2021 Annual INCOSE international workshop
Virtual Event
January 29 - 31, 2021
Premier Systems Engineering Workshop

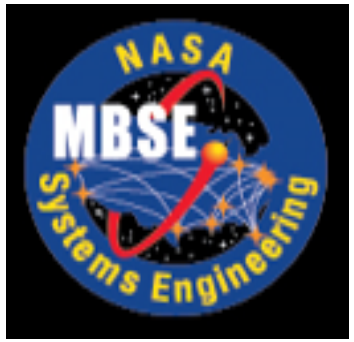
Samantha Infeld, AMA Inc. and Taekyoo Won, UC Irvine

Grab-and-Go MBSE for Smallsats

MBSE Lightning Round

www.incose.org/iw2021/

MBSE at NASA and the EDS MBSE Template



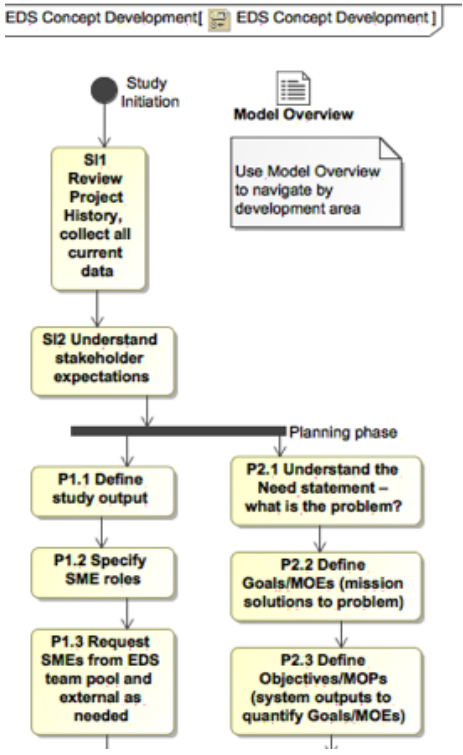
- Making systems engineering easier for the workforce
- NASA MBSE Infusion And Modernization Initiative (MIAMI) 2016-2020 and the on-going MBSE Community of Practice

- Engineering Design Studio, NASA Langley Research Center (LaRC)
- Tech development plan for collaboration and system modeling
- AR/VR, Office 365 environment, SysML

MBSE Lightning Round

Motivation for an EDS MBSE Template

- Short-term nature of EDS studies calls for a **structured environment**, **repeatable processes**, and **common products**
- Incorporate modeling ideas and examples from studies into a **re-usable template**
- Follow the **general structure** of a flight project organization, with space-based example diagrams and tables linked from each starter artifact
- Assistance and consistency for **navigation and tracking** of the study (separate easily removable EDS package) and then the flight project
- Support a **consistent EDS process** and **successful systems engineering** throughout a project's life
- **Post-study usability** in the transition to project systems engineers



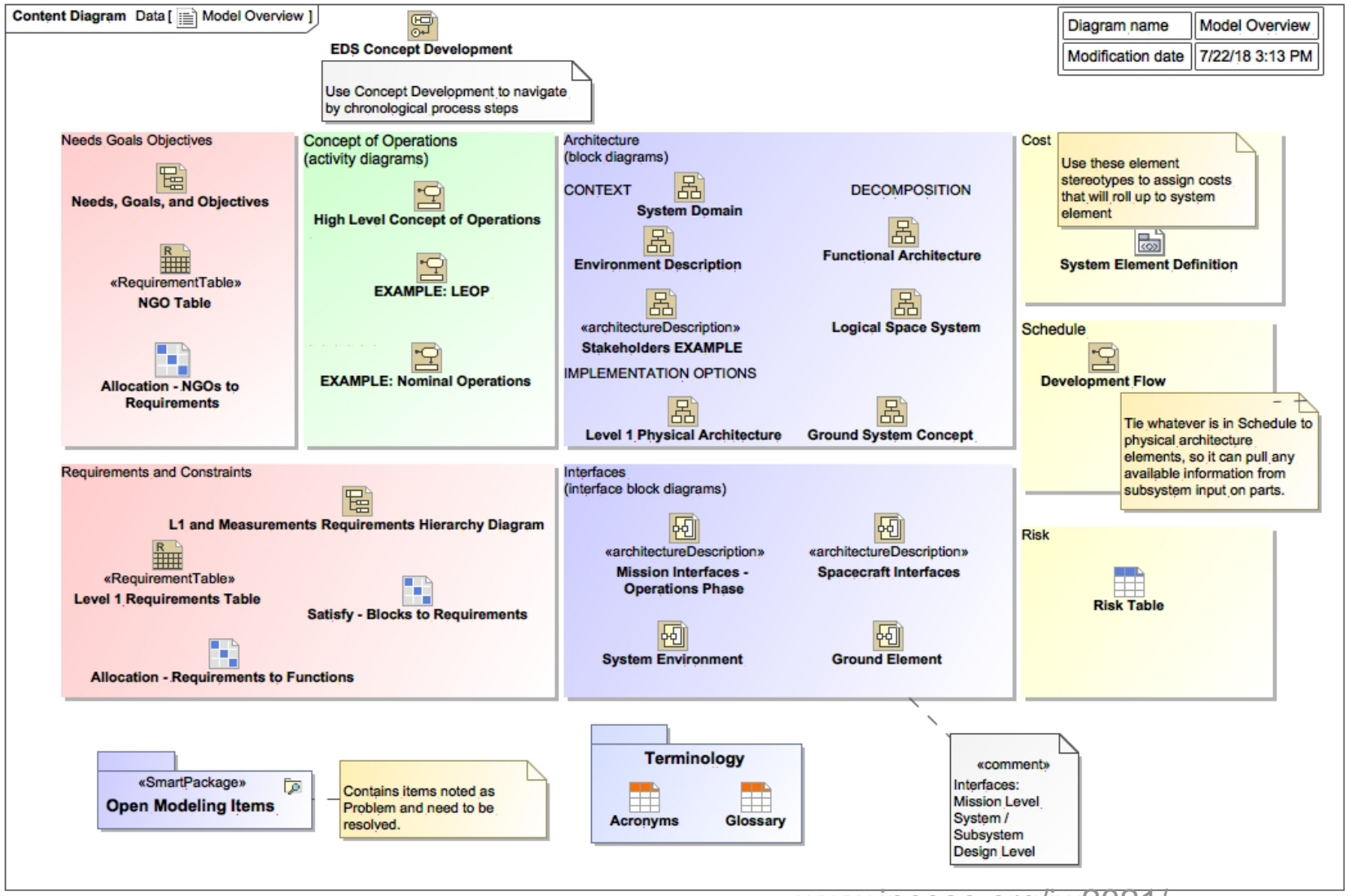
MBSE Lightning Round

Smallsat MBSE Template

- Needs
  - a simple, accessible MBSE template and available libraries for **rapid prototyping** and transitioning models into **flight project development.**
  - rigorous, trackable **System Engineering support** for growing number of CubeSat projects
- Goals
  - **validate MBSE use** in EDS and projects
  - provide **direction for MBSE resources**
  - enhance capability to **rapidly reconfigure** in additional variables
  - plug into emerging **standardized smallsat model**
    - Cubesat System Reference Model (CSRM), from INCOSE Space Systems Working Group
  - ease use of a smallsat modeling plug-in out of a NASA SBIR (Orbital Transport's METIS)
  - make the template **ready for smoother regular use** by smallsat community

MBSE Lightning Round

LaRC Small Satellite Template Overview



Content diagram for navigation while adding content

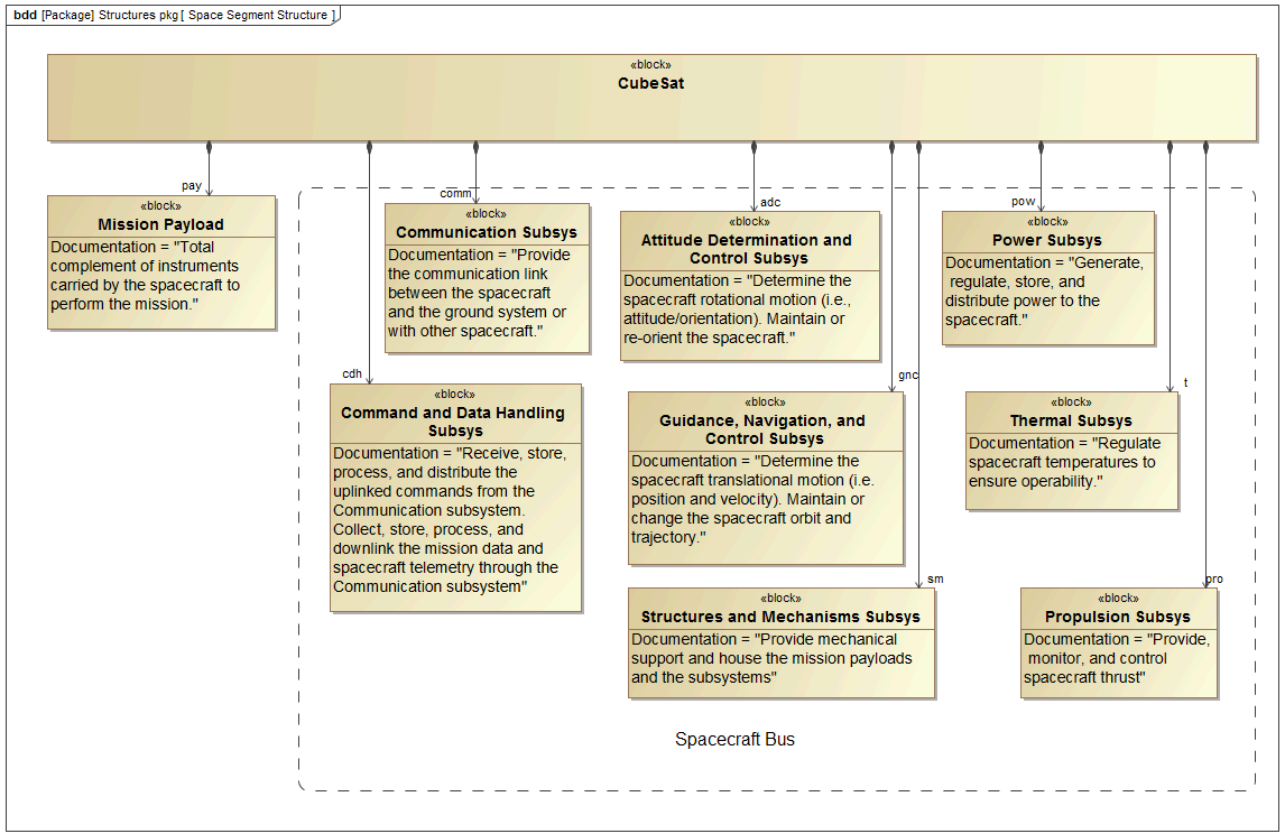
review and navigate the system by the major areas of concept development to ensure appropriate work is completed in each

update if diagrams/tables are added or deleted

MBSE Lightning Round

Integrated with the CSRM structure

- CubeSat System Reference Model
  - 0 – CSRM Overview and Navigation – xsc pkg
  - 1 – Stakeholder pkg
  - 2 – Technical Measures pkg
  - 3 – Behaviors – xsc pkg
    - Activities – Population – xsc
    - Behaviors – Population – xsc
    - Behaviors – Use Cases – Activities – Population – xsc
    - Use Cases – Population – xsc
    - Hyperlinks
  - 4 – Requirements pkg
  - 5 – Architecture pkg
    - Facilities
    - L0_Domain pkg
    - L1_Enterprise pkg
    - L2_Segment pkg
    - L3_Subsystems pkg
    - L4_Components pkg
    - Architecture Hierarchy
    - Hyperlinks
  - 6 – Data Models – xec pkg
  - 7 – Validation Verification pkg
  - 8 – CSRM Elements and Population pkg
  - 9 – CubeSat Reference Information – xsc pkg
  - 10 – Background – xsc pkg

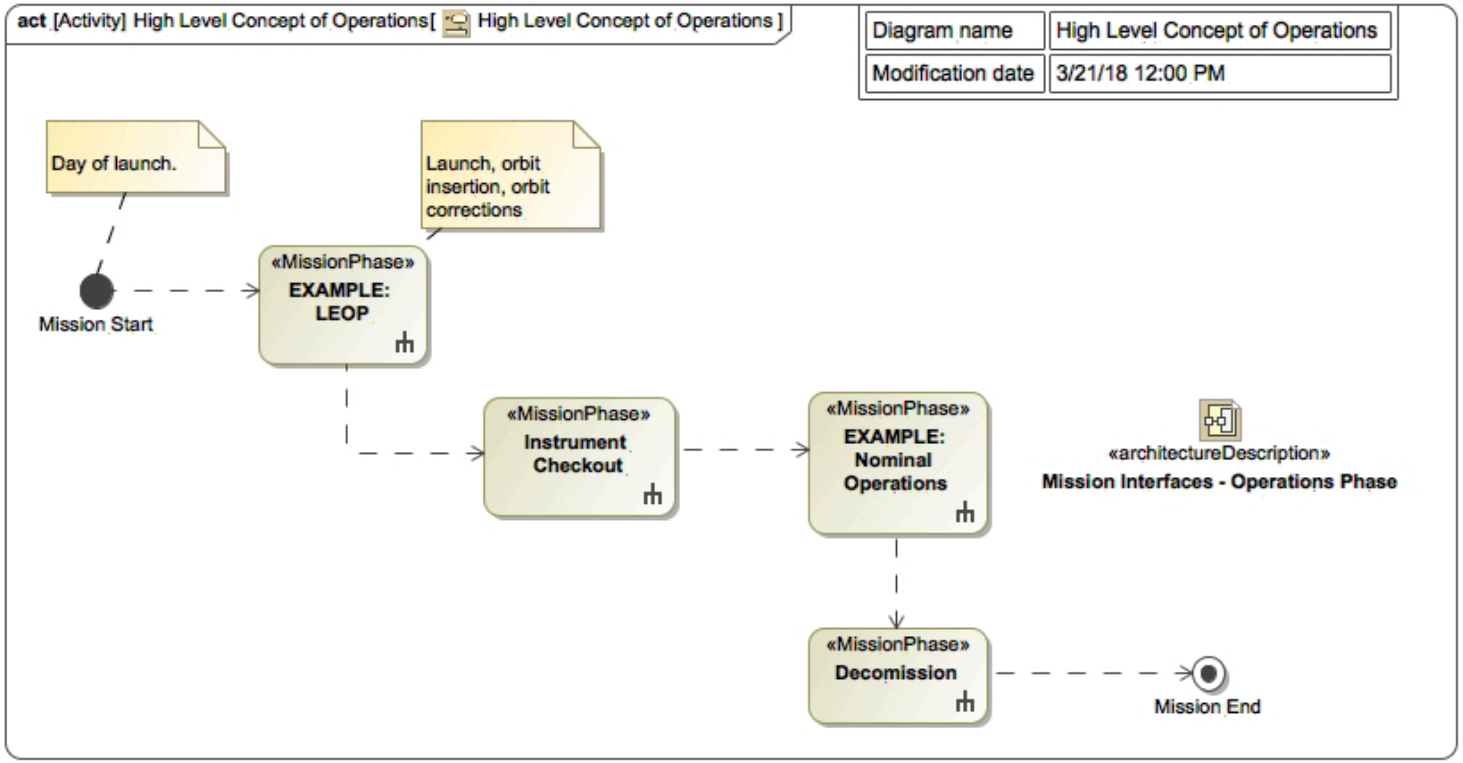


- starter diagrams contain elements placed in the correct place of CSRM
- links to the population information in the CSRM
- tailor, or find them in the model and create new elements in the same way

MBSE Lightning Round

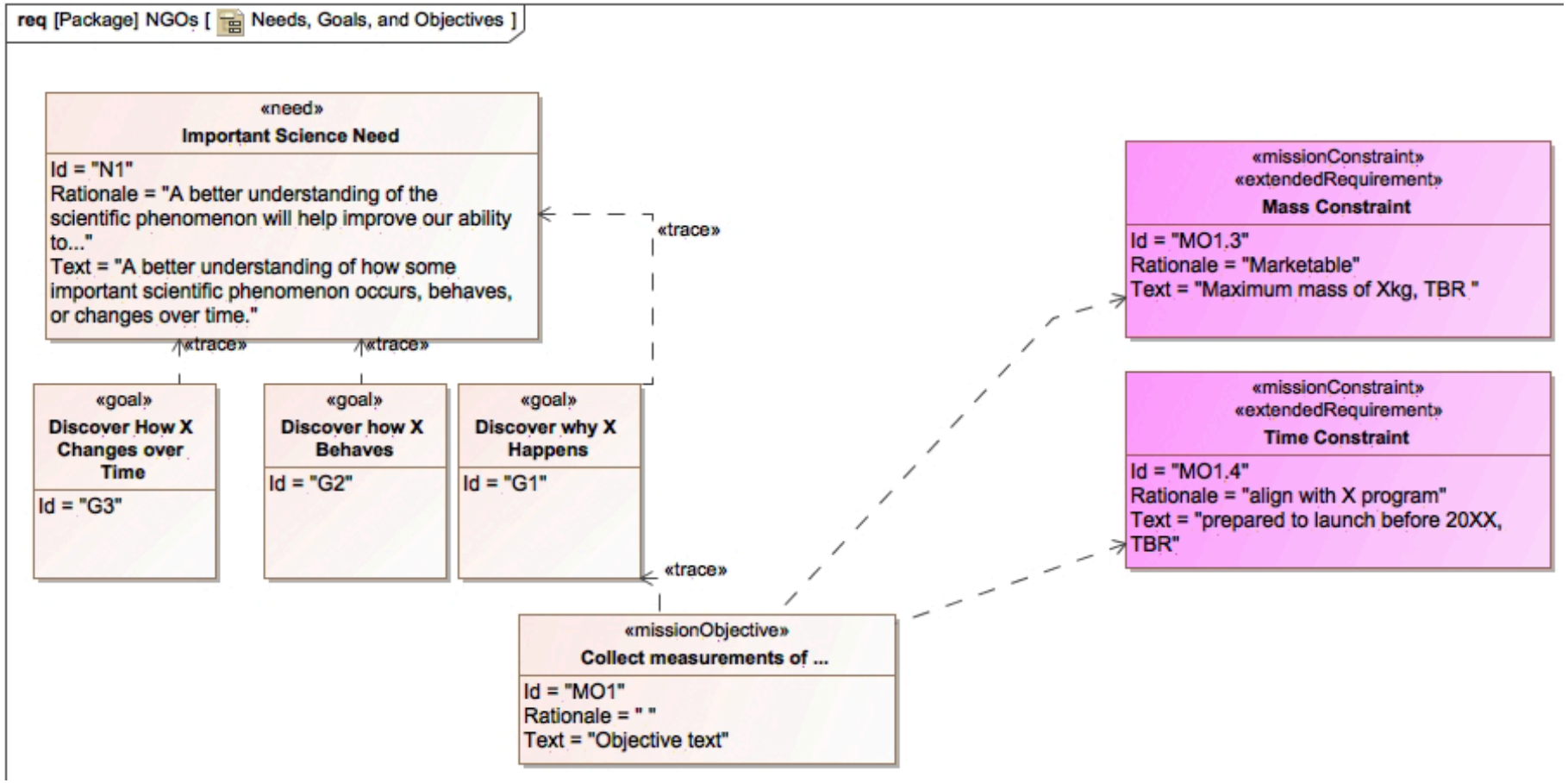
Example starter diagrams – ConOps

- 5 – Architecture pkg
  - Facilities
  - L0_Domain pkg
  - L1_Enterprise pkg
    - L1.1_Behaviors pkg
      - L1.1.1_Enterprise Behaviors pkg
      - L1.1.2_Enterprise Use Cases pkg
      - L1.1.3_Enterprise Activities pkg
        - Collect and Distribute Mission Data – Activity pkg
        - Enterprise Activity A
        - Enterprise Activity Name
        - Mission Life Overview
          - GENERIC: High Level Concept of Operations
            - Relations
            - GENERIC: High Level Concept of Operations
            - Mission End
            - System Delivery
            - AI&T
            - :GENERIC: Nominal Operations
            - Build & Acquire
            - Decomission:Decomission
            - Design
            - Instrument Checkout:Instrument Checkout
            - LEOP:GENERIC: LEOP
            - Development Start
            - Mission Start



MBSE Lightning Round

Example starter diagrams – Needs, Goals, Objectives



MBSE Lightning Round

LaRC SmallSat Template User's Guide

- Guides user through each aspect of concept development as shown on Content Diagram
  - Needs Goals and Objectives
  - Concept of Operations
  - Architecture
  - Requirements and Constraints
  - Interfaces

Needs, Goals, Objectives

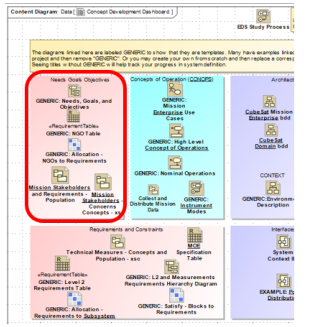
Needs, Goals, and Objectives: A graphical representation of all NGOs and their flowdowns/derivations; needs derive from goals which derive from objectives, good for showing trace relationships

NGO Table: A tabular representation of all NGOs

Allocation – NGOs to Requirements: A matrix style display of NGOs, showing segment requirements traced to mission objectives

Mission Stakeholders and Requirements – Population: Consolidation of all stakeholders, along with compilations of tables containing NGOs

Mission Stakeholders – Concerns Concepts: example diagram of how NGOs, constraints, concerns, requirements, and specifications derive from each other



Needs, Goals, Objectives

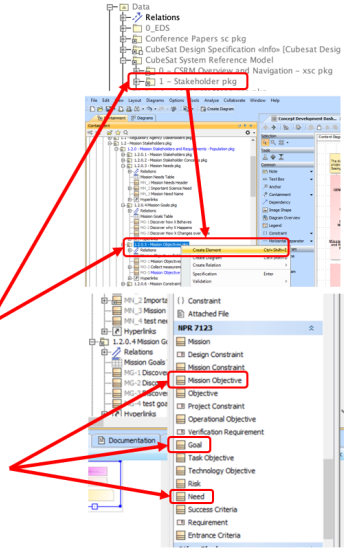
Mission Stakeholders and Requirements - Population:

- Objective: Overall missions (ex: "Collect measurements of…")
- Goal: How to accomplish the mission (ex: "Discover how X behaves…")
- Need: Required result of mission (ex: "Better understanding of how Y occurs, or how it behaves")

To add each NGO and ensure each is tracked with the correct identifier, it is most reliable to add each of the NGOs through creating an element through the package on the containment tree Mission Stakeholders and Requirements – Population package 1.2.0 in the corresponding sub-package. (pictured right)

- NGO table is automatically populated, but may need to be reorganized
- NGO diagram is not automatically populated; newly created components can be added by dragging and dropping from Containment Tree into the diagram

When adding an NGO, each element corresponds to Need, Goal, and Mission Objective respectively within the NPR 7213 section.

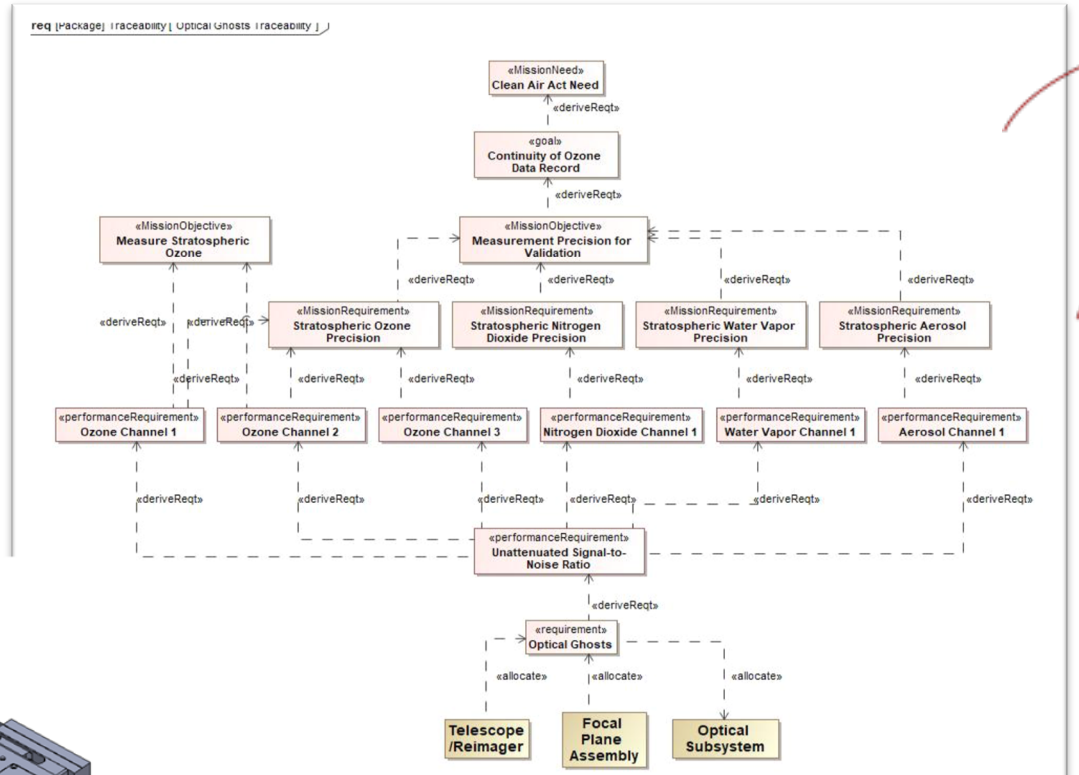


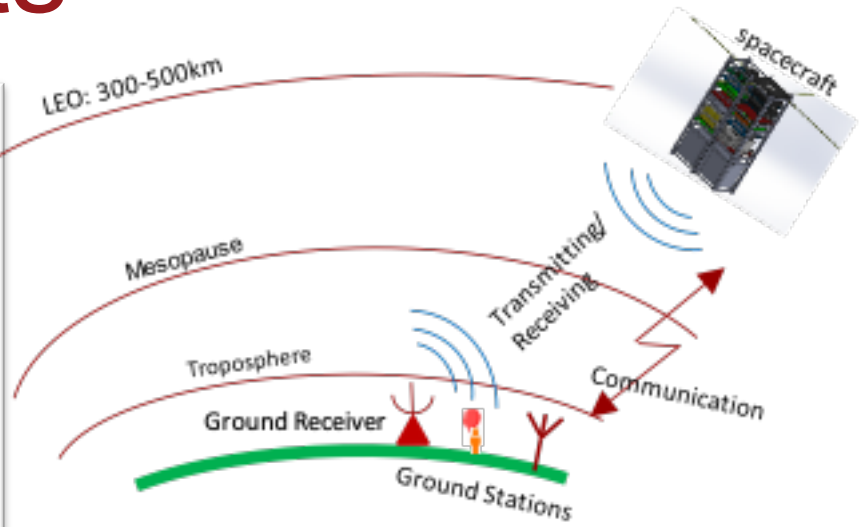
MBSE Lightning Round

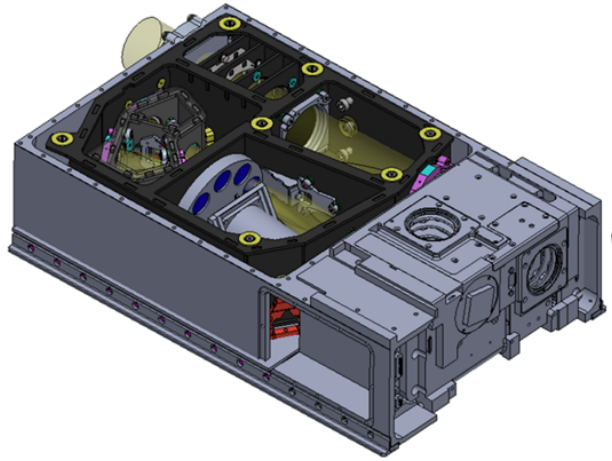
Testing with CubeSat projects

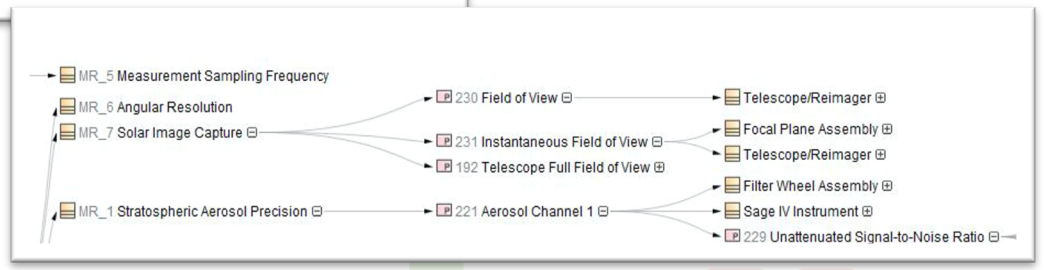
DiBAR

SAGE IV





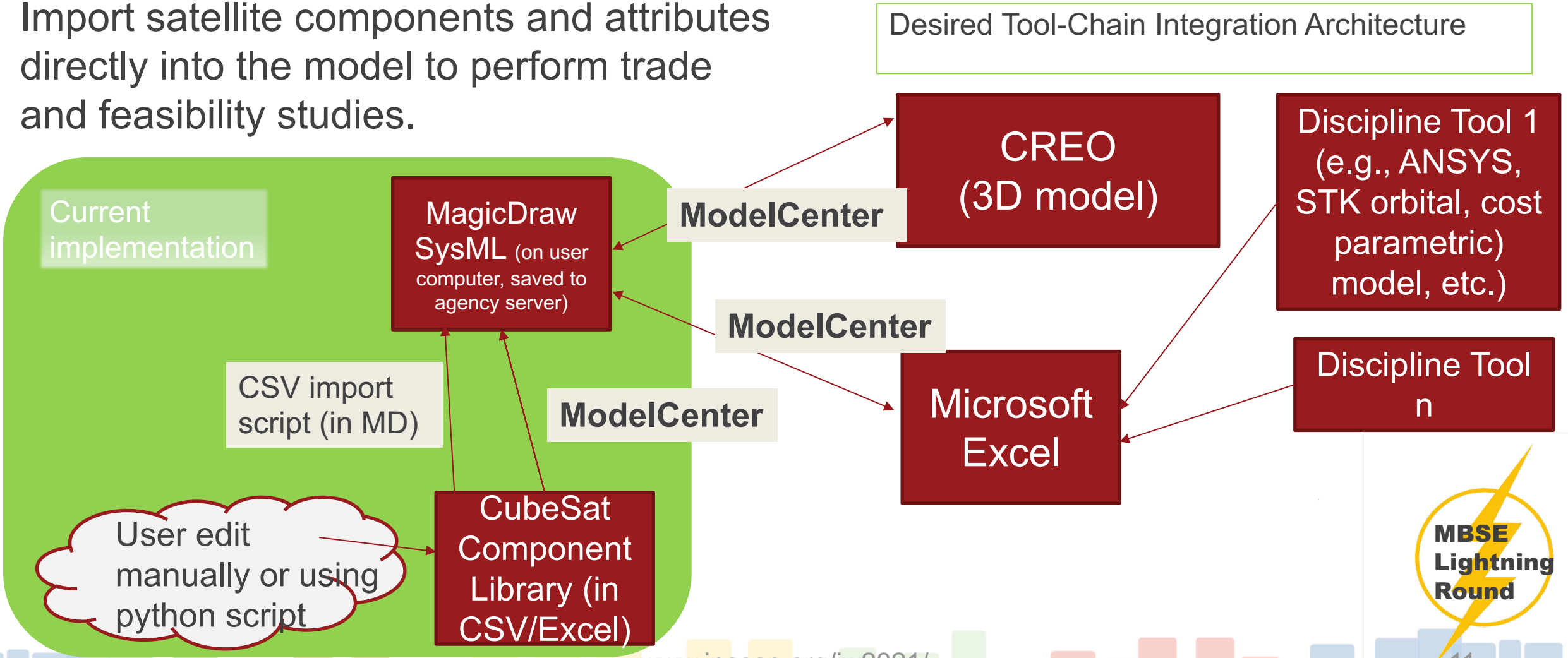




MBSE Lightning Round

Component Library

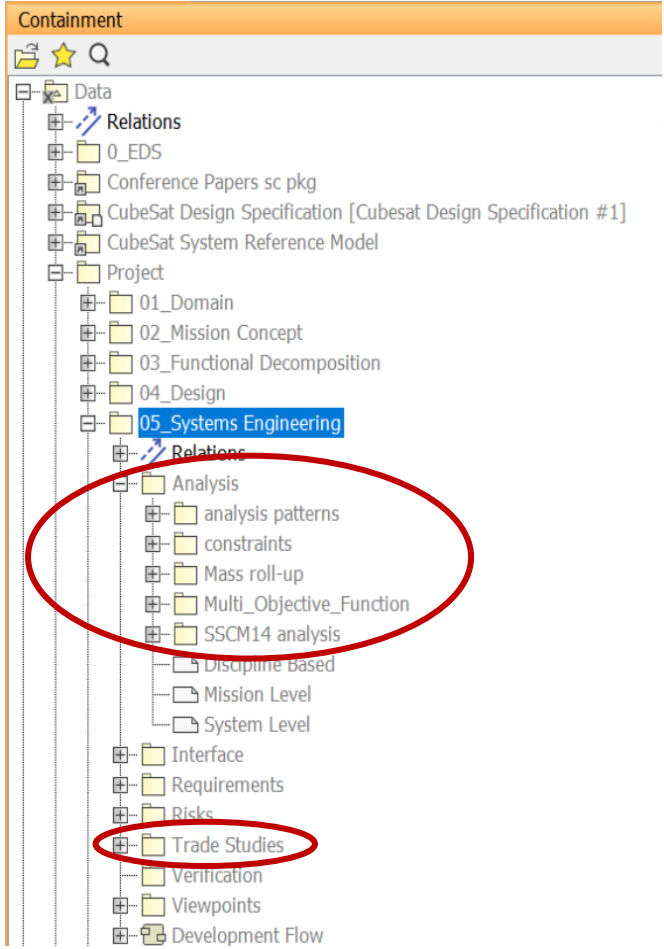
Import satellite components and attributes directly into the model to perform trade and feasibility studies.

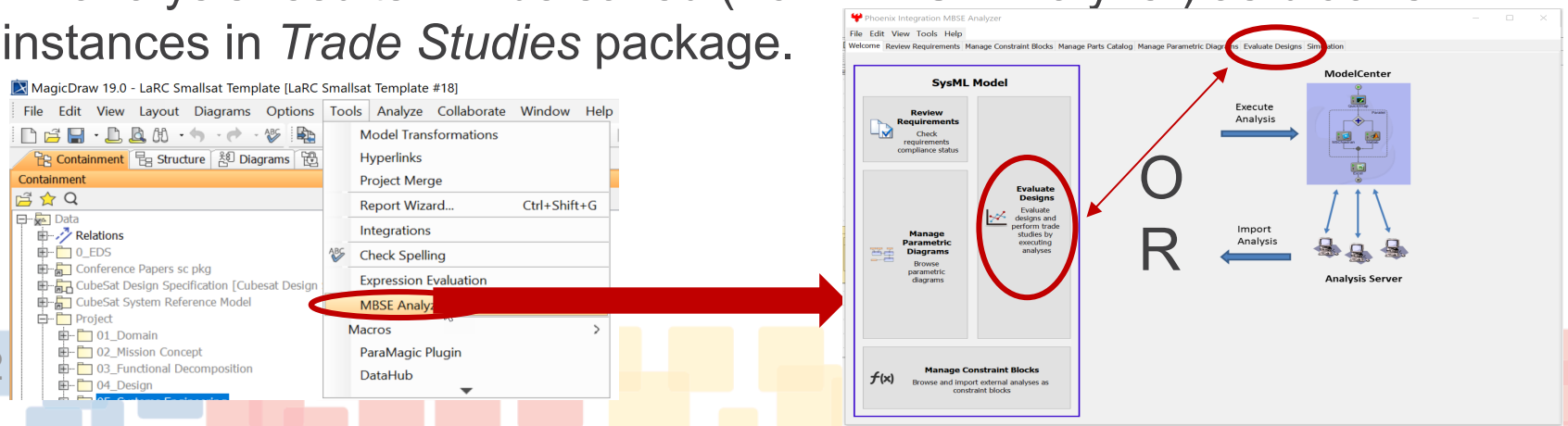


MBSE Lightning Round

Trade Studies with ModelCenter

- All generic analyses (mass and cost) are located in *Analysis* package
- Within the *Analysis* package there are options for analysis,
  - *Analysis patterns* – e.g. mass roll-up definition
  - *Constraints* – constraint blocks created through MBSEAnalyzer
  - *Mass roll-up* – mass analysis context
  - *SSCM14 analysis* – cost analysis context based on Aerospace's SmallSat Cost Model 2014 (SSCM14)
  - *Multi_Objective_Function* – combined mass and cost performance metrics into a composite equally weighted score.
- All analysis results will be saved (from MBSEAnalyzer) as block's instances in *Trade Studies* package.



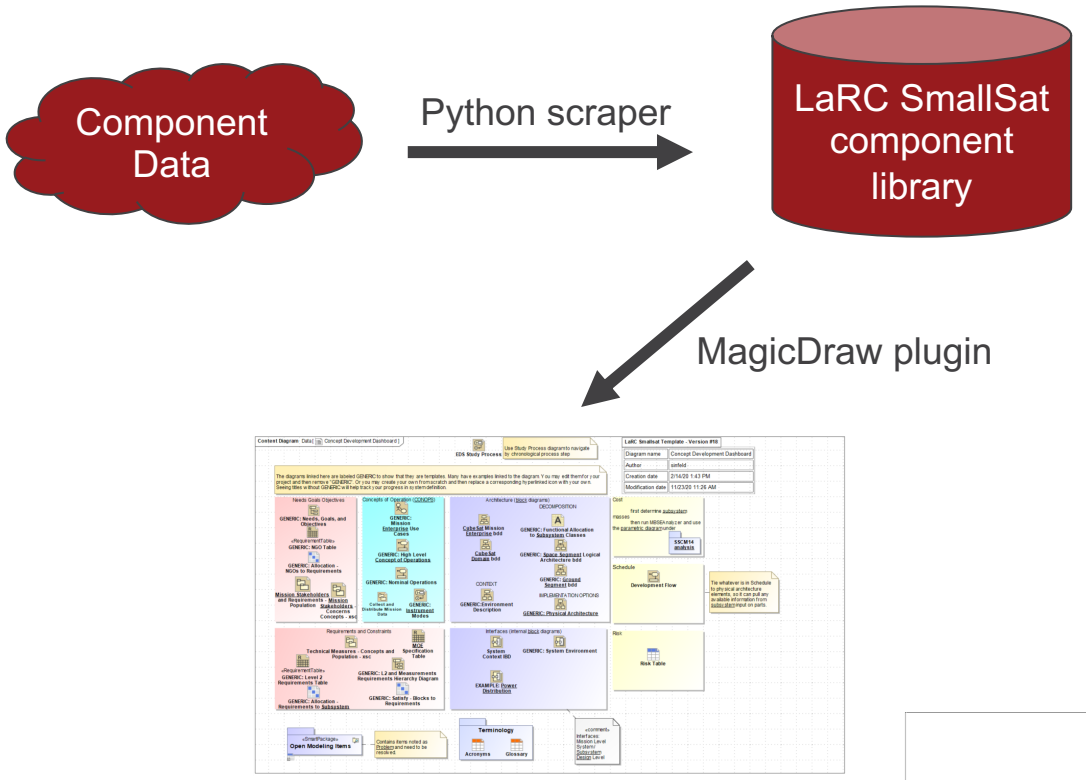


MBSE Lightning Round

12

Component Library Loading Current Work

- Development in Python to scrape data from satellite parts database (e.g. SPOON) and PDF spec sheets to directly populate into component library (Excel or SQL)
- SQL database of components to use with METIS Cameo plug-in (developed as SBIR) for loading components as instances; also based on CSRM
- METIS (Orbital Transports) will have some trade study presets too in future versions



MBSE Lightning Round

2021 Annual INCOSE international workshop
Virtual Event
January 29 - 31, 2021

Premier Systems Engineering Workshop

www.incose.org/iw2021/

MBSE Lightning Round