Simulation-based System Engineering in the Virtual Satellite Project

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Overview

- Goals of the Virtual Satellite project
- Requirements for Data Exchange
- Realization in the Virtual Satellite project
- Conclusions
Goals of the Virtual Satellite project

- Consistent system model in the engineering process
  - Across the space project phases defined in ECSS
  - Across the engineering domains (Thermal, Electric, Propulsion, ...)
- Early analysis of spacecraft design in dynamic mission scenarios
- Early test of control algorithm with the virtual spacecraft model
- Collect enterprise knowledge on systems, components, units and parts
  - Conserved in dynamic or static simulation models
  - Enhanced with performance data collected in real missions
  - To be reused in follow-on projects
- Basis for reuse strategy in the space system design process
Classification in ECSS process

CDF

Virtual Satellite

Phase 0 Phase A Phase B Phase C Phase D Phase E Phase F
Requirements for product data exchange

1. Tool-independent process
2. System design based on a consistent central data model
3. Semantic linkage within the system component library
System Engineering Process

- Three main parts
  - Modeling and Simulation
  - Analysis
  - Optimization

- Define system models and derived options in an iterative process

- Decision on design changes based on review by domain experts
Modeling

Simulation Modeling

Integration

- system components
- system design model
- refine in each phase
- model parameter
- data exchange
- system component library
System Component Library

- Hierarchical structure, from entire spacecraft models to components
  - entire spacecraft models
  - spacecraft subsystems
    - For example a wheel torquer arrangement
  - previously used components
    - Usage Information
    - Sources
    - Reliability Data
    - Alerts
- Model browser: Look-up existing models / create new models
- Spacecraft ontology
  - Definitions of terms and associations
System Component Library (cont.)

- Construction kit for preliminary system designs
  - Provide SysML representation of
    - Components
    - Subsystems
    - Spacecraft designs
  - Meta-models

- Library for simulation know-how
  - Preserve simulation model binary or source codes
    - Parameterizations
    - Model interfaces (Ports)
    - Configurations
Transformation

Simulation Modeling

Transformation

- system design model
- system simulation

- model parameter
- simulation results

- data exchange
- data parking
Model Transformations

- Into integrated design model (IDM)
  - import and export

- Into executable simulation codes
  - Sources
    - Platform specific (Modelica, Matlab, C-Sources, etc.)
    - System model in SysML
    - Simulation codes/binaries from system component library
    - Parameterization

- Data extraction for domain-specific simulation with third-party tools
  (thermal, electric, kinematics, etc.)
Simulation and Analysis

Simulation Modeling

Integration

Transformation

automatic test environment

system simulation

evaluation results

data parking

simulation & analysis environment

mission scenarios
Consistent System Model

- Data exchange during collaboration
  - Consistent model parameter set
  - Notification of data and model changes

- Ensure model quality
  - Definition of meta models
  - Modeling rules
  - Model checking
Concurring Engineering Facility (CEF)

- Similar equipment as in Concurrent Design Facility (CDF)
- Located at DLR Institute of Aerospace Systems (Bremen)

Purpose
- Development of mission scenarios
- System design studies
- Analysis of system design in mission scenarios
  - Static view
  - Dynamic view
Conclusions

- Knowledge management system for spacecraft technology
  - Data base of typical components
  - Reuse of proven subsystem and spacecraft designs
  - Preservation of engineering experiences
  - Management of alerts among different space missions with reused components

- Dynamic simulation early in the development process
  - Detect system inconsistencies early
  - Minimize risk
  - Shorten development time and save costs
Thank you for your attention