Applying INCOSE Rules for writing high-quality requirements in Industry

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KNOWLEDGE REUSE

Short Bio

- PhD in Computer Science on Universal Knowledge Reuse in 2010
- E-Commerce and Networking Master 2004
- Computer Science Engineer 1999
- Professor at UC3M (Carlos III of Madrid University in Madrid)
- Knowledge Manager expert in The Reuse Company

Researchgate and LinkedIn profiles for more information

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Agenda

- Problems found in the Requirement Engineering practice
  - Impact of low quality requirements
- Previous and current efforts (CRYSTAL project)
- Tools supporting the ideas and the research developed so far
  - The Requirements Quality Suite
  - Metrics
  - Rules implemented
- Some results

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Abstract

- Reviews activities are **time consuming** and their performances are not totally satisfying.
- Rely on the **expertise** of the Systems Engineers completely.
- More **advanced practices should combine Requirements Engineering and Knowledge Management** (NLP – Patterns – Ontologies)
- **Identify in a large set of requirements gaps** such as **inconsistencies** or superfluous **similarities**.
- Typical examples are:
  - inconsistent use of measurement units in requirements,
  - lack of domain vocabulary,
  - multiple requirements that mean the same requirement at the end.
- We point out during the lecture **additional instances and focus on the several quality assessment functions** that can be applied.
- In particular, **Guide for Writing Requirements (International Council on Systems Engineering)** is a light in the process.

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Problems found in the Requirement Engineering practice

- Chaos report and some other surveys (e.g. PMI: Pulse of the profession study):
  - ["40%-70% of defects in the projects are related to requirements."]

Source: Chaos Report 2004

Project Success Factors	% of Responses
1. User Involvement	15.9%
2. Executive Management Support	13.9%
3. Clear Statement of Requirements	13.0%
4. Proper Planning	9.6%
5. Realistic Expectations	8.2%
6. Smaller Project Milestones	7.7%
7. Competent Staff	7.2%
8. Ownership	5.3%
9. Clear Vision & Objectives	2.9%
10. Hard-Working, Focused Staff	2.4%
Other	13.9%

- Capers Jones:
  - ["The average rework is over 40%-50%."]

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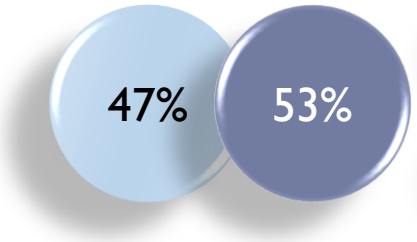
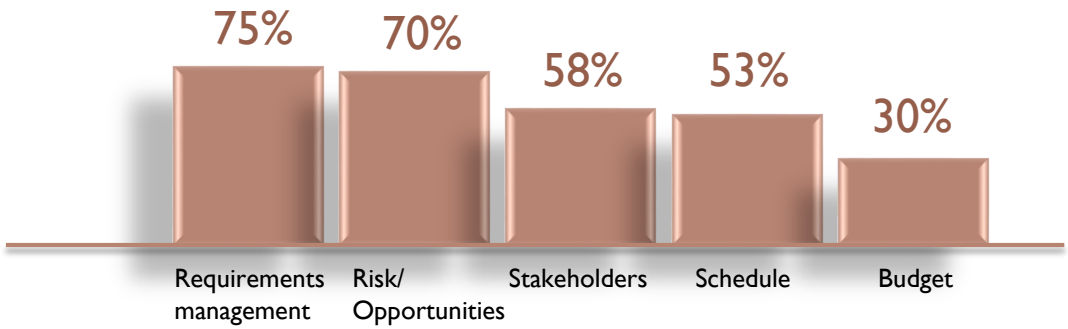
Poor requirements = Poor performance

- "Poor requirements management is a major cause of project failure, second only to changing organization priorities"



Unsuccessful projects where poor requirements management is the primary cause of not meeting goals

Other reasons



Poor communication is primary cause of failure in these areas; and requirements are the reason for this poor communication

Source: PMI 2014. Pulse of the Profession study

Poor Requirements = Poor Performance

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The impact of low quality requirements

- In some cases:

["A good requirements specification may lead to a bad project outcome"]

- But clearly:

["A bad requirements specification will always lead to a bad project outcome"]

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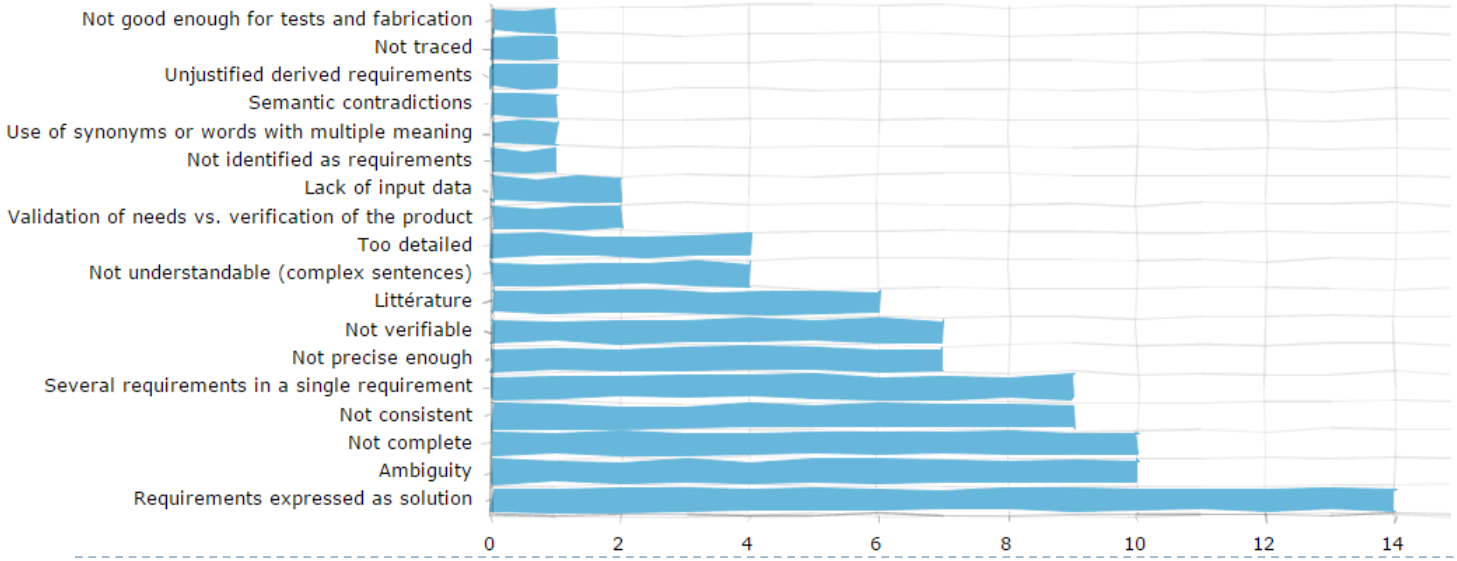
Previous and current effort

- Experiences showed that about **25% of system Requirements are critical and can grammatically be improved**
  - No Shall: 8 to 10%
  - Forbidden words: 10 to 15%
  - Subject, multiple objects, design: 15%
  - Incorrect grammar: 50%
  - …



Source:
AFIS & Gauthier Fanmuy
RAMP Project

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Previous and current effort (CRYSTAL project)

- **CRYSTAL** - CRITICAL SYSTEM ENGINEERING ACCELERATION (ARTEMIS JU project – European)
- This standard will allow loosely coupled tools to share and interlink their data based on standardized and open Web technologies that enables common **interoperability** among various life cycle domains. This reduces the complexity of the entire integration process significantly. Compared to many other research projects.
- CRYSTAL is strongly industry-oriented and will provide ready-to-use integrated tool chains having a mature technology-readiness-level (up to TRL 7).
- In order to reach this goal, CRYSTAL is driven by **real-world industrial use cases** from the automotive, aerospace, rail and health sector and builds on the results of successful predecessor projects like CEASAR, SAFE, iFEST, MBAT on European and national level.
- Creating and establishing a **new standard** on a large scale in an already consolidated market cannot be achieved by individual organizations. With a budget of more than 82 million Euro and 71 partners from 10 different European countries, CRYSTAL has the critical mass to accomplish this endeavor. The project consortium is made up of participants from all relevant stakeholders, including OEMs, suppliers, tool vendors and academia.

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Requirements quality characteristics vs quality metrics

- Can we translate between the set of quality characteristics and a set of quality metrics more *easy to measure*?
- Some approaches to define a set of *easy-to-measure* requirements quality metrics:
  - ARM (Automated Requirement Measurement Tool) by NASA

INDICATORS OF QUALITY ATTRIBUTES											
	Quality Attributes										
Categories of Quality Indicators	1. Complete	2. Consistent	3. Correct	4. Modifiable	5. Ranked	6. Testable	7. Traceable	8. Unambiguous	9. Understandable	10. Validatable	11. Verifiable
1. Imperatives	X			X			X	X	X	X	X
2. Continuances	X			X	X	X	X	X	X	X	X
3. Directives	X		X			X		X	X	X	X
4. Options	X					X		X	X	X	
5. Weak Phrases	X		X			X		X	X	X	X
6. Size	X					X		X	X	X	X
7. Text Structure	X	X		X	X		X		X		X
8. Spec. Depth	X	X		X			X		X		X
9. Readability				X		X	X	X	X	X	X

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Requirements quality characteristics vs quality metrics

- Well-known requirements quality characteristics
- IEEE Std. 830:
  - Correct
  - Unambiguous
  - Complete
  - Consistent
  - Ranked
  - Verifiable
  - Modifiable
  - Traceable
- ESA PSS-05, ISO/IEC 29148, others:
  - Pretty much the same characteristics
- SMART:
  - Specific
  - Measurable
  - Achievable
  - Relevant
  - Traceable

"I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth"

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Requirements quality characteristics vs quality metrics

- More approaches:
  - **INCOSE Guide for Writing Requirements**
  - Describes a set of quality characteristics (based on ISO/IEC 29148):
    - Necessary
    - Implementation independent
    - Unambiguous
    - Complete
    - Singular
    - Conforming
    - Feasible
    - Verifiable
    - Correct
  - But also describes a number of more precise rules
  - And the matching among characteristics and easy-to-measure rules

Characteristic Cxx – Characteristic name
Rationale: xxxx
Strategy: xxxx
Rules that help establish this characteristic:
Rxx - /Section/Rule name Avoid xxxx Ryy - /Section/Rule name Avoid yyy

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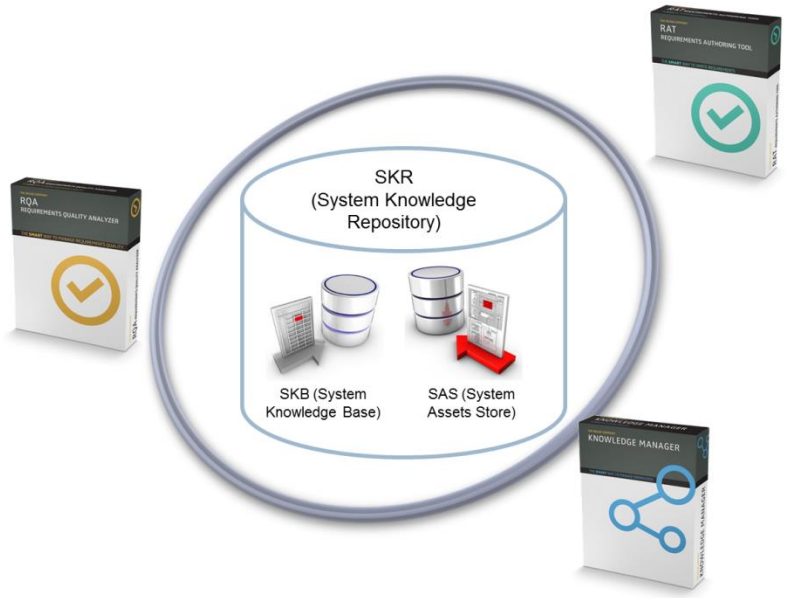
The Requirements Quality Suite

- The Requirements Quality Suite (RQS) intends to tackle requirements quality management by offering a set of tools and processes
- Automatic measurement of requirements quality metric
- Support to Requirements Authoring
- RQS models requirements quality metrics using the CCC approach (Correctness, Consistency and Completeness)



Requirements Quality Analyzer (RQA):
to setup, check and manage the quality of a requirements specification.

Requirement Authoring Tool (RAT):
to assist authors while they are creating or editing requirements.

Knowledge Manager (KM):
to manage knowledge around a requirements specification: the ontology it is based on, the structure of the requirements to be used in the project, the communication between authors and domain architects.

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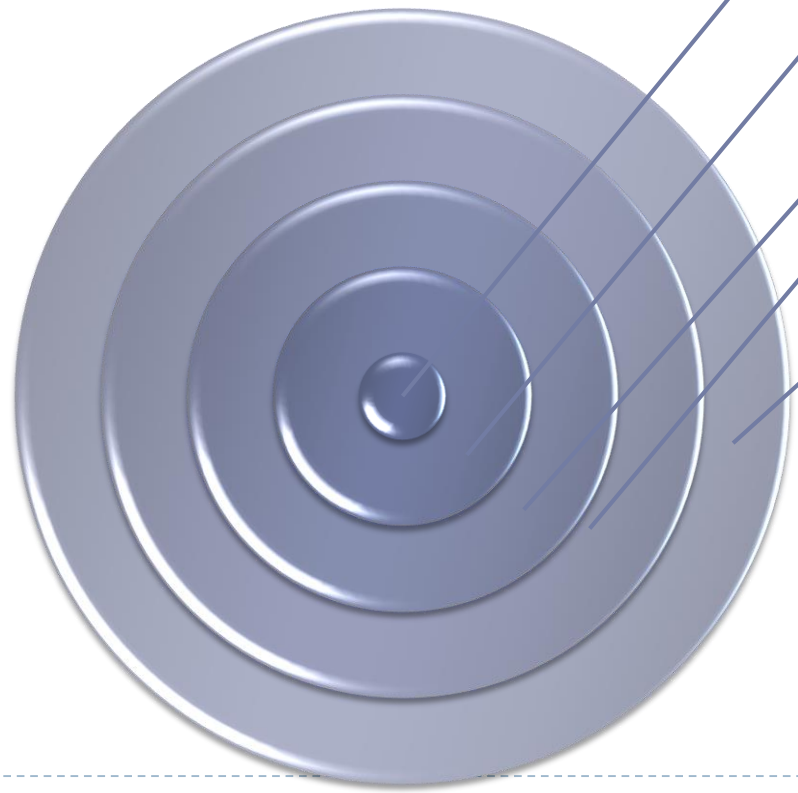
The Requirements Quality Suite: Ontology view

- Ontologies as the driving element for requirements quality
- Allows a set of tools to enhance performance and reduce defects



Terminology: valid terms, forbidden terms, other NL terms, Syntactic clustering types, everything as concepts

Conceptual model: relationships among concepts (hierarchies, associations, synonyms…), PBS, FBS, Etc.

Patterns: Matching Patterns

Formalization: Semantic formalization

Inference rules: for decision making (e.g. consistency, completeness)

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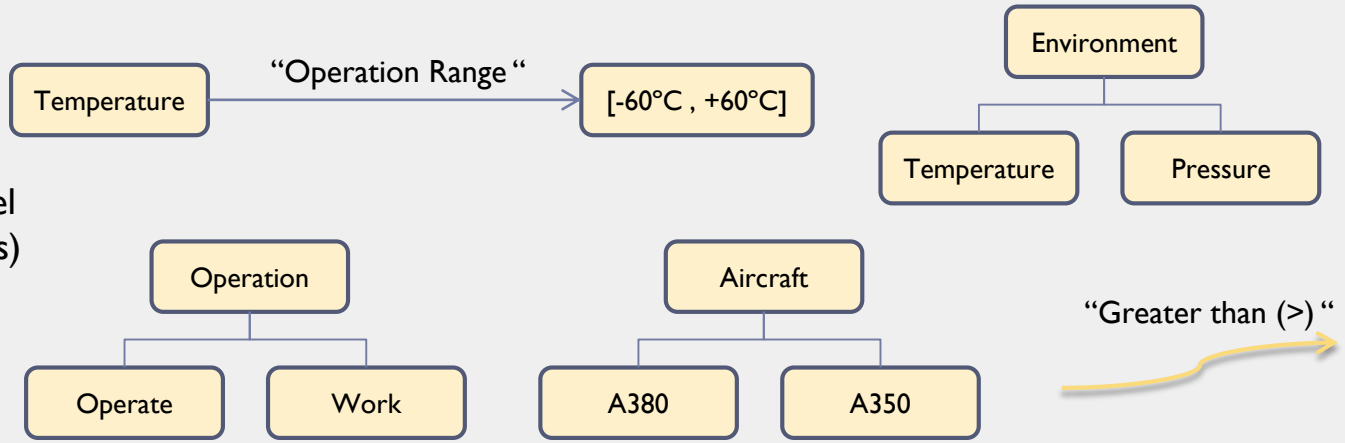
The Requirements Quality Suite: Example

Vocabulary

A380 | A350 | System | Operate | Temperature | Environment | Pressure

Conceptual model (semantic clusters)



Patterns

Aircraft (*) | Shall | Operation (*) | At | «Minimum» | Environment (*) | Of | NUMBER | MEASUREMENT UNIT

Formalizations

The aircraft shall be able to operate at a minimum temperature of -70° C → Temperature — "Greater than (>)" → -70 | °C

Inference Rules

If NUMBER " Lower than (<) " -70° | °C Or NUMBER "Greater than (>)" +65° | °C → ✗

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The Indexing process

- In order to match a pattern from a natural language text, it is necessary to identify and extract the **TERMINOLOGY** accepted by the organization:
  - Identify **valid** terminology
    - Singulars, ranges, Measurement Units
  - Locate terminology in the **Conceptual Model**
  - Check for **restriction** matching
- Without terminology It is not possible to match patterns.
- **Terminology identification implies Natural language processing**

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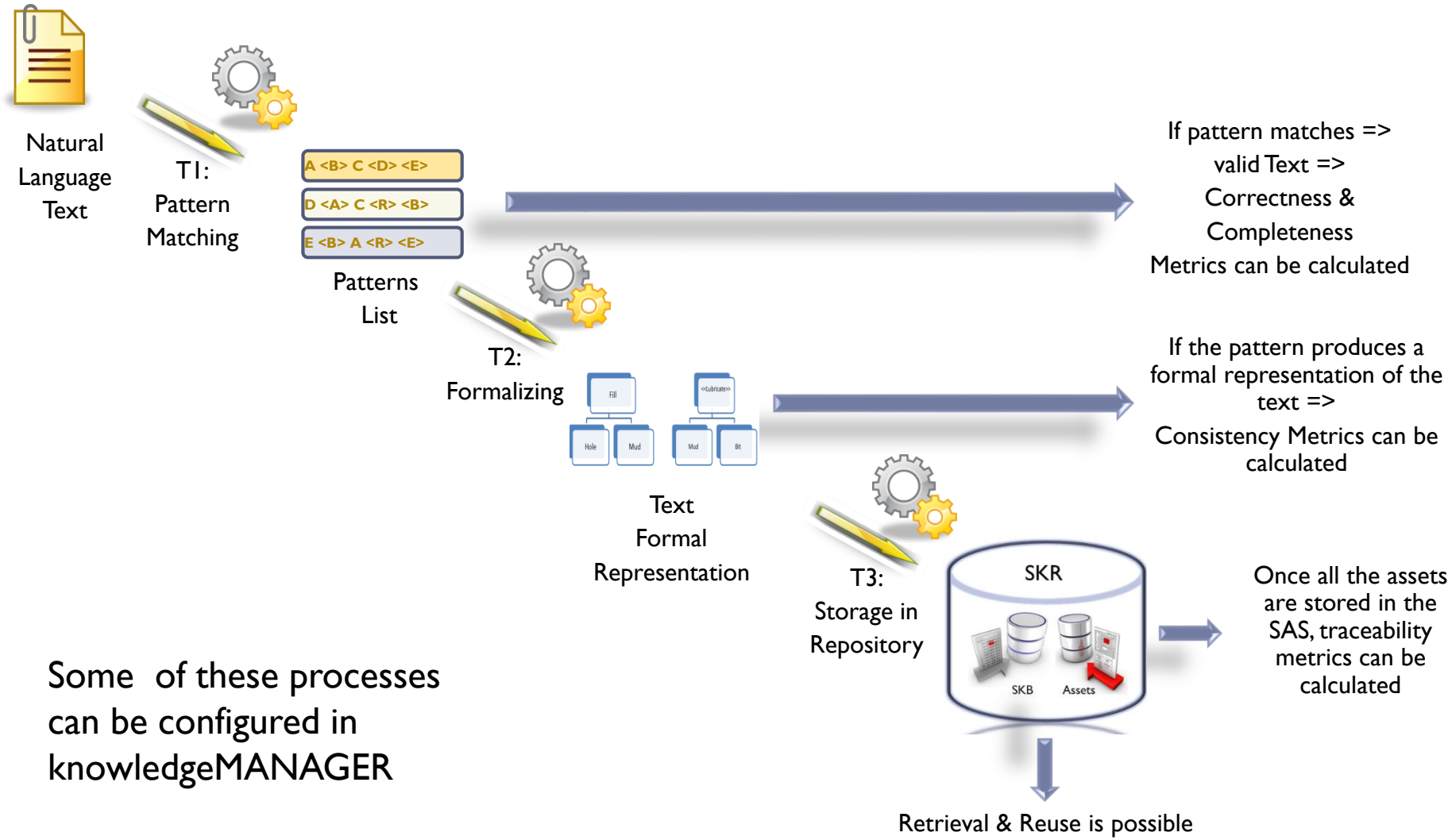
Indexing process in RQS (RQA and RAT)



Some of these processes can be configured in knowledgeMANAGER

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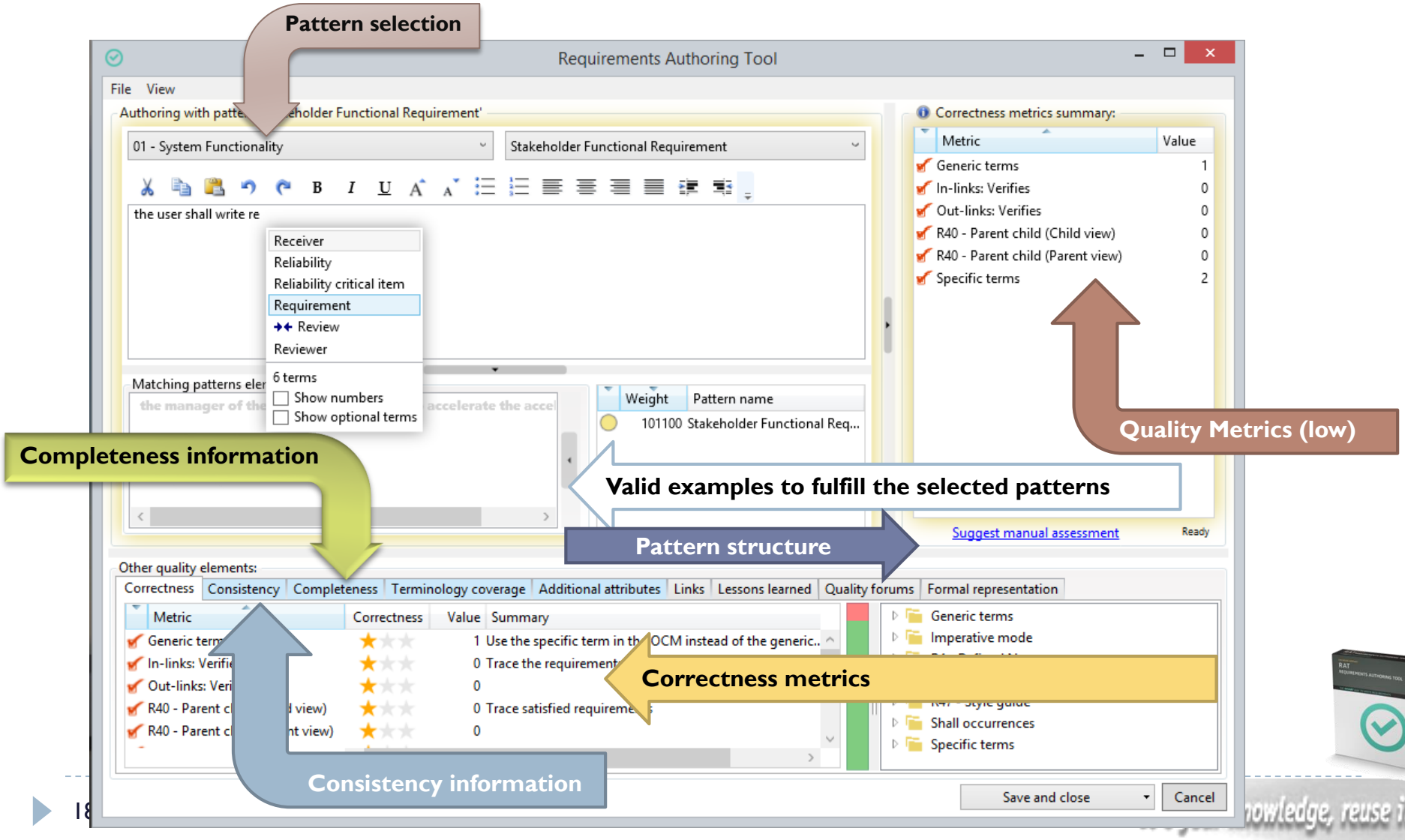
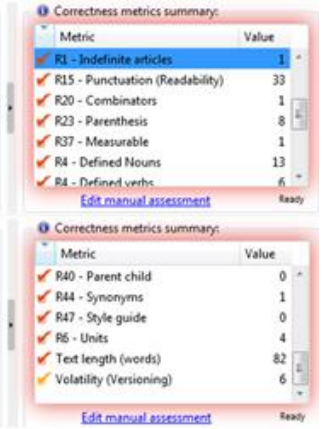
RQS – Requirements Quality Suite: RAT



RQS – Requirements Quality Suite: characteristics and implemented rules

- Fully customizable
- **+60 out-of-the-box quality metrics for correctness**
- **+20 out-of-the-box quality metrics for completeness and consistency**
- Parameterized metrics
- Custom-coded metrics
- Support for requirements verification
- Support for Requirements authoring
- Reporting system
- Knowledge management and semantic approach
- Semantic search engine and requirements reuse

Rule description - INCOSE R1	Metric in RQA	Solution
This rule defines the definite articles to be used. The use of indefinite articles as A leads to ambiguity, it is better to use "THE" instead of "A".	Avoid Articles	Create a list of words: a, an Available in the out of the box version of RQA



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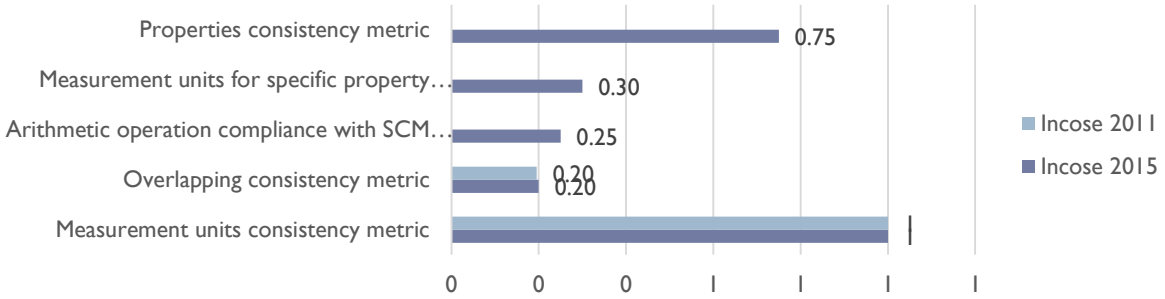
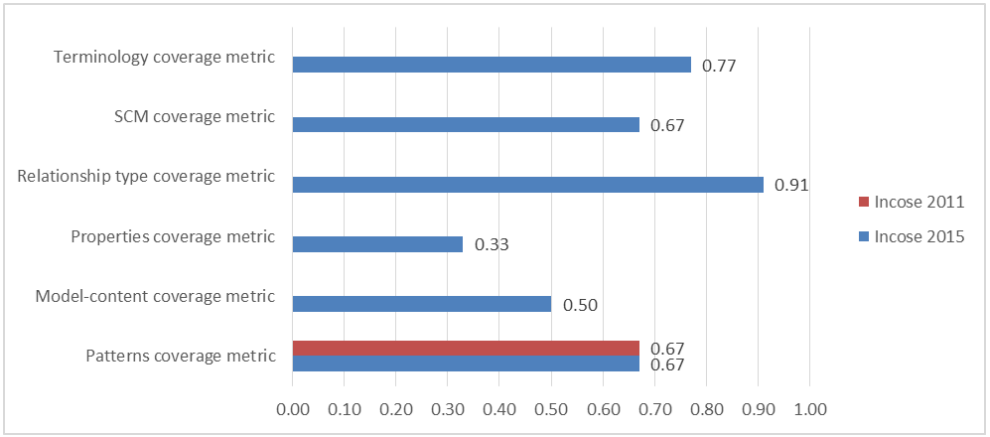
RQS – Some results with INCOSE rules





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