Important Note

All materials in these slides are for the purposes of the conference only and NOT meant for any other purposes. If you wish to use the materials for any other purposes, please seek the consent of the Building and Construction Authority (BCA).

SINGAPORE'S CONSTRUCTION PRODUCTIVITY JOURNEY

Hugh Lim
CEO, Building and Construction Authority (BCA), Singapore

Building and Construction Authority

We shape a safe high quality sustainable and friendly built environment.

SCOPE OF PRESENTATION

i. Singapore's Construction Productivity Journey

ii. Design for Manufacturing and Assembly (DfMA)

iii. Integrated Digital Delivery (IDD)

iv. The Way Forward

Singapore's Construction Industry is Transforming

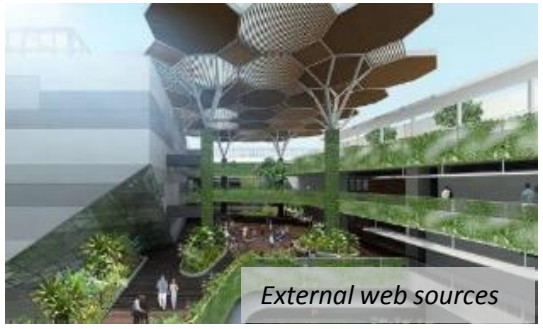
Key Trends driving our transformation

Greater **Urbanisation** and Increasing **Manpower Squeeze**

- Need to adopt more **advanced construction technologies (e.g. DfMA)**

Gearing towards **Digital Revolution**

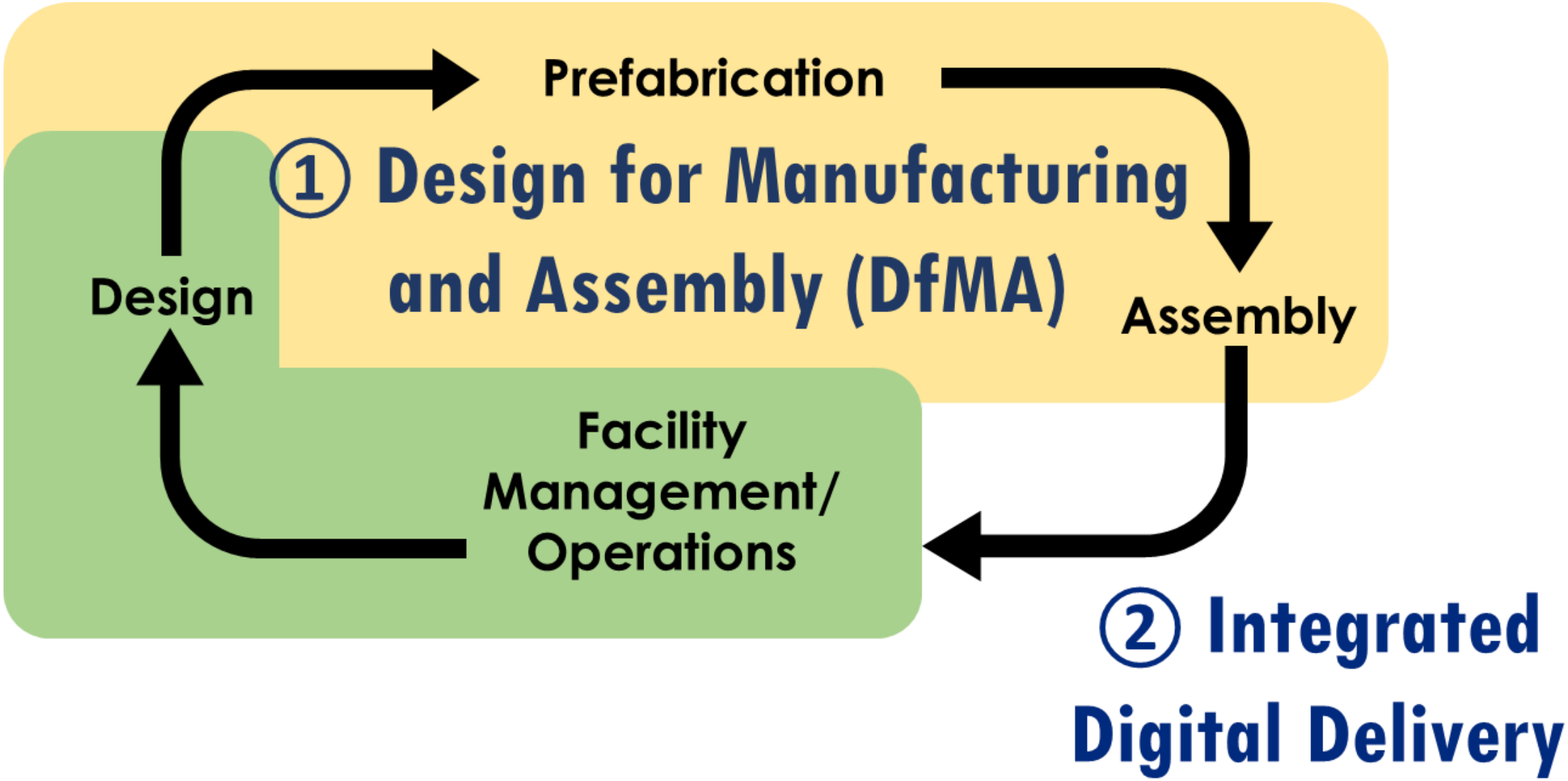
- **Integrated Digital Delivery (IDD)** as key enabler of DfMA adoption



Dealing with **Climate Change**

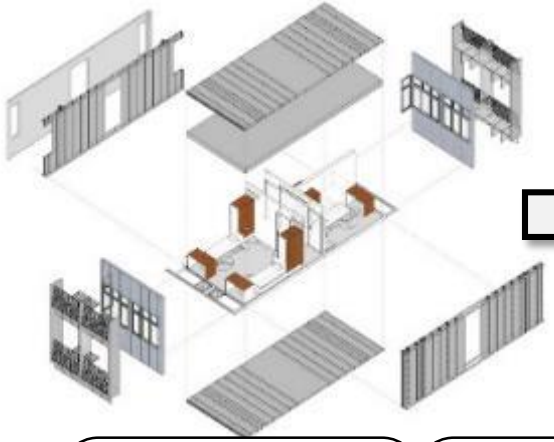
- Greater focus on **sustainable construction practices**

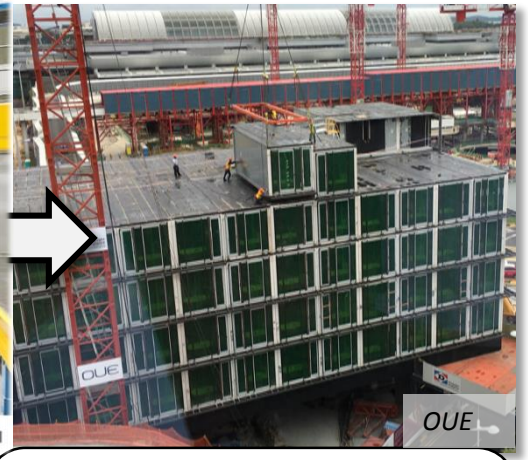
Singapore's Construction Industry Transformation Map (ITM)



Design for Manufacturing and Assembly

DfMA | Digital Engineering





Design **f**or **M**anufacturing **(off-site and automation)** and **A**ssembly **(on-site)**

Moving work offsite will improve productivity in 3 ways

- ***Controlled*** factory environment
- Greater scope for ***automation***
- Options for ***offshoring***

✓ Adopting Prefabrication
  - ***Modular Design***

DfMA Changes the Way We Build

DfMA | Digital Engineering

Continuum of DfMA technology

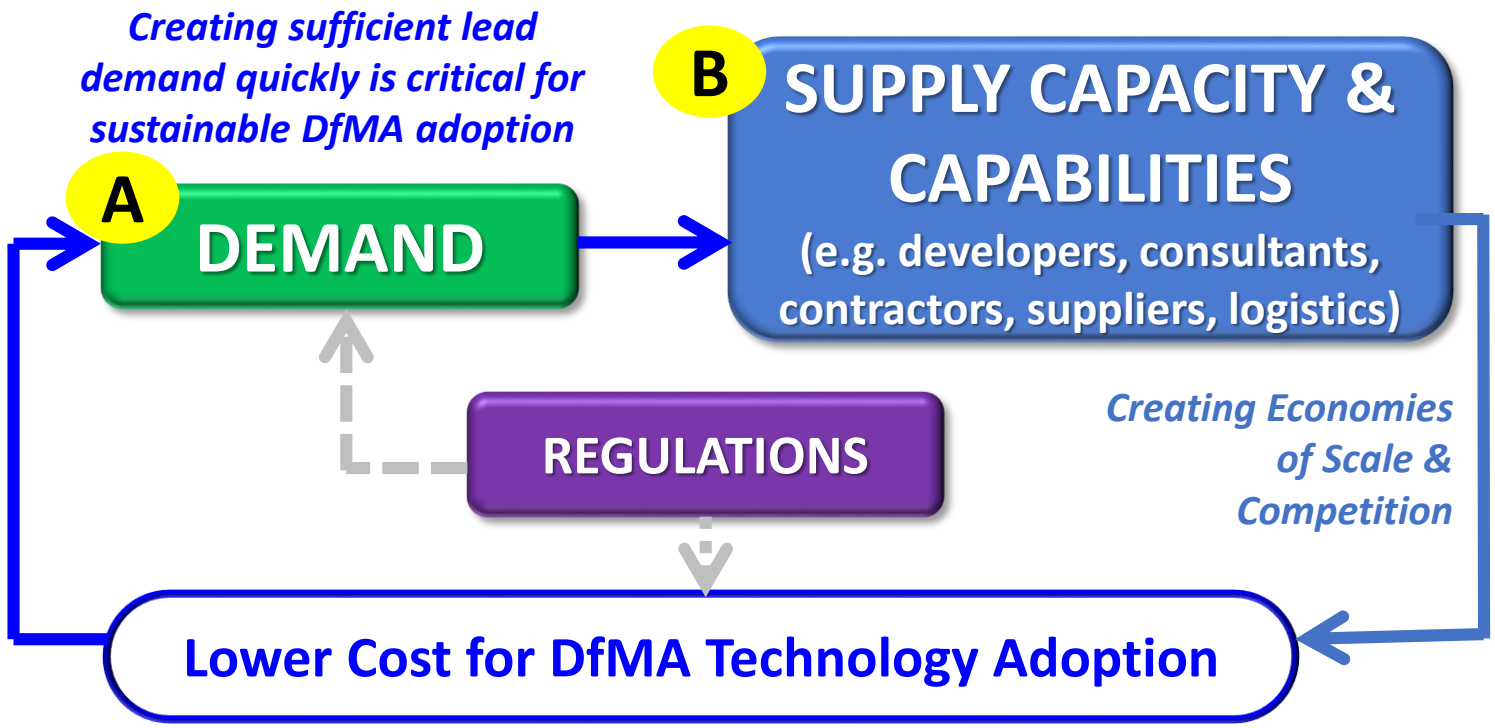
Components: Incremental Improvement… → **…Integrated Assemblies: Game-Changing Improvement**

	Prefab components	Advanced Prefab Systems	Integrated Sub-assemblies	Fully-integrated Integrated Assemblies
Structural	 Precast	 Structural Steel / Advanced Precast / Hybrid	 Mass Engineered Timber (MET)	 Prefabricated Prefinished Volumetric Construction (PPVC) 40%
Architectural	 On-site Dry Applied Finishes	 Prefinished Surfaces	 PBUs	 PPVC
MEP	 Flexible Water Pipe/ Sprinkler Dropper	 Prefab Ceiling Module/ Prefab Plant	 Prefab Module with Platform/ Catwalk	 PPVC

Establishing a Robust DfMA Ecosystem

Key Objectives:

1. ***Increase adoption*** to improve productivity
2. ***Reduce cost premium*** for sustained adoption
3. ***Sufficient capacity and capabilities*** to support adoption



Key Strategies:

- **A** Build sustained demand
- **B** Build supply capacity & capabilities

Creating Lead Demand for DfMA

A DEMAND

Taking the lead - Public sector projects adopting DfMA

Prefabricated Prefinished Volumetric Construction

- **16 projects**

  (4 completed , 12 on-going)

Prefabricated Mechanical, Electrical and Plumbing

- **2 projects**

  (on-going)

9 upcoming projects

Mass Engineered Timber

- **11 projects**

  (3 completed , 8 on-going)

Structural Steel

- **11 projects**

  (2 completed , 9 on-going)

Creating Lead Demand for DfMA

A DEMAND

Public sector taking the lead, in close collaboration with industry

Championing productive technology adoption and processes

DfMA Technology

Integrated BIM

Procurement Methods

Advisory panel of industry experts for DfMA projects

DfMA project implementation

Creating Lead Demand for DfMA

A DEMAND

Government Land Sale (GLS) Sites

Specifying DfMA technology adoption

Total number of sites to date

PPVC

20 residential GLS sites

Structural Steel

2 commercial GLS sites

Productivity Outcomes

1 residential GLS site

Pilot Concept & Price tender approach

More sites to be launched

Private developments

Voluntary DfMA technology adoption

PPVC hotel

Crowne Plaza Extension

PPVC residential

Brownstone

MET

Singapore Sustainability Academy

Funding support for voluntary DfMA adoption by private sector

Note:
PPVC – Prefabricated and Pre-finished Volumetric Construction
MET – Mass Engineered Timber

Competent Suppliers

B SUPPLY CAPABILITIES

Accredited suppliers listed on BCA's website

Building Innovation Panel (BIP)

- Ensuring *design* complies with regulatory requirements

PPVC Manufacturer Accreditation Scheme (MAS)

- Ensuring high *quality* in PPVC production

Suppliers Capabilities Established

B SUPPLY

Highly automated facilities for production, quality ensured

- ✓ Multi-storey prefabrication hubs with automation and mechanization
- ✓ Improved quality control in factory production
- ✓ Considerably reduce labour usage on-site for higher productivity

More will complete in the next 3 years

Courtesy of: GREYFORM

Automated Steel Reinforcement Fabrication

Courtesy of: GREYFORM

Automated Pallet Circulation Plant

Teambuild

Soilbuild

Competent Suppliers

DfMA | Digital Engineering

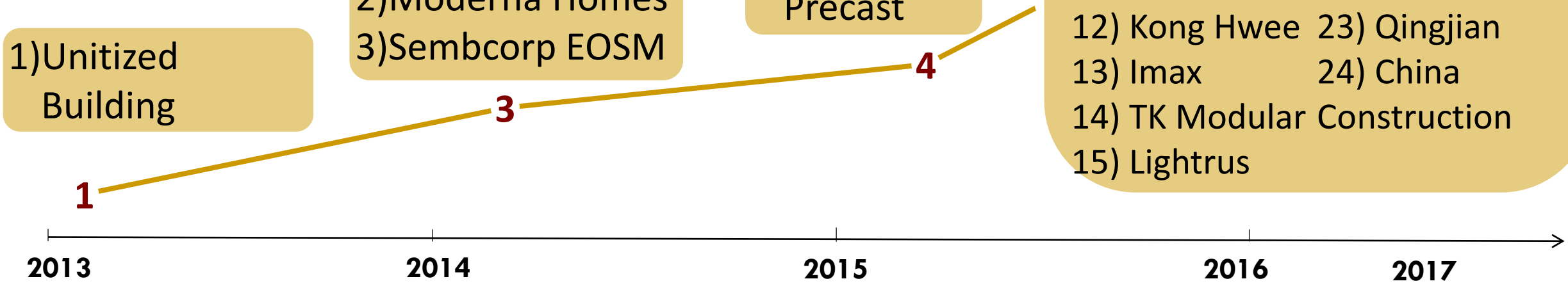
24 SUPPLIERS ***(Through Building Innovation Panel)***

Steel PPVC	Concrete PPVC
5) AM Modular	16) SPP System
6) CIMC	17) Excel Precast
7) Tiong Seng	18) Vico
8) Dragages	19) Dragages
9) Mod Prefab	20) Mod Prefab
10) TTJ	21) Prefab Tech
11) Quicksmart	22) CS Corp
12) Kong Hwee	23) Qingjian
13) Imax	24) China Construction
14) TK Modular	
15) Lightrus	

1) Unitized Building

2) Moderna Homes
3) Sembcorp EOSM

4) Integrated Precast



PPVC – Most Promising DfMA Technology

DfMA | Digital Engineering

PPVC yields significant productivity improvement

Components: Incremental Improvement…

…Integrated Assemblies: Game-Changing Improvement

	Prefab components	Advanced Prefab Systems	Integrated Sub-assemblies	Fully-integrated Integrated Assemblies
Structural	 Precast	 Structural Steel / Advanced Precast / Hybrid	 Mass Engineered Timber (MET)	 Prefabricated Prefinished Volumetric Construction (PPVC) 40%
Architectural	 On-site Dry Applied Finishes	 Prefinished Surfaces	 PBUs	 PPVC
MEP	 Flexible Water Pipe/ Sprinkler Dropper	 Prefab Ceiling Module/ Prefab Plant	 Prefab Module with Platform/ Catwalk	 PPVC

Prefabricated Prefinished Volumetric Construction (PPVC)

DfMA | Digital Engineering

What is PPVC?

1. Modules manufactured, fitted out in Factory

2. Transport to site

3. Easy Installation on-site

Courtesy of: Moderna Homes

Courtesy of: Teambuild

Courtesy of: OUE

Completed PPVC Unit

DfMA | Digital Engineering

No different from conventional construction, but better quality finishes

Living Room

Kitchen View From Living

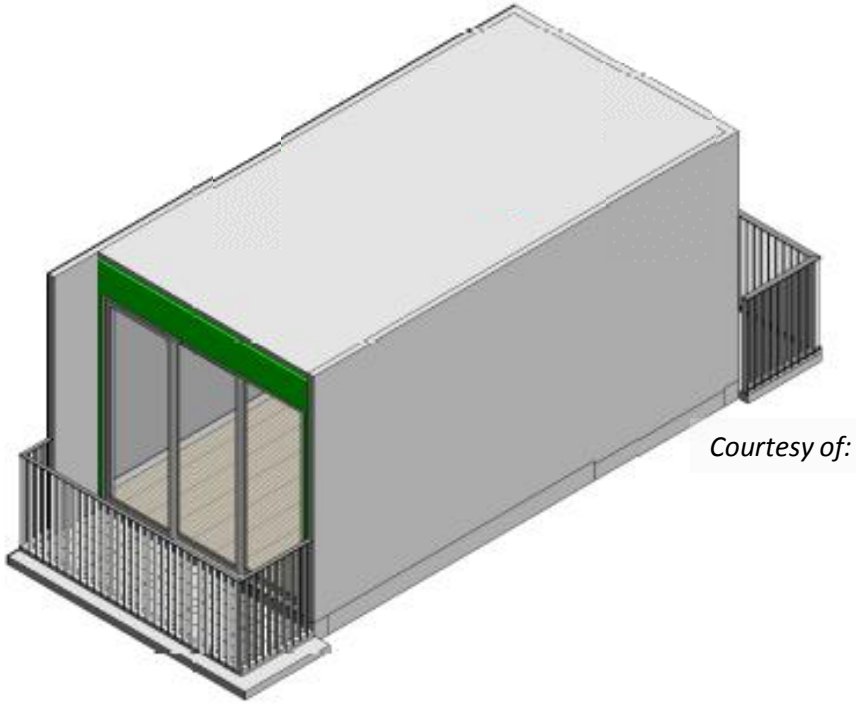
Kitchen

Common Area Within Unit

Bedroom

Bathroom

Types of PPVC

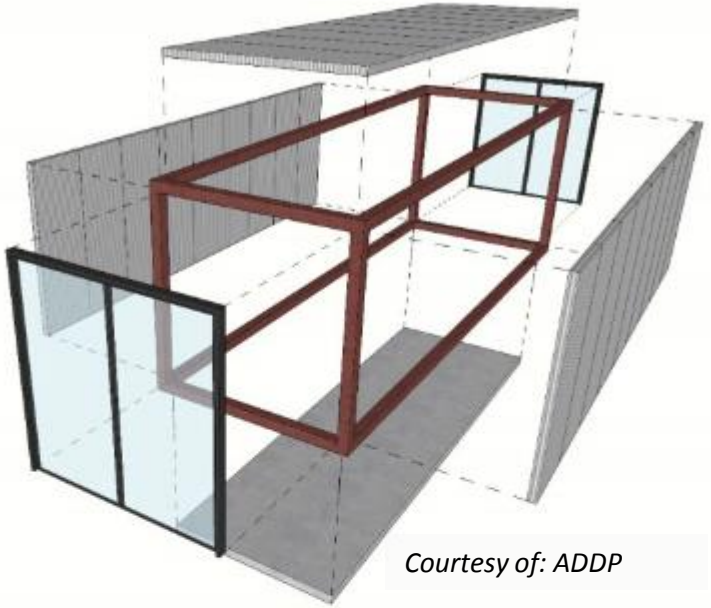


Courtesy of: ADDP

1

REINFORCED CONCRETE PPVC MODULE

Wall: Concrete
Floor: Concrete



Courtesy of: ADDP

2

STEEL PPVC MODULE

Wall: Steel frame with lightweight walls
Floor: Concrete or Lightweight Flooring System

Singapore PPVC Projects

DfMA | Digital Engineering

Wide range of project types done in PPVC

PPVC

- **31** projects

  (6 completed , 25 on-going)

Development types:

Hostel, Nursing Home, Hotel, Dormitory and Residential

Residential

Photo: CDL

10-Storey Brownstone Executive Condo

Photo: Moderna

12-Storey Wisteria Commercial & Condo

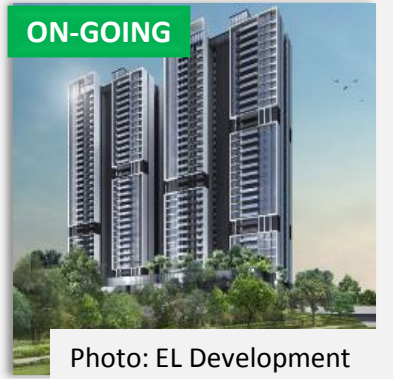


Photo: EL Development

36-Storey Parc Riviera Condo

Photo: UOL

40-Storey Clement Canopy Condo

Hostel

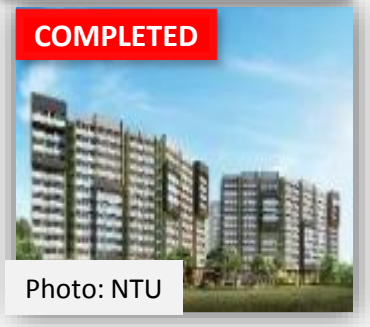


Photo: NTU

13-Storey NTU Hostel

Dormitory

Photo: JTC

9-Storey Dormitory JTC Space @ Tuas

Nursing Home

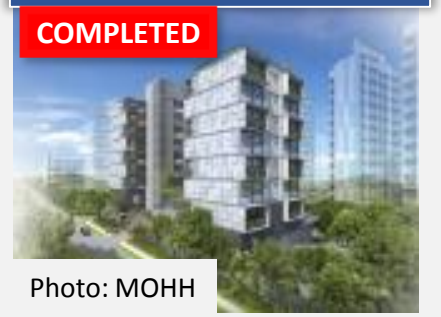


Photo: MOHH

9-Storey Woodlands Nursing Home

Hotel

Photo: OUE

10-Storey Crowne Plaza Hotel Extension

Case Study 1

Teambuild - A PPVC Pioneer in Singapore

West Terra, Public Housing

Courtesy of: HDB

15% manpower savings

2013 2014

The Brownstone, Executive Condo

Courtesy of: CDL

20% manpower savings

2015 2016

Valley spring, Public Housing

Courtesy of: HDB

Construction in progress

2017

Parc Riviera, 36 storey condo

Courtesy of: EL Development

Construction in progress

2018

Gen 1

Courtesy of: Teambuild

Minimal finishes, incomplete modules, with extensive wet joints

Gen 2

Courtesy of: Teambuild

Greater modularization with less wet joints, but still minimal finishes and no floor slab

Gen 3

Courtesy of: Teambuild

Complete 6-sided, ***fully prefinished*** modules

Case Study 2

Crowne Plaza Airport Hotel Extension

DfMA | Digital Engineering

- Made possible by a strong project team, comprising architect, engineer, contractor and fabricator

Developer:
OUE Airport Hotel Pte Ltd
Architect:
WOHA Architects Pte Ltd
Structural Engineer:
RSP Architects & Planners Pte Ltd
M&E Engineer:
Surbana International Consultants Pte Ltd
Main Contractor:
Dragages Singapore Pte Ltd
PPVC Supplier:
Unitised Building Consulting (Aust) Pty

6 months time savings, 44% manpower savings

STEEL PPVC

Case Study 3

Industry Breakthroughs in PPVC

DfMA | Digital Engineering

- PPVC for high-rise developments

Clement Canopy Condominium

40-storey condominium
(World's tallest concrete PPVC building)

Developer:
Singland Homes & UOL Venture Investments
Architect:
ADDP Architects LLP
Structural Engineer:
Tham & Wong LLP
M&E Engineer:
J Roger Preston (S) Pte Ltd
Main Contractor:
Dragages Singapore Pte Ltd
PPVC Supplier:
Dragages Singapore Pte Ltd

Case Study 3

Industry Capabilities developed in PPVC

PPVC Video

Clement Canopy Condominium

Modularisation

Offsite fabrication

Courtesy of: Dragages

Courtesy of: Dragages

Onsite Assembly

Courtesy of: Dragages

Case Study 4

Industry breakthroughs in PPVC

DfMA | Digital Engineering

Designing open-concept PPVC systems

Consultants design capabilities made open-concept PPVC design possible

Woodlands Nursing Home

3 months time savings,
24% manpower savings

Courtesy of: MOHH

STEEL PPVC

Developer:
MOH Holdings Pte Ltd (MOHH)
Architect, Structural Engineer, M&E:
Surbana International Consultants
Main Contractor:
Dragages Singapore Pte Ltd
PPVC Supplier:
Dragages Singapore Pte Ltd

JTC Space @ Tuas

16%
manpower savings

Courtesy of: JTC

STEEL PPVC

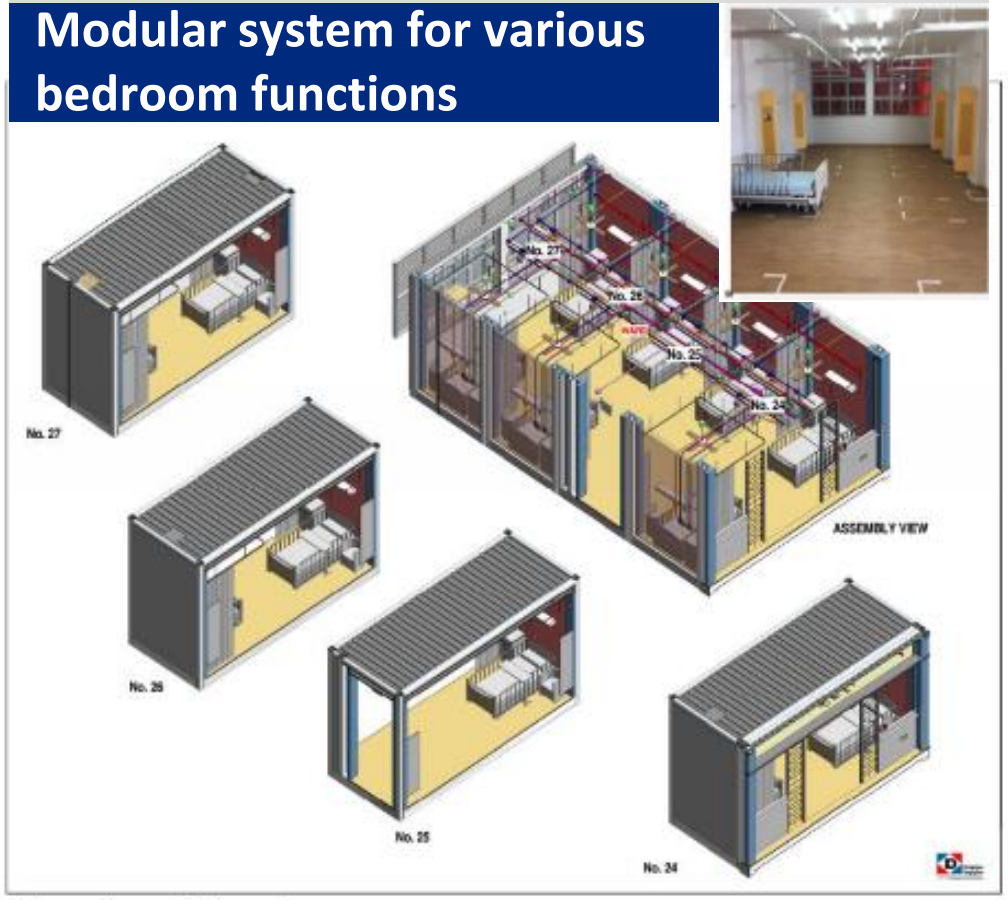
Developer:
JTC Corporation
Architect:
SAA Architects Pte Ltd
Structural Engineer:
Aecom Singapore Pte Ltd
Main Contractor:
Tiong Seng Contractors Pte Ltd
PPVC Supplier:
Tiong Seng Contractors Pte Ltd

Case Study 4

Open concept PPVC systems

Woodlands Nursing Home

Modular system for various bedroom functions



Typical Bedroom

Courtesy of: Dragages

JTC Space @ Tuas (Dormitory)

Modular Layout

Courtesy of: Tiong Seng

PPVC projects achieving variety of building forms

- With capable architects on board, creative building features can be achieved

Overseas PPVC Projects

Habitat 67, Canada (Residential)

By Arch Moshe Safdie

Courtesy of: Habitat 67

12 STOREYS

Victoria Hall, London

Courtesy of: Victoria Hall

19 STOREYS

Singapore PPVC Projects

Crowne Plaza Hotel Extension

Courtesy of: OUE

10 STOREYS

Wisteria Condominium

Courtesy of: Moderna Homes

Mixed residential and commercial

12 STOREYS

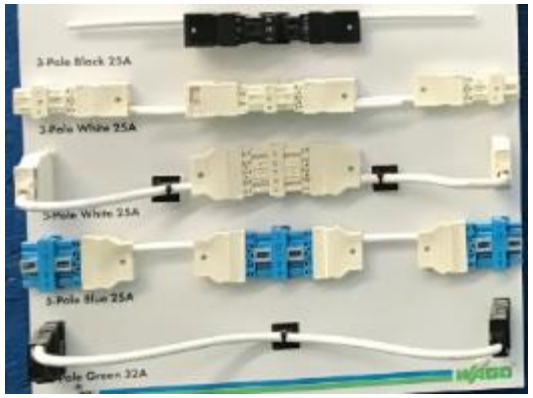
Prefab Mechanical, Electrical and Plumbing (MEP) Systems

Components:
Incremental Improvement…

…Integrated Assemblies:
Game-Changing Improvement

Prefab Components

Pre-insulated plastic piping



Sub-assemblies

Include MEP services only

Prefab horizontal services / vertical riser modules

Integrate with architectural/ structural components

Prefab horizontal module with ceiling board

Prefab vertical riser module with catwalk

Integrated Assemblies MEP PPVC

Complete assembly

Prefab plant room

Benefits of Prefab MEP Systems

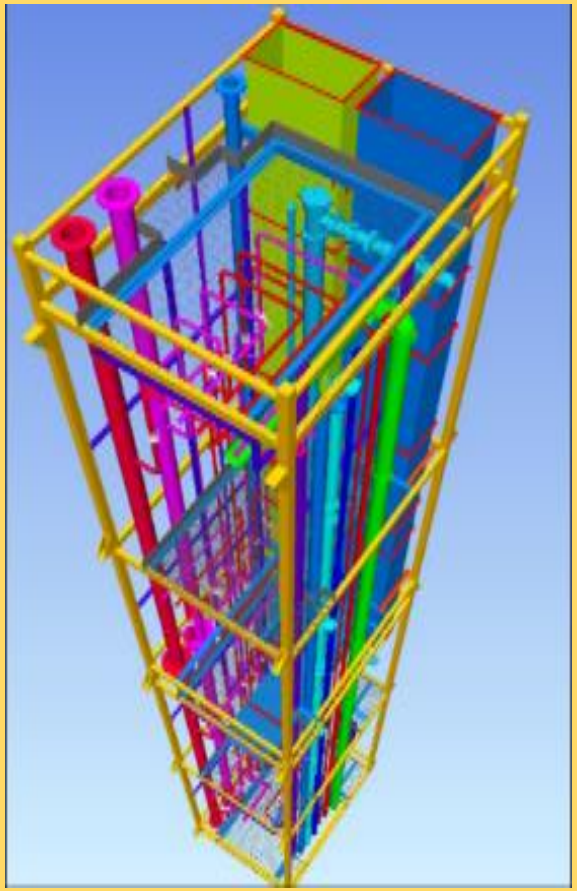
Better Health and Safety

Neat and tidy factory

Photograph courtesy by DSG Modular, Newcastle, England, UK

Improved Quality and Productivity

Upfront detailed design



Working in a factory environment and at ground level improve productivity

Photograph courtesy by Crown House Manufacturing

Easy to install (lifting one subassembly instead of multiple ducts, pipes, etc.)

Case Study - Global Switch Data Centre

Up to 70% productivity improvement

Developer:
Global Switch Singapore

Architect:
AWP

M&E Engineer:
Aurecon

Main Contractor:
Gammon

MEP Module Supplier:
Gammon

Project Period:
October 2017 – November 2018

Adopted Prefab MEP Systems

- Horizontal module
- Roof cooling tower modules
- Riser modules
- Plant room modules
- External modules with catwalk

Enhanced Collaboration through Digital Engineering

DfMA | Digital Engineering

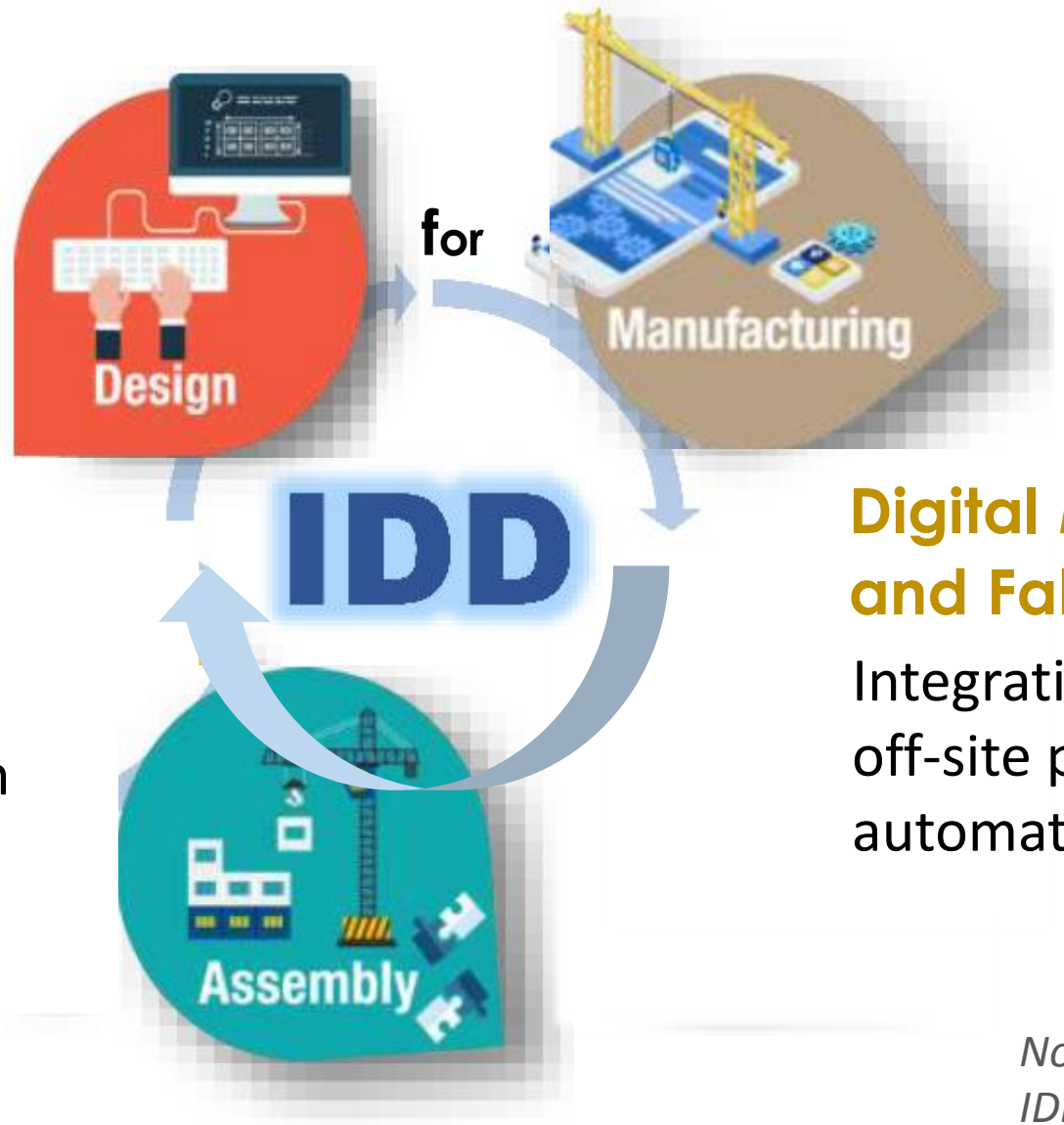
Championing of DfMA is supported by Digital Engineering

Digital Design

Collaborative and coordinated DfMA design using BIM/VDC or other computational tools

Digital Assembly

Using real–time Info-Comm Technology (ICT) to deliver and install on-site



Digital Manufacturing and Fabrication

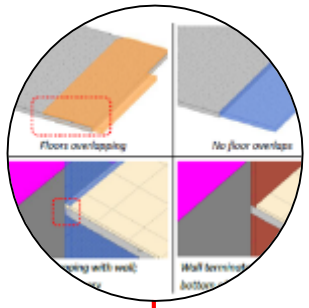
Integration of BIM/VDC for off-site production through automation, robotics

Note:
IDD – Integrated Digital Delivery

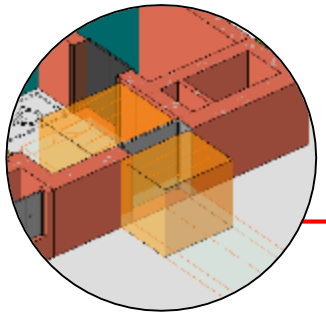
Digital Design - components

DfMA | Digital Engineering

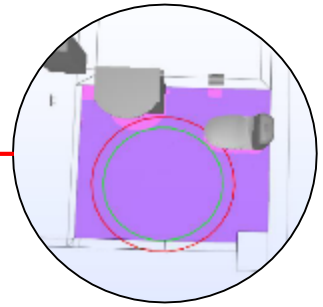
AR-VR



BIM Quality Checks

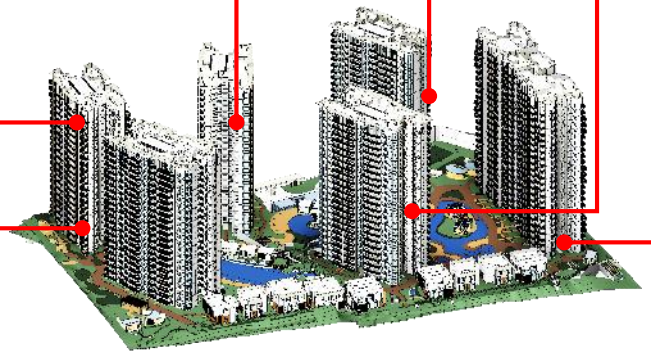


Use of Intelligent Objects

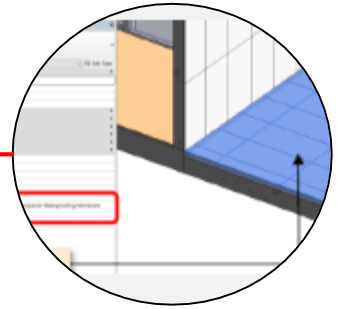


Automated Code Compliance Checker

Computational & Rule-based design



DESIGN BIM MODEL



Tender Release & Handover

Digital manufacturing and fabrication - components

DfMA | Digital Engineering

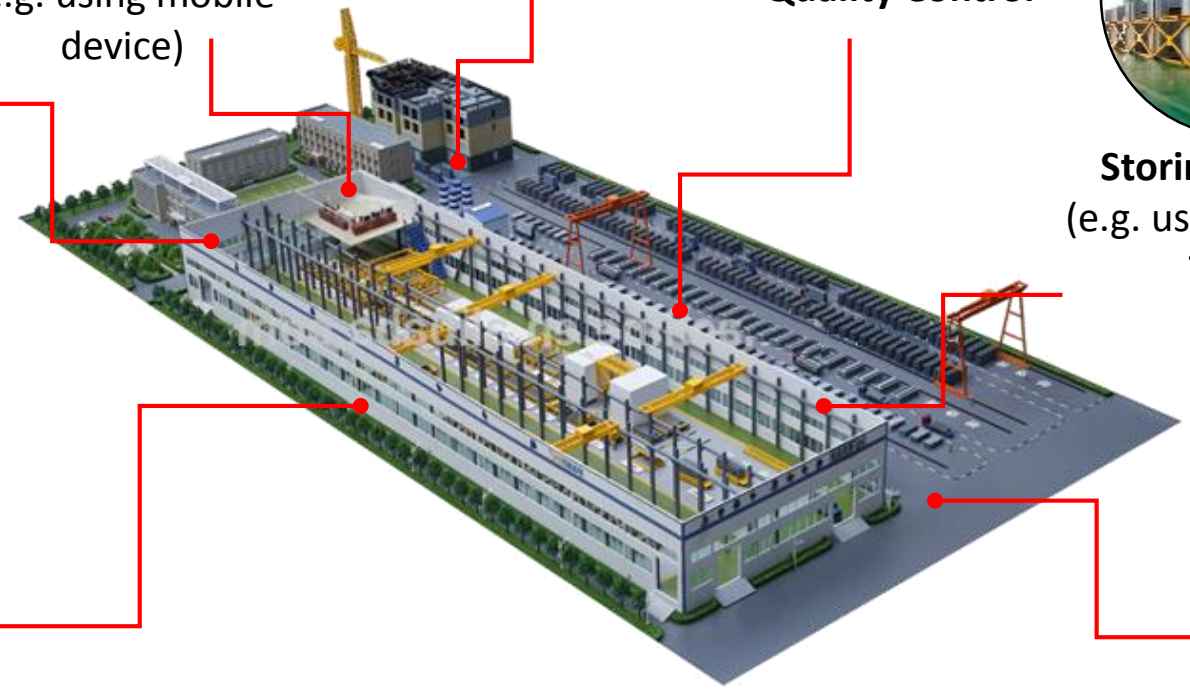
Production Management System
(e.g. from BIM to machinery)

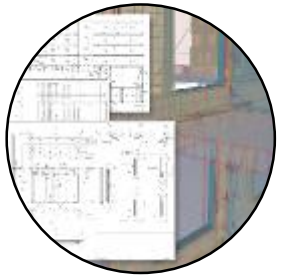
BIM to Shop Floor
(e.g. using mobile device)

Robotics installation

Quality Control

Storing & Tagging
(e.g. using RFID linked To BIM)





Fabrication Model Creation
(e.g. Detailing & BBS)

Delivery
(e.g. Fleet Tracking)

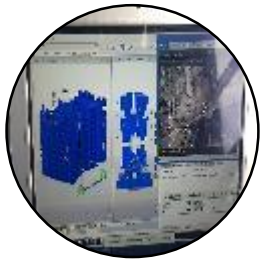
Digital Construction and Assembly - components

DfMA | Digital Engineering

Equipment Tracking
(e.g. using GPS)

Material Tracking
(e.g. using RFID)

Site Progress Tracking & Inspection
(e.g. using drone)



Smart Installation
(e.g. smart crane & robotics)

Site Safety & Security
(e.g. using video analytics)

Lean Construction

ICE Meeting Session

Project Management Command Centre

Construction BIM model

Field BIM
(e.g. using BIM for layout)

Manpower Tracking
(e.g. using wearable)

Site Data Monitoring & Submission
(e.g. Silt Detection System)

An IDD Scenario

Design

Architect uses BIM to generate design options

Engineers perform analysis

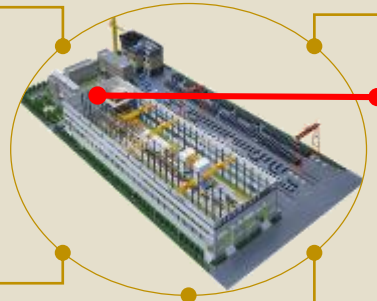
Contractor, Fabricator give early input on constructability

Developer use VR tool to visualise building

Manufacturing

Fabricator uses digital DfMA model for production

Supervisor monitors activities in central control room



Digital data and robotics to drive machinery

Digital IDs embedded in DfMA modules

DfMA modules delivered just-in-time to site

Assembly

Contractor uses BIM to plan construction

Contractor uses BIM-to-Field technology for setting out

PM monitors site using drones

Crane Operator operates smart crane

IDD Platform: Data Storage, Data Exchange, Data Processing, Data Mining, Analytics Engine/Machine Learning

Where to next?

CHANGING THE WAY WE BUILD

DfMA

More projects to adopt DfMA

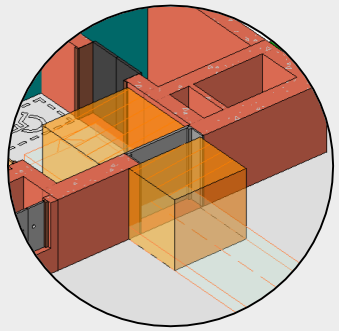
From conventional construction..

..to offsite manufacturing

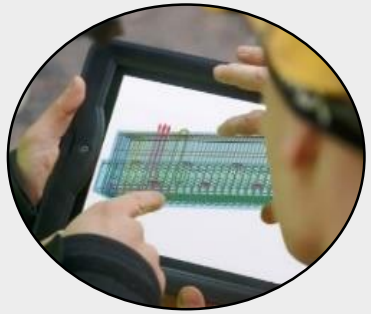
and onsite assembly

IDD

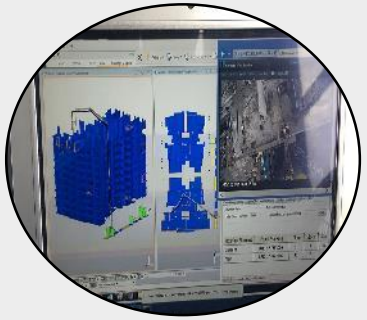
Pilot adoption of IDD



Digital Design



Digital Manufacturing



Digital Assembly

Developing full suite of digital solutions and capabilities

Collaboration

Require close Partnership & Collaboration among Stakeholders

Thank You