Model Based Verification and Validation Planning for a Solar-Powered High-Altitude Platform

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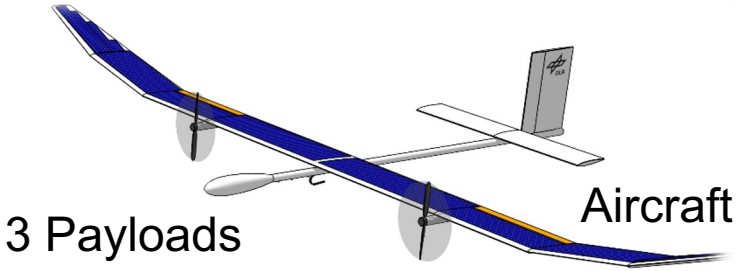
German Aerospace Center (DLR)

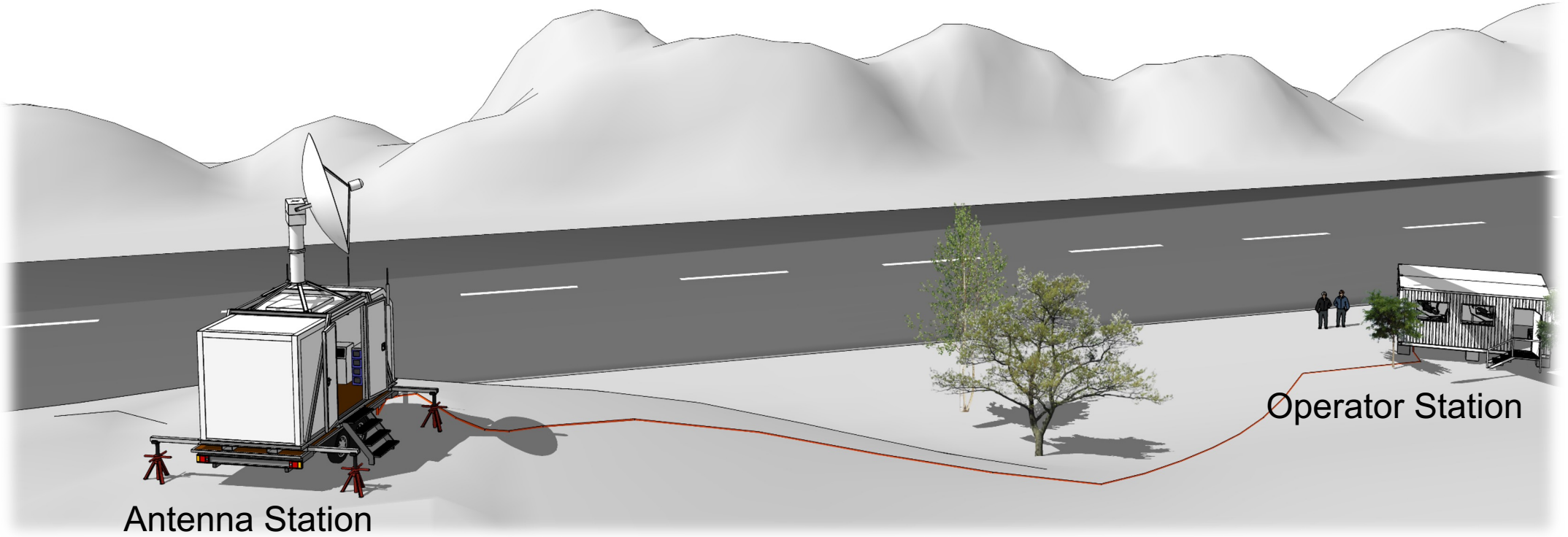
33rd Annual INCOSE international symposium
hybrid event
Honolulu, HI, USA
July 15 - 20, 2023

DLR

DLR Project HAP-alpha

- High Altitude Long Endurance Aircraft
- Earth Observation Scenarios





Technology Demonstrator HAP alpha

- Wing span 27 m
- Mass 136 kg
- Service Ceiling >22 km
- 5 kg payload
- Developed Payloads: High resolution camera system and a radar with synthetic aperture

DLR Project HAP-alpha

Project initiated in 2018 with a budget of around 40 M€

Currently 16 DLR Institutes all over Germany are involved:

Flight Systems FT,

Systemhaus Technik SHT,

Aeroelasticity AE,

Flight Guidance FL,

Remote Sensing Technology MF,

Atmospheric Physics PA,

Microwaves and Radar HR,

Networked Energy Systems VE,

Software Technology SC,

Aerodynamics and Flow Technology AS,

Communications and Navigation KN,

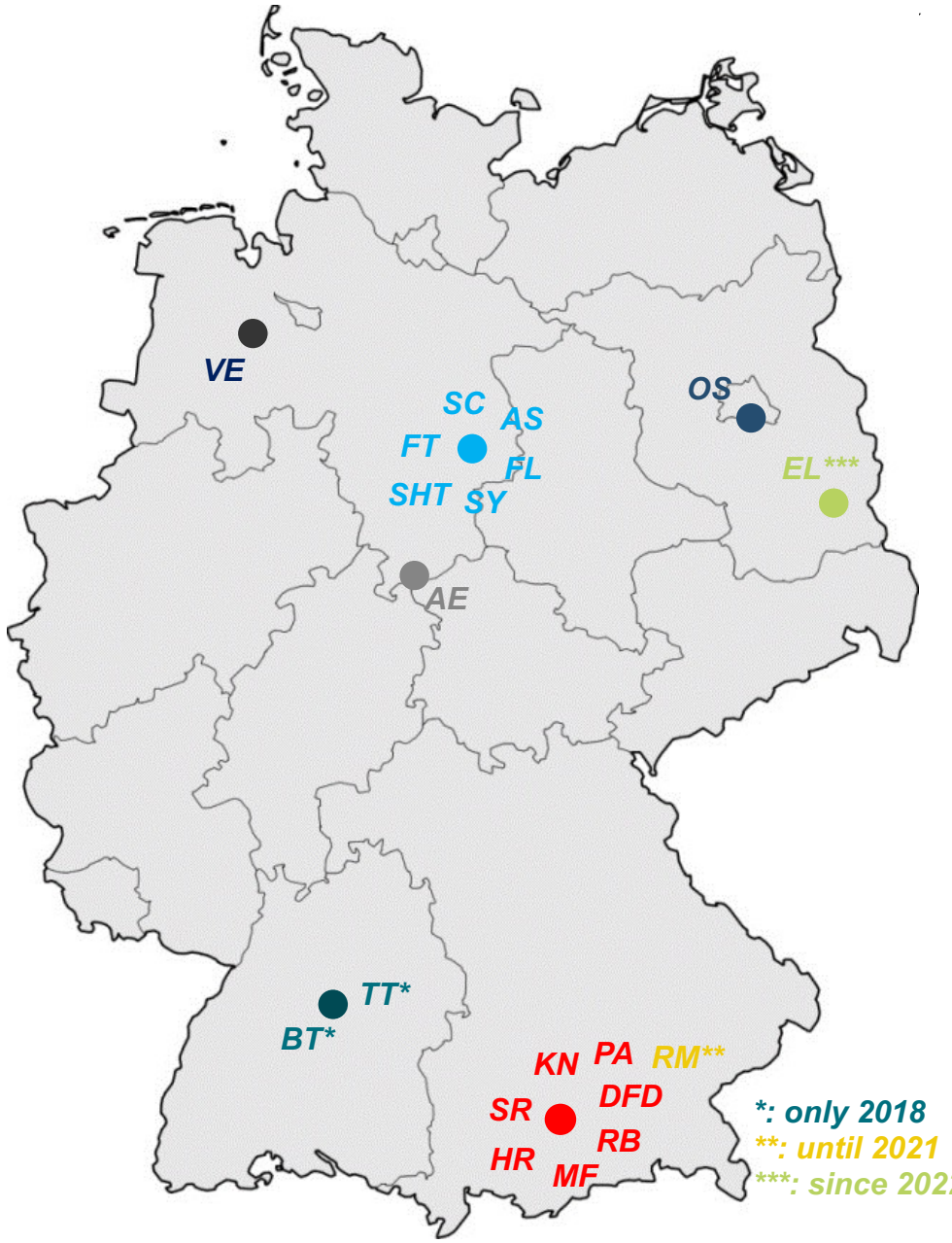
Optical Sensor Systems OS,

German Remote Sensing Data Center DFD,

Electrified Aero Engines EL,

Lightweight Systems SY,

System Dynamics and Control SR



Motivation – What we need

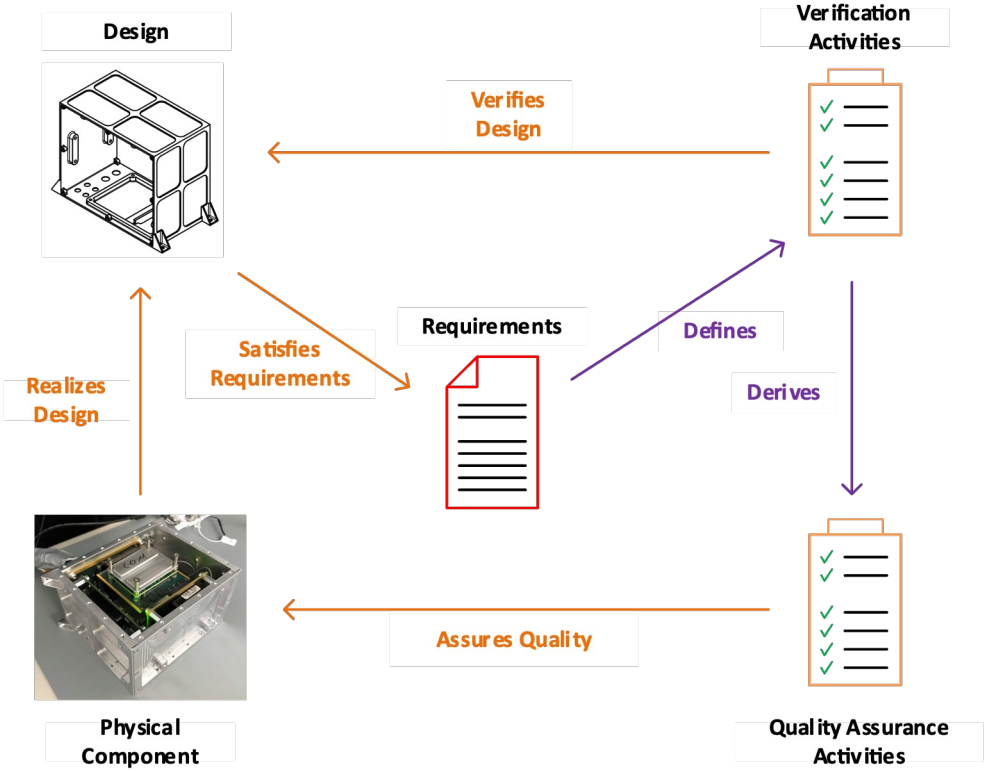
- Ultra-light weight and highly integrated design needed
- Complex system needs requirements
- Requirements only state intentions, they must be verified
- Simple review of verification
- Document based approach is tedious → Model Based (SysML)

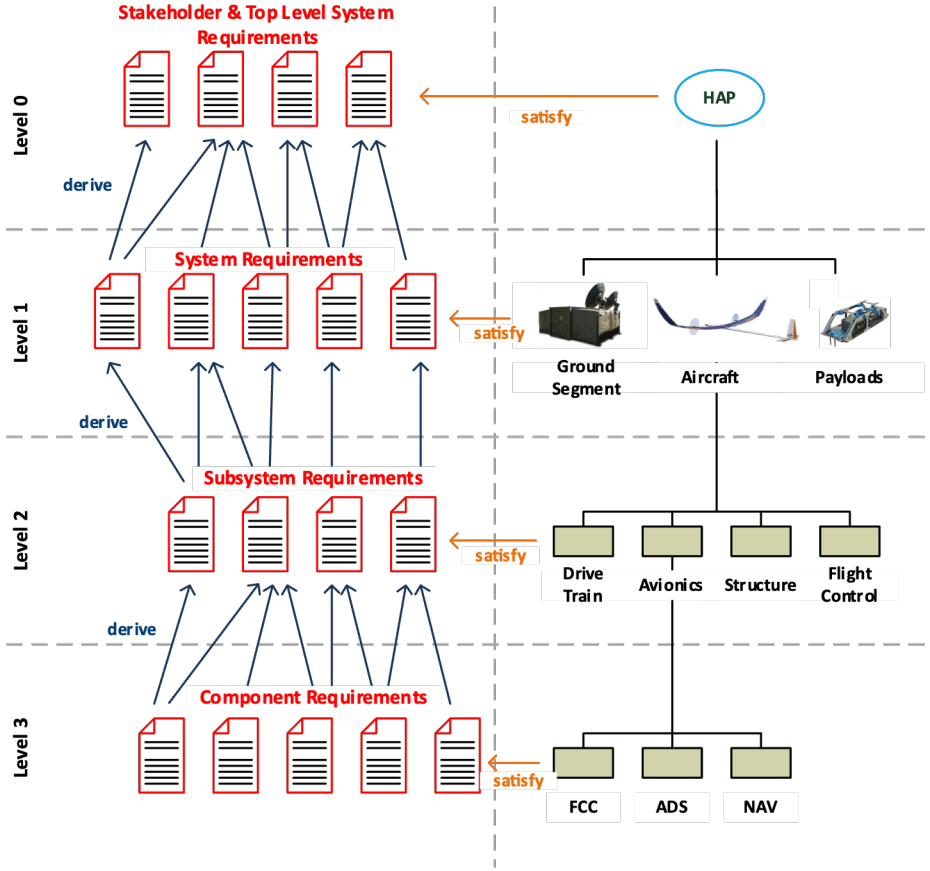
Complexity in Management

- Scarcity of financial resources, limiting workforce
- Trade off between quality and effort for documentation and verification
- Highly distributed workforce
- Project members often part time at project

The Process

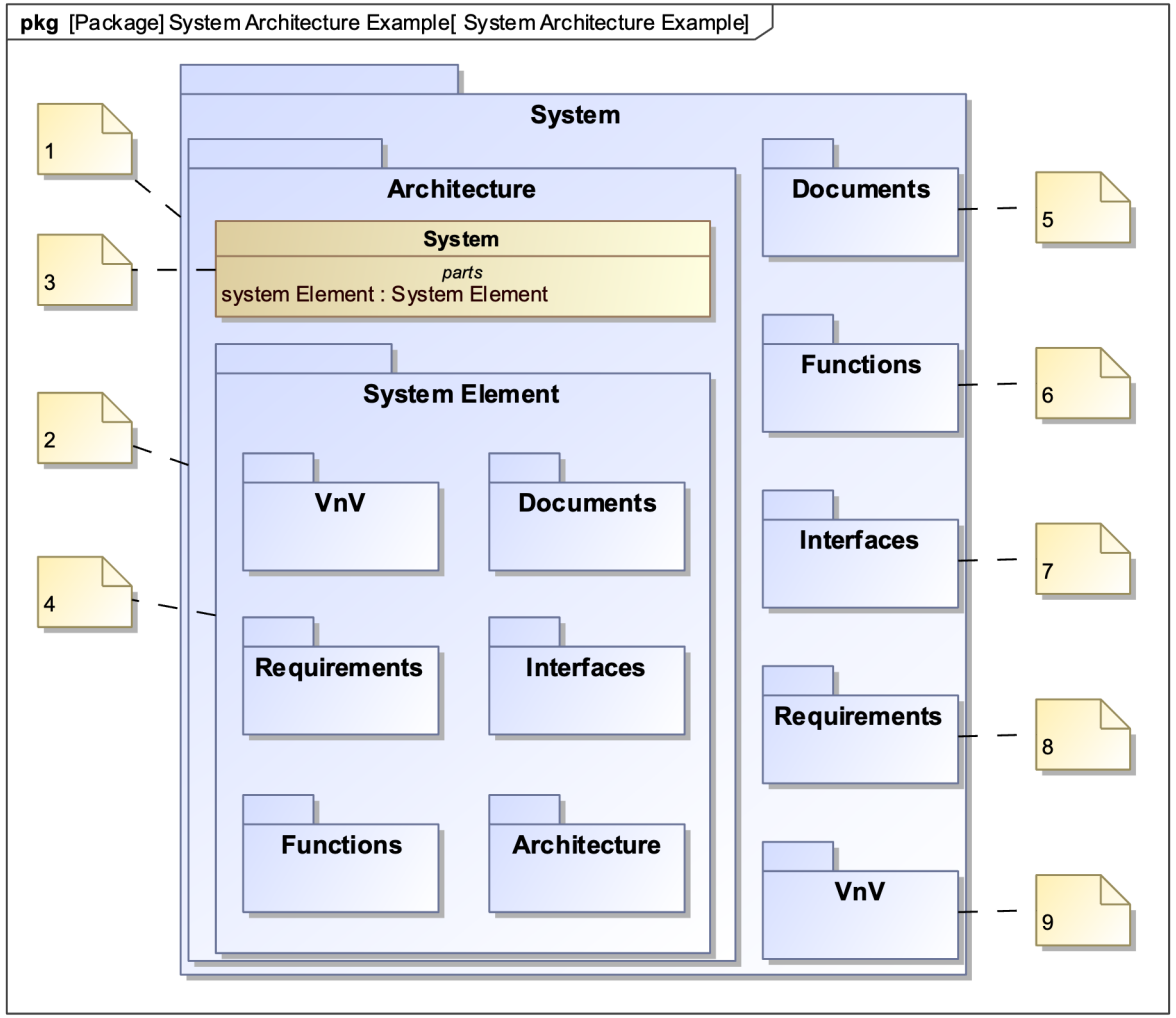
- Based on V-Model
- Focus on verification



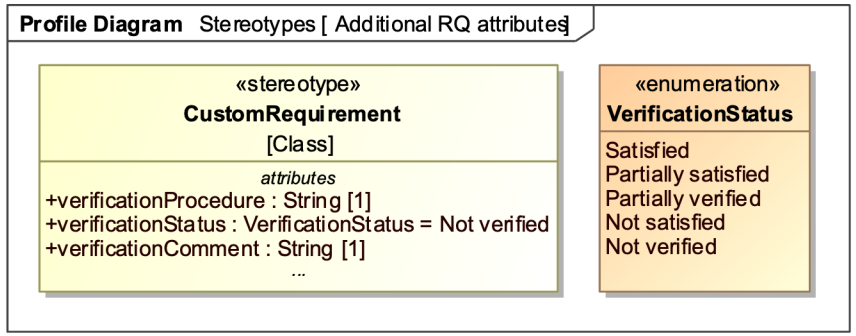


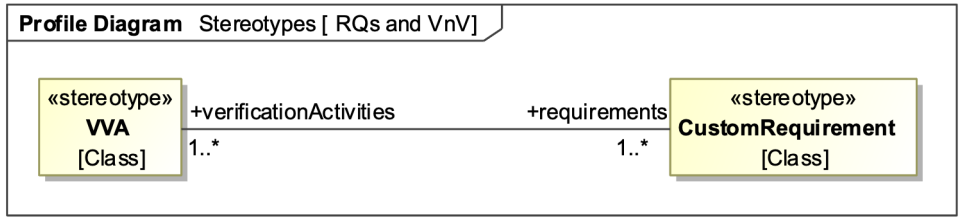
Basic Model Architecture

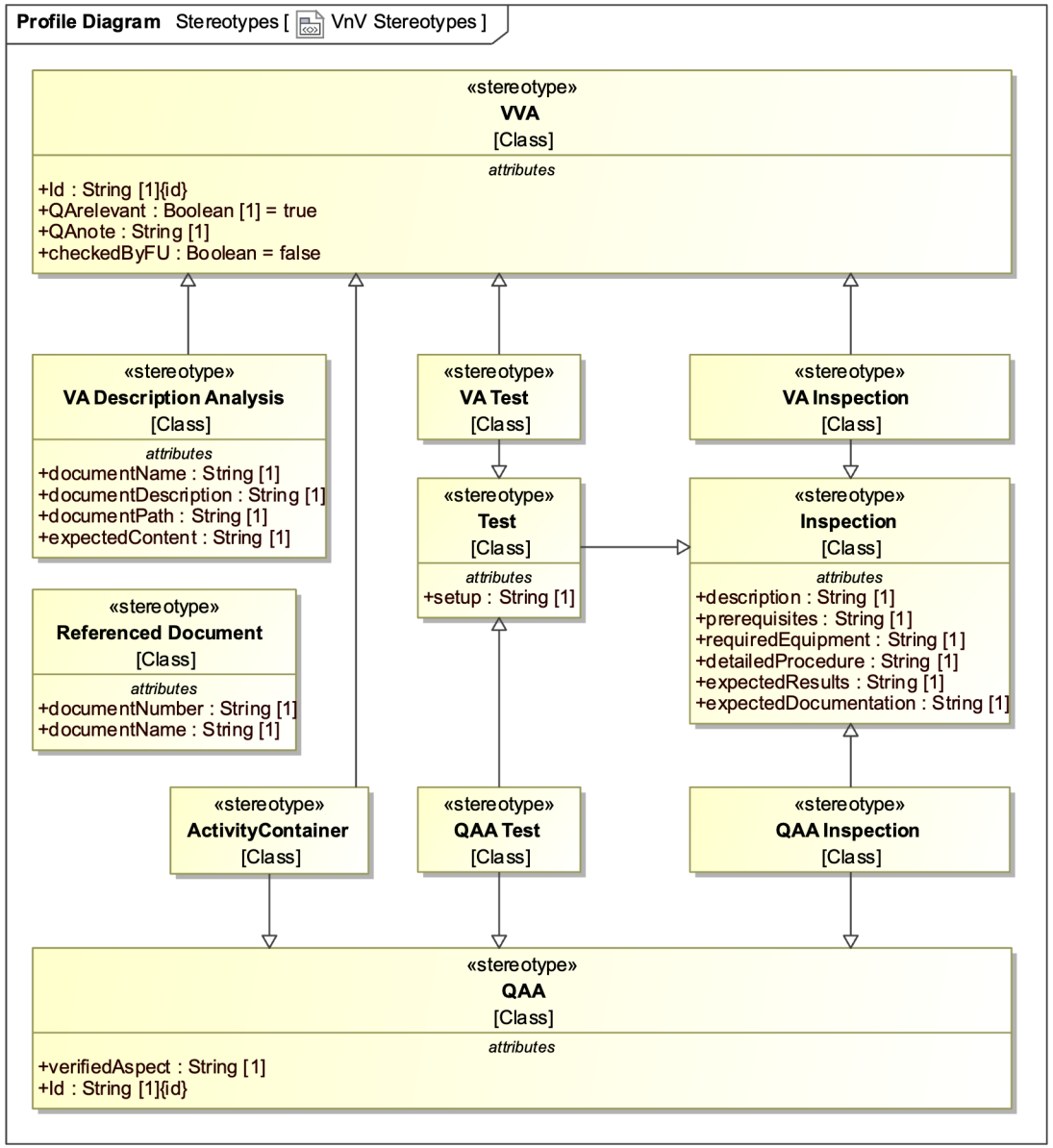
- Recursive model architecture
- 1 Package per system element
- Subpackages for
  - Requirements
  - System Breakdown
  - Documents
  - Verification Activities



The Profile for Verification (and Validation)







Input the verification activities

- Adding the Verification Activities is simple
- → Training for tool novices is 30 min
- Data is put into the model via 6 tables & 1 matrix (1 table for results)
- Automated checks for completeness of VAs possible

#	△ Name	Mo C	Compliance Statement	Verification Procedure	Verification Activities
1	1040 Environmental conditions	Calculation/Analysis	The components of the system are selected such that they operate at the expected conditions, or that they can be sufficiently shielded.	All electrical systems of the Air Data System (concretely the Air Data Computer) are subjected to EM emissions as specified in the environmental handbook (REF-4). The resistance against temperature and pressure will be tested in a climate chamber suitable for the conditions expected for the system (using results from the thermal management).	VA 1040.1 ADC EMC Test VA 1040.3 ADC climate chamber test

#	△ Id	Name	Description	Prerequisites	Required Equipment	Setup	Detailed Procedure	Expected Results	Expected Documentation
1	VA 1040.1	ADC EMC Test	The Air Data Computer and Boom will be subjected to EM radiation in the EMC chamber according to the environmental handbook (REF-04).	• Fully assembled Air Data Computer and Air Data Boom (including heating circuits) • Cables to connect the Air Data Computer to the FCC or a test computer • Software to read sensor data from Air Data Computer • EM conditions specification • Fixation Hardware for the Air Data Boom for Tests	EMC chamber, connection cables, test pc, power supply 28 VDC	The Air Data Computer and Air Data Boom are placed in the chamber and connected to a test computer capable of processing the measurement data. The Air Data Computer is turned on, and valid measurements must be seen at the connected computer.	The chamber steps through all frequencies and intensities specified in the environmental handbook (REF-04), while the correct operation of the Air Data Computer is verified by observing the measurements through the connected test computer.	The Air Data Computer must produce valid measurements over the full range of frequencies specified in the environmental handbook (REF-04).	The results from the test will be specified in the EMC Qualification Report (REF-06).

Exporting the modelled information

- Reading a document is faster than reading the model
- External reviewers don‘t need to read the model
- Export is automated (nightly build)
- Same template used as for manual written VVPs / VVRs

2. System requirements

The verification of the system under test is performed based on the requirements defined in the system requirements specification (REF-05). Each requirement specifies a *Means of Compliance* (MoC) indicating the type of verification strategy to be performed.

RQ 1040	L3	Environmental conditions	Calculation/Analysis
Compliance statement		The components of the system are selected such that they operate at the expected conditions, or that they can be sufficiently shielded.	
Verification activities		• VA 1040.3 (ADC climate chamber test) • VA 1040.1 (ADC EMC Test)	
Verification procedure		All electrical systems of the Air Data System (concretely the Air Data Computer) are subjected to EM emissions as specified in the environmental handbook (REF-4). The resistance against temperature and pressure will be tested in a climate chamber suitable for the conditions expected for the system (using results from the thermal management).	

Evolution of Process in project

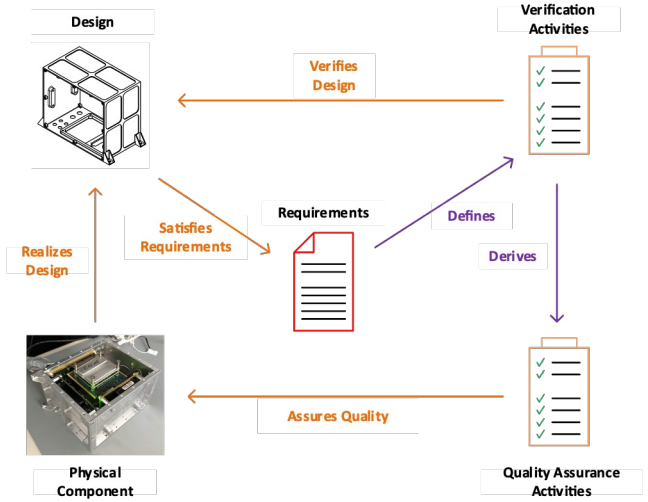
- Process of introducing MBSE for VnV still ongoing in project
- Only requirements in the model in the beginning
- VVPs written manually
- Changes in requirements needed to be manually updated
- Tedious work → SysML Profile
- Need to plan Quality Assurance
- Addition for verification results
- Advantages of modelling lead to more users in the project

Lessons Learned & Future Work

- MBSE has a steep learning curve and high front-loading
- Reduction of redundant information is advantageous
- Project members can be trained
- Documents needed for reviewers, debugging/operation and archives
- Documents can be generated, HTML gives better linking than MS Word
- Improve traceability of requirements for better validation

Conclusion

- Process works for our project, adaptions needed for other projects
- Profile for modelling VnV activities
- Exports are good for reviewing and prevent copy/pasting



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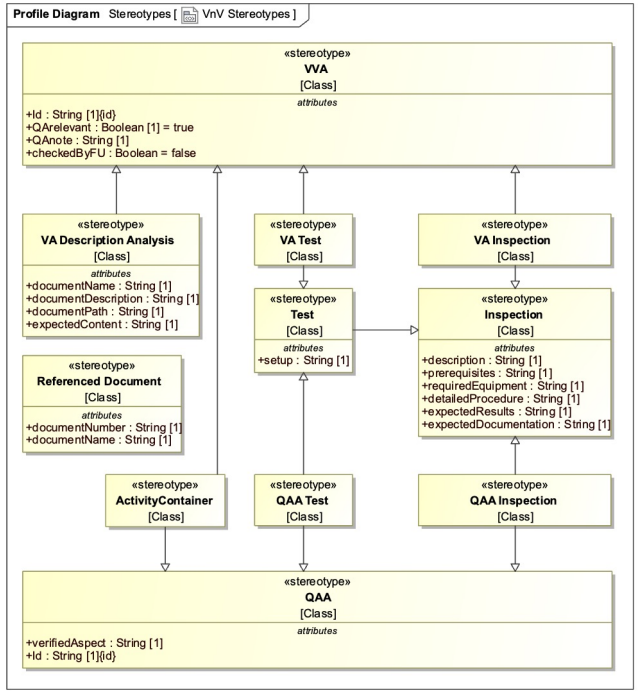

THANK YOU FOR YOUR ATTENTION

Questions?

Imprint

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