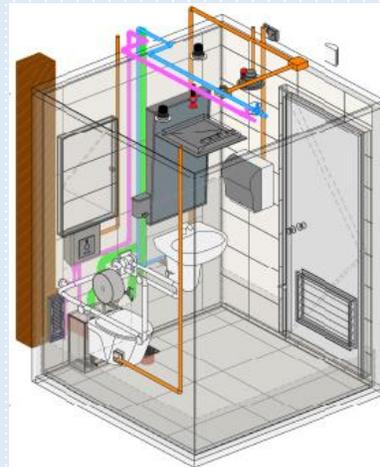


Construction Industry Council



Consultancy Services for Driving Design for Manufacture and Assembly (DfMA) Adoption to Enhance Productivity For E&M Works in Hong Kong Building Projects for Construction Industry Council

Driving DfMA Adoption in the Hong Kong Construction Industry



Aim and Objectives of the Consultancy

Aim

1. To enhance E&M Works productivity, using measures supported by the industry.

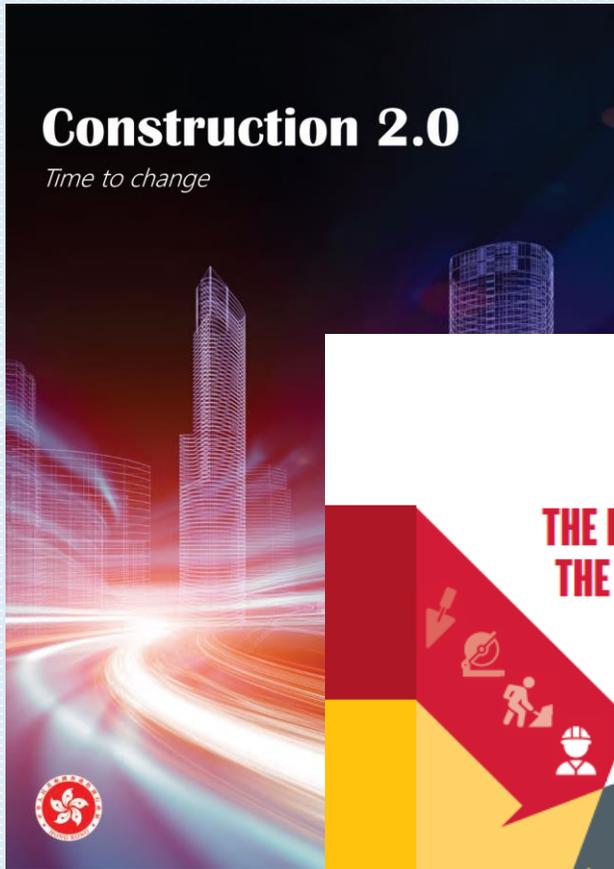
Objectives

1. To **review current best practices** both locally and internationally, as well as to document the extent of DfMA adoption for E&M Works and the results in respect of productivity enhancement.
2. To **assess current** regulations, Government policies, specifications, and design, procurement and construction **practices of E&M Works in Hong Kong** to identify the **barriers and opportunities** for improvement to enhance productivity through DfMA adoption.
3. To **propose** practical strategies, changes to remove barriers, and supporting measures for achieving productivity enhancement through DfMA adoption in the local E&M Works.
4. To compile a **DfMA Guidebook** on E&M Works for the local industry.



Source of Images: Internet

Re-industrialization and Rejuvenation for Industry 4.0

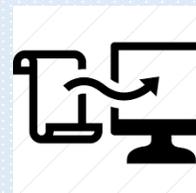
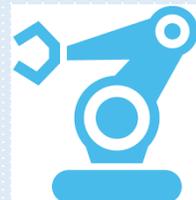


Key Challenges:

1. Significant Future Constructions Volumes
2. High Costs
3. Unsatisfactory Site Safety Performance
4. Declining Productivity
5. Lack of Creativity and Innovation

Key Initiatives:

1. Offsite Construction (DfMA and MiC)
2. Building Information Modelling
3. Smart Infrastructure
4. Uplifting project governance and leadership
5. Professional Development
6. Attracting and nurturing young talents
7. Project management Information systems
8. Digitalization of site management



DfMA and the Industrialization of Construction

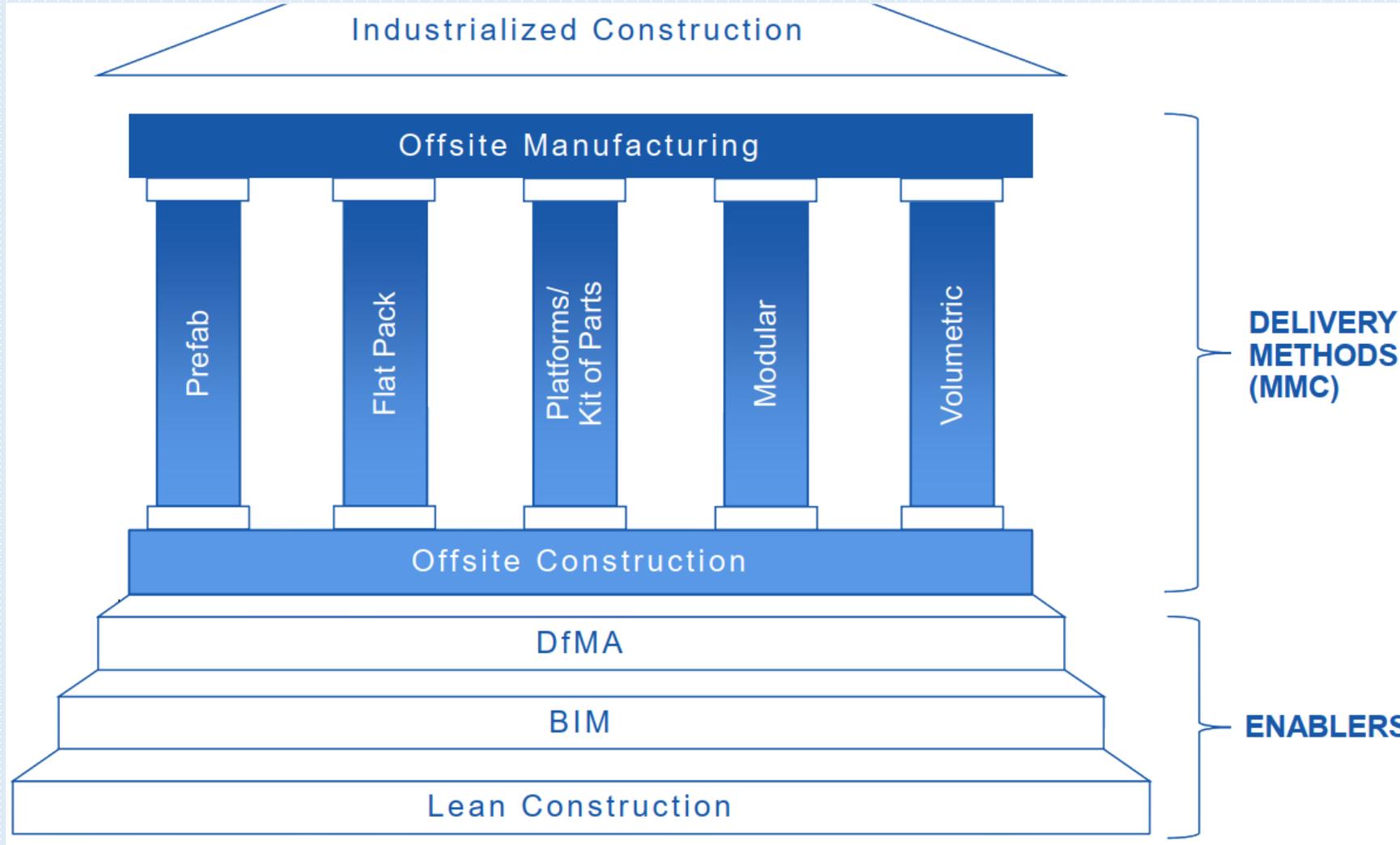
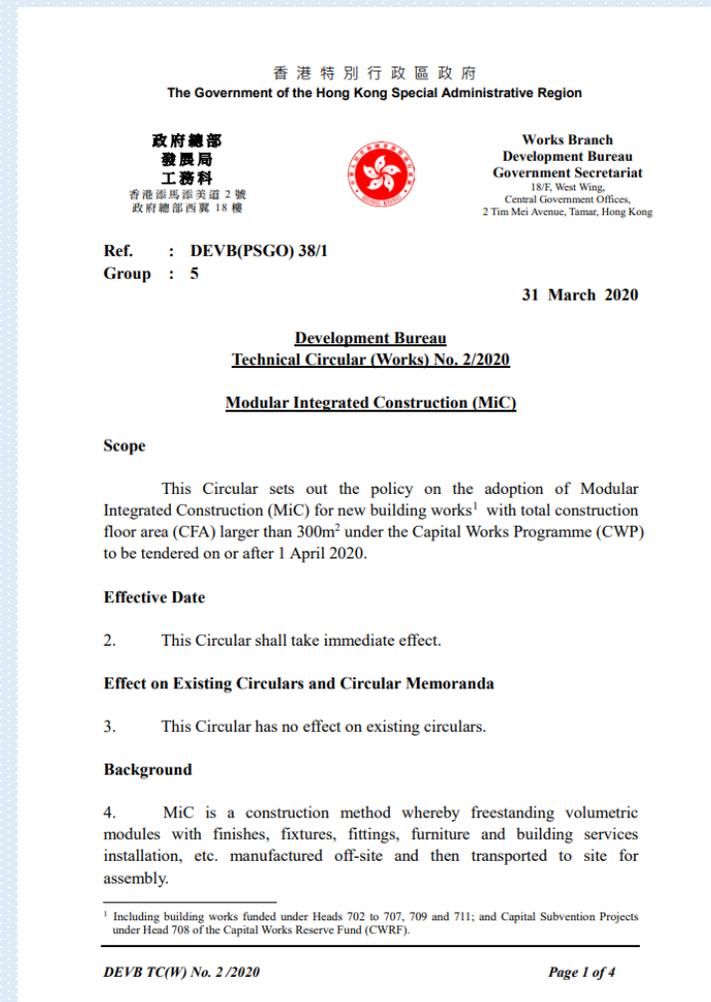


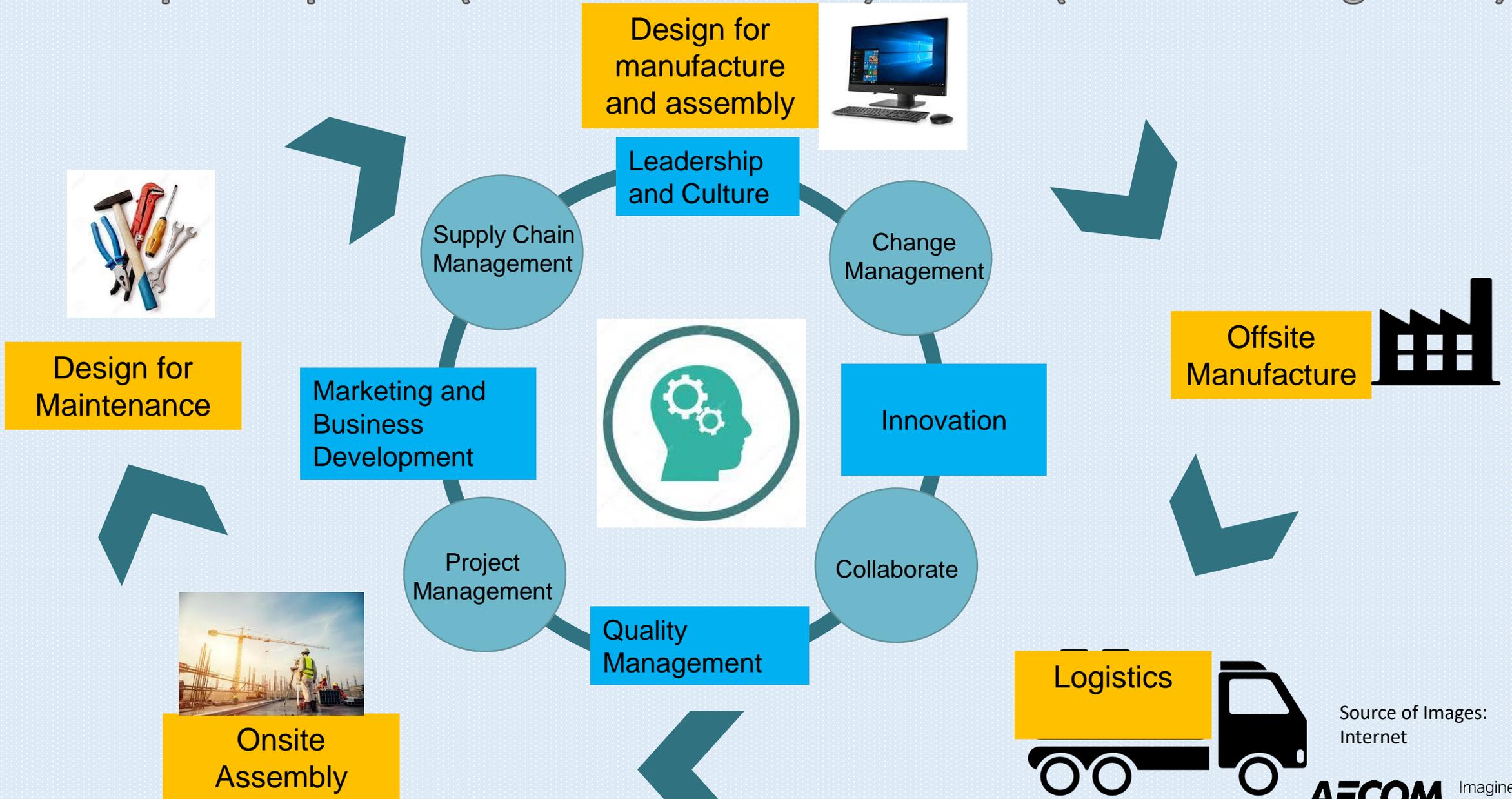
Image source: <https://www.autodesk.com/autodesk-university/class/DFMA-and-Industrialization-Construction-2019>

Adoption of MiC in Various Building Types

Building Types	Accommodations	
	List 1	List 2
Staff Quarters Hostels Residential and Care Homes Schools Office Buildings Medical Facilities General	<ul style="list-style-type: none"> Residential Units Kitchen / Pantries Lavatories Classrooms Office Areas General Wards Consultation Rooms Treatment Rooms Accommodation for Medical Staffs, e.g. Quarters and Offices Education Facilities 	<ul style="list-style-type: none"> Corridors / Communal Areas Management Offices Recreational Facilities Principal / Teacher's Rooms, Special Rooms, Laboratories, Libraries Receptions Guard Rooms Typical E&M Rooms Special Wards Operation Theatres Accommodations of Special Equipment Staircase and Lobbies of Above Buildings
Note	Mandatory for All Projects	As Far As Practicable



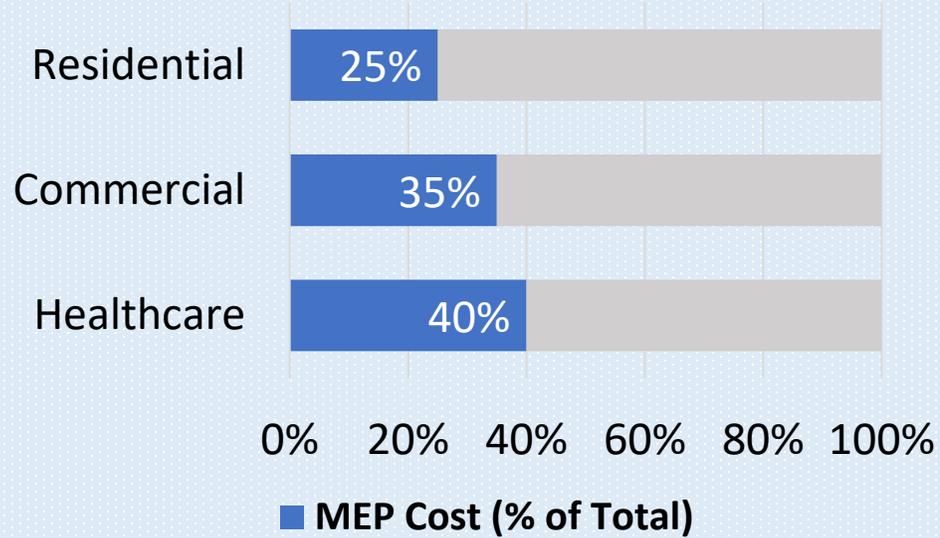
Duo Championship : MiC (Product Deliverable) + DfMA (Process Management)



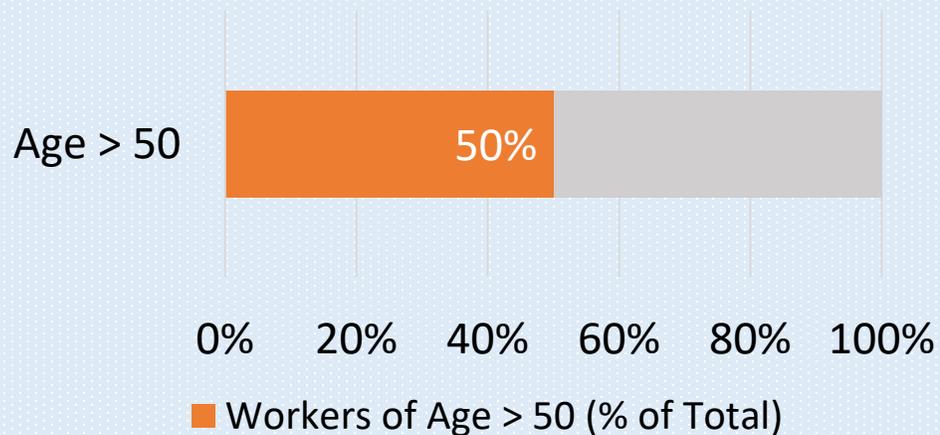
Source of Images:
Internet

MEP Cost, Labour Forces and Time Saving

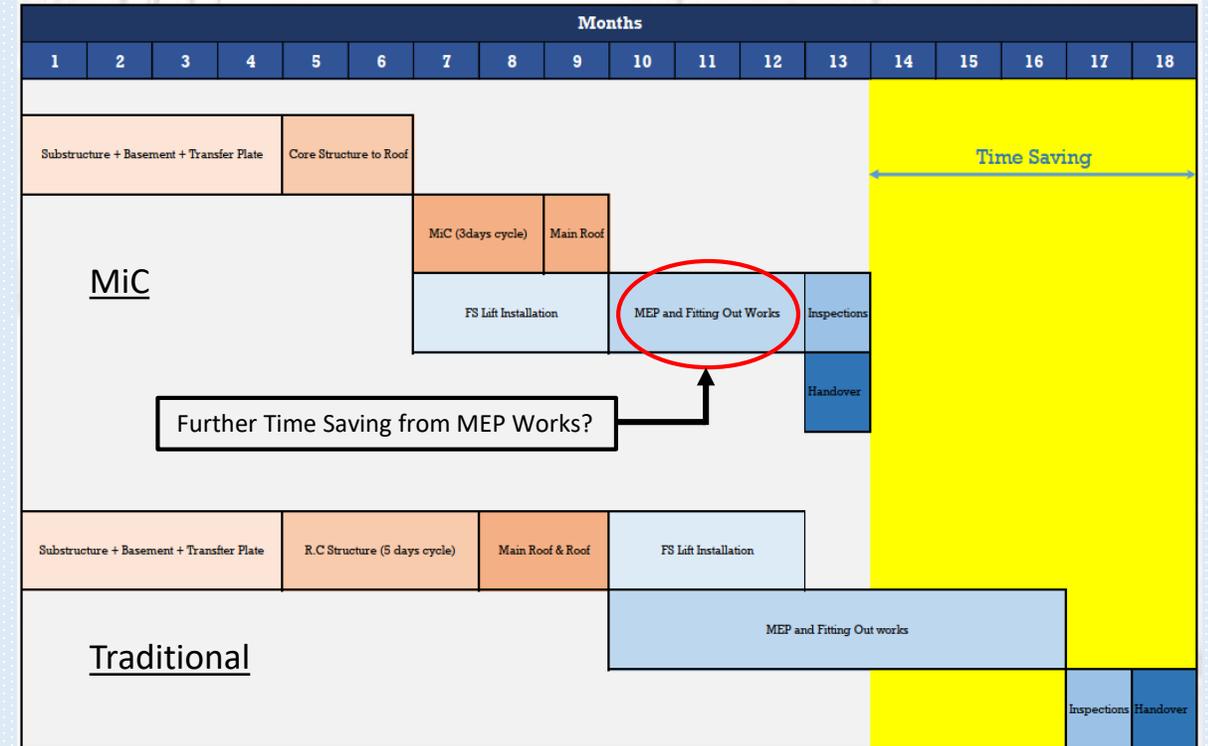
MEP Cost in Construction Projects



Age of Workers (MEP)



Time Saving (Project Overall)



Source: Presentation: MiC Journey & Adoption for InnoCell by HKSTP in 2019

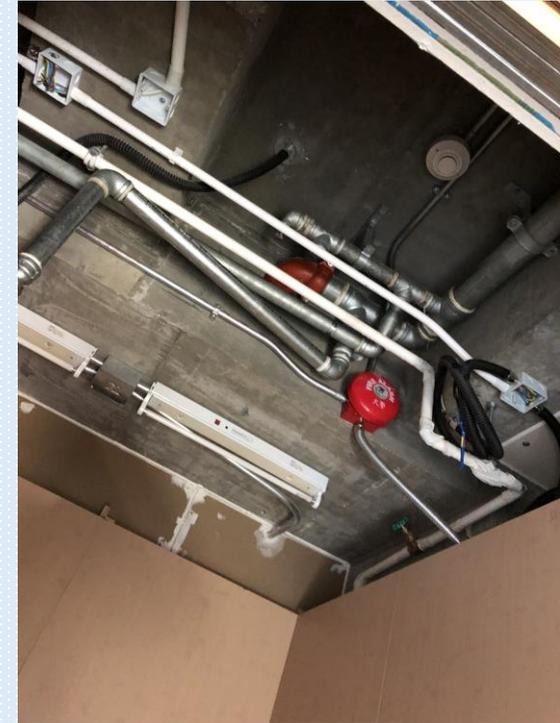
Note: Total No. of Registered Workers of MEP Trades: **67637** (as of May 2020)

Challenges of Traditional MEP Approach

- Fragmented and Congested MEP Services
- Reactive Site Coordination
- Compromised Workplace Safety
- Fatal Risk due to Improper Wiring and Labelling
- Fall from Height
- Construction Wastage



Congested MEP Services

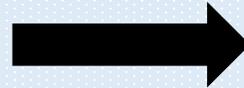


Reactive Site Coordination

Benefits of MEP DfMA

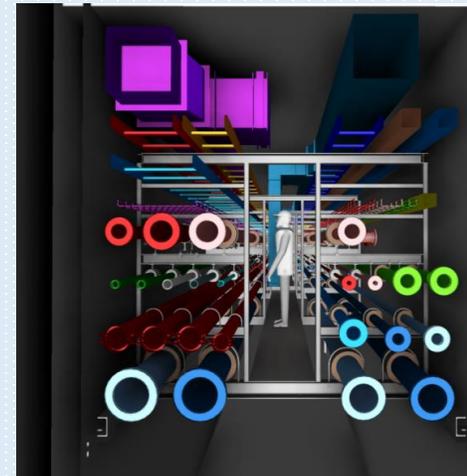
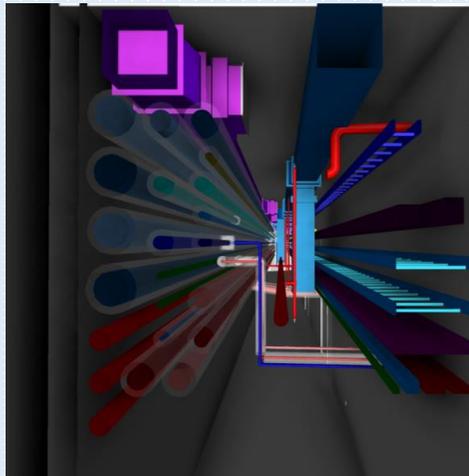
- Coordination of Fragmented MEP Trades

BEFORE:
Fragmented,
Disorganized MEP
Installations



AFTER:
Coordination Made
Easier by Using
DfMA MEP
Modules

BEFORE:
Service Tunnel
with Difficult
Access



AFTER:
Planned Installation
and Safe Access

Source of Images:
Crown House
Technologies



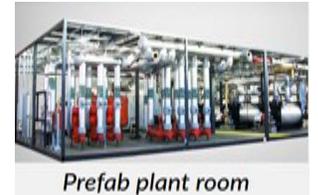
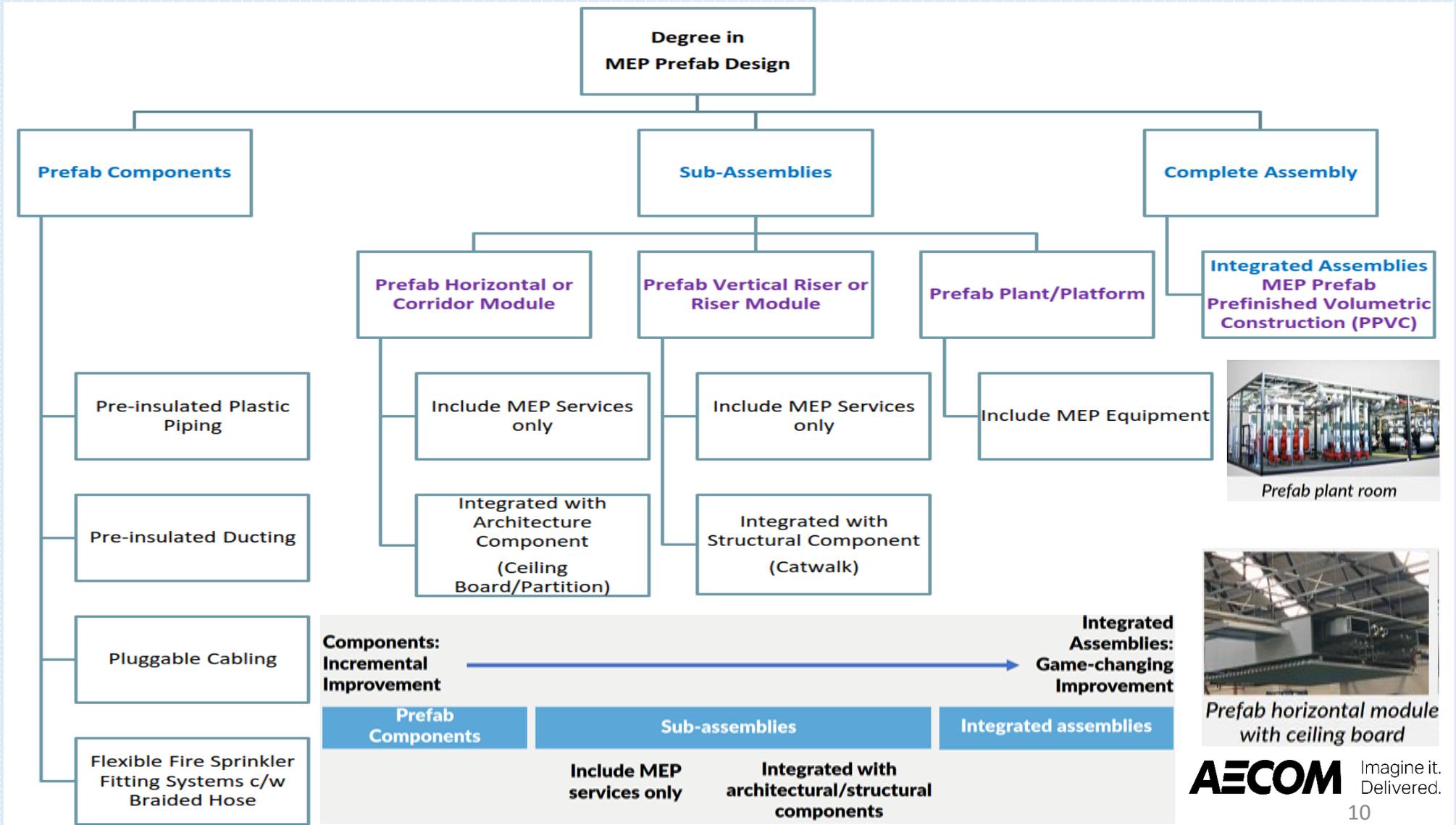
Wide Spectrum of Opportunities



Pre-insulated plastic piping



Prefab horizontal module or vertical riser



Prefab plant room



Prefab horizontal module with ceiling board

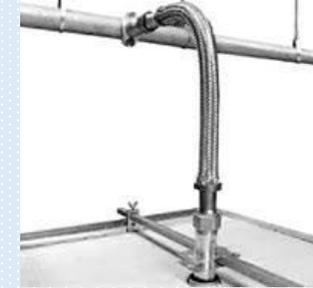
Extent of MEP Modularity

Prefabricated MEP components

- Prefabricated and pre-insulated duct for air conditioning (mandatory for all projects)
- Flexible sprinkler dropper
- Flexible water pipes
- Common M&E brackets (at least 3 M&E services)



Prefab air duct



Flexible sprinkler dropper

Advanced Prefabricated MEP

- Prefabricated MEP modules e.g. pipes, cable trays/trunking etc.
- Prefabricated MEP plant module e.g. pump, compressor etc.



Vertical module



Prefab pump skid with header pipe



Horizontal module

Fully Integrated Sub-assemblies for MEP

- Steel-Mechanical, Electrical and Plumbing (MEP) floor system
- Prefinished wall with MEP services
- Prefinished ceiling with MEP services
- Prefabricated MEP modules integrated with work platform/catwalk



Raised floor system with MEP



Prefab horizontal module with ceiling board



MEP modules integrated with catwalk

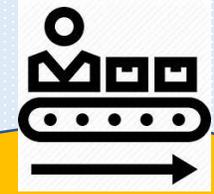
Source of Images: Internet

Re-engineering MEP for a Rewarding Venture



Cost effective,
automated/robotic and
quality manufacture

DfMA/BIM based
Design and
Procurement to
Maximize off site

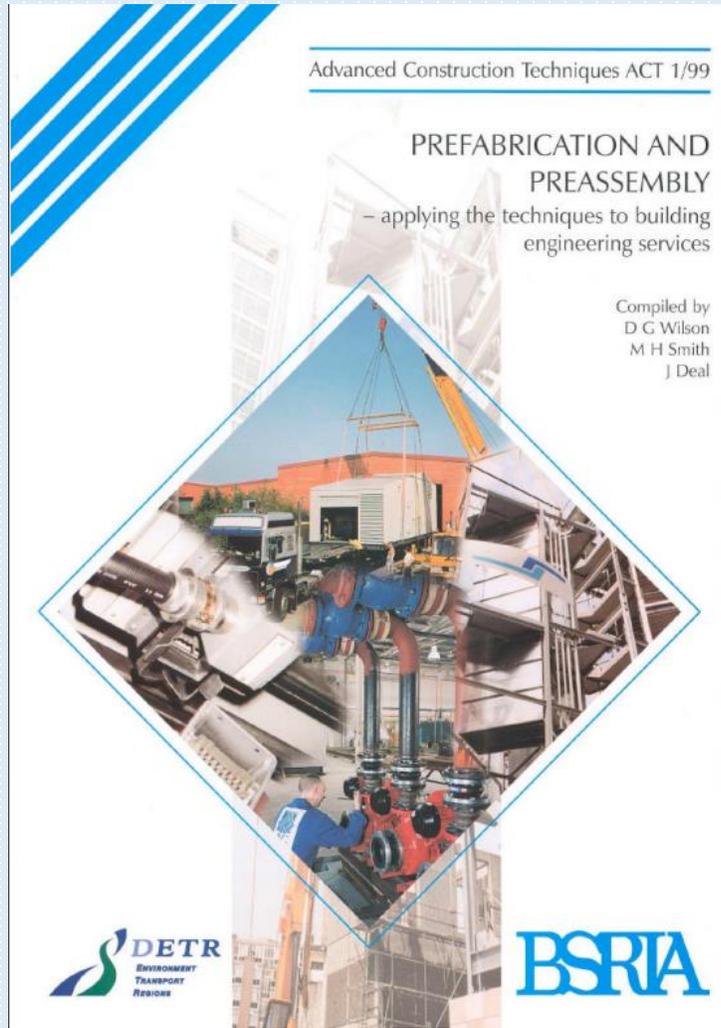


Mechanised and
Safe Assembly (DfA)

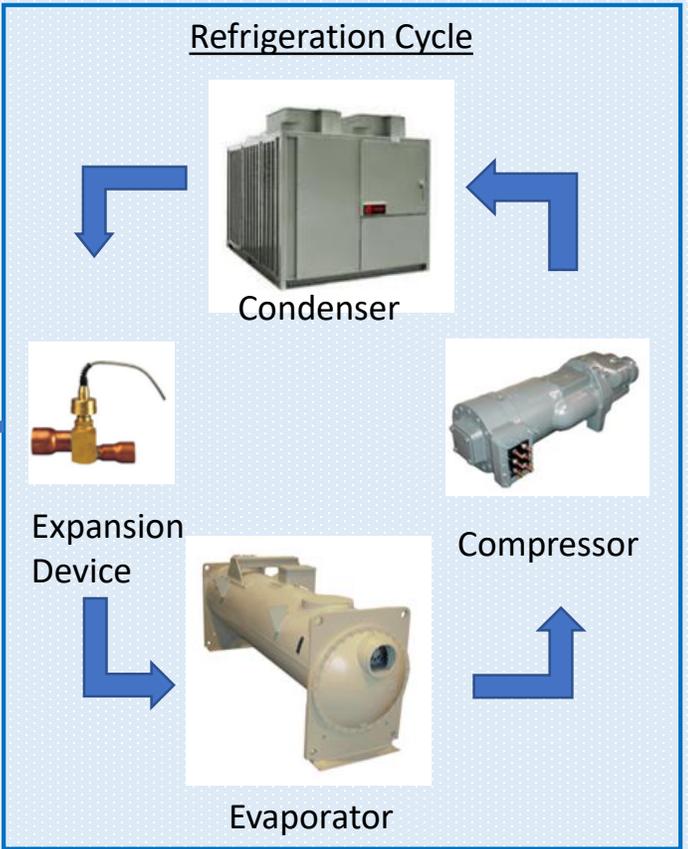
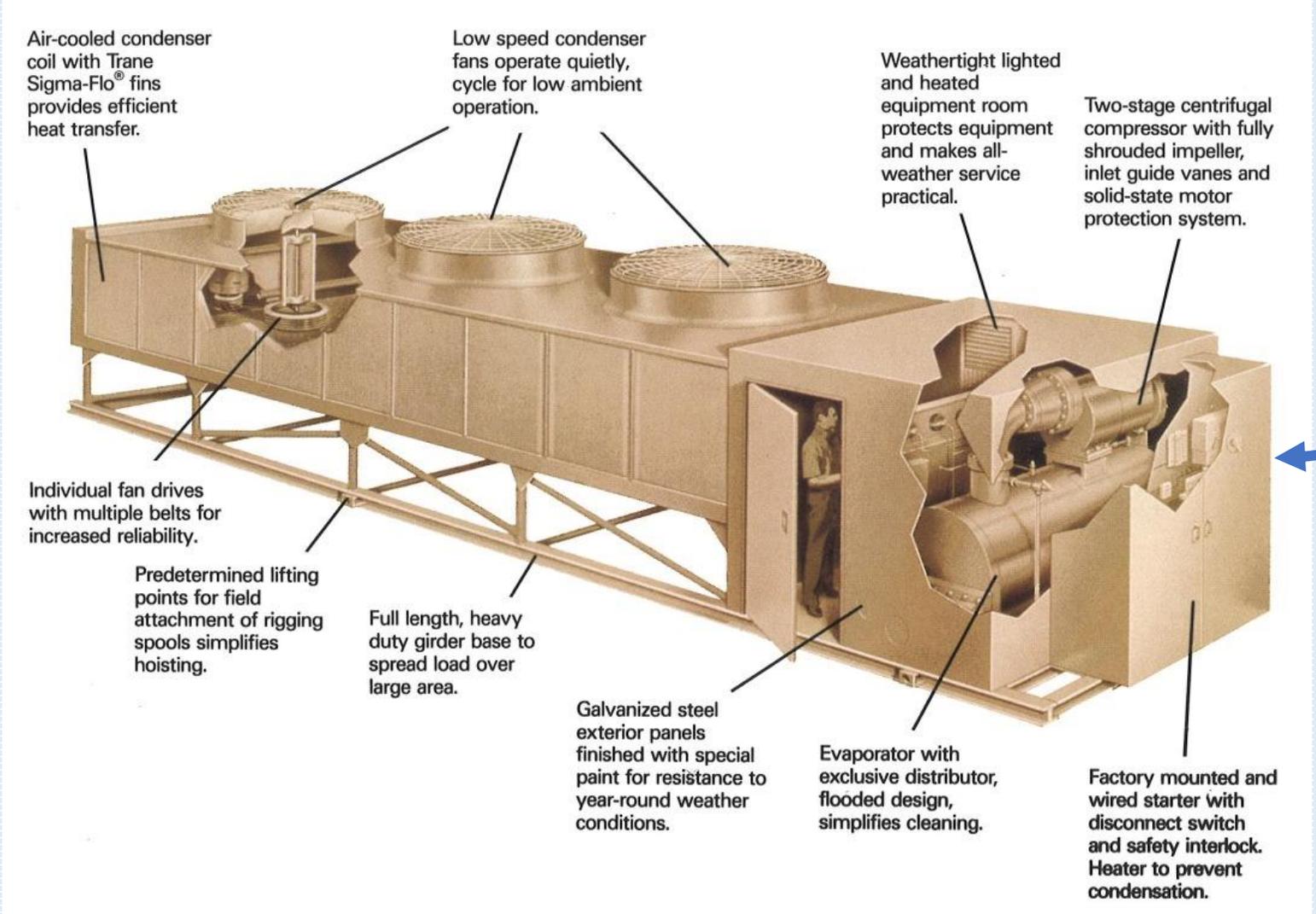
Challenges between offsite and on site

1. Re - demarcation of work
2. Change Management
3. Risk on delivery and assembly space and facilities
4. Just in-time delivery
5. Collaboration for installation sequence and access
6. Risk for on site connections interface and tolerance
7. Responsibility demarcation for statutory requirements
8. Innovative solutions

Guidebooks related to MEP Prefabricication (1990 to 2019)



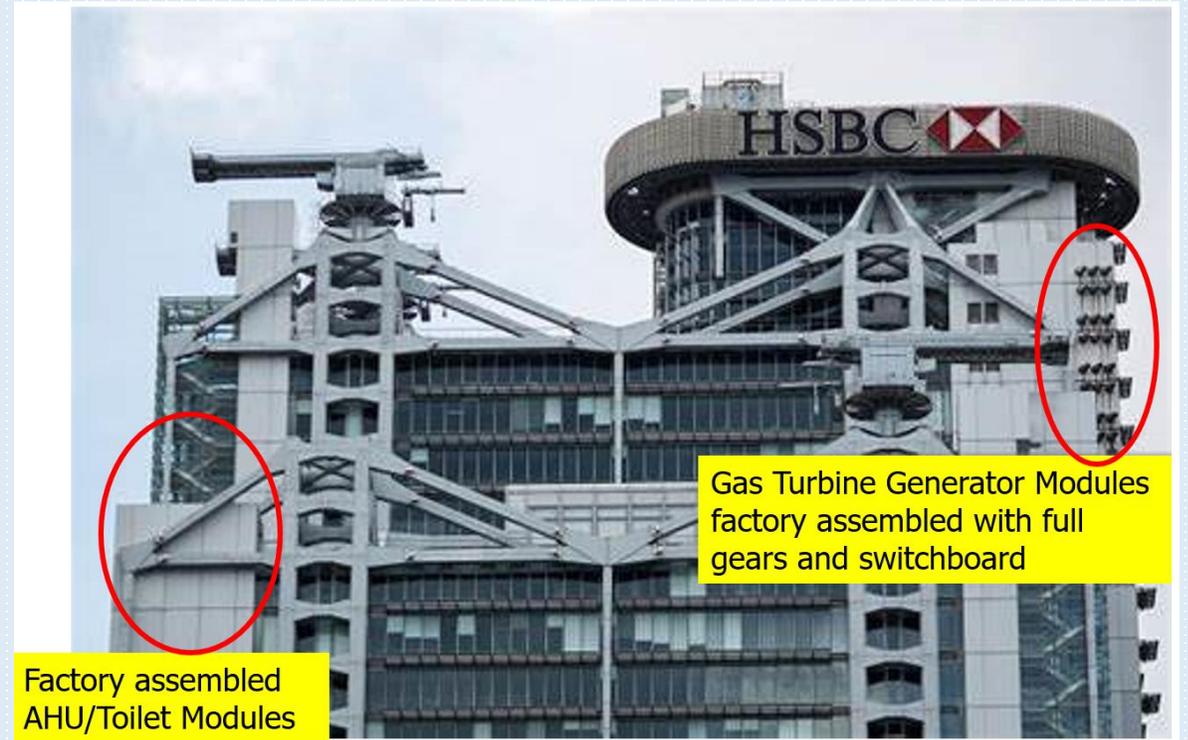
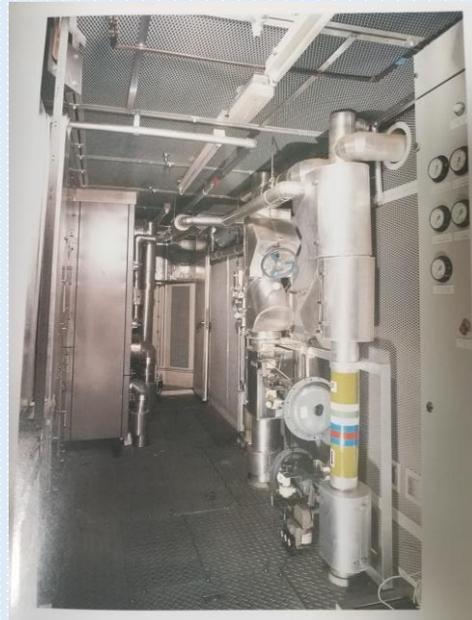
Air-cooled Packaged Chiller in 1970s



Source of Images: Trane

DfMA MEP in Hong Kong in 1980s

AHU
Module
Stacking
in HSBC



Gas Turbine Generator Modules
factory assembled with full
gears and switchboard

Factory assembled
AHU/Toilet Modules

DfMA MEP Elements in HSBC

Enablers for Offsite Migration (New Process for Old Wine)

PPVC Modules (Bare Shell)



1. Bathroom



2. Accommodation Room

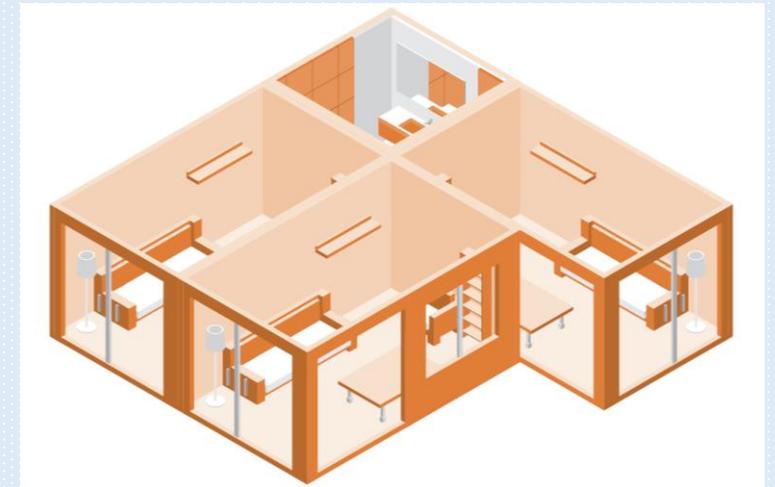
MiC Modules (Fully Integrated)



Innovative Enablers



- BIM as CAD/CAM for Construction Industry
- Sensing Technologies
- Artificial Intelligence (AI)
- Robotics and Other Automation and Mechanization
- Digital Logistic Management
- Digital Construction Management
- Internet of Things (IOT)
- DfMA Design and Procurement Management



Source of Images: Internet

MiC Projects in Hong Kong



Disciplined Services Quarters for the Fire Services Department at Pak Shing Kok, Tseung Kwan O (16-17 Storeys)



Elderly's Home at Jat Min Chuen in Sha Tin (10 Storeys)



InnoCell at Hong Kong Science Park (15 Storeys, 59.2m(H))



Residential Care Homes for the Elderly ("RCHE") in Kwun Tung North (8 Storeys)



Temporary Quarantine Facilities at Penny's Bay



Student Residence at Wong Chuk Hang Site for the University of Hong Kong (17 Storeys)



Transitional Homes at Nam Cheong Street in Sham Shui Po (4 Storeys)



Transitional Homes at Yen Chow Street in Sham Shui Po (4 Storeys)



Transitional Homes at Yip Shing Street in Kwai Chung (4 Storeys)



MiC Negative Pressure Isolation Ward (Prototype) at Zero Carbon Park, Kowloon Bay

Source of Images: Internet

AECOM Imagine it. Delivered.

DfMA MEP Projects in Hong Kong

- **Tuen Mun Chek Lap Kok Link – Northern Connection Tunnel Buildings – E&M Works (4.8 km underground)**
- Main Contractor and MEP Module Supplier: Gammon
- Constraint(s)
 - **45,000 m** of E&M Service Pipes
- Extent of DfMA for E&M Works
 - Around **6450 nos.** of Prefabricated Modules, including:
 - Horizontal Modules
- Key Lessons Learnt
 - BIM Model Library Consolidation
 - Fine Adjustment of Installation in 3D Environment
 - Installation Process Simulation
 - Unique QR Code Identification for Each Module
- Benefit(s) Reported
 - Enhanced Safety
 - Better Quality Control
 - Improved Productivity



Horizontal Pipe Modules under Fabrication at Factory

Planning and Fine-tuning by Using 3D Environment



Source: YouTube Video by Gammon

DfMA MEP Projects in Hong Kong & Singapore

- **Global Switch Singapore Woodlands Data Centre**
- Main Contractor and MEP Module Supplier: Gammon
- Constraint(s)
 - Tight Programme Schedule
- Extent of DfMA for E&M Works
 - Around **350 nos.** of Prefabricated Modules, including:
 - Horizontal Modules
 - Vertical Riser Modules
 - Raised Floor Modules
 - Pump Skid and Header
 - External Façade and Catwalk Modules
 - Roof Air-Conditioning (AC) Pipe Modules
- Outcome
 - High Quality Building Completed within a Short Period
- Benefit(s) Reported
 - Construction Period Reduced by >10%



Vertical Riser Module



Raised Floor Modules



DfMA Thermal Tank
(for Hong Kong Only)



Horizontal E&M Module



Roof AC Pipe Modules

Source of Images: Internet

Pipeline of Projects in Singapore

Pipeline of Projects Prescribing DfMA Technologies (for construction tenders expected to be called between Jan 2020 to Dec 2021)

There is continued strong support from the public sector to prescribe DfMA technologies in projects. The table below shows the expected number of upcoming projects in Singapore prescribing DfMA technologies, for construction tenders expected to be called between Jan 2020 to Dec 2021. In summary, there will be 90 of such projects in the pipeline.

	≤S\$40 mil	S\$40 mil < X ≤ S\$85 mil	S\$85 mil < X ≤ S\$150 mil	S\$150 mil < X ≤ S\$300 mil	>S\$300 mil	Total
Prefabricated Prefinished Volumetric Construction (PPVC)	0	9	23	7	0	39
Mass Engineered Timber (MET)	3	0	1	0	0	4
Structural Steel	0	1	1	2	4	8
Advanced Precast Concrete System (APCS)	0	12	10	2	1	25
Hybrid/ Multi-tech	5	1	1	0	7	14
Total No. DfMA Project	8	23	36	11	12	90
Prefabricated MEP Systems	1	0	1	1	7	10

Prefabricated Prefinished Volumetric Construction (PPVC) remains the most widely adopted DfMA technology in the next 2 years, while the use of Advanced Precast Concrete System (APCS) is gaining traction, particularly in residential projects. Confidence in prefabricated MEP systems is growing and 9 larger projects (with construction value of at least \$85mil) will be adopting prefabricated MEP systems.

Note:

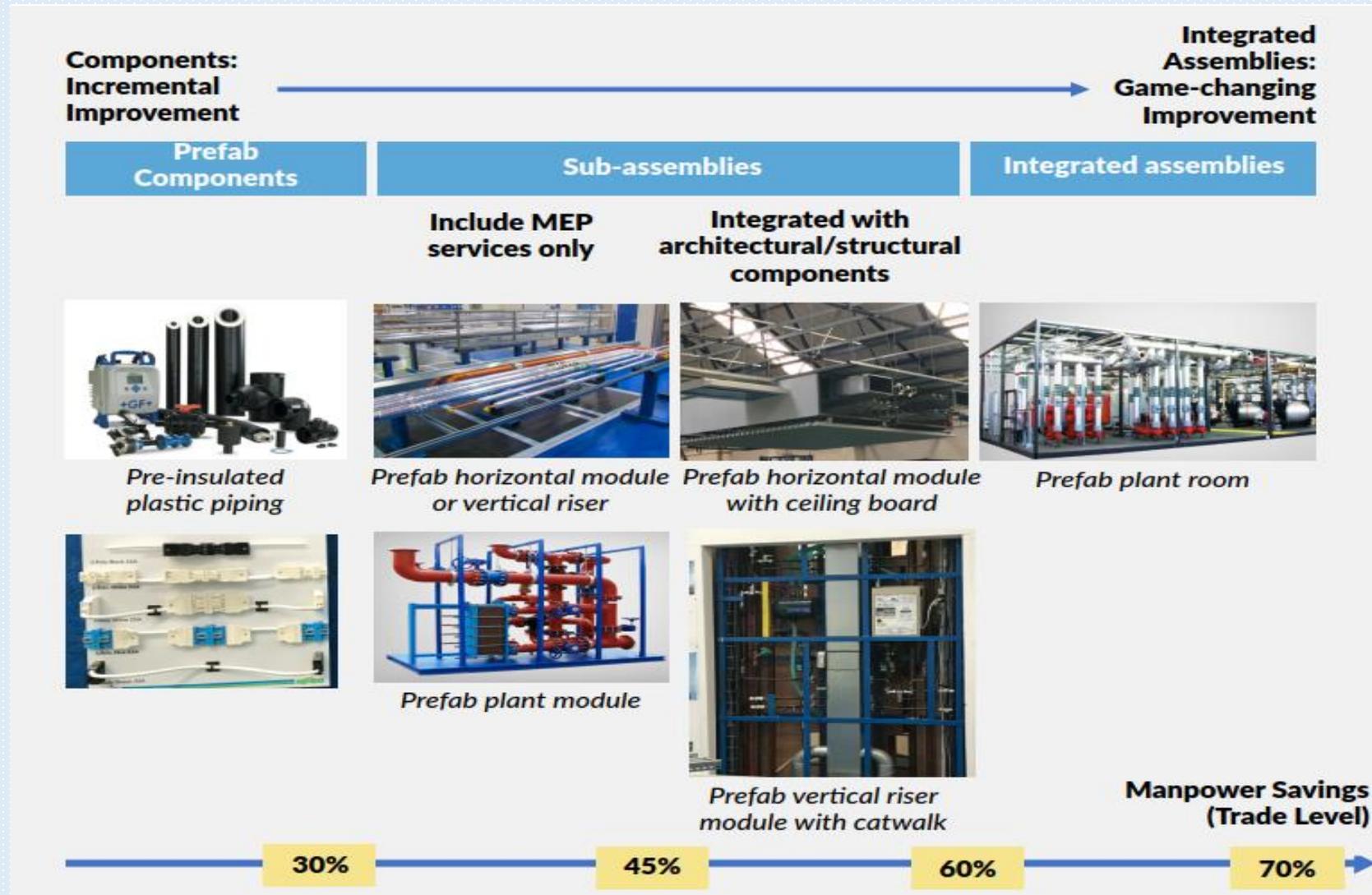
Of the 10 projects adopting prefabricated MEP systems, 9 projects are also adopting other DfMA technologies. These 9 projects are accounted for under the 90 DfMA projects.

Disclaimer:

The above information is provided to the best of BCA's knowledge. All figures in the above table, including project values, are **indicative only, and subject to change** without notice. BCA will not be liable for any loss or damages (including any special, indirect, incidental or consequential damages) which may be incurred from any use of or reliance on the information contained in the above table.

Source: https://www1.bca.gov.sg/docs/default-source/docs-corp-form/dfma_pipeline.pdf?sfvrsn=59659a90_2

Manpower Saving by DfMA MEP



Source of Image:
Design for Manufacturing and Assembly (DfMA). Prefabricated Mechanical, Electrical and Plumbing (MEP) Systems by the Building and Construction Authority, Singapore

DfMA MEP Projects in Singapore

- Case studies for prefabricated MEP systems



- a. Construction period: Dec 2016 to Nov 2018
- b. GFA ~ 25000 m²
- c. 337 prefab modules for:
 - Horizontal ceiling svcs
 - Roof cooling tower
 - Riser
 - Plant room
 - External MEP svcs with catwalk

(5 Data Floors)



- a. Construction period: Jul 2018 to Oct 2019
- b. GFA: ~8600 m²
- c. Prefab modules for:
 - Horizontal ceiling svcs (L3 – L5)
 - Risers (L2 – L5)
 - Plant room

(5 Storeys)



- a. Construction period: Sep 2018 to Sep 2020
- b. GFA 5,726 m²
- c. Prefab modules for:
 - 10 nos. horizontal corridor ceiling svcs
 - Riser
 - Pump skids

(5 Storeys)



- a. Construction period: Aug 2018 to Apr 2020
- b. GFA 43,900 m²
- c. Total 272 prefab modules for:
 - 272 nos. horizontal modules for electrical, ELV and air-con duct

(9 Storeys)



- a. Construction period: Dec 2017 to Nov 2020
- b. GFA 93,350 m²
- c. 522 prefab modules for:
 - Horizontal corridor ceiling svcs
 - AHU
 - FCU
 - Prefabricated toilet sub-assemblies

(51 Storeys, 280m(H))

Source of Images:
Building and
Construction
Authority, Singapore

CapitaSpring at 88 Market Street

Details extracted from the speech by MOS Zaqy Mohamad at BCA Awards Night (29 May 2019) and The Skyscraper Center (Website)

- Client: CapitaLand Commercial Trust; Mitsubishi Estate Company Ltd
- Main Contractor: Dragages Singapore Pte Ltd
- Main Driver(s) for DfMA MEP Adoption
 - CapitaLand's Commitment to Adopt the Latest Building Technologies for Productivity Gains
- Extent of DfMA for E&M Works
 - Prefabricated Modules, including:
 - Horizontal Modules
 - Vertical Riser Modules
 - Plantroom Modules
- Benefit(s) Expected
 - Productivity Improvement by around 50%
 - Better Coordination, Workmanship and Safety



Source of Image: The Skyscraper Center

MiC Projects in the UK



101 George Street, Croydon (Residential)
(44-Storey, 135m(H))



11 Mapleton Crescent, Wandsworth (Residential)
(23 Storeys, 89.2m(H))



Apex House, Wembley (Residential)
(23 Storeys, 75.3m(H))



Two-Fifty One, London (Residential-commercial)
(43 Storeys, 134.05m(H))



The Madison, London (Residential-commercial)
(53 Storeys, 184m(H))



Felda House, Wembley (Student accommodation)
(19 Storeys, 55m(H))

Source of Image: Internet

AECOM

Imagine it.
Delivered.

DfMA MEP Projects in the United Kingdom

Infrastructure and High-rise Building

Crossrail's Underground Train Stations



Vertical Riser Module at
Factory



Vertical Riser Module
during Installation



Horizontal Module

Two-Fifty One

(High-rise Residential-Commercial Complex)



13m (H) Prefabricated mechanical services
riser for residential floors



Extent of DfMA for MEP Works

- 13 Nos. Horizontal Modules
- 11 Nos. Vertical Riser Modules
- 11 Nos. Prefabricated Plantroom Skids
- 499 Nos. Bathroom Pods

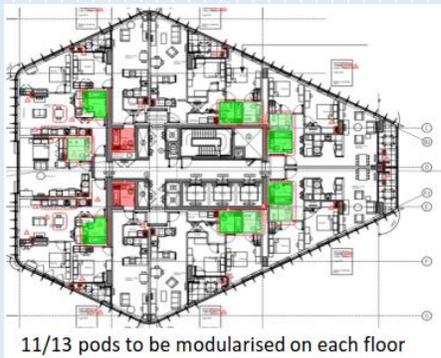
Source of Image:
Internet

DfMA MEP Projects in the United Kingdom

- **The Madison (High-rise Residential Building)**



MEP Panels



11/13 pods to be modularised on each floor



Bathroom Pod in Factory

Extent of DfMA for MEP

Prefabricated Modules, including:

- 482 nos. bathroom pods
- MEP Panels, comprising of Heat Interface Units (HIU), insulated water supply pipework, drainage pipework, MCB board and socket outlets

Image Source:
Balfour Beatty

- **Quadram Institute (Healthcare Facility)**



Horizontal MEP Module



Vertical MEP Module

Image Source: Internet
and Offsite Hub

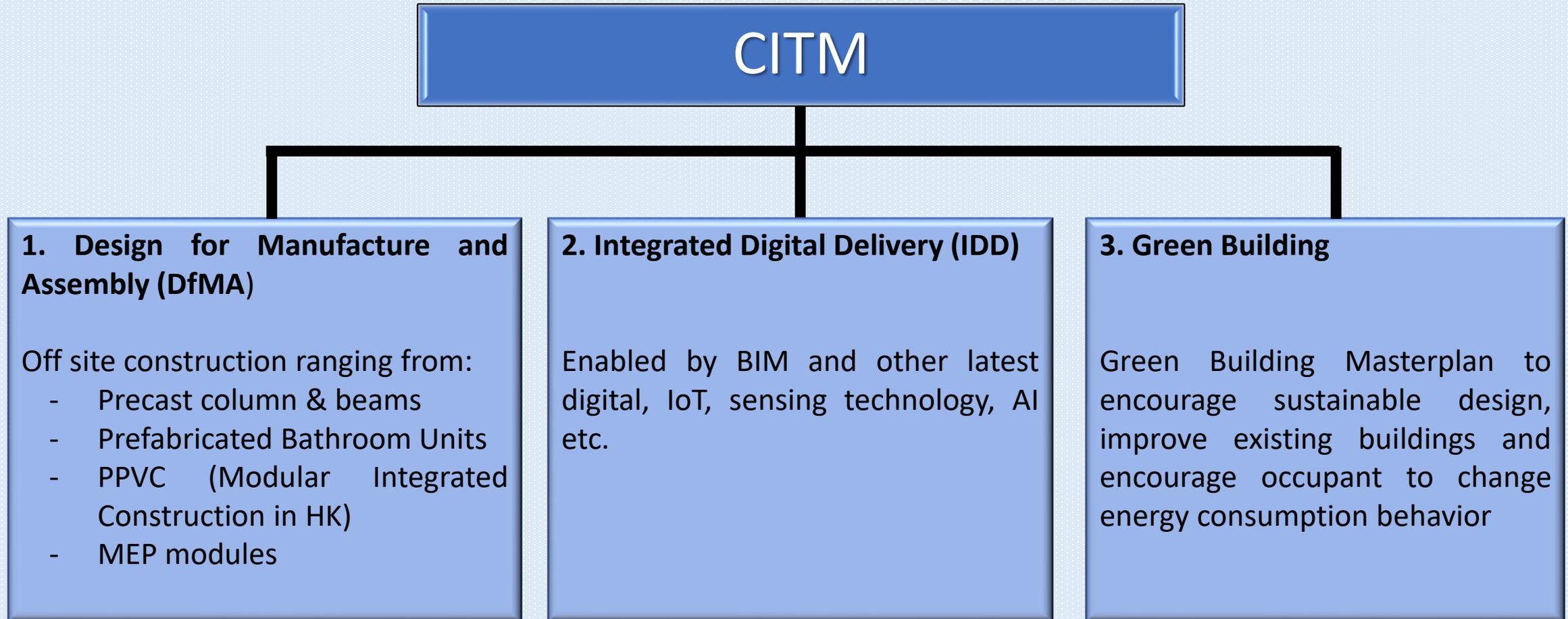
Extent of DfMA for MEP

217 Nos. Prefabricated Modules, including:

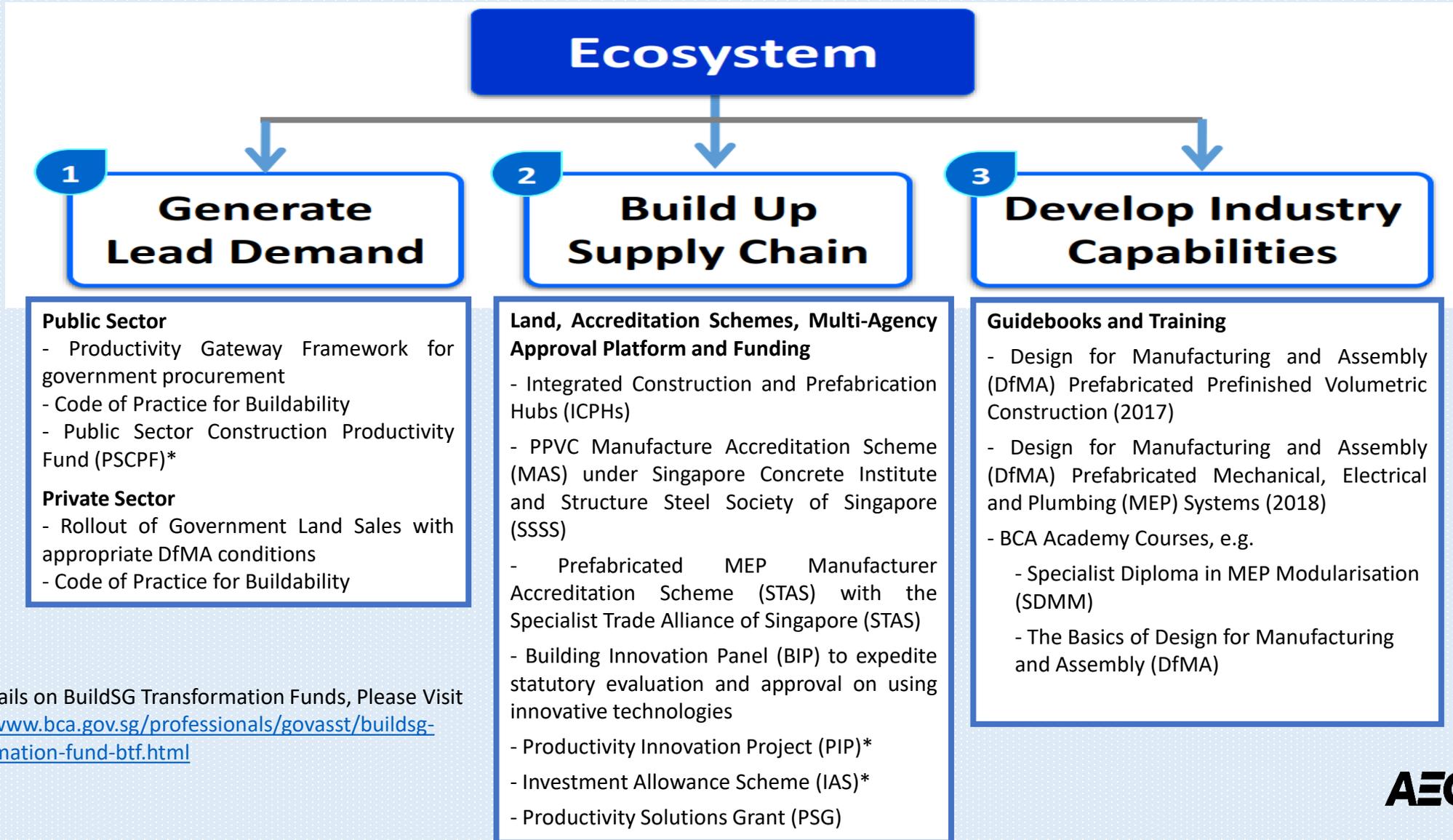
- 36 Nos. AHU valve arrangements
- 164 Nos. Horizontal Pipework and Electrical Containment Modules
- 6 Nos. Ductwork Risers (with Platforms, 4 floors in height)
- 4 Nos. Pipework Risers (Ditto)
- 3 Nos. Electrical Risers (Ditto)
- 4 Nos. Plantroom Pump Skids

Construction Industry Strategy for Singapore

Pillars for the Construction Industry Transformation Map (CITM)



Ecosystem for Supporting the CITM



Source of Image:
Building and
Construction
Authority

*For Details on BuildSG Transformation Funds, Please Visit <https://www.bca.gov.sg/professionals/govasst/buildsg-transformation-fund-btf.html>

Legislation Framework to Enhance DfMA

Buildability Score for Building/ Structural/ MEP DfMA Technologies (Table 3, COP on Buildability, 2017 Edition)

A1. First Class – Fully Integrated System	
A1.1 – A1.2	PPVC w/ and w/o PPVC MAS Accreditation
A2. 2nd Class (Upper) – Fully Integrated Sub-assemblies	
A2.1	Mass Engineered Timber
A2.2	Prefab Volumetric Construction
A2.3	Structural Steel w/ Innovative Connections
A2.4	Steel-MEP Floor System
A2.5 – A2.7	Prefinished Wall/ Ceiling/ Catwalk w/ MEP
A2.8(a) – A2.8(b)	Prefab Bathroom Units (PBU)
A3. 2nd Class (Lower) – Advanced Prefabricated Systems	
A3.1	Structural Steel
A3.2	Unitized Curtain Wall
A3.3 – A3.5	Prefinished Wall/ Slab/ Ceiling
A3.6	Prefab MEP Modules, e.g. Pipes, Trunking etc.
A3.7	Prefab MEP Plant Modules, e.g. Pumps etc.

A4. 3rd Class – Prefabricated Components	
A4.1	Integrated Precast Components c/w ≥ 2 Elements, e.g. Multi-tier Column/Wall, Double Bay Façade Wall)
A4.2	Precast External Wall w/ Cast-in Windows
A4.3 – A4.5	Mechanical Connection for Precast Column/ Precast Wall (Horizontal Joints), Precast Beam Joints & Precast Wall (Vertical Joints)
A4.6 – A4.8	Prefab Wall/Façade, Slab, Ceiling w/ Onsite Dry Applied Finishes
A4.9	Prefab & Pre-insulated Air Duct (Mandatory for All Projects)
A4.10 – A4.11	Flexible Sprinkler Dropper/ Water Pipes
A4.12	Common M&E bracket (at least 3 M&E services)

Note: DfMA for MEP Works items are highlighted in red.

Construction Industry Strategy for the United Kingdom

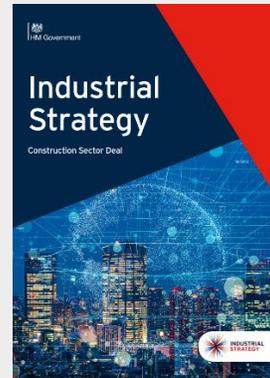
The Farmer Review of the UK Construction Labour Model (2016)



The Construction Sector Problems are:

- Low productivity
- Low predictability
- Structural fragmentation
- Leadership fragmentation
- Low margins, adversarial pricing models and financial fragility
- A dysfunctional training funding and delivery model
- An ageing workforce
- Lack of collaboration and improvement culture
- Lack of R&D and investment in innovation
- Poor industry image.

Construction Sector Deal (2018)



Three focuses for better productivity and performance:

- **Digital Techniques**
- **Offsite Manufacturing Techniques**
- **Whole Life Asset Performance**

Five foundations of the Industry Strategy :

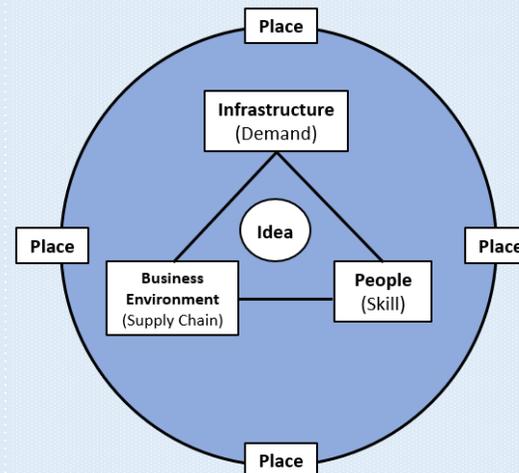
1. **Idea** – investment to innovate and accelerating in the development of digital and manufacturing-based approaches
2. **People** – reforming industry recruitment and training
3. **Infrastructure** – National Infrastructure and Construction Pipeline to support the government’s ambition
4. **Business environment** – developing a better procurement and sustainable business model
5. **Places** – working across the sector to strengthen the supply chain and skills base across the UK and extend to overseas

Autumn Budget 2017



The Chancellor of the Exchequer made the following commitment:

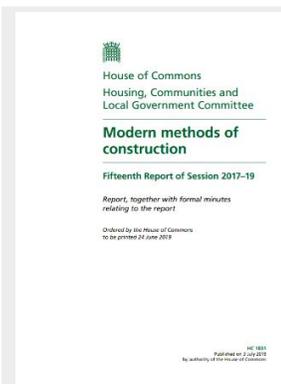
‘Building on progress made to date, the Department for Transport, the Department of Health, the Department for Education, the Ministry of Justice, and the Ministry of Defence will adopt **a presumption in favour of off-site construction** by 2019 across suitable capital programmes, where it represents best value for money.’



Relationship between the five foundations

Construction Industry Strategy for the United Kingdom

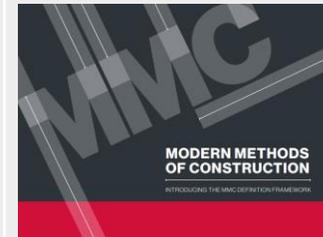
Housing, Communities and Local Government Select Committee Report on: Modern Methods of Construction (July 2019)



Overcome the housing shortage problem by Modern Methods of Construction (MMC) through:

- Supporting the pipeline
- Access to finance
- Encouraging lending and managing risk
- Planning
- Expanding the evidence base
- Supporting local authorities in housebuilding
- Support for affordable housing
- Improving access to land
- Improving skills provision

Modern Methods of Construction: Introducing the MMC Definition Framework (2019)



The MMC Definition Framework helps evaluate the different ways of increasing the 'Pre-Manufactured Value' (PMV):

Category 1 – Pre-Manufacturing - 3D primary structural systems

Category 2 – Pre-Manufacturing - 2D primary structural systems

Category 3 – Pre-Manufacturing - Non systemised structural components

Category 4 – Pre-Manufacturing - Additive Manufacturing

Category 5 – Pre-Manufacturing – Non-structural assemblies and sub-assemblies, including MEP items such as utility cupboards, risers, plant room as well as pre-formed wiring looms and mechanical engineering components

Category 6 – Traditional building product led site labour reduction/productivity improvements

Category 7 – Site process led labour reduction/productivity improvements

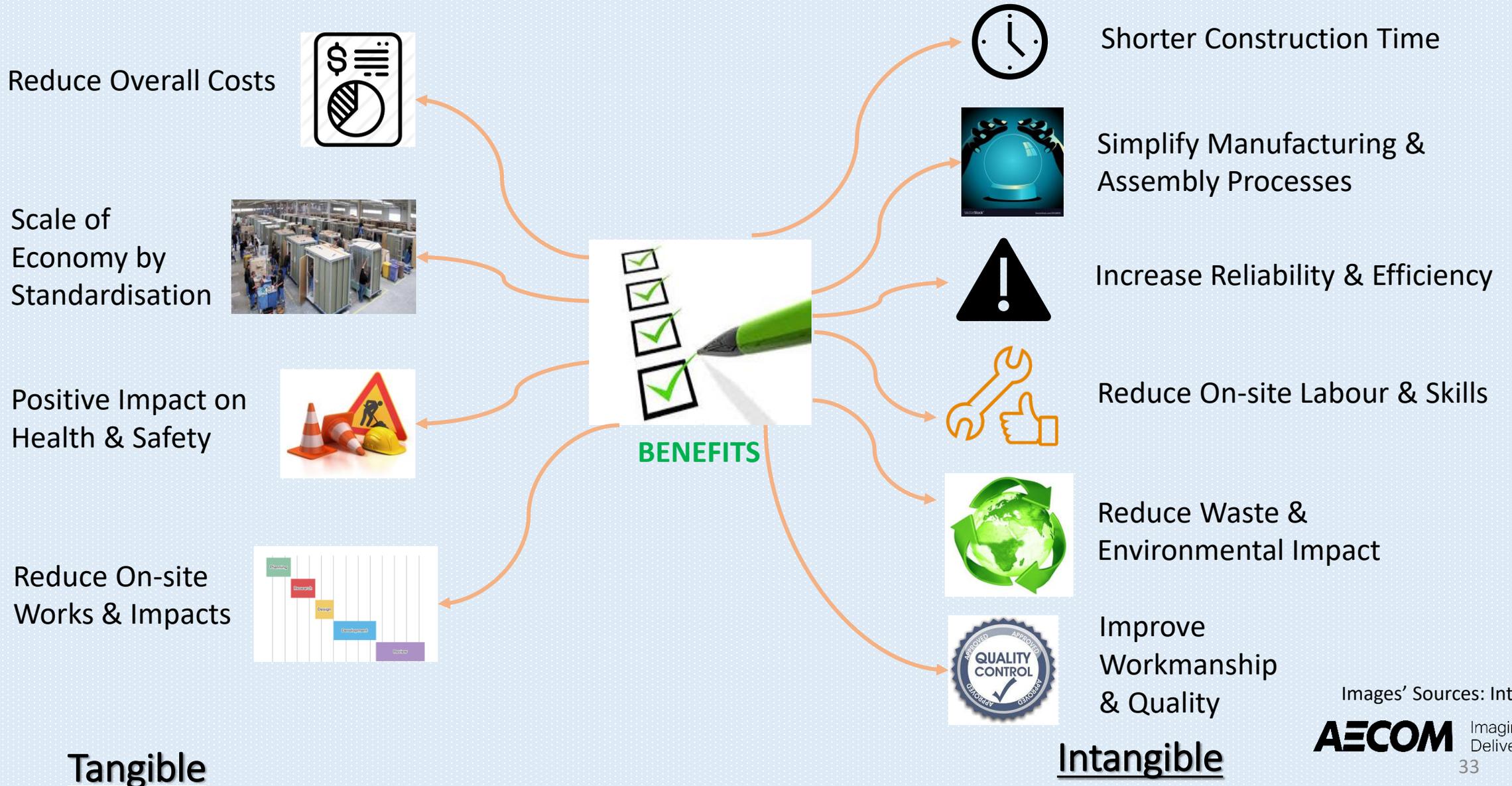
HELP Us to Find Answers for Hong Kong

- Road Map for Hong Kong Construction Transformation?
- Ecosystem?

Survey Questionnaire

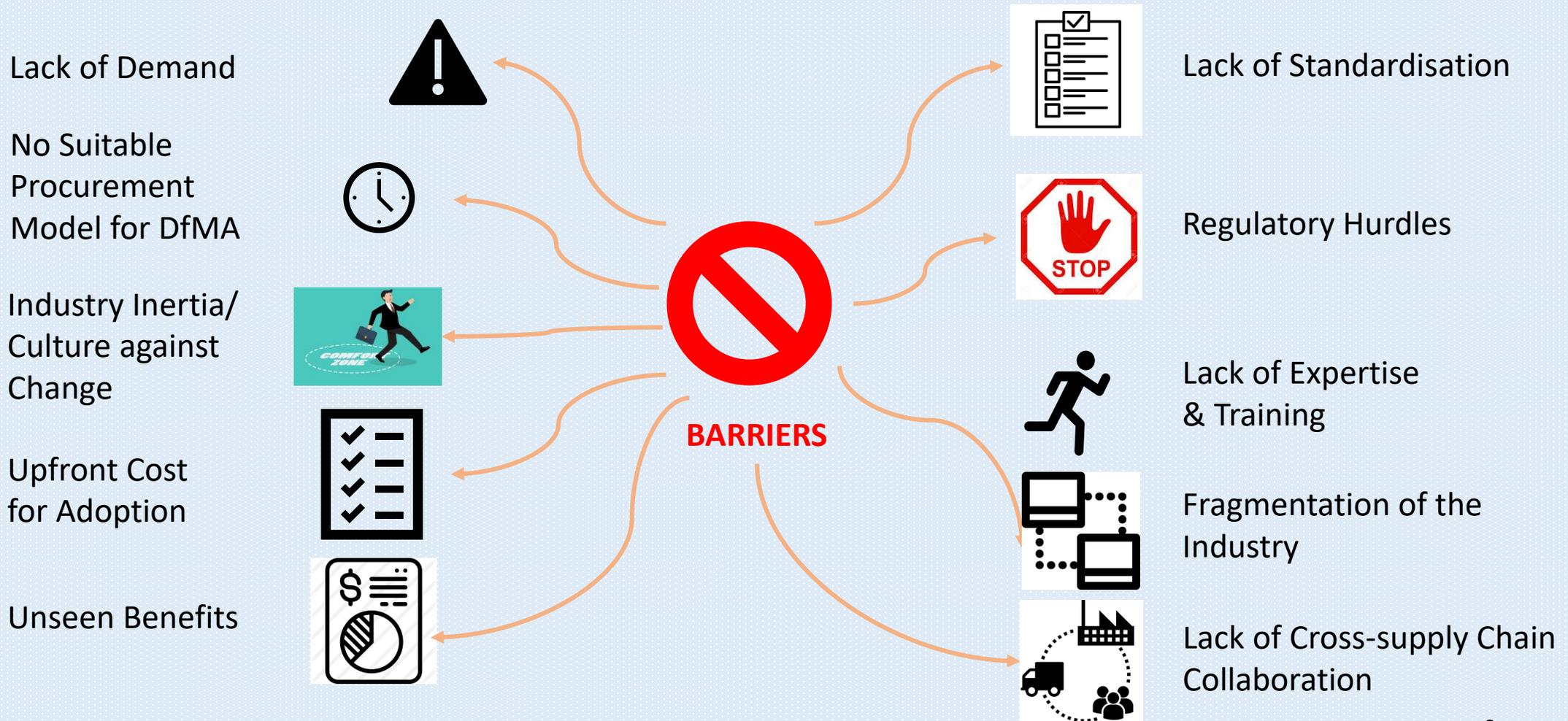
1. Profile of the Respondent
2. Knowledge Level of DfMA
3. Barriers and Opportunities for DfMA in MEP Works
4. Strategies and Supporting Measures for DfMA in MEP Works

Your View on the Benefits of DfMA Adoption



Images' Sources: Internet

Your View on the Barriers Affecting DfMA Adoption



Economical and Societal

Technical and Resources

Source of Images: Internet

How to Respond to this Survey?

- Please help fill in the Questionnaire at the Google Forms link below:
 - <https://forms.gle/CuHhjs7Bh5rjsCBI6>
- For enquiries, please contact Mr. Civic Ip at
 - Phone: 3922 8478
 - Email: Civic.ip@aecom.com

**THANK
YOU!**