the REUSE company

Automatic Traceability between Models and Requirements

Trigger for SE Interoperability

AEIS ASOCIACIÓN ESPAÑOLA DE INGENIERÍA DE SISTEMAS
INCOSE CHAPTER ESPAÑA

INCOSE International Council on Systems Engineering

INCOSE SESE Tour
Tuesday, July 18, 2017

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Presenter's profile

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  - Board member of AEIS (INCOSE Spanish Chapter)
  - Main contributor to the INCOSE Guide for Writing Requirements
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    - Requirements WG
    - Ontology WG

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Brief description of The Reuse Company

T(he) **R**(euse) **Q**(ompany)(y)

Trace + Retrieval + Quality

Towards systematic Reuse

By means of : **Repositories** containing **Ontologies and Assets**

Model Based Systems Engineering

The present trend….

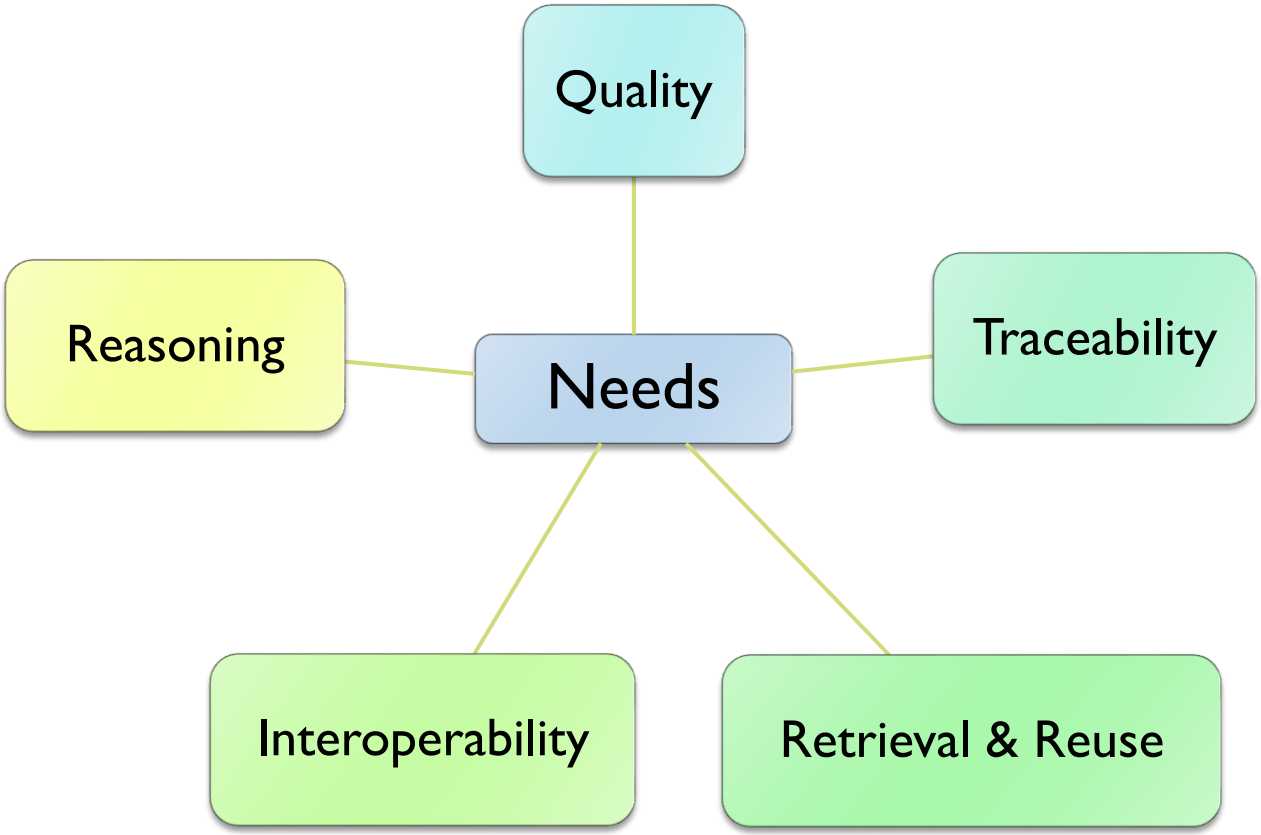
Model Based Systems Engineering (MBSE)

- "*The formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.*"

INCOSE SE Vision 2020 (INCOSE-TP-2004-004-02 September, 2007)

- Models as part of the flow information among activities and processes
- Eases traceability possibilities
- Enable computers to operate (transformations, simulations, V&V aids)

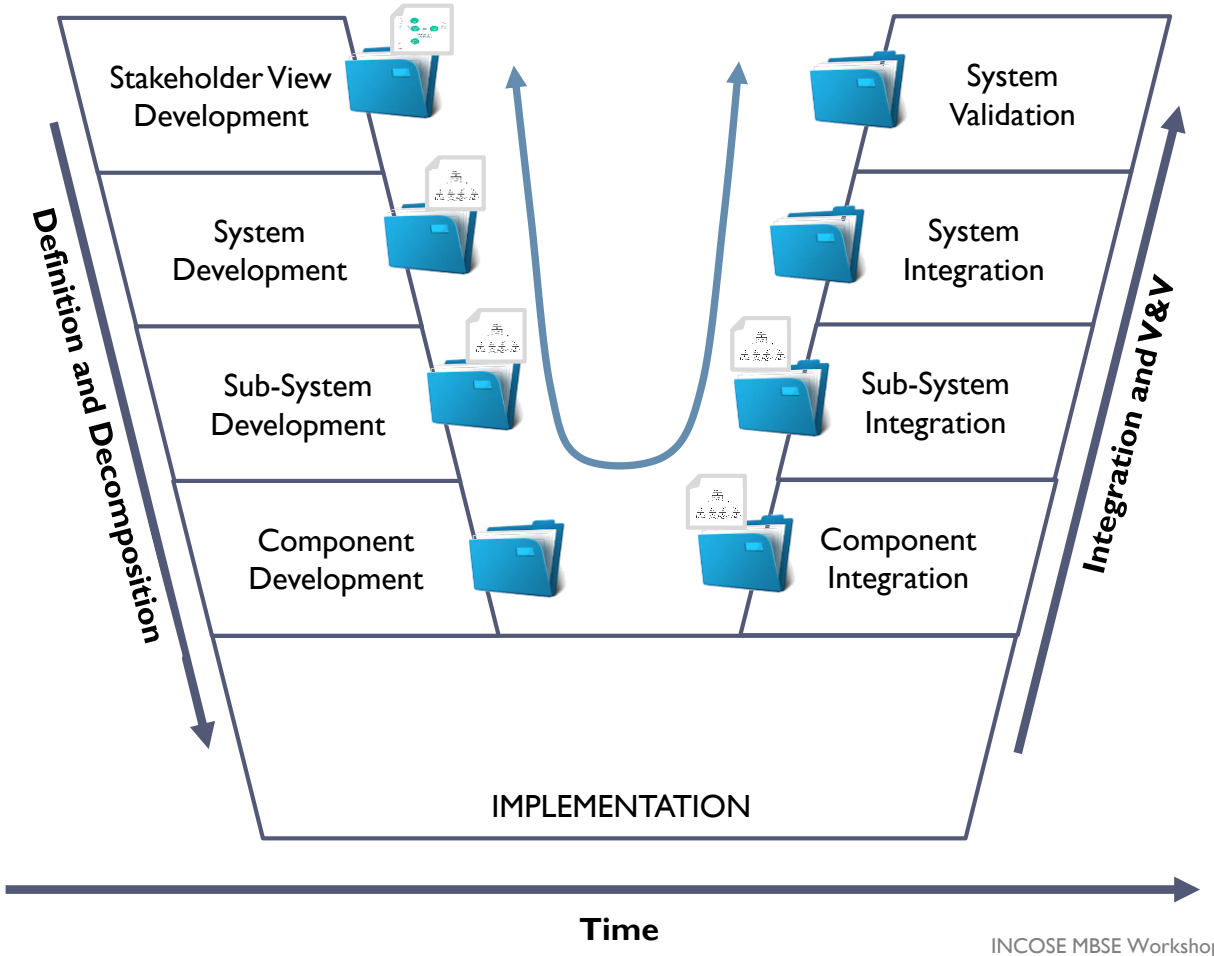
Current needs in SE



- Are these needs covered/solved/managed by MBSE?

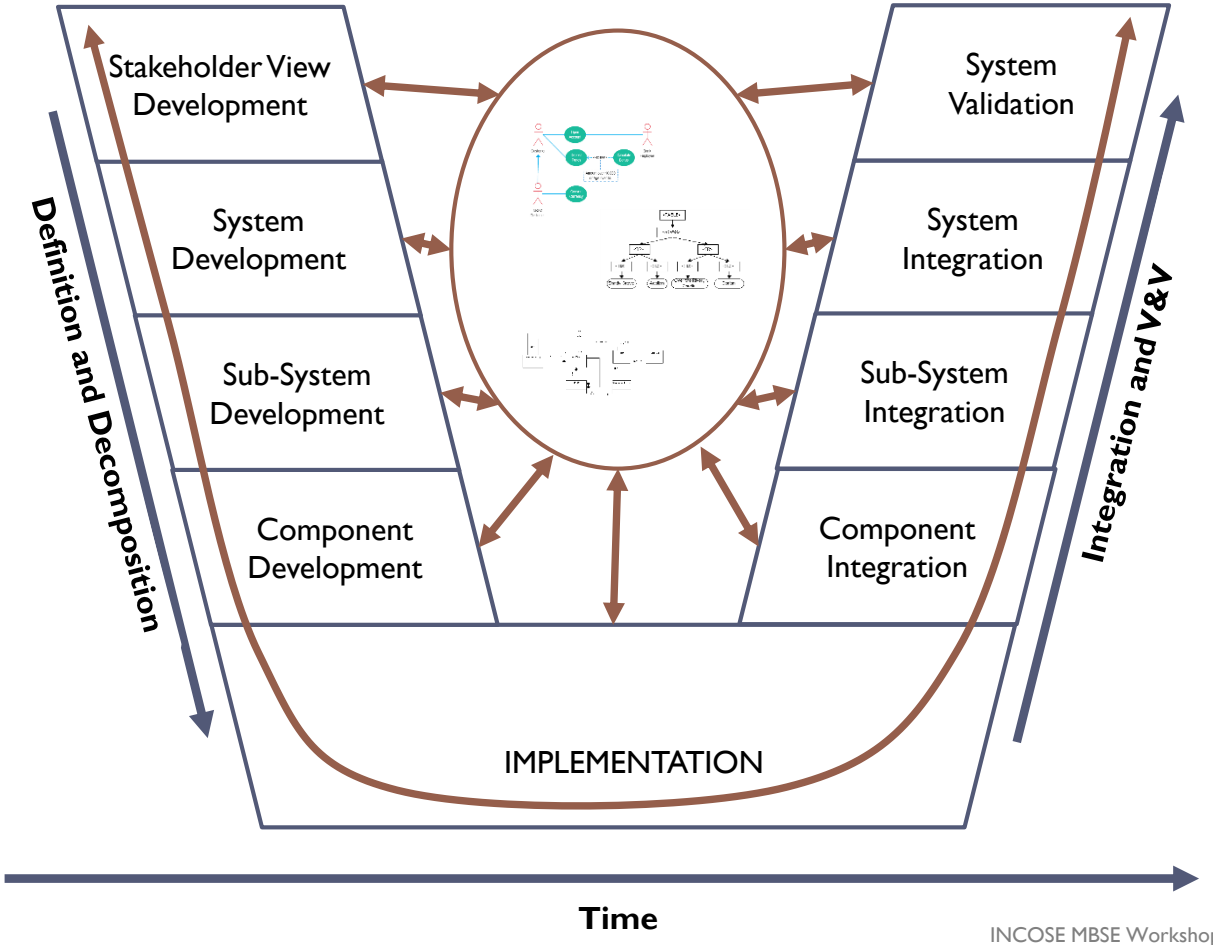
Systems Engineering – From Document Centric (DBSE)

Stand-alone models related through documents. Documents are part of configuration management systems.



…Towards Model Based (MBSE)

- MBSE: Shared system model with multiple views and connected to discipline models. Reusable model-based engineering with virtual product development and simulation capability



INCOSE MBSE Workshop, Jan 2014

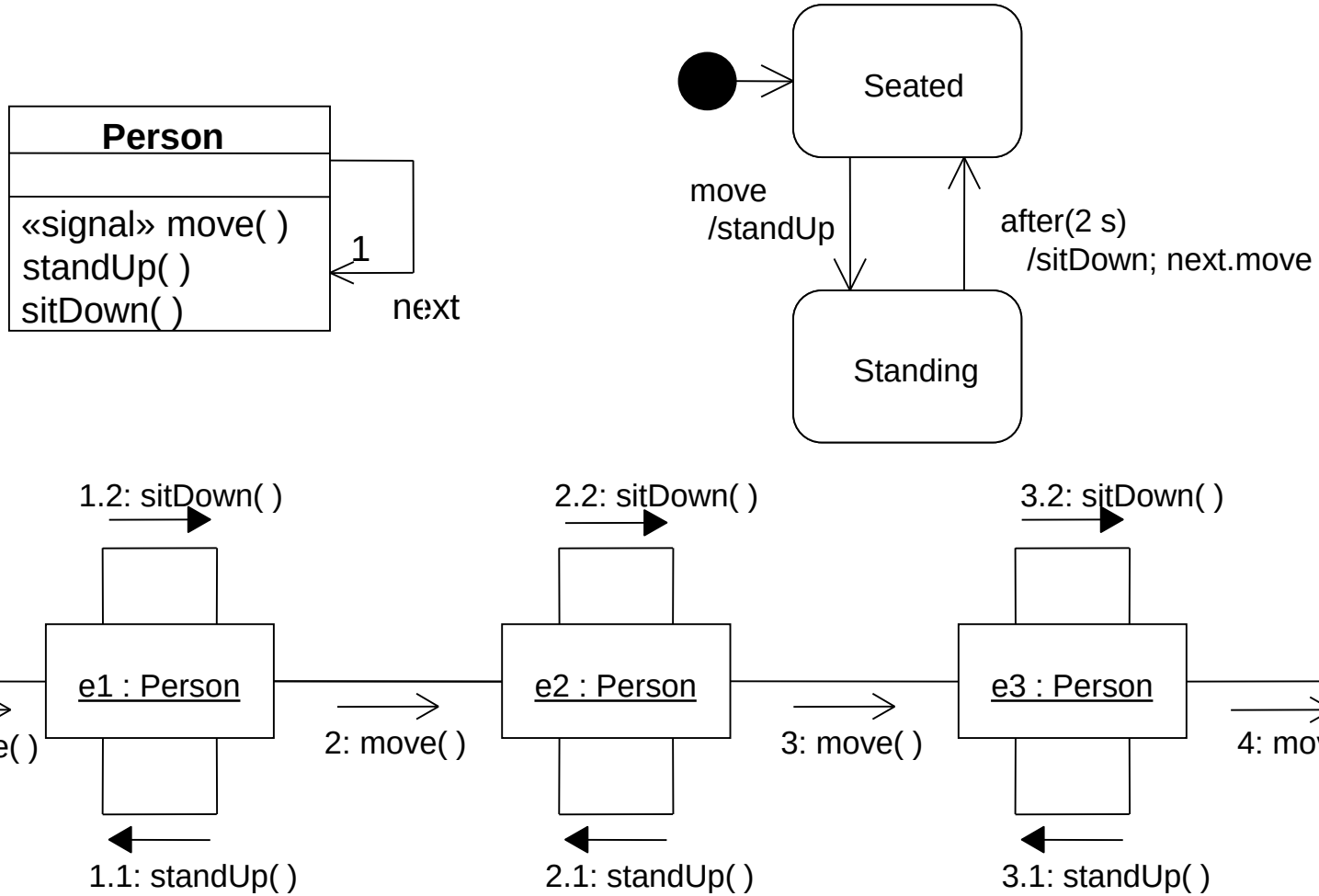
Model Based Systems Engineering (MBSE)

But…

- Requirements Specs and Mgmt.?,
- Stakeholders needs?,
- Operational Documentation?,
- Maintenance Documentation?

- Are models really useful to communicate between humans?
- Every single human?

It is clear what I want to model, right?



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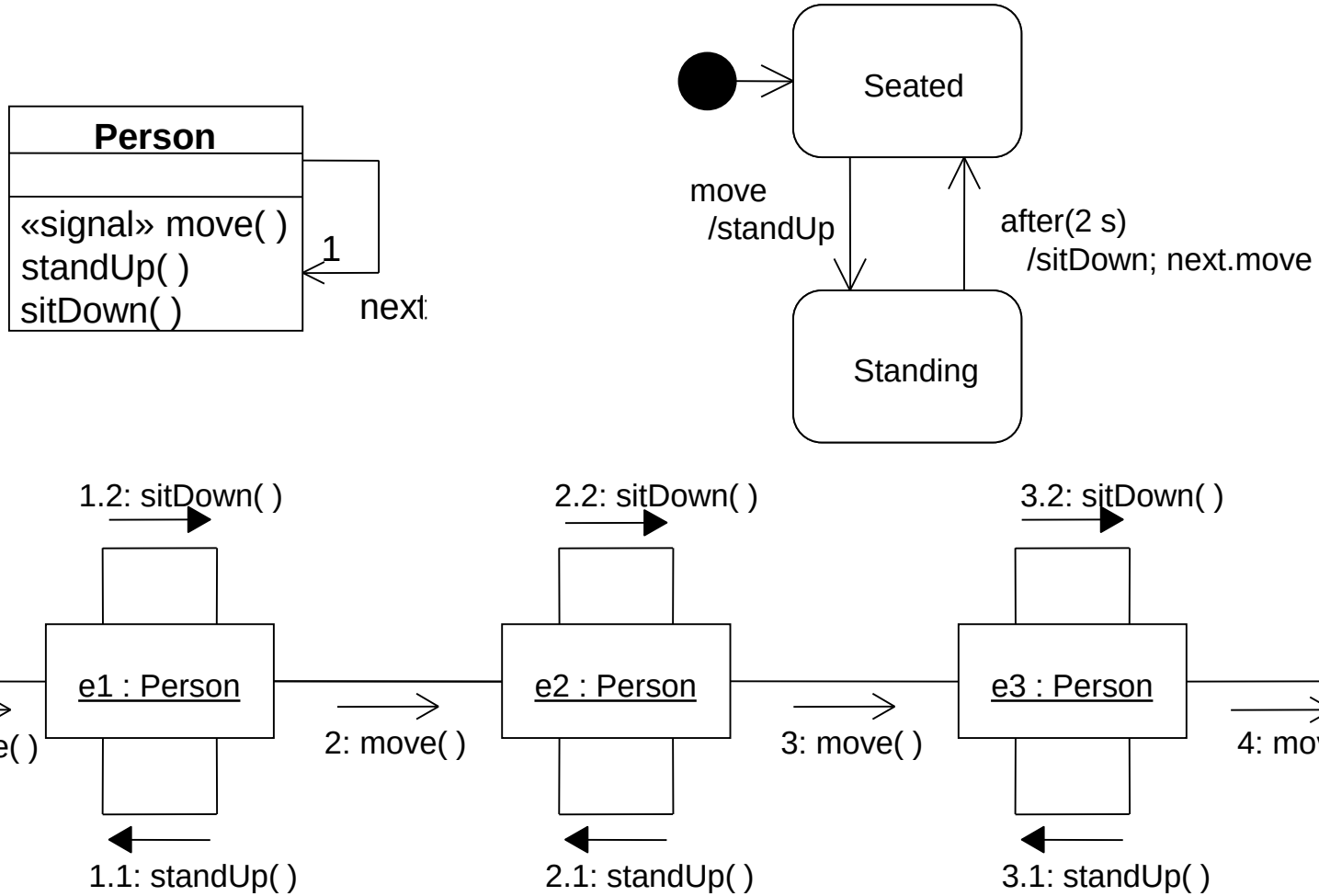

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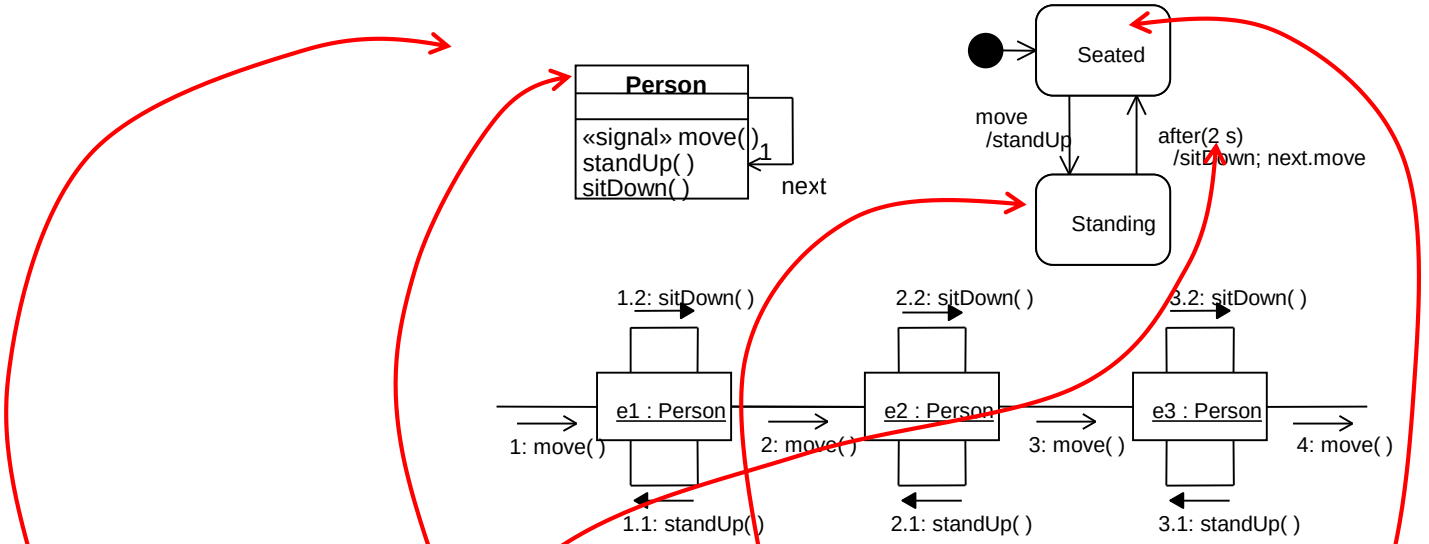
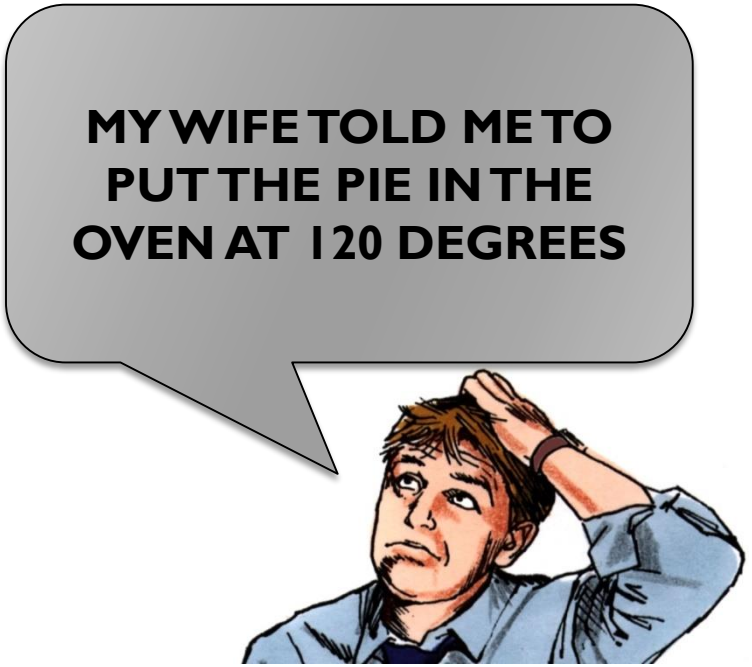


- The "WAVE" in a Stadium
  - I need a logical model for a computer to simulate what humans call "the wave" in a stadium.
  - Consider the possibility to do the wave by standing up from a sitting position.
  - I want the wave to be slow, so the person must wait a long time before (s)he sits down.

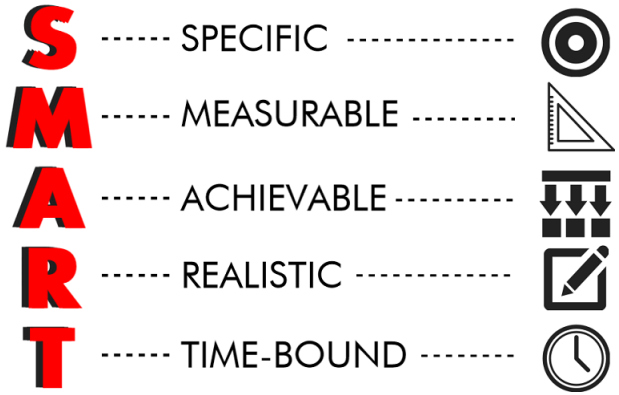
Are NL and NL Requirements the solution?

- Not really!!
- Natural Language can be really ambiguous



Are NL and NL Requirements the solution?

- High quality requirements are a MUST in Systems Engineering



Correctness

Every single requirement is correct

Completeness

The set of requirements represents a complete definition of the product (ISO 24766)

Consistency

Not a single requirement conflicts with another one in the set

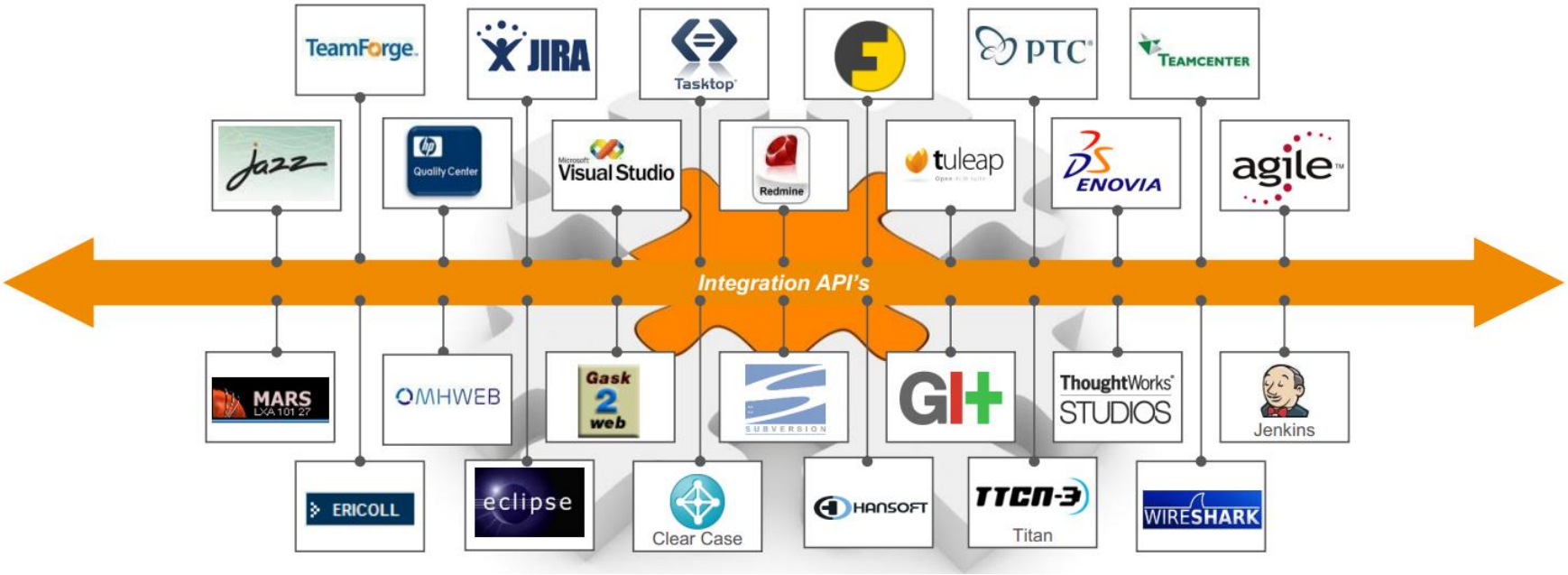
Natural Language (DBSE) vs. MBSE

- We need the best of both worlds
- … and we need to connect both worlds
- Both, for humans and also for computers
- What must be the **glue** in the middle of both worlds?

Knowledge Centric Systems Engineering

Interoperability needs

"A real engineering environment…"



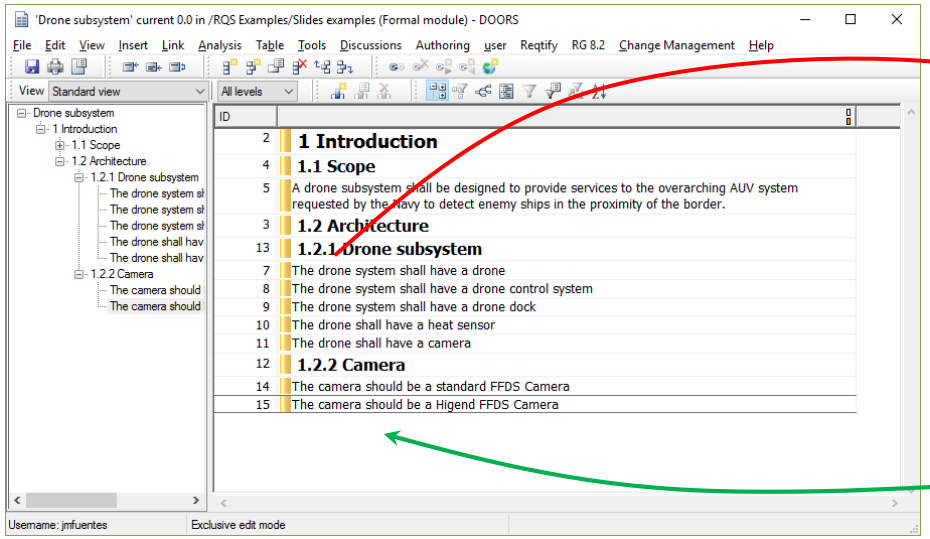
Mats Berglund (Ericsson) http://www.ices.kth.se/upload/events/13/84404189f85d41a6a7d1cafd0db4ee80.pdf

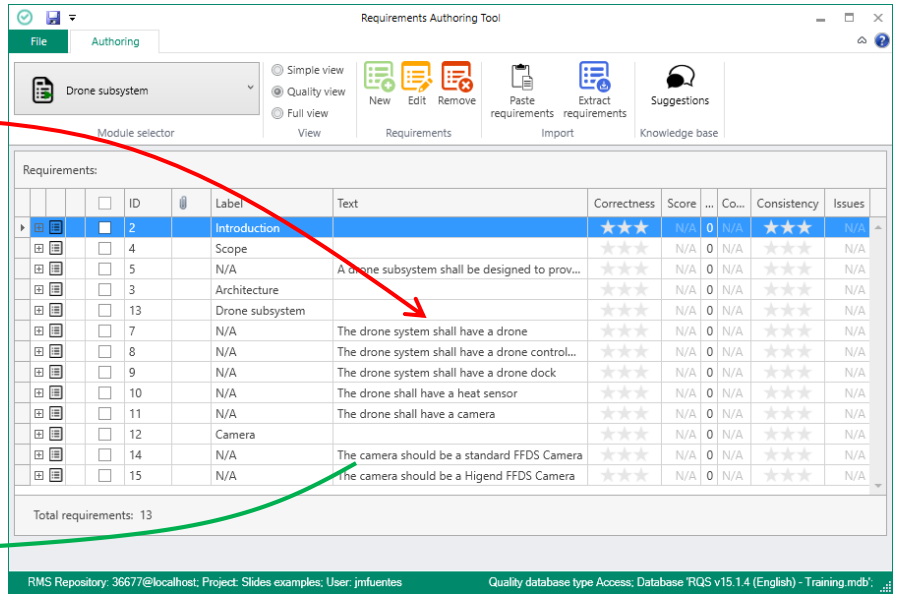
- Multiple **domains**
  - Different **types of artifacts**
- Need of **intra-operability**
  - Intra-domain
- Need of **interoperability**
  - Inter-domain

Interoperability

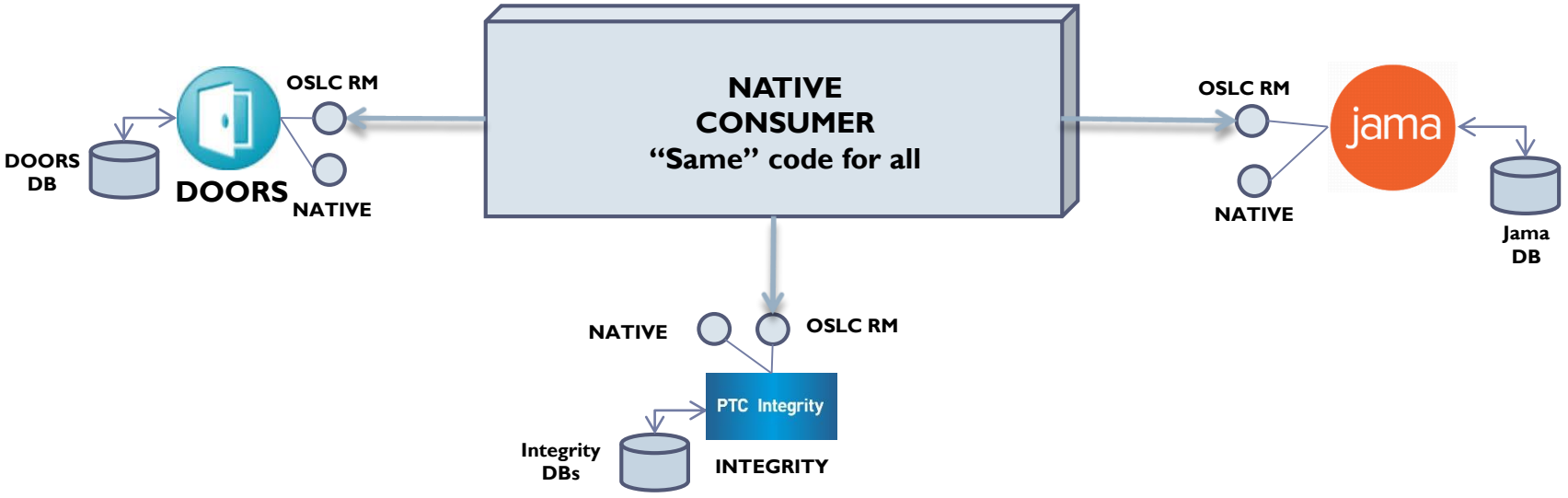
Open Services for Life-cycle Collaboration (OSLC)
Standard for the Exchange of Product model data (STEP) - ISO 10303
Other

Interoperability (or **intra**-operability)

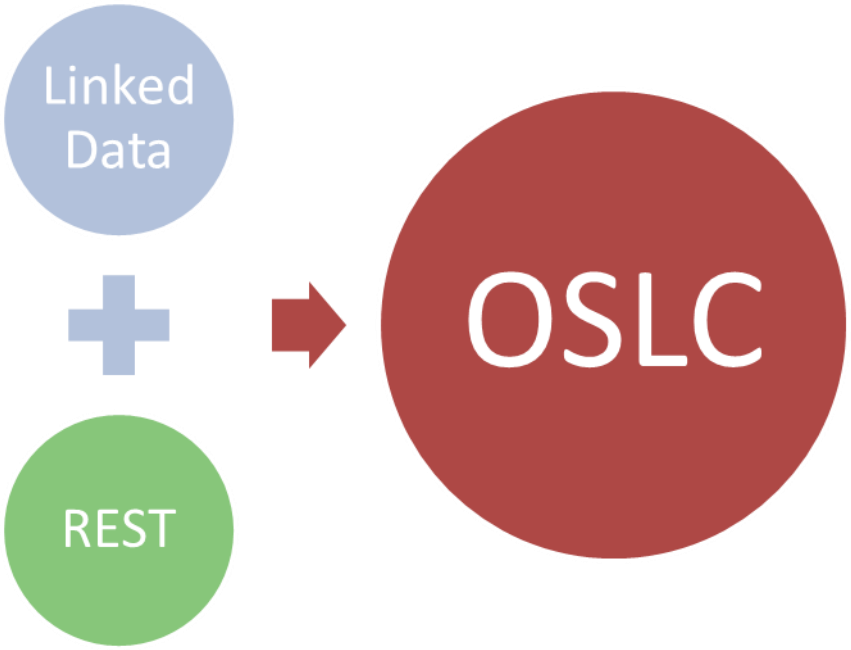


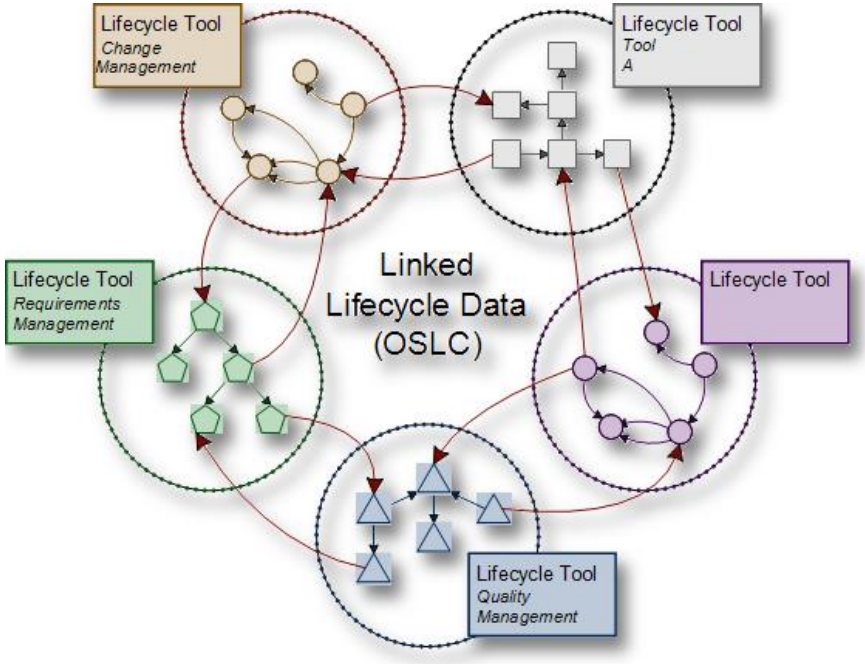


Example: Access to all-kinds work-products content



Open Services for Lifecycle Collaboration (OSLC)





Source: http://upload.wikimedia.org/wikipedia/en/7/7e/OSLC_diagram.png

OSLC Building blocks (keywords)

REST Architect.
- Resource-oriented

RDF (graph data model)

Linked Data

Serialization
- RDF/XML & JSON

Service Provider

Resource Shape

Query Capability

Configuration Management

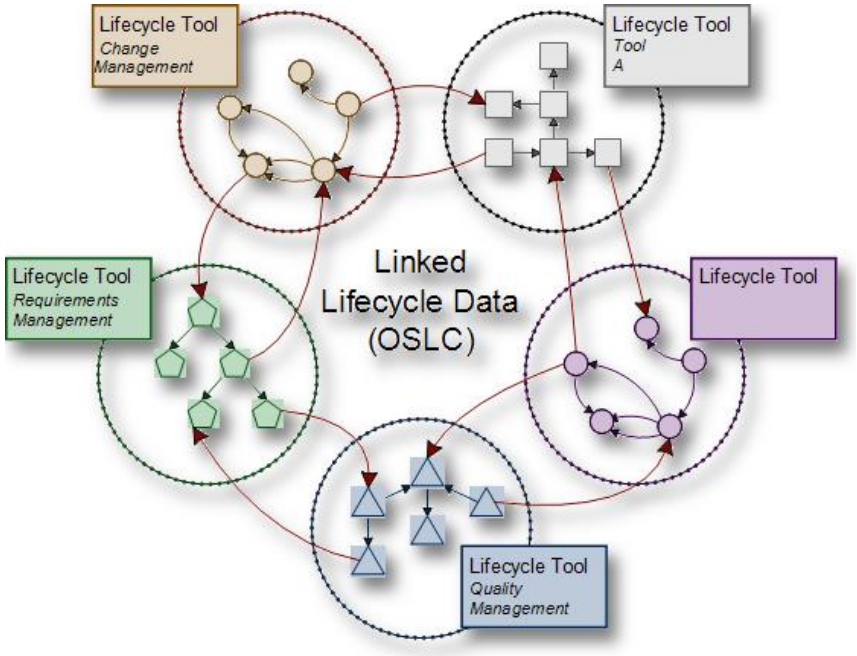
Delegated User Interface

Authentication
- OAUTH 2.0

Resource
- Collection

Intra-operability-OSLC

Open Services for Life-cycle Collaboration



OSLC resource to OSLC resource

Individual problem solving

http://www.oasis-oslc.org/

Eg: OSLC – Requirements Management – Resource Shape

Prefixed Name	Occurs	Read-only	Value-type	Representation	Range	Description
OSLC Core: Common Properties						
dcterms:title	exactly-one	unspecified	XMLLiteral	n/a	n/a	Title (reference: Dublin Core) of the resource represented as rich text in XHTML content. **SHOULD** include only content that is valid inside an XHTML element.
dcterms:description	zero-or-one	unspecified	XMLLiteral	n/a	n/a	Descriptive text (reference: Dublin Core) about resource represented as rich text in XHTML content. **SHOULD** include only content that is valid and suitable inside an XHTML element.
dcterms:identifier	zero-or-one	True	String	n/a	n/a	An identifier for a resource. This identifier may be unique with a scope that is defined by the RM provider. Assigned by the service provider when a resource is created. Not intended for end-user display.
oslc:shortTitle	zero-or-one	unspecified	XMLLiteral	n/a	n/a	Short name identifying a resource, often used as an abbreviated identifier for presentation to end-users. **SHOULD** include only content that is valid inside an XHTML element.
dcterms:subject	zero-or-many	False	String	n/a	n/a	Tag or keyword for a resource. Each occurrence of a dcterms:subject property denotes an additional tag for the resource.

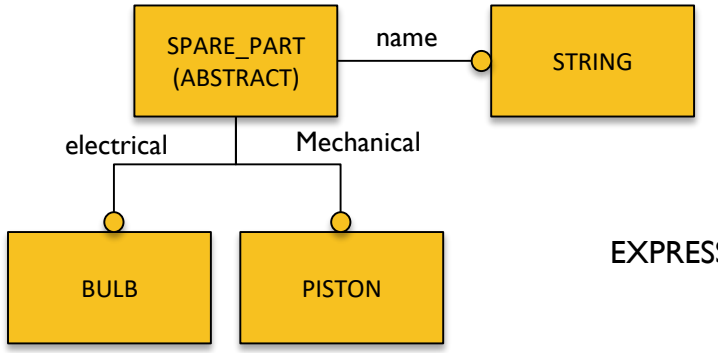
http://open-services.net/bin/view/Main/RmSpecificationV2#Resource_Requirement

STEP – ISO 10303

- STEP Schema:
  - Information model written in EXPRESS
- EXPRESS:
  - STEP's data definition language
- EXPRESS-G:
  - Graphical form of EXPRESS
- STEP File:
  - Populated STEP Schema
- Application Protocol (AP):
  - Implementable portion of STEP. S Schema for particular application.

STEP – ISO 10303

```
SCHEMA PBS
 ENTITY Spare_Part
  ABSTRACT SUPERTYPE OF (ONEOF (Gear_Shift, Piston));
   Name: STRING;
   electrical OPTIONAL Bulb
   Mechanical OPTIONAL Piston
 END_ENTITY;
 ENTITY Bulb
   SUBTYPE OF (Spare_Part);
 END_ENTITY;
 ENTITY Piston
   SUBTYPE OF (Spare_Part);
 END_ENTITY;
END_SCHEMA;
```

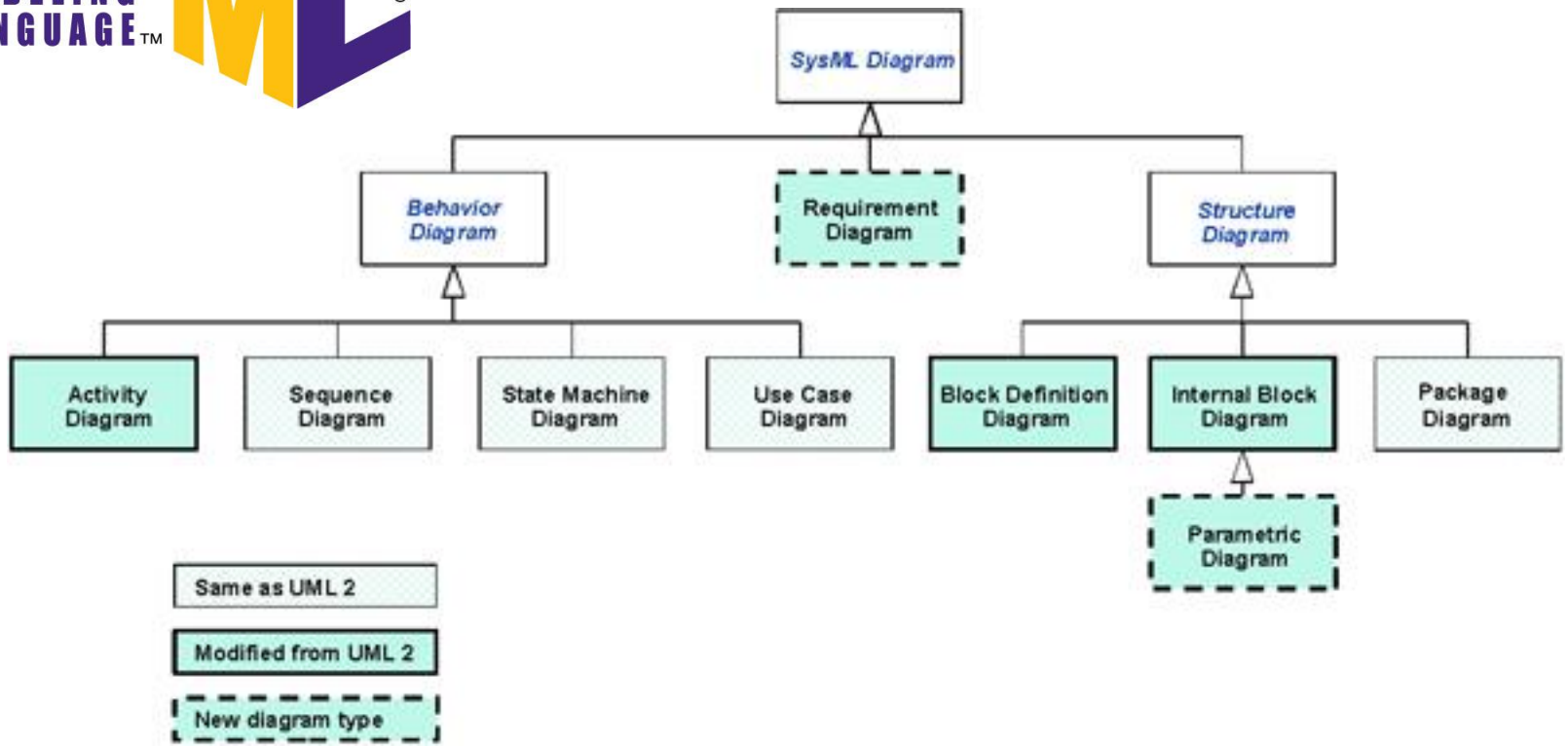


EXPRESS-G

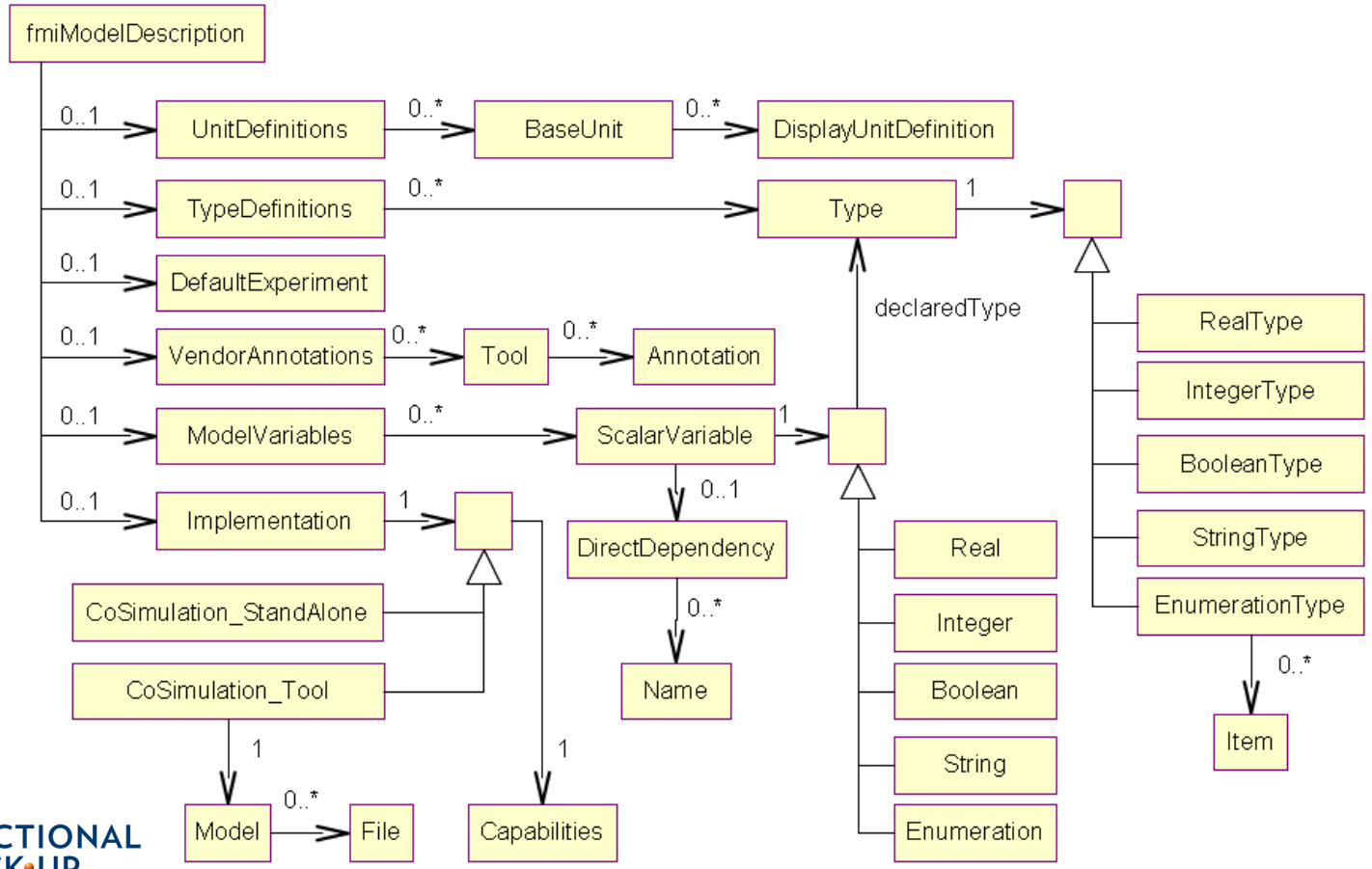
-- EXPRESS --

SysML – Interoperability at Logical (Architectural) Level

OMG SYSTEMS MODELING LANGUAGE™



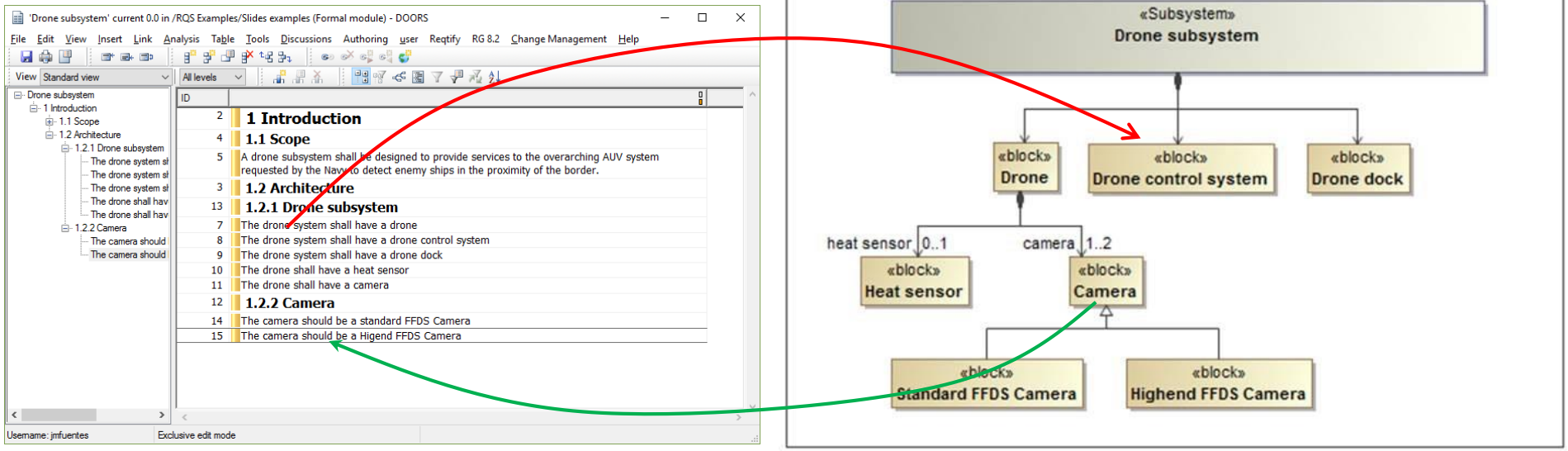
FMI/FMU – Interoperability at Physical (Mathematical) Level



FUNCTIONAL MOCK-UP INTERFACE

https://resources.qtronic.de/fmusdk/FmuSdk_reference.html

So, if our problem is…

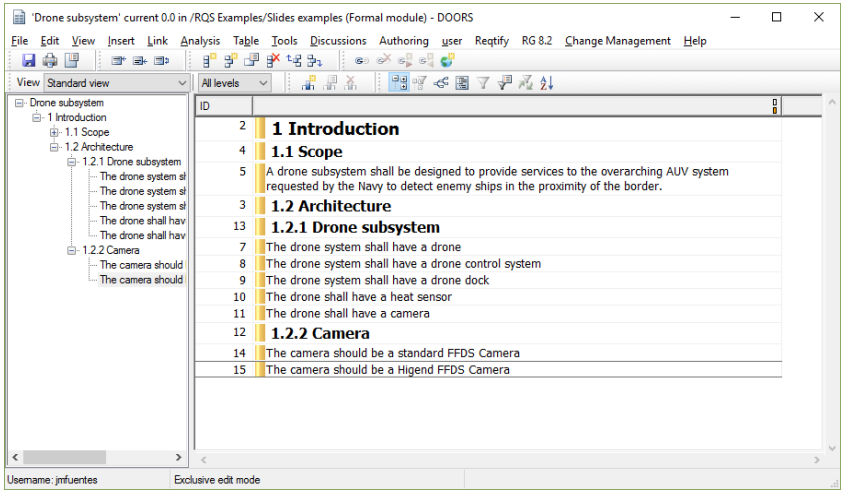


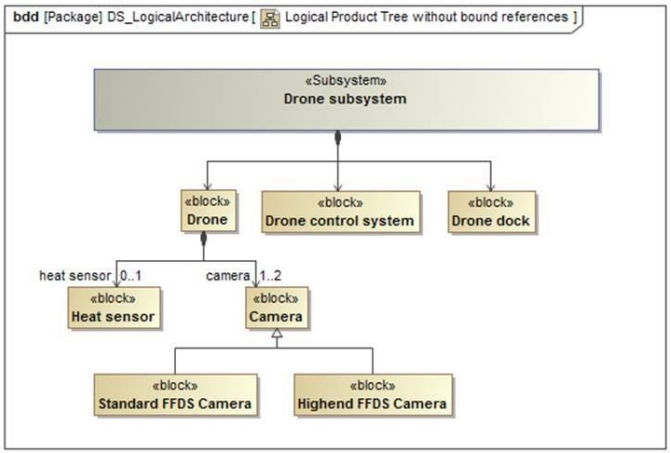
- Need for real **inter**operability implies a common way to represent inter domain knowledge

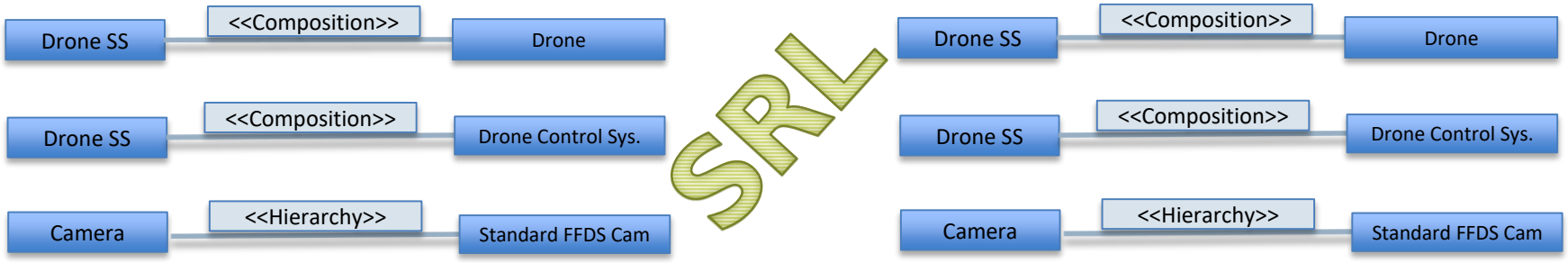
Knowledge Centric Systems Engineering (KCSE)

The need of a common language
- System Representation Language (SRL) -

Means to solution: Need for Inter (and not Intra) Operability



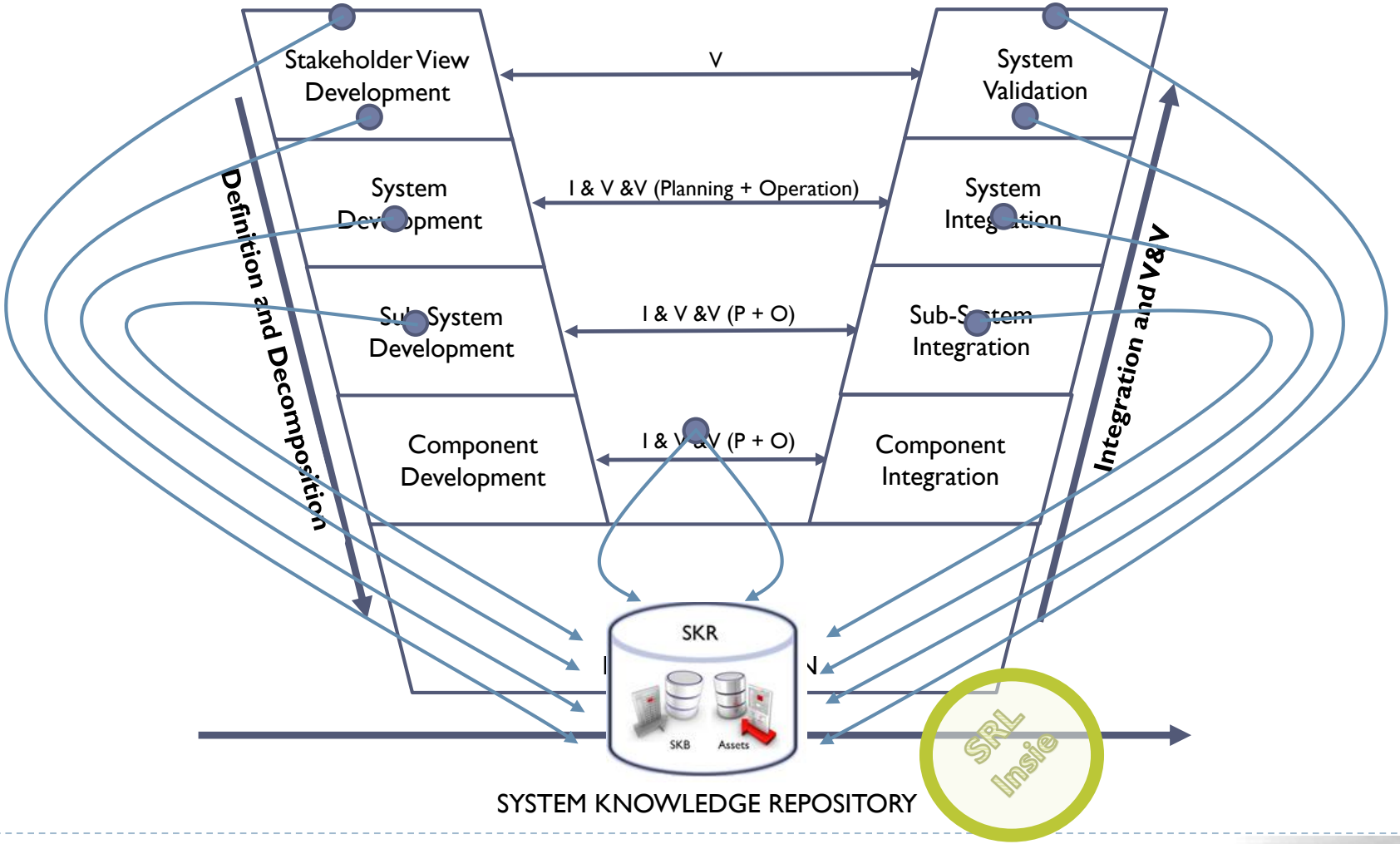




- Define a common language to represent Requirements and Models

The GOAL

MBSE must smoothly integrate formal and structured information with fuzzy, flexible and necessary unstructured information in a knowledge centric approach

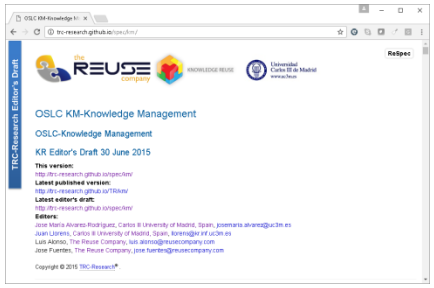


SRL

System Representation Language

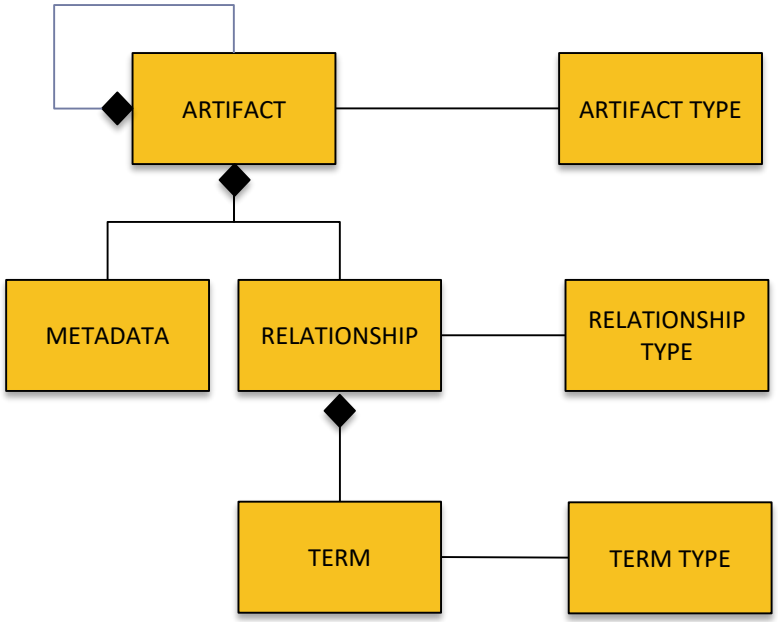
New **Domain**

New **Resource Shape**

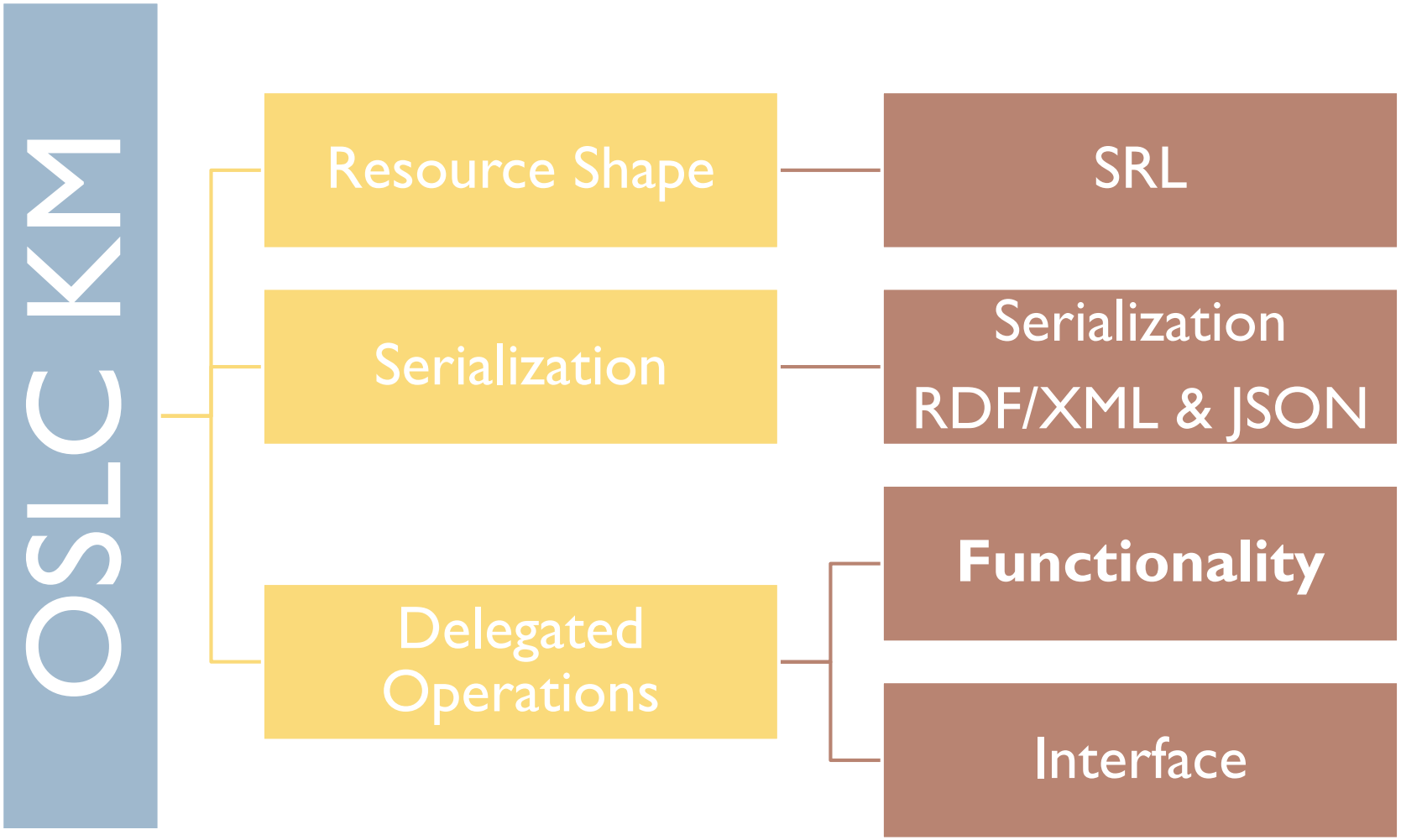


http://trc-research.github.io/spec/km/

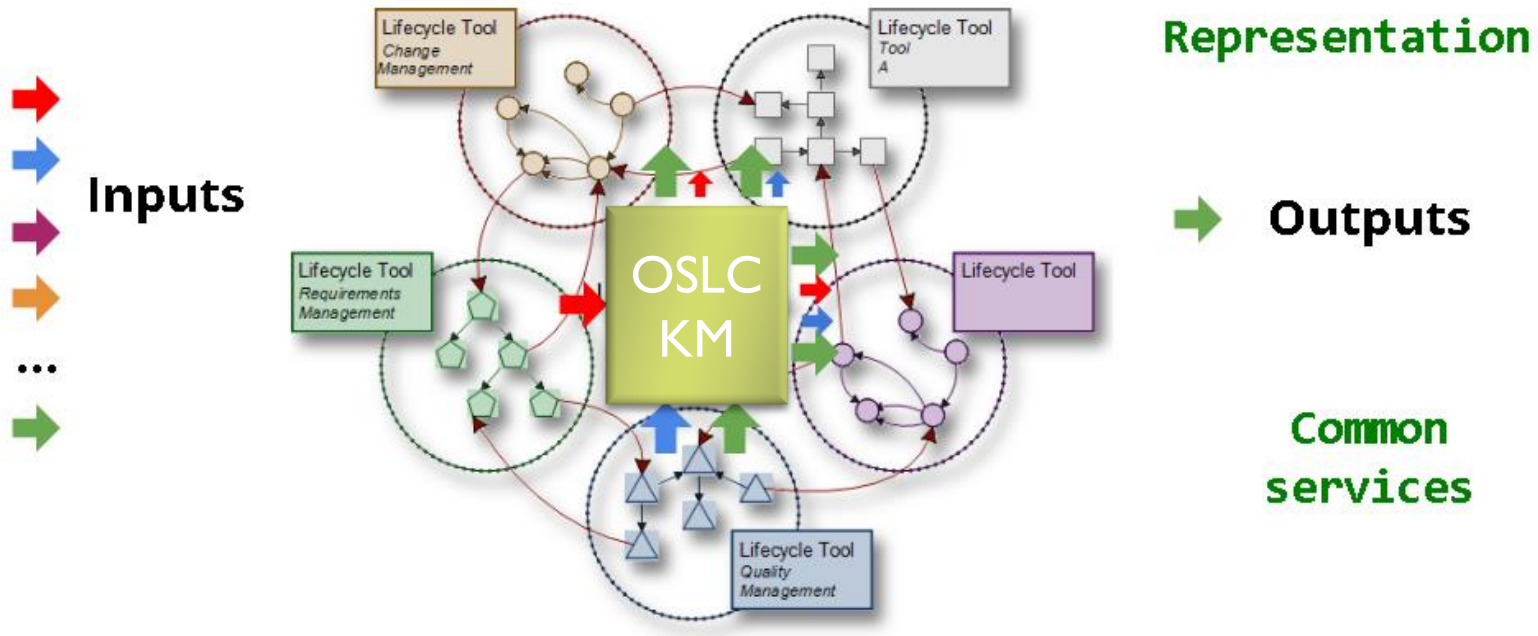
System Representation Language (SRL) – Ground Metamodel



The approach…



Interoperability with OSLC KM

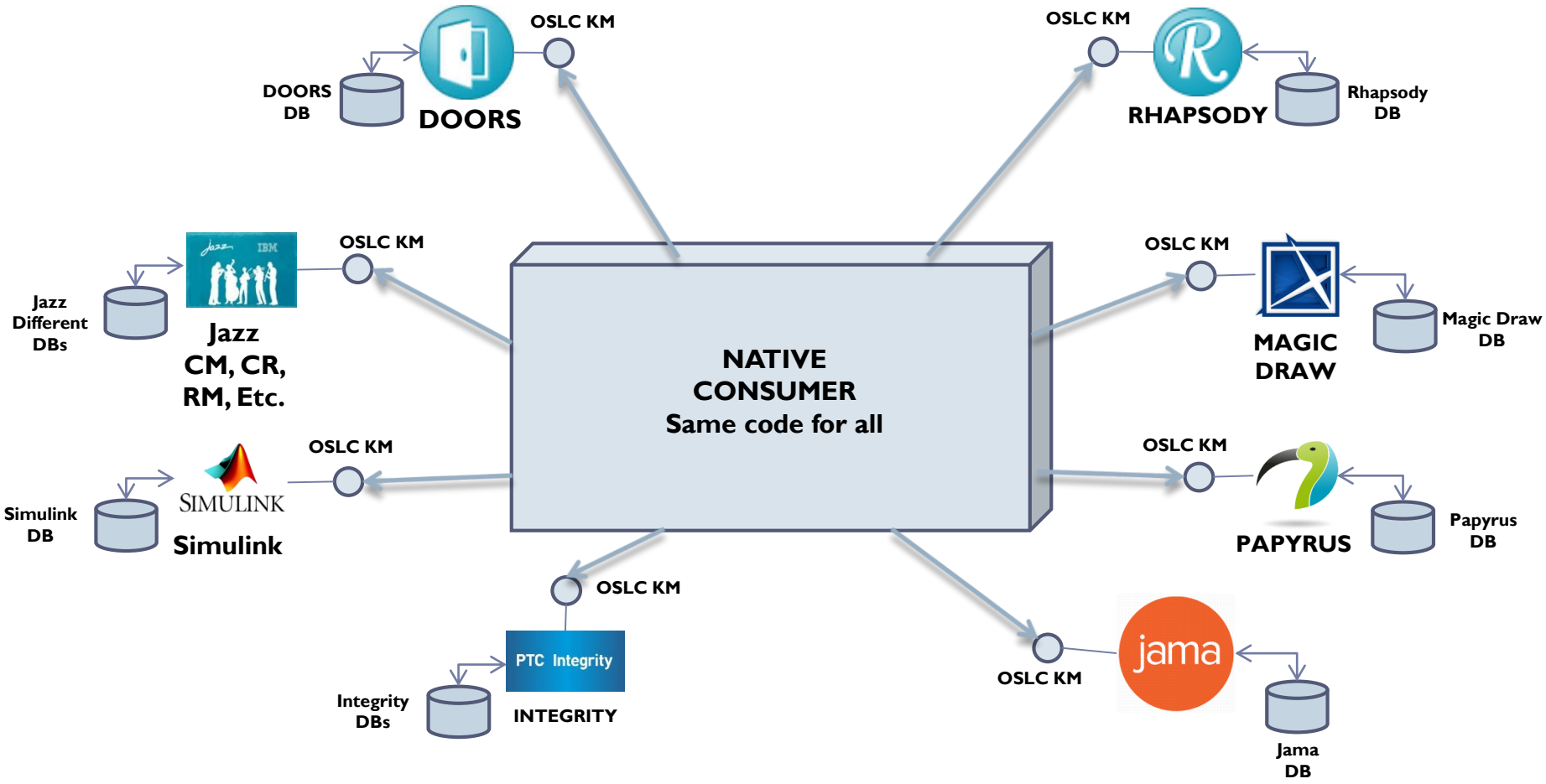


Benefits of a common language within all the SE processes and activities

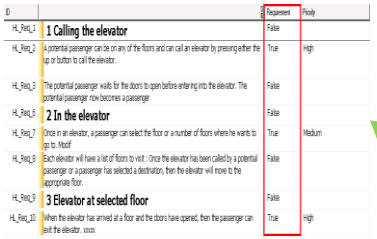
- The common language for communication purposes
  - Not specifically needed for humans to communicate (we use and will use Natural language)
  - Specifically needed for computers to communicate
  - The computers only have to "understand" one ADDITIONAL language besides the native representation language used in every different artifact (as we humans want to do)

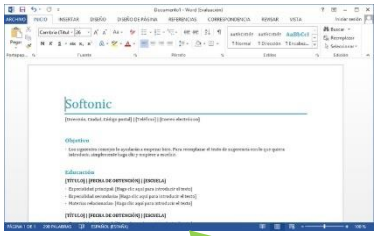
"One *language* to understand them all; one language to interoperate them all"

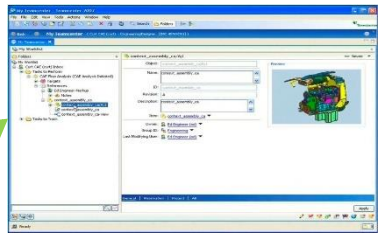
Example : Access to all-kinds work-products content

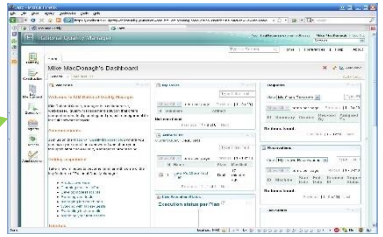


Ideal tool interoperability using OSLC KM

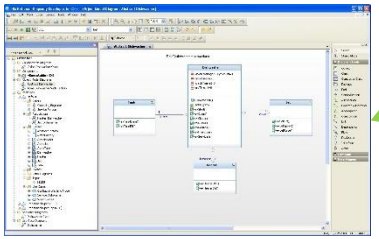


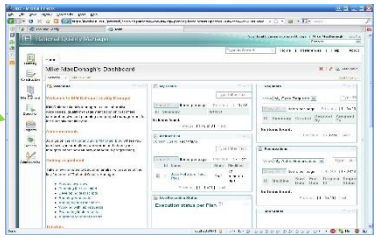


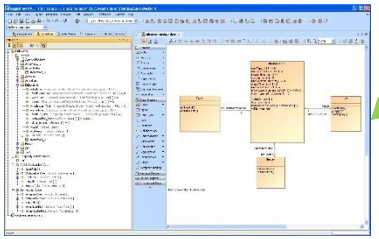


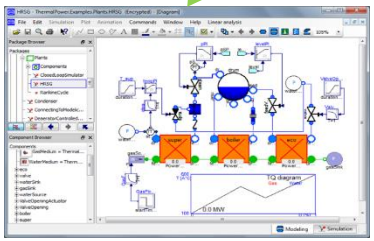


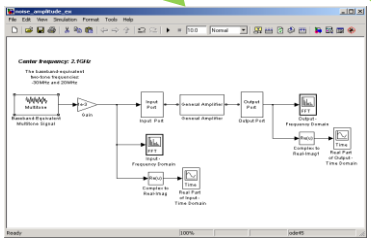
NATIVE CONSUMER
Same code for all

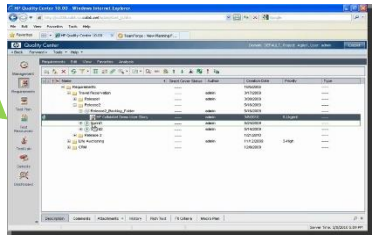












Case Study

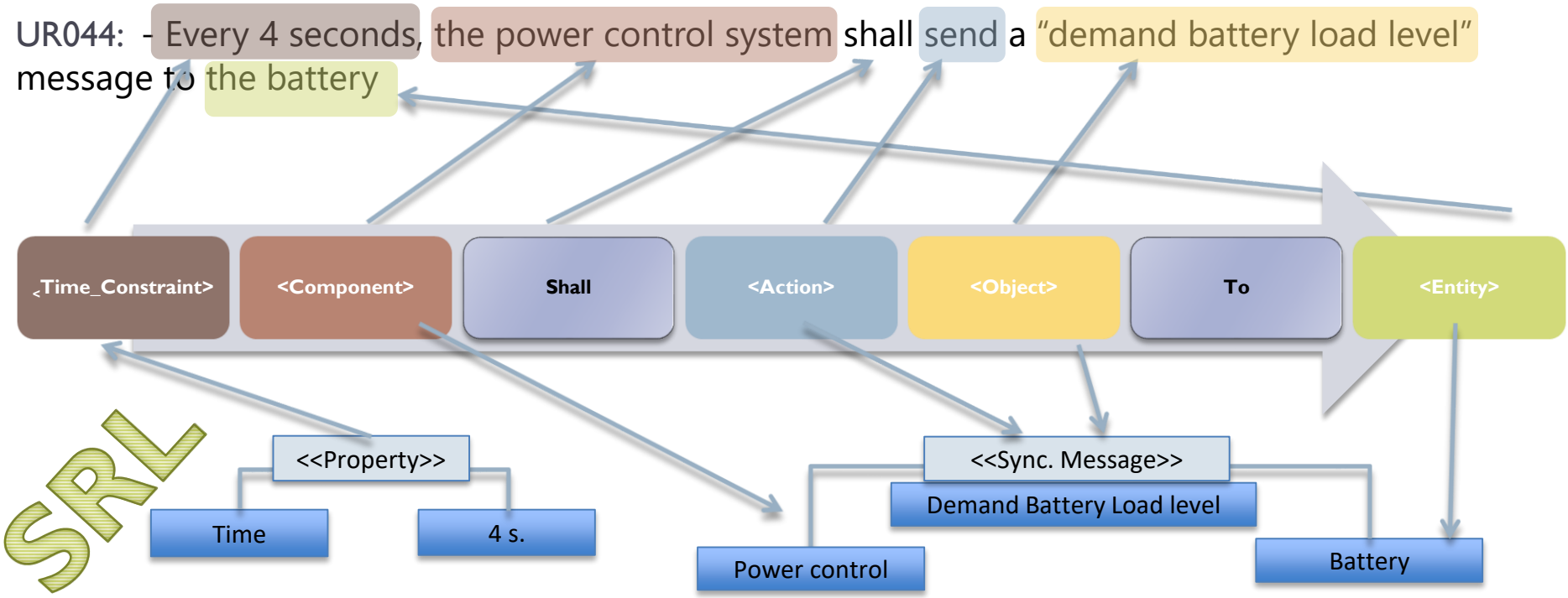
Automatic Traceability between Requirements and Models

Requirements Side:

Representing Requirements (Natural Language) in SRL

Basics: Formalization of Requirements Statements

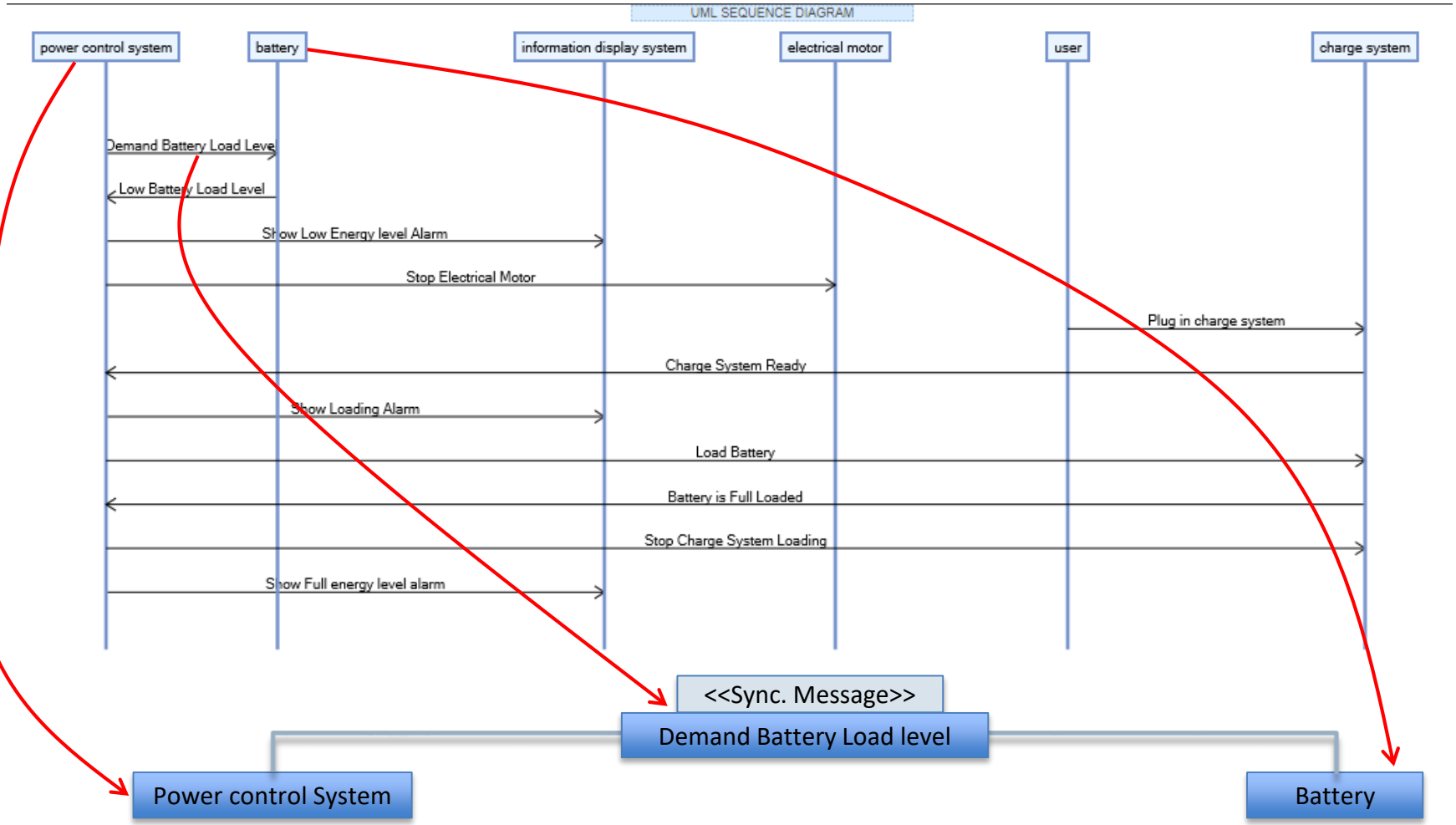
- Necessary IT solutions that attempt to represent and formalize Requirements as Conceptual Graphs
- Using Ontologies and Requirements Patterns



Models Side:

Representing Sequence Diagrams in SRL

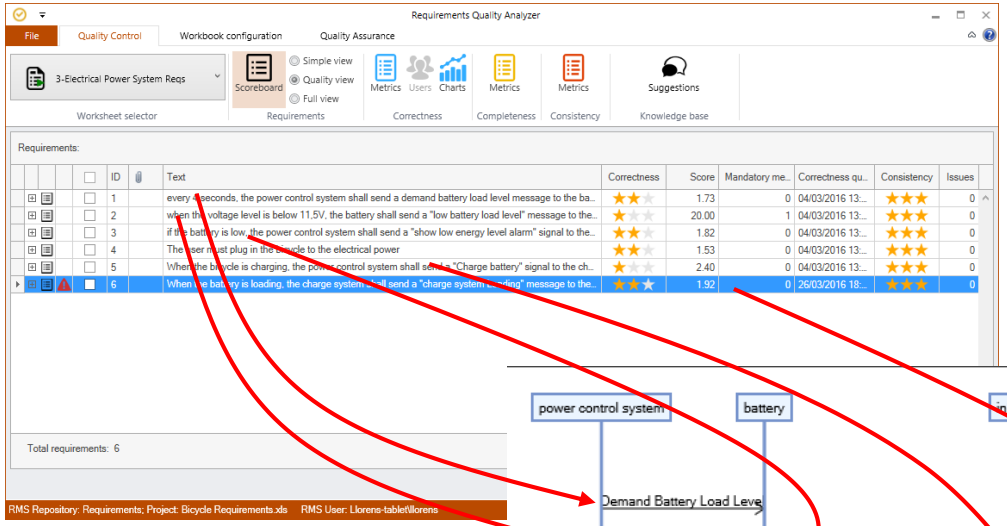
Structured Information -> SRL: a Straightforward transformation



Knowledge Centric Systems Engineering

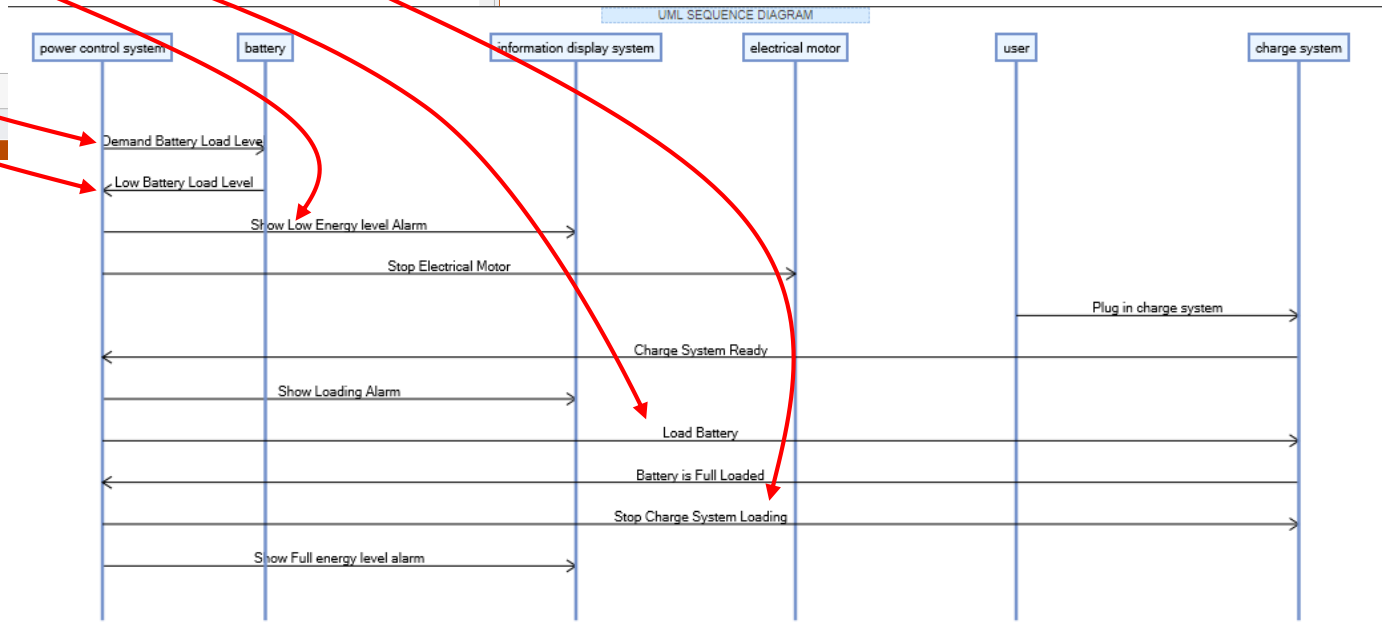
Traceability

Automatic Traceability between Models and Requirements



Matches requirements with relationships between elements of whatever model

Checks if the requirements specification covers all the relationships in the model, or the contrary.



Resolved at SRL Level

4-Traceability KPI (KPP)

- (In)-Completeness of Requirements specs against models
  - This metric compares the number of Relationship that are extracted from the requirements specification (through requirements patterns formalizations) with the Relationships that are extracted from a set of models accessed by OSLC KM
  - Returns a % value (from 0 to 1) representing the coverage ratio:

$$Ratio = \frac{\text{Relationships found in the selected Model(s) that are } \textbf{not} \text{ found in the Requirements Specification}}{\text{All relationships found in the selected Model(s)}}$$

0 = 0% = nothing in the model(s) is missing in the Spec

1 = 100% = everything represented in the model(s) is missing in the Spec

4-Models-Content Coverage Example: Requirements Spec

- Every 4 seconds, the power control system shall send a “demand battery load level” message to the battery

- When the voltage level is below 11,5V, the battery shall send a "low battery load level" message to the power control system.

- If the battery is low, the power control system shall send a "show low energy level alarm" signal to the information display system

- The user must plug in the bicycle to the electrical power

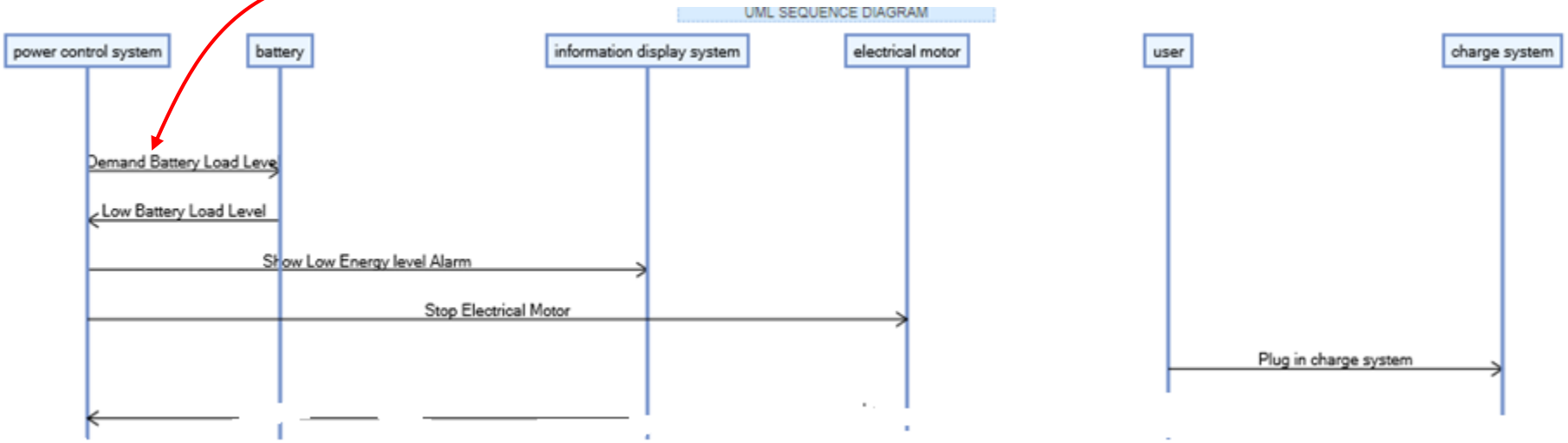
- When the bicycle is charging, the power control system shall send a “Load battery" signal to the charge system.

- When the battery is loaded, the charge system shall send a “stop charge system Loading" message to the Power control system

- Total number of Requirements in Specification = 6

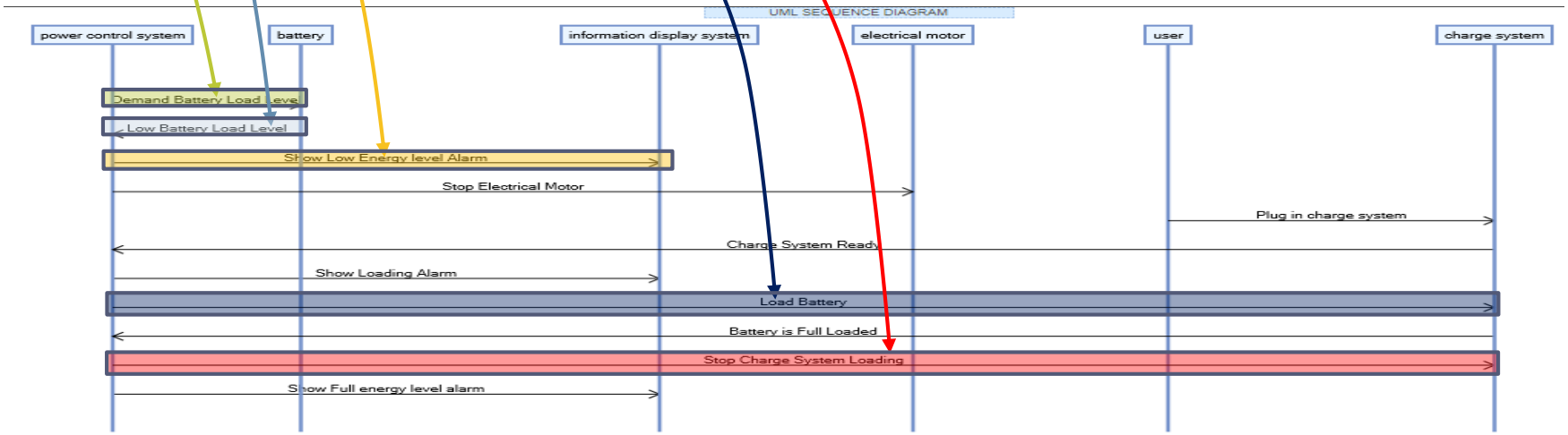
4-Models-Content Coverage Example: Matching process

every 4 seconds, the power control system shall send a "demand battery load level" message to the battery



4-Models-Content Coverage: Calculations

- Every 4 seconds, the power control system shall send a "demand battery load level" message to the battery
- When the voltage level is below 11,5V, the battery shall send a "low battery load level" message to the power control system.
- If the battery is low, the power control system shall send a "show low energy level alarm" signal to the information display system
- The user must plug in the bicycle to the electrical power
- When the bicycle is charging, the power control system shall send a "Load battery" signal to the charge system.
- When the battery is loaded, the charge system shall send a "stop charge system Loading" message to the Power control system



- Total number of Matches = 5
- Number of Requirements with no match in the model = 1
- Number of transitions in the model with no match in requirements = 6

4-Models-Content Coverage: Calculations

- Incompleteness Coverage = $6/11$ = 54.55% → returned value = 0.55
  - The specification is 55% incomplete!

- It controls all the relationships (11)
  - Even if they are duplicated between the same 2 elements

Other scenarios based on a knowledge centric approach

- Consistency checking among different disciplines
- Traceability discovery
- Work product reuse: based on semantic retrieval
- Automatic creation of work products along the left part of the "V"
- Quality Analysis scoreboard
- Requirements translation

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