



27th annual **INCOSE**
international symposium

Adelaide, Australia

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Speeding up Projects in the Transportation Industry Using Ontologies

Your wish, my command

Guillermo CHALÉ GÓNGORA
Product Line Engineering Director

THALES

Juan Llorens
Universidad Carlos III de Madrid

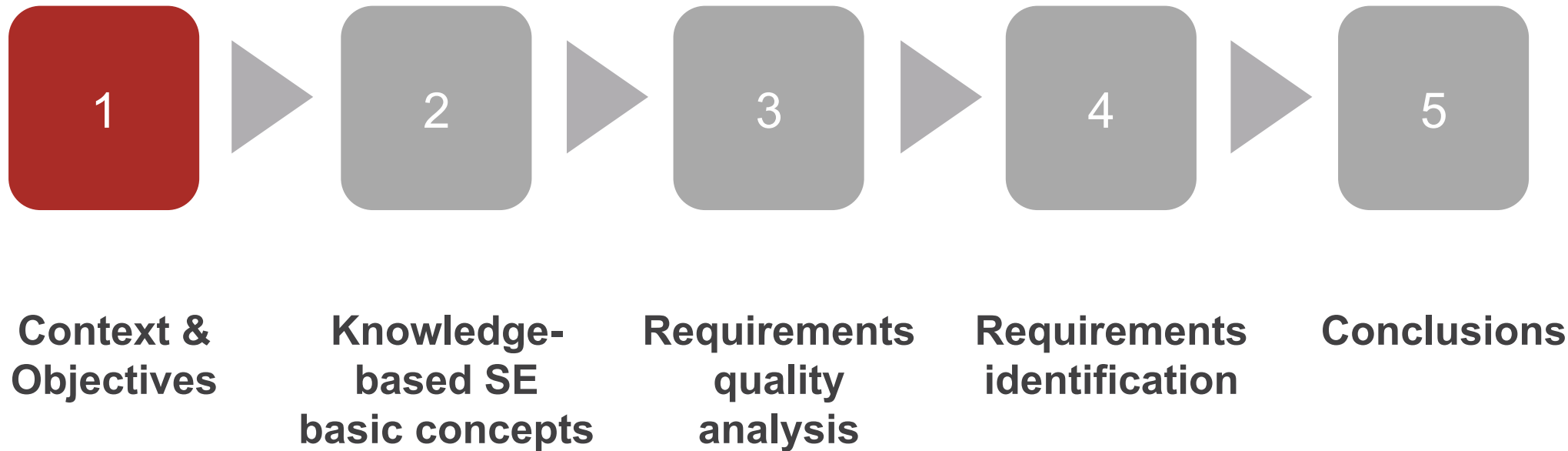
Elena GALLEGO
The Reuse Company



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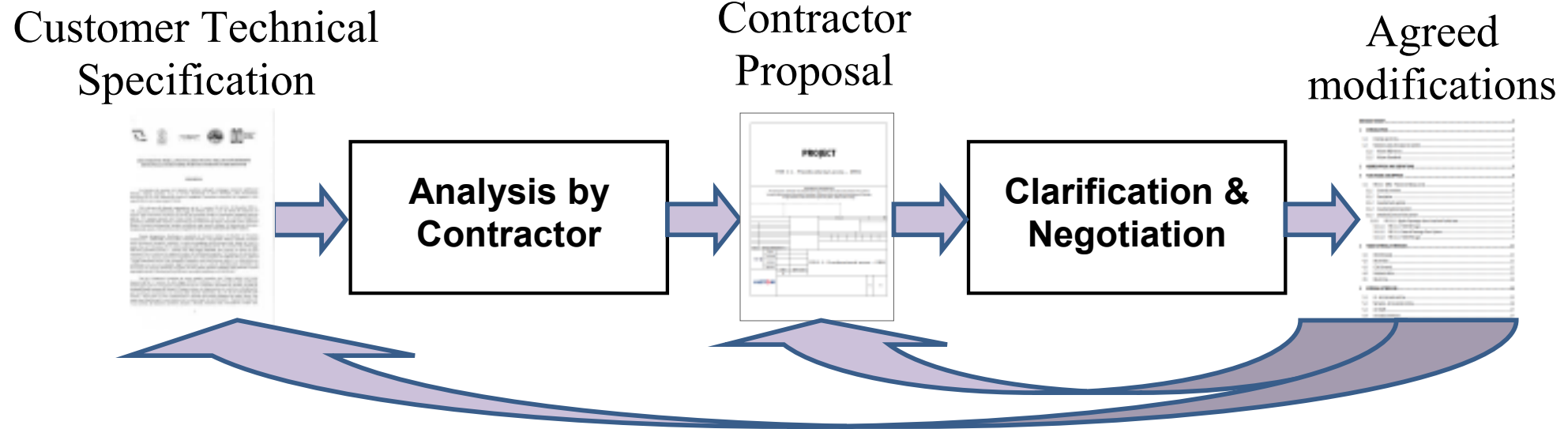
Stakeholder Needs & Requirements development process



- **Purpose**
“...define the stakeholder requirements for a system that can provide the capabilities needed by users and other stakeholders in a defined environment”
- These are later elaborated into a set of system technical requirements that meet the operational needs of the user
- It is necessary to perform verification and validation activities to guarantee that a common understanding of the stakeholder needs and requirements is obtained and that the system requirements are a correct and appropriate elaboration of the stakeholder’s expectations

ISO/IEC/IEEE 15288:2015. *Systems and software engineering -- System life cycle processes*. ISO/IEC JTC 1/SC 7. First edition. Geneva (CH): ISO

Typical stakeholder needs and requirements definition cycle in railway





Aggravating factors

- Intricacy of the customer documentation
- Number and format of expected deliverables from the contractor
- Documentation process to which the contractor must comply
- Project complexity
 - e.g. multi-systems and multi-contract deliveries
- Experience and the technical background of the customer
...and (often in today's railway industry) of his consultants, too!
- Number of changes/version in the customer specification

Example: how long can it take to analyze 5 000 requirements?

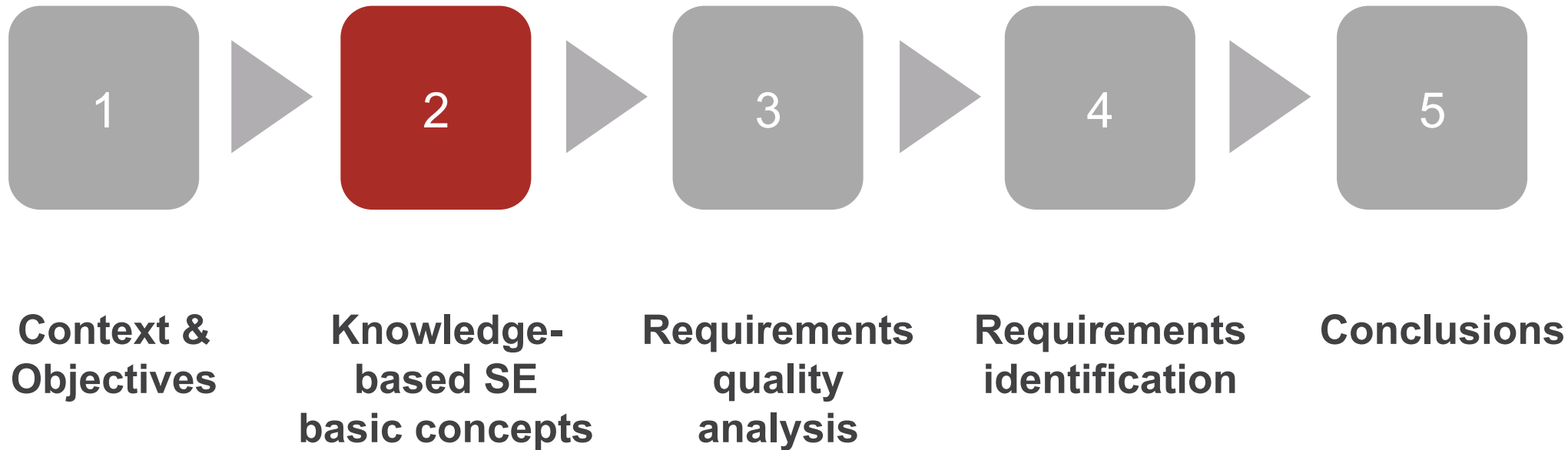


Objectives

- Two complementary initiatives on the application of knowledge-centric analysis to overcome the previous difficulties
 1. Computer-assisted requirements quality analysis to ensure the correctness, completeness and consistency of requirements
 - Improve the quality of our specification documents
 2. Computer-assisted identification of requirements
 - Accelerate the stakeholder requirements capture and elicitation activities



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System Knowledge Base - Ontology:

A complete knowledge sharing approach

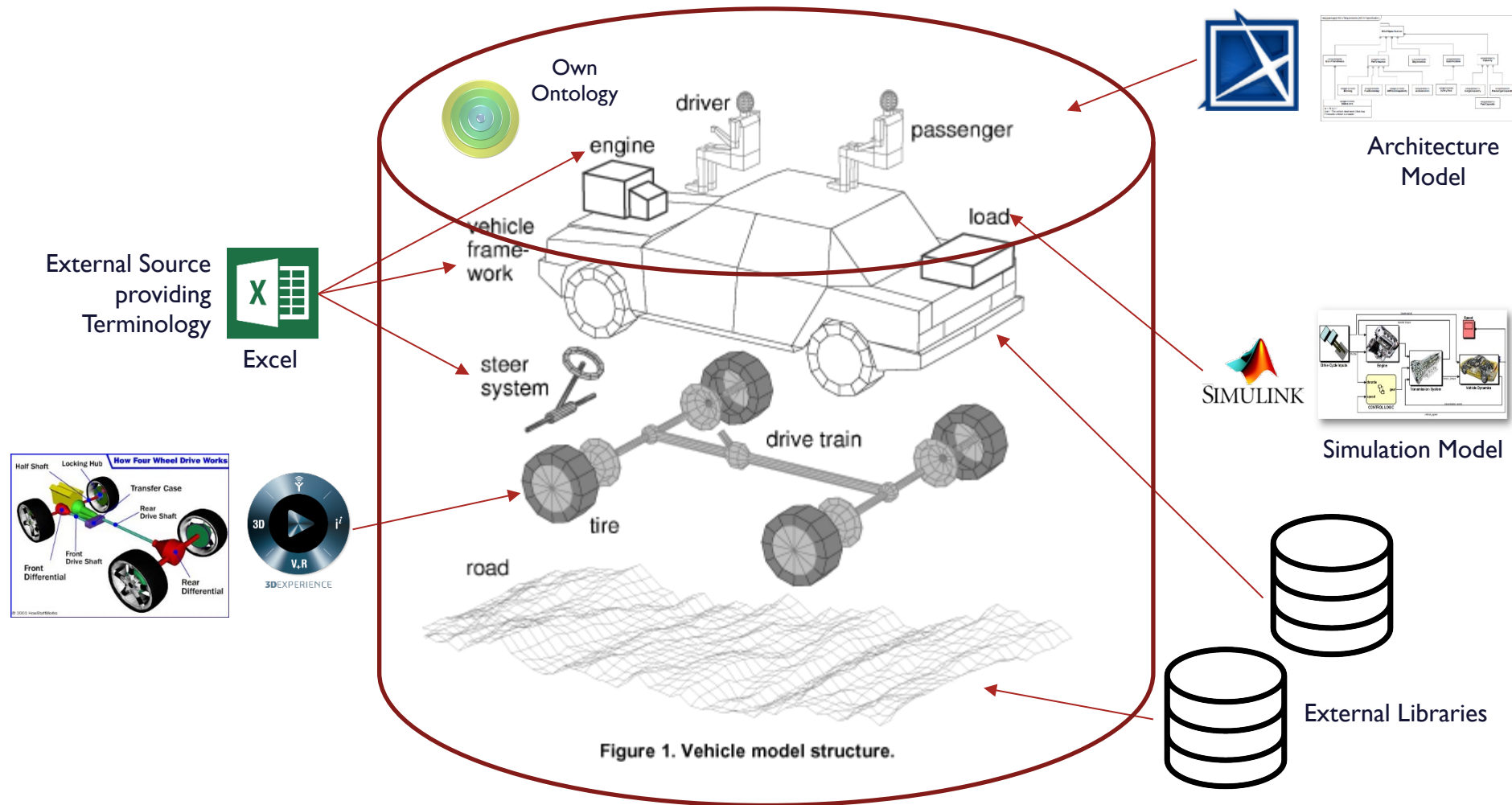
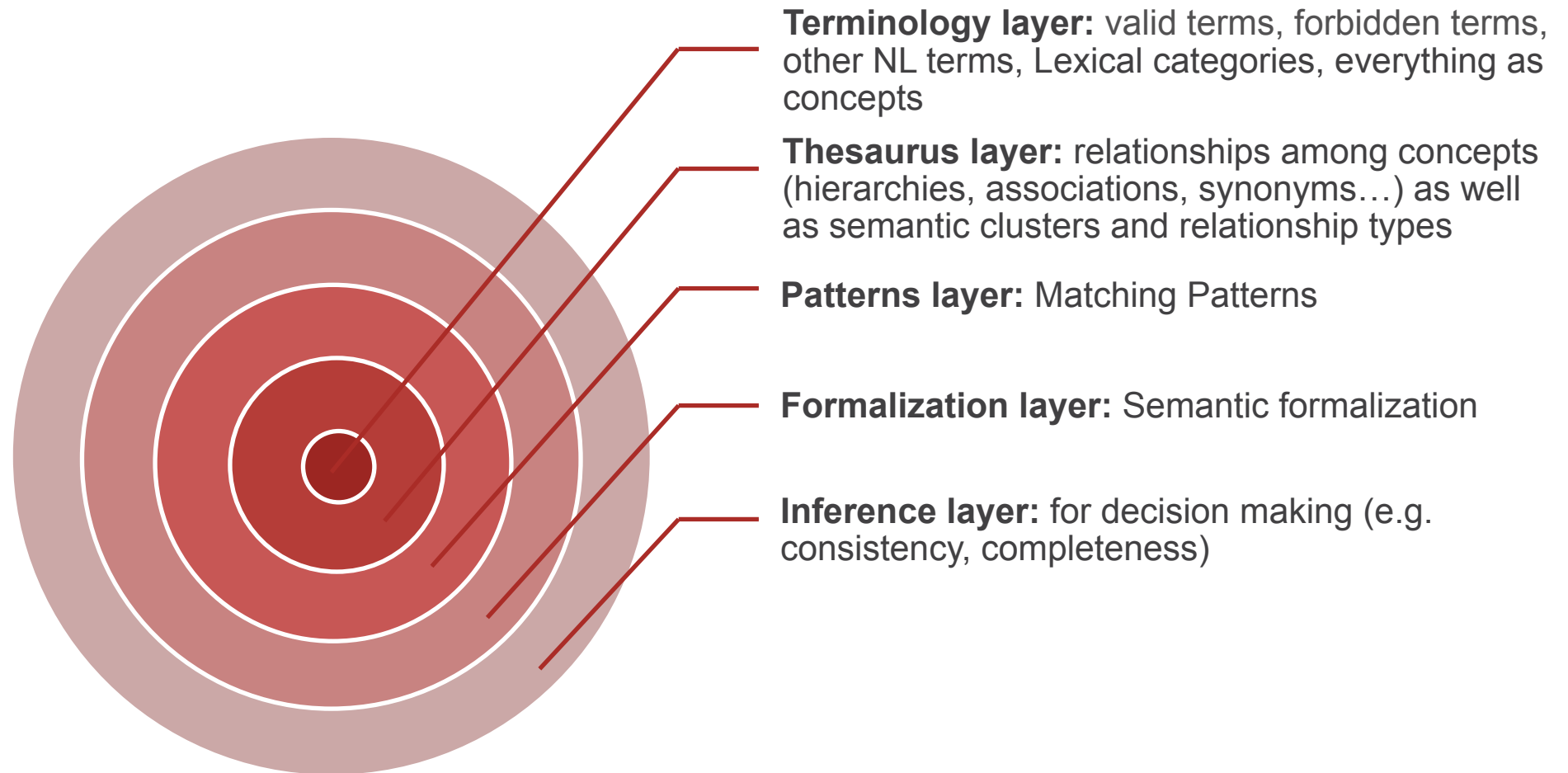


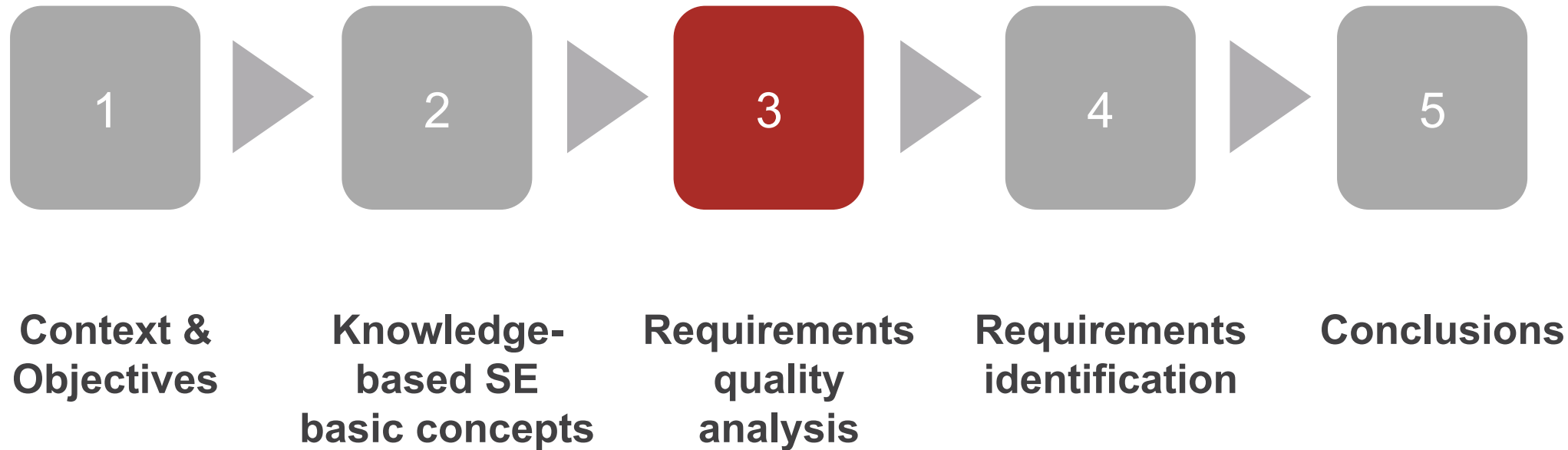
Figure 1. Vehicle model structure.

What is an Ontology within KCSE Approach?

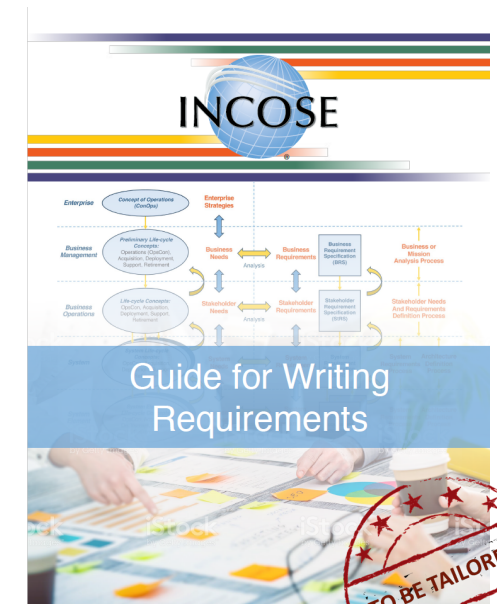
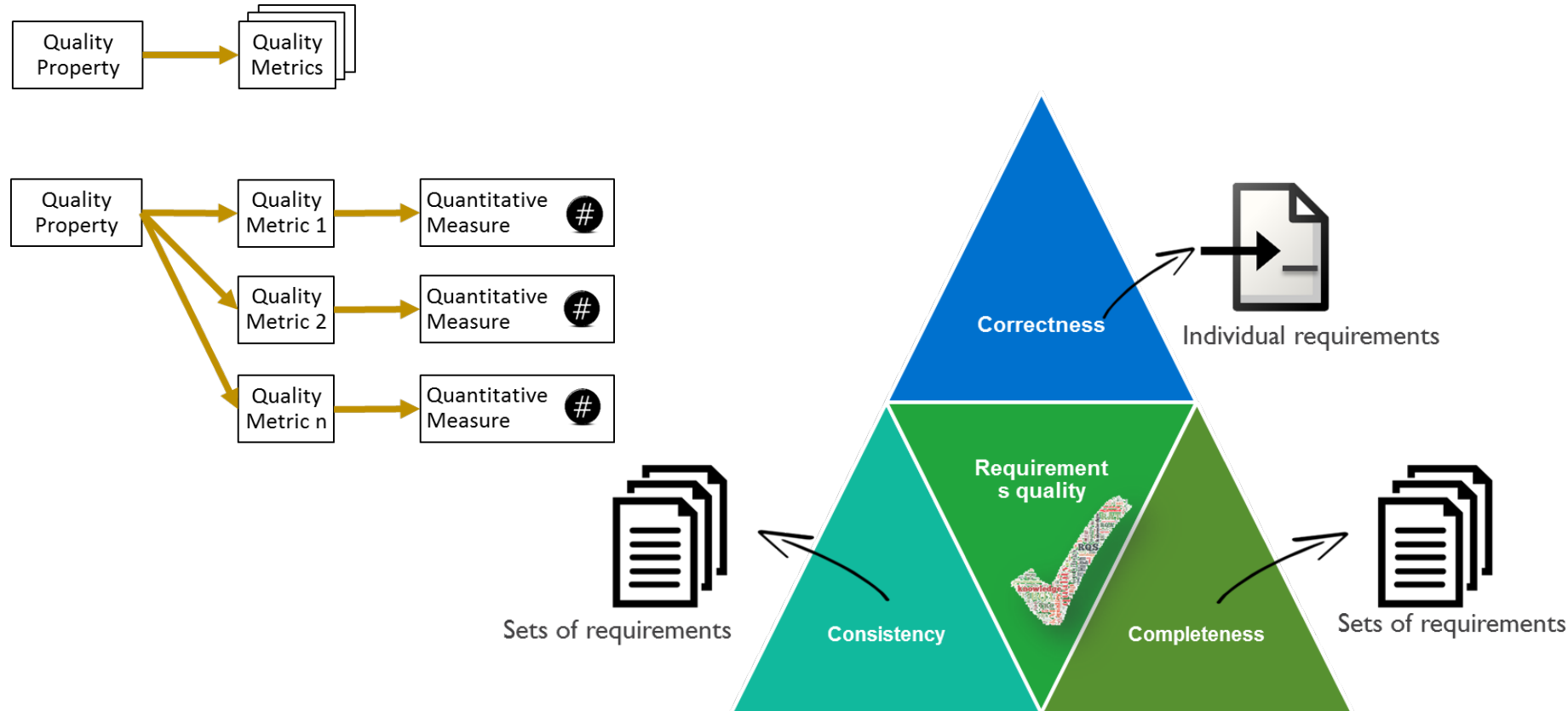




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Requirements quality metrics: CCC Approach



Requirements Quality Management: Methods

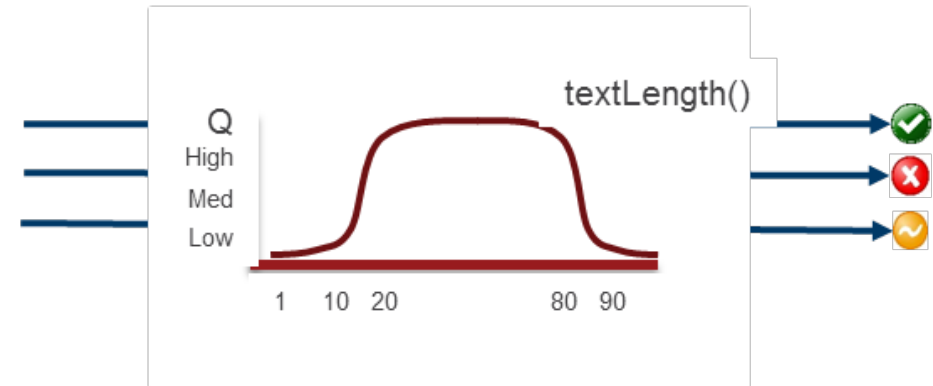


Correctness

Text Length



Req1 = 53 words
Req2 = 5 words
Req n = 85 words



Requirements Quality Management: Methods



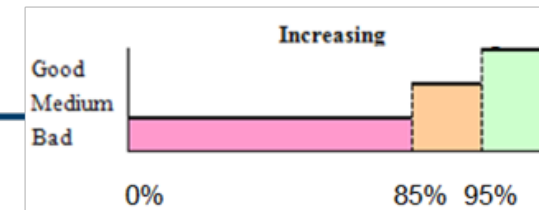
Completeness

Requirements
Typology



75%

Found Only:
- Reliability Requirements
- Maintainability Requirements

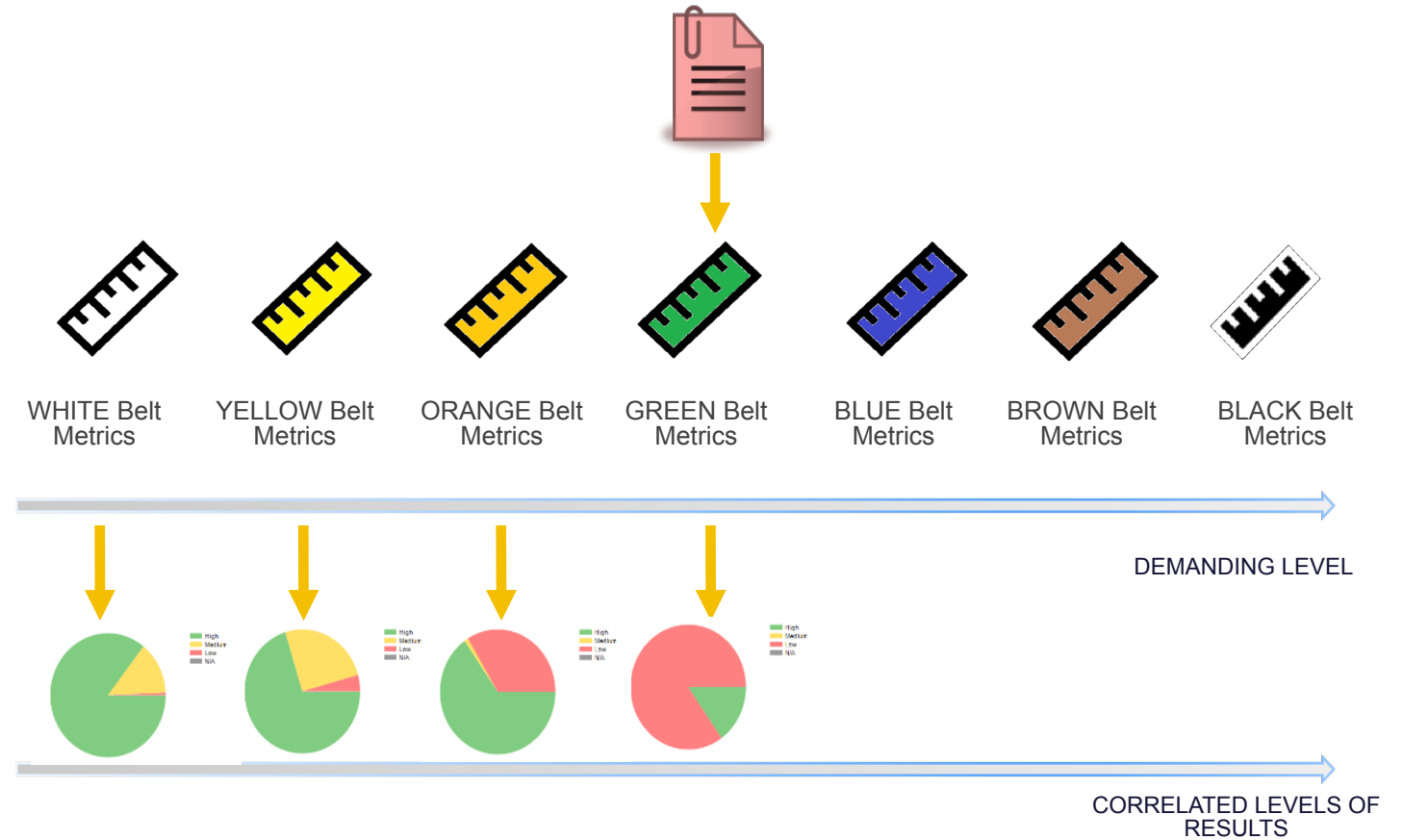




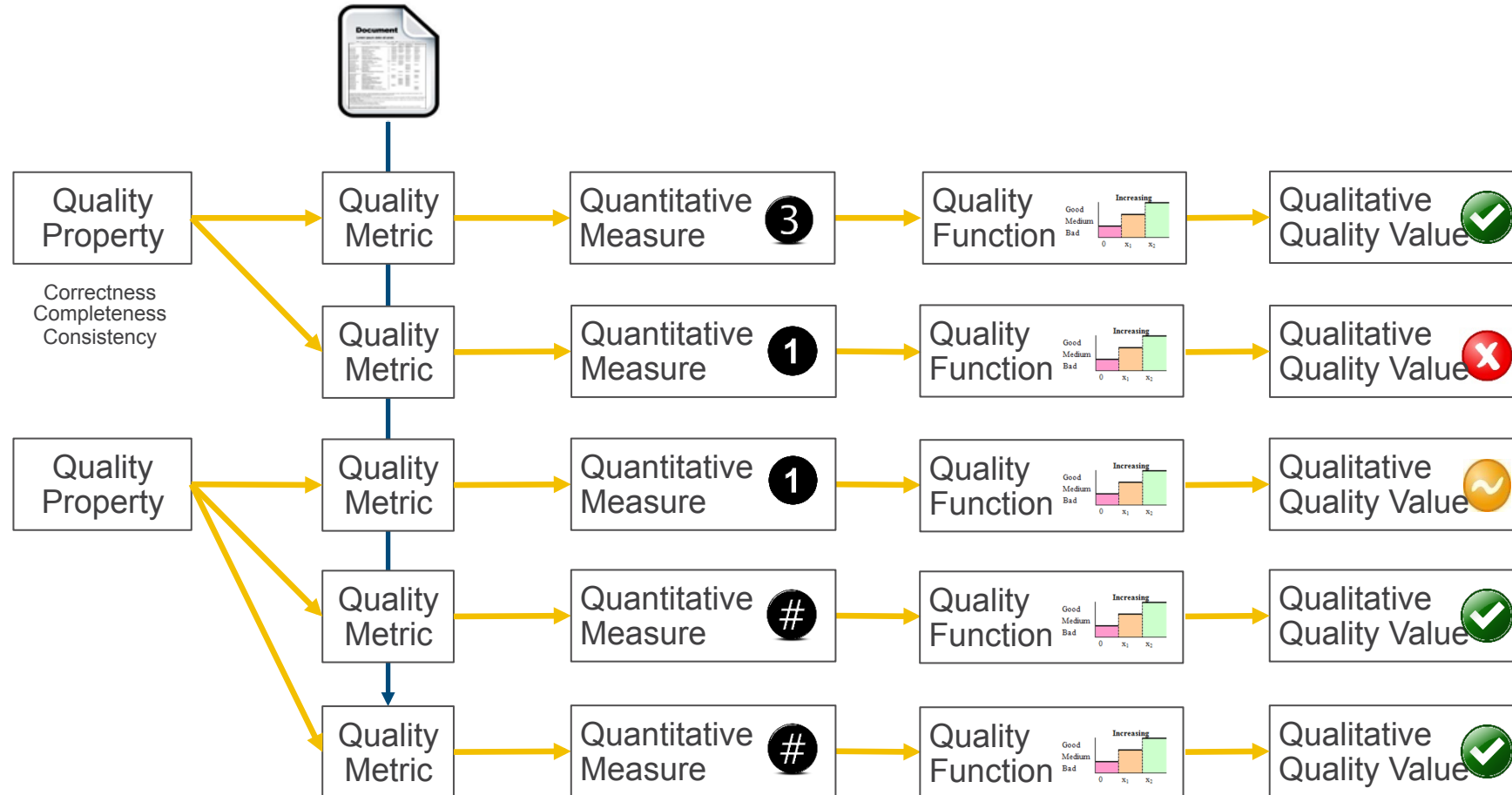
Configuring the process – Quality Maturity Model

Definition of a requirements quality model based on quality levels, allowing the corresponding team to select the appropriate quality level for a particular project.

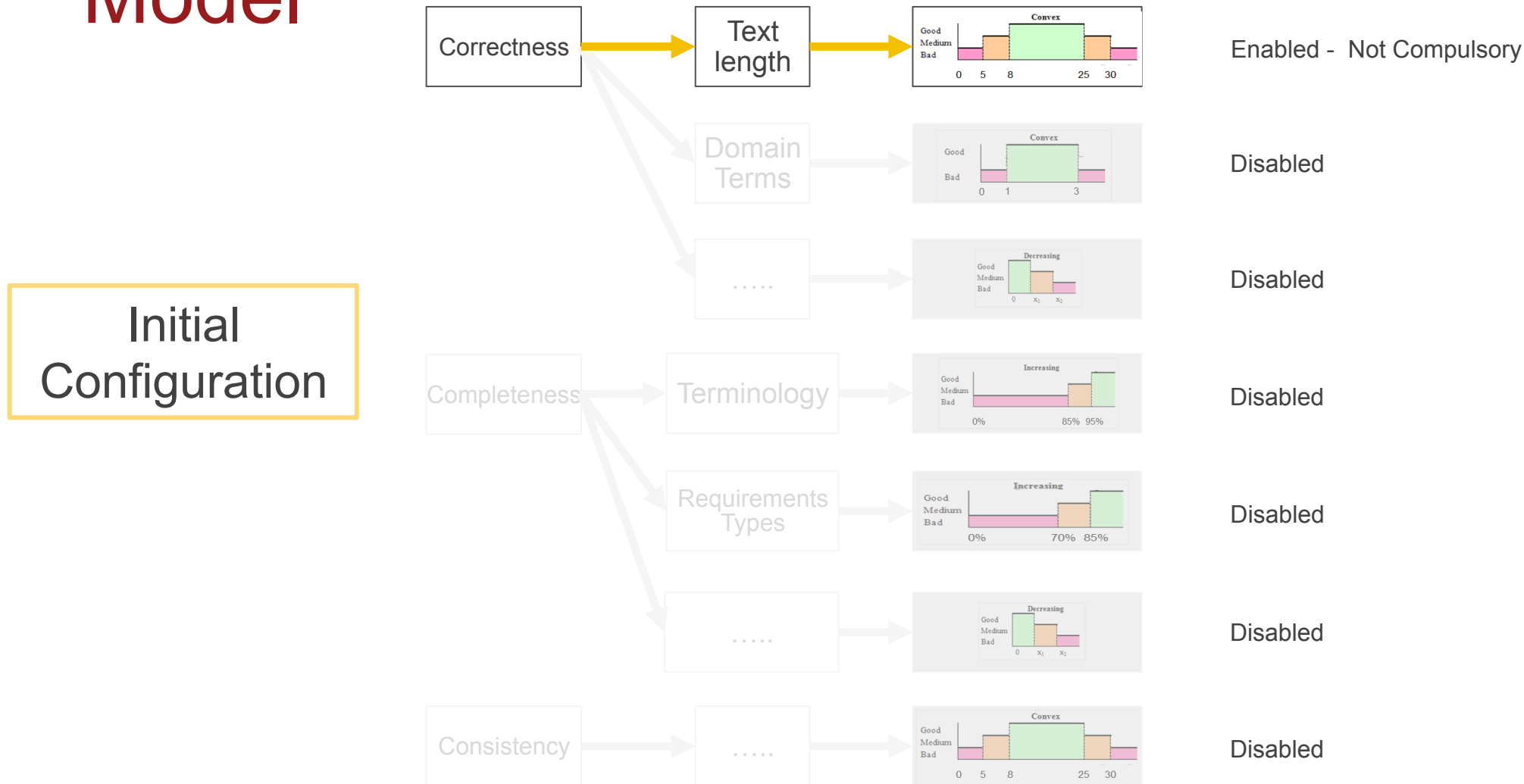
The requirements specification quality is measured applying the quality configuration of the selected level in an incremental way, traversing from the initial level towards the most mature level



Configuring the process – Quality Maturity Model



Configuring the process – Quality Maturity Model

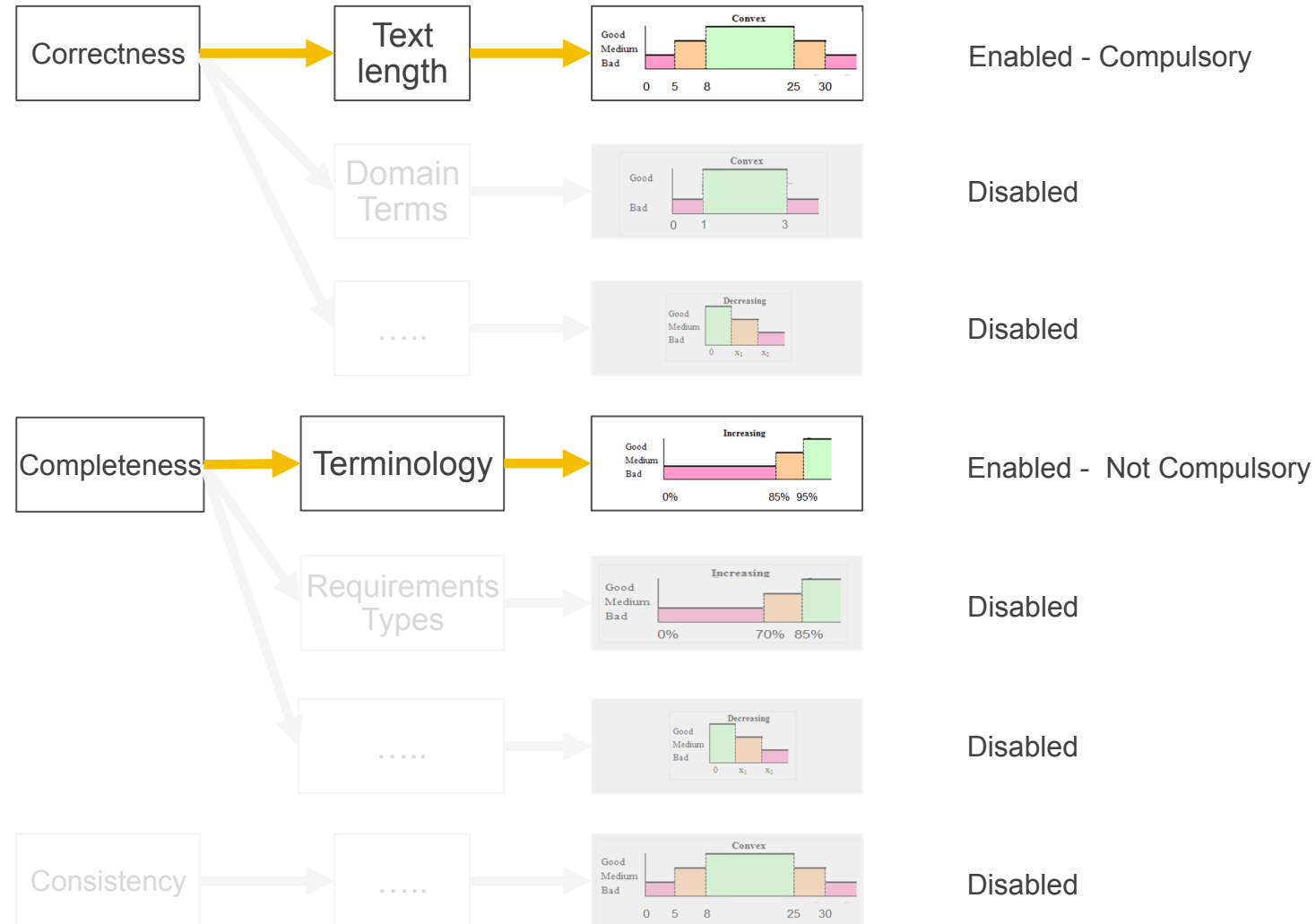


WHITE
Belt
Metrics

Configuring the process – Quality Maturity Model



Intermediate Configuration

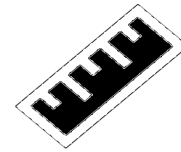
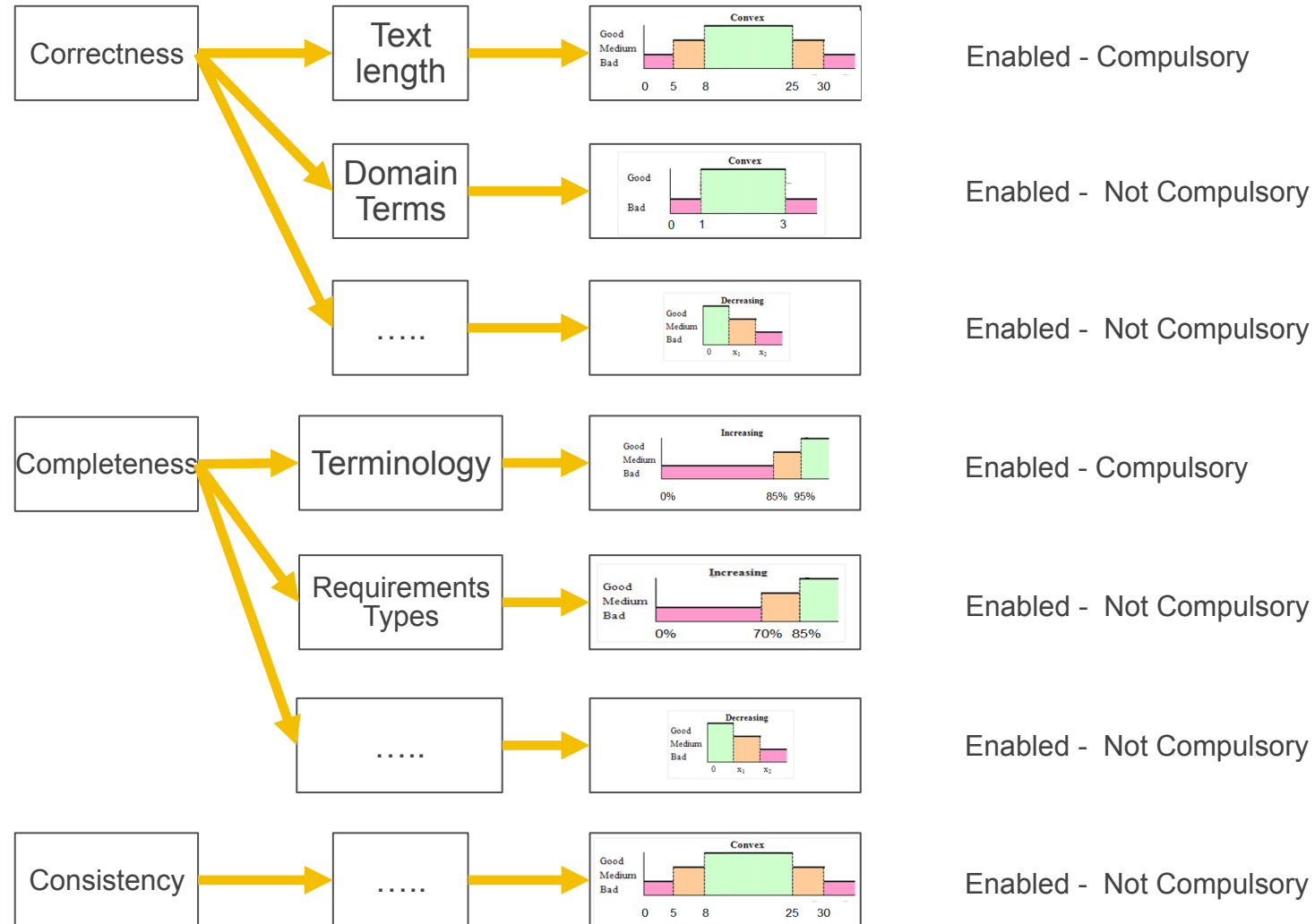


ORANGE Belt Metrics

Configuring the process – Quality Maturity Model



Final Configuration

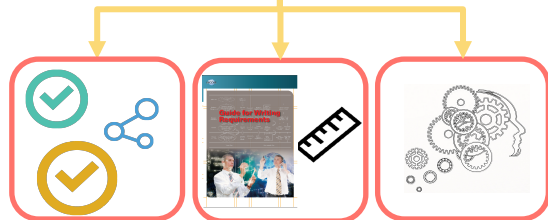


BLACK
Belt
Metrics

Configuring the process – Work methodology



One-Week Workshop



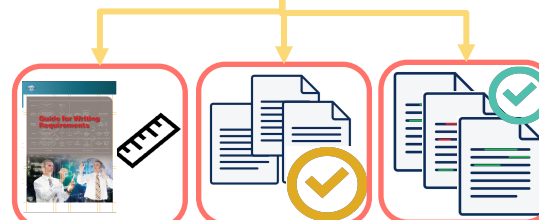
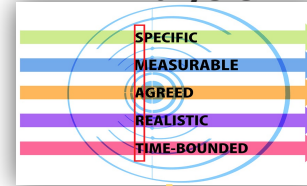
RQS Tools Training Requirements Quality Organizational Knowledge Analysis

One-Week Use Case definition



Documents Analysis: Standards, Glossaries and System Documents

Two-Week Requirements Quality Analysis



Quality Rules Definition Requirements Quality Analysis Requirements Improvement: Rephrasing

Two-Week Knowledge Base Elaboration



Reuse Organizational Know-How Writing Good Requirements for Org.: Patterns and Rules



Week 1

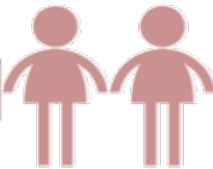
Week 2

Week 3

Week 4

Week 5

Week 6



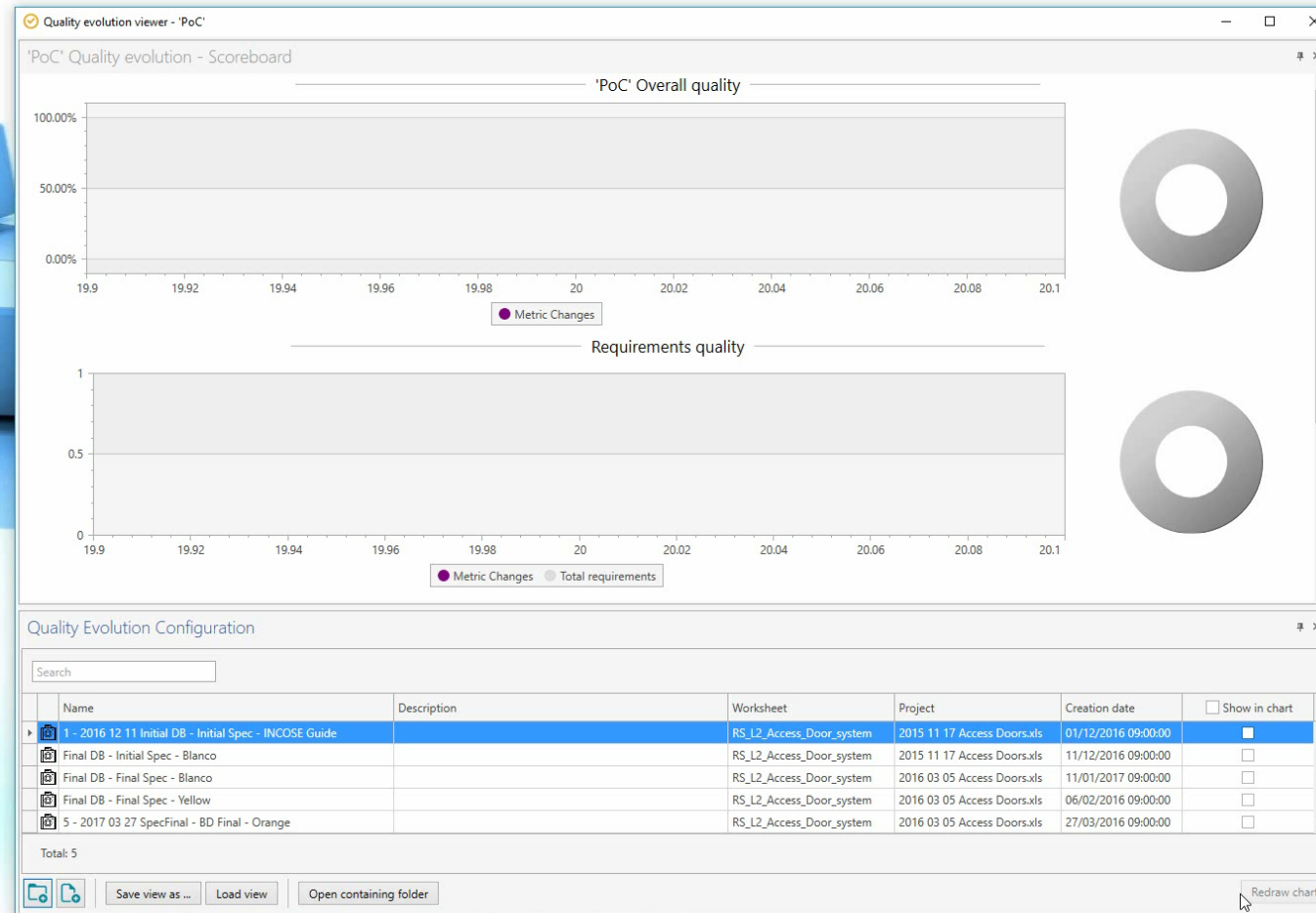
2 Org. Engineers
1 TRC Consultant

2 Org. Engineers
1 TRC Consultant

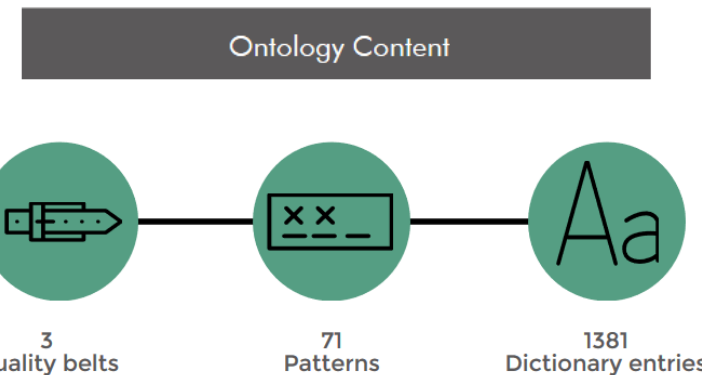
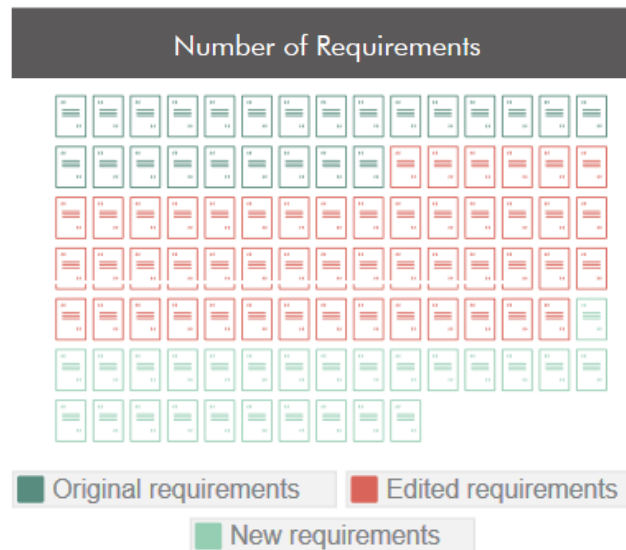
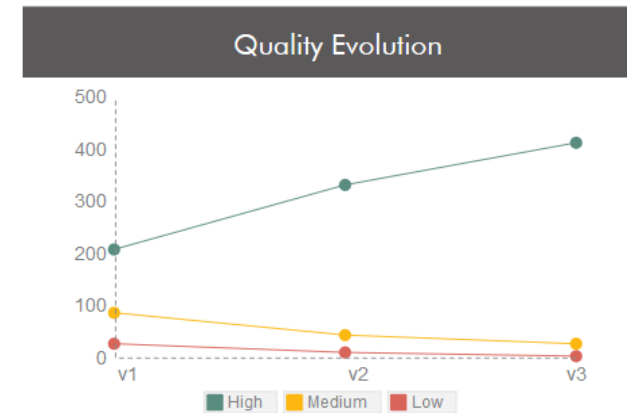
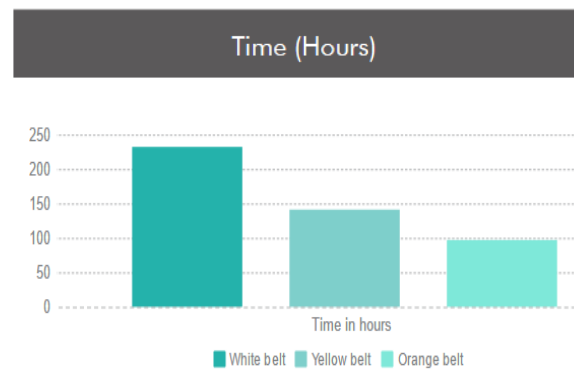
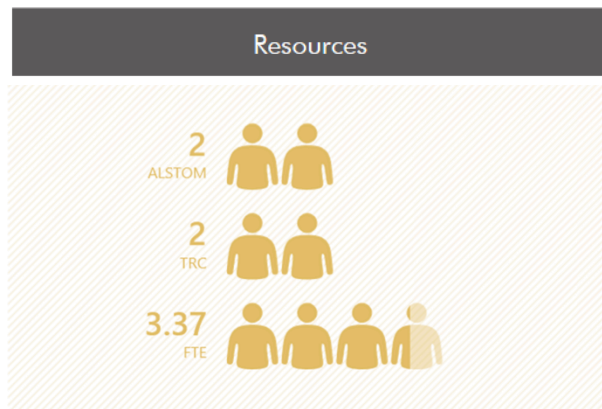
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Making it all come true: The Quality Results at Alstom

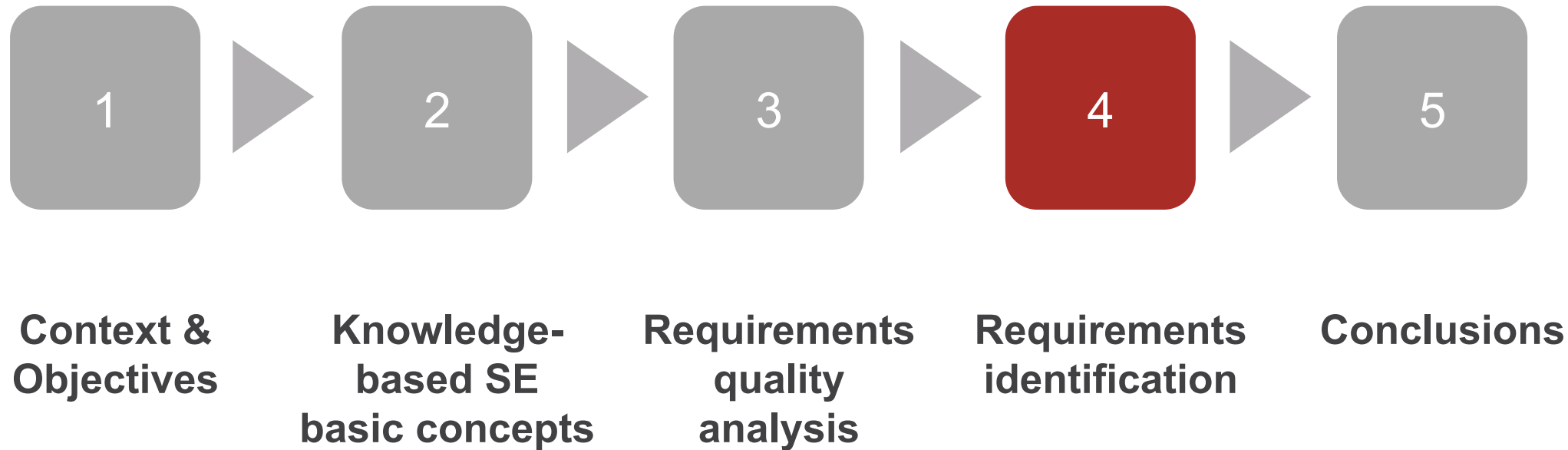


Making it all come true: The Quality Results at Alstom

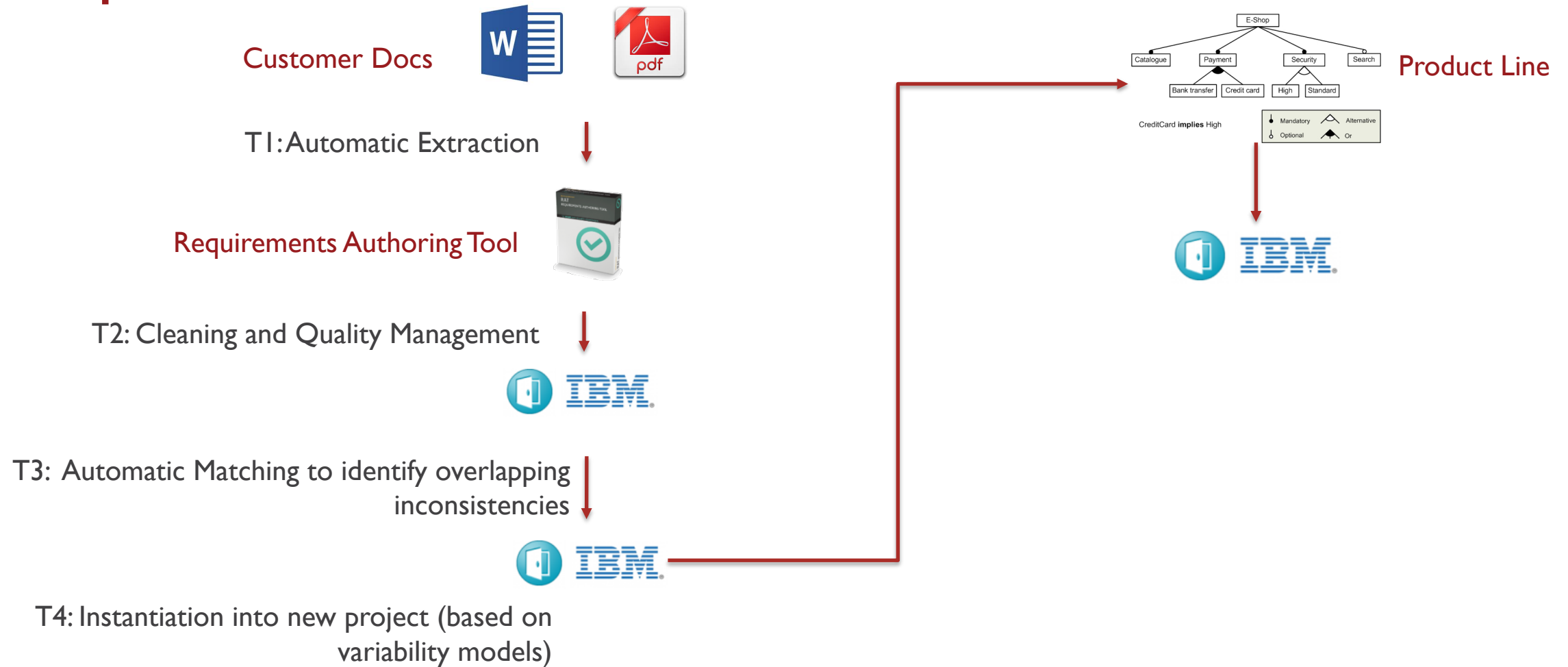




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Multiple applications of this approach: Requirements Identification





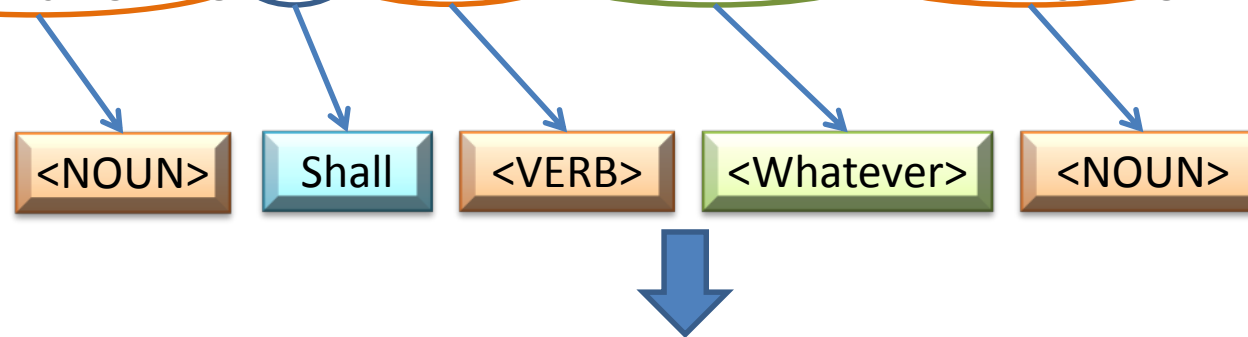
Multiple applications of this approach: Requirements Identification

The numbers and spacing of the tubes shall be such as to achieve a minimum lighting level of 300 lux over the whole saloon area, in each car and in each section, measured at a height of 1.0m above floor level. The lighting level shall be sensibly uniform over the whole saloon area.

The Contractor shall propose and provide a lighting arrangement that will illuminate each of the doorway areas right up to the platform or side walkway for doors designated as emergency doors

The Contractor shall propose emergency lighting arrangements in the saloon.

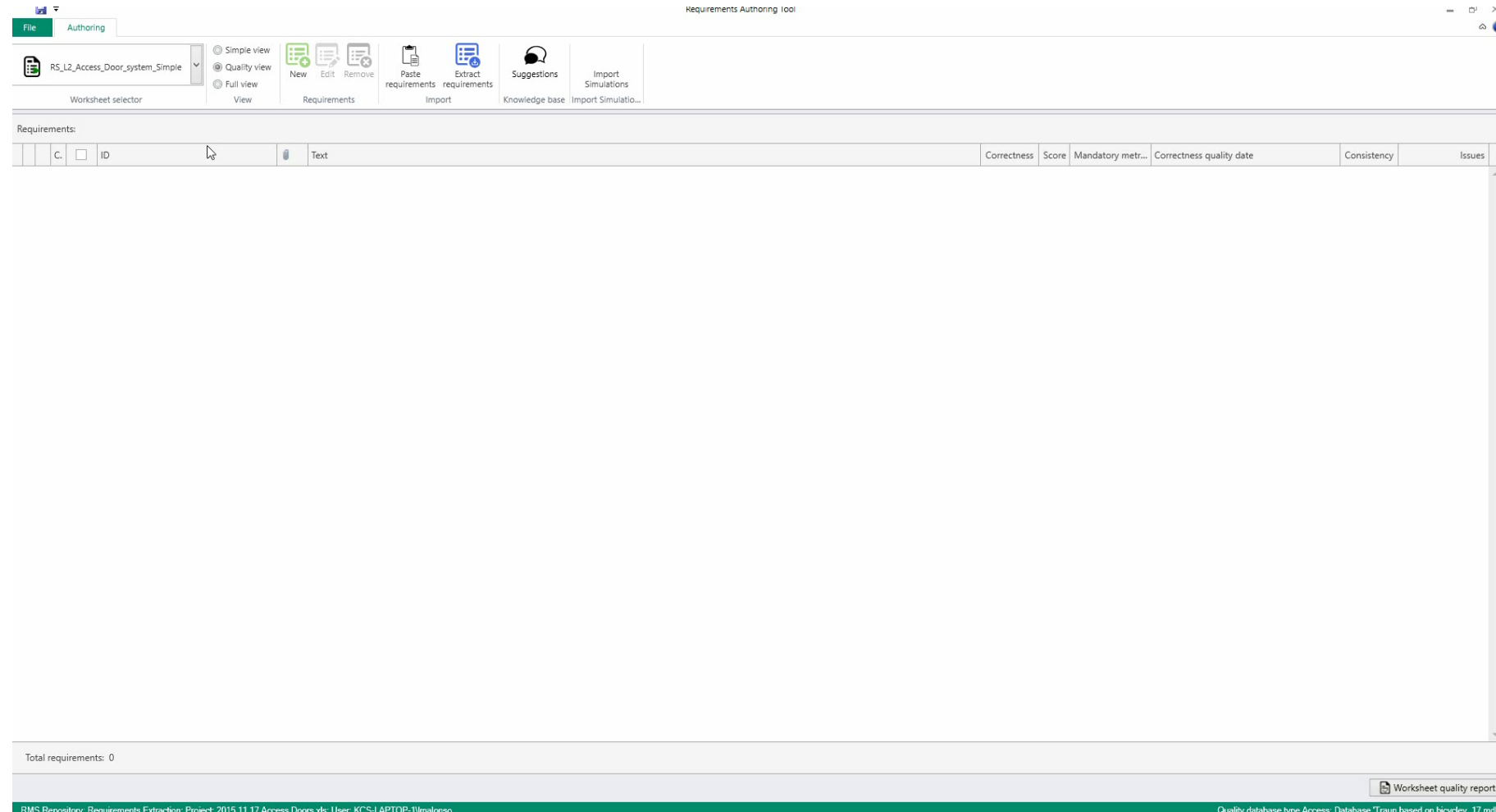
Emergency lighting shall represent at least 30% of normal lighting.



Req_Lig_0030 Emergency lighting shall represent at least 30% of normal lighting.

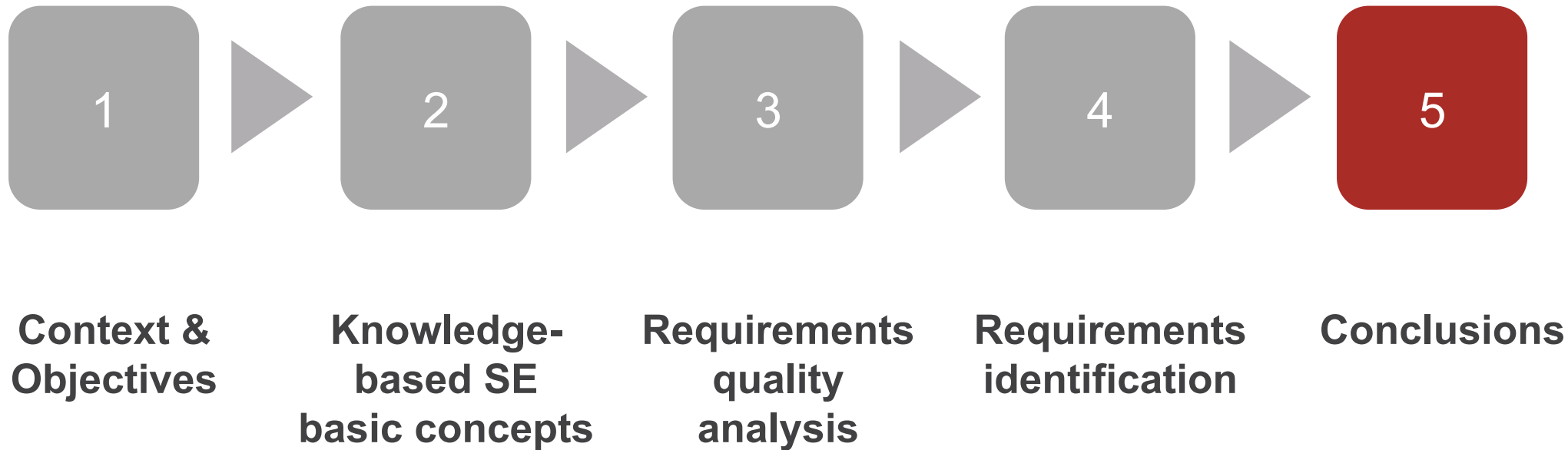
Different Patterns imply that Different requirements are extracted

Making it all come true: The Requirements Extraction at Alstom





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Conclusions

- We presented the results of an exploratory study on the application of knowledge-centric approaches to the requirements definition process
- Original scope of the study: application of ontologies to the analysis and improvement of the quality of specifications
- Collateral benefit: perform computer-assisted identification of requirements from structured and unstructured documents
 - The purpose of this new approach is to improve the execution of projects in railway transportation by accelerating the requirements management and development processes and, in particular, the stakeholder requirements capture and elicitation activities



Conclusions – Possible applications

Product Line Engineering

- Upgrade the ontology with the terms used in variability models to perform computer-assisted gap analyses
 - ➔ Automatically identify variants (or features) in the customer specifications, then, configure a product that satisfies the customer technical specification
- Capture the knowledge contained in legacy assets, in order to leverage this knowledge for the construction and consolidation of our product lines
- Analyze other stakeholder requirements documents (standards and regulations)
 - Whose intricate “structure” seem indeed to have been elaborated for someone possessing genuine machine-like interpretation capabilities

We hope that the arguments presented here will contribute to establish a compelling case to advance the practice of Systems Engineering in the railway industry and to foster the application of *leaner* methods in the execution of railway projects



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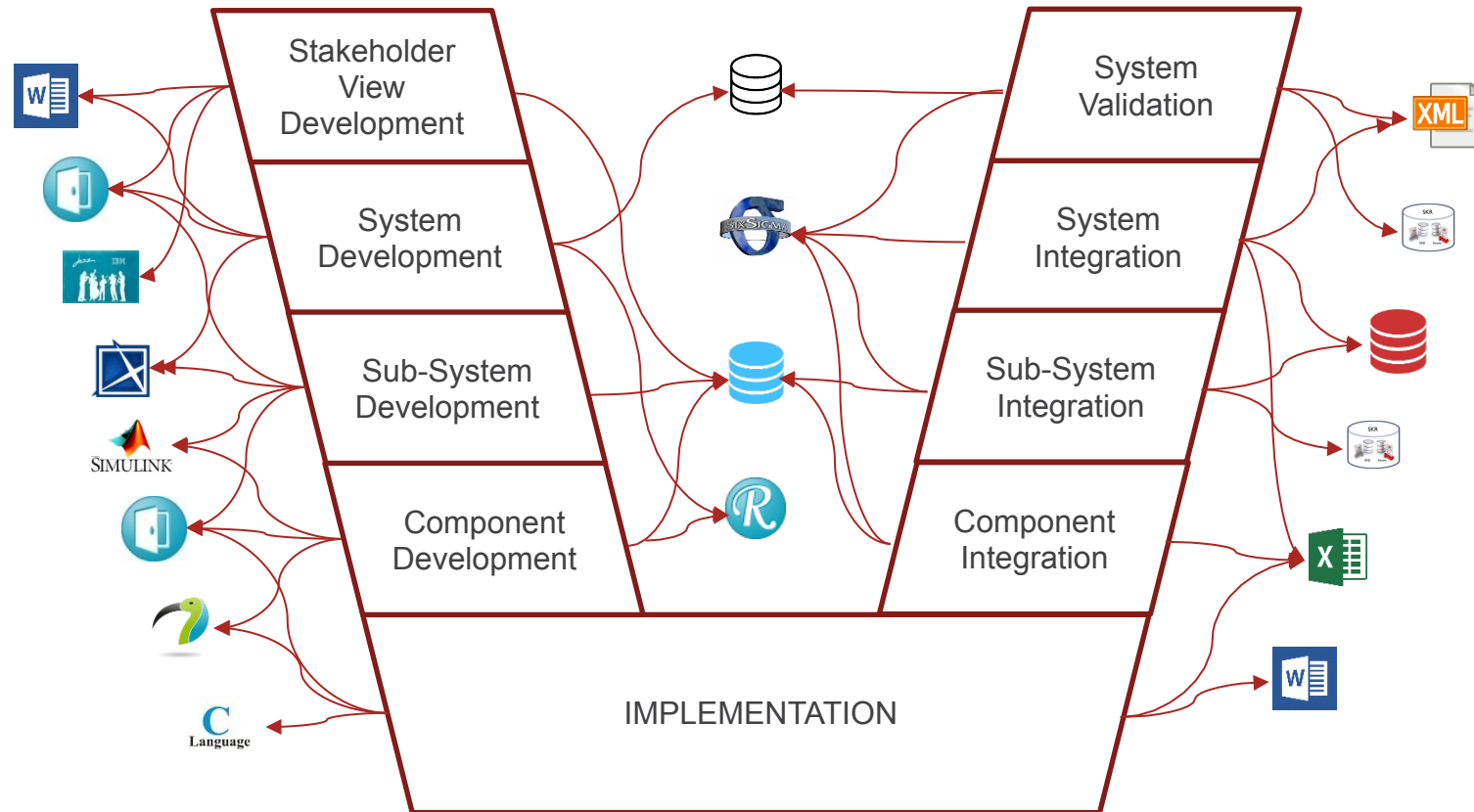
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hugo-guillermo.chalegongora@thalesgroup.com

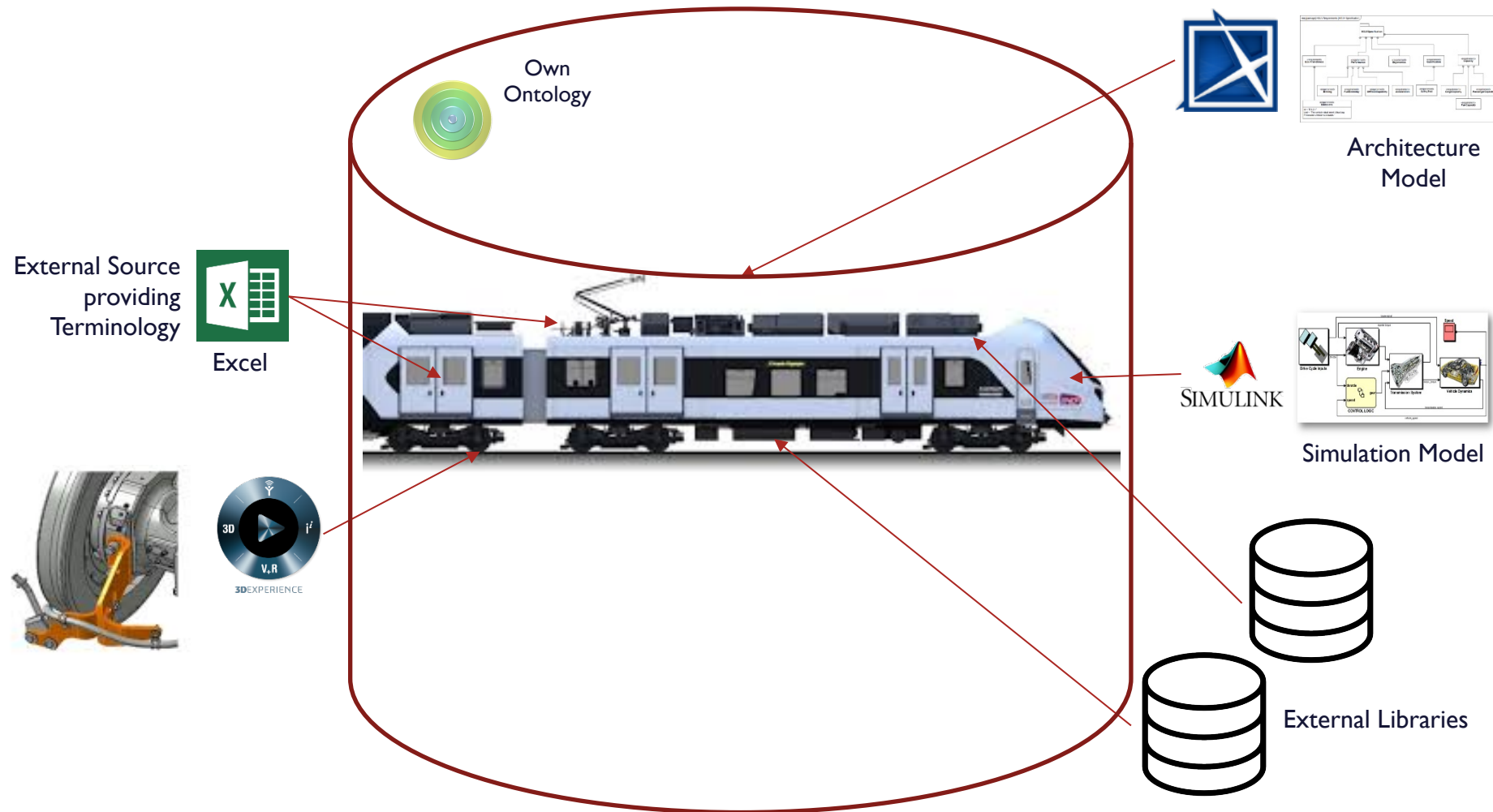
elena.gallego@reusecompany.com

Knowledge-centric SE (KCSE)



System Knowledge Base - Ontology:

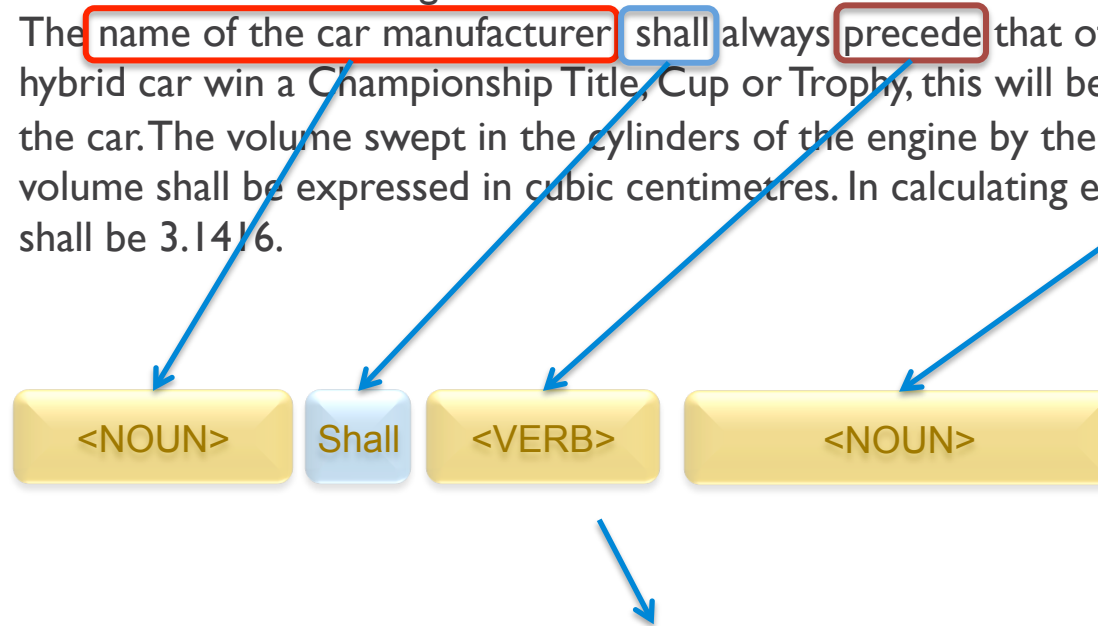
A complete knowledge sharing approach





Multiple applications of this approach: Requirements Identification

- ▶ In the case of Formula racing cars, an automobile make is a complete car. When the car manufacturer fits an engine which it does not manufacture, the car shall be considered a hybrid and the name of the engine manufacturer shall be associated with that of the car manufacturer. The name of the car manufacturer shall always precede that of the engine manufacturer. Should a hybrid car win a Championship Title, Cup or Trophy, this will be awarded to the manufacturer of the car. The volume swept in the cylinders of the engine by the movement of the pistons. This volume shall be expressed in cubic centimetres. In calculating engine cubic capacity, the number Pi shall be 3.1416.

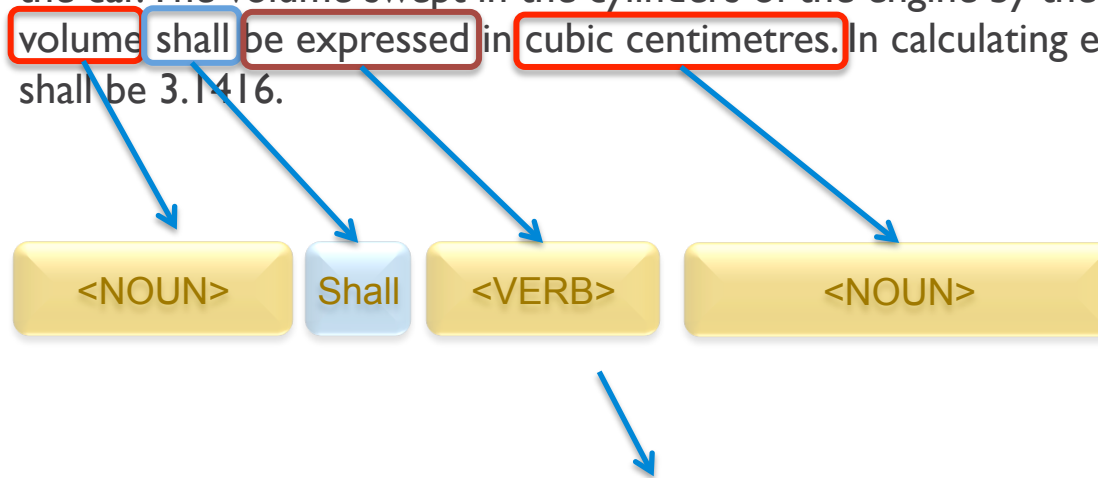


- ▶ **REQ002:** The name of the car manufacturer shall always precede that of the engine manufacturer



Multiple applications of this approach: Requirements Identification

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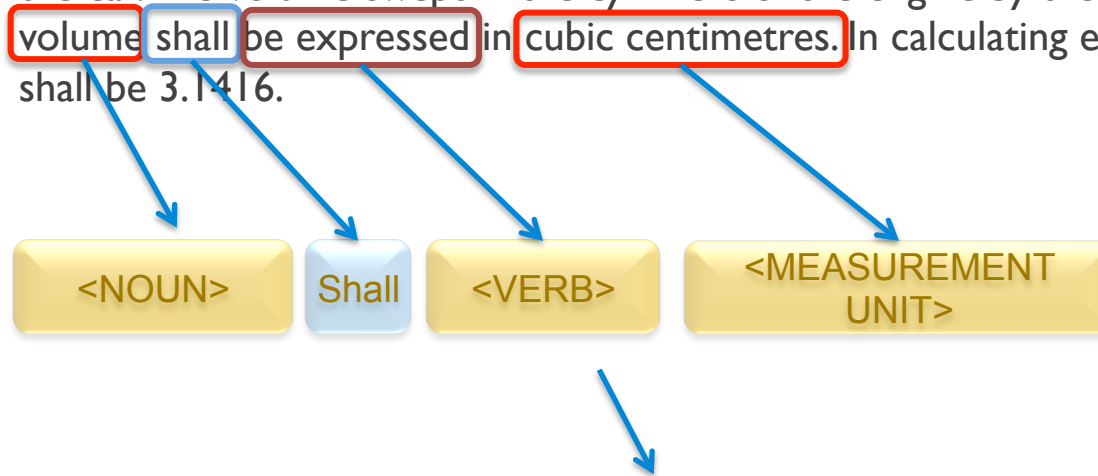


- ▶ **REQ003:** This volume shall be expressed in cubic centimetres



Different Patterns imply that Different requirements are extracted

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