



PHOENIX INTEGRATION

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April 17 – 19, 2018

Annapolis, Maryland | USA



Distributed Model Based Systems Engineering

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Parsons

Agenda

- Purpose
- Distributed Engineering
- Model Based Systems Engineering Approach
- Demonstration Overview
- Demonstration Video
- Requirements Verification
- Summary

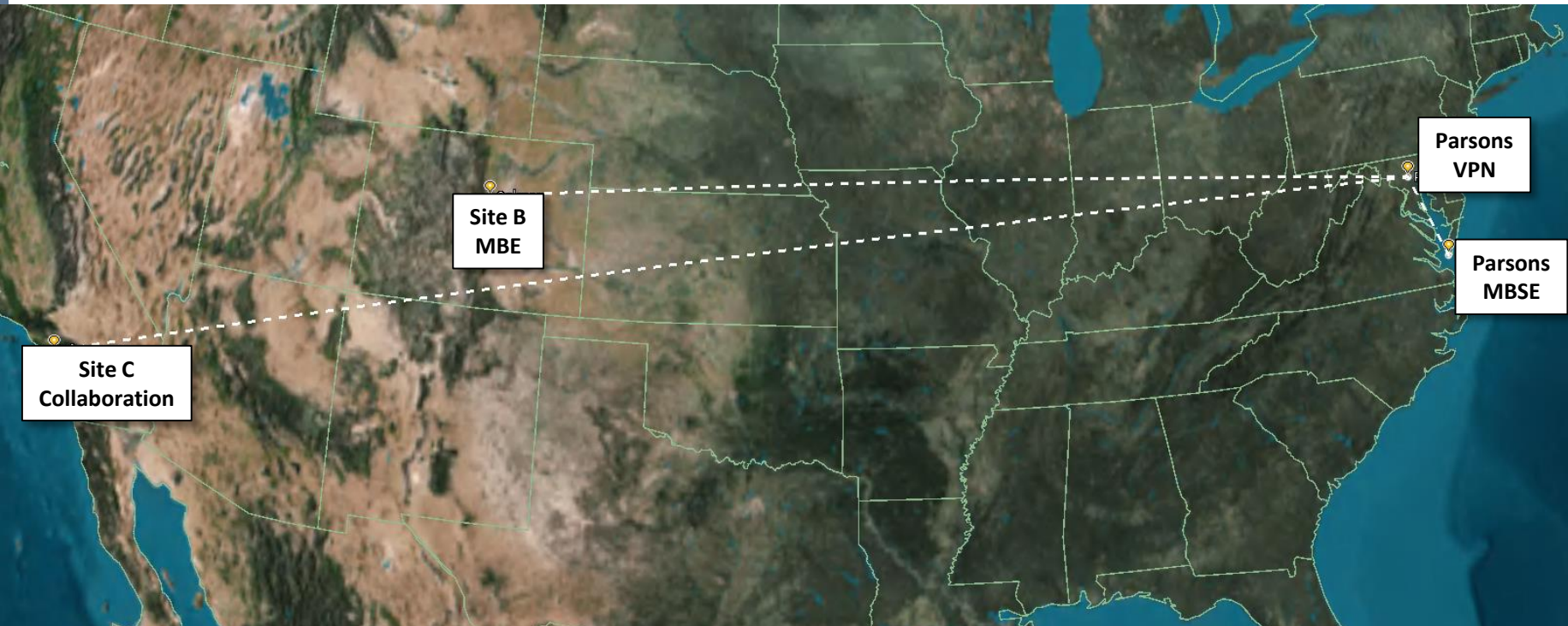
Purpose

- Provide a Demonstration of the Capabilities to Support an Integrated Approach to Satellite Design
- Demonstrate the Value of Model Based Systems Engineering, Distributed Engineering, and Model Based Engineering
- Highlight the Ability to Collaborate using a set of Common Environments to enable rapid responses to changing requirements

MBSE/MBE/DE Enable the Development, Management, and Evaluation of Complex Systems of Systems

Distributed Engineering

- Asynchronous Automated Performance Evaluation and Trade Study Capability from Any Place in the USA as Long as There is Internet Connectivity
- Data Protected via a Cloud Based Virtual Private Network (VPN)



Distributed Engineering – Effective Use of Simulations and Subject Matter Experts on a Protected Network

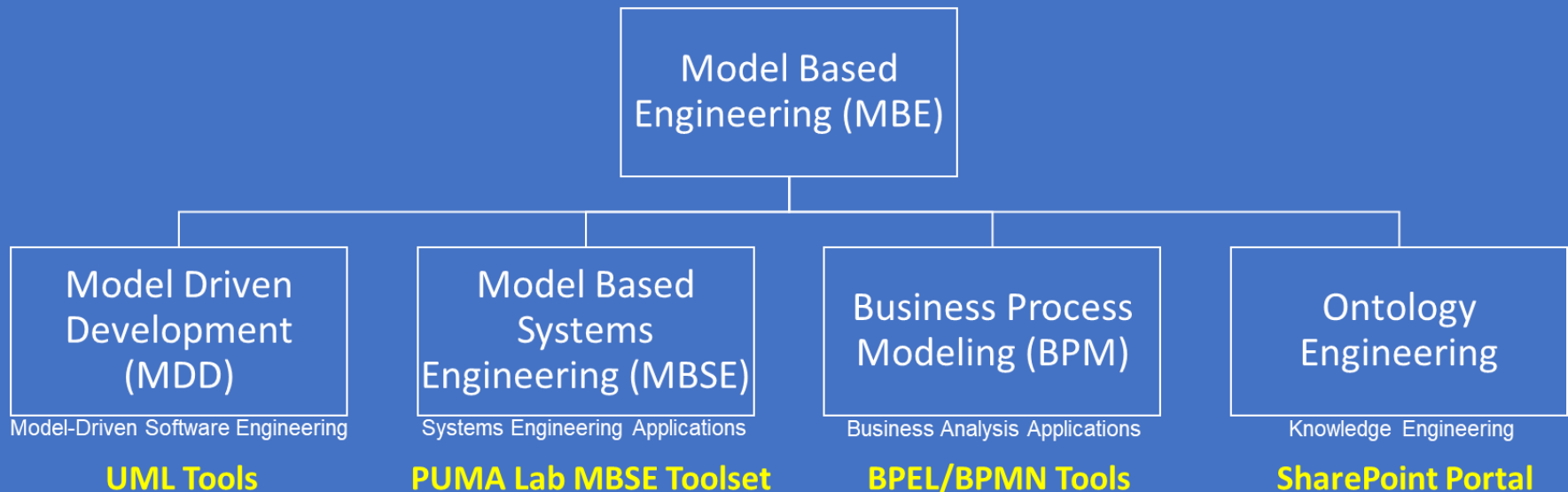
Model Based Engineering Approach

- Model Based Approach
- Wide Range of Applications
- Supports and Enables Modernization

PUMA Lab Model Based Engineering Architecture

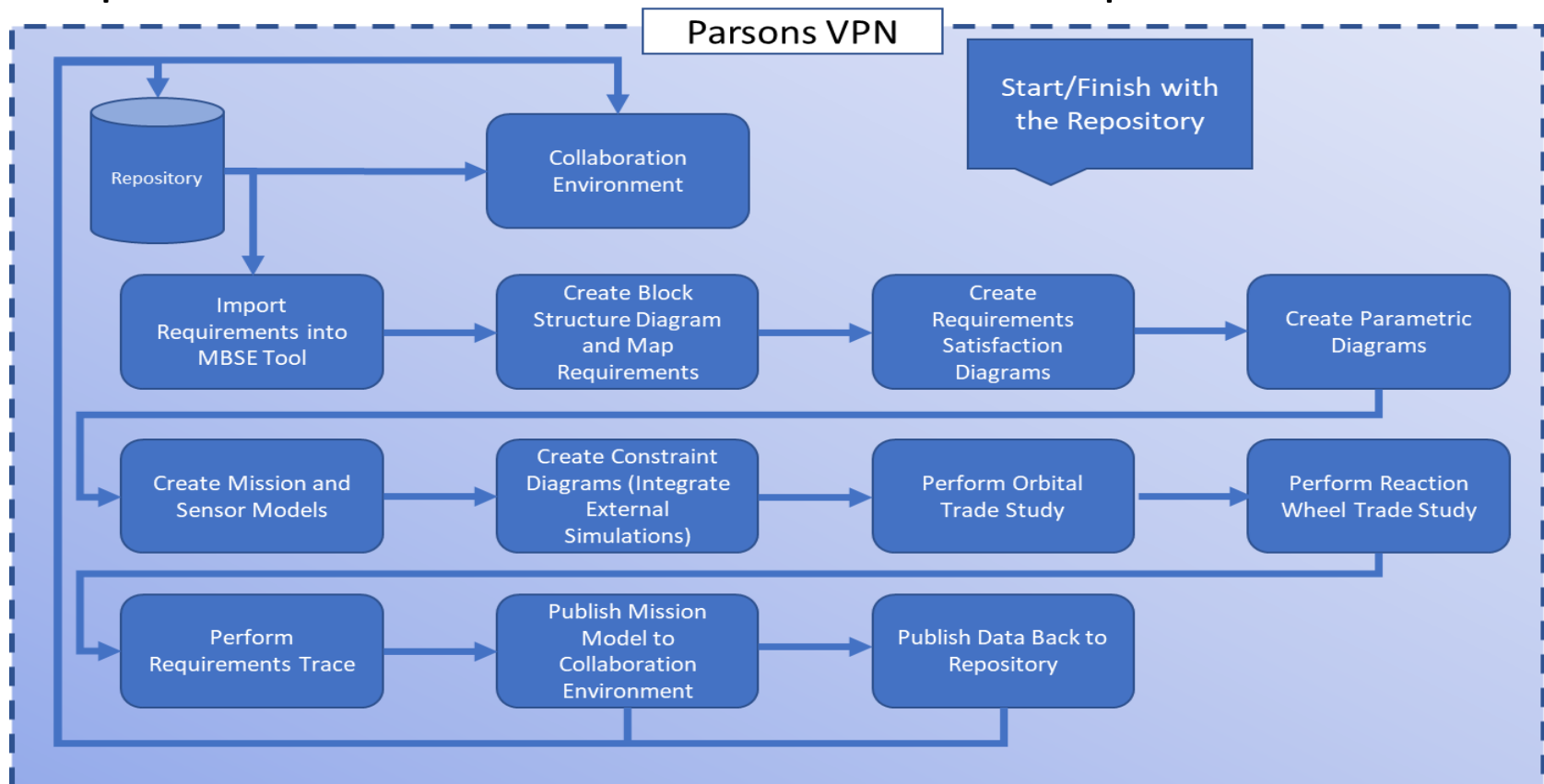
Open Model Based Engineering Environment (OMBEE)

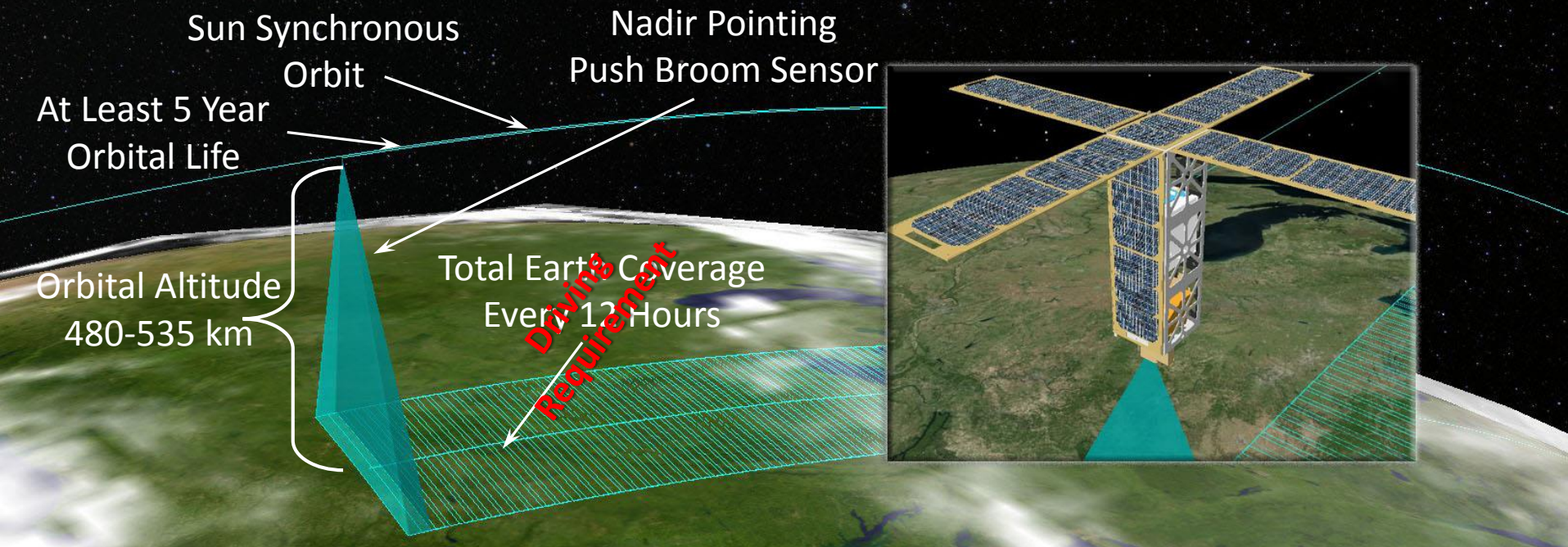
PARSONS



Demonstration Overview

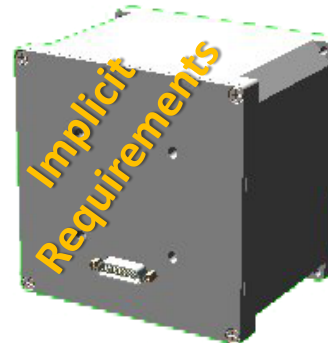
- Model Based systems Engineering (MBSE) Approach
- Based on Low Earth Orbit Weather Satellite
- Requirements Derived from the Technical Requirements Document



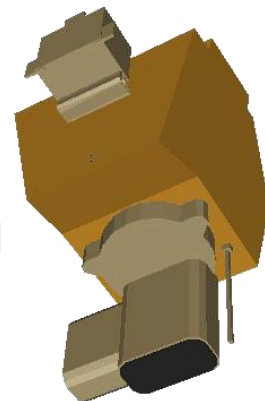


- 88 Requirements Derived From the Technical Requirements Document
- Orbital Trade Study Focuses on Five Requirements that are all Related

Reaction Wheel:
1) Nadir Pointing within 0.25°
2) Wheel Saturation less than 90%

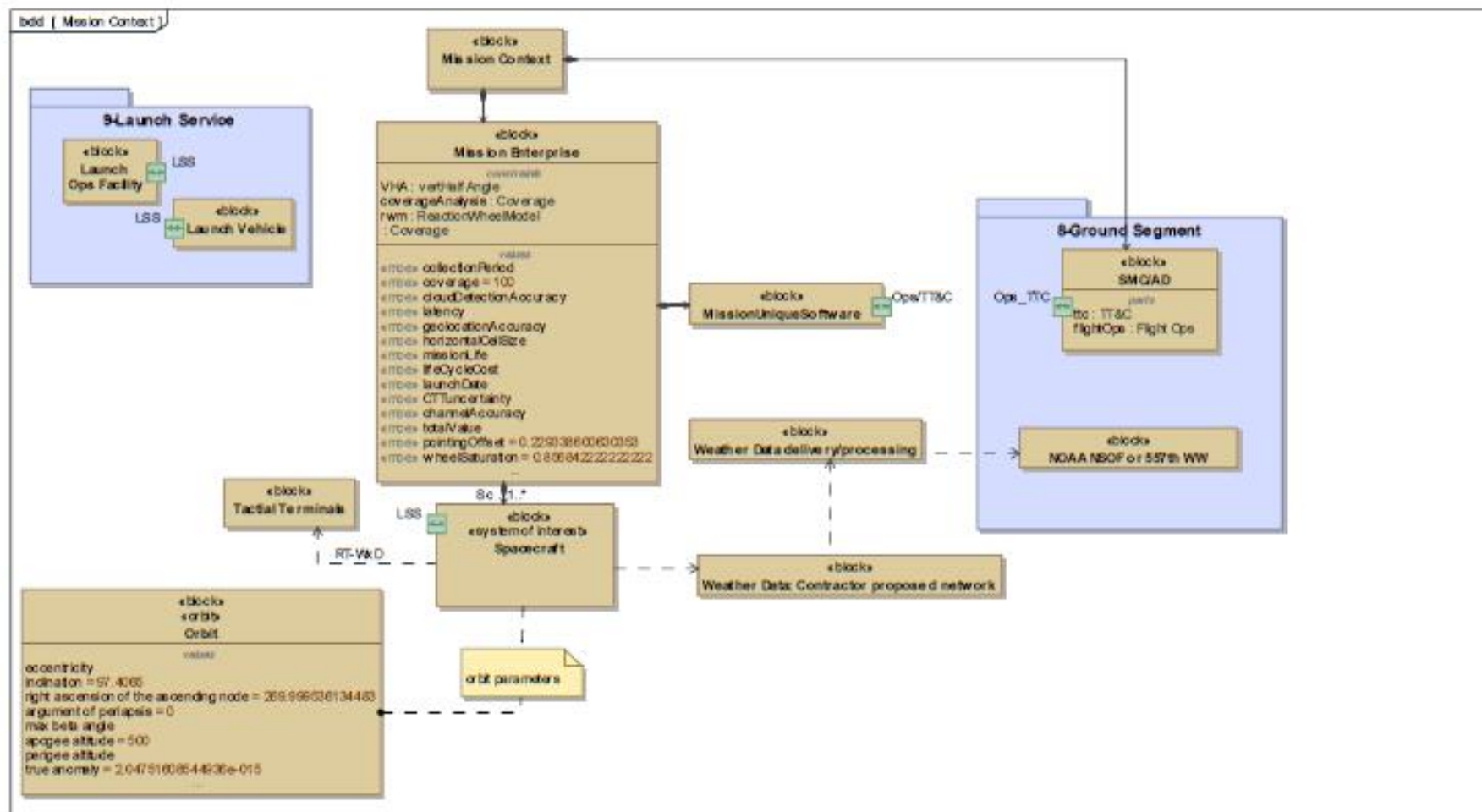


Push Broom Sensor
Horizontal Cell Resolution of < 2 km



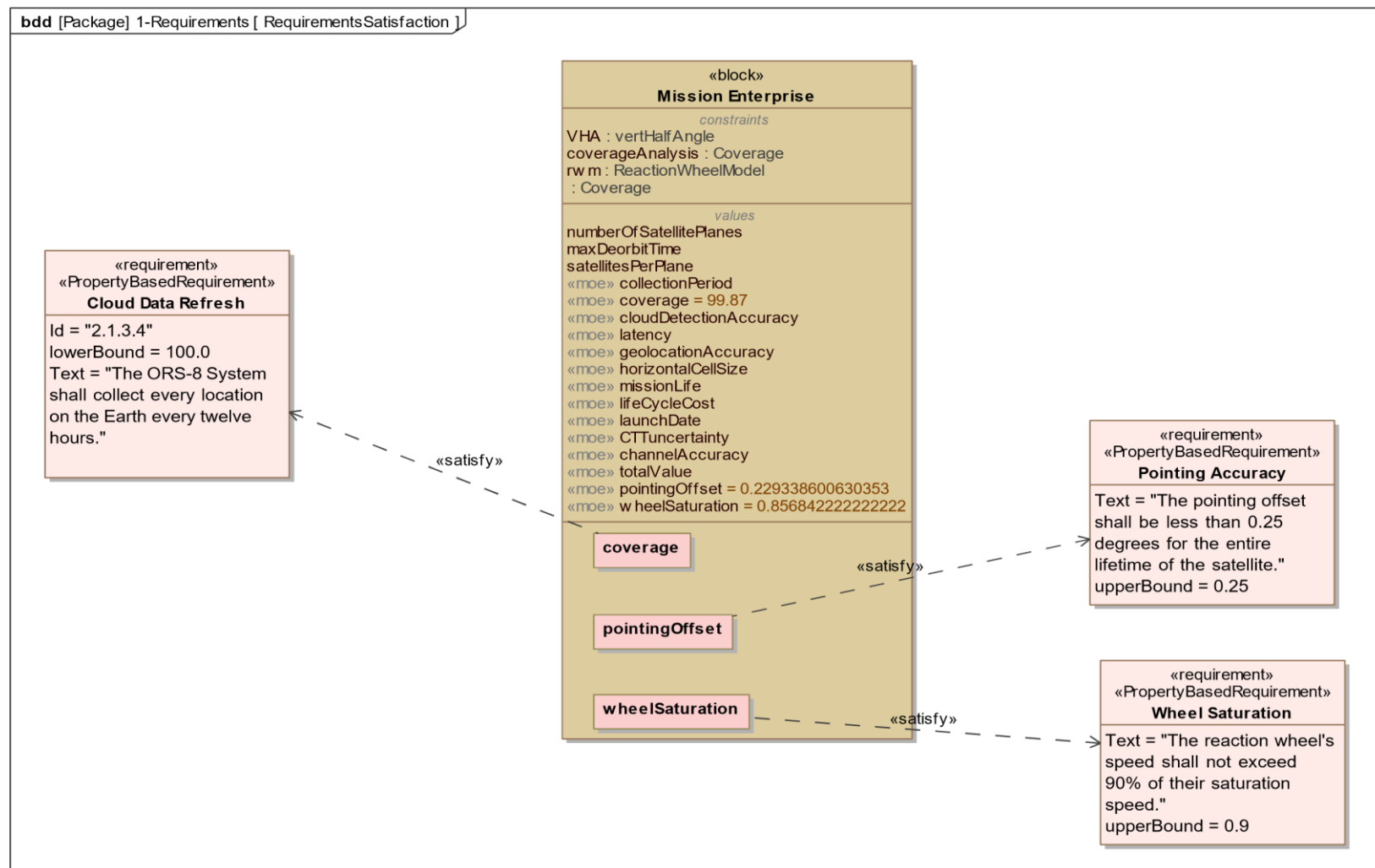
Block Definition Diagram

- Decomposition of the System into its mission areas and mapping data requirements



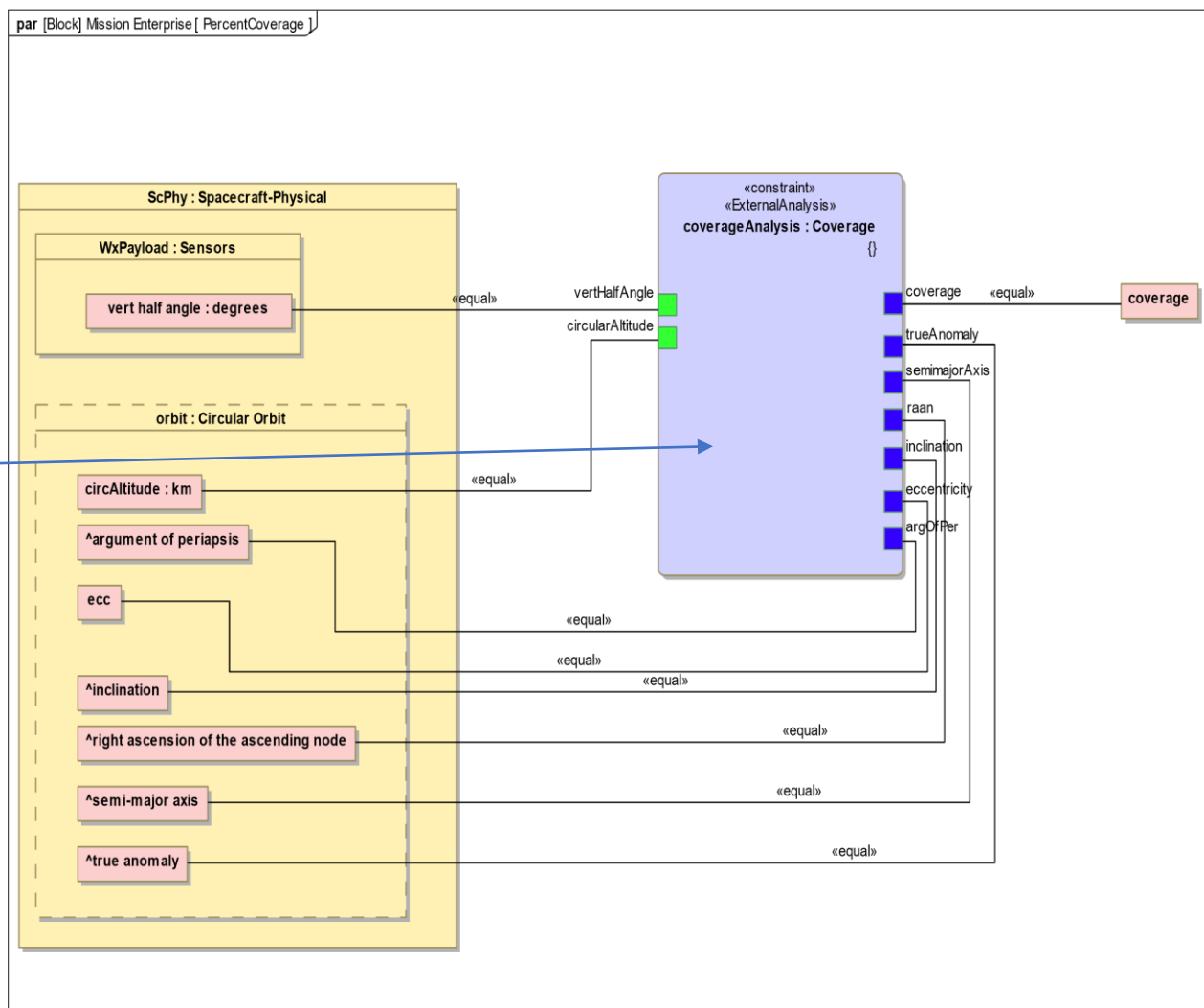
Requirements Satisfaction

- Defining the Performance Parameters that Satisfy the Requirements



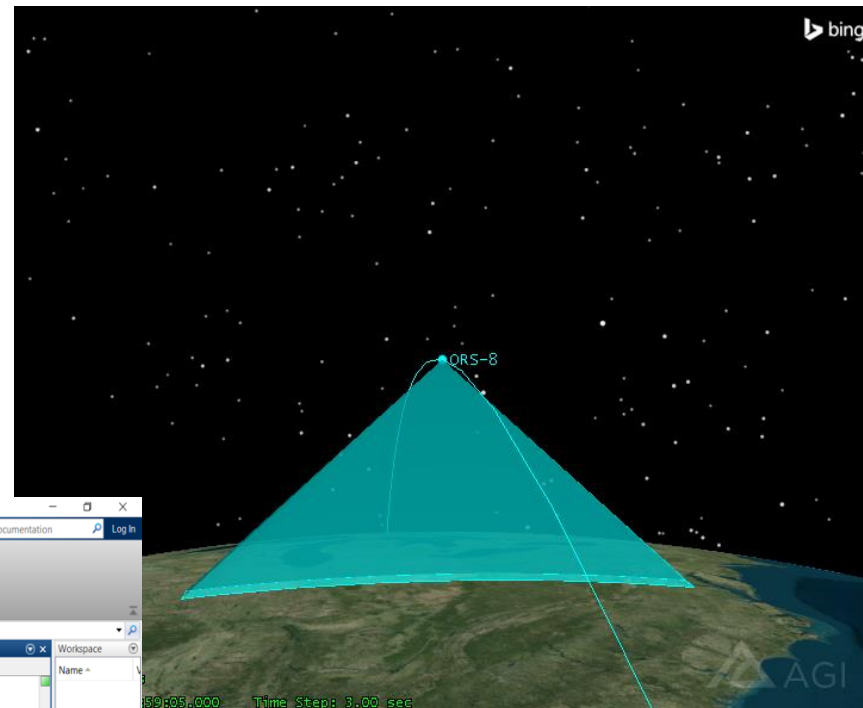
MBSE Parametric Diagrams

- Connect the Requirements to a Mission Context Performance Model



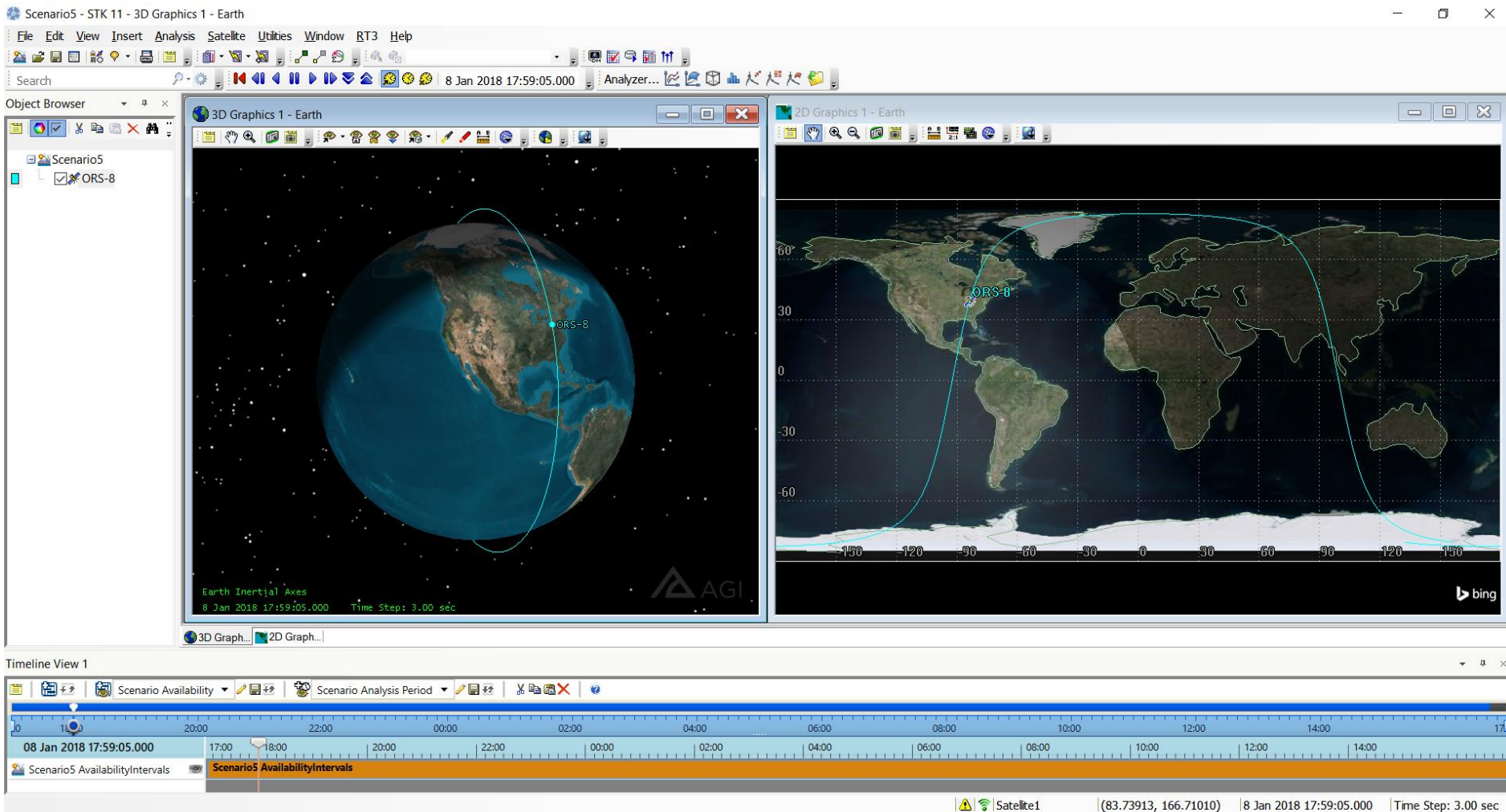
Sensor Model

- Custom Code in Matlab
 - Calculates Sensor Resolution based on Satellite Altitude
 - Used to Calculate Sensor Coverage



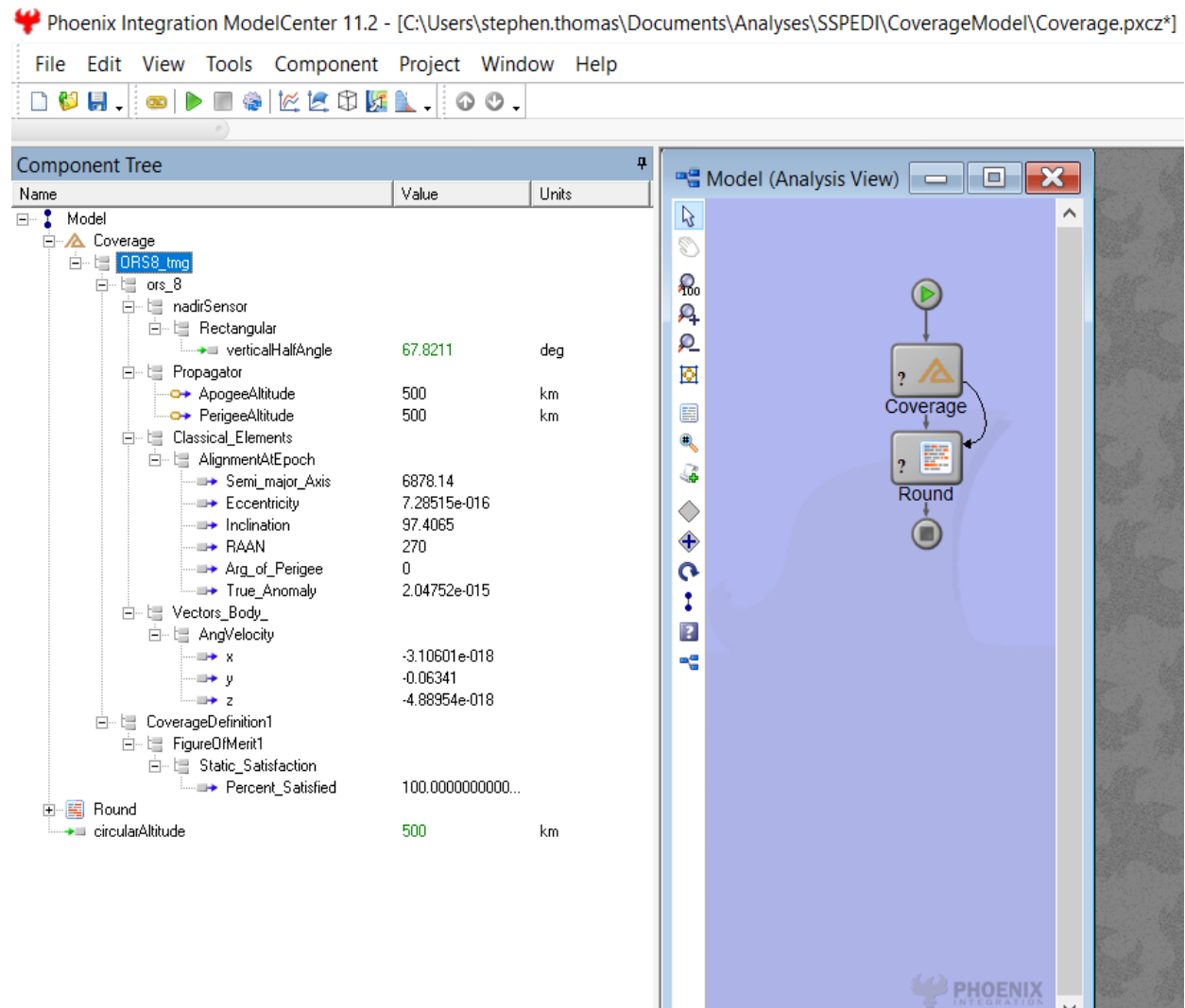
Mission Model

- Repeating Ground Track Sun Synchronous Orbit



Integrate Mission Model

- Create wrapper for models and integrate into SysML model



Trade Studies

Phoenix Integration MBSE Analyzer

File Edit View Tools Help

Welcome Review Requirements Manage Constraint Blocks Manage Parts Catalog Manage Parametric Diagrams Evaluate Designs Simulation

Design Exploration

Analysis Case: <none> Trade Study: <none>

Select a Subject to Analyze

- 2-Structure
 - Earth
 - Endoatmosphere
 - GPS
 - Launch Environment
 - Mission Context
 - Mission Enterprise**
 - Region
 - Space Debris

Parametric Diagrams Selection Filter

- Mission Enterprise
 - MaxVerticalHalfAngle
 - PercentCoverage

Property	Units	Original	New	Margin
Mission Enterprise				
ScPhy				
orbit				
circAltitude	km	1200.0	485.0	
argument of periapsis		0	0	
ecc		1.8067183452589e-015	1.81788310637083e-015	
inclination		97.3086897243934	97.3086897243934	
right ascension of the ascending node		0	0	
sma	km	7578.137000000002	6863.137000000002	
true anomaly		0	0	
WxPayload				
horizontal cross section1	km	2.0	2.0	
ifov1	milliradian	1.51	1.51	
vertical half angle1	°	47.8471210865642	68.5200878883778	
coverage		98.98	100	0.0000

- Trade Studies and Design of Experiments
 - Variable Automatically Tracked for Each Simulation Run
 - Delta's in Input/Outputs
 - Comparison to Requirements

In Demo Scenario, High Resolution Coverage Analysis Took Approx. 2 min per Run, Automation is Required. 30 Minutes to Sweep 15 Runs in the Trade Study. However, it only takes 1 min to setup experiment, the rest is automatic...

Demo – Orbital Trade Study Video

Cameo Systems Modeler 18.5 - SSPEDItmg_v3.5.1.mdzip [C:\Users\stephen.thomas\Documents\SSPEDItmg_v3.5.1.mdzip]

File Edit View Layout Diagrams Options Tools Analyze Collaborate Window Help

Containment Diagrams

Selection Tools

Common Note Comment Problem Rationale Element Group Containment Constraint Parametric Diagram Constraint Property Moe Binding Connector Item Property Internal Block Diagram Value Property Part Property Reference Property Constraint Property Flow Property Participant Property Bound Reference Information Flows Conveyed Information Item Flow

par [Block] Mission Enterprise [PointingAccuracy]

ScPhy : Spacecraft-Physical

orbit : Circular Orbit

sma : km

*argument of periapsis

ecc

*true anomaly

*right ascension of the ascending node

*inclination

semimajorAxis

argOfPer

eccentricity

trueAnomaly

raan

inclination

maxWheelSpeed

wheelPartNum

rw : Reaction Wheel

maxWheelSpeed

partNumber

«constraints» «ExternalAnalysis» rwm : ReactionWheelModel

wheelSaturation

maxWheelSpeedPercent

pointingOffset

Properties

Element Symbol Tags Traceability Allocations

(Name) (Description)

Type here to filter properties

Ready

Type here to search

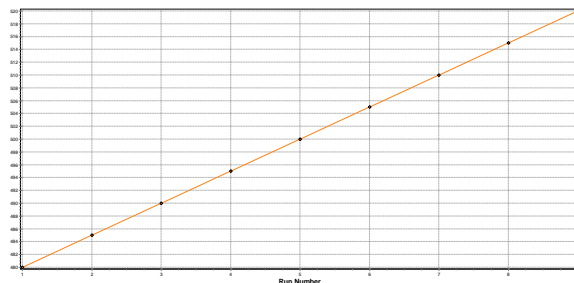
2 E, 21 W 175429

2:30 PM 1/31/2018

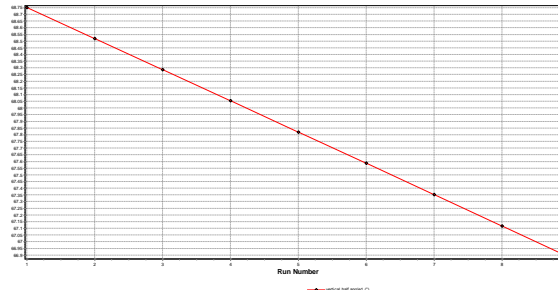
MBSE Analyzer - Results

- To Maintain the Sensor Resolution and 100% Coverage Requirements
 - Single satellite Design
 - Decreasing Altitude Maintained Requirements
 - Corollate to Min Satellite Orbital Lifespan
 - Implicit Requirement is Reaction Wheel Performance Required to Maintain Bias to Keep Sensor Pointed to Nadir, which is a function of Satellite Altitude

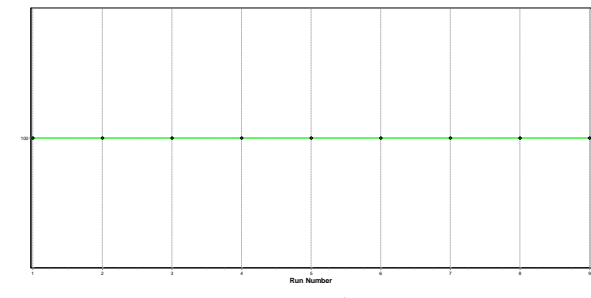
Circular Altitude



Sensor Angular FOV



Percent Coverage



Data Explorer (DOETool)SSPED-1.pxt: 1/6/2016, 14:41:00

File Edit Chart Options Help

Standard Plots Data Visualizer Plug-ins Templates

Legend

	1	2	3	4	5	6	7	8	9
AUTO SCROLL									
Mission Integration for the initial coordinate	400	400	400	400	400	400	400	400	400
Mission Integration for the initial area	40011300	40011300	40011300	40011300	40011300	40011300	40011300	40011300	40011300
Mission Integration for the initial vertical half angle	40 701300	40 50000	40 307400	40 094400	40 07000	40 00100	40 00100	40 00100	40 00100
Mission Integration coverage	100	100	100	100	100	100	100	100	100

0: 30 Line Chart

3: 20 Line Chart

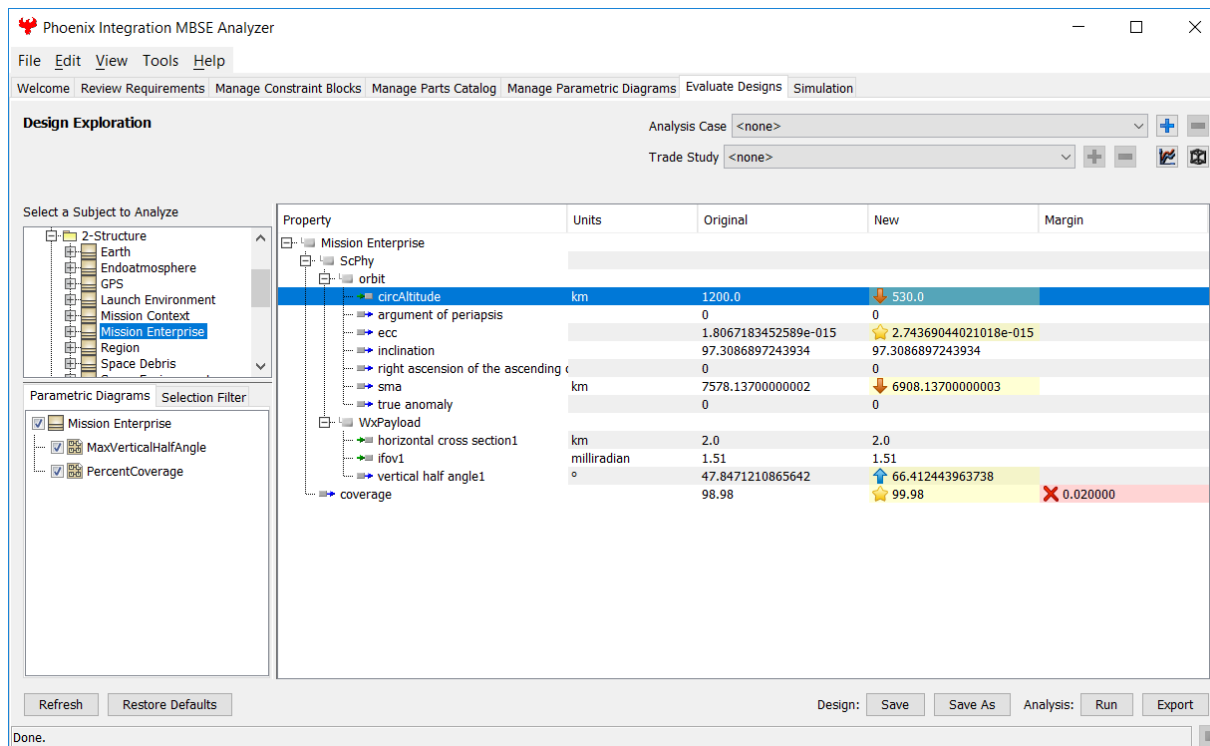
4: 20 Line Chart

6: 20 Line Chart

For Help, press F1

MBSE Analyzer - Results

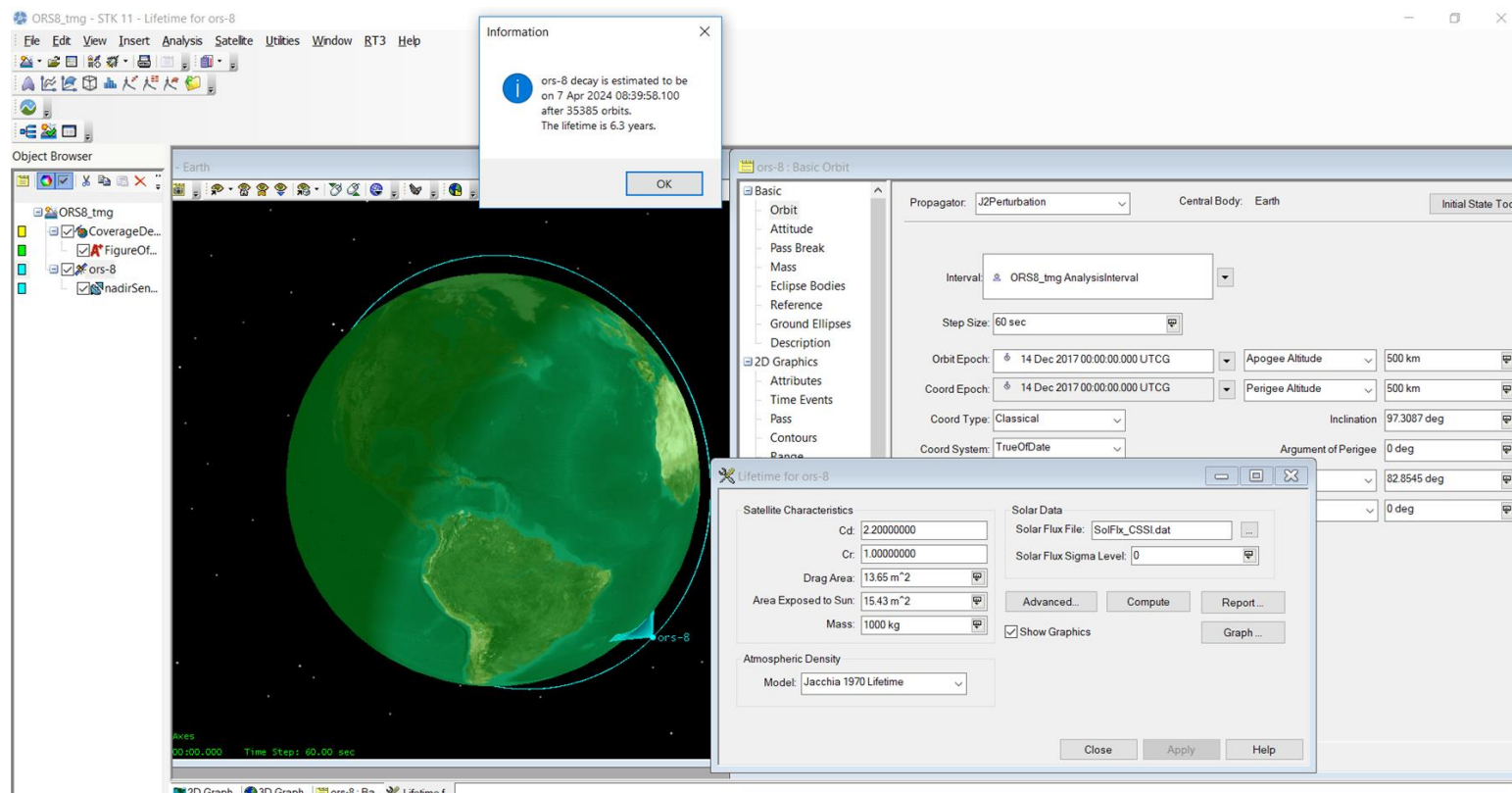
- To Maintain the Sensor Resolution and 100% Coverage Requirements
 - 530 km and Higher Orbits do not Satisfy the 100 % Coverage Constraint



An Orbital Altitude Range of 480 – 520 Km will Satisfy the Orbital Life, Coverage, and Resolution Requirements

MBSE Analyzer - Results

- To Maintain the Sensor Resolution and 100% Coverage Requirements
 - 500 Km Orbit Satisfies the 100 % Coverage Constraint
 - Orbital Life is satisfactory



Demo – Reaction Wheel Trade Study Video

Cameo Systems Modeler 18.5 - SSPEDItmg_v3.5.1.mdzip [C:\Users\stephen.thomas\Documents\SSPEDItmg_v3.5.1.mdzip]

File Edit View Layout Diagrams Options Tools Analyze Collaborate Window Help

Containment Diagrams

Technical Requirements T... Notional Requirements Ta... RequirementsTrace Derived Mission Requirement... RequirementsSatisfaction Mission Context MaxVerticalHalfAngle PercentCoverage PointingAccuracy

Selection Tools

Common Note Comment Problem Rationale Parametric Diagram Constraint Property Binding Connector Internal Block Diagram Value Property Part Property Reference Property Constraint Property Information Flows Conveyed Information Item Flow

Zoom Documentation Properties

Element Tags Traceability Allocations

(Name) (Description)

Type here to filter properties

Notification Window

com.phoenix_int.sysml.mbse.panels.execution.tasks.BuildAnalysisCaseTask.doWork (BuildAnalysisCaseTask.java:15) at com.phoenix_int.sysml.mbse.panels.execution.tasks.Task.run (Task.java:89) at java.lang.Thread.run (Thread.java:748)

Ready 2 E, 21 W 175440

Type here to search

2:39 PM 1/31/2018

Requirements Verification

- 500 km Orbit
 - Meets 100% Coverage within a 12 hr. Period
 - Meets Sensor Resolution Requirements of 2 km
 - Orbital Life Estimate is Greater than 6 Years
- Reaction Wheel Design #1
 - Meets Wheel Saturation Percent Requirement $<90\%$
 - Meets Nadir Pointing Accuracy Requirement 0.25 deg

Summary

DEMONSTRATED

- Collaboration Between the Team to Provide a Rapid Capability to:
 - Manage Complexity of Design of Satellites Through MBSE
 - Perform quick turn Trade Studies to Optimize Performance, Cost, Risk, or Schedule
 - Early Identification of Disconnects Between the Architecture and Requirements
 - Automated Distributed Engineering Analysis
 - Model Based Engineering

BACKUP