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OMG standard for integrating safety and reliability analysis into MBSE: Concepts and applications

Outline

- Motivation and history
- Current status of the specification for integrating safety and reliability analysis into MBSE
  - The structure of the specification
  - Methods covered
- Core concepts, implementation principles
- Demonstration of model-based FMEA
- Future plans

Terms and definitions

- Reliability
  - Ability of a functional unit to perform a required function under given conditions for a given time interval

ISO/IEC 2382:2015 Information Technology

- Safety
  - Freedom from unacceptable risk

IEC 61508:2010 EEPE safety-related systems

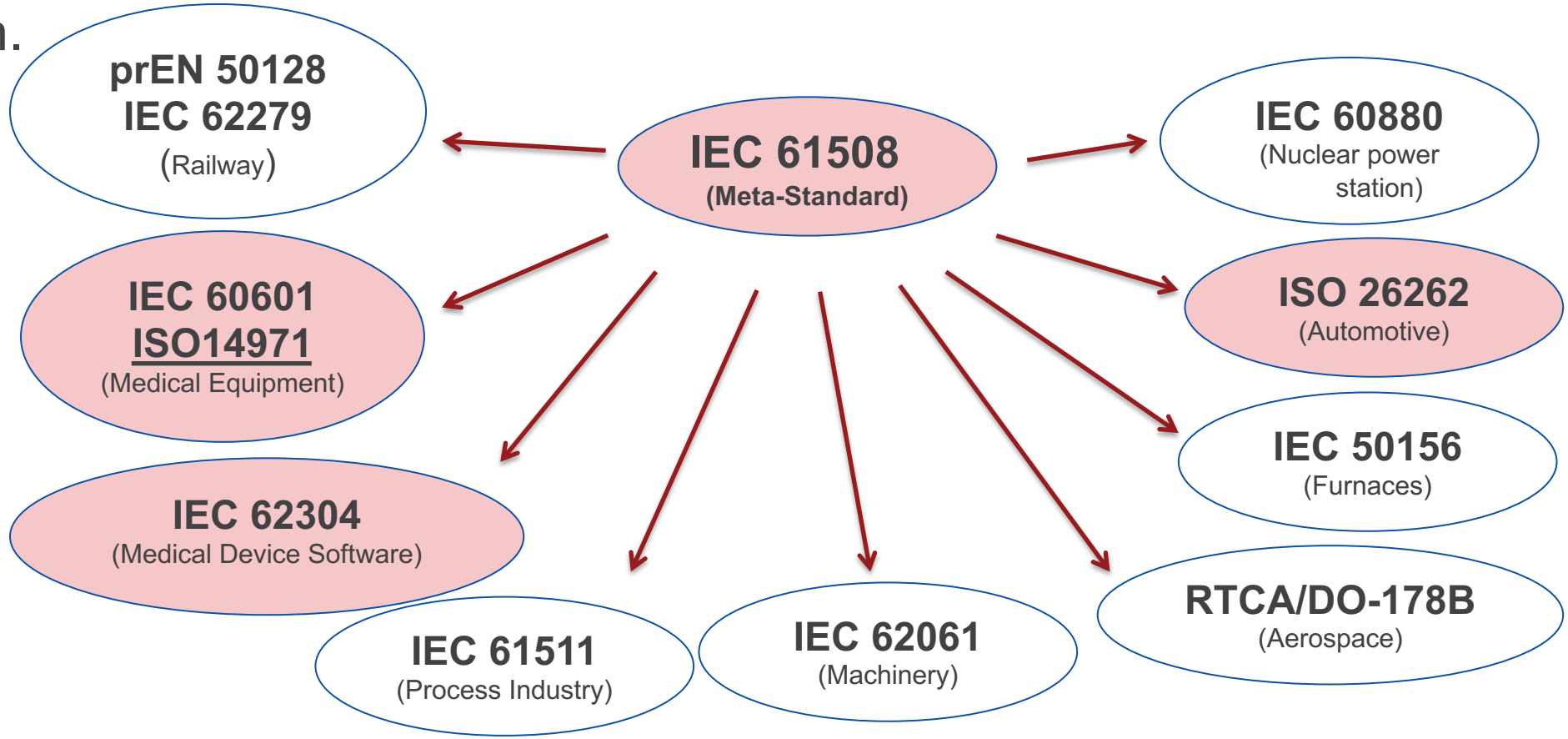
Terms and definitions

- The objective of functional safety is freedom from unacceptable risk of:
  - physical injury or
  - damage to the health of people either directly or indirectly (through damage to property or to the environment)

https://en.wikipedia.org/wiki/Functional_safety

Safety Standards

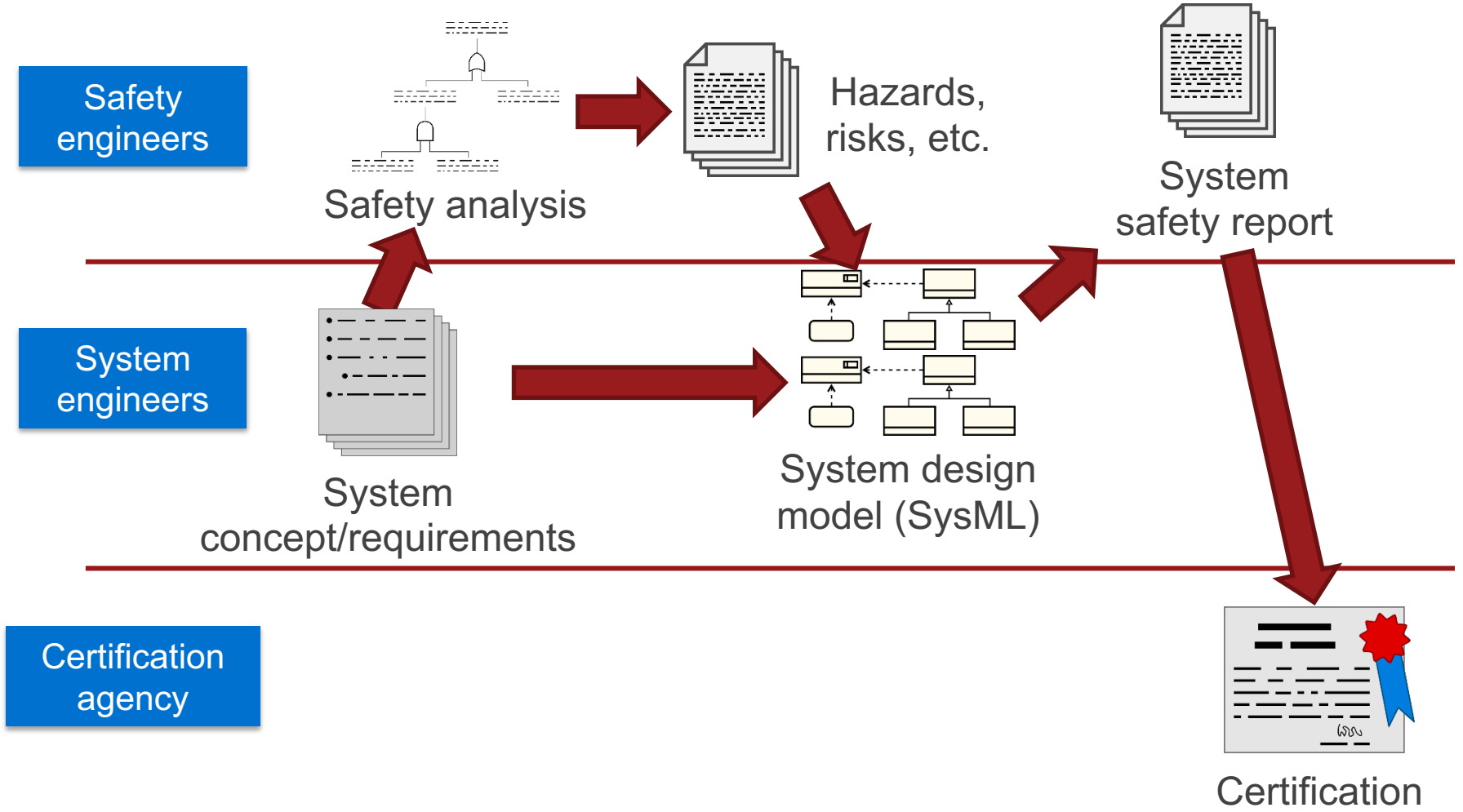
- Each industry has developed domain specific ISO standards, derived from IEC 61508 that reflect more accurately the needs and challenges within their domain.



Why do model-based Safety and Reliability?

- Current methods have been in use for decades.
- They seem to work…

The problem with the traditional approach



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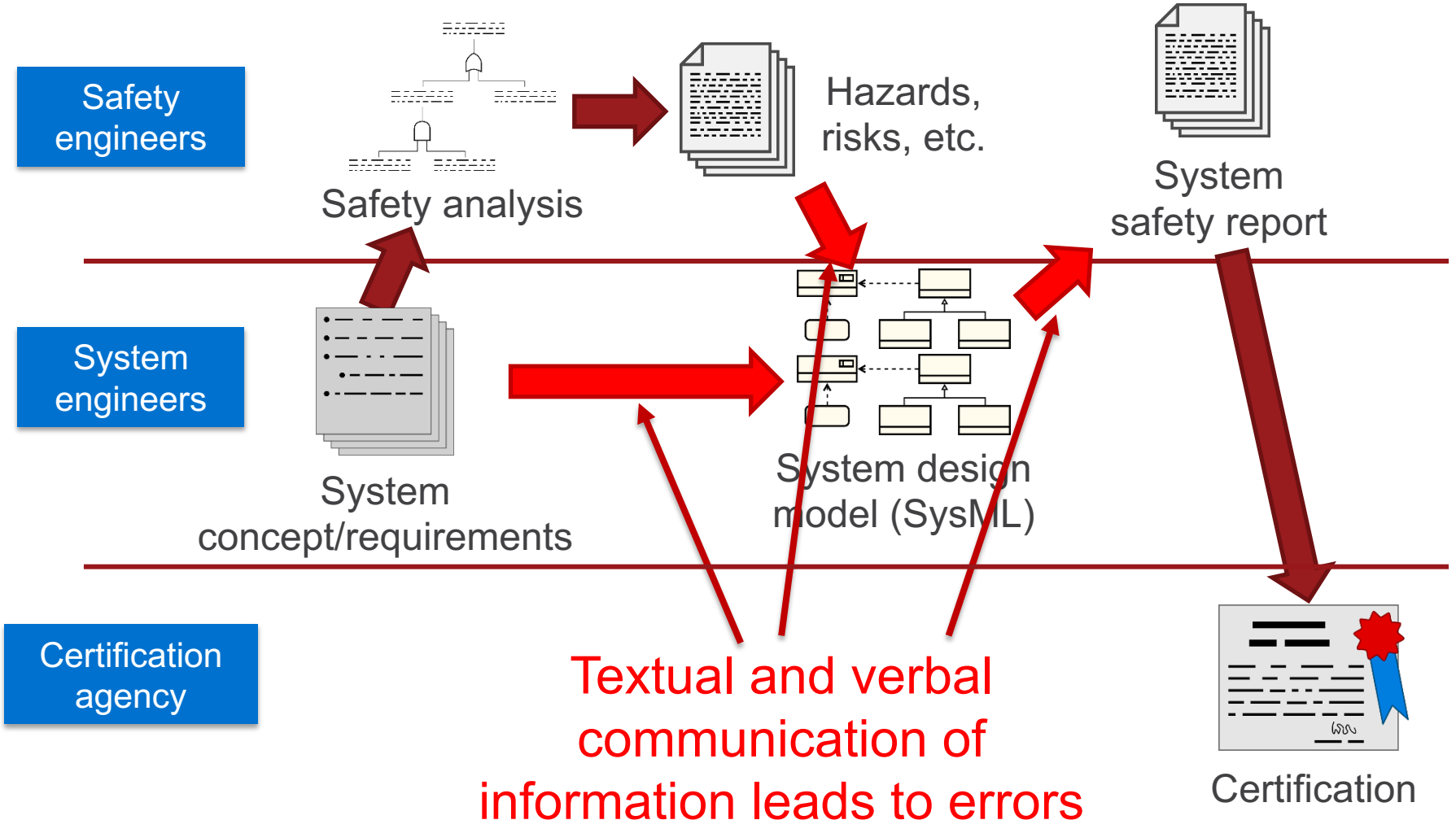

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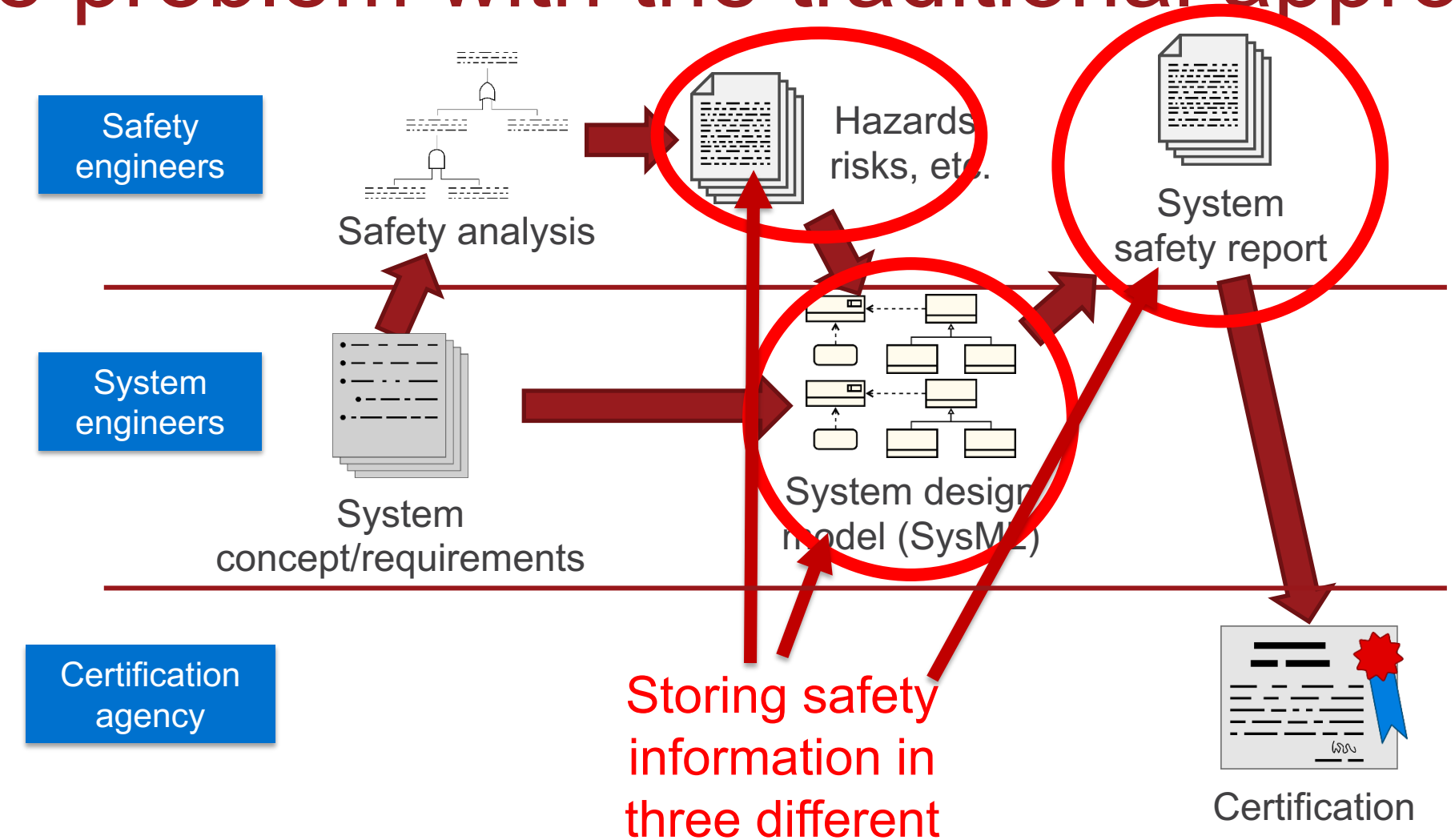

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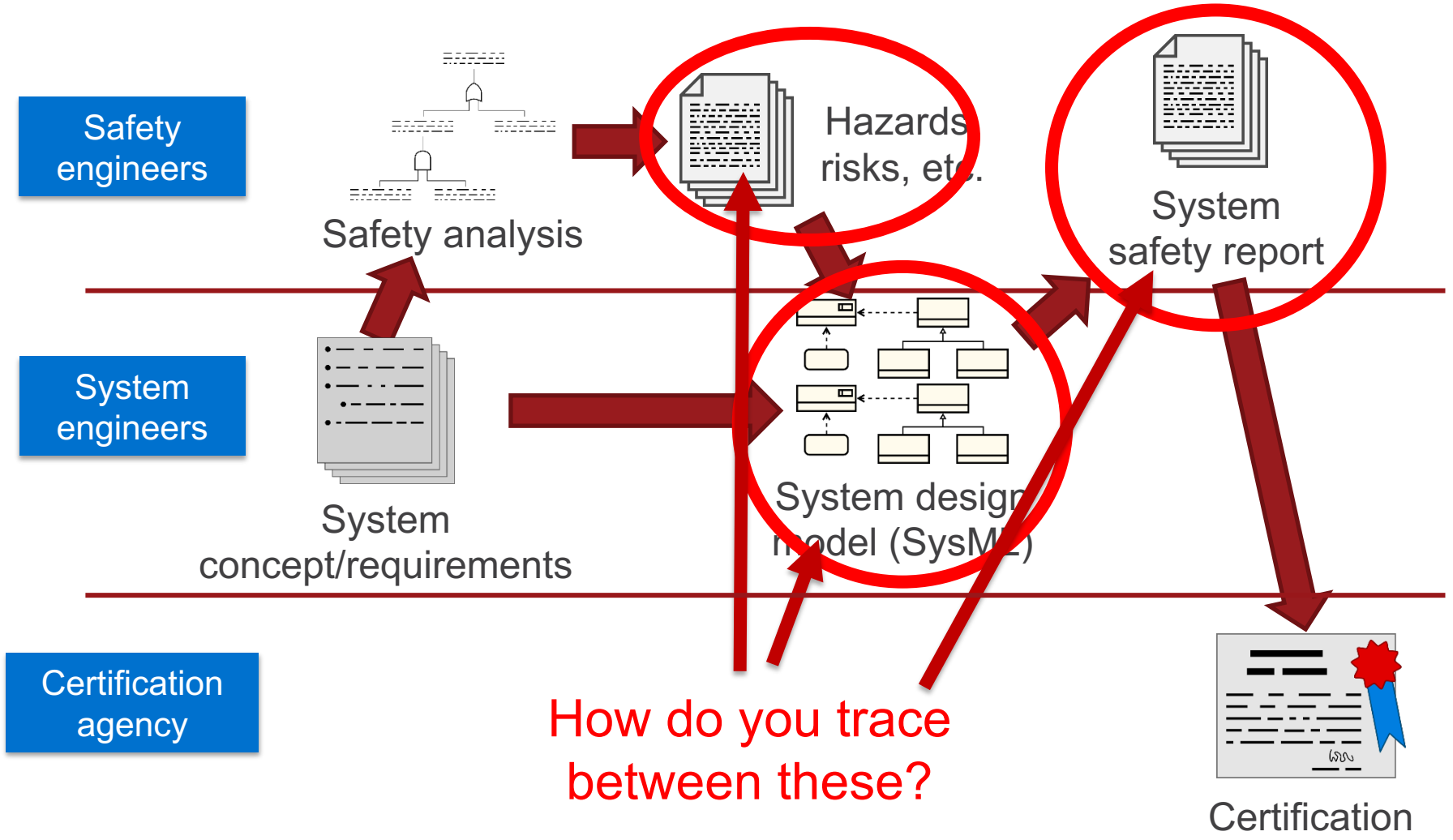

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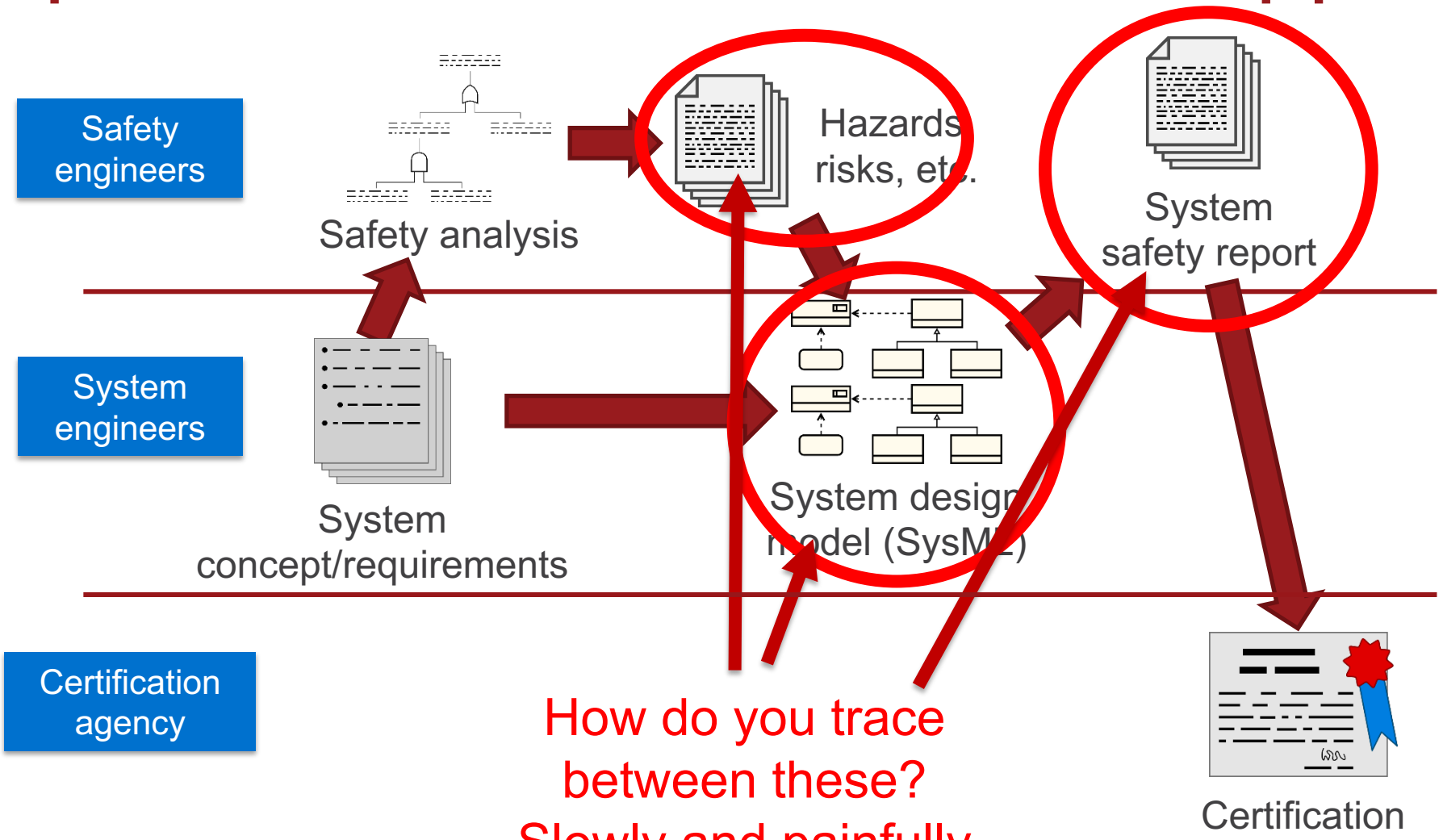
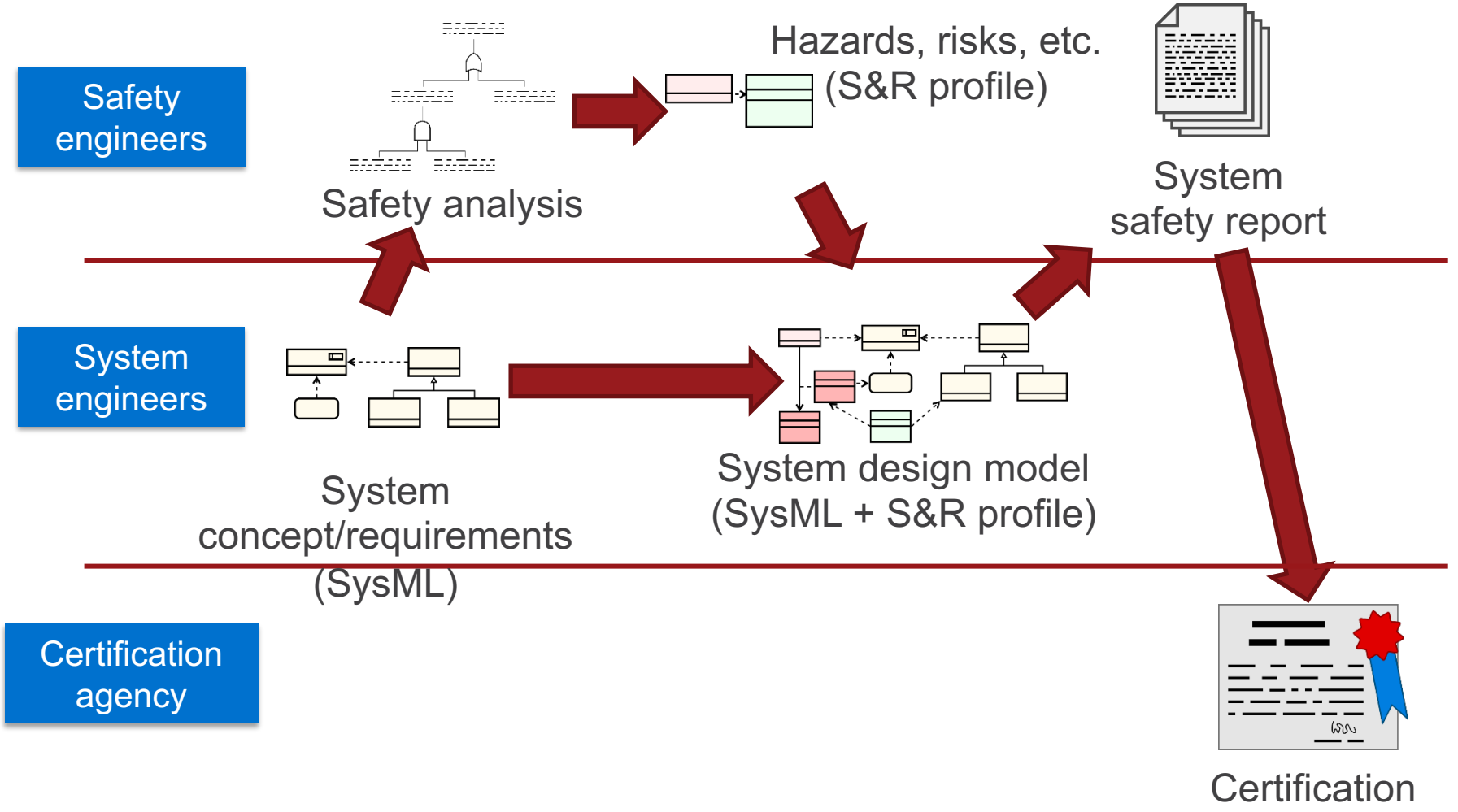


Benefits of a model-based approach



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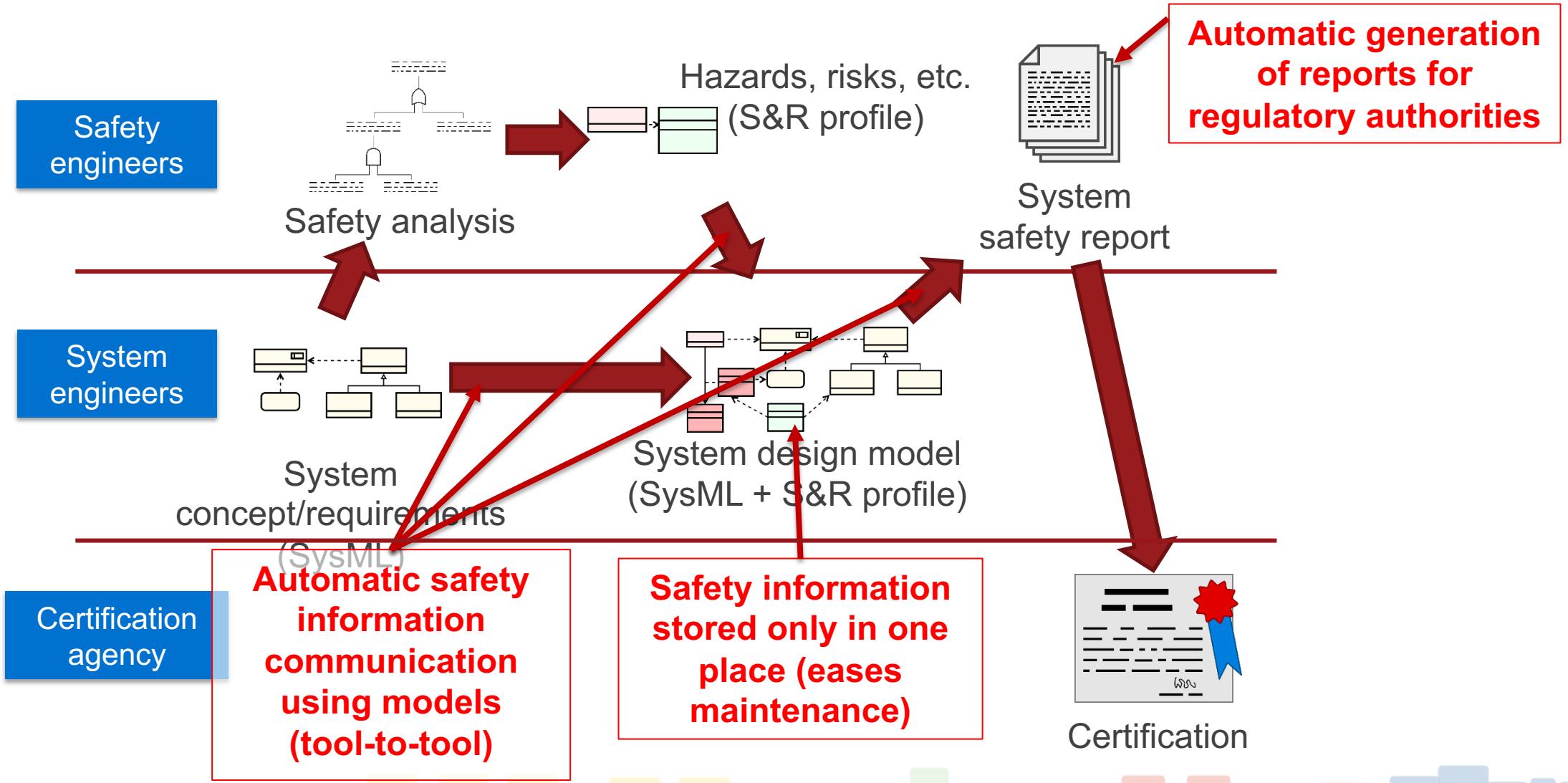
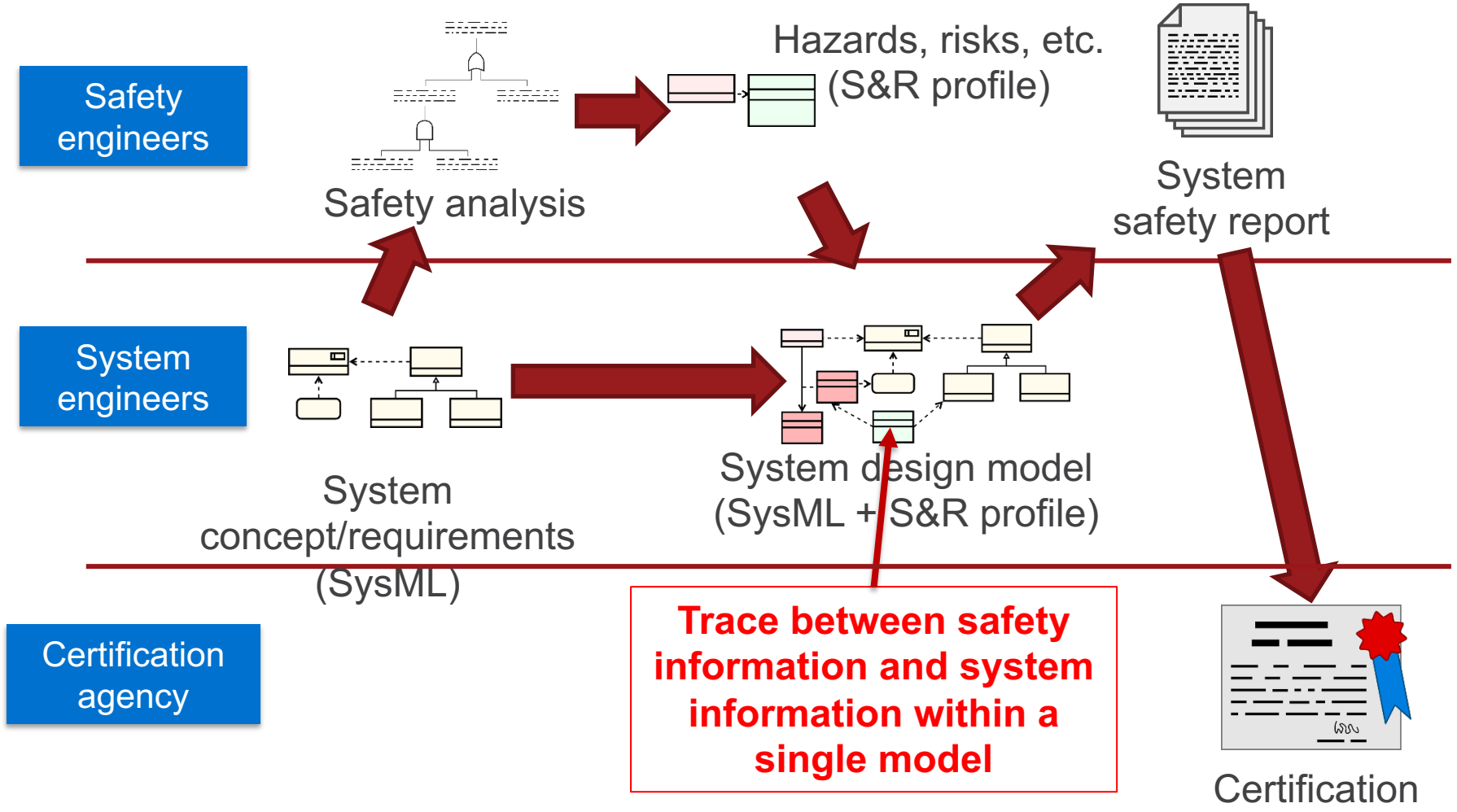


Benefits of a model-based approach



OMG Safety and Reliability profile working group

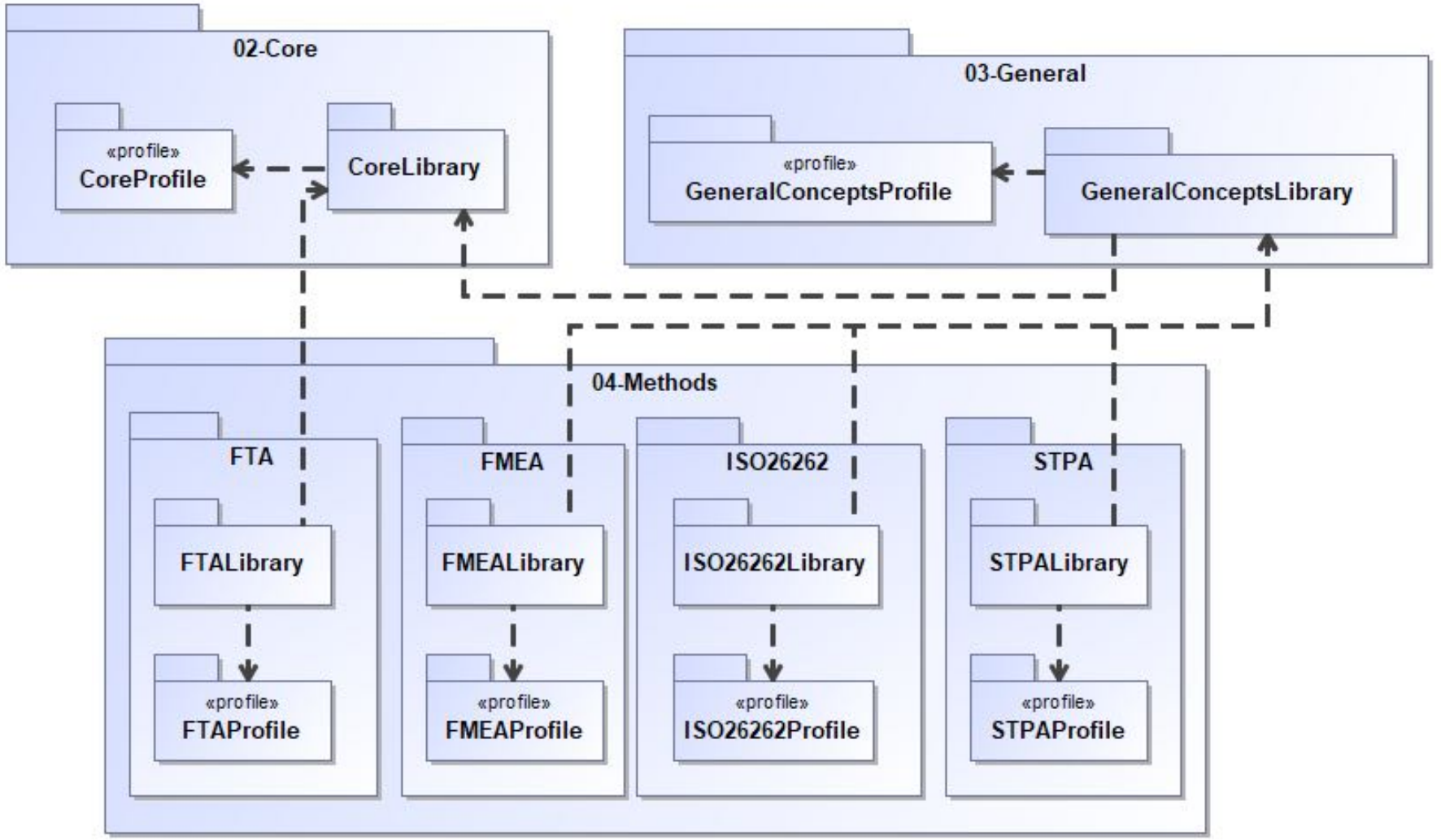
- RFP published by OMG in March, 2017
- Initial version submitted to OMG on Aug 28, 2017
- Current status: revising the specification (until Aug 2019)
- Main contributors of content:
  - Japan's National Institute of Advanced Industrial Science and Technology
  - NASA Jet Propulsion Laboratory
  - France's Alternative Energies and Atomic Energy Commission (CEA)
  - No Magic, Inc. / Dassault Systemes
  - Ford Motor Company
  - GfSE e.V. (the German chapter for systems engineering, Gesellschaft für Systems Engineering)
  - The Aerospace Corporation
- Plus comments from many others

Standards-based

- Based on established international standards as much as possible
- Reliability: IEC 60812 for FMEA and IEC 61025 for FTA
- Safety: IEC 61508 and its offspring
  - Medical software safety: IEC 62304
  - Medical equipment safety: ISO 14971
  - Automotive safety: ISO 26262
  - Other fields welcome, of course!

The library & profile

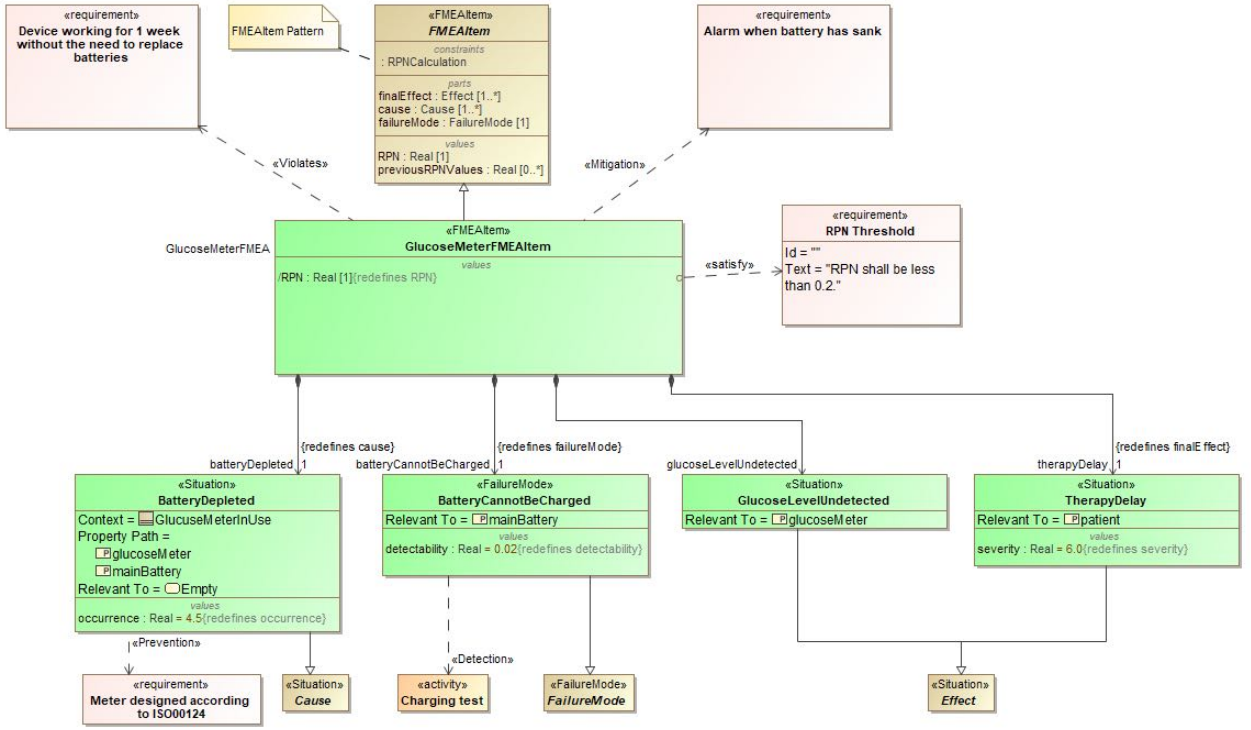
Profile and library structure



Supported Methods

FMEA

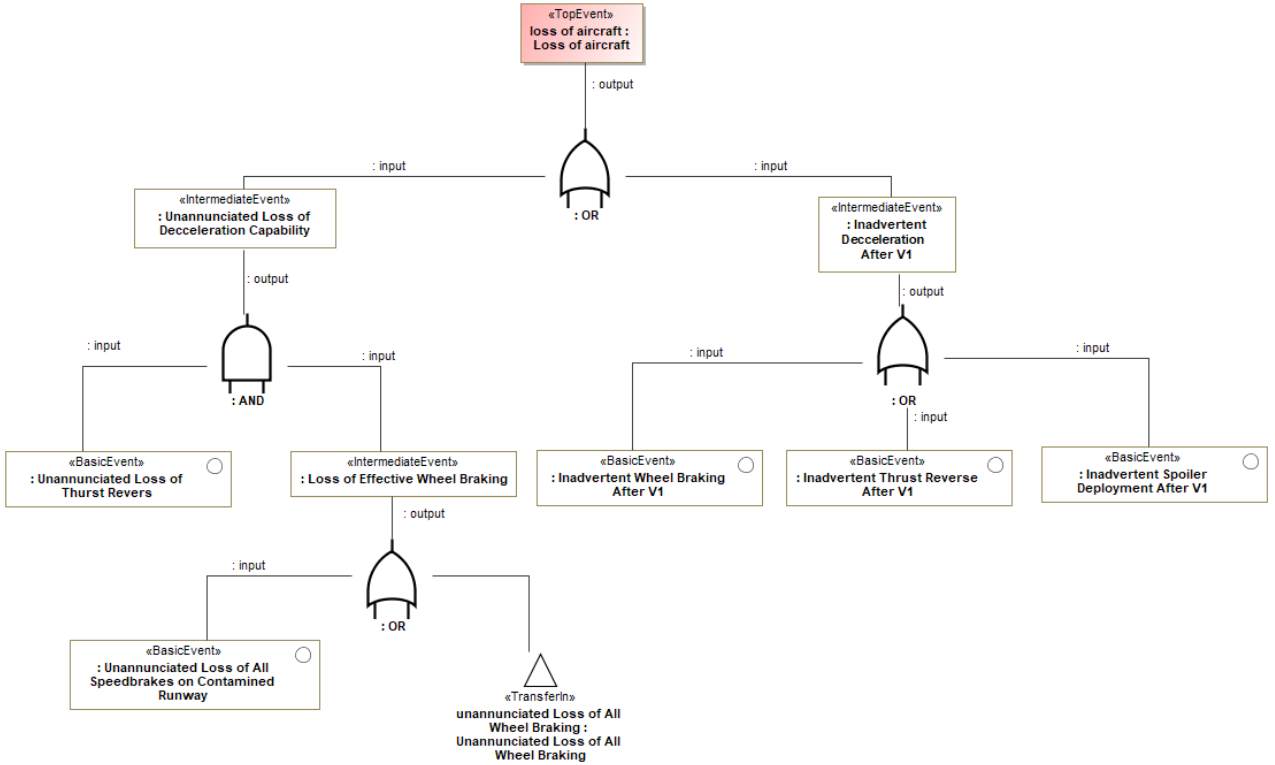
- FMEA (Failure Mode and Effect Analysis) is a bottom-up (or can performed functionally for top-down) methodology designed:
  - to identify potential failure modes for a product, part or process,
  - to assess the risk associated with those failure modes,
  - to rank the issues in terms of importance, and
  - to identify and carry out corrective actions to address the most serious concerns.



IEC 61025

FTA

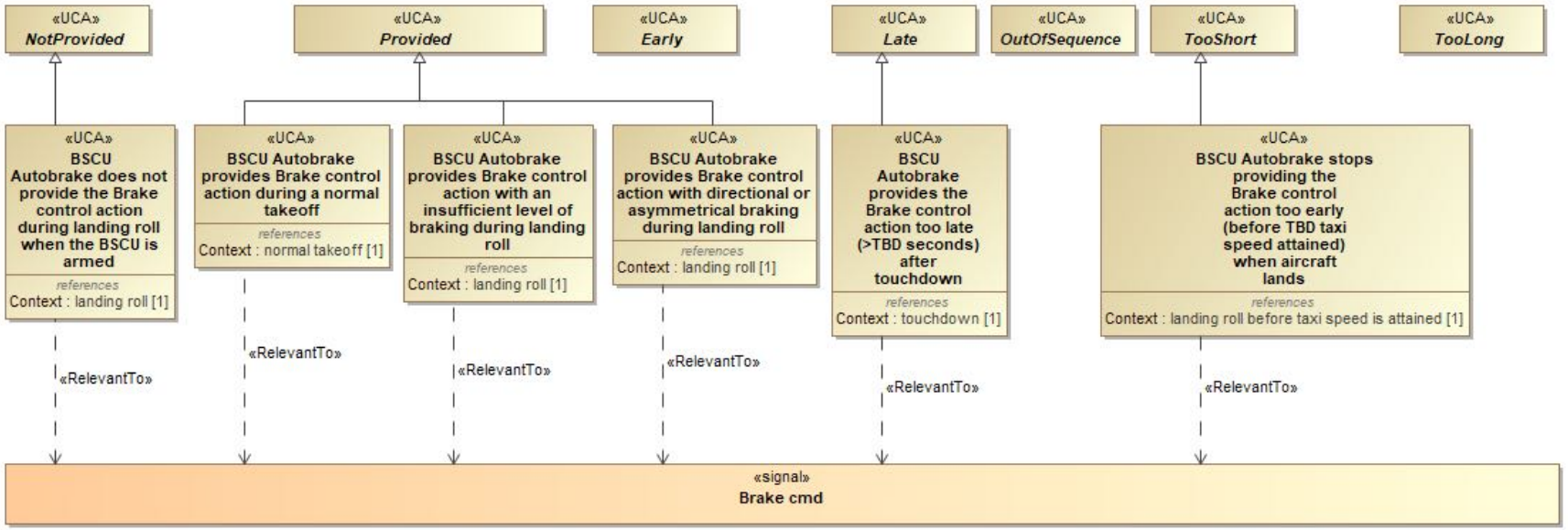
- FTA (Fault Tree Analysis) is a top-down methodology designed:
  - to identify the contributing events to an undesired event across a whole system,
  - to identify how those events combine to enable the undesired event, and
  - to identify the most likely combinations of contributing events for design of preventative actions.



IEC 60812

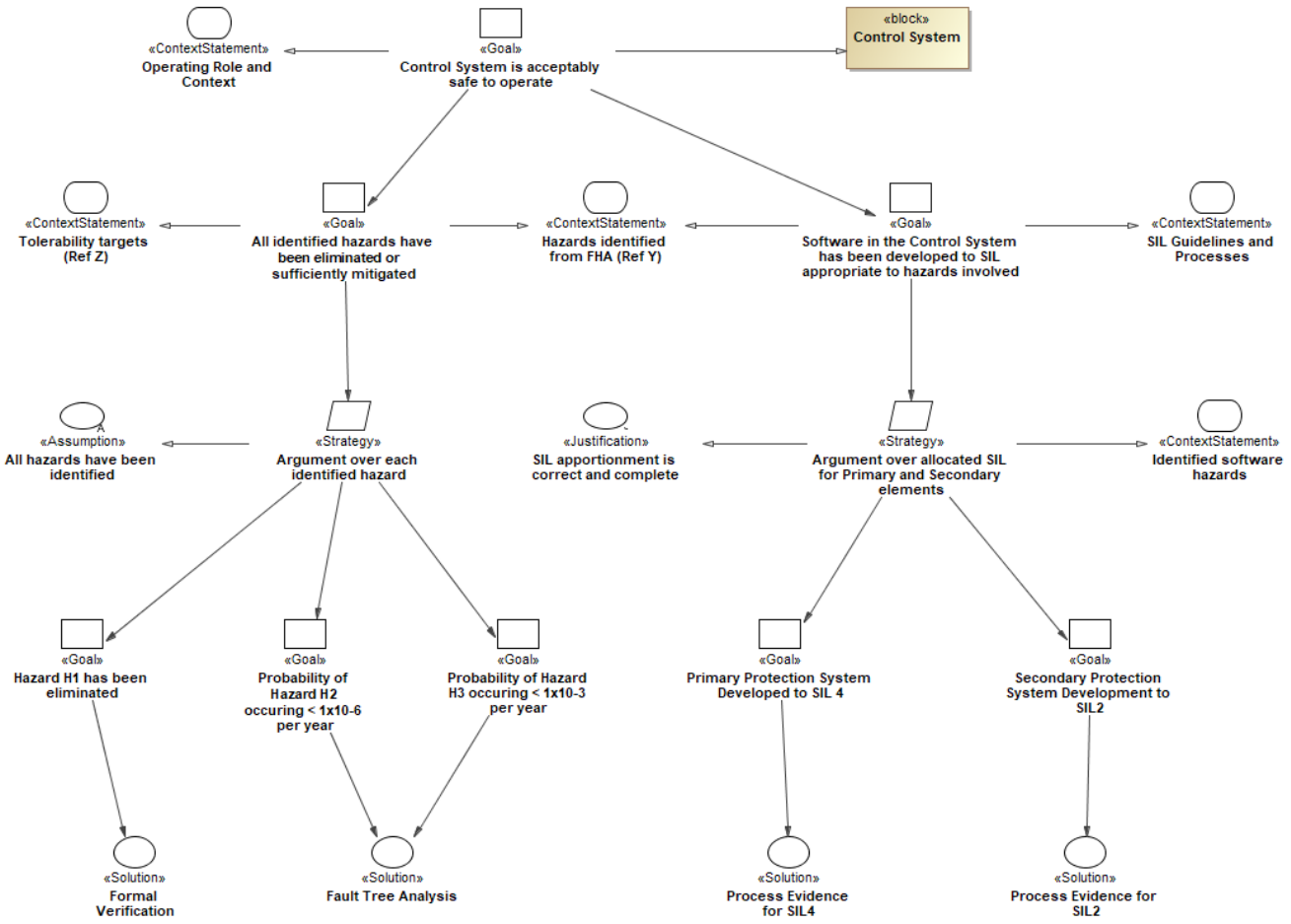
STPA

- STPA (Systems-Theoretic Process Analysis) is a systems and controls theory based exploratory methodology designed:
  - to identify system losses to avoid and the contributing hazards
  - to identify control actions which could lead to a hazard and their causes
  - to identify constraints (requirements) on the system to prevent or mitigate hazards
  - can be applied to cyber-physical systems



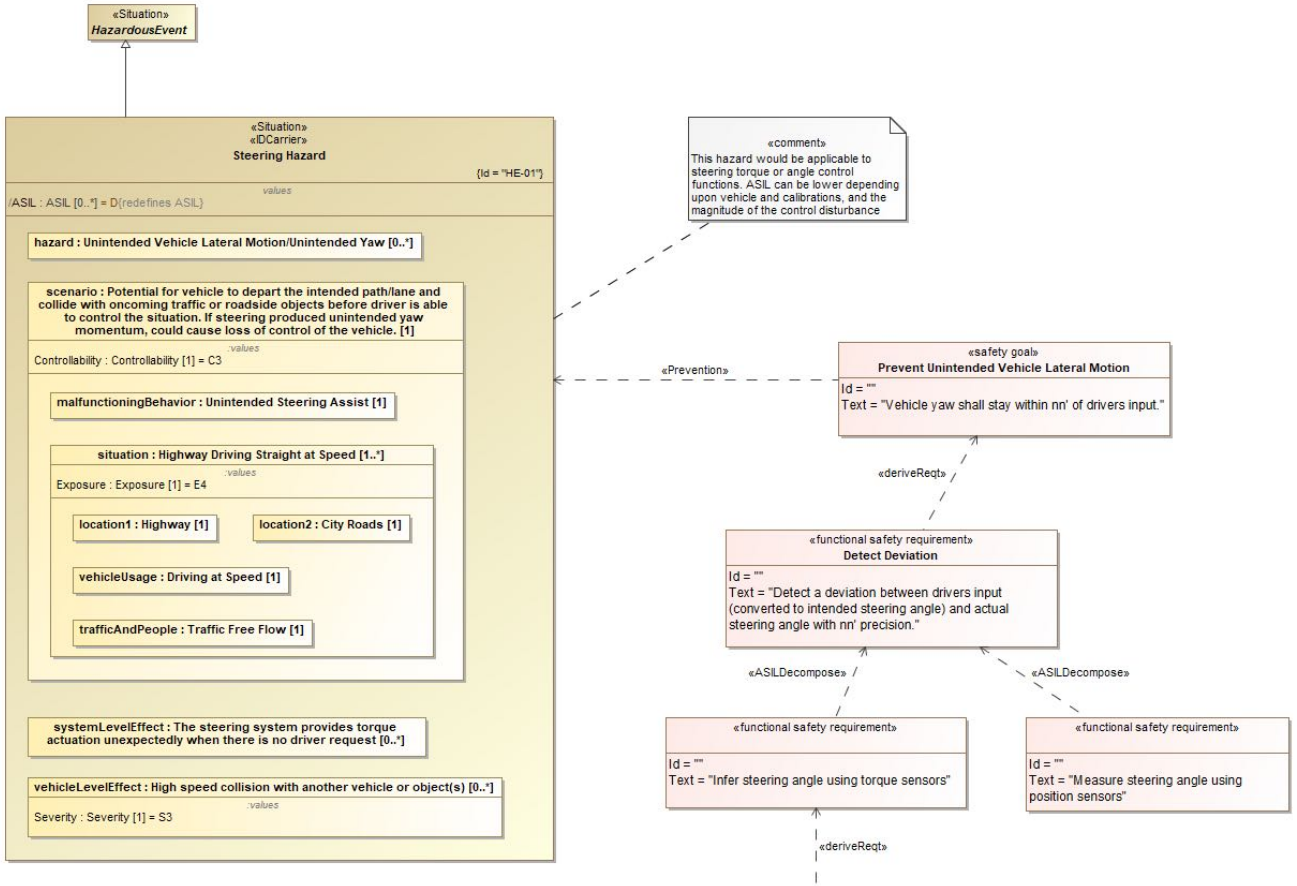
GSN

- GSN (Goal Structured Notation) is a argumentation notation:
  - used to graphically present the proof that that a goal is fulfilled
  - can be used to argue a system's safety case.



ISO 26262

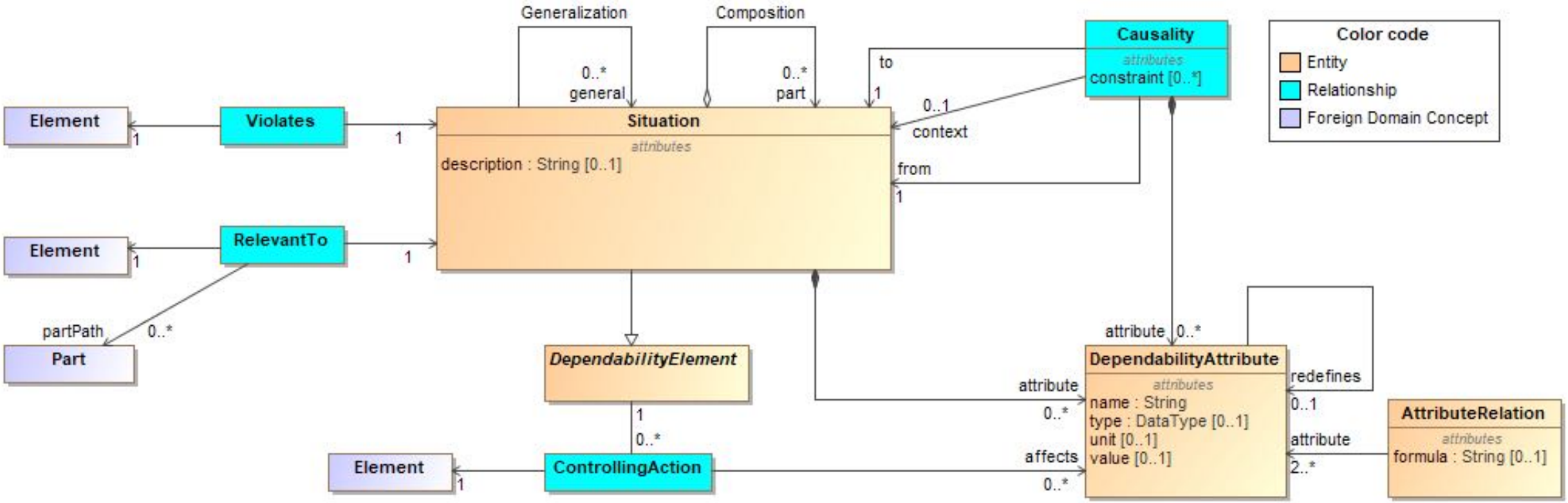
- ISO 26262 (Functional Safety) is a automotive specific functional safety standard:
  - Provides an automotive safety lifecycle
  - Defines a risk-based approach to determine Automotive Safety Integrity Levels



Key concepts

- A core foundation on which to build model-based S&R tools
- Representative profiles for specific domains and methodologies
- Easy to extend to additional domains and methodologies
  - In particular, without needing a long standardization cycle

Core Concepts



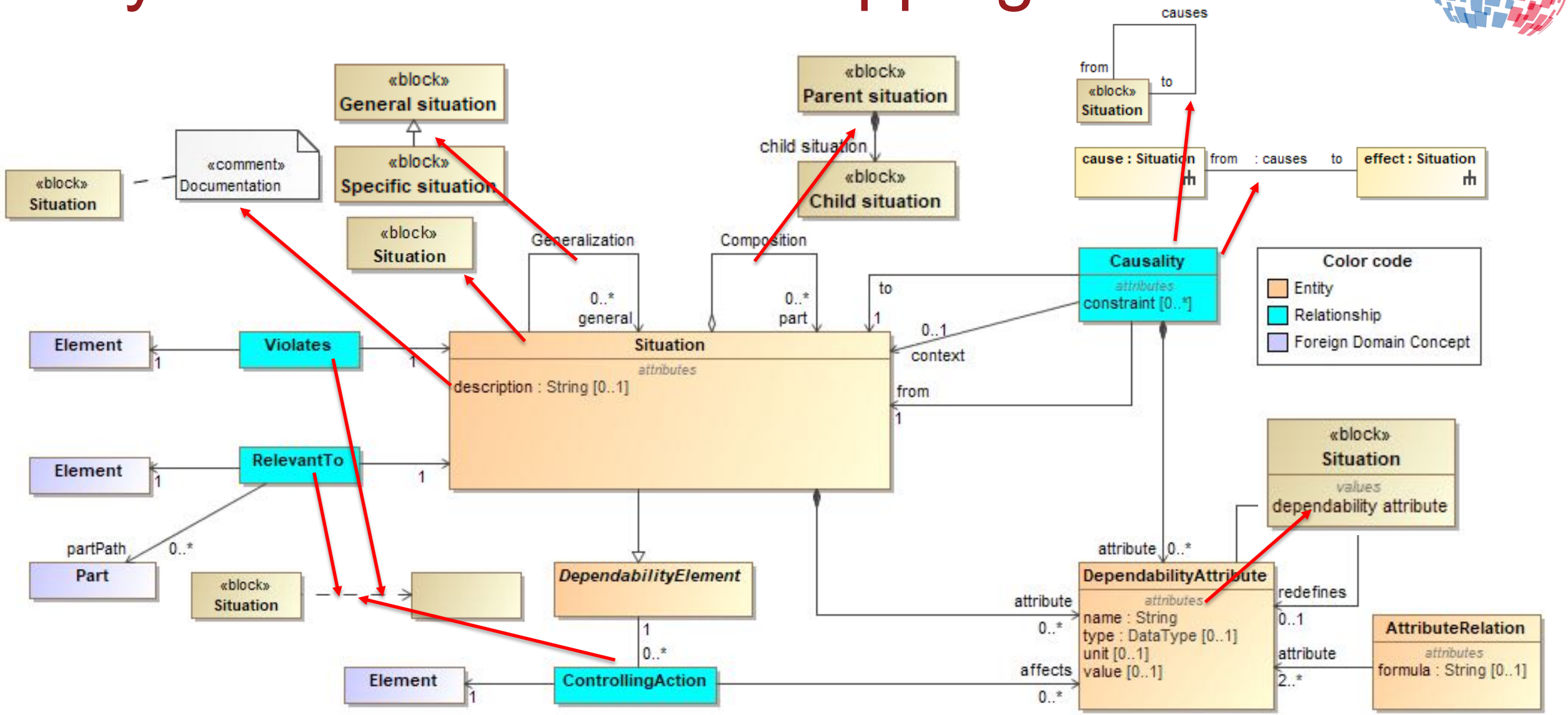
Implementation Approach

- UML Structure-description mechanisms are used
  - Block Definition Diagram/Internal Block Diagram (aka Class diagrams, Composite Structure diagrams for non-SysML people)

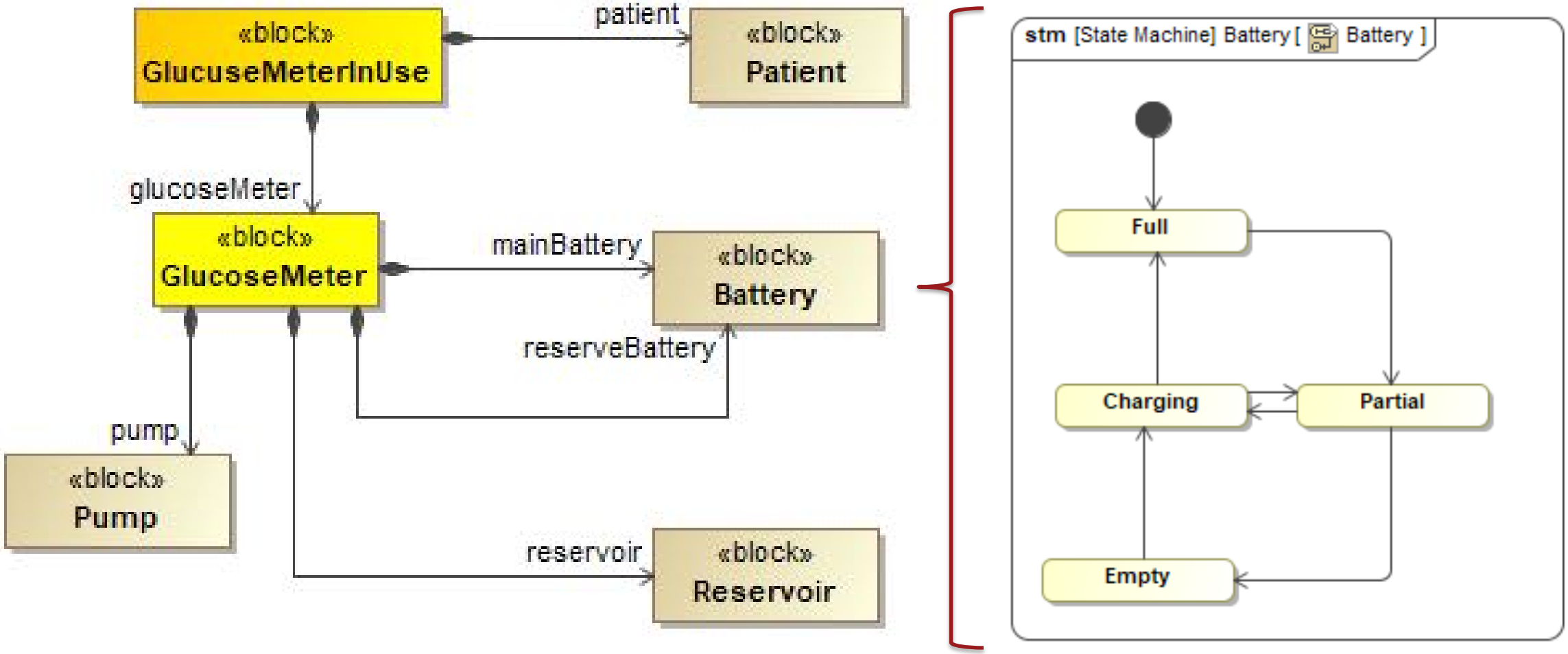
- Effort to reduce the usage of Profiling mechanisms (Stereotypes, Tags) in favor of using more Model Library Approach

- Seems to “rhyme” well with the SysML v2 group efforts!

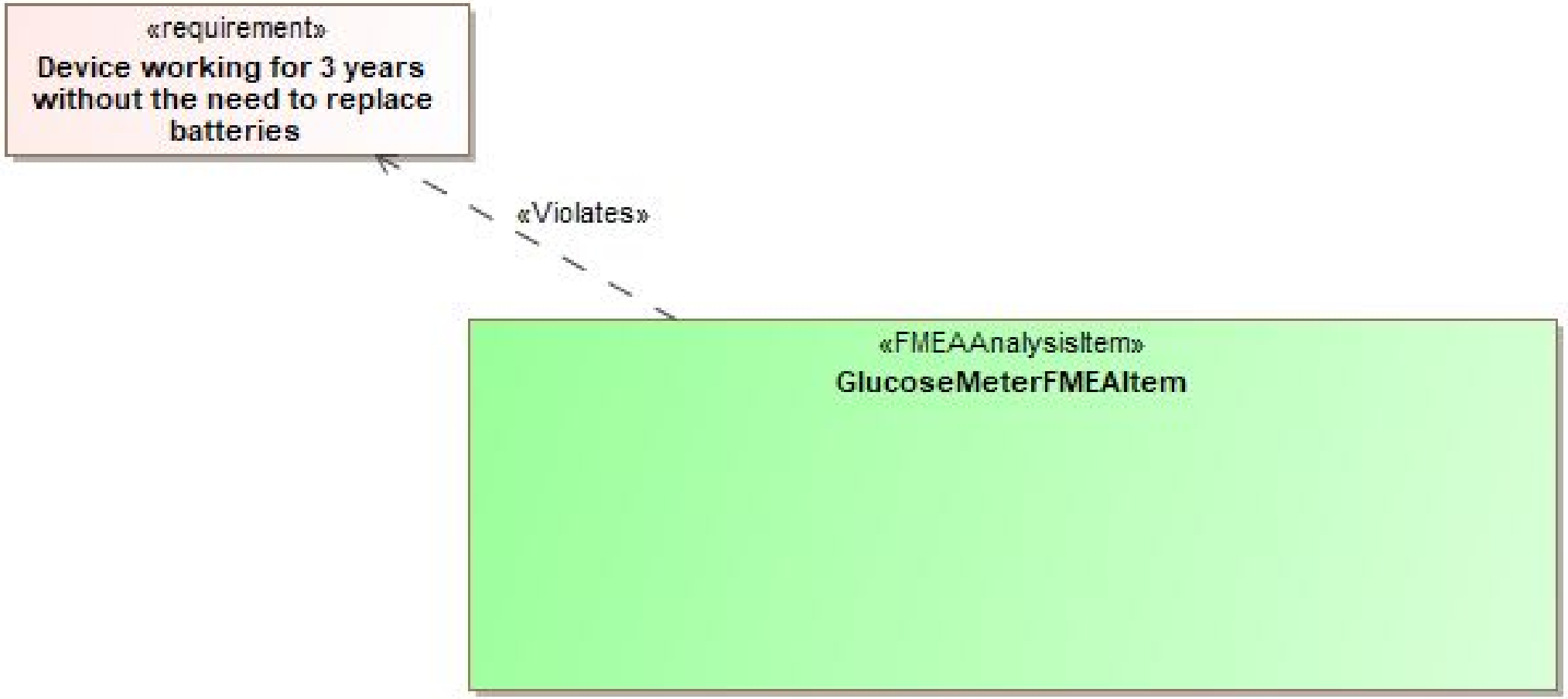
SysML/UML-to-S&R mapping



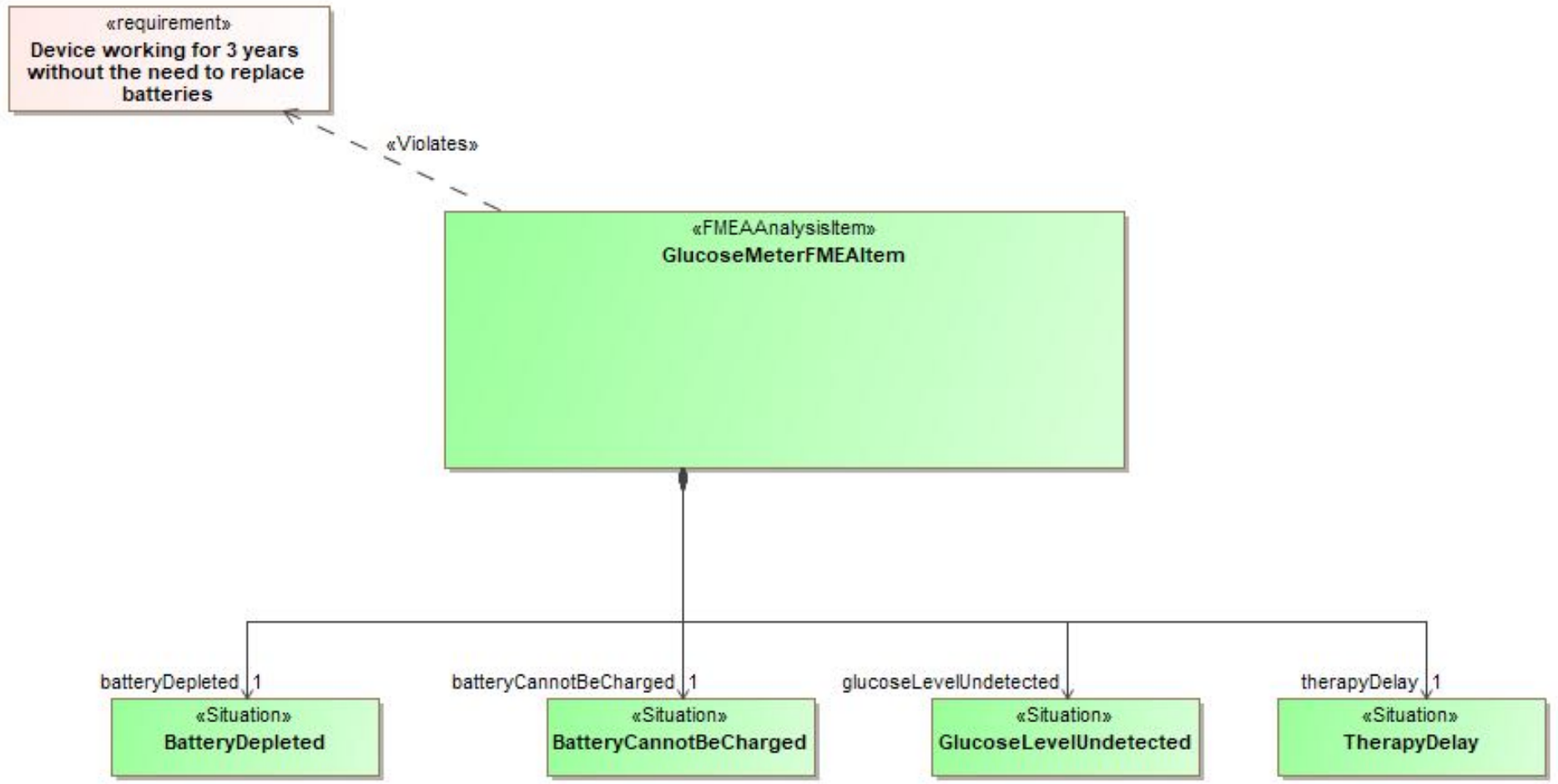
FMEA example: system model



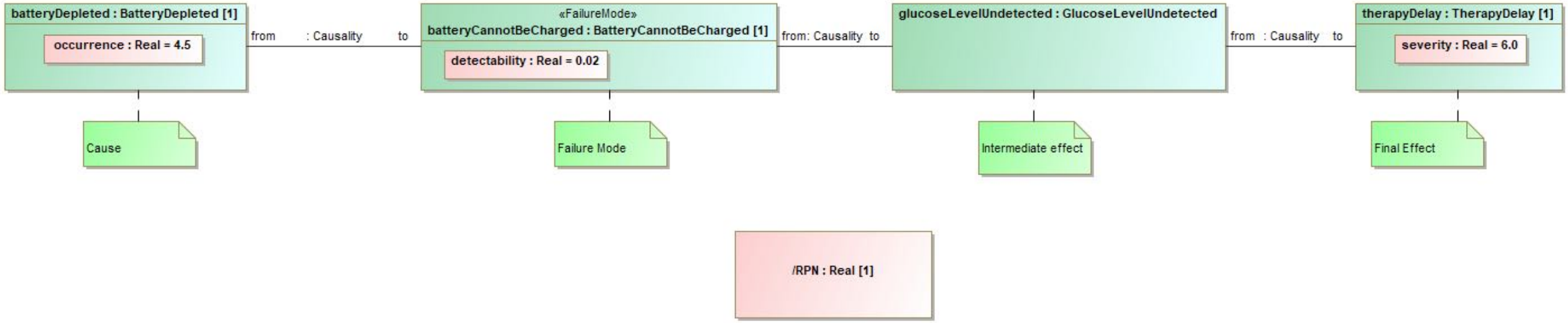
FMEA example: requirements violation



FMEA example: identification of situations



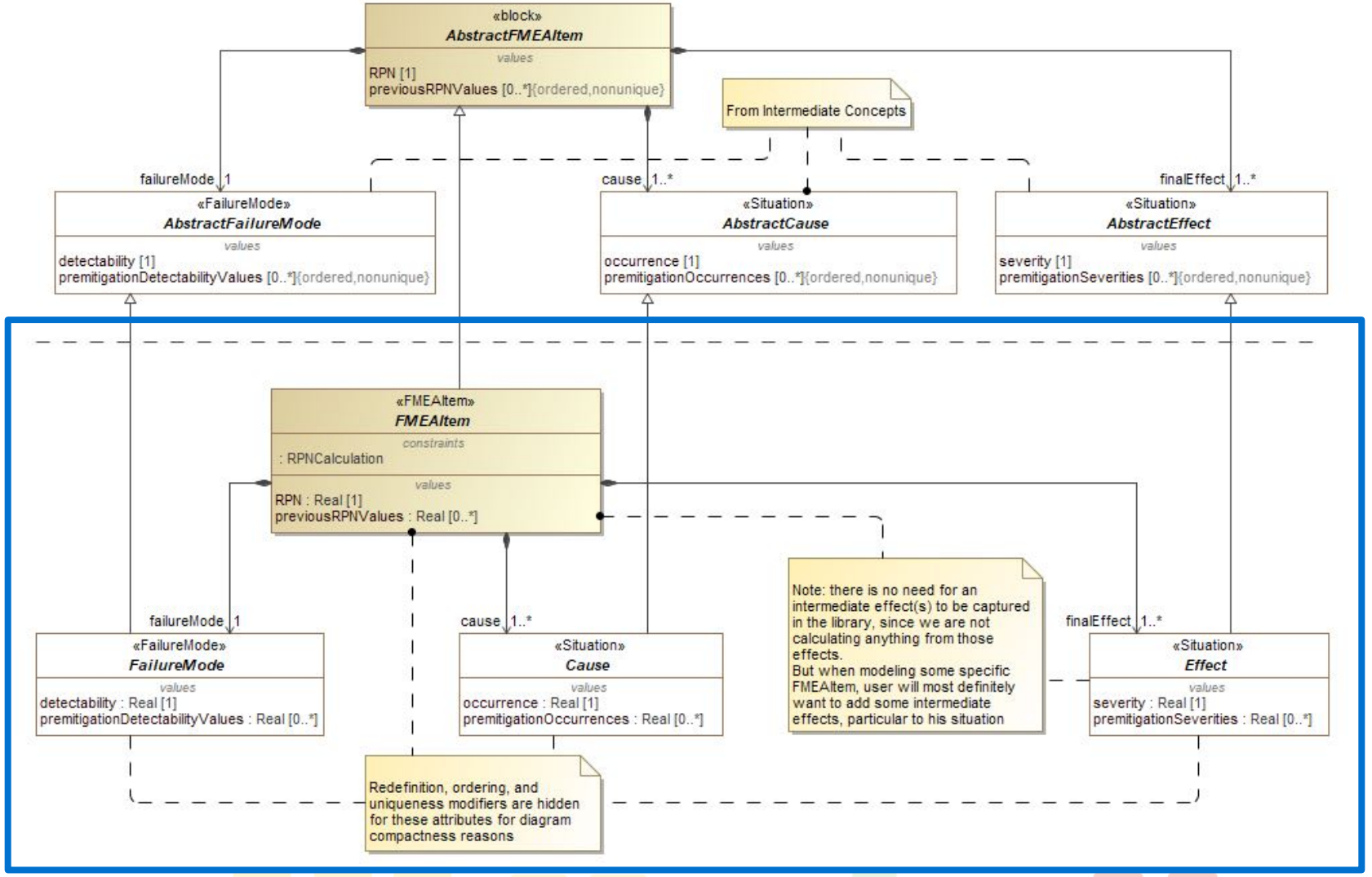
FMEA example: chaining and rating situations



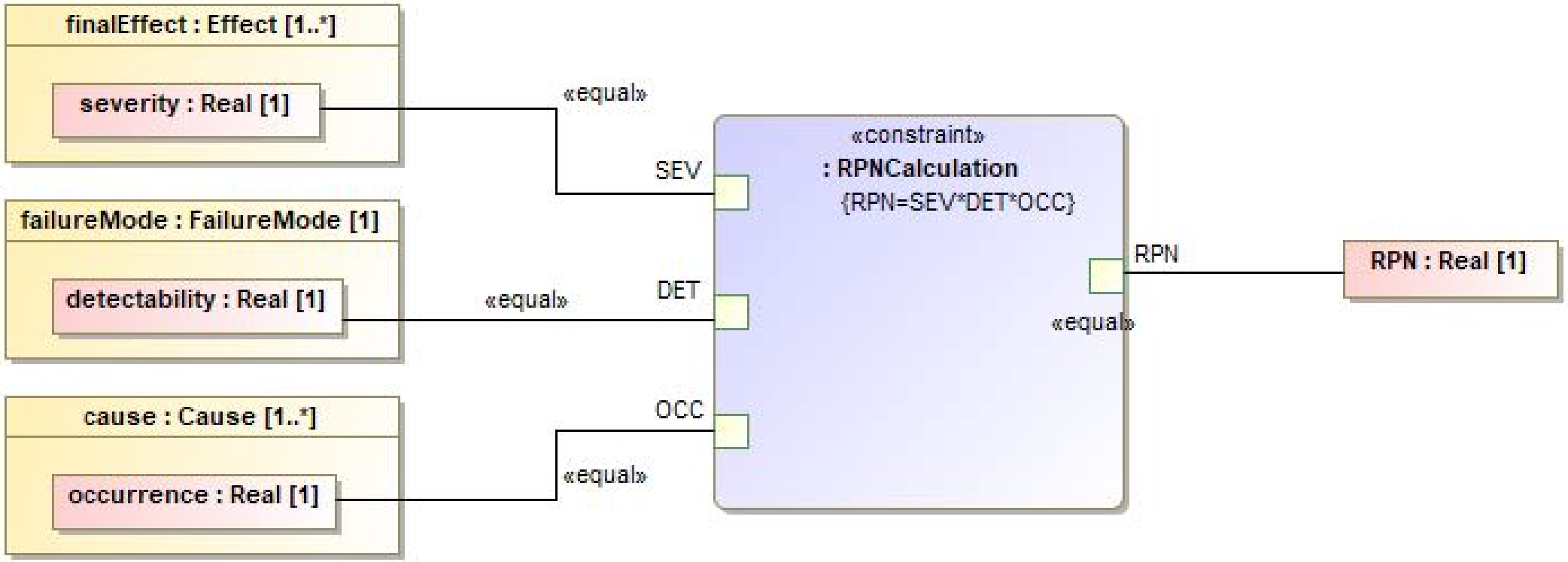
FMEA example: tabular view

#	Name	Item	Failure Mode	Local Effect Of Failure	Final Effect Of Failure	SEV	Cause Of Failure	OCC	Prevention Control	Detection Control	DET	OxD	RPN	Recomm
1	F1	airbag : Airbag	Bag does not open on impact		Injure Passenger	4.0	Sensor is not functioning properly Broken wire Controller is not functioning prope	4.0	Designed per material standard MS-XX123	Environmental stress test 03-000	4.0	16.0	64.0	Add reduno monitor imp Light to not
2	F2	light : Light	Light does not turn on	Car inoperable at night Car inoperable under ba		3.0	Battery dead	2.0			3.0	6.0	18.0	
3	F3	light : Light	Light does not turn on	Car inoperable at night Car inoperable under ba		3.0	Broken wire	2.0			3.0	6.0	18.0	
4	F4	light : Light	Light does not turn off	Car won't start		3.0	Short circuit in switch	2.0			3.0	6.0	18.0	Redesign: A indicator wl driver's doo while lights
5	F5	light : Light	Light does not turn on	Car inoperable at night Car inoperable under ba		3.0	Headlight out	2.0			1.0	2.0	6.0	Redesign: a lights-on di in console;
6	F6	light : Light	Light does not turn off	Car won't start		2.0	Operator error (left on)	2.0			2.0	4.0	8.0	Redesign: A indicator wl driver's doo while lights visual lights
7	F7	light : Light	Light does not turn on	Car inoperable at night Car inoperable under ba		2.0	Switch broken	2.0			1.0	2.0	4.0	
8	F8	light : Light	Light does not turn on	Car inoperable at night Car inoperable under ba		2.0	Switch corroded	2.0	Designed per material standard MS-XXX1		3.0	6.0	12.0	

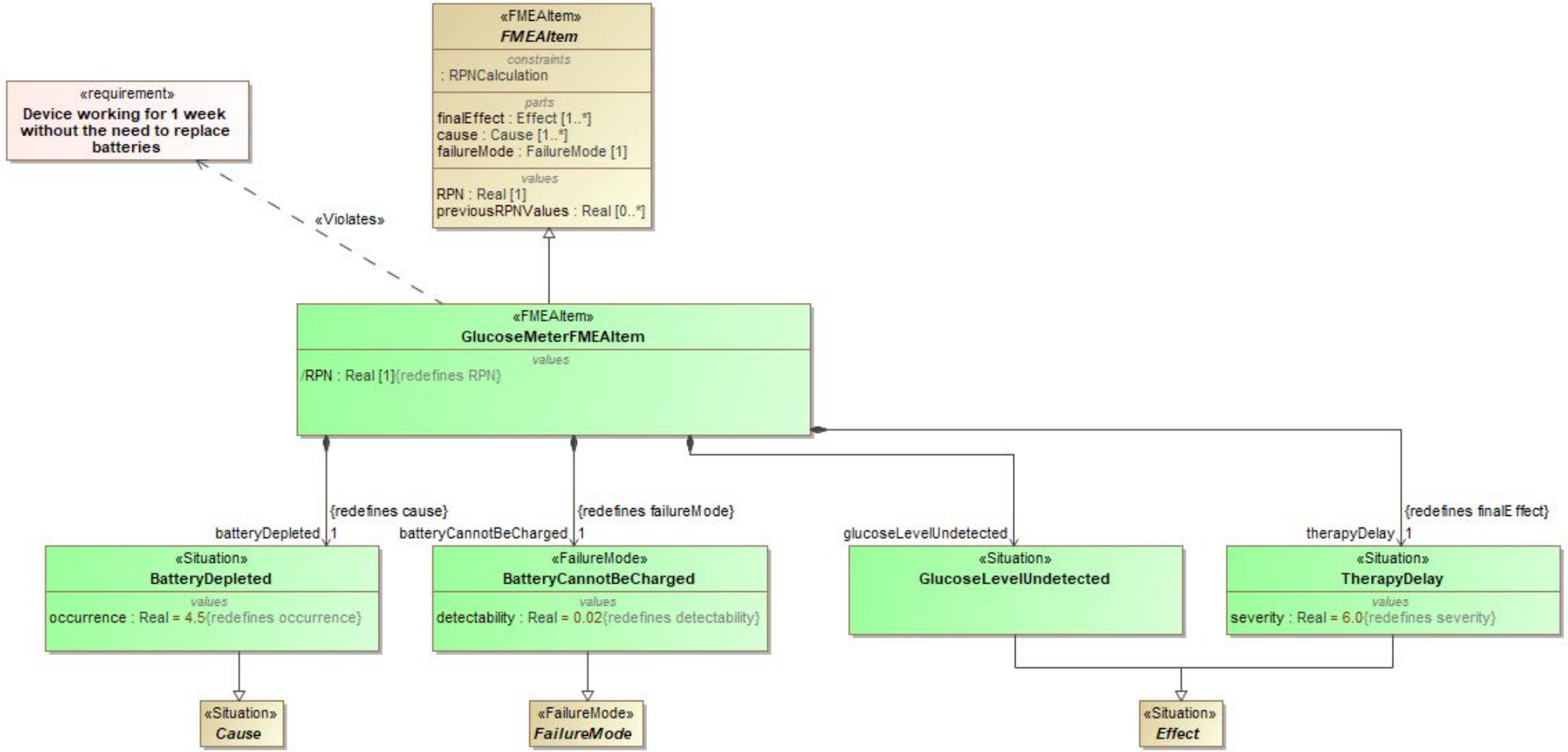
FMEA example: FMEA pattern



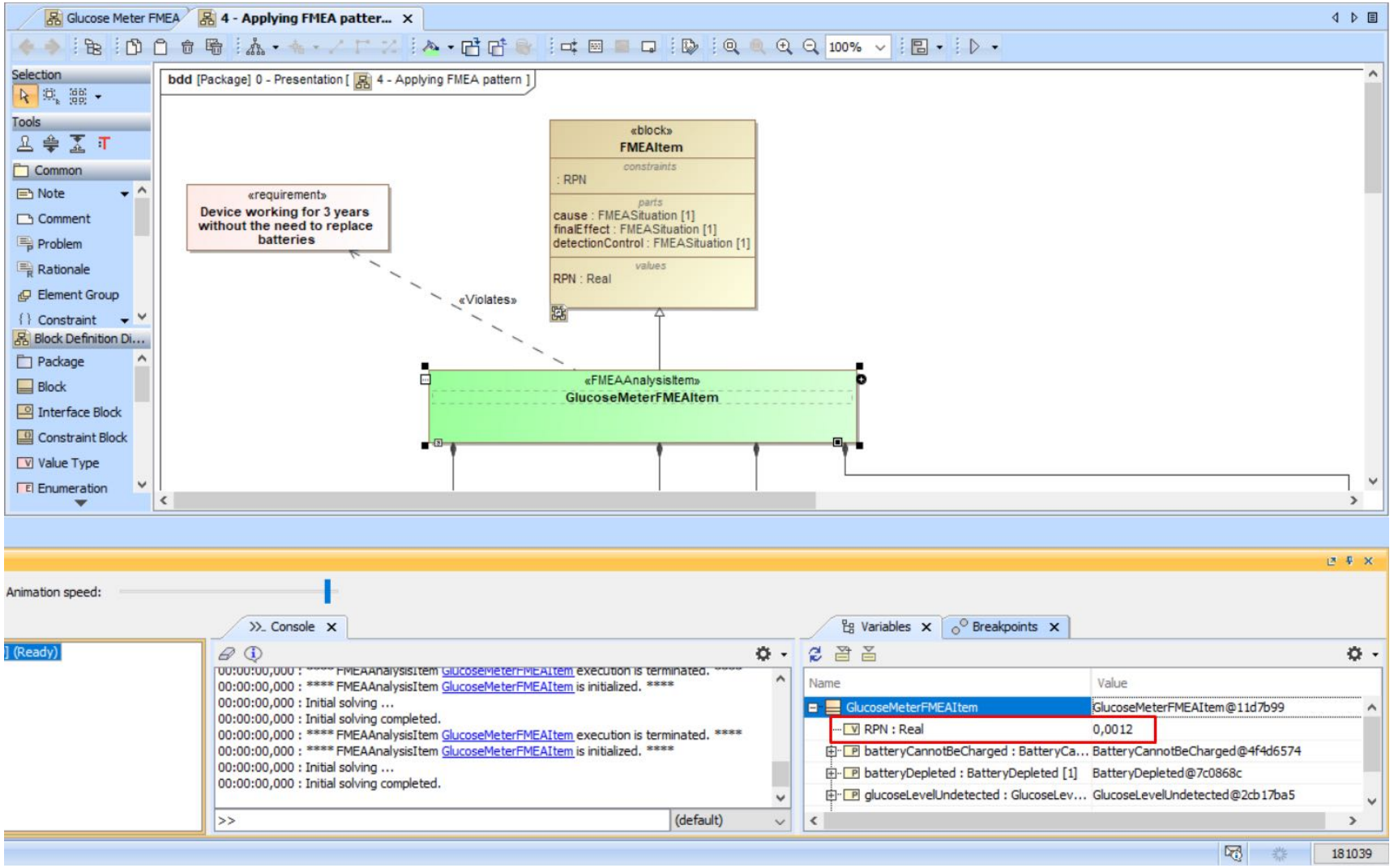
FMEA example: FMEA pattern parametrics



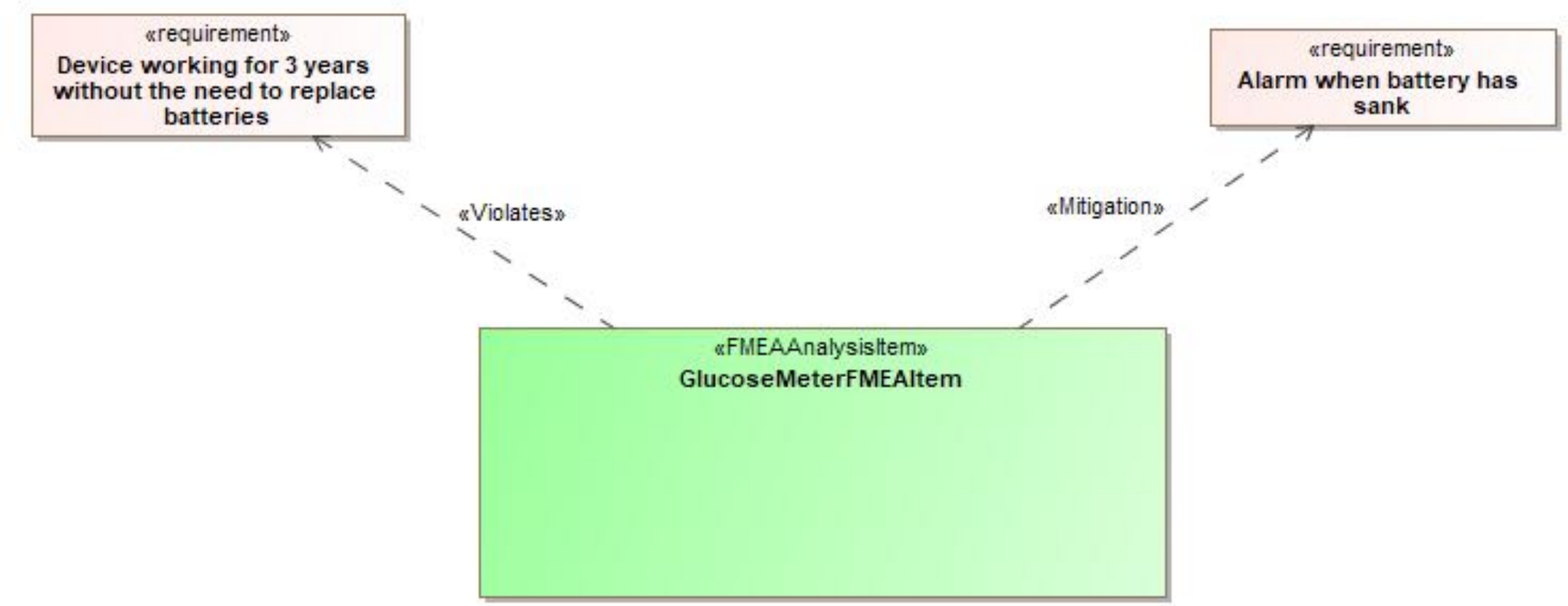
FMEA example: applying FMEA analysis pattern



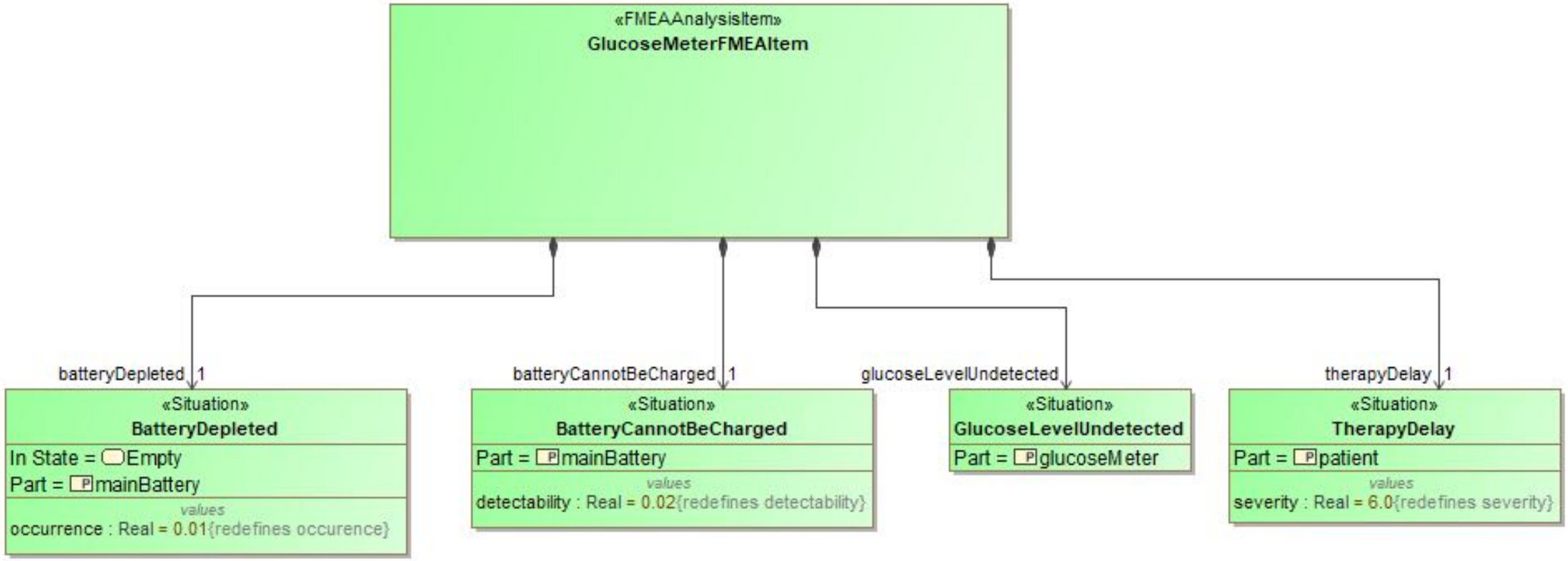
FMEA example: RPN calculation



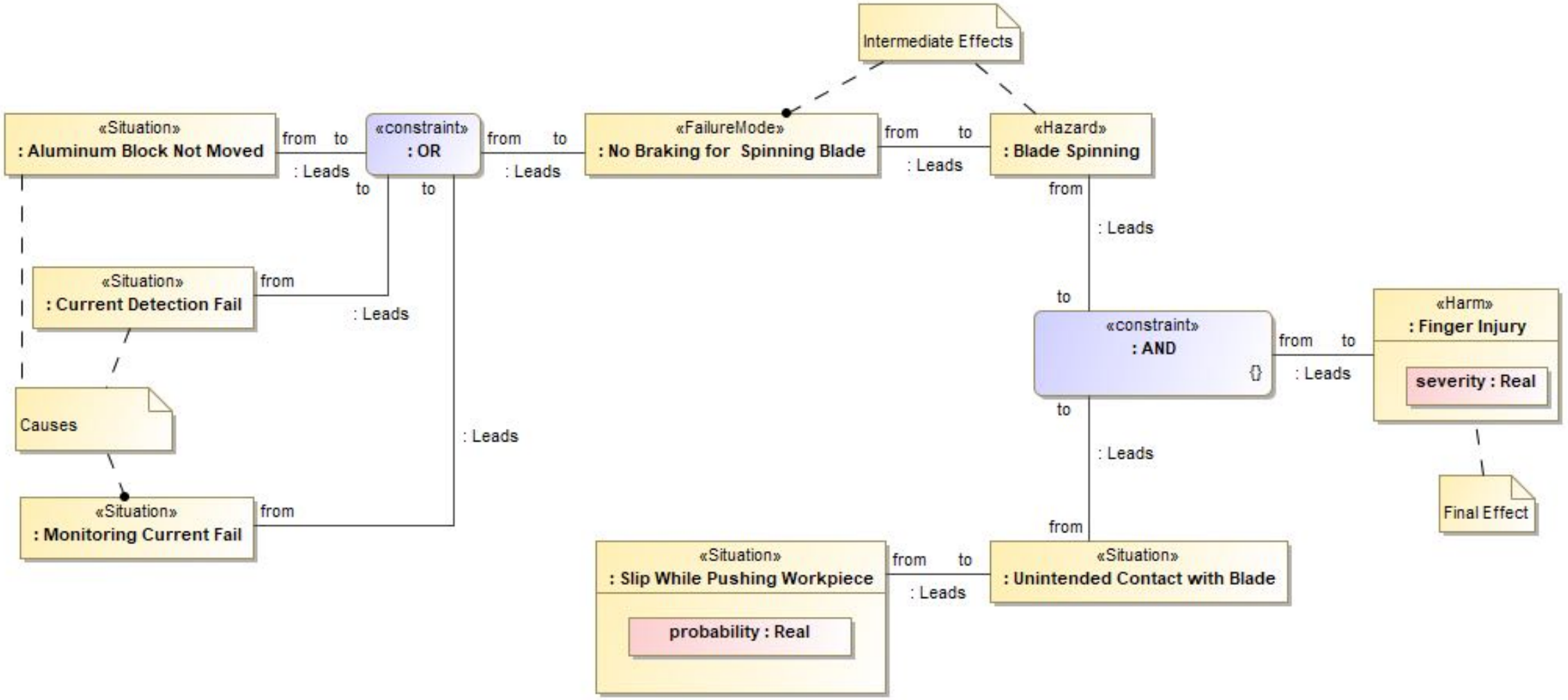
FMEA example: mitigation



FMEA example: tying situations to states and parts



FTA integrated with FMEA: example



Let’s keep in touch!

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