



DigiPrime

DIGITAL PLATFORM FOR CIRCULAR ECONOMY IN
CROSS-SECTORIAL SUSTAINABLE VALUE NETWORKS

The Manufacturing Partnership Day

Brussels, September the 26th 2023



POLITECNICO
MILANO 1863



Presenter: Marcello Colledani

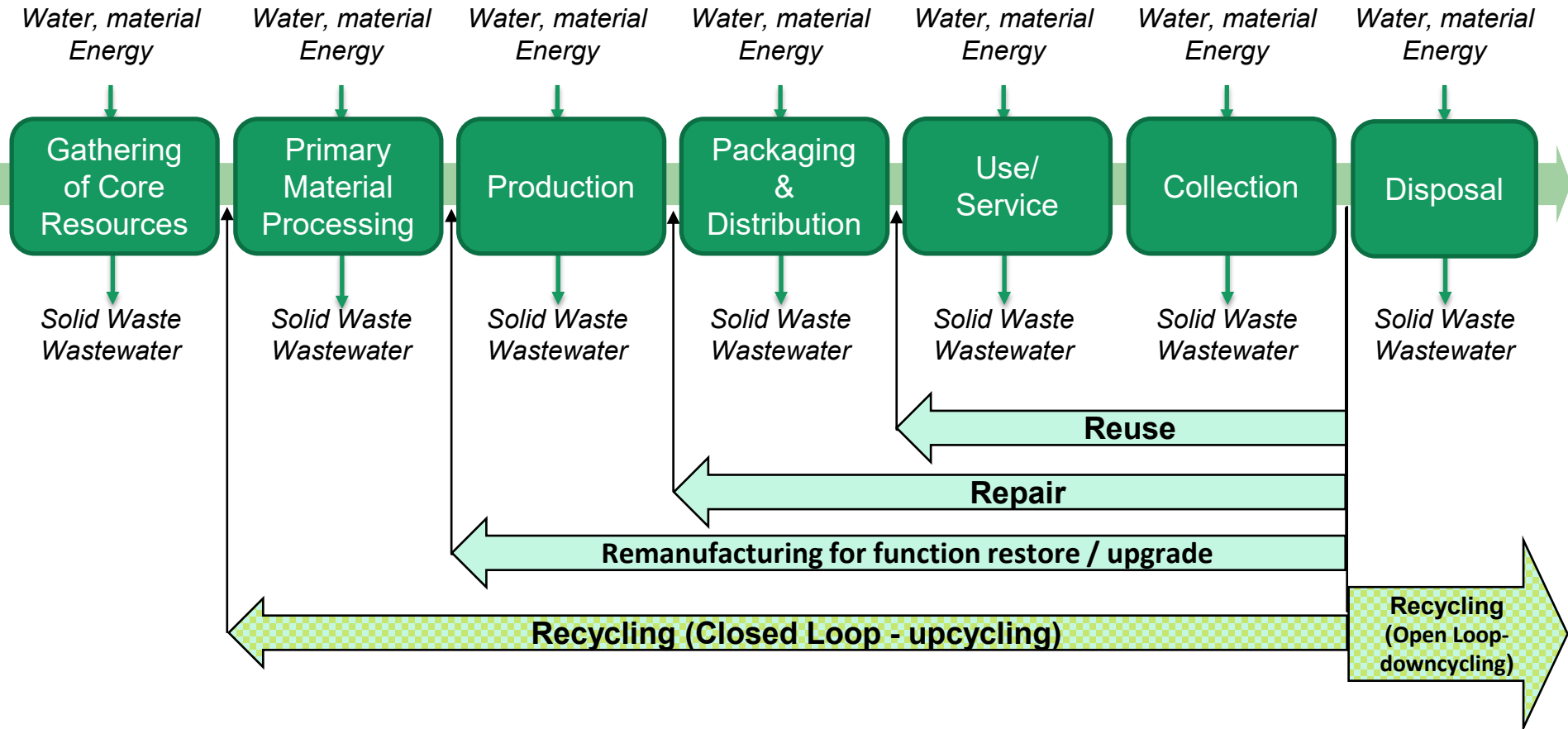
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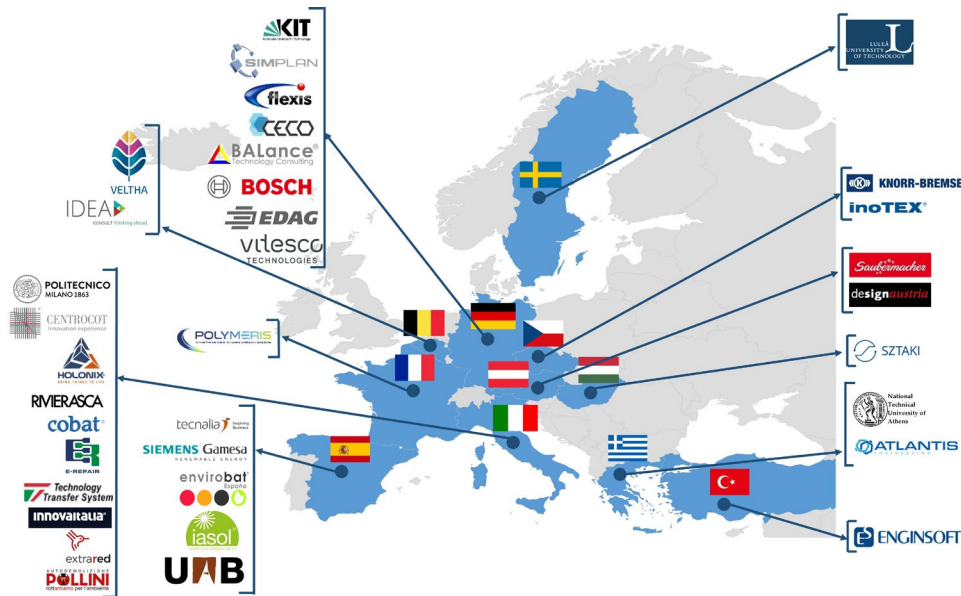


Motivation and Objectives



- Product data and knowledge is not exchanged among manufacturers and de- and remanufacturers, as well as among sectors leading to unlocked cross-sectorial material re-use opportunities.
- Lack of certification protocols for secure re-used materials and components transfer among sectors.
- Poor acceptability of products embedding recycled materials by end-customers.

The DigiPrime project



- 36 European organizations from 11 EU states;
- 6 manufacturing sectors;
- 25 **industrial partners**, 18 of which are SMEs;
- 8 **academic and research partners**.

CALL

H2020-DT-ICT-07- 2018-2019

Digital Manufacturing Platforms for Connected Smart Factories

BUDGET

Project costs: 19.257.130,00€

Funding: 15.963.173,50€

DURATION

January 2020 – Dec 2023

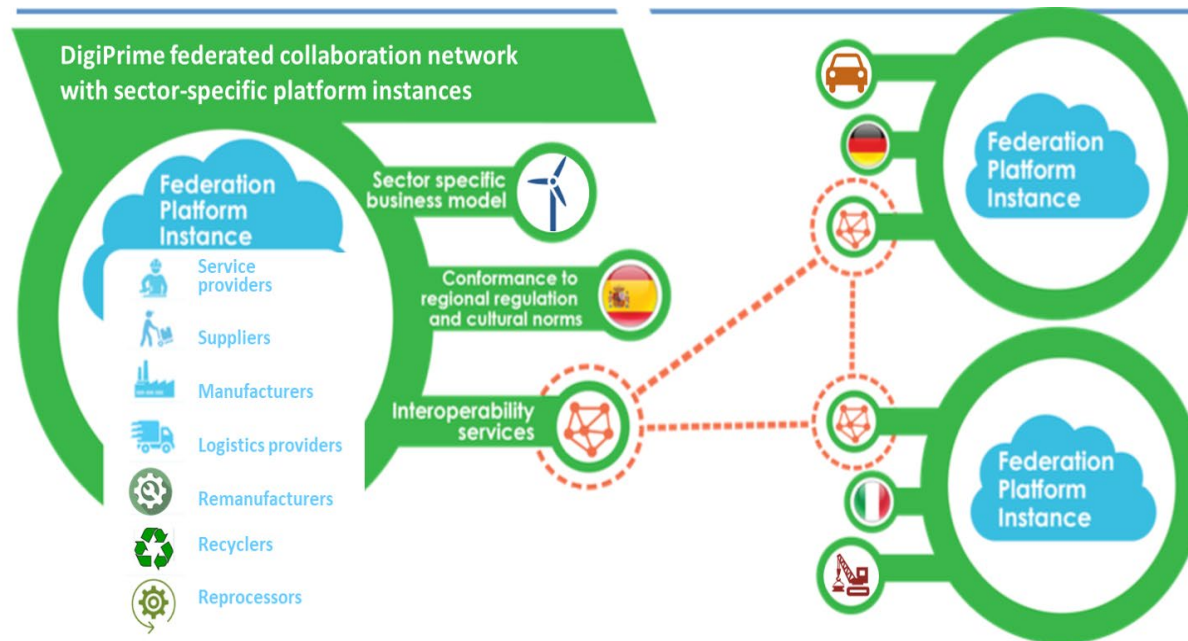
OBJECTIVE

To develop a new concept of **Circular Economy digital platform** overcoming current information asymmetry among value-chain stakeholders, in order to unlock new circular business models based on the data-enhanced recovery and re-use of functions and materials from high value-added post-use products with a cross-sectorial approach.

Platform Architecture: concept of federation

The overall architecture level of the DigiPrime platform includes:

- A **Multi-node federation structure**, replicable on different existing and new sectorial platform instances, which will support the future systematic creation of cross-sectorial circular value-chains.
- A **Semantic data infrastructure**, based on ontological repositories and semantic search, able to manage and standardize the Babel of information coming from heterogeneous nodes.
- A **Data Policy Framework** to ensure privacy, security, authentication and authorization policies to any information shared among registered users.

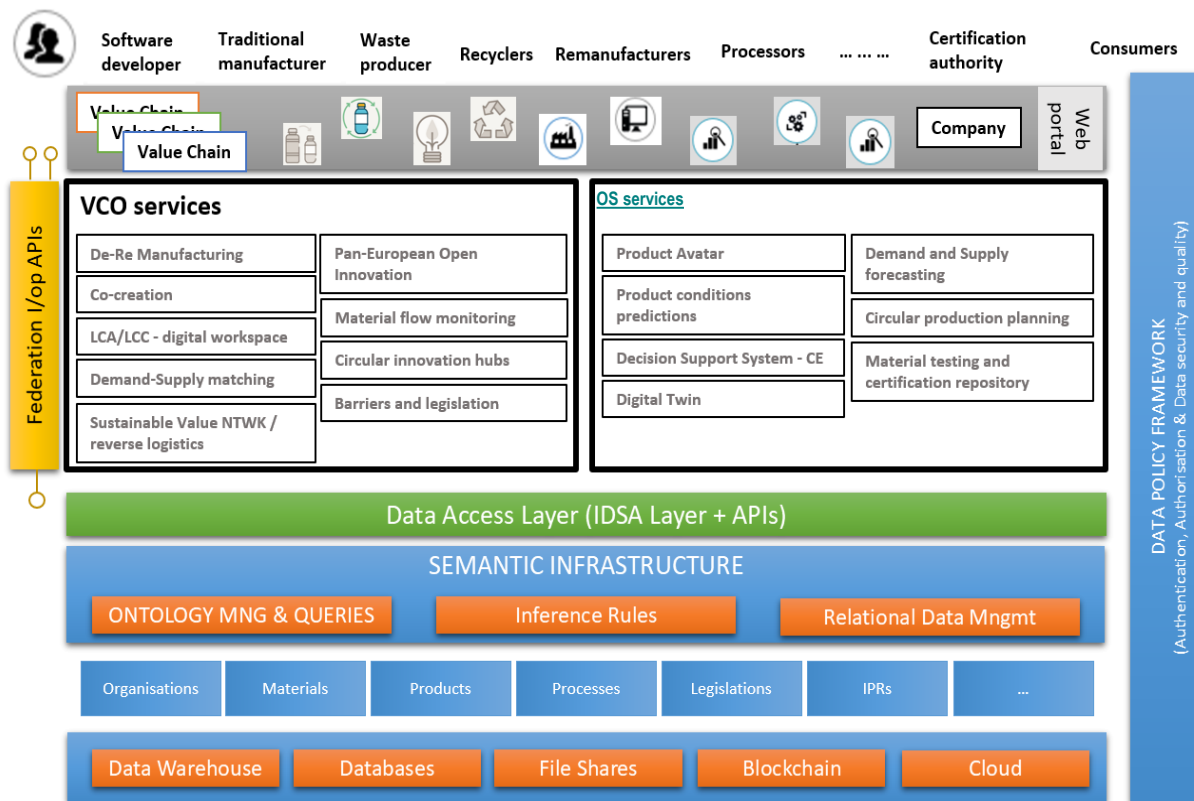


The Blockchain technology will ensure that data cannot be altered, and will keep track of any transaction taking place in the platform.

The DigiPrime platform Services

Value-chain Oriented Services (VCO) and Operational Services (OS).

- **VCO** services are horizontal services that can be made accessible to other nodes of the federation, to offer access to information of interest to stakeholders across sectors.
- **OS** services are vertical services, used by companies internally, mainly to support decision- making aiming at improving the effectiveness and profitability of the circular business processes.

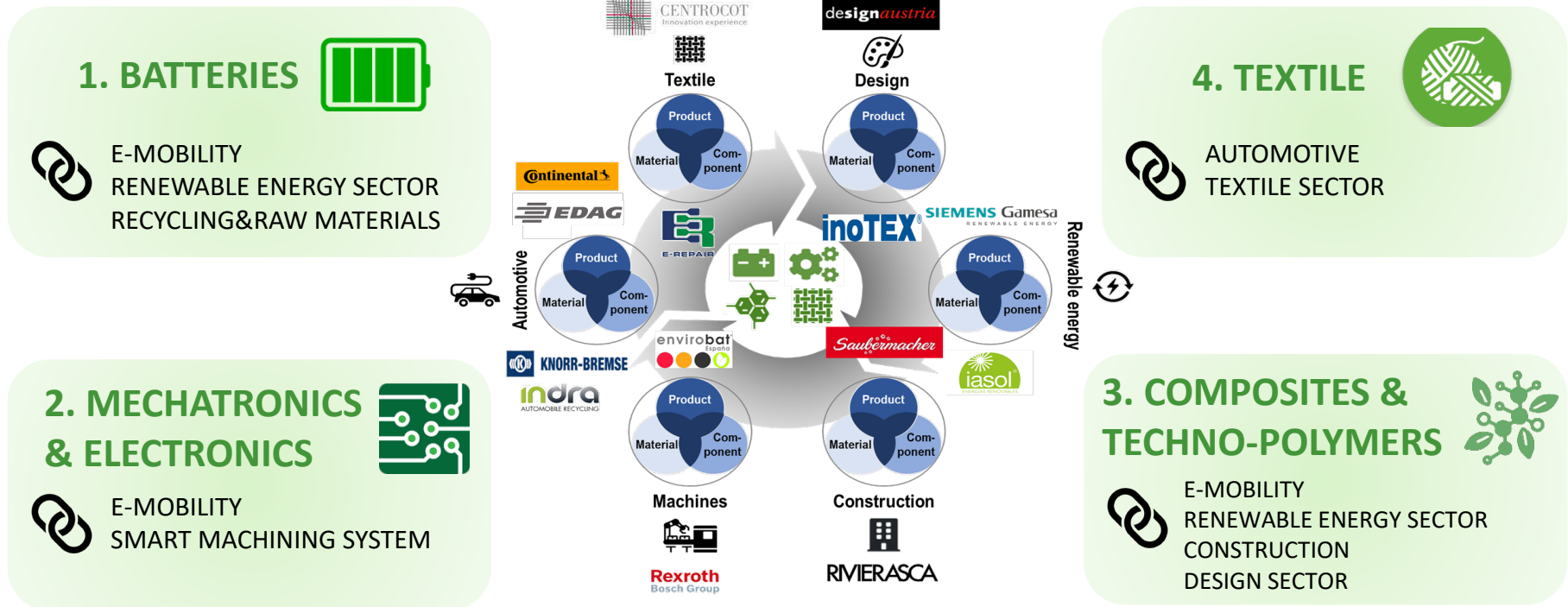


The DigiPrime Pilots

The platform and the related service applications will be **adopted and validated within the DigiPrime cross-sectorial pilots.**

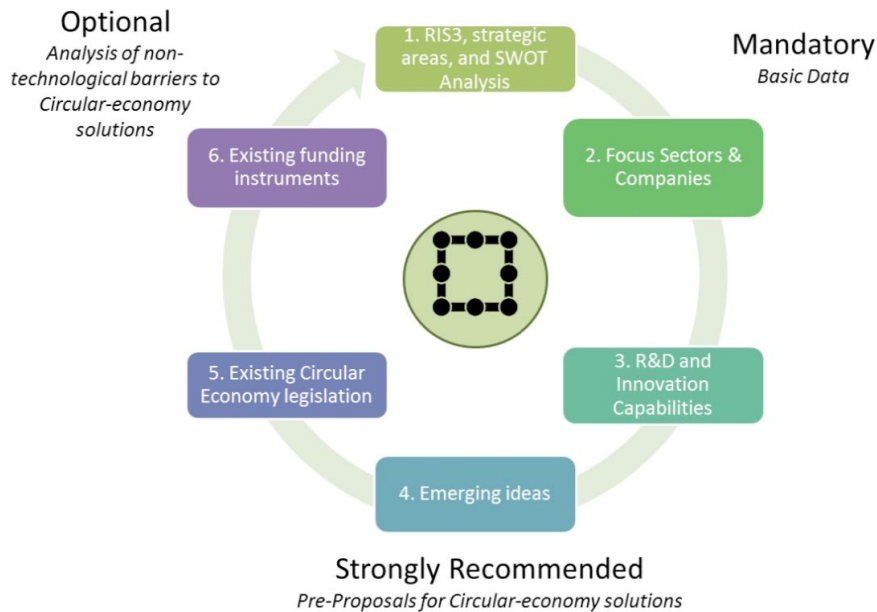
Executing the demonstration experiments for specific use-cases allows to test:

- The interoperability with the company pre-existing ICT infrastructure;
- The continuous interaction with the platform modules and services;
- The generated data to populate the platform for future business cases;
- The industrial feedback for platform maintenance and improvement.



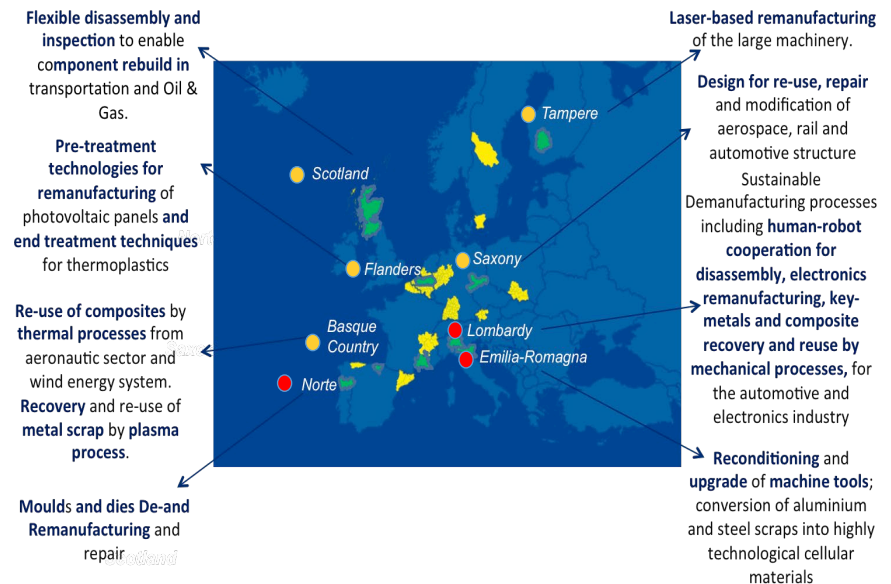
Pilot 5: Cross-regional value-chain identification and open innovation.

In this pilot, the capabilities of the DigiPrime platform are exploited for achieving a systematic implementation of the methodology developed in the SCREEN H2020 project.



Pilot 6: Circular innovation hubs integration.

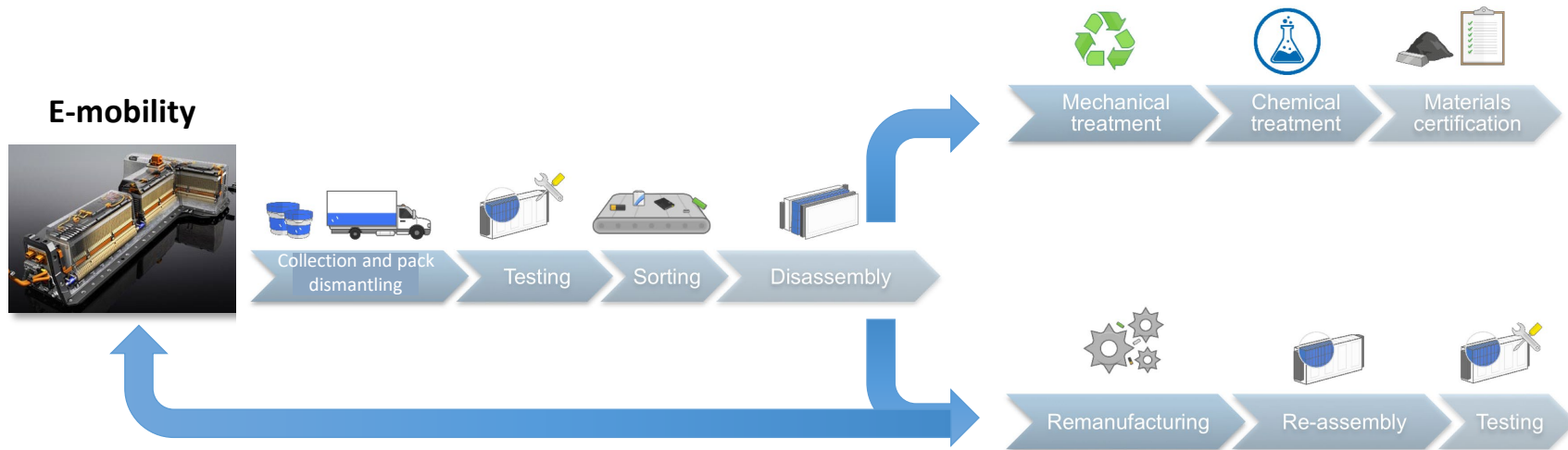
This pilot will demonstrate the effectiveness of the DigiPrime platform in supporting the integration and business operation of European networks of Circular Innovation Hubs.



Vanguard Initiative ESM pilot demo-case. DG Regio Pilot action for "Interregional innovation projects". Pilot within the SSP on Industrial Modernization.

The DigiPrime Pilots: example pilot 1 - Batteries

Goal: a new process-chain for the re-use of Li-Ion battery cells under a circular economy perspective, with a cross-sectorial approach.



Characteristics:

- Average life-time 8 years.
- Current cost 150 Euro kWh.
- Residual capacity >80% (24 kWh on average).
- Warranty for manufacturers usually for 5 years (e.g. Tesla, Nissan).



Second-life stationary systems (renewable energy, home, office)

The pilot circular value chain

To effectively achieve pilot goals, the use cases architecture has been furtherly structured in a **multi-stage circular value chain** which involves several stakeholders.

Information sharing using the product avatar tool

Decisional step are managed using DSS service



Transport assessment through the reverse logistic service



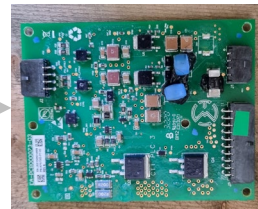
Characterize with a complete dataset a specific automotive battery into product nominal database

Disassembly the battery using data from product nominal database and exploiting the digital twin

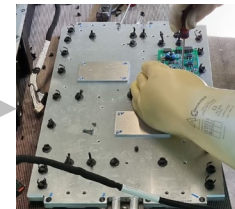


Testing the modules using AI for prediction

Testing and remanufacturing the BMS using DSS service



Recycling target raw materials using product nominal database

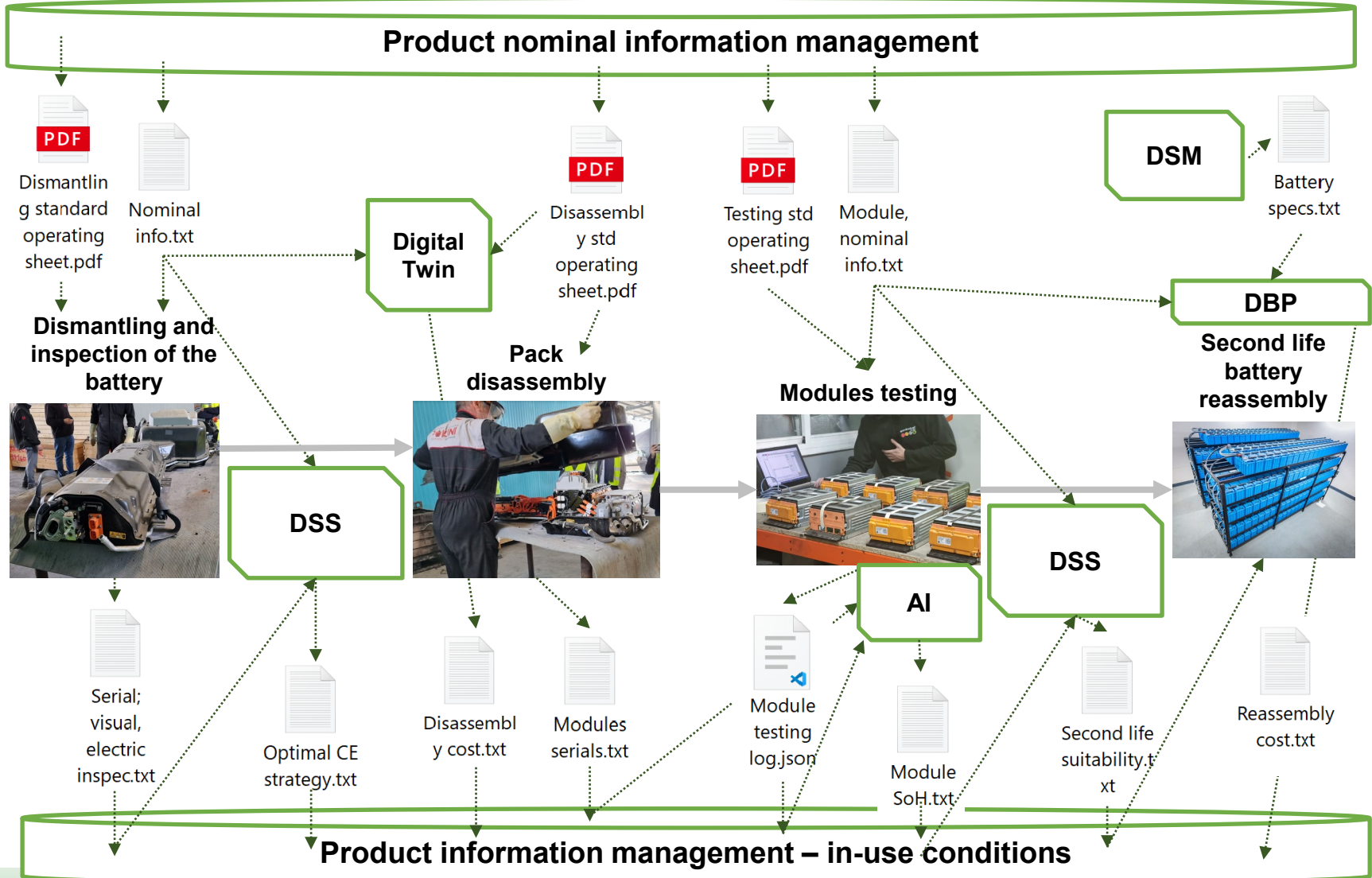


Re-marketize the BMS using demand supply matching



The pilot integrated dataflow

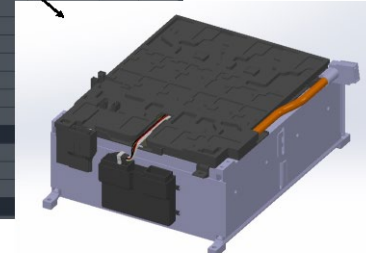
This structure enables an effective validation of the capabilities of the DigiPrime platform to manage **data sharing within different nodes of the value chain**, exploiting the so called **VO-services**.



A service application for boosting a collaborative approach between stakeholders in the cross-sectorial value-chain based on the transfer of relevant product information

String based and technical files datasets to effectively test the early developments

Car model	Car Brand	Type	Number of modules	Module Voltage [V]	Module Capacity [Ah]	Cell chemistry	Module Weight [kg]	Module Length [mm]	Je Width	Je Height
A1 Sportback e-L	Audi	BEV	8	44	25	NMC	15	320	160	118
Q7 TFSI e	Audi	BEV	14	45	28	NMC	15	320	160	118
A7 Sportback TFSI	Audi	BEV	8	45	37	NMC	19	350	250	150
A8 TFSI e quattro	Audi	BEV	8	48	37	NMC	19	350	250	150
e-tron	Audi	BEV	36	44	68	NMC	19	350	250	150
13/13s	BMW	BEV	8 (12 cells)	47	68	NMC L186FO	25	360	310	145
Series 2e	BMW	BEV	6	47	26	nan	nan	nan	nan	nan
330e	BMW	BEV	6	47	26	nan	nan	nan	nan	nan
18 Coup/roadster	BMW	BEV	6 (16 cells)	68	34	NMC	16	nan	nan	nan
Series 5e	BMW	BEV	8 (12 cells)	47	34	NMC L186FO	25	nan	nan	nan
Series 7e	BMW	BEV	8 (12 cells)	47	34	NMC L186FO	25	nan	nan	nan
volt	Chevrolet	BEV	4 (12 cells)	68	32	nan	nan	nan	nan	nan
Bolt	Chevrolet	BEV	3 (24 cells)	44	32	nan	nan	nan	nan	nan
Bolt 2	Chevrolet	BEV	8 (30 cells)	37	350	NMC	45	nan	nan	nan
Bolt Z	Chevrolet	BEV	2 (24 cells)	38	350	NMC	36	nan	nan	nan
C-Zero	Citroen	BEV	38 (8 cells)	38	350	NMC	24	nan	nan	nan
C-Zero	Citroen	BEV	2 (4 cells)	15	50	nan	nan	nan	nan	nan
E-Berling Multis	Citroen	BEV	nan	nan	nan	nan	nan	nan	nan	nan
E-Meari	Citroen	BEV	nan	nan	nan	nan	nan	nan	nan	nan
Pacifica	Chrysler	BEV	nan	nan	nan	nan	nan	nan	nan	nan
500e	Fiat	BEV	7 (6 cells)	23	63	nan	15,2	nan	nan	nan
			11 (5 cells)	38	63	nan	12,6	nan	nan	nan

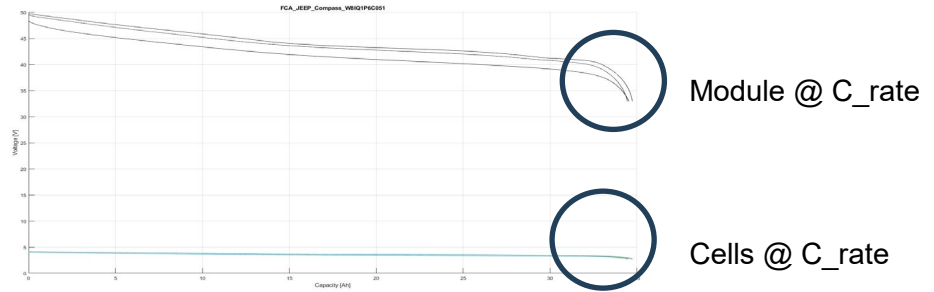


All information				
<input type="checkbox"/> Car Brand ↑	Car Model	Information	Data Type	Value
<input type="checkbox"/>	Jeep	Compass	Pack - Weight including brackets [kg]	String-based 145
<input type="checkbox"/>	Jeep	Compass	Pack - Battery pack disassembly, standard operating sheet (Document)	File (pdf) Download
<input type="checkbox"/>	Jeep	Compass	Pack - Cells configuration	String-based 96s1p
<input type="checkbox"/>	Jeep	Compass	Module - Number of modules	String-based 8
<input type="checkbox"/>	Jeep	Compass	Module - Cells per module	String-based 12
<input type="checkbox"/>	Jeep	Compass	Module - Electric external connections	String-based Stiff cables, bolts.

Application of operational services

Furthermore, **operational digital tools** vertically exploit available data. Here the example of **AI** used to exploit EIS testing to estimate the **state of health** and **residual useful life** of battery modules.

~	Heterogeneity index [%] @ {0.1C; 25 [°C]}	1.09
~	HFR [m Ω] @ {0.01 Hz; 10000 [Hz]; 25 [°C]}	7.0325
~	RCT [m Ω] @ {0.01 Hz; 10000 [Hz]; 25 [°C]}	1.2020
~	LFR [m Ω] @ {0.01 Hz; 10000 [Hz]; 25 [°C]}	3.4391
~	SOH_ Capacity [%] 0.5 C; 25 [°C]}	104.3
~	SOH_ Capacity [%] 3 C; 25 [°C]}	104.5
~	SOH_ Capacity [%] 0.1 C; 25 [°C]}	105.3
~	HFR [m Ω] @ {0.01 Hz; 10000 [Hz]; 25 [°C]}	7.0325
~	RCT [m Ω] @ {0.01 Hz; 10000 [Hz]; 25 [°C]}	1.2020
~	LFR [m Ω] @ {0.01 Hz; 10000 [Hz]; 25 [°C]}	3.4391

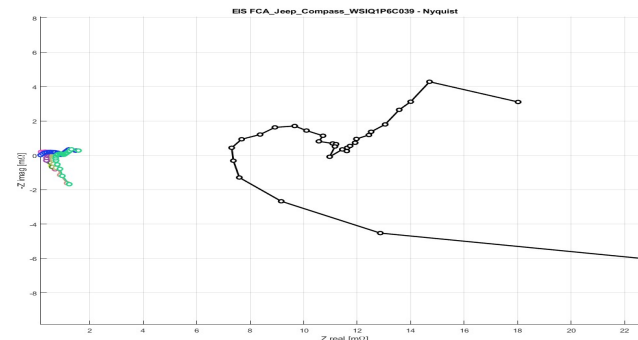


~ Power/Energy ratio [kW/kWh] @ {0.5C; 25 [°C]}

0.5429

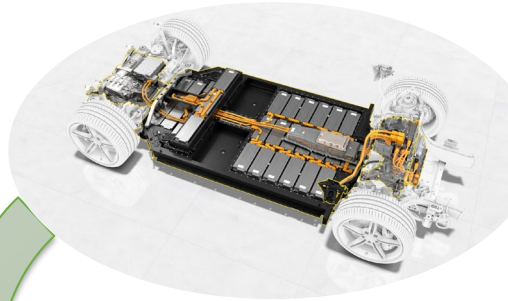
SOH_e ± Heterogeneity index

- Indicative of
- module energy
 - cell-to-cell dispersion



The pilot integrated dataflow

The whole **pilot approach is validated** by the production of market-appealing **second life stationary battery prototypes**, and of high-grade recycling of non reusable battery units.



Electronics

- BMS (*repaired and refurbished*)
- Fuses, contactor, shunt, ... (*re-use*)

Connections

Re-use of:

- Busbars
- Wiring harness
- Screw

Provided by 

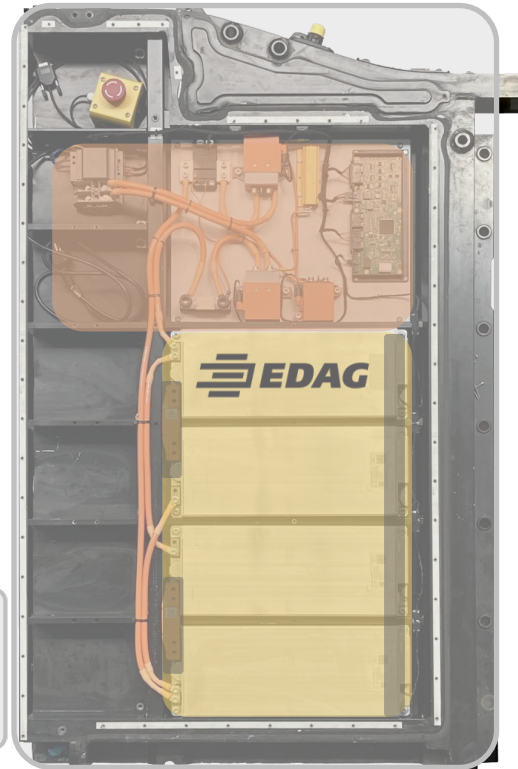
Modules



SOH testing by 



2nd Life enabled by DigiPrime



Housing



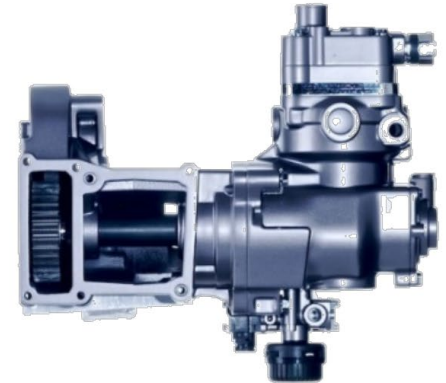
Cover

- glebanite cover (in progress)
- Material provided by RIVIERASCA 

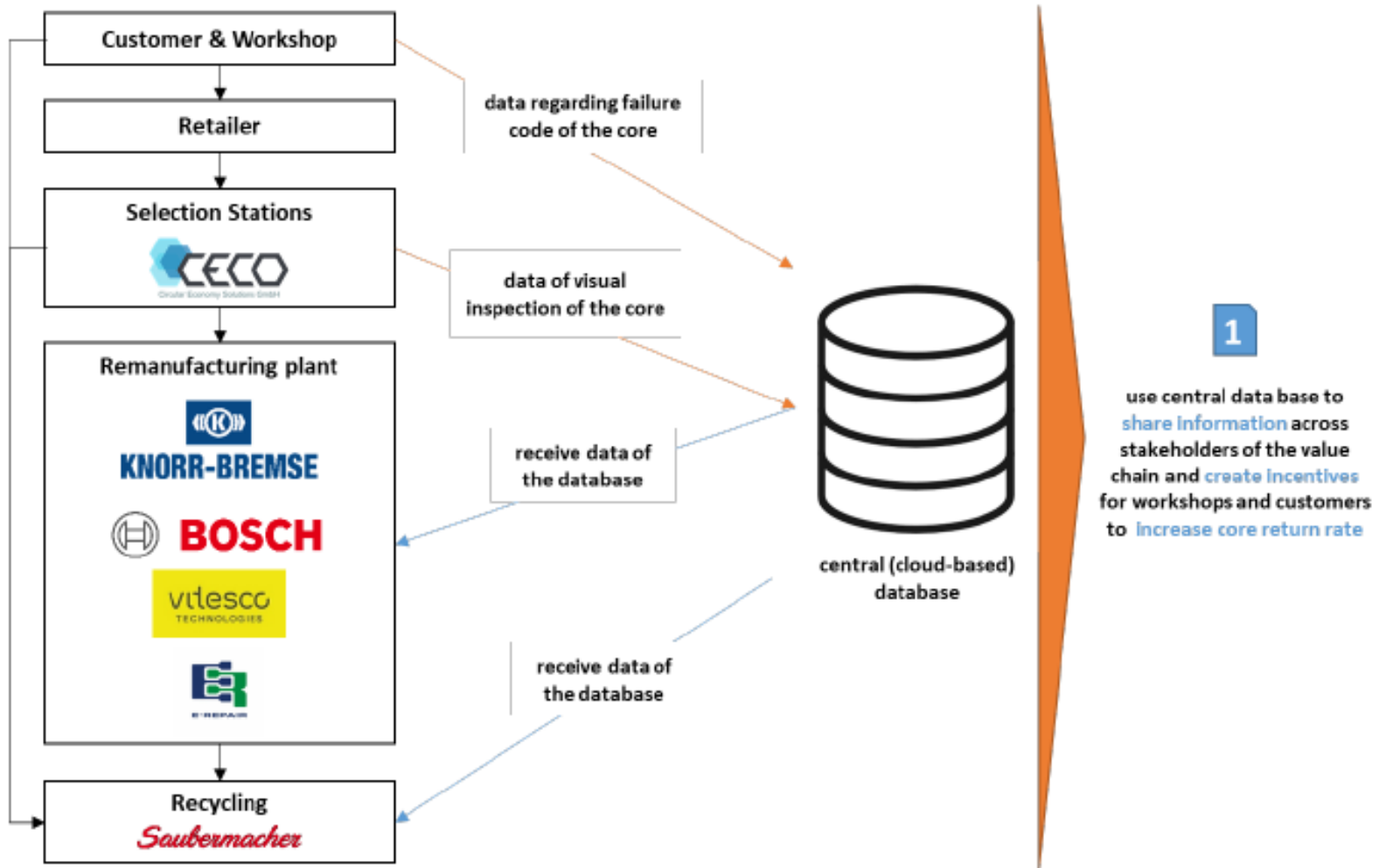
Technical data (estimation)

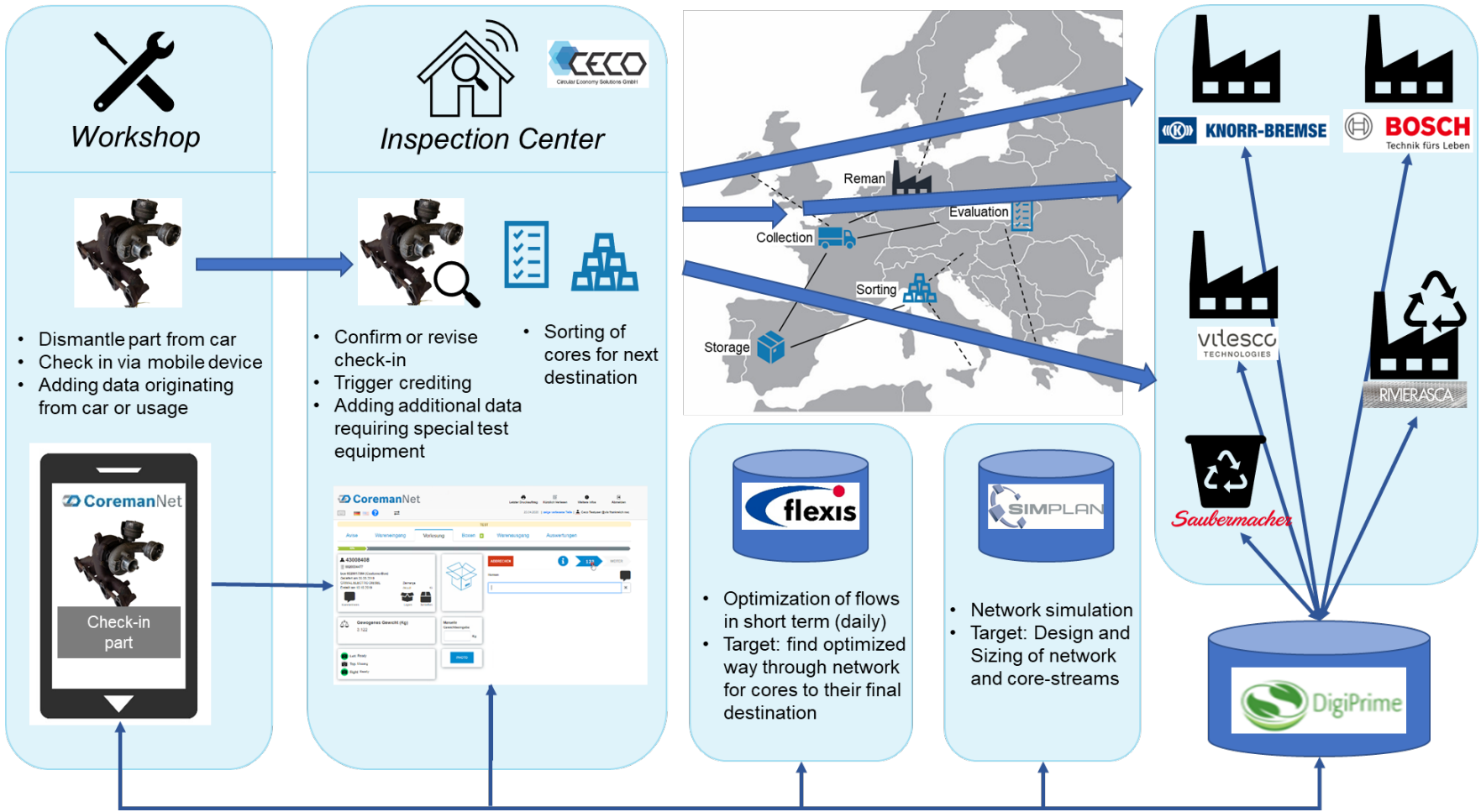
Energy (usable)	8 kWh
Voltage (nominal)	44 V
Max. current	80 A
Weight	~ 125 kg

- **Mechatronics and Electronics**
- **Involved sectors:** Automotive; Machines and Engines; Raw Materials.
- **Components:** Braking systems for automotive vehicles; Engines and drives in machine tools
- **Strategic importance:** With the increasing age of commercial vehicles, the question of replacing old or defect parts and its profitability arises more often and more likely. Especially when it comes to safety-related components, e.g. braking systems, the use of the vehicle itself is not possible anymore.
- **4 use-cases**



Pilot 2: Mechatronics and electronics demonstrators







Input Sectors

AUTOMOTIVE

WIND

CONSTRUCTION

DESIGN

- *Material*
- *Components*
- *Products*



Technologies & Processes

- *MECHANICAL RECYCLING*
- *THERMOCHEMICAL RECYCLING*
- *RE-PROCESSING*



Output Sectors

WIND

AUTOMOTIVE

CONSTRUCTION

DESIGN

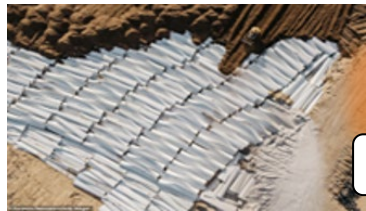
- *Material*
- *Components*
- *Products*

The scope of Pilot3 is to demonstrate the feasibility (technical and economical) of producing new materials, components and products, embedding recycled material from the composite industry. From input to output sectors, through recycling and reprocessing technologies, new value and production chains are well identified and supported by the DigiPrime platform. Pilot3 is working both on physical (operative tasks) and digital (digital tasks) level.

Input Sectors



AUTOMOTIVE
Car tailgate (SMC)



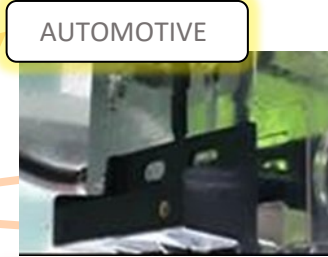
WIND
EoL wind blades



EoL roof sheets
CONSTRUCTION



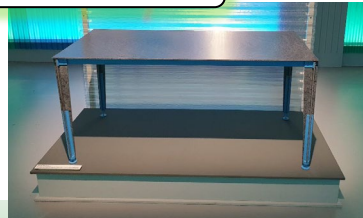
GRP furniture
DESIGN



AUTOMOTIVE
WIND



CONSTRUCTION



DESIGN

CONSTRUCTION



CONSTRUCTION

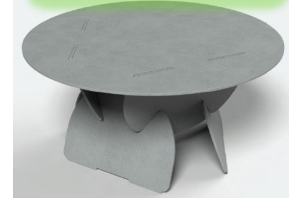


CONSTRUCTION



Output Sectors

DESIGN



DESIGN



DESIGN





Input Sectors

AUTOMOTIVE

SMC or
BMC part

fiberglass car tailgate



Technologies & Processes

GRINDING/SIEVING

lbrid pultrusion-lamination



Output Sectors

Use case 3.1

Cable cover

CONSTRUCTION



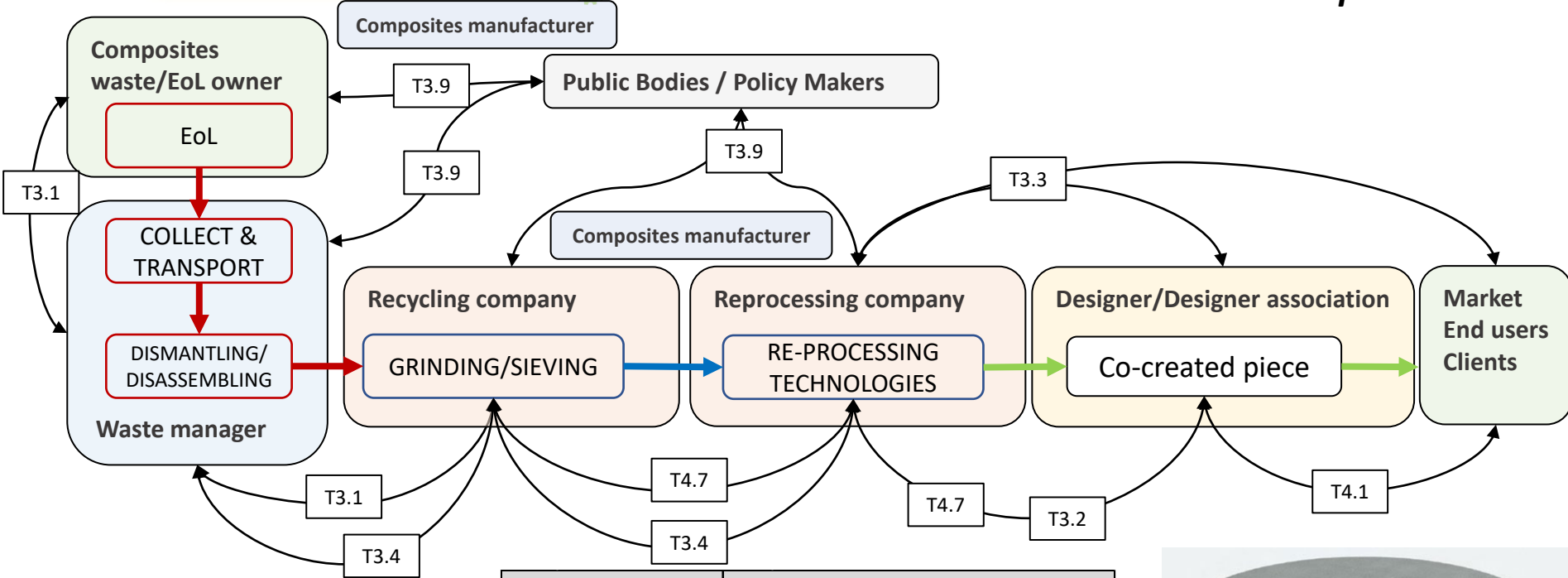
Pilot 3: Composite and techno-polymers demonstrators

AUTOMOTIVE
Input Sectors



Open mould casting
Technologies & Processes

DESIGN
Output Sectors



		Services	
Use Case 2		T3.1	Product Information Management
		T3.2	Production Co Creation
	from automotive	T3.3	LCA / LCC for eco-design
	SMC/BMC parts	T3.4	Demand Supply Matching
	design	T3.9	Barriers identification and legislation
	to co-created piece	T4.1	New Product from Recycling (product avatar)
		T4.7	Material testing and certification



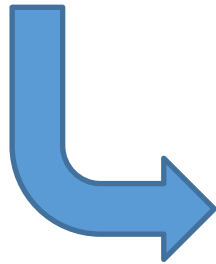
Pilot 4: Textile demonstrators



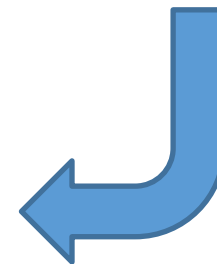
Safety belts (polyester)



Airbags (polyamide 66)



**Mechanical and/or
Thermomechanical recycling**



Pilot 4: Textile demonstrators – safety belts



Cutted safety belts



Grinding



Safety belts powder



100% polyester pellets from EoL safety belts

Pilot 4: Textile demonstrators – Airbags



Airbags fraying



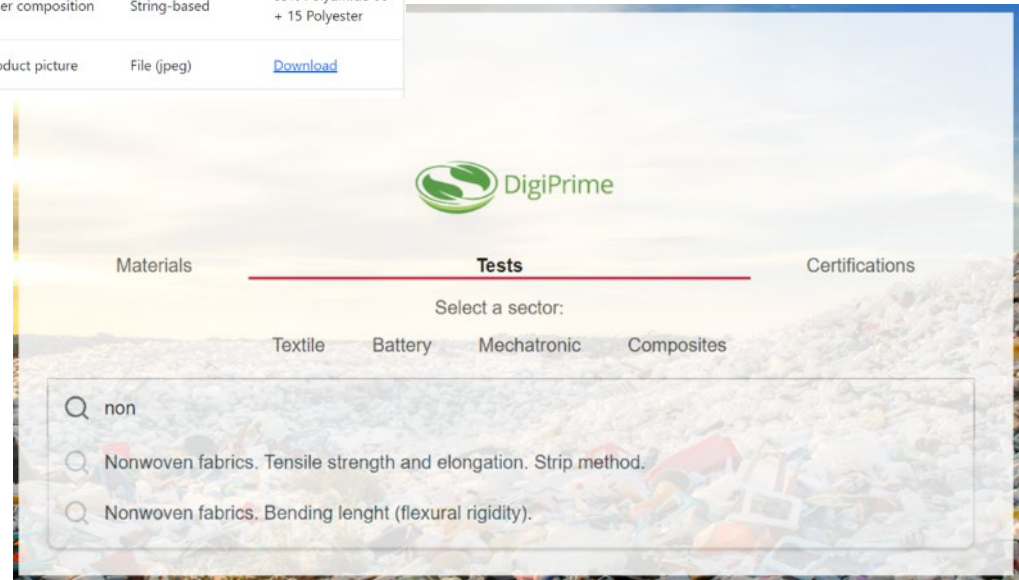
Mats from airbags


All information Search × ☰

<input type="checkbox"/>	Sector	Product	ID	Component	Sub-component	Information	Data Type	Value
<input type="checkbox"/>	Non automotive	Recycled	202301RNW	Finished product	Nonwoven	Mass per unit area (kg/m2)	String-based	0,75
<input type="checkbox"/>	Non automotive	Recycled	202302RNW	Finished product	Nonwoven	Mass per unit area (kg/m2)	String-based	1,0
<input type="checkbox"/>	Non automotive	Recycled	202303RNW	Finished product	Nonwoven	Mass per unit area (kg/m2)	String-based	2,0
<input type="checkbox"/>	Non automotive	Recycled	202301RNW	Finished product	Nonwoven	Fiber composition	String-based	85% Polyamide 66 + 15 Polyester
<input type="checkbox"/>	Non automotive	Recycled	202303RNW	Finished product	Nonwoven	Product picture	File (jpeg)	Download

← Product information management

Testing and Certification →



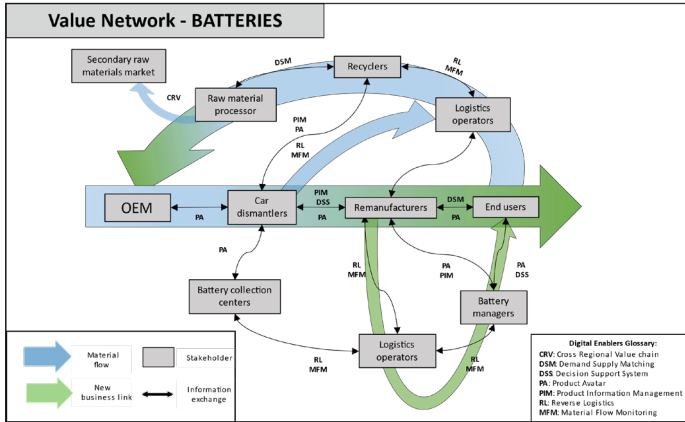


Materials Tests Certifications

Select a sector:

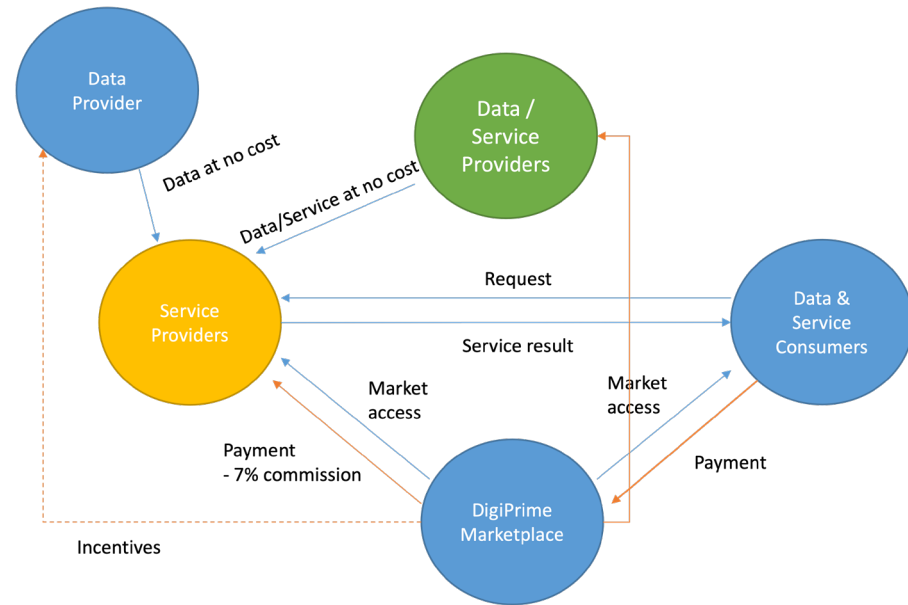
Textile Battery Mechatronic Composites

Scenario-based impact at Pilot level:

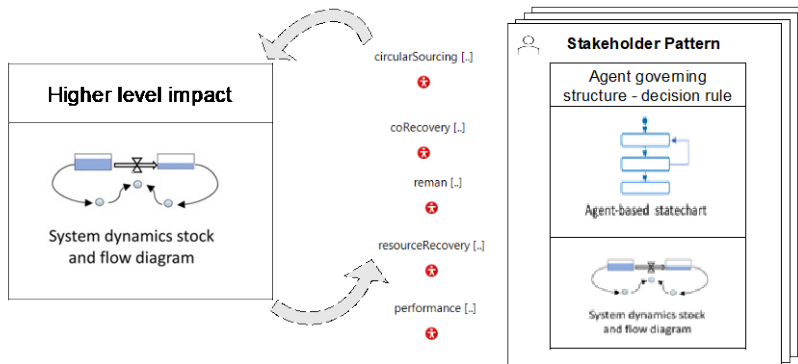


Circular Value-chain perspective

DigiPrime platform uptake:



System Dynamics – Multi Agent System



Scenario-based system dynamics modeling



DigiPrime

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CROSS-SECTORIAL SUSTAINABLE VALUE NETWORKS

The Manufacturing Partnership Day

Brussels, September the 26th 2023



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MILANO 1863



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