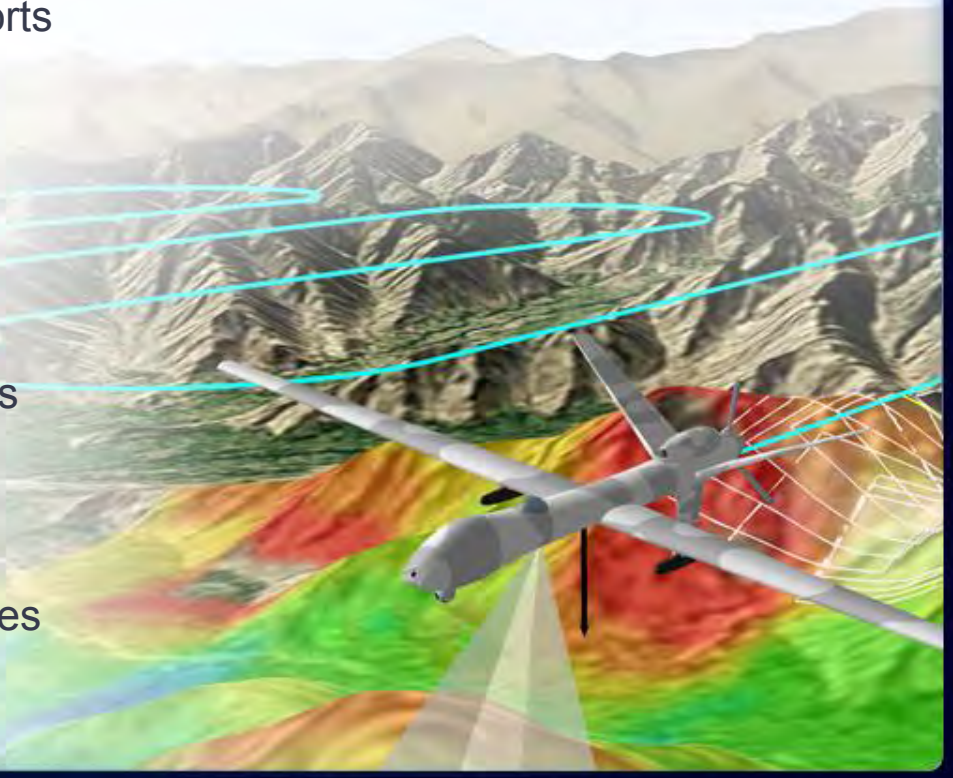
Software for Space, Defense & Intelligence

AGI Software and Solutions for Test and Evaluation (T&E)

Agenda

- **Introductions**
  - Company Overview
  - Current Industry Test & Evaluation Challenges
- **AGI Software Support of T&E Workflow**
  - Typcal Test & Evaluation Processes
  - Software Simulation/Coordination Efforts
- **Pre-Mission Planning Design**
  - Using Commercial Software for Planning/Analysis/Simulation
  - Test Event Rehearsal & Replanning
- **Testing Operations**
  - Real-Time Visualization & Support
  - Data Analysis & Situational Awareness
- **Post Flight Analysis**
  - Flight Reconstruction
  - Analyze Test Data
  - Refine Procedures & Testing Processes
- **Q&A Wrap Up**



AGI Asia Introductions

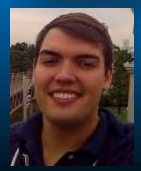
- **Matt Halferty**
  - Director, Asia Pacific
  - US Army Officer - West Point

- **Jim Head**
  - Partner Manager, Asia Pacific
  - Masters Degree Strategic Studies – RSIS Singapore

- **Nate McBee**
  - Systems Engineer Manager, International
  - Masters Aerospace Engineering - Univ. of Tennessee

- **Dan Honaker**
  - Aerospace Systems Engineer, Asia Pacific
  - Masters Aerospace Engineering - Univ. of Colorado

- **Melissa Honaker**
  - Aerospace Systems Engineer, Asia Pacific
  - Bachelors Aerospace Engineering - Univ. of Colorado



- **Alex Ridgeway**
  - Aerospace Systems Engineer, Asia Pacific
  - Bachelors Aerospace Engineering – Pennsylvania State Univ.

AGI Global Overview

- **Analytical Graphics, Inc. (USA): A Global Aerospace Standard**
  - 45,000+ global software installs
  - 700+ user organizations worldwide
- **Provider of COTS software since 1989**
  - Space mission design & engineering
  - Satellite operations
  - Space situational awareness
- **Validated astrodynamics, 16 patents, 75+ developers**

agi

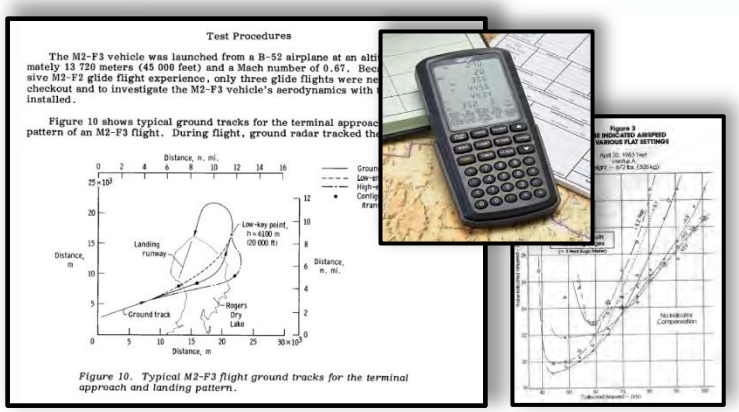
Software for Space, Defense & Intelligence

Test & Evaluation Challenges

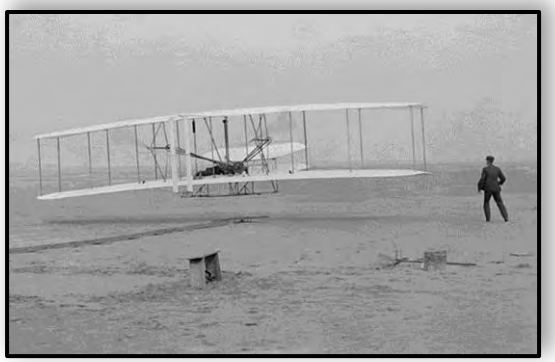
Current Approach

Current Test & Eval Challenges

- **Current planning tools are labor intensive and error prone**
  - Inefficient test tools/methods
  - Long and iterative testing cycles
  - Unsophisticated modeling tools



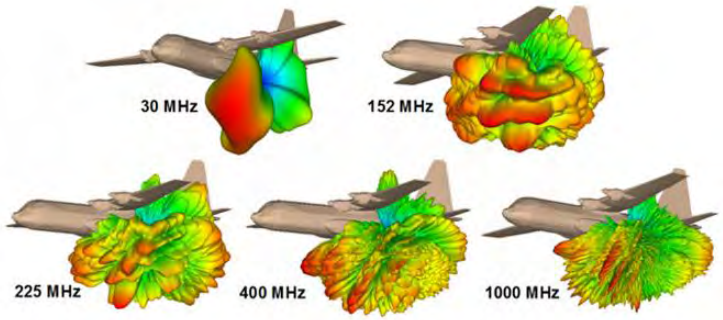
- **The costs to physically test are very high**
  - Military aircraft operating costs can vary from $7500/hour to $1.2M/day*
  - Physical flight testing cycles can be reduced significantly
  - More tests can be performed during a single flight with proper planning

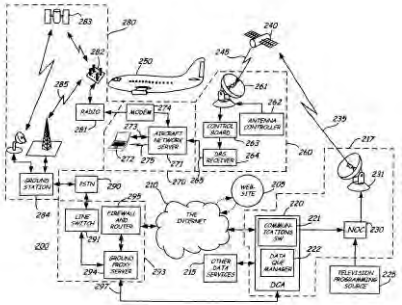


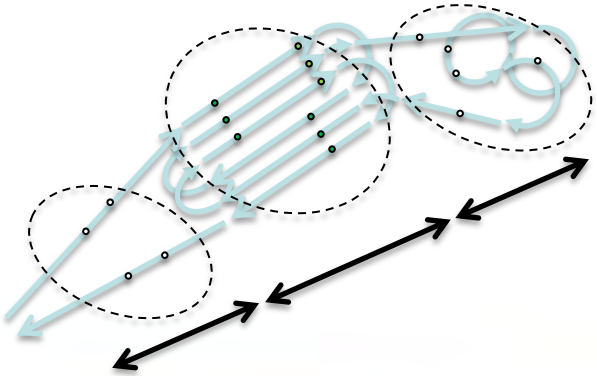
*** - Actual F-35 testing cost for 4-ship (4 aircraft) test in an instrumented test range environment**

Current Test & Eval Challenges

- **Increasing Complexity of Onboard Mission Systems**
  - (EW, EO/IR, Comms, Radar, IFF, Nav, LO, etc)
- **Inefficient Test Flights (Low test-point density)**
- **High re-test/re-fly Rates (as Much as 50%!)**
- **Challenge of Communicating Capability Attainment Along With Test-Point Completion**

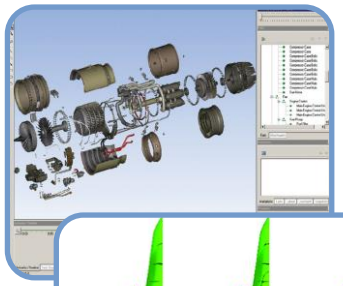




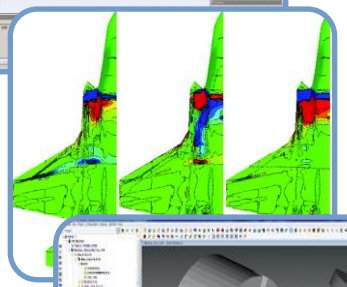


Using Computer Aided Engineering (CAE)

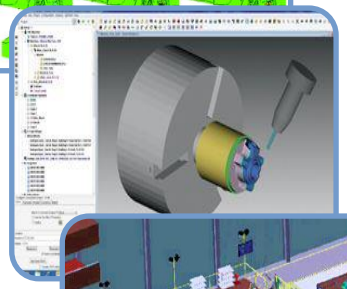
Product design, engineering and lifecycle disciplines take advantage of well established computer aided engineering (CAE) methods



Design



Analysis



Manufacturing

Assembly

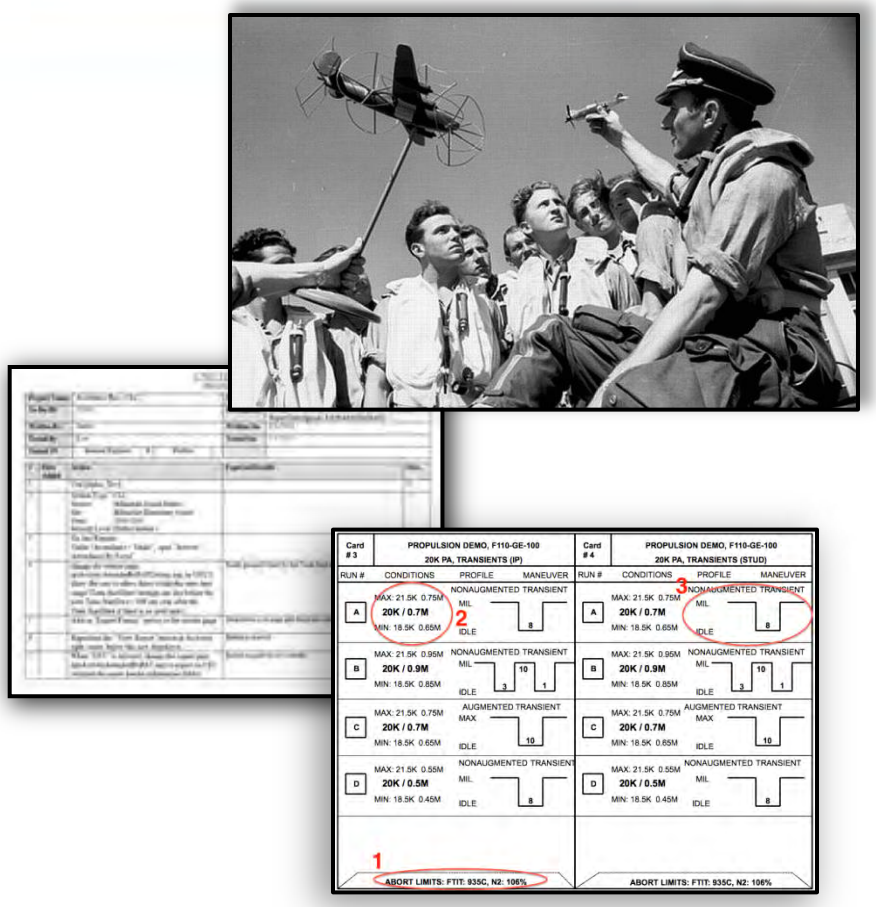
Training

Operations

Maintenance

Addressing Current Methods

- **Current Methods**
  - Microsoft (MS)Excel
  - MS PowerPoint
  - MS Word
  - Custom MATLAB
  - “Planes-on-sticks”
  - “Flying wrist watches”

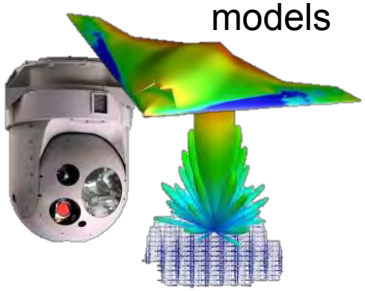


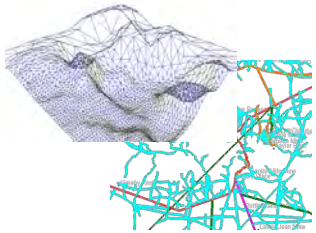
Great opportunity in the T&E discipline to reap similar benefits by using Computer Aided Engineering (CAE) methods in test-event design, execution & post-flight analysis

AGI Systems Tool Kit Modeling

Build/Import Models
Characterize System

Performance models





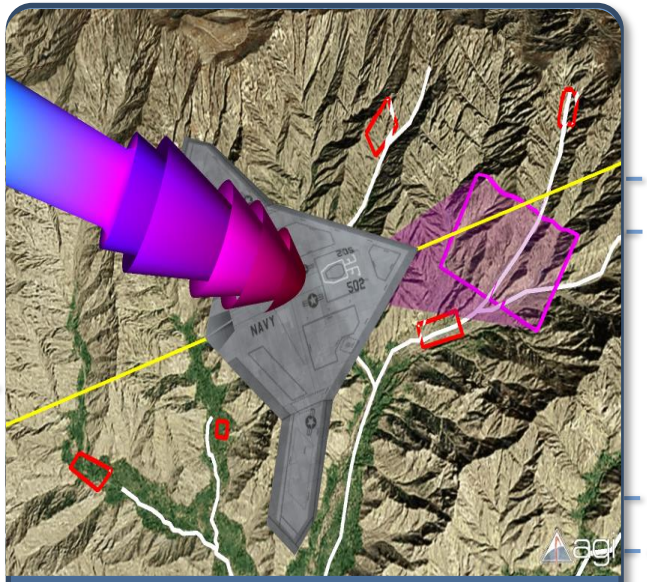
Environment models

Mission specific data

Combine into system model

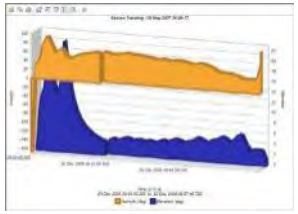
Define measures of mission effectiveness

Run Simulations & Evaluate Performance



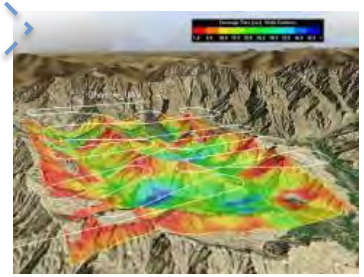
Iterative design & analysis
Evaluate mission performance
Test Planning

Convey Results



Reports & graphs

Video



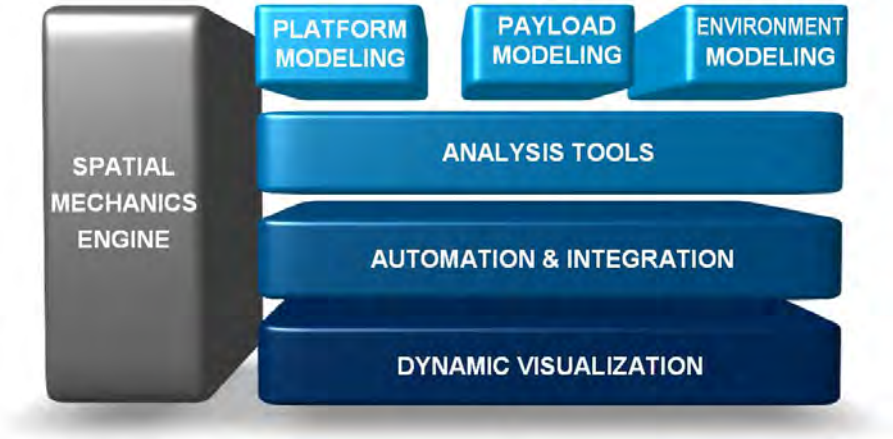
Mission results or status

Software for Space, Defense & Intelligence

AGI Software Overview

Model Based Engineering Approach

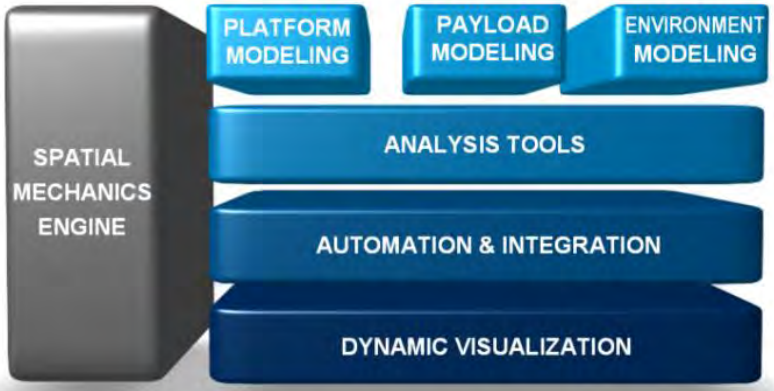
AGI Software Building Blocks

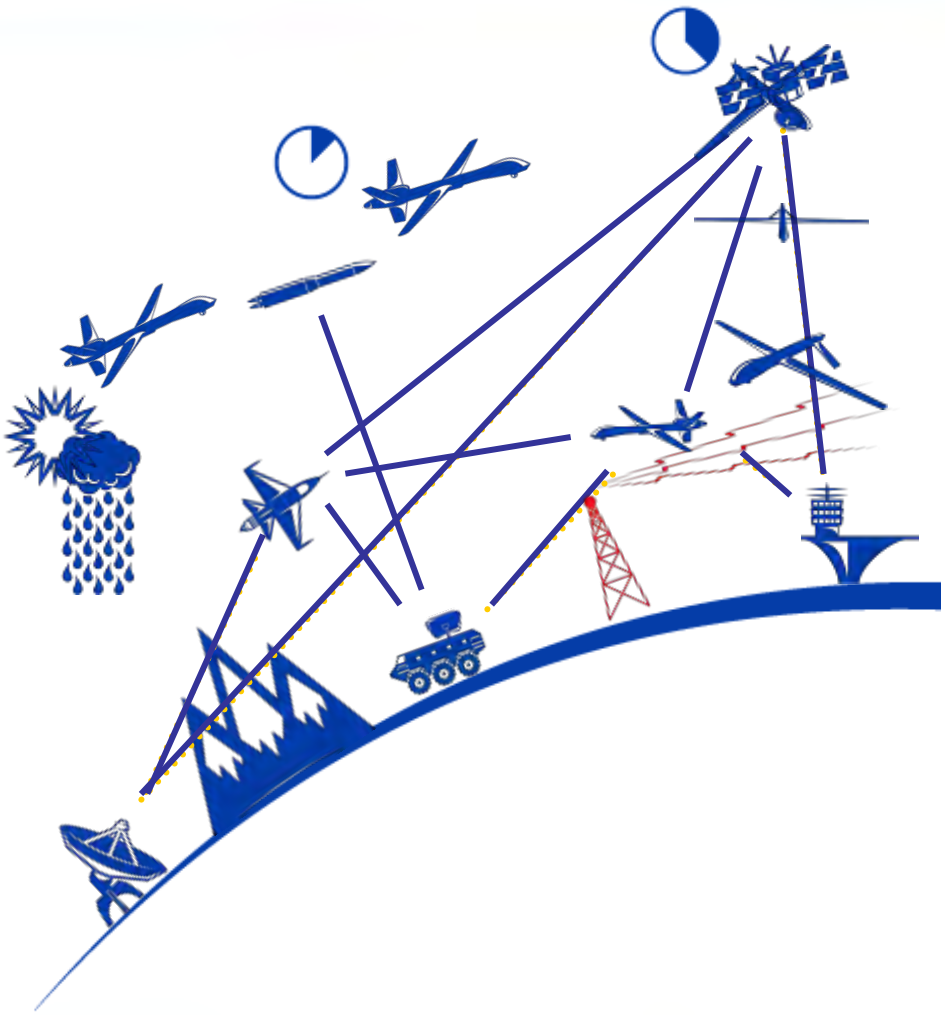


- **Spatial Mechanics Engine**
  - Precision mapping of time and space
- **Advanced Vehicle Motion**
  - Advanced platform propagation
- **Payload and Environment Modeling**
  - Configure sensors, communications, terrain, buildings, atmosphere
- **Analysis Tools**
  - Analyze the relationships of objects over time
  - Evaluate quantitative and qualitative measures
- **Display**
  - Visualize complex system mechanics in dynamic 3D

Systems Tool Kit Summary

- **COTS software for space, defense, and intelligence**
- ***Model*** **your system**
- ***Analyze your mission***
- ***Convey*** **your results**

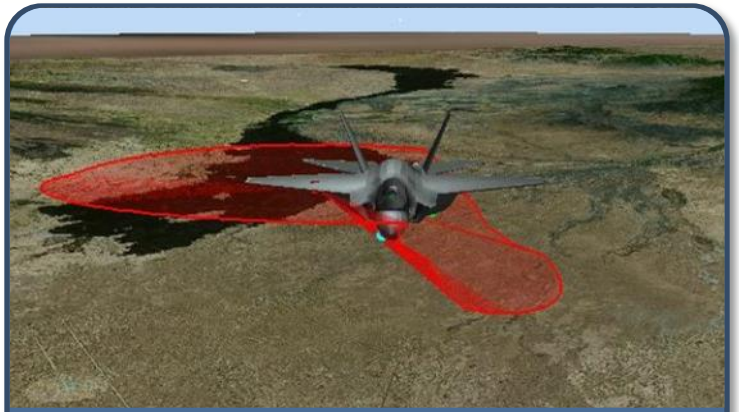




Models

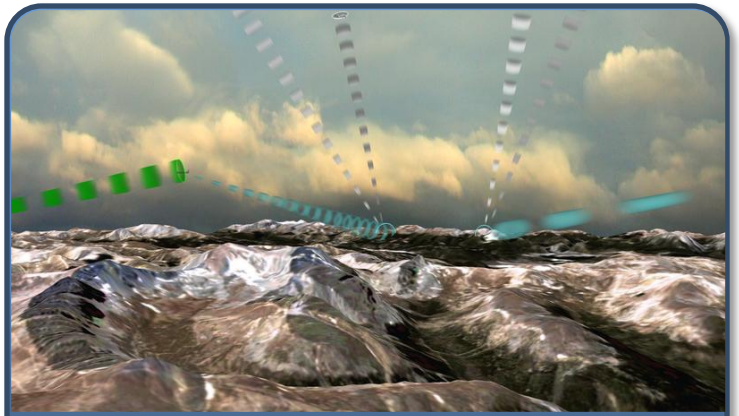
Vehicle Motion Models

Model vehicle position and attitude



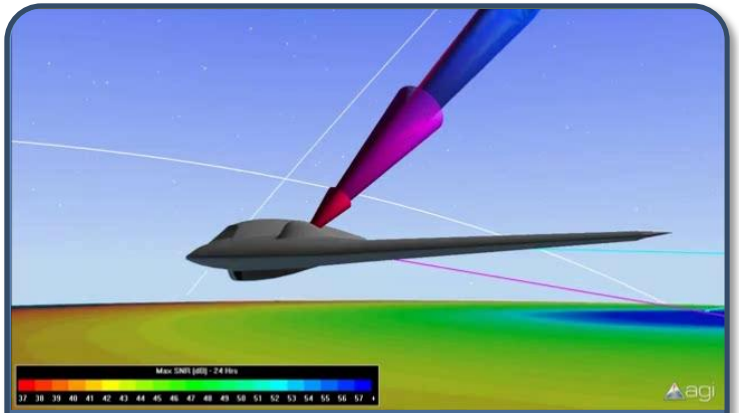
Sensor Models

Model sensor geometry & pointing



Environment Models

Model terrain, atmosphere & space



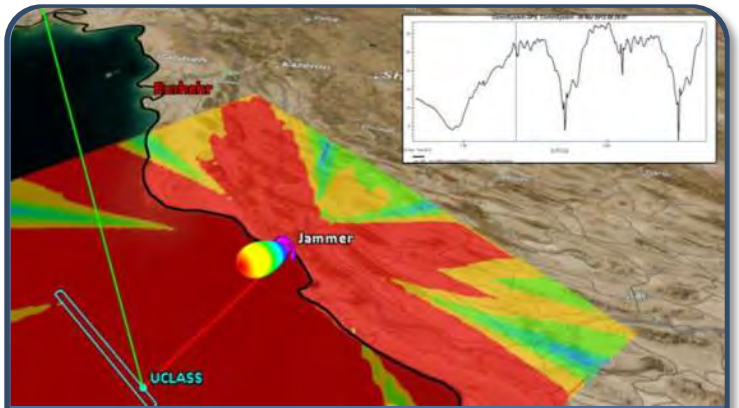
Comms & Radar Models

Model RF propagation & interference

Simulate

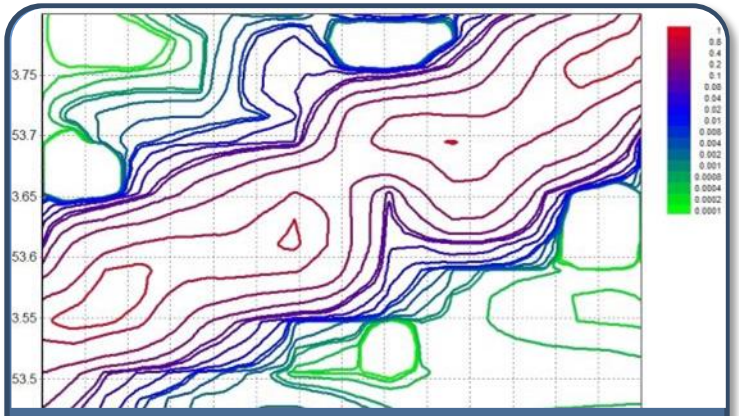
Simulate mission

Analyze system behavior in theater



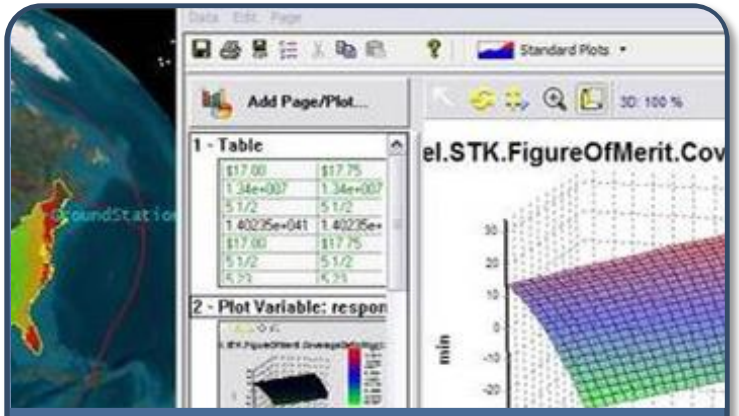
Calculate system performance

Measure against mission objectives



Evaluate system relationships

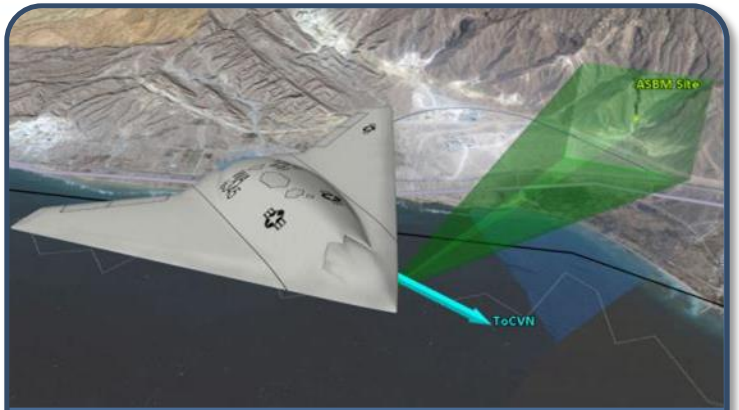
Measure system impact



Explore trade space

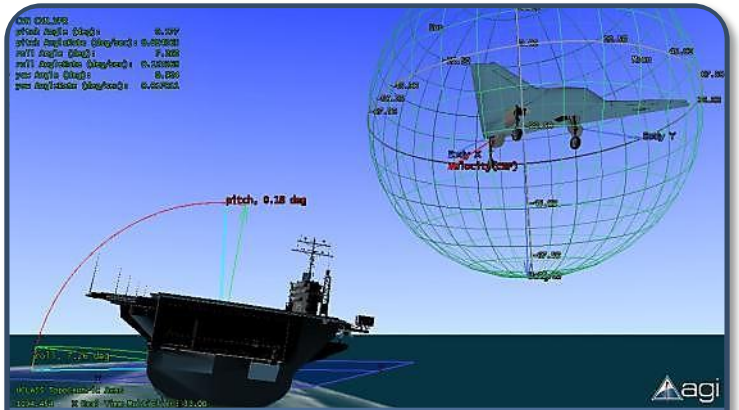
Analyze system design

Analyze



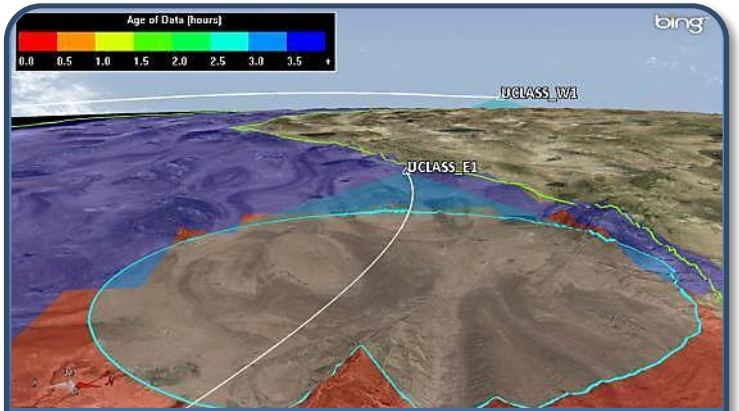
2D and 3D visualization

Vehicles, routes, sensors & analysis



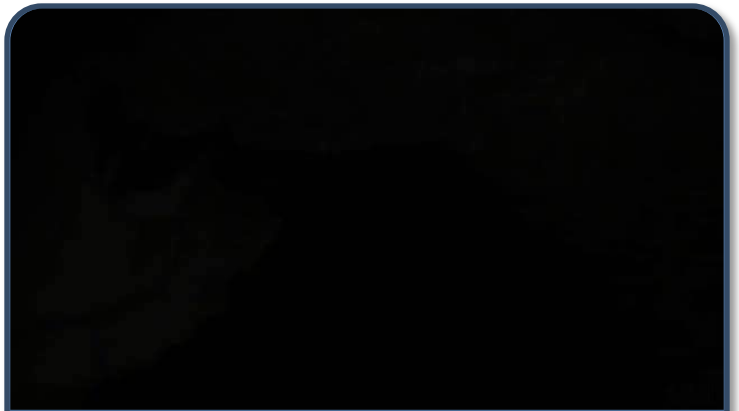
3D object representations

Position, orientation & articulation



Mission environment

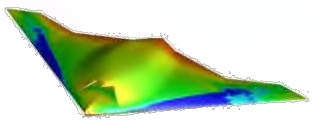
Terrain & imagery



Analyze results

Graphs, reports, images & videos

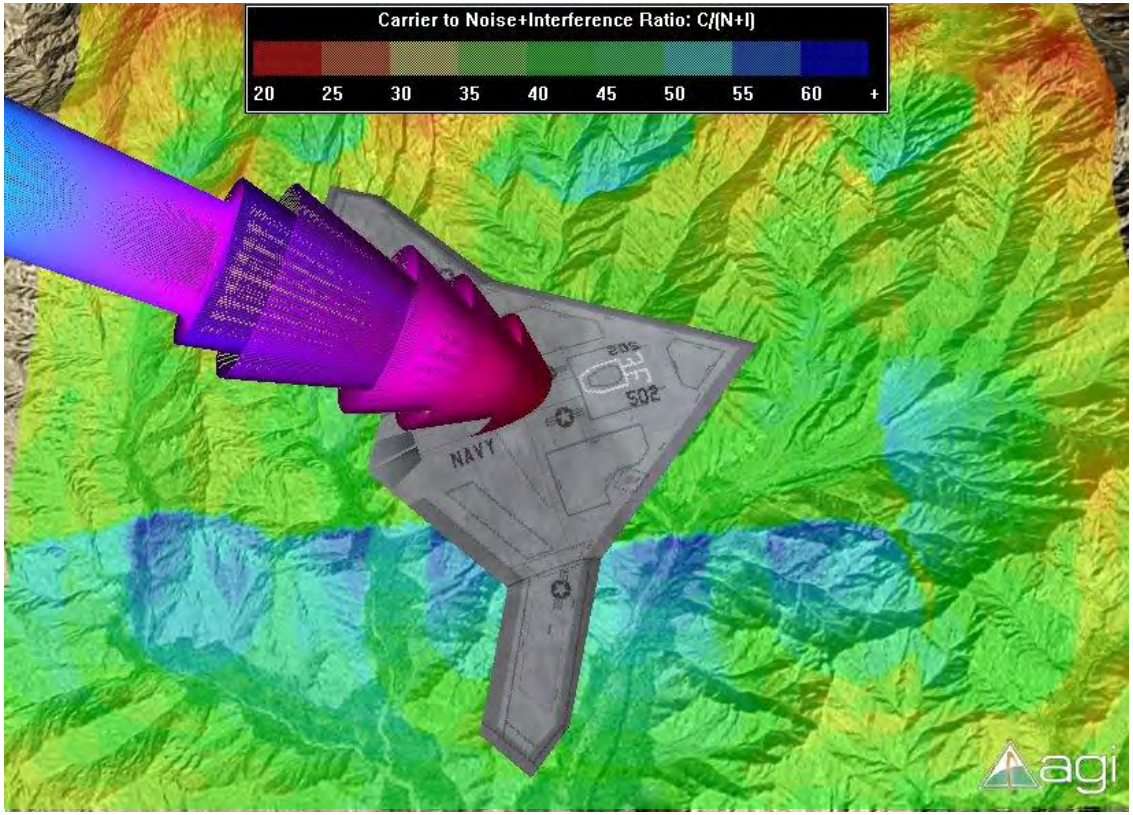
Create Systems Models



Aircraft Model

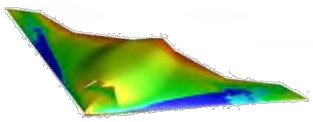
Environment Model

Communications Model



- Build Representative System Models
- Model Payloads (Sensors/Radars/Comms/Etc.)
- Dynamic Depiction of Systems in Theatre
- Expose Unforeseen Problems

Evaluating Mission Success

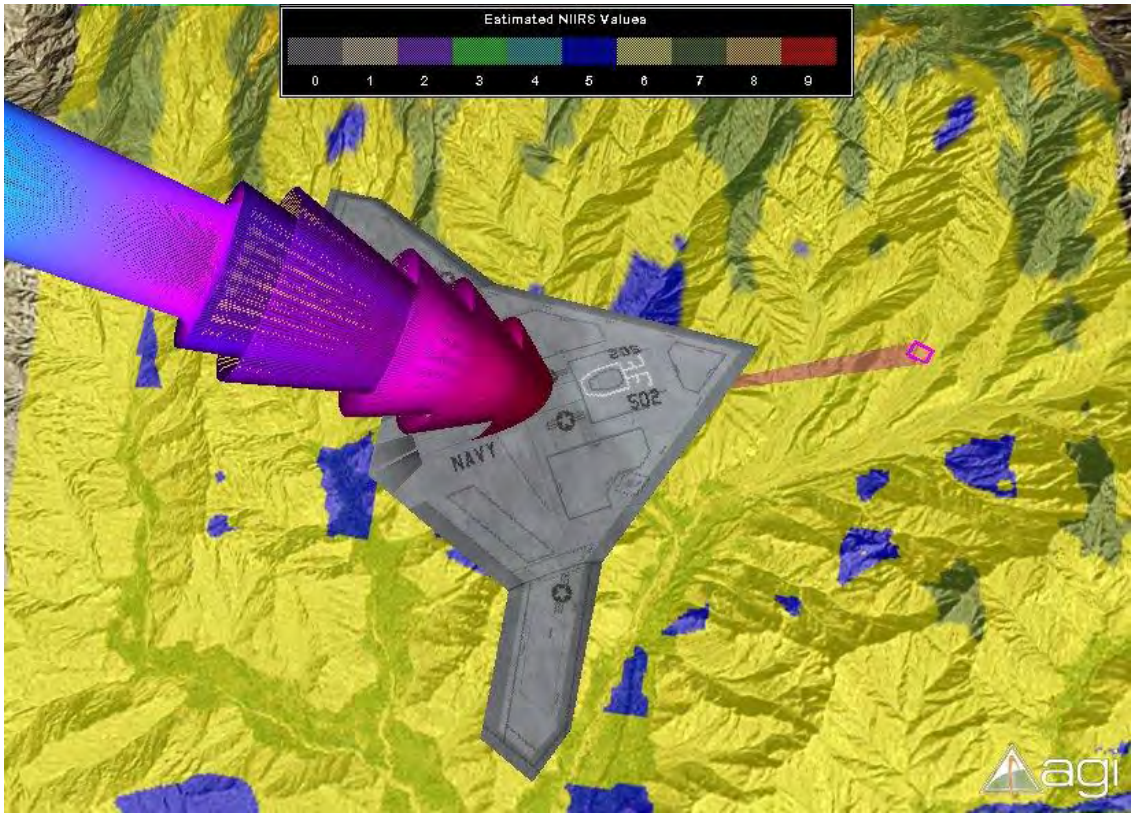


Aircraft Model

Sensor Model

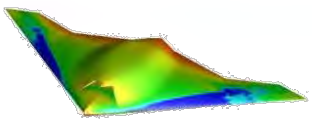
Environment Model

Communications Model



- Increase Fidelity With Updated Models
- Flexible Modeling Options
- Convey Complex Concepts
- Mission Design/Planning/Re-Planning and Optimization

Creating a Complete Representation



Aircraft Model

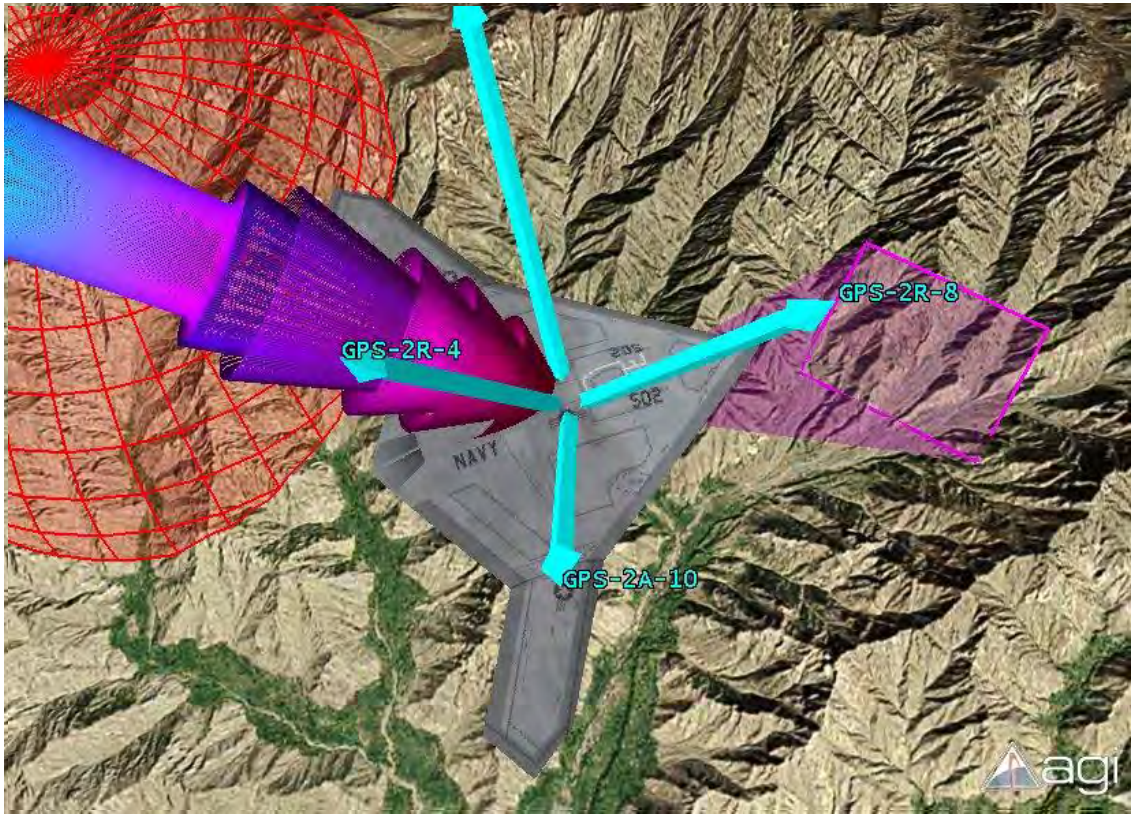
Sensor Model

Environment Model

Navigation Model

Communications Model

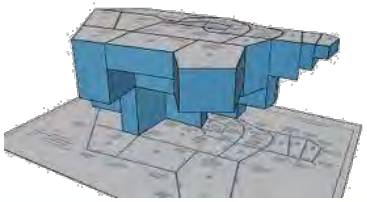
Threat Model



Acoustic Model

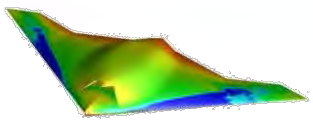
Radar Model

Line of Sight



Airspace Geometry

Mission Execution



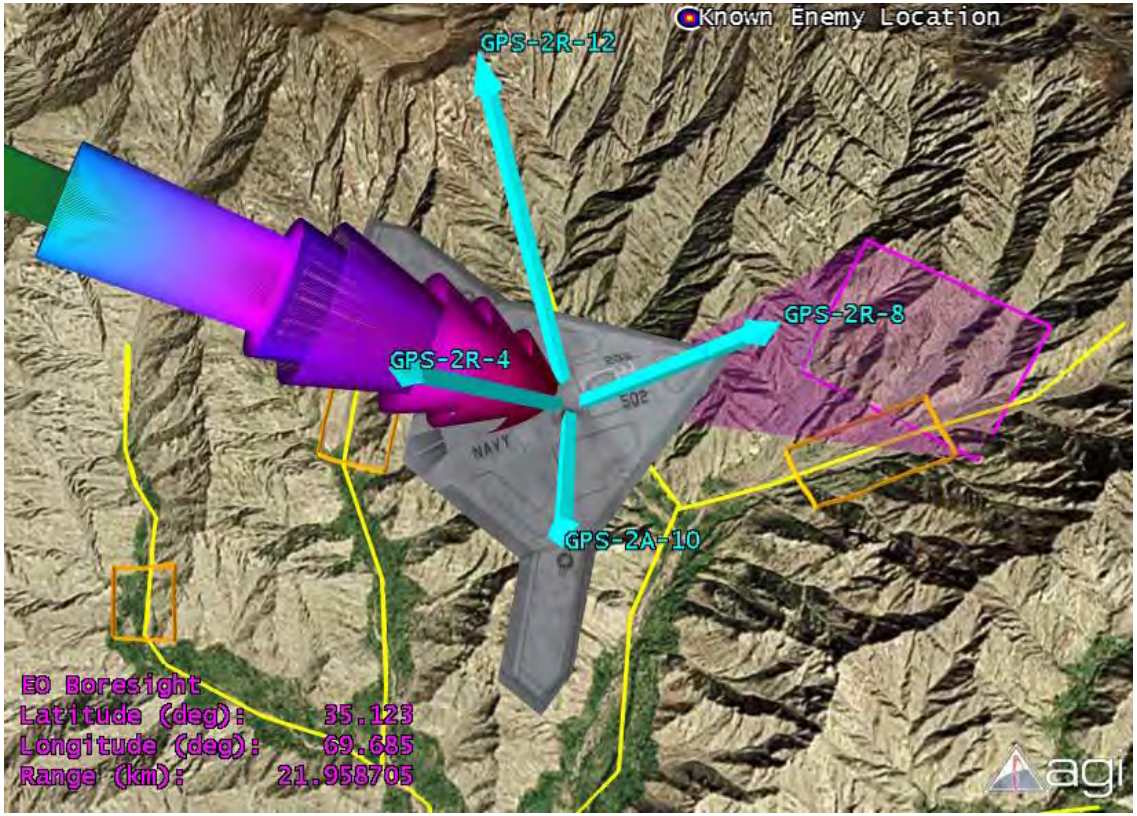
Aircraft Model

Sensor Model

Environment Model

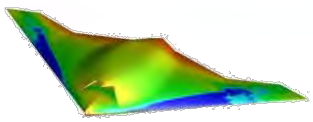
Threat Model

Communications Model



- Conduct “What-If” Analysis
- Allow Operators to Focus on Mission
- Enhance Mission Situational Awareness
- Easily Evaluate Mission Success

Example: Mission Planning



Aircraft Model

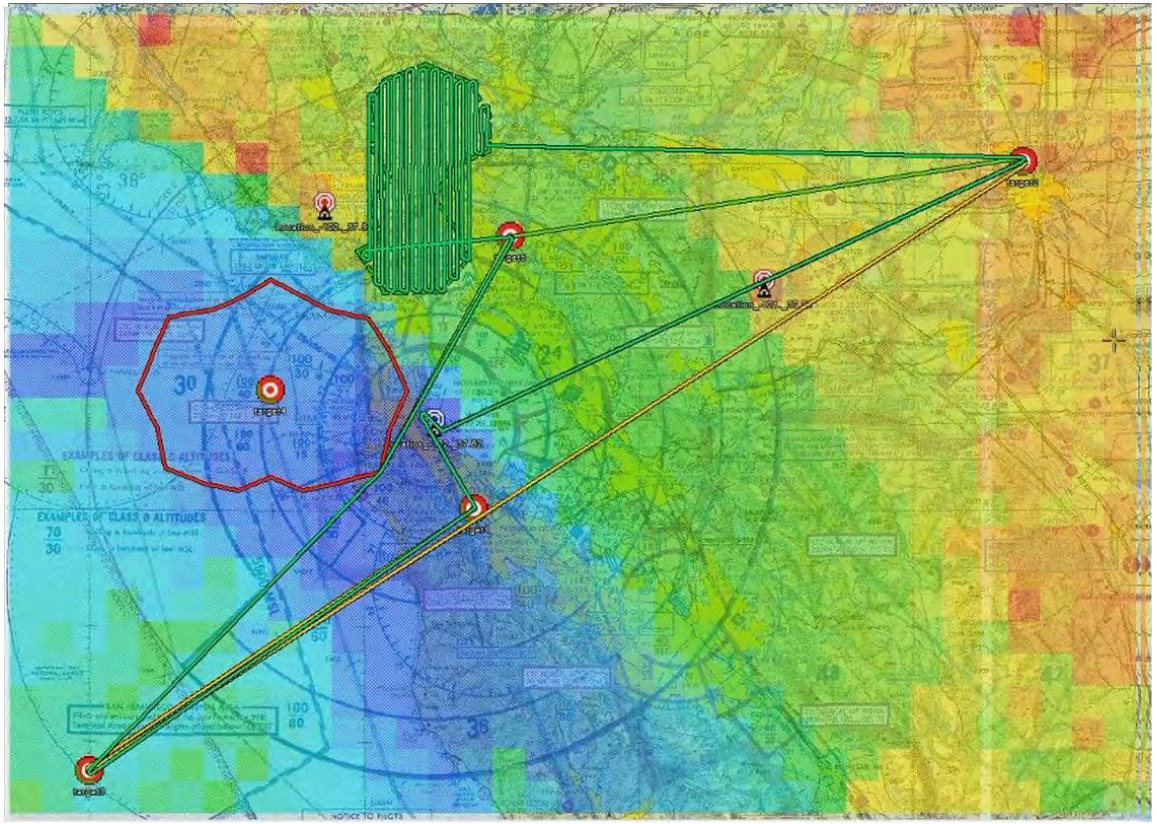
Acoustic Model

Environment Model

Sensor Model

Communications Model

Automation

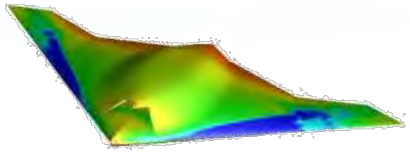


- Incorporate layers that represent mission effectiveness
- Display results in a format already familiar
- Allow for flexibility in tactical mission planning
- Apply automation to suggest mission plans

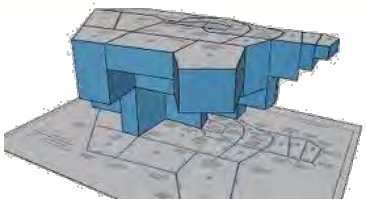
STK Modeling Environment

Navigation Model

Communications Model



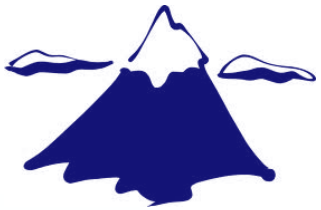
Aircraft Model



Airspace Geometry

Acoustic Model

Sensor Model



Environment Model

Threat Model

Automation

Line of Sight

Radar Model

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)

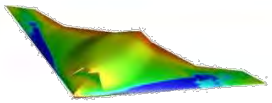
- **Remcom –** Urban comms modeling
- Alion - TIREM
- **VT Mak –** SimMetrics
- **AER –** Weather Data
- **SDL –** Electro Optic Sensor Modeling
- **Satsoft –** Antenna Design
- **ASI -** Satellite Simulation
- SAIC – Missile modeling

Software for Space, Defense & Intelligence

STK Modeling Tools

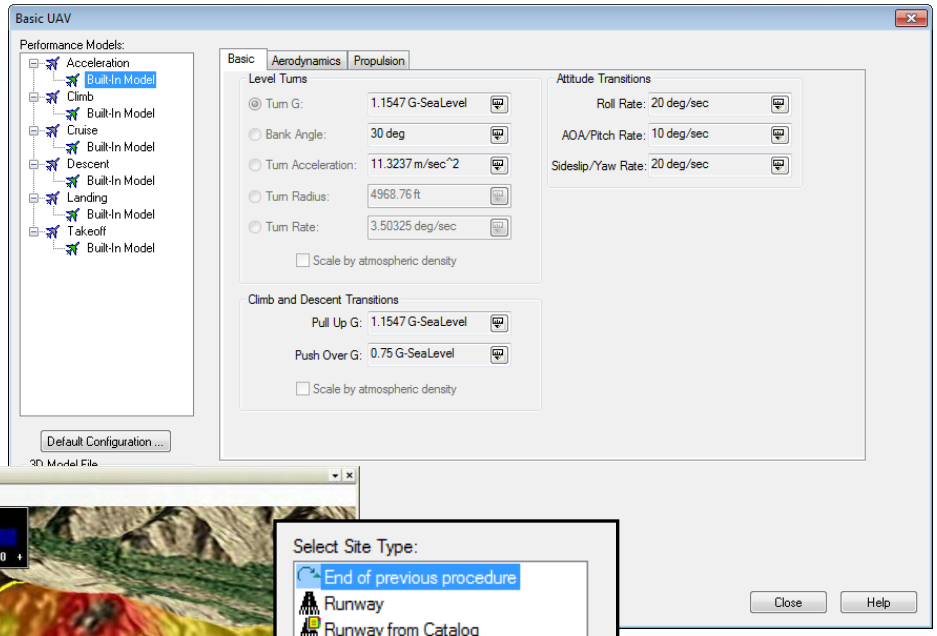
Detailed Look At STK Modules

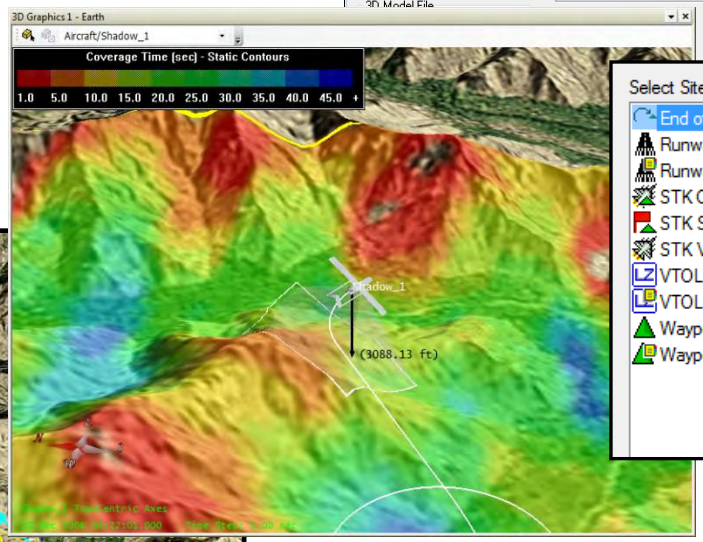
Aircraft Mission Modeler

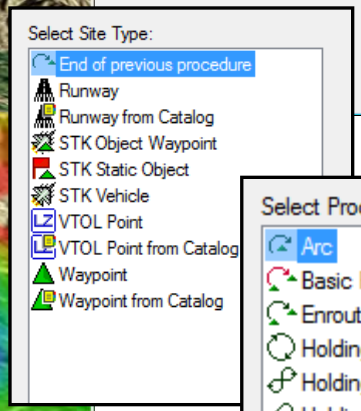


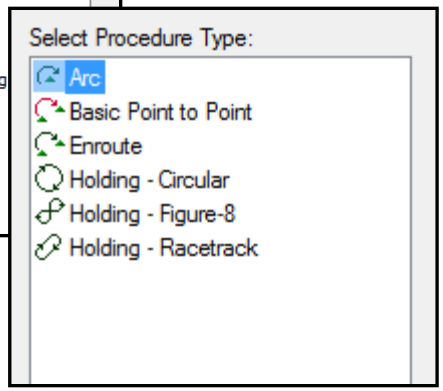
Aircraft Model

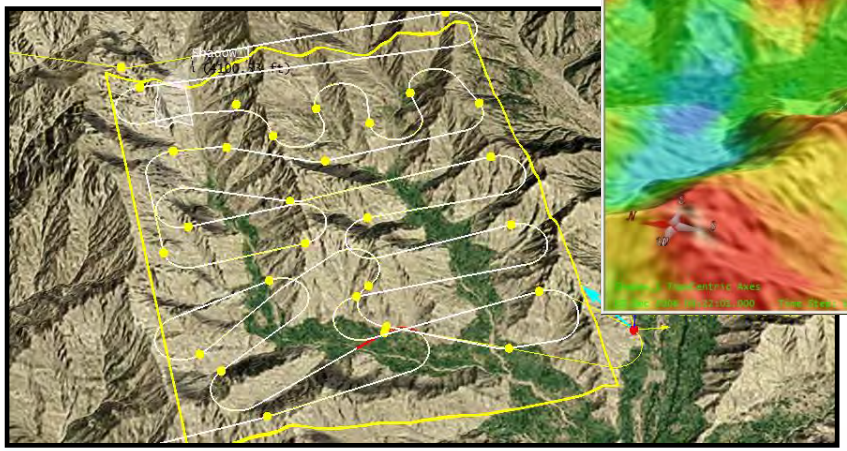
- Performance Driven Models
- 3D Edit Flight Paths on the Fly
- Common Procedure Library
- Holding Patterns
- Takeoff/Landing & VTOL/Hover
- Fuel Management







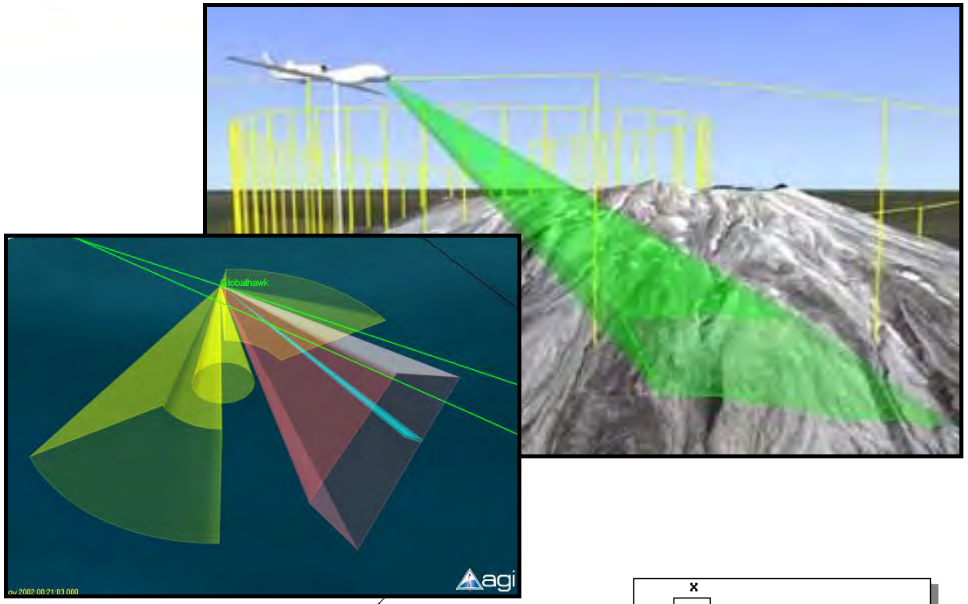




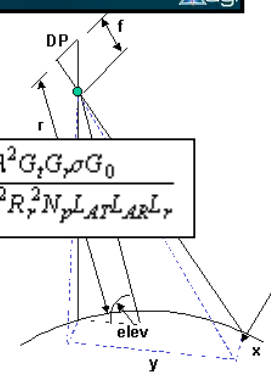
System Design – Sensors

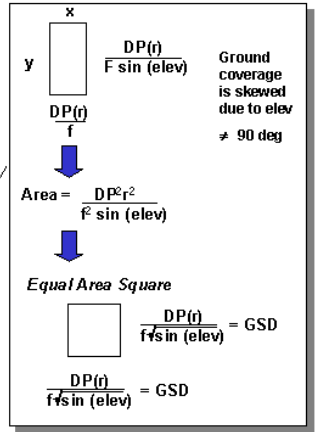
Sensor Model

- **What can your systems see?**
  - Dynamic environment
  - Number/type of platforms
  - Number/type of sensors
  - Target constraints
    - Terrain
    - RCS
- **Complex detection**
  - Visual
  - IR (GSD)
  - RF
  - Search/Track Radar
  - Synthetic Aperture Radar (SAR)
  - GMTI (flexible constraints)
- **Use the right sensor for the mission**



$$SNR_1 = \frac{P_t \lambda^2 G_t G_r \sigma G_0}{(4\pi)^3 R_t^2 R_r^2 N_p L_{AT} L_{AR} L_r}$$





Legend

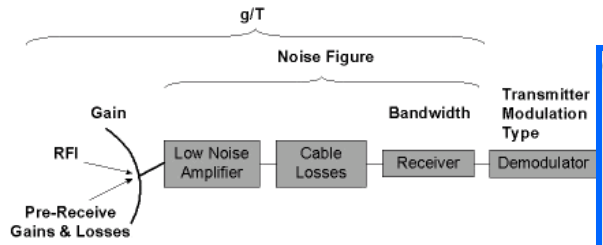
IQ	=	Image Quality
DP	=	Detector Pitch
GSD	=	Ground Sample Distance
f	=	focal length
elev	=	elevation
r	=	range

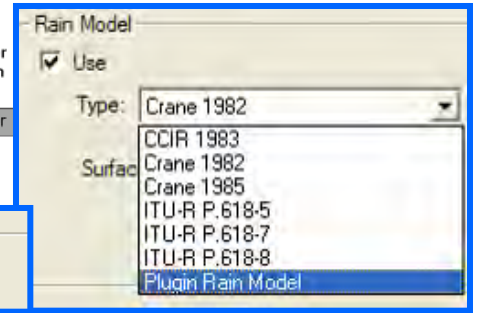
$$GSD = \frac{(\text{detector pitch})(\text{range})}{(\text{focal length})\sqrt{\sin(\text{elevation})}}$$

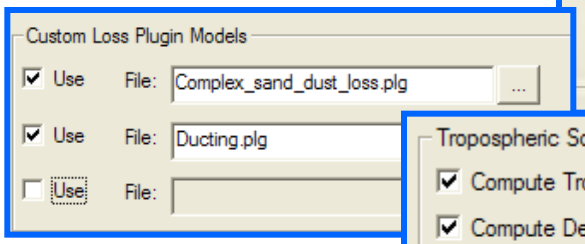
Imperfect RF Enviroment Analysis

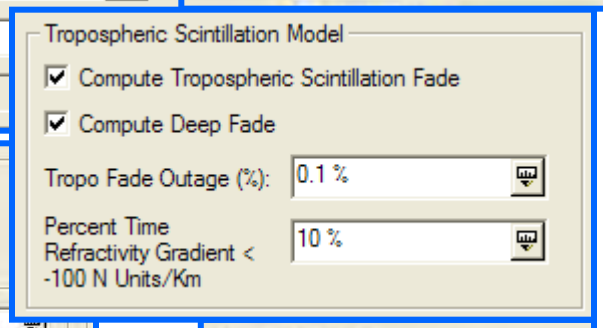
Environment Model

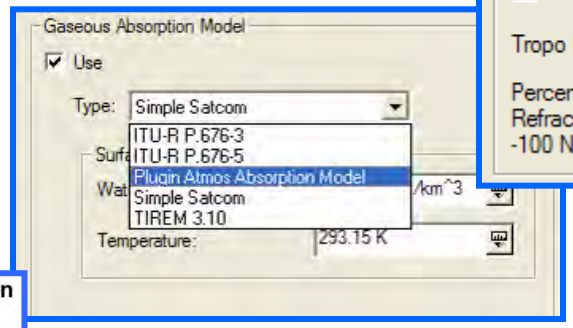
- Terrain blockage
- Rain, clouds, fog
- Gaseous absorption
- Foliage / Urban
- Custom loss plug-ins

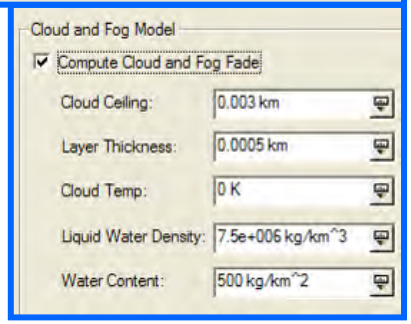


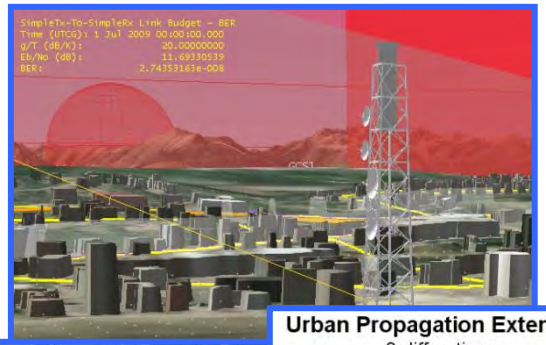


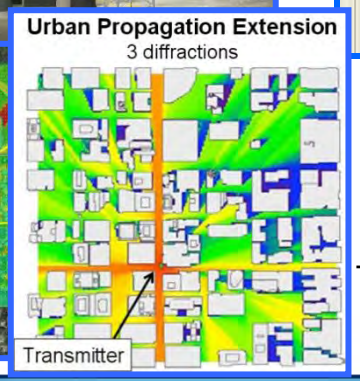


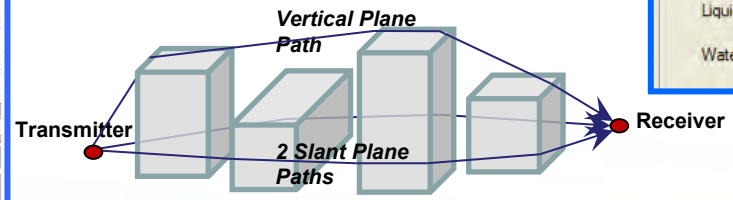




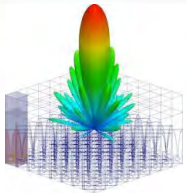






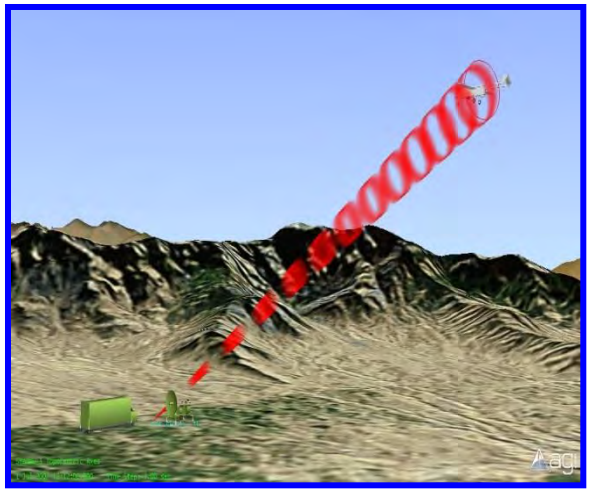


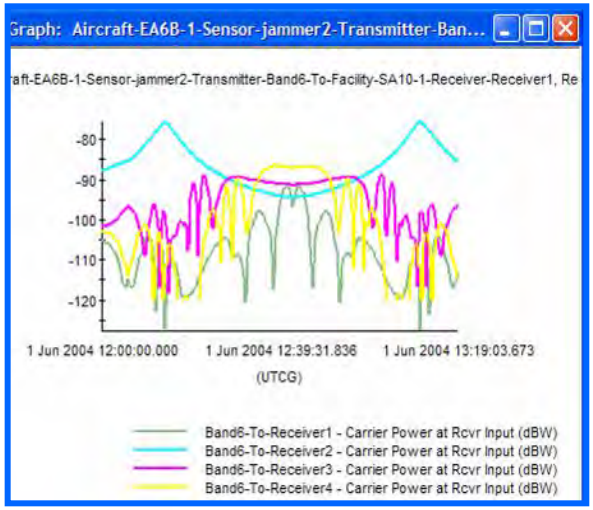
System Design- Communications



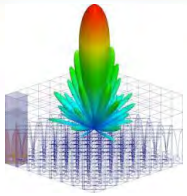
Communications Model

- **What is my Comm Environment?**
  - Modelling Comm Effects
  - Specify the RF environment model
- **Number of Nodes**
  - Transmitters / receivers
  - Multi-hop links
- **Predicting the link quality**
  - Detailed emitter patterns, modulators, spectral filters, etc.
  - Link budget (BER, Eb/No, C/N, etc.)
  - Interference / jamming
  - Link performance over large areas
- **Evaluate Alternate Asset Usage**



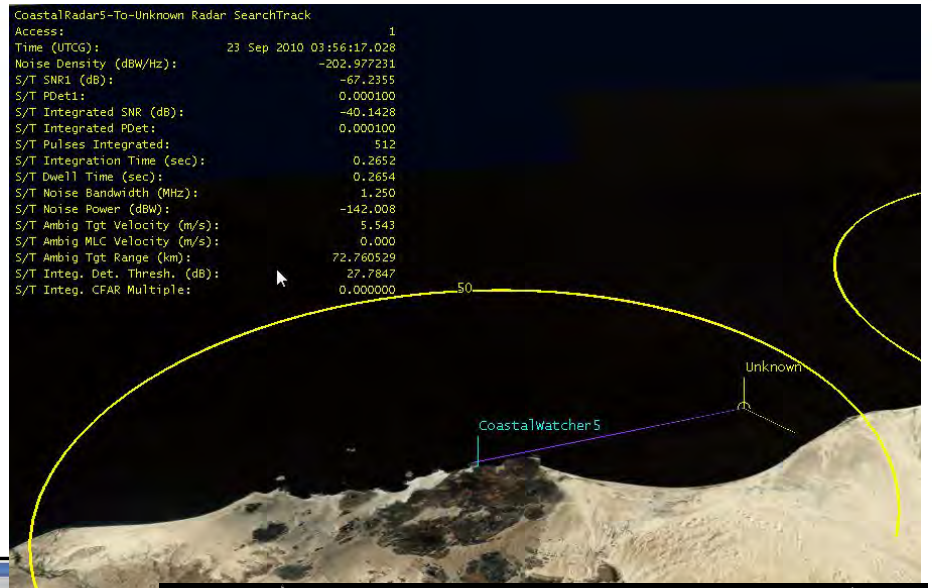


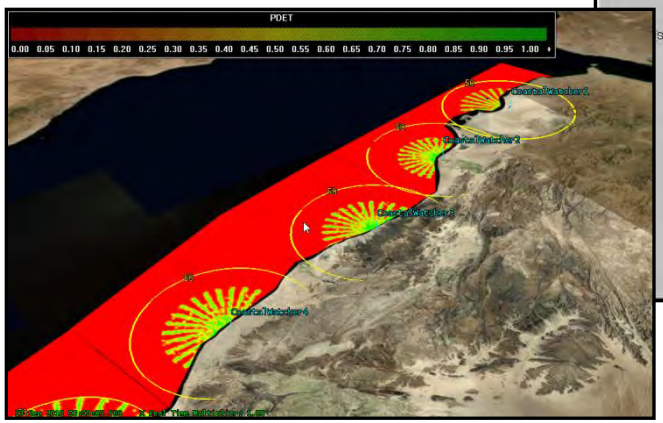
Radar Modeling

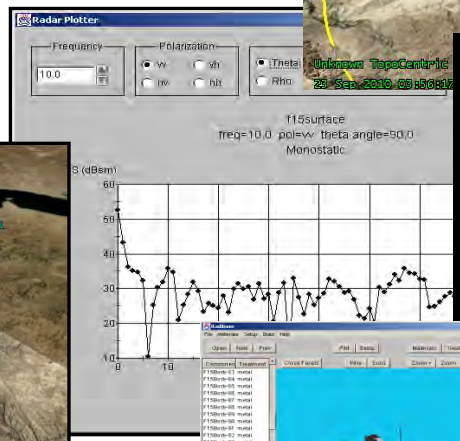


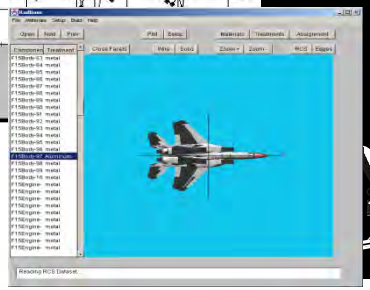
Radar Model

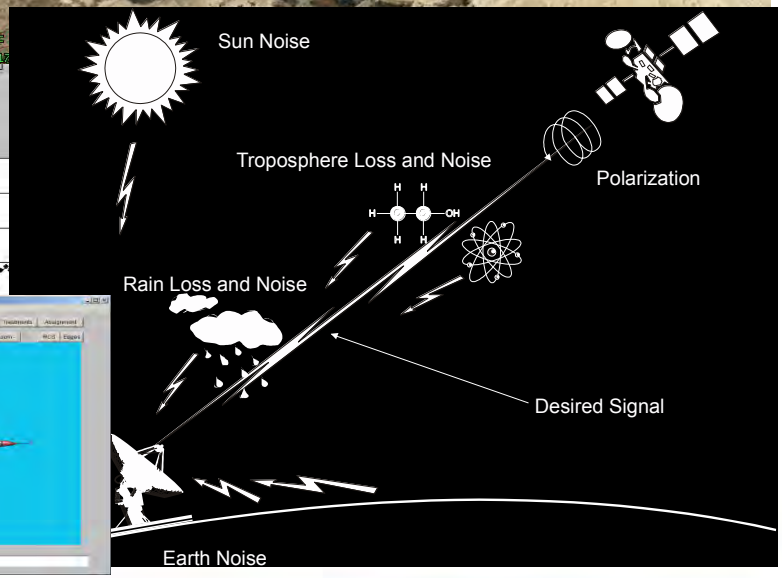
- Pulsed & Continuous Wave
- SAR
- Filters
- Gaseous absorption
- Polarization
- Custom Antennas
- Radar Cross Section



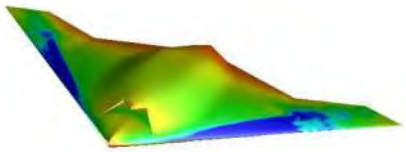






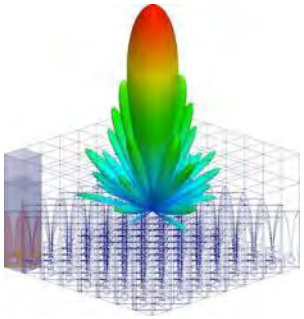


STK for Model Based Systems Engineering

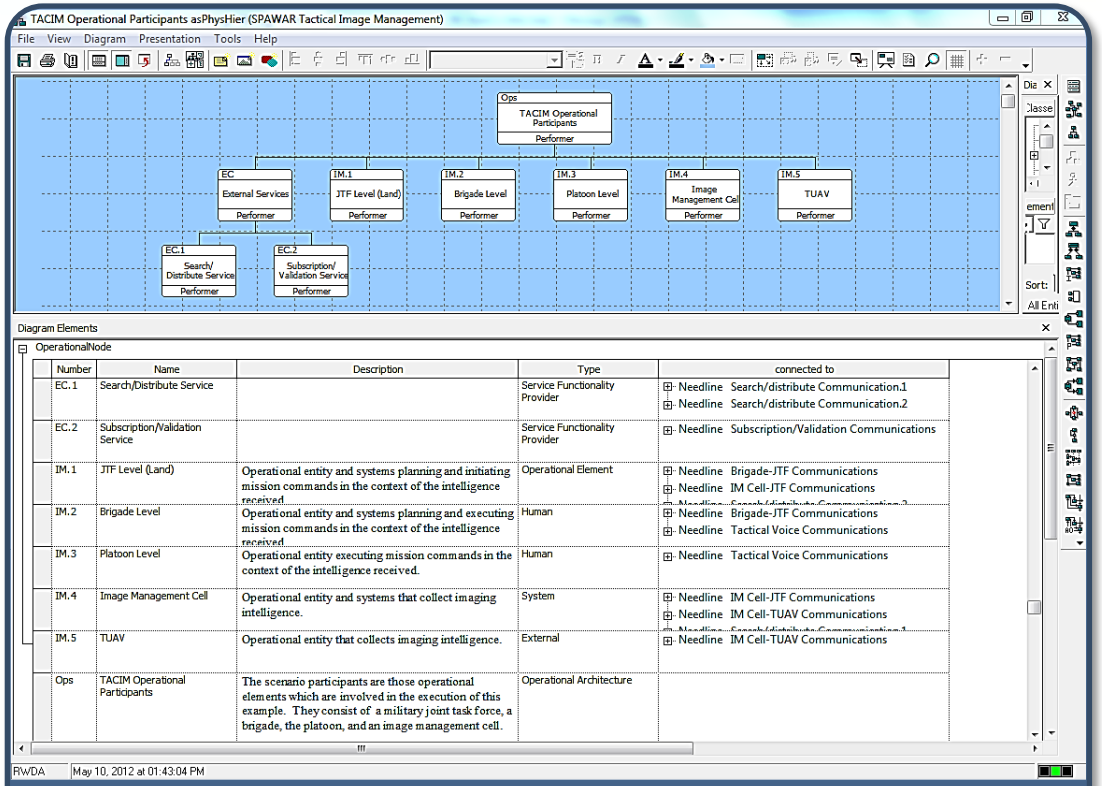


Aircraft Model

Sensor Model

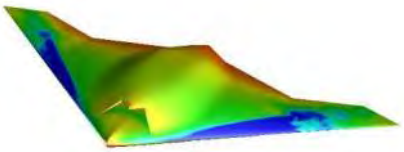


Communications Model



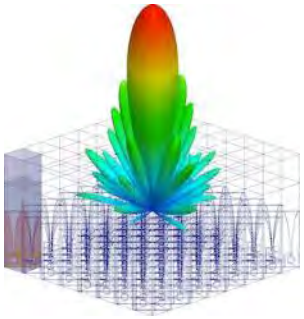
Systems Architecture

STK for Model Based Systems Engineering

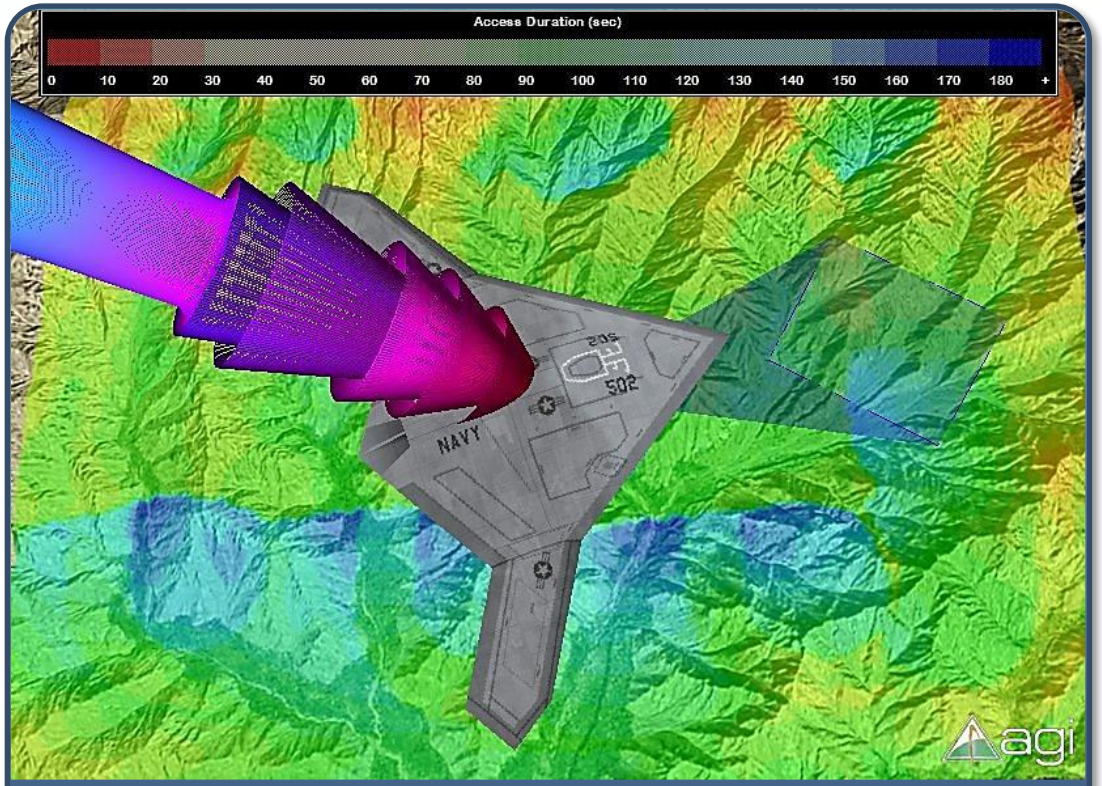


Aircraft Model

Sensor Model

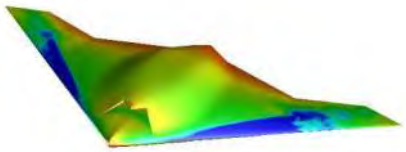


Communications Model



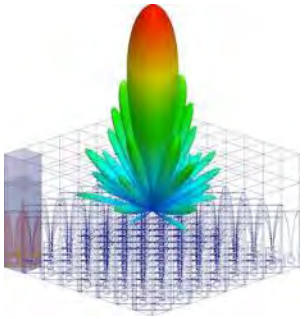
Mission Specific Analysis

STK for Model Based Systems Engineering

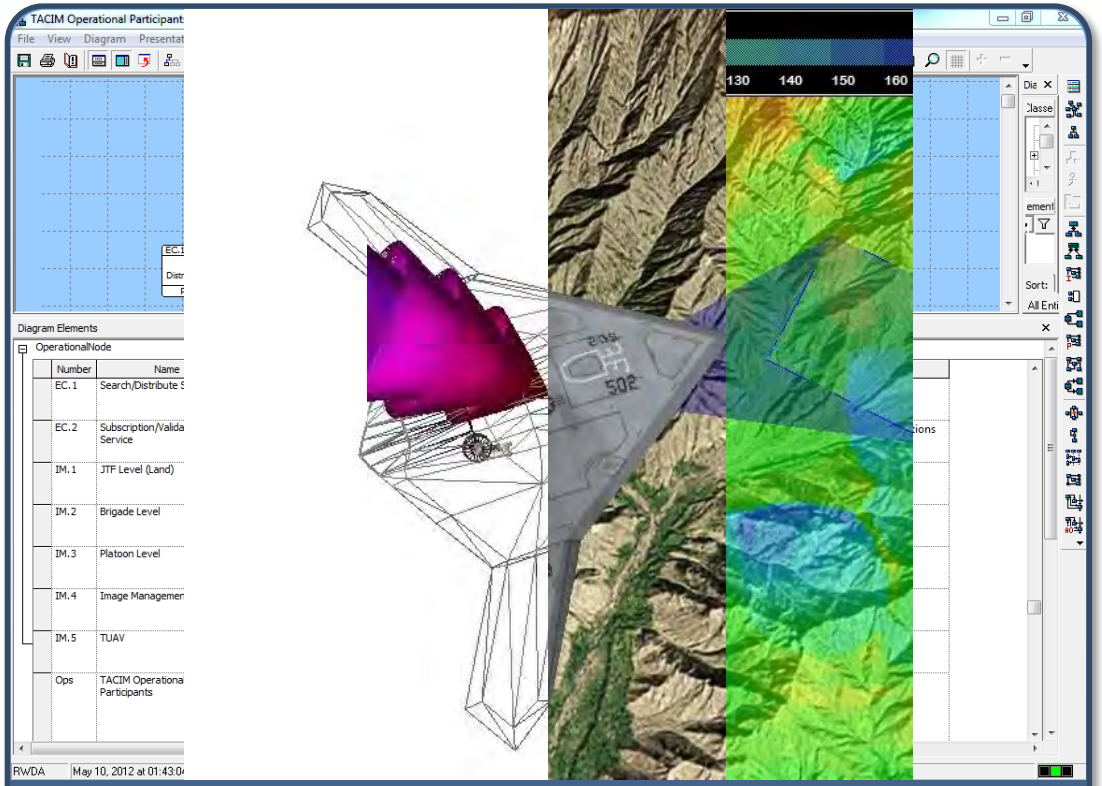


Aircraft Model

Sensor Model



Communications Model



End-to-End System Design

Software for Space, Defense & Intelligence

STK Software Demonstration

Quick Overview of STK for Modeling Systems

AGI Software – Test & Evaluation Timeline

STK Benefit Potential in T&E Process

Develop Test Plan

- Test scenario development
- Timing of test events
- Gross system trades
- Detailed system trades
- Determine objectives – given & derived
- Determine essential elements of analysis and MOEs
- Identification of variables for control and measurement
- Gross trades of schedule of objectives
- Design of Experiments

Test-Event Design

- Selection of test points for specific objectives
- Flight plan design to match test point goals
- Coordination of test resources
  - Multiple aircraft
  - Multiple sensors
  - Air & ground
- Design & planning of specific test
- Scheduling
- Planning & analysis of infrastructural items
  - Telemetry systems
  - Test range radars
  - Comm systems
- Pre-flight briefing material production – animations, snap shots, event schedules

Event Rehearsal

- Use of pre-flight briefing materials
- Nominal test scenario run through
- Scheduling check
- Coordination of test resources
- Quick reaction test plan modifications

Pre-Test Re-Plan

- Pre-test adaption to last minutes changes
- Flexibility to bring up nominal test plan in M&S environment and quickly make changes
  - Airspace changes impact assessment & adaption
  - Wind direction impact assessment & adaption
  - Weather conditions changes impact assessment & adaption
- Provides a means to allow for changes with low impact to test objectives achievement

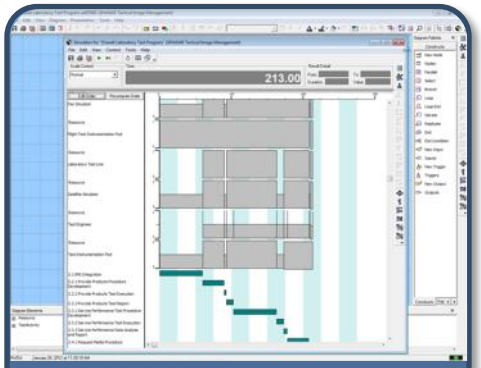
Test Execution

- Test event situational awareness tools
- Real-time visualization of test event
  - On-board aircraft
  - Local to test range
  - Remote to contractor facility or customer facility
- Monitoring of test points achievement versus nominal plan
- Quick reaction to real-time changes in actual flight paths versus planned nominal and impact on test points and objectives
- Real-time re-planning to adapt to changes and to execute secondary objectives and test points
- Remote real-time SA of test events and participation in real-time re-plans

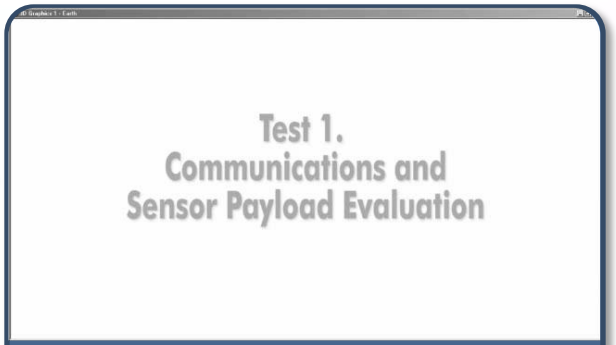
Post-Test Analysis

- Rapid production of "quick-look"
  - Actual flight path –vs– nominal
  - Actual test points achieved comparison to plan
  - Visualization of test geometry history correlated with collected test data
- M&S supplement to actual test results
  - Use of STEP process approach to validate M&S models as part of the feedback loop within the test series
  - Test point trade space extrapolation
  - Variations of parameters to aid in the design of next test event
- Post test briefing material production
  - Animation of entire test event
  - Specific test point geometry depictions and animations

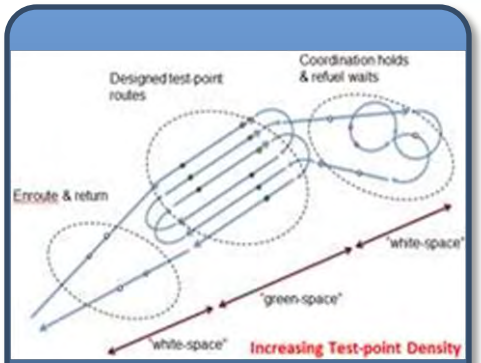
STK Impact Across Test and Evaluation Process



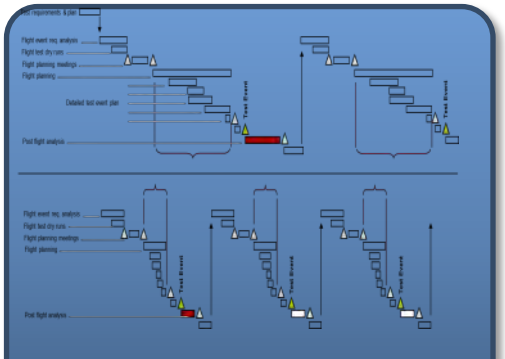
Test scheduling



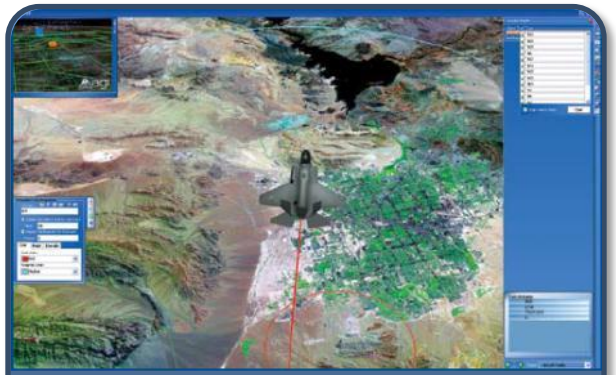
Test event simulated in STK



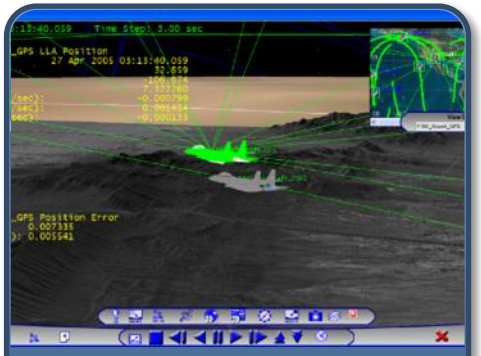
Test route optimization



Schedule compression using new processes



Test event monitored in real time

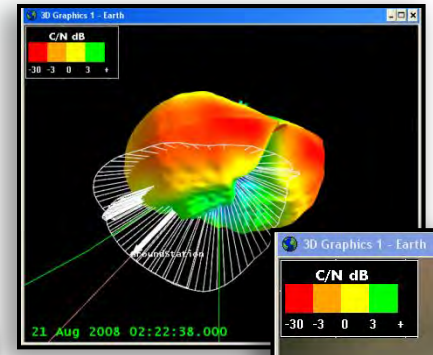


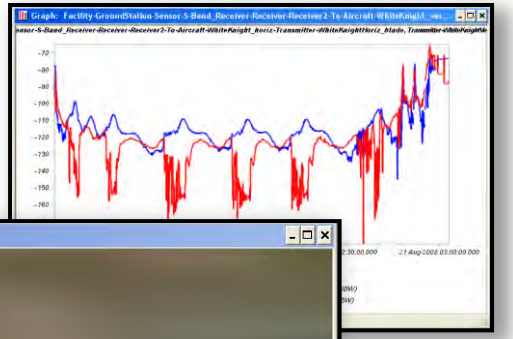
Quick-turn post-flight analysis

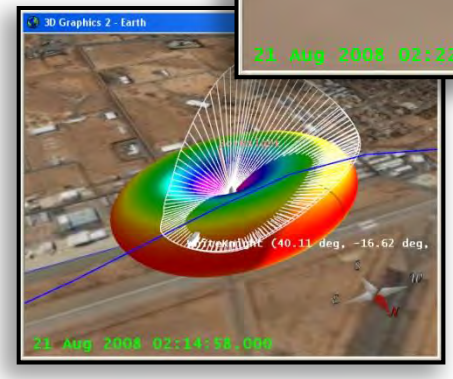
Developing Test Plans

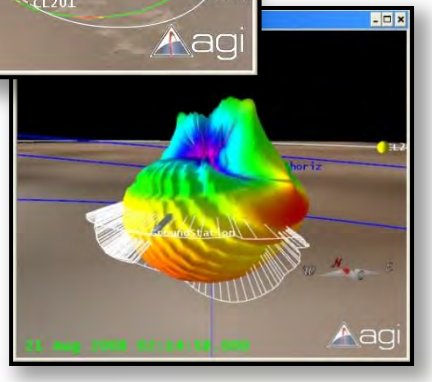
Develop Test Plan

- Create “Scenario” in STK
  - Time Period
  - Terrain
  - Imagery
  - RF Environment
- Create “Objects”
  - Aircraft
    - Aircraft System Models
    - Sensors/Comms/Etc
  - Targets
    - Radar Cross Section
  - Areas of Interest
  - Test Point Locations
- Data Sources
  - GIS/KML/Shapefile/Etc.









Example : Mojave Flight Test

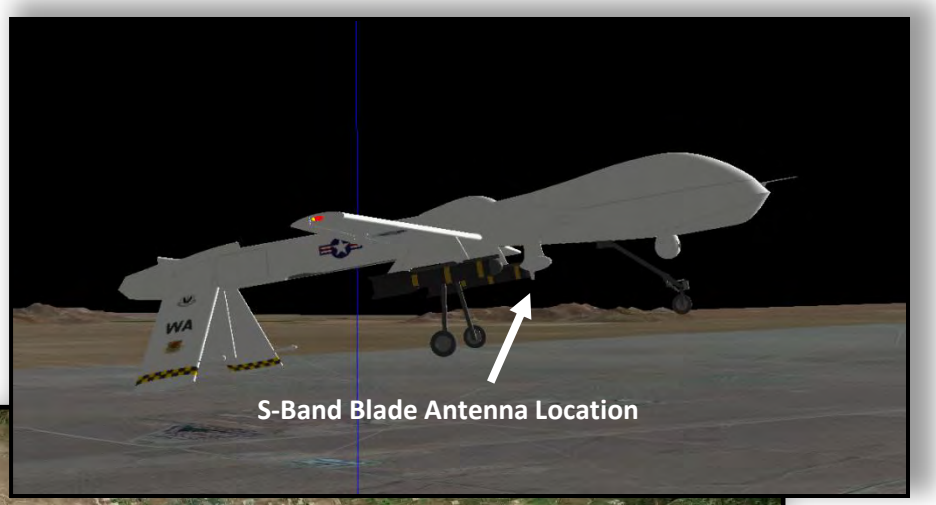
Downlink Communications Test

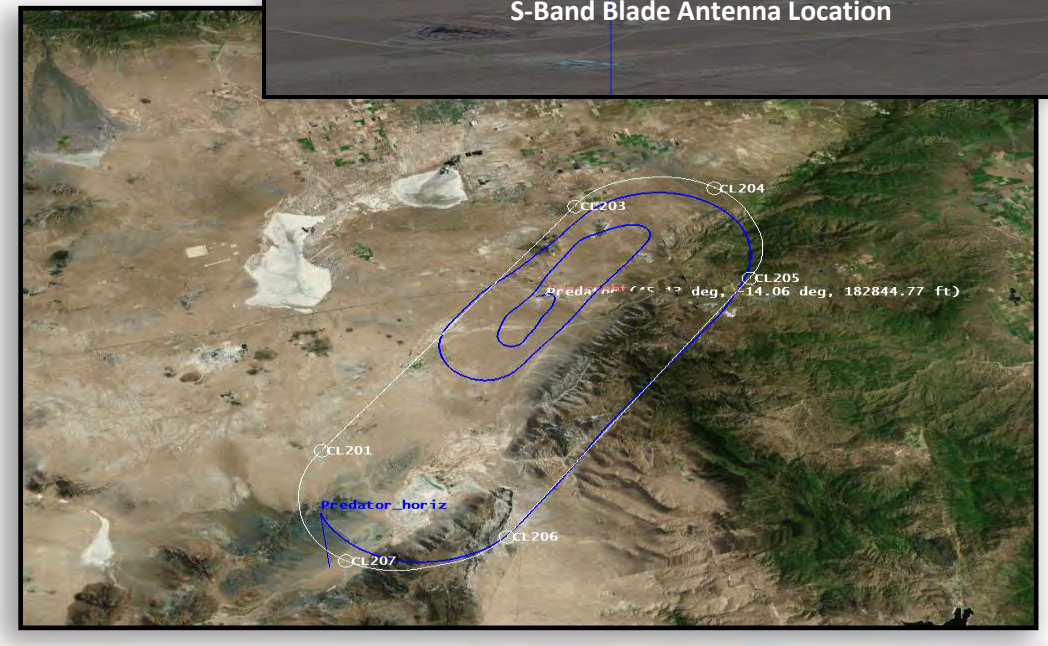
Issue

- Loss Of Signal During Aircraft Ground Taxi to End of Runway
- Loss of Signal at Northeast Part of Flightpath; Particularly in the Turn and At Max Altitude of 50Kft

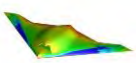
Fixes

- Moved Receive Antenna Location On Building Roof – Fixed Taxi Issue
- Adding Low Noise Amplifier to the Receive Antenna Produced Much Improved Signal at Northeast Part of Flightpath
- Narrowed Bandwidth on Receiver to Improve Signal-to-Noise Ratio



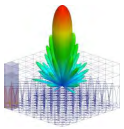


Model The Problem



Flight Path

- Aircraft Mission Modeler
- External Ephemeris
- 3D Aircraft Model

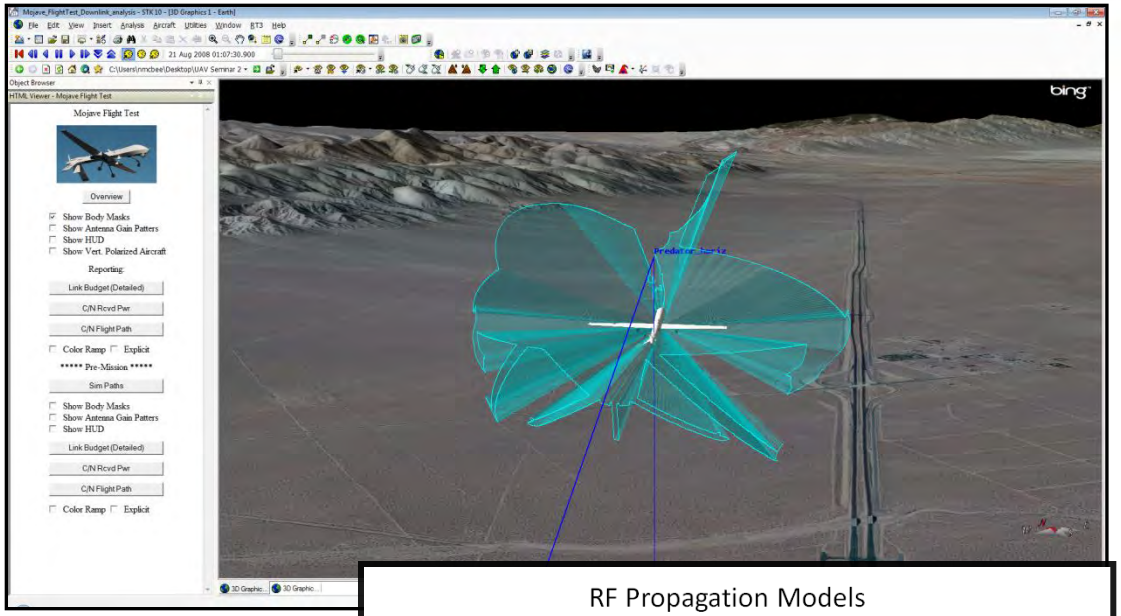


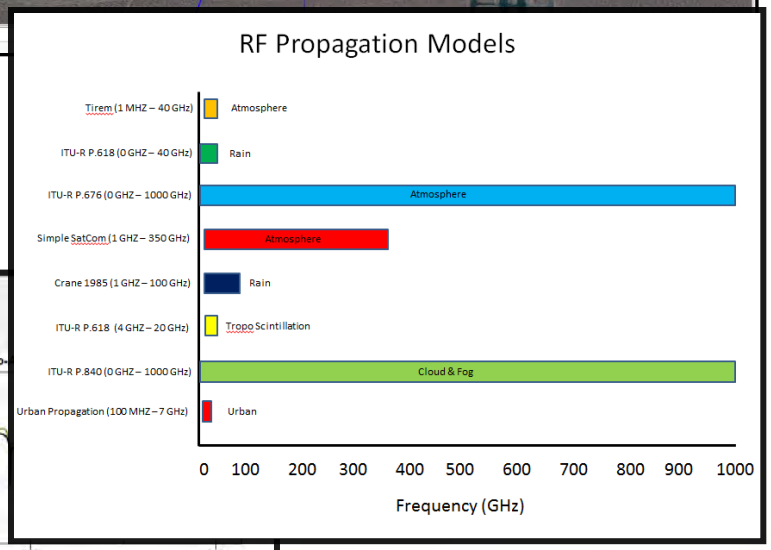
Antenna

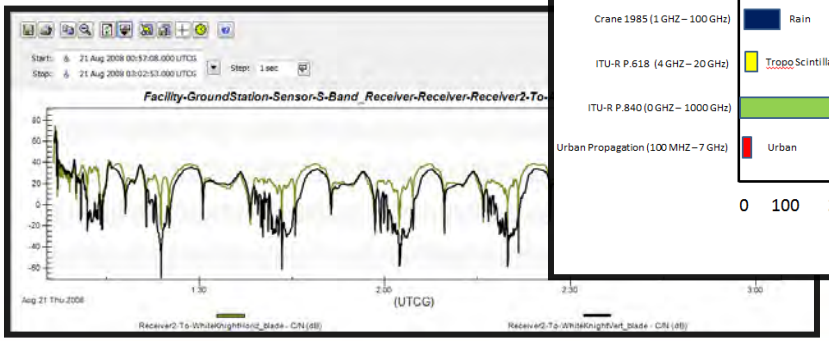
- External Data
- Built in Models
- Plugin Models

RF Environment

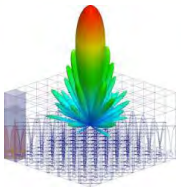
- Propagation Loss Models
- Weather
- Terrain
- Custom Plugins







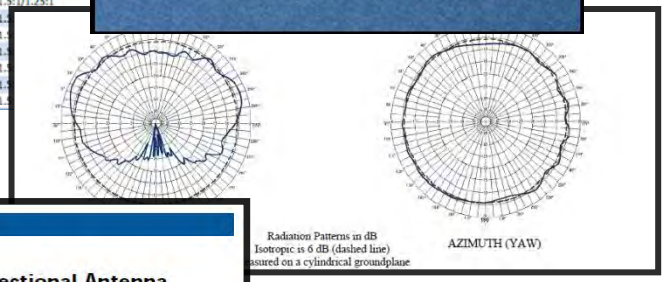
System Design Considerations

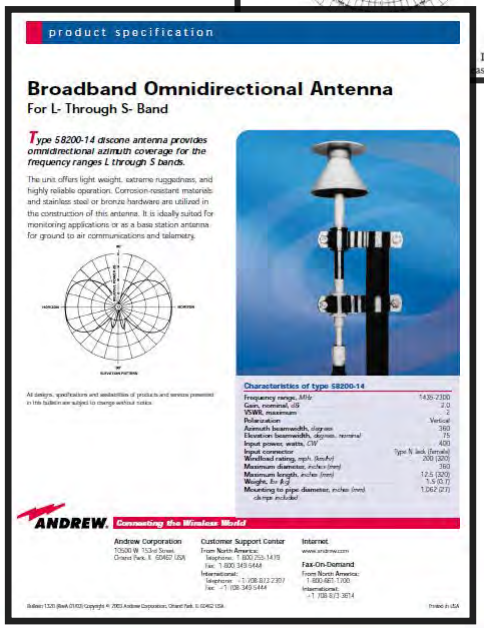


Antenna Choices

- Antenna Type?
- Antenna Location?
- Antenna Data Sheets
- General Assumptions
- Enhanced Scripting
- Etc.

Round Blade P/N	Straight Blade P/N	Frequency Range GHz	VSWR MAX/TYPICAL	SKW[1] ALTITUDE	PEAK[2] POWER	Height Inches [mm]	Weight (SMA) OZ [grams]
6107	6007	1.060 ± .030	2.0:1/1.50:1	116	160 W	2.30 [58.4]	1.0 [28.3]
6108	6008	0.9165 ± .025	2.0:1/1.50:1	116	160 W	2.30 [58.4]	1.0 [28.3]
6109	6009	1.35 – 1.54	2.0:1/1.50:1				
6110	6010	1.43 – 1.54	1.5:1/1.25:1				
6110-2	6010-2	1.425 – 1.525	1.5:1/1.25:1				
6110-3	6010-3	1.45 – 1.65	2.0:1/1.50:1				
6110-4	6010-4	1.50 – 1.80	2.0:1/1.50:1				
6115	6015	1.60 – 1.70	1.5:1/1.25:1				
6120	6020	1.71 – 1.85	1.5:1/1.25:1				
6125	6025	2.00 – 2.10	1.5:1/1.25:1				
6125-1	6025-1	2.00 – 2.30	2.0:1/1.50:1				
6130	6030	2.20 – 2.30	1.5:1/1.25:1				
6130-1	6030-1	2.30 – 2.40	1.5:1/1.25:1				
6130-2	6030-2	2.40 – 2.50	1.5:1/1.25:1				
6130-3	6030-3	2.20 – 2.40	1.5:1/1.25:1				
6130-4	6030-4	2.30 – 2.50	1.5:1/1.25:1				
6130-6	6030-6	2.20 – 2.50	2.0:1/1.50:1				
6135-1	6035-1	3.10 – 3.30	1.5:1/1.25:1				
6135-2	6035-2	3.45 – 3.55	1.2				
6135-3	6035-3	3.65 – 3.85	1.2				
6140	6040	4.50 – 5.00	1.3				
6150	6050	5.40 – 5.90	1.3				
6150-1	6050-1	5.27 – 5.75	1.3				
6150-2	6050-2	6.40 – 6.60	1.3				





product specification

Broadband Omnidirectional Antenna
For L- Through S- Band

Type 58200-14 discone antenna provides omnidirectional azimuth coverage for the frequency ranges L through S bands.

The unit offers light weight, extreme ruggedness, and highly reliable operation. Corrosion-resistant materials and stainless steel or bronze hardware are utilized in the construction of this antenna. It is ideally suited for monitoring applications or as a base station antenna for ground to air communications and telemetry.

Characteristics of type 58200-14

Frequency range, MHz	1435-2300
Gain, nominal, dBi	2.0
VSWR, maximum	2
Polarization	Vertical
Azimuth beamwidth, degrees	360
Elevation beamwidth, degrees, nominal	75
Input power, watts, CW	400
Input connector	Type N Jack (female)
Windload rating, mph, (km/hr)	200 (320)
Maximum diameter, inches (mm)	360
Maximum length, inches (mm)	12.5 (320)
Weight, lbs (kg)	1.5 (0.7)
Mounting to pipe diameter, inches (mm) clamps included	1.062 (27)

ANDREW. Connecting the Wireless World

Andrew Corporation
10500 W 153rd Street
Orland Park, IL 60462 USA

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Software for Space, Defense & Intelligence

AGI Software – Test & Evaluation Timeline

Mojave Flight Test Demonstration

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Software for Space, Defense & Intelligence

Test Planning - Adding Scheduling & Coordination

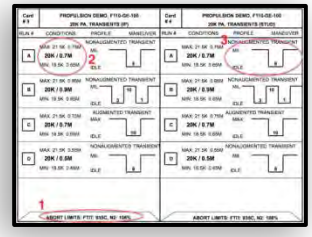
Detailed Test Event Planning

Test Plans

Test-point details

Requirements
Objectives
Resources
Evaluation Criteria
MOPS
…

Test Cards



Test point details
Requirements
Objectives
Resources
Evaluation Criteria
MOPS
…

Test point details
Requirements
Objectives
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Evaluation Criteria
MOPS
…

Test point details
Requirements
Objectives
Resources
Evaluation Criteria
MOPS
…

Test point details
Requirements
Objectives
Resources
Evaluation Criteria
MOPS
…

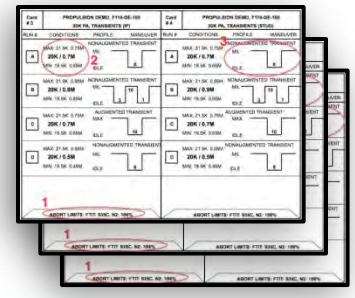
Data Links

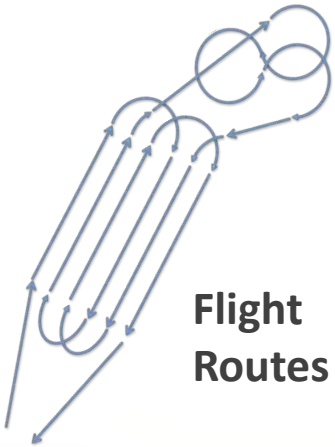
Radar

EW

EO/IR

Mission Deck Test Cards

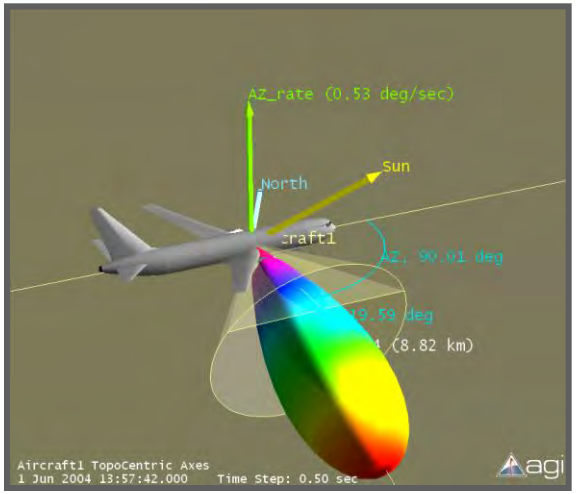


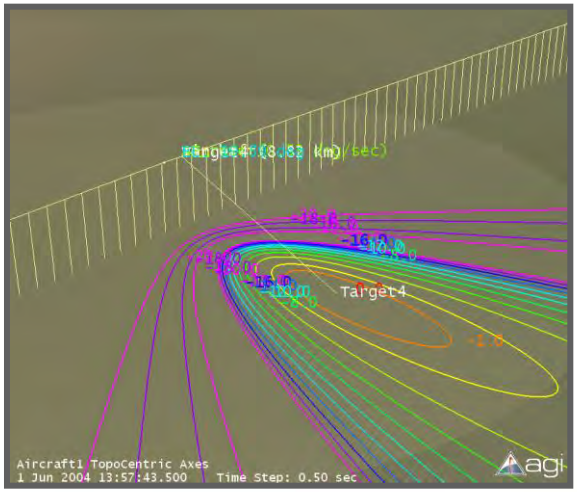


Flight Routes

Predictive Computation

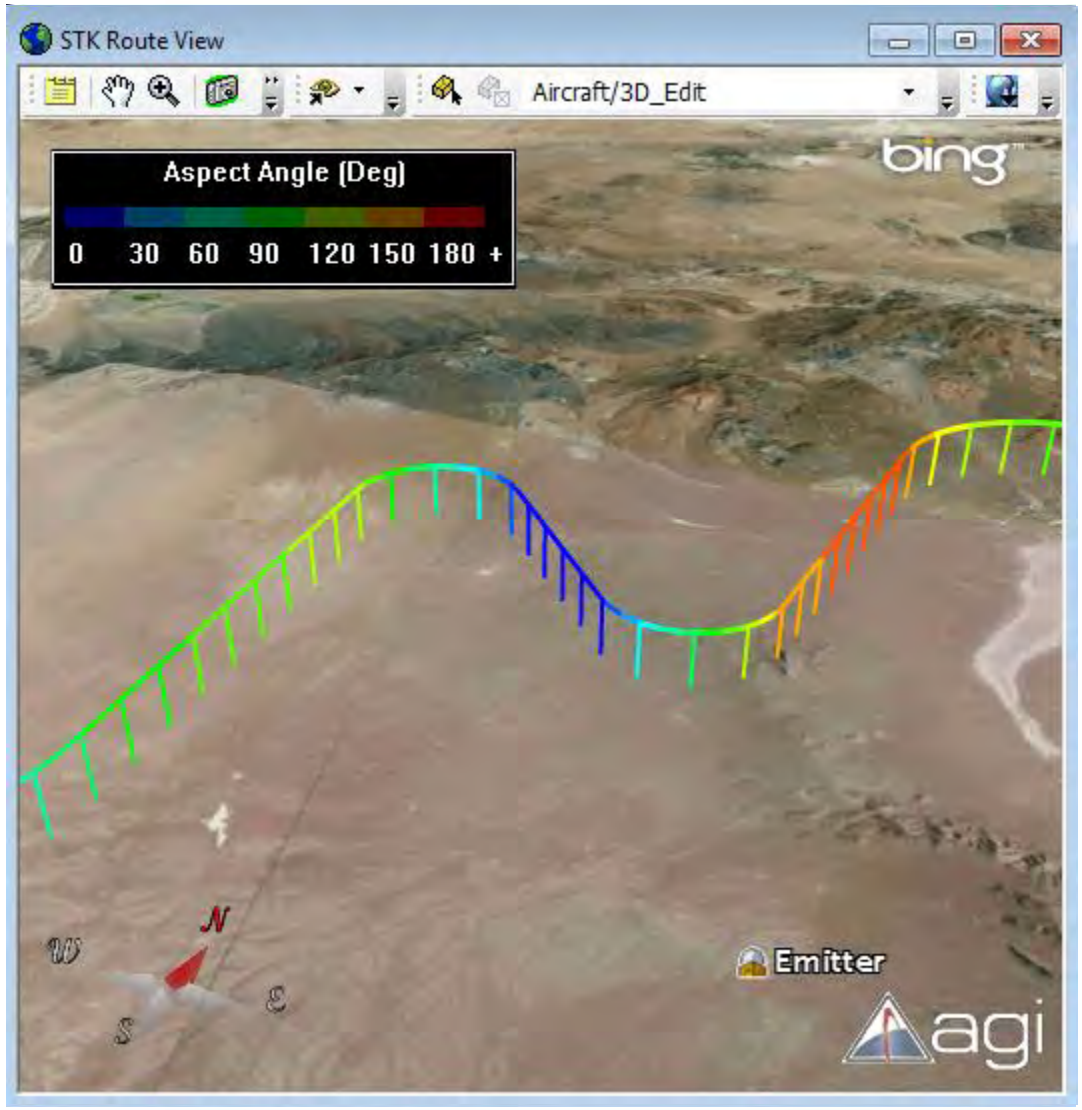
- **Determine Values Which Meet Mission Objectives**
  - Geometric
  - Proximity
  - Pointing
  - Lighting
  - Line-of-sight / atmospheric conditions
  - Inter-object geometry
  - Comm link quality, Jamming values
  - Radar performance measures
  - Terrain vertical profile
  - GPS DOP and Nav accuracy prediction
  - Etc!



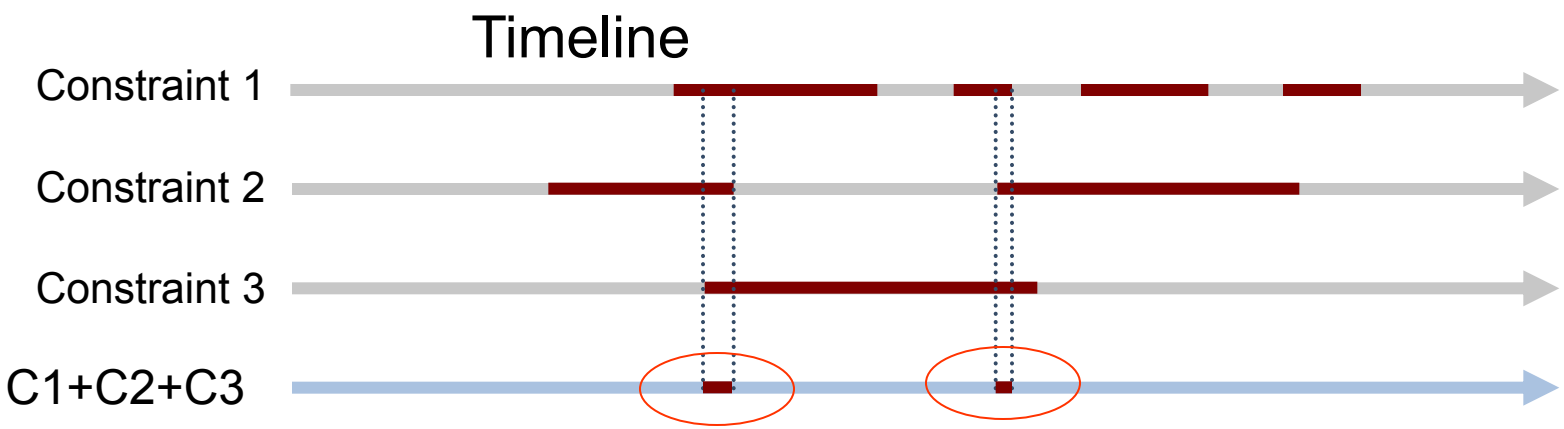


Test Event Route Assessment

- **Interactive Route Design**
  - Fuel Remaining
  - Aspect Angle
  - Comm Performance
  - Telemetry Assurance
  - Dynamic Geometry
  - Lighting Directionality
  - RF Directionality
  - Safety of flight
  - Multi-Ship Choreographing
  - Number of Test-Points

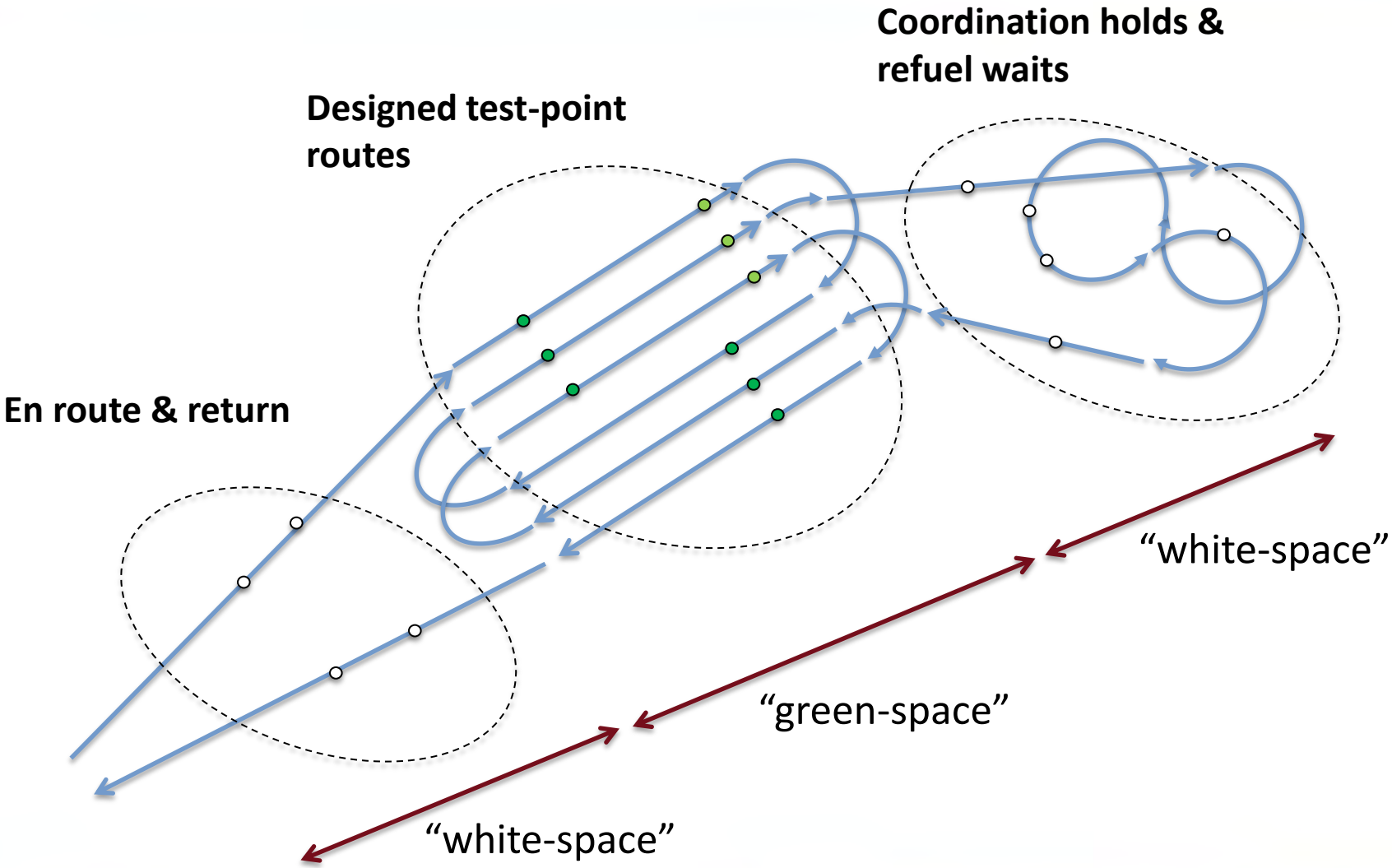


Multi-Constraint Prediction



- **Determination of "Multi-Constraint" Satisfaction Times**

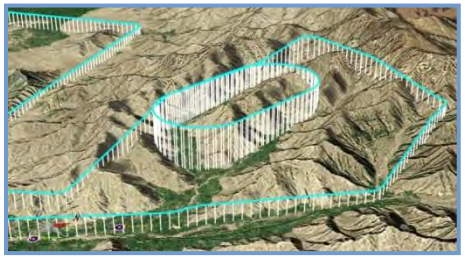
Increasing Test-point Density per Flight



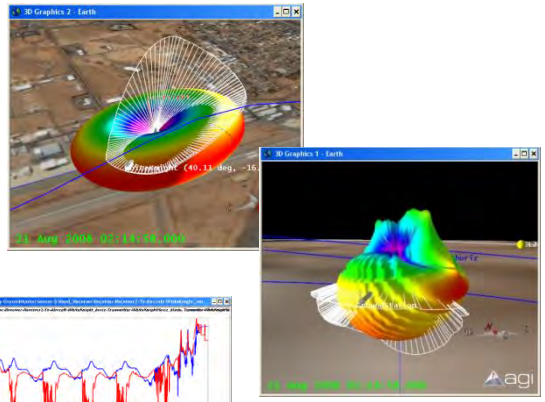
System Modeling Tools to Evaluate Plans

Aircraft Performance Modeling

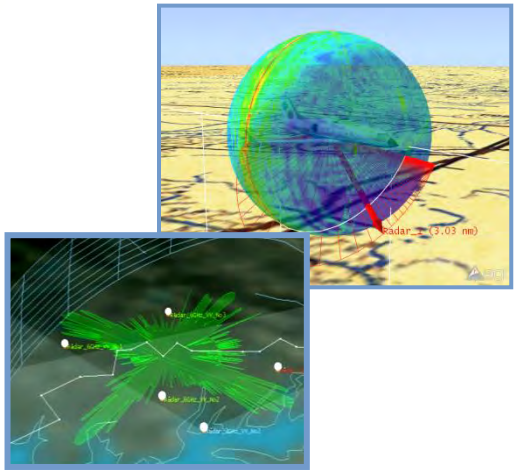
Route Modeling

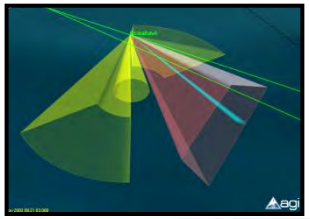


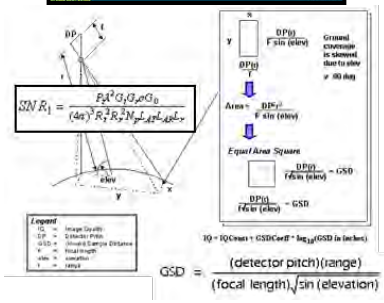
Comm Link Modeling



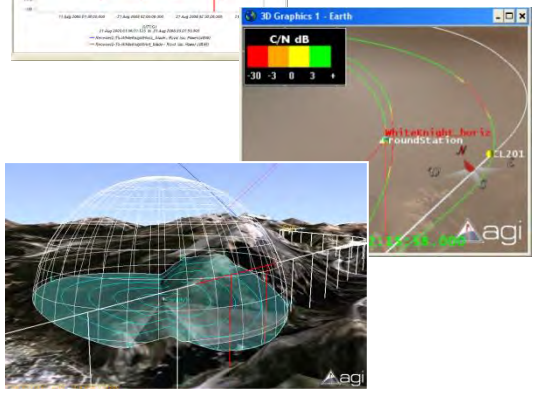
Radar Modeling





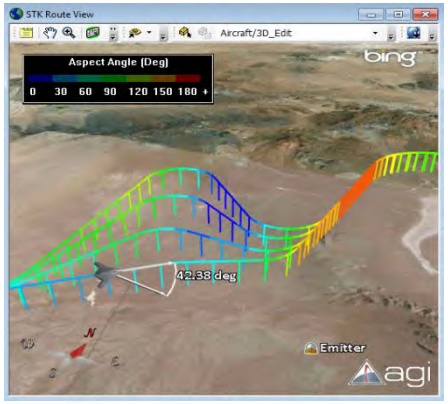


Sensor Modeling



Terrain Effects

Route Parametrics



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Software for Space, Defense & Intelligence

Test & Evaluation Demonstration

Advanced Test Execution and Timing Plans

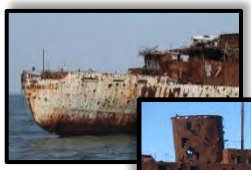
Software Demonstration

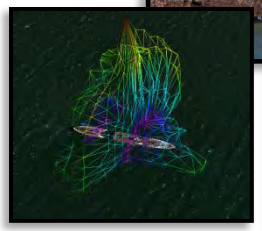
PAX River Flight Test

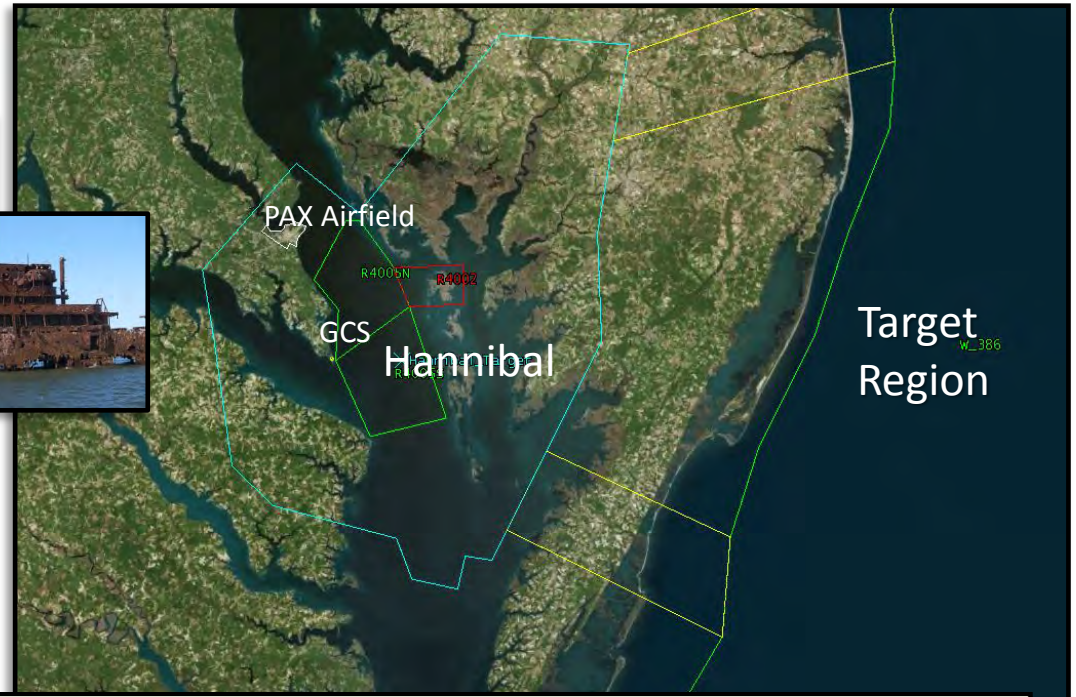
- **Radar System Test**
  - Flight pattern around "Hannibal" target
  - Model "Hannibal" in STK for radar test
- **Comm System Test**
  - Ground comm systems test
  - Model xmit/rcvr in STK
- **Target Acquisitions**
  - Various ship detection tests
  - Model ship targets & detection criteria

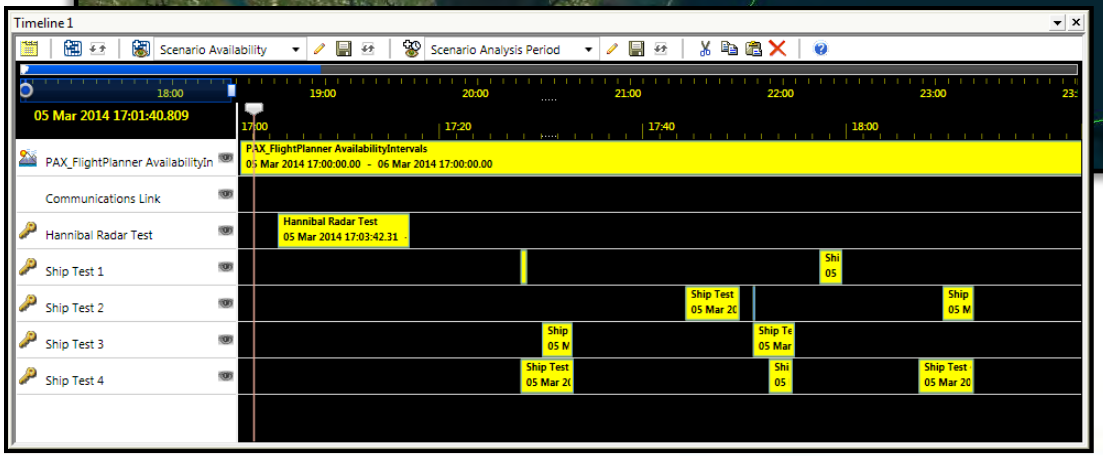
Challenges

- Test Event Coordination
- Timing
- Fuel Considerations









STK Benefit Potential in T&E Process

Develop Test Plan

- Test scenario development
- Timing of test events
- Gross system trades
- Detailed system trades
- Determine objectives – given & derived
- Determine essential elements of analysis and MOEs
- Identification of variables for control and measurement
- Gross trades of schedule of objectives
- Design of Experiments

Test-Event Design

- Selection of test points for specific objectives
- Flight plan design to match test point goals
- Coordination of test resources
  - Multiple aircraft
  - Multiple sensors
  - Air & ground
- Design & planning of specific test
- Scheduling
- Planning & analysis of infrastructural items
  - Telemetry systems
  - Test range radars
  - Comm systems
- Pre-flight briefing material production – animations, snap shots, event schedules

Event Rehearsal

- Use of pre-flight briefing materials
- Nominal test scenario run through
- Scheduling check
- Coordination of test resources
- Quick reaction test plan modifications

Pre-Test Re-Plan

- Pre-test adaption to last minutes changes
- Flexibility to bring up nominal test plan in M&S environment and quickly make changes
- Airspace changes impact assessment & adaption
- Wind direction impact assessment & adaption
- Weather conditions changes impact assessment & adaption
- Provides a means to allow for changes with low impact to test objectives achievement

Test Execution

- Test event situational awareness tools
- Real-time visualization of test event
  - On-board aircraft
  - Local to test range
  - Remote to contractor facility or customer facility
- Monitoring of test points achievement versus nominal plan
- Quick reaction to real-time changes in actual flight paths versus planned nominal and impact on test points and objectives
- Real-time re-planning to adapt to changes and to execute secondary objectives and test points
- Remote real-time SA of test events and participation in real-time re-plans

Post-Test Analysis

- Rapid production of "quick-look"
  - Actual flight path –vs– nominal
  - Actual test points achieved comparison to plan
  - Visualization of test geometry history correlated with collected test data
- M&S supplement to actual test results
  - Use of STEP process approach to validate M&S models as part of the feedback loop within the test series
  - Test point trade space extrapolation
  - Variations of parameters to aid in the design of next test event
- Post test briefing material production
  - Animation of entire test event
  - Specific test point geometry depictions and animations

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Software for Space, Defense & Intelligence

Break

Please Return in 15 Minutes……

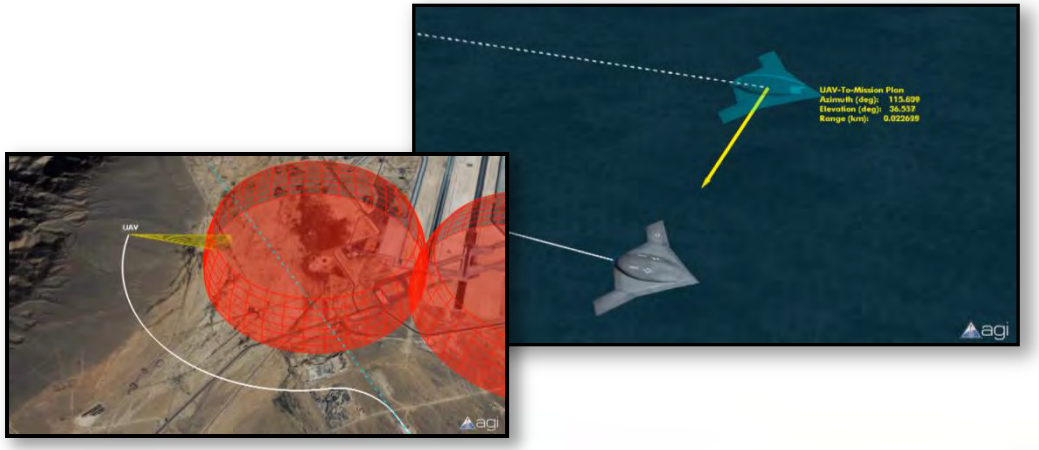
Test Execution

Test Execution

- **Enhanced Situational Awareness**
  - Monitor Events in Real-Time
  - Visualize Systems/Platforms
    - Position & Attitude
    - Sensor Behavior
  - Geometric Relationships
    - Proximity to Other Assets
    - Stand-off Distances
    - No-Fly Zones/Air Corridors
- **Planned vs. Achieved**
  - Actual Flight Path Measured Against Planned Route
- **Rapid Re-Planning**
  - Identify Needs To Alter Flight Plan
  - Re-plan Quickly and Analyze Mission Impacts

Real-Time Operations Example

Click To Play



Data Streaming Example (Realtime)

- **STK Realtime Mode**
  - Attached sensor payload projection
  - Communication link between aircraft and ground facility

- **Simulated Flight Data**
  - UDP Broadcast
  - Streaming position/attitude data

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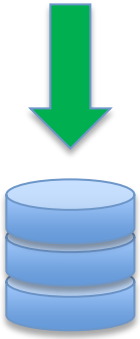
Software for Space, Defense & Intelligence

Post Flight Analysis

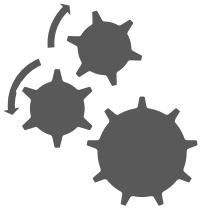
Post Flight Analysis

Test Flight

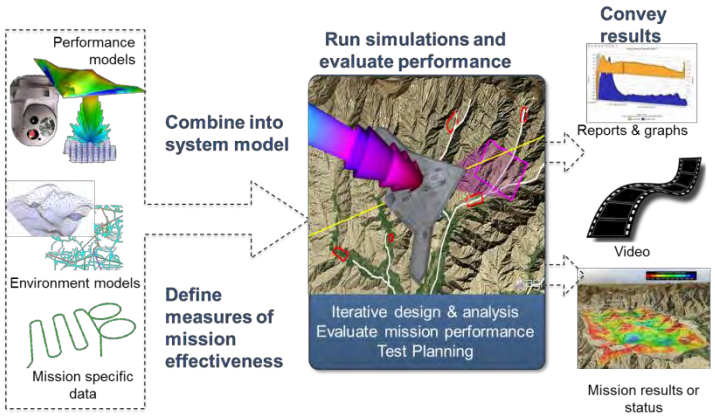


Raw Flight Data

Test & Evaluation Tool Kit



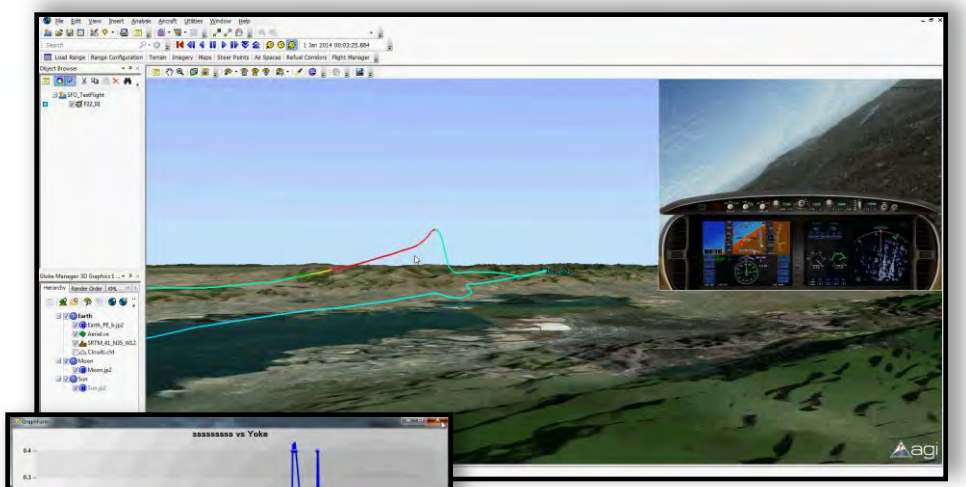
Processed Data

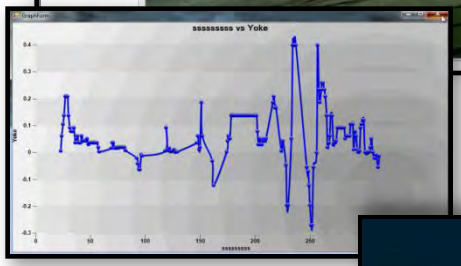


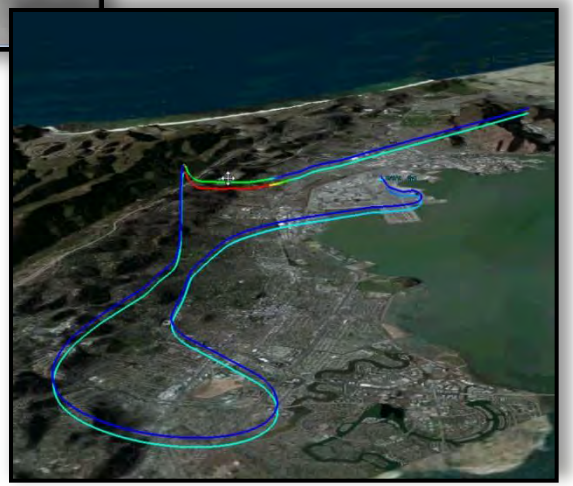
STK Reconstruction

Post Flight Analysis

- **Ingest Recorded Flight Data**
  - Ingest formatted data
  - Any time-correlated data of interest
    - Postion/Orientation
    - Control Surface States
    - Instrumentation Readings / Yoke States
    - Engine Data
    - Onboard Instrumentation Data
    - Data Recorders
    - Range Instrument Data
    - Etc.
- **Dynamically Color & Stack Routes**
  - Color route lines based on any flight data parameter or test result
  - Stack lines for easy visual comparison
- **Video Overlay (Picture In Picture)**
  - Overlay in 3D Window
  - Time-synced video overlays (cockpit video, range cameras, etc.)

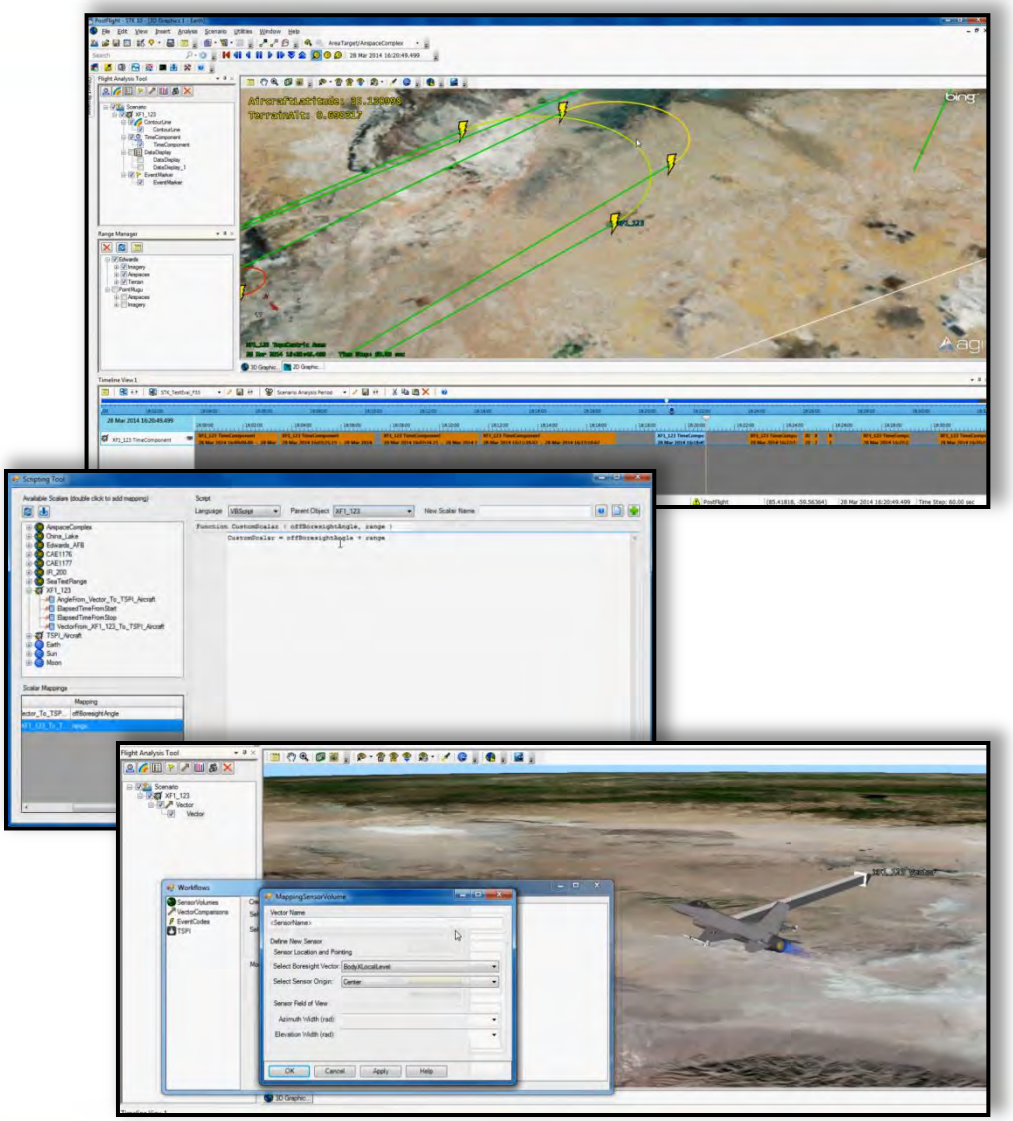






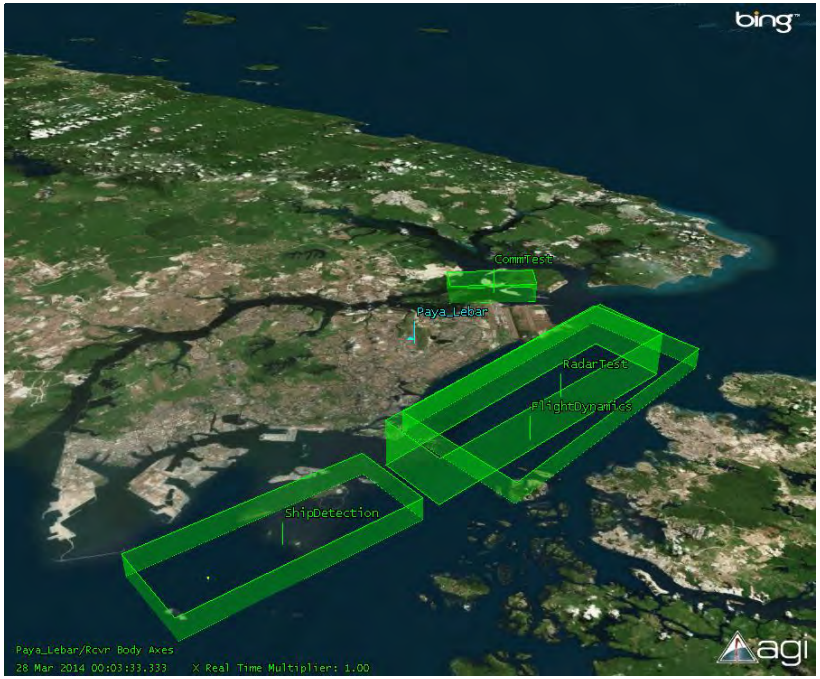
Post Flight Analysis

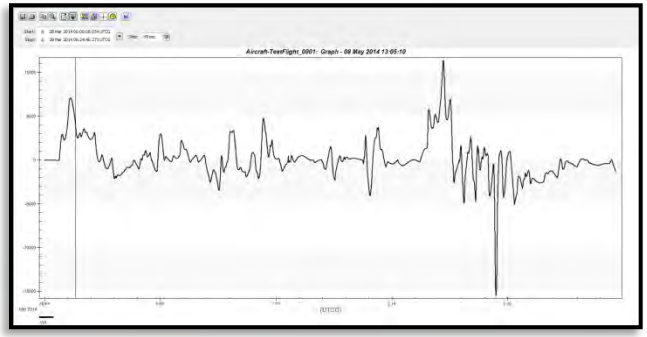
- **Vector Creation**
  - Create vectors/angles of interest from flight data
- **Visualize Test Point (Start/Stop)**
  - Overlay icons/markers representing test intervals along vehicle route
  - Visualize correlated test intervals in STK's Timeline View Window
- **Manage Terrain, Imagery, Maps, GIS**
  - Easily manage data sets for visualization and analysis
- **Custom Scripting Window**
  - Utilize scripting languages (MATLAB, VBSCRIPT, etc.) natively within the toolkit for custom manipulation of ingested data

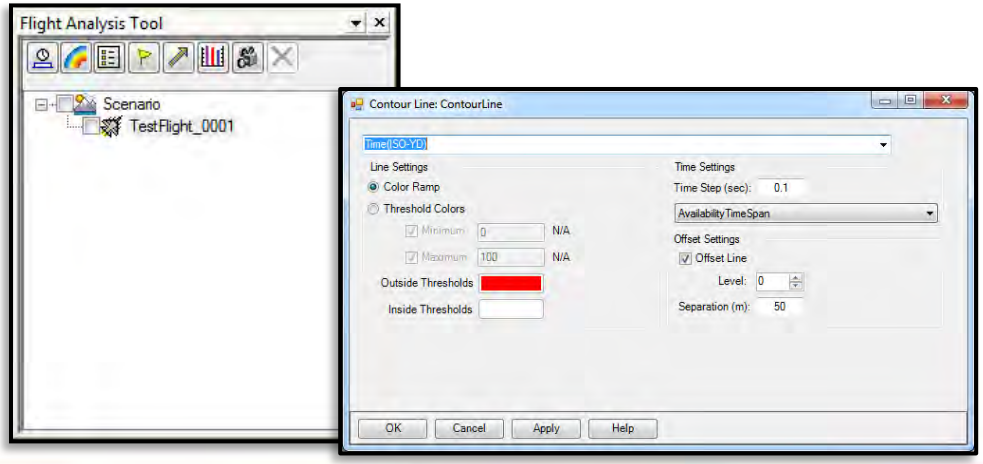


Post Flight Demonstration

- **Paya Lebar – Singapore Test Flight**
  - Test Flight from Paya Lebar airfield in Singapore
  - Specific zones for the following tests
    - GCS Communications System Test
    - Air-to-Air Radar System
    - Air-to-Ground Radar (Ship Detection)
    - Flight Dynamics Test
  - External flight data import via Test and Evaluation Tool Kit
    - Test data explored and analyzed via streamlined tools and utilities within the tool kit workflow







AGI Analysis Solutions

Desktop applications

Stand-alone or integrated:

- System and mission design
- Analysis
- Simulation
- Operations

Application engine

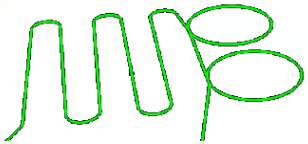
Mission-specific applications and work flows

Software components

Modular capability libraries:

- Enterprise integration
- Thin clients
- Servers
- Web Services

Exploiting the Data

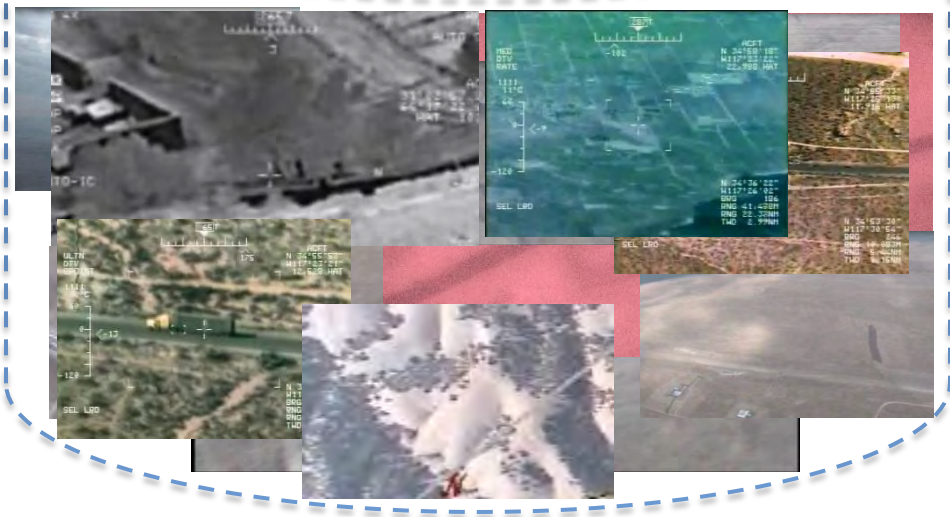


Mission Data

Sensor Model

Environment Model

Imagery and Video Archive



- Begin with traditional imagery request techniques
- Incorporate models to infer information about the imagery
- More accurate images returned based on request
- Faster image retrieval

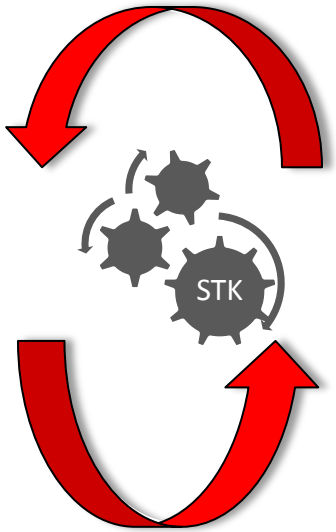
Discoverable Full Motion Video Application

- Aircraft Route
- Attitude

- Sensor FOV
- Sensor Pointing

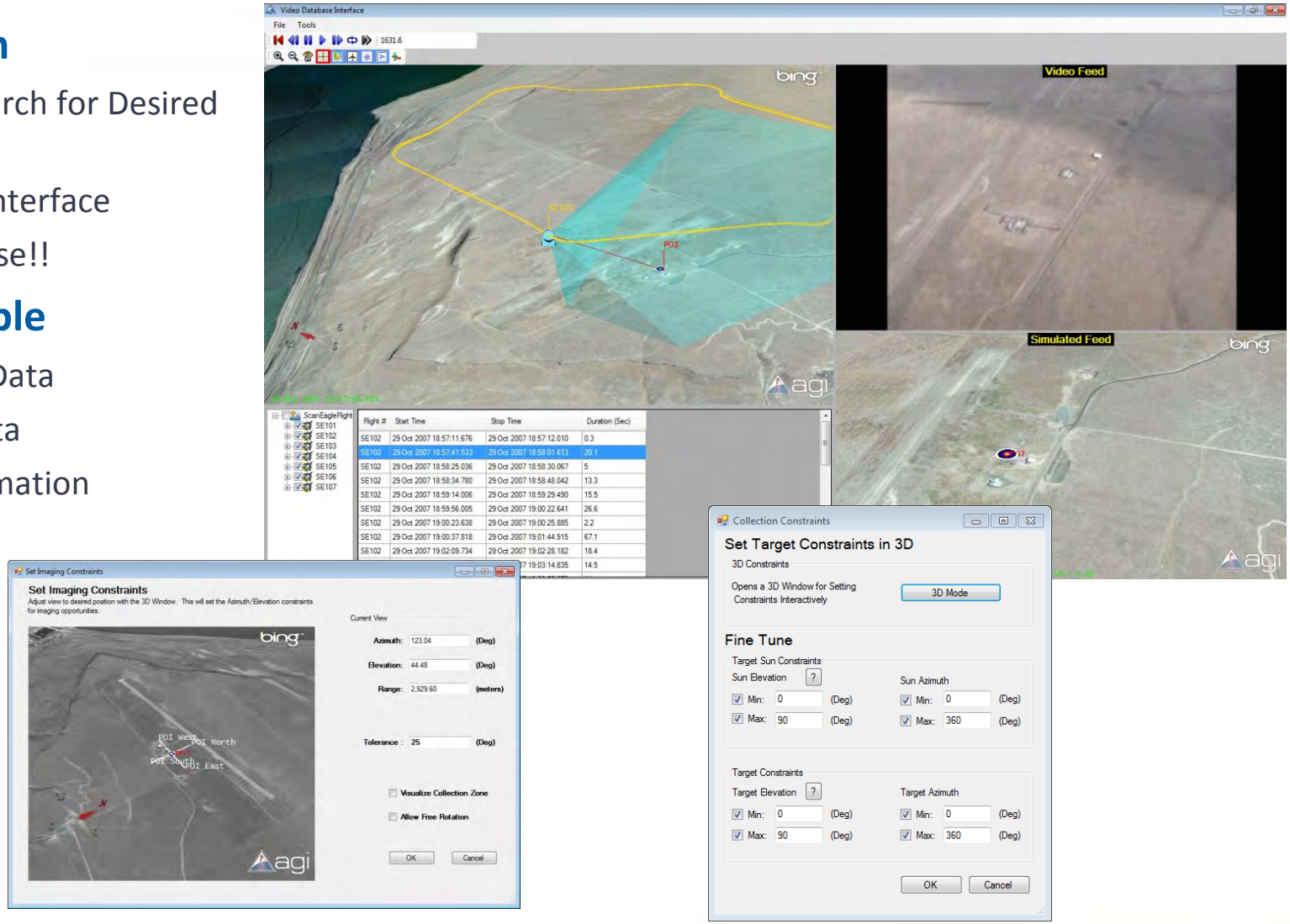
- Terrain Data
- Imagery
- GIS Information
- Etc.

STK Objects



Video Exploitation / Demo

- **Data Fusion**
  - Quick Search for Desired Video
  - Custom Interface
  - Easy to Use!!
- **Interoperable**
  - Imagery Data
  - Video Data
  - GIS Information



User Success Stories

Summary of Proven Potential

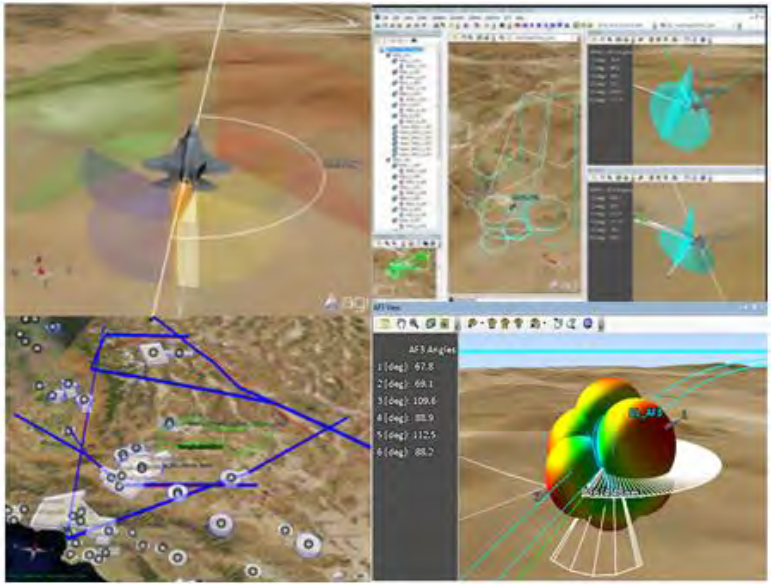
- **Efficiency of Test Force Operations**
  - Reduced time for test-force process elements
    - Test-plan process, test-card development process, post-test process — $$
  - Shortened and more effective meetings, pre-flight reviews, etc. — $
- **Effectiveness and efficiency of test flights**
  - Improved robustness of test-card designs – validation against test plan objectives — $
  - Increased number of test-points per flight — $$$$$
  - Improved scheduling of refuel operations — $$
  - Positive overall test-force flight schedule impact — $$
  - Enabling the complicated choreographing of multi-ship flights — $$$
- **Communications within the program and with customer**
  - Illustration of complex concepts and issues at all stages of the execution T&E lifecycle — $
  - Enable greater collaboration — $$
  - Shortened and more effective meetings, pre-flight reviews, etc. — $$
  - Positive impact to test-point sign-off activities
- **Flight safety**
  - Rich material enabling added insight to pre-flight briefings
  - Robust treatment of multi-ship flight choreographing and event scheduling

F-35 Flight Testing - Case Study

All notional depictions on this slide

Problem: Flight test planning is largely manual, relying on talent and intuition of experienced engineers.

Solution: Use STK MS&A Environment to improve flight test efficiency, effectiveness and repeatability.



Outcome: Proof-of-Concept demonstrated improved flight test plans, designs and analysis for mission systems testing.

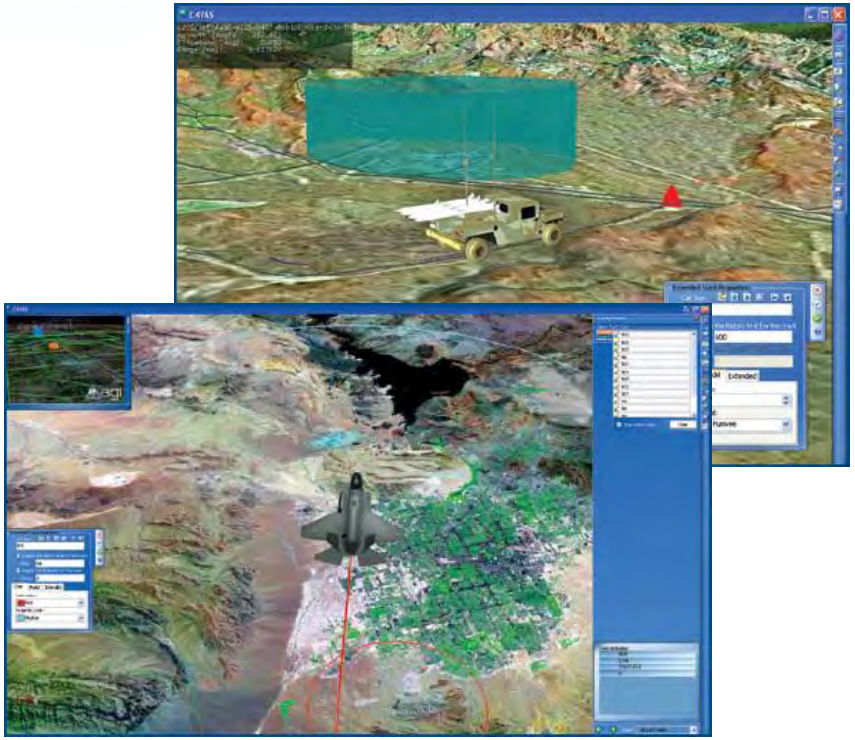
Accelerated & optimized test planning,
Increased flexibility in test event execution and
Faster post-test analysis

C4VAS situational awareness

Problem: Hundreds of personnel operate in dangerous area with different data feeds and tracking systems.

Solution: STK Engine was integrated to create a real-time common operating picture (COP).

Outcome: C4VAS fuses multiple data feeds to help commanders keep units safe.



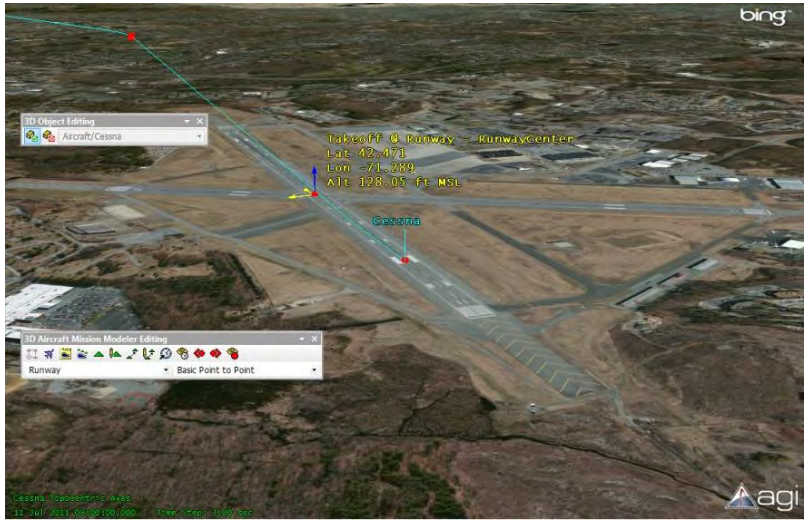
AGI software supports daily operations over large areas of the southwest US.

ESC Hanscom AFB/WYLE

Planning Airborne Network Test Events

Problem: Wyle performs test and evaluation of new airborne networks and ground systems for USAF ESC/XR and the DoD.

Solution: STK selected STK as a conceptual planning tool for ESC and DoD test events and analysis.



Outcome: STK is used during the planning phase of nearly every test event to predict link margin and antennae gain, optimize performance and enhance technical decision-making.

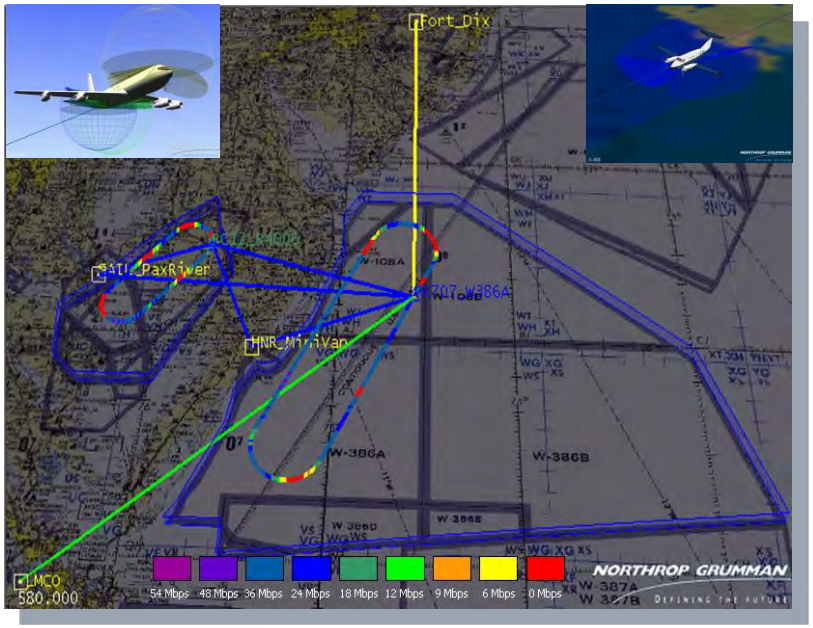
STK's modeling and simulation helped reduce the test cycle, saving Wyle and its customers' time, money and effort.

NGAS - Airborne Networking

Problem: *Build A Realistic Model Of an Airborne Network Through Simulation to Predict Network Performance Over the Flight Regime. Validate AN Models Through Live Fly Results*

Solution: *Use STK, OPNET and Custom Integration Tools to Build a Robust Network Simulation. Compare Initial Model Results with Model Outputs Driven by Real Flight Data*

Outcome: *Allowed "Pre-flight" of the Network to Highlight Potential Issues and Supported "Post-flight" Link Performance Analysis After Live Exercise*



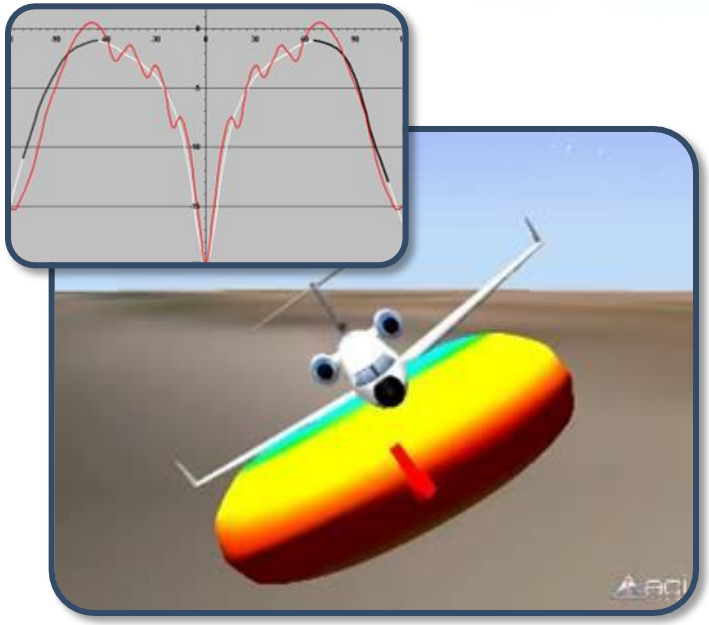
Risk Reduction Through Physics-based Modeling of the Airborne Network

This invention was made in the performance of a Cooperative Research and Development Agreement with the Department of the Air Force.

Aircraft Communications Testing

Northrop Grumman Integrated Systems

- **Problem**
  - Determine antenna coverage and blockage from aircraft keel
- **Solution**
  - "As installed" antenna patterns analyzed with multiple flight profiles for coverage



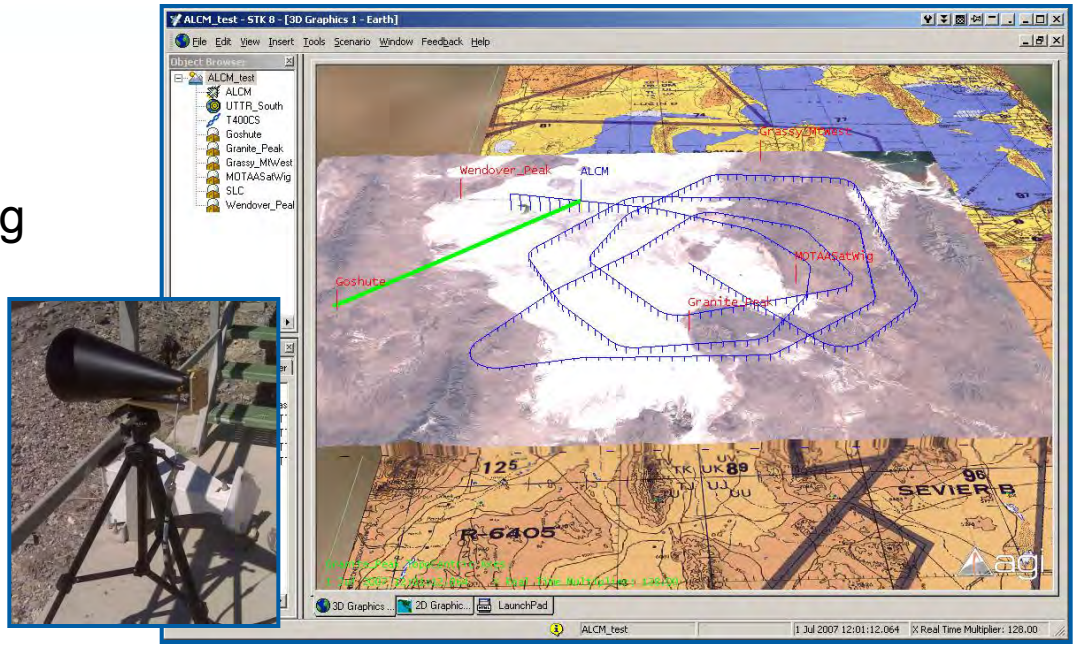
- **Outcome**
  - Millions of dollars saved in reduced required flight tests of high value aircraft and reduced schedule risk

"Valid flight testing at your desk"

— Bruce MacDougall, NGC

Improved Test Range Operations

Problem: Precisely replicate RF signals as they would appear in nature to support range planning and rehearsal.



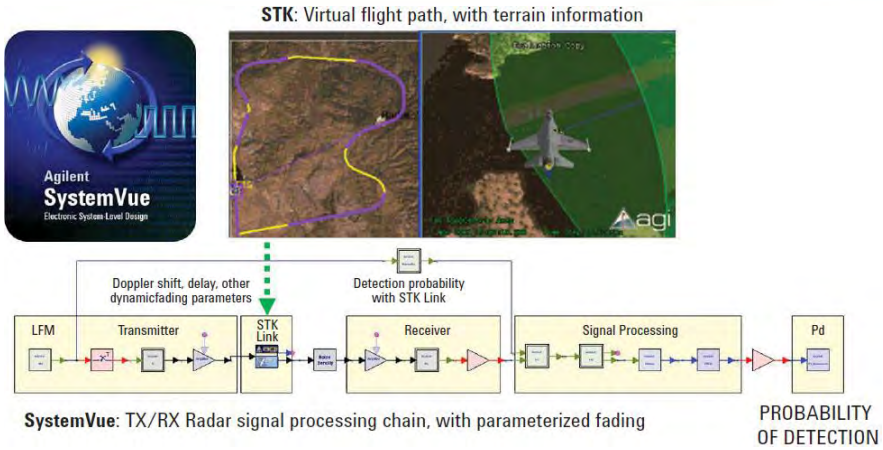
Solution: Drive RF channel simulator using STK Engine.

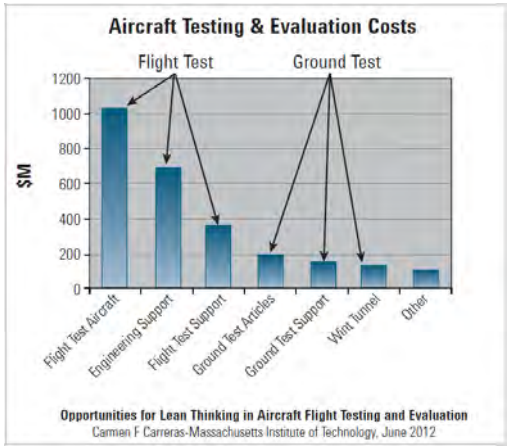
Outcome: Integrated mission model and accurate wireless communication that allows range operators to model all aspects of range.

HWIL Simulated signals that are indistinguishable from live test events.

Virtual Flight Testing of Radar System Performance Using SystemVue and STK

- Integrated SystemVue (communications physical layer design) and STK (3D kinetic scenario modeling) for RF-accurate signals and results, with terrain-accurate Doppler and fading.
- Provide a "system-level" approach to traditional design and test to
  - Evaluate new jamming techniques or threats
  - Inject multiple dynamic emitters and targets
  - Allow various types of jamming based on a defined set of criteria for dynamic operation
  - Model and evaluate cross-domain effects, such as automatic gain control
  - Include unintended interference from commercial wireless networks, etc.





Virtual flight testing allows measurement-hardened algorithms to be deployed quickly, and a minimum of true operational testing to be done with greater confidence, to save costs. By closing the loop between lab-based virtual testing (simulation and test equipment) and operational testing, virtual testing can be made even more effective.

STK Benefit Potential in T&E Process

Develop Test Plan

- Test scenario development
- Timing of test events
- Gross system trades
- Detailed system trades
- Determine objectives – given & derived
- Determine essential elements of analysis and MOEs
- Identification of variables for control and measurement
- Gross trades of schedule of objectives
- Design of Experiments

Test-Event Design

- Selection of test points for specific objectives
- Flight plan design to match test point goals
- Coordination of test resources
  - Multiple aircraft
  - Multiple sensors
  - Air & ground
- Design & planning of specific test
- Scheduling
- Planning & analysis of infrastructural items
  - Telemetry systems
  - Test range radars
  - Comm systems
- Pre-flight briefing material production – animations, snap shots, event schedules

Event Rehearsal

- Use of pre-flight briefing materials
- Nominal test scenario run through
- Scheduling check
- Coordination of test resources
- Quick reaction test plan modifications

Pre-Test Re-Plan

- Pre-test adaption to last minutes changes
- Flexibility to bring up nominal test plan in M&S environment and quickly make changes
- Airspace changes impact assessment & adaption
- Wind direction impact assessment & adaption
- Weather conditions changes impact assessment & adaption
- Provides a means to allow for changes with low impact to test objectives achievement

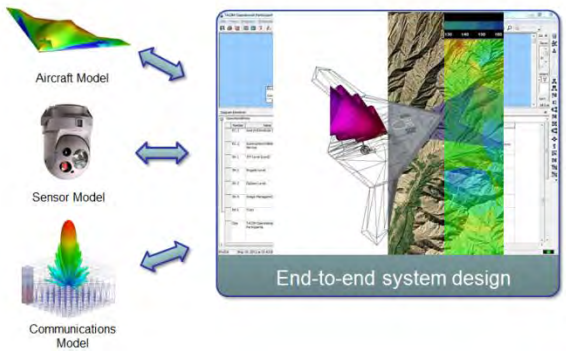
Test Execution

- Test event situational awareness tools
- Real-time visualization of test event
  - On-board aircraft
  - Local to test range
  - Remote to contractor facility or customer facility
- Monitoring of test points achievement versus nominal plan
- Quick reaction to real-time changes in actual flight paths versus planned nominal and impact on test points and objectives
- Real-time re-planning to adapt to changes and to execute secondary objectives and test points
- Remote real-time SA of test events and participation in real-time re-plans

Post-Test Analysis

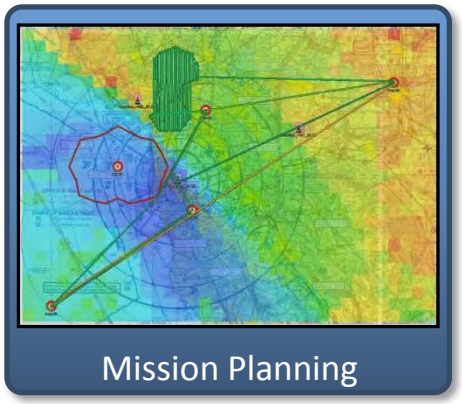
- Rapid production of "quick-look"
- Actual flight path –vs– nominal
- Actual test points achieved comparison to plan
- Visualization of test geometry history correlated with collected test data
- M&S supplement to actual test results
- Use of STEP process approach to validate M&S models as part of the feedback loop within the test series
- Test point trade space extrapolation
- Variations of parameters to aid in the design of next test event
- Post test briefing material production
  - Animation of entire test event
  - Specific test point geometry depictions and animations

Wrap-Up



System Modeling

Custom Applications



Flight Test Mission Design Tools

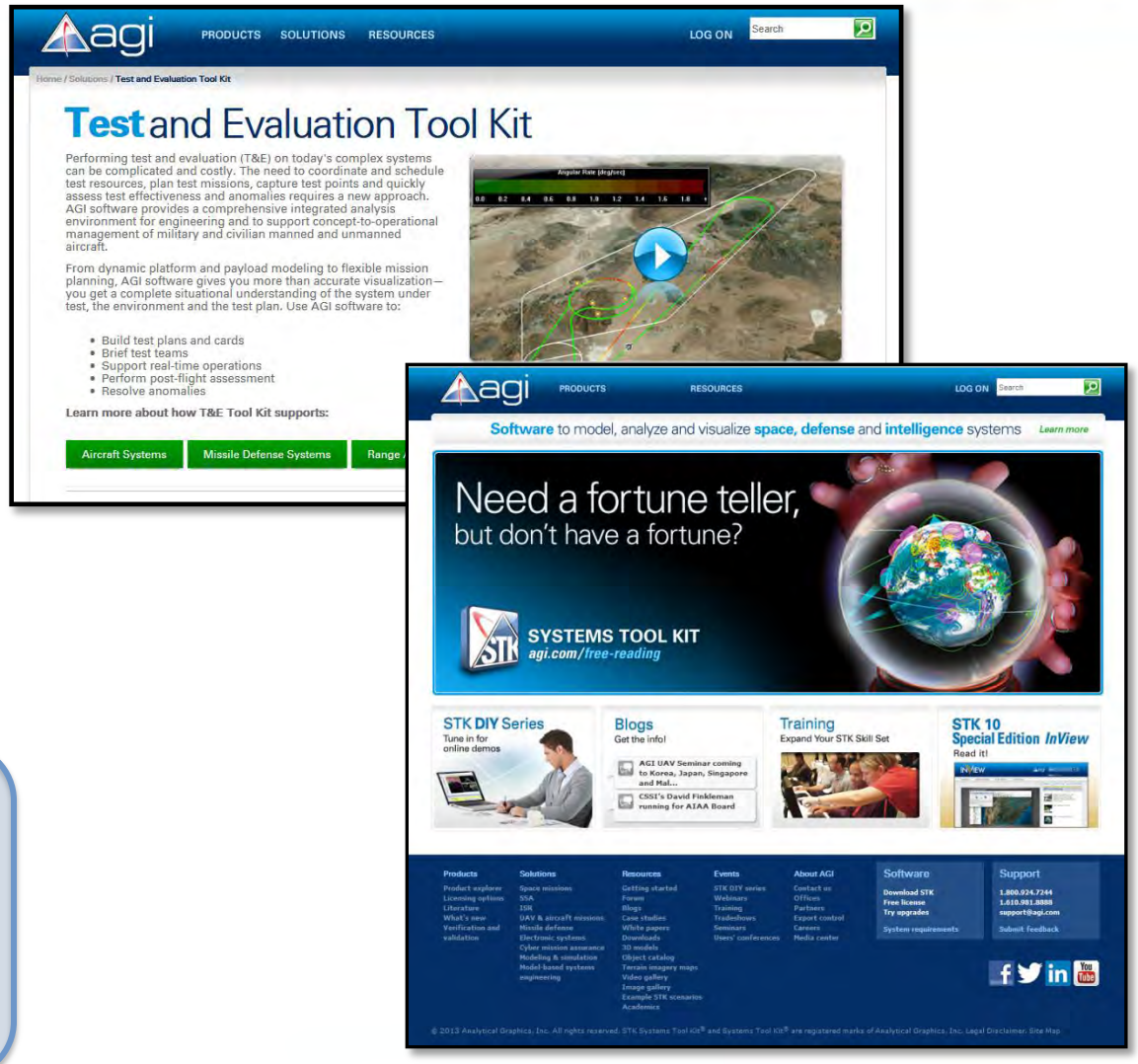
Interoperability

Resources

AGI Website

- White Papers
- Case Studies
- Software Resources
- Blogs
- Forum
- Events

www.agi.com



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Questions?

Thank You