Create your Digital Twin in days, not months.

Application of a standard based framework for Digital Twin implementation

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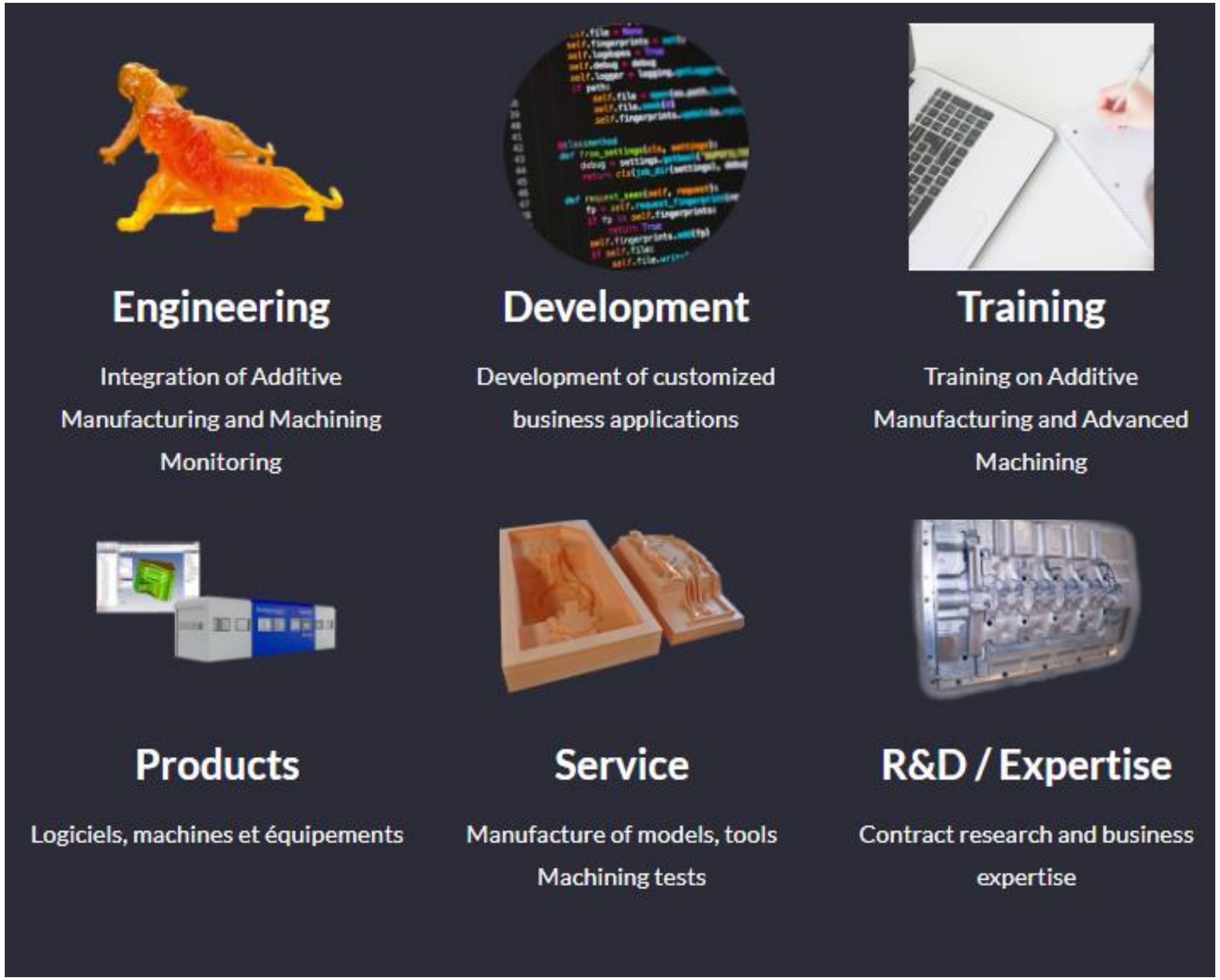
Supported by advanced EU H2020 projects

CIRTES


Engineering
Integration of Additive Manufacturing and Machining Monitoring
Development
Development of customized business applications
Training
Training on Additive Manufacturing and Advanced Machining
Products
Logiciels, machines et équipements
Service
Manufacture of models, tools
Machining tests
R&D / Expertise
Contract research and business expertise

Partners of the project

HTTPS://KYKLOS40PROJECT.EU/

- KYKLOS 4.0 HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT NO 872570

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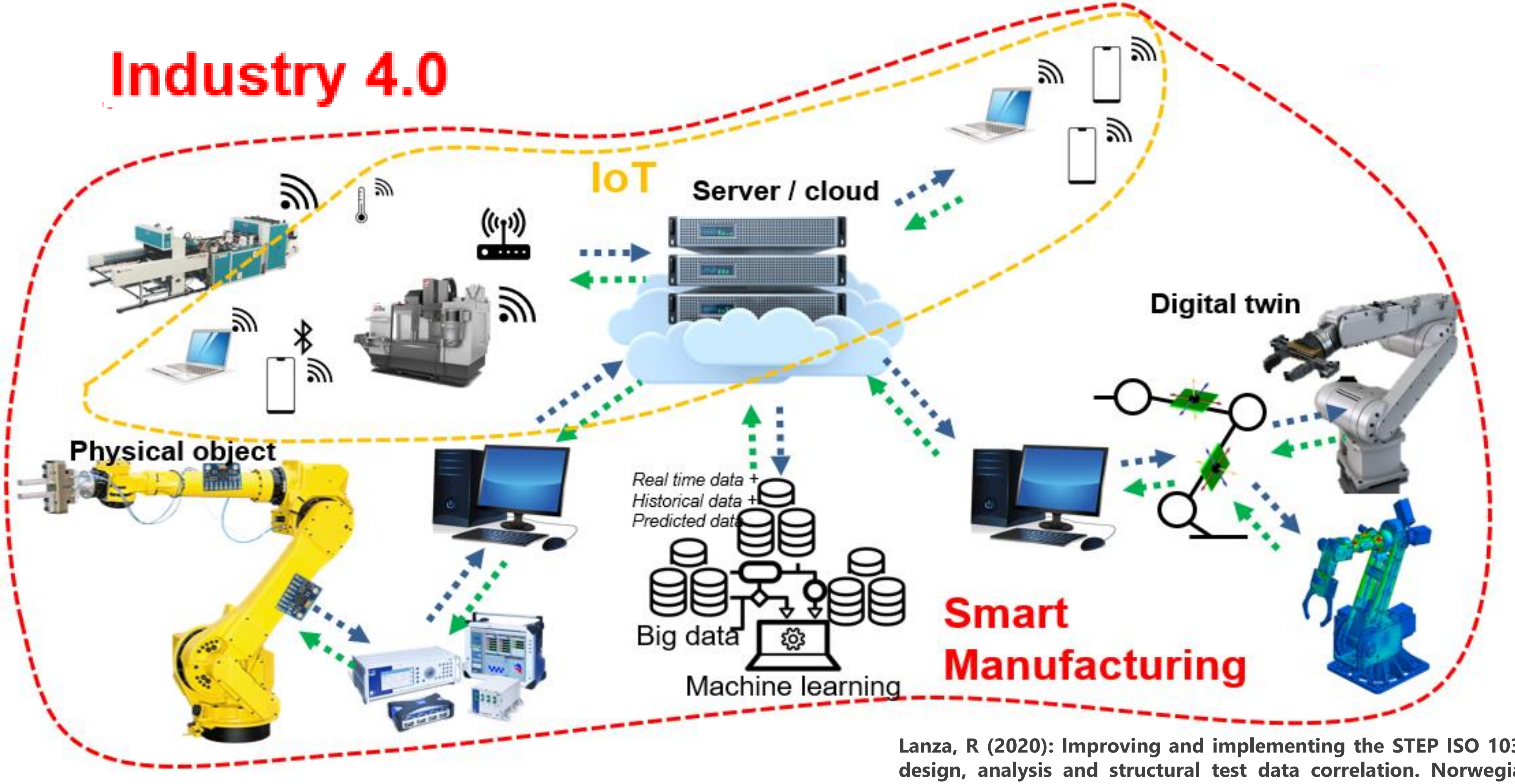
- BASED IN OSLO, NORWAY
- SPECIALIZED IN PRODUCT DATA EXCHANGE AND SHARING
- HTTPS://JOTNEIT.NO/

Smart Manufacturing



Lanza, R (2020): Improving and implementing the STEP ISO 10303 standard for design, analysis and structural test data correlation. Norwegian University of Science and Technology.

Smart Manufacturing

Digital Twin Definitions

Two identical spaces physical and virtual, which allows the mirroring between them to analyze the condition that occur in all phases of the life cycle. ***(Rosen et al. 2015)***

An integrated multi-physics, multiscale, probabilistic simulation of a vehicle or system that uses the best available physical models, sensor updates, fleet history, and so forth, to mirror the life of its flying twin ***(Glaessgen and Stargel, 2012)***

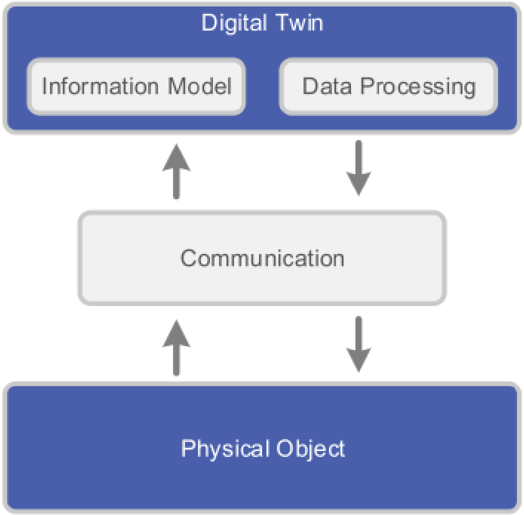
Physical product in real space, virtual product in virtual space and the connection of data and information that ties the two spaces together. (Information; describe the asset completely, geometry to behavior). ***(Grieves and Vickers, 2017)***

The digital twin of a real distributed product is a virtual mirror, which can describe the comprehensive physical and functional properties of the product throughout its life cycle and can deliver and receive product information ***(Tharma et al., 2018)***.

The term DT define the replica of a physical asset, process or system used for control and decision making. ***(Vatn, 2018)***

It is the virtual and computerized counterpart of a physical system. ***(Kritzinger, 2018)***

Errandonea, I.; Beltrán, S.; Arrizabalaga, S. (2020): Digital Twin for maintenance: A literature review. In *Computers in Industry* 123, p. 103316. DOI: 10.1016/j.compind.2020.103316.

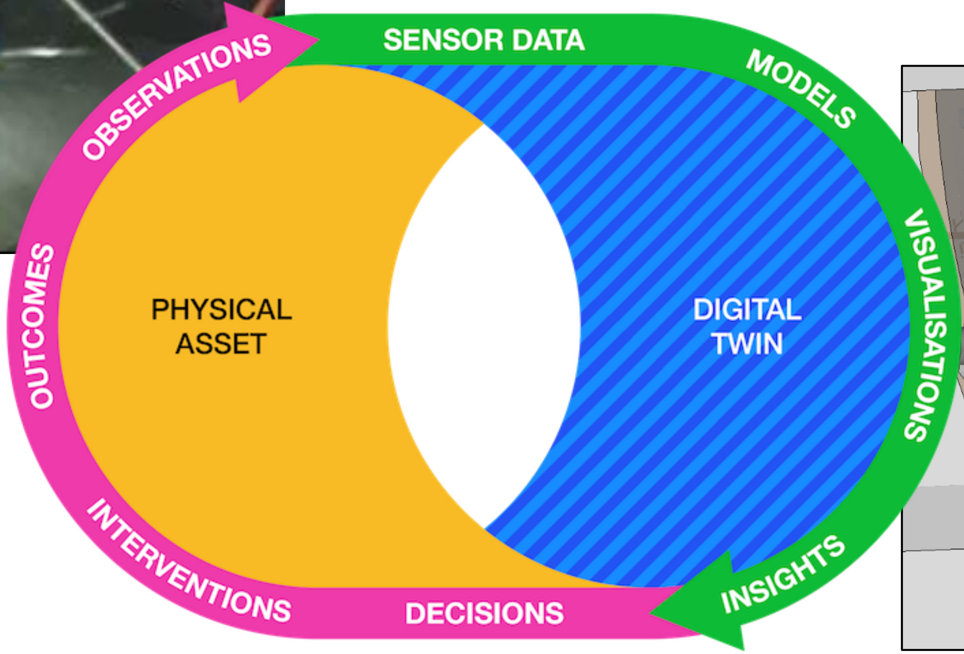


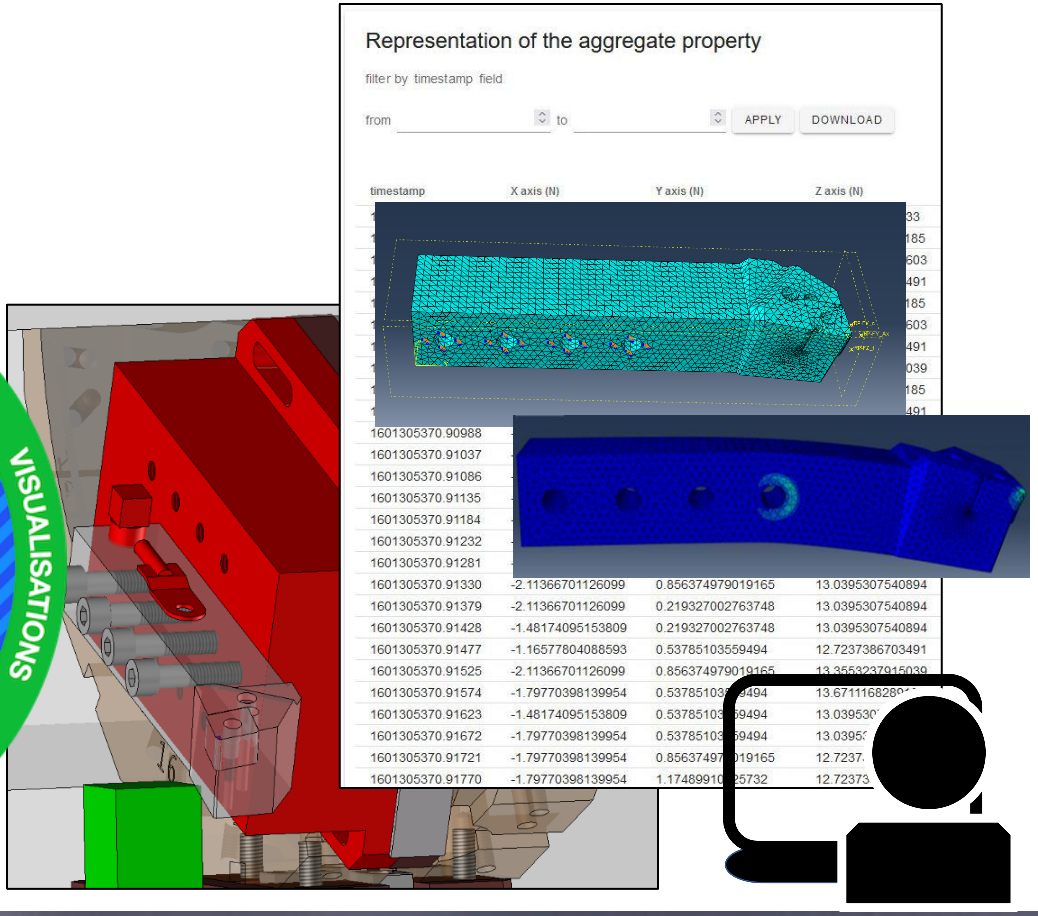
Lu, Y.; Liu, C.; Wang, K. I-K; Huang, H.; Xu, X. (2020): Digital Twin-driven smart manufacturing: Connotation, reference model, applications and research issues. In *Robotics and Computer-Integrated Manufacturing* 61, p. 101837. DOI: 10.1016/j.rcim.2019.101837.

Digital Twin

Physical process

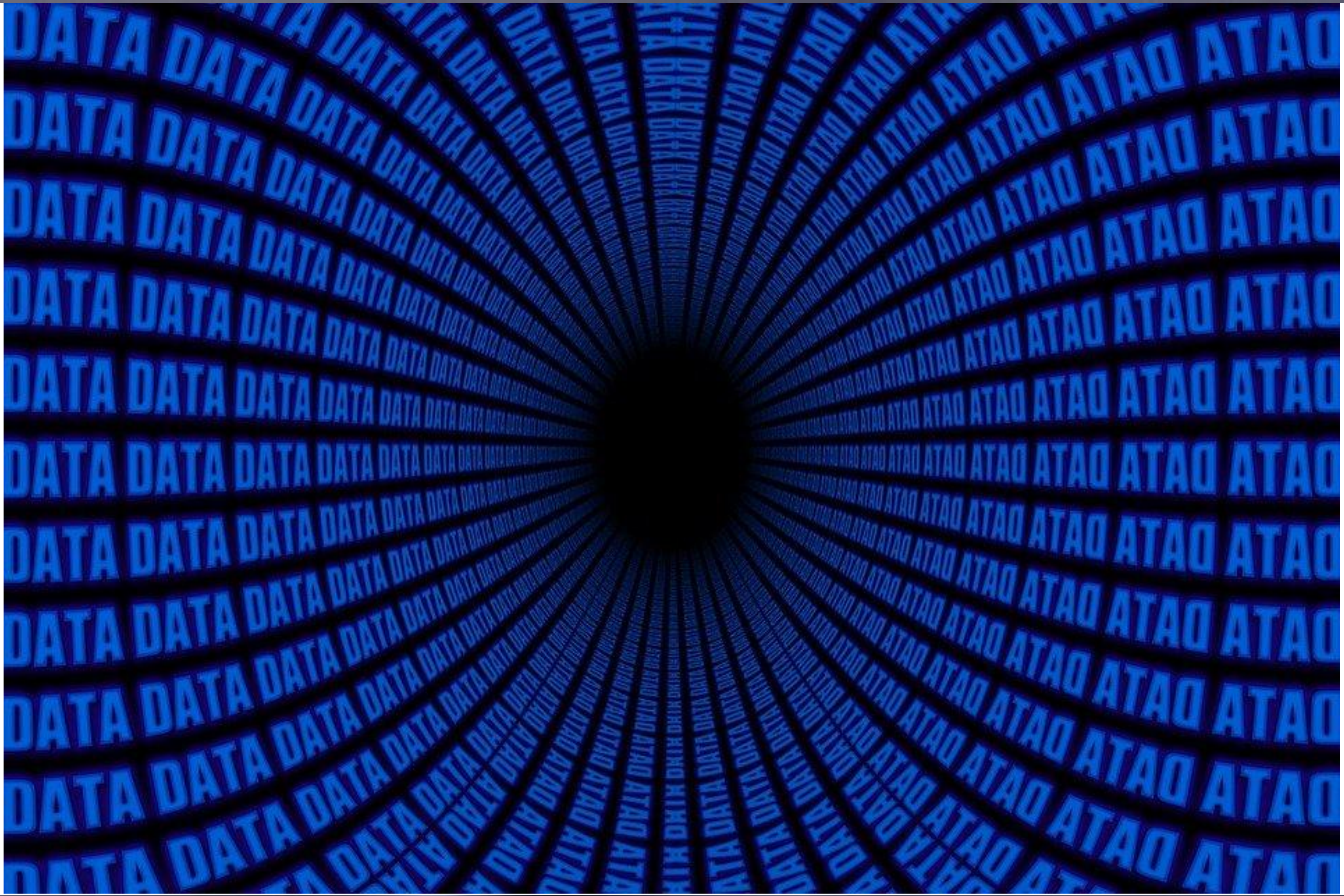
Digital Twin





O'Donnell, F. (2019): Sharing models between 'digital twins'. Open Data Institute. Available online at https://theodi.org/article/sharing-models-between-digital-twins/, checked on 8/27/2021.

Digital Twin



Digital Twin Applications

Complexity of Digital Twin

- **Monitor** component, asset, system, process, factory etc. in real-time
  - Understand what is happening
  - Visualize environment virtually
- **Simulate** and calculate different possible scenarios
  - Discover possible future problems
  - Try out new strategies before deployment
- **Optimize** the whole manufacturing process
  - Optimize processes, products, services, supply chain…
  - Monitor and simulate loop → optimize
- **Predict** with "smart use of available data"; machine learning etc.
  - Identify problems before they occur -> *Predictive maintenance*
  - Predict new possible problems
  - Predict possible outcomes
- **Customized manufacturing**
  - Relate custom customer needs with factory equipment

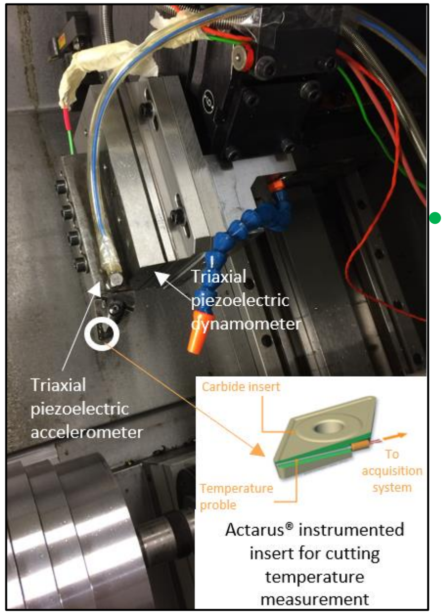
Lanza, R (2020): Improving and implementing the STEP ISO 10303 standard for design, analysis and structural test data correlation. Norwegian University of Science and Technology.

Implementation challenges

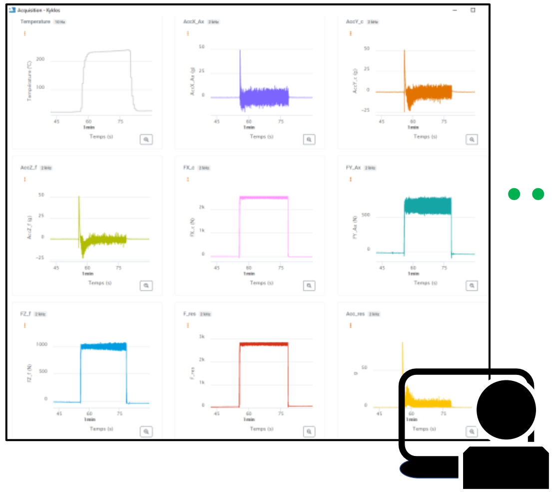
- To exchange different information in a consistent format
- Diverse communication standards
- Heterogeneous data structures and interfaces
- To store data over the entire lifecycle of a product / process

This work

Instrumented Physical Process



TWS Acquisition Software

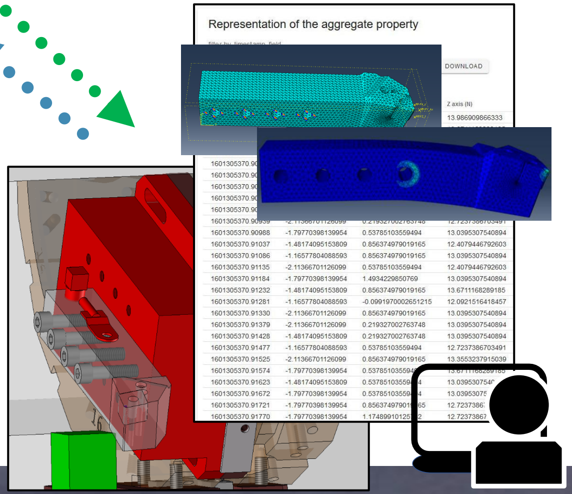


TWS PLM

EDMtruePLM ISO 10303 Repository

Digital Twin

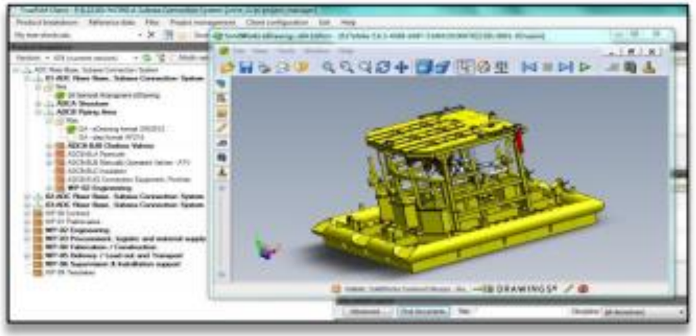
- 3D CAD Models
- Simulation Models
- Simulation Analysis
- Sensor Data
- Documentation



Main Elements of the framework

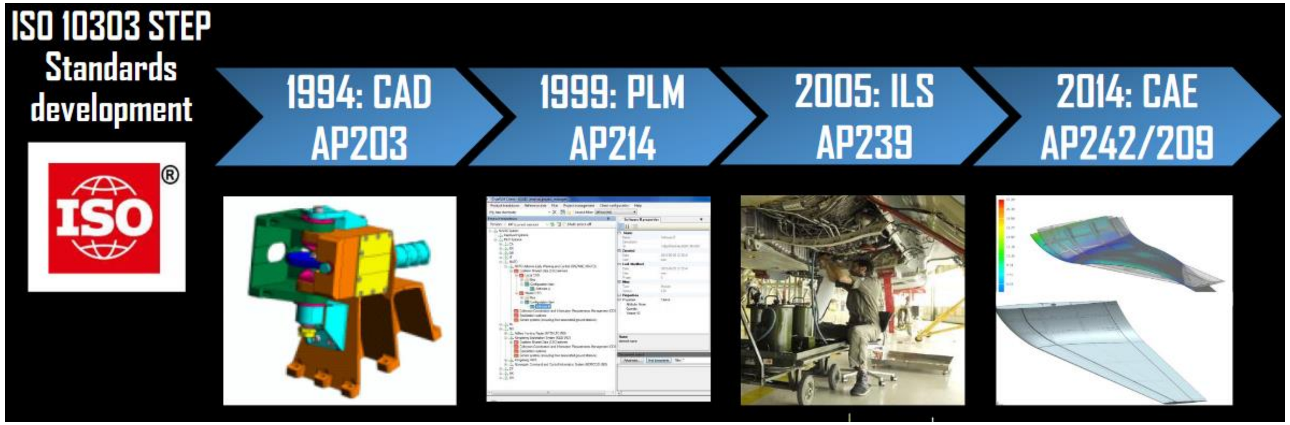
EDMtruePLM

- Product Lifecycle Management platform
- Developed by Jotne
- Based on ISO 10303
- Product model server for integrating, storing, and accessing product related information



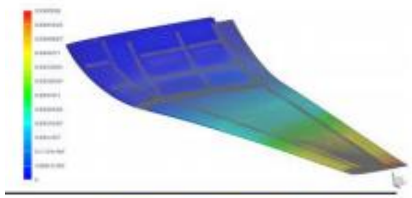
MAIN ELEMENTS OF THE FRAMEWORK

ISO 10303 STEP STANDARD



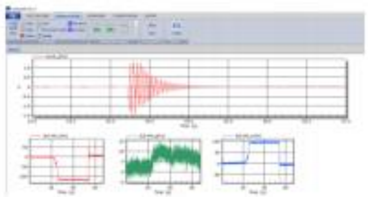
- HOW TO REPRESENT AND EXCHANGE DIGITAL PRODUCT INFORMATION
- WIDE RANGE OF PRODUCT-RELATED DATA
- ENTIRE LIFE-CYCLE OF A PRODUCT

Design CAD

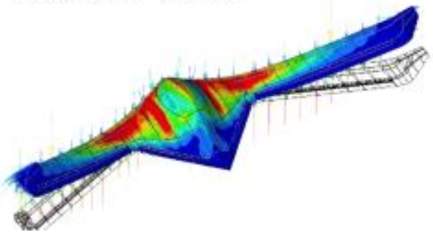


Analysis FEM

Manufacturing



Sensor data



Main elements of the framework

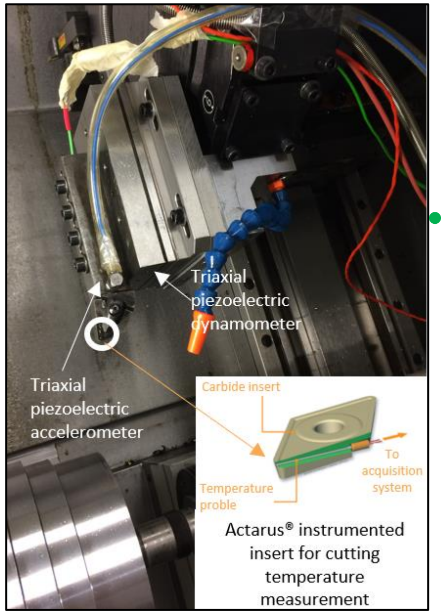
TWS ACQUISITION

- DATA ACQUISITION SOFTWARE
- DEVELOPED BY CIRTES
- SYNCHRONIZED RECORDING FROM SEVERAL HARDWARE INPUTS
- REAL TIME COMPUTATION ON DATA AND VISUALIZATION TOOLS

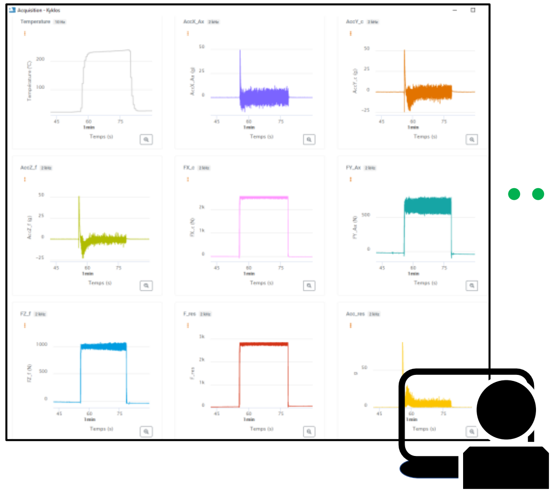
	A	B
1	Vibration Axe X	
2		
3	Temps (s)	Vibration Axe X (g)
4	8 164,0	- 3,55627
5	8 165,0	- 3,73978
6	8 166,0	- 3,54294
7	8 167,0	- 3,50513
8	8 168,0	- 3,58419
9	8 169,0	- 3,70764
10	8 170,0	- 3,57542
11	8 171,0	- 3,68112
12	8 172,0	- 3,65838
13	8 173,0	- 3,66714
14	8 174,0	- 3,62891
15	8 175,0	- 3,69363

Main elements of the framework

Instrumented Physical Process



TWS Acquisition Software



TWS PLM

REST APIs

EDMtruePLM ISO 10303 Repository

Digital Twin

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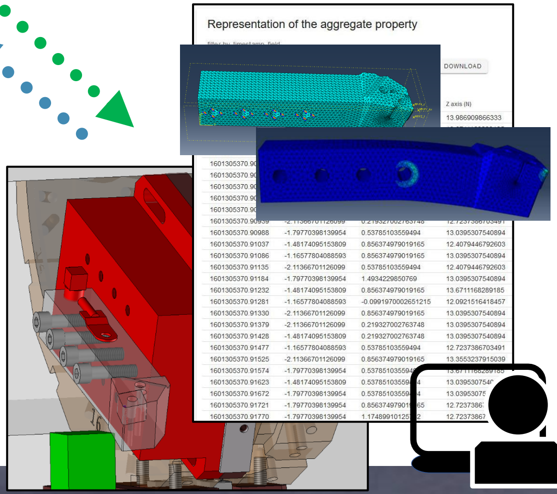
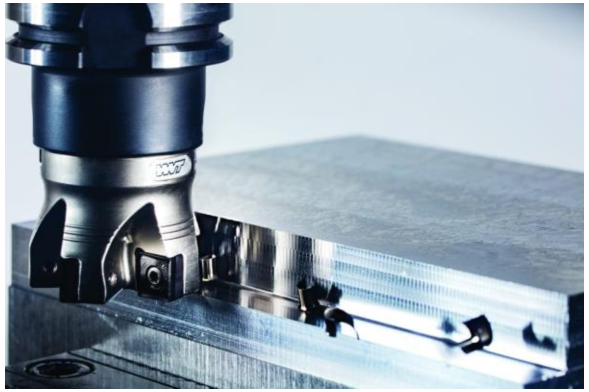


Machining

MACHINING IS THE PROCESS OF CUTTING, SHAPING, OR REMOVING MATERIAL FROM A WORKPIECE USING A MACHINE TOOL.

http://the-machining.com/



https://www.theengineer.co.uk/

https://www.thyssenkrupp-materials.co.uk/

ACCORDING TO THE BEROE INC REPORT FROM 2019, THE GLOBAL MACHINING MARKET IS CURRENTLY ESTIMATED TO BE WORTH $341.91 BILLION AND GROWING AT A CAGR OF 6-7% THROUGH 2022

Beroe Inc (2019): Machining Market to Reach $414.17 Billion by 2022, Says Beroe Inc, 10/16/2019. Available online at https://www.prnewswire.com/news-releases/machining-market-to-reach-414-17-billion-by-2022--says-beroe-inc-300939464.html, checked on 7/8/2021.

Machining

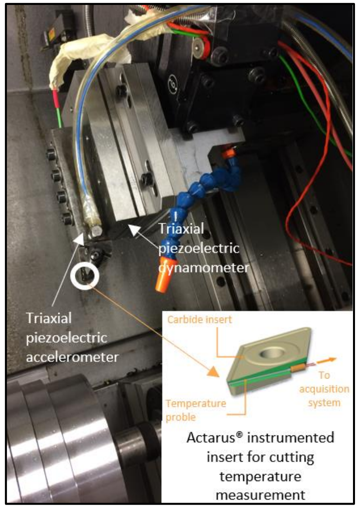
- Highly dynamic process
- Harsh environement
- Limited process information
- Necessity of models
- Integration of models and data

https://prototechasia.com/

The framework

- Instrumented product
- Real product modeling
- Click 1 - Upload
- Click 2 – Mount sensors
- Click 3 - Configure
- Digital Twin of product

Instrumented Physical Process



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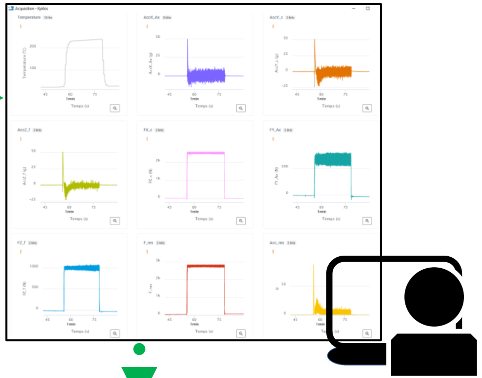

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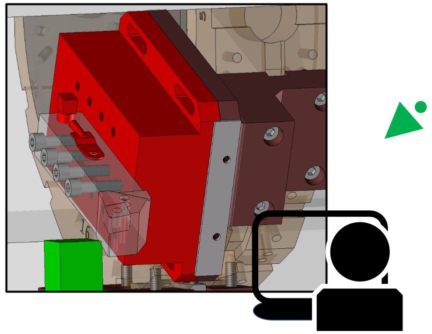
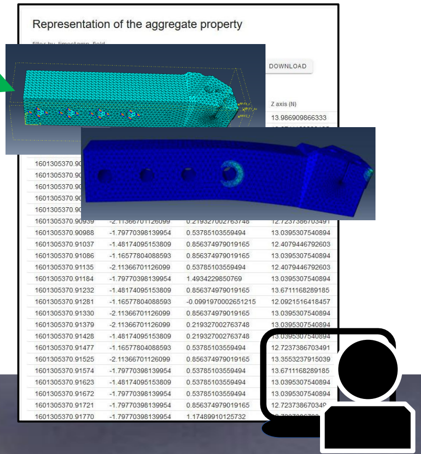


Digital Twin

- 3D CAD Models
- Simulation Models
- Simulation Analysis
- Sensor Data
- Documentation



Use Case demonstration

The Framework

- Instrumented product
- Real product modeling
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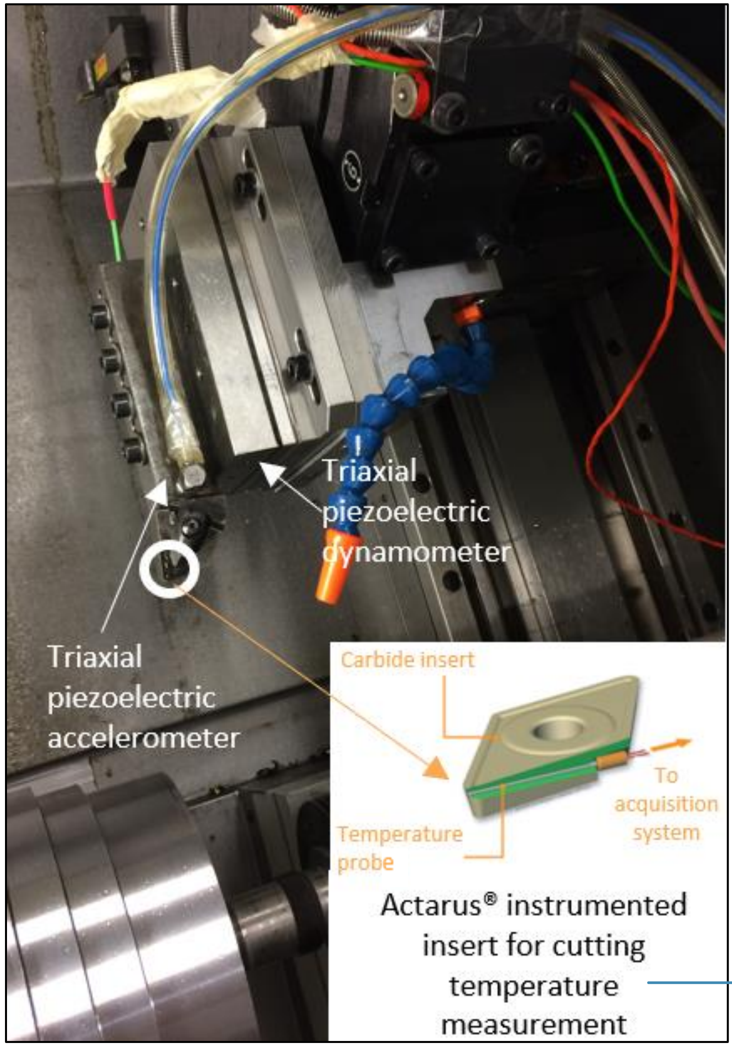
Instrumented product



Materials	
Machine	Spinner TC600 65M
Machining operation	Turning
Tool	DCLNL 3232 P16 tool holder and Sandivik CNMG 16 06 16-PR 4305 insert
Workpiece	Z38CDV5 (AFNOR) tool steel.
Lubrification	External lubrication with S-Aero Fluch soluble oil
Temperature measurement	Actarus® system developed by Cirtes
Cutting forces measurement	Kistler 9257B triaxial piezoelectric dynamometer
Vibration measurement	Kistler 8763B accelerometer
Video image acquisition	M-ONE Mini DV camera Full HD 1920x1080
Acquisition Software	TWS Suite®

Barlier, C.; Lescalier, C.; Mosian, A. (1997): Continuous Flank Wear Measurement of Turning Tools by Integrated Microthermocouple. In *CIRP Annals* 46 (1), pp. 35–38. DOI: 10.1016/S0007-8506(07)60770-7.

Use Case demonstration

The Framework

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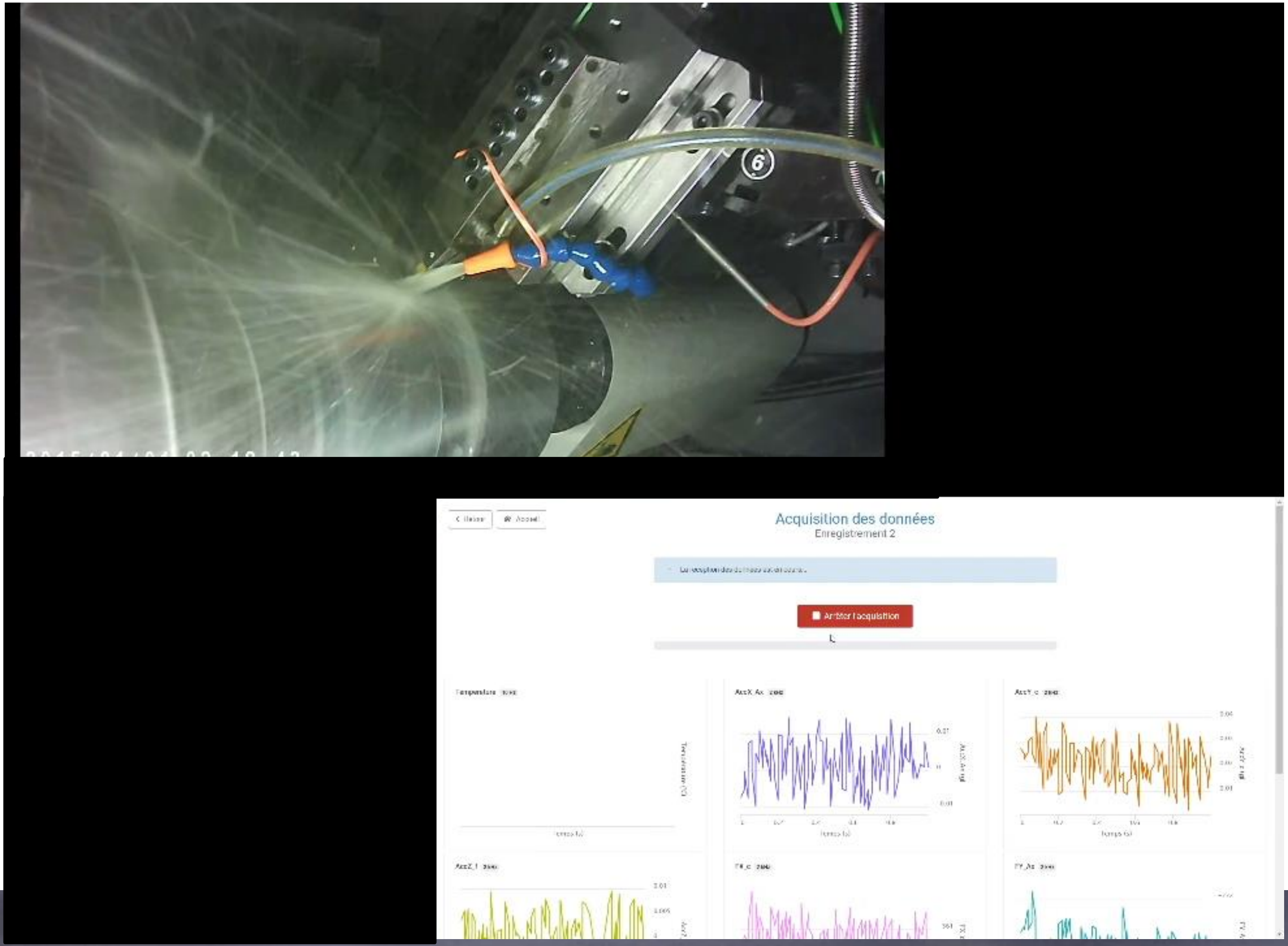
Instrumented product



Use Case demonstration

The Framework

Instrumented product

Real product modeling

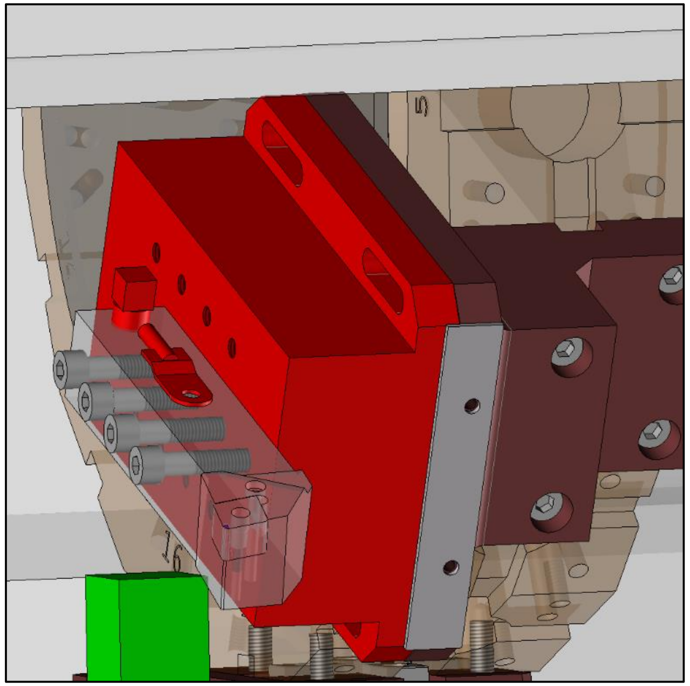
Click 1 - Upload

Click 2 – Mount sensors

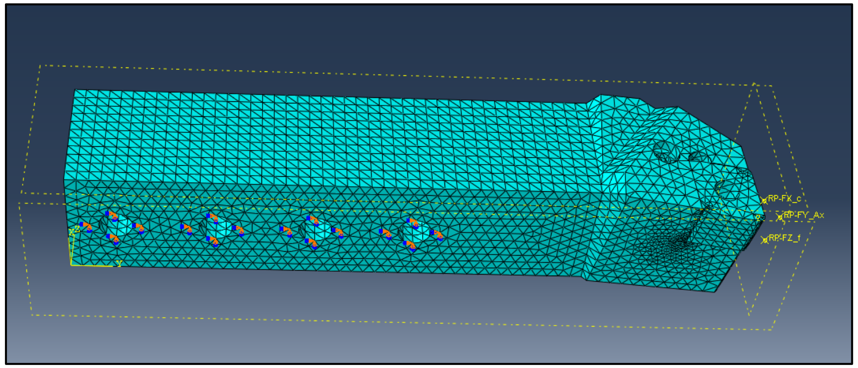
Click 3 - Configure

Digital Twin of product

3D models of the product using a CAD software TopSolid



Finite Element models of the product using FE software Abaqus

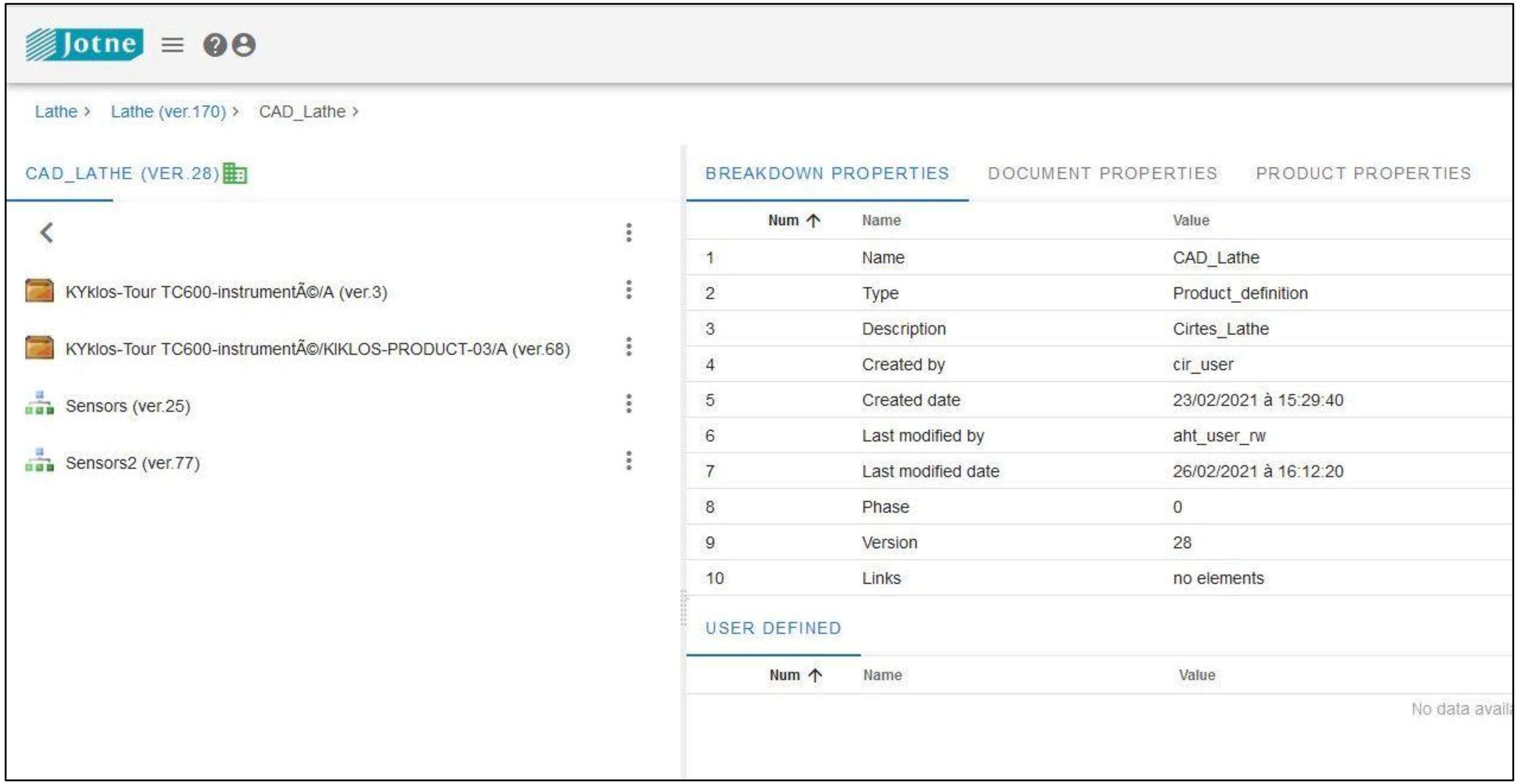


Use Case demonstration

The Framework

- Instrumented product
- Real product modeling
- **Click 1 - Upload**
- Click 2 – Mount sensors
- Click 3 - Configure
- Digital Twin of product

Automatic breakdown structure based on the CAD model



Use Case demonstration

The Framework

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Sensors of the product

Jotne

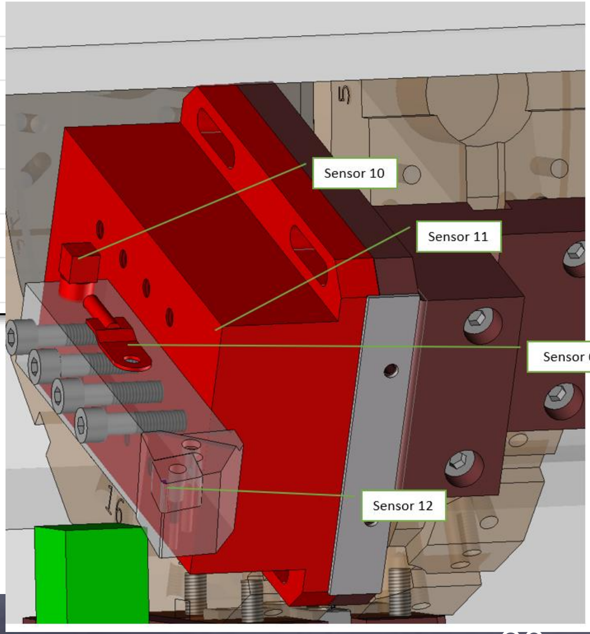
Lathe › Lathe (ver.170) › CAD_Lathe ›

SENSORS2 (VER.77)

- Sensor 1 (ver.148)
- Sensor 10 (ver.168)
- **Sensor 11 (ver.169)**
- Sensor 12 (ver.170)

BREAKDOWN PROPERTIES | DOCUMENT PROPERTIES | PRODUCT PROPERTIES

Num ↑	Name	Value
1	Name	Sensor 11
2	Type	Force 4 values sensor
3	Description	Sensor 11
4	Created by	aht_user_rw
5	Created date	29/03/2021 à 12:24:07
6	Last modified by	cir_user
7	Last modified date	19/04/2021 à 17:47:25



Use Case demonstration

The Framework

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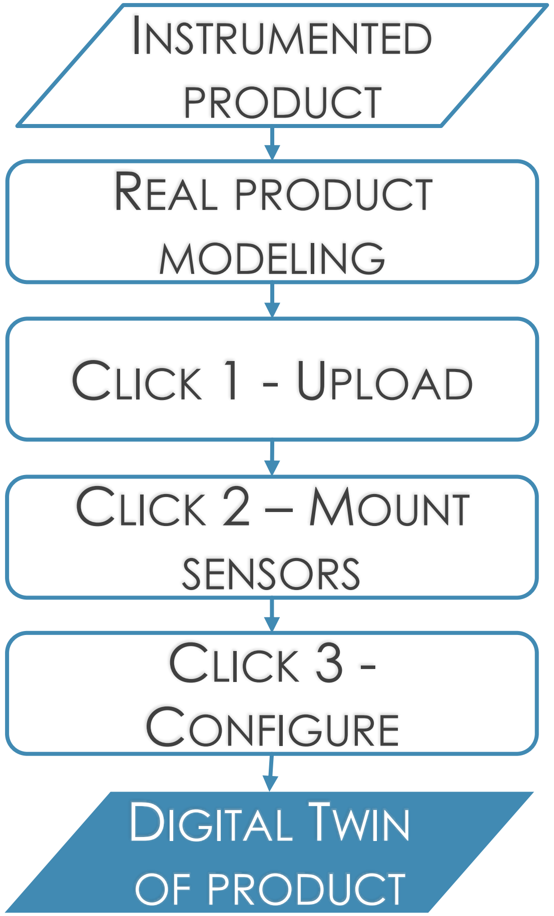
Configure communication between TWS Acquisition and EDMTruePLM

Use Case demonstration

The Framework



The Digital Twin

Representation of the aggregate property

filter by timestamp field

from ⬍ to ⬍ APPLY DOWNLOAD

timestamp	X axis (N)	Y axis (N)	Z axis (N)	combined (N)
1601305370.90500	-2.11366701126099	0.219327002763748	13.986909866333	
1601305370.90549	-1.48174095153809	0.219327002763748	13.6711168289185	
1601305370.90598	-1.79770398139954	0.53785103559494	12.4079446792603	
1601305370.90646	-1.79770398139954	0.53785103559494	12.7237386703491	
1601305370.90695	-2.11366701126099	0.219327002763748		
1601305370.90744	-1.16577804088593	0.53785103559494		
1601305370.90793	-1.79770398139954	0.53785103559494		
1601305370.90842	-2.42962980270386	0.856374979019165		
1601305370.90891	-1.16577804088593	0.53785103559494		
1601305370.90939	-2.11366701126099	0.219327002763748		
1601305370.90988	-1.79770398139954	0.53785103559494		
1601305370.91037	-1.48174095153809	0.856374979019165		
1601305370.91086	-1.16577804088593	0.856374979019165		
1601305370.91135	-2.11366701126099	0.53785103559494		
1601305370.91184	-1.79770398139954	1.4934229850769		
1601305370.91232	-1.48174095153809	0.856374979019165		
1601305370.91281	-1.16577804088593	-0.0991970002651215		
1601305370.91330	-2.11366701126099	0.856374979019165		
1601305370.91379	-2.11366701126099	0.219327002763748		
1601305370.91428	-1.48174095153809	0.219327002763748		
1601305370.91477	-1.16577804088593	0.53785103559494		
1601305370.91525	-2.11366701126099	0.856374979019165		
1601305370.91574	-1.79770398139954	0.53785103559494		
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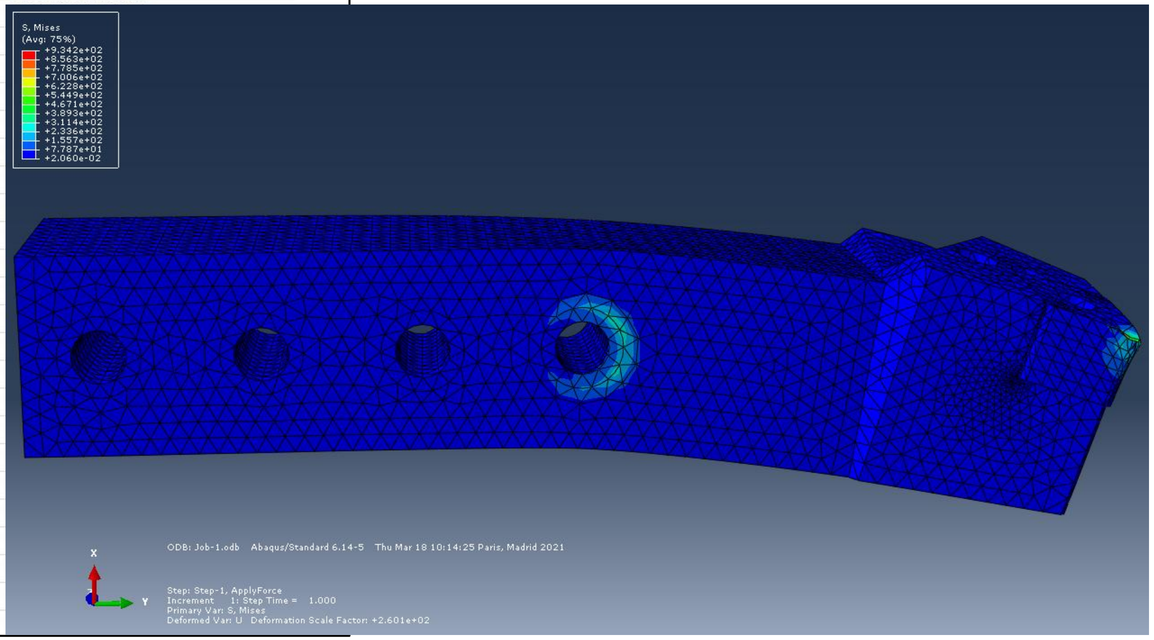
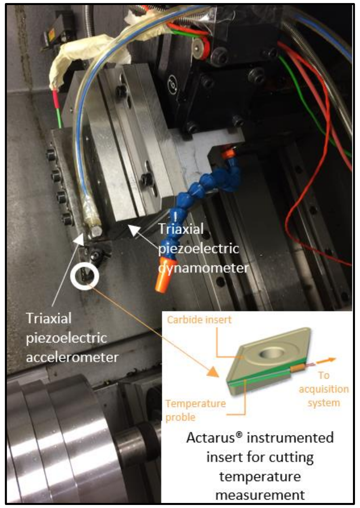
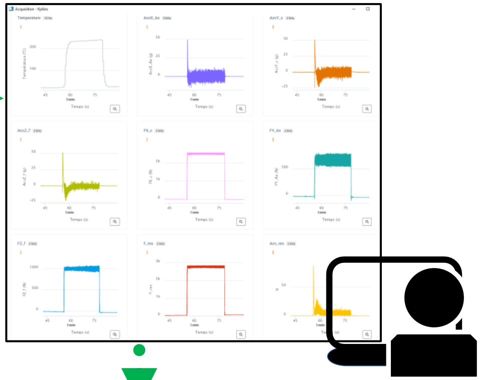


Conclusions

Instrumented Physical Process

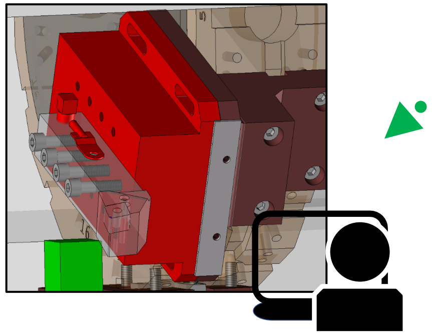


TWS Acquisition Software



TWS PLM

EDMtruePLM ISO 10303 Repository



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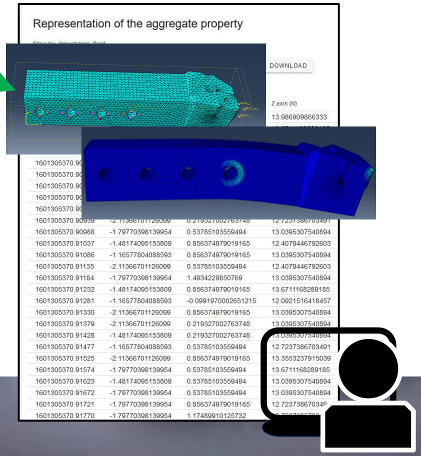

Digital Twin data cycle

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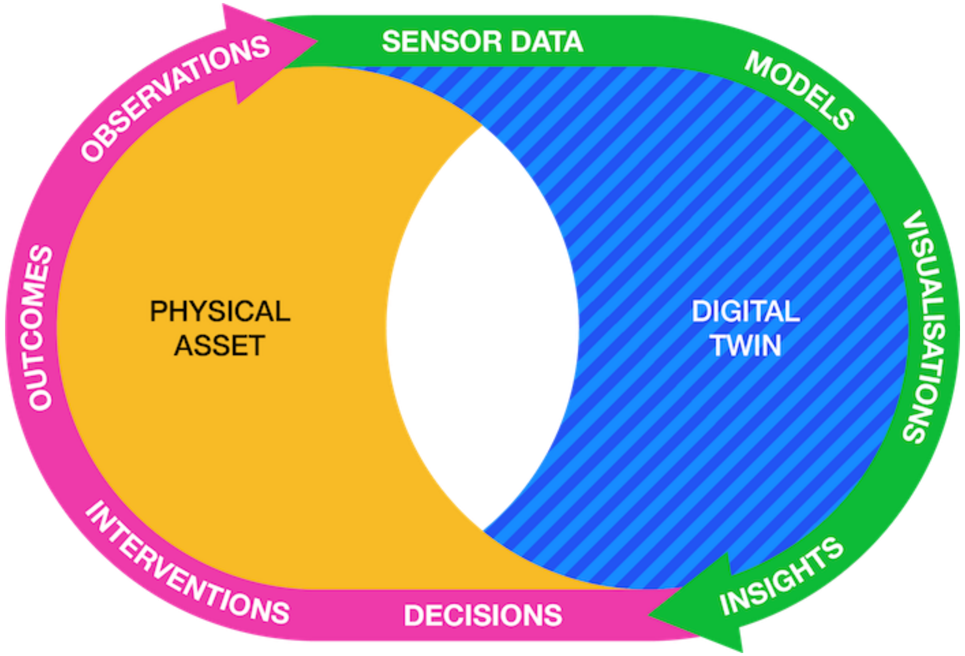

Future works

- Communication with Numerical Control systems of manufacturing machines.

- Data-driven artificial intelligence models

- Open standards approaches

"Need to develop appropriate standards and/or standard approaches so that Digital Twins can interact with other Digital Twins across the life cycle and supply chain. […] Therefore, additional focus and effort should also be given to addressing which elements of this foundation should be open."

AIAA Digital Engineering Integration Committee (2020): Digital Twin: Definition & Value. An AIAA and AIA Position Paper.

Contact Information

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recherche & développement

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Questions ?