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BUILDING BRIDGES

WATERFALL > AGILE

PRACTICE > SCIENCE

METHODOLOGY > PROCESS

STARTUP > CORPORATE

SysDICE

KNOWLEDGE FOR IMPACT

Automatic Norm Compliance using AI & MBSE

Presented by Mohammad Chami, Ph.D.

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Sep 9th, 2024

Zürich, Switzerland

This presentation includes work related to our publication, part of the [CyberTech Project](#), along with the latest updates and developments:

“Ghanawi, I., Chami, M.W., Chami, M., Coric, M. and Abdoun, N. (2024), [Integrating AI with MBSE for Data Extraction from Medical Standards](#). INCOSE International Symposium, 34: 1354-1366. <https://doi.org/10.1002/iis2.13212>”

AGENDA

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



34th Annual **INCOSE**
international symposium
hybrid event

Dublin, Ireland
July 2 - 6, 2024

Integrating AI with MBSE for Data Extraction from Medical Standards

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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**?

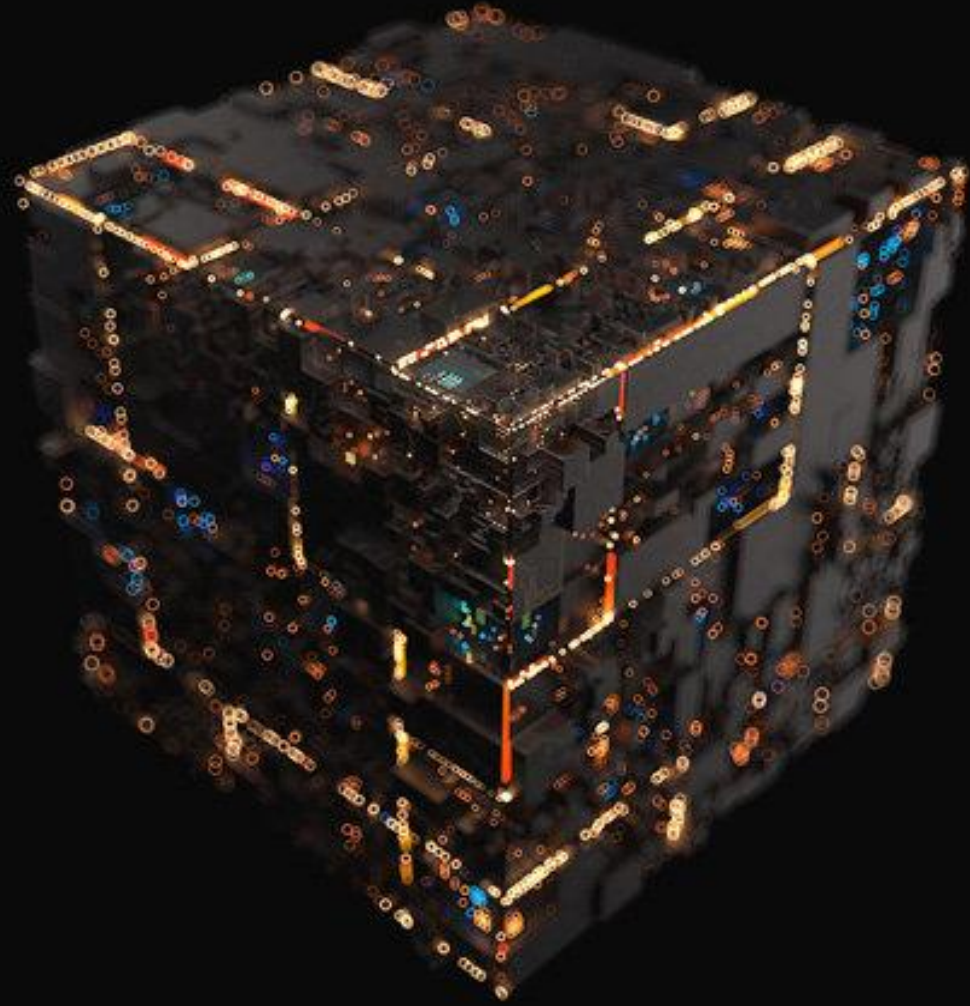


Instead of focusing solely on
delivering intelligent products,

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

WHY NOT MATCHING EXISTING
MBSE CHALLENGES
WITH
SUCCESSFUL AI APPLICATIONS
IN OTHER DOMAINS?

WHAT CAPABILITIES WOULD AN AI4MBSE SOLUTION REQUIRE?





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 Bruel²

...AI HYPE OR
TRUE
INTEREST?

MORE
THAN A
DECADE AGO...

ResearchGate

Home 7

More ▾

Search for research, journals, Q



Add new



Well done, Mohammad!

Your chapter reached 10,000 reads

Achieved on May 31, 2024

Chapter: A First Step towards AI for MBSE: Generating a Part of SysML Models from Text Using AI



AI4SE
1st Edition 2019

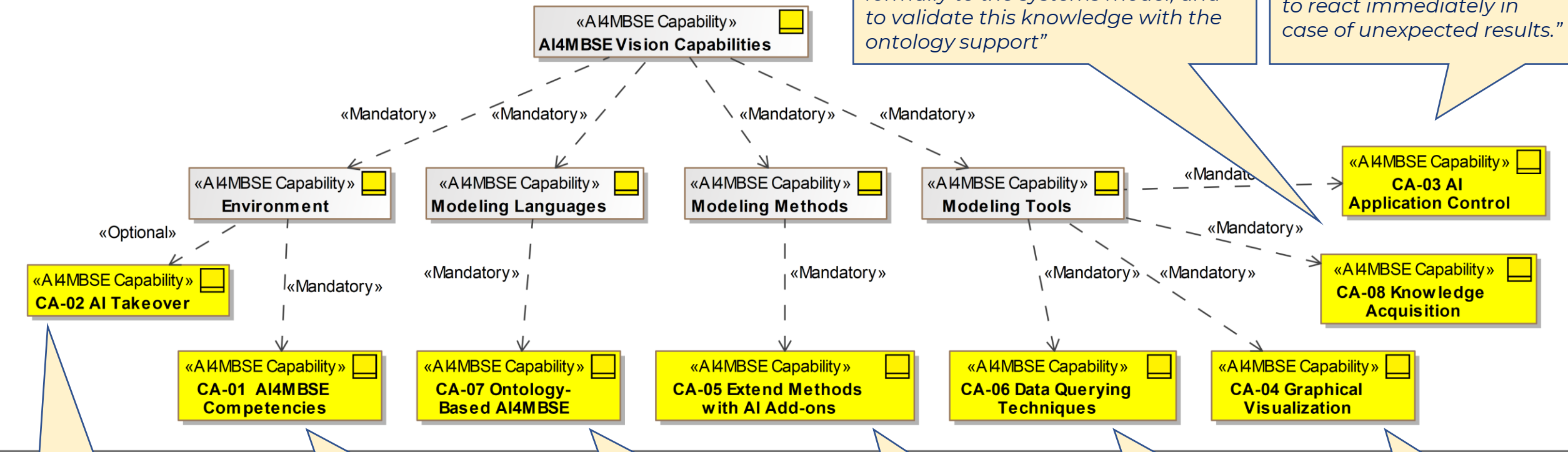
INCOSE Artificial Intelligence
for Systems Engineering

Conference Proceedings

First Edition of the main international academic and industrial event where Systems Engineering meets Artificial Intelligence

AI4MBSE CAPABILITIES

bdd [Package] AI4MBSE Capabilities [AI4MBSE Capabilities Definition]



“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.”

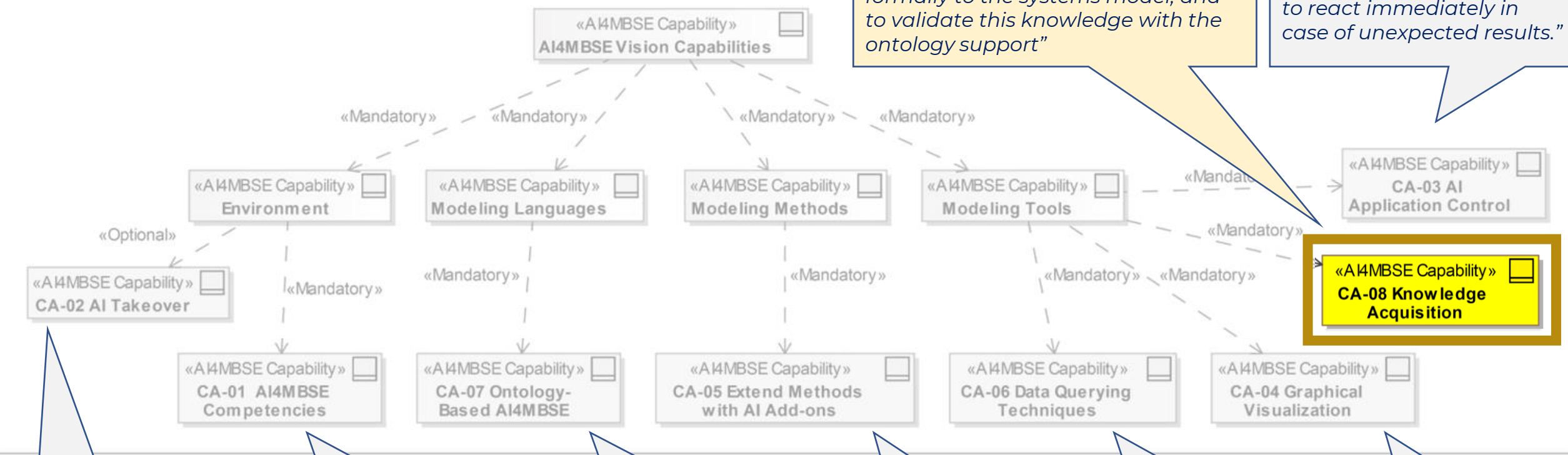
“MBSE applied modeling methods shall be extended with the related AI development and deployment steps.”

“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”

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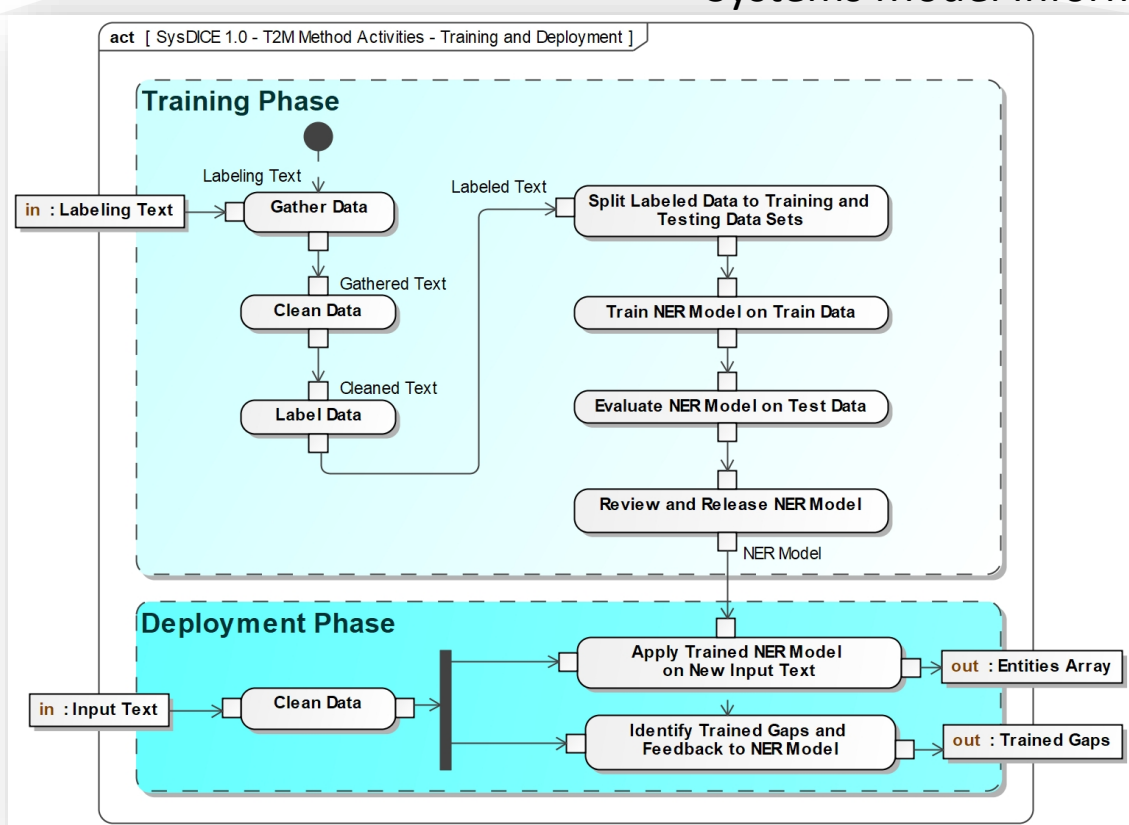
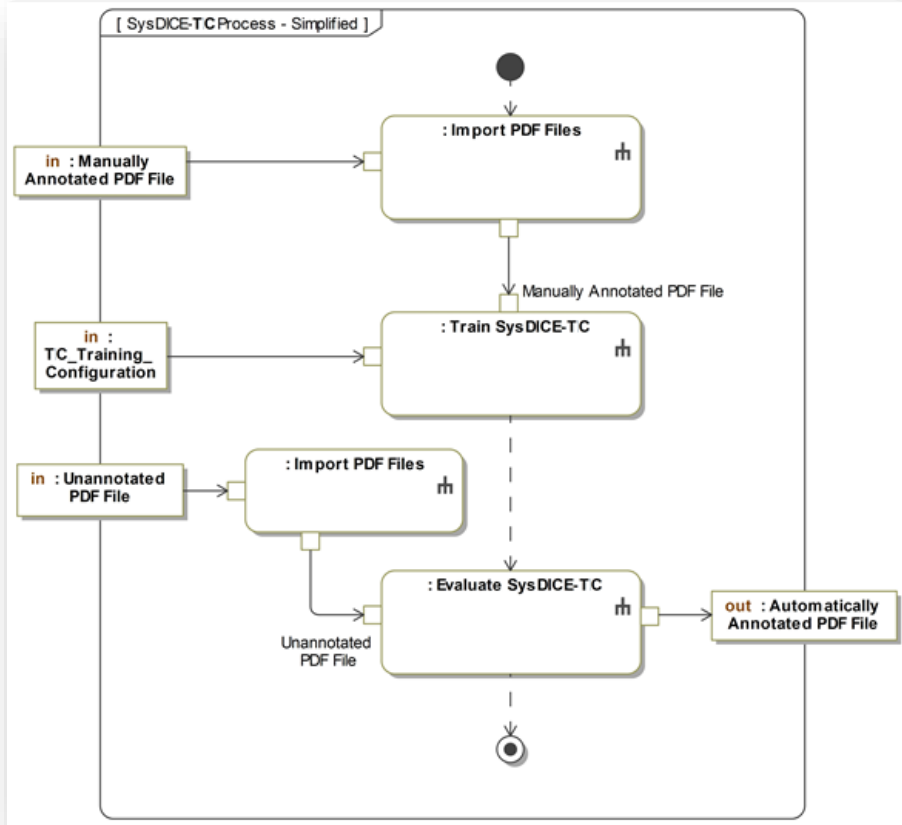
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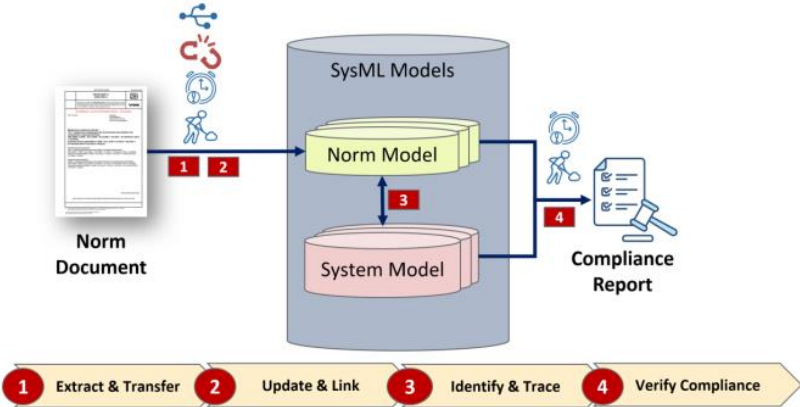
From “Text-to-Model” To “PDF-to-Model”

The How – Simplified

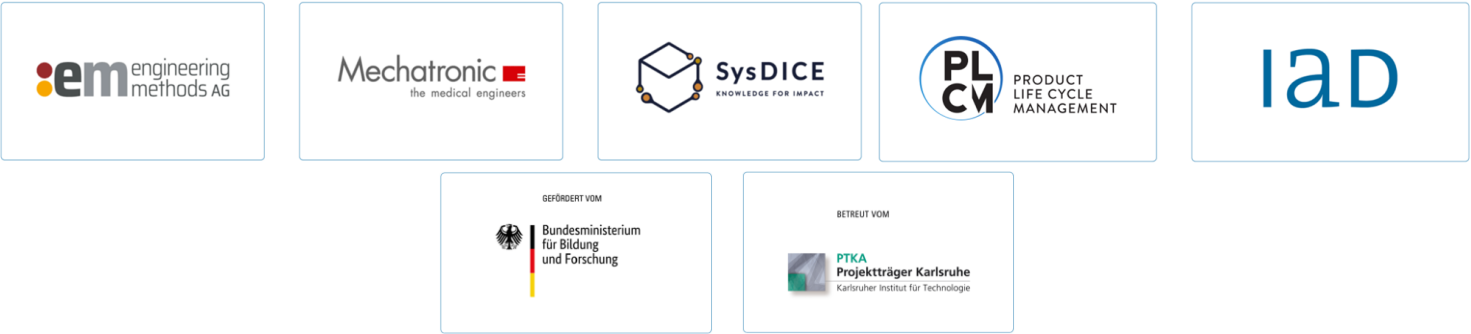


Presentations' Scope: Ongoing AI4MBSE Project

Automated Norm Compliance in MedTech



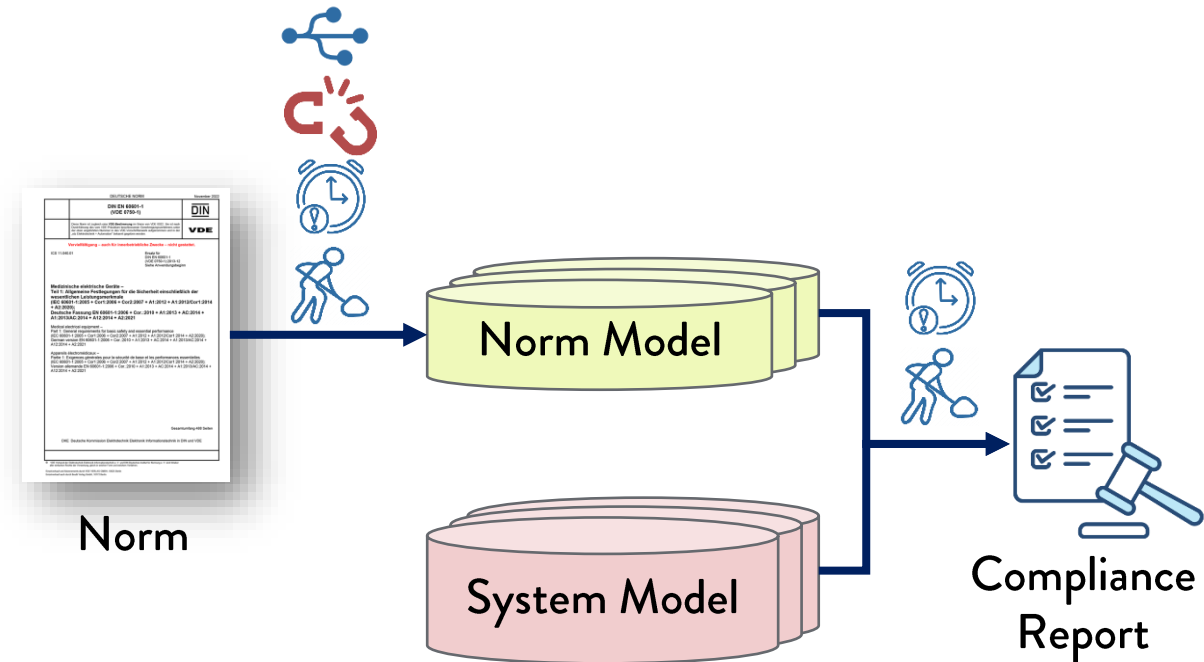
SysDICE Teams' Scope



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**

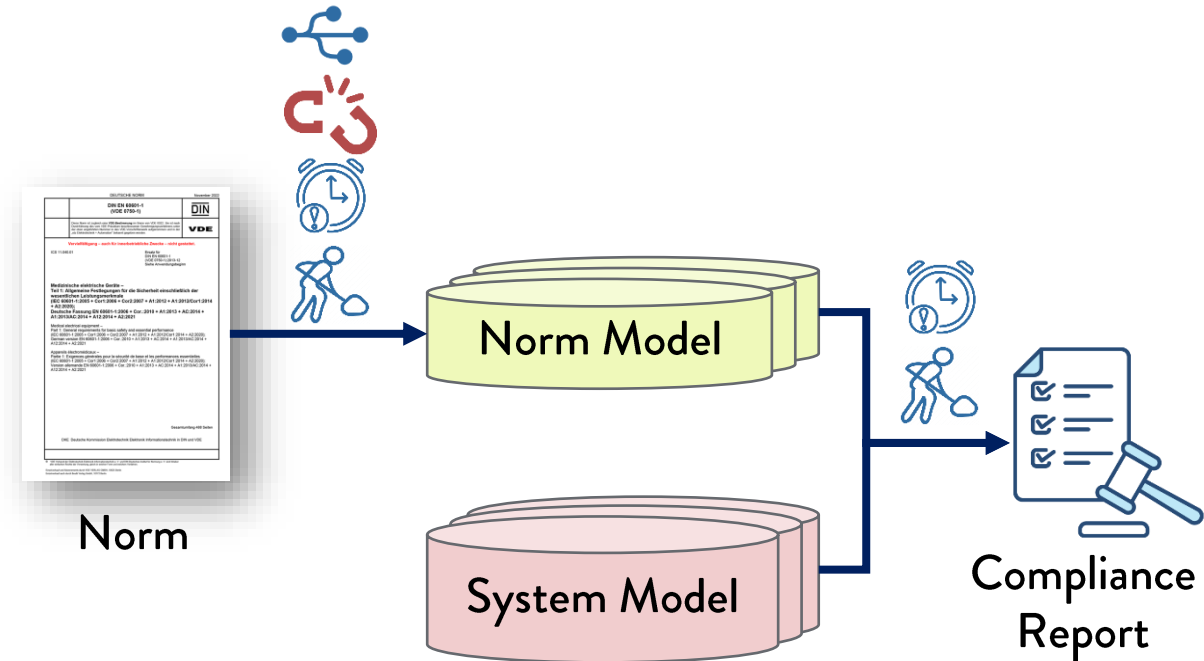


HOW CAN WE **ASSIST** AND **AUTOMATE** THE PROCEDURES FOR NORM COMPLIANCE?

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:

- 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:

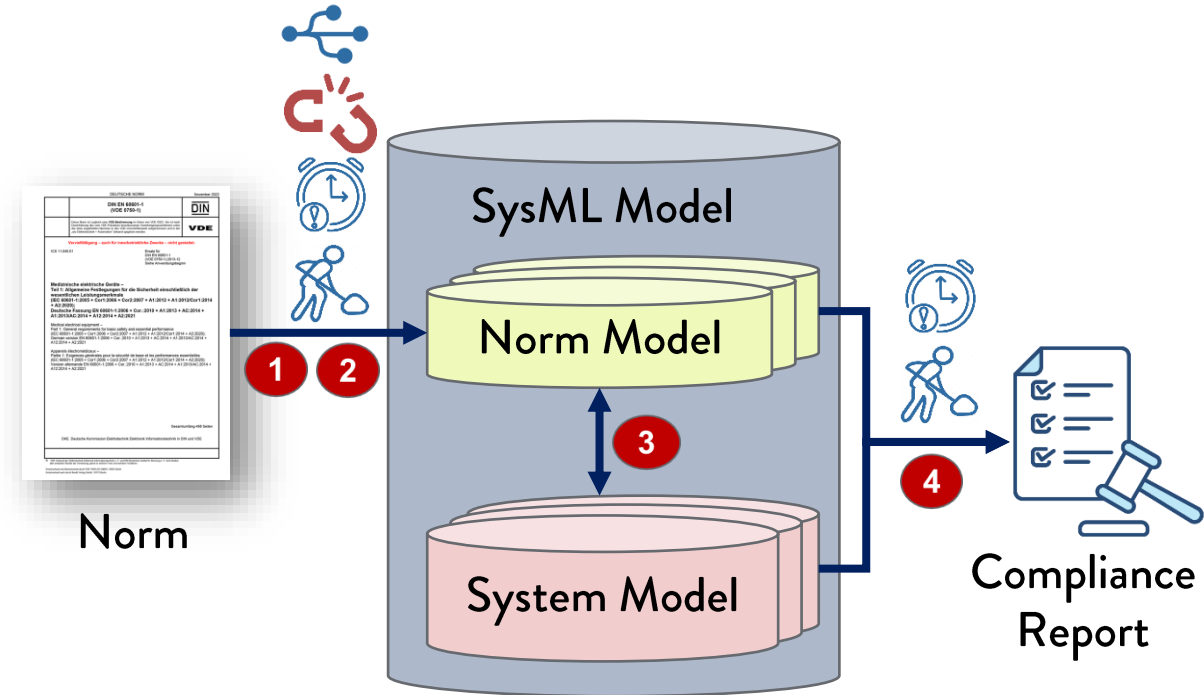
- Manage multiple versions of the standard documents.
- Analyse the impacts of a change on the model.

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:

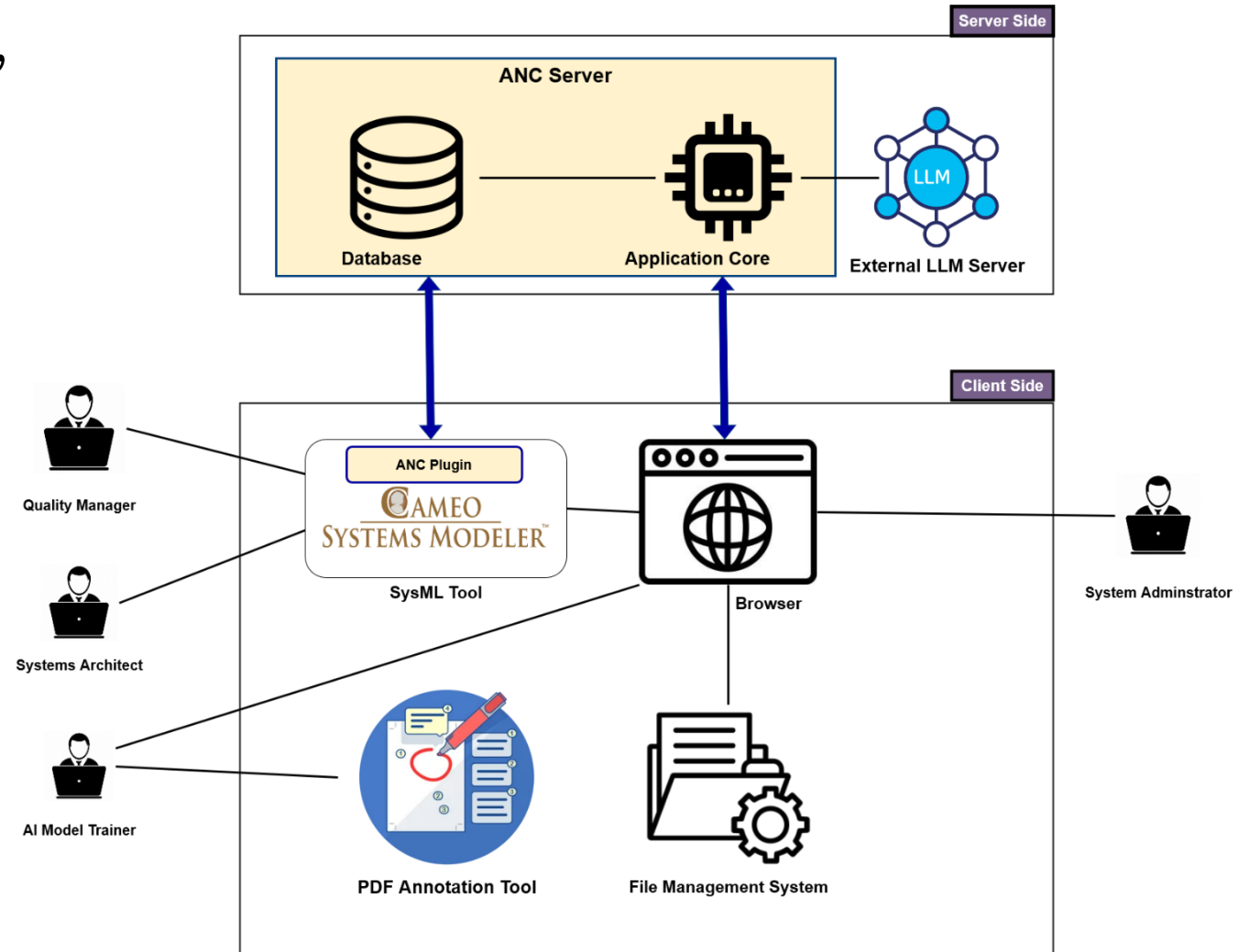
- Verify if the system model element corresponds to the corresponding standard model elements.



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)



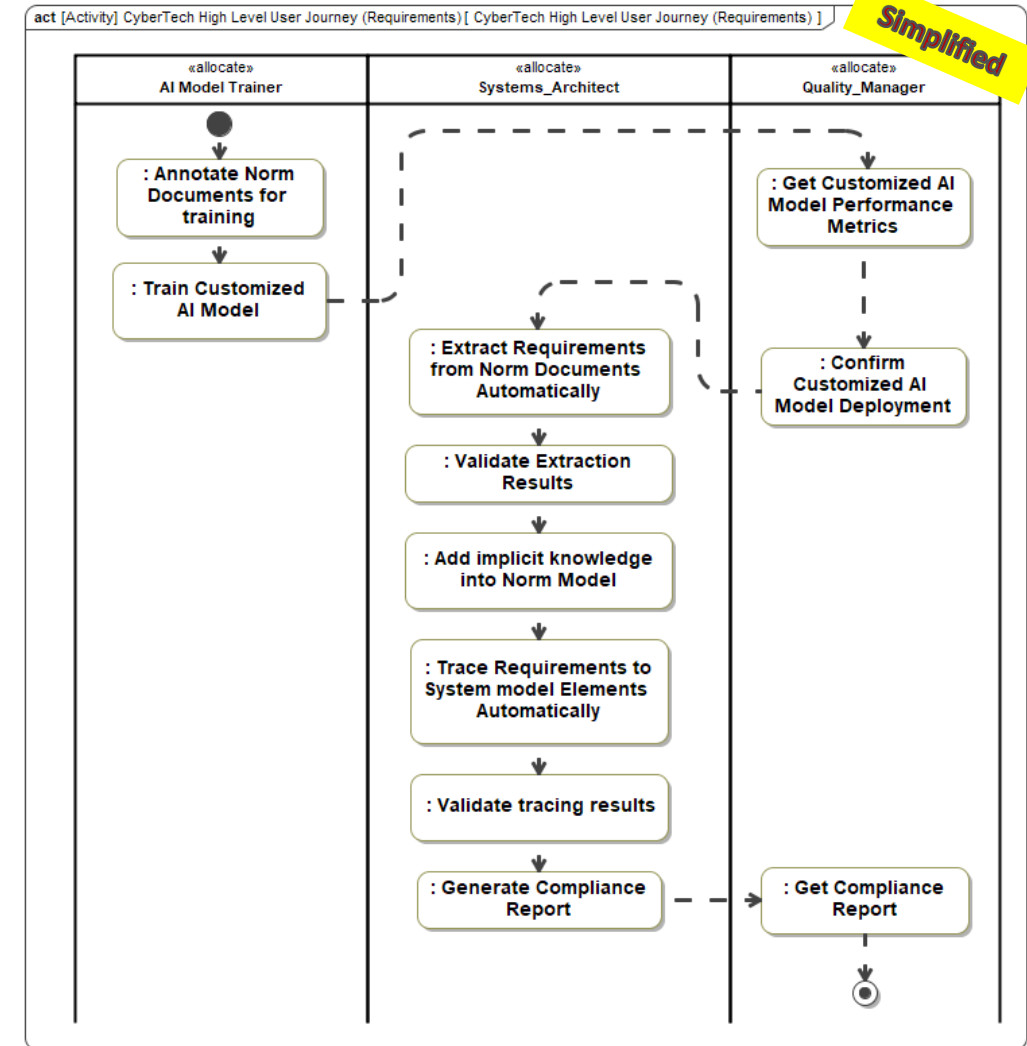
Use case: Automatic Norm Compliance

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



SysDICE

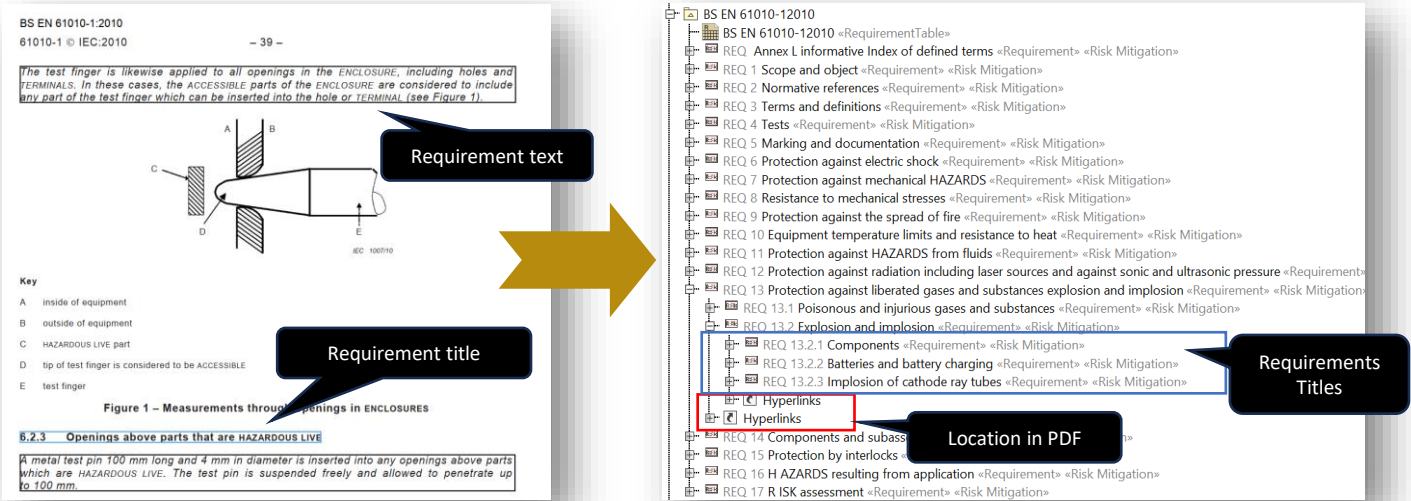
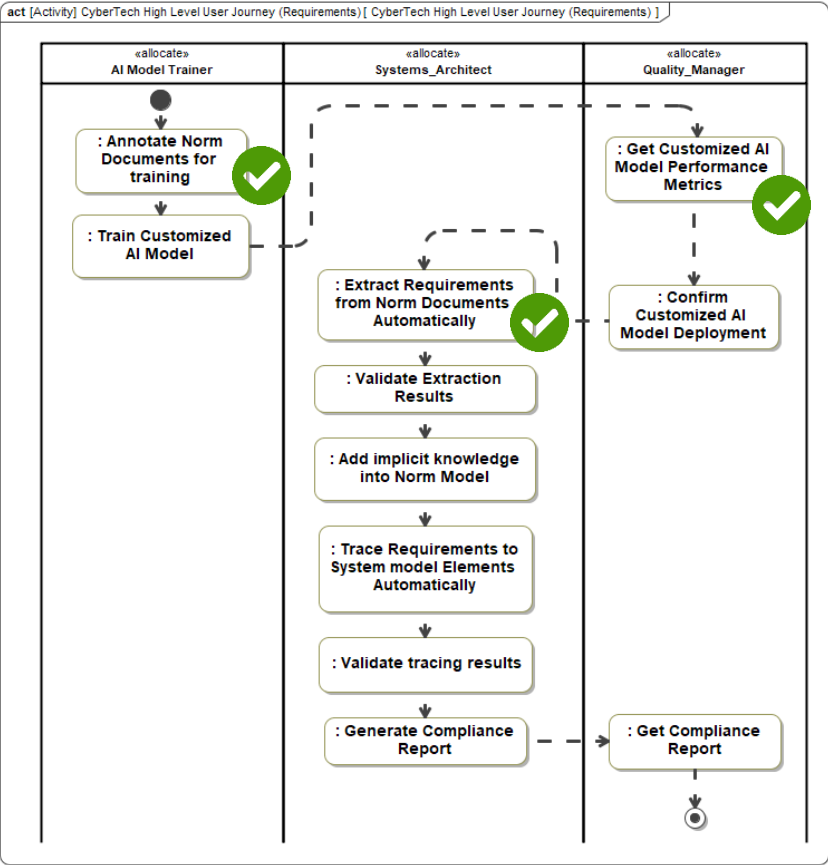


Use case: Automatic Norm Compliance

Demonstrative Example

1

Extract & Transfer



mlflow2.5.0

Experiments

Models

GitHub

Docs

Default

Provide Feedback

Experiment ID: 0

Artifact Location: file:///home/ubuntu/Training_for_PDF_Extraction/mlruns/0

Description

Edit

Table view

Chart view

Artifact view

metrics.rmse < 1 and params.model = "tree"

Time created

State Active

Refresh

Sort: Created

Columns

Expand rows

Metrics												
		Run Name	Created	Duration	Average Score	Caption	Figure	Margin	Normal Text	Table	Title	ToC
		Iteration 4	3 minutes ago	3.0min	0.94	0.98	0.86	0.99	0.95	0.91	0.94	1
		Iteration 3	1 hour ago	2.6min	0.917	0.4	0.73	0.99	0.95	0.92	0.83	0.93
		Iteration 2	1 hour ago	5.6min	0.874	0.87	0.85	0.64	0.93	0.81	0.75	0.98
		Iteration 1	4 hours ago	2.8min	0.849	0.97	0.86	1	0.9	0.68	0.89	1

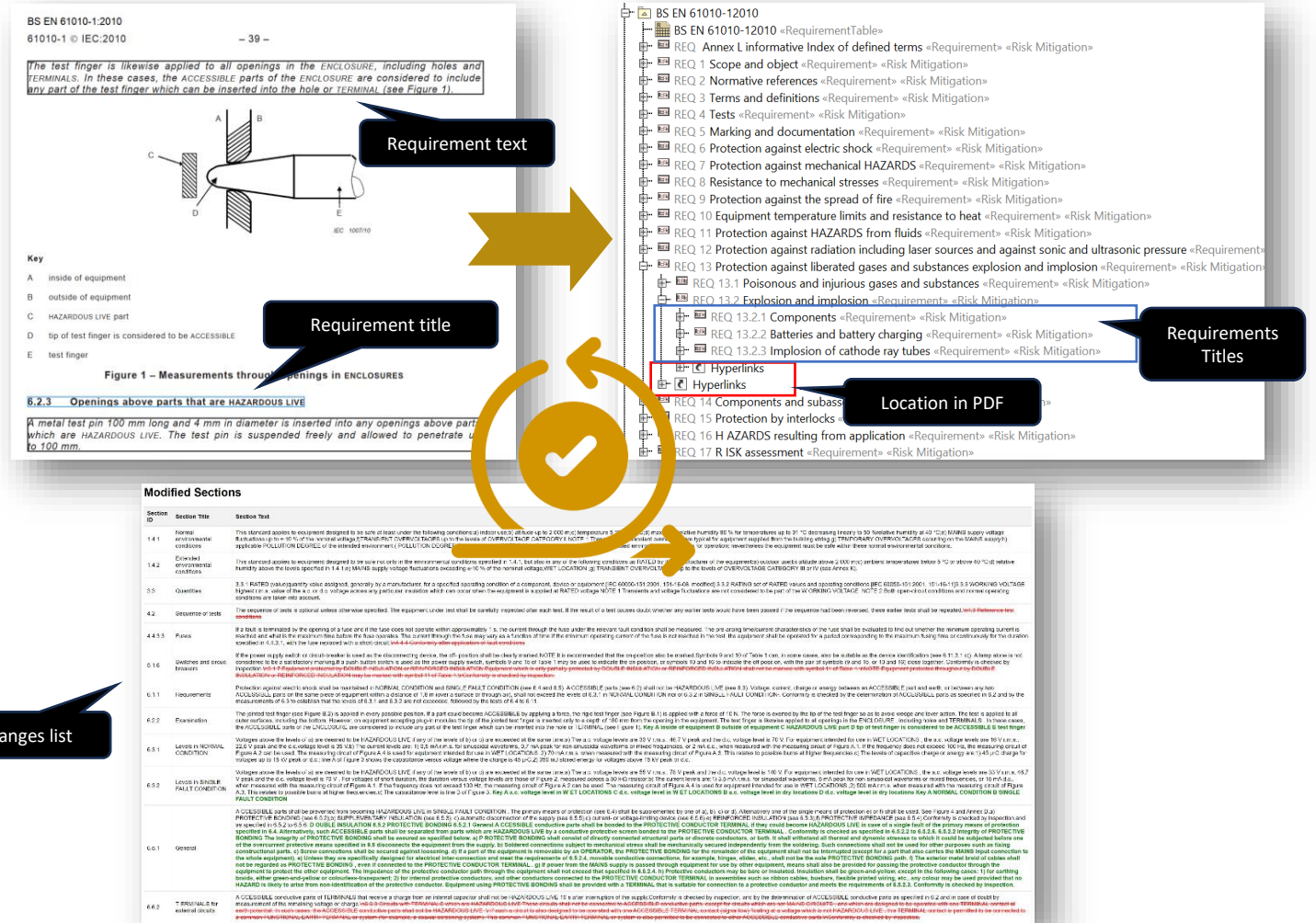
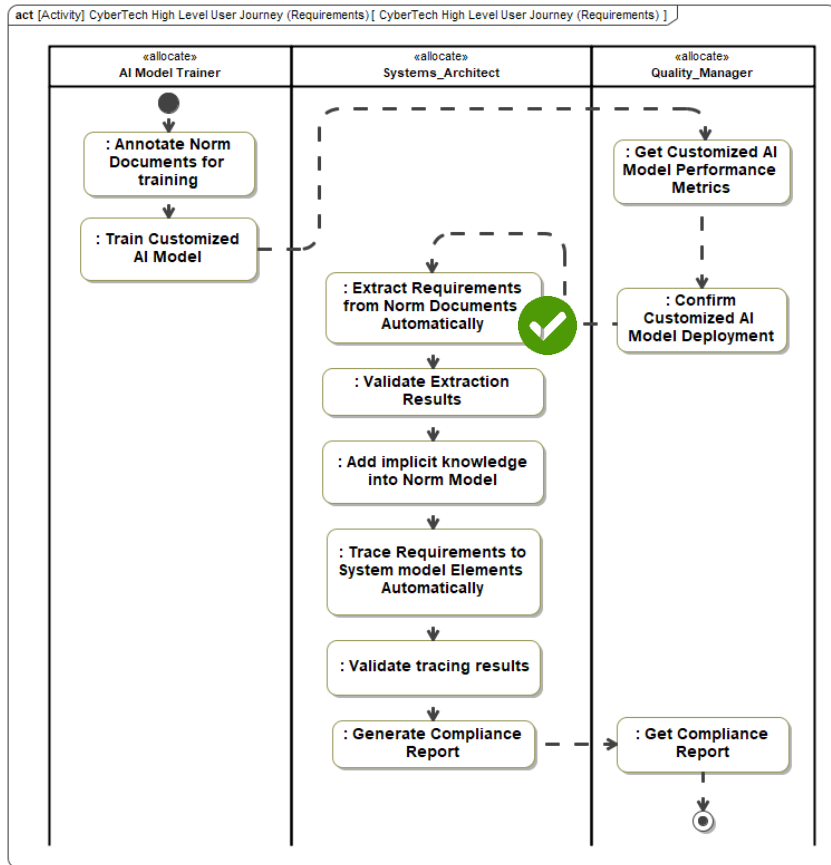
show more columns

(11 total)

Demonstrative Example

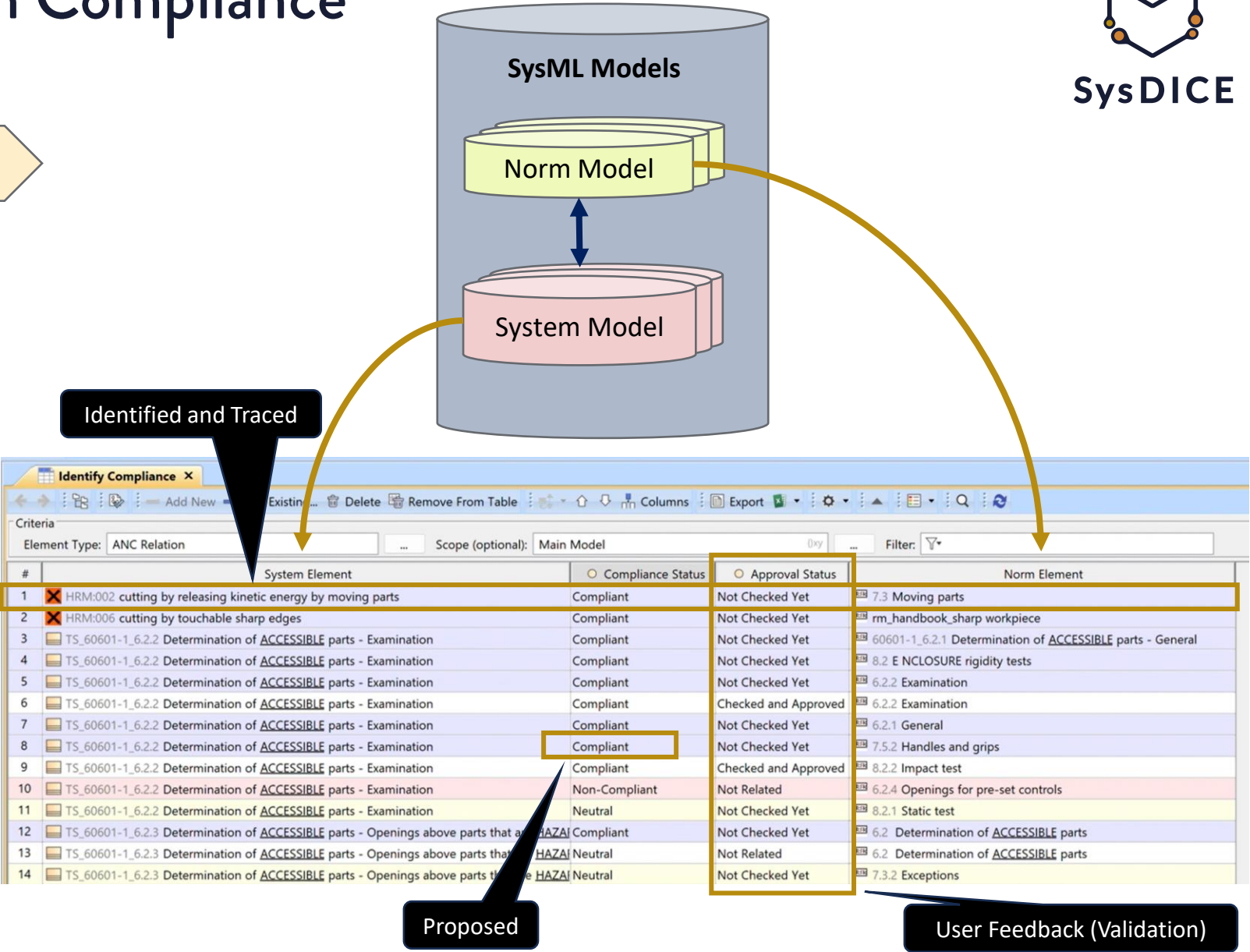
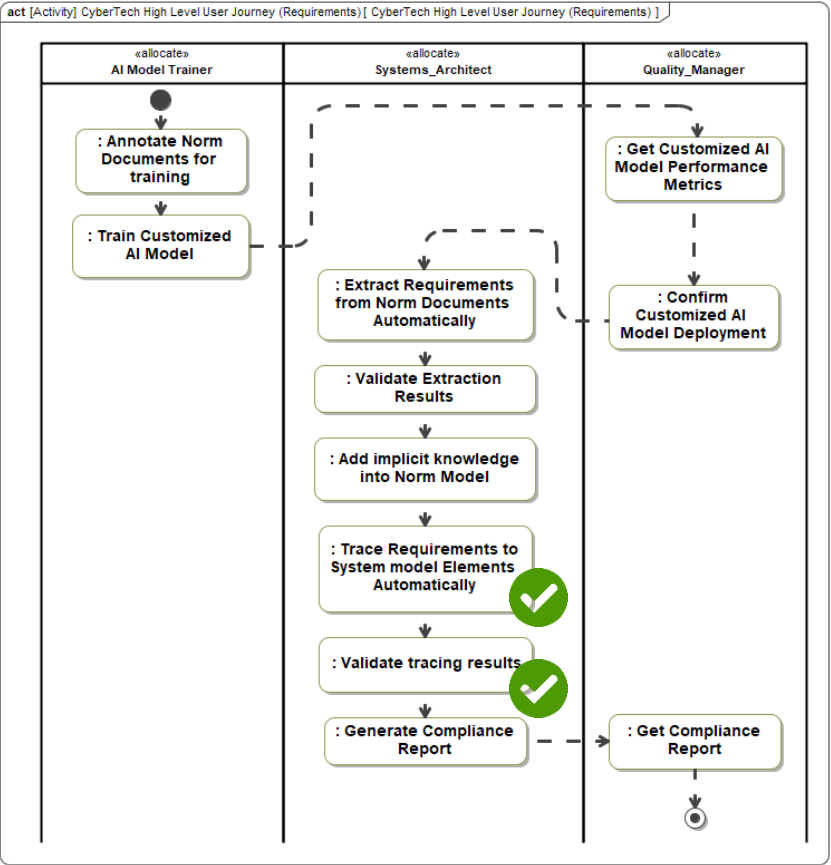


Update & Link



Use case: Automatic Norm Compliance

Demonstrative Example



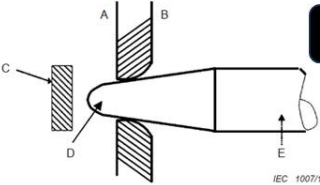
Use case: Automatic Norm Compliance

UC 1 & UC 2

BS EN 61010-1:2010
61010-1 © IEC:2010

– 39 –

The test finger is likewise applied to all openings in the ENCLOSURE, including holes and TERMINALS. In these cases, the ACCESSIBLE parts of the ENCLOSURE are considered to include any part of the test finger which can be inserted into the hole or TERMINAL (see Figure 1).



Key

- A inside of equipment
- B outside of equipment
- C HAZARDOUS LIVE part
- D tip of test finger is considered to be ACCESSIBLE
- E test finger

Figure 1 – Measurements through openings in ENCLOSURES

6.2.3 Openings above parts that are HAZARDOUS LIVE

A metal test pin 100 mm long and 4 mm in diameter is inserted into any openings above parts which are HAZARDOUS LIVE. The test pin is suspended freely and allowed to penetrate up to 100 mm.

Requirement text

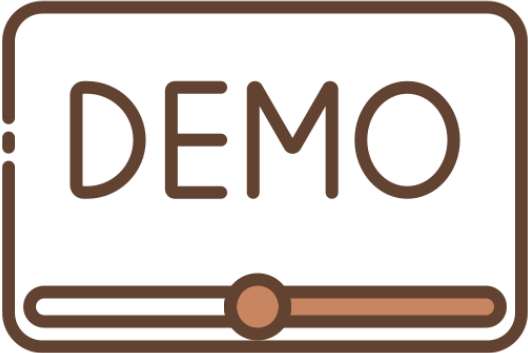
Requirement title

BS EN 61010-12010

- BS EN 61010-12010 «RequirementTable»
- REQ Annex L informative Index of defined terms «Requirement» «Risk Mitigation»
- REQ 1 Scope and object «Requirement» «Risk Mitigation»
- REQ 2 Normative references «Requirement» «Risk Mitigation»
- REQ 3 Terms and definitions «Requirement» «Risk Mitigation»
- REQ 4 Tests «Requirement» «Risk Mitigation»
- REQ 5 Marking and documentation «Requirement» «Risk Mitigation»
- REQ 6 Protection against electric shock «Requirement» «Risk Mitigation»
- REQ 7 Protection against mechanical HAZARDS «Requirement» «Risk Mitigation»
- REQ 8 Resistance to mechanical stresses «Requirement» «Risk Mitigation»
- REQ 9 Protection against the spread of fire «Requirement» «Risk Mitigation»
- REQ 10 Equipment temperature limits and resistance to heat «Requirement» «Risk Mitigation»
- REQ 11 Protection against HAZARDS from fluids «Requirement» «Risk Mitigation»
- REQ 12 Protection against radiation including laser sources and against sonic and ultrasonic pressure «Requirement» «Risk Mitigation»
- REQ 13 Protection against liberated gases and substances explosion and implosion «Requirement» «Risk Mitigation»
- REQ 13.1 Poisonous and injurious gases and substances «Requirement» «Risk Mitigation»
- REQ 13.2 Explosion and implosion «Requirement» «Risk Mitigation»
- REQ 13.2.1 Components «Requirement» «Risk Mitigation»
- REQ 13.2.2 Batteries and battery charging «Requirement» «Risk Mitigation»
- REQ 13.2.3 Implosion of cathode ray tubes «Requirement» «Risk Mitigation»
- Hyperlinks
- Hyperlinks
- REQ 14 Components and sub-components «Requirement» «Risk Mitigation»
- REQ 15 Protection by interlocking «Requirement» «Risk Mitigation»
- REQ 16 HAZARDS resulting from application «Requirement» «Risk Mitigation»
- REQ 17 RISK assessment «Requirement» «Risk Mitigation»

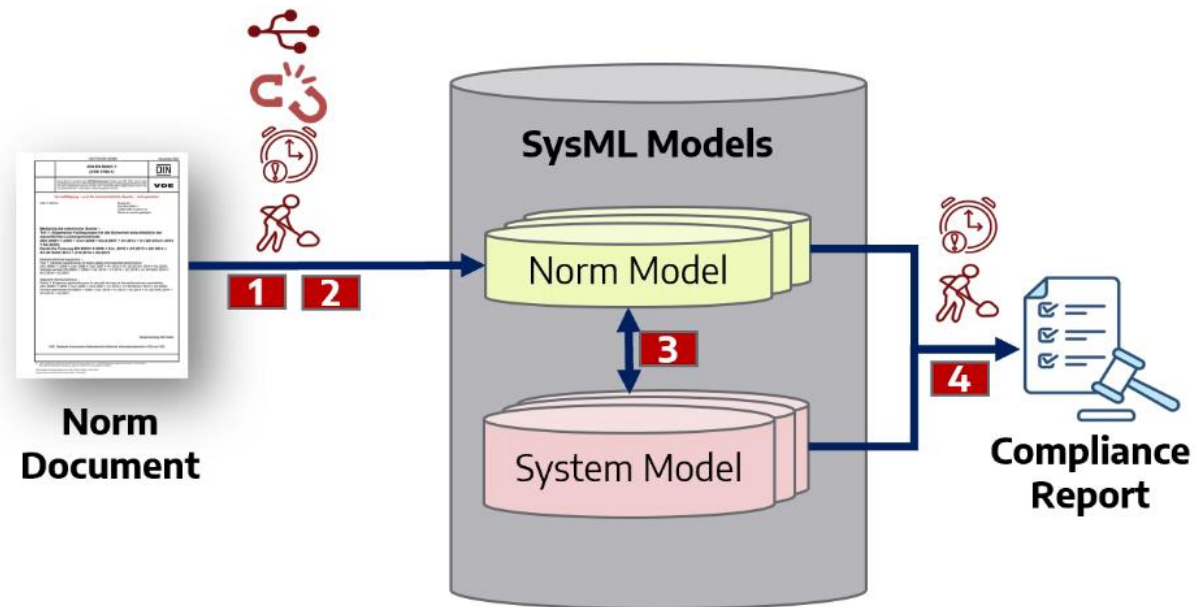
Location in PDF

Requirements Titles



UC 3 & UC 4

Identify Compliance X				
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 ENCLOSURE rigidity tests
5	TS_60601-1_6.2.2 Determination of ACCESSIBLE parts - Examination	Compliant	Not Checked Yet	6.2.2 Examination



Use case: Automatic Norm Compliance

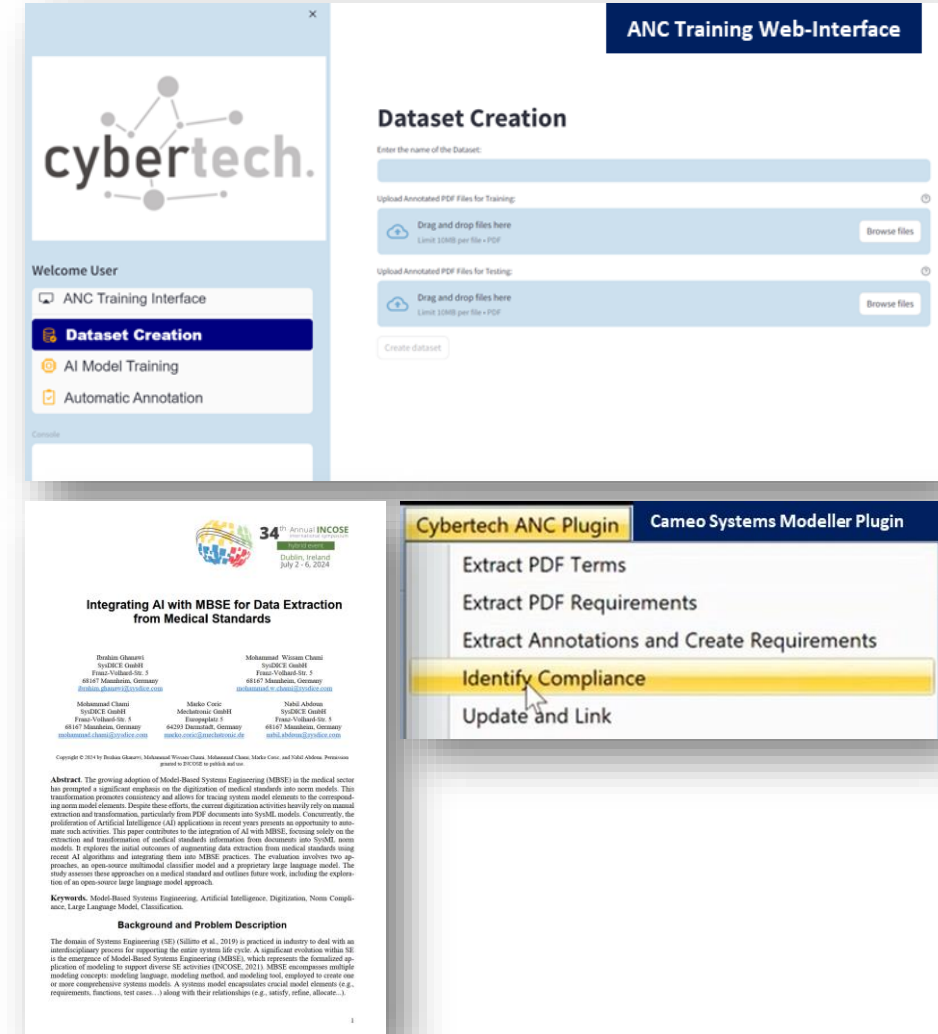
Takeaways

- 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.

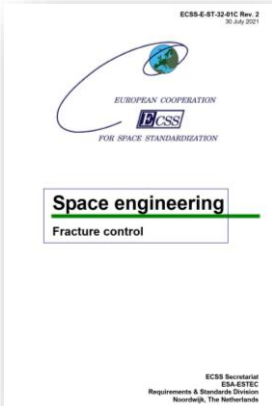
A BIG STEP TOWARDS **ASSISTANCE** AND A
STEP FORWARD TOWARDS **AUTOMATION**.



SysDICE



Other Domain: Digitizing ECSS Standards Using AI and MBSE



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

Glossary Definition

3.2.2 analytical life

life evaluated analytically by crack-growth analysis or fatigue analysis

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.

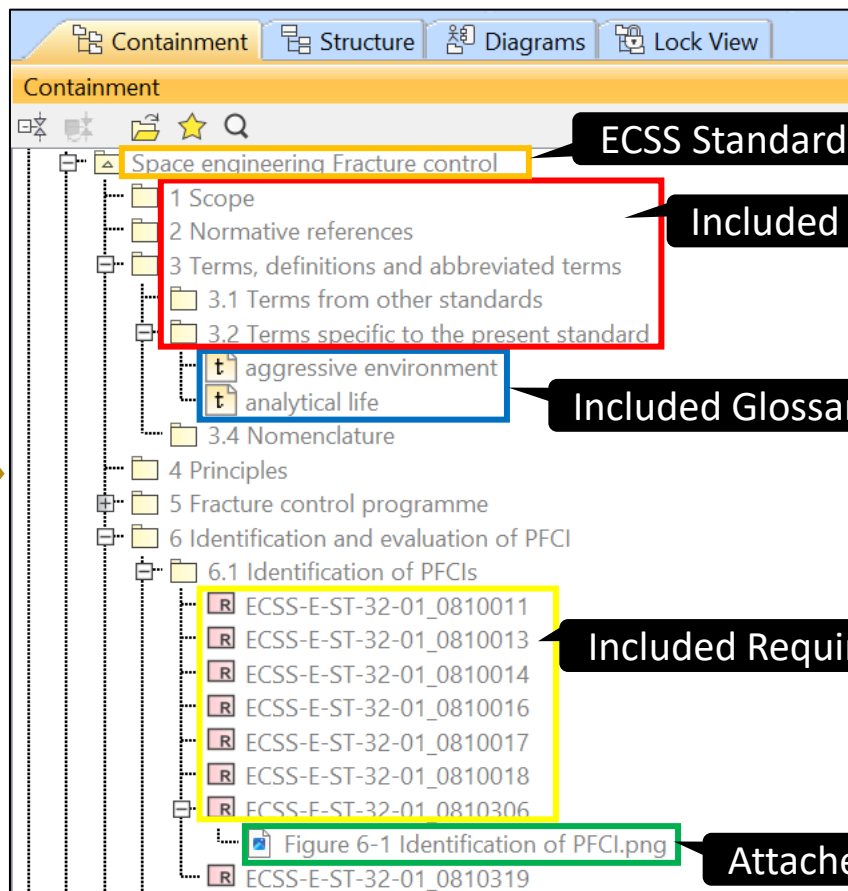
Requirement Text

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

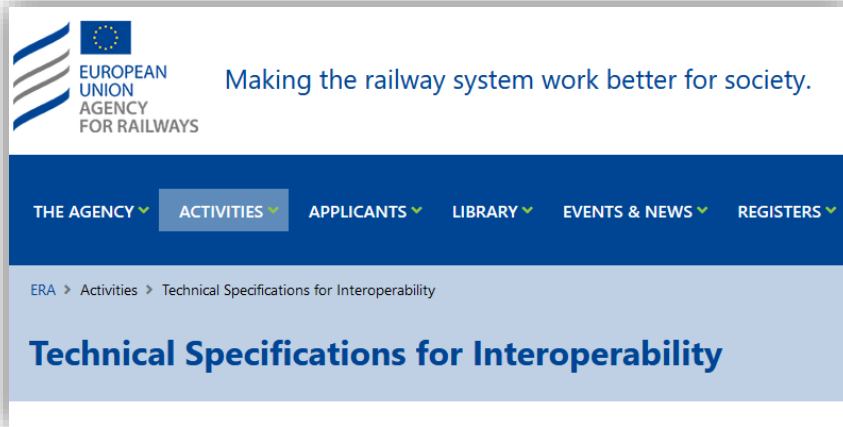
Included Glossary Terms

Included Requirements

Attached Figures

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

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:

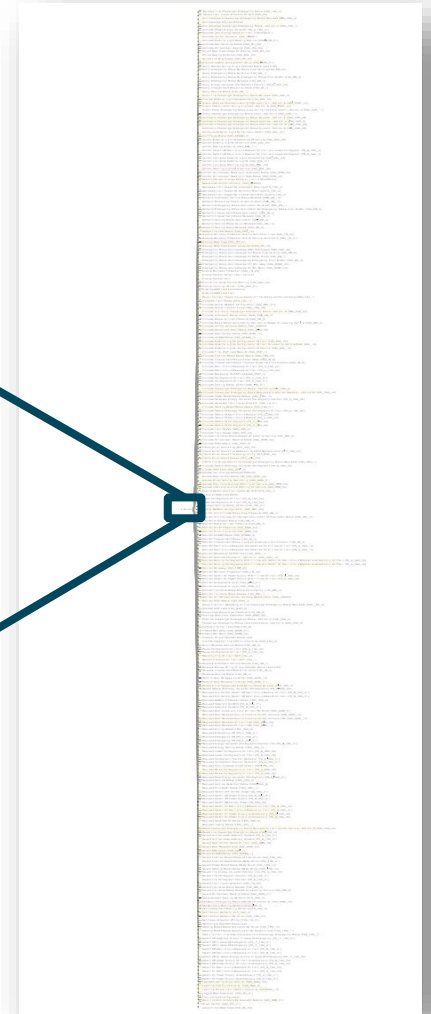
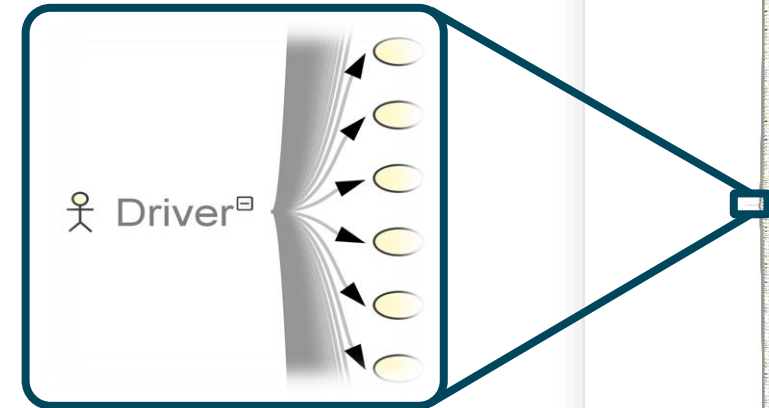
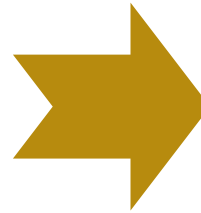
In case where an automatic sanding function is provided, it shall be possible for the **driver** to suspend its use.

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?



Contact Us

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- Mobile: +4915117679156
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