ConnectedFactories Webinar

Standards for digital manufacturing

20 October 2020
at 09:30

ISO 10303 in EU Projects like Kyklos 4.0, Arrowhead Tools, Change2Twin

Kjell Bengtsson , Jotne, kjell.bengtsson@jotne.com

CONNECTED FACTORIES

ARROWHEAD TOOLS

KYKLOS 4.0

Digital Twin for every manufacturing SME!

Change2Twin is a European project which supports manufacturing SMEs in their digitalization process by providing Digital Twin solutions. The concept of Digital Twin is one of the big game-changers in manufacturing and allows companies to significantly increase their global competitiveness.

- 18 Partners, Grant Agreement nr. 951956
- Web: https://www.change2twin.eu/

- Digital Innovation Hubs
- Part of I4MS: the EU initiative to digitalise the manufacturing industry

HORIZON 2020

PILOTS

CHANGE2TWIN

Packaging Industry	Process Manufacturing	Additive Manufacturing	Biomedical Manufacturing
			

Change2Twin

Economic Impact
- Reduce new product time-to-market and lead time
- Reduce operational costs
- Improve overall quality
- Improve efficiency of service

Social Impact
- Create high-skilled jobs
- Improve working conditions
- Create novel resource management strategies

Environmental Impact
- Reduce waste
- Lower energy consumption
- Reduce material consumption

HORIZON 2020

Prothesis Adapter: Considered Solutions

Requirements

Requirements Update

- PLM system for version control

Proper versioning based on updates

Design

Design Update

- Tool for better model conversions for topology optimised models
- PLM system

- .stmod to .step conversion
- Updating .stmod files in other CAD softwares
- File versioning
- Include manufacturing limitations

Analysis

- IGA analysis
- PLM for version control
- Aid for data documentation
- Faster analyses possibilities

- Converting .stmod files analysis inputs.
- File versioning
- Proper versioning and update of data in analysis report with each iteration

Manufacturing

Manufacturing

- Inputs on manufacturing techniques / tolerances and parameters
- PLM system to save this for further tasks

Consider all tolerances and limitations of different suppliers / machines

Commissioning

Testing

- PLM on data management
- PLM to link data on design/ production methods influencing quality

- Update test plan with requirement updates
- Feed information from test output towards requirement / design

Documentation in each phase

Possible solutions

Problems faced

HORIZON 2020

SPACE STRUCTURES

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

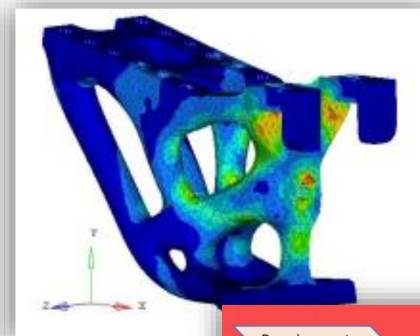
Data Storage – Collect data along the life of a product or project cycle

Interoperability

↓

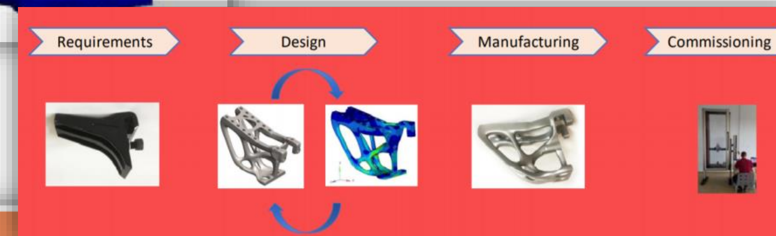
Data Exchange - Export/import facilities using ISO 10303-239/209

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



Unified ISO 10303 Repository

ISO®



Jotne

SPS_C2T › SPS_C2T (ver.64) ›

SPS_C2T (VER.64)

- 01_Input Data (ver.6)
- 02_Requirements (ver.64)
- 03_Structural Analysis (ver.54)
- 04_Assembly (ver.64)
- 05_Manufacturing (ver.10)
- 06_Testing (ver.15)

SPS_C2T › SPS_C2T (ver.63) › 04_Assembly ›

04_ASSEMBLY (VER.63)

- Distanzplatte *(rev.1 ver.001)*
- Winkelblech *(rev.1 ver.001)*
- Assembly *(rev.1 ver.004)*

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

CHANGE2TWIN funding scheme

- **€10.000 Assessment Voucher:** get a ready to use twinning recipe
- **€90.000 Deployment Voucher:** get the digital twin based on the recipe and test it
- **2x2 Open Calls** for SMEs: 2021 and 2023
- **multistakeholder principle:** manufacturing SMEs, technology providers, Digital Innovation Hubs

Artwork by Micheile Henderson on Unsplash

HORIZON 2020

KYKLOS 4.0 Factsheet

KYKLOS 4.0

KYKLOS 4.0	An Advanced Circular and Agile Manufacturing Ecosystem based on rapid reconfigurable manufacturing process and individualized consumer preferences
Project Number	872570
Starting Date	01/01/2020
Project Duration	48 months
Call (part) Identifier	H2020-DT-2019-1
Topic	Digital Manufacturing Platforms for Connected Smart Factories
Budget	€19.227.110
Number of partners	29
Coordinator	Technalia - Jason.Mansell@tecnalia.com
Web site	https://kyklos40project.eu/

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.
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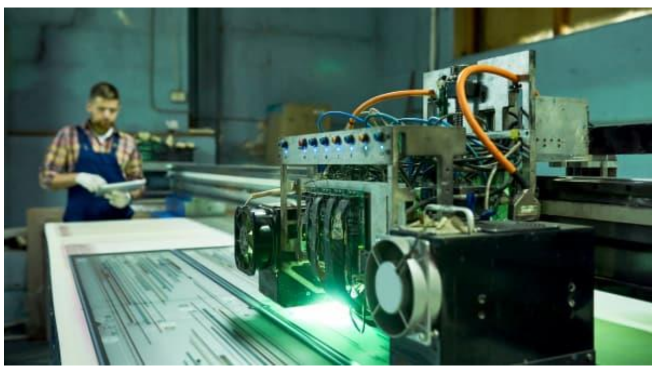
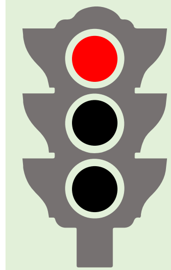
Rationale

KYKLOS 4.0

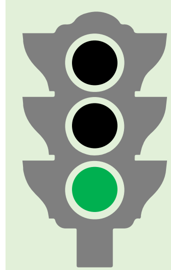


Manufacturing companies **consume** high amounts of energy as well as **natural resources** in their product-making processes:

- The respective amounts and overall costs of product making are increasing
- EU energy prizes are continuously increasing
- Raw materials price trend is ascending, increasing short term volatility



Optimizing the manufacturing processes becomes “a must” to ensure **sustainability**



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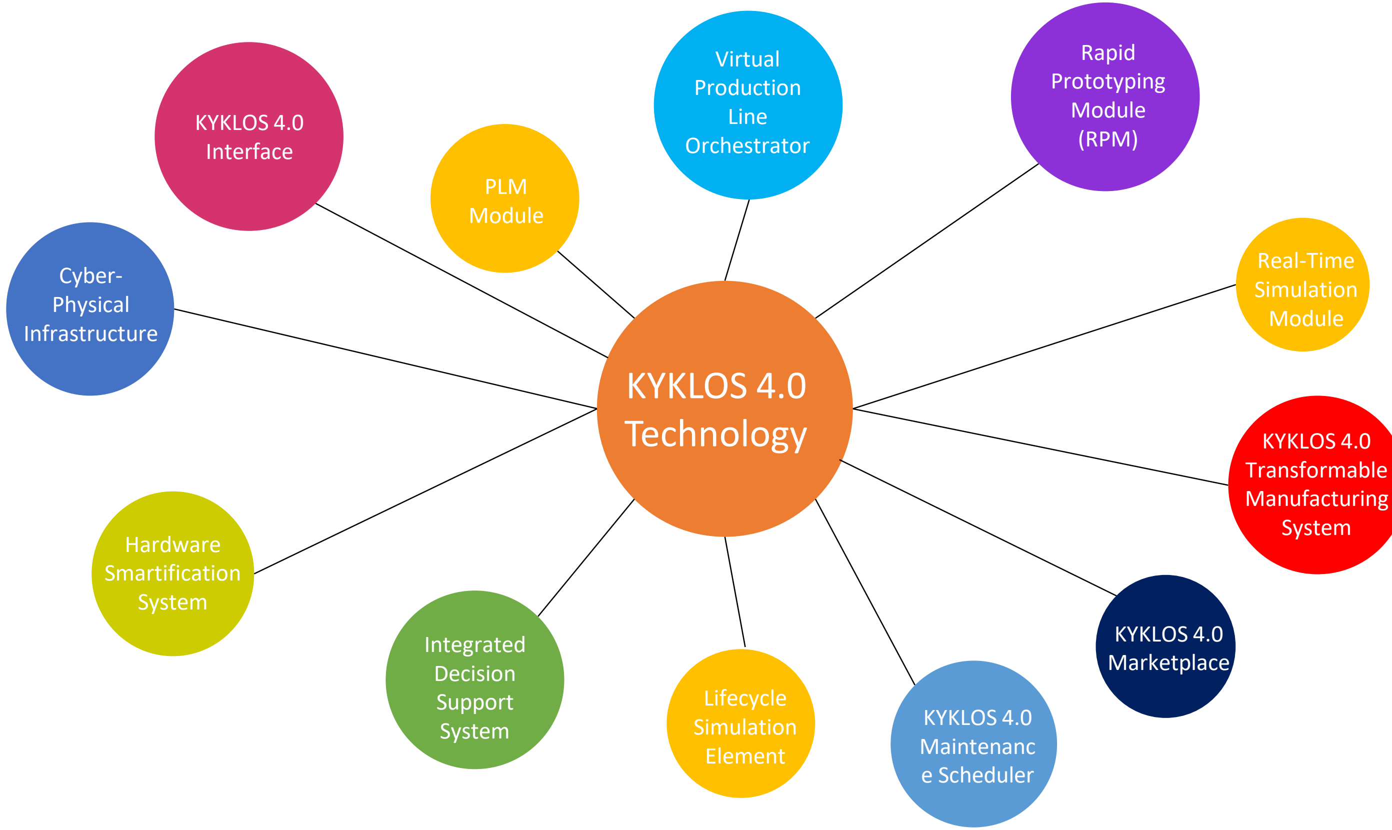
KYKLOS 4.0 Technology & Solutions

KYKLOS 4.0

KYKLOS 4.0 technology involves a set of **intelligent tools** for **real-time analytics & prediction, and recommendation systems,** integrated into the KYKLOS 4.0 configuration environment

Rapid Reconfigurable Manufacturing Process

Individualization of Consumer Preferences



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KYKLOS 4.0 Pilots

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

Large-scale piloting in 7 pilots to demonstrate the technical, environmental and economic viability of KYKLOS 4.0 Ecosystem

Pilots will be divided into two main categories: Pilots related to **Smart Manufacturing**, and to **Circular Manufacturing** (energy efficiency and waste management) 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)

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KYKLOS 4.0 Open Calls

KYKLOS 4.0

KYKLOS 4.0 will organize two Open Calls during the project with the objective of **engaging European SMEs** in the design and implementation of highly innovative experiments/prototypes using research infrastructure available within the framework of the project

Several events, including online webinars and local face-to-face events across Europe are expected to be implemented within the framework of the two Open Calls

Funding will be provided to projects led by small consortia (third parties) and targeting **innovative concepts**. Each project is expected to define their own project objectives while adhering to the larger objectives and vision of the KYKLOS4.0 project

A total of **€3M** has been budgeted for the KYKLOS 4.0 Open Calls. In principle, €1M for the 1st and €2M for the 2nd Open Call. **Awarded projects may receive up to €150.000**, with each third party receiving a maximum of €60.000

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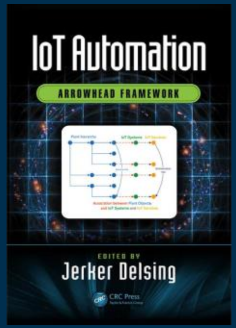
Arrowhead Tools

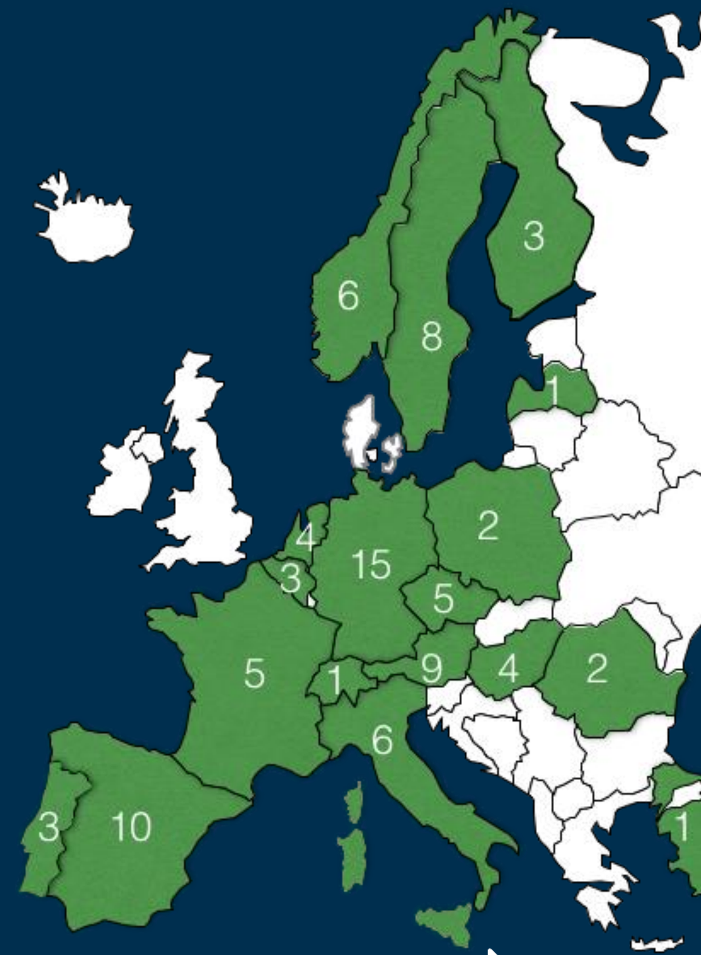
Europe's larges Automation and Digitalisation Engineering project

- 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/

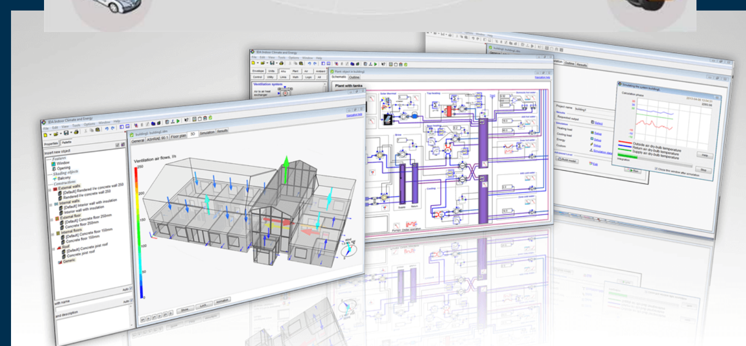




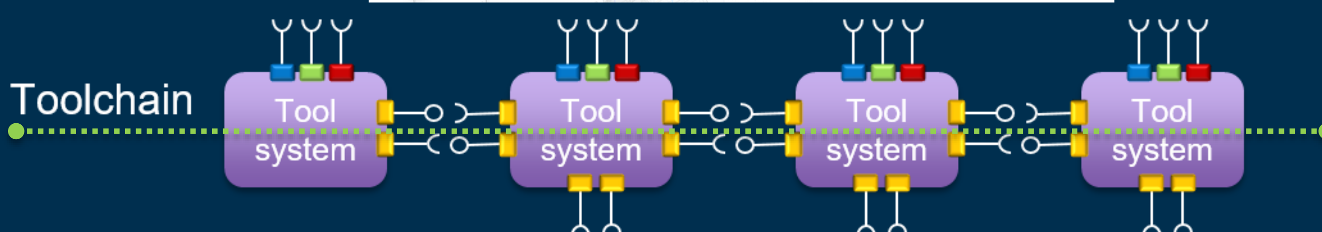
ARROWHEAD
TOOLS

Engineering efficiency improvements
Validation and verification in 21 advanced use cases

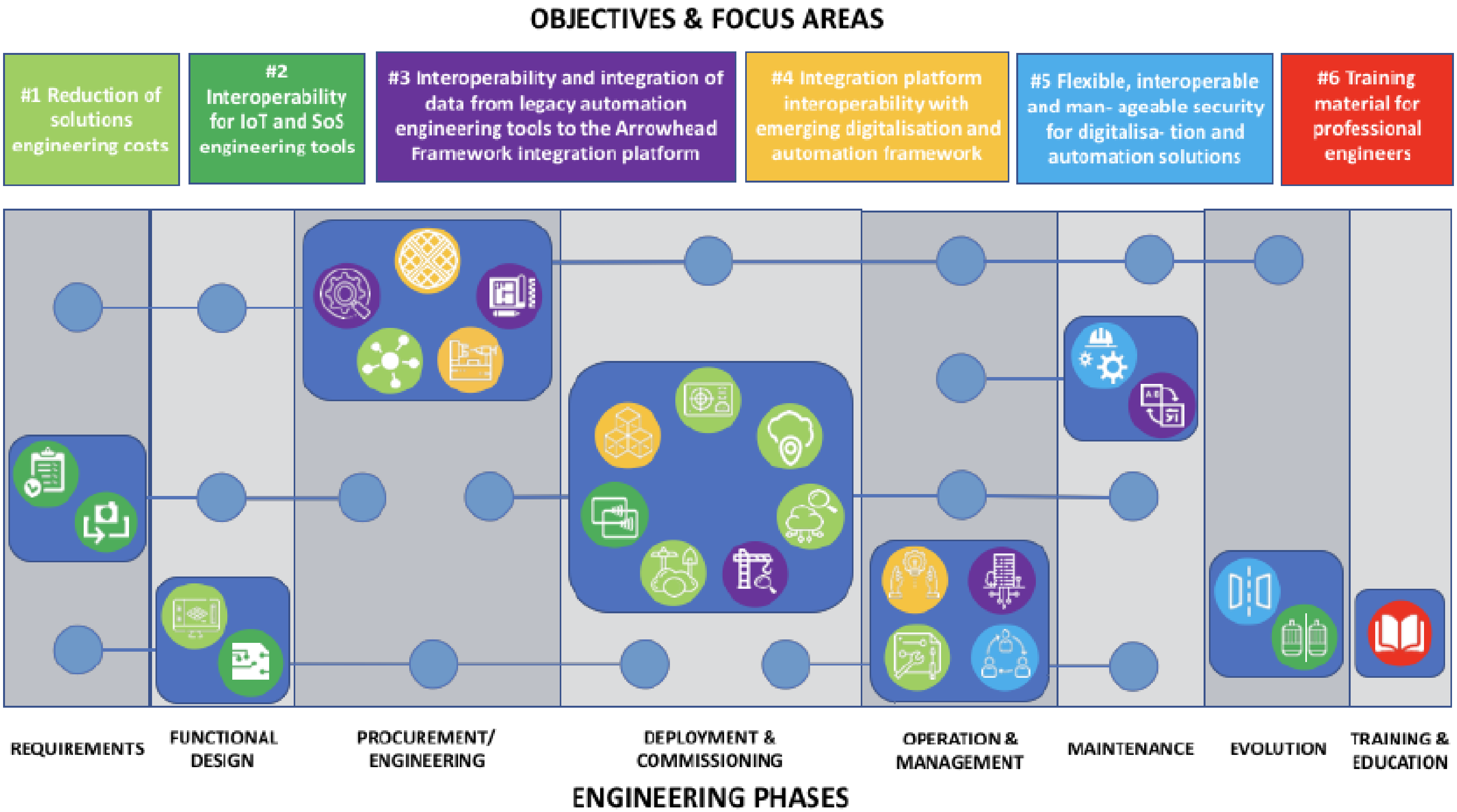
- Automotive
- Mining
- Electronics



- Software
- Building Sector
- Offshore



ARROWHEAD TOOLS


OBJECTIVES & FOCUS AREAS
#1 Reduction of solutions engineering costs
#2 Interoperability for IoT and SoS engineering tools
#3 Interoperability and integration of data from legacy automation engineering tools to the Arrowhead Framework integration platform
#4 Integration platform interoperability with emerging digitalisation and automation framework
#5 Flexible, interoperable and man- ageable security for digitalisa- tion and automation solutions
#6 Training material for professional engineers
REQUIREMENTS
FUNCTIONAL DESIGN
PROCUREMENT/ ENGINEERING
DEPLOYMENT & COMMISSIONING
OPERATION & MANAGEMENT
MAINTENANCE
EVOLUTION
TRAINING & EDUCATION
ENGINEERING PHASES

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.

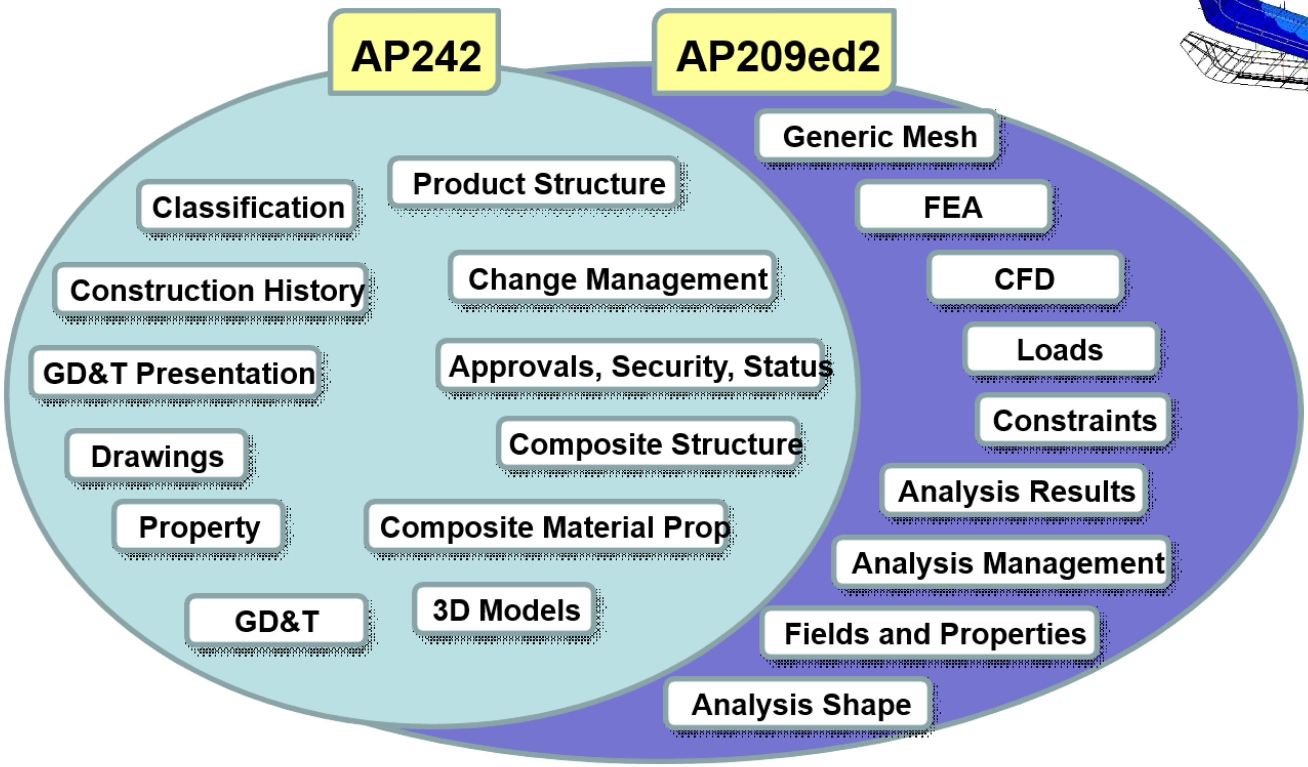
www.arrowhead.eu/arrowheadframework and download www.github.com/arrowhead-f

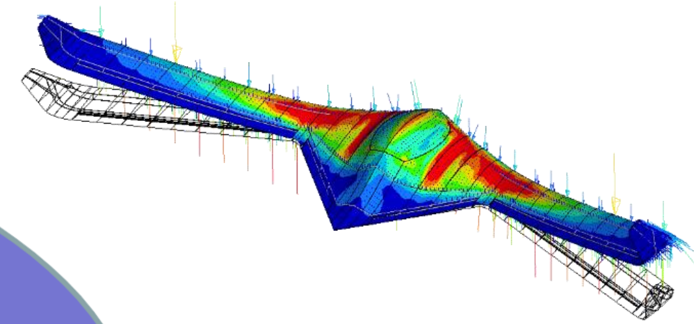
ARROWHEAD TOOLS

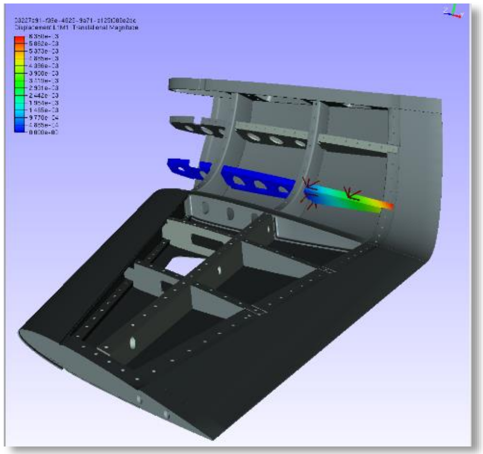
Norwegian Use Case: Digital twins and structural monitoring

ARROWHEAD
TOOLS

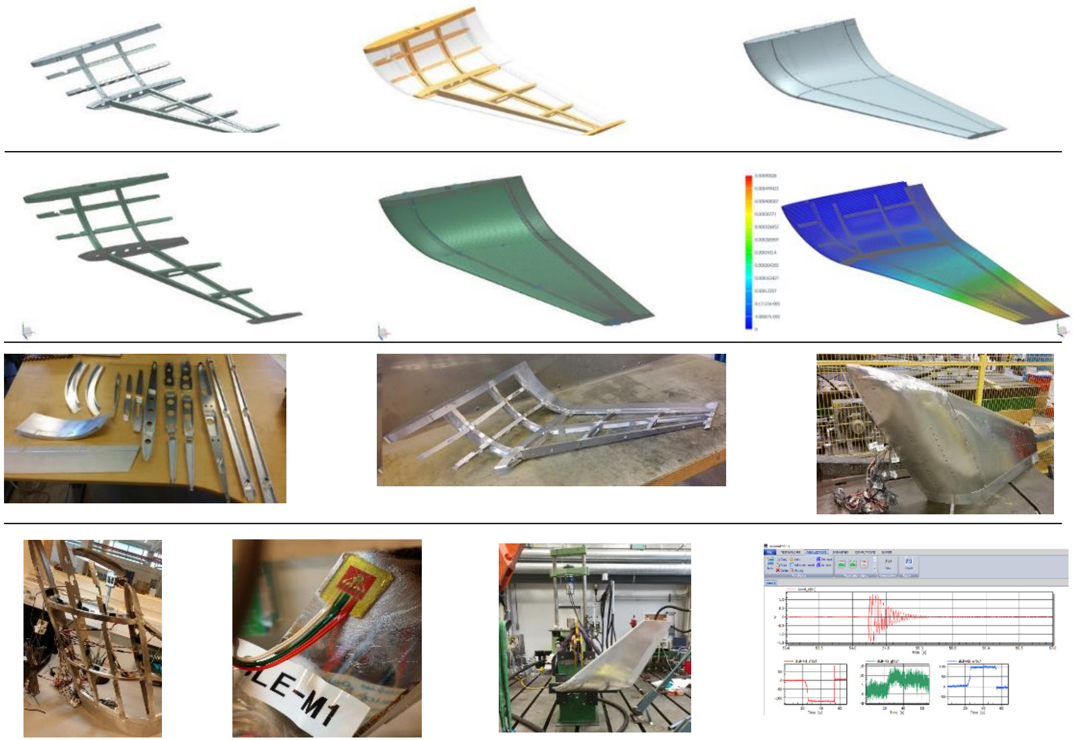
Content of ISO 10303-242/209







Using AP209 for Simulation and structural test data



Design CAD

Analysis FEM

Manufacturing

Sensor data

Some related SW

SIEMENS NX

creo

SOLIDWORKS

NX NASTRAN

ANSYS

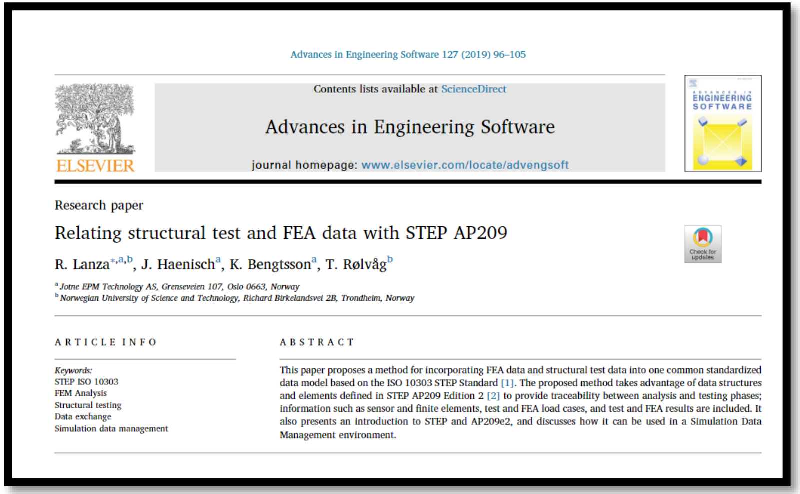
SIMULIA ABAQUS

Elmer

HBM catman

ISO 10303 – AP209

- Part of PhD study:
  - Investigate the use of AP209 to handle Structural test data and it's relations to Simulation data.
  - Paper in *Advances in Engineering Software*: https://www.sciencedirect.com/science/article/pii/S0965997818301947


Advances in Engineering Software 127 (2019) 96–105

Contents lists available at ScienceDirect

Advances in Engineering Software

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

Research paper

Relating structural test and FEA data with STEP AP209

R. Lanza[*,a,b], J. Haenisch[a], K. Bengtsson[a], T. Rølvåg[b]

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ARTICLE INFO

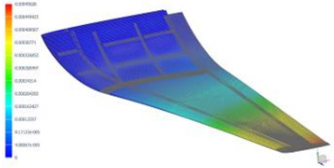
Keywords:
STEP ISO 10303
FEM Analysis
Structural testing
Data exchange
Simulation data management

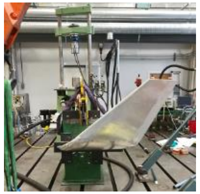
ABSTRACT

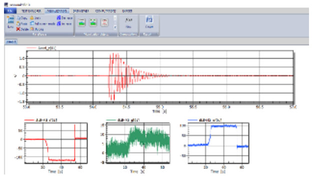
This paper proposes a method for incorporating FEA data and structural test data into one common standardized data model based on the ISO 10303 STEP Standard [1]. The proposed method takes advantage of data structures and elements defined in STEP AP209 Edition 2 [2] to provide traceability between analysis 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 and project with Lockheed Martin (Crystal Project):

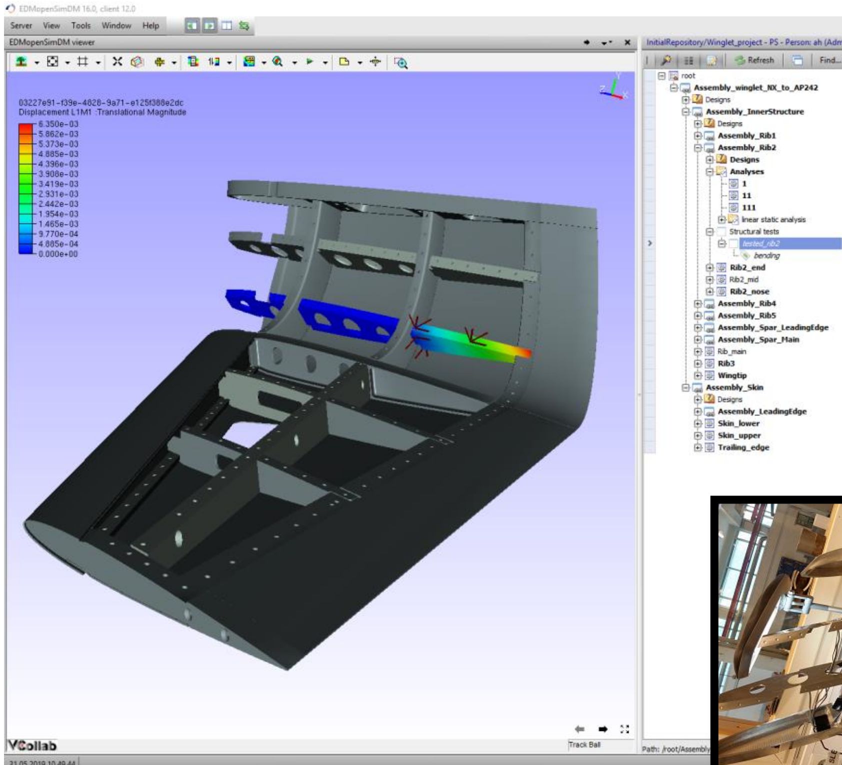
Winglet prototype design by Lockheed Martin
Produced at NTNU
Analyzed (FEA)
Mounted sensors and set in test rig
FEA load cases tested physically
Design (CAD) → AP209
Simulation data → AP209
Structural Test data → AP209
All data managed in AP209 in Jotne's SDM tool (EDMopenSimDM)
All traceability kept

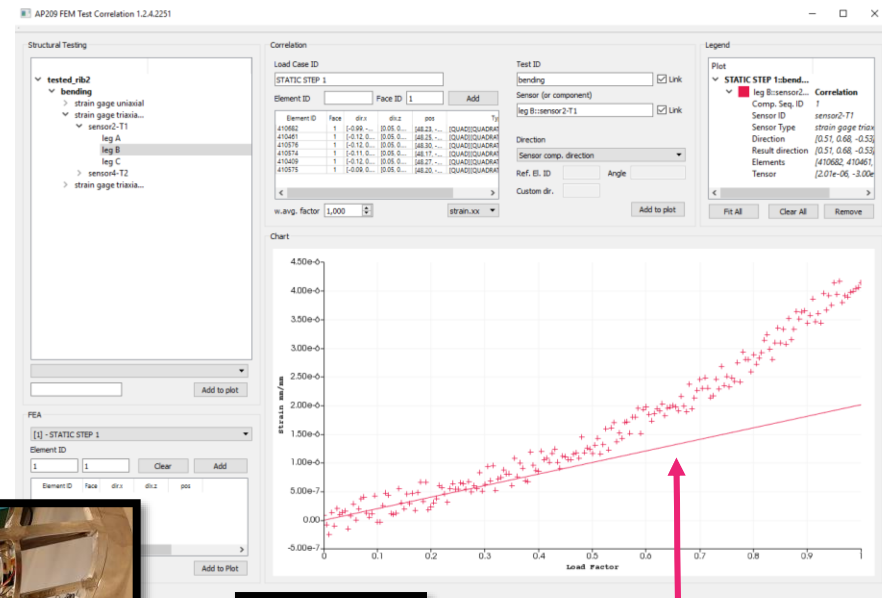


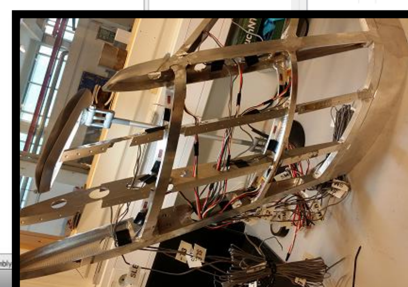




EDMopenSimDM (Simulation Data Management)





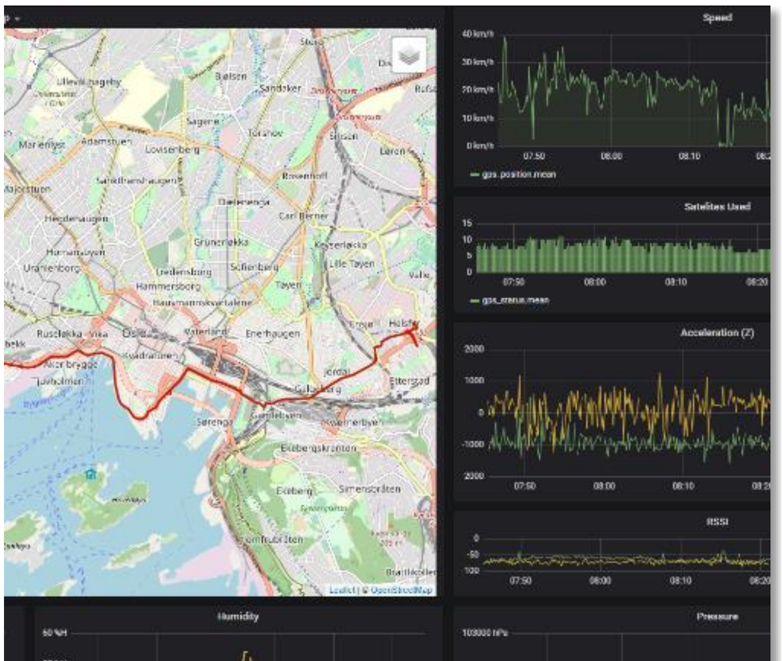


Correlation between simulations and testing

The Challenge

Sensor data in the cloud → ARROWHEAD TOOLS → Sensor data in the ISO 10303 cloud PLM repository

EXPRESS Data Manager
TruePLM ™



- D00 / ASD/AIA Bike
  - DA0 / Wheels
  - DA1 / Brake System
  - DA2 / Steering System
  - DA3 / Frame System
    - DA3-10 / Main Frame
    - DA3-20 / Saddle
      - Tellu-sensor

Representation of the aggregate property

time	ax (millig)	ay (millig)	az (millig)	battery (mV)	humidity (%RH)	pressure (Pa)	rssi (dBm)	temperature (C)
2.7.2019, 09:16:46	176	-100	-989	3223	30	99581	-77	22.77
2.7.2019, 09:16:56	-1	5	-1025	3217	30	99582	-71	22.76
2.7.2019, 09:17:07	241	-142	-1061	3217	30	99581	-73	22.75
2.7.2019, 09:17:17	-167	77	-1010	3223	30	99582	-57	22.74
2.7.2019, 09:17:27	-209	86	-1000	3217	30	99581	-48	22.73
2.7.2019, 09:17:37	-207	83	-1001	3223	30	99583	-48	22.73
2.7.2019, 09:17:47	-204	84	-1000	3217	30	99582	-57	22.73
2.7.2019, 09:17:57	-205	82	-998	3223	31	99582	-58	22.72
2.7.2019, 09:18:07	-209	82	-1006	3223	31	99582	-57	22.72
2.7.2019, 09:18:17	-203	81	-1001	3217	31	99582	-44	22.72
2.7.2019, 09:18:27	50	-5	-1004	3217	31	99582	-65	22.72
2.7.2019, 09:18:37	-10	14	-1062	3223	31	99593	-63	22.72
2.7.2019, 09:18:47	65	-24	-1027	3223	31	99585	-66	22.72
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2.7.2019, 09:19:37	-114	51	-1013	3217	31	99582	-65	22.71
2.7.2019, 09:19:47	-109	46	-1013	3223	31	99580	-48	22.72
2.7.2019, 09:19:57	-116	45	-1018	3217	31	99581	-58	22.72
2.7.2019, 09:20:07	116	-101	-1072	3223	31	99579	-44	22.71
2.7.2019, 09:20:17	304	-140	-981	3223	31	99579	-40	22.71
2.7.2019, 09:20:27	151	-101	-1029	3211	31	99582	-44	22.71
2.7.2019, 09:20:38	182	-60	-1006	3223	31	99584	-41	22.71
2.7.2019, 09:20:48	159	-47	-1007	3217	31	99585	-43	22.71
2.7.2019, 09:20:58	145	-14	-1001	3217	31	99584	-41	22.71
2.7.2019, 09:21:08	193	-72	-943	3223	31	99584	-41	22.71
2.7.2019, 09:21:18	68	-166	-1105	3223	31	99584	-41	22.7
2.7.2019, 09:21:29	164	-4	-771	3217	31	99585	-42	22.7
2.7.2019, 09:21:40	249	-99	-1008	3223	31	99585	-42	22.7

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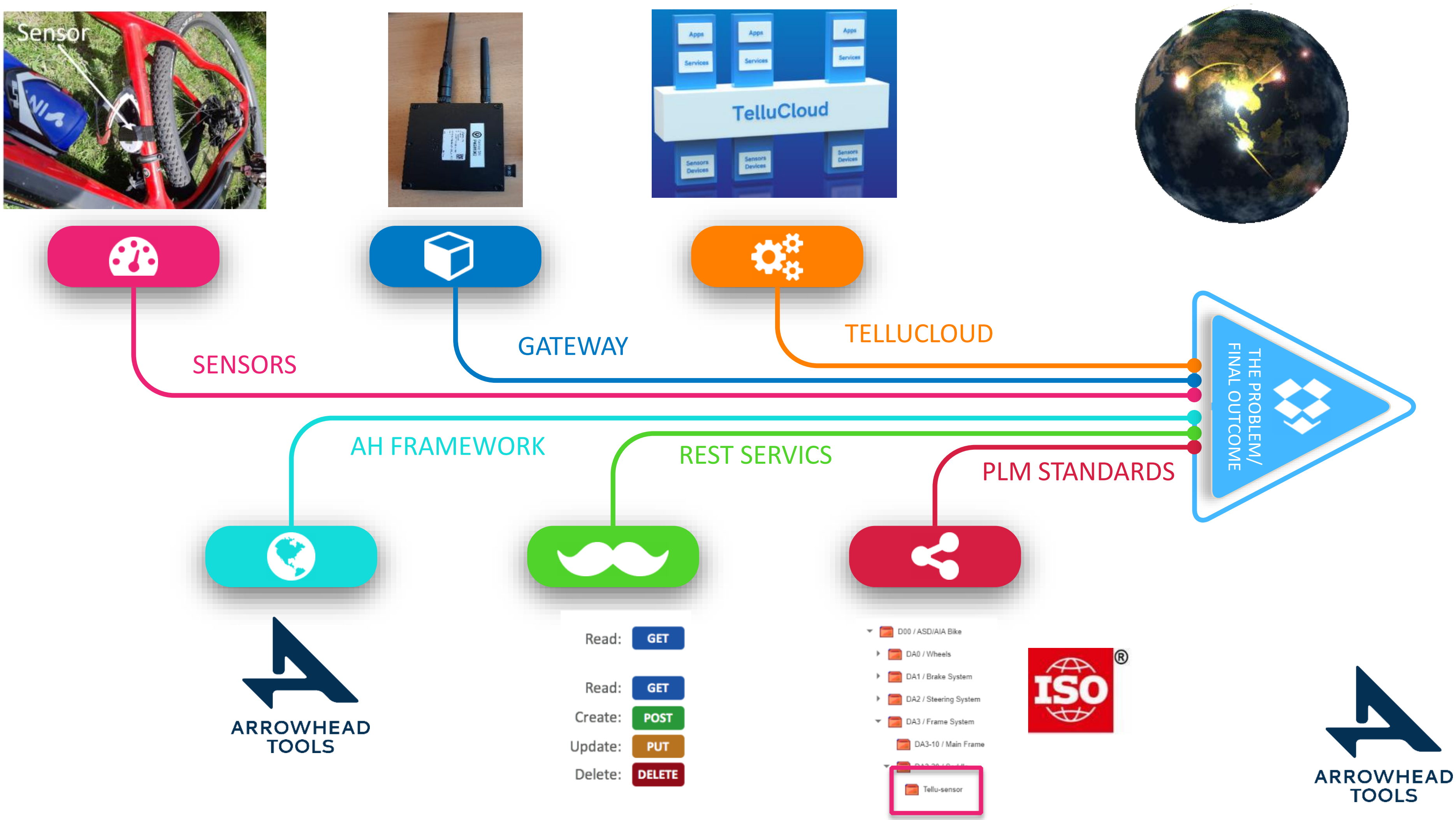
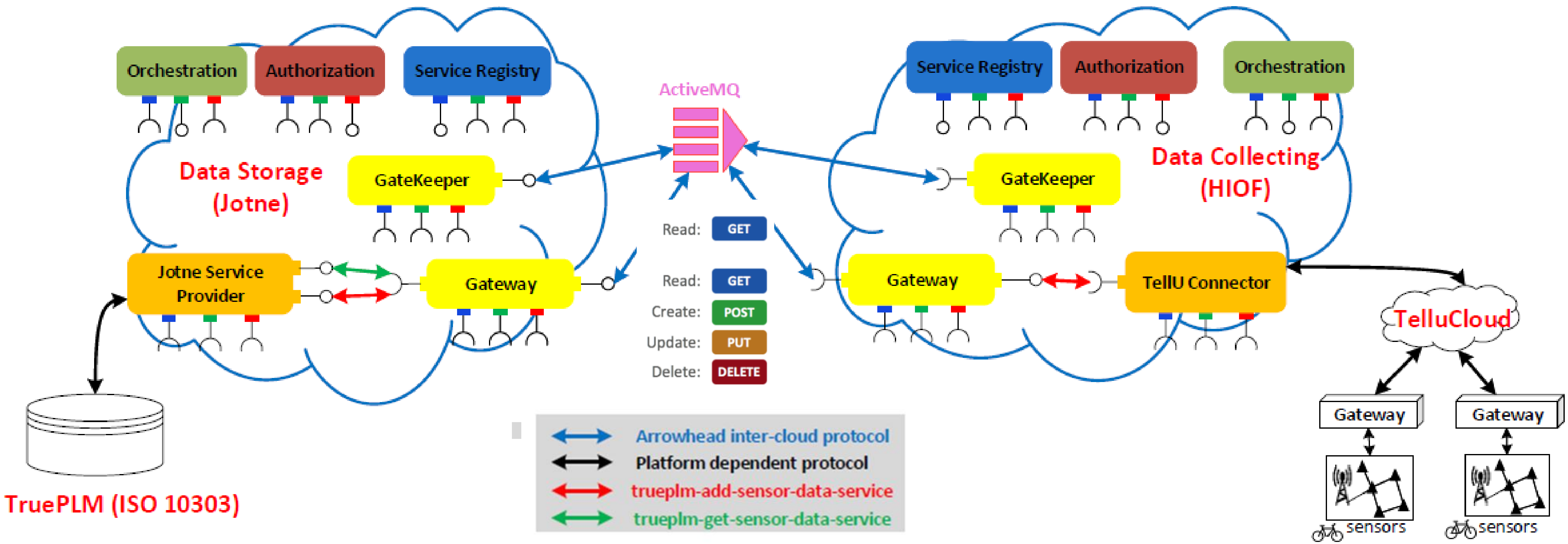
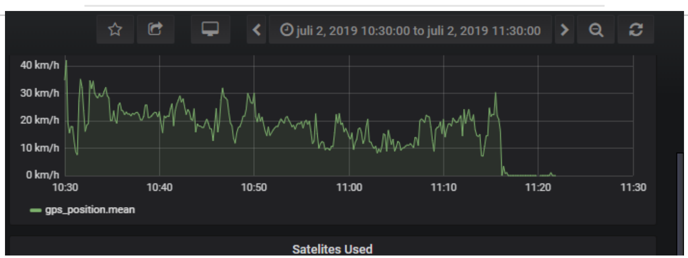


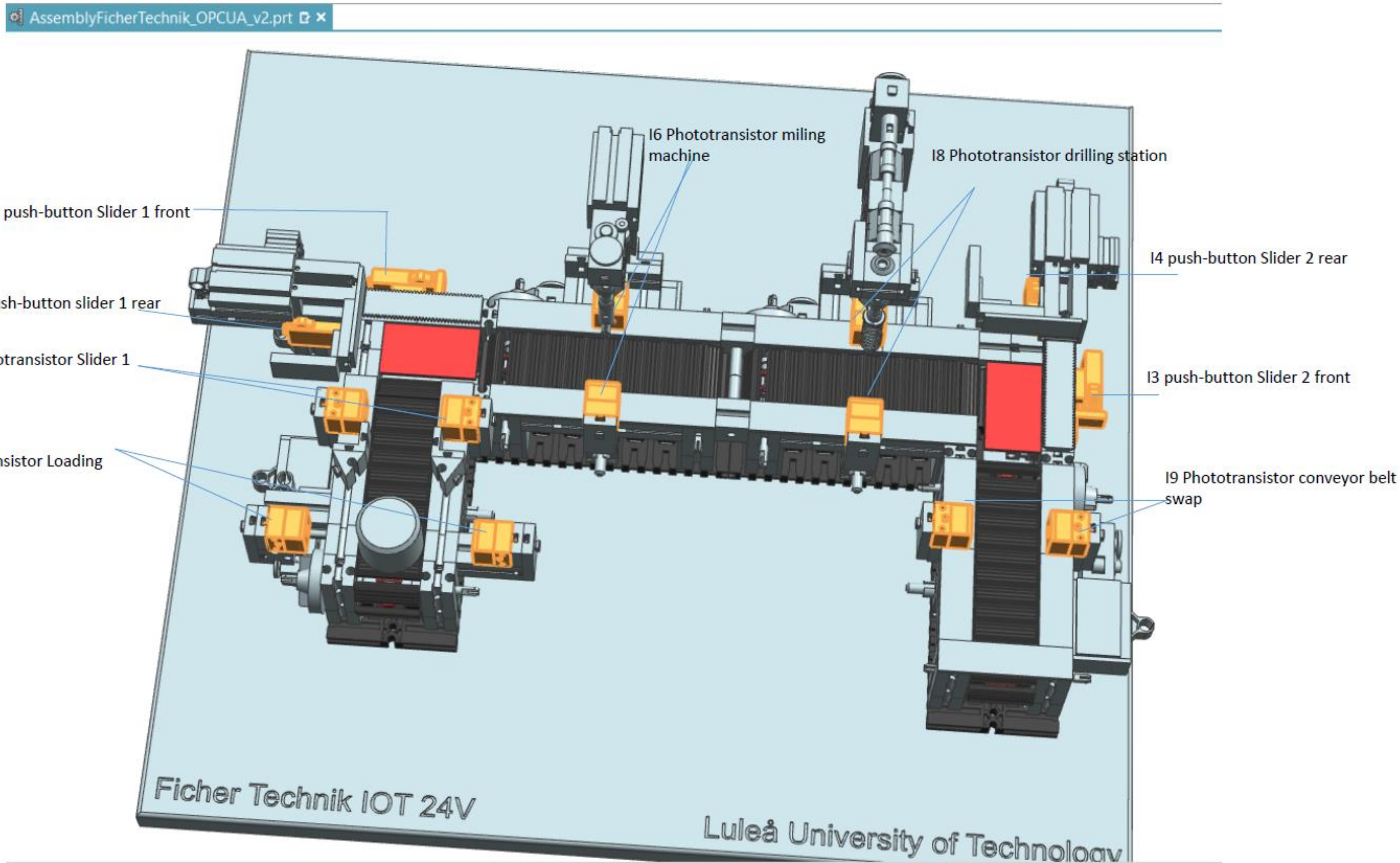
Sensor
Apps
Services
TelluCloud
Sensors Devices
SENSORS
GATEWAY
TELLUCLOUD
THE PROBLEM/
FINAL OUTCOME
AH FRAMEWORK
REST SERVICS
PLM STANDARDS
ARROWHEAD TOOLS
Read: GET
Read: GET
Create: POST
Update: PUT
Delete: DELETE
D00 / ASD/AIA Bike
DA0 / Wheels
DA1 / Brake System
DA2 / Steering System
DA3 / Frame System
DA3-10 / Main Frame
Tellu-sensor
ISO
ARROWHEAD TOOLS

PLM using Arrowhead 4.2



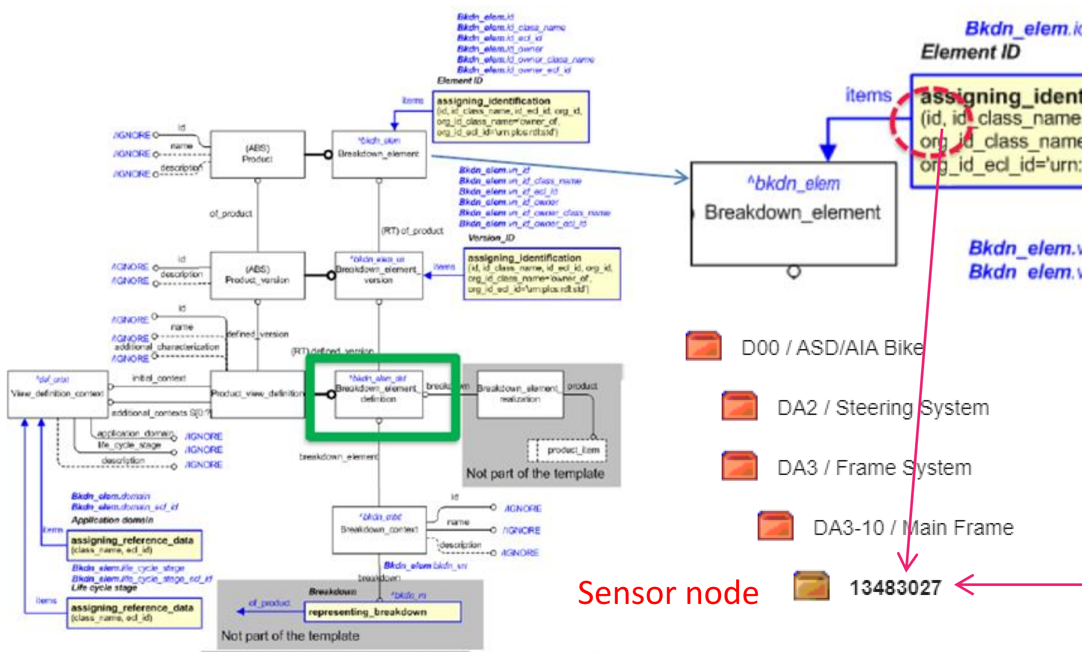


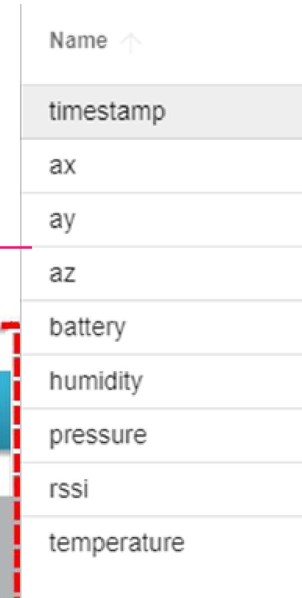
ISO 10303-242, implemented to the repository and also demonstrated for the Fischer Factory



Properties in ISO 10303 and ISO 12006

Jotne





ptc

ISO 10303

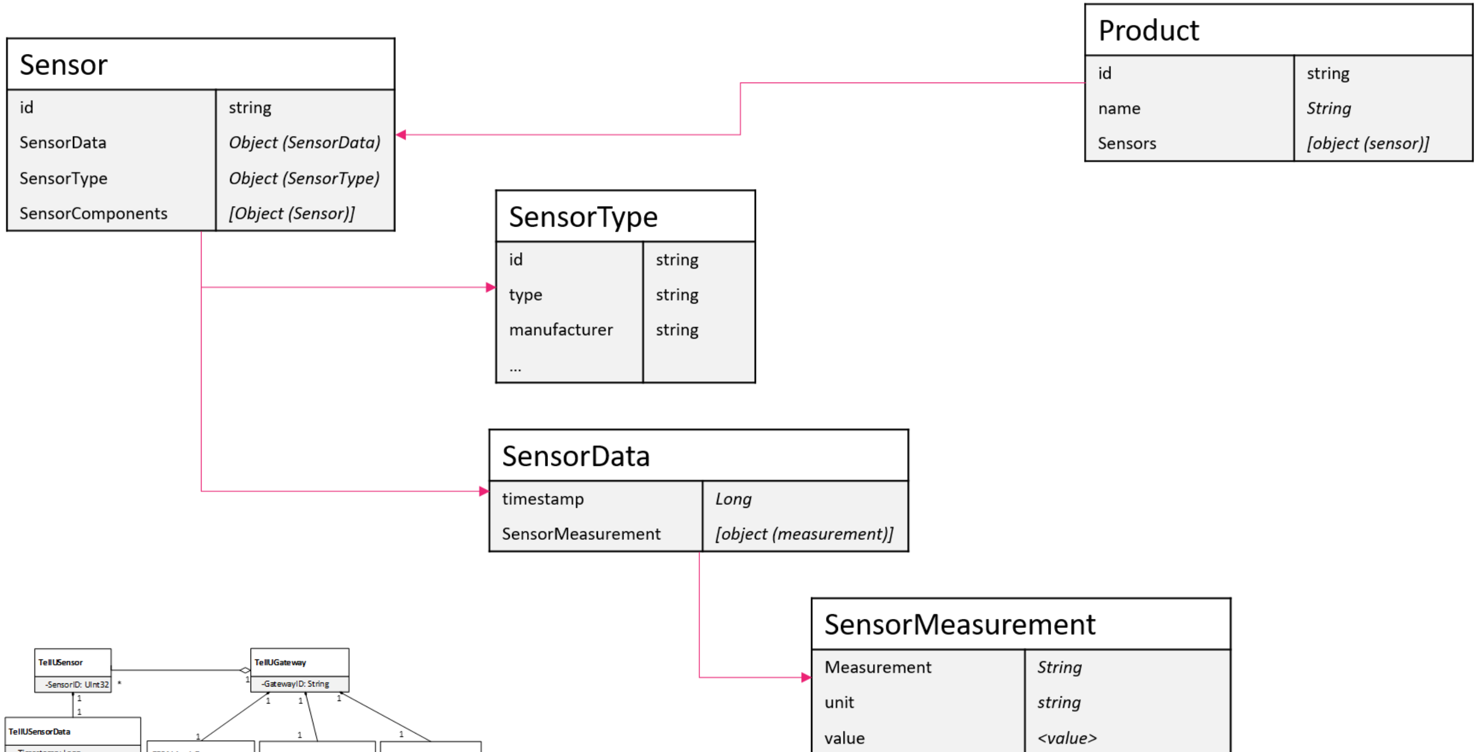
OWL

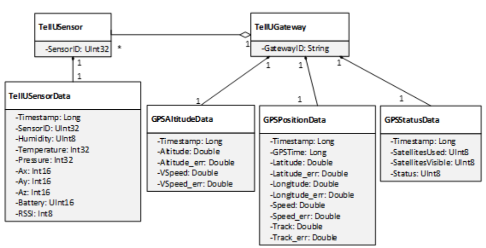
ISO 12006

These concepts are deployed by PLM vendors like PTC

ARROWHEAD TOOLS

First we needed create the sensor data model (1)





ARROWHEAD TOOLS

What we did (2) – AHT Producer, Consumer

- Configured and run the following AHT components:
  - Service registry 

  - Authentication 

  - Orchestration 

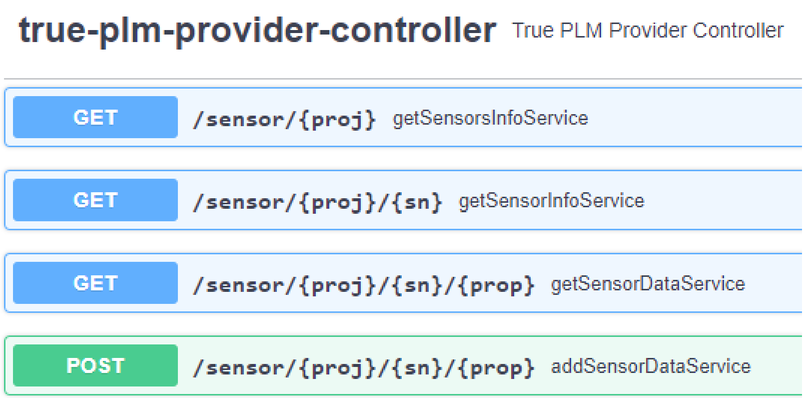
  - Gatekeeper 

  - Message broker(ActiveMQ) 

ARROWHEAD TOOLS

What we did (3)

- Created the services to connect sensor data to the ISO 10303 repository.
  - https://trueplm.j-spb.com/EDMtruePLM/swagger.html

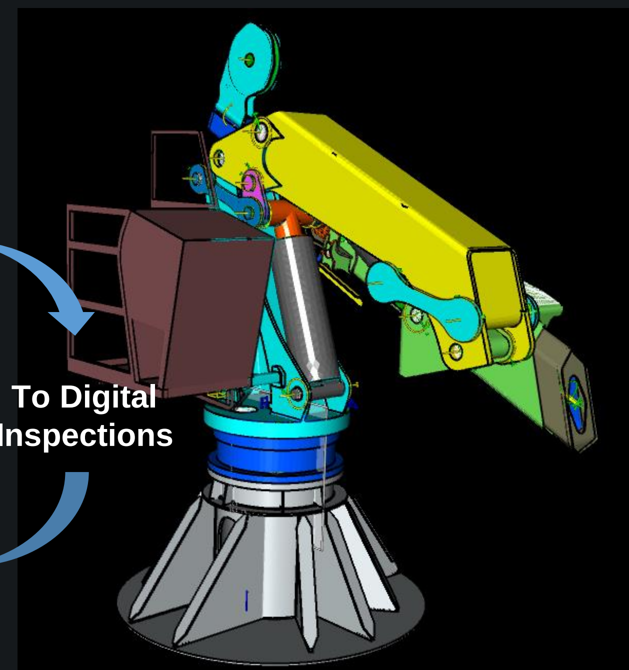


Digital Twin Based Crane Monitoring

Crane Implementation

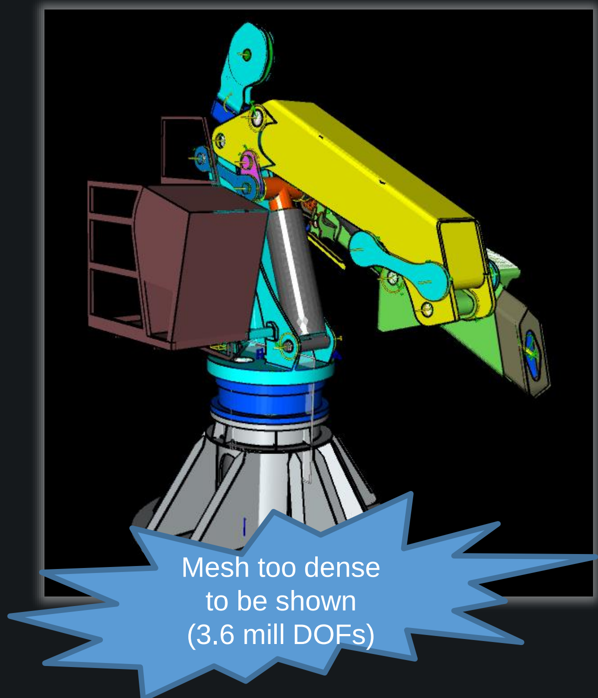
From Physical Inspections

To Digital Inspections



Digital Twin FEA technology

Our Digital Twin models are simulated real time in FEDEM:

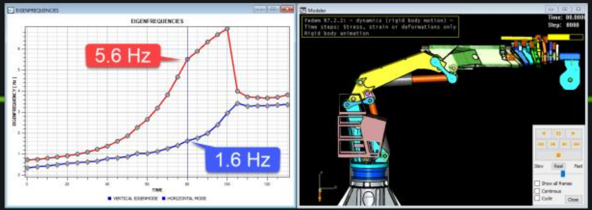


- CAE
  - 3D modelling / idealization
  - Joint / spring / damper / sensor modelling
  - Substructuring (25 super elements)
  - Meshing
- Dynamic simulation (nonlinear FEA)
  - Forces, Positions, Velocities and Accelerations
- Structural Analysis
  - Stresses / strains
  - Vibration frequencies
  - Damage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

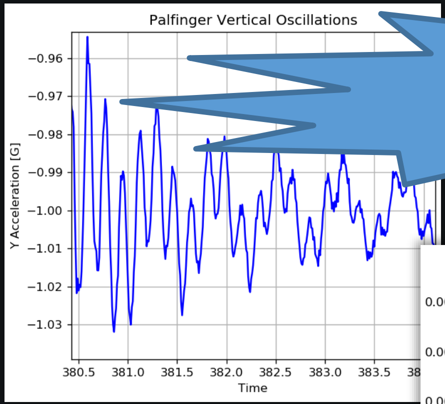
$$\mathbf{M}(\mathbf{r}, t)\,\ddot{\mathbf{r}}(t) + \mathbf{C}(\mathbf{r}, \dot{\mathbf{r}}, t)\,\dot{\mathbf{r}}(t) + \mathbf{K}(\mathbf{r}, t, \sigma)\,\mathbf{r}(t) = \mathbf{F}(t)$$

$$\boldsymbol{\varepsilon}_{rosette} = \left[\mathbf{T}_{re}\widetilde{\mathbf{B}}\,\mathbf{T}\,\mathbf{A}\,\mathbf{L}\,\mathbf{H}\right]\mathbf{v}_{sup}$$

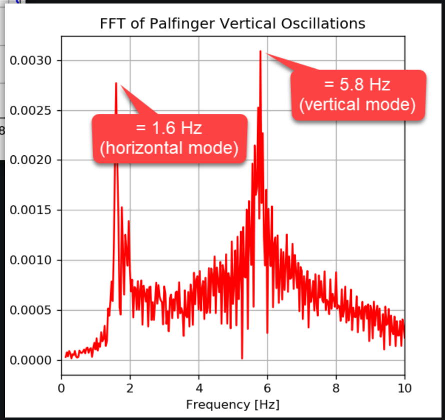
Palfinger DT Validation



Measured eigenfrequency at minimum extension:



Perfect match mode 1 (1.6 Hz)
Close match mode 2 (5.8 versus 5.6 Hz)

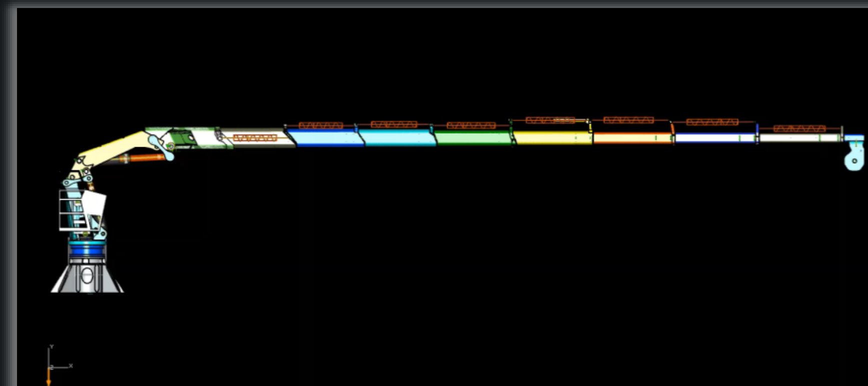


Palfinger DT Validation

FEDEM runs faster than real time with 3.6 mill DOFs!

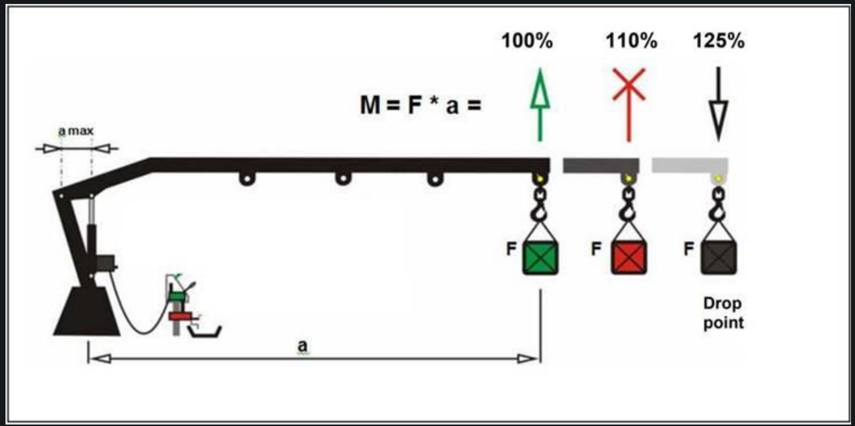
Crane deployment takes 130 seconds:

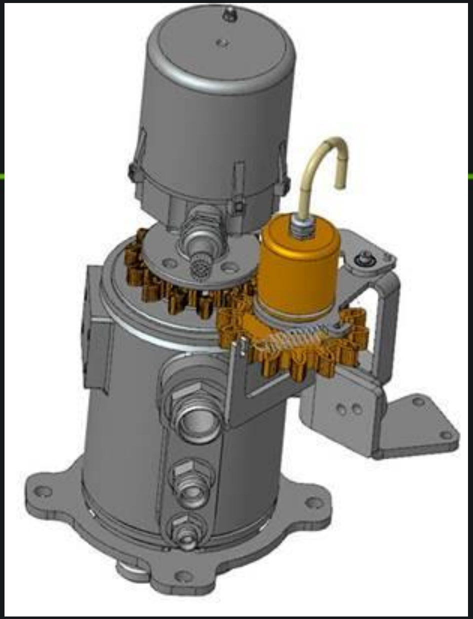
FEDEM simulation takes 75 seconds:

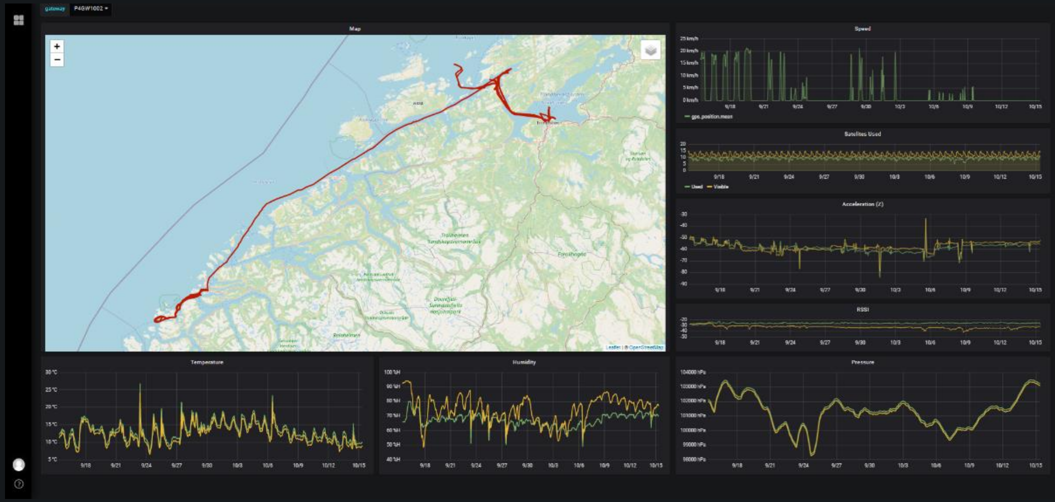


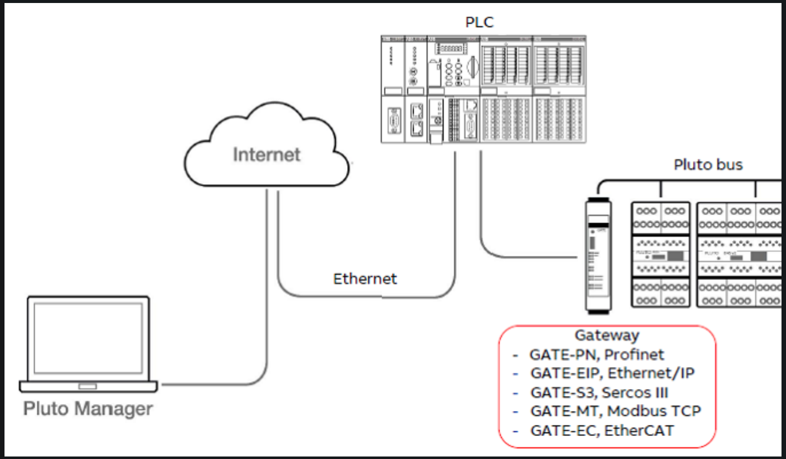
```
-----------------------------------------
Elapsed time :    0 days 00:01:30.38
CPU time     :    0 days 00:01:15.06
-----------------------------------------

Simulation successfully completed :-)
```

Sensors installed









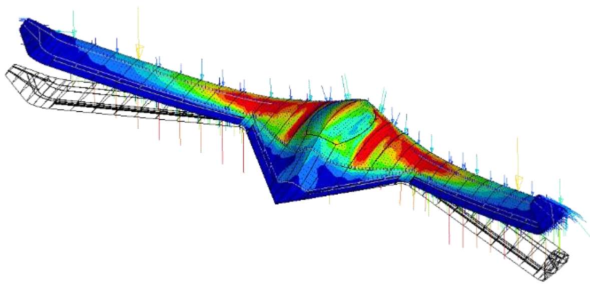
CRANE PLC/Cloud based solutions

ISO

Questions?

ARROWHEAD TOOLS

ISO 10303 (STEP)



KYKLOS 4.0

CHANGE2TWIN

1 2

3 4

The Mountain Bike experiment

Digital Twin Based Crane Monitoring