NOSE TOUR 2021

Systems Engineering, Today and Tomorrow

Presentation

The REUSE Company

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Agenda

1. Current context in Systems Engineering
2. The SMART Compass: a *Knowledge-Centric* approach
3. SMART User-Stories: as a *Systems Engineer*

Current context in Systems Engineering

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Current context in Systems Engineering

- **Sailing the V with an intelligent compass: Engineering digitalization through the automatization of traceability, reuse, and early quality in the development cycle.**
  - While we cannot say that all you need to do Systems Engineering is a good tool, but clearly process and skills need to be empowered by a set of suitable tools. Systems Engineering is aiming at addressing complex problems: the outcome of these projects is increasingly complicated, demanding the integration of multiple systems into a System of Systems. This makes that this kind of project is not only dealing with an enormous amount of requirements, also these requirements are prone to evolution and change.
  - Furthermore, the ecosystems of tools required to fully digitalize such projects across the "V" model is also incredibly large, demanding the connection of tools in a toolchain that were not originally designed to be connected. The underlying necessity of exchanging and linking different types of artifacts like textual requirements, logical models, physical models, quality metrics, etc. keeping consistency really represents a challenge to boost the digitalization of the engineering lifecycle through the understanding and reuse of embedding knowledge.
  - How can we reconcile this lifecycle conceptualization and technical environment to deliver timely and cost-effective systems?

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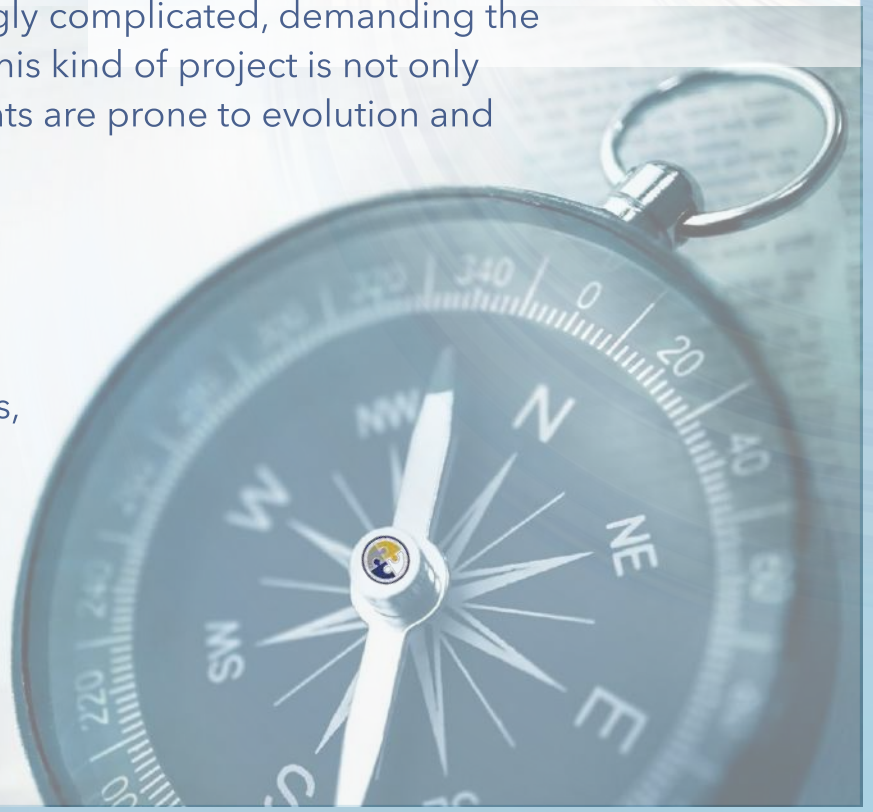

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Process

1

-Properly tailored
-Big vs Small companies
-Continuous improvement
-KPI's and scoreboards

Skills

2

-Engineers properly trained
-Contribute to the evolution of the process

Tools

3

-Interoperable
-Flexible to be adapted to process and skills
- Intelligent!!

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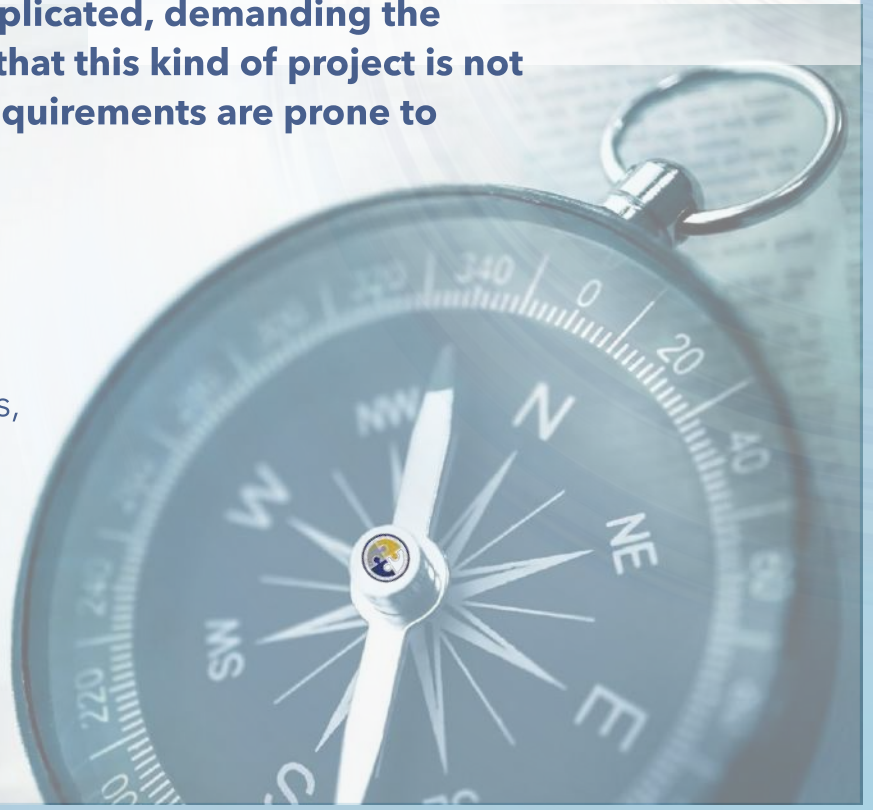

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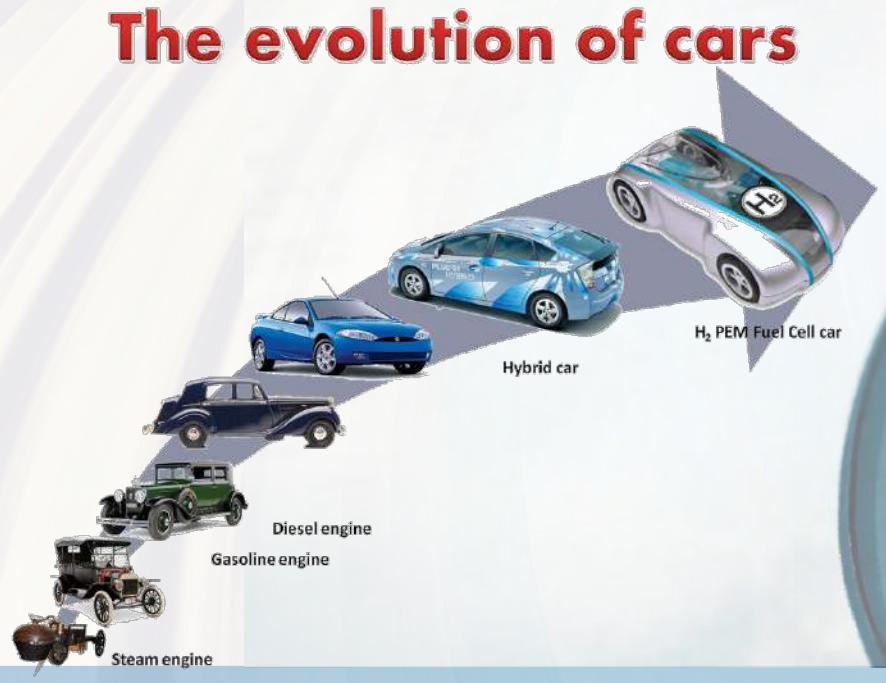

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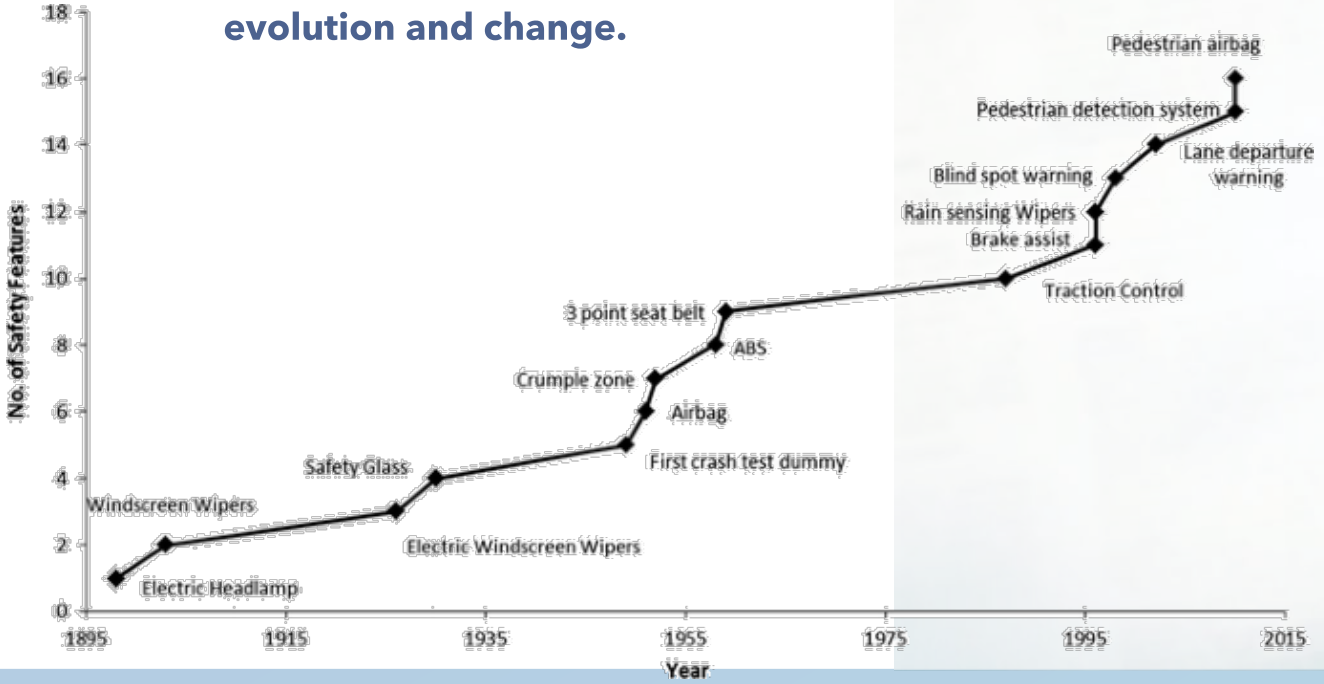

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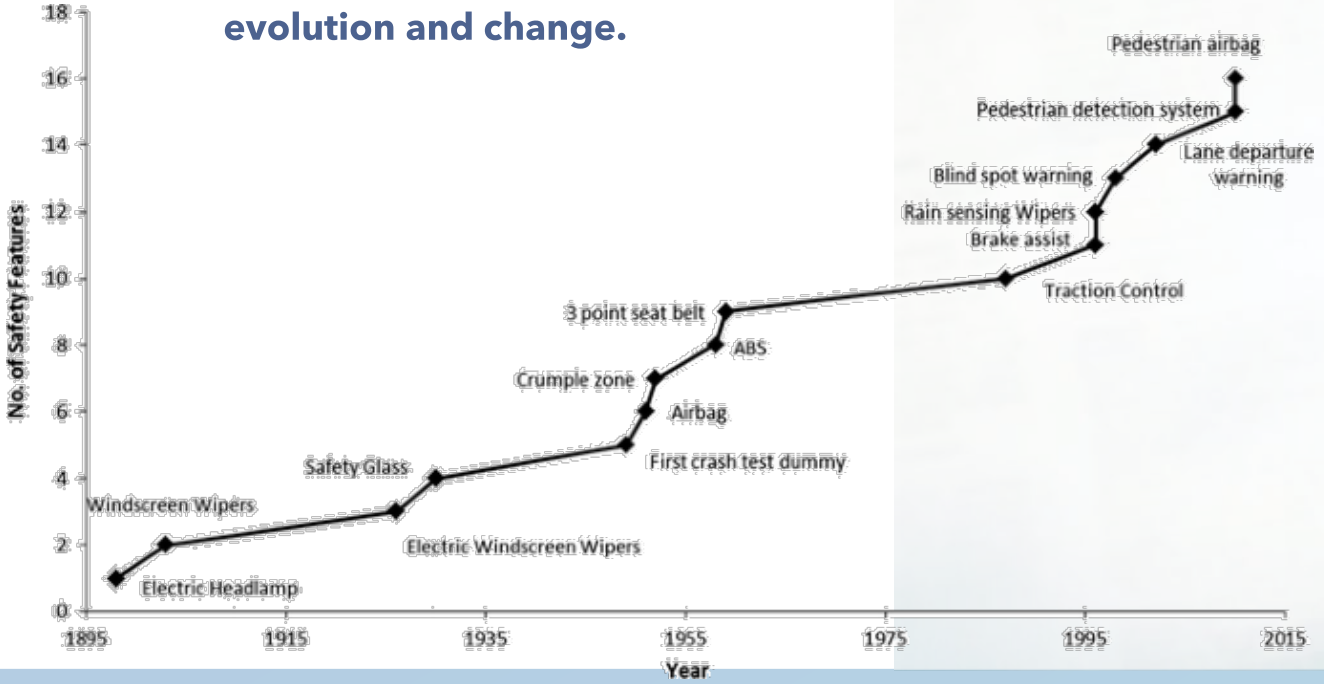

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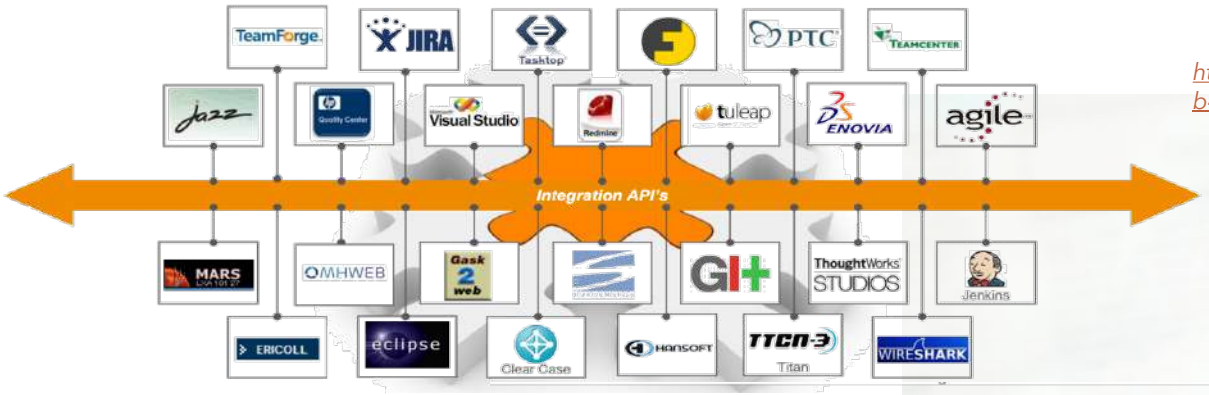
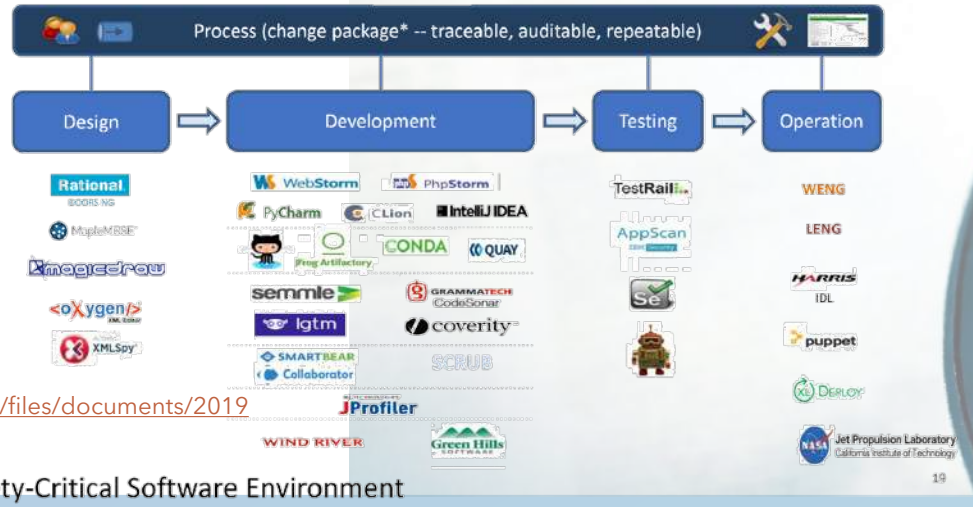


Mats Berglund (Ericsson)
http://www.ices.kth.se/upload/events/13/84404189f85d41a6a7d1cafd0db4ee80.pdf



Source:
https://www.nist.gov/system/files/documents/2019/04/05/14_delp.pdf

Safety-Critical Software Environment

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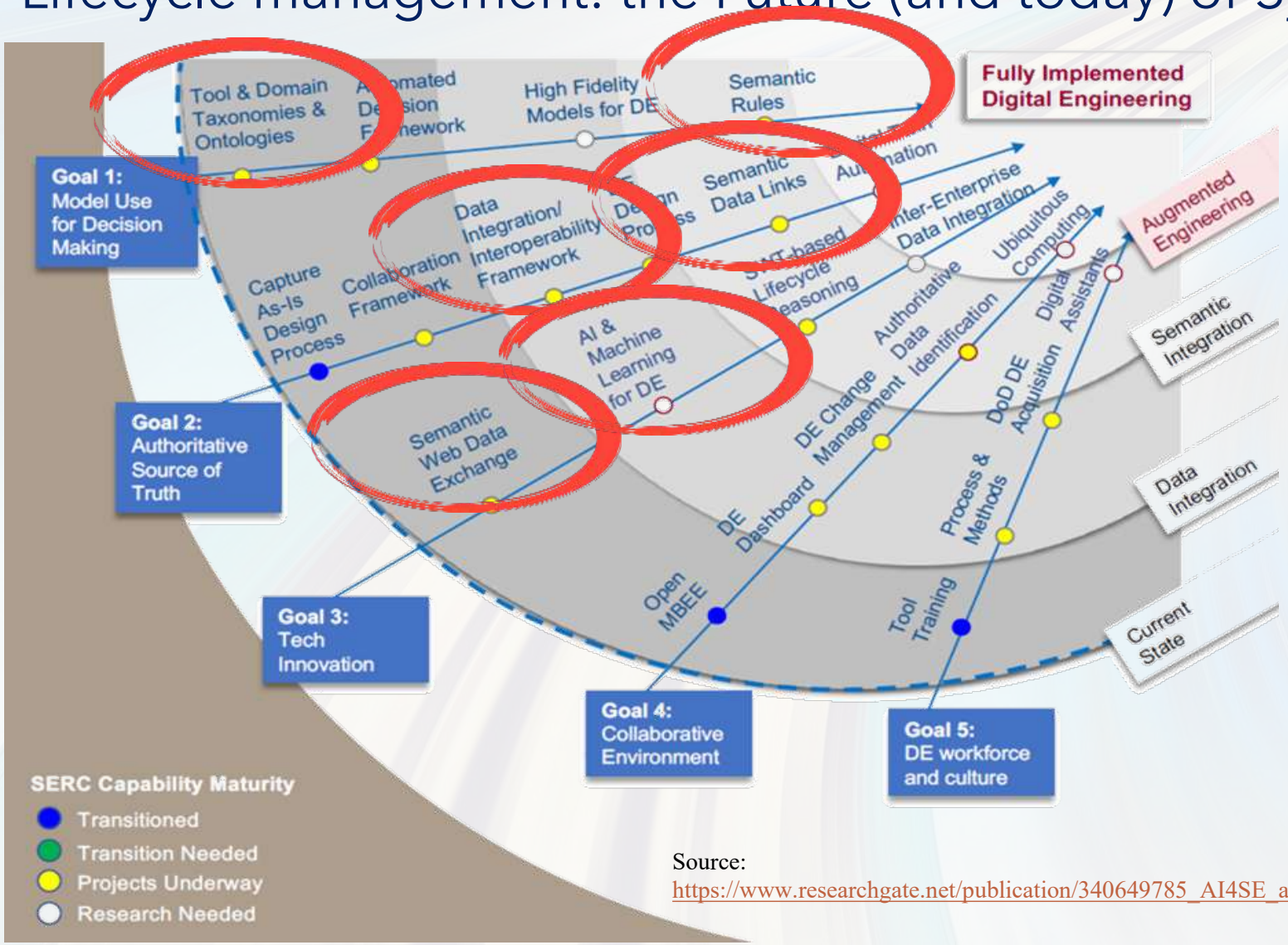
Lifecycle management: the Future (and today) of Systems Engineering



Source:
https://www.researchgate.net/publication/340649785_AI4SE_and_SE4AI_A_Research_Roadmap

The SMART Compass

Knowledge-centric

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The Knowledge Management process

Technical processes		Technical management processes	Agreement processes	Organizational project-enabling processes
Business or mission analysis process	Integration process	Project planning process	Acquisition process	Life cycle model management process
Stakeholder needs & requirements definition process	Verification process	Project assessment and control process	Supply process	Infrastructure management process
System requirements definition process	Transition process	Decision management process		Portfolio management process
Architecture definition process	Validation process	Risk management process		Human resource management process
Design definition process	Operation process	Configuration management process		Quality management process
System analysis process	Maintenance process	Information management process		Knowledge management process
Implementation process	Disposal process	Measurement process		
		Quality assurance process		

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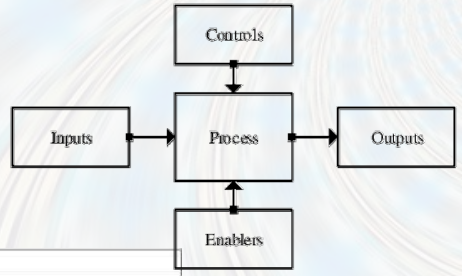
The Knowledge Management process



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0	EXT	X	X													X								X	X	X	X	X	X	X	X
1		BMA	X				X									X		X	X	X	X	X									X	
2		X	SNRD	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X									X	
3				SRD	X	X	X			X						X		X	X	X	X	X									X	
4					AD	X	X	X								X		X	X	X	X	X									X	
5						DD	X	X	X	X						X		X	X	X	X	X									X	
6							SA									X	X	X	X	X	X										X	
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14		X	X	X	X	X	X								DSP	X	X	X	X	X	X			X	X						X	
15		X	X													PP	X	X	X	X	X			X			X		X		X	
16																X	PAC	X	X	X	X	X						X			X	
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18																X	X	X	RM	X	X										X	
19																X	X	X	X	CM	X										X	
20																X	X	X	X	X	INFOM										X	
21																X	X	X	X	X	X	MEAS									X	
22																X	X	X	X	X	X		QA							X	X	
23	X								X							X	X	X	X	X	X			ACQ							X	
24	X															X	X	X	X	X	X				SUP			X			X	
25	X															X						X				LCMM					X	
26	X																									INFRAM					X	
27	X															X											X	PM	X		X	
28	X															X													HRM		X	
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31																X										X						TLR

KEY		
	Outputs horizontal; Inputs vertical	
Technical Processes	BMA	Business or Mission Analysis
	SNRD	Stakeholder Needs & Requirements Definition
	SRD	System Requirements Definition
	AD	Architecture Definition
	DD	Design Definition
	SA	System Analysis
	IMPL	Implementation
	INT	Intergration
	VER	Verification
	TRAN	Transition
	VAL	Validation
	OPER	Operation
	MAINT	Maintenance
	DSP	Disposal
Technical Management Processes	PP	Project Planning
	PAC	Project Assessment & Control
	DM	Decision Management
	RM	Risk Management
	CM	Configuration Management
	INFOM	Information Management
	MEAS	Measurement
	QA	Quality Assurance
Agreement	ACQ	Acquisition
	SUP	Supply
Organization Project-Enabling Processes	LCMM	Life Cycle Model Management
	INFRAM	Infrastructure Management
	PM	Portfolio Management
	HRM	Human Resources Management
	QM	Quality Management
	KM	Knowledge Management
Tailor	TLR	Tailoring

The Knowledge Management process

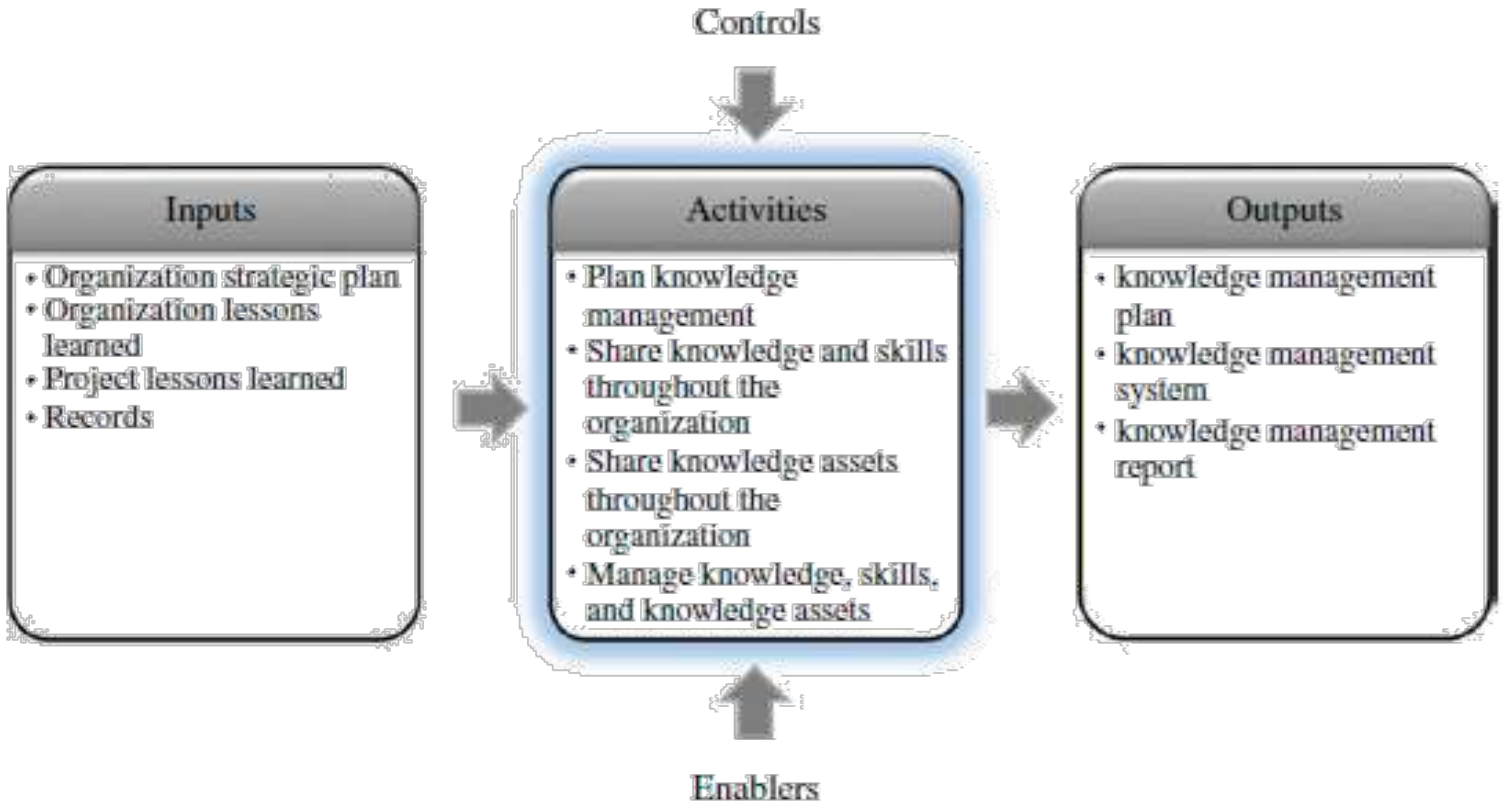

FIGURE 7.7 IPO diagram for the knowledge management process. INCOSE SEH original figure created by Shortell and Walden. Usage per the INCOSE Notices page. All other rights reserved.

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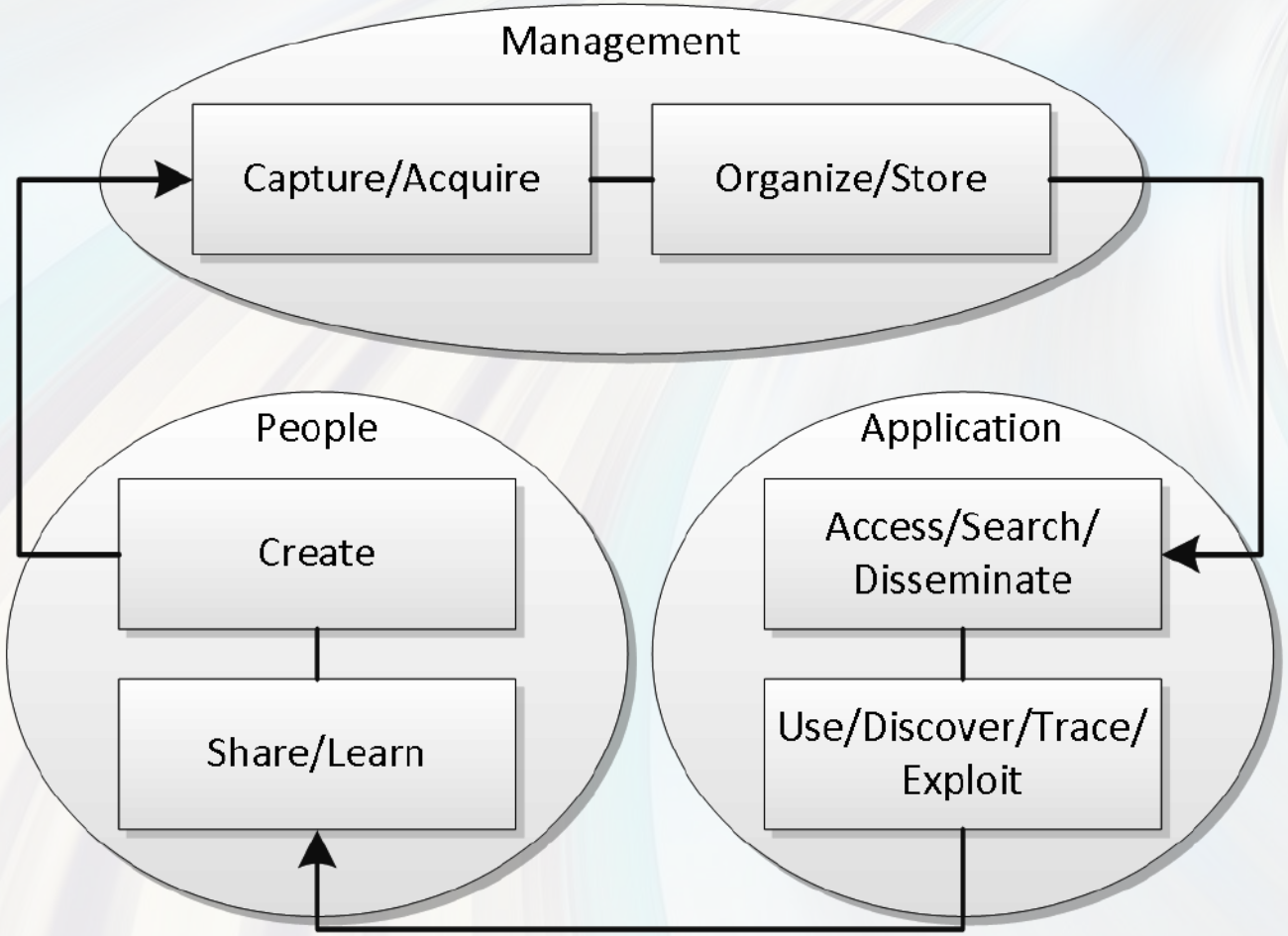
The Knowledge Management process

- The purpose of the **Knowledge Management process** is to create the capability and assets that enable the organization to **exploit opportunities to re-apply existing Knowledge**
- KM is a broad area that transcends the bounds of SE and project management
- Includes the identification, capture, creation, representation, dissemination, and exchange of knowledge across targeted groups of stakeholders
- Includes both, explicit and tacit knowledge

Knowledge Management Strategy



Definition of the ground truth

01 Vocabulary / Terminology

Controlled Organizational and Project Vocabulary for a common understanding among stakeholders

02 Terms Relationships

Relate the terms in different way representing semantic relationships:
- Relationships between terms (Thesaurus)
- Clusters of Terms

03 Textual Patterns

Represent text structures in a way it is possible to do Pattern Matching within the text

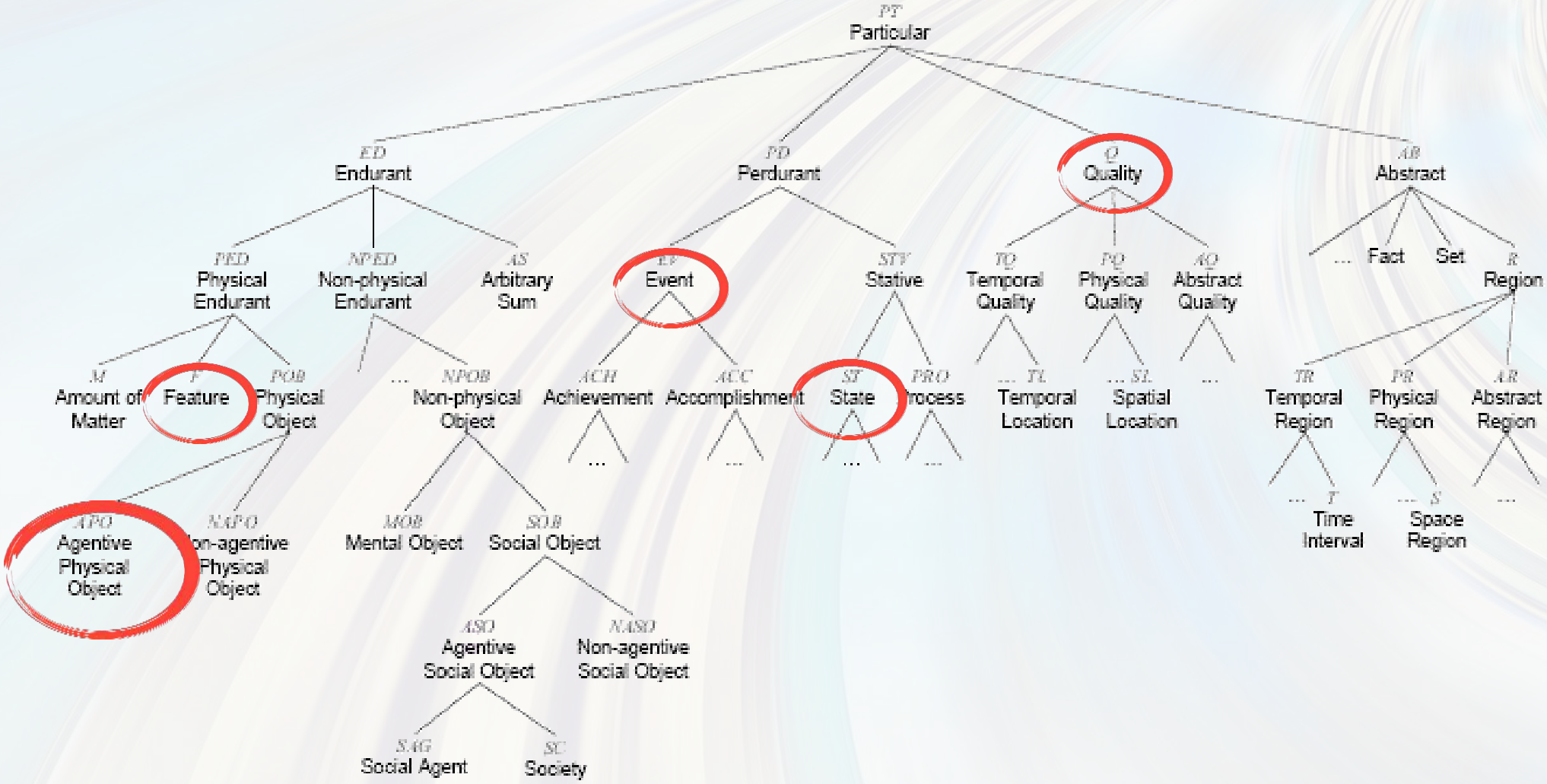
04 Formalization

Information about how can the text being matched by the patterns be represented using graphs

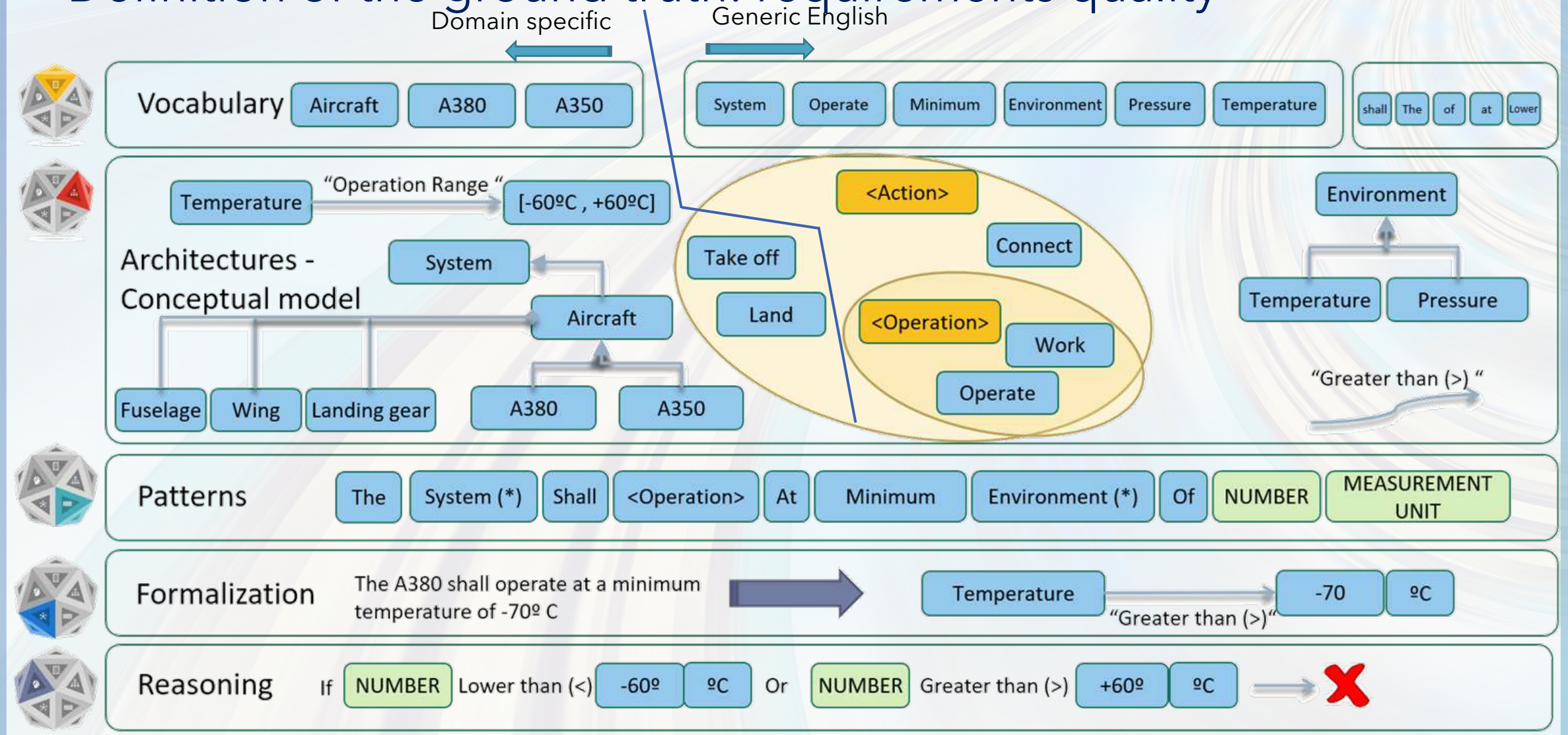
05 Reasoning Info

A combination of rules, tasks and groups to infer information from existing text

Definition of the ground truth: Upper ontologies ≈ SysML Metamodel



Definition of the ground truth: requirements quality



Definition of the ground truth

- Reasoning layer: understanding requirements

StR0168 - The targets shall be detected by the Electromagnetic sensor with a frequency not lower than 10 units per second

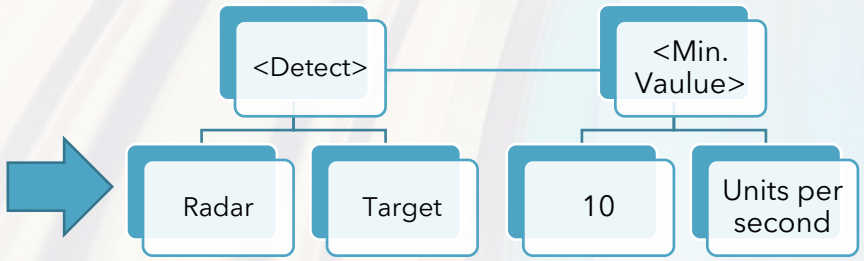
SyR0451 – The Radar shall identify hits at a minimum rate of 10 units per second

StR0168

The targets shall be detected by the Electromagnetic sensor with a frequency not lower than 10 units per second

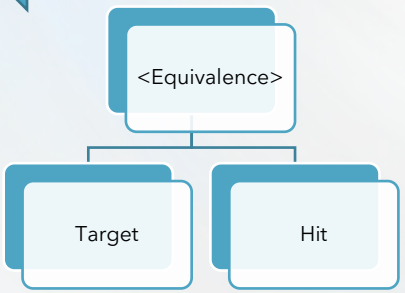
SyR0451

The Radar shall identify hits at a minimum rate of 10 units per second



<Detect>
Identify
Discover
Detect
Find
…

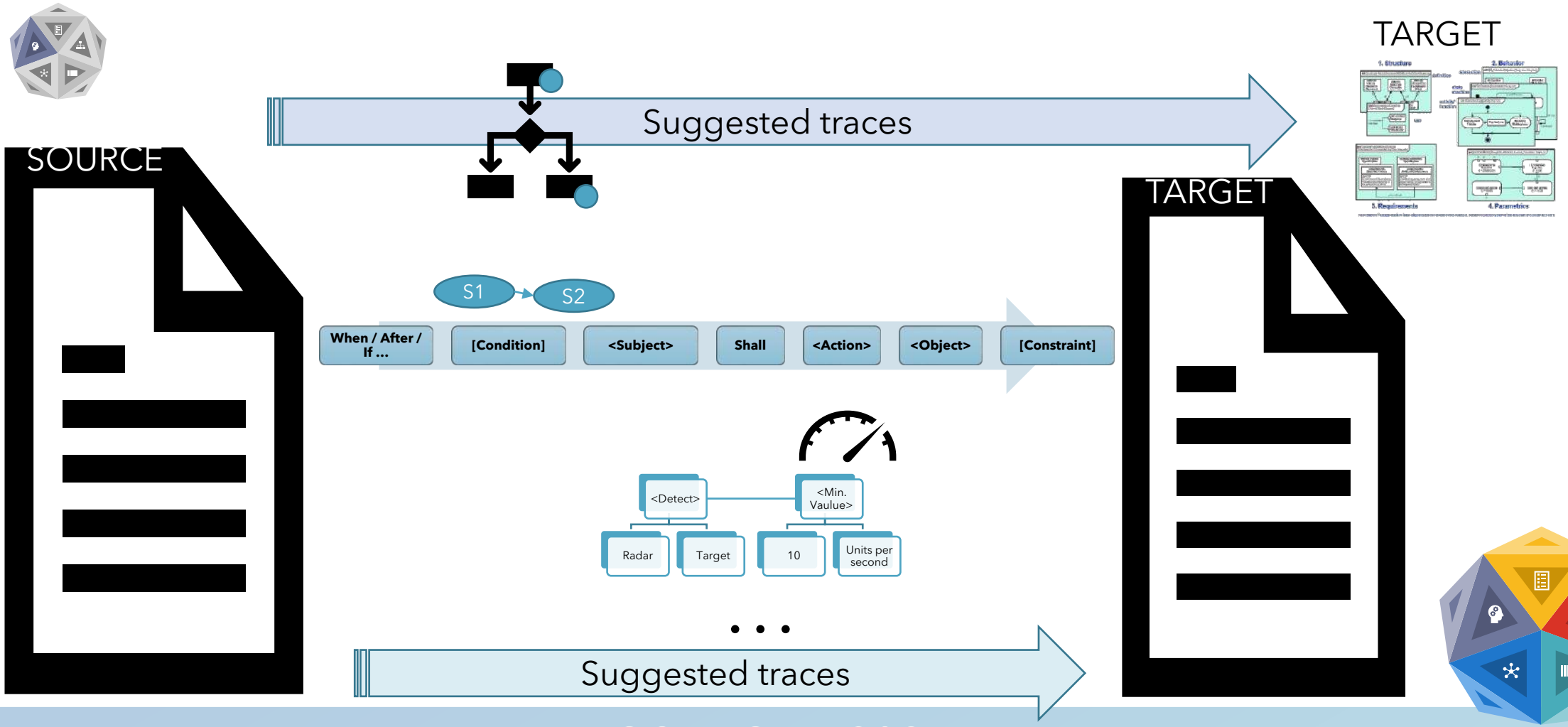
Taxonomy:
System
.Electromagnetic device
..Electromagnetic sensor
…Radar



Definition of the ground truth : reuse

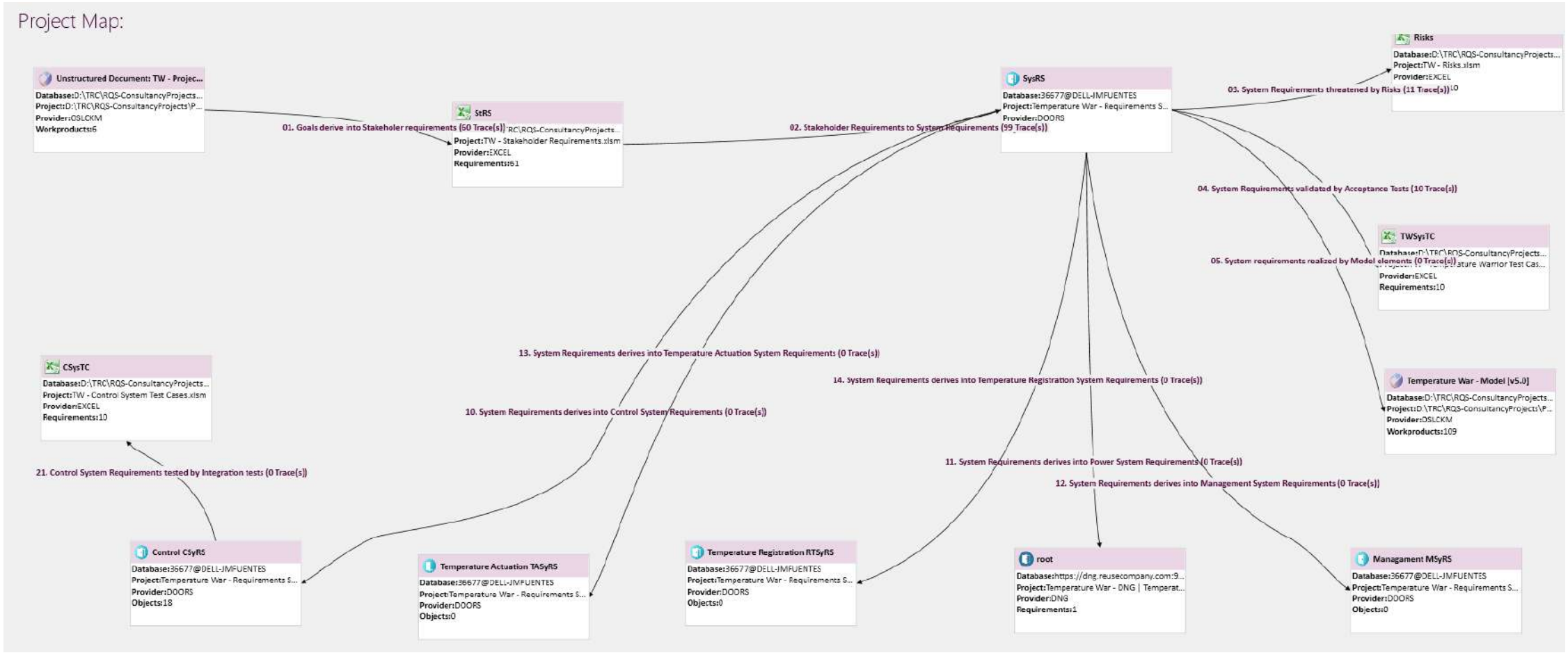
Definition of the ground truth

- Reasoning layer: understanding requirements



Ontologies and the digital thread

- Basic traceability



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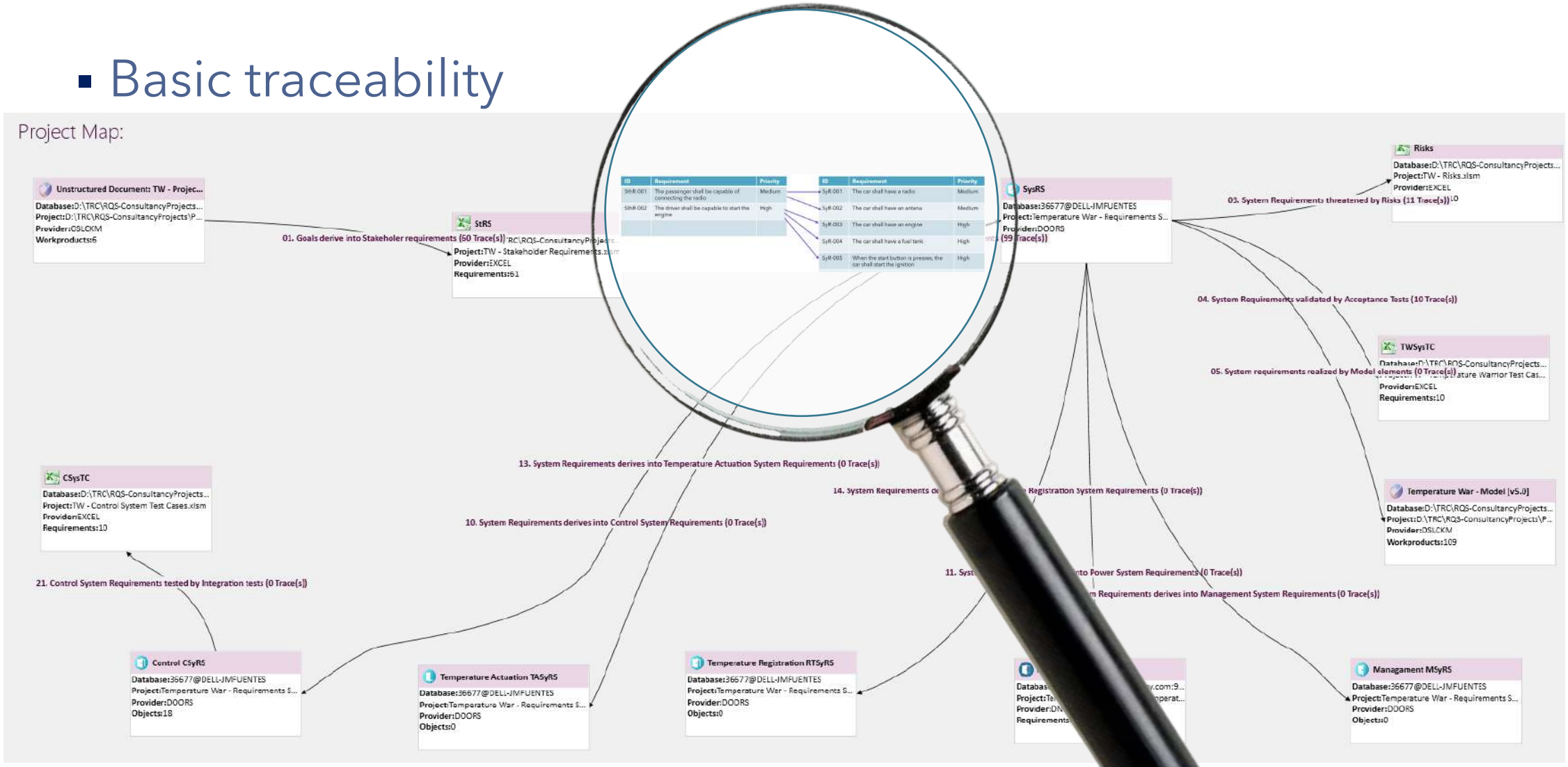
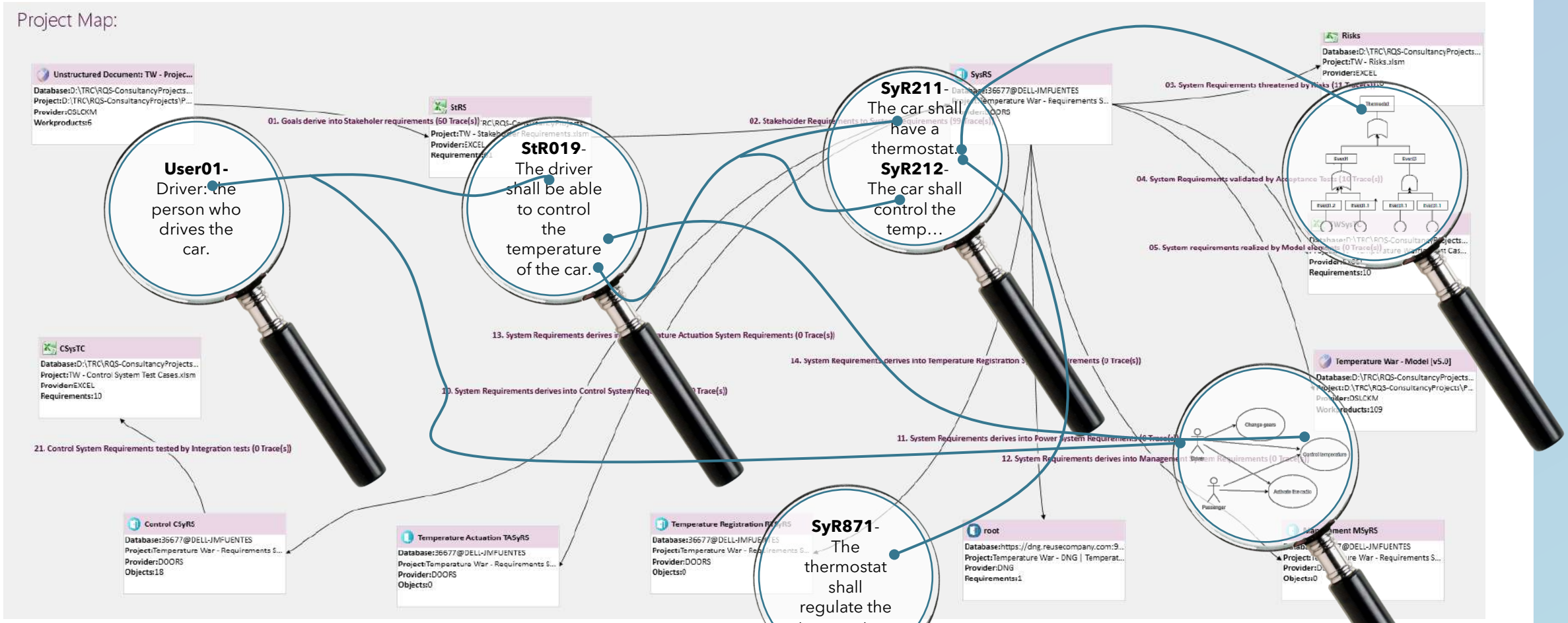


Ontologies and the digital thread

- Semantic traceability



Definition of the ground truth: conclusions

- **"The truth is in the models"**

- **"The truth is in the ontology…**

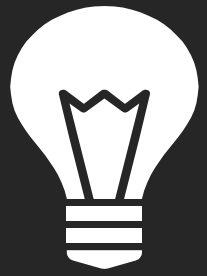
  … the ontology **gathers knowledge from the MBSE** Tools…

  … both sources of truth can be **blended in real-time**…

  … elicits knowledge also **from other textual sources**…

  … and keep **coherence** among all the work products:

  Ontologies to maintain the digital thread (allowing engineers to *sail the 'V' model*)".



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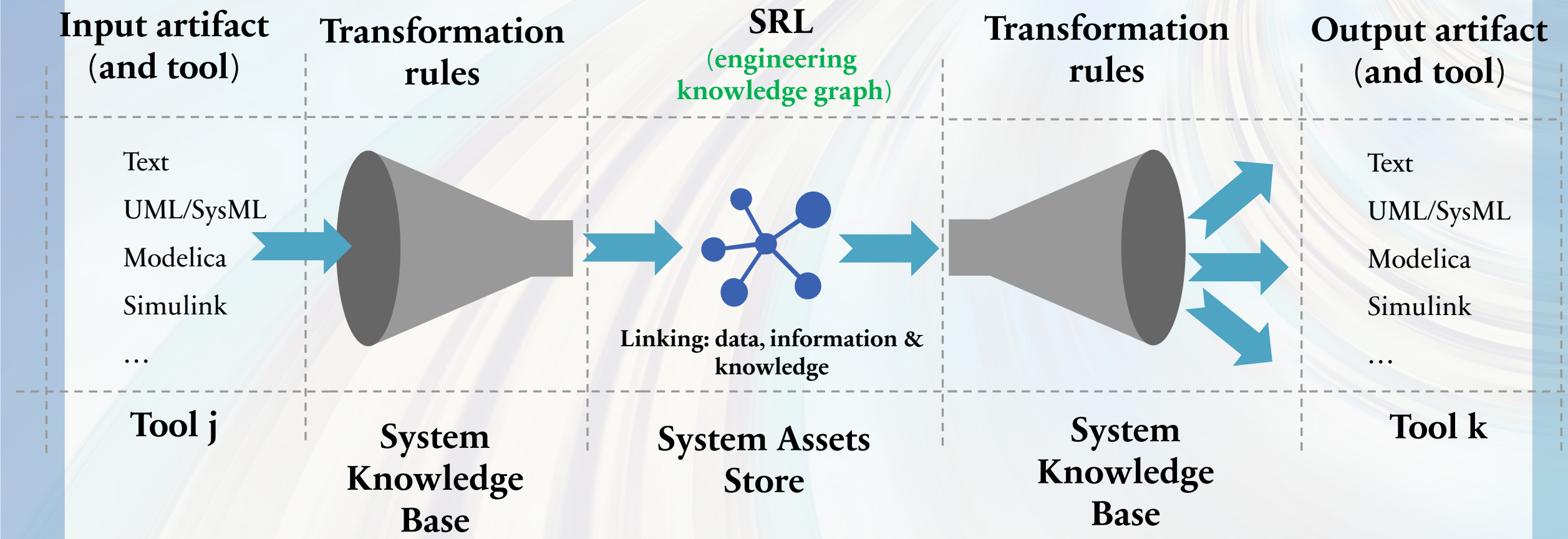
Systems engineering

User Stories

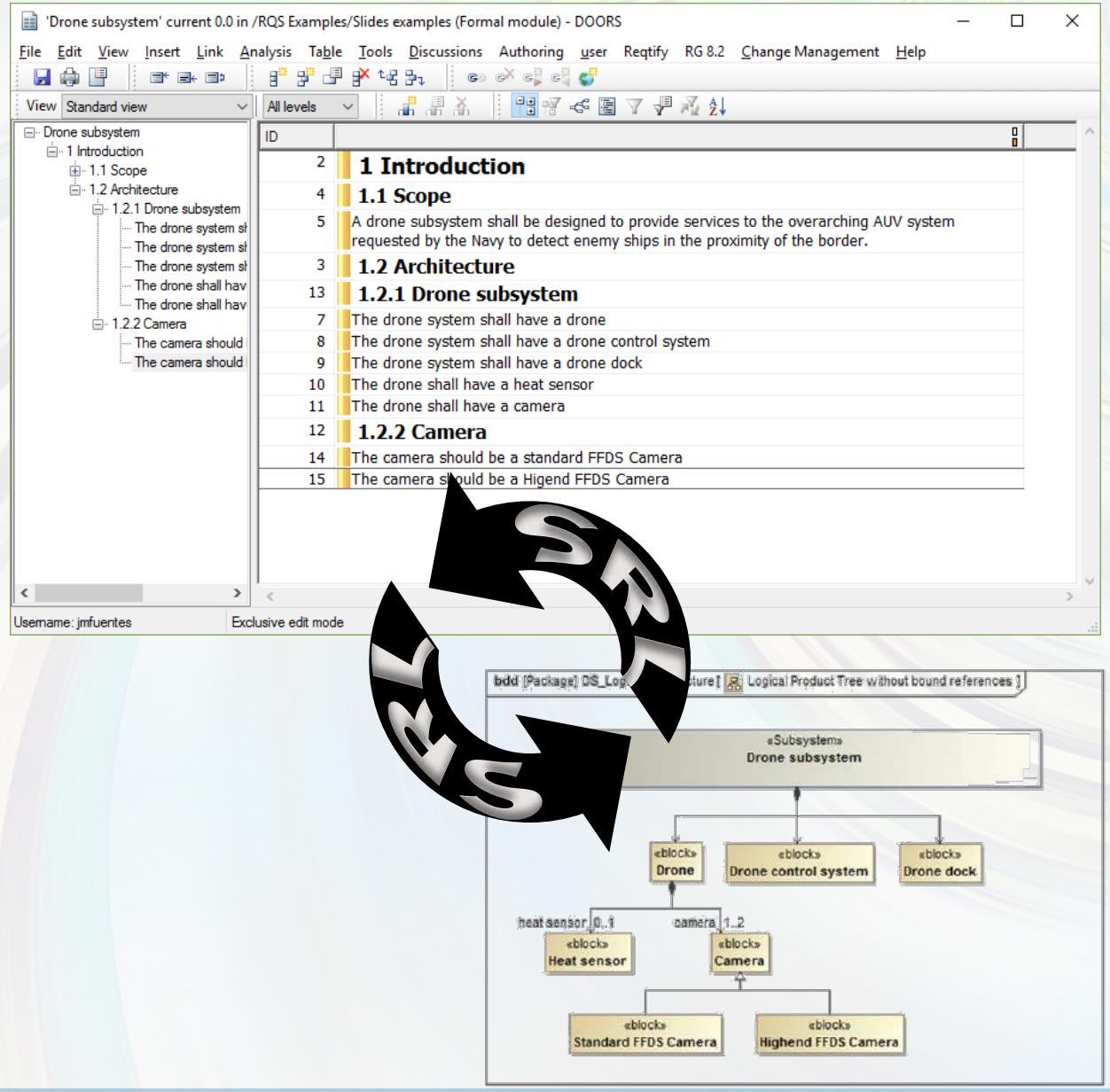
User-stories: sailing the V

- **Semantic transformations:**



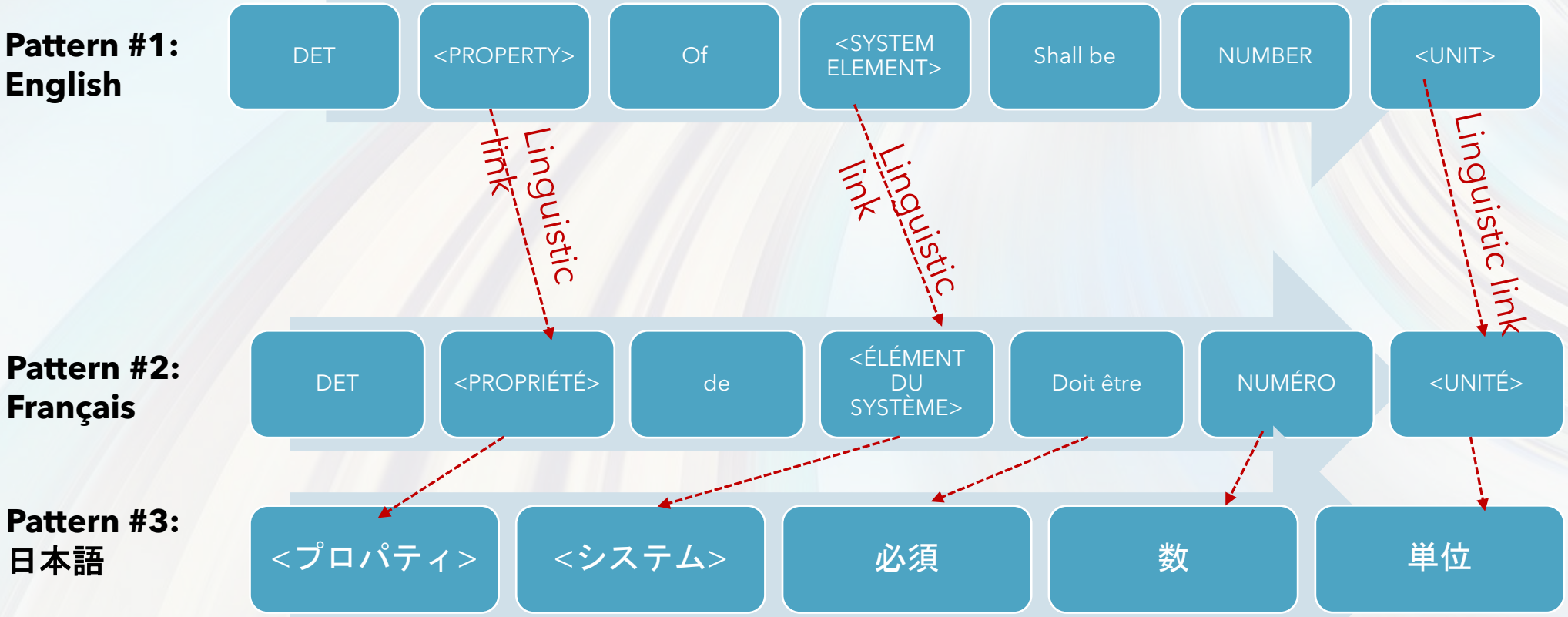
User-stories: sailing the V

- **Semantic transformations: Example #1**
- **A requirements specification produces and maintains Models during its development:**
  - **You have struggled to produce a good requirements specification.**
    - **Why shouldn't you automatically produce Models out of them?**
    - **Perhaps physical Models in Modelica?**
  - **Could I do it the other way around?**
    - **Generate Requirements from my very mature models**
  - **Could I dream with automatically tracing the models (and their elements) with the originating requirements on the fly?**



User-stories: sailing the V

- **Semantic transformations: Example #2**
  - **Based on bi-lingual dictionaries… and patterns represented in both source and target language**



Other user-stories (1/2)

- **Sailing the "V" with a SMART Compass: Requirements**

Requirements Engineering

As requirements engineer

I want to identify and extract requirements from legacy documents.

So that I can **automate** requirements population.

Requirements Engineering

As requirements engineer

I want to classify requirements automatically from legacy documents.

So that I can **speed up** the process to respond to tenders.

Requirements Engineering

As requirements engineer

I want to write requirements based on patterns and ontologies.

So that I can **improve consistency** between my requirements and other workproducts (requirements, models…)

Reuse

As domain engineer

I want to exchange information between tools, find similar system artifacts (e.g. models) and recover traces.

So that I can **reuse existing knowledge** embedded in system artifacts.

Quality

As quality manager

I want to check quality of my system artifacts: models, requirements, etc.

So that I can **ensure high-quality** artifacts from early stages of my project, thus reaching the CCC objectives.

Other user-stories (2/2)

- **Sailing the "V" with a SMART Compass: traceability and more**

Requirements Engineering

As requirements engineer

I want to trace requirements at different levels of abstraction.

So that I can **maintain** the **digital thread**.

Project Management

As project manager

I want to automatically detect missing traces.

So that I can **save time** and **not forget** any **important requirement** and **trace.**

Requirements Engineering

As requirements engineer

I want to automatically create derived or allocated requirements from higher level requirements.

So that I can **save time** and **not forget** any **important requirement** and **trace.**

MBSE & Requirements

As domain engineer

I want to populate models from requirements.

So that I can keep **consistency over time** and make my **system artifacts executable**.

Keep data links alive and consistent.

Simulation

As systems engineer

I want to have a human friendly environment for the engineering process.

So that I can share all information and data with my colleagues in **different disciplines**.

Digitalization

As systems engineer

I want to maintain a complete digital thread repository.

So that I can **successfully manage my projects** with **complete dashboards**.

This MINI presentation has shown how Artificial Intelligence, ontologies, and a semantic approach can be applied to leverage activities all along the "V" model, thus making it feasible to meet the demanding success criteria that these projects normally face.

Sailing the V with an intelligent compass: Engineering digitalization through the automatization of traceability, reuse and early quality in the development cycle.

If you want to see the full presentation, please request it here:

https://share.hsforms.com/1Q7CyaIWXSwKFGJxbqikvuQ2lpn5

If you want to book a SES Engineering Studio tools demo, please request it here:

https://www.reusecompany.com/demonstration

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