AUTODESK. UNIVERSITY

DfMA for Industrialized Construction Myths and Truths

Tom Closs

Principal Solution Architect



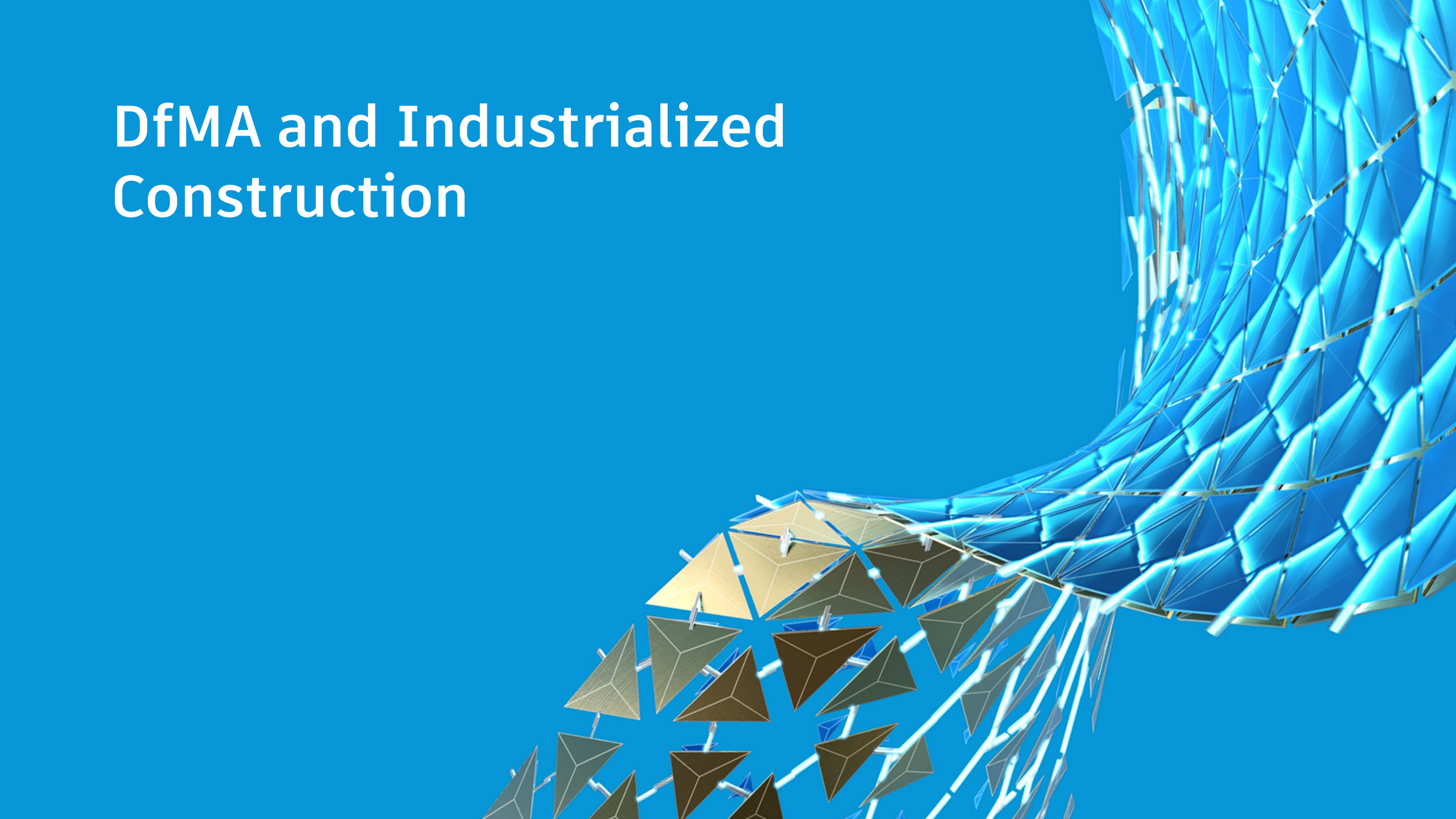


About the speaker

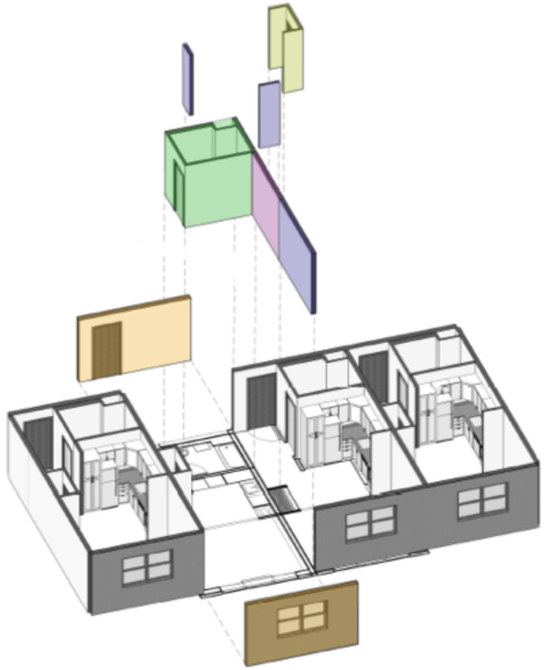
Autodesk Principal Solution Architect

Tom Closs has worked with multiple manufacturing technologies since 1994. Prior to joining Autodesk, Tom worked as an Automated Machine, Design Engineer, before moving into consulting full time. Tom joined the Autodesk Vault Team in 2007, and Autodesk Consulting in 2012. Throughout Tom’s career, he has completed many large-scale projects from Vault implementations and system integrations to custom tool development and teaching. Tom has worked with a wide variety of technologies, including AutoCAD, Inventor, AutoCAD Mechanical, Revit, Navisworks, Fusion 360, Vault, Fusion Lifecycle, 3DS Max, BIM360, Power Mill, NetFabb and others.

DfMA and Industrialized Construction




DfMA ≠ IC



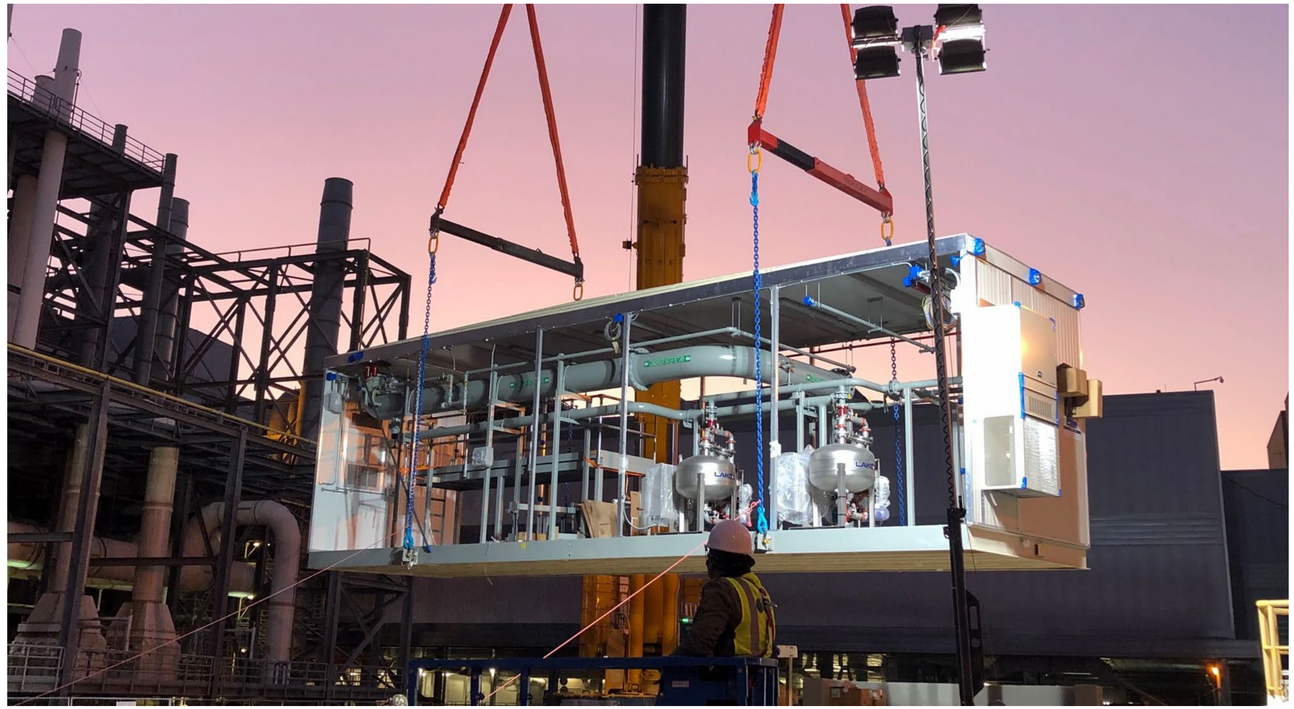


Image courtesy of Systecon

DfMA

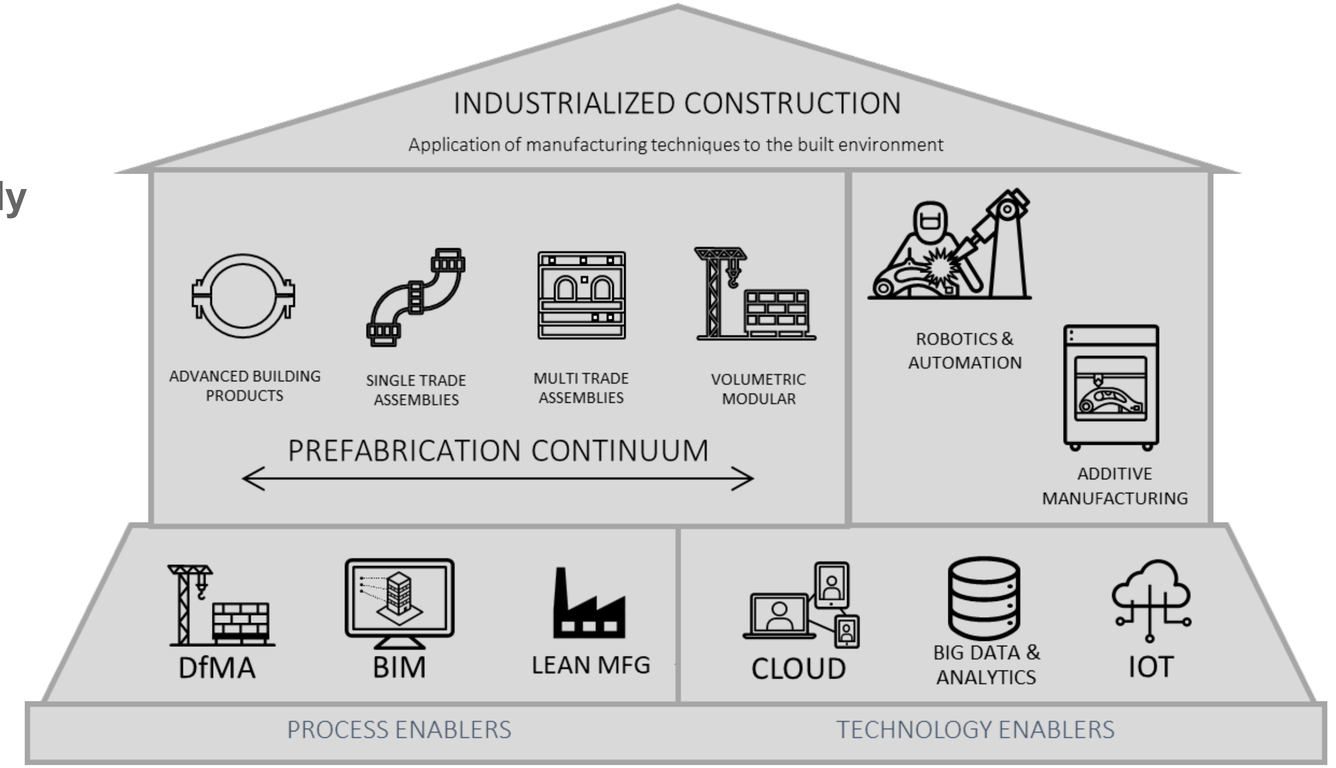
Design for Manufacture and Assembly (DfMA) is a process of improving designs and design methods to gain improvement in manufacturing and construction assembly processes

Industrialized Construction

Industrialized Construction (IC) is the application of manufacturing techniques in the built environment, to reduce the level of onsite work needed

DfMA / IC Relationship

- **DfMA is a process enabler for Industrialized Construction**
- **Industrialized Construction is the framework to apply of manufacturing techniques to improve the traditional construction process, removing unnecessary manual labour**



Design for Manufacturing



DfM Principals

- Use optimal materials for functional requirement
- Remove unnecessary part features (low value feature removal)
- Choose optimal manufacturing process
- Optimise production time and throughput
- Automate where possible in production process
- Always high-quality parts
- Support DfA objectives if possible

Cost of Change Influence Influencers

Level of Influence on Cost/Quality and Production Cycle Time

Perfect World:
Alignment
Between Design &
Production Teams



Major
Influence:
Get This
Wrong, and
Fail

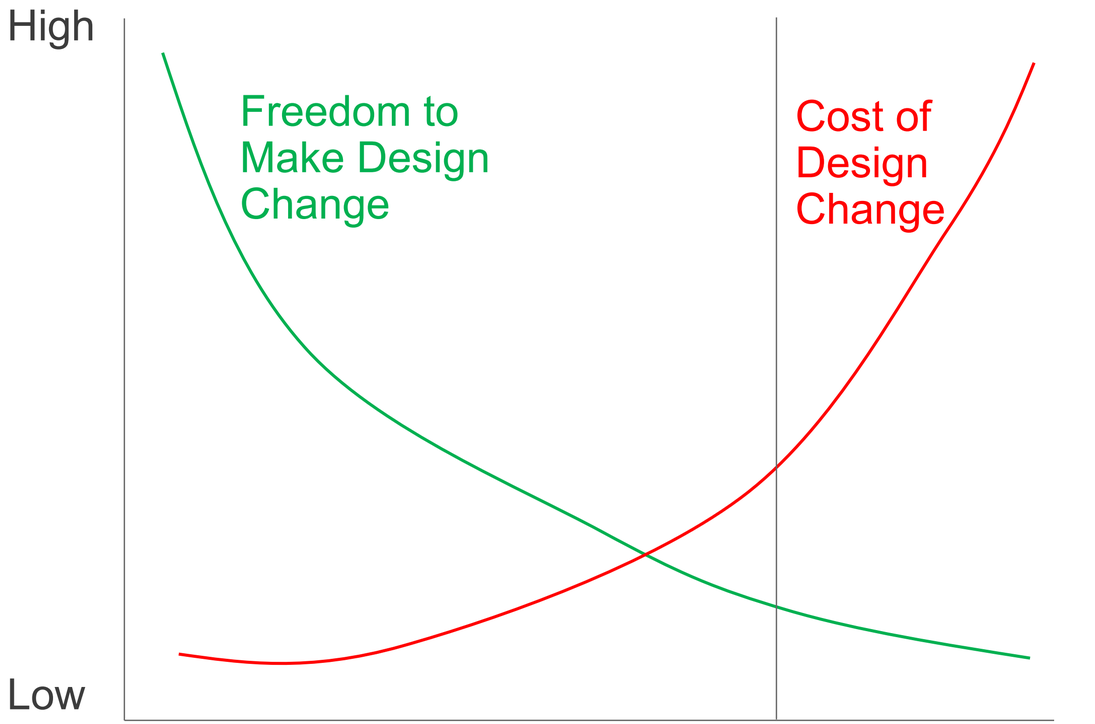
70-80
%

20-30
%

Significant
Enough
Contributor
to NOT be
Ignored

Design

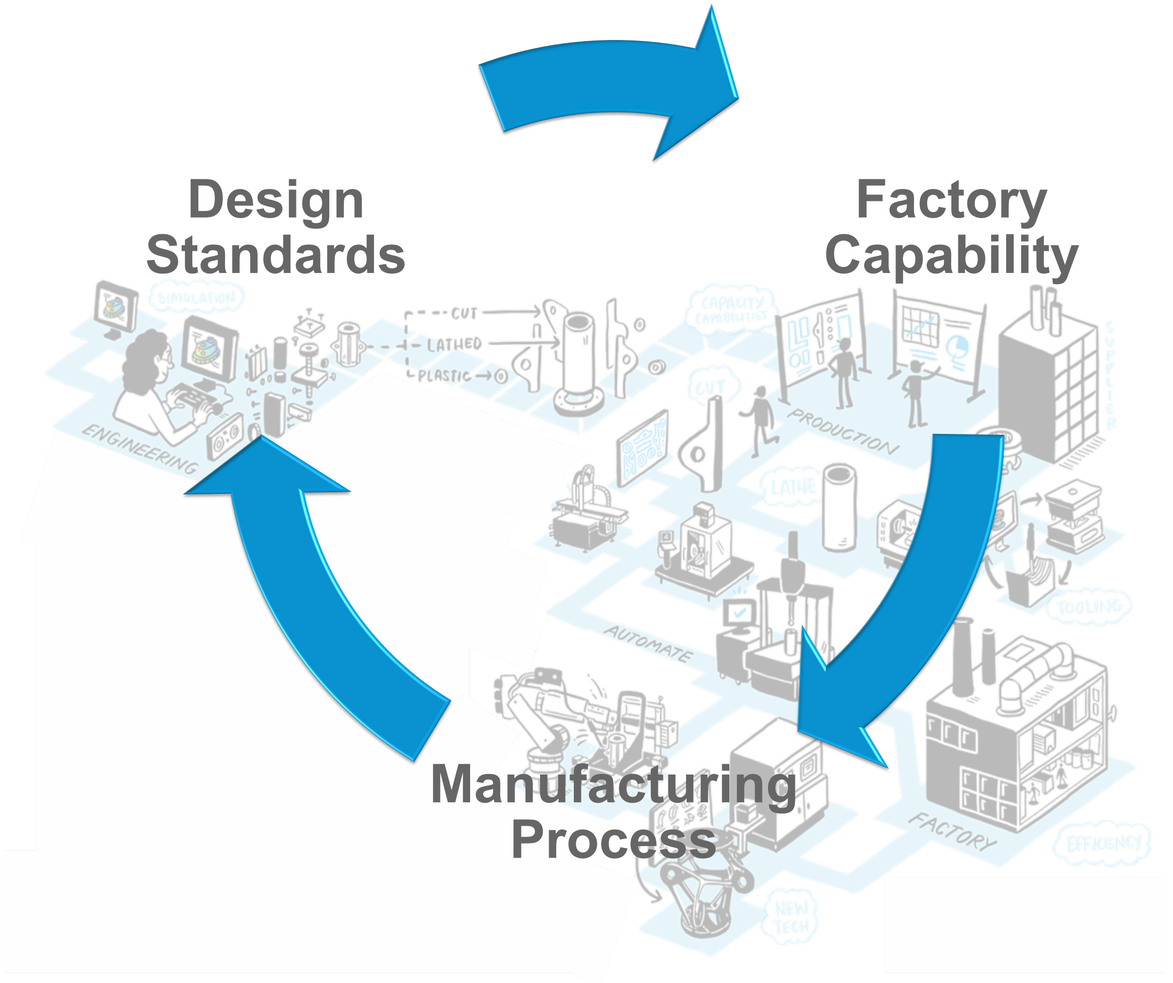
Production



Manufacturing Limitations

Design within the production capability

- **What can the factory produce?**
- **How can the factory produce?**
- **How efficient can the factory produce?**
- **Where can we produce?**



Question the Process

- **Is this good DfA example still a good example of DfM?**
  - Maybe not – still using traditional construction methods; limited machine automation
- **DfM questions here would be:**
  - Is timber frame the best material/process?
    - Is there a better solution?
    - Could we optimise in a more automated factory production line?

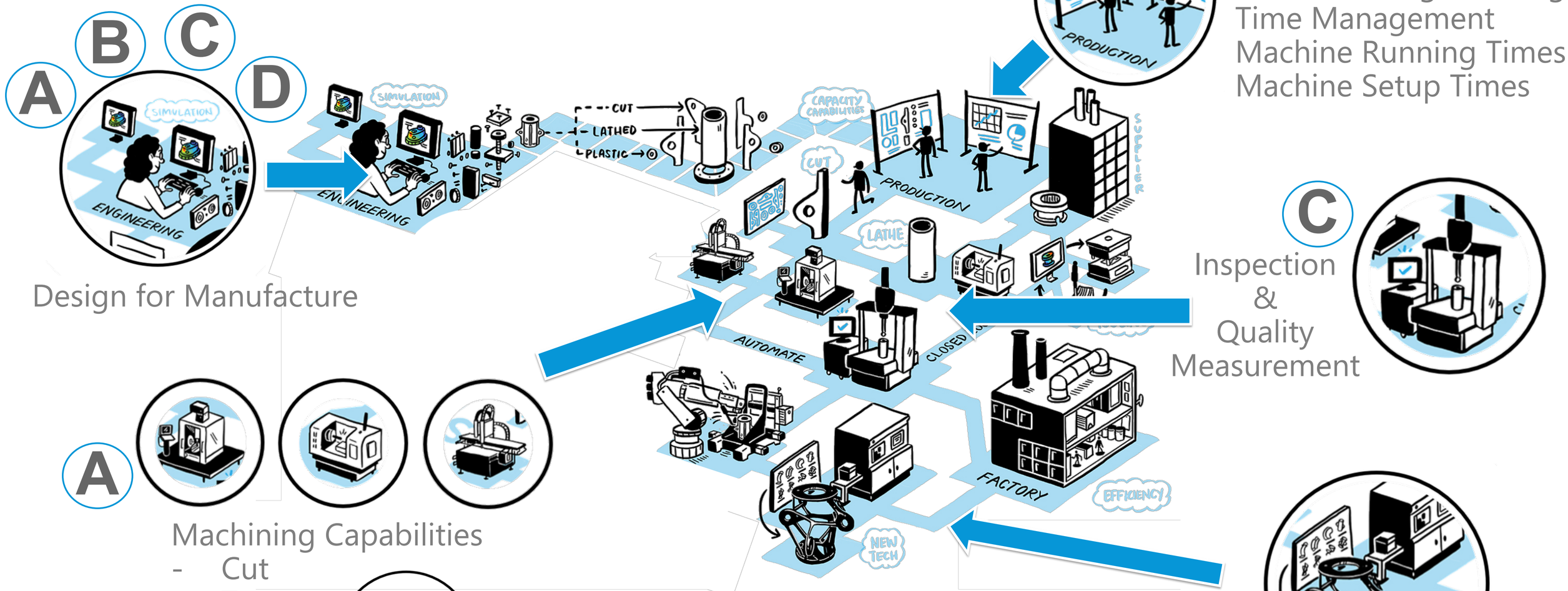








Understanding Production Capability



D

Manufacturing Planning
Time Management
Machine Running Times
Machine Setup Times

Design for Manufacture

C

Inspection
&
Quality
Measurement

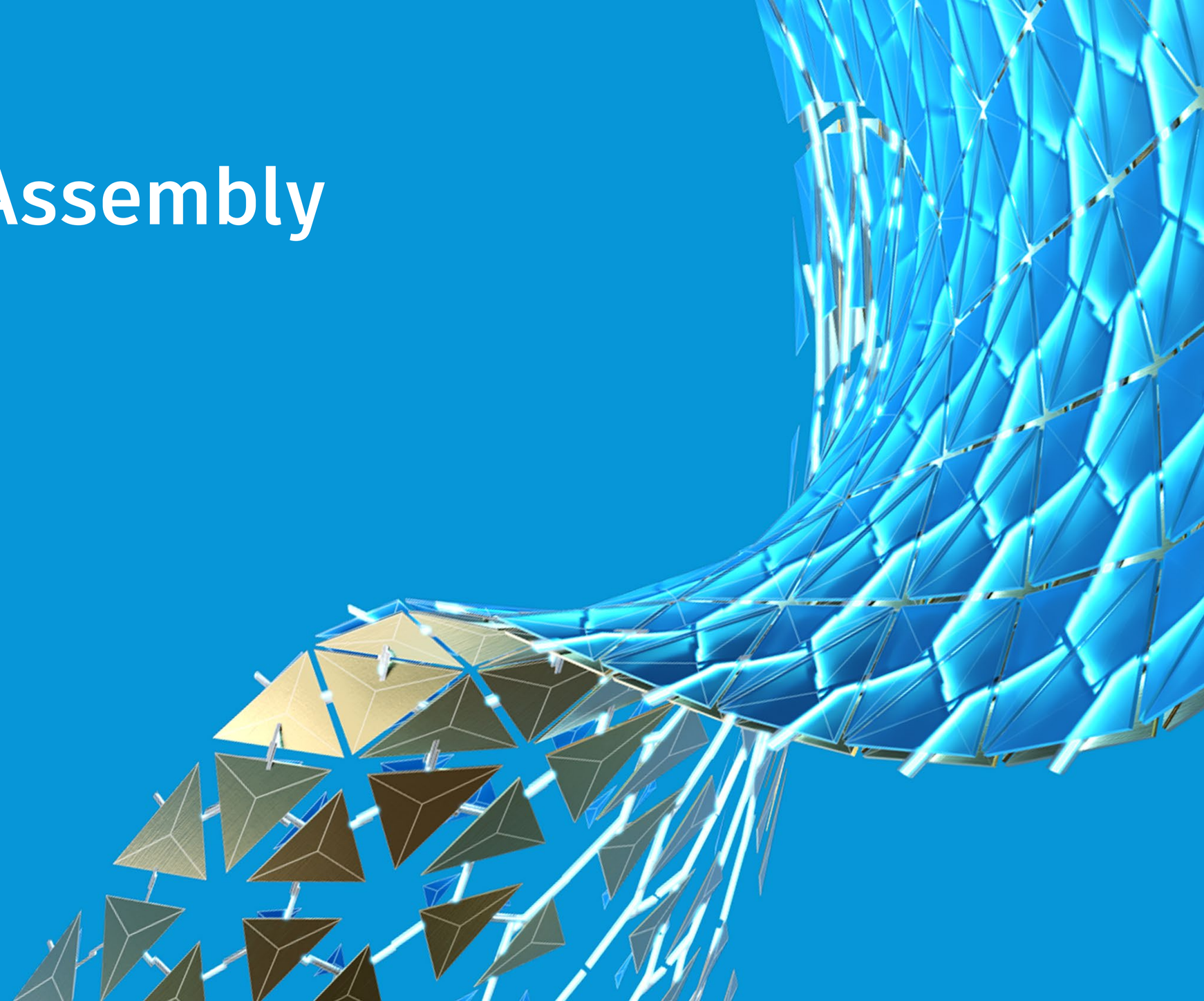
A

Machining Capabilities
- Cut
- Turn
- Mill
- Print
- Robot
- …others?…

B

New Technology Capabilities:
- Additive Manufacturing
- Generative Design
- New Materials

Design for Assembly



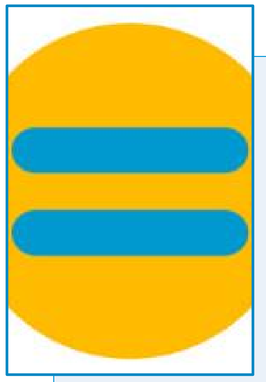
Part Reduction

Removed Parts Are Never

Designed / Detailed	
Prototyped / Produced	
Scrapped	$
Tested / Re-engineered	
Purchased	
Received and Stored	
Inspected / Tested / Rejected	
Outdated / Written-off	$
Unreliable / Late from Supplier	

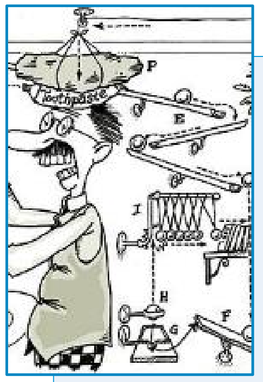
Remove the part, remove the problem!

Part Standardisation / Complexity / Cost



Can Part be Standard?

- Within this Sub- Assembly?
- Within the Full Assembly?
- Within the Business Unit?
- Across the Enterprise?
- Across the Industry?
- Does a Standard Part Already Exist in the Market?



$$\sqrt{Np \times Ni} \times 100$$

Is Part Too Complex?

- Np = Number of Parts
- Ni = Number of Interfaces to Other parts
- Complexity = Square Root of (Np*Ni) x 100
- Smaller value is always better
- Simplify both Np and Ni



Does Part Cost Too Much?

- **Estimate** the percentage of overall cost of each part in the assembly

  Question: if a part has high expense: is it too complex? Why is this?

  Question: if Fasten/Glue/Bond costs are high: is there a better design option?

Error Proofing



Remove Possibility to Omit Parts

- Try to design such that parts will not fully assemble if a part is missing



Remove Possibility to Assemble Wrong Part

- Try not to have similar looking parts in same assembly

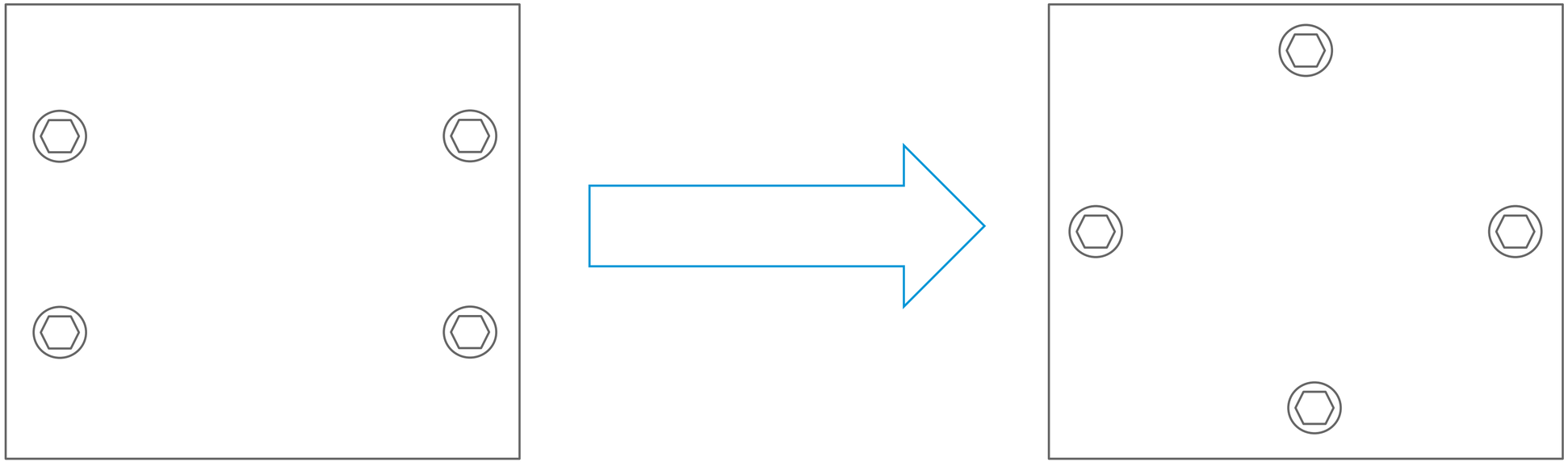


Remove Possibility to Assemble a Part the Wrong Way Around

- Encourage symmetrical design wherever possible

Reduce Re-orientation

Symmetry Reduce Need to Re-orient Parts



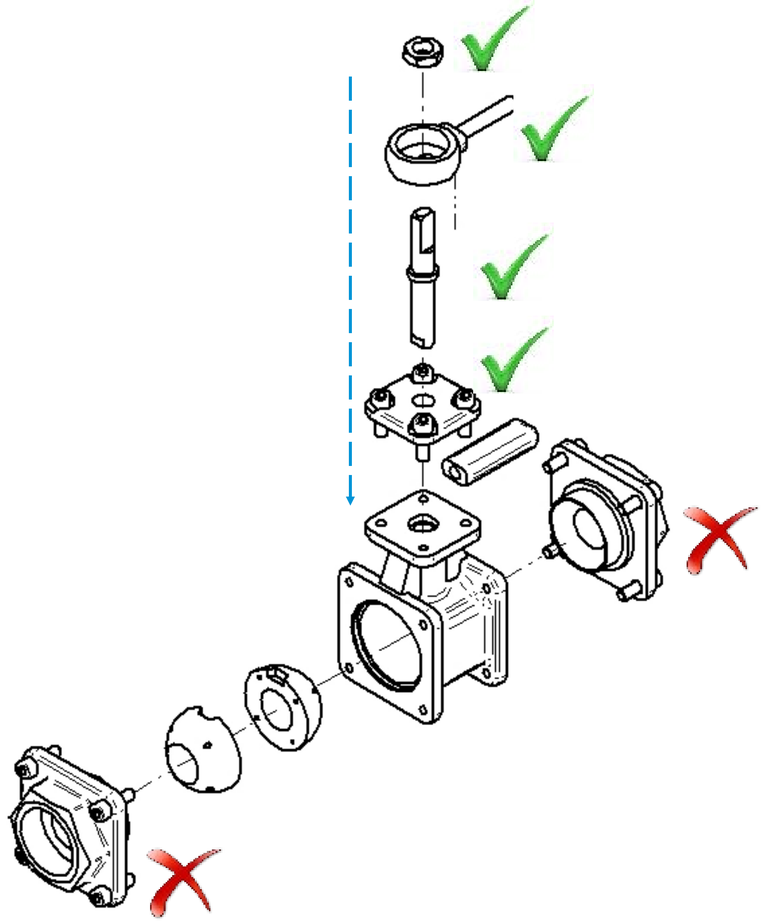
Part may need to be rotated for correct assembly position

Part can be assembled any way around

Top-Down Assembling

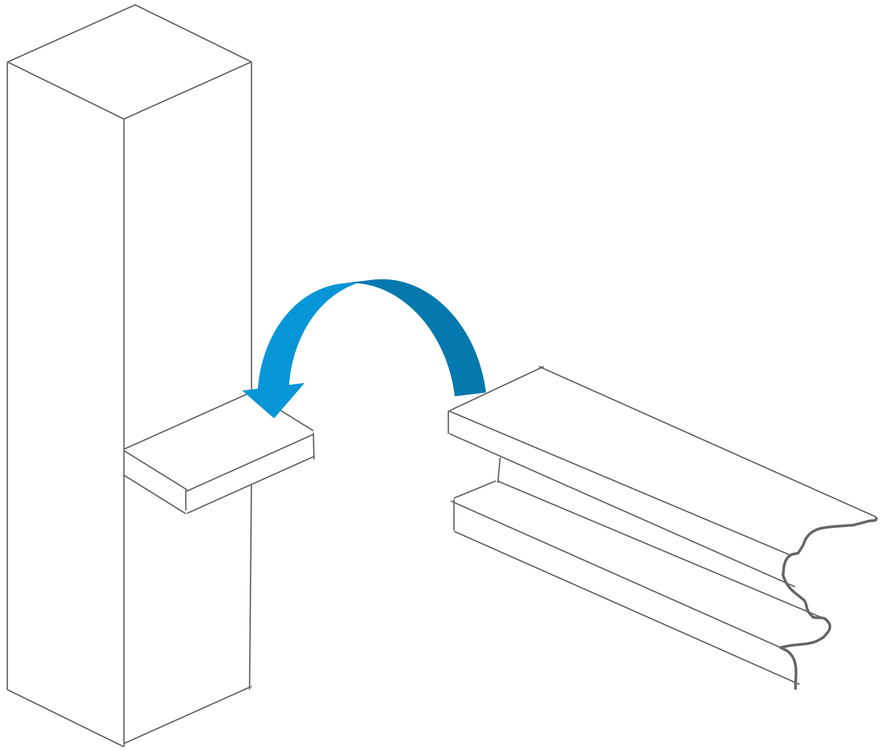
Make Gravity Work For You

- **Always Design (where possible) to Assemble from Above: (gravitational advantage)**
  - Less need for additional holding actions/equipment during assembly process
  - Parts “lead into place” naturally
  - Reduces assembly time
  - Reduces likelihood to drop parts (which could damage or get lost)

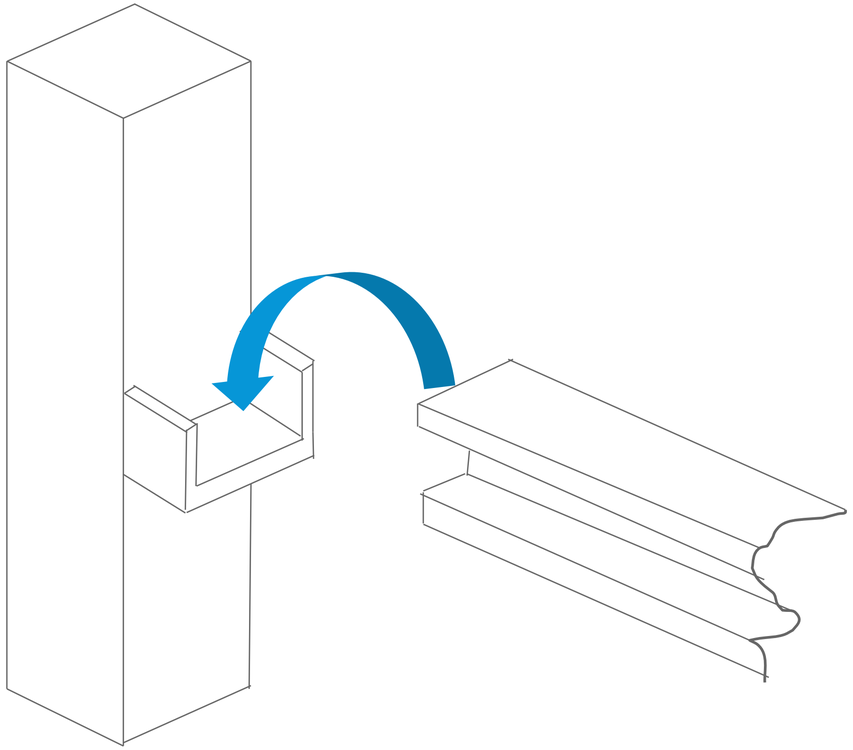


Example Consideration of DoF

How many DoF are there, if the I-Beam sits on the plate, hard up against the column, ready for welding?



How many DoF are there, if the I-Beam sits in the cup, hard up against the column, ready for welding?



Difficult to Handle Optimisation



Too small: Droppages/losses, needs handling tools, difficulty in aligning



Too big: Is it adding extra weight? Do we need handling equipment? Does it slow down assembly?



Too thin: Will it break? Can the worker be cut/injured?

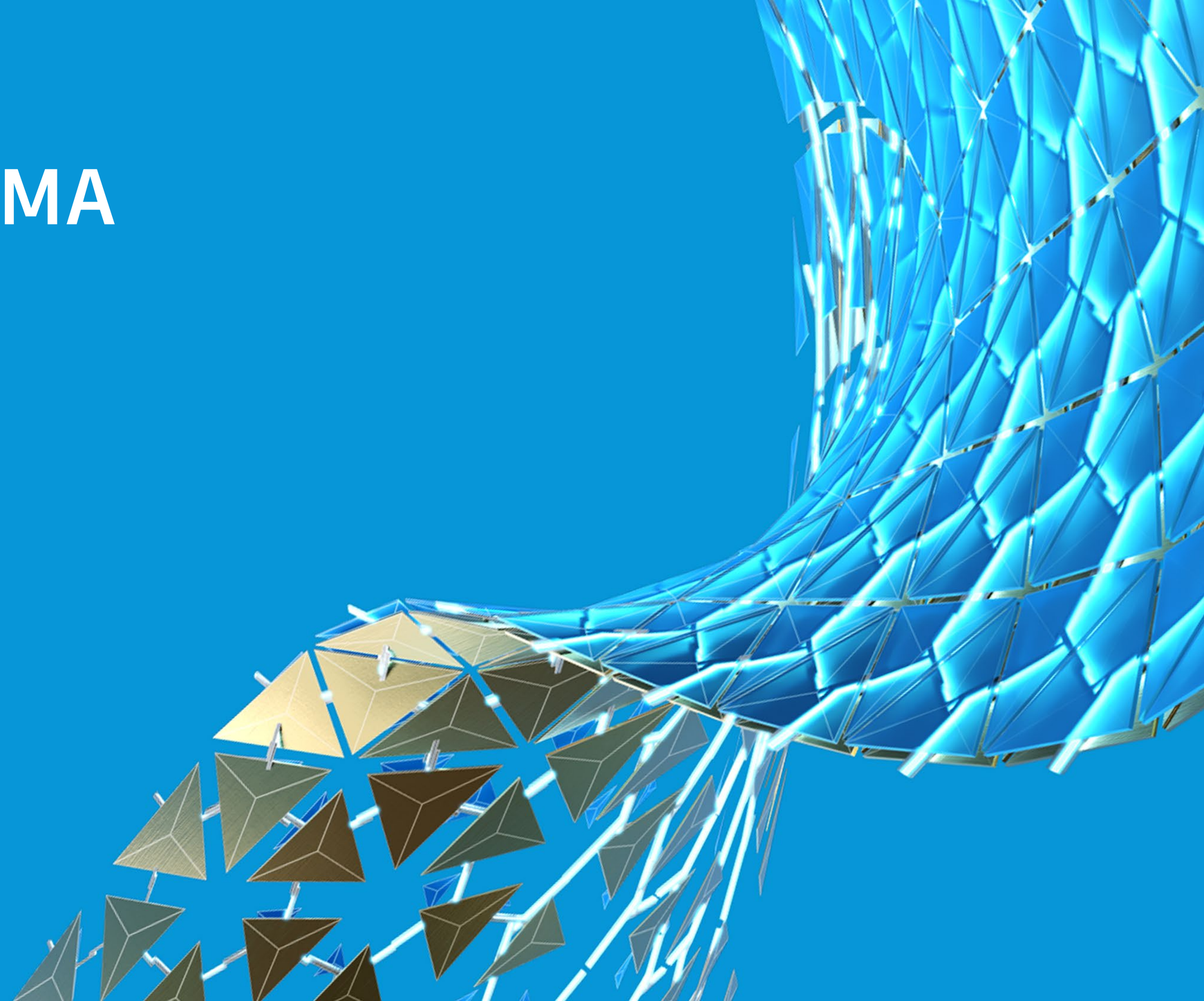


Too thick: Is it adding extra weight? Do we need handling equipment? Does it slow down assembly?

Modular Assemblies

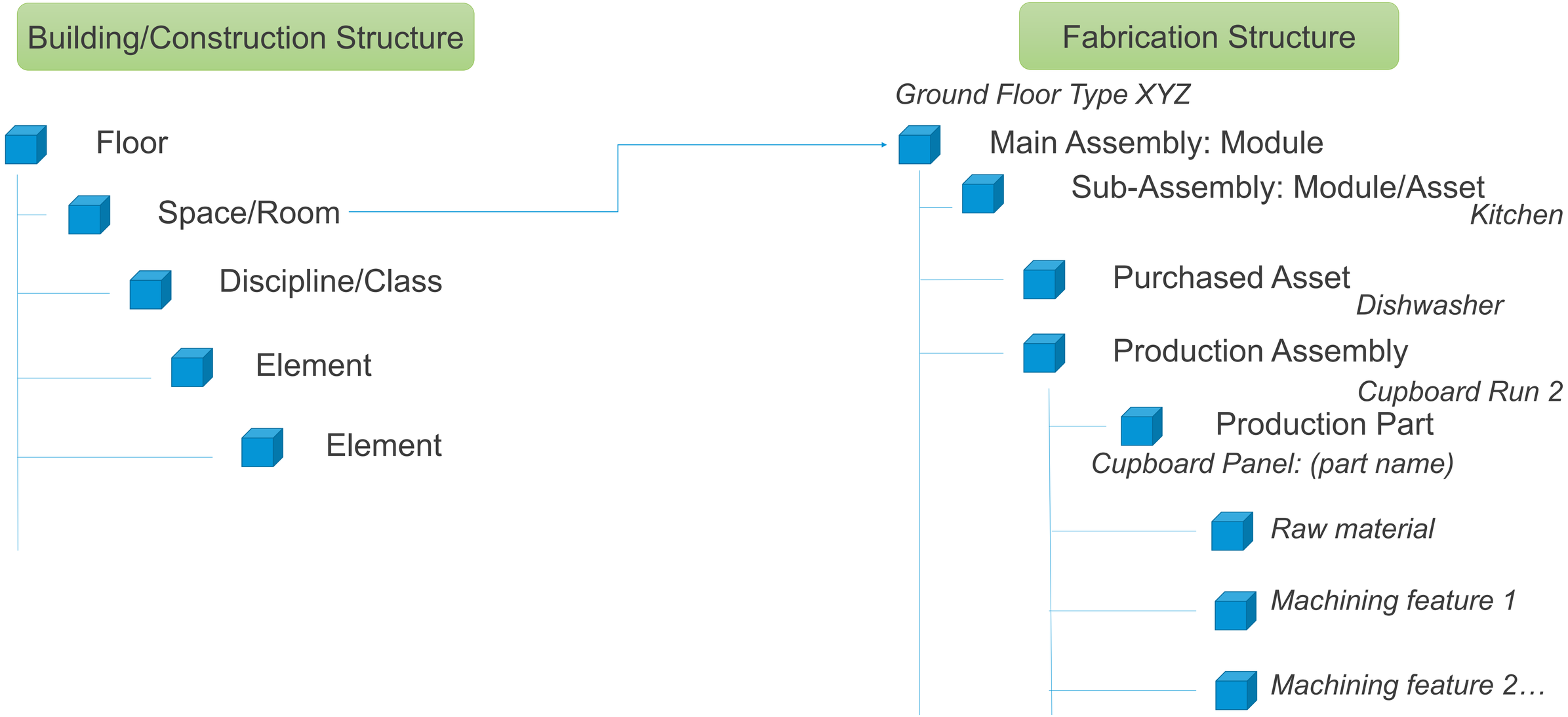
- Possibility to pre-assemble (and pre-test) complex sub-assemblies
- Encourages common alignment across designs/project; increasing quality/ reliability and reducing cost
- Enables faster assembly/maintenance operations
- Drives down costs, drives up quality/compliance (faster assembly with less errors than onsite assembly)
- Faster process allows more space to work on “special custom projects”
- Reduces tendency for “one-off” obscure designed parts
- Encourages removal of unnecessary parts
- Supports faster, better design process (through parametric models)

Applying DfMA



Importance of Stable Product Structures

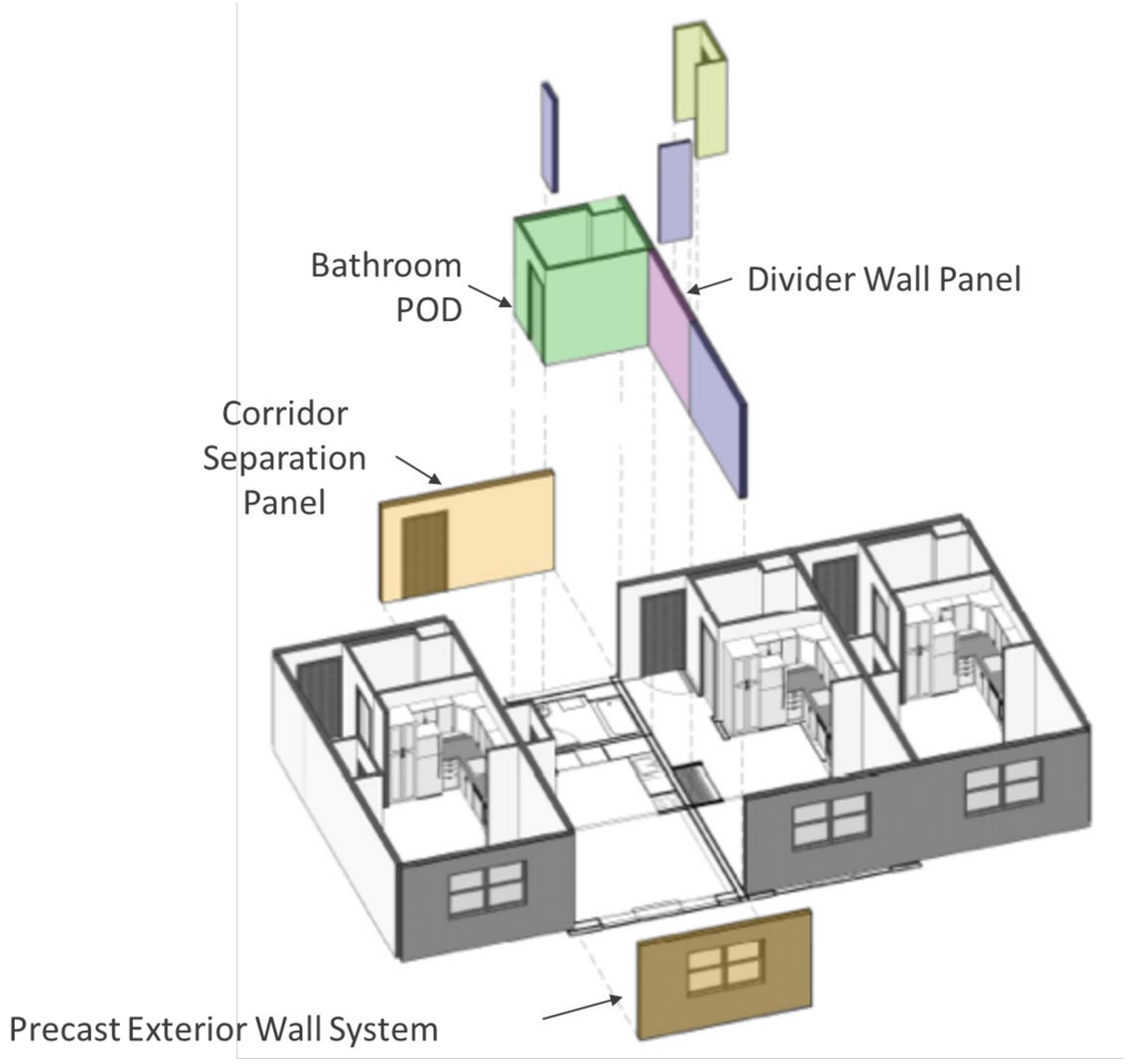
DfMA requires well defined product structures, to realize optimization benefits



DfMA Element Specific

DfMA principles are both generic and element specific

Element specific DfMA is a particular set of instructions that apply to one type of element and include the proprietary rules of each manufacturer – because there are few standards



Prefabrication Continuum

Prefabrication is a broad term that encompasses the creation of building elements in a **controlled environment** that are **transported** to their final destination preferably **installed on-site** using accelerated **assembly** methods.



Advanced Building Products



Single-Trade Assemblies



Multi-Trade Assemblies



Volumetric Modules



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