Circular TwAIn: integrating Data Spaces, Digital Twins and Artificial Intelligence for Sustainable and Circular Manufacturing

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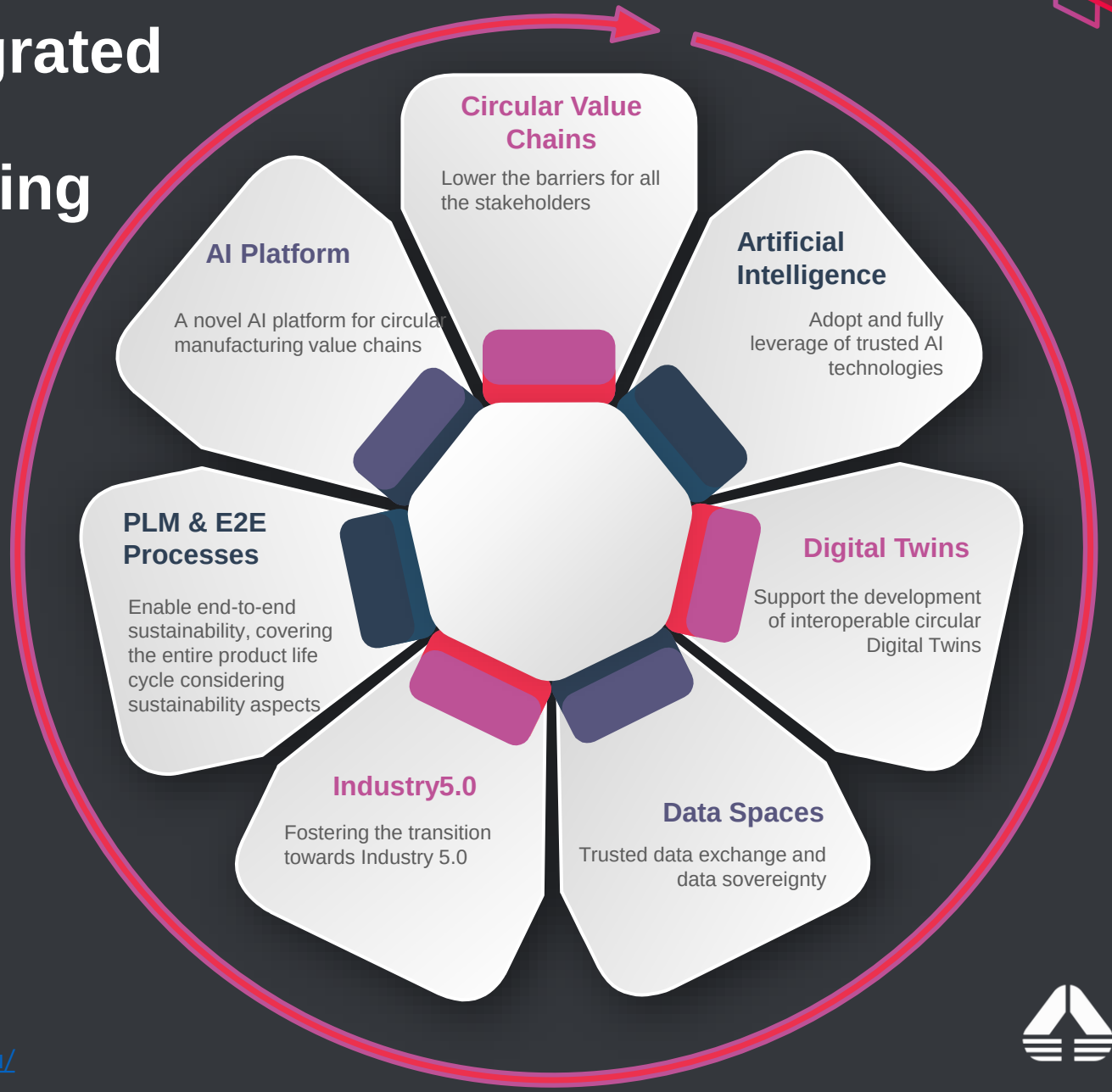
Co-funded by the European Union

Circular TwAIn GA n. 101058585

Circular TwAIn

AI Platform for Integrated Sustainable and Circular Manufacturing



Circular TwAIn GA n. 101058585

07.2022 - 06.2025 https://www.circular-twain-project.eu/

Topic: HORIZON-CL4-2021-TWIN-TRANSITION-01-07

AI4SAM cluster

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AIDEAS

AIDEAS develops AI technologies for supporting the entire life cycle of i**ndustrial equipment** (design, manufacturing, use and repair/reuse/recycle) as a strategic instrument to improve the sustainability, agility and resilience of the European machinery manufacturing companies.

Design: AI technologies, integrated with CAD/CAM/CAE systems, for optimising the design of industrial equipment structural components, mechanisms and control components.

Manufacturing: AI technologies for industrial equipment purchased components selection and procurement, manufactured parts processes optimisation, operations sequencing, quality control and customisation.

Use: AI technologies with added value for the industrial equipment user, providing enhanced support for installation and initial calibration, production, quality assurance and predictive maintenance for working in optimal conditions.

Repair-Reuse-Recycle: AI technologies for extending the useful life of machines through prescriptive maintenance (Repair), facilitating a second life for machines.

s-X-AIPI

s-X-AIPI aims to research, develop, test and experiment with an innovative toolset of custom trustworthy **self-X AI technologies** for the transformation of the European process industry.

The explored solutions will see the formulation of a novel architecture, data pipeline and realistic datasets derived from four real-world demo cases. These will combine with an **autonomic manager based on the MAPE-K model** (continuous Monitoring-Analyzing-Planning-Execution flow based on the Knowledge of the AI system under control) for the development of self-improving AI systems.

The end goal of these applications is to optimize human involvement in the creation and maintenance loop of AI applications for industrial usage, while exhibiting self-improving abilities.

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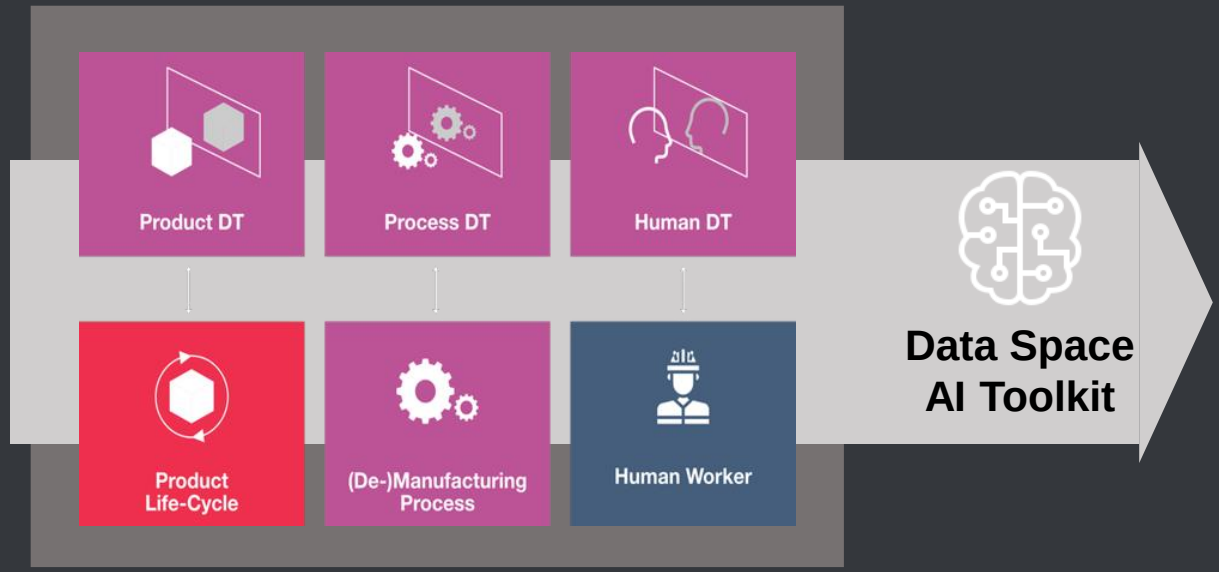
WHY is Circular TwAIn unique?

A short introduction

Circular
TwAIn

Circular TwAIn in a nutshell

Deliver a **unique AI platform** to support manufacturing and process industry towards a **sustainable, eco-friendly and circular production**. The key factor is a full integration among systems, reached through the usage of **AI and Digital Twins** for each level (product/process/value chain) leading to the **'Circularity by-design'**.



OUTCOME1 :: Seamless Data Sharing
Data Spaces with product-specific information and sustainability and waste data, to improve the overall product/production (life)cycle.

OUTCOME2 :: Collaborative AI
AI will exploit the knowledge provided by Digital Twins and models built within the Data Space for: (i) product/part recognition through machine vision; (ii) disassembly operations; and (iii) production and shopfloor process optimization.

BATTERY Pilot

Demonstrating the improvements in **de-/re- manufacturing** lead by **DPP and AI**

WEEE Pilot

PETRO-CHEMICAL Pilot

Showcasing how the process industry benefits from **DT and AI**

Circular TwAIn Unique Value Proposition

Holistic, domain-agnostic approach to enhance the sustainability and the circularity of product and process industries, with **tailored** and easy to scale technological solutions, mainly based on **open-source components**.

- Adaptation of current AI/DT (as-a-Service) technologies to **circular manufacturing models**, adopting DPP Semantic and Data Models
- Design and development of **interoperable circular twins** for end-to-end sustainability, exploiting data coming from different sources
- Creation and management of the DT for realizing **sustainable manufacturing** processes along the edge-to-cloud digital continuum
- Create new **circular Business Models** through digitalization along the value chain

Our pathway toward the Circular Data Spaces

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Data Integration and Storage (Data Managed as part of it)

- Edge, Cloud, On-Premise, etc.

Data Aggregation and Use (Data as strategic asset)

- Machine Learning, Data Analytics, Value Creation, …

Data Exchange (Data as new business asset)

- document-centric, data-centric, etc.

Data Spaces (Self-determined control of data use)

- cloud and data sovereignty for end-to-end data value chains in ecosystems

KEY CHALLENGES:

- Change from linear DVC to distributed data ecosystems
- Keep control over your data when crossing your organization boundaries
- Combine different data strategies (on private data, trusted data, open data, …)
- Support and demonstrate Data Spaces interoperability
- Implement most recent standards from IDSA and Gaia-X
- Build a business vision on top of the technological offering

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WHAT is a Circular Data Space?

The BATTERY Pilot Example

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The Circular TwAIn BATTERY Pilot

De- and Re-manufacturing of Li-Ion battery packs in e- mobility

Remanufacture and the re-use of the disassembled cells with proper residual characteristics into second-life stationary applications

The mission of this pilot is implemented in five use cases

1. Computer-vision driven collaborative robotics for the disassembly of LIB packs
2. Machine learning aided automated disassembly of LIB modules
3. AI tool for the characterization of the LIBs state-of-health combining historical and testing data
4. AI tool for optimised mechanical recycling of degraded LIBs
5. Market oriented holistic decision-support-system for the LIBs de- and re-manufacturing

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POLITECNICO MILANO 1863

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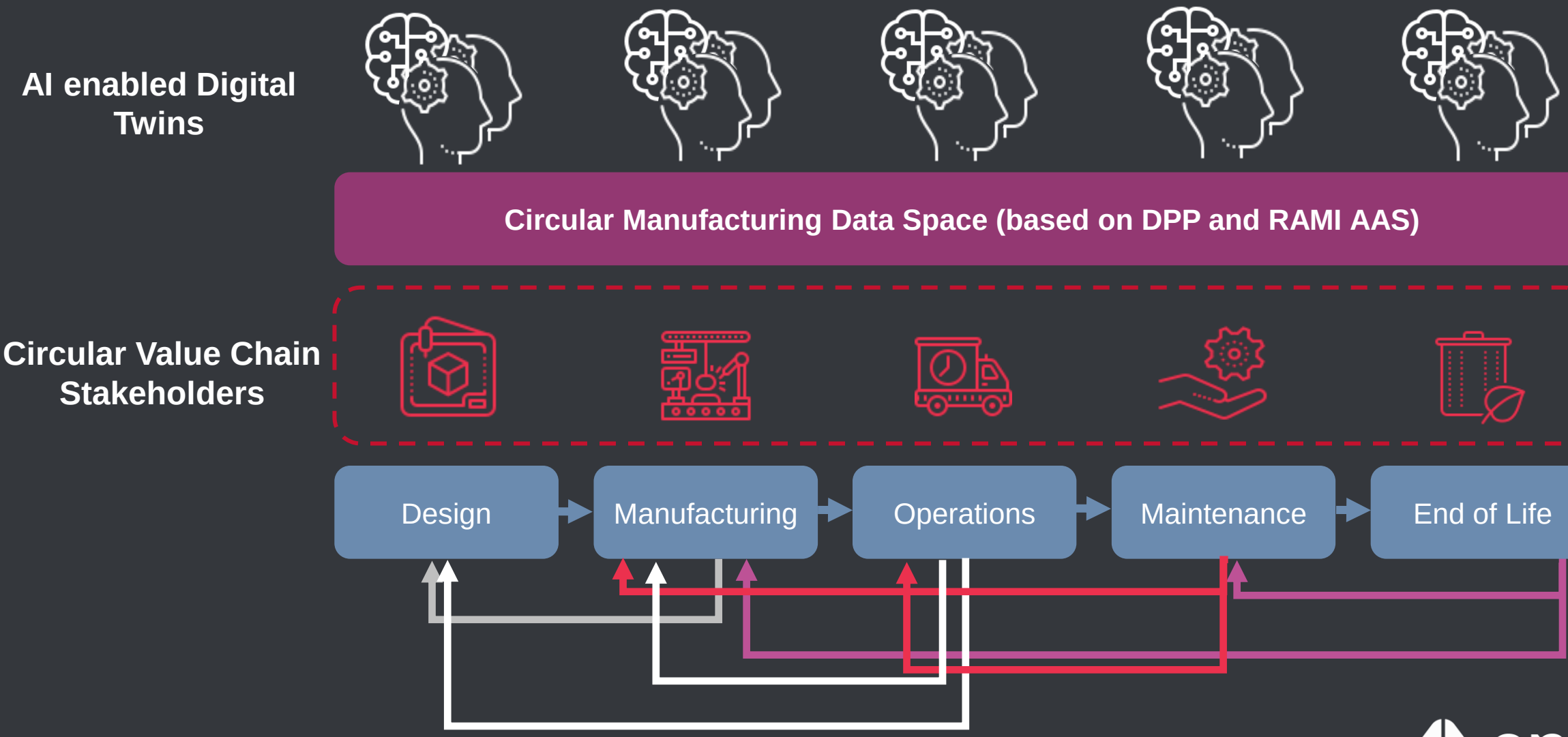
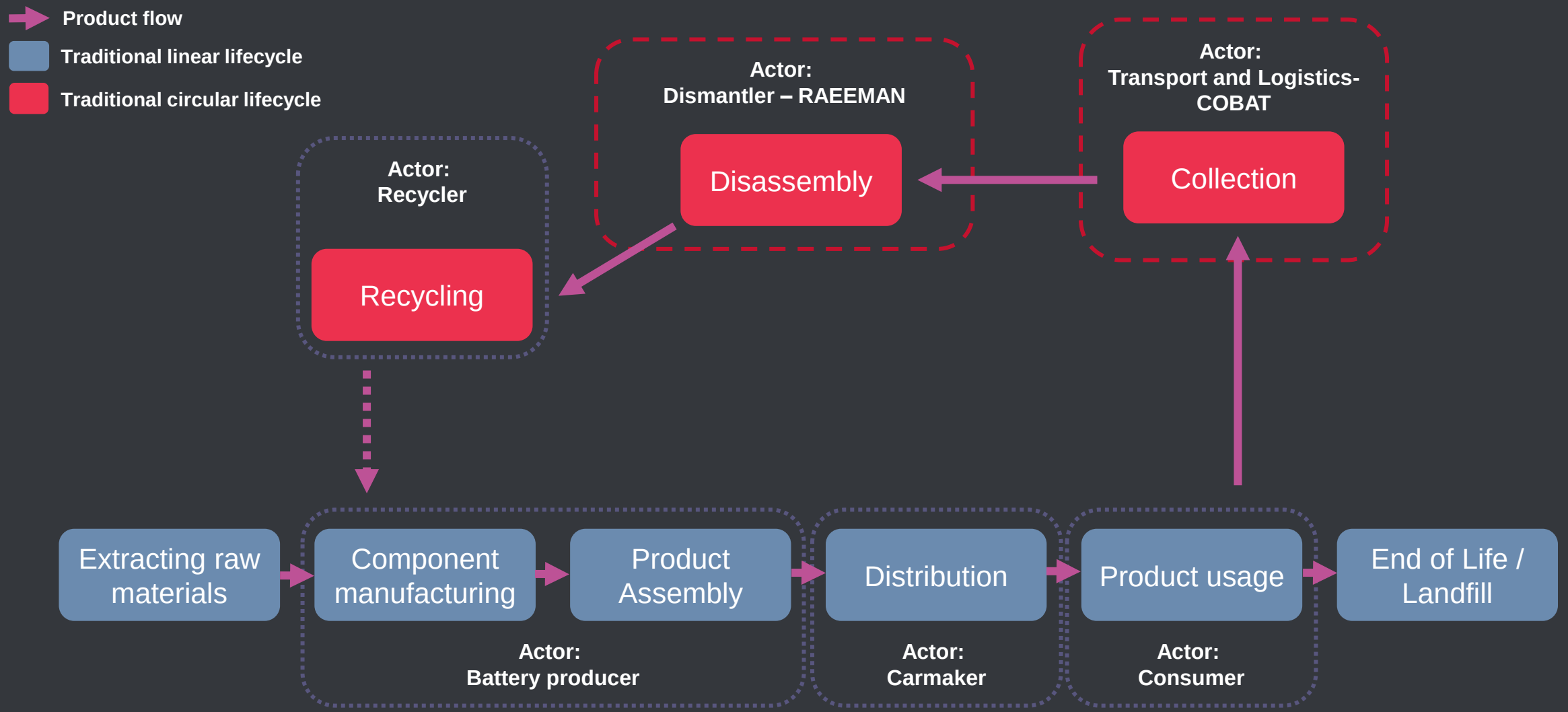
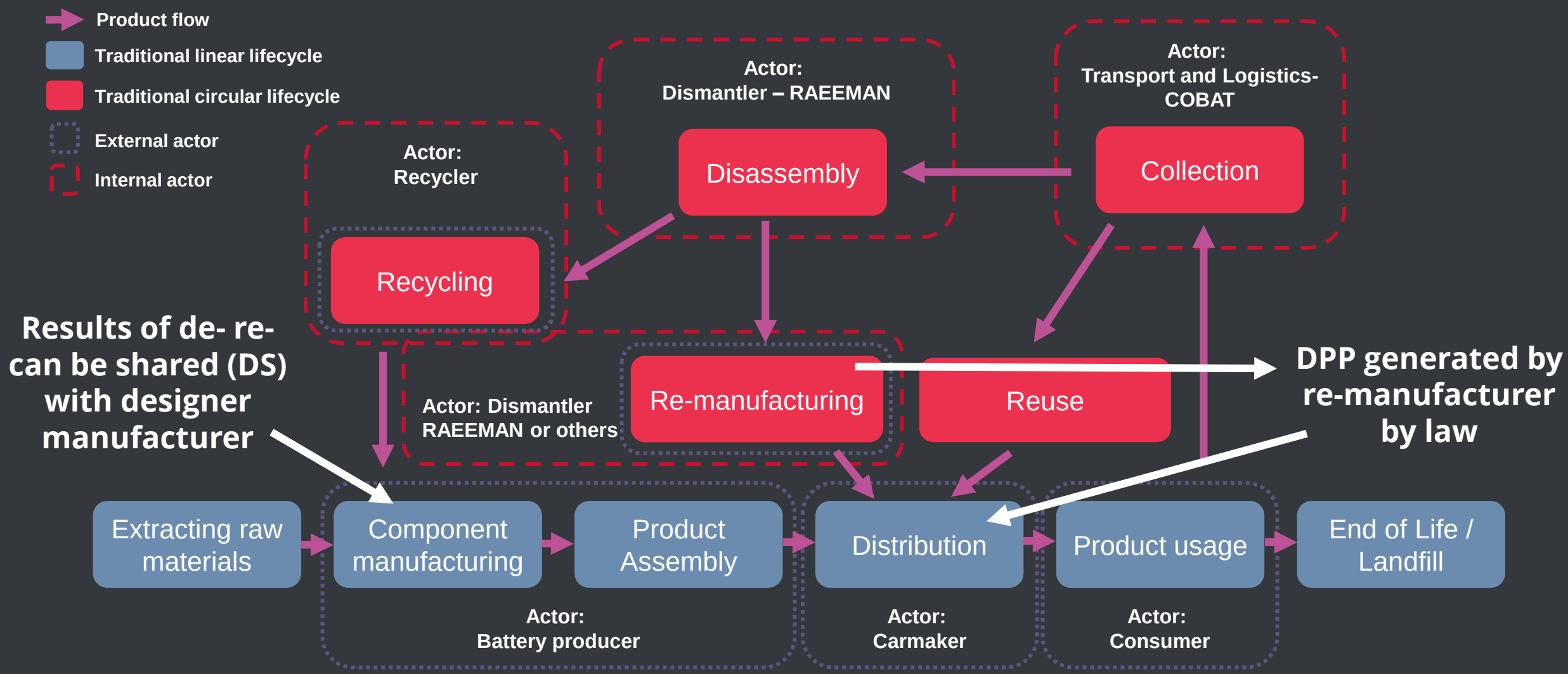
Circular TwAIn – Adding Circularity to Data Spaces



BATTERY Pilot: AS-IS Scenario



BATTERY Pilot: The Circularity by Design approach



Value Network of Stakeholders

BATTERY ASSEMBLER

Production of battery packs

CAR OWNER

Via carmaker member state division – car sale (and usage)

AFFILIATED WORKSHOPS

BATTERY CELL MANUFACTURER

Production of cells for new batteries

CAR MAKER

Recovery of cores (batteries) suitable for reuse or remanufacturing

AFFILIATED CAR DISMANTLERS

Via carmaker member state division – management of EoL batteries

EPR ORGANIZATION

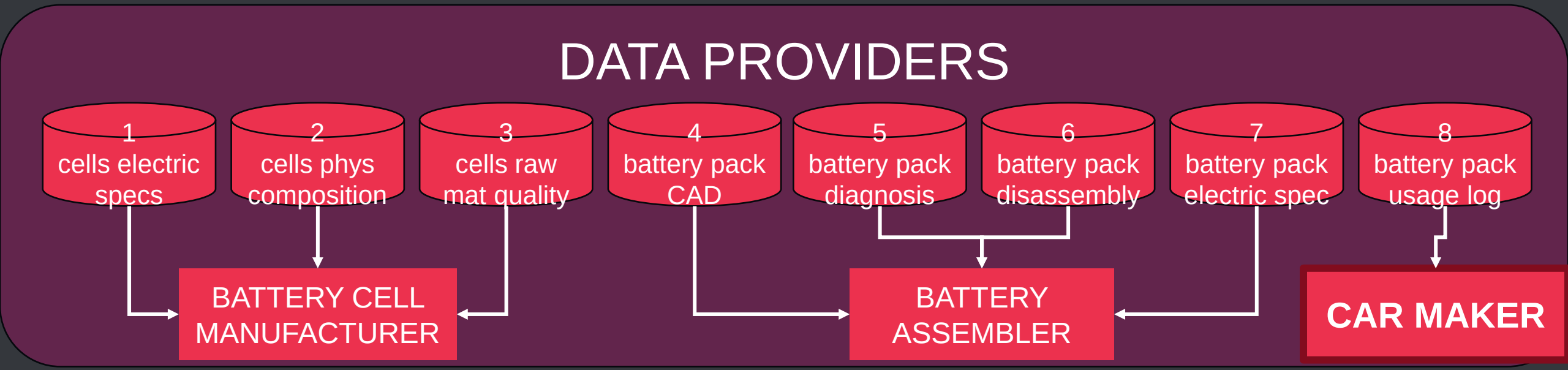
Recycling of raw materials for cells manufacturing

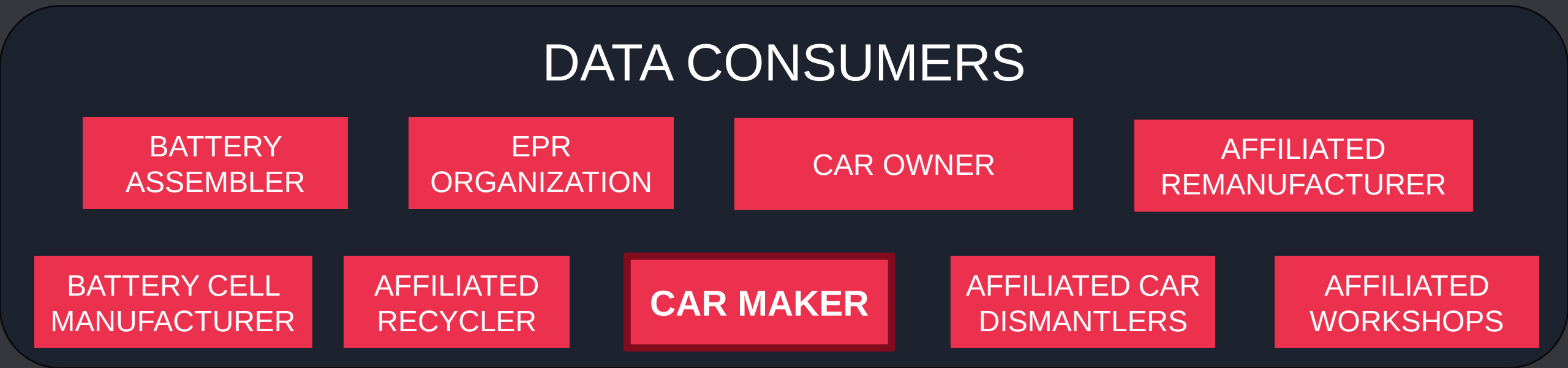
AFFILIATED RECYCLER

Remanufacturing of batteries

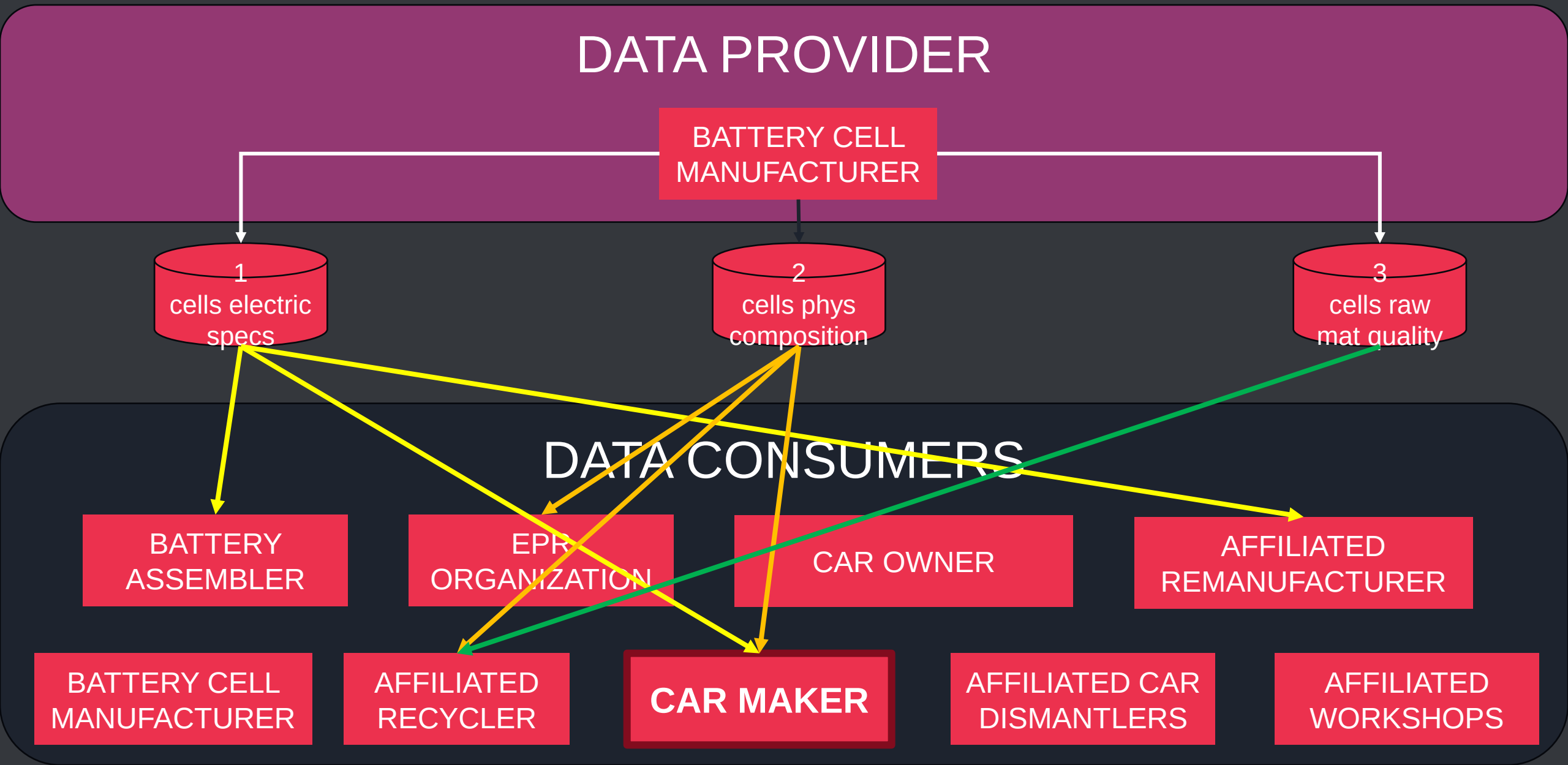
AFFILIATED REMANUFACTURER

FAIR High Value Pools of Data

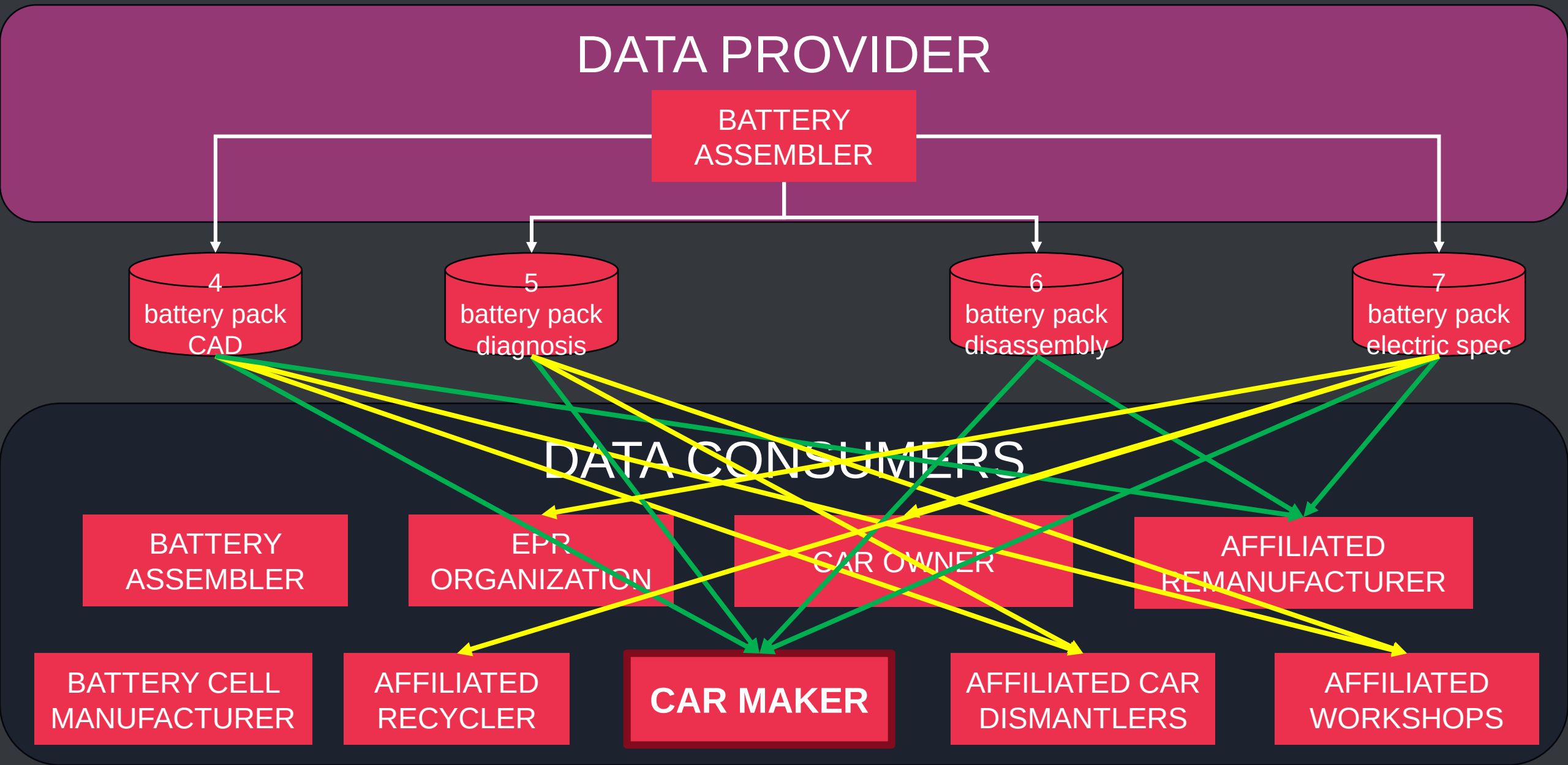




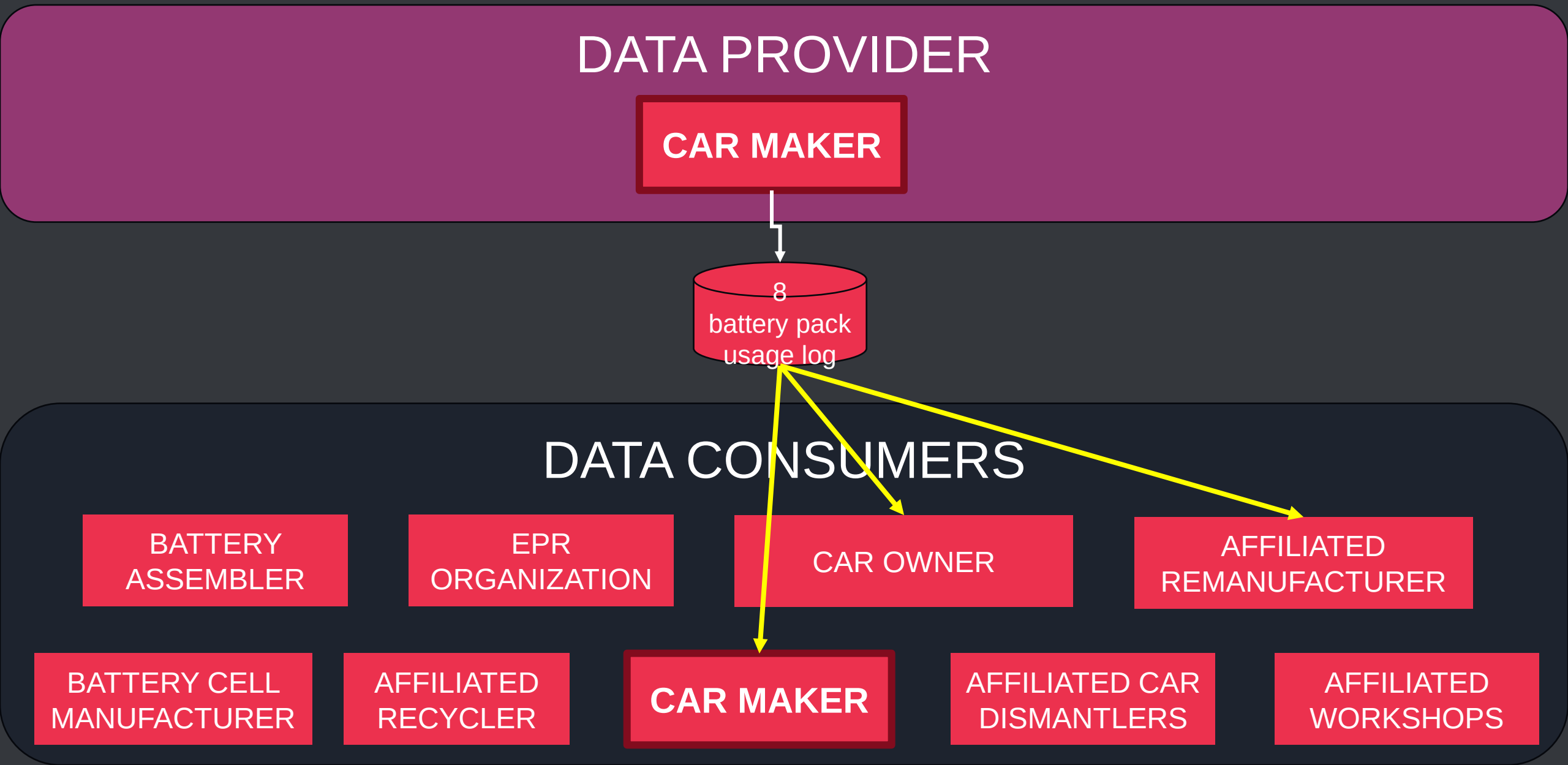
Data Sources from BATTERY CELL MNF.RER



Data Sources from BATTERY ASSEMBLER



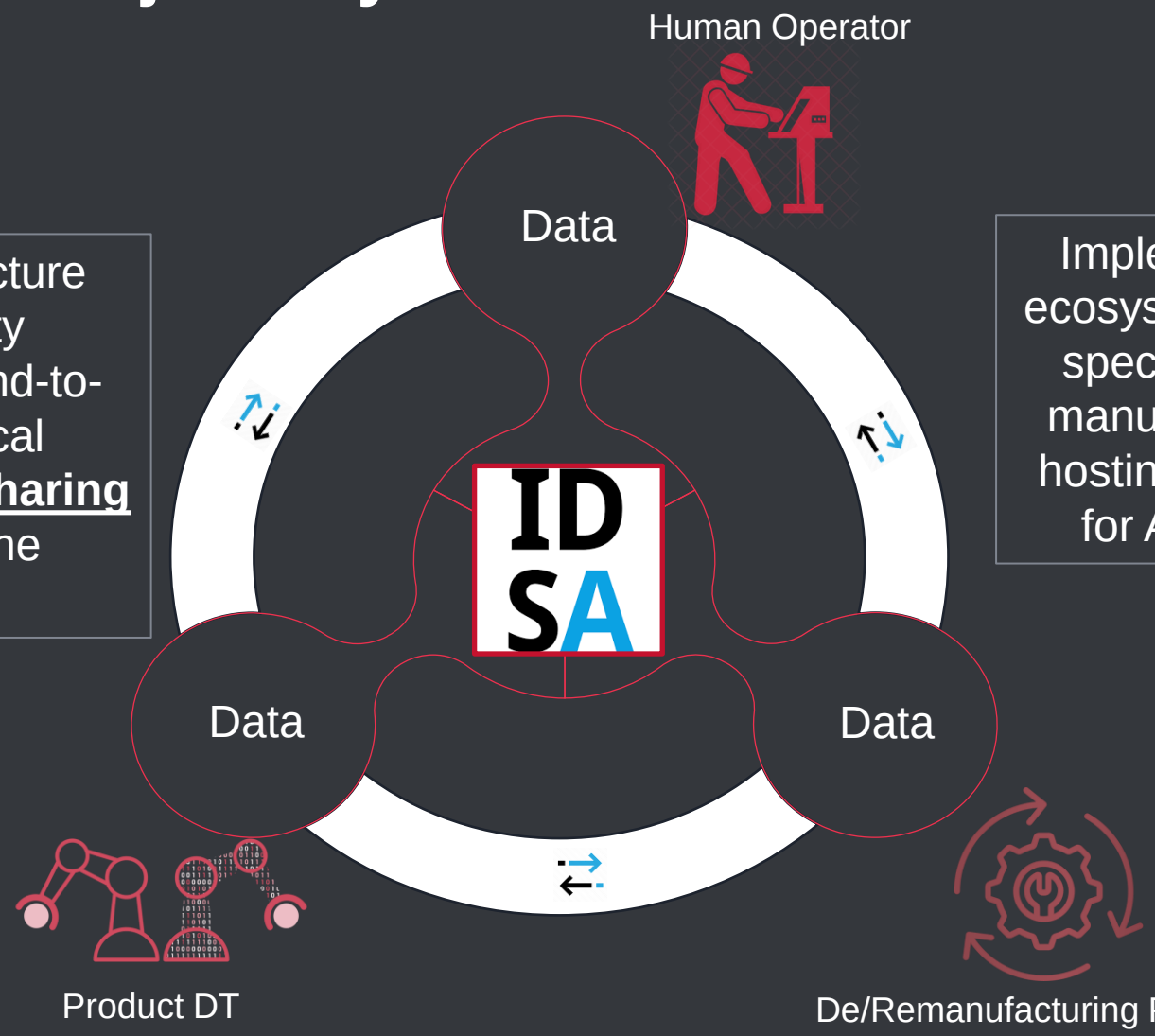
Data Sources from CAR MAKER



Our development journey

Develop a digital infrastructure aligned with connectivity standards, guaranteeing end-to-end horizontal and vertical integration, boosting **Data Sharing** and exploitation under the EU legal framework.

General



Implement and deploy a digital ecosystem following the **IDS-RAM** specs for gathering data along manufacturing value chains and hosting all the services and apps for AI-enhanced digital tools.

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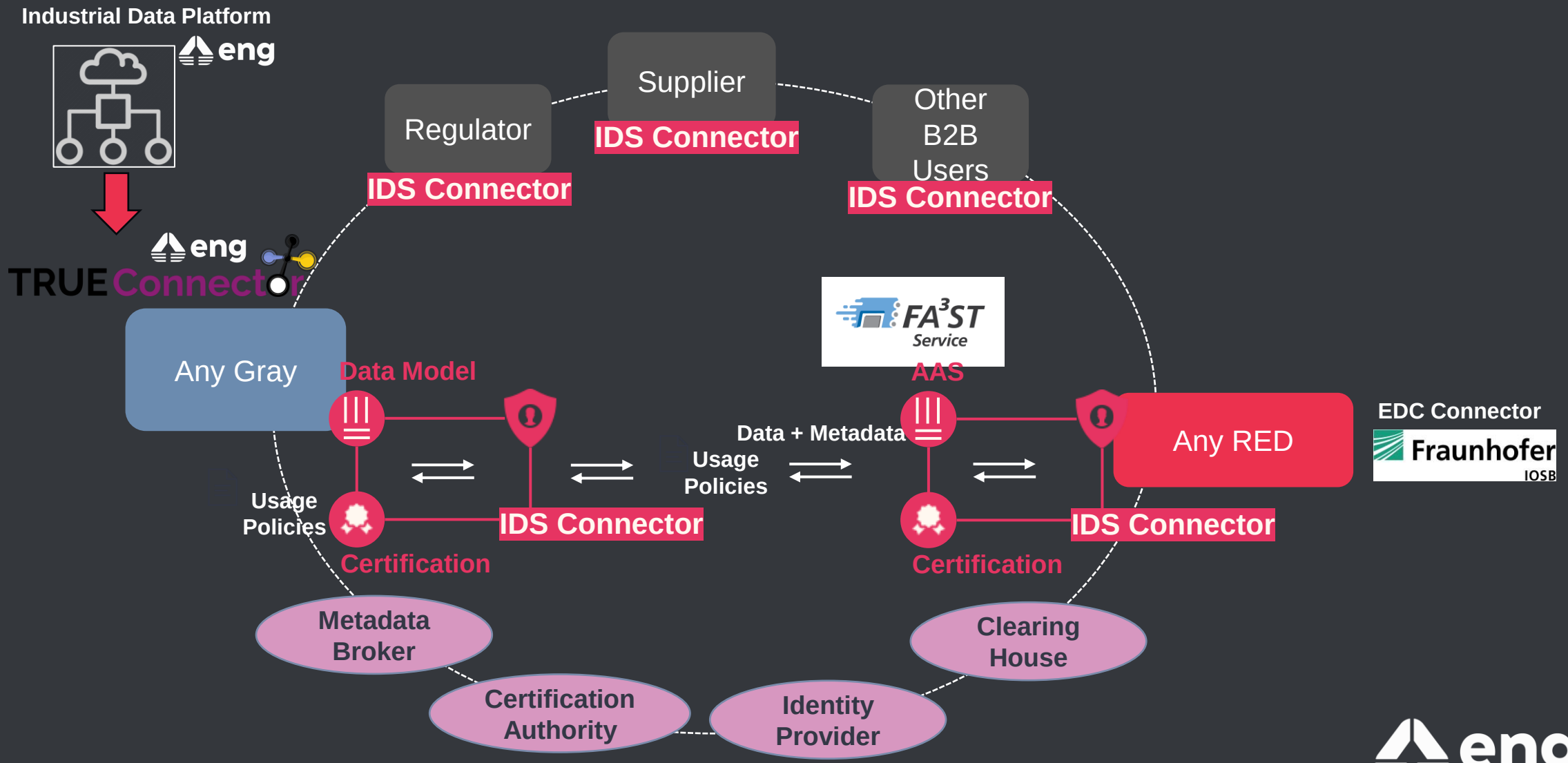
Leveraging a Manufacturing Data Space

Battery Pilot Circular Data Space



HOW to build a wider impact

A quick view on the market uptake

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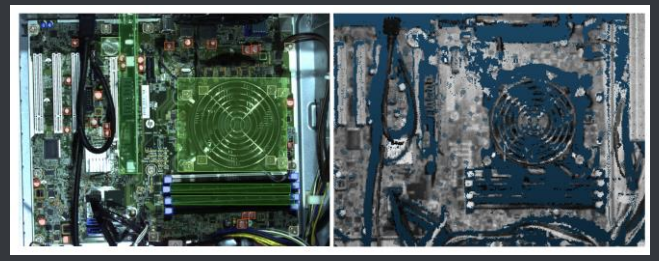
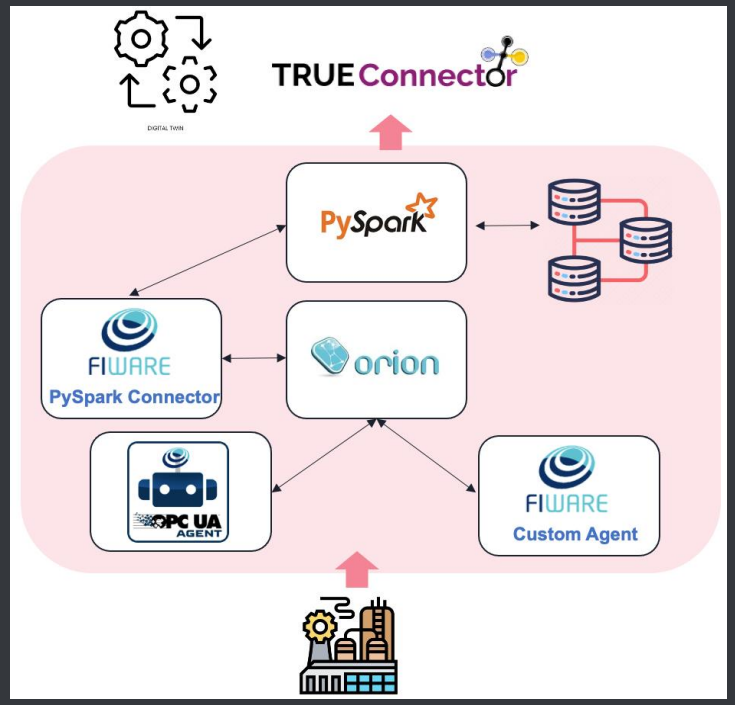
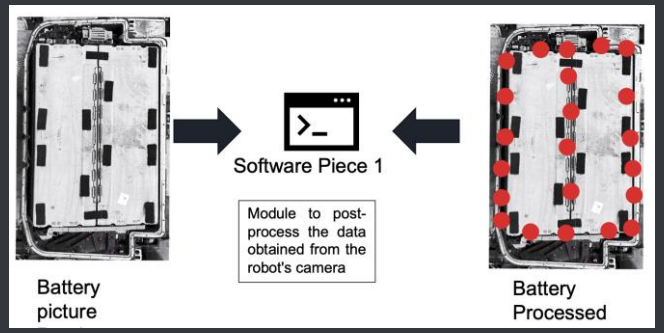
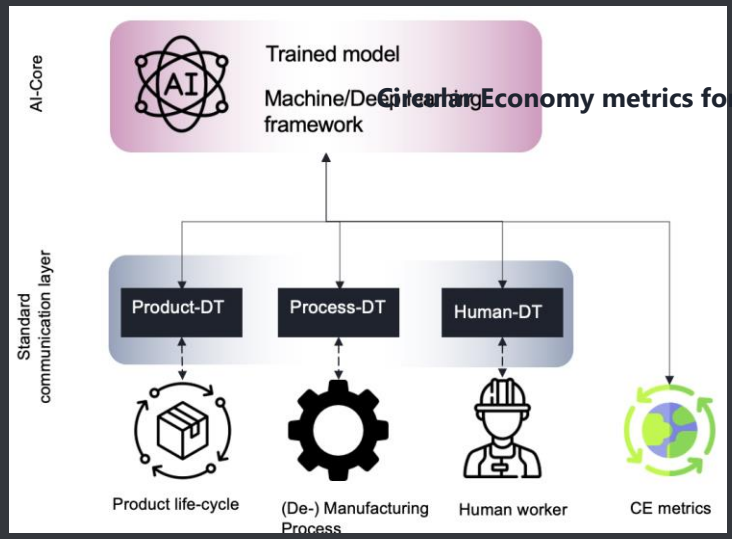
Circular TwAIn: Main Results









Circular TwAIn Marketplace

Asset Overview

The Eclipse Dataspace Connector (EDC) is a technical Dataspace component implementation with an open-source community for sharing data between participants in a Data Space. However, managing all data assets and resources to be shared requires effort, expertise, and continuous care. In Circular TwAIn, the data sources and sinks are Digital Twins or Digital Product Passports (DPP) realized with Asset Administration Shell (AAS). Since the EDC can be extended with "EDC Extensions", the "EDC Extension for AAS" was created to simplify the sharing and managing process for AAS providers and consumers. The extension provides functionality for providers sharing AAS and consumers interacting with AAS. Most steps to share data are automated and continuous effort is reduced by synchronizing changes in the meta-data with the EDC. A graphical interface is provided so that professionals without developer knowledge can share or request data.

Technical Description

AAS Extension simplifies the integration of DPP into Data Space, e.g., Battery DPP by reducing the effort in maintaining the metadata. Onboarding Guidelines show how the EDC Extension for AAS can be installed.

Reference Use Case

BATTERY Pilot

Customer Benefits

Reduces effort and quick onboarding reduces expensive training.

Company

Fraunhofer IOSB FhG-IOSB

Other Contributors

-

Unique Selling Point

First tool to simplify the manual process of sensor and DPP integration.

Website

https://www.iosb.fraunhofer.de/

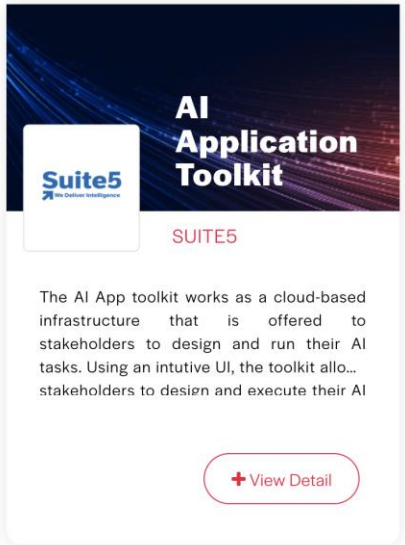
Service

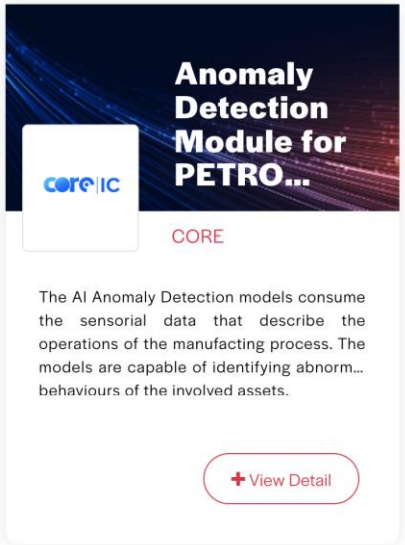
On-Premises software

License Type

Copyright

The website section about the **Circular TwAIn Marketplace** is now up and running





Innovative solutions for NetZero industries

Circular TwAIn

- Reduce CO_2 emissions and in general optimize the energy efficiency
- Implement strategies to optimize the logistic, the process, the products
- Support a conscious end-of-life facilitating the R-cycles

A NEW INITIATIVE:

To promote the most promising technical solutions to support industries towards the **green transition**, collecting digital assets and recognized expertise that have been proved to have an impact on achieving NetZero objectives.

DFA TRANSFORMING MANUFACTURING TOGETHER

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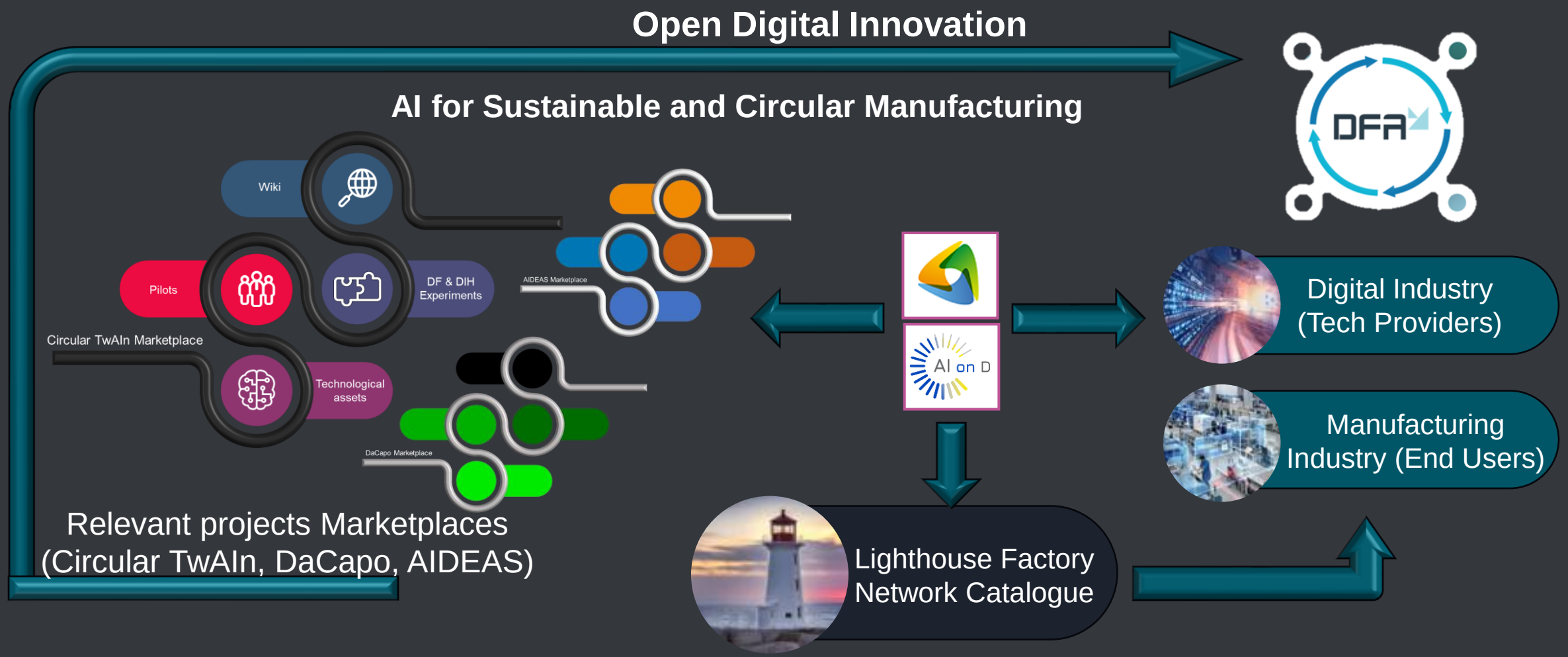
Digitalization strategies to boost Circularity and Sustainability



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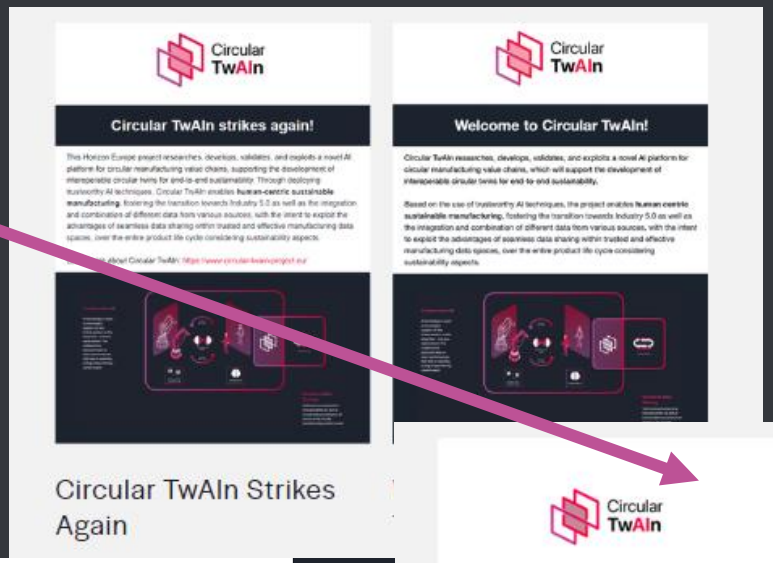
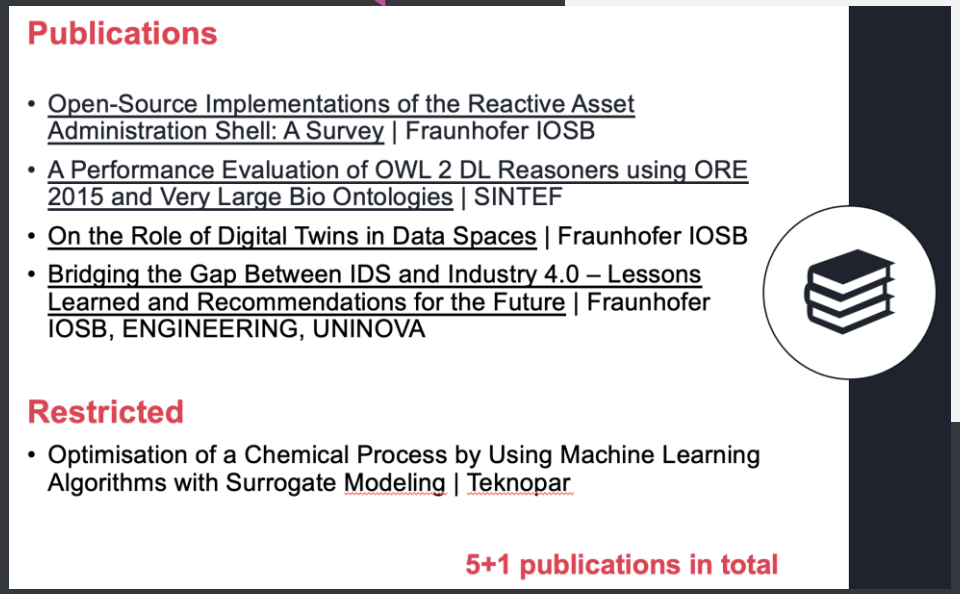
Newsletters



Press Releases

Publications



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Thank you!

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