Modeling, Simulation, and Analysis Support for Mission Engineering at SAIC

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Purpose

- Outline how SAIC uses Modeling, Simulation, and Analysis (MS&A) as part of its Mission Engineering (ME) efforts

- List and illustrate some considerations in implementing MS&A for ME

Also…

- Describe some lessons learned and tips in applying Phoenix Integration's ModelCenter software for such efforts

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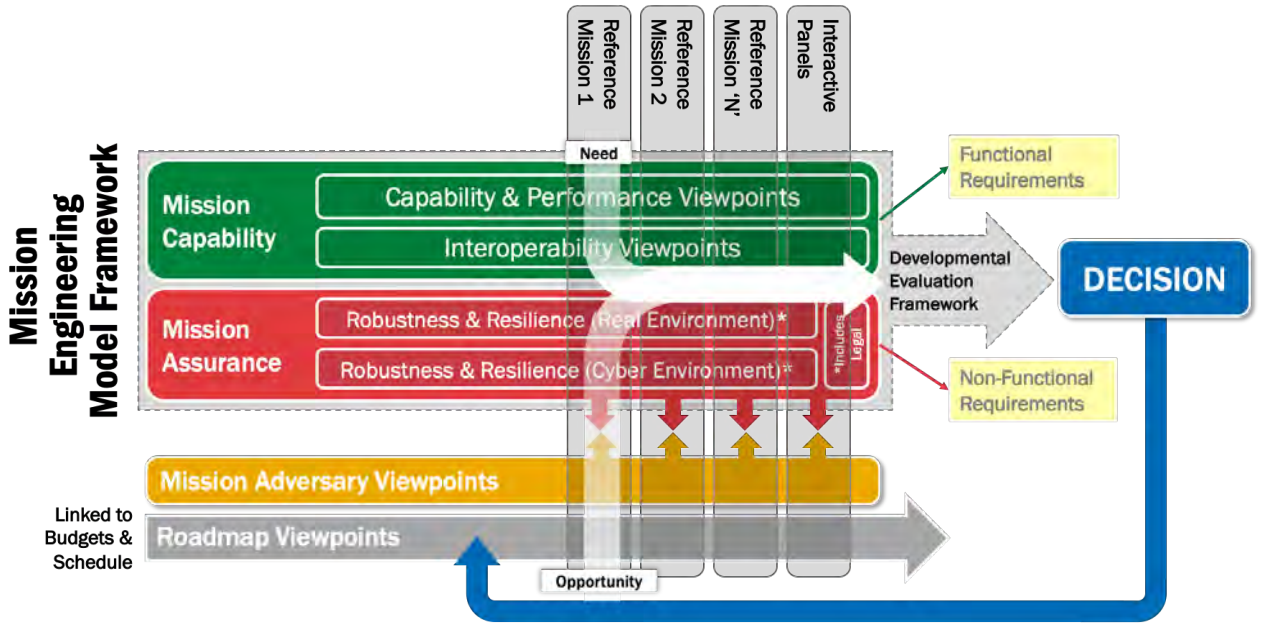
Topics

- Brief SAIC overview
  - Who we are
  - MS&A and ME offerings
  - Example using our methods
- Some Considerations for using MS&A within Mission Engineering
  - Accessibility
  - Compatibility
  - Applicability
  - Innovation



<u>For each Consideration:</u>

Factors and challenges

One or more examples

Disclaimers

- *Discussion of specific vendor products does not imply endorsement, by SAIC, as the sole approach for all customer use cases*
- *No classified material in this presentation*

SAIC at a Glance

DOMINANT

POSITION IN FASTEST GROWING SEGMENTS:
SPACE AND DIGITAL TRANSFORMATION

$7.1B	26,000+	5,900	54%	60+
REVENUES	EMPLOYEES	VETERANS	HOLD A SECURITY CLEARANCE	ALLIANCE PARTNERS

Our Customer Mix

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SAIC Digital Engineering Transforms Mission Success

MBSE

- Developing and using *SysML models* that serve as the *authoritative source for system design* and the "hub" for the rest of the digital thread

DE Ecosystems

- Deploying, configuring, and maintaining the *underlying infrastructure* with the required performance, scalability, security, and accessibility *to run the integrated toolchains* needed to implement our DE capabilities *in a collaborative integrated data environment*

Digital Thread

- Integrating engineering solutions, composed as a set of models and data, where *information is digitally linked* across tools and domains to ensure traceability, completeness, and design consistency *across the entire solution*

Digital Twin Frameworks

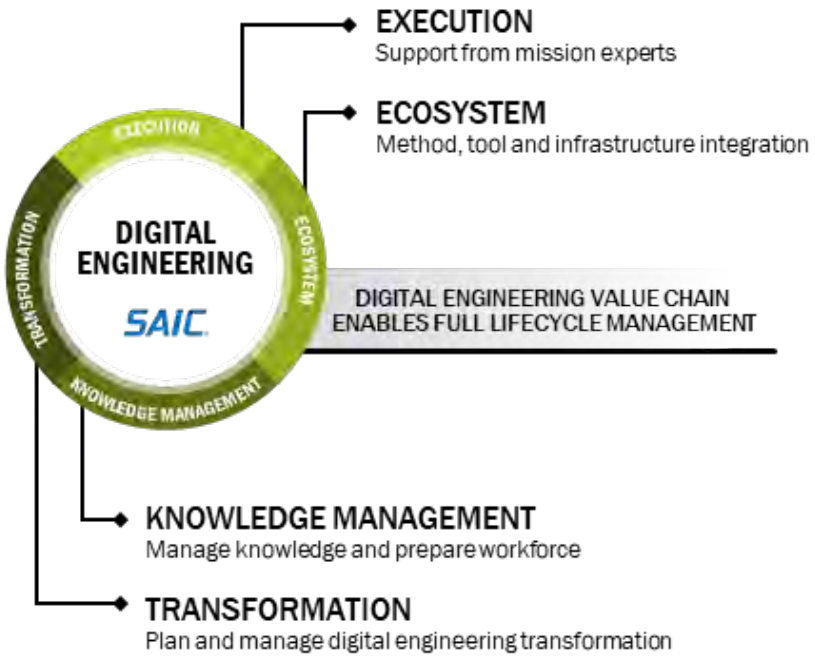
- Creating digitally linked *sets of physics-based simulations* that answer high consequence, high probability performance questions, *based on field data input*, over the life of its *corresponding physical twin*

Tool Federation (Semantic Broker)

- Using *domain ontologies* to *integrate data across disparate tool chains* that otherwise would not integrate to ensure critical Mission Engineering *data can persist* when applications are no longer available

Core DE Capabilities

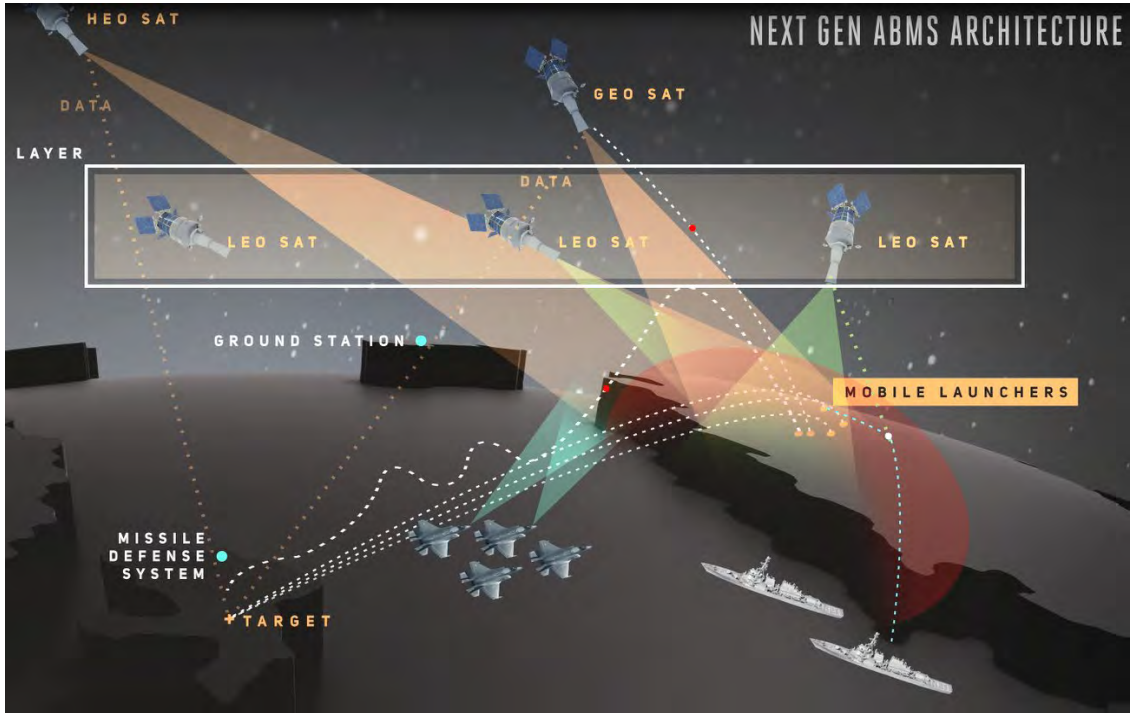
WE PROVIDE



Leveraging $15M+ SAIC investments in Digital Engineering

Threat-Based Analysis and Mission Engineering

- **SAIC uses proven (>35 years) quick response M&S**
  - Examine existing and future force design performance against present and potential threat system capabilities
  - Customers → MDA, JIAMDO, DARPA, SSC, USAFE, COCOMs, DTRA, OSD, JCS, Services, DHS, etc.
  - Mission Engineering: Complete End-to-End Kill Chain
  - Hypersonics, Space, C4ISR, IAMD, CUAS, Multi-Domain Ops
- **Analysis determines performance gaps and drivers**
  - Mission dictates future force design
- **Rapid turnaround allows us to analyze many threat parameters and force designs**
  - Compare, identify and optimize force designs using appropriate metrics
  - Agility to adapt tools to customer questions and needs
- **SAIC delivers force design analysis and solutions**
  - World-class quick response modeling, simulation and analysis capability
  - Proven experience, knowledge and capabilities



Advanced Concept Experience

- Airborne Comm Node
- Global Hawk & Dark Star
- JSTARS, Predator
- Counter sUAV
- Hyper/Supersonic CMs
- Airborne Weapons Layer (AWL)
- Air Defense Initiative
- Airborne EA AoA
- C-Hypersonics AoA
- Space SA, SC

Threat-Based Digital Force Design Enables Speed to Mission

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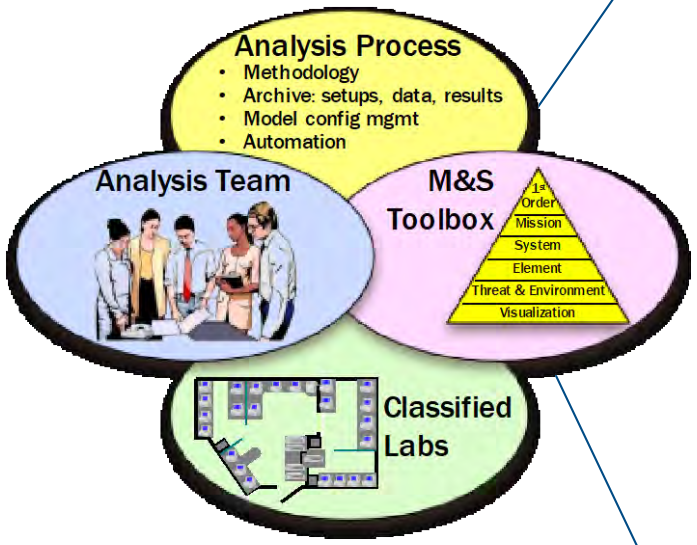
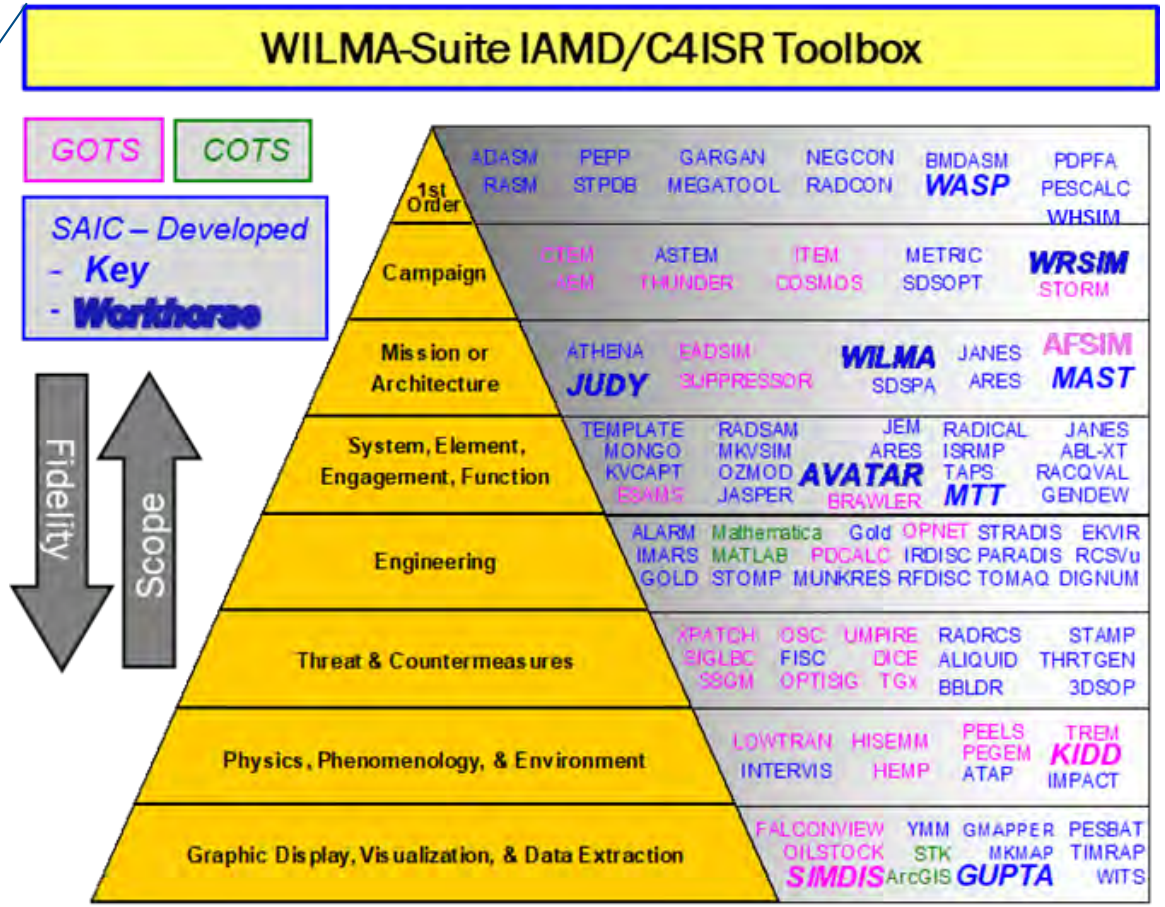
Example: M&S Suite Development and Analysis Support

People, Processes, M&S Toolbox, & Computer Labs



End-to-end simulation covers difficult- or impossible-to-test scenarios



Maintain Large Suite Of M&S Tools Support Customer, With These Key Models:

- **WILMA → Cornerstone For Med-Fi, Quick-Turn BMDS Effectiveness**
- **JUDY → Evaluation Of Air Defense/Cruise Missile Defense Advanced Concepts**
- **AVATAR → Hi-Fi Simulation For 1–on–1 Interceptor Engagement Analysis**
- **WRSIM → Examine BMDS performance Within The Raid Context**

Analysis needs drive model choices

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Some Considerations for MS&A in Mission Engineering

1. Accessibility of Tools for Non-Experts
   - Can we apply models across the engineering lifecycle if only a few people can use the tools?

2. Compatibility of Key Simulations for Mission Engineering
   - Can industry-standard tools fulfill mission engineering requirements?

3. Applicability of Models within Mission Engineering
   - What are some ways to integrate detailed models for ME?

4. Innovation in a Process-Oriented Enterprise
   - How can we enforce process rigor but still foster innovation?

Consideration 1: Accessibility of Tools for Non-Experts

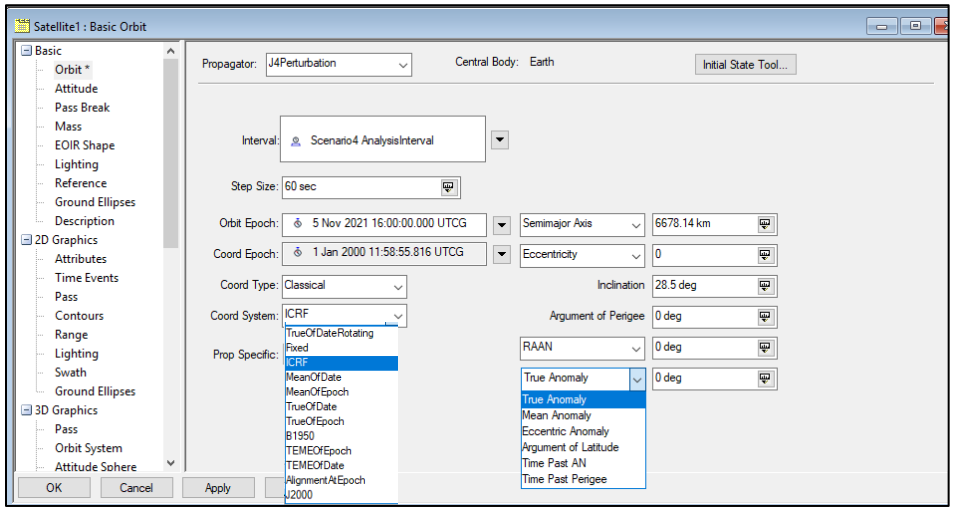
Aspiration: Make tools accessible, to the workforce, across the engineering lifecycle

Difficulties

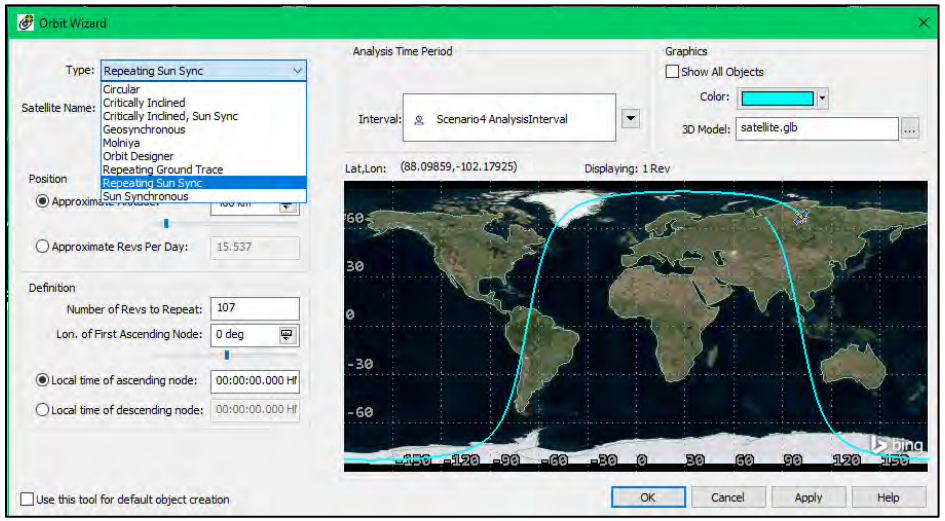
- Some tools require considerable training and experience for effective use
- Available workers lack background and skills
  - Domain knowledge
  - Coding
- Insufficient time and budget to learn and do

Approaches

- Investment in user interfaces
- Workflow tool with U/I's
- AI/ML-empowered tools



Good but hard for non-experts: STK Orbit Parameter GUI



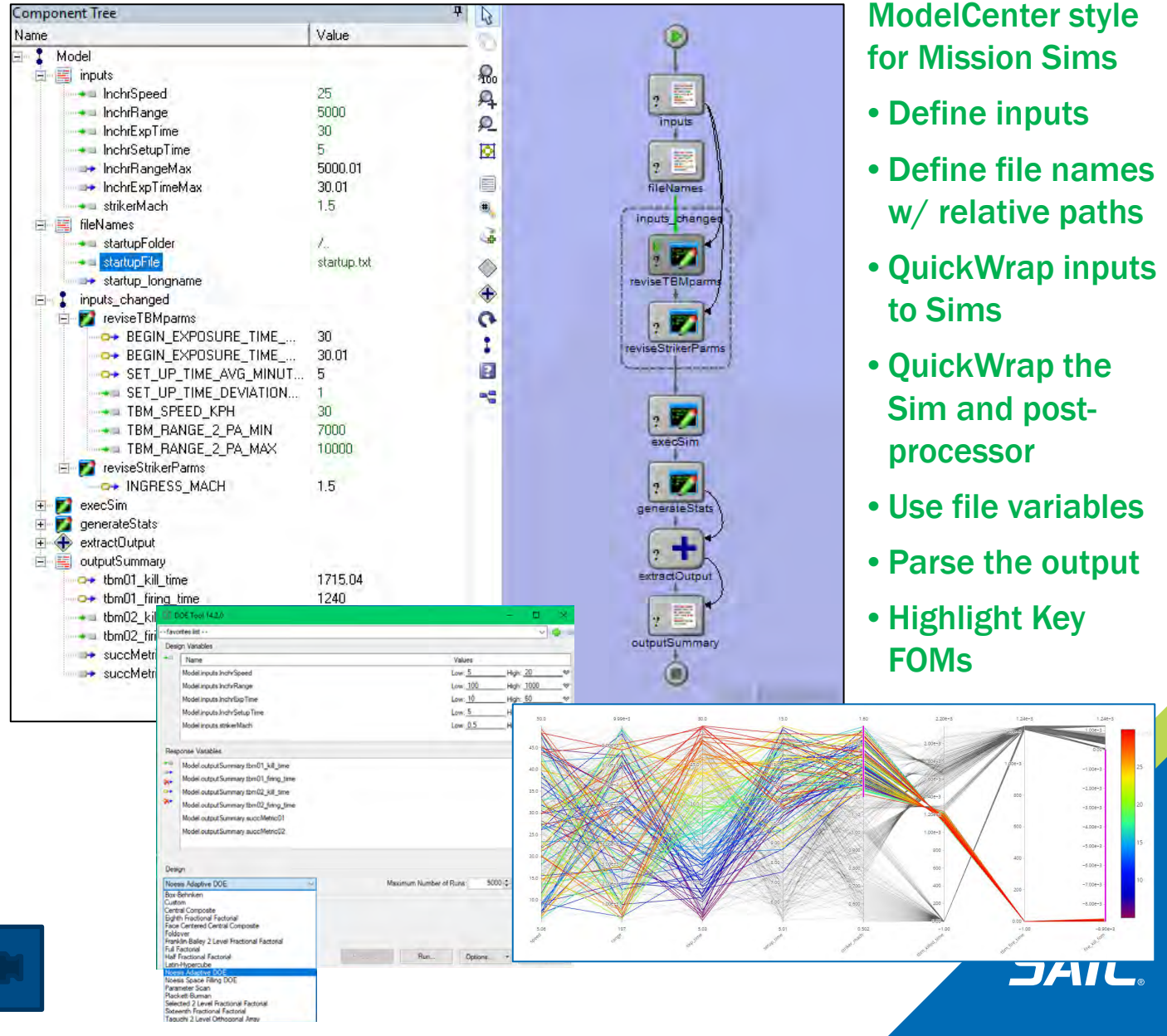
Refined, user-friendly interface: STK Orbit Wizard

ModelCenter as a User Interface (U/I)

- Considerable capability in software with lacking or complex U/I's
- ModelCenter provides a unified U/I for
  - Legacy, command line tools
  - Mission Simulations (e.g., AFSIM)
  - Excel, Matlab, STK, other COTS tools
- Enables a workflow designer to limit variables exposed to end users
- Relatively quick way to provide a U/I
- Added benefit: access to ORSA, optimization, and prob. analysis tools

Result

"You can do in a few minutes what would have taken me weeks…"



ModelCenter style for Mission Sims

- Define inputs
- Define file names w/ relative paths
- QuickWrap inputs to Sims
- QuickWrap the Sim and post-processor
- Use file variables
- Parse the output
- Highlight Key FOMs

Excerpts of
AFSIM-RAVE-ModelCenter
Approved for public release

MSBAI's GURU: AI/ML-enabled U/I for SAIC's AVATAR

Problem

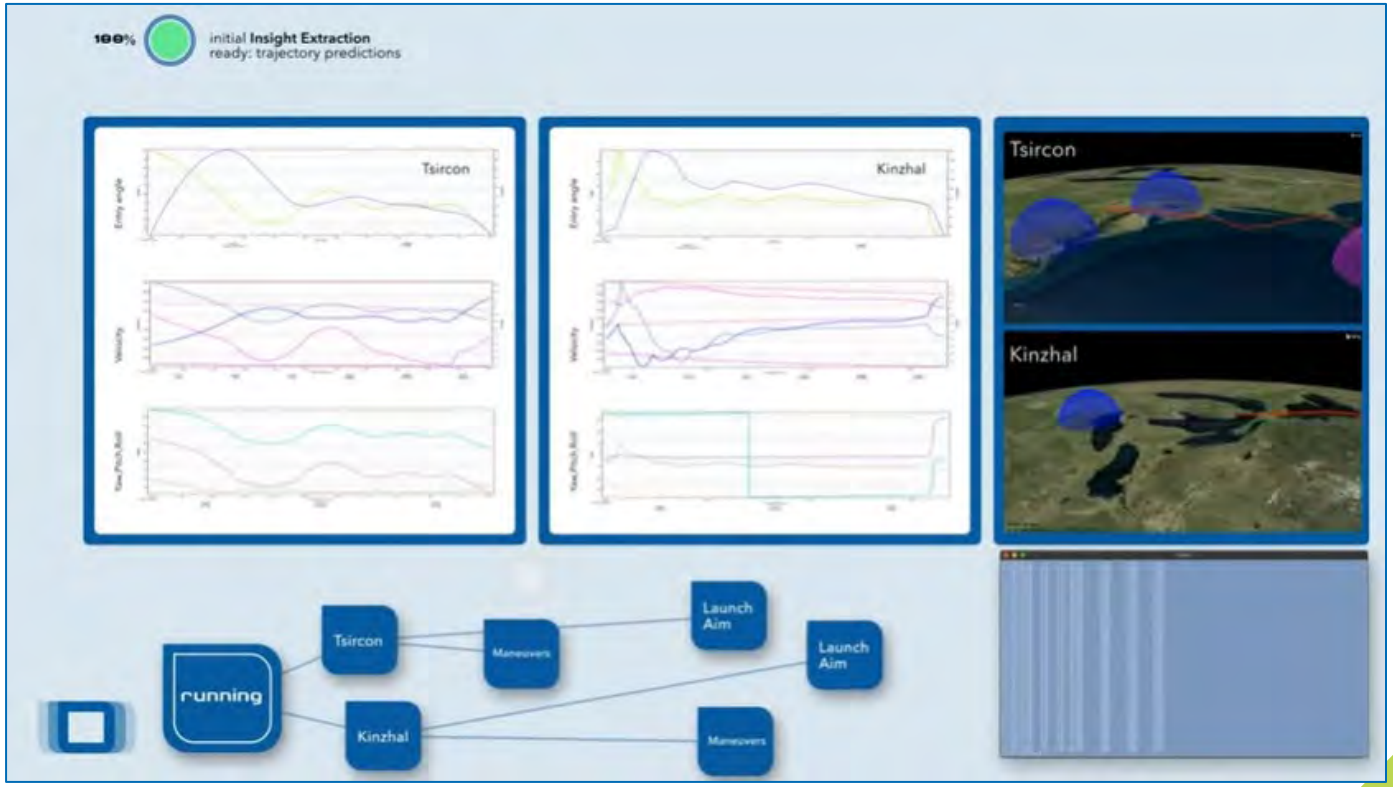
- Engineering-level simulations are complex
  - Many inter-dependent variables
  - Much experience and expertise often needed to create meaningful simulations
  - Can take experts a long time to build new models
- Simulation SMEs often not available
- We often cannot wait for training

Solution

- Use AI/ML to run numerous cases on HPC
- Create a U/I that assists in defining meaningful cases

Result

- Lowers barriers for non-SME users



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Consideration 2: Compatibility of Simulations for ME

Aspiration: Use industry-standard tools and mission simulations together seamlessly

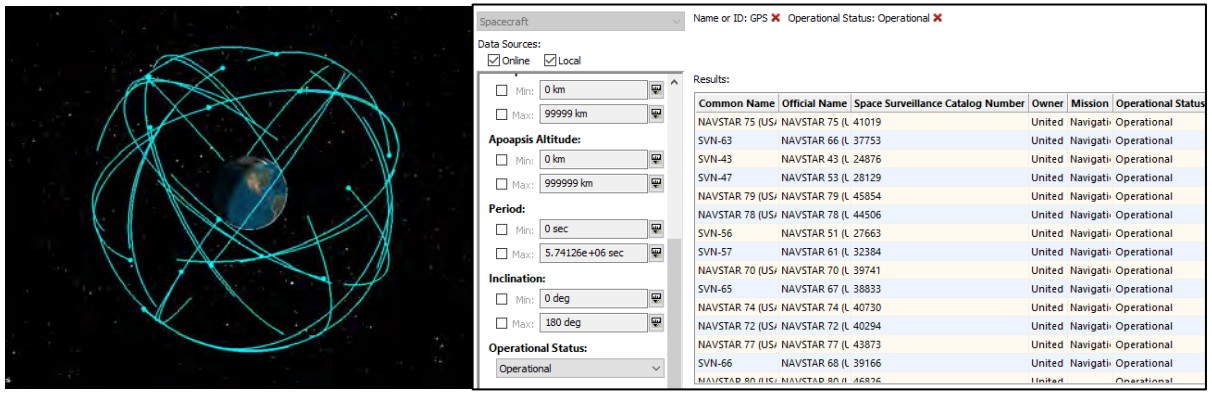
Difficulties

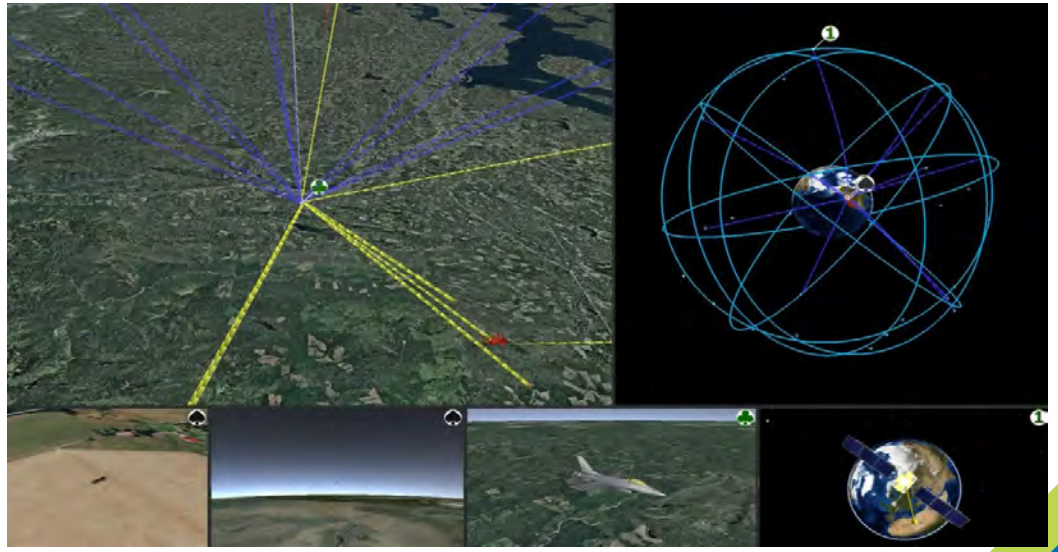
- Some tools don't do mission simulation;
  - Do not describe behaviors and interactions
- No simple way to integrate analysis and mission tools for all models and functions

Approaches

- Convert selected features from MS&A tool to mission tool
- Integrate with DIS/HLA
- Make the mission simulation more capable
- Make the analysis-focused simulation more capable

STK and satellite database





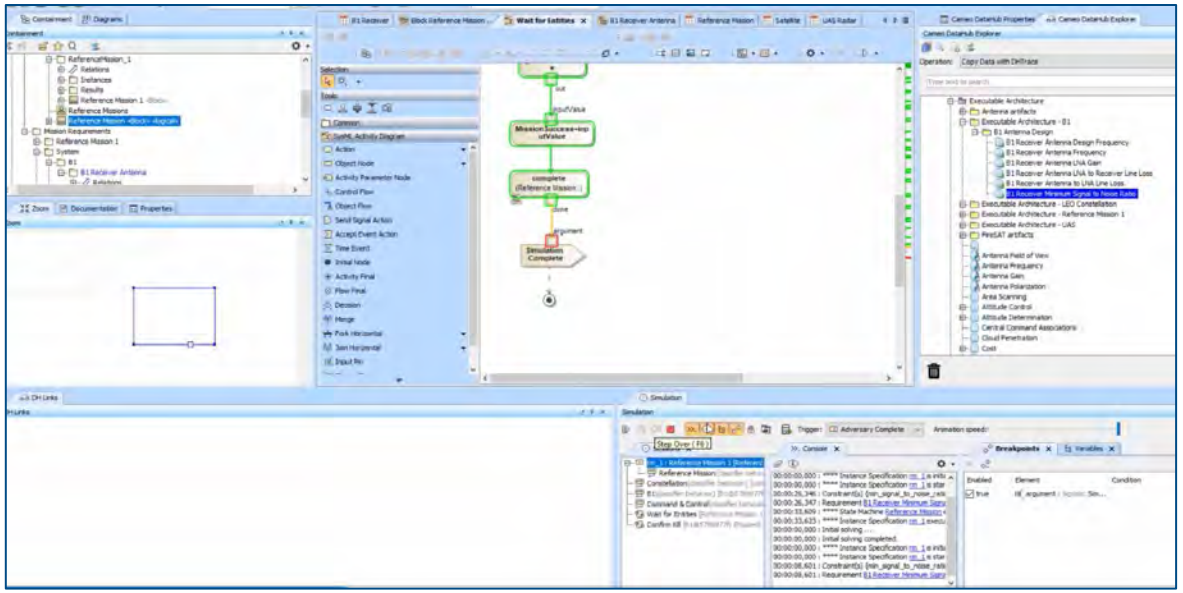
AFSIM https://www.youtube.com/watch?v=8DMY5leZ2kA

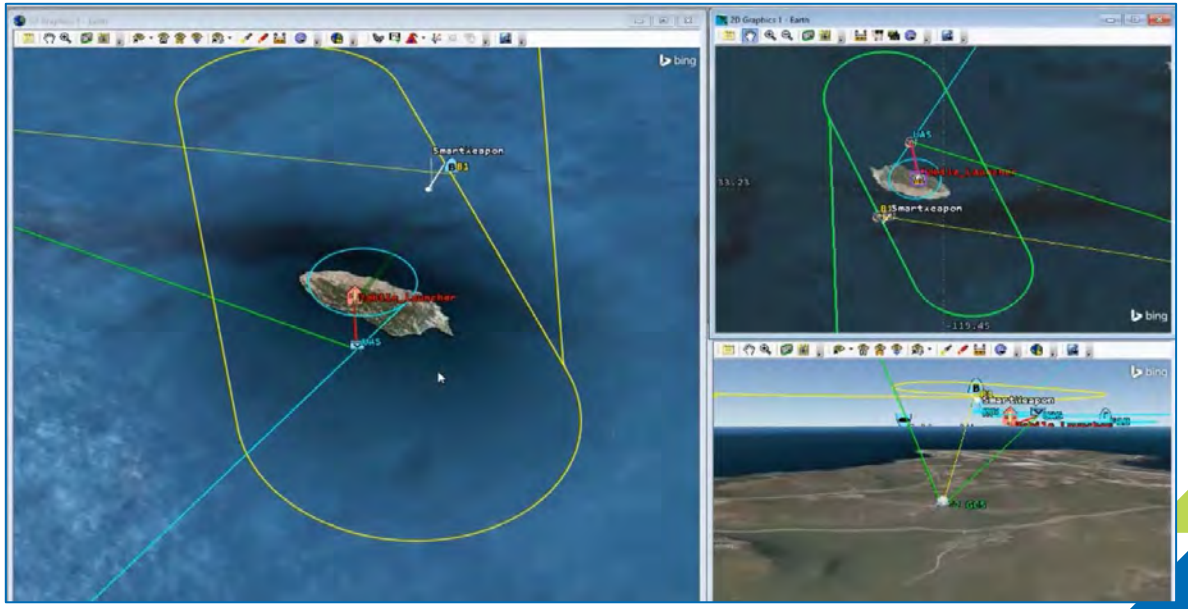
Combined MS&A/Mission Tool: STK, Ansys Minerva, and Cameo

Use STK's mission capabilities with Cameo's behavior descriptions

- Based on Ansys Minerva
- Drive STK from the Cameo model
  - STK follows behaviors defined in SysML
  - Extract mission FOMs
  - Confirm requirements met based on a simulation

Result: Industry-standard tools adapted to Mission Engineering





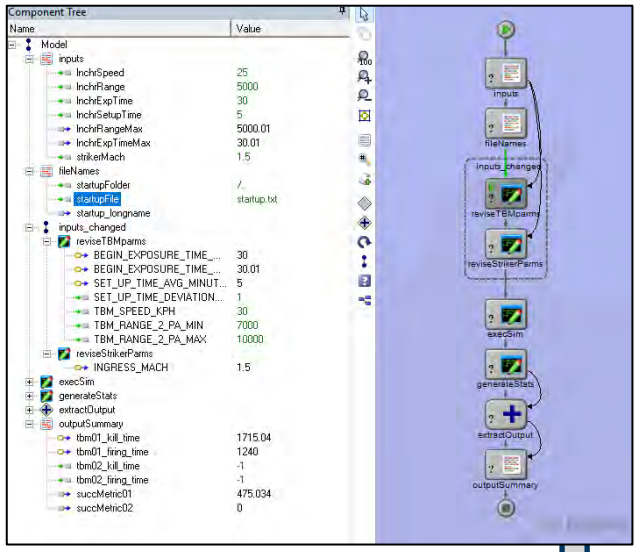
SAIC JADC2 video

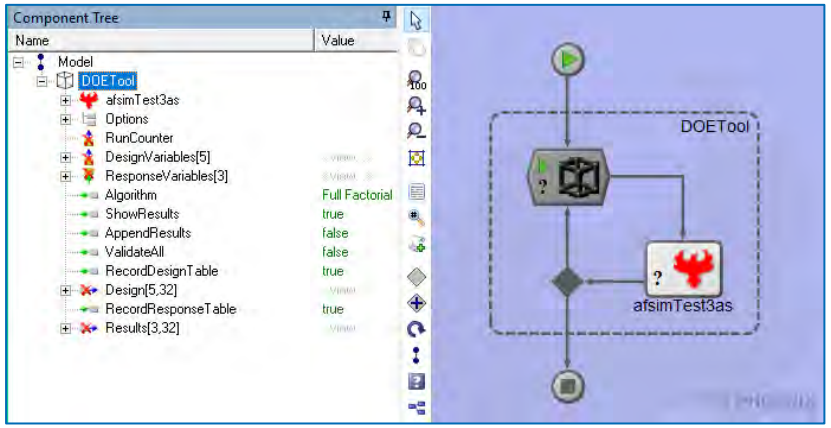
ModelCenter with PACZ

Ensure ModelCenter workflows are widely applied in the DE/ME ecosystem

- Consider portability from the beginning of a ModelCenter project
  - Use relative file paths, file variables
  - Use AnalysisServer or ModelCenter Cloud
- Clearly define variables and artifacts
  - You might not be the next user
  - Makes it easier to verify
- Plan to create PACZ files
  - Test on multiple platforms
  - Access to Cameo or Rhapsody via ModelCenter MBSE

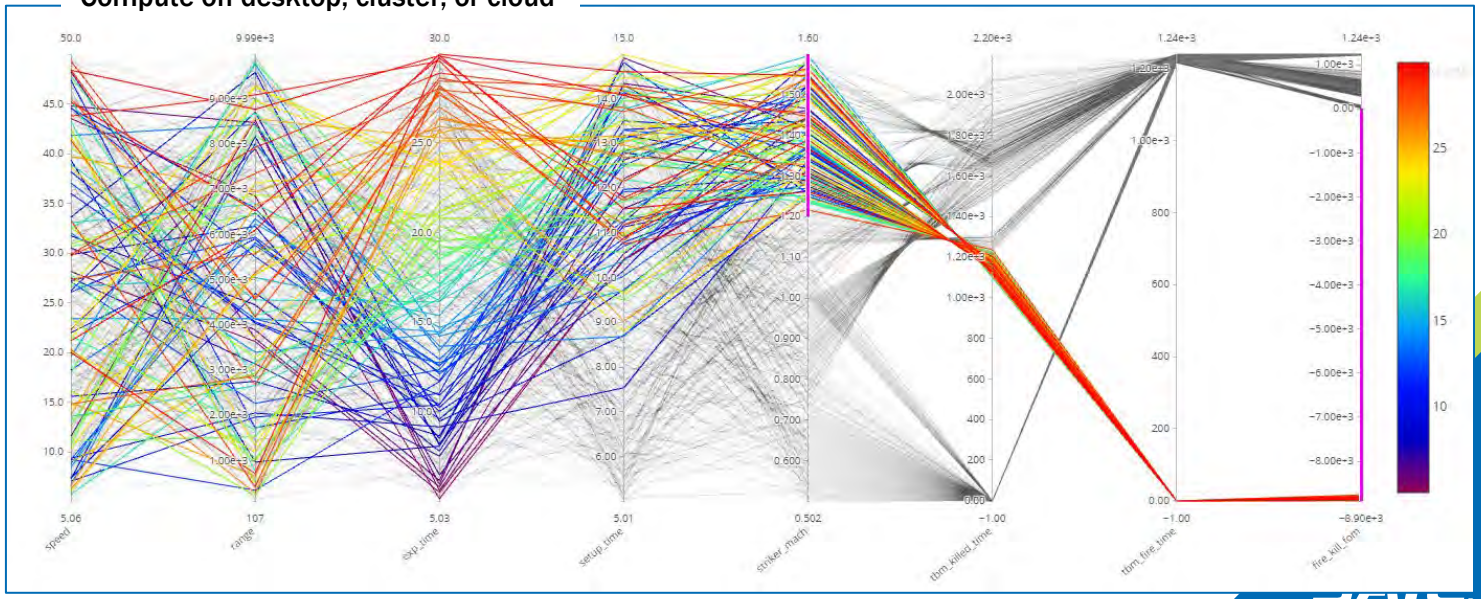
Result: Improved ability to combine and curate tools





Project saved as PACZ Embedded in DOE block

Compute on desktop, cluster, or cloud



Consideration 3: Applicability of Models Within Mission Engineering

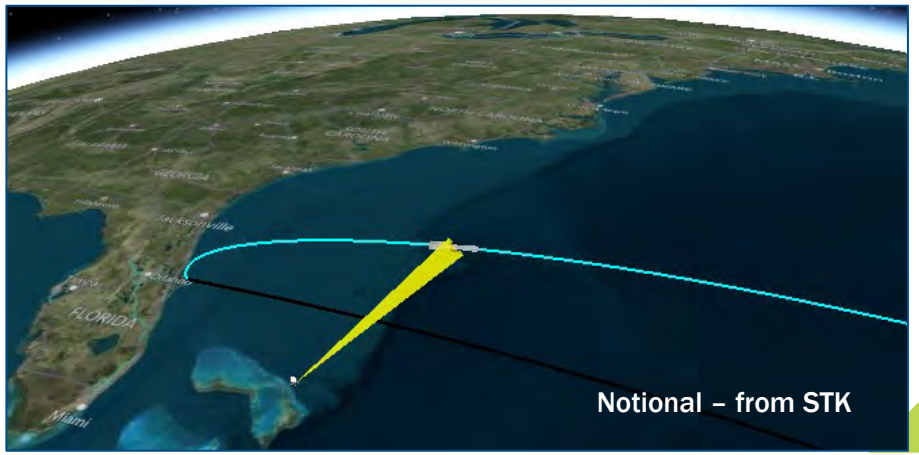
Aspiration: Apply the same engineering models throughout the lifecycle

- Consistent with a single source of truth
- Fewer models to maintain

- Difficulties
  - Hard to use the same solution end-to-end
  - Model might be too detailed for a mission simulation
  - Might be too slow to execute
  - Might be hard or impossible to obtain
    - OEM-owned; proprietary; not deliverable; IP issues
    - Represents a system not in digital form

- Approaches
  - Derive, simplify, validate, curate with a process
  - Benchmark simplified models vs. more detailed
  - Create and verify surrogate models


nasa.gov



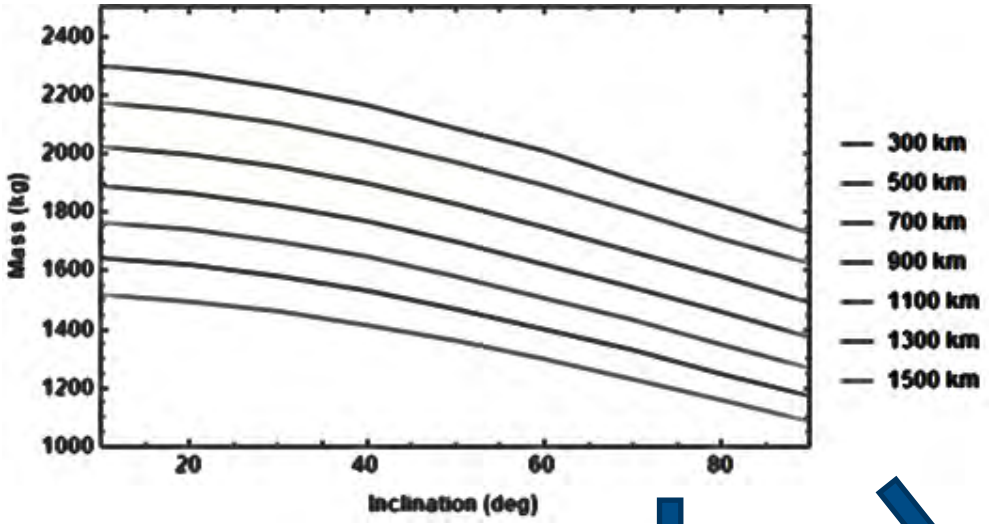
Notional – from STK

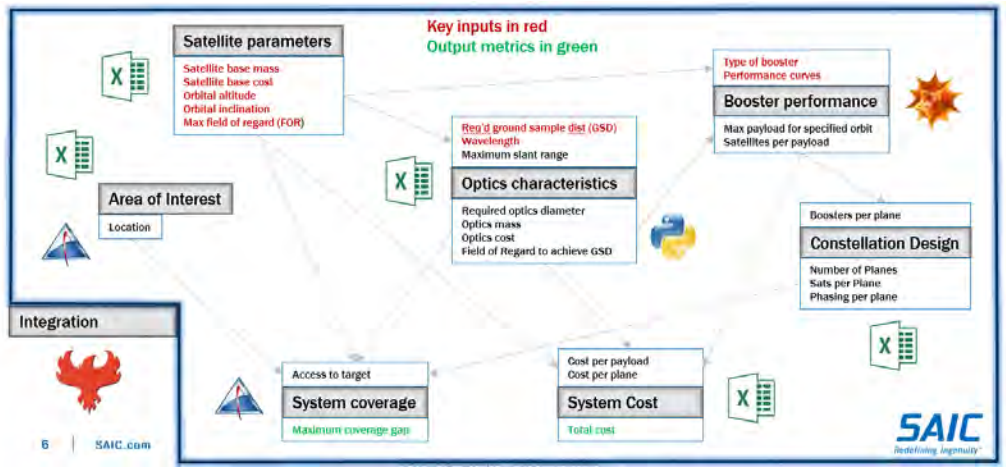
Surrogate Modeling

Rapid analysis requirement

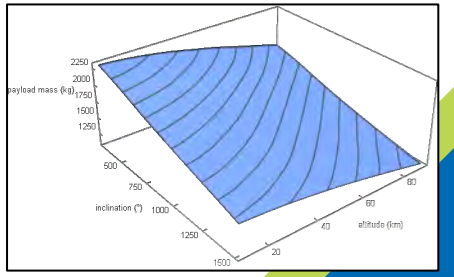
- Include mass-on-orbit performance in an initial, integrated smallsat analysis
  - Very sparse documentation available from OEM
  - Parametric analysis; optimization
- Naïve method
  - Put a full launch simulation in the workflow - “In the loop”
  - Slow, difficult, and uncertain to create and verify new models for a launch system
- First solution
  - Measure a table of points from OEM graphics
  - Create a surrogate model
    - Two days to code and verify
  - Embedded in a ModelCenter QuickWrap, .bat file

Input data from OEM – graphic only
(notional example; intentionally blurred)





Digital surrogate model

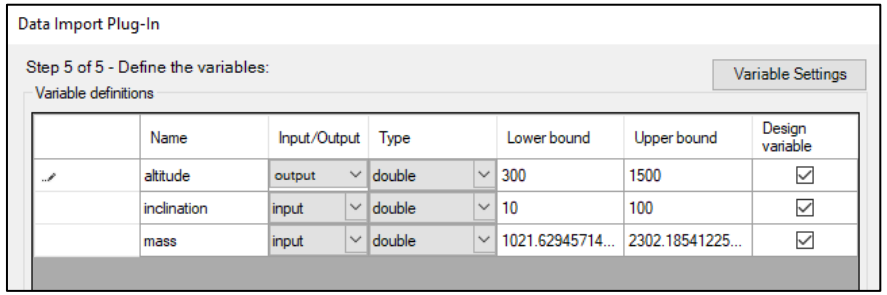


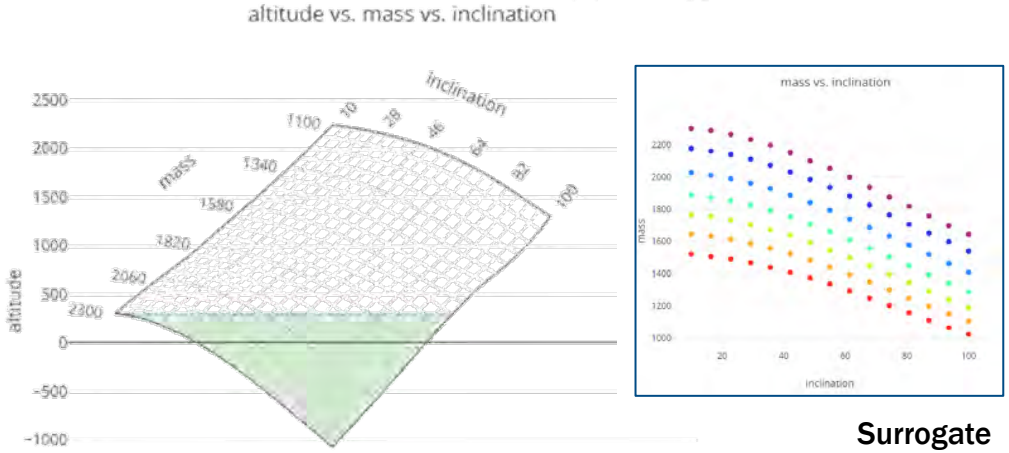
Better Solution for Surrogate Modeling

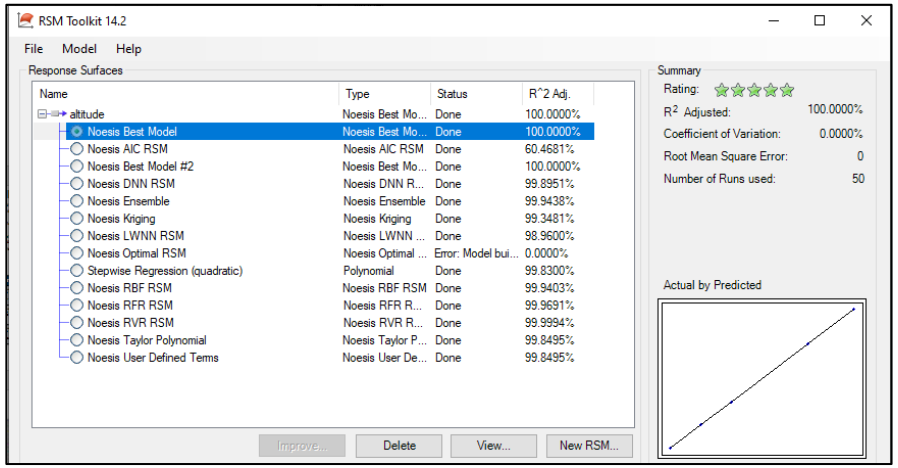
Create a surrogate from a data table

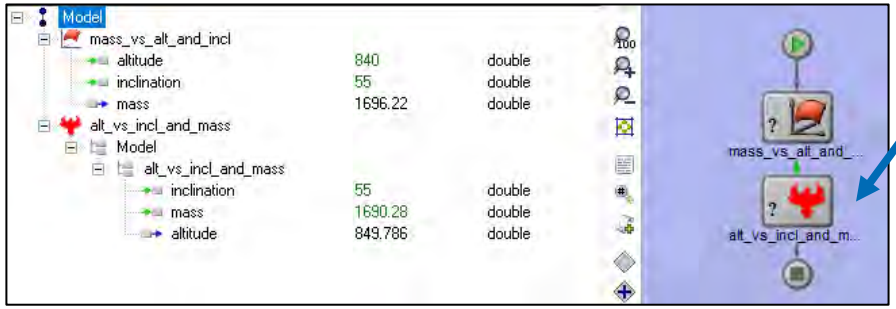
- Ingest into ModelCenter Explore with the Data Import Plug-in
- Apply the RSM Toolkit

- Took less than two minutes to ingest the data, evaluate, and place into ModelCenter
- Provides diagnostics of accuracy
- Enables redefining dependent variable









Export to AnalysisServer
- Curate
- Reuse

Surrogate modeling example

Consideration 4: Innovation in a Process-Driven Enterprise

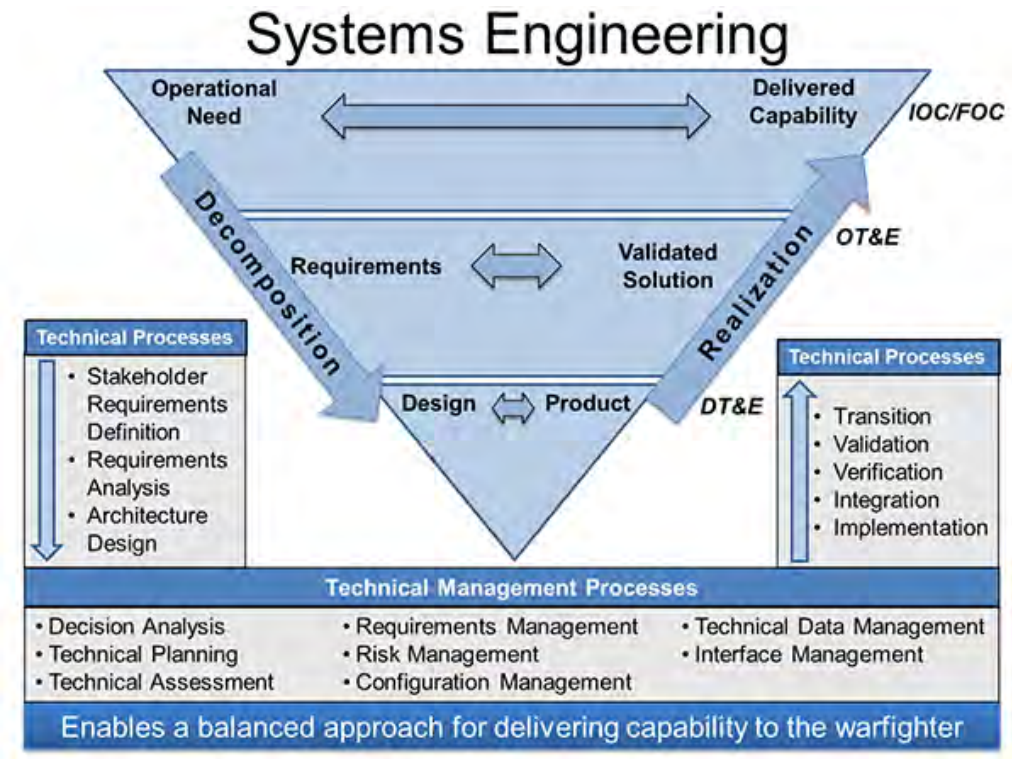
Aspiration: Encourage Mission Engineering innovation within the DE framework

Difficulties

- To reduce risk, we look only to proven SE tools and processes
- Sometimes have to use validated M&S tools even if hard to integrate or inferior
- Biased towards sunk costs and existing infrastructure

Approaches

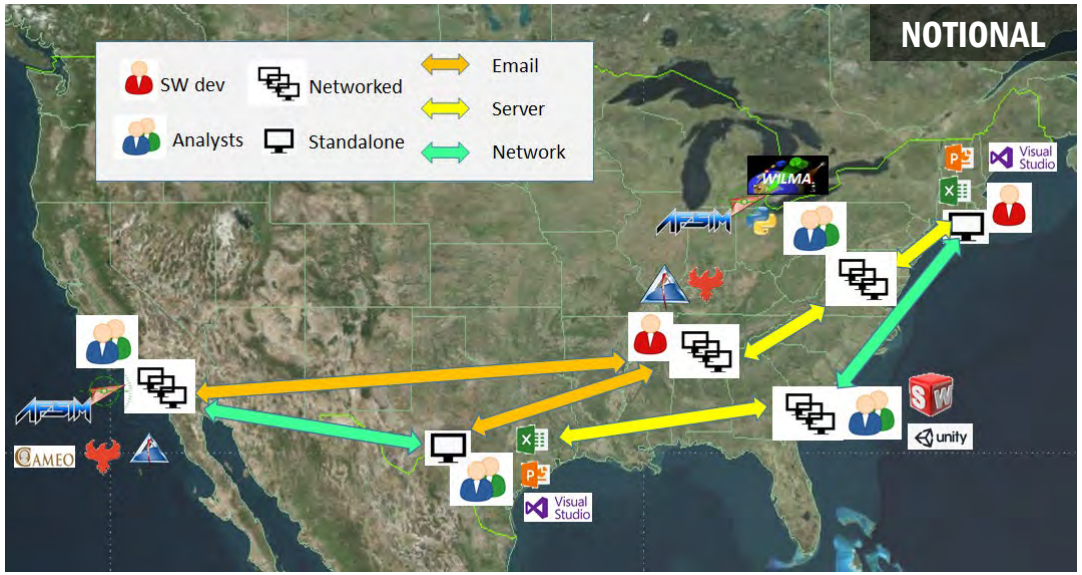
- Use Agile processes where appropriate
- Make the SE process itself resilient
- Include innovation in contract scopes if possible
- Create pilot programs
- Give selected workers freedom to innovate



DAU Acquipedia: Systems Engineering Process

How do we enable innovation happen in a rigorous process?

Innovation in Infrastructure: MS&A on Cloud

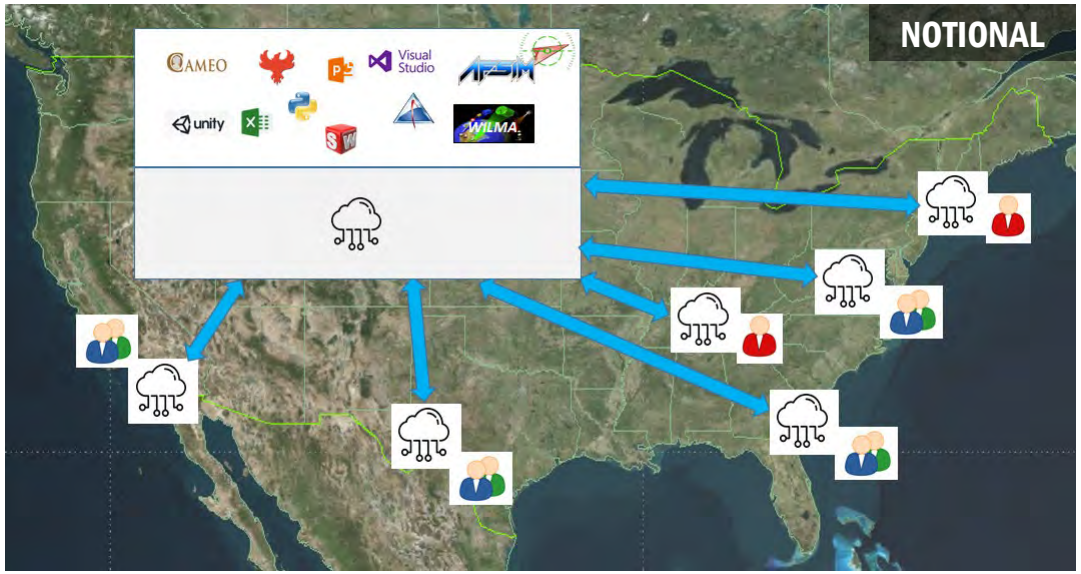


PREVIOUS/CURRENT STATE

- **Solution Teams:** M&S analysts, developers, operators
- **Obstacles:** Geography, orgs, time zones, networks, data transfer, …
- **Moving Parts:** M&S software, analytics, software development, formats, …
- **Data Transfer:** Email, server, network
- **Integration:** Slow, tedious, error-prone, bottlenecked
- **Cost Assessment:** Hard to estimate
- **Security:** Long ATO

SOLUTION

- **Execute:** M&S and analytic tools in one GovCloud environment
- **Scale:** Elastic cloud based
- **Integrate** with cloud based M&S
- **Transfer** data within cloud
- **Access** from anywhere and by anyone on project
- **Define** a reusable solution
- **Visualize** from M&S on cloud
- **Security:** Continuous ATO



OUTCOMES

- Eliminate M&S stovepipes
- More effort on solutions, not IT
- Faster solutions
- Stand up new work faster
- Teamwork without geographic and network barriers
- Common framework across multiple security levels

Innovation for Production Speed: Temporary AWS Nodes

Objective

- Satellite constellation coverage trades – in-house code
- Vary satellite orbit and viewing parameters
- Create Pareto fronts for analysis
- Example FOMs: average gap, max gap, and minimum number of satellites for for full coverage

Problem

- With standard employee computer – would take 6-8 weeks based prior scenarios
- Compute cluster occupied with other work

Solution

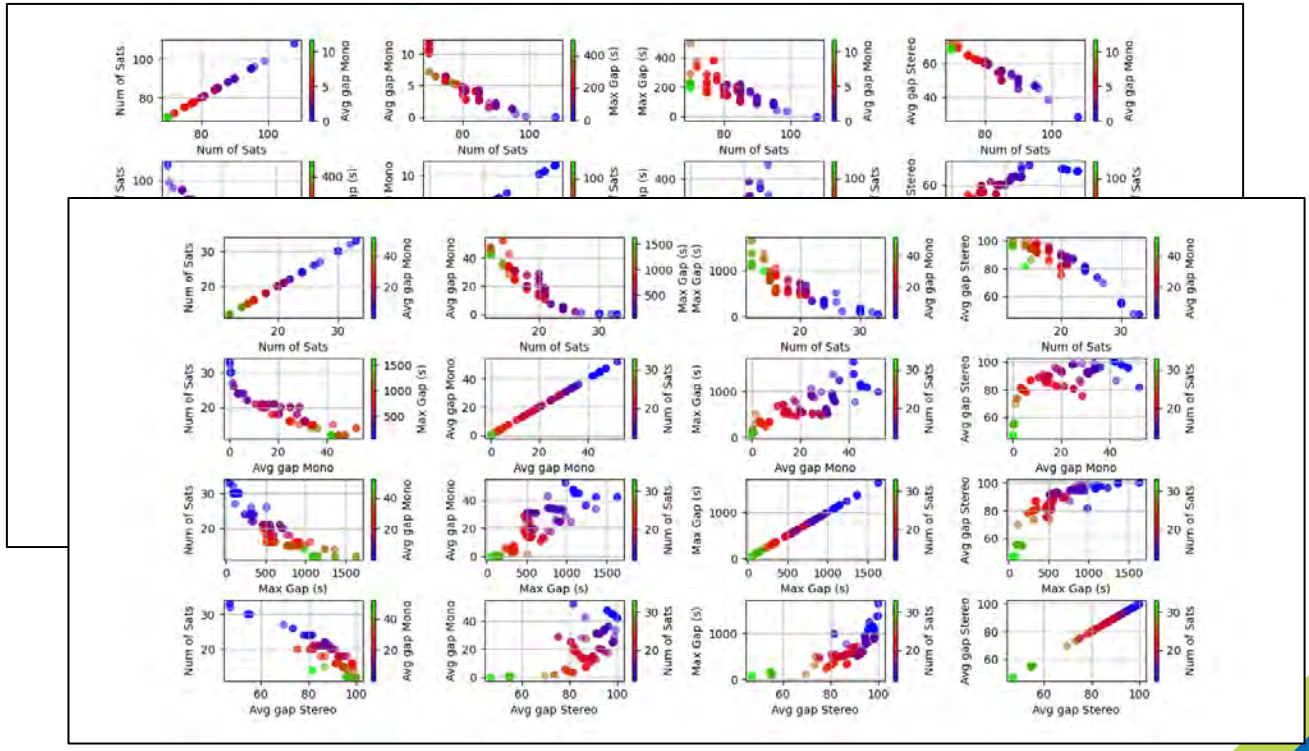
- Used AWS GovCloud: 9 servers with 96 CPUs each
- Parallel processes
- Runtime decreased to 72 hours

Cost

- About $6000 for AWS cores – no recurrent cost

Result

- Supported time critical analysis



For COTS, flexibility in licensing is key

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Summary
Modeling, Simulation, and Analysis in Mission Engineering at SAIC

- Supporting work of national significance
- Innovating to improve human interaction, integration, interoperability, curation, cost, and more
- Continuing to develop and innovate to support emerging customer needs

Looking for further connections with other innovative partners

For More Information

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