Standard Based Digital Twins with Flexible IoT Solutions

Track: **(ET/IT) Emergent Technologies/Industry Transformation**

VP. Kjell.Bengtsson@jotne.com (presenter)
Dr. Remi.Lanza@jotne.com

GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2021

Virtual Sessions

4 512

36 816

155 279 548 416

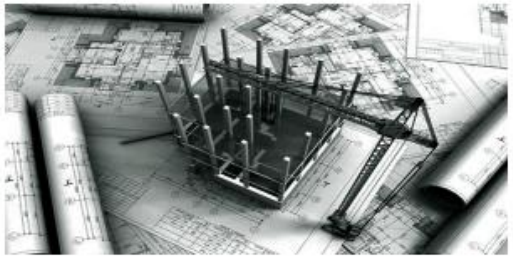
Presenters Bio

- Kjell Bengtsson, Jotne: is a Vice President at Jotne, has a Mechanical Engineering background and a diploma in Marketing. He started out at Volvo Car and General Electric doing CAD/DB applications and later management positions and is now VP at Jotne EPM Technology. Kjell has been exposed to ISO 10303 (STEP), and other related standards for the last 30 years and is actively involved in Open Standards Based Digital Twin implementation projects in the most complex aeronautics, space and defence sector projects. Kjell is a Member of the Board of PDES, Inc. and supports other industry organizations like AIA/ASD, NIAG (NATO), FSI, CENSSS, AIOTI, NAFEMS and more. Further, Kjell also manage the Jotne extensive R&D portfolio at EU and the European Space Agency (ESA).

- Dr. Remi Lanza, Jotne: completed M.Sc. in Mechanical Engineering in 2015 within the field of finite element analysis. He joined Jotne in 2016 where he started his industrial PhD with the Norwegian University of Science and Technology (NTNU). He completed his thesis "Capture and reuse of engineering knowledge in digital twins" in 2020 and is currently employed as a Mechanical Engineer. During and after his PhD research Remi was involved in ISO 10303-209 standardization activities, and projects related to SDM, PLM, Digital Twin, FEM/test correlation and development of data exchange applications.

Business verticals

Built Environment



Defence

Aeronautics

ABOUT JOTNE IT

The leader in product data exchange and sharing
Jotne EPM Technology data products have successfully reduced development and product lifecycle costs through the use of intelligent data management in the areas of Defense, Aeronauti Oil & Gas, Built Environment and Aerospace.

EXPRESS Data Manager™

Space

AEROSPACE INDUSTRIES ASSOCIATION

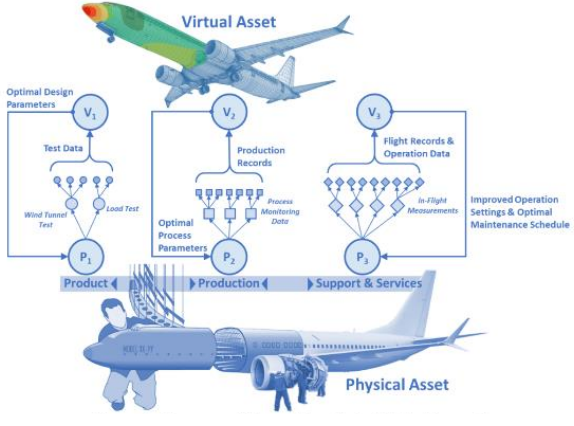
AEROSPACE INDUSTRY GUIDELINES FOR IMPLEMENTING INTEROPERABILITY STANDARDS FOR ENGINEERING DATA

AIAA SHAPING THE FUTURE OF AEROSPACE

AIA AEROSPACE INDUSTRIES ASSOCIATION

DIGITAL TWIN: DEFINITION & VALUE

An AIAA and AIA Position Paper
December 2020



Planned by the AIAA Digital Twin Subcommittee

AIAA SHAPING THE FUTURE OF AEROSPACE

DIGITAL TWIN IMPLEMENTATION

An AIA and AIAA Position Paper

Authored by the

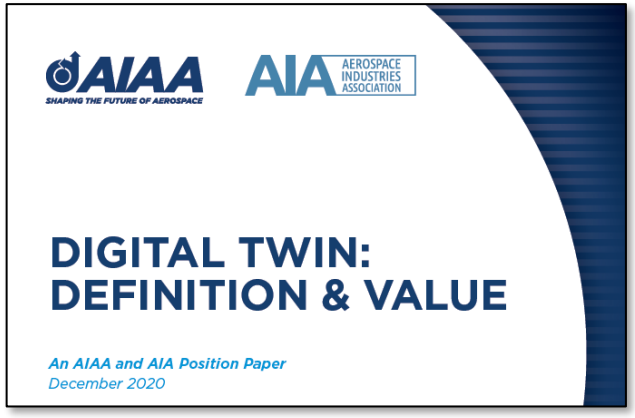
AIAA Digital Engineering Integration Committee,

Approved by the

XXXX

Presented by Digital Engineering Integration Committee (DEIC), 18 August

Standards



1. 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*.

2. Significant value and increased collaboration could be realized by establishing appropriate foundational *open standards (e.g. data and models)* and life cycle architecture frameworks.

3. Therefore, additional focus and effort should also be given to addressing which *elements of this foundation should be open*.

Used in Eurofighter PDM

ISO®

AIRBUS

LEONARDO

BAE SYSTEMS

How is STEP Used at Lockheed Martin

Geometric Data Exchange - AP 203, AP 242

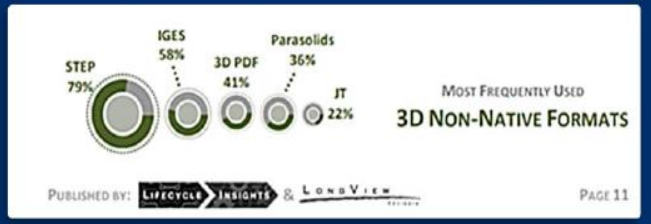
- Exchanging data between different systems (CAD, CAM, CAE, and PDM)
- Enabling 3D model information to integrate into non-CAD applications
- Supplier data exchange

Technical Data Package Core Information Exchange - AP 232

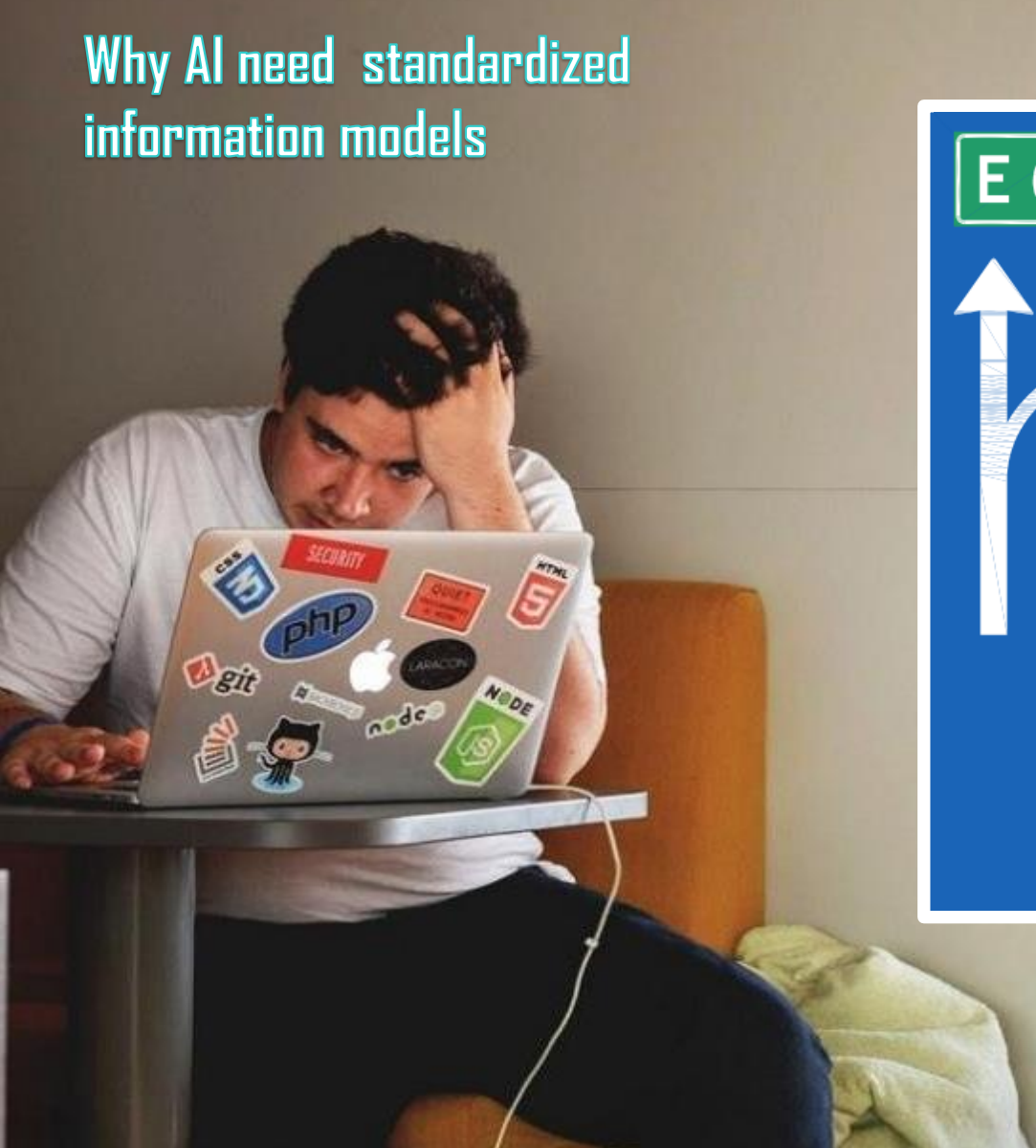
Supporting Various Aircraft Programs Including F-16, F-22, F-35, T-50, F-2 and C-130J

STEP converter development

Lockheed Martin Handles 500,000+ STEP Files per year



Why AI need standardized information models



E 6 AI has a data quality problem

AI needs better data, not just more data

Big data is so often improperly formatted, lacking metadata, or “dirty,” meaning incomplete, incorrect, or inconsistent, that data scientists typically spend 80 percent of their time on cleaning and preparing data to make it usable, leaving them with just 20 percent of their time to focus on actually using data for analysis.

CENTER FOR DATA INNOVATION

77% of professionals believe that interoperability is the largest challenge facing the industrial internet. © survey by IoT Nexus

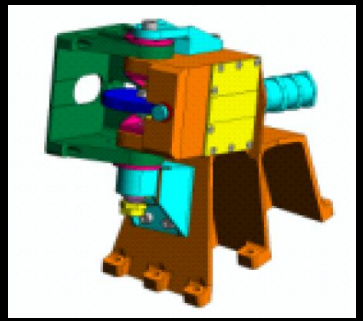
ISO 10303 STEP Standards development

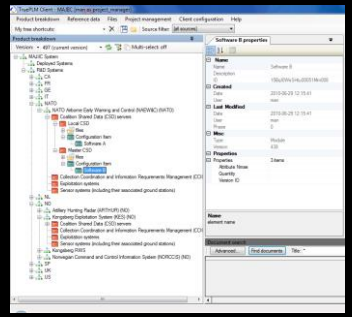
1994: CAD AP203

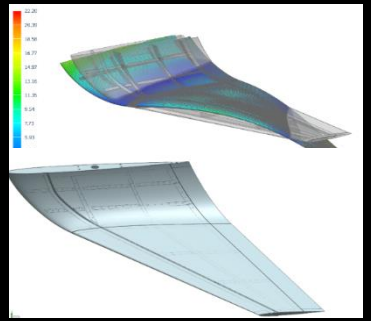
1999: PLM AP214

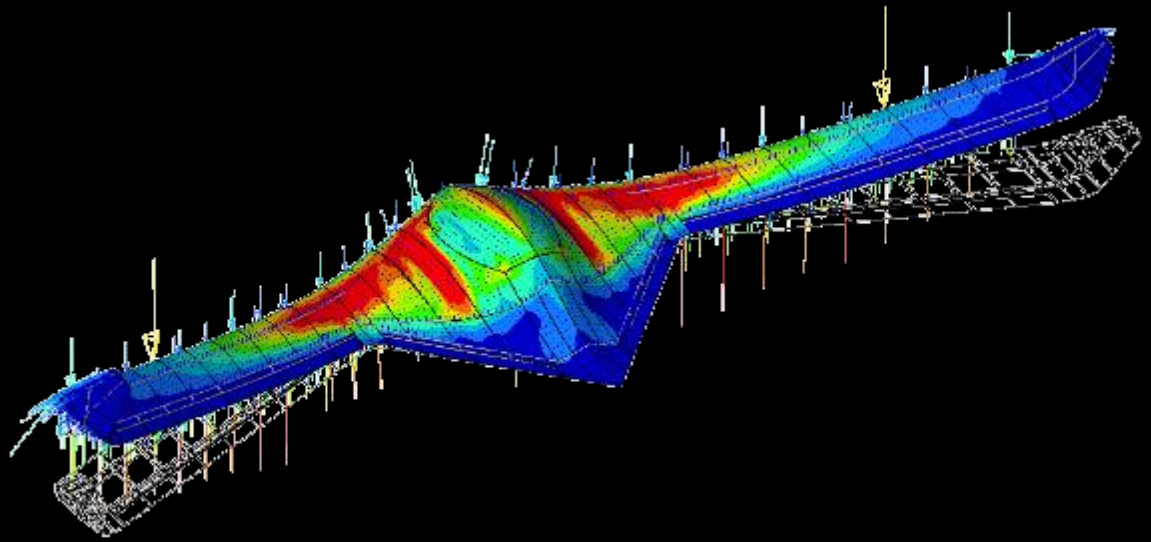
2005: ILS AP239

2014: CAE AP242/209

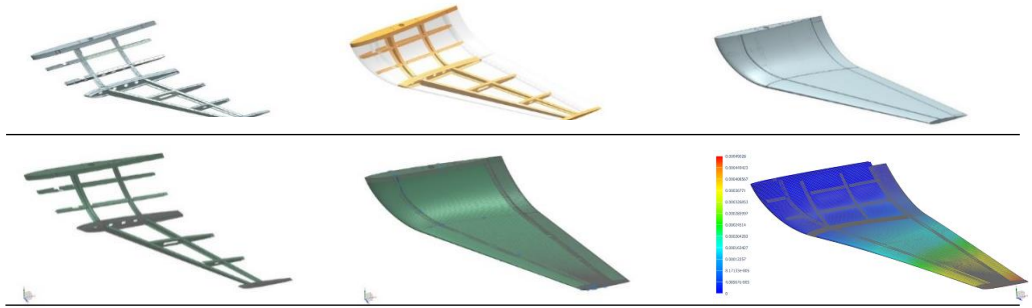








CAD, Simulation, Manufacturing, Test, Sensor and Operational Data in one standardized repository using ISO 10303. Facts or fiction?

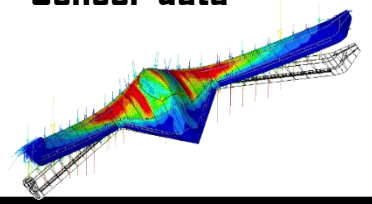


Design CAD

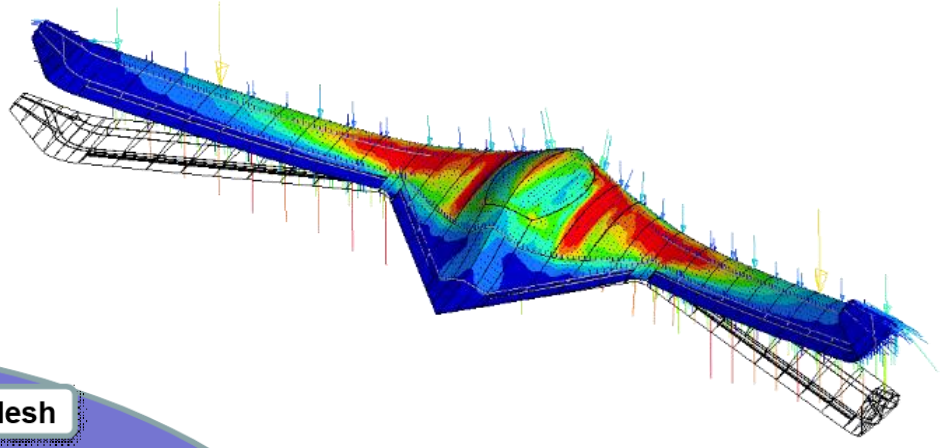
Analysis FEM

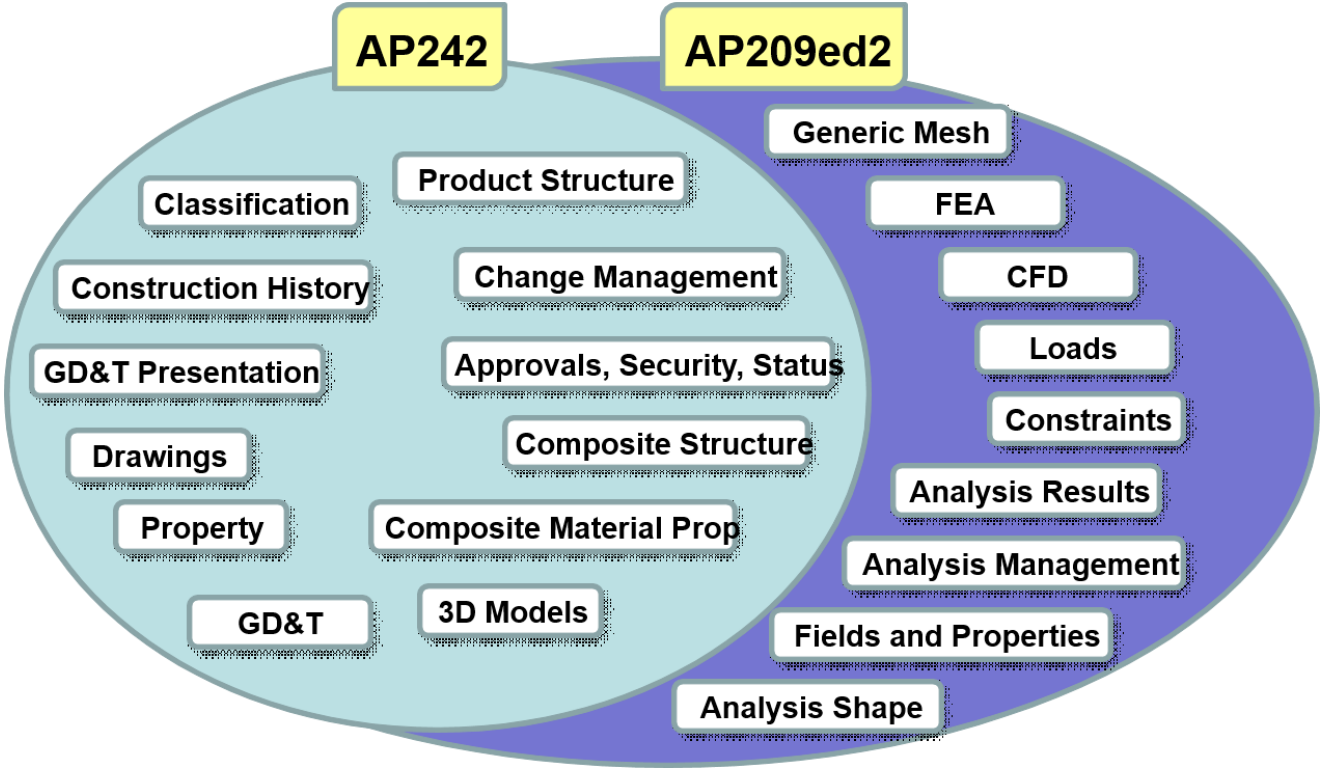
Manufacturing

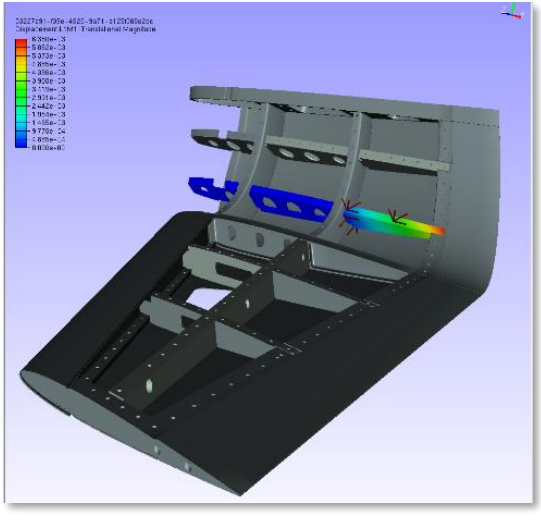
Sensor data



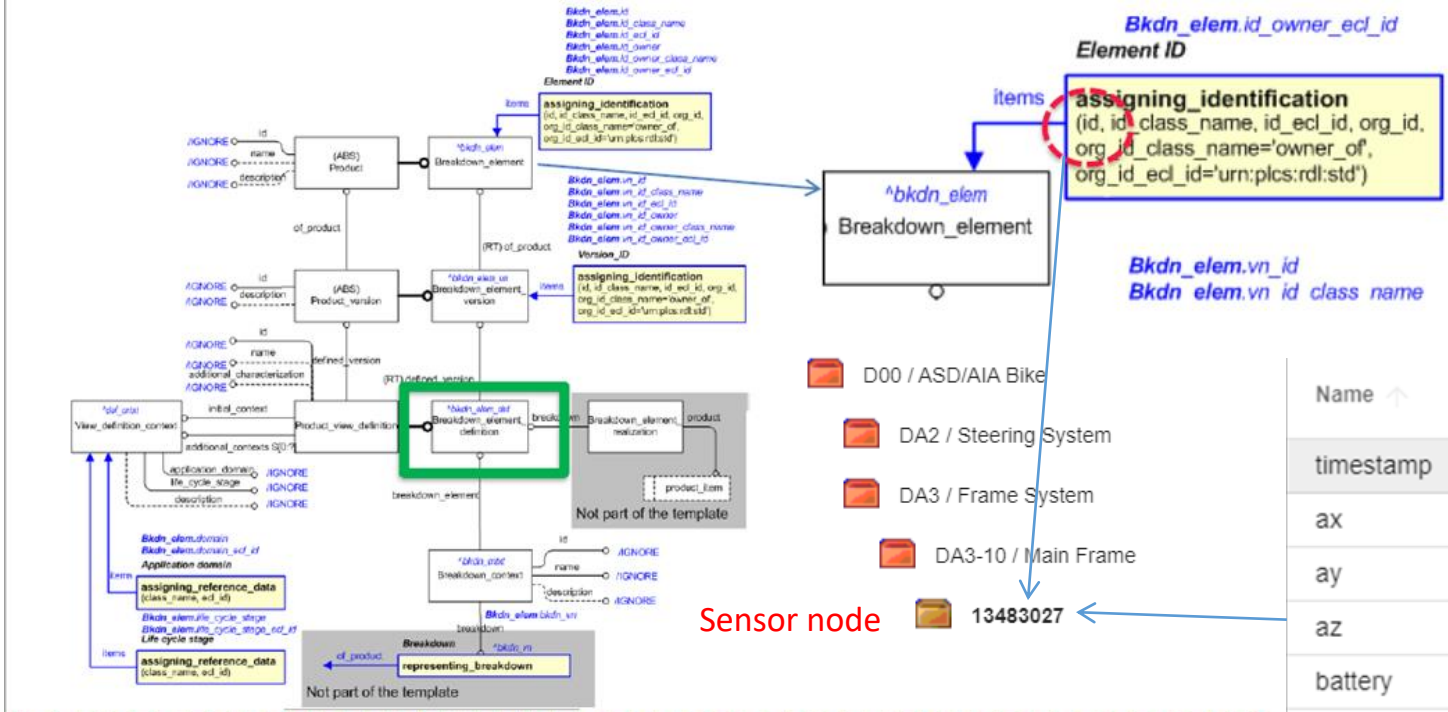
Content of ISO 10303-242/209







Properties in ISO 10303 and ISO 12006

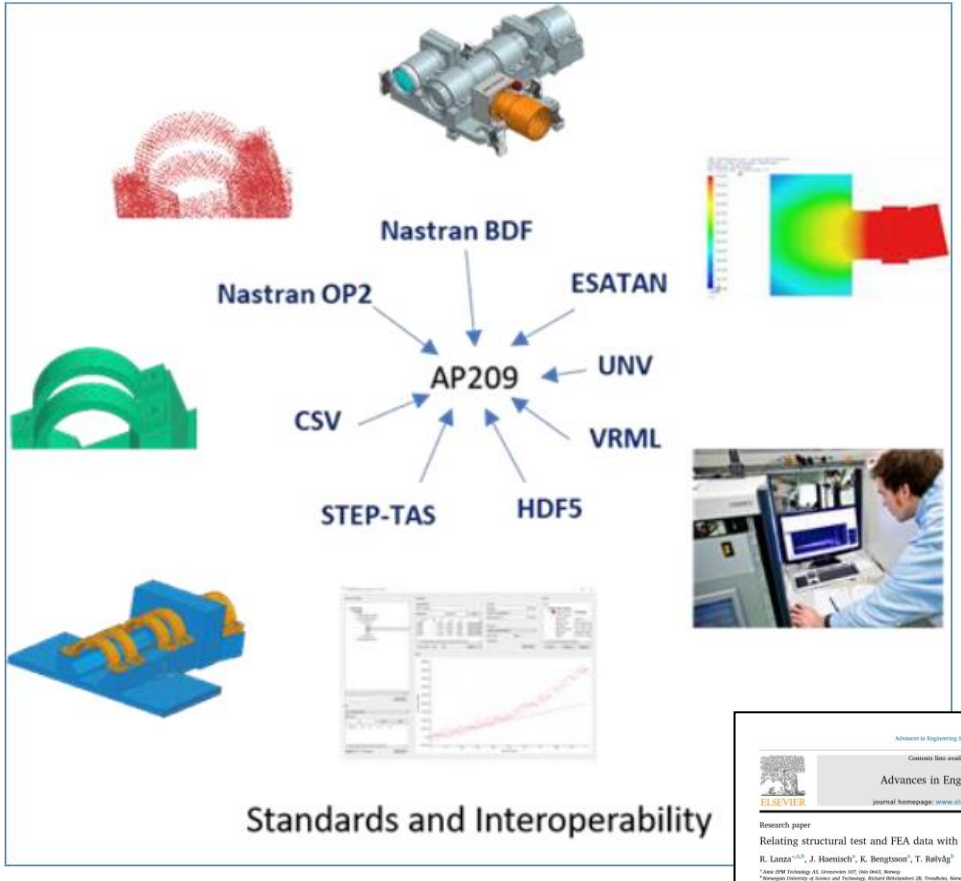


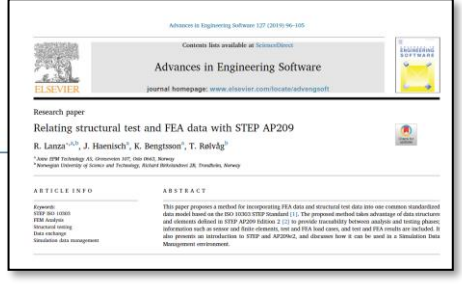
ptc

ISO 10303 | OWL | ISO 12006

These concepts are deployed by PLM vendors like PTC

DEFINE – Digital Twin for validation




Advances in Engineering Software 127 (2019) 96–105

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Advances in Engineering Software

journal homepage: www.elsevier.com/locate/advengsoft

Research paper

Relating structural test and FEA data with STEP AP209

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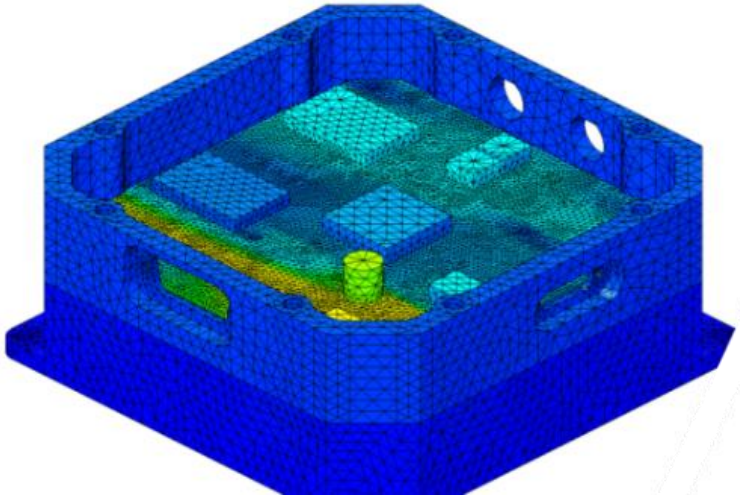
ARTICLE INFO

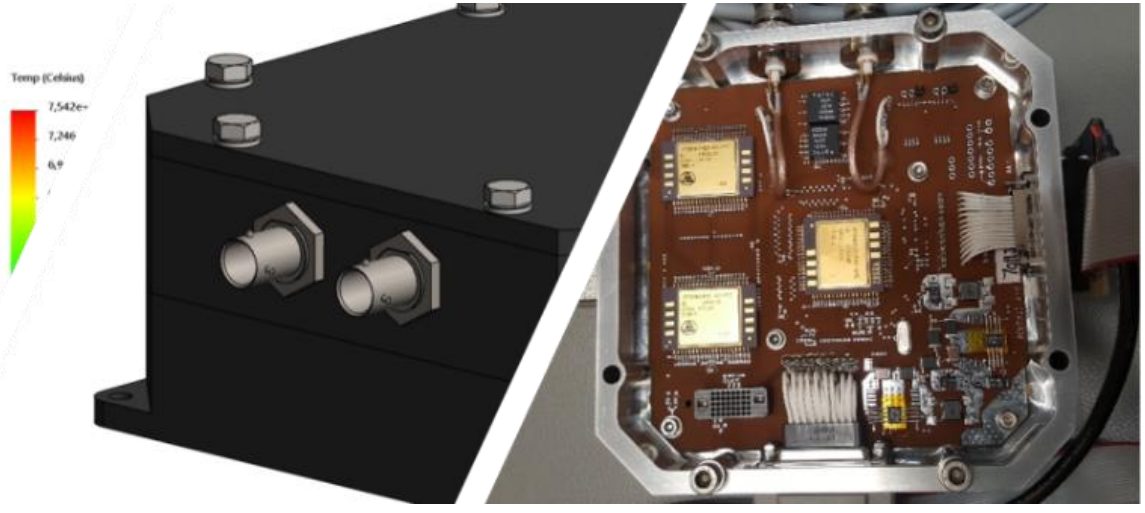
Keywords:
STEP ISO 10303
FEM Analysis
Structural testing
Data exchange
Simulation data management

ABSTRACT

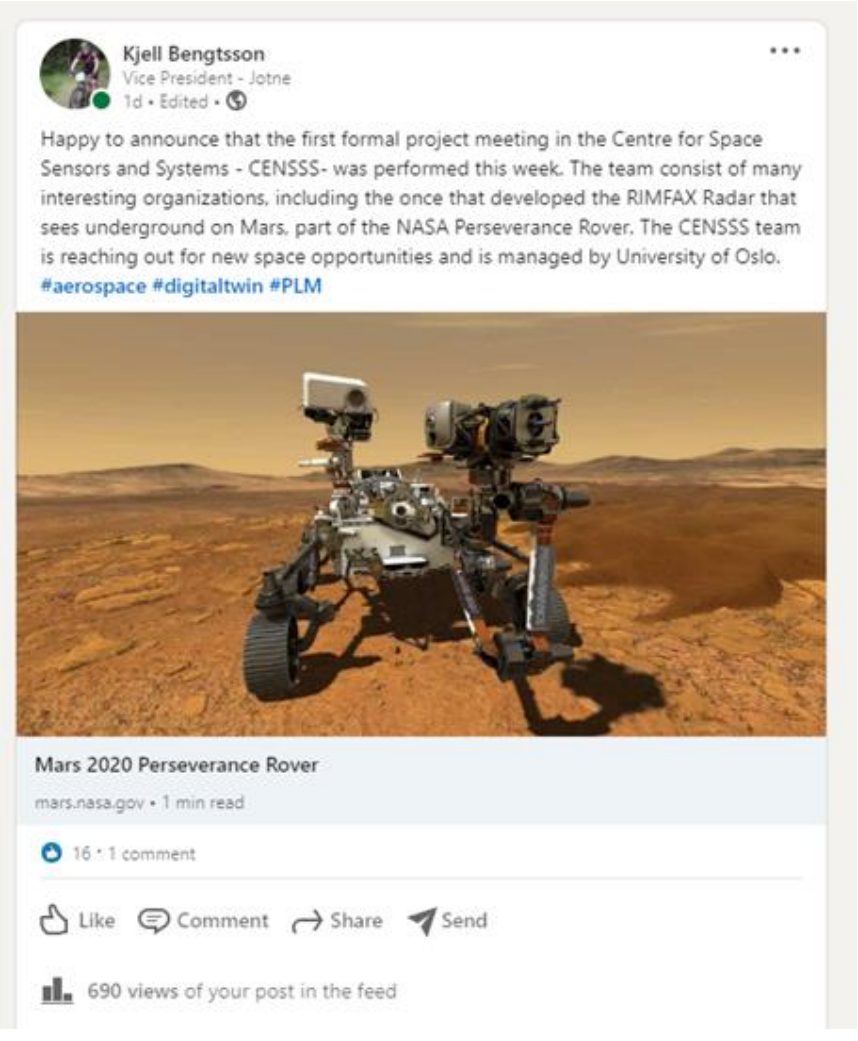
This paper proposes a method for incorporating FEA data and structural test data into one common standardized data model based on the ISO 10303 STEP Standard [1]. The proposed method takes advantage of data structures and elements defined in STEP AP209 Edition 2 [2] to provide traceability between analysis and testing phases; information such as sensor and finite elements, test and FEA load cases, and test and FEA results are included. It also presents an introduction to STEP and AP209e2, and discusses how it can be used in a Simulation Data Management environment.

PhD paper here:
https://www.sciencedirect.com/science/article/pii/S0965997818301947





Jotne



CENSSS.no
Digital Twin for Spacecraft

CENSSS will in collaboration with Norwegian industry develop new instruments and sensor systems, New-Space satellites system integration, operation and exploitation of satellite data.

Using Standard Based Digital Twins based on open and publicly available specifications makes it easier to trace products and sensor information, and to integrate these in a well-arranged manner. This improves data exchange, sharing and archiving processes, cutting both time and cost, yet improving quality.

Jotne on Digital Twin - EU R&D

1 2

3 4

Digital Twin for Additive Manufacturing Process

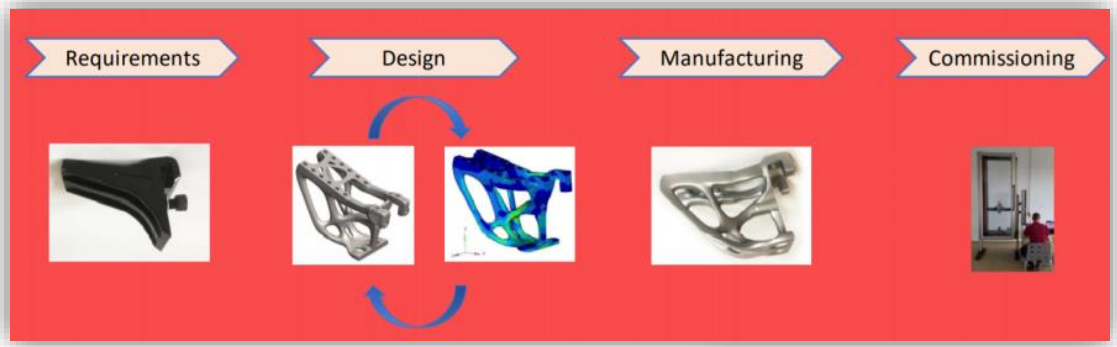
Jotne provides Digital Twins capabilities to overcome existing issues SMEs are facing

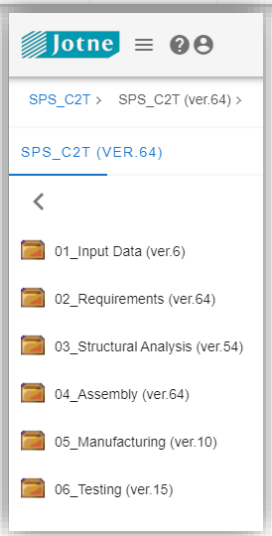
Data Storage – Collect data along the life of a product or project cycle

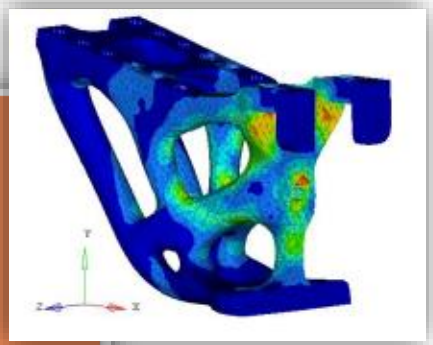
Interoperability

Data Exchange - Export/import facilities using ISO 10303-239/209

Data Archiving - project data can be exported in a standard format that does not depend on specific software







SPS working on Pilot Use Case - Prothesis Adapter in colloboratiion with Jotne

- Integration of other CAD tool with PLM
- CAD and document management
- Change management Functionality
- Follow Standardised procedure for data exchange

CHANGE2TWIN

KYKLOS 4.0 Smart and Circular Manufacturing

KYKLOS 4.0

KYKLOS 4.0 will **demonstrate** the transformative effects that Circular Production System (CPS), Product Life Management (PLM), Life Cycle Analysis (LCA), Augmented Reality (AR) and Artificial Intelligence (AI) technologies and methodologies will have to the **Circular Manufacturing** framework

Smart Manufacturing Pilots

01 Aerospace Pilot (**GENERAL ELECTRIC and KANFIT3D** facilities – Israel)

02 Electronic Devices/Equipment Pilot (**VESTEL** facilities – Turkey)

03 Medical Pilot (**PRO MEDICARE** facilities– Italy)

04 Electronic Manufacturer Pilot (**CONTINENTAL** facilities – Romania)

Circular Manufacturing Pilots

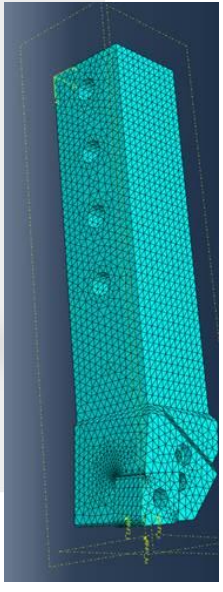
01 Automotive Pilot (**DIGRO** facilities – Italy)

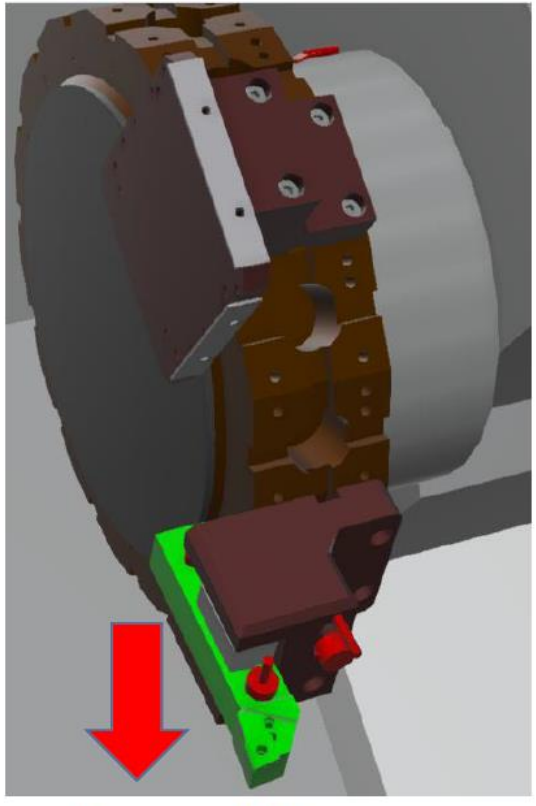
02 Shipyard Pilot (**ASTANDER** facilities – Spain)

03 Food Industry Pilot (**PINDOS Cooperative** facilities – Greece)

The KYKLOS 4.0 project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 872570. This document reflects only authors' views. The EC is not liable for any use that may be done of the information contained therein

Digital Twin: Manufacturing process

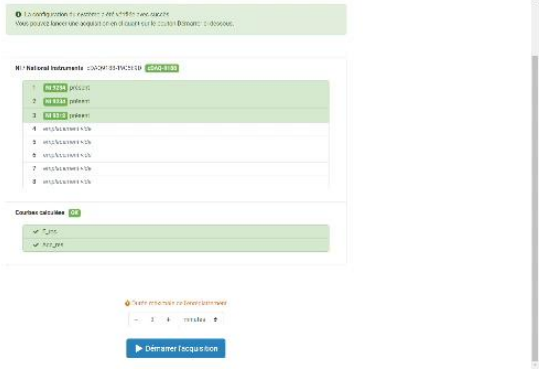


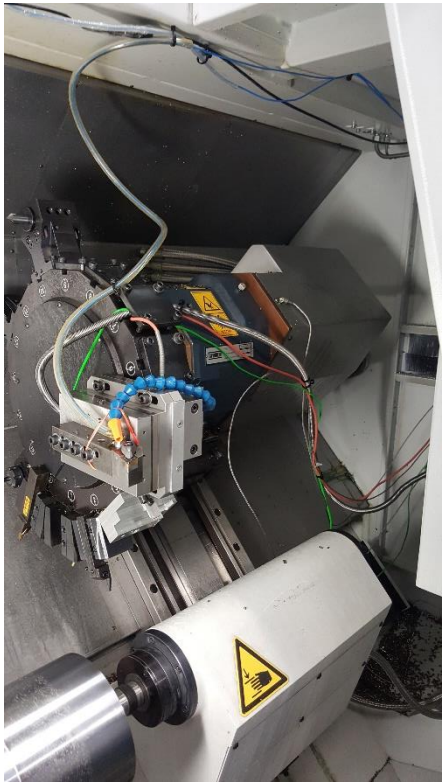


Force / Time

Paper @ NAFEMS World 2021 Congress:
PhD Student Mariane Prado Motta

Real Sensor data in ISO 10303





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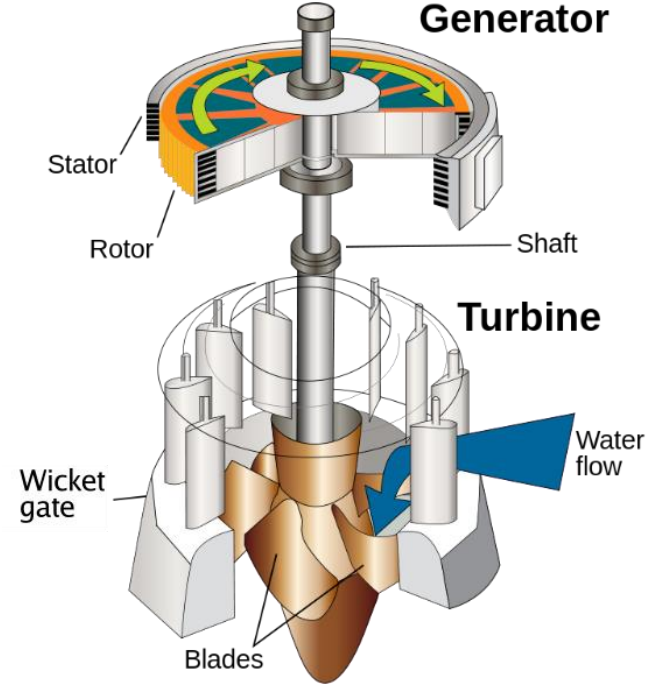
Digital Twin of Waterpower Solutions

Distributed Artificial Intelligent Systems
Large EU/ECSEL project



Source: Wikipedia

Norwegian use case:

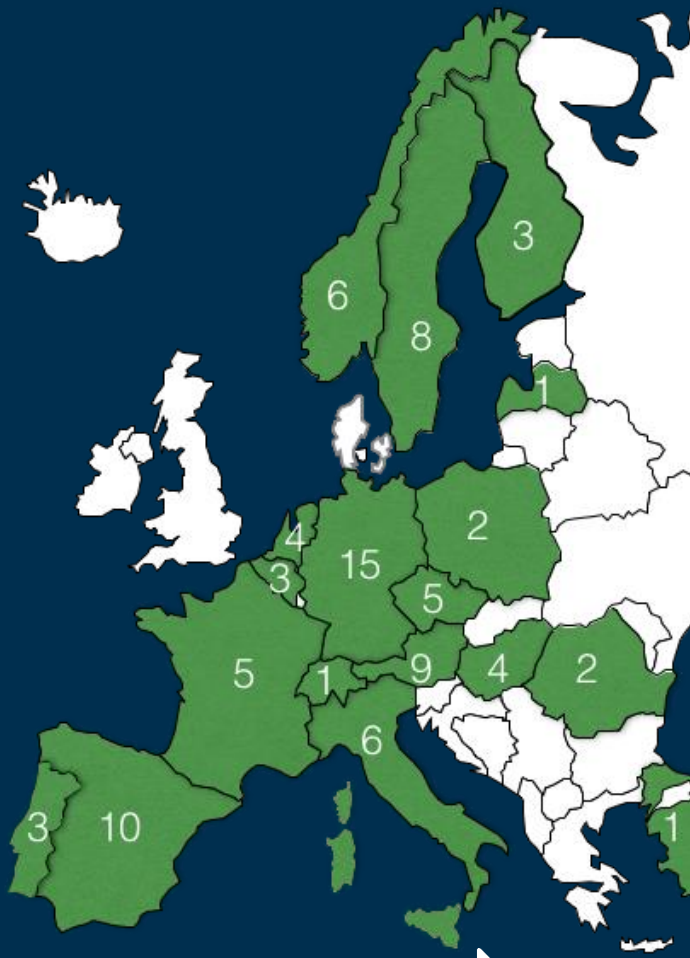
Due to a variable demand in the energy market, frequent start and stop actions are required by hydropower plants to provide regulation of turbines.

Instrumenting the turbines with microphones and analysing anomalities in the gathered sound data could help optimise start- and stop routines and consequently reduce wear.

Arrowhead Tools

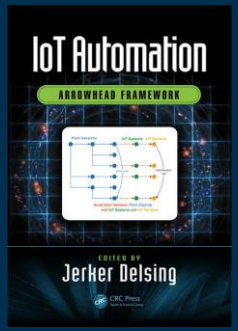
Europe's larges Automation and Digitalisation Engineering project

- Joint European effort in 18 countries
- 80 partners
- 90 M€ budget
- Duration 2019-2022



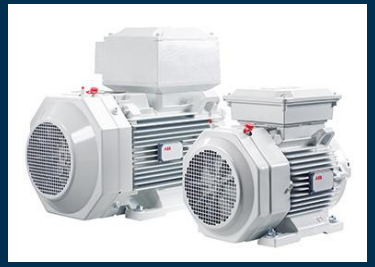
Coordinator: Prof. Jerker Delsing,
Lulea University of Technology

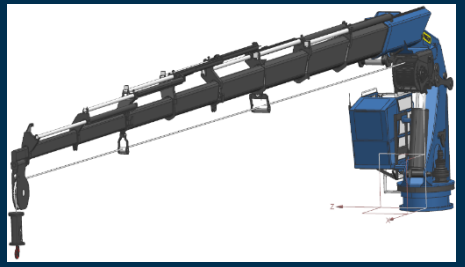
https://www.arrowhead.eu/

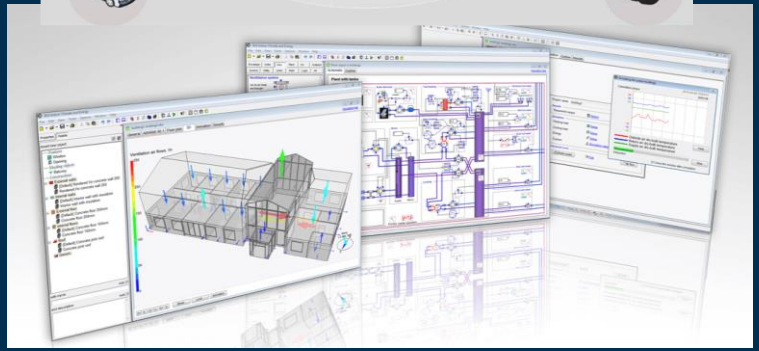


ARROWHEAD TOOLS

Engineering efficiency improvements
Validation and verification in 21 advanced use cases

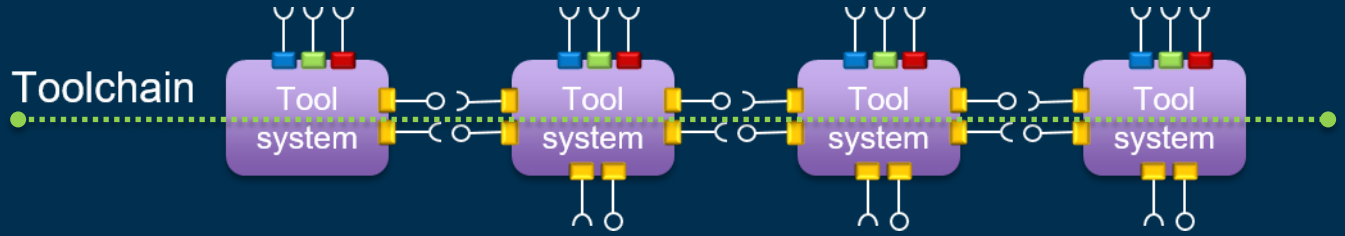






- Automotive
- Mining
- Electronics

- Software
- Building Sector
- Offshore



ARROWHEAD TOOLS

A comparison of IoT-SoS Architectures & Platforms

Features	Arrowhead	AUTOSAR	BaSyx	FIWARE	IoTivity	LWM2M	OCF
Key principles	SOA, Local Automation Clouds	Runtime, Electronic Control Unit (ECU)	Variability of production processes	Context awareness	Device-to-device communication	M2M, Constrained networks	Resource Oriented REST, Certification
Real-time	Yes	Yes	No	No	Yes (IoTivityConstrained)	No	No
Run-time	Dynamic orchestration and authorization, monitoring, and dynamic automation	Runtime Environment layer (RTE)	Runtime environment	Monitoring, dynamic service selection and verification	No	No	No
Distribution	Distributed	Centralize	Centralize	Centralize	Centralize	Centralize	Centralize
Open Source	Yes	No	Yes	Yes	Yes	Yes	No
Resource accessibility	High	Low	Very low	High	Medium	Medium	Low
Supporters	Arrowhead	AUTOSAR	Basys 4.0	FIWARE Foundation	Open Connectivity Foundation	OMA SpecWorks	Open Connectivity Foundation
Message patterns	Req/Repl, Pub/sub	Req/Repl, Pub/sub	Req/Repl,	Req/Repl, Pub/sub	Req/Repl, Pub/sub	Req/Repl	Req/Repl
Transport protocols	TCP, UDP, DTLS/TLS	TCP, UDP, TLS	TCP	TCP, UDP, DTLS/TLS	TCP, UDP, DTLS/TLS	TCP, UDP, DTLS/TLS, SMS	TCP, UDP, DTLS/TLS, BLE
Communication protocols	HTTP, CoAP, MQTT, OPC-UA	HTTP	HTTP, OPC-UA	HTTP, RTPS	HTTP, CoAP	CoAP	HTTP, CoAP
3rd party and Legacy systems adaptability	Yes	Yes	Yes	Yes	No	No	No
Security Manager	Authentication, Authorization and Accounting Core System	Crypto Service Manager, Secure Onboard Communication	--	Identity Manager Enabler	Secure Resource Manager	OSCORE	Secure Resource Manager
Standardization	Use of existing standards	AUTOSAR standards	Use of existing standards	FIWARE NGSI	OCF standards	Use of existing standards	OCF standards

C. Paniagua and J. Delsing, "Industrial Frameworks for Internet of Things: A Survey," in *IEEE Systems Journal*, doi: 10.1109/JSYST.2020.2993323.

www.arrowhead.eu/arrowheadframework and download www.github.com/arrowhead-f

ARROWHEAD TOOLS

Digital Twin Based Crane Monitoring

Digital Twin: As simulated

In Operation

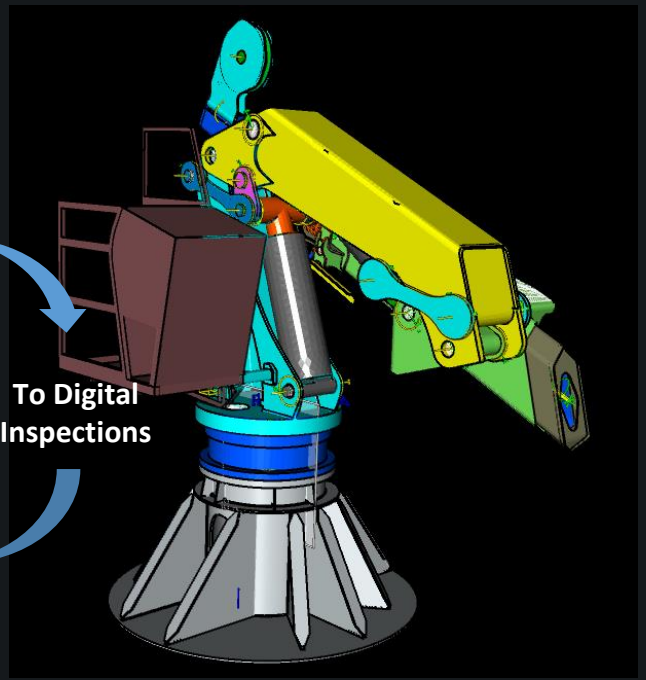
Norwegian Use Case: Digital twins and structural monitoring

ARROWHEAD TOOLS

Crane Implementation

From Physical Inspections

To Digital Inspections



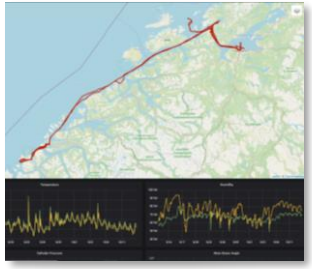
Digital Twin FEA technology

Our Digital Twin models are simulated real time in FEDEM:

- CAE
  - 3D modelling / idealization
  - Joint / spring / damper / sensor modelling
  - Substructuring (25 super elements)
  - Meshing
- Dynamic simulation (nonlinear FEA)
  - Forces, Positions, Velocities and Accelerations
- Structural Analysis
  - Stresses / strains
  - Vibration frequencies
  - Damage / durabillity
- Control / hydraulics
  - PI / PD / PID Controllers
  - Closed loop dynamics

$$\mathbf{M}(\mathrm{r},t)\,\ddot{\mathbf{r}}(t) + \mathbf{C}(\mathrm{r},\dot{\mathrm{r}},t)\,\dot{\mathbf{r}}(t) + \mathbf{K}(\mathrm{r},t,\sigma)\,\mathbf{r}(t) = \mathbf{F}(t)$$

$$\varepsilon_{rosette} = \left[\mathbf{T}_{re}\tilde{\mathbf{B}}\mathbf{T}\mathbf{A}\mathbf{L}\mathbf{H}\right]\mathbf{v}_{sup}$$



SENSORS

GATEWAY

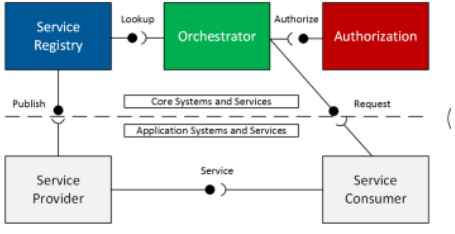
CLOUD

THE SOLUTION
FINAL OUTCOME

AHT IoT FRAMEWORK

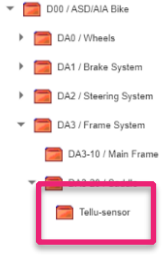
REST SERVICS

PLM STANDARDS



Read: GET

Read: GET
Create: POST
Update: PUT
Delete: DELETE



ISO®

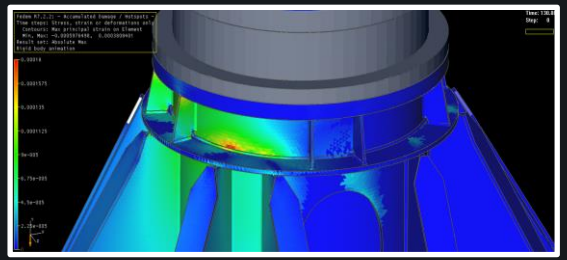
ARROWHEAD
TOOLS

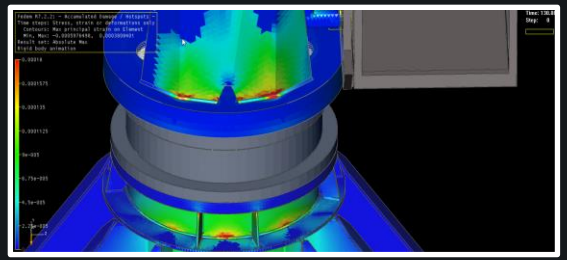
Crane Digital Twin Validation

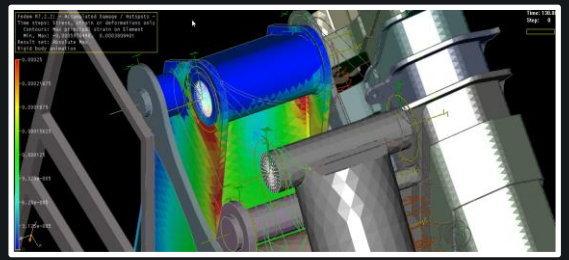
ARROWHEAD TOOLS

Crane deployment takes 130 seconds:

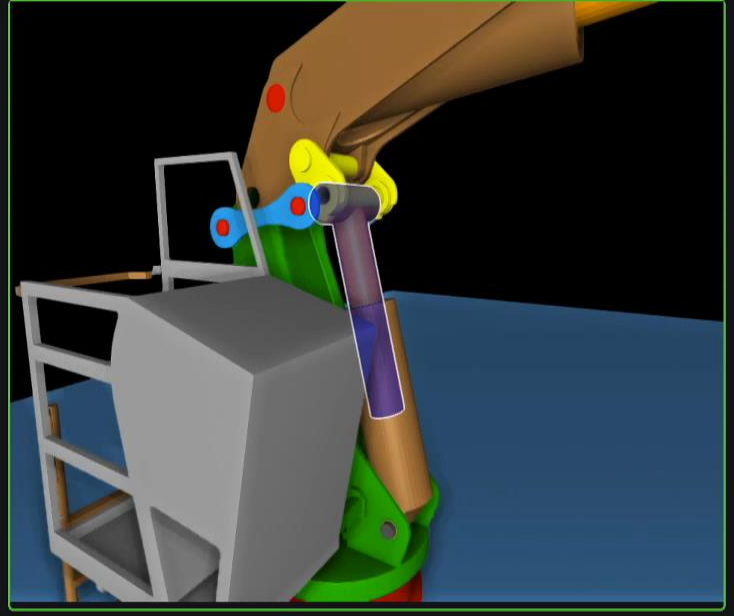
Simulation takes 75 seconds:

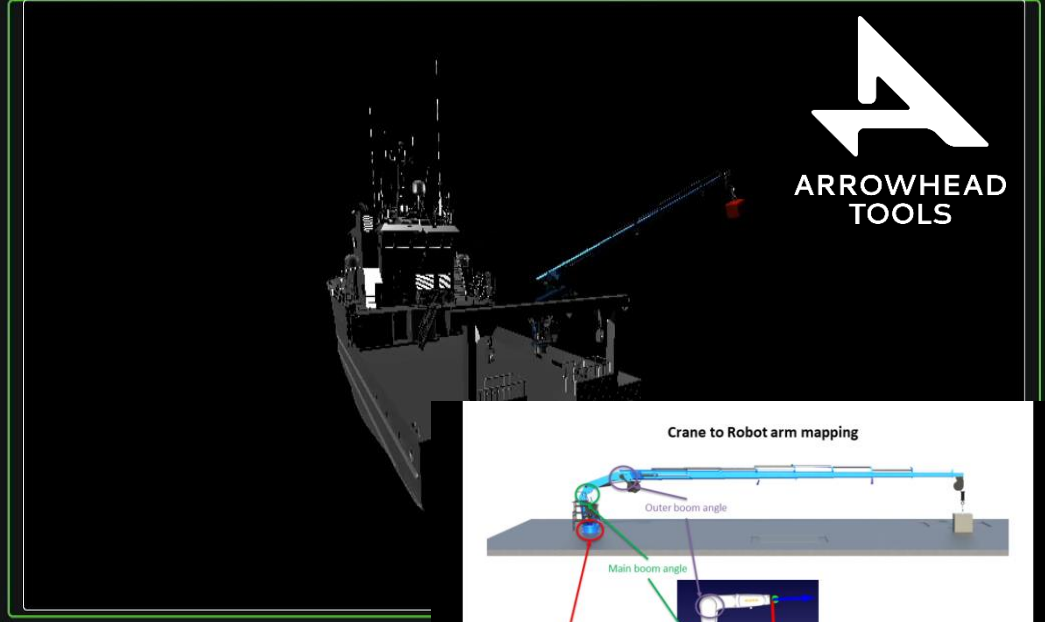






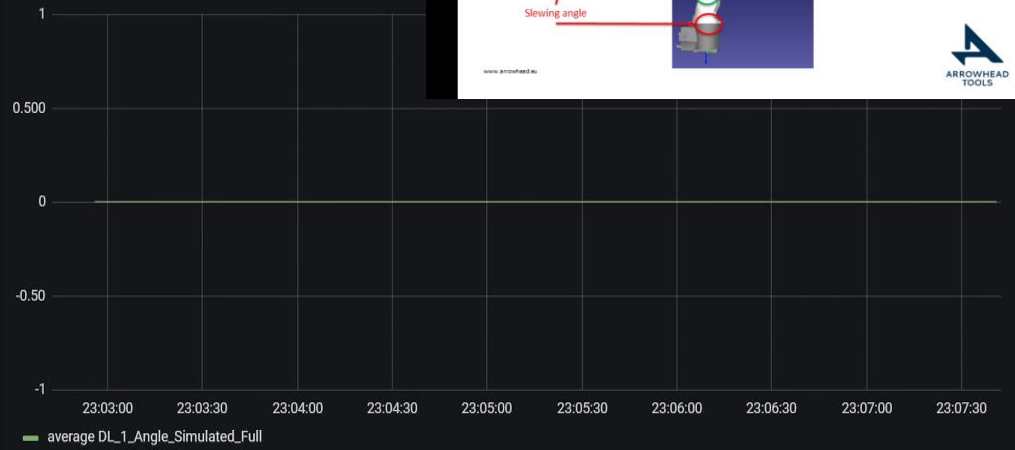
© Video from NTNU



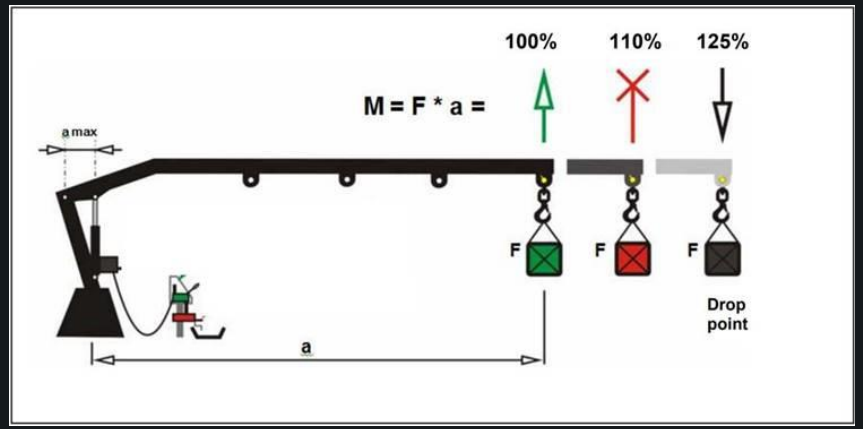


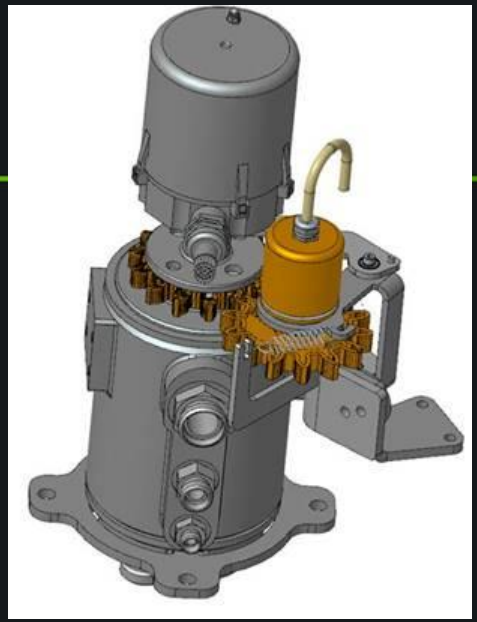
Main Cylinder Angle

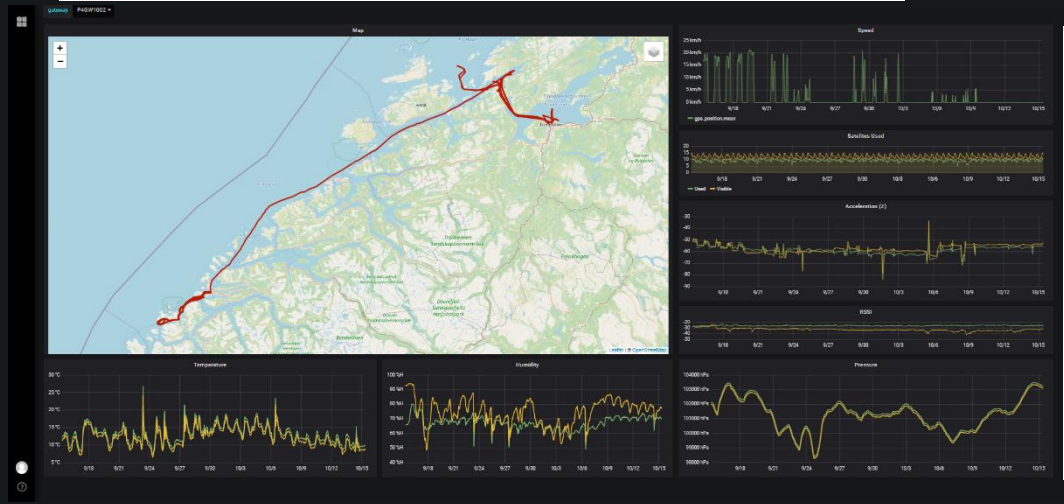
- Main Cylinder Angle
- Second Cylinder Angle
- Outer Link Angle
- Outer Link Extension Length
- Slewing Angle

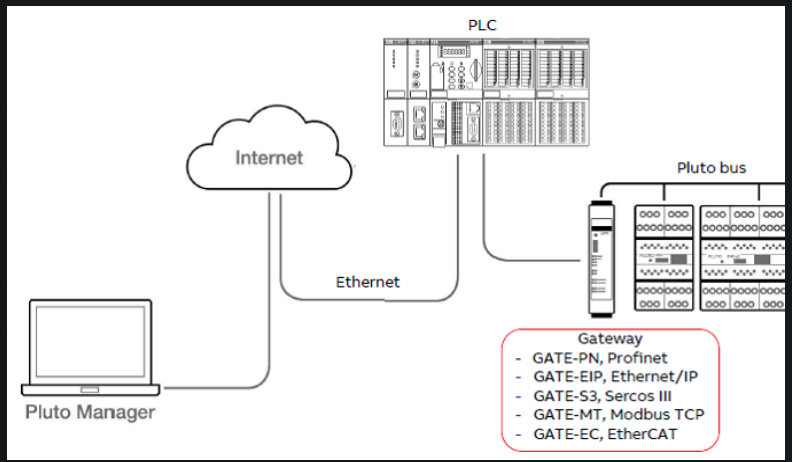


Sensors installed









CRANE PLC/Cloud based solutions

Summary of the open-source Eclipse Arrowhead framework (video)

https://youtu.be/vf28cQVgPss

- **Questions**