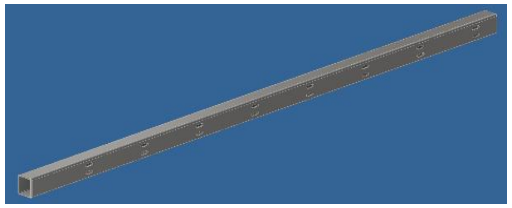
Practicing Digital Transformation in the Offsite sector

Fabien Crochetet

crochetet@cobuilder.com

Offsite Construction Show 2019

Going digital…is about dealing with the **How** as well as the **What**



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Extending digital **data flow**

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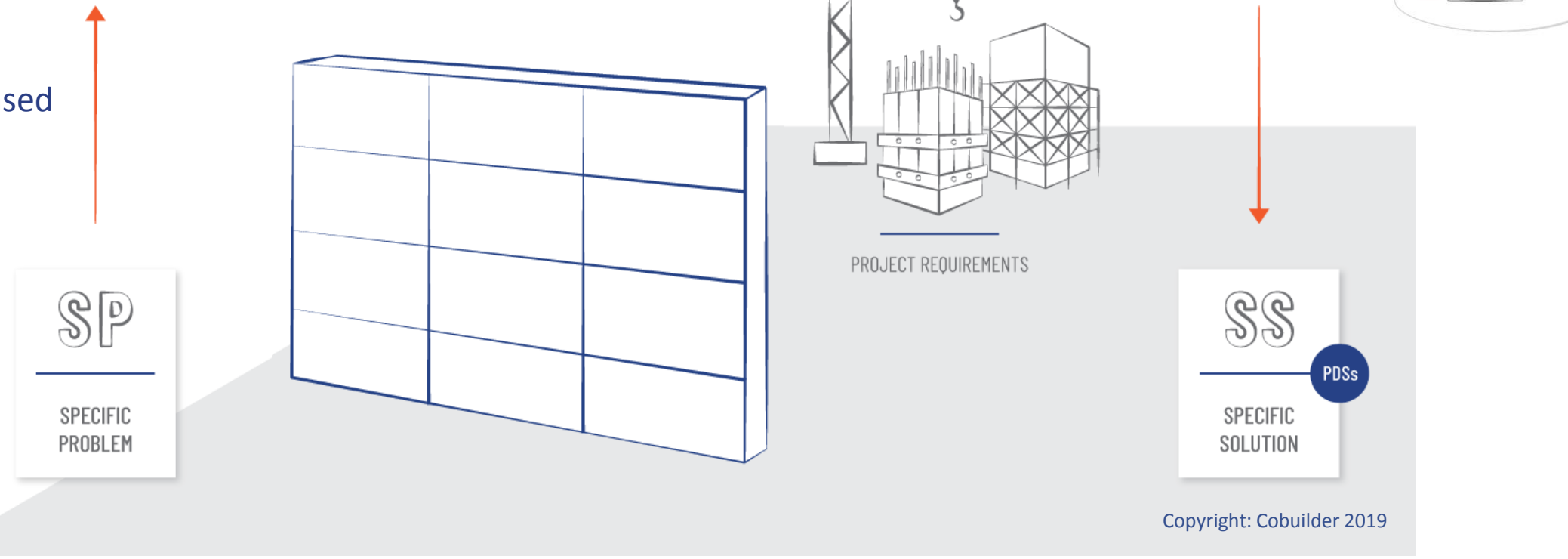
Cobuilder: Standard-based data Management approach

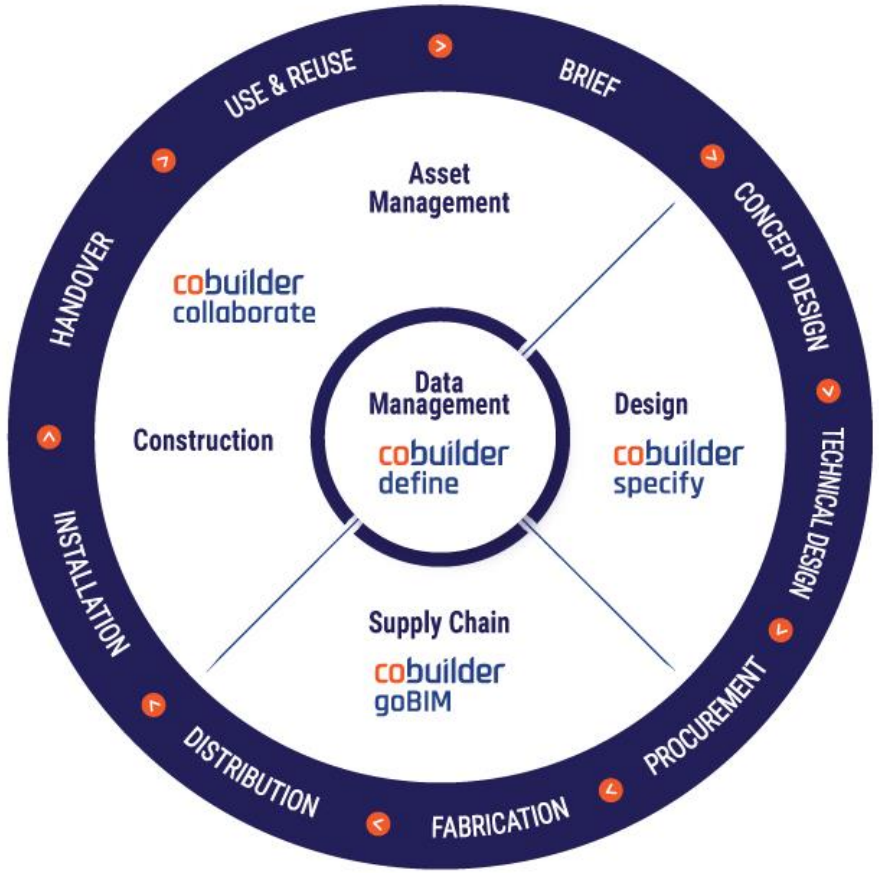
No standard-based data model



- Siloed Info
- Low data quality
- Redundancy
- Low efficiency
- Errors

The Cobuilder Platform

- Provides BIM data solutions
- Enables clients to streamline business processes
- Flexible and integrated SaaS platform provides customers with a centralized approach to manage documents and product data



- Aims to help all players in the AECO industry to connect and exchange information along the supply chain
- Improve project efficiency, productivity and accountability
- Lowers the cost and risks in delivering projects of all sizes

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Thank you!

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Pioneering an offsite manufacturing logic
James Smith – Technical Director – Majenta
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AGENDA

- Disruptive Technologies / BML Approach + Strategic Drivers
- Offsite Manufacturing
- Module Design
- Controlling Data Flow / Structured Product Data
- A PLM mindset
- Solution Challenges
- Solution As-is

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Disruptive Technologies

c200 years ago → Industrial Revolution

c100 years ago → Transport Revolution

c0 years ago → Offsite Revolution

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BML Approach –

- Peak capacity: 2no shifts
- Shift Capacity: 6no modules
- Max Module Size: 12.0m*4.5m* 3.5m
- Module Cycle Time: 40 hours
- Max Module Weight: 20 tonnes
- Daily Replenishment: 244 tonnes

BML Strategic Drivers –

- Skills
- Pipeline Surety
- Product Performance

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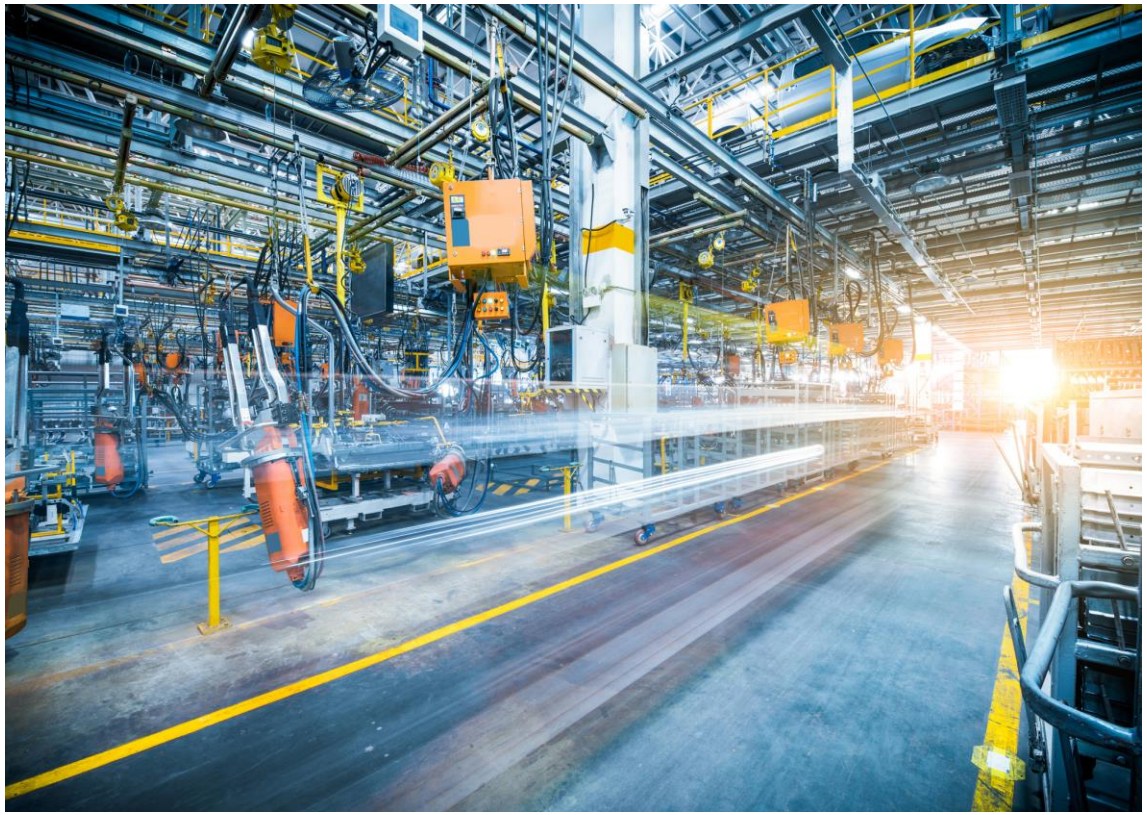
Offsite Manufacturing

1. Manufacturing, not construction
2. Productivity cn be leveraged using robotics, advanced automation and sophisticated control systems
3. A factory-based approach yields scope for scalability



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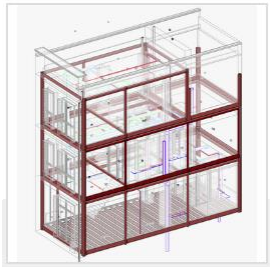
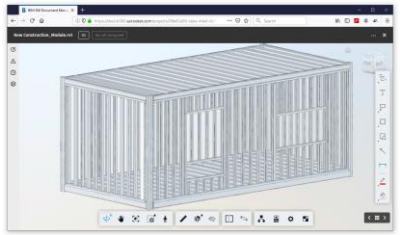
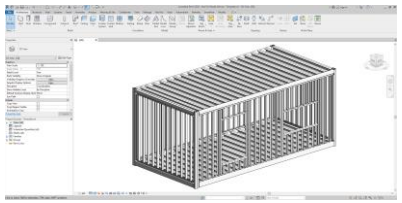
Module Design



Architectural Model



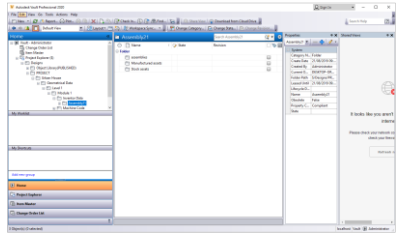
BIM Data



Module Rules

Module Requirements

Rules Engine



Manufacturing Encyclopedia

Mechanical CAD Model

Cold Rolled Steel NC Data

Paneling/Insulation NC Data

AUTOCAD

Works Instructions

ERP Data

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Module Design

RULE-BASED APPROACH ADVANTAGES –

- Resource efficient with automatic data generation after
- Predictable outcomes as generation of data always yields same results
- Auditable rules and data sets from formalized / captured learning
- Rules enhancement captures learning and design improvements
- Control of change management
- Rapid execution supporting compresses production cycles
- Scalable solution

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Module Design

RULE-BASED APPROACH DISADVANTAGES

- Needs Defined Product – Manual variants disruptive
- Up-Front Investment – Offset by cost benefit of each advantage

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Controlling Data Flow

- Challenges associated with creating a complete and accurate digital record for a new residential development from conception, through the design and build cycle to practical completion, are pernicious
- At BML, we have sought to develop a transformative methodology for creating digital connectivity and our digitally enabled agile manufacturing platform is intended to help resolve the conundrum of capturing the golden thread of information

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SUPPLIER REQUIREMENTS

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PRODUCT
DATA
TEMPLATE

cobuilder deliver

cobuilder collaborate

PRODUCT
DATA
SHEETS

AUTODESK® VAULT

API

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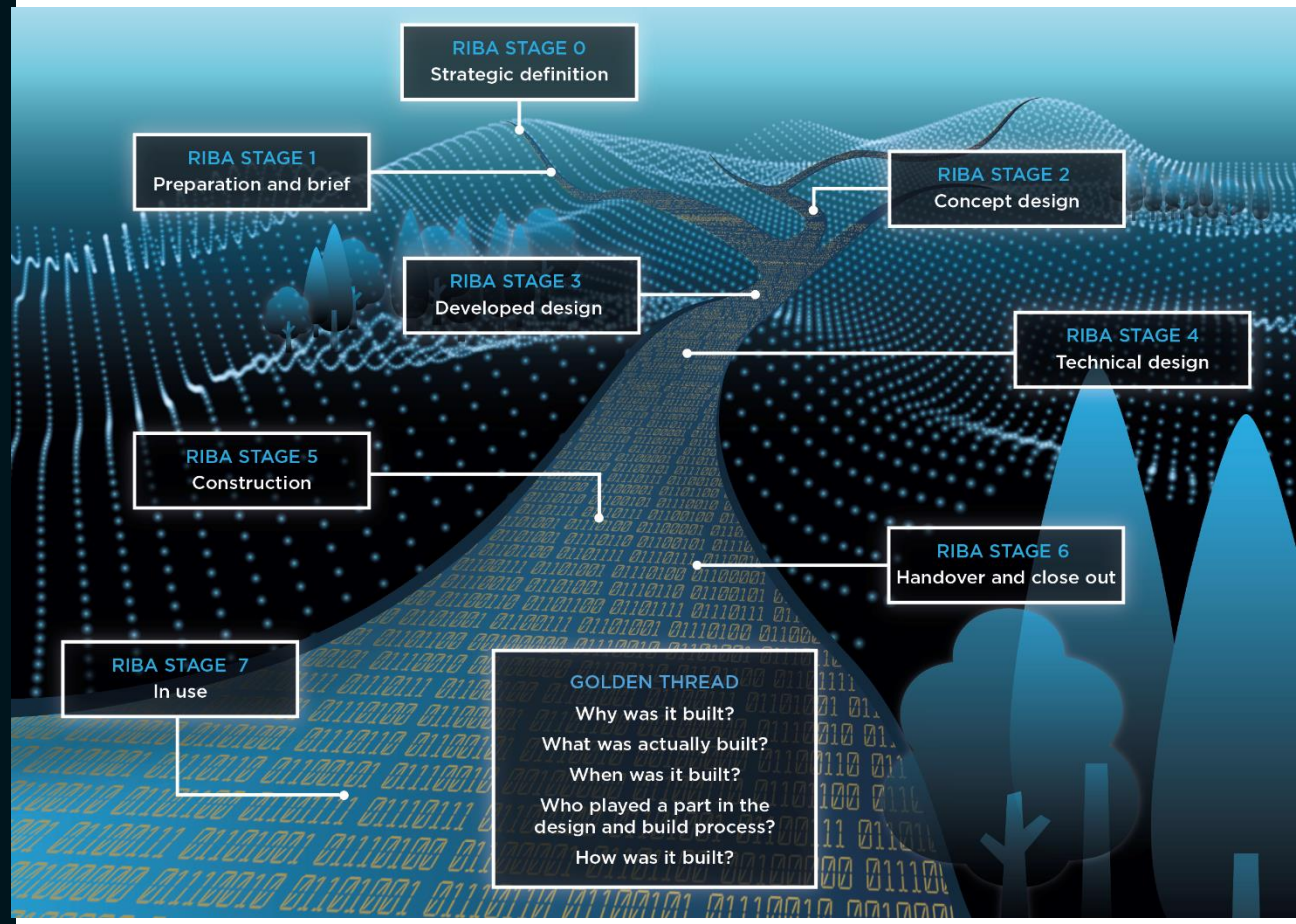
Structured Product Data.

- Lots of data
- Only create / consume what is needed
- Ready for consumption & usable
- Data lake – Must be agnostic
- Model-to-Machine code generation from digital twin
- COBie data from digital twin



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Why should I create a specification sheet for BML?

1. It gives focused product data that is co owned
2. You as a Manufacturer **OWN** your data
3. Streamlining process – Data is not being passed back and forth so there is no data loss
4. Design changes can be relayed at pace

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Focus on Productivity.

1. Not restricted to a single tool
2. Automation
3. Streamlining process
4. Removing human interaction

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Single Source of Truth.

1. Data is king
2. Reliable and robust
3. Ordering materials
4. Downstream liability
5. Partnership with suppliers

AUTODESK.

das
Design Automation Systems

ORACLE®

SIEMENS

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Scalable Solution (Capable of creating 2500 Modules per year).

1. Data useable / Increase in scope
2. Not limited to manpower
3. 2500 Target
4. Agile/Adaptable

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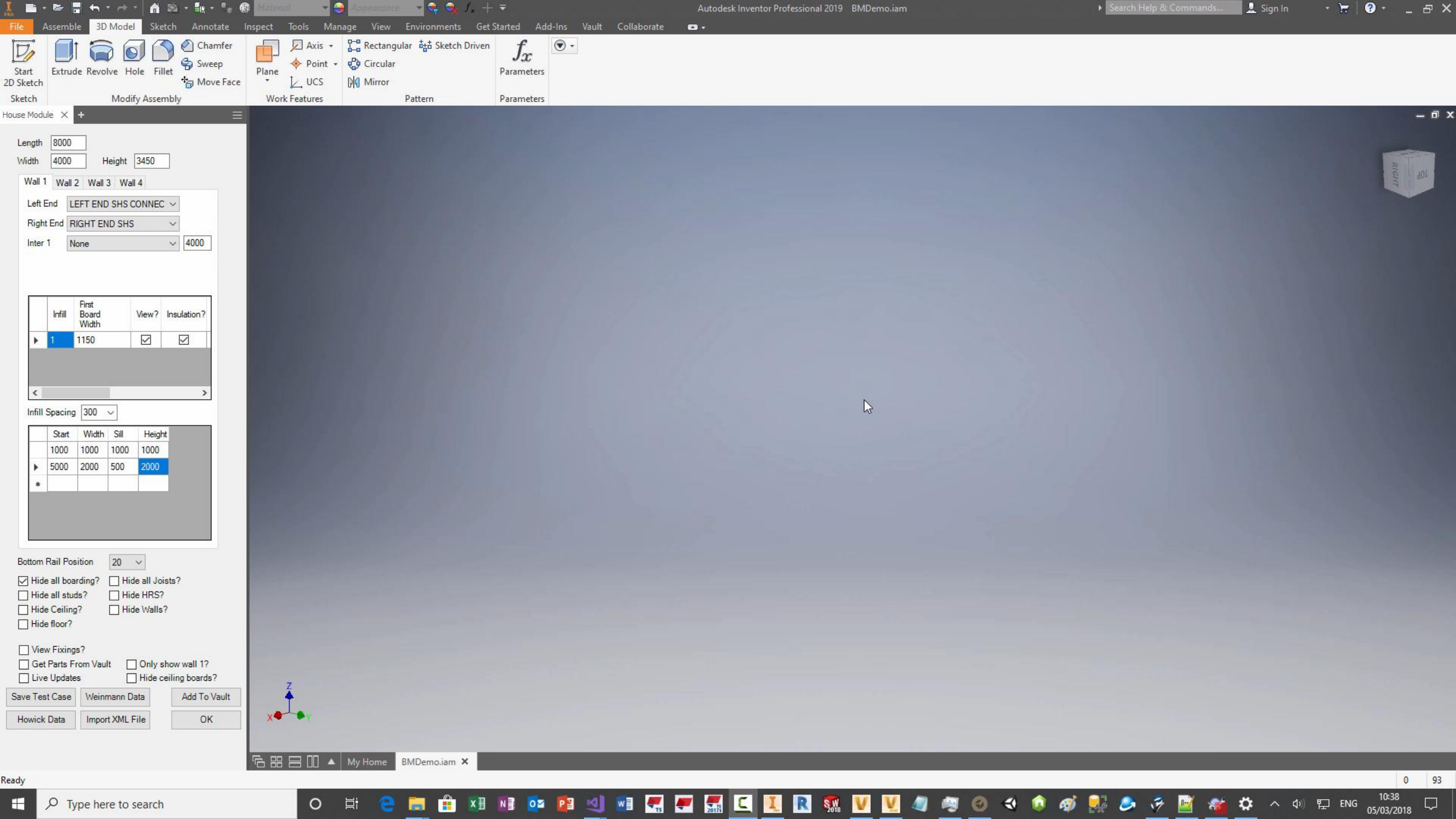
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Tools
Manage
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Environments
Get Started
Add-Ins
Vault
Collaborate
Start 2D Sketch
Extrude
Revolve
Hole
Fillet
Chamfer
Sweep
Move Face
Modify Assembly
Plane
Axis
Point
UCS
Work Features
Rectangular
Circular
Mirror
Sketch Driven
Pattern
Parameters
Parameters
House Module
Length 8000
Width 4000
Height 3450
Wall 1
Wall 2
Wall 3
Wall 4
Left End LEFT END SHS CONNEC
Right End RIGHT END SHS
Inter 1 None 4000
Infill
First Board Width
View?
Insulation?
1 1150
Infill Spacing 300
Start
Width
Sill
Height
1000 1000 1000 1000
5000 2000 500 2000
Bottom Rail Position 20
Hide all boarding?
Hide all Joists?
Hide all studs?
Hide HRS?
Hide Ceiling?
Hide Walls?
Hide floor?
View Fixings?
Get Parts From Vault
Only show wall 1?
Live Updates
Hide ceiling boards?
Save Test Case
Weinmann Data
Add To Vault
Howick Data
Import XML File
OK
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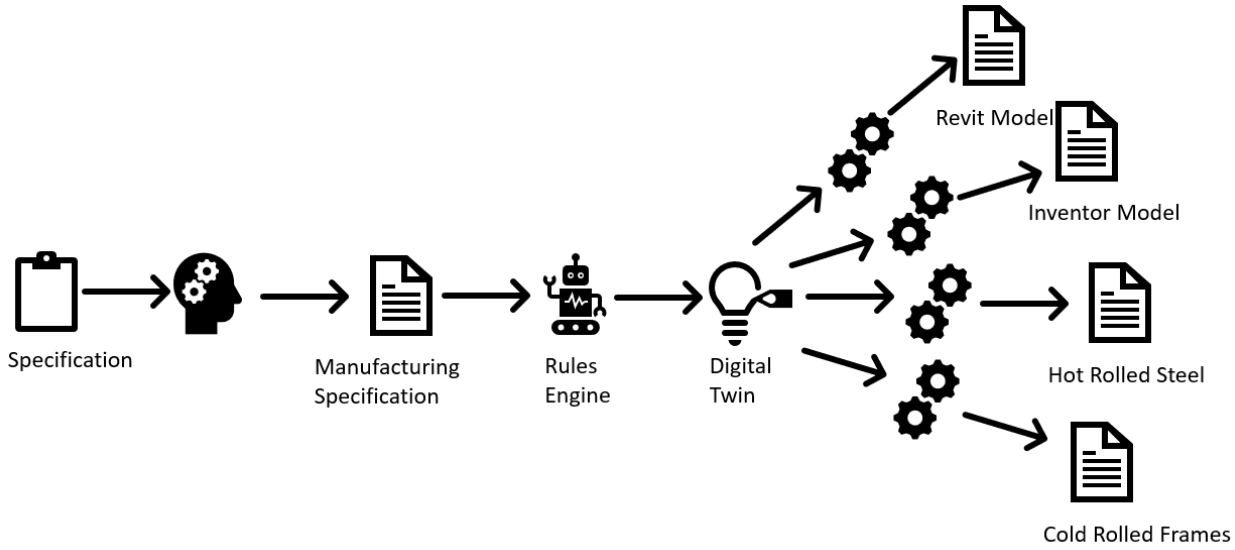
A PLM Mindset.

1. Learn from Automotive / Aerospace / Traditional Manufacturing
2. Golden thread



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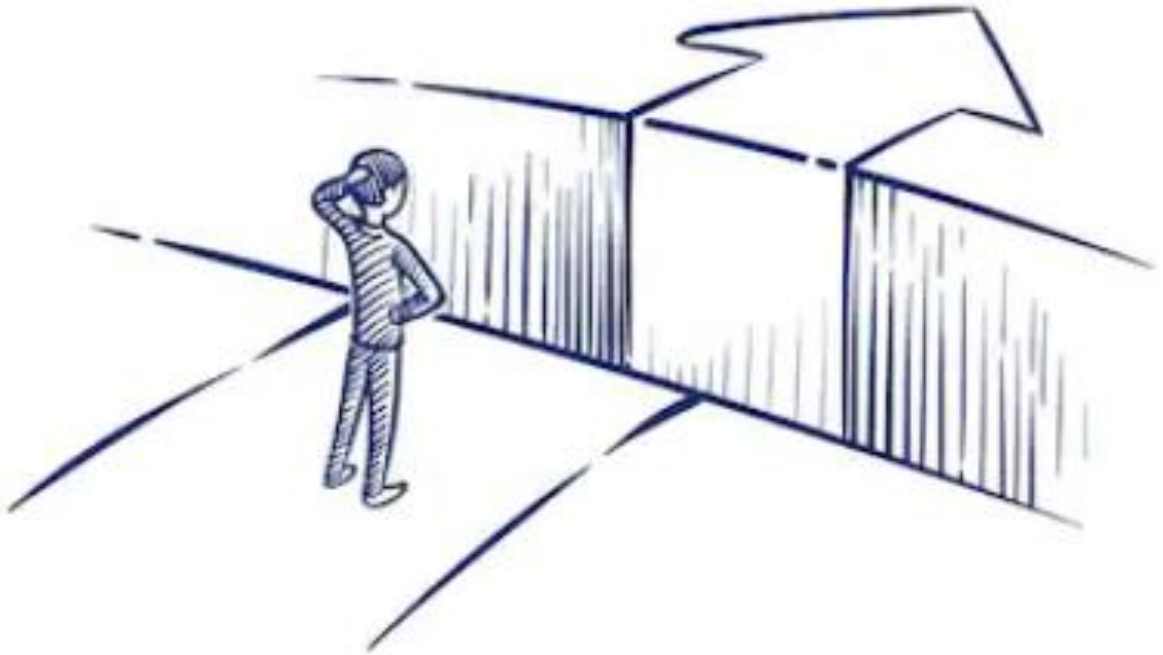
Solution Challenges.

1. Data Validation/Quality
2. Data Filtering
3. Storage



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“Data pollution will quickly turn our Data Lake into a Data Swamp”

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Application of rule-based engineering to modelling

Royston Young / Neil Lee

November 2019

About the speakers

Royston Young

A founding director of Design Automation Systems Ltd (DAS) with over 20 years experience of working with proprietary Knowledge Based Engineering (KBE) platforms and developing platforms for both Autodesk and their own .NET platform for construction. Worked on key infrastructure projects such as Heathrow T5, reducing a 26 man-year wall detailing process to 8 hours.

Neil Lee

Director of Design Automation Systems, a software consultancy that has specialised in rules-based automation of design and engineering for over 20 years. Prior to this, Neil did a combined software / engineering degree and was a Director of a consultancy focused on finance, ERP and accounting software

Digital As An Enabler

ERP
ORACLE

Critical functionality associated with product management, people management, supply chain engagement and finance

MES
SIEMENS

Critical functionality associated with delivery of work instructions to people and machinery, plus capture of quality data

PLM
AUTODESK

Critical functionality associated with model generation data hosting, bill of material / process creation, and information exchange management

X
DAS / MAJENTA

Critical functionality associated with product data migration, design automation and direct model-to-machine conversion logic

Module Design

OUTPUT

Peak capacity of facility based on two shifts is a finite number of modules

DURATION

Days required to create a fully federated, data rich digital model of a single module

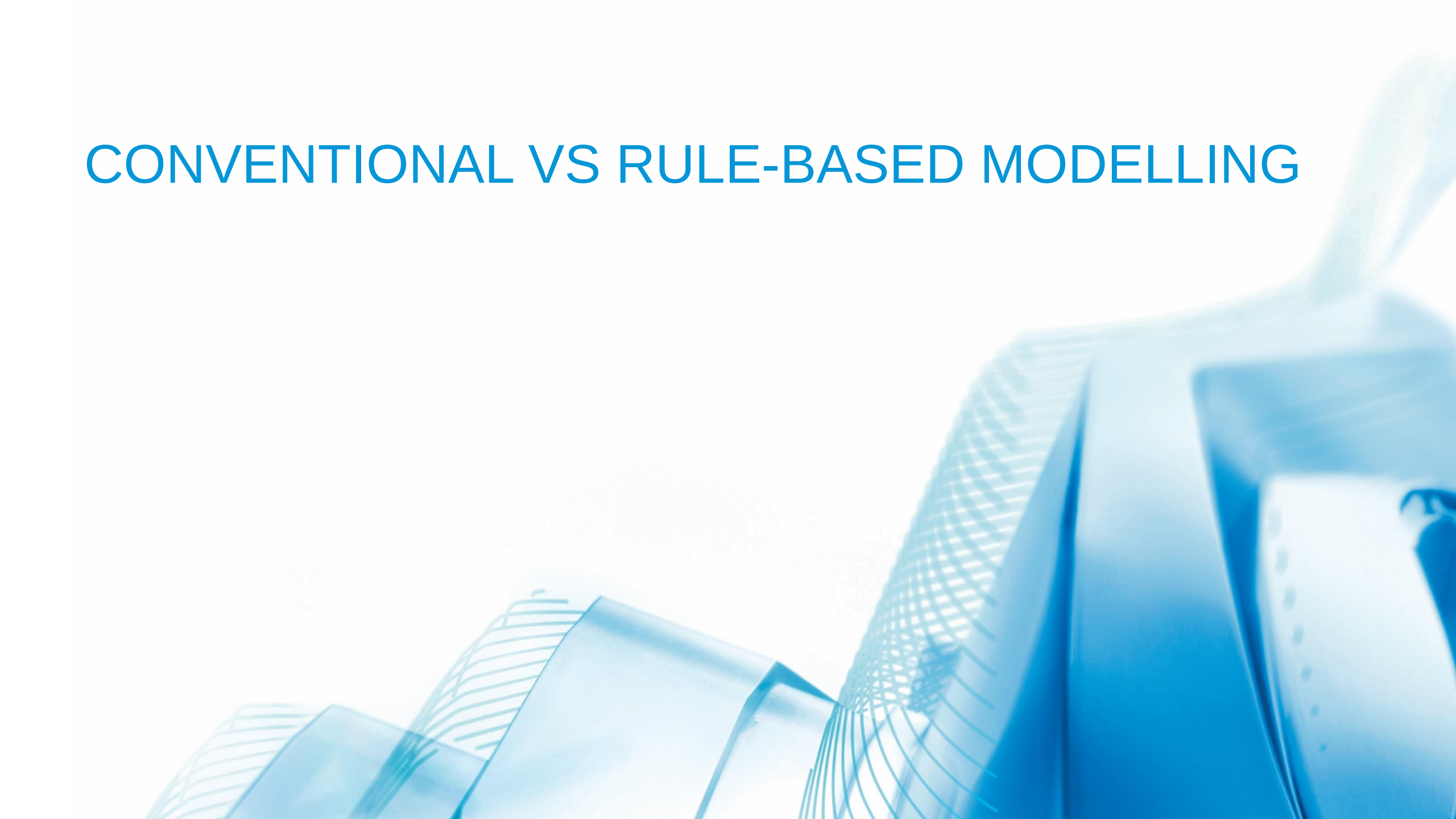
WORKING TIME

Number of physical working days in each calendar year is limited assuming no overtime

DESIGN RESOURCE

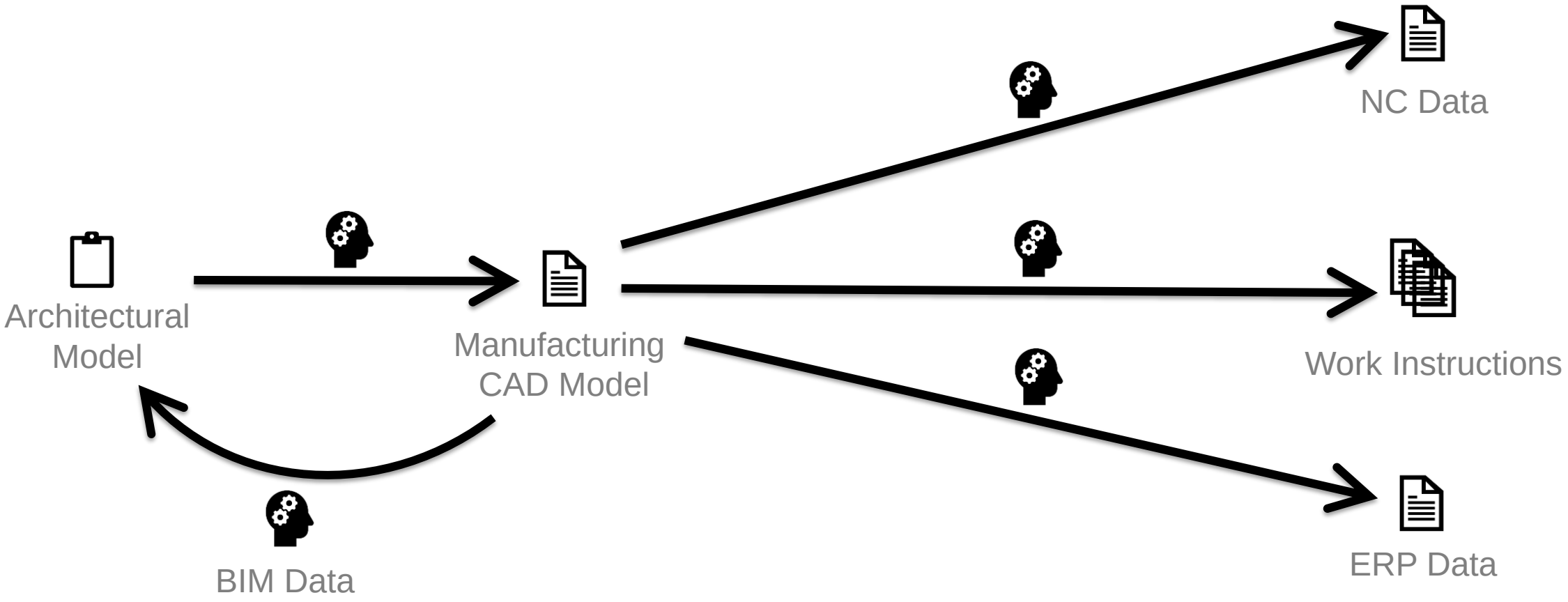
Conventional approach to modelling would yield a technical headcount that was unaffordable

CONVENTIONAL VS RULE-BASED MODELLING



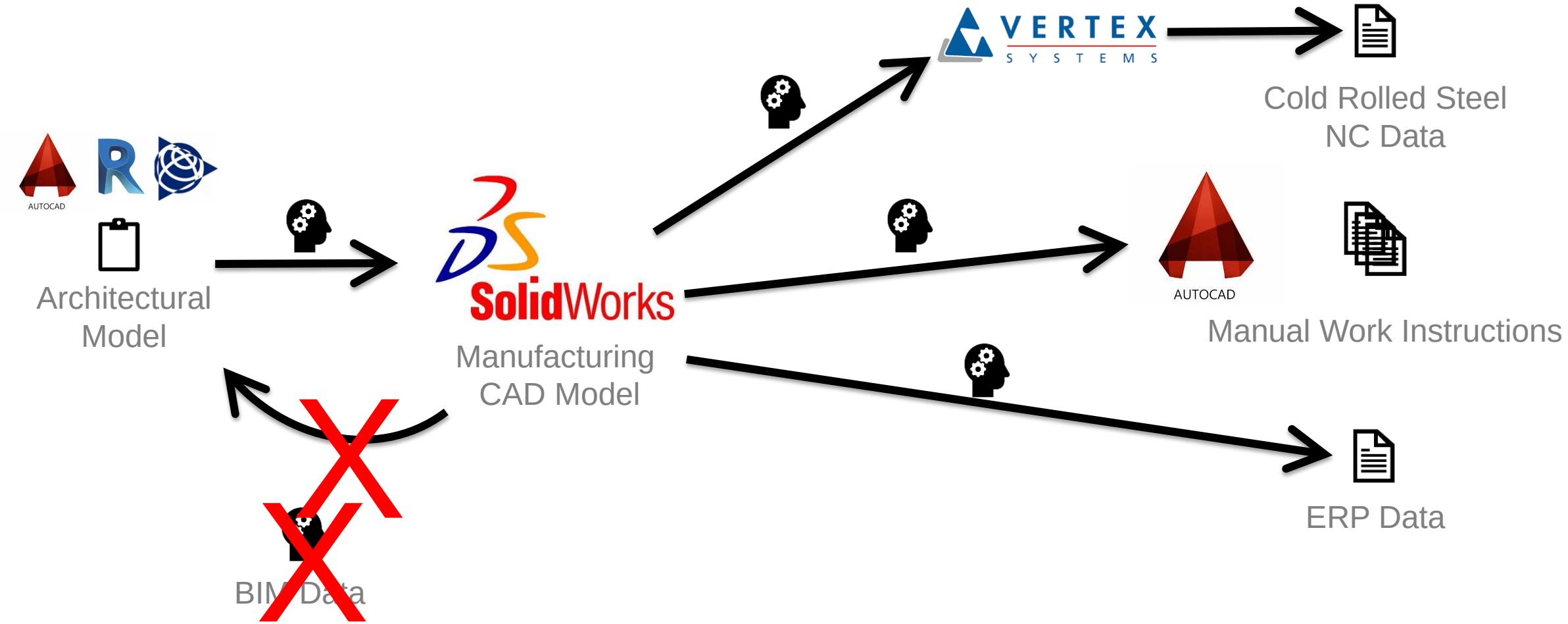
Module Design

Conventional approach –



Module Design

Real world example – Building steel frames with cold-forming machinery



Module Design

CONVENTIONAL APPROACH ADVANTAGES –

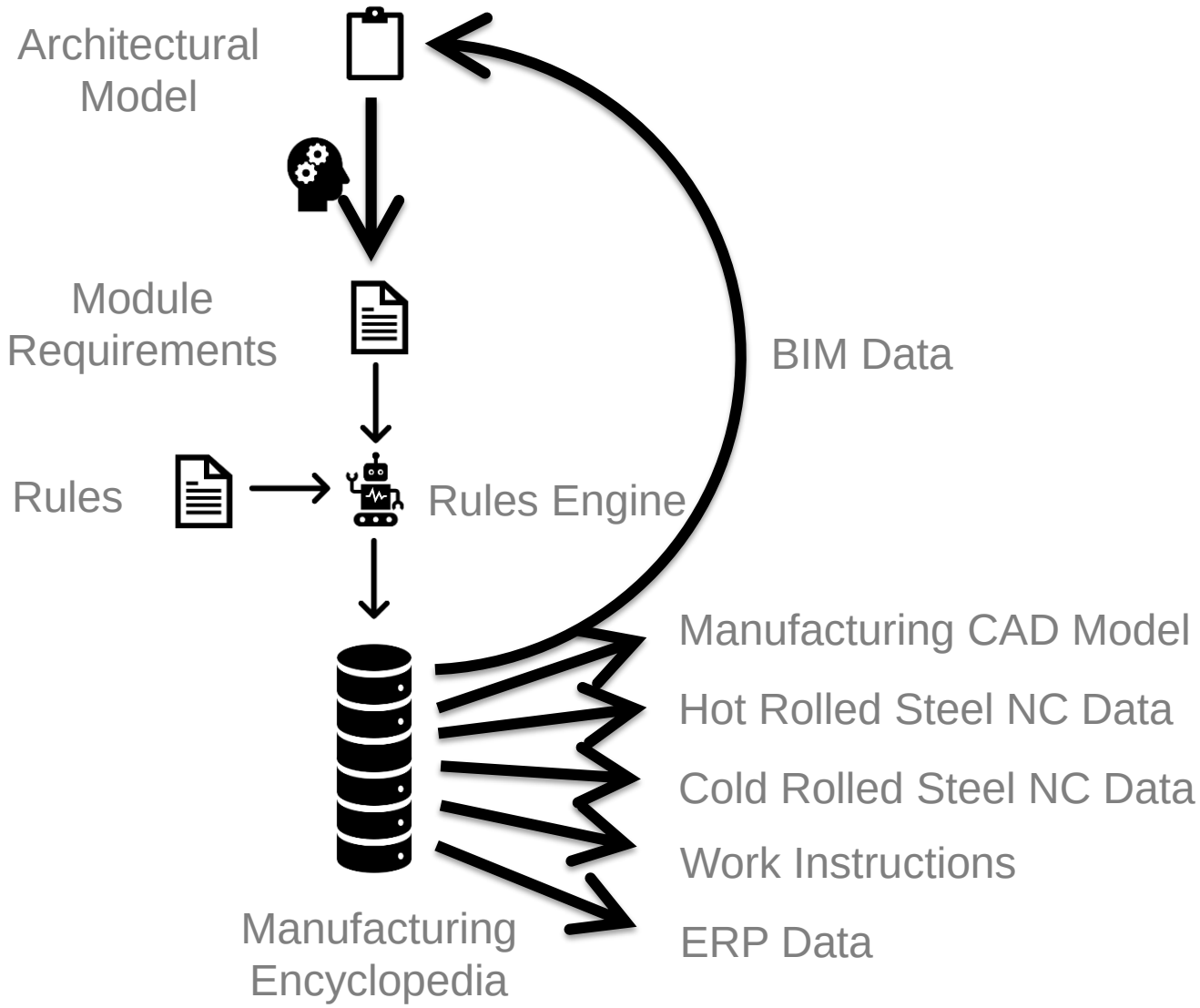
- Flexible since it allows changes at any stage

CONVENTIONAL APPROACH DISADVANTAGES –

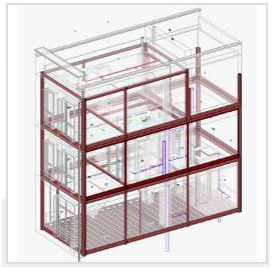
- Resources
  - Labor intensive and cumbersome
  - Multiple software platforms
    - Fragmented – Multiple CAD activities/teams
    - Recruitment – Training needs and difficult to scale
- Process
  - Error prone due to continual transcription
  - Complicated change management due to fragmentation
  - Incompatible data formats
  - No single source of truth
  - No “Golden Thread” as non-manufacturing outputs are late/non-existent/unchecked

Module Design

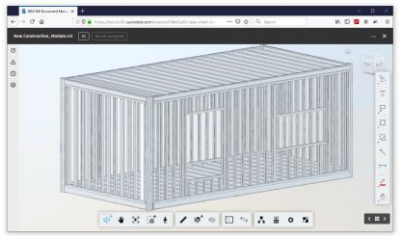
Rule-based approach –



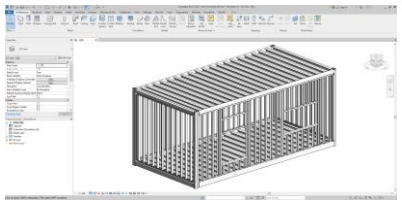
Module Design



Architectural Model



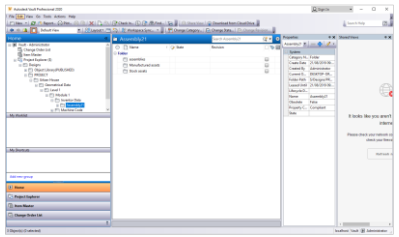
BIM Data



Module Rules

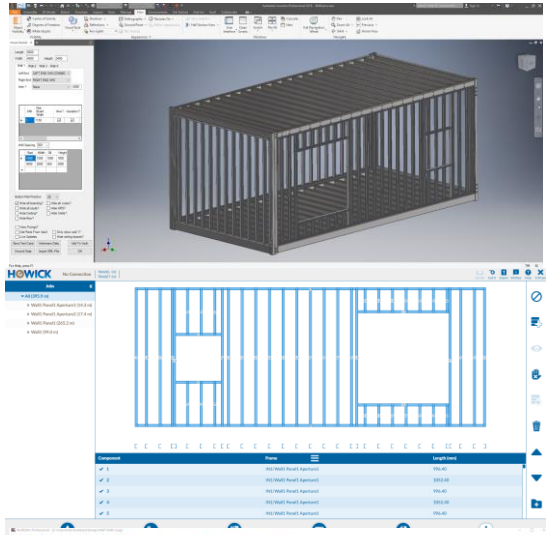
Module Requirements

Rules Engine

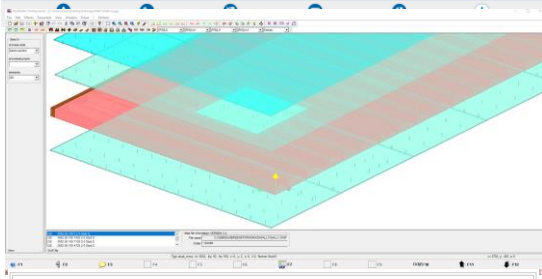


Manufacturing Encyclopedia

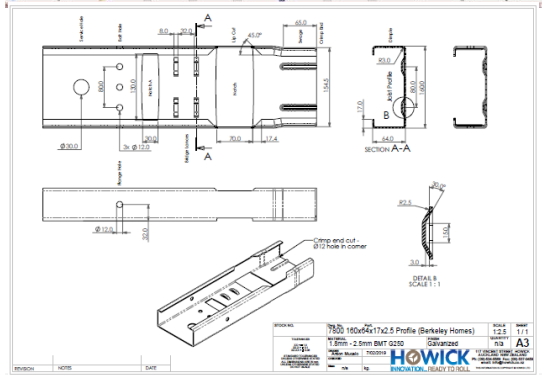
Mechanical CAD Model



Cold Rolled Steel NC Data

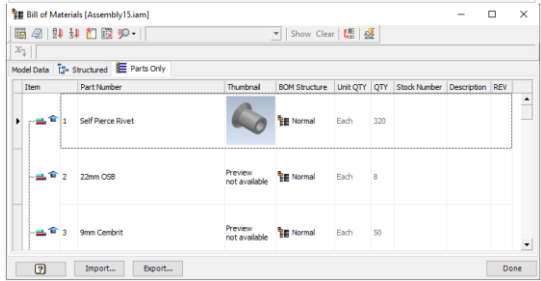


Paneling/Insulation NC Data



AUTOCAD

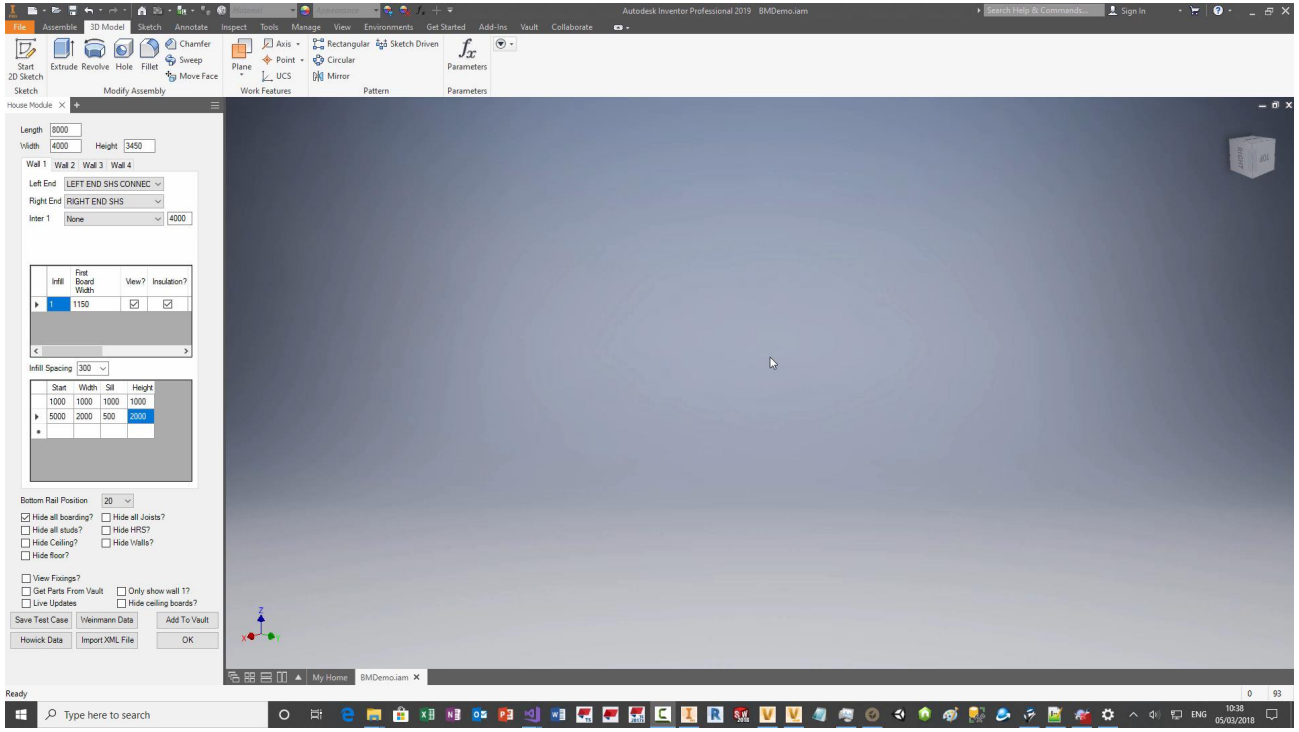
Works Instructions



ORACLE

ERP Data

Module Design



https://youtu.be/9KoSU9YhCf4

Module Design

RULE-BASED APPROACH ADVANTAGES –

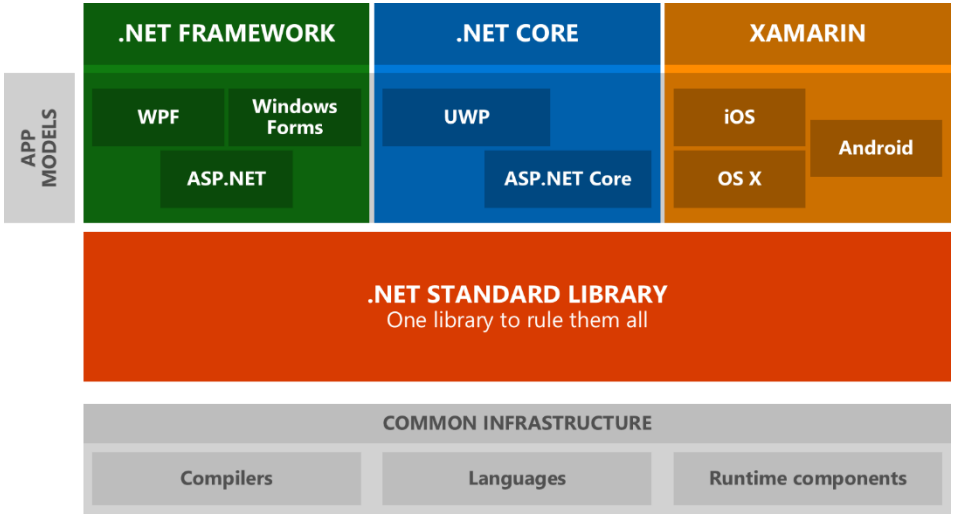
- Resource efficient with automatic data generation
- Predictable outcomes as generation of data always yields same results
- Auditable rules and data sets from formalized / captured learning
- Rules enhancement captures learning and design improvements
- Control of change management
  - Changes to requirements updates entire Manufacturing Encyclopedia
  - Engineering and manufacturing validation prevents production issues
- Rapid execution supporting compressed production cycles
- Scalable solution

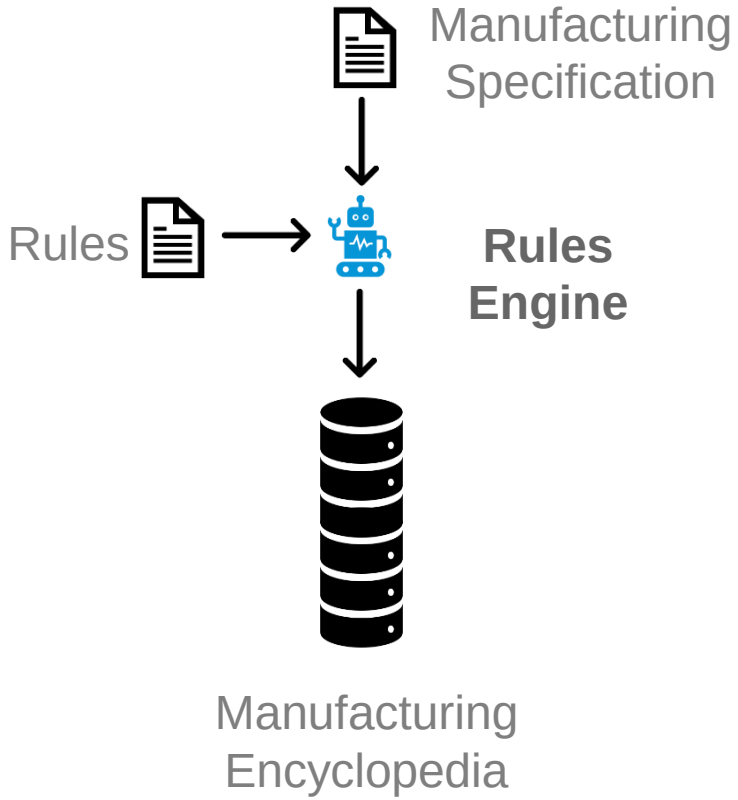
RULE-BASED APPROACH DISADVANTAGES –

- Needs Defined Product – Manual variants disruptive
- Up-Front Investment – Offset by cost benefit of each advantage

Rules Engine (Future Proofing)

- Leading development environment (Microsoft Visual Studio)
- Standard languages, so resource availability is not a concern
- Platform longevity as ONLY .NET Standard based – Evolves with new hardware and OS versions without external software / licenses
- Not vulnerable to obsolescence of third party applications
- Platform Independent – Windows/Mac/AWS/Azure/Forge

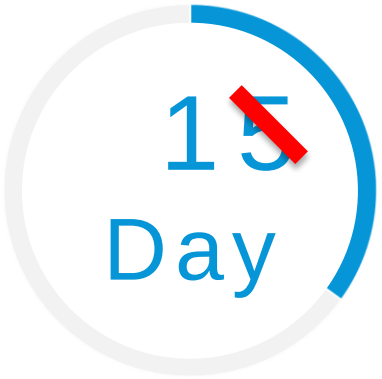




The Modelling Challenge

OUTPUT

Peak capacity of facility based on 2no shifts is a finite number of modules



DURATION

Days required to create a fully federated, data rich digital model of a single module

WORKING TIME

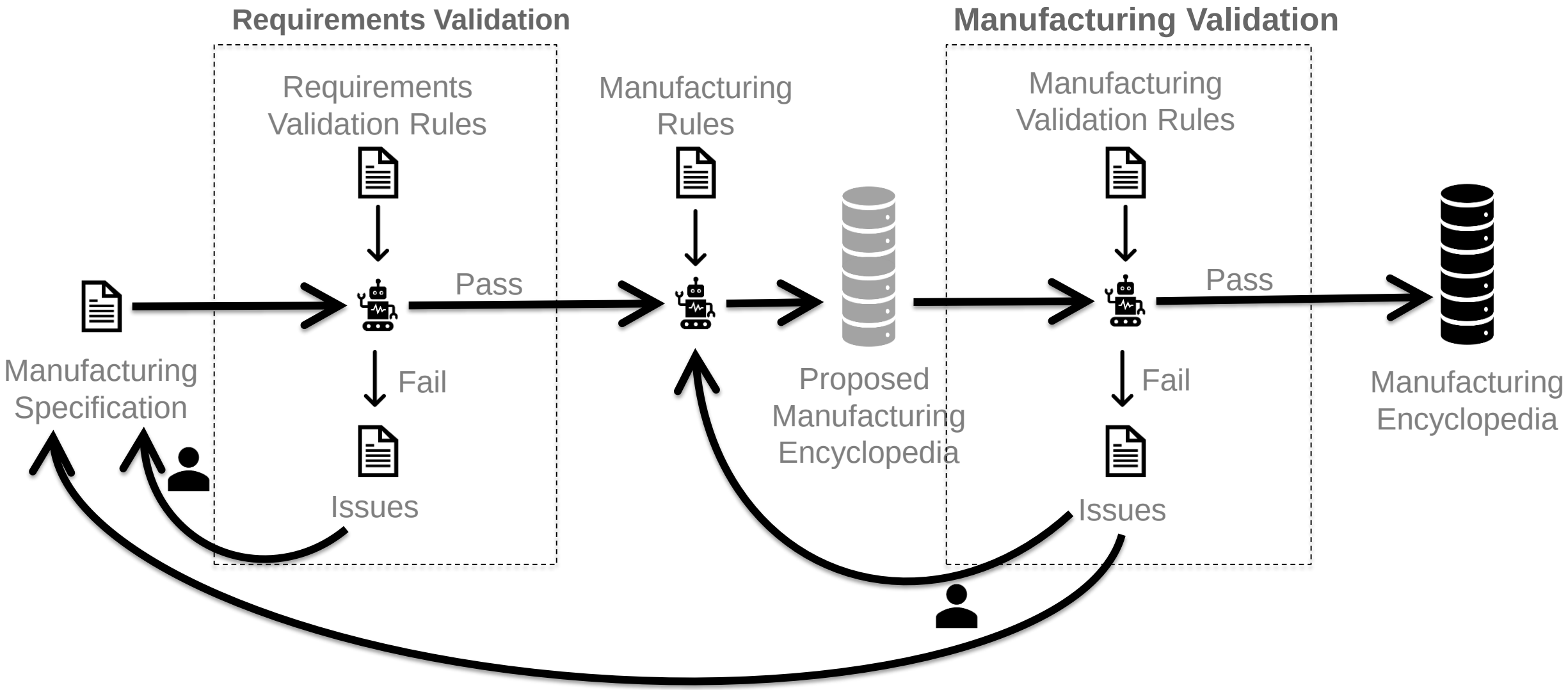
Number of physical working days in each calendar year is limited assuming no overtime

DESIGN RESOURCE

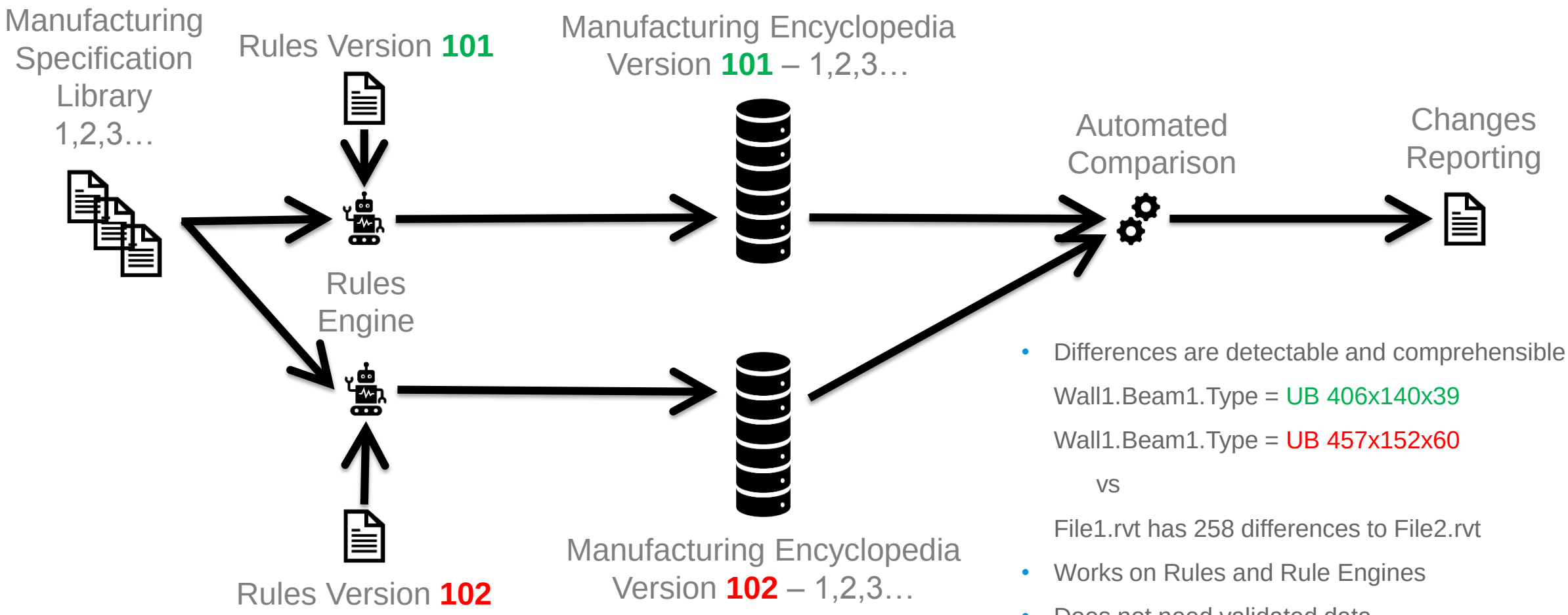
Conventional approach to modelling would yield a technical headcount that was unaffordable

VALIDATION AND TESTING

Validation Workflow and Regression Testing



Validation Workflow and Regression Testing



- Differences are detectable and comprehensible

  Wall1.Beam1.Type = UB 406x140x39

  Wall1.Beam1.Type = UB 457x152x60

  vs

  File1.rvt has 258 differences to File2.rvt
- Works on Rules and Rule Engines
- Does not need validated data
- Very fast

Colin Dixon

Berkeley Modular Ltd

Offsite Manufacturing vs Offsite Construction

21 November 2019

MARKET DEVELOPMENT

Strategic imperatives facilitate disruptive technology that is driving transformational approach to construction–

Berkeley Group Strategic Drivers –

- Skills
- Pipeline Surety
- Product Performance

BML Vision –

- Peak capacity: 2no shifts
- Shift Capacity: 6no modules
- Max Module Size: 12.0m*4.5m* 3.5m
- Module Cycle Time: 40 hours
- Max Module Weight: 20 tonnes

LEAN AS A BASIS FOR COMPARISON

The terms offsite manufacture and offsite construction do not imply the same meaning –

- Manufacturing bears little resemblance to construction. Differences exist between the two relating to culture: operating philosophy; productivity; return on investment; employment and talent development rationale, etc.
- To compare the notions of offsite manufacturing and offsite construction, we can use the concept of lean because it chimes directly with the **elimination of unnecessary waste**
- The intent of this presentation is not to necessarily prove that either of these alternative approaches to traditional construction represents a better business model than the other, rather to use a simple logic for comparing the two in order to highlight the fact that an underlying **variance in operational efficiency exists**

BASIS OF AN HYPOTHETICAL ANALYSIS

Creating an artificial model for comparison purposes –

- Assume that the separate notions of offsite manufacturing and offsite construction are used as the basis of a production logic to create an equivalent output of **5no** fully-fitted modules per day with each fully-fitted module comprising **20 tonnes** of materials (i.e. parts, components, equipment, etc.),

- Assume that this notional material content amounts to **£30k** of theoretical cost, and whilst this theoretical cost of material per module in itself is arbitrary it provides a baseline for subsequent adjustment of the artificial model contingent upon differences in logic between the two approaches

- Assume for the purpose here that we are going to limit such adjustment to some key characteristics, rather than try to compile an exhaustive narrative that would not necessarily add extra value in creating transparency

BASIS OF AN HYPOTHETICAL ANALYSIS

Differences associated with physical material waste –

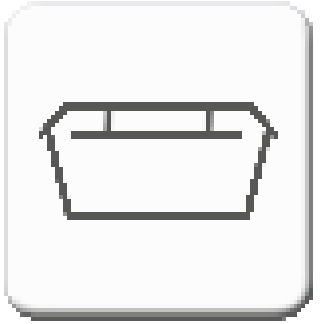
Offsite manufacturing is a process wherein physical material waste is associated with genuine yield as opposed to excess:

- Assume yield is limited to **2 percent**
- Hence, offsite manufacturing-biased output of 5no modules per day with each module nominally weighing 20 tonnes implies a total weight of required material to produce of **102 tonnes**
- Assuming £30k of theoretical cost per 20 tonnes of material, then the total calculated cost of required material to output 5no modules per day would be **£153k**

2% → +£3k

Offsite constriction is a process more akin to traditional construction where physical material waste is associated with incorrect process / damage / defects / inefficiency:

- Assume excess amounts to **15 percent**
- Hence, offsite construction-biased output of 5no modules per day with each module nominally weighing 20 tonnes implies a total weight of required material to produce of **115 tonnes**
- Assuming £30k of theoretical cost per 20 tonnes of material, then the total calculated cost of required material to output 5no modules per day would be **£173k**



15% → +£23k

BASIS OF AN HYPOTHETICAL ANALYSIS

Differences associated with administrative resource waste –

Offsite manufacturing is an approach which borrows best practice principles related to supply / operations planning from sectors such as automotive and aerospace:

- Assume the administrative resource required to support the sourcing, ordering, receipting and inspection of materials is **0.5 percent** of cost of required material
- Hence, the adjusted cost of required material to output 5no modules per day at £153k would imply **£8k** of people cost
- Revised total calculated cost is **£161k**

0.5% → +£8k

Offsite construction reflects an approach which borrows best practice principles the broader construction sector, often relying upon merchants and trade contractors for the supply of materials:

- Assume the administrative resource required to support the sourcing, ordering, receipting and inspection of materials is **1.0 percent** of cost of required material
- Hence, the adjusted cost of required material to output 5no modules per day at £153k would imply **£17k** of people cost
- Revised total calculated cost is **£190k**

1% → +£17k

BASIS OF AN HYPOTHETICAL ANALYSIS

Differences associated with logistics waste –

–

Offsite manufacturing is predicated on the just-in-time delivery of materials on a daily replenishment basis. A properly considered logistics strategy will facilitate optimisation of deliveries based on controlled logic capturing how material is consumed; where it is consumed; when it is consumed; etc:

- Assume a cost of **£1k** per delivery (whether full or part-load)
- Assume optimised loads of **25 tonnes** per delivery
- Hence, the costs associated with delivery of 102 tonnes of required materials is **£5k**
- Revised total calculated cost is **£166k**

5no → +£5k

Offsite construction is inherently less efficient due to the nature of the supply chain relations and sourcing strategies. The scope to optimise deliveries is much reduced, and due to factors such as minimum order quantities it is common to observe much more physical stock in the production facility:

- Assume a cost of **£1k** per delivery (whether full or part-load)
- Assume optimised loads of **15 tonnes** per delivery
- Hence, the costs associated with delivery of 115 tonnes of required materials is **£8k**
- Revised total calculated cost is **£198k**

8no → +£8k

BASIS OF AN HYPOTHETICAL ANALYSIS

Differences associated with disposal / recycling of physical waste –

Offsite manufacturing affords more opportunity to control what happens to surplus material, and there are often direct or indirect costs associated with dealing with this. Since strategic supply chain relations ensure that more material is likely to be recycled than disposed of:

- Assume that direct / indirect costs associated with disposal / recycling amount to **£500** per tonne
- Assume **2 tonnes** of surplus material as a result of yield
- Hence, the costs associated with disposal / recycling of 2 extra tonnes is **£1k**
- Revised total calculated cost is **£167k**

2t → +£1k

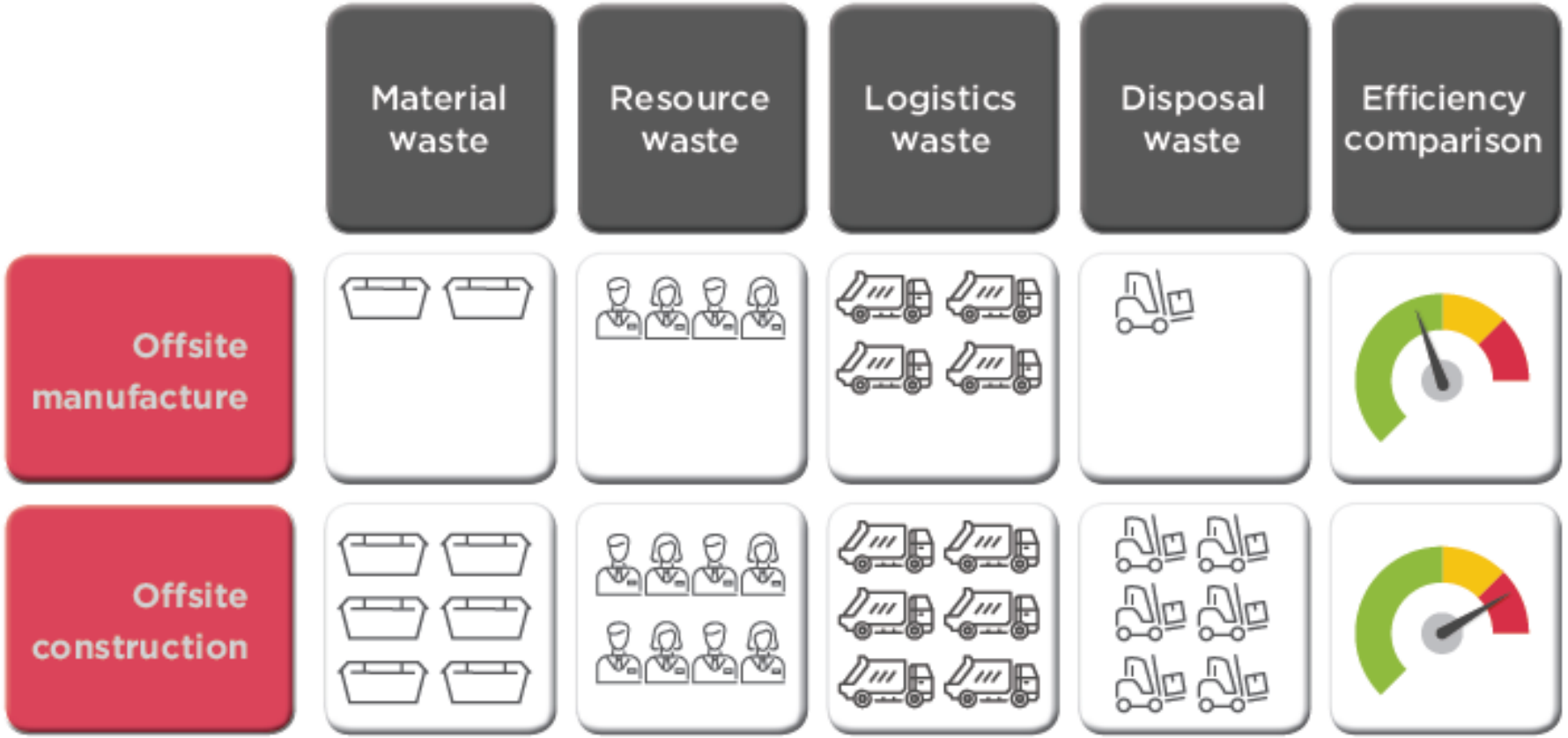
Offsite construction is inherently less efficient in terms of creating waste, and this can be related to the increased number of deliveries and associated off-loading; more sorting and increased inventory; etc. The lack of strategic supply chain relations also means that more material is likely to be disposed of than recycled:

- Assume that direct / indirect costs associated with disposal / recycling amount to **£500** per tonne
- Assume **15** tonnes of surplus material as a result of excess
- Hence, the costs associated with disposal / recycling of 15 extra tonnes is **£8k**
- Revised total calculated cost is **£206k**

15t → +£8k

SCOPE TO LEVERAGE PRODUCTIVITY

:Measuring levels of unnecessary waste facilitates understanding of scale of difference:



-25%

SUMMARY

Conclusions to be drawn from hypothetical analysis –

- Whilst entirely theoretical, the calculated costs of £167k and £206k reveal that even with a limited number of adjustments offsite construction can be shown to be **25 percent** less efficient than offsite manufacturing

- Useful to ask why it is so important to understand the demarcation between offsite manufacturing and offsite construction, the key point really being about the fact that a manufacturing-biased approach facilitates predictability and repeatability as well as the elimination of unnecessary waste

- Further, manufacturing more readily affords scope to **embrace digitisation** with a stronger emphasis on Design for Manufacture and Assembly (**DFMA**). Hence, it better fits with UK Government's recent appeal to the offsite community to think more radically and create more technology-biased approaches which embrace digitalisation and can help attract a new population of potential talent