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MiC logistics and supply chain QA/QC during the COVID-19 pandemic time: A trilogic solution based on BIM and blockchain

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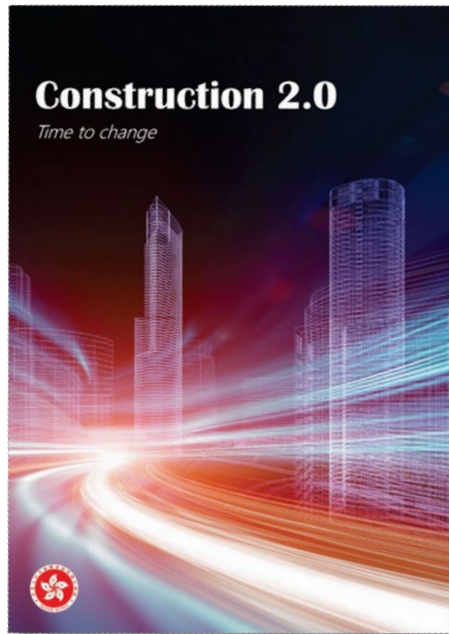
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1. Starting from Construction 2.0



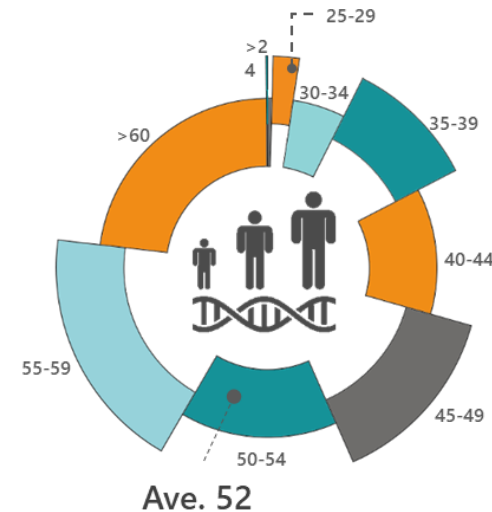
<https://www.psgo.gov.hk/assets/pdf/Construction-2-0-en.pdf>

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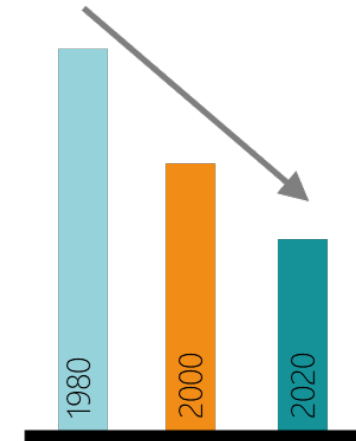
Construction
Cost

The Construction cost
in HK is the third
highest in the world



Aging

Average age of skilled
construction workers is 52



Construction
Techniques

There is a decrease in
construction techniques



2. MiC as a response to the Construction 2.0 report as a strategy of procurement innovation

Modular Integrated Construction (MiC) is an innovative construction method. By adopting the concept of “factory assembly followed by on-site installation”, MiC helps to ease some of the current challenges faced by the local construction industry. In this method, free-standing integrated modules (completed with finishes, fixtures and fittings) are manufactured and assembled in a factory. By transferring on-site construction processes to a controlled factory environment, buildings can be substantially completed off-site. The adverse impacts of weather conditions, scarce labour resources and site constraints can all be substantially reduced. MiC provides a great degree of production quality control, and can improve construction productivity, safety and sustainability.

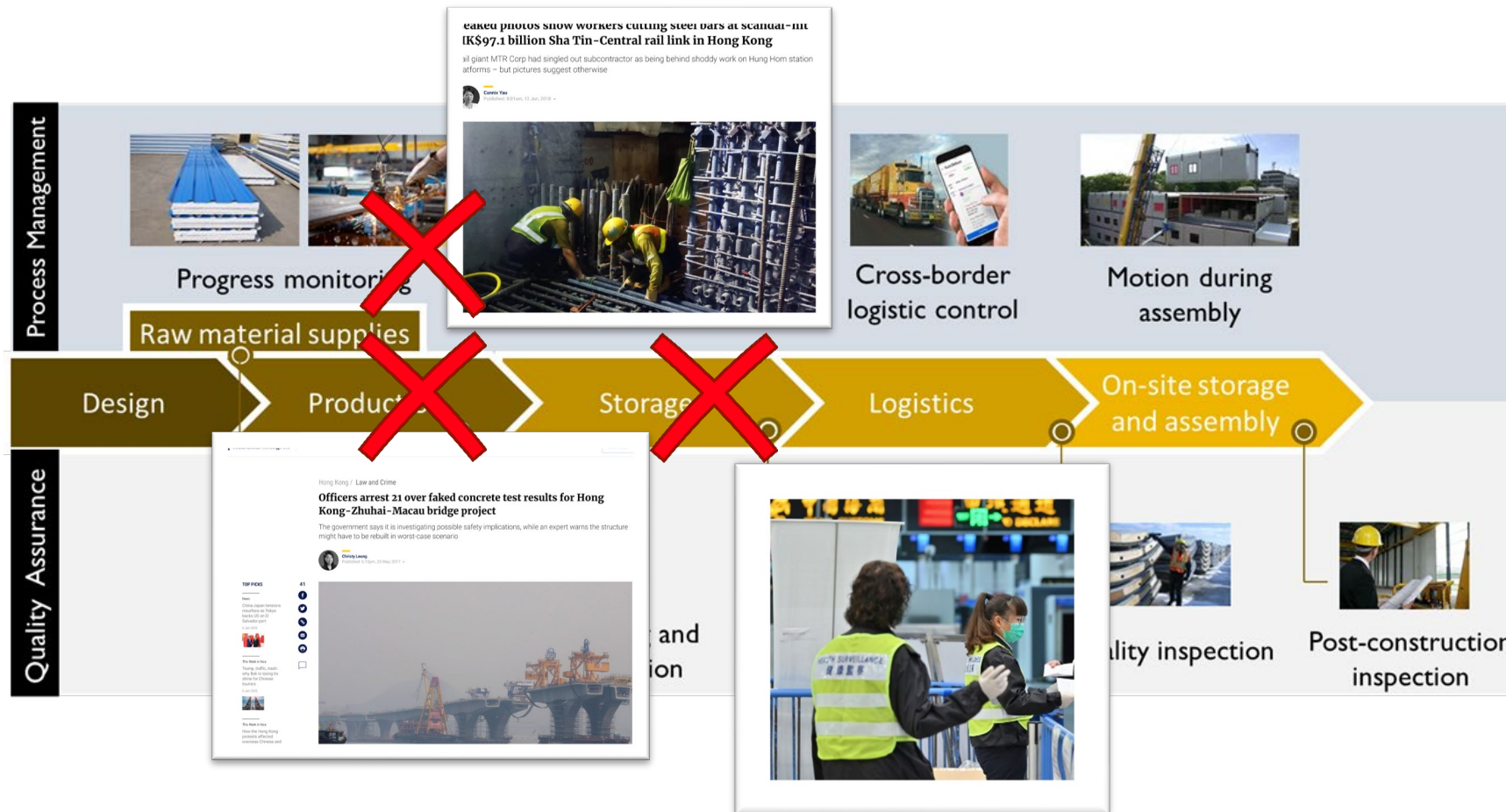
Source: CIC website



Courtesy: HKU Estate Office



3. MiC logistics and supply chain QA/QC during the difficult time





3. MiC logistics and supply chain QA/QC during the difficult time



Quality inspections required at
Mainland factories



Infeasible to dispatch now due to 14 + 14
days quarantines

(Photo source: Authors, SCMP)



4. Our trilogy (MiC 三寶)





4. Our trilogy (MiC 三寶)



Off-Site Production

- **Digitalized** workflow procedures
- Detailed record of **inspection records** carried out by AP/RSE/RC streams
- **Test reports** uploads
- **Production progress** status



Cross Boarder Logistics

- **Real time tracking** of modules during transportation
- **Pin point** exact location of module
- Estimated **arrival time**



On-Site Installation

- **Real time** update of installation progress
- **Positioning checking** for installed modules
 - Recording of **installation time**



4. Our trilogy (MiC 三寶)



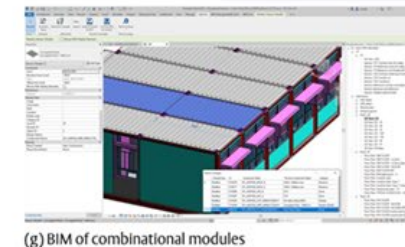
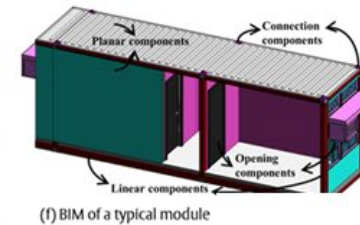
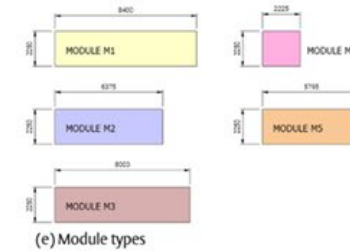
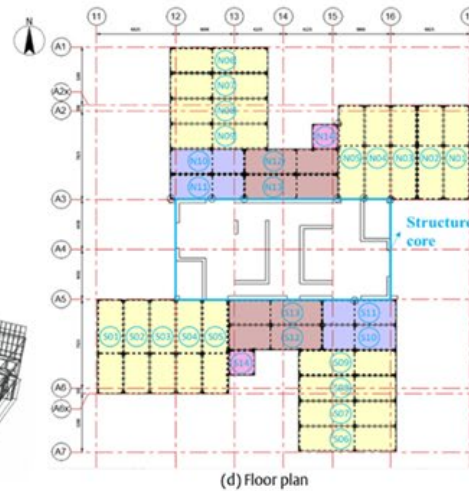
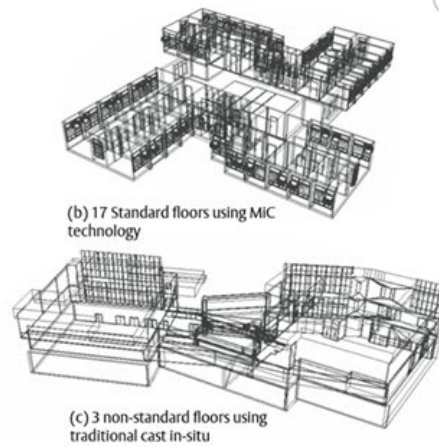
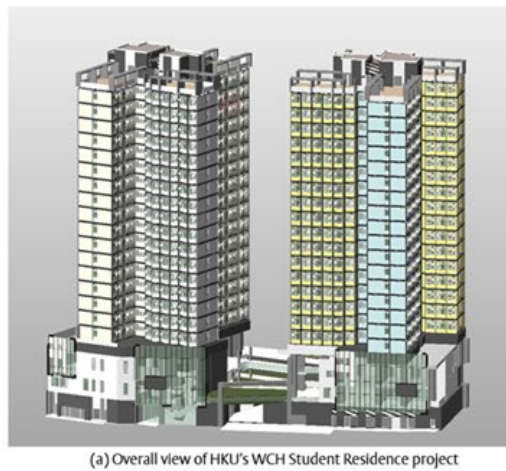
- A 3-storey non-residential podium with common space, canteen, support facilities and car-parking space
- Two 17-floor towers of student residences and staff accommodation
 - 1,224 hostel places
 - Site Area: 4306 m²
 - NOFA: 14,277 m²
 - CFA: 28,176 m²





4. Our trilogy (MiC 三寶)

Figure 1 - The Pilot Project



Project Name: HKU's Wong Chuk Hang Student Residence
Functions: A total of 1224 student places and supporting facilities such as canteen, common room, laundry rooms and car park
CFA: 28,176m²
Contract sum: ~HK\$1.1 billion
Address: Police School Road, Wong Chuk Hang, Hong Kong
Structure: Two 17-storey tower buildings on top of a 3-storey podium
Construction technology: Modular Integrated Construction (MiC)

buildingSMART Tools used:



Software Used:



4. Our trilogy (MiC 三寶)

Off-Site Production Workflow

Workflow and Inspection and Test Plan (MIC Factory Process) Hostel Room										
Sl. No.	Item	Description	Inspection / Test Point	Point / MIC	Test	Qty	Test	Unit	Criteria	Remarks
0		Steel material delivery 鋼材運到	FORM WORKING AND MATERIALS CHECK	As per RE req. no.	H	C				
1		Rein. profile production and punching 鋼材加工及沖孔	Steel reinforcement 鋼筋加工	Routine	H				Re inspection	
2		Element flat top casting treatment 鋼筋表面處理	STEEL REINFORCEMENT 鋼筋加工	Routine	H	C			Re inspection	
3		20 Form Assembly (Steel wall and Floor slab) delivery 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
4		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
5		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
6	Insulation	20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
7		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
8		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
9		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
10		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
11	Roofing	20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
12		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
13		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
14		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
15		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
16	Roofing	20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
17		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
18		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
19		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
20		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
21	Roofing	20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
22		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
23		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
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26	Roofing	20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
27		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
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31	Roofing	20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
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41	Roofing	20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
42		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
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46	Roofing	20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	
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50		20 Form flat top 鋼筋加工	STEEL REINFORCEMENT 鋼筋加工	Routine	C				Re inspection	

Transform 40+ workstage procedures into a digital platform

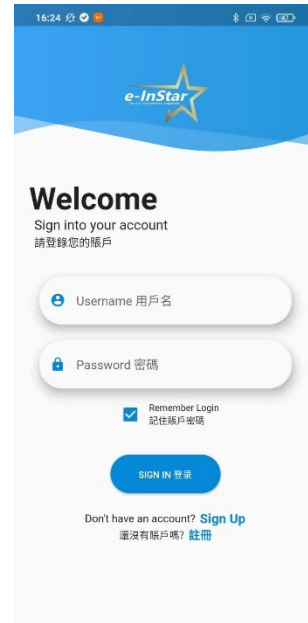
Item	no.	Location	Inspection Test Method	Frequency	Fix n	RTR	SP	EC	Client Ref	Follow up	NO
16	2nd	System Plaster and Sanding (wall and ceiling) 柱及	Visual Inspection								Inspected
17		1st layer painting (horizontal room and corridor) 柱面及天花第一層之牆紙及天花漆	Visual Inspection								Follow up
18		Second layer painting 第二層牆紙	Visual Inspection								
20		Top coat paint (ceiling) 天花頂漆	Visual Inspection	Routine	C						
21	ENJ	Unbreakt Fluting (at Corridor Ceiling) 抗衝擊裝飾板吊頂	Visual Inspection	Routine	C						
22		Decorative Glass Wiring 樓梯玻璃扶手欄杆	Visual Inspection	Routine	C						
23		Installation of sprinkler pipes (sprinkler reverts to contract) 安裝噴水系統水喉(請參閱合約)	Visual Inspection	Visual Inspection							
25		Sprinkler Pipes Air Pressure Test 水喉噴水系統氣壓測試	Visual Inspection	Visual Inspection							
26	ENJ	Apply paint to EEM Services 鐵閘表面噴塗漆	Visual Inspection	Routine							
27		MEP Tra Firing Window Type AC Installation 機械發熱窗式中央冷氣機安裝	Visual Inspection	Routine	C						
28		MEP Final Firing Lighting & Wiring Accessories 機械發熱、照明、電線、開關等	Visual Inspection	Routine	C						
29		Final Firing Lighting & Wiring Accessories 機械發熱、照明、電線、開關等	Visual Inspection	Visual Inspection							
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165		Final Firing Lighting & Wiring Accessories									





4. Our trilogy (MiC 三寶)

Inspection Record



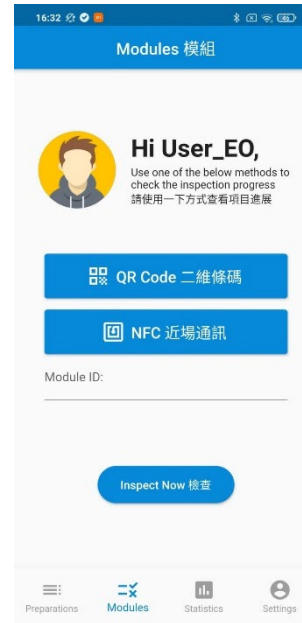
Two Factor Authentication



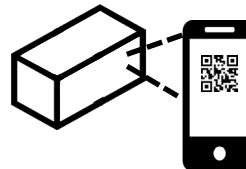
User ID



Fingerprint
verification



Scan Module ID



Inspection status of module





4. Our trilogy (MiC 三寶)

Inspection Record



3:27 PM

Inspection 檢查

Rebar fixing Visual Inspection, Cleaning 鋼筋固定檢測、清潔

Dimension result 尺寸結果:

S NS

Remarks 備註:

Write your remarks here... 此處寫備註...

Photo 現場照片:

Take Photos 拍攝相片

Comment box

3:27 PM

Inspection 檢查

此處寫備註...

Photo 現場照片:

Take Photos 拍攝相片

Instruction 輔助教程 (doc, drawing):

See Help 幫助

Submit 提交

Help button

14:23

Inspection Record 檢查記錄

Remarks 備註:

Dimension Result 尺寸結果: S

Photo Records 相片記錄:

Take Photos 拍攝相片

Photo upload function

14:23

Inspection Record 檢查記錄

Water Test for chassis enclosure 壳体防水 (AP spot check)

Remarks 備註:

Dimension Result 尺寸結果: S

Photo Records 相片記錄:

Take Photos 拍攝相片



4. Our trilogy (MiC 三寶)

Blockchain visualization



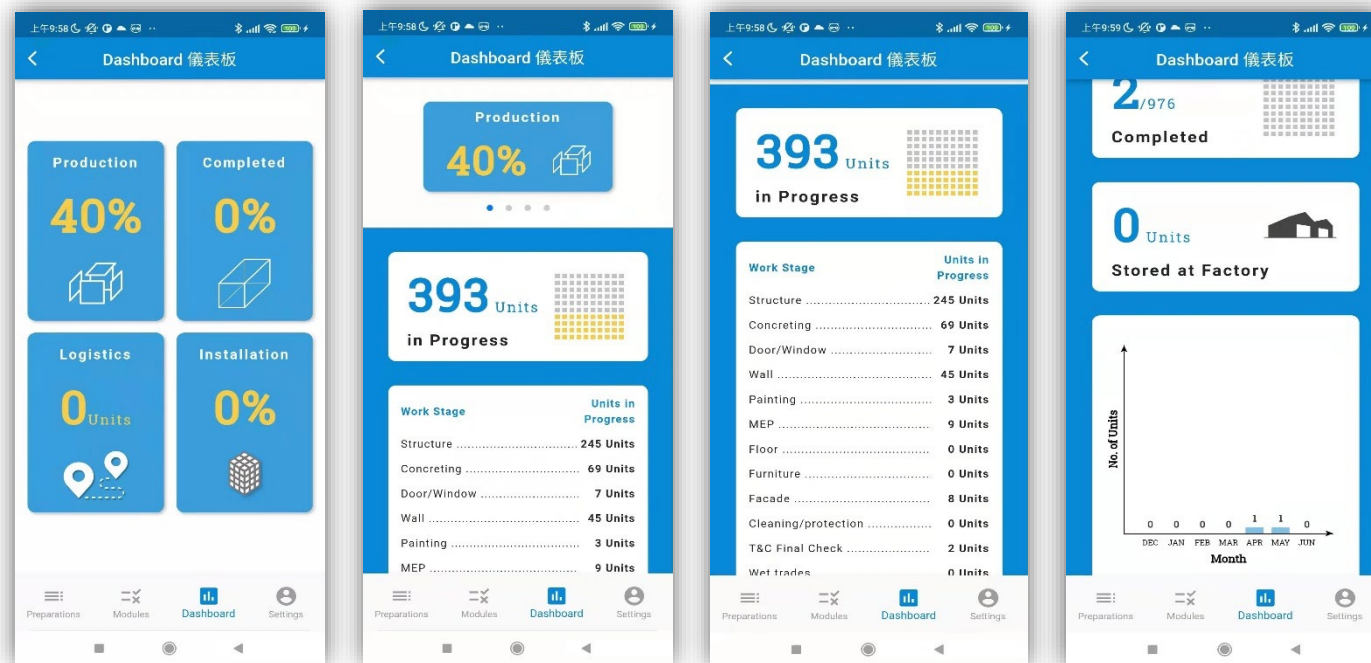
Transaction
(Inspection record)





4. Our trilogy (MiC 三寶)

Dashboard

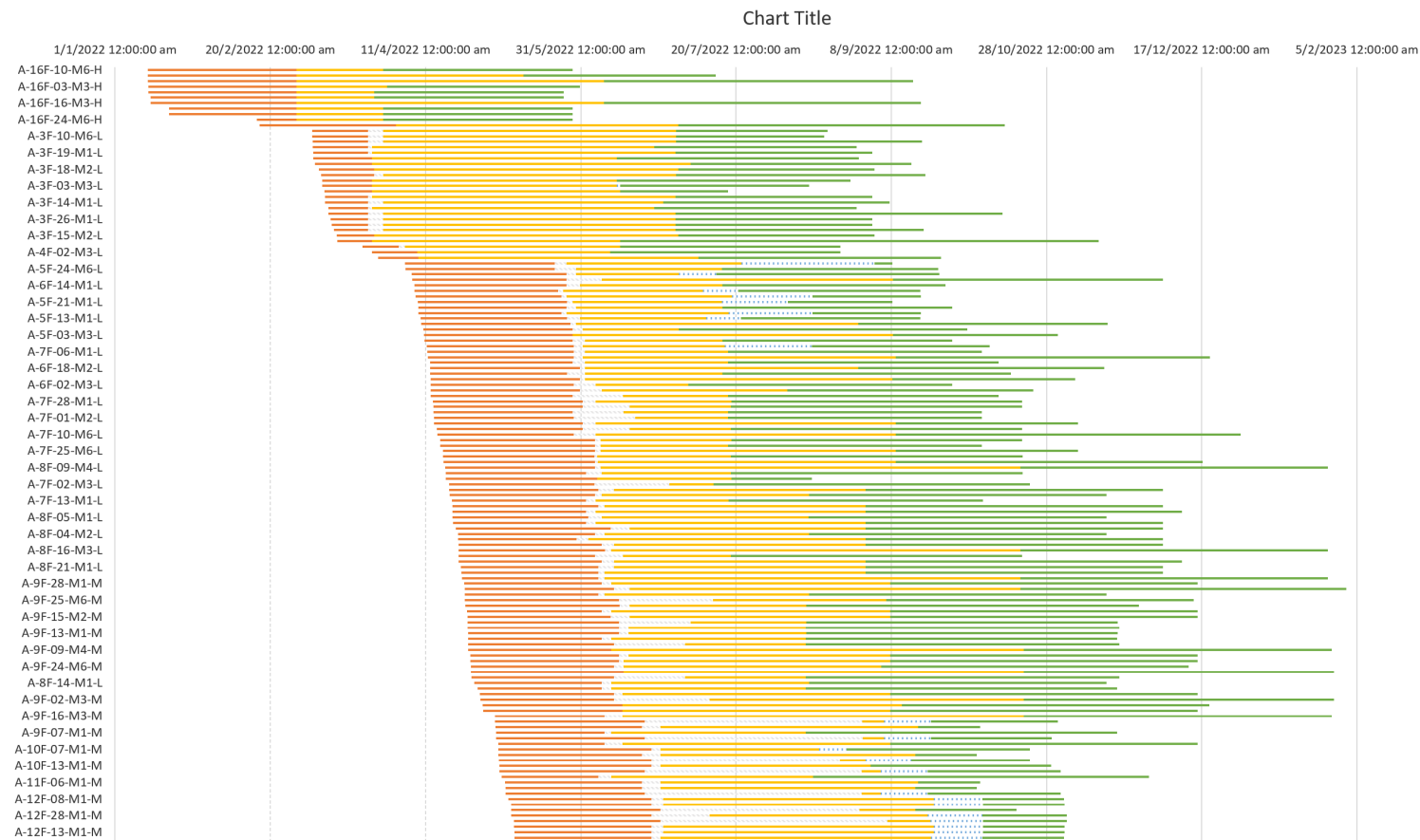


Statics for decision-making



4. Our trilogy (MiC 三寶)

It is used on a daily basis throughout the 40+ steps, all 900 modules!



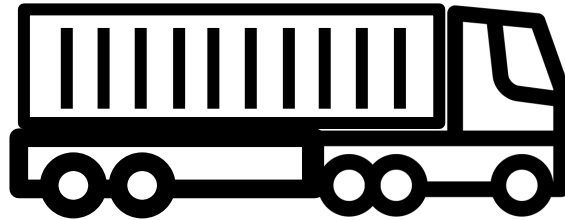


4. Our trilogy (MiC 三寶)

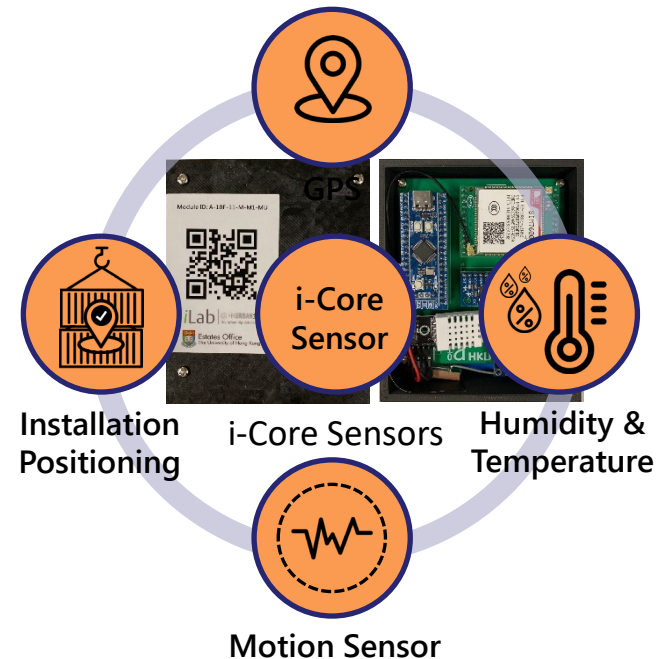


Logistics: *i*-core and blockchain oracle

The ***i*-Core sensors and smart address systems** are one of the development tools with multi-functions to monitor both the logistics and installation of MiC modules



***i*-Core sensors and smart address plates** are installed in the MiC modules

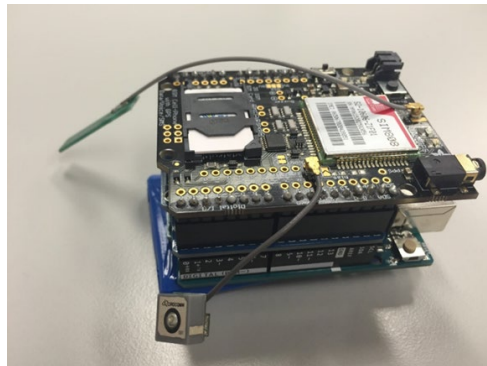




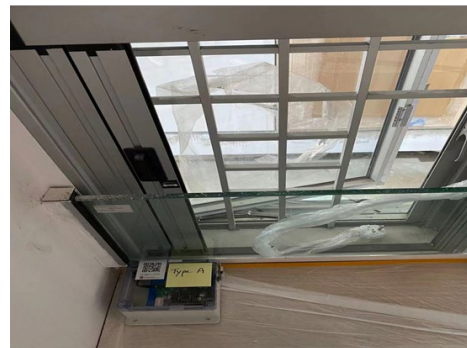
4. Our trilogy (MiC 三寶)

Logistics: *i*-core and blockchain oracle

i-Core sensors are installed in the MiC modules



i-core Generation I



i-core Generation II

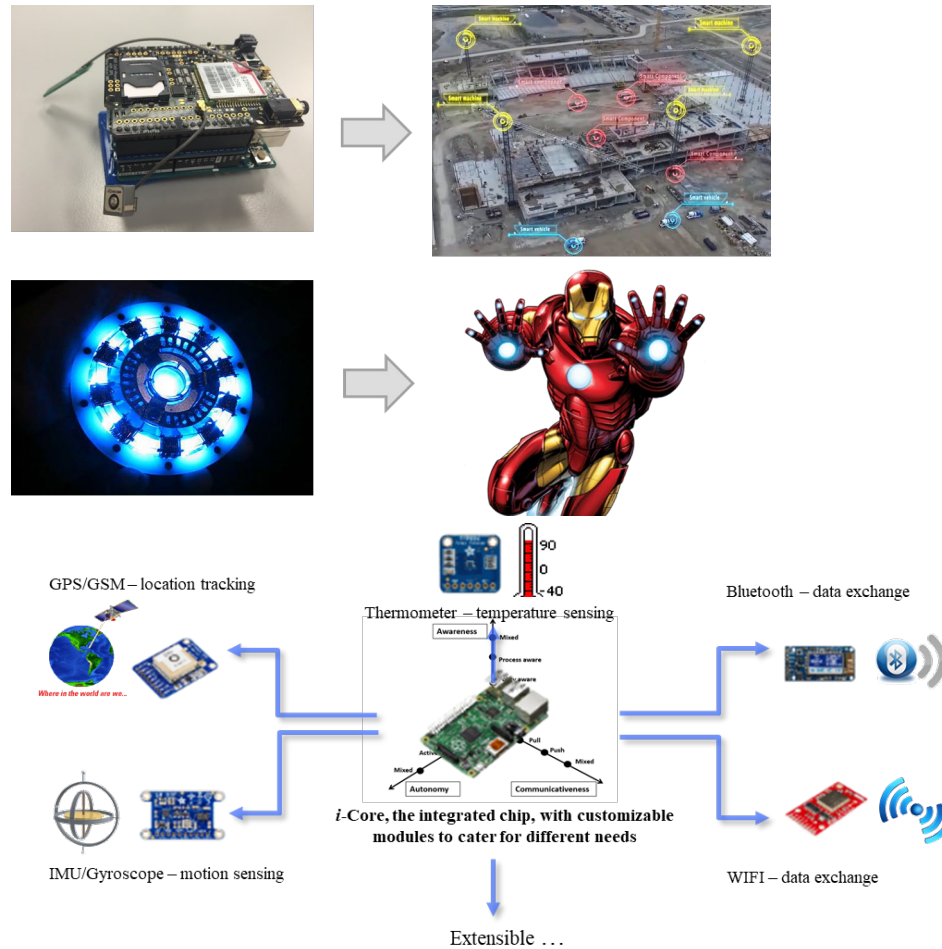


i-core Generation III



4. Our trilogy (MiC 三寶)

Logistics: i-core and blockchain oracle

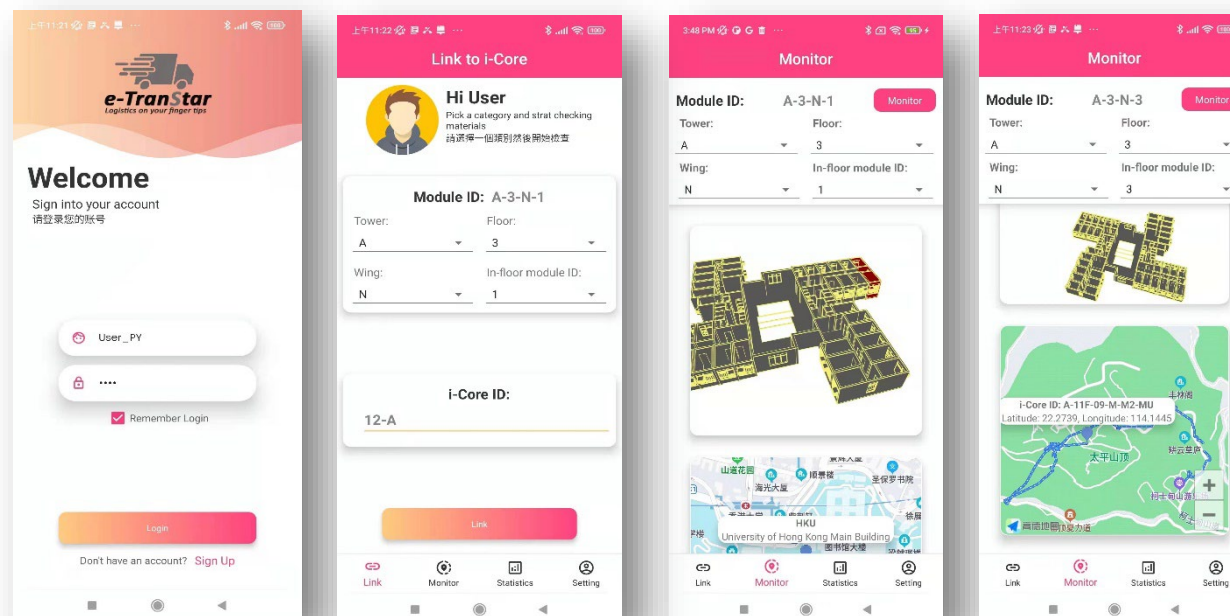




4. Our trilogy (MiC 三寶)



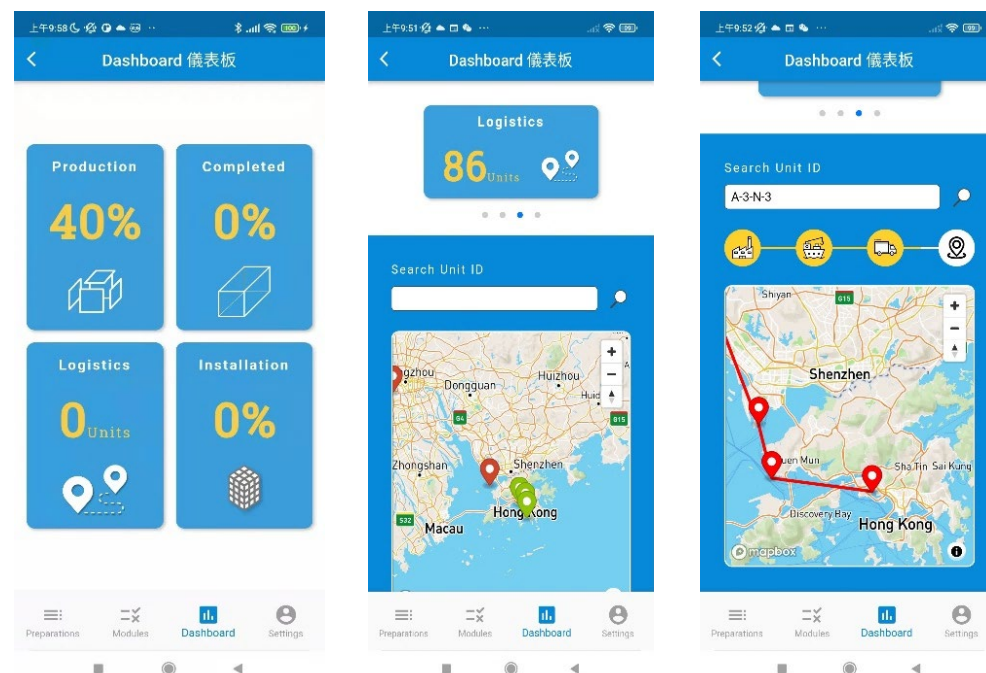
Logistics: app





4. Our trilogy (MiC 三寶)

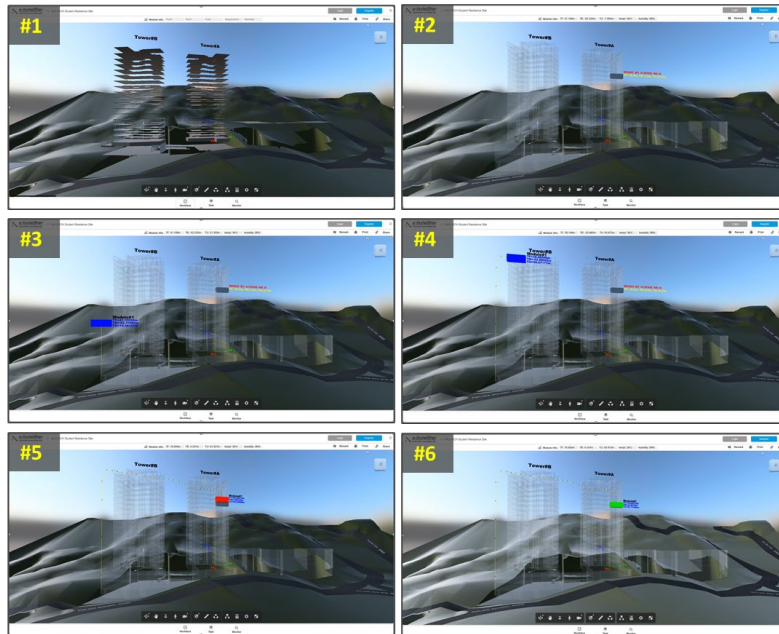
Dashboard



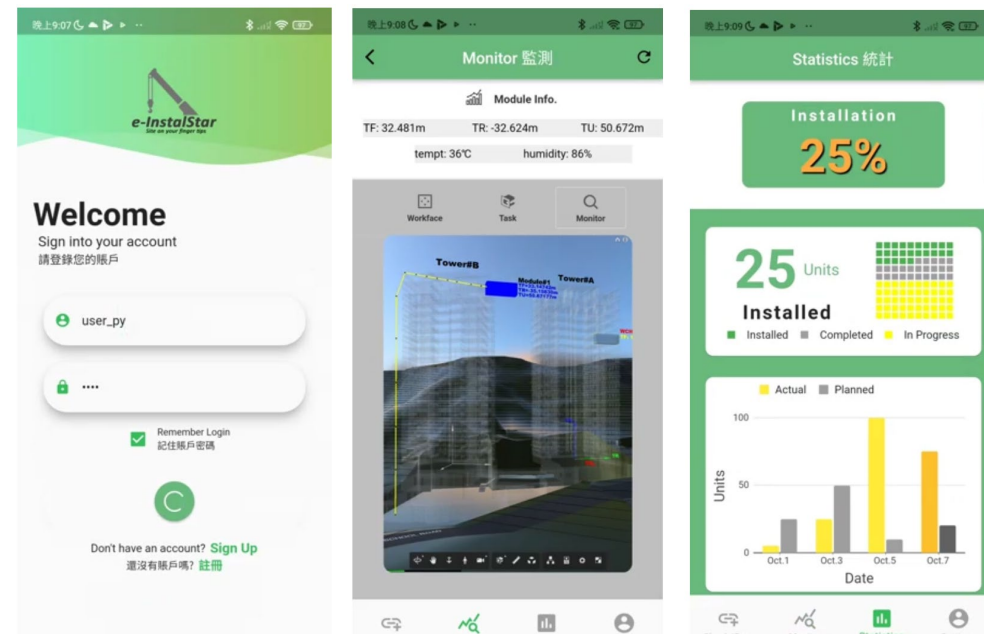


5. Acknowledgement and prospects

Web-base dashboard



App





5. Acknowledgement and prospects



發展局
Development Bureau



CEM2
CENTRE OF EXCELLENCE
FOR MODERN PROJECT COLLABORATION



CONSTRUCTION
R&D FORUM
BRINGING APPLIED R&D
TO A NEW HEIGHT

A MiC digital transformation trilogic solution (MiC三寶)

Organisation
The University of Hong Kong (HKU)

Funding Scheme
Government Innovation and Technology Fund

Project Duration
2.5 Years (1-Jan-2021 to 30-Jun-2023)

Principal Investigator
Professor Wilson LU, Prof. Anthony Yeh, Ir.
Mr. KL Tsim, Dr Frank ~~Xue~~

Amount Awarded
HK\$10.36m (including Industrial sponsor)

Project Status
Ongoing

Introduction (e.g. project summary and objectives)
Modular integrated Construction (MiC) is a game-changing innovation to address the many challenges related to Hong Kong's construction industry, e.g., declining productivity, escalating cost, unsatisfactory safety record, and aging labor force. However, its power cannot be fully harnessed without the processes being digitally transformed. This research project aim to develop a trilogy of MiC digital transformation solution by focusing on its offsite fabrication ('factory'), cross-border logistics ('road'), and onsite assembly ('site'). The final product is formed by three apps organized on a BIM-blockchain enabled platform:

- **e-Instar**: For remote e-inspection of MiC quality in factory;
- **e-TranStar**: For e-monitoring MiC logistics on road; and
- **e-InstallStar**: For e-planning and monitoring MiC installation. All the information will be simultaneously displayed in web BIM, kept in a database, and safeguarded in a blockchain system.

Research activities in the project (e.g. research methodology, work progress and next stage of work)
The research project adopts BIM, i-Core (An award-winning IoT technology), and blockchain technologies. An iteration of 'lab development' and 'field test' has been conducted over the past two years to achieve the objectives. The research progresses well by successfully developing the e-Instar and e-TranStar and we are now working on the e-InstallStar. The product has been implemented in HKU's hostel MiC projects. Next stage, we will scale up the solution to other MiC projects.

Collaboration with industry/government sectors, if applicable
Funding support:
Logistics and Supply Chain MultiTech R&D Centre (LSCM)
The Innovation and Technology Fund (ITF)
Government support:
The Development Bureau
The Construction Industry Council
Industrial support:
Estate Office, The University of Hong Kong
Paul Y. Engineering

Research products/patents produced, if applicable
The trilogic solution is almost finished their development. The e-Instar and e-TranStar are used in daily operation.

Achievements of project objectives

- Construction Industry Council (CIC) "Celebration of BIM Achievement 2022" Award (Category: BIM Projects)
- ASCE (American Society of Civil Engineering), Best Paper Award of Journal of Management in Engineering 2022
- buildingSMART International Awards 2021 (Category: Professional Research)
- Construction Industry Council (CIC) Construction Digitalisation Award 2021 (Silver, Category: Training/Research Institute)

Research findings
A combination of BIM, blockchain, i-Core, and other technologies has been innovatively integrated together to form a good solution for MiC produced in factory, cross-border transportation, and on-site installation. It can:

- Ensure the visibility and traceability of MiC throughout its production circle;
- Guarantee offsite production quality during the COVID-19 pandemic era;
- Ensure the immutability of the records; and
- Ensure the quality and productivity of MiC.

Impact/application to the community
The project was well connected from the outset with the stakeholders, including the government, the CIC, client, industrial partners, and other suppliers.

The solution is used in HKU WCH MiC project on a daily basis in inspecting the quality of its 900+ modules. It is also used for MiC cross-border transportation monitor. The research is finalizing the installation app.

Great impacts have been achieved by engaging with the frontliner practitioners, government bodies, funding agencies, interested stakeholders and the general public.

Some "taste" sessions using robotics and MiC installation have been organized with hundreds of secondary school students.

The project is being scaled up to other types of MiC projects.



5. Acknowledgement and prospects



港大遙距電子檢測系統 奪智慧物流金獎

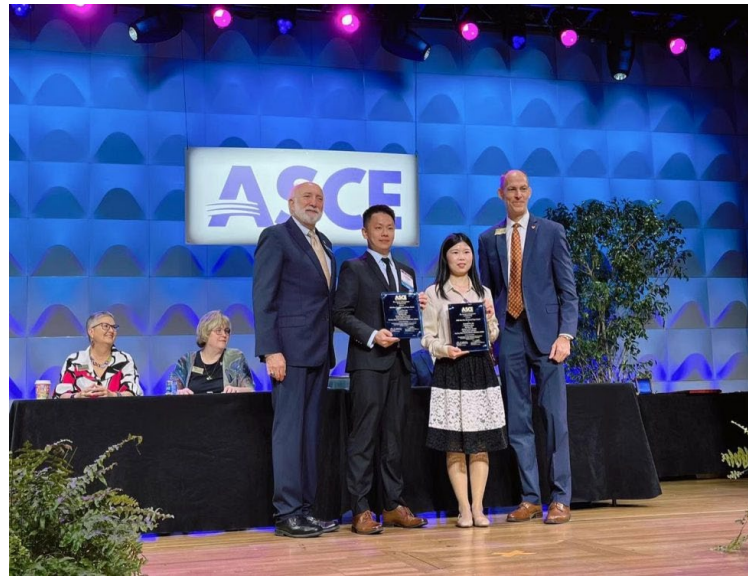
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港大研發電子檢測系統，跨境遙距監察組裝合成建築模塊的質量，獲香港資訊及通訊科技智慧物流金獎。



5. Acknowledgement and prospects



iLab members Dr Jinying Xu and Mike Wu received the ASCE Journal of Management in Engineering (JME) Best Paper Award 2022 on in California, USA



港大研區塊鏈技術應用於組裝合成工程 獲選土木工程界最佳論文

香港大學建築學院iLab團隊研究人員關於應用區塊鏈技術於
hk.on.cc

港大研區塊鏈技術應用於組裝合成工程 獲選土木工程界最佳論文

https://hk.on.cc/hk/bkn/cnt/news/20221110/bkn-20221110010024365-1110_00822_001.html



5. Acknowledgement and prospects



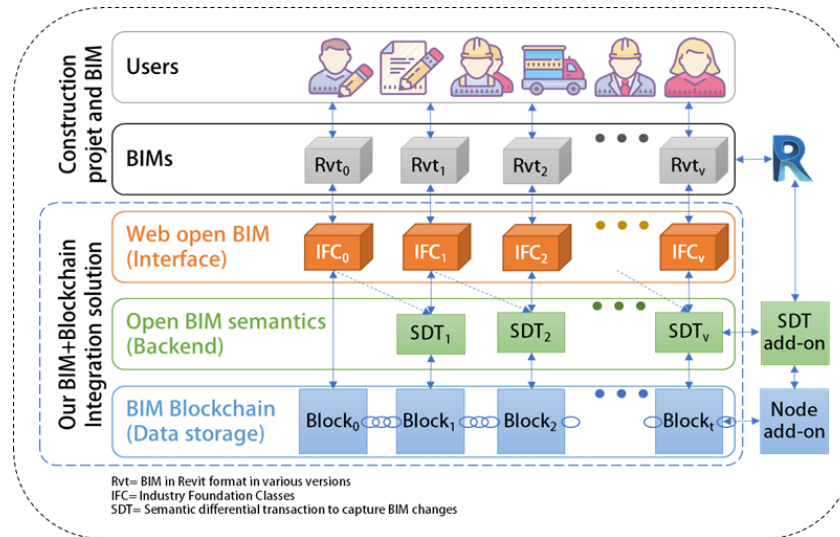
HKU Wong Chuk Hang (WCH) project won the the Celebration of BIM Achievement (CBA) in 2022 – ‘BIM Project’ Category



5. Acknowledgement and prospects



OpenBIM and Blockchain integration (OBBi)



港大研建築信息模型新技術 贏國際大獎賽

2021-10-21 03:23



港大研建築信息模型新技術，贏得國際大獎賽。（前排左起）徐進英博士，呂偉生教授和薛帆博士；（後排左起）吳劉鵬飛和趙銳。受訪者提供。



5. Acknowledgement and prospects

e-instar 2.0: From single project to portfolio; from small to big flats



From Wong Chuk Hang to High West



5. Acknowledgement and prospects

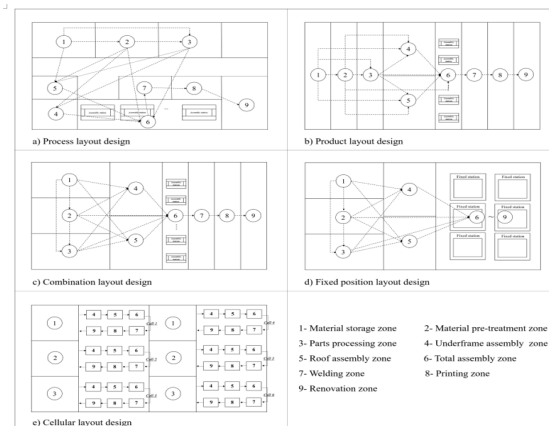
Tesla factories for MiC QA/QC, Accreditation



a) A snapshot of a prefabrication factory in the Pearl River Delta (PRD) region of China (Source: authors, 2010)



b) A snapshot of a MC factory in the PRD region of China (Source: authors, 2020)





5. Acknowledgement and prospects

Digital transforming MiC

Digital transformation of modular integrated construction (MiC): Synergizing management theories, construction practices, and digital technologies



THE UNIVERSITY OF HONG KONG 香港大學
faculty of architecture 建築學院



Department of Real Estate and Construction
房地產及建設系

Thank you!