Vers une approche "model-based system engineering »

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What is MBSE ?

Domain models as the primary means of information exchange and single source of engineering truth

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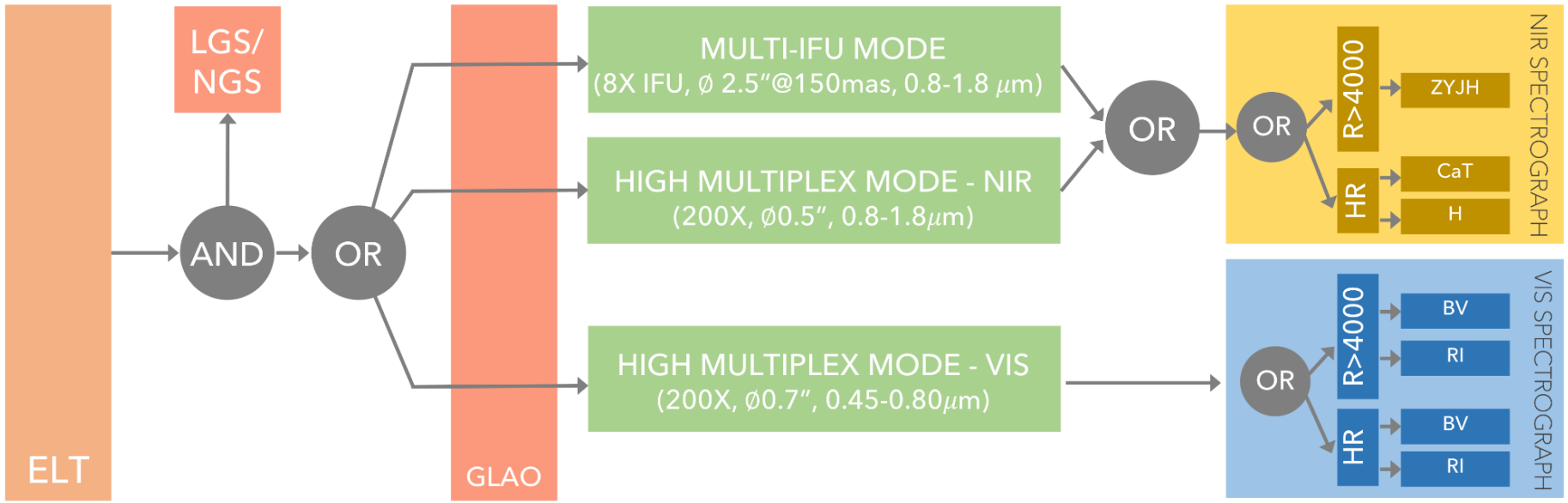
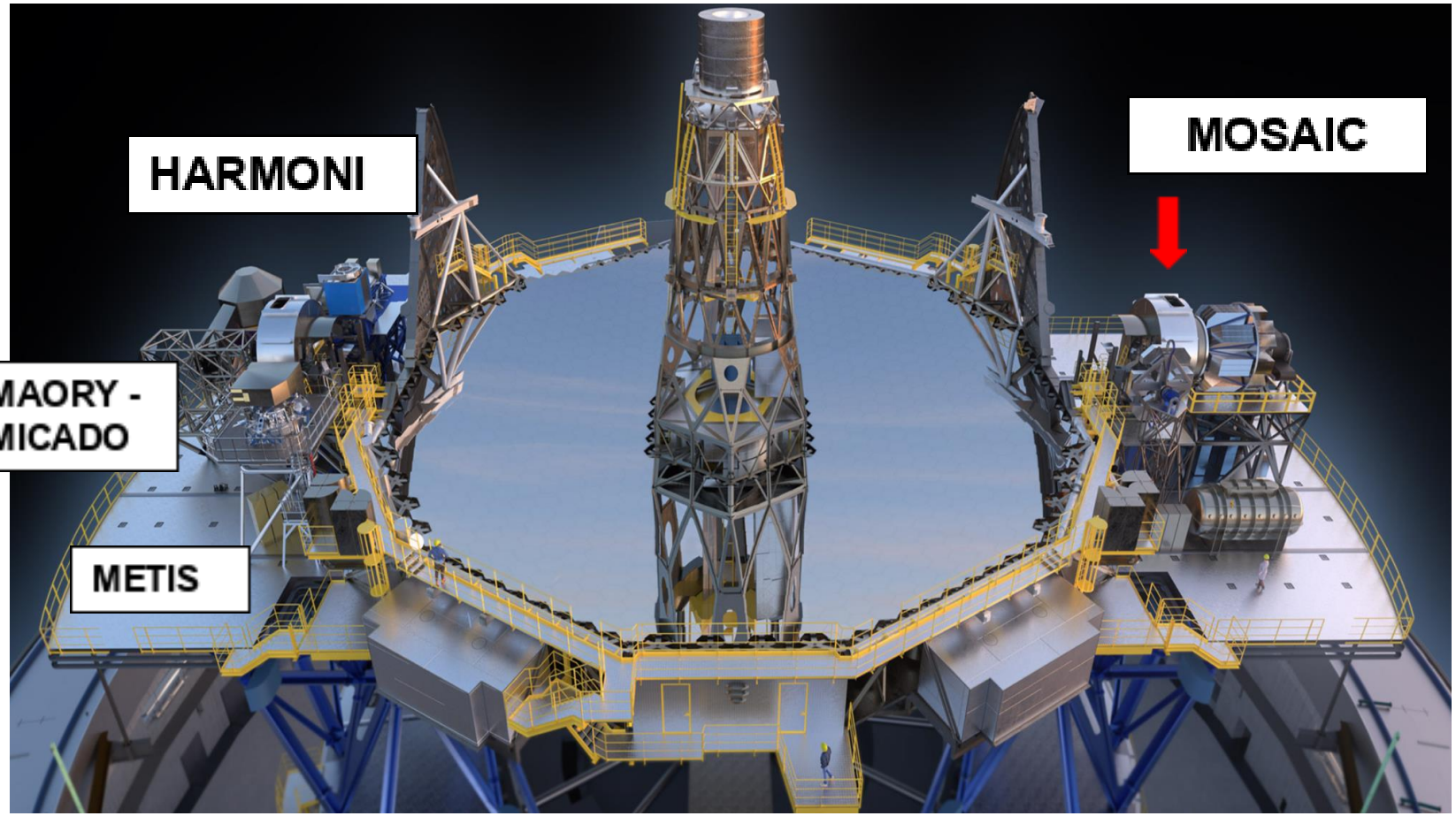
01 MOSAIC in a nutshell

MOSAIC is a versatile Multi-Object Spectrograph, to be located at one of the Nasmyth ports of the Extremely Large Telescope.

- Two types of observations: multi object spectroscopy (MOS) and multi-integral field Units (mIFU)
- Covers 0.39 to 1.8 microns at R~5 000 and 4 High Resolution bands (R~18 000)
- Widest possible FoV provided by the ELT (~40 arcmin²)
- Parallele observations with VIS and NIR spectrographs (6 modes)



01 MOSAIC in a nutshell



40 Tons

- 6 mastodons

11m X 7m

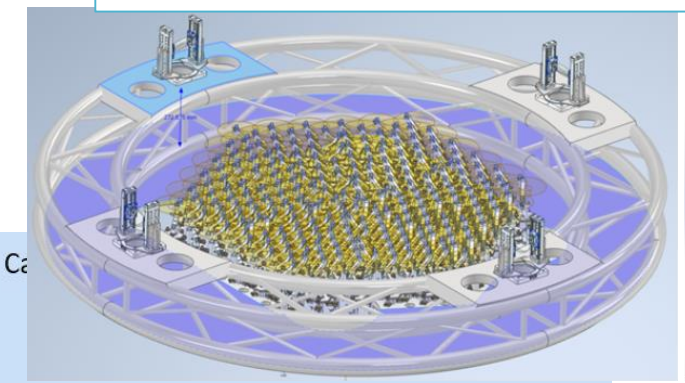
– 2 Petanque fields

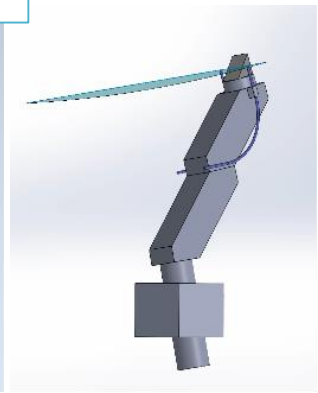
Height 8m

- 1.5 Giraffe or
- 13 baguettes

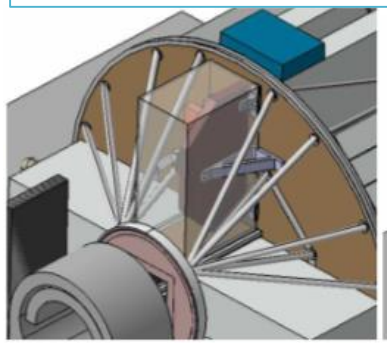
01 MOSAIC in a nutshell

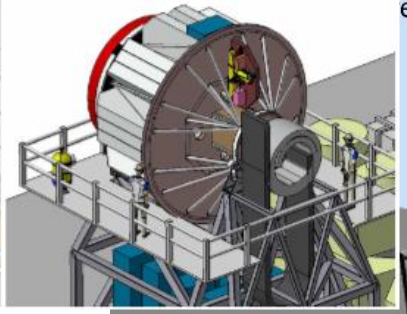
Focal plane with 300 robots

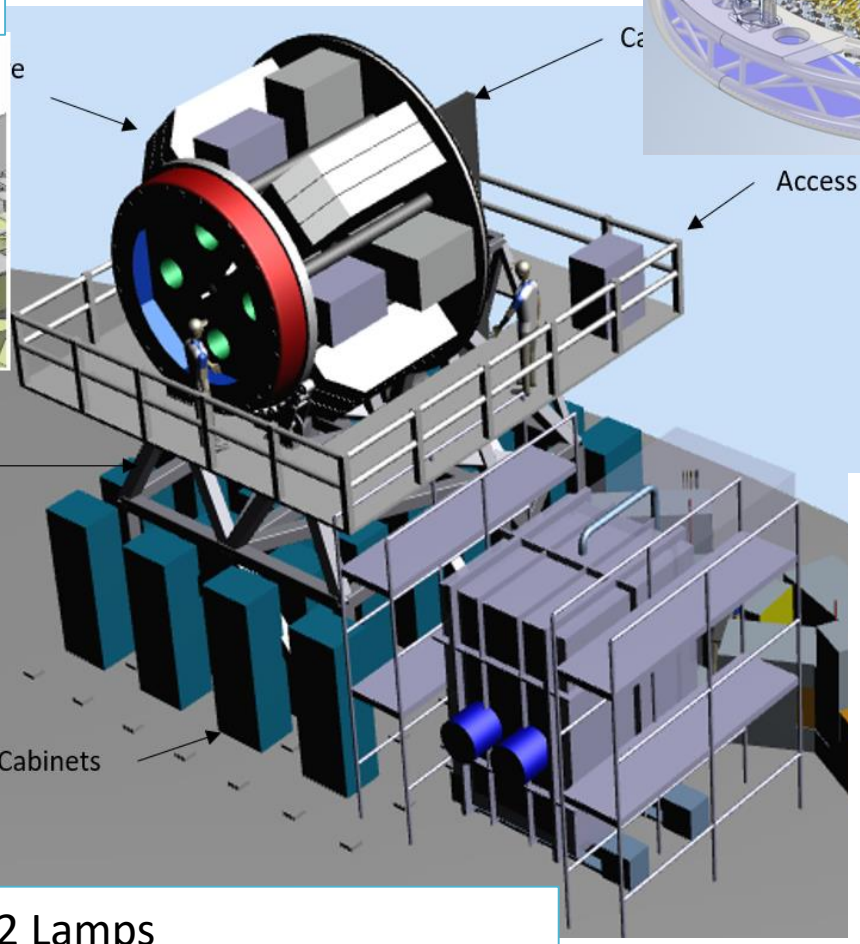




Ground layer Adaptive optics system

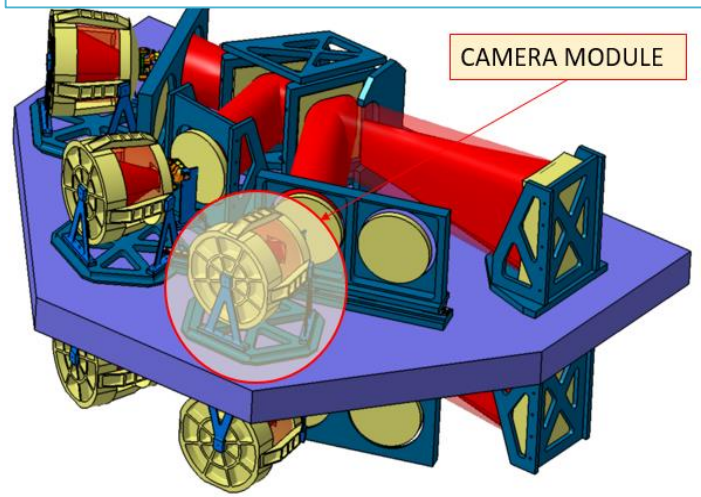






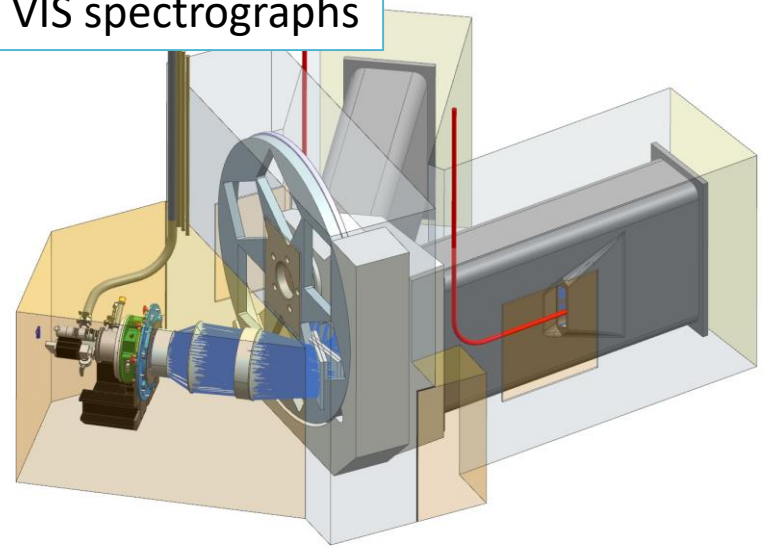
7 438 Fibers
Total ~200 km

3 channel NIR spectrograph x2
Large Cryostat 130K



32 Lamps
1057 Moving devices
400 sensors

2 VIS spectrographs



01 MOSAIC ELT in numbers

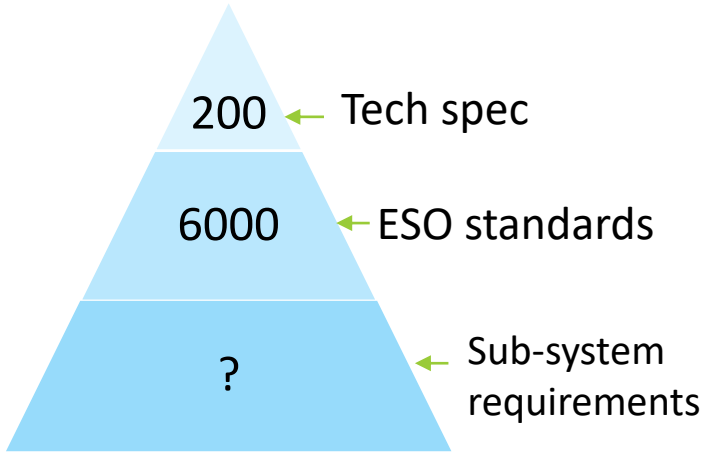
07 Systems

27 Sub-systems

~200? Internal interfaces

06 Observing modes

15 Spectral configurations



12 Countries

20 Work Packages

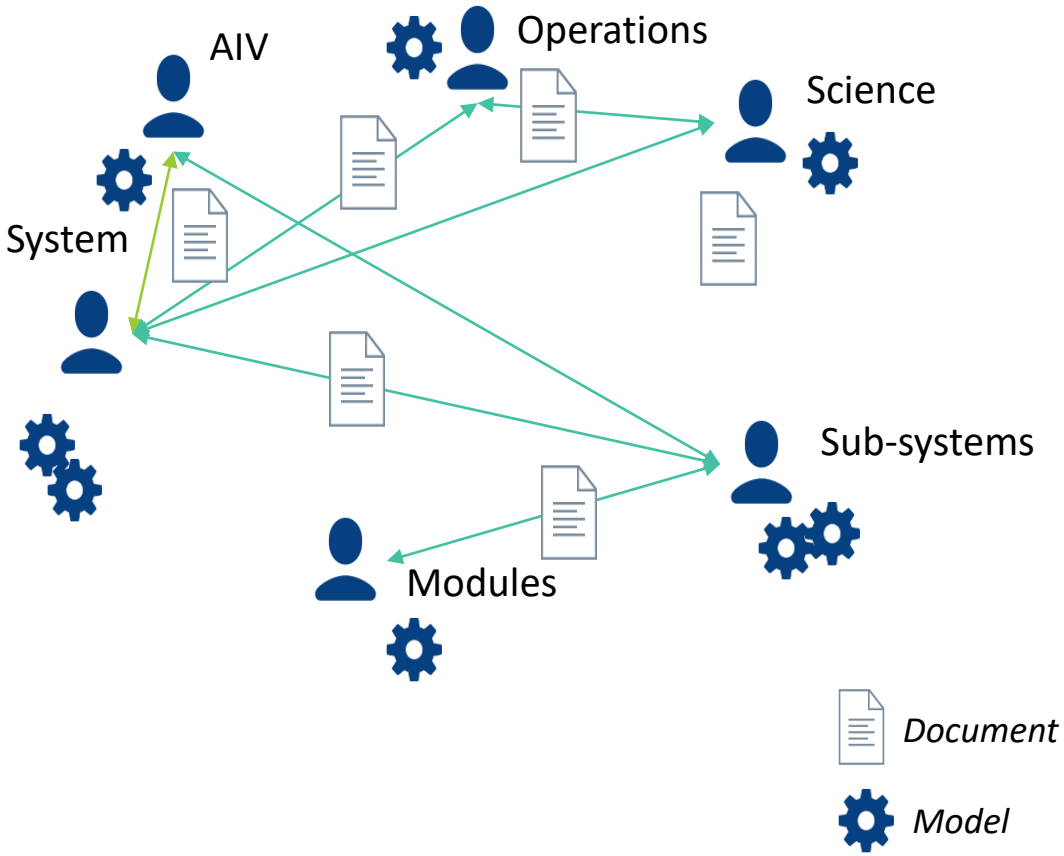
13 Labs provinding hardware

700 FTE over ~10 years

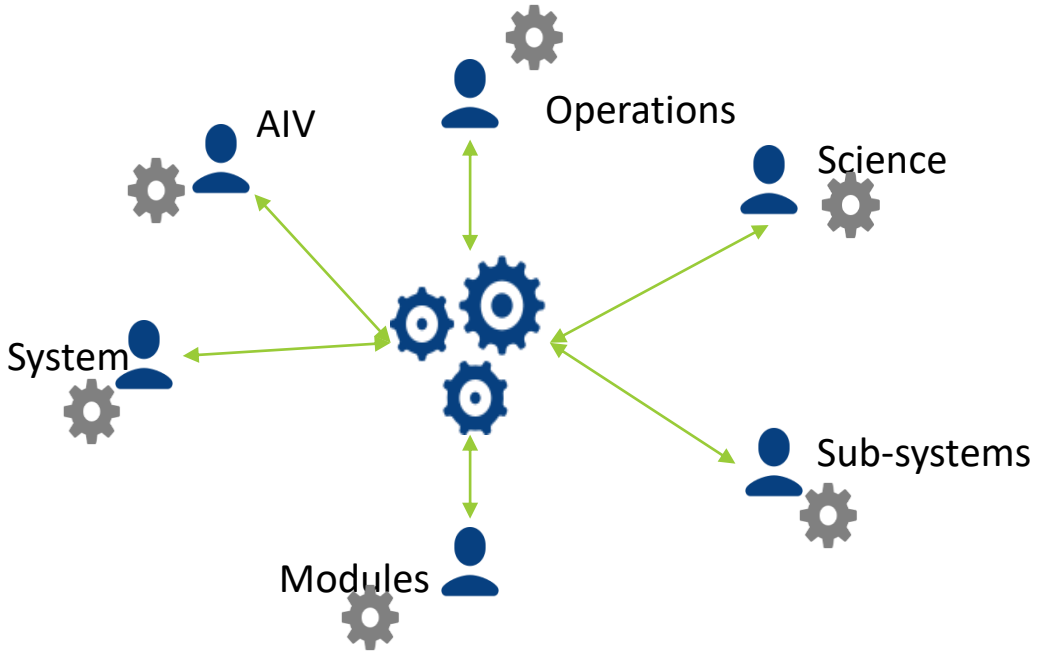
02 Why Moving towards Model-based SE?

Limitation of traditional document-based system engineering

- Using documentation to manually manage SE data, information and knowledge is exceptionally labor-intensive and error-prone for complex systems
- Implicit dependencies between documents
- Ineffective for producing and sharing SE knowledge via voluminous documentation
- Exceptionally difficult to assess impact of changes in complex solutions



02 Why Moving towards Model-based SE?



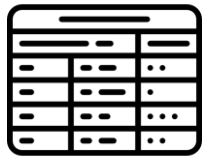
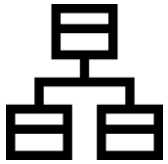
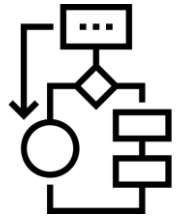
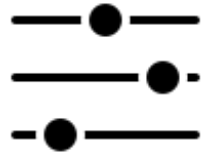
- Shared system model with multiple views, and connected to discipine models
- Single source of engineering truth
- Rapidly analyze the impact of changes
- Standardized environment/methodology that provides linkage, rules, metrics and views of engineering artifacts created to define, solve, and manage problems and solutions of high complexity

02 Are teams ready for the change?

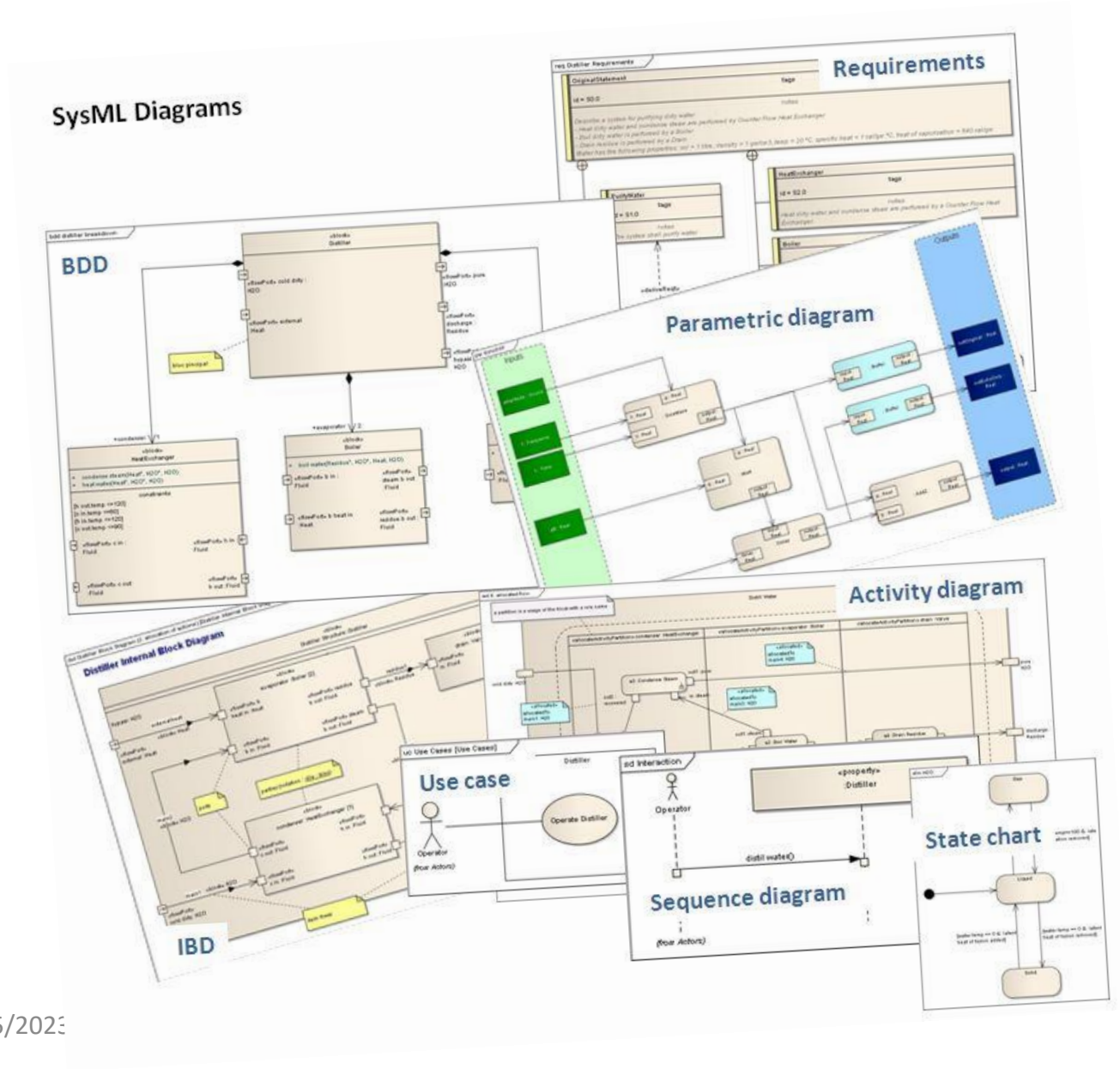
YES !

- Teams are exhausted by project with tremendous volume of documentation. E.g. *Harmoni PDR documents would have literally weigthed 1T if printed in A4 format*
- Domain engineering rely heavely on models
- Already procedures to integrate domain models and cross-domain models (e.g Zemax and CAD)
- UML diagrams start to be well known by the community
- Variety of software tools available to implement MBSE
- MBSE is a well known process in industry

03 System engineering models

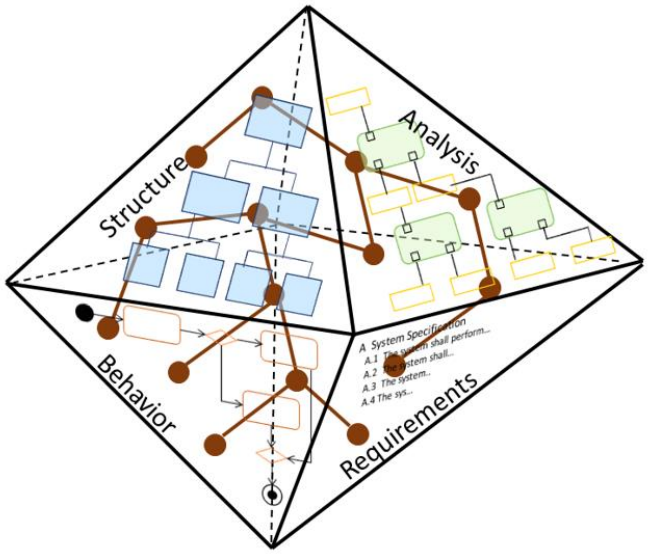
Systems engineering Model			
			
Requirements	**Structure**	**Behavior**	**Parametrics**
• System requirements • Sub-system flowdown • Justification (budgets)	• Product breakdown structure • Interfaces	• Machine state • Functional analysis • Observing sequences	• End-to-end performance • Trade-off analysis

03 System models

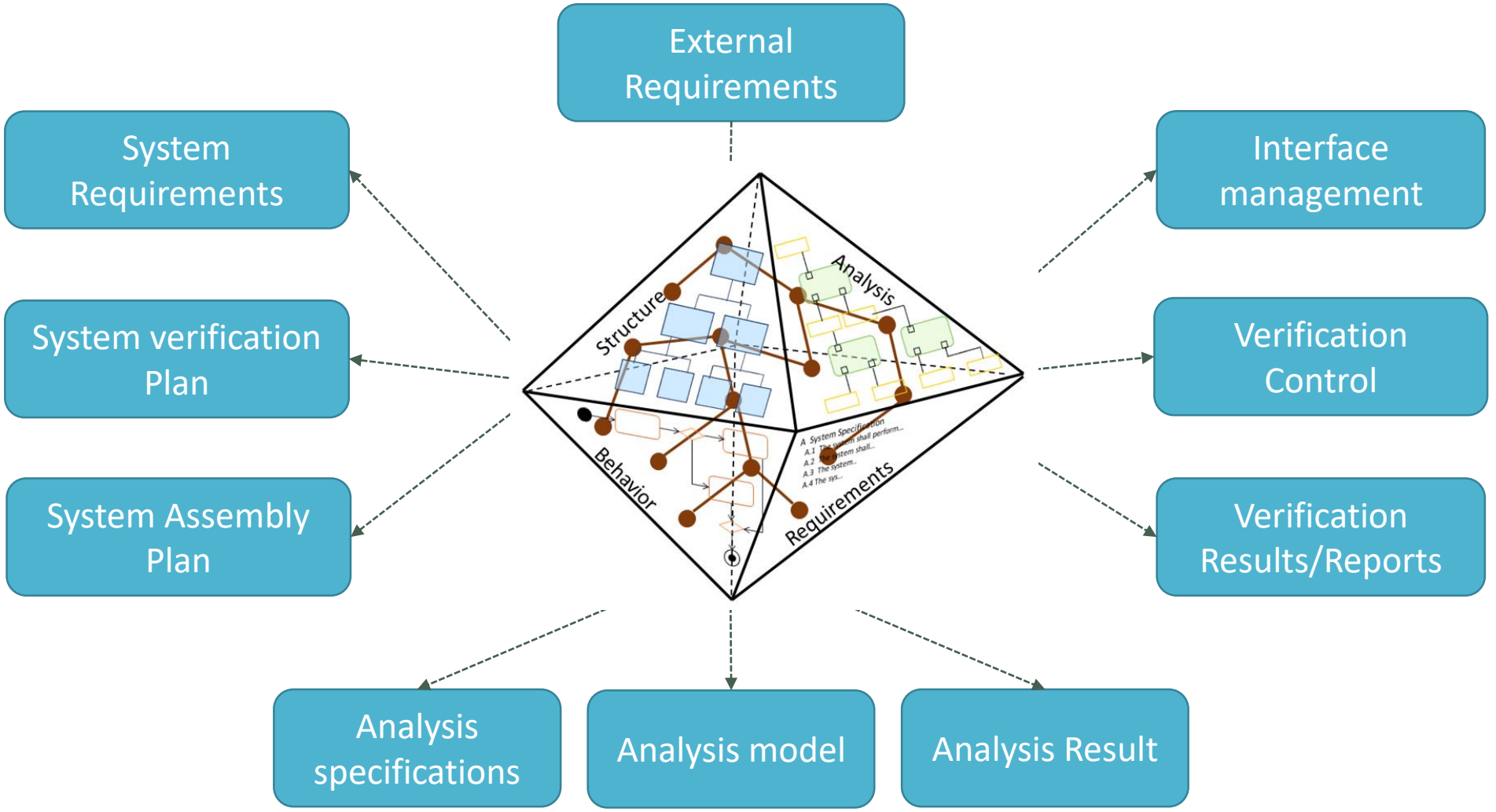


Structure and behaviour models are described in SysML.

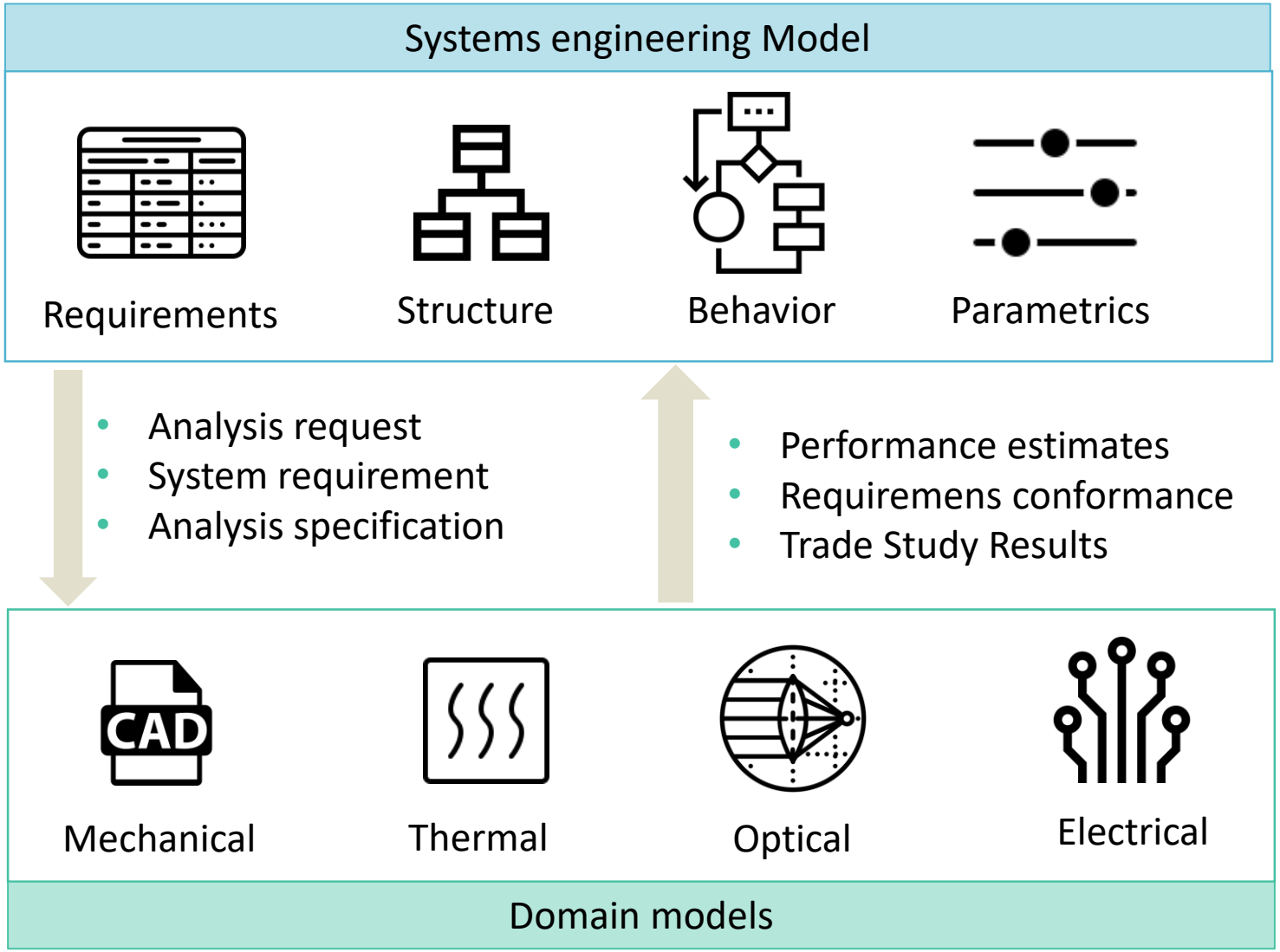
Not just drawings but a holistic model of the instrument



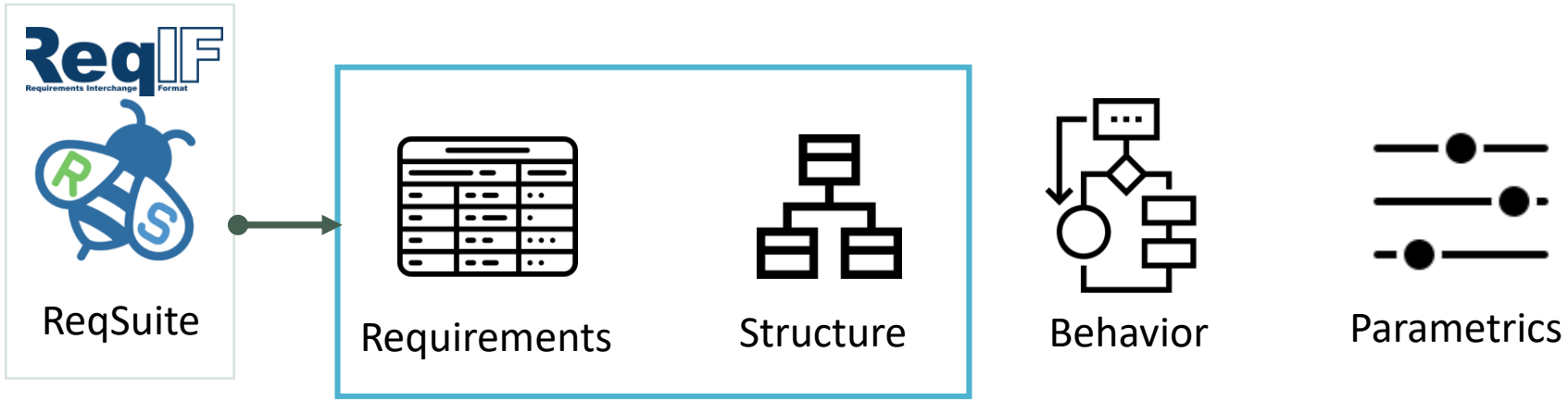
03 System model and Engineering processes



03 System and domain models



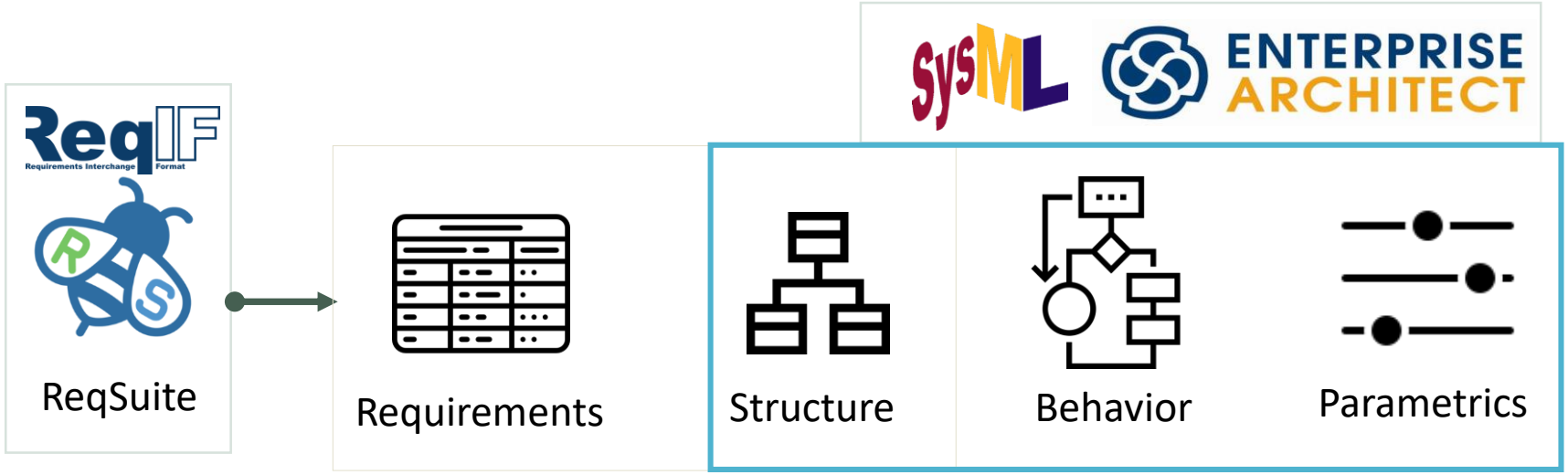
03 System models in practice



Reqsuite by Osseno

- Relational database oriented for requirement management
- Exchange requirements using the ReqIF standard
- Use for requirement management: content, flow-down, traçability, configuration control
- Also use to store the Product breakdown structure
- and much more …
- User access is a webpage with 3 levels of privilege (Manager, worker and reader)
- Server hosted at LAM

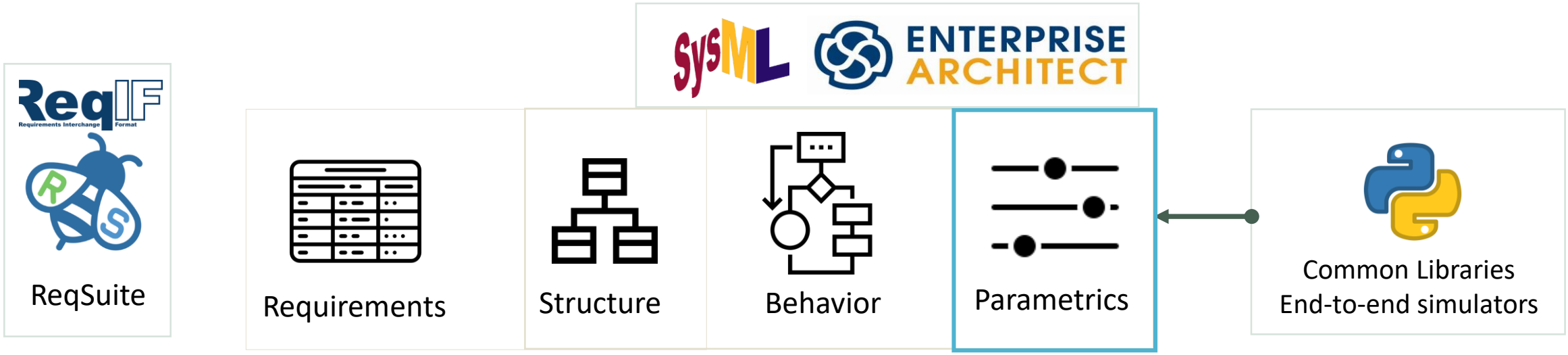
03 System models in practice



Entreprise Architect by Sparx

- Visual modelling tool (UML) supporting SysML
- Exchange models in xmi standard
- Use to model the structure and the behaviour of the system
- Reqsuite – EQ plugin: synchronise the two models. *E.g. use products defined in ReqSuite as building blocks in EA*
- Standalone software to build the model (windows)
- Model can be export as a browsable webpage accessible by all the team

03 System models in practice



Python code and simulators

- Analysis model using common python Libraries hosted in project GitLab repo
- End-to-End simulators (e.g Mosaic ScopeSim)
- Plan to interface EA models and python models through a common instrument database

04 Requirement management tool

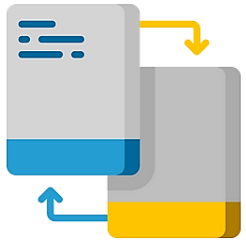
ReqSuite® RM

MANAGING & EDITING

ReqSuite **can manage requirements and related artefacts in a structured manner in freely definable categories**. In addition to text, graphics, file attachments and links to other tools can also be stored.

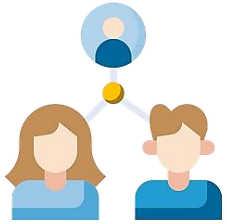
VERSIONING & BASELINING

ReqSuite **automatically saves each modification** so that you can always trace who made which changes and when. ReqSuite also **offers the option of comparing individual version** and resetting them, if necessary.



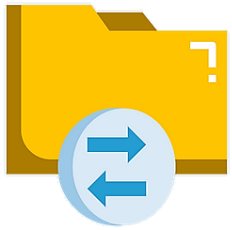
TRACING & ANALYZING

ReqSuite **can maintain semantic links between requirements and related artifacts** and **automatically check them for consistency and completeness.**



COLLABORATING & INTERACTING

ReqSuite **offers numerous functions for collaborative work**. Requirements can be assign to individual user for processing, control access rights via roles and groups, or users can have the opportunity to comment and review.



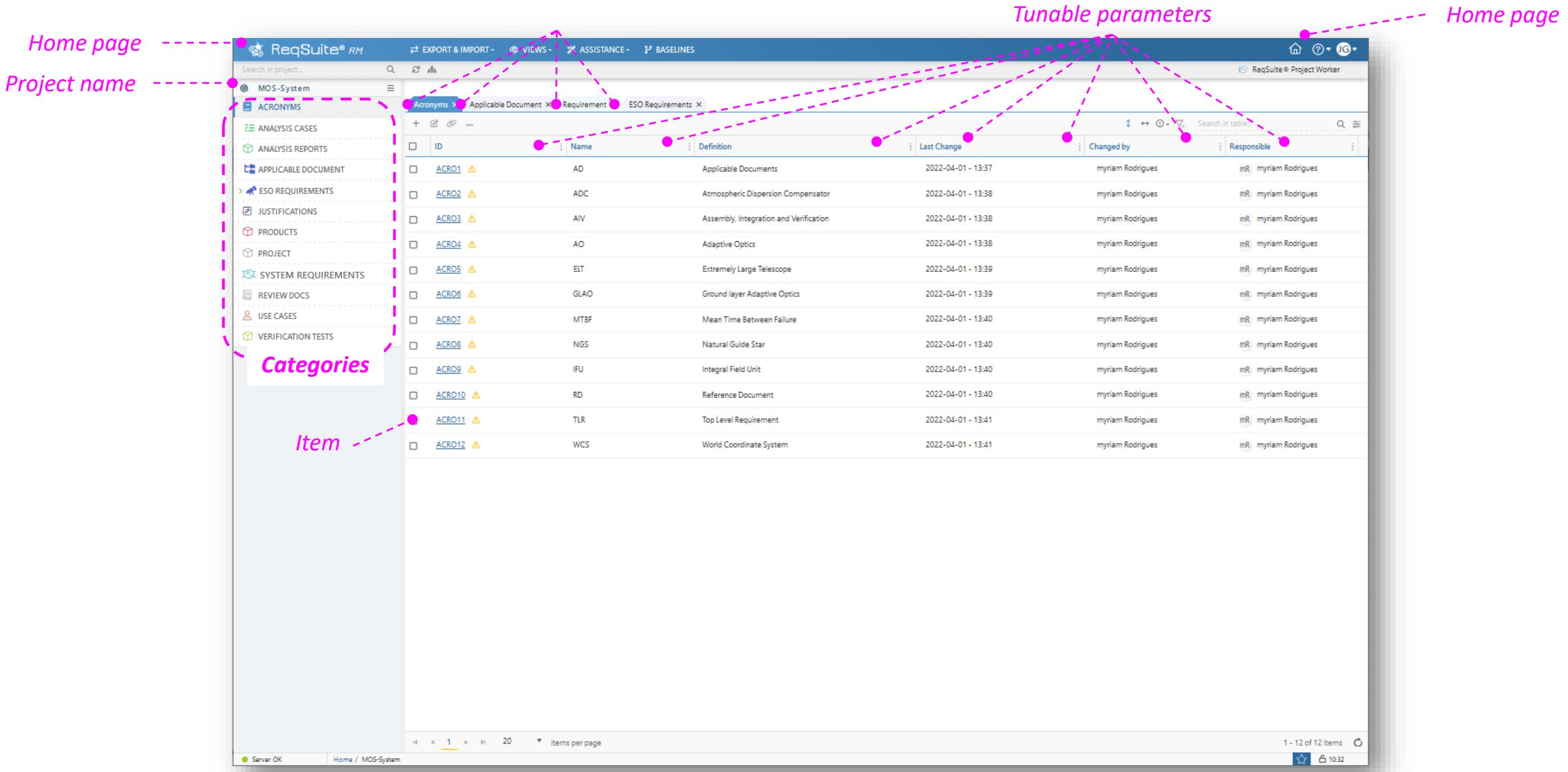
IMPORT, EXPORT & SYNCHRONIZING

All data stored in ReqSuite can be bidirectionally synchronized (ex: Enterprise Architect ; GitLab). **Import and export options** are also available for Word, Excel and ReqIF. Documentation generation from template is available.

CONTROLLING & MONITORING

ReqSuite can define **workflows for reviewing, approving and processing requirements** and use them to control the overall progress in the project.

04 Requirement management tool



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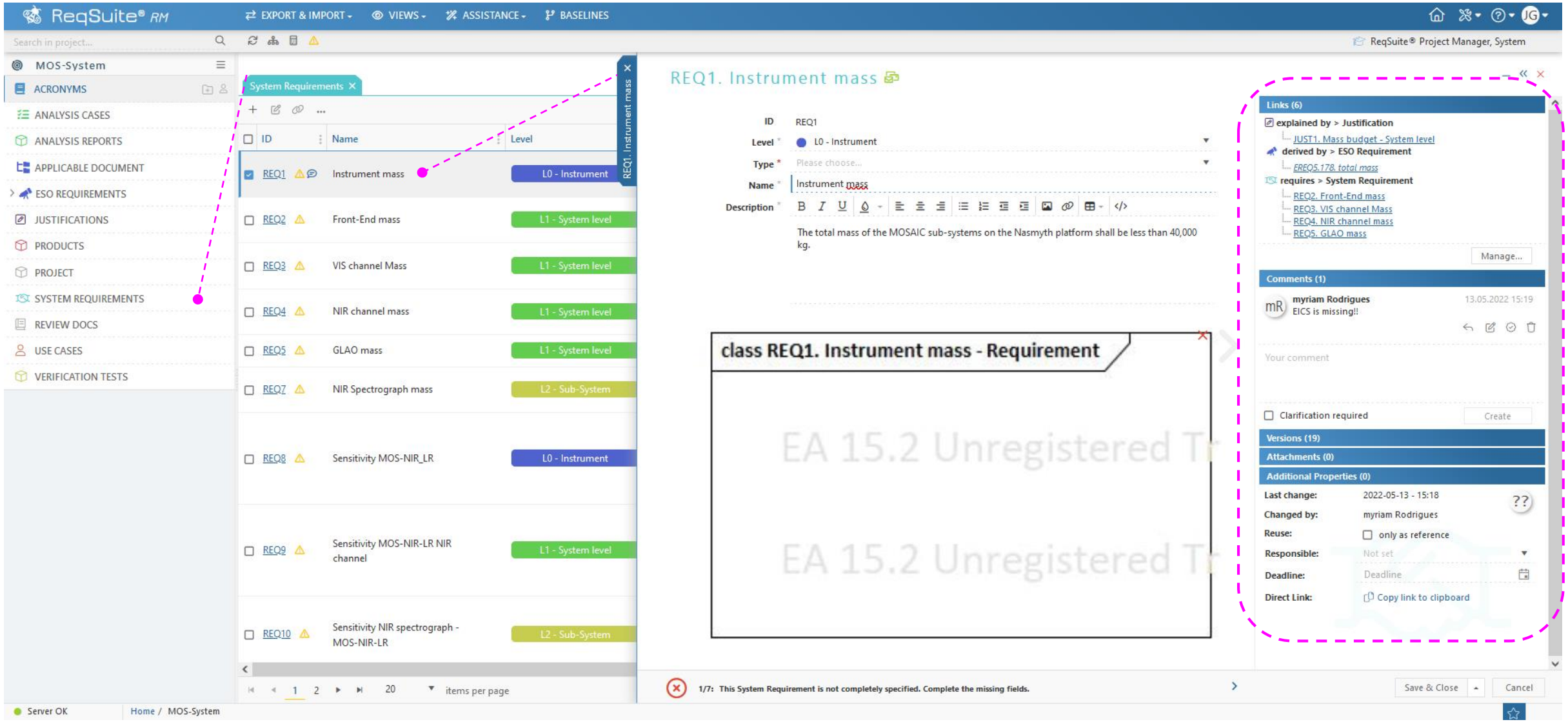

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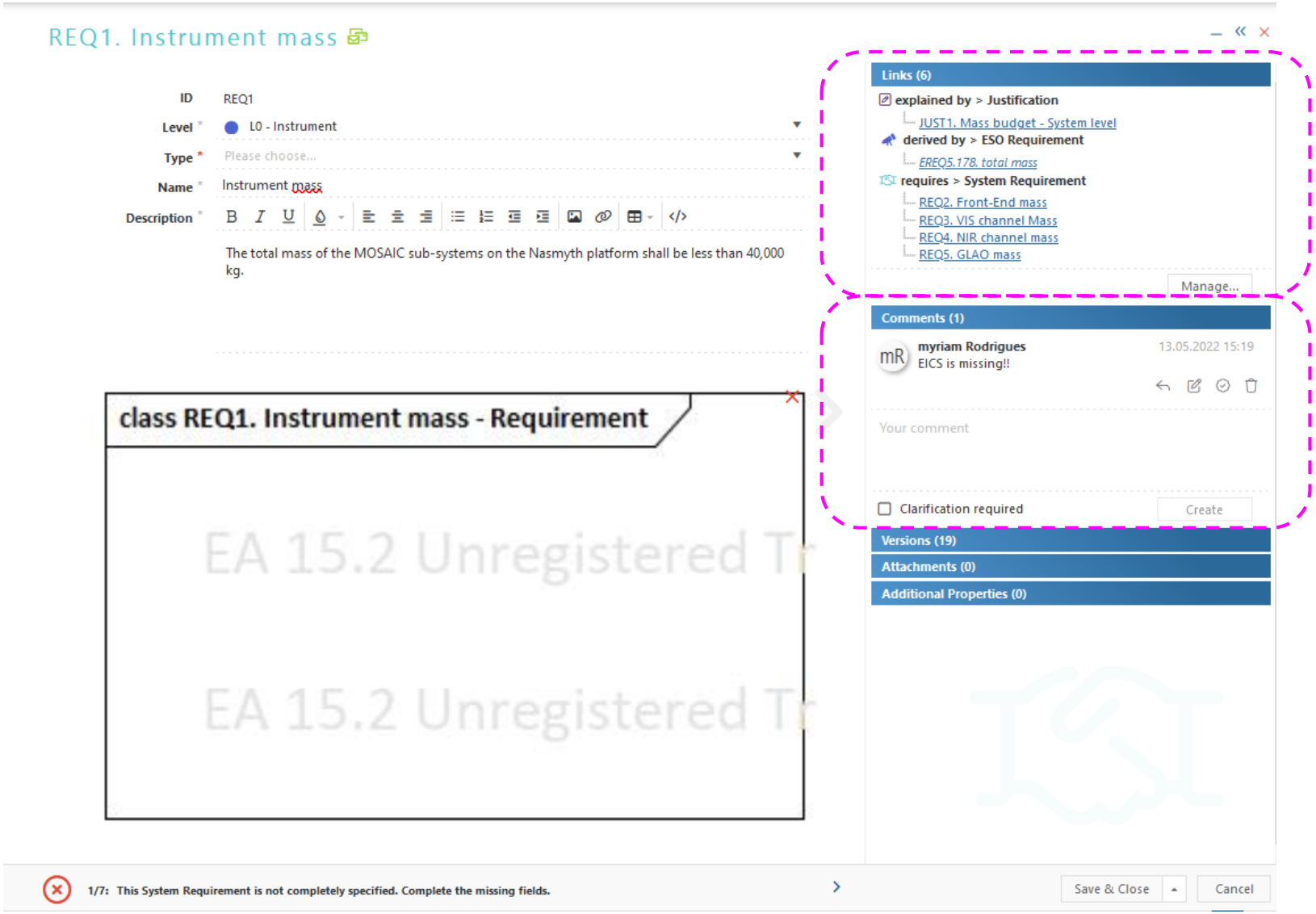
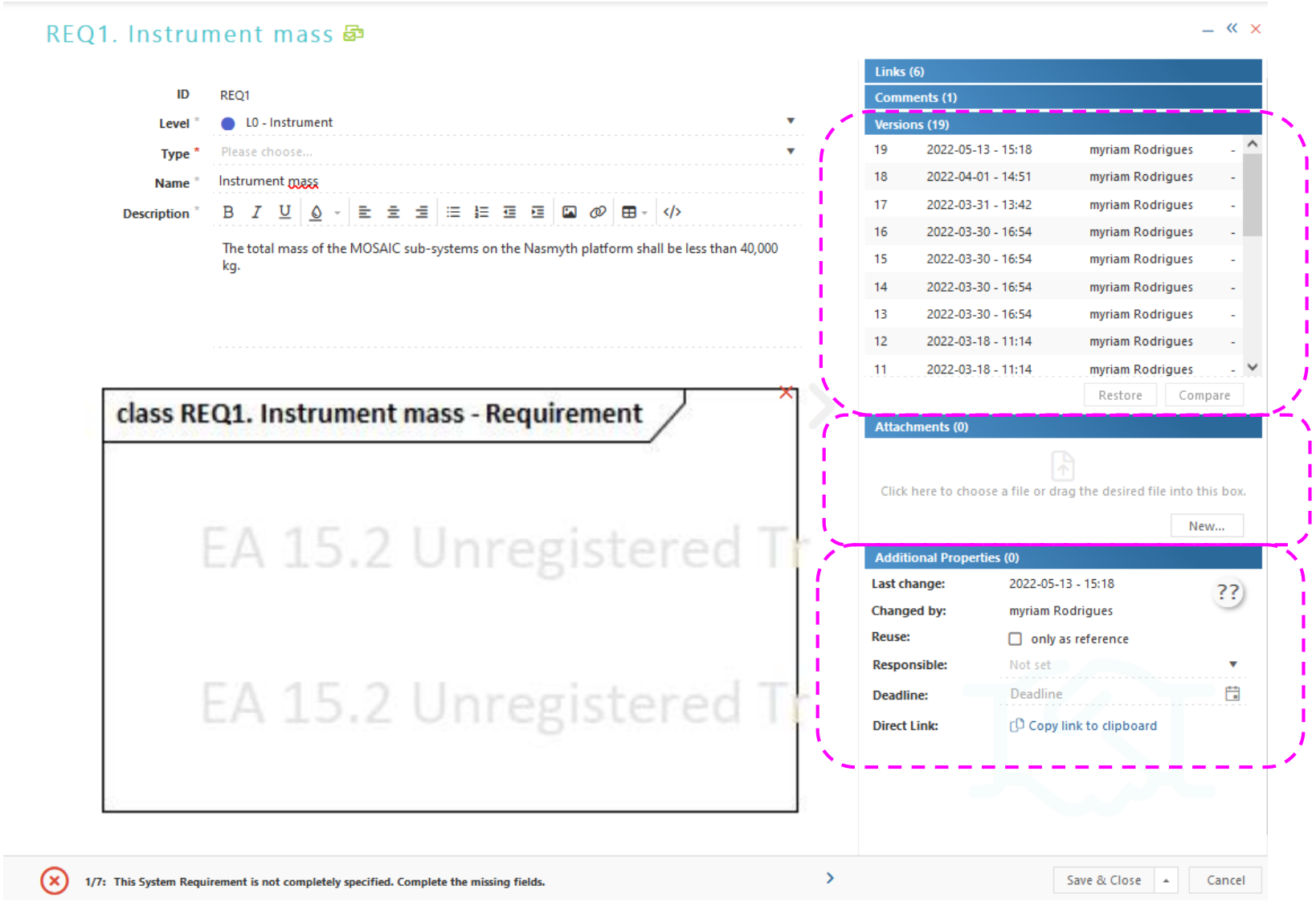


relationships through the project

Comments area

04 Requirement management tool

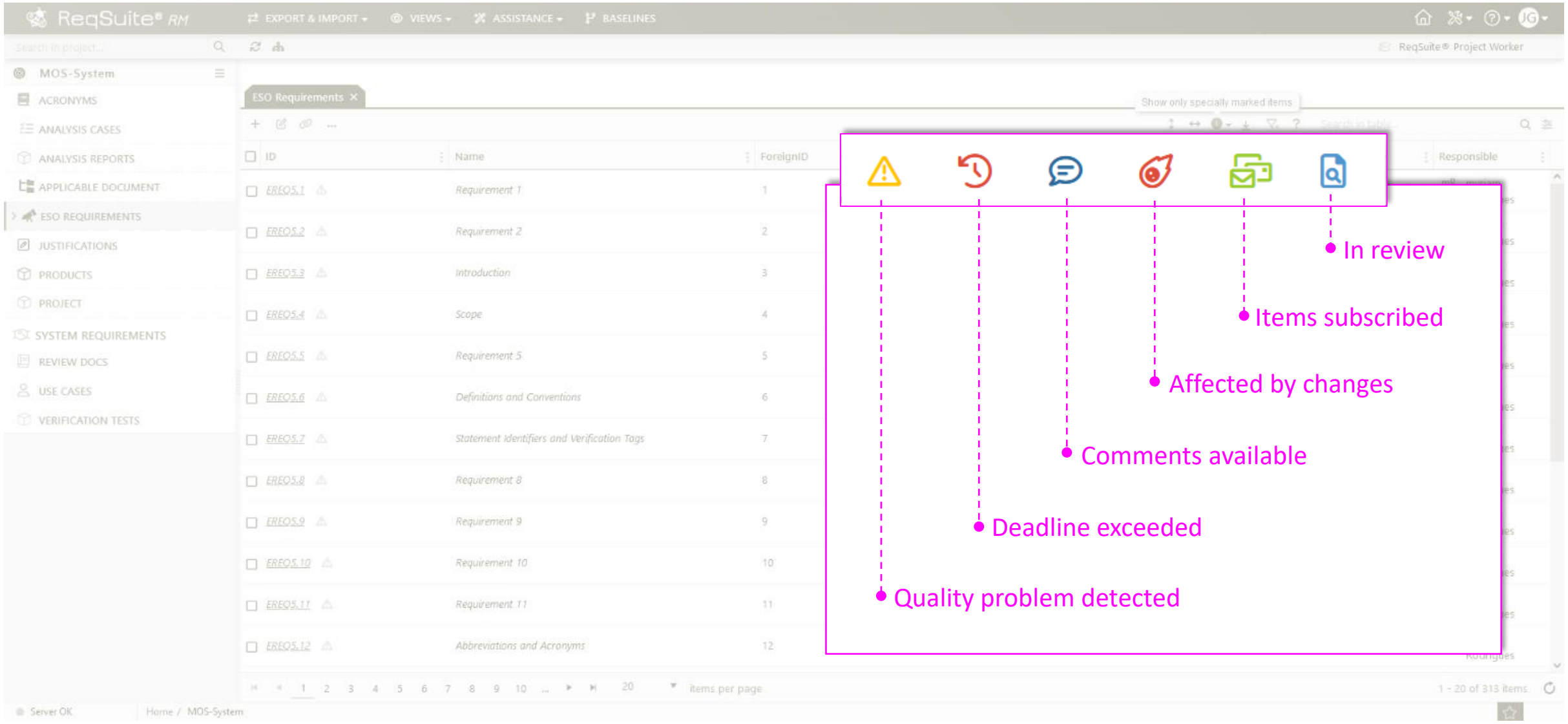


Versioning area

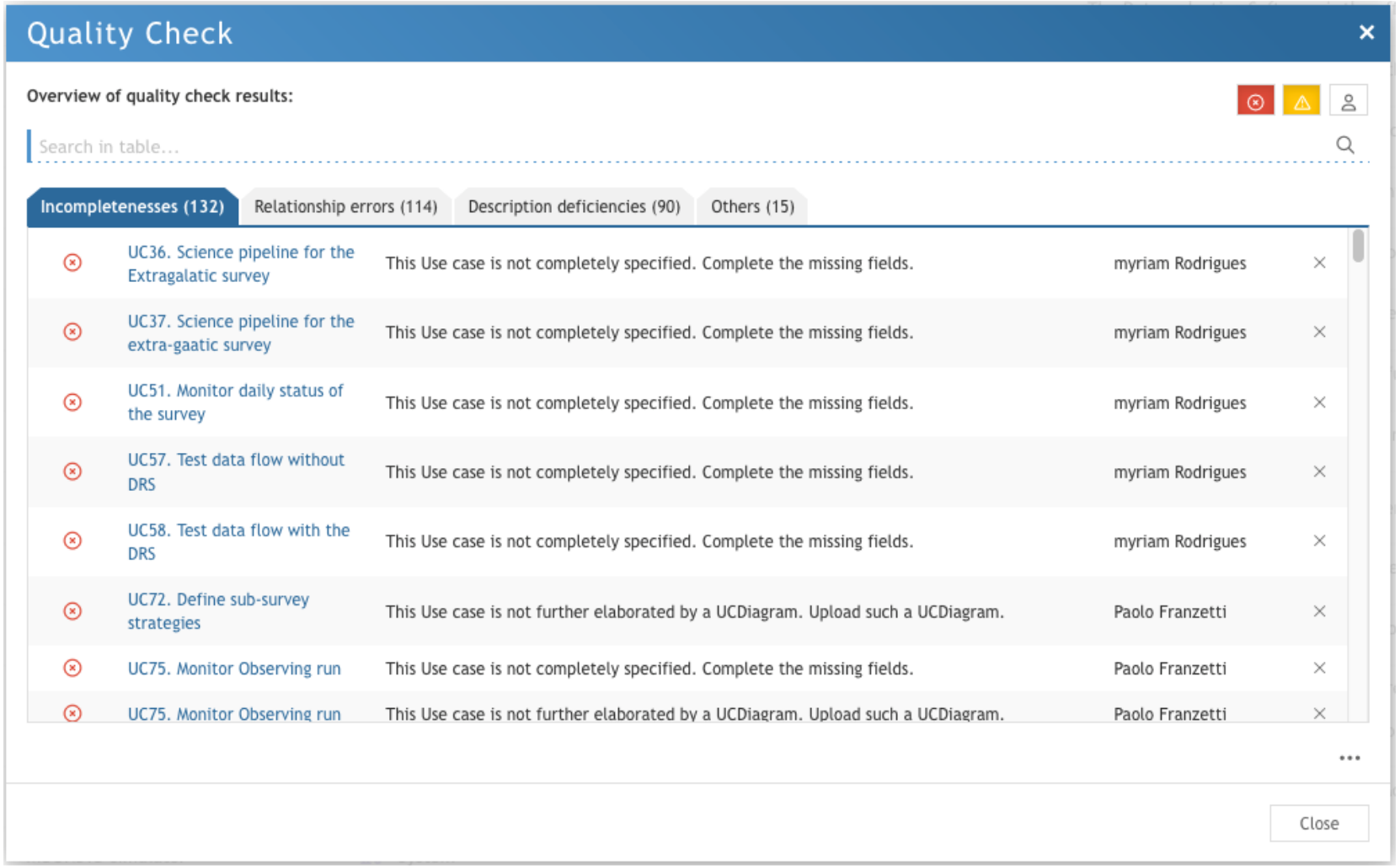
Item attachments aera

Changes indications

04 Requirement management tool

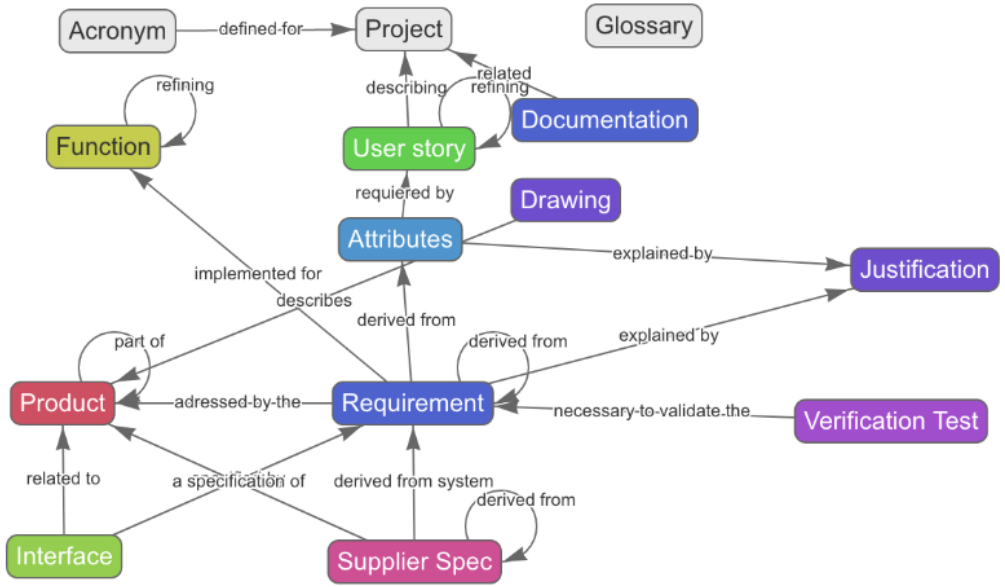


04 Requirement management tool

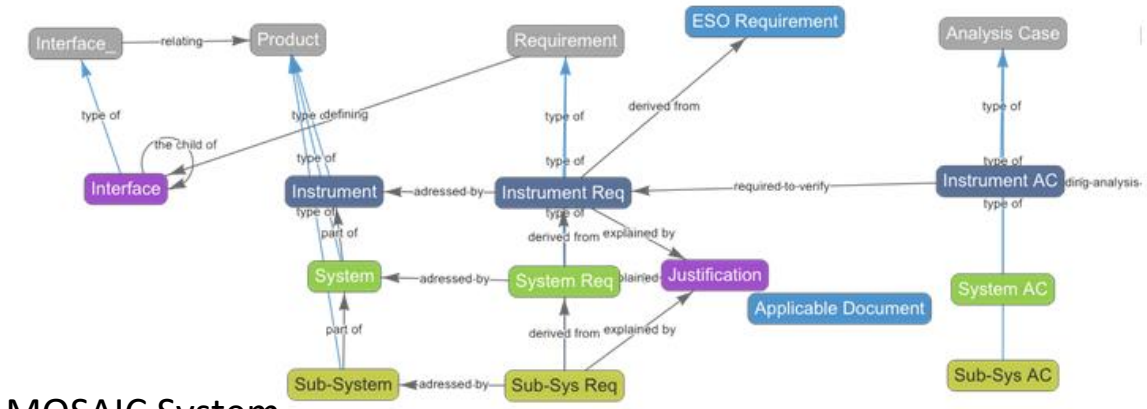


04 Configuration model

- Reqsuite is highly configurable (starting with a blank page)
- Tailor a configuration model that best fit the need

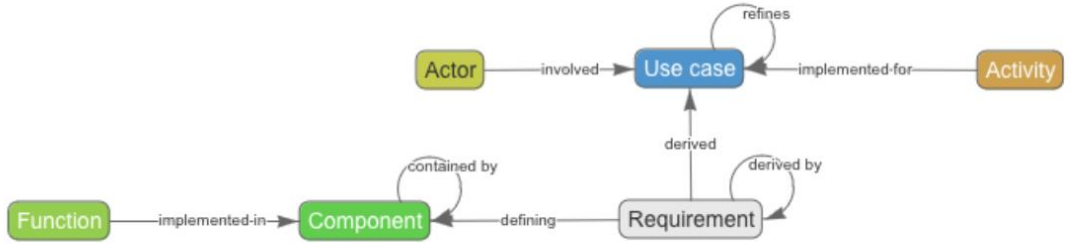


Exemple implementation for a small space instrument

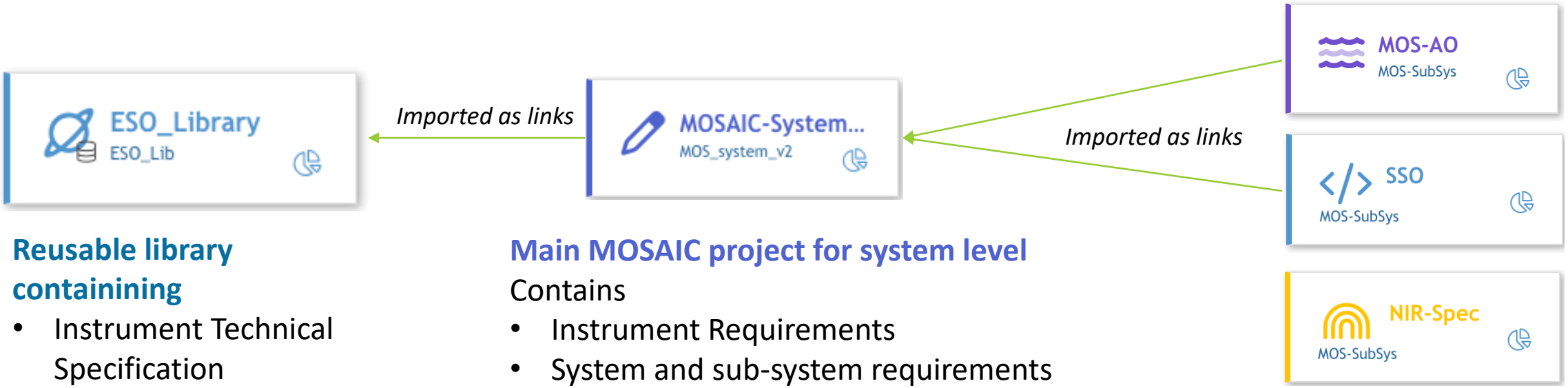


MOSAIC System

MOONS/VLT Data Flow software



04 MOSAIC implementation



Reusable library containining

- Instrument Technical Specification
- ESO Standards
- ESO common interfaces

Import reqif files from ESO

Version comparision

Main MOSAIC project for system level

Contains

- Instrument Requirements
- System and sub-system requirements
- Justification of flow-down (inc. technical budgets)
- Product break down structure
- Interfaces
- Analysis Cases and Reports
- Verification
- Documentation list (generated via the tool)
- Acronyms, glossary

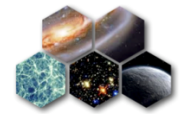
Collection of Sub-system level project

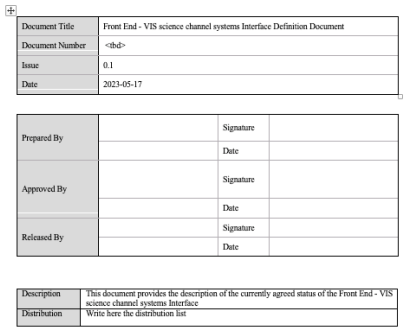
- Sub-system requirements (imported)
- Product break down structure (imported)
- Interfaces (imported)
- …

04 MOSAIC implementation

- Impact analysis
- Generate documentation for reviews

Category	Relationships - Child of	Relationships - Parent of	Generated document
Instrument Requirements	ESO requirements Concept of Operation	Lower-level requirements Verification	• Compliance matrix
System and sub-system requirements	Instrument Requirements Justifications	Supplier specifications	• System/Sub system specification documents • Flow-down justification document
Products	Products	Products	• PBS and BOM
Interfaces	Products	System/sub-system Requirements	• Interface Description document
Analysis Case	Requirement	Analysis Report	
Analysis Report	Analysis Case		• Compliance matrix Analysis reports





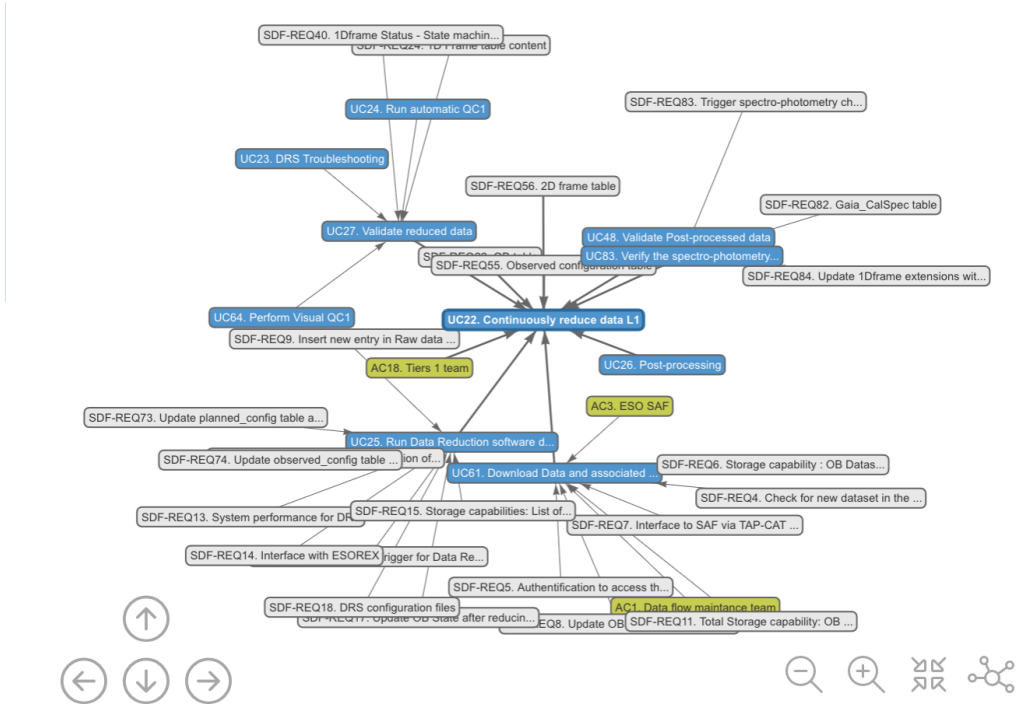
Document Title	Front End - VIS science channel systems Interface Definition Document
Document Number	<tbd>
Issue	0.1
Date	2023-05-17

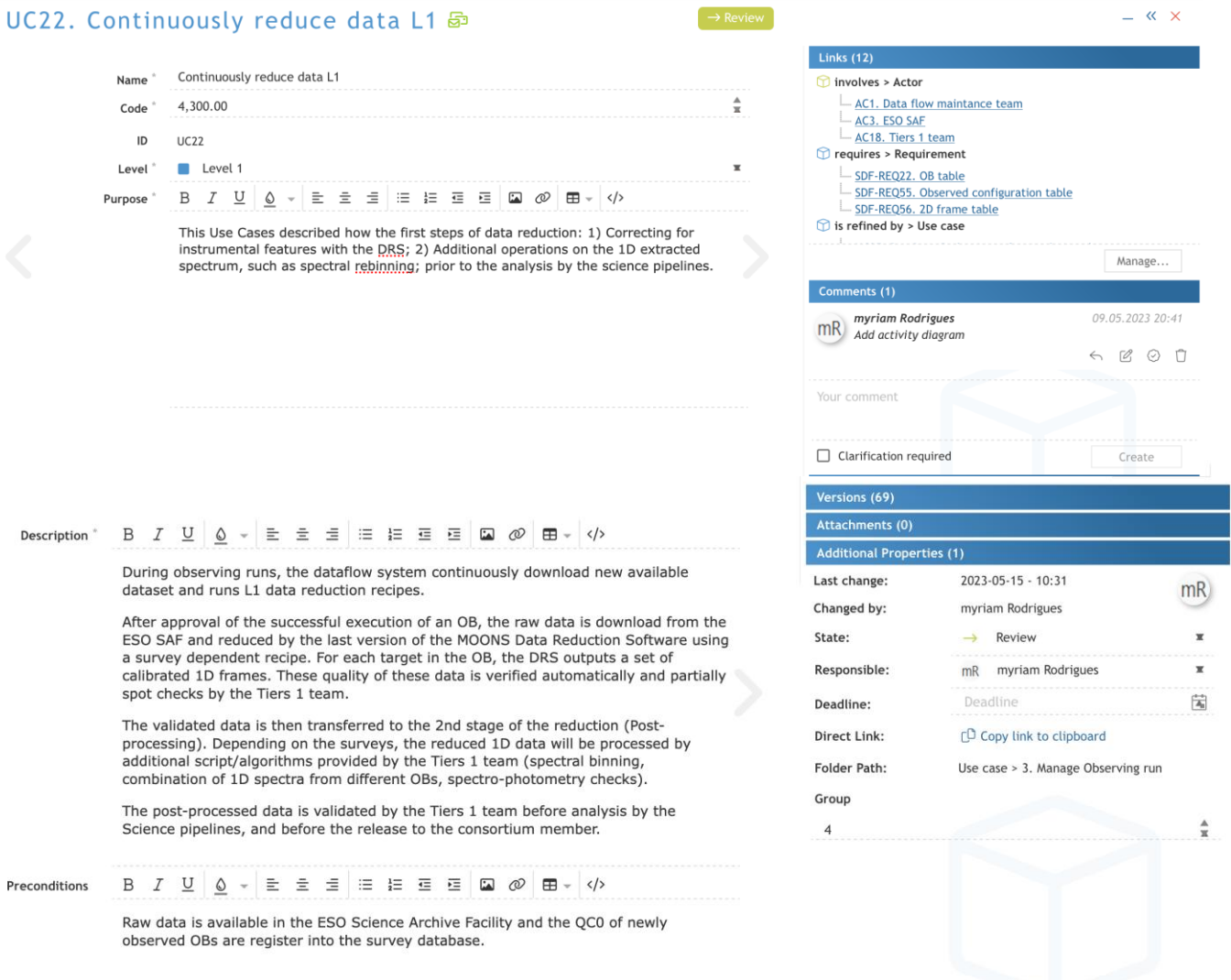
Prepared By		Signature	
		Date	
Approved By		Signature	
		Date	
Released By		Signature	
		Date	

Description	This document provides the description of the currently agreed status of the Front End - VIS science channel systems Interface
Distribution	Write here the distribution list

04 MOONS implementation

- Defining requirements for a data flow tool for the MOONS GTO survey
- Software devloppement approach-based on Use Cases

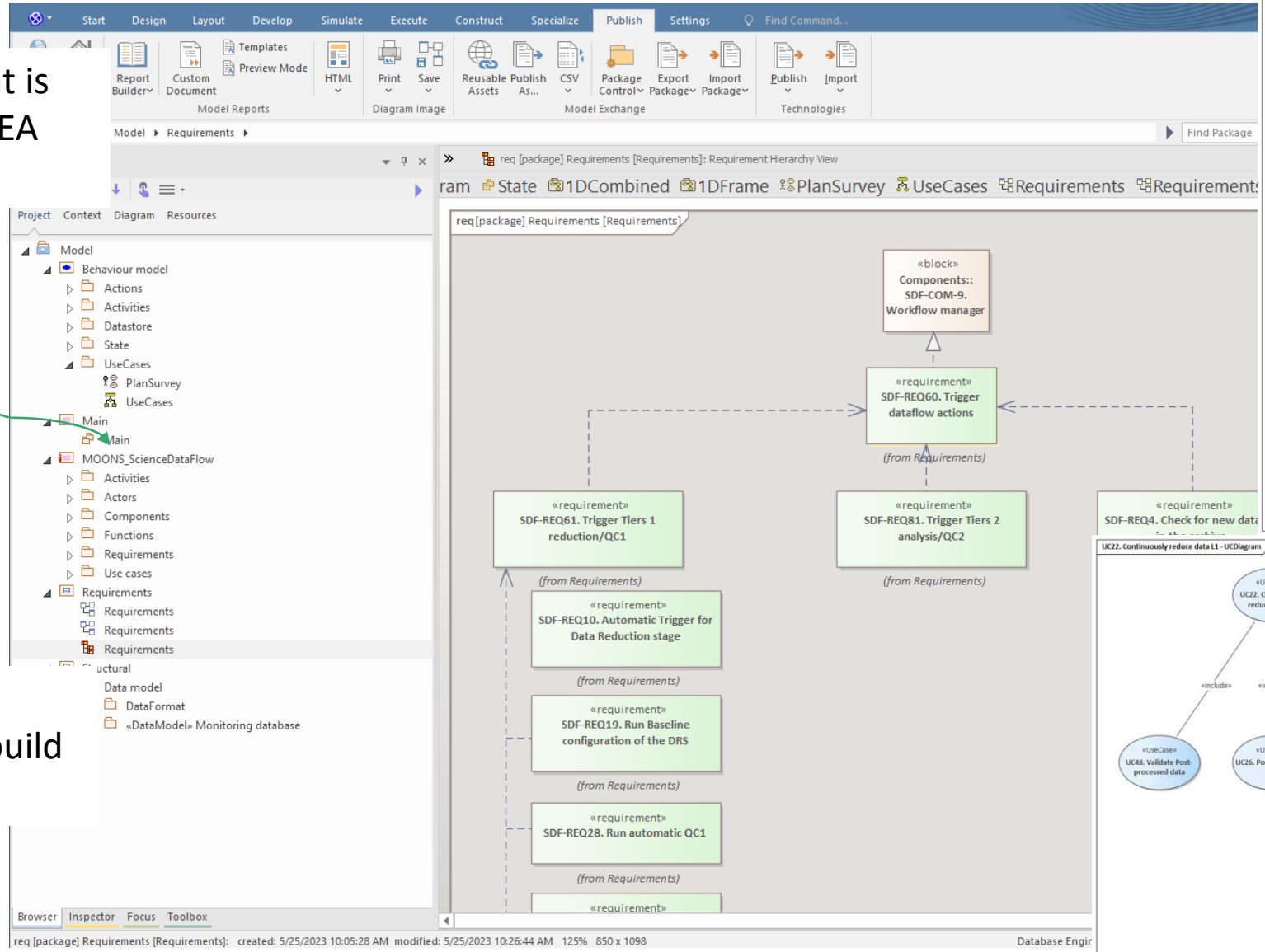


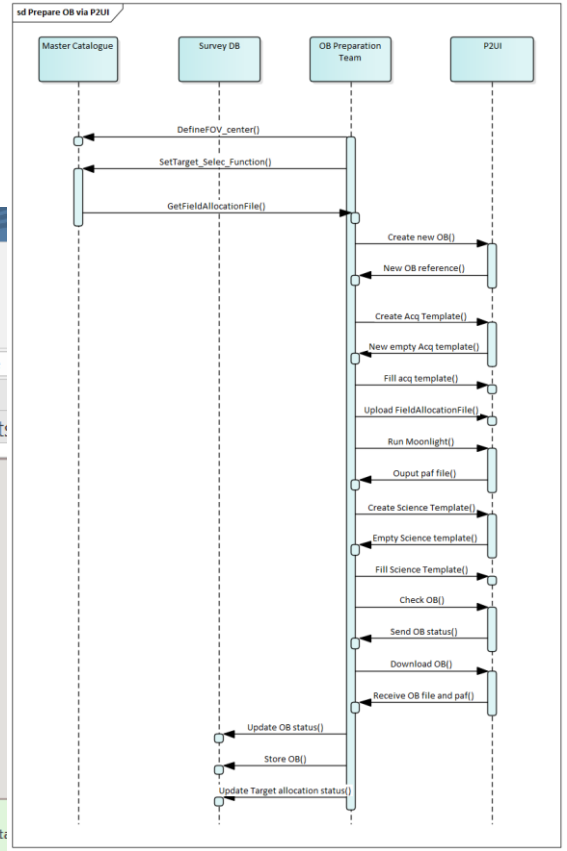


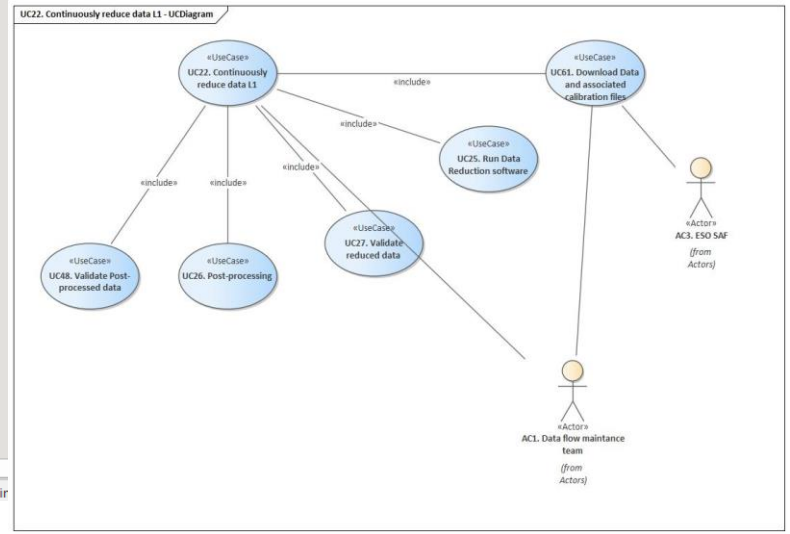
05 Connecting to SysML

Reqsuite content is downloaded to EA (library model)

Use the reqsuite components to build the Sysml model

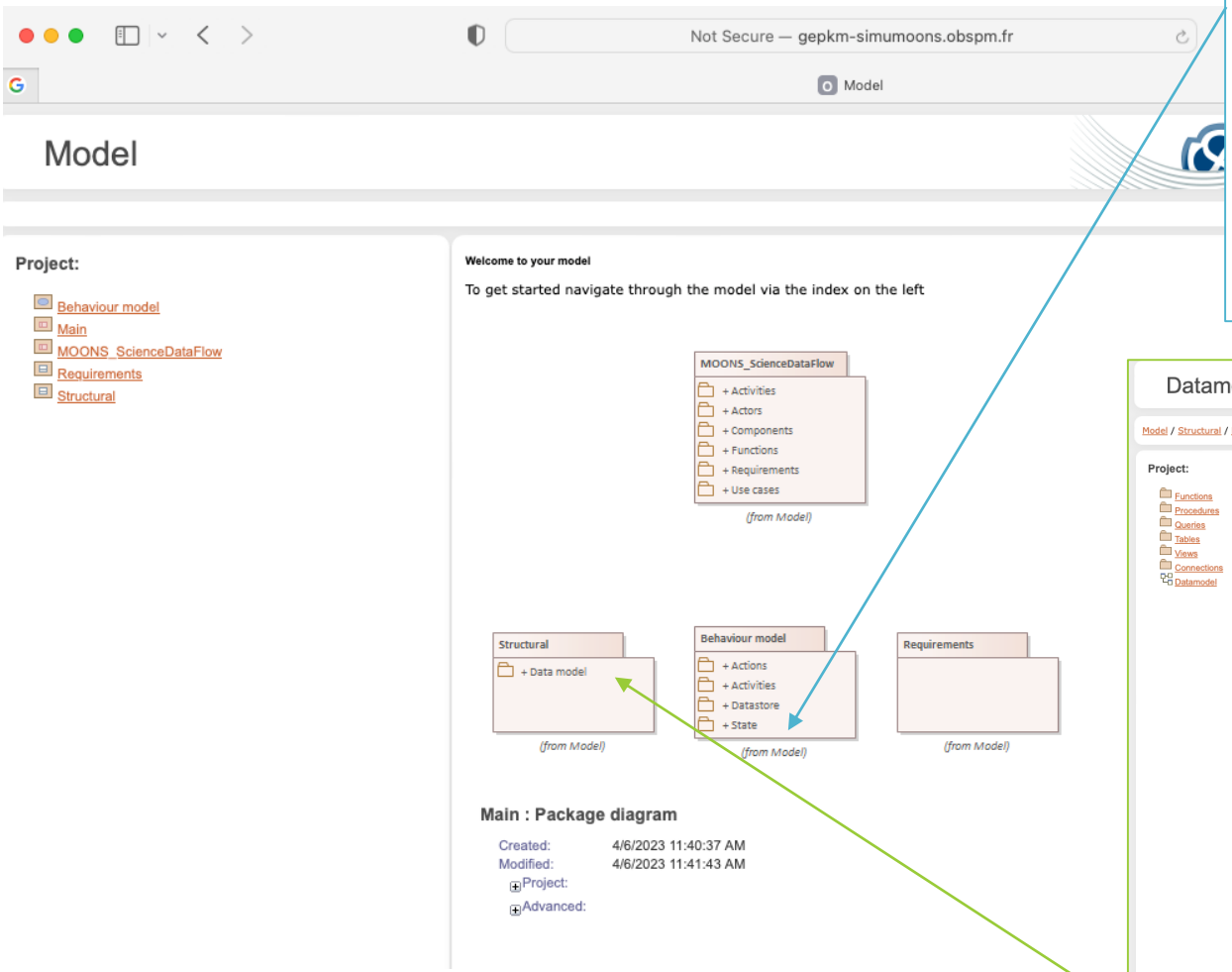


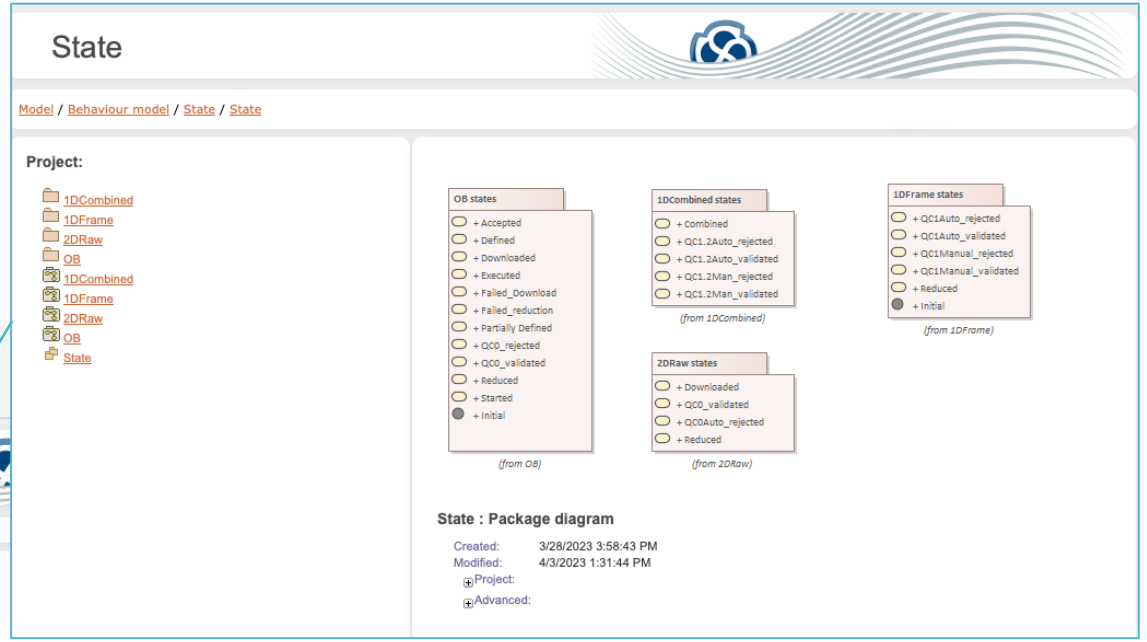


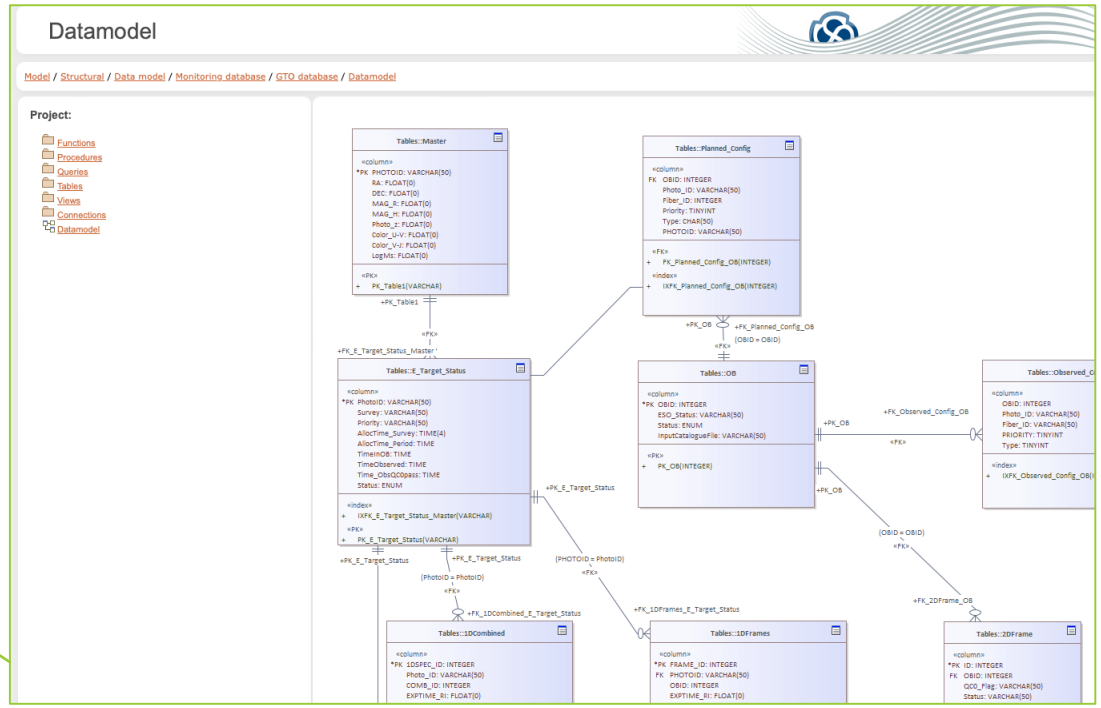


05 Connecting to SysML

Online view of the SysMl model



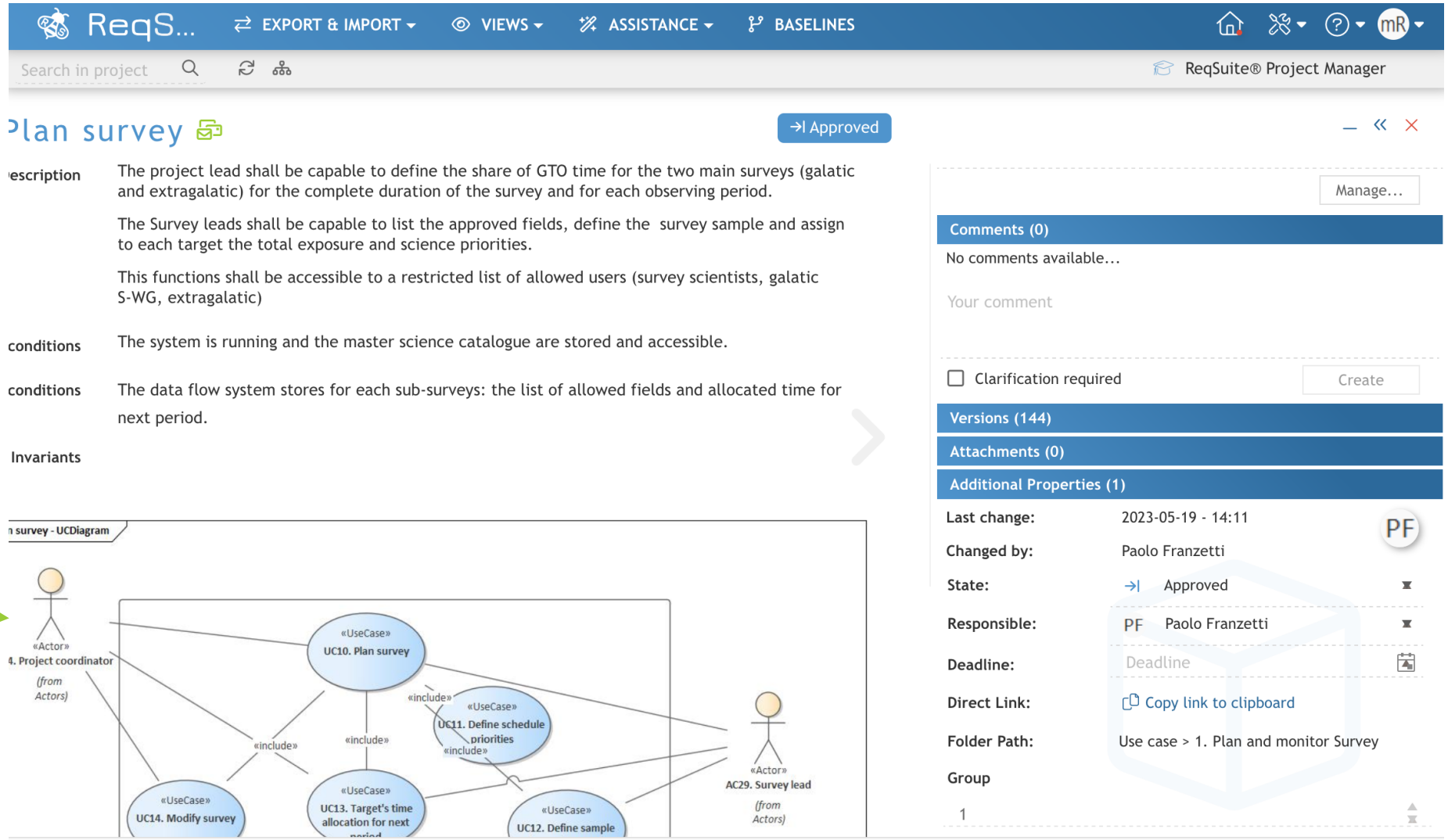




05 Connecting to SysML

Two-way connection

Diagrams from EA automatically updated into reqsuite



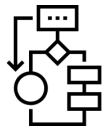
06 Roadmap for MOSAIC

System DB I

- Requierements flow down
- Interfaces
- Analysis cases
- PBS
- Sub-system integration

System models II

- SysML model
- Interfaces between domain models
- Analysis scripts on models



System DB

- Model config control tool
- Instrument DB (sync to Reqsuite and Entreprise Architect)
- Dashboard and report tools

Baserow

ToolJet

Full MBSE