

# URBAN SOLUTIONS AND SUSTAINABILITY R&D CONGRESS 2023

BUILDING SUSTAINABLE, RESILIENT, AND LIVEABLE CITIES OF TOMORROW

4TH - 5TH OCTOBER 2023



# Construction Transformation Project in collaboration with HDB

Resilience: Automation, Digitalization

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Obayashi Singapore Private  
Limited



# Enhancing Construction Productivity

**Not just through automation and digitalization, but through integration of design and planning**

The Project ultimately targets to achieve higher overall construction productivity through design, planning and systems. Design standardisation was sought, and yet provide creative space planning to the residents. More types of 3D volumetric precast elements were planned to raise productivity and safety. Manpower and resources at site were planned to optimize the overall construction period.

Further, Obayashi will also bring in equipment which are either productized or in R&D stage to assist in enhancing productivity. “Skyjuster” is a productized equipment which enables the reduction of hook time per element. The component can be remotely rotated and oriented to its intended position. Autonomous tower crane is at the R&D stage and we have developed a practical system whereby our system will control the optimum path to the destination where the elements are to be hoisted. This technology is relevant to this Project because we have elements which are designated to a specific location on repetitive floors. In collaboration with HDB, whereby Obayashi was allowed to use the HDB’s 3D printing machine, we have printed a sculpture that offers shade and rest for the residents using our 3D printing solution. Obayashi intends to further develop this and install a 3D printed element at site.



# Enhancing Construction Productivity

Not just through  
automation and digitalization,  
but through integration of  
design and planning

**Design**  
Design  
standardisation was sought,  
and yet  
provide creative space  
planning to the  
residents

**Digital  
Systems**  
Digital Twin to  
track production  
and installation

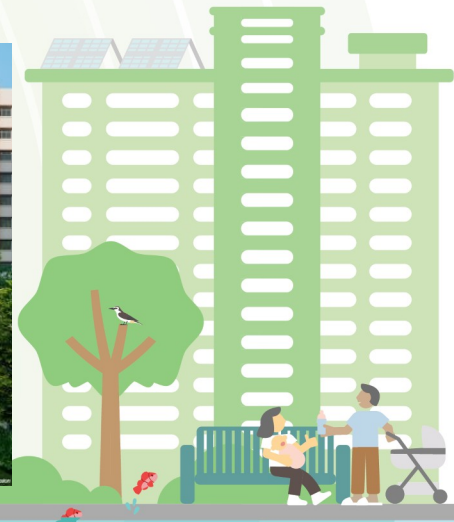
**Planning**  
Manpower and  
resources at site  
were planned to  
optimize the  
overall  
construction  
period

**Automation**  
Controlling the  
optimum path to  
the destination  
where the  
elements are to  
be hoisted

# Project Overview

Waterfront I & II @ Tengah

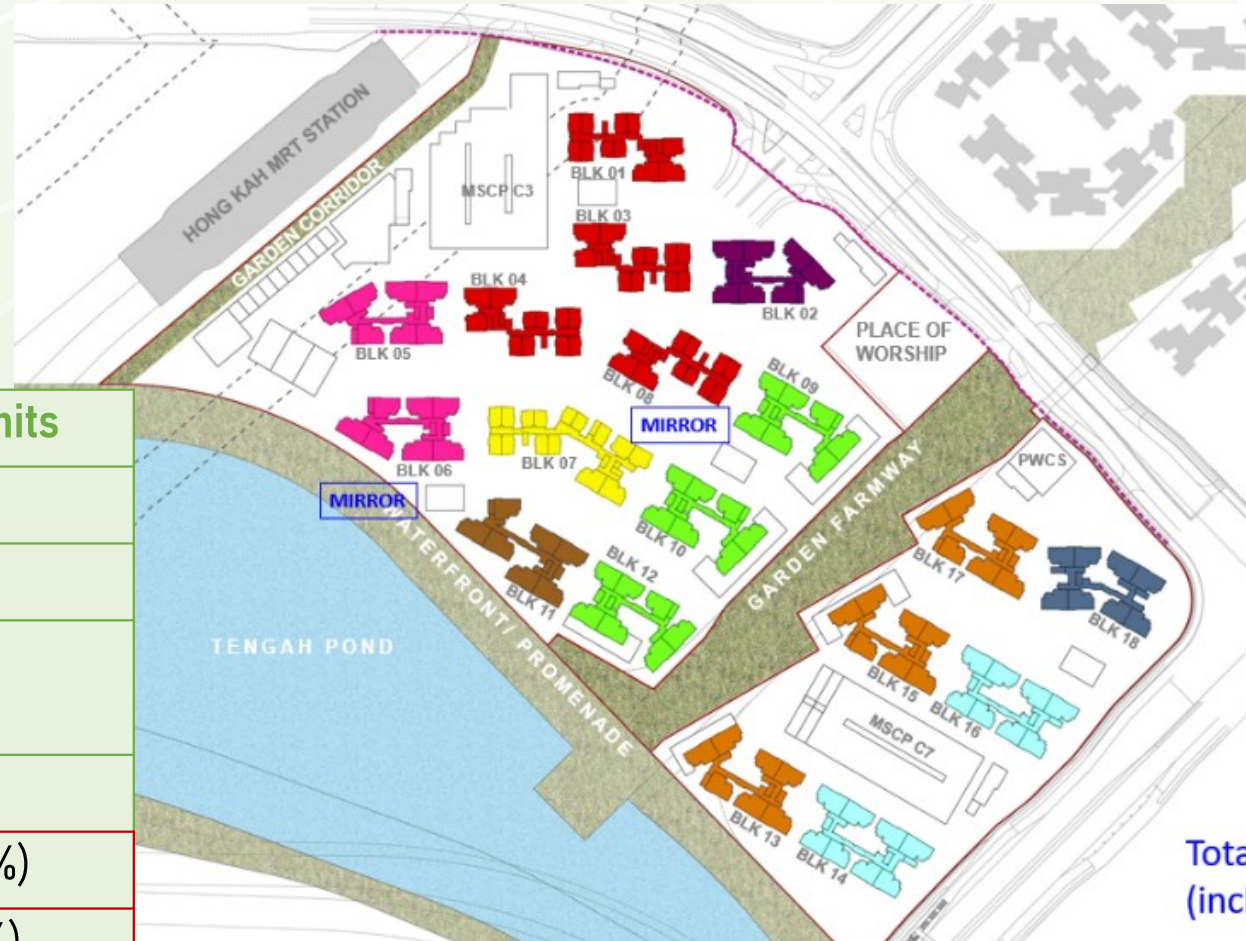
Consultants' QP	Tender & Completion Date
<p>HDB BRI(Design QP) In collaboration with P&amp;T Consultants Pte Ltd and Obayashi Singapore Private Limited</p>	<p>Tender: Award Jan 2022 Launch: Nov 2022 Completion Date: 1Q 2027</p>



# High Level of Unit and Block Repetition

- Maximizing unit repetition increases repetition of precast elements, improving buildability
- High block repetition with 11 block keys (including mirror) out of 18 total blocks reduces time required to design and develop drawings

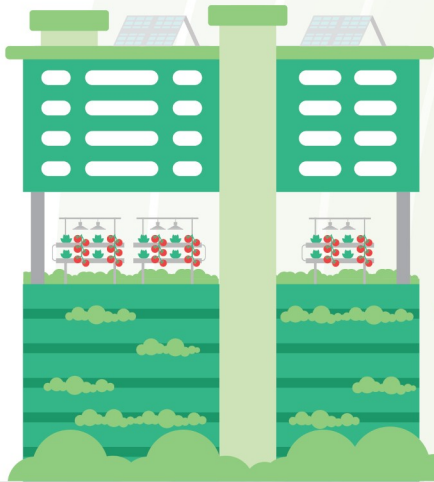
Unit Type	No. of units
2R-1 (36sqm)	178
2R-2 (46sqm)	400
2R-2 (46sqm) Rental	58
3R (66sqm)	89
4R (90sqm)	740 (35%)
5R (110sqm)	670 (31%)



## KEY BLOCKS

- KEY BLOCK TYPE A (4 NOS.)
- KEY BLOCK TYPE B (3 NOS.)
- KEY BLOCK TYPE C (3 NOS.)
- KEY BLOCK TYPE D (2 NOS.)
- KEY BLOCK TYPE E (2 NOS.)
- KEY BLOCK TYPE F (1 NOS.)
- KEY BLOCK TYPE G (1 NOS.)
- KEY BLOCK TYPE H (1 NOS.)
- KEY BLOCK TYPE I (1 NOS.)

Total Block type : 11 nos  
(including mirror)



# Beamless Flat Plate System

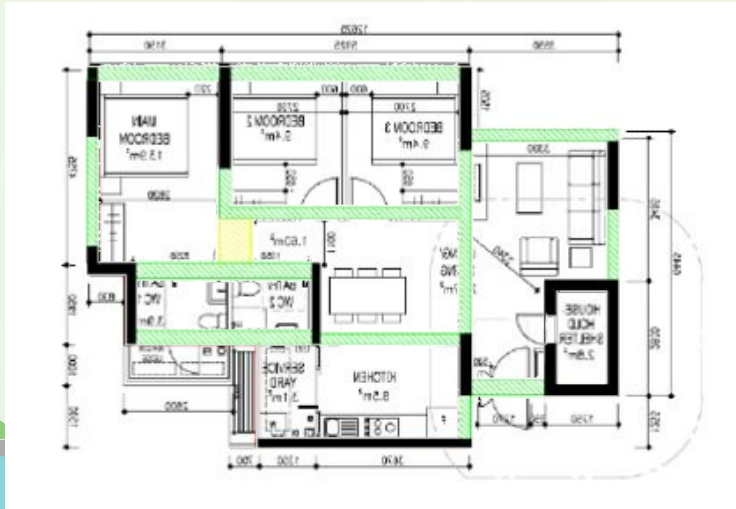
## Innovative Design

- HDB's first precast flat plate system for residential building, with only peripheral beams
- No internal ceiling beams
- Improve productivity (easier propping installation – all flat with minimal beam)



Conventional – Prototype Unit Plan

4R



Proposed

4R

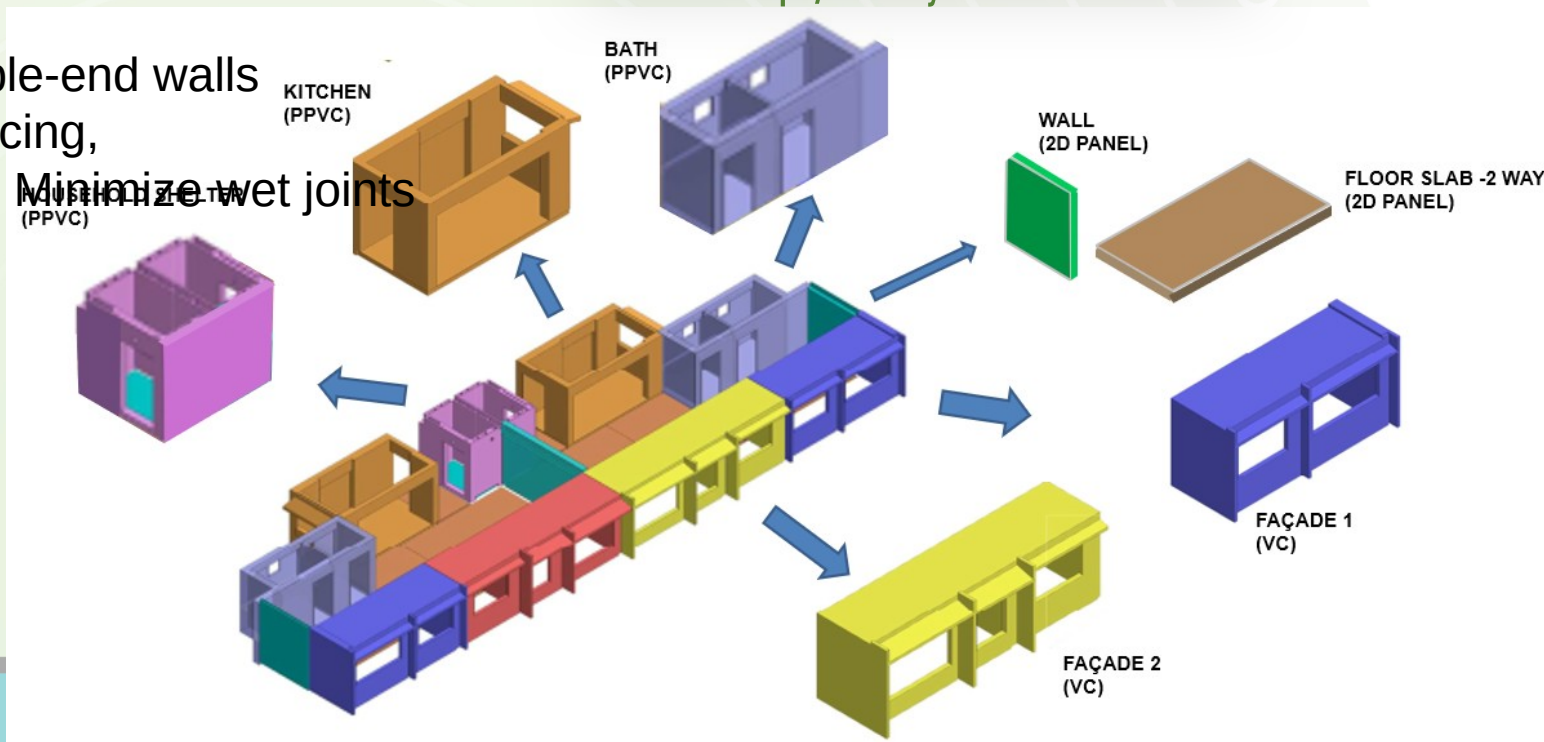


# Modularization of Complex

- 3D components:
  - Duplex/Triplex Precast Volumetric Structural Façade integrated with columns/walls
  - Precast kitchen & bathrooms / Household Shelter
- 2D components:
  - Long spanned precast flat slab to create beam-free internal spaces
  - Large panel structural walls and gable-end walls
- Reduced need for propping/diagonal bracing, improving productivity on site.

Target 25% ↑

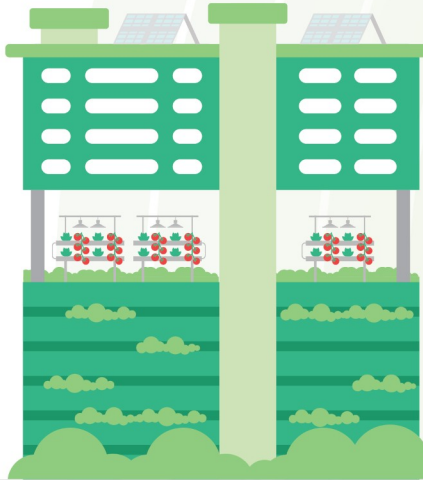
in productivity over prevailing industry standard  
0.75 sqm/manday



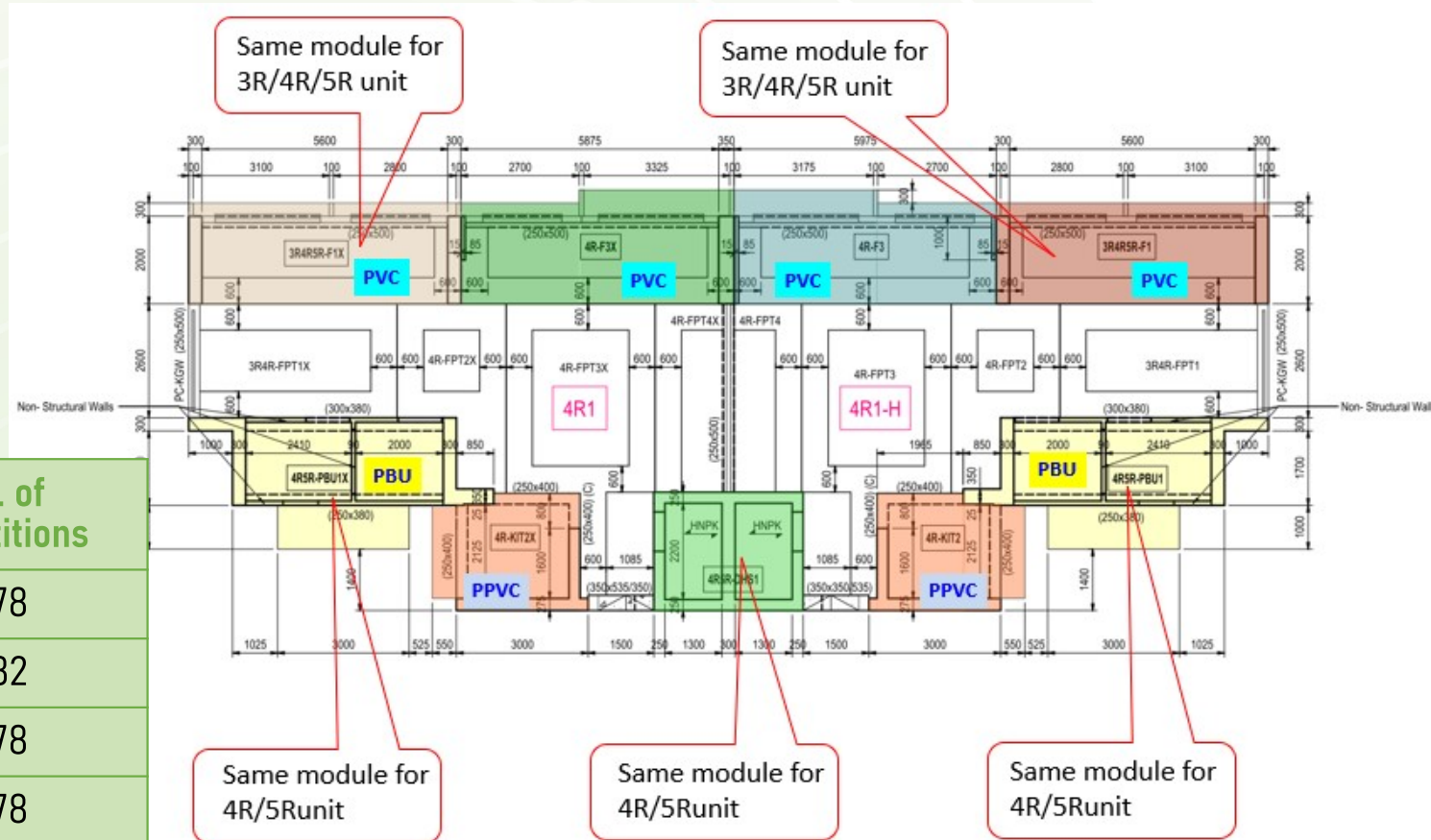


# High Repetition of Precast Elements

- Precast modules are designed to be repeated across different unit types
  - Façade components can be reused across 3R/4R/5R units
  - PBU is the same for 4R/5R
  - Duplex HHS is the same for 4R/5R
- As 4R and 5R make up 66% of total units, high repetition is achieved

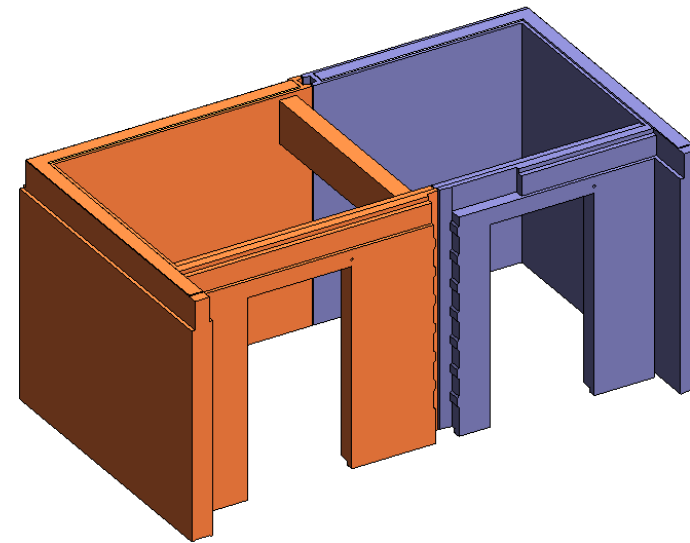


S/N	Component Type	No. of Repetitions
1	3R4R5R-F1	678
2	3R4R5R-F1X	732
3	4R5R-PBU1	678
4	4R5R-PBU1X	678
5	4R5R-DHS1	639



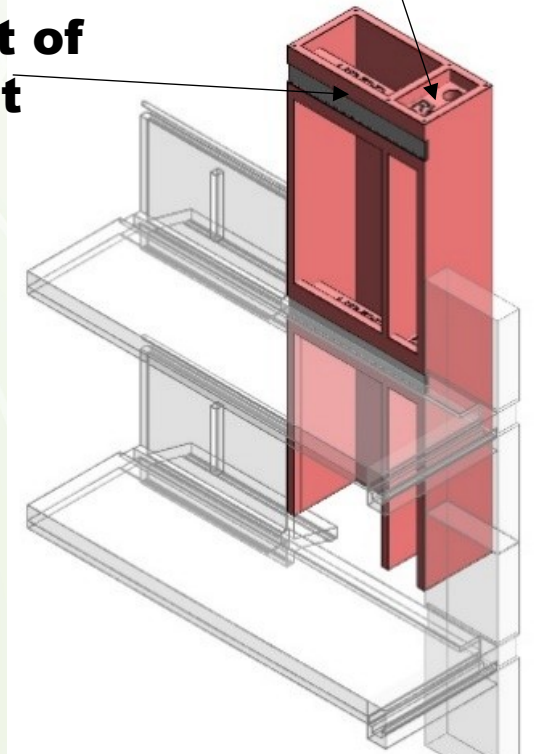
# Corridor Modularization

- 3D large integrated components for common areas
- 3D volumetric lift wall with separator beam
- Double tier volumetric precast duct
- Minimize wet joint and diagonal propping on site (improve productivity and safety), reduce installation time by half (improve productivity)



**Volumetric lift wall**

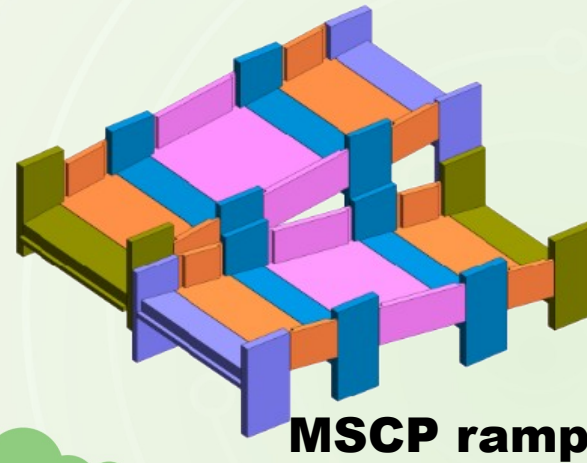
**RC lintel above  
door part of  
precast**



**Double-tier volumetric  
precast duct**

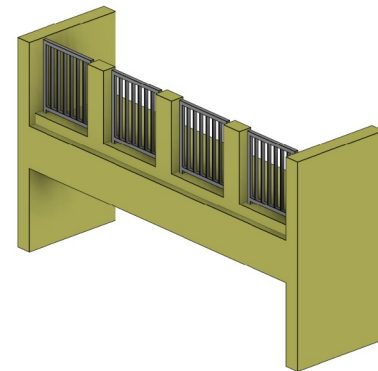
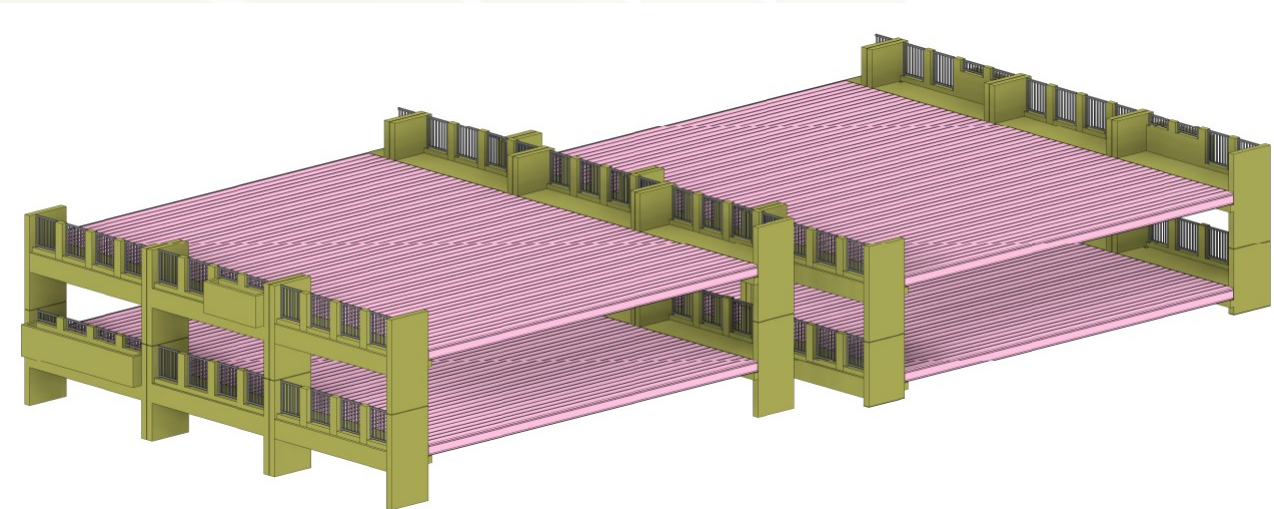
# Multi Story Carpark Modularization

- H-shape volumetric construction for peripheral façade module with barriers and railing with hollow core slab for proless MSCP construction
- Standardized to maximize repetition
- Precast H-shape ramp modules
- Larger single integrated modules to reduce hoisting operations
- Improves overall productivity on site with reduction in man-hours

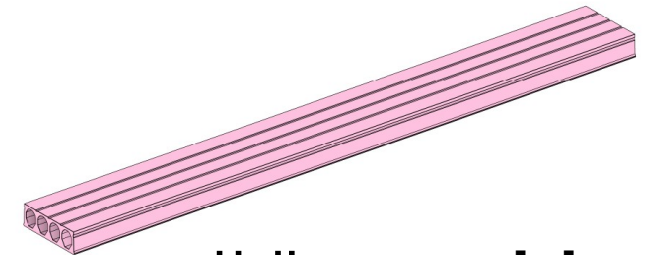


1 RAMP-3D.VIEW

**MSCP ramp**



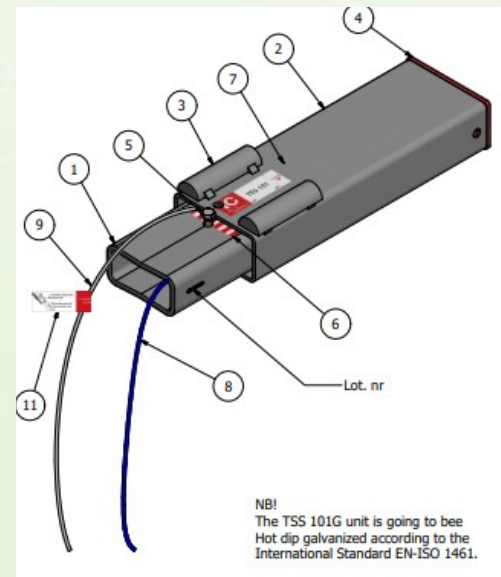
**Volumetric façade (column, beam, kerb and railing)**



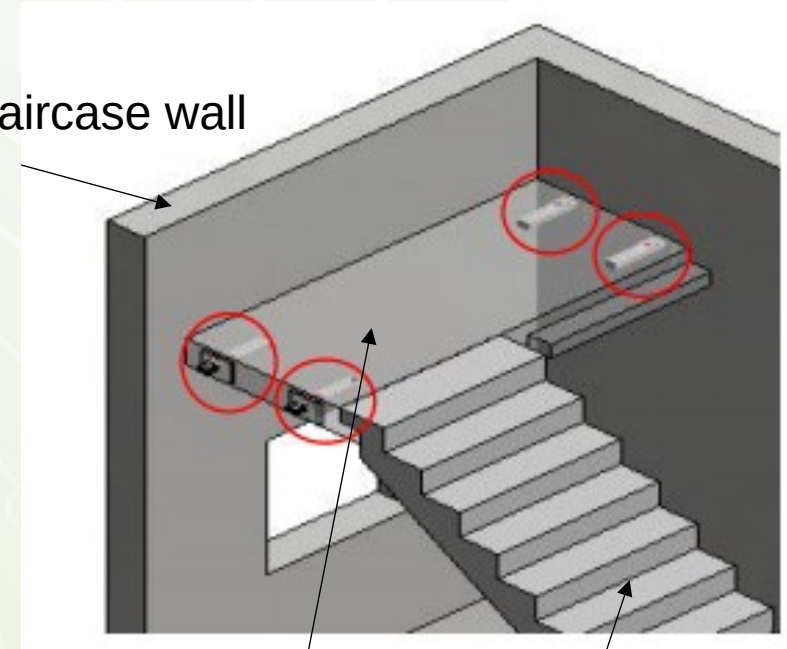
**Hollow core slab**

# Connection Detail for Full Precast Staircase at MSCP

- Full precast staircase construction (precast landing, flight and wall), no CIS topping for MSCP
- Mechanical invisible joint between precast to precast
- Fast erection of staircase core improve productivity and safety



Precast staircase wall

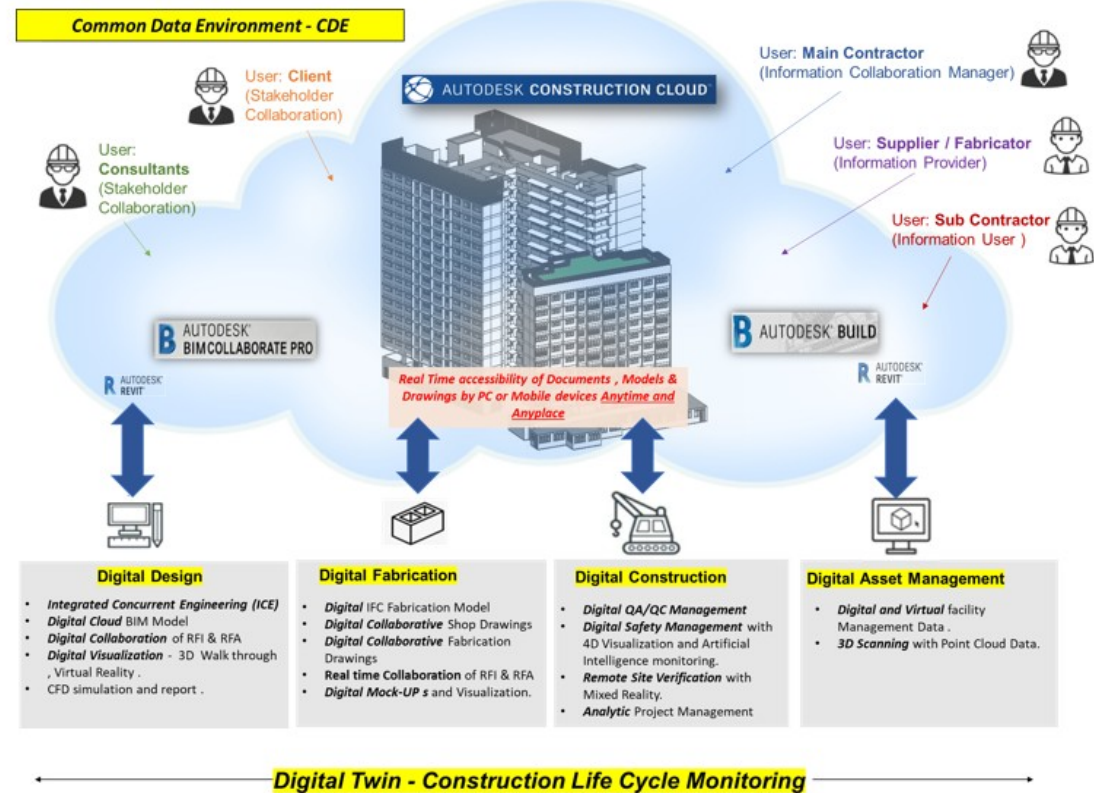
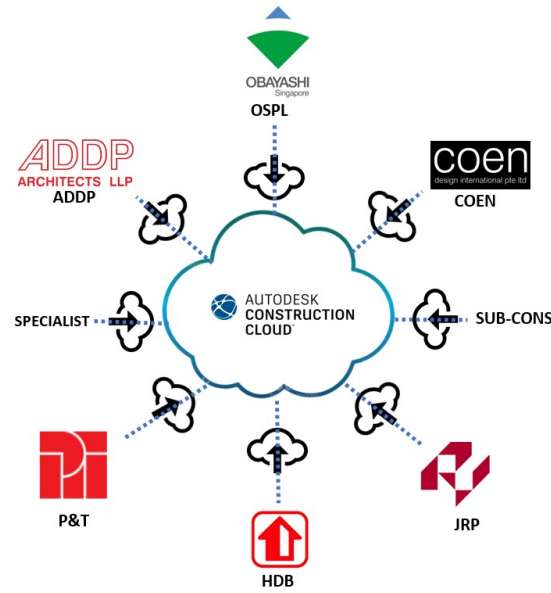


Precast landing

Precast flight

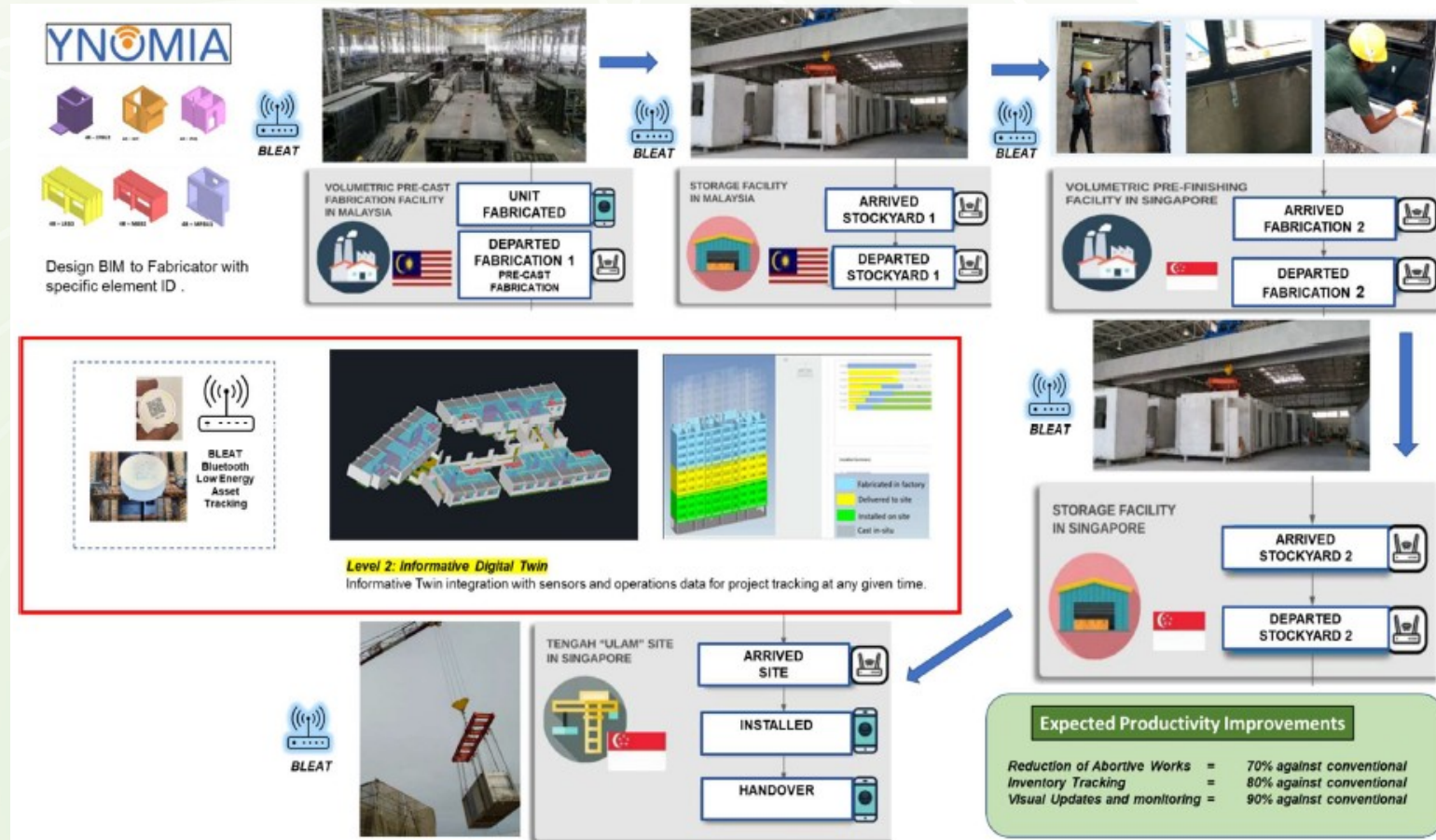
# IDD Integrated Digital Delivery

Integrating work processes and connect stakeholders working on the same project throughout the construction and building life-cycle. This includes design, fabrication and assembly on-site, as well as the operations and maintenance of buildings

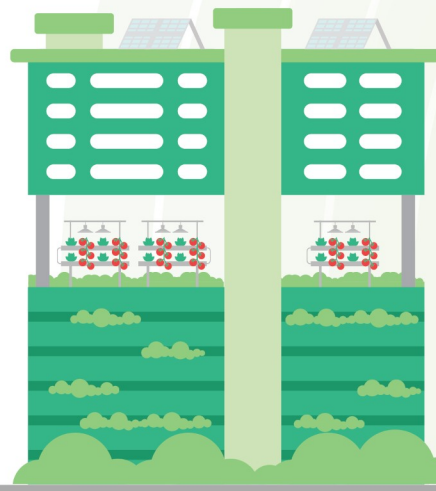
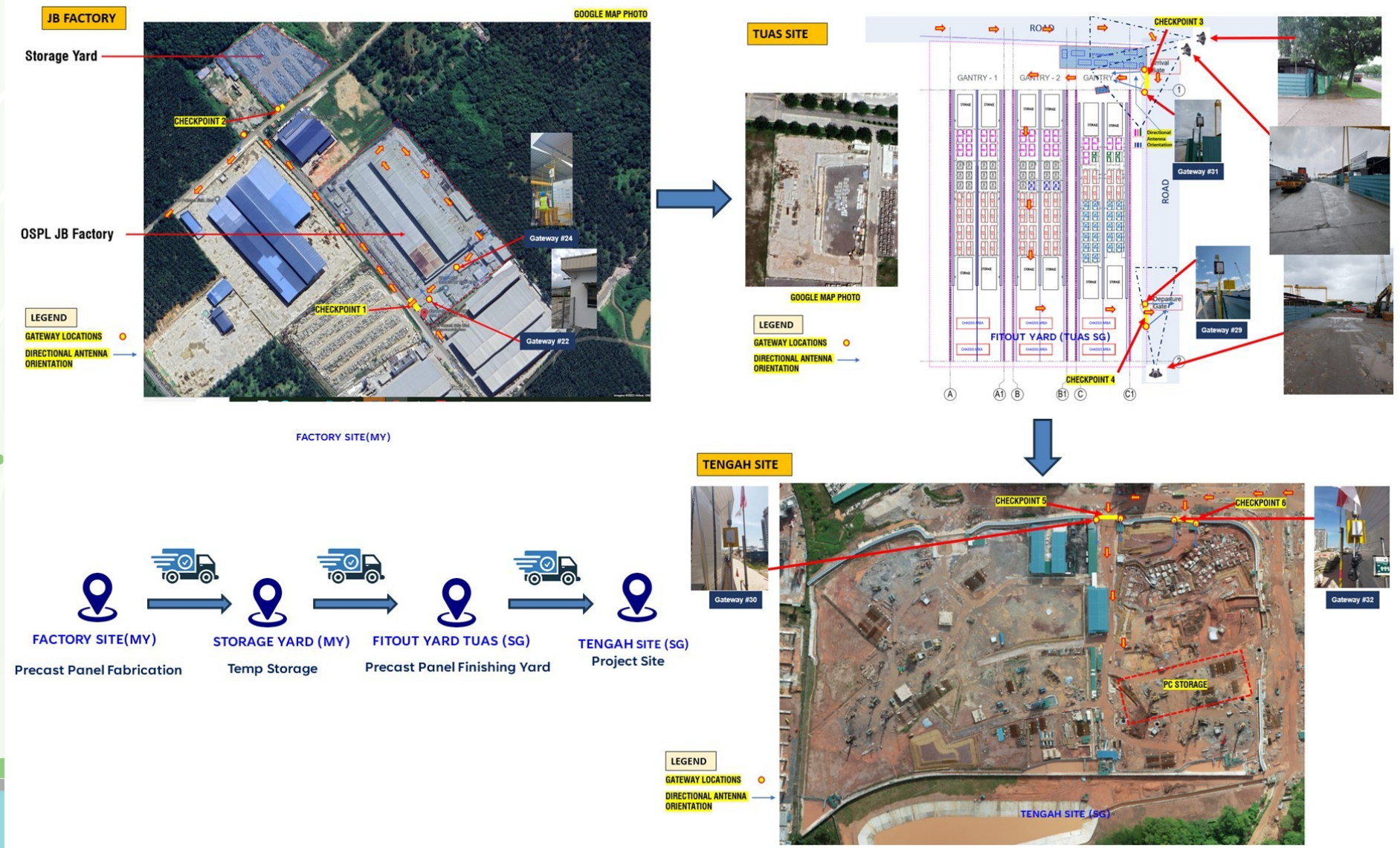


# Tracking Fabrication to Delivery to Site

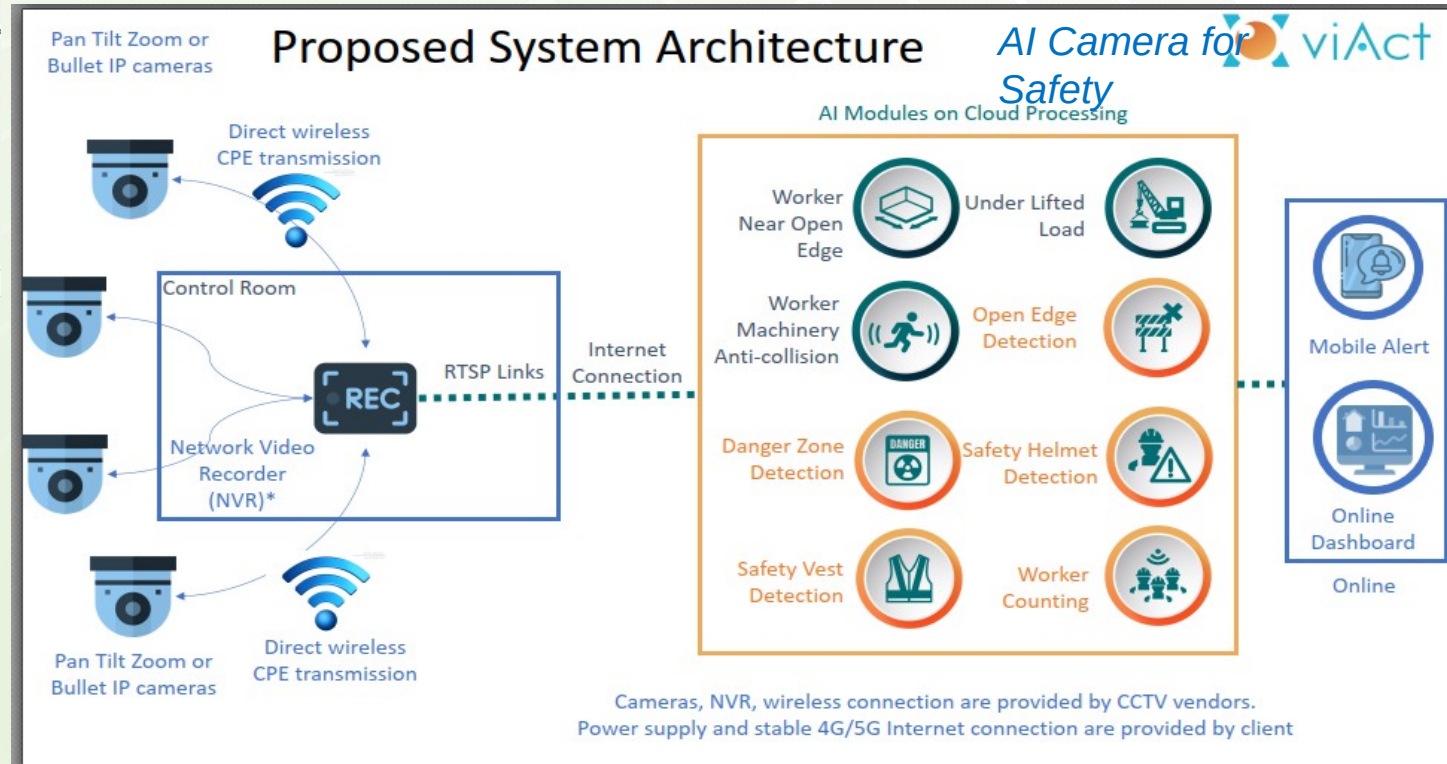
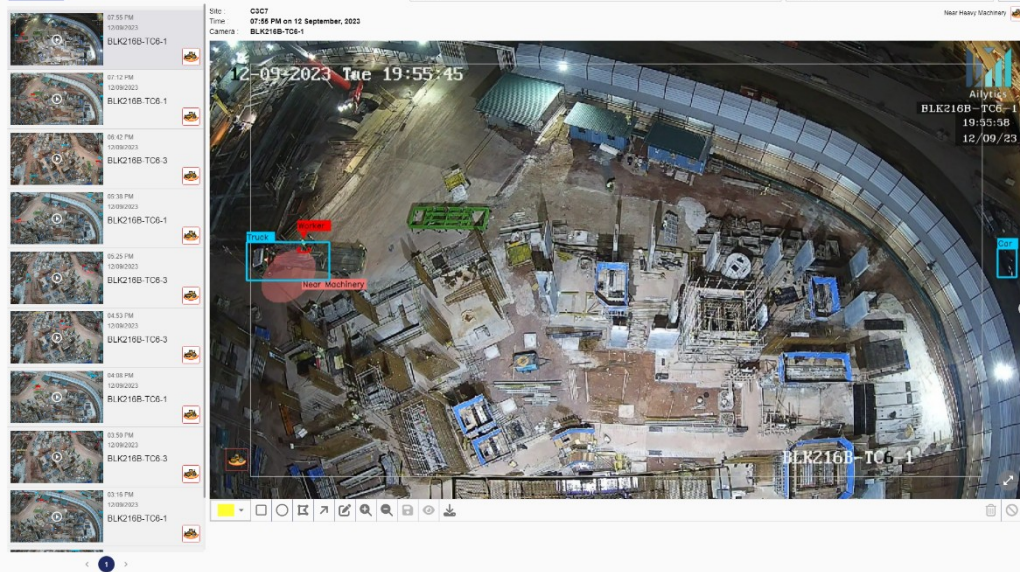
- Precast components tracked with Bluetooth tags from fabrication to delivery and assembly on site
- BIM model will be updated once precast components are installed
- Improved productivity in inventory tracking, reducing abortive works and visual updates and monitoring



# Tracking Fabrication to Delivery to Site



# AI Camera for Safety





# Automation

Adoption of Construction  
Technology from Japan  
Increased resilience through  
reduced reliance on manual  
labour

## Autonomous Tower Crane

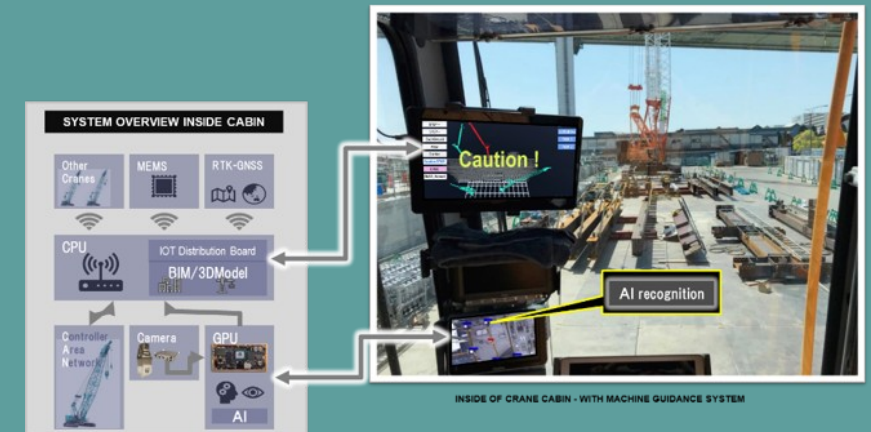
### Enhanced Productivity

- Complement and reduces the amount of manual operation
- Optimizes hoisting route and avoids obstructions

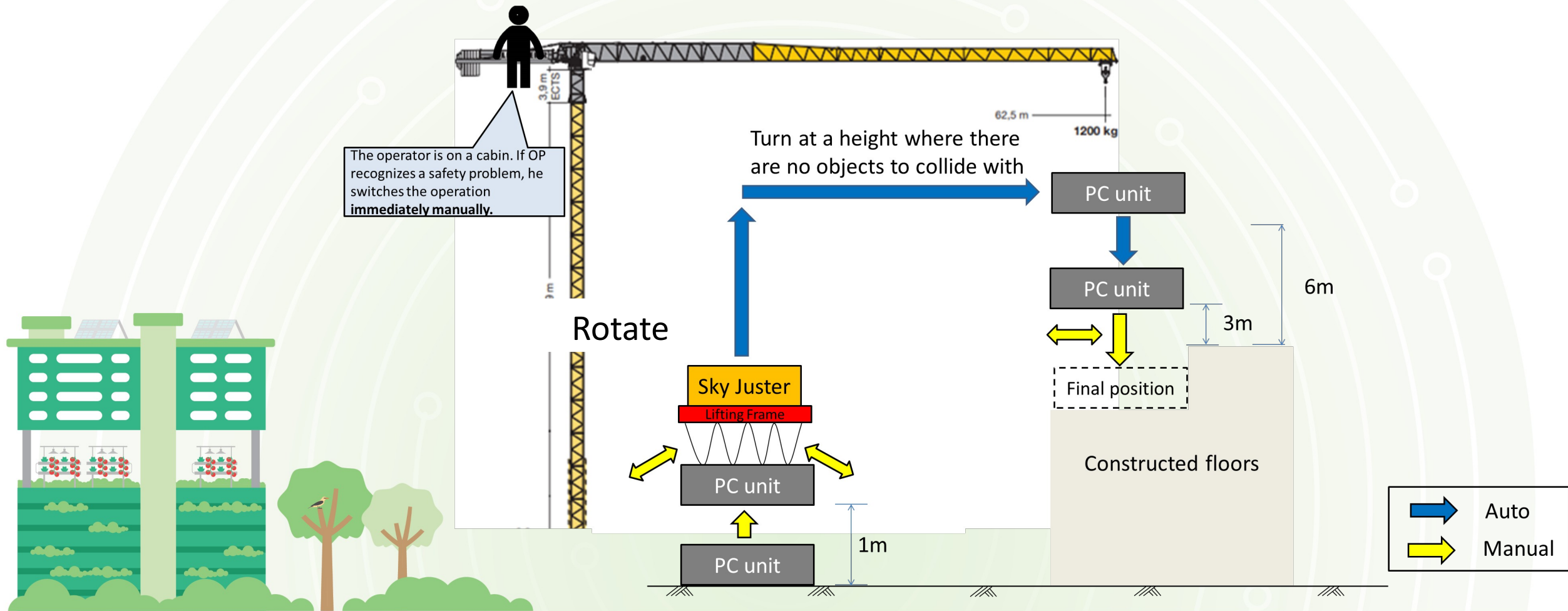


## Crane Machine Guidance

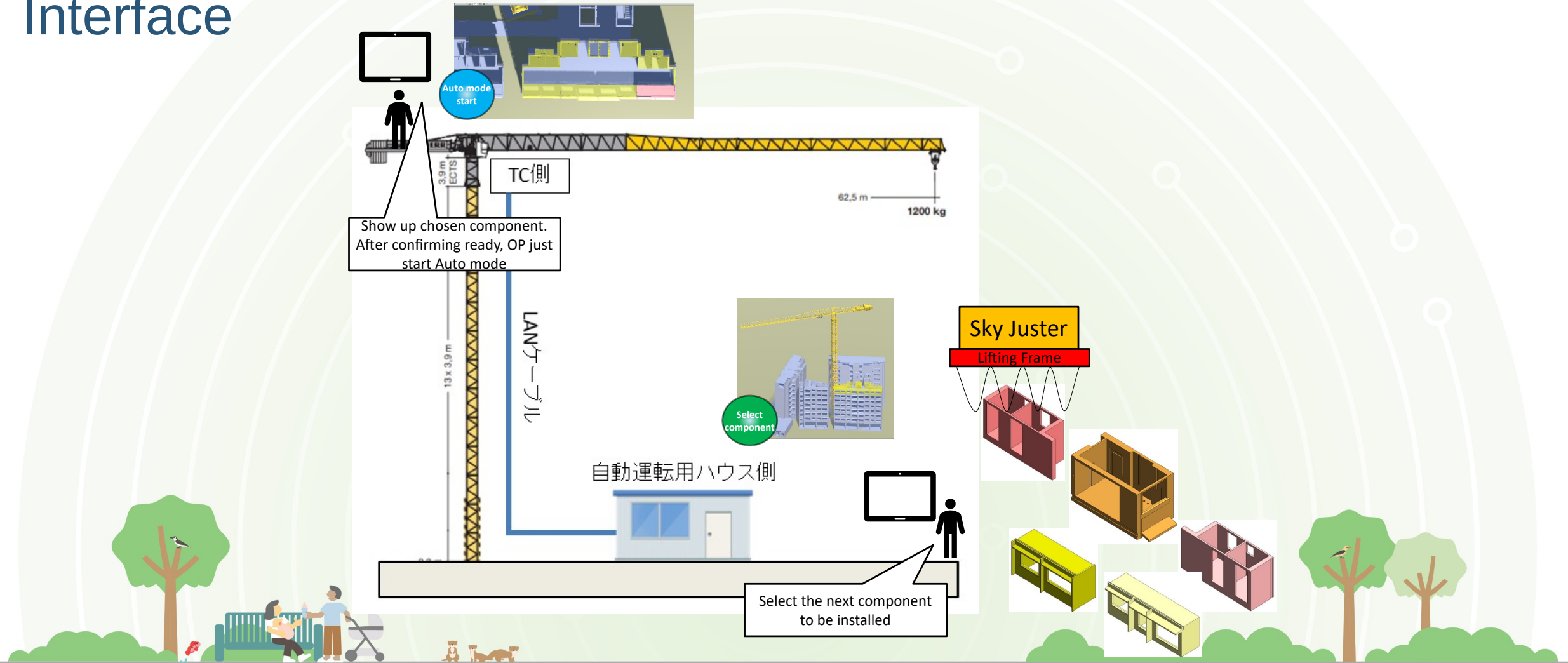
- Guides the crawler crane operator with optimal hoisting coordinates retrieved via GNSS
- Analyses the best hoisting manoeuvre and provides information to operator e.g. rotation and boom angle



# Autonomous Tower Crane

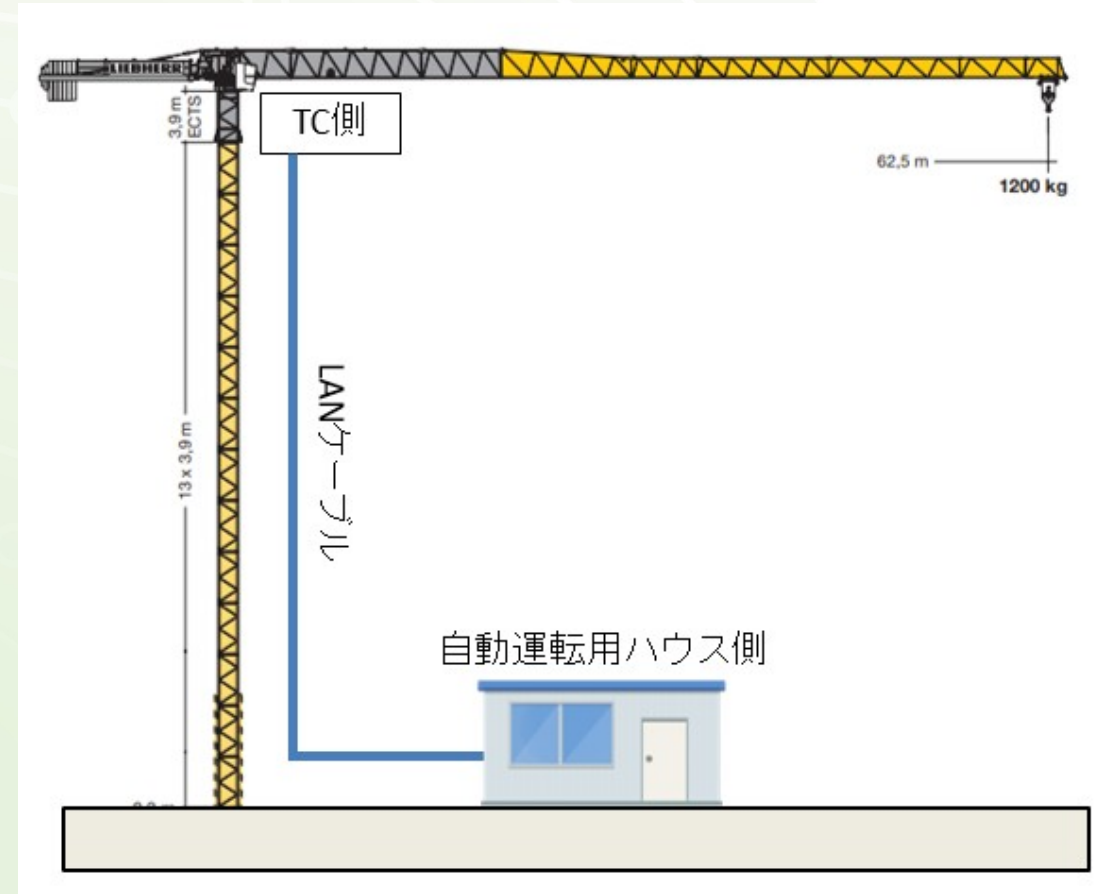


# Autonomous Tower Crane User Interface



# Autonomous Tower Crane

- ①A: Send coordinates of destination and current location and lifting distance
- ②B: Transmits winding, turning, and traversing notch signals
- ③Crane notches in upon receiving signal
- ④Repeat steps ①, ②, and ③ until the coordinates of the destination and current location match



# Autonomous Tower Crane User Interface

Unity 2017.4.40f1 Personal (64bit) - 共有部非表示:unity - OSPL\_test20230510 - PC, Mac & Linux Standalone\* <DX11>

File Edit Assets GameObject Component Window Help

Center Local

# Scene Shaded 2D

Gizmos All

Collab Account Layers Layout

Auto mode

Settings

End

Slewing control

Trolley control

Hoist control

Trolley limit

Roll limit

Load limit

Emergency stop

Change Auto/Manual

Manual OP

Slewing: 0.0° (---°) Trolley: 3.0m (---m) Hoist: 1m (---m) Load: 0.0t

Window speed: 2m Slewing Maser control: 0.0 Trolley master control: 0 Hoist master control: 0 Installation area: 8F

Crane Lamp display of crane status Inverted color when ON

Gray when the automatic operation enable/disable lamp is disabled.

The crane's Detailed numerical display of crane status

Emergency stop button. Basically, OP uses the crane's emergency stop

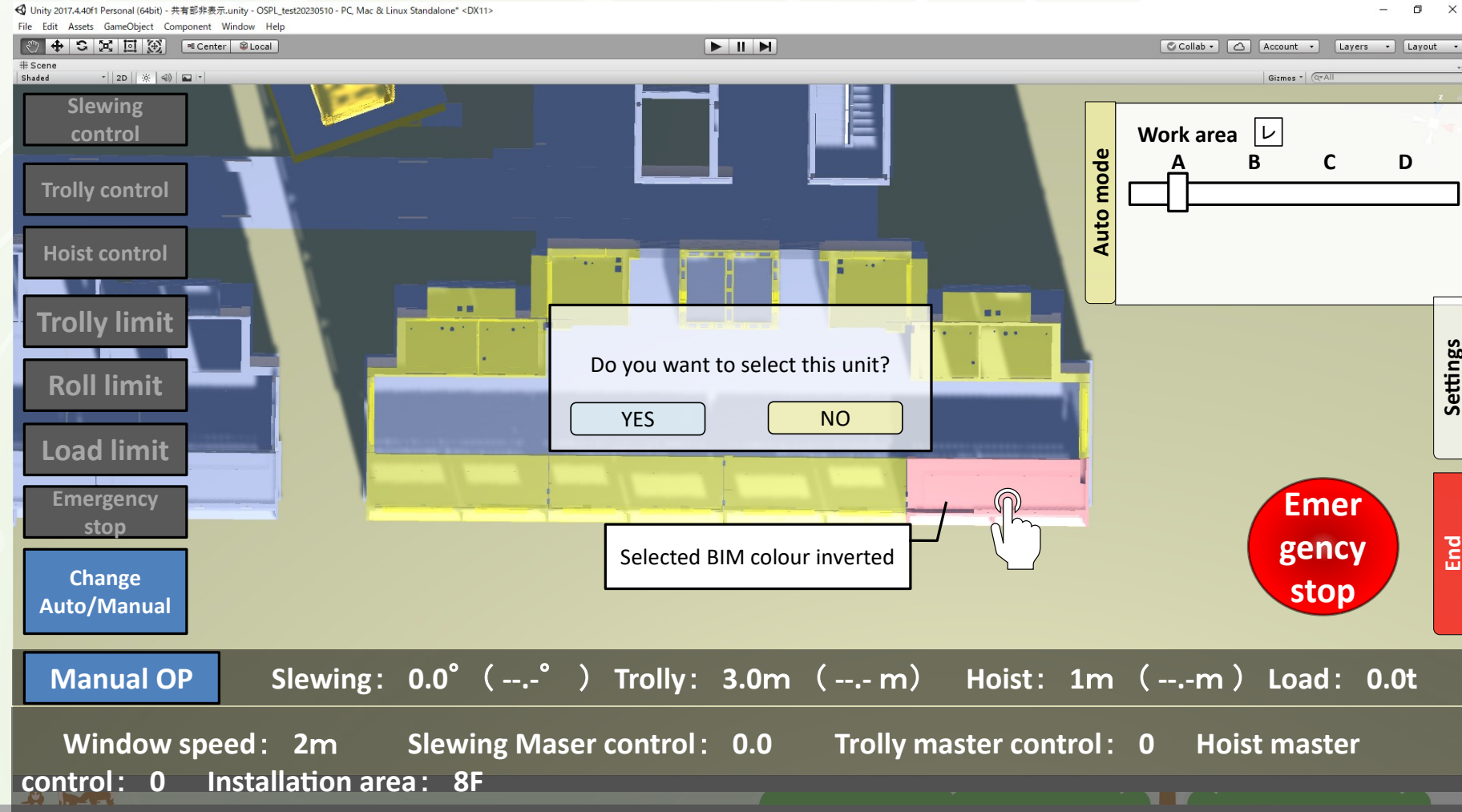
Automatic Operation Select/Start tab

System Settings Tab

System exit button

Emergency stop

# Autonomous Tower Crane User Interface



# Tracking Fabrication Site Installation via Digital Twin Model



Unity 2017.4.40f1 Personal (64bit) - 共有部非表示.unity - OSPL\_test20230510 - PC, Mac & Linux Standalone <DX11>

File Edit Assets GameObject Component Window Help

Center Local

Scene Shaded 2D 3D

Slewing control

Trolley control

Hoist control

Trolley limit

Roll limit

Load limit

Emergency stop

Change Auto/Manual

Auto OP

Arrived at the designated position. Do you want to end automatic operation?

YES NO

End when the unit arrive.

If YES is pressed, it determines that construction has been completed and the colour is inverted.

Emergency stop

End

Auto mode

Settings

Slewing: 225.0° ( 00.0° ) Trolley: 0.0m ( 16.0 m) Hoist: 15.6m ( 0.0m ) Load: 21.0t

Window speed: 2m Slewing Maser control: 0.0 Trolley master control: 0 Hoist master control: 0 Installation area: 8F

# Adoption of Construction Technology

- **SKY JUSTER**, an automated precast components installation device that can self-level, reduce swaying and rotate components during hoisting
- **Enhances safety** during lifting by minimizing operation time and reduces need for physical control i.e. guide wire not required to orient the component
- Able to control Rotation & Sway movements with remote control device at construction level to facilitate final placement of components

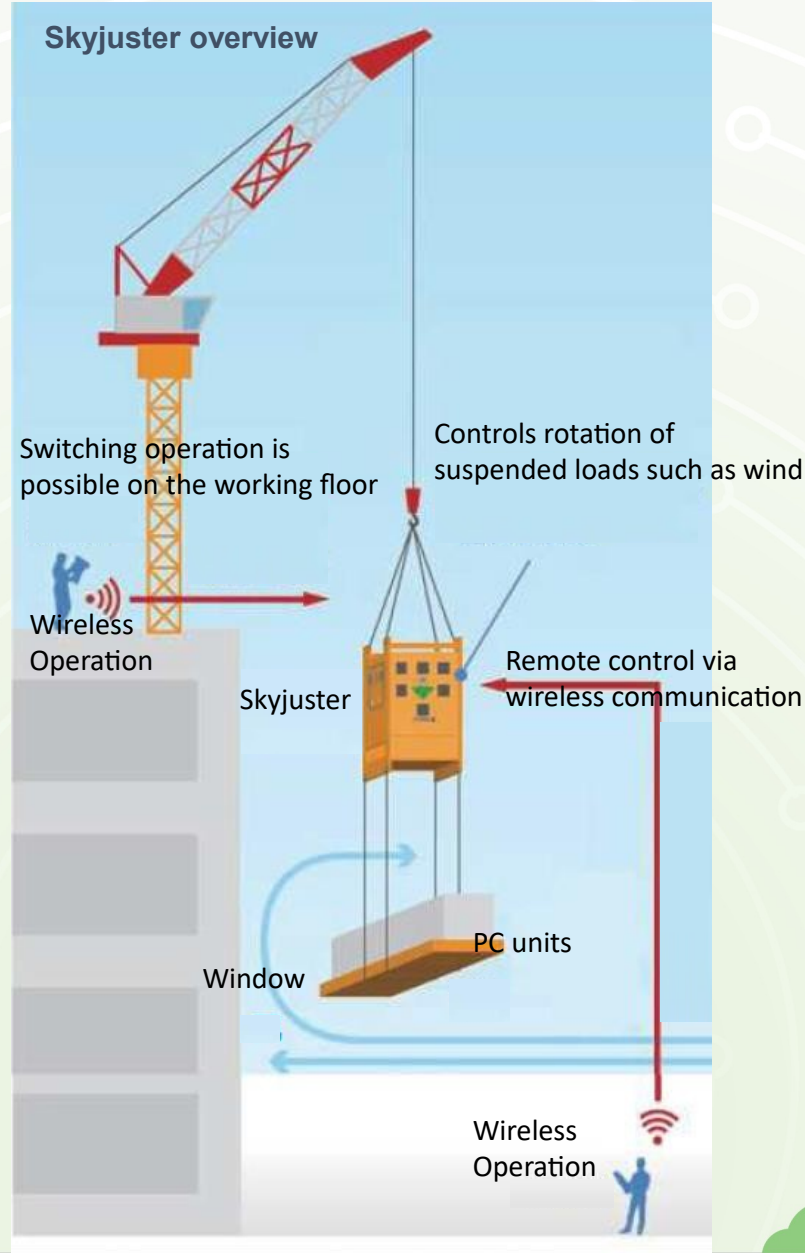
PRODUCTIVITY  15%



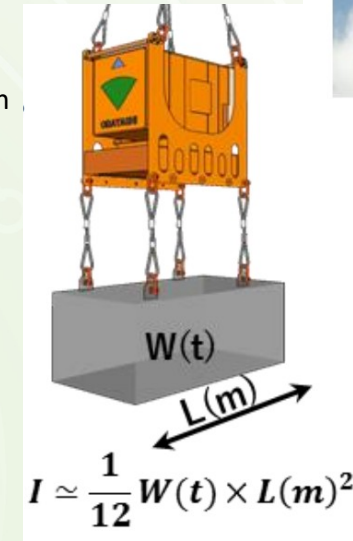


# SkyJuster©

- The horizontal rotation is **controlled by the gyroscopic effect** of the flywheel.
- The flywheel can **stop a suspended load against external forces such as wind**
- Easy to operate with a **remote wireless controller with in 100m.**

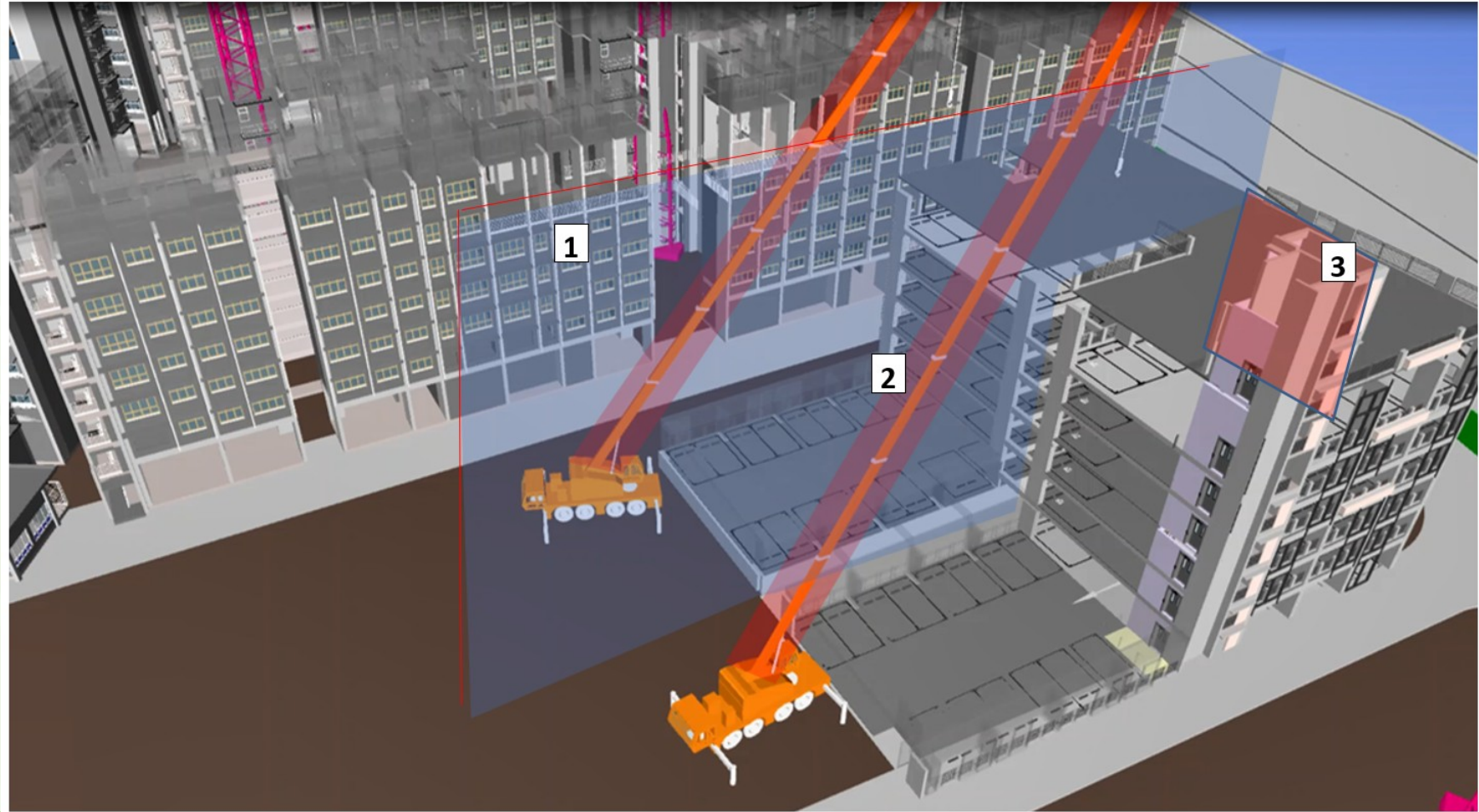


SJ-125

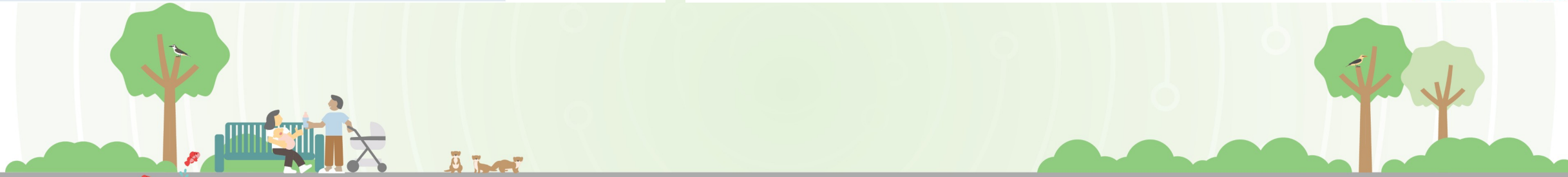
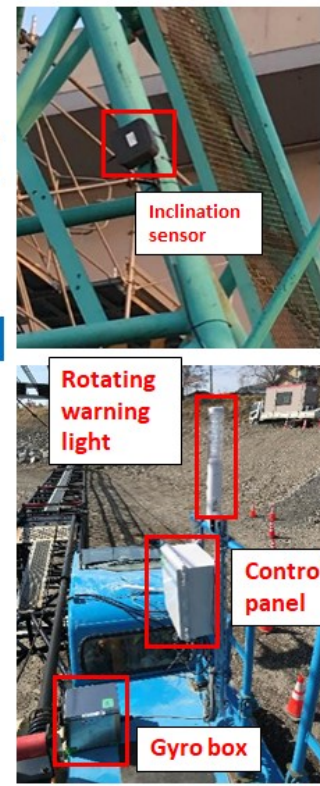
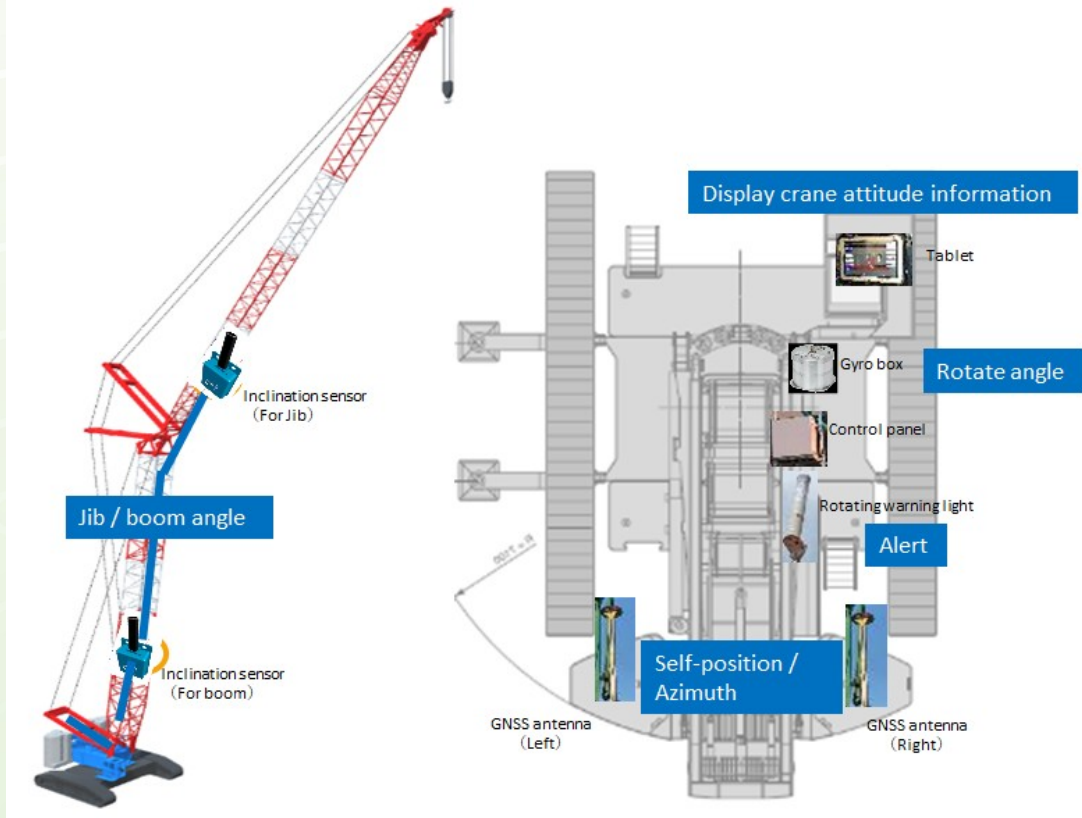
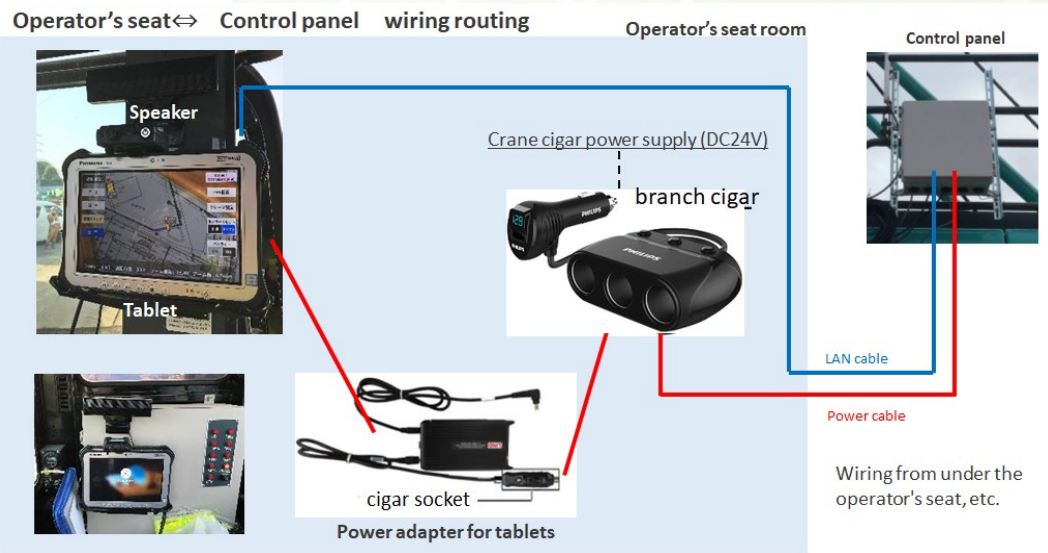


# Crane Machine Guidance for Multi Storey Carpark

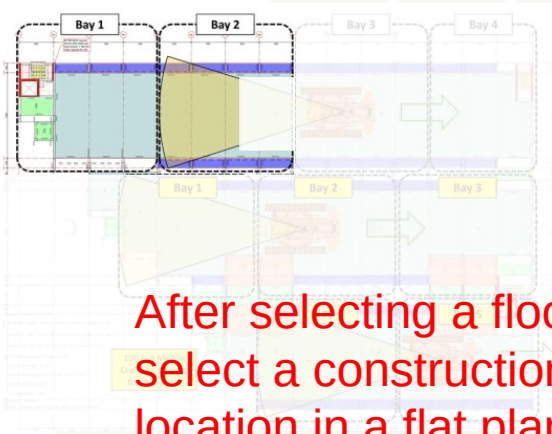
1. Border prevention
2. Crane-to-crane boom collision prevention
3. Preventing collisions between cranes and building



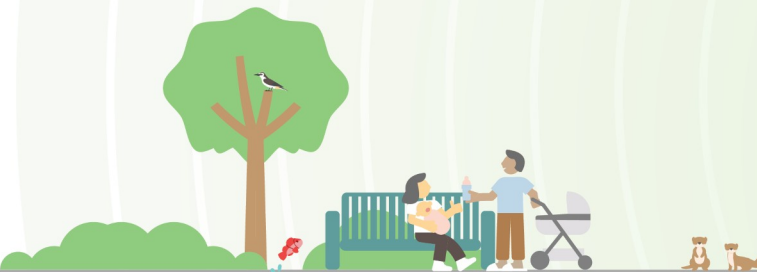
# Crane Machine Guidance Elements



# Crane Machine Guidance



After selecting a floor, select a construction location in a flat plane. Uninstalled Translucent Installed inverted (not selectable)



The main part of the slide is a 3D simulation of a crane machine in a construction site. The crane is orange and is positioned on a construction site with buildings in the background. The simulation includes several UI elements and callouts:

- System Image**: A red-bordered box containing the text "System Image".
- Construction Floor Selection**: A panel with buttons for "2F", "Part Selection", "Guidance starts", and "Guidance ends".
- Border Crossing Prevention**: A red-bordered box containing the text "Border Crossing Prevention 'warning text' display and".
- Warning text display and alarm sound**: A red-bordered box containing the text "Warning text display and alarm sound when approaching".
- Calculate and display the values**: A red-bordered box containing the text "Calculate and display the values".
- Calculate and display the values to the centre of the hook position and the selected member**: A red-bordered box containing the text "Calculate and display the values to the centre of the hook position and the selected member".
- Slewing : 15° Boom angle : 3°**: A callout box showing the crane's current position and angle.

# 3D Concrete Printing (trial using HDB printing machine)

- Adoption of 3D concrete printing technology for curved and irregular landscape structures
- Creates complex concrete structures more efficiently as compared to cast-in-situ construction that requires complex and special formwork
- Adopt fibre reinforced concrete technology to strengthen the 3D printed structures and reduces the steel reinforcement bars required

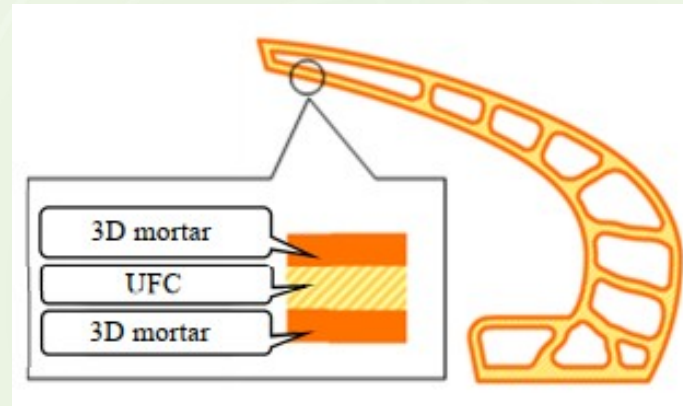
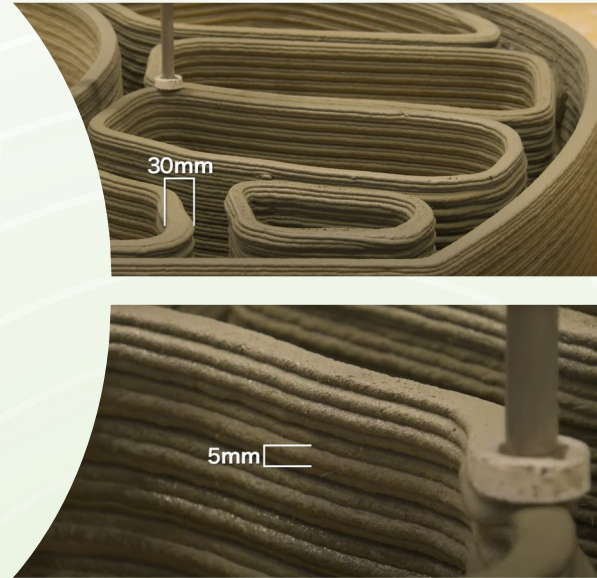


Ultra high strength fiber reinforced concrete

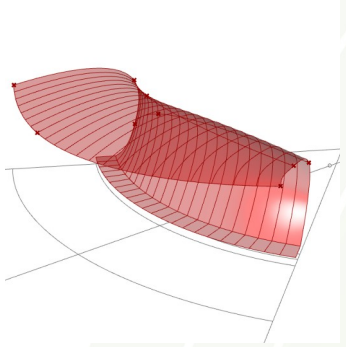
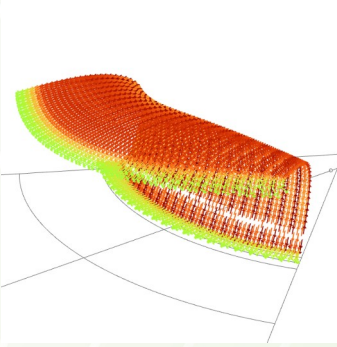
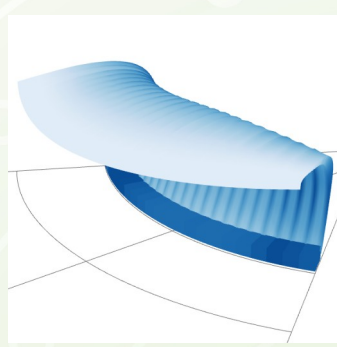


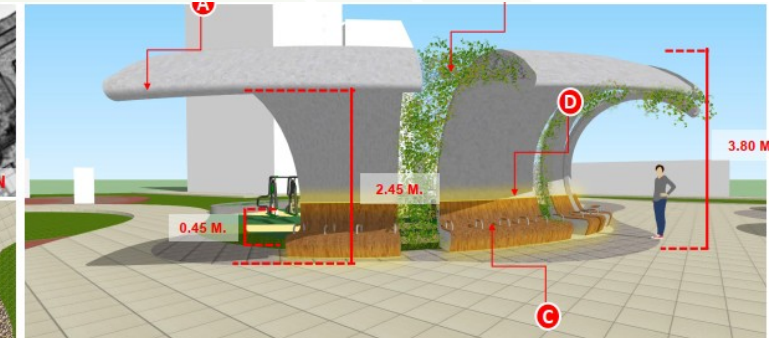
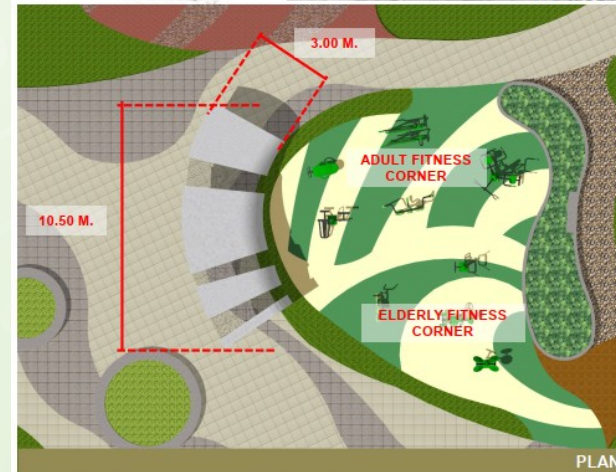
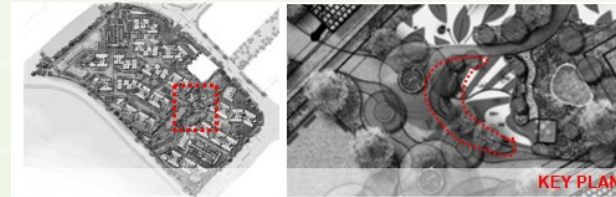
# 3D Printing Technology R&D

1. 3D mortar
2. Composite structure formed by the UFC ultra-high-strength fiber-reinforced concrete Slim-Crete©
  - Slim-Crete is a cement material with high tensile strength
  - Hardens at room temperature
  - Used to fill external shapes manufactured using special 3D printing mortar. No rebar reinforcement.



# 3D Botanical Arbour Design

Parametric shaping	Structural Analysis	Required Thickness
		



# Thank You