



32nd Annual **INCOSE**
international symposium

hybrid event

Detroit, MI, USA
June 25 - 30, 2022

INCOSE Requirements Working Group

IS2022 RWG Meeting

www.incose.org/symp2022



Meeting Agenda

- Welcome and Introduction (10 min)
- Overall status of last year (10 min)
- Overview of NRM and guide concepts (25 min)
- Status of Guide to Writing Requirements V3.1 updates
 - Suggestions for V4.0 of the Guide (30 min)
- RWG plans for rest of 2022 (10 min)
 - SEBok updates
 - SoS and SSE working group collaboration
 - RWG Meetings



Welcome and Introduction

Tami Katz



Welcome!

- Welcome to the Requirements Working Group (RWG) Meeting for IS2022!
- Working group highlights from IW2022 and address plans for the second half of 2022.
- New members are welcome to join us in the discussions, this is an open meeting for anyone to attend.
- Introductions of meeting attendees



Our last in-person/hybrid meeting at IW2022

RWG Charter



1

Purpose

Advance:

- Practices, education, and theory of needs and requirements development and management
- Relationship of needs and requirements to other systems engineering activities.

2

Goal

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

3

Scope

Activities relating to best practices throughout the product lifecycle including:

- Elicitation, Analysis, Allocation, Traceability
- Elaboration, Management
- Change Management
- Expression, Verification, Validation

RWG is About...

- How to improve the practice of systems engineering through excellence in needs and requirements development and management across the lifecycle
- Learning from experiences and sharing with the SE community
- Questioning approaches that yield poor outcomes
- Publishing guidance and continuing research into requirements development and management, including the understanding of Needs, Requirements, Verification, and Validation

RWG Leadership



- **Chair:** Tami Katz; Ball Aerospace, USA
- **Co-Chair:** Lou Wheatcraft; Wheatland Consulting, USA
- **Co-Chair:** Mike Ryan; Capability Associates Pty Ltd, AU
- **Co-Chair:** Raymond Wolfgang; Sandia National Labs, USA
- **INCOSE Websites:**
 - <https://www.incose.org/incose-member-resources/working-groups/process/requirements>
 - <https://connect.incose.org/WorkingGroups/Requirements/Pages/Home.aspx>
 - <https://www.youtube.com/channel/UCadgYaqKWDckenP2SU8-cPw>
- **Number of Members:** 401, one of INCOSE's largest WG



The RWG is comprised of members from industry and academia with a common purpose of improving the practice of systems engineering through improvement of **Needs and Requirements** development and management across the system lifecycle.



INCOSE RWG YouTube Channel

- [YouTube](#) channel has recordings of meetings and presentations to the broader community.
- Available to everyone to catch up on events and learn more about the RWG efforts and products.
- Also exists to attract interest in joining INCOSE and the RWG and share wisdom, experience and ideas with all that engage in needs and requirements efforts.

YouTube Search

Validation

INCOSE Requirement WG

RWG INCOSE RWG 256 subscribers

SUBSCRIBED

HOME VIDEOS PLAYLISTS CHANNELS ABOUT

Multiple playlists

RWG IW2022 Sessions 13

Needs, Requirements, Verification, and Validation... 12

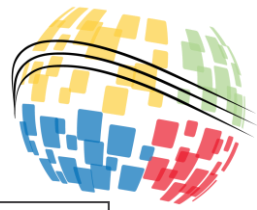
Needs and Requirements Definition 8

Requirement Quality 8

VIEW FULL PLAYLIST

<https://www.youtube.com/channel/UCadgYaqKWDckenP2SU8-cPw/playlists>

INCOSE RWG External Website



- The RWG maintains an external website (no INCOSE membership needed to view)
- Information on upcoming meetings and work in effort is provided.
- Anyone interested in participating in requirement working group data share is welcome to use this site to stay informed and obtain links to content.

Requirements Working Group

Link to INCOSE RWG YouTube Channel: [INCOSE RWG - YouTube](#)

Link to INCOSE RWG Connect Site for INCOSE members: <https://connect.incose.org/WorkingGroups/Requirements/Pages/Home.aspx>

Link to INCOSE Store: [Pages - Store \(incose.org\)](#)

List of INCOSE RWG Products:

- Needs and Requirements Manual (NRM) - Needs, Requirements, Verification, Validation Across the Lifecycle
- Guide to Needs and Requirements (GtNR) - a practical application guide for the NRM on developing, managing, and confirming needs and requirements
- Guide to Verification and Validation (GtVV) - a practical application guide for the NRM for the planning and implementation of verification and validation activities
- Guide to Writing Requirements (GtWR) - a practical application guide to generating needs and requirements statements
- Guide to Writing Requirements Summary Sheet - a two page sheet summarizing the GtWR rules and characteristics

RWG Products

Over the last several years, the RWG has been working on new products and supporting development of other INCOSE publications. A major effort is our contributions to the update to version 5 of the **INCOSE Systems Engineering Handbook (SE HB)** that is planned to be available in 2023.

Another major effort was the development of new products and updating existing products. The figure below shows our products and their relationship to each other and how they align with the INCOSE Systems Engineering Handbook and SEBok. We are pleased that these new products also support the INCOSE Corporate Advisory Board (CAB) needs as it is our aim to provide value to the future practice of System Engineering in support of industry, the academic community, and INCOSE's newly released **SE Vision 2035 – Engineering Solutions for a Better World**.

The first of our new products, **Needs, Requirements, Verification and Validation Lifecycle Manual (NRVVLN)**, was first released in the INCOSE Store just prior to IW2022. An update to this manual with a shorter title, **Needs and Requirements Manual (NRM) v1.1** was released the end of May 2022.

Our other new products, the **Guide to Needs and Requirements (GtNR)** and the **Guide to Verification and Validation (GtVV)** are now complete. These Guides will help the user with application of the NRM, giving guidance on practical application, examples, and checklists. This fits into our larger portfolio of working group products, which provide a rich body of knowledge for all things dealing with Needs and Requirements! As part of our product development activities, we have ensured that all our products are in alignment. As part of the alignment effort, we updated the **Guide to Writing Requirements (GtWR)** and the **GtWR Summary Sheet to version 3.1**. All our new and updated products are now available in the INCOSE Store, free for INCOSE members and a nominal charge for non-members.

RWG Events

The RWG holds regular RWG Exchange Cafes and also hosts guest speakers. We alternate between the RWG Exchange Cafes and guest speaker presentations. A preliminary schedule between now and IW2023 is shown below.

- June 25 – 30:IS2022 - We are planning a RWG Session for Tuesday, June 28 in the afternoon 1:30-2:55 pm EST. Zoom link: <https://incose-org.zoom.us/j/98395272788?pwd=eEvidmxCc25SbFhwMEJ2b2dWpXQT09#success>
- July 20: Presentation by Beth Wilson on Systems of Systems (SoS) challenges.
- August 24, 3 pm: RWG Exchange Café – Beth Wilson lead on SoS vs the NRM, GtNR, GtVV
- September 28: RWG Exchange Café – General discussion focusing on interfaces
- October 26: Presentation by Beth Wilson – System Security Challenges
- November 16: RWG Exchange Café – Beth Wilson lead on System Security vs NRM, GtNR, GtVV
- December 14: Presentation by Henrik Mattfolk “Configuration Management Across the Digital Thread”
- January 2023: IW 2023 RWG prevent sessions - TBD

Notifications of our monthly meetings is via the RWG member mailing list, LinkedIn, Twitter, and the INCOSE Teams and Yammer sites. Both INCOSE members and non-members alike are welcome to attend and participate in our monthly meetings as well as view recordings of our meetings via the **INCOSE RWG YouTube channel**.

[Back to Top](#)

<https://www.incose.org/incose-member-resources/working-groups/process/requirements>

RWG Connect Site



- Information about RWG meetings, products, and ongoing efforts are found on the INCOSE RWG Connect website, available to INCOSE members.
- Content from this IS2022, past events, general meetings, and product working pages are available from this site.

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Needs and Requirements Manual

Guide to Needs and Requirements

Guide to Verification & Validation

Guide to Writing Requirements

RWG General Meetings

RWG sessions at IS2022

RWG sessions at IW2022

RWG sessions at IW2021

RWG Sessions at IW2020

RWG sessions at IS2019

RWG sessions at IW2019

Documents

Site Content

- Guide to Needs and Requirements
- Guide to Verification & Validation
- Guide to Writing Requirements
- Needs and Requirements Manual
- RWG General Meetings
- RWG sessions at IS2019
- RWG sessions at IS2022
- RWG Sessions at IW2014
- RWG sessions at IW2017

Connect > Working Groups > Requirements > Requirements Work...

Welcome to the Requirements Working Group SharePoint Site!

Please see our charter below.
Use the links on the left of the screen to navigate to the different areas of the RWG site to see the past and current efforts in work.
Link to public website: Requirements (incose.org)

INCOSE RWG Whitepaper: Integrated Data as a Foundation of Systems Engineering

INCOSE Systems Engineering Handbook

SEBok

Needs and Requirements Manual

Guide to Writing Requirements

Guide to Needs and Requirements

Guide to Verification and Validation

Other Domain Specific Guides

Information about the INCOSE RWG:

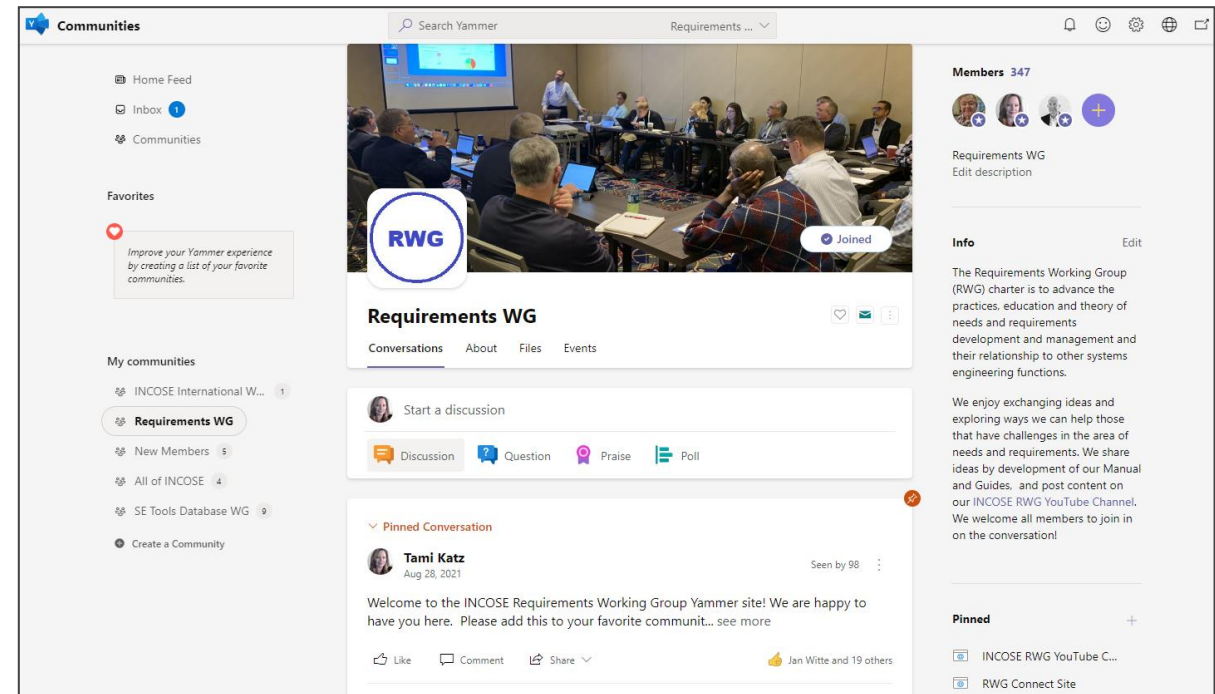
RWG About INCOSE RWG 2021 Watch later Share

<https://connect.incose.org/WorkingGroups/Requirements/Pages/Home.aspx>

RWG Yammer Community



- The INCOSE organization has established Microsoft platforms for INCOSE member engagement.
- Upon obtaining the member login from the INCOSE CIO Barclay Brown, navigate to Communities (Yammer) and join the Requirements Working Group Community.
- This platform enables more interactive announcements, questions, and discussions throughout the year!

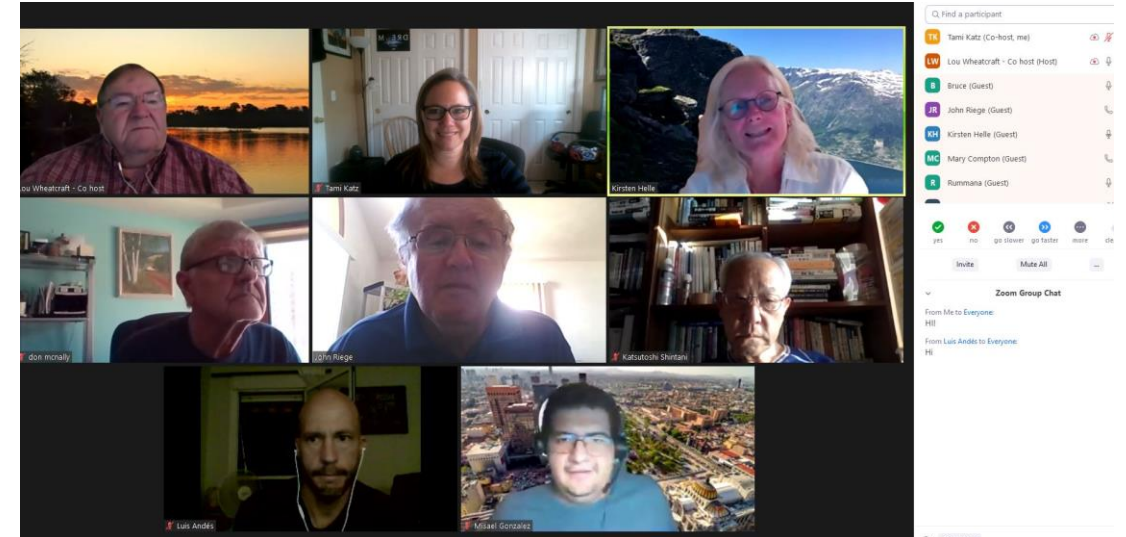


Access to Communities is through the Microsoft Teams App, or the online Microsoft Teams site.



RWG Events

- RWG engages the INCOSE community through regular events around the topic of Needs and Requirements
 - Guest speakers on Requirements Topics
 - RWG Exchange Cafés
- RWG members contribute ideas towards topics discussed and are encouraged to share their experiences and questions with the broad working group community.





How to Become Involved in RWG

- As a large working group, the RWG has been very active in virtual events as well as smaller product team efforts.
- Joining the working group enables the members to learn about the products, provide opportunity to contribute (or review), and participate in the RWG virtual events with other practitioners.
- Members can be very involved (product support) or minimally involved (watch meeting recordings), the intention is to enable all levels of participation and interaction.

Members:

- ➔ Contribute the benefit of their experience
- ➔ Promote the purposes of the group
- ➔ Write, edit and review work products
- ➔ Liaise with other working groups and organizations
- ➔ Assist the leadership team with specific activities

My Committees/Working Groups *(Join a group here)*

Committee	Position
SE Tools Database	Member

- [View My Committees/Working Groups](#)
- [Browse / Join a Working Group](#)



RWG 2022 Activities and Status

Tami Katz

RWG 2022 Completed Events

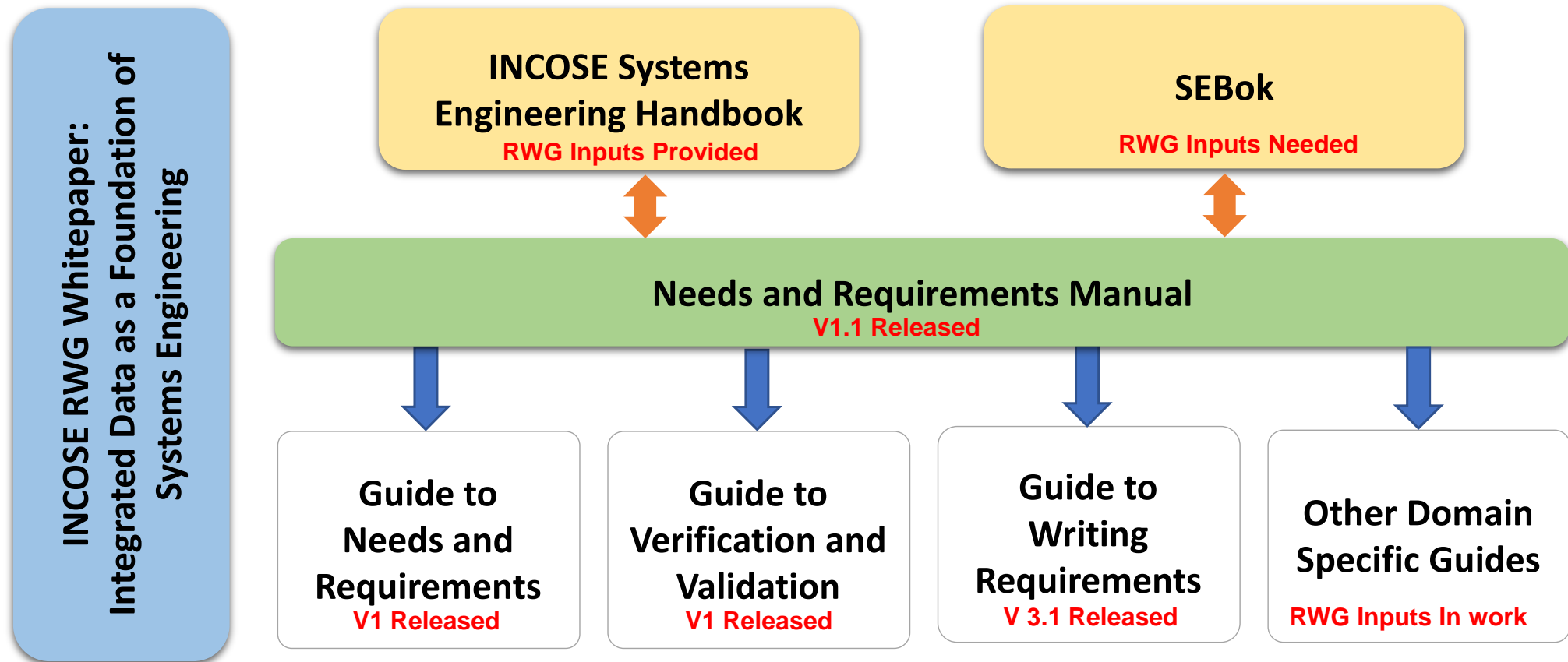


- **May 25, 2022** - Demonstrating SE Value Using Traceability Measurement
 - Slides: [INCOSE RWG Jama Software Measurement May 2022.pdf](#)
 - Recording: <https://youtu.be/GSpQdachXZU>
- **April 27, 2022** - RWG Exchange Café (Addressing the Operational Environment)
 - Slides: [RWG Exchange Cafe 042722.pdf](#)
 - Recording: <https://youtu.be/Ei81HLUxxAE>
- **March 24, 2022** - Using Model-Based Systems Engineering Techniques to support Requirements Generation for the Design of New Generation Armored Combat Vehicle Systems (Mark Egger)
 - Slides: [Presentation-INCOSE-MBSE in Combat Vehicle Design-1hr-Mar 22-v1.0.pdf](#)
 - Recording: <https://youtu.be/bMtoDvsKB84>
- **February 23, 2022** - RWG Exchange Café (NRM Questions and Overview).
 - Recording: <https://youtu.be/HZo2jR-zDFY>
- **January 25-30, 2022** – RWG at IW2022
 - Slides and Recordings:
https://connect.incose.org/WorkingGroups/Requirements/RWG_IW2022/SitePages/Home.aspx



RWG Product Tree

- The RWG has been working on new products and supporting development of other INCOSE publications



RWG Products are in the INCOSE Store!



- RWG Products are released in the INCOSE Store!
- Free to INCOSE members
- All are encouraged to download and start using, feedback is welcome!

INCOSE.org INCOSE CONNECT INCOSE Store

BROWSE PAGE

Needs and Requirements Manual (soft copy)
Digital Download via e-mail link

Product Code:
NRVLM

Price: \$35.00
Member Price: \$0.00

[ADD TO CART](#)

[DETAILS](#)

INCOSE.org INCOSE CONNECT INCOSE Store

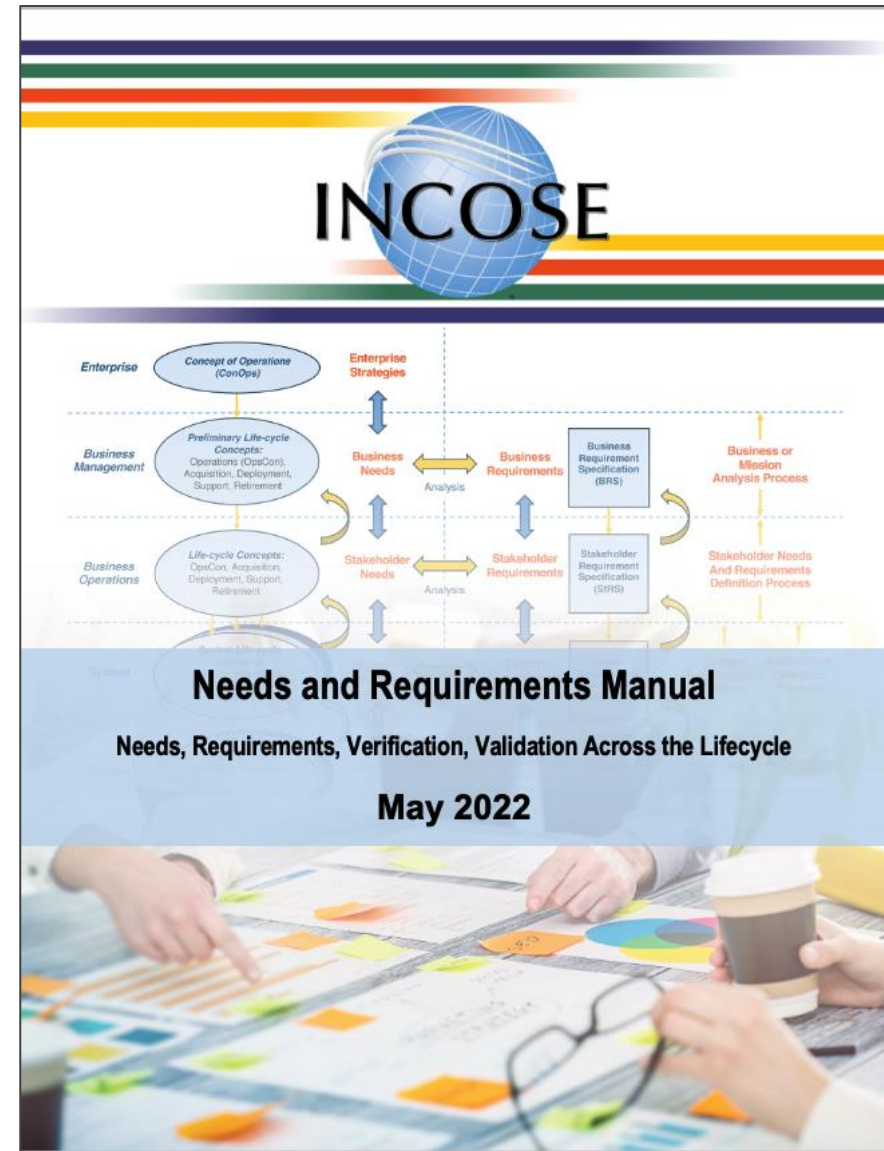
BROWSE PAGE

- Guide to Needs and Requirements (soft copy)**
Digital Download via e-mail link
Product Code: GNRv1
Price: \$25.00
Member Price: \$0.00
[ADD TO CART](#)
[DETAILS](#)
- Guide to Verification and Validation (soft copy)**
Digital Download via e-mail link
Product Code: GVV1
Price: \$25.00
Member Price: \$0.00
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- Guide to Writing Requirements (Soft Copy)**
Digital Download via e-mail link
Product Code: TechGuideWR2022Soft V3.1 updated 2022
Price: \$25.00
Member Price: \$0.00
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[DETAILS](#)
- Guide to Writing Requirements Summary Sheet (soft copy)**
Digital Download via email link.
Product Code: TechGuideSummary
Price: \$0.00
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Needs and Requirements Manual (NRM)

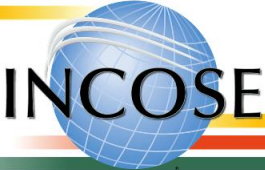


- The NRM (was NRVVLM) is the RWG flagship product, V1 released in January 2022
- V1.1 minor updates in May to shorten title, add subtitle, and align with other RWG products
- Content from this aligns with, and expands, the INCOSE SE Handbook version 5 material.
- Material and concepts from this is presented later in today's RWG meeting!







The RWG Guides Provide Practical Application of the NRM




Guide to Needs and Requirements
May 2022



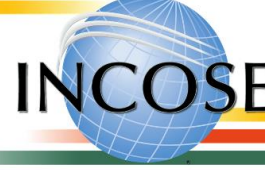
The diagram illustrates the INCOSE framework for Needs and Requirements. It is organized into three horizontal layers: Enterprise, Business Management, and Business Operations. Each layer contains a set of interconnected elements: Enterprise (Concept of Operations (ConOps) and Enterprise Strategies), Business Management (Preliminary Life-cycle Concepts and Business Requirements Specification (BRS)), and Business Operations (Life-cycle Concepts and Stakeholder Requirement Specification (SRS)). Vertical arrows indicate the flow of information and processes between these layers, including Business or Mission Analysis Process and Stakeholder Needs and Requirements Definition Process.




Guide to Writing Requirements
May 2022



The diagram illustrates the INCOSE framework for Writing Requirements. It follows the same three-layer structure as the first guide: Enterprise, Business Management, and Business Operations. The elements and their interconnections are similar, but the focus is on the processes of defining and specifying requirements, such as the Business or Mission Analysis Process and Stakeholder Needs and Requirements Definition Process.



Guide to Verification and Validation
May 2022



The diagram illustrates the INCOSE framework for Verification and Validation. It maintains the three-layer structure: Enterprise, Business Management, and Business Operations. The diagram highlights the processes of verifying and validating requirements, showing how they are integrated with the other stages of the INCOSE framework.



NRM, GtNR, & GtVV Overview

Lou Wheatcraft

Introduction



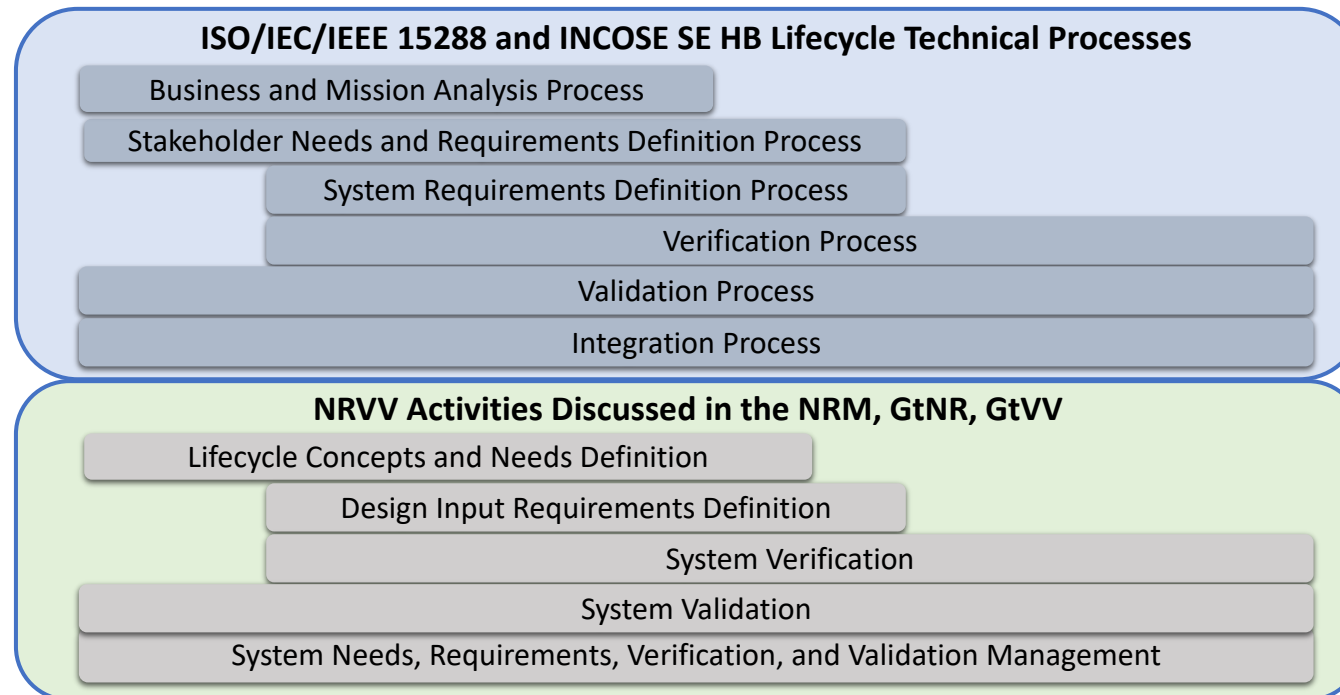
- The NRM, GtNR, GtVV present systems engineering lifecycle concepts and activities from the perspective of needs, requirements, verification, and validation (NRVV) definition and management across the system lifecycle.
- To successfully complete system verification and system validation, the needs and requirements of the system as well as the system verification and system validation artifacts must be managed throughout the entire system lifecycle.
- **The NRM, GtNR, GtVV provides practical guidance on the activities required to achieve those outcomes.**

“Needs, Requirements, Verification, and Validation are common threads that tie all lifecycle activities and processes together.” Lou Wheatcraft

Introduction



- The NRM, GtNR, GtVV supplements and elaborates on the INCOSE SE HB
 - Provides more detailed guidance on the what, how, and why concerning needs and requirement definition and management, verification, and validation across the lifecycle.
 - Addresses ambiguity and inconsistencies in ontology concerning needs and requirements definition and management, verification, and validation.
- Focus is on activities performed as part of the SE HB Technical Processes.



Relationships



- 1: Introduction
- 2: Needs Definition, Verification, & Validation
- 3: Requirements Definition, Verification, & Validation
- 4: Needs & Requirements Management
- Appendix A: Acronyms & Abbreviations
- Appendix B: Needs and Requirements Definition & Management Plan Content
- Appendix C: Needs Elicitation Questions
- Appendix D: Checklists
- Appendix E: References
- Appendix F: Comment Form

GtNR
(120 pgs.)

- 1: Introduction
- 2: Definitions and Concepts
- 3: Information-Based Needs & Requirement Development and Management
- 4: Lifecycle Concepts & Needs Definition
- 5: Needs Verification & Needs Validation
- 6: Design Input Requirements Definition
- 7: Design Input Requirements Verification & Validation
- 8: Design Verification & Design Validation
- 9: Production Verification
- 10: System Verification & System Validation Common Principles
- 11: System Verification & System Validation Processes
- 12: The Use of OTS System Elements
- 13: Supplier Developed SOI
- 14: Needs, Requirements, Verification, & Validation Management
- 15: Attributes for Needs & Requirements
- 16: Features an SE Toolset Should Have
- Appendix A: References
- Appendix B: Acronyms and Abbreviations
- Appendix C: Glossary
- Appendix D: Comment Form

NRM
(457 pgs.)

- 1: Introduction
- 2: Verification & Validation Common Principles
- 3: Needs and Requirements Verification & Validation Process
- 4: Design Verification & Validation Process
- 5: Production Verification
- 6: System Verification & Validation Processes
- 7: Use Of Off-The-Shelf Parts, Supplier Developed System Elements, & The Supplier-Customer Relationship
- 8: Needs, Requirements, Verification, & Validation Management
- 9: Conclusion
- Appendix A: Acronyms
- Appendix B: Glossary
- Appendix C: References

GtVV
(109 pgs.)



Basic Concepts

Basic Concepts



- Terminology
 - Stakeholder needs vs Stakeholder-owned system requirements
 - Requirements vs specifications
 - Design inputs vs design outputs
 - Verification and Validation in Context
 - Requirements Verification is not system verification!
- Concurrent, iterative, recursive nature of SE activities
 - Avoid organizational silos

Needs vs Requirements



- Needs and Requirements – not just requirements
 - Lifecycle concepts and needs definition before requirements
 - Needs are not requirements

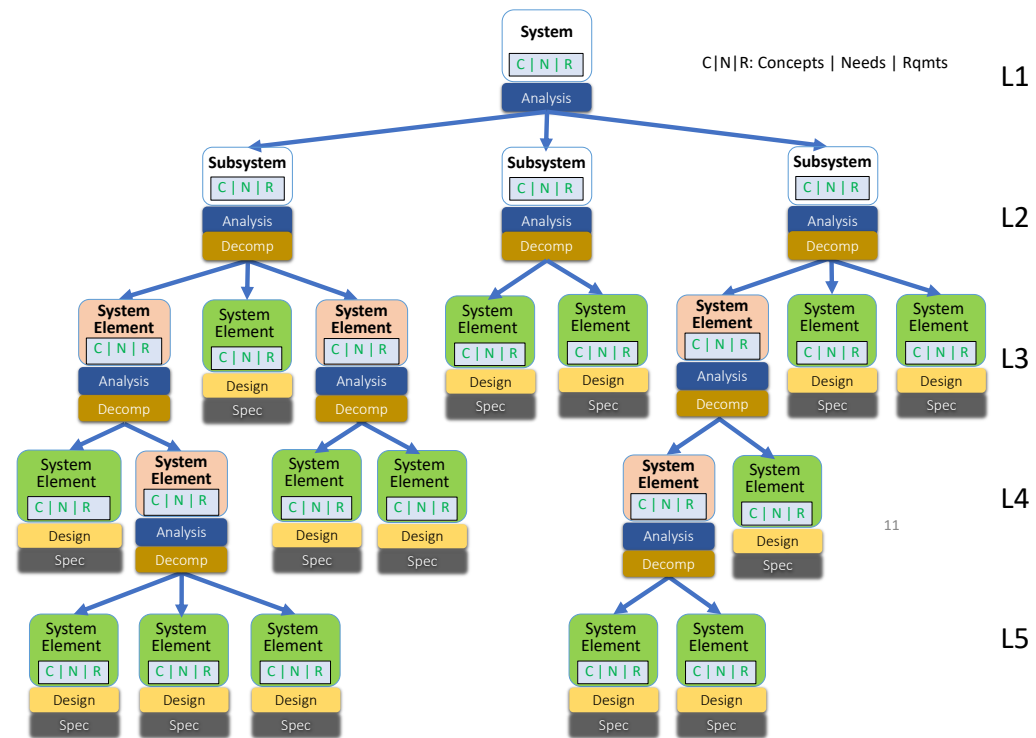
The quality of the requirements is dependent on the quality of the needs from which they are transformed.

Needs vs Requirements

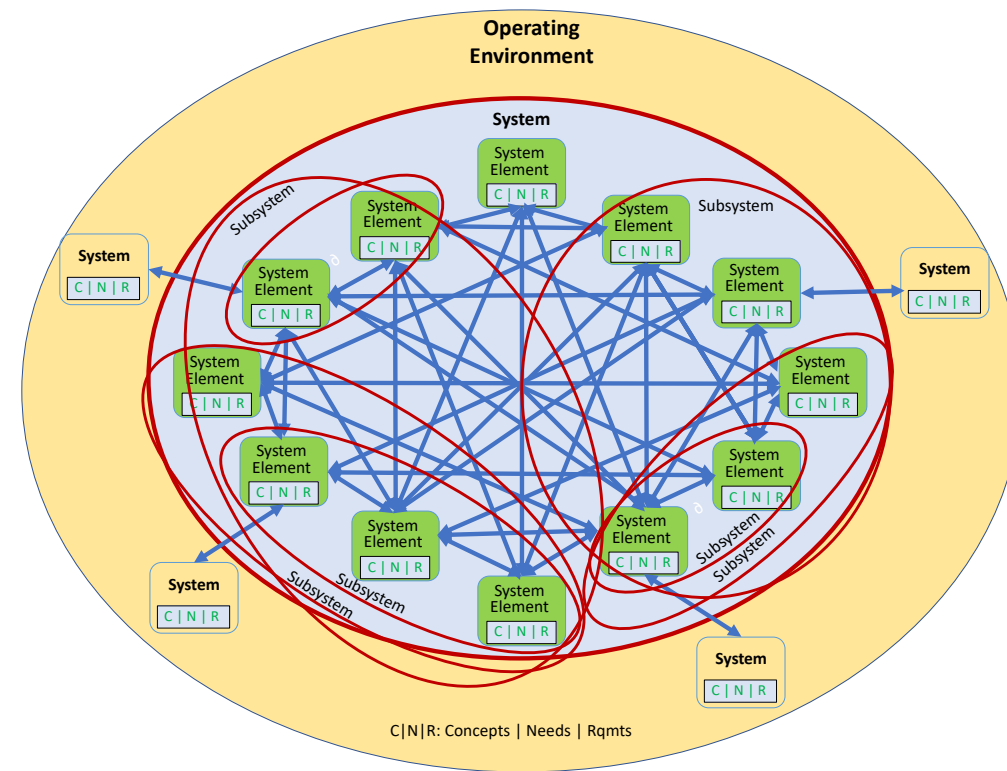


- Needs represent the stakeholder, customer/acquirer view of the system of interest (SOI)
 - What do the stakeholders need the system to do that will result in their problem to be solved or opportunity to be realized within defined constraints?
 - Communicates the stakeholder expectations for the end-state once the SOI is delivered – in the end **what will make the customer happy?**
 - The SOI will be validated against its integrated set of needs
- Requirements represent the technical, developer view of the SOI
 - What must the SOI do in order to meet the needs?
 - Inputs to the design definition process
 - Both the design and realized SOI will be verified against its design input requirements

Hierarchical Architecture View vs Holistic View



VS



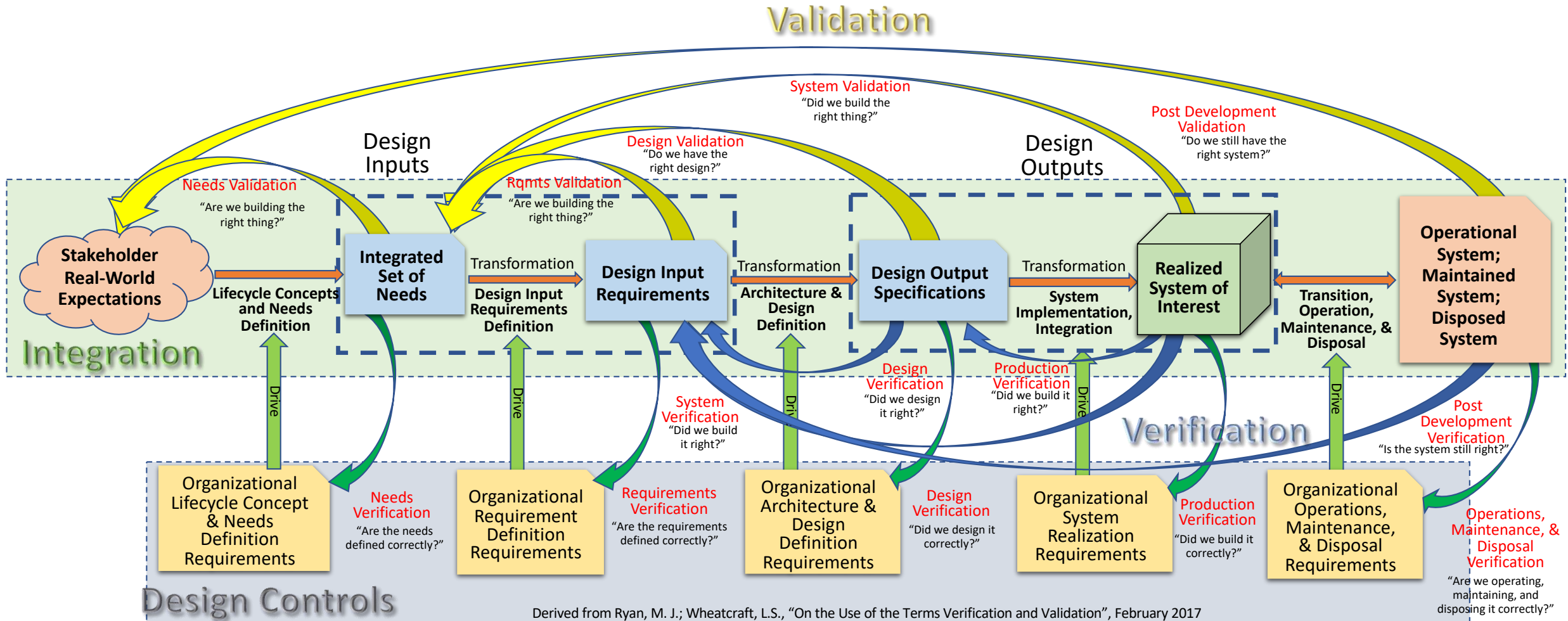
Basic Concepts



- Integration, Verification, & Validation occur across the lifecycle
 - Validation is more important than verification
 - To validate against needs an integrated set of needs must be defined that represents all stakeholders – not just users or the customer

Needs, Requirements, Verification, & Validation are the common threads that tie all SE activities together.

Verification and Validation in Context



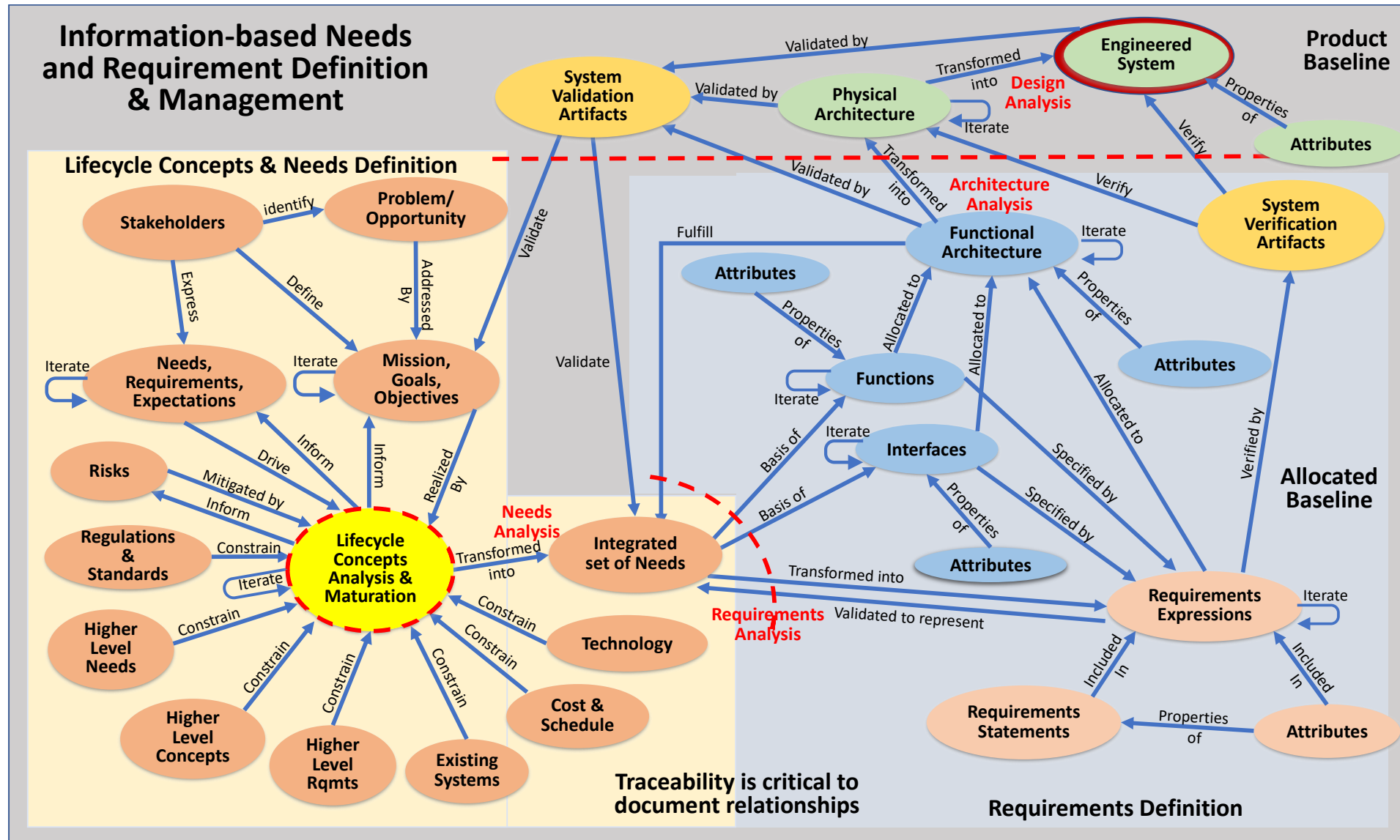
Derived from Ryan, M. J.; Wheatcraft, L.S., "On the Use of the Terms Verification and Validation", February 2017



Data-centric practice of SE

- Data-centric practice of SE – vs document-centric practice of SE
 - Single source of truth
 - Traceability of all artifacts across the system lifecycle.

Data-Centric Practice of SE



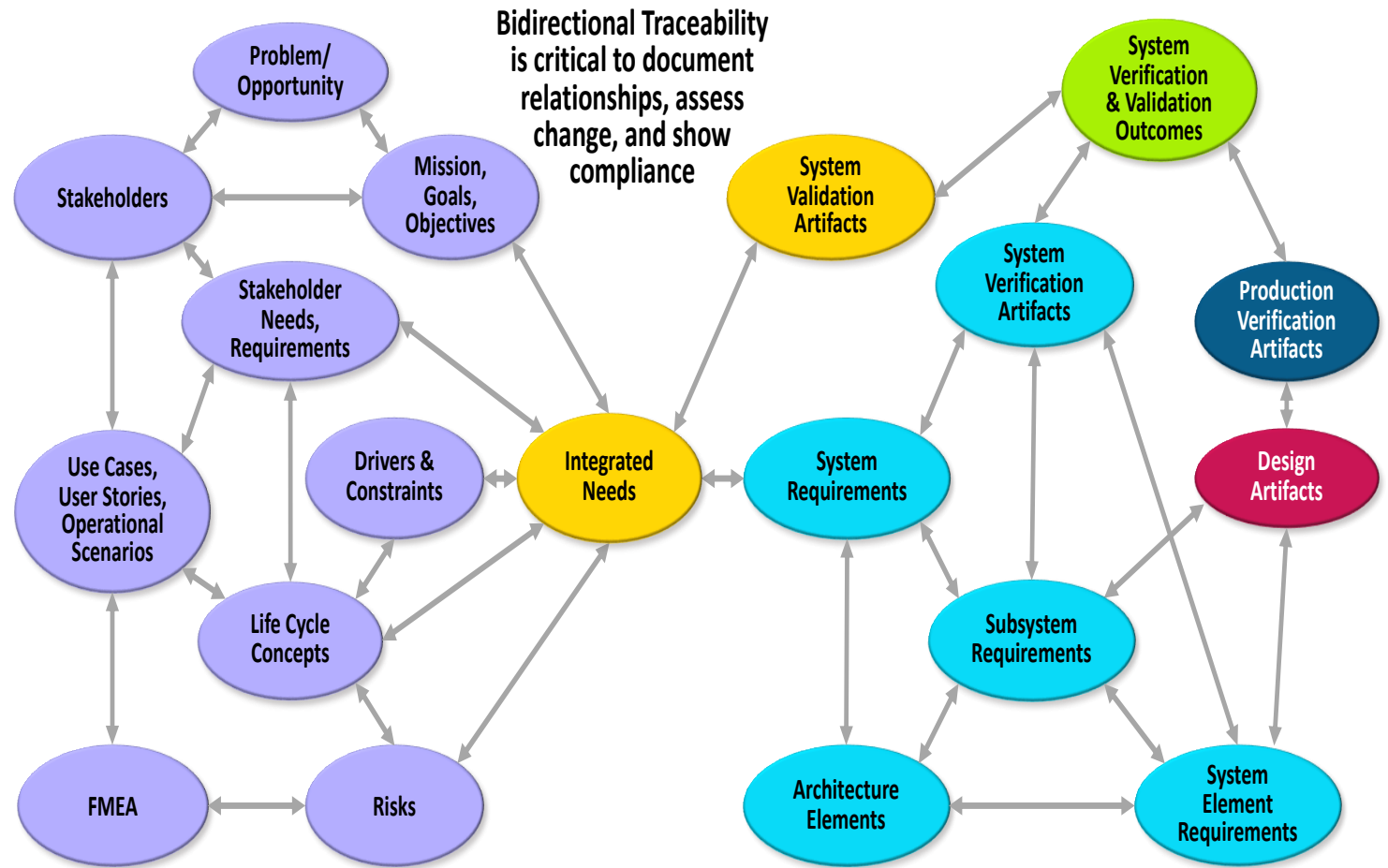
Traceability Relationship Model



At the beginning of your project, you must choose to develop your product using a data-centric practice of SE.

A first step is selecting your SE toolset and determining what data and information will be developed and managed within the toolset.

A second step is defining a traceability relationship model addressing which relationships will be established and managed via traceability.





YouTube Presentations

- For a more detailed overview of the NRM, GtNR, and GtVV you can watch the following videos:
 - NRM (NRVVLM) overview (IW2022): <https://youtu.be/ypgGHHaLbqI>
 - NRM and GtNR “Lifecycle and Needs Definition”
<https://youtu.be/hEGfNLvuyXo>
 - Underlying Concepts (IW2021): https://youtu.be/ZRli_wSCmRg
 - GtNR and GtVV Overview (IW2022): <https://youtu.be/Uy5oZmneJM0>



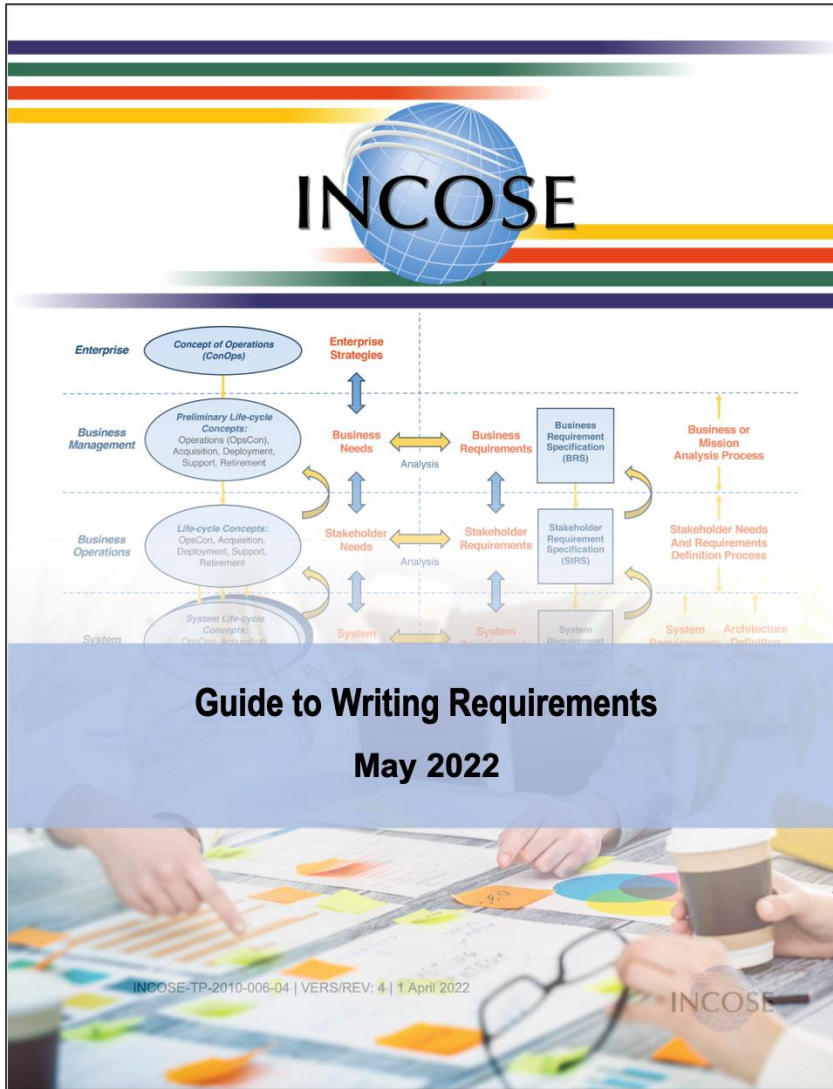
Guide to Writing Requirements

Lou Wheatcraft and Tami Katz

Recent Updates to the Guide to Writing Requirements



- The Guide to Writing Requirements (GtWR) has been a popular product from the RWG for many years.
- The RWG recently released V3.1 update to align the GtWR with the NRM, GtNR, & GtVV.
- The following slides highlights these updates.
- Future updates are planned, discussed later in this section!



116 pages

1: Introduction

1.1 Purpose and Scope

1.2 Audience

1.3 Approach

1.4 Why Use the Textual Form of Communication?

1.5 Definitions

1.6 Needs, Requirements, & the Entity to Which They Apply

1.7 Needs Vs Requirements

1.8 Quality of Needs & Requirements

1.9 Needs and Requirements In The Context of Verification & Validation

1.10 Organizing and Managing Needs & Requirements

1.11 Guide Organization

2: Characteristics of Need & Requirement Statements

3: Characteristics of Sets of Needs & Requirements

4: Rules for Need and Requirement Statements & Sets Of Needs & Requirements

Appendix A: References

Appendix B: Acronyms and Abbreviations

Appendix C: Requirement Patterns

Appendix D: Cross Reference Matrices

Appendix E: Comment Form

Change Summary (1)



- Key insight addressed in the update
 - Quality of the needs and requirements and sets of needs and requirements is more important than how well the needs and requirements statements are formed.
 - A perfectly formed need or requirement statement could still be incorrect or inconsistent and the sets could still be incomplete or not feasible.
 - The GtWR focus is on textual requirements using a structured natural language.
- Name changed from Guide **for** Writing Requirements to Guide **to** Writing Requirements
- General updates concerning typos, formatting, and addressing reader comments
- Section 1
 - Moved some information to the NRM
 - Reorganized
 - Added key concepts from the NRM dealing with the crafting of well-formed needs & requirements statements

Change Summary (2)



- Sections 2 & 3 (characteristics)
 - Added references as appropriate to the other products for additional guidance.
 - Added traceability between characteristics and concepts and activities discussed in the NRM
- Section 4 (rules)
 - Added references as appropriate to the other products for additional guidance
- Old Section 5 (Attributes) moved to the NRM
- Appendixes
 - Added rules to characteristics cross reference matrix
 - Added NRM concepts and activities to characteristics matrices.

2.3 C3 - Unambiguous



Definition:
Need statements must be written such that the stakeholder intent is clear. Requirement statements must be stated such that the requirement can be interpreted in only one way by all the intended stakeholders.

Rationale:
A need or requirement statement must lend itself to a single interpretation of intent. An agreement is difficult to enact unless both parties are clear on the exact obligation. Ambiguity leads to multiple interpretations such that the stakeholder expectations may not be met.
The intent of a need or requirement must be understood in the same way by the writer, the designer, and those doing verification and validation activities across the lifecycle following the "reasonable person" guideline. Ambiguity leads to interpretations of a need or requirement not intended by the author leading to problems such schedule slips, budget overruns, or a failure of the SOI to pass system validation and not be accepted for its intended use; which could result in litigation and financial loss.
An ambiguous need is not correct nor able to be validated. An ambiguous requirement is not Verifiable (C7) nor Correct (C8).

Guidance:
When writing a need or requirement statement, ask whether it could be interpreted more than one way. For needs, ask whether, it can be validated, i.e., whether it is stated in such a way that evidence can be obtained that the stakeholder need has been met based on the wording of the need statement without having to interpret the stakeholder intent or make assumptions of that intent.
For a requirement ask whether the requirement is verifiable, i.e., whether it is stated in such a way that evidence can be obtained that the requirement has been met based on the wording of the requirement without having to interpret the meaning or make assumptions as to the meaning.
The possibility of ambiguity is reduced by addressing these questions and applying the rules in this Guide.
Additionally, it is useful for the parties (stakeholders) who are involved in the implementation of the needs and resulting requirements or system verification and system validation to be involved in the development, review, and baseline of the needs and resulting requirements. When they see needs or requirements that are ambiguous and their intent not clear, they can identify the issue and suggest an alternate, unambiguous wording of the need or requirement statement. As a minimum, it is recommended that the need or requirement owner(s) take the development team and those involved in system verification and system validation on a walkthrough of the need or requirement set to ensure that needs and requirements are understood, individually and as a set. As discussed in Section 1.8, this activity is referred to as need or design input requirement validation.

Due to the limitations of language, it may prove difficult to completely remove all ambiguity. In this case the use of the attribute, A1- Rationale, to include contextual information to better understand the reason, and source of the requirement may provide additional insight of the intent, helping to reduce ambiguity. This may include supporting information or commentary on how the requirement was formed.
When text only makes it difficult to communicate the intent of complex requirement, the inclusion of a diagram may help remove the ambiguity. See R23.
Ambiguity of individual need and requirement statements can be assessed during early system verification and design verification activities discussed in the NRM and GtVV.

- Rules that help establish this characteristic:**
- R1 - /Accuracy/SentenceStructure
 - R2 - /Accuracy/UseActiveVoice
 - R3 - /Accuracy/SubjectVerb
 - R4 - /Accuracy/UseDefinedTerms
 - R5 - /Accuracy/UseDefiniteArticles
 - R6 - /Accuracy/Units
 - R7 - /Accuracy/AvoidVagueTerms
 - R8 - /Accuracy/NoEscapeClauses
 - R9 - /Accuracy/NoOpenEnded
 - R10 - /Concision/SuperfluousInfinitives
 - R11 - /Concision/SeparateClauses
 - R12 - /NonAmbiguity/CorrectGrammar
 - R13 - /NonAmbiguity/CorrectSpelling
 - R14 - /NonAmbiguity/CorrectPunctuation
 - R15 - /NonAmbiguity/LogicalCondition
 - R16 - /NonAmbiguity/AvoidNot
 - R17 - /NonAmbiguity/Oblique
 - R18 - /Singularity/SingleSentence
 - R19 - /Singularity/AvoidCombinators
 - R22 - /Singularity/Enumeration
 - R23 - /Singularity/Context
 - R24 - /Completeness/AvoidPronouns
 - R28 - /Conditions/ExplicitLists
 - R32 - /Quantifiers/Universals
 - R33 - /Tolerance/ValueRange
 - R34 - /Quantification/Measurable
 - R35 - /Quantification/TemporalIndefinite
 - R36 - /UniformLanguage/UseConsistentTerms
 - R37 - /UniformLanguage/DefineAcronyms

- Attributes that help establish this characteristic: (Refer to the NRM Section 15.)**
- A1 - Rationale
 - A6 - System Verification or System Validation Success Criteria
 - A8 - System Verification or System Validation Method

- Activities and concepts associated with this characteristic: (Sections within the NRM)**
- 2.2.1.1 – Communication; 3.2.1.2 – Power of Expression; 3.2.1.6 – Formal, Binding Agreement; 4.4.3 – Get Stakeholder Agreement; 4.6.3.1 – Managing Unknowns; 4.8 – Baseline and Manage Lifecycle Concepts and Needs Definition Outputs; 5.1.2 – Perform Needs Verification; 5.2.2 - Perform Needs Validation; 6.2.1.5 – Managing Unknowns; 6.3 – Baseline and Manage Design Input Requirements; 7.1.2 – Perform Design Input Requirements Verification; 7.2.2 – Perform Design Input Requirements Validation; 8.1 – Design Definition Process Overview, 8.2 – Early System Verification and System Validation; 8.4 – Design Verification, 14.2.1 – Baseline Needs, Requirements, and Specifications; 14.2.4 – Managing Unknowns

Rules to Characteristics Cross Reference Matrix



Quality Focus	Rule	Subject	Characteristics for Individual needs and requirements									Characteristics for Sets of needs requirements				
			C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
Accuracy	R1	Structured, complete sentence			X	X			X	X	X					
	R2	Use active voice		X	X	X			X							
	R3	Use appropriate subject verb		X	X				X			X				X
	R4	Define terms			X				X				X		X	X
	R5	Use definite article "the" vs "a"			X				X							
Concision	R6	Use appropriate units			X	X			X	X						
	R7	Avoid vague terms			X	X			X							
	R8	Avoid escape clauses			X				X							
	R9	Avoid open-ended clauses			X	X	X		X							
	R10	Avoid superfluous infinitives			X				X							
	R11	Use a separate clause			X	X			X	X						
	R12	Use correct grammar			X				X	X	X					
	R13	Use correct spelling			X				X							
	R14	Use correct punctuation			X						X					
	R15	Logical expressions			X				X							
Non-ambiguity	R16	Avoid the use of "not."			X				X	X						
	R17	Avoid the oblique ("/") symbol			X				X							
	R18	Use single thought sentence			X		X		X		X					X
	R19	Avoid combinators			X		X									
	R20	Avoid phrases of purpose or reason	X				X									
	R21	Avoid parentheses & brackets					X									
	R22	Enumerate sets explicitly			X		X									
Completeness	R23	Supporting diagram or model			X	X	X									
	R24	Avoid pronouns & indefinite pronouns			X	X			X							
	R25	Avoid relying on headings				X										
	R26	Avoid using unachievable absolutes						X	X	X				X		
	R27	State applicability conditions explicitly				X			X	X						
Conditions	R28	Single condition for a specific action			X				X							
	R29	Classify by type or category									X	X				
	R30	Express once and only once	X								X		X			
Uniqueness	R31	Avoid stating a solution		X												
	R32	Use "each" for universal quantification			X				X	X						
Quantifiers	R33	Define quantities with a range of values			X	X		X	X	X				X		
	R34	Specific measurable performance targets			X	X			X					X		
Tolerance	R35	Define temporal dependencies explicitly			X	X			X							
	R36	Use terms & units of measure consistently			X					X	X		X		X	X
Uniformity of Language	R37	Use a consistent set of acronyms			X					X		X		X	X	X
	R38	Avoid the use of abbreviations								X		X		X	X	X
	R39	Use a project-wide style guide				X	X			X		X		X	X	X
	R40	Group related needs & requirements				X					X	X	X		X	
Modularity	R41	Conform to a defined structure or template									X	X		X	X	

NRM Concepts and Activities to Characteristics Cross Reference Matrix (1)

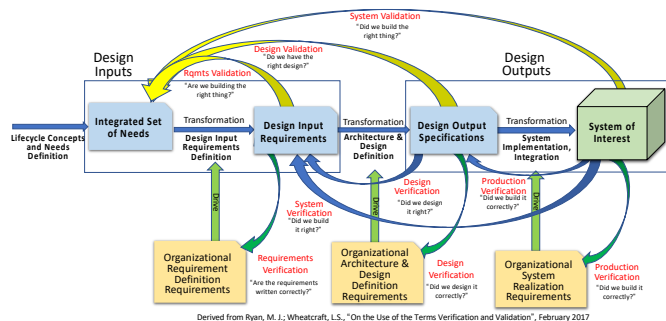


NRM Concepts and Activities		Characteristics for Individual needs and requirements									Characteristics for Sets of needs requirements				
		Necessary	Appropriate	Unambiguous	Complete	Singular	Feasible	Verifiable	Correct	Conforming	Complete	Consistent	Feasible	Comprehensible	Able to be validated
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
SECTION 3: INFORMATION-BASED NEEDS AND REQUIREMENT DEVELOPMENT AND MANAGEMENT															
3.2.1.1	Communication			X				X							X
3.2.1.2	Power of Expression			X	X			X						X	X
3.2.1.3	Managing Sets of Needs And Requirements				X									X	
3.2.1.5	Attributes	X												X	
3.2.1.6	Formal, Binding Agreement	X		X	X		X	X						X	X
3.2.1.7	System Verification and System Validation							X							X
3.2.2.1	Analysis from Which Needs and Requirements are Derived	X					X		X		X	X	X	X	X
3.2.2.2	Completeness										X			X	X
3.2.2.3	Consistency										X			X	X
3.2.2.4	Identity and Manage Interdependencies								X			X		X	X
3.2.2.5	Support Simulations							X						X	X
3.2.2.6	Key to Understanding													X	X
SECTION 4: LIFECYCLE CONCEPTS AND NEEDS DEFINITION															
4.3.3	Identify External and Internal Stakeholders										X				
4.3.6.2	Technology Maturity						X						X		
4.3.7.1	Classes of Risk - Development Risk						X						X		
4.4.3	Get Stakeholder Agreement	X		X	X			X	X		X	X		X	X
4.4.4	Completeness										X				
4.5	Lifecycle Concepts Analysis and Maturation	X			X		X	X	X			X			
4.5.1	Feasibility						X						X		
4.5.3	User of Diagrams and Models for Analysis	X							X		X	X			
4.5.4	Levels of Detail and Abstraction		X												
4.5.7.1	Model Development, Analysis, and Maturation	X							X		X	X			
4.5.7.4	Zeroing in on a Feasible Architecture and Design						X						X		
4.6.2.3	Organizing the Integrated Set of Needs									X	X				
4.6.3.1	Managing Unknowns			X	X		X	X	X						
4.6.3.2	Appropriate to Level		X												
4.6.3.3	Completeness of the Integrated Set of Needs										X				
4.6.3.4	Needs Feasibility and Risk	X	X				X						X		
4.7	Plan for System Validation														X
4.8	Baseline & Manage Lifecycle Concepts & Needs Definition Outputs	X		X	X		X		X		X	X	X	X	X
SECTION 5: NEEDS VERIFICATION AND NEEDS VALIDATION															
5.1.2	Perform Needs Verification	X		X	X					X	X	X			X
5.2	Needs Validation														X
5.2.2	Perform Needs Validation			X			X		X		X		X	X	X

NRM Concepts and Activities to Characteristic Cross Reference Matrix (2)



NRM Concepts and Activities		Characteristics for Individual needs and requirements								Characteristics for Sets of needs requirements					
		Necessary	Appropriate	Unambiguous	Complete	Singular	Feasible	Verifiable	Correct	Conforming	Complete	Consistent	Feasible	Comprehensible	Able to be validated
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
SECTION 6: DESIGN INPUT REQUIREMENTS DEFINITION															
6.2	Perform Design Input Requirements Definition	X	X					X	X		X	X	X	X	X
6.2.1	Transforming Needs into Design Input Requirements	X			X						X				
6.2.1.1	Organizing Sets of Design Input Requirements		X							X	X				
6.2.1.2	Considerations For Each Type Of Requirement				X			X	X		X				
6.2.1.4	Appropriate to Level		X												
6.2.1.5	Managing Unknowns			X	X		X	X	X						
6.2.2	Establish Traceability	X									X	X			
6.2.2.1	Establishing Traceability Between Dependent Peer Requirements											X			
6.2.3.6	Interface Requirements Audit	X			X			X	X		X	X			X
6.2.5	Plan for System Verification							X							
6.2.6.2	Completeness, Correctness, and Consistency								X		X	X			
6.2.6.3	Requirements Feasibility and Risk	X	X				X						X		
6.3	Baseline and Manage Design Input Requirements	X		X	X		X		X		X	X	X	X	X
6.4.3	Allocation – Flow Down of Requirements		X								X	X			
6.4.4	Defining Child Requirements that Meet the Intent of the Allocated Parents										X				
6.4.5	Budgeting of Performance, Resource, and Quality Requirements										X	X			
6.4.7	Use of Traceability and Allocation to Manage Requirements	X							X		X	X			X
SECTION 7: DESIGN INPUT REQUIREMENTS VERIFICATION & VALIDATION															
7.1.2	Perform Design Input Requirements Verification	X		X	X			X		X	X	X			X
7.2	Design Input Requirements Validation														X
7.2.2	Perform Design Input Requirements Validation	X		X	X		X		X		X	X	X	X	X
SECTION 8: DESIGN VERIFICATION AND DESIGN VALIDATION															
8.1	Design Definition Process Overview			X	X		X	X	X		X	X	X	X	X
8.2	Early System Verification and System Validation			X	X		X	X	X		X	X	X	X	X
8.4	Design Verification			X	X		X	X	X		X				
8.5	Design Validation										X	X	X	X	X
SECTION 14: NEEDS, REQUIREMENTS, VERIFICATION, & VALIDATION MANAGEMENT															
14.2.1	Baseline Needs, Requirements, and Specifications	X		X	X		X		X		X	X	X	X	X
14.2.4	Managing Unknowns			X	X		X	X	X		X				
14.2.7	Combine Allocation and Traceability to Manage Requirements	X							X		X				X
14.2.8	Managing Interfaces										X	X			X
14.2.9	Managing System Verification and System Validation							X							X



Needs and Requirements are the common threads that tie all lifecycle activities and artifacts together. When formulating the needs and requirements it is important to understand the role of needs and requirements within the context of verification and validation. Once the needs are verified and validated, all subsequent artifacts are validated against the needs and once the resulting design input requirements are verified and validated, all subsequent artifacts are verified against those design input requirements.

When defining needs and requirements, it is important that they have the characteristics of well-formed needs and requirements. These characteristics are a result of following the rules defined in the Guide to Writing Requirements (GtWR) as well as performing the activities associated with the definition of the needs and requirements as discussed in the Needs and Requirements Manual (NRM) and Guide to Needs and Requirements (GtNR). The underlying analysis from which a need or requirement was derived is as important as how well the need or requirement statement is formed.

Definitions

An **entity** is a single item to which a concept, need, or requirement applies: an organization, business unit, project, supplier, service, procedure, SOI (system, subsystem, system element), product, process, or stakeholder class (user, operator, tester, maintainer, etc.).

A **concept** is a textual or graphic representation that concisely expresses how an entity can fulfill the problem, threat, or opportunity it was defined to address within specified constraints with acceptable risk that provides a business capability in terms of people, process, and products.

A **set of lifecycle** concepts includes multiple concepts across the lifecycle of how the organization (and stakeholders within an organization) expect to manage, acquire, define, develop, build/code, integrate, verify, validate, transition, install, operate, support, maintain, and retire an entity.

A **need statement** is the result of a formal transformation of one or more lifecycle concepts into an agreed-to expectation for an entity to perform some function or possess some quality within specified constraints with acceptable risk.

A **requirement statement** is the result of a formal transformation of one or more needs or parent requirements into an agreed-to obligation for an entity to perform some function or possess some quality within specified constraints with acceptable risk.

<p>Formal Transformation. Given the need and requirement is a result of a formal transformation, the following characteristics of a well-formed need or requirement have been derived:</p> <ul style="list-style-type: none"> • C1 - Necessary: The need or requirement statement defines an essential capability, characteristic, constraint, or quality factor needed to satisfy a lifecycle concept, need, source, or parent requirement. • C2 - Appropriate: The specific intent and amount of detail of the need or requirement statement is appropriate to the level (the level of abstraction, organization, or system architecture) of the entity to which it refers. • C5 - Singular: The stakeholder need or requirement statement should state a single capability, characteristic, constraint, or quality factor. • C8 - Correct: The need statement must be an accurate representation of the lifecycle concept or source from which it was transformed. The requirement statement must be an accurate representation of the need, source, or parent requirement from which it was transformed. • C9 - Conforming: Individual needs and requirements should conform to an approved standard pattern and style guide or standard for writing and managing needs and requirements. 	<p>Agreed-to Obligation. Since the need and requirement is to be a part of a fair agreement to meet an obligation, the following characteristics of a need or requirement have been derived.</p> <ul style="list-style-type: none"> • C3 - Unambiguous: Need statements must be written such that the stakeholder intent is clear. Requirement statements must be stated such that the requirement can be interpreted in only one way by all the intended stakeholders. • C4 - Complete: The requirement statement sufficiently describes the necessary capability, characteristic, constraint, or quality factor to meet the need, source, or parent requirement from which it was transformed without needing other information to understand the requirement. • C6 - Feasible: The need or requirement can be realized within entity constraints (for example: cost, schedule, technical, legal, ethical, safety) with acceptable risk. • C7 - Verifiable: The requirement statement is structured and worded such that its realization can be verified to the approving authority's satisfaction.
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Characteristics of well-formed needs and requirements.

Also updated the GtWR Summary Sheet

The update includes these matrices

https://www.dropbox.com/s/4vr7u3yz5f4kezz/INCOSE_RWG_Guide_to_Writing_Requirements%20v3.1%20Summary%20Sheet%2041822%206%20pg.pdf?dl=0

GtWR V4



- The RWG plans to continue to evolve the GtWR.
- Planning for a V4 to be released by IS2023 (TBD).
- We need suggestions from the INCOSE community concerning future updates.
- Will prepare a TPP addressing the update.
- Will conduct separate virtual meetings to discuss suggestions for inclusion in V4.
 - IW2022 will have session dealing with this update.
- We ask all RWG members to do a detailed review of V3.1 and provide comments (typos, errors, further elaboration, more examples, ideas for improving the Guide.)

Some Ideas Concerning GtWR V4



- Add more material concerning templates and patterns for requirements statements
 - Define for all types of requirements – not just functional/performance requirements
 - EARS (Easy Approach to Requirements Syntax)
 - Ubiquitous requirements, state driven requirements, event driven requirements, optional feature requirements, unwanted behavior requirements
 - Current GtWR addresses conditional statements in the rules based on 29148, but what more should we address?
 - EARS vs design and system verification
 - Applicability from an appropriate to level perspective as well as a design input vs design output perspective.
- Beginning of Life (BOL) vs End of Life (EOL) considerations
- Expand the characteristics of sets of needs and requirements, e.g., should “correct” be added?
- Expand examples to include all types of requirements beyond functional/performance
- Expand bad vs good examples with more explanation of the thought process to go from bad to good (maybe include incremental improvements when going from bad to good?).
- Include examples of transforming needs into design input requirements.
- **Other ideas? Discussion from RWG meeting attendees**



Other RWG Activities for 2022

Lou Wheatcraft and Tami Katz



Update of SEBoK

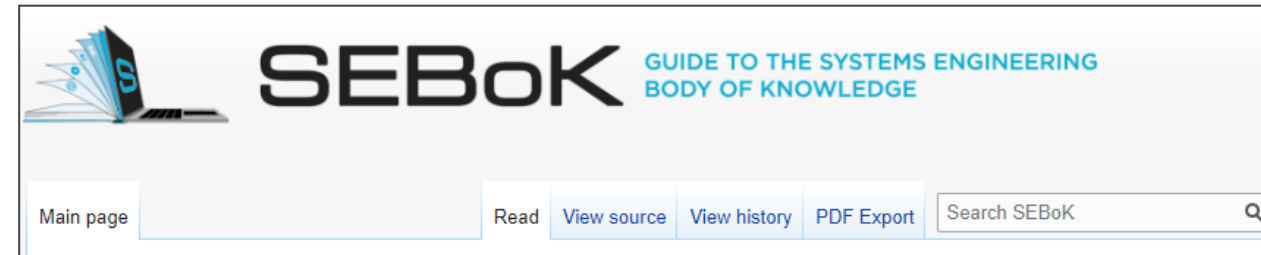
- With updates to RWG material, the next activity is to ensure alignment of the SEBoK with the concepts in the NRM.
- Tami and the co-chairs are seeking volunteer(s) to help find all material on the SEBoK related to Needs, Requirements, Verification, Validation and propose 'pages' that need updates to align concepts and nomenclature.
 - Example presented here ->

The screenshot shows the SEBoK website interface. At the top right, the logo reads "SEBoK GUIDE TO THE SYSTEMS ENGINEERING BODY OF KNOWLEDGE". Below the logo is a navigation bar with buttons for "Page", "Read", "View source", "View history", "PDF Export", and a search box labeled "Search SEBoK". The main heading is "Stakeholder Needs Definition". Below the heading is a breadcrumb trail: "Guide to the Systems Engineering Body of Knowledge (SEBoK) > Special:Search > Stakeholder Needs and Requirements > Stakeholder Needs Definition". The "Lead Authors" are listed as "Alan Faisandier, Garry Roedler" and the "Contributing Author" is "Rick Adcock". The main text explains that stakeholder needs and requirements represent the views of those at the business or enterprise operations level, relating to users, acquirers, customers, and other stakeholders. It describes a structured process to elicit these needs and transform them into defined stakeholder requirements. A list of roles for stakeholder requirements is provided: forming the basis of system requirements and validation, acting as a reference for integration and verification, and serving as a means of communication. The text concludes that defining stakeholder needs involves eliciting and prioritizing needs, identifying opportunities for new solutions, and ensuring consistency through traceability. A "Contents [hide]" section is visible at the bottom, listing "1 Purpose and Definition" and "2 Principles and Concepts", with sub-sections "2.1 Identifying Stakeholders" and "2.2 Identifying Stakeholder Needs". On the left side, there is a sidebar with "Stewards" logos for INCOSE, IEEE SYSTEMS COUNCIL, and STEVENS INSTITUTE OF TECHNOLOGY. Below the logos are sections for "Quicklinks" (Main Page, Editor's Corner, Governance and Editorial Boards, SEBoK Sponsors, Acknowledgements and Release History, FAQs) and "Outline" (Table of Contents, Part 1: SEBoK Introduction, Part 2: Foundations of Systems Engineering, Part 3: SE and Management, Systems Engineering STEM Overview, Model-Based Systems Engineering (MBSE), Systems Lifecycle Approaches, System Lifecycle Models, Systems Engineering Management, Business and Mission Analysis, and Stakeholder Needs Definition, which is highlighted).



Update of SEBoK - Methodology

- As the SEBoK is a large collection of topics, the task would include navigation to various pages and usage of the search function.
- With each page uncovered, the content needs to be scrubbed, and markups can be proposed via PDF or screenshots to Tami and Lou.
- Tami will ensure the material is revised by working with the INCOSE SEBoK leads.
- Objective is to have this done by IW2023.

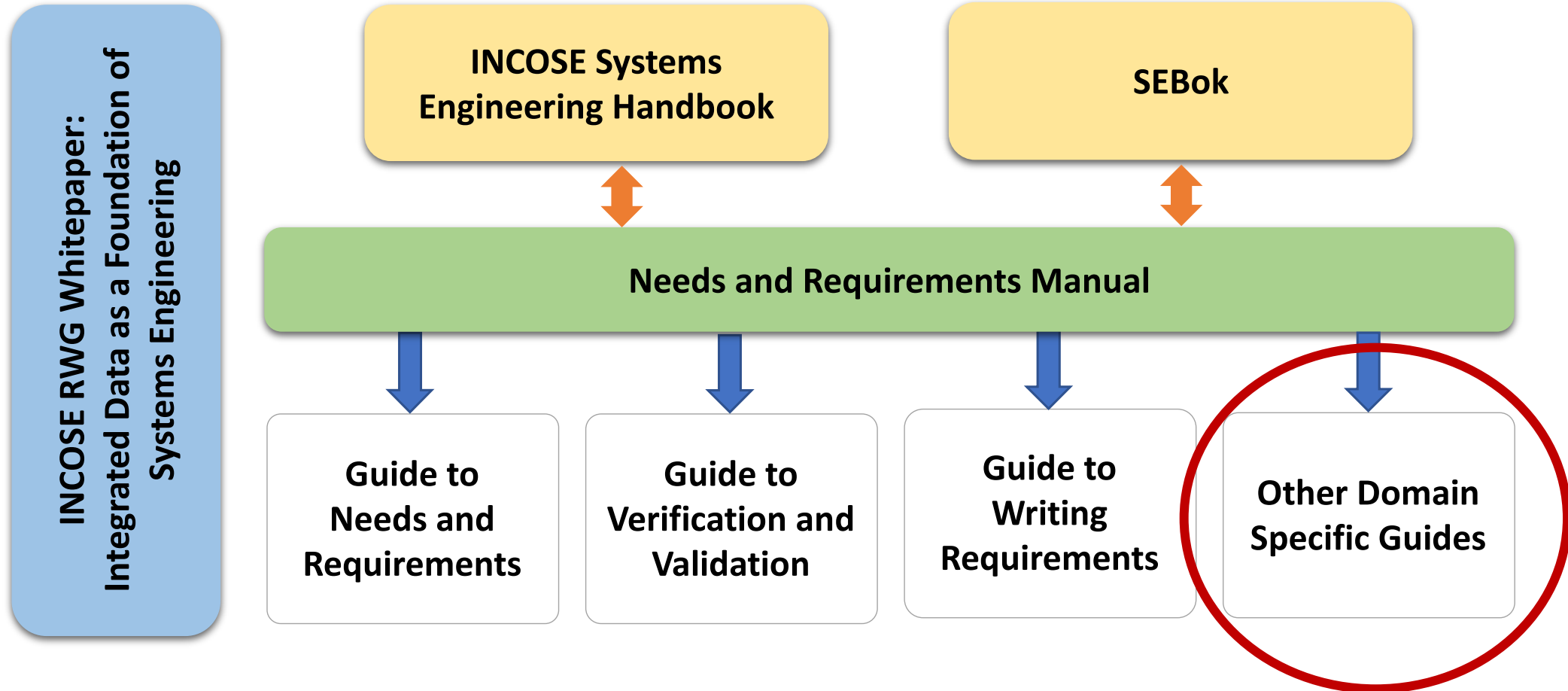


Outline
Table of Contents
⊕ Part 1: SEBoK Introduction
⊕ Part 2: Foundations of Systems Engineering
⊕ Part 3: SE and Management
⊕ Part 4: Applications of Systems Engineering
⊕ Part 5: Enabling Systems Engineering
⊕ Part 6: Related Disciplines
⊕ Part 7: SE Implementation Examples
⊕ Part 8: Emerging Knowledge



[SEBoK \(sebokwiki.org\)](http://sebokwiki.org)

RWG Ongoing Collaboration with other WGs



Collaboration with System Security Engineering (SSE) WG



- As our world becomes increasingly digital, the issue of security also known as cybersecurity is a factor that the systems engineer practitioner needs to consider and understand.
- Both hardware and software systems are increasingly at risk for disruption or damage caused by threats taking advantage of digital technologies.
- Security through systems security engineering (SSE) when properly integrated into SE, provides the needed complementary engineering capability that extends the notion of trustworthiness to deliver trustworthy secure systems.
- The SE should understand the basic systems engineering and system life cycle processes and how they are impacted by the needs for organizational mission and/or business security needs including stakeholder protection needs and security requirements.
- The RWG products mention security as an important consideration but provides no guidance in the context of defining security related needs and requirements nor verification the requirements were met nor validation the needs have been met.

Show how the concepts and activities discussed within the RWG products work within the Cyber Resiliency Engineering Framework, cyber resiliency wheel, criticality analysis, and other techniques the SSE WG are trying to elevate for security requirements analysis.

Collaboration with System of Systems (SoS) WG



- A System of Systems (SoS) is a set of systems or system elements that interact to provide a unique capability that none of the constituent systems can accomplish on its own.
- Constituent systems can be part of one or more SoS.
- Each constituent is a useful system by itself, having its own development, management goals and resources, but interacts within the SoS to provide the unique capability of the SoS.
- Challenges
 - Each system has its own owner, stakeholders, users, needs, processes, & development approaches.
 - Lack of common leadership and funding
 - Each system has a specific purpose of its own, but are being leveraged as part of the SoS
 - SoS purpose, stakeholders, constraints, needs, and requirements may conflict with individual constituent systems purpose, stakeholders, constraints, needs, and requirements.
 - Constituent systems may continue to change independently from the SoS
 - SoS verification and validation against the SoS needs and requirements is difficult
 - Emerging properties and behavior of the integrated SoS is difficult to predict and if issues occur which constituent system contributed and how the issue be resolved given their independence.
 - System Security of the SOS is dependent on the system security of the constituent systems.

Need for a practical SoS guide to applying the concepts and activities discussed within the RWG products to SoS NRVV.

Upcoming RWG Meetings for 2022



- **July 20:** Presentation by Beth Wilson on Systems of Systems (SoS) challenges.
- **August 24:** RWG Exchange Café – Beth Wilson lead on SoS vs the NRM, GtNR, GtVV
- **September 28:** RWG Exchange Café – General discussion focusing on interfaces
- **October 26:** Presentation by Beth Wilson – System Security Challenges
- **November 16:** RWG Exchange Café – Beth Wilson lead on System Security vs NRM, GtNR, GtVV
- **December 14:** Presentation by Henrik Mattfolk – “Configuration Management Across the Digital Thread”
- **January 2023:** IW 2023 RWG present sessions - TBD



Thank you!!

- The RWG appreciates your support of this IWS2022 event!
- Please download the Needs, Requirements, Verification and Validation Manual from the INCOSE Store!
 -and help us further improve it by applying it in your subject areas and providing feedback.
- Please join the INCOSE RWG Yammer Community and help us keep communication going throughout the year!





Backup



32nd Annual **INCOSE**
international symposium

hybrid event

Detroit, MI, USA
June 25 - 30, 2022

www.incose.org/symp2022