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# VSEE - CDF Data Model Transfer and Modelling Guidelines – Final Review Meeting

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## Background

### CDF OCDT

- ESA Concurrent Design Facility (CDF) using the Open Concurrent Design Tool (OCDT) for system engineering in early mission phases 0, A and B1
- OCDT provides environment for concurrent, collaborative and distributed engineering based on ECSS-E-TM-E-10-25A

### VSEE

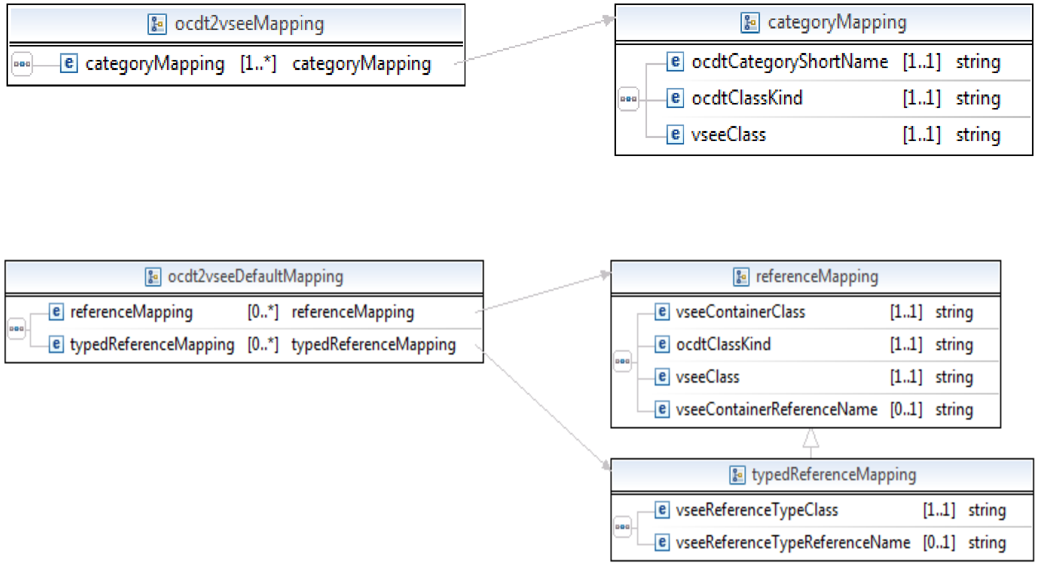
- Virtual Spacecraft Engineering Environment (VSEE) using the Space Systems Design Editor (SSDE) for system engineering in later mission phases (B, C, D, E)
- VSEE framework and tooling based on ECSS-E-TM-10-23A

## Objectives

- Analyse the compatibility between the 10-25 and 10-23 meta-models and specify model mappings and transformations
- Integrate the SSDE and OCDT tooling, enabling model exchange between both environments
- Develop guidelines and associated tooling for system technical budget dashboards and validate them with reference data sets to demonstrate the integration approach

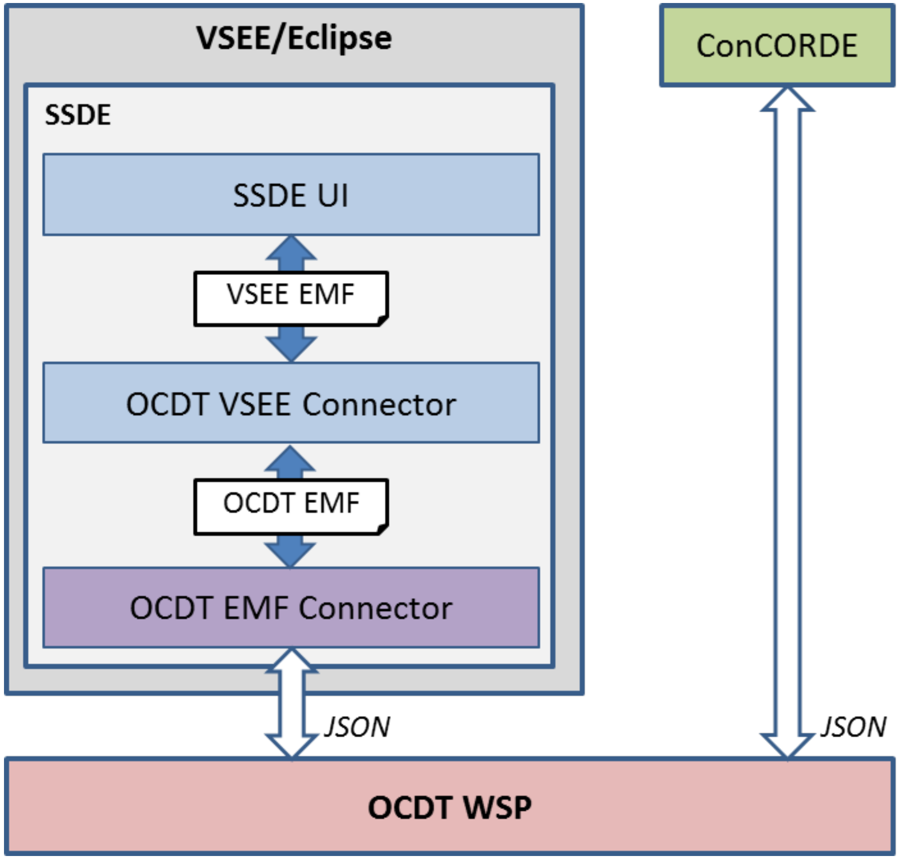
# Meta-Model Mappings

- Import:
  - Custom mappings based on OCDT Category
  - Default mappings for filling semantic gaps according to the target meta-model
  - Implicit mappings for closely related constructs
- Export:
  - Implicit mappings from the semantically richer 10-23 to the more generic 10-25 allowing inversed mapping through custom import mappings



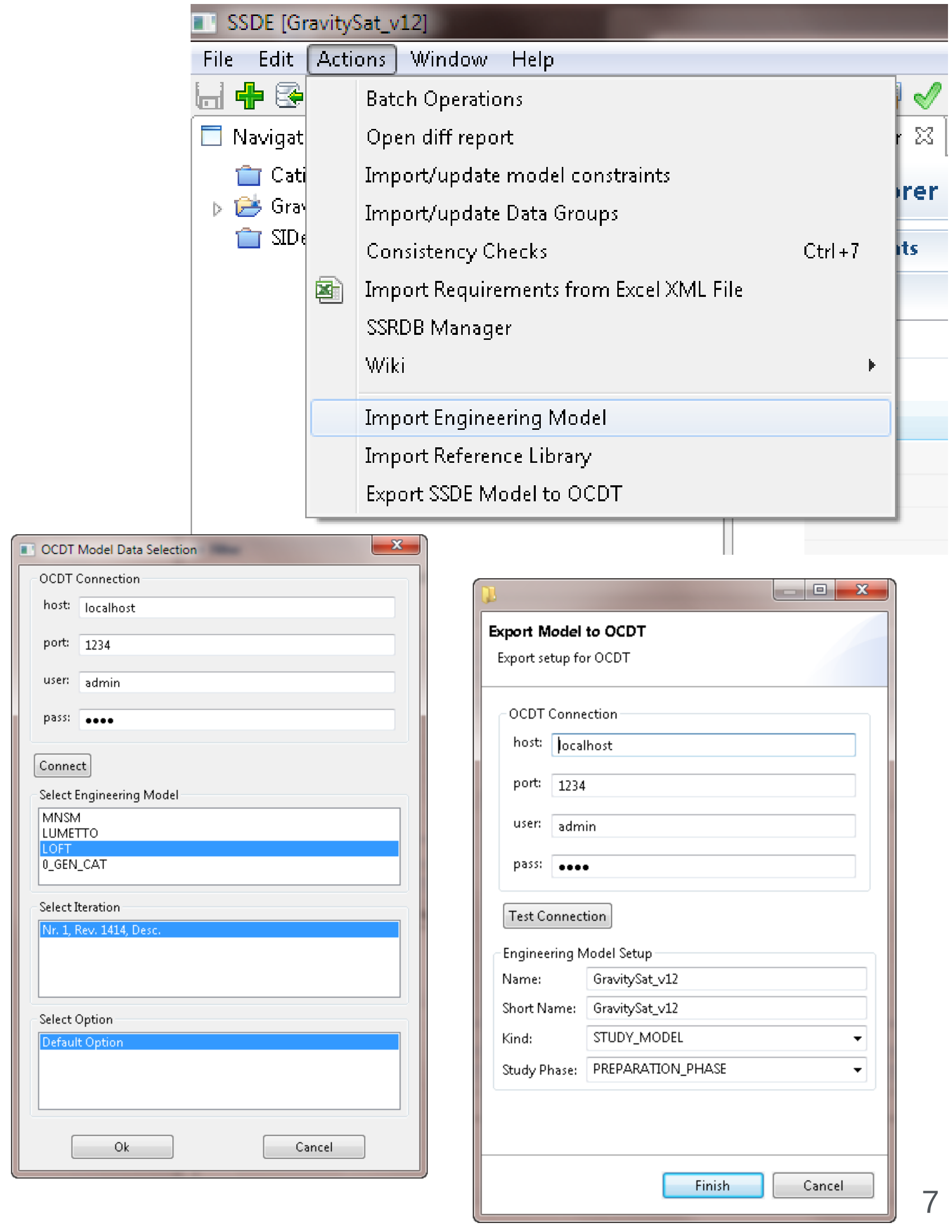
## Solution Overview

- Reuse of the generic OCDT-EMF Connector from CESoS including:
  - OCDT model retrieval through OCDT Web Services Processor (WSP) JSON to EMF conversion
  - OCDT model creation/update through EMF to OCDT WSP JSON conversion
- OCDT VSEE Connector performs OCDT EMF to VSEE EMF conversion (and vise versa)



## Noteworthy

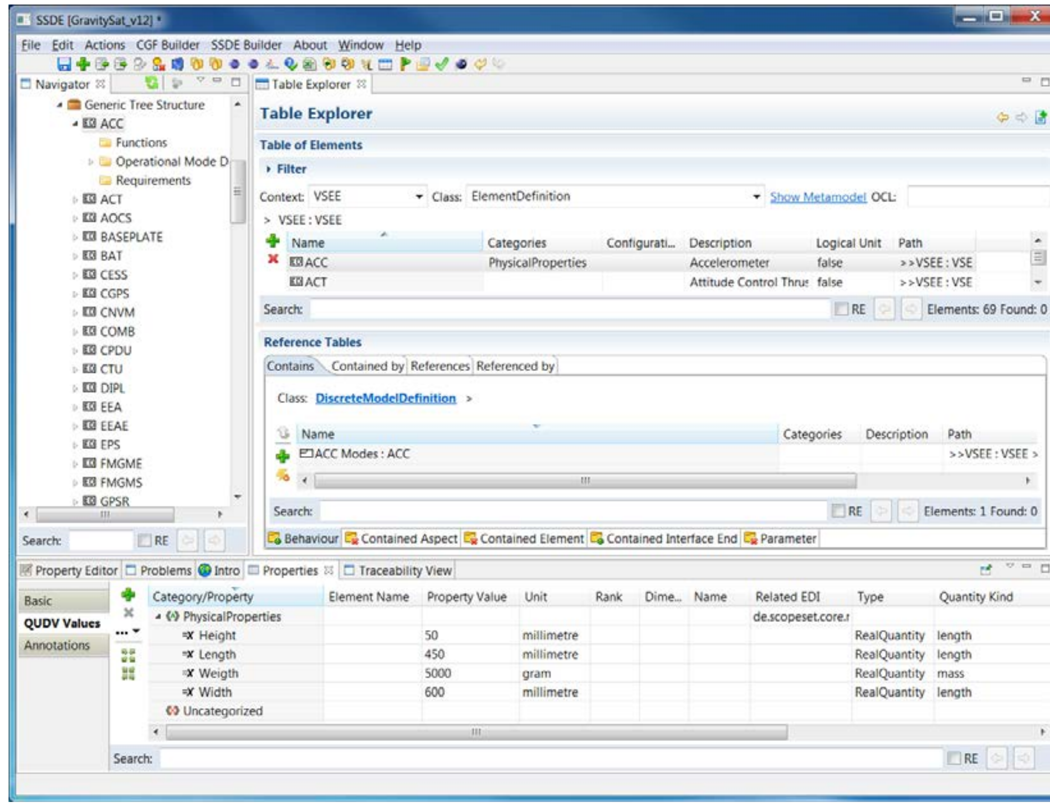
- Import of OCDT ParameterOverrides:
  - No overrides on ElementUsage level in SSDE
  - Occurrence tree generation
  - ValuePropertyValue overrides for OCDT ParameterOverrides in ElementOccurrences and DiscreteStateOccurrences
- Import of OCDT state-dependent Parameter(Overrides):
  - ValuePropertyValues applied to DiscreteStateDefinitions and DiscreteStateOccurrences



# DEMO

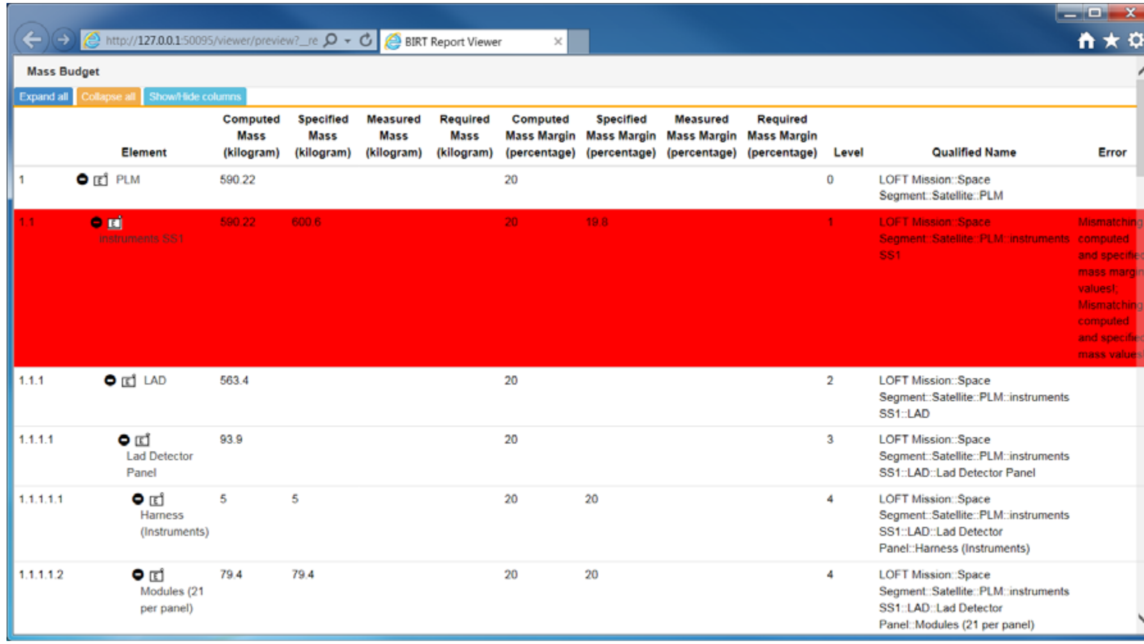
## Mass Budget - Modelling:

- Implicit product structure:
  - Modelling of ElementDefinitions, ElementUsages
  - ValuePropertyValues expected in ‘leaf’ elements
- Explicit product structure:
  - Overriding of ValuePropertyValue where needed in generated ElementOccurrences

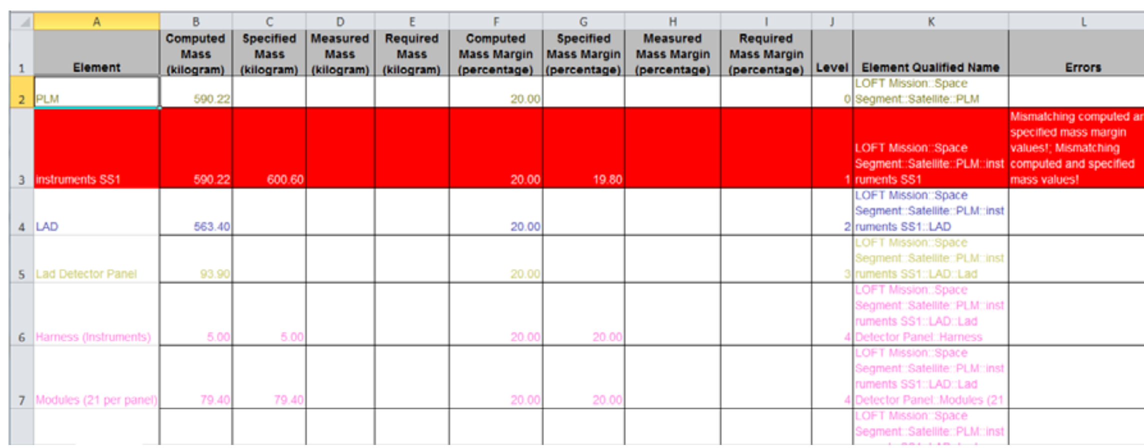


# Mass Budget - Output:

- Value aggregation along occurrence tree
- Dynamic HTML tree-table:
  - Expand/Collapse all nodes
  - Errors visible for expanded nodes
  - Column filtering
- Fixed Layout (non-HTML):
  - Based on table
  - Hierarchy through: coloring, level, qualified name



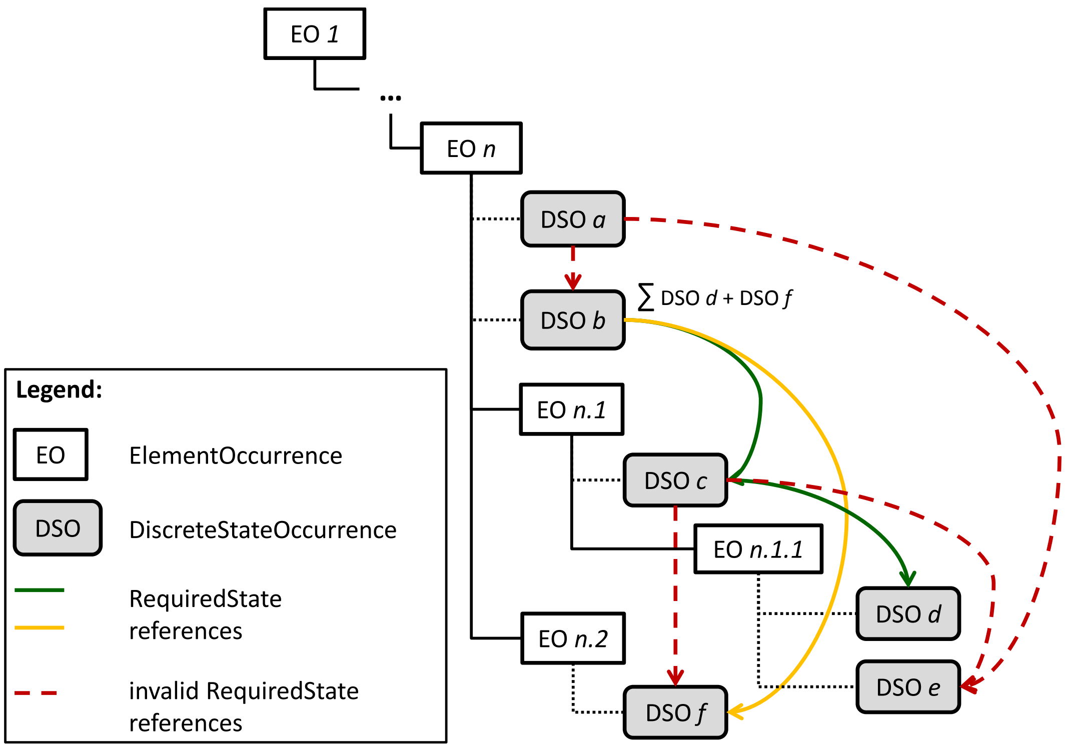

| | Element | Computed Mass (kilogram) | Specified Mass (kilogram) | Measured Mass (kilogram) | Required Mass (kilogram) | Computed Mass Margin (percentage) | Specified Mass Margin (percentage) | Measured Mass Margin (percentage) | Required Mass Margin (percentage) | Level | Qualified Name | Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PLM | 590.22 | | | | 20 | | | | 0 | LOFT Mission::Space Segment::Satellite::PLM | |
| 1.1 | instruments SS1 | 590.22 | 600.6 | | | 20 | 19.8 | | | 1 | LOFT Mission::Space Segment::Satellite::PLM::instruments SS1 | Mismatching computed and specified mass margin values!; Mismatching computed and specified mass values! |
| 1.1.1 | LAD | 563.4 | | | | 20 | | | | 2 | LOFT Mission::Space Segment::Satellite::PLM::instruments SS1::LAD | |
| 1.1.1.1 | Lad Detector Panel | 93.9 | | | | 20 | | | | 3 | LOFT Mission::Space Segment::Satellite::PLM::instruments SS1::LAD::Lad Detector Panel | |
| 1.1.1.1.1 | Harness (Instruments) | 5 | 5 | | | 20 | 20 | | | 4 | LOFT Mission::Space Segment::Satellite::PLM::instruments SS1::LAD::Lad Detector Panel::Harness (Instruments) | |
| 1.1.1.1.2 | Modules (21 per panel) | 79.4 | 79.4 | | | 20 | 20 | | | 4 | LOFT Mission::Space Segment::Satellite::PLM::instruments SS1::LAD::Lad Detector Panel::Modules (21 per panel) | |



| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Element | Computed Mass (kilogram) | Specified Mass (kilogram) | Measured Mass (kilogram) | Required Mass (kilogram) | Computed Mass Margin (percentage) | Specified Mass Margin (percentage) | Measured Mass Margin (percentage) | Required Mass Margin (percentage) | Level | Element Qualified Name | Errors |
| 2 | PLM | 590.22 | | | | 20.00 | | | | 0 | LOFT Mission::Space Segment::Satellite::PLM | |
| 3 | instruments SS1 | 590.22 | 600.60 | | | 20.00 | 19.80 | | | 1 | LOFT Mission::Space Segment::Satellite::PLM::instruments SS1 | Mismatching computed and specified mass margin values!; Mismatching computed and specified mass values! |
| 4 | LAD | 563.40 | | | | 20.00 | | | | 2 | LOFT Mission::Space Segment::Satellite::PLM::instruments SS1::LAD | |
| 5 | Lad Detector Panel | 93.90 | | | | 20.00 | | | | 3 | LOFT Mission::Space Segment::Satellite::PLM::instruments SS1::LAD::Lad | |
| 6 | Harness (Instruments) | 5.00 | 5.00 | | | 20.00 | 20.00 | | | 4 | LOFT Mission::Space Segment::Satellite::PLM::instruments SS1::LAD::Lad Detector Panel::Harness | |
| 7 | Modules (21 per panel) | 79.40 | 79.40 | | | 20.00 | 20.00 | | | 4 | LOFT Mission::Space Segment::Satellite::PLM::instruments SS1::LAD::Lad Detector Panel::Modules (21 | |
| | | | | | | | | | | | LOFT Mission::Space Segment::Satellite::PLM::inst | |

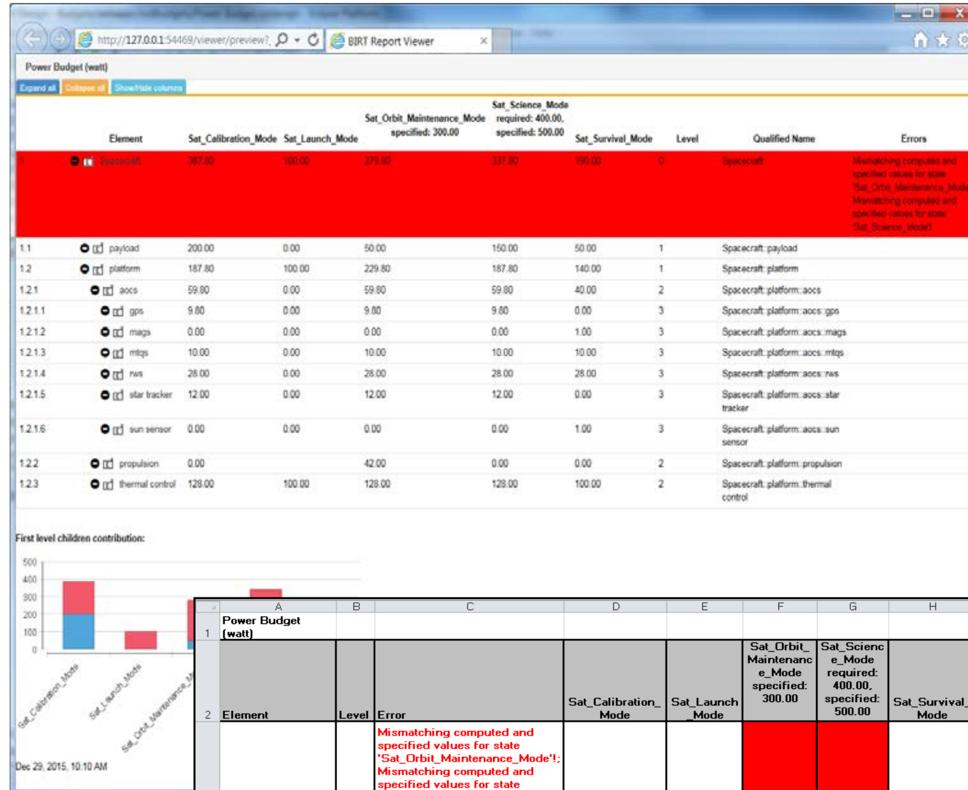
## Power & Data Link Budget - Modelling:

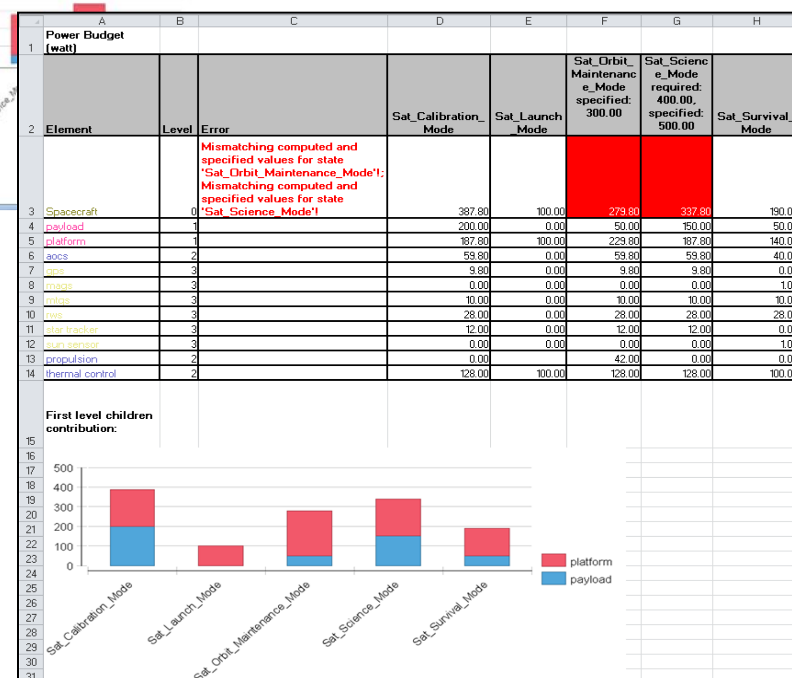
- Implicit product structure:
  - Modelling of DiscreteStateDefinitions
  - ValuePropertyValues expected in ‘leaf’ states in a required states hierarhy
- Explicit product structure:
  - Explicit modelling of RequiredState relationships – only possible on occurrence level with multiplication of efforts!



# Power & Data Link Budget - Output:

- Value aggregation along required states tree for states of selected root element
- Chart of direct root child element contributions to root state values
- Dynamic HTML tree-table:
  - Expand/Collapse all nodes
  - Errors visible for expanded nodes
  - Column filtering
- Fixed Layout (non-HTML):
  - Based on cross-tab
  - Hierarchy through: coloring and level



| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | Power Budget (watt) | | | | | | | |
| 2 | Element | Level | Error | Sat_Calibration_Mode | Sat_Launch_Mode | Sat_Orbit_Maintenance_Mode specified: 300.00 | Sat_Science_Mode required: 400.00, specified: 500.00 | Sat_Survival_Mode |
| 3 | Spacecraft | 0 | Mismatching computed and specified values for state 'Sat_Orbit_Maintenance_Mode'!; Mismatching computed and specified values for state 'Sat_Science_Mode'! | 387.80 | 100.00 | 279.80 | 337.80 | 190.00 |
| 4 | payload | 1 | | 200.00 | 0.00 | 50.00 | 150.00 | 50.00 |
| 5 | platform | 1 | | 187.80 | 100.00 | 229.80 | 187.80 | 140.00 |
| 6 | aocs | 2 | | 59.80 | 0.00 | 59.80 | 59.80 | 40.00 |
| 7 | gps | 3 | | 9.80 | 0.00 | 9.80 | 9.80 | 0.00 |
| 8 | mags | 3 | | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| 9 | mtqs | 3 | | 10.00 | 0.00 | 10.00 | 10.00 | 10.00 |
| 10 | rws | 3 | | 28.00 | 0.00 | 28.00 | 28.00 | 28.00 |
| 11 | star tracker | 3 | | 12.00 | 0.00 | 12.00 | 12.00 | 0.00 |
| 12 | sun sensor | 3 | | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| 13 | propulsion | 2 | | 0.00 | | 42.00 | 0.00 | 0.00 |
| 14 | thermal control | 2 | | 128.00 | 100.00 | 128.00 | 128.00 | 100.00 |
| 15 | First level children contribution: | | | | | | | |

## Annotation Reports:

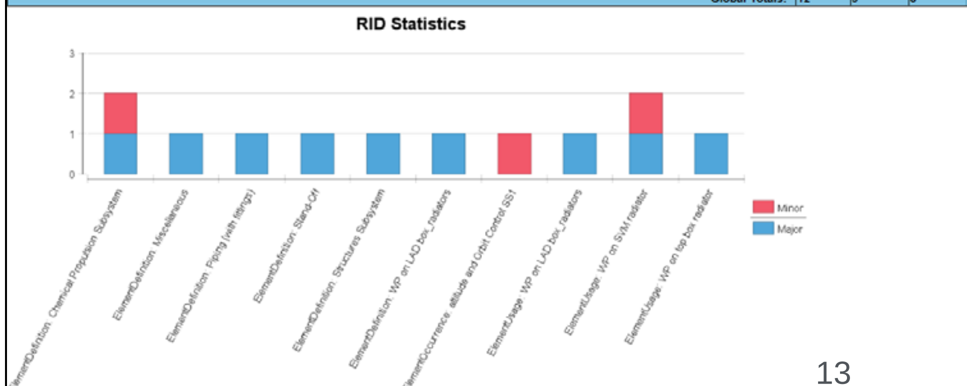
- Supported for all kind of Annotations on: ElementDefinition, ElementUsage, ElementOccurrence
- Element-centric: show how many elements are annotated through a given kind of annotation, not how many annotations there are (single annotation assigned to 3 elements counted 3 times)
- Summary report for all annotations and all elements
- Detailed report for selected annotation kind(s)

**Annotations Summary:**

| Element Type | Element Qualified Name | Annotation Type | Annotation Name | Annotation Title | Annotation Classification | Annotation Description |
|---|---|---|---|---|---|---|
| ElementDefinition | | | | | | |
| | *10 layers MLI on tower* | | | | | |
| | | CR | | | | |
| | | | | | minor | CR test 3 |
| | | | | | major | CR test 1 |
| | *Total CR's:* | *2* | *major: 1* | | *minor: 1* | |
| | | NCR | | | | |
| | | | | | minor | NCR test 3 |
| | | | | | major | NCR test 1 |
| | *Total NCR's:* | *2* | *major: 1* | | *minor: 1* | |
| | | PR | | | | |
| | | | | | minor | PR test 3 |
| | | | | | major | PR test 1 |
| | *Total PR's:* | *2* | *major: 1* | | *minor: 1* | |
| | | RFD | | | | |
| | | | | | major | RFD test 1 |
| | | | | | minor | RFD test 3 |
| | *Total RFD's:* | *2* | *major: 1* | | *minor: 1* | |
| | | RFW | | | | |
| | | | | | minor | RFW test 3 |
| | | | | | major | RFW test 1 |
| | *Total RFW's:* | *2* | *major: 1* | | *minor: 1* | |
| | | SPR | | | | |
| | | | | | major | SPR test 1 |
| | | | | | minor | SPR test 3 |
| | *Total SPR's:* | *2* | *major: 1* | | *minor: 1* | |
| | ***Total element Annotations:*** | ***12*** | ***major: 6*** | | ***minor: 6*** | |

**RID Statistics:**

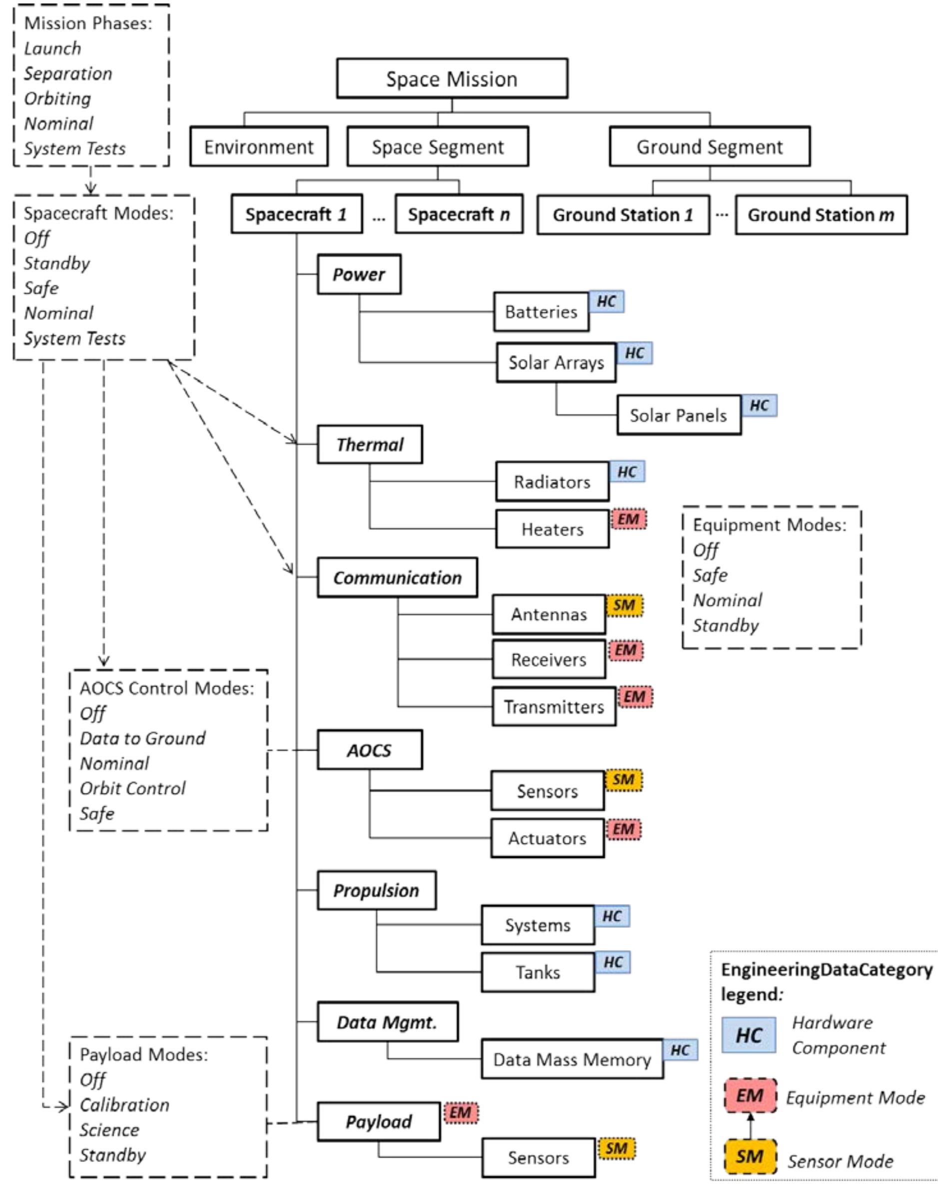
| Element Type | Element Qualified Name | Total | Major | Minor |
|---|---|---|---|---|
| ElementDefinition | | | | |
| | Chemical Propulsion Subsystem | 2 | 1 | 1 |
| | Miscellaneous | 1 | 1 | 0 |
| | Piping (with fittings) | 1 | 1 | 0 |
| | Stand-Off | 1 | 1 | 0 |
| | Structures Subsystem | 1 | 1 | 0 |
| | WP on LAD box_radiators | 1 | 1 | 0 |
| | **ElementDefinition Totals:** | **7** | **6** | **1** |
| ElementOccurrence | | | | |
| | LOFT Mission::Space Segment::Satellite::SVM::attitude and Orbit Control SS1 | 1 | 0 | 1 |
| | **ElementOccurrence Totals:** | **1** | **0** | **1** |
| ElementUsage | | | | |
| | Satellite::WP on LAD box_radiators | 1 | 1 | 0 |
| | Satellite::WP on SVM radiator | 2 | 1 | 1 |
| | Satellite::WP on top box radiator | 1 | 1 | 0 |
| | **ElementUsage Totals:** | **4** | **3** | **1** |
| | **Global Totals:** | **12** | **9** | **3** |



# DEMO

## Modelling for Component Libraries:

- Sample model based on SimVis, CDF models (LOFT), VSEE models (GravitySat_v12)
- Focus on implicit product structure including state definitions, categories and associated value properties
- Generic EngineeringDataCategory for (budget) computations:
  - Hardware: mass
  - Equipment (defines states): power, data link
  - Sensor (extends Equipment, defines pointing)



## Summary

- Implementation of data exchange between OCDT and VSEE available in both directions
- Technical budgets developed and validated with a number of models from CDF and VSD
- Annotation reports developed for basic annotations reporting
- Component library prototype model developed to aid further development of library functionality in the SSDE

## Next Steps

- Consolidate the system engineering meta-models and frameworks towards enabling end-to-end, model-based engineering approaches across all mission phases
- Develop consolidated tooling infrastructure, enabling seamless modelling, tailored to a given mission phase
- Focus on usability and usefulness to ensure adoption by system engineers without knowledge of formal modelling languages and frameworks

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