Digitalisation for the Development and Industralisation of Innovative and Sustainable Solutions

Dr. Ola Isaksson, Professor
Division of Product Development
Systems Engineering Design,
Chalmers University, Gothenborg, SWEDEN
Ola.Isaksson@chalmers.se

PLM Road Map™ EMEA & PDT Europe 2022
Digital Transformation and PLM – a call for PLM professionals to re-define and re-position the benefits and value of PLM
18 & 19 October

The context

PLM Road Map™ EMEA & PDT Europe 2022
Digital Transformation and PLM – a call for PLM professionals to re-define and re-position the benefits and value of PLM
18 & 19 October

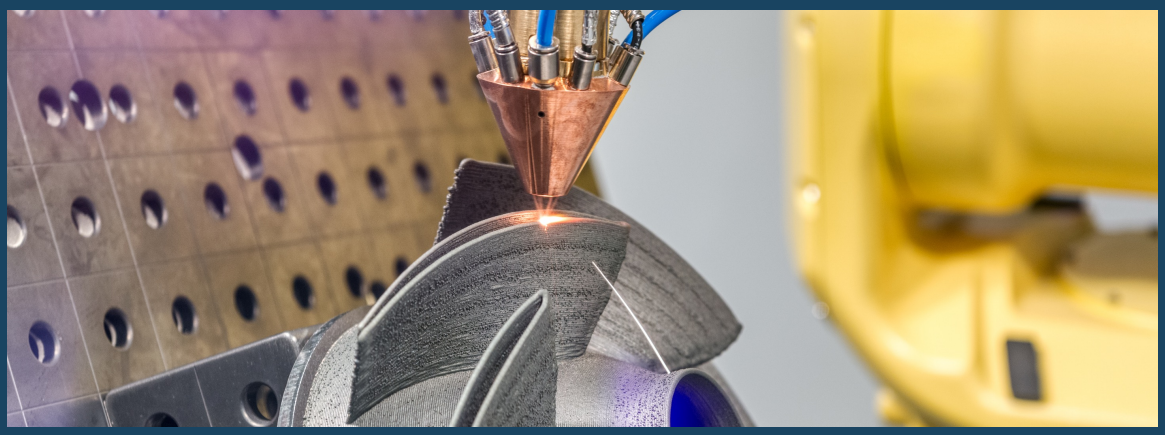
”There is only one planet Earth, yet by 2050, the world will be consuming as if there were three. Global consumption of materials such as biomass, fossile fuels, metals and minerals is expected to double in the next forty years, while annual waste generation is projected to increase by 70% by 2050.”

A new Circular Economy Action Plan For a cleaner and more competitive Europe (2020)

3

Additive Manufacturing

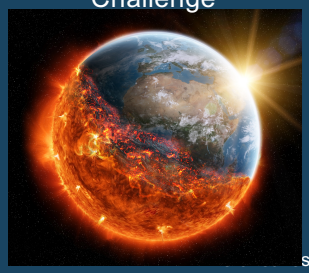
”*The additive manufacturing market size is projected to witness a compounded annual growth rate of 29.86% to grow to US$ 65148.103 million by 2027, from US$ 10459.014 million in 2020.*”



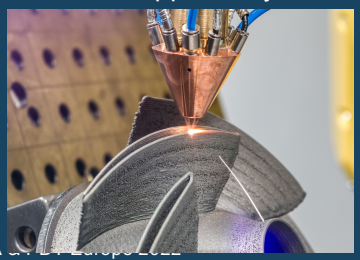
Knowledge Sourcing Intelligence LLP (2022) *Additive Manufacturing Market - Forecasts from 2022 to 2027*

Industry face several disruptive situations simultaneously

Challenge



Opportunity



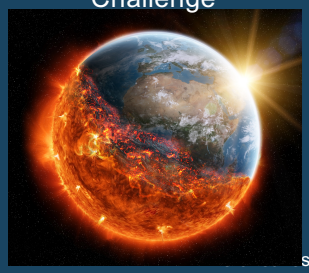
Disruptive Innovation

- Disruptive Innovation differ from ”Radical Innovation”, in that it is NOT about launching a break-through technology, rather building a new business that eventually outcompete exiting solutions, and evolutions of existing solutions.
- Typically, a Disruptive Innovation also rely on factors difficult, or impossible, for any singe actor to control.

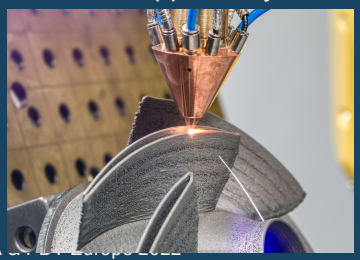
The Innovator’s Dilemma (Christensen, 1997)

Realising solutions is tightly coupled to the ability to process and manage data and information

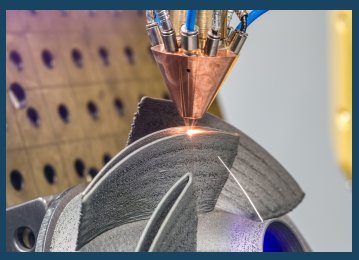
Challenge



Opportunity



Realising solutions is tightly coupled to the ability to process and manage data and infomration



AM require

- *Advanced manufacturing process control*
- *Tight coupling between business, design, production and in service support*
- *Sequre and efficient collaboration in value chains*
- *Intelligent processing of data*
- *Advanced configuration control due to individual design*

Realising solutions is tightly coupled to the ability to process and manage data and information

Development of sustainable solutions require

- *Designing a complete life cycle solution (from produce to provide)*
- *Detailed management of product, material and material element content – producer responsibility*
- *Increase use of monitoring and tracing of products in use*
- *Multi disciplinary, mutli domain and multi organisational development practices*

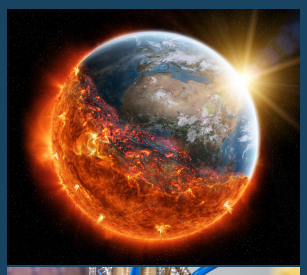
Two industrial challenges

DSIP

VINNOVA UDI

Need for (more) sustainable solutions. Evolution of today's products is not sufficient.

Currently, not products nor product development practices are sufficient

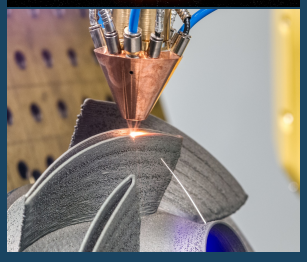


DIDAM

VINNOVA P2030

Take advantage of novel manufacturing technologies, such as Additive Manufacturing (AM)

AM is not established in the industrial manufacturing eco-system



Developing sustainable and circular products?

A brief introduction

PLM Road Map™ EMEA & PDT Europe 2022

Digital Transformation and PLM – a call for PLM professionals to re-define and re-position the benefits and value of PLM

18 & 19 October

Sustainable Product Development

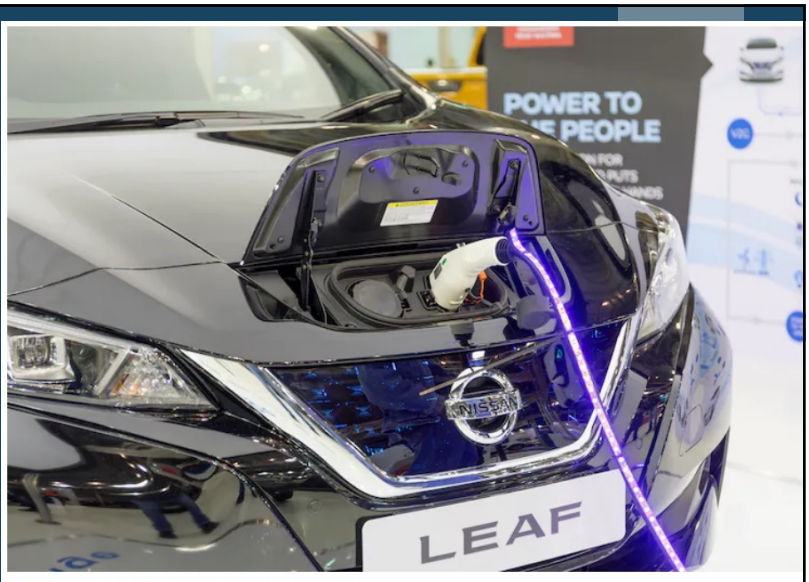
A good start:

- Understand and respond to **societal needs**
- Undertand and responds to **behavioral change**
- Understand, develop and **utlilize advancements in technology**
- **Understand and build on sustainability principles**
- **Understand design and development**
- **Effective use of data and information**

Understand and build on sustainability principles

Example: Electrification

- Replacing petrol cars by Lithium BEWs would consume global reserves in 50 years…



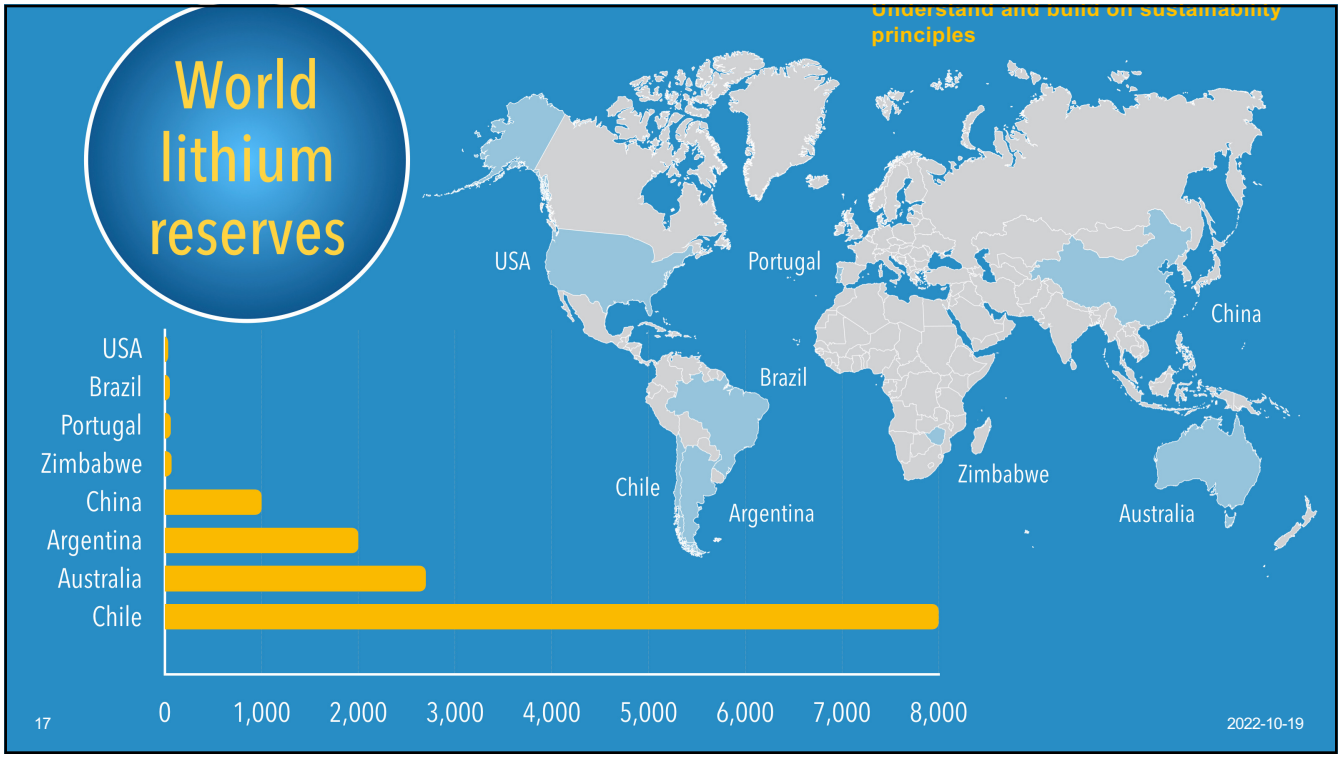
Four kilos of lithium to recharge. Lefteris Papaulakis / shutterstock

Today, a compact electric vehicle battery (Nissan Leaf) uses about 4kg (9lb) of lithium. This means, around 250,000 tonnes of lithium would be required annually to produce enough electric cars to replace their petrol equivalents. At this rate, the 14m tonnes of proven reserves would be exhausted within 51 years.

https://theconversation.com/lithium-is-finite-but-clean-technology-relies-on-such-non-renewable-resources-109630 Ola Isaksson Oct

16

Understand and build on sustainability principles



17

2022-10-19


Do we understand the impact of exploiting natural resources?
Need deeper understanding of sustainability
18
2022-10-19


Sustainability – Trippel Bottom Line (Elkington, 1998)
ECOLOGICAL
SOCIAL
ECONOMICAL
Elkington, J. (1998). Partnerships from cannibals with forks: The triple bottom line of 21st-century business. Environmental quality management, 8(1), 37-51

Sustainable Dependencies

Mebratu, (1998)

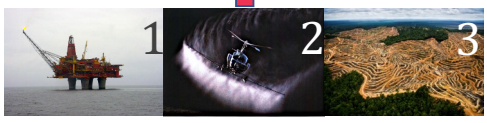
ECONOMICAL

SOCIAL

ECOLOGICAL

Mebratu, D., (1998). Sustainability and sustainable development: historical and conceptual review. Environmental impact assessment review, 18(6), pp.493-52

Mechanisms of destruction



Earth's crust | Societal production | Physical means

Health | Influence | Competence | Impartiality | Meaning-making

Reference:

Broman, G.I. and Robèrt, K.H., 2017. A framework for strategic sustainable development. *Journal of Cleaner Production*, *140*, pp.17-31.

Ecological sustainability principles

In an ecologically sustainable society, nature is not subject to systematically increasing…

1 …concentrations of substances extracted from the Earth's crust.

Eg. scarce minerals and metals, fossil fuels

2 …concentrations of substances produced by society.

Eg. chemicals, long-life, non-biodegradable

3 …degradation by physical means.

Eg. over-fishing, deforestation

Broman, G.I., Robèrt K.-H., 2015. A framework for strategic

Social sustainability principles

In a socially sustainable society, people are not subject to structural obstacles to…

4 …health.

Eg. dangerous working conditions or insufficient rest from work.

5 …influence.

Eg. by suppression of free speech or neglect of opinions

6 …competence.

Eg. by obstacles for education or insufficient possibilities for personal development

7 …impartiality.

Eg. by discrimination or unfair selection to job positions

8 …meaning-making.

Eg. by suppression of cultural expression or obstacles to co-creation of purposeful conditions

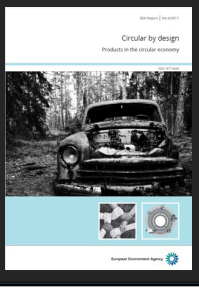
Broman, G.I., Robèrt K.-H.,2015. A framework for strategic sustainable development. *Journal of Cleaner Production*. In Press.

Circular Economy?

”Central to the circular economy concept is the notion that the value of materials and products C kept as high as possible for as long as possible. This helps to minimise the need for the input of new material and energy, thereby reducing environmental pressure linked to the life-cycle of products, from resource extraction, through production and use to end-of-life.”

Circular by Design (2017)

Circular Economy ultimately transfer ownership of products and material to the manufacturer



24

Effects from Transfer of Ownership from user to producer

- **Example Hawker Harrier.**
  - **From spare parts sales to re-design**
- **Change in business model swapped revenue to cost…**

25

”Central to the circular economy concept is the notion that the value of materials and products is kept as high as possible for as long as possible. This helps to minimise the need for the input of new materials and energy, through designing environmental pressure linked to the life-cycle of products and their materials, from production and use to end-of-life.”

Circular by Design (2017)

Design is about finding, exploring, evaluating, defining and validating solutions to needs.

The 9 ’R’s (actually 10 :)

SMARTER

SUSTAIN FUNCTION IN USE

REDUCE VASTE

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, conservation and recycling*, *127*, 221-232.

Circular economy

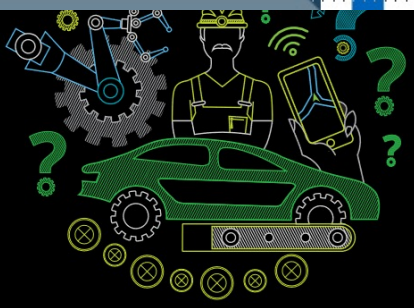
Increasing circularity

Linear economy

	Strategies	
Smarter product use and manu-facture	R0 Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
	R1 Rethink	Make product use more intensive (e.g. by sharing product)
	R2 Reduce	Increase efficiency in product manufacture or use by consu-ming fewer natural resources and materials
Extend lifespan of product and its parts	R3 Reuse	Reuse by another consumer of discarded product which is still in good condition and fulfils its original function
	R4 Repair	Repair and maintenance of defective product so it can be used with its original function
	R5 Refurbish	Restore an old product and bring it up to date
	R6 Remanufacture	Use parts of discarded product in a new product with the same function
	R7 Repurpose	Use discarded product or its parts in a new product with a different function
Useful application of mate-rials	R8 Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
	R9 Recover	Incineration of material with energy recovery

Deloitte.

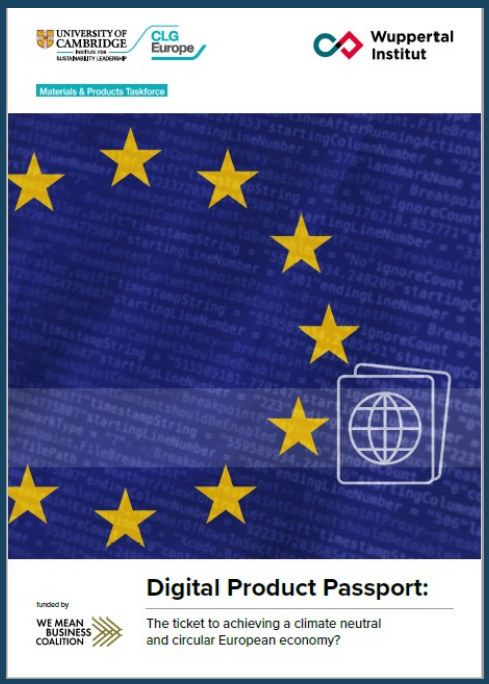
Example: SHARING



In 2025, up to 36% of citizens will be using the sharing economy instead of owning a car. This could decrease vehicle sales by 24%

Deloitte Automotive Value Chain Model

The Future of the Automotive Value Chain
2025 and beyond



Continuous increase in legislation

- Digital Product Passport
- About to be introduced, requesting traceabilty of material origin and history…

Some incentives for manufactures to design Circular Economy based solutions

- Increased producer responsibilities through life
- Value in function provided rather than ownership of artifacts
- Scarcety and Value in resources and technology

- Incentives for manufacturers to go ***from produce to provide***

THE ongoing Projects - DSIP

PLM Road Map™ EMEA & PDT Europe 2022

Digital Transformation and PLM – a call for PLM professionals to re-define and re-position the benefits and value of PLM

18 & 19 October

Digital Sustainability Implementation Package - DSIP

2020-2023

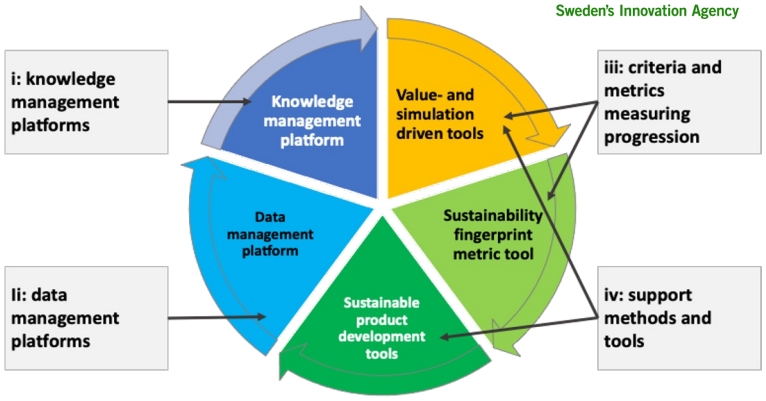
DSIP *focus on developing a digital support package for sustainable product development together with industrial partners and solution providers*

VINNOVA
Sweden's Innovation Agency

DSIP – Digital Sustainability Implementation Package

DSIP in Brief

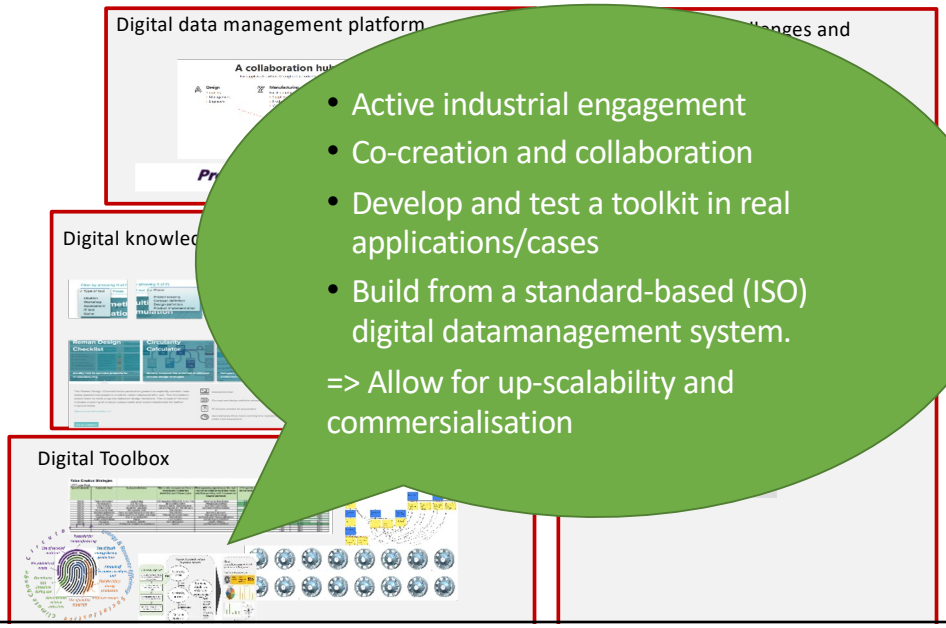
VINNOVA
Sweden's Innovation Agency



Goal: To build a digital plattform to demonstrate and validate that **the DSIP capabilities enable industries to better develop and provide sustainable products and circular solutions** to the market.

DSIP – Digital Sustainability Implementation Package

DSIP - main features



- Active industrial engagement
- Co-creation and collaboration
- Develop and test a toolkit in real applications/cases
- Build from a standard-based (ISO) digital datamanagement system.

=> Allow for up-scalability and commersialisation

- Toolbox and Tool-Guide
- Sustainability Fingerprint
- Traceability of life cycle data

Use case scenario structure

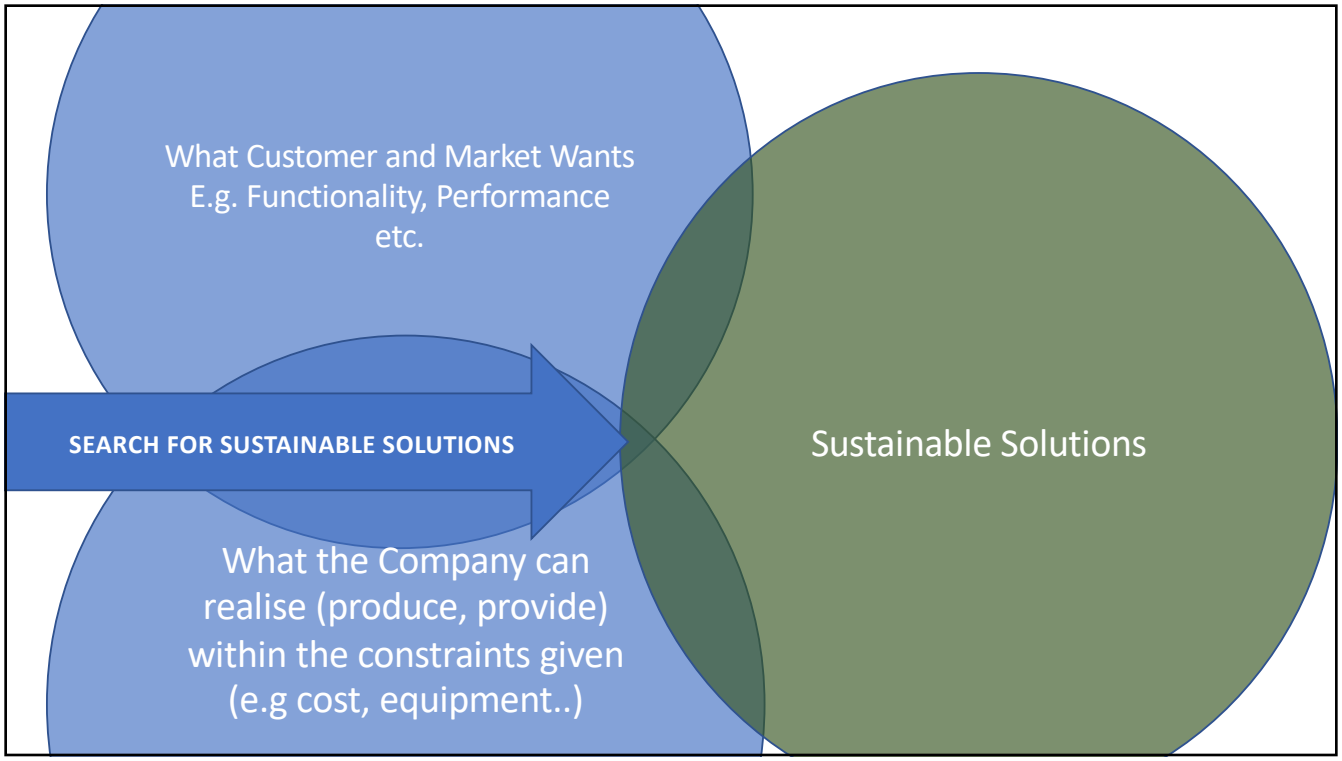
- Each company defined a use case which is represented by use case scenarios.
- The scenarios have been defined in detail, to visualize
  - Process modelling AS IS with GAPS
  - GAP vs CAPABILUTY MAPPING
  - DEMONSTRATE
- DSIP Capabilities demonstrated in collaborative workshops

Use Case – Overall Challenge

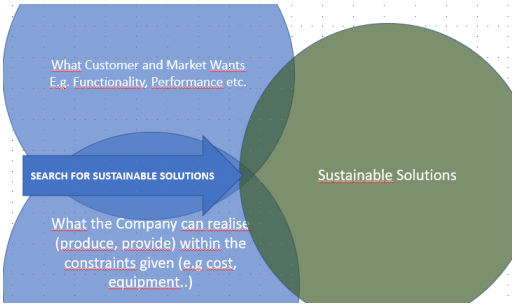
Scenarios – Typical Case

Analysis and Mapping Capabilities

Co Development with Industries



Find and define the ”design space”



WHAT is needed is typically captured as FUNCTIONAL REQUIREMENTS

What can be realised are typically seen as CONSTRAINTS (e.g. the capability of a factory etc)

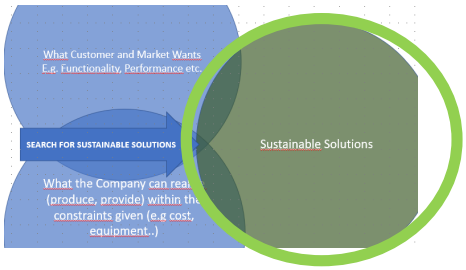
SUSTAINABILITY ADD a dimension – that help to direct the search of feasible options.

DSIP – Digital Sustainability Implementation Package

Example: Sustainability Fingerprint

Desired level & minimum acceptance level of sustainability compliance

Used to seek solutions and evaluate alternatives

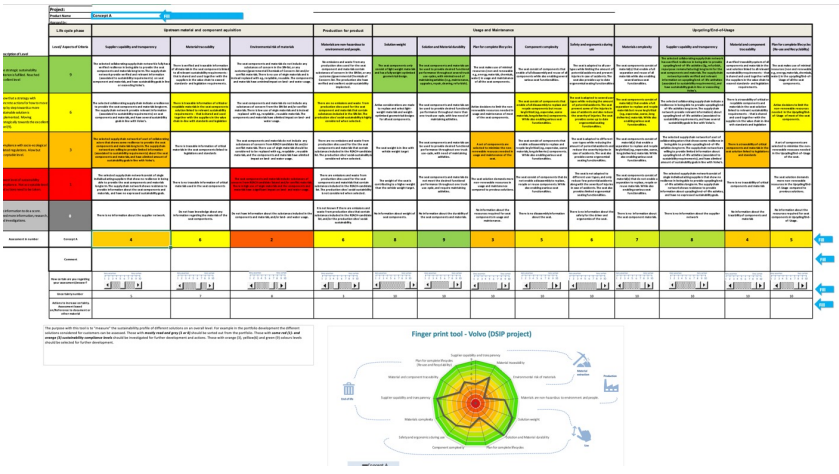


Sustainability criteria Identificaton analysis and requirement profile

	Life cycle phase	Upstrea
	Level/ Aspects of Criteria	Supplier capability and transparency
Description of Level		
The strategic sustainability criterion is fulfilled. Reached excellent level	9	The selected collaborating supply chain network is fully has a verified resilience in being able to provide the seat components and materials long term. The supply chain network provide verified and relevant information (associated to sustainability requirements) on seat component and materials, and have sustainability goals in line or exceeding Volvo's.
Show that a strategy with concrete actions for how to move step by step towards a more sustainable solution is implemented. Moving strategically towards the excellent level (9).	6	The selected collaborating supply chain indicate a resilience to provide the seat components and materials longterm. The supply chain network provide relevant information (associated to sustainability requirements) on seat components and materials, and have several sustainability goals in line with Volvo's.
Compliance with socio-ecological related regulations. A low but acceptable level.	3	The selected supply chain network of a set of collaborating actors that shows some resilience to provide the seat components and materials long term. The supply chain network are willing to provide limited information (associated to sustainability requirements) about the seat components
Lowest level of sustainability compliance. Not acceptable level and actions need to be taken.	1	The selected supply chain network consist of single individual acting suppliers that show no resilience in being able to provide the seat components and materials longterm. The supply chain network shows resistance to provide information about the seat components and materials, and have no expressed sustainability goals.
No information to do a score. Need more information, research, and investigations.	0	There is no information about the supplier network.
Assessment in number	Product A	

Purpose with Sustainability Fingerprint- Guidance of sustainability direction

- Use a set of prioritiesed uniqe criteral for the particular product to be developed
- Assess concept solution(s)
- Strategic selection of product portfolio



Status in DSIP

DSIP capabilites have been developed in scenario situations with companies

Currently first review with ALL DSIP partners

A Value Driven and Sustainable Development logic is proposed and will be validated within the project

Preparation for a UDI Step 3 started.

THE ongoing Projects - DIDAM

PLM Road Map™ EMEA & PDT Europe 2022

Digital Transformation and PLM – a call for PLM professionals to re-define and re-position the benefits and value of PLM

18 & 19 October

Digitalisation for the Development and Industralisation of Innovative and Sustainable Solutions – DIDAM

2020-2023

DIDAM *Focus in Industrial Value Chains and scale up of Additive Technologies in Industrial Ecosystems*

PRODUKTION2030

VINNOVA Sweden's Innovation Agency

DIDAM (2020-2023)

Demonstration of Infrastructure for Digitalization enabling industrialization of Additive Manufacturing

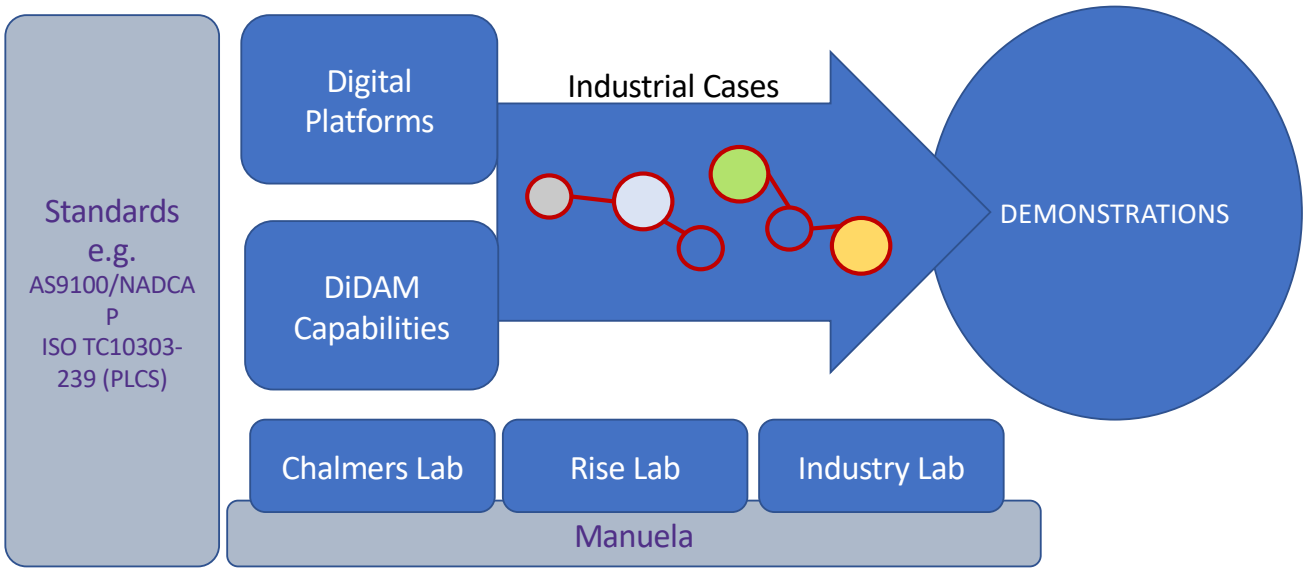
DIDAM *Focus in Industrial Value Chains and scale up of Additive Technologies in Industrial Ecosystems*

DiDAM seek to demonstrate best practice and state of art Digital Technologies from an Industrialisation perspective.

DiDAM will add experience to the ***Digital AM guide***

DIDAM partners represent Industrial Value Chains, Digital Solution providers and Academia

Digital experiments and demonstrations



Demonstrations

- RISE and CHALMERS leading Demonstration Activiteis

Use case 1 Efficient AM Process

Use case 2: Efficient tracing and sharing of the AM Process

Use Case 3: Digital means to realise the potential of AM

Demo 1: DIGITAL PROCESS FOR REPAIR
VOLVO GTO (Lead Industry) – Scaleability of AM repair

Demo 2 A and B: DIGITAL PROCESS FOR PRINTING WITH EXTERNA SUPPLIERS
EPIROC (Lead Industry) – Enabling Print On Demand and Print Where Needed
GESTAMP – Communicating with External Suppliers in the design of advanced production tools

Demo 3: DIGITAL DESIGN FOR ADDITIVE MANUACTURING
VOLVO CE (Lead Industry) - Introducing Additive Manufacturing for Tool Design

A generic process for Additive Manufacturing

A. Product Design	B. Manufacturing Product Design	C. Manufacturing Process Design	D. Printing	E. Post manufacturing processing	F. Repair and Maintain

In DIDAM we focus on the generic process from DESIGN throughout to REPAIR AND MAINTAIN

Demonstrators focus on different phases and digital challenges.

Example: Demo 01 / Digital Process for Repair

A. Product Design	B.Manufacturing Product Design	C. Manufacturing Process Design	D. Printing	E. Post manufacturing processing	F. Repair and Maintain

Objective

To demonstrate the digital flow and its eventual gaps around the restoration of damaged metal components with PBF-LB

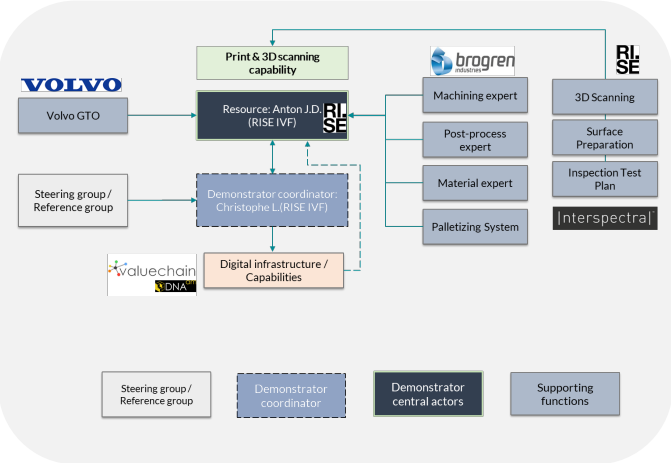
Problem Statement

Capturing geometry and inspection data from worn part

Identifying pre-operation steps and data before repair

Consolidating and preparing captured and targeted data

Connecting positioning in process to digital coordinate system



Demo 01 / Digital Process for Repair

Key issues

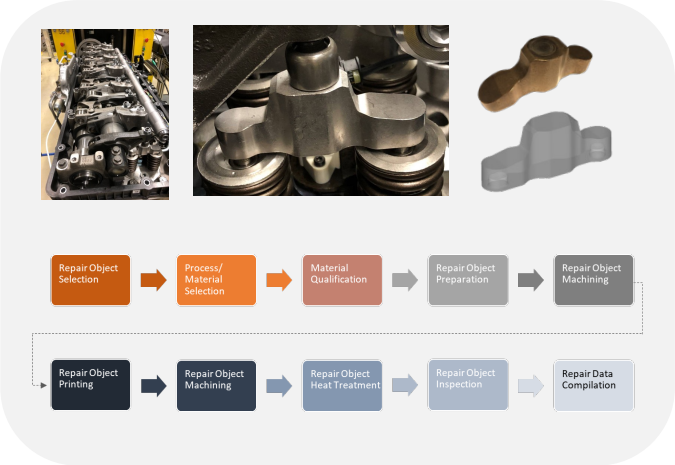
Identify the most optimal Process layout, collect representative data, and predict how sensitive data will affect the workflow

Identify Pre-AM operations

- Inspection tools – data collection
- Mechanical/Chemical/thermal surface preparations
- Part positioning/coordinate system – palletizing system

Identify Post-AM operations

- Inspection tools – 3D/CT-scanning data
- Mechanical/thermal surface modifications
- Data compilation platform – IP protection



Demo 01 / Digital Process for Repair

Expected outcome

Establish best practice for repair components with PBF-LB

Identify and consolidate digital gaps in Process Design

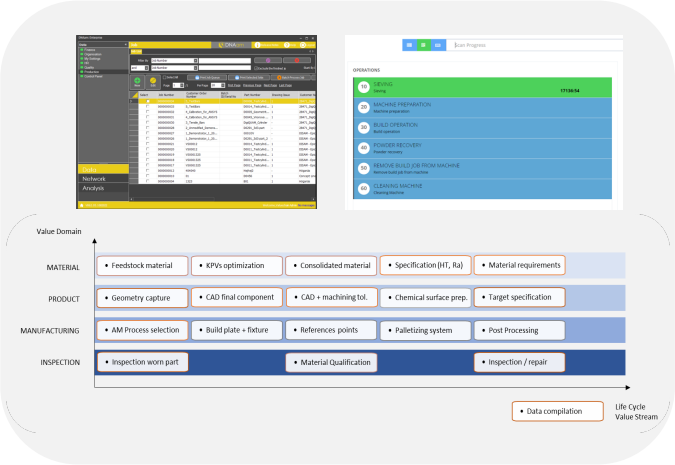
Establish feedback to standardisation work (ISO/ASTM)

Establish feedback to Inspection Test Plan – Digital Analytics

Develop Digital Analytics tool adapted to PBF-LB systems

Visualize Digital Flow through repair case while identifying:

- Data maturity levels
- Life Cycle Value Stream
- Value Domain



Demo 2A / DIGITAL PROCESS FOR PRINTING WITH EXTERNAL SUPPLIERS

A. Product Design	B.Manufacturing Product Design	C. Manufacturing Process Design	D. Printing	E. Post manufacturing processing	F. Repair and Maintain

Key issues

Flexibility to rapidly place orders with new print service provider "where needed". Critical to set up and ensure IP and Quality

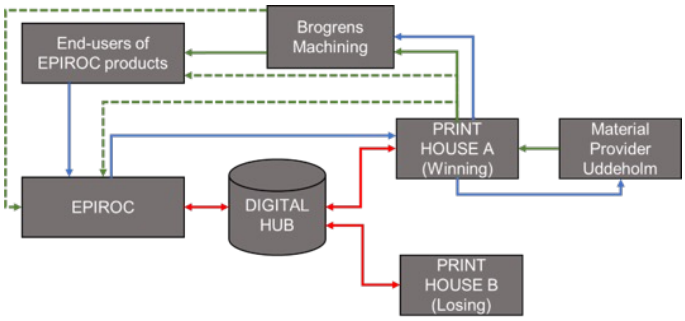
Demonstrate

- Secure set up and sharing of information
- Maintain Intellectural Rights

DiDAM partner representing Value Chain Actors.

EXPECTED IMPACT

Demonstrated Effectiveness (lead time) of Sequre Collaboration



Demo 2B / tool design and manufacture in collaboration with print service providers

A. Product Design	B.Manufacturing Product Design	C. Manufacturing Process Design	D. Printing	E. Post manufacturing processing	F. Repair and Maintain

Key issues

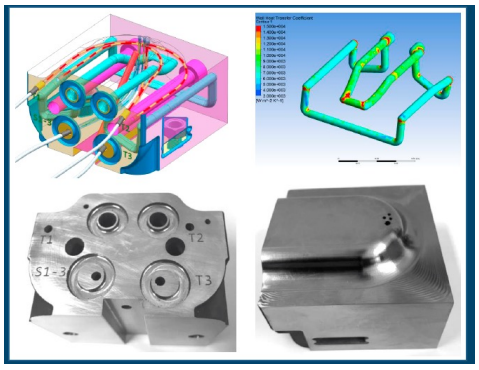
Ensure efficient design and utilization of external services for advanced tool design. Incompativilities and manual intensive bottlenecks in the process

Demonstrate

- Demonstrate efficient and secure sharing
- Demonstrate use of standard way of working

DiDAM partner representing Value Chain Actors.

AM for Hot Stamping (Gestamp)



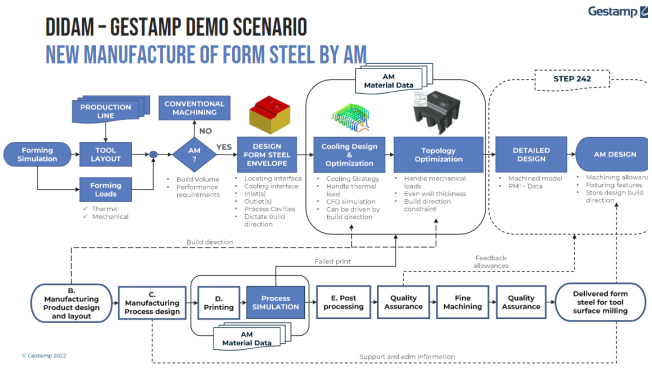
Demo 2B / tool design and manufacture in collaboration with print service providers

A. Product Design	B.Manufacturing Product Design	C. Manufacturing Process Design	D. Printing	E. Post manufacturing processing	F. Repair and Maintain

EXPECTED IMPACT

Demonstrated Best practice in sharing design responsibilities and activities with external partner

Enable design iterations using digital assets (simulation etc) for product and process tradeoffs



Demo 3/ DIGITAL DESIGN FOR ADDITIVE MANUACTURING

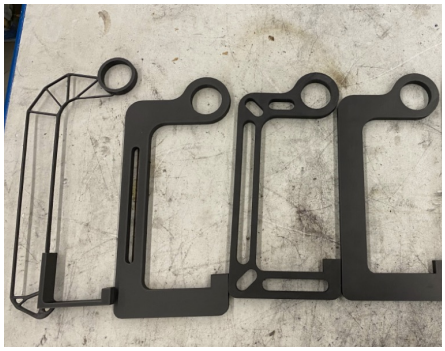
A. Product Design	B.Manufacturing Product Design	C. Manufacturing Process Design	D. Printing	E. Post manufacturing processing	F. Repair and Maintain

VOLVO
Construction Equipment

Expected Impact

Demonstrate the value of Digital Design for Additive Manufacturing

Identification of AM adapted tool design procedures



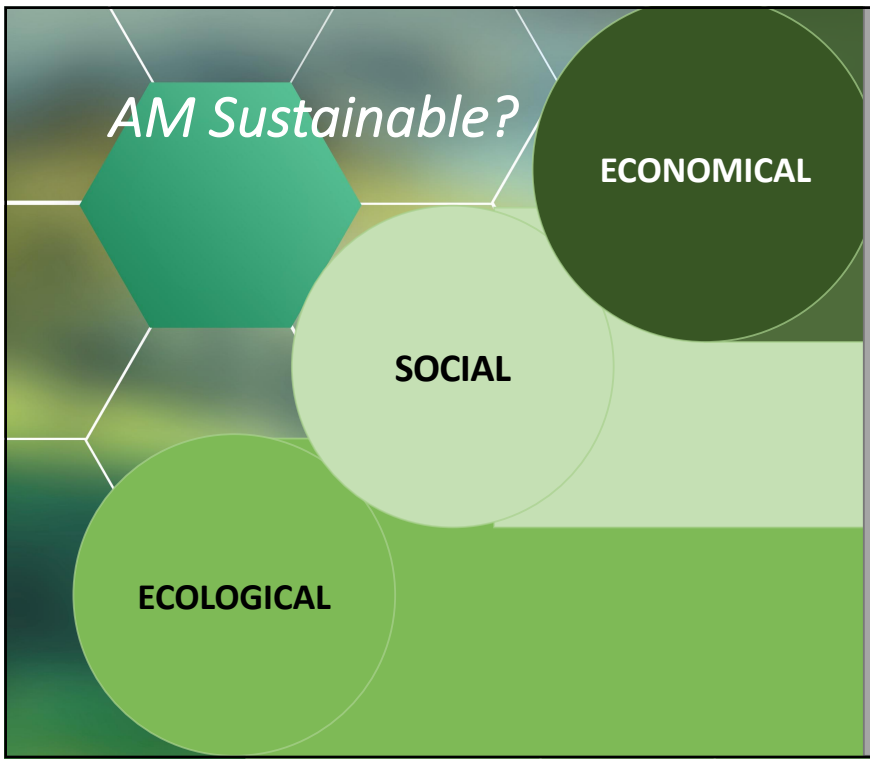
Example: Digital Design require clarified design requirements for optimisation

Current state in DIDAM

- Use cases, objectives, cases, targets defined
- All digital demonstrator development in progress

- Some reflections
  - In industrialisation of AM – digital focus is difficult but important
  - AM means new ways of thinking, requiring new collaboration
  - Secure Collaboration is increasing
  - Digital management of induvidual designs is a consequence
  - Modelling and Simulation a necessity
  - Huge amounts of data used in design and production
    - Used primarily for process control, but LEARNING potential huge

CHALMERS
UNIVERSITY OF TECHNOLOGY



Sustainable AM features

- Induvidualised Designs
- Minimize Vaste
- Lead Time Efficient
- Flexible
- Business Development
- Re Manufacturing
- Print on Demand
- Global Manufacturing
- Reuse of Material ?