The INCOSE GfWR

Raising the Ante

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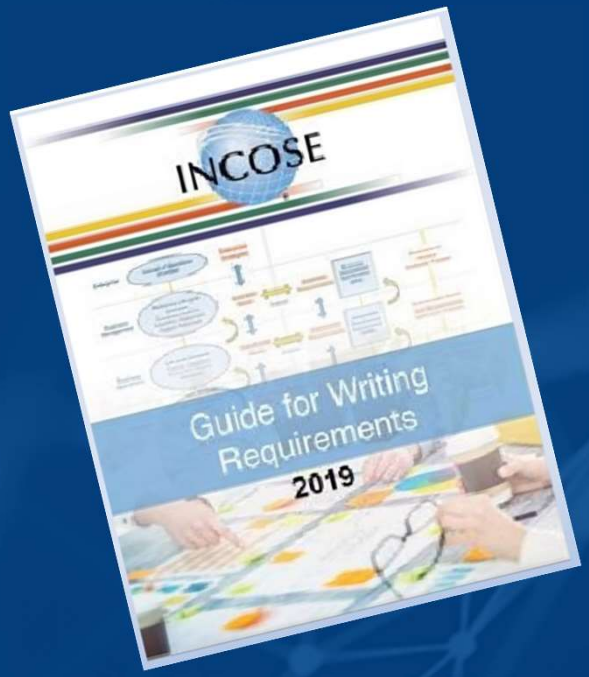
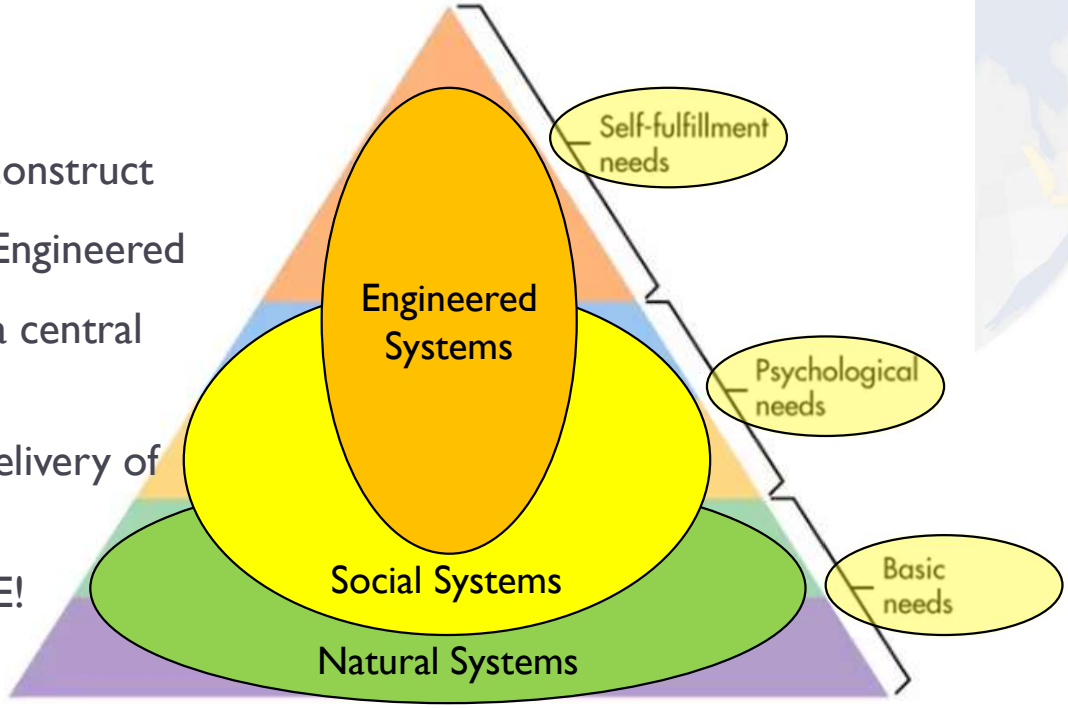


Presentation Overview

- Introduction
  - Requirements – Why the hype?
  - Brief introduction to The REUSE Company
- Brief overview of the INCOSE GfWR
- Challenges & Solutions – Raising the ante
- Raising the Ante – Live demo
- INCOSE GfWR – A Tailoring Guide
- Q&A

Requirements – Why the hype?

- Human needs are ubiquitous
- SE is a "Self-Actualization Need" driven human construct
- System application domains: Natural, Social and Engineered
- Requirements are derived from needs and fulfil a central role in the SE process
- Quality requirements are critical to successful delivery of products and systems
- Conclusion: Requirements are the lifeblood of SE!



Leveraging systems engineering activities through a **semantics-based knowledge centric** approach

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01 The company was established in **1999**

A spin-off from the Carlos III University in Madrid

02 **Systems and Software Engineers**

Smart collaboration between Company and R&D staff from Academia

03 **Headquarters:**
Madrid (Spain)

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

2021:
USA
Chicago/Detroit/Miami

04 To promote **reusable**, **scalable** and global solutions in a **smart** and **interoperable** Systems Engineering environment through a **semantics-based knowledge centric** approach

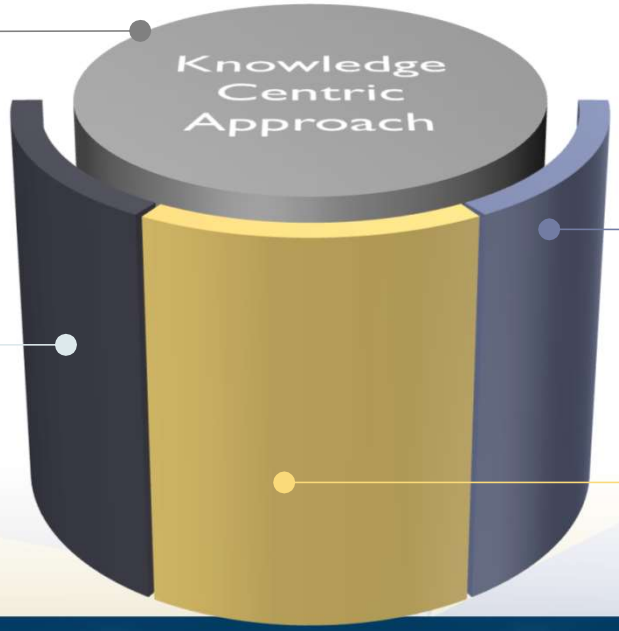
T(he) R(euse) Q(ompany)

Knowledge Centric Systems Engineering (KCSE)

Global Repositories –
Archiving –
Configuration Management –

TRACEABILITY

Links and Interoperability –
Transformations –
Change Management –

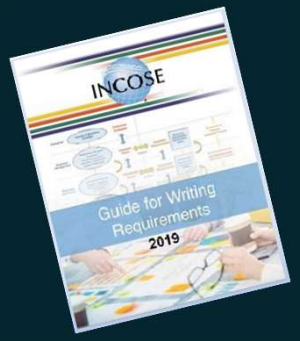


QUALITY (ies)

- Quality Management
- Verification & Validation Management
- Risk Management
- Smart Authoring

REUSABILITY

- Interoperability
- Retrieval & Archiving
- Adaptability to Existing Toolsets

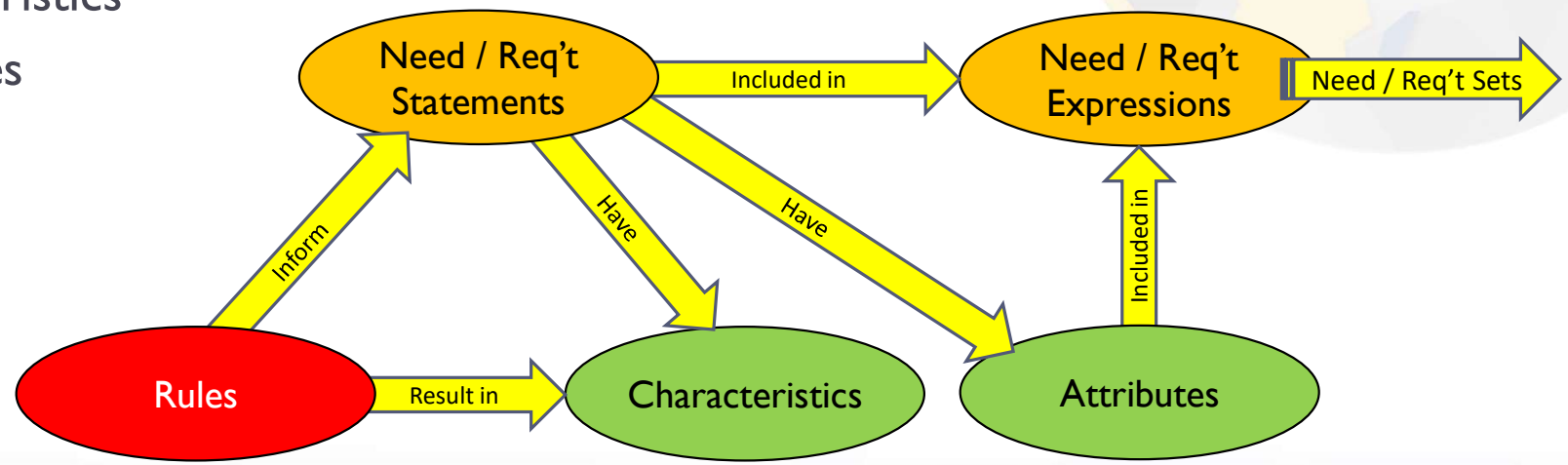


Brief overview of the

INCOSE GfWR

INCOSE GfWR Ontology

- Needs, Requirements & Sets of Needs & Requirements
- Need / Requirement Statements & Expressions
- Characteristics
- Attributes
- Rules

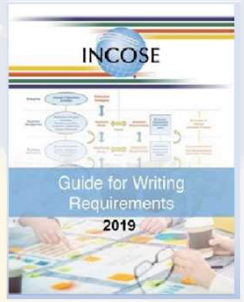


INCOSE GfWR

- **14 Characteristics** of individual and sets of needs and requirements. The GfWR provides rationale and guidance for helping understand characteristics.
- **46 Attributes** are attached to need or requirement statements to form need or requirement expressions. The GfWR provides guidance on the use of attributes.
- **41 Rules** to help formulate individual and sets of needs and requirements. The GfWR provides an explanation of the rules and examples of their application.

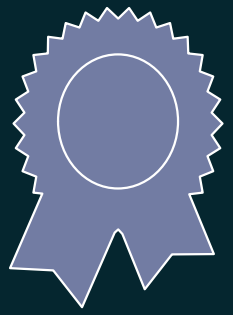
41 Rules / 14 Characteristics

			CHARACTERISTICS OF NEED AND REQUIREMENT STATEMENTS									SETS OF NEEDS AND REQUIREMENTS				
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
Accuracy	R01	Sentence Structure			1				1							
	R02	Use Active Voice			1				1							
	R03	Subject Verb		1	1				1			1				1
	R04	Use Defined Terms			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											
Non Ambiguity	R12	Correct Grammar			1						1					
	R13	Correct Spelling			1											
	R14	Correct Punctuation			1											
	R15	Logical Condition			1											
	R16	Avoid Not			1				1							
	R17	Oblique			1				1							
Singularity	R18	Single Sentence			1	1	1		1		1				1	
	R19	Avoid Combinators			1		1									
	R20	Avoid Purpose					1									
	R21	Avoid Parentheses					1									
	R22	Enumeration			1		1									
	R23	Context			1		1									
Completeness	R24	Avoid Pronouns			1	1			1							
	R25	Use Of Headings				1										
Realism	R26	Avoid Absolutes						1	1					1		
Conditions	R27	Explicit				1			1							
	R28	Explicit Lists			1				1							
Uniqueness	R29	Classify										1	1	1		
	R30	Express Once	1								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
	R37	Define Acronyms			1						1		1		1	1
	R38	Avoid Abbreviations									1		1		1	1
	R39	Style Guide				1	1				1		1		1	1
Modularity	R40	Related Requirements									1		1		1	
	R41	Structured										1	1		1	1



46 Attributes

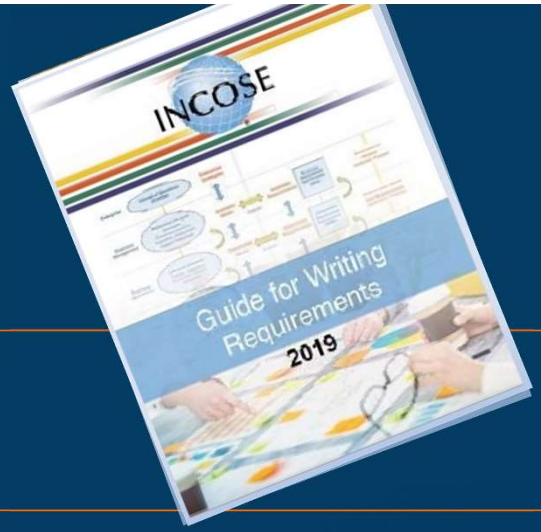
Att	Attribute	Attributes to Help Define the Requirement and its Intent	Associated with the System of Interest (SOI) Verification	Attributes to Help Maintain the Requirements	Attributes to Show Applicability and Allow Reuse
A01	Rationale*	1			
A02	SOI Primary Verification or Validation Method*	1			
A03	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



Challenges & Solutions

Raising the Ante

INCOSE GfWR: Pros and Cons



P

Pros

Represents the state-of-the-art
Very good starting point

C

Cons

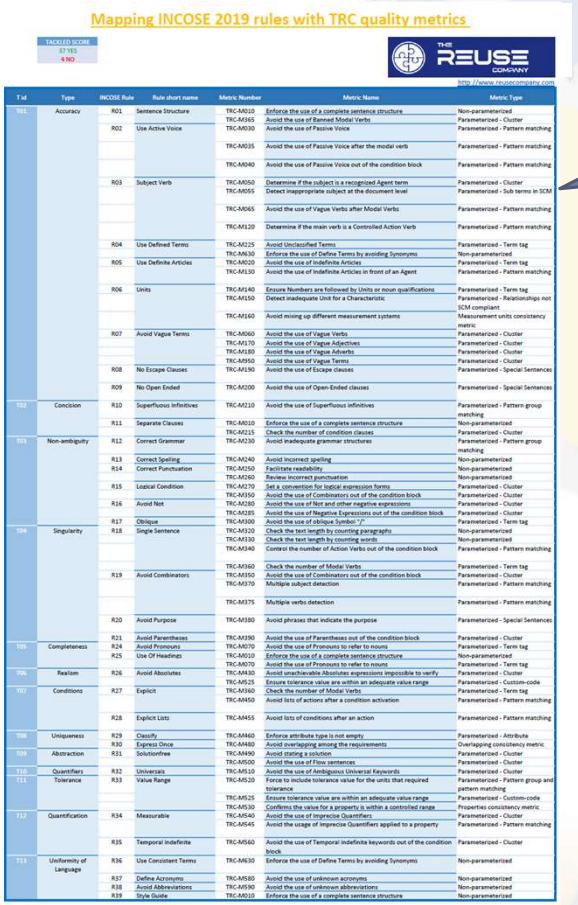
Time consuming
Considered by many as cast in stone
Considered as one single check-list

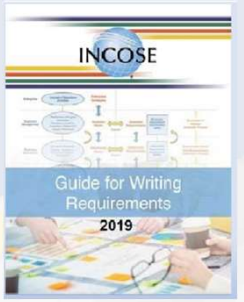
INCOSE GfWR with TRC Tailoring

- Characteristics
- Attributes
- Rules
- **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…)

Challenges & Proposed Solutions – Raising the Ante

Mapping INCOSE 2019 rules with TRC quality metrics





46 Attributes

Need for an automated process: Real-time quality assessment

INCOSE Rule	Rule short name	Metric Number	Metric Name	Metric Type
R06	Units	TRC-M140	Ensure Numbers are followed by Units or noun qualifications	Parameterized - Term tag
		TRC-M150	Detect inadequate Unit for a Characteristic	Parameterized - Relationships not SCM compliant
		TRC-M160	Avoid mixing up different measurement systems	Measurement units consistency metric

Use appropriate units when stating quantities

4.1.6 R6 - /ACCURACY/UNITS

Use appropriate units when stating quantities.

Elaboration:

All numbers should have units of measure explicitly stated in terms of the measurement system used or the thing the number refers.

Within a project, a common measurement system must be used consistently. For example, don't mix both US and metric units of measure within any of the project's artifacts.

There are three primary measurement systems: British imperial, US, Metric

For temperatures the following are used: celsius, fahrenheit, or kelvin, etc.

Need for an automated process: Real-time quality assessment

4.1.2 R2 - /AccuracyUseActiveVoice

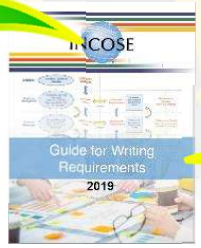
Use the active voice in the main sentence structure of the need or requirement statement with the responsible entity clearly identified as the subject of the sentence.

Elaboration:

The active voice requires that the entity performing the action is the subject of the sentence. This is important in writing needs and requirements since the onus for satisfying the requirement is on the subject, not the object of the statement. If the entity responsible for the action is not identified explicitly, it is unclear who or what should perform the action making verification of that requirement very difficult. Including the entity in the subject also helps ensure the requirement refers to the appropriate level consistent with the entity name (s

Often when the phrase "shall be" is used, the statement is in the

GUIDE



4.4.2 R19 - /SingularityAvoidCombinators

Avoid combinators.

Elaboration:

Combinators are words that join clauses, such as "and", "or", "then", "unless", "but", "as well as", "but also", "however", "whether", "meanwhile", "whereas", "on the other hand", and "otherwise." Their presence in a requirement usually indicates that multiple requirements should be written.

Exception: AND, OR, NOT can be used in need and requirement statements as logical conditions and qualifiers as stated in R15.

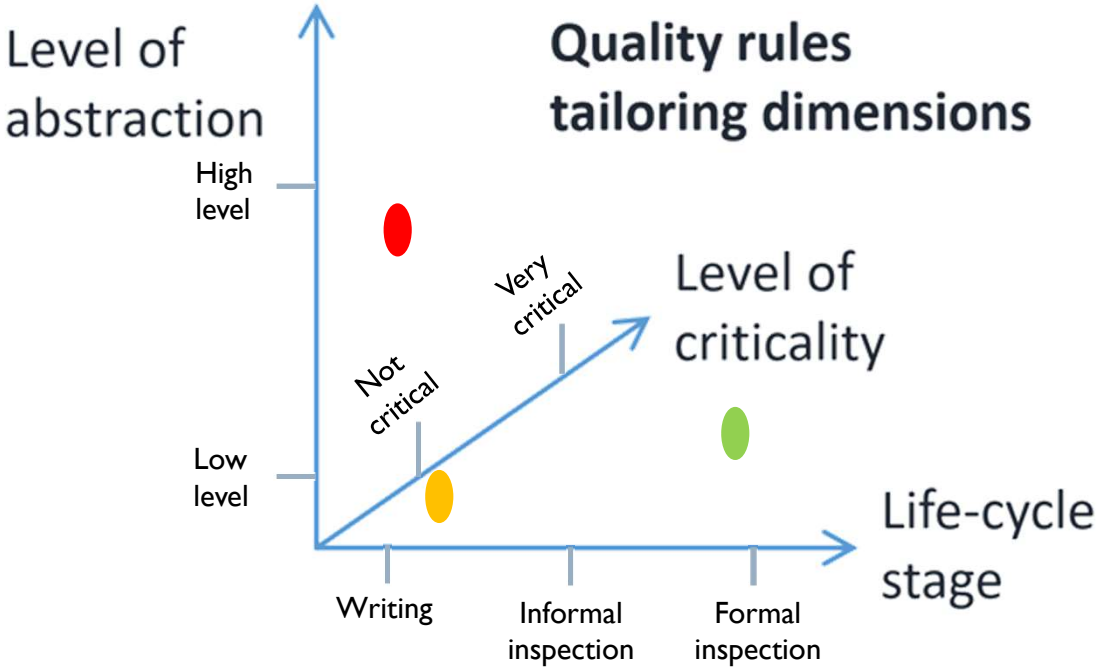
See also R16 and R17.

Why tailoring the INCOSE GfWR poses many challenges

The guide cannot be regraded as a "frozen" set of rules, as it depends on several parameters to be considered:

- The 3-dimensional tailoring space, which includes:
  - Stage in the lifecycle when the rules are applied
  - Level of criticality of the System of Interest (SOI)
  - Level of abstraction
- The need for other characteristics to go beyond correctness checking, i.e. consistency and completeness
- Adaptability to the skills of the team members
- The role of patterns in the tailoring process
- Adaptability to different types of requirements

The 3-dimensional tailoring space



The 3-D tailoring space: Level of Abstraction

The INCOSE GfWR (in Section 1.5 Concepts) states that : ***"How requirements are expressed differs through these levels [of abstraction] and, therefore, so do the rules for expressing them".***

For example:

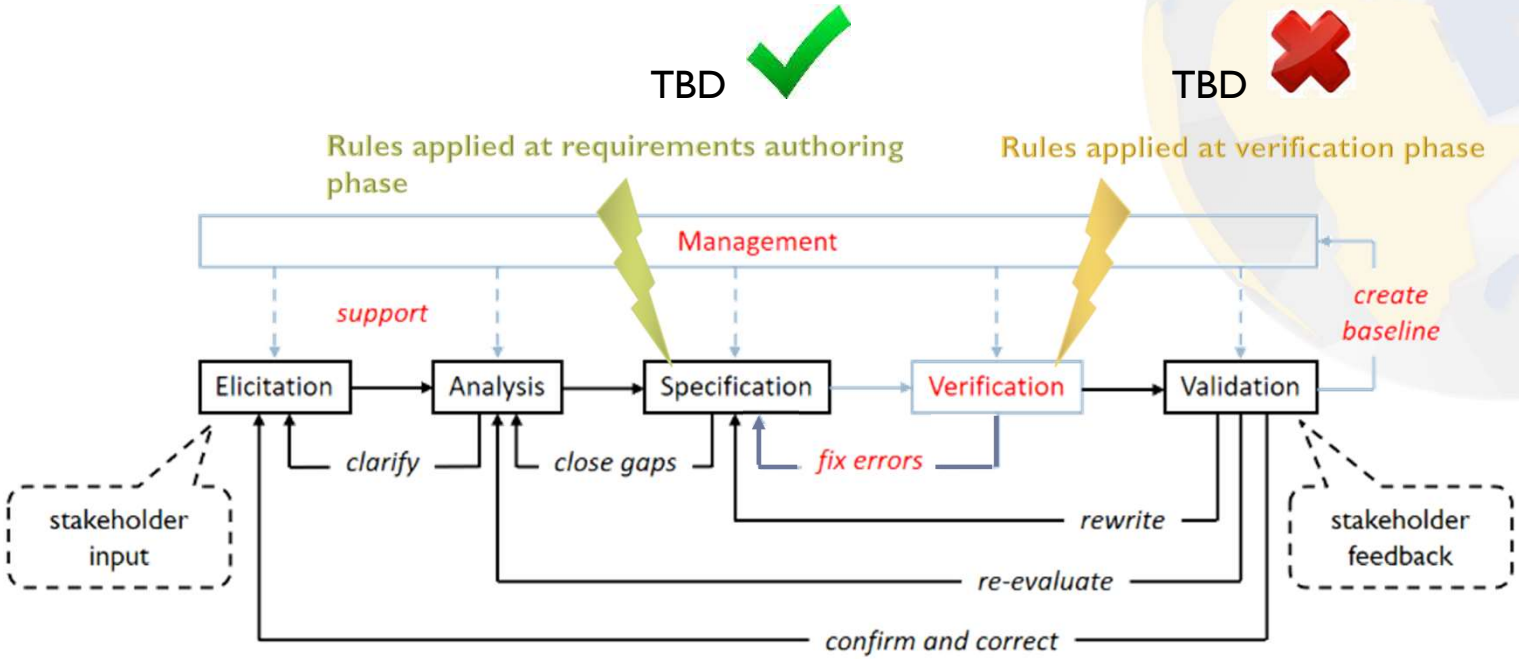
	High-level requirements	Low-level requirements
Ambiguity	Might be ambiguous	No ambiguity
Accuracy in measures	No need for the measures to be precise	As accurate as possible providing a specific tolerance

The 3-D tailoring space: Level of Criticality

The more critical the SOI, the more thorough the set of rules to be applied, for example:

- Non-critical SOI: **Entertainment System**
- Critical SOI: **Engine** or **Electronic Control Unit**

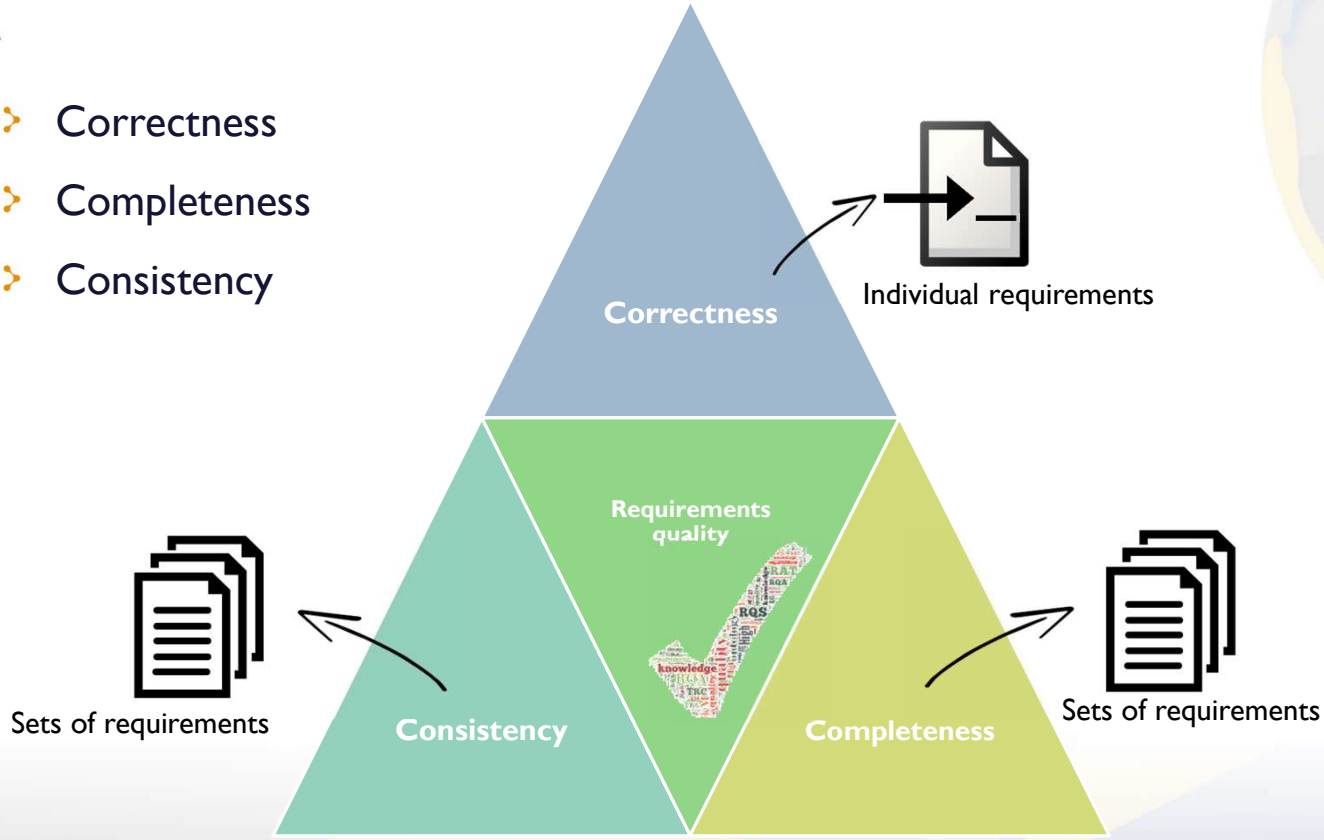
The 3-D tailoring space: Life-cycle Stage



Adapted from: Karl Wiegers

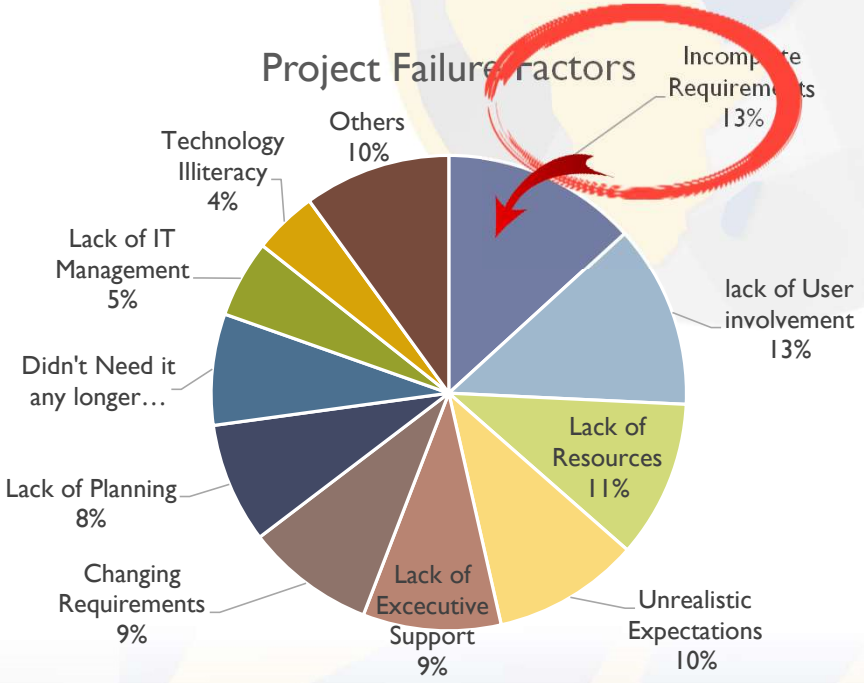
Solution: The CCC approach

- Correctness
- Completeness
- Consistency



Need to go beyond correctness checking: Completeness

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%



Need to go beyond correctness checking: Completeness

Completeness in the GfWR:

Characteristics C4: for individual requirements

Characteristics C10: for sets of requirements

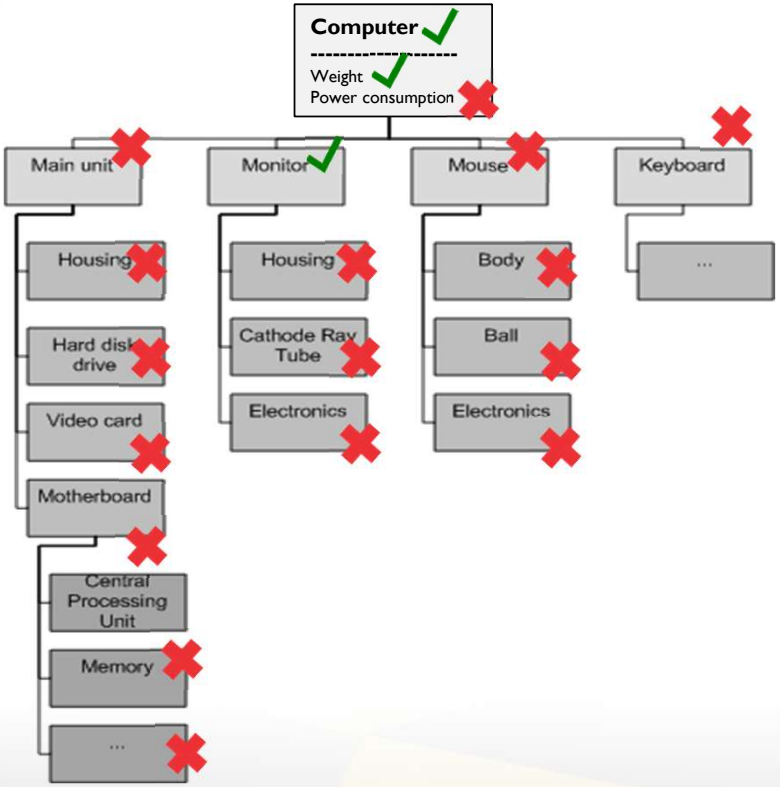
Two Completeness Rules:

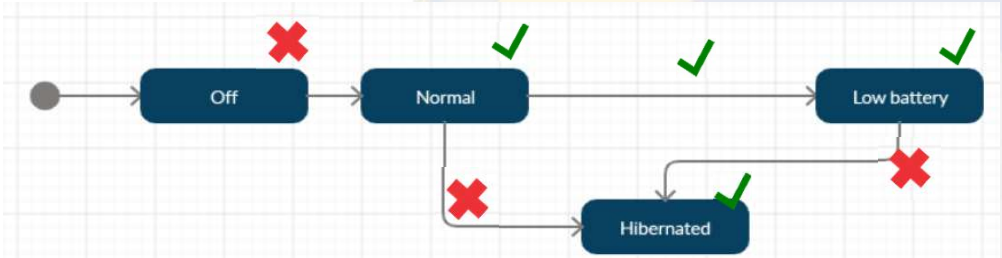
R24 – Avoid the use of pronouns and indefinite pronouns

R25 – Avoid relying on headings to support explanations or understanding of the requirements

CHARACTERISTICS OF NEED AND REQUIREMENT STATEMENTS									CHARACTERISTICS OF SETS OF NEEDS AND REQUIREMENTS				
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
1	2	29	12	8	2	21	4	8	3	9	5	8	7

Solution: Real-time quality checking for Completeness





The computer shall have 2 monitors

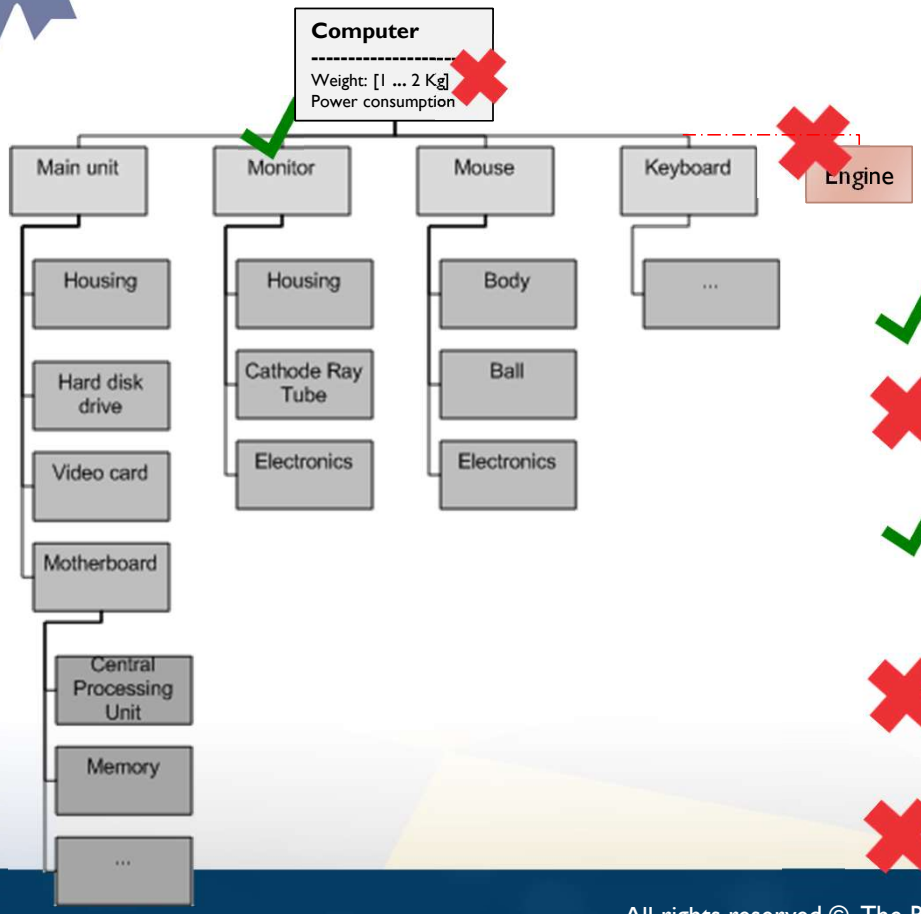
The computer shall have 2 engines

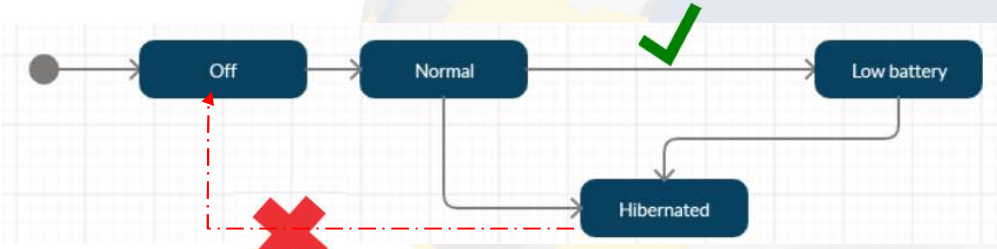
When the Computer is not plugged in, and the computer is in Normal mode and the level of battery drops below 10%, the computer shall transit to Low battery mode

When the Computer is in Hibernated mode, the monitor shall turn black

The weight of the computer shall be 1.2 kg +- 10%

Solution: Real-time quality checking for Consistency





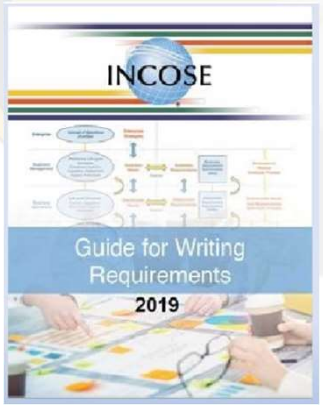
- ✓ The computer shall have 2 monitors
- ✗ The computer shall have 2 engines
- ✓ When the Computer is not plugged in, and the computer is in Normal mode and the level of battery drops below 10%, the computer shall transit to Low battery mode
- ✗ When the Computer is in Hibernated mode and EventX is received, the computer shall transit to Off mode
- ✗ The weight of the computer shall be 3.5 kg +- 10%

Challenges: Adaptability to the skills of team members

- Need for a roadmap to improve the tailored set of rules from the INCOSE GfWR

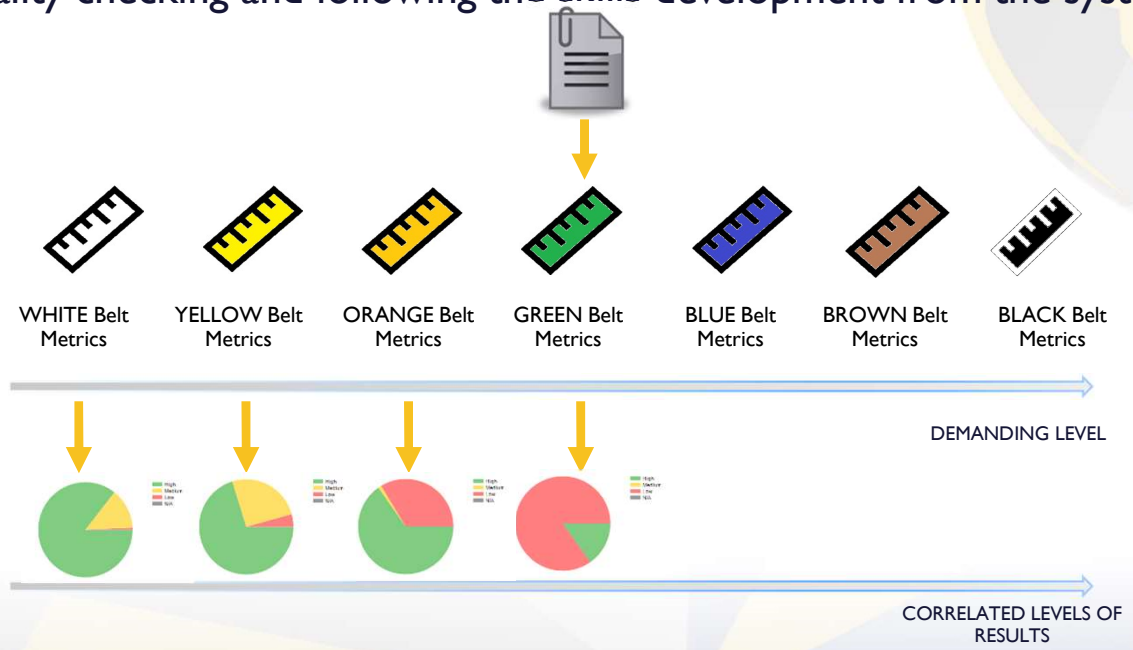
Skills required to achieve requirements complying with these rules

The rules of the INCOSE GfWR as a **target**…

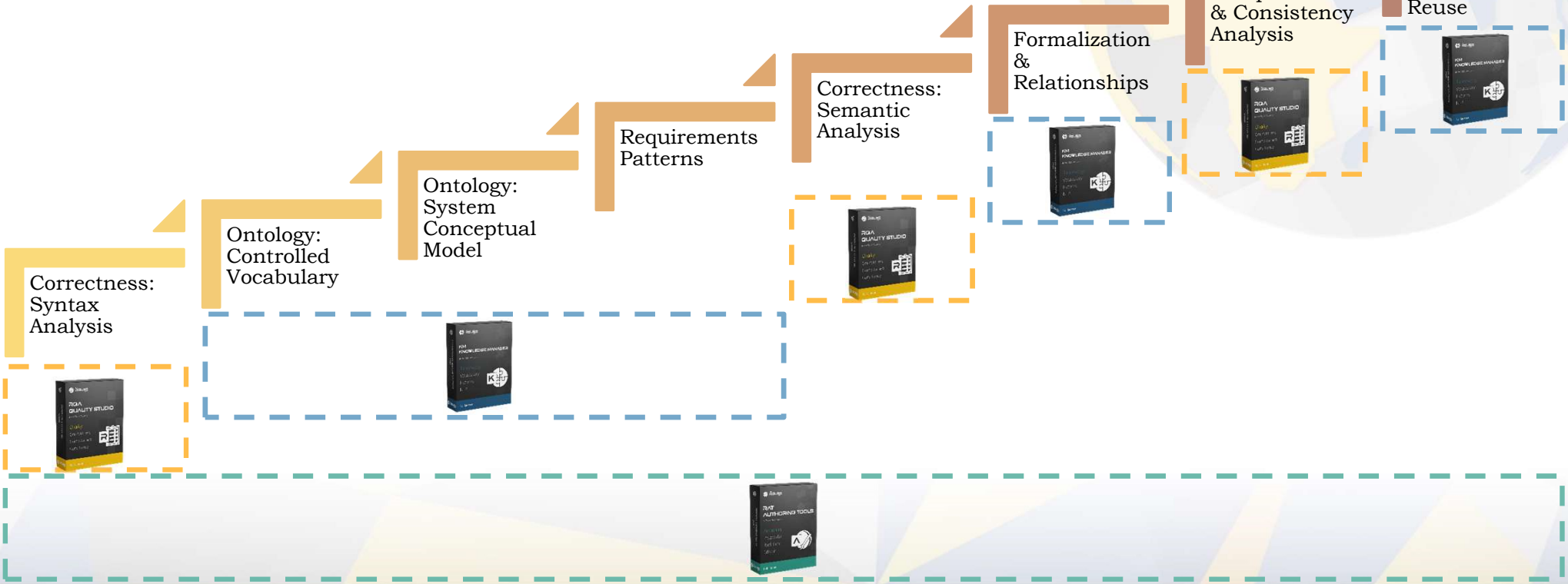


Solution: Incremental methodology – Quality belts

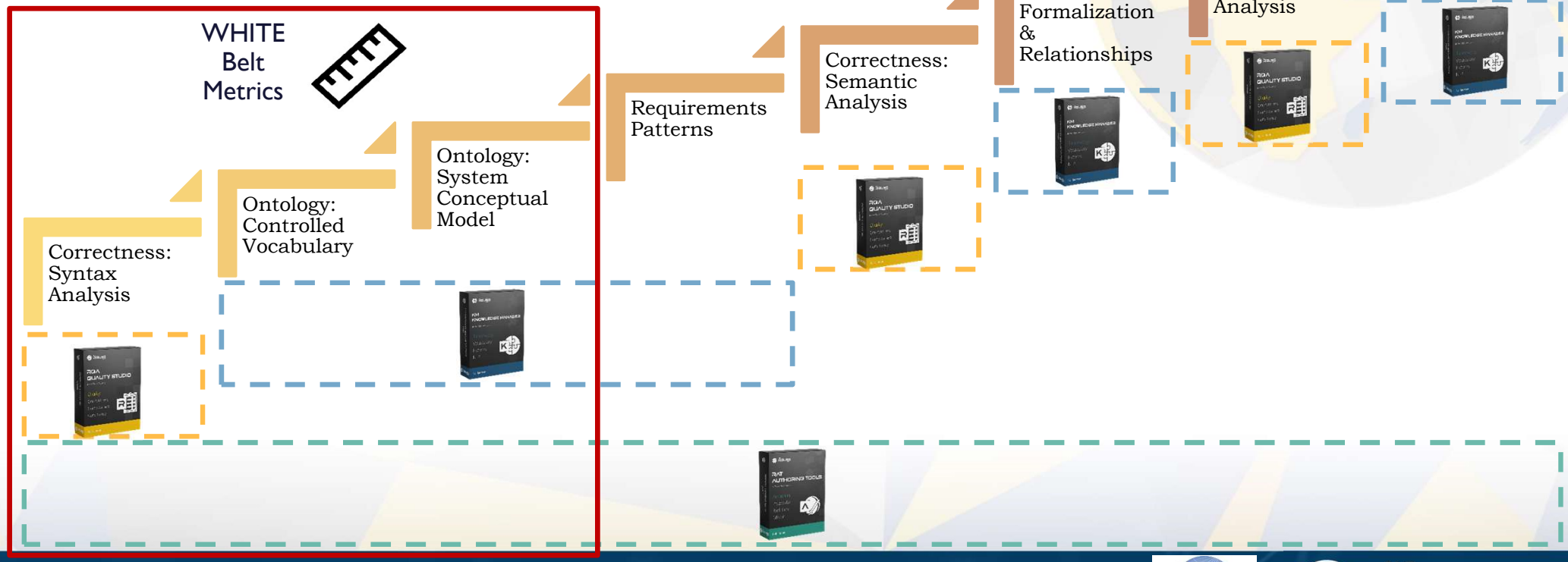
- Design a roadmap based on the concept of belts, like in martial arts, to gradually increase the complexity of quality checking and following the skills development from the systems engineering team.



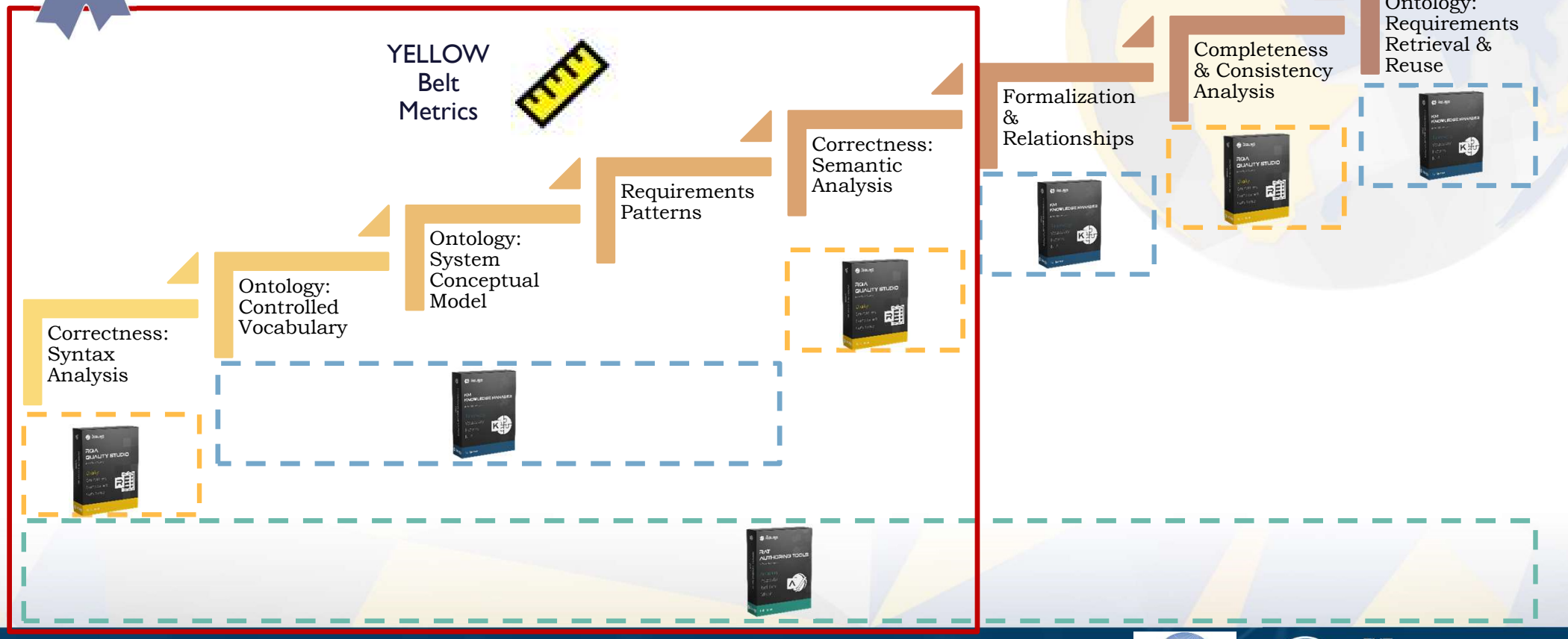
Solution: Incremental methodology – Quality belts



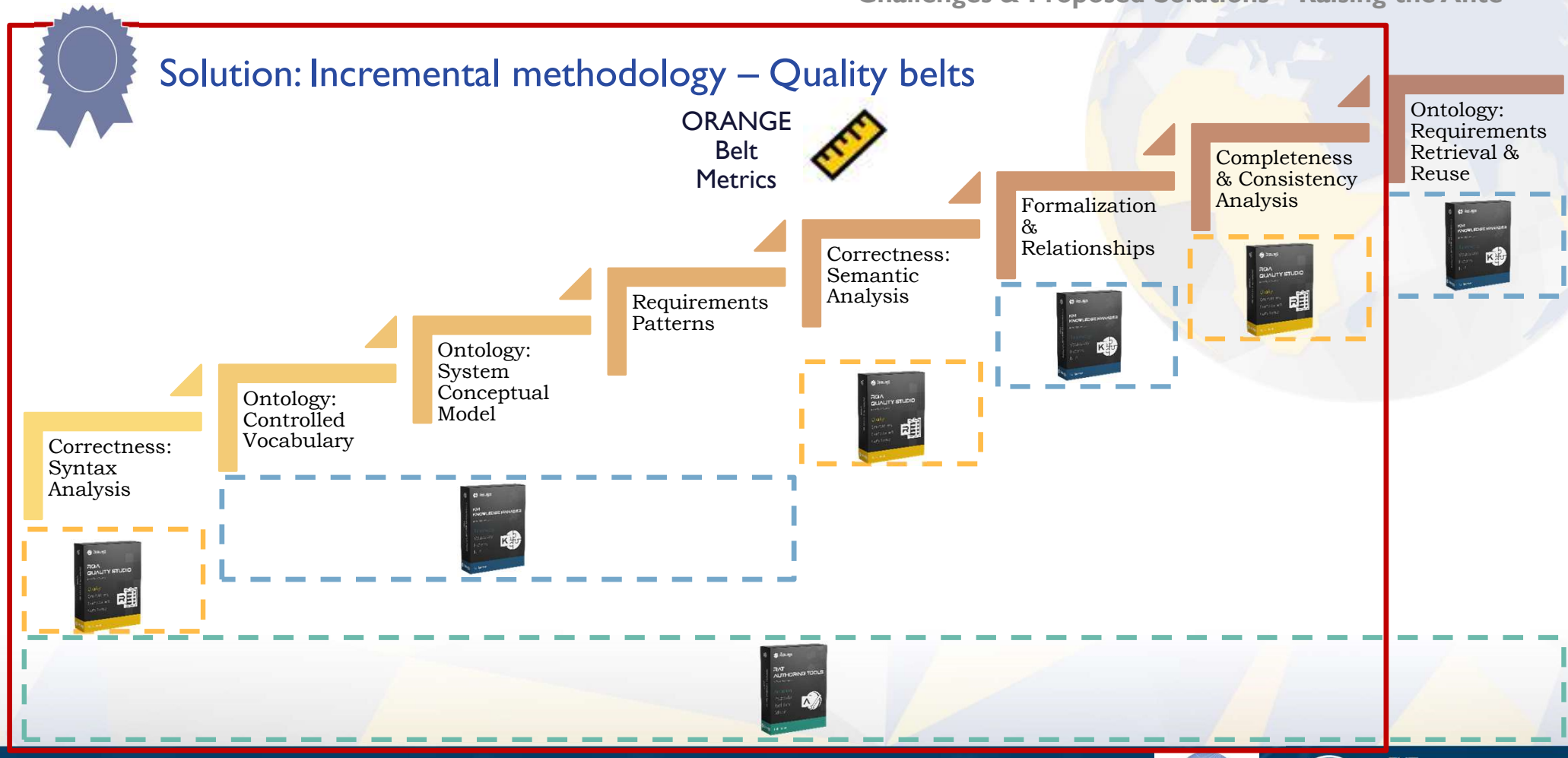
Solution: Incremental methodology – Quality belts



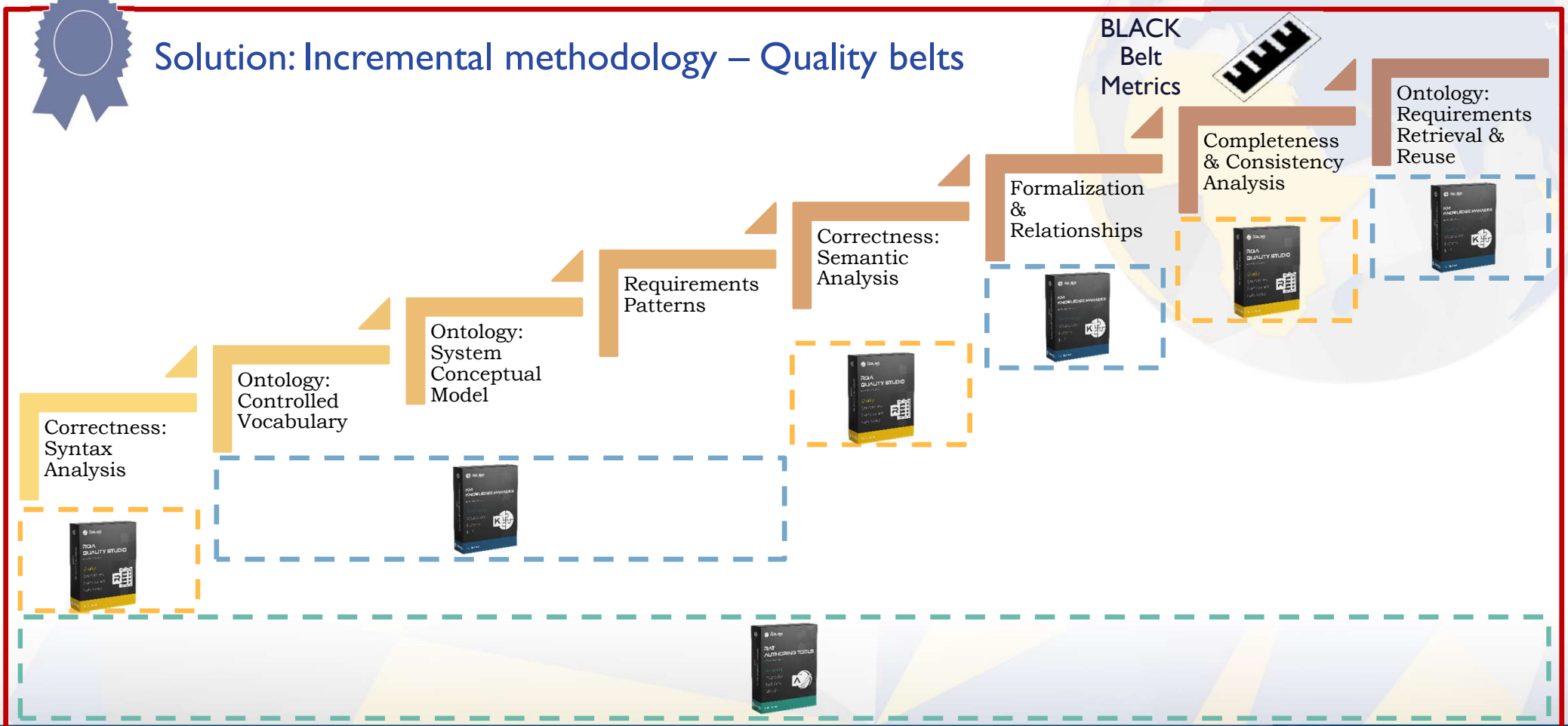
Solution: Incremental methodology – Quality belts



Solution: Incremental methodology – Quality belts



Solution: Incremental methodology – Quality belts

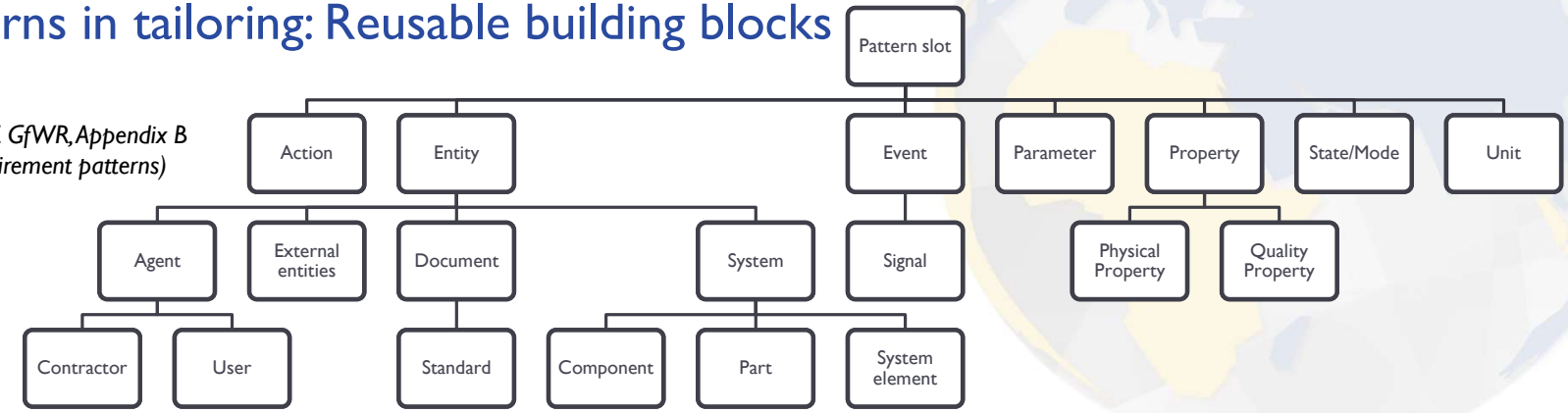


Challenges: The role of patterns in the tailoring

- Some rules of the INCOSE GfWR (for example R1 and R39) rely on requirement patterns (or boilerplates), but patterns are not addressed in great detail
- Some of the benefits offered by requirement patterns are:
  - Write concise, easy to read and atomic requirement statements;
  - Find and classify requirements in large documents and identify missing requirements;
  - Find duplicated requirements (and finding and reusing requirements in general);
  - Follow with other activities such as analysis and implementation.

Role of patterns in tailoring: Reusable building blocks

INCOSE GfWR, Appendix B (Requirement patterns)



The INCOSE GfWR does not mention patterns lists, but the writer can refer to some well-known catalogs such as:

- Jeremy Dick, Juan Llorens, "Using Statement-level Templates to Improve the Quality of Requirements", *International Conference on Software and Systems Engineering and Applications. ICSSEA 2012*, Paris, France.
- Hull et al: *Requirements Engineering*, Springer, 2012.
- EARS Patterns: by Alistair "Mav" Mavin (http://www.alistairmavin.com/ears)
- MASTER Patterns: by SOPHIST GmbH (https://www.sophist.de)
- The PABRE Catalog (http://www.upc.edu/gessi/PABRE/index.html)
- ARTEMIS CRYSTAL EU Research Project (http://www.crystal-artemis.eu)

Adaptability to different types of requirements

- Most of the rules in the INCOSE GfWR can apply to all types of requirements, …
- … but some of them should only apply to specific types of requirements

Example : Rule 16 – Avoid Not (Negations)

Functional requirements

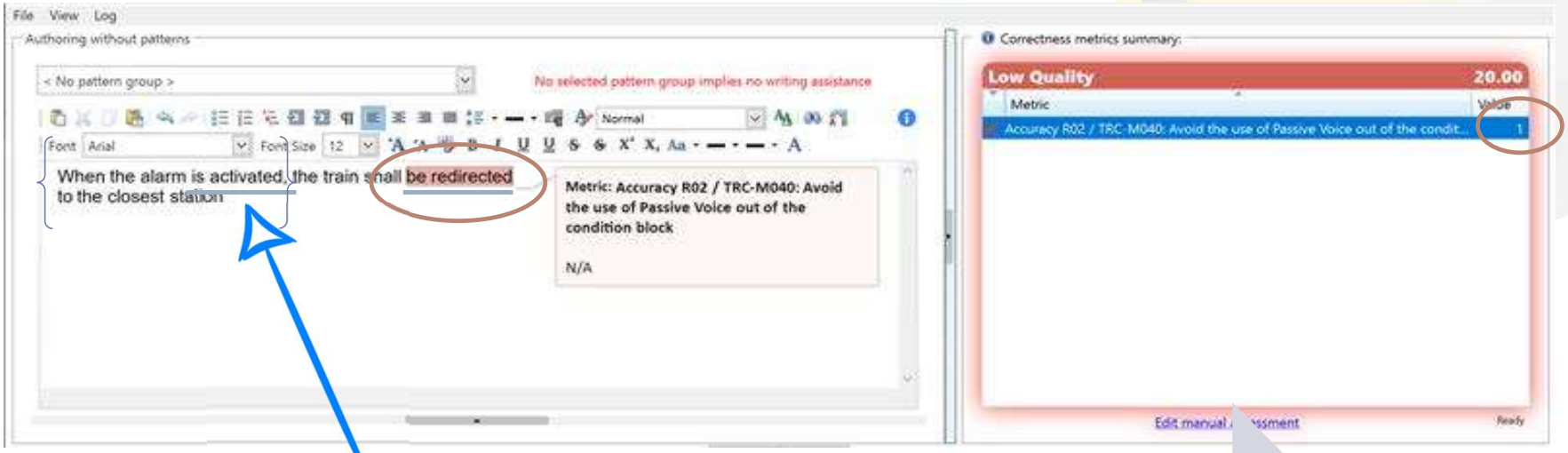
- The car shall **not** start until the driver turns the ignition

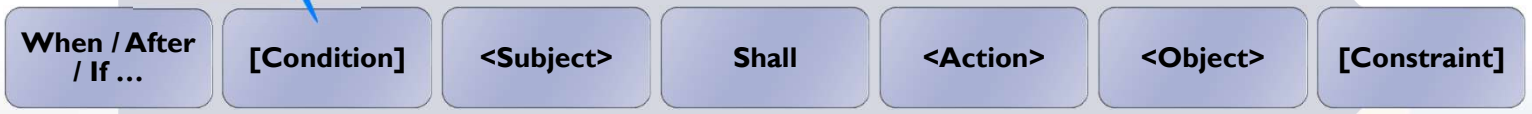
Safety Requirements

- When the car speed is higher than 10 km/h, the passengers shall **not** open the doors

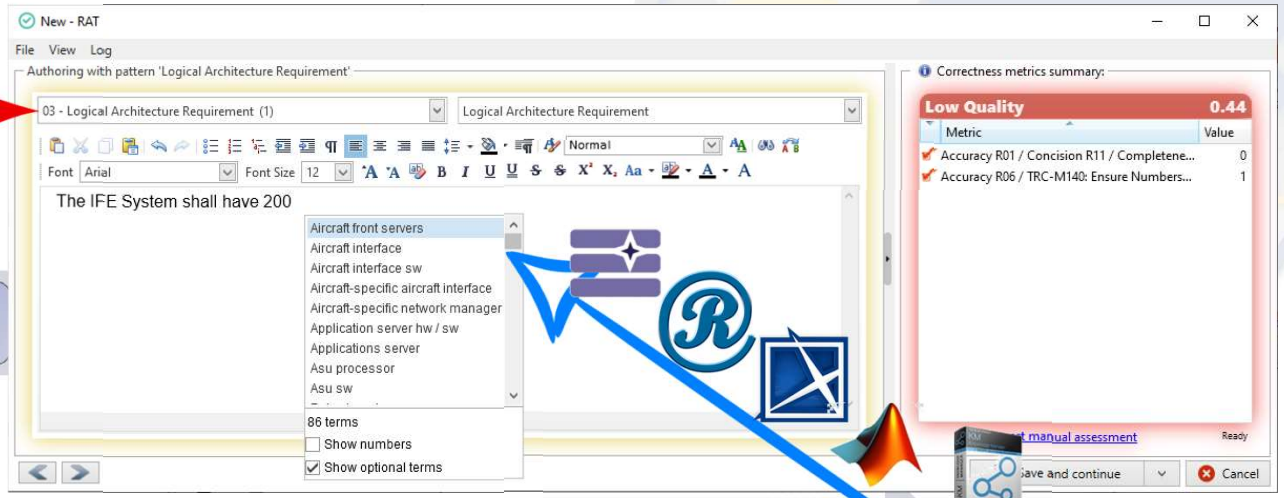
Solution: Quality checking for authors, not only quality inspections

Example: Application of R02 (Use Active Voice) to detect passive voice **only outside condition sentences:**





Solution: Requirements authoring supported by Pattern-based writing



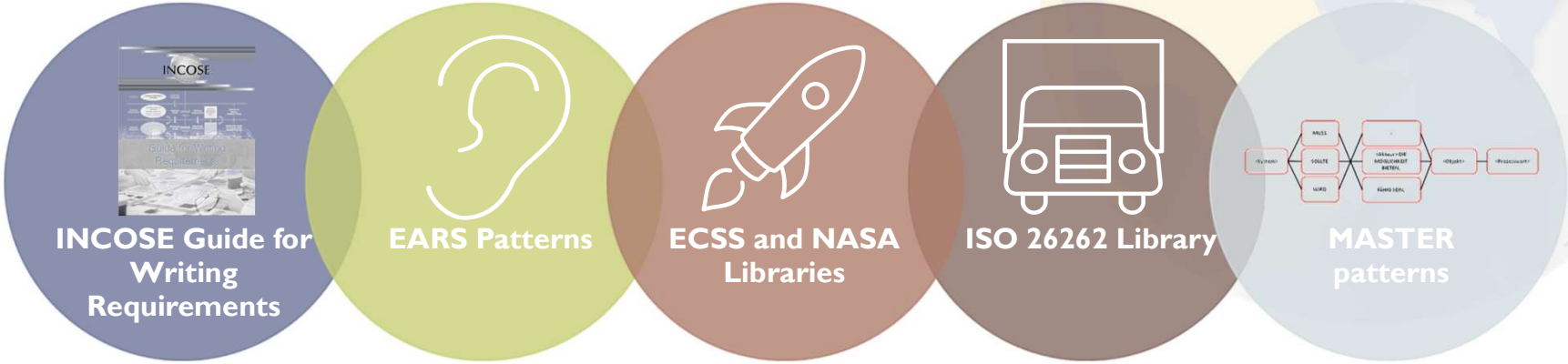
When / After / If …	[Condition]	<Component>

<Component>	Shall	Have	a/NUMBER	<Component>

The	<Property>	Of	<Component>	Shall be	[Value]

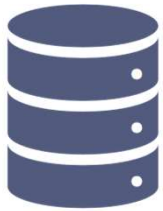
Solution: Domain-specific Libraries

ECSS and NASA
Glossary, patterns and rules



INCOSE
Quality rules for the analysis of textual requirements

EARS
Requirements patterns



Knowledge Base

Users

ISO 26262
Glossary, patterns and rules

MASTER
Quality rules for requirements and requirements patterns

TRC WEBINARS

Link to TRC webinar section:
https://www.reusecompany.com/webinars

Solution: The Systems Engineering Suite

- **RQA / V&V Studio:** to setup, check and manage the quality of a requirements specification
- **Rich Authoring Tool (RAT):** to assist authors while they are creating or editing requirements
- **Knowledge Manager (KM):** to manage knowledge around a requirements specification: dictionaries, glossaries, concept maps, knowledge models, ontologies, patterns…
- **TRACEABILITY Studio:** to link together all the different types of artifacts managed with the rest of the tools

http://www.reusecompany.com

SCAN ME

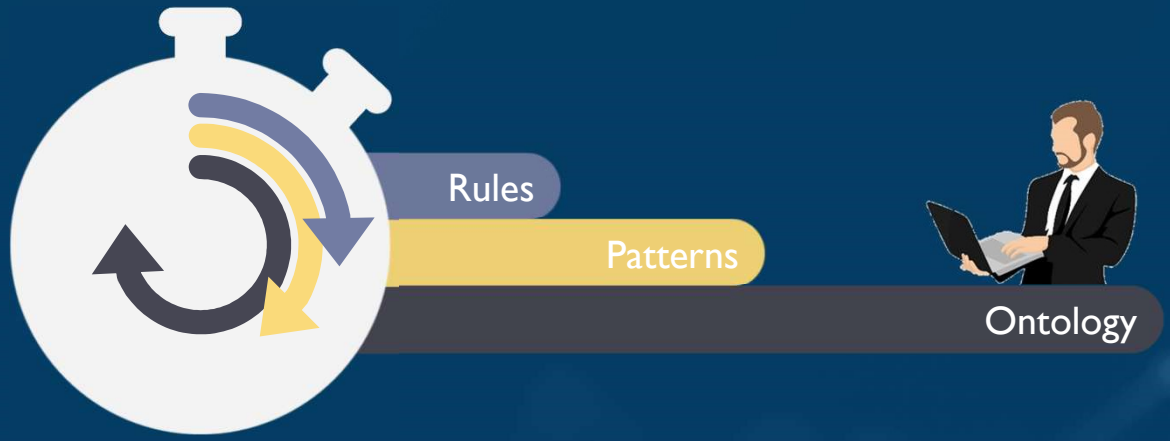
Solutions: Summary of GfWR tailoring benefits

- Provides support for **requirements authors**, not only for **quality analysts**, to **apply the rules at the earliest Life Cycle stages**
- Adopts the **CCC** (Correctness, Consistency & Completeness) approach to analyse requirements
- Enables an **incremental methodology** (Quality Belts) to adapt to the overall context
- Provides automated support for **time-consuming activities**:
  - Pattern-based authoring
  - Distinguishing between requirements writing and quality inspection activities
  - Natural Language Processing (NLP) for advanced semantics
  - Domain-specific libraries to adapt the rules to the requirements domain

Solution: The Systems Engineering Suite + AI

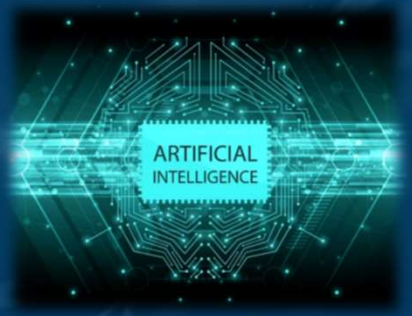
Manual Inspection

- Requires time
- Requires intensive SME support



Automated Assessment (AI + NLP)

- Reduction of time
- Less support from SME



Raising the Ante

Demo

Real-time quality assessment of the INCOSE GfWR Rules: A Tailoring Guide

- Fill out this form: https://share.hsforms.com/1NhIzlZaRRwG53dvfUHgb6Q2lpn5

SCAN ME

- …. and request your personal copy
- plus a complimentary licence for the SES Suite to evaluate the library that implements this tailoring guide
- The licence is valid for a period of 30 days from date of issue

https://www.reusecompany.com/webinars

https://www.reusecompany.com

Q & A

Upcoming Webinars (tentative schedule)

Who	What	When
Jose Fernandez and Carlos Hernandez	ISE&PPOOA a MBSE Methodology from System to Software Architecture	Wednesday 18th November 2020 at 11am EST

Invitations will be emailed in advance and informational updates will be placed on www.incose.org
Go to http://www.incose.org/products-and-publications/webinars for more info on the webinar series, including a way to view the last 143 Webinars and soon – this one!

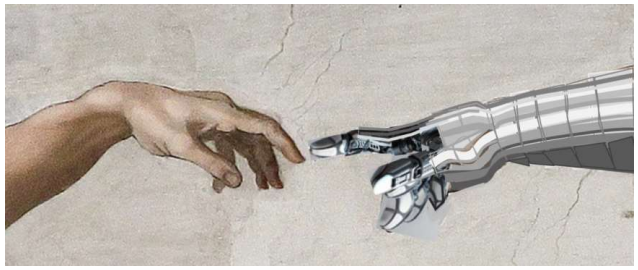
Information on the webinars is now being posted in INCOSE Connect, in the INCOSE Library area, at https://connect.incose.org/Library/Webinars/Pages/INCOSE-Webinars.aspx . Joining instructions will added around two weeks before the webinar is scheduled to take place.

1-Sep-20

Save the Dates

HSI WG – IW2020
Tuesday-Thursday, 27-29.10.2020
International Workshop:
Human System Integration in the Era of Global Crises Challenges and Opportunities.

You are invited to take part in Developing and Advancing the HSI Awareness and Practices in the Systems Engineering Community.
Join us to reinforce the HSI community and inspire to persistent dialogue on HSI.



Virtual event for about 4 hours a day.
13:15 UTC/GMT on 27.10 and 13:55 UTC/GMT on 28, 29.10.
Free Registration. Pre-registration is required.
https://forms.office.com/Pages/ResponsePage.aspx?id=vCENNyqVPkmiyRPPoeY1IC3ta8YTwnNChCe4fC_MqhNUN1NPSFQ0VzZZSlJXOTU1WDRHWEdYRUtVTi4u

INCOSE System of Systems Engineering Mini-Event
4 November 2020

INCOSE presents a System of Systems Engineering mini event!

The event will be virtual, taking place 4 November 2020.

Hosted by Garry Roedler, INCOSE Immediate Past President.

Topics from various speakers include:

- Systems of Systems Engineering: Past, Present, and Future (Judith Dahmann)
- The Systems Challenge of Quantum Technologies (Michael Henshaw)
- A Mindset Shift from SoS to IoTs and Back Again (Kerry Lunney)
- From the Roads to the Skies – Transferring Insights Between Systems of Systems Domains (Alan Harding).

Register now!

Register now!
http://incose.informz.net/z/cjUucD9taT0zMTA4NDY0JnA9MSZ1PTM3Njg1Mzk3MyZsaT0yNjA3Mjc5MA/index.html

INCOSE Systems Engineering Professional PDU Credit

Please note that you can claim 1PDU credit towards your Systems Engineering Professional re-certification by attending this webinar. The webinars may also apply to the PDU requirements of other organizations, depending on the subject matter

To qualify, you must have attended through at least 75% of the webinar for webinars that last less than one hour, or through 45 minutes of the webinar for webinars that last for 1 hour or longer.

You can also claim credit for previous webinars you have attended; please contact info@incose.org if you wish to know which webinars you attended and if you met the qualification requirements

With thanks to our Sponsor for 2020