Lessons learned from a MBSE at ClearSpace

Main insight from a year of Model-Based System Engineering for the ClearSpace-1 Mission

Following the presentation made by Hannes Bartle at SWISSED20

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The issue of space debris

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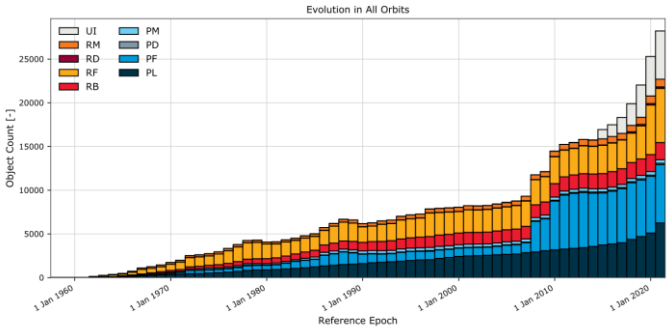
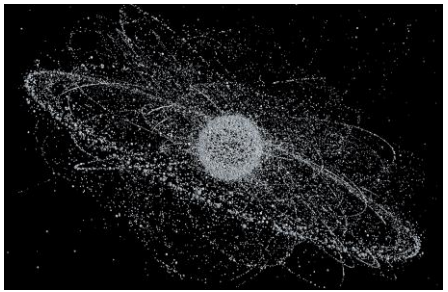
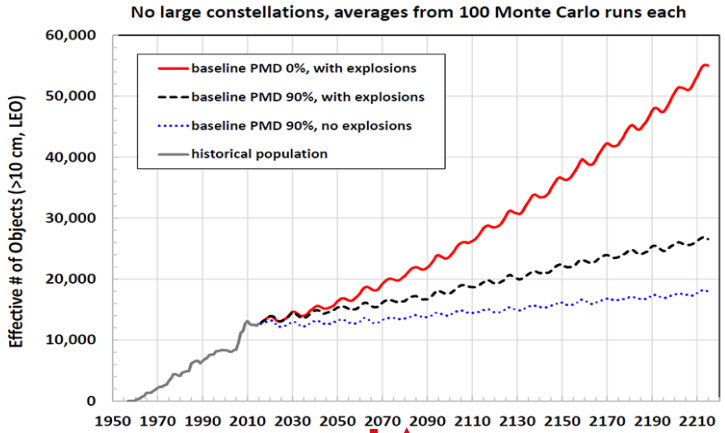


(a) Evolution of number of objects. ESOC Space Debris Office

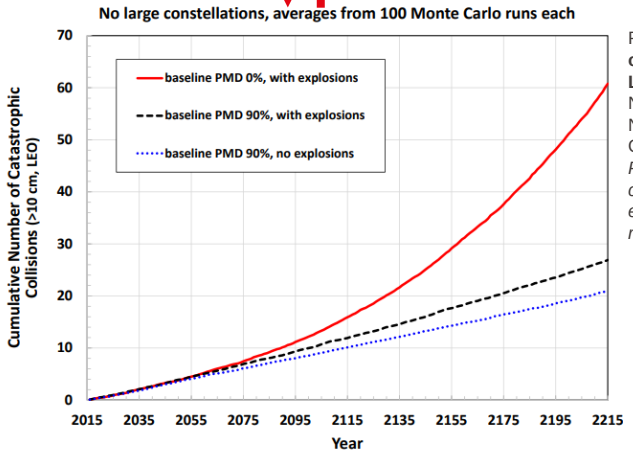
- 3526 new objects added to Earth orbits in 2020.
- With initiative such as Starlink constellations (610 launched in 2021 so far), the trend is still up



- Kessler syndrome : loss of access to LEO and outer space
- Impact on exploration, communication, earth observation and science



Projected **number of objects in LEO**, (simulated by NASA LEGEND) - NASA ODPO ODQN v22.3
PMD : Disposal compliance % with existing mitigation regulations



Projected **number of collisions in LEO**, (simulated by NASA LEGEND) - NASA ODPO ODQN v22.3
PMD : Disposal compliance % with existing mitigation regulations

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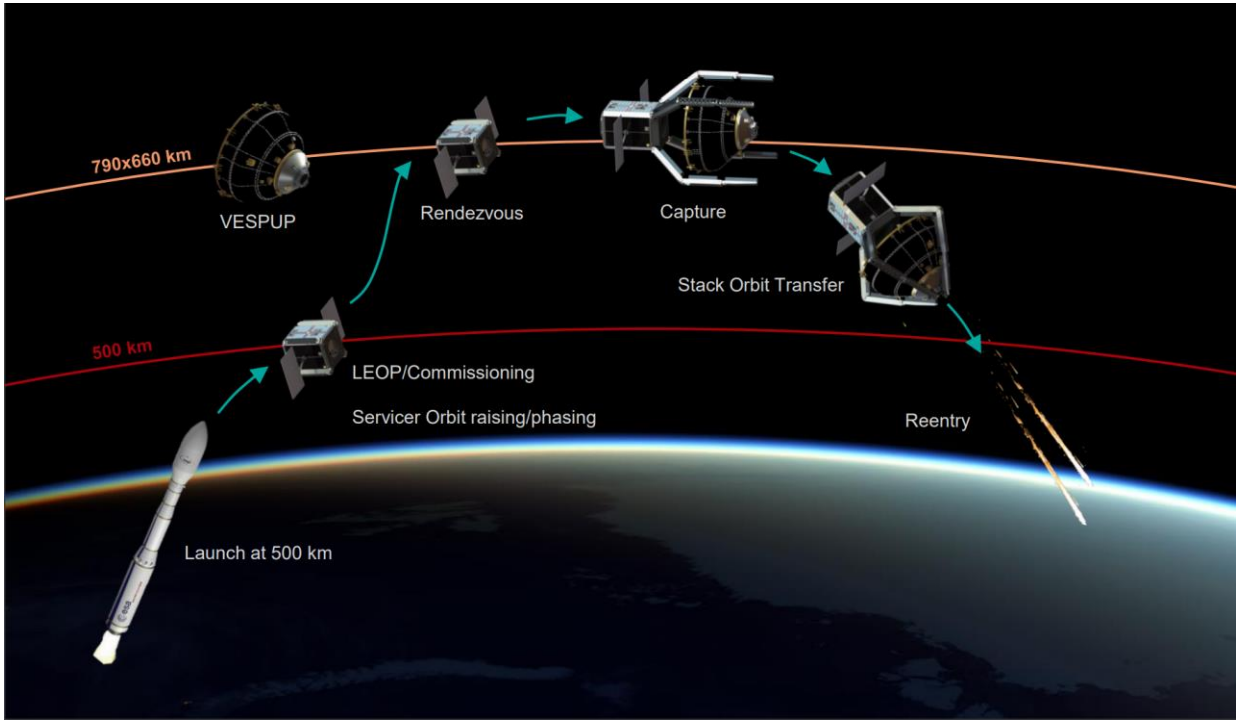
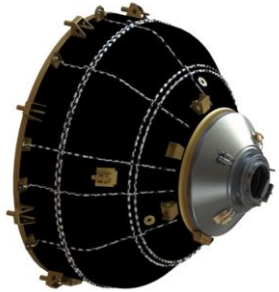
ClearSpace : Tackling the issue of space junk

The first ESA Active Debris Removal / In-Orbit Servicing mission, by 2025

Consortium lead by Swiss start-up ClearSpace SA

Mission and Target





VESPUP : **V**ega **S**econdary **P**ayload **A**dapter - **U**pper **P**art

- ESA owned object
- Uncooperative
- State surface and integrity uncertain
- Tracked, but tumbling state uncertain
- Launched 07.05.2013 for Proba V
- ~100 Kg
- Diam: ~2m, heigh : ~ 1m
- Al / Carbon-fibre composite

ClearSpace-1 System and concept

- Launch date: ~2025
- Team ~50 (w/o subcos), international

- ESA Space project, compliant with a number of PM ECSS standards:
  → Several well defined design phases and periodic delivery milestones.
  → Numerous experts reviewing the design and provide feedback to integrate during de development

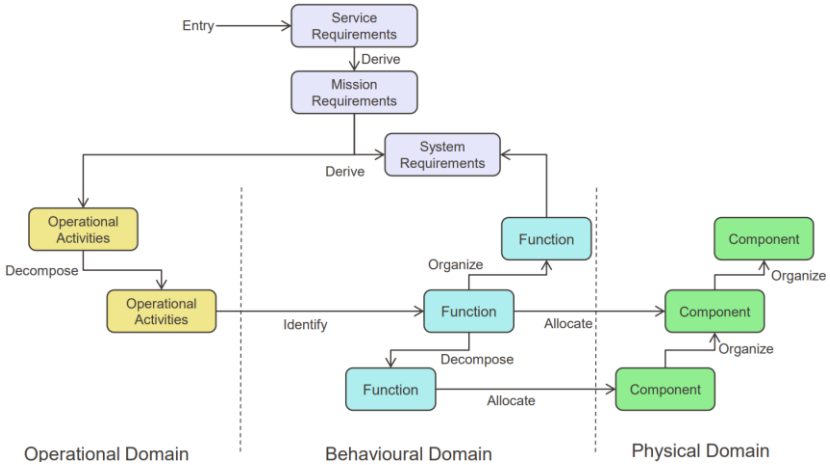
- Diverse engineering domains : STR, GNC, ELEC, safety:
  → Concurrent developments of subsystems

- Remote working is the norm

→ We need a System Model to manage information and share easily it to engineers, reviewers and subcontractors.
→ It needs to be adapted and adaptable to various engineering domains, ways of working and tools.

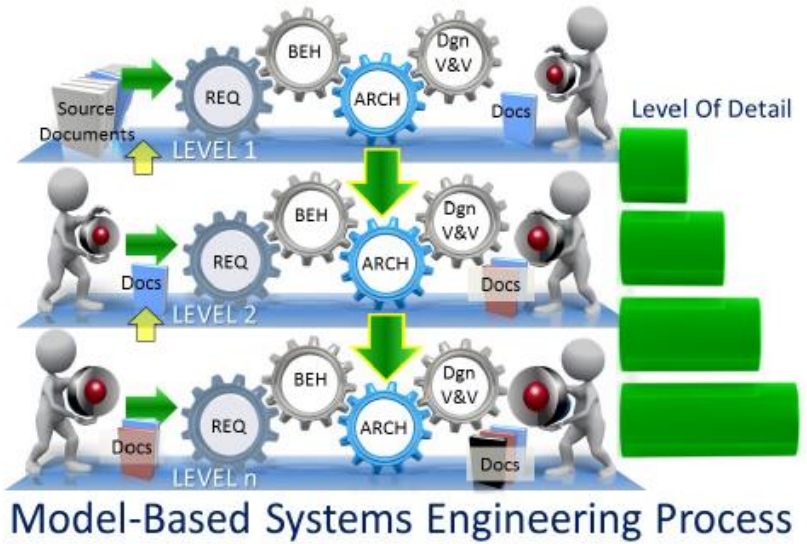
First MBSE implementation at ClearSpace

MBSE strategy STRATA, using a DoDAF-based model:

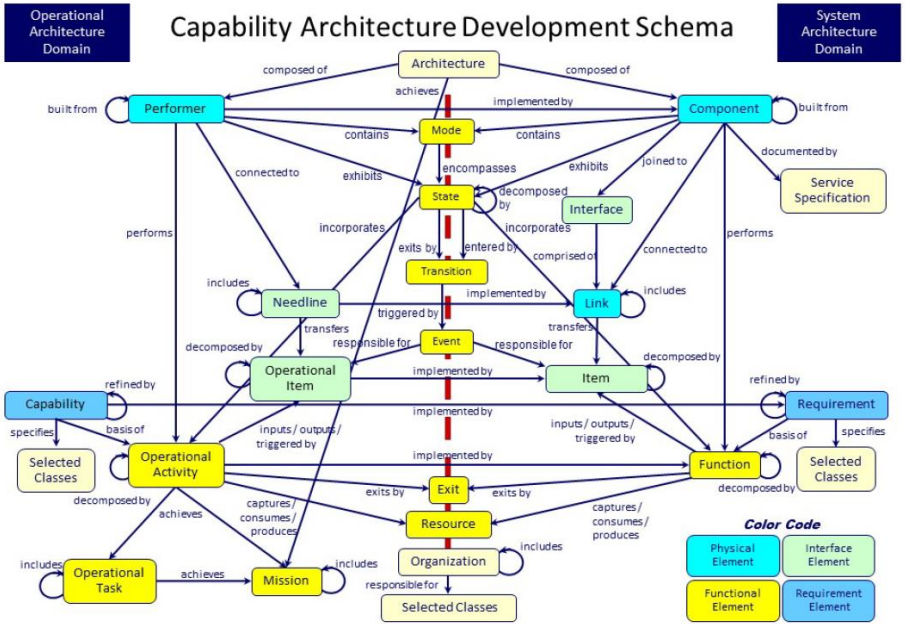


System mainly described as functions (behaviour) and components (physical), fulfilling a mission (operations). All this driven by requirements.

STRATA: Determinations of requirements, behaviours and system architecture in an iterative way, towards more details



First implemented System model:



- Complex framework allowing full modelling of all mission, system, PA, program aspects
- Fully customizable

What we accomplished with this method :

[The SE team]

- Several iterations of requirements, from mission/service to subsystem level
- Modelled functional decomposition from requirements
- Reached a final product decomposition
- Model operational activities for the mission concept

What we need to do next

[The whole ClearSpace team]

- Manage the numbers: compute budgets for mass, energy, data, link..
- Integrate MBSE with external tools and simulations
- Manage R.A.M.S : Failure Mode, Feared Events, Fault Trees
- Increase involvement from engineers and stakeholders
- As a startup, for the moment we need to focus on flexibility on the MBSE method
- We need to allow for a concurrent design of the system, allowing all people from the different engineering domains to interact and collaborate on the model

Evolution of the tools and processes to :

- More efficiently involve all engineers and stakeholder
- Allow complete, easy and fast collaborative work on the whole model
- Manage numerical data and allow dynamic changes within the model (Excel-like calculation for budgets)
- Run quick simulations of operation phases to rapidly assess design changes

"Dynamic" Model

- Have "dashboard" : synthetic representations of the model
- Allow integration with external tools, e.g:
  - Import/export of data, requirements to and from formal documents
  - Seamless dialogue with CAD, mission design

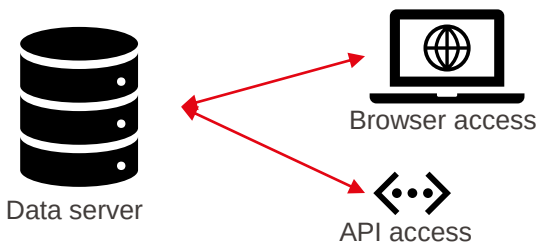
The evolution of ClearSpace SE : A shift to (more) "concurrent engineering" and collaboration

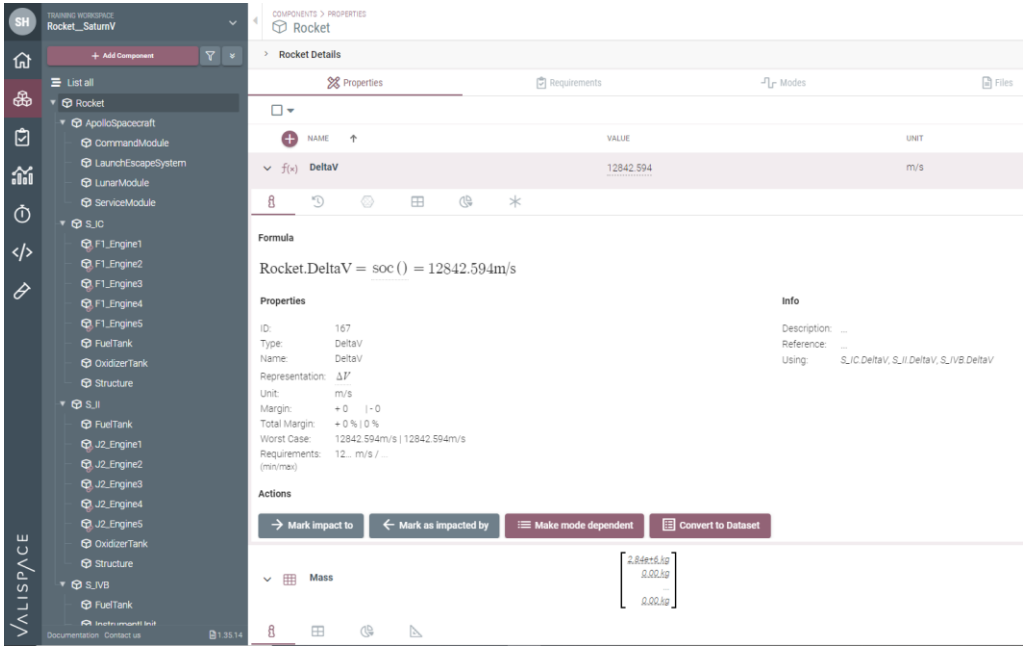
The main tool

Valispace acts as a concurrent design software with a common parametric model.

Main points:

- Management of numerical values and budgets, mode-dependent
- Product trees, with baselining and alternative
- Requirements and test procedures





First results from these evolutions :

- Involvement of the team in MBSE has been increased
- Transition went rather smoothly
- Iterations on requirements at subsystem and now equipment levels
- Product tree finalized and adapted
- MBSE used in few more areas like :
  - Budgets
  - Small numeric simulations
  - V&V, test procedures

What could MBSE bring us more in the future :

- Management of RAMS
  - Modelling of Feared Event and Failures Modes
  - Integrate Fault Tree Analysis tools
  - Manage component Reliability

- A better modelling of the behavioural domain (Capella connection ?)

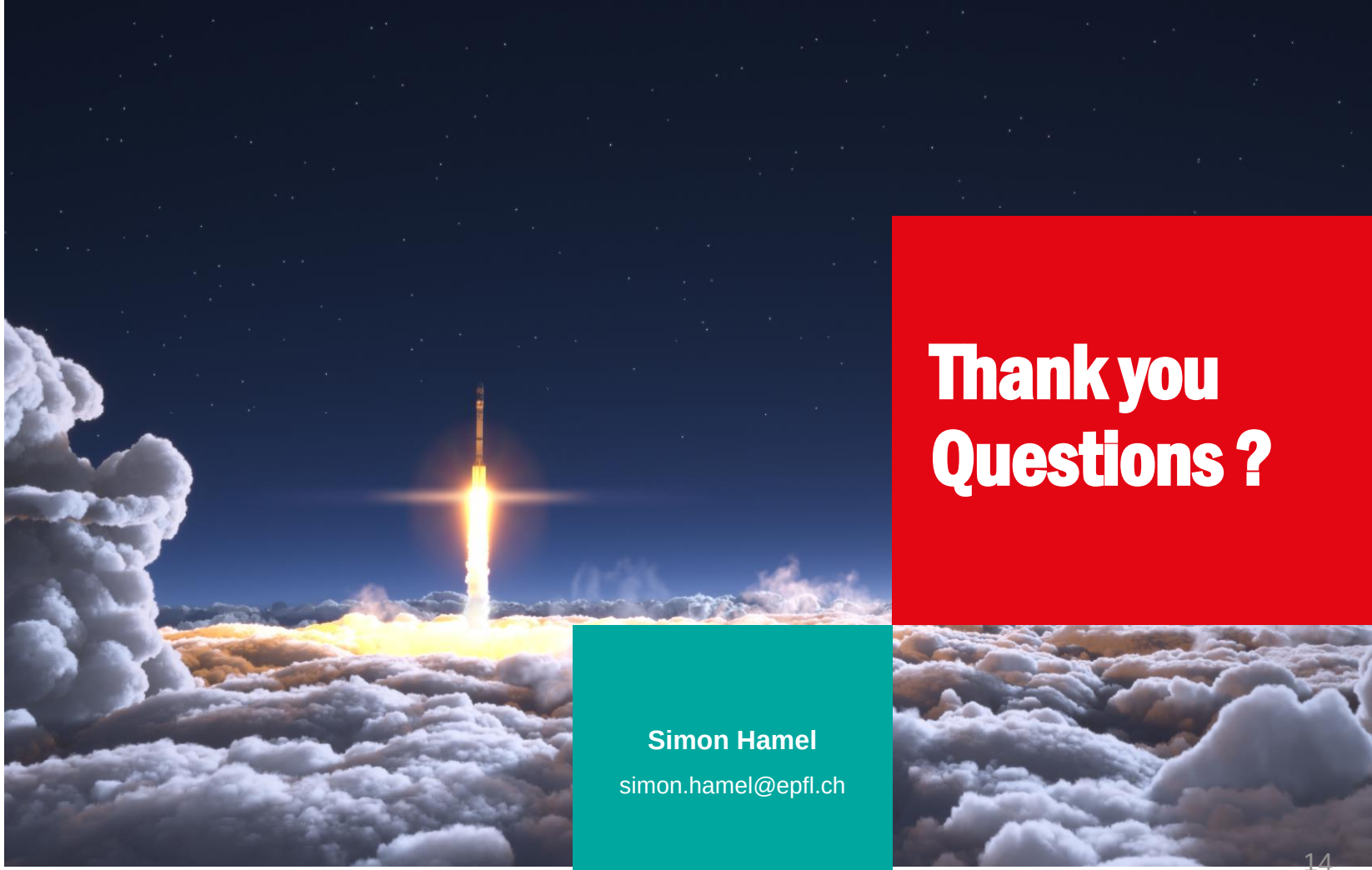
- Integration of program timelines, or even task management at team/personal level

Challenge:

- **How could we further enhance engineering collaboration with MBSE?**
  - How can the tools and processes be improved ?
  - It is not solely a matter of tools, but also of people : how to motivate ?

Summary
Lessons Learned from a year of MBSE at ClearSpace

- Model-Based SE is crucial to gain time and lower risks:
  - The model should act as a single source of truth
  - Collaborative work on the same model
- Involvement is key !
  - Tool accessibility (good UI, short training, easy access)
  - Someone to push the process and be there to resolve any issue during MBSE implementation
  - MBSE advantages should be made clear to the team
- It is central to have flexibility in the SE process ! The tool should fit the engineers needs, not the other way round.
- In an early-phased project, the driver needs in an (MB)SE process are speed and agility. In later phases, it would be more robustness and replicability: how to transition ?
  → Focus on model modularity
  → Have people responsible for model consistency and maintenance, and for the MBSE tool
  → Again, focus on involvement from the engineering team



Thank you
Questions ?

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