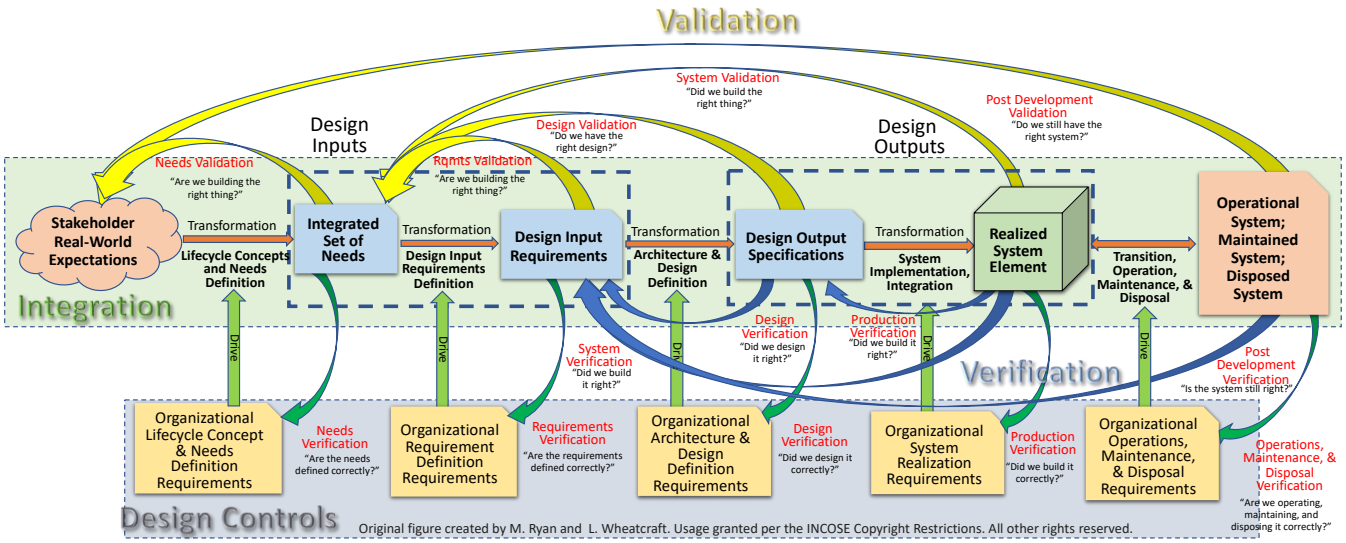
INCOSE Guide to Writing Requirements V4 – Summary Sheet



Needs and Requirements are the common threads that tie all lifecycle activities and artifacts together. 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.

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 in terms of people, process, and products.*

*A set of **lifecycle concepts** includes multiple concepts across the lifecycle for how the organization (and stakeholders within an organization) expects 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 sources or 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 sources, needs, or higher-level requirements into an agreed-to obligation for an entity to perform some function or possess some quality within specified constraints with acceptable risk.

A ***requirement pattern*** or ***need pattern*** is represented by a series of building blocks (also called pattern slots) including all the elements envisioned to represent a well-formed, singular, and complete need or requirement. Several rules, especially R1, are related to the necessity, for needs and requirements, to conform with one and only one pattern. Appendix C provides more information on the concept of pattern and includes some well-known examples.

A ***need set*** is a structured set of agreed-to need expressions for the entity (enterprise/business unit/system/subsystem/system element/process) and its external interfaces. Within the NRM, GtNR, GtVV, and this Guide this set of needs is referred to as an ***Integrated Set of Needs.*** *This Integrated Set of Needs is well-formed, having the characteristics defined in this Guide, communicating the scope of effort to which the system of interest will be validated against.*

A ***requirement set*** is a structured set of agreed-to requirement expressions for the entity (enterprise/business unit/system/subsystem/system element/process) and its external interfaces. Within the NRM, GtNR, GtVV, and this Guide this set of requirements is referred to as a set of system **Design Input Requirements.** This set of system Design Input Requirements is well-formed, having the characteristics defined in this Guide and against which the SOI will be verified.

*An **attribute** is additional information associated with an entity which is used to aid in its definition, understanding, and management.*

*A **need expression** includes a need statement and a set of associated attributes.*

*A **requirement expression** includes a requirement statement and a set of associated attributes.*

Characteristics

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.

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: C1 - Necessary*:* The need requirement statement defines capability, characteristic, constraint, or quality factor *needed or required* to satisfy a lifecycle concept, need, source, or higher-level 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 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 higher-level requirement from which it was transformed. C9 - Conforming: Statements and expressions of individual needs and requirements should conform to an approved standard pattern and style guide or standard for writing and managing needs and requirements.	***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. C3 - Unambiguous*:* Need and requirement statements must be stated such that their intent is clear and can be interpreted in only one way by all intended audiences. C4 - Complete*: The need statement sufficiently describes the necessary capability, characteristic, constraint, conditions, or quality factor to meet the lifecycle concept or source from which it was transformed.* The requirement statement sufficiently describes the necessary capability, characteristic, constraint, conditions, or quality factor to meet the need, source, or higher-level requirement from which it was transformed. 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 need statement is structured and worded such that its realization can be validated to the approving authority's satisfaction. The requirement statement is structured and worded such that its realization can be verified to the approving authority's satisfaction.

Characteristics of well-formed needs and requirements.

Formal Transformation. Given the set of needs and requirements is the result of a formal transformation, the following characteristics of the need and requirement set have been derived: C10 - Complete*:* The set of needs and set of requirements for an entity should stand alone such that it sufficiently describes the necessary capabilities, characteristics, functionality, performance, drivers, constraints, conditions, interactions, standards, regulations, safety, security, resilience, and quality factors without requiring other sets of needs or sets of requirements at the appropriate level of abstraction. C11 - Consistent: A set of needs and a set of requirements is consistent if contains individual needs or requirements that are: - unique; - do not conflict with or overlap with others in the set; - makes use of homogeneous units and measurement systems; and - are developed using a consistent language (that is, the same words are used throughout the set to mean the same thing); and use terms that are consistent with the architectural model, project glossary, and project data dictionary. C15 - Correct*:* The set of needs must be an accurate representation of the lifecycle concepts or sources from which it was transformed. The set of requirements must be an accurate representation of the needs, sources, or higher-level requirements from which it was transformed.	***Agreed-to Obligation***. Since the set of need and requirements is to be a result of a fair agreement to meet an obligation, the following characteristics of the set have been derived: C12 - Feasible*:* A set of needs and a set of requirements is feasible if it can be realized within entity constraints (such as cost, schedule, technical) with acceptable risk. C13 - Comprehensible*:* The set of needs and the set of resulting requirements must each be written such that it is clear as to what is expected of the entity and its relation to the macro system of which it is a part. C14 - Able to be validated*:* It must be possible to validate that the set of needs will lead to the achievement of the product goals and objectives, stakeholder expectations, risks, and lifecycle concepts within the constraints (such as cost, schedule, technical, legal and regulatory compliance) with acceptable risk. It must be possible to validate that the set of requirements will lead to the achievement of the set of needs and higher-level requirements within the constraints (such as cost, schedule, technical, and regulatory compliance) with acceptable risk.

Characteristics of well-formed sets of needs and sets of requirements.

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Rules for Need and Requirement Statements and Sets of Needs and Requirements

Accuracy

R1 - Structured Statements: Need and requirement statements must conform to one of the agreed patterns, thus resulting in a well-structured complete statement.

R2 - Active Voice: Use the active voice in the need or requirement statement with the responsible entity clearly identified as the subject of the sentence.

R3 - Appropriate Subject-Verb: Ensure the subject and verb of the need or requirement statement are appropriate to the entity to which the statement refers.

R4 - Defined Terms: Define all terms used within the need statement and requirement statement within an associated glossary and/or data dictionary.

R5 - Definite Articles: Use the definite article "the" rather than the indefinite article "a".

R6 - Common Units of Measure: 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.

R7 - Vague Terms: Avoid the use of vague terms that provide vague quantification, such as "some", "any", "allowable", "several", "many", "a lot of", "a few", "almost always", "very nearly", "nearly", "about", "close to", "almost", and "approximate". Avoid vague adjectives such as "ancillary", "relevant", "routine", "common", "generic", "significant", "flexible", "expandable", "typical", "sufficient", "adequate", "appropriate", "efficient", "effective", "proficient", "reasonable" and "customary."

R8 - Escape Clauses: Avoid the inclusion of escape clauses that state vague conditions or possibilities, such as "so far as is possible", "as little as possible", "where possible", "as much as possible", "if it should prove necessary", "if necessary", "to the extent necessary", "as appropriate", "as required", "to the extent practical", and "if practicable".

R9- Open-Ended Clauses: Avoid open-ended, non-specific clauses such as "including but not limited to", "etc." and "and so on".

Concision

R10 - Superfluous Infinitives: Avoid the use of superfluous infinitives such as "to be designed to", "to be able to", "to be capable of", "to enable", "to allow".

R11 - Separate Clauses: Use a separate clause for each condition or qualification.

Non-ambiguity

R12 - Correct Grammar, 13 - Correct Spelling, 14 - Correct Punctuation - Use correct grammar, spelling, punctuation.

R15 - Logical Expressions: Use a defined convention to express logical expressions such as "[X AND Y]", "[X OR Y]", [X XOR Y]", "NOT [X OR Y]".

R16 - Use of "Not": Avoid the use of "not."

R17 - Use of Oblique Symbol: Avoid the use of the oblique ("/") symbol except in units, i.e., Km/hr, or fractions.

Singularity

R18 - Single Thought Sentence: Write a single sentence that contains a single thought conditioned and qualified by relevant sub-clauses.

R19 – Combinators: Avoid words that join or combine clauses, such as "and", "or", "then", "unless", "but", "as well as" "but also", "however", "whether", "meanwhile", "whereas", "on the other hand", or "otherwise".

R20 - Purpose Phrases: Avoid phrases that indicate the "purpose of ", "intent of", or "reason for" the need statement or requirement statement.

R21 – Parentheses: Avoid parentheses and brackets containing subordinate text.

R22 – Enumeration: Enumerate sets explicitly instead of using a group noun to name the set.

R23 - Supporting Diagram, Model, or ICD: When a need or requirement is related to complex behavior, refer to a supporting diagram, model, or ICD.

Completeness

R24 – Pronouns; Avoid the use of personal and indefinite pronouns.

R25 – Headings: Avoid relying on headings to support explanation or understanding of the need or requirement.

Realism

R26 – Absolutes: Avoid using unachievable absolutes such as 100% reliability, 100% availability, all, every, always, never, etc.

Conditions

R27 - Explicit Conditions: State conditions' applicability explicitly instead of leaving applicability to be inferred from the context.

R28 - Multiple Conditions: Express the propositional nature of a condition explicitly for a single action instead of giving lists of actions for a specific condition.

Uniqueness

R29 – Classification: Classify needs and requirements according to the aspects of the problem or system it addresses.

R30 - Unique Expression: Express each need and requirement once and only once.

Abstraction

R31 – Solution Free: Avoid stating implementation in a need statement or requirement statement unless there is rationale for constraining the design.

Quantifiers

R32 - Universal Qualification: Use "each" instead of "all", "any", or "both" when universal quantification is intended.

Tolerance

R33 - Range of Values: 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.

Quantification

R34 - Measurable Performance: Provide specific measurable performance targets appropriate to the entity to which the need or requirement is stated and against which the entity will be verified to meet.

R35 - Temporal Dependencies: Define temporal dependencies explicitly instead of using indefinite temporal keywords such as "eventually", "until", "before", "after", "as", "once", "earliest", "latest", "instantaneous", "simultaneous", and "at last".

Uniformity of Language

R36 - Consistent Terms and Units: Ensure each term and unit of measure used throughout need and requirement sets as well as associated models and other SE artefacts developed across the lifecycle are consistent with the project's defined ontology.

R37 – Acronyms: If acronyms are used, they must be consistent throughout need and requirement sets as well as associated models and other SE artefacts developed across the lifecycle.

R38 – Abbreviations: Avoid the use of abbreviations in needs and requirement statements as well as associated models and other SE lifecycle artefacts.

R39 - Style Guide: Use a project-wide style guide for individual need statements and requirement statements.

R40 - Decimal Format: Use a consistent format and number of signification digits for the specification of decimal numbers.

Modularity

R41 - Related Needs and Requirements: Group related needs and requirements together.

R42 – Structured Sets; Conform to a defined structure or template for organizing sets of needs and requirements.

Rules to Characteristics Cross Reference Matrix

			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	Correct
Quality Focus	**Rule**	**Subject**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**
Accuracy	**R1**	Structured Statements			X	X			X	X	X						
	R2	Active Voice		X	X	X			X								
	R3	Appropriate Subject-Verb		X	X				X			X				X	
	R4	Defined Terms			X				X				X		X	X	X
	R5	Definite Articles			X				X								
	R6	Common Units of Measure			X	X			X	X							
	R7	Vague Terms			X	X			X								
	R8	Escape Clauses			X				X								
	R9	Open-ended Clauses			X	X	X		X								
Concision	**R10**	Superfluous infinitives			X				X								
	R11	Separate Clauses			X	X			X	X							
Non-ambiguity	**R12**	Correct Grammar			X				X	X	X						
	R13	Correct Spelling			X				X								
	R14	Correct Condition			X					X							
	R15	Logical Expressions			X				X								
	R16	Use of “Not”			X				X	X							
	R17	Use of Oblique Symbol			X				X								
Singularity	**R18**	Single-thought Sentence			X		X		X		X				X		
	R19	Combinators			X		X										
	R20	Purpose Phrases	X				X										
	R21	Parentheses					X										
	R22	Enumeration			X		X										
	R23	Supporting Diagram, Model or ICD			X	X	X										
Completeness	**R24**	Pronouns			X	X			X								
	R25	Headings				X											
Realism	**R26**	Absolutes						X	X	X				X			
Conditions	**R27**	Explicit Conditions				X			X	X							
	R28	Multiple Conditions			X				X								
Uniqueness	**R29**	Classification										X	X				
	R30	Unique Expression	X								X		X				
Abstraction	**R31**	Solution Free		X													
Quantifiers	**R32**	Universal Qualification			X				X	X							
Tolerance	**R33**	Range of Values			X	X		X	X	X				X			
Quantification	**R34**	Measurable Performance			X	X			X					X			
	R35	Temporal Dependencies			X	X			X								
Uniformity of Language	**R36**	Consistent Terms and Units			X					X	X		X		X	X	X
	R37	Acronyms			X						X		X		X	X	X
	R38	Abbreviations									X		X		X	X	X
	R39	Style Guide				X	X				X		X		X	X	X
	R40	Decimal Format			X	X					X		X				
Modularity	**R41**	Related Needs and Requirements				X					X	X	X		X		X
	R42	Structured Sets										X	X		X	X	X

NRM Concepts and Activities to Characteristics Cross Reference Matrix Part 1

		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	Correct
NRM Concepts and Activities		**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**
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	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	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	X
4.4.4	Completeness										X					
4.5	Lifecycle Concepts Analysis and Maturation	X			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				X
4.5.4	Levels of Detail and Abstraction		X													
4.5.7.1	Model Development, Analysis, and Maturation	X							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							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	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	X

NRM Concepts and Activities to Characteristics Cross Reference Matrix Part 2

		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	Correct
NRM Concepts and Activities		**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**
SECTION 6: DESIGN INPUT REQUIREMENTS DEFINITION																
6.2	Perform Design Input Requirements Definition	X	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					X
6.2.1.4	Appropriate to Level		X													
6.2.1.5	Managing Unknowns			X	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	X
6.2.5	Plan for System Verification							X								
6.2.6.2	Completeness, Correctness, and Consistency								X		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	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	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	X
SECTION 8: DESIGN VERIFICATION AND DESIGN VALIDATION																
8.1	Design Definition Process Overview			X	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	X
8.4	Design Verification			X	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	X
14.2.4	Managing Unknowns			X	X		X	X	X			X				X
14.2.7	Combine Allocation and Traceability to Manage Requirements	X							X		X				X	X
14.2.8	Managing Interfaces										X	X			X	
14.2.9	Managing System Verification and System Validation							X							X	

Attributes of Need and Requirement Statements (defined in the NRM)

A minimum set of attributes that should be defined for each requirement are annotated with an asterisk ("*")

Attributes to Help Define Needs & Requirement and Their Intent
- A1 - Rationale*
- A2 - Trace to Parent*
- A3 - Trace to Source*
- A4 - States and Modes
- A5 - Allocation/Budgeting*

Attributes Associated with System Verification & System Validation
- A6 - System Verification or System Validation Success Criteria*
- A7 - System Verification or System Validation Strategy*
- A8 - System Verification or System Validation Method*
- A9 - System Verification or System Validation Responsible Organization*
- A10 - System Verification or System Validation Level
- A11 - System Verification or System Validation Phase
- A12 - Condition of Use
- A13 -System Verification or System Validation Results
- A14 -System Verification or System Validation Status

Attributes to Help Maintain the Requirements
- A15 - Unique Identifier*
- A16- Unique Name
- A17 - Originator/Author*
- A18 - Date Requirement Entered
- A19- Owner*
- A20 – Stakeholders
- A21 - Change Board
- A22 - Change Proposed
- A23 - Version Number
- A24 - Approval Date
- A25 - Date of Last Change
- A26 - Stability/Volatility
- A27 - Responsible Person
- A28 - Need or Requirement Verification Status*
- A29 - Need or Requirement Validation Status*
- A30 - Status of the Need or Requirement
- A31 - Status (of Implementation)
- A32 - Trace to Interface Definition
- A33 - Trace to Dependent Peer Requirements
- A34 - Priority*
- A35 - Criticality or Essentiality*
- A36 - Risk (of Implementation) *
- A37 - Risk (Mitigation)
- A38 - Key Driving Need or Requirement (KDN/KDR)
- A39 - Additional Comments
- A40 - Type/Category

Attributes to Show Applicability and Allow Reuse
- A41- Applicability
- A42 - Region
- A43 - Country
- A44 - State/Province
- A45 - Market Segment
- A46 - Business Unit

Attributes to Aid in Product Line Management
- A47 – Product Line
- A48 - Product Line Common Needs and Requirements
- A49 - Product Line Variant Needs and Requirements

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