Smart Warehouse using 5G

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Common Problems of Current Warehouse Vehicles/Robots

- For indoor working vehicles e.g. stackers, forklifts,… various sensor data and commands are transmitted from vehicles to backends or vice versa using WiFi.
- Large numbers of sensors and multiple videos are required for precise and robust tele-operations. As WiFi is within ISM band, it would be jammed by other ISM wireless signal.
- Labour storage and ageing are two common challenges faced by many local warehouses in Hong Kong.

What 5G Technology can offer?

- Enabled by 5G, large-coverage, high performance and reliable communication for tele-operations can be established.
- High data rate: More advance sensors with large amount of data can be used/transmitted at the same time.
- Low latency: More real time information for faster response.
- Large numbers of devices allowed: More vehicles for better efficiency and more sensors for better performance.

5G Remote Control and Its Advantages

- A retrofitted stacker with 5G connectivity and control system has been proposed – it might provide a cost-effective solution (in terms of change of infrastructure).

- 5G supports great number of videos and sensor data transmission for the user to remotely control the vehicles.

- Less sensitive to signal jamming problems (compare to WiFi). All 5G devices follow 5G protocols and local regulatory requirements.

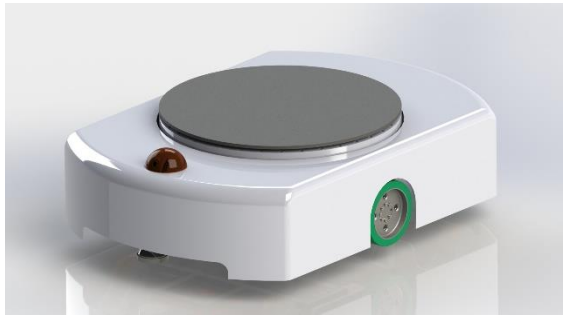
A Smart Warehouse for Hong Kong

Conventional Mode

- People to goods
- Palletized arrangement;
- Labour intensive
- Relatively long terms

Modern Mode

- Goods to people
- Fast In Fast Out;
- small items & small batches; e.g. eCommerce



All diagrams are for illustration only.

How does 5G shape Warehouse Automation ?

Smart Warehouse Using 5G – Major Features

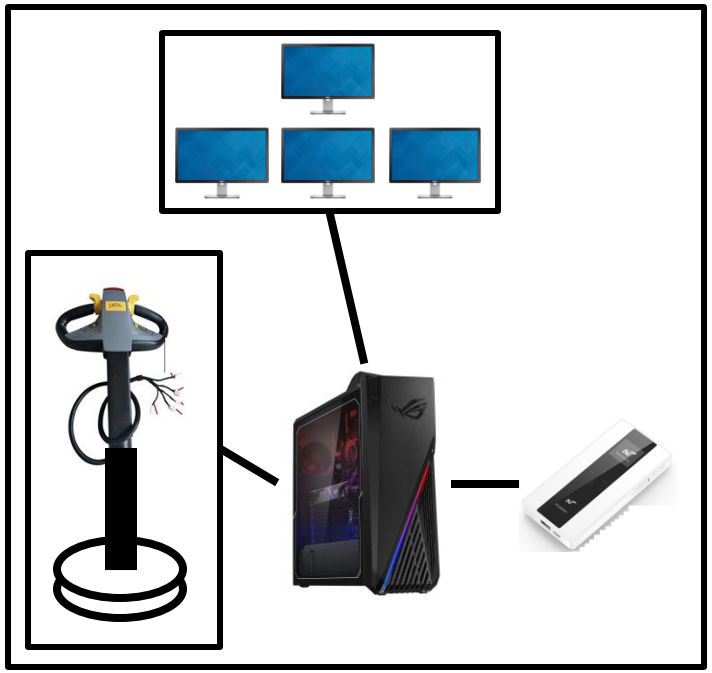
1/ System Approach (at the backends/ in cloud servers)
- able to control/monitor multiple robots/machines (One to Many);
- Multi-dimension analytics for effective/efficient scheduling;
- able to interact with human workers (semi-auto or tele-control tasks);

2/ Intelligence
- able to install multiple sensors (to collect different data for accurate analytic AI models);
- built-in local intelligence at each robot/machine;
- built-in global intelligence at System level (including edge computing).
- robot to robot interactions.

3/ Integration
- to use 5G to reduce system latency;
- able to provide wider adaptation of other robot-robot (R2R) and robot –machines (R2X);
- horizonal and vertical logistic integration.

Use case #1 5G Tele-control stacker

Control station at office

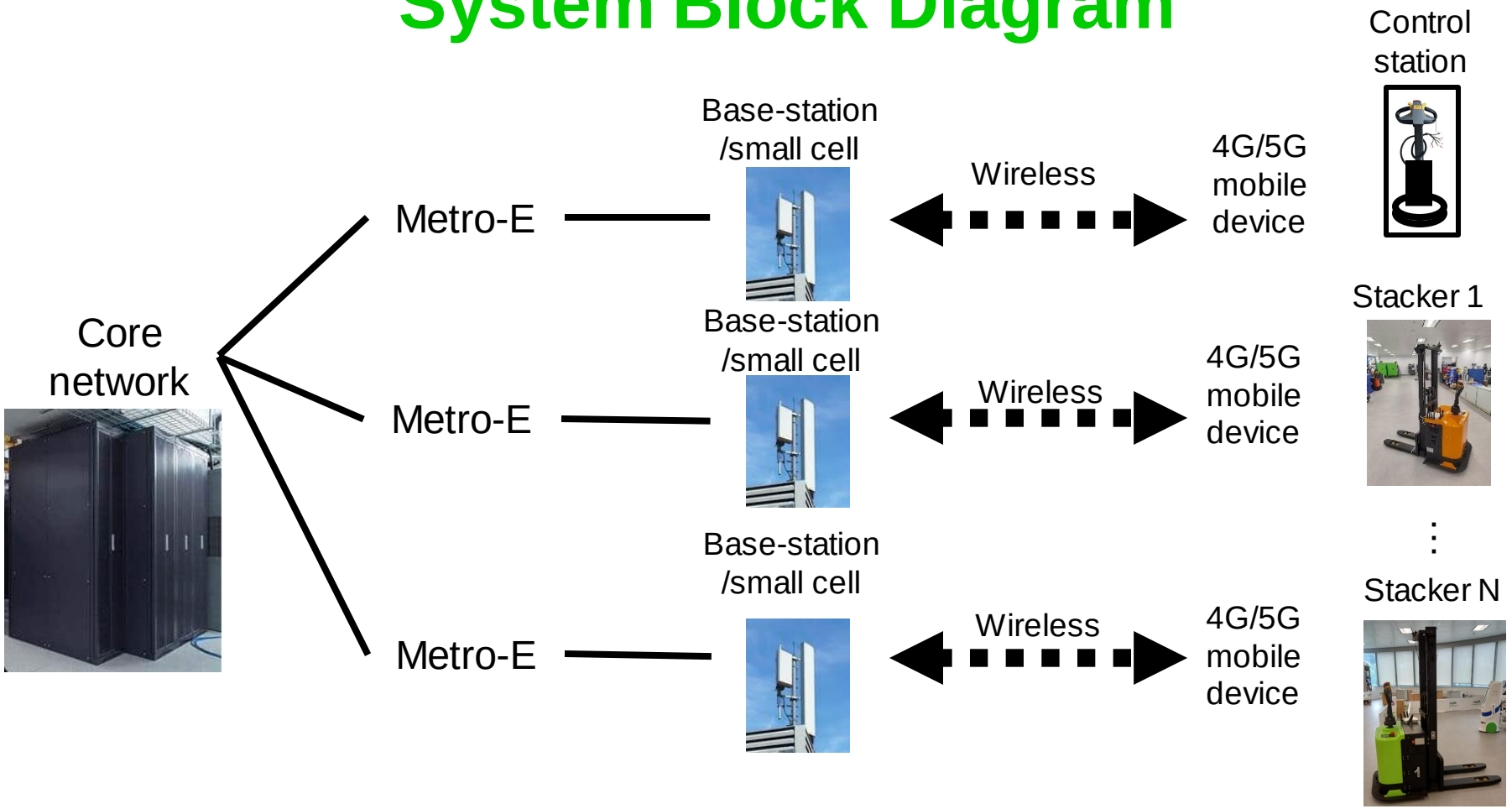


5G network

Retrofitted stacker 1

Retrofitted stacker 2

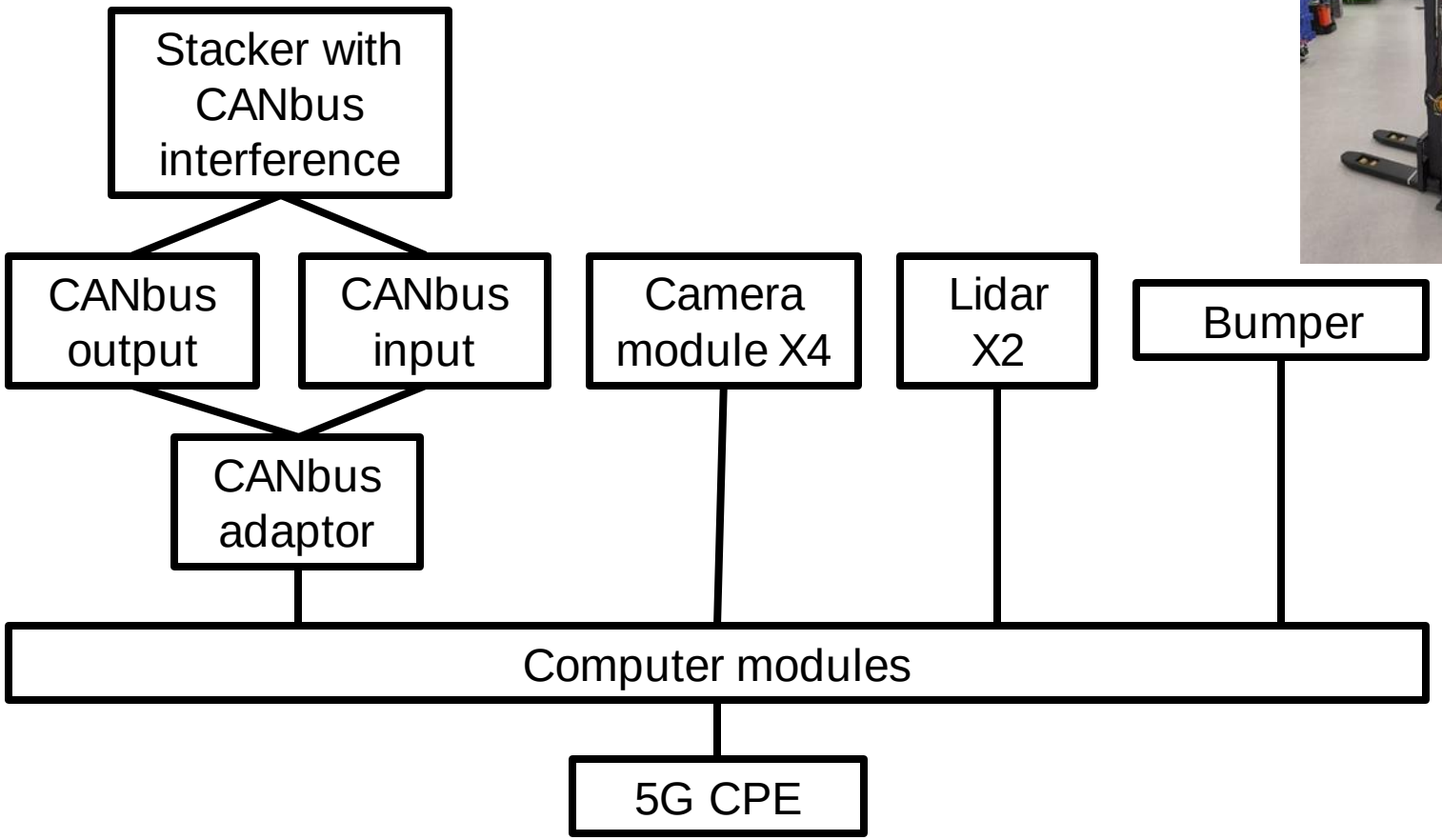
System Block Diagram



- ✓ One driver can control multiple stackers in different locations
- ✓ 0.1s-order latency video/control transmission
- ✓ Dynamic driving speed control and video quality based on network conditions

System of Retrofitted Stacker

Building blocks/modules are retrofitted to a stacker

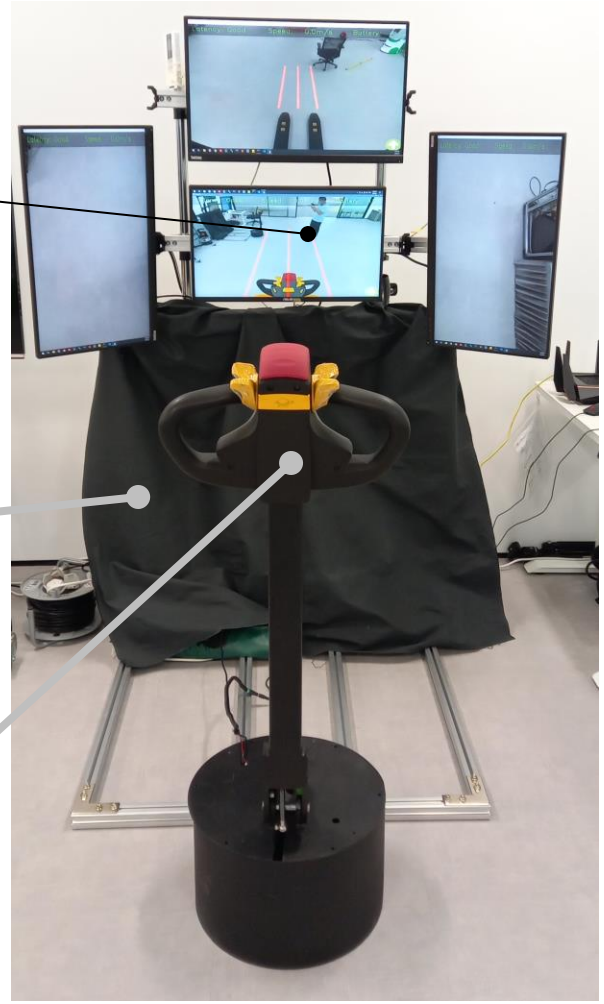


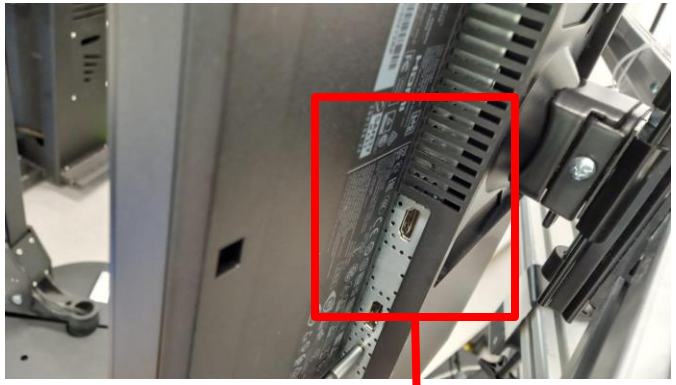
Hardware - Control Station

Four-monitor display

Computer and 5G CPE

Tiller head

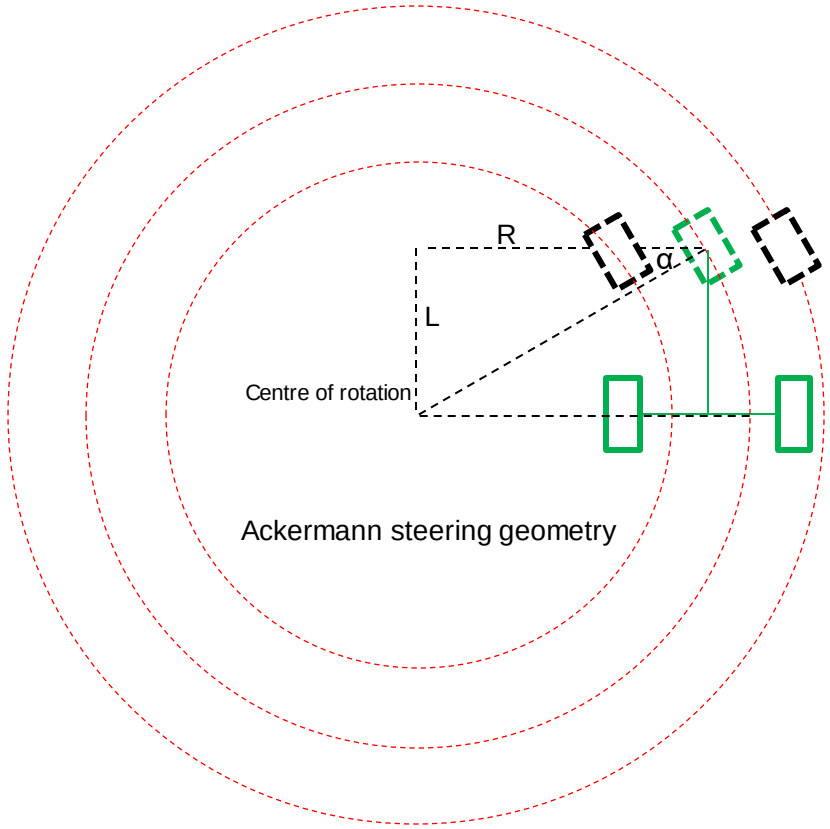


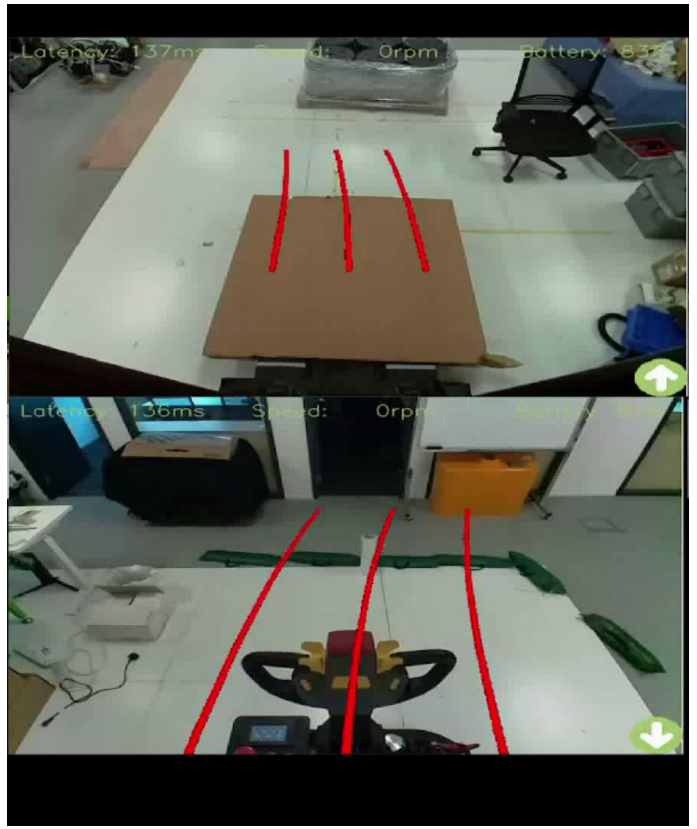


HDMI port

Assistive lines - Locus

The locus of the assistive lines calculated by reading CANbus signal form the stacker through 5G to predict the stacker position in future about 2 second and avoid collision.



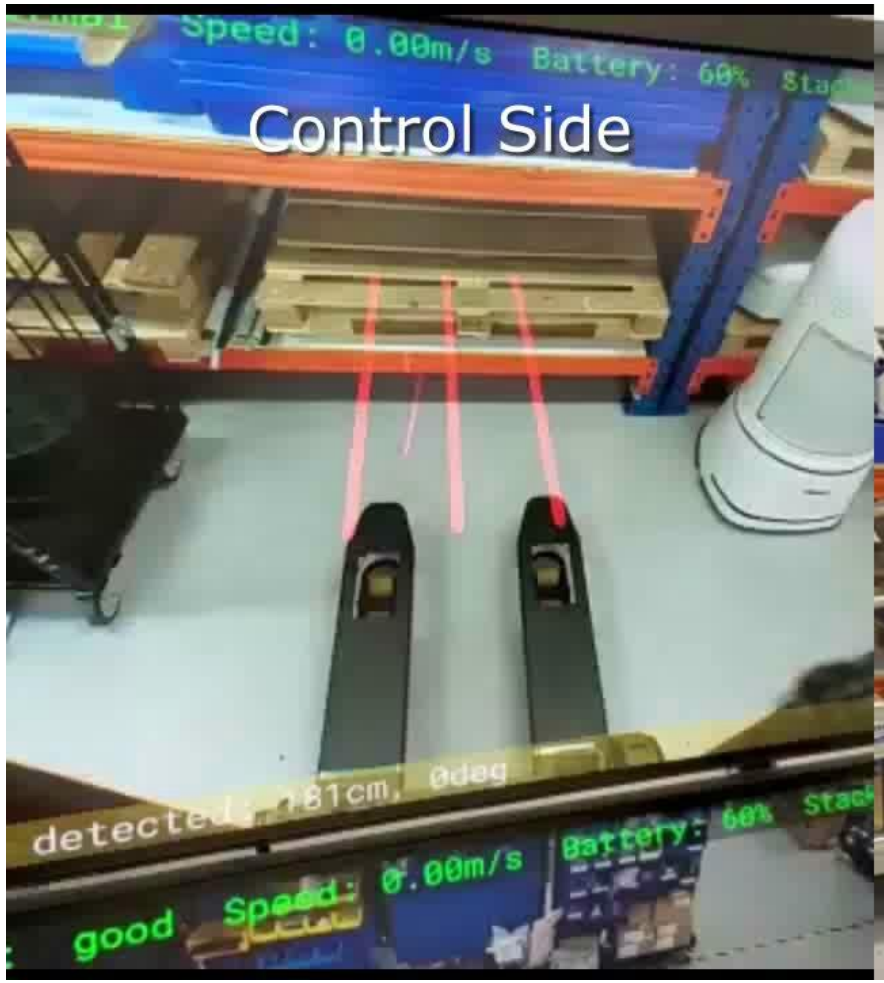


Lidar - Functionality

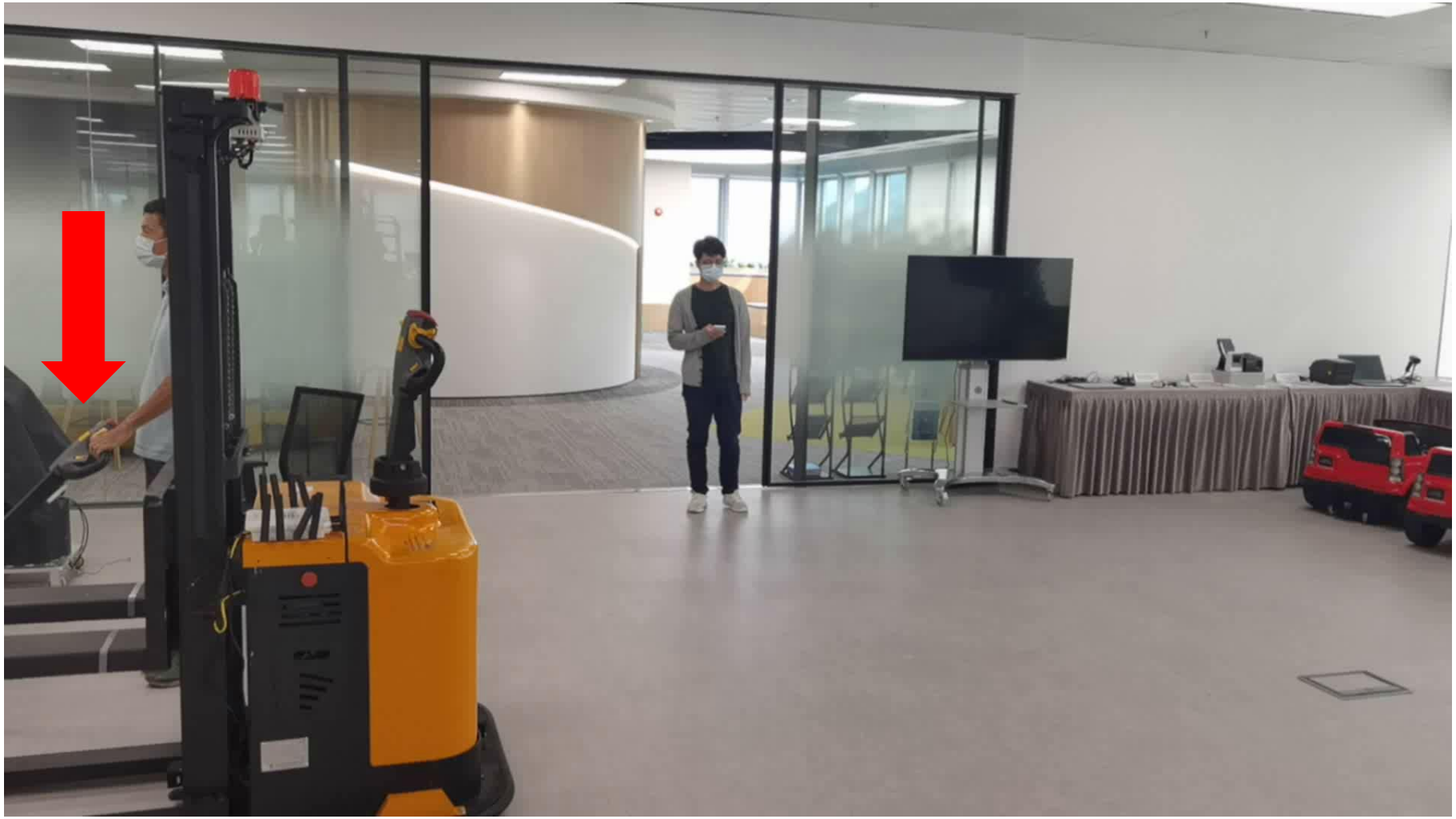
* Total braking distance (assuming the stacker is running at 1m/s)
= moving distance due to latency + braking distance due to inertia
= 0.10m+0.06m = 0.16m

* https://korkortonline.se/en/theory/reaction-braking-stopping/

Stacker Operation by Laser Markings



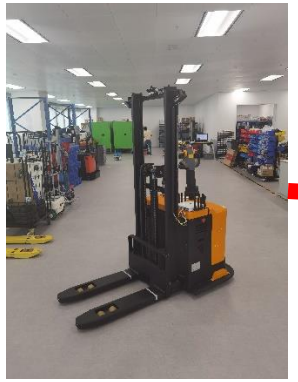
LiDAR - Functionality

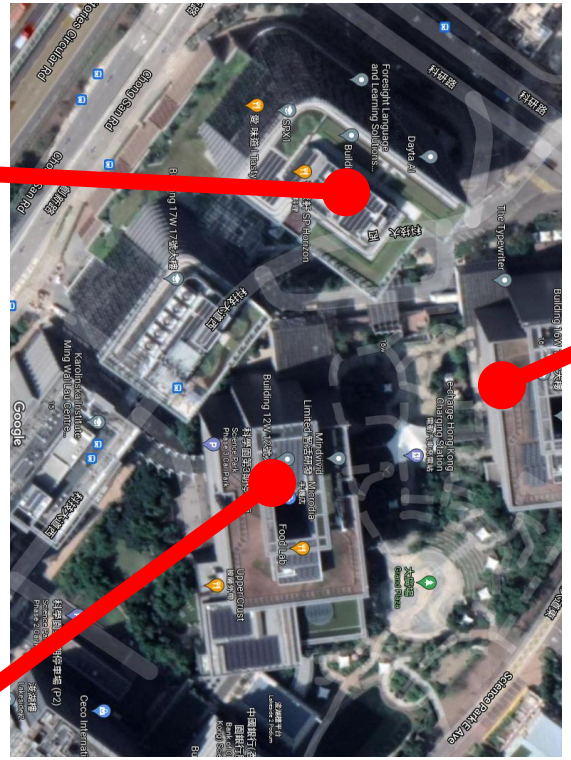


Automatic Stacker Operation

Trial at Different Locations

Stacker at 19W

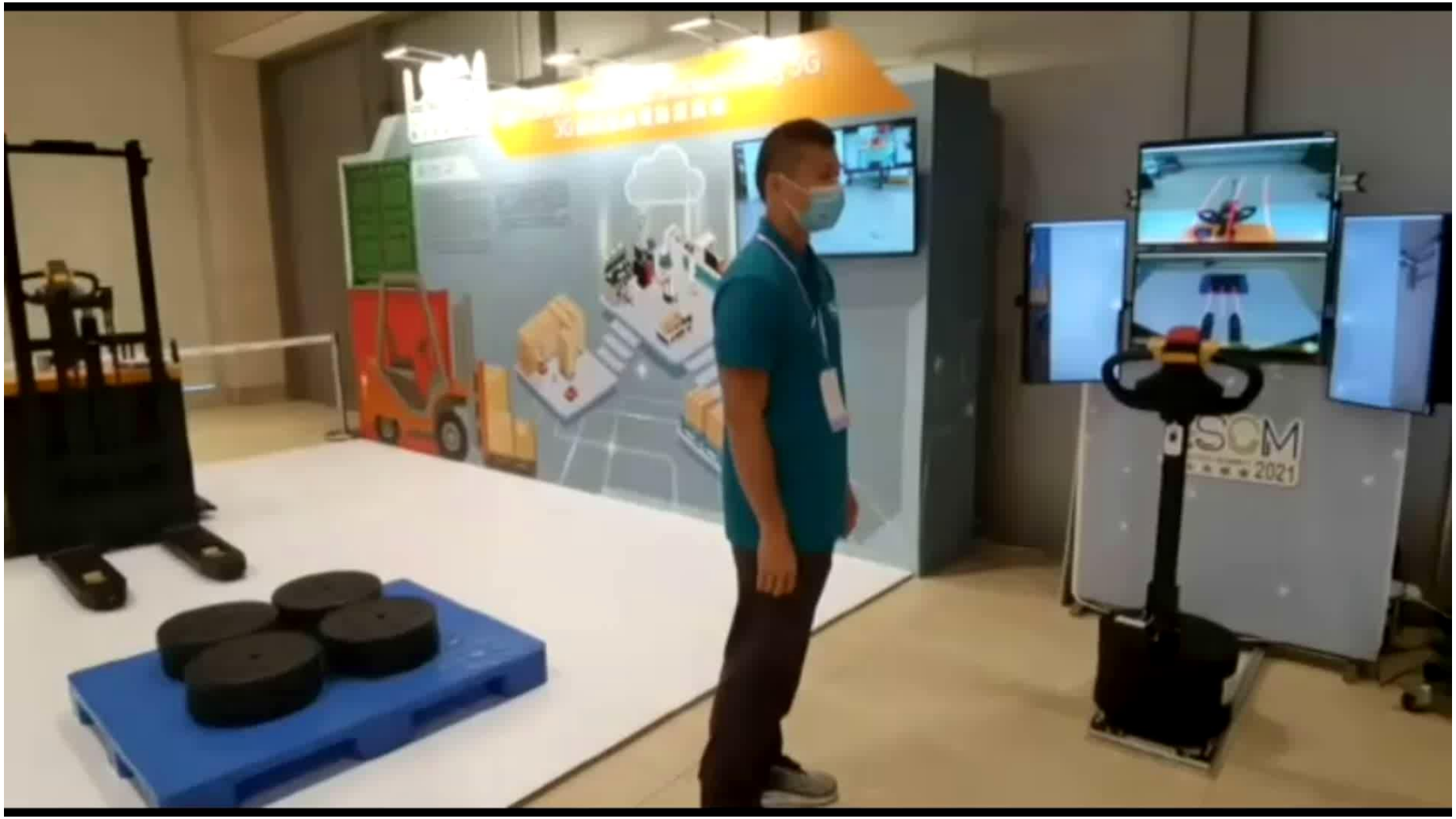




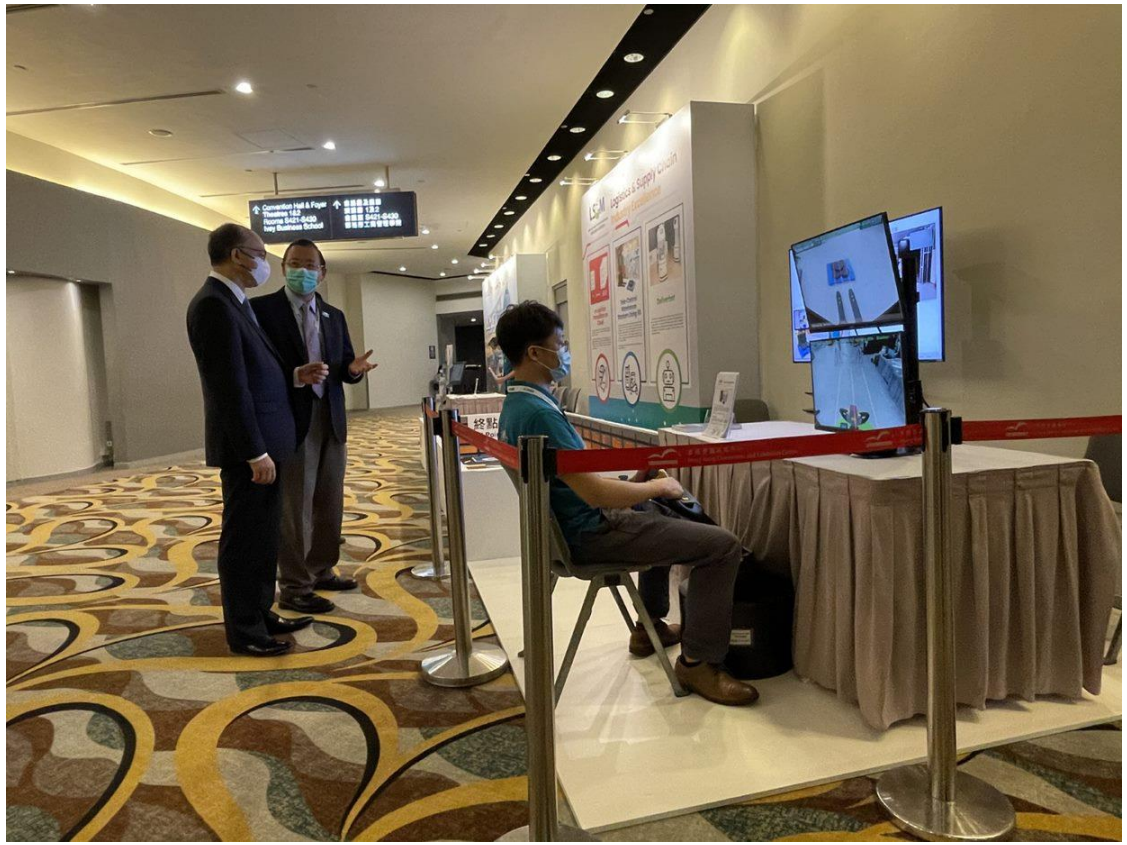
Stacker at 16W

Stacker at Hall

Video Demonstration



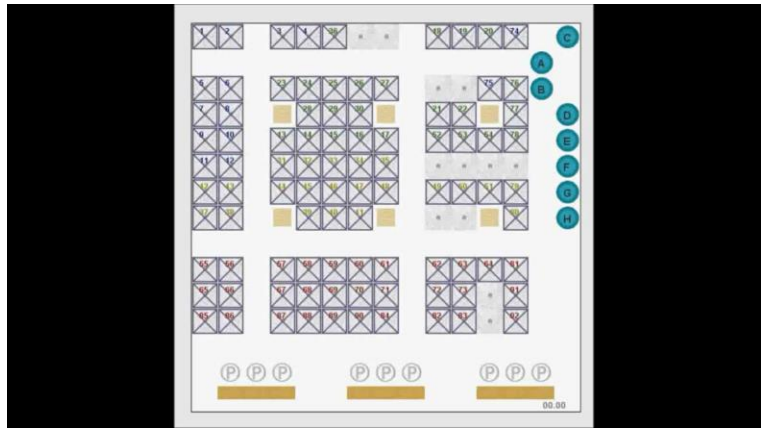
Demo to Mr Chan Fan, Secretary for Transport and Housing at ALMAC on 8 Nov 2021



Use case #2 Autonomous Guided Vehicles (AGVs)

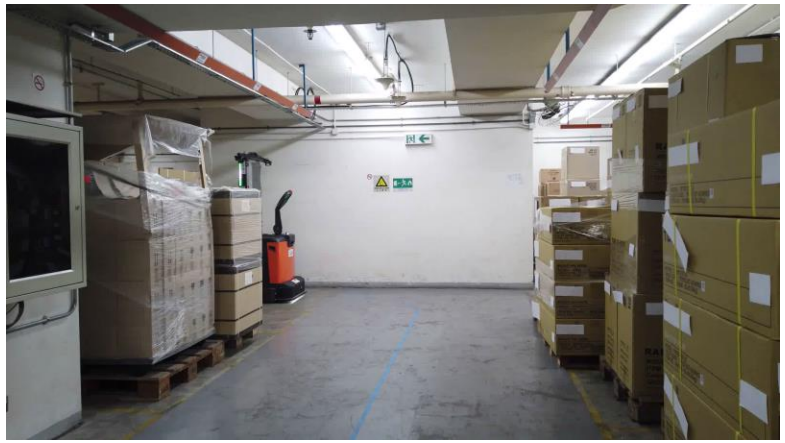
- Autonomous Guided Vehicles (AGVs)
  - A fleet of sensor rich AGVs carry small items/goods to the worker(s).

- The Path Planner
  - The planner to provide a simulated path planning routes of each AGV;
  - It also provide a quick visualization or routing of different warehouse layouts.



Use Case #3 Follow Me

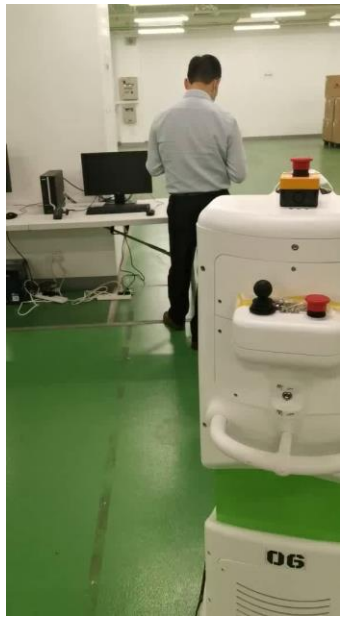
- A semi-auto mobile robot (or stacker) that follows its master (or a worker).



- It can be simply switched to a fully automatic mode with Platooning functions.

Use case #4 Delivery robot and patrolling robot

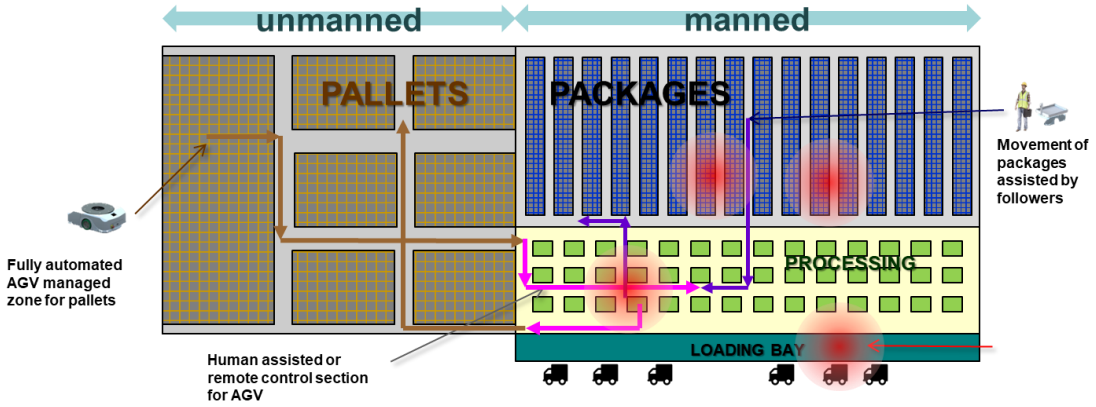
- An autonomous robot is able to carry out patrolling tasks in warehouses. It is able to detect object(s) and go around it.
- By adding different sensors, for example, add thermal sensor(s), it can detect intruders (i.e. body heat) at night or after work.

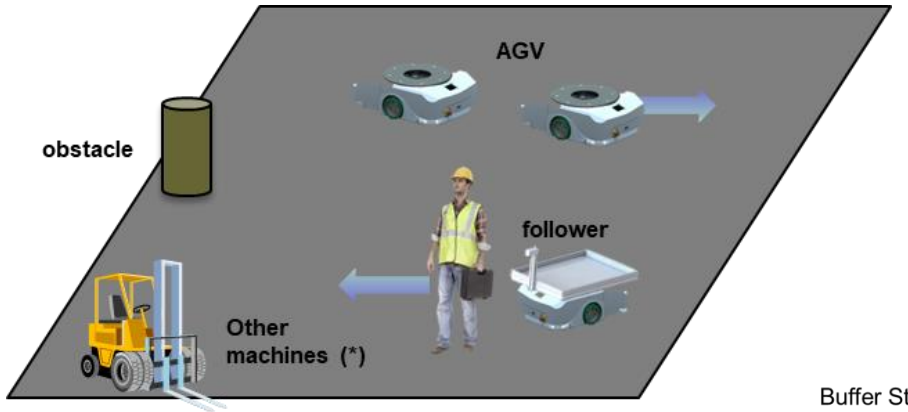


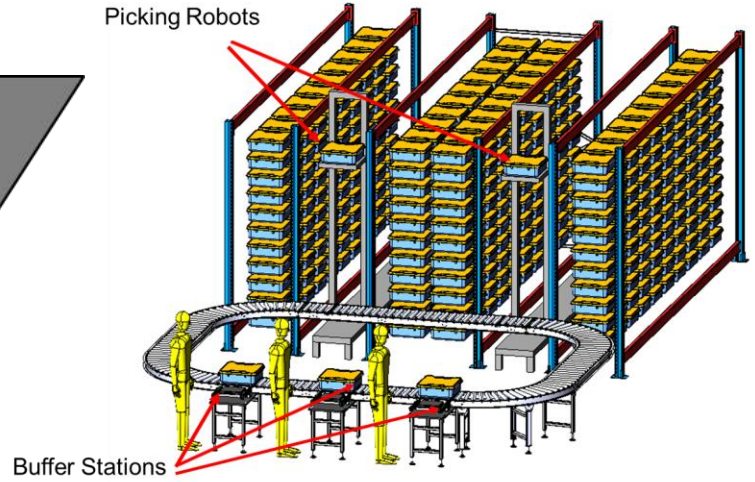
Smart Warehouse Using 5G

Mixed Mode WMS:

- Real time asset/people tracking;
- goods location and arrangement;
- Fast/low latency multi-media (data/video) analytics;
- System-to-robot comm.;
- Realtime monitoring of robot/equipment status;
- Path planning.





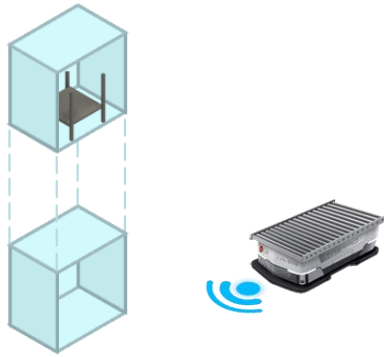


All diagrams are for illustration only.

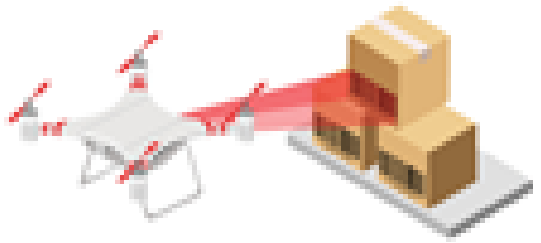
Smart Warehouse Using 5G (new building blocks)

Robot-to-Robot (R2R) or Relay robots:
- Robot to robot using 5G edge computing;
- To enable robot-to-robot collaborations;
- To enhance real-time robot location info;
- To transfer goods or relay goods/items.

Robot-to-everything (R2X) using 5G:
- To enable communication between robots & infrastructures e.g. lifts.



Advanced/real-time video analytics using 5G:
- To enhance warehouse processes monitoring;
- To enable fast stock checking.



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Thank You