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# Systems Integration in Digitally Enabled Modular Building

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## Background Digitally Enabled Modular Building

1. Change the location of activities
2. Fabricate modules in factory conditions and then assembled on the construction site
3. Transforming Construction
4. Platform-based design

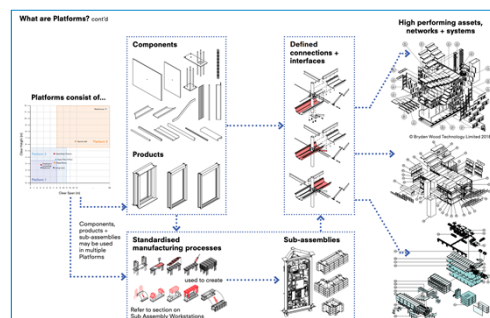


Figure 1: Digitally enabled modular building (Bryden Wood & University of Cambridge Centre for Digital Build Britain, 2018)

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## Background

### System Integration in Supply Chain

Ragatz et al. (1997) noted that the 'effective integration of suppliers into product value/support chains will be a key factor for some manufactures in achieving the improvements necessary to remain competitive'

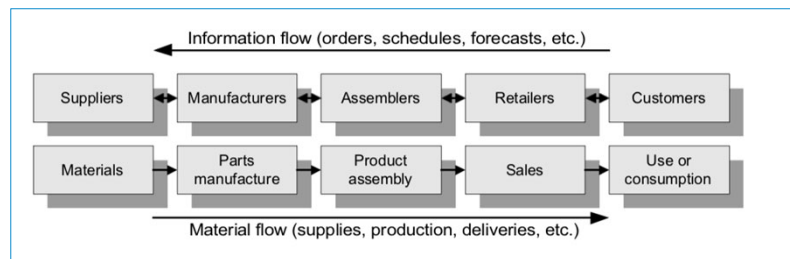


Figure 2: System integration in supply chain (Vrijhoof & Koskela, 2000)

Vrijhoof, R. & Koskela, L.J. (2000) the four roles of supply chain management in construction  
Ragatz, G.L., Handfield, R.B. & Scannell, T.V. (1997) Success factors for integrating suppliers into new product development. Journal of Product Innovation Management, 14, 188-208

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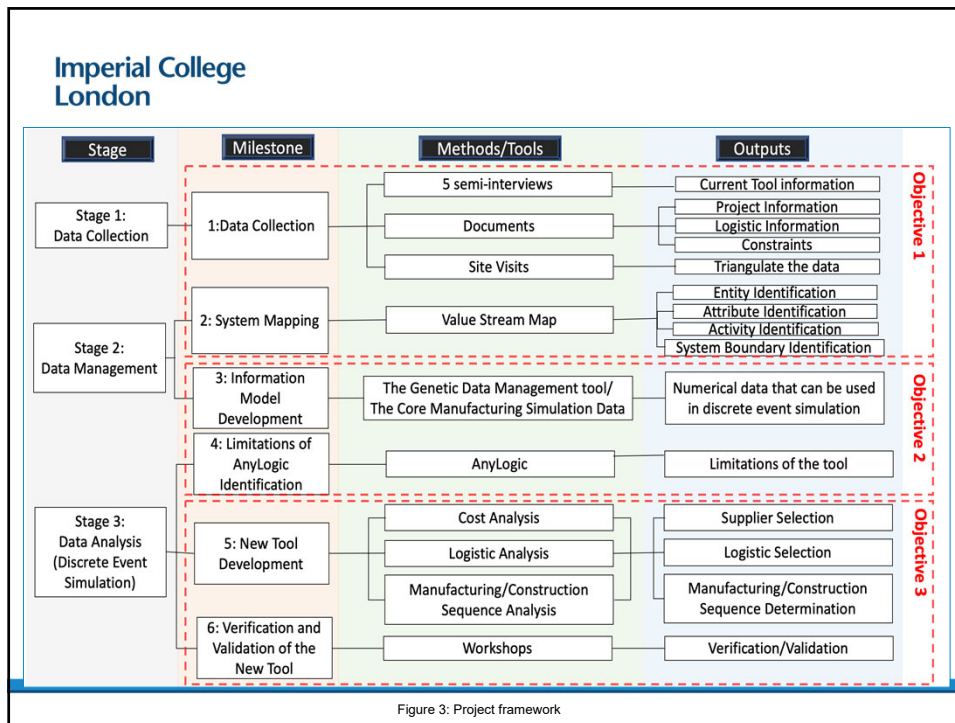
## Aim and Objectives

### Aim:

To develop a new method for integrating system activities across the upstream supply-chain in modular construction. This new method would achieve 1) supplier selection 2) transport route selection 3) manufacturing sequence determination

### Objectives:

- 1) To map activities across the upstream supply-chain in off-site modular construction
- 2) To use discrete event simulation to simulate the upstream supply-chain
- 3) To develop a new digital method for supply-chain integration in off-site modular construction



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## Data Collection

- **Multi-methods**
  - Five semi-structured interviews
  - Documents
- **Validity indicates**
  - Triangulation with site visits and related literature review

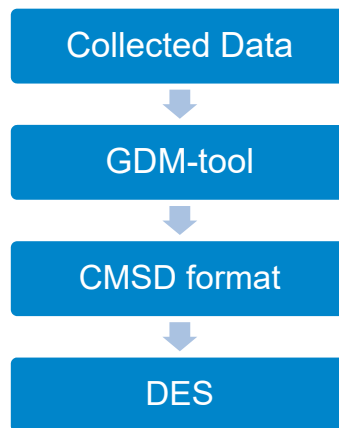
	Type of Bathroom Pod Type	Pod A	Pod B	Pod C
Project Information	Manufacturing rate [no. of pods/day]			
	Manufacturing cost (wage)[Unit cost]			
	Manufacturing cost (machine)[Unit cost]			
	Inventory cost [Unit cost]			
	No. of labours [no. of labour]			
	Volumn of the products [m^3]			
	Storage Capacity [m^3]			
Logistic Information	Components (tick)	C1 C2 ... Cn	C1 C2 ... Cn	C1 C2 ... Cn
	Cost of the component [Unit cost]	√	√	√
	Suppliers (tick)	S1 S2 ... Sn	S1 S2 ... Sn	S1 S2 ... Sn
Constraints	Capacity of the truck [no. of componts]			
	Distance between the supplier and the factory [km]			
	Transportation cost [unit cost/km]			
	Delivery rate [no. of pods/day]			
Expected production rate (time constraints)				
	Expected inputs (cost constraints)			

Figure 3: An example of the required data

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## Data Management

- **Establish a data information model**
  - Store data in one Generic Data Management Tool (GDM-tool)
  - Transfer data to Core Manufacturing Simulation Data (CMSD format)
  - Data are ready to be used for Discrete Event Simulation (DES)



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## Data Analysis

- **Establish a series of mathematical models:**
  - Cost Analysis
  - Logistic Analysis
  - Manufacturing/Construction Sequence Analysis
- **Analyze what-if scenarios for real supply chain problems with DES**
  - Supplier Selection
  - Logistic Selection
  - Manufacturing/Construction Sequences Determination

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## Expected Outcomes

1. Develop a new digital method for supply-chain integration
2. The new tool would be used for suppliers selection, transport routes selection, manufacturing processes decision.
3. Achieve the transparency of the supply-chain
4. Achieve real-time data collection and data analysis
5. Improve the productivity of the bathroom pod
6. Minimize the capital expenditure

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**THANK YOU !**