

# Design & Fabrication

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**Thomas Mantschko** (Tutor), Prof. Florian Michahelles

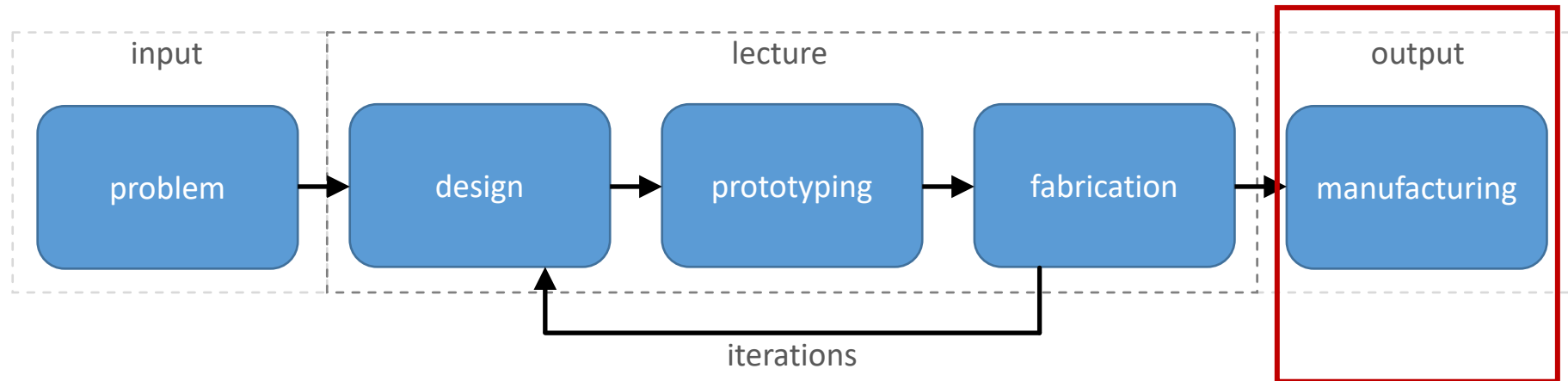
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# From Design to Fabrication

## Recapitulation



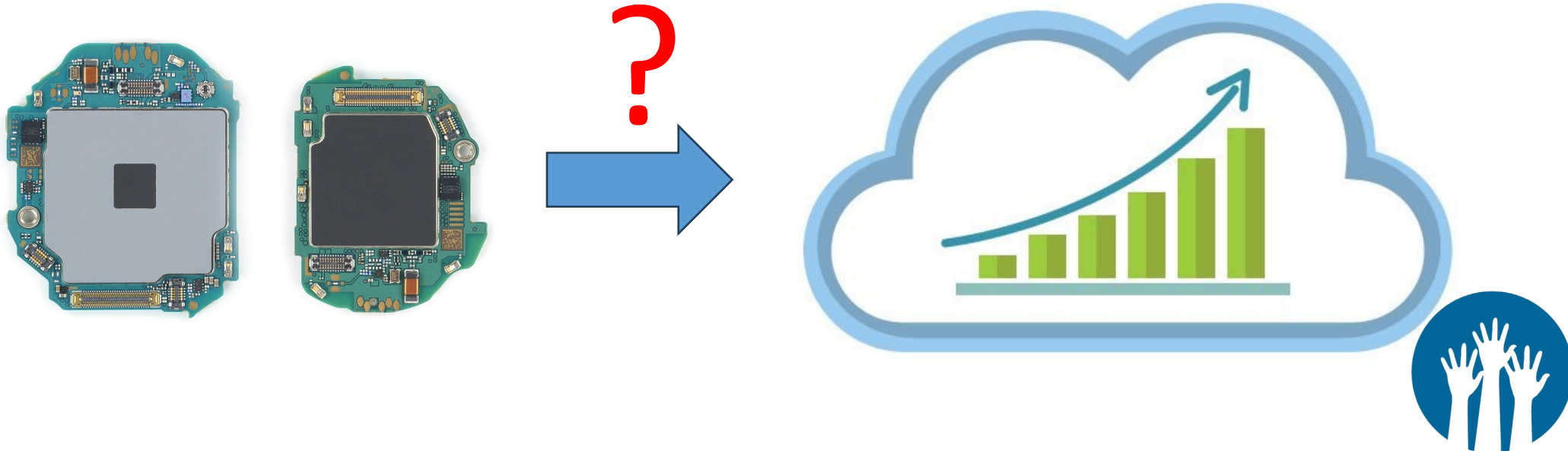
# Lecture 9

## Scalability and Responsible Innovation

# Scalability

Quicker to market, faster iterations, lower costs

- › Scalability refers to the ability of an organization (or a system, such as a computer network) to perform well under an increased or expanding workload.



# 3d printing vs. injection molding



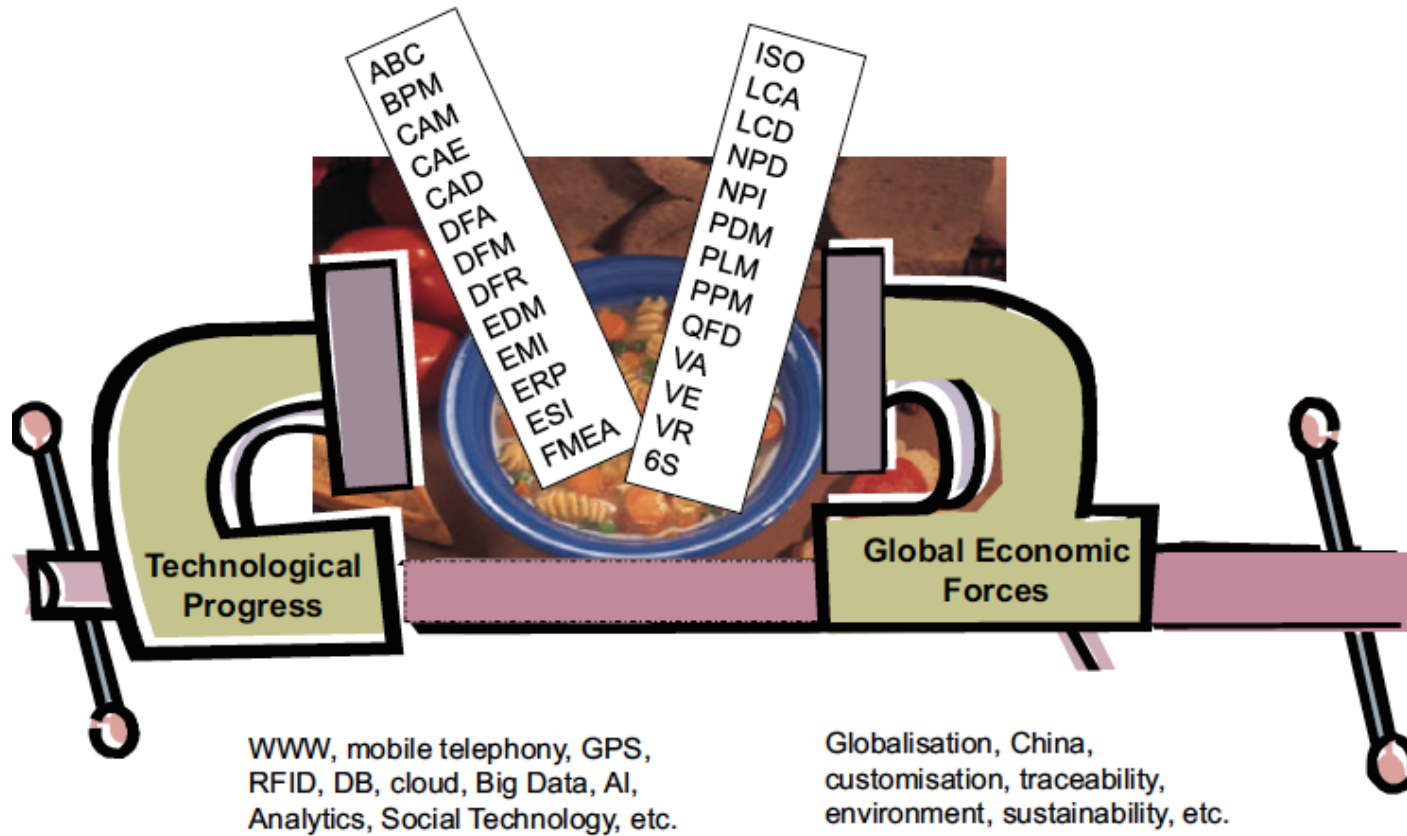
- › 3D printing has a low entry cost
  - › Easy to make design changes.
  - › Good for intricate designs
  - › **a slow production method**
  - › **unable to produce larger items**
  - › **Rough finish**
- 
- Small batch production, including prototyping
  - Intricate designs with gaps or holes in the middle
  - Design changes, even during production



- › Able to mass produce a high volume of parts
  - › Enhanced strength of objects.
  - › Minimal wastage
  - › **Limited design capabilities.**
  - › **Difficult to correct mistakes or change designs.**
  - › **Expensive entry costs.**
- 
- Large batch production as you can create multiple identical objects simultaneously
  - Strong, solid designs that are based on one continuous form
  - Smooth finishes for parts that move against other objects.

➔ By using the processes together, it is possible to shorten pre-production cycles before moving onto large batch production.

# Practice



# Product life cycle management

## five phases

“Product Lifecycle Management (PLM) is the business activity of managing, in the most effective way, a company’s products all the way across their lifecycles; from the very first idea for a product all the way through until it is retired and disposed of.”

Rate of introduction of new products	+100%	Lifecycle control over products	100%
Revenues from extended product life	+25%	Lifecycle visibility over products	100%
Costs due to recalls, failures, liabilities	-75%	Part reuse factor	x 7
Revenues from new services on existing products	+40%	Cost of materials and energy	-25%
Number of significantly innovative new products	x 3	Recycling of products	+90%
Development time for new products	-50%	Product traceability	100%

Fig. 1.1 Typical targets of a PLM Initiative



## Five phases of the product lifecycle

# Product life cycle management

## management structure

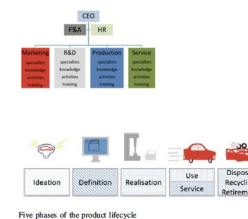
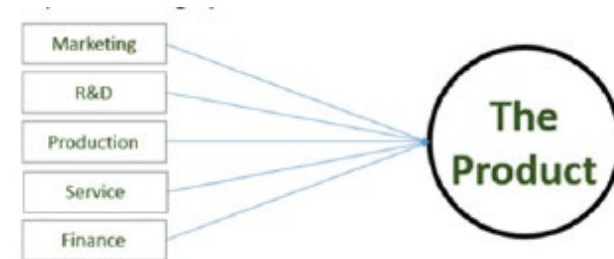
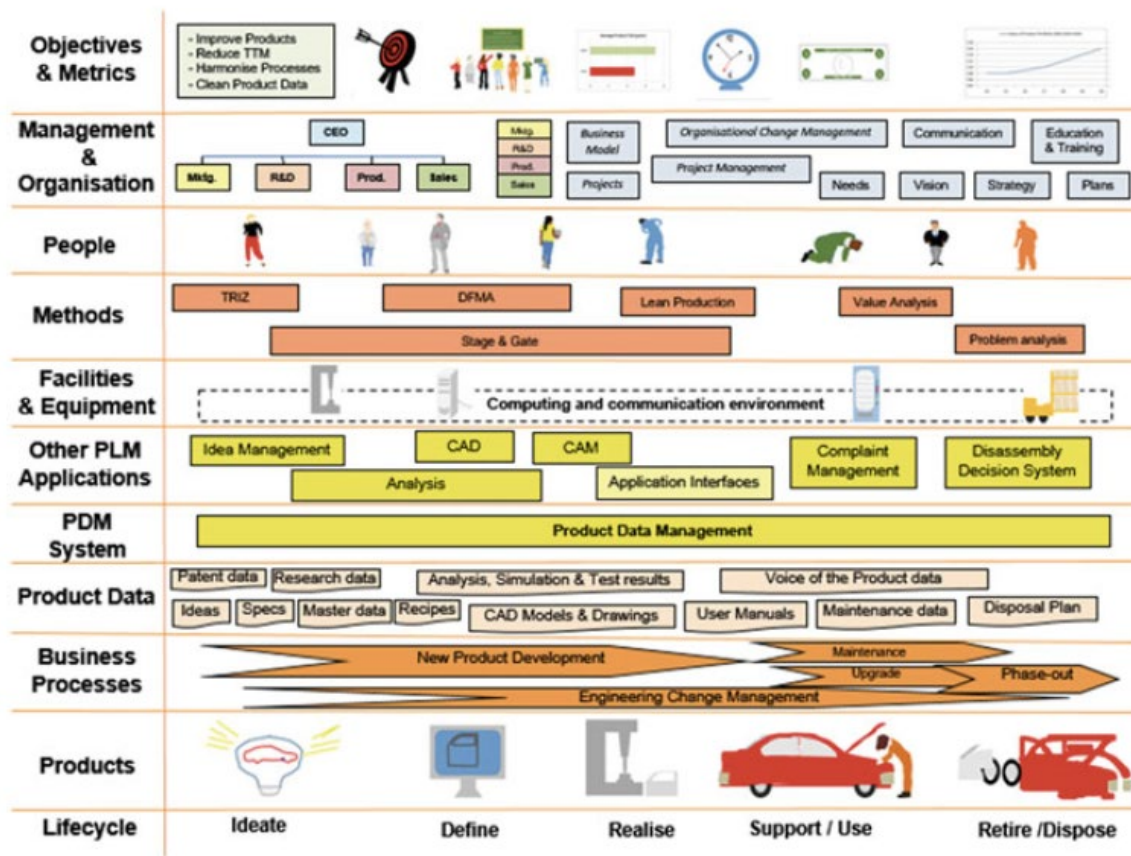


Five phases of the product lifecycle



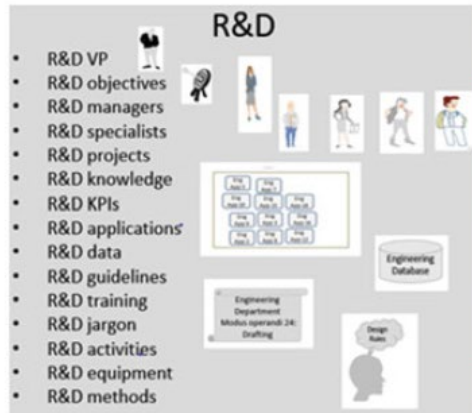
# Product life cycle management

a full organizational structure emerges...



# Product life cycle management

a full organizational structure emerges...



- Earlier market intro/increase revenue
- Reduce development costs
- Extend product life/increase revenue
- Reduce recall costs ...



**Financial Performance**

- Reduce project time overrun
- Reduce engineering change time
- Reduce time to market
- Reduce time to profitability....



**Time Reduction**

- Reduce manufacturing process defects
- Reduce returns
- Reduce customer complaints
- Reduce scrap .....

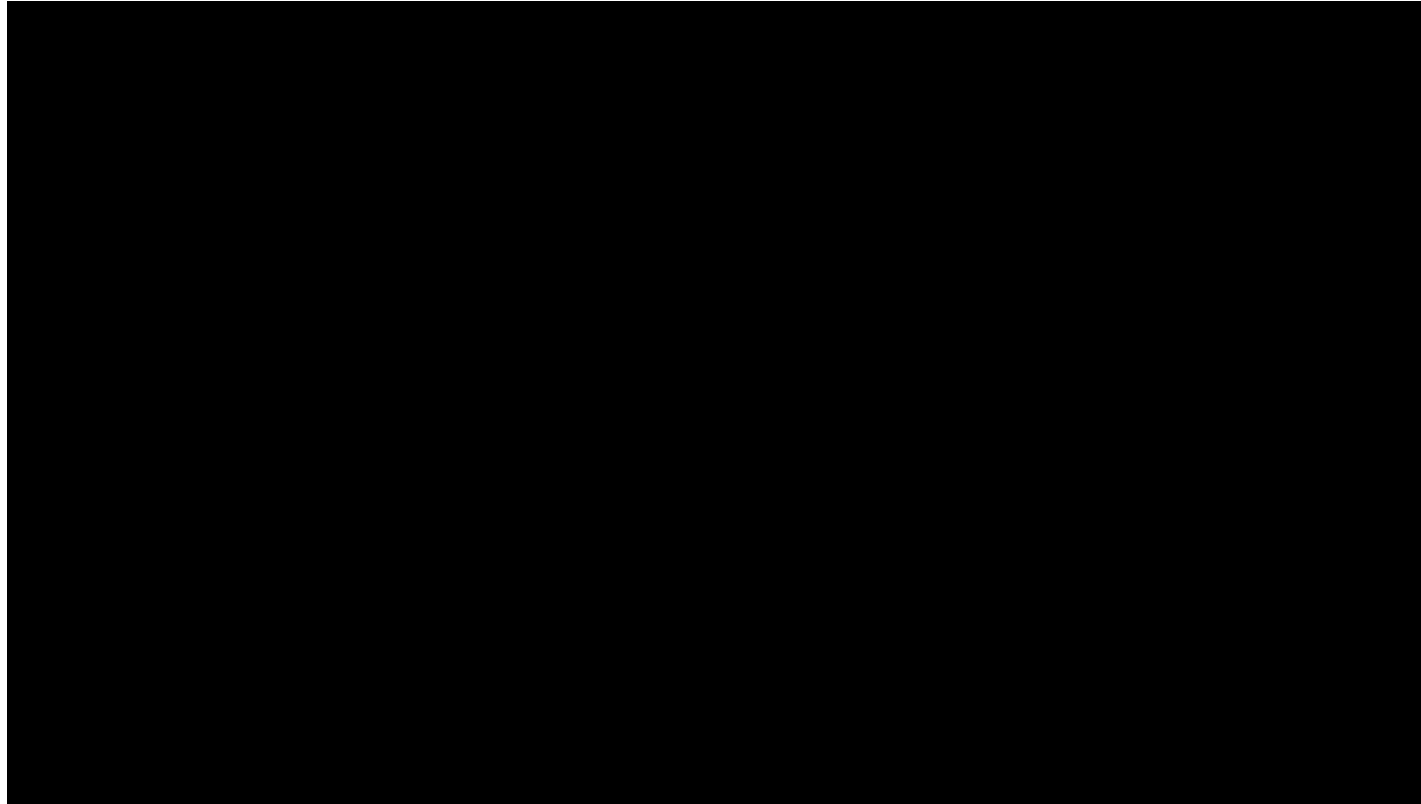


**Quality Improvement**

- Increase new product release rate
- Increase the part reuse factor
- Increase product traceability
- Ensure 100% configuration conformity ...



**Business Improvement**

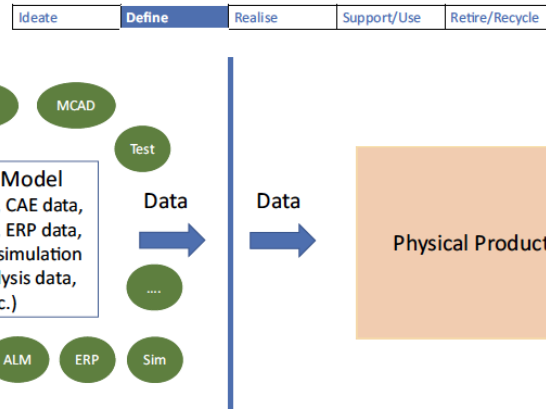
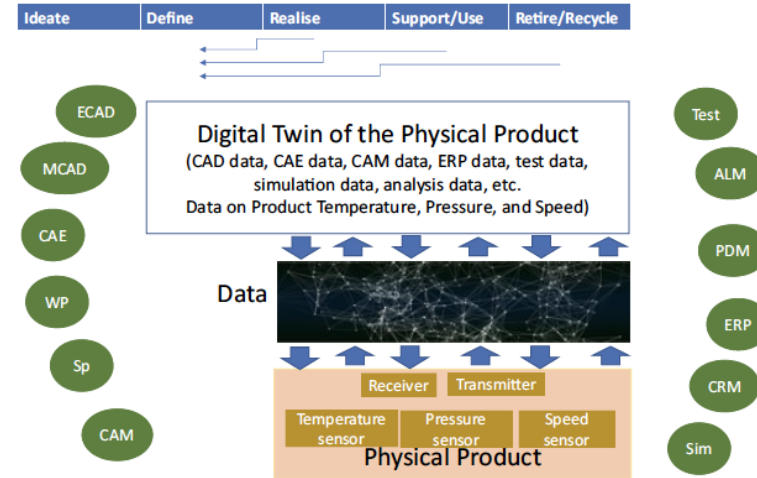
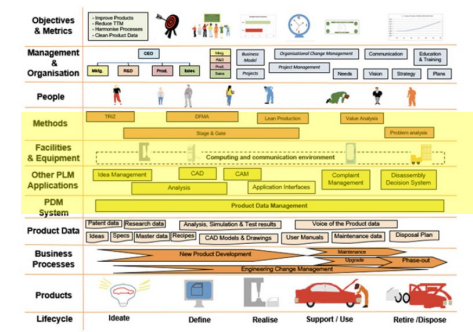


A **digital twin** configures, manages, and stores all product-related content—from final assembly structures to individual components—in a single, central repository

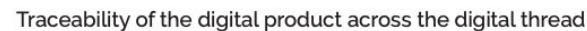
<https://www.youtube.com/watch?v=ObGhB9CCHP8>

# Digital Twin

integrating all product related data



Support repair	Educate customers/users	Forecast future performance
Help communicate	Inform recycling activities	Understand product failures
Underpin services	Support recertification	Support product disassembly
Aid decision-making	Analyse change requests	Provide requested information
Train support staff	Understand product issues	Support complaint investigation
Support product use	Investigate reported issues	Demonstrate product capabilities
Simulate product use	Represent faraway products	Estimate product life expectancy
Illustrate maintenance	Collaborate with suppliers	Identify product performance levels

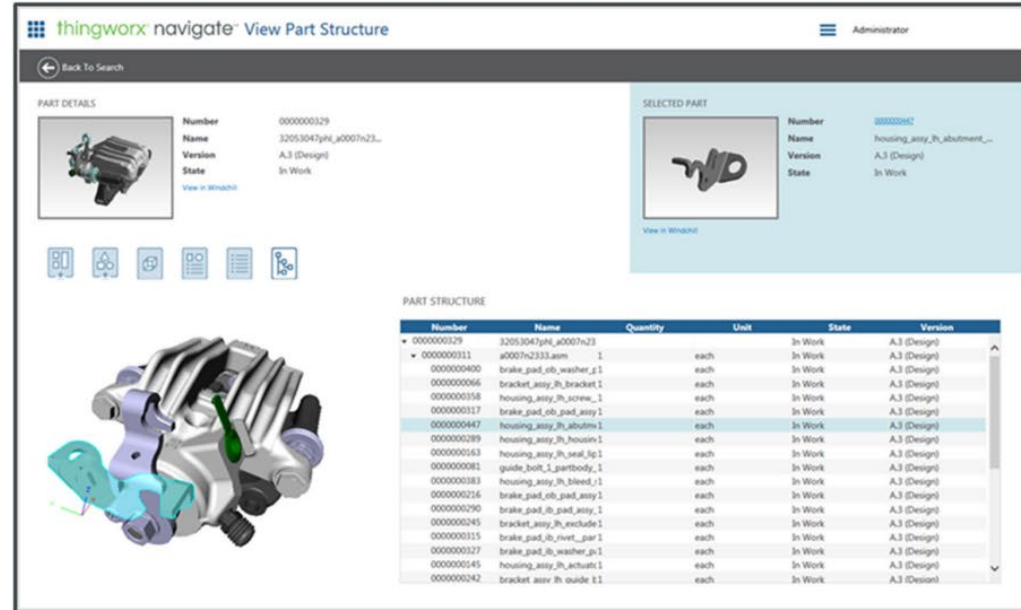


13 | Florian Michahelles



# 1. Provide early visibility to stakeholders

Early involvement of supply chain management

**thingworx navigate View Part Structure**

**PART DETAILS**

Number: 0000000329  
Name: 32053047phl\_a0007n23...  
Version: A.3 (Design)  
State: In Work

**SELECTED PART**

Number: 0000000402  
Name: housing Assy\_Rh\_abutment...  
Version: A.3 (Design)  
State: In Work

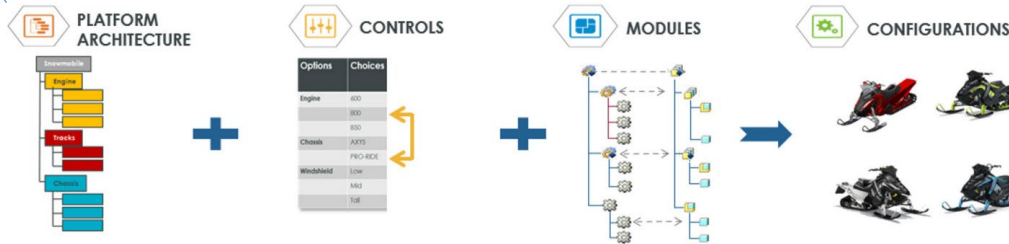
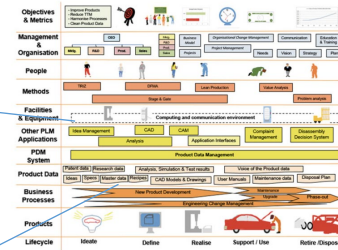
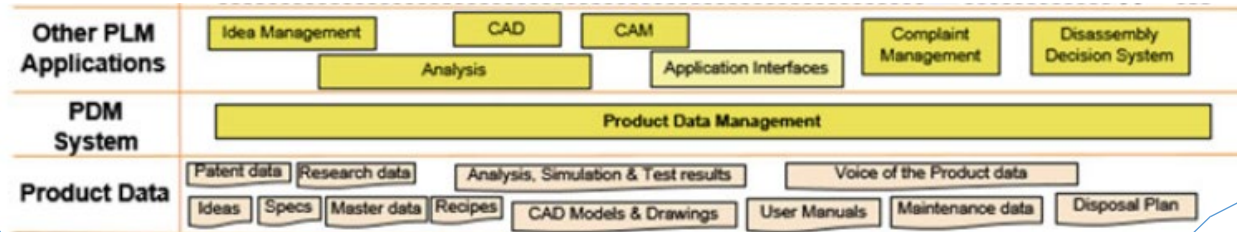
**PART STRUCTURE**

Number	Name	Quantity	Unit	State	Version
0000000329	32053047phl_a0007n23	1	each	In Work	A.3 (Design)
0000000311	a0007n23333.asm	1	each	In Work	A.3 (Design)
0000000400	brake_pad_srb_washer_s 1	each	each	In Work	A.3 (Design)
0000000066	bracket Assy_Rh_bracket 1	each	each	In Work	A.3 (Design)
0000000158	housing Assy_Rh_actuat_1	each	each	In Work	A.3 (Design)
0000000117	brake_pad_srb_pad Assy 1	each	each	In Work	A.3 (Design)
0000000447	housing Assy_Rh_abutms 1	each	each	In Work	A.3 (Design)
0000000289	housing Assy_Rh_housins 1	each	each	In Work	A.3 (Design)
0000000163	housing Assy_Rh_seal_lp 1	each	each	In Work	A.3 (Design)
0000000081	guide_bolt_1_partbody_1	each	each	In Work	A.3 (Design)
0000000183	housing Assy_Rh_breed_1	each	each	In Work	A.3 (Design)
0000000216	brake_pad_srb_pad Assy 1	each	each	In Work	A.3 (Design)
0000000290	bracket Assy_Rh_exclude 1	each	each	In Work	A.3 (Design)
0000000245	bracket Assy_Rh_exclude 1	each	each	In Work	A.3 (Design)
0000000115	brake_pad_srb_rivet_par 1	each	each	In Work	A.3 (Design)
0000000127	brake_pad_srb_washer_ps 1	each	each	In Work	A.3 (Design)
0000000145	housing Assy_Rh_actuat 1	each	each	In Work	A.3 (Design)
0000000242	bracket Assy_Rh_guide 1	each	each	In Work	A.3 (Design)

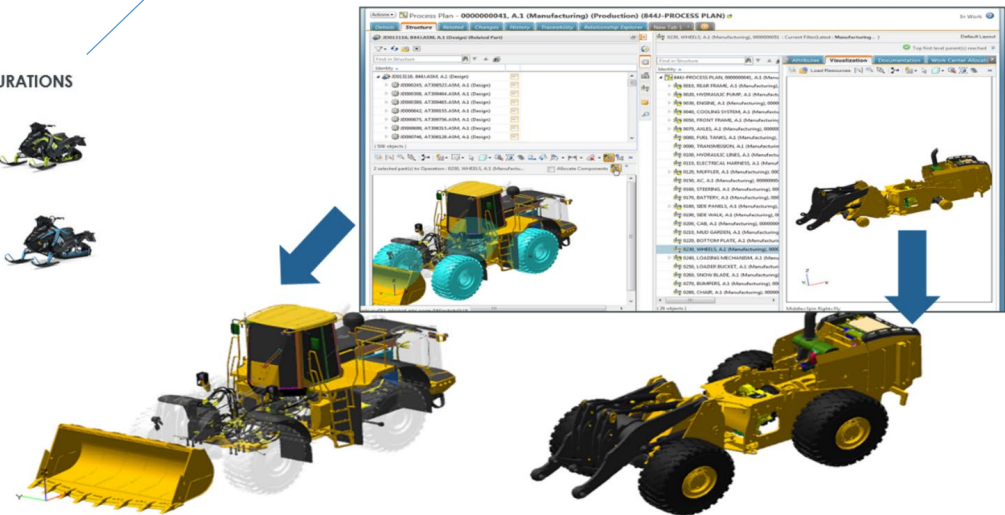
› [https://www.ptc.com/-/media/Files/PDFs/PLM/plm\\_foundation\\_bom-centric-10-ways-wp.pdf](https://www.ptc.com/-/media/Files/PDFs/PLM/plm_foundation_bom-centric-10-ways-wp.pdf)

## 2. Support a range of structures.

traceability between parts (CAD, electrical, mechanical, software, and so on)



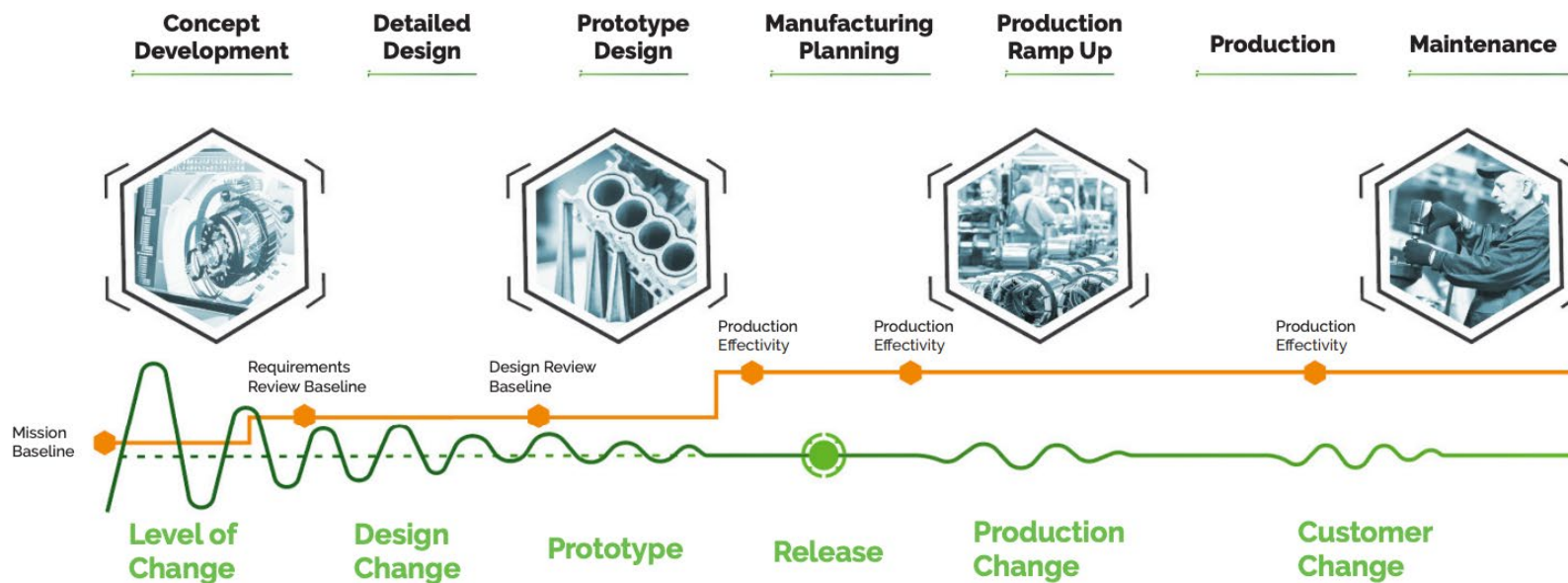
Establishing a common data model



Platform Visualization & Design

› [https://www.ptc.com/-/media/Files/PDFs/PLM/plm\\_foundation\\_bom-centric-10-ways-wp.pdf](https://www.ptc.com/-/media/Files/PDFs/PLM/plm_foundation_bom-centric-10-ways-wp.pdf)

### 3. Manage configurations



Shorten time to production (and to market)

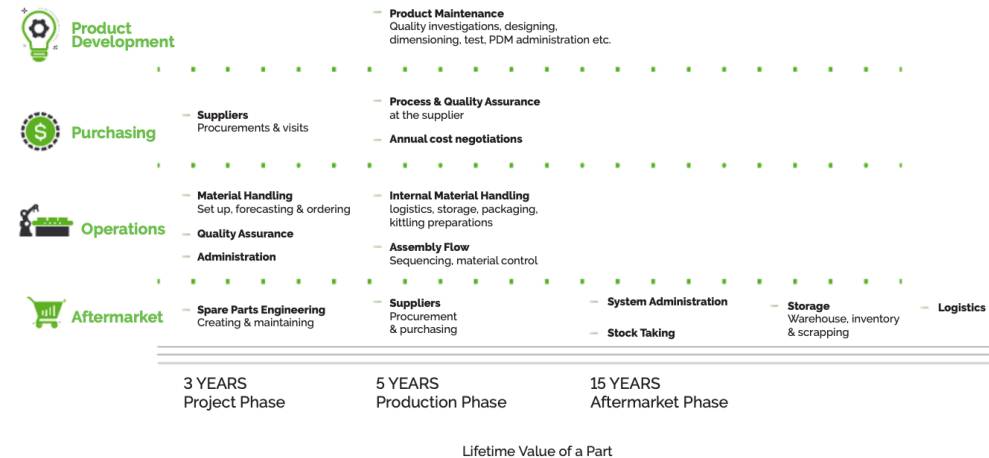
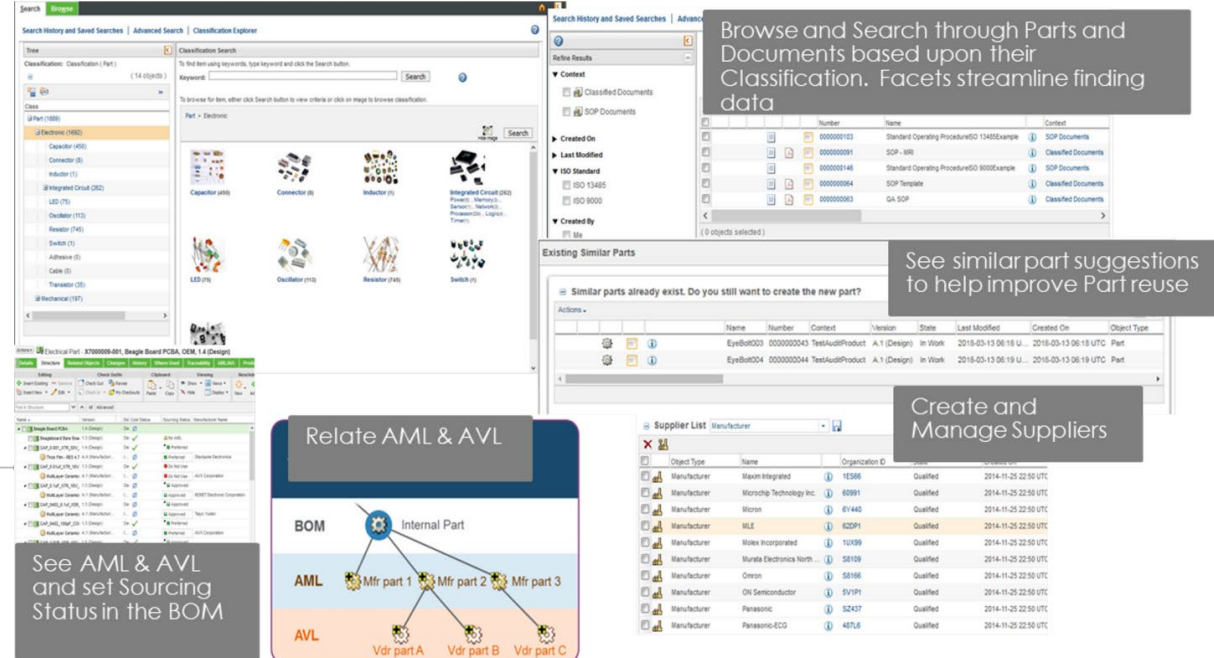
› [https://www.ptc.com/-/media/Files/PDFs/PLM/plm\\_foundation\\_bom-centric-10-ways-wp.pdf](https://www.ptc.com/-/media/Files/PDFs/PLM/plm_foundation_bom-centric-10-ways-wp.pdf)





# 5. Improve component and supplier management.

reuse can help reduce inventory complexity

**Browse and Search through Parts and Documents based upon their Classification. Facets streamline finding data**

**See similar part suggestions to help improve Part reuse**

**Create and Manage Suppliers**

**Relate AML & AVL**

**See AML & AVL and set Sourcing Status in the BOM**

**Supplier List**

Object Type	Name	Organization ID	Status	Created On	Created By
Manufacturer	Maxim Integrated	1ES66	Qualified	2014-11-25 22:50 UTC	
Manufacturer	Winchip Technology Inc.	60981	Qualified	2014-11-25 22:50 UTC	
Manufacturer	Winson	61440	Qualified	2014-11-25 22:50 UTC	
Manufacturer	WLE	620P1	Qualified	2014-11-25 22:50 UTC	
Manufacturer	Wolke Incorporated	10X39	Qualified	2014-11-25 22:50 UTC	
Manufacturer	Wurata Electronics North	58109	Qualified	2014-11-25 22:50 UTC	
Manufacturer	Onsemi	58166	Qualified	2014-11-25 22:50 UTC	
Manufacturer	On Semiconductor	5V1P1	Qualified	2014-11-25 22:50 UTC	
Manufacturer	Panasonic	5Z437	Qualified	2014-11-25 22:50 UTC	
Manufacturer	Panasonic-ECG	457L6	Qualified	2014-11-25 22:50 UTC	

Full Track Vs. Fast Track Changes

Problem Report

Create and view Changes with easy to configure layouts

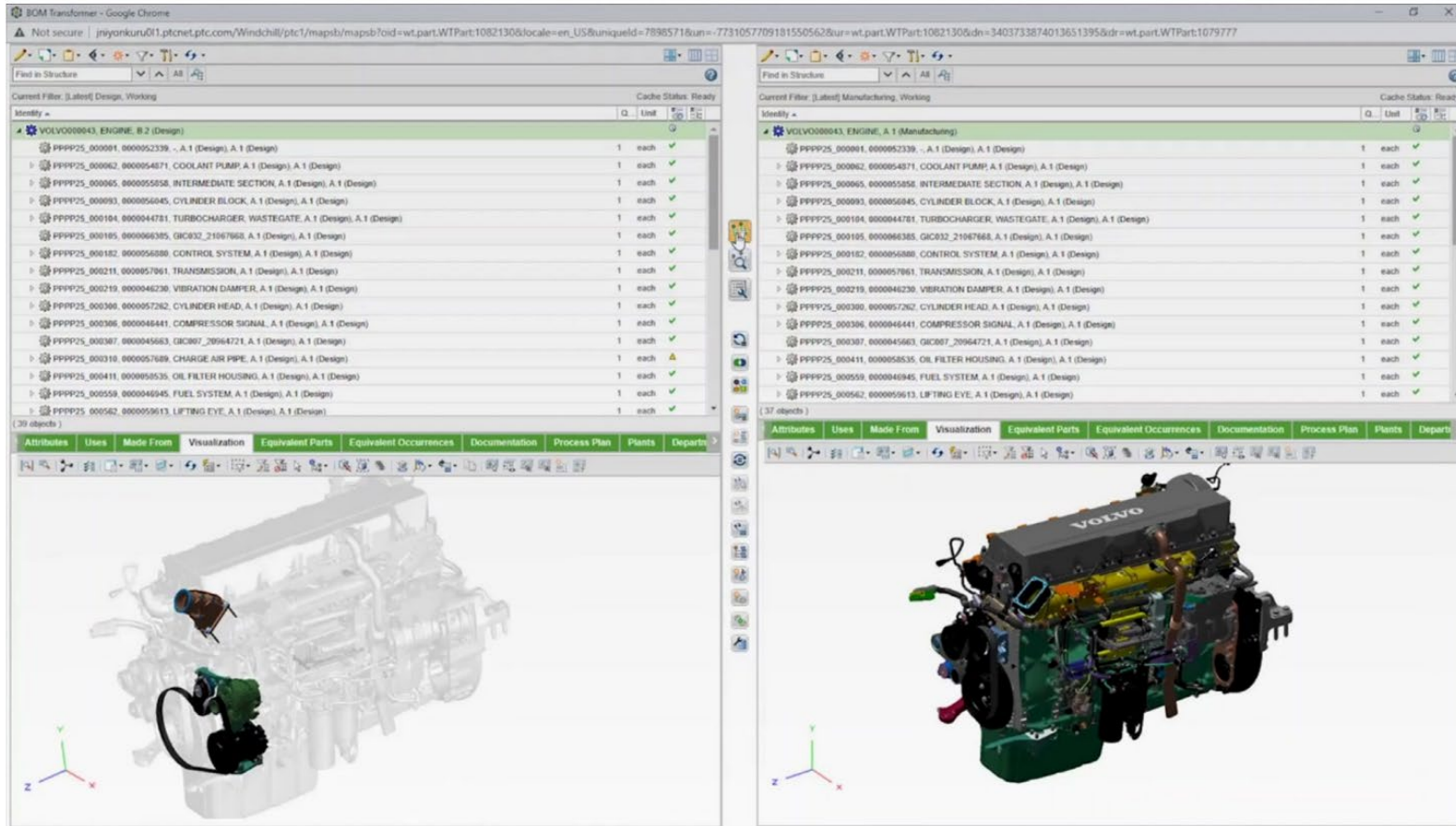
Easy to define closed loop process that scales from simple to rigorous

View Rule Conflicts

Define Business Rules to validate that Changes meet needs

Interact with visual markups during the Change process

# 7. Optimize downstream





## 8. Enable effective collaboration and IP protection.

- › share relevant, accurate, up-to-date data that can be accessed
- › IP policies must be in place to ensure access privileges are consistent
- › optimize collaboration without introducing the risk of losing IP or failing to meet regulatory requirements



Ensure protection of intellectual property

## 9. Create reports.

Part					
Identity	Version	Name	Release Target		
GC000002, Demo Organization, B.6 (Design)	B.6 (Design)	LEG	Change		
On Order	Use Existing				
Work-in-Process	Use Existing				
Finished	Use Existing				
Action	Find Number	Component Number	Quantity	Units	Reference Designator
Change		GC000017, Demo Organization	3 4	each	D20020_1-D20020_3 D20020_1-D20020_4
Replace	10T	0000000041, Demo Organization GC000003, Demo Organization	1	each	D20002_1
Delete	20	GC000011, Demo Organization	1	each	D20040_1
Add		GC000037, Demo Organization	43	each	
Action	Component Number	Component Version	Component	Link Type	
Add	SQB404.PRT, Demo Organization	A.1	sqb404.prt	Content	

Nonconformance Material Report					
Report Date May 03, 2021					
<b>Number</b>	00021		<b>Name</b>	NC-001	
<b>Intake General Information</b>					
<b>Intake Header</b>					
Entered By demo			Date File Opened 2020-10-14 10:29:50.0		
Resolution Date					
<b>Originator Information</b>					
Originated By demo			Originating Location pune		
Process Type Manufacturing			Shift Second		
Nonconformance Type In Process Manufacturing			Occurrence Date 2020-10-13 18:30:00.0		
Nonconformance Category NC-O1D1			Event\Nonconformance (Unplanned)\Other\Documentation		
Description hmm					
<b>Parts/Products</b>					
Number	Name	Lot/Serial Number	Supplier Number	Quantity	Units
GC000002	LEG	1	1	11	BOX

Word									
Office365 Test Document - Saved									
File	Home	Insert	Layout	References	Review	View	Help	Windchill	Open in Desktop App
Tell me what you want to do									
Editing									
New Document   Check In   Check Out   Undo Checkout   View Information									

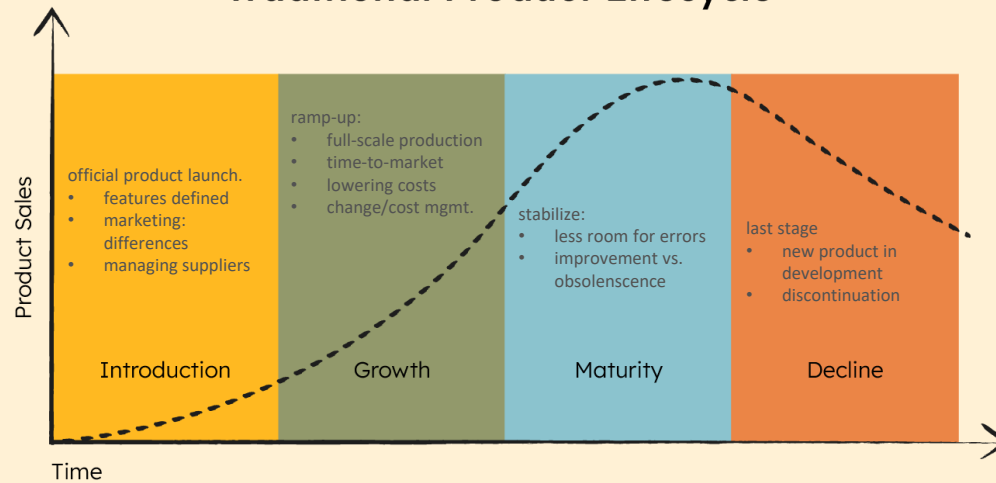
Reporting and Document Management

# Product lifecycle management

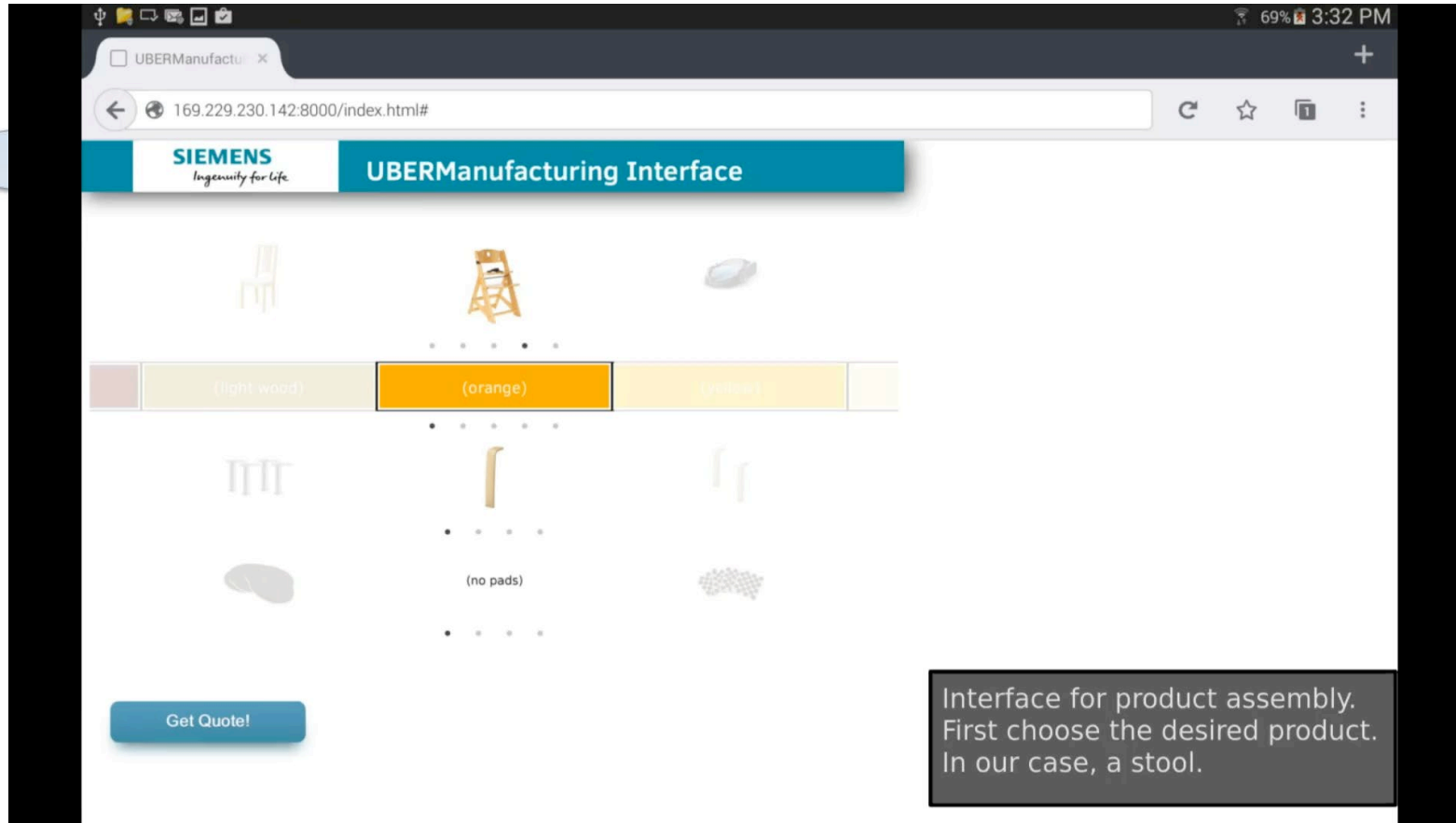
## Example Siemens SIMATIC



### Traditional Product Lifecycle



# Vision: Ubermanufacturing

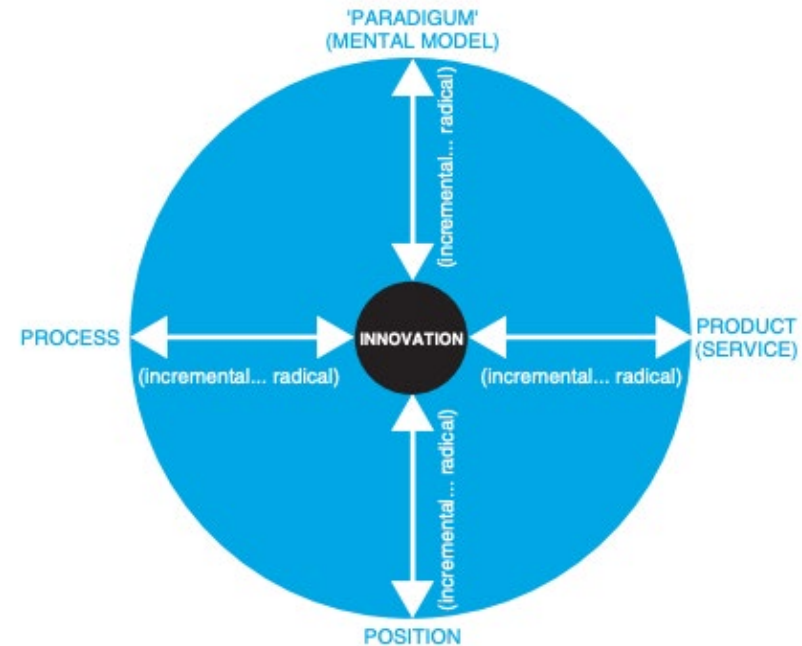


UberManufacturing: A Goal-Driven Collaborative Industrial Manufacturing Marketplace  
S Mayer, D Plangger, F Michahelles, S Rothfuss  
Proceedings of the 6th International Conference on the Internet of Things, 2016



# Where Could We Innovate? – Innovation Strategy

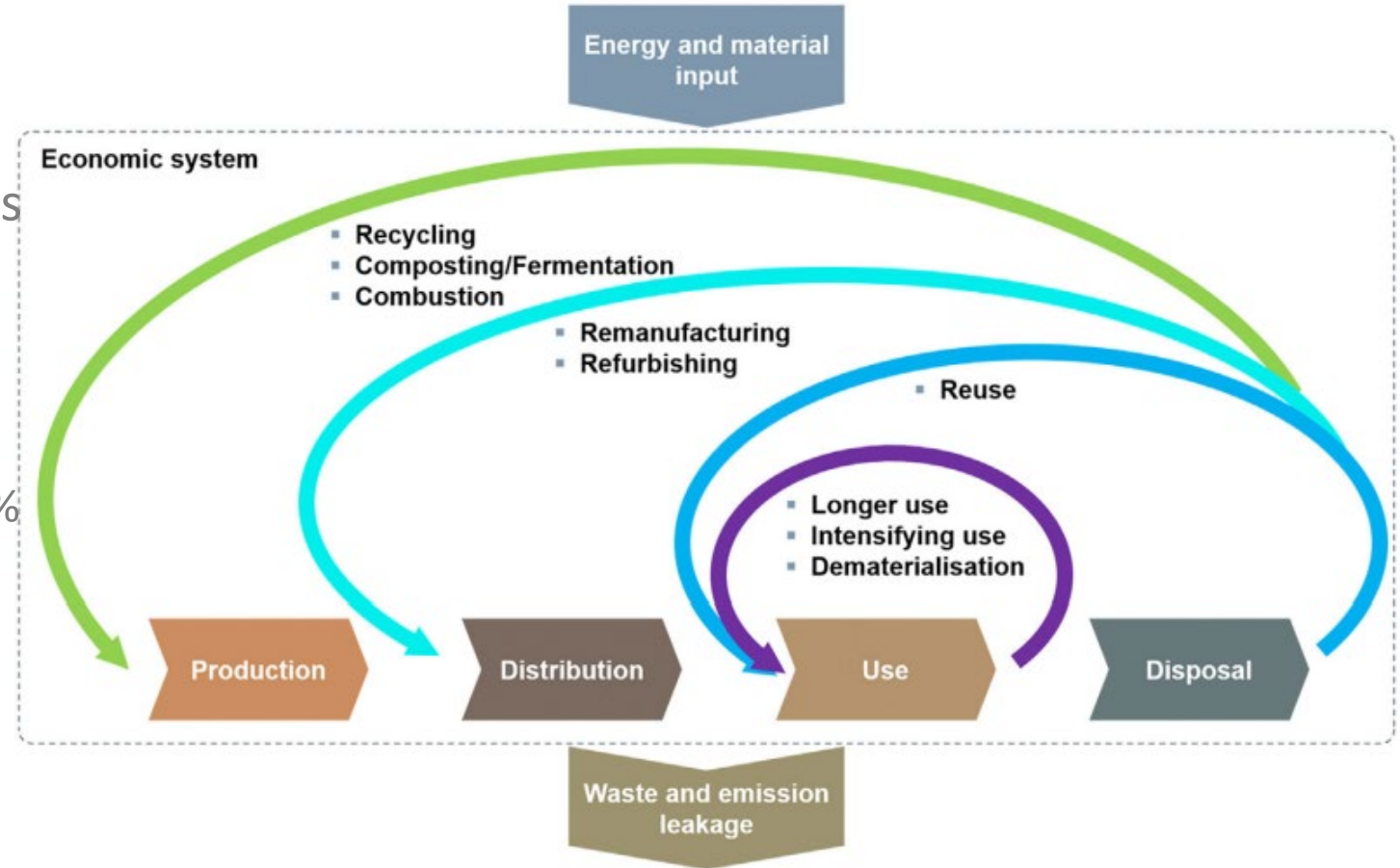
- › “product innovation” – changes in the things (products/services) which an organization offers;
- › “process innovation” – changes in the ways in which products and services are created and delivered;
- › “position innovation” – changes in the context in which the products/services are introduced;
- › “paradigm innovation” – changes in the underlying mental models which frame what the organization does



# Circular economy

towards a sustainable society









- › strategy to address environmental impacts and other objectives like material sovereignty
  - › manufacturing responsible for 30-35% of global greenhouse gas emissions
  - › circularity rate is only 7.1% globally, around 12% in Europe

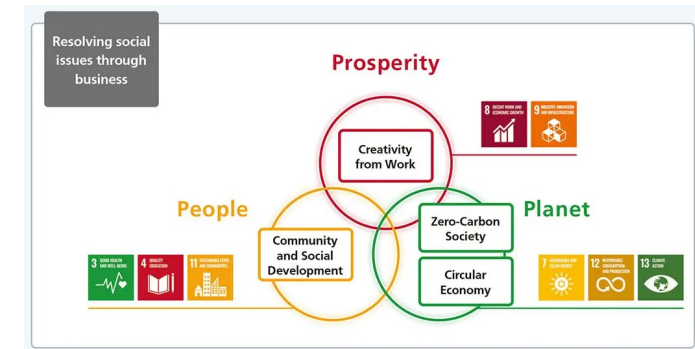


**Fig. 1.** The circular economy.

## Example Ricoh

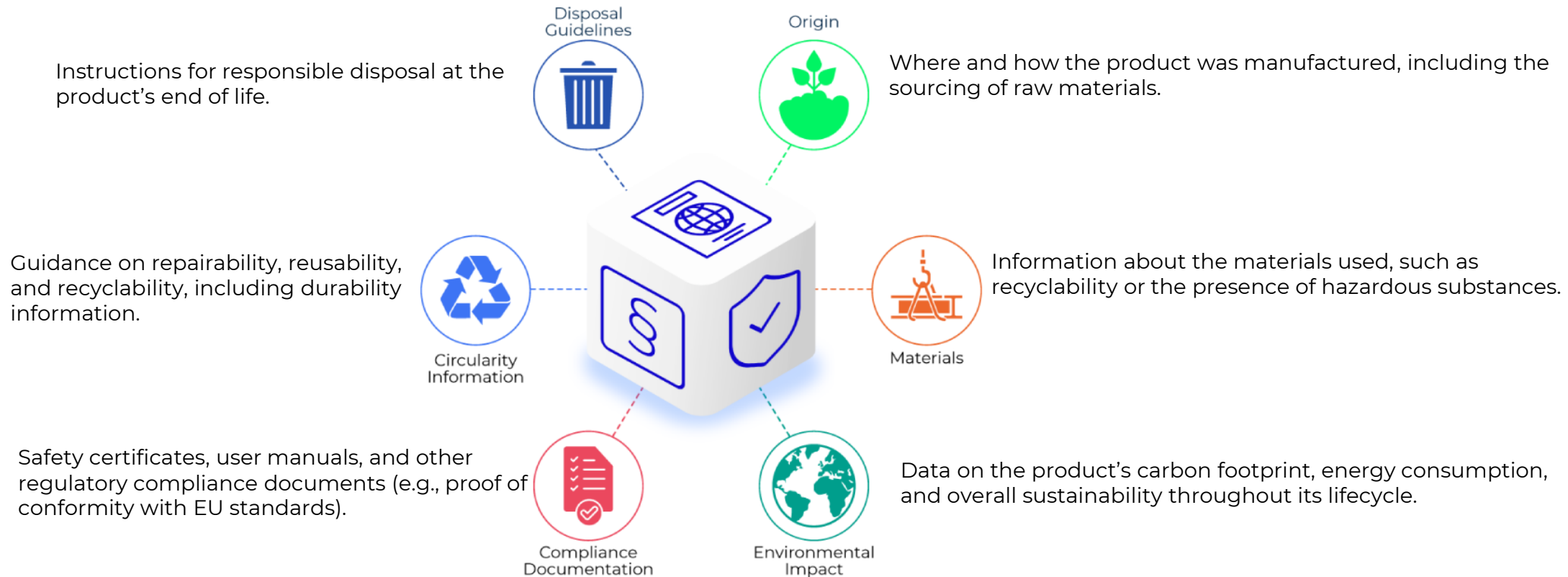
# Management Strategies and Identification of Material Issues

Resolving social issues through business					
Materiality	Strategic Intent	2030 Targets	Focus Domains	21st MTS ESG Targets (End of FY2025)	
<b>Creativity from Work</b>  	To provide digital services that transform the way customers work, and help them improve productivity improvement and value creation	Contribute to "Creativity from Work" of all customers to whom we deliver value	<ul style="list-style-type: none"> <li>Office Services</li> <li>Digital services for printing industry</li> <li>Thermal media</li> <li>Industrial Products</li> <li>Smart Vision</li> </ul>	① Customer survey scores* <sup>1</sup>	29%
<b>Community and Social Development</b>   	To contribute to the maintenance, development, and efficiency of community and social systems. We leverage our technical expertise and customer connections to expand the areas where we provide value.	Contribute to the enhancement of social infrastructure for 30 million people	<ul style="list-style-type: none"> <li>GEMBA</li> <li>Biomedical</li> <li>Municipal digitalization solutions</li> <li>Educational ICT solutions</li> </ul>	② Number of people to whom we have contributed by improving social infrastructure	15~20 million people
<b>Zero-Carbon Society</b>  	To decarbonize the entire value chain and create business opportunities by contributing to carbon neutrality	Reduce GHG emissions by 63% for scope 1 and 2, and 40% for scope 3  Switch to 50% renewable electricity	<ul style="list-style-type: none"> <li>Eco solutions</li> <li>Eco-friendly MFPs</li> <li>Commercial and industrial printing</li> <li>Label-free printing</li> <li>PLAIR</li> </ul>	③ GHG scope 1, 2 reduction rate (vs. FY2015)	50%
<b>Circular Economy</b> 	To create business opportunities by building a circular economy business model for ourselves and our customers	Ensure efficient use of resources throughout the entire value chain and achieve 60% or less of virgin material usage ratio		④ GHG scope 3 reduction rate (vs. FY2015)	35%
				⑤ Renewable energy utilization ratio	40%
				⑥ Avoided emissions	1.4 million metric tons
				⑦ Virgin material usage ratio	80% or less



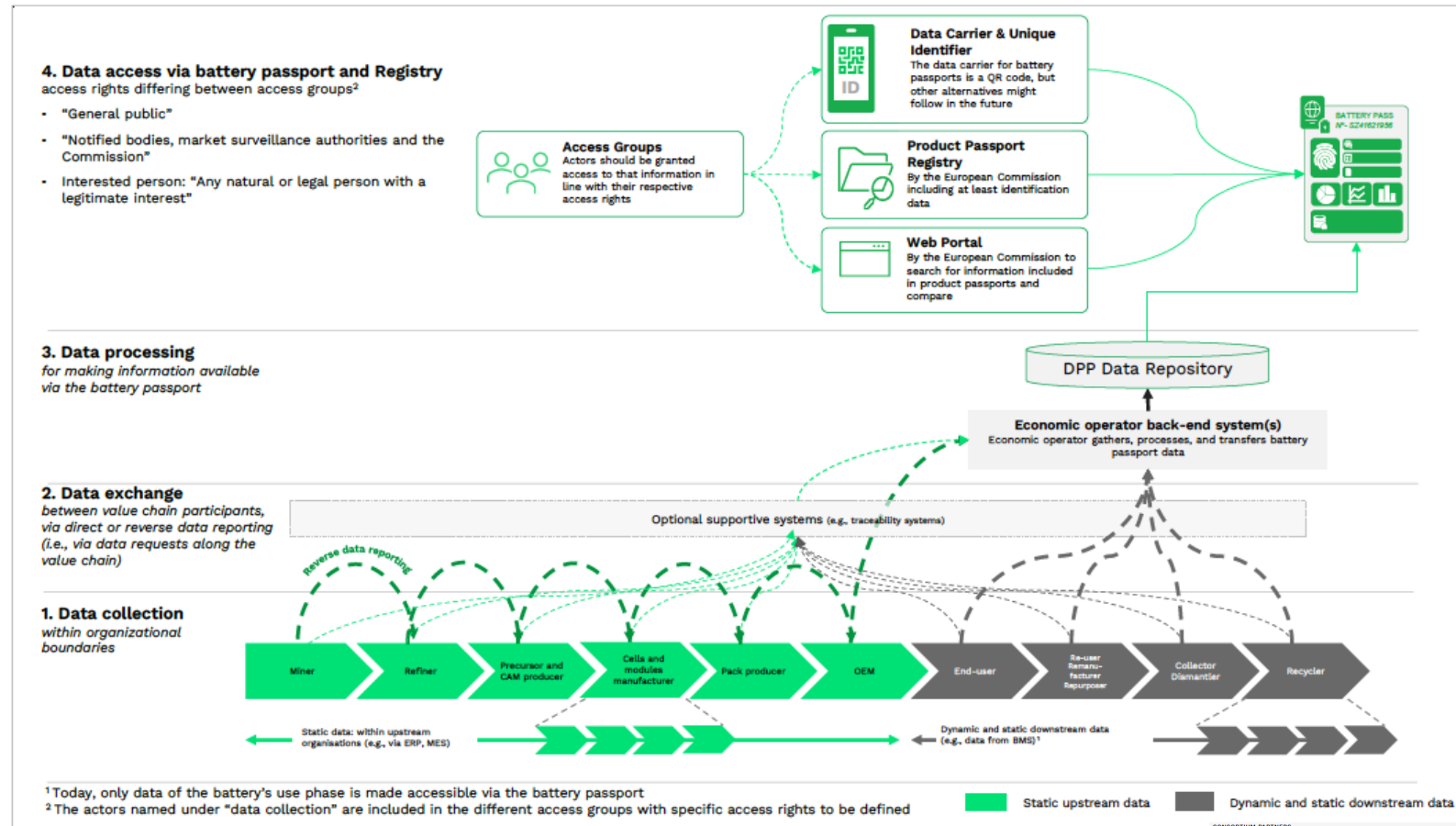
# Forthcoming regulation: EU product passport

## Key Information in a Digital Product Passport



# Example: Battery passport

Figure 6: Technical design and operation of the battery passport



## Example:

# Remanufacturing of turbine blades by laser direct deposition

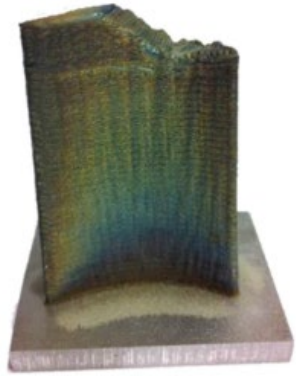


Fig. 4. Damaged turbine blade built with laser direct depositi

- combination of 3d scanning, digital reconstruction and additive manufacturing
- significant impact reduction potential compared to new blade

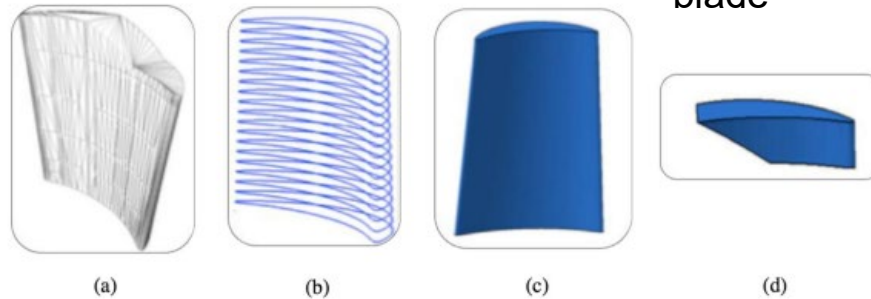


Fig. 5. Process for generating a parameterized geometric model required for LDD based defect repair: (a) acquire point clouds and generate mesh, (b) extract PCS from non-defective region and extrapolate missing section, (c) reconstruct repaired model in CATIA™, and (d) extract Boolean difference between (a) and (c) to obtain the repair volume.

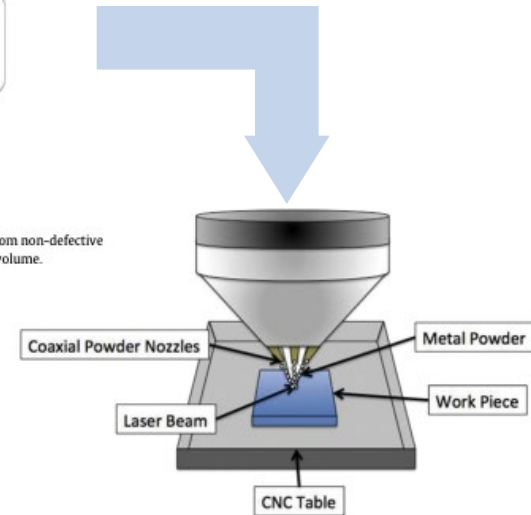


Fig. 6. A schematic of the laser direct deposition.



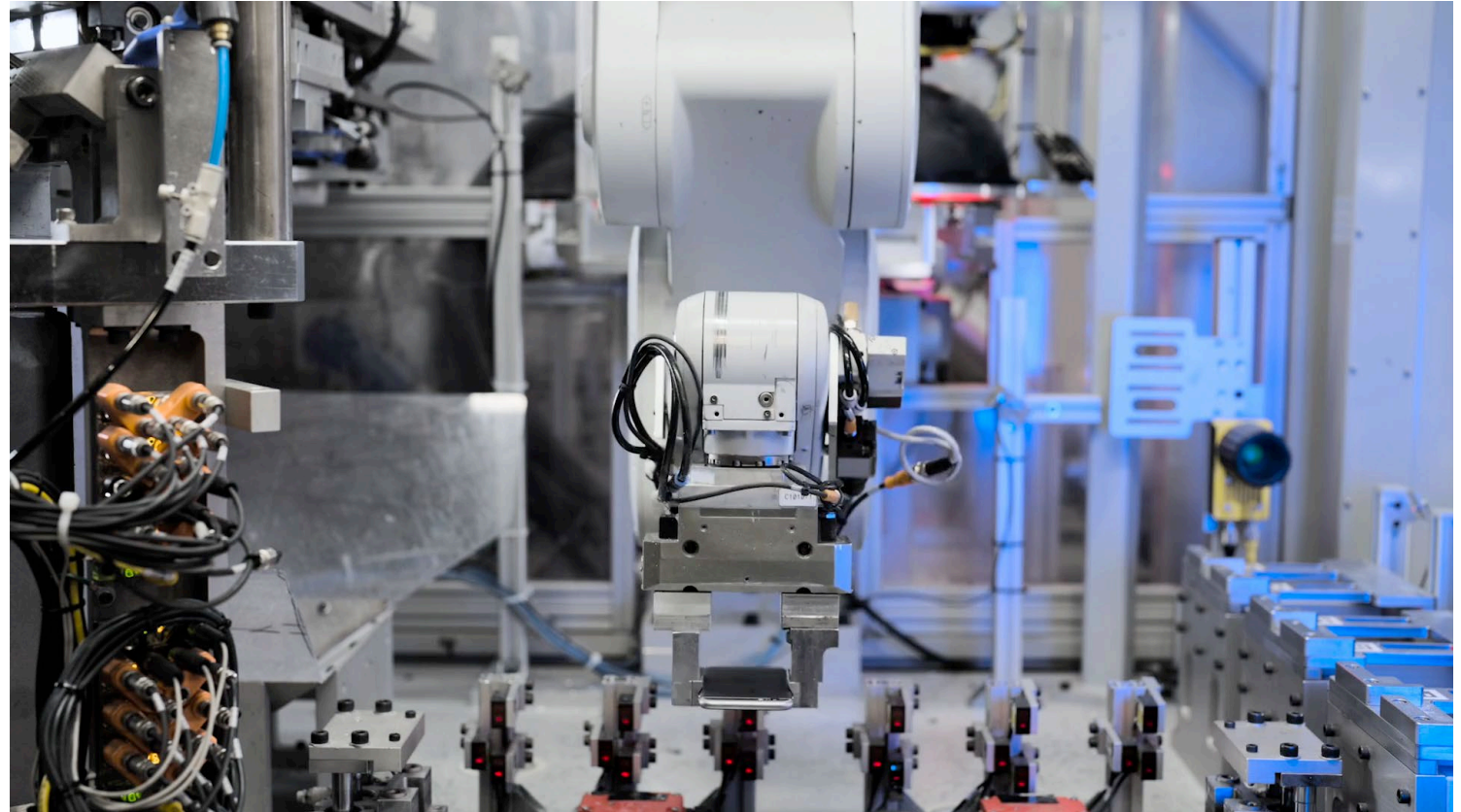


## Example: Consumer electronics

### Daisy – Apple disassembly robot

**Apple will use 100 percent recycled cobalt in batteries by 2025**

Industry-leading innovation paves new path for key recycled metals in batteries, magnets, and circuit boards



# Summary of circulation economy

- › significant potential for cost and environmental impact improvement
- › also towards new operational and business models like circulation factories
- › both humans and automation will play important role
- › success factors
  - › fast identification of state and necessary actions
  - › flexibility of equipment, synergies in factory
  - › digital models and passports with life cycle information
  - › product design!

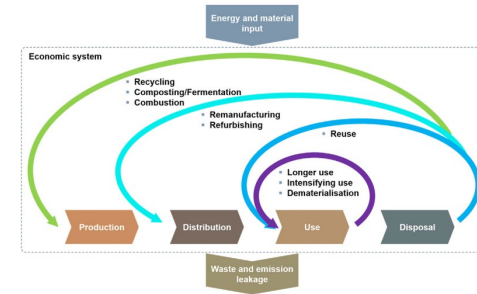


Fig. 1. The circular economy.

## Key Information in a Digital Product Passport





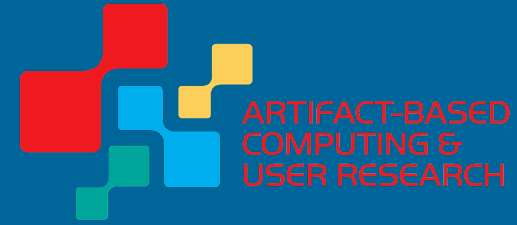
# Scalability and Responsible Innovation

## Questions?



What are your questions?





# Project Final Presentations

## Sample Pitch

A video frame showing a woman with long dark hair, wearing a grey blazer over a black top, smiling and gesturing with her hands. The video is set within a black border.

*Keisha Pimentel*  
Co-Founder and CEO

# Final Presentations: The Pitch Structure

How does your product make the lives of your audience better?

## Problem/Opportunity

- › Articulate the key problem or opportunity your project tackles

## Target group

- › Target user group for your smart prop and explain why this group is important

## Value proposition

- › Unique value your smart product provides in solving the problem

## Illustrate

- › Visually represent key concepts, processes, or components of your project

## Showcase smart prop

- › Integrate a demo into the presentation

## Envisioned Business model

- › Model or strategy, focusing on how it will generate revenue and can be sustainable



# Final Presentations: Organization

- › Submission at all project stages is mandatory
- › Submission of the slides beforehand
  - › January 21, 2025, until 23:59 h
  - › No changes allowed afterward!
- › Final Presentations are given in class
- › There will be two presentation days
  - › January 22, 2025, from 11:00 h (c.t.) to 13:00 h
  - › January 29, 2025, from 11:00 h (c.t.) to 13:00 h
  - › Random assignment of presentation slots – *be prepared and ready!*
  - › Participation is mandatory!



# Final Presentations: Submission Guideline

- › All groups must **submit** the following:
  - Final presentation in PDF format
  - Photos of your final smart devices/ props
  - Final CAD files
  - Reflection on the project in about 300-400 words (ca. one DIN A4 page)
- › Your presentation must be no longer than 5 minutes
- › 5-minute Q&A session
  - Review lecture content like material types and fabrication techniques
  - Each group must ask at least one question to the presenting group

# Design & Fabrication

Dr.-Ing. **Florian Wolling** (Lecture), M.Sc. **Ambika Shahu** (Exercises),  
**Thomas Mantschko** (Tutor), Prof. Florian Michahelles

Technische Universität Wien

Artifact-Based Computing & User Research (<http://media.tuwien.ac.at>)  
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