



PENELOPE

**Close-loop digital pipeline
for large-part and high-
precision manufacturing**

Félix Vidal Vilariño

PENELOPE Project Coordinator

AIMEN Technology Centre

The Manufacturing Partnership Day



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958303



Penelope's Consortium

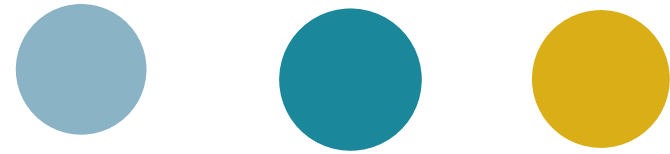
WEBSITE
www.penelope-project.eu



TWITTER
[@PenelopeEU1](https://twitter.com/PenelopeEU1)



LINKEDIN
[/penelope-eu](https://www.linkedin.com/company/penelope-eu)



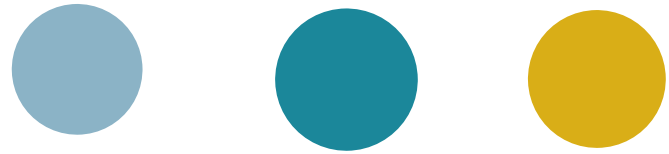
31
EUROPEAN PARTNERS

9
DIFFERENT COUNTRIES

DT-FOF-10-2020
Pilot lines for large-part high-precision manufacturing (IA 50%)

€ 20.891.603
OVERALL BUDGET

€ 14.811.631
EU CONTRIBUTION



CHALLENGES:

Manufacturing and repairing of large-scale components is complex, highly manual, time-consuming and imprecise/inaccurate processes:

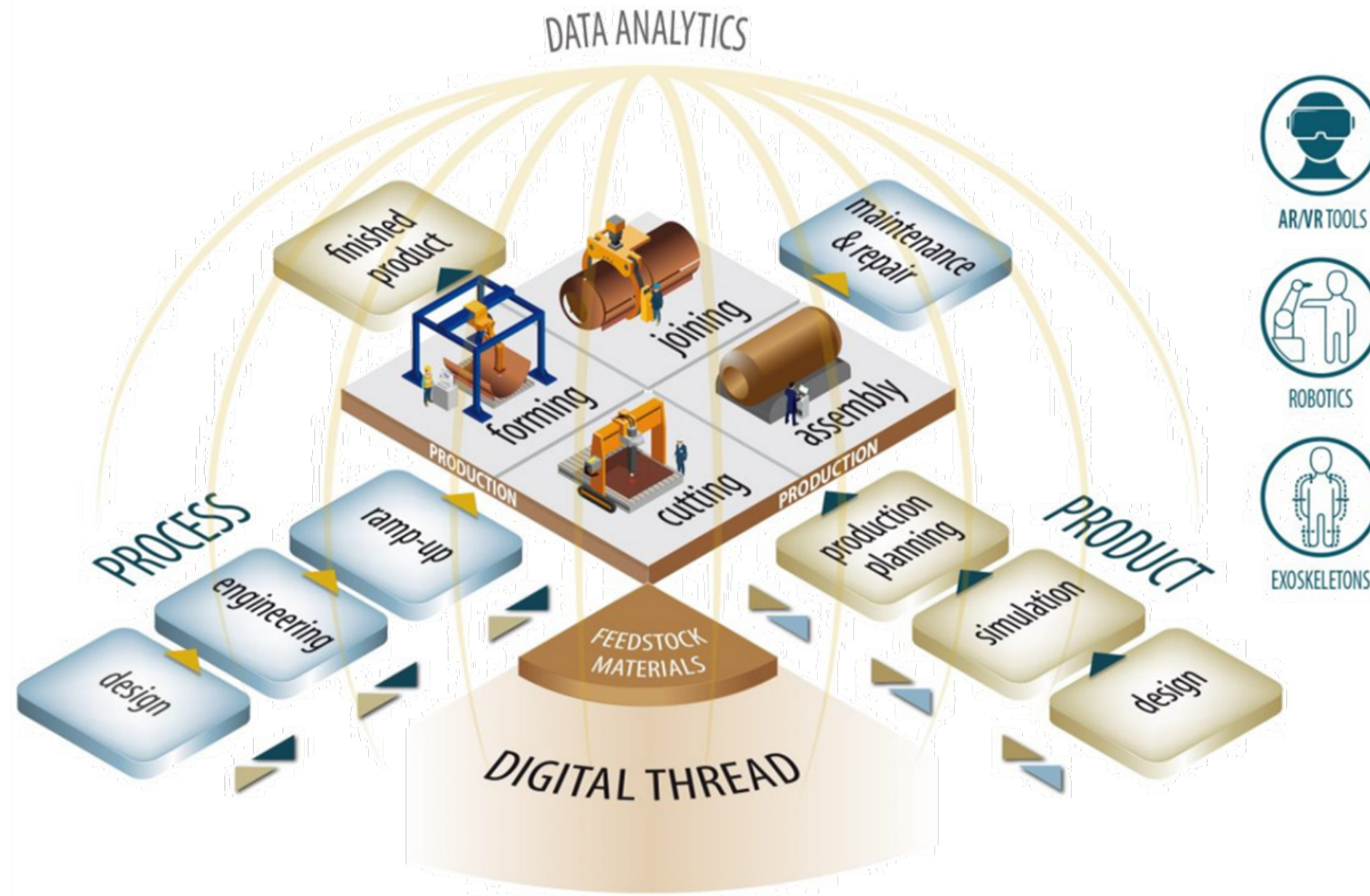
- Design and construction preparation: 20-25% of total costs of one-of-a-kind components.
- Tolerances, deformations... impose constant reconfiguration and adaptation of the work.
- Subassemblies are being manufactured and assembled involving a sequence of different manufacturing processes.
- Preserving industry-specific knowledge and skills.



Novel integrated methodology linking ***product-centric data management*** and ***flexible and reconfigurable production planning***.



Penelope's Vision



01

A CLOSED-LOOP DIGITAL PIPELINE

End-to-end digital manufacturing solution.

- Product-centric data management
- Modular and reconfigurable production

02

WORKER-CENTRIC SOLUTIONS IN SHARED WORKSPACES

Industry-specific workers' knowledge and skills are preserved.

- Product-centric data management
- Modular and reconfigurable production

03

ZERO-DEFECT MANUFACTURING STRATEGY

AI-powered digital twins.

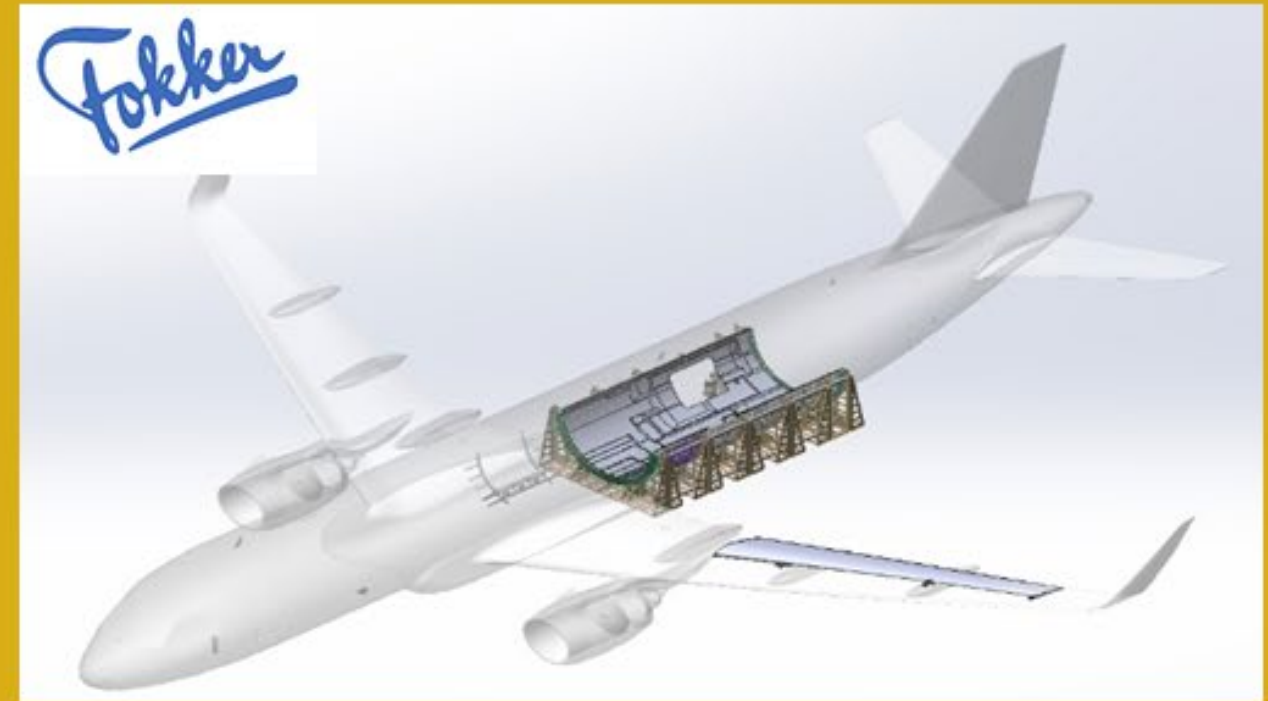


**PRODUCT-SERVICE
FACTORIES**



INDUSTRIAL ADOPTION

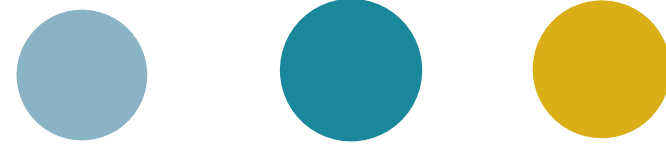
One-of-a-kind



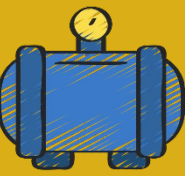
Low-volume



IDESA: ONE-OF-A-KIND MANUFACTURING (OIL&GAS)



IDESIA Pilot line



1 ROLLING



2 WELDING



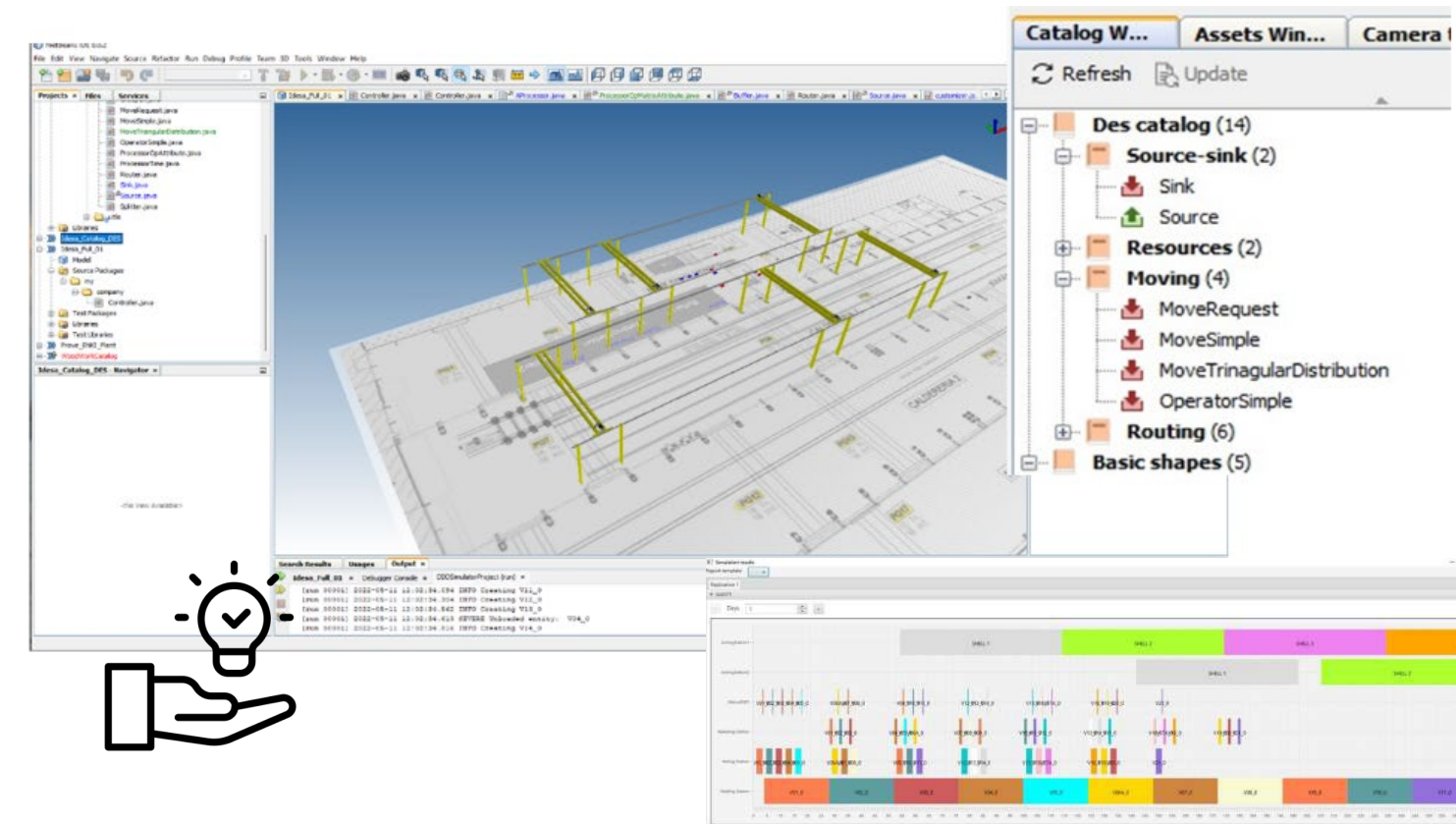
3 ASSEMBLY



4 QA



- One-of-a-kind
- Design/engineering tasks are executed in parallel to production.
- Different references involving variable geometries, sizes, materials...

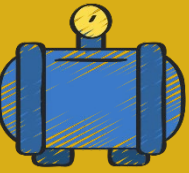


FACTORY PLANNING

- Optimising production efficiency
- CPPS representation



IDESA Pilot line



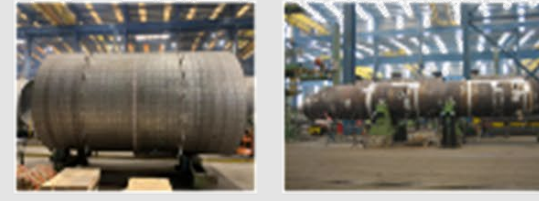
1 ROLLING



2 WELDING



3 ASSEMBLY



4 QA



FEM simulation

Input Parameters

Material properties

Required Diameter

Thickness

width

Length

.....

LS-DYNA keyword deck by LS-PrePost
Time = 0
Contours of Effective Plastic Strain
min=0, at elem# 2689
max=0, at elem# 2689

Effective Plastic Strain

Metamodel

3D Surface

Rolling signals acquisition



ASSISTED FORMING

Roll forming (Metamodel)

PeneloPe

Inputs

Diameter

Length

Width

Thickness

Materials

Controlling variable

Displacement

Outputs

Obtained Diameter

Roundness error (%)

Residual stress

Equivalent Strain

Pressure

Simulation

LS-DYNA keyword deck by LS-PrePost
Time = 4000
Contours of Effective Plastic Strain
min=0, at elem# 2689
max=0.0155139, at elem# 4423

Effective Plastic Strain

1.551e-02

1.396e-02

1.241e-02

1.086e-02

9.308e-03

7.757e-03

6.206e-03

4.654e-03

3.103e-03

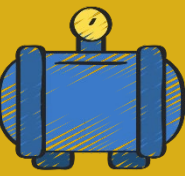
1.551e-03

0.000e+00

Rolling parameters recommendation



IDESA Pilot line



1 ROLLING



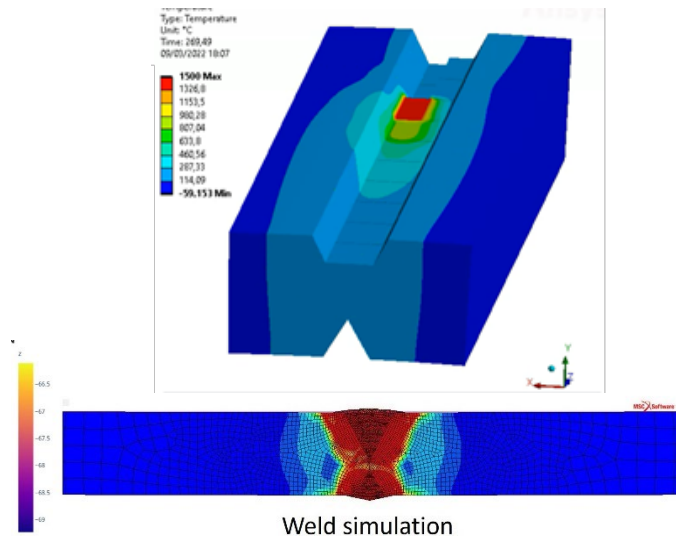
2 WELDING



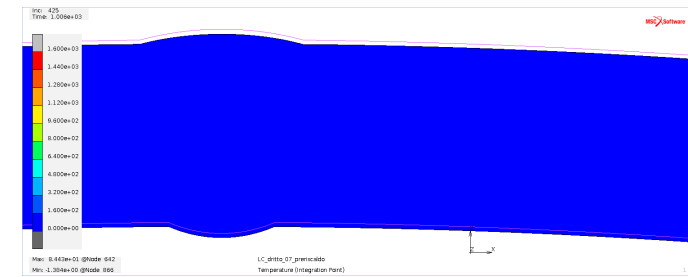
3 ASSEMBLY



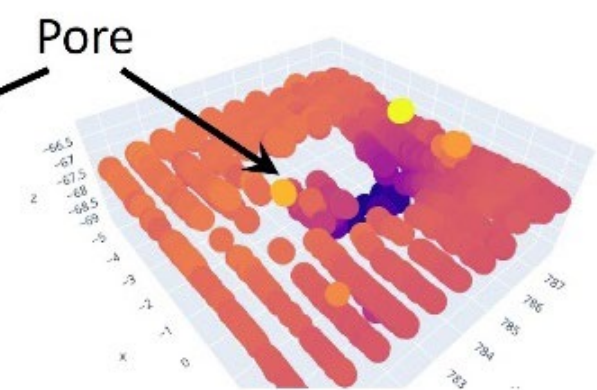
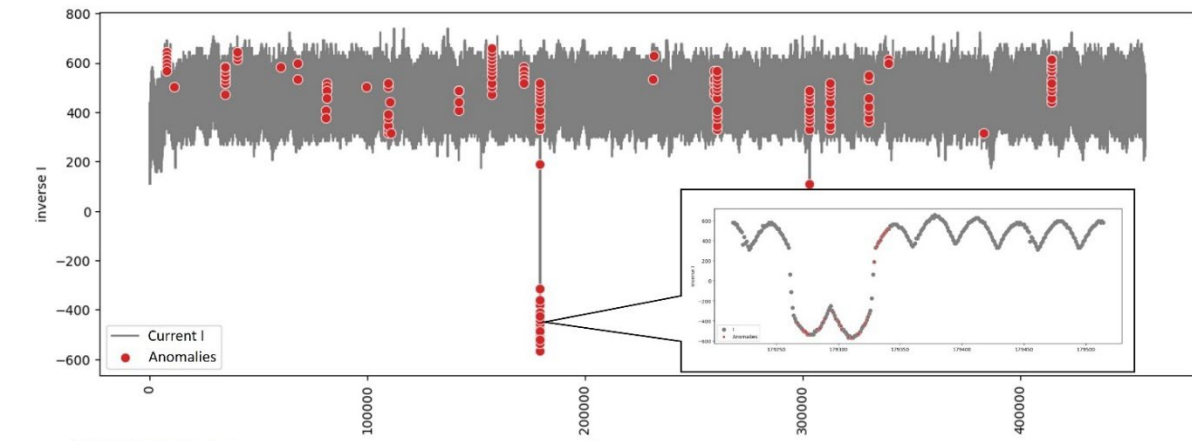
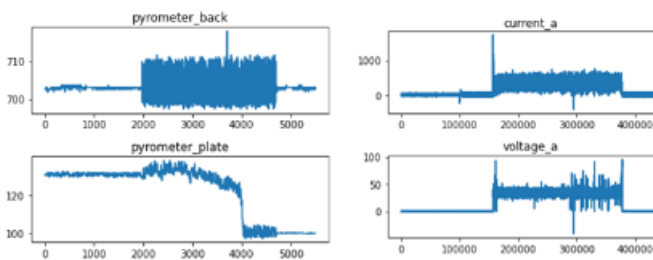
4 QA



Weld simulation



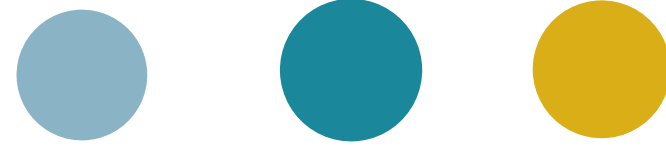
Process data



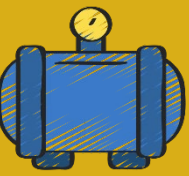
FEM SIMULATION

MULTIMODAL MONITORING

COGNITIVE QA



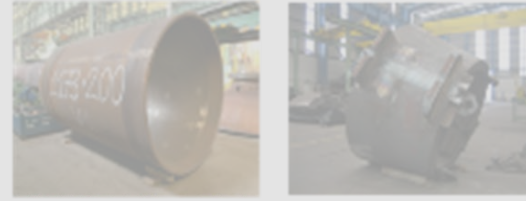
IDESIA Pilot line



1 ROLLING



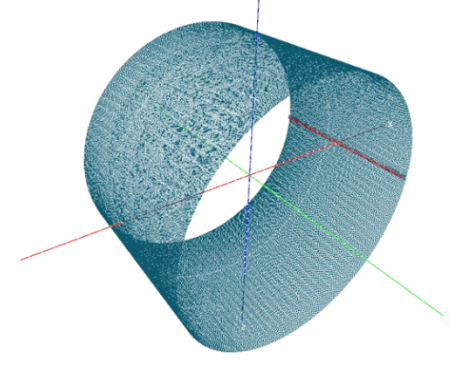
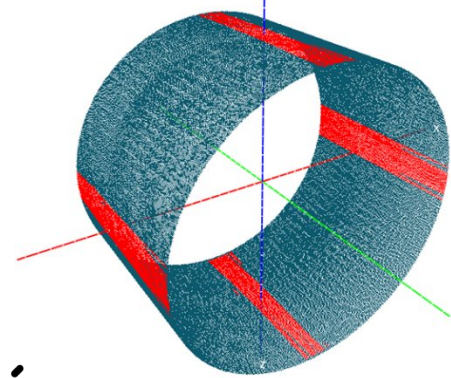
2 WELDING



3 ASSEMBLY



4 QA



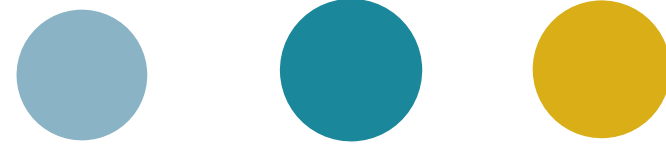
**SCANNING SYSTEM FOR
ROUDNESS VERIFICATION**



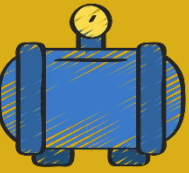
System quickly adjusts to movements in projector or part



**ONSITE AND ADAPTIVE
PROJECTION OF AUXILIARY
EQUIPMENT**



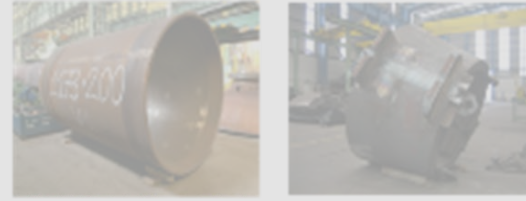
IDESA Pilot line



1 ROLLING



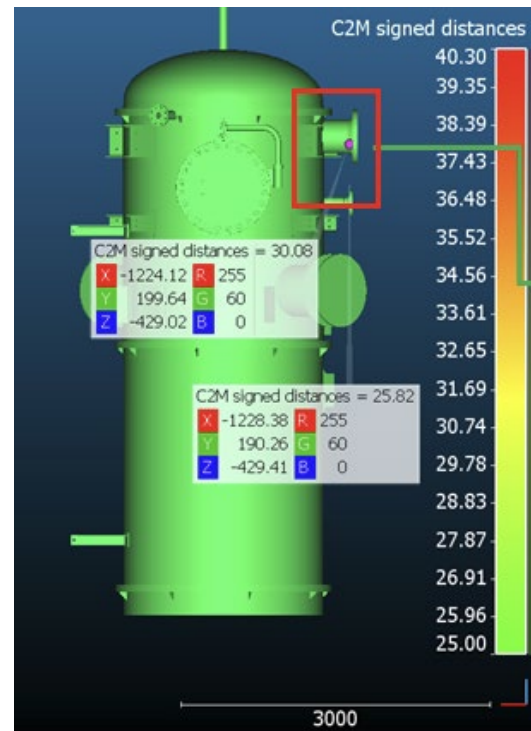
2 WELDING



3 ASSEMBLY



4 QA



Application picks up AML infos & checks for the „isAssembled“ flag

Missing components highlighted in CAD model

CAD Application



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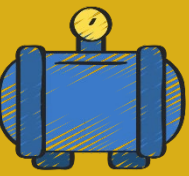
AUTOMATIC VERIFICATION OF THE POSITION OF AUXILIARY EQUIPMENT



REMOTE QUALITY INSPECTION



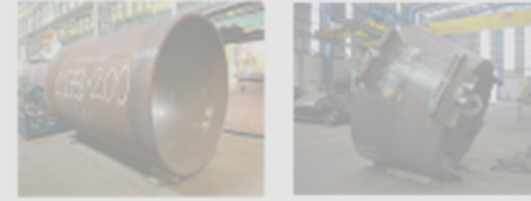
IDESAs Pilot line



1 ROLLING



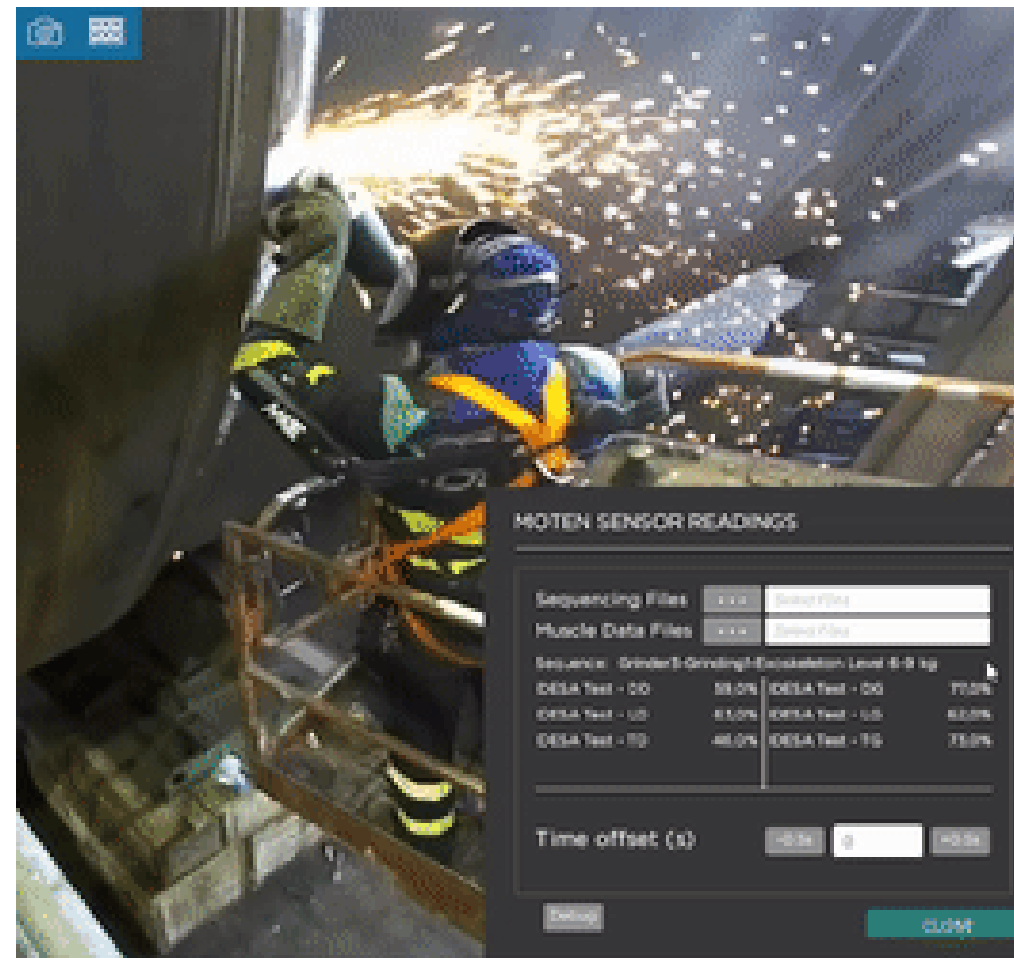
2 WELDING



3 ASSEMBLY



4 QA



MOTEN SENSOR READINGS

Sequencing Files	
Muscle Data Files	
Sequence	Grinder-Grinding-Excavation Level 8-9 kg		
IDESa Test - CO	38.0%	IDESa Test - CO	77.0%
IDESa Test - LB	81.0%	IDESa Test - LB	83.0%
IDESa Test - TD	46.0%	IDESa Test - TD	73.0%

Time offset (s)

Close



EXOSKELETONS ASSISTING WORKERS IN MANUAL OPERATIONS



VISION in PENELOPE

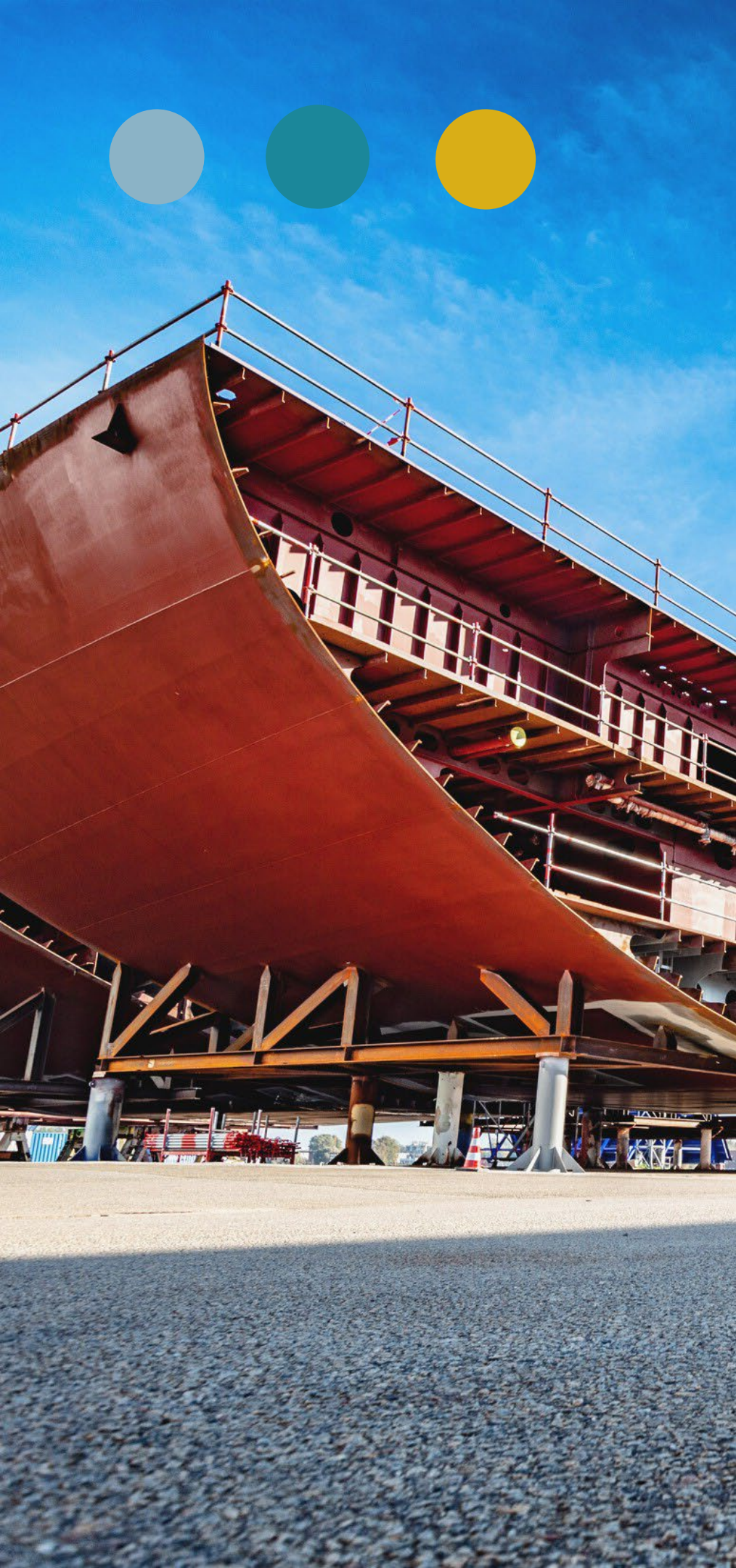
- ✓ End-to-end methodology linking Product, Process and Resources data
- ✓ Hierarchical data orchestration methodology providing an updated view of the component that is being assembled
 - Traceability
 - Data Interoperability along the product lifecycle
- ✓ Future: Cognitive factory by learning from the information collected in the manufacturing dataflow



- ✓ Holistic data management along the product lifecycle (no data silos)
- ✓ Heterogeneous data exchange
- ✓ Adoption of Industry 5.0 concepts



- ✓ Multistage manufacturing (large amount of data generated)
- ✓ Correlation of data



Thank you for your attention!



Félix Vidal Vilariño
PENELOPE Project Coordinator
AIMEN Technology Centre
September, 26th 2023



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