# The challenge of the steel industry

The steel industry is a **strategic pillar of the European economy**, essential for construction, transport, energy and manufacturing. It provides around **1.5 million jobs in the EU** (direct and indirect) and represents the backbone of industrial competitiveness. However, steelmaking is also a **major emitter of greenhouse gases**, accounting for **approximately 4% of total EU $CO_2$ emissions**. In line with the **EU Green Deal** and climate neutrality goals, the sector faces the urgent need for a **systemic transformation of the steel value chain**, embedding sustainability, digitalisation and circularity at its core.

**Key message:** Steel must become **sustainable, digital and circular** to remain competitive and align with EU climate targets.

# Rationale

The **digital transformation is a fundamental enabler of sustainability and competitiveness in the European steel industry**. According to the Clean Steel Partnership Strategic Research and Innovation Agenda, digitalisation is essential to achieve EU climate objectives:

- Carbon neutrality by 2050

- 55% reduction in GHG emissions by 2030

Today, several initiatives are introducing digital technologies in steelmaking, but most of them are focused inside individual plants. What is still missing is a true horizontal integration across the entire steel value chain, from raw materials to final products.

**Key barriers**:

- Lack of suitable tools for secure and confidential data sharing between different actors

- Limited traceability of materials along their lifecycle

- Difficulty in correlating process parameters with final product quality

# SMARTCHAIN Overview



**SMARTChain addresses this gap by enabling seamless digital integration across the steel value chain, creating the foundation for circular and sustainable business models.**

SMARTChain aims at improving digitalisation in steel industry to go a step further in process control and optimisation, realising a horizontal integration in the steel value chain, through **secure data sharing**, promoting the **interoperability of systems and tools** to aim better quality of final and intermediate products, while optimising energy consumption and consequently reducing $CO_2$ emissions, contributing to the achievement of the EU climate neutrality goal. Thus, the project will focus on the <u>connection between steelmakers and steel users</u> enabling an exchange of information devoted to the optimisation of the quality of final and intermediate products

# General Information

- **SEAMLESS DIGITAL INTEGRATION IN STEEL VALUE CHAIN FOR HIGH QUALITY FINAL PRODUCTS**

- **Funded under the call**: HORIZON-CL4-2024-TWIN-TRANSITION-01-44: Digital transformation and ensuring a better use of industrial data, which can optimise steel supply chains (Clean Steel Partnership)

- **Start date**: 1st of October 2024

- **Duration**: 36 months

- **Total budget**: 6,453,527.30 €

- Partners: **RINA-CSM**, RINA-C, ICCS, SYXIS VSI, CIRCE, JSI, ACERINOX, Philips, SIJ ACRONI, SIJ Services, HIDRIA, ADI, TOFAŞ, ADV, SIAT

# SMARTChain main pillar

**Identify and finalise digitalisation challenges**
Across the entire steel supply chain, mapping current gaps and opportunities for data-driven optimisation.

**Define a software environment**
To enable digital integration of the steel value chain through secure and interoperable data sharing, both inside and outside the plant.

**Develop a Digital Material Passport (DMP) and Digital Product Passport (DPP)**
To ensure traceability of material information, supporting reuse, recycling and compliance with EU circular economy policies.

**Build the SMARTChain digital platform for steelmakers**
With AI-based models to optimise process parameters, improve steel quality, and reduce energy consumption.
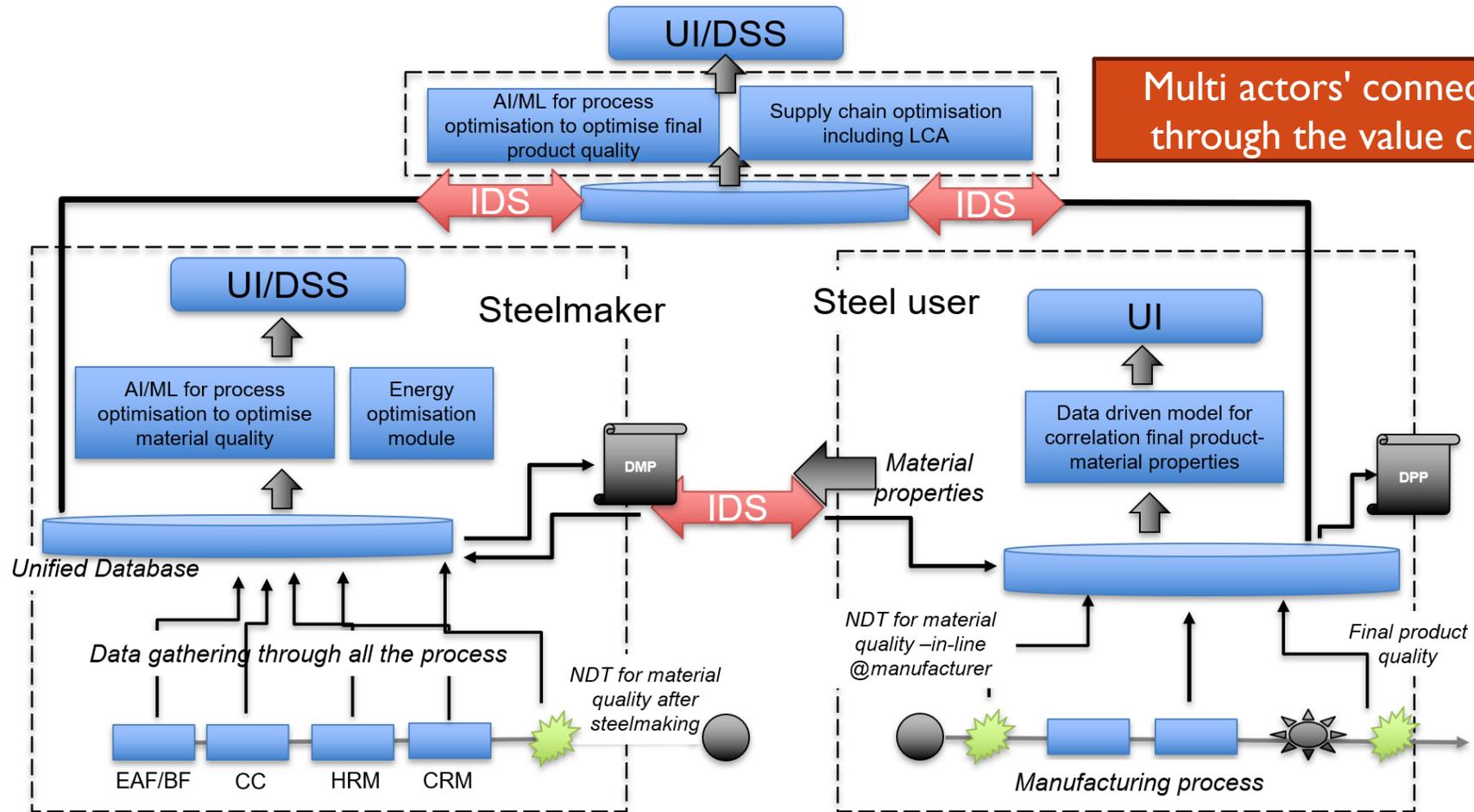
**Build the SMARTChain digital platform for steel users**
Providing better insights on the effect of material properties on final product quality, using AI and advanced analytics.

**Demonstrate the integrated solution at TRL 6/7**
Validation through industrial use cases, ensuring scalability and replicability.
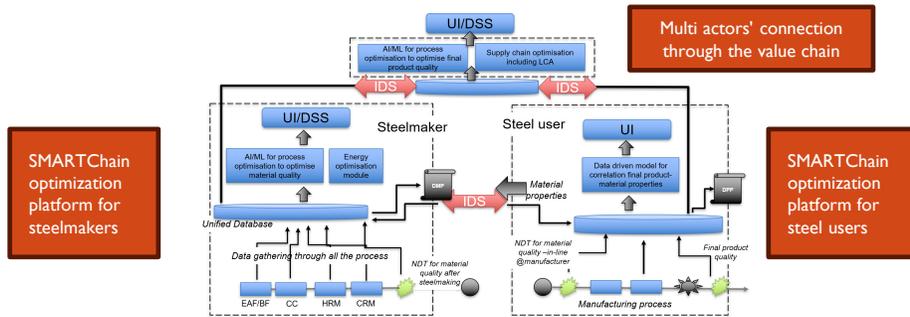
# SMARTChain general approach

# SMARTChain Building Blocks



## SMARTChain optimisation platform for steelmakers

- Data gathering and harmonisation solutions to cover all the steps of the production process

- Centralise data warehouse to store all the process related information to feed AI and models

- AI-based solutions to optimise production process parameters to improve the quality of the steel produced to better meet steel users requirements.

- Advanced statistical analysis and predictive algorithms to predict energy consumption, generation and market prices, as well as the offering of flexibility services to the market

- Decision Support System (DSS) to support operators in optimising the production process

## SMARTChain optimisation platform for steel users

- Sensor fusion for in-line control of the incoming material and of the final product

- Data gathering, harmonisation and storage solutions for process and quality data

- Data driven models to correlate the quality of the final product with the properties of the incoming material

## Multi actors connection through the value chain

- Steel Industrial Data Space to regulate data exchange between steelmakers, steel users and service providers

- Digital Material Passport (DMP) guaranteeing the traceability of material information, exchanged through IDS

- AI-based optimisation model to optimise steelmakers process parameters in order to guarantee the highest quality in the final

# SMARTCHAIN KEY INNOVATION

The true innovation of the SMARTChain project lies in the implementation, **for the first time in the steel industry**, of two key enablers of Europe's digital and green transition: the Industrial Data Space (IDS) and the Digital Product & Material Passport (DPP/DMP).

The Industrial Data Space enables secure and sovereign data exchange across the entire steel value chain, fostering trust and interoperability among steelmakers, suppliers, and end-users.

The Digital Product Passport ensures full traceability of materials and products throughout their lifecycle, supporting reuse, recycling, and circular business models.

**Together, these two innovations will transform the steel value chain, making it more transparent, circular, and sustainable**.

## Trusted Data Sharing in a Federated Ecosystem

- A Data Space is a federated infrastructure enabling sovereign and interoperable data sharing.

- The IDS Connector is a secure and standardized gateway for exchanging data between participants.

- Each organization keeps control over its data using usage policies and access rules.

- Key Features: encryption, identity management, usage control, and data contracts.
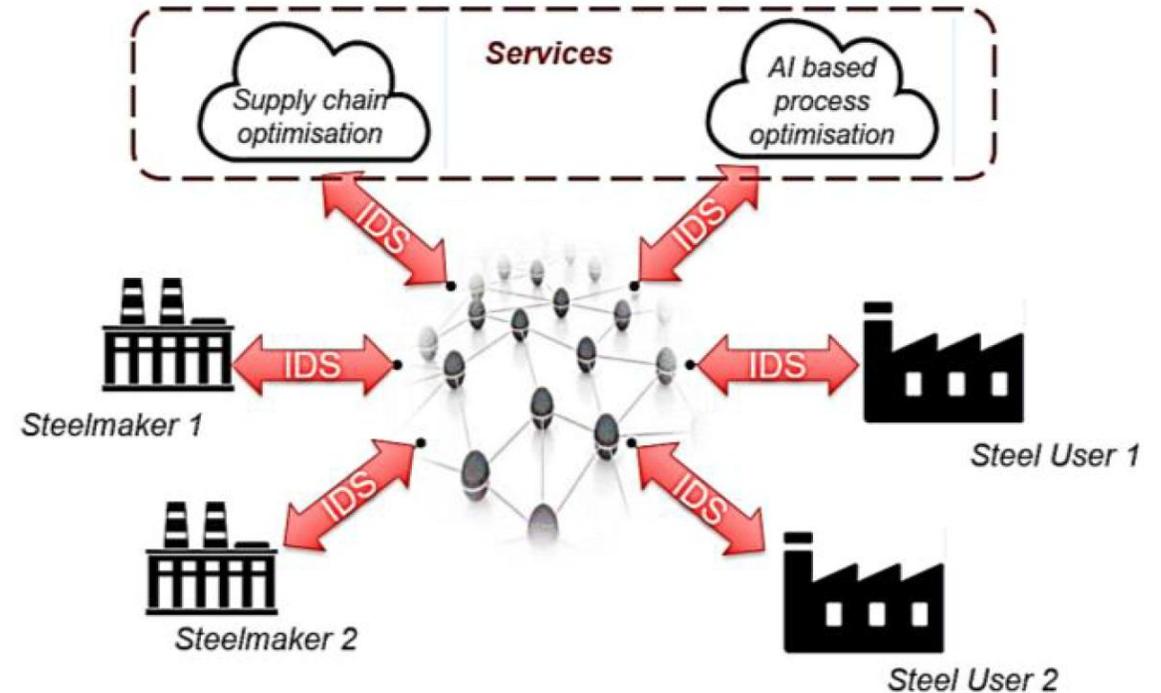
# Built for EU Data Act Compliance

## Standards Based

The Data Space uses European technical standards that directly satisfy Data Act requirements (Article 33)

## Machine Readable Policies

Usage rules are expressed in a standardized format, making compliance verification easier and more transparent

## B2B Industrial Data Sharing

Designed for business to business exchange along the steel value chain

# A Data Space That Adapts to partners Infrastructures

## Flexible Deployment in Practice

In SMARTChain, connectors are deployed in different configurations: some partners host their own connector on local virtual machines or cloud infrastructure, while others rely on the Data Space operator to host the connector on their behalf.

## Integration with Existing Systems

Connectors interface with each partner's Data Management Platform through standards, without requiring changes to existing IT systems

## Scalable

The architecture supports organizations of different sizes, from SMEs to large industrial groups.
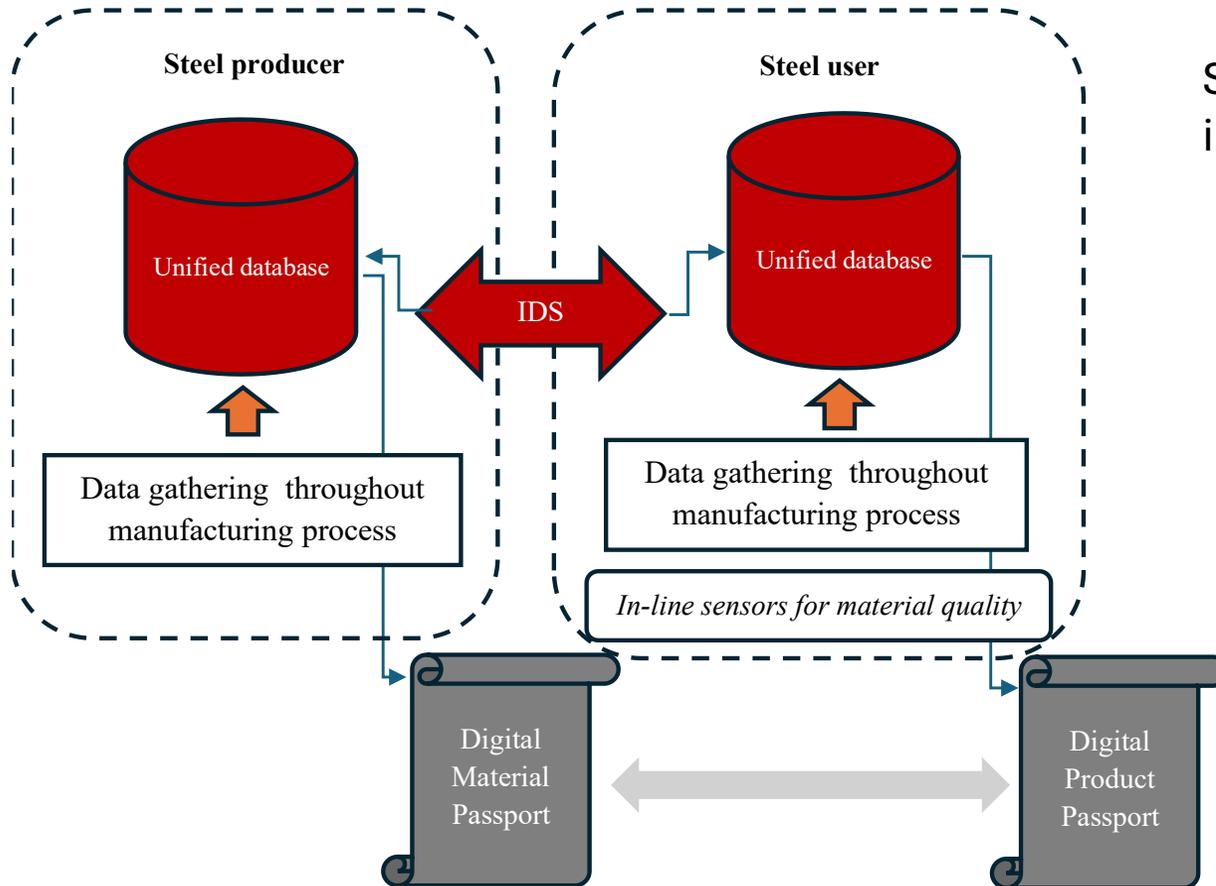
# Digital Material and Product Passport

- The Digital Product Passport (DPP) is a standardized digital record that contains structured information about a product throughout its lifecycle.

- It aims to support circular economy goals by enhancing product traceability, repairability, and recyclability.

- Core information includes:

  - Materials and substances used

  - Carbon footprint and energy use

  - Repair and recycling guidelines

  - Product certifications and compliance

- The DPP enables data sharing across supply chains, authorities, and consumers in a secure and transparent way.

- It is part of the EU's Sustainable Product Initiative and upcoming Ecodesign Regulation.

# SMARTChain DMP and DPP
## End-to-end data flow architecture

**Steel producer**

Unified database

Data gathering throughout manufacturing process

**IDS**

**Steel user**

Unified database

Data gathering throughout manufacturing process

*In-line sensors for material quality*

Digital Material Passport

Digital Product Passport

SMARTChain builds on the steel sector's maturity by integrating :

- ✓ Dynamic DPPs
- ✓ Live traceability methods
- ✓ Real-time data on material properties, production processes, and sustainability metrics
- ✓ Industrial dataspace for seamless information exchange among steelmakers, end-users

**Digital Material Passport for intermediate products**
**Digital Product Passport for final products**

# DMP/DPP software architecture overview

**graphQL**

↓

**BLOCKCHAIN**

↓

**REST API**

↓

**UI/UX**
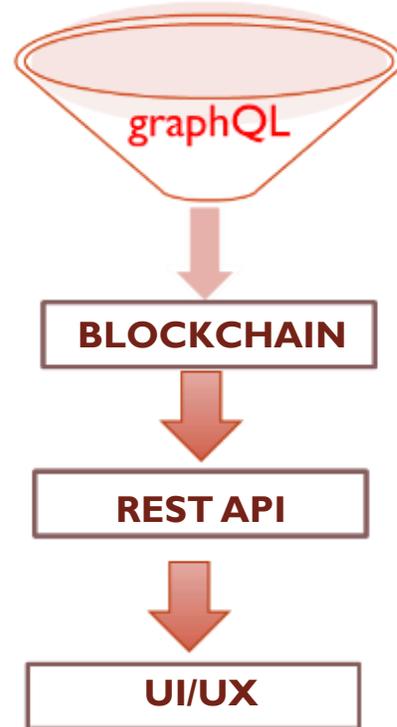
🔍 EPCIS 2.0 events for traceability

🗄 GraphQLAPI for DMP and DPP data access

✓ Hyperledger Fabric blockchain

🤝 Ontology-driven schema across partners

📶 Sensor integration via same DPP interface

At the core, a GraphQL interface ingests data from multiple sources (including in-line sensors and plant IT systems) ensuring structured, schema-compliant input. This data is then recorded on a permissioned Hyperledger Fabric blockchain, which stores cryptographic hashes of each passport update to guarantee immutability and cross-organizational provenance . A REST API layer, exposes secure, standardized endpoints for external applications and services to query or update passport data. Finally, a user-friendly interface for engineers and auditors to visualize dynamic material and product passports, supporting transparency and operational decision-making.

# Traceability architecture and data management

## Indicative traceability events
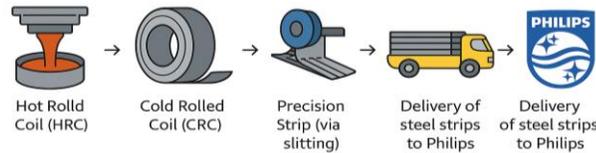


**👷 Steelmakers**

Heat creation → ObjectEvent

Cold-rolling & slitting → TransformationEvent

Shipment → ObjectEvent

TransactionEvent (invoice issued, destination declared)

DMP



**🏭 Steel users**

Receipt of coil → ObjectEvent

Blade punching → TransformationEvent

Hardening & packaging → TransformationEvent

DPP

## Indicative information flow in Digital Material Passport/ Digital Product Passport

Steelmaker Digital Material Passport:

- Heat number, steel grade, production date
- Origin, $CO_2$ footprint, recycled %, certifications
- Mechanical and chemical properties

Steel users-Digital Product Passport:

Product ID, GTIN, serial number
- Linked materials and corresponding DMPs
- Circularity info

# Overall SMARTChain Methodology

1. **Use Case Analysis**: Identifying various scenarios within steel manufacturing and user domains, understanding critical processes, pain points, and opportunities for improvement through stakeholder engagement. Prioritizing use cases based on impact, feasibility, and alignment with project goals.

2. **SW Environment Definition**: Gathering detailed requirements for software environments, selecting appropriate technologies, and designing a comprehensive architecture to ensure alignment with project objectives and future scalability.

3. **SMARTChain Platform for Steelmakers**: Designing and developing platforms tailored to steelmakers' needs, incorporating AI models and advanced data processing methods. Integrating with existing automation systems and conducting rigorous testing for functionality, security, and performance.

4. **SMARTChain Platform for Users**: Designing user-friendly platforms integrating AI models and quality prediction tools, developing and connecting with the SW environment, and testing for quality assurance and integration with material properties.

5. **Overall Integration and Validation**: Integrating steelmaker and user platforms into a unified SMARTChain system through the Industrial Data Space. Gathering stakeholder feedback during validation to address issues and improve system effectiveness.

6. **Deployment and Continuous Improvement**: Rolling out the SMARTChain system in phases, monitoring system performance, user engagement, and impact for continuous optimization based on feedback, technological advancements, and industry needs.

# SMARTCHAIN UC

**USE CASE 1**: Stainless steel production optimisation to guarantee high quality in razor blades production, with wider material specification and lower energy consumption (ACERINOX – PHILIPS)

**USE CASE 2**: NGO Electrical Steel Digital Passport on mechanical and electrical properties to improve the quality of automotive components ( SIJ ACRINI – HIDRIA)

**USE CASE 3**: Improvement of the quality of coated steel flat products for cold forming, with oil layer control and to guarantee suitable roughness of the coil (ADI – TOFAS)

**USE CASE 4**: Optimisation of steelmaking process parameters to reduce defects on cold rolled wire rod and the environmental impact ( ADV – SIAT)

**USE CASE 1: Stainless steel production optimisation to guarantee high quality in razor blades production, with wider material specification and lower energy consumption**

**SMARTChain Platform for steelmakers:**

- Collection and harmonization of data from the various sources to store them in a central unified database
- AI-based models for process optimization and final quality prediction
- Human-centric Decision Support System to provide accurate and thrustable suggestions to operators

**SMARTChain Platform for steel users:**

- Set-up of in-line control to characterize the quality of the stainless strip steel over the full length
- Collection and harmonization of data from the various sources to store them in a central unified database
- Data driven models for correlation of the quality of the final products with the material properties
- Smart UI for visualisation
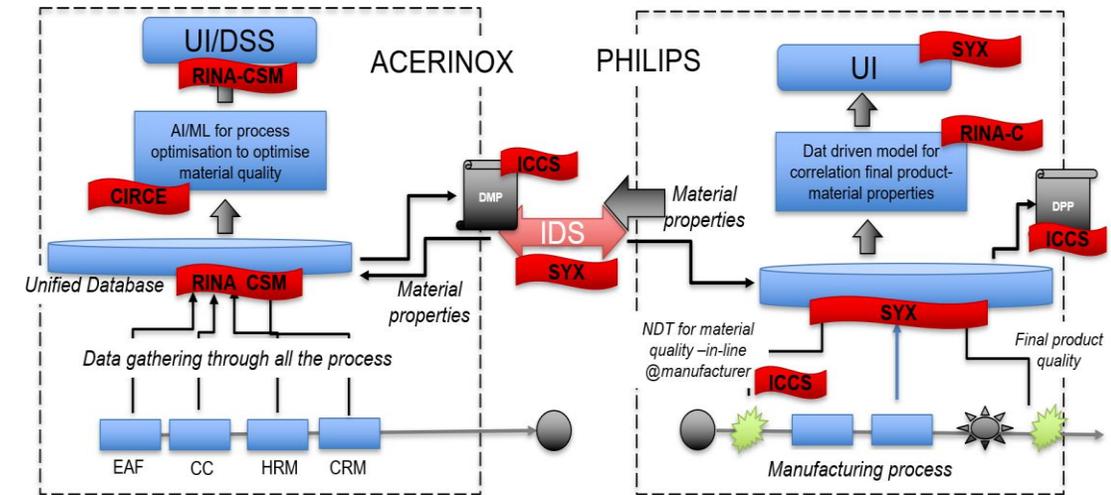


**Data exchange through IDS:**

- Target material properties defined by the steel user
- Digital Material Passport made available by steelmakers

# Conclusions



The project will introduce the power of **digitalization** in the **steel sector** to enable product **tracking** and **optimization** across the entire **value chain**.

This will be accomplished through the introduction of a Digital Product Passport (**DPP**) for traceability and a **data space** to facilitate **data exchange**, fostering data valorization and process optimization throughout the entire value chain.