### 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

### Prof. Wilson Lu (呂偉生教授)

管理平臺」

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:





Hong Kong R&D Centre for Logistics and Supply Chain Management Enabling Technologies 香港物流及供應鏈管理應用技術研發中心







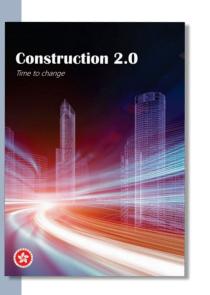
## Outline

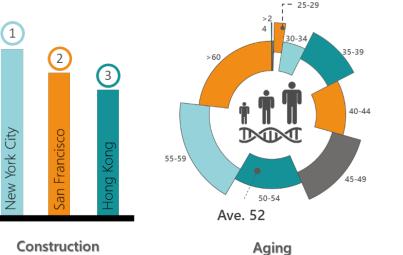
- Background LSCM for MiC
- MiC LSCM digitalization
- The pilot project HKU WCH student hostel project
- Introduction of *e-InStar*, *e-TranStar*, and *e-InstalStar*
- Prospects and challenges

### 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 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.

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





### Shortened construction period Due to controlled nature, tasks can

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

### Improved quality control

Factory automation leads to improved quality control.

### Less potential for contractual claim

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





### The importance of LSCM to MiC **1** Designed in HK Transported cross the border 3 **5** Assembly Manufactured in the PRD 4 Storage 2 Inventory, location Cross-border Motion during **Progress** monitoring of components logistic control Raw material Design Production and assembly

Provenanc

e issues

In-factory testing and

quality supervision

Truck loading

Quality Assuran

Post-construction

inspection

assembly

Quality inspection

### New challenges



Quality inspections required at Mainland factories



### Infeasible to dispatch now due to 14 + 14 days quarantines

(Photo source: Authors, SCMP)

### **New challenges**



# Part II

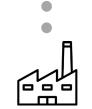
## MiC LSCM digitalization



### **Digitalization of MiC Off-Site Fabrication**



Compliance with BD's Statutory Requirements Credibility of workmanship & inspection records



**Off-Site Factory** 

•	

**Mobile Platform** 



Digitalised Management Control

## Part III

# The pilot project

## **Project Information**

Extensive site formation and lateral support

### WONG CHUK HANG SITE

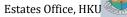
CROW

POLICE COLLEGE

Police School,Rd

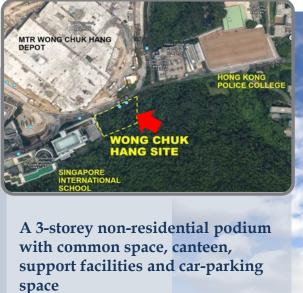
港鐵貨術坑車廠 Nong Chuk Hang Depot ⇒新加坡國際學校(香港)

POLICE SCHOOL ROAD



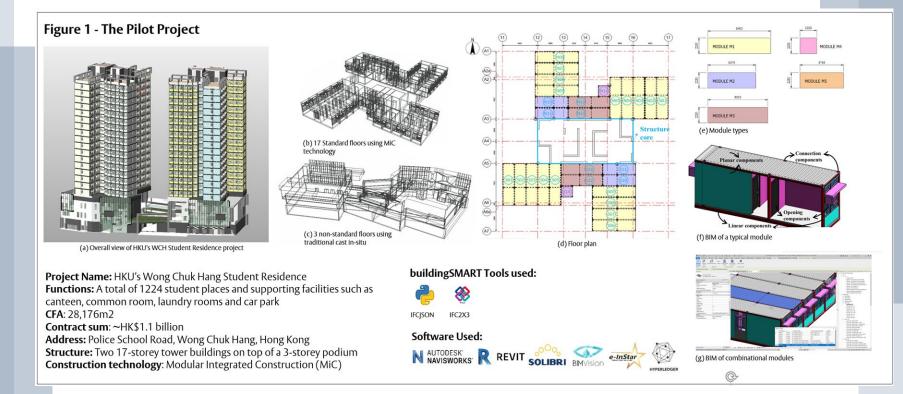
粘明物滤

### **Project Information**



- Two 17-floor towers of student residences and staff accommodation
- 1,224 hostel places
- Site Area: 4306 m<sup>2</sup>
- NOFA: 14,277 m<sup>2</sup>
- CFA: 28,176 m<sup>2</sup>





# Part IV

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

### Mobile Platforms for MiC



### 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**

# e-instalStar Site on your Jinger type On-Site Installation

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

### **Off-Site Production Workflow**

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# Transform 40+ workstage procedures into a digital platform

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	General cleaning/ protection	繁碧浣海,贮枝栄蝉 Packing & Protection of Furniture	Visual Inspection							ion
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e-InStar

### 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

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



- Block

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

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

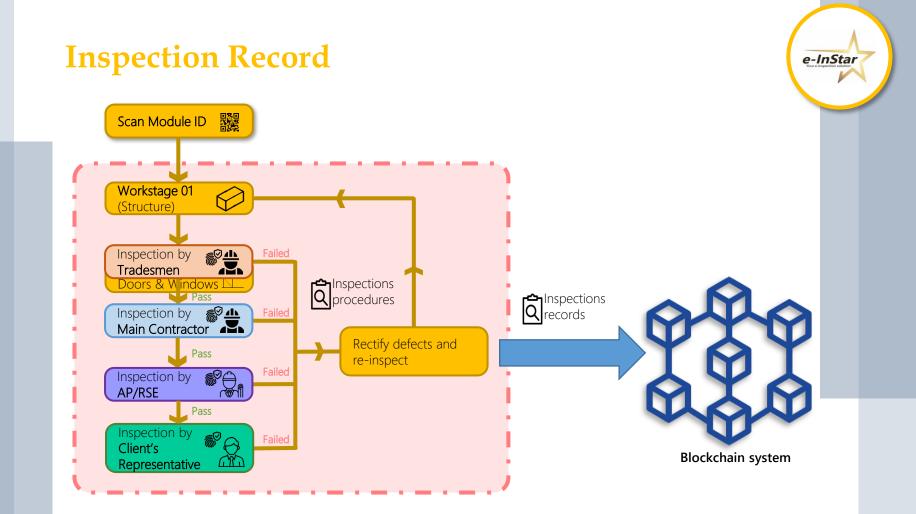
CONSTRUCTION 建造業議會

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

www.cic.hk

June 2022

e-InStar



### **Inspection Record**







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e-InStar

Inspection status of module

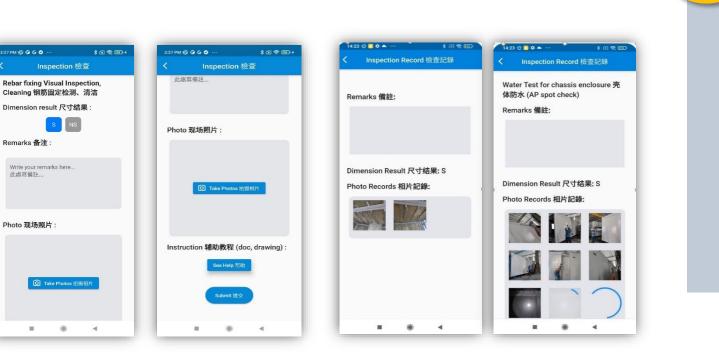


### **Inspection Record**

3:27 PM 🕼 🔁 G 😁 …

Remarks 备注:

此處寫備註...



Comment box

.

Help button

Photo upload function

e-InStar

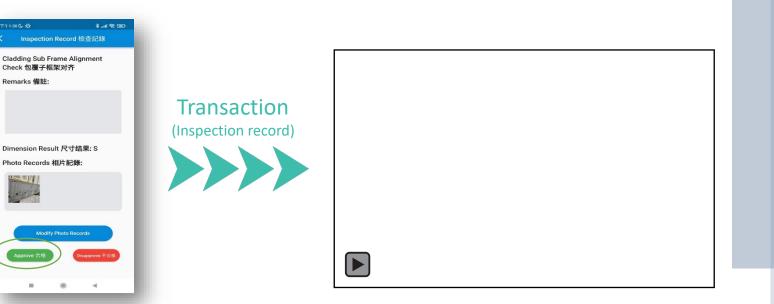
### Dashboard

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e-InStar

Statics for decision-making

### **Blockchain visualization**



e-InStar

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Remarks 備註:

## **Publication and publicity**

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

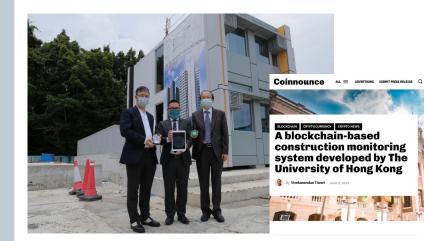


Photo credit: HKU Media Team

As per the preus 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; loTs, and GIS, 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

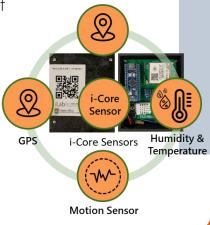
## **i-Core sensors** are installed in the MiC modules





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**



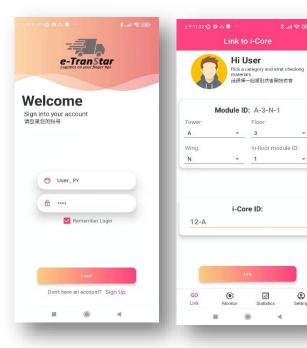
Hong Kong Disneyland Park, 20 June 2022

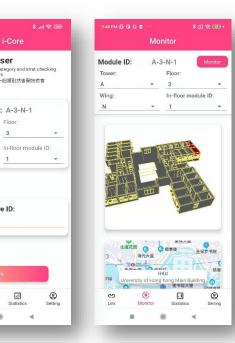
### Logistics: i-core and blockchain oracle



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

### The app



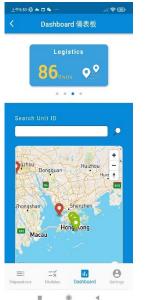


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### **Logistics dashboard**

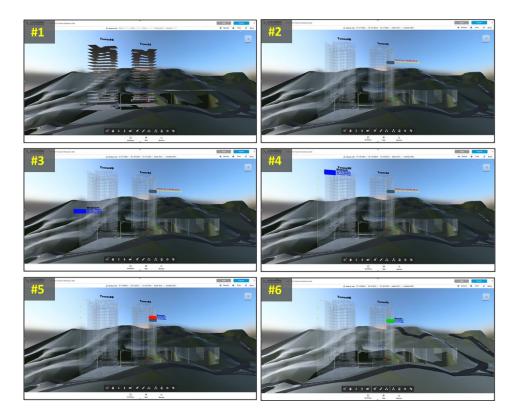






e-TranStar

### E-InstalStar: Web-base dashboard





## Part V

## **Prospects and challenges**

## Acknowledgement



發展局 **Development Bureau** 



建築署 Architectural Services Department





Hong Kong Housing Authority









DEPARTMEN









INDUSTRY COUNCIL 建造業議會









**Department of Civil Engineering** The University of Hong Kong













### Acknowledgement



ASD visited on 23 Nov 2021



ICAC visited on 13 Jul 2022

Β





FSD visited on 16 Nov 2021

WSD visited on 14 Dec 2021

# 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



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 <u>Construction Industry Council (CIC) Young</u> <u>Innovator Award 2015</u>. 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 blockhain 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 redundarcy 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 retriving data. The project team, from the University of Hong Kong, harnessed openBIM to solve the informediation (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 **OBB**, 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.

This 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 bSTs openBIM ecosystem for implementation, with the core input-output format being IFC. Lastly, the prototype was tested and validated in the WCH protect.

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





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

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July 14, 2022			E LEADY SANDARD LEADY REAL FRANK	900000 181 181 181	
Dept. Real Estate and Construction Management	Weisheng Lu Dept. Real Estate and Construction Management Univ. of Hong Kong, Hong Kong, China	1801 Alexandre Bell Drive Restor, VA 20191-4382 18001 548 2773 vol for 7001 295 6300 erf 17001 295 6383 for a weereASCE.org	Frank Xue	NIRAAN 1931 1931	
Dept. Real Estate and Construction Management	Jinying Xu Dept. Real Estate and Construction Management Univ. of Hong Kong, Hong Kong, China		Eupengfel WU	RC NRANK RC NC	
Dept. Real Estate and Construction Management	Fan Xue Dept. Real Estate and Construction Management Univ. of Hong Kong, Hong Kong, China		Ri El PI El El	80° 821 82	
Dear Mr. Wu, Prof. Lu, Mr. Zhao, Dr. Xu, Dr. Li, and Dr.	r. Xue		Xiao L		
On behalf of the American Society of Civil Engineers, of the ASCE 2022 Journal of Management in Engine paper entitled, "Using Blockchain to Improve Informa Modular Construction" (Volume 38, Issue 3).	ering Best Peer Reviewed Paper Award for you	r	RE E E E E E E E E E E E E E E E E E E	enanas Rei Rei Rei Vorteanas	
Again, please accept my personal congratulations on Sincerely,	this significant milestone in your career.		ia ia ia ia ia ia ia ia ia ia ia Jinying xu	181 181 181	
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Young Hong Kwak, Ph.D., M.ASCE Editor-in Chief, Journal of Management in Engineeri	JOURNALS BOOKS ~		THOR SERVICES Y USER	SERVICES ~	
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### 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' einspection future?







Hong Kong R&D Centre for Logistics and Supply Chain Management Enabling Technologies 香港物流及供應鏈管理應用技術研發中心









Paul

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Paul Y. Engineering