

## Module 5

# Requirements Management

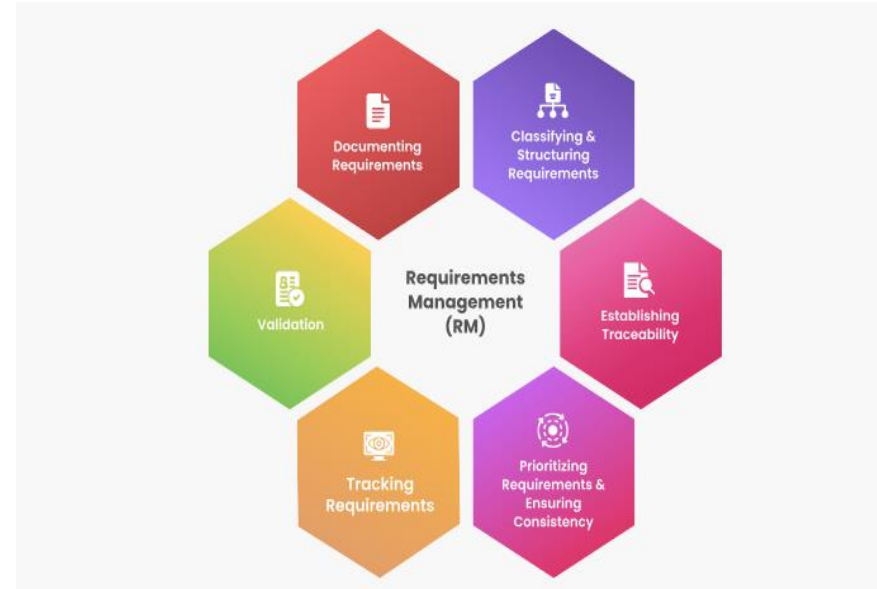
# Outline

- Managing and Communicating System Requirements
- Systems Engineering Tool
- Requirements Allocation / Hierarchy
- Verification and Validation

# Managing and Communicating System Requirements

# Requirements Management

- It is a set of techniques for documenting, analysing, prioritizing, and agreeing on requirements so that engineering teams always have current and approved requirements.
- Requirements management provides a way to avoid errors by keeping track of changes in requirements and fostering communication with stakeholders from the start of a project throughout the engineering lifecycle.



# Requirements Management Plan

Having a **Requirements Management Plan (RMP)** is critical to the success of a project because it enables engineering teams to control the scope and direct the product development lifecycle. Requirements management software provides the tools for you to execute that plan, helping to reduce costs, accelerate time to market, and improve quality control

## The Proper Requirements Management Plan



Requirement Management Plan (RMP) helps in creating a strategy to manage requirements.

Why ?



A Requirements Management Plan (RMP) helps explain how to receive, analyze, document and manage all the requirements within a project.

What ?



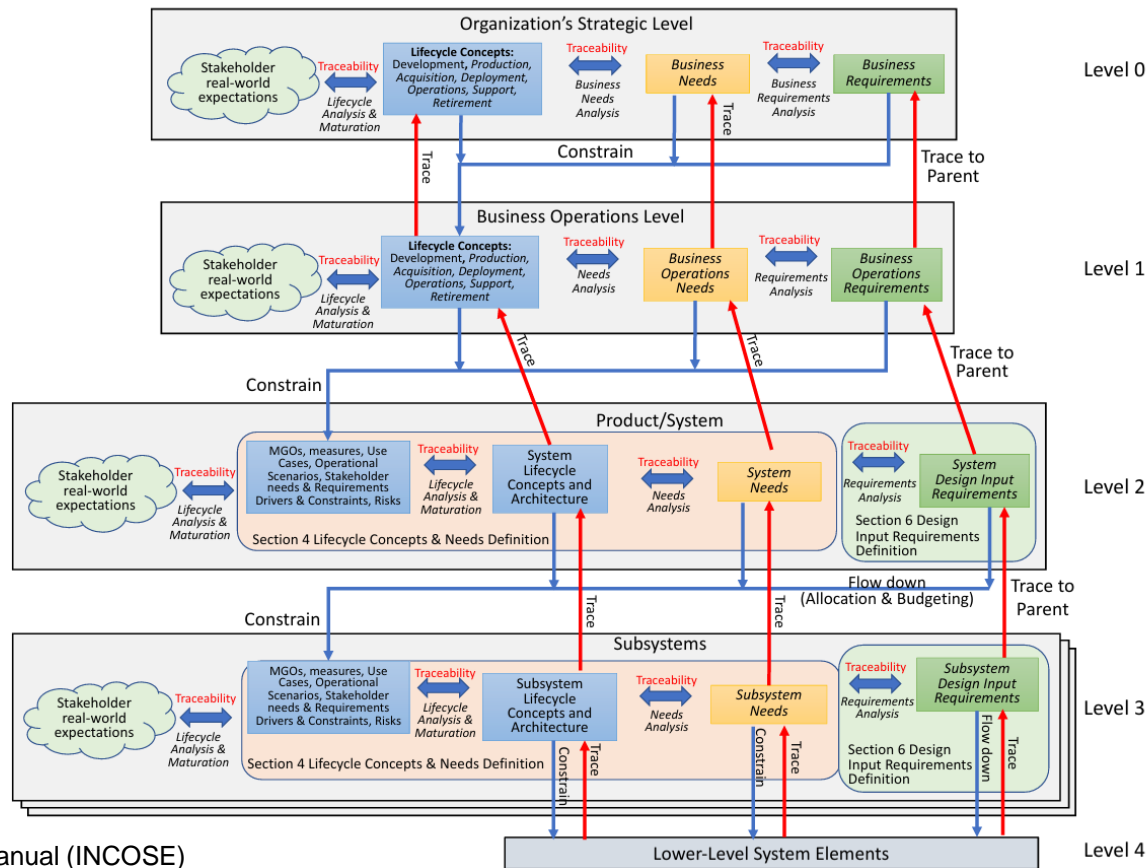
Key items to define in a RMP are the project overview, requirements gathering process, roles and responsibilities, tools and traceability.

How ?

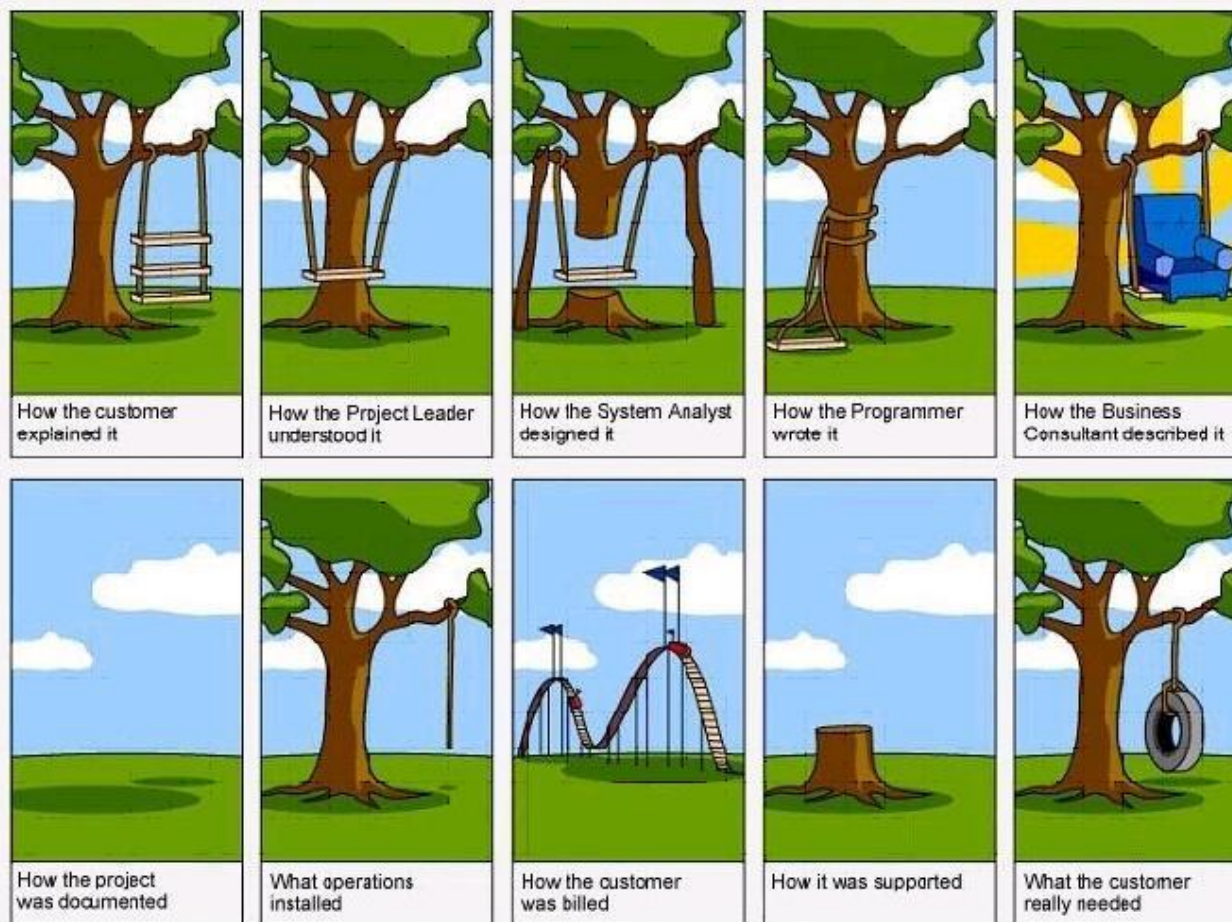
# Requirements Communication

- Requirements must be documented
  - Textual format
  - Operational scenarios, use cases, user stories
  - Diagrams / models
  - Tabular format
- Requirements must be communicated across the system life cycle
  - Original/baseline; modified; added; deleted
- Requirements Tools are useful in the managing and communicating requirements

Flow down (allocation and budgeting) that occurs from one level of the system architecture to another.

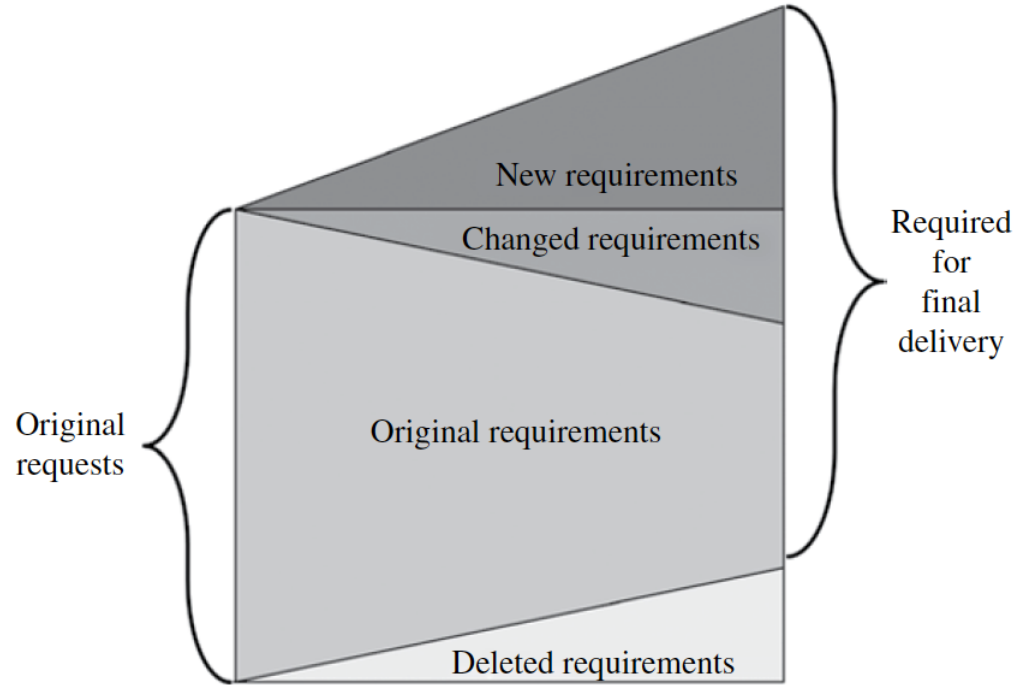


Source : NeedsRequirementsmanual (INCOSE)





# Requirements Over Time



# Requirements Attributes

- Attributes aid in the definition, verification, validation, management, and reuse of requirements
- Organizations must define an attribute scheme that is specific to their domain, product line, and organization
- While attributes are all potentially useful, too many should not be created because of the time and effort needed to define and maintain them.

# Attributes for Requirements (1)

- Attributes to help define needs and requirements and their intent.
  - A1 - Rationale
  - A2 - Trace to Parent
  - A3 - Trace to Source
  - A4 - States and Modes
  - A5 - Allocation / Budgeting

# Attributes for Requirements (2)

- Attributes associated with system verification or 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 for Requirements (3)

- Attributes to help manage the needs or requirements across the lifecycle.
  - A15 - Unique identifier
  - A16 - Unique name
  - A17 - Originator / Author
  - A18 - Date requirement entered
  - A19 - Owner
  - A20 - Stakeholders
  - A21 - Change Control 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

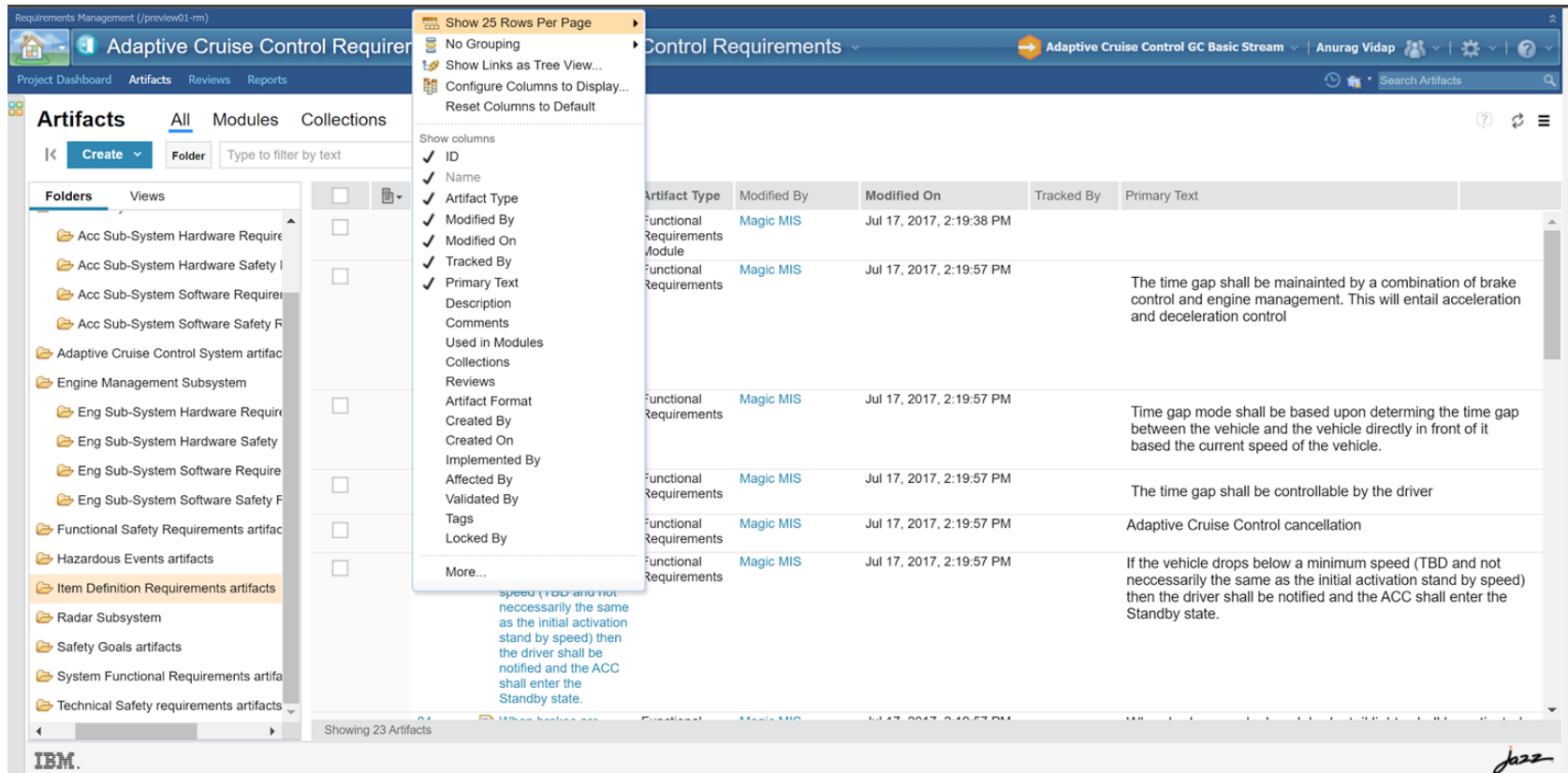
# Attributes for Requirements (4)

- 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
- A39 - Additional comments
- A40 - Type / Category

# Attributes for Requirements (5)

- Attributes to show applicability and enable 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

# Attributes example from IBM Jazz



The screenshot displays the IBM Jazz Requirements Management interface. The main window shows a list of artifacts under the 'Adaptive Cruise Control Requirements' project. A configuration menu is open, showing the 'Show 25 Rows Per Page' dropdown and a list of columns to be displayed. The artifacts list includes columns for Artifact Type, Modified By, Modified On, Tracked By, and Primary Text.

**Configuration Menu:**

- Show 25 Rows Per Page
- No Grouping
- Show Links as Tree View...
- Configure Columns to Display...
- Reset Columns to Default

**Columns to Show:**

- ☒ ID
- ☒ Name
- ☒ Artifact Type
- ☒ Modified By
- ☒ Modified On
- ☒ Tracked By
- ☒ Primary Text
- ☐ Description
- ☐ Comments
- ☐ Used in Modules
- ☐ Collections
- ☐ Reviews
- ☐ Artifact Format
- ☐ Created By
- ☐ Created On
- ☐ Implemented By
- ☐ Affected By
- ☐ Validated By
- ☐ Tags
- ☐ Locked By
- More...

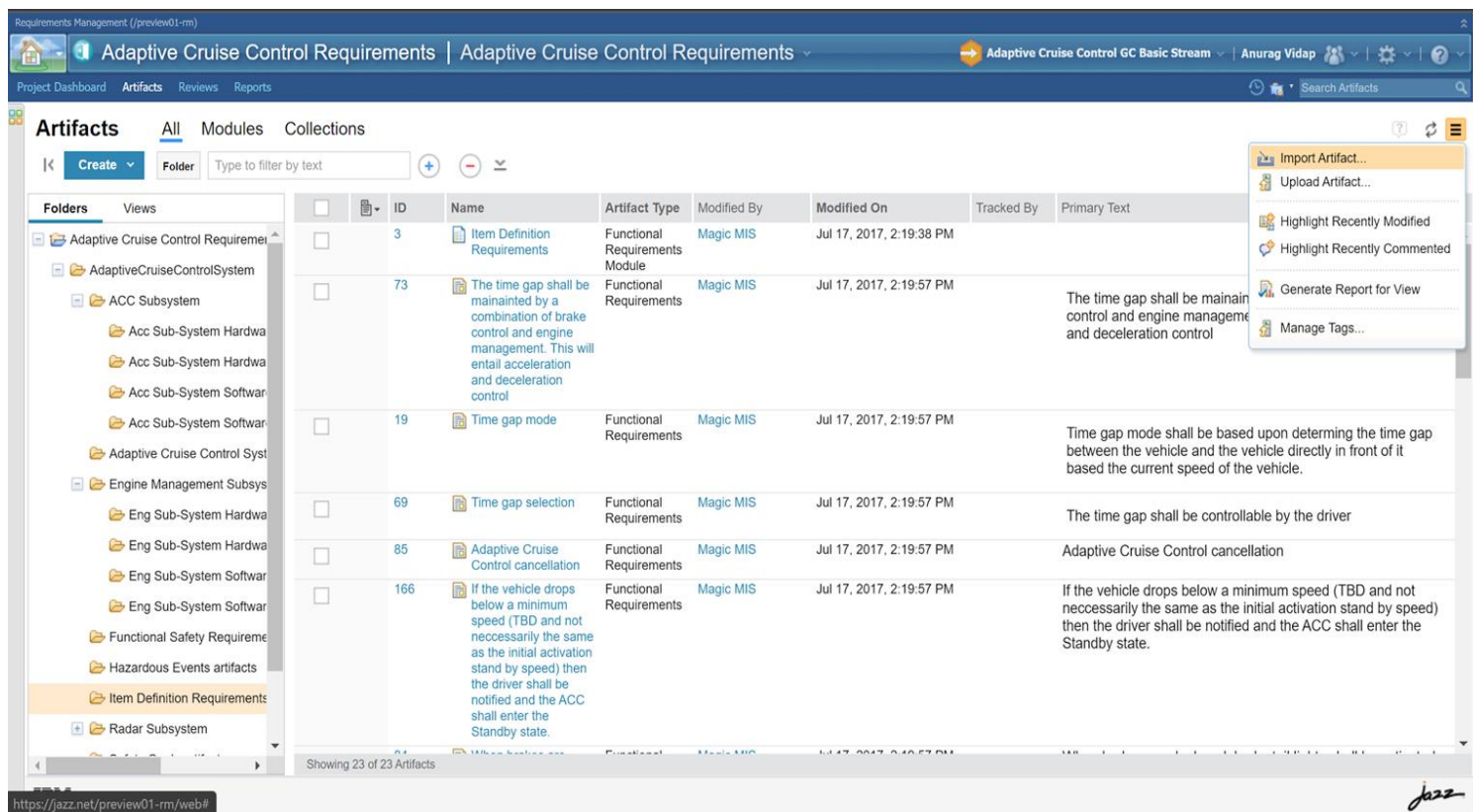
**Artifacts List:**

Artifact Type	Modified By	Modified On	Tracked By	Primary Text
Functional Requirements	Magic MIS	Jul 17, 2017, 2:19:38 PM		
Functional Requirements	Magic MIS	Jul 17, 2017, 2:19:57 PM		The time gap shall be maintained by a combination of brake control and engine management. This will entail acceleration and deceleration control
Functional Requirements	Magic MIS	Jul 17, 2017, 2:19:57 PM		Time gap mode shall be based upon determining the time gap between the vehicle and the vehicle directly in front of it based the current speed of the vehicle.
Functional Requirements	Magic MIS	Jul 17, 2017, 2:19:57 PM		The time gap shall be controllable by the driver
Functional Requirements	Magic MIS	Jul 17, 2017, 2:19:57 PM		Adaptive Cruise Control cancellation
Functional Requirements	Magic MIS	Jul 17, 2017, 2:19:57 PM		If the vehicle drops below a minimum speed (TBD and not necessarily the same as the initial activation stand by speed) then the driver shall be notified and the ACC shall enter the Standby state.

Showing 23 Artifacts



# Requirements Example from IBM Jazz



The screenshot displays the IBM Jazz Requirements Management interface for a project titled "Adaptive Cruise Control Requirements". The interface includes a navigation pane on the left with a tree view of folders and artifacts. The main area shows a table of artifacts, and a context menu is open over one of the items.

**Navigation Pane:**

- Adaptive Cruise Control Requirements
  - AdaptiveCruiseControlSystem
    - ACC Subsystem
      - Acc Sub-System Hardwa
      - Acc Sub-System Hardwa
      - Acc Sub-System Softwar
      - Acc Sub-System Softwar
      - Adaptive Cruise Control Syst
    - Engine Management Subsys
      - Eng Sub-System Hardwa
      - Eng Sub-System Hardwa
      - Eng Sub-System Softwar
      - Eng Sub-System Softwar
    - Functional Safety Requireme
    - Hazardous Events artifacts
    - Item Definition Requirements
    - Radar Subsystem

**Artifacts Table:**

ID	Name	Artifact Type	Modified By	Modified On	Tracked By	Primary Text
3	Item Definition Requirements	Functional Requirements Module	Magic MIS	Jul 17, 2017, 2:19:38 PM		
73	The time gap shall be maintained by a combination of brake control and engine management. This will entail acceleration and deceleration control	Functional Requirements	Magic MIS	Jul 17, 2017, 2:19:57 PM		The time gap shall be mainin control and engine managem and deceleration control
19	Time gap mode	Functional Requirements	Magic MIS	Jul 17, 2017, 2:19:57 PM		Time gap mode shall be based upon determing the time gap between the vehicle and the vehicle directly in front of it based the current speed of the vehicle.
69	Time gap selection	Functional Requirements	Magic MIS	Jul 17, 2017, 2:19:57 PM		The time gap shall be controllable by the driver
85	Adaptive Cruise Control cancellation	Functional Requirements	Magic MIS	Jul 17, 2017, 2:19:57 PM		Adaptive Cruise Control cancellation
166	If the vehicle drops below a minimum speed (TBD and not necessarily the same as the initial activation stand by speed) then the driver shall be notified and the ACC shall enter the Standby state.	Functional Requirements	Magic MIS	Jul 17, 2017, 2:19:57 PM		If the vehicle drops below a minimum speed (TBD and not necessarily the same as the initial activation stand by speed) then the driver shall be notified and the ACC shall enter the Standby state.

**Context Menu (over artifact 73):**

- Import Artifact...
- Upload Artifact...
- Highlight Recently Modified
- Highlight Recently Commented
- Generate Report for View
- Manage Tags...

Showing 23 of 23 Artifacts

URL: <https://jazz.net/preview01-rm/web#>

# Exercise 5.1

For your SOI,

1. Pick a few Software Requirements already identified, and discuss the following:
  - a) Define various attributes for SW Requirements
  - b) Fill out the attributes for those SW Requirements

# Systems Engineering Tool

# Desirable features of an SE tool (1)

- Functionality

- Needs and requirements quality
- Grammatical structure of needs and requirements
- Allocation, budgeting, and traceability
- Interface management
- Dependencies between artifacts and work products and their underlying data and information
- Impact assessment
- Ontology
- Schema
- Embedded Objects
- Diagrams and drawings
- Modeling
- Reusability

# Desirable features of an SE tool (2)

- Tool attributes

- Tailorable
- Configuration / Customization
- Learnability / Usability
- Security
- Accessibility (devices / location)
- Online version Offline modes
- Concurrent access
- Performance
- Collaboration
- Tool integration - needs and requirements
- Interoperability/tool integration - data sharing
- Sharing of Data - external
- Storage location
- Scalability / extendibility
- Archive/Backup/Long term availability

# Desirable features of an SE tool (3)

- Management and Reporting
  - Attributes
  - Measures
  - Reports
  - Metrics/dashboards
  - Notifications
  - Project management work products
  - Lifecycle support
  - Workflow
  - CM

# Desirable features of an SE tool (4)

- General Considerations
  - Price
  - Cost of infrastructure to support the use of the SE toolset
  - Vendor/product maturity
  - User feedback and satisfaction

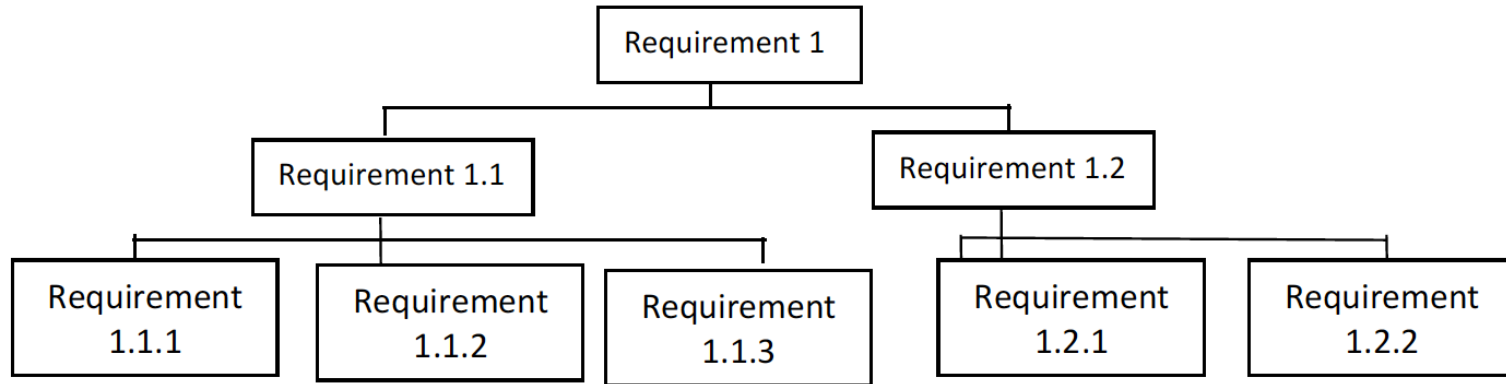
# Traceability

- Every requirement must be traced back to a source
- Traceability is bi-directional
- Significantly enabled by SE Tool
- Establishing traceability cannot be automated
- Horizontal Traceability: across the lifecycle, and between peers
- Vertical Traceability: between levels
- Essential for performing impact analysis resulting from requirements change/modification, insertion, or deletion



# Requirements Allocation / Hierarchy

# Requirements Hierarchy



Source: "Systems Engineering Practices", Ian Faulconbridge

# Requirements Traceability

# Stakeholder & System Requirements

- Elicitation of stakeholder requirements starts in **Concept Definition**
- System requirements will be considered in detail during **System Definition**.
- Stakeholder Requirements and System Requirements cannot be considered complete until **consistency between the two has been achieved, as demonstrated by traceability,** for *which a number of iterations* may be needed.

# Traceability Example

Requirements Management (/preview01-rm)

Adaptive Cruise Control Requirements | Adaptive Cruise Control Requirements

Project Dashboard Artifacts Reviews Reports

Adaptive Cruise Control GC Basic Stream Anurag Vidap Search Artifacts

## Adaptive Cruise Control Requirements Project Dashboard

General

### Test Cases Validating Requirements

Filters

10 Items Per Page

Previous 1 - 4 of 4 items Next

QM Test Case	Requirement
FlexRay and CAN Bus TC	The hardware shall provide a layer to communicate with both FlexRay and CAN bus systems
FlexRay and CAN Bus TC	The hardware shall provide a layer to communicate with both FlexRay and CAN bus systems
Standard 16 bit D2A Converter TC	The hardware shall provide a standard 16 bit +/- 5 V digital to analogue converter
Standard 16 bit A2D Converter TC	The hardware shall provide a standard 16 bit +/- 12 V Analogue to digital converter

### Safety Goals by ASIL

Filters View as: Graph

Open in a new window...

ASIL	Count
A	4
B	8
C	2

### Safety Goals by ASIL Traceability

Filters

10 Items Per Page

Previous 1 - 10 of 14 items Next

ASIL	Safety Goals	Satisfied By
A	If any part of the system fails due to power outage the ACC shall out itself into a safe state	
	If any part of the system fails due to power outage the ACC shall out itself into a safe state	A watchdog running at 2 Khz shall be used by the ACC module to determine if the radar subsystem fails due to loss of power
	If any part of the system fails due to power outage the ACC shall out itself into a safe state	A watchdog running at 2 Khz shall be used by the ACC module to determine if the brake subsystem fails due to loss of power
	If any part of the system fails due to power outage the ACC shall out itself into a safe state	A watchdog running at 2 Khz shall be used by the ACC module to determine if the Speed subsystem fails due to loss of power

**Tip of the week**

Your mini dashboard is accessible from all projects that are on the same Jazz Team Server.

IBM. jazz

# Traceability Example

## Safety Goals by ASIL Traceability

Filters

20 Items Per Page

Previous 1 - 14 of 14 items Next

Export

Duplicate

MY CHOICES

**DATA SOURCE:**  
Lifecycle Query Engine scoped by a Configuration

**DETAILS:**  
Safety Goals by ASIL Traceability

**ARTIFACT RELATIONSHIPS:**

**PROJECTS:**

**COLUMNS:**

**PRIVACY AND SHARING:**  
Public (publish to catalog and visible to everyone)

ASIL	Safety Goals	Satisfied By
A	If any part of the system fails due to power outage the ACC shall out itself into a safe state	
	If any part of the system fails due to power outage the ACC shall out itself into a safe state	A watchdog running at 2 Khz shall be used by the ACC module to determine if the radar subsystem fails due to loss of power
	If any part of the system fails due to power outage the ACC shall out itself into a safe state	A watchdog running at 2 Khz shall be used by the ACC module to determine if the brake subsystem fails due to loss of power
	If any part of the system fails due to power outage the ACC shall out itself into a safe state	A watchdog running at 2 Khz shall be used by the ACC module to determine if the Speed sensor subsystem fails due to loss of power
B	When thecruise control is active it shall be possible to deactivate it automatically in the case of a potential collision or the vehicle speed is less than 30 mph, or by action of the driver using the brake or off switch.1198: Vehicle Crashes into an obstr	Adaptive Cruise Control CancellationCM
	If any of the communication systems used fail then the driver shall be warned in an appropriate manner and the ACC shall put itself in a safe state	When a signal corruption is detected by the RadarArbtrator, the cruise
	If any of the communication systems used fail then the driver shall be warned in an appropriate manner and the ACC shall put itself in a safe state	If a difference between signals on the communication channels is detected then a warning signal shall be indicated to the driver and an error code captured
	If any of the communication systems used fail then the driver shall be warned in an appropriate manner and the ACC shall put itself in a safe state	When brake signal corruption is detected by BrkArbtrator, the
	If any of the communication systems used fail then the driver shall be warned in an appropriate manner and the ACC shall put itself in a safe state	When a signal corruption is detected by the RadarArbtrator, the cruise
	If any of the communication systems used fail then the driver shall be warned in an appropriate manner and the ACC shall put itself in a safe state	If a difference between signals on the communication channels is detected then a warning signal shall be indicated to the driver and an error code captured
	If any of the communication systems used fail then the driver shall be warned in an appropriate manner and the ACC shall put itself in a safe state	When brake signal corruption is detected by BrkArbtrator, the
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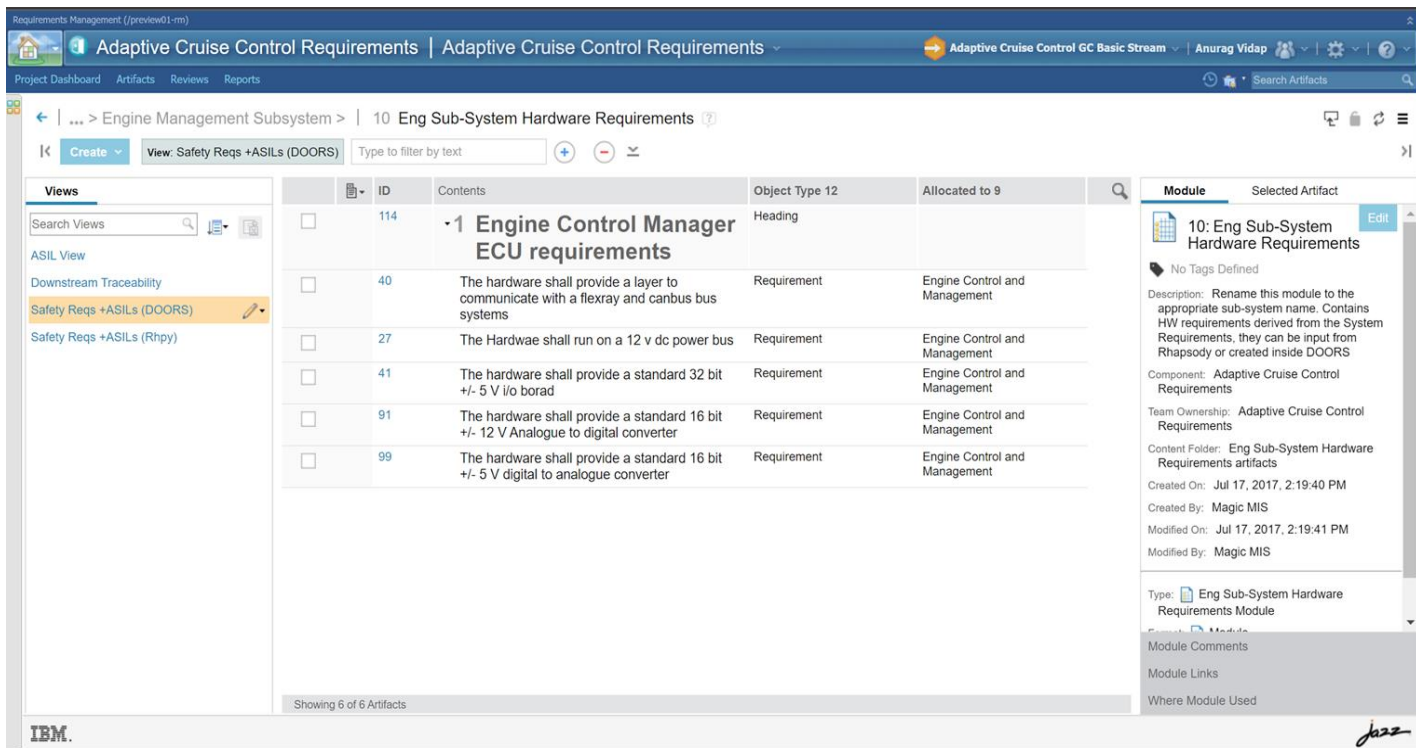
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Module 5

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# Allocation Example

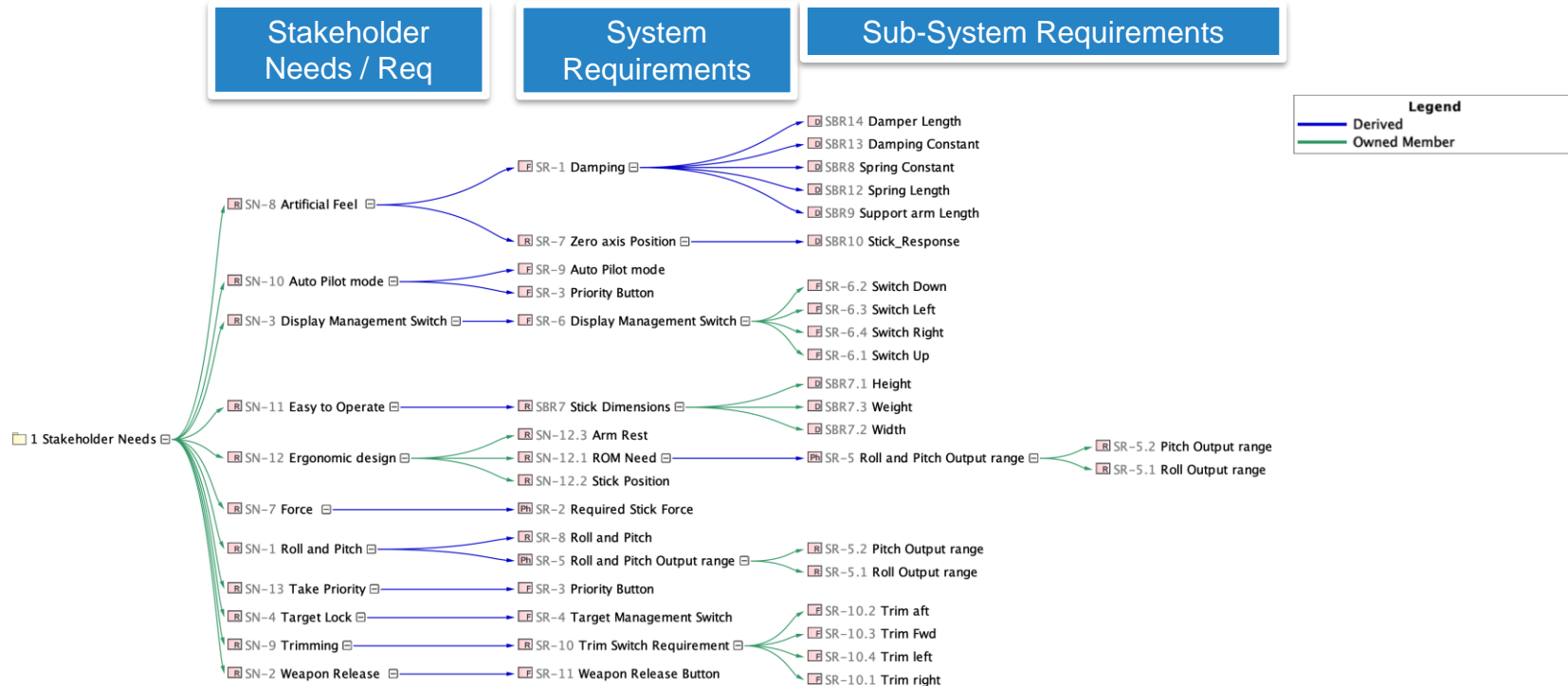


The screenshot displays the 'Requirements Management' application. The main window shows a table of requirements for the '10: Eng Sub-System Hardware Requirements' module. The table has columns for ID, Contents, Object Type, and Allocated to. The first row is a heading, and the following five rows are specific requirements.

ID	Contents	Object Type	Allocated to
114	<b>1 Engine Control Manager ECU requirements</b>	Heading	
40	The hardware shall provide a layer to communicate with a flexray and canbus bus systems	Requirement	Engine Control and Management
27	The Hardware shall run on a 12 v dc power bus	Requirement	Engine Control and Management
41	The hardware shall provide a standard 32 bit +/- 5 V i/o board	Requirement	Engine Control and Management
91	The hardware shall provide a standard 16 bit +/- 12 V Analogue to digital converter	Requirement	Engine Control and Management
99	The hardware shall provide a standard 16 bit +/- 5 V digital to analogue converter	Requirement	Engine Control and Management

The interface also includes a sidebar with 'Views' (ASIL View, Downstream Traceability, Safety Reqs +ASILs (DOORS), Safety Reqs +ASILs (Rhy)) and a right-hand pane showing details for the selected module, including description, component, team ownership, content folder, creation/modification dates, and type.

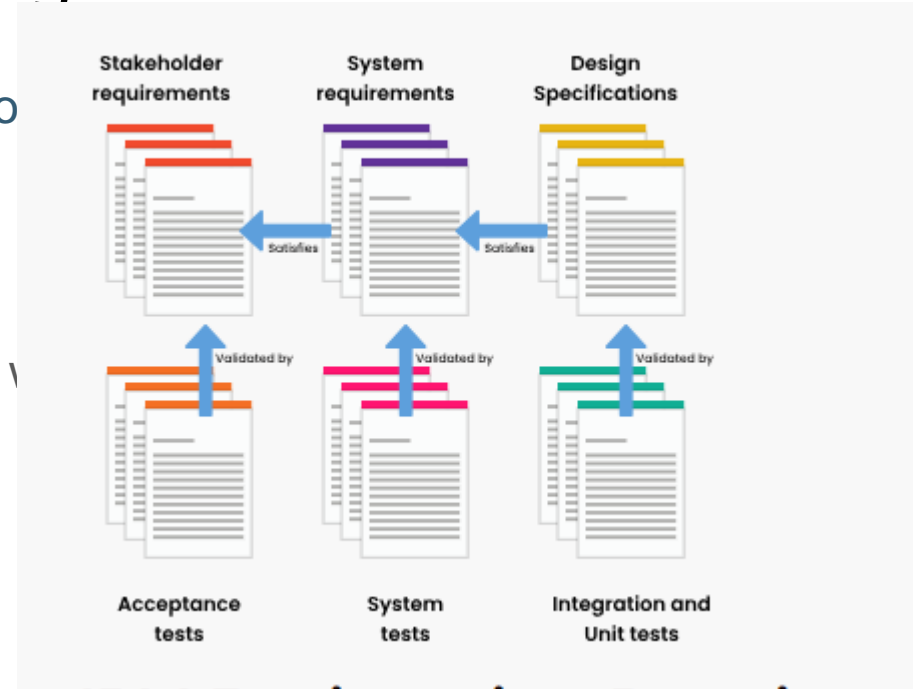
# Requirements Breakdown Example





# Digital Requirement Management

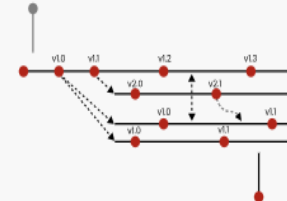
- Collaborating all the Stakeholders of
- End-End Traceability
- Change Management
- Variant Management
- Quality Management and Baseline v
- Scalability and Reusability



# Variant Management

- Reduced Costs
- Better Agility
- Better Efficiency
- Better Traceability
- Better Quality
- Better Reusability

Branch, merge  
and baseline all  
engineering data



Reuse your changes  
across variants

## 150% Design

Consists of linked  
Requirements, Architecture,  
Test Cases and Code



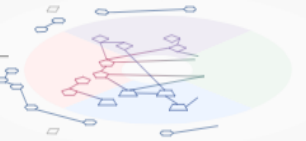
## Project A

Consists of linked  
Requirements, Architecture,  
Test Cases and Code

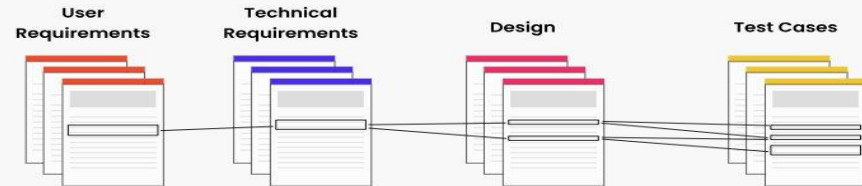


## Milestone 1

A subset of Project A  
for delivery

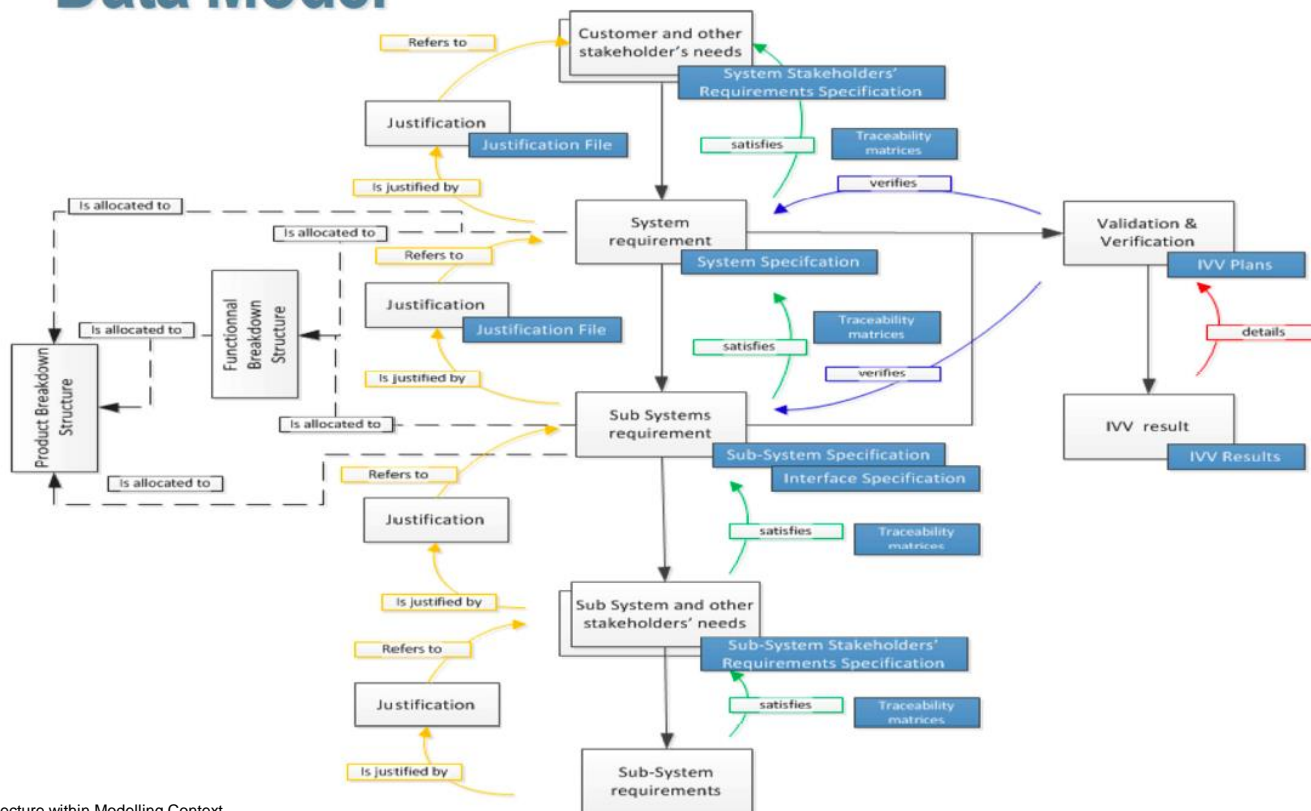


## End-to-End Lifecycle Traceability with Requirements Management



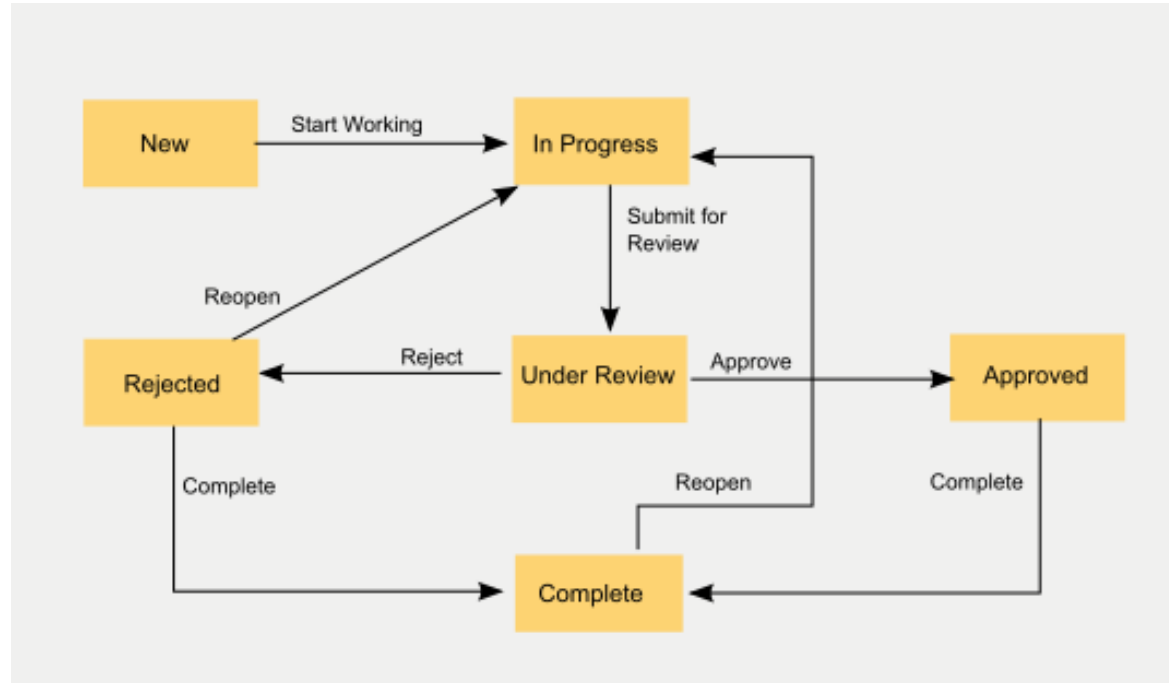
# Data Model and Workflow

# Data Model



Source : Requirements and Architecture within Modelling Context  
 This White Paper is an AFIS collective work directed by the MBSE technical Committee (INCOSE)

# Requirements Management Workflow Example



Source : IBM

*The End*