SOFTWARE PA WORKSHOP 2023

Definition of a Metrication Model for Model-Based Engineering

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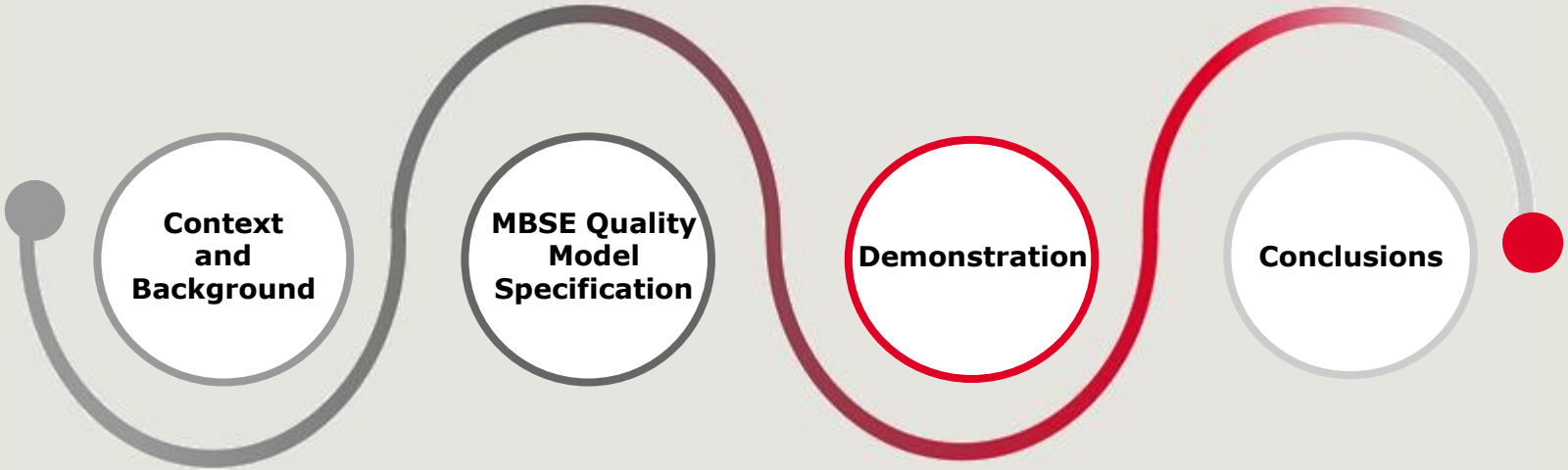
Speaker
Carlos Redondo (carlos.redondo.aparicio@gmv.com)

INNOVATING SOLUTIONS

Content Structure



Definition of a Metrication Model for Model-Based Engineering

1. **Context and Background**
2. **MBSE Quality Model Specification**
3. **Demonstration**
4. **Conclusions**

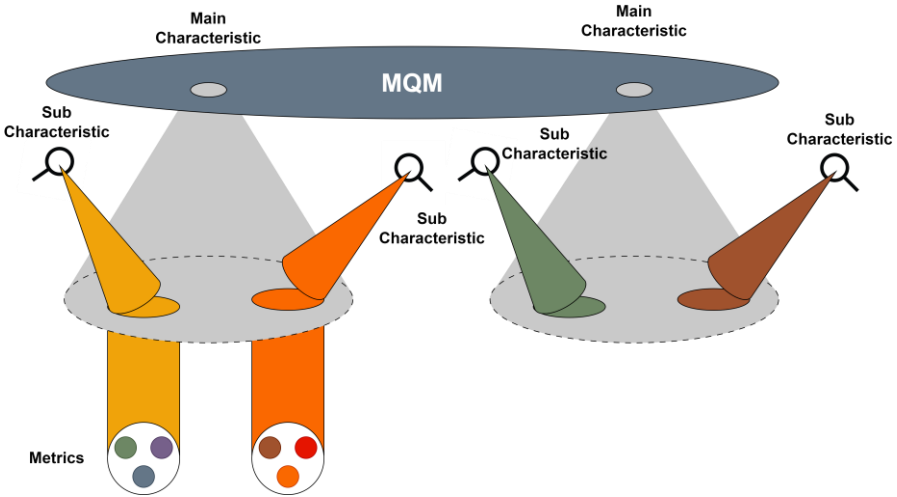
METMOD PROJECT

Project	Definition of a Metrication Model for Model-Based Engineering (METMOD)
Motivation	Model-Based Engineering is rapidly becoming the state of practice for the development of Space systems: source of truth for the extraction of quality-related information shifts from documents to models. **As consequence, the traditional Product Assurance (PA) methods, inspection points and practices need to be examined** in detail to establish if they need to be adapted and/or reinforced.
Objective	"To specify a reusable Quality Model - **MBSE Quality Model (MQM) -** which if implemented is capable of measuring the quality of any System or Software engineering model, so that quality levels are maintained in those cases when MBSE is used"
Duration	12 months activity (January 2023 - January 2024)
Consortium	ESA Technical Officer: Isabelle Conway
	Prime Contractor: GMV
	No Subcontractors

WHAT IS A QUALITY MODEL? (1/2)

A Quality Model is defined as a set of characteristics and the relationships between them which provide the basis for specifying quality requirements an evaluating quality (ISO/IEC 25000:2014)

- Typically, a Quality Model defines a set of Main Characteristics (e.g. Functionality, Reliability, Maintainability) and Sub Characteristics (e.g. Completeness, Correctness, Complexity) that are measured through a set of metrics (e.g. Requirements completeness).
- Quality Models are usually defined and used within software intensive systems.
- As an example, the **ECSS-Q-HB-80-04A** defines a Quality Model for the development of software in a Space project.



Example extracted from ECSS-Q-HB-80A

1. CONTEXT AND BACKGROUND

WHAT IS A QUALITY MODEL? (2/2)

A.2.1 Functionality

The capability of the software product to provide functions which meet stated and implied needs when the software is used under specified conditions.

Definition taken from: [ISO 9126], [SPEC]

Mentioned in: [ECSS-E-40], [ECSS-Q-80]

A.2.1.1 completeness

The capability of the software to provide full implementation of the functions required.

Definition taken from: [SPEC]

Mentioned in: [ECSS-E-40], [NASA-1740]

(Main) characteristic	Sub characteristic	Metrics	First provided at	Frequency
PRODUCT RELATED CHARACTERISTICS				
Functionality	Completeness	Requirement allocation	SRR	Every Review

Table 5-3: Target value for metric depending on criticality category

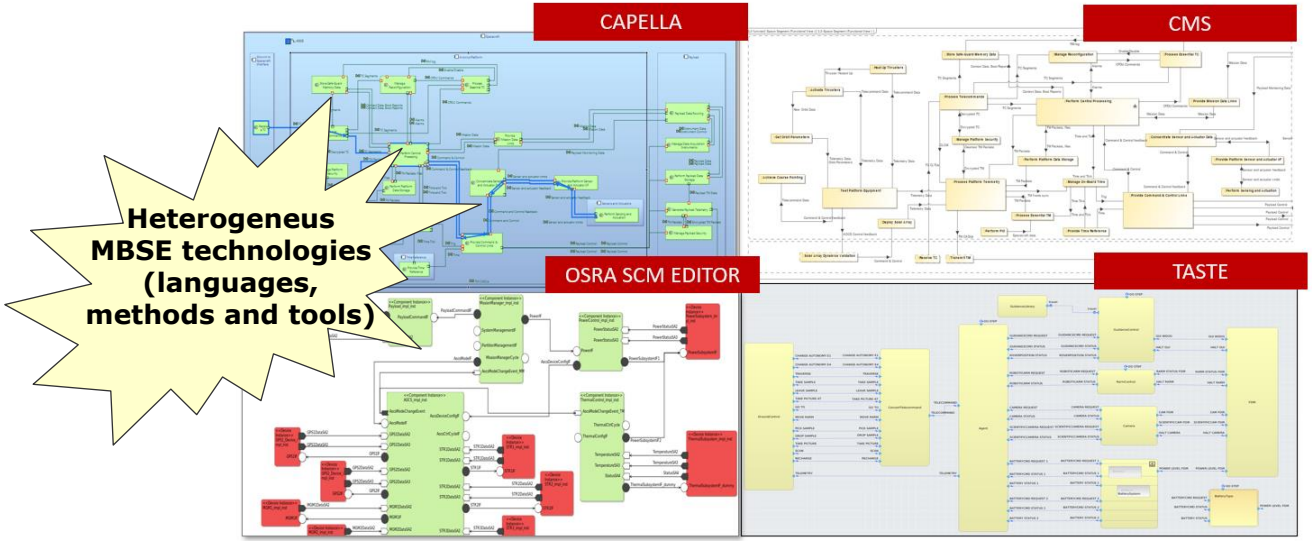
Metric name	Proposed target value/ criticality category			
	A	B	C	D
Requirement allocation	1	1	1	1

A.3.3.1 Requirement allocation

Main Characteristic	Functionality
Sub Characteristic	Completeness
Metric name	Requirement allocation
Goal	This metric identifies the relationship among: - Higher level requirements and software level requirements; - SW requirements and SW design.
Owner / Producer	Owner: development leader Producer: development team
Target audience	Development leader, SW PA manager, V&V leader
Evaluation method	Traceability matrices contained in SW requirements and SW design documentation.
Formula	X= A/B, where: A = number of system level requirements for software that have one or more trace to SW requirements or SW design components; B = number of system level requirements for software
Interpretation of measured value	0 <= X <= 1, the closer to 1 the better
Life cycle phase	Collected during software related system engineering, SW requirements & architecture engineering, SW design & implementation engineering processes. Provided at SRR, and updated afterwards (e.g. PDR) as required.
Applicability	- MANDATORY for all criticality categories.
Pre-conditions	Availability of traceability matrices.
Report format	*See example below.*
Other remarks	

WHAT IS THE MBSE QUALITY MODEL (MQM)? (1/2)

- The MBSE Quality Model will assess the quality of System and Software developments through their engineering models.
  - Main Characteristics, Sub Characteristics and Metrics address specific goals adapted to the model-based paradigm.
  - It will be applicable to System and Software engineering models.
- The main challenge is to define useful and representative metrics which measure the engineering models' quality independently from the selected MBSE technology.



WHAT IS THE MBSE QUALITY MODEL (MQM)? (2/2)

MBSE technology independent

systems engineering **software engineering**

ECSS compliant **applicable to MBSE**

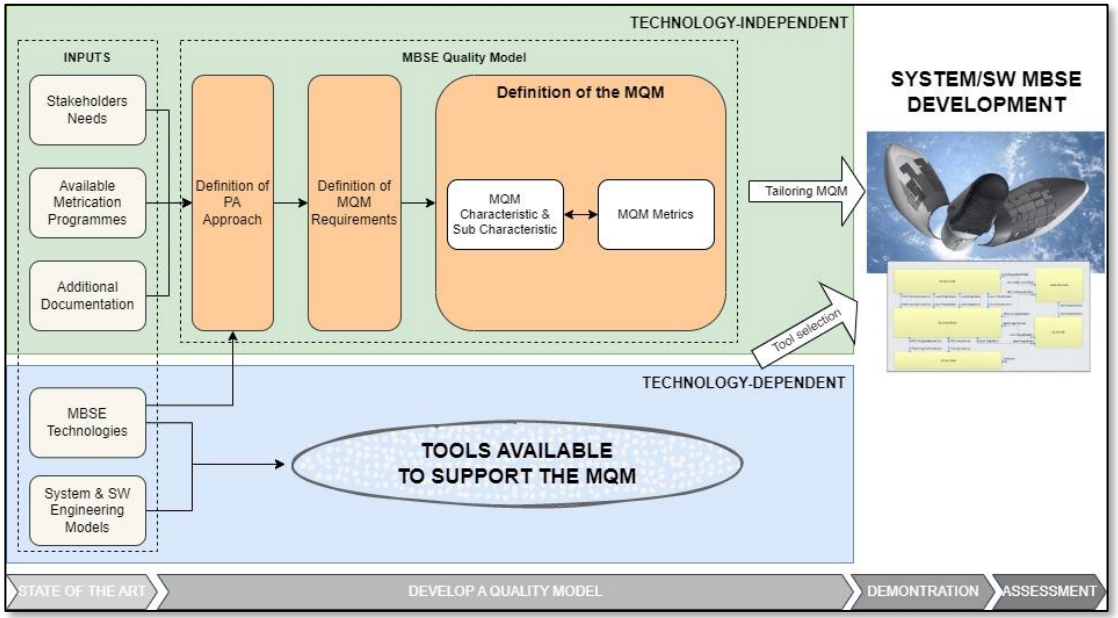
product **process**

measurable **goal-oriented**

tailored

automatic

DEVELOPMENT PROCESS



1. **State-of-the-Art & Practice:** COMPLETE
   - Survey on Industry Software and System Model-Based development lifecycle processes, methodologies and tools
   - Survey on Industry available quality models and metrics, and associated relevant standards
   - Selection of System and Software Engineering Models for MQM demonstration
   - Questionnaire on the use of Quality Models and their integration with MBSE
2. **Specification of an MBSE Quality Model** to be implemented as part of an effective and reusable Metrication Programme ON-GOING
3. **Demonstrate the implementation** of the Quality Model in the selected System and Software Engineering Models
4. **Assessment**: Guidelines and potential changes to ECSS Handbooks to integrate the Quality Models NOT STARTED

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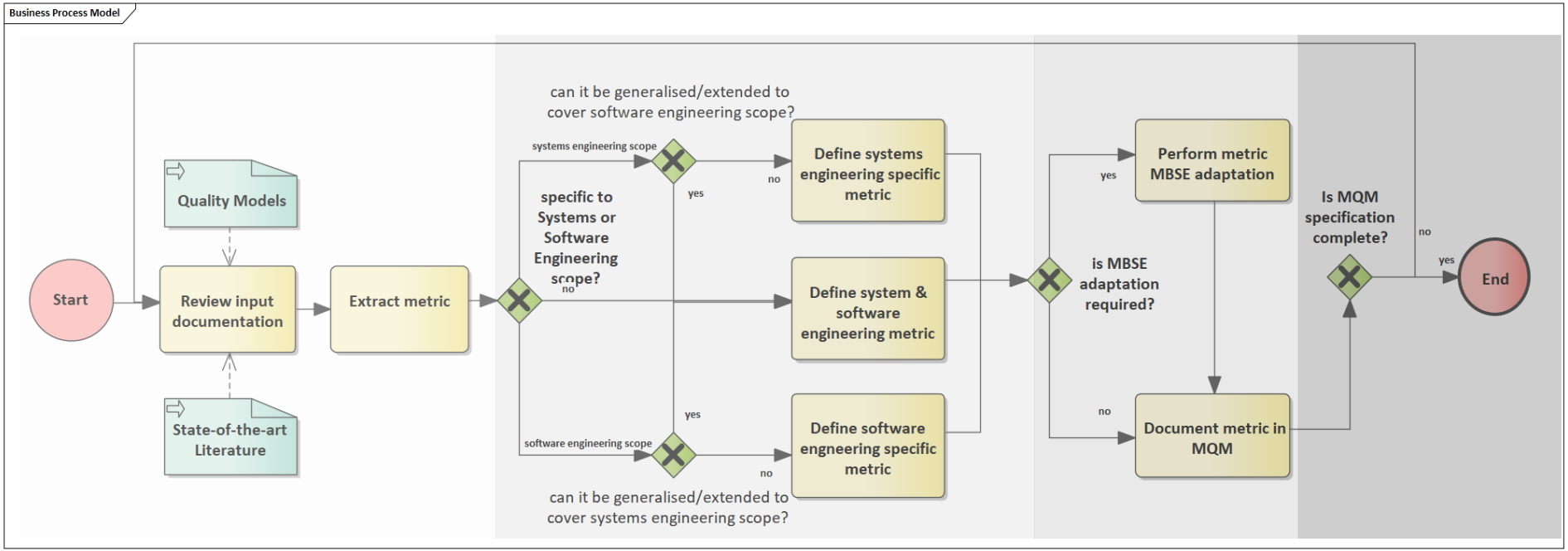
MQM SPECIFICATION: Development Strategy



Metric derivation and reuse

MQM Scope Completeness

MQM MBSE relevance

MQM Specification Completeness

MQM SPECIFICATION: A look into some of the Metrics…

Main Characteristic	Sub Characteristic	Metric
Functionality	Completeness	Requirements allocation
		Requirements functional allocation
		Functions physical allocation
		Requirement implementation coverage
		Requirements completeness
		V&V coverage
		Verification product category coverage
	Correctness	Adherence to modelling language laws
		Requirements uniqueness
		Model diagrams uniqueness
		Mass budget margin
	Volatility	Requirements volatility
		Functional volatility
		Physical volatility
		Model diagrams volatility
	Size	Requirements size
		Functional size
		Physical size
		Model diagrams size
	Model Coverage	Model elements heterogeneity
		Model diagrams heterogeneity
	Testability	Requirements testability
		Requirements test traceability

Main Characteristic	Sub Characteristic	Metric
Maintainability	Complexity	Mean requirements decomposition
		Mean functional architecture decomposition
		Effective functional architecture decomposition
		Functional architecture decomposition homogeneity
		Mean physical architecture decomposition
		Effective physical architecture decomposition
		Physical architecture decomposition homogeneity
		Number of physical assemblies
	Modularity	Modular coupling
		Modular cohesion
		Change impact strength
…	…	…

(*) MQM Metric specification is on-going

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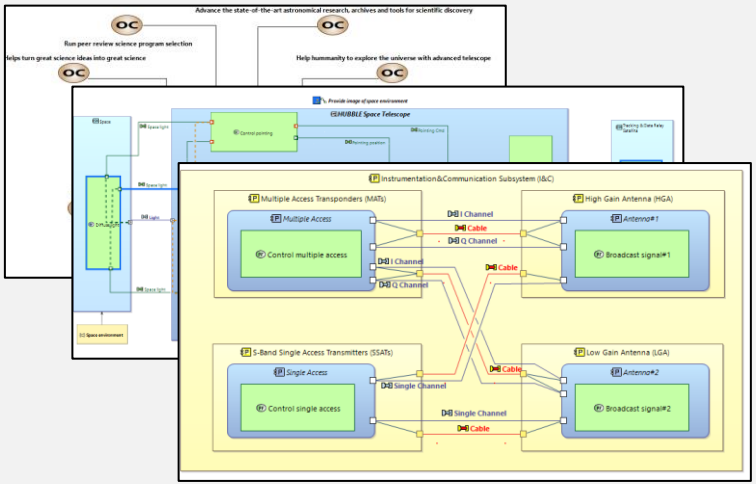
(*) Hubble Space Telescope Model - https://github.com/DROUINRemy/hubble-capella-sample

(*) TASTE Website - https://taste.tools/

3. DEMONSTRATION

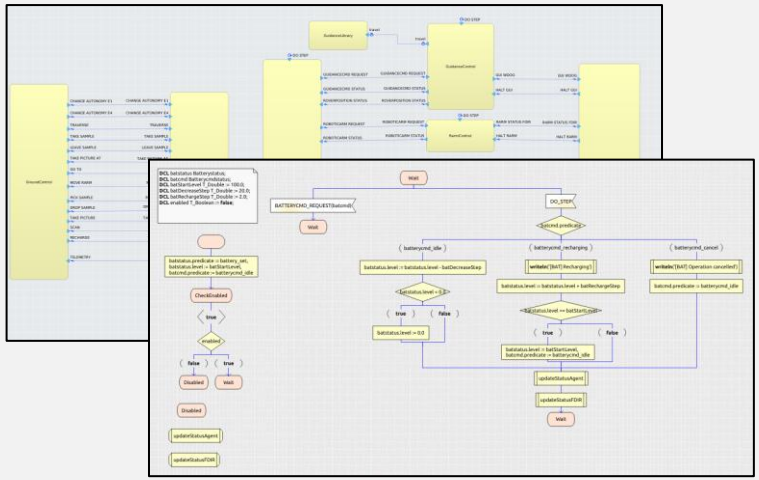
ENGINEERING MODEL SELECTION

System Engineering Model: ***HUBBLE Space Telescope (*)***



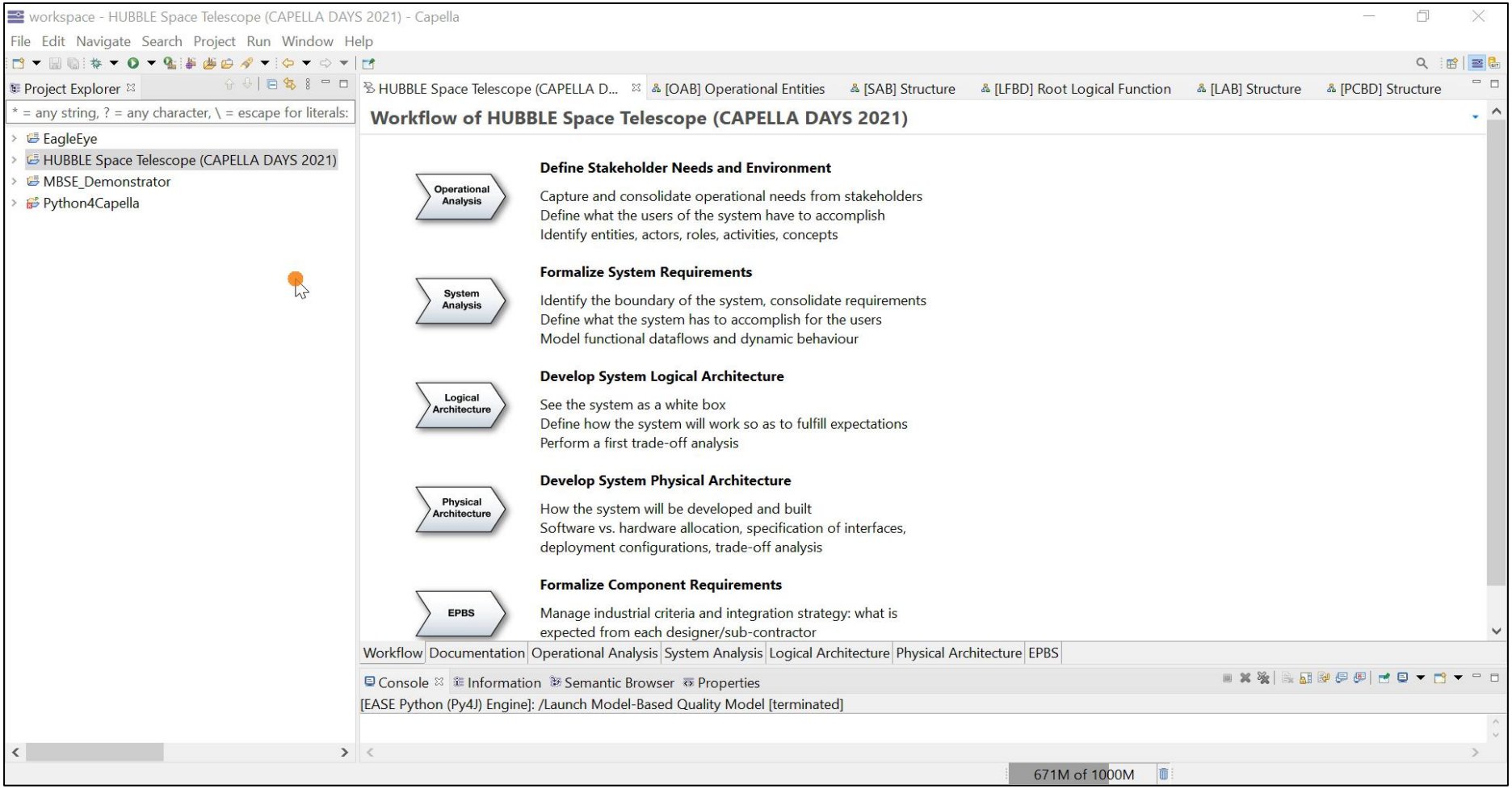
- Models HUBBLE Space Telescope in a simplified fashion
- Modelling tool is Capella following the ARCADIA method

Software Engineering Model: ***ERGO***

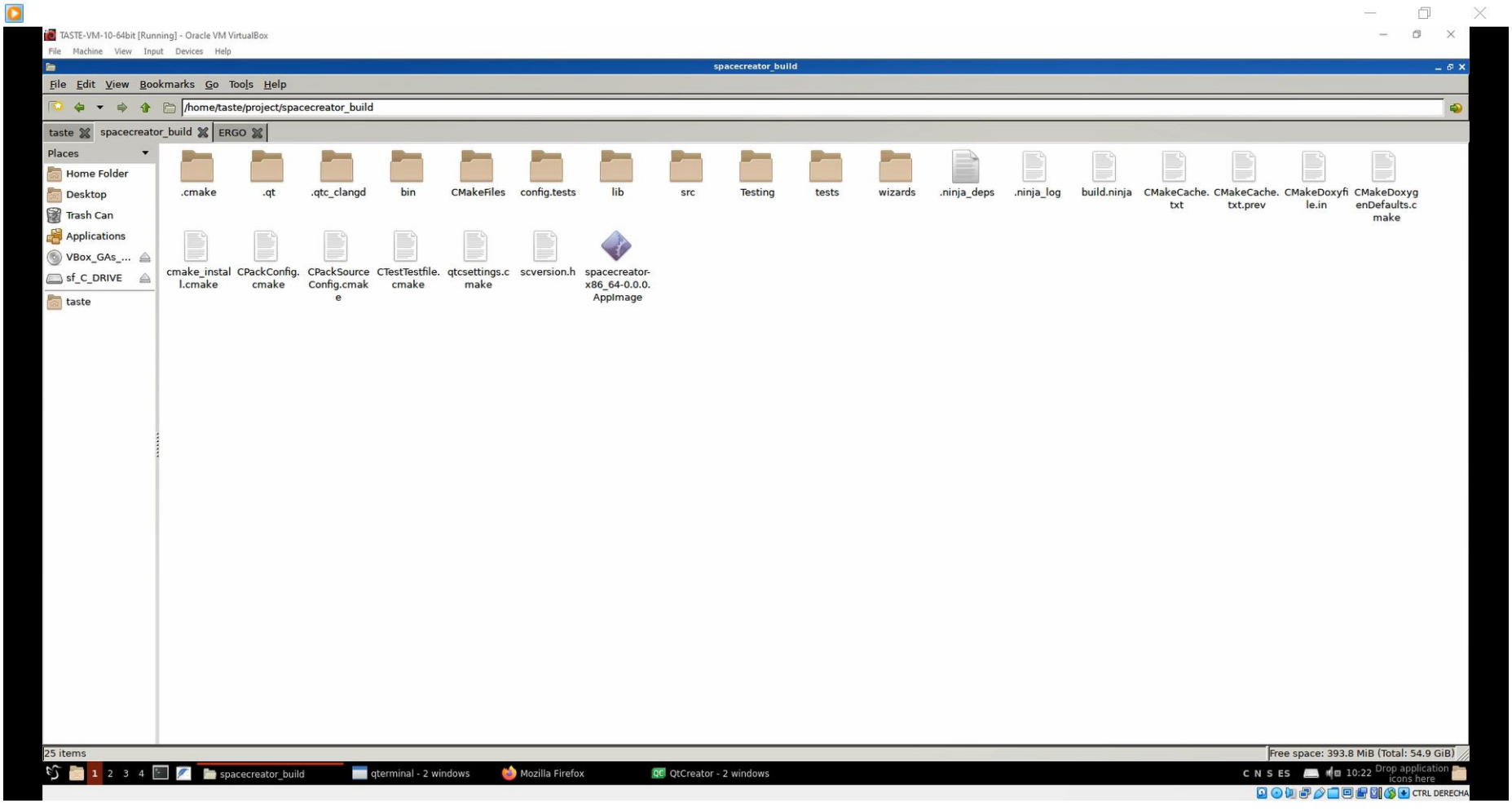


- Models ERGO rover inspired by the Mars Sample Return mission
- Modelling tool is TASTE (*), based on AADL, ANS.1, SDL and MSC

METMOD - Capella Implementation



METMOD - TASTE Implementation



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Wrap-up

Summary

- METMOD project **addresses Systems and Software Engineering quality-related concerns when adopting an MBSE approach** through the specification of an MBSE Quality Model (MQM) and its subsequent implementation in a set of engineering models.

Challenges

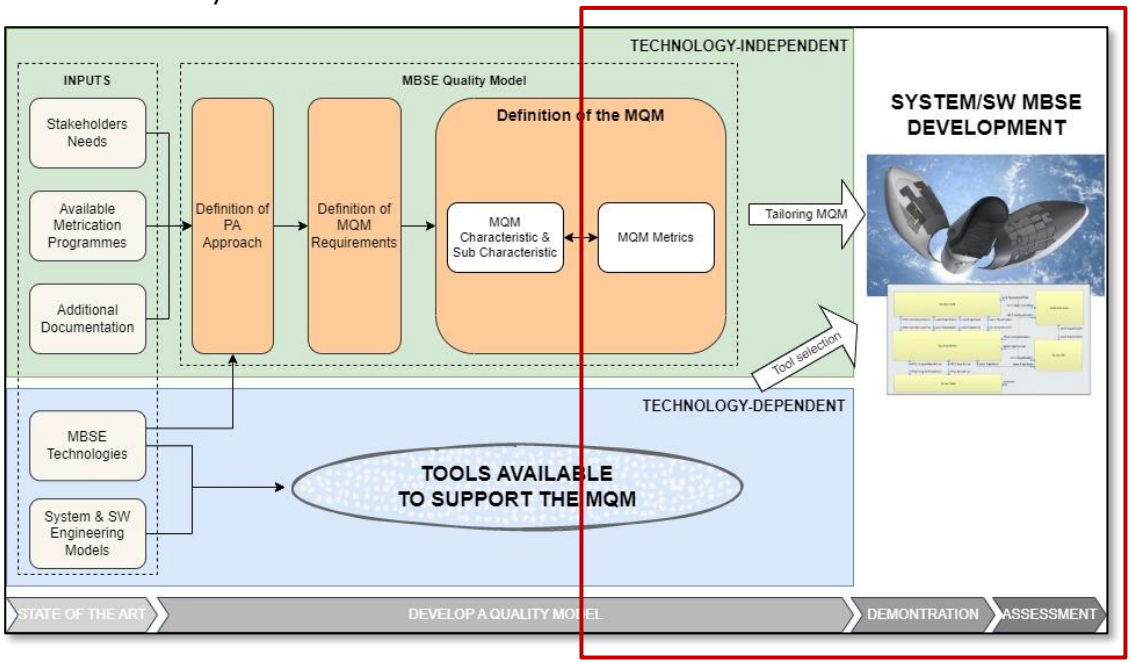
- Definition of **representative, meaningful and complete set of metrics for MBSE developments** which represents an answer to the Systems and Software Engineering quality-related concerns when adopting a model-based framework.
- **Independence** of the Metrication Programme **from any MBSE technology** (language, method and tool).
- Capture of some system/software engineering related data in a model-based fashion -> **quality metrication needs to be preceded by solid data modelling.** MBSE adoption advancement will progressively diminish this challenge.

Lessons Learnt

- Critical to **tailor the MQM implementation** to the specific **MBSE methodology employed**.
- ECSS need to **reflect and formalise (model-based) Systems and Software Engineering-related metrics**. General guidelines for their tailoring to specific MBSE methodologies shall be provided. This is on-going as part of this activity.
- (Model-Based) Systems Engineering metrics shall be **aligned to the Space Systems Ontology (SSO) UoDs.** New SSOs UoDs will unlock the formal definition of more metrics (e.g. Verification, Interface Management…).

Next Steps

1. Finalise the Metrication Programme definition and its prototype implementation in Capella and TASTE.
2. Carry out a demonstration using the selected engineering models.
3. Propose changes to ECSS based on the results and lessons learnt from this activity.
4. Final assessment on the activity results.



Thank you!

METMOD Points of Contact

ESA:	Isabelle Conway	isabelle.conway@esa.int
	Clement Puybareau	clement.puybareau@esa.int
GMV:	Carlos Redondo	carlos.redondo.aparicio@gmv.com
	Elena Alaña	ealana@gmv.com
	Marina García	marina.garcia.d@gmv.com
	Teresa Íscar	tiscar@gmv.com