# MBSE - Final Presentation

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| MATAKIDIS, Panagiotis (Airbus Defence and Space) [GB] / | Jul 30, 2021 12:39:37 PM GMT |

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# MBSE Deployment for EnVision Science Mission Study
## Final Presentation

ENVI-PF-ADSS-PS-1001011198

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V1.0 – Final Presentation Meeting (29/07/201)
V1.1 – minor update to correct typo

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# Change Record

| Issue | Date | Relevant Information |
|-------|------|----------------------|
| 1.0 | 29/07/21 | As presented in the Final Presentation Meeting between ESA/ADS |
| 1.1 | 30/07/21 | Minor update in slide 19 - corrected typo in CDP4 version |

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# Agenda

- Objective(s) and work logic
- MBSE modelling activities
  - Engineering data modelling with CDP4
  - System modelling with CAMEO
- Requirements justification tracing
- Way forward

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# Activity Objectives and Work Logic

# Objectives

- Top-level goals:
  - Elaborate and maintain a digital architecture model encompassing all equipment and its physical properties
  - Create system-level syntheses based on the model and track their evolution as the design is iterated
  - Facilitate the exchange and reporting of the physical architecture and system budgets with ESA study team on a regular basis

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# Activities & Deliverables

- Main activities:
  - Deployment of the selected Engineering Data Model (EDM) tool
  - Definition of the modelling conventions
  - Build of a digital architecture of the spacecraft including definition of system-level options of interest (Mass and Power budgets).
  - Explore the opportunity of:
    - Modelling of the mission and spacecraft using CAMEO (SysML) starting with linking the Mission Requirements Document (MRD) to the definition of the Concept of Operations, from which a functional architecture is decomposed, creating a traceability matrix between elements.
    - Tracing the justification of the design to the mission performance requirements

- Deliverables:
  - Modelling conventions report
  - System Budget Reports (Mass and Power)
  - Provision of a dashboard (together with the associated engineering data) to allow to see the evolution of the parameters.
  - Provision of the inputs for the Mission Design Description and Autonomy Concept extracted from CAMEO.
  - Requirement traceability matrix linking performance requirements to the design justification documents

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# Work Logic

- The core of the activity duration was about 10 months

- The work has been structured in two main tasks:

  1. MBSE coordination and support
     - aiming at coordinating the deployment of the selected tools, training and supporting the EnVision team

  2. MBSE modelling
     - aiming at making use of MBSE for the functional and physical description of the EnVision mission and spacecraft.

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# MBSE coordination and support

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# Engineering Data Modelling (EDM) Tool Selection

- Two tools were identified to be tested and benchmarked for the EDM tool.

  o **CDP4**
    - Developed by RHEA System and deployed on Airbus UK premises in its open source Community Edition version.
    - Current version deployed is IME is 5.1.1.0.
    - RHEA and ESA have announced they would merge CDP4 with ESA's Open Concurrent Design Tool (OCDT), with which it shares a similar data model based on ECSS-E-TM-10-25. The new tool is named COMET
  o **Shadox**
    - Developed internally by ArianeGroup, and deployed within ArianeGroup in Phase 0 projects and up to Ariane 6 production programme.
    - Provides powerful, browser-based, Python-integrated system that address most of the shortcomings of the CDP family and improves team collaboration.

- Despite an early engagement with the different stakeholders, the deployment of the Shadox tool encountered issues with the network connectivity of Airbus DS, which together with current firewall/security governance policies, did not allow for a timely deployment of the tool.
  o Due to resource and schedule impacts, the decision was made to proceed with CDP4 instead.

- Corporate IT firewall/security policy restrictions and network configuration issues can prove to be the main bottleneck in the deployment of tools. The introduction of such tools requires the adoption of a long-term strategy  together with  the allocation of significant resources.

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# MBSE modelling activities
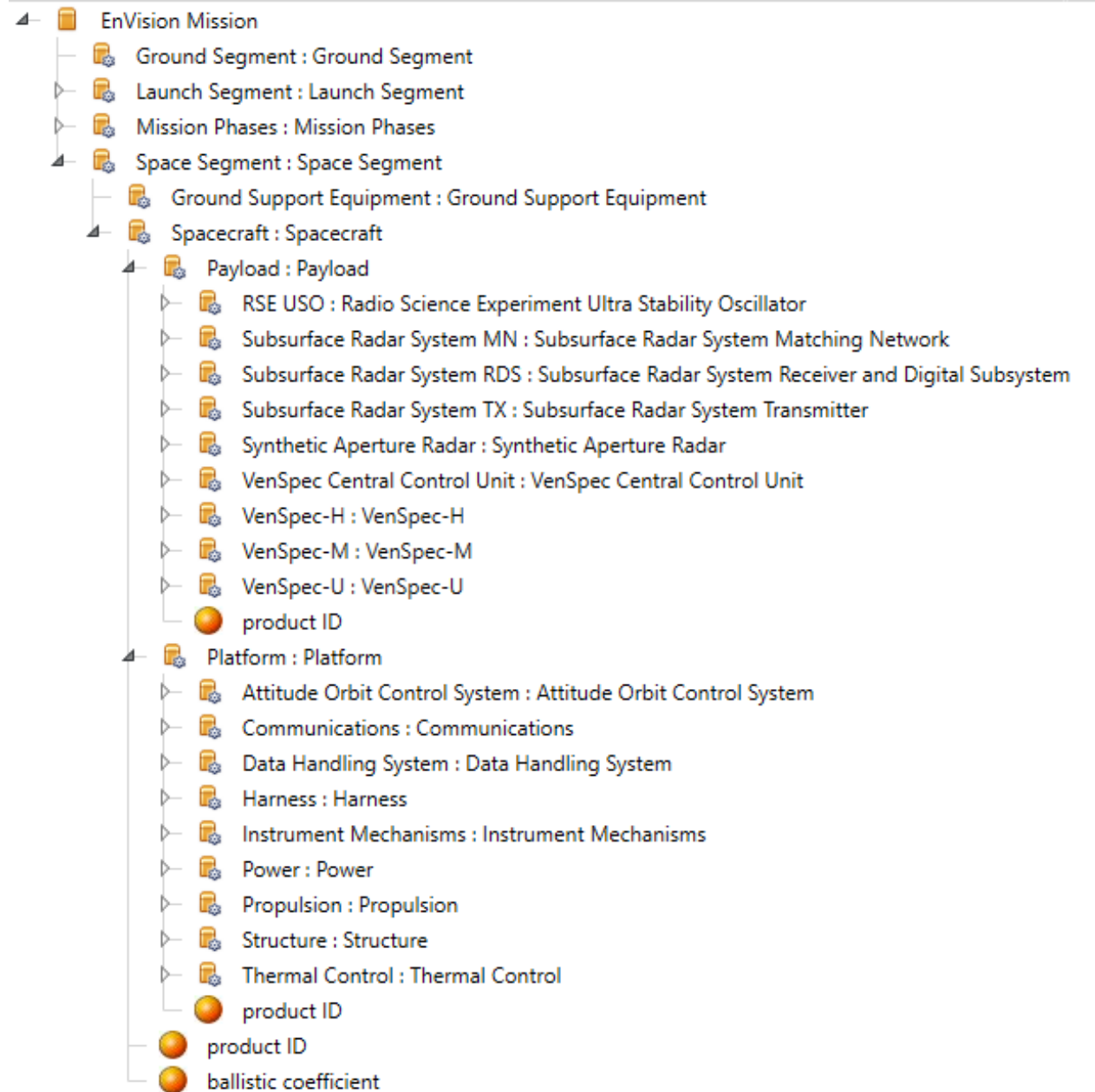
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# MBSE  Engineering  Data Modelling
# with CDP4

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# Introduction to CDP4

- Current IME version deployed is the 5.1.1.0 Community Edition (open source). The respective github is located at https://github.com/RHEAGROUP/COMET-IME-Community-Edition

- CDP4 implements a central database, which users can connect to via an API. Typically, this is done via the furnished Integrated Modelling Environment (IME) stand-alone application or Excel Add-in, which every team member in a project should have access to. As the server deploys an API, any tool can in principle be connected to it.

- In the EnVision deployment, the focus was on integrating the Product Tree, Mass Budget and Power Budget.

- As it was not possible to deploy Shadox, no formal benchmark was performed.

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# Product Tree

- The CDP4 Data Model is the ECSS-E-TM-10-25, which is defined based on building blocks called Element Definitions (*yellow parallelepiped*). When an Element Definition is used to define another Element Definition, it is an Element Usage (*yellow parallelepiped with a gear*). A series of Element Usages can be used to define a product tree, with one element being defined as top-element (in this case *EnVision Mission*). Elements can also contain parameters (*orange sphere*).

- In CDP4, the Product Tree is at the heart of the model and allows us a quick and demonstrative visualisation of its current state. All elements down to Equipment and all parameters can be visualised.

- In order to support future work in managing the Mission Product tree, the Product ID parameter has been added to all relevant Elements in the Product Tree.

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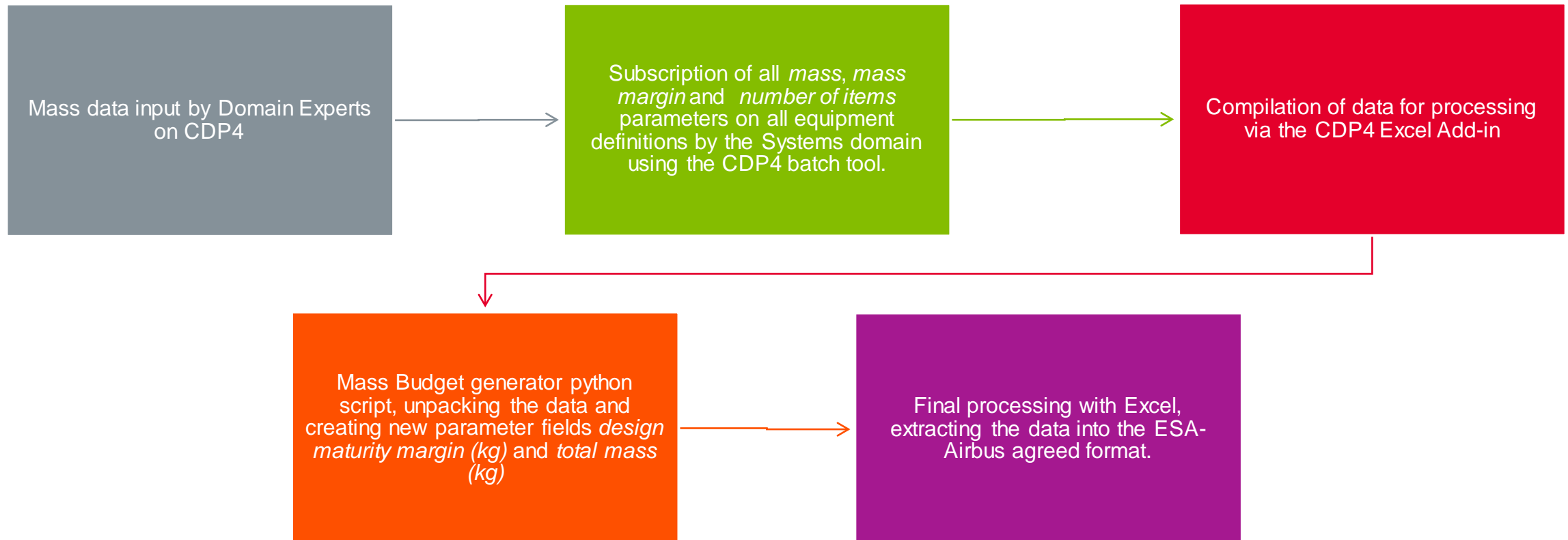
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# Equipment modelling

- These parameters support the formulation of various system budgets, such as:
  - the mass budget, making use of:
    - *mass*, understood as Current Best Estimate in Kg
    - *mass margin*, with value 5%, 10% or 20% according to the equipment's maturity category.
    - *number of items*
  - power budget, making use of:
    - *power while on*, which is marked as state-dependent on the *Power Levels* state list
    - *number of items*
  - thermal budget, making use of:
    - *power while on*
    - *power dissipated while on*, which is kept blank if it is the same as *power while on* but otherwise made state-dependent on the *Power Levels* state list.
    - *number of items*
    - *max and min op/non-op temperatures*
- *Power while on* and *power dissipated while on* are marked as state-dependent parameters, with states defined in *Power Levels* state list. This list is taken from the standard Airbus power budget (ON, OTHER_1, OTHER_2, OTHER_3, OTHER_4).

| Generic Equipment Definition for Thermal | THE | |
| --- | --- | --- |
| mass | THE | kg |
| mass margin | THE | % |
| maximum non-operational temperature | THE | °C |
| maximum operational temperature | THE | °C |
| minimum non-operational temperature | THE | °C |
| minimum operational temperature | THE | °C |
| number of items | THE | - |
| power dissipated while on | THE | W |
| ON | THE | W |
| OTHER 1 | THE | W |
| OTHER 2 | THE | W |
| OTHER 3 | THE | W |
| OTHER 4 | THE | W |
| power while on | THE | W |
| ON | THE | W |
| OTHER 1 | THE | W |
| OTHER 2 | THE | W |
| OTHER 3 | THE | W |
| OTHER 4 | THE | W |
| product ID | THE | - |
| supplier | THE | - |

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# Modelling in use: Mass Budget

- The Community Edition Excel interface does not generate a worksheet fit for the needs of a detailed Mass Budget via the use of Pivot Tables. A Python script has been created that runs in Excel, takes the data and manipulates it into the format traditionally used, breaking down the masses per subsystem and including the mass margin.



Mass data input by Domain Experts on CDP4

Subscription of all *mass, mass margin* and *number of items* parameters on all equipment definitions by the Systems domain using the CDP4 batch tool.

Compilation of data for processing via the CDP4 Excel Add-in

Mass Budget generator python script, unpacking the data and creating new parameter fields *design maturity margin (kg)* and *total mass (kg)*

Final processing with Excel, extracting the data into the ESA-Airbus agreed format.

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# Modelling in use: Mass Budget

| | | Baseline 1 | | | Baseline 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | CBE Mass (Kg) | DMM (Kg) | Total Mass (Kg) | CBE Mass (Kg) | DMM (Kg) | Total Mass (Kg) | Δ | Change Comments |
| Platform | AOCS | 45.4 | 2.4 | 47.7 | 45.4 | 2.4 | 47.7 | 0.0 | |
| | Communications | 57.5 | 11.4 | 68.9 | 57.5 | 11.4 | 68.9 | 0.0 | |
| | Data Handling | 26.0 | 2.6 | 28.6 | 26.0 | 2.6 | 28.6 | 0.0 | |
| | Mechanisms | 8.8 | 1.8 | 10.6 | 12.1 | 2.4 | 14.5 | 3.9 | SRS entry corrected |
| | Propulsion | 103.2 | 10.2 | 113.4 | 91.4 | 9.0 | 100.4 | -13.0 | |
| | Power | 103.9 | 17.1 | 121.1 | 112.4 | 18.8 | 131.2 | 10.1 | increase for SAFE mode battery |
| | Structures | 251.8 | 50.4 | 302.1 | 278.3 | 52.3 | 330.6 | 28.4 | growth in structure, addition of flaps and balance mass |
| | Thermal | 74.4 | 14.9 | 89.3 | 81.9 | 16.4 | 98.3 | 9.0 | increase in thermal H/W |
| Harness | 7.50% | | | 58.6 | | | 61.5 | | |
| Total Platform | | | | 840.3 | | | 881.7 | 41.4 | |
| Payload | | | | 200.8 | | | 194.8 | -6.0 | SRS entry corrected |
| Dry Mass | | | | 1041.1 | | | 1076.5 | 35.4 | |
| System Mass Margin | 20% | | | 208.2 | | | 215.3 | 7.1 | |
| DRY TOTAL (incl. System Margin) | | | | 1249.3 | | | 1291.8 | 42.5 | |



Subsytem Mass Evolution
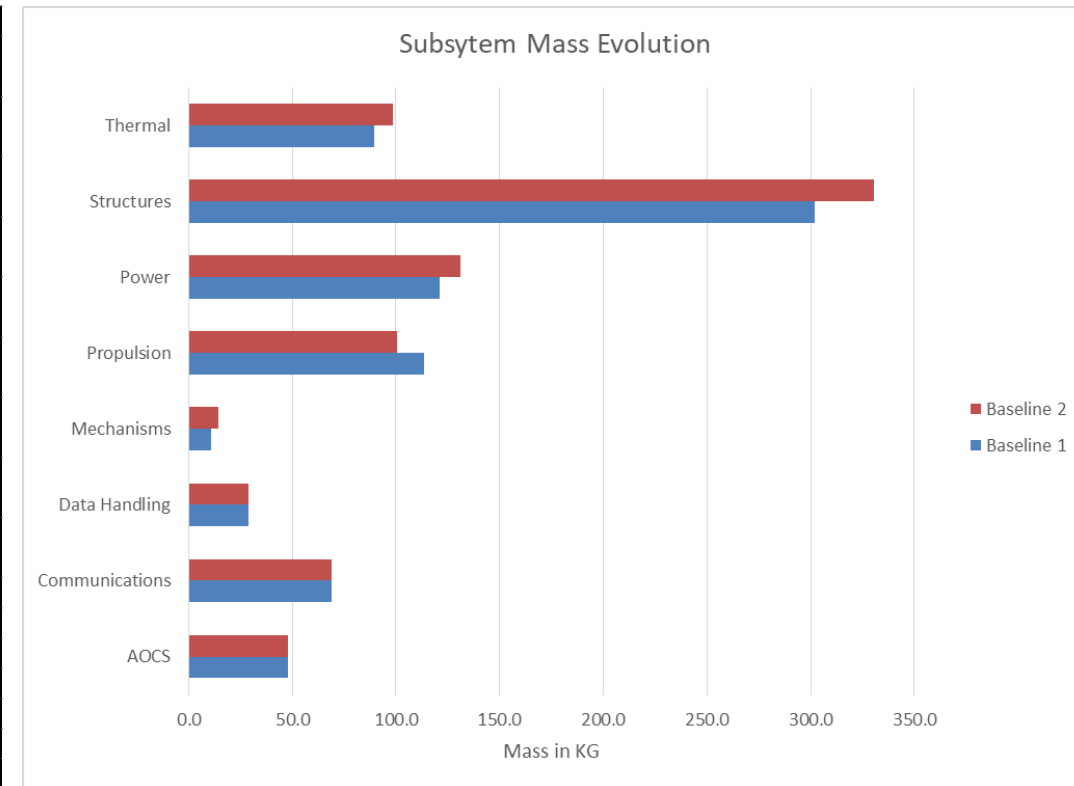
Mass Budget evolution across two temporally-separated baselines.

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# Modelling in use: Power Budget

- The Power Budget is a simpler import/export. Domain Experts can upload the parameter values under their responsibility on the IME. These are then downloaded by the Power and/or System Engineer directly onto the existing Power Budget Excel workbook, in its inputs sheet.

| | | | |
|---|---|---|---|
| Transponder : Transponder | | Ka_X_band_asmbly.... | COM |
| mass | 4 [kg] | TRSP.m | COM |
| mass margin | 20 [%] | TRSP.mass_margin | COM |
| maximum non-operational... | - [°C] | TRSP.T_nonop_max | COM |
| maximum operational tem... | - [°C] | TRSP.T_oper_max | COM |
| minimum non-operational... | - [°C] | TRSP.T_nonop_min | COM |
| minimum operational tem... | - [°C] | TRSP.T_oper_min | COM |
| number of items | 2 [-] | TRSP.n_items | COM |
| power dissipated while on | - [W] | TRSP.P_diss | COM |
| power while on | | TRSP.P_on | COM |
| ON | 0 [W] | TRSP.P_on\ON | COM |
| OTHER 1 | 12.5 [W] | TRSP.P_on\OTHER_1 | COM |
| OTHER 2 | 30 [W] | TRSP.P_on\OTHER_2 | COM |
| OTHER 3 | 42.5 [W] | TRSP.P_on\OTHER_3 | COM |
| OTHER 4 | 0 [W] | TRSP.P_on\OTHER_4 | COM |
| product ID | - | TRSP.Prod_ID | COM |
| supplier | - | TRSP.supplier | COM |

| Equipment | Maturity Assessment | OFF | ON | OTHER 1 | OTHER 2 | OTHER 3 | OTHER 4 |
|---|---|---|---|---|---|---|---|
| **Comms Subsystem** | | | | | | | |
| X & Ka-Band Transponder 1 | Minor Modification | 0.0 | | 12.5 | 30.0 | 42.5 | |
| X & Ka-Band Transponder 2 | Minor Modification | 0.0 | =TRSP.P_on\OTHER_1 | | 42.5 | | |
| Ka Band TWTA | Minor Modification | 0.0 | 15.0 | 200.0 | 75.0 | 137.5 | |
| X Band TWTA | Minor Modification | 0.0 | 6.2 | 290.9 | 222.22 | 90.0 | |

The values are imported into the existing Power Budget Excel tool by making use of its inputs worksheet and connecting it via the use of cell names generated by CDP4 IME (=TRSP.P_on\OTHER_1 in the example highlighted).

The power parameter *power while on* can be used to parametrise the power levels in different power modes. For simplicity, the already existing power modes were used (ON, OTHER 1, OTHER 2, OTHER 3).

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# Engineering Data Modelling with CDP4 – Return of Experience

- The EDM tool provides a consistent and reliable single source of truth. While every Domain Expert can contribute, the System Engineer maintains control over what actually goes into a design baseline(s) and what is rejected by appropriate functionality within the tool. A System Engineer can also go further in defining appropriate system options, each with a corresponding design baseline.

- The benefits of the EDM approach were demonstrated by the fact that forcing a harmonised product tree across Product Tree, Mass Budget and Power Budget lead to the discovery of discrepancies between as delivered by CDP4 and as delivered on the previous Excel-only tool.

*By forcing a consistent structure transversal to all tools and workbooks, CDP4 can help the project teams maintain a common system baseline that everyone can refer to and use to quickly catch inconsistencies across the design.*

- Overall, CDP4 excels in moments when the design is undergoing fast iteration, such as when a milestone review leads to changes in mission requirements and subsequently to S/C design. In this situation, CDP4 supports team collaboration by offering a single source of truth the team can work around and contribute to . Nevertheless, CDP4 lacks Functional and Logical architecting capabilities when compared to SysML-like tools and methodologies. Investment in both models can be rewarding, with SysML-like tools offering a more complete architectural view, while CDP4-like tools offer teams more collaborative power.

# Engineering Data Modelling with CDP4 - Return of Experience

- The CDP4 IME 5.1.1.0 version that was tested does not take special provisions in the handling of mass parameters (as OCDT did), and hence a workaround had to be implemented
  - Workaround implies taking manual subscriptions on relevant parameters (mass, mass margin, number of items, total mass) and then processing this with a Python script running from within Excel. This script delivers a finalized Mass Budget table.
  - In order to take the subscriptions, it is necessary to use the BatchEditor, a command line tool made available by RHEA.
  - As scripting and command line tool are necessary, the CDP4 IME 5.1.1.0 is suboptimal with regards to facilitating its use by new personnel.

- As access to data from previous iterations is not straight-forward, trend analysis has in practice to be performed by storing historical data on Excel and running the analysis there.

- Power budget
  - Current Excel workbook is already configured to accept inputs easily. Airbus simply linked its inputs sheet onto the CDP4 generated worksheets.

- NOTE: As mentioned, ESA and RHEA have merged their tools into COMET, although this appears to be largely based on CDP4. COMET IME is now on version 8.0.0 (version number continued from CDP4). This more recent version promises simpler budgeting and trend analysis functionality directly on the tool.

# MBSE system modelling with CAMEO

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# System Modelling with CAMEO

- For EnVision the mission and operations concept designs have been developed adopting the MBSE approach using the NoMagic Cameo System Modeller environment (https://www.3ds.com/products-services/catia/products/no-magic/cameo-systems-modeler/).

- The ESA requirements, defined in the Mission Requirement Document (MRD), were imported into Cameo, from there the Mission Architecture and the Operational Architecture were developed and exported to Word documents.

- The Airbus MOFL design methodology has been applied to define the Mission Architecture and the Operational Architecture. MOFL represent the conceptual approach to designing space missions from **M**ission design, to **O**perational design, **F**unctional and **L**ogical design.

- The methodology follows these sequential steps:
  - At each MOFL level: identification of **needs** defined as **Capabilities**
  - **Capabilities** are engineered into **concepts** and **architectures**
  - From the architectures **requirements** are defined, or as in the case of EnVision, mission and operational requirements have been traced to the mission and operational architectures.

ESA MRD               ADS TN-A1-2
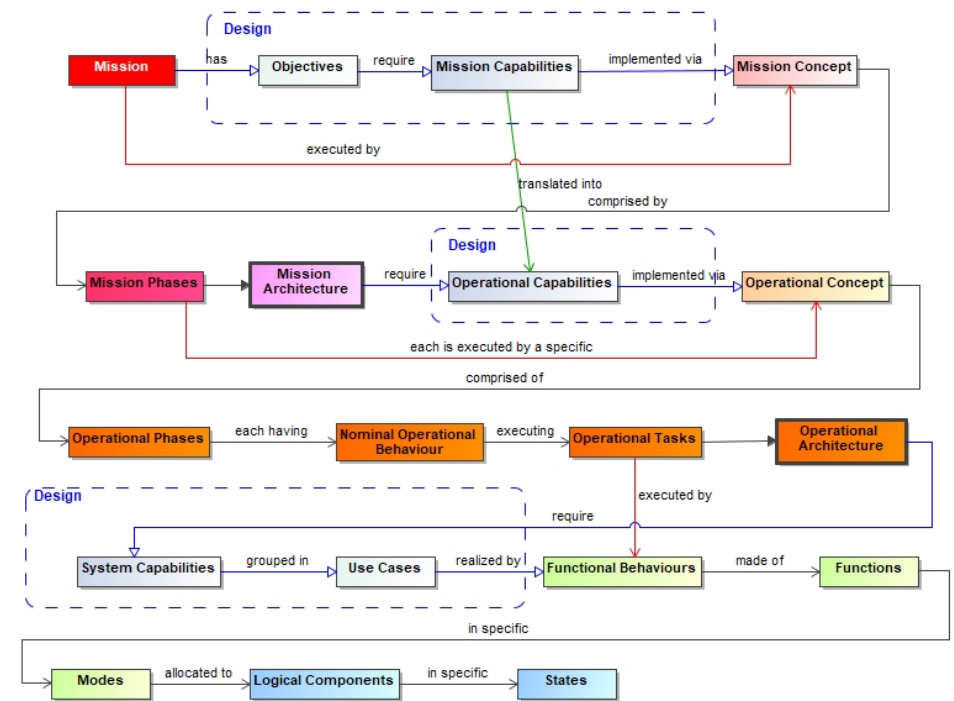
# Model exploration

- The model based approach enables a rigorous design justification traceability throughout the whole design.
- Cameo provides very powerful design tools allowing to "explore" the design from different views.

- In this view we can check how the mission concept has been translated into mission phases, then engineered into operational phases and operational tasks.
- This is effectively an "Operational view" of the mission.
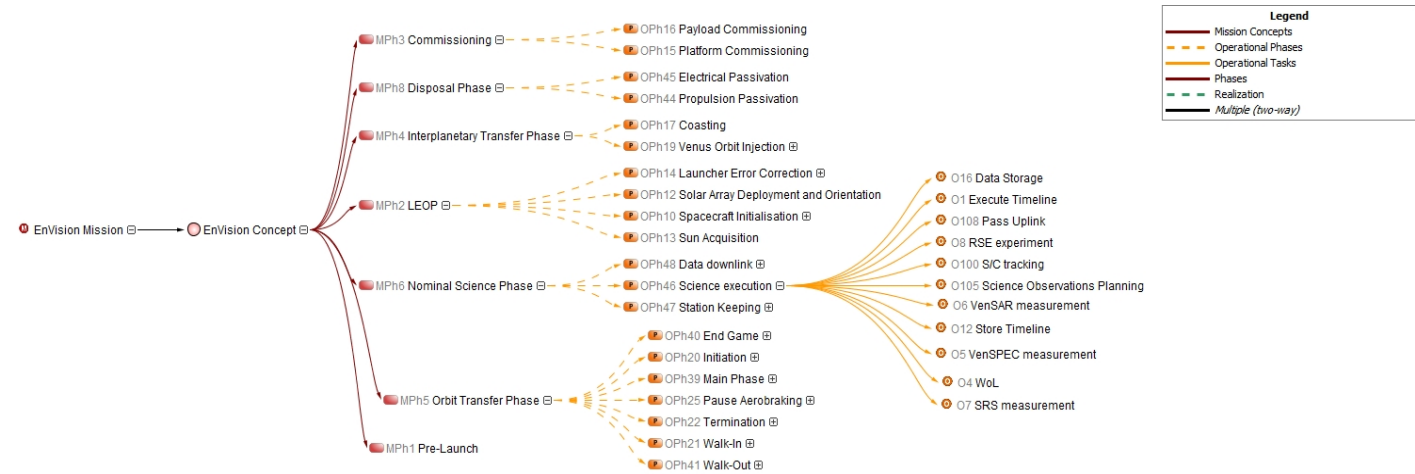
- In this view we can check how the mission objectives have been translated into mission capabilities, then engineered into operational capabilities.
- Further, we can see how such operational capabilities have been allocated to operational tasks.
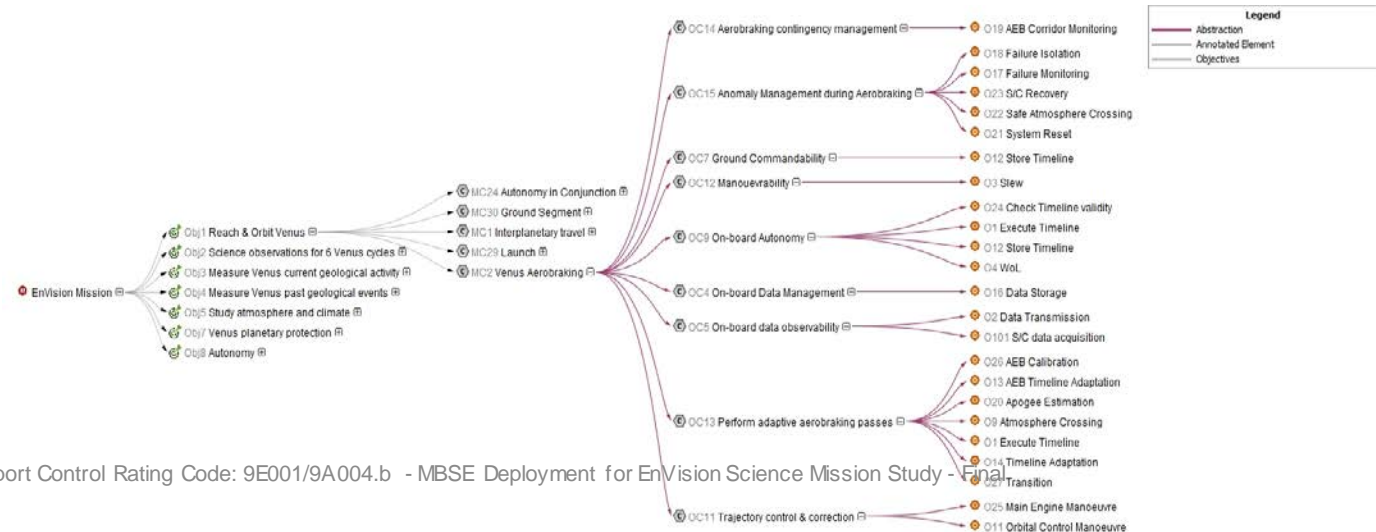
# Design and requirements traceability

- In the model it's possible to establish clear flow down from the Mission Capabilities to the Mission level requirements (Level 1 - Mission)

- In the model it's possible to establish clear flow down from the Operational Capabilities to the Operational level requirements (Level 1 - Ops)

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# MBSE system modelling with CAMEO – return of experience

- The Airbus MBSE MOFL methodology provides a robust approach to design a mission from its objectives
- The MBSE approach adds a richer, multi-dimensional and integrated perspective to system design
- Design justification and traceability is a major asset of the MBSE approach
- The MBSE approach might encounter some resistance as a number of engineering disciplines have not been exposed to model thinking
- The CAMEO tool might incur in an adoption barrier as is based on SysML modelling but Airbus developed formal methodology and guidelines to facilitate the adoption

**Overall summary**
- MBSE application for EnVision: the overall impact and effectiveness has been positive as it allowed a strong design-to-requirements approach. Moreover it establishes a solid basis for digital continuity to bring forward and build upon in the study next phases.
- Specific and focused training should be considered for future phases.

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# Requirement Justification Tracing with DOORS

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# Documentation vs information data



Computer scientist Margaret Hamilton
with the Apollo guidance software she and
her team developed at MIT - 1969

- Should we reconsider the role of Documentation in engineering practices?
- What needs Documentation was/is addressing?
  - Divulgement of information
  - Stakeholder communication
  - Capture of information
  - -etc. etc.

- Documentation is a *vehicle* for managing **information**

- There needs to be a shift from documentation to **information data** whilst keeping the end objective of disseminating information

- This pivots around the concept of having a **single** central documentation source of truth

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# MRD Justification Traceability



**Before**

**Paper based trail.** Traceability is via referencing at document level only. Laborious to maintain and use.
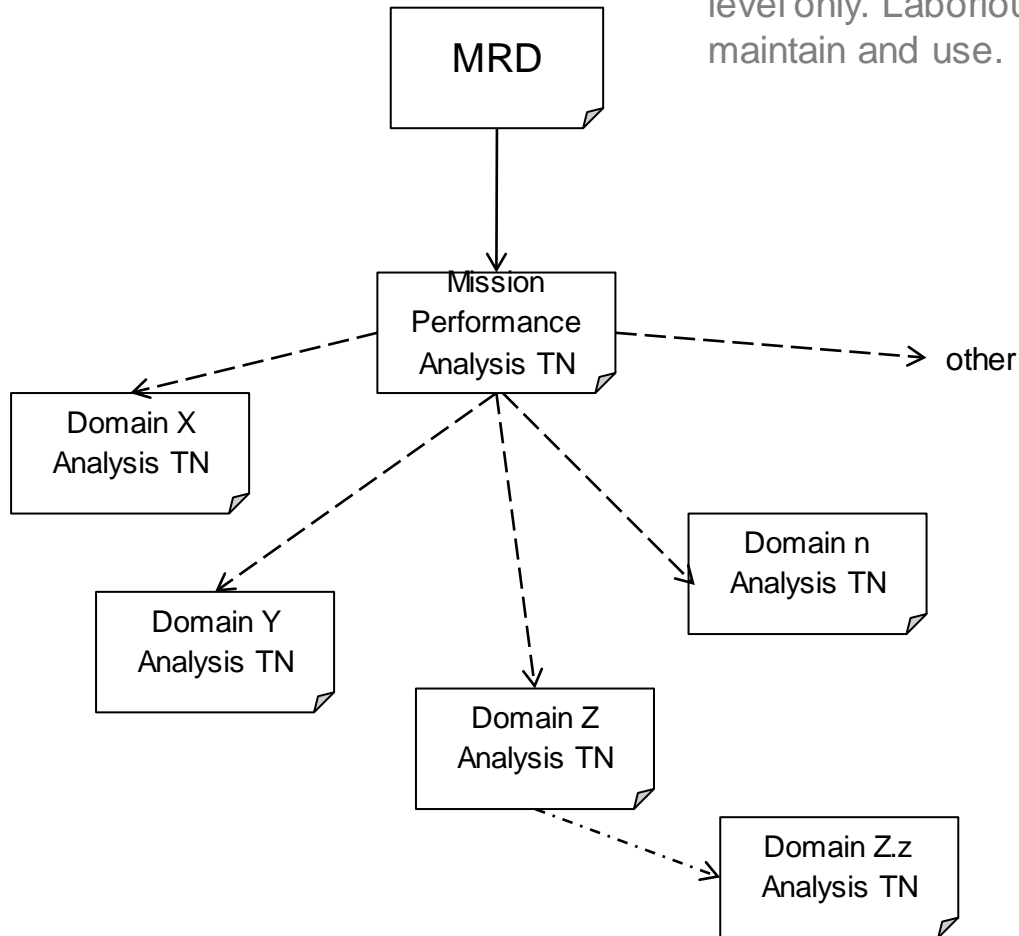
**Information DB.** All relevant documentation is transferred to a DOORS database structure. Every textual information becomes an indexed DB object that can be linked upstream or downstream. Establish robust linking down to relevant chapters (hence preserving context).

**After**
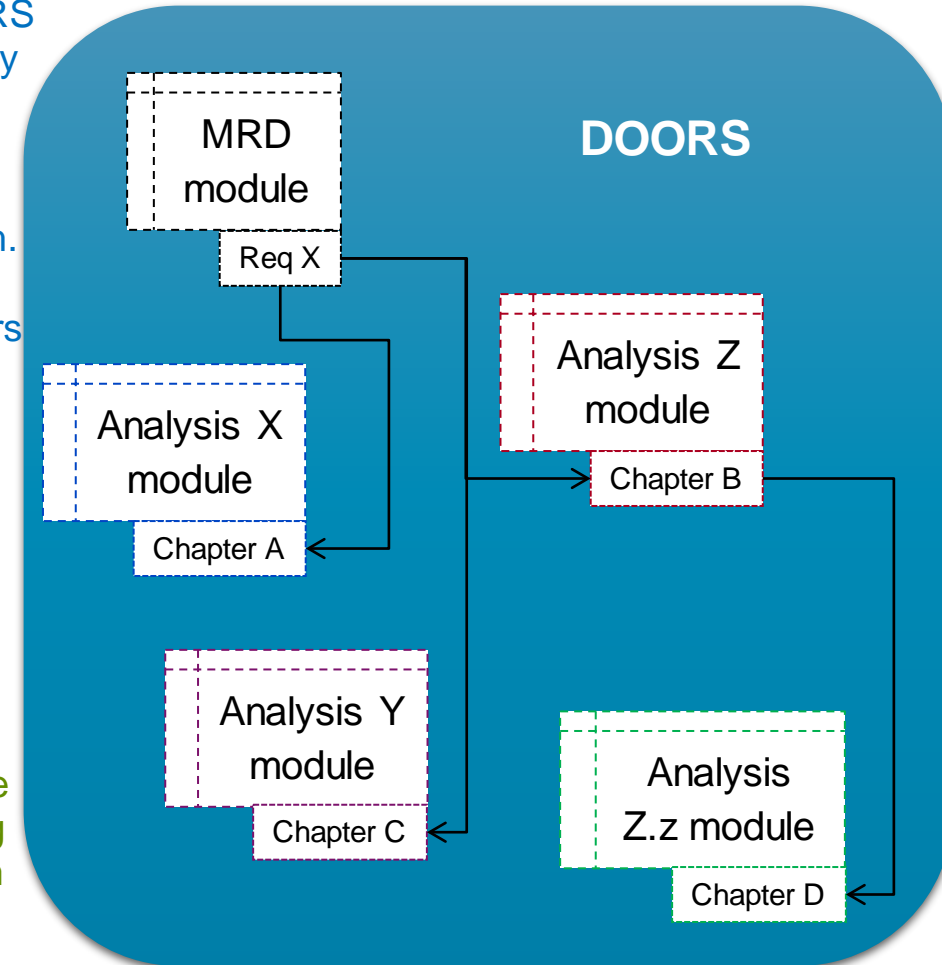
**Web browser export.** The MRD module can be exported as HTML giving a user browsing platform throughout the entire DOORS structure.

# Documentation tree

- Structure the project documentation (in DOORS) in accordance with the following objectives (or aims):
  - Hierarchy: keeping it aligned with the study logic, from mission to system to sub-systems
  - Consistency: keeping it as aligned as possible with WBS and PT
  - Incremental: plan for "organic" grow in future phases

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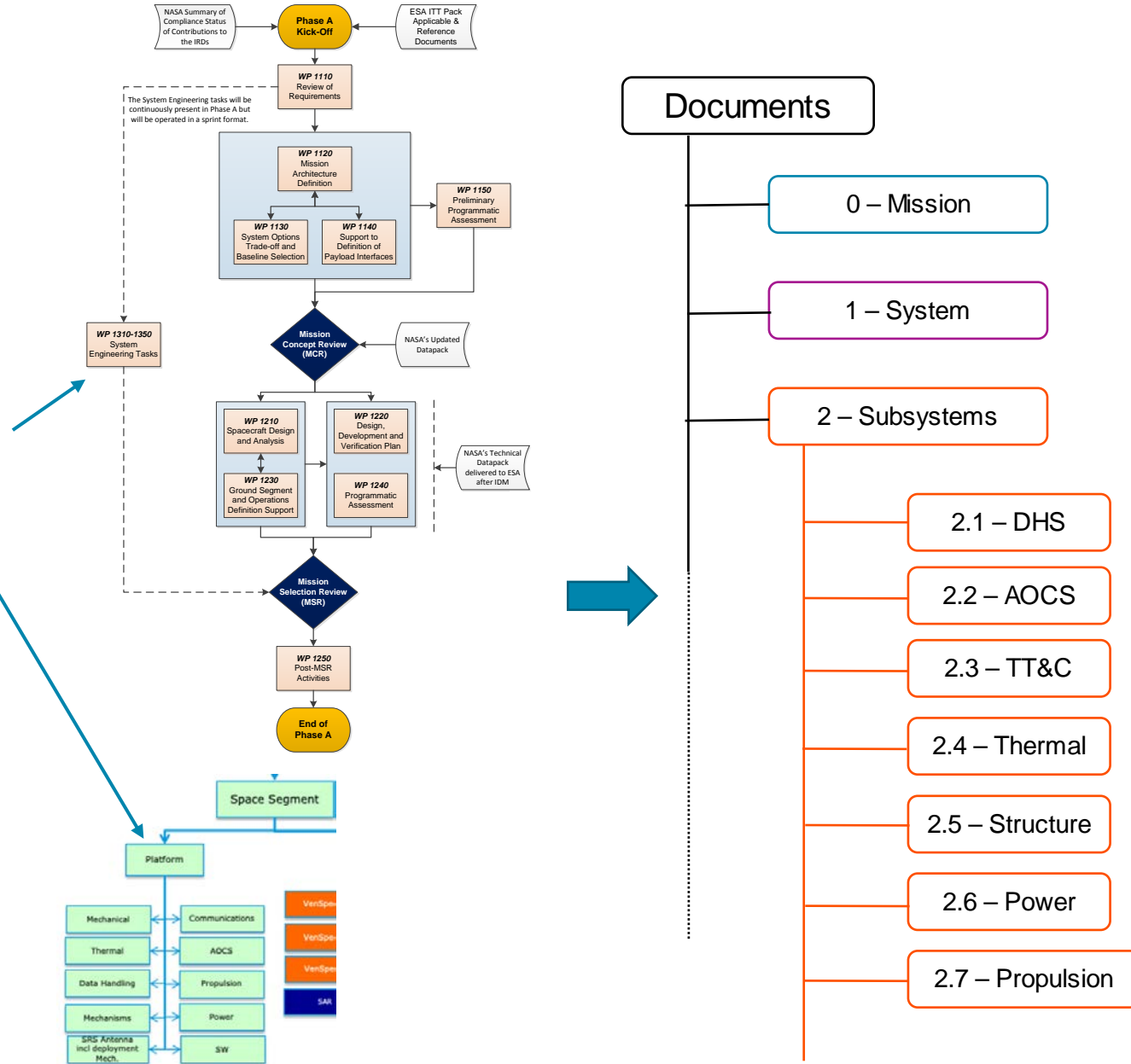
# Documentation mapping against requirements

Once most documentation is in DOORS then links and dependencies can be established between "Documentation Tree" and "Requirements Tree"

**Documents**
- 0 – Mission
- 1 – System
- 2 – Subsystems
  - 2.1 – DHS
  - 2.2 – AOCS
  - 2.3 – TT&C
  - 2.4 – Thermal
  - 2.5 – Structure
  - 2.6 – Power
  - 2.7 – Propulsion

**Requirements**
- L0 – MRD/SSRD
- L1 – SSRS
- L2 – Subsystem Req Specs

M5 EnVision
- Documents
  - 0 - Mission
  - 1 - System
  - 2 - Subsystems
    - 2.1 - DHS
    - 2.2 - AOCS
    - 2.3 - TTC
    - 2.4 - Thermal
    - 2.5 - Structure
    - 2.6 - Power
    - 2.7 - Propulsion
  - Level 0
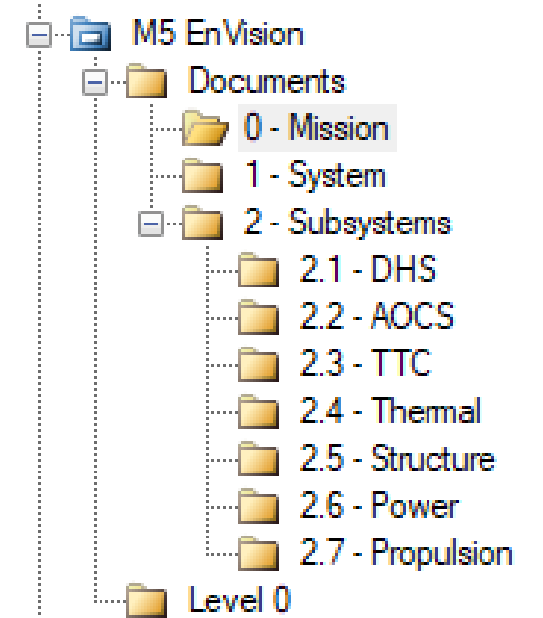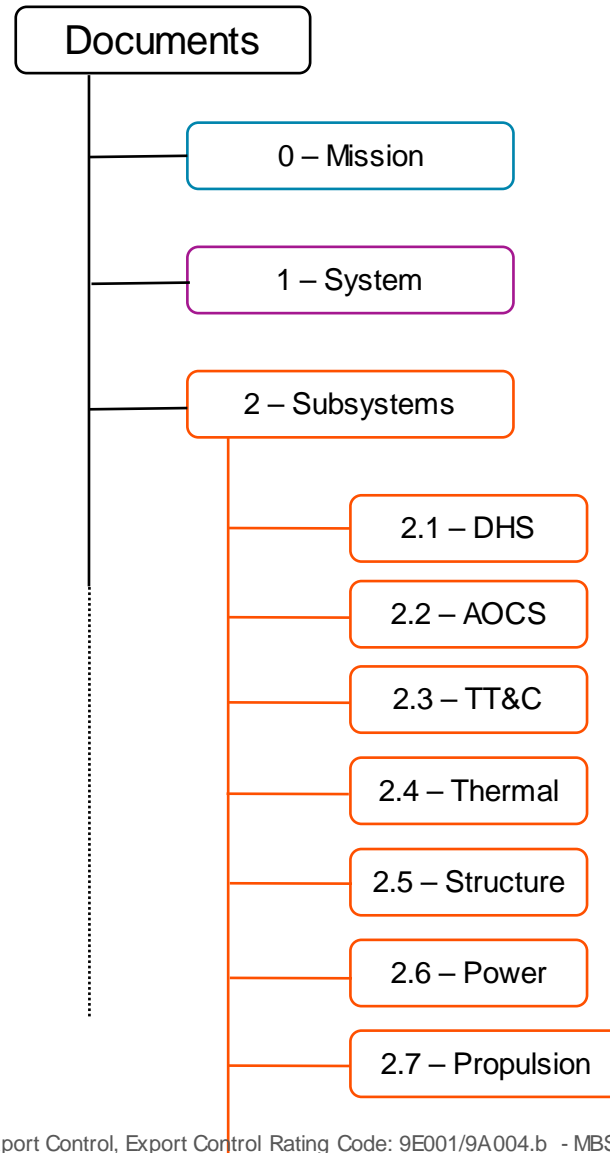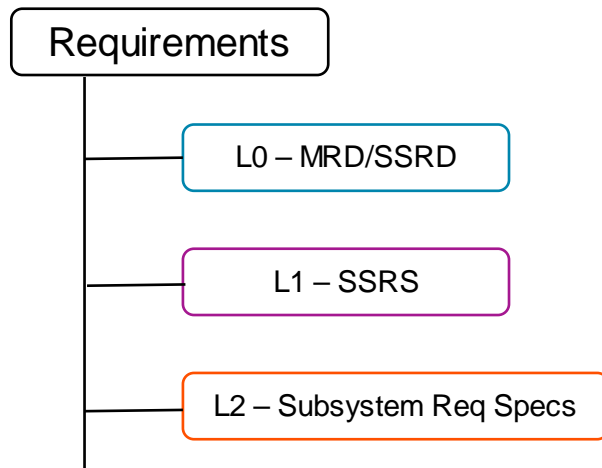
# Requirement Justification Tracing



| ESA Ref | ESA-ENVIS-EST-RS-001 | Object Type | Compliance | Justification tracing level 1 | Justification tracing level 2 |
|---|---|---|---|---|---|
| | 9 (LEVEL 0) SCIENCE PERFORMANCE REQUIREMENTS | Heading | TBD | | |
| | 9.1 Science observation requirements | Heading | TBD | | |
| | 9.1.1 Science phase duration | Heading | TBD | | |
| R-MIS-PER-0010 | The nominal science phase shall cover 6 Venus cycles. | Requirement | TBD | Mission Performance Analysis ENVI-ENVI-ADSS-RP-1000722855 Issue 1.1 Chapter 4.1 Lifetime Requirements | Mission Analysis Recommendations Report ENVI-SYS-ADSS-RP-1000654802 Issue 1.1 Chapter 9 Delta-V Budgets<br><br>AOCS and GNC Analysis Report ENVI-PF-ADSS-RP-1000718237 Issue 1.0 Chapter 5.7 Impulse Budget for AOCS |
| R-MIS-PER-0025 | Overlap requirement for repeated radar imagery (stereo SAR), for a given ROI-R<br>For a given ROI-R for which targeted STEREO observations are required, the mission design shall allow two observations constituting a stereo pair to overlap over at least 90% of their respective swath, with a 95% (2 sigma) confidence level.<br>Note : The identified contributors to the overlap error are :<br>The along track error (driven by the uncertainty on orbit phase prediction)<br>The across-track error (dominated by the altitude uncertainty and its effect on the predicted SAR timing parameters resulting in a shifted swath).<br>Both are dominated by the on-orbit timing uncertainty justifying the requirement on orbit prediction at lower level (R-MIS-OGS-0850) and the necessity to take into account a reduction in the available SAR observation duration (e.g. 11s for a 122s SAR observation) wrt standard SAR observation duration for the 2nd observation, in the Stereo SAR coverage assessment | Requirement | TBD | Mission Performance Analysis ENVI-ENVI-ADSS-RP-1000722855 Issue 1.1 Chapter 4.2 SAR Viewing Geometry Requirements | Science Operations Implementation Report ENVI-PF-ADSS-RP-1000718251 Issue 1.0 Chapter 5.3.1 Targeted Observations |
| | 9.1.2 Regions of Interest | Heading | TBD | | |
| R-MIS-PER-0420 | Targeted observations for change detection<br>The Envision mission shall enable at least two repeated SAR 30m resolution standard observations of the "type A" regions (type A are regions of interest for geological activity as per [RD-01]) imaged in standard SAR as per R-MIS-PER-0022. The repeated observations shall be acquired with the same incidence angle and direction, and shall cover at least 2% of the Venus surface. Each pixel across the swath shall be imaged with the same incidence angle for the two repeated observations, within 1/15th of the elevation beamwidth, with a 68% confidence level, and with incidence angle greater than 35 deg (TBC).<br>Note 1: The measurement performance is specified in the following requirements: R-MIS-PER-1020 for standard 30m resolution SAR.<br>Note 2: For the purpose of mission performance assessment, incidence angles of 29 degree can be assumed. | Requirement | TBD | Mission Performance Analysis ENVI-ENVI-ADSS-RP-1000722855 Issue 1.1 Chapter 4.3 Coverage and observability of ROI-R regions | Science Operations Implementation Report ENVI-PF-ADSS-RP-1000718251 Issue 1.0 Chapter 5.3.1 Targeted Observations |
| R-MIS-PER-0427 | Targeted observations over two cycles<br>The Envision mission shall enable SAR standard imagery to be obtained at a second viewing angle optimized for creating stereo digital elevation models, over the areas imaged for R-MIS-PER-0022. Both stereo images shall be collected in the same look direction. Each pixel across the swath shall be imaged at two different incidence angles which must be at least 5 degrees apart.<br>Note 1: For the purpose of mission performance assessment, incidence angles of at least 24 and 29 degree can be assumed.<br>Note 2: The measurement performance is specified in the following requirement R-MIS-PER-1020 for standard 30m resolution SAR. | Requirement | TBD | Mission Performance Analysis ENVI-ENVI-ADSS-RP-1000722855 Issue 1.1 Chapter 4.3 Coverage and observability of ROI-R regions | Science Operations Implementation Report ENVI-PF-ADSS-RP-1000718251 Issue 1.0 Chapter 5.3.1 Targeted Observations |

## 9.1.1 *Science phase duration*

*ESA Ref:* R-MIS-PER-0010

The nominal science phase shall cover 6 Venus cycles.

**This object is linked to:**

Lifetime Requirements (MIS-PER-RP-365)(IN)

### ESA – MRD Level 0

### 4.1 Lifetime Requirements

**This object is linked to:**

The nominal science phase shall cover 6 Venus cycles. (MRD-314)(OUT)

Delta-V Budgets (MAR-3198)(IN)

Impulse Budget for AOCS (AOCS-RP-1726)(IN)

| R-MIS-PER-0010 | The nominal science phase shall cover at least 4 Venus sidereal days (2.7 Earth years) |
|---|---|
| G-MIS-PER-0015 | The extended science phase should cover at least 6 Venus sidereal days (4 Earth Years) |

This requirement on the duration of the science phase(s) will result, primarily, in sizing the required consumables (propellant) as appropriate.

Secondary implications are the assessment of the degradation of equipment and hardware (eg Solar Arrays) for the correct EOL.

### Airbus – Mission Performance Analysis

## 5.7 Impulse Budget for AOCS

**This object is linked to:**

Lifetime Requirements (MIS-PER-RP-365)(OUT)

The impulse budget for AOCS becomes a very relevant input to the system architecture trade-off since the total mass of the spacecraft is a key driver. The results presented below correspond to the Chemical + Aerobraking option and the impulse budgets for the other options have been scaled or adapted when relevant (e.g disturbance torque for the main engine compensation removed from full EP option).

The estimated impulse cost computation can be broken down in several major contributions,

### Airbus – AOCS and GNC Analysis Report

# Requirements justification tracing – return of experience

- An information database tool can provide an effective traceability between requirements and design documents.
- DOORS v9.6 has been used to investigate such an approach:
  - **Strengths**
    - Relatively quick way to establish links from requirement baseline DOORS module to design DOORS modules
    - Links are embedded in DOORS modules so traceability is kept automatically and support further iterations
    - Simple scripts allow generation of top-level justification traceability matrices
    - Can use HTML extract features to attempt very crude browse ability of design
  - **Weaknesses**
    - DOORS is quite a rigid tool and conversion of design docs into DOORS modules required lot of manual intervention
    - DOORS is not the best environment to digitally capture and document design. Some overheads appear when asking team to switch from Word to DOORS.
    - DOORS lacks modern graphical visualisation and HTML export was a poor attempt at giving reviewers a more modern way to navigate through documents and verify requirements
    - CAMEO was investigated to have these added graphical navigation features but quickly realised CAMEO use as a traceability and document navigator was extremely inefficient

**Overall Summary:**
- A more promising strategy/ tool suite for performing this activity will be needed and therefore this is considered a lower priority in terms of operational deployment within the Envision study.

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# Way Forward

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# Way Forward

- EDM
  - The EDM tool enables the use of a consistent structure across the project domains, allowing to control and publish common system baselines that everyone can refer to and use to quickly detect inconsistencies.
  - The CDP4 IME 5.1.1.0 version can address the basic needs as an EDM tool for Phase A/B1 activities - capturing of physical properties, controlling changes to the common baseline, deriving mass and power budgets
  - The use of the CDP4 tool will be phased out by Q2.2022 with the internal SEDB (Engineering Database + System Design Editor and Mission and Scenario Editor as interfaces to edit the data relative to the design/mission).

- MBSE MOFL (Cameo)
  - The Airbus MBSE MOFL methodology provides a robust approach to design a mission from its objectives
  - Continuation of the on-going activity to progress from the current Operational Architecture to the Functional Architecture thus allowing a robust derivation of functional requirements for the Spacecraft Technical Specification
  - Connection of MBSE MOFL to EDM will start being operational Q2.2022 enlarging the global MBSE consistency

- Requirements Justification Tracing
  - An information database tool provides a more effective traceability between requirements and design documents.
  - A suitable tool suite will need to be identified as the DOORS tool imposes significant inefficiencies.
  - This has been identified as a new use case in the digitalisation strategy (therefore is not planned to be available on time for Envision Phase B1).

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# Way Forward

Airbus objective is to progressively integrate MBSE methods in an integrated digital ecosystem covering:
  – From system architecture (MOFL) to system design, including geometrical aspects, trajectory and attitude and connection towards system simulation
  – From requirements to V&V definition and realization
  – EDM (also named SEDB for System Engineering Data Base) is a core element ensuring data continuity and allowing re-use and Product Line approach

  – This environment will be developed step by step and delivered to studies when available.

  – As such Envision project could benefit from additional digital MBSE developments during the course of the program.

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