Open reference architecture for engineering model spaces

Deliverable 6.1

Links to related R&D Projects and Standardisation Communities

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Executive Summary

Links to related R&D Projects and Standardisation Communities – A roadmap for projects, communities and interaction plan for this purpose.

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1. Introduction

This Deliverable describes a roadmap for projects, communities and interaction plan for this purpose. It links to related R&D Projects, AI Act and Standardisation Communities.

Primary Goal of this deliverable are

- Alignment: Ensure the SMARTEM comply with and support the AI Act's requirements and principles.
- Sharing models in virtual engineering
- Standardisation for better interoperability
- Collaboration: Foster active participation in standardization communities.
- Innovation: Drive forward R&D projects that are impactful and scalable.

2. Roadmap

This report outlines a comprehensive roadmap to integrate ongoing and future R&D projects with the principles of the AI Act and standardization efforts. It establishes a structured interaction plan to collaborate effectively with regulatory bodies and standardization communities. The roadmap is designed to enhance compliance, foster innovation, and ensure the responsible development of AI technologies.

Primary Goals:

- Alignment: Ensure that R&D projects adhere to the AI Act's requirements and ethical principles.
- Collaboration: Engage with international standardization bodies to shape and follow best practices.
- Innovation: Promote cutting-edge developments in AI that comply with regulatory and ethical standards.

2.1. Interoperability:

Sharing models in virtual engineering: European industries are necessarily moving towards digitization of their organizations. Many companies follow a strategy of product line management and platforms in which products are configured out of platform components. Components may either come from internal groups or from suppliers and disciplines. Entering this route requires a modelling framework that understands such models, their relationships, versions, variants, composition, and exchange mechanisms. Related open engineering communities – e.g. TNO ESI[1], SERC[2] or NAFEMS ASSESS Initiative[3] - aim to go beyond MBSE and discuss the topic of developing, using and managing a large variety of models, and building consistent composition of models of different abstraction levels.

Standardisation for better interoperability: OPENDEI and IDSA mention, that "*data spaces can be overlapping or even nested. To prevent fragmentation of the data economy into multiple, mutually isolated domains, and to create appropriate conditions for setting up an open data ecosystem characterized by mutual trust between participants, a European 'soft infrastructure' is needed, specifying legal, operational and functional agreements as well as technical standards for being widely adopted by users.*"

SmartEM's strategy for standardisation of collaborative model engineering will combine model management concepts with widely accepted standards for data and model spaces to enable a new ecosystem of engineering models. SmartEM has identified some major levels where the use cases and technical development work can benefit from and contribute to:

- Meta-data provide information about model without revealing technical details.
- Taxonomies provide schemes of (hierarchical) classification of information.
- Ontologies offer schemes to guarantee semantic coherence between model description parameters, meta-data, interface details, domain taxonomies, and IP concepts.
- Software interface standards for module APIs and data format enable best interoperability between hybrid surrogate models and end-user's working environments.
- Model governance concepts: Open organisational rules will deal with aspects such as variant management, consistent co-evolution, design rationale tracking and instantiating virtual prototypes, and interoperability in a project management process like context.

- Finally, the model store reference architecture will incorporate concepts, standards, and solution practices from all levels into a consistent system of definitions and specifications. Model store implementations will demonstrate the technical and commercial benefits of the SmartEM approach.

[1] ESI - Embedded System Institute at TNO https://esi.nl/
[2] SERC – Systems Engineering Research Center https://sercuarc.org/
[3] ASSESS - Analysis, Simulation & Systems Engineering Software Strategies https://www.nafems.org/community/assess/

2.2. Collaborative projects

Relations to other collaborative projects

Project	Program	Period	Technical focus	Relationship
Enable-S3	Ecsel	2016-2019	Model-based Design validation using digital twins consisting of multiple integrated models. Identifies model governance as essential to enable integrating models into system-level	Model interface technologies (FMI, HLA and Model.CONNECT) proposed for co-simulation; reference architecture for digital twins
VMAP	ITEA3	2017-2020	Interface Standard for Integrated Virtual Material Modelling in Manufacturing Industry	model output could be leveraged for data exchange between surrogates
MODELISAR	ITEA2	2008-2011	FMI model exchange format standard for co-simulation	FMI provides concepts for executable system models
MODRIO	ITEA2	2012-2016	Extend state-of-the-art modelling and simulation environments based on open standards (as FMI) to increase system safety, dependability and performance.	Improve exploitation and use of simulation models to address challenging applications
BUMBLE	ITEA3	2019-2023	Domain-Specific Language technology for blended and real-time collaborative modelling	could be exploited to realise parts of searchable model spaces
UpSim	ITEA3	2020-2023	Creating credible Digital Twins by extending Simulation Governance and continuous collaborative simulation model development in CLOSED collaborations	addresses collaboration model exchange, credibility readiness levels definitions which SmartEM could exploit, and extend to OPEN collaborations
Compas	ITEA3	2021-	Development of compact models	MOR methods for generating non-linear

		2023	and digital twins, capable of self-sufficiently cast decisions for prognostic health management	compact models could be exploited by SmartEM
XILforEV	H2020	2019-2021	Experimental environment for designing complex systems, which connects test platforms and setups from different domains /locations	Can be used for testing and validation purposes
KI-Delta Learning	German BMWi	2020-2022	Transferring knowledge from one domain to another by only learning the deltas. Generation and use of synthetic data for the learning and evaluation process.	Useful for surrogate model learning
Asimov	ITEA4	2021-2024	Digital Twins and Artificial Intelligence for determining cyber physical system control parameters	The activities in and results from ASIMOV are expected to be complementary to SmartEM
AIToC	ITEA 3	2020-2023	Artificial Intelligence supported Tool Chain in Manufacturing Engineering	Formalisation and automation of analysis workflows
ALICE I ALICE III	BMBF BMBF	2010 – 2014 2019 - 2022…	AI-based analysis of operating data for gas and wind power plants to enable dynamic adaptation to the current environmental conditions.	Operating conditions and data as well as AI-based control methods from ALICE can be used to generate further load cases for the evaluation of the surrogate models for wind/gas turbines

2.3. Standardization communities

AI Act

With the EU's AI Act having entered into force on August 1, 2024, SMARTEM project partners will focus on its implementation within the execution of the AI components, e.g. smart search. In January 2023, the CEN-CENELEC Joint Technical Committee proposed a road map to support the standardization of AI[1].

JTC 21 published a list of AI Harmonized Standards that the committee has officially adopted[2] The adopted standards include:

CEN/CLC ISO/IEC TR 24027:2023, published in December 2023, addresses bias related to AI systems and describes measurement techniques and methods for assessing bias.

[1] https://www.cencenelec.eu/areas-of-work/cen-cenelec-topics/artificial-intelligence/

[2] https://standards.cencenelec.eu/dyn/www/f?p=205:32:0::::FSP_ORG_ID,FSP_LANG_ID:2916257,25&cs=1827B89DA69577BF3631EE2B6070F207D

ISO/IEC 23894:2023, published in February 2024, provides guidance on how organizations that develop, produce or deploy AI or that use products, systems and services that utilize AI can manage risk specifically related to AI.

Reference architectures, IP-management, standardisation, and ontologies

Gaia-X data spaces can be seen as a data integration concept, which does not require common database schemas and physical data integration, but is rather based on distributed data spaces and integration on an "as needed" basis on a semantic level. The H2020 OPENDEI project[1] proposes a general architecture for open data spaces.

Initial approaches for **management of IP** such as patents, trademarks, or multi-media use blockchain[2] technology. There are also first solutions to use blockchain for simple AI-models [3].

Cybersecurity and data protection are rapidly growing and changing technical and application domains. CEN/CENELEC JTC13[4] intends to become the European standardisation focal point for Cybersecurity and Data protection.

Standards to enable interoperability between systems and software tools is a key issue for any engineering solution used in industry. SmartEM will use and contribute to standards like:

- FMI[5] - container and interfaces to exchange and co-simulate coupled system models
- STEP[6] - model based 3D engineering and archiving for design and analysis information
- VMAP[7] – CAE data storage
- ONNX[8] - open format to represent machine learning models
- ISO/IEC JTC 1/SC 41[9] – a set of standards for IoT and Digital Twins
- DIN SPEC 91345:2016 / IEC PAS 63088 – RAMI4.0 with AAS
- OPC-UA/ IEC62541 - open standard for data exchange from sensors to cloud applications
- OMG Data Governance - roles and responsibilities related to handling sensitive data[10]
- NAFEMS ASSESS initiative on homogenisation of meta data for virtual engineering processes[11]

Ontologies in the manufacturing domain are still not widely used due to the variety of information sources and incompatible sub-domain conventions. Existing ontologies focus on smart factory planning or system level properties[12] with little reconciliation of local properties[13]. EMMO[14] was developed for material science, niche application ontologies building on BFO[15] are a step forward.

[1] „Design Principles for Data Spaces", position paper Horizon 2020 project "OPEN DEI Aligning Reference Architectures, Open Platforms and Large-Scale Pilots in Digitising European Industry", April 2021, https://doi.org/10.5281/zenodo.5244997

[3] Teerapittayanon, Surat, et al. " DaiMoN: A Decentralized Artificial Intelligence Model Network" *IEEE International Conference on Blockchain* (2019)

[4] BUSINESS PLAN CEN/CENELEC JTC 13 Cybersecurity and data protection https://standards.cencenelec.eu/BPCEN/2307986.pdf

[5] https://fmi-standard.org

[6] http://www.ap242.org/ and http://www.ap242.org/

[7] https://www.vmap.eu.com, redirected to https://vmap.vorschau.ws.fraunhofer.de/ (domain shift in progress, VMAP SC officially has been founded on December 20, 2022)

[8] https://onnx.ai/

[9] https://www.iec.ch/dyn/www/f?p=103:7:507272095232846:::FSP_ORG_ID,FSP_LANG_ID:20486,25

[10] https://www.omg.org/events/wa-18/special-events/Data_Governance.htm
[11] NAFEMS ASSESS Analysis, Simulation & Systems Engineering Software Strategies https://www.nafems.org/community/assess/
[12] S. Lemaignan, et al., "MASON: A Proposal For An Ontology Of Manufacturing Domain," in *Collective Intelligence and Its Applications*, 2006.
[13] F. Ocker, et al., "Applying knowledge bases to make factories smarter," *Automatisierungstechnik,* vol. 67, no. 6, 2019.
[14] E. Ghedini, et al., "European Materials & Modelling Ontology (EMMO)," 2019. http://github.com/emmo-repo/EMMO/.
[15] B. Smith, "Basic Formal Ontology 2.0," *Tech. Rep.,* 2015

3. Conclusions

In conclusion, this SmartEM roadmap provides a robust pathway for aligning R&D efforts with the evolving regulatory and standardization landscape, ensuring both compliance and innovation. By following this approach, the organization can lead the way in creating ethical, safe, and impactful engineering technologies that meet societal and regulatory expectations.