Realizing
Space System Data Repository

Harald Eisenmann, Michel Janvier Astrium Satellites

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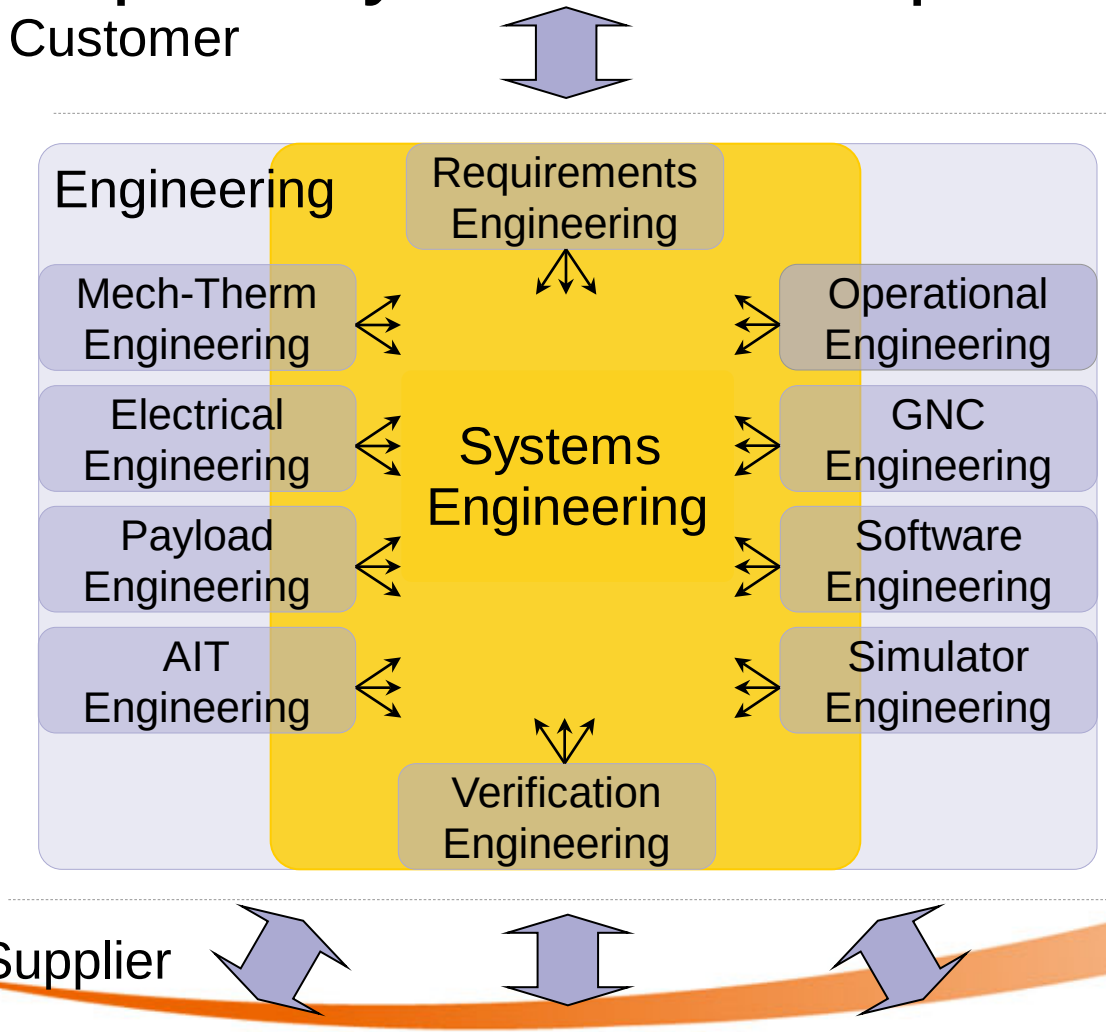
Space System Data Repository is the key element for Model-Based Systems Engineering

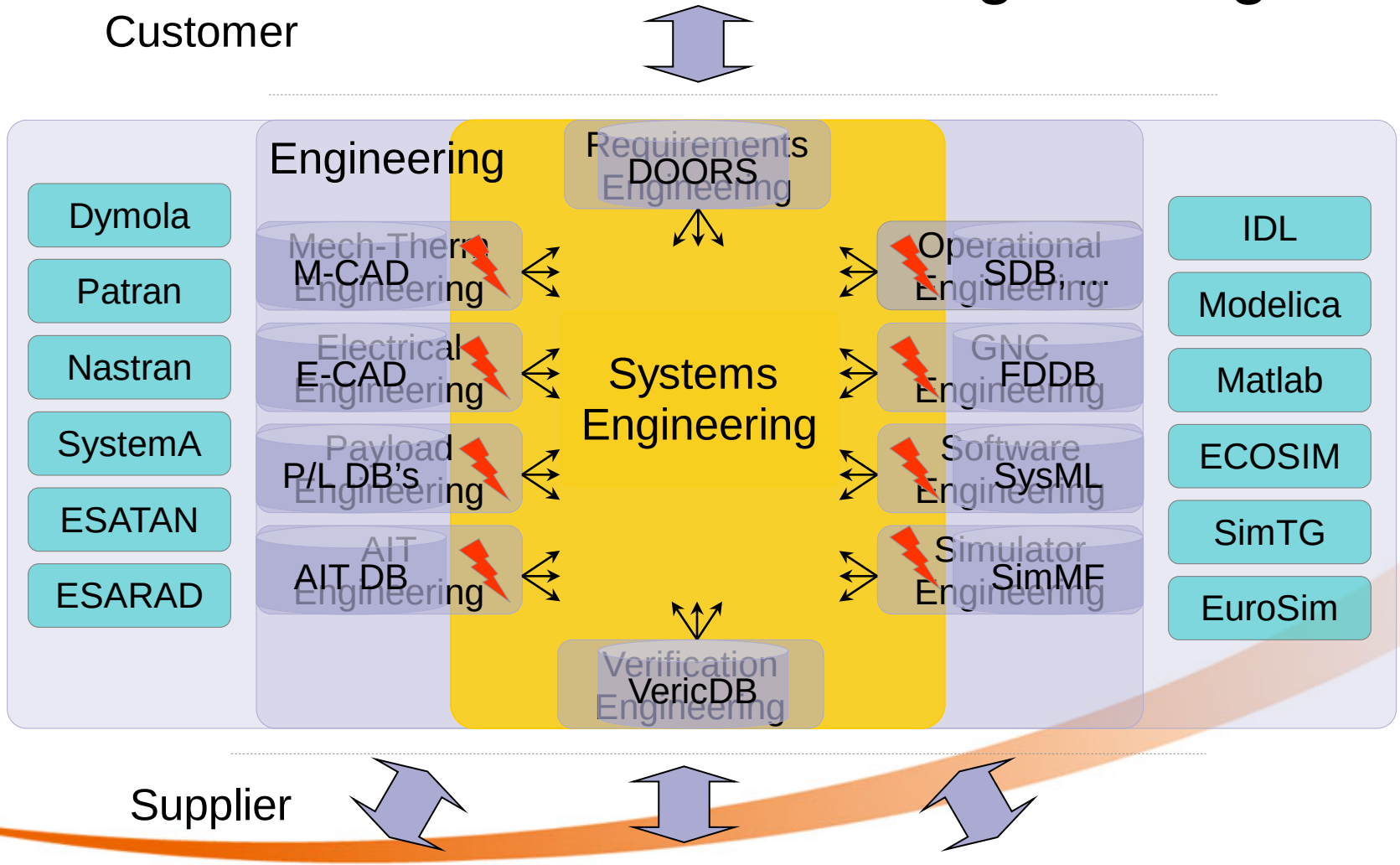
- Struggling with the transition of model-based systems engineering into model-based systems engineering
- Considerable progress has been made in the past to improve the specification and development of databases (modeling tools) and tool integration
- Adoption of commonly shared elements, requires the coordination of the various processes, and stakeholder needs

Systems Engineering has a key role of for space systems development



- Process Integration
  - Data exchange along customer supplier chain (“extended enterprise”)
  - Data sharing among disciplines
  - Ensure that life-cycle consideration
- System level decision making
  - System performance
  - Trade-off
  - Design optimization
  - Design consolidation
  - Impact analysis
  - System verification
  - …

Today systems engineering is performed in the context of model-based engineering



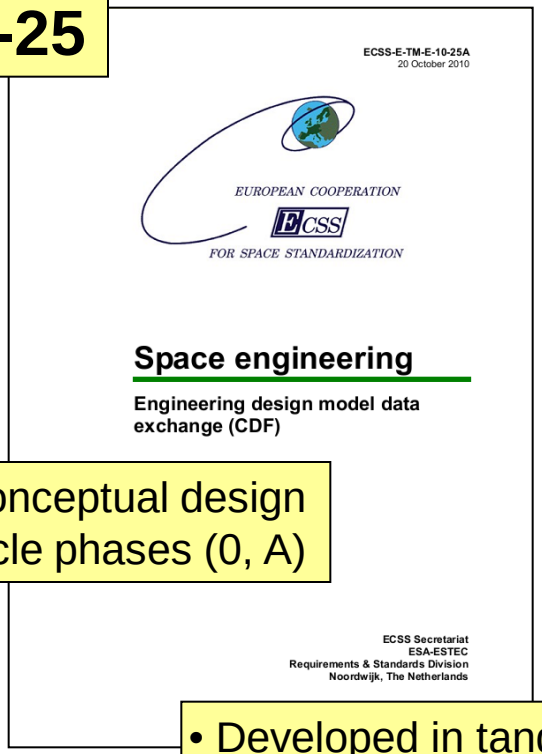
Valuable progress has been made in past years overcoming the tool imposed boundaries

- Shared conceptual data model is the key element to enable the integration of the various models
  → ECSS E-TM-10-23 and ECSS E-10-25
- Model-driven S/W engineering has been matured for database and modeling tool development
- Open source frameworks are for model-driven engineering are rapidly emerging

➔Large-scale validation has been performed in frame of ESA Virtual Spacecraft Design (VSD)

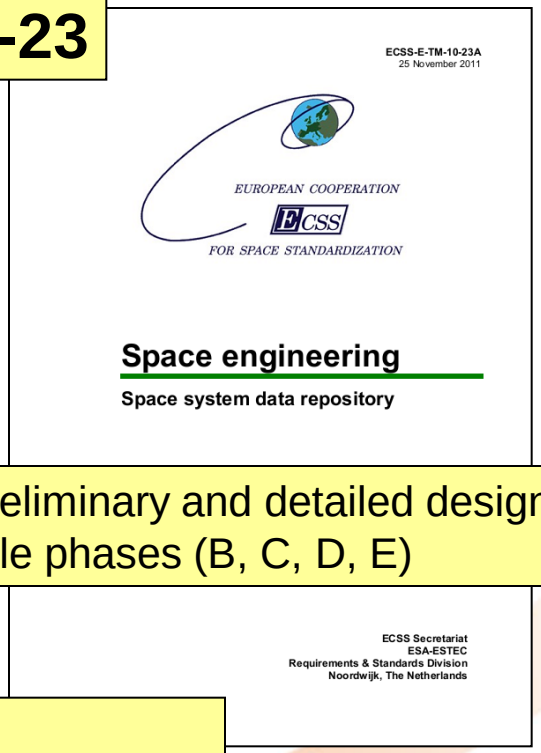
Emerging ECSS standards in support of MBSE

E-TM-10-25



Focuses on conceptual design in early life cycle phases (0, A)

E-TM-10-23



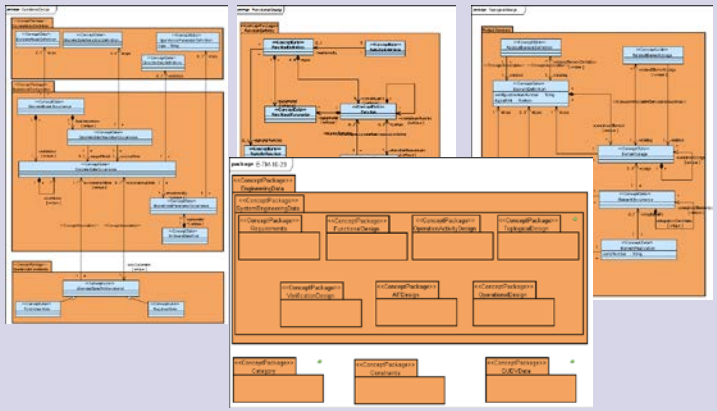
Focuses on preliminary and detailed design in later life cycle phases (B, C, D, E)

- Developed in tandem
- Where possible common approach and semantics
- Where possible aligned with OMG SysML
- Future merge to single real standard
- E-TM-10-25A made available Oct 2010
- E-TM-10-23A made available Nov 2011

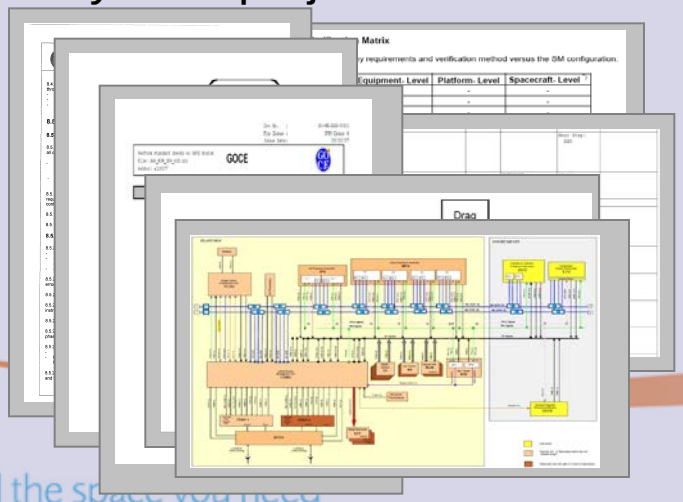
E-TM-10-23 Conceptual Data Model is derived directly from project artefacts

Existing Standards

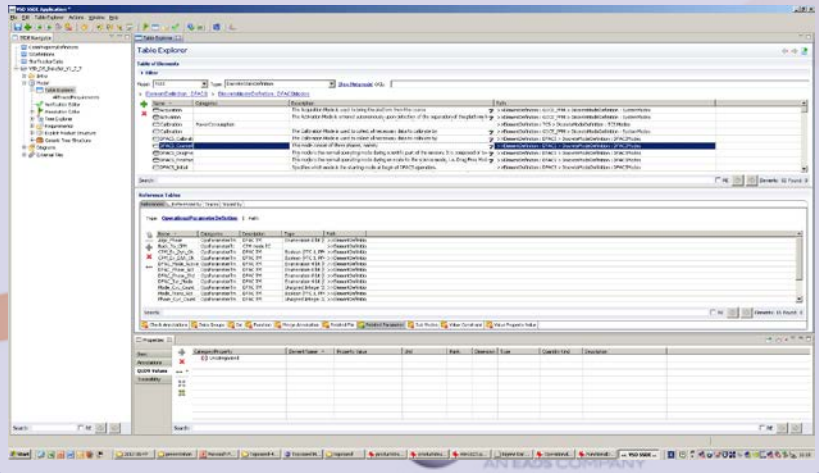
Definition of Data Model in UML



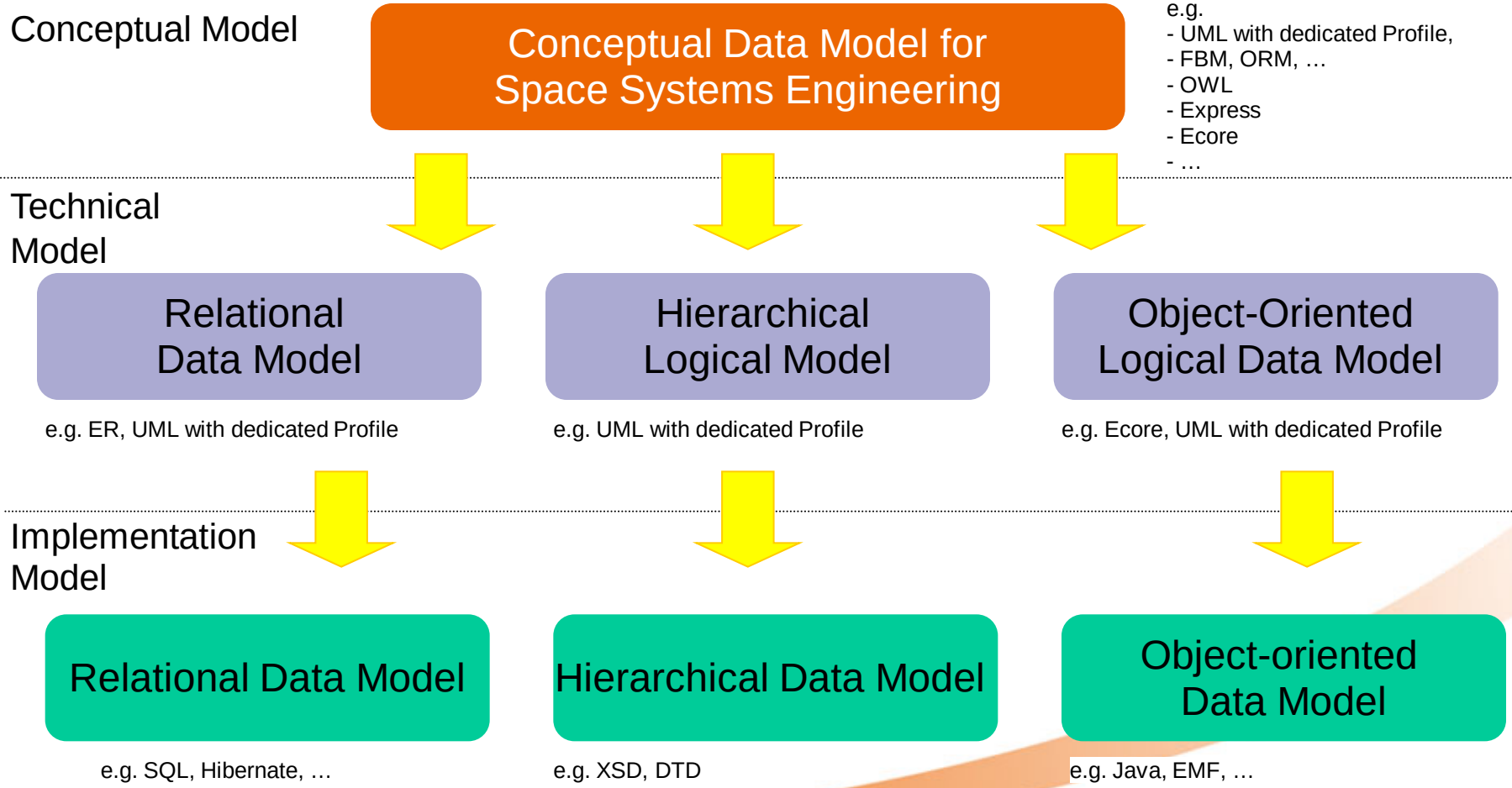
Analysis of project models



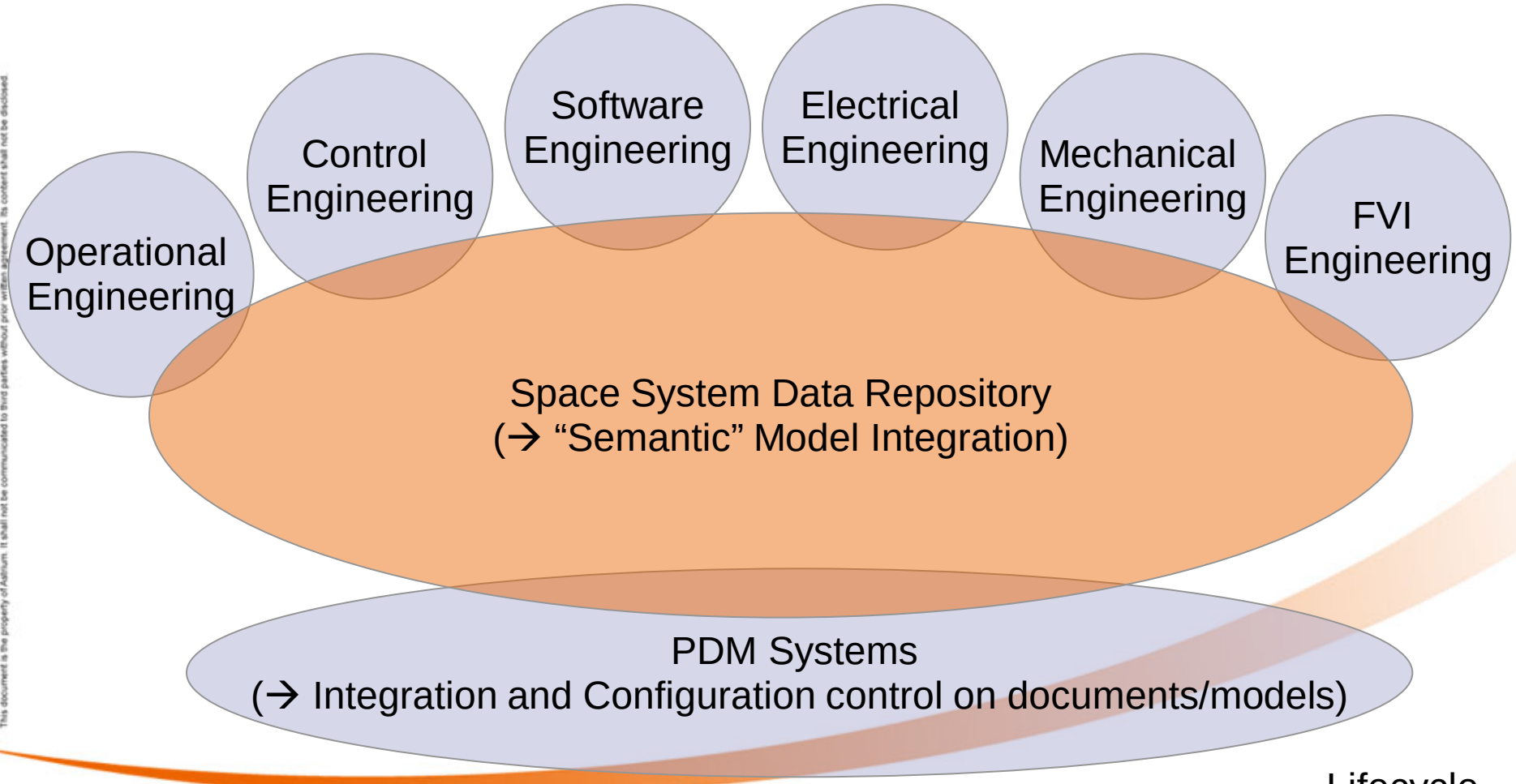
Data model validation



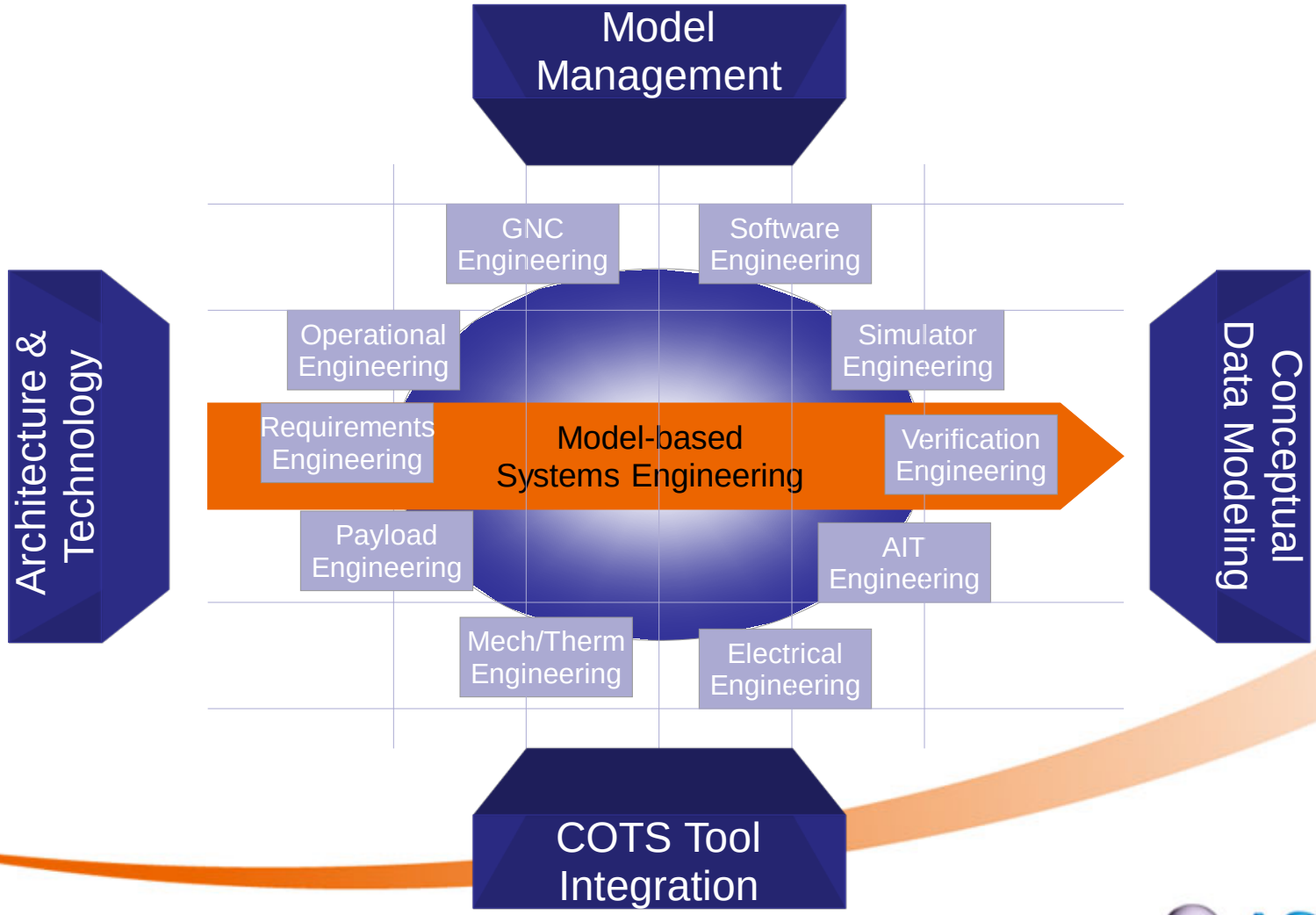
The conceptual data model enables the application of model-driven S/W engineering



Tool integration requires a 2-step integration with different “model resolution”

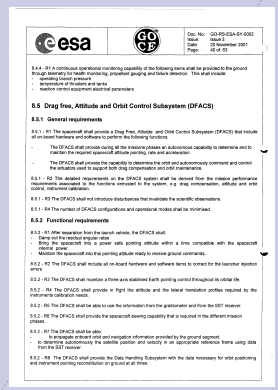


ESA Virtual Spacecraft Design delivered a demonstrator to validate the approach



Various disconnected manually defined “views” form the system model

Requirements



8.4.4 - R1 A continuous operational monitoring capability of the following items shall be provided to the ground through telemetry for health monitoring, propellant gauging and failure detection. This shall include:
- temperature of the valves and tanks
- temperature of the valves and tanks
- reaction control equipment electrical parameters

8.5 Drag free, Attitude and Orbit Control Subsystem (DFACS)

8.5.1 General requirements

8.5.1 - R1 The spacecraft shall provide a Drag Free, Attitude and Orbit Control Subsystem (DFACS) that include all on-board hardware and software to perform the following functions:
- The DFACS shall provide during all the missions phases an autonomous capability to determine and to maintain the required spacecraft attitude pointing, rate and acceleration.
- The DFACS shall provide the capability to determine the orbit and autonomously command and control the actuators used to support both drag compensation and orbit maintenance.

8.5.1 - R2 The detailed requirements on the DFACS system shall be derived from the mission performance requirements associated to the functions entrusted to the system, e.g. drag compensation, attitude and orbit control, instrument calibration.

8.5.1 - R3 The DFACS shall not introduce disturbances that invalidate the scientific observations.

8.5.1 - R4 The number of DFACS configurations and operational modes shall be minimized.

8.5.2 Functional requirements

8.5.2 - R1 After separation from the launch vehicle, the DFACS shall:
- Damp out the residual angular rates
- Bring the spacecraft into a power safe pointing attitude within a time compatible with the spacecraft power budget
- Maintain the spacecraft into this pointing attitude ready to receive ground commands.

8.5.2 - R2 The DFACS shall include all on-board hardware and software items to correct for the launcher injection errors

8.5.2 - R3 The DFACS shall maintain a three-axis stabilised Earth pointing control throughout its orbital life

8.5.2 – R4 The DFACS shall provide in flight the attitude and the lateral translation profiles required by the instruments calibration needs.

8.5.2 - R5 The DFACS shall be able to use the information from the gradiometer and from the SST receiver

8.5.2 - R6 The DFACS shall provide the spacecraft slewing capability that is required in the different mission phases.

8.5.2 - R7 The DFACS shall be able:
- to propagate onboard orbit and navigation information provided by the ground segment,
- to determine autonomously the satellite position and velocity in an appropriate reference frame using data from the SST receiver.

8.5.2 – R8 The DFACS shall provide the Data Handling Subsystem with the data necessary for orbit positioning and instrument pointing reconstitution on ground at all times.

Operational Modes

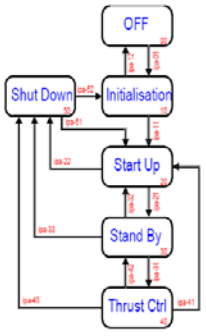
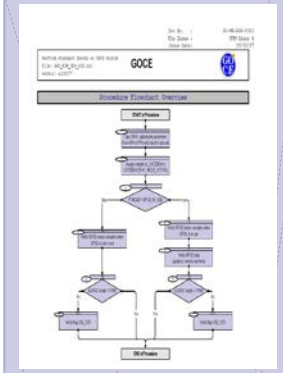
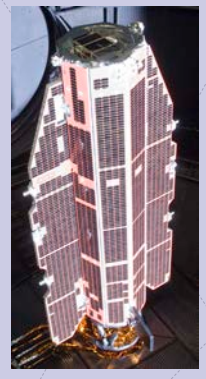


Figure 4-10: IPA Operational Modes and Transitions

Operational Proc



Configuration



Integration Procedure

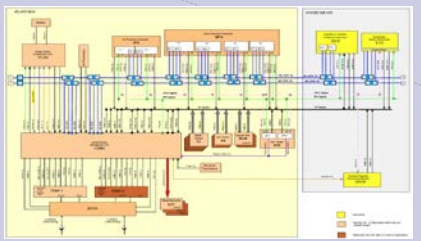
Verification Matrix

7.1.1 Platform SM Verification Matrix

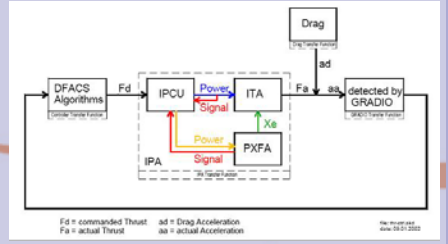
The following table summarises the key requirements and verification method versus the SM configuration:

Requirement Category	Equipment- Level	Platform- Level	Spacecraft- Level [1]
Function	-	-	-
Performance	-	-	-
Leakage	-	-	-
Alignment	-	T	T
Thermo Elastic Stability	-	A	T
Interfaces	T, I	T, I	-
Physical Properties (mass, CoG)	T [2]	-	T
Quasi Static Load	-	-	T
Vibration	-	-	T
Acoustic	-	-	T
Separation Shock	-	-	T
Thermal Verification (TV/TB Test)	-	-	-
EMC- R & C	-	-	-
ESD	-	-	-
Magn. Moment	-	-	-
Radiation environment	-	-	-
Oxygen	-	-	-

Electrical Interfaces



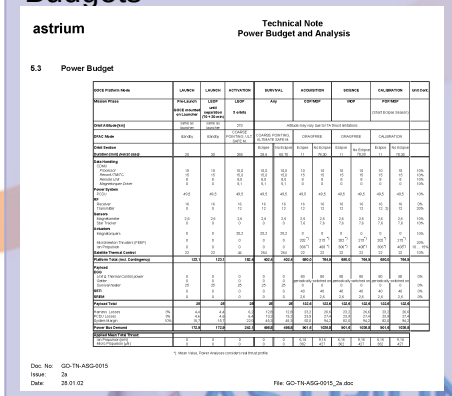
Functional Architecture



Fd = commanded Thrust ad = Drag Acceleration
Fa = actual Thrust aa = actual Acceleration

Manual process to ensure coherence between views

Budgets



astrium

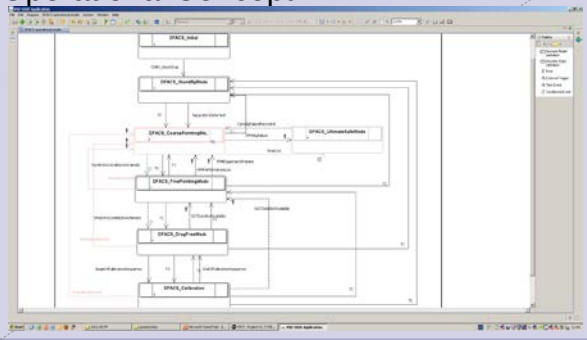
Technical Note
Power Budget and Analysis

5.3 Power Budget

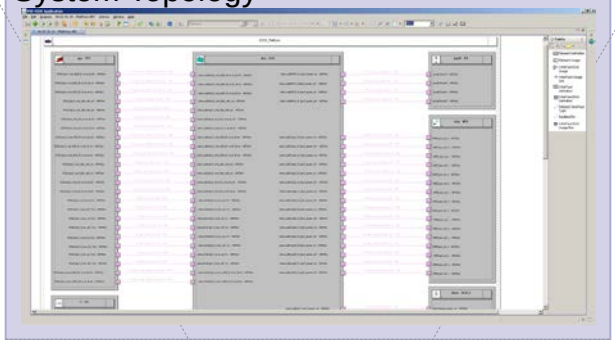
Doc. No: GO-TN-ASG-0015
Issue: 2a
Date: 28.01.02
File: GO-TN-ASG-0015_2a.doc

Conceptual data model enables common representation and visualization of data

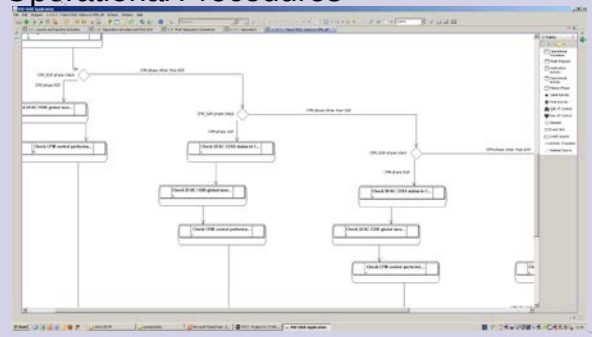
Operational Concept



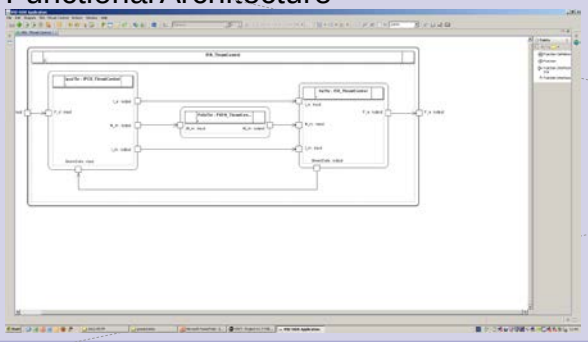
System Topology

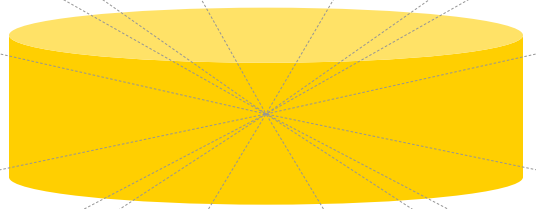


Operational Procedures

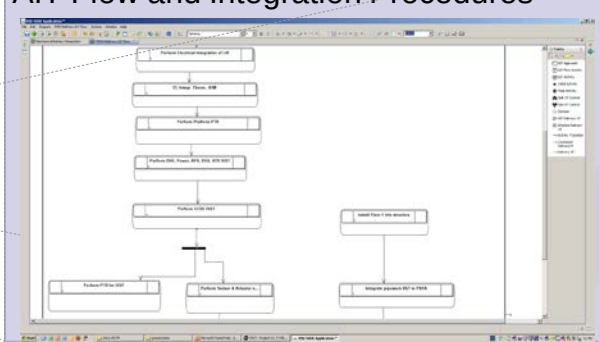


Functional Architecture

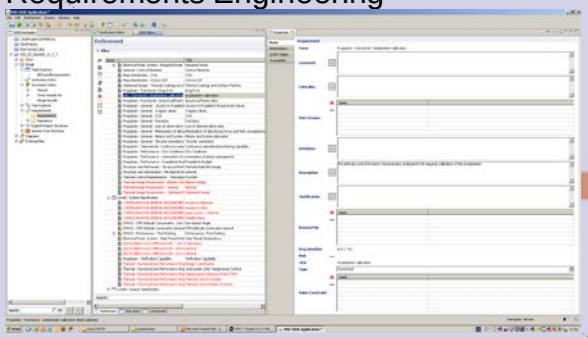




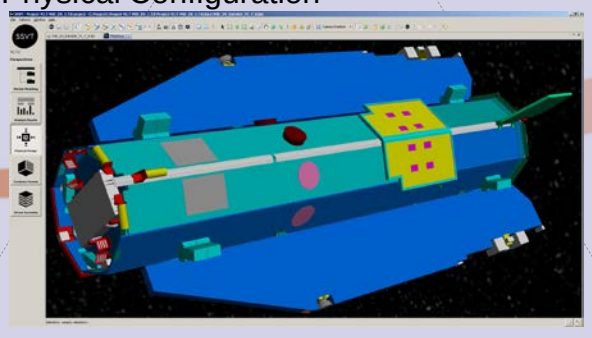
AIT Flow and Integration Procedures



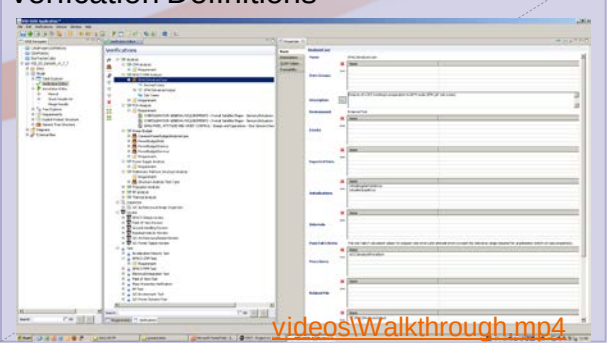
Requirements Engineering



Physical Configuration



Verfication Definitions



videos\Walkthrough.mp4

Operational application of conceptual data model requires continuous coordination

- Conceptual data models derived from E-TM-10-23 are used for operational implementations
  - E.g. EGS-CC, RangeDB @ Astrium
- But further technological improvement activities are being performed at the same time
- Careful coordination is required to provide stable baseline for operational implementations
  - Careful manage the commonly shared items
  - Care for migration
  - Provide planning to coordinate different efforts

The common coordination might provide a forum to cover the following elements

- Align interests and constraints of stakeholder needs
  - Agree on roadmaps
  - → Imposed solutions will fail to bring value (at least lead delay use)
- Joint assessment of maturity of emerging technologies
  - Data modeling language and methodology (!)
- Manage evolution of the conceptual data model
- Care for sufficient set of sample data
  - “Realistic” data set with sufficient complexity
  - Validation data sets for conformance testing
- Initiate shared / sample implementation for interfaces
  - →EGS-CC