

BIM and blockchain-enabled Logistics and Supply Chain Management for Modular Integrated Construction (MiC)

「基於BIM和區塊鏈技術的組裝合成建築物流和供應鏈管理平臺」

Prof. Wilson Lu (呂偉生教授)

本研究 (項目編號: ITP/029/20LP) 獲以下機構撥款資助:
This research (project number: ITP/029/20LP) is funded by:



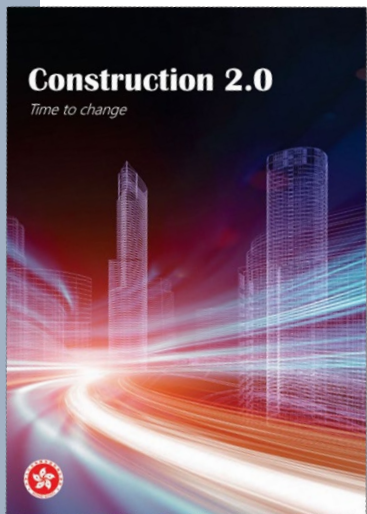
Outline

- **Background - LSCM for MiC**
- **MiC LSCM digitalization**
- **The pilot project - HKU WCH student hostel project**
- **Introduction of *e-InStar*, *e-TranStar*, and *e-InstalStar***
- **Prospects and challenges**

Part I

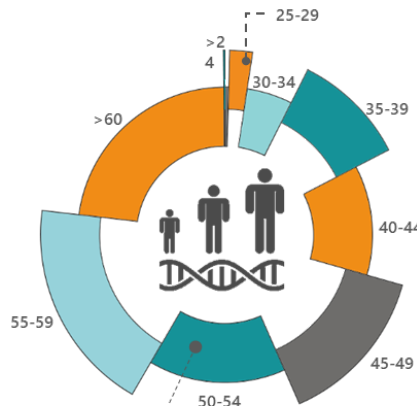
Logistic and supply chain management (LSCM) for Modular integrated Construction (MiC)

Challenges faced by HK's construction industry



Construction Cost

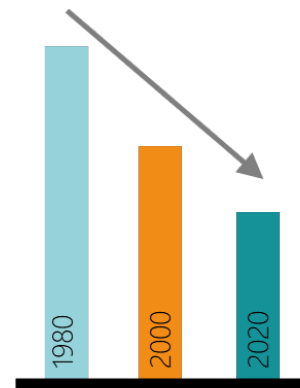
The Construction cost in HK is the third highest in the world



Ave. 52

Aging

Average age of skilled construction workers is 52



Construction Techniques

There is a decrease in construction techniques

Slide courtesy:
Estates Office, HKU

Why MiC?

BIM integration

MiC facilitates the use of BIM within the design and construction phase.



Improved site safety

Some procedures can be carried out in a controlled factory environment.

Less waste and reduced carbon footprint

Factory construction facilitates a reducing in waste and carbon footprint also.



Shortened construction period

Due to controlled nature, tasks can be run parallel reducing the construction timeframe.

Improved supply chain management

A reduction in external variables leads to improved supply chain management.



Improved quality control

Factory automation leads to improved quality control.

Less local disruption

Disruptive construction activities can be relocated off-site.



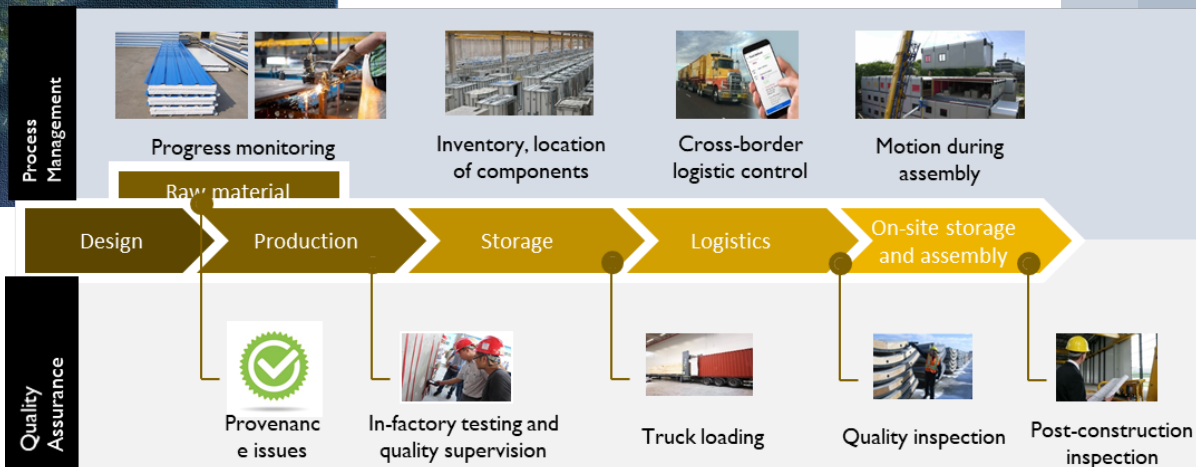
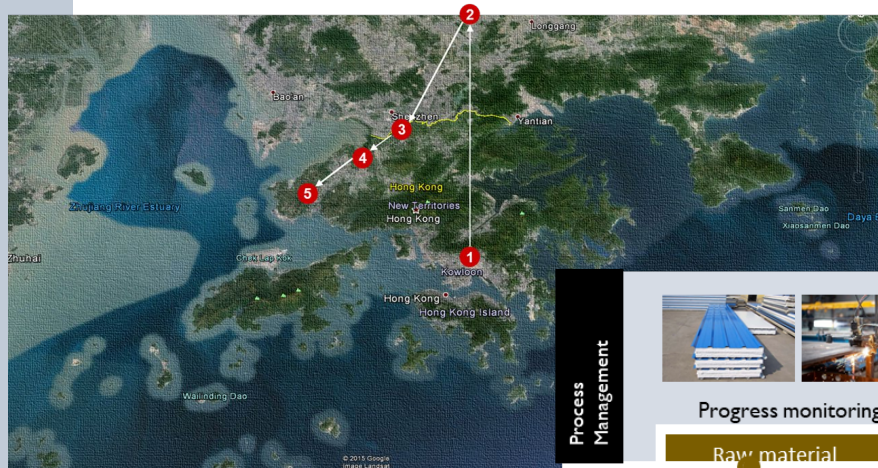
Less potential for contractual claim

A more controlled work environment leads to less potential for contractual claim.

Slide courtesy:
Estates Office, HKU

The importance of LSCM to MiC

- 1 Designed in HK
- 2 Manufactured in the PRD
- 3 Transported cross the border
- 4 Storage
- 5 Assembly



New challenges



Quality inspections required at Mainland factories

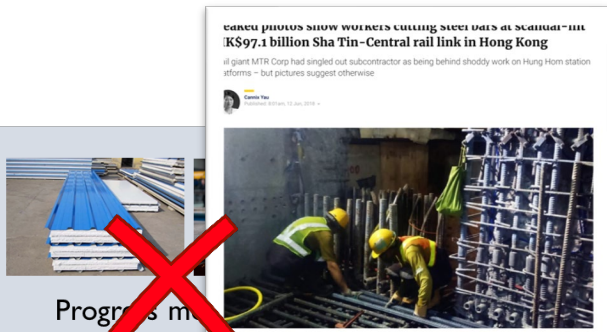


Infeasible to dispatch now due to 14 + 14 days quarantines

(Photo source: Authors, SCMP)

New challenges

Process Management



Progress monitoring

Production of components



Cross-border logistic control



Motion during assembly

Raw material supplies

Design

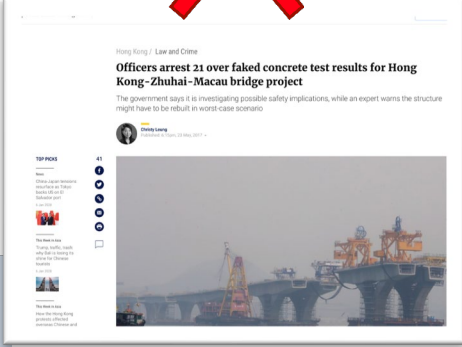
Production

Storage

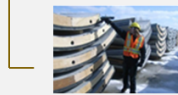
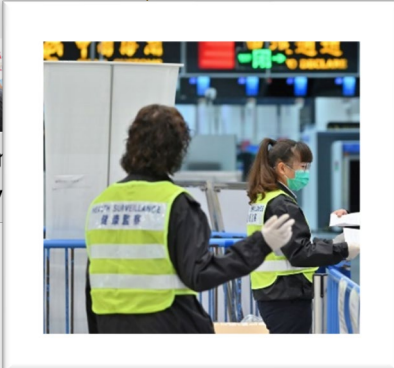
Logistics

On-site storage and assembly

Quality Assurance



Factory testing and quality supervision



Quality inspection



Post-construction inspection

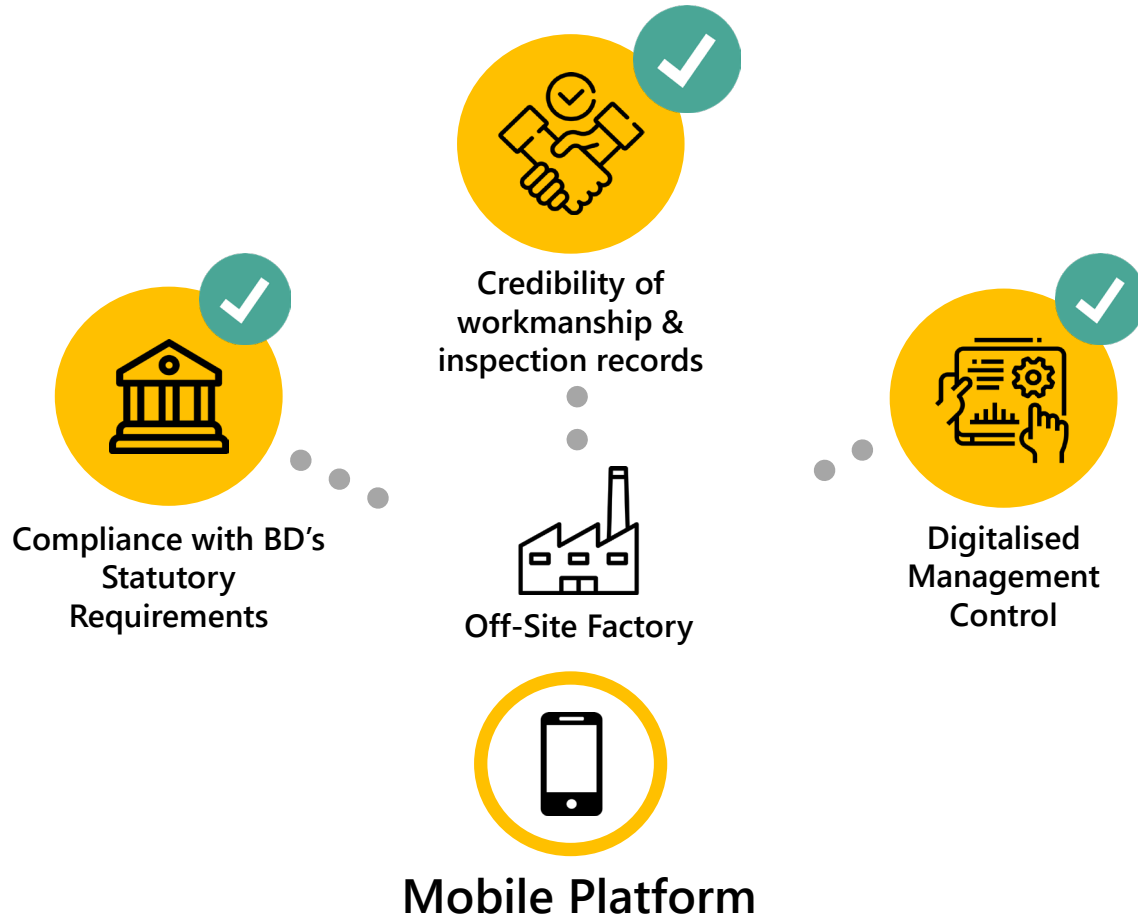
Part II

MiC LSCM digitalization

Digitalization of MiC



Digitalization of MiC Off-Site Fabrication



Part III

The pilot project

Project Information

Extensive site formation and lateral support



Project Information



- 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



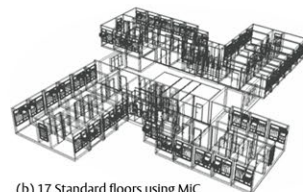
Student Hostels (MiC)

Podium (RC Structure)

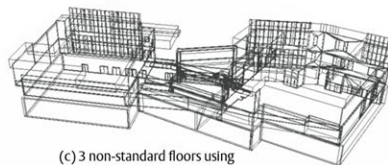
Figure 1 - The Pilot Project



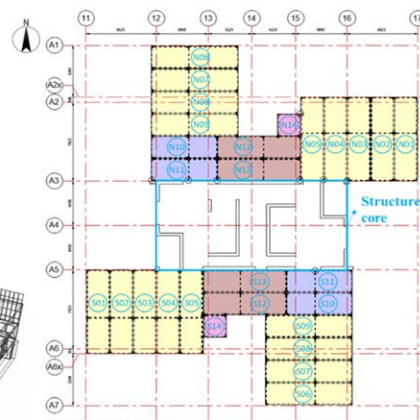
(a) Overall view of HKU's WCH Student Residence project



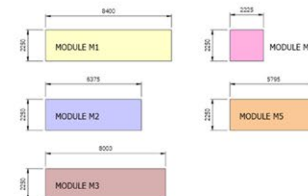
(b) 17 Standard floors using MIC technology



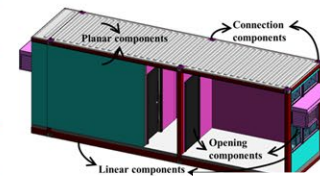
(c) 3 non-standard floors using traditional cast in-situ



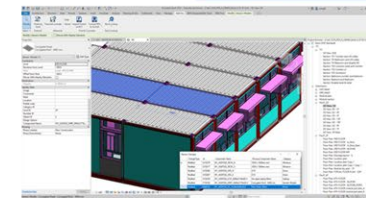
(d) Floor plan



(e) Module types



(f) BIM of a typical module



(g) BIM of combinational modules

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:



Part IV

**Introduction of
e-InStar,
e-TranStar,
*e-InstalStar***

Mobile Platforms for MiC



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

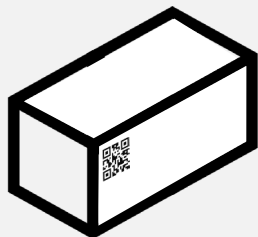
- **Real time tracking** of modules during transportation
- **Pin point** exact location of module
- Estimated **arrival time**



On-Site Installation

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

Module ID and naming



- **Each Module** is given a **unique ID** using a naming convention system
- A **QR code** is generated from the ID
- The QR code is created as soon as the 3D module is formed and applied to the structure.

Create a **Naming Convention System Standard** for all future MiC Module projects



A-10F-09-M-M2-MU

The **Naming Convention System** created for the modules allows us to identify the following information;

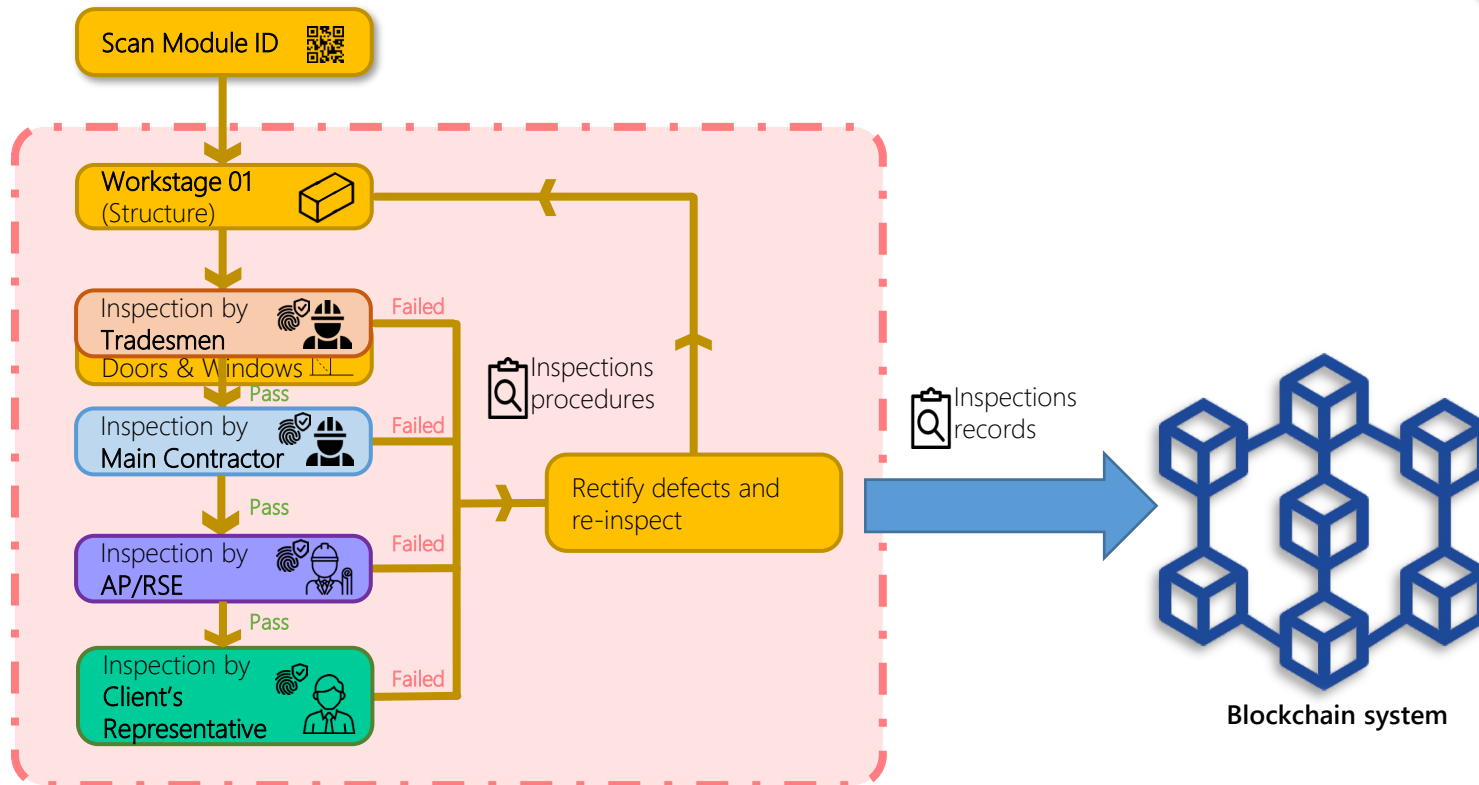
- **Block**
- **Floor**
- **Module Sequence**
- **High / Middle / Low Zone**
- **Module Type**



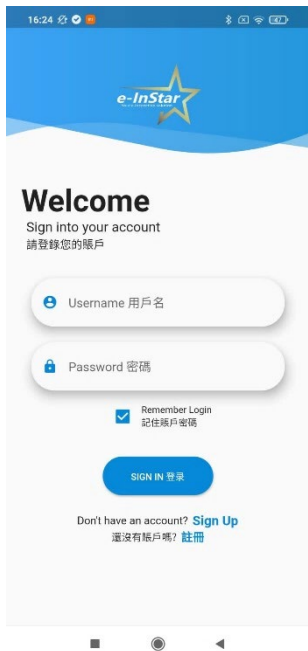
Reference Material on Use of Digital Technologies for QA/QC of MiC Modules in MiC Factories

www.cic.hk June 2022

Inspection Record



Inspection Record



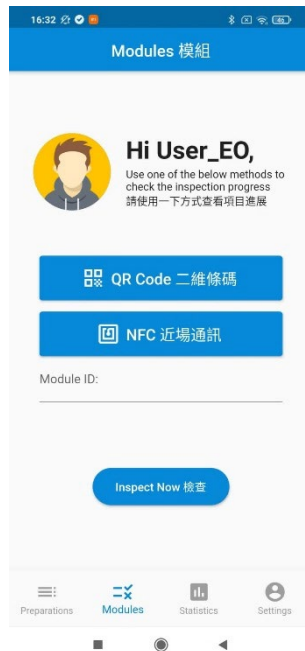
Two Factor Authentication



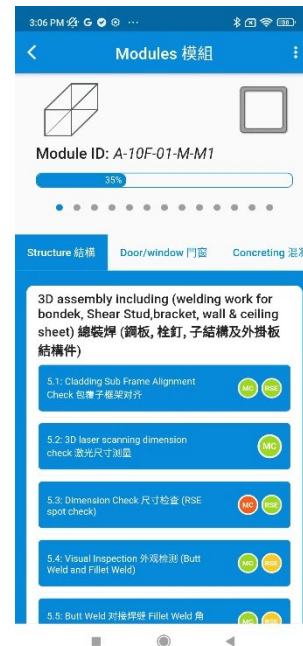
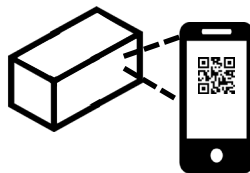
User ID



Fingerprint verification



Scan Module ID



Inspection status of module



Inspection Record



Comment box



Help button

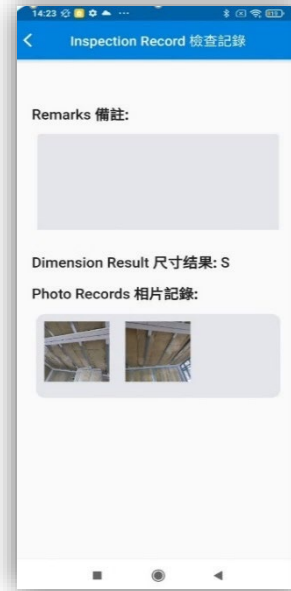
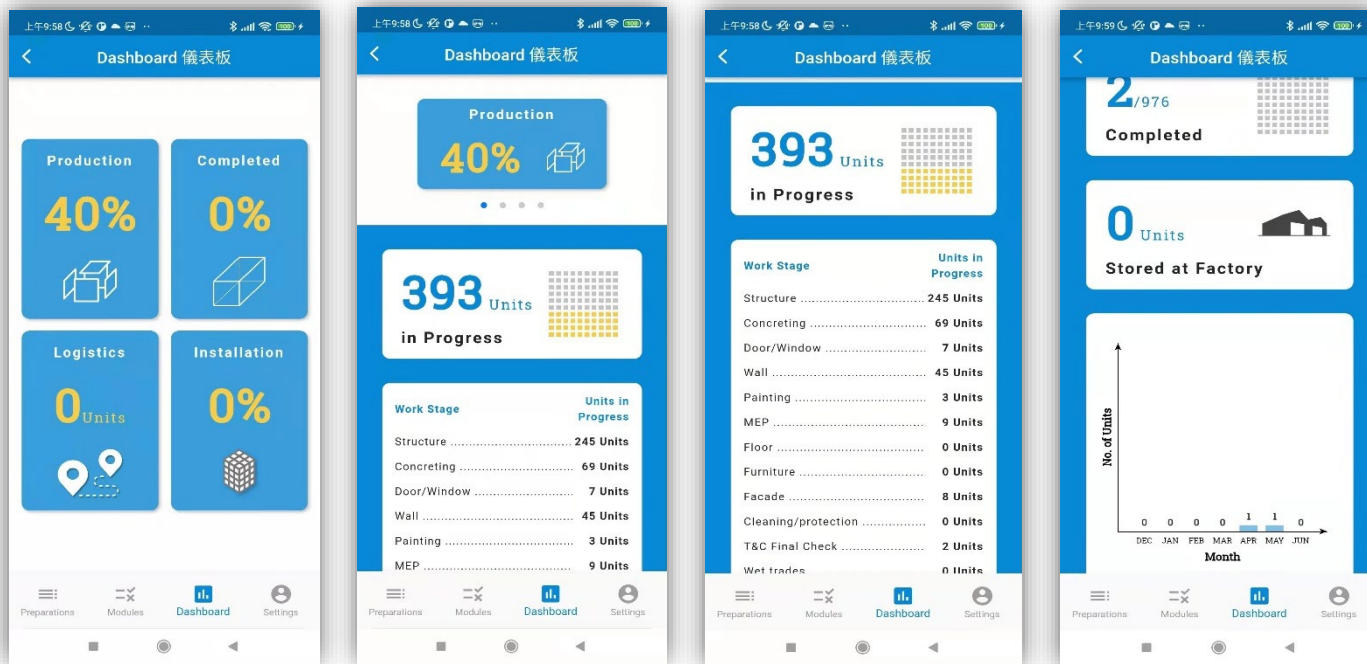


Photo upload function

Dashboard



Statics for decision-making

Blockchain visualization



Transaction
(Inspection record)



Publication and publicity

A press conference on e-inspection 2.0 and MiC held on 6 June 2022.

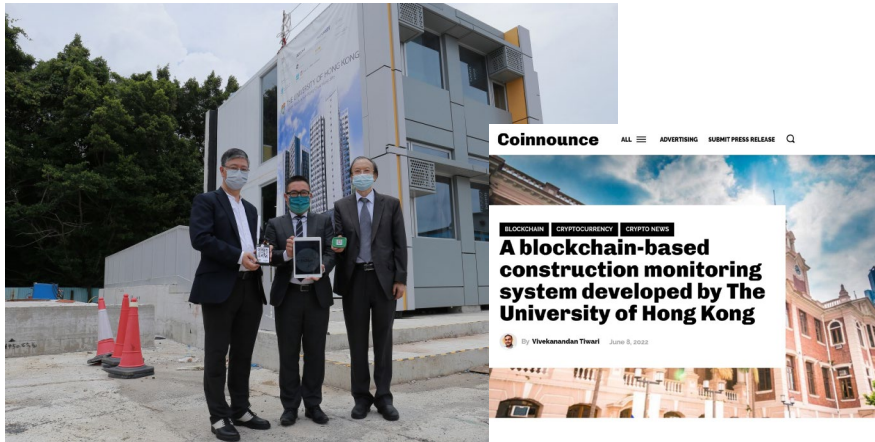


Photo credit: HKU Media Team

As per the [press release](#), the technology, dubbed E-Inspection 2.0, aids in managing construction quality inspection papers by ensuring that construction site images and back-and-forth approved inspection files are all "accountable, traceable, and immutable."

How does the system work?

"The core of the e-inspection 2.0 system is the blockchain technology which can ensure the accountability, immutability, and traceability of all the inspection information collected from the APP, MiC, and GIC," said Professor Wilson Lu from the Department of Real Estate and Construction who led the study.

Professor Lu said that "This e-inspection 2.0 system is the world's first. It has set new standards and will serve as a prototype for the industry."

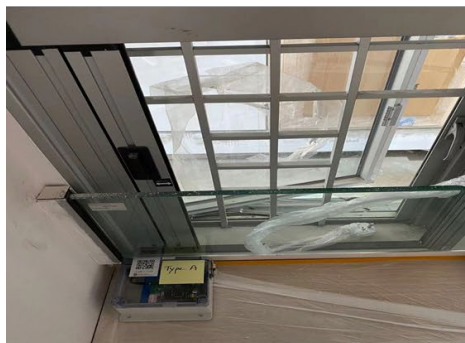
The article announced more details of the system:



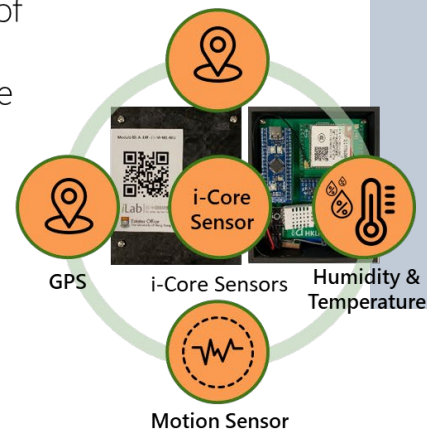
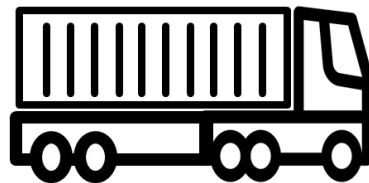
Logistics



i-Core sensors are installed in the MiC modules



The **i-Core sensors** are one of the development tools with multi-functions to monitor the logistics of MiC modules



Logistics: i-core and blockchain oracle



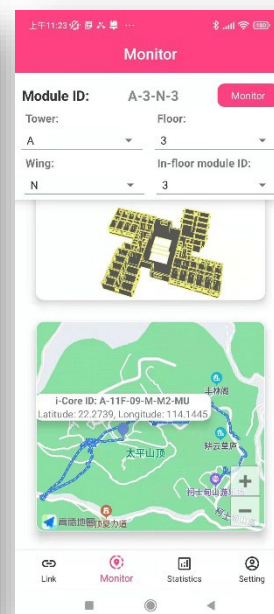
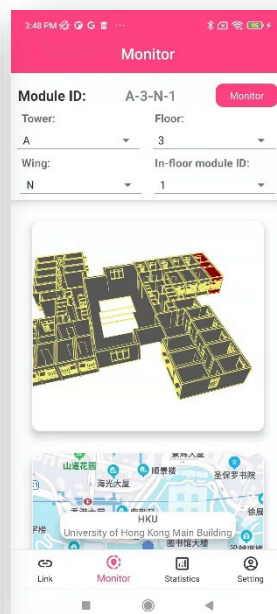
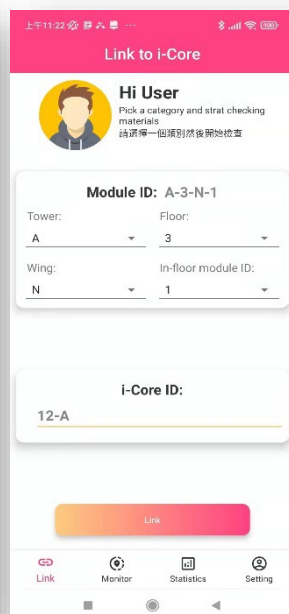
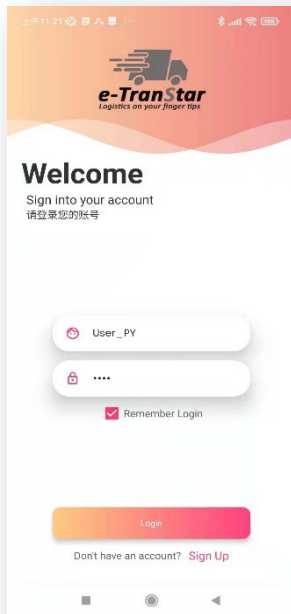
Hong Kong Disneyland Park, 20 June 2022

Logistics: i-core and blockchain oracle

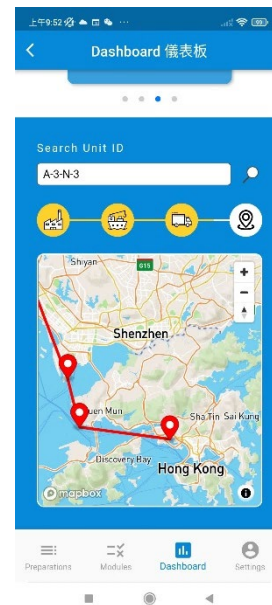
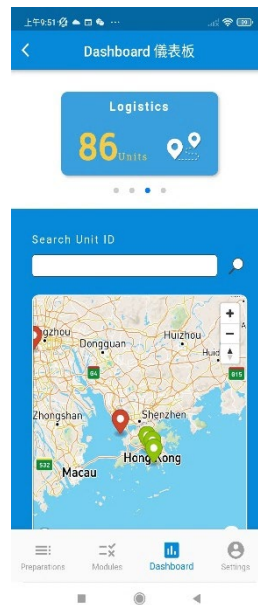


- All awardees with judges and the then chief executive Leung Chun-ying (Hong Kong Government House, December, 2015)

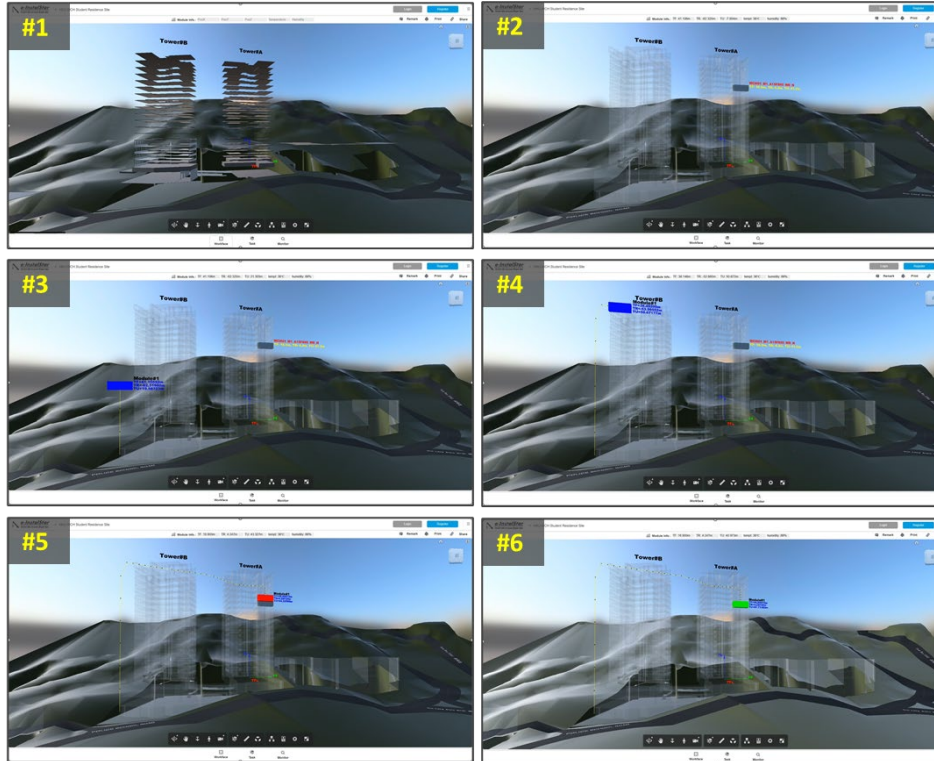
The app



Logistics dashboard



E-InstalStar: Web-base dashboard



Part V

Prospects and challenges

Acknowledgement



發展局
Development Bureau



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INDUSTRY COUNCIL
建造業議會



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Architectural Services
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THE D.H.CHEN
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香港女童軍總會
THE HONG KONG GIRL GUIDES ASSOCIATION

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THE UNIVERSITY OF HONG KONG
DEVELOPMENT &
ALUMNI AFFAIRS
OFFICE



Department of Civil Engineering
The University of Hong Kong



香港城市大學
City University of Hong Kong

Acknowledgement

"BIM Future": BIM and Blockchain



Ricky Lau
Permanent Secretary for
Development (Works)



DevB visited on 04 Nov 2021



Lam Sai-Hung
Secretary for Transport & Logistics



Lam Sai-Hung visited on 04 Nov 2021



Winnie Ho
Secretary for
Housing



ASD visited on 22 Nov 2021



Clarice YU
Director of Buildings



BD visited on 15 Nov 2021

Acknowledgement



WSD visited on 08 Dec 2021



ASD visited on 23 Nov 2021



ICAC visited on 13 Jul 2022



FSD visited on 16 Nov 2021



WSD visited on 14 Dec 2021

“BIN

and blockchain

Acknowledgement



CEDD visited on 06 Dec 2021



HKU Project Group on 08 Dec 2021



DevB visited on 04 Jan 2022



ASD visited on 24 Nov 2021

Awards



CIC Innovator Awards 2015

A team formed by Dr Nina Niu, Dr Leo Chen, Dr Megan Ye, Dr Diandian Liu, and Dr Kevin Wang led by Prof Wilson Lu, won the Hong Kong [Construction Industry Council \(CIC\) Young Innovator Award 2015](#). The winning idea is an “i-Core” developed in Dr Wilson Lu’s team to encapsulate smart construction objects (SCOs) properties. Similar to a CPU to a computer, this “i-Core” can be understood as the ‘heart’ of smart construction. With this ‘i-Core’, it is possible to develop scalable and customizable smart construction, which is perceived as a promising direction of future construction. The Award Presentation Ceremony was held in the Government House on 15 December 2015 hosted by the Chief Executive, Hon Mr. LEUNG Chun-ying.



buildingSmart International Awards 2021

A team led by Professor Wilson Lu, and Dr Frank Xue (Assistant Professor) at iLab, Faculty of Architecture, The University of Hong Kong (HKU) won the [buildingSMART International \(bSI\) Awards 2021](#) in the “Professional Research” category. Their project is called “OpenBIM: Opening the gate for BIM and blockchain integration (OBBi)”.

The bSI Award is a prestigious international award programme initiated since 2018 with an aim to promote OpenBIM for project design, construction, operation, research, and technology. In this year, there were 133 submissions entering the eight categories of the Award. The submissions were predominantly from developed, BIM-advanced countries/regions. A highly selective jury was formed to shortlist 3 finalists in each category, deliberating their presentations, and finally selecting a single winner from each category. The OBBi submitted by iLab is the **sole winner in the Professional Research category**. It is also the **sole winner from Hong Kong** across all the 24 finalists.

Press Releases:





About the Project

There is great enthusiasm within the AEC industry for the potential for blockchain and BIM integration to overcome challenges arising from multiple parties working concurrently on collaborative BIM programs (e.g. cybersecurity risks, lack of single source of truth), as well as the information redundancy and massive data volume that result from file-based data exchange.

However, the integration of BIM and blockchain faces challenges such as lack of interoperability, information redundancy, and resemblance and swiftness of retrieving data. The project team, from the University of Hong Kong, harnessed openBIM to solve the interoperability issue and applied their Semantic Differential Transaction (SDT) method to solve the information redundancy problem.

Core Objectives

This research project aimed to take advantage of BIM and blockchain integration to solve challenges in building projects, such as communication, provenance and quality assurance, installation, traceability, lifecycle management and more.

Project Description

A prototype system integrating BIM and blockchain (called OBBI, openBIM and Blockchain Integration) was developed for managing AEC processes in a real-life building project in Hong Kong called the WCH project. In particular, it looked to manage

design changes, offshore production, cross-border logistics and supply chain, and on-site assembly.

The research adopted a threefold approach. Firstly, the in-house research team developed the OBBI system architecture, its major components, and interlinks. Secondly, the system was contextualized in BS's openBIM ecosystem for implementation, with the core input-output format being IFC. Lastly, the prototype was tested and validated in the WCH project.

The OBBI system was designed to meet the demands of BIM users for the WCH project. Four vital layers were designed:

- (1) Commercial BIM as the base model designed in Revit
- (2) Web openBIM interface for the visualization of nD BIM in IFC;
- (3) openBIM semantics-based server back-end for minimization of changed BIM components as SDT records; and



iLab@HKU team wins in the buildingSMART International Awards 2021

20 Oct 2021

< Back

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1 / 2

Show caption >

A team led by Professor Wilson Lu, Dr Frank Xue and Dr Jinying Xu at iLab of the Faculty of Architecture at the University of Hong Kong (HKU) is the sole winner in the "Professional Research" category of the buildingSMART International (bsi) Awards 2021, with the project "OpenBIM: Opening the gate for BIM and blockchain integration (OBBI)". The results have been announced on October 7.

Awards

July 14, 2022



1801 Alexander Bell Drive, Reston, VA 20191-4302
1000 1402 2022 ext: 7002-7001, 6063 or
1702-295-6333 or e: w.hoon@asce.org

| | |
|-------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Lupengfei Wu Dept. Real Estate and Construction Management Univ. of Hong Kong, Hong Kong, China | Weisheng Lu Dept. Real Estate and Construction Management Univ. of Hong Kong, Hong Kong, China |
| Rui Zhao Dept. Real Estate and Construction Management Univ. of Hong Kong, Hong Kong, China | Jinying Xu Dept. Real Estate and Construction Management Univ. of Hong Kong, Hong Kong, China |
| Xiao Li Dept. Real Estate and Construction Management Univ. of Hong Kong, Hong Kong, China | Fan Xue Dept. Real Estate and Construction Management Univ. of Hong Kong, Hong Kong, China |

Dear Mr. Wu, Prof. Lu, Mr. Zhao, Dr. Xu, Dr. Li, and Dr. Xue

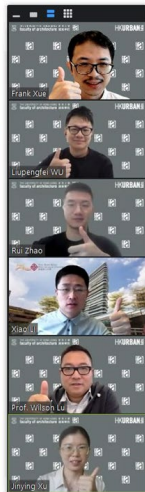
On behalf of the American Society of Civil Engineers, I wish to congratulate you on being the winner of the **ASCE 2022 Journal of Management in Engineering Best Peer Reviewed Paper Award** for your paper entitled, **"Using Blockchain to Improve Information Sharing Accuracy in the Onsite Assembly of Modular Construction"** (Volume 38, Issue 3).

Again, please accept my personal congratulations on this significant milestone in your career.

Sincerely,



Young Hoon Kwak, Ph.D., M.ASCE
Editor-in-Chief, Journal of Management in Engineering



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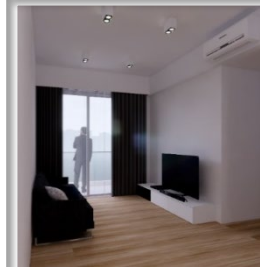
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The George Washington
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AWARDS

2022 Best Paper Award
Lupengfei Wu; Weisheng Lu; Rui Zhao; Jinying Xu; Xiao Li; and Fan Xue
Using Blockchain to Improve Information Sharing Accuracy in the Onsite Assembly of Modular Construction

HKU High West Development



Student Hostel

- Two 19-storey towers on a single storey podium providing 938 student places

670 MiC Modules

Staff Quarters

- Two 20-storey towers providing a variety of 2 Bedroom, small 3 bedroom and Large 3 bedroom units
- 1140 MiC Modules

- **E-Instar** will be used for the mass production of the MiC modules
- **E-Transtar** will be used for the transportation of the MiC modules to site

The readiness of the industry



Are the technologies robust enough for MiC cross-border inspection during the pandemic?

Are the institutional arrangements (e.g., inspection related regulations, norms, or common practices) ready for this e-inspection 2.0?

Shall we go back to “business as usual” or embrace a ‘lighter’ e-inspection future?



Thank You

