

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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SysML

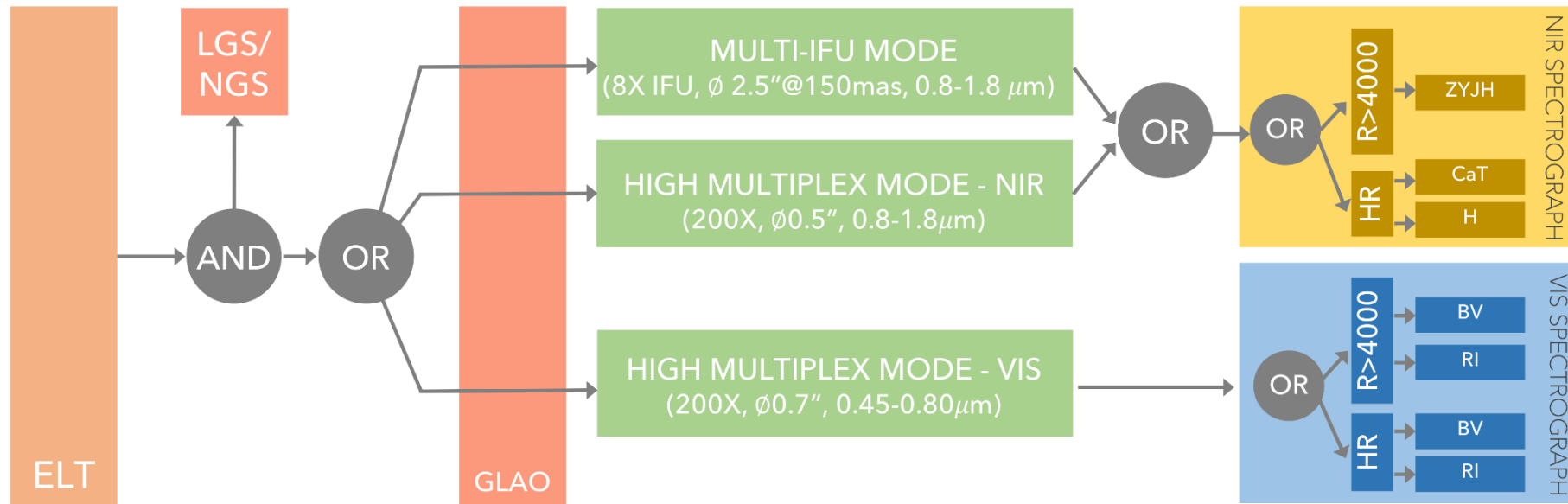
06

Rodmap for
MOSAIC

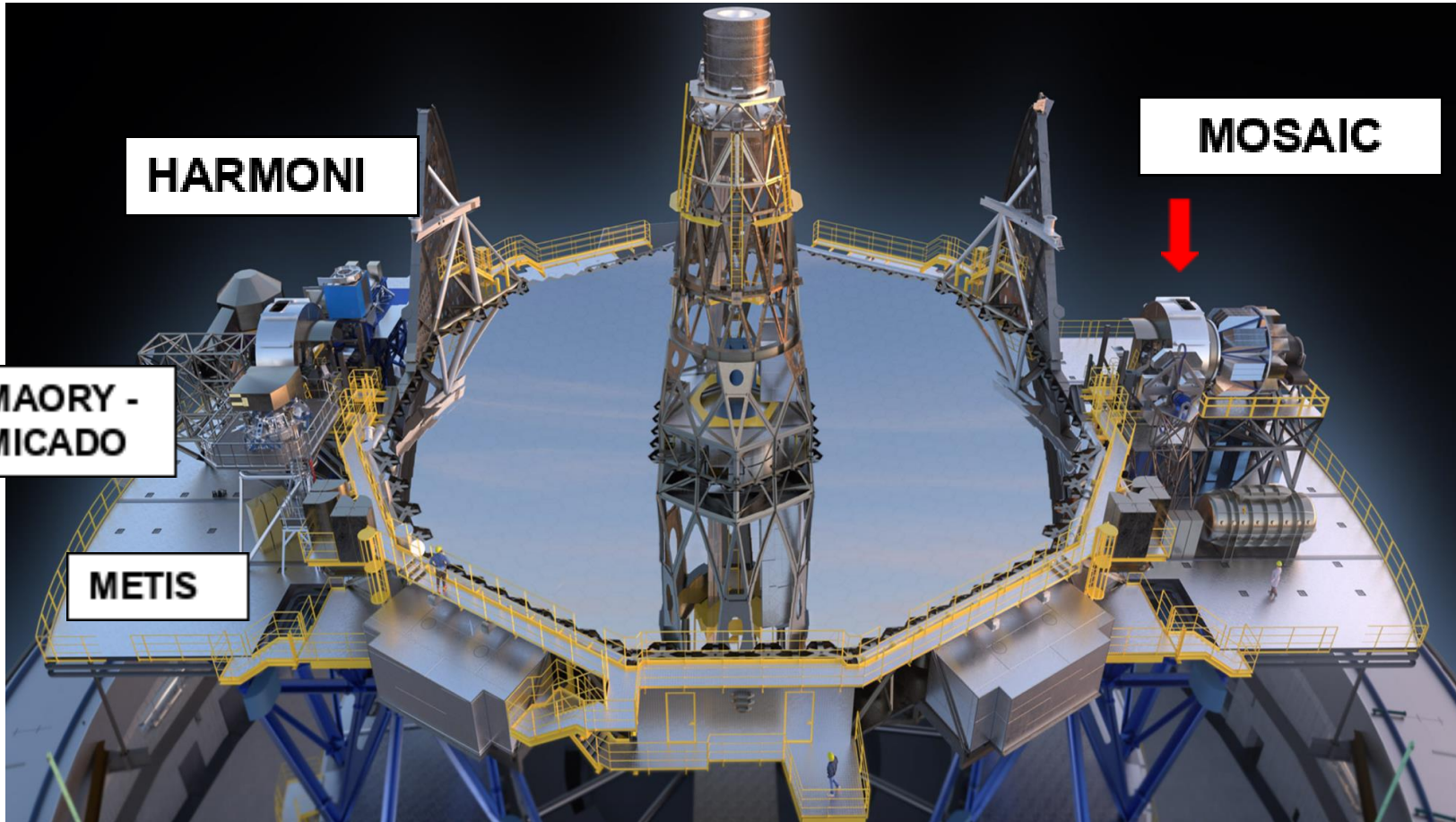
01 MOSAIC in a nutshell

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 $R \sim 5\,000$ and 4 High Resolution bands ($R \sim 18\,000$)
- Widest possible FoV provided by the ELT ($\sim 40 \text{ arcmin}^2$)
- Parallele observations with VIS and NIR spectrographs (6 modes)



01 MOSAIC in a nutshell



40 Tons



- 6 mastodons

11m X 7m



- 2 Petanque fields

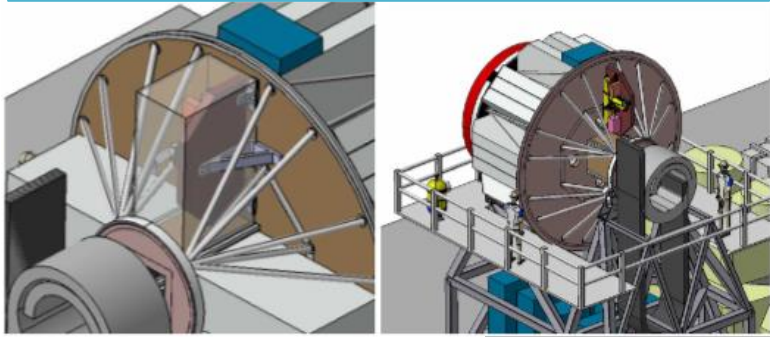
Height 8m



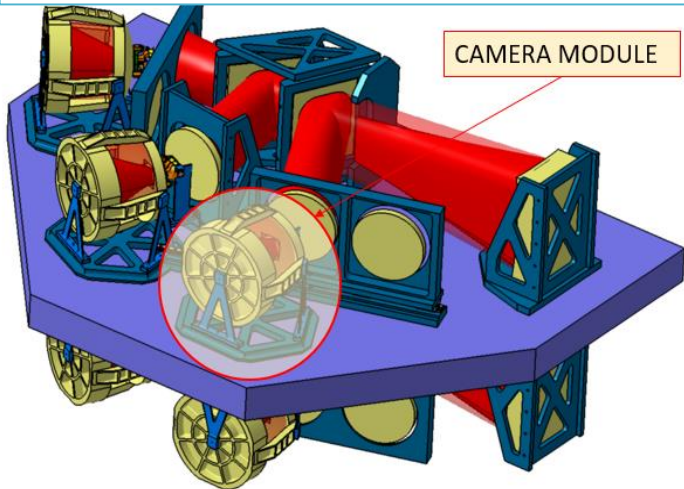
- 1.5 Giraffe or
- 13 baguettes

01 MOSAIC in a nutshell

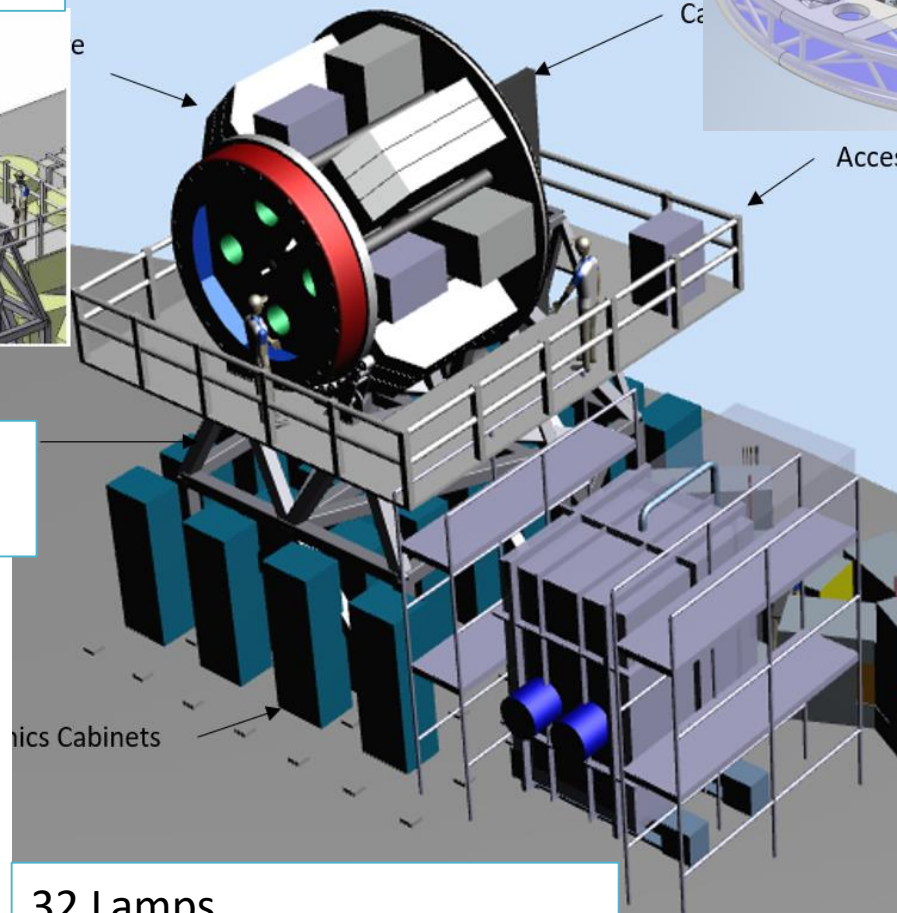
Ground layer Adaptive optics system



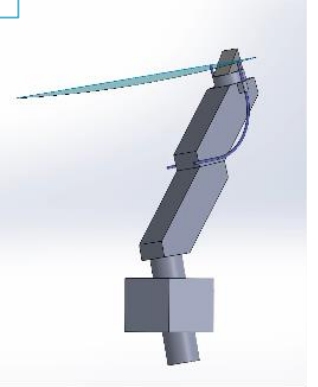
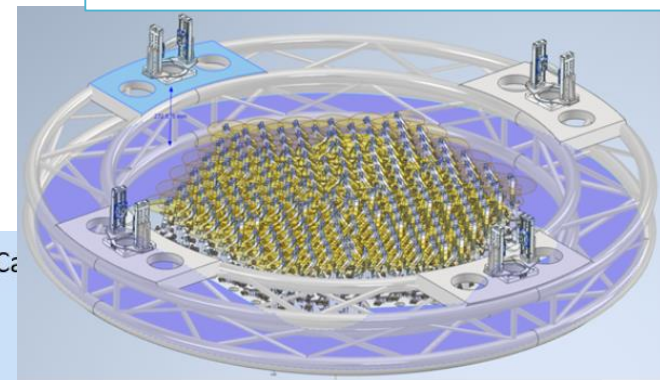
3 channel NIR spectrograph x2
Large Cryostat 130K



32 Lamps
1057 Moving devices
400 sensors

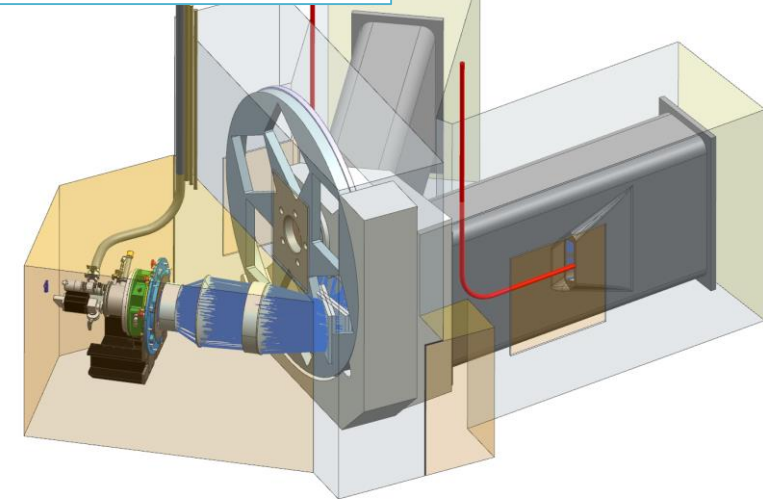


Focal plane with 300 robots



7 438 Fibers
Total ~200 km

2 VIS spectrographs



01 MOSAIC ELT in numbers

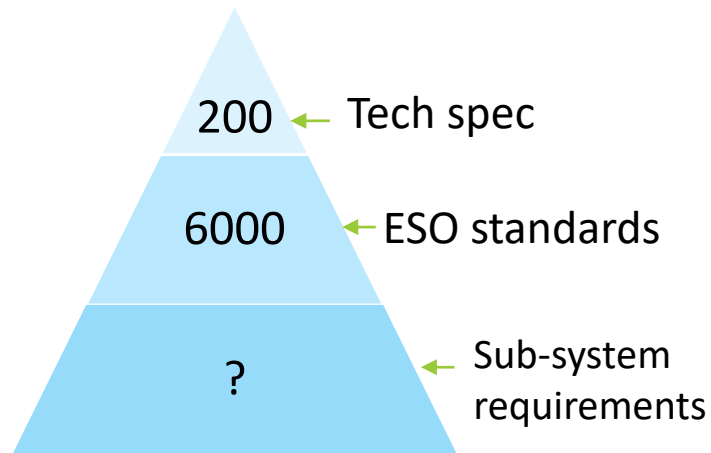
07 Systems

27 Sub-systems

~200? Internal interfaces

06 Observing modes

15 Spectral configurations



12 Countries

20 Work Packages

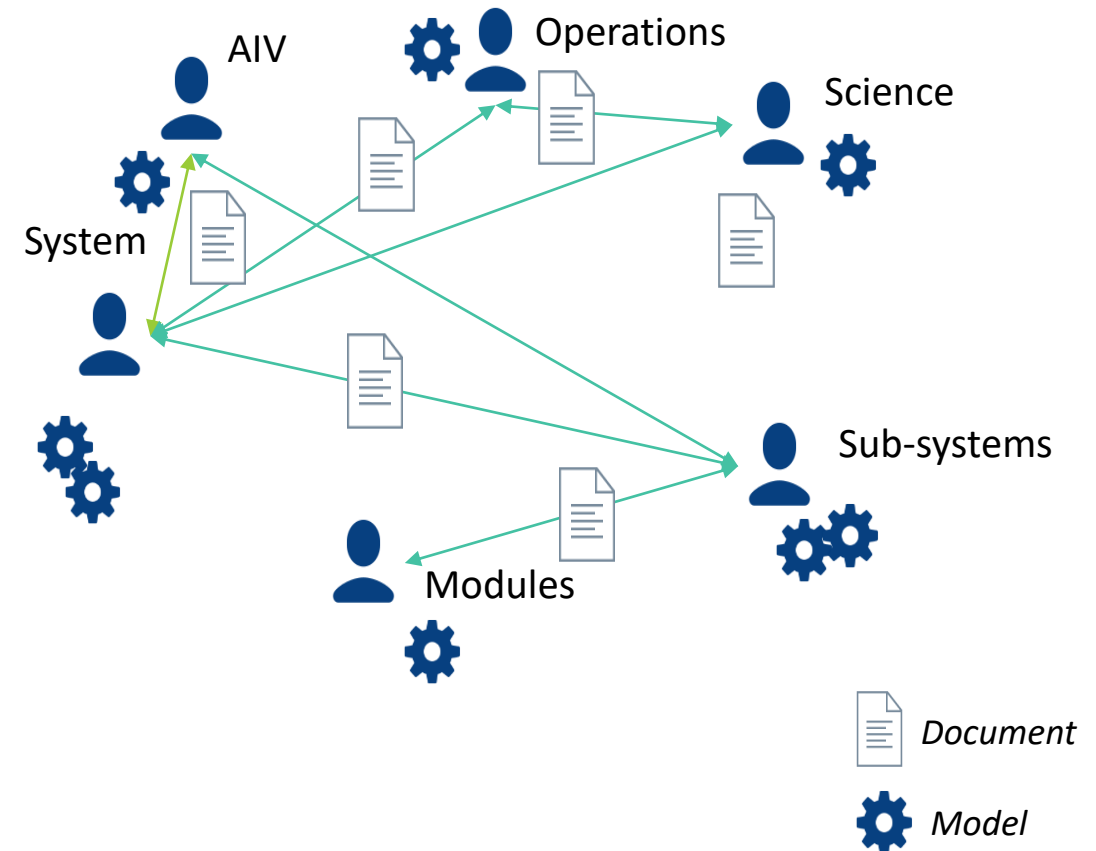
13 Labs providing hardware

700 FTE over ~10 years

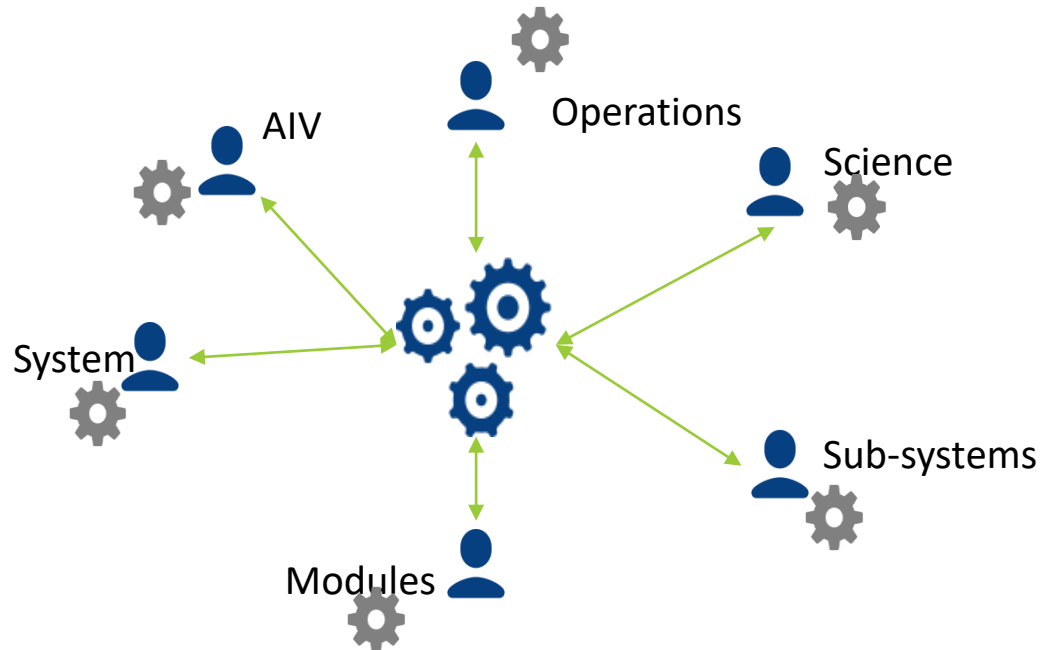
02 Why Moving towards Model-based SE?

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 discipline 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 weighed 1T if printed in A4 format*
- Domain engineering rely heavily 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

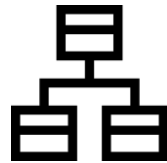
03 System engineering models

Systems engineering Model



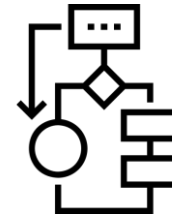
Requirements

- System requirements
- Sub-system flowdown
- Justification (budgets)



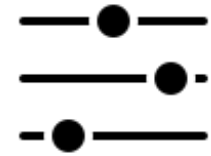
Structure

- Product breakdown structure
- Interfaces



Behavior

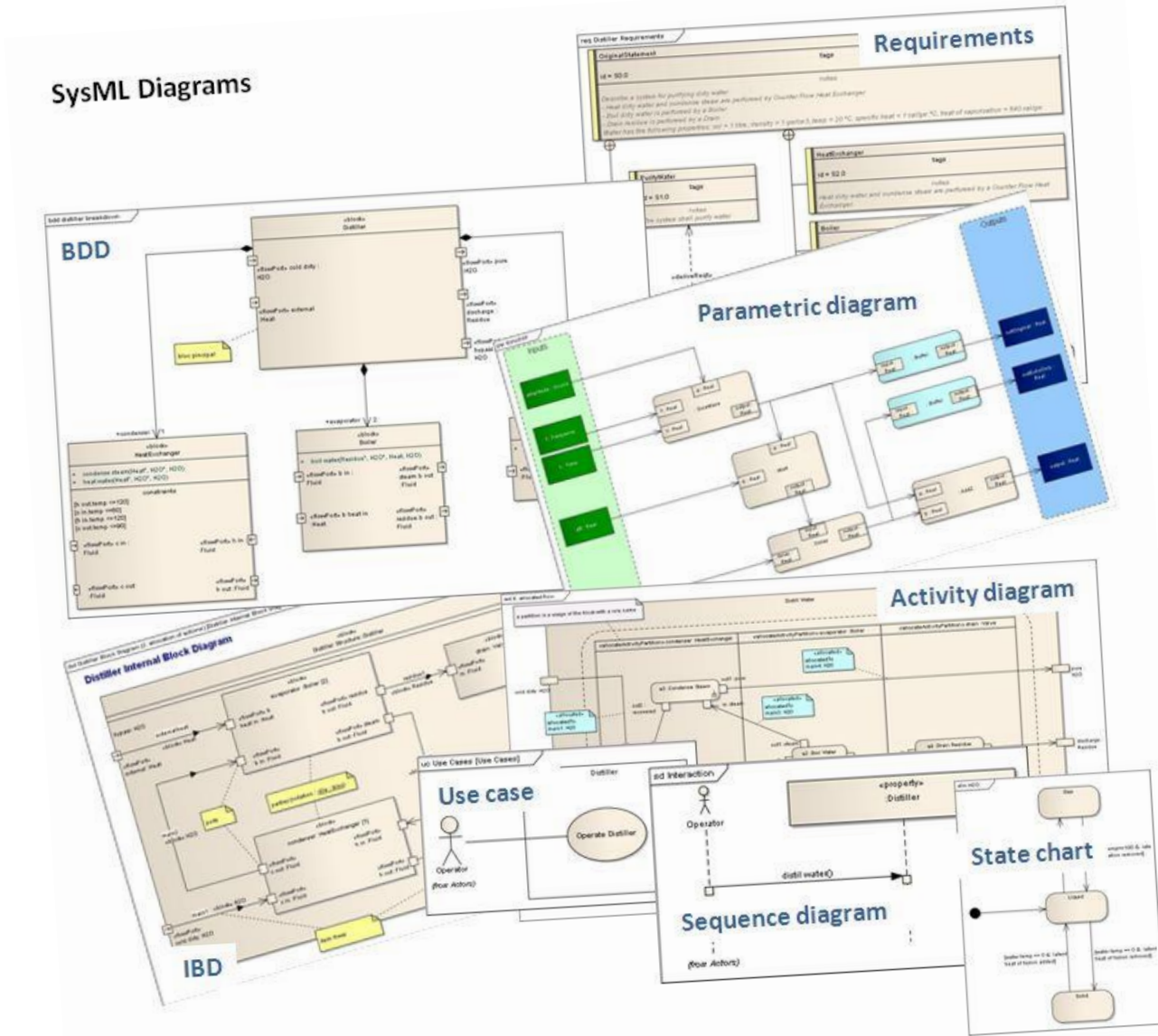
- Machine state
- Functional analysis
- Observing sequences



Parametrics

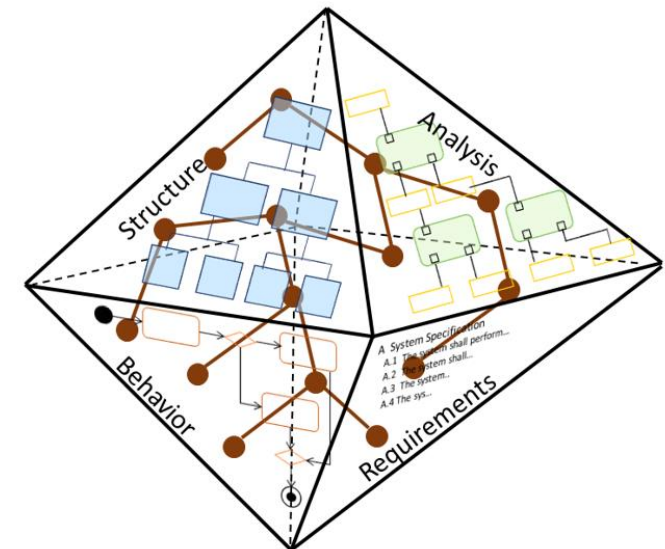
- End-to-end performance
- Trade-off analysis

03 System models

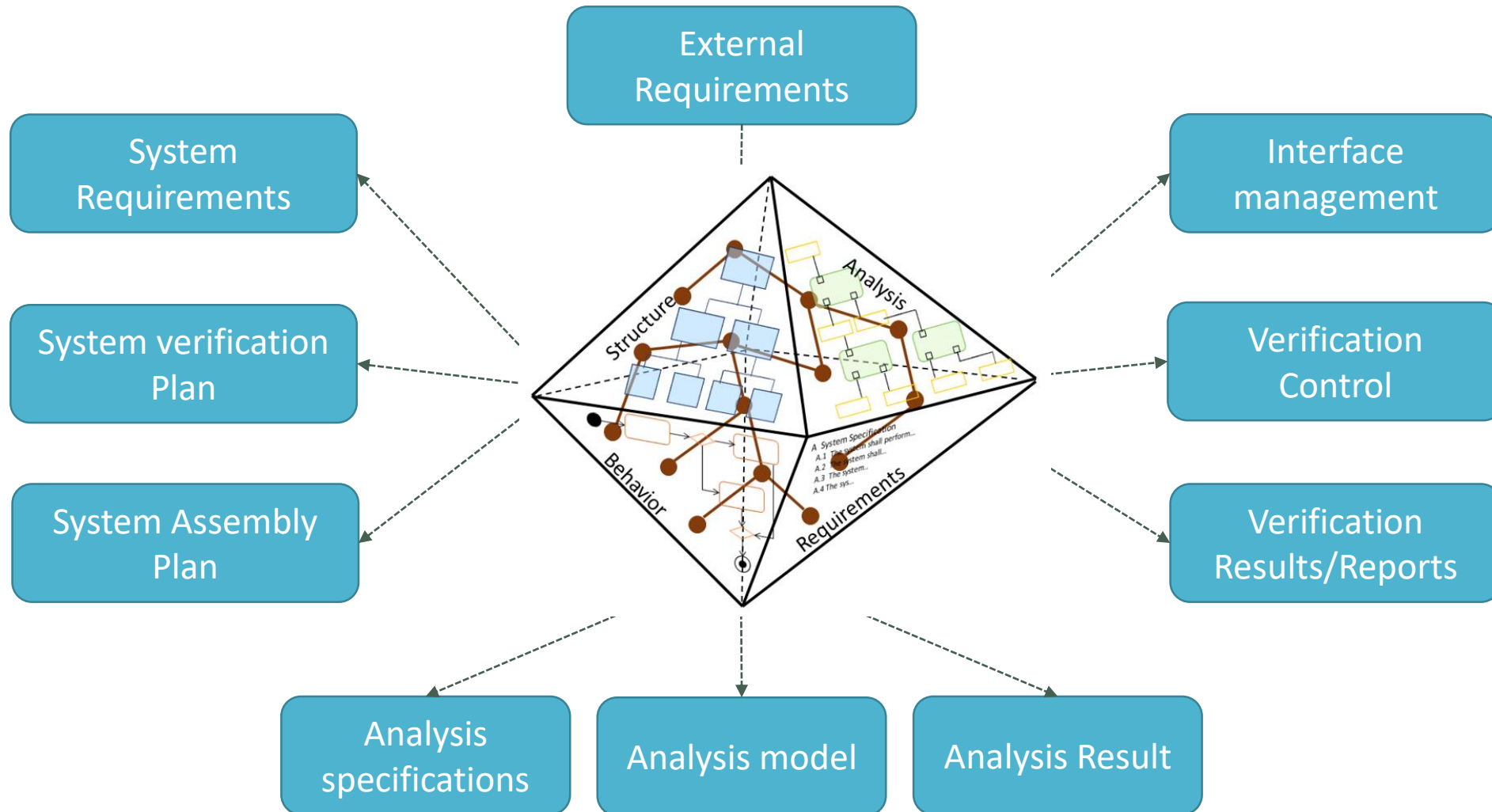


Structure and behaviour models are described in SysML.

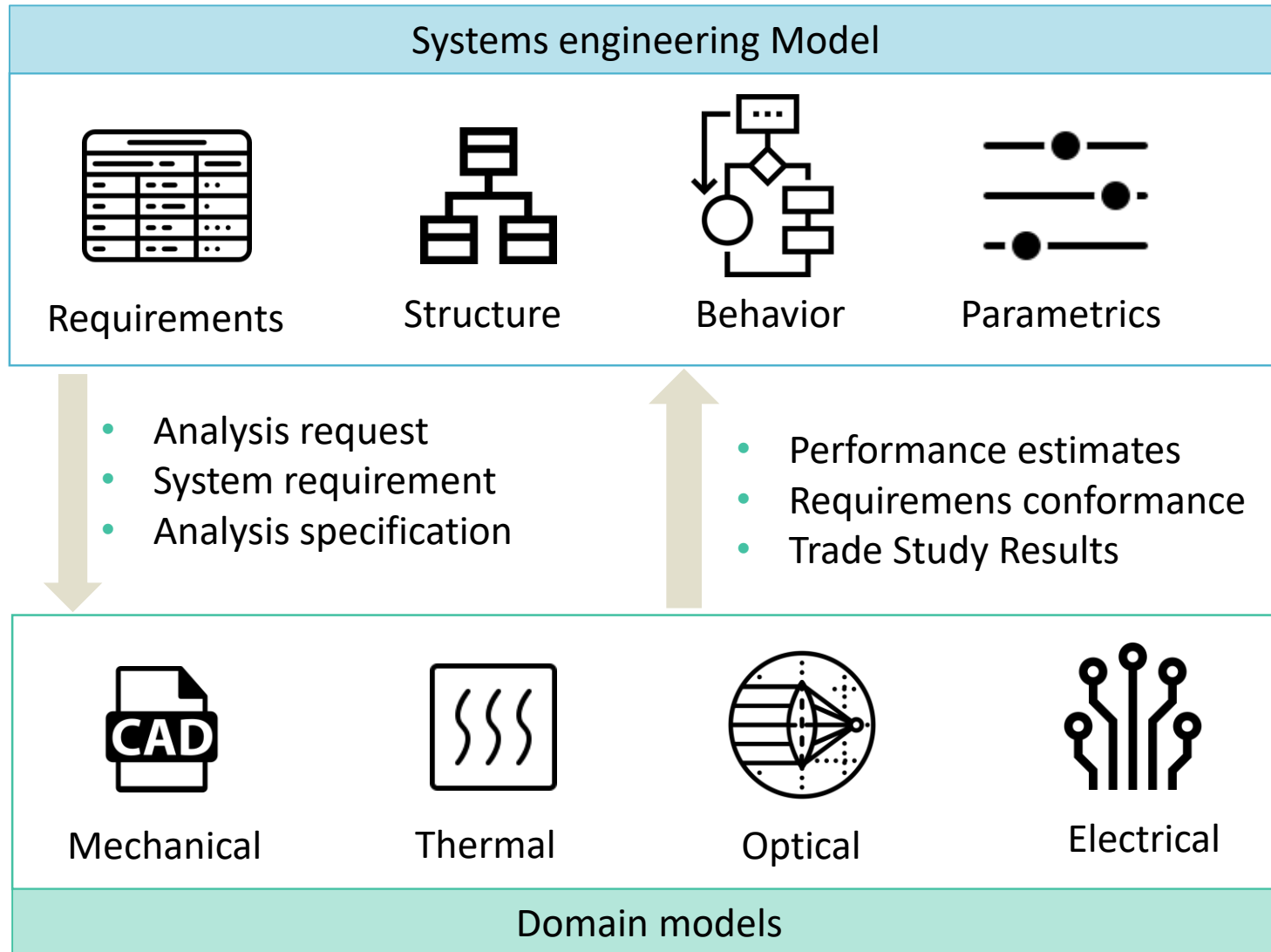
Not just drawings but a holistic model of the instrument



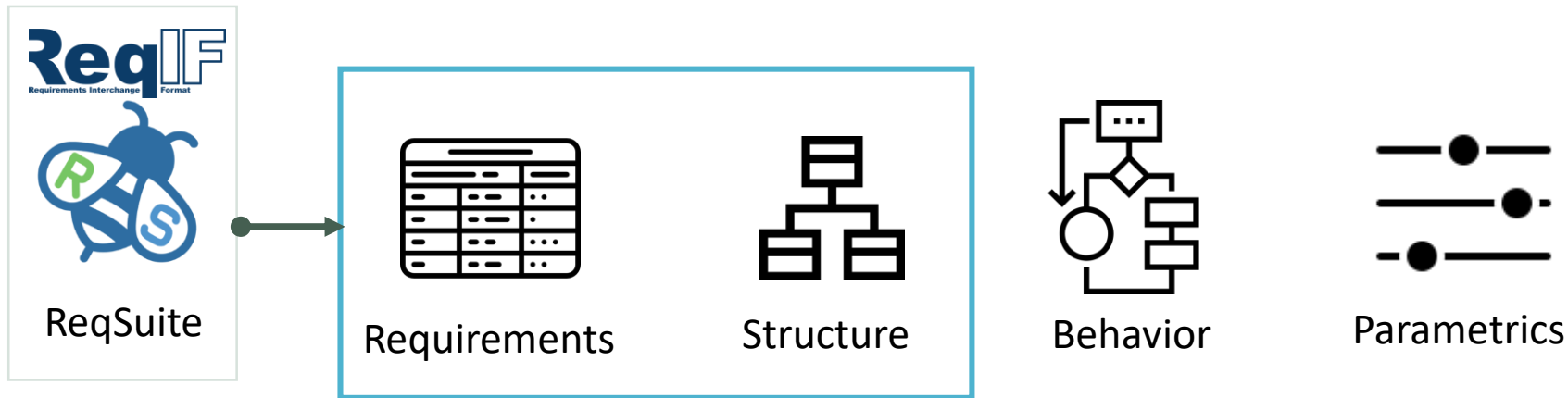
03 System model and Engineering processes



03 System and domain models



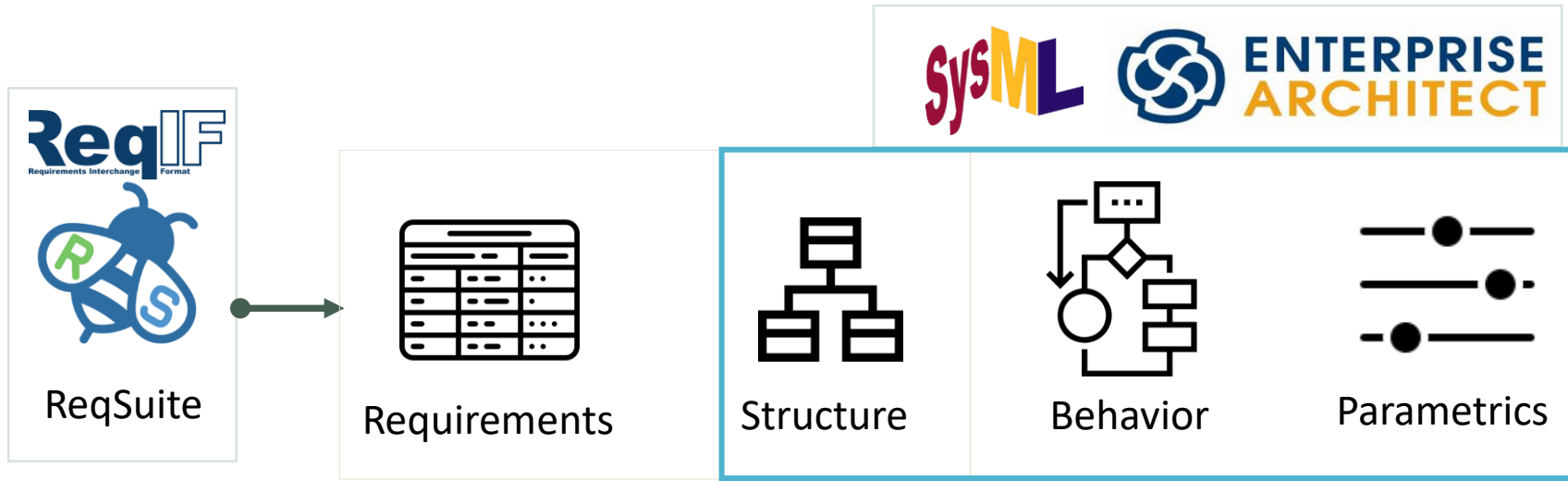
03 System models in practice



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

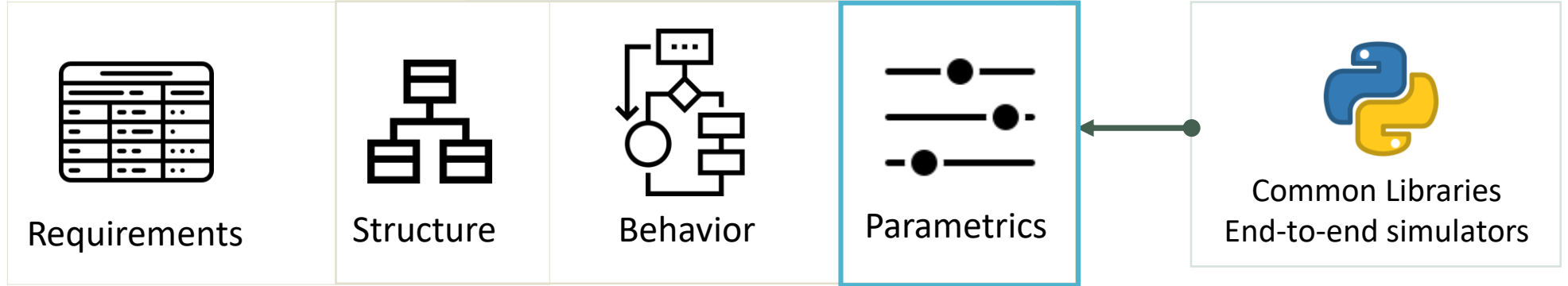
03 System models in practice



Enterprise 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

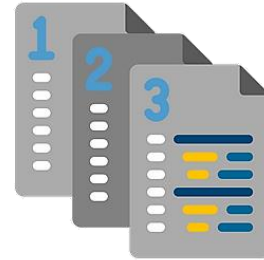
- Analysis model using common python Libraries hosted in project GitLab repo
- End-to-End simulators (e.g Mosaic ScopeSim)
- Plan to interface EA models and python models through a common instrument database

04 Requirement management tool



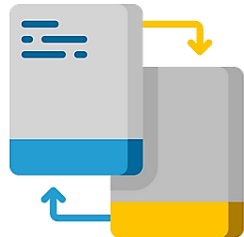
MANAGING & EDITING

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.



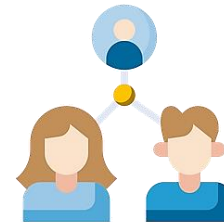
VERSIONING & BASELINING

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.



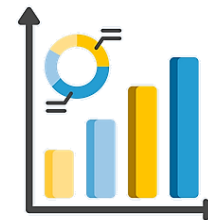
COLLABORATING & INTERACTING

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

Home page

Project name

Categories

Item

Tunable parameters

Home page

ReqSuite[®] RM

EXPORT & IMPORT - VIEWS - ASSISTANCE - BASELINES

Search in project...

MOS-System

ACRONYMS

ANALYSIS CASES

ANALYSIS REPORTS

APPLICABLE DOCUMENT

ESO REQUIREMENTS

JUSTIFICATIONS

PRODUCTS

PROJECT

SYSTEM REQUIREMENTS

REVIEW DOCS

USE CASES

VERIFICATION TESTS

Acronyms x Applicable Document x Requirement x ESO Requirements x

ID	Name	Definition	Last Change	Changed by	Responsible
ACRO1	AD	Applicable Documents	2022-04-01 - 13:37	myriam Rodrigues	mR myriam Rodrigues
ACRO2	ADC	Atmospheric Dispersion Compensator	2022-04-01 - 13:38	myriam Rodrigues	mR myriam Rodrigues
ACRO3	AIV	Assembly, Integration and Verification	2022-04-01 - 13:38	myriam Rodrigues	mR myriam Rodrigues
ACRO4	AO	Adaptive Optics	2022-04-01 - 13:38	myriam Rodrigues	mR myriam Rodrigues
ACRO5	ELT	Extremely Large Telescope	2022-04-01 - 13:39	myriam Rodrigues	mR myriam Rodrigues
ACRO6	GLAO	Ground layer Adaptive Optics	2022-04-01 - 13:39	myriam Rodrigues	mR myriam Rodrigues
ACRO7	MTBF	Mean Time Between Failure	2022-04-01 - 13:40	myriam Rodrigues	mR myriam Rodrigues
ACRO8	NGS	Natural Guide Star	2022-04-01 - 13:40	myriam Rodrigues	mR myriam Rodrigues
ACRO9	IFU	Integral Field Unit	2022-04-01 - 13:40	myriam Rodrigues	mR myriam Rodrigues
ACRO10	RD	Reference Document	2022-04-01 - 13:40	myriam Rodrigues	mR myriam Rodrigues
ACRO11	TLR	Top Level Requirement	2022-04-01 - 13:41	myriam Rodrigues	mR myriam Rodrigues
ACRO12	WCS	World Coordinate System	2022-04-01 - 13:41	myriam Rodrigues	mR myriam Rodrigues

1 - 12 of 12 items

Server OK Home / MOS-System 10:32

04 Requirement management tool

The screenshot displays the ReqSuite RM software interface. On the left, a navigation pane lists project elements: MOS-System, ACRONYMS, ANALYSIS CASES, ANALYSIS REPORTS, APPLICABLE DOCUMENT, ESO REQUIREMENTS, JUSTIFICATIONS, PRODUCTS, PROJECT, SYSTEM REQUIREMENTS, REVIEW DOCS, USE CASES, and VERIFICATION TESTS. The 'SYSTEM REQUIREMENTS' section is active, showing a table of requirements.

ID	Name	Level
REQ1	Instrument mass	L0 - Instrument
REQ2	Front-End mass	L1 - System level
REQ3	VIS channel Mass	L1 - System level
REQ4	NIR channel mass	L1 - System level
REQ5	GLAO mass	L1 - System level
REQ7	NIR Spectrograph mass	L2 - Sub-System
REQ8	Sensitivity MOS-NIR_LR	L0 - Instrument
REQ9	Sensitivity MOS-NIR-LR NIR channel	L1 - System level
REQ10	Sensitivity NIR spectrograph - MOS-NIR-LR	L2 - Sub-System

The central pane shows the detailed view for 'REQ1. Instrument mass'. The ID is REQ1, the Level is L0 - Instrument, and the Name is Instrument mass. The Description is: 'The total mass of the MOSAIC sub-systems on the Nasmyth platform shall be less than 40,000 kg.' A red error message at the bottom states: '1/7: This System Requirement is not completely specified. Complete the missing fields.'

On the right, a sidebar contains several panels: 'Links (6)' showing a hierarchy of requirements (e.g., explained by > Justification, derived by > ESO Requirement), 'Comments (1)' with a comment from myriam Rodrigues, 'Versions (19)', 'Attachments (0)', and 'Additional Properties (0)' with fields for Last change, Changed by, Reuse, Responsible, Deadline, and Direct Link.

04 Requirement management tool

REQ1. Instrument mass

ID REQ1

Level * L0 - Instrument

Type * Please choose...

Name * Instrument mass

Description * The total mass of the MOSAIC sub-systems on the Nasmyth platform shall be less than 40,000 kg.

Links (6)

- explained by > Justification
 - [JUST1. Mass budget - System level](#)
- derived by > ESO Requirement
 - [REQ05.178. total mass](#)
- requires > System Requirement
 - [REQ2. Front-End mass](#)
 - [REQ3. VIS channel Mass](#)
 - [REQ4. NIR channel mass](#)
 - [REQ5. GLAO mass](#)

relationships through the project

Comments (1)

myriam Rodrigues 13.05.2022 15:19
EICS is missing!!

Your comment

Clarification required

Comments area

class REQ1. Instrument mass - Requirement

EA 15.2 Unregistered Tr

EA 15.2 Unregistered Tr

04 Requirement management tool
































































REQ1. Instrument mass 

ID REQ1

Level * LO - Instrument

Type * Please choose...

Name * Instrument mass

Description * **B** *I* U                                                               

04 Requirement management tool

The screenshot displays the ReqSuite RM interface. The left sidebar contains a navigation menu with categories like MOS-System, ACRONYMS, ANALYSIS CASES, ANALYSIS REPORTS, APPLICABLE DOCUMENT, ESO REQUIREMENTS (selected), JUSTIFICATIONS, PRODUCTS, PROJECT, SYSTEM REQUIREMENTS, REVIEW DOCS, USE CASES, and VERIFICATION TESTS. The main area shows a table titled 'ESO Requirements' with columns for ID, Name, and ForeignID. The table lists 12 requirements, each with a checkbox and a status icon. A red box highlights a set of icons: a yellow warning triangle, a red clock, a blue speech bubble, a red target, a green envelope, and a blue magnifying glass. Dashed red lines connect these icons to callout text: 'Quality problem detected' (warning triangle), 'Deadline exceeded' (red clock), 'Comments available' (speech bubble), 'Affected by changes' (red target), 'Items subscribed' (green envelope), and 'In review' (magnifying glass).

ID	Name	ForeignID
EREQS.1	Requirement 1	1
EREQS.2	Requirement 2	2
EREQS.3	Introduction	3
EREQS.4	Scope	4
EREQS.5	Requirement 5	5
EREQS.6	Definitions and Conventions	6
EREQS.7	Statement Identifiers and Verification Tags	7
EREQS.8	Requirement 8	8
EREQS.9	Requirement 9	9
EREQS.10	Requirement 10	10
EREQS.11	Requirement 11	11
EREQS.12	Abbreviations and Acronyms	12

04 Requirement management tool

Quality Check

Overview of quality check results:

Search in table...

Incompletenesses (132) Relationship errors (114) Description deficiencies (90) Others (15)

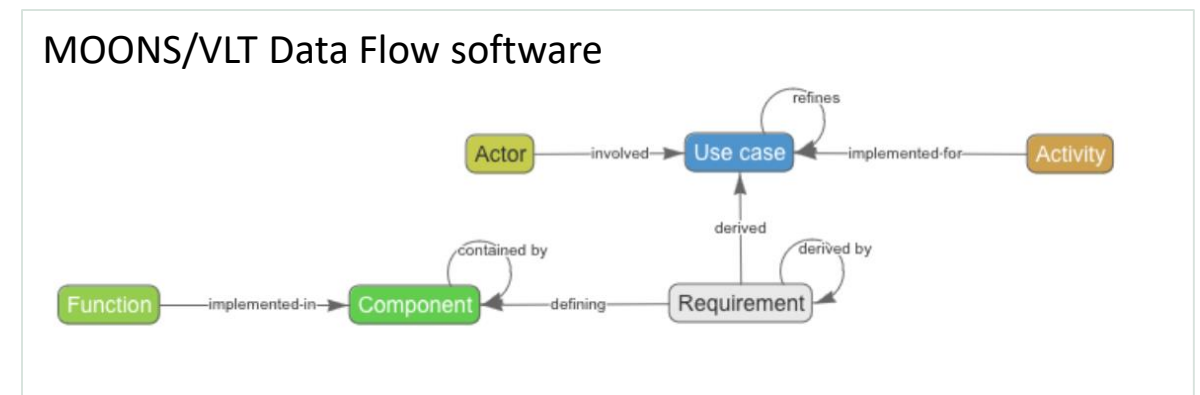
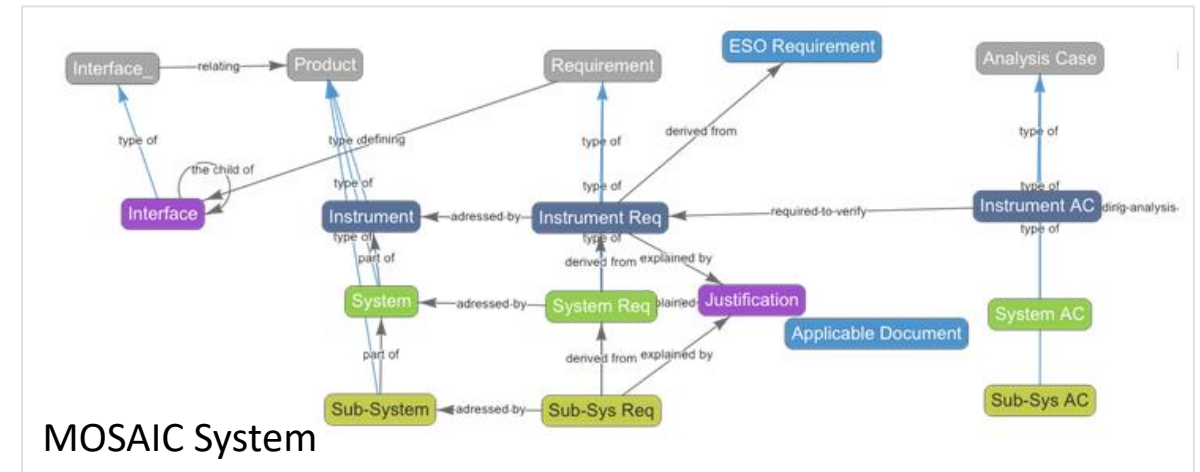
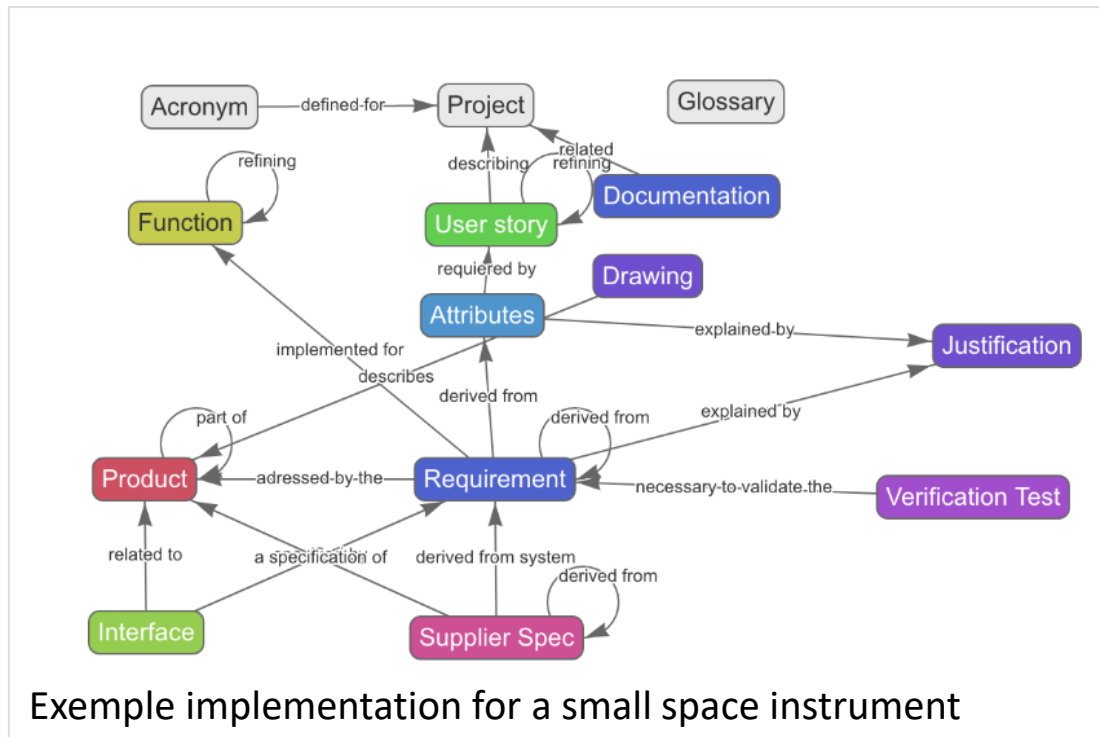
⊗	UC36. Science pipeline for the Extragalactic survey	This Use case is not completely specified. Complete the missing fields.	myriam Rodrigues	×
⊗	UC37. Science pipeline for the extra-gaatic survey	This Use case is not completely specified. Complete the missing fields.	myriam Rodrigues	×
⊗	UC51. Monitor daily status of the survey	This Use case is not completely specified. Complete the missing fields.	myriam Rodrigues	×
⊗	UC57. Test data flow without DRS	This Use case is not completely specified. Complete the missing fields.	myriam Rodrigues	×
⊗	UC58. Test data flow with the DRS	This Use case is not completely specified. Complete the missing fields.	myriam Rodrigues	×
⊗	UC72. Define sub-survey strategies	This Use case is not further elaborated by a UCDiagram. Upload such a UCDiagram.	Paolo Franzetti	×
⊗	UC75. Monitor Observing run	This Use case is not completely specified. Complete the missing fields.	Paolo Franzetti	×
⊗	UC75. Monitor Observing run	This Use case is not further elaborated by a UCDiagram. Upload such a UCDiagram.	Paolo Franzetti	×

...

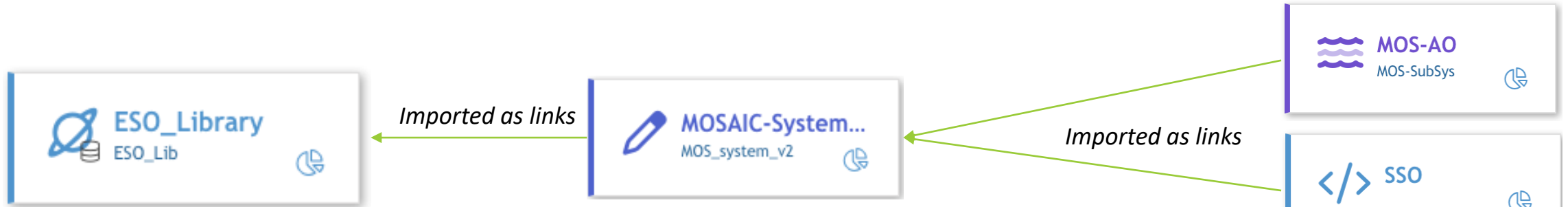
Close

04 Configuration model

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



04 MOSAIC implementation



Reusable library containing

- Instrument Technical Specification
 - ESO Standards
 - ESO common interfaces
- Import reqif files from ESO
Version comparison

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	<ul style="list-style-type: none"> • Compliance matrix
System and sub-system requirements	Instrument Requirements Justifications	Supplier specifications	<ul style="list-style-type: none"> • System/Sub system specification documents • Flow-down justification document
Products	Products	Products	<ul style="list-style-type: none"> • PBS and BOM
Interfaces	Products	System/sub-system Requirements	<ul style="list-style-type: none"> • Interface Description document
Analysis Case	Requirement	Analysis Report	
Analysis Report	Analysis Case		<ul style="list-style-type: none"> • Compliance matrix Analysis reports

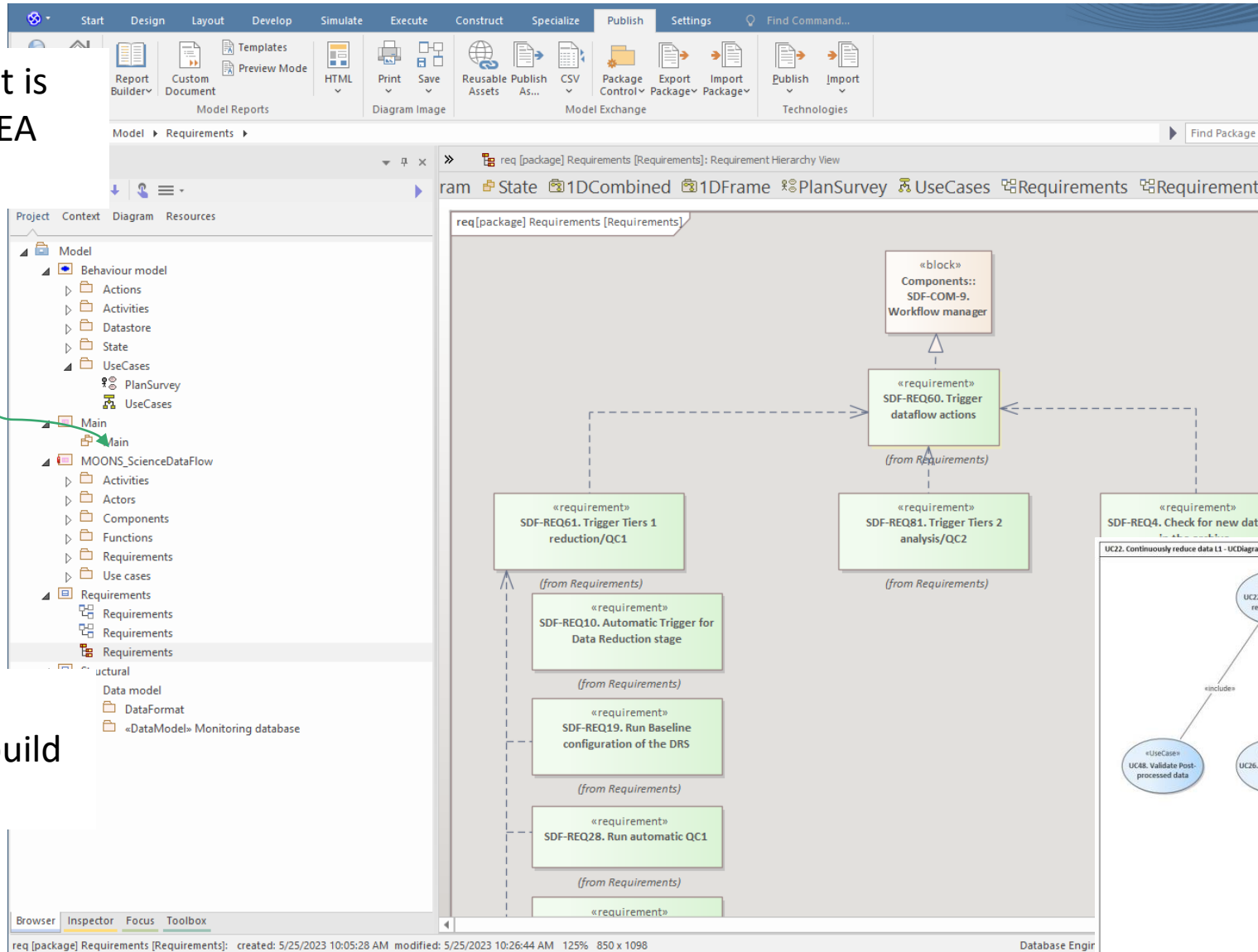


Document Title	Front End - VIS science channel systems Interface Definition Document		
Document Number	<td>		
Issue	0.1		
Date	2023-05-17		
Prepared By		Signature	
		Date	
Approved By		Signature	
		Date	
Released By		Signature	
		Date	
Description	This document provides the description of the currently agreed status of the Front End - VIS science channel systems Interface		
Distribution	Write here the distribution list		

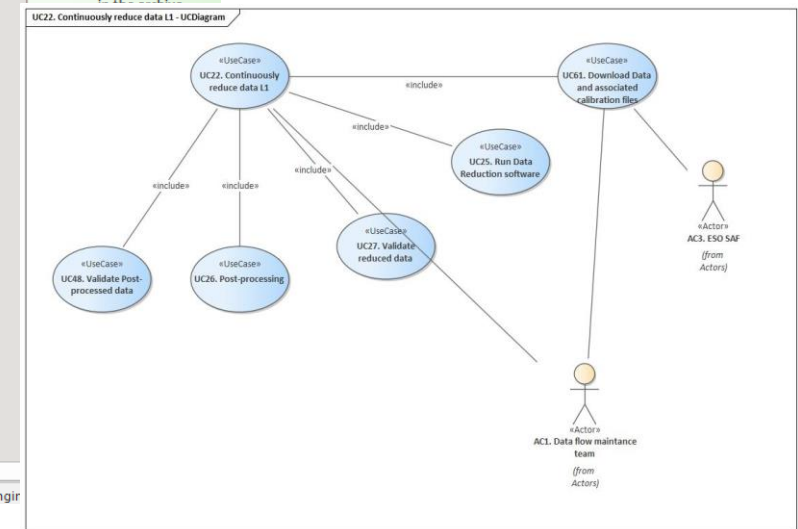
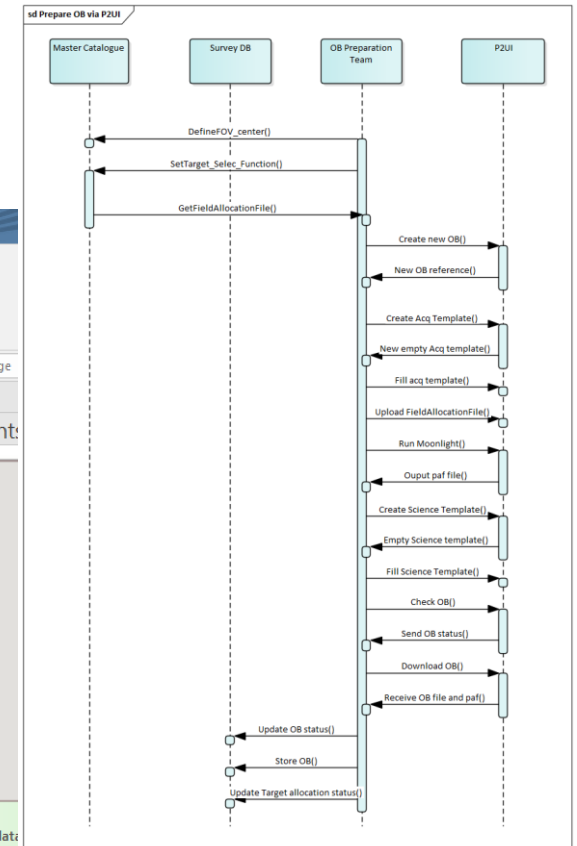


05 Connecting to SysML

Requisite content is downloaded to EA (library model)



Use the requisite components to build the Sysml model



05 Connecting to SysML

Online view of the SysML model

Model

Project:

- Behaviour model
- Main
- MOONS_ScienceDataFlow
- Requirements
- Structural

Welcome to your model

To get started navigate through the model via the index on the left

MOONS_ScienceDataFlow

- + Activities
- + Actors
- + Components
- + Functions
- + Requirements
- + Use cases

(from Model)

Structural

- + Data model

(from Model)

Behaviour model

- + Actions
- + Activities
- + Datastore
- + State

(from Model)

Requirements

(from Model)

Main : Package diagram

Created: 4/6/2023 11:40:37 AM

Modified: 4/6/2023 11:41:43 AM

Project:

Advanced:

State

Model / Behaviour model / State / State

Project:

- 1DCombined
- 1DFrame
- 2DDraw
- OB
- 1DCombined
- 1DFrame
- 2DDraw
- OB
- State

OB states

- + Accepted
- + Defined
- + Downloaded
- + Executed
- + Failed_Download
- + Failed_reduction
- + Partially Defined
- + QCO_rejected
- + QCO_validated
- + Reduced
- + Started
- + Initial

(from OB)

1DCombined states

- + Combined
- + QC1.2Auto_rejected
- + QC1.2Auto_validated
- + QC1.2Man_rejected
- + QC1.2Man_validated

(from 1DCombined)

1DFrame states

- + QC1Auto_rejected
- + QC1Auto_validated
- + QC1Manual_rejected
- + QC1Manual_validated
- + Reduced
- + Initial

(from 1DFrame)

2DDraw states

- + Downloaded
- + QCO_validated
- + QCOAuto_rejected
- + Reduced

(from 2DDraw)

State : Package diagram

Created: 3/28/2023 3:58:43 PM

Modified: 4/3/2023 1:31:44 PM

Project:

Advanced:

Datamodel

Model / Structural / Data model / Monitoring_database / GTO_database / Datamodel

Project:

- Functions
- Procedures
- Queries
- Tables
- Views
- Connections
- Datamodel

Tables:Master

- PHOTOID: VARCHAR(50)
- RA: FLOAT(0)
- DEC: FLOAT(0)
- MAG_R: FLOAT(0)
- MAG_H: FLOAT(0)
- Photo_E: FLOAT(0)
- Color_V-I: FLOAT(0)
- Color_V-J: FLOAT(0)
- LogM: FLOAT(0)

Tables:Planned_config

- OBID: INTEGER
- Photo_ID: VARCHAR(50)
- Fibre_ID: INTEGER
- Priority: TINYINT
- Type: CHAR(50)
- PHOTOID: VARCHAR(50)

Tables:E_Target_Status

- PHOTOID: VARCHAR(50)
- Survey: VARCHAR(50)
- Priority: VARCHAR(50)
- AllocTime_Survey: TIME(4)
- AllocTime_Period: TIME
- TimeObs: TIME
- TimeObserved: TIME
- TimeObsAccess: TIME
- Status: ENUM

Tables:OB

- OBID: INTEGER
- ESO_Status: VARCHAR(50)
- Status: ENUM
- InputCatalogueFibre: VARCHAR(50)

Tables:Observed_C

- OBID: INTEGER
- Photo_ID: VARCHAR(50)
- Fibre_ID: VARCHAR(50)
- Priority: TINYINT
- Type: TINYINT

Tables:1DCombined

- LSDFEC_ID: INTEGER
- Photo_ID: VARCHAR(50)
- COMS_ID: INTEGER
- EXPTIME_R: FLOAT(0)

Tables:1DFrame

- FRAME_ID: INTEGER
- Photo_ID: VARCHAR(50)
- OBID: INTEGER
- EXPTIME_R: FLOAT(0)

Tables:2DFrame

- FRAME_ID: INTEGER
- Photo_ID: VARCHAR(50)
- QCO_Flag: VARCHAR(50)
- Status: VARCHAR(50)

Datamodel

Created: 3/28/2023 3:58:43 PM

Modified: 4/3/2023 1:31:44 PM

Project:

Advanced:

05 Connecting to SysML

Two-way connection

Diagrams from EA
automatically
updated into reqsuite

The screenshot displays the ReqSuite Project Manager interface. At the top, there is a navigation bar with icons for 'EXPORT & IMPORT', 'VIEWS', 'ASSISTANCE', and 'BASELINES'. Below this is a search bar and a 'ReqSuite® Project Manager' label. The main content area shows a requirement titled 'Plan survey' with a status of 'Approved'. The requirement is detailed with a description, conditions, and invariants. Below the text is a SysML Use Case Diagram (UCDiagram) showing actors '4. Project coordinator' and 'AC29. Survey lead' connected to use cases 'UC10. Plan survey', 'UC11. Define schedule priorities', 'UC12. Define sample', 'UC13. Target's time allocation for next period', and 'UC14. Modify survey'. The diagram includes 'include' relationships between the use cases. On the right side, there is a sidebar with sections for 'Comments (0)', 'Versions (144)', 'Attachments (0)', and 'Additional Properties (1)'. The 'Additional Properties' section lists 'Last change: 2023-05-19 - 14:11', 'Changed by: Paolo Franzetti', 'State: Approved', 'Responsible: PF Paolo Franzetti', 'Deadline: Deadline', 'Direct Link: Copy link to clipboard', and 'Folder Path: Use case > 1. Plan and monitor Survey'. A green arrow points from the text on the left to the 'Plan survey' requirement in the interface.

ReqSuite... EXPORT & IMPORT VIEWS ASSISTANCE BASELINES

Search in project ReqSuite® Project Manager

Plan survey

→ Approved

Description

The project lead shall be capable to define the share of GTO time for the two main surveys (galatic and extragalatic) for the complete duration of the survey and for each observing period.

The Survey leads shall be capable to list the approved fields, define the survey sample and assign to each target the total exposure and science priorities.

This functions shall be accessible to a restricted list of allowed users (survey scientists, galatic S-WG, extragalatic)

conditions

The system is running and the master science catalogue are stored and accessible.

conditions

The data flow system stores for each sub-surveys: the list of allowed fields and allocated time for next period.

Invariants

Plan survey - UCDiagram

«Actor»
4. Project coordinator
(from Actors)

«UseCase»
UC10. Plan survey

«UseCase»
UC11. Define schedule priorities

«UseCase»
UC12. Define sample

«UseCase»
UC13. Target's time allocation for next period

«UseCase»
UC14. Modify survey

«Actor»
AC29. Survey lead
(from Actors)

Comments (0)

No comments available...

Your comment

Clarification required

Versions (144)

Attachments (0)

Additional Properties (1)

Last change: 2023-05-19 - 14:11

Changed by: Paolo Franzetti

State: → Approved

Responsible: PF Paolo Franzetti

Deadline: Deadline

Direct Link: Copy link to clipboard

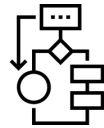
Folder Path: Use case > 1. Plan and monitor Survey

Group: 1

06 Roadmap for MOSAIC

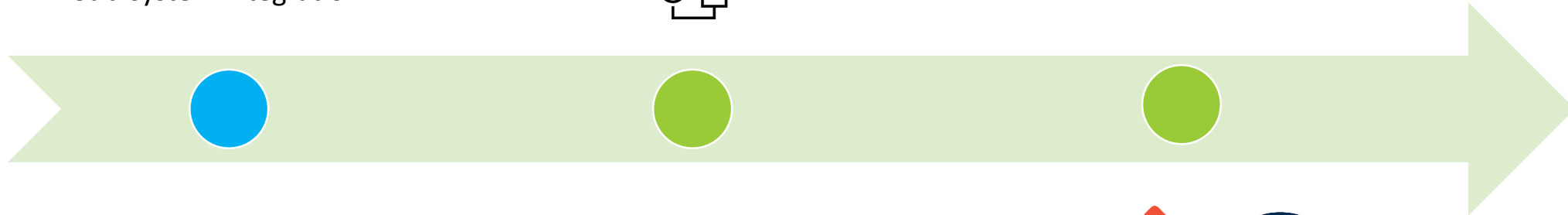
System DB I

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



System DB

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



Full
MBSE



System models II

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



Baserow

