

# MBSE Demonstrator CDF study

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29/09/2020



# Outline

- Objectives
- Study plan
- Preliminary Results
- Conclusions



# Objectives (1/4)



3 main objectives:

- To obtain an **IPR-free representative multi-disciplinary space system reference mission**,
- To apply **Model-Based System Engineering process**,
- To develop - and possibly integrate (3x) - the related **simulation models**, to build up simulators and test-facilities as input into the R&D activities.

**Note:** *heritage models and lessons-learned from EagleEye Reference Mission, as used since 2005 in R&D (avionics-oriented and documentation-based)*

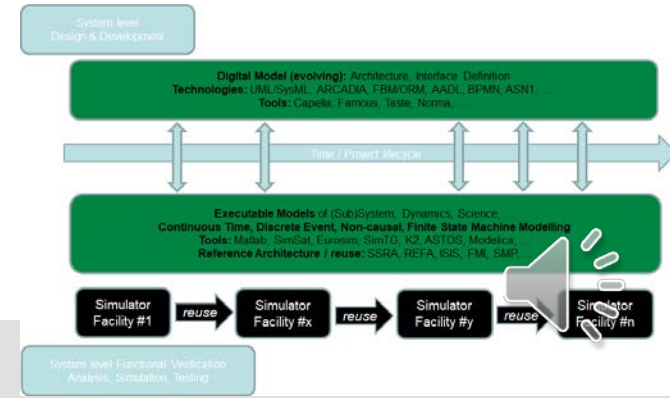
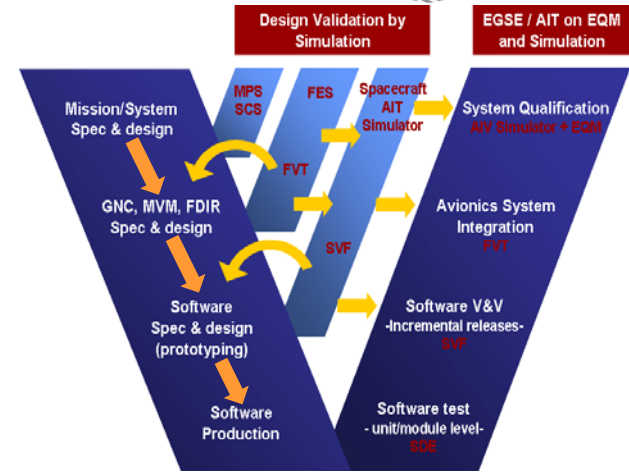


# Modelling “Reminder”



For this CDF study (and this presentation) to distinguish between the:

- **Space system reference mission**, e.g. Mission Objectives, Mission and System specification and Design; *the “what”*,
- **MBSE models** for the space system reference mission; to capture and maintain the above mentioned information in tooling such as OCDT, Capella and/or Enterprise Architect, but also the domain-specific MBSE tooling (e.g. Catia),
- **Simulation models** for verification and validation of the space system reference mission; functional dynamic / behavioural models to be executed as part of simulators using tools like STK, Matlab/Simulink, EcosimPro, etc...



To obtain an **IPR-free representative multi-disciplinary space system reference mission**

- Definition of the SSRM mission to serve ESA future domain-specific R&D needs.
  - *This means that not only the “mission needs” are driving the design but also that the “**R&D needs**” - coming from all interested **domains** - must be considered in case they have an impact on the definition of the SSRM mission baseline.*
- *Could be based on “definition and consolidation of the **EagleEye** mission baseline across non-avionics domains”*

To apply **Model-Based System Engineering** approach:

- For the specification of the SSRM mission, systems and subsystems requirements.
- For the definition of the product tree and its implementation in OCDT (Phase 0)
- For the definition of an MBSE model in a Capella-like environment, to cover and support to later phases (Phase A/B1).
- For the development of MBSE models across the domains.
  - *Note that the **integration** of MBSE models and Simulation models is also part of the ongoing “Digital Engineering DataHub” activities.*

# Objectives (4/4)



To develop - and possibly integrate - the corresponding **simulation models**

- **Identification, specification and implementation** of simulation models as needed to verify the “space system reference mission” baseline design in the CDF context. **This includes the alignment with the information as captured in the MBSE models.**
- **Identification and specification** of simulation models as needed to support the usage of the “space system reference mission” for future R&D activities in each domain.
  - This will serve as a starting point for work/efforts *after* the study.
- **Analysis and identification** of the simulation technologies and interfaces to “support continuous integration of simulation models” towards the concept of a **Digital Twin.**



# Study Plan



Session	Day	Date	Time	Objective
Session #1	Thursday	04/06/2020	09:30 – 13:30 CET	Kick Off
<i>Offline</i>				<i>Gathering of inputs</i>
Session #2	Thursday	11/06/2020	09:30 – 13:30 CET	Discussion on inputs
Session #3	Thursday	18/06/2020	09:30 – 13:30 CET	Discussion on inputs
<i>Offline</i>				<i>Preliminary definition of space system reference mission</i>
Session #4	Tuesday	07/07/2020	09:30 – 13:30 CET	Space system reference mission iteration
Session #5	Tuesday	01/09/2020	09:30 – 13:30 CET	Space system reference mission consolidation
<i>Offline</i>				<i>MBSE and Sim model work</i>
Session #6	Tuesday	06/10/2020	09:30 – 17:30 CET	MBSE and Sim model overview
IFP	Tuesday	12/11/2020	09:30 – 17:30 CET	Internal Final Presentation

ESA



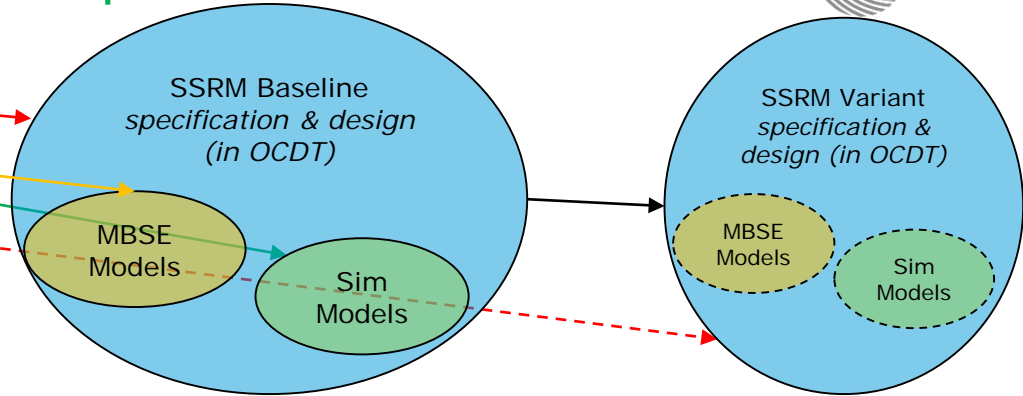


# Mission, System and "R&D" Specification



## Part-1: Session #2 and #3 inputs:

- RM requirements fitting a Baseline
- MBSE related requirements
- Sim Model related requirements
- RM requirements needing a variant
- *RM requirements **not** fitting (around 100 requirements)*



## Part-2: EagleEye Mission, System and Subsystem specifications

## Part-3: EO Phase-A MRD and SRD as input in order to complete and further detail

ID	TYPE	LEVEL	PARAMETER ID	DESCRIPTION	COMMENT	COMMENTS
26	H	2	4.1	General requirements		
27	H	2	4.6	Spacetrack Subsystems Requirements		
28	H	3	4.6.1	Attitude and Orbit Control and Guidance and Navigation Subsystem Capabilities		
29	RT	4	4.6.1.1	The ACS (Attitude and Orbit Control Subsystem), including a Orbit Navigation (Satellite System) (ONSS) tracking device and its satellite processor, shall provide the hardware and software capabilities and performances:	AOC	(OCDT excluded and reference to satellite propulsion. Normal ACS, CCM (which includes ECU, on-orbit, emergency and anomaly situations according to its state (loading to the FDR) and its mission availability (driving its autonomy possibilities).
30	RT	4		1. to perform the attitude measurement, estimation, guidance, pointing and control needed for the mission, both real-time in orbit and on ground a posteriori.		
31	RT	4		2. to perform the Orbit Control Manoeuvres (OCM), as specified by the mission requirements.		
32	RT	4		3. to ensure a safe state of the spacecraft at any time, including emergency and anomaly situations, according to failure management requirements.		
33	RT	4		4. to ensure the mission availability, as specified at satellite level.		
34	RT	4		Attitude keeping		
35	RT	5	EE_ACC000	The ACS shall provide during all phases of the mission the capability to acquire and keep the attitudes necessary to perform the mission.	AOC	
36	RT	4		Hardware and software		
37	RT	5	EE_ACC000	The ACS shall provide the hardware and software means for autonomous on-board determination of the spacecraft attitude and its orbital state which includes position, velocity and time.	AOC	Autonomous attitude and orbit state determination
38	RT	4		Accuracy		
39	RT	5	EE_ACC000	The accuracy of the estimation and control of attitude, position, velocity and angular rates shall be derived from the observational, geo-location requirements and from the needs of the satellite operations (including calibration), with due allowance for error contributions from on-board and ground sources.	AOC	Currently this requirement is to be refined by further analysis (e.g. space WB1 analysis). For EagleEye we could already fill this with numbers.
40	RT	4		GNSS		
41	RT	5	EE_ACC000	Time, real-time satellite position and velocity shall be determined by an on-board GNSS receiver and shall be distributed to other Satellite subsystems.	AOC	
42	RT	4		Actuator sizing		
43	RT	5	EE_ACC000	The ACS sizing of sensors and actuators shall be such that saturation of actuators and internal parameters shall not occur under any worst case combination of internal and external disturbances. This requirement excludes only to Safe Hold Mode.	AOC	It can be assumed that the ACS size is defined by the specification. The requirement includes external disturbances due to impact of aerodynamic forces or micrometeoroids.
44	RT	4		Orbit Control Manoeuvring		
45	RT	5	EE_ACC000	The ACS shall provide the capability for achieving orbit control manoeuvres specified by mission analysis.	AOC	Currently open to different OCM items like EE_ACC000. To be further specified.

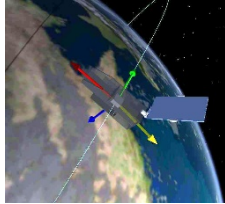
SSRM excell-based SRD model



# SSRM Mission and System Design

1. "Ocean Earth Watch" Earth observation mission *(to speed up process)*

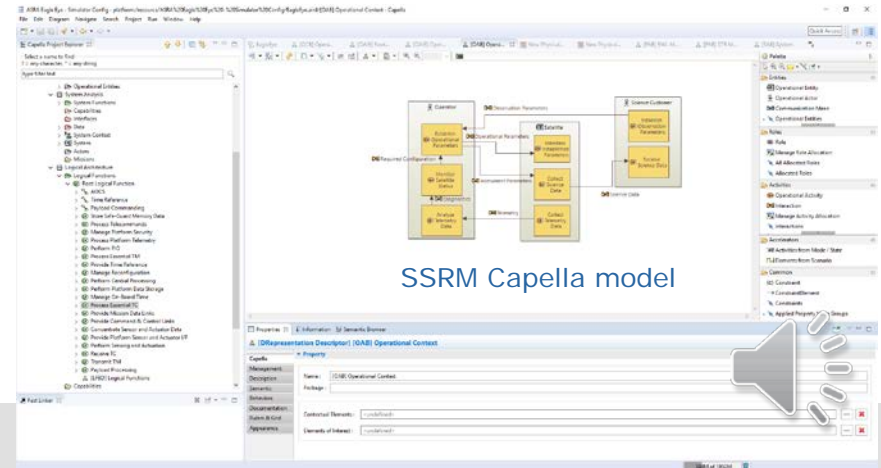
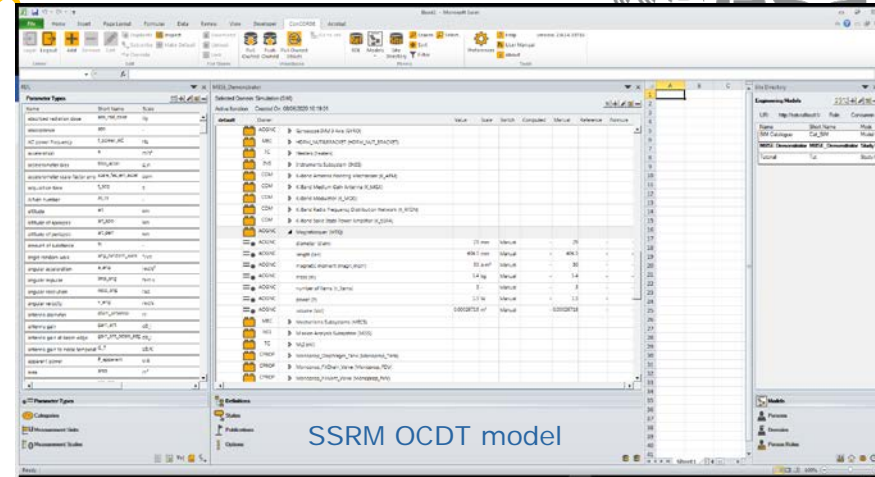
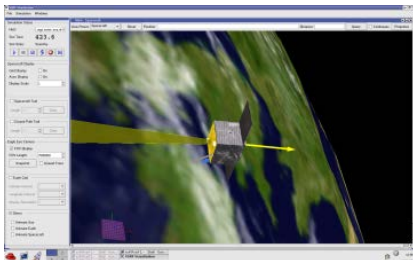
CDF study done in 2006, IDM, configuration and Final Report available



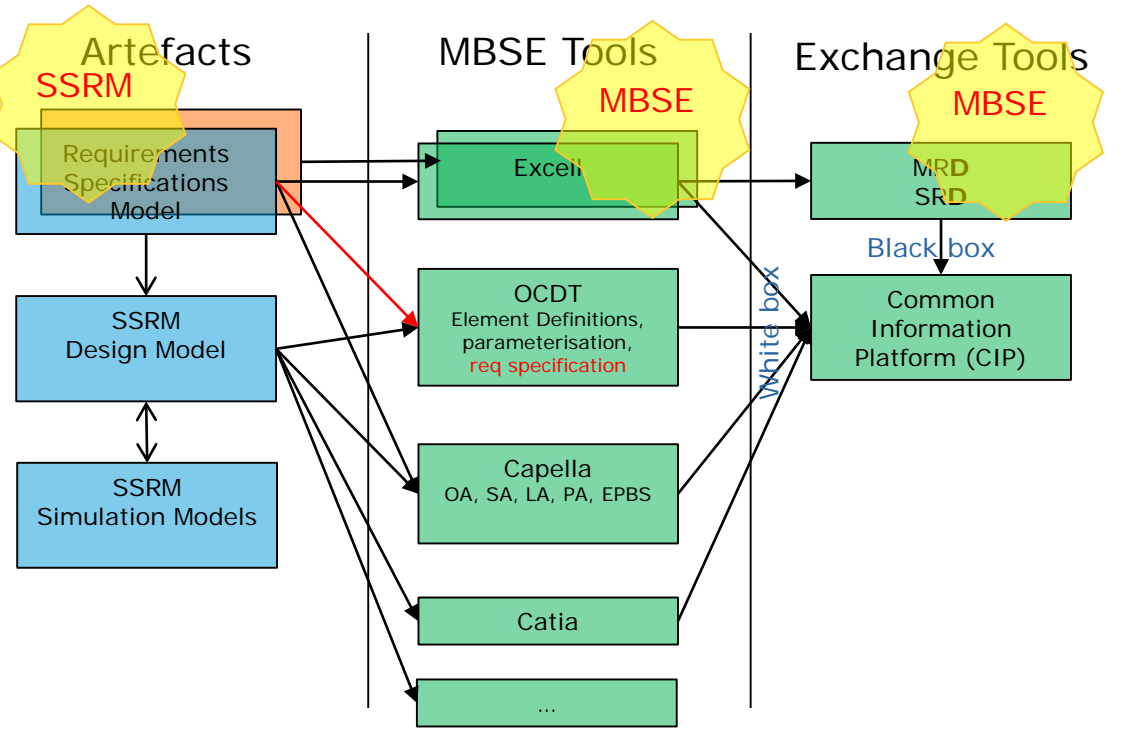
2. "EagleEye" Earth observation reference mission *(for availability of models)*

as captured in RAC Earth Observation Reference Mission requirements specification document.

as implemented by number of simulators and simulation models



# Schematic: SSRM artefacts and MBSE tooling

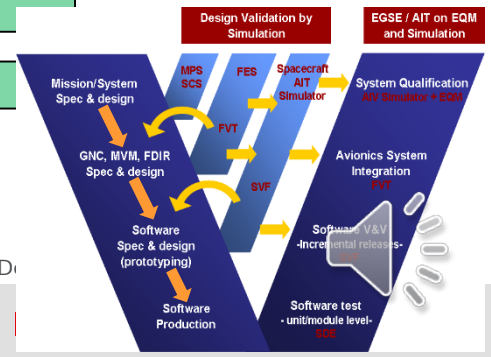


## Simulation Tools

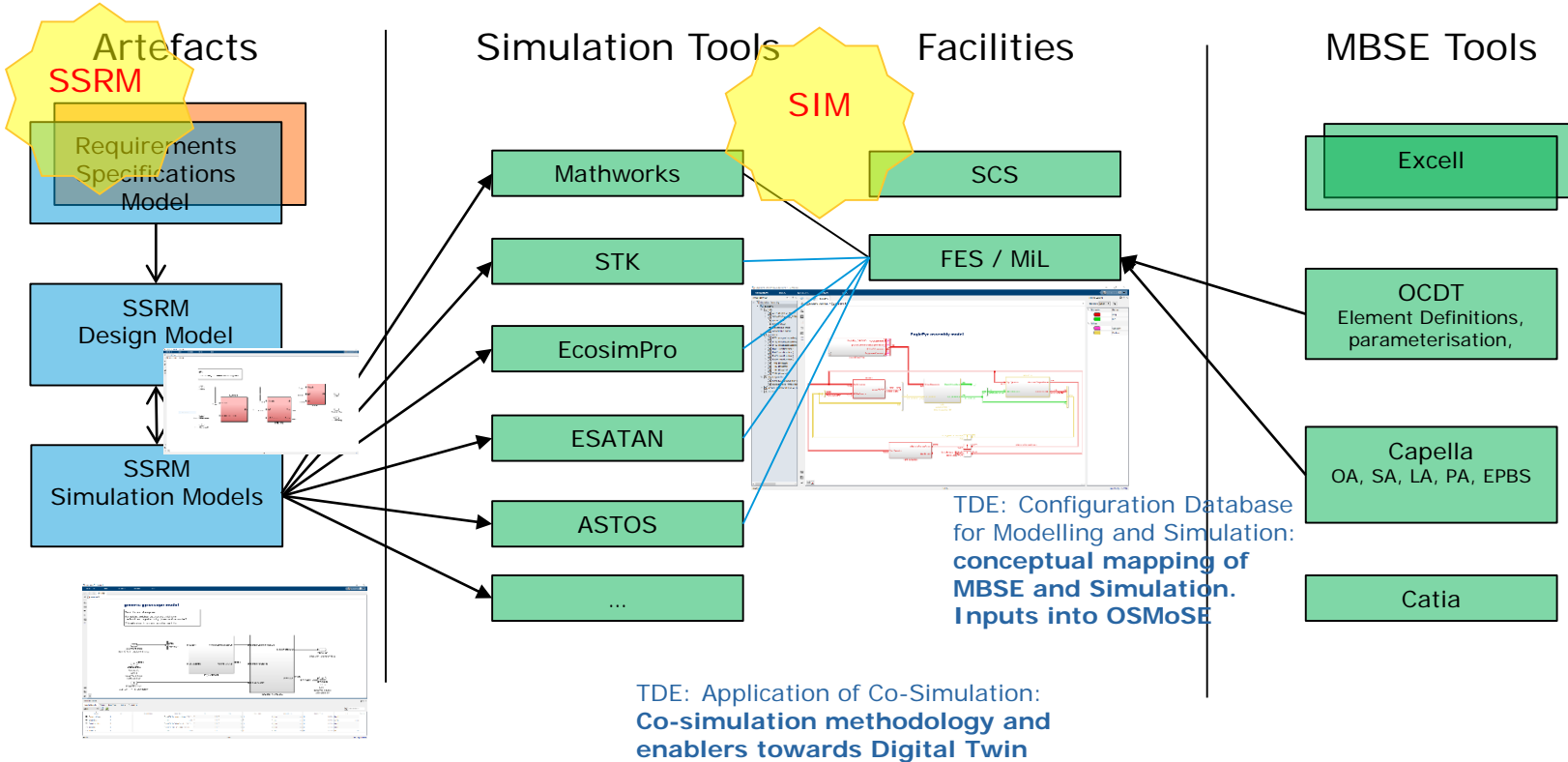
- Mathworks
- STK
- EcosimPro
- ESATAN
- ASTOS
- ...

## Facilities

- SCS
- FES / MIL
- ...



# Schematic: SSRM artefacts and Simulation tooling



# (Preliminary) Conclusions

- MBSE Demonstrator Study is ongoing
  - “Nature of study” and “Off-site team” challenging
- Requirements Specifications phase was difficult:
  - “Domains” **are** the users of the SSRM
  - Different nature of specifications
  - Scattered over Mission, System and Subsystem level
  - Gaps (to be filled)
  - Heritage inputs (OEW and EagleEye)
  - Phase 0 and Phase A/B1 “dynamics”
- Preliminary SSRM design in OCDT and Capella; consolidation ongoing
- Simulation modelling is just starting
  - Co-Simulation V&V methodology is available
- Complete and consistent dataset (including MBSE / Sim Models) is required before starting new R&D activities using the SSRM (e.g. OSMoSE ontology skeleton)
  - Urge from starting/ongoing R&D activities ;-)



# Questions?

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