



**STARION**

# ESA SysML Solution – Specification and Implementation

Final Presentation

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# Contents

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- Introduction
- Partners
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- Specification, Mapping & Implementation
- Enterprise Architect Plugin

# The ESA SysML Solution



Based on ECSS




Based on SysML v1




A rigorous and iterative process



Implementation on tools



Modelling methodology



Scalable

# Partnership and roles



Product owner



Prime, implementation and development  
(Enterprise Architect)



Analysis and  
validation



Implementation (Cameo)  
and consultancy



Consultancy

# Objective

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- Iterative process: building new concepts from the previous iteration.
  - Specification of the new elements
    - Interfaces specification
    - Validation specification
  - Implementation of the profile onto SysML v1
    - Cameo Systems Modeler
    - Enterprise Architect
  - Customisation of tool interface
- Cameo Systems Modeler & Enterprise Architect Plugin development

# Specification, mapping & implementation



# Data model inputs

ECSS-E-ST-10-24C  
1 June 2015

## 4 Principles

### 4.1 Type of interfaces

In a Space System there can be three major types of interfaces.

- interfaces within the Space Segment, Ground Segment or Launch Segment.
- interfaces between the different Segments of the Space System.
- interfaces between the Support Segment and the Space Segment, Ground Segment or Launch Segment.

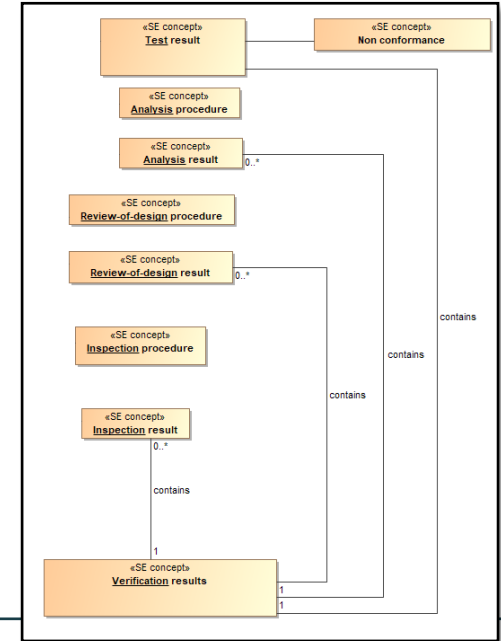
Refer to Figure 2-1 of ECSS-5-ST-00-01 for details on Space System breakdown. In addition, a distinction can be made between internal and external interfaces. The notion of internal or external depends on the position and role of an actor in the customer supplier chain.

An internal interface is an interface under the control of a given actor. An external interface is an interface outside the control of a given actor. For example, an interface between two suppliers of the same customer is considered external by the suppliers and internal by the customer.

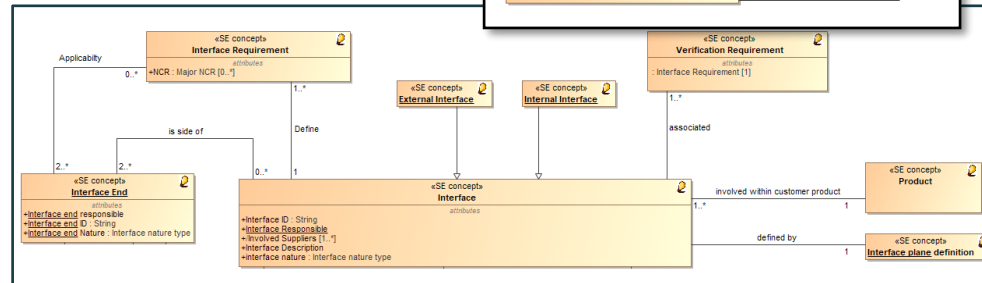
### 4.2 Interface management process

#### 4.2.1 General description

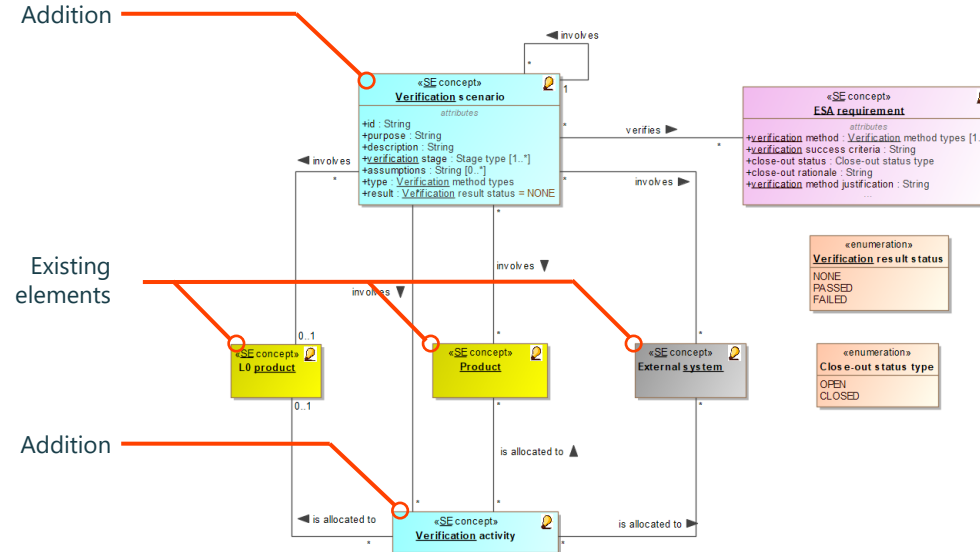
The interface management process is applied at all levels of the supplier/customer chain. The standard describes the process at one level, between one customer and its lower tier suppliers. The customer or his delegate is responsible for the definition, development and verification of the interface. In addition to the interface responsible, the interface actors are all the parties involved in the interface end definition, design, development. This process can impact the similar activities done at higher or lower levels.



ECSS-E-ST-10-24C analysis extract



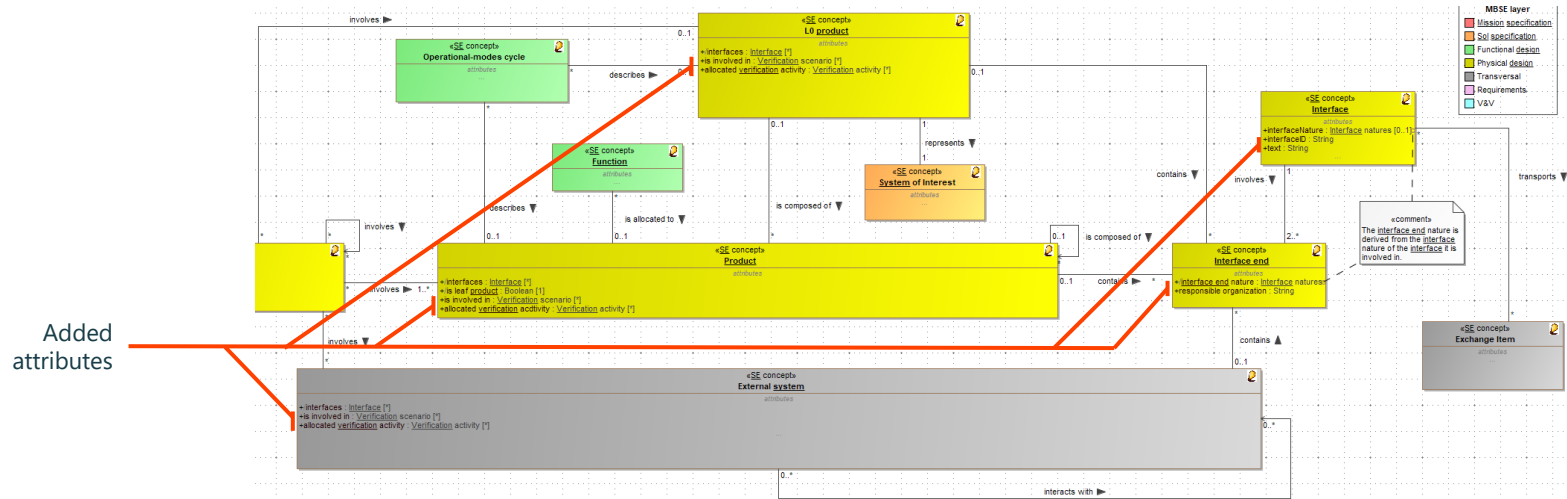
# Nexus - Representation of verification



Architecture simplified for readability

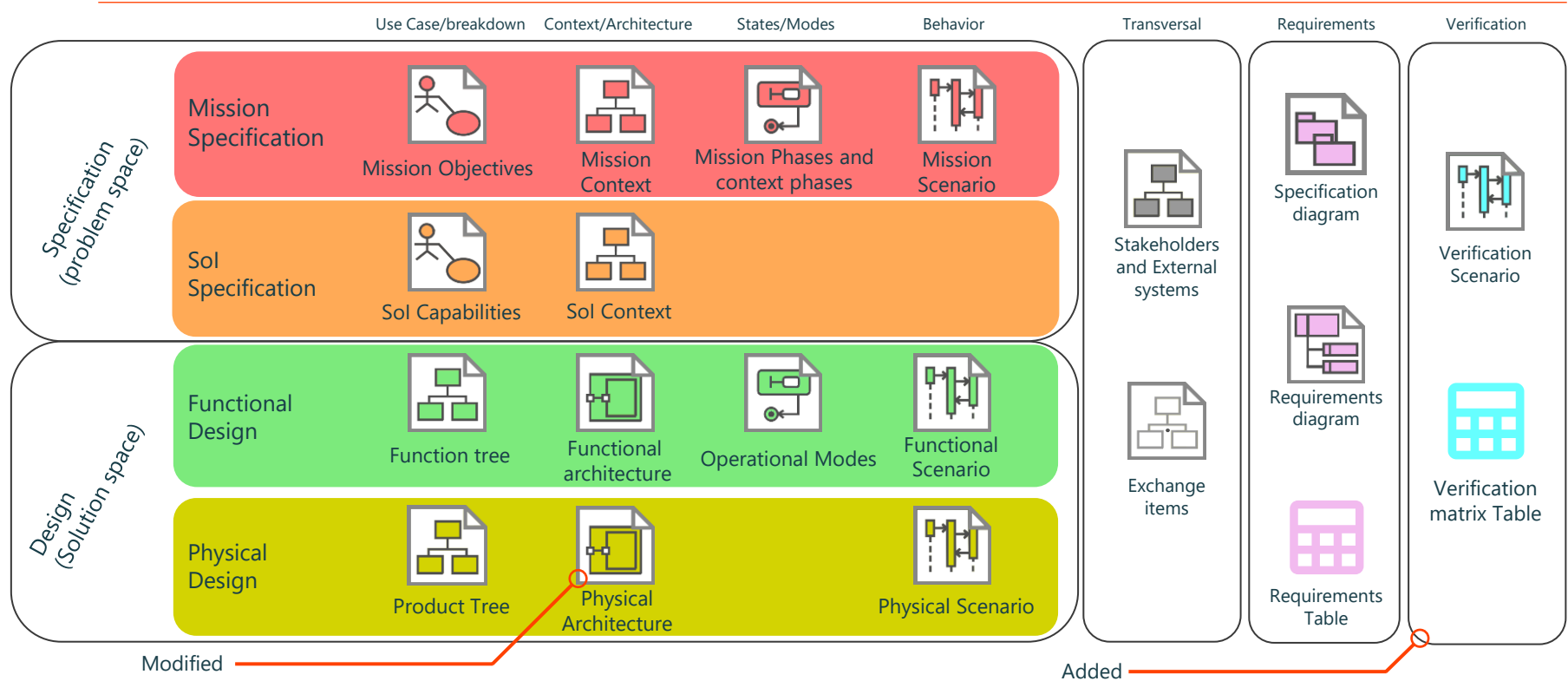


# Nexus - Representation of Interfaces



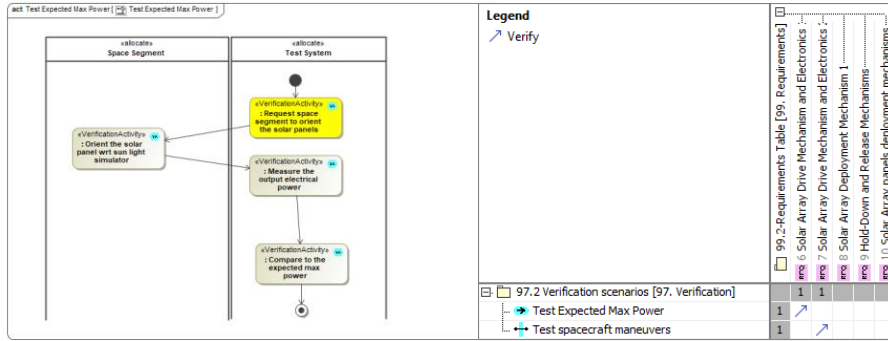
Architecture simplified for readability

# Integration in the current methodology

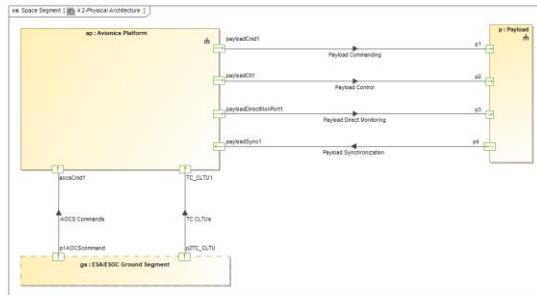


# Implementation and demonstration

## Cameo System Modeler

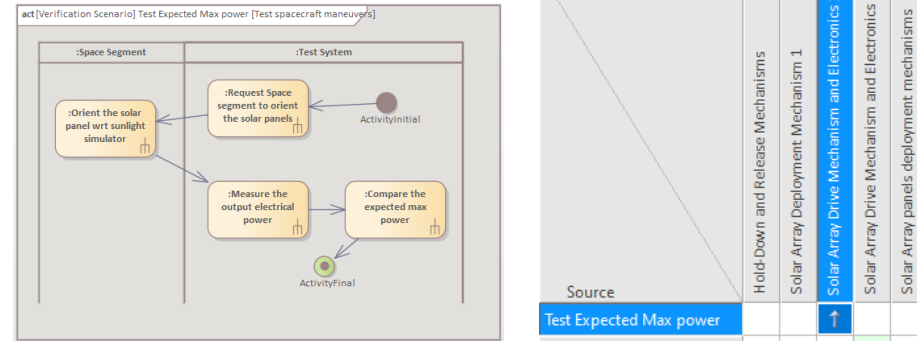


Verification layer

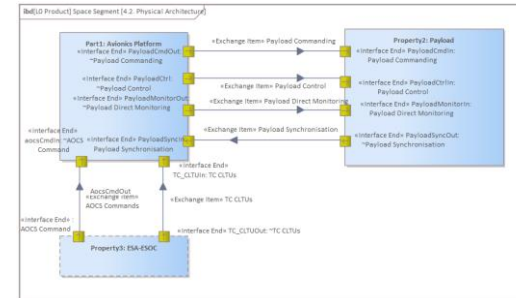


Physical Architecture

## Enterprise Architect



Verification layer

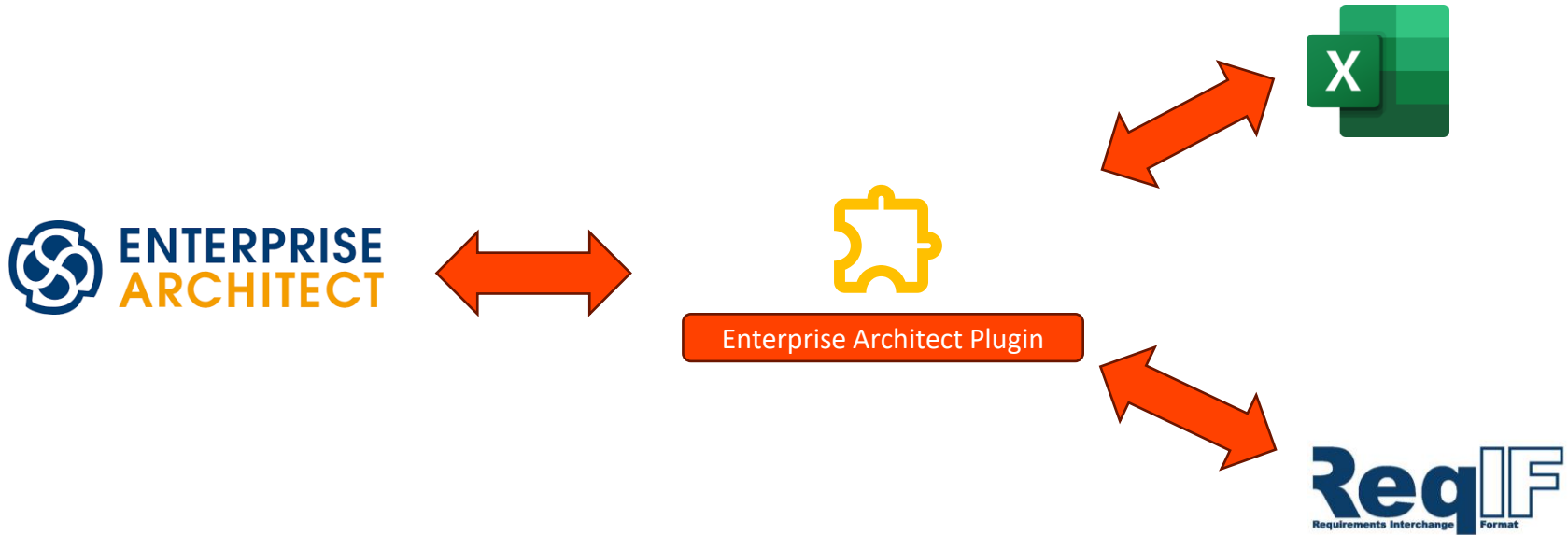


Physical Architecture

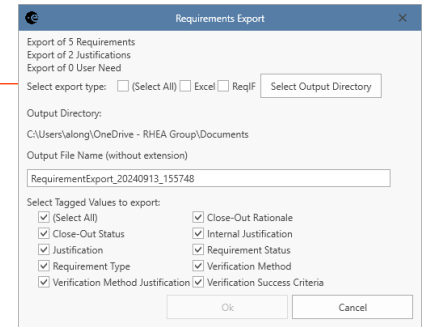
# Enterprise Architect plugin



# Enterprise Architect Plugin for ESA SysML solution



# Exporting requirements (Excel + ReqIF)



Id	Title	Text	Specification	Specification chapter	Justified by	Derives to	Derives from	Responds to user need	Satisfied by	Is verified by	Close-Out Rationale	Close-Out Status	Internal Justification	Justification	Requirement Status	Requirement Type	Verification Method
ESASYSML-EA-EXT-GEN-R-030		The ESA SysML plugin for Enterprise Architect shall mention the version of the profile used.	Package1		ESASYSML-EA-EXT-GEN-J-030										Proposed		
ESASYSML-EA-EXT-GEN-R-040		The ESA SysML plugin for Enterprise Architect shall be compatible with ESA SysML Solution 1.2 only.	General Specification						ESA SysML plugin Enterprise Architect						Proposed		
ESASYSML-EA-EXT-GEN-R-050		The ESA SysML plugin for Enterprise Architect shall be clear for the user	General Specification		ESASYSML-EA-EXT-GEN-J-020										Proposed		
ESASYSML-EA-EXT-GEN-R-070		The ESA SysML plugin shall import requirements from XLSX documents.	General Specification			ESASYSML-EA-EXT-IMP-R-010									Proposed		
ESASYSML-EA-EXT-GEN-R-080		The ESA SysML plugin for Enterprise Architect must give feedback to the user about the process status	General Specification												Proposed		
ESASYSML-EA-EXT-GEN-R-100		The ESA SysML plugin for Enterprise Architect shall mention the version of the profile used.	General Specification												Proposed		
ESASYSML-EA-EXT-GEN-R-110		The ESA SysML plugin for Enterprise Architect shall be clear for the user The ESA SysML plugin for Enterprise Architect shall support:	General Specification												Proposed		
ESASYSML-EA-EXT-EXP-R-010		Word Export Excel Export ReqIF Export	Exporting Requirements			ESASYSML-EA-EXT-EXP-R-020 ESASYSML-EA-EXT-EXP-R-030	ESASYSML-EA-EXT-GEN-R-060			Verification Scenario1					Proposed		
ESASYSML-EA-EXT-EXP-R-020		The ESA SysML plugin for Enterprise Architect shall provide a template for the export. The export shall comprises as minimum:	Exporting Requirements		Justification1		ESASYSML-EA-EXT-EXP-R-010								Proposed		
ESASYSML-EA-EXT-EXP-R-030		Requirement Alias Requirement Name Requirement Text Derives From (requirements IDs) Derives To (requirements IDs) Justification text Any other attributes	Exporting Requirements		Justification1	ESASYSML-EA-EXT-EXP-R-040	ESASYSML-EA-EXT-EXP-R-010								Proposed		
ESASYSML-EA-EXT-IMP-R-030		During the import of the excel file, the plugin shall create all relationships between requirement and justifications in the requirement file.	Specification1				ESASYSML-EA-EXT-IMP-R-020										
ESASYSML-EA-EXT-IMP-R-010		The import from XLSX shall be defined from a template.	Specification1			ESASYSML-EA-EXT-IMP-R-040	ESASYSML-EA-EXT-GEN-R-070								Proposed		
ESASYSML-EA-EXT-IMP-R-020		During the import of the excel file, the plugin shall create all relationships between requirements in the requirement file. Requirements in the imported excel file shall be identified either by	Specification1			ESASYSML-EA-EXT-IMP-R-030											

# Importing requirements (Excel + ReqIF)

Requirements Import

Selected Input File:  
C:\Users\along\OneDrive - RHEA Group\Documents\RequirementExport\_20240806\_145251-mod.reqif

Reference Value:  Id  Name

Deletion Behavior:  Soft  Hard

Element Id	Stereotype
Launcher User Manual	Specification
4.2.1	ESARRequirement
4.2.2	ESARRequirement
4.2.3.42	ESARRequirement
4.2.3.1	ESARRequirement
4.2.3.2.a	ESARRequirement
4.2.3.5	ESARRequirement
5.3.1	ESARRequirement
J-1	Justification
J-2	Justification
4.2.3.2.b	ESARRequirement

4.2.3.5 Summary

Message  
Value Text will be updated

Represents the current pre-mapping for each Element.  
The color coding is the following :  
Black : Element that won't be updated  
Blue : Element that will be updated  
Green : Element that will be created

Warnings will be discarded during the import

On Soft deletion, Requirement Status will be set to 'Rejected'. Other elements are unchanged.  
On Hard deletion, elements are removed from the model.

Export Warnings

	A	B	C
1	Id	Stereotype	Issue(s)
2	Justification2	Justification	The Alias of the Justification with Id Justification2 is not set



# Traceability of Requirements

From one package, for each justification, what requirements are justified.

Launcher User Manual	"Justifies" Launcher User Manual	"Justifies" Pointing Specification
J-1	4.2.3.5	
J-2		9

For each requirement, which requirements it derives to in the different packages.

Launcher User Manual	"Derives to" Pointing Specification	"Derives to" Data Exchange Specification
4.2.1		
4.2.2		
4.2.3.1	9	
4.2.3.2.a		
4.2.3.2.b		
		6
4.2.3.5		10
5.3.1	9	10



# Change Log - Color change

- ChangeLog-20240913\_160541
- «block» ChangeLog-MBSE Demonstrator\99. Requirement\Specification\Data Exchange Specification
- «block» ChangeLog-MBSE Demonstrator\99. Requirement\Specification\Environmental Specification
- «block» ChangeLog-MBSE Demonstrator\99. Requirement\Specification\GenSRD
- «block» ChangeLog-MBSE Demonstrator\99. Requirement\Specification\Launcher User Manual
- «block» ChangeLog-MBSE Demonstrator\99. Requirement\Specification\Mission Analysis Guidelines
- «block» ChangeLog-MBSE Demonstrator\99. Requirement\Specification\Pointing Specification

**Block (ChangeLog-MBSE Demonstrator\99. Requirement\Specification\Data Exchange Specification)**

date 20240913\_160541

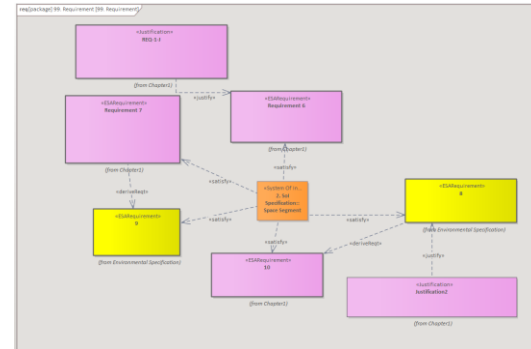
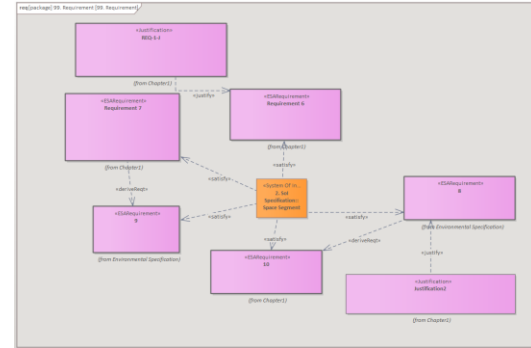
elementId MBSE Demonstrator\99. Requirement\Specification\Data Exchange S.

elementStereotype Specification

elementType Package

reason Modification

Element Id	Stereotype	Type	Date	Reason
MBSE Demonstrator\99. Requirement\Specification\Data Exchange Specification	Specification	Package	20240913_160541	Modification
MBSE Demonstrator\99. Requirement\Specification\Environmental Specification	Specification		20240913_160541	Deletion
MBSE Demonstrator\99. Requirement\Specification\GenSRD	Specification		20240913_160541	Deletion
MBSE Demonstrator\99. Requirement\Specification\Launcher User Manual	Specification		20240913_160541	Deletion
MBSE Demonstrator\99. Requirement\Specification\Mission Analysis Guidelines	Specification		20240913_160541	Deletion
MBSE Demonstrator\99. Requirement\Specification\Pointing Specification	Specification		20240913_160541	Deletion



# Model Validation

```
System Output
System Job History Script ESA SysML Plugin

Validation of the model in progress...
Verification that all 'User Need' are the target of at least 1 'respond' relationship succeeded
Verification that all 'Justification' are the origin of at least 1 'justify' relationship succeeded
Verification that all 'Exchange Item' are the origin of at most 1 relationship succeeded
Verification that all 'External System' are the origin of at most 1 relationship succeeded
Verification that all 'External System' are the origin of at most 1 'interact' relationship succeeded
Verification that all 'External System Function' are the origin of at least 1 and at most 1 'allocate' relationship failed:
1. Rule violation for Element 'Model\MBSE Demonstrator\3. Functional Specification\3.1. Function Tree\External System Functions\Analyse Coastal Coverage': 'Number of connector allocate found: 0, minimum required: 1'
2. Rule violation for Element 'Model\MBSE Demonstrator\3. Functional Specification\3.1. Function Tree\External System Functions\Analyse Ground Station': 'Number of connector allocate found: 0, minimum required: 1'
3. Rule violation for Element 'Model\MBSE Demonstrator\3. Functional Specification\3.1. Function Tree\External System Functions\Analyse Land-Ice Coverage': 'Number of connector allocate found: 0, minimum required: 1'
4. Rule violation for Element 'Model\MBSE Demonstrator\3. Functional Specification\3.1. Function Tree\External System Functions\Receive TC': 'Number of connector allocate found: 0, minimum required: 1'
5. Rule violation for Element 'Model\MBSE Demonstrator\3. Functional Specification\3.1. Function Tree\External System Functions\Analyse Science Target Coverage': 'Number of connector allocate found: 0, minimum required: 1'
6. Rule violation for Element 'Model\MBSE Demonstrator\3. Functional Specification\3.1. Function Tree\External System Functions\Analyse Sea-Ice Coverage': 'Number of connector allocate found: 0, minimum required: 1'
7. Rule violation for Element 'Model\MBSE Demonstrator\3. Functional Specification\3.1. Function Tree\External System Functions\Validate Solar Array Dynamics': 'Number of connector allocate found: 0, minimum required: 1'
8. Rule violation for Element 'Model\MBSE Demonstrator\3. Functional Specification\3.1. Function Tree\External System Functions\Transmit TM': 'Number of connector allocate found: 0, minimum required: 1'
Verification that all 'Function' are the origin of at most 1 relationship succeeded
Verification that all 'Functional Chain' are the target of at least 1 'participate' relationship succeeded
Verification that all 'Product' are the origin of at most 1 relationship succeeded
Verification that all 'Stakeholder' are the origin of at most 1 relationship succeeded
Verification that the model contains at most 1 'LO Product' succeeded
Verification that the model contains at most 1 'LO Function' succeeded
Verification that the model contains at most 1 'System Of Interest' succeeded
Verification that the model contains at least 1 'Space System' succeeded
Validation of the model finished...
Model Validation Summary:
14 Rules checked
4 Objects verified
87 Relationships verified
8 Error(s) found
```

# Conclusion




# Dissemination

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- MBSE 2024 Conference (Paper + Presentation)
  - Scope: Interfaces and validation domains
  
- IAC 2024 Conference (Article + Presentation)
  - Scope: The building of the ESA SysML solution.

# Conclusion

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Profiles implementation



Examples in Cameo and EA



Maintenance manual



Methodology pages



Data Model



Enterprise Architect Plugin

# ESA SysML Solution availability

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The ESA SysML Solution can be found on the European Space Software Repository, to companies of ESA Member States :

<https://essr.esa.int/project/esa-sysml-solution>



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