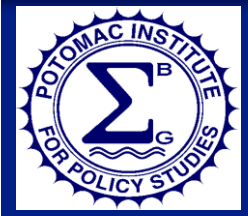

Integrum Se Servare

Making ERS Possible

Robert (Bob) Hummel, PhD

Chief Scientist, Potomac Institute

Oct 24, 2012

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www.PotomacInstitute.org

THE POTOMAC INSTITUTE FOR POLICY STUDIES

Making ERS Possible: Current Commercial Tools and Techniques

- System Engineering practices are destined to change radically
  - May be driven by Government
  - Certainly driven by Industry
    - Including service vendors
  - Recent book: Chris Anderson, *Makers: The New Industrial Revolution*
  - Forthcoming paper: Neches & Hummel, "The coming revolution in engineering complex systems"
- How will industry respond?
- What tools are already available?

THE POTOMAC INSTITUTE FOR POLICY STUDIES

Panel Session Introduction

A sample of industry ERS developers

- Lockheed Martin ATL
  - Shahrukh Tarapore, and Fouse
- AGI
  - Mark Visco, Richard Buskens
- Dassault Systèmes
  - Brian Chambers, Brent Earl
- Phoenix Integration
  - Greg Salow, Peter Menegay

Time for questions and discussion following presentations

THE POTOMAC INSTITUTE FOR POLICY STUDIES

Engineering Resilient Systems from the Battlefield to the Drawing Board

How do we enable the General and the Engineer to work together?

LOCKHEED MARTIN

Shahrukh R. Tarapore
Advanced Technology Laboratories

Advanced Technology Laboratories

Innovation for Application

- **Our Purpose**
  - **To be leaders of technological change by primarily leveraging external R&D funding to develop revolutionary warfighter capabilities and ultimately enable disruptive new businesses for Lockheed Martin.**
- **Guiding Principles**
  - **Develop transformational technologies**
  - **Nurture creativity**
  - **Embrace relentless entrepreneurialism**
  - **Build enduring relationships**

We create new opportunities

Beyond Traditional Systems Engineering

- **The ever changing operational landscape threatens our ability to field adaptable, effective, affordable system to meet warfighter and stakeholder needs.**
- **The next generation of systems of systems tools need to extend beyond a single mission, operating environment, or product**
- **The new frontier is in understanding how the interdependent relationships between the General's strategy, the warfighter's operational context, and the engineer's design influence mission success and system resiliency.**

A Vision Engineering Resilient Systems

- **Two areas of Computer Science have had tremendous advances enabling radical approaches for systems engineering:**
  - **Broad acceptance of modeling and simulation across disciplines**
  - **Readily available computational power in traditional and mobile forms**
- **These capabilities enable collaborative analysis and co-evolution through rapid trade space exploration.**
- **Alternatives can be kept longer and explored deeper, and leveraged to inform evolving requirements.**
- **Integrated tools enable rapid composability of models and analyses, exposing risks sooner and accelerating design and test.**

Transition from analyzing a few design alternatives over years to exploring thousands of designs in days.

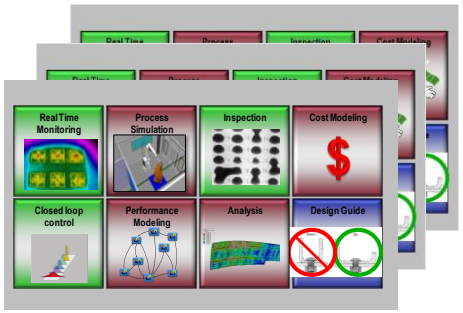
What do we invest in to get there?

- **To realize this radical approach to engineering future resilient systems we need aggressive research areas including:**
  - **systems representation and modeling**
  - **data-driven trade space exploration and analysis**
  - **cross-domain coupling of models across scales**
  - **characterization of changing operational contexts**
  - **mixed-initiative, collaborative design and decision support.**

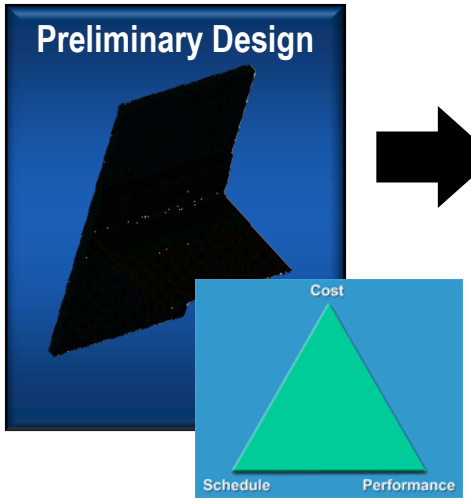
Digital Factory

- **Challenge: significant barriers to introduce new materials and manufacturing processes into product life cycle**

- **Lack of manufacturing readiness leads to cost and schedule overruns**

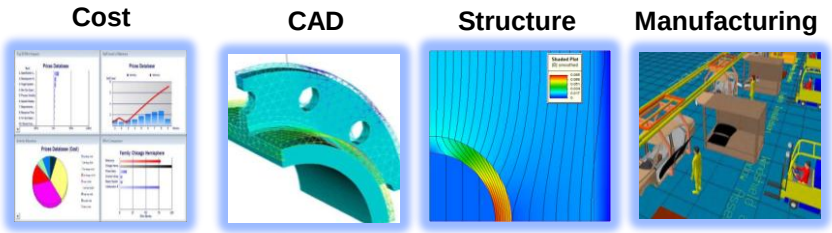


Library of Material Properties and Manfacturing Processes

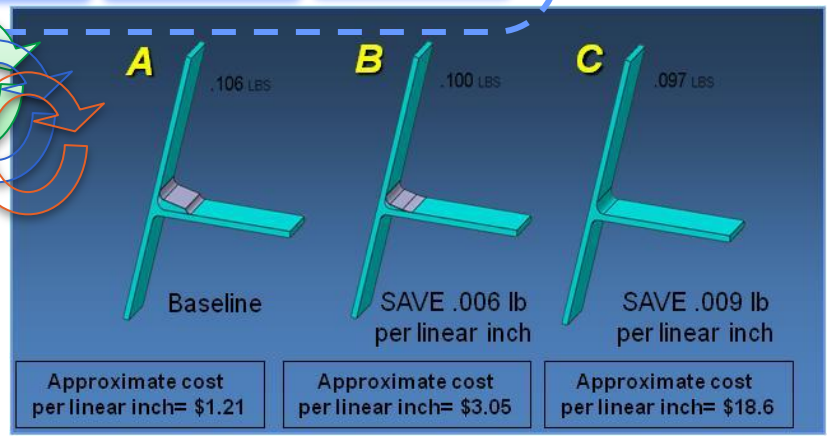


Requirements

System Architecture Analysis



Rapid Tradespace Analysis

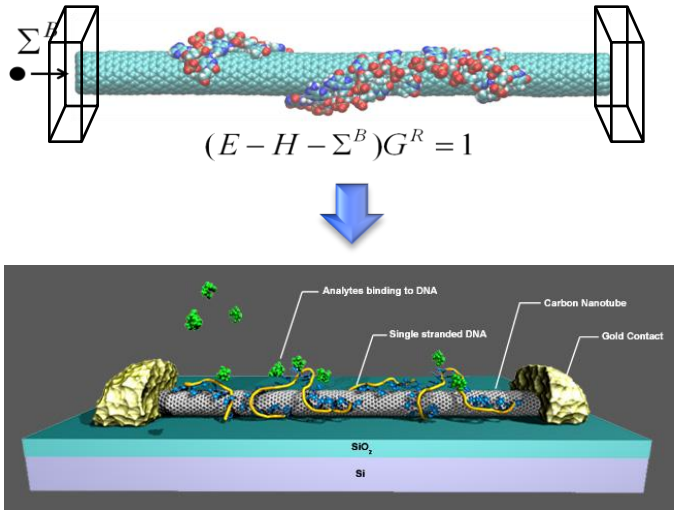


Goal: Develop extensible framework enabling trade studies of traditional and emerging materials and manufacturing processes

Artificial Nose -- Chem Bio Sensing

Automating Multi-Scale/Multi-Dimension Modeling

- **Objective: build a workflow coordination tool that automates multi-scale/multi-dimensional modeling**
  - Application: chemical bio-sensing
  - Requires multi-scale, multi-dimensional modeling of a carbon nanotube with an attached DNA strand and the dynamic interaction of several analyte molecules simultaneously – a modeling first!



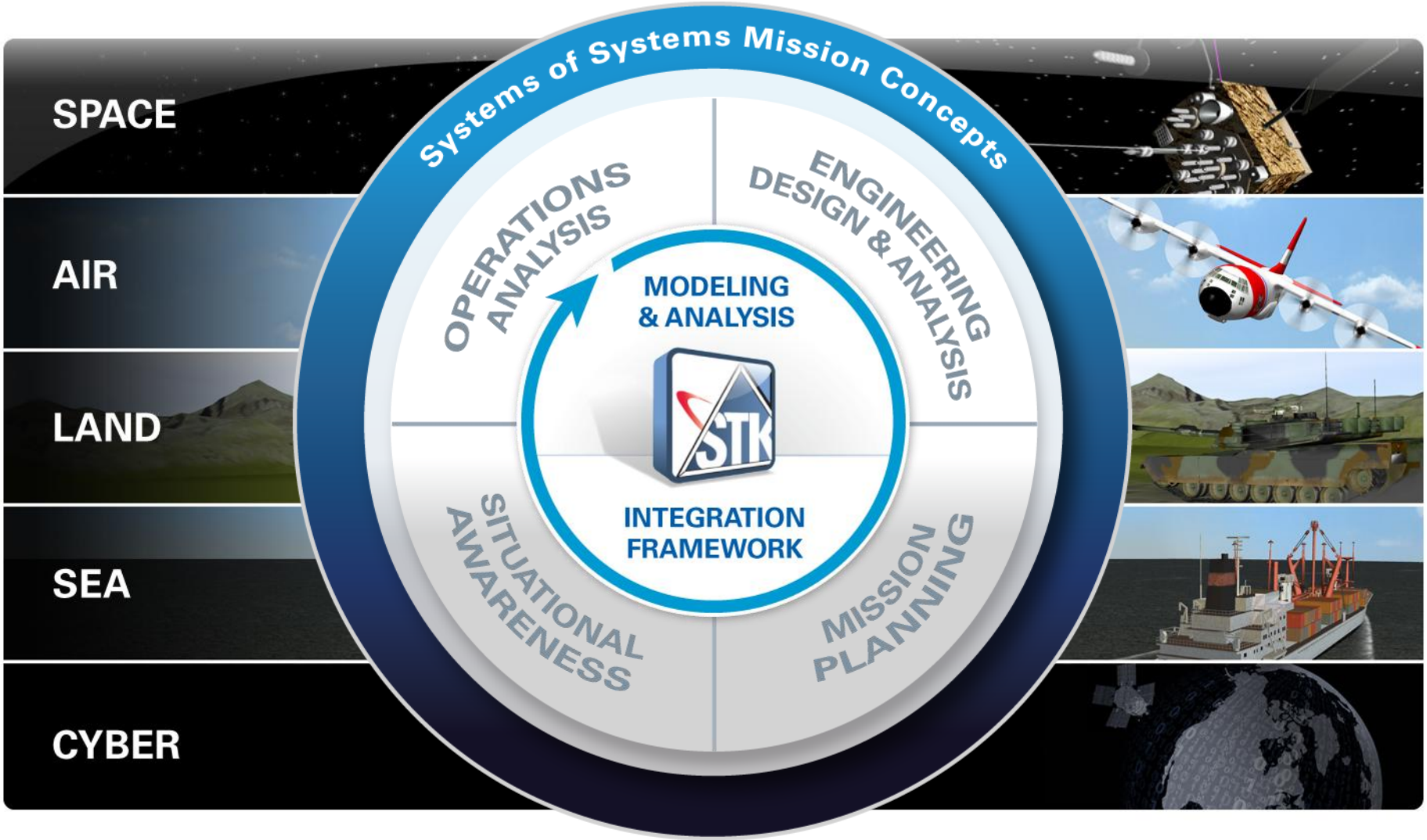
- **Results to date**
  - One-day manual process now takes 15 minutes with no errors!
- **Benefits**
  - No more ‘pain factor’ involved in running collections of simulations
  - Eliminates human error
  - Speeds (automates) propagation of model changes
  - Simplifies changes to workflow
  - Simplifies addition of new models

Software for Space, Defense & Intelligence

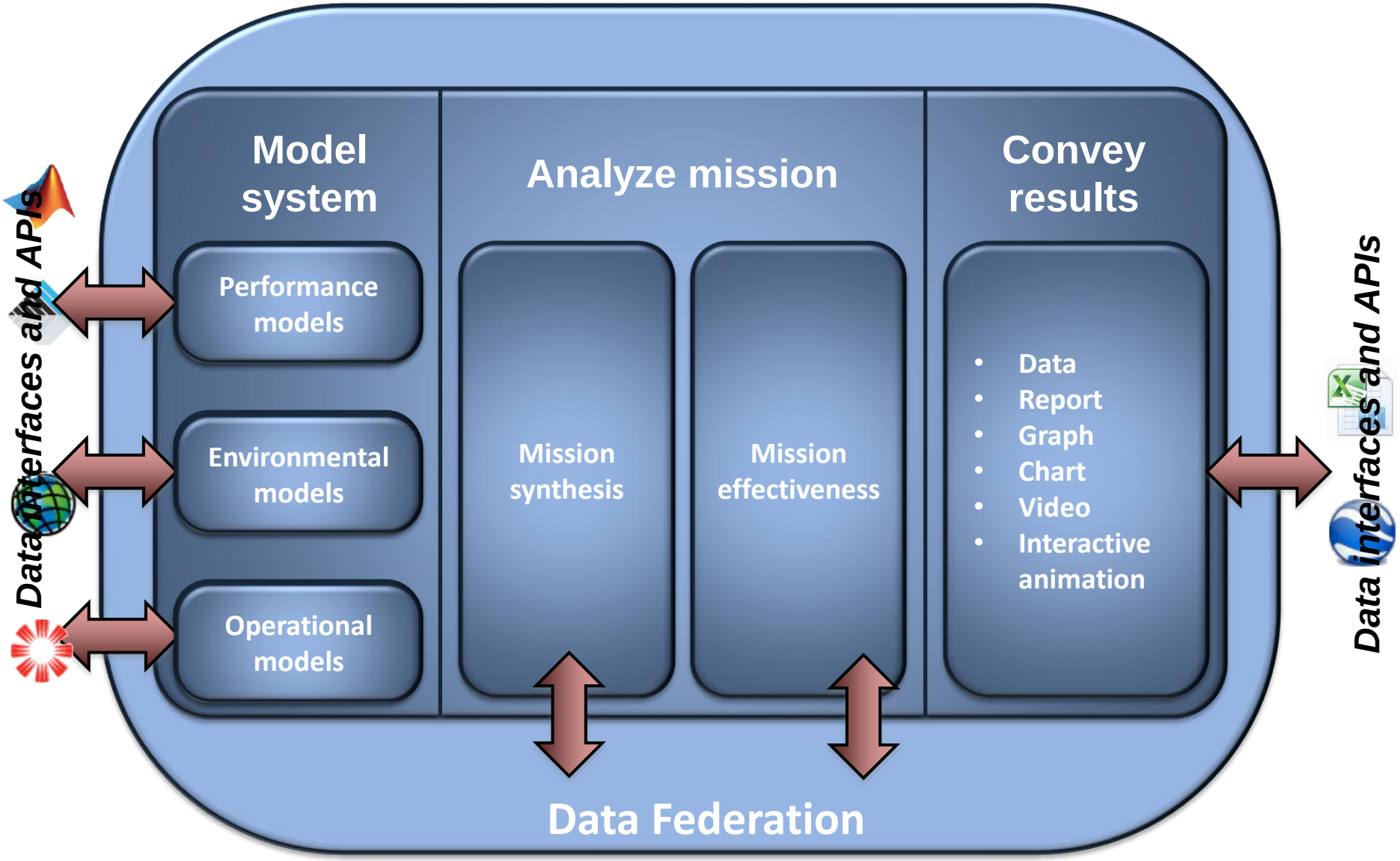
Software Framework for Engineered Resilient Systems

October 2012

Systems Tool Kit overview



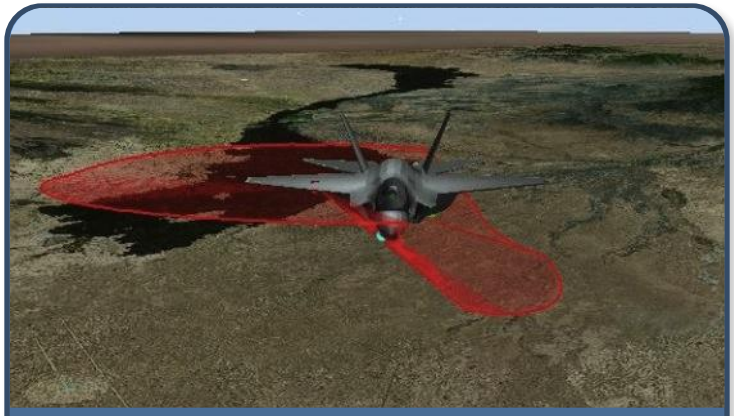
Systems Tool Kit Framework



Models

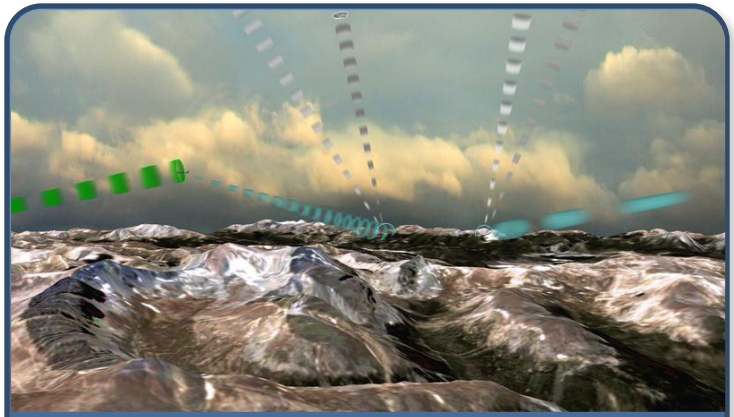
Vehicle Motion Models

Model vehicle position and attitude



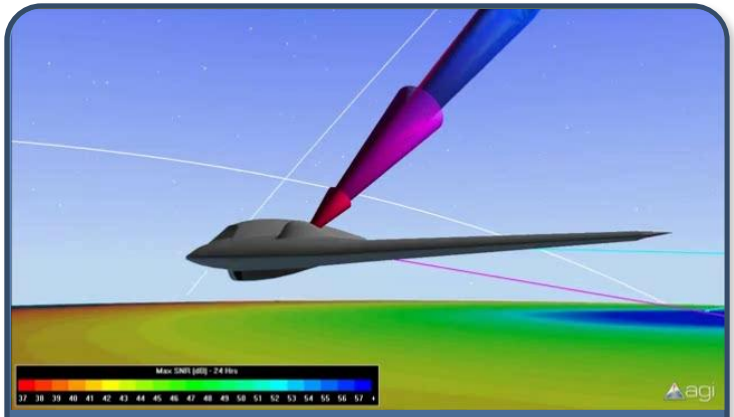
Sensor Models

Model sensor geometry & pointing



Environment Models

Model terrain, atmosphere & space



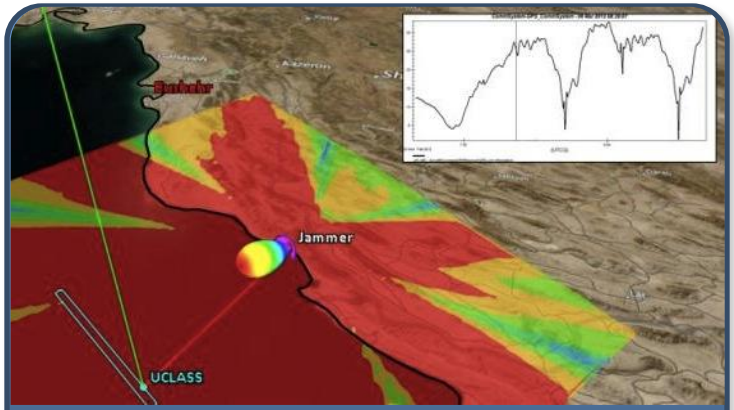
Comms & Radar Models

Model RF propagation & interference

Analysis

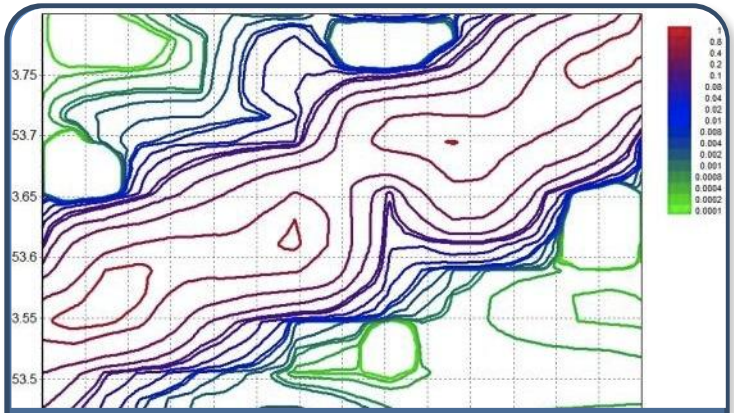
Simulate mission

Analyze system behavior in theater



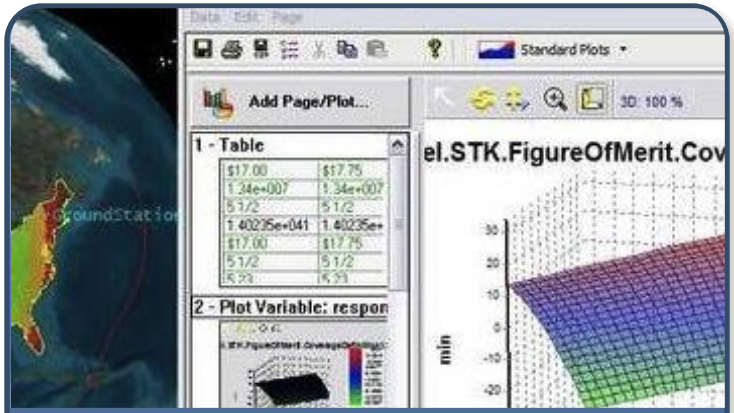
Calculate system performance

Measure against mission objectives



Evaluate system relationships

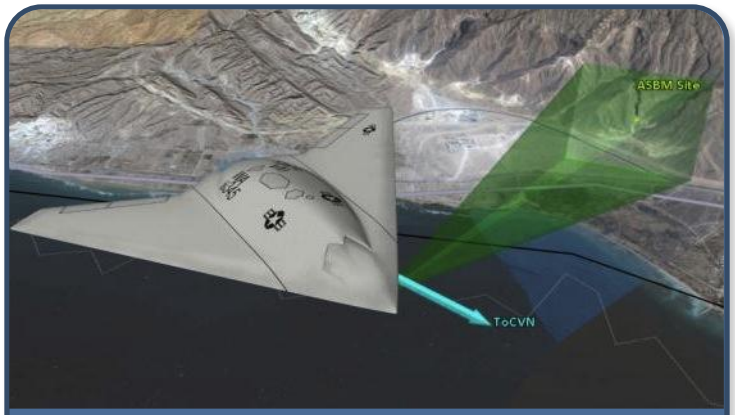
Measure system impact



Explore trade space

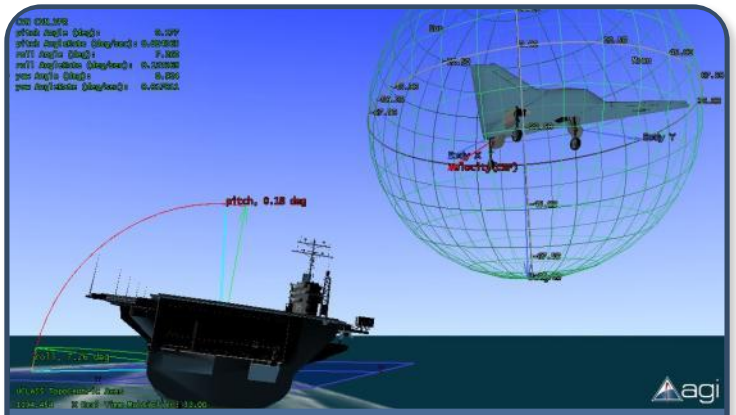
Analyze system design

Visualization



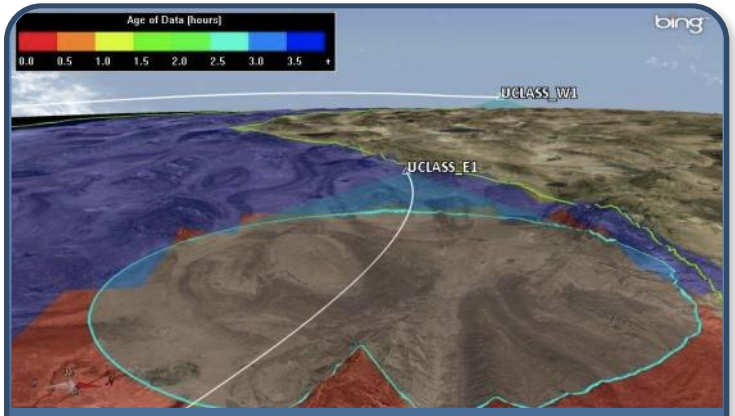
2D and 3D visualization

Vehicles, routes, sensors & analysis



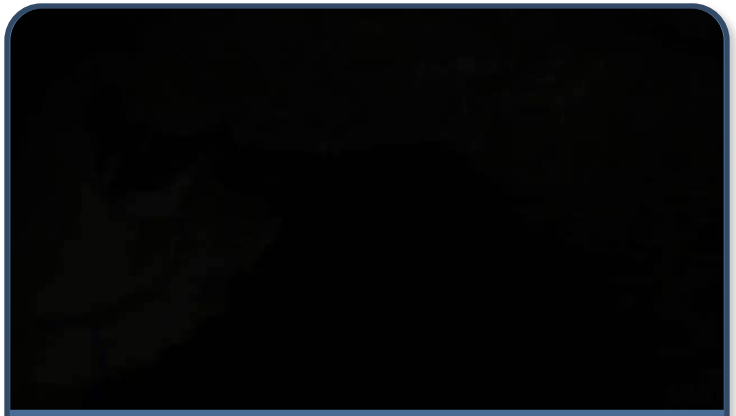
3D object representations

Position, orientation & articulation



Mission environment

Terrain & imagery



Convey results

Graphs, reports, images & videos

Systems Tool Kit Interoperability

COTS Tools

- **Scalable Networks** – Qualnet
- **Mathworks** - Matlab
- **Anark Core** – data file exchange
- **Opnet** - NG using HLA
- **Lightwave – IGES,STEP conversion**
- **SystemVue** by Agilent
- **LabVIEW**
- **DOORS**
- IBM **Rational**
- **HFSS** – antenna models
- **Xplane**
- **Real Flow** – Importing wave motion
- **RTLogic** - Channel Simulator
- **Elekrobit** - PropSim
- **Rhode & Schwartz**–RF Channel Simulator
- **Spirent** – GNSS Simulator.
- **CAST** - Navigation
- **MSoft Excel, PowerPoint**
- **Harpoon 3** Naval Warfare sim.
- **Virtual Sim Tasker** - VirtualSim CGF
- **FuzzyTech**. Fuzzy Logic Engine Controller
- **Sharepoint** - collaboration
- **Pheonix Integation** - Model Center
- **ESRI**.
- TruePlanning – Cost estimation system
- **CARPET** - a radar simulation tool that generates radar parameters

GOTS Analysis and Operations Tools & Data

- **FalconView** - comms analysis
- DCGS-AF
- **EADSIM**
- **Navy's Missile Planning Tool** by APL
- **JMPS** - by Gnostech
- **Naval Sim System** by Mectron)
- **NETWARS** - Cyber Hacking
- SEAS (http://teamseas.com/)
- **NASA SPICE and CCDS**
- **GPS Almanacs**
- **TLE data**
- **BVI** - BattleSpace Visualization tool
- **GDM** (INSCOM)
- *coming soon....*
- **ESAMS – by Booz Allan Ham**
- **HF RAD** - OTH Radar model
- **NORAD** - Operational Risk Assessment tool.

Data Providers, formats and Imagery

- **Scribe Workbench**
- **Simulize** - Flight Control
- JP2, NITF, etc
- DTED, DEM...
- Navteq - urban data
- ITU - satellite payload data
- OCG
- NMEA
- AIS Data
- Shapefile import/export

Hardware/ Software/ Protocols

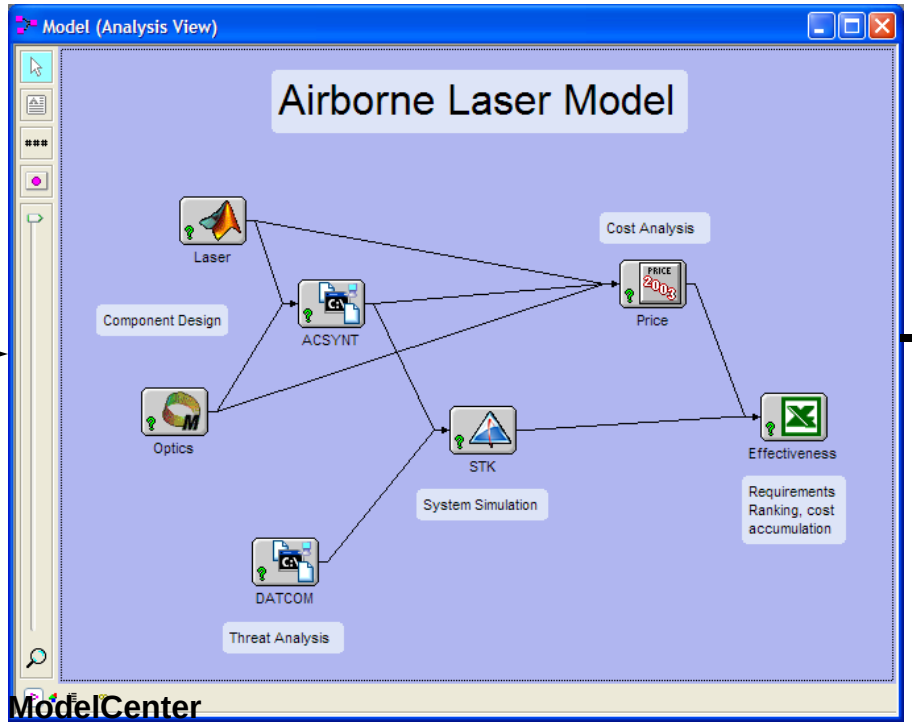
- Touch Table
- Next Computing
- Scalable Display Technologies
- Max Vision
- MS Surfance
- Droid OS
- Sys ML
- Magnolia Forge.
- Google Earth - KML import/export
- MS Virtual Studio - through JAVA, Com, .NET APIs
- TCP/IP API - network based interactions
- DIS/HLA/TENA

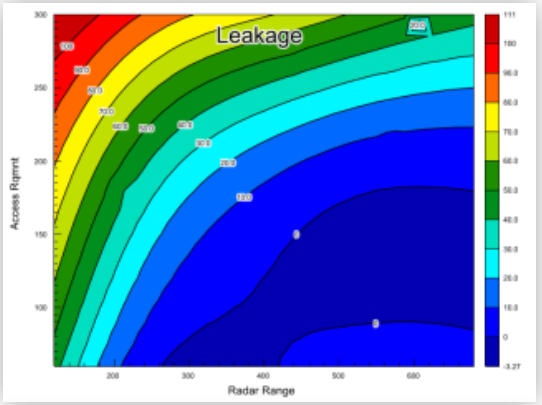
Third Party Applications

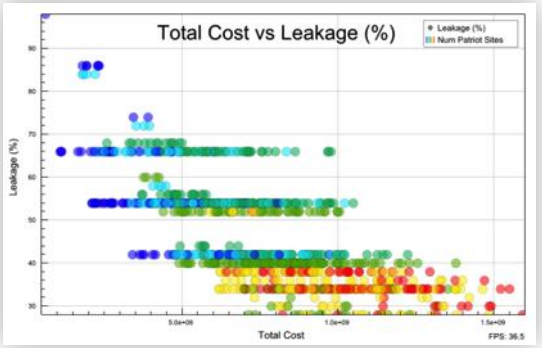
(also sold as a separate product by the source company)

- **Remcom** – Urban comms modeling
- Alion - TIREM
- **VT Mak** – SimMetrics
- **AER** – Weather Data
- **SDL** – Electro Optic Sensor Modeling
- **Satsoft** – Antenna Design
- **ASI** - Satellite Simulation
- SAIC – Missile modeling

STK/Analyzer: Trade Studies







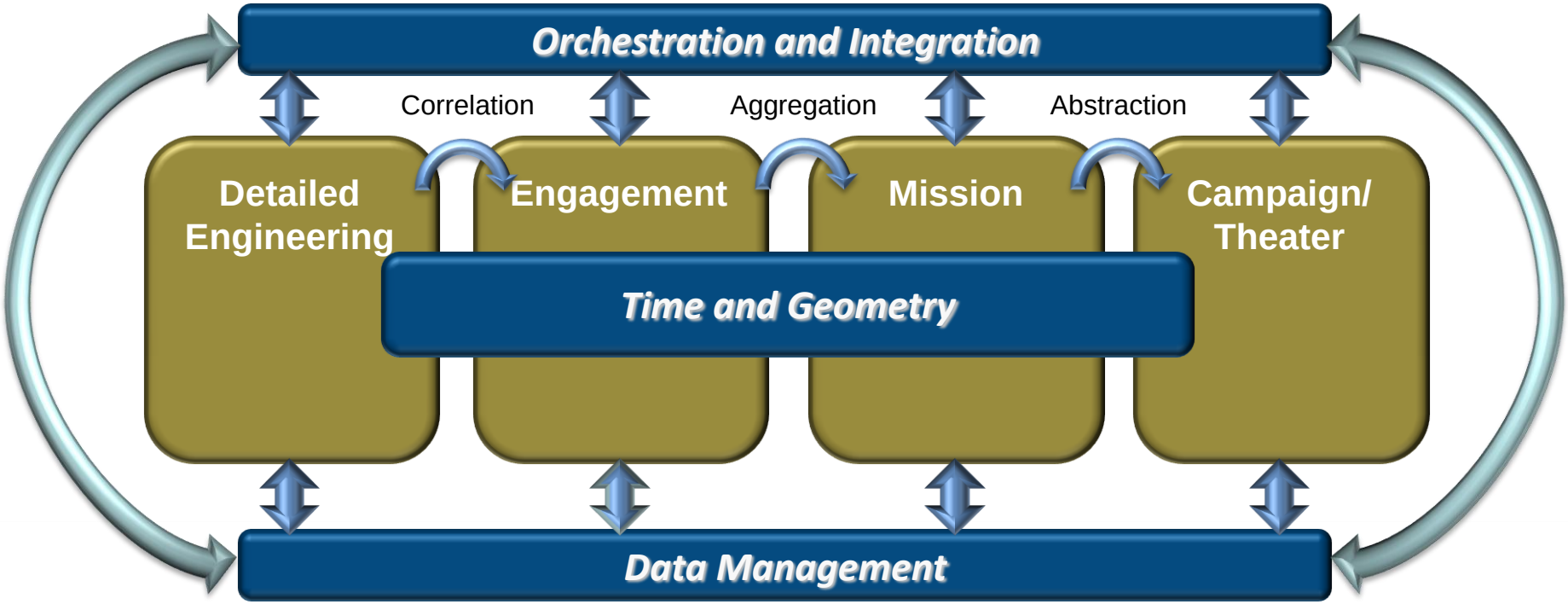
Design of Experiments
Optimization
Statistical Engineering
Analysis of Alternatives

Run models multiple times and visualize results to improve decision making capabilities

Enterprise Modeling and Analysis Framework

Integrated framework elements:

- Open, data-driven platform
- Physics-based engine
- Model-based analytics
- Dynamic, multi-level model
- Multi-domain application
- CONOPS & behavioral process modeling
- Scalable & re-usable
- User definable workflows



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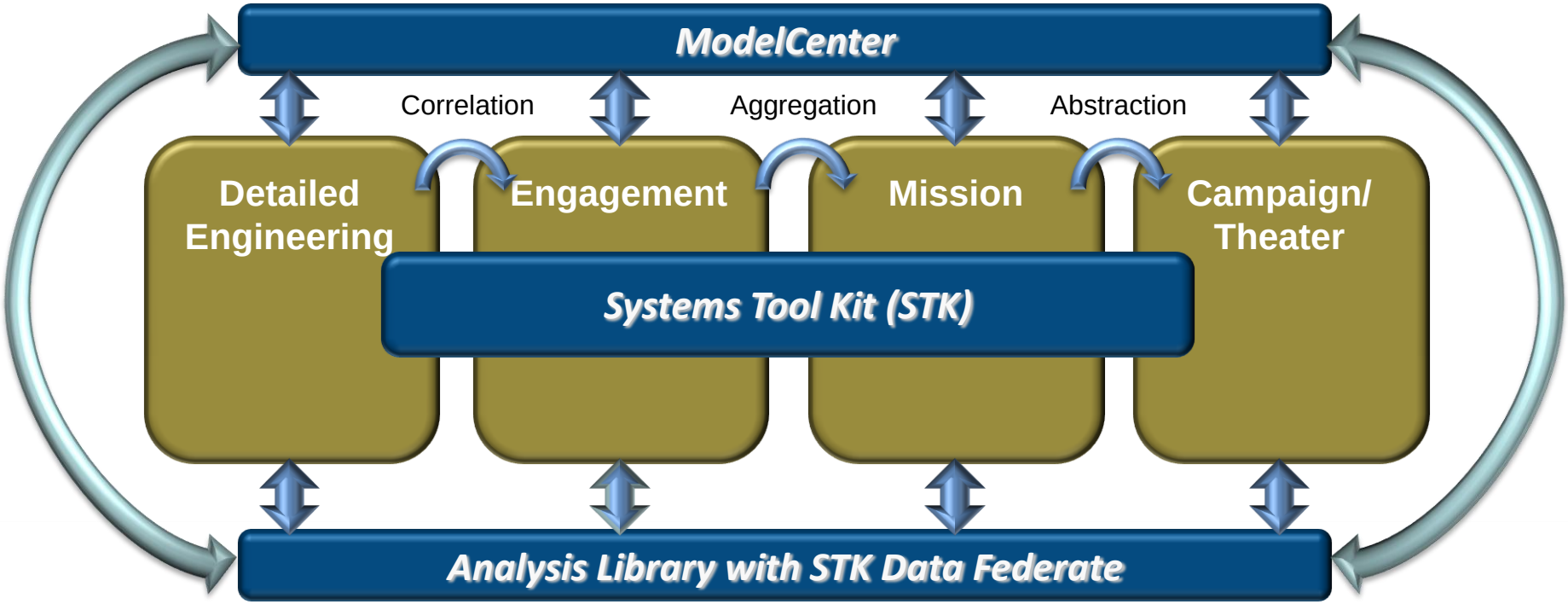


Enterprise M&A Framework – Next Steps

Decision Maker

- Scenario Design
- Analysis / Trade space
- Results View

Role-based User Interface

System Designer

- Architecture
- Definitions
- Configurations

Modeler / Analyst

ModelCenter

Correlation | Aggregation | Abstraction

Detailed Engineering | **Engagement** | **Mission** | **Campaign/ Theater**

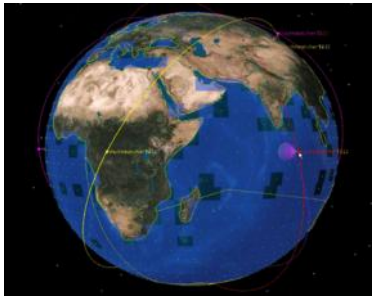
Systems Tool Kit (STK)

Analysis Library with STK Data Federate

MBSE Definitions

(Structural, behavioral, parametric, requirements definitions)

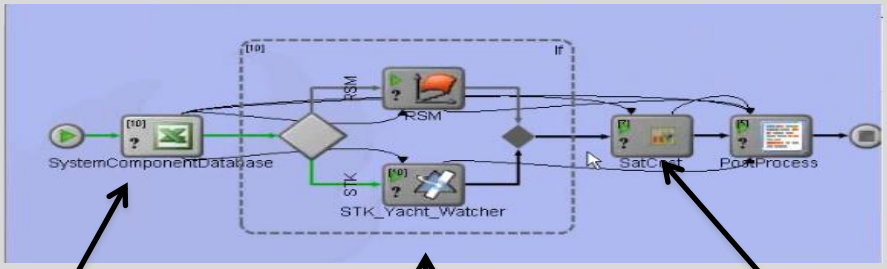
N-dimensional Trade Study : Costs vs Mission Effectiveness



- **Determine capability v cost of maritime domain awareness from satellite constellation**
  - Evaluate Mission “Figures of Merit (FOM)” across 3 design dimensions - camera designs, communications designs and # of assets

Study Setup

Design options + **STK** + **SEER** + **Model center**

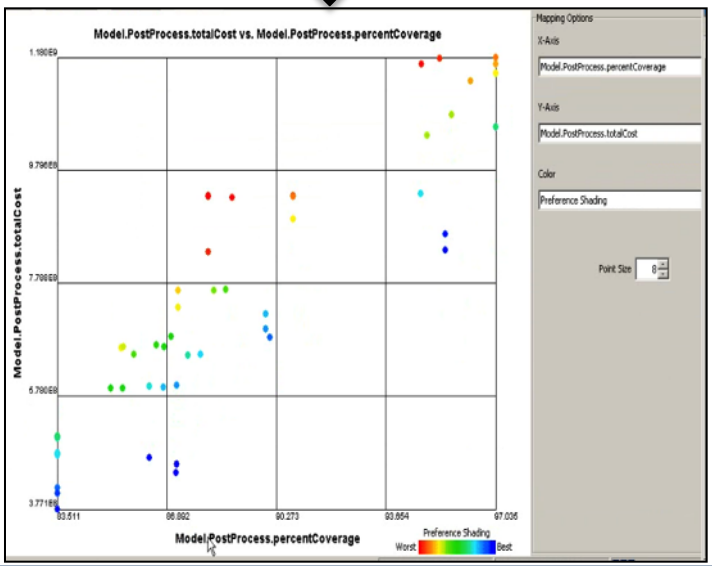


Vary subsystem design parameters, assets employed and/or tactics

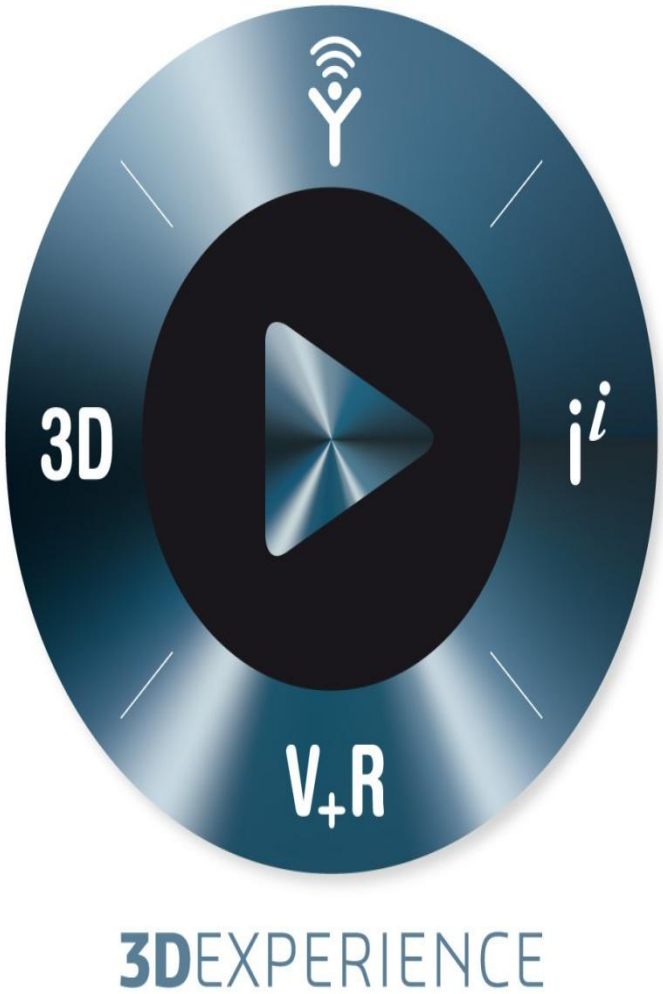
- Vary the # of each asset employed
- Determine mission FOMs based upon configuration and/or tactics

Estimate cost of design iterations

Cost vs Mission FOM



Making ERS Possible: Current Commercial Tools and Techniques



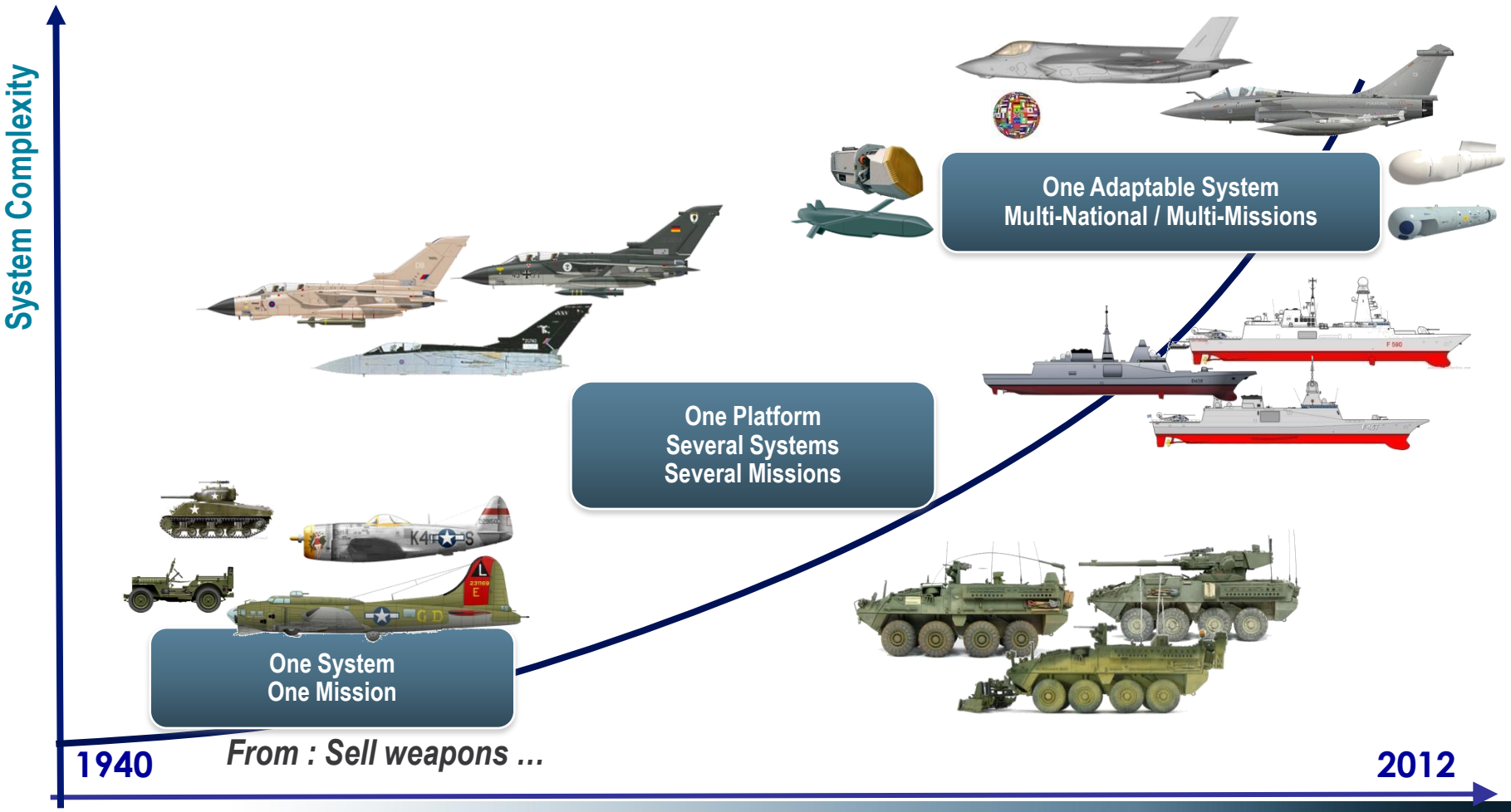
Dassault Systèmes Perspective

Brian Christensen
A&D Solution Director
October 24, 2012

Defense & Security Industry

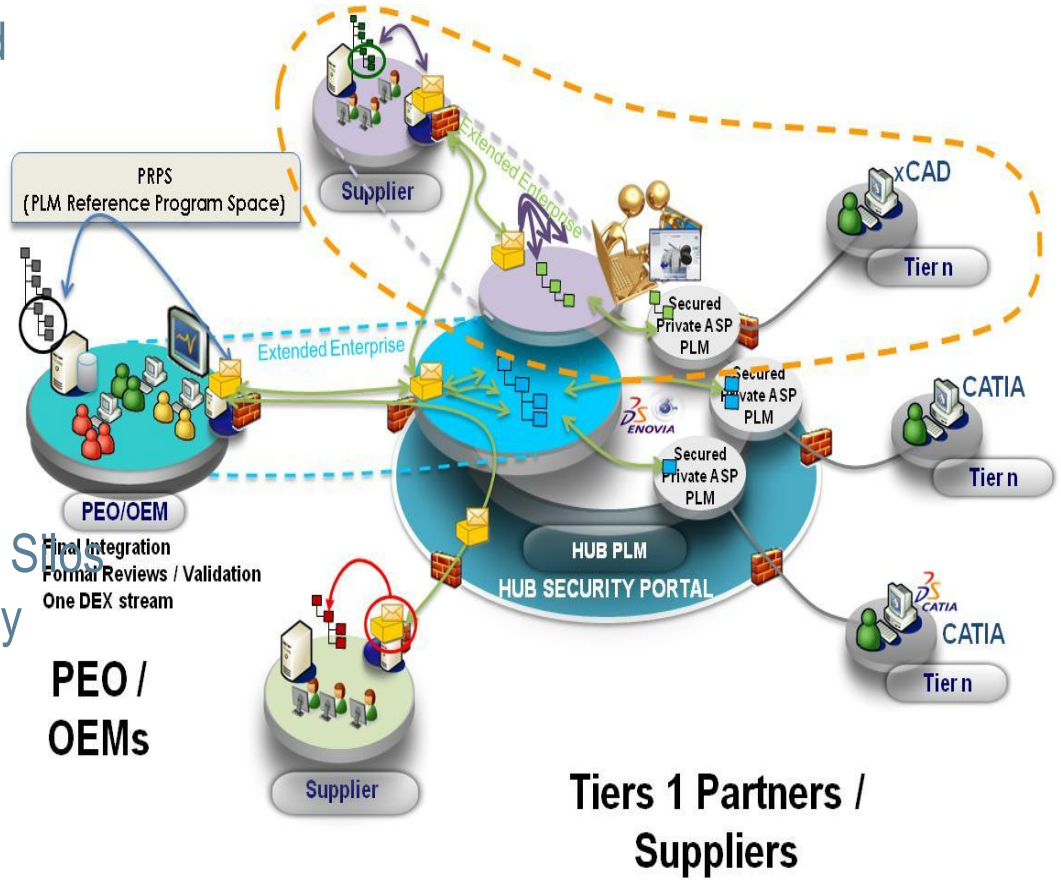
New Paradigm …

Design a defense and/or security adaptable system, with an affordable price and time table, integrated in a complex heterogeneous environment, which copes with new threats and can be easily maintained…



V6 Architecture

- Improve Operational Efficiency
  - Flexible, Modular Architecture
  - Centralized for Single Source of Truth
  - Open to External CAD Tools and Enterprise Systems
  - Secure Access from Anywhere
- Accelerate time to market
  - Integrated Design Chain from Conception to Fabrication
  - Instant Global Collaboration
- Decrease costs
  - Data Consolidation from Legacy Silos
  - Horizontal and Vertical Scalability
  - Centralized Administration



V6 Systems Engineering Solution

Collaborate across engineering disciplines and development teams

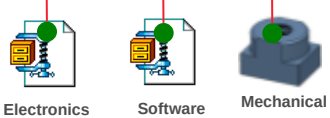
Requirements, Functions, Logical Components, Physical Components Allocations

Requirements	Description	Priority
Requirement	Description	High

Requirement Management ***R***

Functional Analysis ***F***

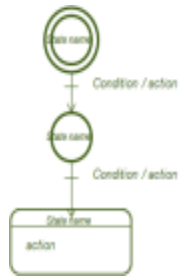
Logical Architecture Design ***L***



Physical Design ***P***

Collaborative process management and traceability

Systems Behavior Modeling and Simulation



y=f(x)
y=f(x,t)
f(dx/dt,x,y,t)=0

Discrete (Events)

Continuous (Physics)

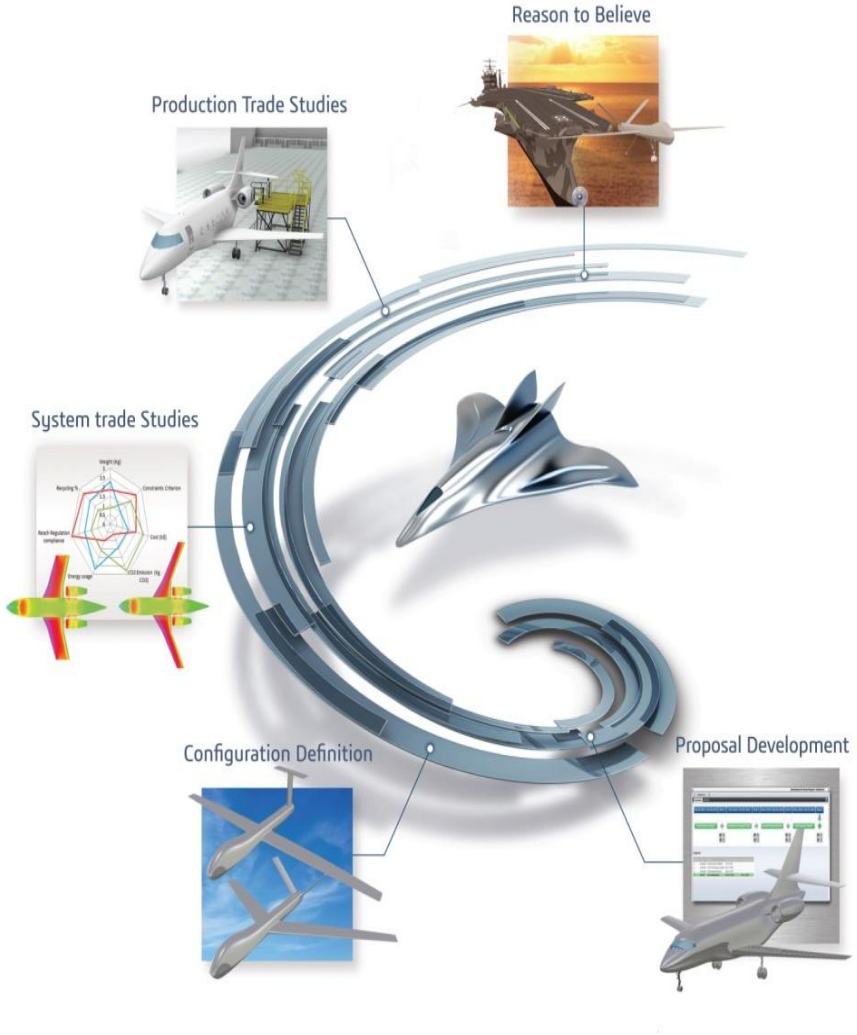
System Analysis and Control (Inc. Safety)

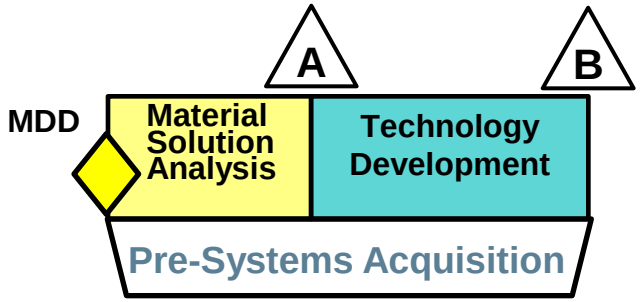
Tests

System Integration Verification, Validation and Qualification

Test	Description	Result
Test	Description	OK

Winning Program Solution Experience

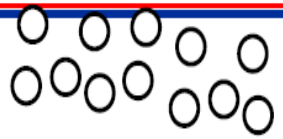




- Proposal/Offer & Program Management for Systems Engineering Engagement
- Requirements Engineering for Traceability and Impact Analysis
- Product Architecture – Functional and Logical System Definition
- System & Production Trade Studies – Analysis of Alternatives
- Life Like Experiences

Engineered Resilient Systems
Key Technical Thrust Areas

Systems Representation and Modeling

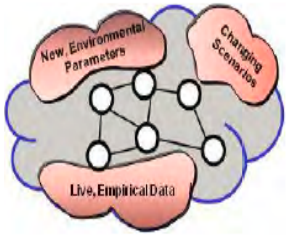


– Capturing physical and logical structures, behavior, interaction with the environment, interoperability with other systems

Characterizing Changing Operational Contexts

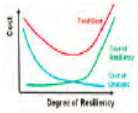
– Deeper understanding of warfighter needs, directly gathering operational data, better understanding operational impacts of alternative designs

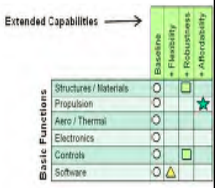
Cross-Domain Coupling



– Better interchange between "incommensurate" models
– Resolving temporal, multi-scale, multi-physics issues across engineering disciplines

Data-driven Tradespace Exploration and Analysis





– Efficiently generating and evaluating alternative designs, evaluating options in multi-dimensional tradespaces

Collaborative Design and Decision Support

– Enabling well-informed, low-overhead discussion, analysis, and assessment among engineers and decisionmakers

Phoenix Integration

Panel Session: "Making ERS Possible: Current Commercial Tools and Techniques"

Oct 2012

Dr. Peter Menegay
Greg Salow

PHOENIX INTEGRATION

DESIGNPROCESSOPTIMIZATION

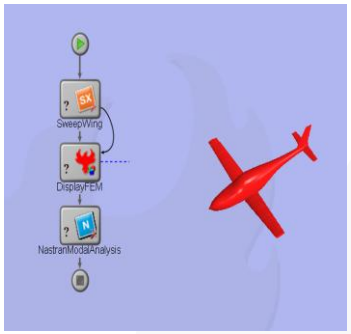
What tool capabilities do leading M&S organizations want?

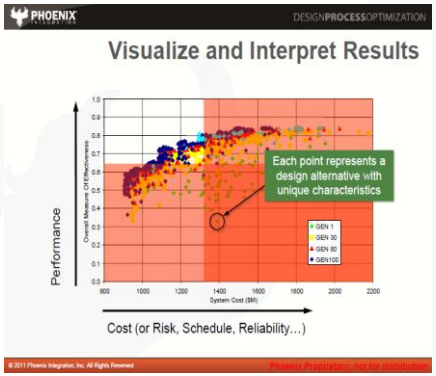
- Well-Integrated system level framework (managed by one company); best of breed solvers (open sandbox for 3rd party tools)
- Open Environment; Vendor-Neutral Infrastructure;
  (Don't want to be locked in to one vendor's underlying models.)
- Better, faster, more trade study analysis, earlier and throughout the design cycle with fewer resources and time
- System level analysis tools for M&S integration, optimization, visualization, reliability analysis
- Integration of commercial and internal software tools; local or distributed; cross platform.
- Trade study access for decision makers, model providers other stakeholders not directly involved in the integration (ie. viewers, and ways to share "necessary" model info)

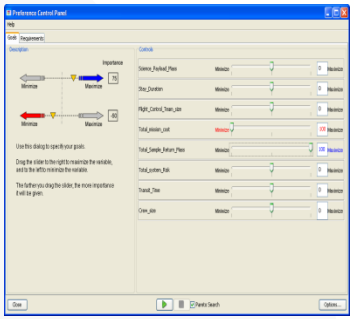
Want More….

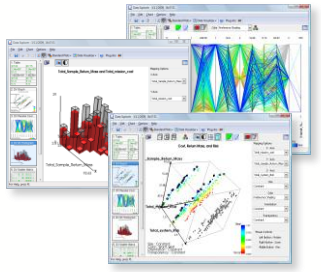
- Ability to perform effective analysis of alternatives at an early level.
- Integration of requirements with systems engineering and analysis tools.
  - What happens when a requirement changes or when it is not met?
- Clear traceability of data between systems and domain-level analysis functions; so results are not lost
- Rigorous communication between engineering silos and between systems and analysis layers.
- Centralized data repositories for models and results.
- Reuse of modeling knowledge through libraries.

Phoenix Integration ModelCenter System Level Capabilities









1 Integration

*"Open", adaptable, vendor/tool agnostic environment for multi-level models & simulations;
*Distributed analysis over a network to access multi-disciplinary models as needed

2 Trade Study Automation

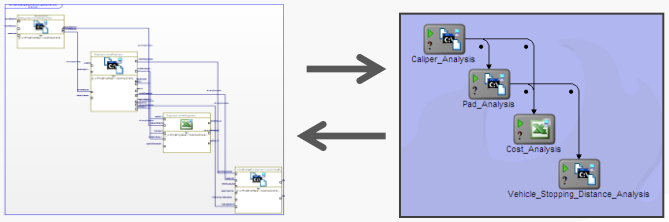
*"What if" analysis tools for better understanding of tradespace -> cost reductions, improve quality..
*100s or 1000s more alternatives in same time vs. traditional methods
*Design Exploration, Optimization, Surrogate Modeling, Uncertainty/Reliability

3 Visualization

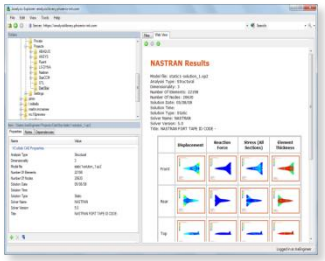
*Find Better Designs; *Leverage for design review to get everyone on the same page
*Stakeholder-friendly views,
*Dashboards, Free Viewers, etc to bridge communication gaps among technical and sponsor collaborators

4 Model Based Systems Engineering (MBSE)

Bi-directional modeling and requirements integration; SysML



5 Data Management, HPC



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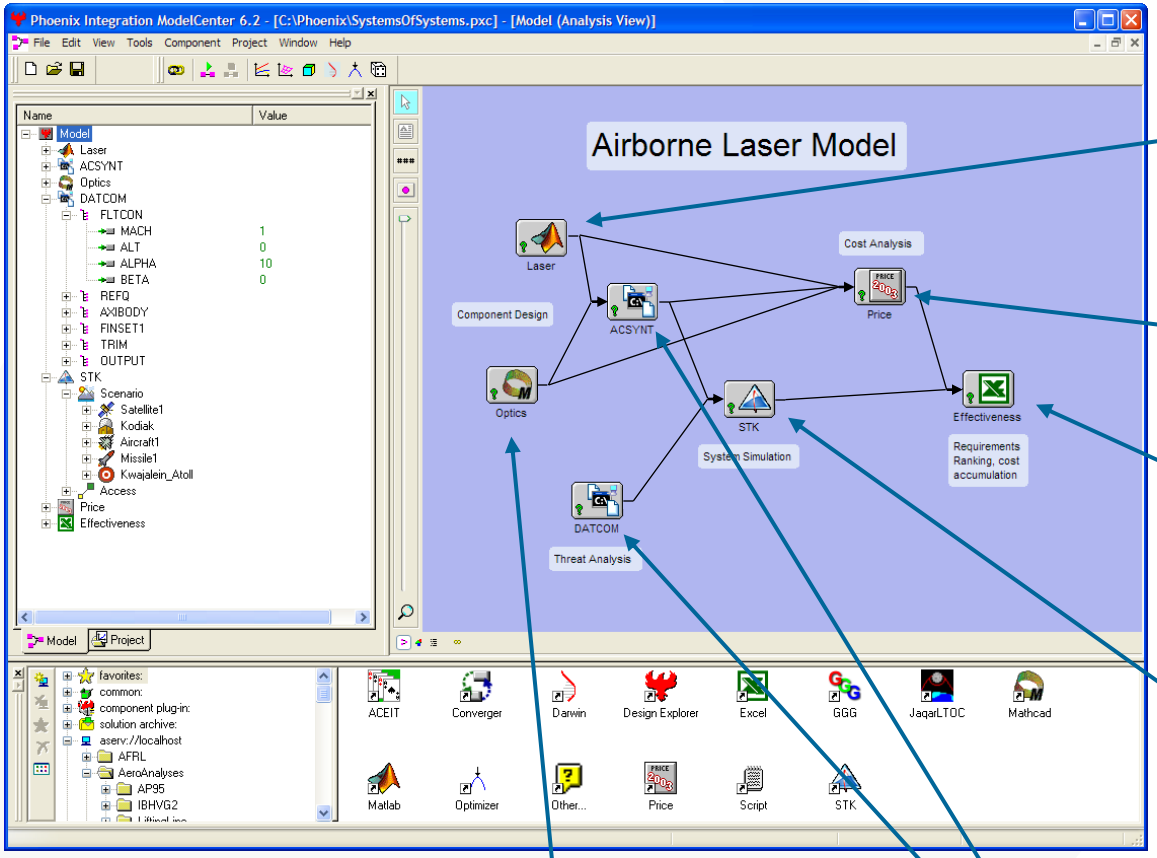
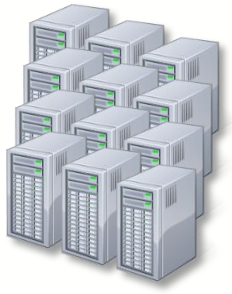
PHX ModelCenter: Multi-Level Models



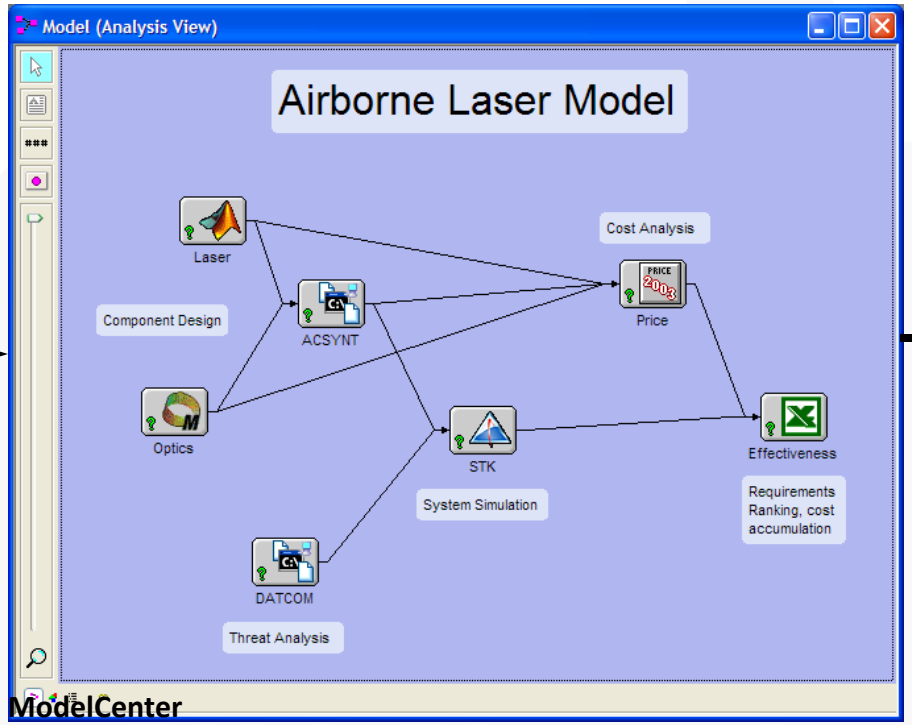
Network



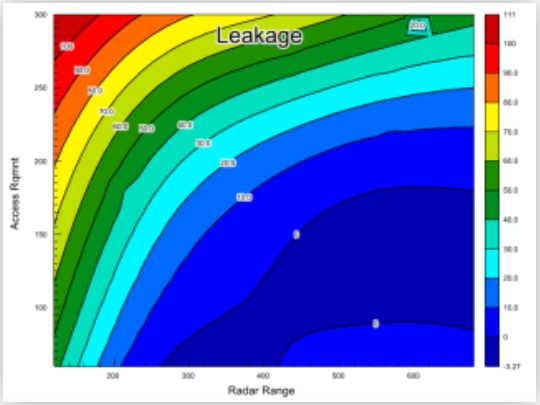
ModelCenter

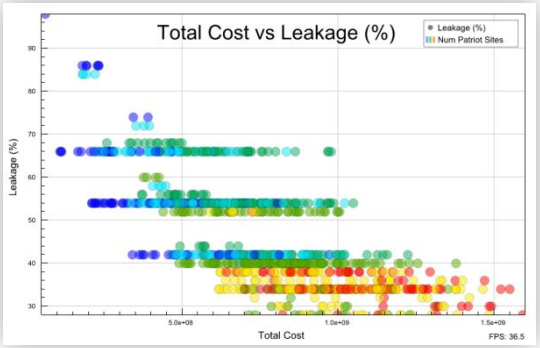
Link together multiple simulation models into a single “what if” environment

PHX ModelCenter: Trade Studies



Design of Experiments
Optimization
Statistical Engineering
Analysis of Alternatives





Run models multiple times and visualize results to improve decision making capabilities

Takeaways

- Open; Vendor-neutral, System level analysis tools for M&S integration, optimization, visualization, reliability analysis
- Turn dials at the engineering level and see impacts at the campaign level…
- System level "what if" analysis tools provide:
  - More choices and better understanding of trade space
  - quality improvements
  - risk and cost reductions

- **Thank You!**

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