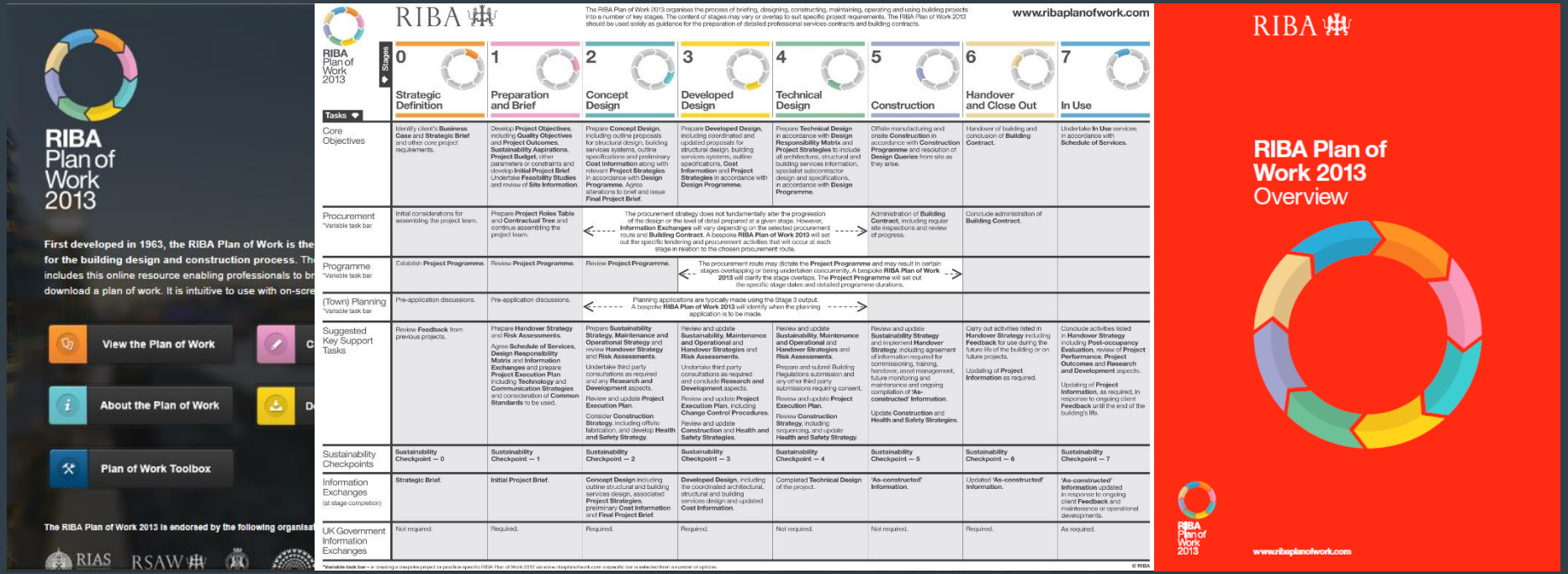
AECOM Imagine it. Delivered.

CIC

Designing for Manufacture and Assembly

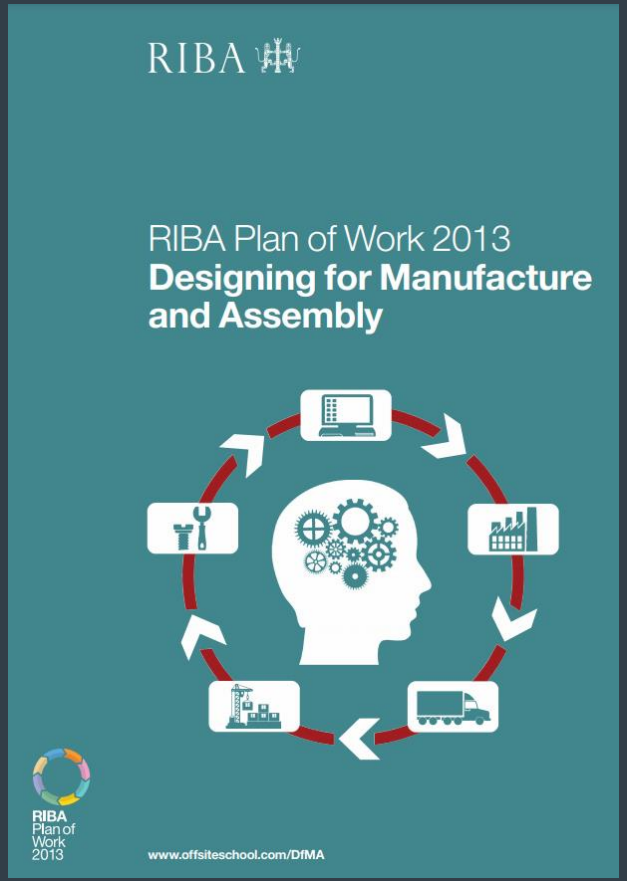
Dale Sinclair, Director of Innovation
October 2020

RIBA Plan of Work 2013



www.ribaplanofwork.com

DfMA overlay to RIBA Plan of Work



Different Levels of Pre-Assembly

1. Component manufacture
2. Sub-assembly
3. Non-volumetric preassembly
4. Volumetric preassembly
5. Modular buildings

RIBA Plan of Work 2020

RIBA
Plan of Work
2020

The RIBA Plan of Work organises the process of briefing, designing, delivering, maintaining, operating and using a building into eight stages. It is a framework for all disciplines on construction projects and should be used solely as guidance for the preparation of detailed professional services and building contracts.

Stage Boundaries:
Stages 0-4 will generally be undertaken one after the other.
Stages 4 and 5 will overlap in the **Project Programme** for most projects.
Stage 5 commences when the contractor takes possession of the site and finishes at **Practical Completion**.
Stage 6 starts with the handover of the building to the client immediately after **Practical Completion** and finishes at the end of the **Defects Liability Period**.
Stage 7 starts concurrently with Stage 6 and lasts for the life of the building.

Planning Note:
Planning Applications are generally submitted at the end of Stage 3 and should only be submitted earlier when the threshold of information required has been met. If a **Planning Application** is made during Stage 3, a mid-stage gateway should be determined and it should be clear to the project team which tasks and deliverables will be required. See Overview guidance.

Procurement:
The RIBA Plan of Work is procurement neutral – See Overview guidance for a detailed description of how each stage might be adjusted to accommodate the requirements of the **Procurement Strategy**.

ER Employer's Requirements
CP Contractor's Proposals

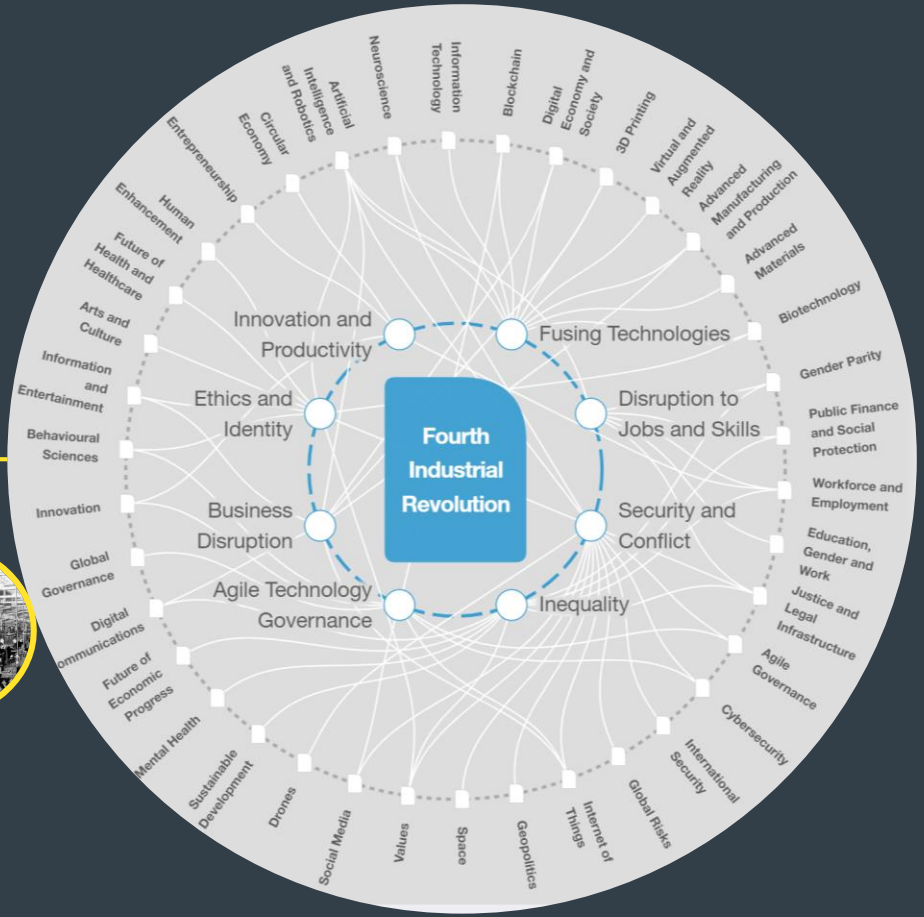
	0 Strategic Definition	1 Preparation and Briefing	2 Concept Design	3 Spatial Coordination	4 Technical Design	5 Manufacturing and Construction	6 Handover	7 Use
	← Projects span from Stage 1 to Stage 6; the outcome of Stage 0 may be the decision to initiate a project and Stage 7 covers the ongoing use of the building. →							
Stage Outcome at the end of the stage	The best means of achieving the **Client Requirements** confirmed If the outcome determines that a building is the best means of achieving the **Client Requirements**, the client proceeds to Stage 1	**Project Brief** approved by the client and confirmed that it can be accommodated on the site	**Architectural Concept** approved by the client and aligned to the **Project Brief** The brief remains "live" during Stage 2 and is derogated in response to the **Architectural Concept**	Architectural and engineering information **Spatially Coordinated**	All design information required to manufacture and construct the project completed Stage 4 will overlap with Stage 5 on most projects	Manufacturing, construction and **Commissioning** completed There is no design work in Stage 5 other than responding to **Site Queries**	Building handed over, **Aftercare** initiated and **Building Contract** concluded	Building used, operated and maintained efficiently Stage 7 starts concurrently with Stage 6 and lasts for the life of the building.
Core Tasks during the stage **Project Strategies** might include: – **Conservation** (if applicable) – **Cost** – **Fire Safety** – **Health and Safety** – **Inclusive Design** – **Planning** – **Plan for Use** – **Procurement** – **Sustainability** See RIBA Plan of Work 2020 Overview for detailed guidance on **Project Strategies**	Prepare **Client Requirements** Develop **Business Case** for feasible options including review of **Project Risks** and **Project Budget** Ratify option that best delivers **Client Requirements** Review **Feedback** from previous projects Undertake **Site Appraisals** No design team required for Stages 0 and 1. Client advisers may be appointed to the client team to provide strategic advice and design thinking before Stage 2 commences.	Prepare **Project Brief** including **Project Outcomes** and **Sustainability Outcomes**, **Quality Aspirations** and **Spatial Requirements** Undertake **Feasibility Studies** Agree **Project Budget** Source **Site Information** including **Site Surveys** Prepare **Project Programme** Prepare **Project Execution Plan**	Prepare **Architectural Concept** incorporating **Strategic Engineering** requirements and aligned to **Cost Plan**, **Project Strategies** and **Outline Specification** Agree **Project Brief Derogations** Undertake **Design Reviews** with client and **Project Stakeholders** Prepare stage **Design Programme**	Undertake **Design Studies**, **Engineering Analysis** and **Cost Exercises** to test **Architectural Concept** resulting in **Spatially Coordinated** design aligned to updated **Cost Plan**, **Project Strategies** and **Outline Specification** Initiate **Change Control Procedures** Prepare stage **Design Programme**	Develop architectural and engineering technical design Prepare and coordinate design team **Building Systems** information Prepare and integrate specialist subcontractor **Building Systems** information Prepare stage **Design Programme** Specialist subcontractor designs are prepared and reviewed during Stage 4	Finalise **Site Logistics** Manufacture **Building Systems** and construct building Monitor progress against **Construction Programme** Inspect **Construction Quality** Resolve **Site Queries** as required Undertake **Commissioning** of building Prepare **Building Manual** Building handover tasks bridge Stages 5 and 6 as set out in the **Plan for Use Strategy**	Hand over building in line with **Plan for Use Strategy** Undertake review of **Project Performance** Undertake seasonal **Commissioning** Rectify defects Complete initial **Aftercare** tasks including light touch **Post Occupancy Evaluation**	Implement **Facilities Management** and **Asset Management** Undertake **Post Occupancy Evaluation** of building performance in use Verify **Project Outcomes** including **Sustainability Outcomes** Adaptation of a building (at the end of its useful life) triggers a new Stage 0
Core Statutory Processes during the stage: Planning Building Regulations Health and Safety (CDM)	Strategic appraisal of **Planning** considerations	Source pre-application **Planning Advice** Initiate collation of health and safety **Pre-construction Information**	Obtain pre-application **Planning Advice** Agree route to **Building Regulations** compliance Option: submit outline **Planning Application**	Review design against **Building Regulations** Prepare and submit **Planning Application** See **Planning Note** for guidance on submitting a **Planning Application** earlier than at end of Stage 3	Submit **Building Regulations Application** Discharge pre-commencement **Planning Conditions** Prepare **Construction Phase Plan** Submit form F10 to HSE if applicable	Carry out **Construction Phase Plan** Comply with **Planning Conditions** related to construction	Comply with **Planning Conditions** as required	Comply with **Planning Conditions** as required
Procurement Route Traditional Design & Build 1 Stage Design & Build 2 Stage Management Contract Construction Management Contractor-led	Appoint client team	Appoint design team	ER Appoint contractor Appoint contractor	ER Pre-contract services agreement Preferred bidder	Tender Appoint contractor ER CP Appoint contractor CP Appoint contractor CP Appoint contractor			Appoint **Facilities Management** and **Asset Management** teams, and strategic advisers as needed
Information Exchanges at the end of the stage	**Client Requirements** **Business Case**	**Project Brief** **Feasibility Studies** **Site Information** **Project Budget** **Project Programme** **Procurement Strategy** **Responsibility Matrix** **Information Requirements**	**Project Brief Derogations** Signed off **Stage Report** **Project Strategies** **Outline Specification** **Cost Plan**	Signed off **Stage Report** **Project Strategies** Updated **Outline Specification** Updated **Cost Plan** **Planning Application**	**Manufacturing Information** **Construction Information** **Final Specifications** Residual **Project Strategies** **Building Regulations Application**	**Building Manual** including **Health and Safety File** and **Fire Safety Information** **Practical Completion** certificate including **Defects List** **Asset Information** If **Verified Construction Information** is required, verification tasks must be defined	**Feedback** on **Project Performance** **Final Certificate** **Feedback** from light touch **Post Occupancy Evaluation**	**Feedback** from **Post Occupancy Evaluation** Updated **Building Manual** including **Health and Safety File** and **Fire Safety Information** as necessary

RIBA
Architecture.com

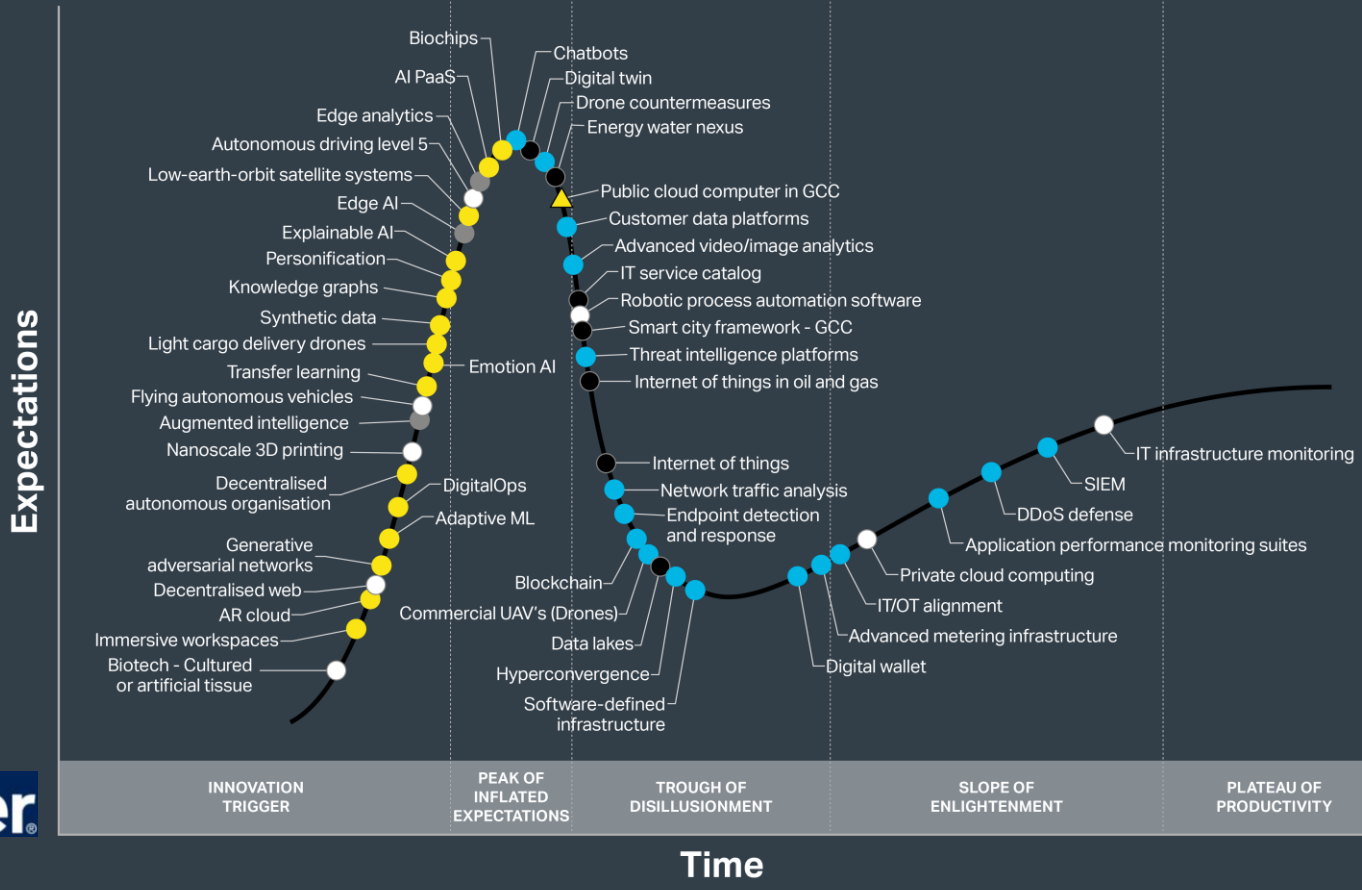
Core RIBA Plan of Work terms are defined in the RIBA Plan of Work 2020 Overview glossary and set in **Bold Type**.

Further guidance and detailed stage descriptions are included in the RIBA Plan of Work 2020 Overview.

Paradigm shifts



Hype cycle: timing is everything



Gartner

Changing industry

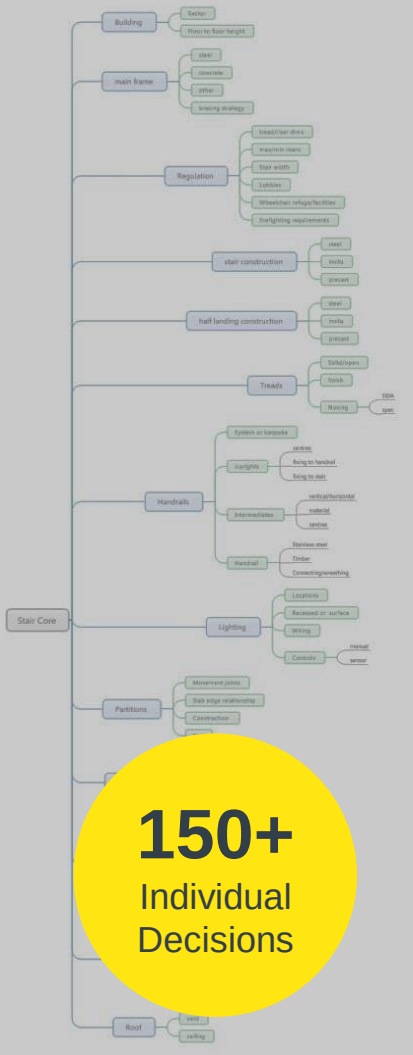
Occupation	Probability
Mechanical Engineers	0.011
Architectural & Engineering Managers	0.017
Architects	0.018
Civil Engineers	0.019
Interior Designers	0.022
Lawyers	0.035
Landscape Architects	0.045
Construction Managers	0.071
Electrical Engineers	0.1
Electricians	0.15
Construction Trades Supervisors	0.17
Engineering Technicians	0.24
Plumbers & Pipefitters	0.35
Surveyors	0.38
Mechanical Engineering Technicians	0.38
Architect and Civil Draftsmen	0.52
Tapers	0.62
Construction & Building Inspectors	0.63
Mechanical Insulation Workers	0.64
Mechanical Draftsmen	0.68

Occupation	Probability
Construction & Related Workers	0.71
Carpenters	0.72
Glaziers	0.73
Tile & Marble Setters	0.75
Painters	0.75
Civil Engineering Technicians	0.75
Drywall and Ceiling Installers	0.79
Floor layers	0.79
Brick masons	0.82
Labourers	0.88
Terrazzo workers	0.88
Roofers	0.9
Crane and tower operators	0.9
Electrical Installers (inc lifts)	0.91
Model makers	0.93
Accountants	0.94
Surveying and mapping technicians	0.96
Estate agents	0.97
Insurance underwriters	0.99

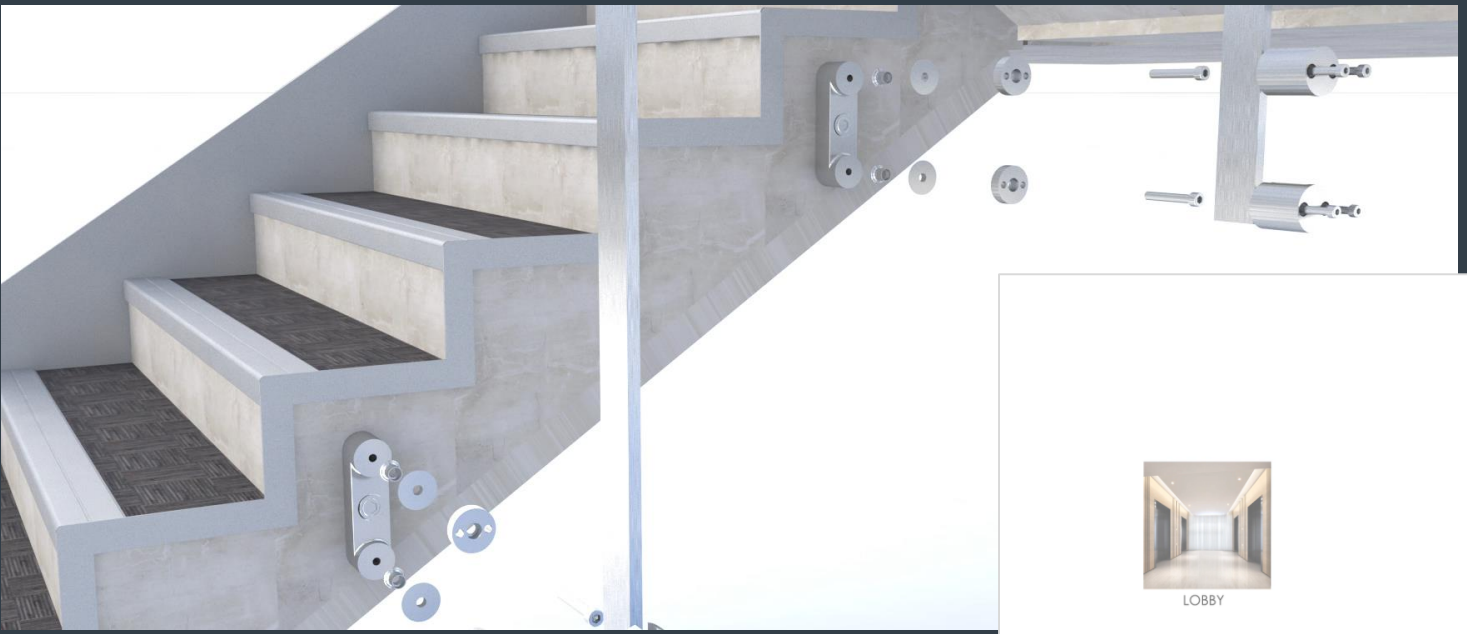
New ways of making

Increasing complexity

Digital libraries: transforming decision making



Future workflow



LOBBY

CONFIGURE
YOUR CORE

Degrees of DfMA

Projects and products

Scope of DfMA

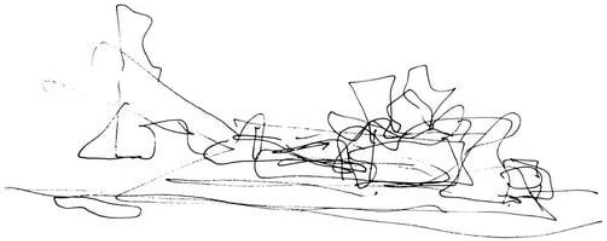
Scope of DfMA

DFMA Possibilities however different innovations required including faster system production

Reduced volumetric opportunity

Reduced industrialized components opportunity

Design stages

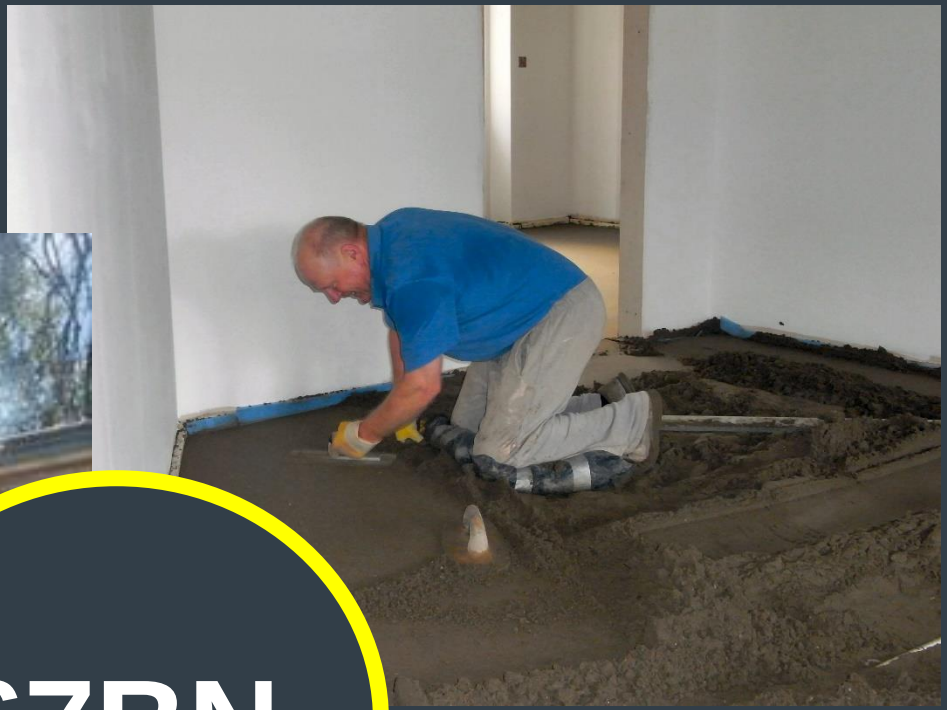


2 Concept Design

3 Spatial Coordination

4 Technical Design

Quick wins



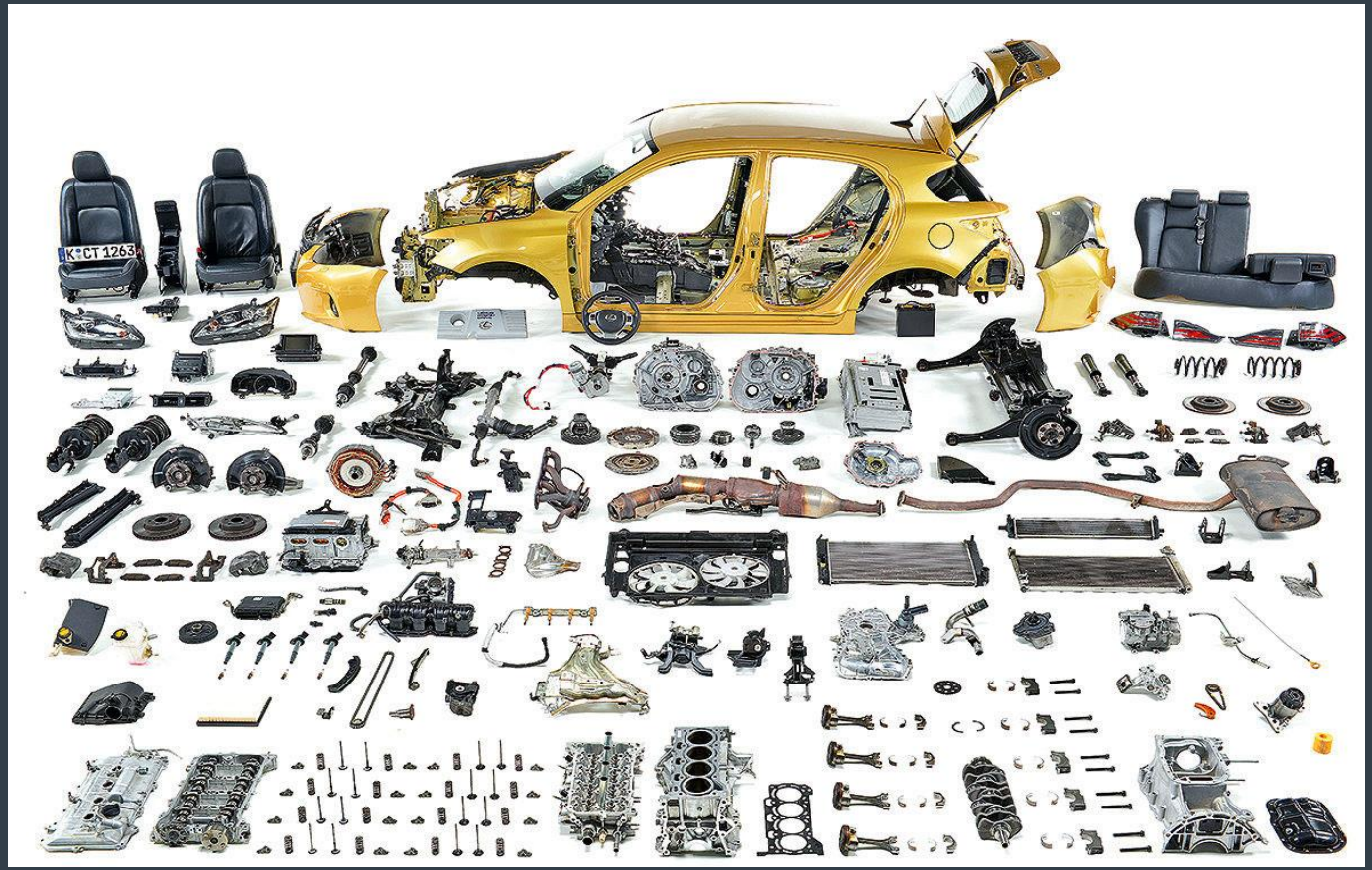
£7BN

Optimising traditional

Lights out manufacturing

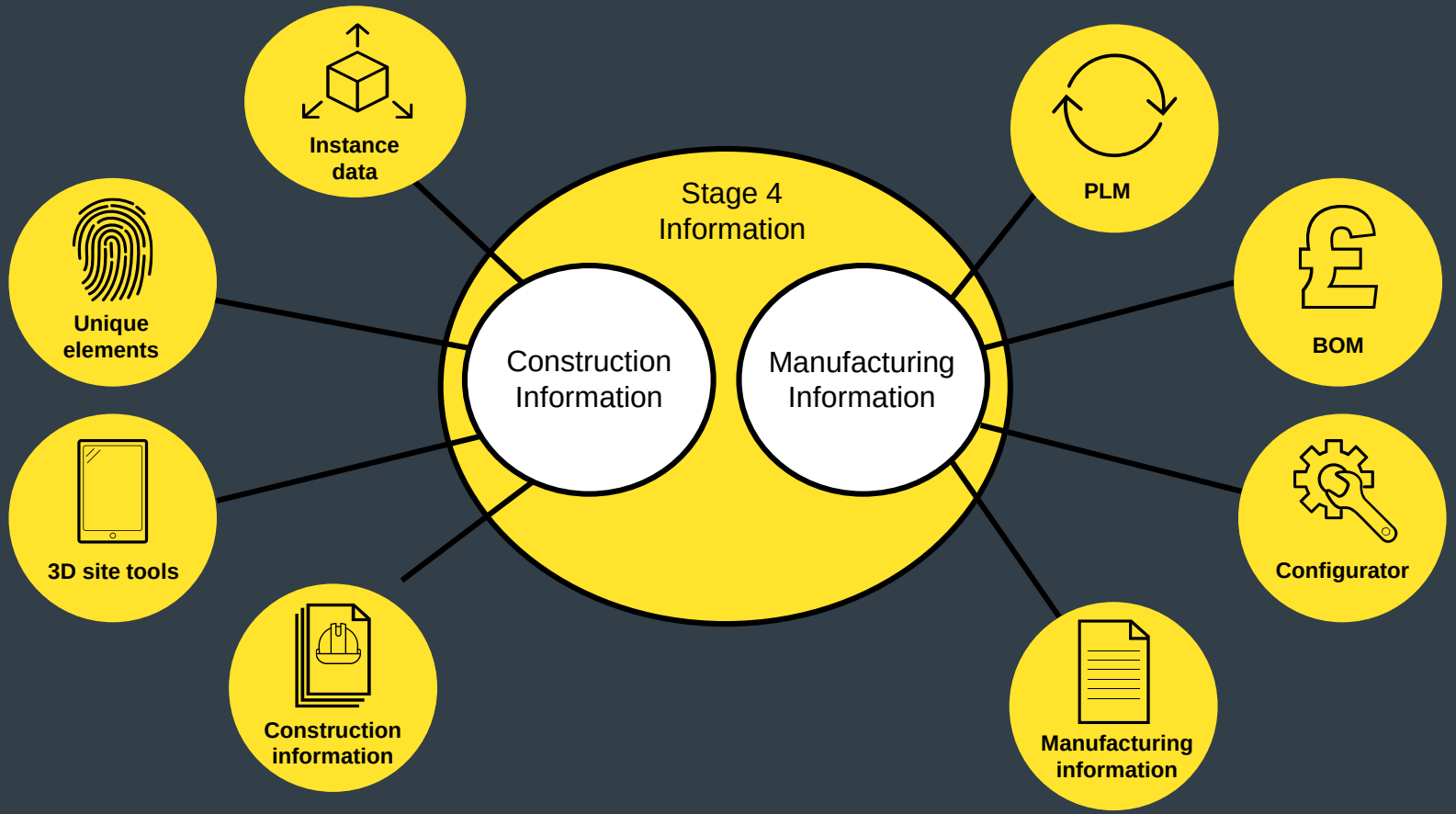
Volumetric Maturity

Appropriate lessons



DfMA: Future Trends

Convergence of manufacturing and construction



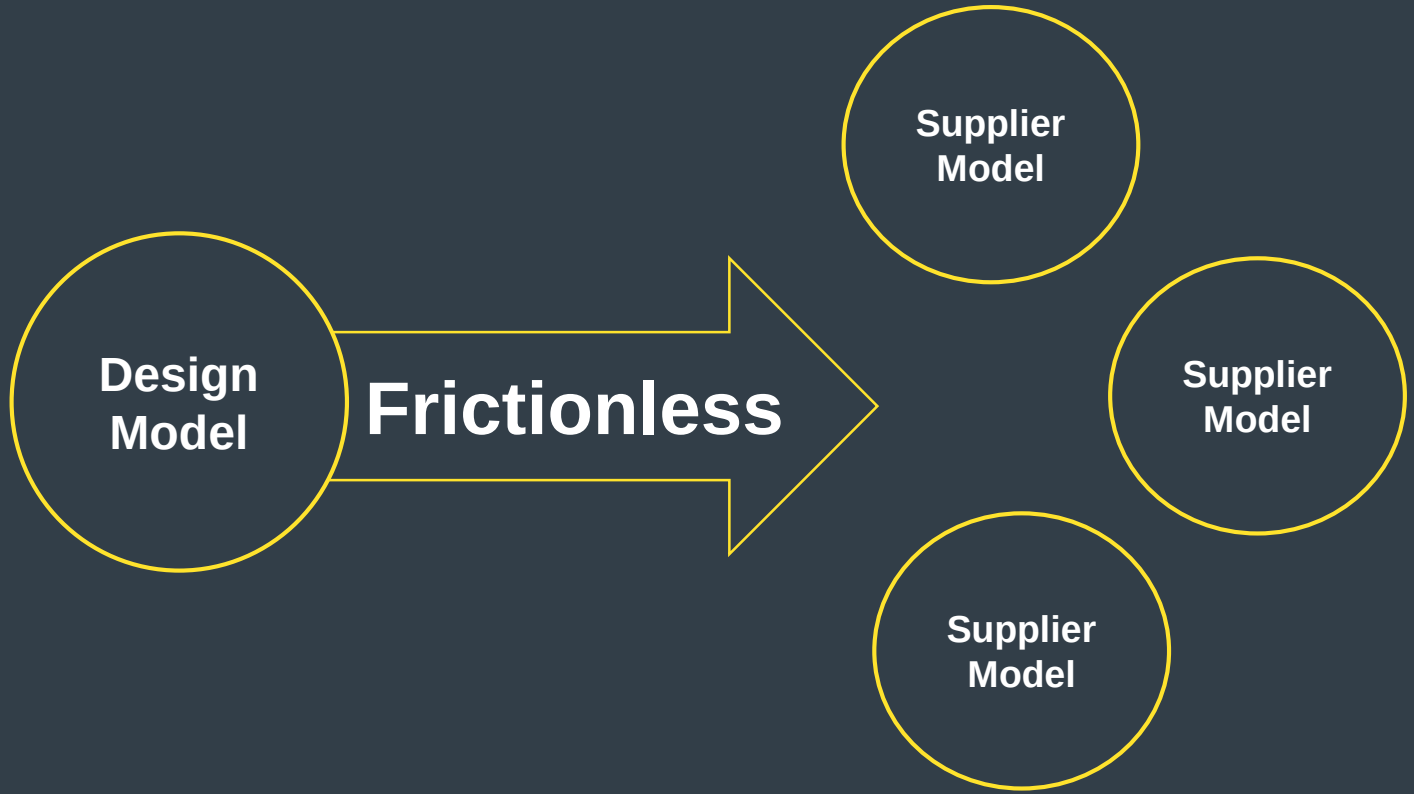
Mass-customisation / mass-configuration

DESIGN FOR FLEXIBILITY
Millions of design options to allow design diversity in our built environment.

DESIGN FOR AUTOMATION
Automation downstream into production, engineering, documentation and manufacturing.

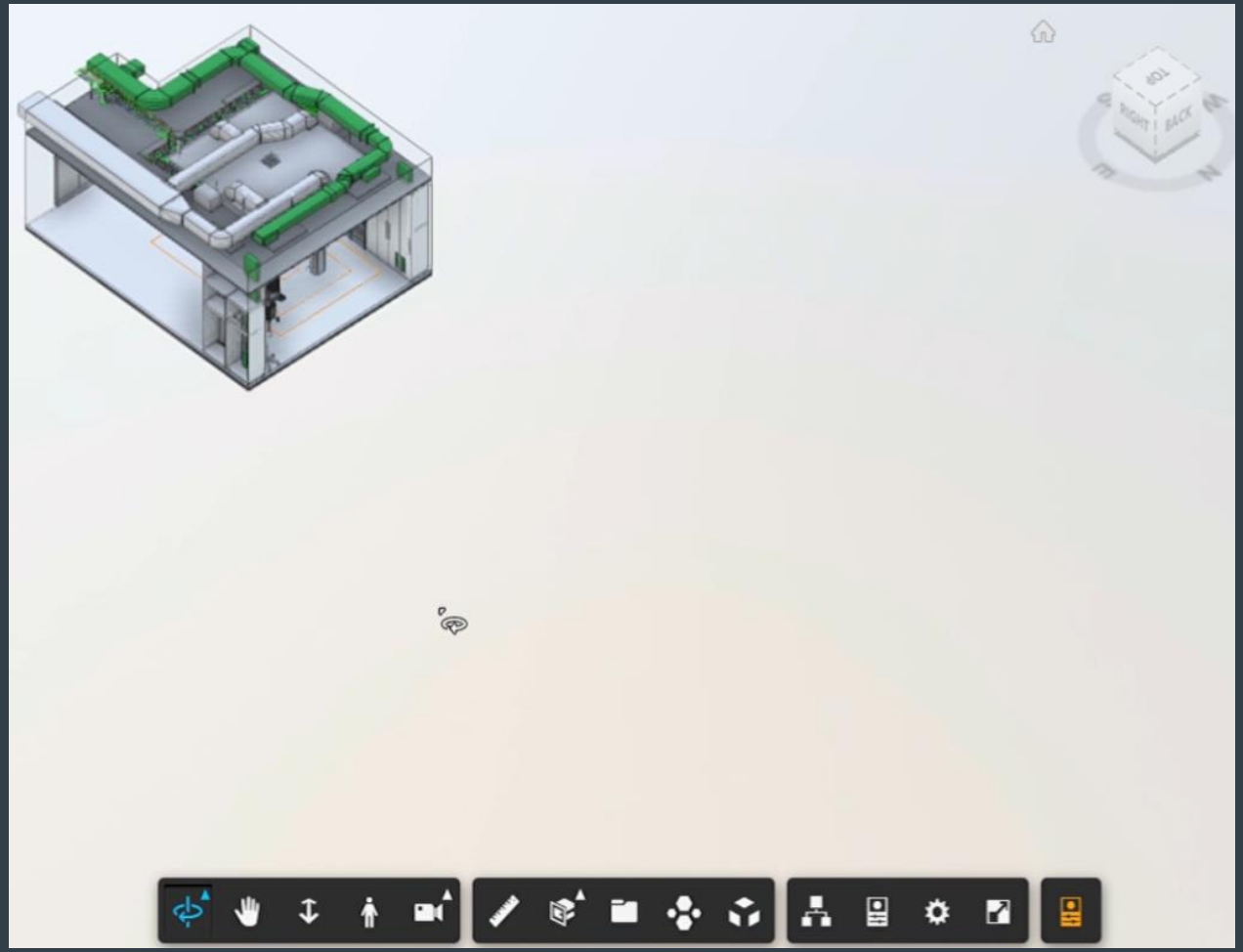
DESIGN FOR USABILITY
To remove barriers to entry for designers, manufacturers, asset managers and contractors.

Supplier resilience / procurement

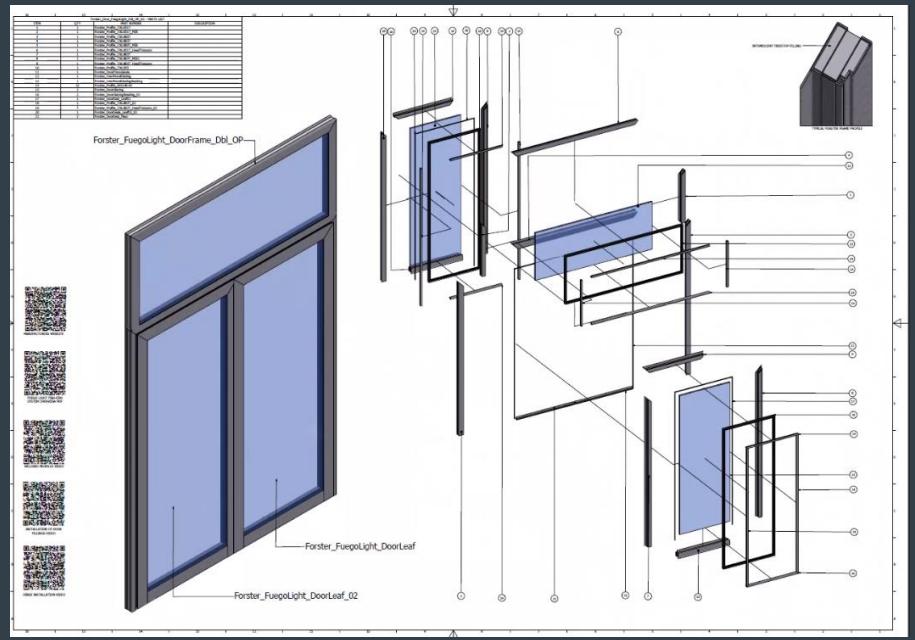


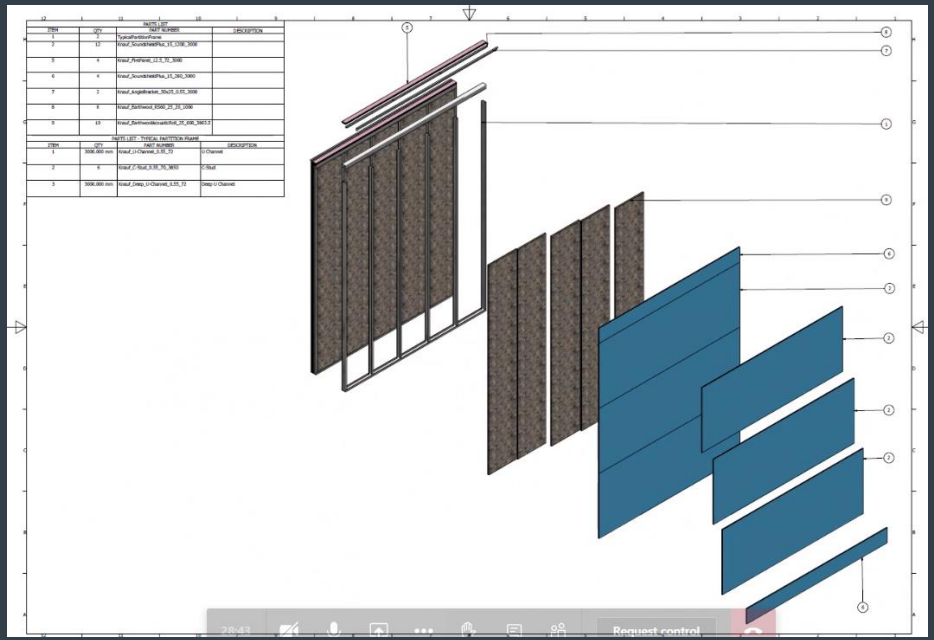
Configurators

Intelligent libraries

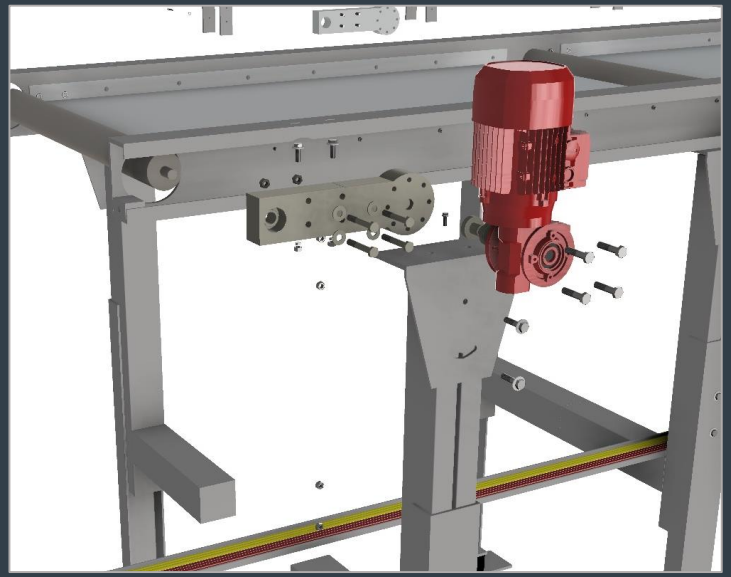


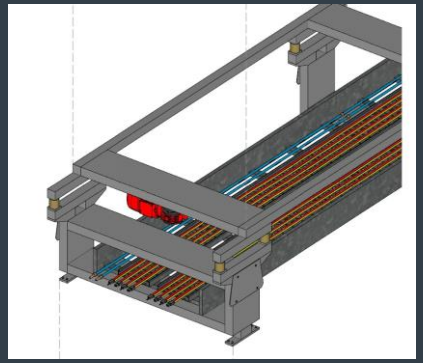
Next generation deliverables





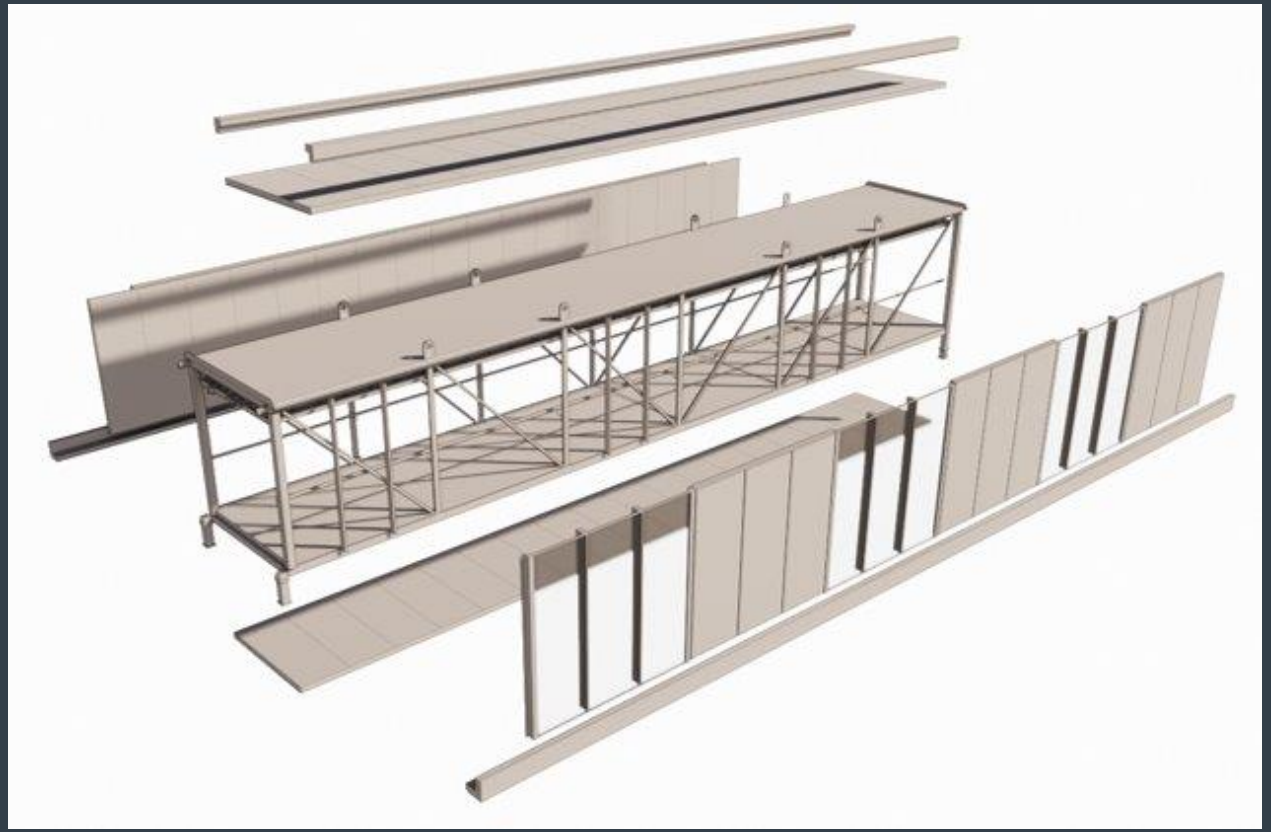
Bills of materials / MEP connections

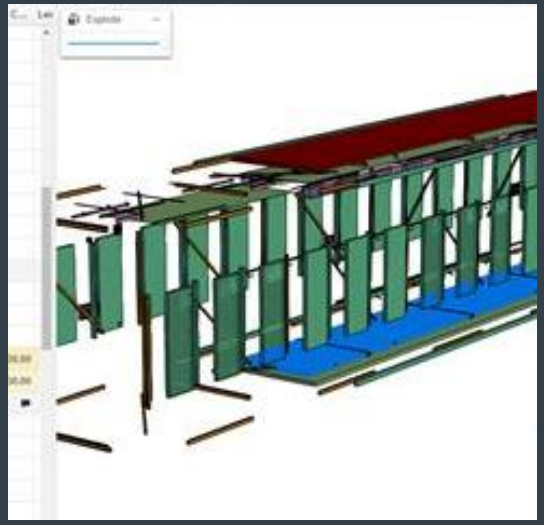


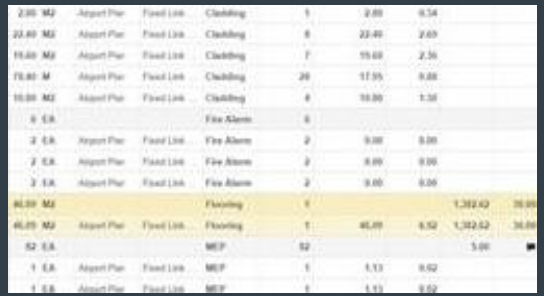


Conveyor_Aluminium Sheet small	2
House Bearing - non -Drive Shaft Gear Side small	6
C channel Guide1	10
M6 Nut1	80
M6 x 25_MIR31	40
M6 Washer_MIR11	40
guide connection bracket1	20
c channel mating plate1	20
M6 x 251	104
M6 Washer1	104
DIN EN ISO 4017 - M6 x 401 Hex-Head Bolt	40
ISO 7089 - 6 - 140 HV(1)1 - Plain washers - Normal series - Product grade A	40
ISO 4032 - M6 - ISO1 - Hexagon nuts, style 1 - Product grades A and B	64
DIN EN ISO 4017 - M10 x 301	16
ISO 7091 - 10 - 100 HV1 - Plain washers- Normal series- Product grade C	16
ISO 4032 - M10 - ISO1 - Hexagon nuts, style 1 - Product grades A and B	16
M6 Nut_MIR2	60
Conveyor drive shaft_MIR	8
House Bearing - Drive Shaft Gear Side small_MIR	8
Bearing_UC204-Ø20_MIR1	8
motor drive_MIR	8
DIN EN ISO 4014 - M10 x 70_MIR - Hex-Head Bolt	32
ISO 7091 - 10 - 100 HV_MIR - Plain washers- Normal series- Product grade C	32
ISO 4032 - M10 - ISO_MIR - Hexagon nuts, style 1 - Product grades A and B	32
E-stop	6
c channel mating for e stop	6
Floor plate	5
Joining Legs top Y	10
ISO 4017 - M6 x 20 - Hexagon head screws	40
Current leg design	12
Current leg design_MIR1	12
DIN EN ISO 4017 - M10 x 30_MIR1 - Hex-Head Bolt	24
ISO 7091 - 10 - 100 HV_MIR2 Plain washers- Normal series- Product grade C	72
ISO 4032 - M10 - ISO_MIR2 - Hexagon nuts, style 1 - Product grades A and B	72
DIN EN ISO 4014 - M10 x 45_MIR1 - Hex-Head Bolt	48
TOTAL PARTS QTY.	2515

Stage 1 fabrication: weight / carbon







MEP considerations

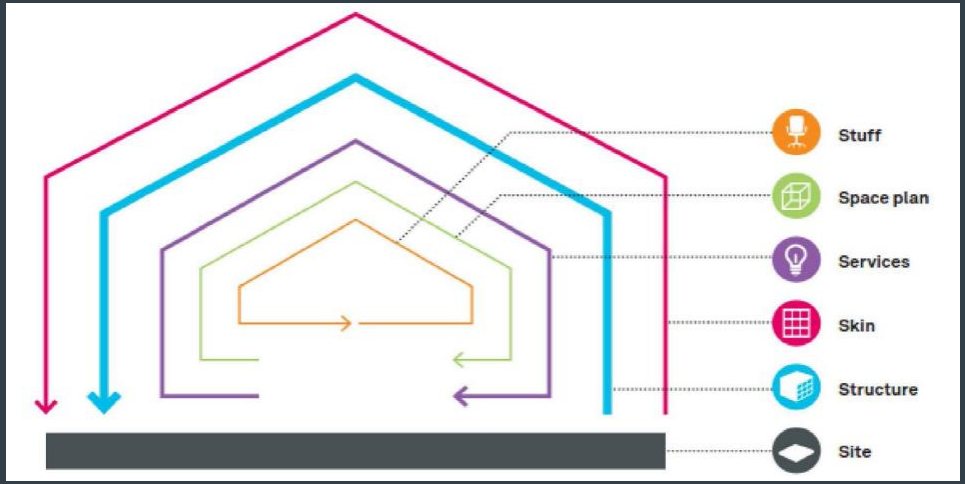
Spatial Allowances – risers and main horizontal services routes must allow for framing

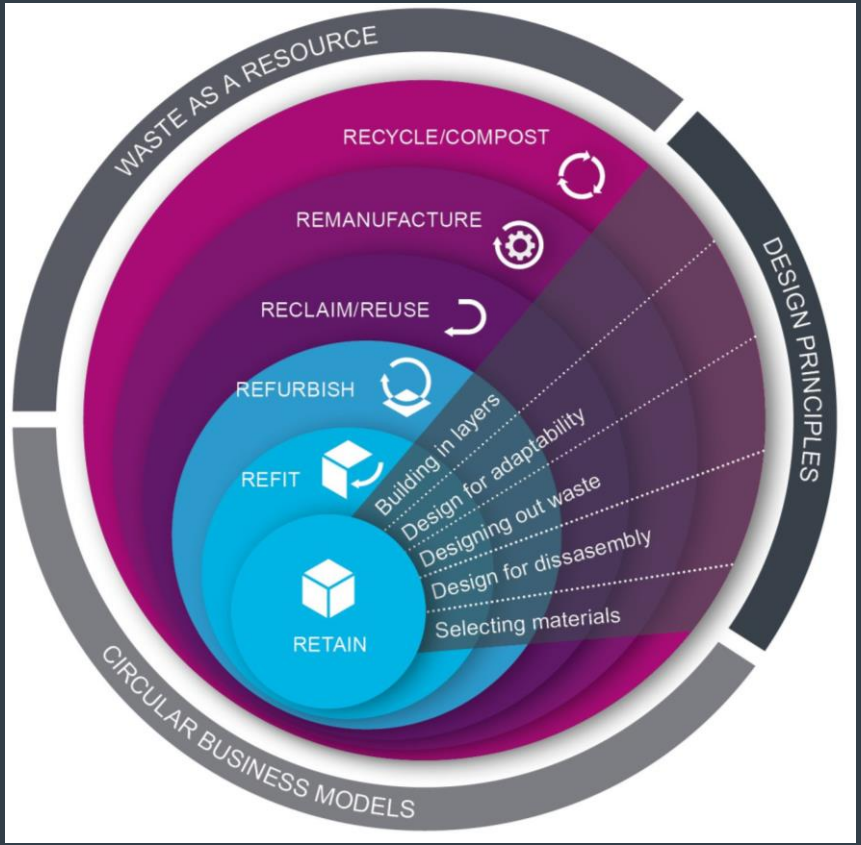
Plantrooms need to consider pre-assembly – for example, pumpsets on skids

Early involvement of suppliers essential to ensure all DfMA options have been considered during the concept design

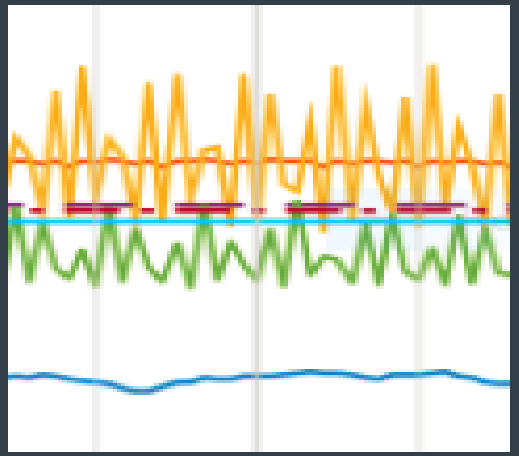
Logistics and craneage impact on approach

Circular economy





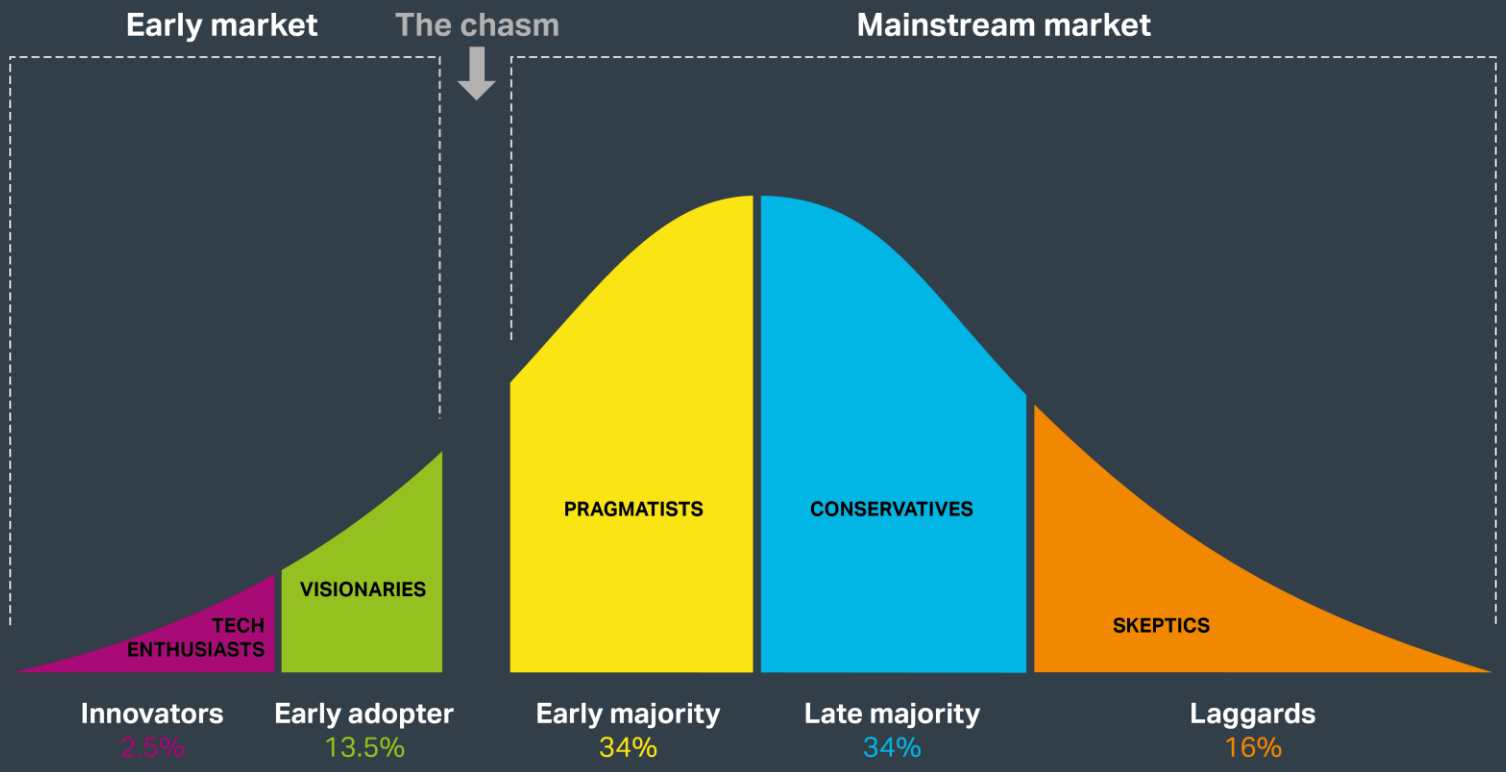
CLOUD and IOT: free buildings!



Capital Costs **20:80** Operational Costs

Capital Costs **=24** Greater than Capital Cost

Innovation curve: crossing the chasm



AECOM

Imagine it.
Delivered.