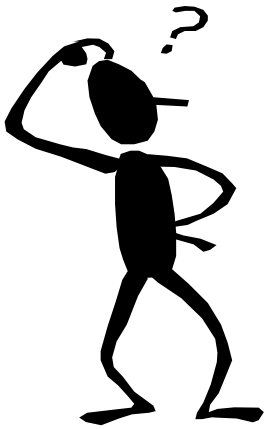
Module 1 How to write good requirements
Session 2 of 2
Introduction to requirements

Version 1.1.4

Module topics

- Exercise presentations
- Background
- Glossaries and definitions
- Purpose of requirements
- Some of the problems caused by poorly-written requirements
- **Well-written requirements**
  - **Attributes**
  - Spelling and grammar
  - Structure of a requirement
  - Vocabulary of a requirement
- Generic and system specific requirements
- Examples of bad requirements and how to fix them
- Exercises

Six attributes of a well-written requirement



1. Atomic
2. Unambiguous
3. Verifiable
4. Consistent
5. Understandable*
6. Adequate*
7. ~~Linked or traced~~
    1. is an attribute of a 'requirement' but does not show up in the statement
    2. Is an attribute of a good requirement

* IREB, EU 3.8

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1. Atomic

- One action per sentence
- The use of words, "and" and "or" generally
    - Creates non-atomic requirements
    - Leads to ambiguity
        - E.g. 73. The system shall display the number of inputs and outputs in each 15 minute period
        - Individual or combined numbers?
    - Missing constraint (when?)
    - Example of non-atomic more complete ambiguous requirement
        - 73. The system shall display the number of inputs and outputs in each 15 minute period within 2 seconds of the end of the period

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2. Unambiguous

- Has only one interpretation
  - in all contexts
  - by all readers
- Problems in natural languages
  - driver for formal requirements specification languages
- Example, clarifying ambiguity

73 Displaying both items

73.1 The system shall display the number of inputs ~~and outputs~~ in each 15 minute period within 2 seconds of the end of the period

73.2 The system shall display the number of ~~inputs and~~ outputs in each 15 minute period within 2 seconds of the end of the period

73 Displaying the combination

73.0 The system shall display the combined number of inputs and outputs in each 15 minute period within 2 seconds of the end of the period

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Can you see the ambiguity?

- Help victims?
- Offering the service?

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3. Verifiable

- Every requirement shall be verifiable by a cost effective method
  - Well-written ~~test~~ verification procedure
  - Stated in specific terms
- Verification shall be by
  - Test or demonstration
  - Analysis
  - Simulation
  - Other, as agreed by customer and contractor
- Defined acceptance criteria

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4. Consistent

- No two or more requirements shall describe the same something using different terminology
  - No synonyms
- Requirements shall not contradict each other
  - Logical
  - Temporal
  - Conflicting instructions

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5 and 6. Understandable and adequate

202.1 DADS shall statistically monitor the integrity of data stored in the archive and safe-store in order to detect degrading media.

- Understandable and adequate at the time it was written
- But 18 months later after staff turnover?
  - No data dictionary or glossary

- Define the following terms
  - Statistically monitor
  - Integrity
  - Degrading media

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1. Spelling and grammar

- Spelling
  - What
    - The correct arrangement of letters to form the words you mean to use to communicate concepts
  - Why
    - Accurate spelling is essential for effective communication, as incorrect spelling can lead to misunderstandings and confusion
- Grammar
  - What
    - The structure and rules of how words are combined to form sentences and convey meaning
  - Why
    - Proper grammar ensures that sentences convey the intended message

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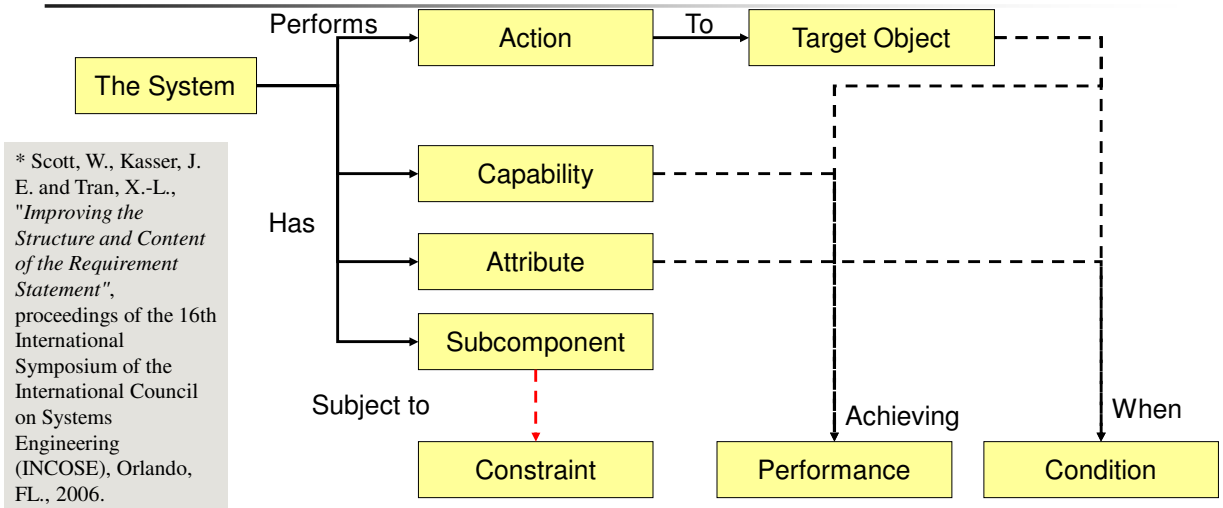
2. The structure of a requirement*



* Scott, W., Kasser, J. E. and Tran, X.-L., "*Improving the Structure and Content of the Requirement Statement*", proceedings of the 16th International Symposium of the International Council on Systems Engineering (INCOSE), Orlando, FL., 2006.

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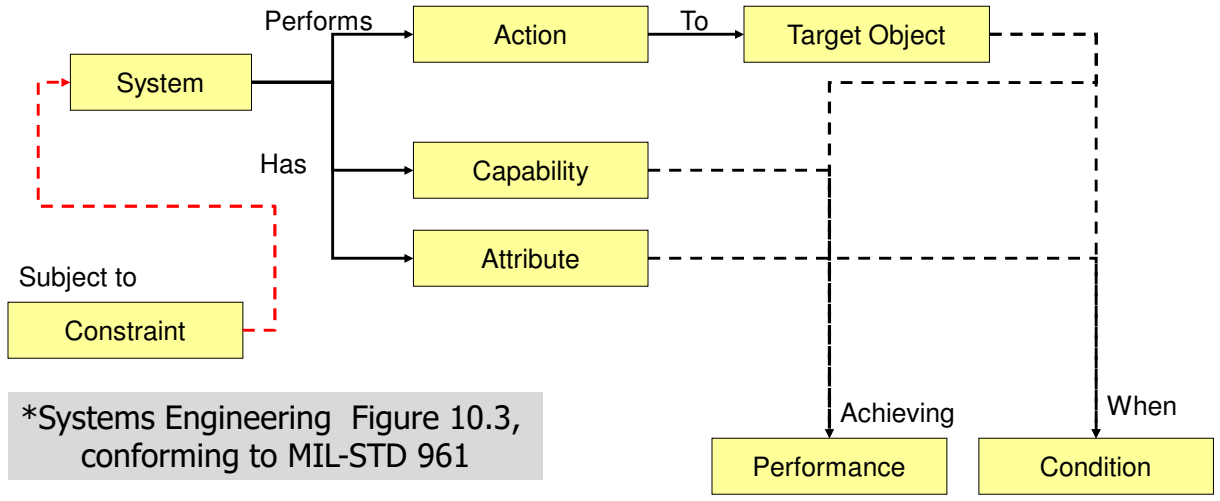
The structure of a well-written requirement*



*Systems Engineering Figure 10.3, conforming to MIL-STD 961

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Requirement statement

A single imperative instruction that complies with the "*requirements for writing requirements*", containing the following elements:

Traditional order

- ID number
- Subject
- Verb
- Target object
- Qualifiers (if any)
- Conditions (if any)

Well-written approach

- ID number
- Conditions (if any)
- Subject
- Verb
- Target object
- Qualifiers (if any)

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Traditional requirements

Bus operations

1.2.1 The buses shall operate on their specific routes from 0530 to 2300 daily except on Friday and Saturday

1.2.2 The buses shall operate on their specific routes from 0530 to 1 hour before sunset on Fridays

1.2.3 The buses shall operate on their specific routes from 1 hour after sunset to 2330 on Saturdays

Non-functional requirements

- The state of being requirements
  - "ilities"
- Availability can be written as:
  - The system shall be operational for 24 hours each day
    - What shall be **done**
  - The Availability of the system shall be 24 hours daily
    - What shall **be**
- Acceptance criteria in this situation are generally a combination of reliability and mean time to repair
- Safety
  - Combination of "built into the system" and procedures
  - Risk procedure will be overridden
- Require safety to be "built into the system" rather than rely on procedures

Ensure system can meet the functional requirements as and when required

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Commonly used words and phrases - Alternative course of action*

- "Unless otherwise specified"
  - Clarify the expression by providing a reference (e.g. in Section 6).
  - Used at the start of the sentence
  - Example
    - Unless otherwise specified in Section 6, the buses shall operate on their specific routes from 0530 to 2300 daily
- "Except"
  - Implies unless otherwise specified

* MIL-STD-961B (31 May 1985) Section 4.9.5

Commonly used words and phrases - Verbs

- Requirement for use of verbs is originally from the era of paper documents and extracted from MIL-STD-961B (31 May 1985) Section 4.9.6, (accessed on 31 July 2023 from http://everyspec.com/)
- "Shall", requirement is intended to express a provision that is binding
- "Will" - used to state
  - a declaration of purpose (goal) on the part of the specifier
  - simple future tense
- "Should" and "may" - non-mandatory provisions
  - Inclusion of non-mandatory requirements is confusing and leads to errors
  - Including them as requirements (shall) but with low priorities makes them and their need unambiguous
- "Must" shall not be used
  - But may be used in a requirement request (signifying it has not yet been accepted as a requirement) if defined in the glossary and used consistently

Commonly used words and phrases - Limits

- Upper limit
  - "The diameter shall be less than 2 cm" (<2.00)
  - "The diameter shall not be greater than 2 cm " (<=2.00)
- Lower limit
  - "The diameter shall be greater than 0.5 cm" (>0.5)
  - "The diameter shall not be less than 0.5 cm" (>=0.5)
- Do not use error prone words
  - "The diameter shall not be less than 0.5 cm " (but what if you want >=0.5)
    "The diameter shall be greater **or** equal to 0.5 cm"
- Beware of specifying exact numbers. Always add a 'tolerance' or reference
  - 2 ± xx cm
  - 0.5 ± xx cm
  - Tolerance shall be as tight as needed ~~and no more~~

Commonly used words and phrases – vague and ambiguous*

- Except when the term is unambiguous,
  the terms "and/or", "etc.", "e.g." and "i.e.' shall not be used in specifications*
- Example
  - The diameter shall be greater **or** equal to 0.5 cm" (>=0.5)

* MIL-STD-961B Section 4.9.7

Commonly used words and phrases – Citations*

- Referenced documents shall be cited as:*
  - "conforming to"
  - "as specified in"
  - "in accordance with"
- Be consistent
  - Use same wording in each requirement
- Cite applicable section, not entire document
  - You may not want other parts of document to level requirements
- Add version/date of referenced document to citation
  - Documents are revised and changes may affect whatever you are citing without you knowing

* MIL-STD-961B (31 May 1985) Section 4.9.5

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The difference between "system generic" and "system specific" requirements

- System generic requirements
  - Come from the system generic attributes
  - Are specific system independent
  - Maximize the probability of creating a complete set of requirements
  - Provide an inherited template to quantify system generic attributes
- System specific" requirements are the instance of the system generic requirements (properties) for the system specific attributes

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The benefits of using "system generic" and "system specific" requirements

- Requirements state the attributes and properties of something needed
- Example
  - System generic requirement for operating temperate of system is -10 to +50 degrees centigrade
  - System specific requirement for operating temperate of system in application is +5 to +50 degrees centigrade
- Prompts stakeholders not to forget operating temperature
- Instead of thinking about the needed temperature, stakeholder can think if generic value is needed or needs to be changed in specific application

Examples of generic and mission specific requirements

- Generic
  - Product requirements
    - Mission requirements
    - Support requirements
      - Safety requirements
      - Class of system
      - Foisted on project by laws and regulations
  - Process requirements
    - Foisted on project by laws and regulation, e.g. Standards, e.g. ISO9001.
    - Workplace constraints, e.g. in-house tools, etc.
- Mission specific
  - Product requirements
    - Specific mission and support requirements
    - Manufacturing requirements
    - Delivery requirements
  - Process requirements
    - Implementation requirements

Some sources of generic functions and requirements

- Similar systems
- Government mandates
- Domain knowledge
- Standards
- Relevant documents
- Market studies
- Legacy system dictates
- Bodies of knowledge for solution system in operation
  - E.g., Business Analysis Body of Knowledge (BABOK)
- Existing and legacy systems*
- Process documents*
- Legal or regulatory documents*
- Company specific regulations*
- (marketing) information about potential future users*
- Similar situations in different domains*
- Guideline documents

* IREB, 3.10., 4.1

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Example 1 [Communications system]

1234.5 An objective requirement is that the downlink control shall be flexible enough to allocate extra downlink time slots for high-priority participants if more downlink data is required from a particular participant.

1234.5 ~~An objective requirement is that~~ the downlink control shall be flexible enough to allocate extra downlink time slots for high-priority participants if more downlink data is required from a particular participant.

Example 2 [ST-DADDS]

"204.1 DADS shall automatically maintain *statistics* concerning the number of times and the most recent time that each data set has been accessed. These same statistics shall be maintained for each *piece of media* in the DADS archive" (ST-DADS 1992)

- The requirement contains:
  - ***Undefined terms:*** statistics, piece of media.
  - ***Multiple requirements:*** and, two sentences.

Example 2 [ST-DADDS]

"204.1 DADS shall automatically maintain *statistics* concerning the number of times and the most recent time that each data set has been accessed. These same statistics shall be maintained for each *piece of media* in the DADS archive" (ST-DADS 1992)

- The requirement contains:
  - ***Undefined terms:*** statistics, piece of media.
  - ***Multiple requirements:*** and, two sentences.

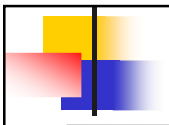
Creating four atomic requirements

204.1a DADS shall automatically maintain statistics concerning the number of times ~~and the most recent time~~ that each data set has been accessed. ~~These same statistics shall be maintained for each piece of media in the DADS archive~~.

204.1b DADS shall automatically maintain statistics concerning the ~~number of times and~~ the most recent time that each data set has been accessed. ~~These same statistics shall be maintained for each piece of media in the DADS archive.~~

204.1c DADS shall automatically maintain statistics concerning the number of times ~~and the most recent time~~ that ~~each data set has been accessed. These same statistics shall be maintained for~~ each piece of media in the DADS archive has been accessed.

204.1d DADS shall automatically maintain statistics concerning the ~~number of times and~~ the most recent time that ~~each data set has been accessed. These same statistics shall be maintained for~~ each piece of media in the DADS archive has been accessed.



Four atomic requirements

204 Access to data sets

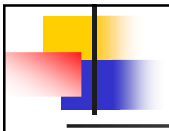
204.1a DADS shall automatically maintain statistics concerning the number of times that each data set has been accessed.

204.1b DADS shall automatically maintain statistics concerning the most recent time that each data set has been accessed.

204 Access to each piece of media

204.1c DADS shall automatically maintain statistics concerning the number of times that each piece of media in the DADS archive has been accessed.

204.1d DADS shall automatically maintain statistics concerning the most recent time that each piece of media in the DADS archive has been accessed.



Four atomic requirements

204 Access to data sets

204.1a DADS shall automatically maintain statistics concerning the number of times that each data set has been accessed.

204.1b DADS shall automatically maintain statistics concerning the most recent time that each data set has been accessed.

Statistics

204.1c DADS shall automatically maintain statistics concerning the number of times that each piece of media in the DADS archive has been accessed.

204.1d DADS shall automatically maintain statistics concerning the most recent time that each piece of media in the DADS archive has been accessed.

Example 4 [ST-DADDS]

509.1 DADS shall monitor and provide reports (to the operator) on all requests for DADS products and services. This capability shall include recording the name and organization of the requester, the product or service requested, the date and time of the request, the service priority, the current disposition of the request, and the date and time of service completion.

When you write or approve (sign off) on a requirement, you are demonstrating your level of competency in requirements engineering

Better poorly-written requirement

509.1 DADS shall monitor and provide reports to the operator about the state of transactions in the system. This capability shall contain the following:

a. the name and organisation of the requester
b. the product or service requested
c. the date and time of the request
d. the service priority
e. the current disposition of the request
f. the date and time of service completion.

Better poorly-written requirement

509.1 DADS shall monitor *and* provide reports to the operator about the state of transactions in the system. This capability shall contain the following:

a. the name and organisation of the requester
b. the product or service requested
c. the date and time of the request
d. the service priority
e. the current disposition of the request
f. the date and time of service completion.

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Exercise 1-21 Compliance to a poorly written requirement

1. Imagine that you have just written the test procedure for verifying the system compliance to the poorly written requirement 509.1
2. Visualize the test procedure performed
3. Prepare a <5 minute presentation containing
    1. Reformulated problem per COPS Problem Formulation Template
    2. What you did to test each part of the requirement
    3. How you ensured the whole poorly-written requirement was tested
    4. A compliance matrix for the exercise
    5. Lessons learned from exercise
4. Save as a PowerPoint file in format Exercise1.21-abcd.pptx
    1. Note (abcd are your initials, where d is to be used when two participants have the same initials)
5. Post/email presentation as and where instructed

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Compliance matrix for meeting the objectives

#	Objective	Met
1	To provide the background to requirements	9-21
2	To provide definitions of the terminology used in the course	23-29
3	To explain the purposes of requirements	31
4	To explain some of the problems caused by poorly-written requirements	33-34
5	To explain the difference between requirements, well-written requirements and good requirements	25
6	To explain what constitutes a well-written requirement	36-55
7	To explain generic and system specific requirements and the benefits of the distinction	57-60
8	To show some examples of bad requirements and how to fix them	62-70
9	To explain why they are bad	62-70
10	To explain what needs to be done to convert them to well-written requirements	62-70
11	To provide the opportunity to obtain 5 levels of knowledge updated Blooms taxonomy	72-74

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Any questions ?

1. Best
2. Worst
3. Missing

Email:
beyondsystemsthinking@yahoo.com
Subject: <class title> BWM module #

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