建築署
Architectural Services Department

GUIDEBOOK FOR

INNOVATIVE AND SMART TECHNOLOGIES FOR DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE OF GOVERNMENT BUILDINGS

DISCLAIMER

The Guidebook for Innovative and Smart Technologies for Design, Construction, Operation and Maintenance of Government Buildings ("the Guidebook") is solely compiled for providing an overview of innovative and smart building technologies that have application potential in the government premises of the Hong Kong Special Administrative Region ("HKSAR").

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ABBREVIATIONS

AGV	Automatic Guided Vehicle
AHU	Air Handing Unit
AI	Artificial Intelligence
AIPV	Air Improvement Photovoltaic
AIU	Air Induction Unit
AM	Asset Management
AMI	Advanced Metering Infrastructure
API	Application Programming Interface
APS	Automated Parking System
AR	Augmented Reality
ArchSD	Architectural Services Department
Arup	Ove Arup & Partners Ltd
B/Ds	Bureaux/ Departments
BACnet	Building Automation and Control Networks
BEC	Building Energy Code
BIM	Building Information Modelling
BIM-AM	Building Information Modelling for Asset Management
BIM-MR	Building Information Modelling and Mixed Reality
BIPV	Building Integrated Photovoltaic
BMS	Building Management System
CCTV	Closed Circuit Television
CIC	Ceramic Insulation Coating
CITF	Construction Innovation and Technology Fund
CLT	Cross Laminated Timber
CO_2	Carbon Dioxide
DCS	Destination Control System
DEVB	Development Bureau
DfMA	Design for Manufacturing and Assembly
DLT	Dowel Laminated Timber
DSF	Double Skin Façade
EMSD	Electrical and Mechanical Services Department
EPD	Environmental Protection Department
EV	Electric Vehicle
GIS	Geographic Information System

GPS	Global Positioning System
GWIN	Government - Wide IoT Network
HCHO	Formaldehyde
HVAC	Heating, Ventilation, and Air-Conditioning
Hz	Hertz
IAQ	Indoor Air Quality
iBMS	Integrated Building Management System
IOC	Interoperable Operational Control Centre Platform
IoT	Internet of Things
IR	Infrared Radiation
IWS	Integrated Weather Station
kWh	Kilowatt Hour
LiDAR	Light Detection and Ranging
LOD	Level of Detail
LoRaWAN	Long Range Wide Area Network
LPLAN	Low Power Local Area Network
LPR	Licence Plate Recognition
LPWAN	Low Power Wide Area Network
LVL	Laminated Veneer Lumber
M-Bus	Meter-Bus
M&E systems	Mechanical and Electrical Systems
MBF	Microalgae Bioreactive Façade
MEP	Mechanical, Electrical and Plumbing
MiC	Modular Integrated Construction
MiMEP	Multi-trade Integrated Mechanical, Electrical and Plumbing
MIU	Meter Interfacing Units
MR	Mixed Reality
MTR	Mass Transit Railway
OTTV	Overall Thermal Transfer Value
PAU	Primary Air Unit
PCM	Phase-Change Material
PM2.5	Particulate Matter 2.5
PM10	Particulate Matter 10
PRCP	Passive Radiative Cooling Paint

ABBREVIATIONS

PV	Photovoltaic
QR Codes	Quick Response Codes
QTO	Quantity Take Off
RFID	Radio Frequency Identification
RH	Relative Humidity
RTTV	Residential Thermal Transfer Value
SHM	Structural Health Monitoring
SPD	Suspended Particle Device
SRV	Solar Responsive Ventilation
SWMS	Smart Waste Management System
TC	Technical Circulars
UV	Ultraviolet
V	Voltage
VGS	Vertical Green System
VLHS	Vertical Lifting and Horizontal Sliding System
VOC	Volatile Organic Compound
VR	Virtual Reality
Wi-Fi	Wireless Fidelity
3D	Three-dimensional
5G	Fifth Generation Mobile Network

EXECUTIVE SUMMARY

BACKGROUND

In view of the development of innovative and smart building technologies, Architectural Services Department (ArchSD) commissioned Ove Arup & Partners Ltd ("Arup") to undertake the "Consultancy Services for Study on Innovative and Smart Technologies for Government Building Projects" ("the Study") to explore innovative and smart technologies for implementation in government buildings. The main objectives of the Study are:

- to conduct research on potential smart and innovative building technologies;
- to identify high potential smart and innovative building initiatives for implementation in government buildings;
- to develop practical information to support implementation of smart and innovative building initiatives in government buildings; and
- to recommend ways for future implementation of smart and innovative building initiatives in government buildings.

A Guidebook for Innovative and Smart Technologies for Design, Construction, Operation and Maintenance of Government Buildings (the Guidebook) is also developed to introduce and recommend smart and innovative building initiatives for government buildings and encourage designers and project teams to consider and apply appropriate initiatives in the government building project across multiple stages.

SUMMARY OF EACH CHAPTER

The content of the Guidebook is structured such that designers and project teams can easily make reference with and consider for applying appropriate smart and innovative building initiatives in government buildings throughout the project life cycle. Below are different chapters in this Guidebook:

Chapter 1	Provides the introduction of the Guidebook
Chapter 2	Provides the overview of the Guidebook
Chapter 3	Outlines the design outcomes and the framework of smart and innovative government buildings
Chapter 4	Suggests the application of smart and innovative building initiatives in specific government buildings types
Chapter 5	Provides key information including benefits, potential constraints, technical requirements and application recommendations for each smart and innovative building initiative
Chapter 6	Recommends and highlights relevant emerging technology that can be potentially applied in the government buildings in the future

EXECUTIVE SUMMARY

DEVELOPMENT PROCESS OF THE SMART AND INNOVATIVE BUILDING INITIATIVES

The development process of smart and innovative initiatives for government buildings has gone through the following key stages:

- **Desktop Review –** Research on innovative and smart technologies to identify high potential initiatives for government buildings.
- **Expert Engagement Workshops –** Interactive workshops to gather insights and feedback from experts in the field of design, construction, technologies and academia.
- **Literature Review –** Further research on high potential smart and innovative building initiatives, including their benefits / strengths, potential barriers and constraints, technical requirements, application cases and application scenarios.
- **Case Study –** Case Studies of building projects from local, regional and overseas with adoption of smart and innovative building initiatives.
- **Selection of Smart and Innovative Building Initiatives –** Throughout the extensive process of desktop review, expert engagement workshop, literature review and case study, there were 45 smart and innovative building initiatives considered as suitable for adoption locally in government building projects.
- **Development of Technical Requirements and Application Scenario of Smart and Innovative Building Initiatives –** The 45 potential smart and innovative initiatives were categorised in six themes, namely Passive Design, Active Design, Smart and Wellness Technologies, Design Tools, Construction, and Facilities Upkeep. The technical requirements and application scenario for respective initiatives were further developed with the support of a multi-disciplinary team comprising architects, consultants, contractors, quantity surveyors, building surveyors and university professors.

THE SIX KEY THEMES OF SMART AND INNOVATIVE BUILDING INITIATIVES

The smart and innovative initiatives in this Guidebook are categorised into 6 key themes:

PASSIVE DESIGN

Passive building design aims to maximise building energy efficiency and occupant comfort by minimising the need for M&E systems. Passive design takes advantages of natural elements such as the sun and wind through building design. It also adopts advanced materials in the building envelope that offers better control over light, heat, humidity, ventilation etc, and even pollution control.

ACTIVE DESIGN

Active design aims to improve operation efficiency by actively monitoring and controlling building operational performance in different aspects, such as energy, air, and waste.

SMART & WELLNESS

Advanced smart and innovative building initiatives are used to streamline and enrich the building users' experience related to health, comfort, convenience, and safety of the indoor environment. The indoor building environment is meticulously maintained to safeguard occupant's health.

DESIGN TOOLS

Advanced building design tools assist architects, engineers, and designers in making informed decisions during the planning and design phases. These tools, grounded in data and technology, provide clear, detailed, and transparent insights into the translation of design into reality.

CONSTRUCTION

Smart and innovative initiatives can be used in construction stage to reduce labour resources, enhance construction site safety, and to reduce environmental impacts from construction activities.

FACILITIES UPKEEP

Smart and innovative building initiatives can be applied to continuously monitor and maintain the condition of building structures and systems to facilitate predictive maintenance, improve maintenance efficiency and enhance maintainability, which are essential in determining the success of facilities upkeep.

RECOMMENDATIONS

To further promote and support the implementation of smart and innovative building initiatives, the following recommendations are made:

- **Comprehensive Adoption of Initiatives in both Ongoing and New Government Projects –** implement smart and innovative building initiatives in both current and future government projects for encouraging technological improvement and advancement.
- **Performance Review of Existing Technologies and Mechanism of Tracking New and Emerging Technologies –** emerging technologies such as advanced building materials, advanced AI application, and robotic system should be kept in view to ensure the smart and innovative government buildings can be developed in parallel with technological capabilities and respond to future technological and societal needs.
- **Capacity Building and Strengthening –** provide trainings to induce the awareness and enrich the knowledge on new technologies for scaling up the adoption of smart and innovative buildings initiatives in different aspects in government buildings. The sharing of hands-on experience can allow cross-fertilisation of skills on smart and innovative technologies to enhance the operation and building performance of government buildings.

INTRODUCTION

In recent years, the local construction industry has experienced increasing pressures to improve resource efficiency and productivity. These challenges have led to an important juncture whereby changes are needed. The Government has developed Construction 2.0 to strengthen the industry's sustainability and long-term growth prospects. Innovation is one of the key elements under Construction 2.0, to develop a culture that embraces change, innovation and technologies to drive forward productivity, efficiency and enhanced project delivery outcomes.

The application of innovative and smart technologies to buildings are also relevant to various policies and initiatives in Hong Kong, such as the Smart City Blueprint for Hong Kong, Hong Kong's Climate Action Plan 2050, Technical Circular for Adoption of Building Information Modelling, etc. These policies and initiatives have created a supportive environment for the adoption of innovative and smart technologies in buildings to achieve better outcomes during various work stages of building projects.

The Government has been encouraging the building and construction industry to proactively adopt innovation and technology to enhance productivity, built quality, site safety and environmental performance. With a densely populated urban environment, along with challenges of carbon, climate risk and sustainability, our buildings must keep abreast with the times, introduce and adopt smarter and more adaptive technology to accommodate the changing needs and facilitate better utilisation of resources. The ultimate objective is to optimise occupant health and comfort while reducing environmental impacts, and to make positive impacts by creating a more liveable built environment in Hong Kong.

Smart and innovative building is more than just providing the smart devices to the buildings. It is about making our buildings more integrated and connected, both internally and externally, by leveraging smart technologies that enable our buildings to be more responsive to the needs of building occupants to improve wellness, increase efficiency, and enhance security. In this respect, the Architectural Services Department (ArchSD) has commissioned Ove Arup & Partners Ltd (the Consultant) to develop the Guidebook for Innovative and Smart Technologies for Design, Construction, Operation and Maintenance of Government Buildings (the Guidebook) to help designers and project teams to make design decisions, and to explore means to apply innovative and smart technologies to government building projects in different stages.

ABOUT THE GUIDEBOOK

The Guidebook aims to introduce and recommend smart and innovative building initiatives for government buildings to encourage designers and project teams to consider and incorporate appropriate initiatives to government building projects across multiple stages.

It intends to provide a snapshot to capture innovative yet feasible initiatives in government buildings. These initiatives fall into various domains including passive design, active design, smart and wellness technologies as well as tools for architectural design, quantity surveying, building services, structural, site management and facilities upkeep. With the appropriate adoption of innovative and smart technologies, the quality of government buildings can be uplifted in different areas: (1) enhance the overall government building quality and operation efficiency; (2) improve construction safety; (3) facilitate design and construction processes; and (4) facilitate effective maintenance.

The content of the Guidebook is structured such that designers and project teams can easily make reference with and consider for applying appropriate smart and innovative building initiatives in government buildings throughout the project life cycle. Here are the key contents of the subsequent chapters:

Chapter 3	Outlines the design outcomes and the framework of smart and innovative government buildings
Chapter 4	Suggests the application of smart and innovative building initiatives for specific government buildings types
Chapter 5	Provides key information including benefits, potential constraints, technical requirements and application recommendations for each smart and innovative building initiative
Chapter 6	Recommends and highlights relevant emerging technology that can be potentially applied in the government buildings in the future

DESIGN OUTCOMES AND ASPECTS FOR SMART AND INNOVATIVE GOVERNMENT BUILDINGS

Designing a smart and innovative building requires consideration of a range of factors, including the building type or use, needs of its occupants, environmental impacts, and the available technology and resources. Smart and innovative buildings utilise innovative technology to bring connectivity, functionality, and productivity to new heights while keeping the needs of people and the environment in consideration. Smart buildings strive to achieve the following outcomes:

- **Integration and connectivity –** A smart building includes many subsystems and control interfaces which can communicate and coordinate with each other. Highly integrated buildings deliver optimised building performance and in turn, enhance resource efficiency. Apart from interconnection among building systems, smart buildings are connected with its users through personal devices and sensors that collect real-time data of occupant's behaviour.
- **Automation –** A smart building utilises advanced computational technology such as AI and machine learning to automatically analyse data and make decisions based on result analyses. Building automation improves decision making and optimises performance. A robust data infrastructure is required for collecting, storing and analysing data from a range of sensors and building systems.
- **Flexibility and adaptability –** A smart building is designed to evolve and adapt in response to the changing needs and circumstances of technologies over time. Flexible and modular design in the building are required to allow flexibility to accommodate new systems and features.
- **Towards carbon neutrality –** A smart building helps to reduce carbon emissions. This includes significant reduction in energy consumption in its operation and construction processes, as well as the carbon emission from materials used in the building.
- **Resource efficiency –** A smart building reduces environmental impact and promotes sustainable practices throughout the whole life cycle. It maximises resource efficiency including energy, water, and building materials and minimises waste from building construction and operation processes.
- **Health and wellbeing –** A smart building devotes to improve occupant's quality of life through improvements in health, comfort, convenience, and safety of indoor conditions. The indoor environment of the building (e.g. air quality, temperature, humidity, lighting) is adjusted to best suit human needs, while building facilities (e.g. meeting rooms, lifts, entry gates) are enhanced for more convenient and safer usage.

The above outcomes can be achieved through the adoption of smart and innovative initiatives at different stages of government building projects. These initiatives can be categorised into 6 key themes, which can be considered for adoption in government buildings:

- **Passive Design –** A passive building design aims to maximise building energy efficiency and occupant comfort by minimising the need for M&E systems. Passive design takes advantages of natural elements such as the sun and wind through building design. It also adopts advanced materials in the building envelope that offers better control over light, heat, humidity, ventilation etc, and even pollution control.
- **Active Design –** Active design aims to improve operation efficiency by actively monitoring and controlling building operational performance in different aspects, such as energy, air, and waste.
- **Smart & Wellness –** Advanced smart and innovative building initiatives are used to streamline and enrich the building users' experience related to health, comfort, convenience, and safety of the indoor environment. The indoor building environment is meticulously maintained to safeguard occupant's health.
- **Design Tools –** Advanced building design tools assist architects, engineers, and designers in making informed decisions during the planning and design phases. These tools, grounded in data and technology, provide clear, detailed, and transparent insights into the translation of design into reality.
- **Construction –** Smart and innovative initiatives can be used in construction stage to reduce labour resources, enhance construction site safety, and to reduce environmental impacts from construction activities.
- **Facilities Upkeep –** Smart and innovative building initiatives can be applied to continuously monitor and maintain the condition of building structures and systems to facilitate predictive maintenance, improve maintenance efficiency and enhance maintainability, which are essential in determining the success of facilities upkeep.

APPLICATION OF SMART AND INNOVATIVE BUILDING INITIATIVES IN GOVERNMENT BUILDINGS

The indications as shown below suggest the level of applicability of each smart and innovative building initiative on different government building types. Different level of applicability are indicated below:

LEVEL OF APPLICABILITY	DESCRIPTION
▪▪▪	High application potential in general
▪▪	High application potential but subject to project conditions (e.g. scale, complexity etc.)
▪	Less application potential

The indicated smart and innovative building initiatives may be developing in rapid speed. It is suggested to keep track of the latest development of corresponding initiatives during application. Details of each initiative and its corresponding application scenarios are provided in the next Chapter.

ID	SMART AND INNOVATIVE BUILDING INITIATIVES IN GOVERNMENT BUILDINGS	OFFICE	EDUCATIONAL BUILDING	HEALTHCARE FACILITIES	QUARTERS	CULTURAL FACILITIES	SOCIAL WELFARE FACILITIES	COLUMBARIUM	DISCIPLINED SERVICES RELATED FACILITIES
	ENABLING TECHNOLOGIES								
01	Wireless / Wired Communication Network Infrastructure	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪
02	Integrated BMS and Interoperable Operational Control Centre Platform (IOC)	▪▪▪	▪▪▪	▪▪▪	▪	▪▪	▪▪	▪	▪▪▪
	PASSIVE DESIGN								
A1	Advanced Building Envelope (e.g. Smart Windows/ Smart Insulating Paint)	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪	▪▪▪
A2	Advanced Building Envelope (e.g. Smart Green Façade)	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪	▪▪	▪▪▪
A3	Advanced Building Envelope (e.g. Air Tightness & Infiltration Control Façade)	▪▪▪	▪▪▪	▪▪▪	▪	▪▪▪	▪▪▪	▪	▪▪
A4	Advanced Materials (e.g. Carbon Absorbing Paint)	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪
A5	Recycled Material (e.g. Recycled Steel)	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪
A6	Low Embodied Carbon Material (e.g. Engineered Wood)	▪▪	▪▪	▪▪	▪▪	▪▪	▪▪	▪▪	▪▪

ID	SMART AND INNOVATIVE BUILDING INITIATIVES IN GOVERNMENT BUILDINGS	OFFICE	EDUCATIONAL BUILDING	HEALTHCARE FACILITIES	QUARTERS	CULTURAL FACILITIES	SOCIAL WELFARE FACILITIES	COLUMBARIUM	DISCIPLINED SERVICES RELATED FACILITIES
	ACTIVE DESIGN								
B1	Advanced Lighting Devices and Control	■■■	■■■	■■■	■■	■■■	■■	■■	■■
B2	Integrated Weather Station	■■■	■■■	■■■	■	■■■	■■■	■	■■■
B3	Advanced Smart Grid & RE (Solar-PV / Wind / In-line Hydropower, Energy Floor) System Integration	■■■	■■■	■■■	■■■	■■■	■■■	■■■	■■■
B4	Bio-diesel Co-genset Plus Heat Wheel for Energy Recovery	■■■	■■	■■■	■	■■	■■	■	■■
B5	Integrated and High-Performance Air Distribution System	■■■	■■	■■■	■■■	■■■	■■■	■■■	■■■
B6	Water Metering and Sub-metering – Monitoring, Reporting and Data Analytic	■■■	■■	■■■	■■	■■	■■	■	■■
B7	Waste and Recycling Monitoring System	■■■	■■■	■■■	■■	■■	■■	■	■■
B8	Lift Calling Services Management and Optimisation	■■■	■■	■■	■	■	■■	■	■■
B9	Chiller Plant Optimisation	■■■	■■	■■■	■	■■	■■	■	■■
	SMART & WELLNESS								
C1	Self-Sanitising Door Handle	■■■	■■■	■■■	■	■■	■■	■	■■
C2	Touchless Access & Control System	■■■	■■■	■■■	■■■	■■■	■■■	■■■	■■■
C3	Outdoor / Indoor Seamless Wayfinding	■■	■■	■■■	■■	■■	■■	■■	■■
C4	Automated Parking System (APS)	■■	■■	■■	■■	■■	■■	■■	■■
C5	EV Charging and Booking System	■■■	■■■	■■■	■■	■■■	■■■	■■	■■
C6	Gateless Parking System	■■■	■■■	■■■	■■	■■■	■■■	■■	■■
C7	Smart Pest Control System	■■■	■■■	■■■	■■	■■■	■■■	■	■■■
C8	Smart Washroom	■■■	■■■	■■■	■	■■■	■■■	■■	■■■
C9	Blind Cane Navigation System	■■■	■■■	■■■	■	■■■	■■■	■■■	■■■
C10	Multi-Purpose Lamppost System (Smart Lamppost)	■■	■■	■■	■■	■■	■■	■■	■■
C11	Multi-Purpose CCTV System	■■■	■■■	■■■	■	■■■	■■■	■	■■■
C12	Flood Risk Detection & Protection System (e.g. Flood Detection System & Automatic Flood Gate)	■■	■■	■■	■■	■■	■■	■■	■■

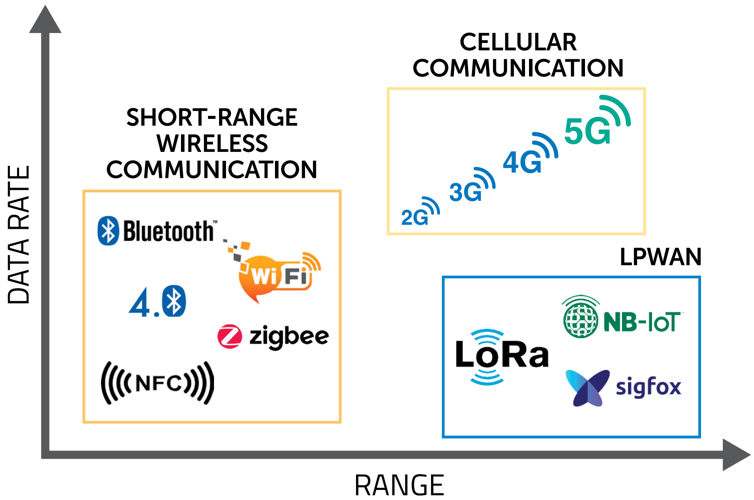
APPLICATION OF SMART AND INNOVATIVE BUILDING INITIATIVES IN GOVERNMENT BUILDINGS

ID	SMART AND INNOVATIVE BUILDING INITIATIVES IN GOVERNMENT BUILDINGS	OFFICE	EDUCATIONAL BUILDING	HEALTHCARE FACILITIES	QUARTERS	CULTURAL FACILITIES	SOCIAL WELFARE FACILITIES	COLUMBARIUM	DISCIPLINED SERVICES RELATED FACILITIES
	DESIGN TOOLS								
D1	Incorporating Construction Safety Planning into Time Programme Visualisation	■■■	■■■	■■■	■■	■■	■■	■■	■■■
D2	Improving Project Data Outcome from Quantity Takeoff	■■■	■■■	■■■	■■	■■	■■	■■	■■■
D3	Improve Energy Modelling and Visualisation in using Digital Twin	■■■	■■■	■■■	■■	■■	■■	■■	■■■
D4	Enhance Design Optimisation for Structural Analysis	■■■	■■■	■■■	■■	■■	■■	■■	■■■
D5	Enhance Building Services Routing and Taggings in Modelling	■■■	■■■	■■■	■■	■■	■■	■■	■■■
D6	Digital Design Simulation for Complex 3D Parametric Design, with AR/VR Tools for Visualisation	■■■	■■■	■■■	■■	■■	■■	■■	■■■
	CONSTRUCTION								
E1	Laser Scanning for Construction	■■	■■	■■	■■	■■	■■	■■	■■
E2	Automation / Robotics for Repeated Construction Activities	■■	■■	■■	■■	■■	■■	■■	■■
E3	Use of Drone for Site Surveying in Construction Sites	■■	■■	■■	■■	■■	■■	■■	■■
E4	Smart Site Safety and Quality Monitoring System	■■	■■	■■	■■	■■	■■	■■	■■
E5	Site Activity and Equipment Tracking System	■■	■■	■■	■■	■■	■■	■■	■■
E6	Lean Construction for DfMA, MIC, MIMEP in Facilities Upkeep and Refurbishment Projects	■■	■■	■■	■■	■■	■■	■■	■■
	FACILITIES UPKEEP								
F1	AI / Machine Learning Based Optimisation and Predictive Maintenance	■■■	■■■	■■■	■	■■	■■	■	■■■
F2	Structural Health Monitoring System	■■■	■■■	■■■	■■■	■■■	■■■	■■■	■■■
F3	Robotic System for Outdoor (Façade Monitoring / Cleaning) and Indoor (Movable IAQ / Water Tank Cleansing)	■■	■■	■■	■■	■■	■■	■■	■■
F4	BIM MR Maintenance Training and Virtual Simulation	■■■	■■	■■■	■	■■	■■	■	■■■

01 WIRELESS / WIRED COMMUNICATION NETWORK INFRASTRUCTURE

DESCRIPTION

Wireless/wired communication network infrastructure enable the communication between digital and smart devices, including IoT sensors used across industries to aggregate large volumes of data. Cellular network, WiFi, LPWAN, LPLAN and fibre cables are examples of wireless / wired communication network infrastructure, which facilitate the transceiving of data between IoT devices and servers. One example of wireless communication network infrastructure in Hong Kong is the Government-Wide IoT Network (GWIN), which is a dedicated wireless communication network to support various smart applications for the improvement of public service quality, such as improving maintenance and repairs of equipment, managing utilisation of public facilities, flood monitoring and underground pipe leakage analysis.



Data Rate vs Coverage of Communication Technologies

BENEFITS / STRENGTHS

- The implementation of communication network provides the advantage of future proofing (e.g. provision of network space in anticipation for future applications), with the capacity to incorporate and facilitate more smart applications in the future.
- With the communication network infrastructure in place, a ubiquitous, high performance network connection will be enabled to enhance connectivity and communication between devices and sensors and thus the subsequent applications such as real-time monitoring and big data analytics etc.

POTENTIAL CONSTRAINTS / WEAKNESSES

- With the huge amount of data to be transmitted within the communication infrastructure, more attention will need to be placed on data security and privacy.

TECHNICAL CONSIDERATION

- The connection speed and network configuration requirements varies for different communication technologies. Suitable communication system should be identified for different applications to avoid inefficient use of resources. For example, LPWAN technology can be used for IoT sensors of energy meters since a low data transmission rate and frequency is required.

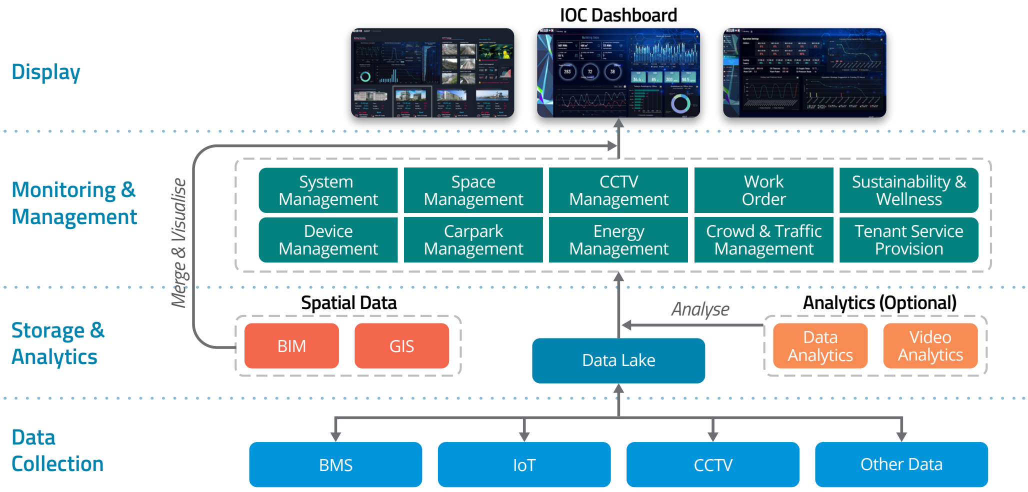
APPLICATION SCENARIOS

- Wireless/wired communication networks are essential to buildings with IoT sensors and detectors installed to facilitate data collection and transmission. Data collected from such devices are used for subsequent data visualisation and analytics.

02 INTEGRATED BMS AND INTEROPERABLE OPERATIONAL CONTROL CENTRE PLATFORM (IOC)

DESCRIPTION

An Integrated BMS and Interoperable Operational Control Centre Platform (IOC) is a smart management platform that enhances operational and management efficiency. Acting as a central data repository, it aggregates a wide range of data to visualise the running status of different systems, enable efficient collaboration across parties, and facilitate decision-making. The IOC platform collects and converges relevant information for data visualisation to provide insights for management teams.



Example of System Architecture of IOC Platform

BENEFITS / STRENGTHS

- By integrating data from various sources such as surveillance cameras and IoT sensors, IOC can help building management teams to identify and respond to potential issues more quickly and effectively.

POTENTIAL CONSTRAINTS / WEAKNESSES

- IOC relies heavily on data and information technology infrastructure, making it more vulnerable to cyber attacks and hacking attempts. Ensuring cybersecurity of the system to protect the privacy and security will be crucial for implementation.

TECHNICAL CONSIDERATION

- The platform should be integrated with different systems for centralised management and control, such as building management system (BMS), BIM-AM system, IoT system, CCTV cameras and local control room data, etc.
- Data sharing function should be in place, in which open API should be available to enable data sharing with other third-party platforms. The design of the data schema should make reference to requirements from other B/Ds, such as BIM-AM and iBMS system of EMSD, etc.
- Standard communication protocol such as BACnet, etc. should be used for communication between different subsystems. The use of proprietary communication protocol should be avoided.
- A user-friendly display portal should be provided to visualise the key statics to facilitate operation and management activities.
- Functional modules of the platform should be determined based on the operational needs.
- The design of the Integrated BMS and IOC should allow provision for future integration of users' systems (e.g. user's CCTV and access control system, etc.).

APPLICATION SCENARIOS

- IOC is more applicable to buildings with complex and multiple building systems and monitoring systems.

A1 ADVANCED BUILDING ENVELOPE (e.g. Smart Windows)

DESCRIPTION

Smart windows assist building envelopes in controlling the influence of external environmental factors such as temperature, relative humidity and light (UV/IR) to indoor environments. Smart windows help reduce solar heat gain to reduce increase in indoor temperatures. Photochromic (light-sensitive), thermochromic (heat-sensitive) and hygro-chromic (humidity-sensitive) hydrogel smart windows are examples of passive smart windows. Suspended particle device windows are switchable and is a type of active smart window.

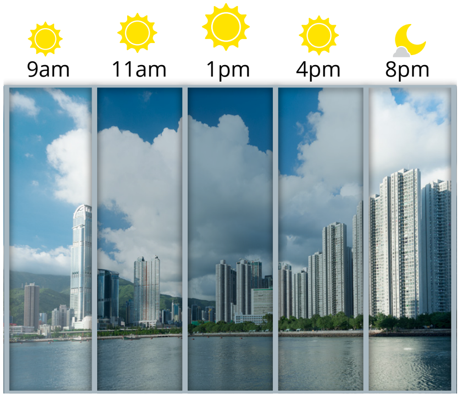


Illustration of Smart Windows
(The stronger the sunlight, the darker the light control film)

Photochromic Smart Windows

Photochromic smart windows have a photo-sensitive film laminated on the surface of the glass. Photo-sensitive molecules in the film change structure when exposed to UV rays, altering the amount of light passing through.

Thermochromic Smart Windows

Thermochromic smart windows are made with materials (e.g. hydrogels) that can change infrared transmission properties according to temperature. The materials turn from transmissive to blocking mode when met with higher temperatures, scattering incoming light and reducing heat gain.

Hygro-chromic Hydrogel Smart Windows

The hydrogel in hygro-chromic smart windows change between dehydrated and hydrated states in response to humidity. Under high relative humidity, the hydrated hydrogel is opaque and can block off around 50% of solar transmittance.

Suspended Particle Device (SPD) Smart Windows

In an SPD window, there are millions of microscopic light-absorbing particles known as SPDs between two panels of glass or plastic. SPD smart windows can turn from clear to varying opacity through a control device. When met with an electric current, the SPDs line up in a straight line to allow light to pass through. Without electricity, the SPDs move to a random position and block light.

BENEFITS / STRENGTHS

- Smart windows can reduce the energy consumption in air-conditioning by reducing the solar heat gain of buildings and associated operational cost.

POTENTIAL CONSTRAINTS / WEAKNESSES

- The application of smart windows is mainly subject to the aesthetics, cost and maturity of the products.

TECHNICAL CONSIDERATION

- The smart windows should be capable to reduce the solar heat gain of the buildings, such as changing their optical properties in response to various stimuli, e.g. temperature, light, or electricity.
- PNAP-APP156 related to RTTV/OTTV should be complied.
- Code of Practice for Structural Use of Glass in Hong Kong should be complied.

APPLICATION SCENARIOS

- Smart windows are more applicable to the buildings with large window or extensive area of glass façade which are highly exposed to sunlight.

A1 ADVANCED BUILDING ENVELOPE (e.g. Smart Insulating Paint)

DESCRIPTION

Smart insulating paint reduces solar heat gain and control temperature increase. Examples of smart paint include passive radiation cooling paint, infrared-reflective paint, ceramic insulation coating and phase-change material paint.

Passive Radiative Cooling Paint (PRCP)

PRCP uses nanomaterial technology to achieve a high solar reflectivity and thermal emissivity. It can reflect incoming solar radiation and emit thermal radiation simultaneously, achieving effective cooling even under direct sunlight.

Infrared-Reflective Paint

Infrared-reflective paint reflects wavelengths in the near infrared region of the sun's radiation which are primarily responsible for heating up surfaces.

Ceramic Insulation Coating (CIC)

CIC consists of ceramic microspheres with low thermal conductivity and create a thermal barrier on building surfaces. The microspheres also reflect infrared rays.

Phase-Change Material (PCM) Paint

PCM paint absorbs excess heat during the day and releases it at night when temperatures are cooler though a specialised material that absorbs and releases heat during phase changes.

Application of Smart Insulating Paint

BENEFITS / STRENGTHS

- Smart insulating paint can reduce the energy consumption in air-conditioning by reducing the solar heat gain of buildings and associated operational cost.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Aesthetics and glare effects are the major concerns and considerations of smart insulating paint.

TECHNICAL CONSIDERATION

- The smart insulating paint should be capable to reduce solar heat gain of the building to reduce the building energy use.
- Glare effects on surrounding neighbourhood should be considered when application.
- Requirements of volatile organic compound (VOC) content limits for regulated architectural paints governed by Environmental Protection Department (EPD) should be complied with.

APPLICATION SCENARIOS

- Smart insulating paint is more applicable to the buildings with large surface area that are highly exposed to sunlight.

A2 ADVANCED BUILDING ENVELOPE (e.g. Smart Green Façade)

DESCRIPTION

Smart green façade offer better insulation and shading to reduce solar gain improve energy performance. They can also bring other benefits such as enhancement in air quality. Examples of smart green façade technologies include but are not limited to double skin façade (DSF), vertical green system (VGS) and microalgae bioreactive façade (MBF).

DSF systems consist of two layers of glass in which air flows through the intermediate cavity. The air acts as a good insulation against temperature and sound.

VGS have vegetation spread across the façade. The plants act as barriers to sunlight and noise as well as bio-filters that improve air quality.

MBF systems have microalgae and a growing medium within the cavity of two layers of glass. The microalgae provides shading and thermal insulation and can even be harvested to produce biogas for generating electricity and heat for the building to use.


Double Skin Façade (DSF)


Vertical Green System (VGS)


Microalgae Bioreactive Façade (MBF)

BENEFITS / STRENGTHS

- Enhanced thermal insulation provision of shading reduces cooling and heating loads in the building and therefore overall energy use.
- Good acoustical performance can be brought about by smart green façades.

POTENTIAL CONSTRAINTS / WEAKNESSES

- The application of such technologies is subject to various considerations such as aesthetics, cost and maturity of the products.

TECHNICAL CONSIDERATION

- Material dimensions, material properties, structural performance, fire resistance, acoustic performance, moisture resistance and thermal performance should be considered according to the project needs.
- Environmental factors such as indoor air quality and carbon footprint should be considered.
- PNAP-APP156 related to RTTV/OTTV should be complied.
- Code of Practice on Wind Effects in Hong Kong should be complied.
- For MBF, the whole system supporting microalgae growth conditions for an operating necessity like mixing, dilution rate, cleaning, control of light saturation point and oxygen production rate should be provided.

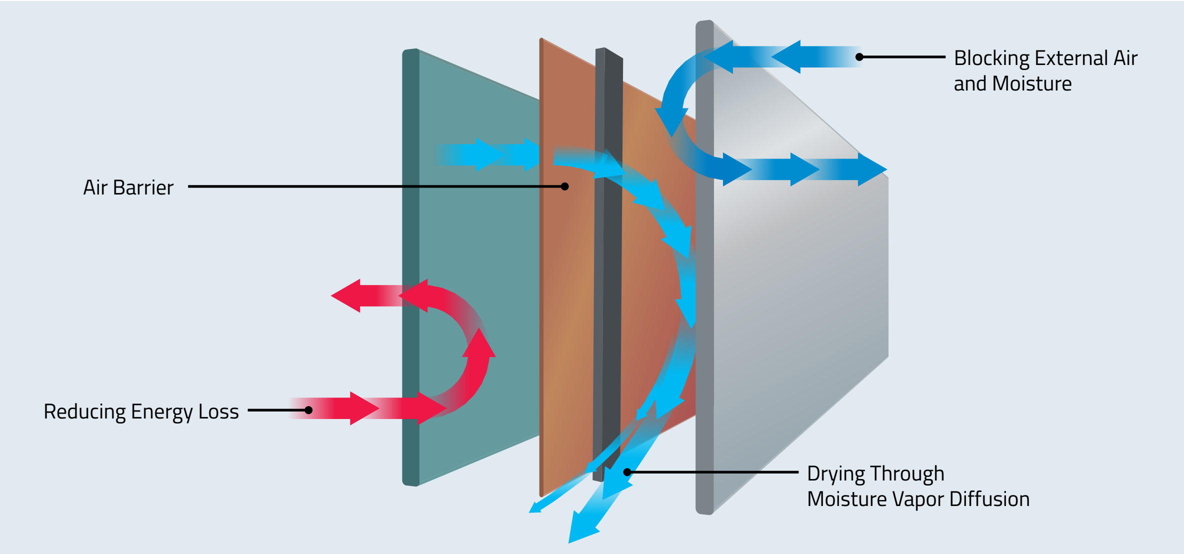
APPLICATION SCENARIOS

- DSF is applicable for high-rise buildings to enable effective control of indoor temperature.
- VGS is applicable for both residential buildings, office buildings and small buildings (e.g. toilets) to improve building insulation and air quality in urban areas.
- MBF is more applicable to small and medium scale buildings with surfaces highly exposed to sunlight.

A3 ADVANCED BUILDING ENVELOPE (e.g. Air Tightness & Infiltration Control Façade)

DESCRIPTION

Air-tightness and infiltration control of a building envelope can be enhanced by a breathable but air-tight air barrier system. The system allows moisture to escape while reducing energy losses due to air leakage (i.e. uncontrolled flow of air through building fabric gaps and cracks). As such, the thermal efficiency, thermal comfort and indoor air quality of the building is improved.



Self-Adhered Water Resistive and Air Barrier Membrane

BENEFITS / STRENGTHS

- A breathable and airtight air barrier system can help seal the building envelope and prevent air leakage, reducing the amount of warm, humid air that enters the wall cavity and come in contact with cooler surfaces to form water droplets.
- Prevention of air infiltration enhances thermal insulation of the building envelope, reducing energy required to meet cooling and heating loads for the buildings.
- The risk of building envelope damage due to moisture infiltration can be significantly reduced. Mould, mildew and rot can be avoided due to the high drying capacity of the breathable membrane.
- Extensive compatibility allows for different applications such as exterior gypsum sheathing, rigid insulation, precast concrete, concrete block, cast-in-place concrete, pre-painted steel, galvanised metal, aluminum, window and door frames, etc.

POTENTIAL CONSTRAINTS / WEAKNESSES

- The surface where the barrier is adhered to should be clean, dry and structurally sound and avoid contamination with the building site chemicals (e.g. surfactants).

TECHNICAL CONSIDERATION

- PNAP-APP156 related to RTTV/OTTV should be complied.
- Requirements of VOC content limits for regulated architectural paints governed by EPD should be complied.
- Fire resistance performance of the materials should be ensured and tested.

APPLICATION SCENARIOS

- The breathable and air-tight air barrier system is applicable to buildings with extensive air-conditioning instead of natural ventilation, such as office buildings and healthcare facilities.

A4 ADVANCED MATERIALS (e.g. Carbon Absorbing Paint)

DESCRIPTION

A building can achieve carbon absorption by using graphene-based lime paints on exterior and interior surfaces. Lime in the paint absorbs CO_2 from the air during the drying process. Graphene has unique properties that can improve the quality of paint and coatings. Adding graphene fibres to traditional lime paint can improve its durability and electrochemical properties, making them more resistant to physical damage and corrosion respectively. Graphene-based paints can also be designed to have self-cleaning and antibacterial properties, making them more hygienic and easier to maintain. Graphene-based lime paints integrates lime's carbon absorption properties with graphene's various favourable characteristics.

Illustration of Carbon Absorbing Process

BENEFITS / STRENGTHS

- CO_2 can be captured by the paint to in the natural carbonation process. The paint can also help to remove pollutants from the air, such as VOCs and formaldehyde.
- The high solar reflectance feature of lime can reduce the temperature of the surfaces and improve energy efficiency due to less energy consumption for space cooling, hence, reducing operational cost.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Graphene paint and coatings can just absorb a maximum amount of CO_2. Further CO_2 absorption would only be feasible by touching up the paint.
- The room relative humidity (RH) may be increased to some extent since water molecules are one of the by-products of the chemical reaction when the graphene paint absorbs the make subscript in the air.

TECHNICAL CONSIDERATION

- PNAP-APP156 related to RTTV/OTTV should be complied.
- VOC content limits for regulated architectural paints governed by EPD should be complied.
- Appropriate air temperature and RH conditions should be provided for proper product applications (e.g. RH = 50-70% for coatings, 35-40% for paints).

APPLICATION SCENARIOS

- Carbon absorbing paint is applicable to different types of buildings, which can be applied to building exterior/interior, roof and external walls.

A5 RECYCLED MATERIAL (e.g. Recycled Steel)

DESCRIPTION

Recycled materials play a significant role in sustainable construction practices as they offer numerous benefits by reducing the demand for virgin resources, minimising waste generation, and reducing environmental impact. One of the examples of recycled materials is recycled steel. Recycled steel is produced by melting down and reprocessing existing steel products or waste materials, which offers environmental benefits by reducing the need for iron ore extraction, conserving energy and water, and lowering greenhouse gas emissions.


Steel Recycling

BENEFITS / STRENGTHS

- The use of recycled material supports the principles of circular economy and resource conservation, which could also help to reduce the carbon emission from the production of new materials. For instance, the recycled steel minimises the need for new mining and extraction, which can also reduce associated carbon emission of these activities. By reusing materials and extending their lifespan, the generation of waste can be reduced and a more sustainable use of resources can be promoted.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Limited availability and a less developed supply chain may hinder the adoption of recycled materials.
- Traditional materials have well-established industry standards and regulations governing their use in construction. However, recycled materials may have different specifications and performance characteristics that require new or revised standards.

TECHNICAL CONSIDERATION

- Recycled materials should provide more environmental benefits compared with original materials. The performance of recycled materials should also be ensured and be complied with relevant regulations, while the adoption of such materials should comply with statutory requirements and obtain regulatory approvals as appropriate.

APPLICATION SCENARIOS

- It is applicable to different types of buildings.

A6 LOW EMBODIED CARBON MATERIAL (e.g. Engineered Wood)

DESCRIPTION

Engineered wood structures are highly innovative and versatile construction materials. They are created by bonding layers or strands of wood together using adhesives or other techniques. This results in a composite material with superior strength, durability, and other properties compared to natural wood. Varying ways of stacking wood layers produce different types of engineered wood products with specific properties and applications. Examples of engineered wood include Glulam, Cross Laminated Timber (CLT), Laminated Veneer Lumber (LVL), and Dowel Laminated Timber (DLT).

Engineered wood designs have a negative global warming potential when compared to conventional concrete buildings, meaning that the carbon stored in the engineered wood can exceed the carbon emissions produced during the entire life cycle of the building. Therefore, engineered wood is a more environmentally-friendly choice for construction, offering long-lasting benefits that extend beyond the building's lifetime.

Examples of Engineered Wood

BENEFITS / STRENGTHS

- Engineered wood products are a sustainable construction material as they have low embodied carbon characteristics.
- Engineered wood products generate less waste than traditional construction materials and have high recyclability.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Timber is a flammable material that might have a safety concern. However, borate-based treatments can be applied to improve fire retardancy, and mixed materials can be considered for the structure members of the building to reduce the risk of fire.
- In humid climates like Hong Kong, moisture-proof treatment is required to prevent rotting, mould, and decay to improve the performance and lifespan of timber structures.

TECHNICAL CONSIDERATION

- Engineered wood products should have varying levels of fire resistance depending on several factors, including the size and number of layers or laminations, fire retardants or insulation use, and fire protection systems. It should comply with the requirements in the Code of Practice related to fire safety in buildings, if not, Fire Engineering Approach may have to be adopted.
- Engineered wood products should have low moisture content, which ensures their structural integrity and dimensional stability over time.

APPLICATION SCENARIOS

- Engineered wood is more applicable to the structures that would require lightweight properties of materials, such as long-span structures and vertical extension.

B1 ADVANCED LIGHTING DEVICES AND CONTROL

DESCRIPTION

Daylighting Devices (e.g. Light Pipe/Tube, Solar Tracking Optic Fibre Lighting, etc.)

Daylighting devices are devices that help to collect outdoor sunlight and re-distribute to various locations within the building. Examples of such devices include light pipes/tubes and solar tracking optic fibre lighting.

Circadian Lighting Design

A circadian lighting strategy is one where lighting design supports the human diurnal need for illumination and darkness cycles in tune with their circadian system.

Advanced Lighting Control

Advanced lighting control is lighting that can be controlled by various mobile/central devices through Bluetooth/network connection. Users can use devices to turn lighting on or off, choose color and brightness, schedule lights to turn on, off, dim or even flash through sending commands.

Examples of Advanced Lighting Devices and Control

BENEFITS / STRENGTHS

- Advanced lighting devices and control can reduce energy consumption for lighting and associated operational cost.
- Daylighting devices and lighting control strategy in response to natural light levels provide the most comfortable lighting strategy (i.e. colour spectrum, intensity, directionality, etc.) for human beings.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Daylighting devices are highly weather reliant.

TECHNICAL CONSIDERATION

- Daylighting devices such as light pipes/tubes should be placed on the roof to admit light into a focused area of the interior. The dome should be made of clear plastic, while the pipe should be a smooth cylinder with a highly reflective inside surface.
- Circadian lighting systems should ensure that wavelength impacting human biological rhythm can be modified without shifting the visual appearance of light colour.
- Advanced lighting control should be provided with occupancy and daylight sensors to detect the presence of people and amount of natural daylight in a room respectively.

APPLICATION SCENARIOS

- Advanced lighting devices are more applicable to buildings that are not surrounded and shaded by high-rise buildings.
- Advanced lighting control is applicable to different types of buildings.

B2 INTEGRATED WEATHER STATION

DESCRIPTION

Integrated Weather Station (IWS) is an advanced station with multiple sensors. The sensors detect a range of indoor parameters and outdoor parameters, such as temperature, relative humidity, IAQ, wind speed, wind direction, air pressure, rainfall, solar radiation, PM2.5, PM10, noise and ozone.

The IWS sends the collected data to an advanced analysing platform for further analysis. The advanced analysing platform makes the best control strategy based on data received from the IWS to control the indoor building service devices (e.g. air conditioning, lighting, etc.) to achieve human comfort environment.

Integrated Weather Station

BENEFITS / STRENGTHS

- Provides advanced environmental monitoring as IWS can detect various parameters while sending data to the analysing platform at the same time.
- Provides better indoor environment for human comfort by making use of collected data (both indoor and outdoor) to make the best control strategy of each space in the building.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Maintenance of IWS is complicated as IWS contains multiple sensors in a single device. The whole monitoring system may be suspended if one of its instruments malfunctions.
- Stable network for IWS and central control platform communication is required to ensure data continuity.

TECHNICAL CONSIDERATION

- Both indoor and outdoor air quality should be monitored and properly maintained for building occupants. Such sensors should be able to measure typical air quality index, such as carbon dioxide, volatile organic compound (VOC), PM10, PM2.5, etc. Such data should be monitored by facility management by accessing the system.
- The system should be able to collect air quality related data as well as analyse the air quality in real time. Data statistics should be analysed and the air quality can be converted to usable information and displayed to users.

APPLICATION SCENARIOS

- IWS is more applicable to indoor locations with various environmental control needs in different building types such as office, educational building and healthcare facilities.

B3 ADVANCED SMART GRID & RENEWABLE ENERGY (Solar-PV / Wind / In-line Hydropower / Energy Floor) SYSTEM INTEGRATION

DESCRIPTION

A smart grid is an electricity distribution network that uses advanced digital and telecommunication networks to facilitate the flow of information and in turn improve the efficiency of power generation, delivery and consumption.

While the use of renewable energy is one of the core elements in sustaining an efficient smart grid from the supply side, renewable energy application at the building-level is encouraged. Examples of building scale renewables application are listed below.

Building Integrated Photovoltaic (BIPV) and Transparent PV

Building Integrated Photovoltaic (BIPV) and transparent PV can be used directly as the building envelope. They can serve the dual function of building façade and power generator by replacing conventional building envelope materials.

Air Improvement Photovoltaic (AIPV)

Air Improvement Photovoltaic (AIPV) can be used to build canopies. They can serve the dual function of canopy and power generator by replacing conventional canopy materials. AIPV can also provide additional functions such as air purification and disinfection.

Walkable PV and Flexible PV

Walkable PV and flexible PV offer the flexibility to apply solar PV technology in different parts of a building, such as walkable PV can be integrated with the floor for capturing solar energy.

Wind Turbine

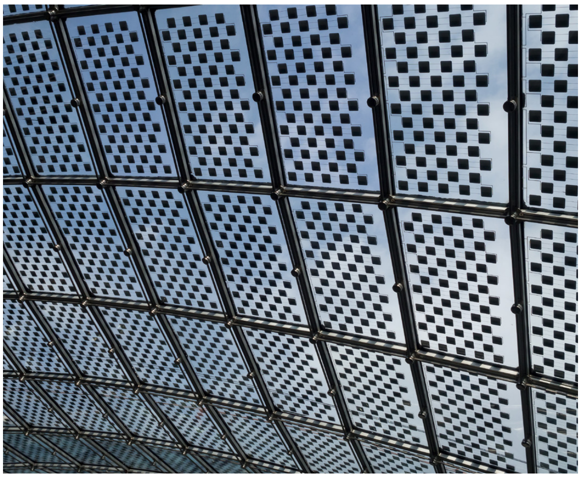
Wind turbines can be installed in new developments which are located in areas with sufficient wind speed for driving the turbine.

In-line Hydropower

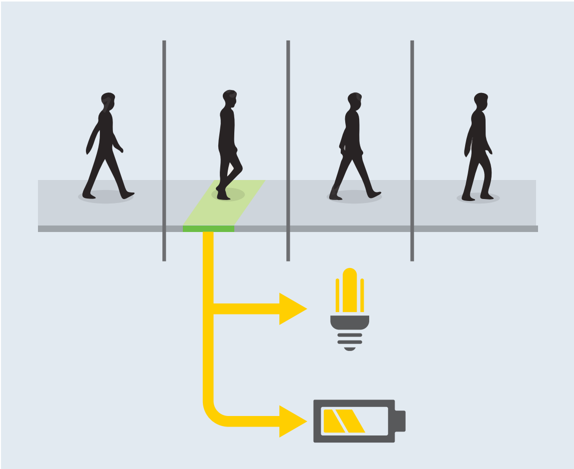
In-line hydropower refers to a type of hydropower system that is designed to generate electricity by harnessing the energy from flowing water in existing water delivery systems. It involves the use of a highly efficient micro hydro-turbine fitted within water pipes of buildings to convert kinetic energy from the flowing water into electric energy for storage or direct consumption.

Energy Floor

Energy floor is developed based on piezoelectric technology that captures kinetic energy from human movements and store or redistribute them as other forms of energy such as electricity.



Examples of Renewable Energy System (Left: Rooftop PV System, Right: BiPV System)




Examples of Renewable Energy System (Left: Energy Floor, Right: Rooftop Wind Turbine)

BENEFITS / STRENGTHS

- Renewable energy can be generated by using various resources which can reduce the carbon emission of buildings.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Renewable energy is highly reliant on the weather, in particular for PV and wind turbine, which depends on the solar irradiation and wind speed.
- Installation and maintenance cost are higher than using traditional material and device.
- Intermittency in renewable energy is the major concern if such system is on-grid connected. The risk of power quality exists.

TECHNICAL CONSIDERATION

- The efficiency of renewable systems should be considered, such as the shading effect of surrounding structures and buildings regarding the proposed PV and/or wind turbine location, and the installation orientation and condition with justifiable assumption and calculation.
- Advanced metering infrastructure (AMI) should be installed to enable real-time monitoring and communication between the grid and renewable energy systems. Real-time monitoring and control such as demand response and load management function should be provided to optimise the utilisation of renewable energy systems.
- Renewable systems to be installed in existing structure should comply with the Buildings Regulation. There should be no adverse impact on the existing structures after installation.

APPLICATION SCENARIOS

- Renewable energy system is more applicable to buildings that can offer more area for installation to increase the amount of renewable energy captured.

B4 BIO-DIESEL CO-GENSET PLUS HEAT WHEEL FOR ENERGY RECOVERY

DESCRIPTION

Bio-diesel co-genset is a generator that consumes bio-diesel to generate electricity and capture the waste heat for reuse, which includes below systems:

Bio-diesel generator

Bio-diesel generator is a generator that is specifically designed to operate with different percentage contents of bio-diesel.

Co-generation system

The co-generation system is a system that harvests waste heat from engine coolant, oil coolant, turbo coolant and exhaust gas by heat exchangers. The harvested heat can be used as heat source for various applications such as desiccant wheel, portable hot water and absorption chiller.

Heat Wheel

Heat wheel is a rotating wheel used in Air Handing Unit (AHU) or Primary Air Unit (PAU) to harvest waste energy from exhaust air to pre-cool the outdoor air.

Bio-diesel Generator and Absorption Chiller

BENEFITS / STRENGTHS

- Bio-diesel produced from waste food/oil can reduce waste disposed to landfill and reduce the consumption of fossil fuel.
- Greenhouse gas and other pollutant emissions of bio-diesel is lower than that of fossil diesel which enhances the local air quality and reduces the carbon footprint.

POTENTIAL CONSTRAINTS / WEAKNESSES

- The generator is required to operate continuously to increase the energy generation. Noise, vibration and air-quality issue will be induced during the operation of generator.
- Installation and maintenance cost may be higher than using traditional device.

TECHNICAL CONSIDERATION

- The system should generate electricity that meets the current Hong Kong on-grid power standard (i.e. 380V and 50Hz).
- Separate plant room with similar size of emergency generator should be provided to house the bio-diesel co-genset system and fuel tank.
- The heat wheel should be placed in the exhaust gas stream to capture the waste heat and should be the media for heat transfer between exhaust air and fresh air.

APPLICATION SCENARIOS

- The system is more applicable to buildings with high electricity demand such as office and healthcare facilities.

B5 INTEGRATED AND HIGH-PERFORMANCE AIR DISTRIBUTION SYSTEM

DESCRIPTION

Integrated and high-performance air distribution system such as Windcatcher, Air Induction Unit (AIU) and Solar Responsive Ventilation (SRV) can improve the air movement and enhance thermal comfort in the space.

Windcatcher

Windcatcher is a chimney structure that located on the roof. Two opposite openings are exposed to open air for capturing wind into the room and discharging air from the room to improve the room ventilation.

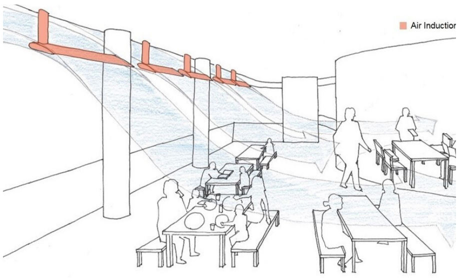
Air Induction Unit (AIU)

AIU is a patented air distribution system, which is installed at ceiling level and connected in series to serve various room sizes. The aerodynamically designed AIU produces high speed air jets via two narrow slots and accelerate the surrounding air to induce a larger flow.

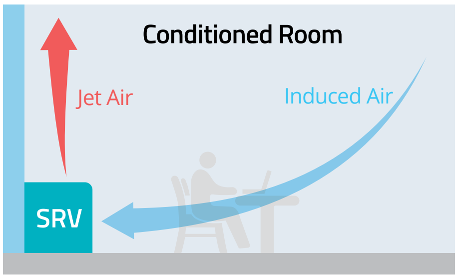
Solar Responsive Ventilator (SRV)

SRV is a patented air distribution system powered by solar panels, which is installed at a low-level near the window or external wall and connected in series to serve various length of surface. The air flow is driven by a ventilation fan and flows along the external wall together with buoyancy effect.

Application of Windcatcher



Application of AIU



Application of SRV

BENEFITS / STRENGTHS

- Integrated and high-performance air distribution system can enhance the indoor ventilation to reduce the cooling demand of buildings. Hence, energy consumption and operational cost associated with air-conditioning can be reduced.

POTENTIAL CONSTRAINTS / WEAKNESSES

- The high-density building in Hong Kong urban area obstructs wind availability and reduces the applicability of the system.

TECHNICAL CONSIDERATION

- The windcatcher should be installed in a location that is free from obstructions to allow efficient capture of wind. It should also be installed away from exhaust air sources or emissions to ensure that the air entering the building is clean and free from pollutants.
- The AIU should be mounted to the ceiling, where ventilation fans should be provided.
- The SRV should be mounted to the floor and powered by solar panels. Small ventilation fans should be provided for SRV to drive the air flow.

APPLICATION SCENARIOS

- Windcatcher is more applicable to locations with relatively less stringent requirements on indoor temperature and RH control.
- AIU is applicable to buildings with sufficient headroom and spaces.
- SRV is applicable to buildings with air-conditioning provided.

B6 WATER METERING AND SUB-METERING – MONITORING, REPORTING AND DATA ANALYTIC

DESCRIPTION

Smart Water Metering can be applied at different scales, i.e. from building to city/district scale. The system connects to multiple smart water meters installed at different sections of the water supply system, such as at each main distribution pipe. Relevant data such as flow rate can be transferred to the central monitoring system via signal wiring or wireless network. Real time condition of different sections can be visualised on the displays of sub-meter and the collected data can be analysed to provide further information on water consumption.

Installation of Smart Water Meter

BENEFITS / STRENGTHS

- With the information collected, the water supply system can be optimised through implementation of smart water metering. This allows information collection for providing more accurate response to the demand, thus reduce water and pump power consumption.
- The detection on abnormal water use provides warning to system defects and allows fast response to reduce system downtime. Abnormal water usage or data can be detected through data monitoring and logging.
- Leak detection through data analysis helps to reduce water wastage as well as preventing other equipment to be damaged by the water leakage.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Due to the data deficiency during the first year, the optimisation effectiveness is limited.
- Due to the variation in different sensor manufacturers, the data transmission protocol is required to be standardised to avoid complication and redundant work.

TECHNICAL CONSIDERATION

- Each water meter should be installed with a dedicated Meter Interfacing Units (MIU) to read the water meter data and transmit the data through various means.
- The MIU should be able to transmit the water meter data with at least one standard protocol such as M-Bus, Modbus, BACnet, etc. for recording and storing meter readings. The readings should be uploaded to the cloud server through wired or wireless network.
- Each water meter with MIU should be calibrated and licenced in accordance with the manufacturer's requirement for accurate reading and water meter record setup.

APPLICATION SCENARIOS

- Smart water metering system is more applicable to buildings with intensive water use.

B7 WASTE AND RECYCLING MONITORING SYSTEM

DESCRIPTION

The waste and recycling monitoring system can be applied in building to reduce strain of waste collection and treatment. The smart waste management system (SWMS) based on IoT technology connects to multiple sensors installed in different types of bins, such as rubbish bins, recycling bins and refuse collection trucks at different locations in each building. Relevant data such as position and filling level can be stored onboard or transferred to the central system via different networks depending on the distance and scale of the application such as LoRaWAN, Wi-Fi, GPS or others. Real time monitoring of equipment conditions can be enabled once the data is transferred to a centralised system.

Smart Waste Bin

BENEFITS / STRENGTHS

- Through the data collected in each bin and analysis of the collected data, the capacity and distribution density of the bins can be adjusted according to the needs. It will reduce the chance of overflow, improve hygiene as well as user experience.
- Utilisation of resources and efficiency for waste management can be improved.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Some rubbish bins may require a longer time to reach its full capacity, which will increase the odour dispersion due to the rotten waste during the prolonged period of time. The use of smart bins should be accompanied by regular cleaning.

TECHNICAL CONSIDERATION

- The smart waste and recycling monitoring system should consist of smart waste bin and web-based waste management platform.
- The smart waste bin should be equipped with sensor to detect the fill-level of bins and send data to the waste management platform.
- The waste management platform should provide a dashboard for easy monitoring, in which the real-time data and locations of all bins should be displayed on the map via the dashboard for the operator’s waste management purpose.
- The waste management platform should alert the operators if undesirable incidents happen such as sudden temperature rise.

APPLICATION SCENARIOS

- Waste and recycling monitoring system is more applicable to buildings that have more occupants such as office or buildings that need to maintain a high standard of hygiene such as healthcare facilities.

B8 LIFT CALLING SERVICES MANAGEMENT AND OPTIMISATION

DESCRIPTION

Lift calling services management and optimisation is achieved through an auto lift calling system which is also named a destination control system (DCS). The DCS is a full destination based dispatching system which use algorithms based on the planned traffic flow of the building. The DCS considers desired destination floors and the number of waiting passengers to significantly improve efficiency and convenience of the lift system.

By selecting the destination floor before entering the lift, passengers going to the same floor will be directed to take the same lift. The DCS reduces the number of intermediate stops for each round trip, enabling the lift to return to the main lobby sooner to collect more passengers.

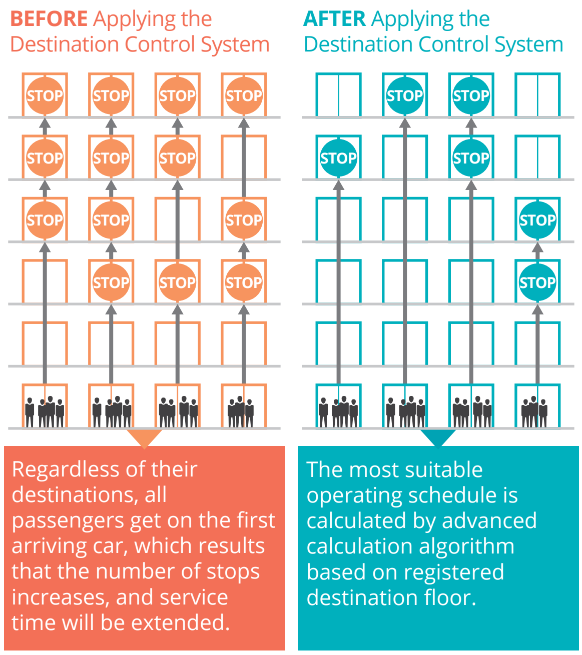


Illustration of Lift Calling Service Management and Optimisation

BENEFITS / STRENGTHS

- Due to the reduction in lift stops and optimisation of lift capacity, the lift traveling time and queuing time of passengers can be reduced.
- The reduced traveling time and start/stop frequency can reduce the operational cost, maintenance frequency and maintenance cost.
- The user experience can be improved by relieving crowded lift situations and providing touchless design inside the lift car.
- Further improvement on seamless user experience can be achieved by integrating with other systems such as access control system.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Due to the auto assign nature of the system, it may cause inconvenience to passengers who want to change destination.

TECHNICAL CONSIDERATION

- The lift calling services management and optimisation system should be a full destination based dispatching system which use algorithm based on the planned traffic flow of the building. The system should consider desired destination floors and the number of waiting passengers to significantly improve efficiency and convenience of the lift system.
- To avoid confusion to first-time users or visitors, clear instruction (e.g. signage, public address, staff assistance, etc.) should be considered to improve the system effectiveness and user experience.

APPLICATION SCENARIOS

- It is more applicable to venues with large population, high-rise buildings, and buildings with regular traffic patterns and conditions such as office.
- Application in healthcare facilities is subject to the operational arrangement and traffic pattern. Further study before application in healthcare facilities is highly recommended to suit the operational need.

B9 CHILLER PLANT OPTIMISATION

DESCRIPTION

The chiller plant optimiser is a digital twin model-based optimisation solution to provide control of the chiller plant in a way that delivers overall plant efficiencies beyond that of the individual equipment. Chiller plant optimisation controls the chillers, heat rejection systems, pumps and valves to achieve optimal operation combinations. The sensor readings on different locations such as chiller water temperature, condenser water temperature and flow rate determine the current required cooling demand. The equipment and other actuators such as valves will respond to the demand in a combination that requires minimal power consumption within the equipment limitations such as the minimum part load ratio of chillers.

Illustration of Chiller Plant Optimisation Dashboard

BENEFITS / STRENGTHS

- The chillers and other system equipment can be operated at highest effectiveness to meet the cooling demand so as to reduce the energy consumption.
- With the sensors and actuator to perform real time monitoring and control, the system can be more responsive and accurate. Overcooling and undercooling can be minimised to enhance thermal comfort. Reduction in energy consumption and cost in chiller operation.

POTENTIAL CONSTRAINTS / WEAKNESSES

- The effectiveness of the system may be reduced if the cooling demand of the building fluctuates frequently due to the lack of operation pattern and limitation on response time of the chillers.

TECHNICAL CONSIDERATION

- The chiller plant optimiser should provide control of the chiller plant in a way that delivers overall plant efficiencies beyond that of the individual equipment.
- The chiller plant optimiser should use feedback from its on-board real time analytics, diagnostics, measurement, and verification systems to continually readjust the chiller plant operation for optimal performance.

APPLICATION SCENARIOS

- Chiller plant optimiser is more applicable to medium to large scale buildings with higher cooling demand, such as office and healthcare facilities.

C1 SELF-SANITISING DOOR HANDLE

DESCRIPTION

Door handles are often teemed with harmful bacteria, which may spread diseases and raise the concern of public health and hygiene. In view of these circumstances, self-sanitising door handle can be used to tackle the problems of spreading of germs and bacteria through indirect contact from door handle. Self-sanitising door handle is a door handle that can clean itself to reduce the spreading of germs and bacteria. It is often designed with special materials or coating, such as leveraging chemical reaction of certain coating or the use of materials with antiviral compounds to continuously or periodically killing or removing bacteria, viruses, and other microorganisms that may be present on the surface.

Example of Self-Sanitising Door Handle

BENEFITS / STRENGTHS

- The self-sanitising door handle can provide self-cleaning properties, remove volatile organic compounds, and kill microorganisms, which can improve public hygiene and avoid spreading of bacteria.
- The self-sanitising door handle can reduce the manpower on disinfecting and maintaining the hygiene of the surface of door handle.

POTENTIAL CONSTRAINTS / WEAKNESSES

- There may be limitations on the duration of effectiveness on self-sanitising door handles. Wear and tear of self-sanitising door handle may lead to reduced effectiveness or failure of the sanitising feature.

TECHNICAL CONSIDERATION

- Sanitising mechanism should be effective and reliable on killing or removing bacteria, viruses, and other microorganisms that are present on the surface.
- Sanitising performance should be ensured, while performance test on sanitising performance should be conducted periodically to ensure that the self-sanitising door handle is functioning well.

APPLICATION SCENARIOS

- Self-sanitising door handle is more applicable to buildings that need to maintain a high level of hygiene condition such as educational buildings and healthcare facilities.

C2 TOUCHLESS ACCESS & CONTROL SYSTEM

DESCRIPTION

Touchless access control system offers a choice for safe and secure access system and eliminate unnecessary physical contact. Key touchless access and control system includes touchless access system (automatic door opening and touchless lift button sensors) and biometric access control system. These systems are designed to eliminate any indirect contact between individuals through commonly touched objects and improve the convenience of the major circulation.

Touchless Lift Button

Biometric Access Control

BENEFITS / STRENGTHS

Touchless Access System

- Eliminate any need for physical contact and stop virus and bacteria from exchanging hosts. The risks of diseases transfer and spread can be reduced.

Biometric Access Control System

- Prevent unwanted and unauthorised personnel from entering the designated area to ensure security.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Some access control technologies such as biometric access control involves using personal information of building occupants, privacy concerns on whether users' information is properly treated and encrypted is crucial.

TECHNICAL CONSIDERATION

Touchless Access System

- **Automatic door opening:** Sensing devices should be provided to detect motion in front of the door, activate the control mechanism and enable the door to operate automatically.
- **Touchless lift button sensors:** A touch sensor should be installed to detect if there is an object entering to active detection zone. Corresponding floor button should be activated without touching the lift panel.

Biometric Access Control System

- Digital encoding and encryption should be performed on the edge side and transmit the encrypted personal data to central server via private network for authentication.

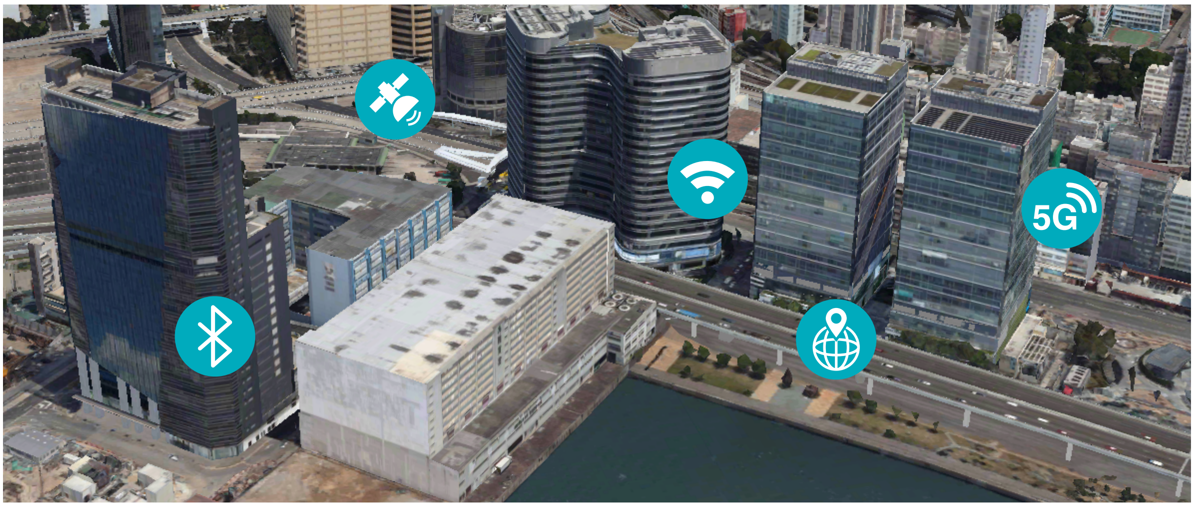
APPLICATION SCENARIOS

- It is applicable to different types of buildings.

C3 OUTDOOR / INDOOR SEAMLESS WAYFINDING

DESCRIPTION

Outdoor/indoor seamless wayfinding is achieved by implementing a ubiquitous positioning infrastructure for outdoors and indoors to deliver accurate and reliable positioning information/ services. The positioning infrastructure comprises of hardware (positioning sensors and central lookup server), software (integrated positioning services platform and APIs), data (map data and location data), and data sharing standards to provide seamless indoor-outdoor positioning services for all indoor/outdoor venues.



Technologies to Enable Outdoor/ Indoor Seamless Wayfinding

BENEFITS / STRENGTHS

- There are many locations at indoor venues that are "dead spots", where GPS signals are not able to be received. With the installation of positioning sensors, precise indoor navigation and wayfinding services can be provided.
- The use of positioning sensors facilitates the collection of end user data, such data can be analysed and understand users' behavior to provide more customised services.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Technical issues need to be overcome, including the changing of zones from one site to another under different site owners. There can be "jumpy" issues when the system is still identifying the correct location and positioning technologies being used.

TECHNICAL CONSIDERATION

- For seamless outdoor-indoor location-based services, different signal modes need to be deployed for localisation system in indoor environments. These signals require different sensing hardware (or sensor) supports, such as Wi-Fi access points, iBeacon, cameras, magnetometer, etc.
- Site signal data, i.e. the raw signal strength data of the site, is required for the calculation of user location.

APPLICATION SCENARIOS

- The ubiquitous positioning infrastructure is more applicable to buildings that are physically connected with other buildings, MTR or other public transport facilities, providing a passageway in densely populated urban area.

C4 AUTOMATED PARKING SYSTEM (APS)

DESCRIPTION

An automated parking system (APS) is a mechanical system designed to minimise the area and/or volume required for parking cars. The system is generally equipped with mechanical devices, for example an express elevator and a revolving platform for transporting vehicles. APS can provide parking for vehicles on multiple levels stacked vertically to maximise the number of parking spaces while minimising land usage. Typical technologies for APS include vertical lifting and horizontal sliding system (VLHS), puzzle stacking system (Puzzle) and the automatic guided vehicle (AGV).

Example of APS - Puzzle Stacking System

BENEFITS / STRENGTHS

- Better land utilisation when compared to traditional multi-storey car parks as ramps, driveways, passenger lifts, etc., can be eliminated, which will provide more parking space to meet the rising parking demand.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Mechanical safety and fire safety are of particular concern when implementing APS.
- Additional maintenance works will be required compared with traditional parking space.

TECHNICAL CONSIDERATION

- Requirements as outlined in the Guideline for Implementing Mechanised Vehicle Parking Systems published by EMSD should be strictly followed.
- Considering the future uses of electric vehicles (EVs), charging facilities for EVs should be provided as practical as possible.

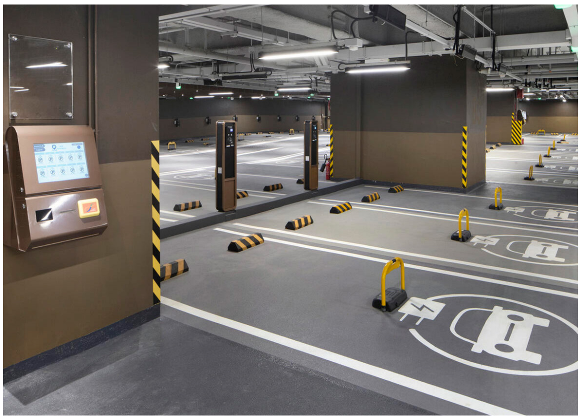
APPLICATION SCENARIOS

- APS is more applicable to buildings with large parking demand such as office and healthcare facilities.

C5 EV CHARGING AND BOOKING SYSTEM

DESCRIPTION

The demand of EV charging infrastructure is expected to increase in the upcoming years due to the continued rising number of EVs in Hong Kong. The EV charging and booking system is therefore introduced for support the application of EVs. Such system includes EV charger as well as parking space and EV charger booking system.



EV Charger

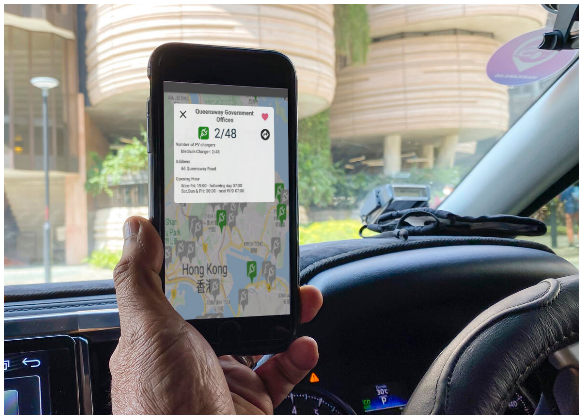


Illustration of EV Charger Booking System

BENEFITS / STRENGTHS

- Provides a convenient way to obtain the availability of EV charging facilities in real time. Requests can be made by the users to reserve the EV charging facilities and parking space.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Power system of existing building may need to be upgraded to cater for additional power requirements of EV chargers.

TECHNICAL CONSIDERATION

EV Charger

- The EV charger should be able to meet the charging speed and charging capacity of the selected types of charging. Depending on the mode of charging, several types of charging coupler can be provided as appropriate to suit different EV owners.

Parking Space and EV Charger Booking System

- Vehicle detection sensors should be installed at the ceiling or on the ground of each parking space for the detection of vehicles.

APPLICATION SCENARIOS

- EV charging and booking system is applicable to all building types, while EV charger will be provided in all the car parks of new government buildings.

C6 GATELESS PARKING SYSTEM

DESCRIPTION

Gateless parking system is a parking entrance security system which uses cameras, infrared lights, optical character recognition software, licence plate databases and licence-plate recognition (LPR) systems instead of conventional entrance gates to reduce traffic congestions near parking entrance gates caused by vehicles queuing to enter parking facilities. Gateless parking systems automatically register vehicles entering the car park through recording information such as licence plates. This helps to reduce the time required for vehicles to enter the car park and alleviate the busy traffic at parking entrances.

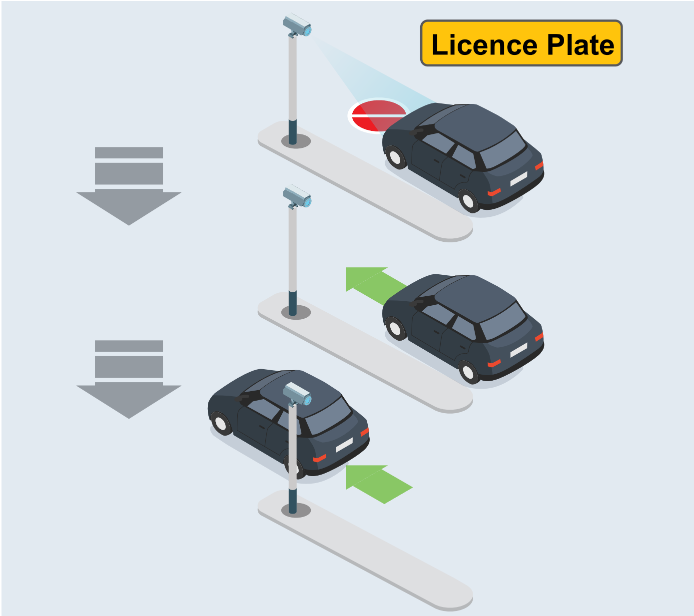


Illustration of Gateless Parking System

BENEFITS / STRENGTHS

- The system provides a more efficient parking operation and reduce traffic congestions at the car park entrance.

POTENTIAL CONSTRAINTS / WEAKNESSES

- The use of LPR system can raise privacy concerns as it involves the collection and storage of personal information. People may be uncomfortable with the idea of their movements being tracked. It may also have concerns about how the data will be used and who can access the data.

TECHNICAL CONSIDERATION

- Camera should be installed at the entrance of the car park for capturing the licence plate information of vehicles, while captured information should be used for registering the vehicles accordingly.

APPLICATION SCENARIOS

- Gateless parking system is more applicable to buildings with large parking demand such as office and healthcare facilities.

C7 SMART PEST CONTROL SYSTEM

DESCRIPTION

Smart pest control systems consist of smart traps and pest detection devices (e.g. night vision camera surveillance systems) With the use of these smart pest control devices, disease-carrying pests can be controlled and reduce the risk of spreading diseases by pests. In addition, the regular check on potential vermin in pest traps will no longer be required as remote monitoring can be achieved with the help of smart devices.

Example of Smart Pest Control System

BENEFITS / STRENGTHS

- Pest and hygiene condition at black spots can be monitored such that facility management can be informed when pests are detected or caught.
- Hygiene condition of bait points in the building can be recorded and used by facility management to formulate corresponding cleaning plan.
- Compared to traditional pest control methods (e.g. pesticide) they are non-toxic and will not harm other animals and non-target organisms.

POTENTIAL CONSTRAINTS / WEAKNESSES

- As pests will exist in a wide range of environments, the system needs to be designed to operate consistently under varying conditions, such as temperature, humidity, and light.

TECHNICAL CONSIDERATION

- A variety of sensors should be installed for detecting pests (e.g. motion sensor, infrared sensor, acoustic sensor, etc.) to provide continuous monitoring for installed areas. These sensors should be capable of detecting the presence of specific pests, such as rodents or insects, with high accuracy and low false positive rates.
- The actuator devices such as traps, repellents, or other pest control mechanisms should be strategically placed at the blackspots of the building to deal with pests.

APPLICATION SCENARIOS

- Smart pest control system is more applicable to buildings that have higher concern on hygiene, such as wet market, healthcare facilities and educational buildings.

C8 SMART WASHROOM

DESCRIPTION

A smart washroom is a technologically advanced washroom that utilises a range of IoT sensors and smart devices to improve the user experience, enhance hygiene and conserve resources. Key features of a smart washroom are touchless technology to reduce the spread of germs and bacteria, and data analytics to enhance user experience and help facility management to optimise the maintenance schedule.

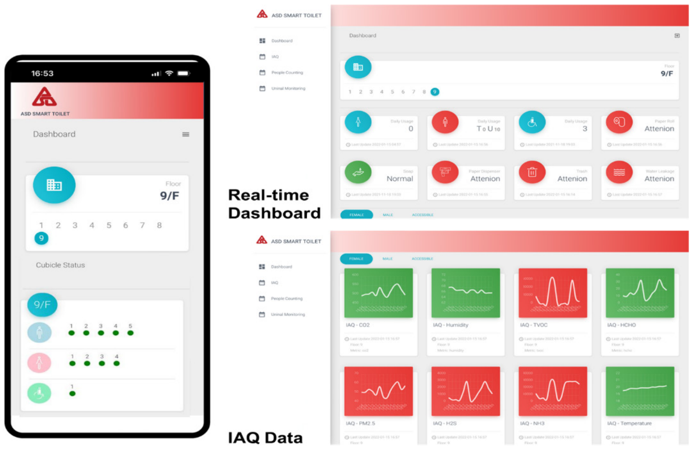


Illustration of Smart Washroom Dashboard

BENEFITS / STRENGTHS

- Smart washrooms can provide a more comfortable and convenient experience for users, such as allowing users to check occupancy status using mobile app, monitoring and controlling environmental condition (e.g. air quality, humidity, etc.) by deploying different sensors, etc.
- By monitoring usage and detecting maintenance issues, smart washrooms can reduce the need for manual inspections and repairs, resulting in cost savings and reduced downtime.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Some people may feel uncomfortable with sensors for monitoring the use of washroom, leading to concerns about privacy and data security.

TECHNICAL CONSIDERATION

- Smart washroom should be able to collect relevant information with the sensors installed across the washroom. Collected information should be able to be used for monitoring and analysis (e.g. washroom cubicle occupancy, queuing situation and indoor air quality). Such collected data should be able to be visualised through an IoT platform and mobile applications in real-time for users to check.

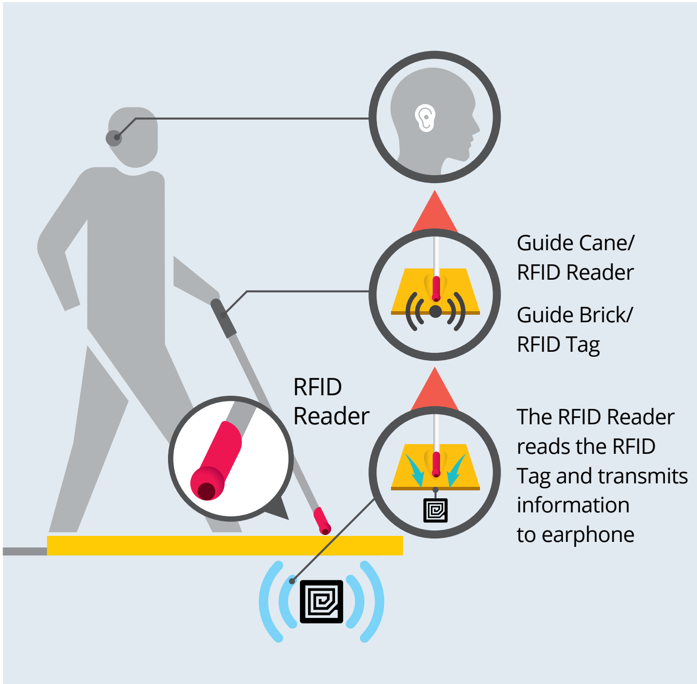
APPLICATION SCENARIOS

- Smart washroom is more applicable to public toilets, as well as buildings that have more occupants such as office and healthcare facilities.

C9 BLIND CANE NAVIGATION SYSTEM

DESCRIPTION

A digital blind cane navigation system uses RFID technology and audio navigation to provide guidance to the visually impaired and lead them to their destination by the shortest route. The system consists of smart guiding tactiles with RFID tags, a smart white cane with RFID reader paired with a mobile app and earphones, and a cloud platform that connects these components. When a visually impaired person uses a smart white cane, the RFID reader on the white cane reads the respective tag ID and location on the smart guide brick. This information is then transmitted to the mobile app and the users' earphones. The cloud platform allows the impaired to obtain the latest updates on the map and enjoy a seamless navigation across different regions.



Blind Cane Navigation System based on RFID

BENEFITS / STRENGTHS

- With RFID technology and audio navigation, the system provides guidance to the visually impaired and leads them to their destination by the shortest route, thus enlarging the social community of the visually impaired and facilitating the development of a barrier-free city.

POTENTIAL CONSTRAINTS / WEAKNESSES

- The system may not be able to reflect temporary changes or situations occurred in the path, such as temporary obstructions on the suggested path. Therefore, devices (e.g. CCTV) to ensure there are no obstructions may be needed to monitor the real-time situation and alert users if any blockages are present, or suggest another path to the destination.

TECHNICAL CONSIDERATION

- Passive RFID tags should be installed beneath guiding tactiles, if available, to facilitate signal transmission, which should be installed at 6-8m with appropriate interval subject to different models and actual site environment. RFID tags should also be placed at all strategic spots inside the building such as entrances, junctions, corners, etc.

APPLICATION SCENARIOS

- The blind cane navigation system is more applicable to common public facilities such as healthcare facilities and social welfare facilities.

C10 MULTI-PURPOSE LAMPPOST SYSTEM (Smart Lamppost)

DESCRIPTION

A smart lamppost is equipped with different sensors, cameras, and other technology that provide a range of services and benefits to the public. One of the primary objectives of smart lampposts is to collect real-time data to make informed decisions, such as the collection and monitoring on various location-specific environmental factors (e.g. air quality, temperature, humidity, etc.) and using this data to monitor and manage the environment, such as identifying areas with high pollution levels and adopting measures to reduce emissions.

Multi-Purpose Lamppost (Smart Lamppost)

BENEFITS / STRENGTHS

- Different sensors can be housed on the lamppost to collect real-time data such as sensors that measure air quality, temperature, humidity, and other environmental factors. Collected data can be used for analysis and conduct appropriate action.
- Smart lampposts can also be used to enhance the connectivity by installing different devices, such as providing Wi-Fi coverage or mobile network coverage (e.g. 5G).

POTENTIAL CONSTRAINTS / WEAKNESSES

- Privacy concern is the major barrier for the implementation of smart lamppost, especially when personal identifiable data will be collected.

TECHNICAL CONSIDERATION

- Different devices (e.g. sensors) should be installed on the smart lampposts to enable corresponding function based on operational needs. Devices may include but not limited to meteorological sensor, air quality sensors, thermal detector, geo-marker, 5G small cell, Wi-Fi hotspots, LPWAN, CCTV, etc.
- As there will be a large amount of data to be collected, data analytic function should be provided for analysing such data to generate insights for informed decision-making.

APPLICATION SCENARIOS

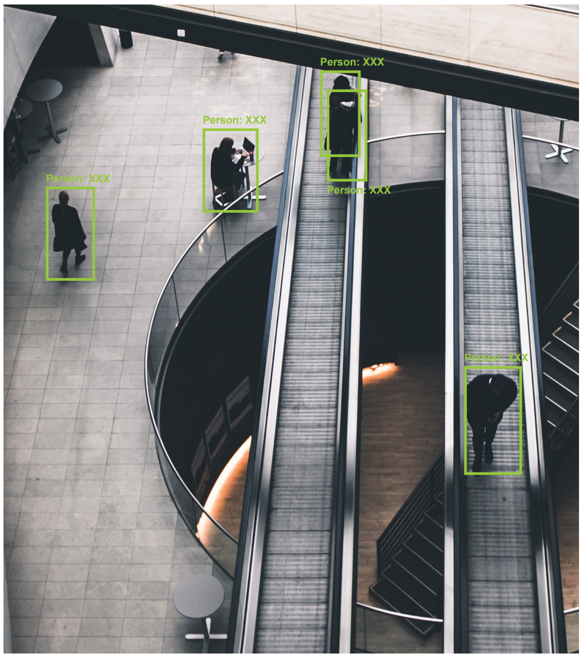
- Smart lampposts are more applicable to buildings with outdoor areas that will deploy sensors.

C11 MULTI-PURPOSE CCTV SYSTEM

DESCRIPTION

The multi-purpose CCTV system consists of a CCTV system and an AI / machine learning video analytics algorithm. Real-time video streams are captured from CCTV cameras and are used for analysis (e.g. people counting and crowd management). Through the adoption of AI / machine learning and video analytics on the video streams, insights are provided to optimise building facilities that adapt to the people flow in the building and detect any abnormal or accident situations.

This technology can be used to identify out-of-hours motion or even suspicious behaviour like loitering and crowding. If an abnormal situation is recognised in the camera's field of view, the system will raise an instant alert for real-time response.



Video Analytics by Multi-Purpose CCTV System

BENEFITS / STRENGTHS

- With the adoption of AI / machine learning assisted data analysis, multi-purpose CCTV system can monitor the real-time people flow and dynamically optimise various systems in the building, such as lighting system, HVAC system, lift control system etc., to adapt to the real-time demand accordingly.
- The system can raise an instant alert if abnormal situations are detected.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Huge amount of data will be needed for training of AI modelling and trend analysis for accurate predictions and optimisation. Faulty situations may be experienced at the beginning when video streams of the building are insufficient.

TECHNICAL CONSIDERATION

- The system should continuously monitor surrounding activities, with functions including object detection, object tracking, predictive modelling etc. AI video analytics algorithm should be included to perform analysis, such as people counting and people flow monitoring functions.

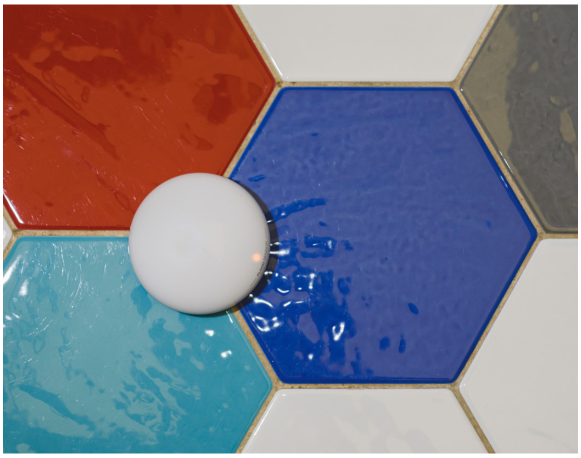
APPLICATION SCENARIOS

- The multi-purpose CCTV system is more applicable to buildings with high people flow such as office and healthcare facilities.

C12 FLOOD RISK DETECTION & PROTECTION SYSTEM (e.g. Flood Detection System & Automatic Flood Gate)

DESCRIPTION

Flood risk detection and protection system includes flood detection system and automatic flood gate. For the flood detection system, it is a system designed to detect flooding and alert building occupants when emergency arises. Automatic flood gate is a type of flood control structure that does not require human intervention to operate, which is designed to automatically activate in response to flooding and prevent flood water to enter the building.



Sensors to Detect Flood Water in Flood Detection System

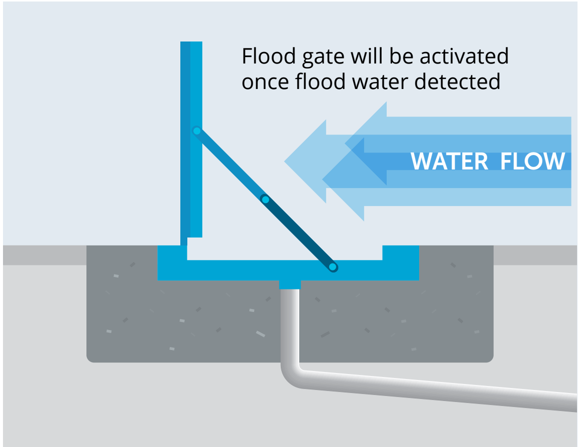


Illustration of Automatic Flood Gate

BENEFITS / STRENGTHS

- When flood water is detected, the system will trigger alarm to notify relevant stakeholders (e.g. building occupants, facility management, etc.) and allow them to take action to prevent injury or harm from flooding. Automatic flood gate will be automatically activated accordingly, so as to prevent flood water getting through the protected area to reduce flood impacts and capital loss.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Flood detection systems may sometimes generate false alarms, which will lead to costly and disruptive operation.
- Automatic flood gate is a permanent structure which is less flexible as compared to the temporary flood gate.

TECHNICAL CONSIDERATION

Flood Detection System

- The system should detect and alert quickly to minimise the damage caused by the flooding. Alarm should be activated to notify relevant stakeholders (e.g. building management, building occupants, etc.) when flood water is detected.

Automatic Flood Gate

- Automatic flood gate should be designed to fit the dimensions of the area being protected. The automatic flood gate should have sufficient strength and stiffness to prevent the flood water entering the building.

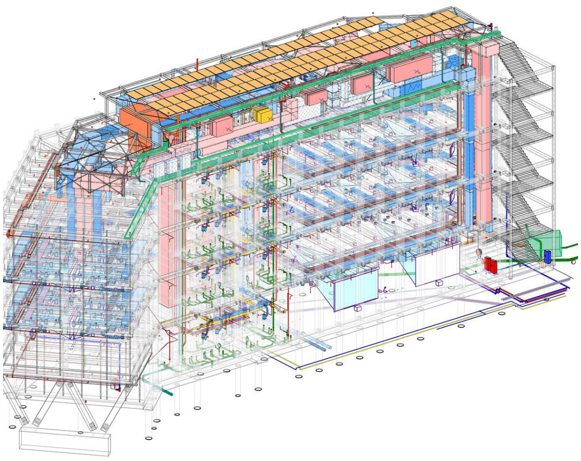
APPLICATION SCENARIOS

- The system is applicable to buildings that are sensitive to flooding, such as the buildings located in a low-lying area or buildings located near to water bodies (e.g. rivers or sea).

D1 INCORPORATING CONSTRUCTION SAFETY PLANNING INTO TIME PROGRAMME VISUALISATION

DESCRIPTION

Digital design models in specialised software can be used to integrate construction planning in the design stage and better understand potential construction and logistical issues before they arise on site. The software takes elements in the design model and associates them with construction programme activities, visualising the construction sequence, spatial planning, and overall expected rollout of the construction project. Insights garnered from the visualisation exercise help to make improvements regarding site logistics or the construction programme. Apart from construction programme and logistics planning, safety planning can also be conducted and improved in the design stage.



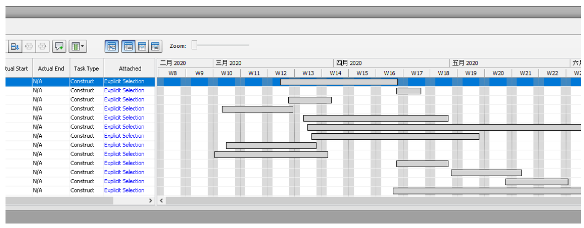


Illustration of Simulating Construction with Digital Tool

BENEFITS / STRENGTHS

- Potential construction issues can be identified in the design stage such that it can be rectified and reduce such impacts in the construction stage.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Data quality will be a major barrier for modelling, especially when utilising design models in the early stages of projects as they may not be developed enough to show certain aspects of the construction.

TECHNICAL CONSIDERATION

- The design model should be used for enhancing the time programme planning and visualisation, where the arrangement of corresponding construction activities (e.g. logistic, safety planning) should be improved.

APPLICATION SCENARIOS

- It is applicable to all building types, while buildings with more complex construction site may have more potential for such application to enhance construction planning.

D2 IMPROVING PROJECT DATA OUTCOME FROM QUANTITY TAKEOFF

DESCRIPTION

The estimated cost of the materials involved in construction is conventionally done manually by counting required construction material based on construction drawings. However, with the introduction of BIM authoring software, quantities of materials and equipment schedules can be created and exported easily such that information required for the Quantity Take Off (QTO) can be produced more efficiently and accurately. Project data outcome will also be improved as such data is required to be consistent throughout project lifecycle.

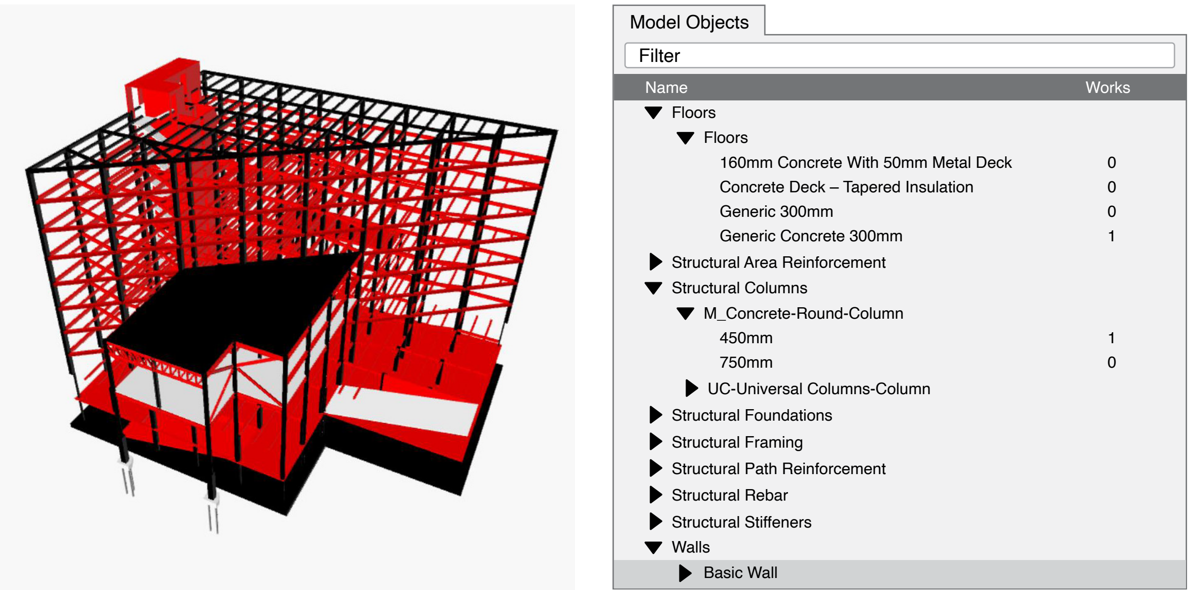


Illustration of Quantity Takeoff with Digital Tool

BENEFITS / STRENGTHS

- The efficiency of cost estimation is improved due to faster extraction and higher accuracy of quantities than the traditional approach.
- Changes of material quantities due to design changes can be assessed instantly.
- Cost estimation and budget analysis can be conducted based on the result of QTO.

POTENTIAL CONSTRAINTS / WEAKNESSES

- It requires consistency in the modelling approach, naming of elements and their properties. If the construction material is not specified consistently, the accuracy of such cost estimation will not be reliable.

TECHNICAL CONSIDERATION

- Compliance with standard method of measurement should be ensured.
- The modelling approach and information assigned to the elements should be standardised and consistent.
- Schedules of elements should be extracted in an .xml or .csv format so that the data can be reviewed in any common workbook applications (such as Microsoft Excel).

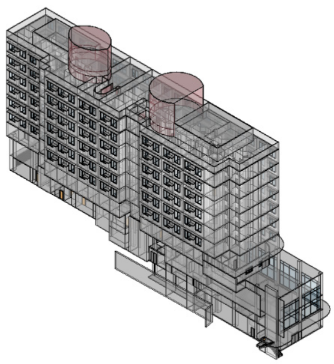
APPLICATION SCENARIOS

- It is applicable to all building types, while complex project such as healthcare facilities may require higher level of detail (LOD) and refinement level of model to suit specific project needs.

D3 IMPROVE ENERGY MODELLING AND VISUALISATION IN USING DIGITAL TWIN

DESCRIPTION

The use of digital tools for advanced analysis enables prediction of the building's behaviour before construction. With various digital tools to perform energy modelling and simulation, different scenarios of building performance can be formulated and compared before construction for creating an energy-efficient building. A more comprehensive understanding on building energy performance can be achieved through the integration of digital model and energy data.



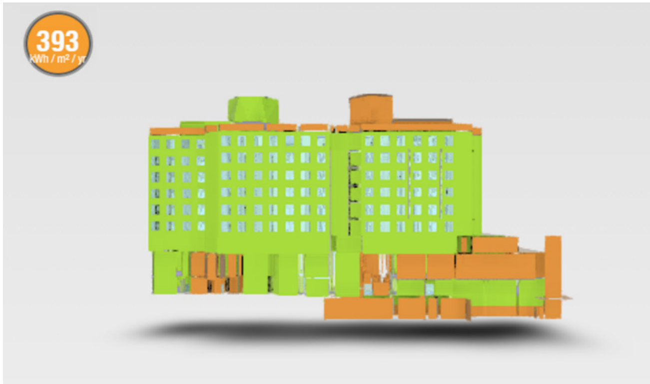


Illustration of Building Energy Modelling

BENEFITS / STRENGTHS

- The energy performance of building can be evaluated before implementation, and thus different design scenarios can be compared for delivering a more energy-efficient building design.
- The digital model can be integrated with different energy data to provide better visualisation on energy performance of building and allow stakeholders to identify potential optimisation more easily.

POTENTIAL CONSTRAINTS / WEAKNESSES

- The changing of layout and building design may lead to inconsistent geometric representation of the model which will affect subsequent analysis.

TECHNICAL CONSIDERATION

- The digital model should be capable to integrate information from various sources, including building sensors, weather information, and energy bills, to produce a comprehensive and accurate picture of the building's energy performance.
- It should be complied with regulatory requirements (e.g. latest BEC or Green Building Certifications) for measuring and reporting energy performance.

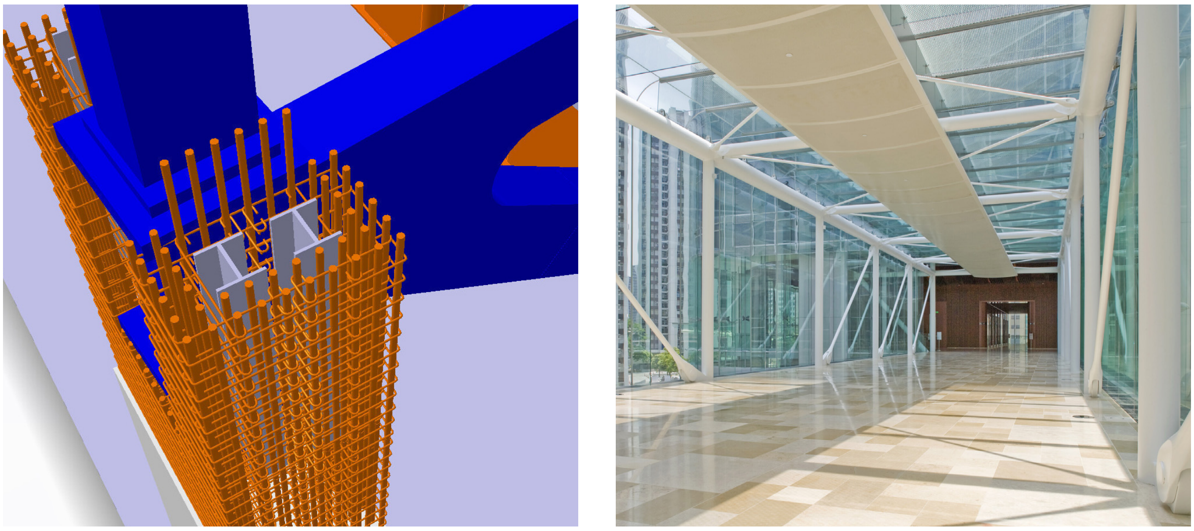
APPLICATION SCENARIOS

- It is applicable to all building types for building performance optimisation.

D4 ENHANCE DESIGN OPTIMISATION FOR STRUCTURAL ANALYSIS

DESCRIPTION

Structural design and analysis using digital design tools involve several steps, including data modelling, analysis, simulation, and visualisation. The design model needs to host relevant information and be fed into a structural model for various structural analysis, in which the data can be used to analyse the structure's performance and optimise its design. Simulation tools can be used to test the structure's response to various loads and environmental conditions. Visualisation tools can be used to communicate the design to stakeholders and facilitate decision-making. The workflow of using digital design tools for structural analysis can improve collaboration, communication, and decision-making among stakeholders, leading to more efficient and sustainable structural design and analysis.



Structural Design Optimisation with Digital Tool

BENEFITS / STRENGTHS

- Different structural design options can be evaluated and compared quickly and accurately. This helps to reduce errors and saves time and resources, resulting in more efficient workflows for structural design.
- The response of buildings to various external forces such as wind and earthquakes can be evaluated efficiently, and thus optimisation can be made according to the structural analysis.

POTENTIAL CONSTRAINTS / WEAKNESSES

- There is a lack of standardisation for structural analysis in the industry, which will lead to compatibility issues and a lack of collaboration among stakeholders.

TECHNICAL CONSIDERATION

- The quality and accuracy of the data used in the structural model should be ensured. This requires the development of a clear data modelling and management strategy, including the establishment of standards and protocols for data input, verification, and maintenance.

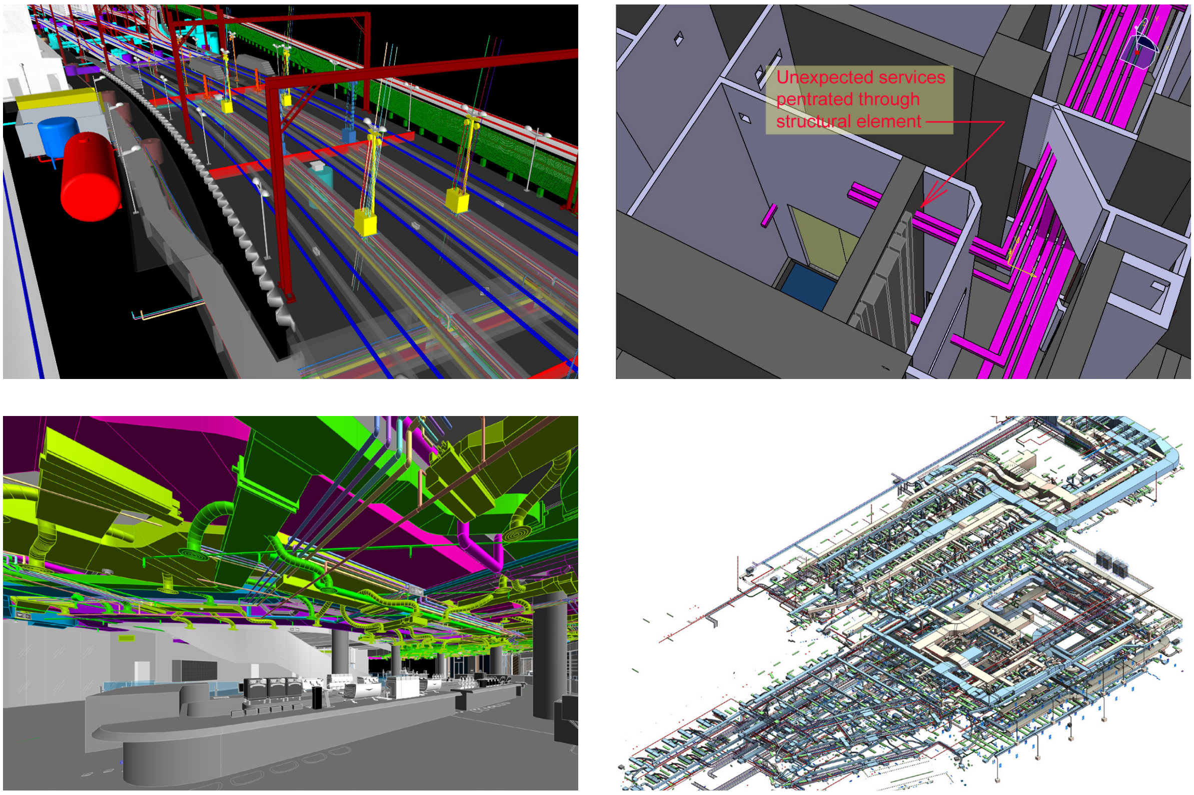
APPLICATION SCENARIOS

- It is applicable to all building types while it has more potential to be applied to buildings with complex structural design.

D5 ENHANCE BUILDING SERVICES ROUTING AND TAGGING IN MODELLING

DESCRIPTION

MEP services can be complex in a digital model with multiple lines stepping over one another and numerous tagging during the modelling process. The use of digital design tools allow users to modify the designed services easily, such as stepping over or under other services to avoid clashes.



Building Service Routing Optimisation with Digital Tool

BENEFITS / STRENGTHS

- The design of MEP system can be evaluated to check if there are any existing clashes, which can also simplify the removal of MEP elements by modifying existing services to step over or under other services to avoid clashes.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Key potential barrier is the human error such as missing design information on modelling work.

TECHNICAL CONSIDERATION

- The design of MEP system should be evaluated in which the clashes should be identified and highlighted to notify designers to follow up. Easy modification function should be provided for design change.

APPLICATION SCENARIOS

- It is applicable to all building types while it has more potential to be applied to buildings with complex MEP systems.

D6 DIGITAL DESIGN SIMULATION FOR COMPLEX 3D PARAMETRIC DESIGN WITH AR/VR TOOLS FOR VISUALISATION

DESCRIPTION

One of the key tools used in digital design simulation is 3D parametric design with AR/VR tools. This approach involves creating 3D models using advanced software that can be manipulated and tested in real-time using augmented reality (AR) and virtual reality (VR) tools. AR/VR tools provide an immersive experience that allows designers and stakeholders to experience the design in a more realistic way, making it easier to identify potential issues and make design decisions.

Example of Utilisation of Virtual Reality Device for Design Collaboration

BENEFITS / STRENGTHS

- Efficiency and productivity in the design process can be enhanced by providing designers real-time feedback on design decisions.
- With the use of AR/VR tools, stakeholders can experience the design in a more realistic way, making it easier to understand and provide feedback to the design.

POTENTIAL CONSTRAINTS / WEAKNESSES

- There is limited interoperability between software platforms as different software packages may use different file formats or have different modeling capabilities, which can make it difficult to share models or collaborate with other stakeholders.

TECHNICAL CONSIDERATION

- A variety of compatible software for digital design simulation with AR/VR tools should be adopted. This includes 3D modeling software, AR/VR software, and simulation software.
- File interoperability, or the ability to exchange design data between different software applications should be considered when selecting software solutions.

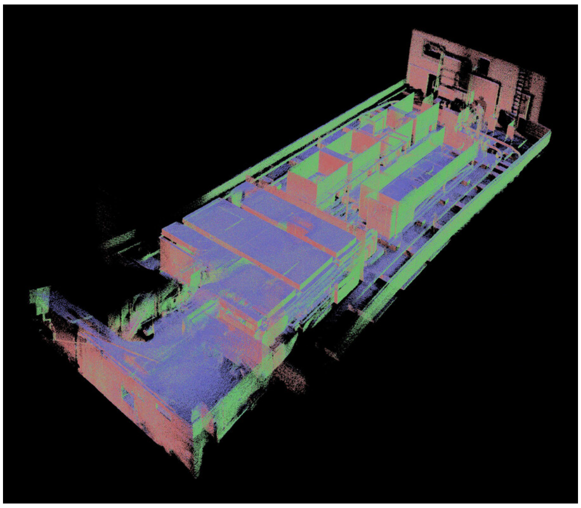
APPLICATION SCENARIOS

- It is more applicable to buildings that allow future occupants and specific end-user groups to comment and join in decision making about the design, such as schools, healthcare facilities, and community service facilities.

E1 LASER SCANNING FOR CONSTRUCTION

DESCRIPTION

Laser scanning is a technology utilised to capture highly precise and detailed measurements of buildings and construction sites. A laser scanner emits a laser beam that reflects off surfaces in the environment and is captured by the scanner. The resulting data can be transformed into a 3D and visualised for work progress and quality monitoring. The captured data can be further transferred to a BIM (Building Information Modelling). Laser scanning may also facilitate and expedite building inspections and facilities upkeeping.



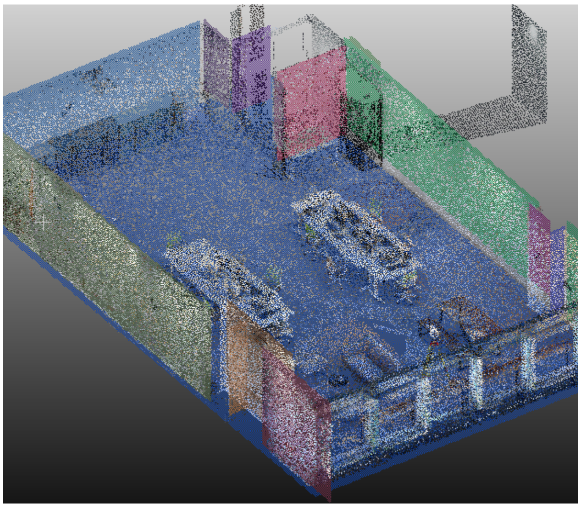


Illustration of Captured Point Cloud Data

BENEFITS / STRENGTHS

- Laser scanning technology can capture precise and detailed measurements of the site, which will help digitise and measure large structures. It can save time and reduce costs in construction projects by providing accurate measurement data for planning, design, and quality control.

POTENTIAL CONSTRAINTS / WEAKNESSES

- The quality of laser scanning will be influenced by various factors, such as the surface characteristics of the object and weather conditions.

TECHNICAL CONSIDERATION

- The scanner should be able to capture accurate data in different environment conditions, which should include but not limited to complex built environment, open spaces, and uneven terrain.
- Reliable power source should be provided for scanning devices and the devices should be sturdy and durable to withstand the harsh conditions of a construction site, such as dust, debris, and extreme weather.

APPLICATION SCENARIOS

- Laser scanning is more applicable to buildings with complex site conditions, or complex and large-scale existing buildings that need to build a 3D model through point cloud to BIM.

E2 AUTOMATION / ROBOTICS FOR REPEATED CONSTRUCTION ACTIVITIES

DESCRIPTION

The use of robots to perform construction tasks that were traditionally executed by human labour can enhance productivity, reduce human error, and improve the safety of construction projects. Typical examples include automated brick laying robot, remote control drilling machine, and automatic painting robot.

Automated Welding Robot

Automated Wall Plastering Machine

BENEFITS / STRENGTHS

- Robots can perform tasks for a longer duration, which can improve the productivity and reduce the time required to complete such tasks.
- The use of robots can improve the overall safety of construction as the robots can be used to perform tasks that are hazardous for workers.

POTENTIAL CONSTRAINTS / WEAKNESSES

- There may be regulatory and legal issues when implementing robotics and automation systems in construction, such as safety regulations and liability concerns.

TECHNICAL CONSIDERATION

- The robots should operate safely and reliably in construction environments, with fail-safe mechanisms in place to ensure the safety of workers and the public.
- The robots should be sturdy and durable to withstand the harsh and demanding conditions of construction sites such as extreme temperatures and dusty and dirty environments.

APPLICATION SCENARIOS

- The use of robot is applicable for performing construction tasks that are hazardous to workers (e.g. lifting weight, working at height, hazardous material, etc.) as well as performing repetitive construction tasks.

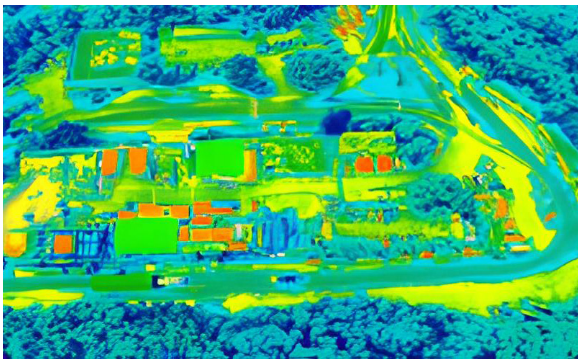
E3 USE OF DRONE FOR SITE SURVEYING IN CONSTRUCTION SITES

DESCRIPTION

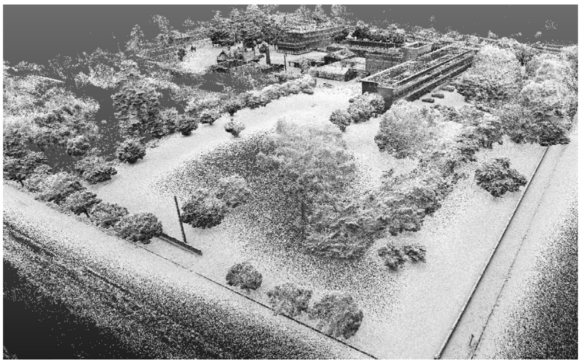
Drones are becoming increasingly popular in the construction industry due to their ability to provide valuable data and insights that were previously difficult or impossible to obtain. By integrating with AI and LiDAR cameras, drones can help capture high-resolution images and generate accurate 3D models of construction sites to improve planning, monitoring, and management of construction projects. Use of drones may also facilitate and expedite building inspections and facilities upkeeping.

Drone Inspection

Progress Checking



Site Surveillance with Thermal Camera



Point Cloud Data Capturing

BENEFITS / STRENGTHS

- Drones can cover large areas quickly and efficiently, reducing the time and cost required for traditional survey methods.
- Drones can be equipped with advanced cameras to capture highly accurate data to provide precise measurements and mapping.
- There is less safety concern to use drones to inspect hard-to-reach or hazardous areas.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Drones are sensitive to weather conditions such as strong winds, rain, and fog. These conditions will limit their ability to fly and collect data, which can impact the quality of collected data and project timelines.

TECHNICAL CONSIDERATION

- The drone should be able to maintain a stable flight to ensure the quality of captured data for creating high-quality maps and 3D models.

APPLICATION SCENARIOS

- The use of drone is more applicable to buildings with complex site conditions.

E4 SMART SITE SAFETY AND QUALITY MONITORING SYSTEM

DESCRIPTION

Smart site safety and quality monitoring system refers to the system that can be used for data visualisation, workflow streamlining and connecting with various smart site applications for safety and site management. Key components of such system include centralised management platform and various smart devices (e.g. smart monitoring devices, AI camera, etc.). The application of smart site safety and quality monitoring can be providing a more comprehensive view of construction site safety and quality to help different parties to make more informed decisions as well as improve communication and collaboration among stakeholders to ensure that construction projects to be completed safely, on time, and to a high standard.

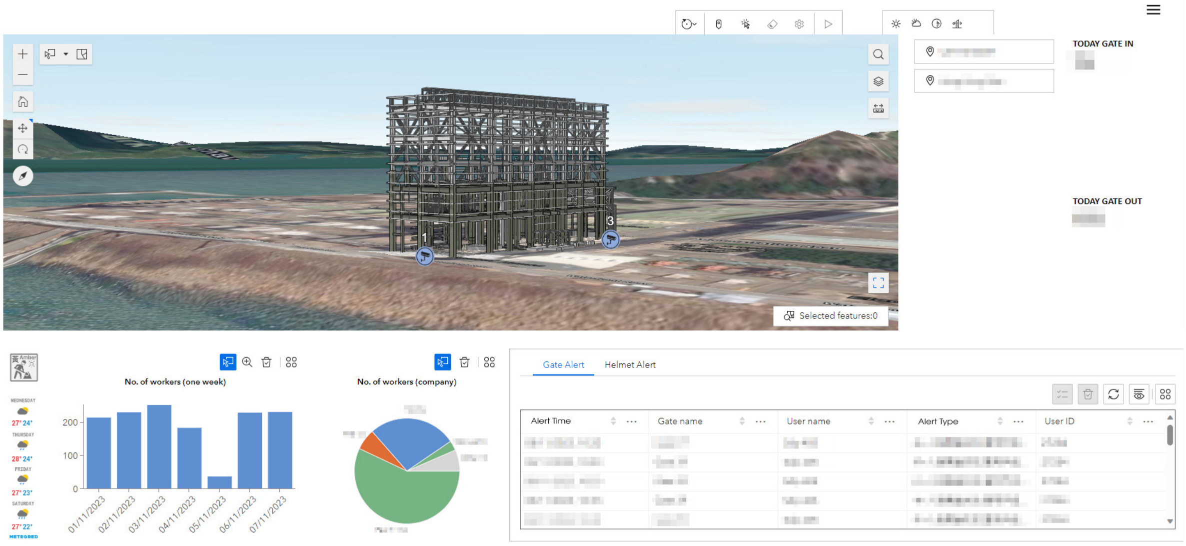


Illustration of Centralised Management Platform of Smart Site Safety and Quality Monitoring System

BENEFITS / STRENGTHS

- Smart site safety and quality monitoring system can collect and analyse data from various sources, providing valuable insights for informed decision-making. The system can also enhance coordination among various stakeholders by providing progress tracking function to reduce project delays and overspending.

POTENTIAL CONSTRAINTS / WEAKNESSES

- All parties are required to be well trained on using such system to maximise its effectiveness.

TECHNICAL CONSIDERATION

- Smart site safety and quality monitoring system should be capable to visualise construction site data and perform analysis, where real-time alerts or notifications should be provided when unsafe conditions are detected.

APPLICATION SCENARIOS

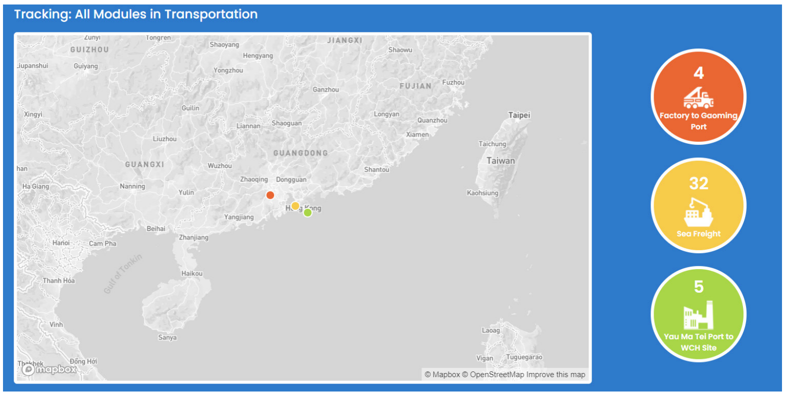
- Smart site safety and quality monitoring system is more applicable to buildings with more construction works to be performed.
- According to DEVB TC(W) No. 3/2023, capital work contract exceeding 30M need to incorporate the Smart Site Safety System in the project.

E5 SITE ACTIVITY AND EQUIPMENT TRACKING SYSTEM

DESCRIPTION

Site activity and equipment tracking system are solutions that perform tracking functions by utilising positioning technologies such as GPS, RFID, or QR Codes and other IoT sensors.

Scanning of QR Code to Obtain Information of Site Equipment



Logistic Tracking

BENEFITS / STRENGTHS

- The system can provide location information on site activity and equipment to enhance the communication and collaboration between project team and equipment operators as well as optimising site equipment usage and arrangement.

POTENTIAL CONSTRAINTS / WEAKNESSES

- The system may require users to change their existing workflows, such as registering site equipment for tracking purpose.

TECHNICAL CONSIDERATION

- The system should utilise appropriate technologies to enable the tracking function, which include but not limited to GPS, RFID, or QR Codes and other IoT sensors.

APPLICATION SCENARIOS

- Site activity and equipment tracking system is more applicable to buildings with complex site conditions, site activities and construction equipment.
- According to DEVB TC(W) No. 3/2023, capital work contract exceeding 30M need to incorporate the Smart Site Safety System in the project.

E6 LEAN CONSTRUCTION FOR DFMA, MIC, MIMEP IN FACILITIES UPKEEP AND REFURBISHMENT PROJECTS

DESCRIPTION

One of the main challenges in facilities upkeep and refurbishment projects is to minimise the disruption caused by construction activities to existing building operation. Pre-fabrication, MiC, MiMEP are lean construction approaches that can reduce on-site construction activities while ensuring productivity within the given time constraints to effectively manage this challenge.

Example of Using MiC in Existing Building (JTC Dormitory at Buroh Lane, Singapore)

BENEFITS / STRENGTHS

- It can minimise the disruption caused by construction activities to the existing building, such as reducing the overall on-site construction period as well as alleviate the noise and wastes generation issues associated with construction activities.

POTENTIAL CONSTRAINTS / WEAKNESSES

- On-site temporary storage space for modules might be limited when it is used in facilities upkeep and refurbishment projects.

TECHNICAL CONSIDERATION

- Precise survey of existing building conditions should be performed to identity site constraints and improve construction planning.
- Digital tools should be used to facilitate detail planning of site utilisation, modules design, installation phasing, simulation of construction sequence and training to streamline the project delivery process.

APPLICATION SCENARIOS

- It is applicable for large scale retrofitting works such as major MEP system upgrade, change of building compartments and functions, expansion on rooftop or podium. It is more applicable to buildings that need to minimise the disruption caused by facilities upkeep and refurbishment, such as office and healthcare facilities.

F1 AI / MACHINE LEARNING BASED OPTIMISATION AND PREDICTIVE MAINTENANCE

DESCRIPTION

AI / machine learning algorithms make use of data collected from interconnected technologies (IoT sensors) to perform analytics and provide insights for improving the performance of relevant building systems. The development of this AI / machine learning-based platform is to drive the concept of smart buildings with the provision of predictive insights to the building operator, such as lift fault signal remote monitoring, lighting system remote monitoring, motor and pump remote monitoring, and cable health remote monitoring.

Example of AI and Data-Driven Smart Building Platform

BENEFITS / STRENGTHS

- With the adoption of AI / machine learning assisted data analysis, various building systems, such as lighting system, HVAC system, lift control system etc., can be optimised in terms of performance enhancement and energy efficiency. Operating cost of building can also be reduced due to optimised performance.
- Predictive maintenance can be enabled through applying machine learning analysis to provide more insights and forecasts to the operators.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Comprehensive historical data set is necessary for model building and accurate prediction result, while in most cases the data resource is limited.

TECHNICAL CONSIDERATION

- AI / machine learning based optimisation and predictive maintenance should include lift fault signal remote monitoring, lighting system remote monitoring, motor and pump remote monitoring, and cable health remote monitoring as appropriate. Sensors should be deployed in such building systems to collect corresponding operation data.
- Collected data and analysed result should be converted to usable information and visualised in a user-friendly interface. Alarms should be activated if any abnormal situation of such building systems is detected or predicted.

APPLICATION SCENARIOS

- It is more applicable to buildings with various MEP systems, such as office and healthcare facilities.

F2 STRUCTURAL HEALTH MONITORING SYSTEM (SHM)

DESCRIPTION

Structural health monitoring (SHM) systems monitor the condition of buildings and help ensure the safety and longevity of the building. SHM systems detect and assess any potential damage or deterioration in the structure and provide early warning of potential failure. Various sensors, such as accelerometers, temperature sensors, and corrosion sensors, etc., are placed in strategic locations throughout the building to detect changes in the buildings' structural behavior as well as provide future cathodic protection.

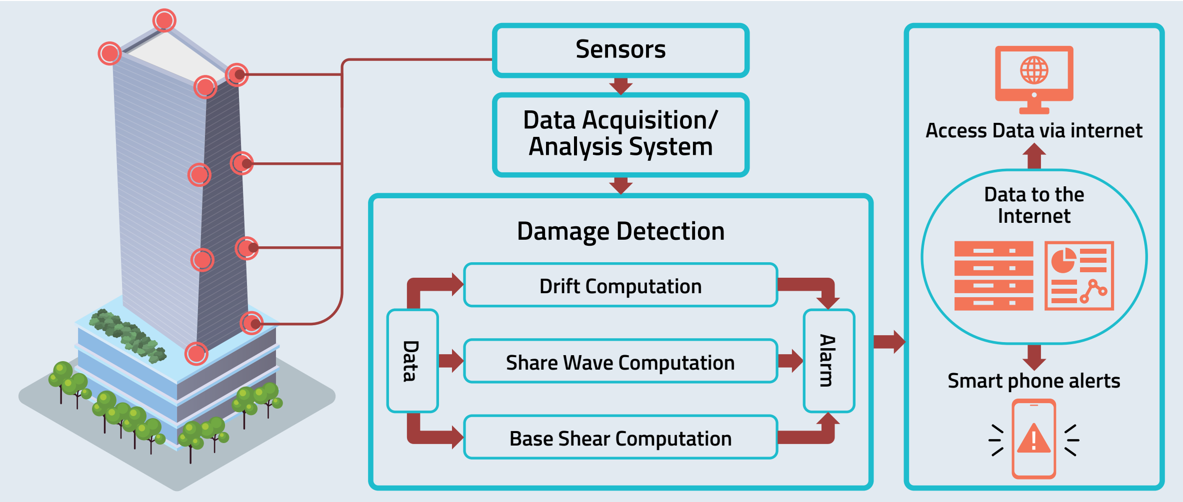


Illustration of Operation Principle of SHM

BENEFITS / STRENGTHS

- By deploying such system on structures, a reliable and accurate understanding of the structural safety and integrity can be achieved, which can reduce the need and cost of engineering inspection.
- Building management (e.g. facilities management) is given the ability to compare the acquired data with the assumptions made in design and can make informed decisions. Information regarding the health of the structures will provide insight to facilitate maintenance, rehabilitation or replacement.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Analysis result may be vulnerable to noise corruption and any other induced vibrations (e.g. earthquake). Such false alarms or missed detections will lead to unnecessary repairs and maintenance.

TECHNICAL CONSIDERATION

- The SHM system should include a range of sensors that can collect structural-related data, such as accelerometers, displacement sensors, strain sensors, temperature sensors and corrosion sensors, etc. It should be capable of collecting and transmitting real-time data on the structural performance and condition.
- The SHM system should include algorithms and softwares for processing and analysing the structural-related data collected by the sensors. It should be capable of providing continuous monitoring of the structure and evaluate the structural condition of the building such to detect any abnormal changes in structural-related behaviour or condition.

APPLICATION SCENARIOS

- It is more applicable to buildings that are difficult to conduct structural inspection, such as healthcare facilities.

F3 ROBOTIC SYSTEM FOR OUTDOOR (Façade Monitoring / Cleaning) AND INDOOR (Movable IAQ / Water Tank Cleansing)

DESCRIPTION

Outdoor Robotic System

An outdoor robotic system is a fully automated robot system used for performing exterior tasks on buildings. Typical examples include façade monitoring robot and façade cleaning robot.

Indoor Robotic System

An indoor robot is a type of automated machine that can execute specific tasks (e.g. building operation/ maintenance tasks) to enhance versatility and maximise maneuverability. Typical examples include movable IAQ monitoring robots and water tank cleansing robot.

Example of Indoor Robotic System

BENEFITS / STRENGTHS

- In general, the use of both outdoor and indoor robotic systems can enhance resource efficiency in building operation and maintenance due to less labour required for performing corresponding tasks.

Outdoor Robotic System

- Outdoor robots can reach hard-to-access areas of a building to perform tasks.
- Traditional scaffolding works and hiring of cherry pickers are not required if such tasks (e.g. façade inspection/ cleaning) can be performed by outdoor robots.

Indoor Robotic System

- Indoor robots can perform task that normally require human intervention, which can save time and cost for facility management.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Robotic system may raise privacy concerns as they are typically equipped with cameras and sensors.

TECHNICAL CONSIDERATION

- Enabling facilities should be provided for the application of robotic system, which should include but not limited to power source and communication network such as LPWAN/ Wi-Fi.
- The robots should be able to perform specific tasks without causing any danger to building occupants. Sensors such as anti-collision sensors should be equipped as appropriate to ensure safe operation.

APPLICATION SCENARIOS

- It is applicable to all building types for enhancing building operation efficiency.

F4 BIM-MR MAINTENANCE TRAINING AND VIRTUAL SIMULATION

DESCRIPTION

BIM-MR maintenance training and virtual simulation is a technology that combines Building Information Modeling (BIM) and mixed reality (MR) to create a more immersive and interactive experience for designing, building, and maintaining buildings and infrastructure.

It enables the creation of highly detailed digital models of buildings and infrastructure that can be overlaid onto the real-world, in which users can use the models to simulate a wide range of real-world scenarios.

Application of MR for Facilities Management

BENEFITS / STRENGTHS

- It enables all stakeholders to work together more effectively, reducing the risk of miscommunication and errors.
- It enables the exploration of wide range of options and simulation of real-world scenarios, helping to identify potential issues.

POTENTIAL CONSTRAINTS / WEAKNESSES

- Challenging integration with existing workflows and technologies. There may be compatibility issues between different software and hardware and may require changes to existing processes and systems.
- The technology requires the collection and storage of sensitive data, which may have data security and privacy concerns.

TECHNICAL CONSIDERATION

- MR devices with high-resolution displays should be provided to enable the overlay of digital models on the real world.
- It should be capable of overlaying detailed digital models of buildings on the real world as well as providing interactive functions to facilitate facilities maintenance workflow.

APPLICATION SCENARIOS

- It is more applicable to buildings with complex building service systems, such as office and healthcare facilities.

EMERGING TECHNOLOGIES FOR SMART AND INNOVATIVE BUILDING

The development and deployment of technology are evolving at an unprecedented pace. Building designers and project teams must keep tracking on the latest development of emerging technologies to ensure the building technological capabilities. There are also different available sources providing more information on innovative and smart technologies in Hong Kong, such as the E&M InnoPortal launched by Electrical and Mechanical Services Department (EMSD) and the Pre-Approved List launched by Construction Innovation and Technology Fund (CITF). This chapter highlights some examples of emerging technologies that will contribute to the advancement of smart and innovative buildings and can be taken into consideration in building design. These technologies have yet to reach technical maturity and commercial availability but sheds light on what the future can entail.

Advanced Building Materials

Advanced building materials refer to a new generation of construction materials with exceptional properties, making buildings and infrastructure smarter, stronger, more sustainable and resilient. These materials offer innovative alternatives to traditional building materials and enhanced forms of existing materials by reinforcing desirable material capabilities (e.g. durability, lightness, strength, conductivity, insulation, resistance to high temperatures), and improving disadvantageous qualities. Some examples include:

Self-healing materials – Self-healing materials are synthetic substances that automatically repair itself without the need of external diagnosis or human intervention. Microcapsules and vascular channels embedded in the building materials are two mechanisms where healing agents within the capsules or channels are released when the material breaks. There is growing potential to incorporate self-healing capabilities into concrete, steel, glass, as well as paints and coatings.

Nanomaterials – Nanomaterials are a group of materials that are smaller than 100 nanometres in any of their dimensions. By incorporating nanomaterials in basic construction materials such as concrete, the building element can become stronger, more durable, and more resistant. Examples included carbon nanotubes, carbon nanofibers, and aerogels. Nanoparticles are being explored to create self-healing concrete, air purifying concrete, and smart windows and coatings that have self-cleaning and transparency-adjusting properties. Aerogel can be used to enhance insulating capabilities of walls and windows.

Bio-based materials – Bio-based materials are manufactured using substances derived from plant-based or other renewable biomass sources. They can provide a sustainable alternative for conventional high-carbon materials as they grow and sequester carbon. Some of them also offer a way to use organic waste as a resource. Examples of bio-based materials include the incorporation of bamboo and timber in building design, bricks created from corn stalks and mushroom mycelium, hemp rebar where hemp is used to replace steel reinforcement in concrete structures, and the use of cork, hemp and straw for insulation and cladding.

Advanced AI application

AI and machine learning are progressively being used in the design process through incorporation in BIM, in the planning process to predict costs and time, and in the construction process to identify potential construction site hazards and drive autonomous construction machinery.

Furthermore, AI and machine learning will drive predictive maintenance. Predictive maintenance optimises the performance and lifespan of equipment by continuously assessing its health in real time. Advanced sensors and machine learning powered data analytics can detect anomalies in operation and potential defects in equipment and flag these issues up before failure occurs. Analysis of vibrations, oil, and even current and energy flows help monitor MEP systems such as lifts, cables, and motors and pumps.

Compared to MEP systems, the use of AI and machine learning enabled predictive maintenance for building structural health is still in the research and development phase as structural health is comparatively less visible than MEP failures. AI-powered sensors can be installed in buildings to monitor structural integrity and detect potential problems. By feeding different types of data such as seismic activity, weather conditions, and building materials into the AI-based algorithms, it can predict whether a structure failure is likely to occur. However, this technology is not yet mature as there is a lack of training data and a high presence of noise and outliers. Nonetheless, this area is gaining more traction and more data will be made available for the technology to mature.

Robotic Systems

Robots are already being used in building operation to replace manual labour and improve the overall occupant experience. Meal delivery robots, disinfection robots, indoor air quality monitoring and purification robots are some examples. The application of drones and robots are expanding to other stages of a building's life cycle. They are being increasingly utilised during building design, construction, and maintenance phase for various purposes such as inspection, monitoring, and automated construction tasks.

Apart from the application of drones in building processes, the development of drone usage in daily life will affect future building designs. Commercial drone delivery is rapidly moving from demonstration to commercialisation stage and can potentially assume the last-mile delivery role in the future. Meanwhile, passenger drones are being explored as a viable alternative to ground transport in high-density urban environments. These emerging drone technologies will potentially affect the design of buildings as landing area and charging facilities for drones will need to be taken into account in the building design.

EMERGING TECHNOLOGIES FOR SMART AND INNOVATIVE BUILDING

Summary

A wide range of innovative technologies that aim to improve the functionality, efficiency, and reliability of buildings are being researched, trailed, demonstrated and pursuing commercialisation. By keeping high awareness on emerging technologies, building users and project teams can obtain a better foresight on the latest development on smart and innovative technologies, facilitate the adoption in government buildings, and update the building design requirements as appropriate to achieve better building performance in the long run.