The Digital Twin and the need of open, public available and international standards



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KSEE 2023, 14-15 June 2023

The difficult relationship between software (and data) and systems

University of South-Eastern Norway

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)

Recent R&D updates from Brussels: EDA, EDF and Horizon Europe

Importance of Digital Twins for Defence

INVITATION TO THE EXPLORATORY WORKSHOP ON DIGITAL TWINS IN

WORKSHOP

DEFENCE, 5 JUNE 2023, EDA EDA would like to invite you to attend the Exploratory Workshop on Digital Twins in Defence, on 5th June 2023. The objectives of this Exploratory Workshop are the following:

- inform about EDA R&T activities in the areas of digital twinning for military use;

- prospect digital twins exploitation and scenarios in defence applications;
- explore the boundaries to scope new projects and R&T work strands.

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Operat perform and resi	ional nance lience	Digita accel	Preventing costly failures							
	Spee time mar	ding e to ket	Reduc burc maint	cing len o enai	the of nce					





dTHOR



EUROPEAN UNION EUROPEAN DEFENCE **FUND**

dTHOR will develop the predictive Ship Structural Health Monitoring system **EDINAF** will provide a European digital ship reference architecture, integrating the systems onboard altogether in order to achieve vessels fastest reaction and enhanced capabilities

Jotne main focus:

- WP4 Digital Platform: Simulation Process and Data Management (SPDM)
- WP8 Digital Twinning

EDINAF 4 Pillars Data Connectivity System Integration Digital Twinning

EDINAF



EUROPEAN UNION EUROPEAN DEFENCE FUND









SDMMS

The project "Secure Digital Military Mobility System" (**SDMMS**) will develop a secure, ICT-based solution that will facilitate direct and secure exchange of information between nations requesting and approving any military movement.





Digitalisation of manufacturing for space through the application of ISO 10303

3rd ESA Workshop on Advanced Manufacturing – Day 1 ESTEC 14.03.2023

Henrik Galtung Project Manager – Jotne EPM Technology AS <u>henrik.galtung@jotne.com</u>





25 years of innovation in the aerospace industry

- European Space Agency
- Airbus
- Lockheed Martin
- Leonardo
- BAE Systems and many more





Jotne in European research and technology programs





Digital Twins and standards for space activities

ESA AGENDA 2025

Make space for Europe

"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/artemisaccords/img/Artemis-Accords-signed-13Oct2020.pdf



 Need to develop appropriate standards and/or standard approaches so that Digital Twins can interact with other <u>Digital Twins across the life cycle and</u> <u>supply chain</u>.





COMMISSION RECOMMENDATION (EU) 2023/498 of 1 March 2023 on a Code of Practice on standardisation in the European Research Area

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

METRIC: STANDARD BASED DIGITAL TWIN

mp (Celsius) 7.542e-

6.9



"E**m**bedded sensor n**et**work in spacec**r**aft structures compatible with d**i**gital fa**c**tories"

- 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

- STandard for the Exchange of Product model data
- Foundation for Jotne EDM suite of products
- Split into different application protocols
- For METRIC: Digital repository based on this standard



80% of data exchange processes using STEP (ISO 10303)





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

Design CAD

Analysis FEM

Manufacturing



Next generation of the Open Standard based Digital Twin



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

Realizing the open standard based Digital Twin

Manufacturing – Milling 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





Product Manufacturing Information (PMI) in STEP

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



Improving verification workflow through PMI in ISO 10303

- Improved workflow/reduction in processing time
- Automatic measurement reports

CT Images of DGU



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Additive Manufacturing for production

- Area of development for FFI
 - 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 ECSS standard





Managing manufacturing data (AM)

Uploaded to the ISO 10303 repository



	A	B	C	D	E	F	G	Н	I		К	L
1	Time	Pressure (mBar)	Filter Status	Gas flow speed (m/s)	Gas pump power (%)	Oxygen top (%)	Oxygen bo	Oxygen 1	Oxygen 2	Dew point	Dew point	Gas Temp
2	Mon Sep 6 10:14:31 2021	12.1	1.8	18.9	39.7	0.10	0.23	983	2321	-33.1	-27.8	39.4
3	Mon Sep 6 10:14:32 2021	12.2	1.8	19.0	39.4	0.10	0.23	983	2331	-33.2	-27.8	39.4
4	Mon Sep 6 10:14:33 2021	12.1	1.8	19.0	39.5	0.10	0.23	987	2331	-33.2	-27.8	39.4
5	Mon Sep 6 10:14:34 2021	12.1	1.8	18.9	39.9	0.10	0.23	979	2331	-33.3	-27.8	39.4
6	Mon Sep 6 10:14:35 2021	12.3	1.8	19.0	39.6	0.10	0.23	983	2331	-33.4	-27.8	39.3
7	Mon Sep 6 10:14:36 2021	12.2	1.8	19.1	39.3	0.10	0.23	987	2321	-33.4	-27.8	39.4
8	Mon Sep 6 10:14:37 2021	12.1	1.8	19.0	39.4	0.10	0.23	983	2321	-33.5	-27.7	39.4
9	Mon Sep 6 10:14:38 2021	12.2	1.8	19.0	39.5	0.10	0.23	983	2321	-33.5	-27.7	39.4
10	Mon Sep 6 10:14:39 2021	12.2	1.8	19.1	39.2	0.10	0.23	987	2321	-33.6	-27.8	39.4
11	Mon Sep 6 10:14:40 2021	12.1	1.8	19.0	39.3	0.10	0.23	983	2331	-33.6	-27.7	39.4
12	2 Mon Sep 6 10:14:41 2021	12.1	1.8	19.0	39.4	0.10	0.23	983	2331	-33.6	-27.7	39.4
17	8 Mon Sen 6 10:14:42 2021	12.1	1.8	19.0	39.4	0 10	0.23	979	2331	-33 7	-27 7	39.4



Time	Pressure	Filter Status	Gas flow speed (m/ss)	Gas pump power (%)	Oxygen top (%)	Oxygen bottom (%)	Oxygen 1 (ppm)	Oxygen 2 (ppm)	Dew point dryer (C)	Dew point process gas (C)	Gas Temp (C)	Platform (C)	Build Chamber	Optical Bench	Collimator	T_U	TU_ML	T_MR
1630916071	24.71	0.000	1.8	18.9	39.7	0.10	0.23	983	2321	-33.1	-27.8	39.4	150.1	33.7	25.1	24.4	null	0

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



FFI Considerations for AM as alternative to milling

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



Many parameters to be considered for evaluation of manufacturing process

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





(1) 10 minutes to read





More about Jotne in Space : <u>https://www.iso.org/news/isofocus_142-2.html</u> Contact: <u>space@jotne.com</u>



Introducing ISO TC184/SC 4 Standards



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