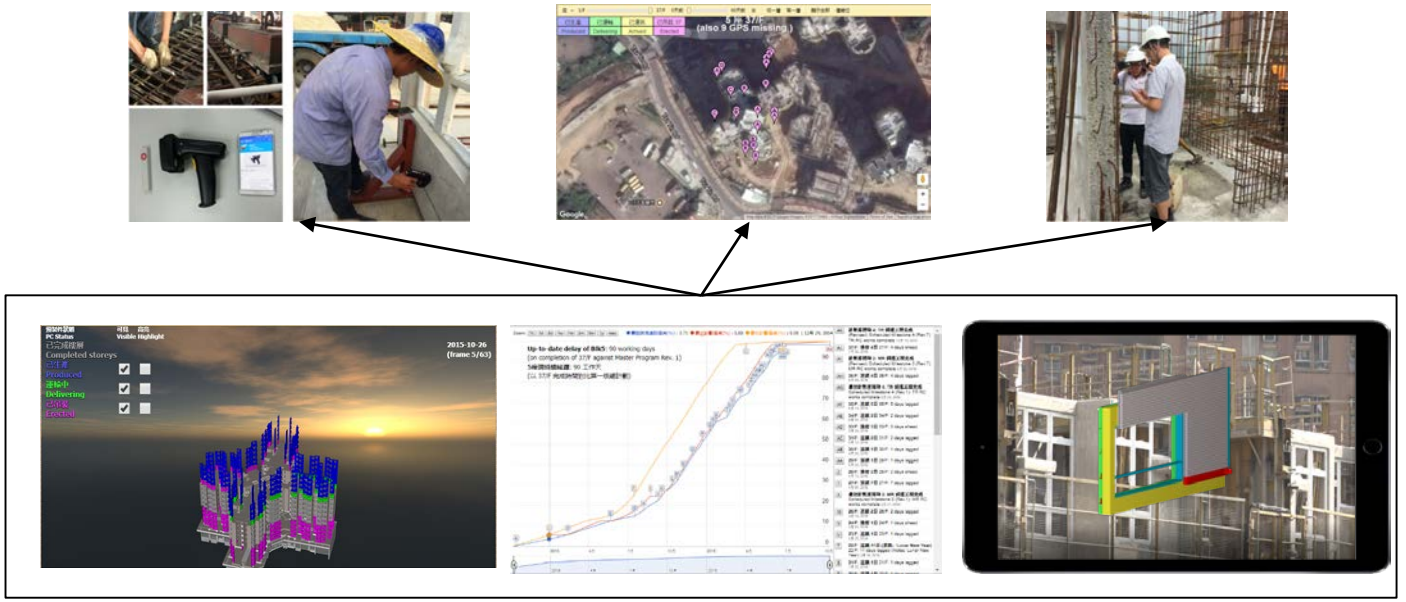
Scenario 3: a construction assembling service to integrate the Auto-ID technologies into BIM platform to precisely and visually monitor and alarm assembly progress for time and cost management.

Background

Scenarios

Focus Area

Research Plan



Productivity indicators:

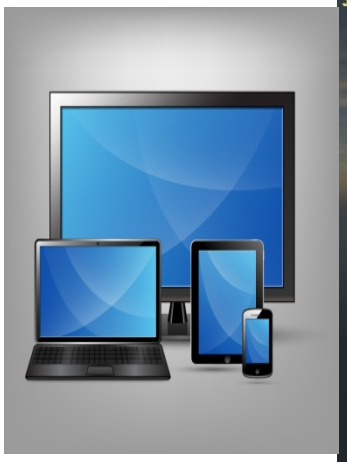
- Assembly productivity (e.g. time to assembly each prefabricated component, number of errors in assembly, number of unrepaired prefabricated component in assembly
- Compatibility of visualization tools

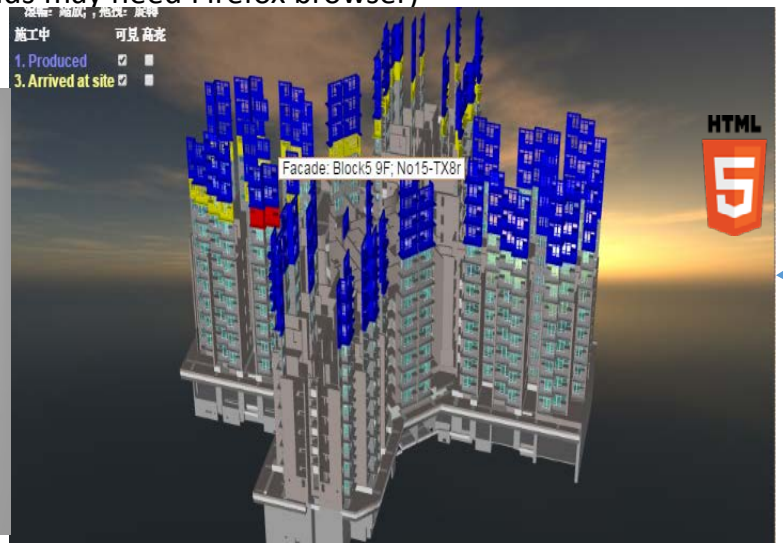
Real-time BIM Visualization

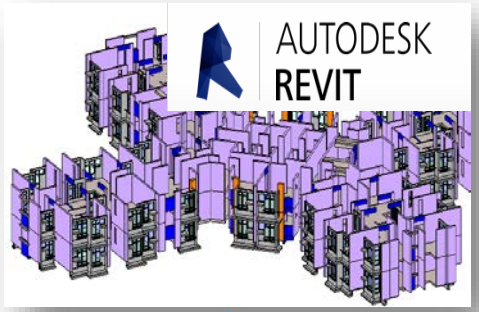
Real-time *n*D model on web

- Compatible with any PC, Smart phone* and tablet*
- Colors representing status of precast components
- By converting BIM models from *expensive & large* software to *free & light-weight* WebGL format

(*: some Androids may need Firefox browser)







Monitoring of Project Progress

Estimate volume of works

- by BIM and actual assembly
- Compared with planned progress

5. Conclusions

- Smart industry, smart technologies
- Accurate and reliable information
- More efficient cross-border logistic and SCM
- Real-time monitoring: alert, alarm, action
- Integration with existing ERPs
- Seamless communication among stakeholders
- Immediate identification of installation errors

- **Look forward to collaborations with you!**

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Thank You!

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