Utilizing PLM and ISO 10303 (STEP) for managing advanced manufacturing processes of critical space components to reduce production cost by 60%

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Jotne

GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2023

BOEING ELYSIUM NORTHROP GRUMMAN Parker PDES, Inc.® Connecting the Digital Enterprise

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Presenters Bio

Kjell Bengtsson, Jotne: is 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, NAFEMS and more. Further, Kjell also manage the Jotne extensive R&D portfolio at EU and the European Space Agency (ESA).

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esa

Part of this presentation and its related results arrives from the European Space Agency ARTES program and ESA Contract No. 4000132891/20/NL/FGL "Embedded sensor network in spacecraft structures compatible with digital factories".

Jotne Background

30 years of innovation in the aerospace industry

LOCKHEED MARTIN

AIRBUS

LEONARDO

BAE SYSTEMS

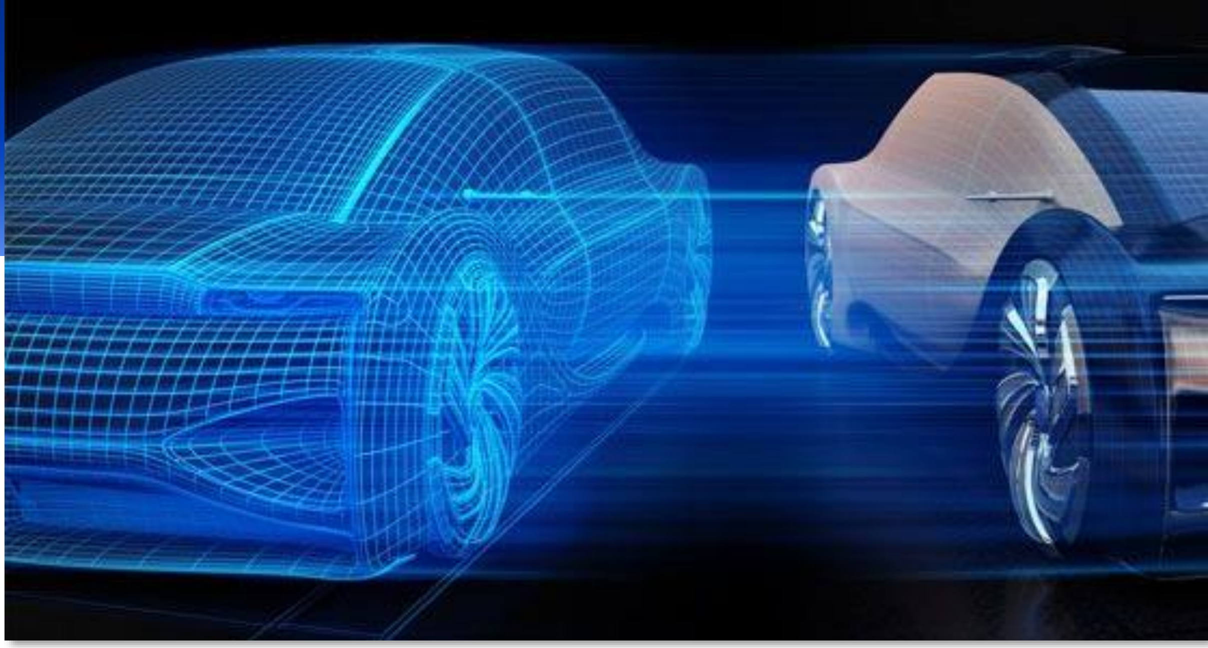
esa

Jotne

Jotne Background

Examples of leading organizations that trust the ISO 10303 standards and the Jotne applications to support it

Setting the scene



- There are many definitions of a Digital Twin
- We mainly categorize the Digital Twin into two aspects
  - Virtual Twin (“as Designed”, and “as Simulated”)
  - Physical Twin (“as Manufactured”, “as Tested”, and “as Operated”)
- Realizing The Open Standard Based Digital Twin
- We arrive from ISO/TC 184/SC 4 – Industrial Data, and ISO 10303 (STEP)
- Focus on connectivity, control, digitalization and augmentation (AI/ML)

Jotne in European research and technology programs

Jotne

HORIZON EUROPE

ARROWHEAD TOOLS

KYKLOS 4.0

DAIS

ABS of EU

TREEADS

manu net

Mine.io

CHANGE2TWIN

5G-TIMBER

EUROPEAN UNION

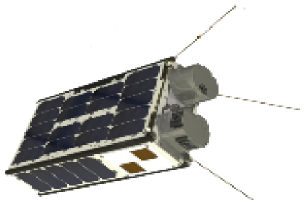
EUROPEAN DEFENCE FUND

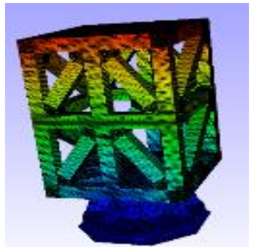
dTHOR
Digital Ship Structural Health Monitoring

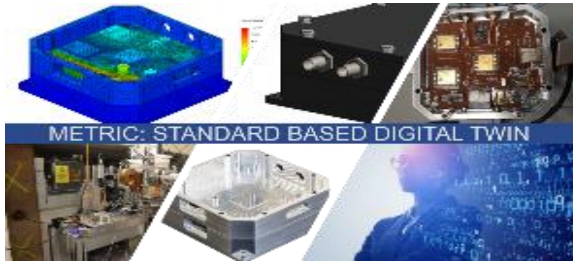
SDMMS
Secure Digital Military Mobility System

EDINAF
European Digital Naval Foundation

esa



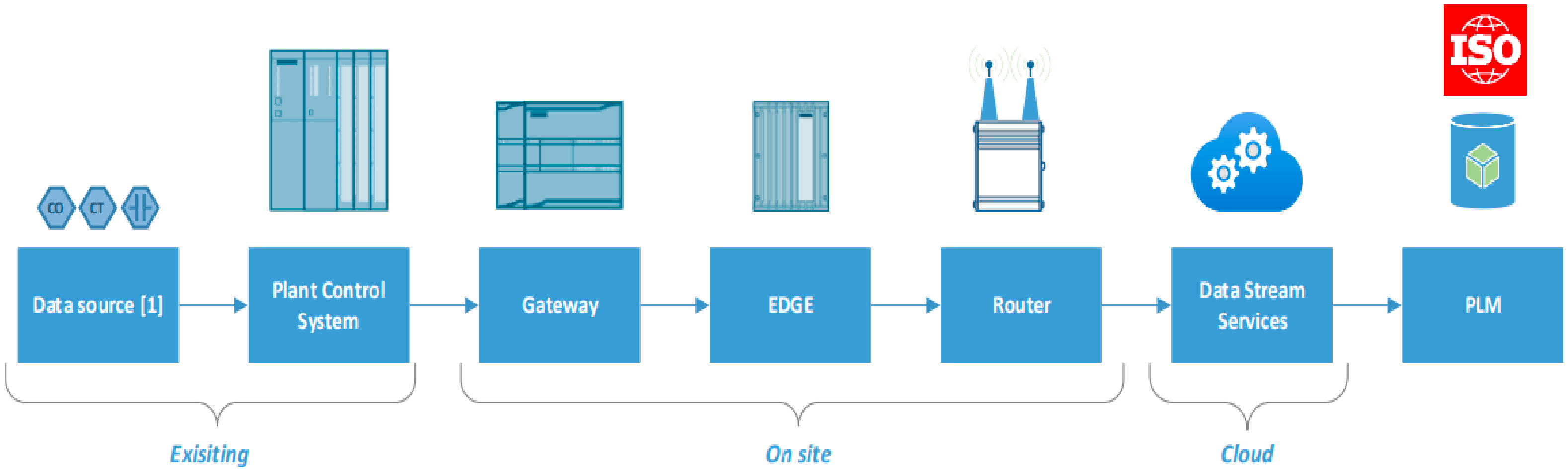




Industrial Plant for Plasterboard – Digital Transformation

<u>Impact Mill and Calcination</u>

AI analytics of data captured from 19 embedded sensors, such as temperature, gas flow, humidity, gypsum flow etc.



- AI to Monitor crystal water content
- Reduces environmental impact

by

- Detect and identify anomalies in production
- Production optimization
- Mechanical lifecycle control
- Predictive maintenance

European Defence Funds projects related to Digital Twin

dTHOR

EUROPEAN UNION

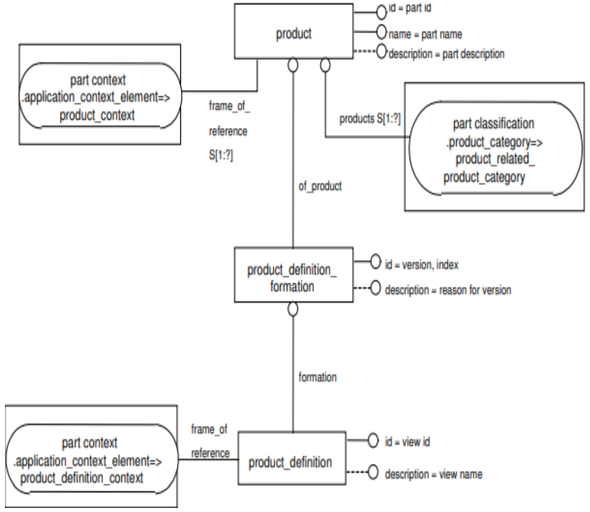
EUROPEAN DEFENCE FUND

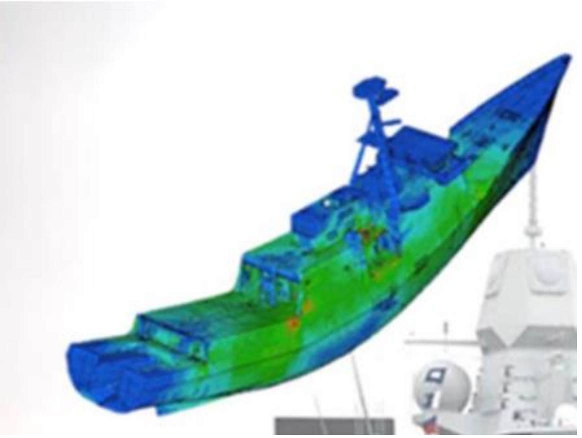
EDINAF

EDINAF will provide a European digital ship reference architecture, integrating the systems onboard altogether in order to achieve vessels fastest reaction and enhanced capabilities

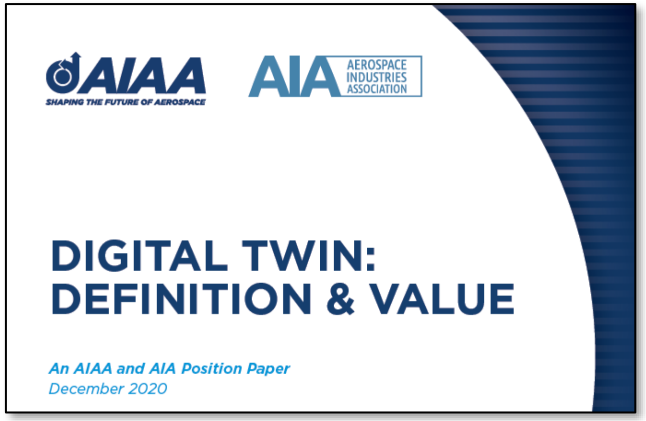
dTHOR will develop the next generation of a predictive Ship Structural Health Monitoring system

Standardized





Statements related to standards



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.

European Commission

EU Reports - STANDARDS - offer a basis for the integration of diverse technologies into complex, innovative systems and solutions, and enable interoperability between components, products and services thereby avoiding vendor lock-in and providing more choice for customers globally – a critical role in a world undergoing digital transformation across all industries and sectors

ESA AGENDA 2025

Make space for Europe

ARTEMIS

ARTEMIS ACCORDS

United for Peaceful Exploration of Deep Space

“ESA will therefore digitalise its full project management, enabling the development of digital twins, both for engineering by using Model Based System Engineering, and for procurement and finance, achieving full digital continuity with industry.”

https://www.esa.int/About_Us/ESA_Publications/Agenda_2025

“Interoperability of systems is critical to ensure safe and robust space exploration.
Therefore, the Artemis Accords call for partner nations to utilize open international standards, develop new standards when necessary, and strive to support interoperability to the greatest extent practical.“

https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf

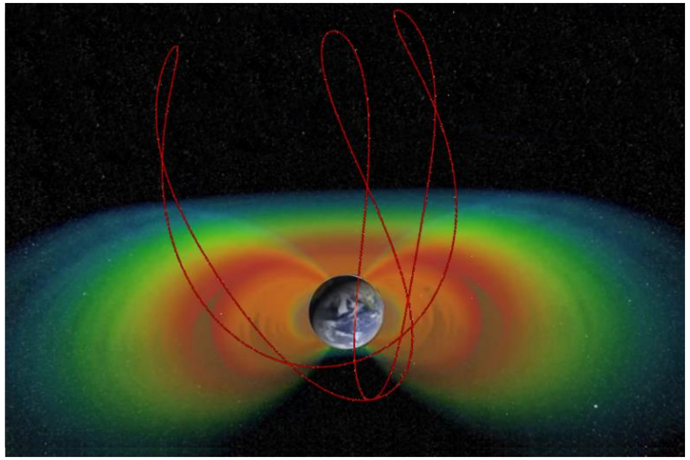
The Space Use Case for the Digital Twin in Manufacturing – Radiation Monotoring

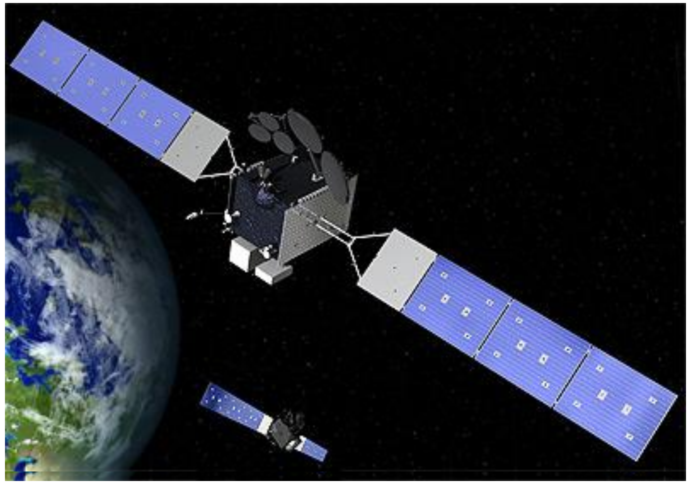
Embedded sensor network in spacecraft structures compatible with digital factories

- Part of the Advanced Research in Telecommunications Systems (ARTES) program at ESA
- In collaboration with the *Norwegian Defence Research Establishment (FFI)* and *IDEAS*
- METRIC is a Technology Demonstrator
  - Technology Readiness Level goal by the end of project: 4
- Closely linked to industry 4.0

The NORM Use-case - NORM: Norwegian Radiation Monitor

- Application: Measuring kinetic energy for energetic charged particle radiation in space
- Onboard Norwegian communication satellite, part of the *Arctic Satellite Broadband Mission* (ASBM)
- 15-year mission, 5 years nom. NORM operation
- Detector design: **IDEAS**
- Structural design and environmental testing: **FFI**





NORM Instrument Hardware

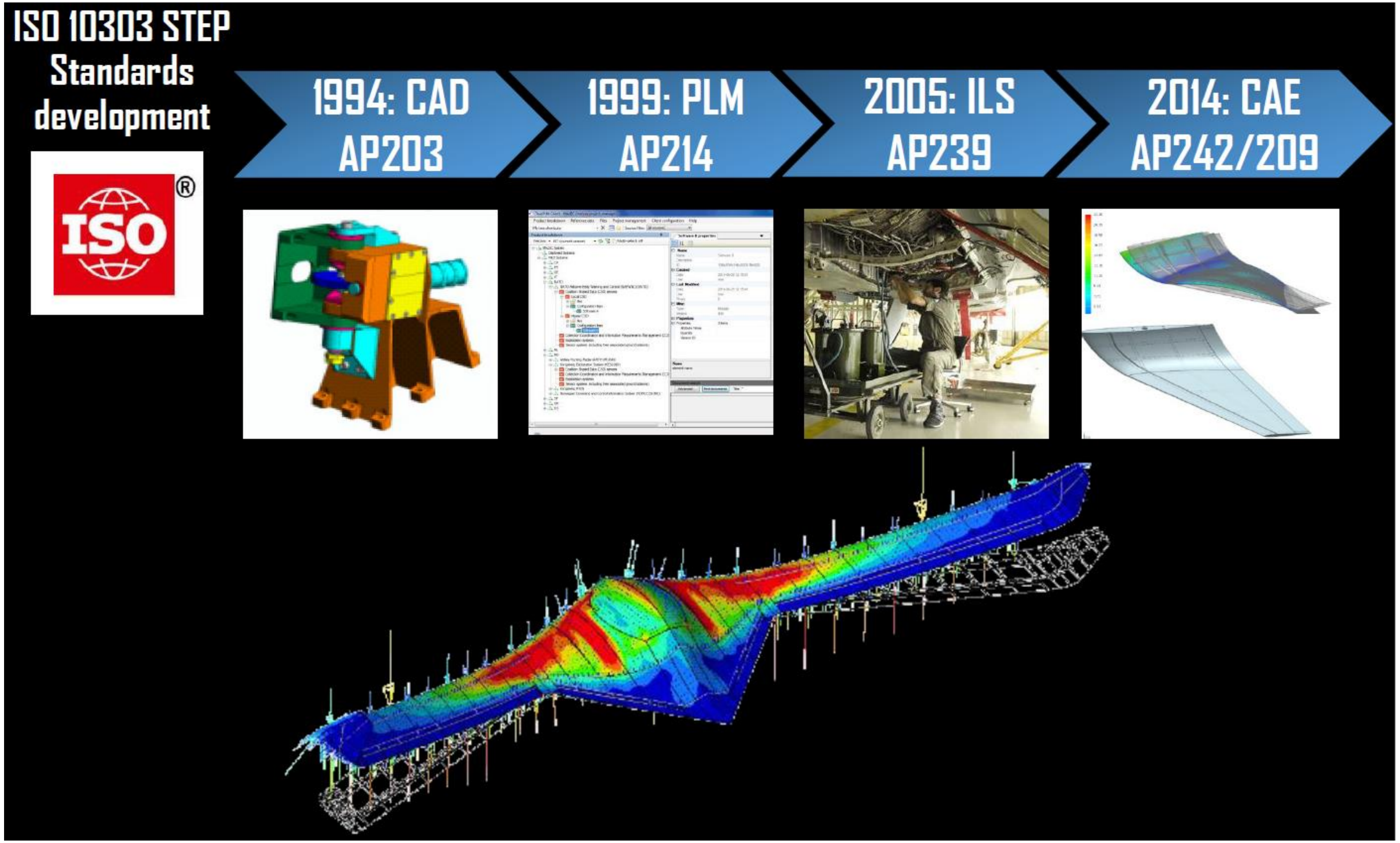
Data Generating Unit (DGU)

Data Handling Unit (DHU)

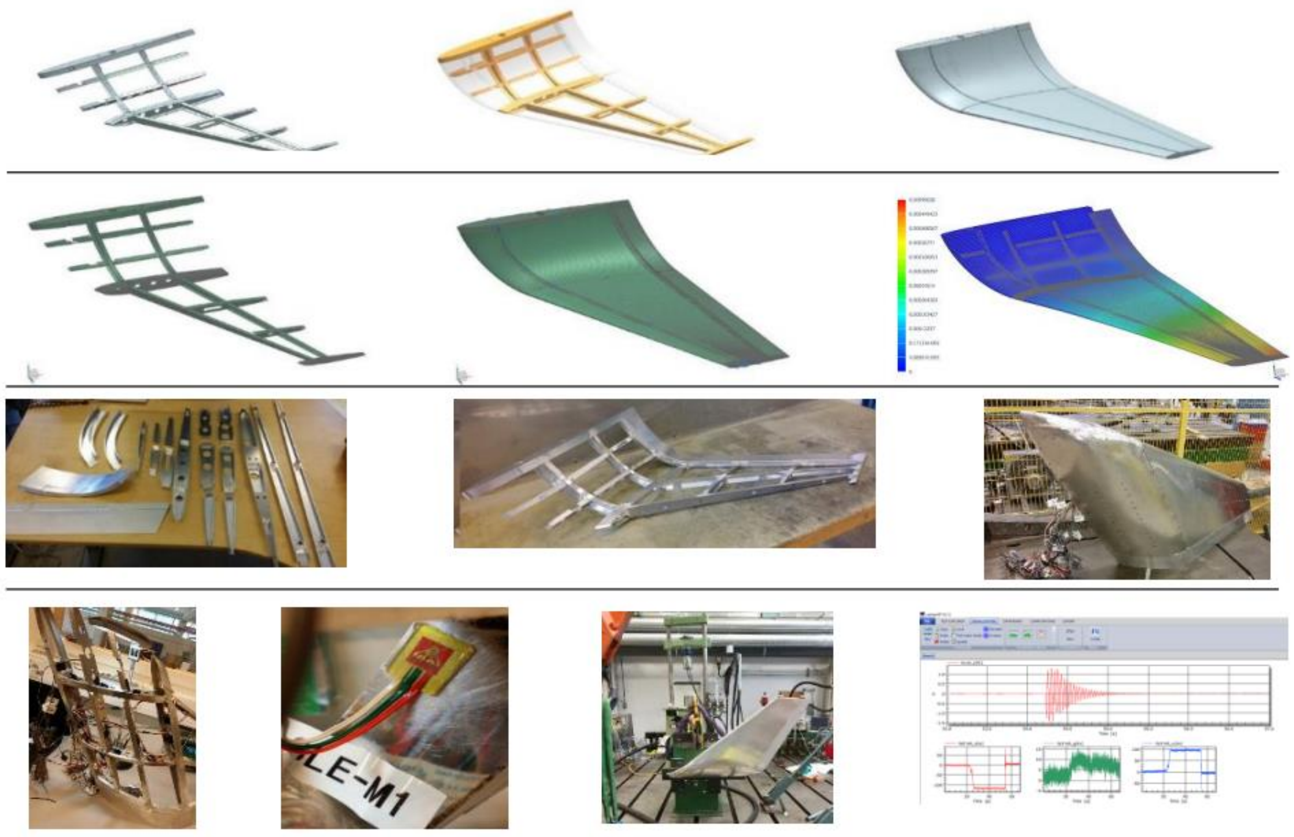
ISO 10303 – The STEP standard

For METRIC: The Digital repository is based on ISO 10303

Contains: CAD, Simulation, Manufacturing, PMI, CT-SCAN, CMM, Sensors for machining and 3D print, including 3D Print Camera.



Reusing the results from the Lockheed Martin partnership

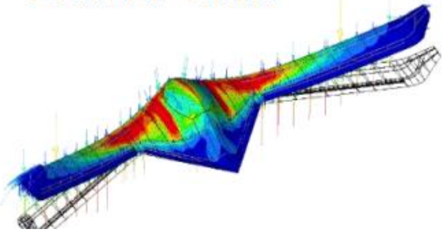


Design CAD

Analysis FEM

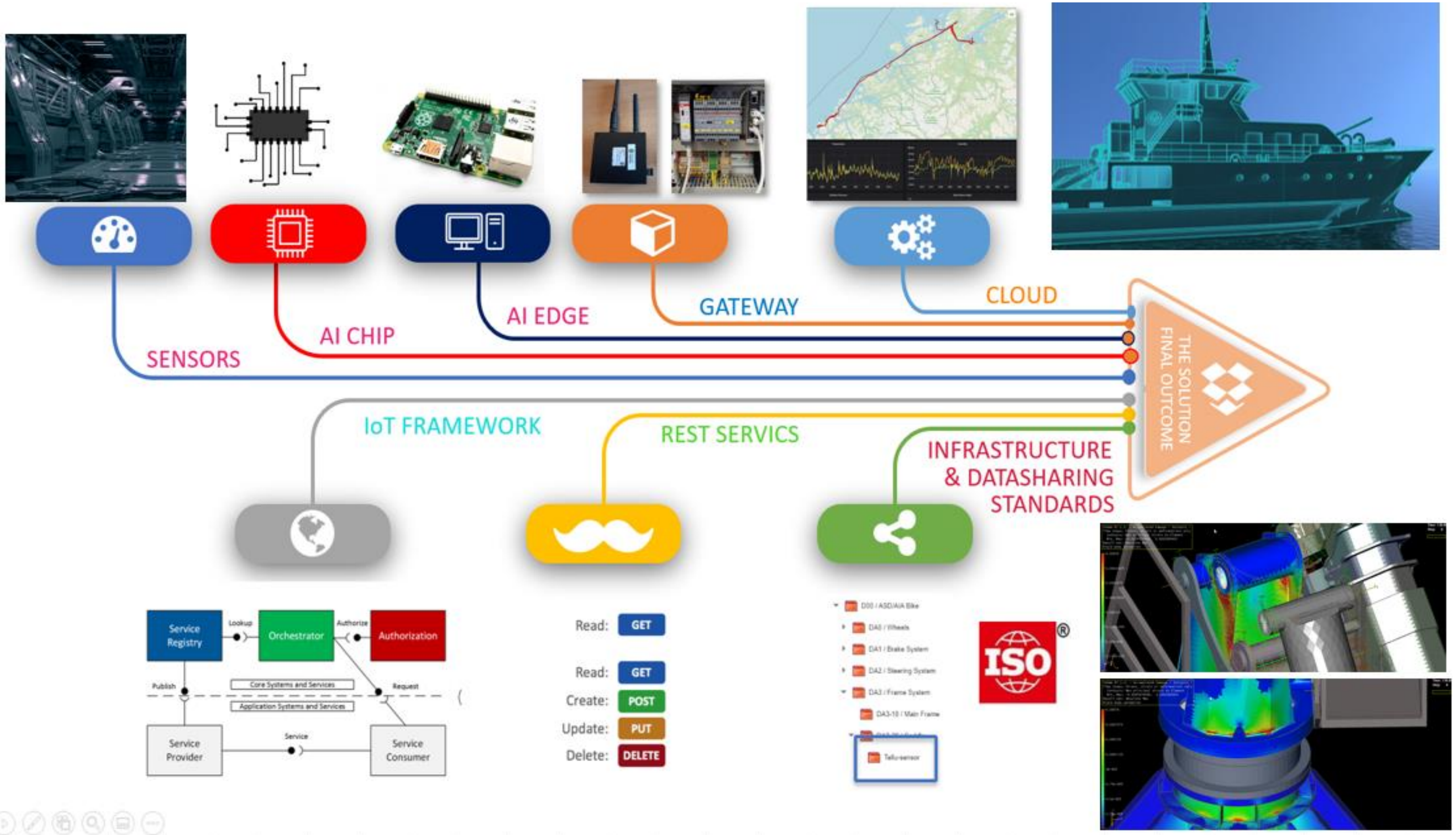
Manufacturing

Sensor data

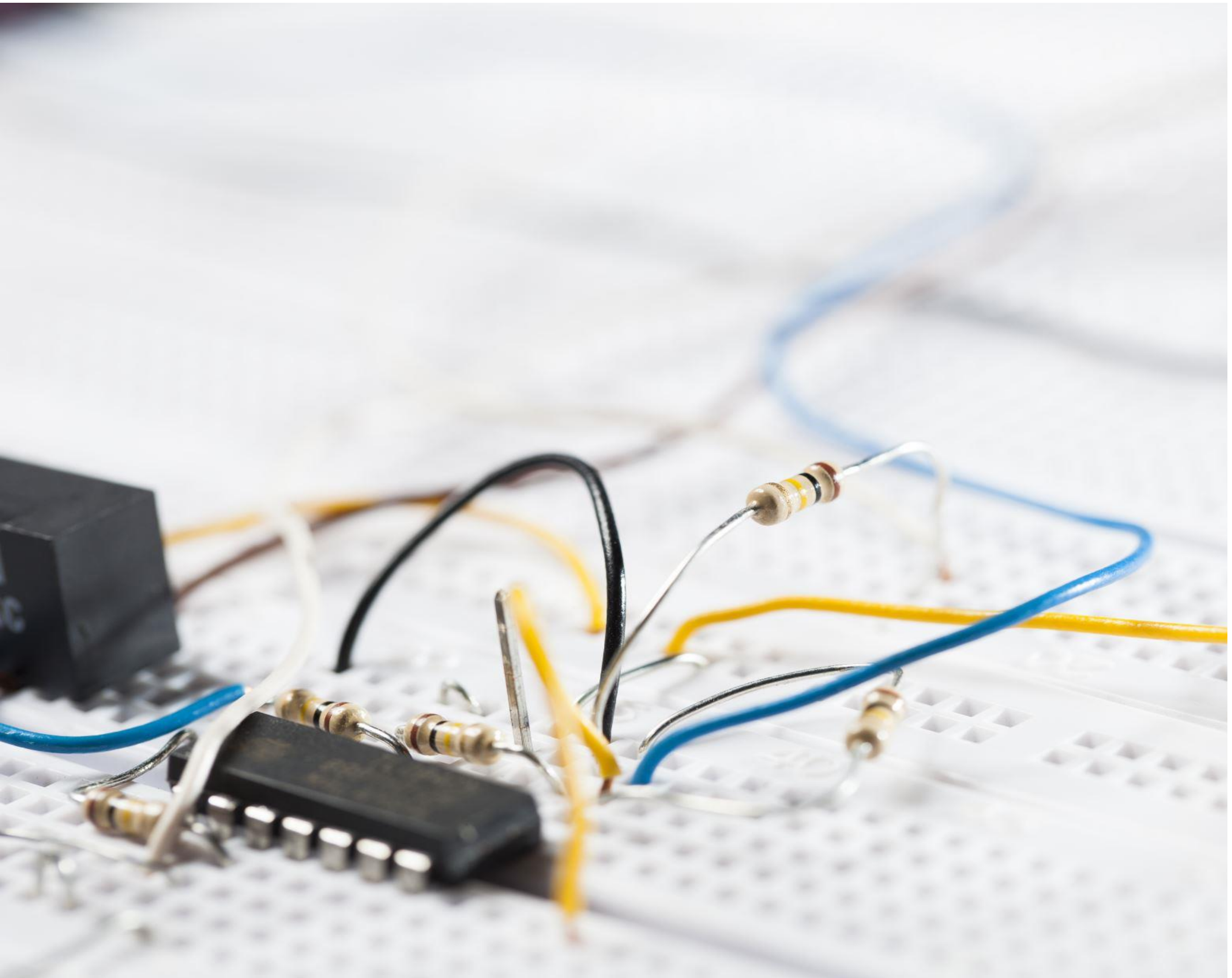


Doctoral thesis: (Industrial PhD) Improving and implementing the STEP ISO 10303 standard for design, analysis and structural test data correlation. Download here

Next generation of the Open Standard based Digital Twin
Sensor data directly to STEP Object FEM nodes for correlations

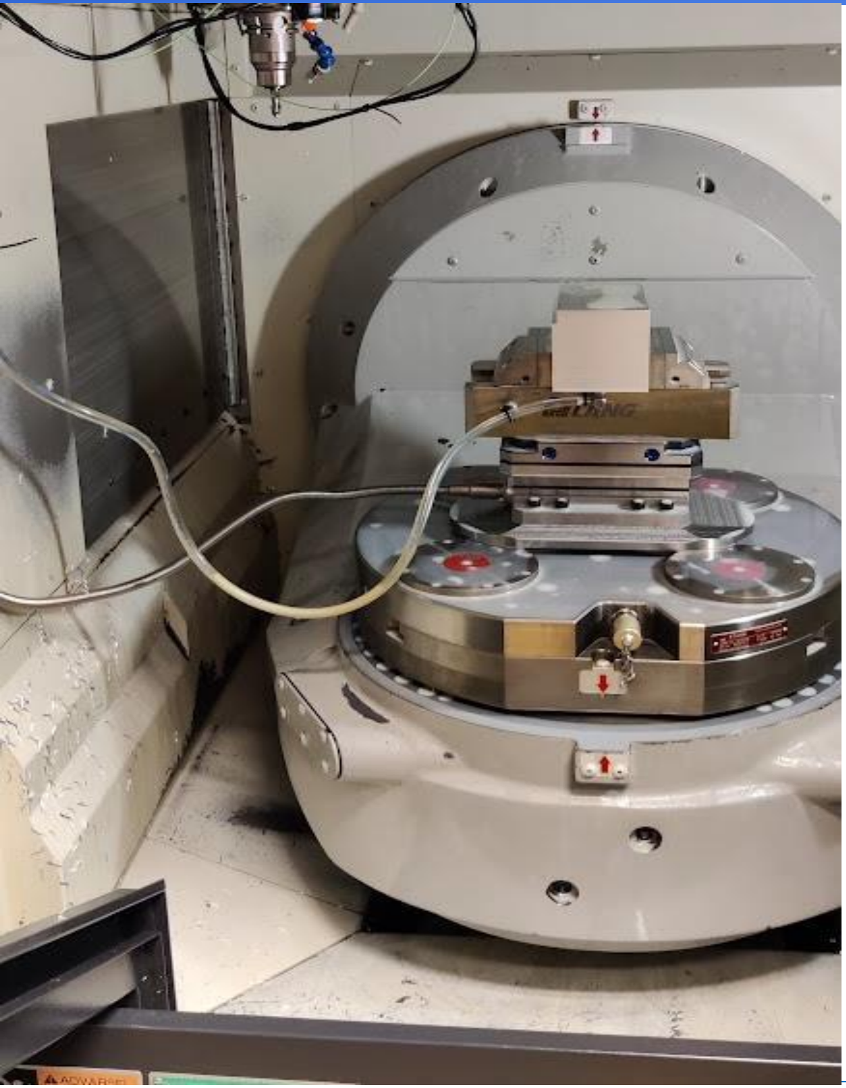


Embedded Sensor Network



- Embedding sensors in part
  - Capture live data of experienced loads
- Embedding sensors in environment/equipment
  - Manufacturing and inspection equipment
- Selected sensors for part embedding:
  - Temperature
  - Humidity
  - GPS
  - Accelerometer
- Investigated potential candidates for permanent embedding

Manufacturing – Milling Optimization

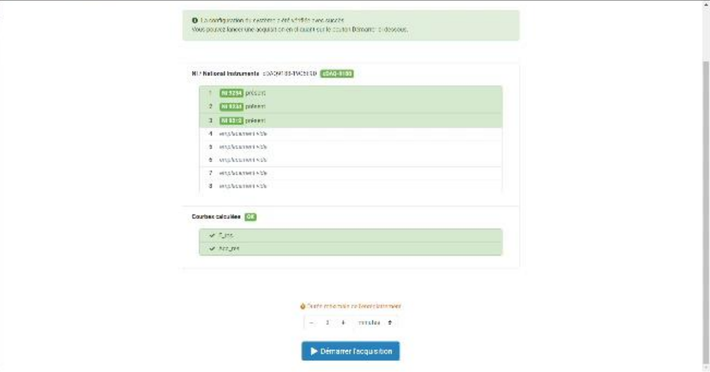


- In collaboration with the french company CIRTES
- Optimized milling parameters through instrumentation and analysis:
  - Force (dynamometer)
  - Vibration
  - Chamber temp
  - Coolant flow & temp
- Optimized for high chip volume flow with minimized energy input (Aluminium 6082 grade T6)
- Significant time reduction for rough cutting (60%)
- Option for optimization of surface finish

Jotne Actarus CIRTES research & development

Realizing the open standard based Digital Twin: Manufacturing Monitoring

- Instrumented machining process connected to specific part
- Milling data archived for product in open standard model
- Potential benefits:
  - Predictive maintenance of tools
  - Reduction in consumables cost
  - Productivity improvement
  - Improved cutting conditions
  - Guidance of the residual machining stresses
  - Control machining processes remotely and securely



With courtesy of CIRTES

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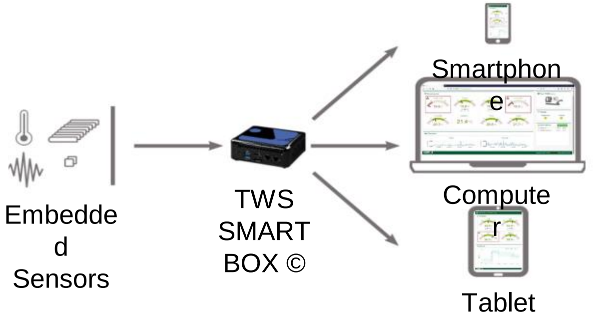
Actarus

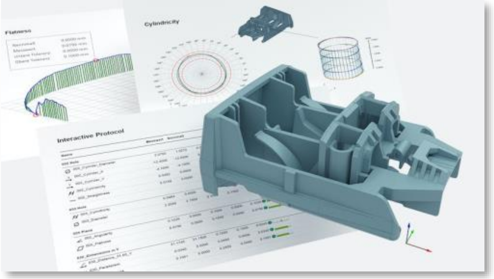
CIRTES research & development

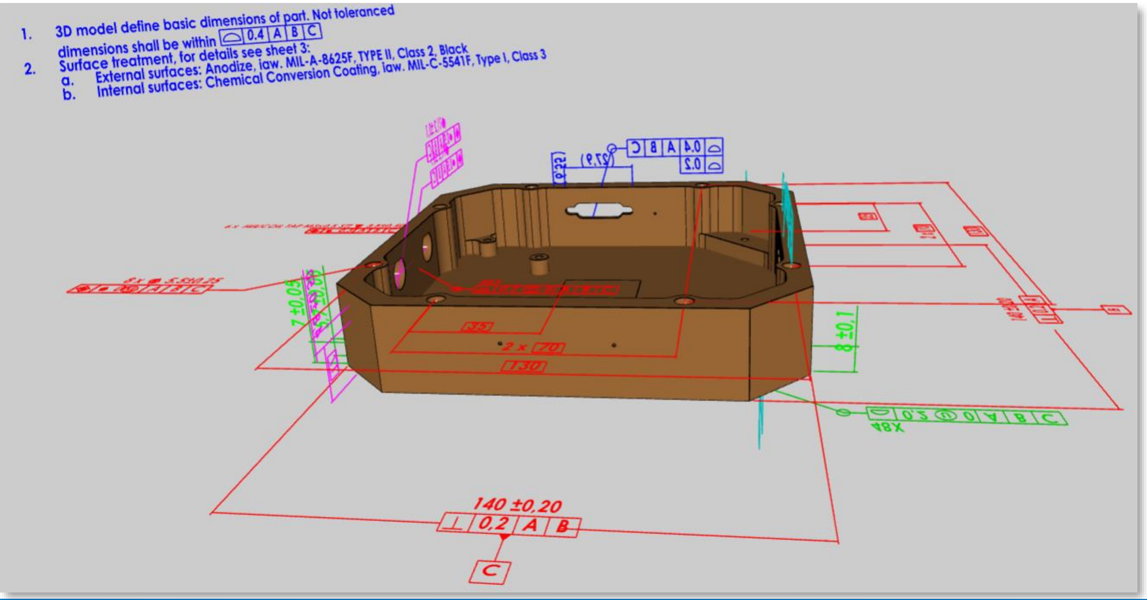


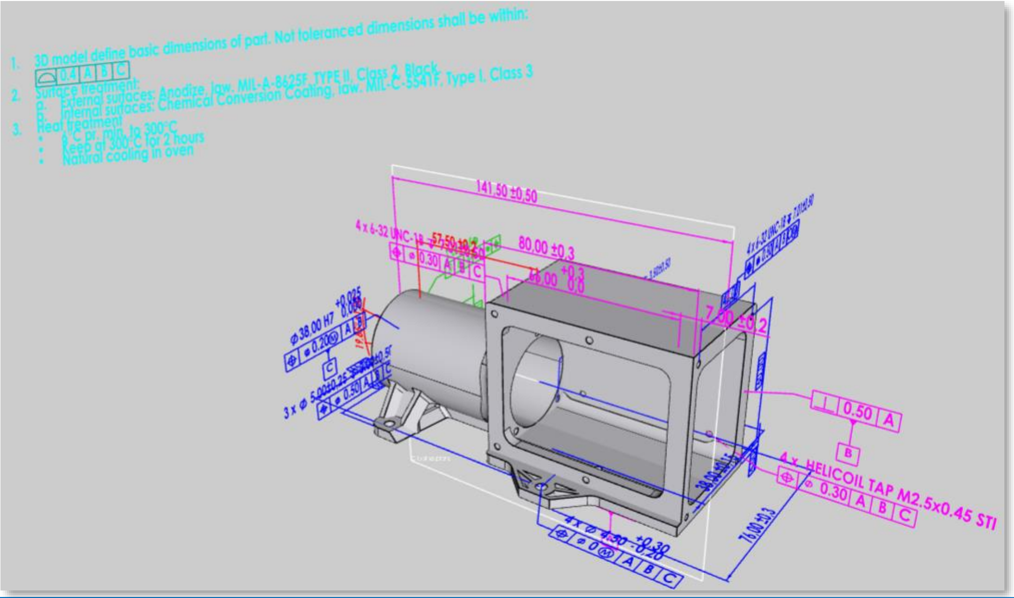
Product Manufacturing Information (PMI) in STEP

- PMI is Supported in STEP AP242
- Potential benefits:
  - Improved accuracy
  - Enhanced communication
  - Streamlined manufacturing
  - Cost savings
  - Increased flexibility
  - Regulatory compliance
- Automated data pipeline to CMM tools like Zeiss Calypso that reads AP242 PMI data

Seeing beyond

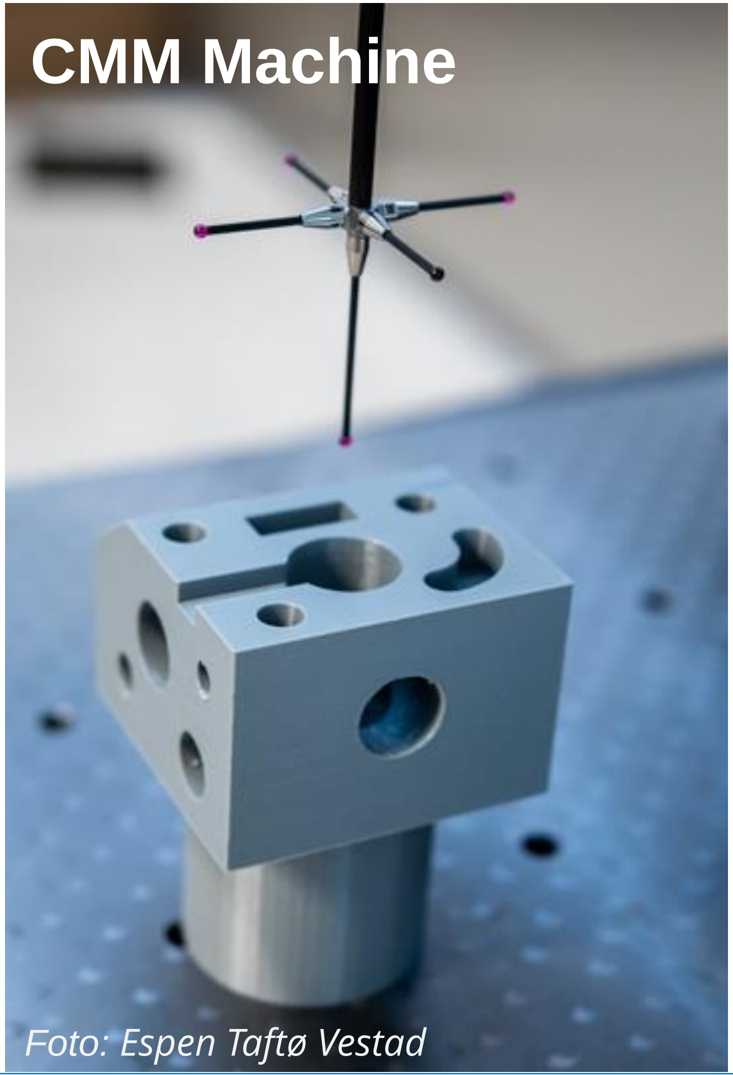


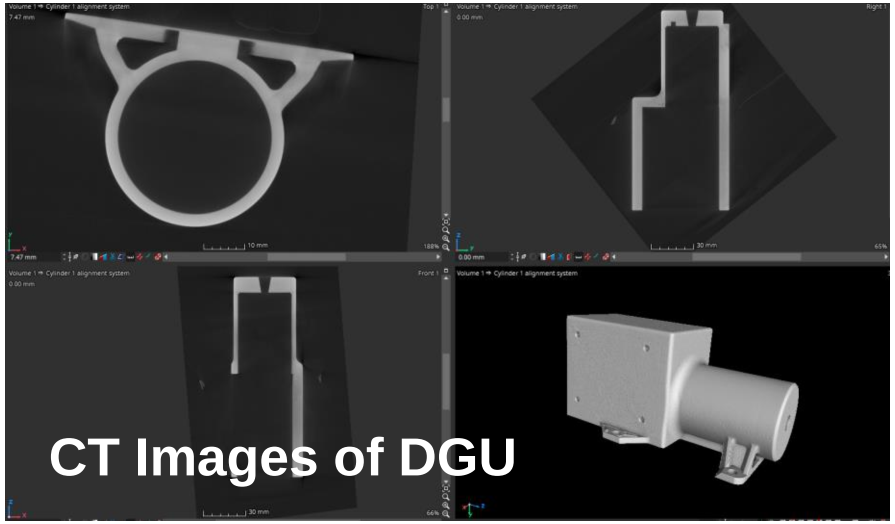




Improving verification workflow through PMI in ISO 10303

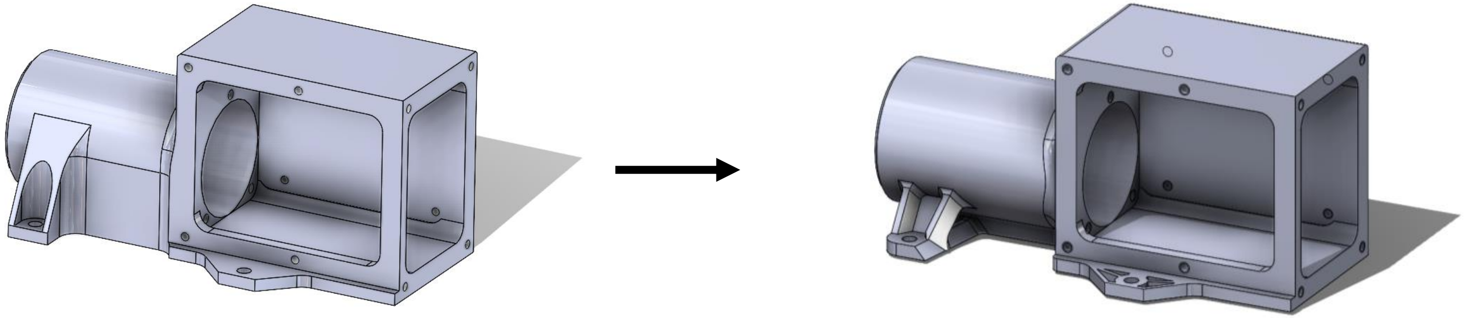
- Improved workflow and reduction in processing time
- Automatic measurement reports
- Utilizing AP242 PMI data





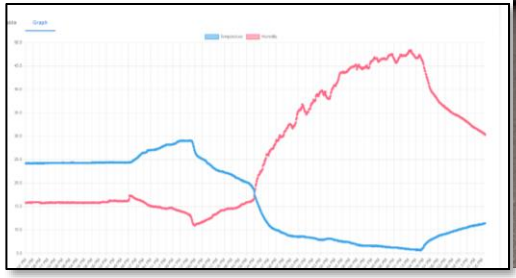
Additive Manufacturing for production

- Area of development for the workshop (Machining vs. 3D Print)
  - Defense & space
    - Quality control, improved data exchange
    - Rapid prototyping, improved logistics solution for spare part production
- Cost analysis: AM Serial production of multiple DGU as competitive alternative in cost
- Quality assurance and verification of AM produced parts according to newly published ESA-ECSS standard



Managing manufacturing data (AM) - Connected to the ISO 10303 repository

	A	B	C	D	E	F
1	Time	Pressure (mBar)	Filter Status	Gas flow speed (m/s)	Gas pump power (%)	Oxygen top (%)
2	Mon Sep 6 10:14:31 2021	12.1	1.8	18.9	39.7	0.10
3	Mon Sep 6 10:14:32 2021	12.2	1.8	19.0	39.4	0.10
4	Mon Sep 6 10:14:33 2021	12.1	1.8	19.0	39.5	0.10
5	Mon Sep 6 10:14:34 2021	12.1	1.8	18.9	39.9	0.10
6	Mon Sep 6 10:14:35 2021	12.3	1.8	19.0	39.6	0.10
7	Mon Sep 6 10:14:36 2021	12.2	1.8	19.1	39.3	0.10
8	Mon Sep 6 10:14:37 2021	12.1	1.8	19.0	39.4	0.10
9	Mon Sep 6 10:14:38 2021	12.2	1.8	19.0	39.5	0.10
10	Mon Sep 6 10:14:39 2021	12.2	1.8	19.1	39.2	0.10
11	Mon Sep 6 10:14:40 2021	12.1	1.8	19.0	39.3	0.10
12	Mon Sep 6 10:14:41 2021	12.1	1.8	19.0	39.4	0.10
13	Mon Sep 6 10:14:42 2021	12.1	1.8	19.0	39.4	0.10



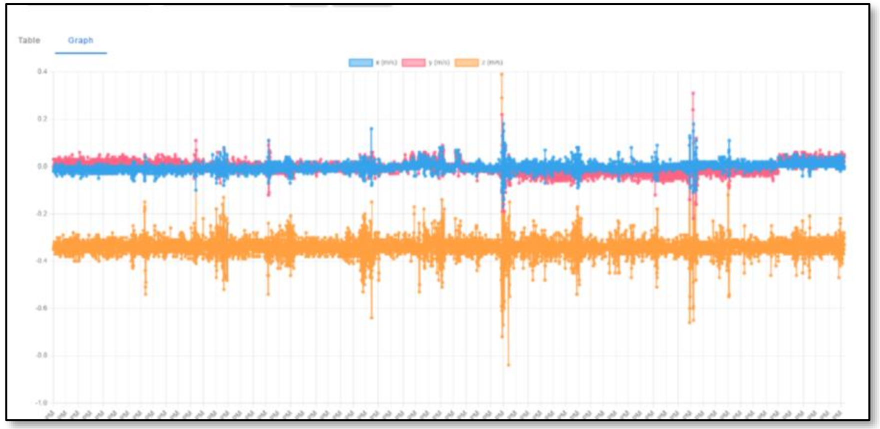
Data stored directly on ISO 10303 STEP Objects

Examples of typical plots

EXPRESS Data Manager
TruePLM ™

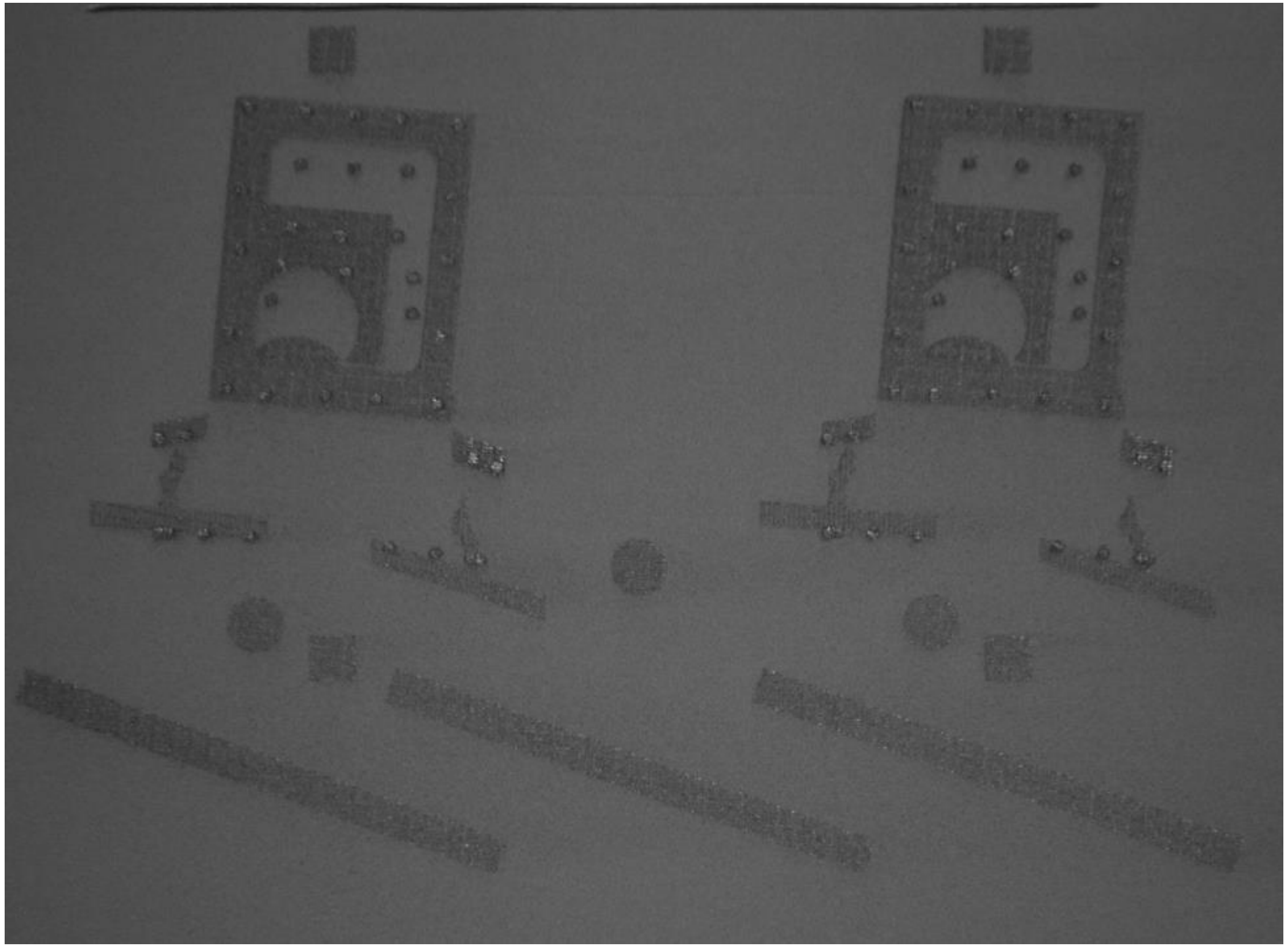
ISO ®

Time	Pressure	Filter Status	Gas flow speed (m/ss)	Gas pump power (%)	Oxygen top (%)	Oxygen bottom (%)	Oxygen 1 (ppm)
1630916071	24.71	0.000	1.8	18.9	39.7	0.10	0.23



Managing manufacturing data (AM)

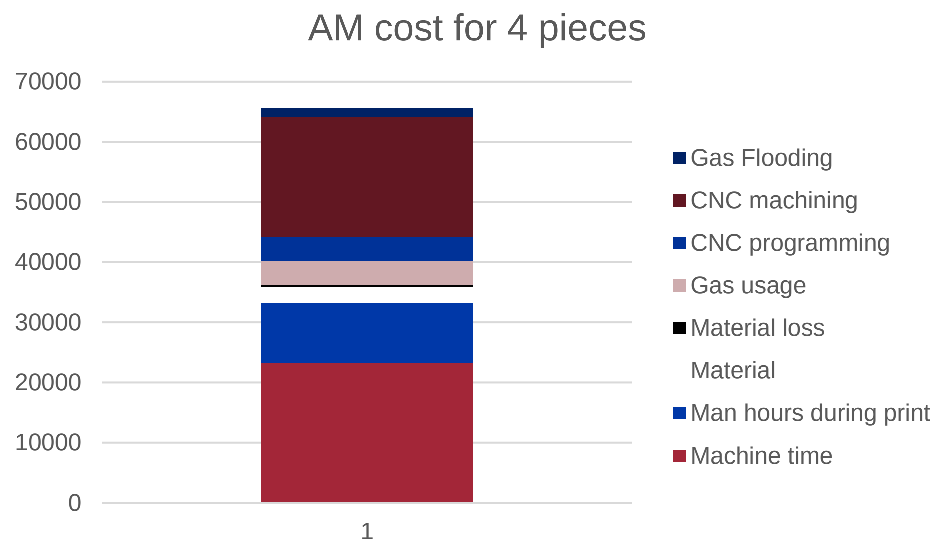
- Layer image from the AM process as part of dataset
- Camera embedded within 3D printer
- Picture used for QA purposes
- Detection of issues and used for future reference

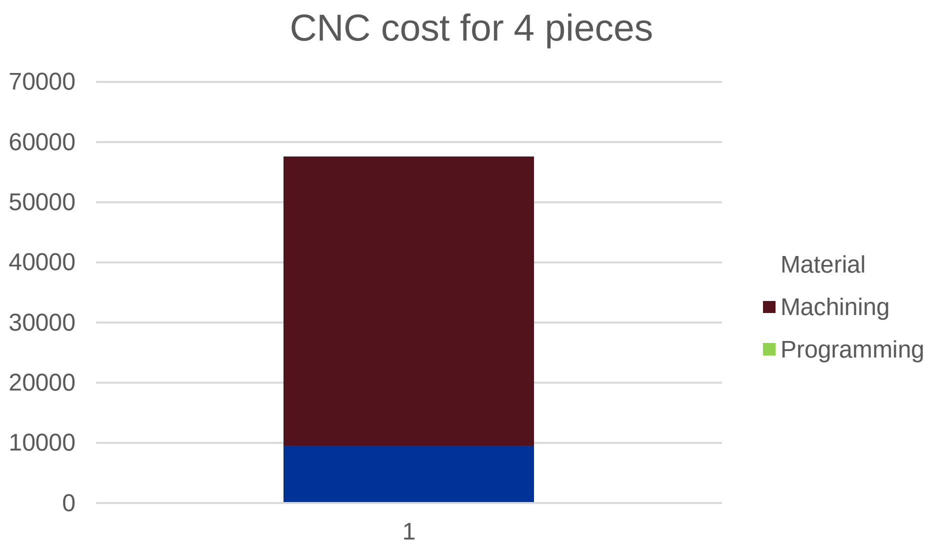


Considerations for AM as alternative to milling, Many parameters to be considered for evaluation of manufacturing process

Competitive considerations:

- Post processing of AM-part should be minimized
- The build chamber volume should be fully utilized
- The benefit of design complexity/weight reduction can justify higher costs
- Use a multi laser machine with automatic powder handling (faster build and less manual work)
- Serial production
- Long lead times





The way forward

- Investigating future applications/use case scenarios
  - Stress-corrosion cracking analysis based on captured sensor data
  - Monitoring of thermo-elastic deformations through embedded strain gauge & temp gauge
  - Live-streaming AM sensor data (thermal imaging)
- DT of full spacecraft and its subsystems

Back-up slides

Video: Introducing ISO/TC 184/SC 4 Standards

https://www.youtube.com/watch?v=jeiGT2jB-to

Additional information from the ISO Newsletter

More about Jotne in Space : https://www.iso.org/news/isofocus_142-2.html

Contact: space@jotne.com