INCOSE GtWR 4.0

Implementation of the latest concepts "At the crossroads between needs and requirement statements"

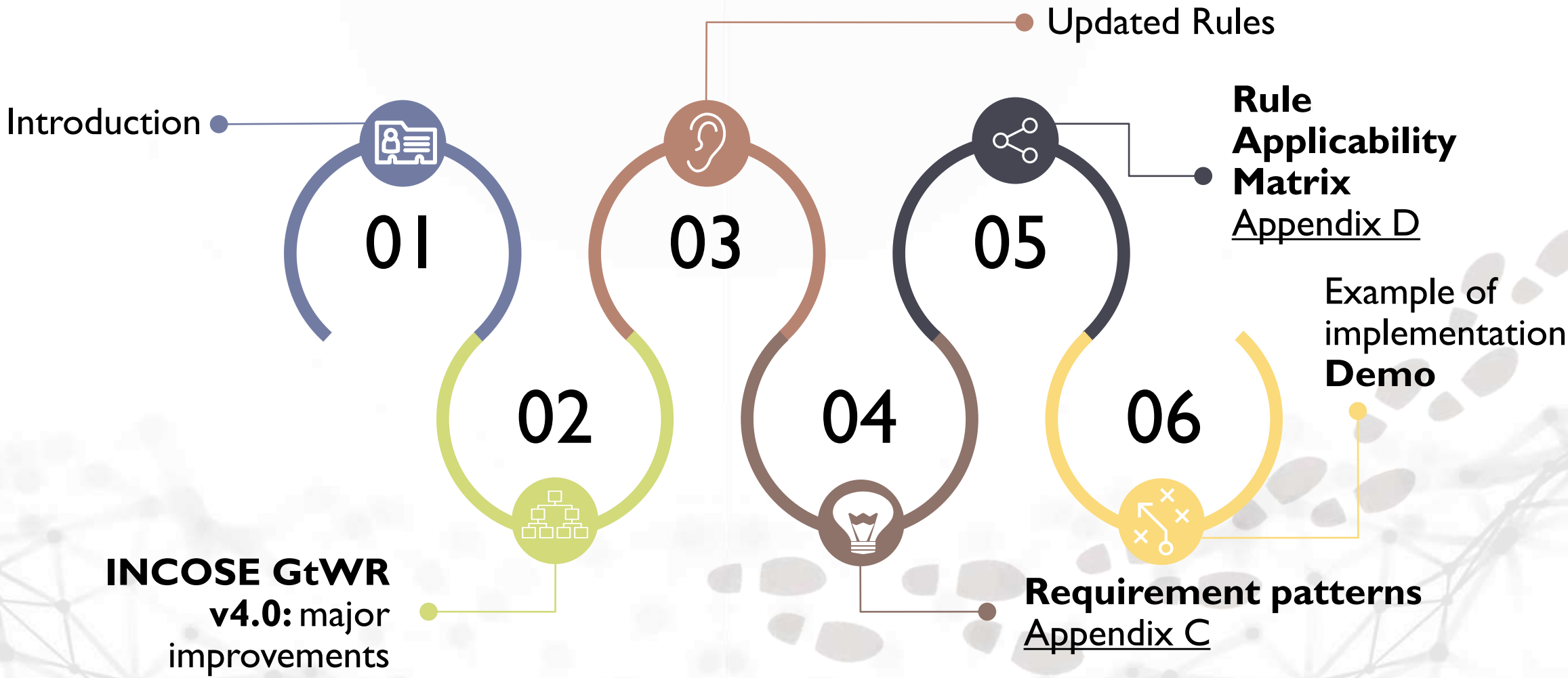
Ilyes Yousfi
The REUSE Company
ilyes.yousfi@reusecompany.com

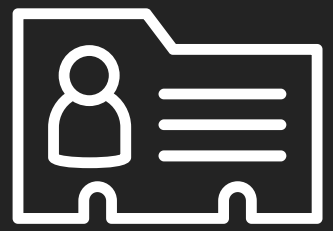
THE REUSE COMPANY

September 19th, 2023

INCOSE International Council on Systems Engineering

Contents





1. Brief intro

The REUSE Company

02

Systems + Software Engineers

Smart combination between Company staff and R&D (University)

04

To promote **reusable** solutions to **SMART** and Systems Engineering environments, by offering a **knowledge centric** approach.

01

The company was established in **1999**

Spin-off of a University in Madrid

03

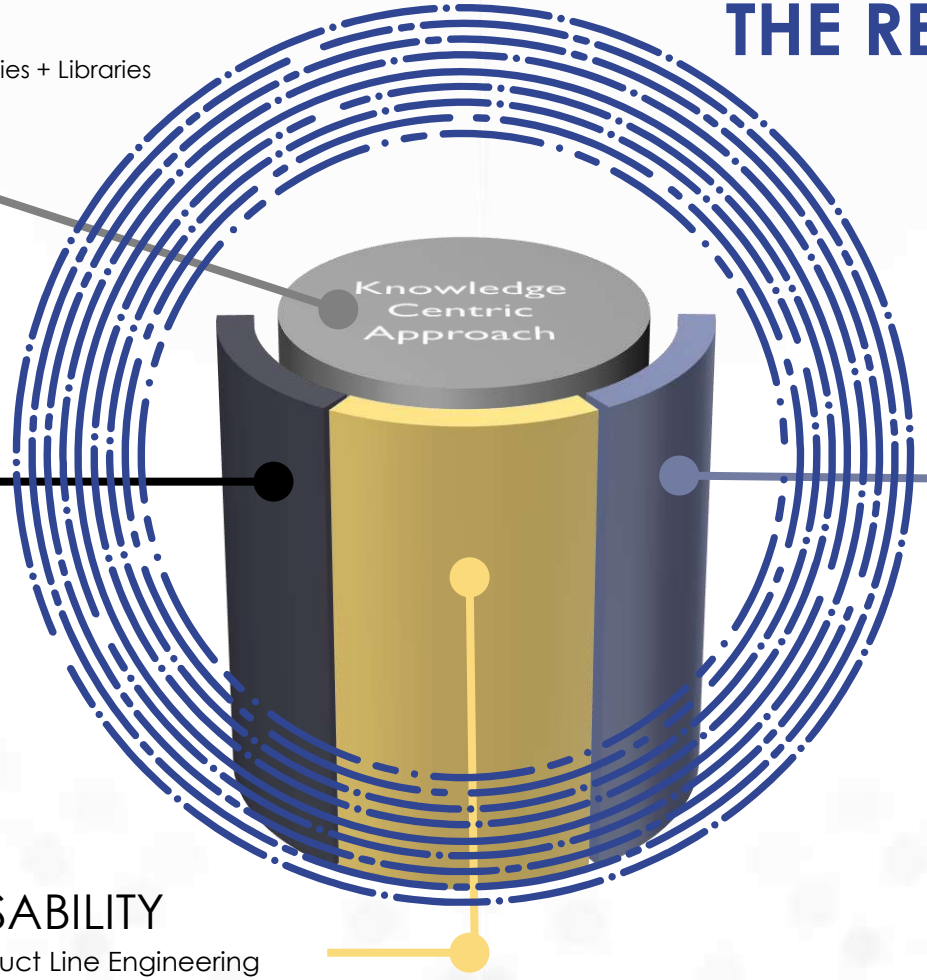
Headquarters:
Madrid (Spain)

International offices:
Stockholm (Sweden)
Tokyo (Japan) Delegation

Knowledge Centric Systems Engineering (KCSE)

Connectivity & Interoperability
Configuration Management
SMART Authoring
Lifecycle Management
Global Repositories: Ontologies + Libraries

THE REUSE COMPANY = TRC



TRACEABILITY

Links and Interoperability –
Transformations –
Change management –

QUALITY

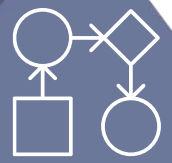
- Quality Management
- Verification & Validation management
- Alerts & Risks Management
- Decision management

REUSABILITY

- Product Line Engineering
- Retrieval & Archiving
- Adaptability to Existing Toolsets

THE REUSE COMPANY = TRC

01



SES TMP – TMx

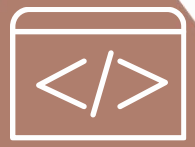
Technical Management Processes:
Quality
V&V
Traces…

02

SES Interop – HUBx

Interoperability HUB
Connectivity to external sources

03



SES Req Eng – REx

SMART Requirements Engineering
Using MS Word as tech platform

04

SES SLCM – SLx

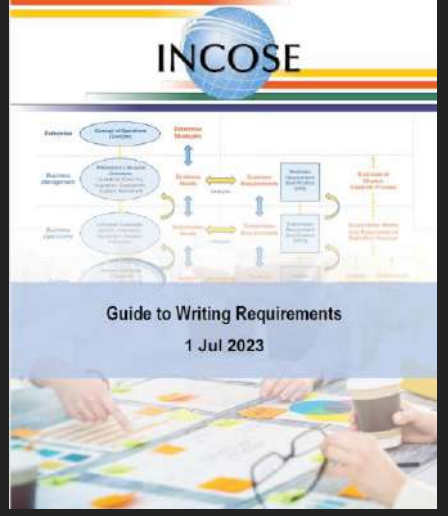
System Life cycle management

05

Knowledge – KMx

Knowledge and Information Management
Ontologies
Virtual Assistants
Search eng.

The REUSE Company is specialized in the application of semantic technologies and artificial intelligence to improve the digitalization of the Systems Engineering life cycle.



2. INCOSE GtWR v4.0

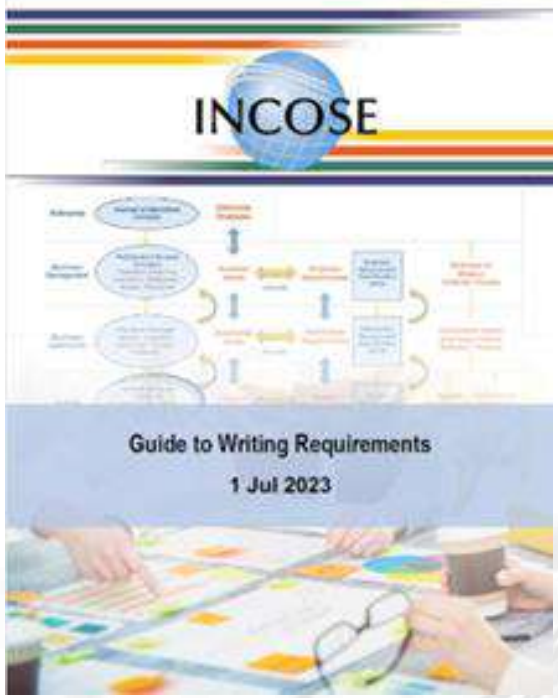
Major improvements

INCOSE Guide for Writing Requirements: get to know it!

The INCOSE RGW (**Requirements Working Group**) in line with its goal

(Expand and promote the body of knowledge of requirements engineering and its benefits within the systems engineering community)

has developed the INCOSE GtWR (**Guide to Writing Requirements**)



The GtWR provides *guidance* on how to express textual needs *AND* requirements expressions.

The GtWR draw advice into a single, comprehensive set of

characteristics, rules and attributes

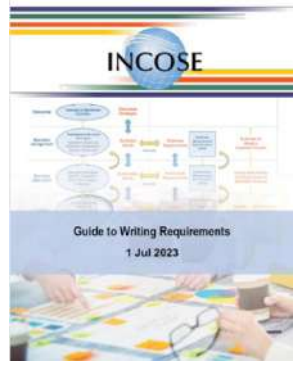
for well-formed need and requirement expressions.

INCOSE GtWR v4.0

- **15 Characteristics** of individual and sets of needs and requirements.
- **42 Rules** to help formulate individual and sets of needs and requirements.
- **49 Attributes** are attached to need or requirement statements to form need or requirement expressions.

42 Rules / 15 Characteristics

Type	Rule Number	Rule name	C1 - NECESSARY	C2 - APPROPRIATE	C3 - UNAMBIGUOUS	C4 - COMPLETE	C5 - SINGULAR	C6 - FEASIBLE	C7 - VERIFIABLE	C8 - CORRECT	C9 - CONFORMING	C10 - COMPLETE	C11 - CONSISTENT	C12 - FEASIBLE	C13 - COMPREHENSIBLE	C14 - ABLE TO BE VALIDATED	C15 - CORRECT
Accuracy	R01	Sentence Structure			1	1			1	1	1						
	R02	Use Active Voice		1	1	1			1								
	R03	Subject Verb		1	1				1			1				1	
	R04	Use Defined Terms			1				1				1		1	1	1
	R05	Use Definite Articles			1				1								
	R06	Units			1	1			1	1							
	R07	Avoid Vague Terms			1	1			1								
	R08	No Escape Clauses			1	1			1								
	R09	No Open Ended			1	1	1		1								
Concision	R10	Superfluous Infinitives			1				1								
	R11	Separate Clauses			1	1			1	1							
Non Ambiguity	R12	Correct Grammar			1				1	1	1						
	R13	Correct Spelling			1				1								
	R14	Correct Punctuation			1					1							
	R15	Logical Condition			1				1								
	R16	Avoid Not			1				1	1							
	R17	Oblique			1				1								
Singularity	R18	Single Sentence			1		1		1		1				1		
	R19	Avoid Combinators			1		1										
	R20	Avoid Purpose	1				1										
	R21	Avoid Parentheses					1										
	R22	Enumeration			1		1										
	R23	Context			1	1	1										
Completeness	R24	Avoid Pronouns			1	1			1								
	R25	Use Of Headings				1											
Realism	R26	Avoid Absolutes						1	1	1				1			
Conditions	R27	Explicit				1			1	1							
	R28	Explicit Lists			1				1								
Uniqueness	R29	Classify										1	1				
	R30	Express Once	1								1		1				
Abstraction	R31	Solutionfree		1													
Quantifiers	R32	Universals			1				1	1							
Tolerance	R33	Value Range			1	1		1	1	1				1			
Quantification	R34	Measurable			1	1			1					1			
	R35	Temporal Indefinite			1	1			1								
Uniform Language	R36	Use Consistent Terms			1					1	1		1		1	1	1
	R37	Define Acronyms			1						1		1		1	1	1
	R38	Avoid Abbreviations									1		1		1	1	1
	R39	Style Guide				1	1				1		1		1	1	1
	R40	Decimal Format			1	1					1		1				
Modularity	R41	Related Requirements				1					1	1	1		1		1
	R42	Structured										1	1		1	1	1

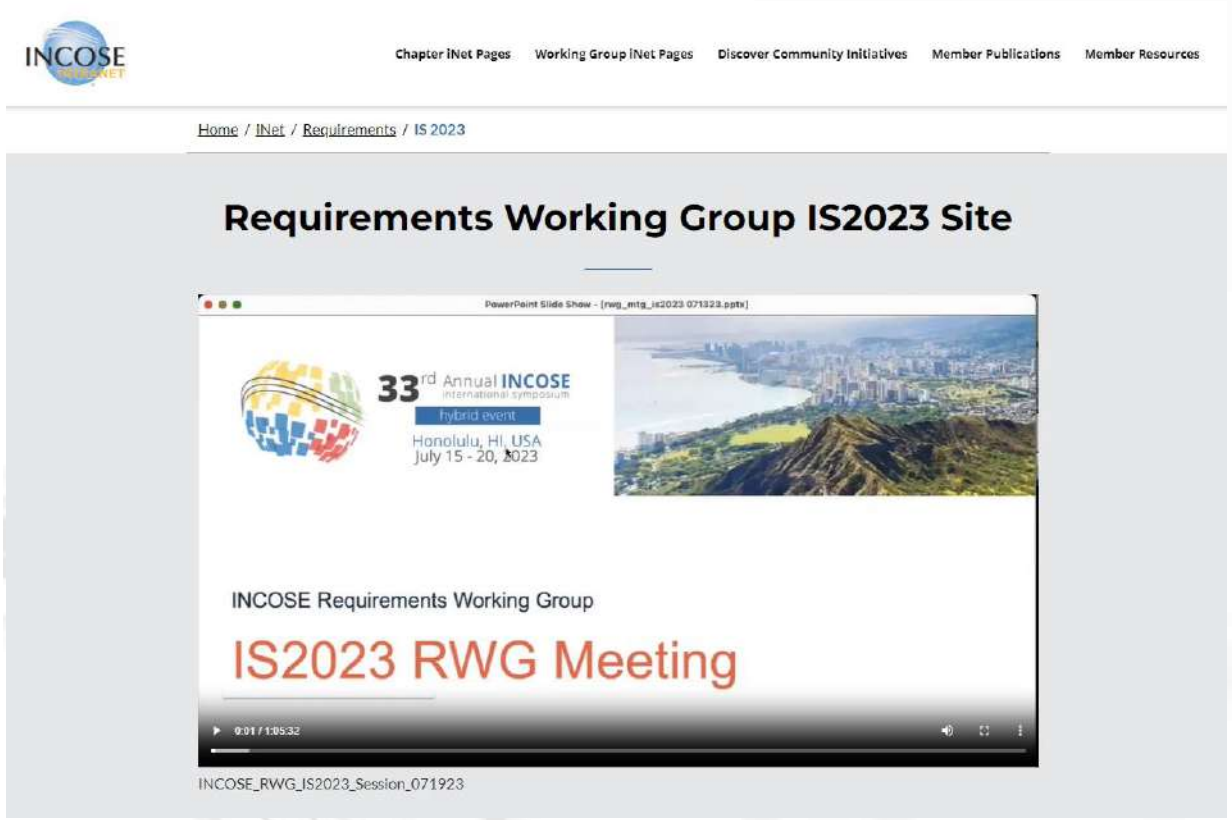


49 Attributes

Att #	Attribute	Attributes to Help Define the Requirement and its Intent	Associated with the System of Interest (SOI) Verification	Attributes to Help Maintain the Requirements	Attributes to Show Applicability and Allow Reuse
A01	Rationale*	1			
A02	SOI Primary Verification or Validation Method*	1			
A03	SOI Verification or Validation Approach	1			
A04	Trace to Parent*	1			
A05	Trace to Source*	1			
A06	Condition of Use	1			
A07	States and Modes	1			
A08	Allocation*	1			
A09	SOI Verification or Validation Level		1		
A10	SOI Verification or Validation Phase		1		
A11	SOI Verification or Validation Results		1		
A12	SOI Verification or Validation Status		1		
A13	Unique Identifier*			1	
A14	Unique Name			1	
A15	Originator/Author*			1	
A16	Date Requirement Entered			1	
A17	Owner*			1	
A18	Stakeholders			1	
A19	Change Board			1	
A20	Change Status			1	
A21	Version Number			1	
A22	Approval Date			1	
A23	Date of Last Change			1	
A24	Stability			1	
A25	Responsible Person			1	
A26	Need or Requirement Verification Status*			1	
A27	Need or Requirement Validation Status*			1	
A28	Status (of the Need or Requirement)			1	
A29	Status (of Implementation)			1	
A30	Trace to Interface Definition			1	
A31	Trace to Peer Requirements			1	
A32	Priority*			1	
A33	Criticality or Essentiality*			1	
A34	Risk (of Implementation)*			1	
A35	Risk (Mitigation)			1	
A36	Key Driving Need or Requirement (KDN/KDR)			1	
A37	Additional Comments			1	
A38	Type/Category			1	
A39	Applicability				1
A40	Region				1
A41	Country				1
A42	State/Province				1
A43	Application				1
A44	Market Segment				1
A45	Business Unit				1
A46	Business (Product)Line				1

INCOSE GtWR: more details about the updates

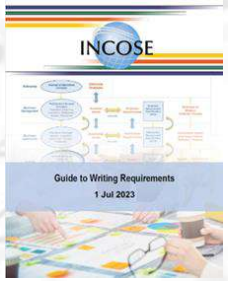
IS 2023 RWG Meeting



- Change summary
- Details about the updated definitions and concepts
- Added figures in Elaboration section of Characteristics & Rules

MEMBERS ONLY

https://www.incose.org/inet/working-groups/requirements/requirements-meetings/is-2023



INCOSE GtWR v4.0 release: focus of this presentation

i) Rules:

- Updated Rules: R06 (Units), R33 (Tolerance)
- ****New Rule** :** R40 (DecimalFormat)

ii) Requirement Patterns (Appendix C)

iii) Rule Applicability Matrix (Appendix D) : Needs vs. Requirements and Data Dictionaries

*****THE CHALLENGE*****

"address both need and requirement statements and understand the differences between the two"

INCOSE GtWR sect. 1.8

3.
Rules

Updates in v4.0 release

- **Updated Rule**
  - Rule 06/ Common Units of Measure

Definition:
When stating quantities, all numbers should have appropriate and consistent units of measure explicitly stated using a common measurement system in terms of the thing the number refers.

  - Added the triplet {*Component, Property, MeasurementUnit*} consistency concept

Example:

REQ-001 "The Fuel_System shall have a maximum Fuel_Tank volume of 60 l." → **{Fuel_System, Fuel_Tank volume, l}**

REQ-002 "When the Sensor detects the Fuel_Tank volume is less than 50 dl, the Sensor shall light the Low-Fuel_indicator within 1 second."

REQ-003 "While the Fuel_System has a Fuel_Tank volume higher than 60 l, the Low-Fuel_indicator light shall be Off.

REQ-004 "While the engine is on, If the Cooling_System_volume is lower than 3400 ml, the Water_Pump shall transit to Emergency mode.

Updates in v4.0 release

- **Updated Rule**
  - Rule 33 / Range of Values (Tolerance)

Definition:
Define each quantity with a range of values appropriate to the entity to which the quantity applies and against which the entity will be verified or validated.

  - Uniformity of Format
    - Use a consistent format for tolerances

Example:

REQ-004 "The Fuel_System shall have a maximum weight of 600 lb ± 5%."

REQ-005 "The Fuel_System shall have a maximum power consumption of 2.4 kW (-0.0 kW / +0.4 kW)

  - Unit for each value?
  - Numerical vs. textual format : "between...and..." / "from....to..." etc.

Updates in v4.0 release

- **New Rule**
  - Rule 40 / DecimalFormat

Definition:
Use a consistent format and number of signification digits for the specification of decimal numbers.

- Symbol for decimals , vs. .
- ...and symbol for thousands !
- **Set a convention**

Example:

	,	.
	9,499	9.499
.	9,499.99	, 9.499,99

Updates in v4.0 release

- **New Rule**
  - Rule 40 / DecimalFormat
  - Decimal format for numbers between -1 and 1
    - ,99 vs. **0**,99

4. Requirements patterns

INCOSE GtWR appx. C

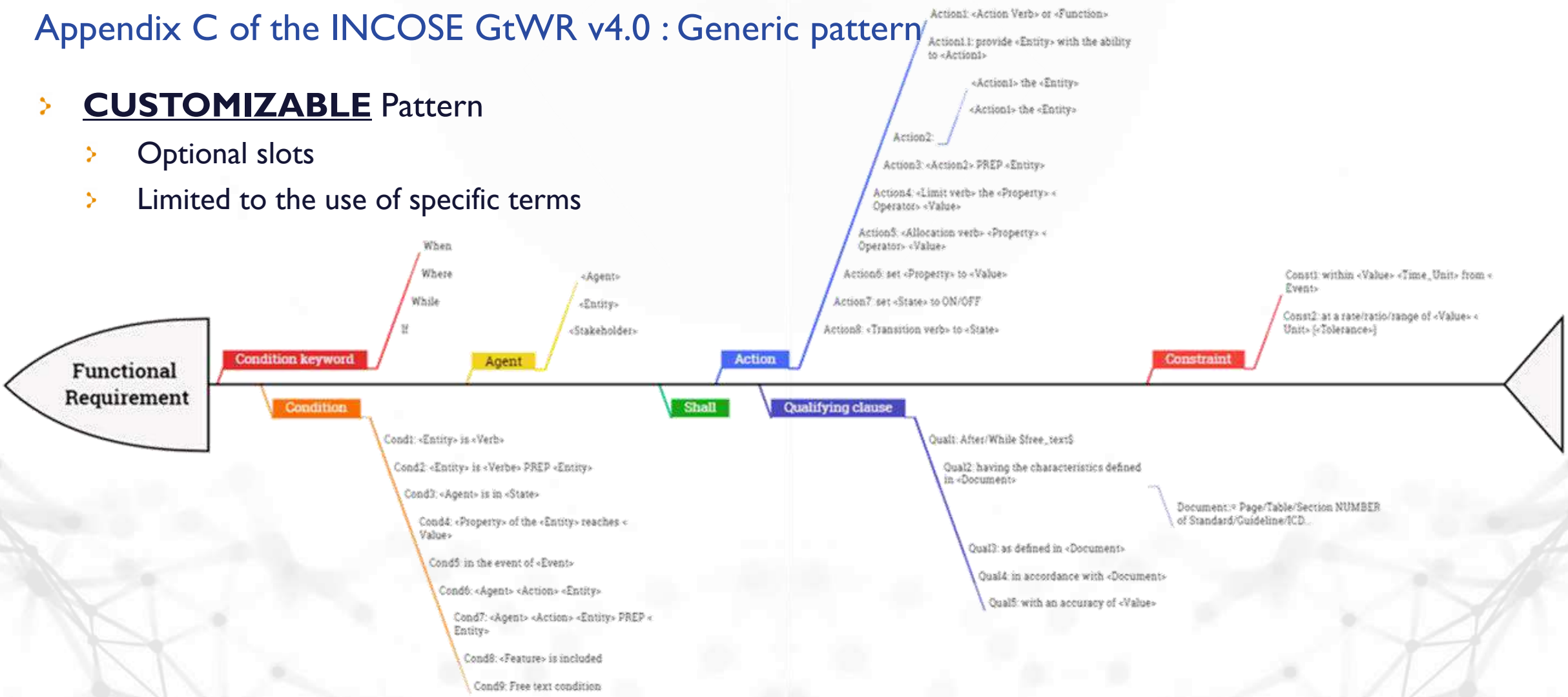
Benefits of requirement patterns

- Sets an internal standard for well-formed requirements
- Help identifying keywords (i.e. the subject before the "shall")
- Customizable for every domain, customer and content of each requirements document
- **Pattern Libraries**

Condition Keyword | Condition | Agent | Shall | Action | Qualifying Clause | Constraint

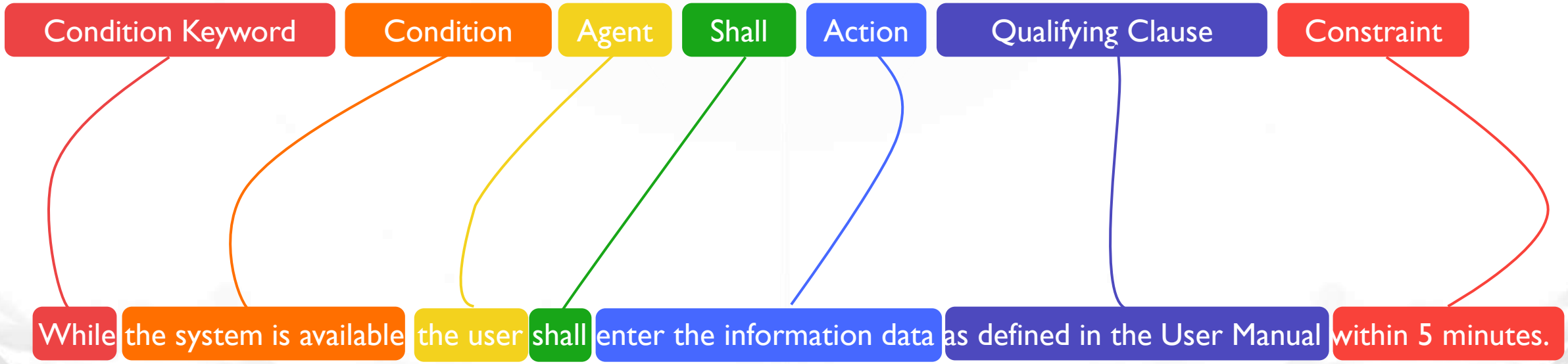
Appendix C of the INCOSE GtWR v4.0 : Generic pattern

- **CUSTOMIZABLE** Pattern
  - Optional slots
  - Limited to the use of specific terms



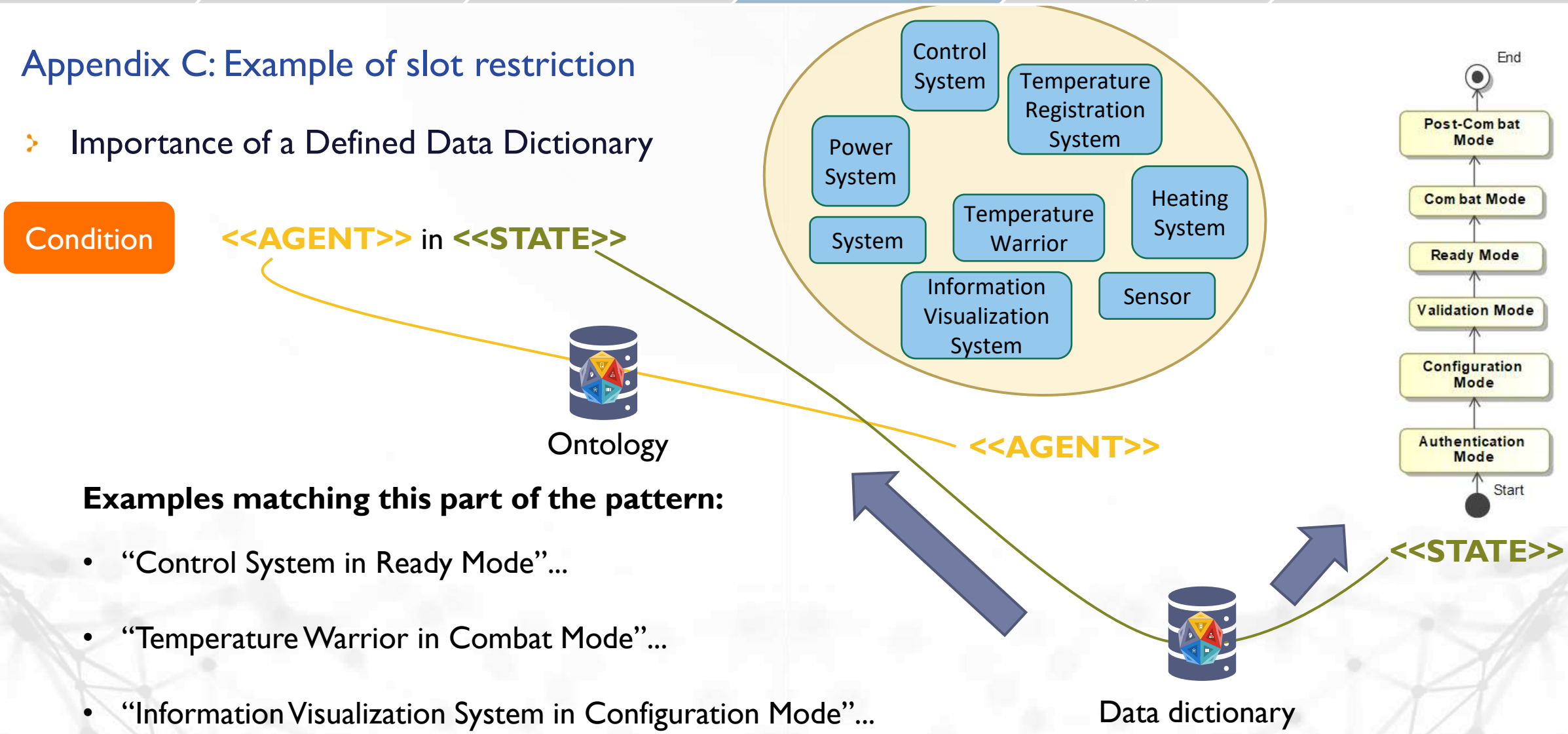
Appendix C of the INCOSE GtWR v4.0 : Generic pattern

- **CUSTOMIZABLE** Pattern



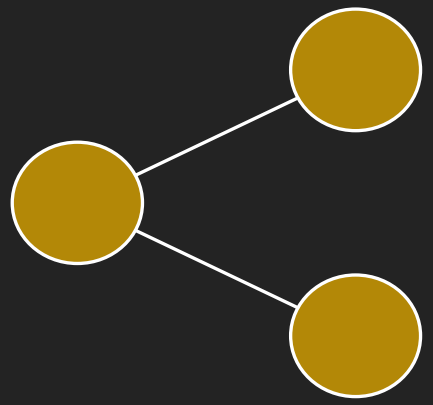
Appendix C: Example of slot restriction

- Importance of a Defined Data Dictionary



Examples matching this part of the pattern:

- "Control System in Ready Mode"...
- "Temperature Warrior in Combat Mode"...
- "Information Visualization System in Configuration Mode"...



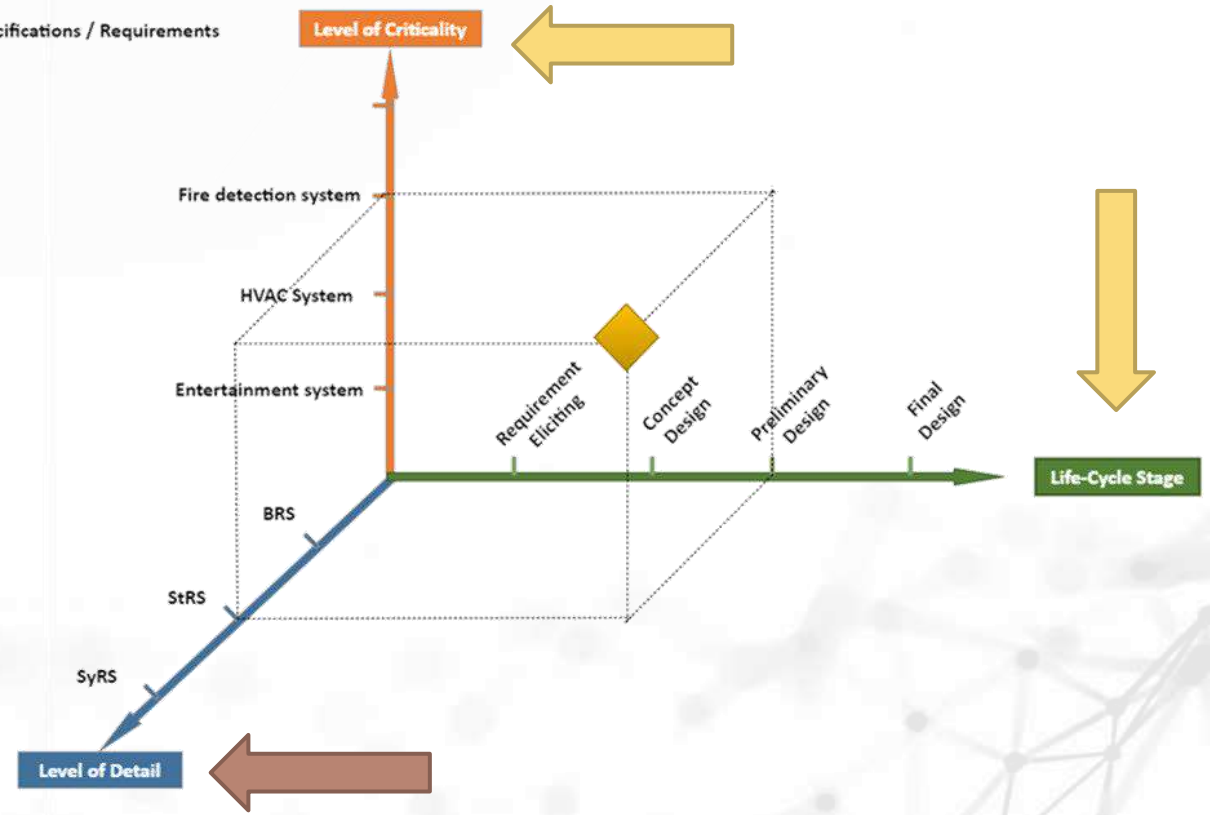
5. Rule Applicability Matrix (Appendix D)

Introduction to the Rule Applicability Matrix

- Guidelines/**Recommendations** to apply a tailored set of rules to either Needs or Requirements
  - *Optional / Recommended* rule for Needs
  - *Compulsory* rules for Requirements

- **Tailoring** to either Needs or Reqs
- Is a **Project Data Dictionary** needed?
  - 1. check cross-domain aspects
  - 2. check domain-specific aspects

Tailoring Guide
(Link to download the book) :



Needs & Requirements – what is the difference?

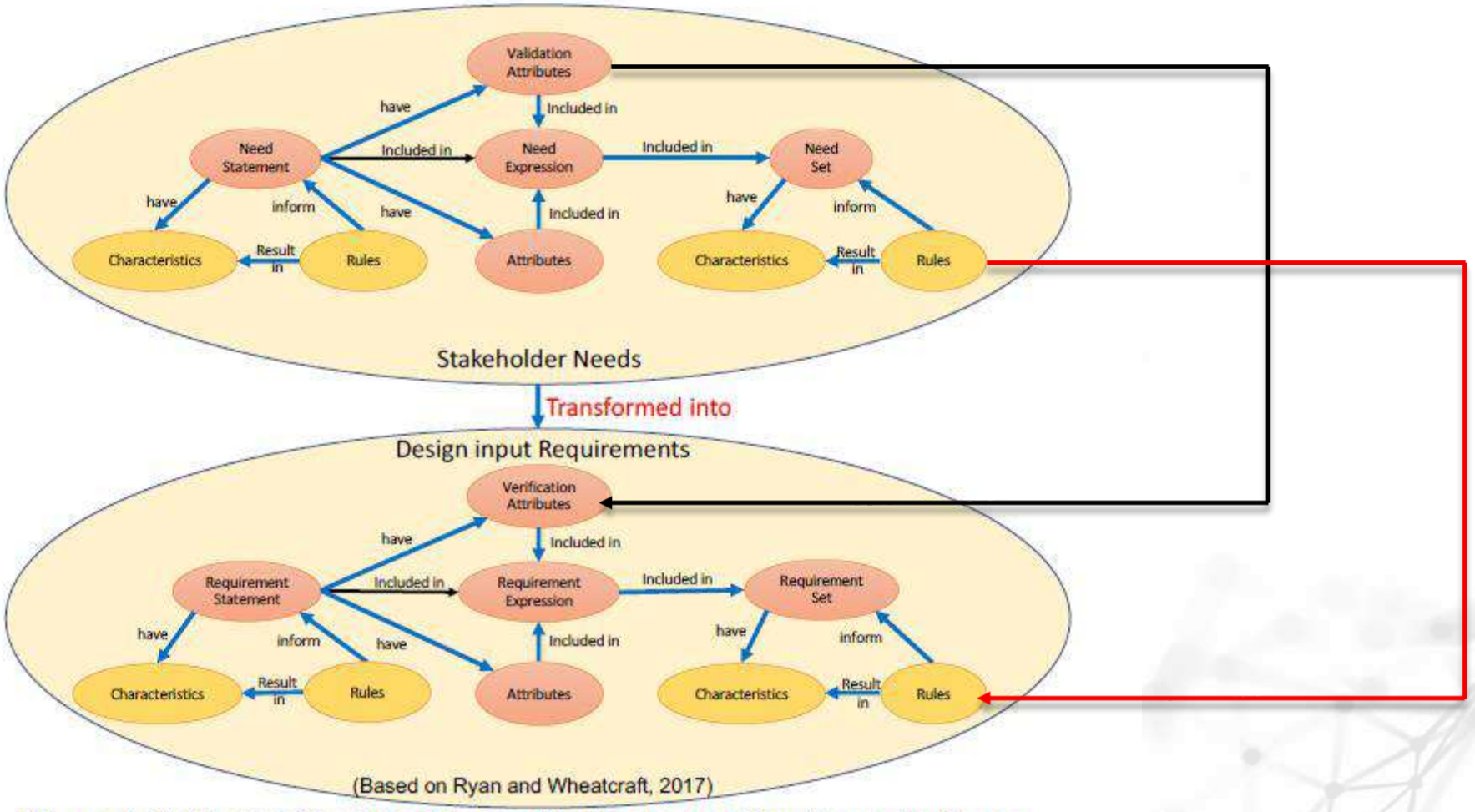


Figure 4: Entity-Relationship Diagram for Needs and Requirements Terms.

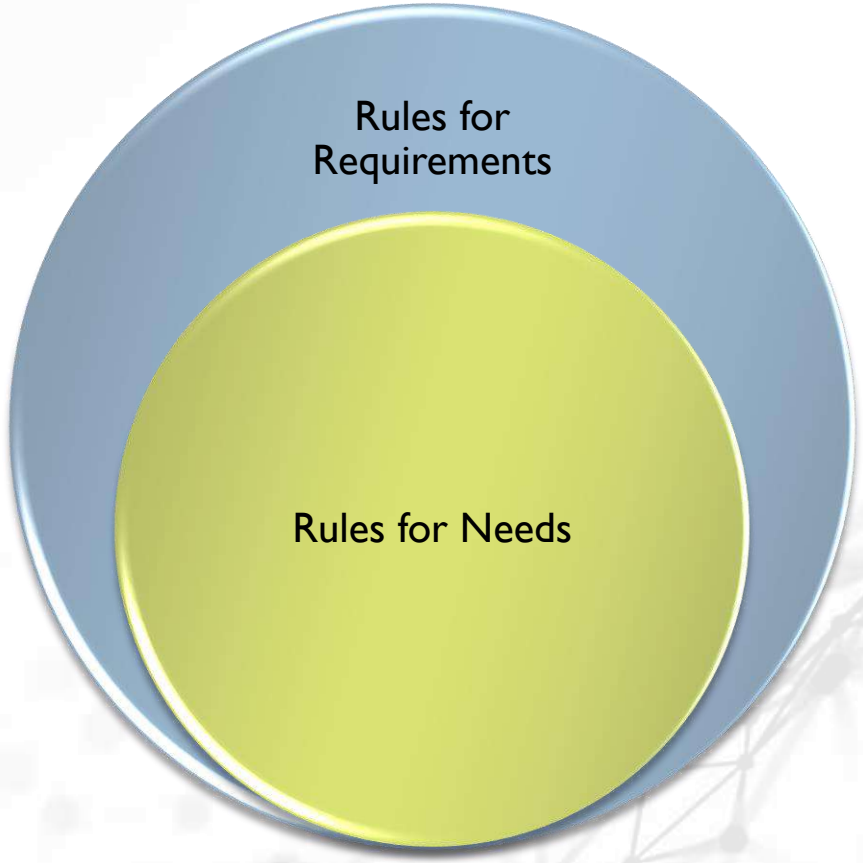
Characteristics of Needs and Requirements

- Different purposes
  - Needs -> Meet the business expectations
  - Requirements -> What to do to achieve the needs.

But...

Requirements translate needs ('Derived Requirements')

- Rules that apply to needs would also apply to requirements.
- 1 Need -> X Requirements!
- Which ones? Based on which characteristics?
  - REQUIRES TO DEFINE **RULE APPLICABILITY FOR NEEDS AND REQUIREMENTS!**



Main Content of the Rule Applicability Matrix

- Rule ID / Name / Description
- **RULE APPLICABILITY**
  - CNCR = Compulsory for Needs AND Requirements
  - RNCR = Recommended for Needs; Compulsory for Requirements [+Comments]
  - CR = Compulsory for Requirements (Optional for Needs)
- **RULE SCOPE** : Requires Project Data Dictionary, Glossary, Models or Ontology?
  - Y/N

Main Content of the Rule Applicability Matrix: Example

RULE #	RULE NAME	RULE SHORT DESCRIPTION	RULE APPLICABILITY	APPLICABILITY COMMENTS	RULE SCOPE Requires Project Data Dictionary, Glossary, Models or Ontology? (Y/N)	SCOPE COMMENTS
R01	Sentence Structure	Use the form of a complete sentence: subject, verb, object.	**CNCR**		N	
R02	Use Active Voice	Use the active voice in the main sentence structure with the responsible entity clearly identified as the subject.	**RNCR**	**Needs:** The use of active voice can have a higher tolerance when considering needs, although it is recommended to avoid it in both cases.	N	

Main Content of the Rule Applicability Matrix: Elaboration

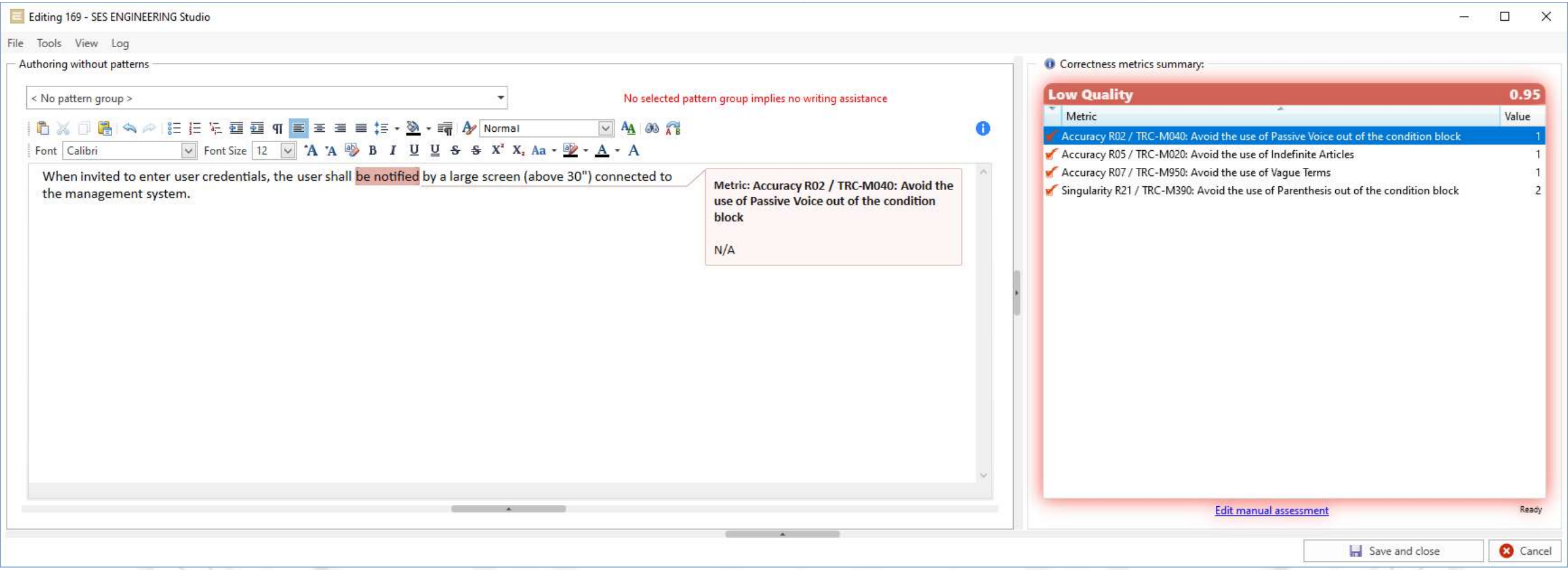
- **Rule 01 – Sentence Structure**
  - Both Needs and Requirements need a proper, standardized sentence structure
  - Project Data Dictionary: Not required
- **Rule 02 – Use Active Voice**
  - Requirements shall use active voice (identify SOI, express functionality, etc.)
  - Needs might use passive voice
  - Project Data Dictionary: Not required (generic syntax checking)

Example #1: Needs vs. Requirements

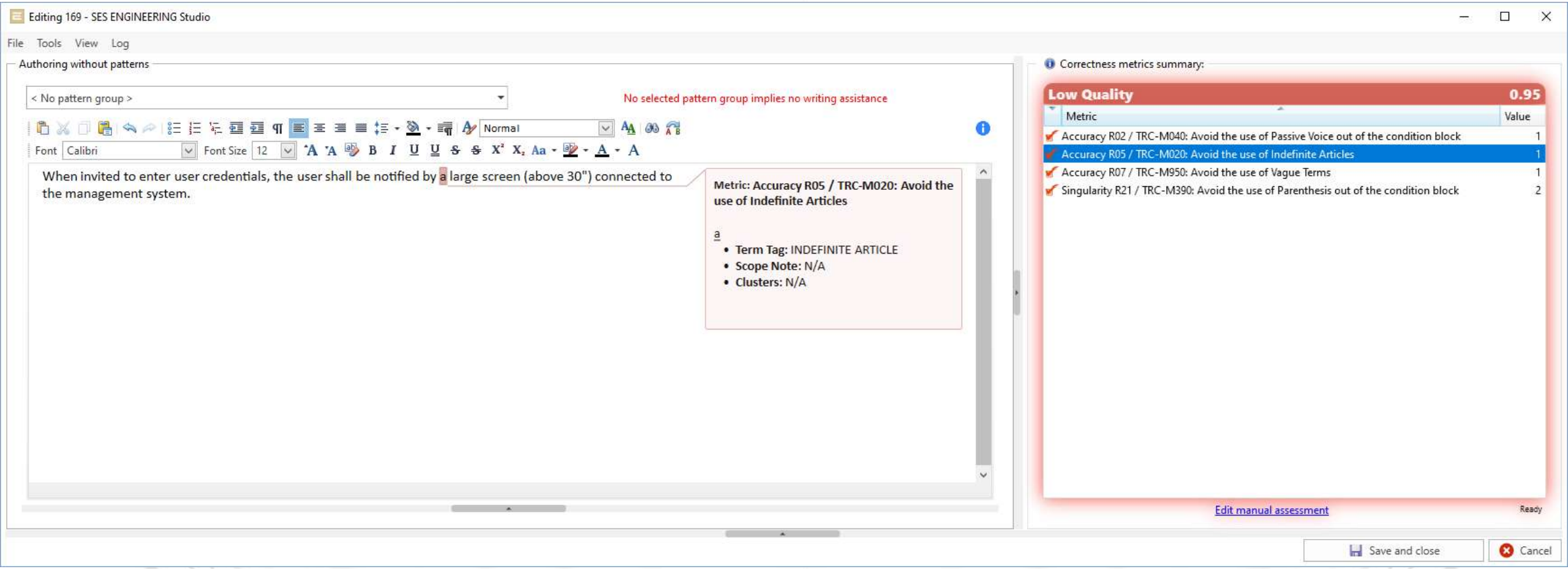
	APPLICABILITY	SCOPE (Requires Project Data Dictionary?)
Rule 02 *Use Active Voice*	**RNCR**	**No**
Rule 05 *Use Definite Articles*	**RNCR**	**No**
Rule 07 *Avoid Vague Terms*	**RNCR**	**No**
Rule 21 *Avoid Parentheses*	**RNCR**	**No**

- ***Example:*** "When invited to enter user credentials, the user shall be notified by a large screen (above 30") connected to the management system."

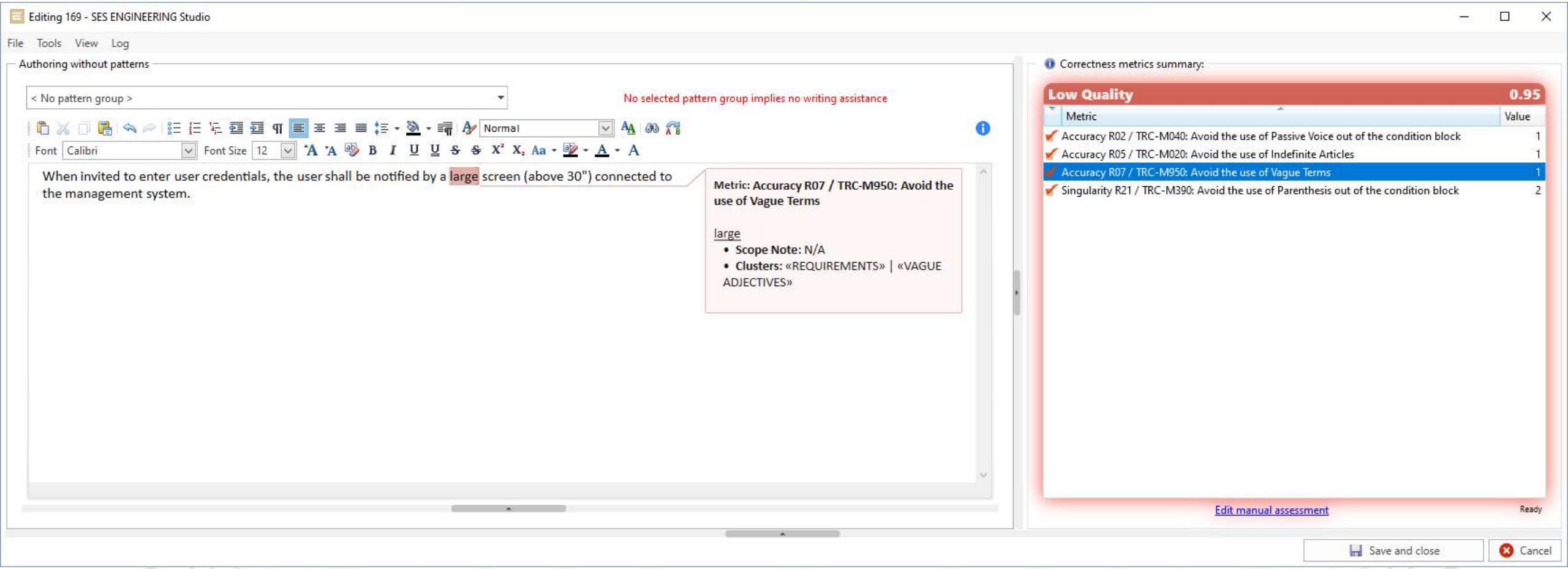
Example #1: Needs vs. Requirements



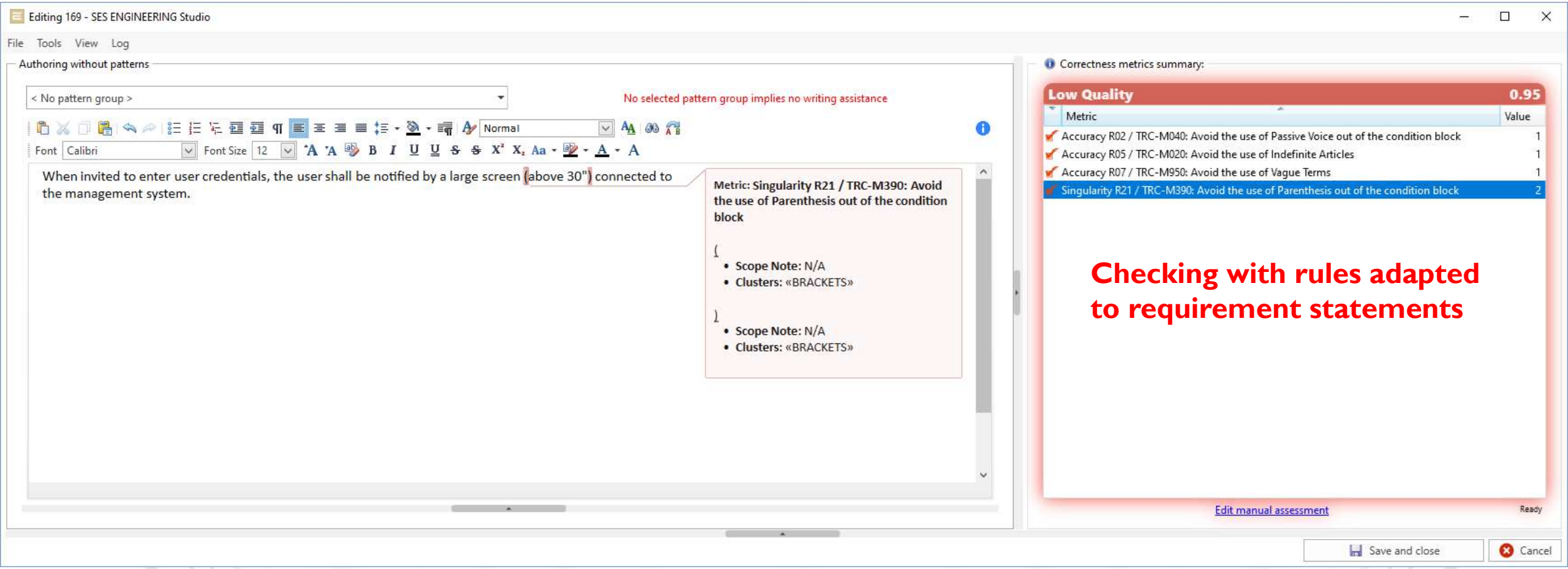
Example #1: Needs vs. Requirements



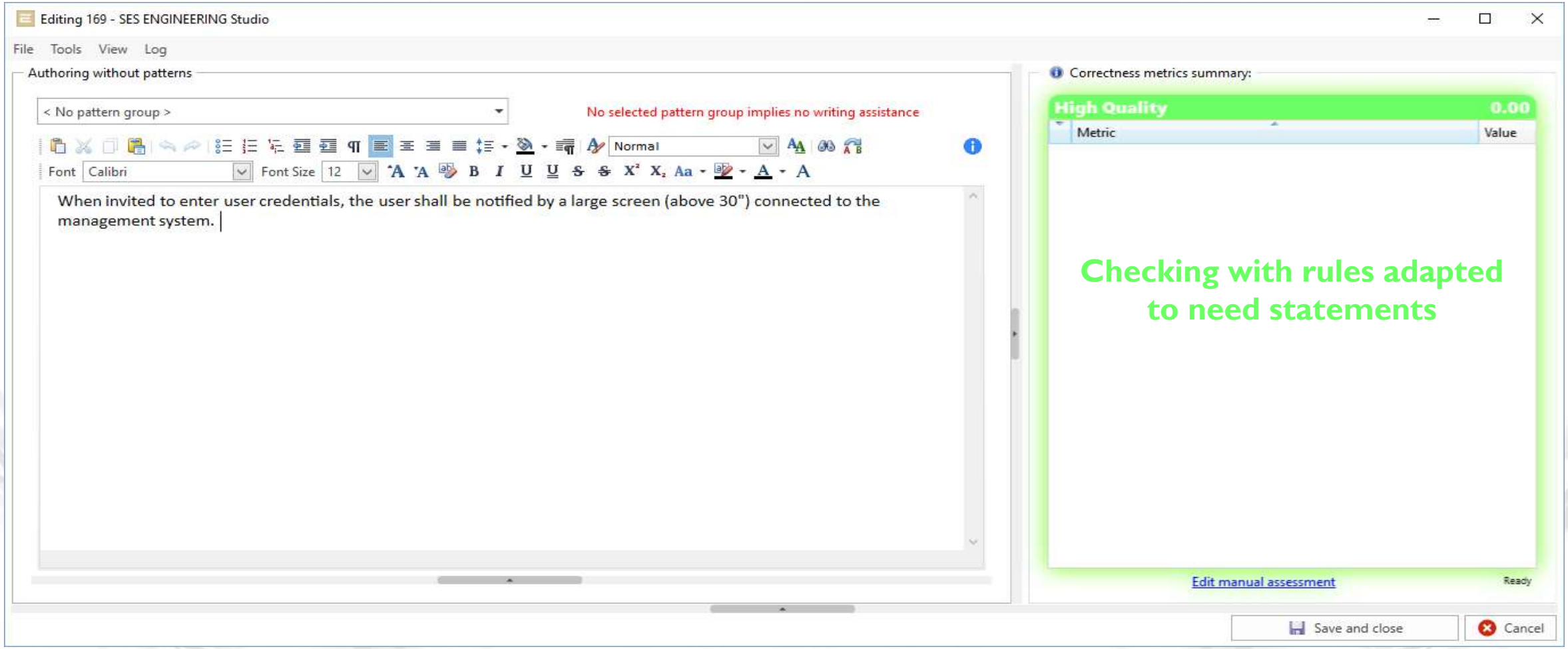
Example #1: Needs vs. Requirements



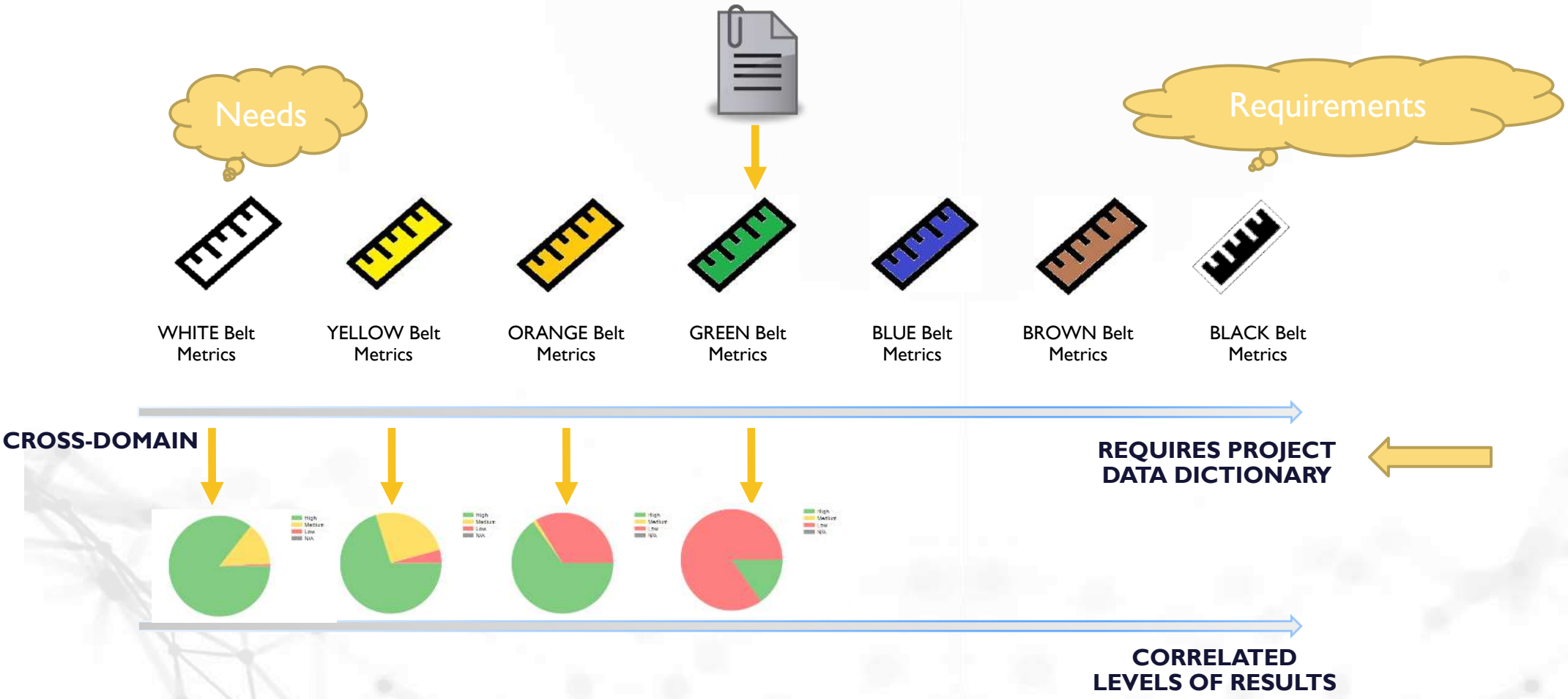
Example #1: Needs vs. Requirements



Example #1: Needs vs. Requirements



The need for Data Dictionaries



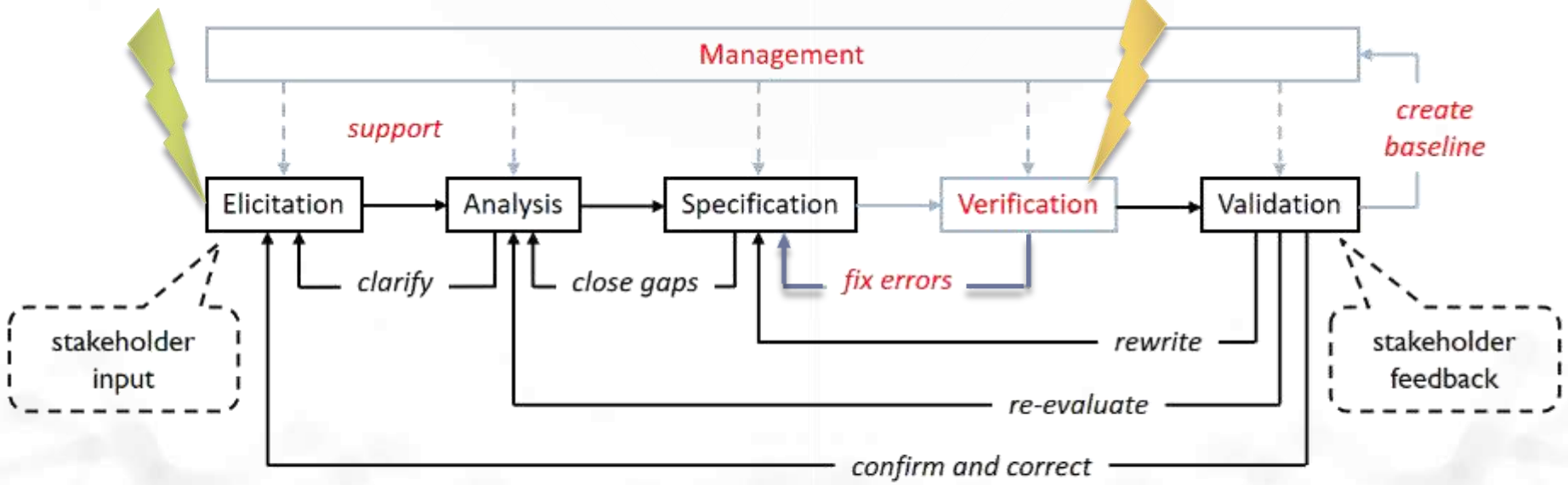
The 3-D tailoring space: Life-cycle Stage – Focus on needs & requirements

TBD

Rules applied at authoring phase (Needs)

TBD

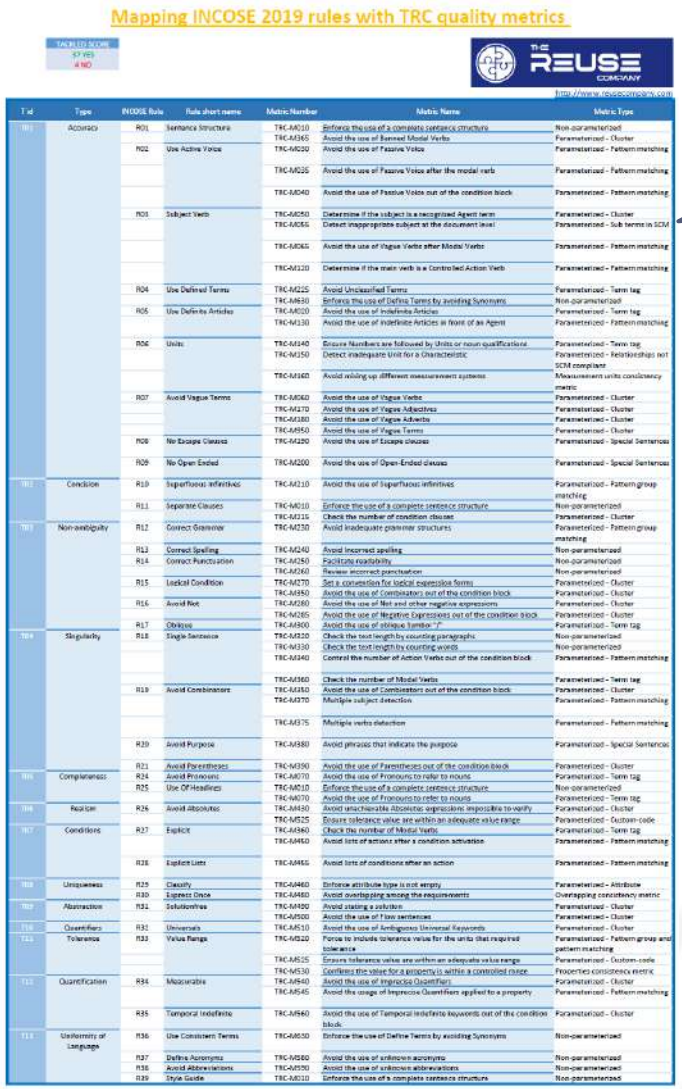
Rules applied at verification phase (SRD)

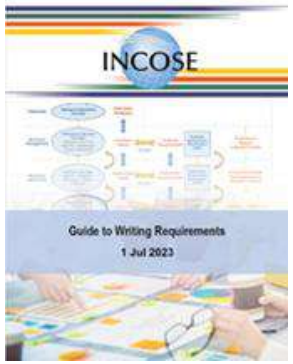


Adapted from: Karl Wiegers

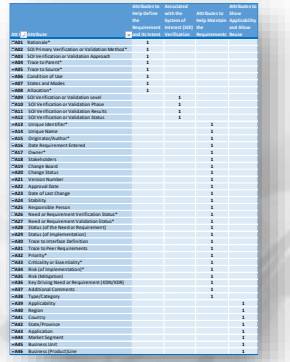
INCOSE GtWR with tailoring

- Characteristics
- Rules
- Attributes
- **Metrics:** A quality metric is a property which aims to quantify a qualitative indicator. It enables answering the question *'How should we measure?'*
- **Quality Function:** After defining the metric, the quality function is the conversion of the obtained result (quantitative value) to a quality level. Different profiles can be set (binary, concave, convex…)



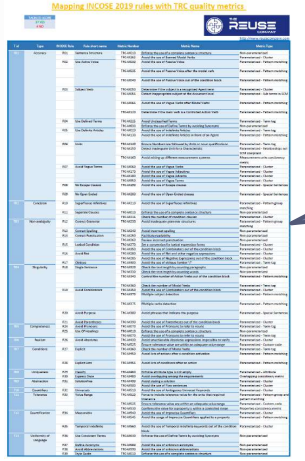


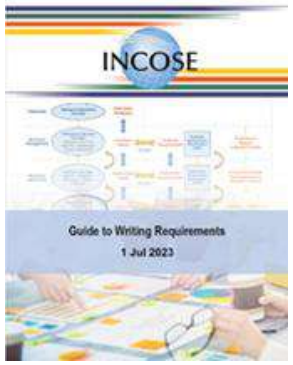
46 Attributes



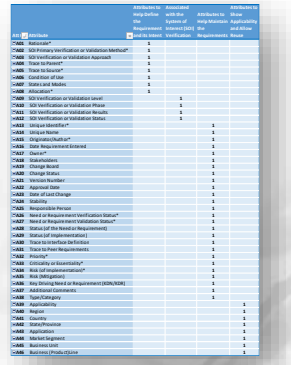
INCOSE GtWR with tailoring

- Characteristics
- Rules
- Attributes
- **Metrics:** A quality metric is a property which aims to quantify a qualitative indicator. It enables answering the question *'How should we measure?'*
- **Quality Function:** After defining the metric, the quality function is the conversion of the obtained result (quantitative value) to a quality level. Different profiles can be set (binary, concave, convex…)





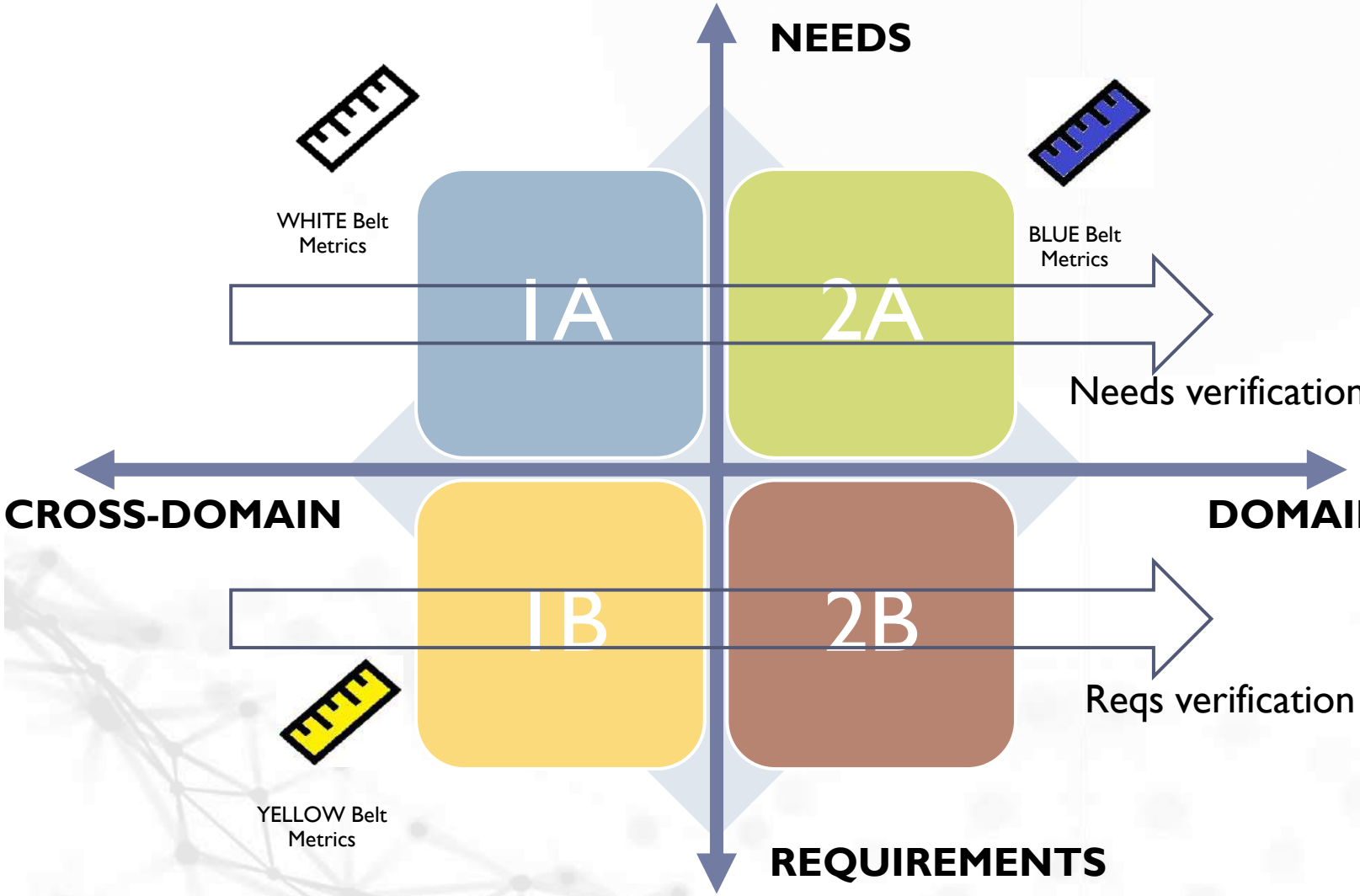
With which data?

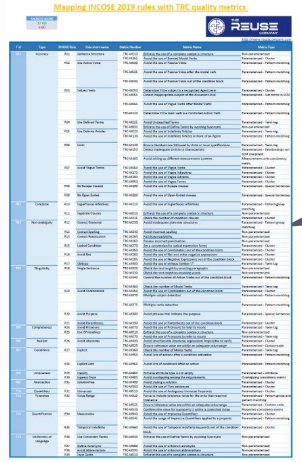


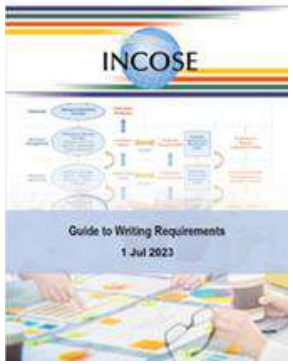
...From the Project Data Dictionary!

- Defined Terms & Acronyms
- Main Terms vs. Synonyms
- Disambiguation (2 acronyms with different meanings)
- Taxonomy
- Etc.

INCOSE GtWR with tailoring







INCOSE GtWR with tailoring

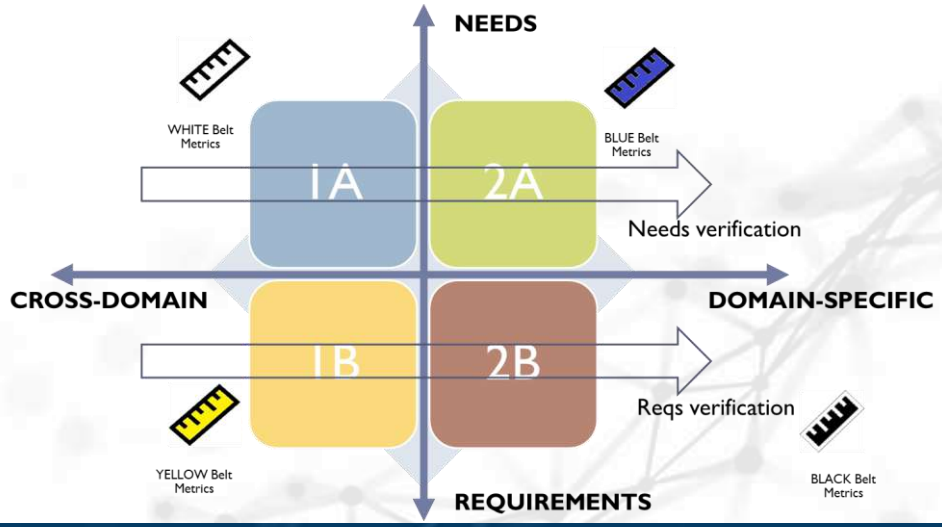
Quality Assurance - Metrics set templates

Metrics set templates:

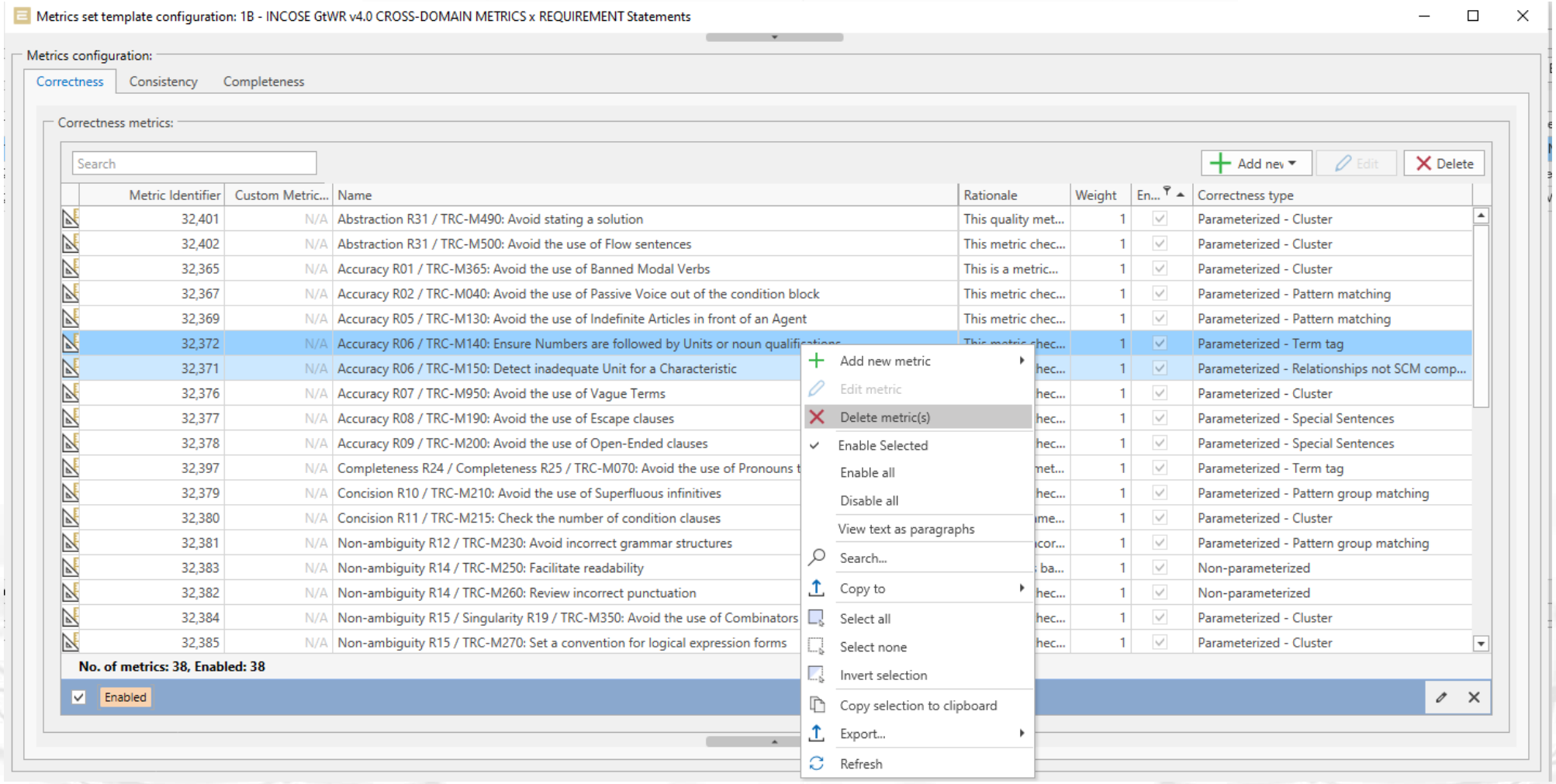
Search...

Add metric set

Identifier	Name	Description
187	1A - INCOSE GtWR v4.0 CROSS-DOMAIN METRICS x NEED Statements	1A. This subset includes cross-domain rules, which do not require domain-specific data dictionaries, and applies to NEED sta
188	1B - INCOSE GtWR v4.0 CROSS-DOMAIN METRICS x REQUIREMENT Statements	1B. This subset includes cross-domain rules, which do not require domain-specific data dictionaries, and applies to REQUIRE
189	2A - INCOSE GtWR v4.0 CROSS-DOMAIN & DOMAIN-SPECIFIC METRICS x NEED Statements	2A. This subset includes cross-domain & domain-specific rules, which require a project data dictionary, and applies to NEED
190	2B - INCOSE GtWR v4.0 CROSS-DOMAIN & DOMAIN-SPECIFIC METRICS x REQUIREMENT Statements	2B. This subset includes cross-domain & domain-specific rules, which require a project data dictionary, and applies to REQU



INCOSE GtWR with tailoring



Why do we need a Project Data Dictionary?

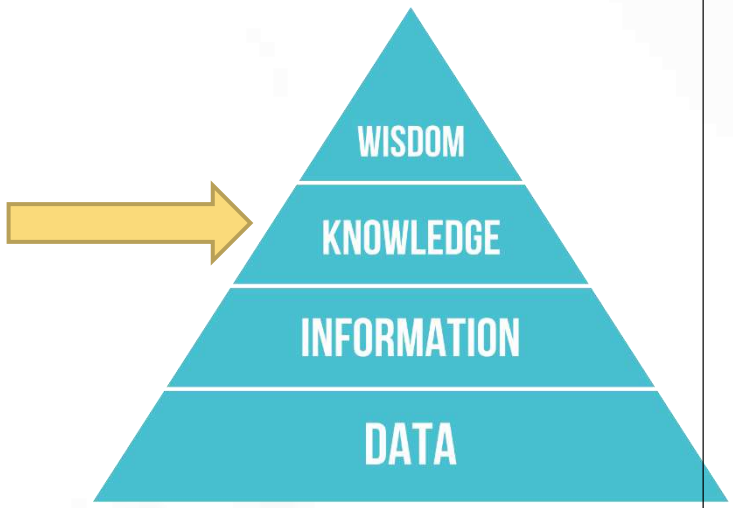
"centralized repository of information about data such as meaning, relationships to other data, origin, usage, and format" (IBM Dictionary of Computing, 1993)

"Agreed-upon set of standards and guidelines to enforce the use of common vocabulary and concepts, thus ensuring the consistency of Needs and Requirements across the project team"

- **Consistent** wording (pre-established by the subject matter experts)
- **Extended** coverage of the INCOSE GtWR set of rules (various rules require a dictionary to be assessed).
- **Standardized** way of drafting requirements : better traceability (either manual or based on NLP), reusability and avoided redundance (duplicated or contradictory requirements).

Why do we need a Project Data Dictionary?

- Data -> Knowledge



Source: INCOSE Systems Engineering Handbook v4

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		

Why do we need a Project Data Dictionary?

12/8/2023

- **August 12th, 2023** ?
- **December 8th, 2023** ?

12/8/23 ??

WHO 

OMS 

who.int

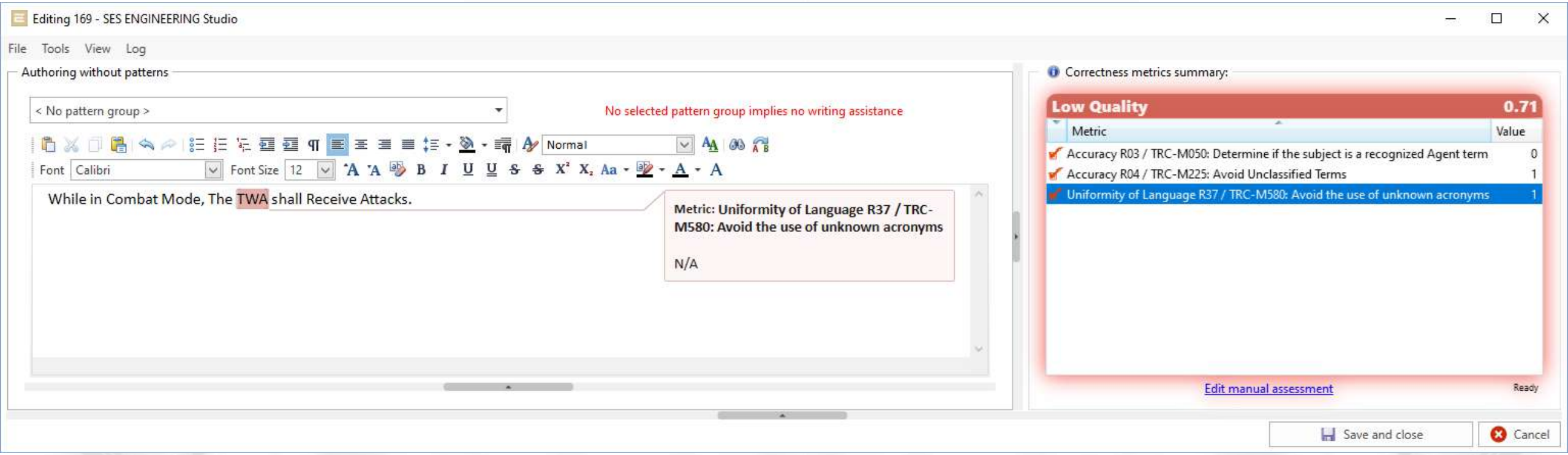
- Let's **imagine the ambiguity** that might be introduced while dealing **with Complex Systems**!!

Example #2: Applying Project Data Dictionaries

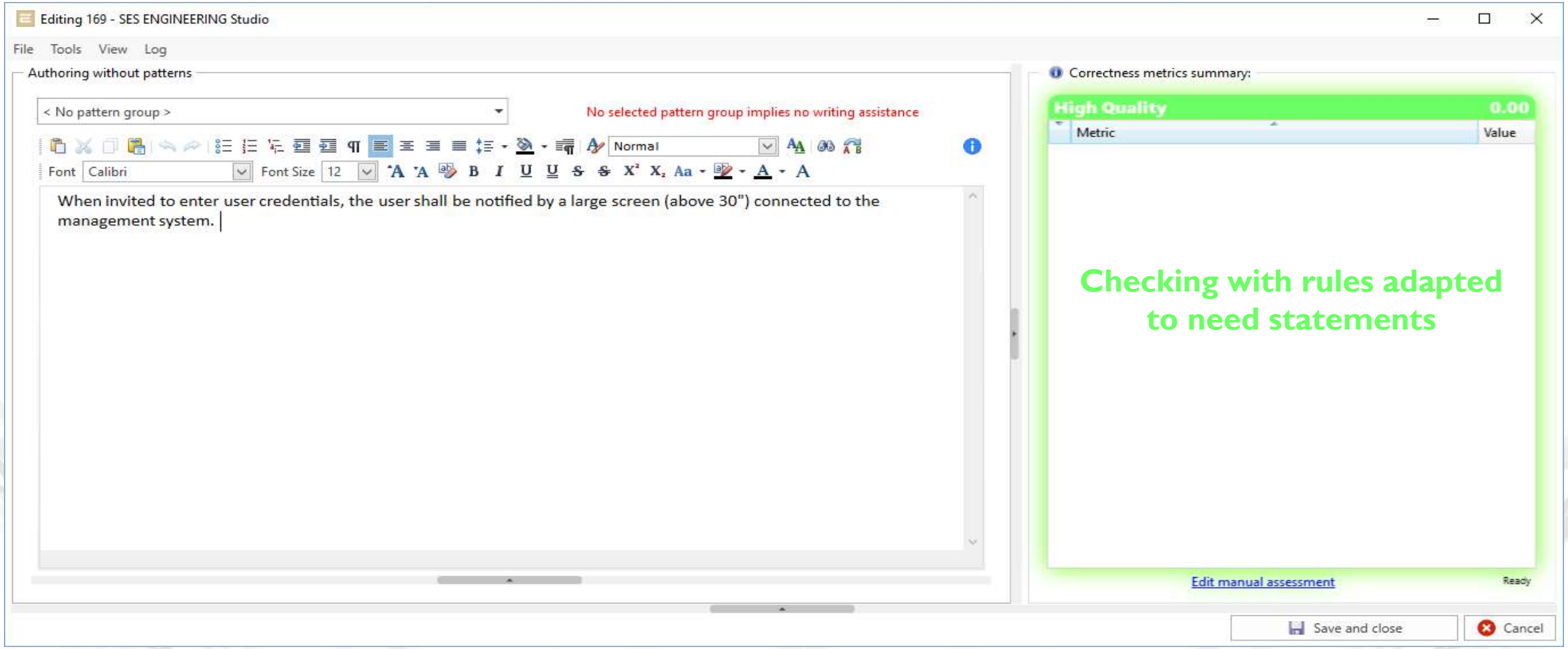
	APPLICABILITY	SCOPE (Requires Project Data Dictionary?)
Rule 03 *Subject Verb*	**CNCR**	**X**
Rule 04 *Use Defined Terms*	**CNCR**	**X**
Rule 13 *Correct Spelling*	**CNCR**	**X**
Rule 37 *Define Acronym*	**CNCR**	**X**

- ***Example:*** "While in Combat Mode, The **TWa** shall Receive Attacks"
  - Rule 03: Invalid subject (not known as a system, entity, stakeholder, function, activity, etc.)
  - Rule 04: Undefined term (not defined in the glossary)
  - Rule 13: Detection as misspelled word
  - Rule 37: Undefined acronym

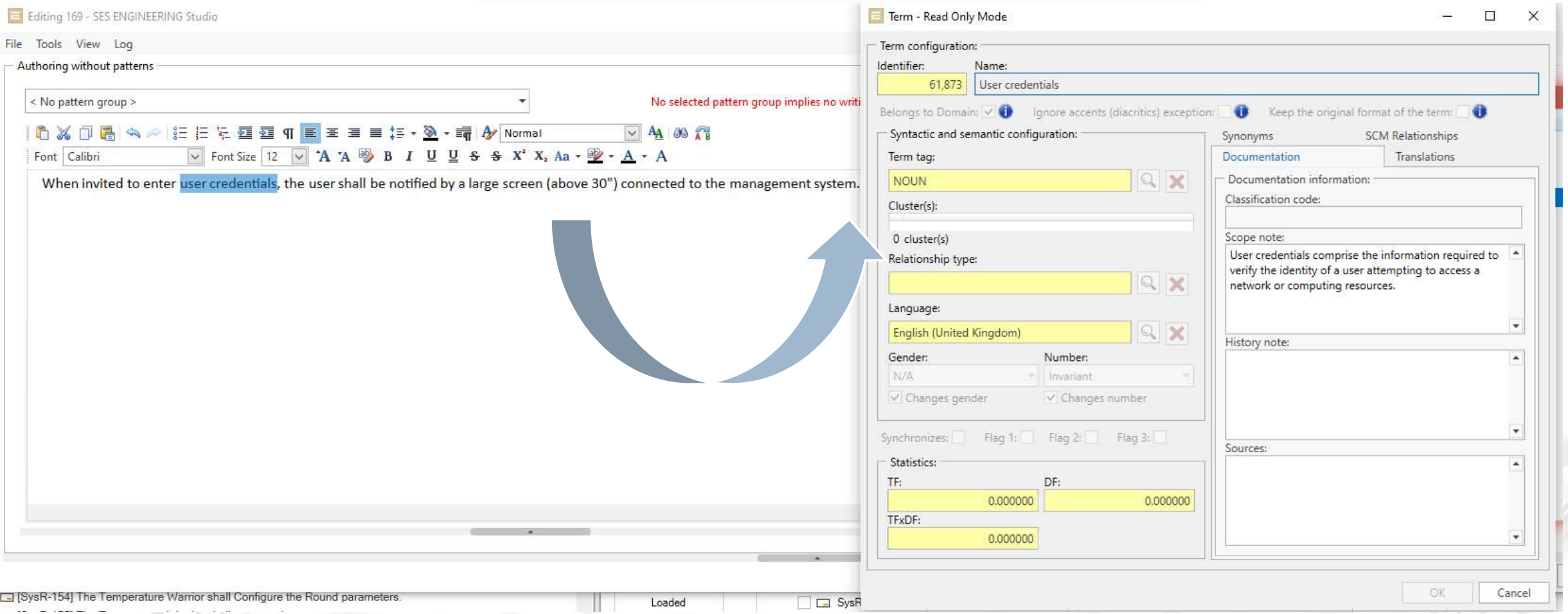
Example #2: Applying Project Data Dictionaries



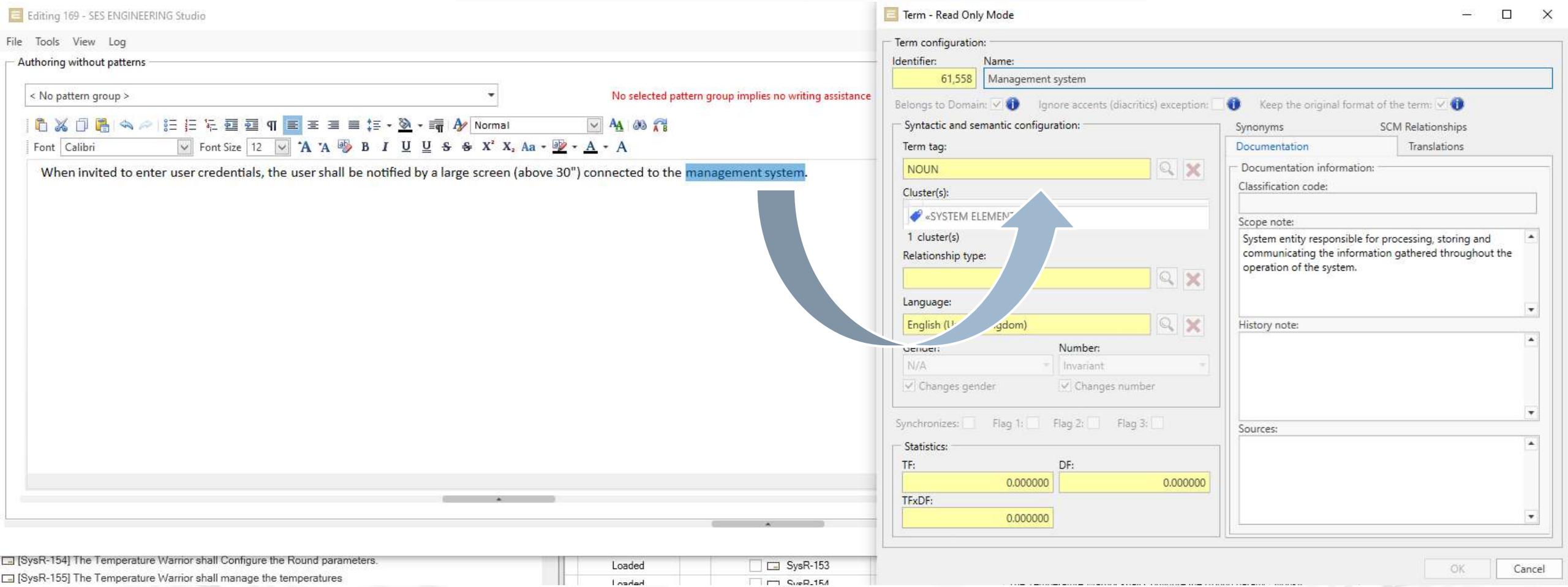
Example #2: Applying Project Data Dictionaries



Example #2: Applying Project Data Dictionaries



Example #2: Applying Project Data Dictionaries

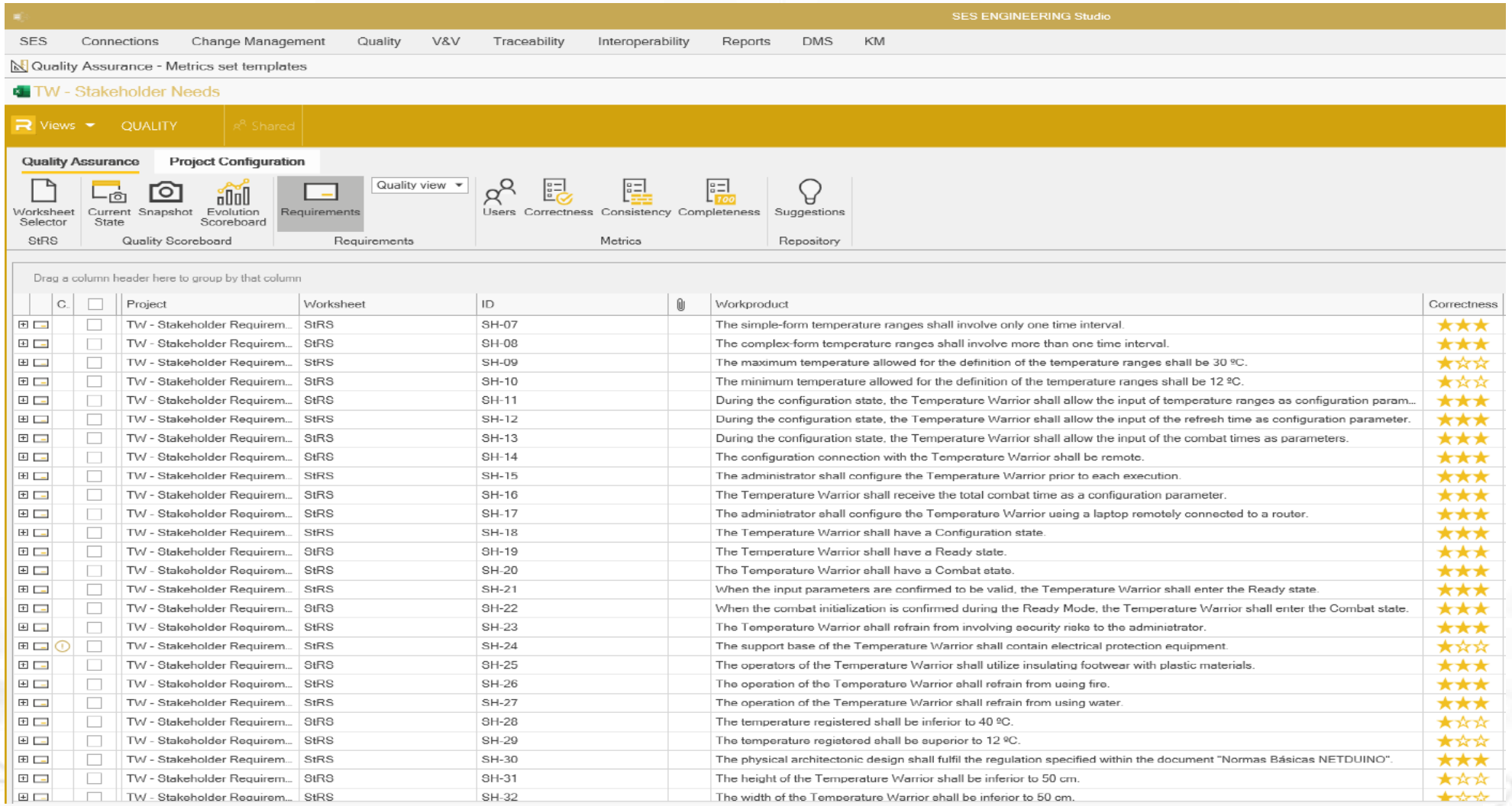


6.

Demo
Rule Applicability Matrix

Use-cases

- Use-case #1 : Quality assessment of stakeholder needs
- Use-case #2 : Quality assessment using requirements quality rules + editing
- Use-case #3 : Live quality check + pattern-based writing assistance + data dictionary



C.		Project	Worksheet	ID		Workproduct	Correctness
		TW - Stakeholder Requirem...	StRS	SH-07		The simple-form temperature ranges shall involve only one time interval.	★★★
		TW - Stakeholder Requirem...	StRS	SH-08		The complex-form temperature ranges shall involve more than one time interval.	★★★
		TW - Stakeholder Requirem...	StRS	SH-09		The maximum temperature allowed for the definition of the temperature ranges shall be 30 ºC.	★☆☆
		TW - Stakeholder Requirem...	StRS	SH-10		The minimum temperature allowed for the definition of the temperature ranges shall be 12 ºC.	★☆☆
		TW - Stakeholder Requirem...	StRS	SH-11		During the configuration state, the Temperature Warrior shall allow the input of temperature ranges as configuration param...	★★★
		TW - Stakeholder Requirem...	StRS	SH-12		During the configuration state, the Temperature Warrior shall allow the input of the refresh time as configuration parameter.	★★★
		TW - Stakeholder Requirem...	StRS	SH-13		During the configuration state, the Temperature Warrior shall allow the input of the combat times as parameters.	★★★
		TW - Stakeholder Requirem...	StRS	SH-14		The configuration connection with the Temperature Warrior shall be remote.	★★★
		TW - Stakeholder Requirem...	StRS	SH-15		The administrator shall configure the Temperature Warrior prior to each execution.	★★★
		TW - Stakeholder Requirem...	StRS	SH-16		The Temperature Warrior shall receive the total combat time as a configuration parameter.	★★★
		TW - Stakeholder Requirem...	StRS	SH-17		The administrator shall configure the Temperature Warrior using a laptop remotely connected to a router.	★★★
		TW - Stakeholder Requirem...	StRS	SH-18		The Temperature Warrior shall have a Configuration state.	★★★
		TW - Stakeholder Requirem...	StRS	SH-19		The Temperature Warrior shall have a Ready state.	★★★
		TW - Stakeholder Requirem...	StRS	SH-20		The Temperature Warrior shall have a Combat state.	★★★
		TW - Stakeholder Requirem...	StRS	SH-21		When the input parameters are confirmed to be valid, the Temperature Warrior shall enter the Ready state.	★★★
		TW - Stakeholder Requirem...	StRS	SH-22		When the combat initialization is confirmed during the Ready Mode, the Temperature Warrior shall enter the Combat state.	★★★
		TW - Stakeholder Requirem...	StRS	SH-23		The Temperature Warrior shall refrain from involving security risks to the administrator.	★★★
	!	TW - Stakeholder Requirem...	StRS	SH-24		The support base of the Temperature Warrior shall contain electrical protection equipment.	★☆☆
		TW - Stakeholder Requirem...	StRS	SH-25		The operators of the Temperature Warrior shall utilize insulating footwear with plastic materials.	★★★
		TW - Stakeholder Requirem...	StRS	SH-26		The operation of the Temperature Warrior shall refrain from using fire.	★★★
		TW - Stakeholder Requirem...	StRS	SH-27		The operation of the Temperature Warrior shall refrain from using water.	★★★
		TW - Stakeholder Requirem...	StRS	SH-28		The temperature registered shall be inferior to 40 ºC.	★☆☆
		TW - Stakeholder Requirem...	StRS	SH-29		The temperature registered shall be superior to 12 ºC.	★☆☆
		TW - Stakeholder Requirem...	StRS	SH-30		The physical architectonic design shall fulfil the regulation specified within the document "Normas Básicas NETDUINO".	★★★
		TW - Stakeholder Requirem...	StRS	SH-31		The height of the Temperature Warrior shall be inferior to 50 cm.	★☆☆
		TW - Stakeholder Requirem...	StRS	SH-32		The width of the Temperature Warrior shall be inferior to 50 cm.	★☆☆


Q&A

Contact information

Ilyes Yousfi

ilyes.yousfi@reusecompany.com

+34 627 08 66 01

@ReuseCompany

https://www.linkedin.com/in/ilyesyousfi/en

THE REUSE COMPANY