DATA SCIENCE IN MANUFACTURING

WEEK 3

ANDREW SHERLOCK, JONATHAN CORNEY, DANAI KORRE

LECTURE: WEEK 3

Product Lifecycle / Material Flow

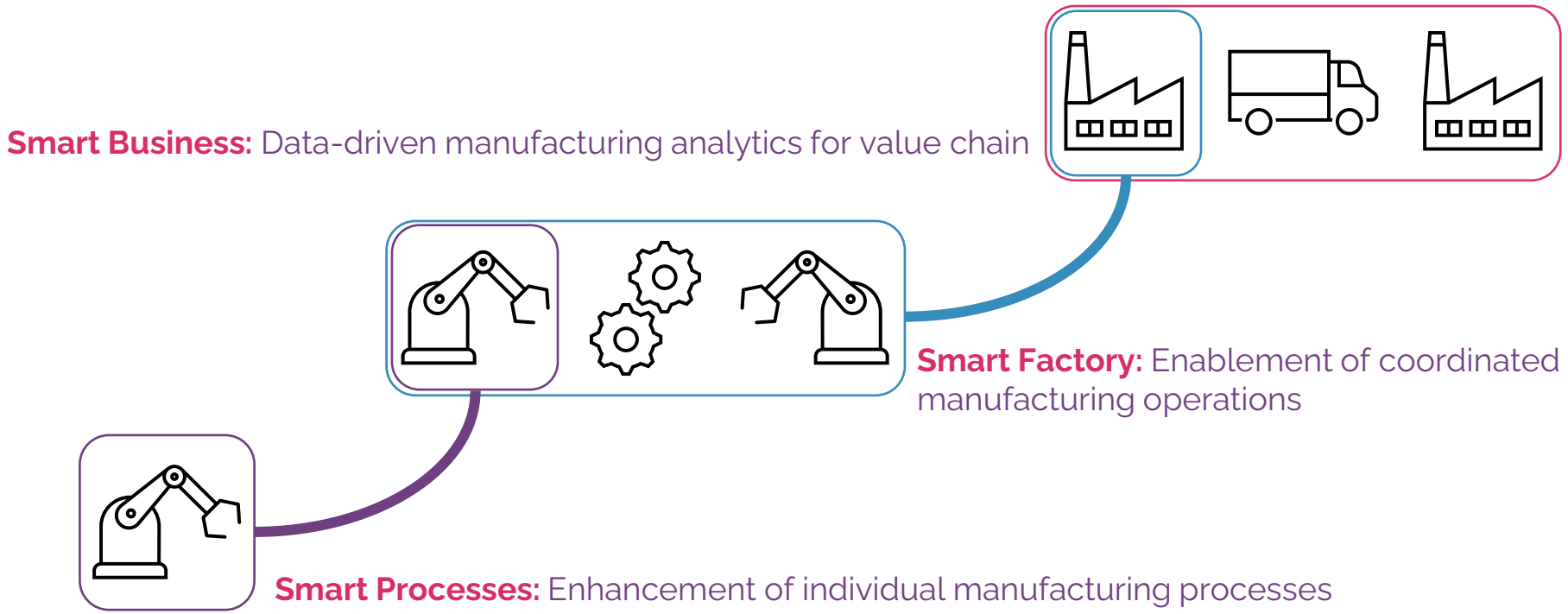
BY THE END OF THIS LECTURE YOU SHOULD:

Understand product lifecycle and material flow

Understand why coding skills are important for a career in manufacturing

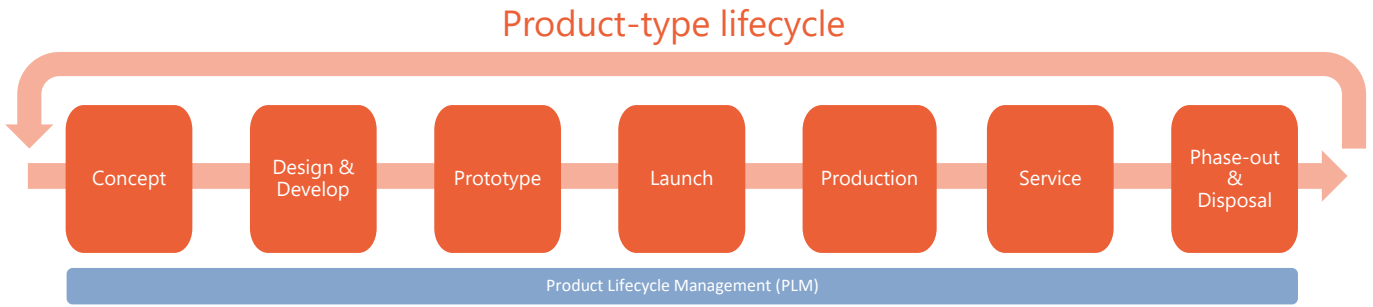
Review applications on industrial cases

Data Carpentry and the importance of structured and clean data


Smart Business: Data-driven manufacturing analytics for value chain
Smart Factory: Enablement of coordinated manufacturing operations
Smart Processes: Enhancement of individual manufacturing processes

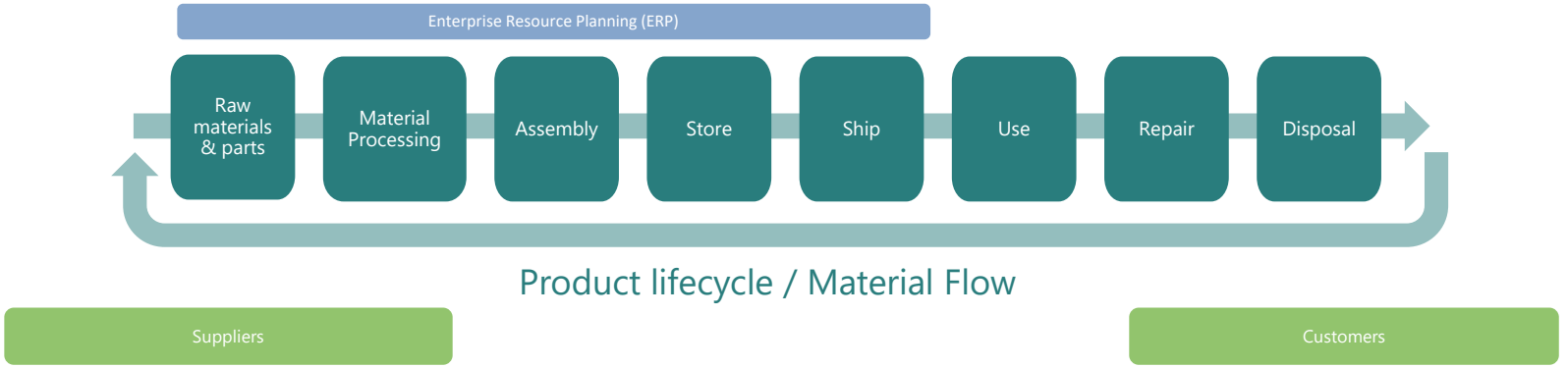
PRODUCT LIFECYCLE

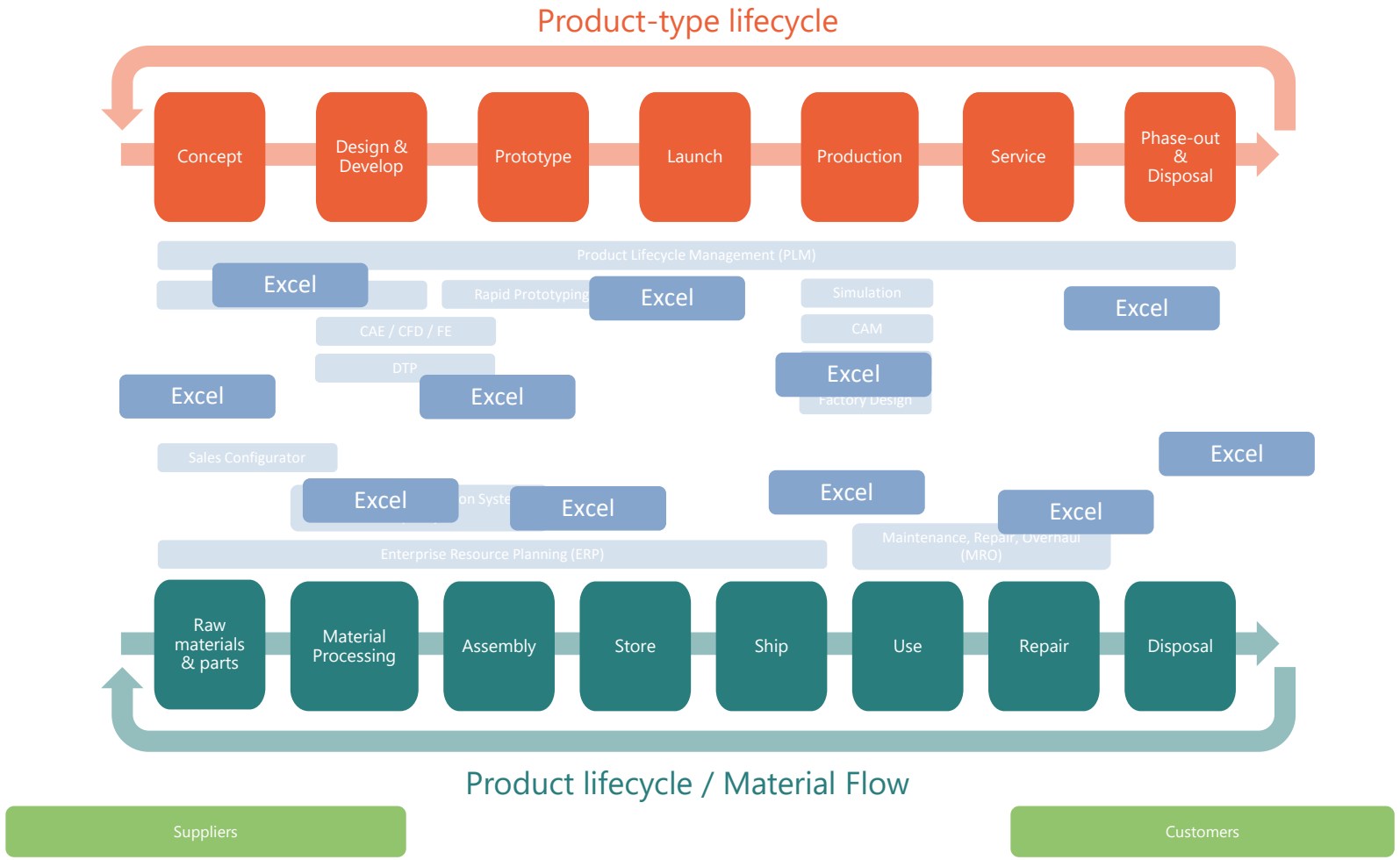
Lifecycle id defined by Grieves [1] as all aspects of a product's life, from its design through manufacture, deployment and maintenance. Culminating in the product's removal from service and final disposal.

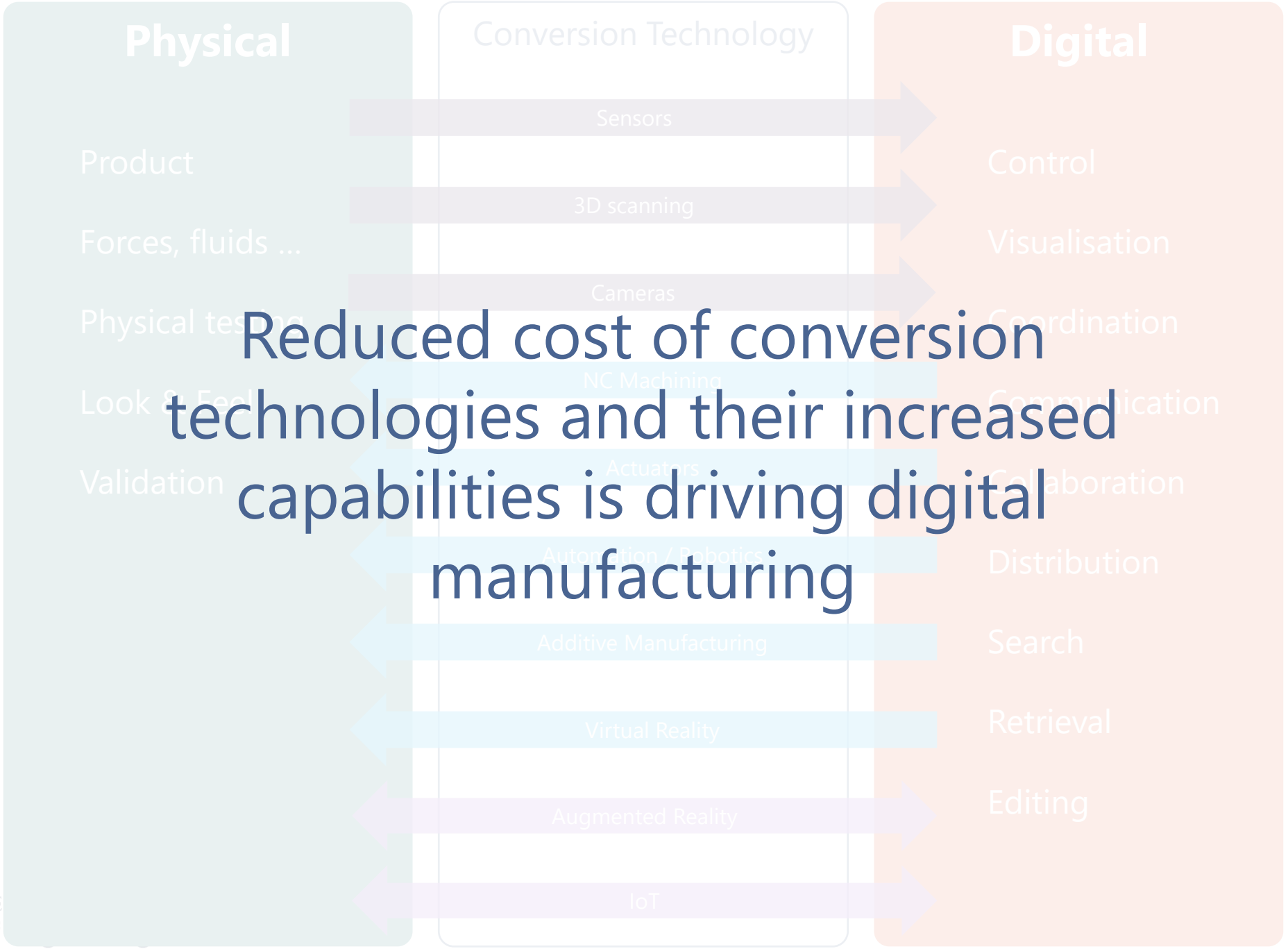


Digital coordination of manufacturing

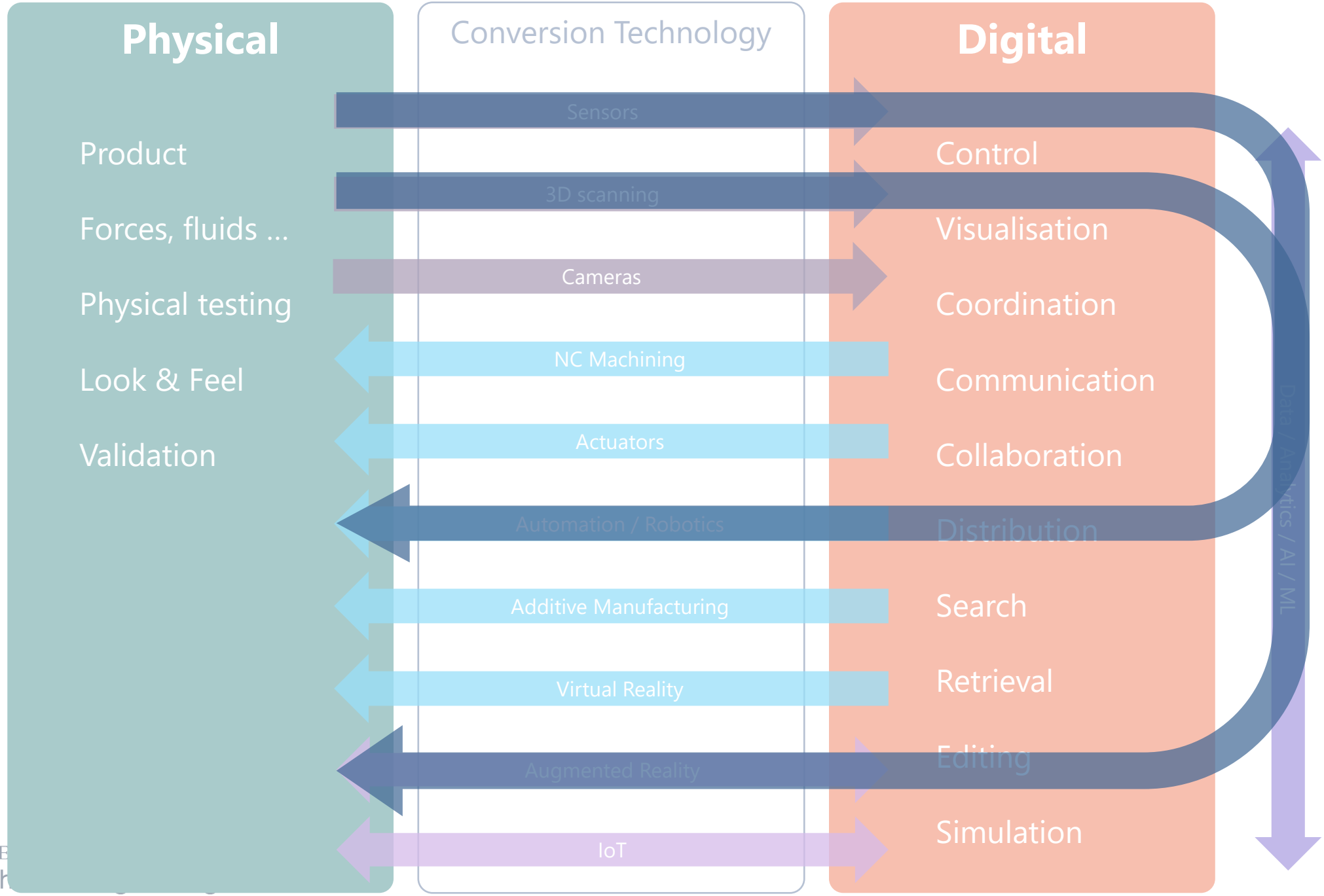
Data-driven Manufacturing and Value-chain

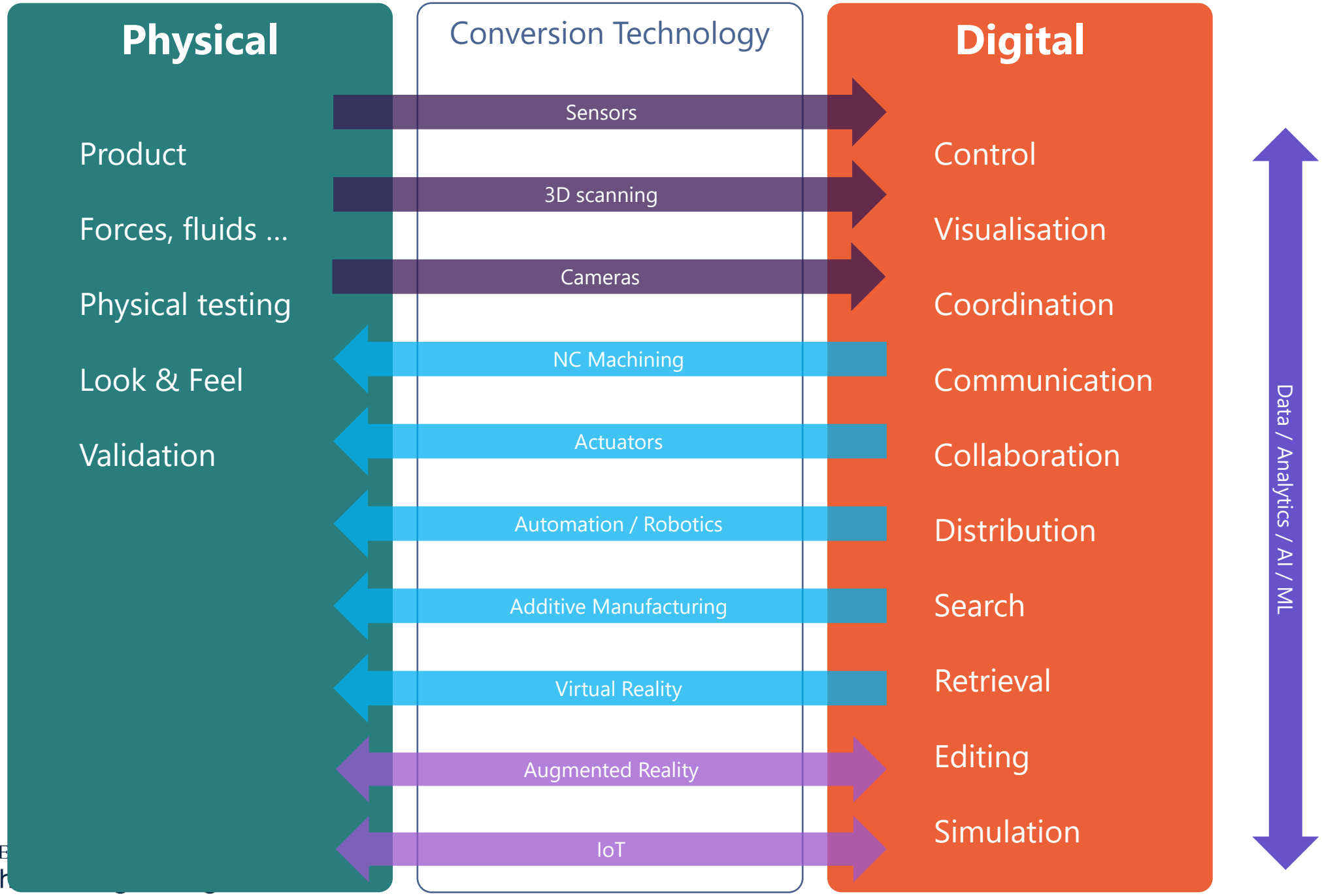



Product-type lifecycle
Concept
Design & Develop
Prototype
Launch
Production
Service
Phase-out & Disposal
Product Lifecycle Management (PLM)
Excel
Rapid Prototyping
Excel
Simulation
Excel
CAE / CFD / FE
CAM
DTP
Excel
Excel
Excel
Factory Design
Sales Configurator
Excel
Excel
Excel
Excel
Excel
Enterprise Resource Planning (ERP)
Maintenance, Repair, Overhaul (MRO)
Raw materials & parts
Material Processing
Assembly
Store
Ship
Use
Repair
Disposal
Product lifecycle / Material Flow
Suppliers
Customers



Reduced cost of conversion technologies and their increased capabilities is driving digital manufacturing


Physical
Conversion Technology
Digital
Product
Forces, fluids ...
Physical testing
Look & Feel
Validation
Sensors
3D scanning
Cameras
NC Machining
Actuators
Automation / Robotics
Additive Manufacturing
Virtual Reality
Augmented Reality
IoT
Control
Visualisation
Coordination
Communication
Collaboration
Distribution
Search
Retrieval
Editing
Simulation
Data / Analytics / AI / ML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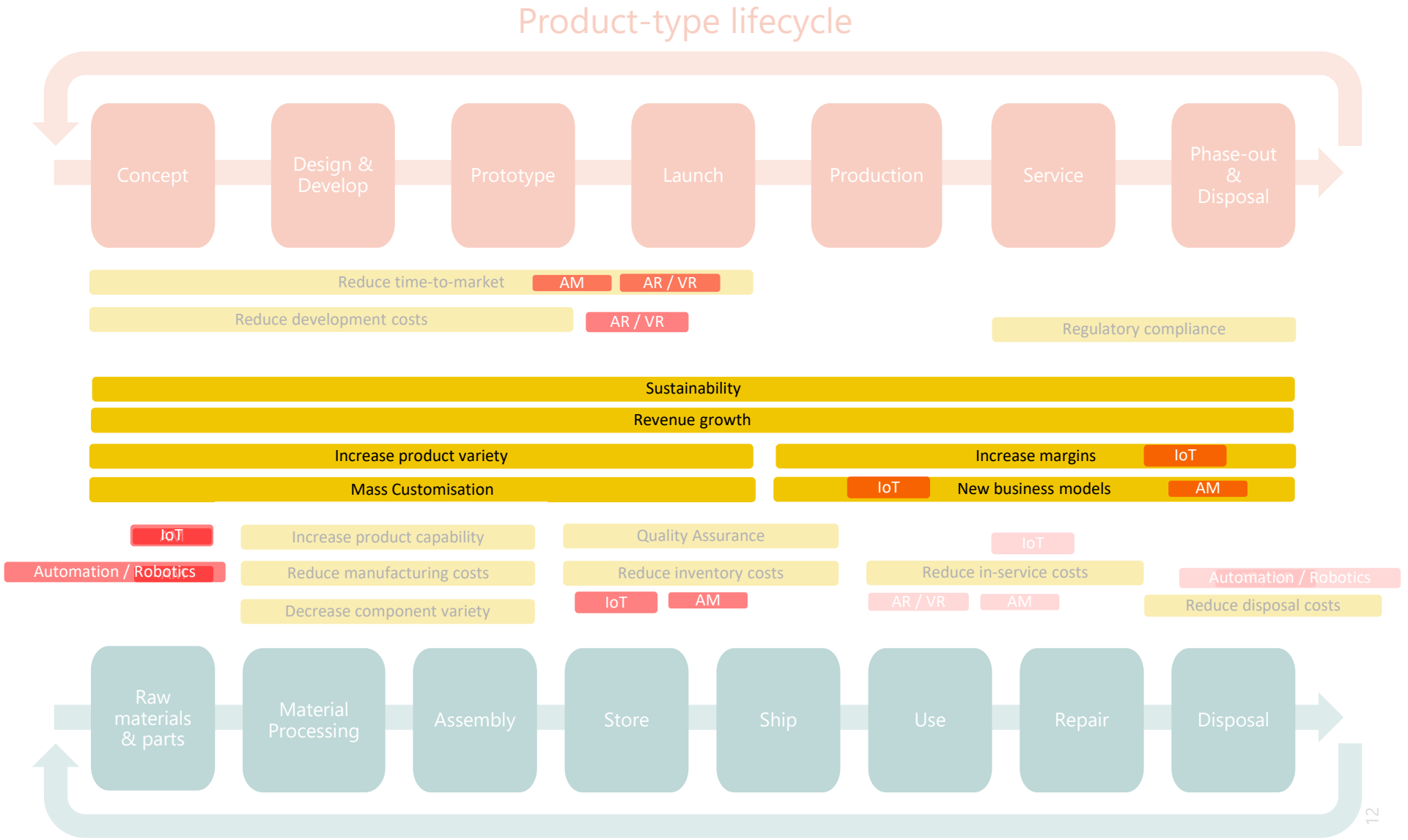
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Design & Develop
Prototype
Launch
Production
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Phase-out & Disposal
Reduce time-to-market
AM
AR / VR
Reduce development costs
AR / VR
Regulatory compliance
Sustainability
Revenue growth
Increase product variety
Increase margins
IoT
Mass Customisation
IoT
New business models
AM
IoT
Automation / Robotics
Increase product capability
Reduce manufacturing costs
Decrease component variety
Quality Assurance
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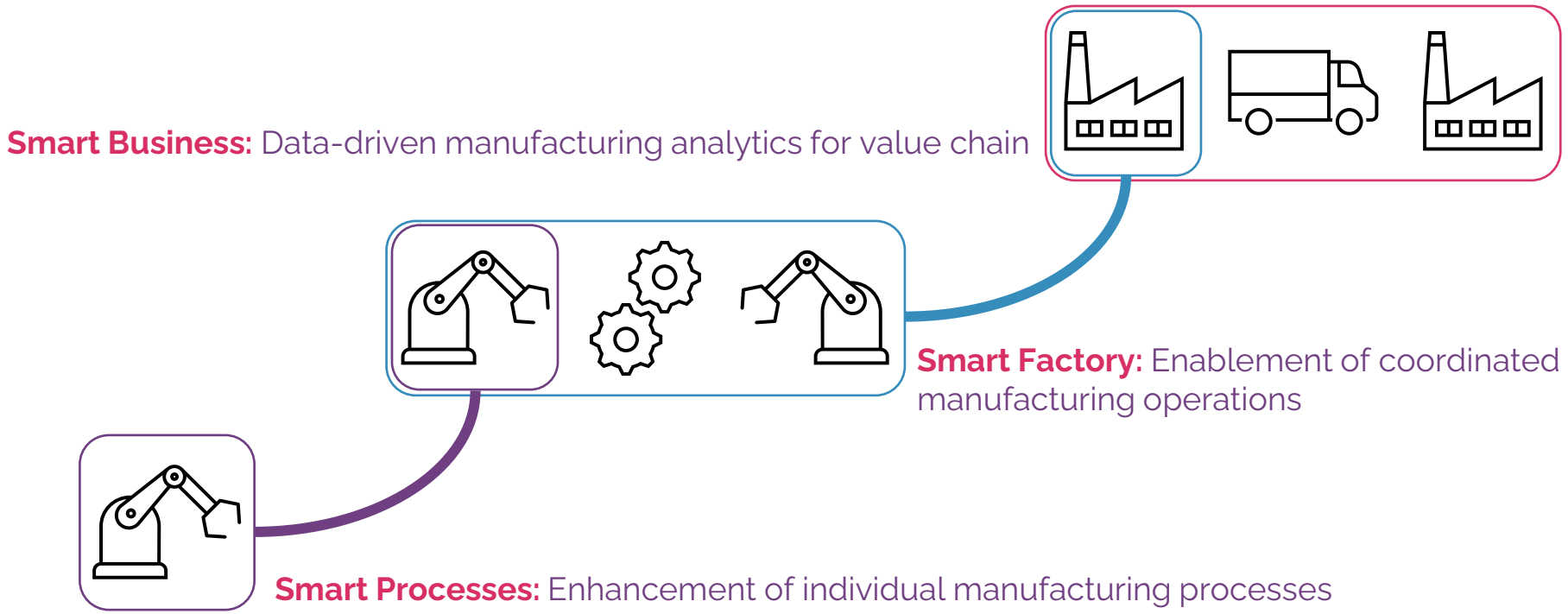
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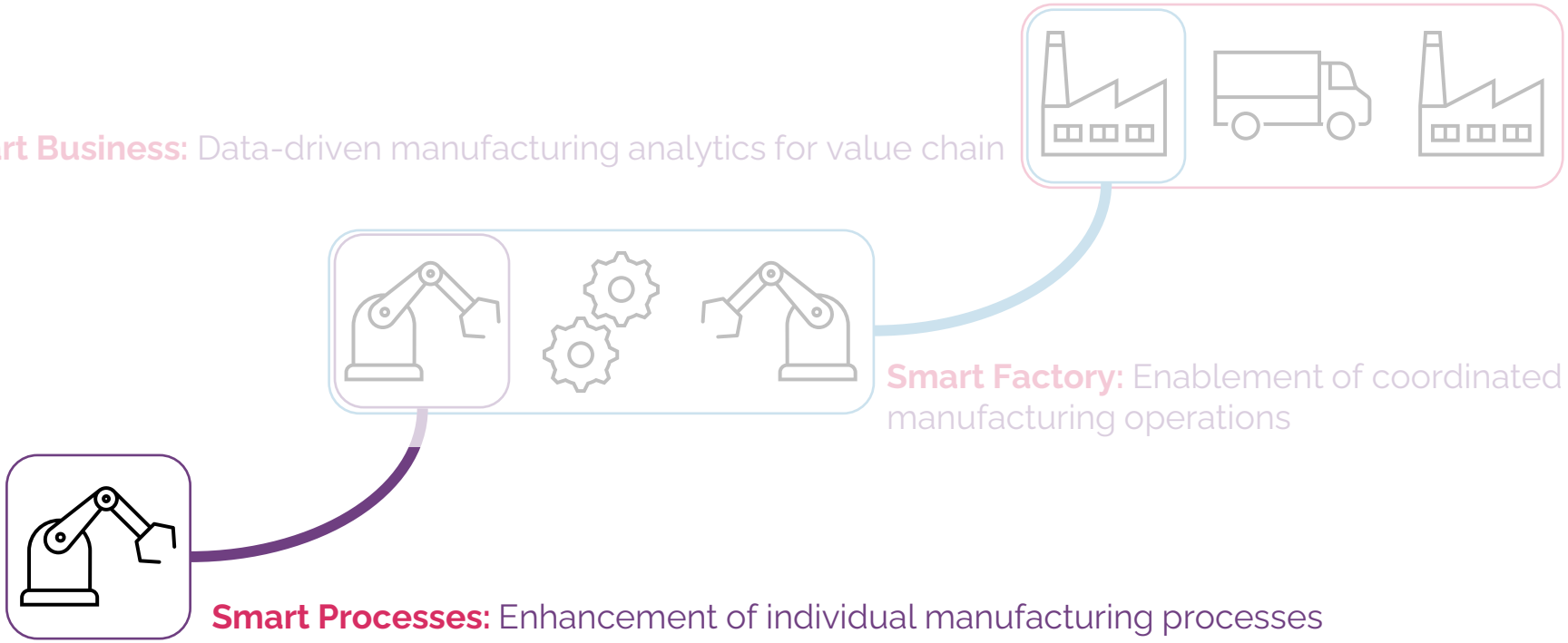
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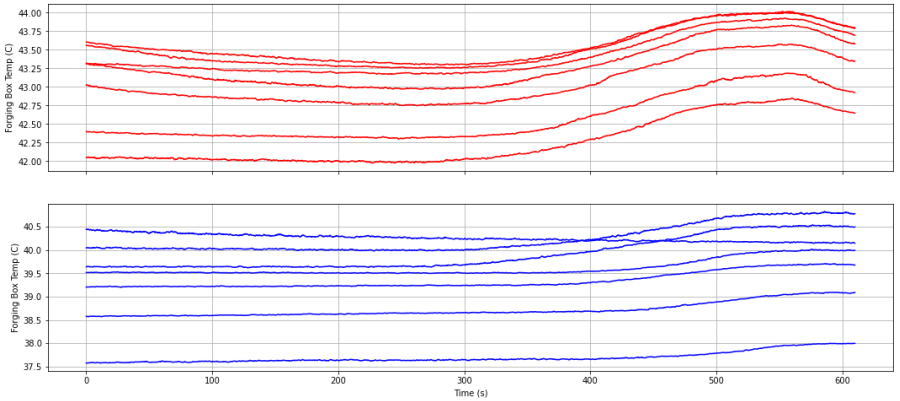
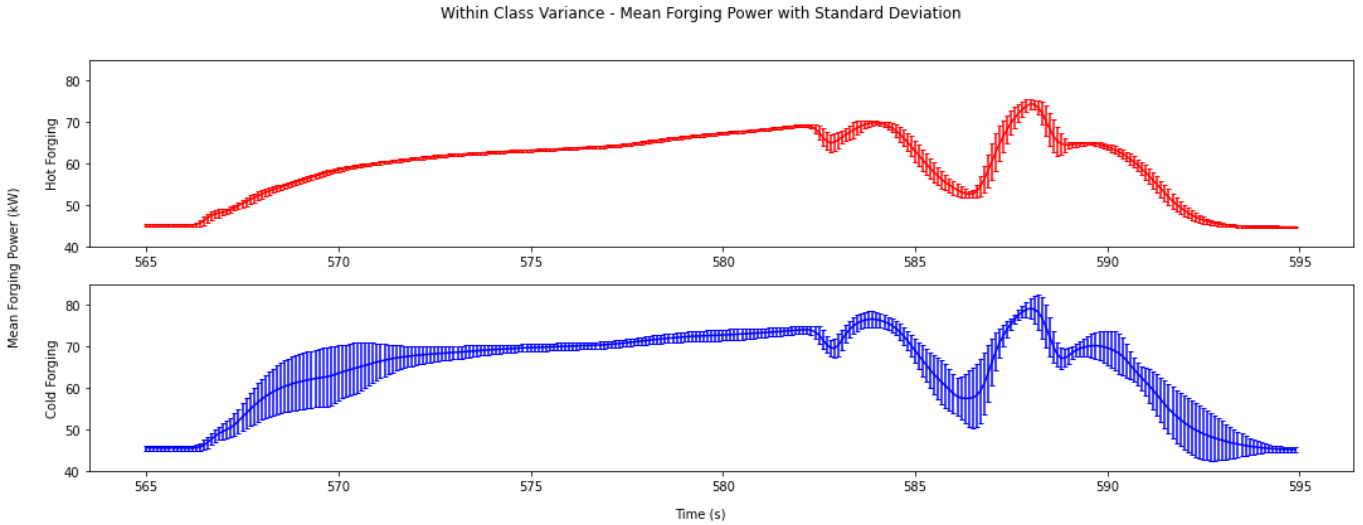
CASE STUDY: DIGITAL THREAD

- External project led by AFRC technical teams with support of Data Analytics Theme
- Objective - explore data engineering/analytics for digital threads of parts manufactured by AFRC Radial Forge and then subsequently machined
- Identified machining chatter and currently exploring the relationship with initial radial forging conditions





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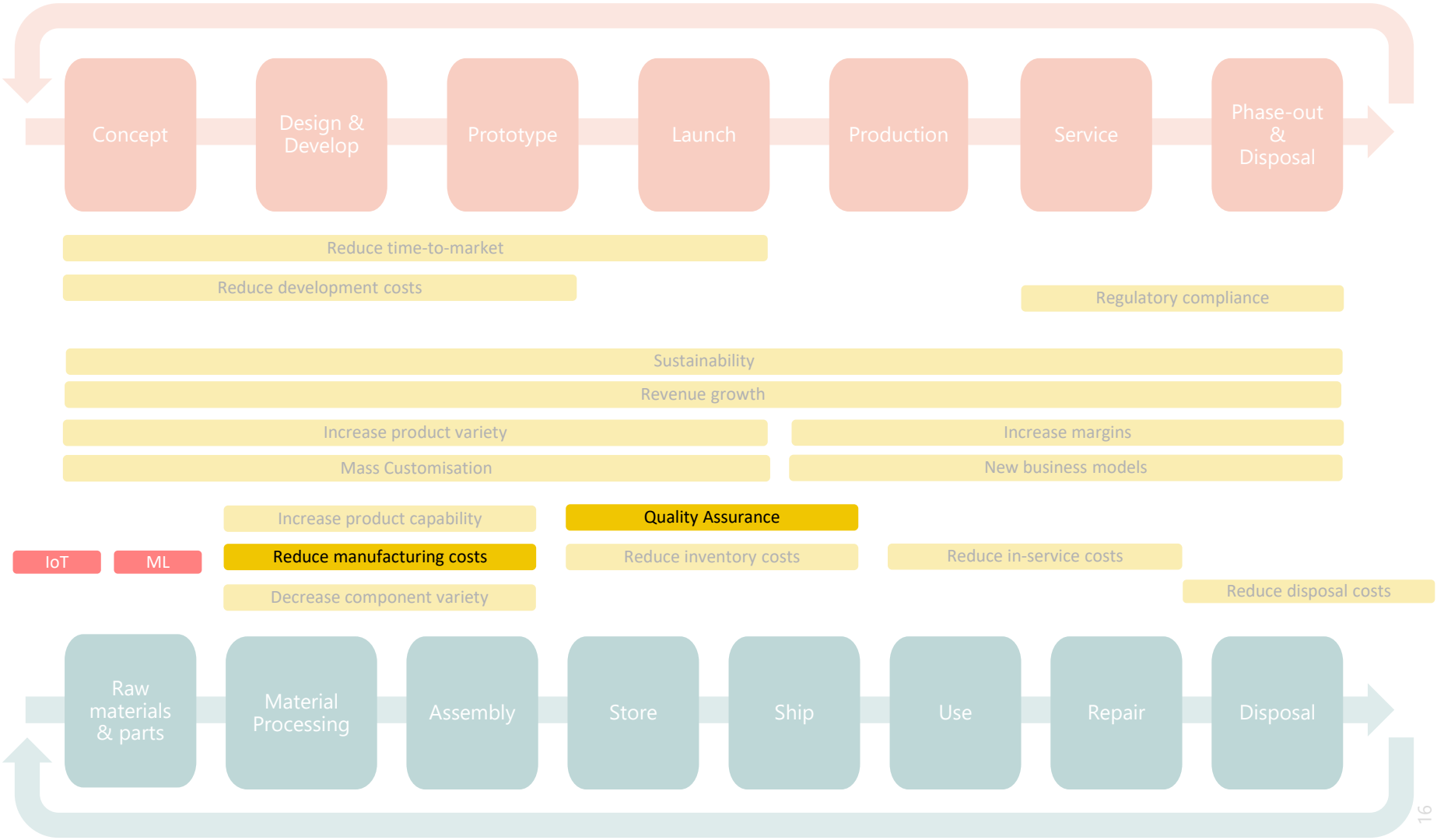
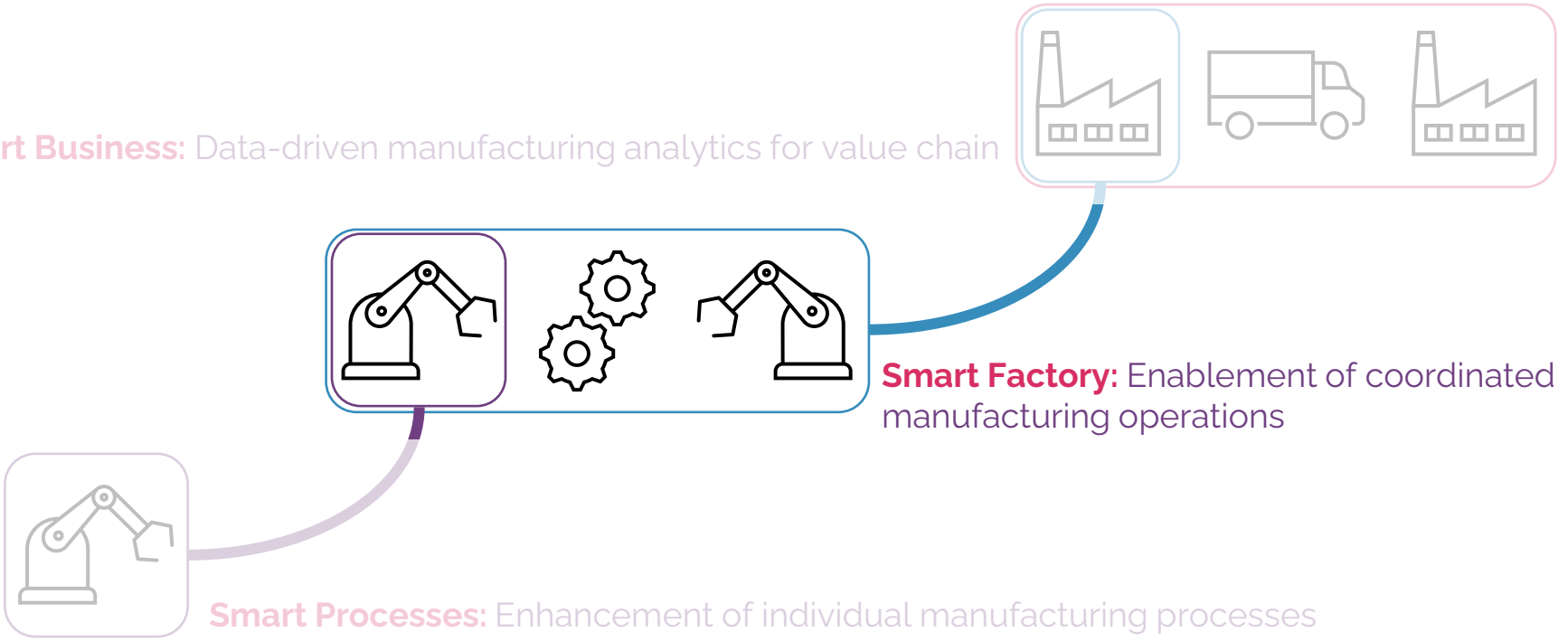
Product-type lifecycle



Product lifecycle / Material Flow

Suppliers

Customers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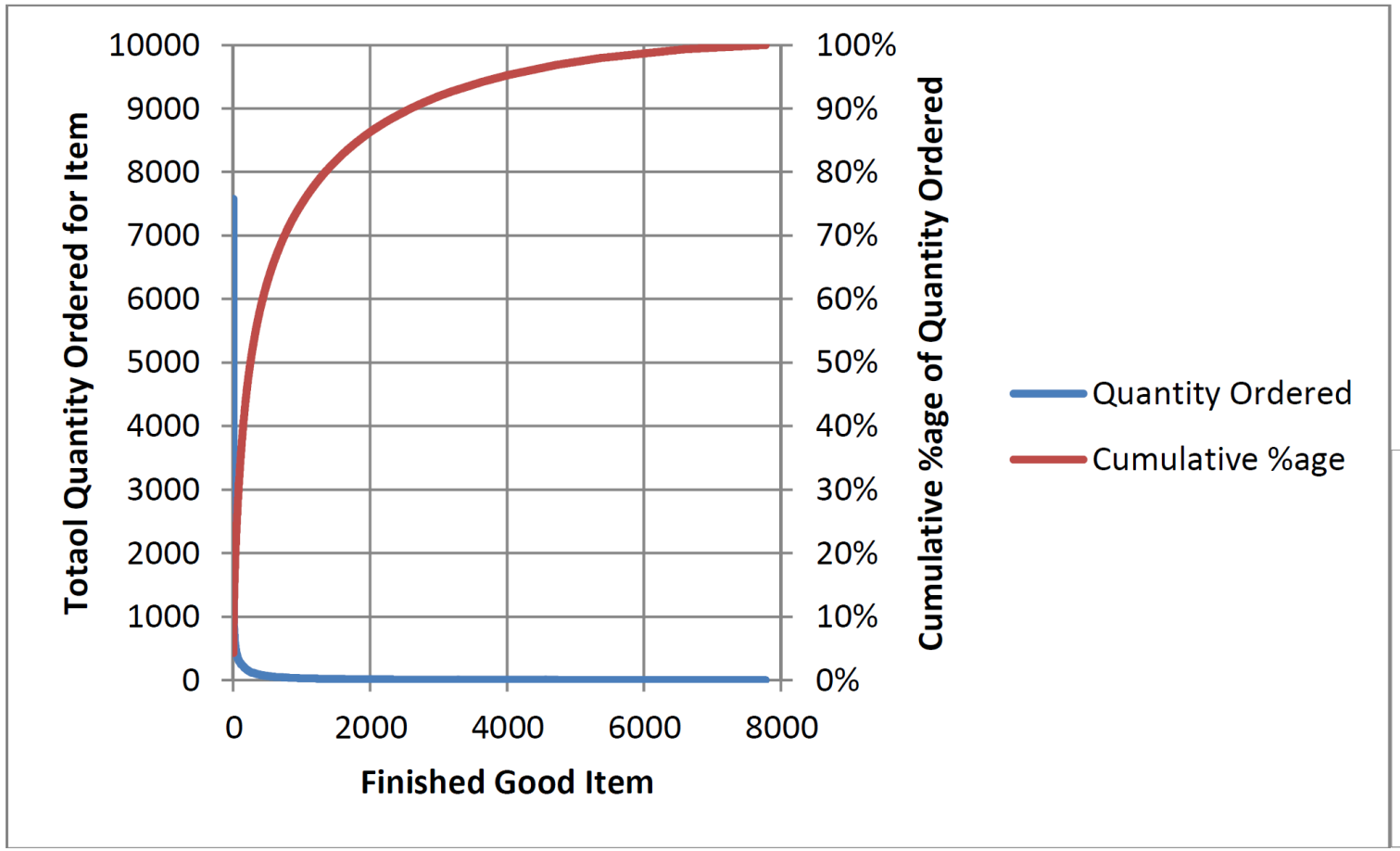
Case Study 1: Valve Company India

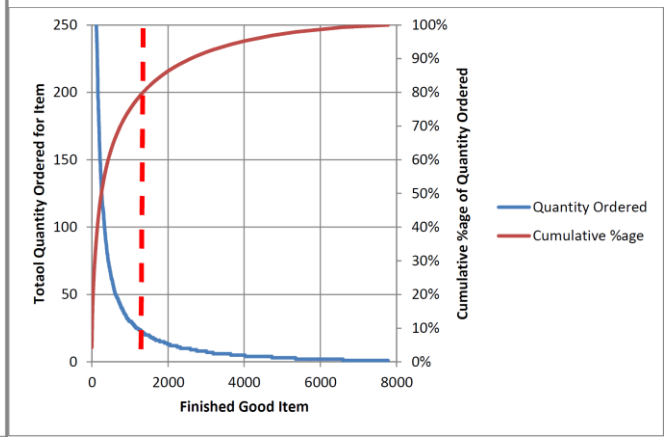
Background	■ Manufacturer of industrial valves ■ Company acquired as low-cost manufacturing base for global manufacturer
Issues	■ Severely underperforming in terms of operational efficiency ■ Significant quality issues ■ Significant on-time delivery problems ■ Needed to understand where problems were to know what needed addressing and fixing ■ Limited ability to understand true performance of different value streams ■ Perception of excessive product and part variety

Case Study 1: Valve Company India

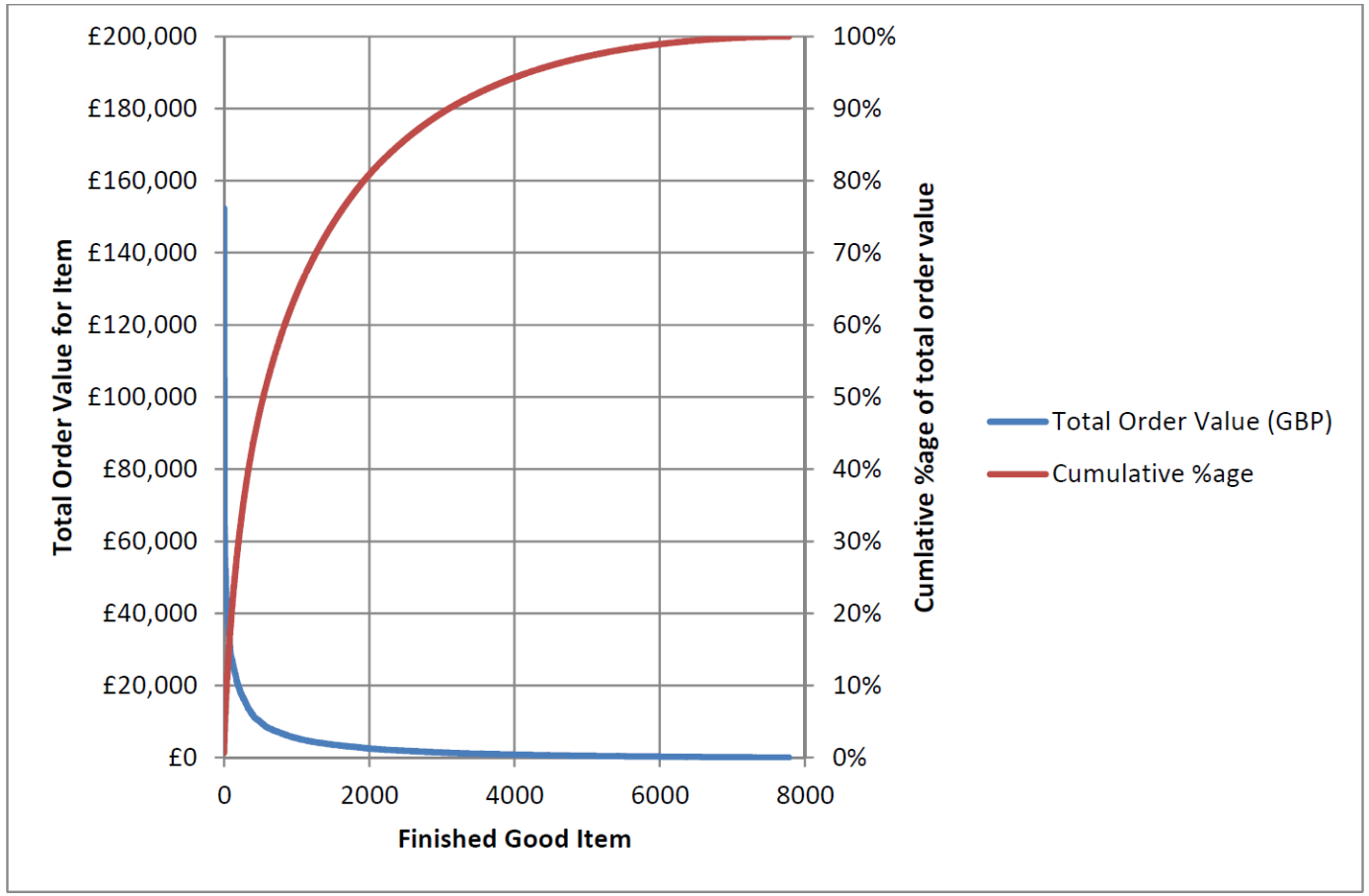
Analysis	■ Large amount of product and part variety discovered (~100,000 parts, ~10,000 valves) ■ However, variety **not** driven by engineering, but instead by **sales**

Case Study 1: Valve Company India





Case Study 1: Valve Company India



Case Study 1: Valve Company India

Follow on analysis	■ Analyse how to rationalise product portfolio on basis of margin

The Approach

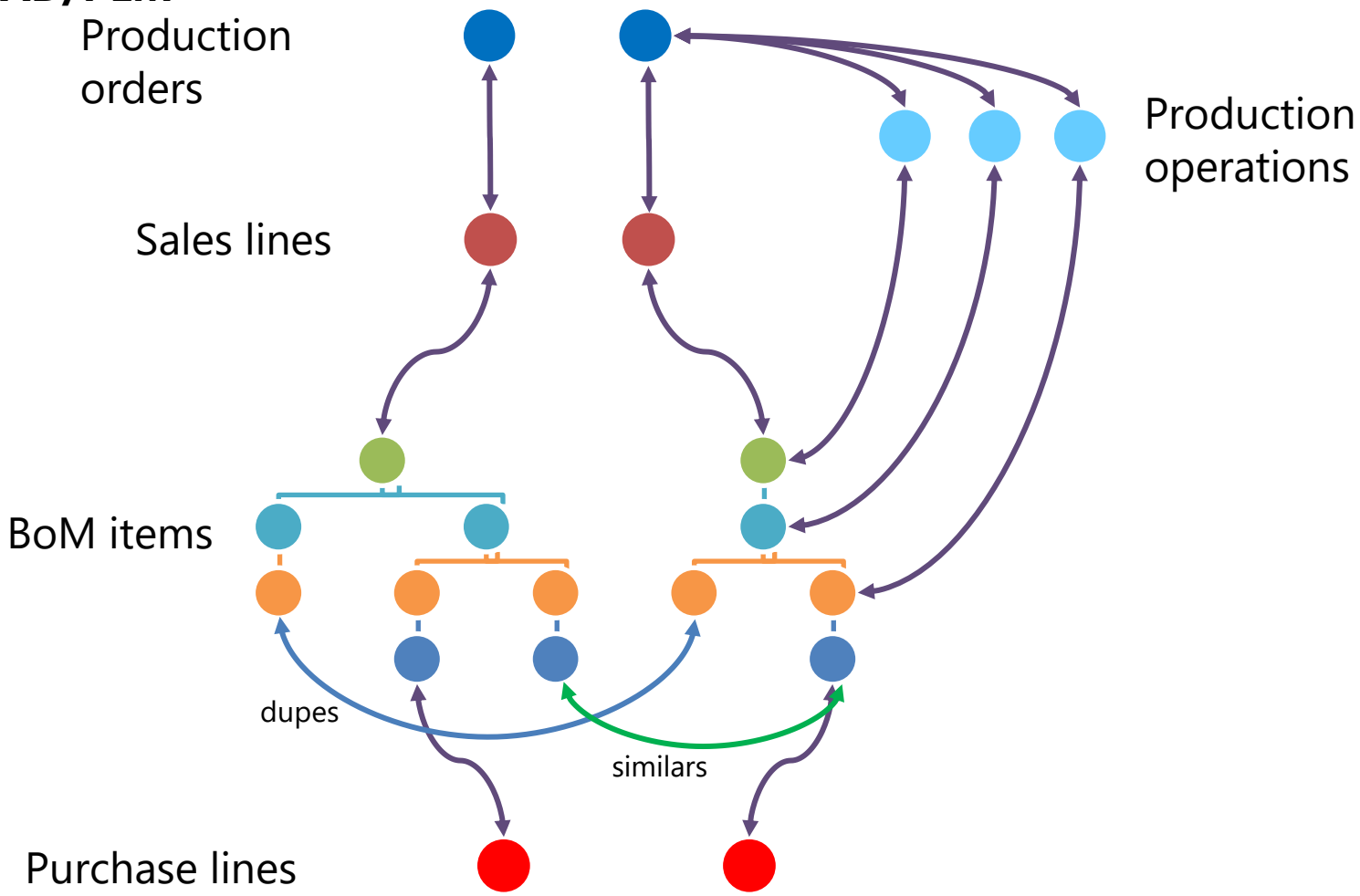
1. Build model by extracting transactional and Bill of Material data from ERP / CAD / PLM

2. Allocate costs to each transaction: 1. direct material costs
   2. non-direct costs down to EBITA
   agree method based on activity or usage

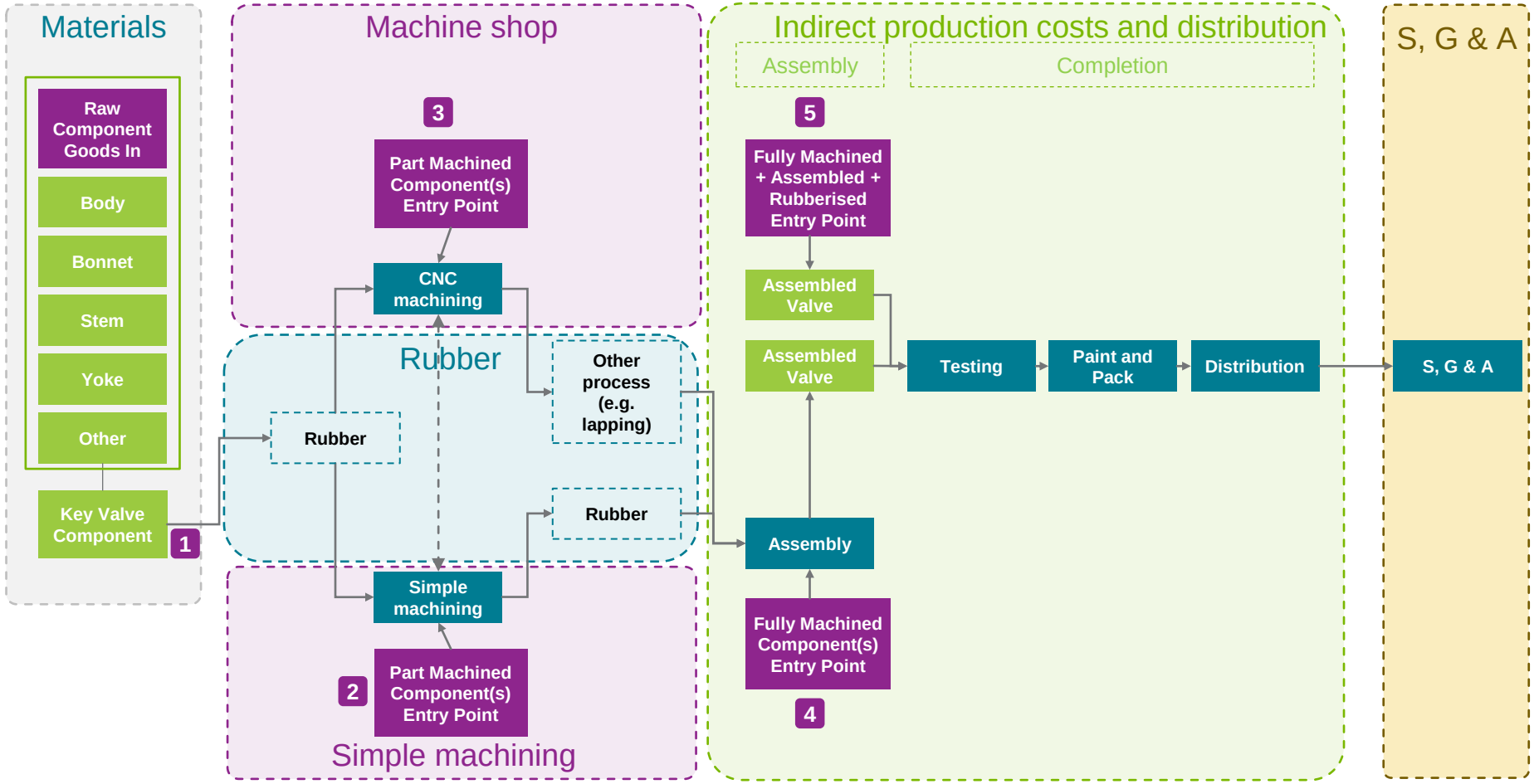
3. Analyse model to identify where profit and losses are in the business and the drivers of profitability.

Step 1: Build model

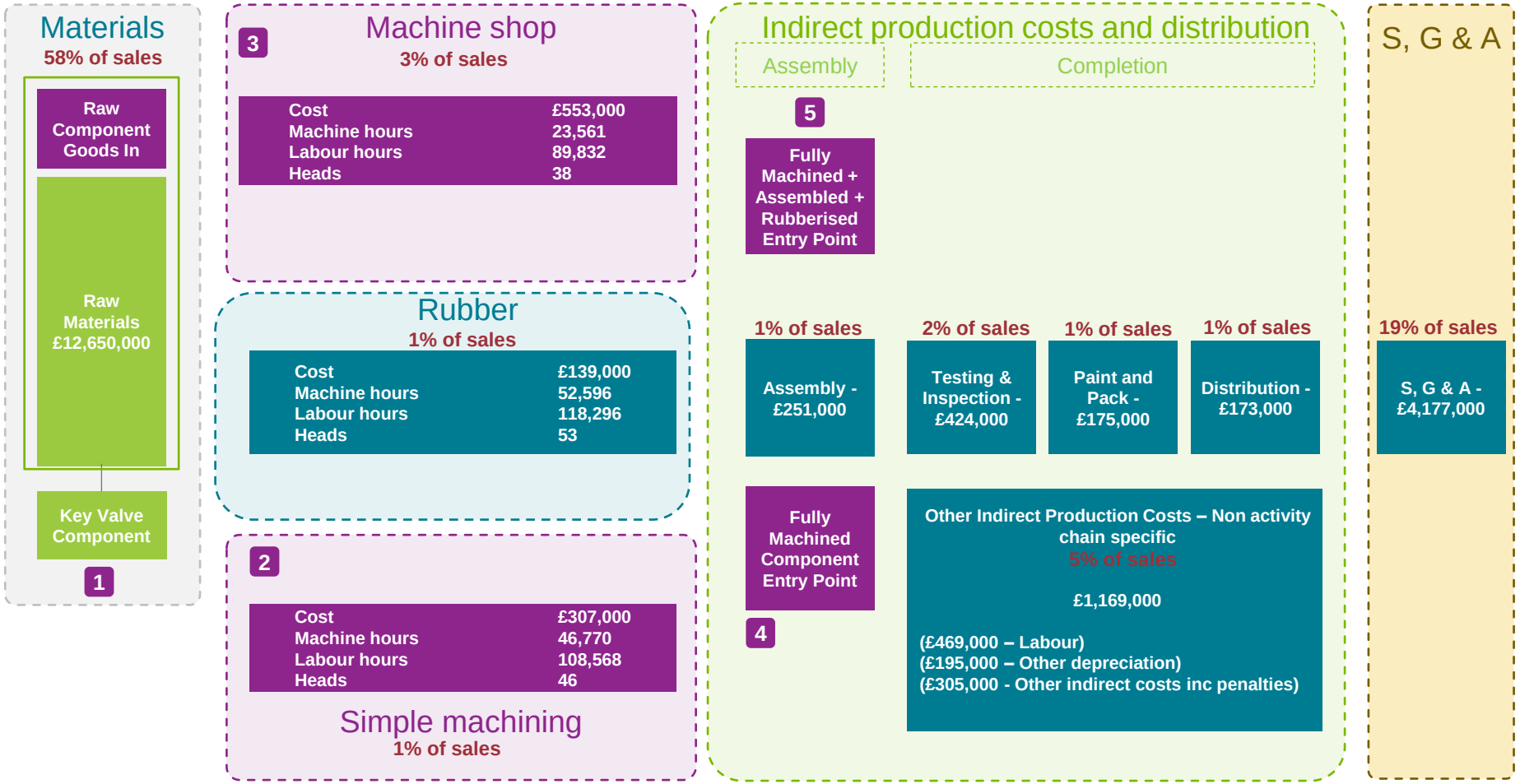
Extract BoM and transactional data from ERP/CAD/PLM



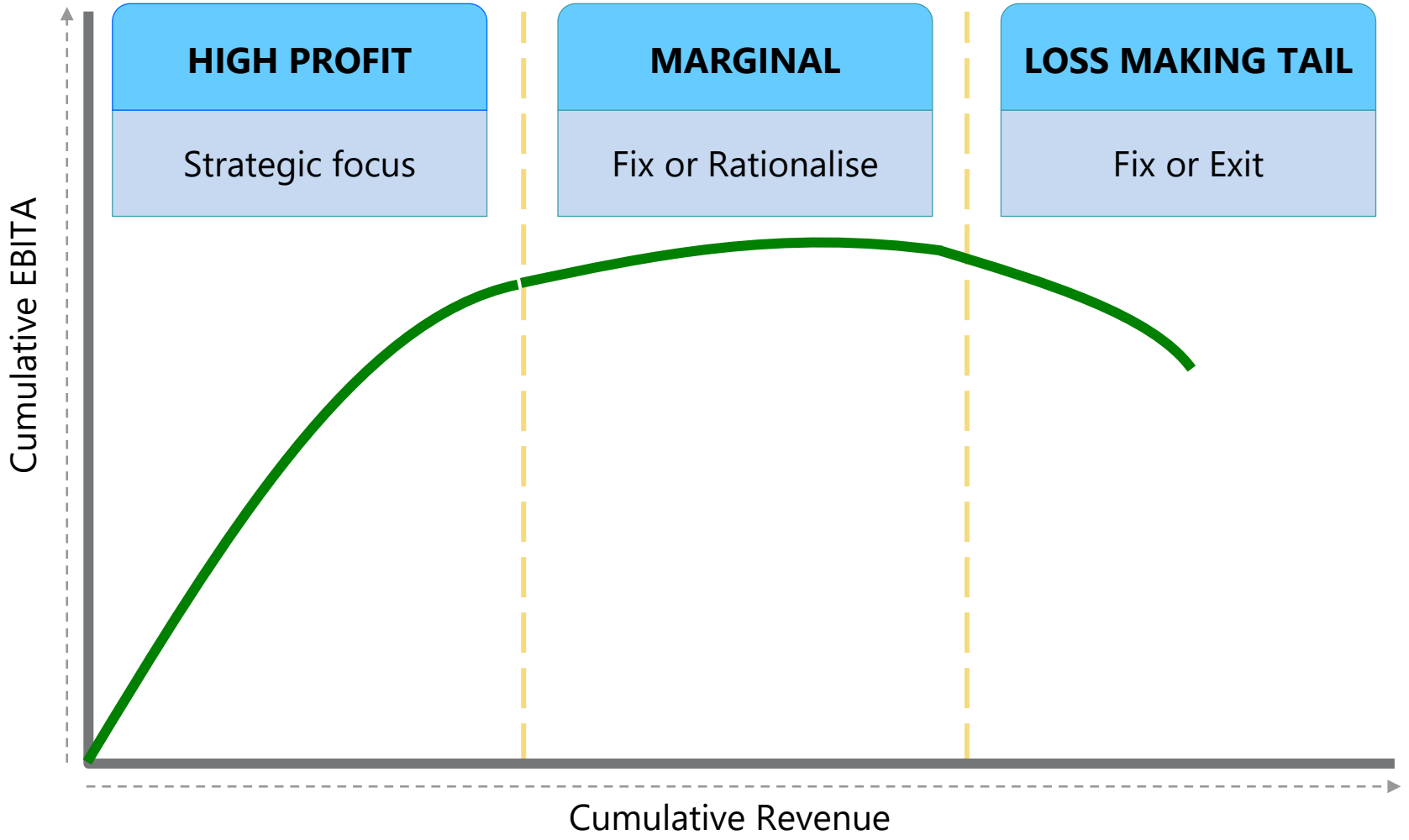
Step 2a: Map Activity Chain



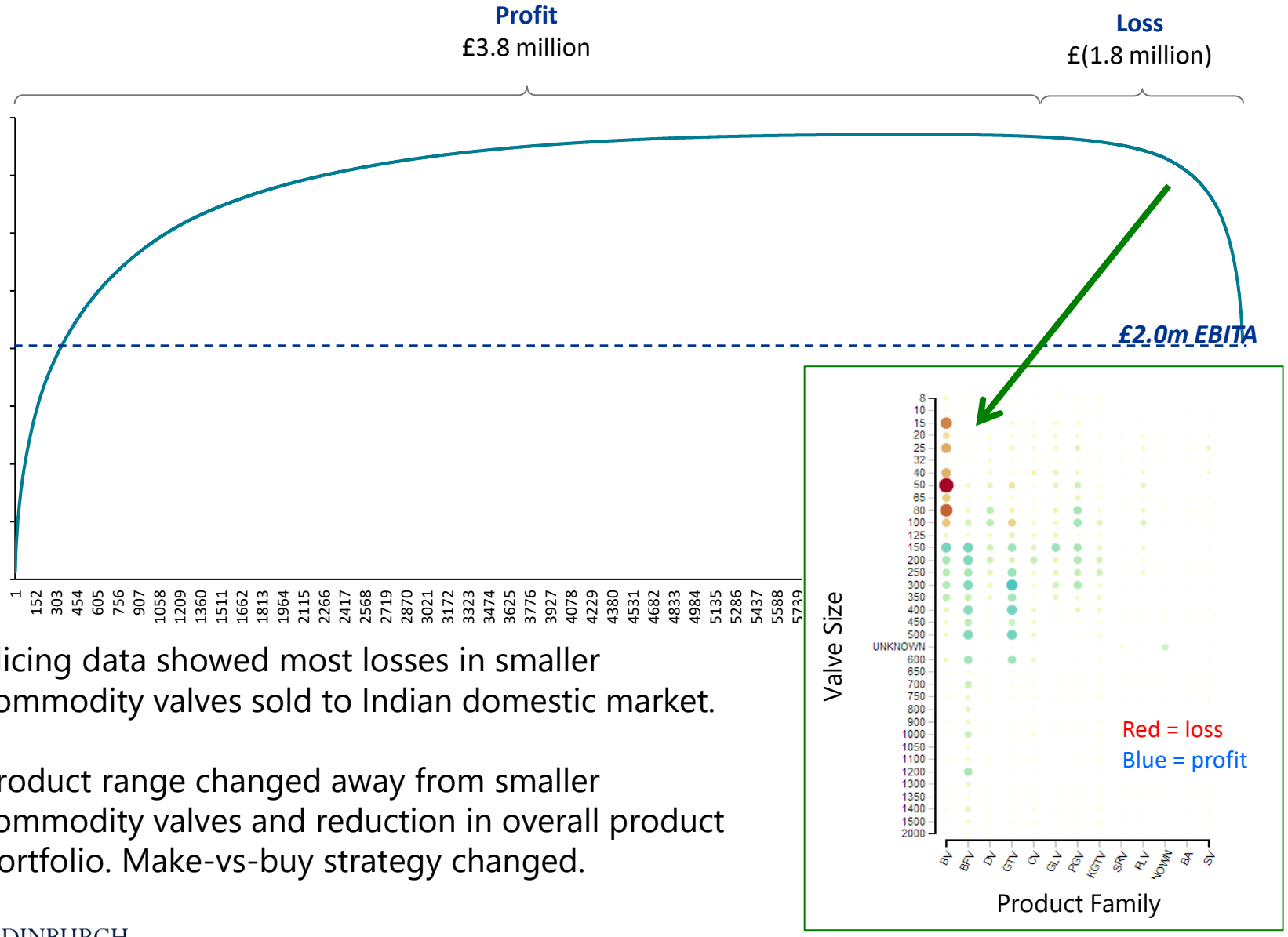
Step 2b: Apply costs to Activity Chain



What did we find?



Example: Valve company (India)



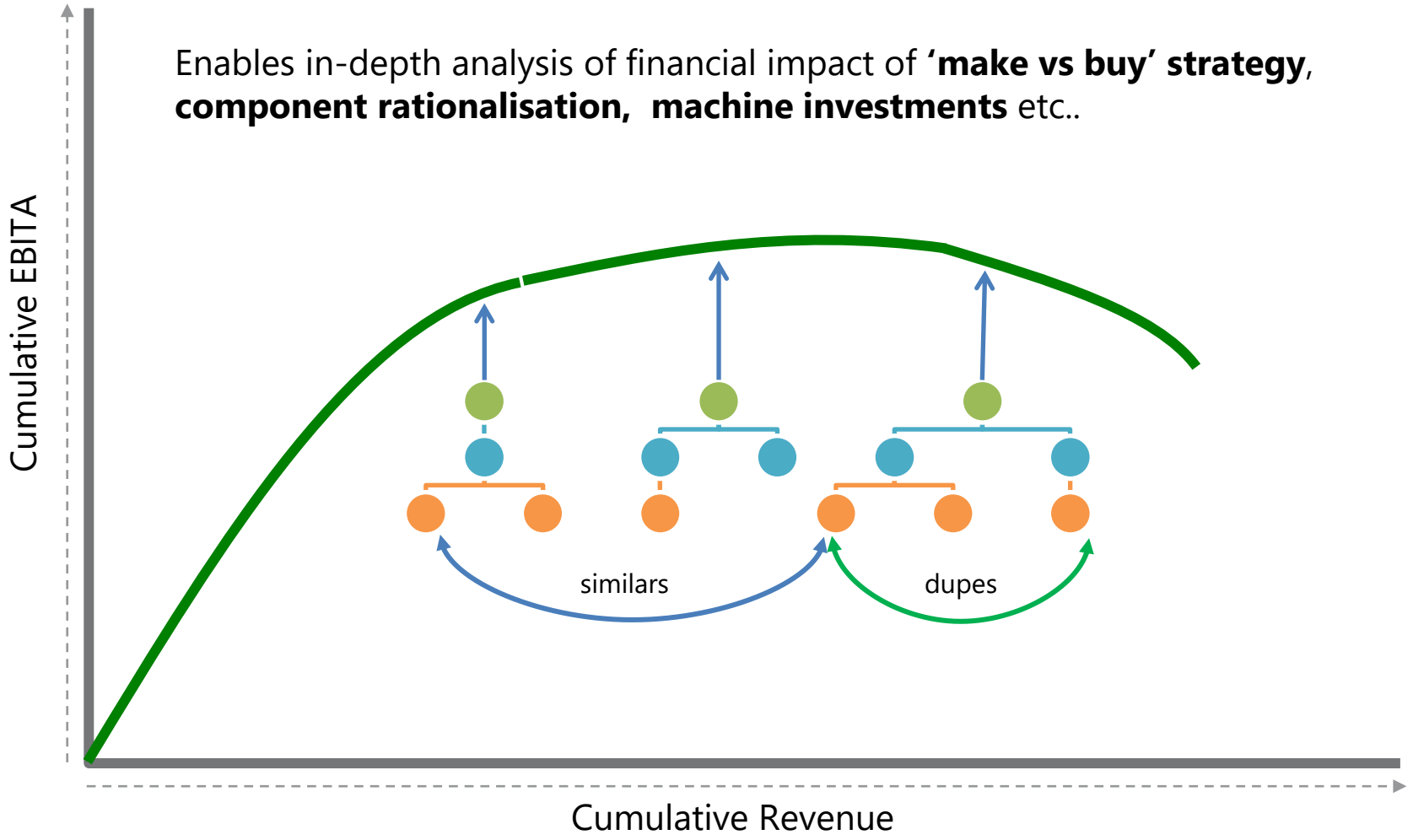
Slicing data showed most losses in smaller commodity valves sold to Indian domestic market.

Product range changed away from smaller commodity valves and reduction in overall product portfolio. Make-vs-buy strategy changed.

Model enables in-depth operational analysis

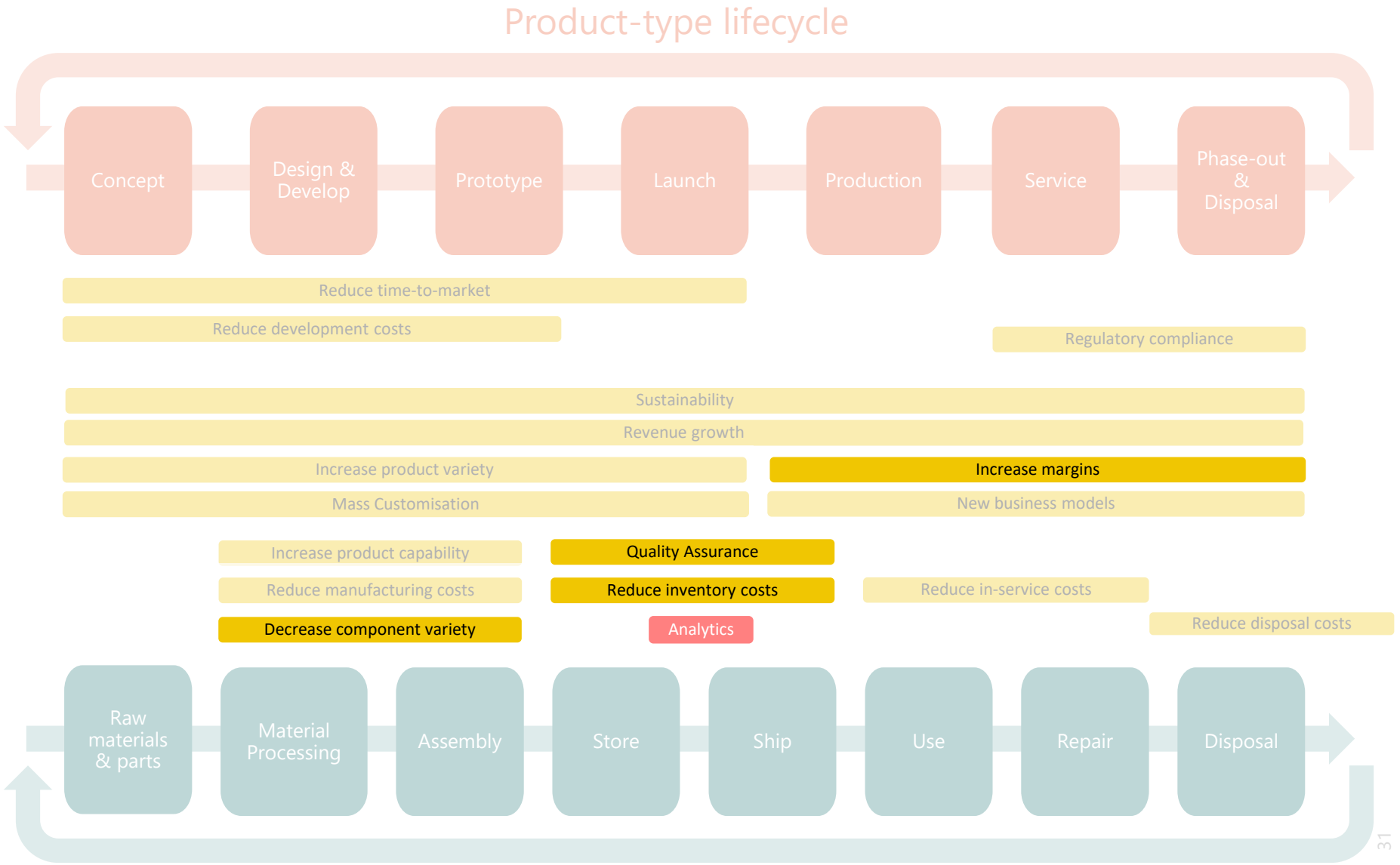
Model has BoM for every transaction + proprietary query language

Enables in-depth analysis of financial impact of **'make vs buy' strategy**, **component rationalisation, machine investments** etc..



Case Study 1: Valve Company India

Outcomes	
	■ Product portfolio rationalized and improved make-vs-buy decisions ■ Sales teams incentivized in line with new product strategy ■ Ongoing engineering effort to develop more ‘configured’ product to reduce variety ■ Significant simplification of operations ■ Significant quality and on-time delivery improvements ■ EBITA increased from £2m to £3.2m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Increase product variety
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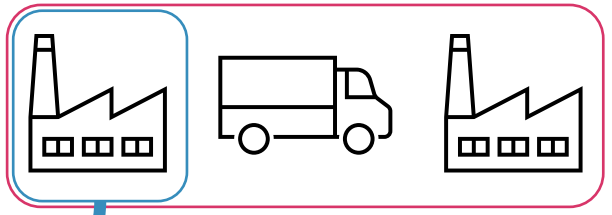
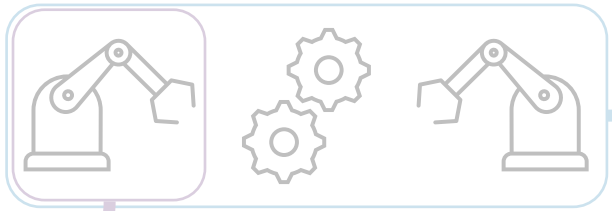
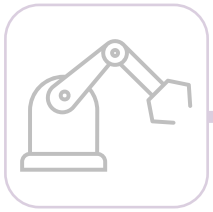




Smart Factory: Enablement of coordinated manufacturing operations



Smart Processes: Enhancement of individual manufacturing processes

Data-driven Manufacturing: example

Large food tray manufacturer

CNC moulds like these…

…to use on machines like these

FOOD TRAY MANUFACTURER:
THE PROBLEM

Customer (supermarket or food manufacturer) asks for quotes for a fixed design

Customer's design often inadequate - not manufacturable, not stiff enough, lip too narrow for bonding film

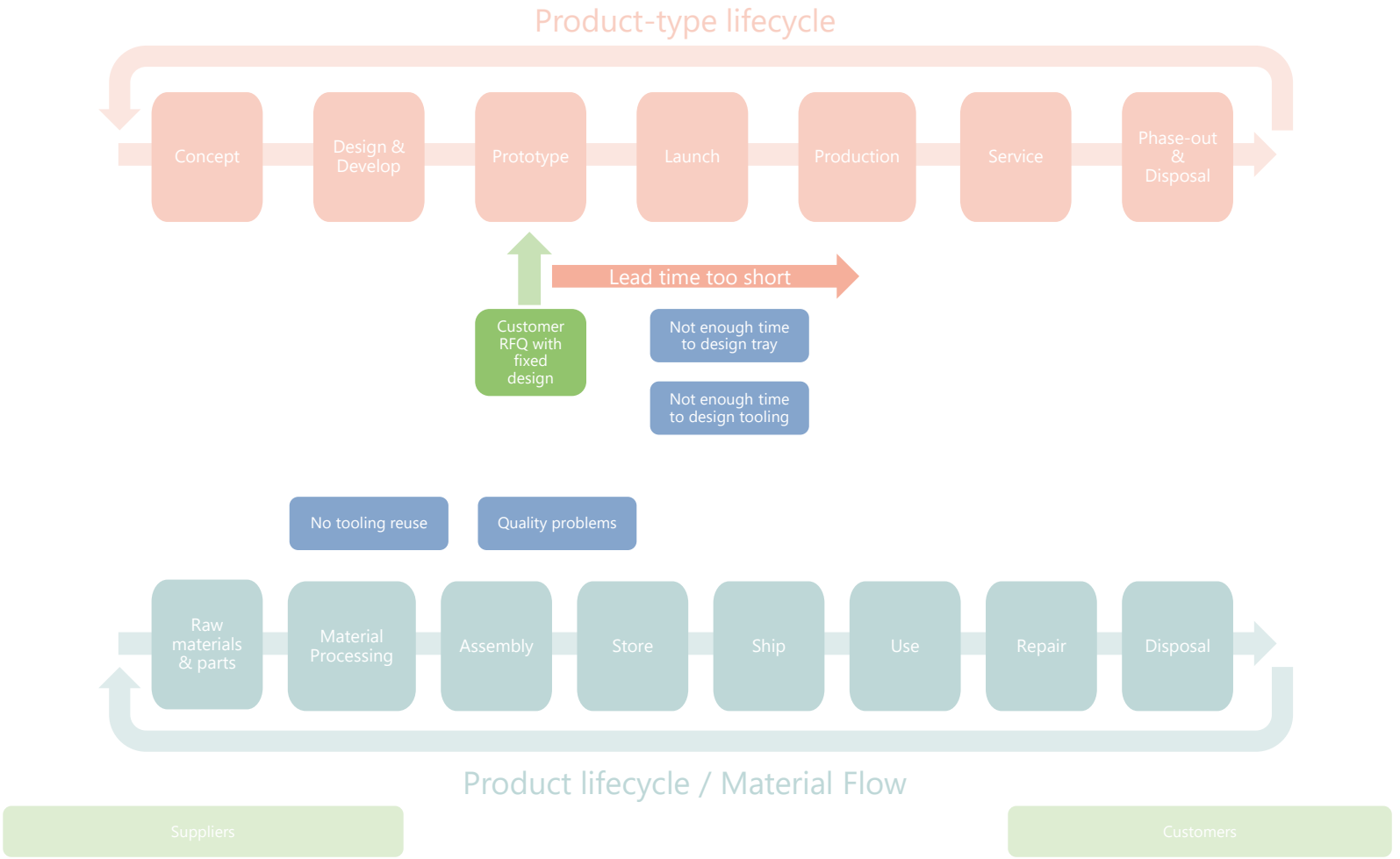
Design requires new tooling

Lead times too short

FOOD TRAY MANUFACTURER:
THE PROBLEM

Quality problems

Very low margin business


Product-type lifecycle
Concept
Design & Develop
Prototype
Launch
Production
Service
Phase-out & Disposal
Lead time too short
Customer RFQ with fixed design
Not enough time to design tray
Not enough time to design tooling
No tooling reuse
Quality problems
Raw materials & parts
Material Processing
Assembly
Store
Ship
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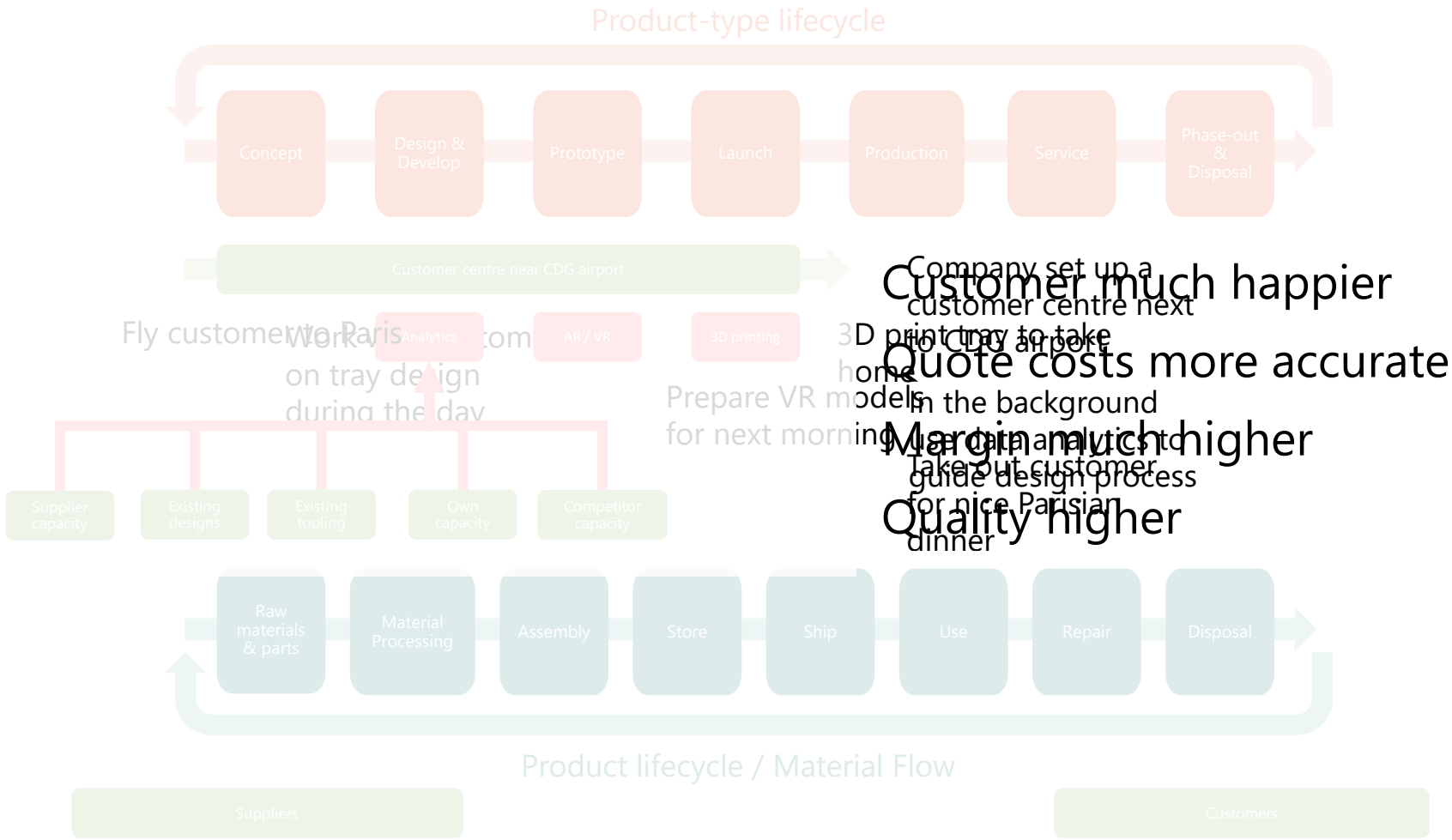


Customer much happier

Quote costs more accurate

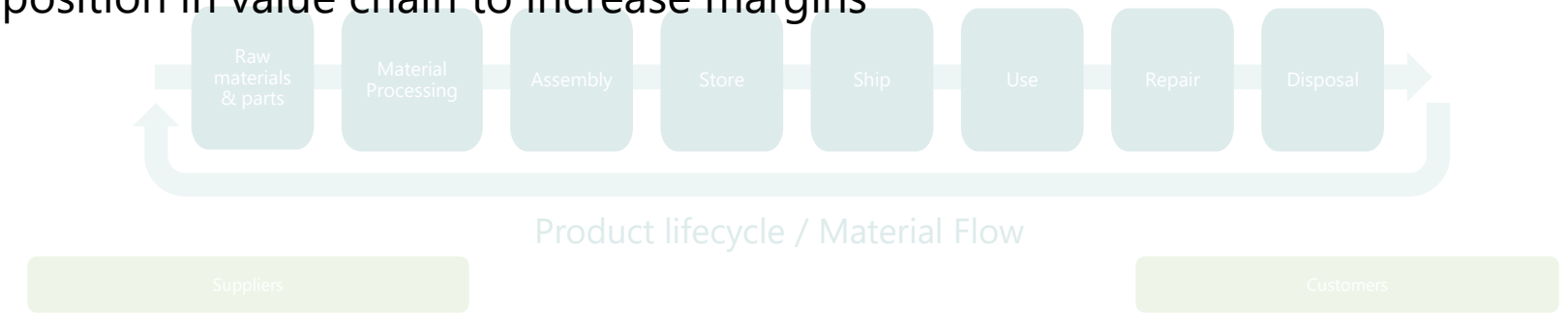
Margin much higher

Quality higher

Company recognised value chain was controlled by the designer of the tray – customer able to force low price

However, customer not in best position to optimise value chain

Imaginative use of data and digital technology put company in dominant position in value chain to increase margins



COMMON PROCESS DIFFICULTIES

1. Approvals
2. Sharing information
3. Maintaining a single source of truth
4. Communication during change

Ken English

INDUSTRY NEEDS: SKILLS

Computer science graduates have the coding and software engineering skills, but lack manufacturing domain knowledge

Engineers have manufacturing domain knowledge, but lack coding skills

There will be a strong demand for graduates who can operate in both domains

REFERENCES

1. Grieves, Michael. (2005). Product Lifecycle Management: Driving the Next Generation of Lean Thinking.