AIRCRAFT ENGINES

SMART TRACEABILITY

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Content

- Presenters
- Context
- Back to basics on ontology
- Reminder of previous PoC
- The issue of complex traceability
- Results
- Way forward

Presenters

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CONTEXT

Context of traceability management

- For all systems (ISO 15288:2015)
  - Requirement definition process : to transform the stakeholder needs into a set of a measurable system requirements.
  - Architecture definition process : to select an architecture that meets the system requirements (“maintain traceability”)
  - Design definition process : to allocate system requirements to its components (“transform architectural characteristics into design characteristics”)

Context of traceability management

- In aeronautics domain, the goal of **ARP4754A**'s validation process requires to prove that the « requirements are sufficiently correct and **complete** so that the product will **meet the needs** of customers […] ».

Traceability is an essential method to support validation

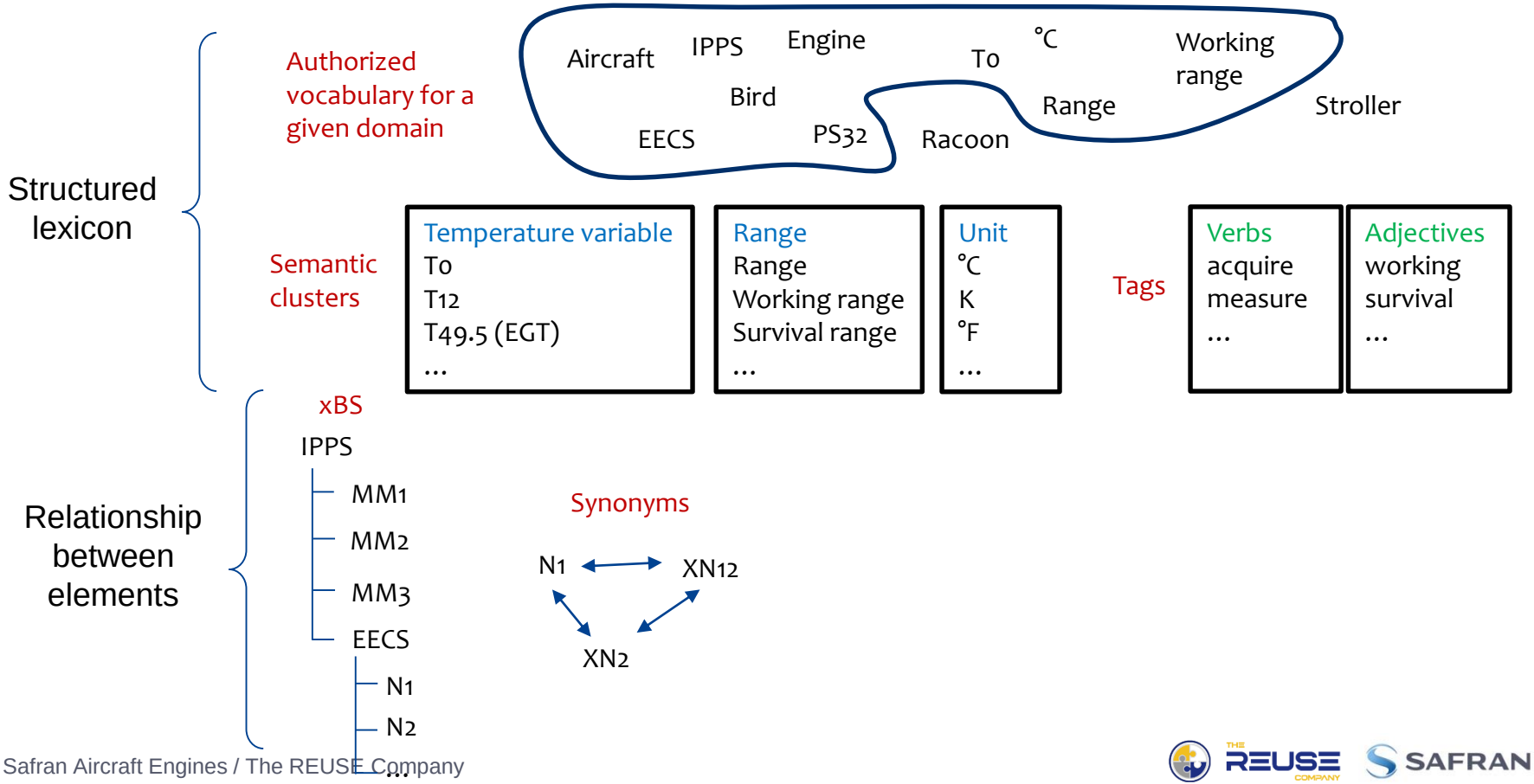
Issues to solve

- Traceability is tedious, time-consuming and manual task (especially for complex system with several levels of subsystems)…
- BUT it is mandatory… and not only in the aerospace domain !
  - Requested by standards and good practices: ISO26262, ARP4754A, DO178C…
  - It is a MUST HAVE in complex and safety critical projects so as :
    - To analyze the inconsistencies between stakeholder's needs
    - To prove the compliance to the stakeholder's needs
    - To analyze the impact of changes
    - To support the safety process

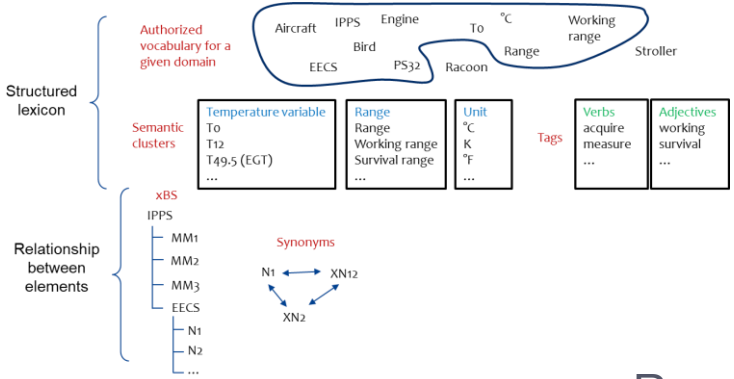
The challenge is to save time and improve the quality of product development


Back
to
Basics

Ontologies – what is it ?



Ontologies – what for ?

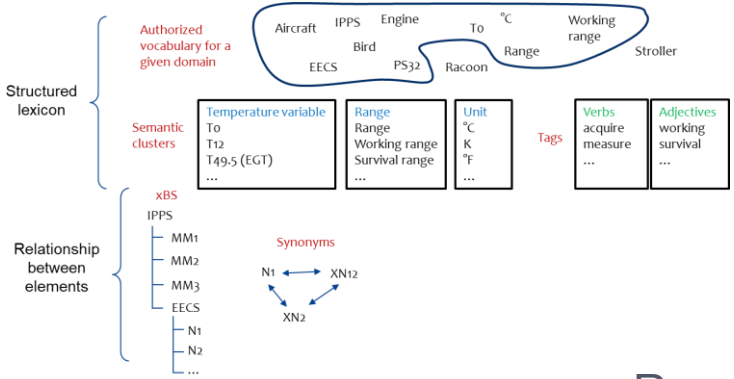


Patterns

Rules

- Requirement analysis
- Requirement authoring
- Requirement traceability

Ontologies – what for ?



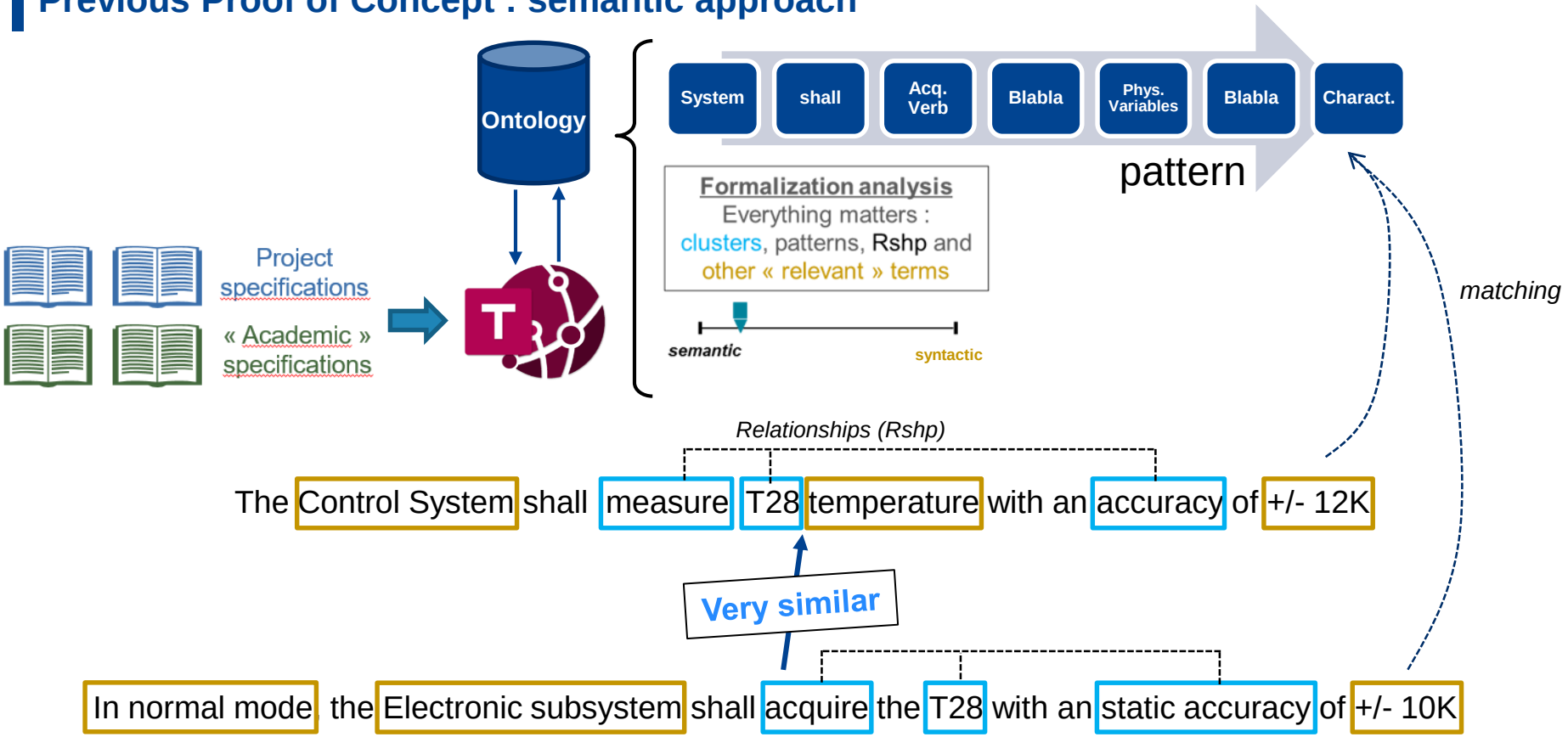
Patterns

Rules

- Requirement analysis
- Requirement authoring
- **Requirement traceability**

PREVIOUSLY ON SMART TRACEABILITY

Previous Proof of Concept : semantic approach



Previous Proof of Concept : semantic approach

Similarity threshold 80%	Case3-Similarity-80R	Case3-Similarity-60R	Case3-Similarity-20R
True Positive	33	**34**	**33**
True Negative	24271	24271	24271
False Positive	3	2	3
False Negative	13	13	13
Automatic Suggested Traces	36	**36**	**36**
Total number of combinations	24320	24320	24320
Expert Suggested Traces	46	46	46
Precision	0,917	0,944	0,917
Recall	0,717	0,723	0,717
Specificity	1,000	1,000	1,000
Accuracy	0,999	0,999	0,999
F1 Score	0,805	0,819	0,805

Good Precision ☺

Traceability studio has found **34 good links** amongst the 46 links referenced by experts.

Relevant ☺

- One False Positive is an oversight of experts !
- The number of suggestions are drastically narrowed down **< 12 suggestions** per requirements

Teething problem 😐

One False Positive is due to the incompleteness of our ontology on some domains.

Promising results !

(PDF) Automatic Traceability with Semantic Technologies Used in Industrial Environments (researchgate.net) or Complex Systems Design & Management | SpringerLink

AIRCRAFT ENGINES

COMPLEX TRACEABILITY

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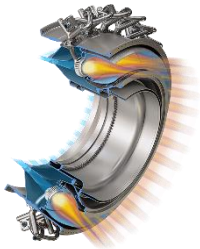
THE REUSE COMPANY SAFRAN

Issue to solve

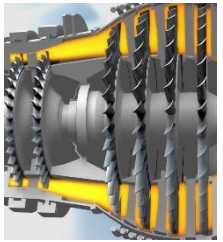
The engine shall provide a thrust of… …

The fan shall compress the air flow with a ratio of …

The chamber shall have a combustion efficiency of …

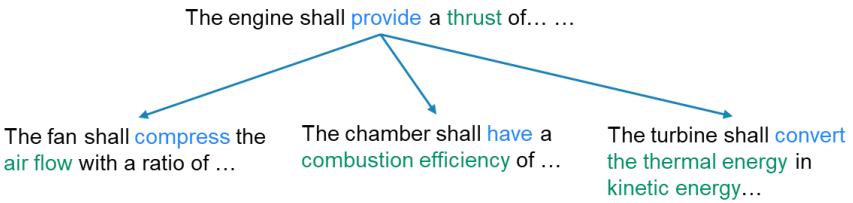


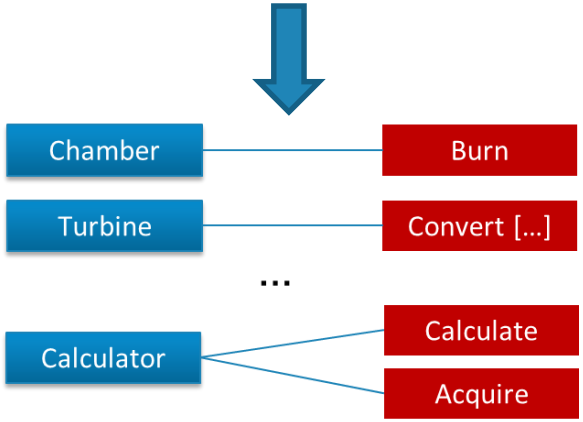
The turbine shall convert the thermal energy in kinetic energy…



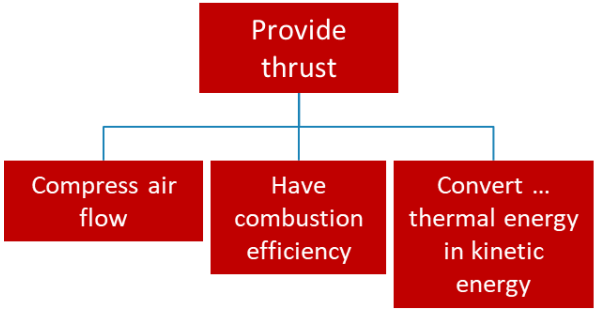
Ideas

- Use a reference architecture model

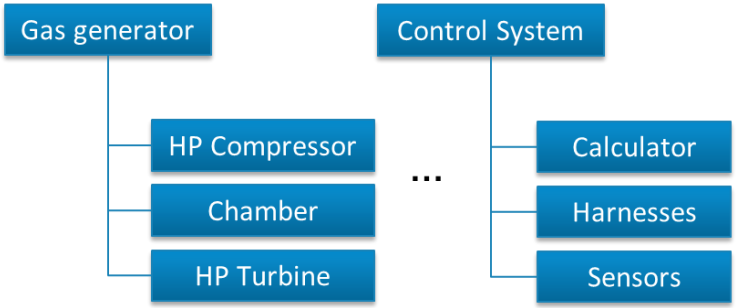




Functional allocation

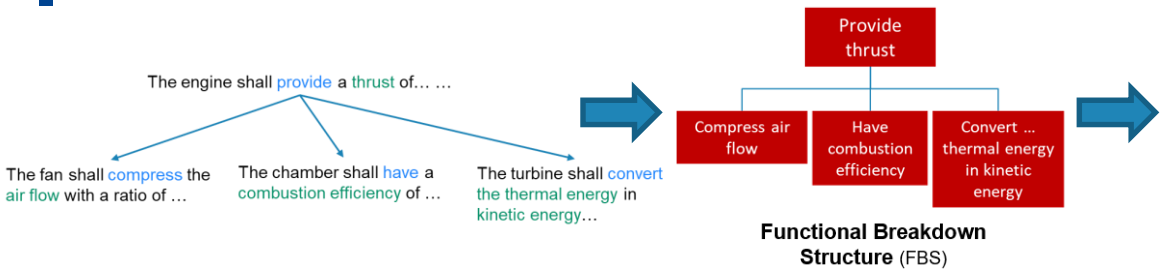


Functional Breakdown Structure (FBS)



System Breakdown Structure (SBS)

Idea : use the FBS



Principle derived from reference :

By nature, the FBS carries within itself the relationships (semantic or not) between functions.

The **Oil System** shall lubricate the engine forward and rear sumps with…

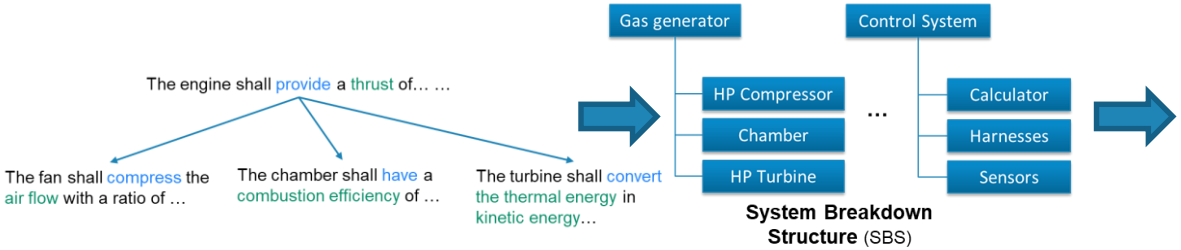
Link suggestion

Dubious link

The **Oil pump** shall supply an oil flow of …

The **ODMS** shall capture debris with an efficiency of…

Idea : use the decomposition



Principle derived from reference :
Our architectures are more or less always the same (except for innovation).

The **Control System** shall measure the T30…

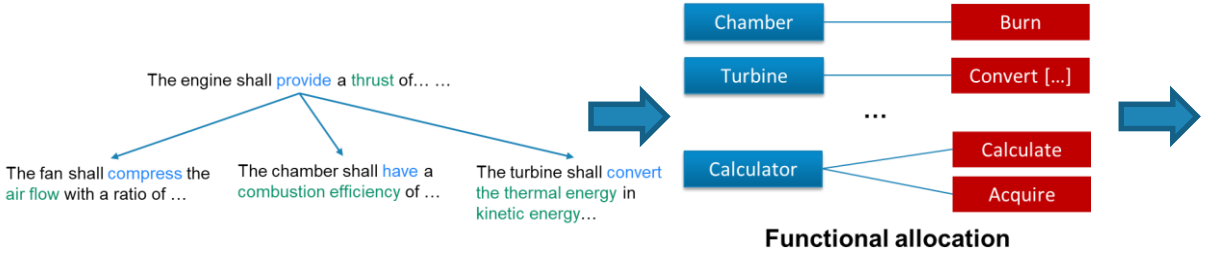
The **Chamber** shall measure the T30…

Link suggestion

Dubious link

The **Calculator** shall acquire the T30 temperature with an accuracy of …

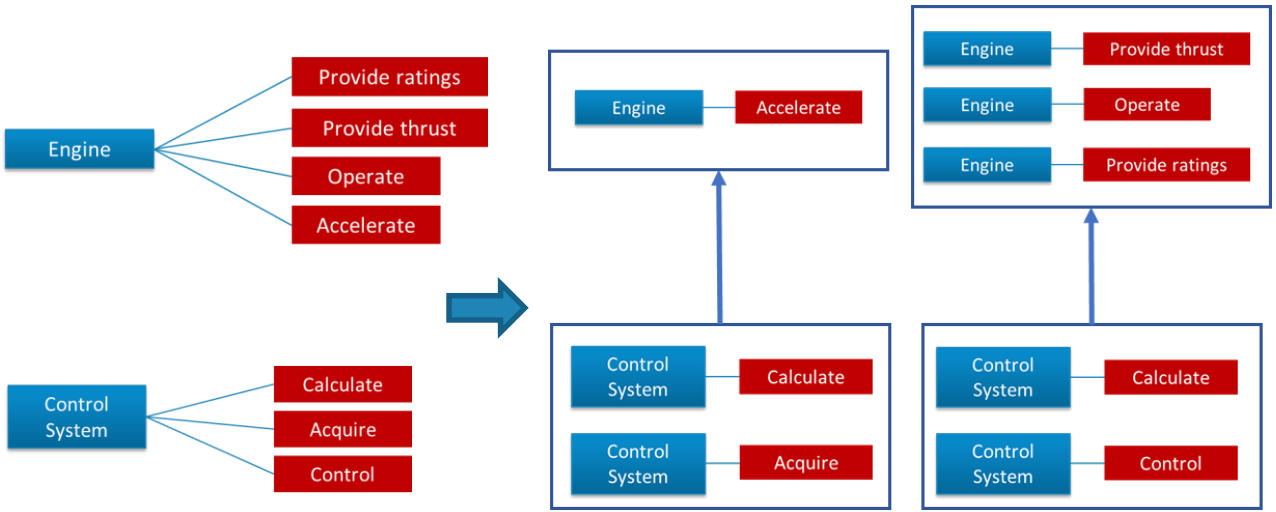
Idea : use functional allocation



Principle derived from reference :

Functions allocated to components

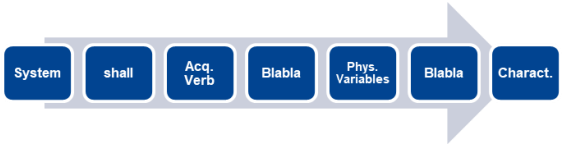
- are limited in number
- are more or less always the same
  (« the object creates the function » principle)



Could be used to reinforce the link suggestions (combined with other ideas)

RESULTS OF THE POC

Method overview

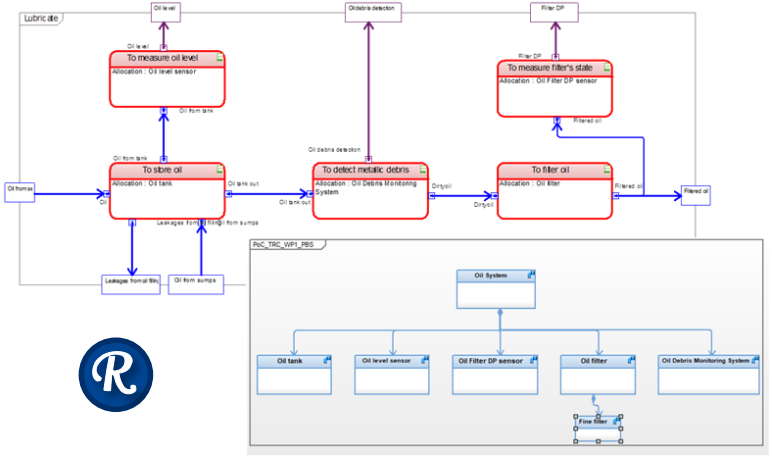


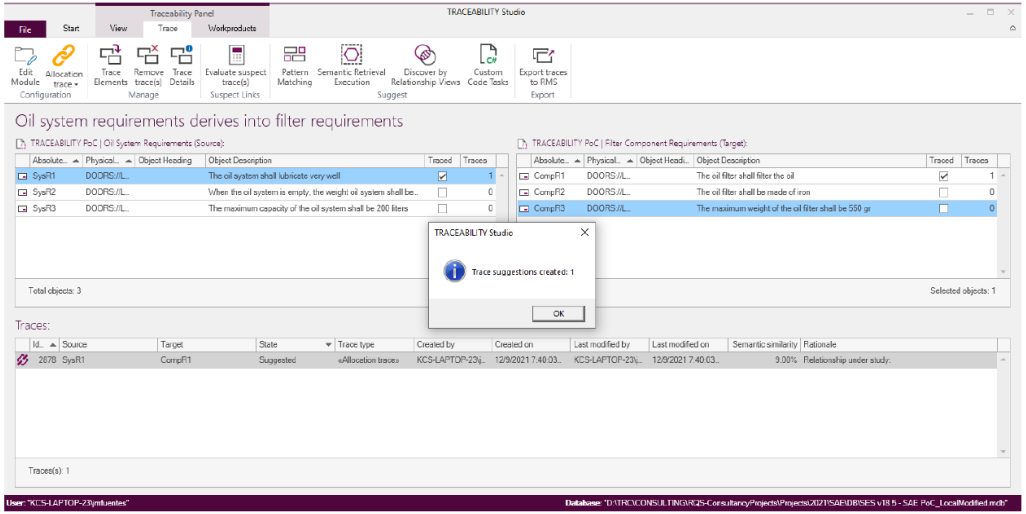
Academic specifications

Ontology

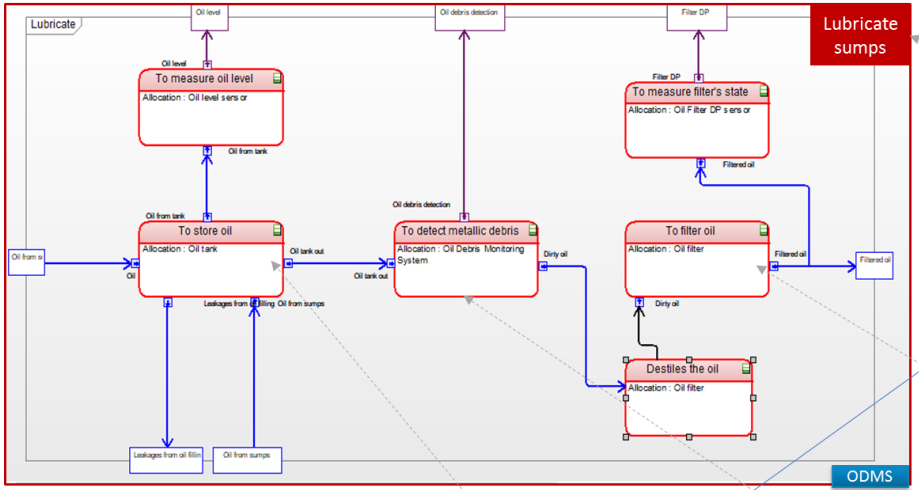
Traceability Studio

Reference model





Results



Lubricate sumps

Implemented by

satisfies

System

Requirement

Oil System

*The Oil System shall **lubricate** the engine forward and rear **sumps** with the following minimum flows and environment conditions :*
flow at bearing#1 : X l/h
flow at bearing#2 : Y l/h
Environment conditions : [...]

100% of good results (expected vs obtained results)

ODMS

*The ODMS shall **detect** the [scavenge in] port from which **debris** (defined in Appendix F) are flowing, for any oil flow between 0 l/h and the XX l/h.*

Suggested
- *lubricate* and *detect debris* are linked via the FBS

Oil tank

*The oil tank shall **store** Z liters of **oil**.*

Suggested
- *lubricate sumps* and *store oil* are linked via the FBS ;
- Oil System and Oil tank are N and N+1

ODMS

*The ODMS shall **capture debris** with an efficiency between X% and Y% through each scavenge flow of debris whose bigger size in between W µm and Z µm.*

Not Suggested
- *capture debris* is not linked to *lubricate oil* in the FBS

Oil filter

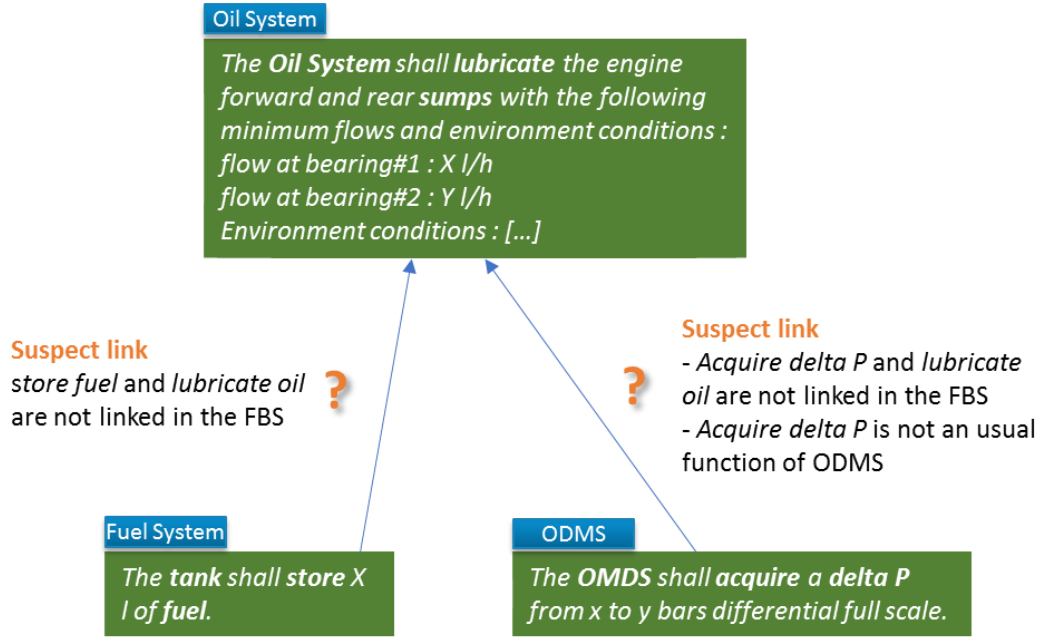
The oil filter shall have a filtration level of xx µm.

The oil filter shall filter the oil at the [supply out].

Suggested
lubricate, *have filtration* and *filter oil* are linked via the FBS

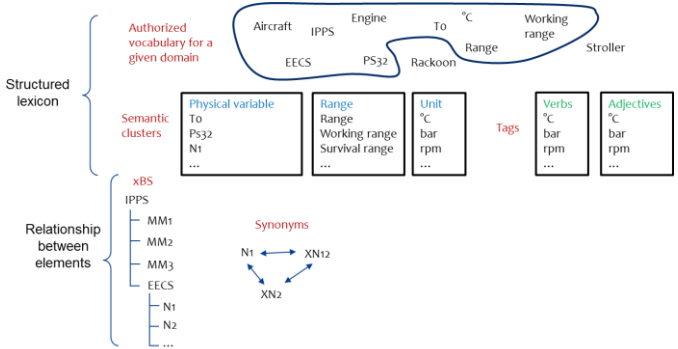
Future work

- Test the method on a real project
  - Complete the reference model
  - More (complicated) requirements
  - Deeper FBS (depth>2)
  - Suggest suspect links when the traceability exists
  - … writing a paper for IS2023 ! ☺



THANK YOU FOR YOUR ATTENTION

Ontologies – what for ?



+ Patterns + Rules