34th Annual INCOSE international symposium

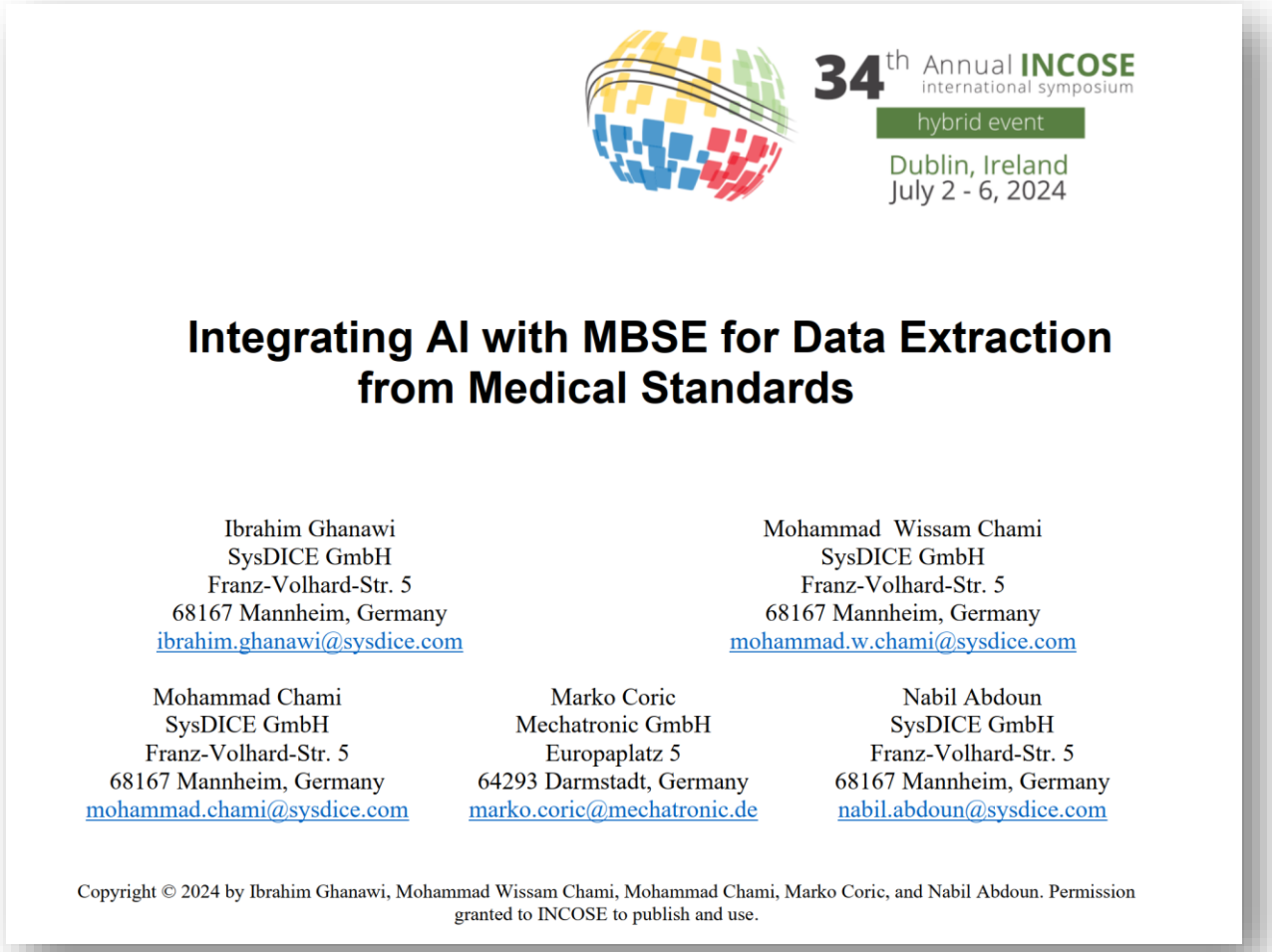
hybrid event

Dublin, Ireland
July 2 - 6, 2024

Integrating AI with MBSE for Data Extraction from Medical Standards

AGENDA

- Background
- Problem Description
- Goals
- Current Status
- Demonstrative Example
- Demo
- Other Domain



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Integrating AI with MBSE for Data Extraction from Medical Standards

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Automatic Norm Compliance using AI & MBSE

WHAT ARE THE MOST FREQUENTLY ASKED QUESTIONS ABOUT MBSE?

Model-Based Systems Engineering

Questions' Evolution

15 years of observations on most common questions asked related to MBSE:

- What is MBSE?
- Why use MBSE?
- How to do MBSE?
- How to scale, integrate, and reuse in MBSE?

Others have been asking:

- How to automate the MBSE adoption without explicitly coding the MBSE solution?
- How would system models design products on their own?

Source: https://www.pinterest.de/pin/563018681245269/

Instead of focusing solely on **delivering intelligent products**,

Why not **support designing** and **developing** them with an **intelligent framework**?

WHY NOT MATCHING EXISTING

MBSE CHALLENGES

WITH

SUCCESSFUL AI APPLICATIONS

IN OTHER DOMAINS?

Procedia Computer Science

Volume 51, 2015, Pages 650–659

ICCS 2015 International Conference On Computational Science

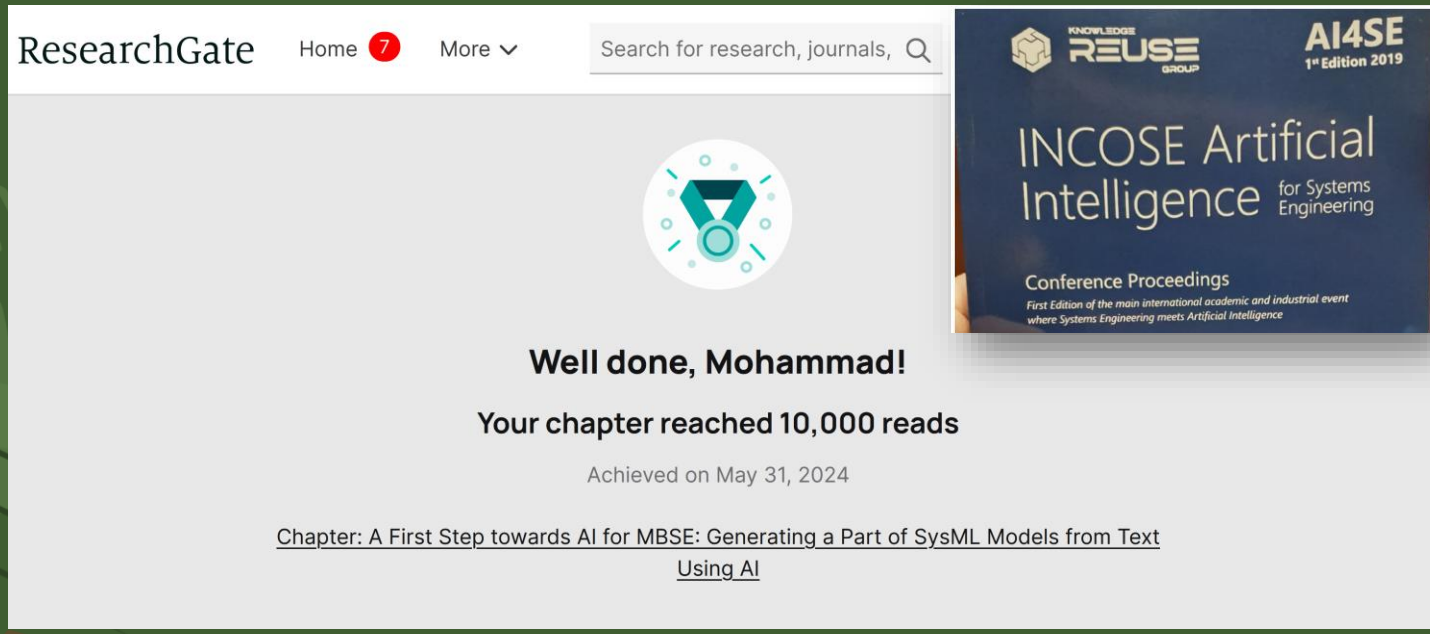
Intelligent

Towards an ~~Integrated~~ Conceptual Design Evaluation of Mechatronic Systems: The SysDICE Approach

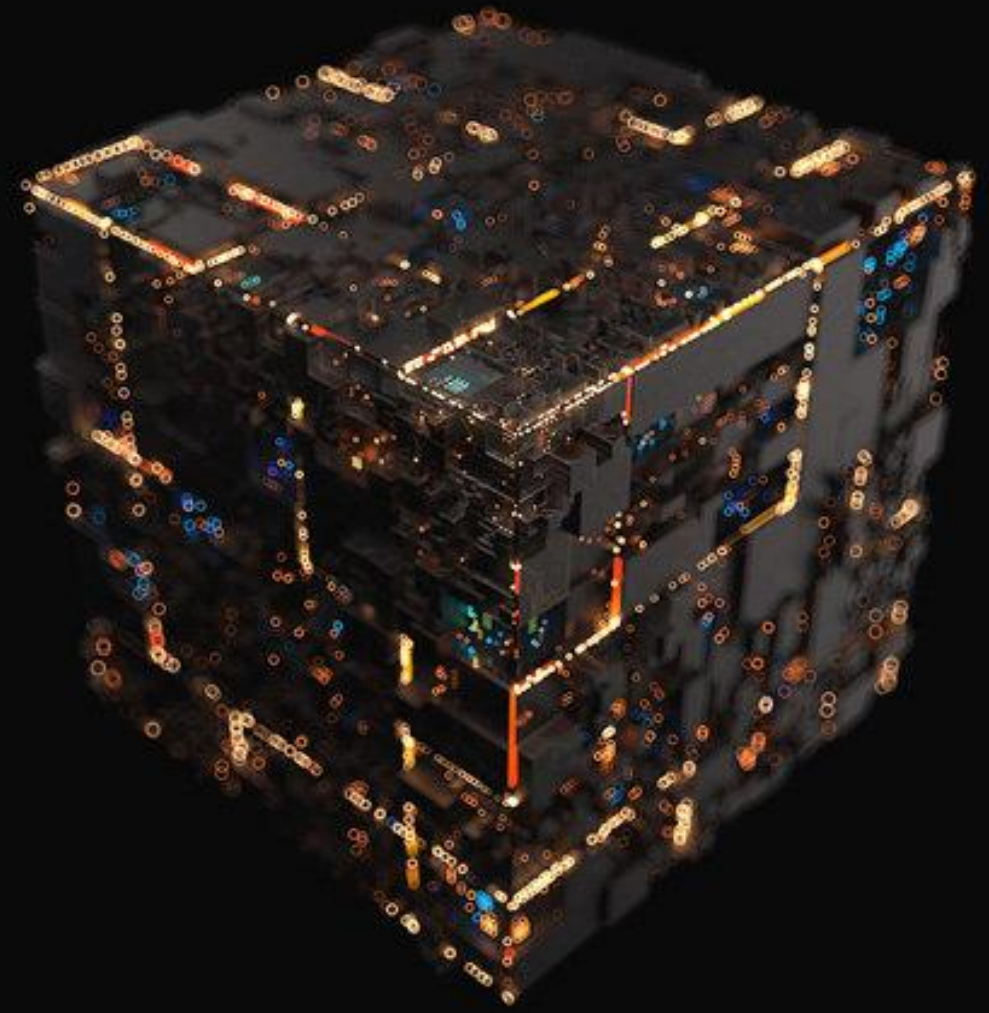
Mohammad Chami[1,2] and Jean-Michel Bruel[2]

MORE THAN A DECADE…

…AI HYPE OR TRUE INTEREST?

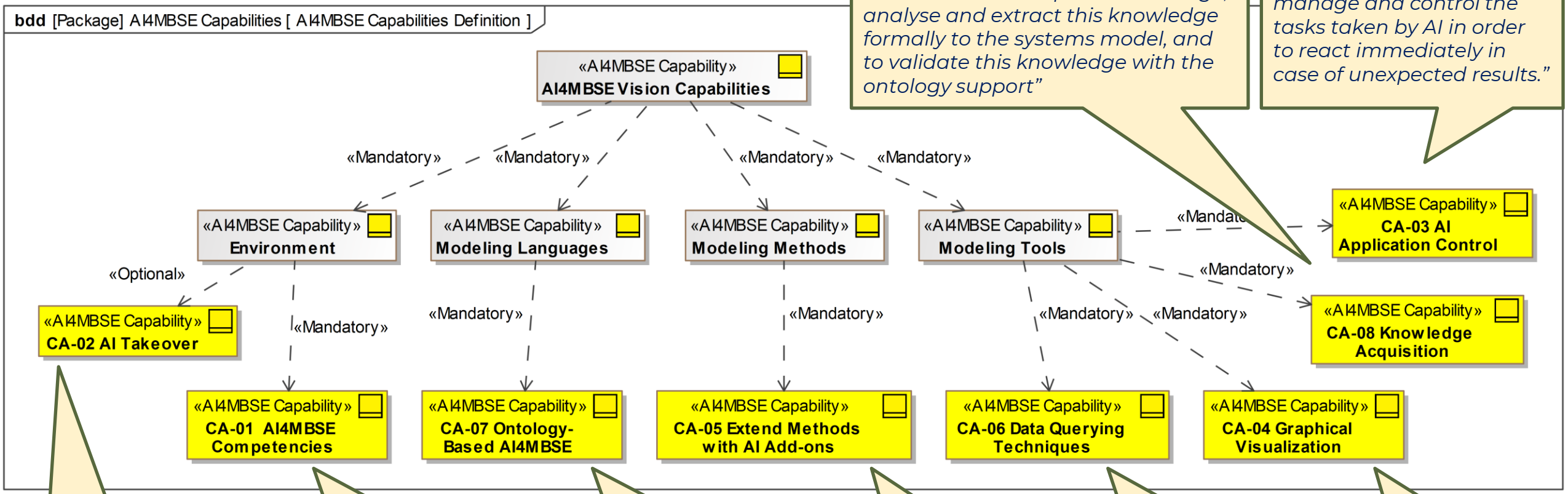


WHAT CAPABILITIES WOULD AN **AI4MBSE** SOLUTION REQUIRE?



Source: https://singularityhub.com

AI4MBSE CAPABILITIES



"AI4MBSE should be compatible with knowledge acquisition techniques to elicitate domain experts' knowledge, analyse and extract this knowledge formally to the systems model, and to validate this knowledge with the ontology support"

"AI4MBSE tools must provide the capability to manage and control the tasks taken by AI in order to react immediately in case of unexpected results."

"AI4MBSE should accommodate an optional AI takeover of a defined systems engineers' task. This must be tested and validated consistently before deployment."

"MBSE universities, training centers, and universities lecturers or researchers shall include related AI techniques and foundations on the existing MBSE curriculum."

"AI4MBSE should be supported by an ontology for elements of modeling language, AI and their mapping for the sake of achieving effective application of AI."

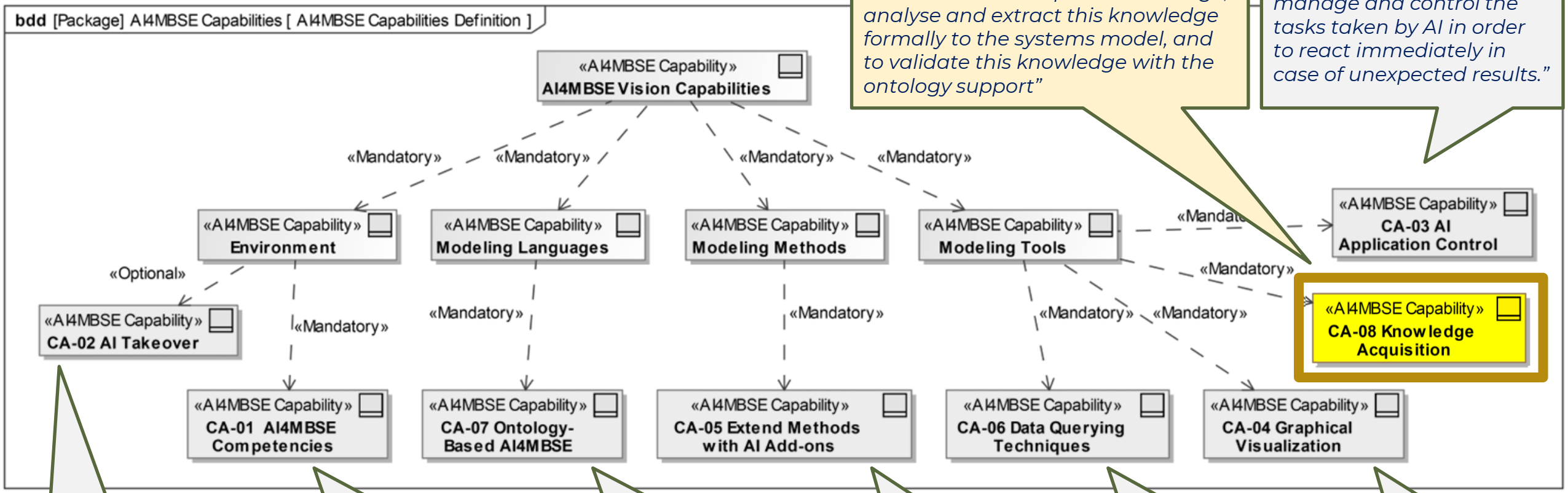
"MBSE applied modeling methods shall be extended with the related AI development and deployment steps."

"AI4MBSE shall be supported with a productive semantic querying technique to answer typical systems engineers' questions about the model content."

"AI4MBSE tools shall provide the means of visualizing models in a graphical manner with the defined methods"

Source: Chami et al., Artificial Intelligence Capabilities for Effective Model-Based Systems Engineering: A Vision Paper. INCOSE IS 2022. https://doi.org/10.1002/iis2.12988

AI4MBSE CAPABILITIES



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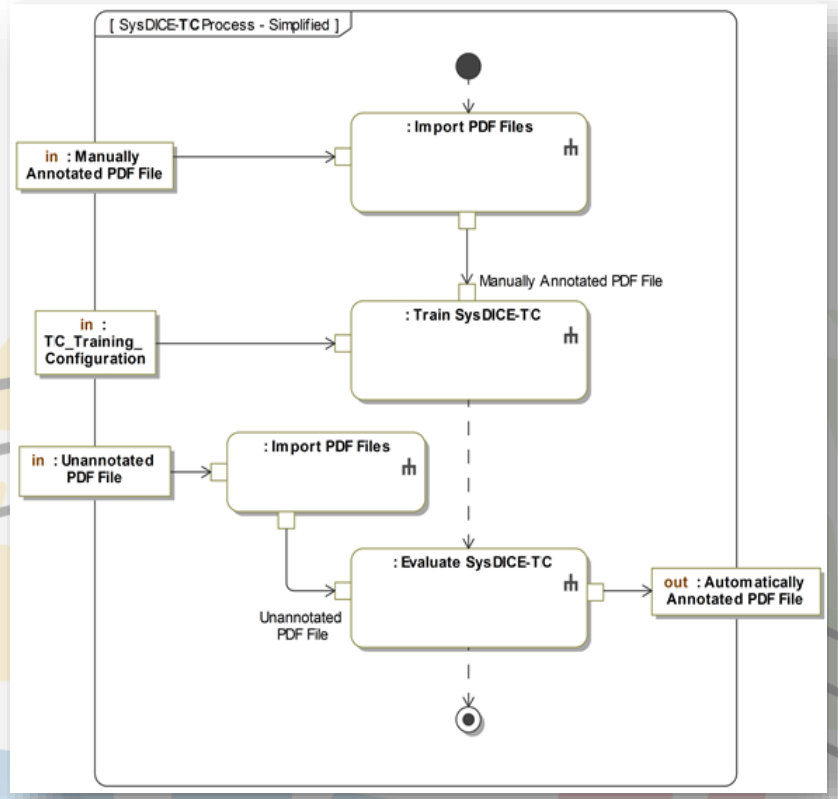
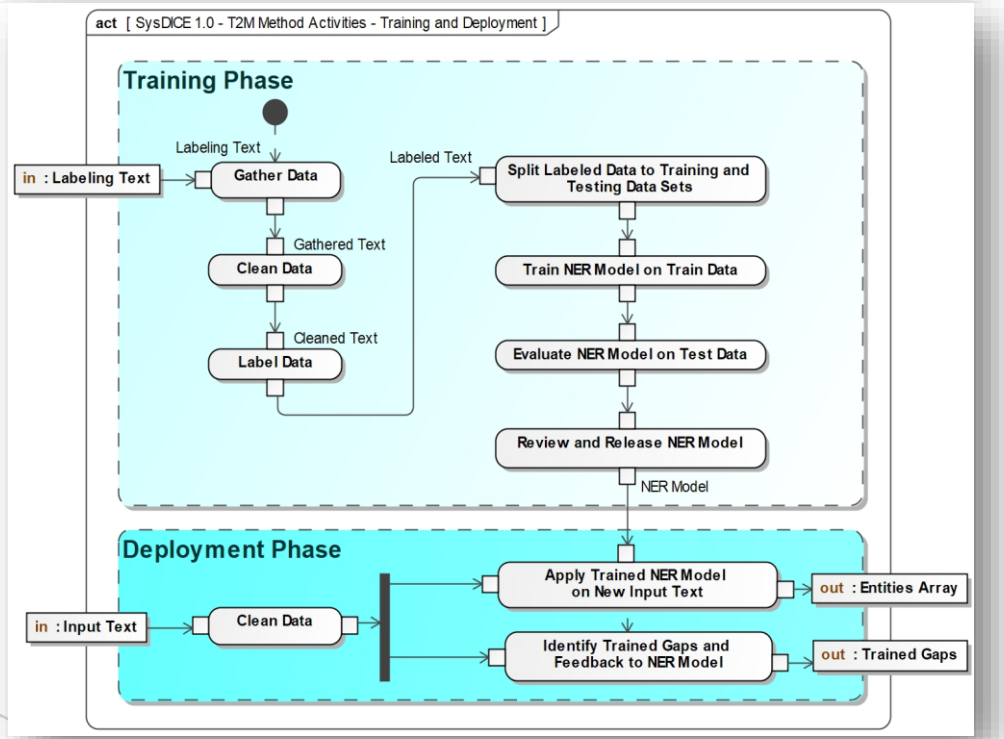
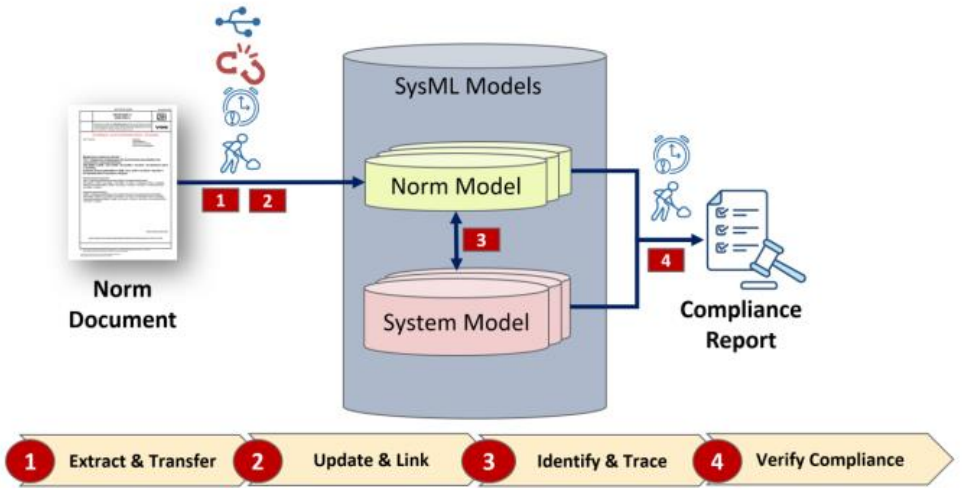
From “Text-to-Model” To “PDF-to-Model”





Source: Chami et al.: A First Step towards AI for MBSE: Generating a Part of SysML Models from Text Using AI. 2019. https://www.researchgate.net/publication/337338933
Source: Abdoun & Chami: Automatic Text Classification of PDF Documents using NLP Techniques. INCOSE IS 2022. https://doi.org/10.1002/iis2.12997

Presentations' Scope: Part of the CyberTech R&D Project *Automatic Norm Compliance in MedTech*



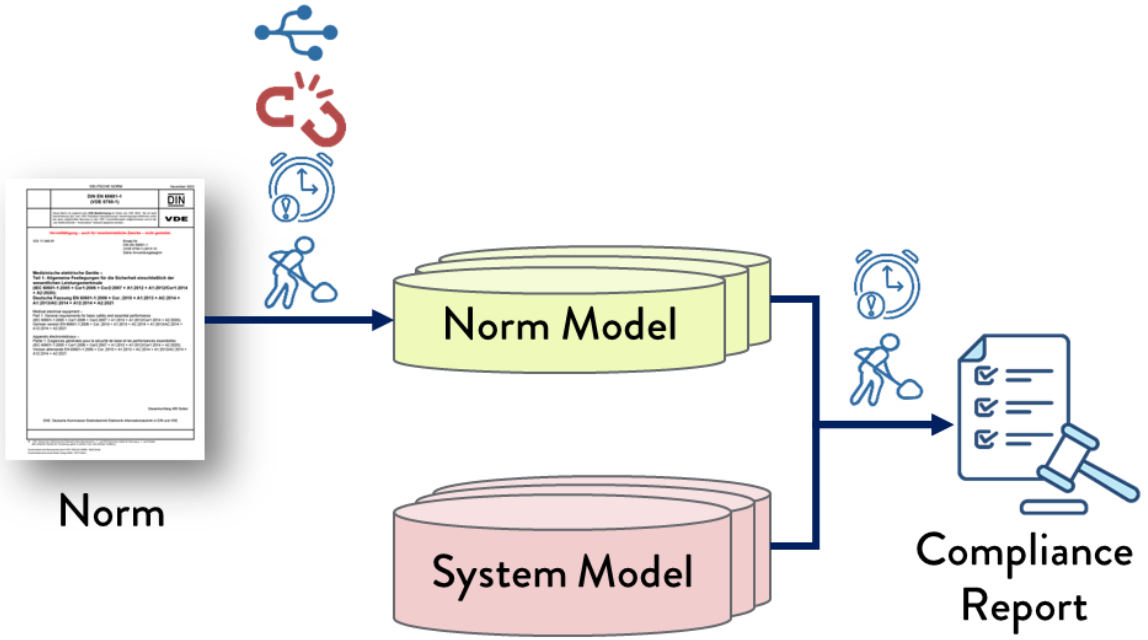
This research and development project CyberTech is funded by the German Federal Ministry of Education and Research (BMBF) within the "Innovations for Tomorrow's Production, Services, and Work" Program (02J19B012) and implemented by the Project Management Agency Karlsruhe (PTKA).

Source: https://www.ase-cybertech.de/

Use case: Automatic Norm Compliance

Problem Description

1. Time-consuming and costly work related to the **digitization of norm documents** into the norm model
2. Lack of **traceability** between norm documents data and norm models elements
3. Manual **version** and **configuration management** for updates of norm documents
4. Time-consuming **norm compliance reporting**

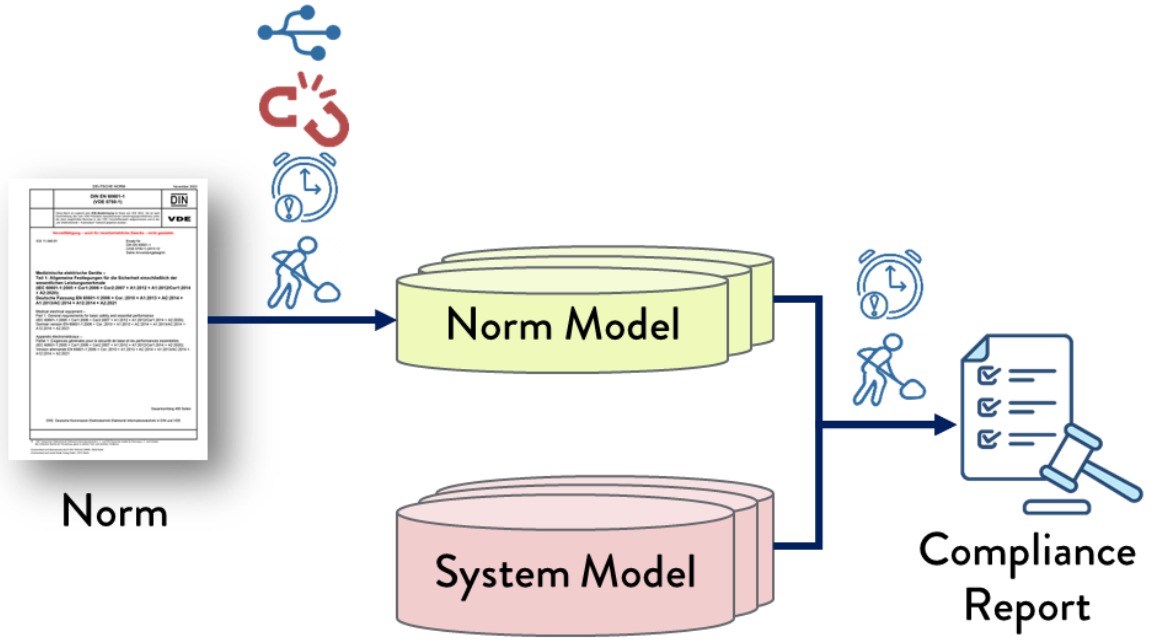


HOW CAN WE **ASSIST** AND **AUTOMATE** THE PROCEDURES FOR NORM COMPLIANCE?

Use case: Automatic Norm Compliance

Need for Change and Goals

1. Automate the **digitization of norm documents** into norm models
2. Maintain **traceability** between norm documents and the created norm models
3. Manage **versions** of the norm document and their impact on changes
4. Automate the **mapping** of norm model elements to system model elements
5. Automate **norm compliance reporting**



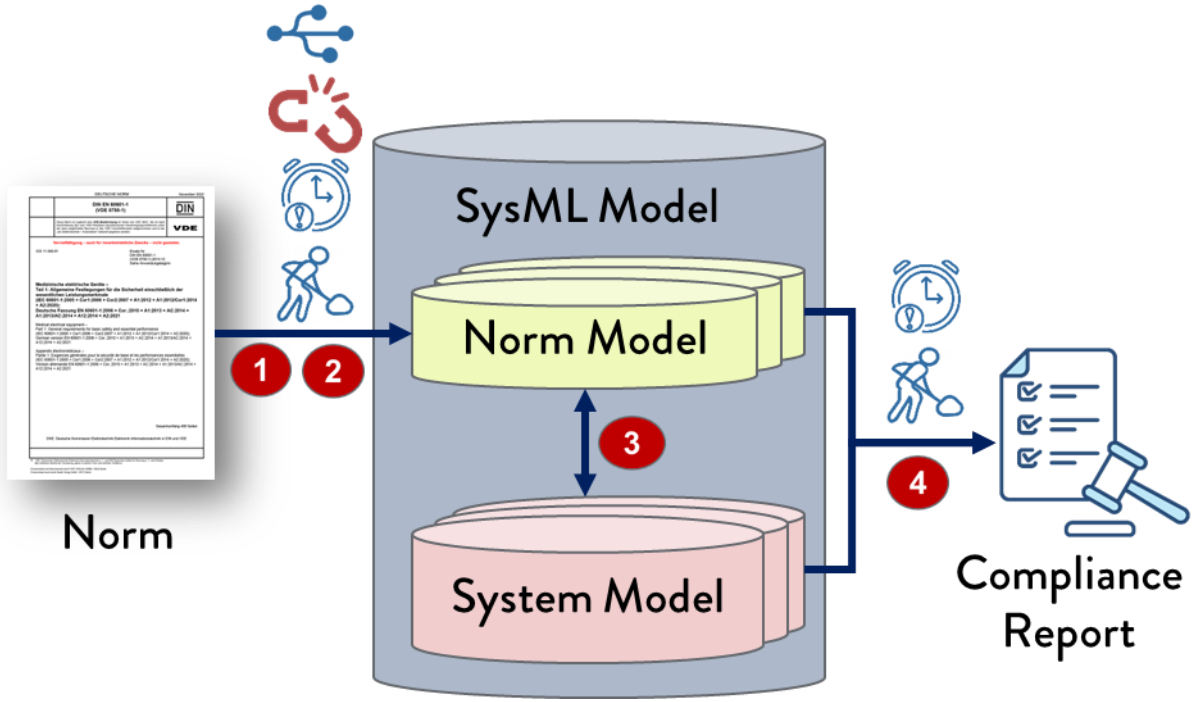
HOW CAN WE DEVELOP A CUSTOMIZABLE SOLUTION BASED ON ANY NORM DOCUMENT?

Use case: Automatic Norm Compliance

Need for Change and Goals

1 Extract & Transfer | 2 Update & Link | 3 Identify & Trace | 4 Verify Compliance

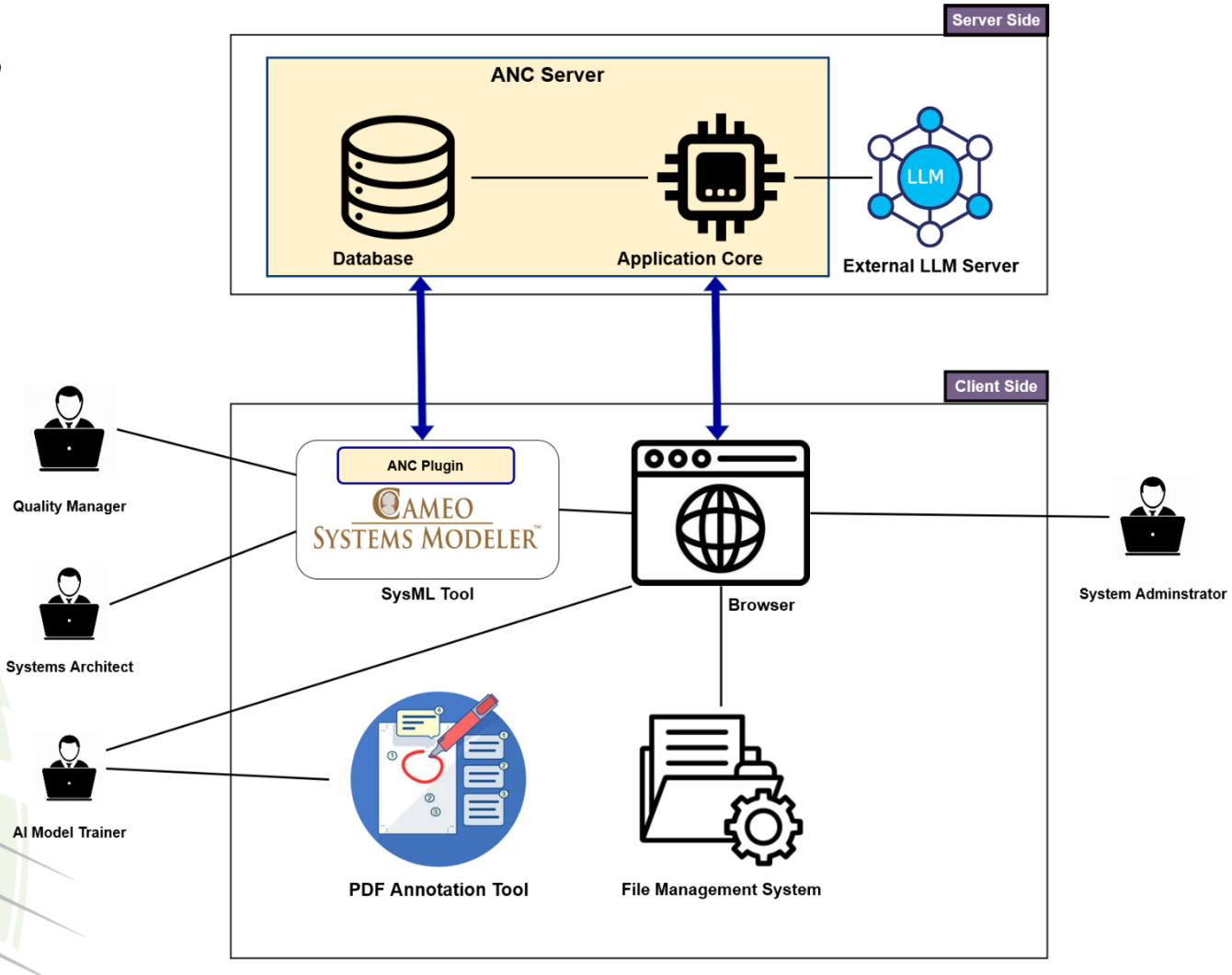
1. **Extract & Transfer:**
   - Automate the transformation of a standard document into a standard model.
   - Maintain traceability between the standard document and the standard model.
   - Adapt the solution and integrate user feedback.
2. **Update & Link:**
   - Manage multiple versions of the standard documents.
   - Analyse the impacts of a change on the model.
3. **Identify & Trace:**
   - Identify which elements of the standard model correspond to an element of the system model.
   - Automate the creation of trace links between the standard and system model elements.
4. **Verify Compliance:**
   - Verify if the system model element corresponds to the corresponding standard model elements.



Use case: Automatic Norm Compliance

Current Status – Tool Architecture

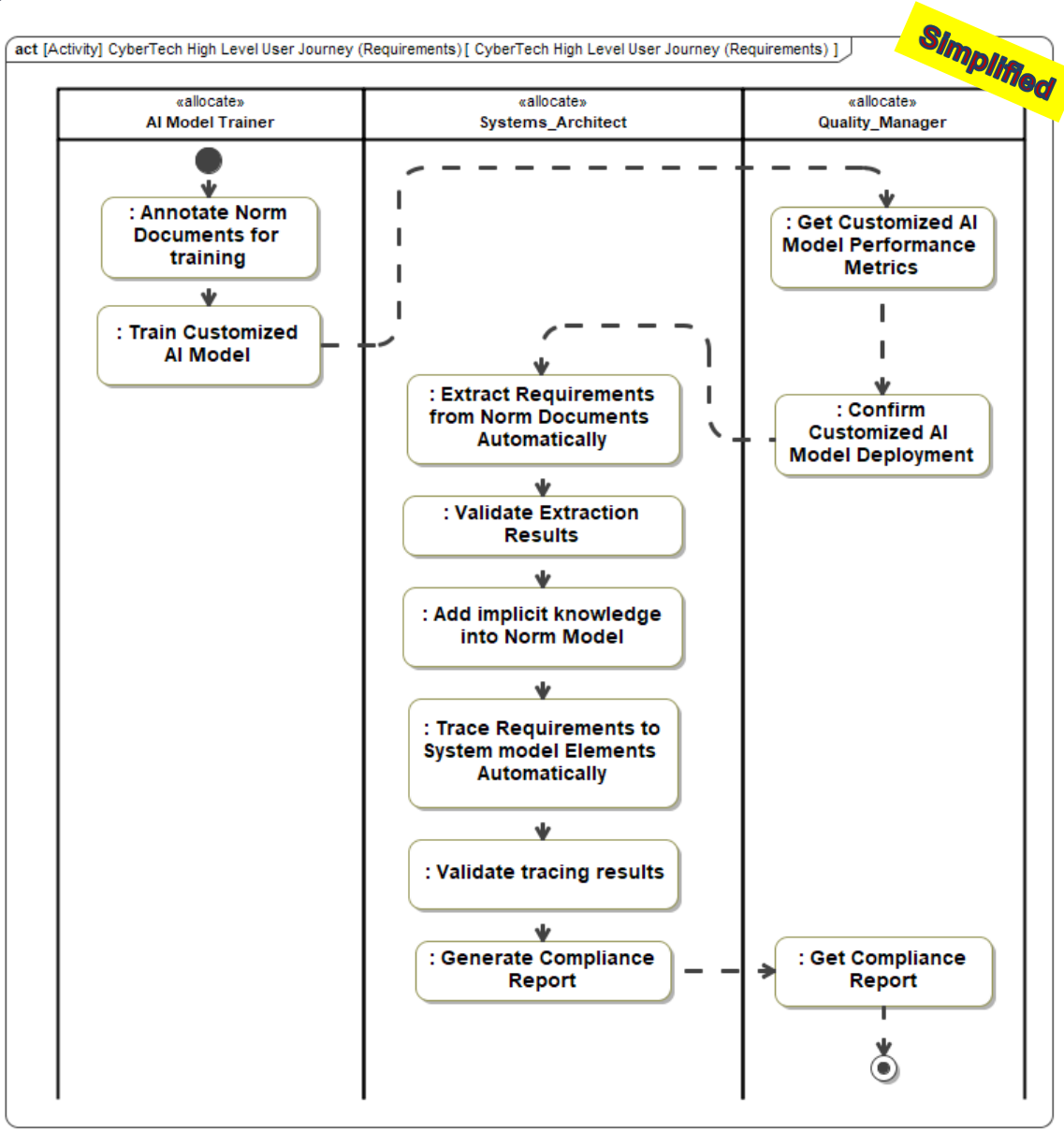
1. **Customizable Solution:** re-label, re-train, re-test
2. **Flexible Solution:** easy to integrate with SysML tools (currently Cameo Systems Modeler)
3. **Easy to set up:** Plugin + Browser
4. **Hybrid Solution:** with or without LLM (Simple and realistic cost training)



Use case: Automatic Norm Compliance

Current Status – A Simplified User Story

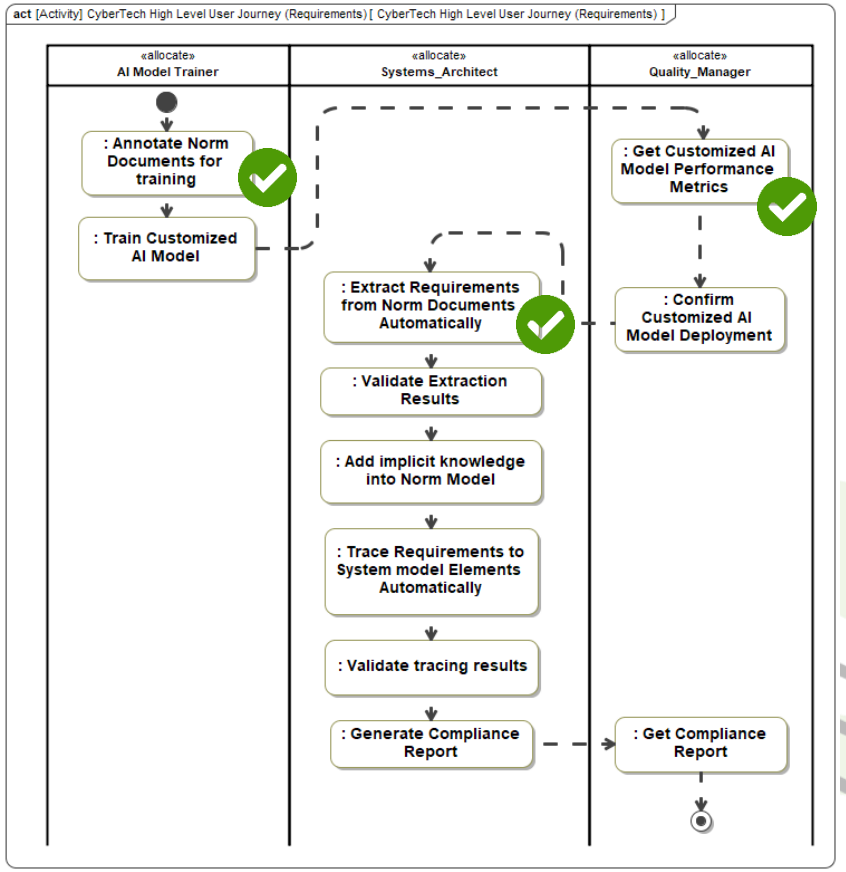
1. **Customizable Solution:** re-label, re-train, re-test
2. **Iterative AI Training**: Re-train the AI algorithms until the desired metric is achieved
3. **Human-in-the-Loop AI**:
   - is crucial to incorporate human expertise into the AI development process
   - can reduce errors and improve the accuracy of machine learning models
   - allows human users to monitor and correct AI models
   - ensures that AI systems adhere to ethical and moral standards

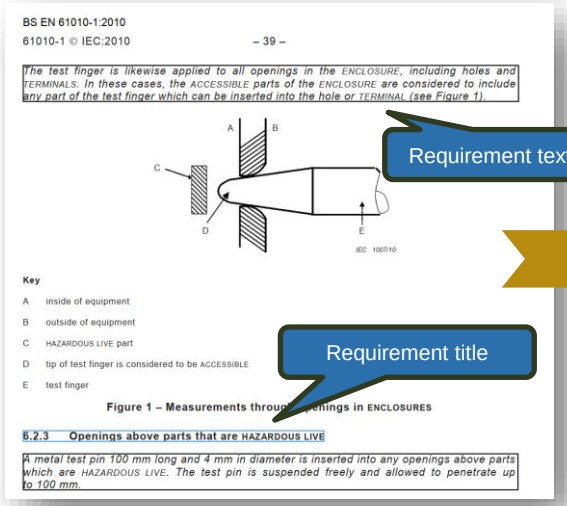


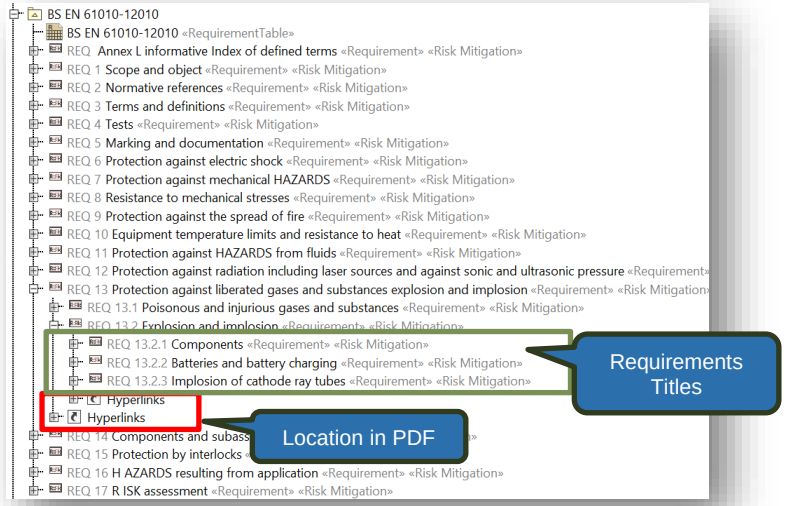
Use case: Automatic Norm Compliance

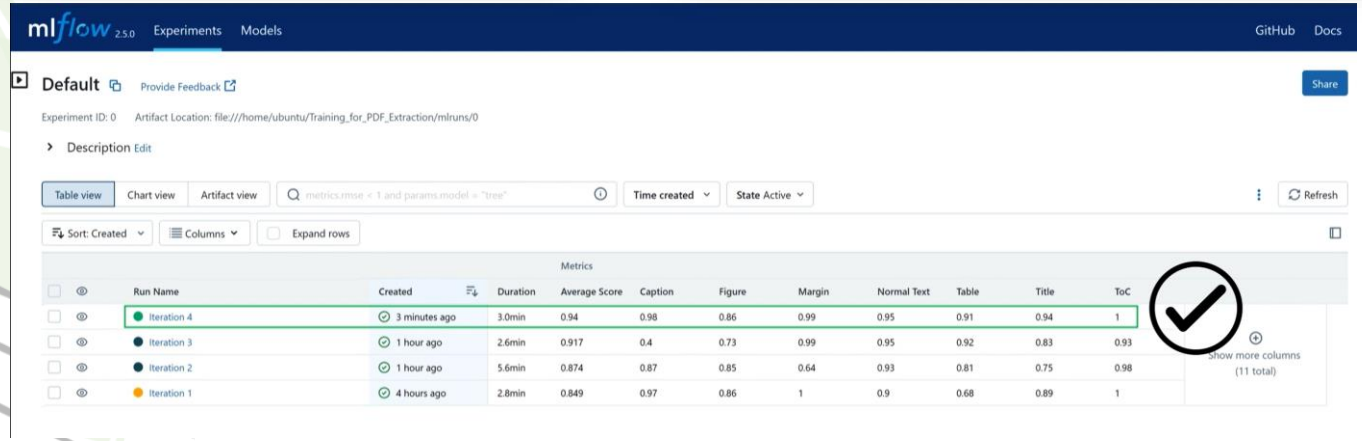
Demonstrative Example

1 Extract & Transfer





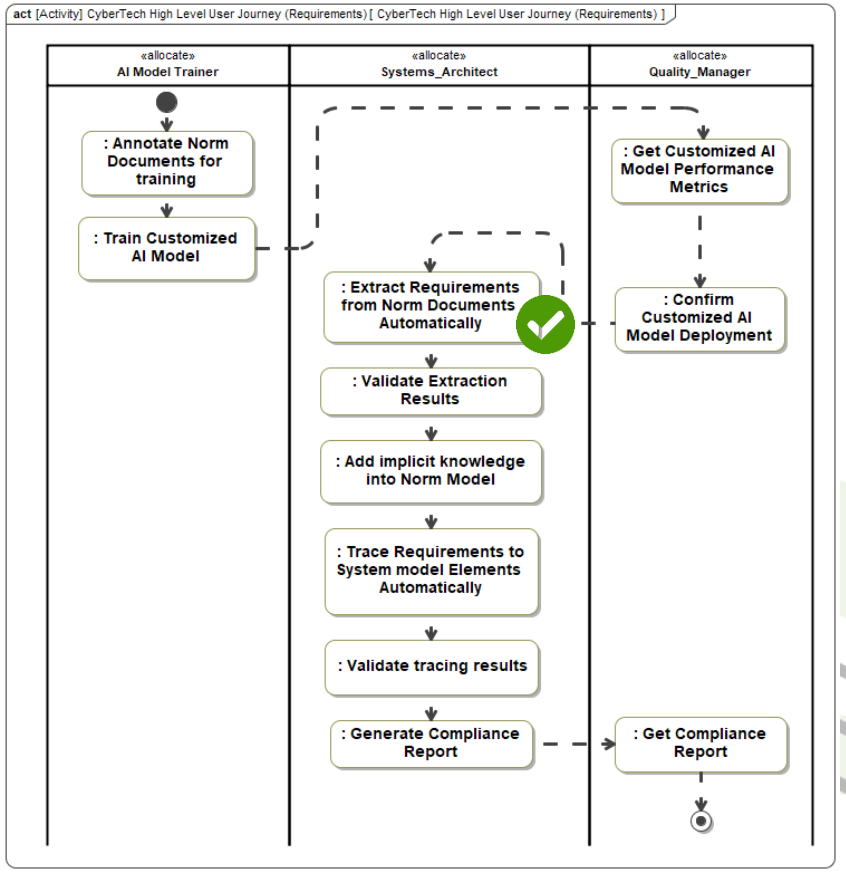


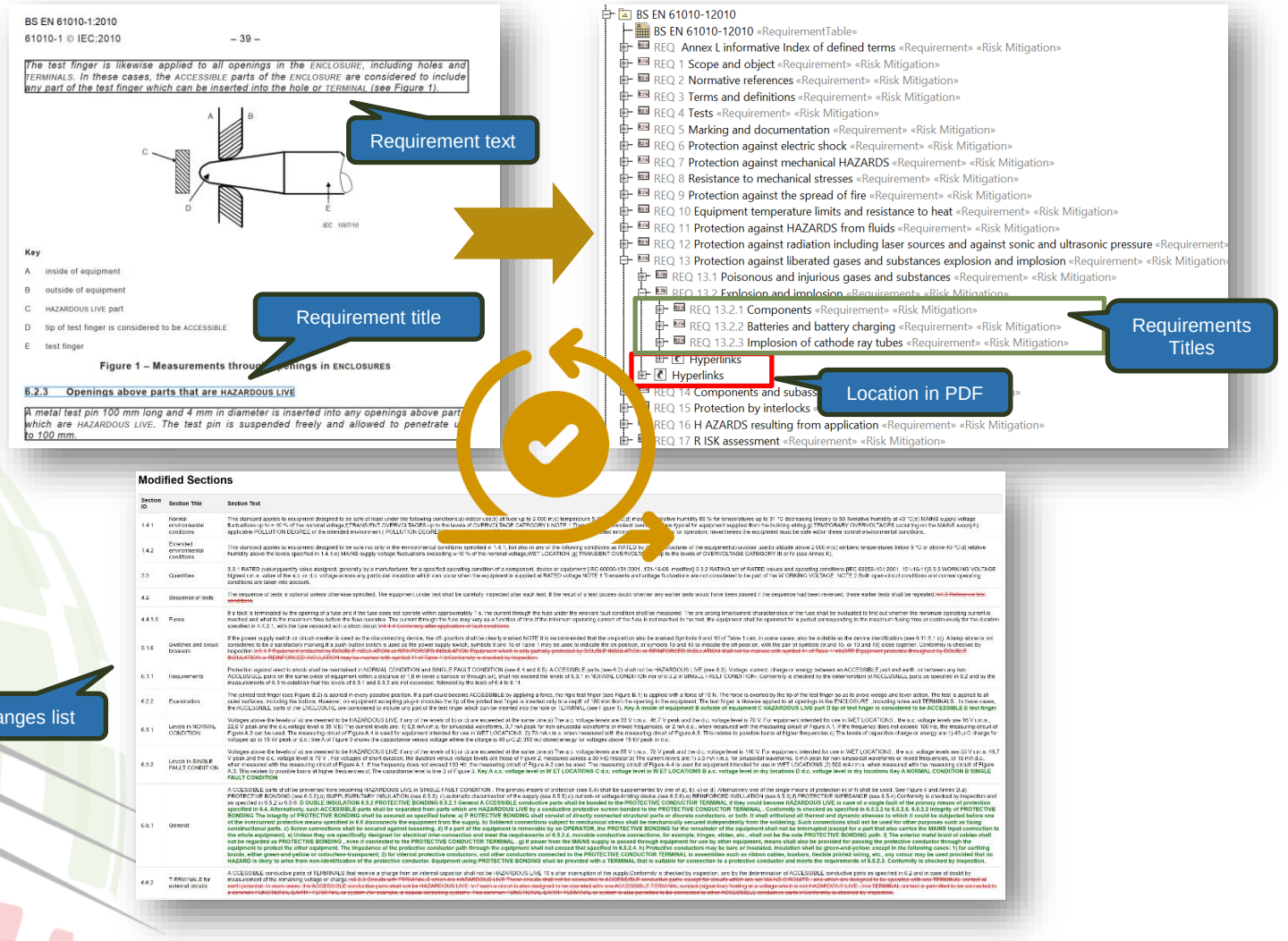


Use case: Automatic Norm Compliance

Demonstrative Example

2 **Update & Link**

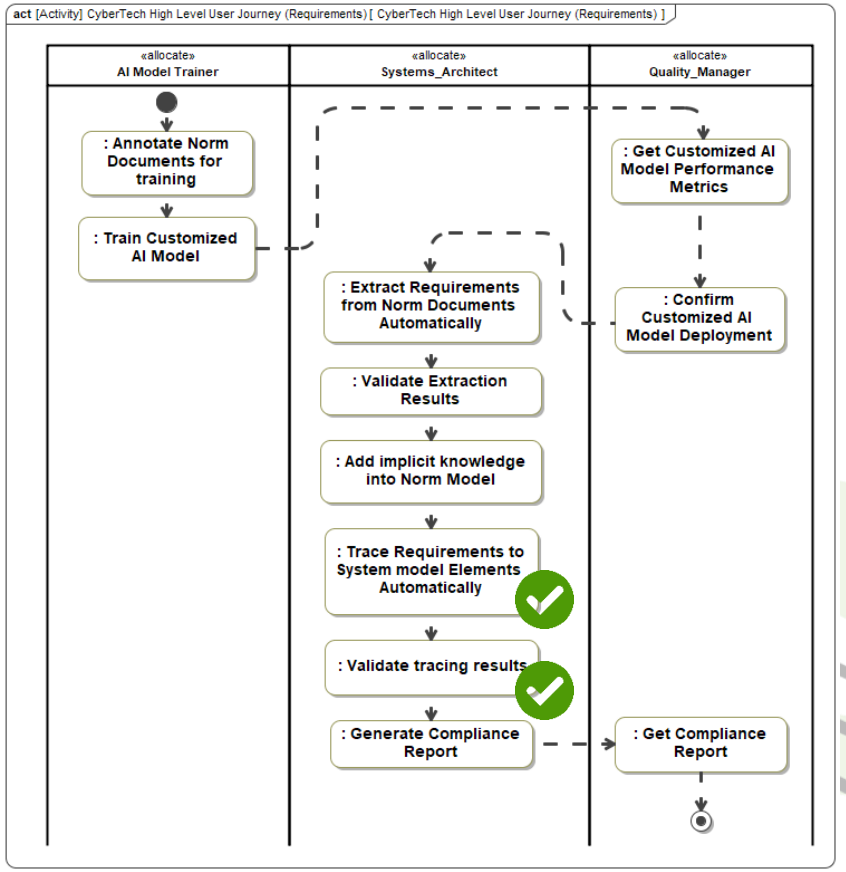


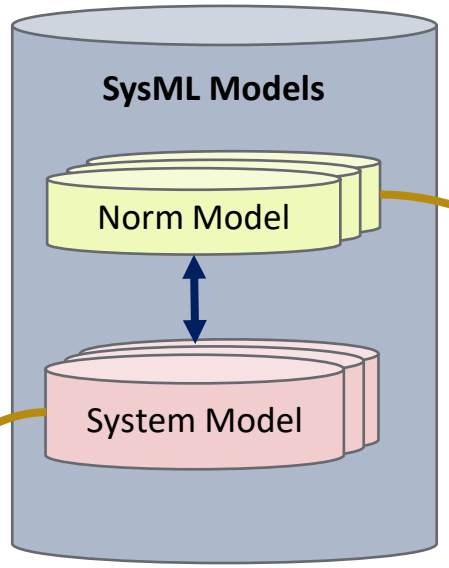


Use case: Automatic Norm Compliance

Demonstrative Example

3 Identify & Trace **4 Verify Compliance**





Identified and Traced

Identify Compliance

Add New | Existing... | Delete | Remove From Table | Columns | Export

Criteria

Element Type: ANC Relation | Scope (optional): Main Model | Filter:

#	System Element	Compliance Status	Approval Status	Norm Element
1	HRM:002 cutting by releasing kinetic energy by moving parts	Compliant	Not Checked Yet	7.3 Moving parts
2	HRM:006 cutting by touchable sharp edges	Compliant	Not Checked Yet	rm_handbook_sharp workpiece
3	TS_60601-1_6.2.2 Determination of ACCESSIBLE parts - Examination	Compliant	Not Checked Yet	60601-1_6.2.1 Determination of ACCESSIBLE parts - General
4	TS_60601-1_6.2.2 Determination of ACCESSIBLE parts - Examination	Compliant	Not Checked Yet	8.2 E NCLOSURE rigidity tests
5	TS_60601-1_6.2.2 Determination of ACCESSIBLE parts - Examination	Compliant	Not Checked Yet	6.2.2 Examination
6	TS_60601-1_6.2.2 Determination of ACCESSIBLE parts - Examination	Compliant	Checked and Approved	6.2.2 Examination
7	TS_60601-1_6.2.2 Determination of ACCESSIBLE parts - Examination	Compliant	Not Checked Yet	6.2.1 General
8	TS_60601-1_6.2.2 Determination of ACCESSIBLE parts - Examination	Compliant	Not Checked Yet	7.5.2 Handles and grips
9	TS_60601-1_6.2.2 Determination of ACCESSIBLE parts - Examination	Compliant	Checked and Approved	8.2.2 Impact test
10	TS_60601-1_6.2.2 Determination of ACCESSIBLE parts - Examination	Non-Compliant	Not Related	6.2.4 Openings for pre-set controls
11	TS_60601-1_6.2.2 Determination of ACCESSIBLE parts - Examination	Neutral	Not Checked Yet	8.2.1 Static test
12	TS_60601-1_6.2.3 Determination of ACCESSIBLE parts - Openings above parts that HAZAI	Compliant	Not Checked Yet	6.2 Determination of ACCESSIBLE parts
13	TS_60601-1_6.2.3 Determination of ACCESSIBLE parts - Openings above parts th HAZAI	Neutral	Not Related	6.2 Determination of ACCESSIBLE parts
14	TS_60601-1_6.2.3 Determination of ACCESSIBLE parts - Openings above part re HAZAI	Neutral	Not Checked Yet	7.3.2 Exceptions

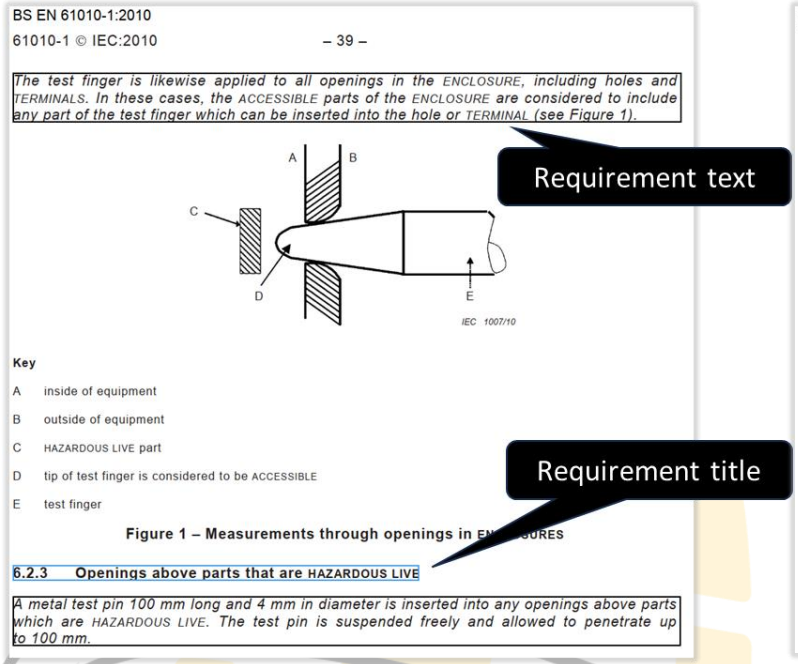
Proposed

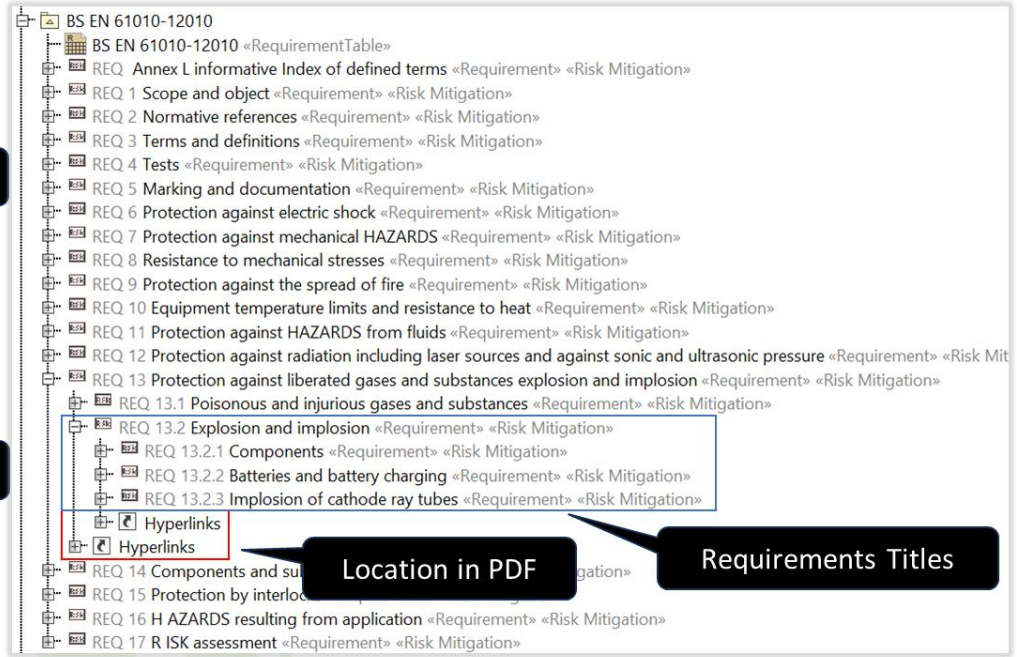
User Feedback (Validation)

Use case: Automatic Norm Compliance

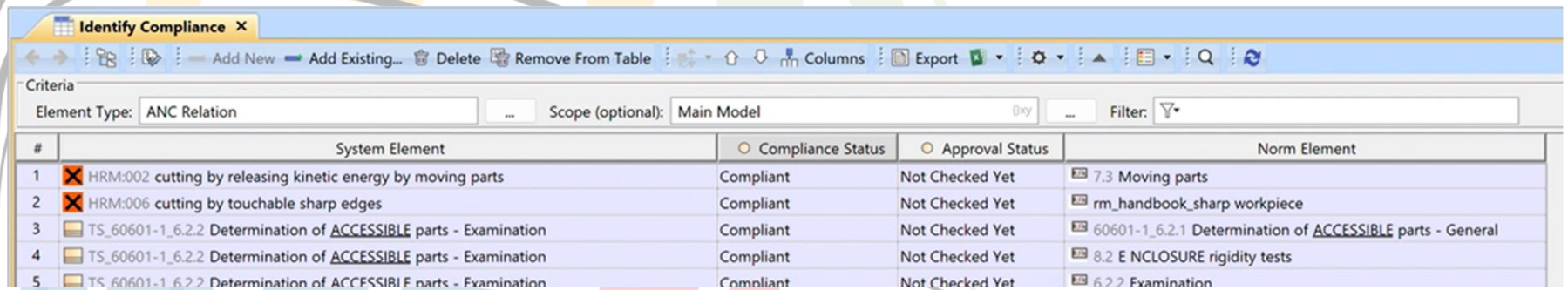
1 **Extract & Transfer** → 2 **Update & Link** → 3 **Identify & Trace** → 4 **Verify Compliance**

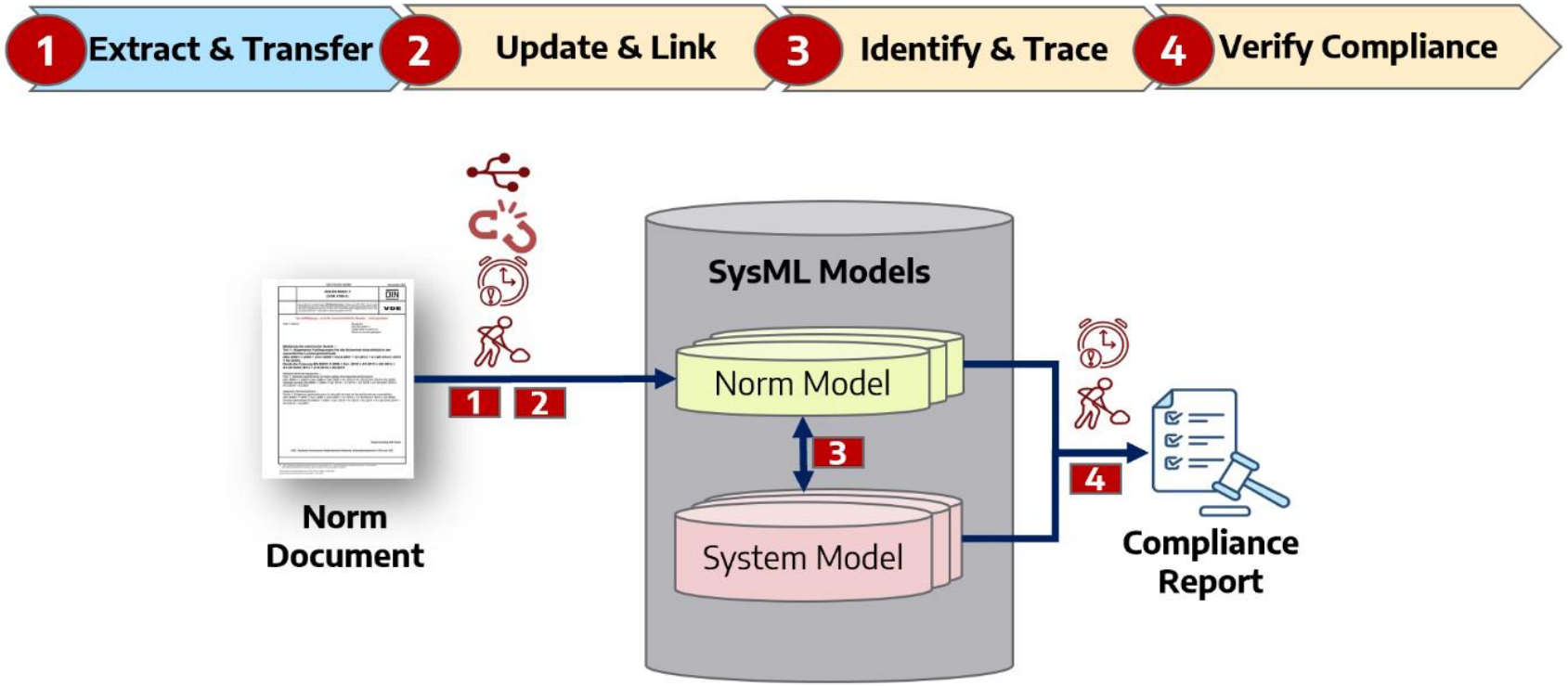
UC 1 & UC 2





UC 3 & UC 4

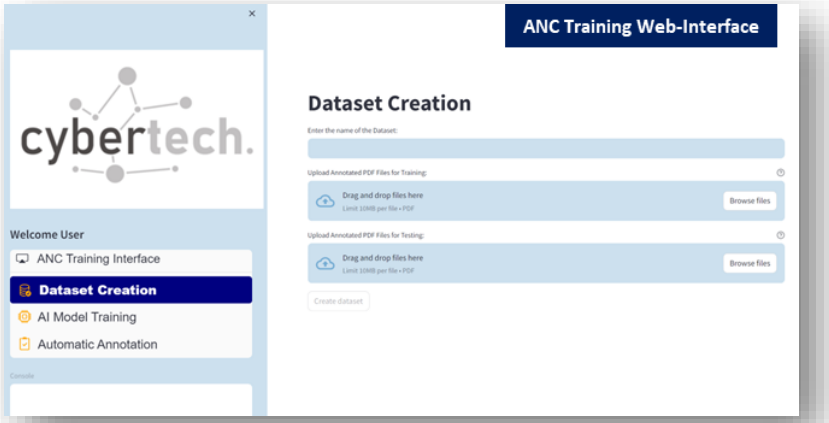


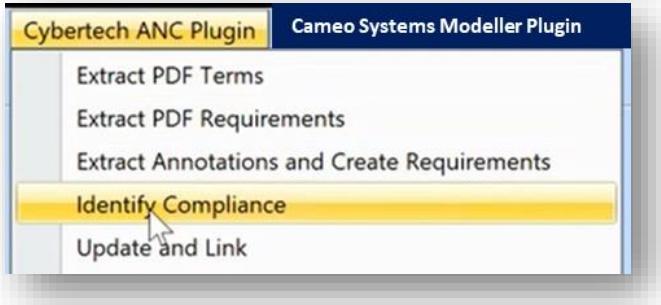

1 Extract & Transfer
2 Update & Link
3 Identify & Trace
4 Verify Compliance
SysML Models
Norm Model
System Model
1
2
3
4
Norm Document
Compliance Report

Use case: Automatic Norm Compliance

Takeaways

- Customizable AI solutions (e.g., BERT-based Classifier, MiniLM) offer lower operational costs and better performance.
- Proprietary out-of-the-box solutions (e.g., OpenAI API) are easier to integrate and provide higher generalization.
- There is a lack of open-source MBSE-SysML models that could accelerate the adoption of AI for norm assurance.
- Future work is needed to optimize human involvement and achieve higher levels of automation.





A BIG STEP TOWARDS **ASSISTANCE** AND A STEP FORWARD TOWARDS **AUTOMATION**.

Other Domain: Digitizing ECSS Standards Using AI and MBSE

ECSS | European Cooperation for Space Standardization

3.2 Terms specific to the present standard — Section Title

3.2.1 aggressive environment

combination of liquid or gaseous media and temperature that alters static or fatigue crack-growth characteristics from normal behaviour associated with an ambient temperature and laboratory air environment

3.2.2 analytical life

life evaluated analytically by crack-growth ar

Glossary Definition

6 Identification and evaluation of PFCI

6.1 Identification of PFCIs — Requirement ID

ECSS-E-ST-32-01_0810011

a. Structural items for which implementation of fracture control programme is performed shall be selected in conformance with Figure 6-1, classified as PFCI, and identified by structural screening for the complete structure, including related GSE directly connected to the flight structure.

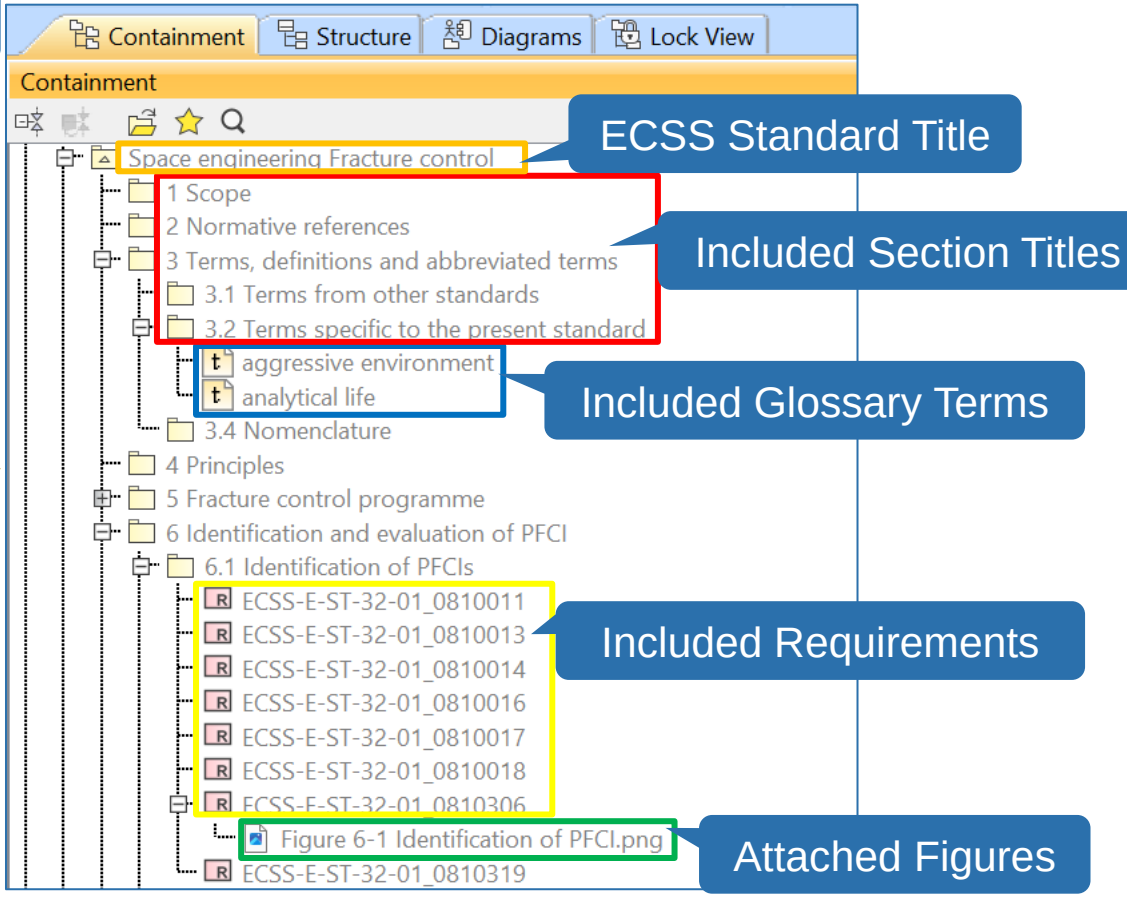
Requirement Text

NOTE This includes structural items whose failure can result in a catastrophic hazard.

Requirement Note

ECSS-E-ST-32-01_0810319

b. For unmanned, single-mission, space vehicles and their payloads, and GSE the identification of PFCIs may be limited to the items listed in clause 11.2.2.1.



ECSS Standard Title

Included Section Titles

Included Glossary Terms

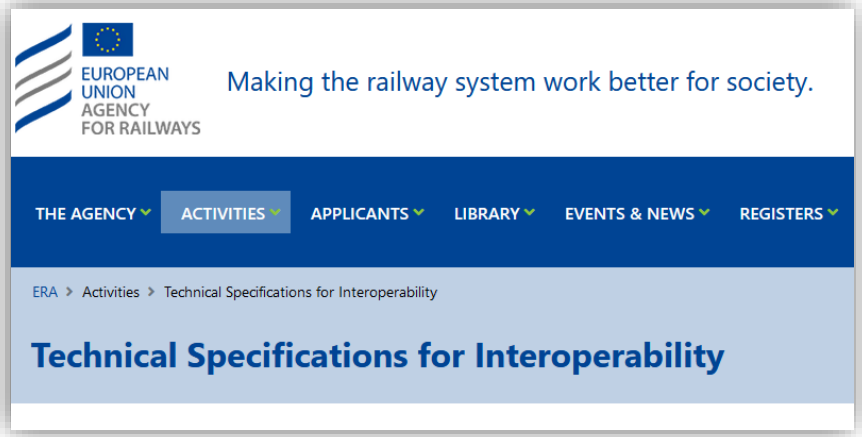
Included Requirements

Attached Figures

A Part of the extracted and transferred data into Cameo Systems Modeller.

Source: https://ecss.nl/standard/ecss-e-st-32-01c-rev-2-fracture-control-30-july-2021/

Other Domain: Digitizing TSI Standards Using AI and MBSE



TSI Standards Documents

4. AMOC content – international brake sheet and wagon list

The international brake sheet and wagon list defines a standard format and content for the document that is to be provided to a locomotive driver before train departure. It can be used for international as well as domestic freight trains. The language of the document can vary but the format and fields (numbers and description) must remain the same. The specification can be found in the Appendix A.

Harmonised parameter for 1520 mm track gauge:

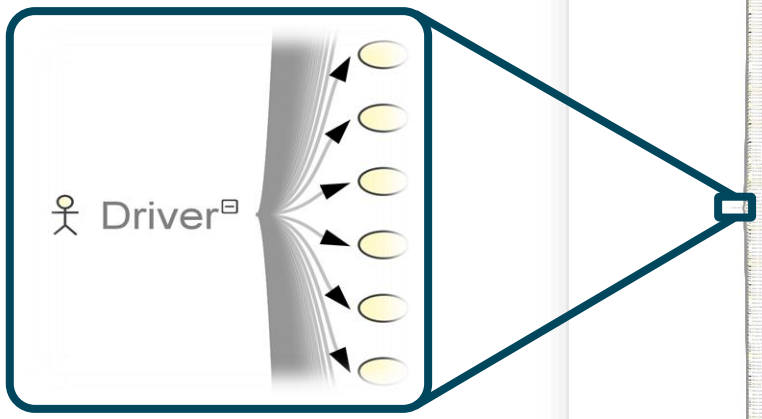
In case where an automatic sanding function is provided, it shall be possible for the driver to suspend its use.

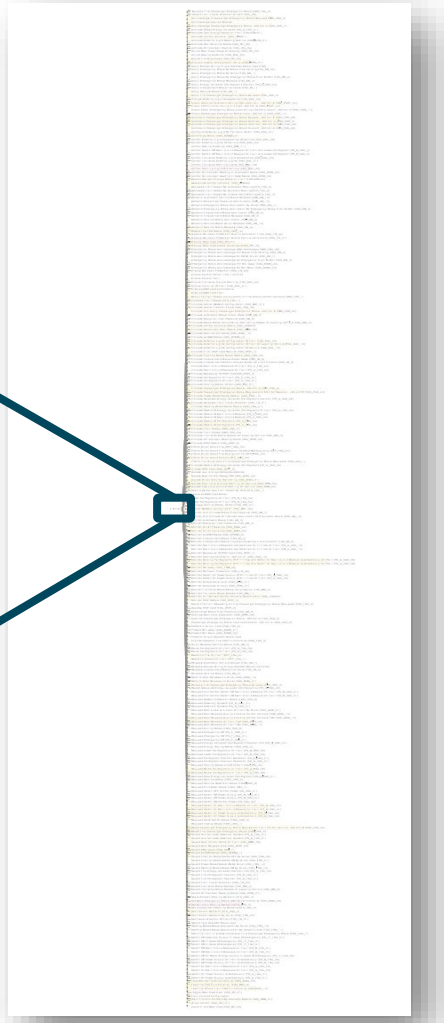
The allowed amount of sand per sanding device within 60 s shall be:

- 1.2 to 1.5 kg for the front wheelsets
- 0.7 to 1.2 kg for all other wheelsets for passenger and freight locomotives respectively

This parameter shall be taken into account jointly with 3.1.4.2 (Sand Characteristics).

WHICH USE CASES IS THE DRIVER INVOLVED IN?





Source: https://www.era.europa.eu/domains/technical-specifications-interoperability_en

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www.incose.org/symp2024
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