Enabling the potential for circular transformation – tech readiness–digitisation and I4.0

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Efficiency and Bussines models ?

Inefficiencies of linear value chains

1. UNSUSTAINABLE MATERIALS

Material and energy that cannot be continually regenerated

2. UNDERUTILISED CAPACITIES

Underutilised or unused products and assets

3. PREMATURE PRODUCT LIVES

Products are not used to fullest possible working life

4 WASTED END-OF-LIFE VALUE

Valuable components, materi and energy is not recovered a disposal

5. UNEXPLOITED CUSTOMER ENGAGEMENTS

Sales organisation focus on selling functionality of product rather than the customer

Sustainability?

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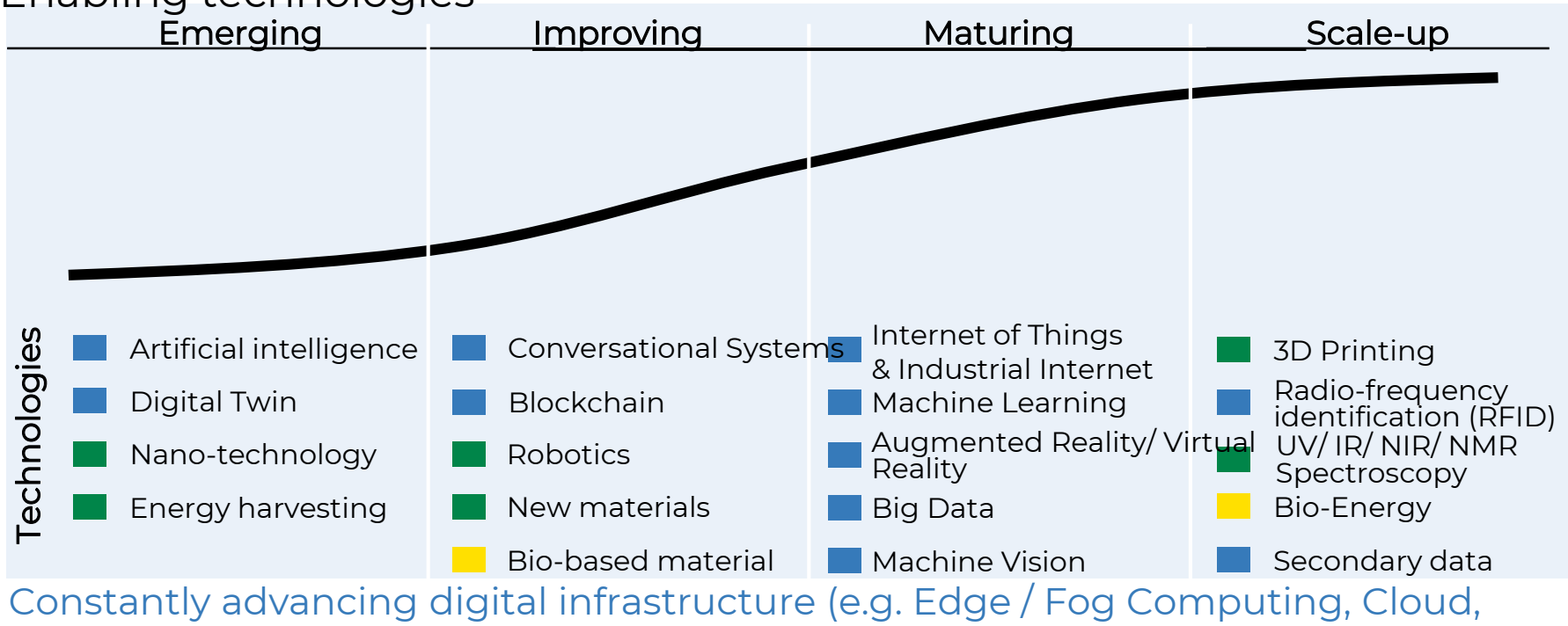
Technologies are developing at a rapid pace, enabling companies to deliver on circular economy objectives

Enabling technologies



Constantly advancing digital infrastructure (e.g. Edge / Fog Computing, Cloud, Scalable API...)

Legend: Type of technology Digital Physical

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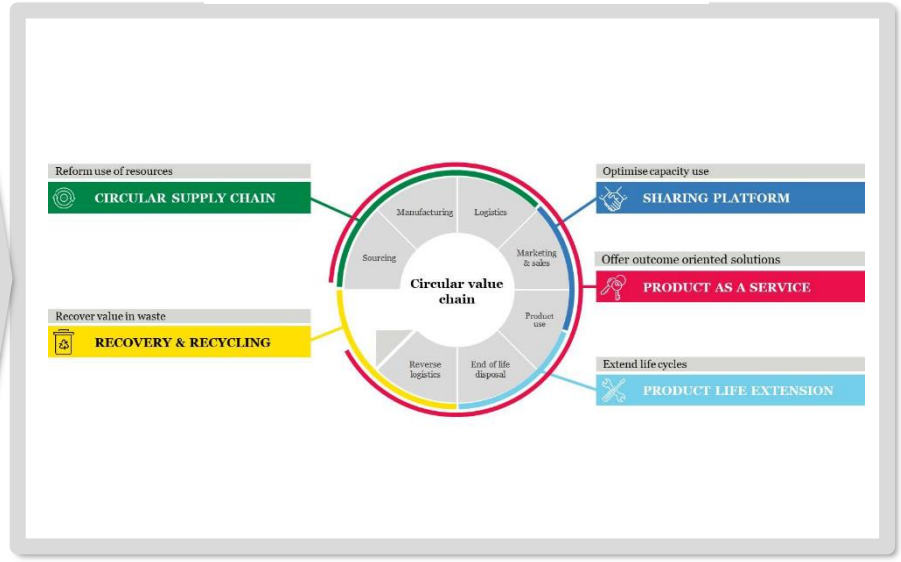
kcstv competence centre for advanced control technologies

Digitally enabled Linear to Circular Change

From Linear...

Take ▶ Make ▶ Waste

...to Circular



Focusing on the change to **customer-centricity** and **digitally enabled** business

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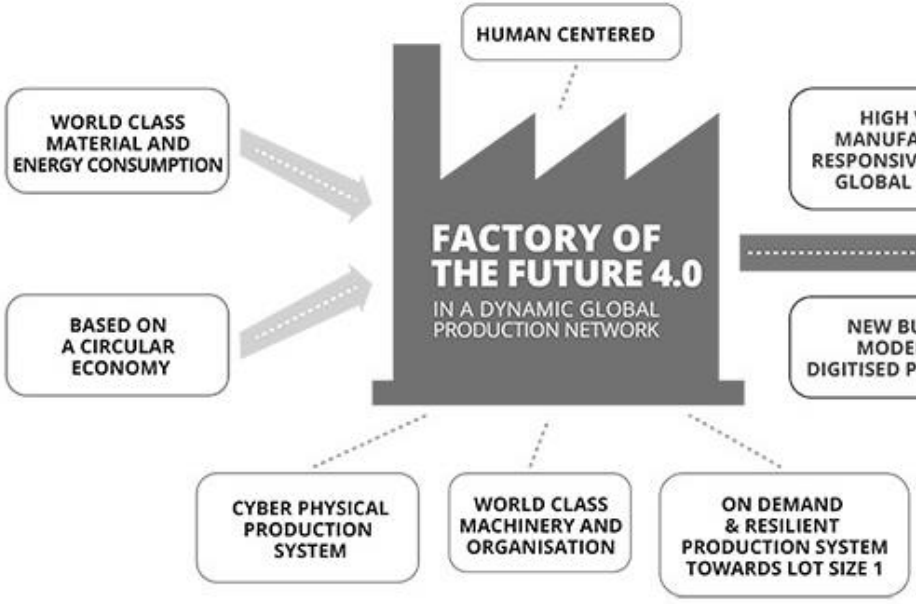
Ideal Factory of the Future

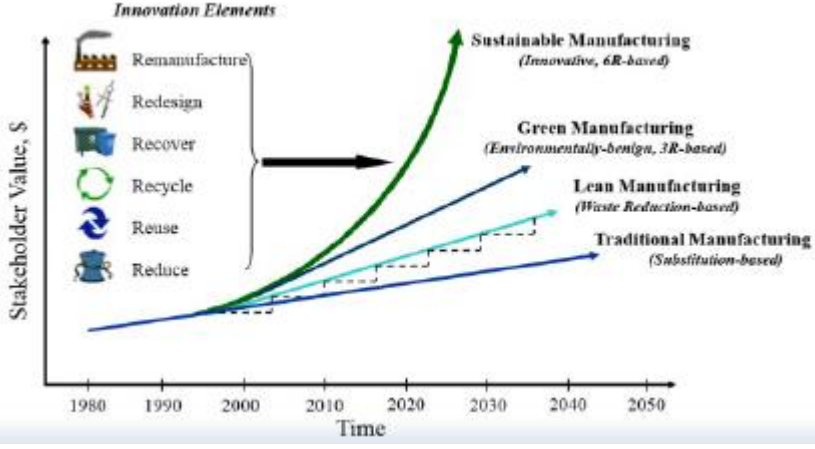


GREEN

SUSTAINABLE

CO2

NEUTRAL



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Industry 4.0 refers to convergence and application of nine digital industrial technologies

Advanced Robotics
- Autonomous, cooperating industrial robots
- Numerous integrated sensors and standardized interfaces

Additive Manufacturing
- 3D printing, particularly for spare parts and prototypes
- Decentralized 3D facilities to reduce transport distances and inventory

Augmented Reality
- Augmented reality for maintenance, logistics, and all kinds of SOP
- Display of supporting information, e.g., through glasses

Simulation
- Simulation of value networks
- Optimization based on real-time data from intelligent systems

Horizontal/ Vertical Integration
- Cross-company data integration based on data transfer standards
- Precondition for a fully automated value chain (from supplier to customer, from management to shop floor)

Industrial Internet
- Network of machines and products
- Multidirectional communication between networked objects

Cloud
- Management of huge data volumes in open systems
- Real-time communication for production systems

Cybersecurity
- Operation in networks and open systems
- High level of networking between intelligent machines, products, and systems

Big Data and Analytics
- Full evaluation of available data (e.g., from ERP, SCM, MES, CRM, and machine data)
- Real-time decision-making support and optimization

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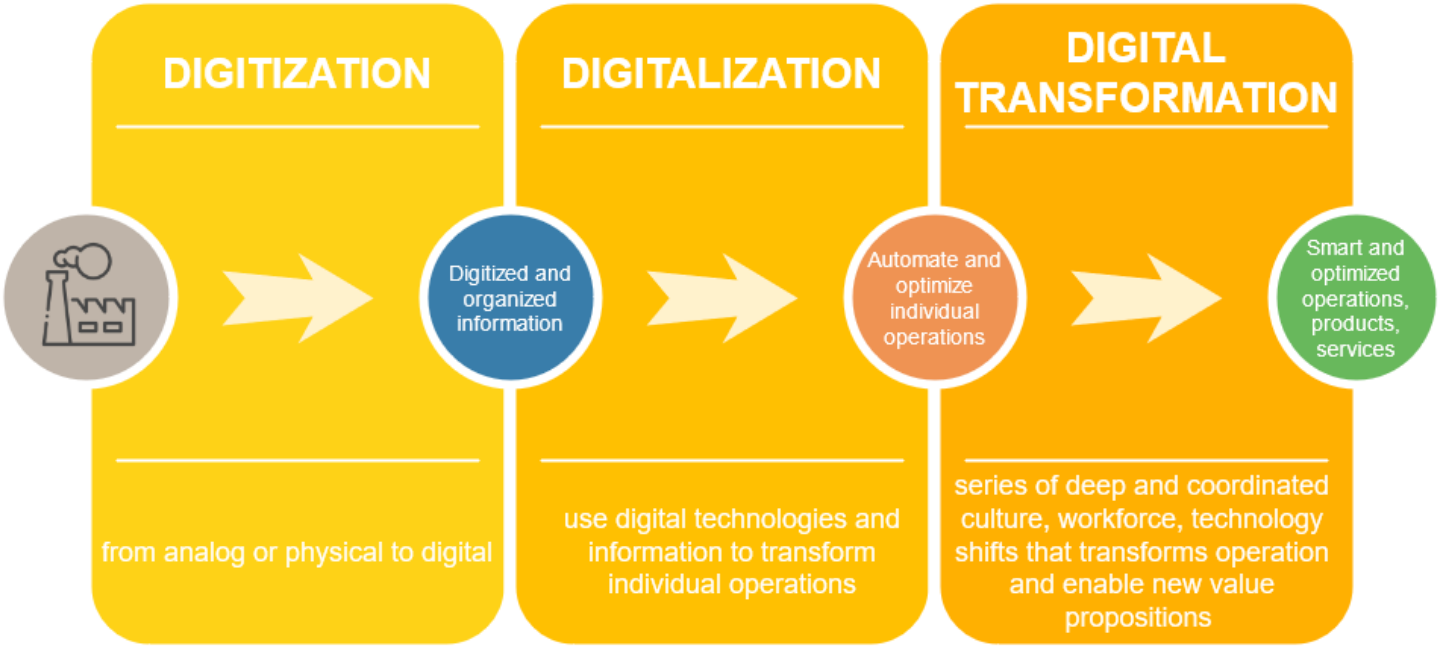
Definition is important … similar is not the same!



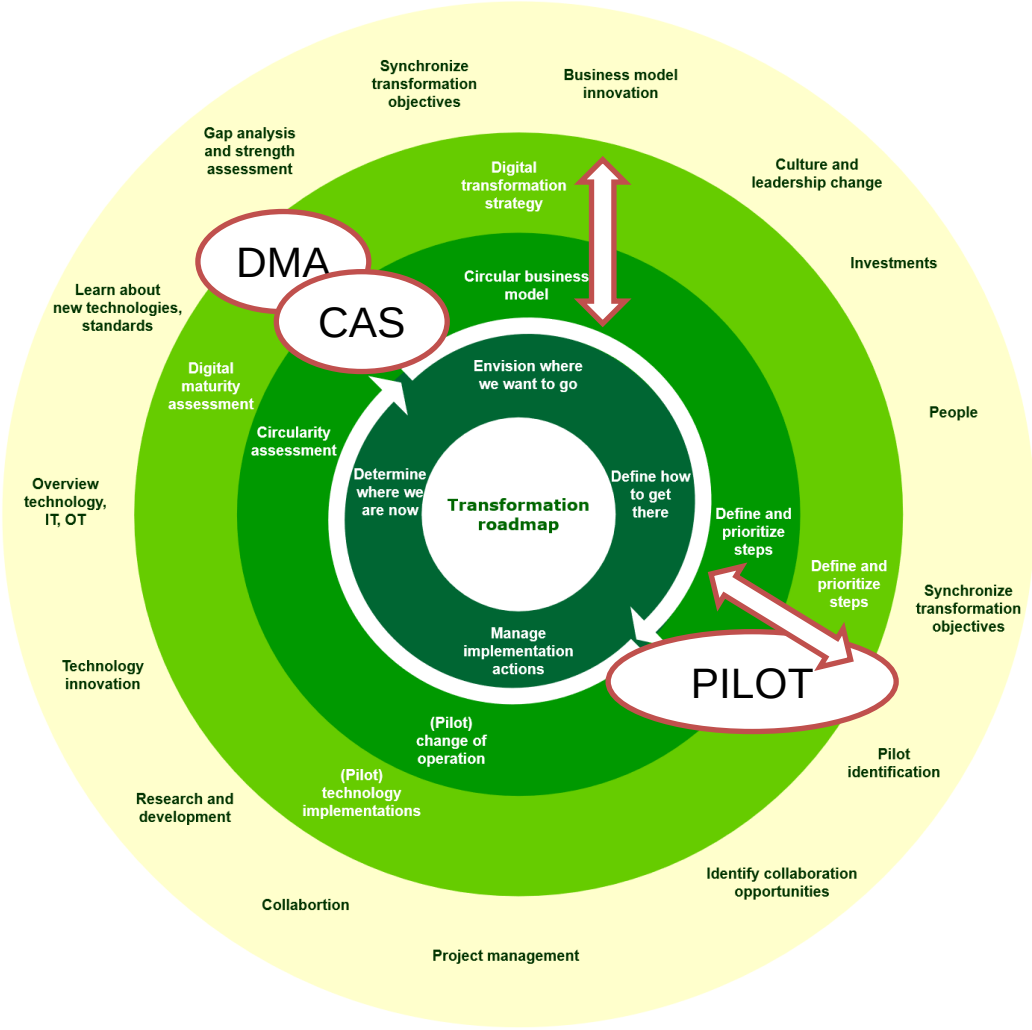
Learn more about digital transformation, I4.0 and enabling technologies:

- https://digital-transformation-tool.eu
- Pwc, Industry 4.0: Building the digital enterprise, 2016 Global Industry 4.0 Survey, 2016
- CGI, Industry 4.0: Making your business, more competitive, 2017
- IYNO, Manufacturing White Paper Software for Industry 4.0 Embracing Change and Decentralization for Success,

Transformation roadmap

Digital and circular transformation is not a project but a process

- Iterative actions to evolve and reach transformation objectives
- Circularity driven innovation of your business model
- Complete digital transformation to support/enable business model objectives
- Digital transformation is not only about technology



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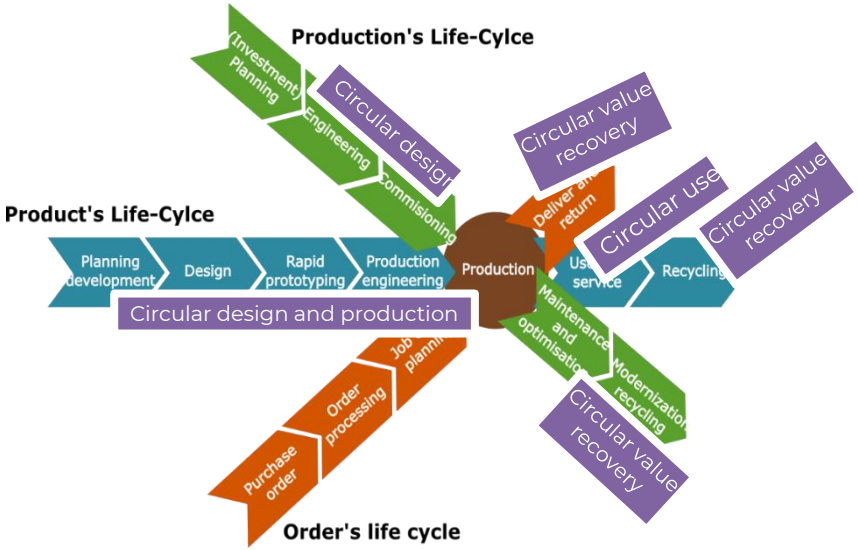
Digital transformation (DT) supporting and enabling circularity (CE)

- DT is not a prerequisite for CE and DT does not guarantee a successful circular transformation
- DT is enabler and disruptor
  - improve/enable new business models, processes, products and services; to change thinking; disrupt current practices
- There is no single approach for DT (depends on sector, core business, value chain position, business model, current digitaliza



Key areas of digital technology supporting circular economy

Value chain positioning

Annika Hedberg, Stefan Šipka, The circular economy: Going digital, EUROPEAN POLICY CENTRE, March 2020.

Digitalization and I4.0

enabling service-based business models (CIRCULAR USE)

Goal

- Shift from producing goods to delivering services (servitisation)
- Enhancing renting & sharing, product-as-a-service
- Stronger customer relation, more stable revenue stream

Impacts

- Encourage product longevity, reusability and sharing; reduce demand for materials and negative externalities (e.g. waste)
- Smarter use of resources, dematerializati on

Role of technology

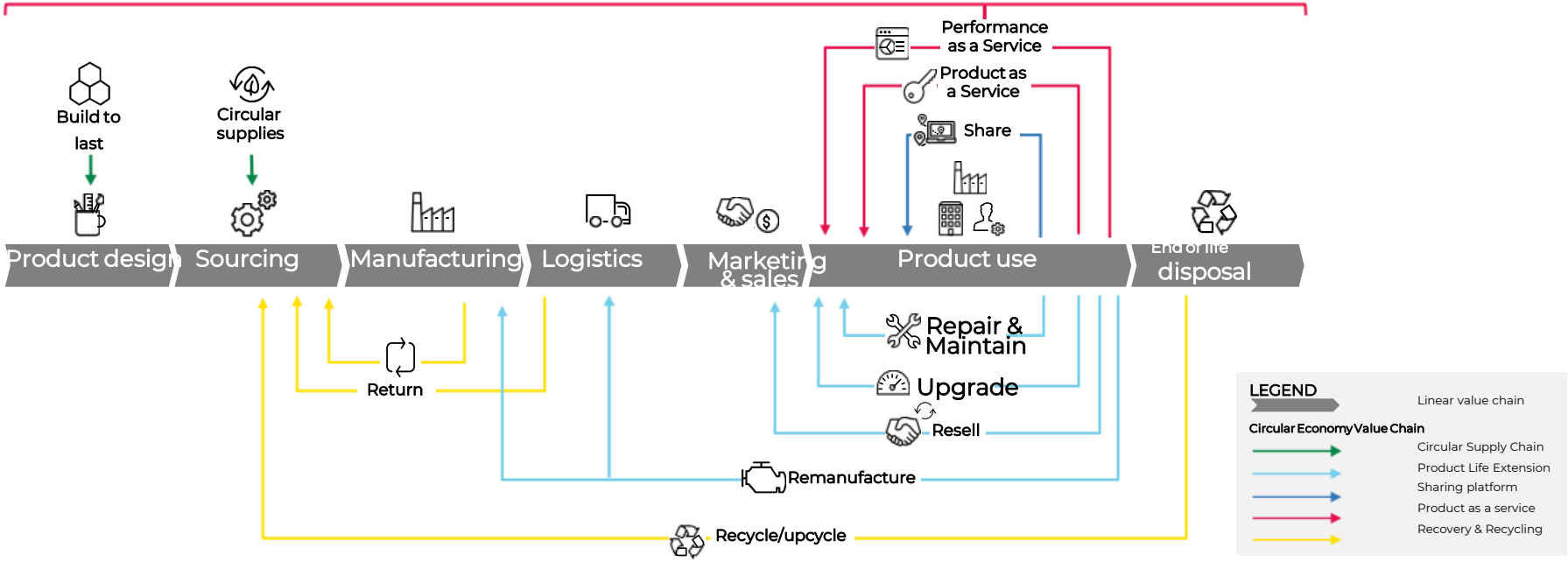
- Operation monitoring systems (cloud solutions, ICT)
- Predictive maintenance
- Optimization of operation
- Customer relation
- Smart functions/smart services

Digitalization and I4.0

New Business Models & Value Chain

Circular sub-models

As a Service models are mostly concerned with the operation phase, but span across the value chain



Circular business models open up the value chain for new collaborations and services enabling bottom line impact

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Digitalization and I4.0

enabling service-based business models (CIRCULAR USE), examples

Michelin: Tire as a service strategy

- FLEET TIRE LEASE PROGRAMS (save fuel, reduce costs)
- PAY BY THE MILE
- IoT monitoring, road support, analysis, advices

- https://business.michelinman.com/freight-transportation/freight-transportation-services/michelin-fleet-solutions
- https://digital.hbs.edu/platform-rctom/submission/michelin-tires-as-a-service/
- https://www.iotworldtoday.com/2020/02/25/a-look-at-michelins-product-as-a-service-strategy/

Rolls-Royce: jet-propulsion-as-a-service

- Power by the hour
- Predictable cost of ownership for the customer
- A joint focus on minimising operational disruptions
- pro-actively determine when maintenance will be necessary, reducing operating costs, slashing engine downtime, and lengthening the average life of its jet engines by 2x over the past 20 years.

- https://www.rolls-royce.com/media/our-stories/discover/2017/totalcare.aspx

Digitalization and I4.0
improving design (CIRCULAR DESIGN)

Goal

- Optimize design for all stages of product (construction, use and deconstruction)
- Sustainable design (materials, durability, reusable, disassembly, upgrade, recycle, etc.)

Impacts

- Extend product life-time (durability, reuse, repair, upgrade, repair)
- Ease disassembly, recyclability
- Reduce raw material consumption

Role of technology

- Virtualization, simulation, 3D printing (test different design and materials)
- Data sharing, collaboration of teams, traceability of materials across value chain
- Employ product use data for improved design through data analytics, modelling and simulation

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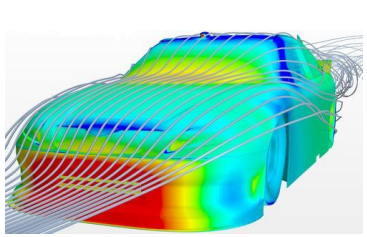
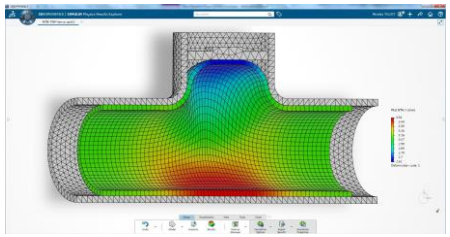
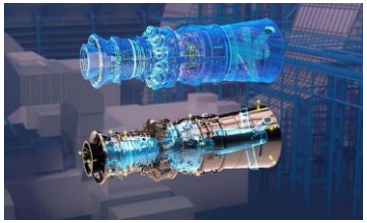
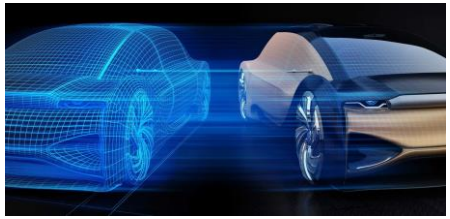
Digitalization and I4.0

Design for Sustainability

Product design | Sourcing | Manufacturing | Logistics | Marketing & sales | Product use | End of life disposal

- Digital Simulation
- Digital Twin
- 3D Printing
- Planning
  - Materials
  - Energy efficiency
  - CO2 impact
  - Recycling Strategy
  - Recycling Logistics
  - Circular Strategy

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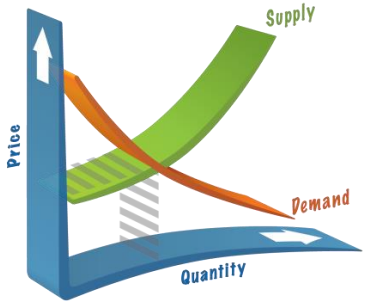
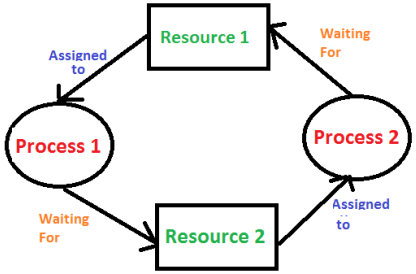
Digitalization and I4.0

CE & I4.0 at Sourcing

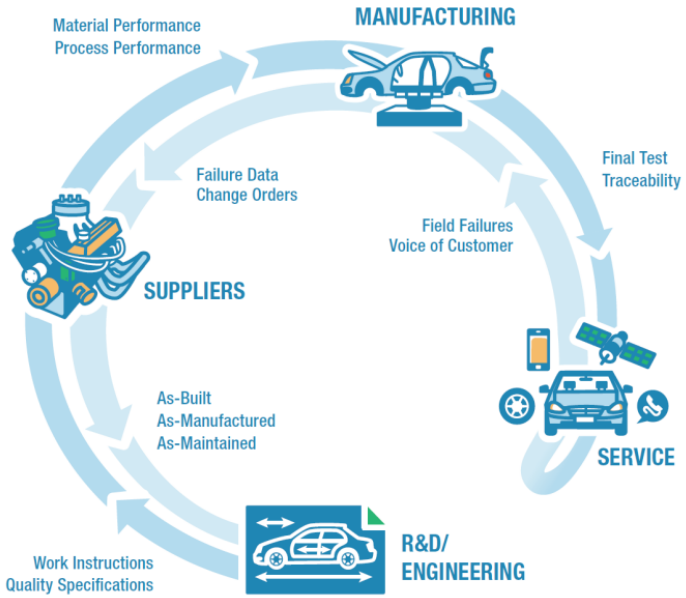
Product design | **Sourcing** | Manufacturing | Logistics | Marketing & sales | Product use | End of life disposal

- Recyclable Material
- Suppliers With Circular DNA
- Supply by demand
- Internal Horizontal & Vertical Circular Processes
- Cooperation with Suppliers
- Material Tracking (Blockchain)



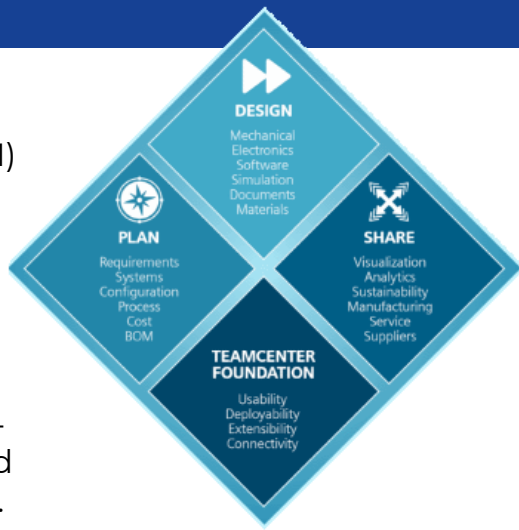


Digitalization and I4.0
improving design (CIRCULAR DESIGN), examples



LNS, The Global State Of Manufacturing Operations Management Software, Weaving the Digital Thread, 2014

Siemens PLM



- Product lifecycle management (PLM) is an information management system that integrates data, processes, business systems, and, people in an extended enterprise.
- PLM software allows to manage this information throughout the entire product lifecycle efficiently and cost-effectively: from ideation, design, and manufacture to service and disposal.

https://www.plm.automation.siemens.com/global/en/our-story/glossary/product-lifecycle-management-plm-software/12506

Data driven design – Whirlpool & PTC

https://www.ptc.com/en/technologies/plm/digital-innovation/innovator-spotlight-whirlpool/whirlpool-plm-demonstrations#data

https://www.ptc.com/en/blogs/cad/data-driven-design

Simulation base design (e.g. Autodesk, …)

- CFD (computational fluid dynamics)
- FEM (finite elements method)

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Digitalization and I4.0

improving production and processes (CIRCULAR DESIGN)

Goal

- Improve and optimize production operations and processes (Quality management, Zero-defect, asset utilization, energy)
- Through value chain cooperation and traceability for improved operations
- Industrial symbiosis (sharing of energy, materials)

Impacts

- Less waste and emissions
- Less energy and resources consumed (resource efficiency)
- More stable product quality

Role of technology

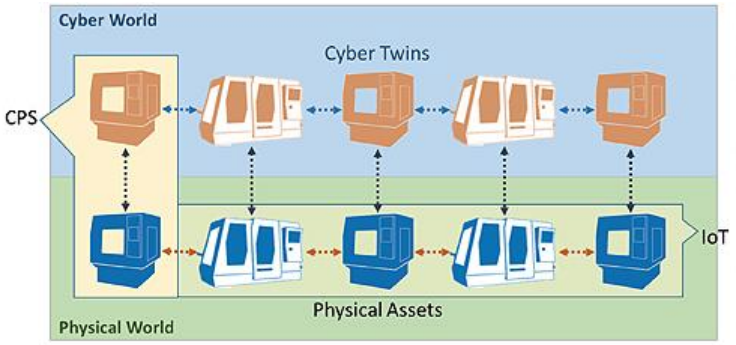
- Traceability of operations and materials
- Data-based analytics, AI, cause-effect analysis
- In-line quality inspection
- 3D printing

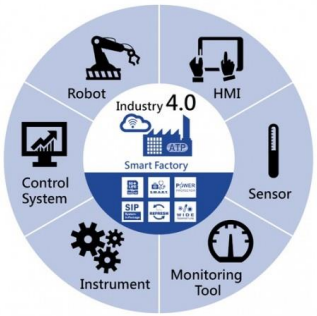
Digitalization and I4.0

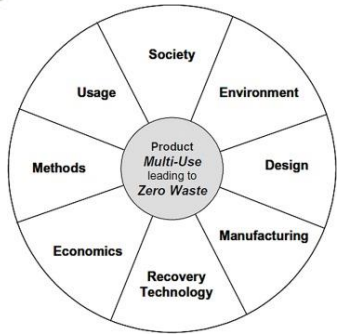
CE & I.40 at Manufacturing

Product design | Sourcing | **Manufacturing** | Logistics | Marketing & sales | Product use | End of life disposal

- Smart Factory
  - Cyber Physical Sys
  - Avtomatization
  - Robotization
  - IOT
  - Big Data & Artificial Intelligence
  - Predictive Maintenance
- Zero Waste
- Energy Efficiency







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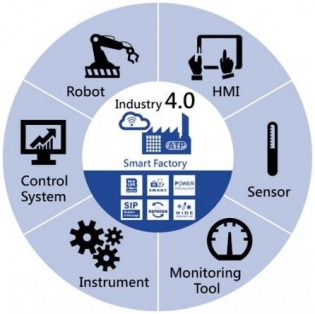
Digitalization and I4.0

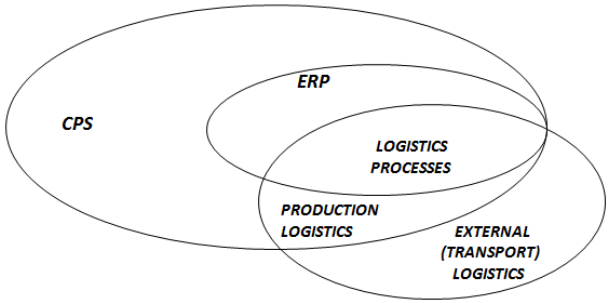
I.40 at Logistics

Product design | Sourcing | Manufacturing | **Logistics** | Marketing & sales | Product use | End of life disposal

- Smart Factory
  - Internal Logistics
  - Robotisation
  - Artificial Intelligence



- Digitally Connected logistics System with Suppliers
- Artificial Intelligence
- Blockchain



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Digitalization and I4.0

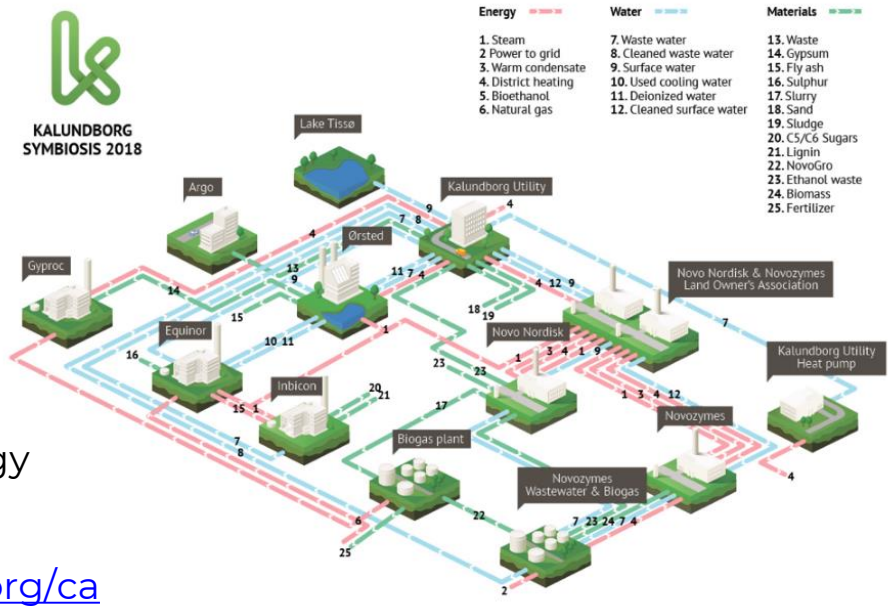
improving production and processes (CIRCULAR DESIGN), examples

Zero defect manufacturing

- Analytics, signal processing, AI, sensing
- https://qu4lity-project.eu/wp-content/uploads/2020/05/PRJ.pdf

Industrial symbiosis & industrial urban symbiosis

- Improve collaboration utilizing technology
- www.symbiosis.dk/en
- https://www.ellenmacarthurfoundation.org/case-studies/effective-industrial-symbiosis



IIoT & Industrial cloud platforms

- 3-4 control hierarchy levels
- Connect, store, monitor, analyze, improve

SAP HANA
Microsoft Azure
SIEMENS MindSphere
AWS IoT

Digitalization and I4.0

improving reuse, repair and remanufacturing of products (CIRCULAR VALUE RECOVERY)

Goal

- Extending the lifecycles of products
- Enhance reusing, repairing and remanufacturing
- Improve predictive maintenance and durability

Impacts

- Longer product lifetime and durability, which leads to less use of resources, waste and emissions
- Improved recyclability

Role of technology

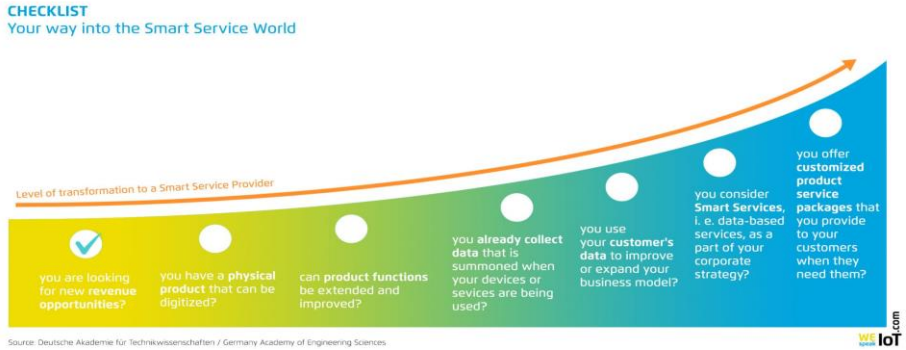
- on-line platforms, marketplaces for encouraging reuse
- Data, traceability, instructions, identification of problems, spare parts identification, 3D printing, platforms PLM, etc. (support for dismantling, repairing or replacing parts, reassembling)

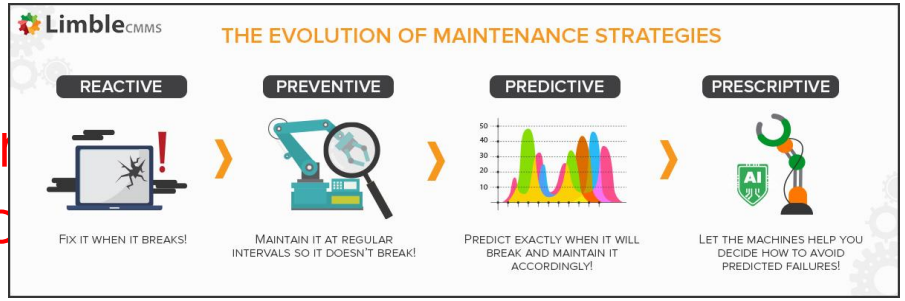
Digitalization and I4.0

I4.0 at Product use

Product design | Sourcing | Manufacturing | Logistics | Marketing & sales | **Product use** | End of life disposal

- Smart Service
  - Pay per use
  - IOT platforms
  - Artificial Intelligenc
  - Parts & products tracking record
- Preventive Maintenar
- Customer Digital Sup
- Data monetisation





Digitalization and I4.0

improving reuse, repair and remanufacturing of products (CIRCULAR VALUE RECOVERY), examples

Re-flekt & Land Rover

- repair faster with AR augmented reality simplifies complex repairs through visual instructions, automatically create documentation
- https://www.re-flekt.com/hubfs/pdf/Case_Study_RangeRover.pdf?hsLang=en

3d printing for remanufacturing

- Cloud manufacturing, https://www.beelse.com/en/

Reuse – exchange portals (e.g. ebay)

Digitalization and I4.0

improving waste management (CIRCULAR VALUE RECOVERY)

Goals

- Around 750 million tons of waste is generated annually in EU, out of which only around 50 % is recycled, only around 10% of those recycled materials are brought back into the economy
- Improve waste collection
- Improve waste sorting and recycling

Impacts

- Less virgin material, use more waste as a secondary material
- Improve reuse and recycling, reduce energy recovery, and landfilling

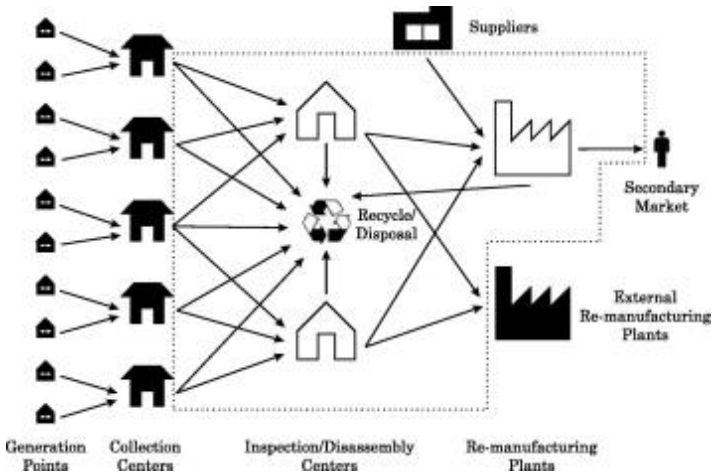
Role of technology

- IoT platforms for data capturing and sharing
- real-time, waste-monitoring sensors
- waste characterization with multi-sensor data to improve waste sorting and recycling
- traceability of waste

Digitalization and I4.0

CE & I4.0 at End of Life Disposal

- Reverse Logistic Network
  - Smart Mobility
  - IOT Platforms for Waste Management
  - Tracking records
  - Waste sharing platforms & data
- Waste Collection
  - Condition tracking and monitoring
  - Return Incentives
  - Regulations
  - New Business Models
  - Awarness building



Digitalization and I4.0
improving waste management (CIRCULAR VALUE RECOVERY), examples

Resyntex

- textile waste as a source of secondary raw materials
- http://www.resyntex.eu/

DiLink - Digital solutions for industrial plastic circuits

- Digital twins of materials, matching material properties
- Support the use of recyclates
- https://www.di-link.de/

Concular - Digital platform enabling circular construction

- Material demands from construction projects can be uploaded onto the platform, while circular materials from demolition projects can be recorded using a digital material passport.
- https://concular.de/

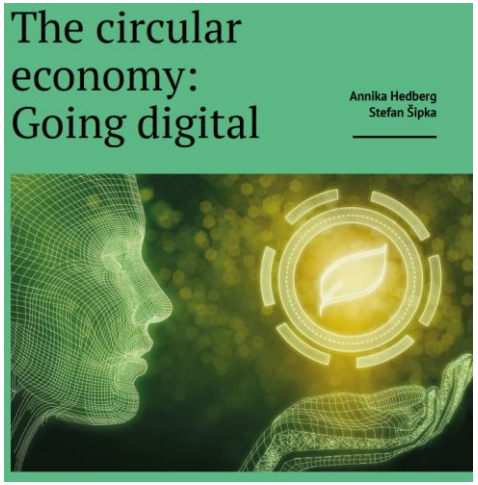
Junker - Recycling support app

- https://www.junker.app/

More examples and good practices …

- Annika Hedberg, Stefan Šipka, The circular economy: Going digital, EUROPEAN POLICY CENTRE, March 2020.

https://circulareconomy.europa.eu/platform/en/knowledge/circular-economy-going-digital

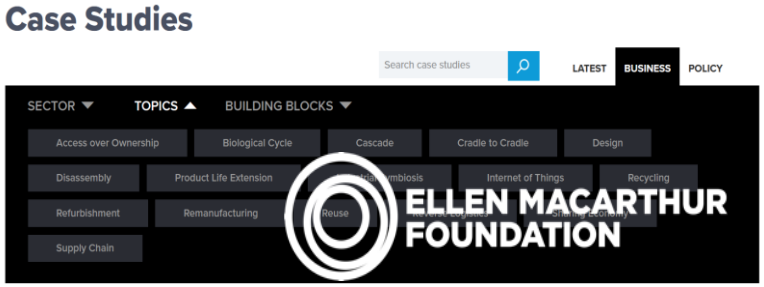


- European Circular Economy Stakeholder Platfor – relevant practices, innovative processes and 'learning from experience' examples provided by the stakeholders

https://circulareconomy.europa.eu/platform/en/good-practices

- Ellen Macarthur Foundation

https://www.ellenmacarthurfoundation.org/case-studies/business/topics



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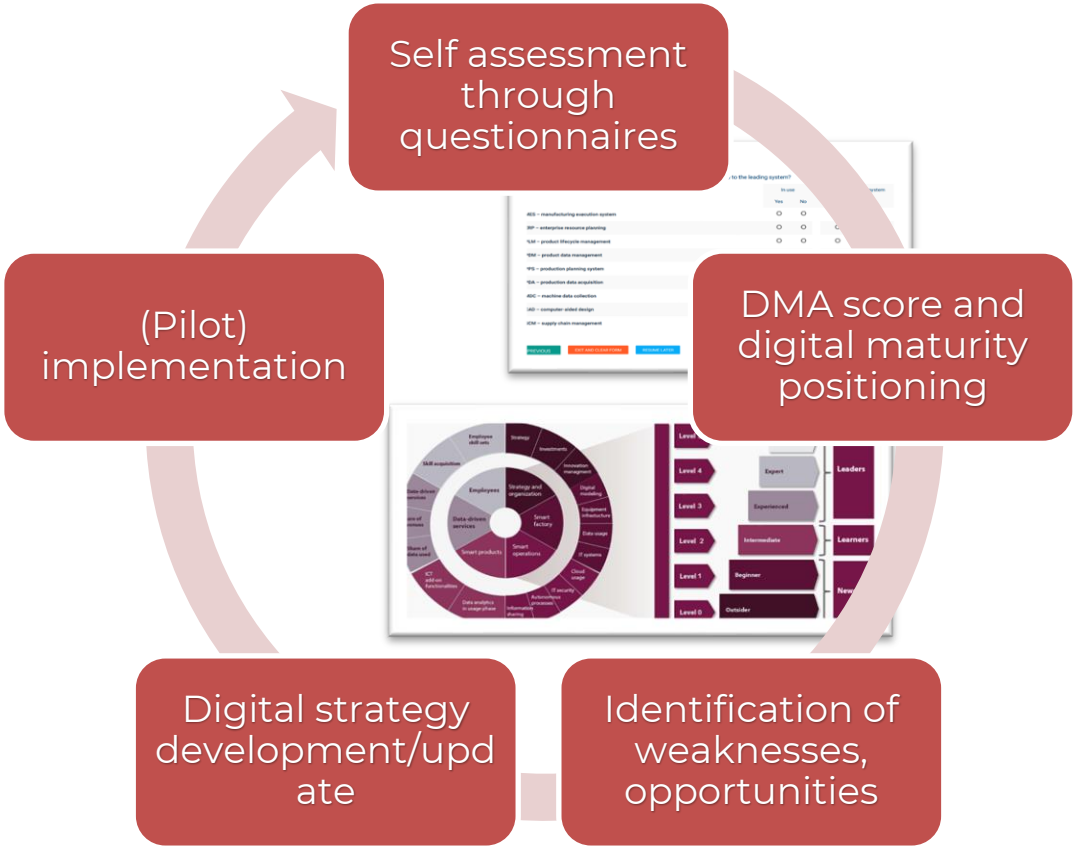
What is Digital Maturity Assessment (DMA)?

Systematic approach for assessing the maturity (knowledge, awareness, status, goals) of the company



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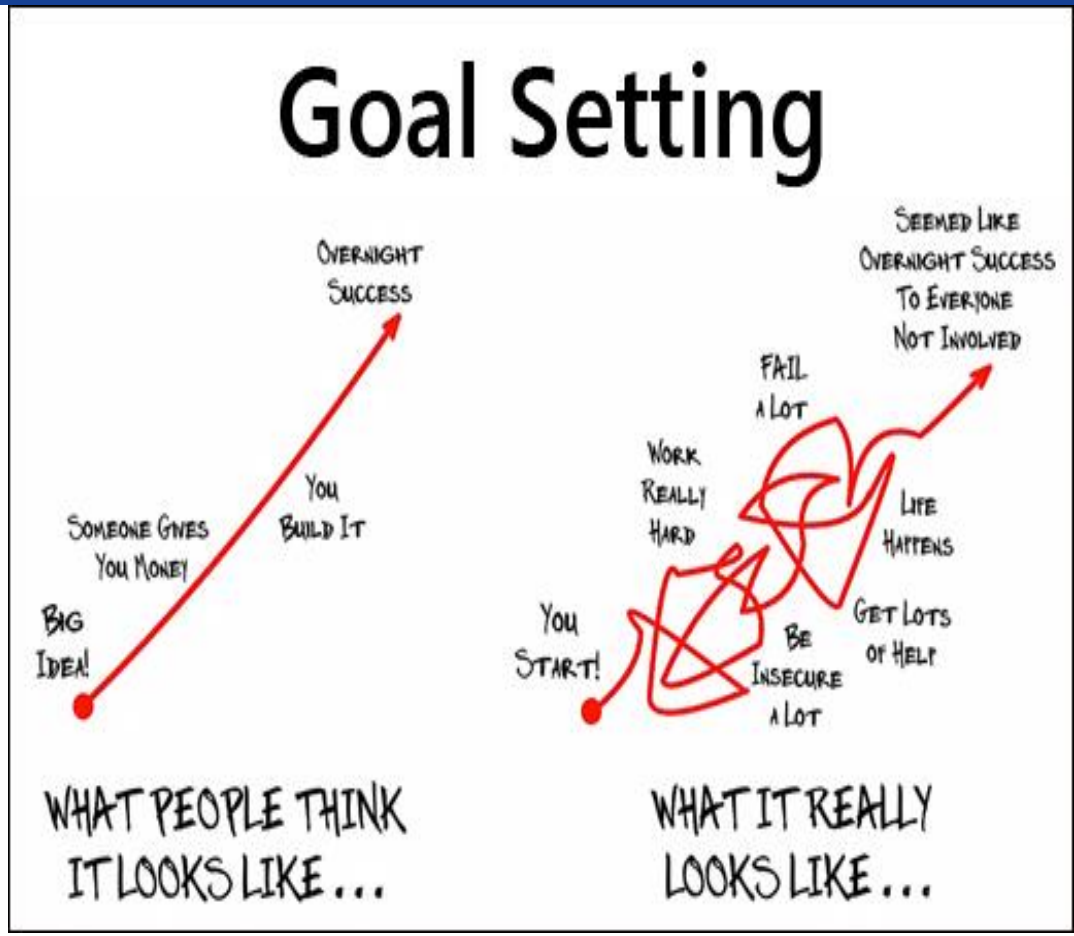
Eligibility criteria

Eligibility criteria for DMA

- Basic lean principles are already applied
- CEO has a demonstrated innovation mindset
- First innovation breakthroughs have already been realized
- Customers are asking the company to move towards smaller lot sizes (“one of kind” production)
- The company's management team is fully committed and engaged

From idea to solutions …

- Step by step
- Customer oriented
- ROI First
- Clean processes
- Enable workers



Wishes differ from reality !

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From DMA to initial digital transformation plan

DEFINE INITIAL DIGITAL TRANSFORMATION STRATEGY

EDUCATE AND FIND ADDITIONAL INFORMATION

- Understand impacts of technologies and digital transformation steps
- Understand DMA question, educate employees, find support/consultancy
- Evaluate current state using DMA questionnaire
- Define 5 year ambitions (consider objectives, business model, ambitions)
- Prioritize next steps (e.g. concrete actions, pilots, collaborations, alliances)

PwC maturity model - Industry 4.0 capabilities develop across seven dimensions and four stages

	1 Digital novice	2 Vertical integrator	3 Horizontal collaborator	4 Digital champion
Digital business models and customer access	First digital solutions and isolated applications	Digital product and service portfolio with software, network (M2M) and data as key differentiator	Integrated customer solutions across supply chain boundaries, collaboration with external partners	Development of new disruptive business models with innovative product and service portfolio, lot size 1
…itisation …oduct …l service …erings	Online presence is separated from offline channels, product focus instead of customer focus	Multi-channel distribution with integrated use of online and offline channels, digital analytics deployed, e. g. for personalisation	Individualised customer approach together with value-chain partners. Shared, integrated interfaces.	Integrated Customer Journey Management across all digital marketing and sales channels with customer empathy and CRM
…itisation …l integration …ertical and …izontal …ue chains	Digitised and automated sub processes. Partial integration including production or with internal and external. Standard processes for collaboration partly in place	Vertical digitisation and standardised and harmonised internal processes and data flows within the company; limited integration with external partners	Horizontal integration of processes and data flows with customers, partners, intensive data use through full integration across the network.	Fully digitised, integrated partner ecosystem with self-optimised, virtualised processes, focus on core competency; decentralised autonomy. Near real-time access to extended set of operative information
…a & …lytics as …e capability	Analytical capabilities mainly based on semi-manual data extracts; Selected monitoring and data processing, no event management	Analytical capabilities supported by central business intelligence (BI) system Isolated event-driven and decision support systems	Central BI system combining internal and external information sources, some predictive analytics Specific decision support and event management systems	Central use of predictive analytics for real-time optimisation and automated event handling with intelligent database and self-learning algorithm enabling impact analysis and decision support
…le IT …hitecture	Fragmented IT architecture in-house.	Homogeneous IT architecture in-house. Connection between different data cubes developing.	Common IT architectures in partner network. Interconnected single data lake with high-performance architecture	Single data lake with external data integration functionalities and flexible organisation. Partner service bus, secure data exchange
Compliance, security, legal & tax	Traditional structures, digitisation not in focus	Digital challenges recognised but not comprehensively addressed	Legal topics addressed with collaboration partners,	Optimising the value chain … security, legal and tax
Organisation, employees and digital culture	Functional focus in "silos"	Cross-functional collaboration but not structured and consistently pursued	Collaboration across company boundaries, culture and encouragement of sharing	Collaboration as a key value driver

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How to use DMA

An industry 4 readiness assessment tool (I4ready)

https://i4ready.co.uk/ SOURCE

Example of DMA tool for CIRCULAR4.0 project purposes

Instructions:

For each row below indicate current readiness & 5 year ambition. Input appropriate values from 0-4 in the yellow marked cells.

See results on "Result plot" excel DIMENSIONS

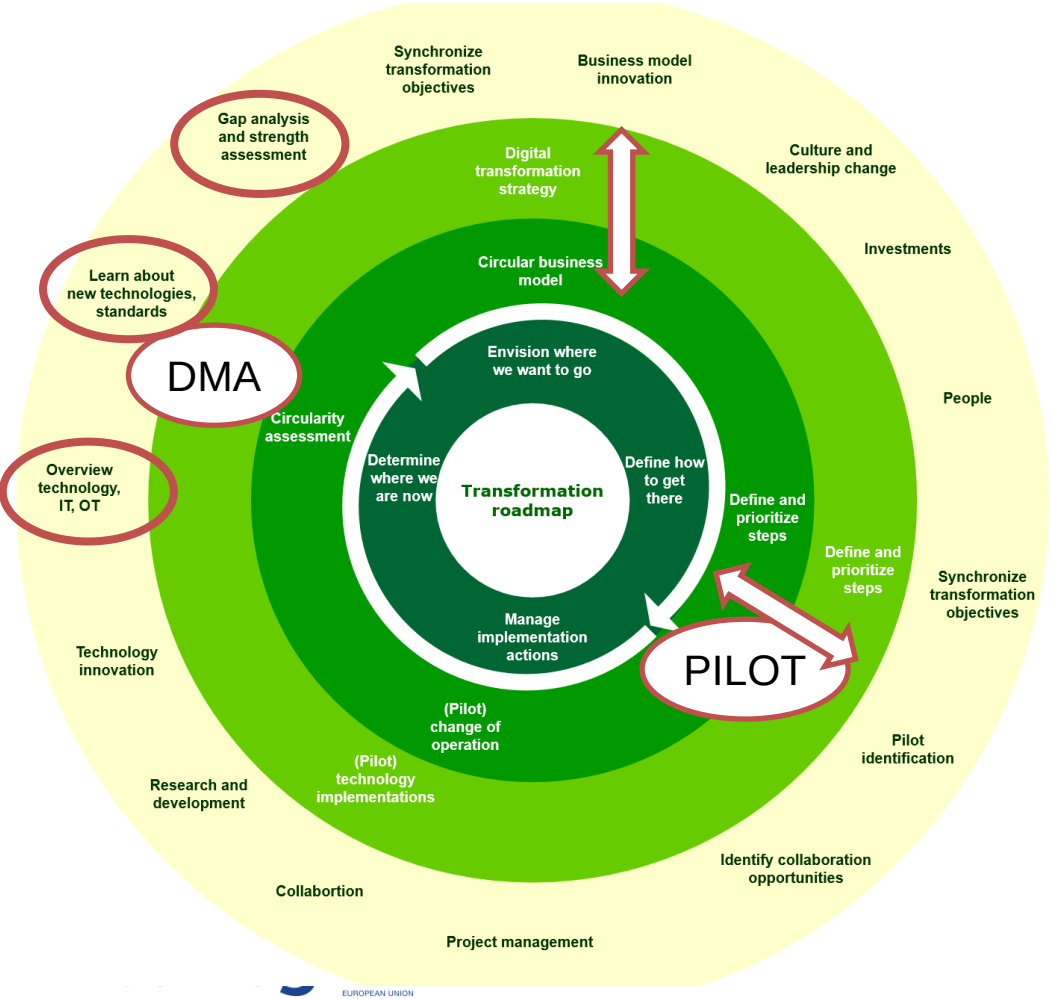
Products and services LEVELS

Readiness level	Current	5 year ambition	Level 1 Beginner	Level 2 Intermediate	Level 3 Experienced	Level 4 Expert	Don't know	Not relevant
QUESTIONS	vel (0-4)	Level (0-4)	1	2	3	4	0	0
Product customisation	0		Product allows for no individualisation, standardised mass production	Majority of products are made in large batch sizes with limited late differentiation	Products can be largely customised but still have standardised base	Late differentiation available for most make-to-order products (batch size 1)	Don't know	Not relevant
Digital features of products			cts show only physical value	Products show value only from intellectual property licensing	Products exhibit some digital features and value from intellectual property licensing	Products exhibit high digital features and value from intellectual property licensing	Don't know	Not relevant
Data-driven services	0		Data-driven services are offered without customer integration	Data-driven services are offered with little customer integration	Data-driven services are offered with customer integration	Data-driven services are fully integrated with the customer	Don't know	Not relevant
Level of product data usage	0		Data is not used	0-20% of collected data is used	20-50% of collected data is used	More than 50% of collected data is used	Don't know	Not relevant
			Data-driven services account for an initial share of revenue (<2.5%)	Data-driven services account for a moderate share of revenue (2.5-	Data-driven services account for a significant share of revenue (7.5-	Data-driven services play an important role in revenue (>10%)	Don't know	Not relevant

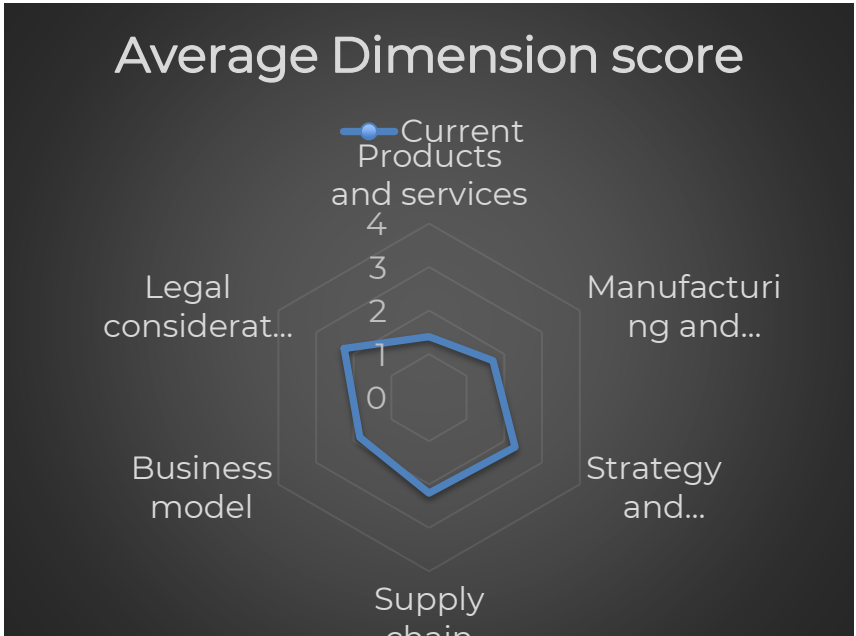
YOUR EVALUATION

Questions | Result plots RESULTS

Transformation steps



- Explore, learn, overview, (find support)



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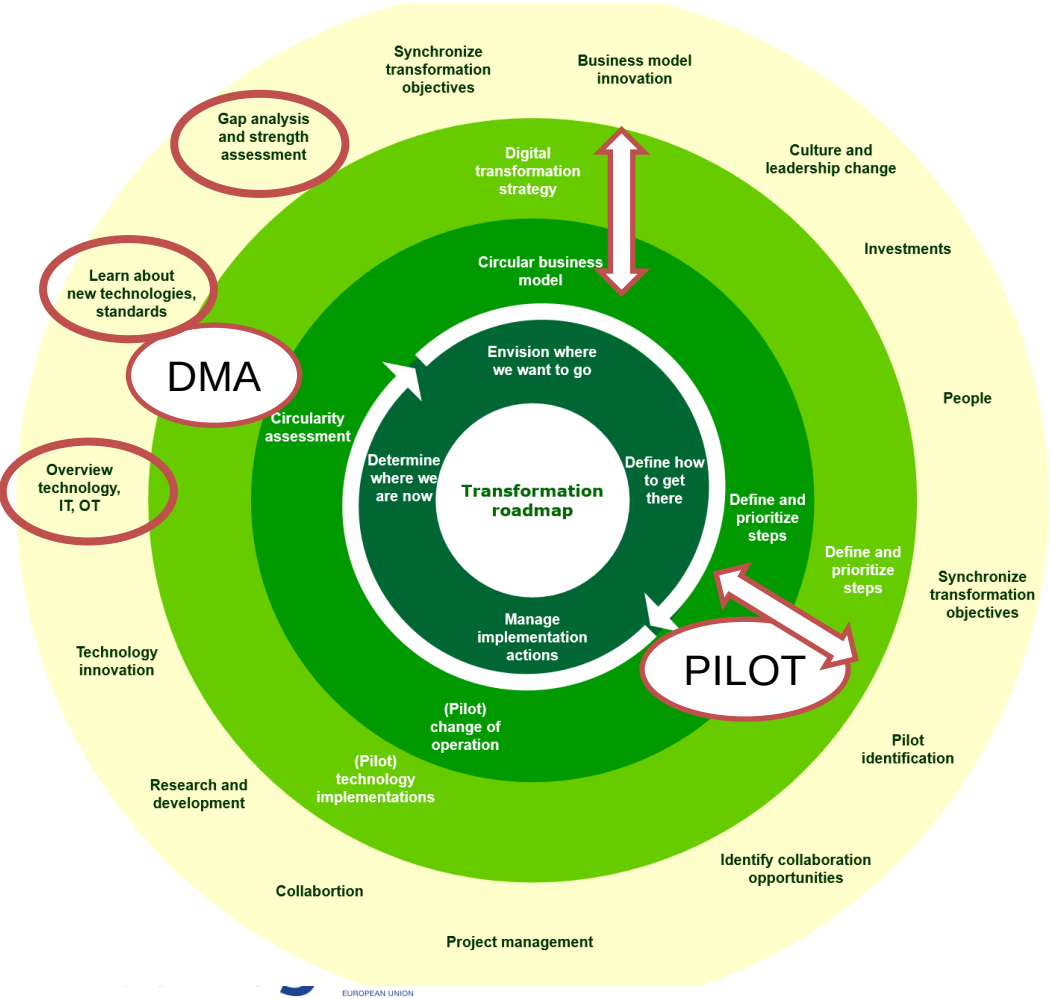
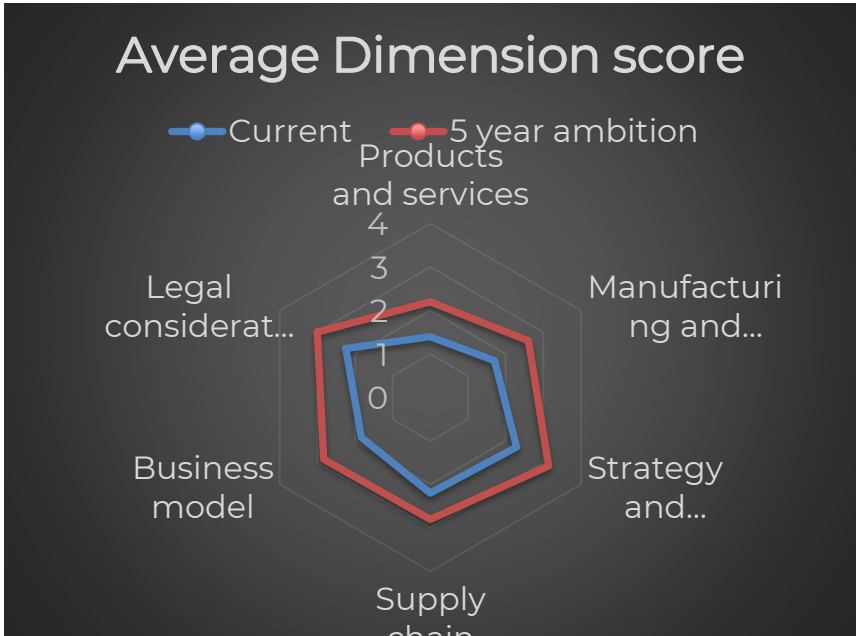
Transformation steps

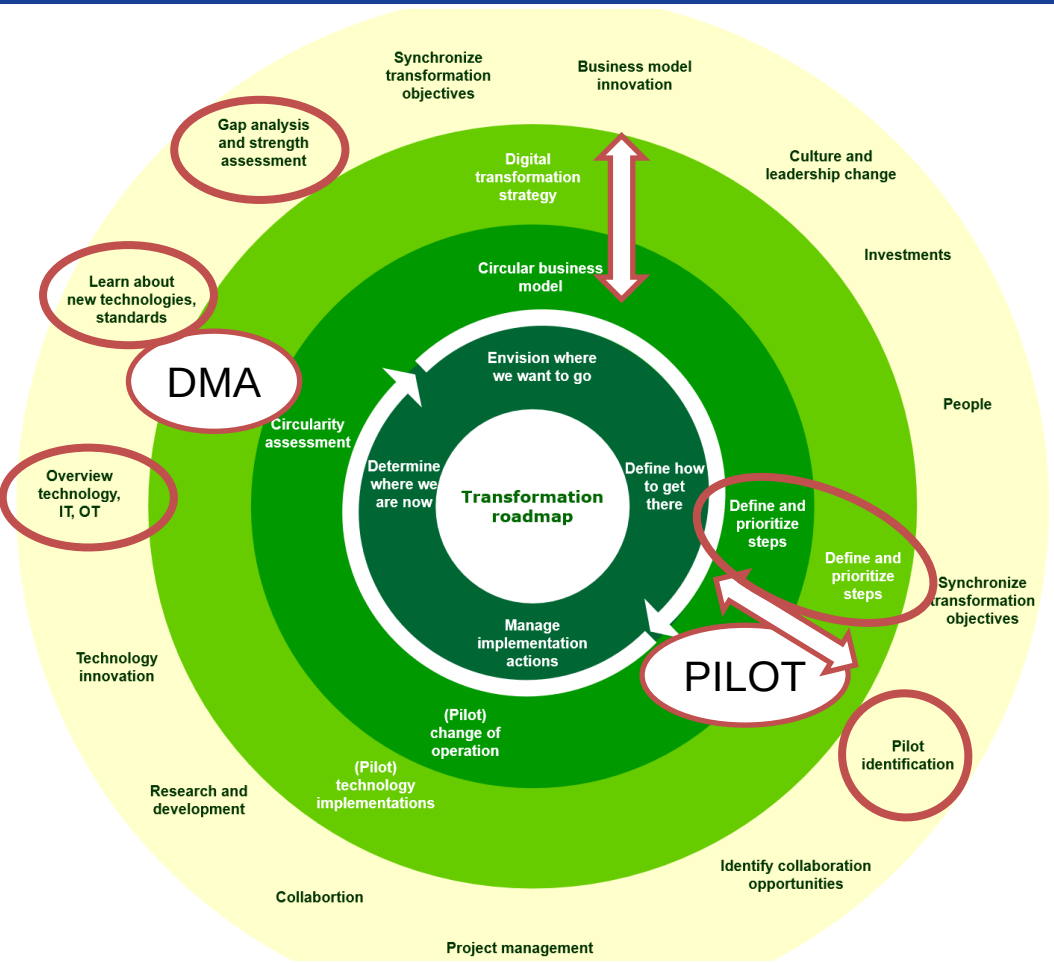


- Review ambitions, define strategy to reach objectives

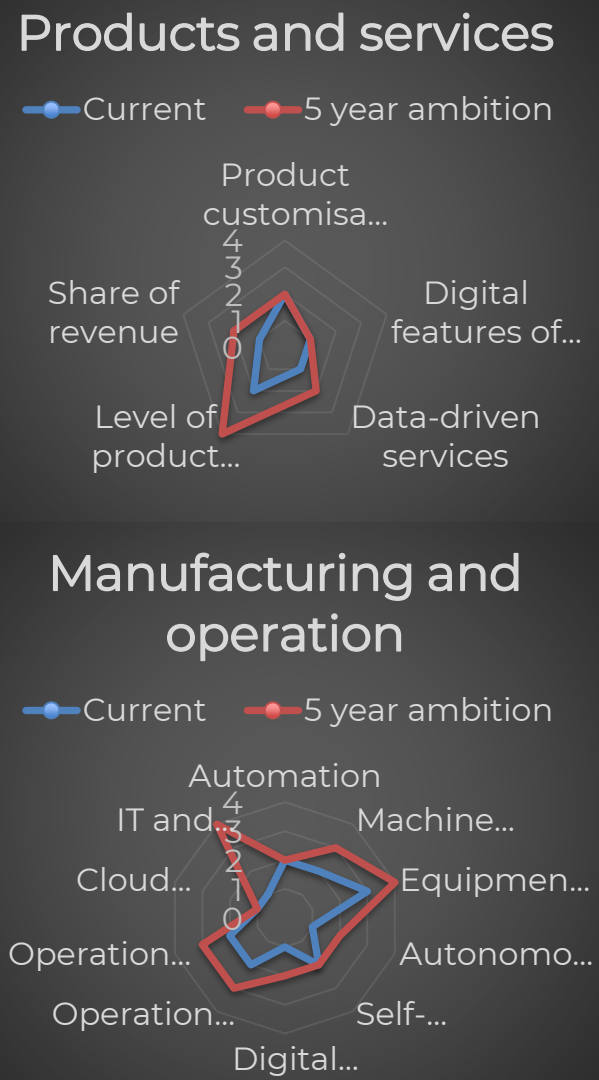


Alpine Space
Circular4.0

Transformation steps



- Refine and prioritize next steps, define pilot, manage changes within company, iterate

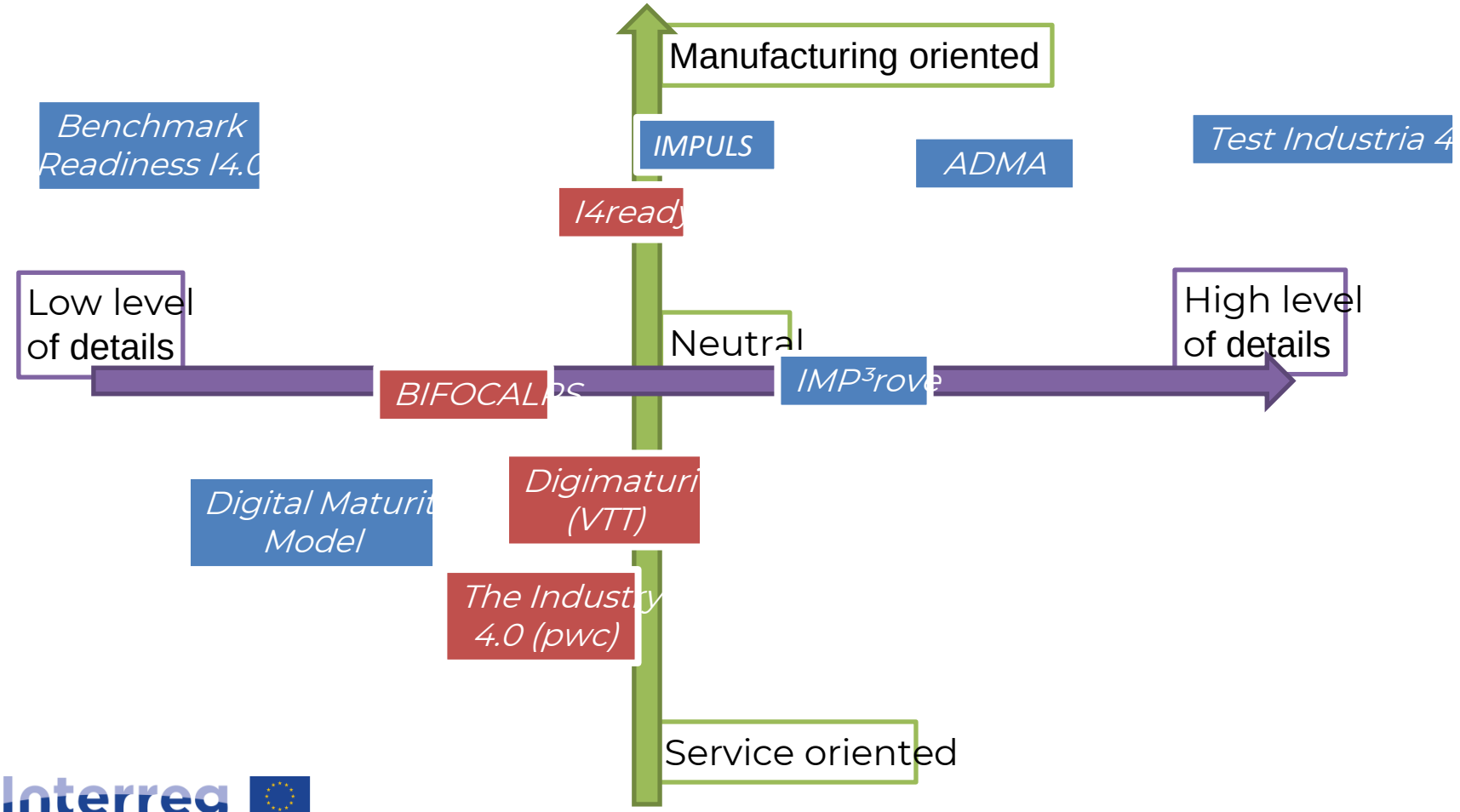


Selection of appropriate DMA tool

- Several tools available (see repository for an overview of dimensions, level of details)

DMA name	Link
Digital Maturity Model	https://www.wiwo.de/downloads/10773004/1/DTA_Report_neu.pdf
IMPULS	https://www.industrie40-readiness.de/
Benchmark Readiness I4.0	http://www.industriebenchmarking.eu/readiness
Test Industria 4.0	https://www.testindustria4-0.com/ https://norstatsurveys.com/wix/6/p1863192646.aspx
IMP³rove Digital Innovation Quotient	https://www.improve-innovation.eu/our-services/assessments/digital-innovation-quotient/
ADMA	https://www.surveymonkey.de/r/YSYDV9Y
BIFOCALPS	https://www.alpine-space.eu/projects/bifocalps/about/deliverables/bifocalps_d.t2.1.2.pdf
i4ready	https://i4ready.co.uk/
The Industry 4.0 (pwc)	https://i40-self-assessment.pwc.de/i40/landing/
VTT Model of Digimaturity	https://digimaturity.vtt.fi/

Selection of appropriate DMA tool



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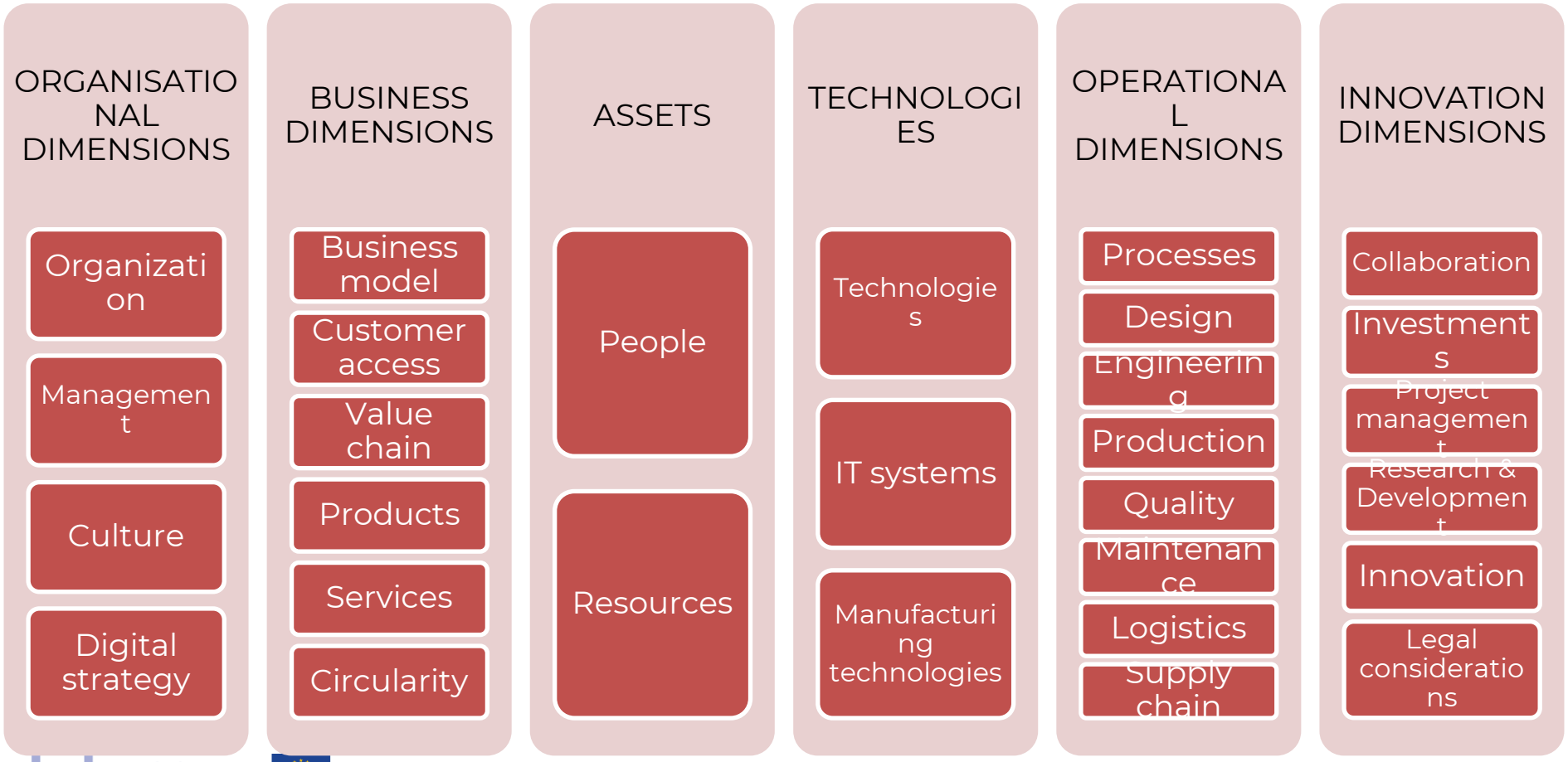
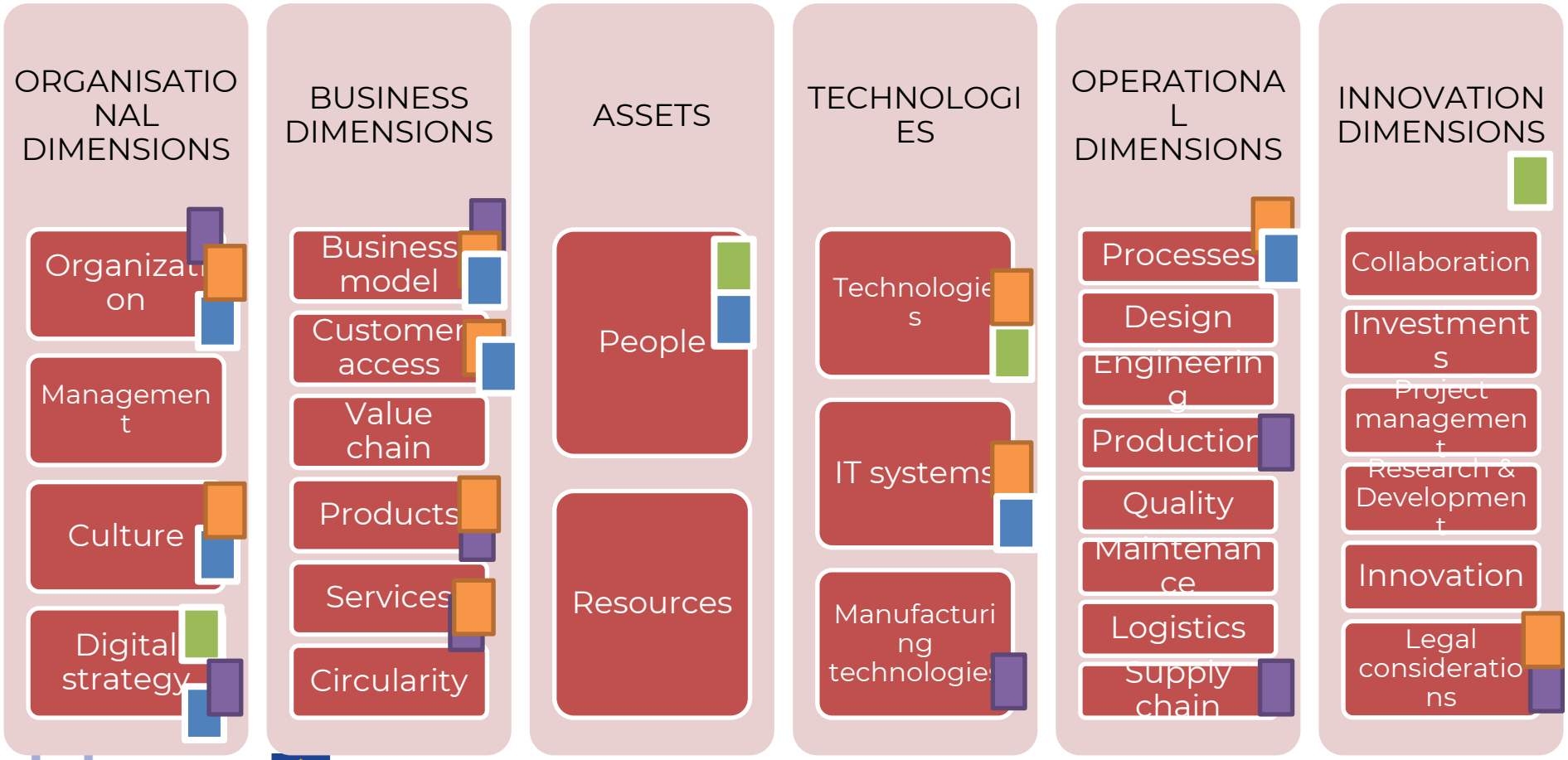
Available online and EXCEL (repo

Available online

DMA dimensions



DMA dimensions



Thank you for your attention!

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