Flexibility
Agility
Speed
Technology
PUMA
PARSONS Universal Modeling Analysis Lab

PARSONS

Cloud Version 1.0

Parsons Digital Engineering Framework (PDEF) Hypersonic Demonstration

Sep 2020

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delivering a better world[SM]

Contents

Rationale for Digital Engineering

- **Cross Element impacts and interdependences for the MDS can be realized with a virtual model**
  - Initial deliveries can be virtual: digitally engineered solutions in the form of a model
  - Leads to earlier prototyping
  - Early deliverable that helps the government understand performance, challenges of integration and the trade space
- **Virtual prototyping prior to physical has less risk**
  - Allows early down selects and competition of virtual designs – digital twin fly offs before bending metal
  - Allows more time in EMD, have more engineering rigor and retiring risk faster
  - Speed and Agility, while leveraging existing *rigor and engineering discipline* - nimble and responsive development environment
- **Supplements existing Acquisition and SE process**
  - Same documentation as the analog engineering effort can be generated
  - Discipline of documentation and a corporate board structure still exists, but with benefit of Live Digital Dash Boards
- **Digital engineering solution maintains the system engineering rigor, and compliance with standards and process**
  - It is faster, more design time provided with digitalization and faster turn rate of analyzing the virtual model
- **Creation of Digital Commonality with the National Team**
  - Authoritative sources of system data and models (truth data) supports development, advancement and sustainment of the MDS

Digital Engineering Increases Speed and Agility While Reducing Risk

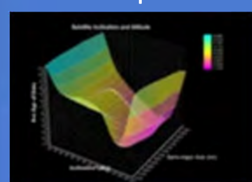
Digital Mission Engineering

- An Extension of MBSE that utilizes computer-based modeling simulation and analytical tools to evaluate mission objectives and outcomes during design, test planning, and execution.
- Connects Requirements to digital representations of components, systems, and system of systems to the mission objectives
- Provides and environment for collaboration and configuration management of all engineering, simulation, and test data

Requirement Engineering

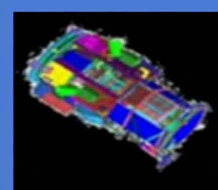
Studies and Analysis

Concept Development



Trade Studies and Optimization

Engineering, Test, and Build

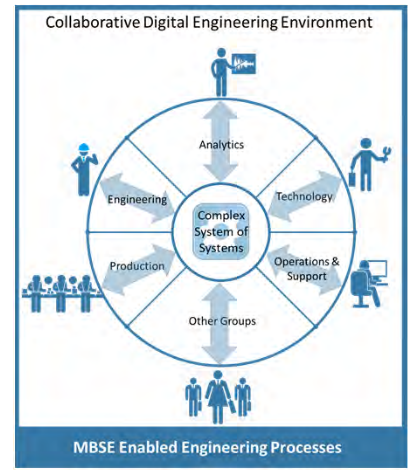


Integration and Engineering M&S

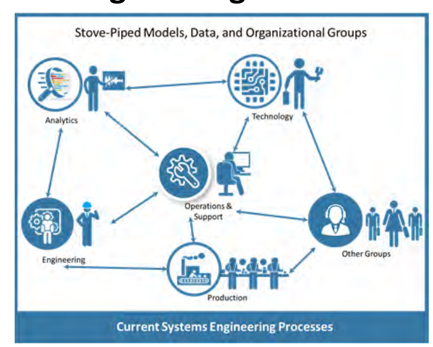
Mission Planning and Operations

Key Measures of Mission Effectiveness

MBSE Digital Engineering Environment



Current Systems Engineering Practice



Definition of Parsons Digital Engineering Framework (PDEF)

- **PDEF is a model-based, simulation-driven framework supporting Model-Based Systems Engineering and the analysis of complex systems and systems of systems**
  - Unifies multiple stakeholder data and sources, models and simulations into an integrated analytical architecture
- **Model Agnostic**
  - Federates any models or simulation tools
  - Supports system requirements determination, design, analysis, verification and validation- *throughout development and system life cycle*
- **Inherent analytic capability supporting**:
  - multi-variate optimization and discrete event simulation techniques
- **Handles a Seamless flow of requirements modifications**
  - Full development lifecycle support - *across the entire systems engineering process*.
- **Enterprise-level system engineering integrating framework and processes**
  - leverages simulations, tools and data residing in the Enterprise Web Services (EWS) cloud

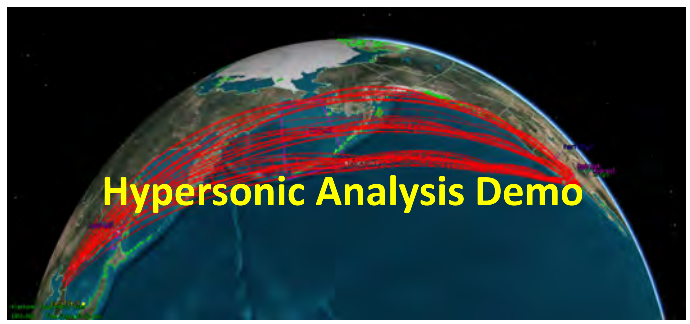
PDEF Hypersonic Use Case – Sensor Track Time Analysis

(U) Use Case: Notional "NK" Hypersonic Constant AoA trajectory to CONUS

- **Sensors (*Representative*):**
  - **Aegis DDGs BMD, TPY-2**
  - **Cobra Dane**
- **Optimization of Track Time**
- **Requirements Determination and Validation**

1. Requirements Determination

- Series of externally generated hypersonic trajectories
- Set of ground-based sensors with just regular sensors (complex conics) with a FOV and Range Constraint



2. Behavioral Analysis (Optimization)

- Optimization using the EVOLVE optimizer
- Allow all mobile sensors to move area targets and maximize total access time

3. Stochastic Analysis

- Conduct probabilistic study taking the best locations from the optimizer
- Perform Gaussian 3 Sigma around locations

4. System Architecture Analysis, Trades Analysis and Model Based-Systems Engineering (MBSE)

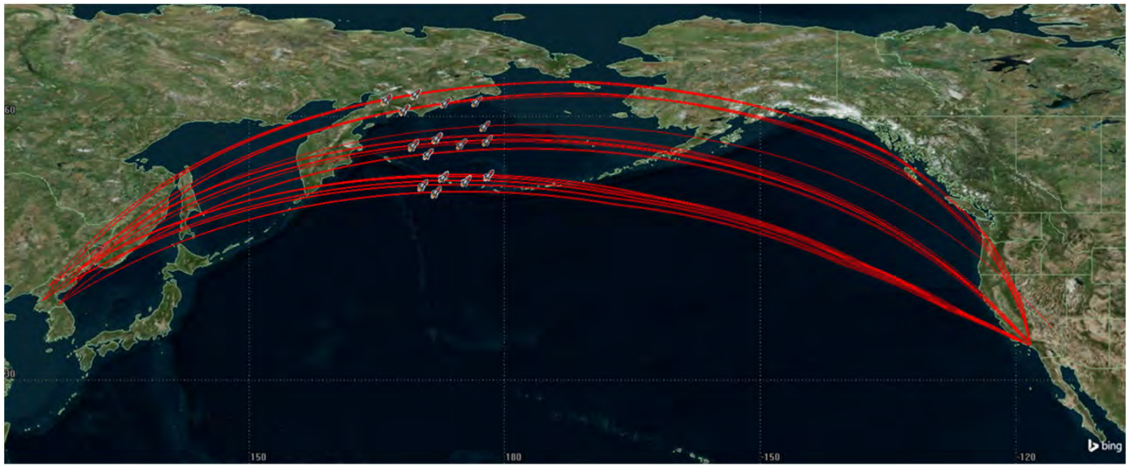
- Take that workflow and publish on the analysis server and then insert it into a MBSE architecture in Cameo
- Relate a "Shall" statement in the requirements based on the optimized access time and the 3 Sigma inbound access time
- Expose the Lat/Lon and range parameters for all the objects in the architecture

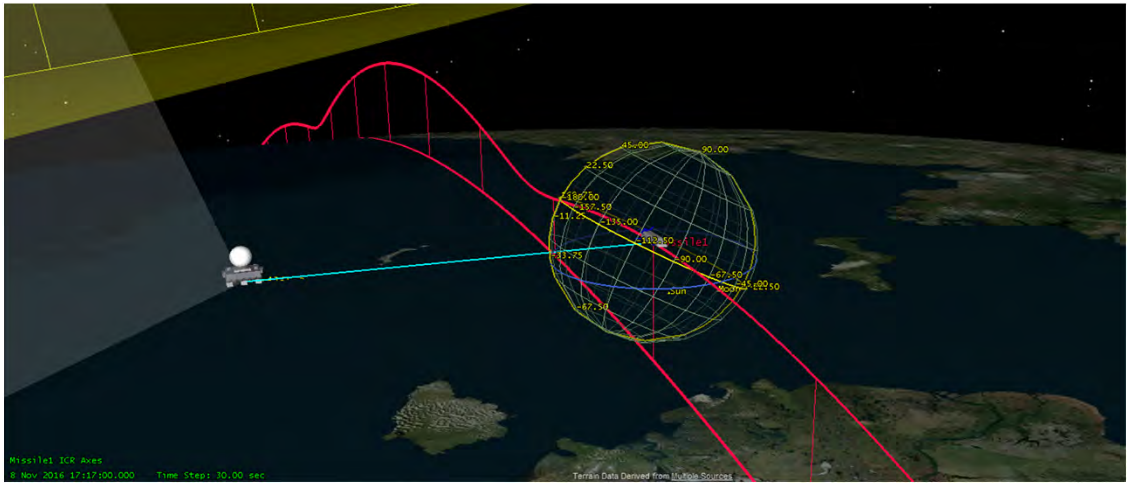
5. Parametric (Verification of Requirements)

- Evaluate the design total access time against the STK based scenario, total access time as a requirements verification

Threat Evaluation and Use Case Development

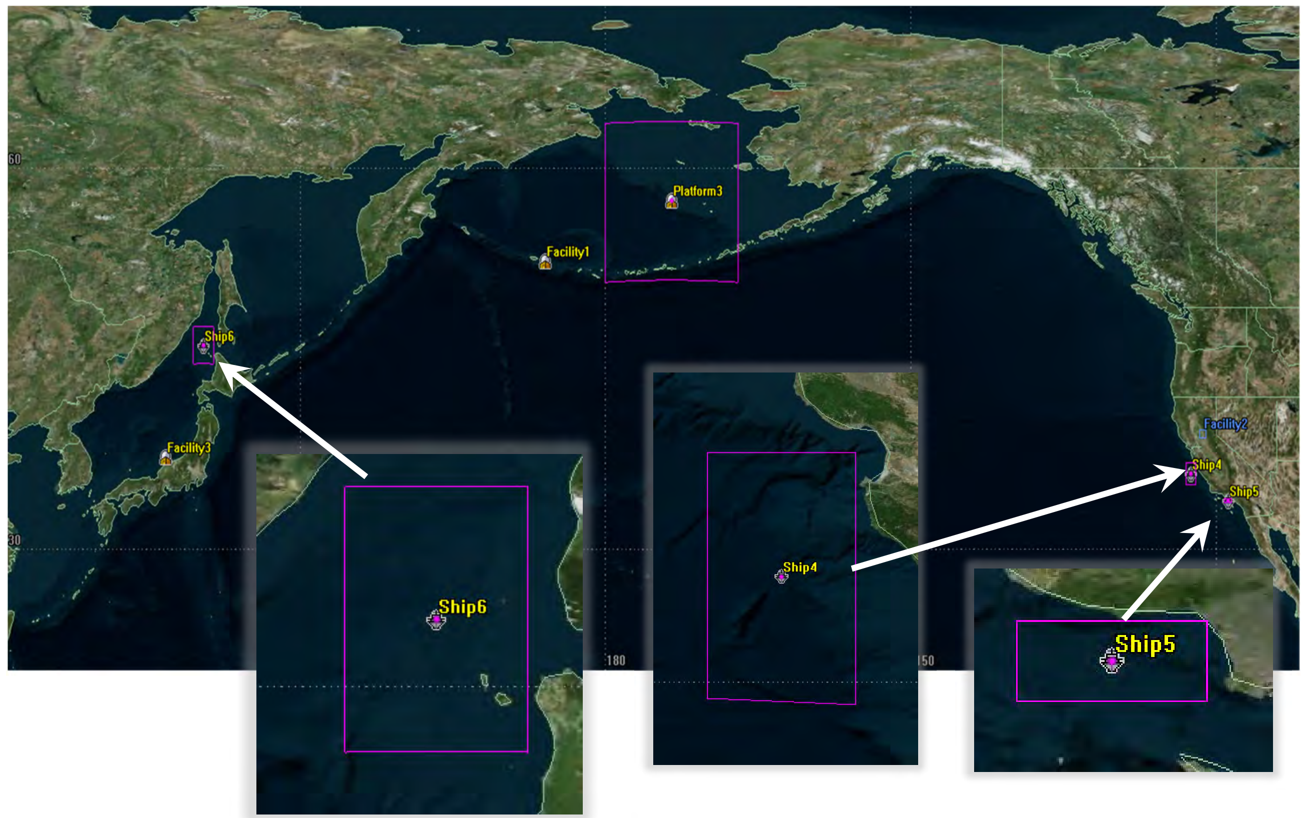
- **Initial Threat Space Development**
  - Sample of 50 Trajectories From Four Launch Points to Two Aim Points
  - Varying Number of Oscillations
  - Covers a Wide Range of Azimuths
- **Can be Expanded for Additional Use Cases**
- **Used to Develop Architecture for Track Opportunities**





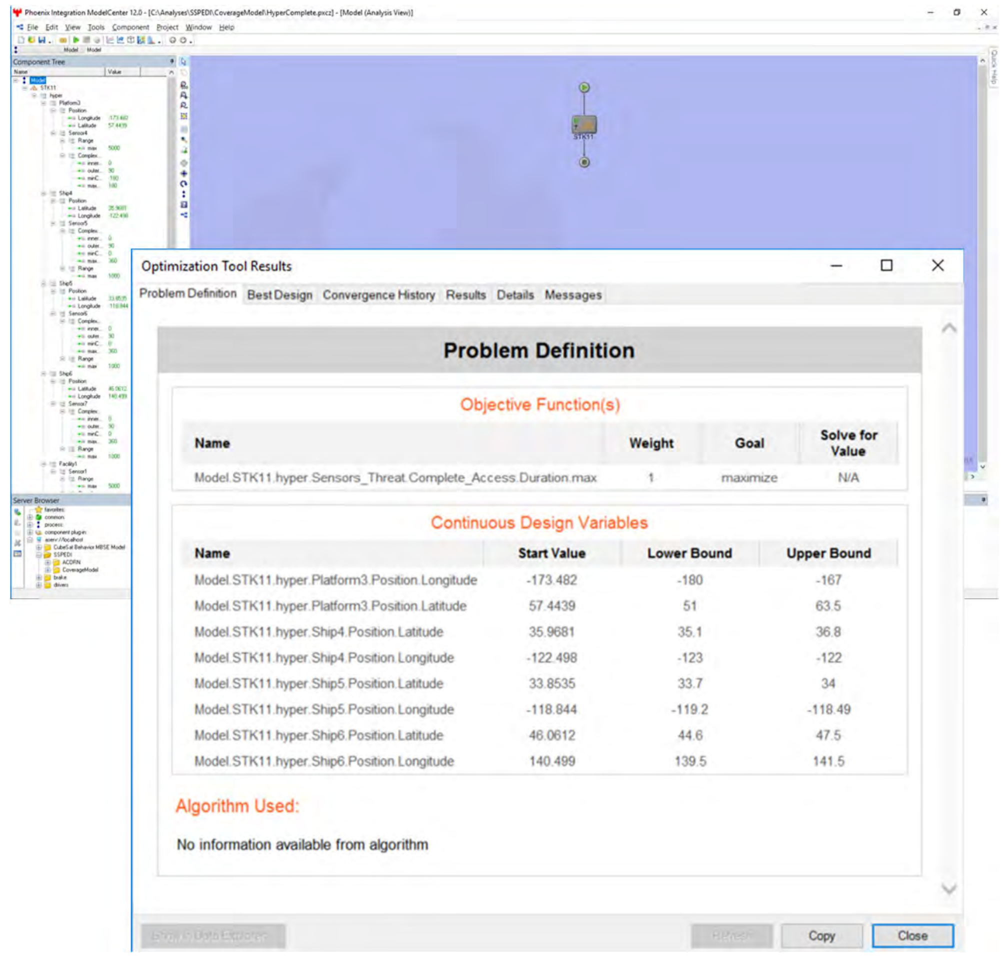
Initial Architecture Development

- **Track Opportunity**
  - Based on Sensor Architecture and Location
  - Mobile Sensors Have Operational Areas
- **First Study - Optimization**
  - Given an Order of Battle Determine Optimal Sensor Location
  - Derived from Sensor Parameters that are included in the Engineering Architecture (i.e. Field of View and Detection/Track Range)
- **Second Study - Stochastic**
  - Probabilistic Study to Determine Most Likely Maximum Track Opportunities



PDEF Configuration For Studies

- **Initial Trajectory Development in MATLAB and Integrated into STK**
- **Configuration "Wrapped" in Model Center**
  - Input Variables are Exposed and Metrics Defined
- **Optimization Problem Defined**
  - Determine Best Possible Locations for Mobile Sensors



Optimized Track Opportunity Results

- Initial Locations are the Centroid of the OPS area
- Max Track Duration 1001 Sec
- Evolve Genetic Algorithm
- 1632 Runs
- Converges to 1094 Sec Track Duration
- 9% Increase from Centroid Locations

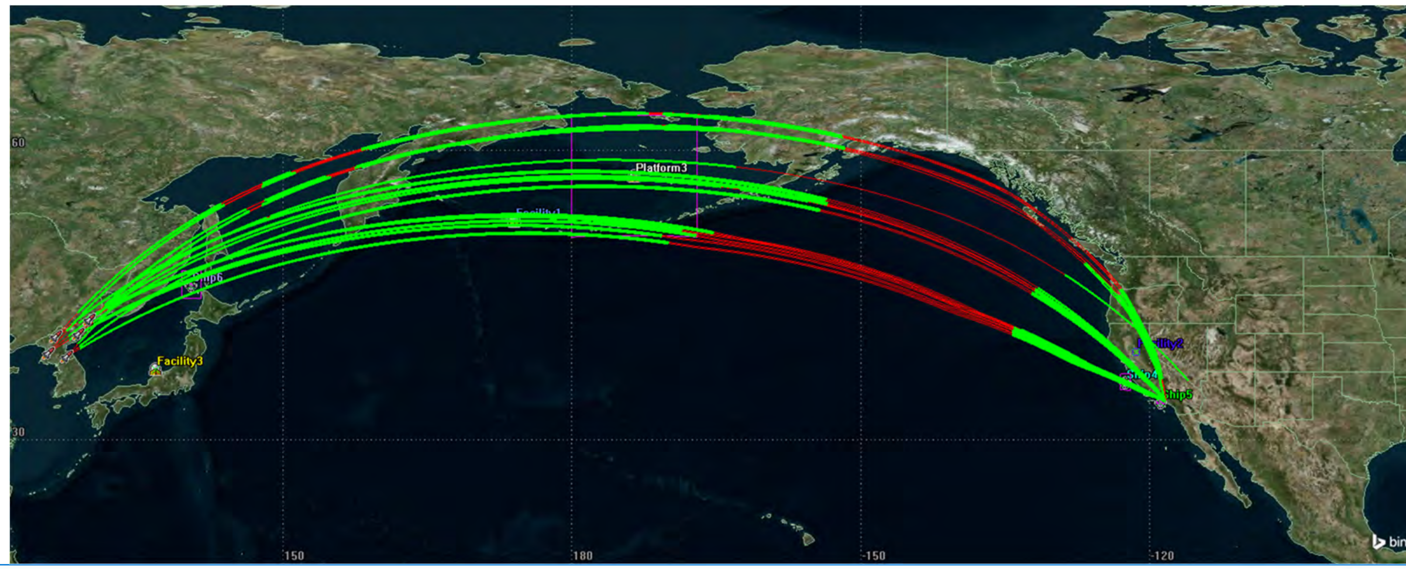


Table - MaxTrackTime.tstudy - Data Explorer

File Chart Help

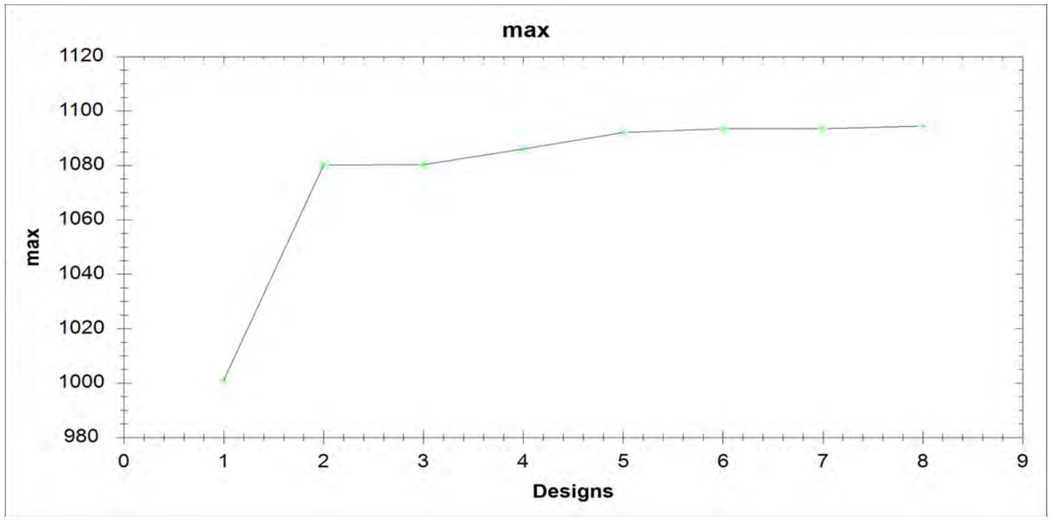
Add View Finder Plug-Ins

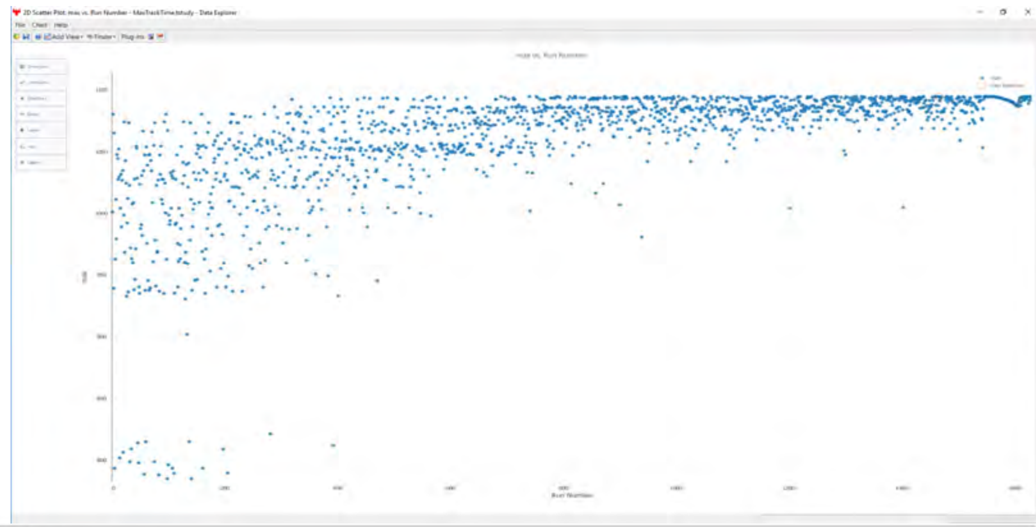
Legend: input | valid output | modified value

AUTO SCROLL	1618	1619	1620	1621	1622	1623	1624	1625
objective(Model.STK11.hyper.Sensors_Threat.Complete_Access.Duration.max)	1094.47	1092.6	1093.89	1093.51	1094.31	1094.38	1088.88	1091.29
design variable(Model.STK11.hyper.Platform3.Position.Longitude)	-167.028	-167.074	-167.082	-167.038	-167.04	-167.028	-167.41	-167.13
design variable(Model.STK11.hyper.Platform3.Position.Latitude)	51.002	51.292	51	51.188	51.008	51.022	51.288	51.42
design variable(Model.STK11.hyper.Ship4.Position.Latitude)	36.096	35.776	36.376	36.49	36.618	36.438	36.478	35.84
design variable(Model.STK11.hyper.Ship4.Position.Longitude)	-122.63	-122.262	-122.626	-122.24	-122.49	-122.066	-122.182	-122.532
design variable(Model.STK11.hyper.Ship5.Position.Latitude)	33.958	33.952	33.87	33.738	33.938	33.702	33.958	33.928
design variable(Model.STK11.hyper.Ship5.Position.Longitude)	-119.072	-119.066	-118.95	-119.07	-119.182	-118.872	-118.88	-119.05
design variable(Model.STK11.hyper.Ship6.Position.Latitude)	47.422	46.772	47.418	47.354	47.106	46.882	47.18	46.776
design variable(Model.STK11.hyper.Ship6.Position.Longitude)	141.21	140.098	140.77	139.596	140.1	139.596	140.198	140.978

AUTO SCROLL	1626	1627	1628	1629	1630	1631	1632
objective(Model.STK11.hyper.Sensors_Threat.Complete_Access.Duration.max)	1094.41	1091.36	1094.35	1094.04	1092.67	1092.04	1094.48
design variable(Model.STK11.hyper.Platform3.Position.Longitude)	-167.034	-167.032	-167.032	-167.04	-167.07	-167.032	-167.028
design variable(Model.STK11.hyper.Platform3.Position.Latitude)	51	51.59	51.02	51.07	51.288	51.478	51
design variable(Model.STK11.hyper.Ship4.Position.Latitude)	35.938	35.872	36.438	36.638	35.778	36.112	36.096
design variable(Model.STK11.hyper.Ship4.Position.Longitude)	-122.866	-122.72	-122.07	-122.842	-122.262	-122.342	-122.71
design variable(Model.STK11.hyper.Ship5.Position.Latitude)	33.962	33.908	33.702	33.996	33.95	33.938	33.932
design variable(Model.STK11.hyper.Ship5.Position.Longitude)	-119.146	-118.8	-118.63	-118.872	-119.07	-119.07	-119.06
design variable(Model.STK11.hyper.Ship6.Position.Latitude)	44.91	46.566	47.42	46.88	47.48	45.968	46.972
design variable(Model.STK11.hyper.Ship6.Position.Longitude)	140.512	140.598	140.472	140.024	140.848	141.21	140.974

Track Opportunity Results Statistics





Best Design
Run Number 1547

Objective(s)

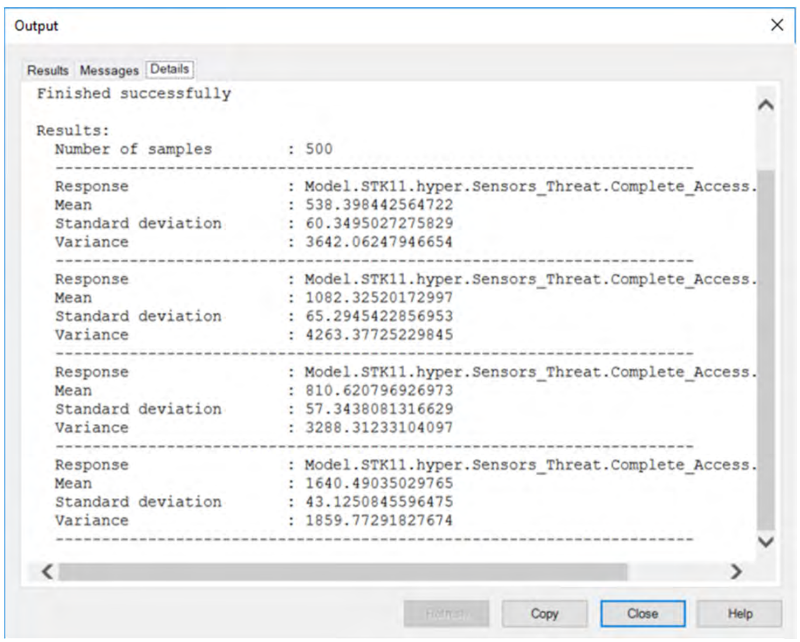
Name	Value
Model.STK11.hyper.Sensors_Threat.Complete_Access.Duration.max	1094.47

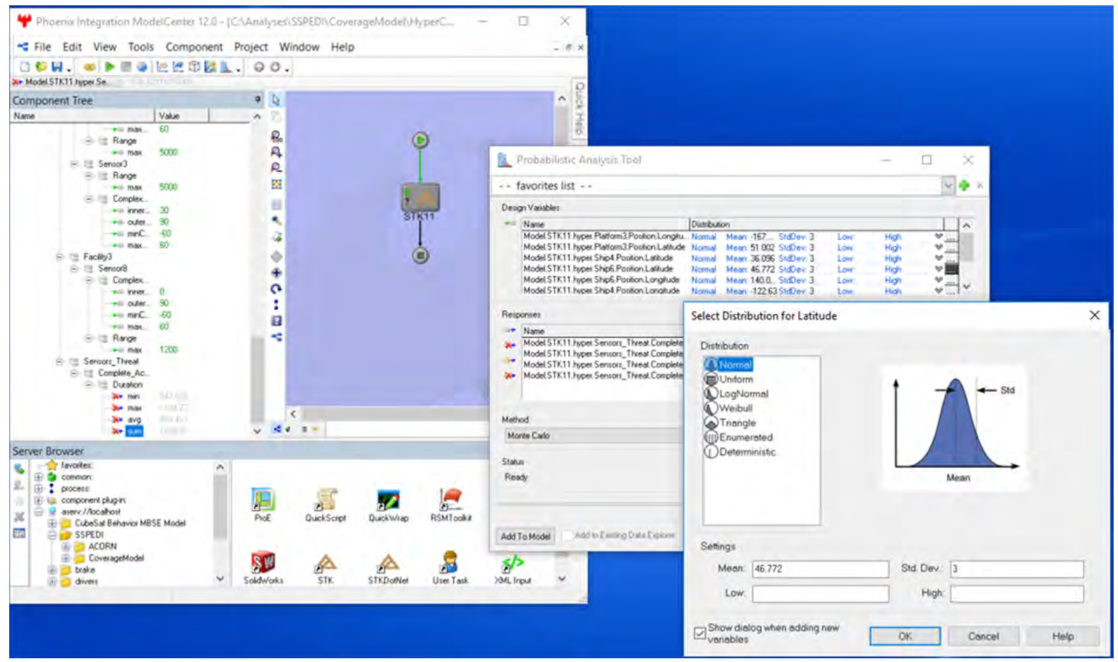
Design Variable(s)

Name	Start Value	Value
Model.STK11.hyper.Platform3.Position.Longitude	-173.482	-167.028
Model.STK11.hyper.Platform3.Position.Latitude	57.4439	51.002
Model.STK11.hyper.Ship4.Position.Latitude	35.9681	36.096
Model.STK11.hyper.Ship4.Position.Longitude	-122.498	-122.63
Model.STK11.hyper.Ship5.Position.Latitude	33.8535	33.958
Model.STK11.hyper.Ship5.Position.Longitude	-118.844	-119.066
Model.STK11.hyper.Ship6.Position.Latitude	46.0612	46.772
Model.STK11.hyper.Ship6.Position.Longitude	140.499	140.098

Probabilistic Analysis – Most Probable Locations

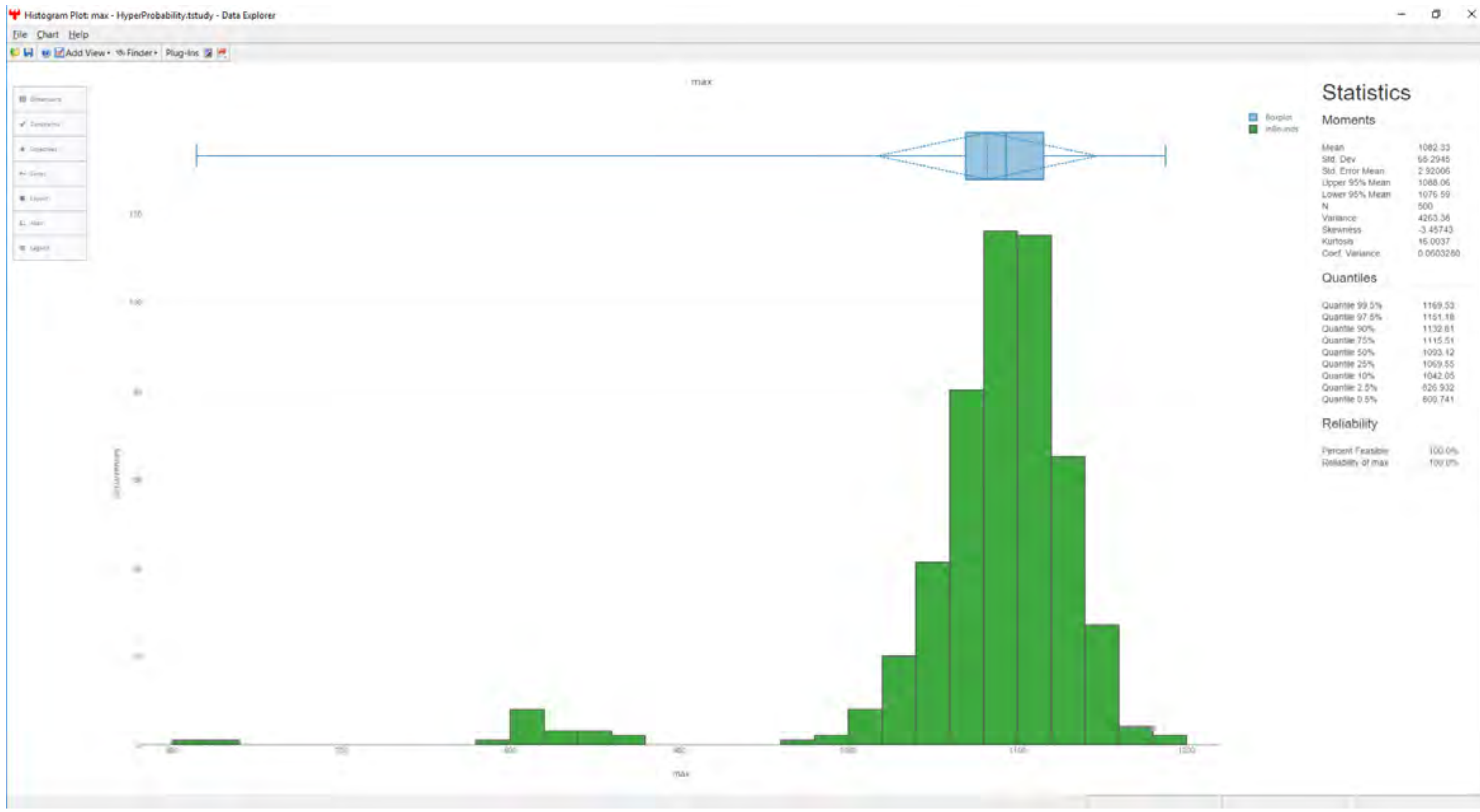
- 3 Sigma Normal Distribution Around Best Locations
- 500 Run Monte Carlo





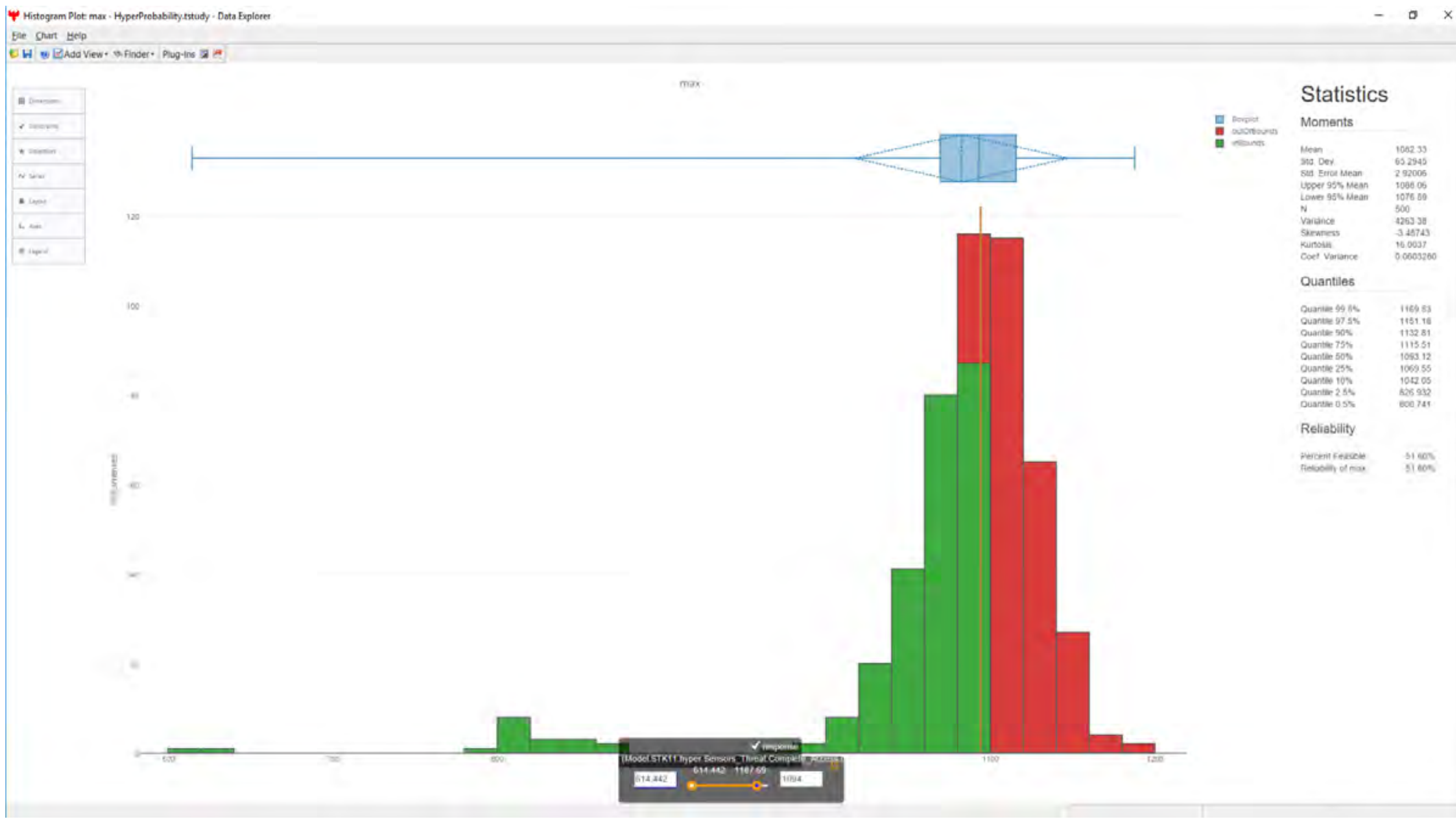
Probabilistic Analysis – Most Probable Results

- Unconstrained Results
- Includes Lat/Lon locations that are out of bounds



Probabilistic Analysis – Most Probable Results (In Bounds)

- Constrained Results
- Reduces Most Probable Track Time from 1094 to 1075 sec



Requirements Scope Summary

- Optimization Study developed candidate sensor locations to maximize in track viewing time
- Probabilistic Study performed a 3 sigma distribution around those locations
- Optimal Max Track time 1094 sec = Objective Requirement
- Probabilistic Most Likely Analysis reduces Max Track time to 1075 secs = Threshold Requirement
- Requirements will be dependent upon Sensor FOV/FOR, Max Detection Range, and Location
- These Parameters incorporated into MBSE Architecture for requirements trace as these values change

Analysis Yields Threshold and Objective Values For Requirements

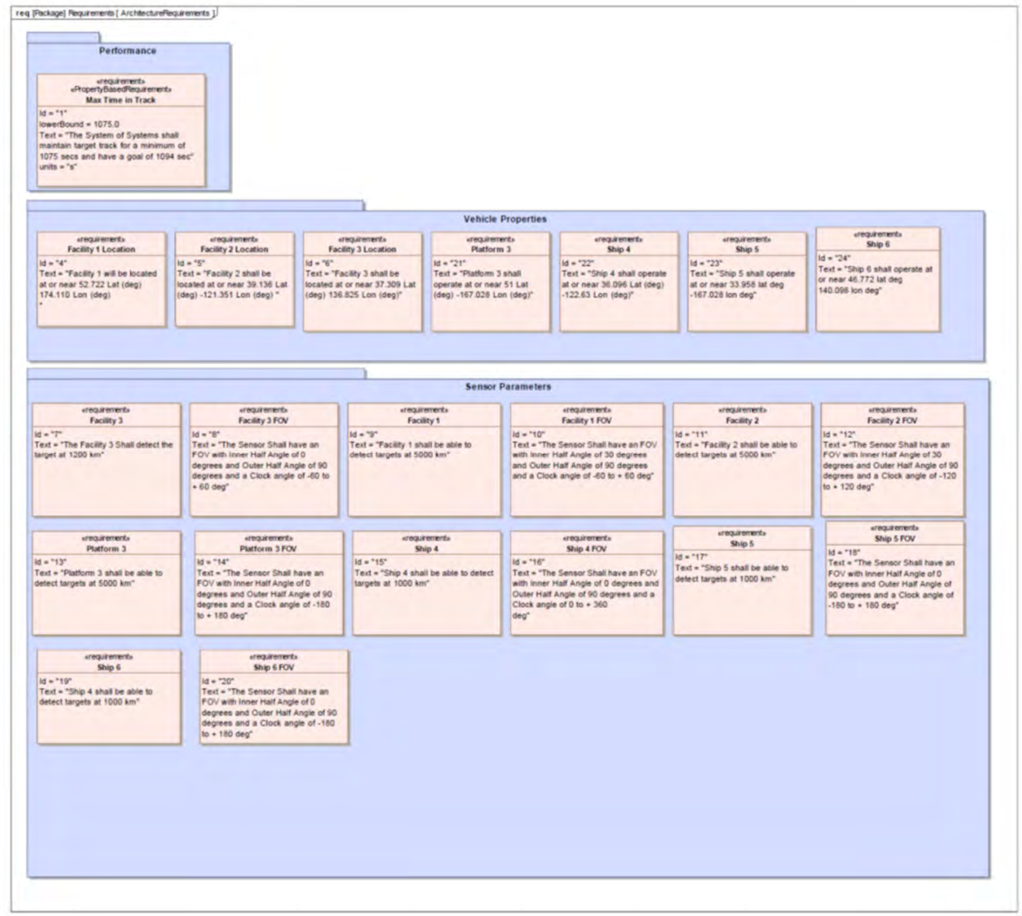
MBSE Architecture Requirements

- Refined Requirements are incorporated into the Virtual Model
- System Level Requirements
  - Track Time
- Component Level Requirements
  - Sensor Platform – Lat/Lon
  - Sensor – FOV/FOR and Max Track Range

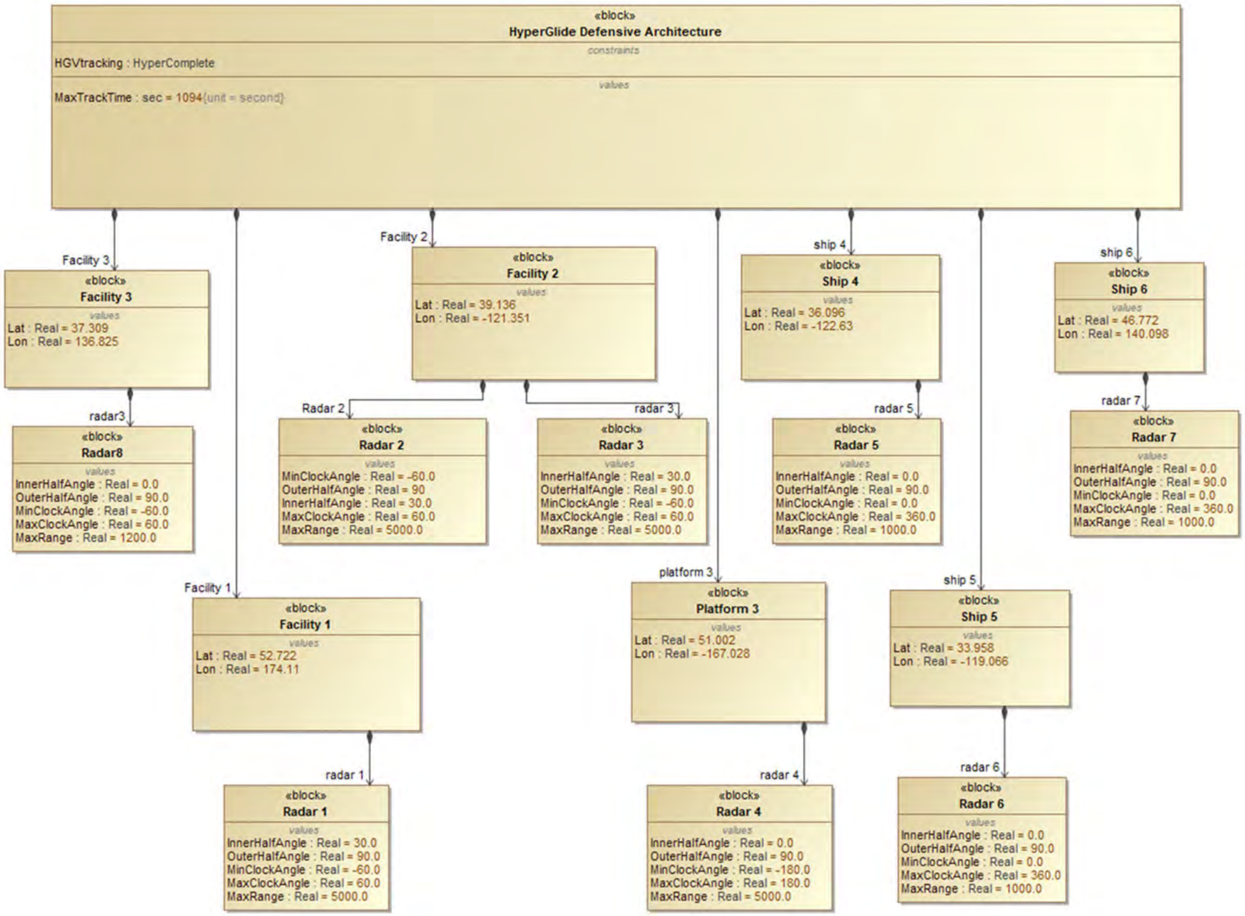
System of Systems Requirements

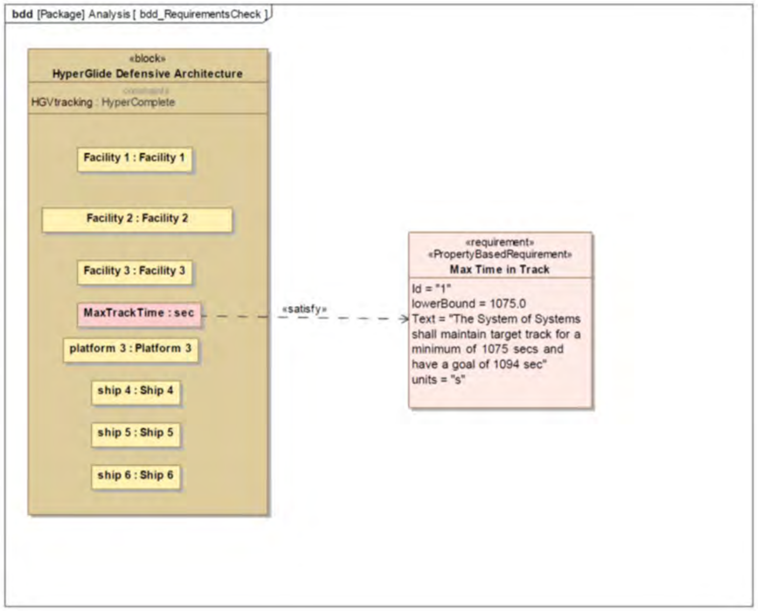
System Requirements

Component Requirements



MBSE Architecture Block Diagram and Requirements Satisfaction



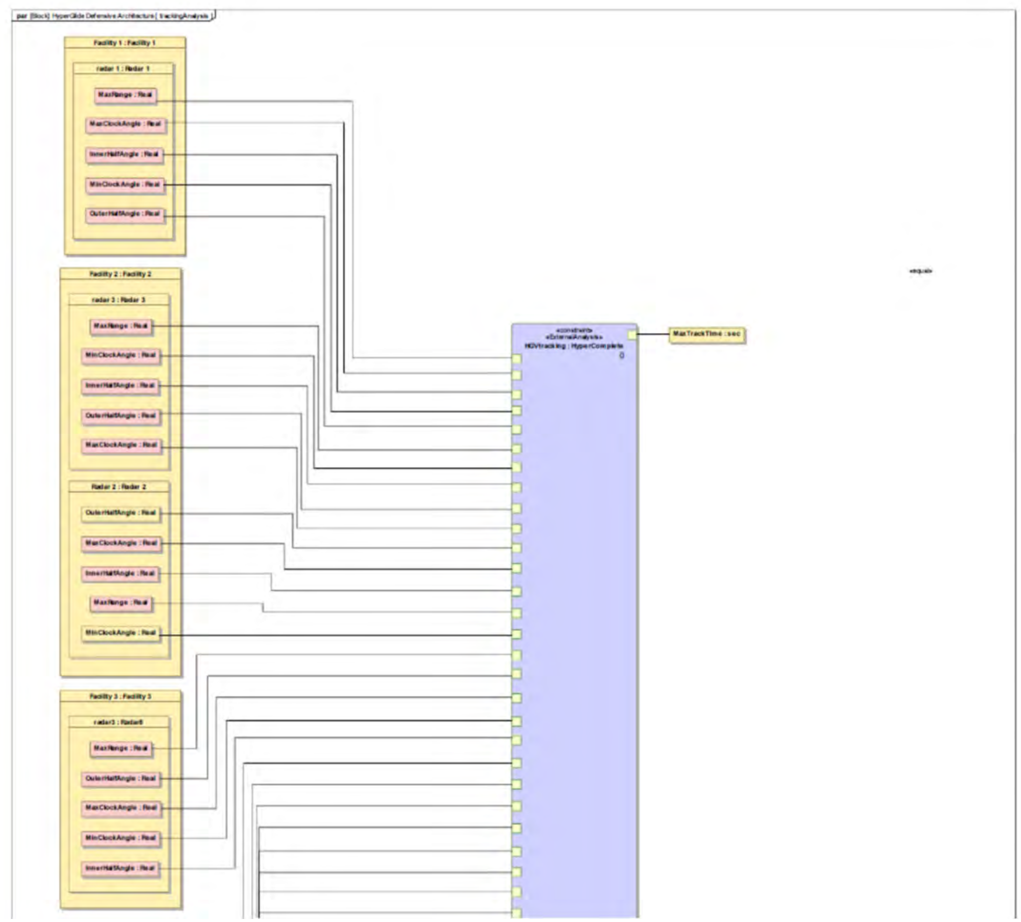


Requirements Satisfaction Diagram Mapping Shall Statement to the Architecture Block that Addresses it

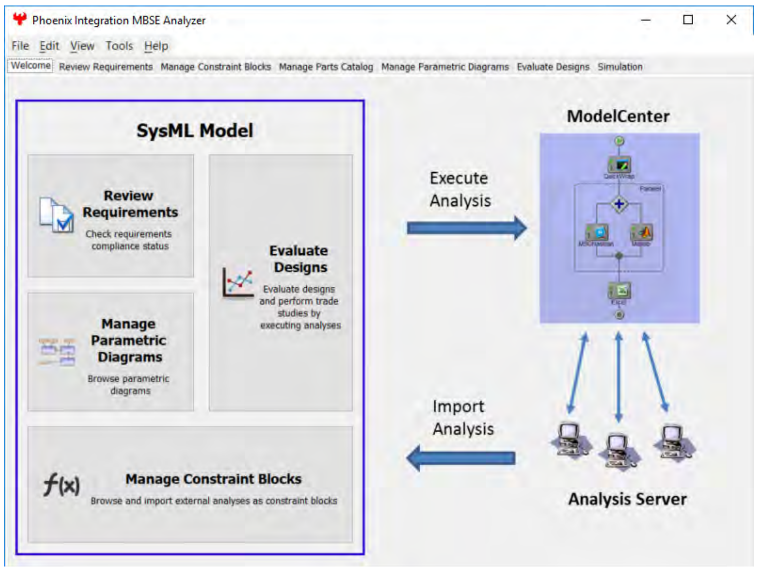
MBSE Architecture Parametric Diagram

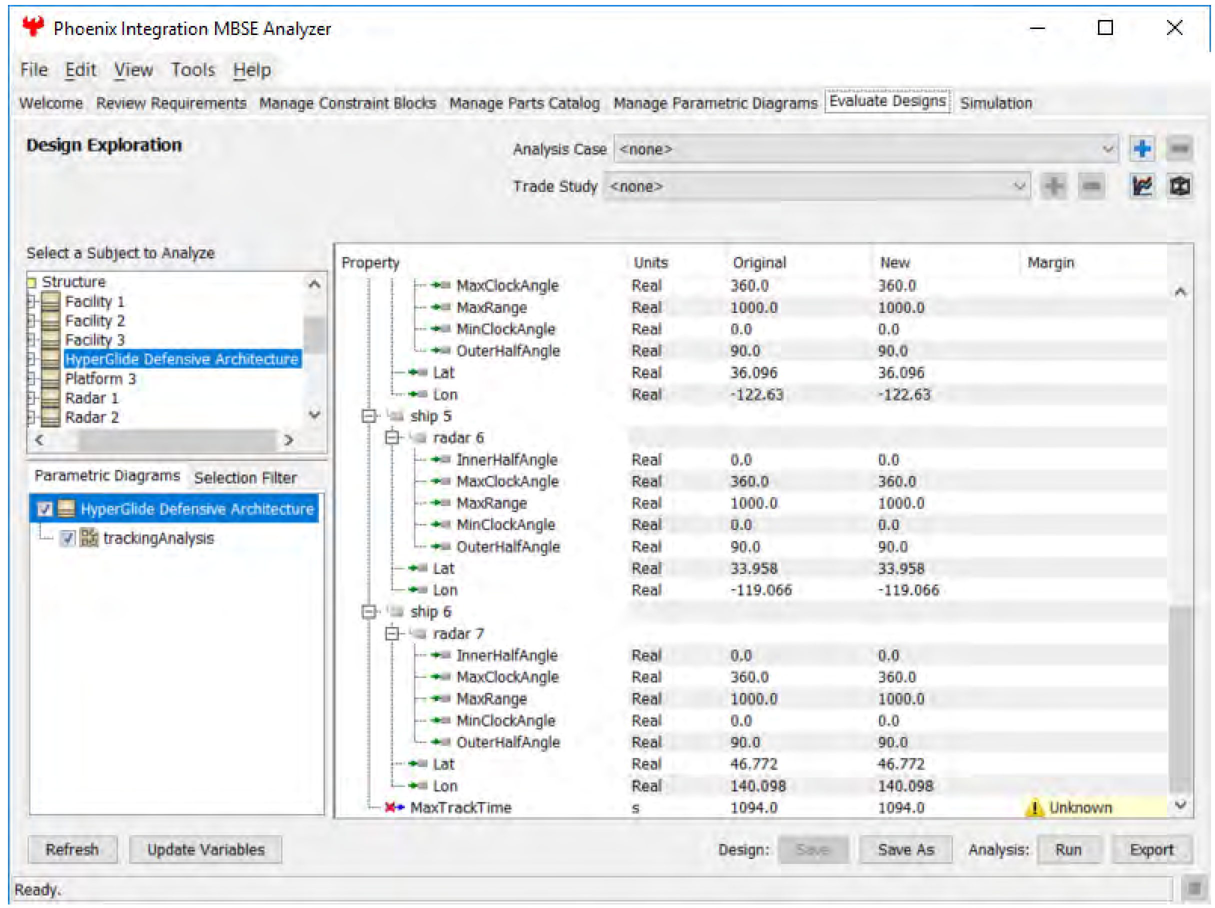
The Creation of the Parametric Diagram

- Links the Architecture Block Values to Analysis Parameters
  - Analysis Workflow Utilized in the Diagram
- Relates Component Requirements to System Level Requirements
- Allows for an Automated Connection to the M&S Based Studies and Analysis Tools to Evaluate Metrics
- Combined with Requirements Satisfaction Diagrams Provides the Basis for Requirements Trace



MBSE Architecture Requirements Trace

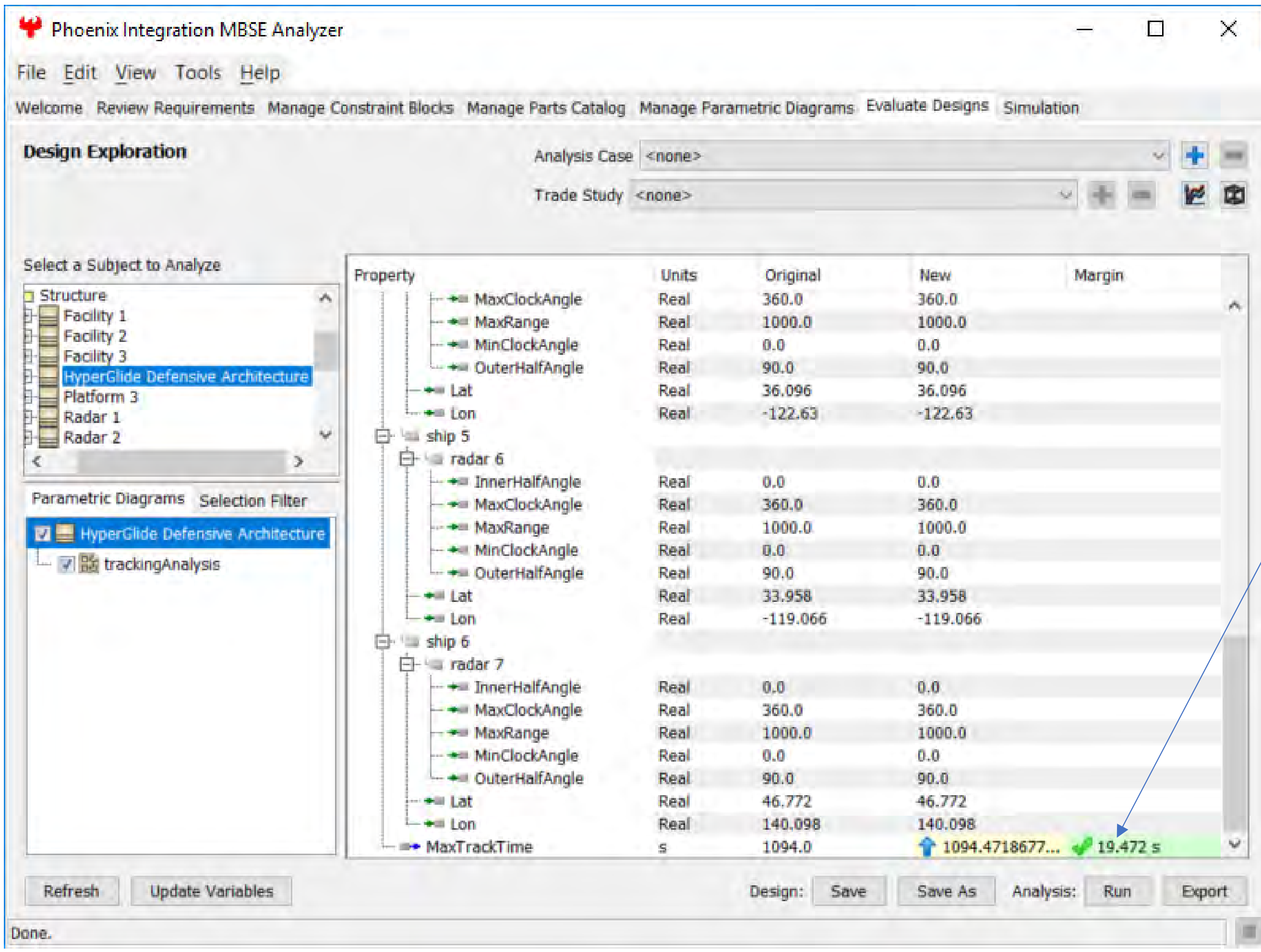


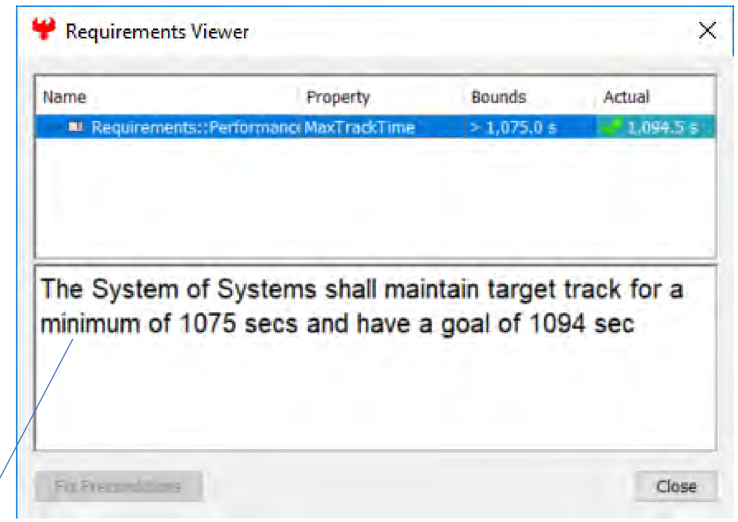


Interface to Perform:

- Requirements Trace
- Excursions
- Trade Studies

MBSE Architecture Requirements Trace Results





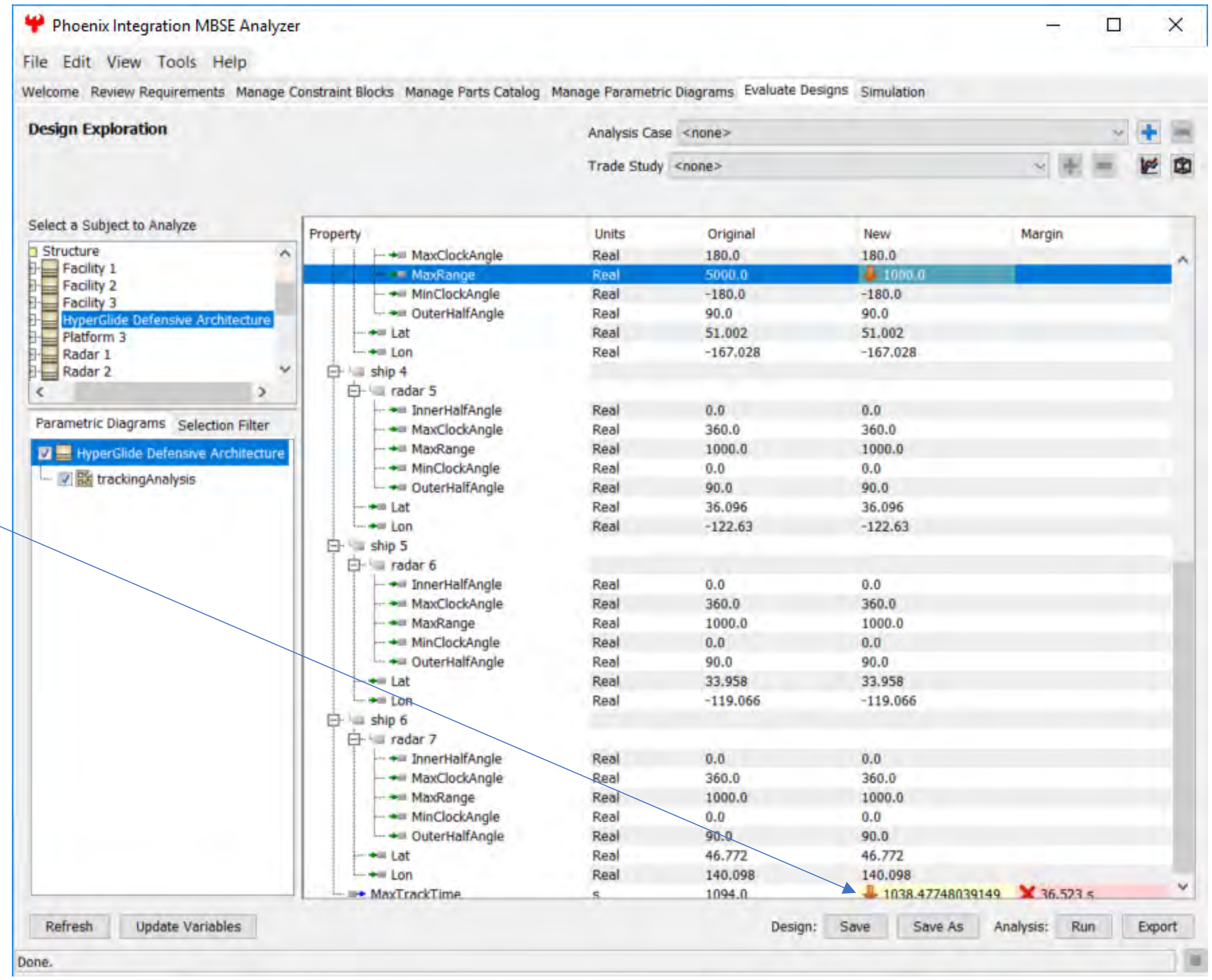
Automated Requirements Trace

- Initiates External Work Flow
- Returns all Outputs
- Performs Comparison to Shall Statement Value

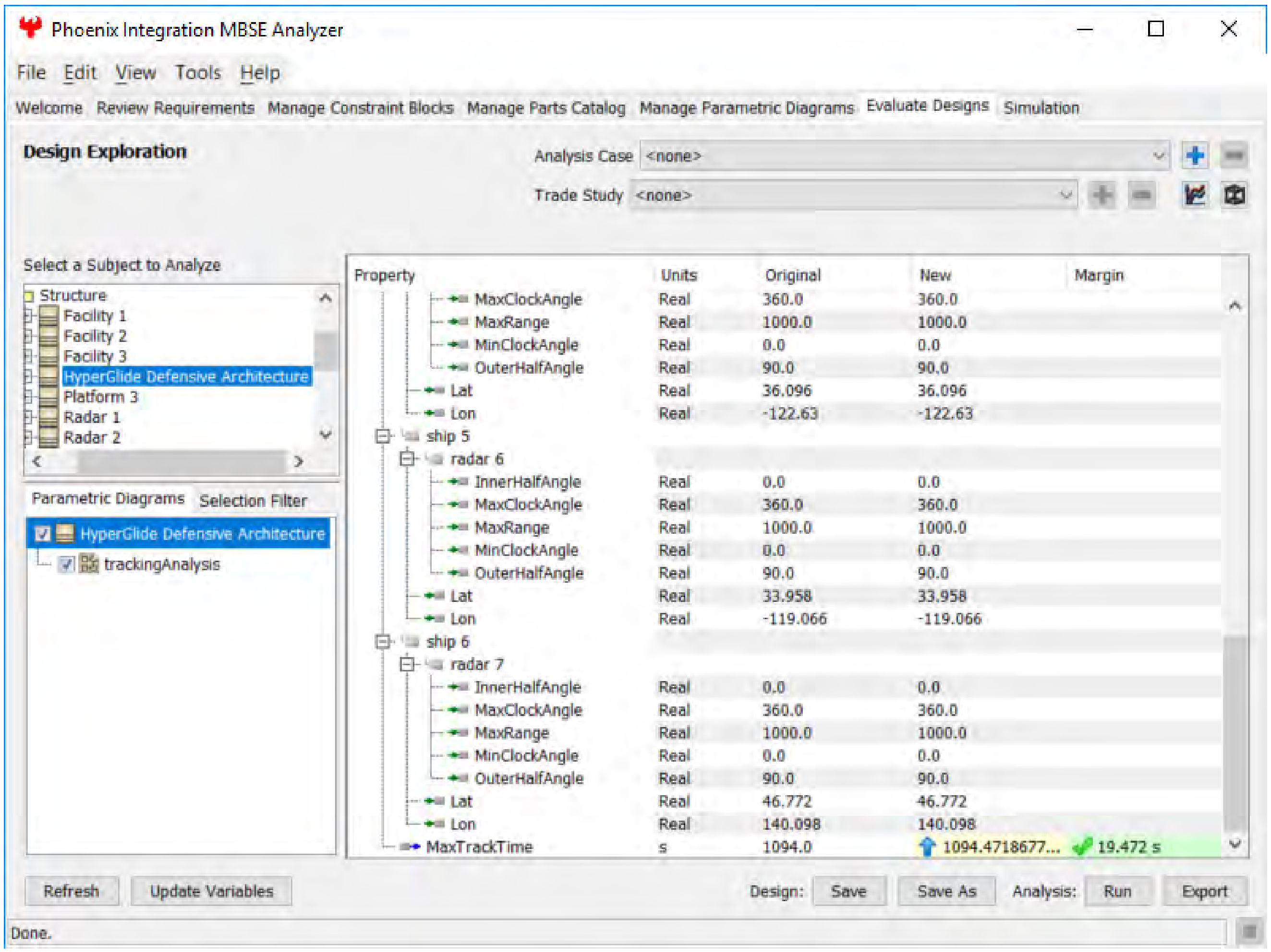
MBSE Architecture Requirements Excursion

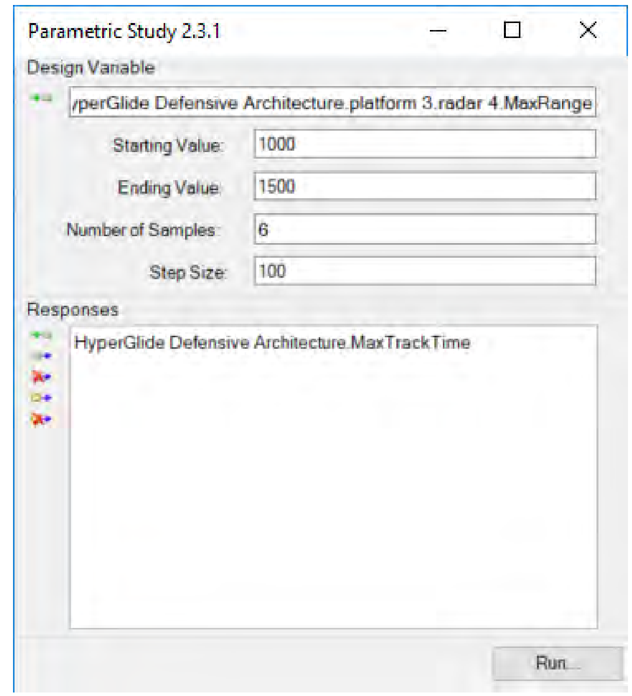
Excursion:

- Reduce the Max Detection Range on Platform 3 from 5000 km to 1000 km
- Results in a track time of 1038 sec
- Breaks the Track Time Requirement of 1075 sec or Greater



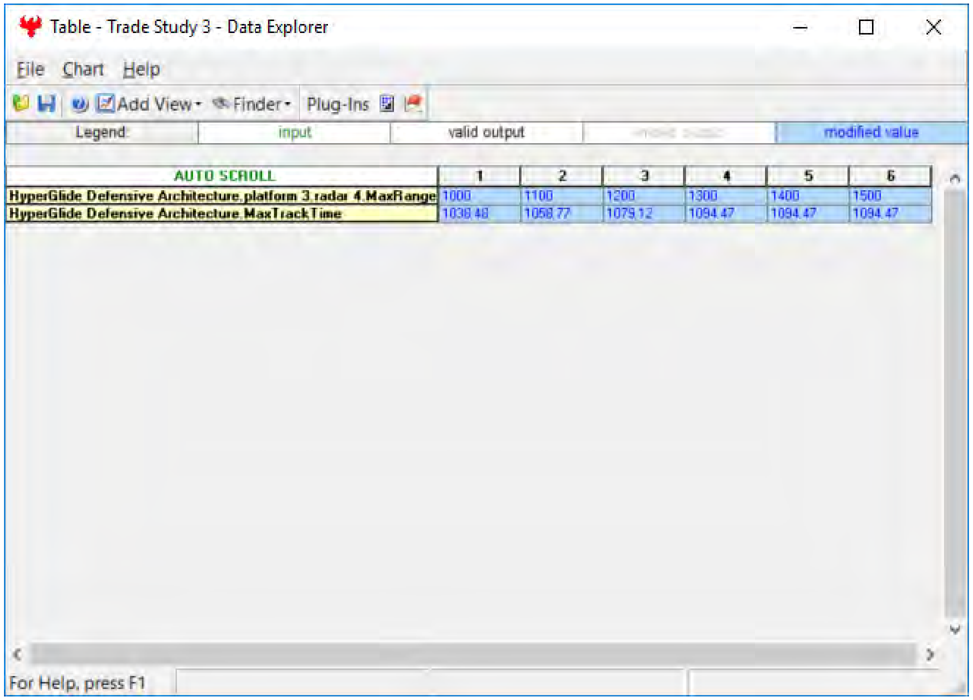
MBSE Architecture Requirements Trade Study

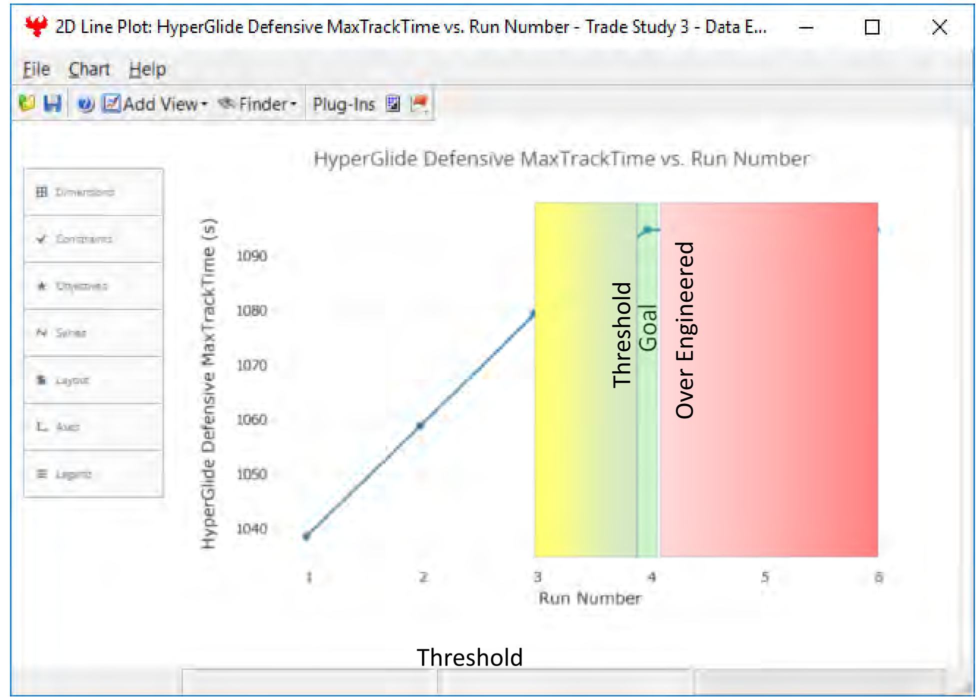




Parametric Study to Perform a Sweep of six runs with increasing track range to determine the minimum value for that parameter

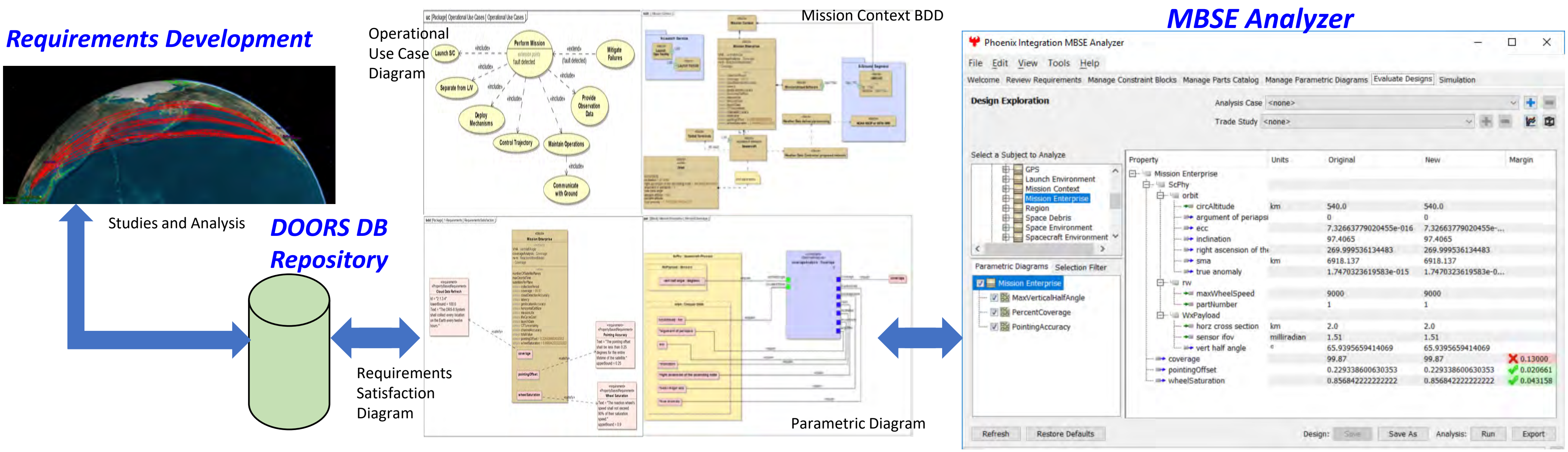
MBSE Architecture Requirements Trade Study Results



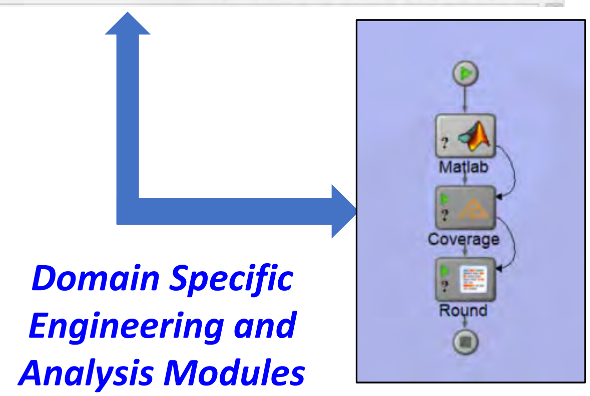


PDEF allows for the detection and characterization of performance metrics on the Left Side of the Systems Engineering V which yields savings by identifying key performance metrics that contribute to the overall Systems Requirements. Reducing Risk, Schedule, and Cost

PDEF MBSE Execution Summary

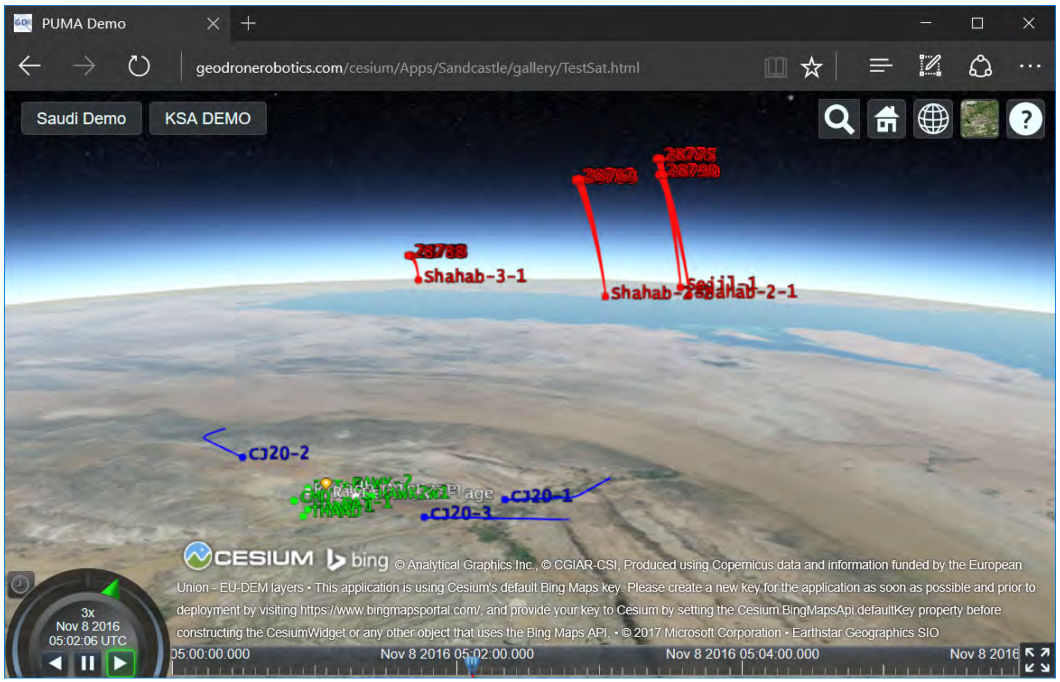


- **Connect systems architecture models with engineering analyses to calculate system performance, validate requirements, and perform Analysis of Alternatives and other trade studies**

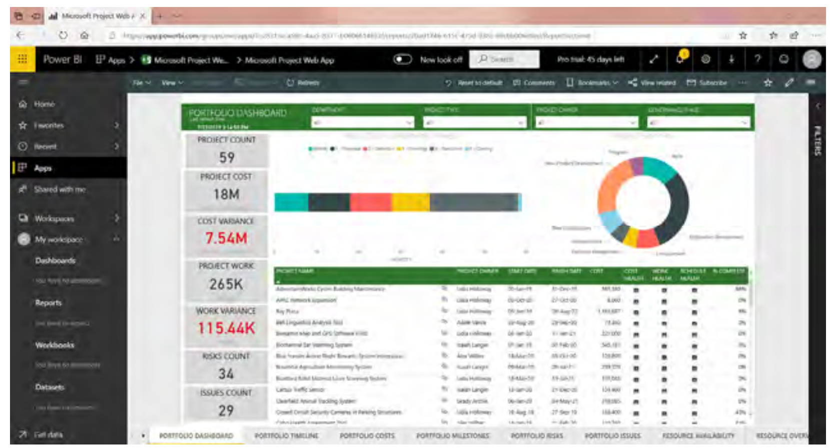


Web-Based Visualization and Decision Support

- Utilizes a web-based user interface
  - Interactive 2D/3D Visualization
  - Business Intelligence (BI) engine for analysis templates



PowerBI Gateway PowerBI Desktop



Interactive Graphical Analytics
Supports SQL, OLAP, Excel, Access
Can be deployed as Client/Server or Web-based
Defined Templates can be saved to xml file
Developer and Read-Only Viewer Versions

PDEF Roles and Missions

PDEF Roles and Missions

Management

PDEF Director

MBSE Administrator
Controls the MBSE baseline – Requirements database, approved MBSE Models, Interactions between models & archive management

Modeling Administrator
Controls all models and the approved model database, System Representations (Weapons systems etc) Officially approved scenarios and threat/adversary database and representations

System Administrator
Responsible for control of the M&S environment – ensures all updates to Software configuration are accomplished & Network Admin and System Backup

Lead Analyst
Responsible for analytic workflows and the Analysis Plan

Configuration Control Board

Execution

Development

- **Modeler:** *Develops all MBSE Diagrams – baseline excursion*
- **Simulator:** *Maintains all system Performance Models, financial and risk models, executes these models*
- **Coder:** *Develops "Wrappers", Sim Dev, Graphics engines , Cesium etc, Assists with output generation*

Production

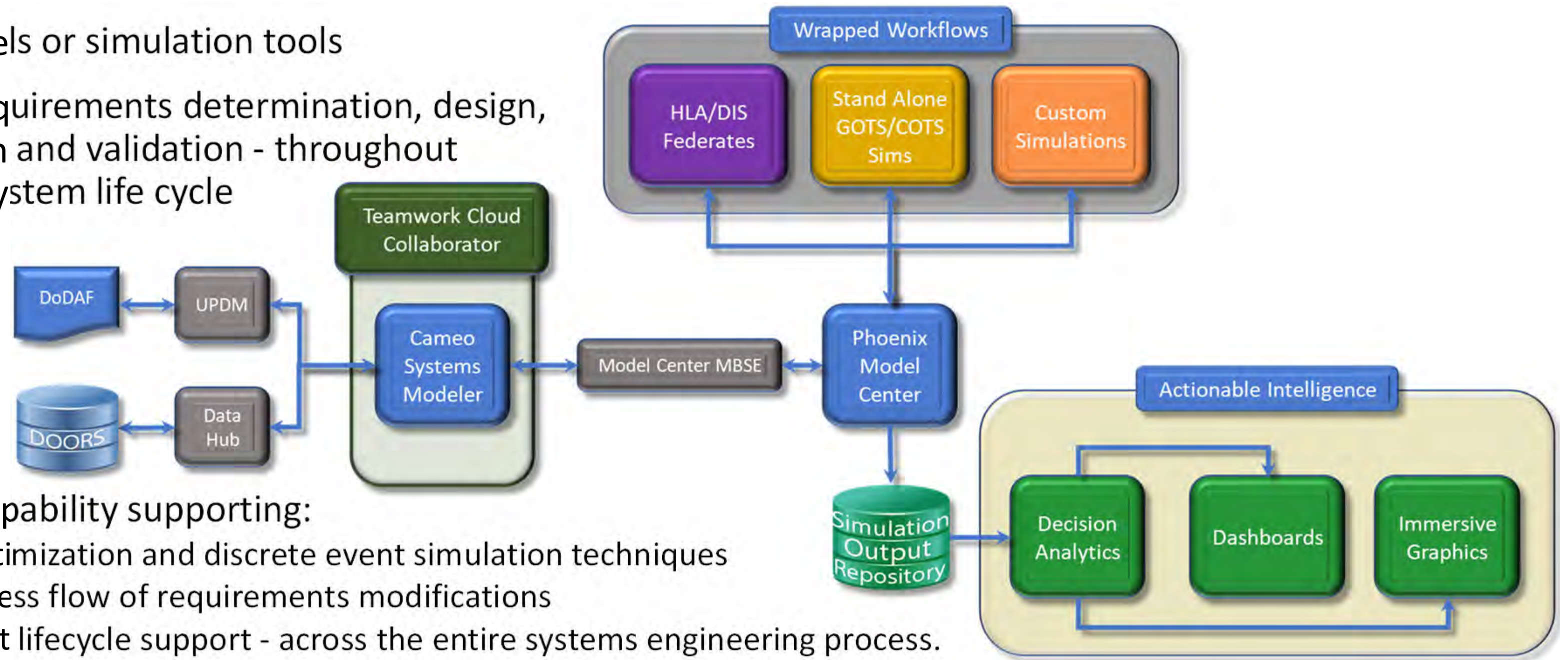
- **Analyst:** *Executes the Analysis Plan, Generates the Outputs – PLM and Windchill /Innoslate*

Sustainment

Trainer
Documents all procedures, develops and maintains the Training Plan

PDEF Summary

- PDEF is a model-based, simulation-driven framework supporting Model-Based Systems Engineering and the analysis of complex systems and systems of systems
- Unifies multiple stakeholder data and sources, models and simulations into an integrated analytical architecture
- Model Agnostic
- Federates any models or simulation tools
- Supports system requirements determination, design, analysis, verification and validation - throughout development and system life cycle



- Inherent analytic capability supporting:
  - Multi-variate optimization and discrete event simulation techniques
  - Handles a Seamless flow of requirements modifications
  - Full development lifecycle support - across the entire systems engineering process.
  - Enterprise-level system engineering integrating framework and processes
  - Leverages simulations, tools and data residing in the Enterprise Web Services (EWS) cloud

BACKUP