INTEGRADDE: Pilot lines for Additive Manufacturing of metal components with DED processes

21st AM PLATFORM MEETING, December 10th, 2020

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INTEGRADDE: Intelligent data-driven pipeline for the manufacturing of certified metal parts through Direct Energy Deposition processes

DT-FOF-04-2018 – Pilot lines for metal Additive Manufacturing

OUTLINE

1. INTEGRADDE IN A NUTSHELL
2. OBJECTIVES
3. CONCEPT
4. APPROACH
5. CASE STUDY

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1. INTEGRADDE IN A NUTSHELL

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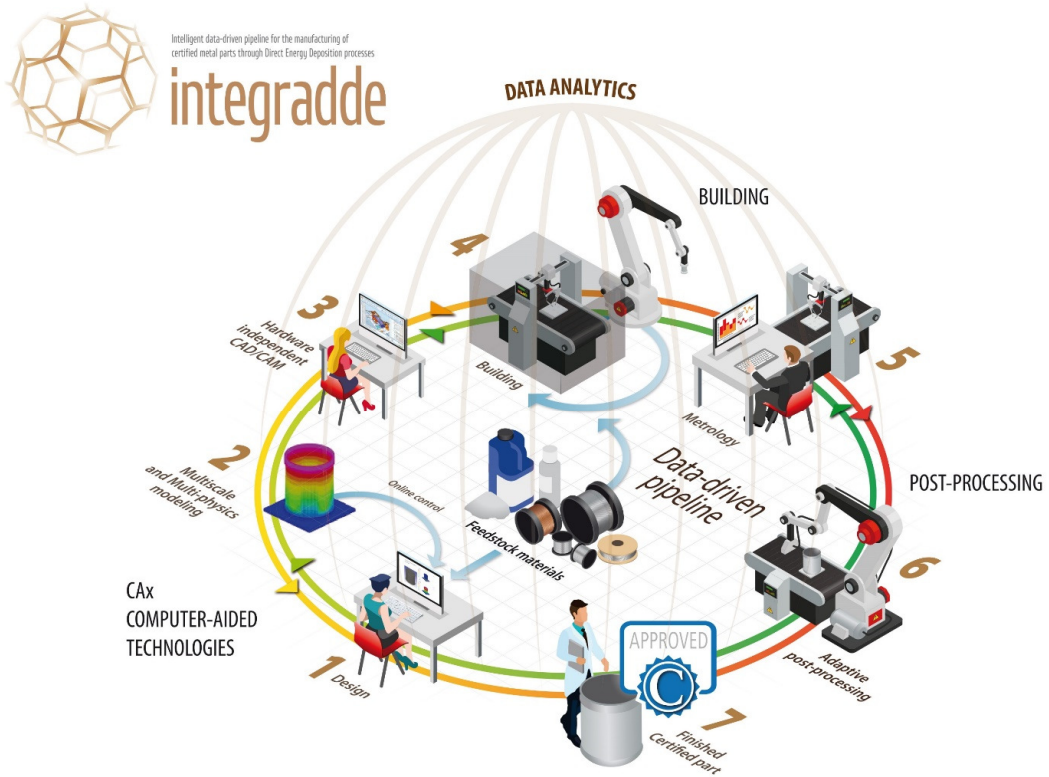
Digital end-to-end manufacturing solution for a seamless integration across the entire AM chain

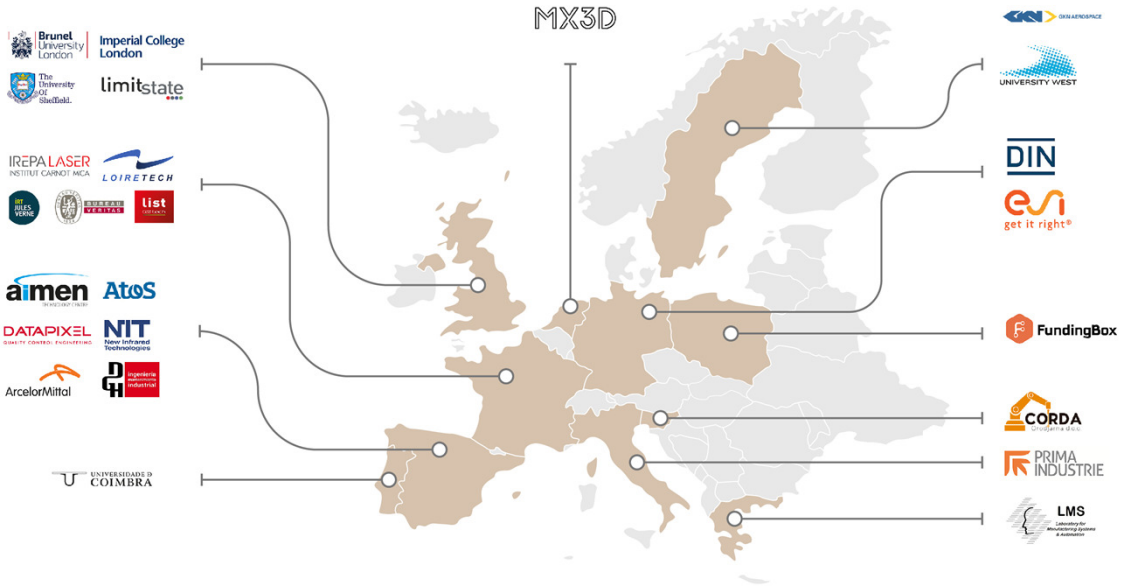


Integradde Digital thread for AM

New manufacturing methodology capable of ensuring the manufacturability, reliability and quality of a target metal component from initial product design **by DED technologies: LMD, WAAM**

- Bidirectional dataflow linking product design, modelling, metallurgy, production planning, online control, inline quality assurance, and post-processing.
- Self-adaptive control implementing a non-defect propagation strategy.
- Artificial Intelligence assisting in the design and manufacturing of new components.

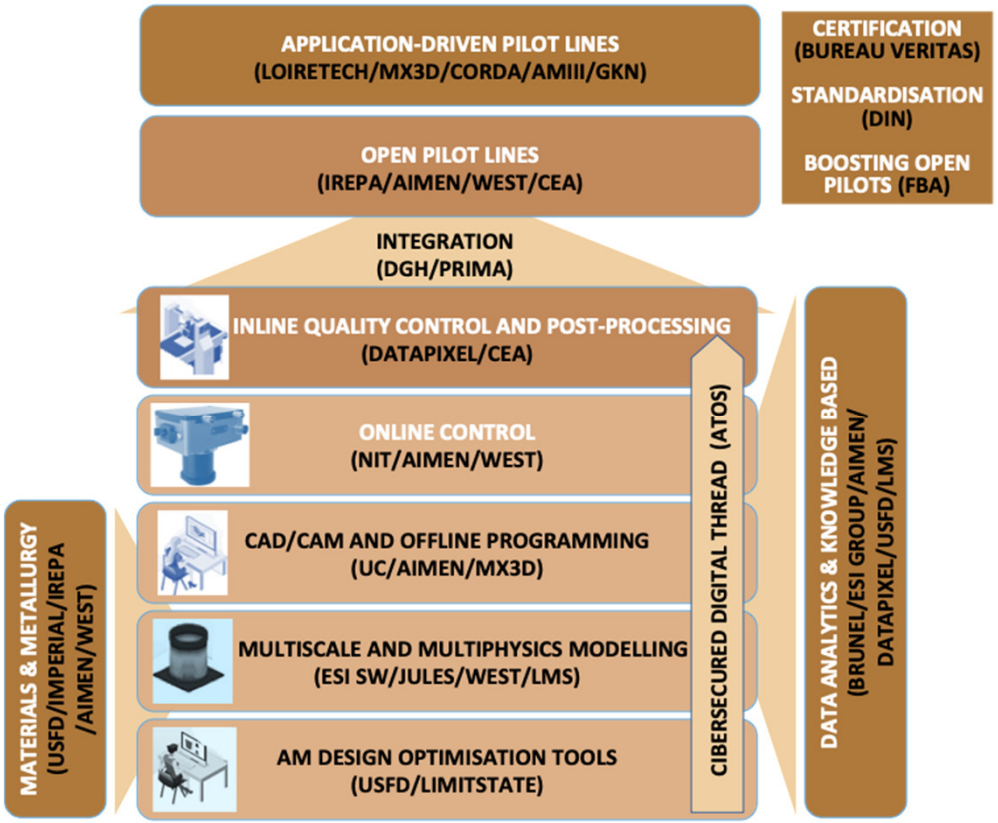
1. IN A NUTSHELL : CONSORTIUM AND VALUE CHAIN



→ *26 ENTITIES, COMING FROM 11 EUROPEAN COUNTRIES*

Overall budget:
€ 16.999.328,75

EU contribution
€ 12.716.173,51



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2. OBJECTIVES

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Needs targeted by INTEGRADDE

To show the full potential of metal AM in real manufacturing conditions

- ***Right-first time manufacturing*** of large metal parts. Ensuring the manufacturability of a component from the initial product design.
- Integration and ***interoperability*** of AM processes into multistage production systems.
- Improve ***quality*** of AM products. Unpredictable defects in final parts are preventing complete deployment and adoption of AM in the metalworking industries.
- ***Certification, regulatory and standardisation.***

Novel approaches are required, capable to deal with:

- Prediction and minimisation of distortion.
- QbD manufacturing strategy.
- Intelligent data-driven pipeline, enabling bidirectional dataflow for a seamless integration across the entire value chain.

2. OBJECTIVES

New manufacturing methodology capable of ensuring the *manufacturability, reliability and quality* of a target metal component *from initial product design.*

Manufacturing of medium-/large-sized metal components by DED technologies:

- LMD: Laser Metal Deposition
- WAAM: Wire-arc Additive Manufacturing

Key manufacturing scenarios for EU economy are *targeted for demonstration:*

- Invar tooling moulds for the aerospace manufacturing sector by WAAM.
- New structural support beams and steel connectors for optimised structures by WAAM.
- Engine case made of titanium by LMD-w.
- Functionalization and reconstruction of large parts for the steel industry by LMD-p.
- New multimaterial tooling components for the automotive sector by LMD-p.

Network of open-pilots, providing services and testing facilities for the uptake of AM in EU industry ecosystem (mainly SMEs and MidCaps).

3. CONCEPT

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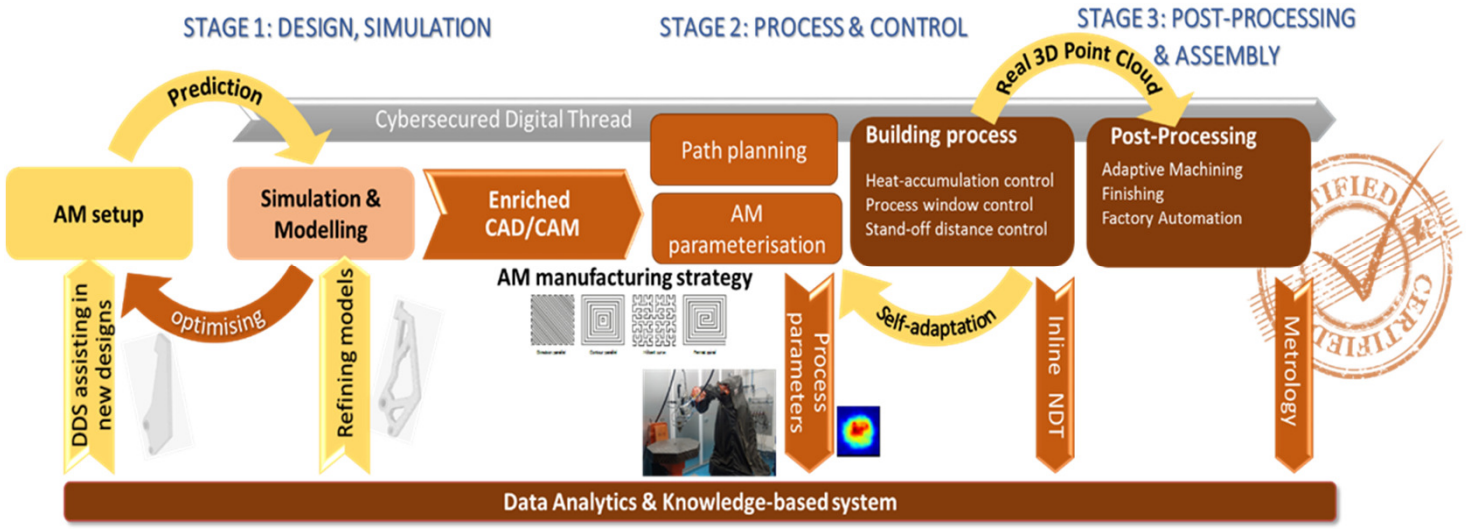
3. CONCEPT



- *Cybersecured digital thread* enabling a holistic and an integrated control approach.
- CAx technologies supporting the design, modelling and process planning for AM.
- *QbD* for a zero-defect manufacturing strategy.
- *Data analytics and AI* for optimisation in the design and manufacturing of new parts.
- *Hardware-independent approach* supporting both novel and legacy infrastructure.
- *Hybridisation* of the AM technologies in a multistage manufacturing.
- *Standardization and product certification* procedures endorsed by the information flow provided by the digital thread.

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4. APPROACH

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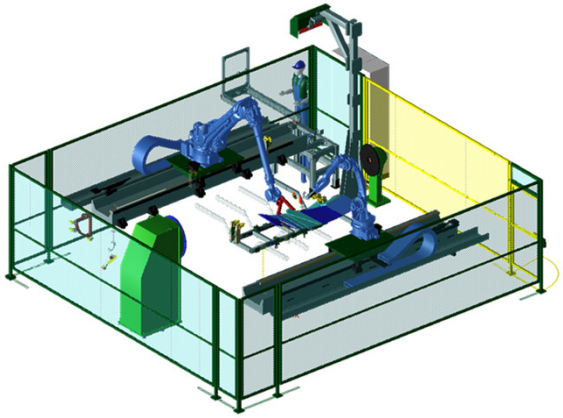
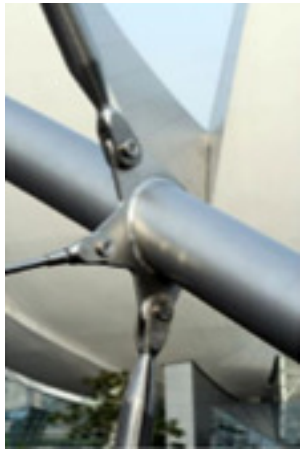
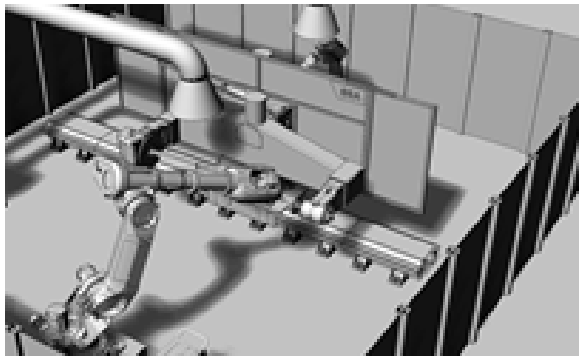
TARGET COMPONENT SCENARIOS – APPLICATION DRIVEN PILOT LINES



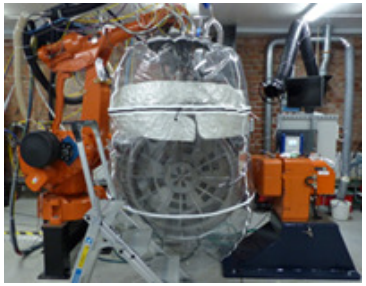
Hybridisation of WAAM with coexisting manufacturing processes (i.e. rolling, folding, welding)
Sector: Tooling for aeronautics
Target component: Panel moulding tooling for aeronautic component by **WAAM**
Material: INVAR





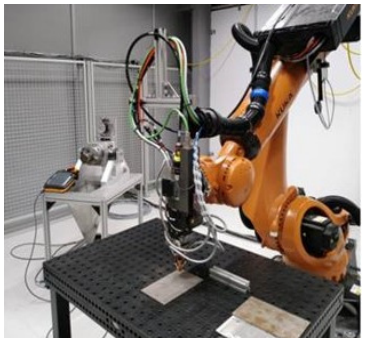
Manufacturing of new structural support beams and steel connectors by **WAAM**
Sector: Construction
Target component: 3D printed steel structural components.
Material: Steel

TARGET COMPONENT SCENARIOS – APPLICATION DRIVEN PILOT LINES



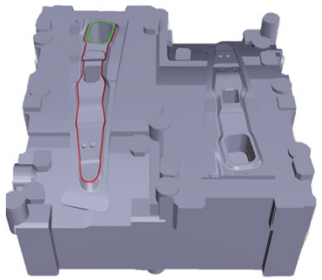
Manufacturing of titanium components for aeronautics by **LMD-w**
Sector: Aeronautics
Target component: Engine case.
Material: Titanium

GKN AEROSPACE



Manufacturing of graded components with a functionalised surface by **LMD-p**
Sector: Steel
Target component: Large parts for steelmaking process.
Material: Carbides in a metal-alloy matrix

ArcelorMittal



Hybrid manufacturing of tooling by graded materials by **LMD-p**
Sector: Tooling for automotive
Target component: Cutting tools for automotive part manufacturing
Material: Tool-steel

CORDA

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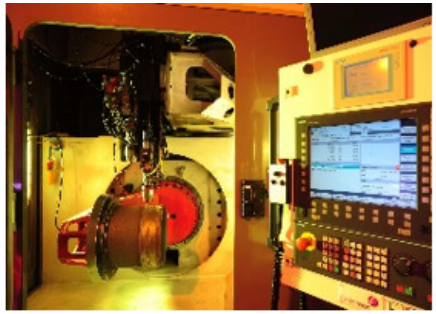
OPEN PILOT LINES NETWORK

Network of open-pilots offering services to EU industry of consultancy and proof-of-concept of DED technologies for the manufacturing of specific metal components.

- Supporting the adoption of AM in European Industry.
- Providing services and testing facilities for the uptake of AM in EU industry ecosystem (mainly SMEs and MidCaps).
- Demonstrating INTEGRADDE on different equipment schemes and AM processes, ensuring interoperability and usability of INTEGRADDE concept in a generic way.



This network will be extended to other RTOs and to previous EU initiatives

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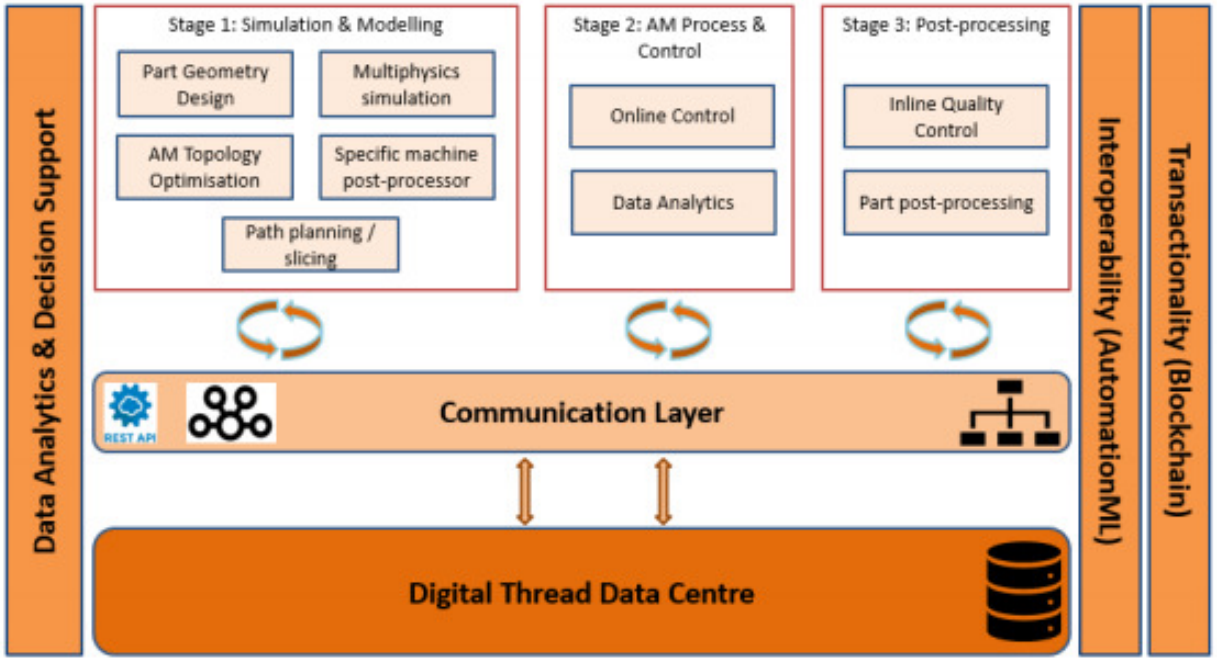
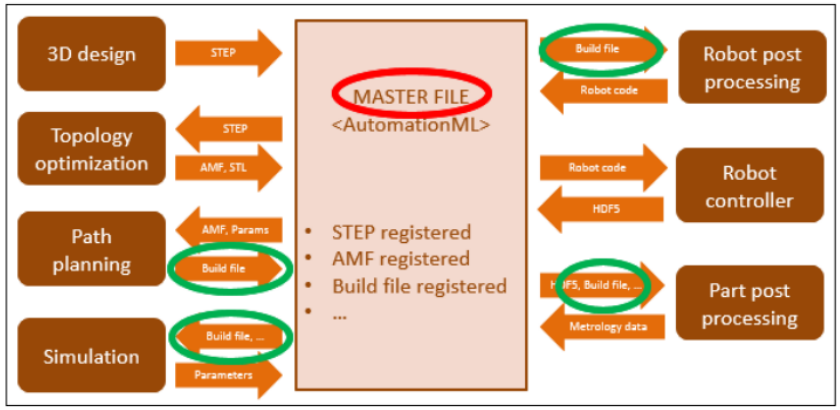
DIGITAL ARCHITECTURE

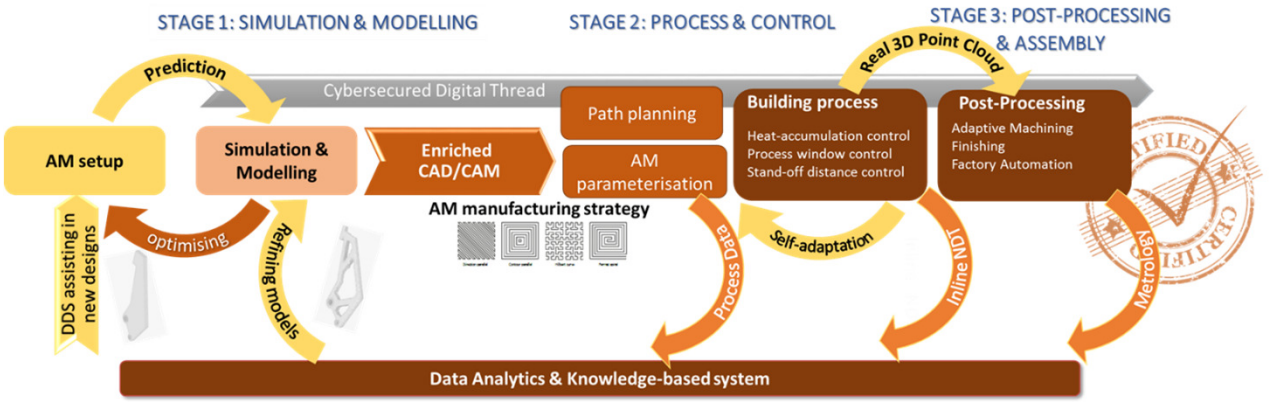
INTEGRADDE Digital Thread is an interoperable solution responsible for the data management and the communication of the pipeline architecture components in INTEGRADDE, acting as an orchestrator that will interconnect all the manufacturing stages.

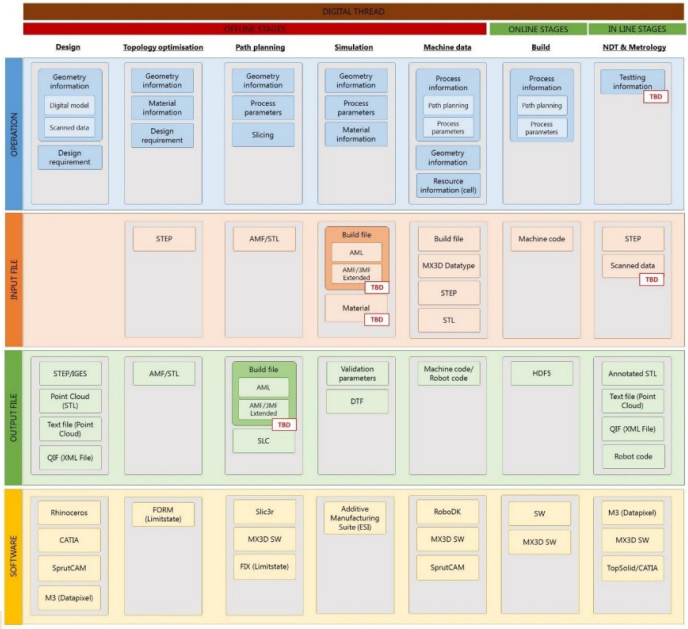
- Communication among different software solutions including open-source, proprietary software and commercial solutions.
- Valid for different hardware layouts.
  - ✓ CNC-based
  - ✓ Robot-based
- Interoperable with novel and legacy systems.
- Cybersecured digital thread
  - ✓ Data Integrity
  - ✓ Traceability
  - ✓ Security



4. APPROACH







- AutomationML (IEC 62714), acting as a glue between all the different software available to be integrated. AutomationML is focused on supporting engineering data dataflow. In this manner, there will be a master AML file to describe all the available processes.
- Data Centre, where all the necessary data will be located
- Traceability: Blockchain linked with the AutomationML master file.

“END TO END” DATAFLOW SOLUTION AND DIGITAL TWINS

PRODUCT ENGINEERING

BUILD & CONTROL

POSTPROCESSING & TESTING

Part design & Topology optimisation (CAD)

Path planning & process simulation (CAPP/CAE)

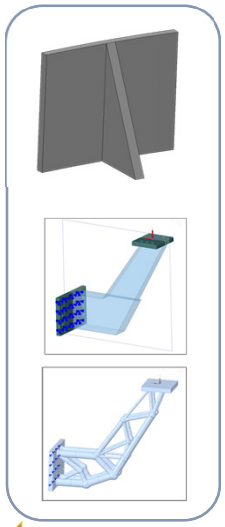
Off line CAM programming

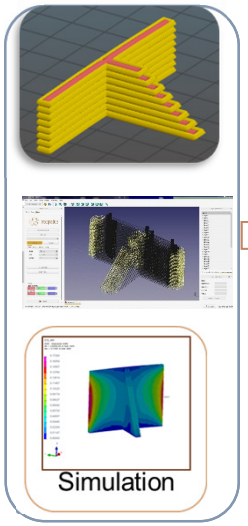
Real robot workstation

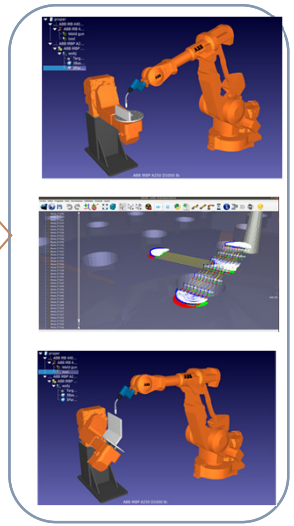
Build process and control

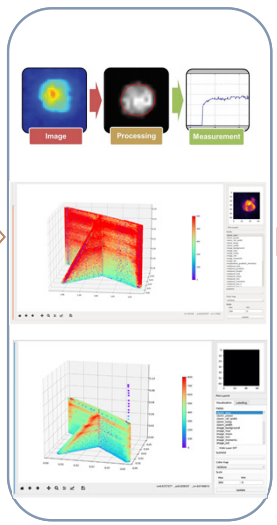
Data analysis

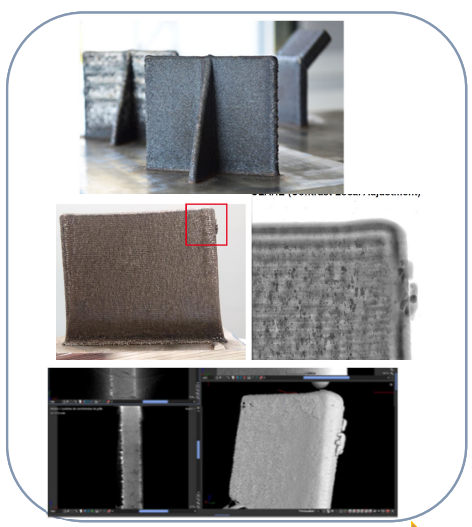
Quality control &verification (DT- NDT)











DIGITAL THREAD + DATA CENTRE

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5. CASE STUDY

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PRODUCT ENGINEERING

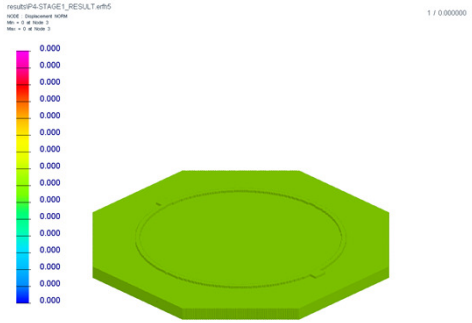
- Part design & Topology optimisation (CAD)
- Path planning & process simulation (CAPP/CAE)
- Automatic Off line programming (CAM)

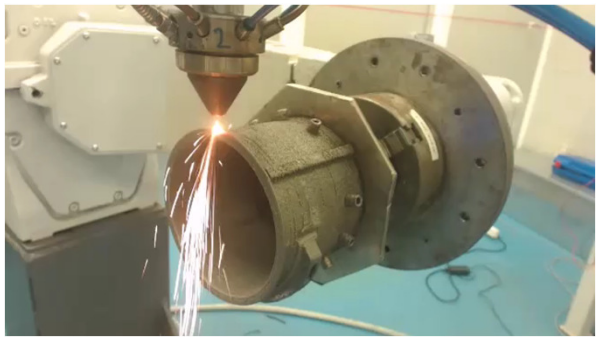
BUILD & CONTROL

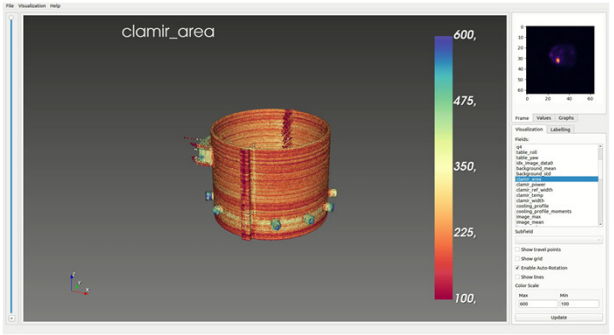
- Build process and control
- Data analytics

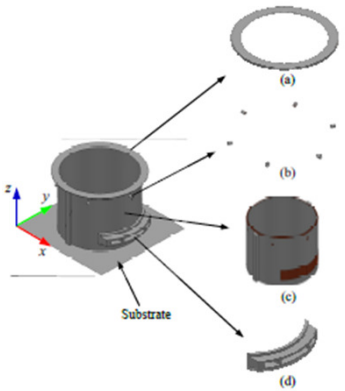
POSTPROCESSING & TESTING

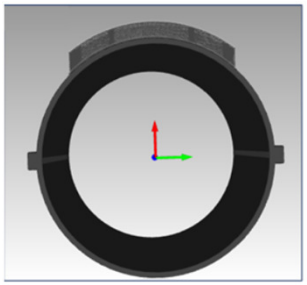
- Quality control &verification (NDT)

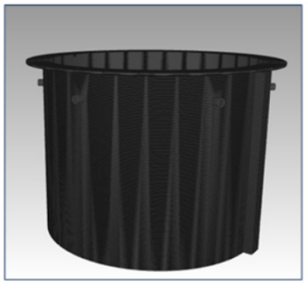


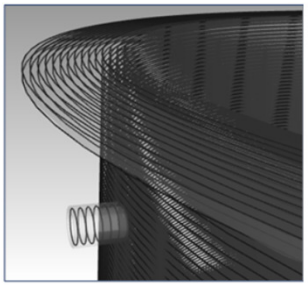


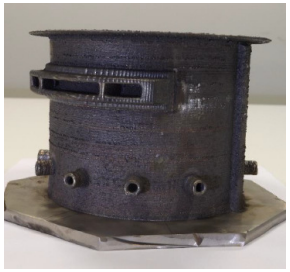












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Intelligent data-driven pipeline for the manufacturing of certified metal parts through Direct Energy Deposition processes

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