Potential of Multi Level Modelling in Model Based Systems Engineering

An ~~Industry~~ "National Research Lab" Perspective

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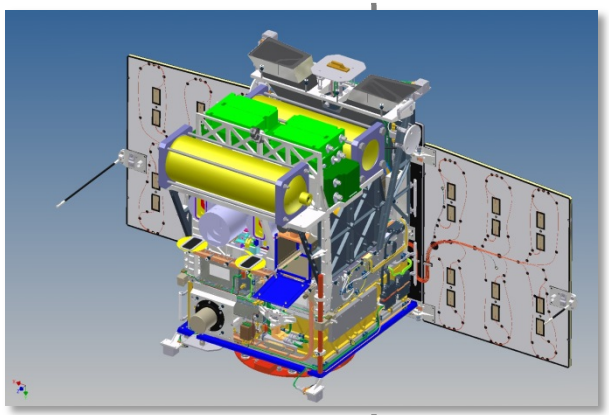
The next few minutes will cover…

1. An overview of why we need a data model when we design a spacecraft.

2. Some state of the art how we model by today.

3. My (Phil's) view on where certain „things" from Multi Level Modelling would lever our approaches.

The Lifecycle and Space System Engineering Process by ECSS



MDR

SRR

PRR

PDR

CDR

AR

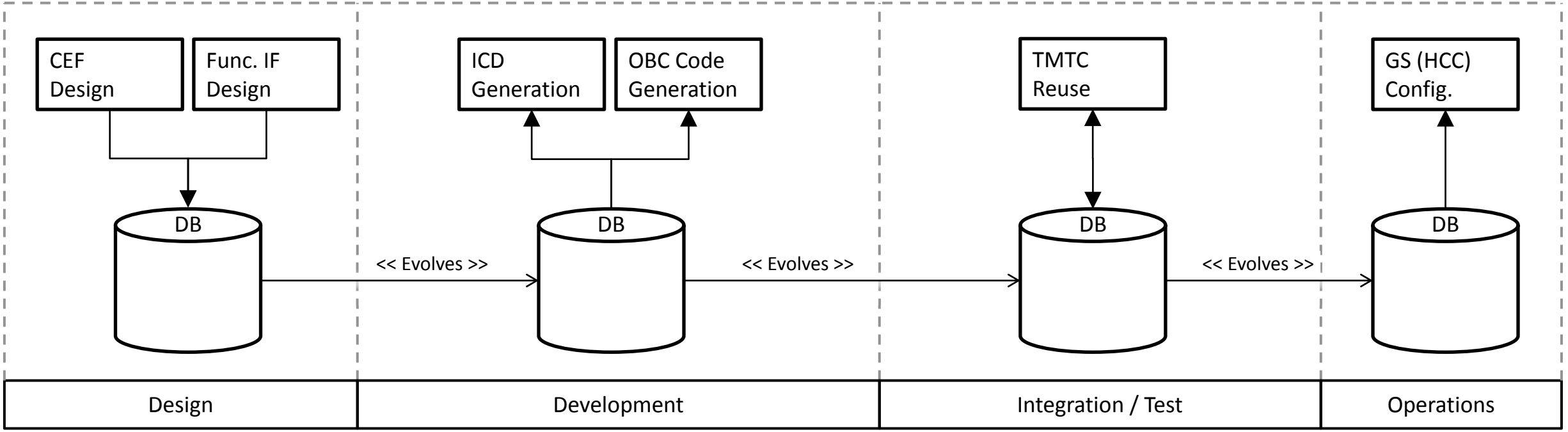
ELR

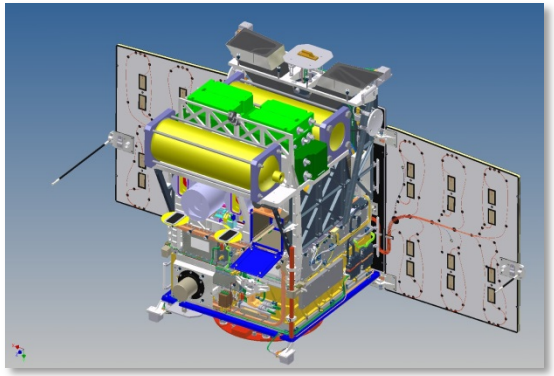
Phase A	Phase B	Phase C	Phase D	Phase E

Time

ECSS: European Cooperation for Space Standardization

Use Cases of an MBSE Database Along the Lifecycle of a Spacecraft





Our MBSE data base – Virtual Satellite

runtime-virsat_cef - CEF Default - VirSat CEF Edition

File Edit Navigate Search Project Run Templates Window Help

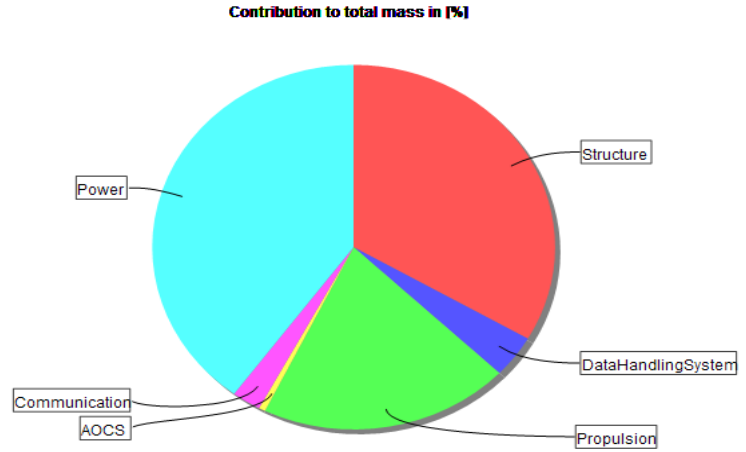
Quick Access

VirSat Navigator | Project Explorer

- satellite
  - Repository
    - apps
    - Concept: de.dlr.sc.virsat.model.extension.cef [1.0]
    - Concept: de.dlr.sc.virsat.model.extension.visualisation [1.
    - S: Satellite
      - documents
      - SM: SafeMode
      - SM: Science
      - SMP: SystemMassParameters
      - SP: SystemParameters
      - SPP: SystemPowerParameters
      - SS: AOCS
      - SS: Communication
        - documents
        - E: Antenna
          - documents
          - MP: MassParameters
          - PP: PowerParameters
          - V: Visualisation
        - MP: MassParameters
        - PP: PowerParameters
      - SS: DataHandlingSystem
        - documents
        - E: CentralBoardComputer
          - documents
          - MP: MassParameters
          - PP: PowerParameters
          - V: Visualisation
        - MP: MassParameters
        - PP: PowerParameters
      - SS: Power
      - SS: Propulsion
      - SS: Structure
      - V: Visualisation
  - Role Management

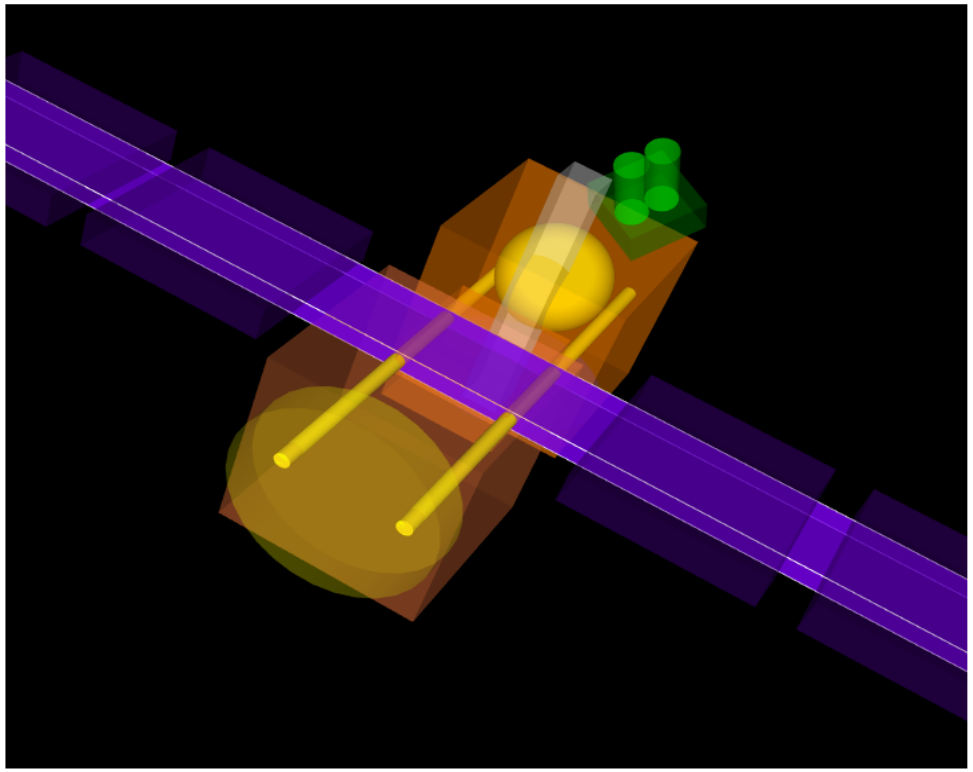
Mass Summary | Satellite | DataHandlingSystem | SystemParameters | SystemMassParameters

	Mass w/o margin [kg]	Margin [%]	Mass with margin [kg]
Total dry mass:	1888.00		1982.40
System margin:		20.00	396.48
Total dry mass with system margin:			**2378.88**
Propellant:			1330.00
Adapter mass:			300.00
Launch mass:			**4008.88**
Max launcher capacity:			4150.00
Buffer to launch mass:			141.12



3D Vtk Viewer

Local Axes | Global Axes | Front View | Side View | Top View



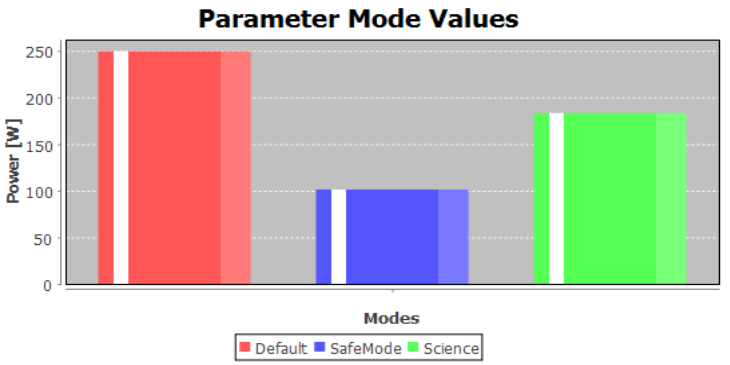
Outline | Mode Table

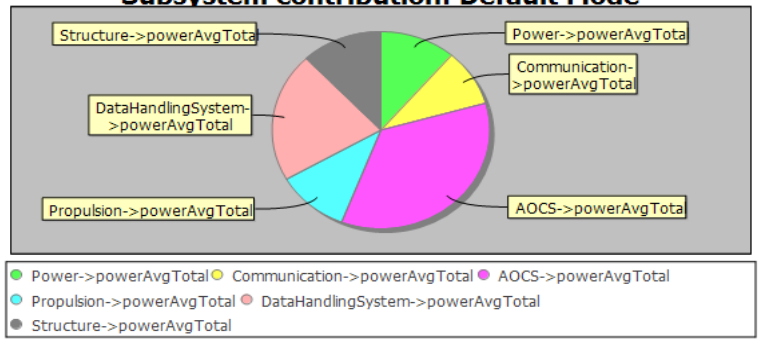
Mode Overview Table: Satellite

SEI	Parameter	Unit	default	SafeMode	Science
Satellite	powerAvgTotal	W	249.320	101.405	183.154
Power	powerAvgTotal	W	28.000	20.000	28.000
Power	powerAvg	W	17.000	9.000	17.000
SolarWings	powerAvgTotal	W	11.000	11.000	11.000
Communication	powerAvgTotal	W	23.320	21.004	23.320
Communication	powerAvg	W	21.000	21.000	21.000
Antenna	powerAvgTotal	W	2.320	0.004	2.320
AOCS	powerAvgTotal	W	88.000	0.085	0.150
Propulsion	powerAvgTotal	W	27.000	5.000	27.000
Propulsion	powerAvg	W	27.000	5.000	27.000
DataHandlingSystem	powerAvgTotal	W	53.000	77.000	53.000
DataHandlingSystem	powerAvg	W	0.000	0.000	0.000
CentralBoardComputer	powerAvgTotal	W	53.000	77.000	53.000
CentralBoardCompute	powerAvg	W	53.000	77.000	53.000
Structure	powerAvgTotal	W	30.000	0.000	30.000

Problems | Properties | Search | Mode Graphs | Domain Round

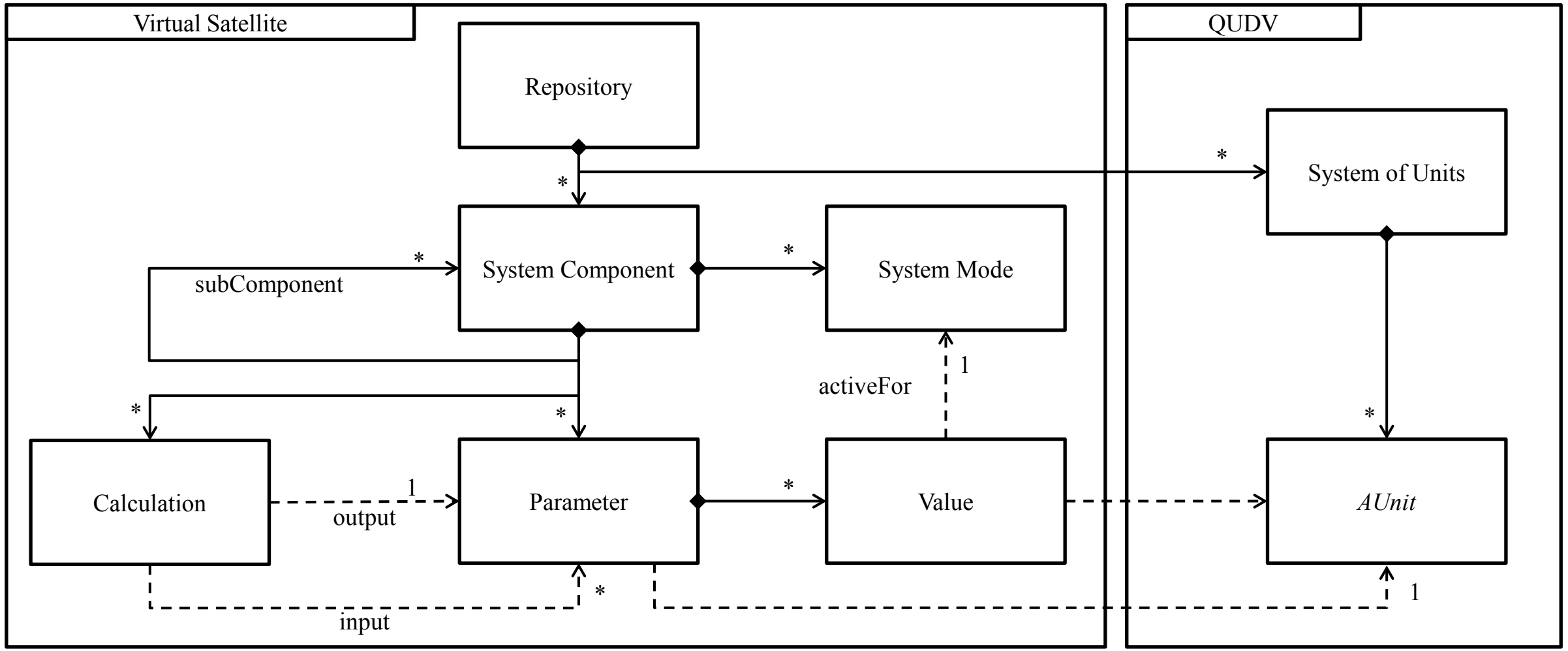
Mode Overview Graphs: powerAvgTotal



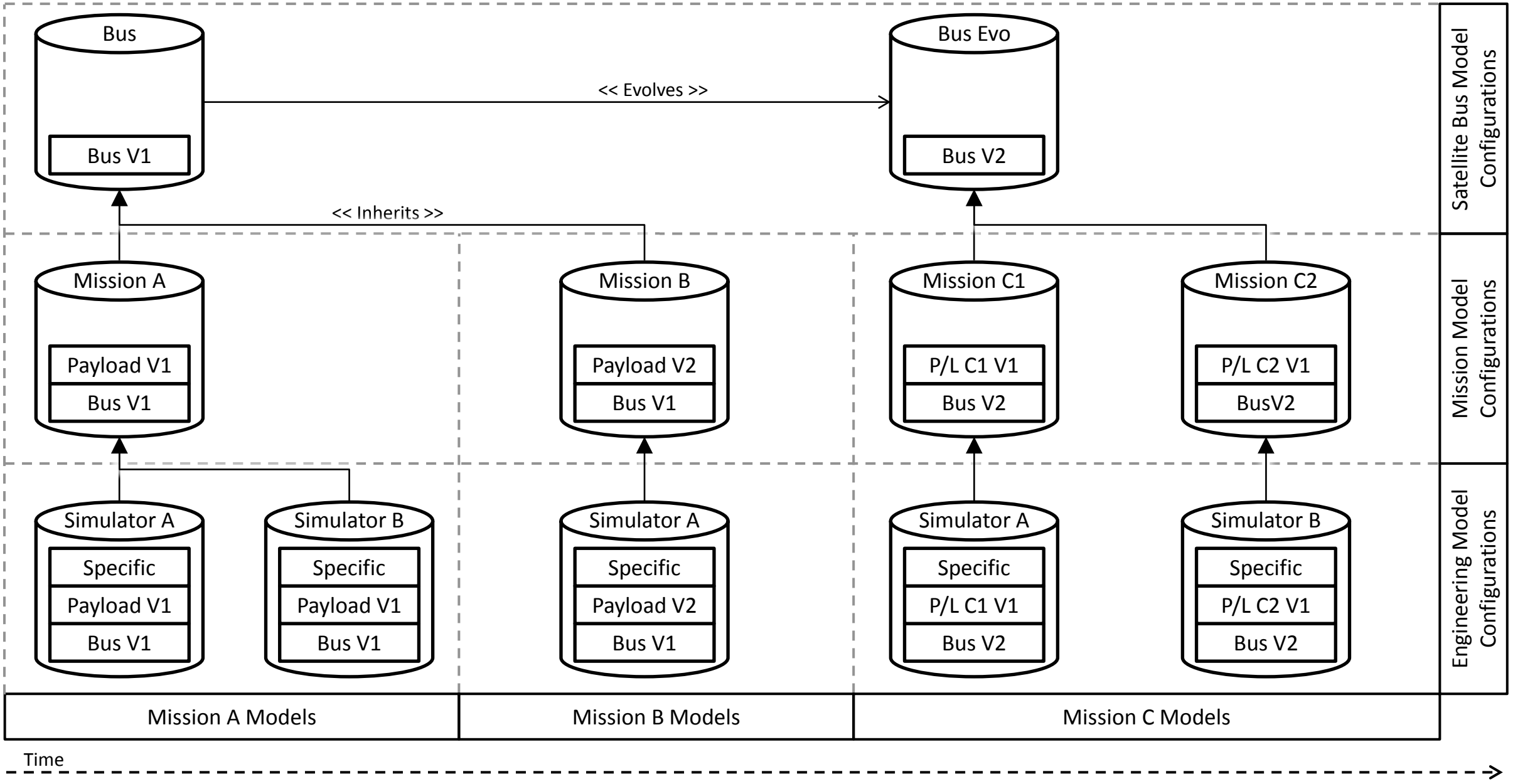


Allowing for new methods to access the data

Underlying Conceptual Data Model (CDM) – Simple but it suits the purpose!

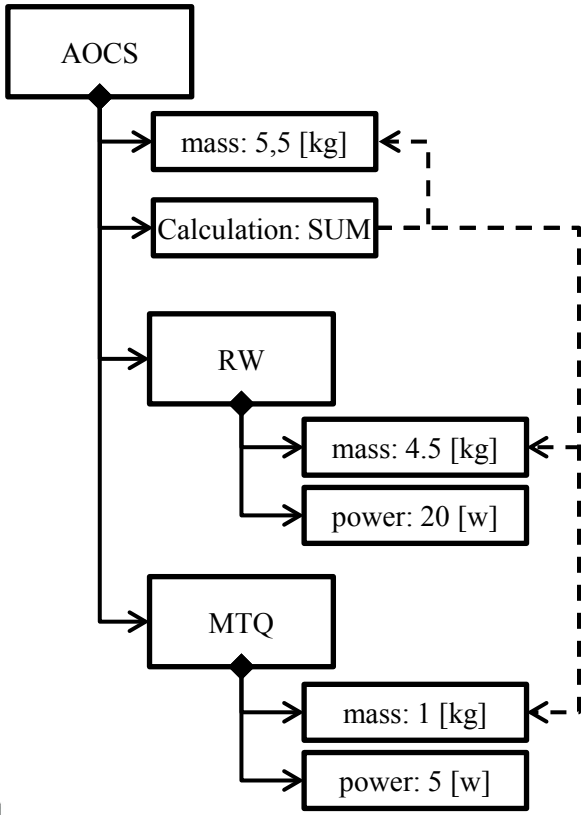


Some Real Configuration Control Challenges for a Multi Mission Platform

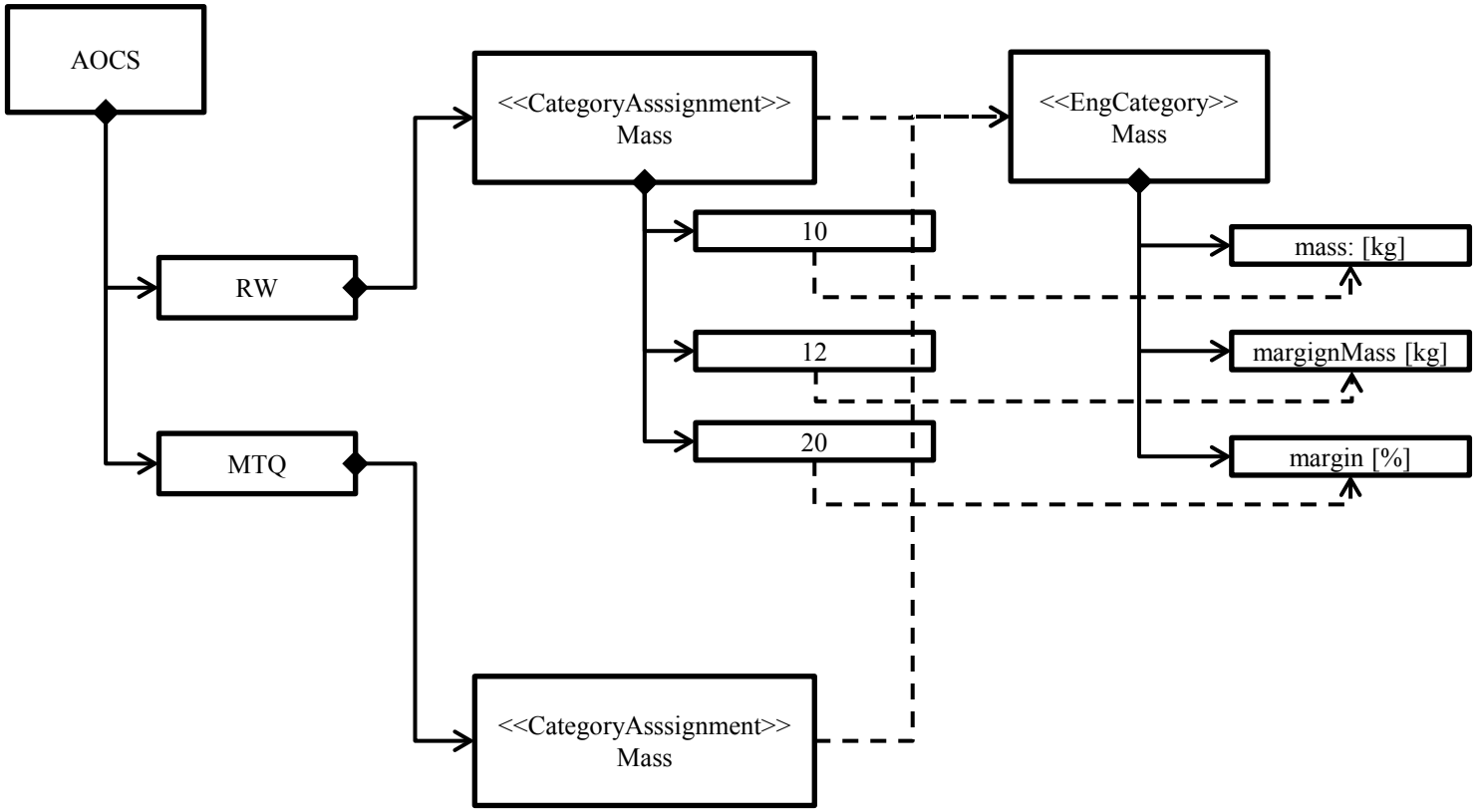


Modeling Actual Information – From Parameters to Engineering Categories

Structural Decomposition + Parameters (Yesterday)

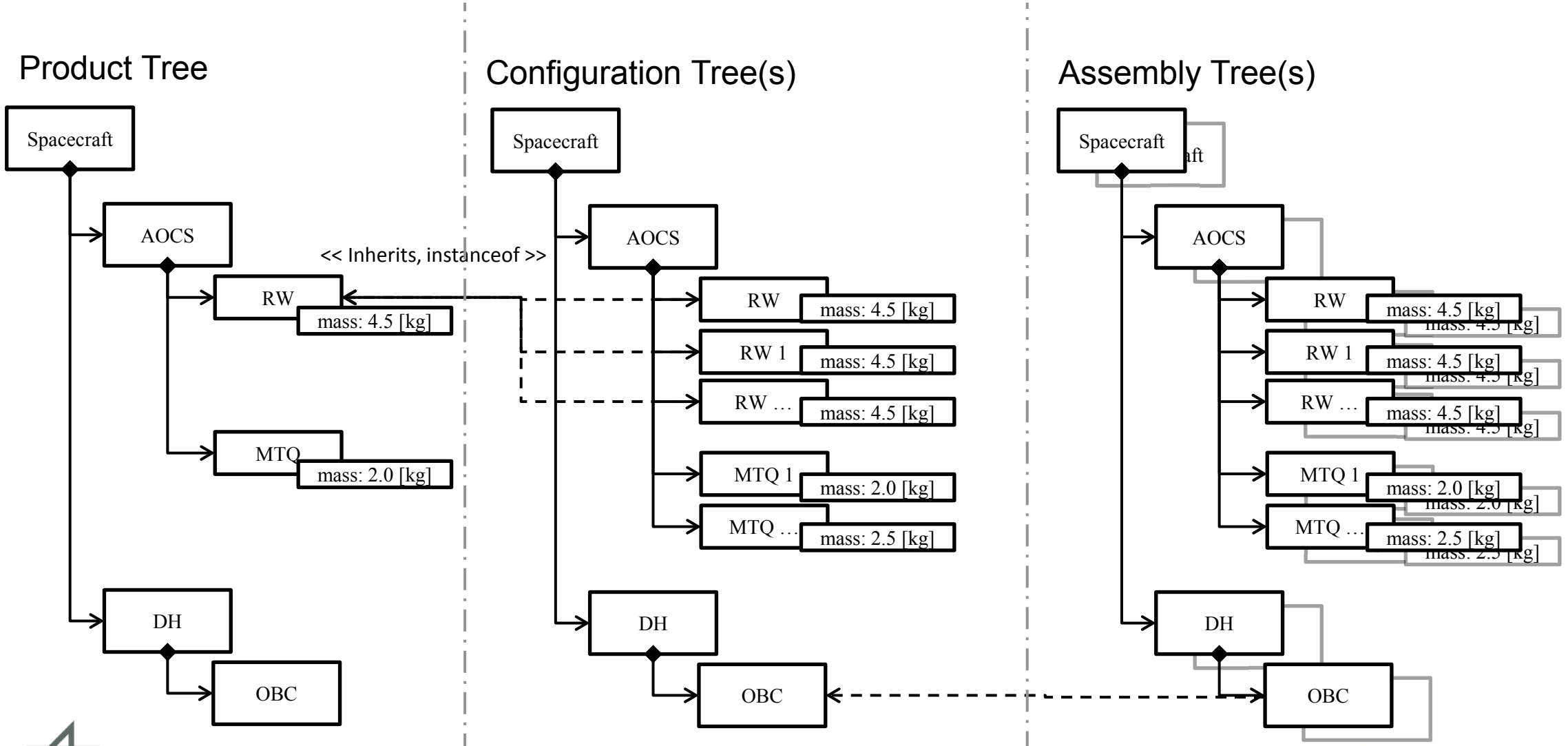


Structural Decomposition + Engineering Categories (Today)



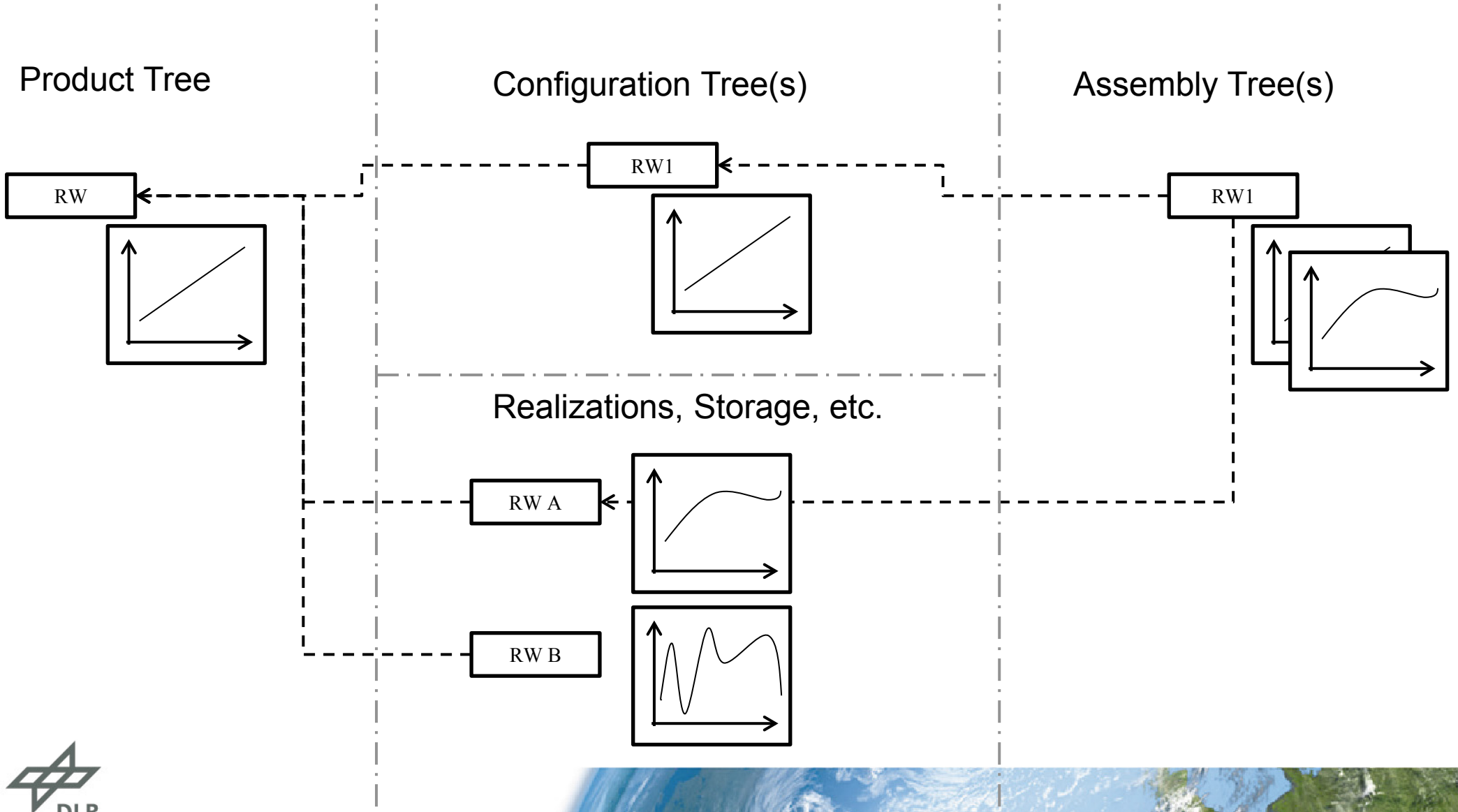
AOCS: Attitude and Orbit Control System RW: Reaction Wheel MTQ: Magnetig Torquer

Product Structure Architecture… Such as EGS-CC, VSD, Virtual Satellite, etc.



EGS-CC: European Ground Segment – Common Core VSD: Virtual Sapcecraft Design
DH: Data Handling OBC: On Board Computer

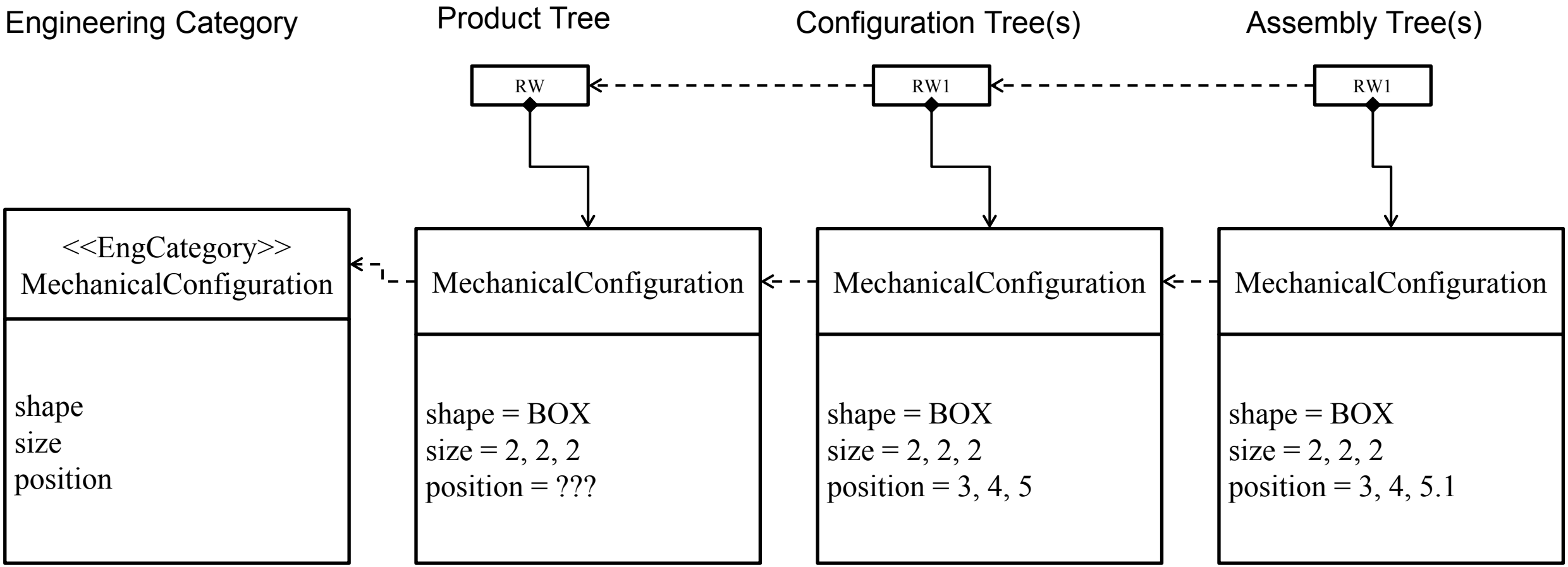
And Now Enriching it with Some Reality…



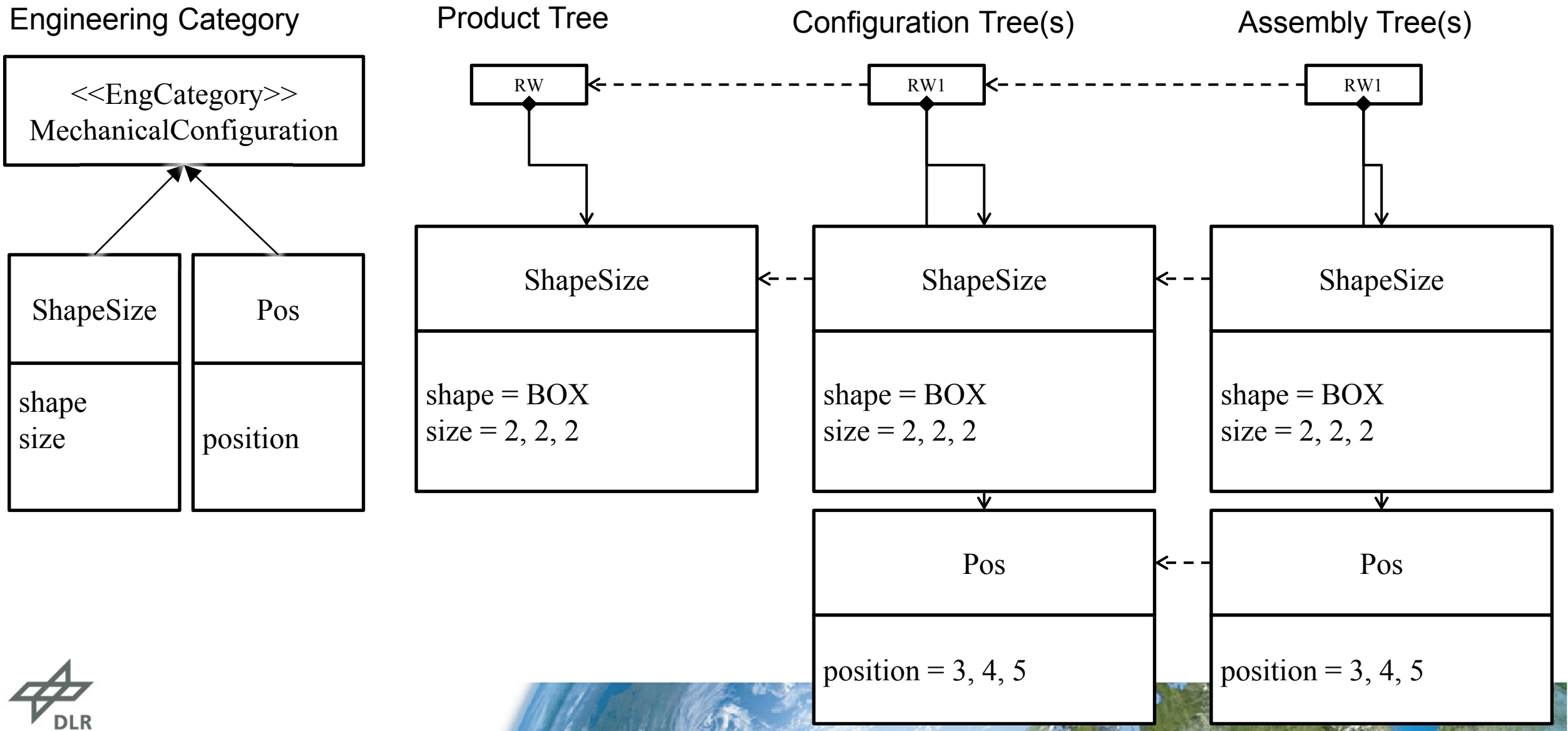
NOW ! Let‘s Bring it Together With Multi Level Modelling !

- Remember about our Visualization
- There is information about shape and position
- But this information only makes sense with the correct Context !

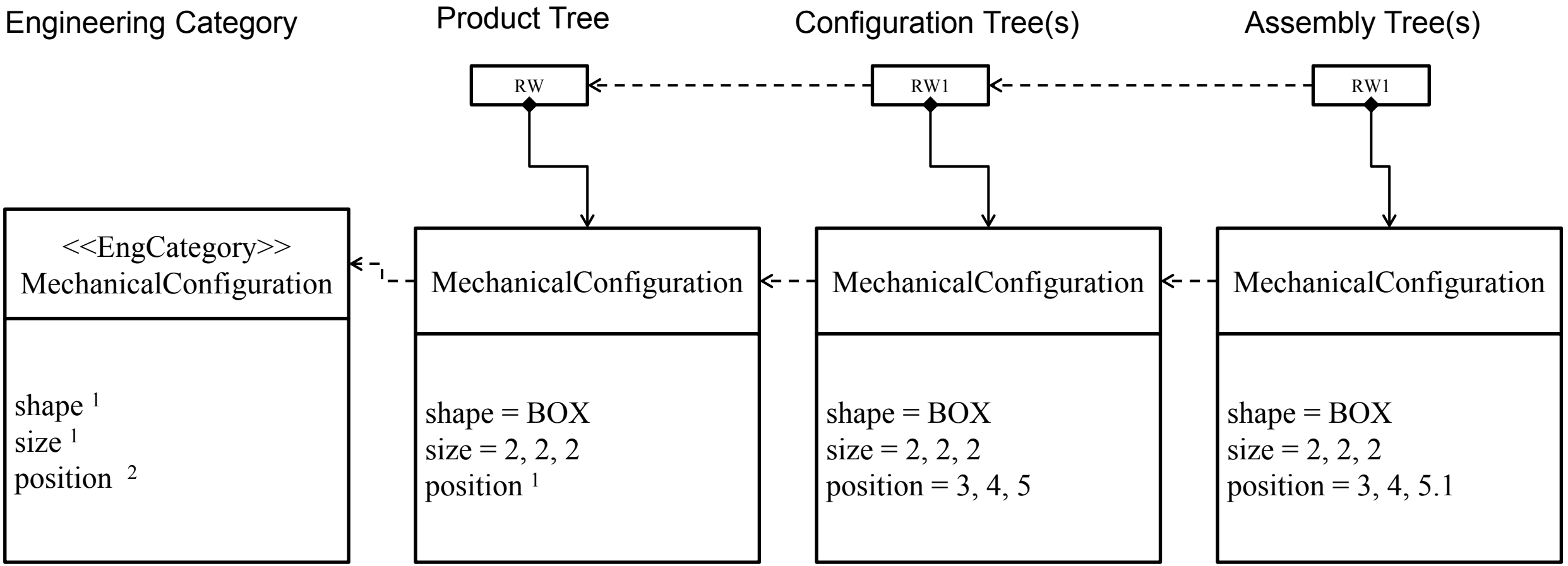
The Simple Approach, And we Start Introducing Implicit Knowledge…



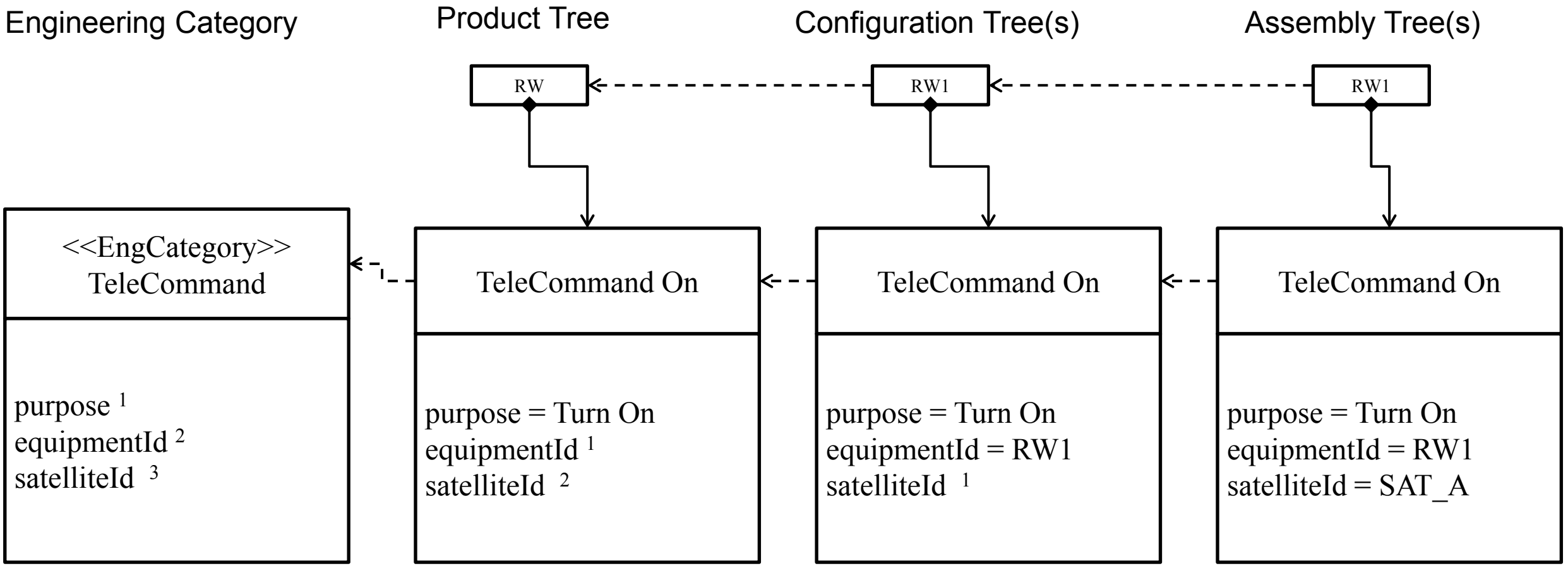
Lets try it Differently, but Now we Separated Things we Don‘t Want To !!!



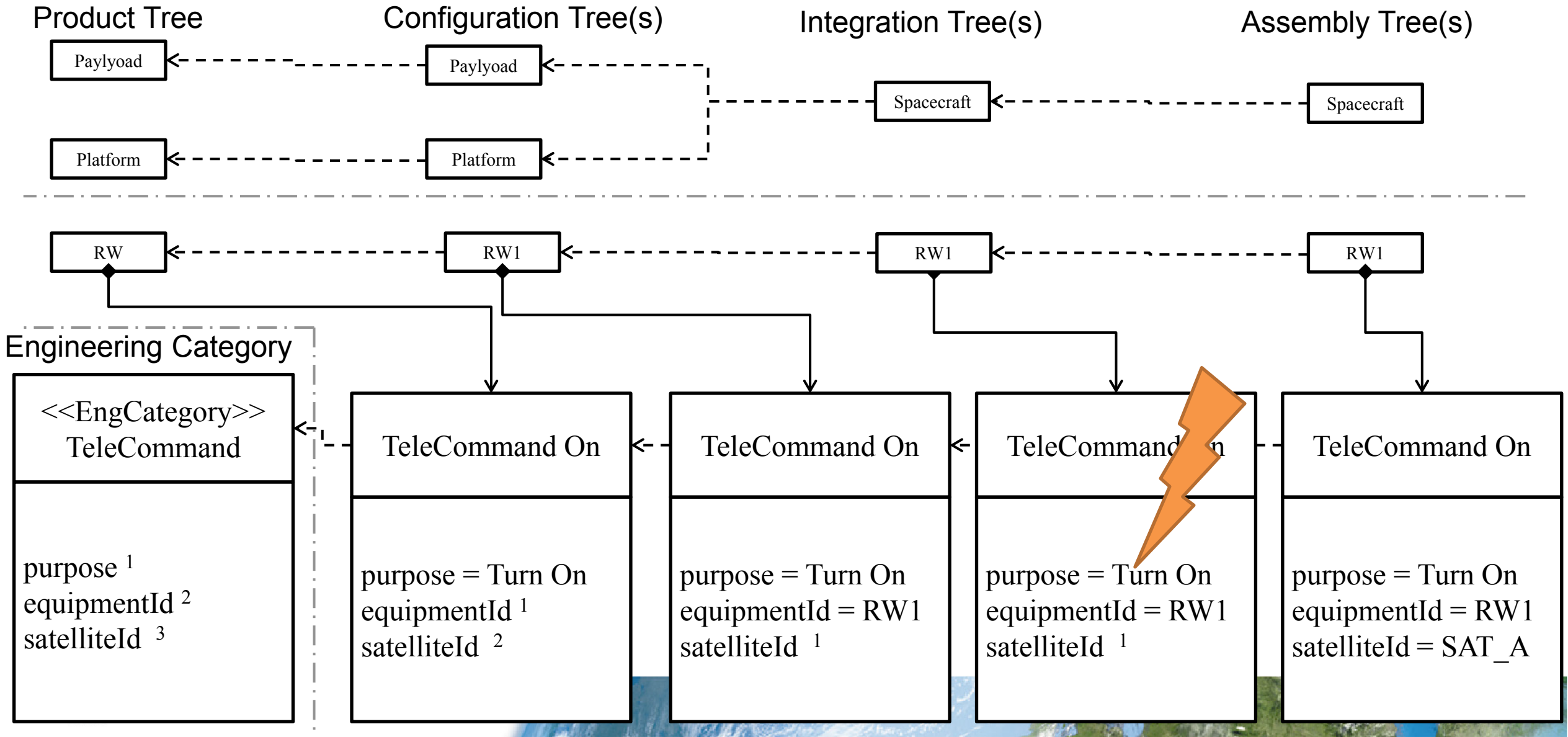
Let‘s Introduce Some Sort of Potency? Simple, but Suits the Purpose….



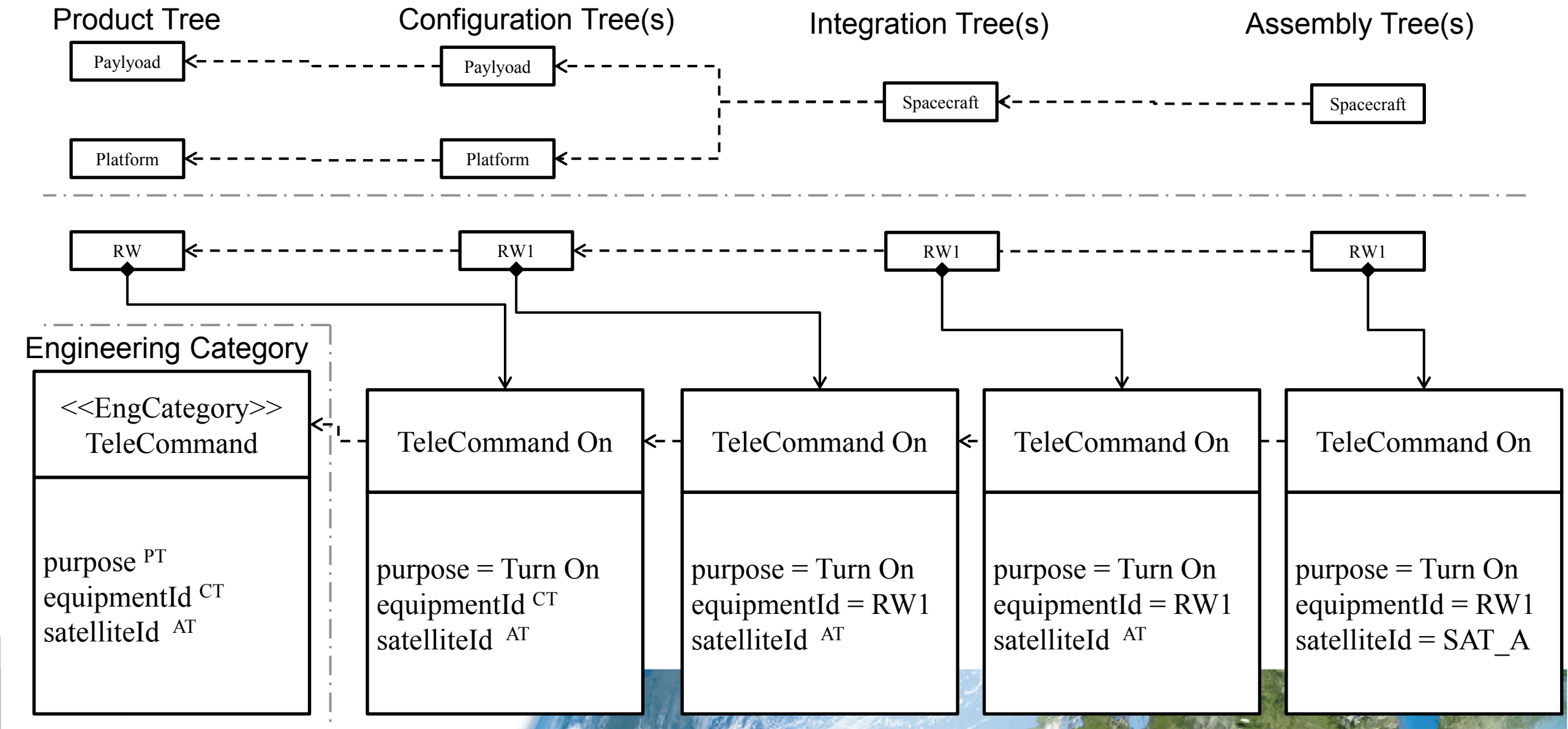
Let‘s do the Same with TeleCommands… Nice, Works as well…



Now Let‘s Break the TeleCommand Example! Our PS is getting more complex…



What About Context Aware Potencies?



Some Thoughts and Conclusion

- We (DLR maybe you) are modelling a reflection of reality, but not for the sake of modelling!
  - We want to send spacecraft into space.

- The most best defined language will not make us change everything
  1. Systems are up and running, supporting our processes and what is the Return of Investment?
  2. We may change where we see a benefit => Going into the direction of a hybrid model!
     - We simply just sacrifice due to the processes and people around us (us means the model)

- Don‘t get fooled by the simplicity and my abstractions of our problems!
  - There are much more details behind.
  - I have other use cases in mind. Our Harness Engineers face issues where MLM could help a lot!

- I see benefit of Multi Level Modelling in some areas.
  - I would like to perform some further research in these areas.
  - Bringing the great ideas of theory into some adopted, practical application.

Relevant Publications

- P. M. Fischer, D. Lüdtke, C. Lange, F.-C. Roshani, F. Dannemann, A. Gerndt, (2017) *Implementing model-based system engineering for the whole lifecycle of a spacecraft*, CEAS Space Journal, 9 (3), Seiten 351-365. Springer Vienna. DOI: 10.1007/s12567-017-0166-4 ISSN 1868-2502

- P. M. Fischer, M. Deshmukh, V. Maiwald, D. Quantius, A. Martelo Gomez, A. Gerndt, (2017) *Conceptual data model: A foundation for successful concurrent engineering*, Concurrent Engineering Research and Application. DOI: 10.1177/1063293X17734592

End of Presentation

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