

Create your Digital Twin in days, not months.

Application of a standard based framework for Digital Twin implementation

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KYKLOS 4.0



Supported by advanced EU H2020 projects

CIRTES



Engineering

Integration of Additive
Manufacturing and Machining
Monitoring



Products

Logiciels, machines et équipements



Development

Development of customized
business applications



Service

Manufacture of models, tools
Machining tests



Training

Training on Additive
Manufacturing and Advanced
Machining



R&D / Expertise

Contract research and business
expertise

Partners of the project



KYKLOS 4.0

[HTTPS://KYKLOS40PROJECT.EU/](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

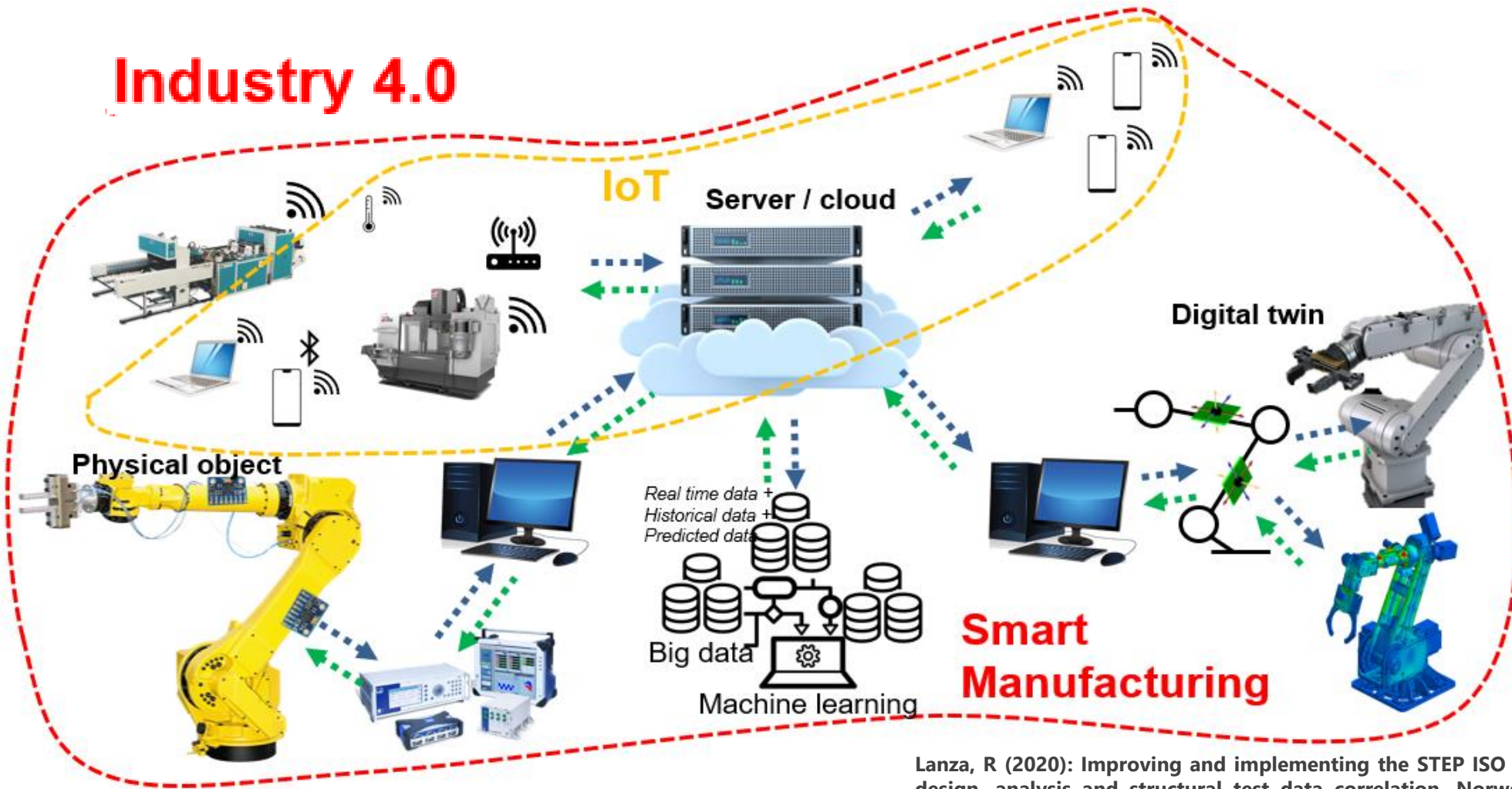
CIRTES
recherche & développement

- BASED IN SAINT DIÉ DES VOSGES, FRANCE
- SPECIALIZED IN ADVANCED MACHINING AND ADDITIVE MANUFACTURING
- [HTTPS://WWW.CIRTES.COM/](https://www.cirtes.com/)

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- BASED IN OSLO, NORWAY
- SPECIALIZED IN PRODUCT DATA EXCHANGE AND SHARING
- [HTTPS://JOTNEIT.NO/](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)**

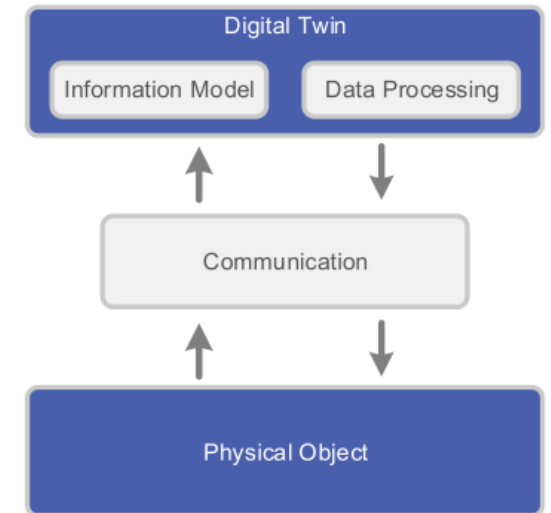
Physical product in real space, virtual product in virtual space and the connection of data and information that ties the two spaces together. (Information; describe the asset completely, geometry to behavior). **(Grieves and Vickers, 2017)**

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.



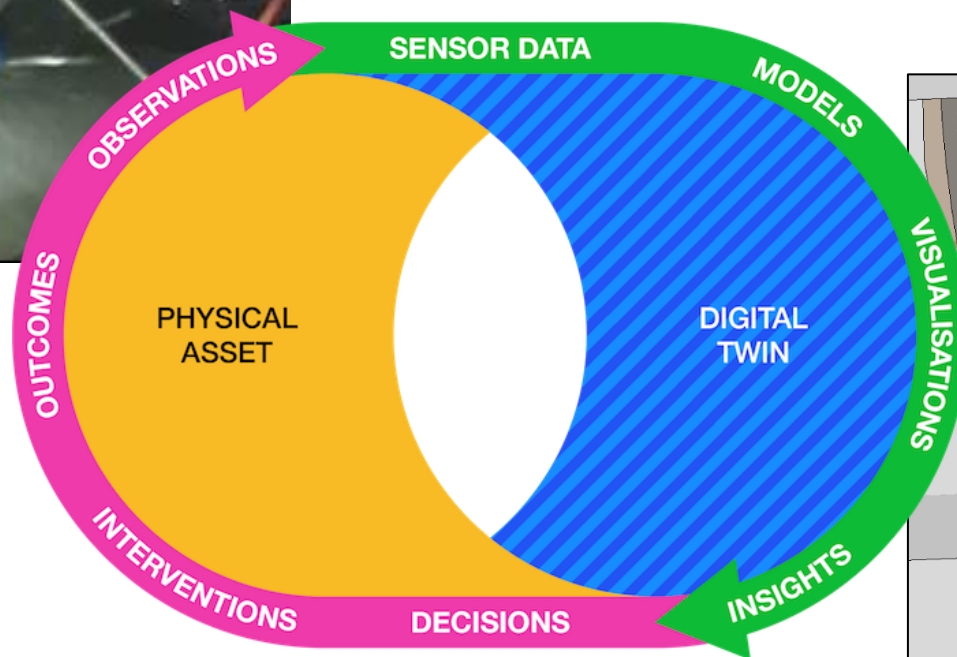
Lu, Y.; Liu, C.; Wang, K. I-K; Huang, H.; Xu, X. (2020): Digital Twin-driven smart manufacturing: Connotation, reference model, applications and research issues. In *Robotics and Computer-Integrated Manufacturing* 61, p. 101837. DOI: 10.1016/j.rcim.2019.101837.

Digital Twin

PHYSICAL PROCESS



DIGITAL TWIN

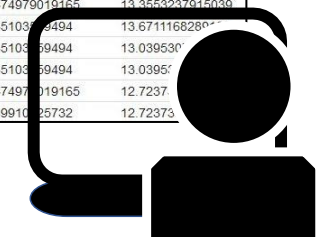
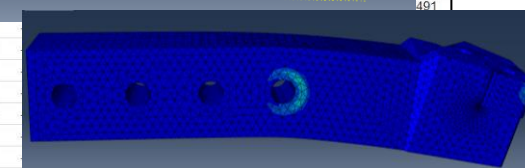
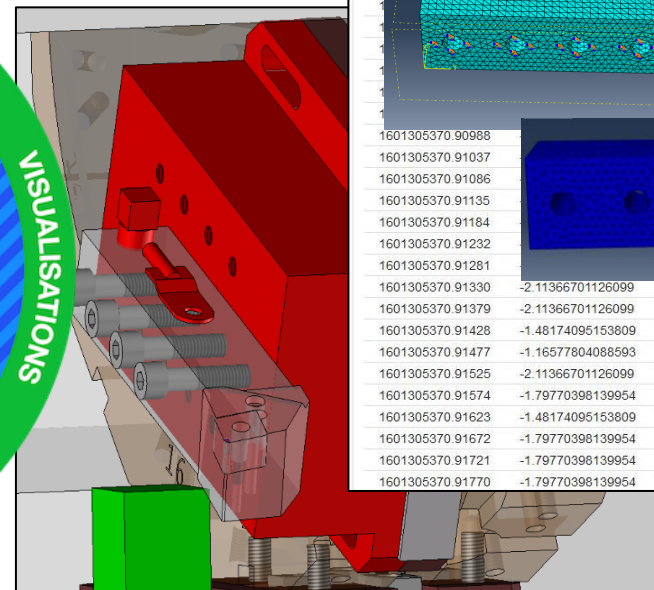


Representation of the aggregate property

filter by timestamp field

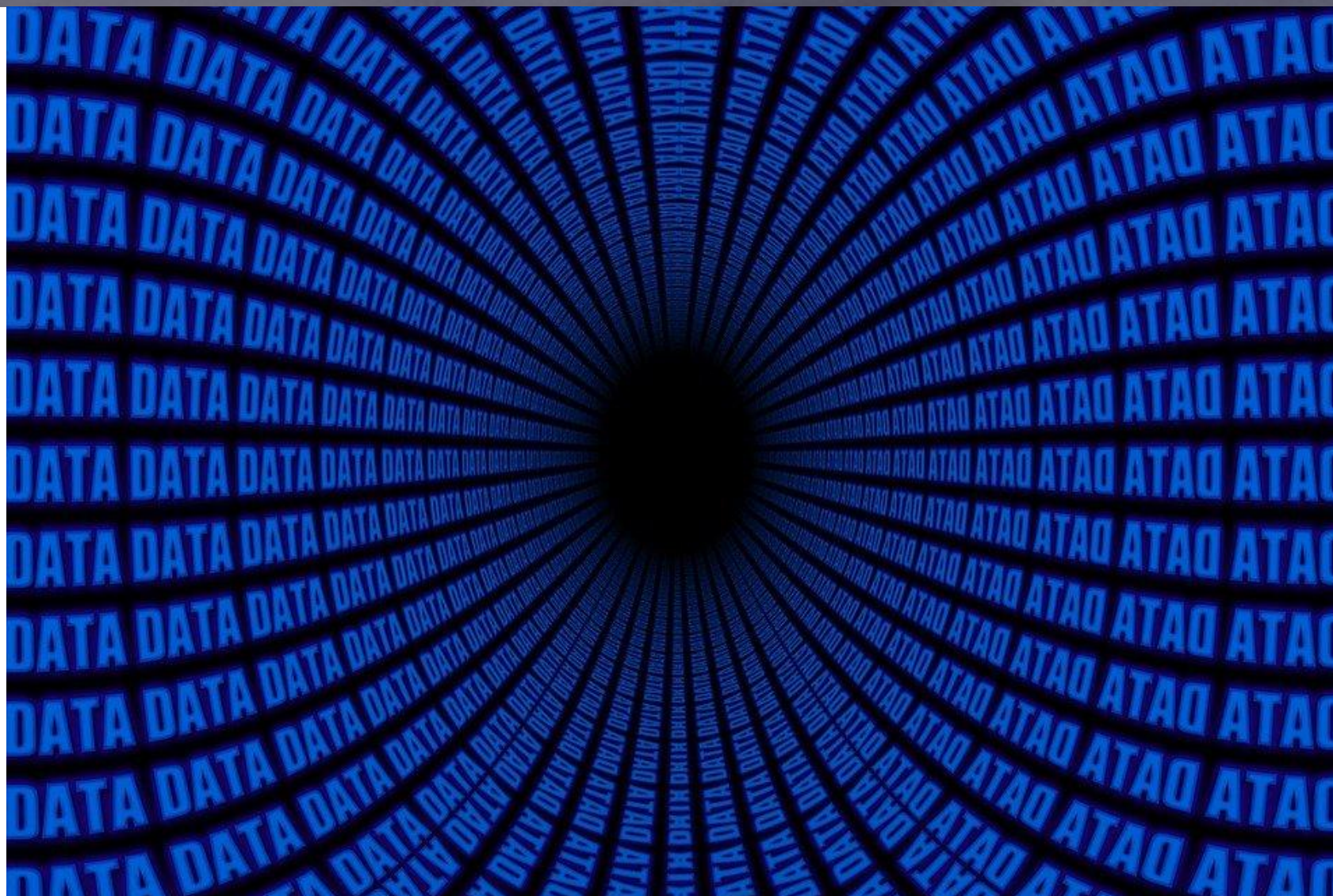
from to

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1601305370.91037			
1601305370.91086			
1601305370.91135			
1601305370.91184			
1601305370.91232			
1601305370.91281			
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1601305370.91770	-1.79770398139954	1.17489910225732	12.7237386703491



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

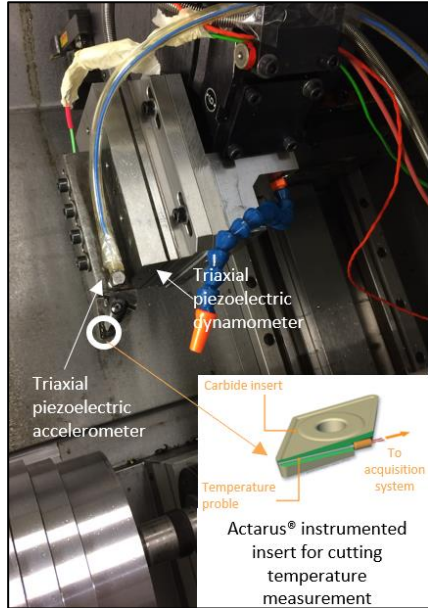
Lanza, R (2020): Improving and implementing the STEP ISO 10303 standard for design, analysis and structural test data correlation. Norwegian University of Science and Technology.

Implementation challenges

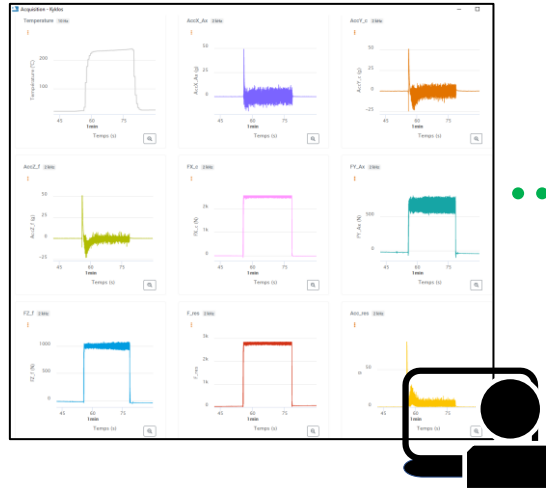
- TO EXCHANGE DIFFERENT INFORMATION IN A CONSISTENT FORMAT
- DIVERSE COMMUNICATION STANDARDS
- HETEROGENEOUS DATA STRUCTURES AND INTERFACES
- TO STORE DATA OVER THE ENTIRE LIFECYCLE OF A PRODUCT / PROCESS

This work

INSTRUMENTED PHYSICAL PROCESS



TWS ACQUISITION SOFTWARE



TWS PLM

EDMTRUEPLM ISO 10303 REPOSITORY

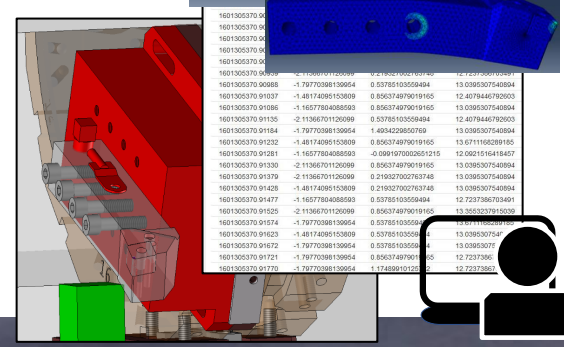


DIGITAL TWIN

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

Representation of the aggregate property

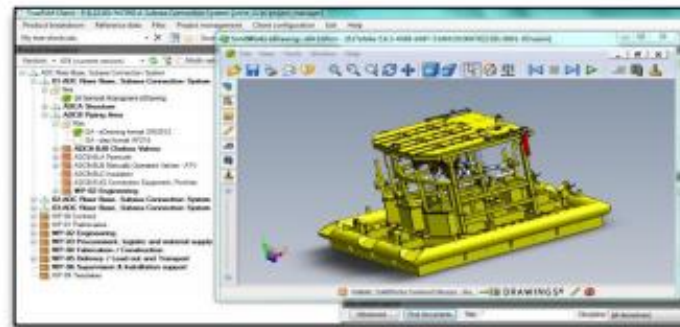
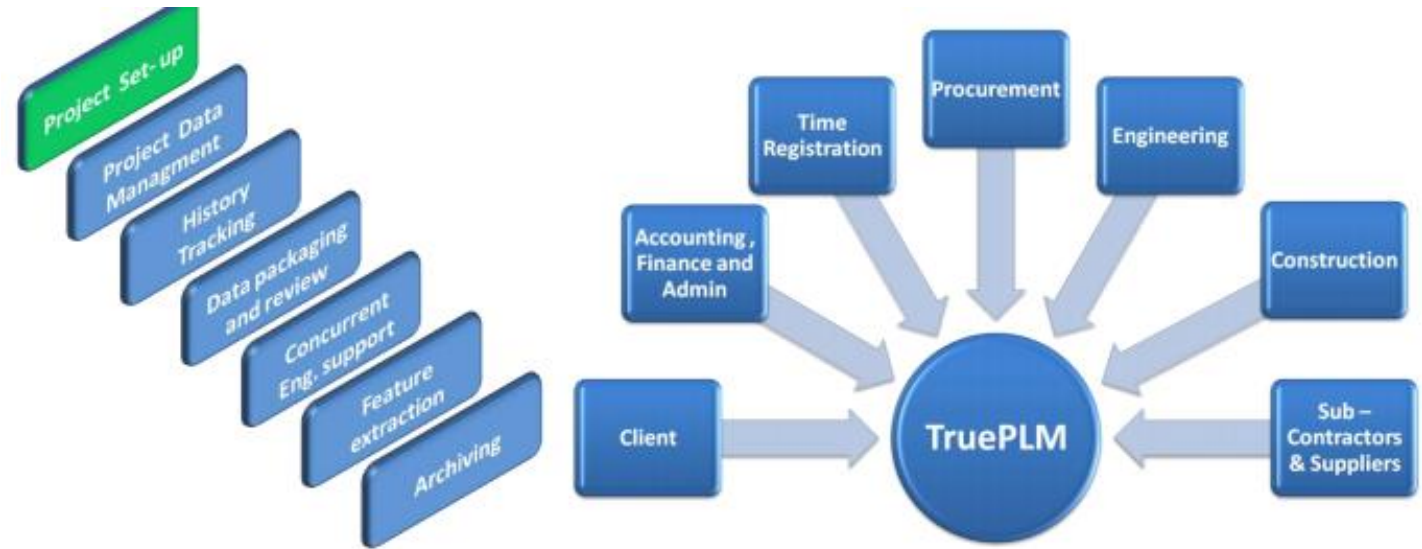
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Main Elements of the framework

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

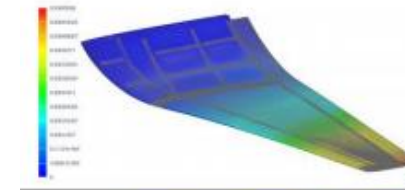
ISO 10303 STEP STANDARD



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



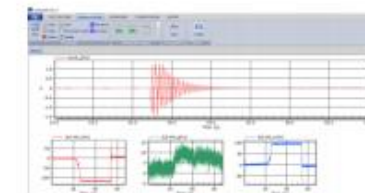
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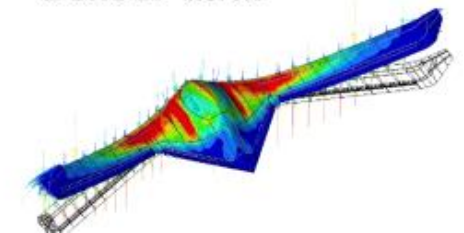
Analysis FEM



Manufacturing



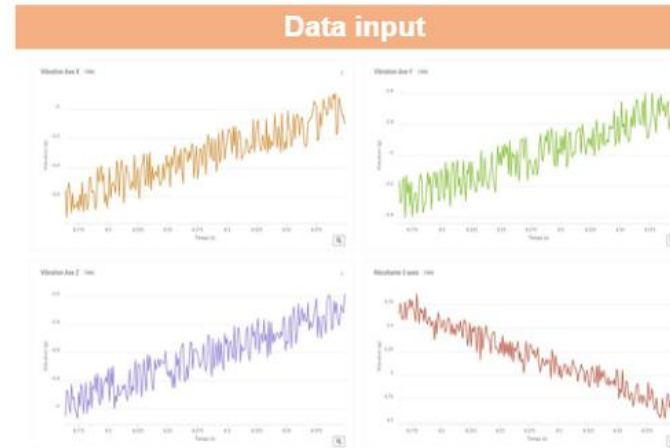
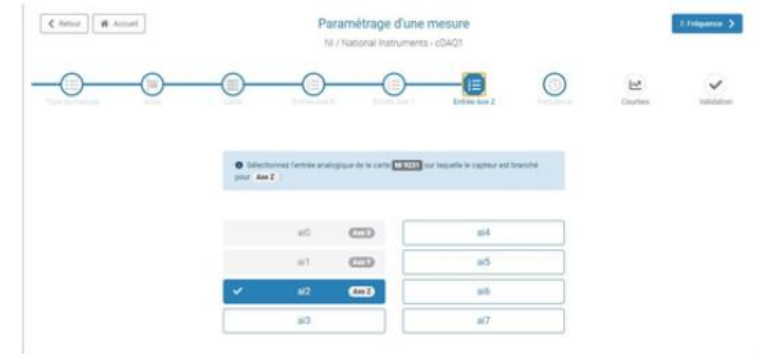
Sensor data



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



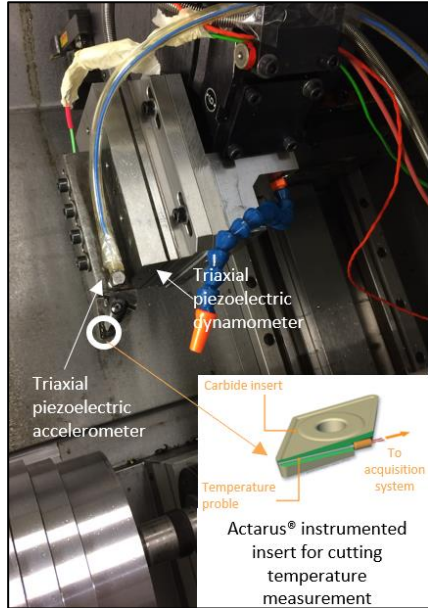
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1	Vibration Axe X					
2						
3	Temps (s)	Vibration Axe X (g)				
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5	8 165,0	- 3,73978				
6	8 166,0	- 3,54294				
7	8 167,0	- 3,50513				
8	8 168,0	- 3,58419				
9	8 169,0	- 3,70764				
10	8 170,0	- 3,57542				
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Curves display

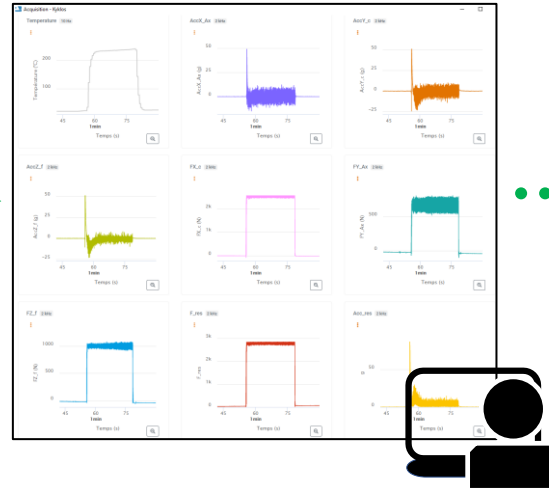
Data spreadsheet export

Main elements of the framework

INSTRUMENTED PHYSICAL PROCESS



TWS ACQUISITION SOFTWARE



TWS
PLM
REST APIs

EDMTRUEPLM ISO 10303 REPOSITORY



DIGITAL TWIN

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

Representation of the aggregate property

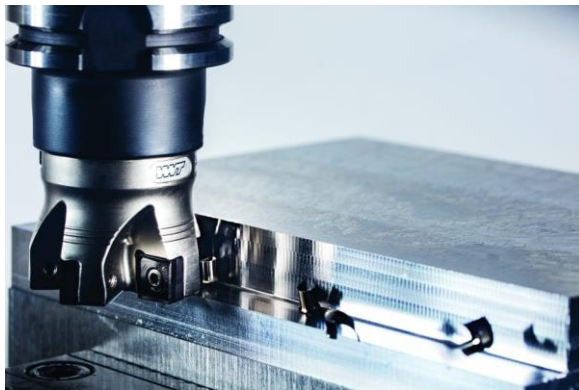
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Machining

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.

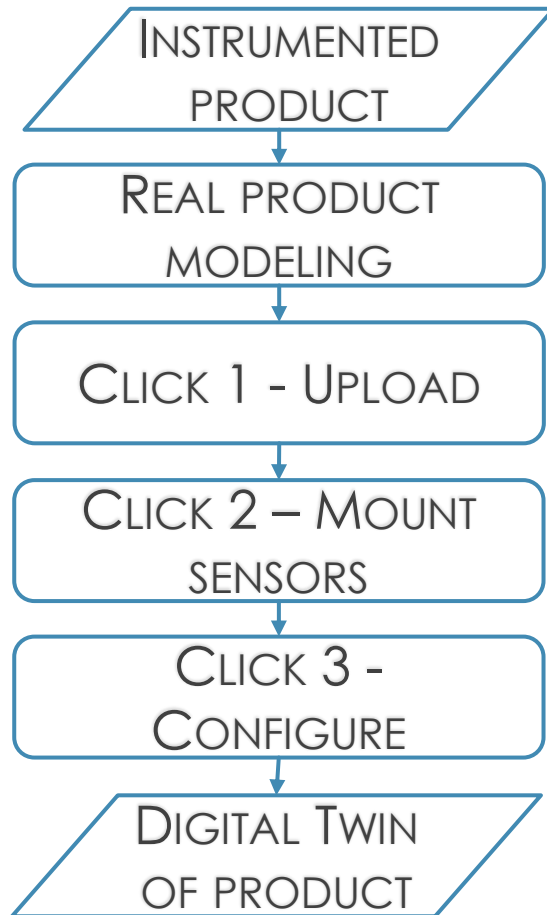
Machining

- HIGHLY DYNAMIC PROCESS
- HARSH ENVIRONNEMENT
- LIMITED PROCESS INFORMATION
- NECESSITY OF MODELS
- INTEGRATION OF MODELS AND DATA

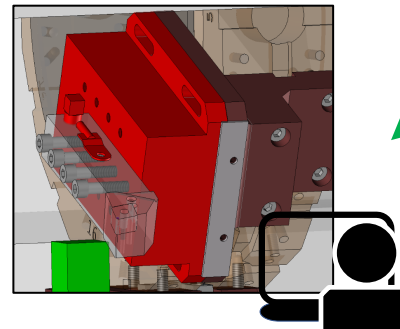
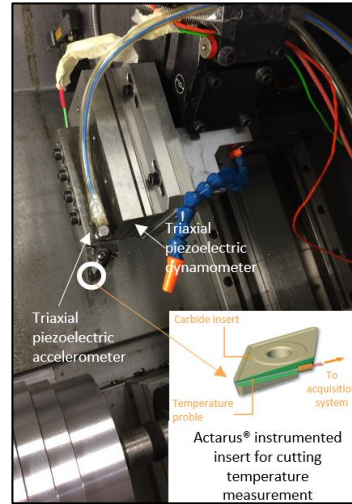


<https://prototechasia.com/>

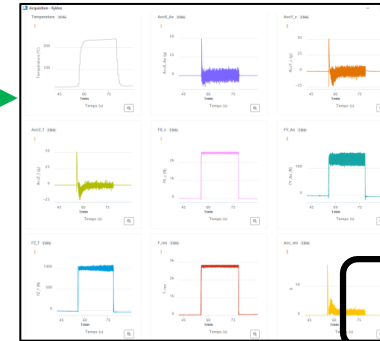
The framework



INSTRUMENTED PHYSICAL PROCESS



TWS ACQUISITION SOFTWARE



TWS PLM

EDMTRUEPLM ISO 10303 REPOSITORY

DIGITAL TWIN

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

Representation of the aggregate property

DOWNLOAD

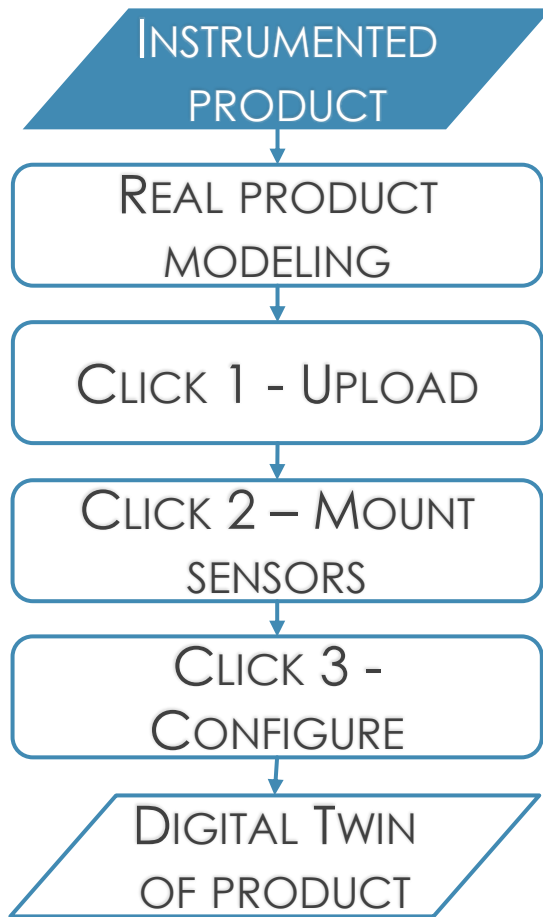
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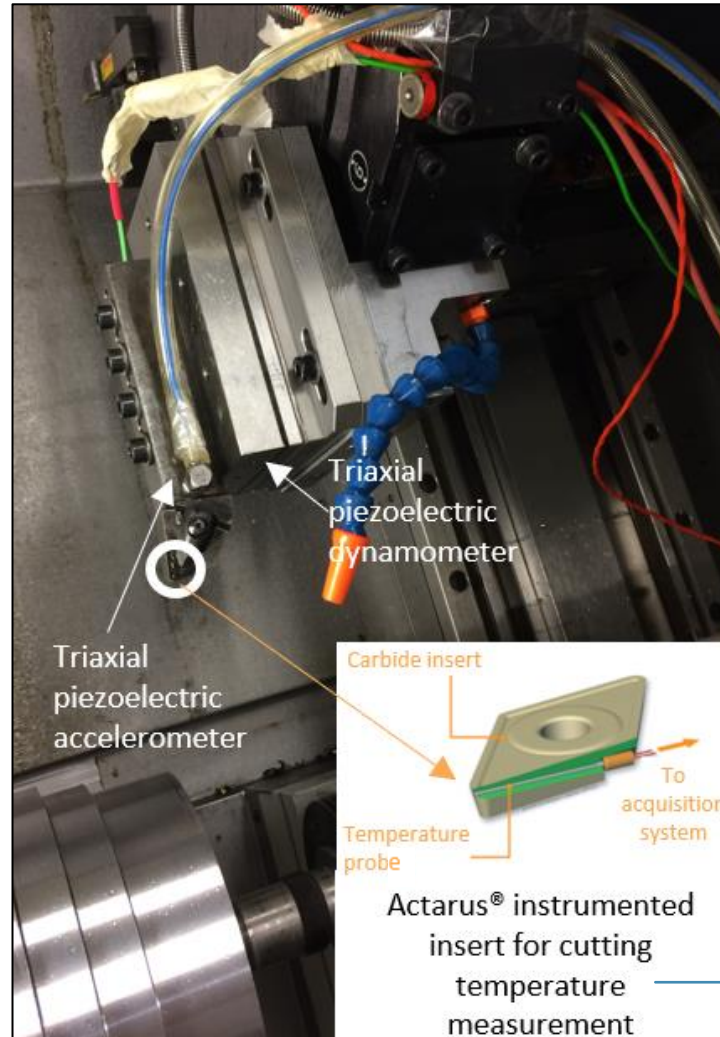
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1601300370 010036	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010037	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010038	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010039	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010040	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010041	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010042	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010043	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010044	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010045	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010046	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010047	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010048	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010049	-1.78770398139064	0.5376510359484	13.038507648084
1601300370 010050	-1.78770398139064	0.5376510359484	13.038507648084

Use Case demonstration

THE FRAMEWORK



INSTRUMENTED PRODUCT

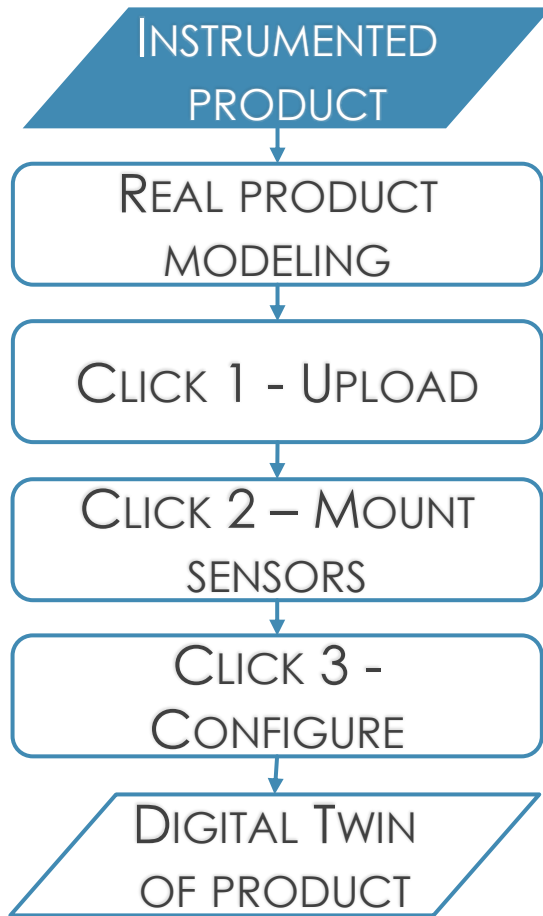


Materials	
Machine	Spinner TC600 65M
Machining operation	Turning
Tool	DCLNL 3232 P16 tool holder and Sandvik CNMG 16 06 16-PR 4305 insert
Workpiece	Z38CDV5 (AFNOR) tool steel.
Lubrication	External lubrication with S-Aero Fluch soluble oil
Temperature measurement	Actarus® system developed by Cirtes
Cutting 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®

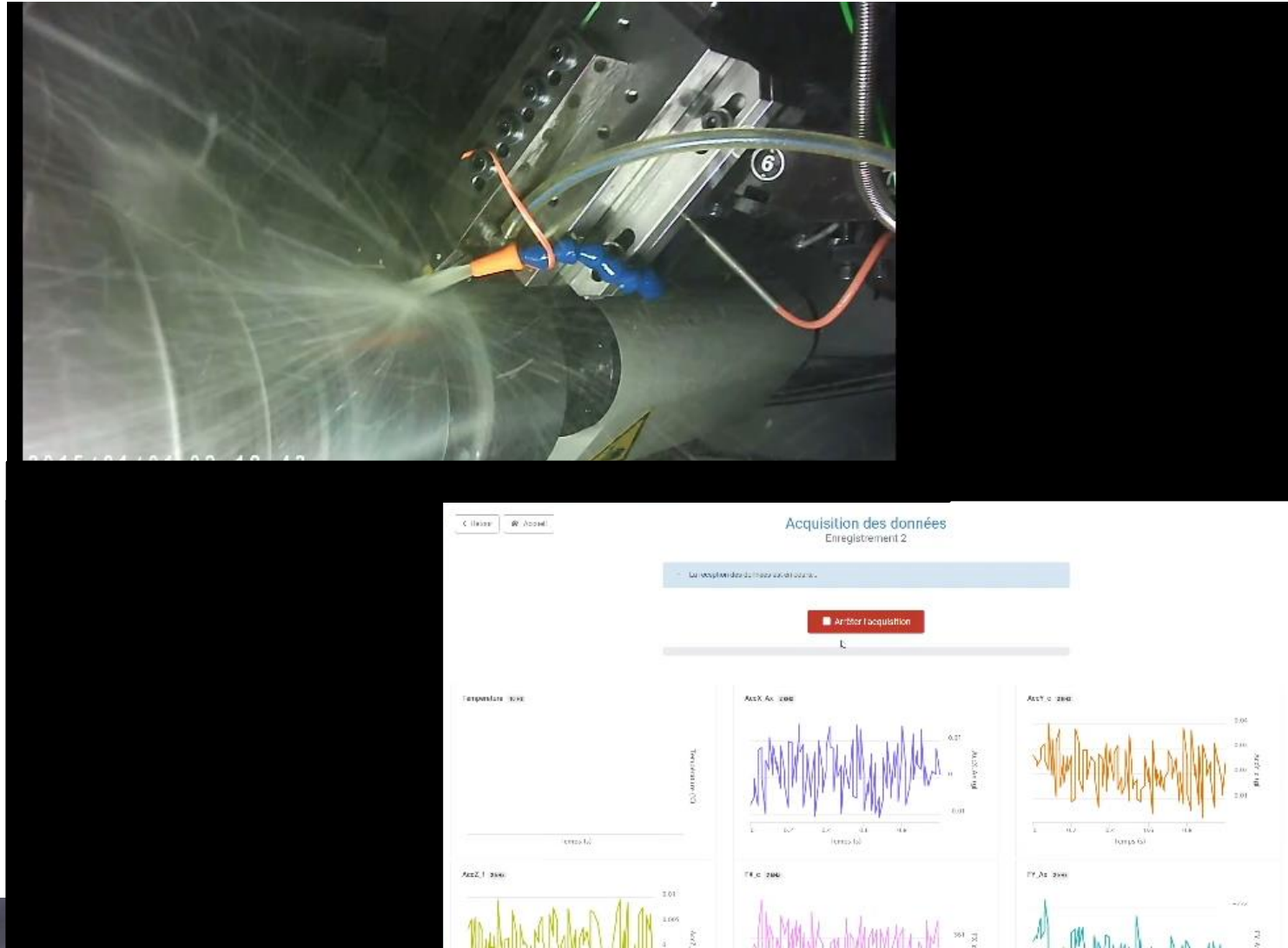
Barlier, C.; Lescalier, C.; Mosian, A. (1997): Continuous Flank Wear Measurement of Turning Tools by Integrated Microthermocouple. In *CIRP Annals* 46 (1), pp. 35–38. DOI: 10.1016/S0007-8506(07)60770-7.

Use Case demonstration

THE FRAMEWORK

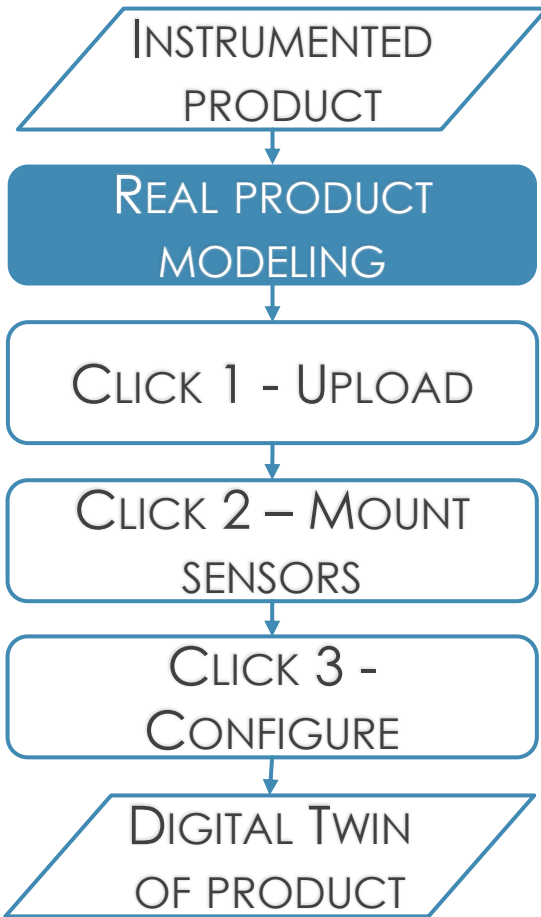


INSTRUMENTED PRODUCT

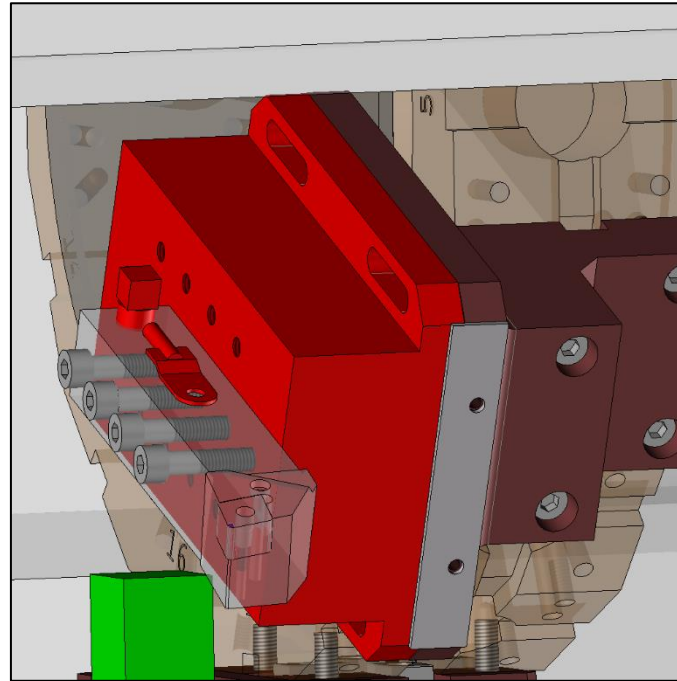


Use Case demonstration

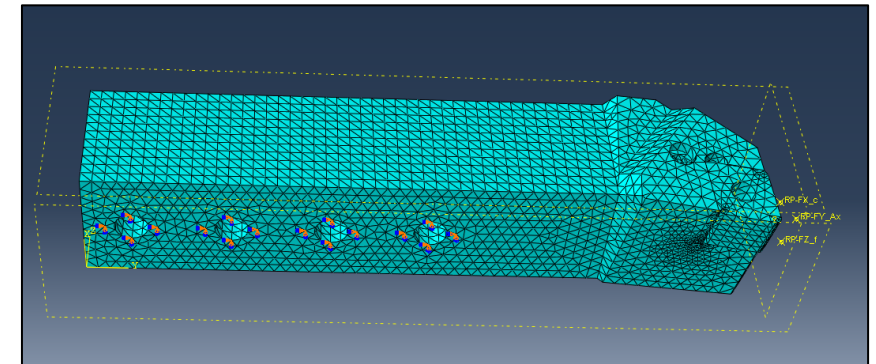
THE FRAMEWORK



3D MODELS OF THE PRODUCT
USING A CAD SOFTWARE
TOPSOLID

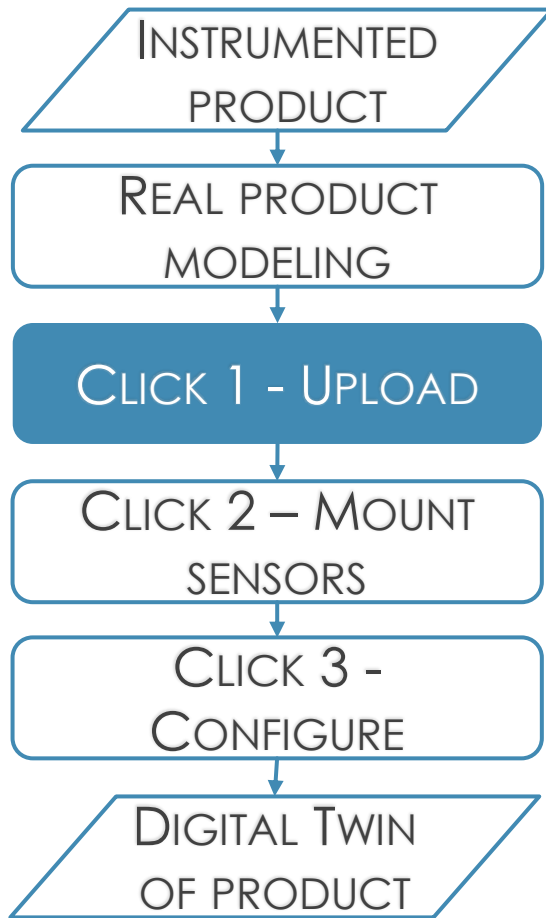


FINITE ELEMENT MODELS OF THE
PRODUCT USING FE SOFTWARE
ABAQUS



Use Case demonstration

THE FRAMEWORK



AUTOMATIC BREAKDOWN STRUCTURE BASED ON THE CAD MODEL

The screenshot shows the Jotne software interface. The breadcrumb navigation is: Lathe > Lathe (ver.170) > CAD_Lathe >. The main content area shows a tree view of the CAD model structure:

- CAD_LATHE (VER. 28) [grid icon]
- <
- KYklos-Tour TC600-instrumentA@/A (ver.3)
- KYklos-Tour TC600-instrumentA@/KIKLOS-PRODUCT-03/A (ver.68)
- Sensors (ver.25)
- Sensors2 (ver.77)

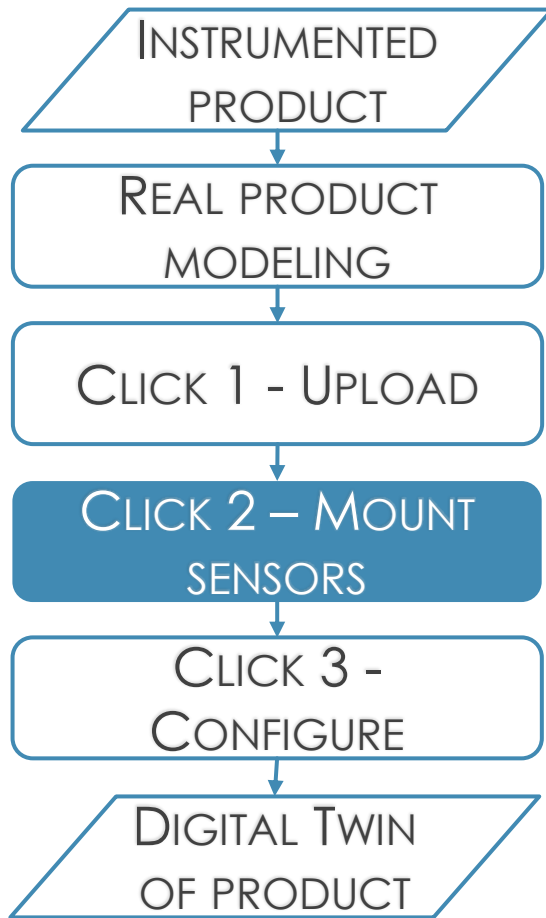
On the right, the 'BREAKDOWN PROPERTIES' table is displayed:

Num ↑	Name	Value
1	Name	CAD_Lathe
2	Type	Product_definition
3	Description	Cirtes_Lathe
4	Created by	cir_user
5	Created date	23/02/2021 à 15:29:40
6	Last modified by	aht_user_rw
7	Last modified date	26/02/2021 à 16:12:20
8	Phase	0
9	Version	28
10	Links	no elements

Below the table, there is a section for 'USER DEFINED' properties, which is currently empty with the text 'No data available'.

Use Case demonstration

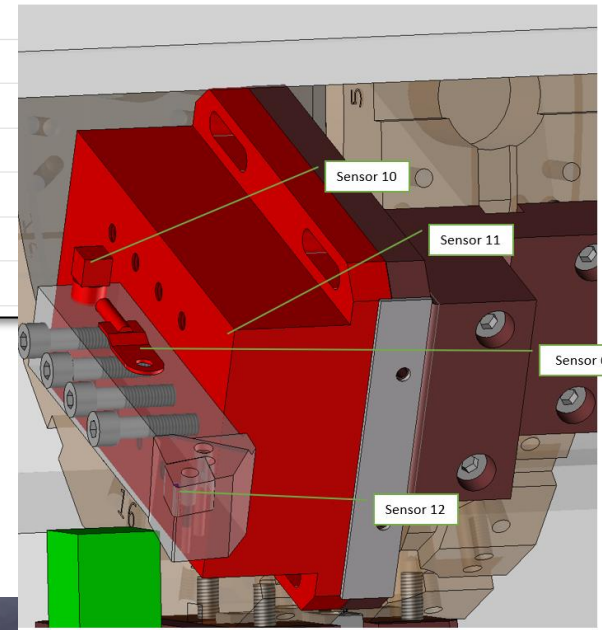
THE FRAMEWORK



SENSORS OF THE PRODUCT

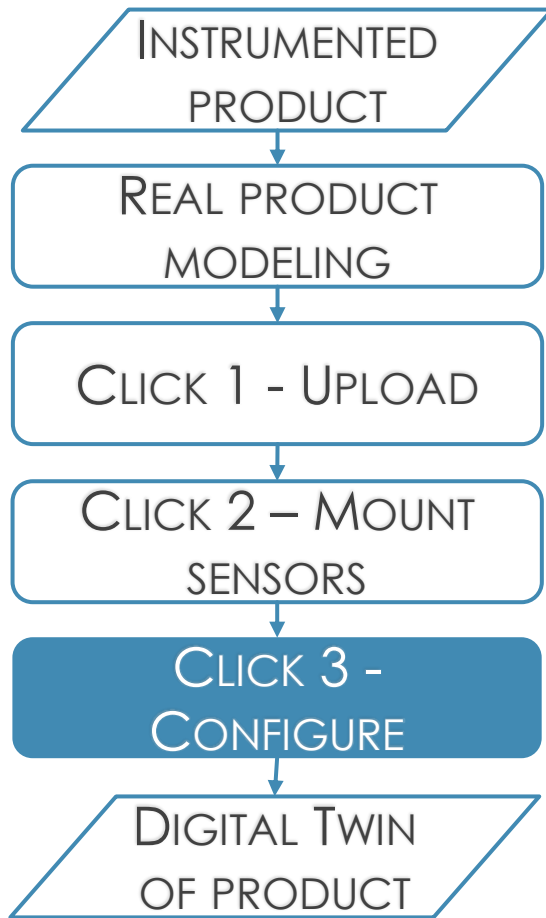
The screenshot shows the Jotne software interface. The breadcrumb navigation is "Lathe > Lathe (ver.170) > CAD_Lathe >". The main content area is titled "SENSORS2 (VER.77)" and has three tabs: "BREAKDOWN PROPERTIES" (selected), "DOCUMENT PROPERTIES", and "PRODUCT PROPERTIES". A table lists the properties for "Sensor 11 (ver.169)".

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

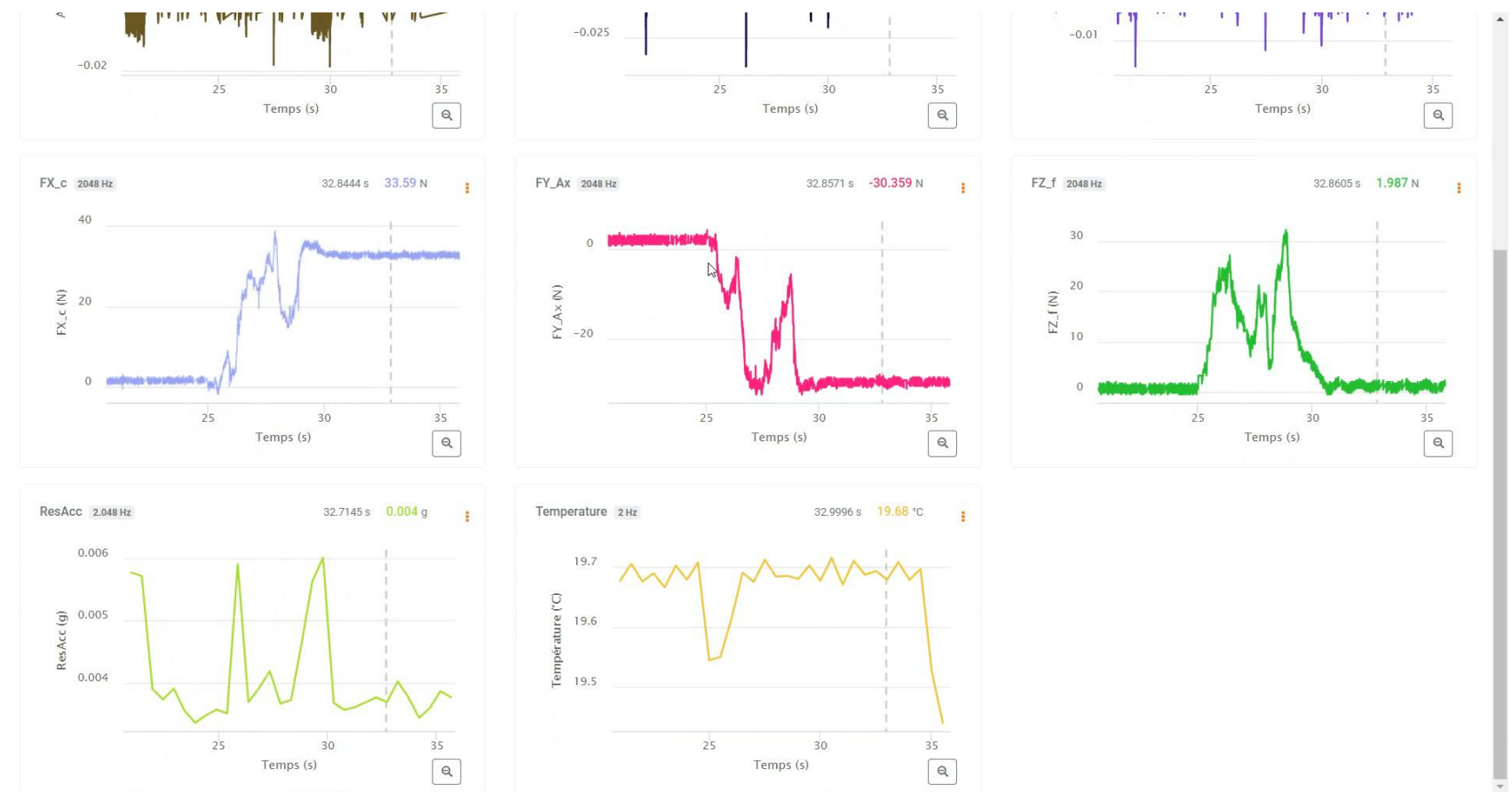


Use Case demonstration

THE FRAMEWORK

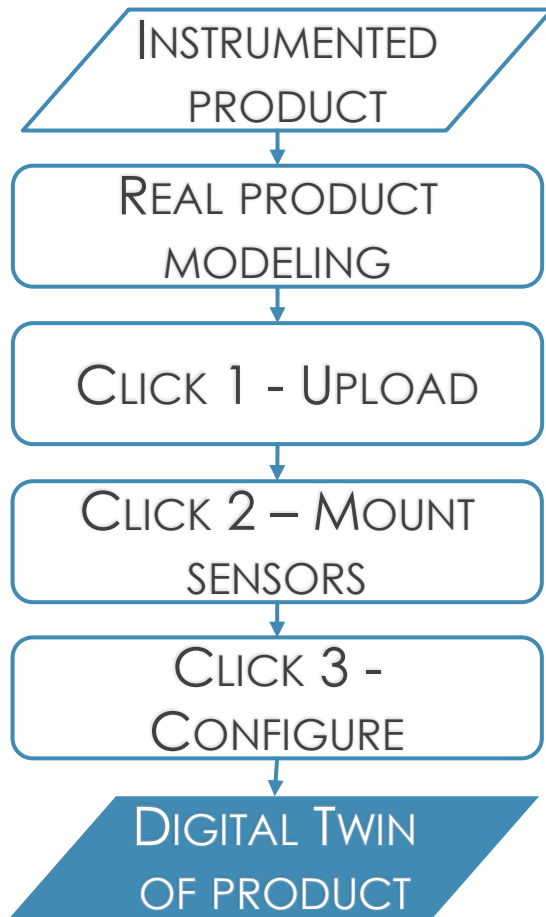


CONFIGURE COMMUNICATION BETWEEN TWS ACQUISITION AND EDMTRUEPLM



Use Case demonstration

THE FRAMEWORK



THE DIGITAL TWIN

Representation of the aggregate property

filter by timestamp field

from to

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		
1601305370.91623	-1.48174095153809	0.53785103559494		
1601305370.91672	-1.79770398139954	0.53785103559494		
1601305370.91721	-1.79770398139954	0.856374979019165		
1601305370.91770	-1.79770398139954	1.17489910125732		

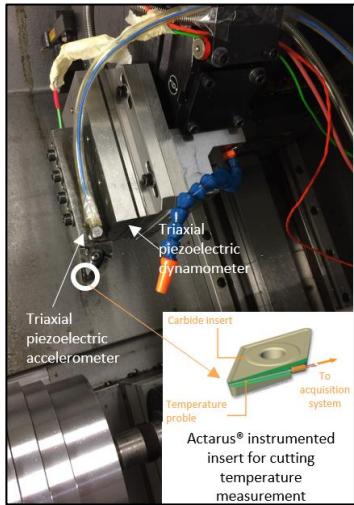
The 3D model shows a blue meshed part with a color scale for S, Mises stress. The scale ranges from -9.342e+02 (red) to +2.060e+02 (blue). A legend is visible on the left side of the model.

ODB: Job-1.odb Abaqus/Standard 6.14-5 Thu Mar 18 10:14:25 Paris, Madrid 2021

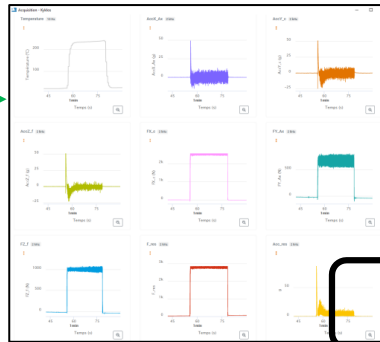
Step: Step-1: ApplyForce
Increment: 1 | Step Time = 1.000
Primary Var: S, Mises
Deformed Var: U | Deformation Scale Factor: +2.601e+02

Conclusions

INSTRUMENTED PHYSICAL PROCESS



TWS ACQUISITION SOFTWARE



TWS PLM

EDMTRUEPLM ISO 10303 REPOSITORY

DIGITAL TWIN

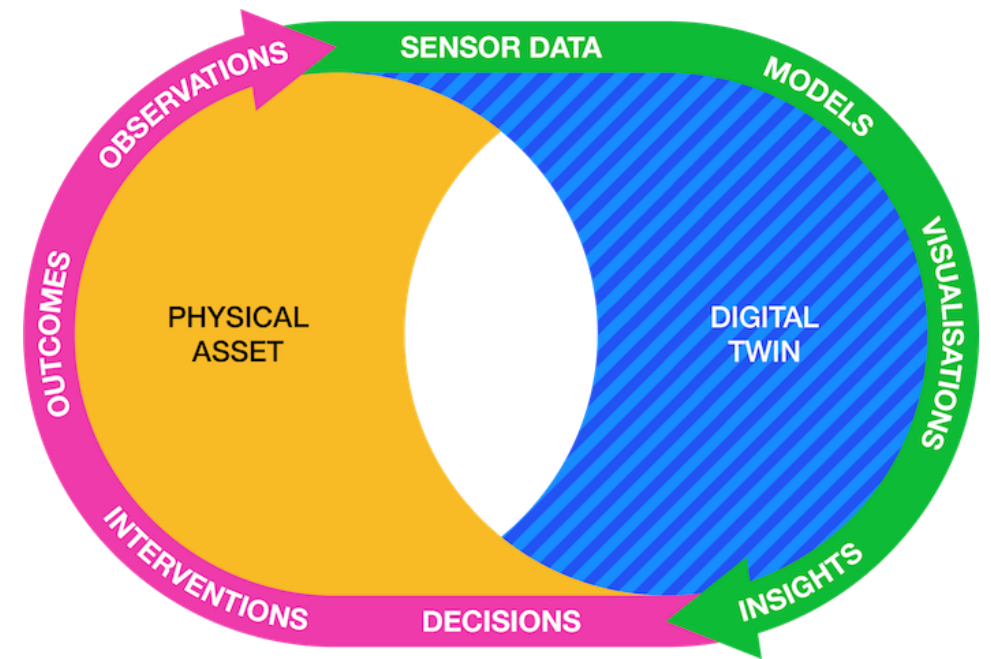
- 3D CAD Models
- Simulation Models
- Simulation Analysis
- Sensor Data
- Documentation

Representation of the aggregate property

Property ID	Value	Unit	Material
1601305370.91008	-1.79770398159654	0.53785103509484	13.0385307540584
1601305370.91007	-1.48174265153809	0.856374879019165	12.4078446782603
1601305370.91086	-1.16577884088893	0.856374879019165	13.0385307540584
1601305370.91130	-2.13366701126099	0.53785103509484	12.4078446782603
1601305370.91184	-1.79770398159654	1.49422880769	13.0385307540584
1601305370.91232	-1.48174265153809	0.856374879019165	13.0385307540584
1601305370.91281	-1.16577884088893	-0.599107002051215	12.0201516418457
1601305370.91330	-2.13366701126099	0.856374879019165	13.0385307540584
1601305370.91379	-2.13366701126099	0.219327002763748	13.0385307540584
1601305370.91428	-1.48174265153809	0.219327002763748	13.0385307540584
1601305370.91477	-1.16577884088893	0.53785103509484	12.7237366703467
1601305370.91525	-2.13366701126099	0.856374879019165	13.3553237915039
1601305370.91574	-1.79770398159654	0.53785103509484	13.0385307540584
1601305370.91623	-1.48174265153809	0.53785103509484	13.0385307540584
1601305370.91672	-1.79770398159654	0.53785103509484	13.0385307540584
1601305370.91721	-1.79770398159654	0.856374879019165	12.7237366703467
1601305370.91770	-1.79770398159654	1.17488919125732	

DIGITAL TWIN DATA CYCLE

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.



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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Questions ?