



AFRL KASSPER Algorithm Testbed

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Outline

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An emerging technology in radar signal processing



- **Motivation**
- **Knowledge Aided Testbed Components**
- **Measures of Performance**
- **Related Activities**
- **Facilities**
- **Summary**

Motivation

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- **Provide a Mechanism for Intelligent Selection of K-A Algorithms, Parameters, and Training Data to Evaluate Performance Improvements Over Conventional Processing**
- **Evaluate System Operational Performance Utilizing an Integrated Approach to K-A Signal & Data Processing**
- **Demonstrate That Greatest Improvements are Achieved in the Most Severe Environments**

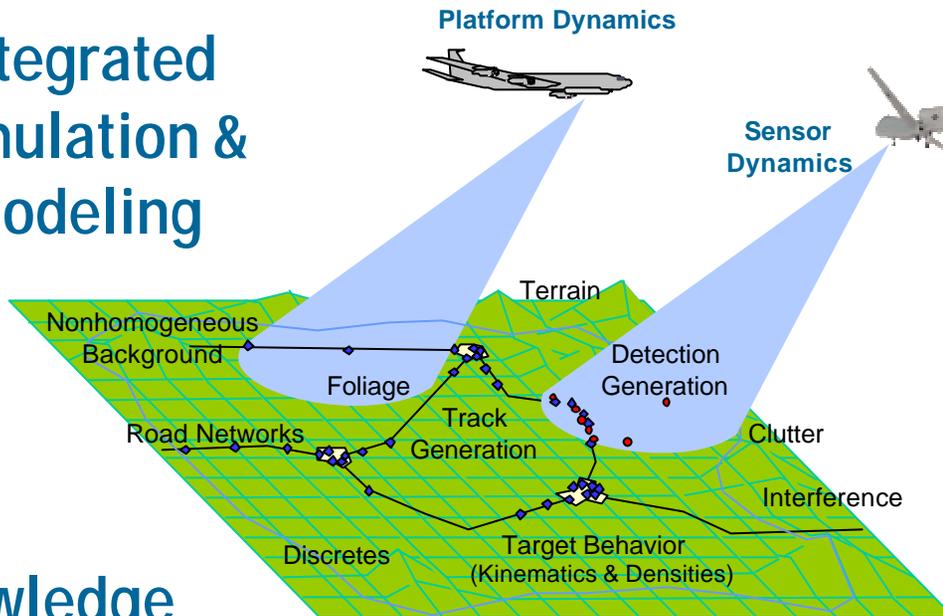
KASSPER Testbed Overview

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Integrated Simulation & Modeling



KASSPER Testbed Components

Knowledge Sources
(USGS, NIMA, SAR, Detections, Track, etc.)

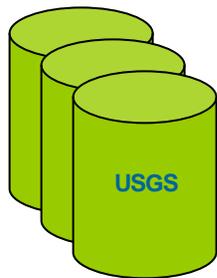
Knowledge-Aided Algorithms
(Sample selection, filtering, detection, track)

Integrated Modeling Tools
(RLSTAP, MIST, STK, GVS, etc)

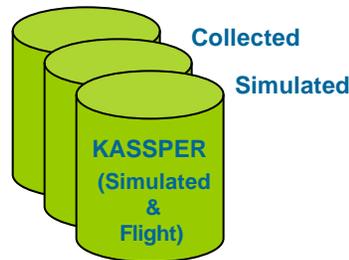
Measures of Performance
(Definitions and Analysis Tools)

Simulated & Measured Data Sets
(Sensor data cubes, target truth, detections, tracks)

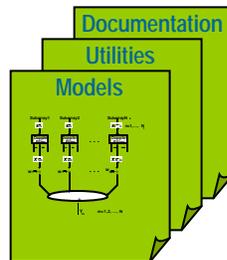
Knowledge Sources



Radar Data



Libraries



Demonstrations

Requirements

- Integrated KASSPER Algorithm Evaluation
- R&D Support

Components

- KASSPER Data Sets
- KASSPER Contractor Algorithms
- Integrated AFRL Testbed

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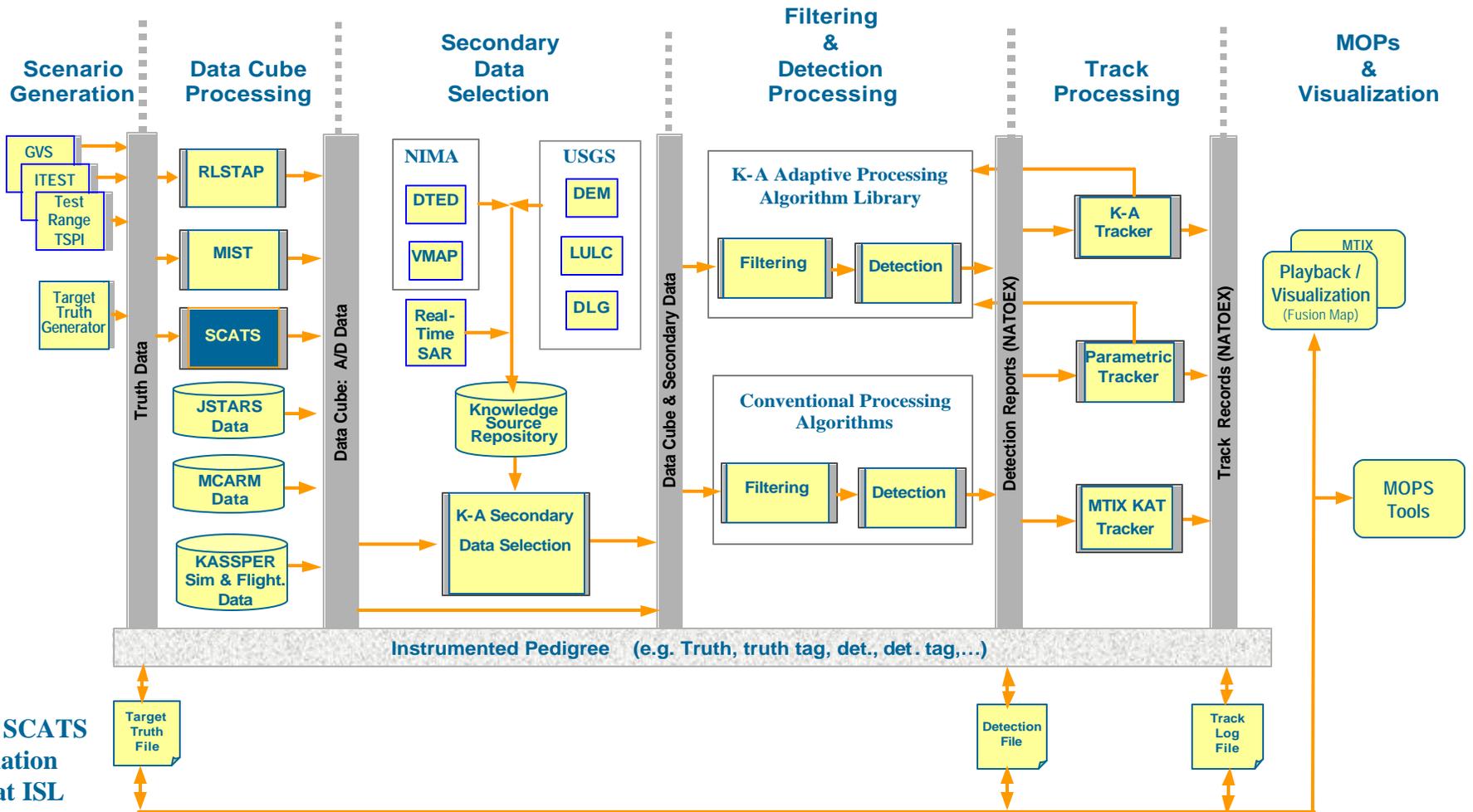
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Knowledge-Aided Algorithm Evaluation Testbed



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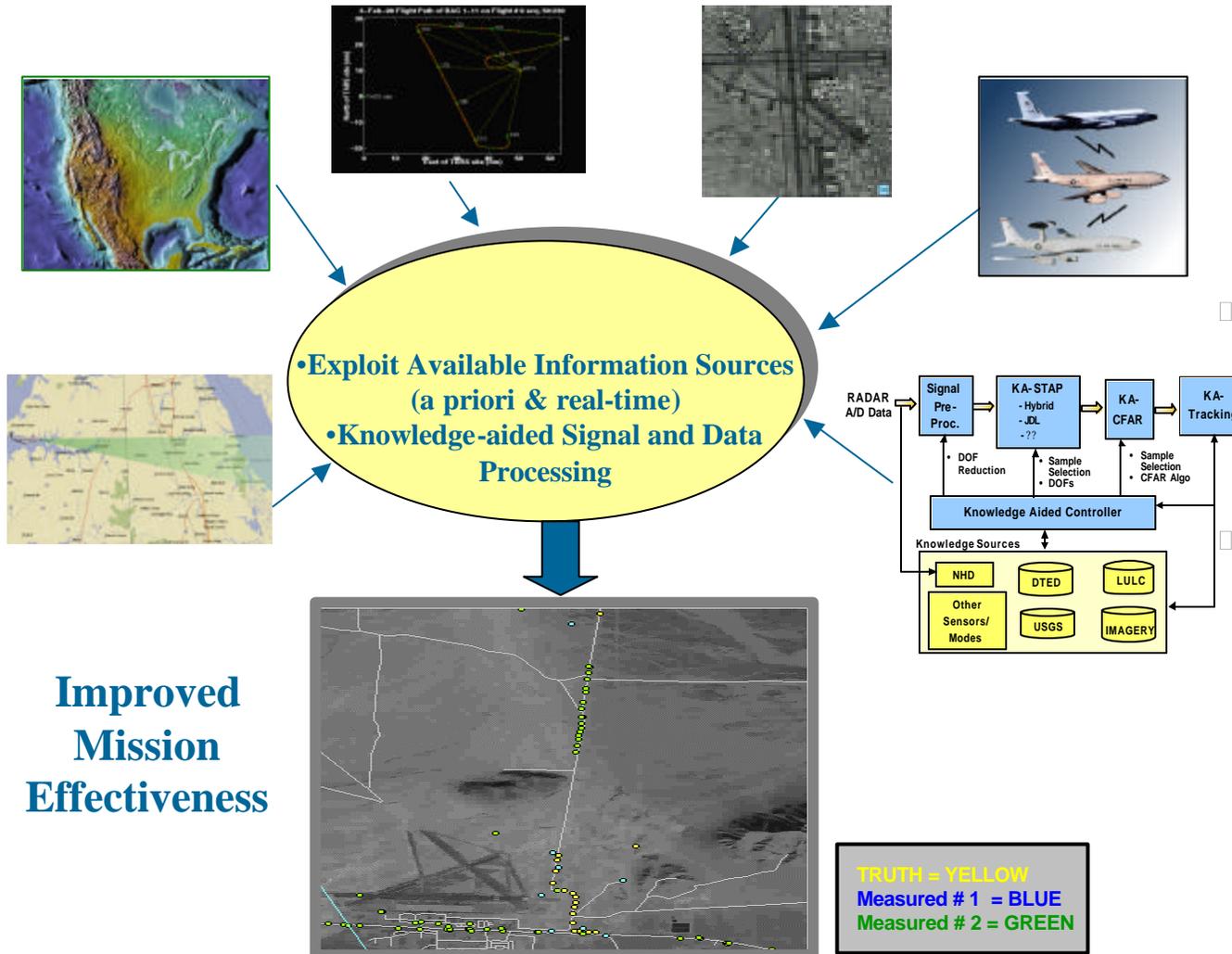
Note: SCATS Simulation Tool at ISL

Multiple Knowledge Sources



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Improved Mission Effectiveness

Data Sources

A Priori Data Sources

- USGS: DEM, LULC, DLG
- NIMA: DTED & VMAP

Real-Time Data Sources

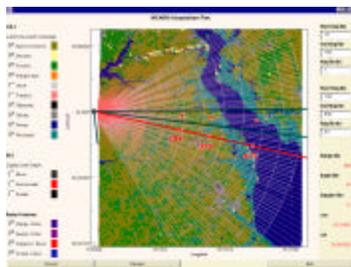
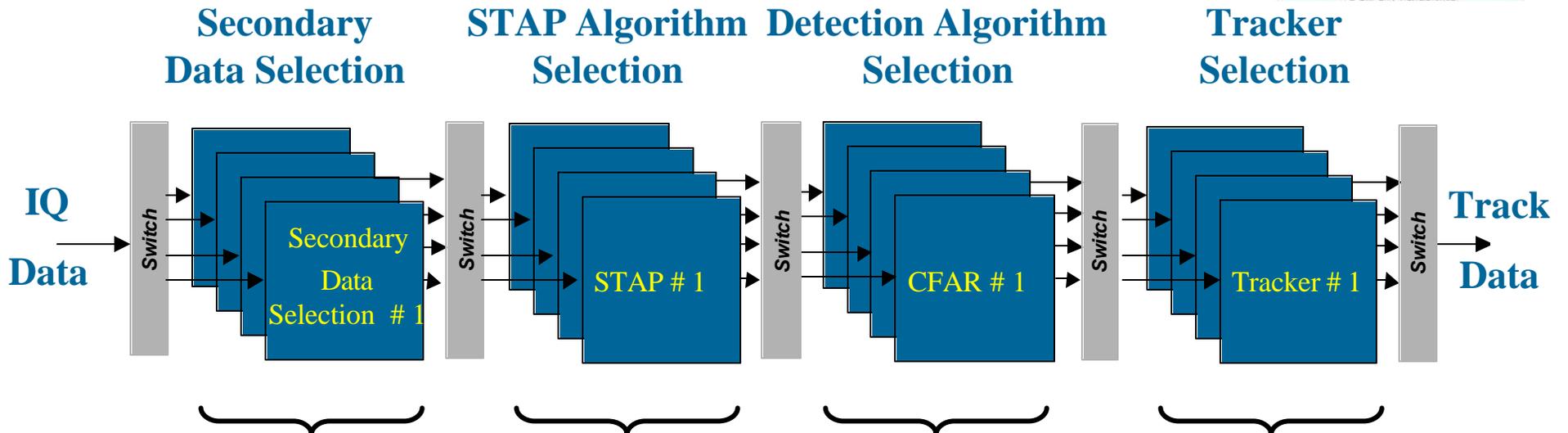
- Detection & Track Data
- Ownship Kinematics
- SAR Imagery
- Off-board Sources

Evaluate K-A Algorithm Combinations

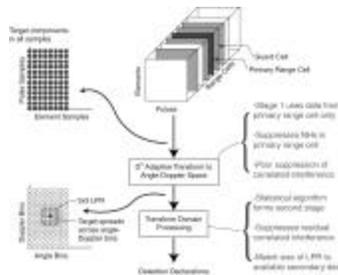


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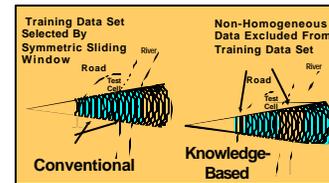
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KBMapSTAP

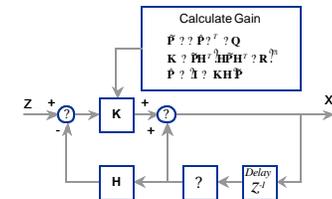


Hybrid Algorithm



ES CFAR

$$\begin{aligned} & \tilde{X} \tilde{X}^T \tilde{X} \tilde{X}^T \tilde{X} \tilde{X}^T \\ & \tilde{P} \tilde{P}^T \tilde{P} \tilde{P}^T \tilde{P} \tilde{P}^T \\ & \tilde{K} \tilde{P} \tilde{P}^T \tilde{H} \tilde{H}^T \tilde{P} \tilde{P}^T \tilde{R} \tilde{R}^T \\ & \tilde{P} \tilde{P}^T \tilde{I} \tilde{I}^T \tilde{K} \tilde{H} \tilde{H}^T \tilde{P} \tilde{P}^T \\ & \tilde{X} \tilde{X}^T \tilde{X} \tilde{X}^T \tilde{K} \tilde{I} \tilde{I}^T \tilde{H} \tilde{H}^T \tilde{X} \tilde{X}^T \end{aligned}$$



Parametric Tracker

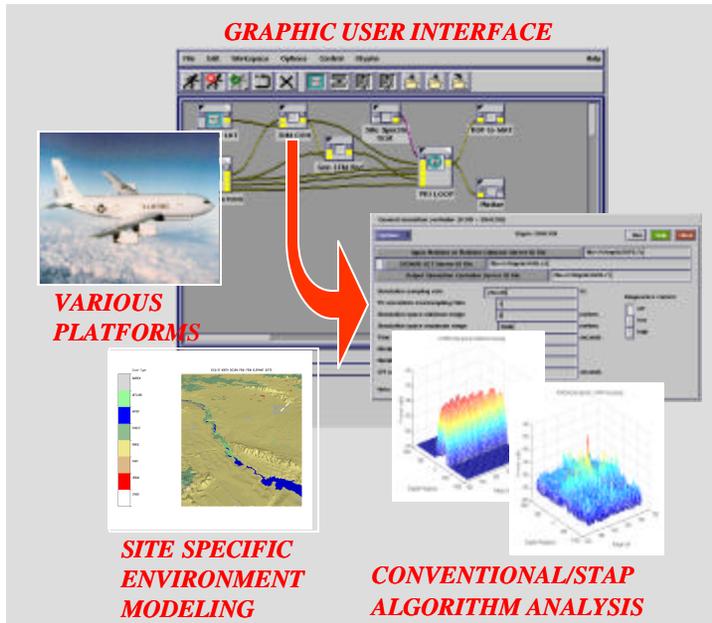
Integrated Modeling Tools

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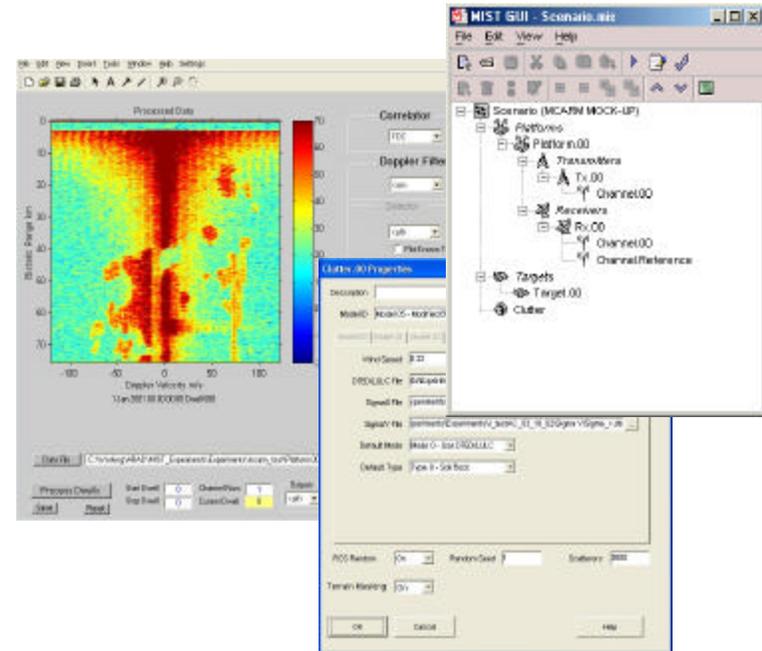


RLSTAP



RLSTAP is an environment for STAP simulations, processing and analysis functions. It creates high fidelity data cubes as its output.

MIST



MIST is a high fidelity analysis tool for MTI radar architecture and scenario evaluation. High fidelity data cubes and detection results are simulated.

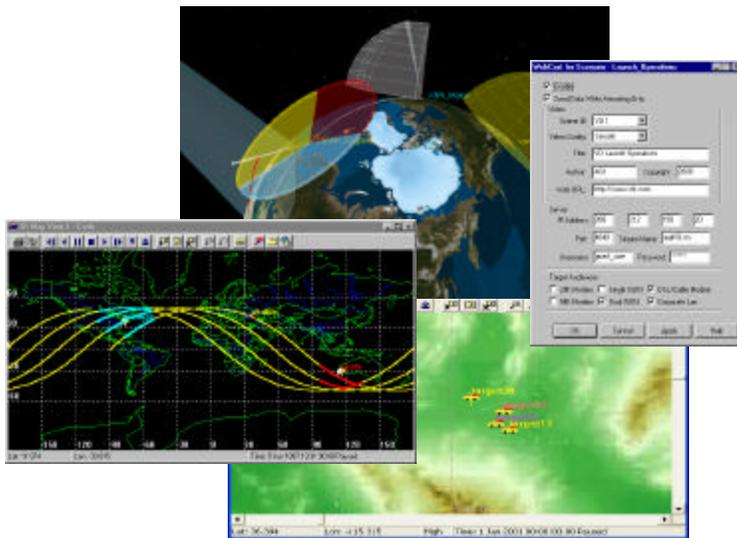
Integrated Modeling Tools

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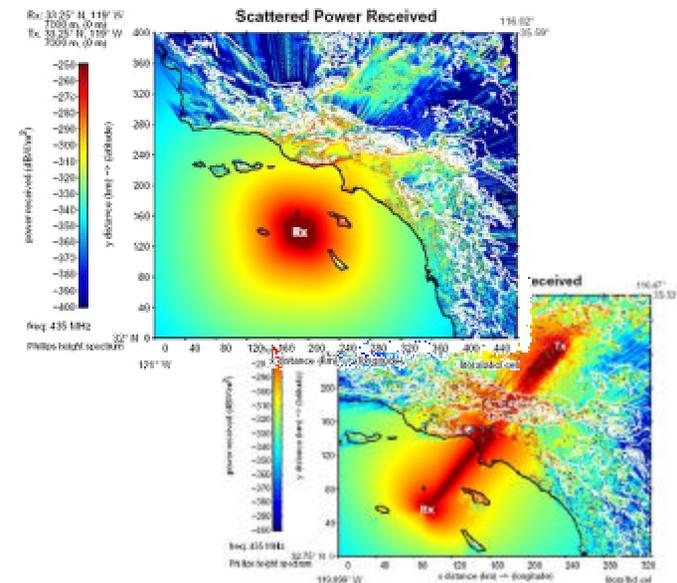
STK



STK is used for determining the concept-level requirements for remote sensing/imaging missions. STK provides the capability to obtain full knowledge of the technical aspects of the platform.

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SCATS



SCATS simulates terrain scattering and propagation effects for radar: return from the target (as affected by the local terrain), scattered, direct signal from an interferer, and interference scattered from the ground. (Resident at ISL)

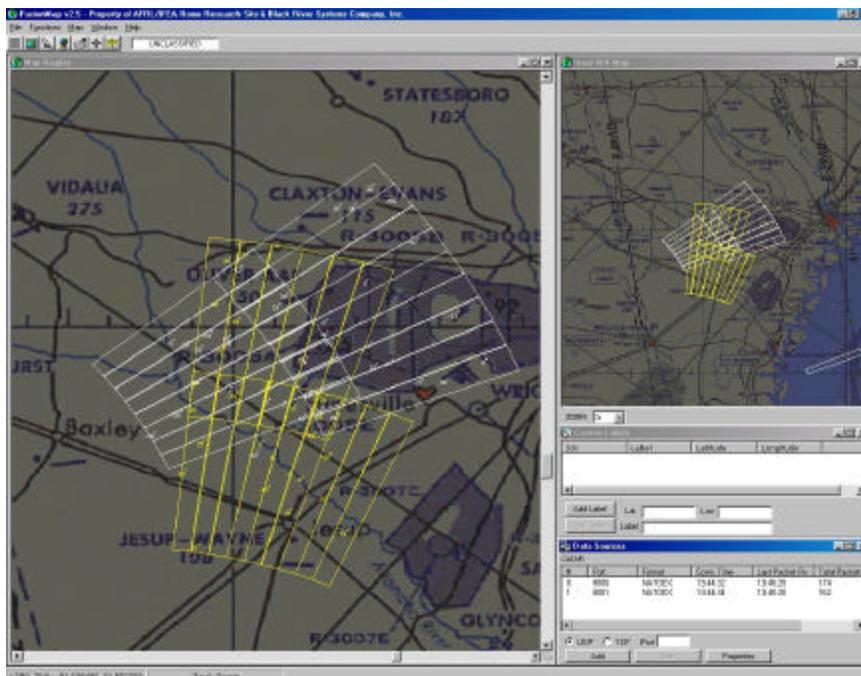
Tools for Visualization

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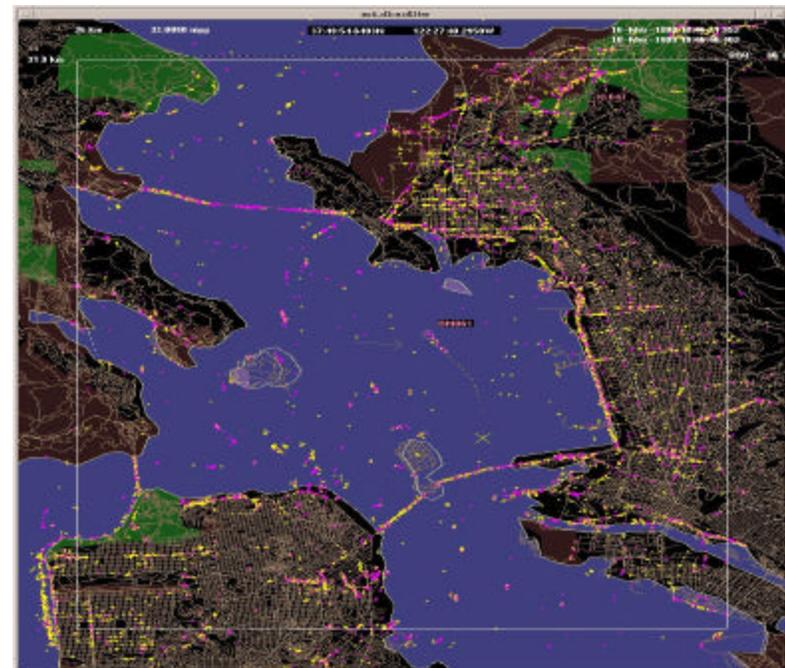
Fusion Map



Fusion Map is a visualization tool capable of displaying truth, detections, tracks, and platform data simultaneously. It accepts broadcast packets and can be set up to use multiple map layers and other parameters.

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MTIX

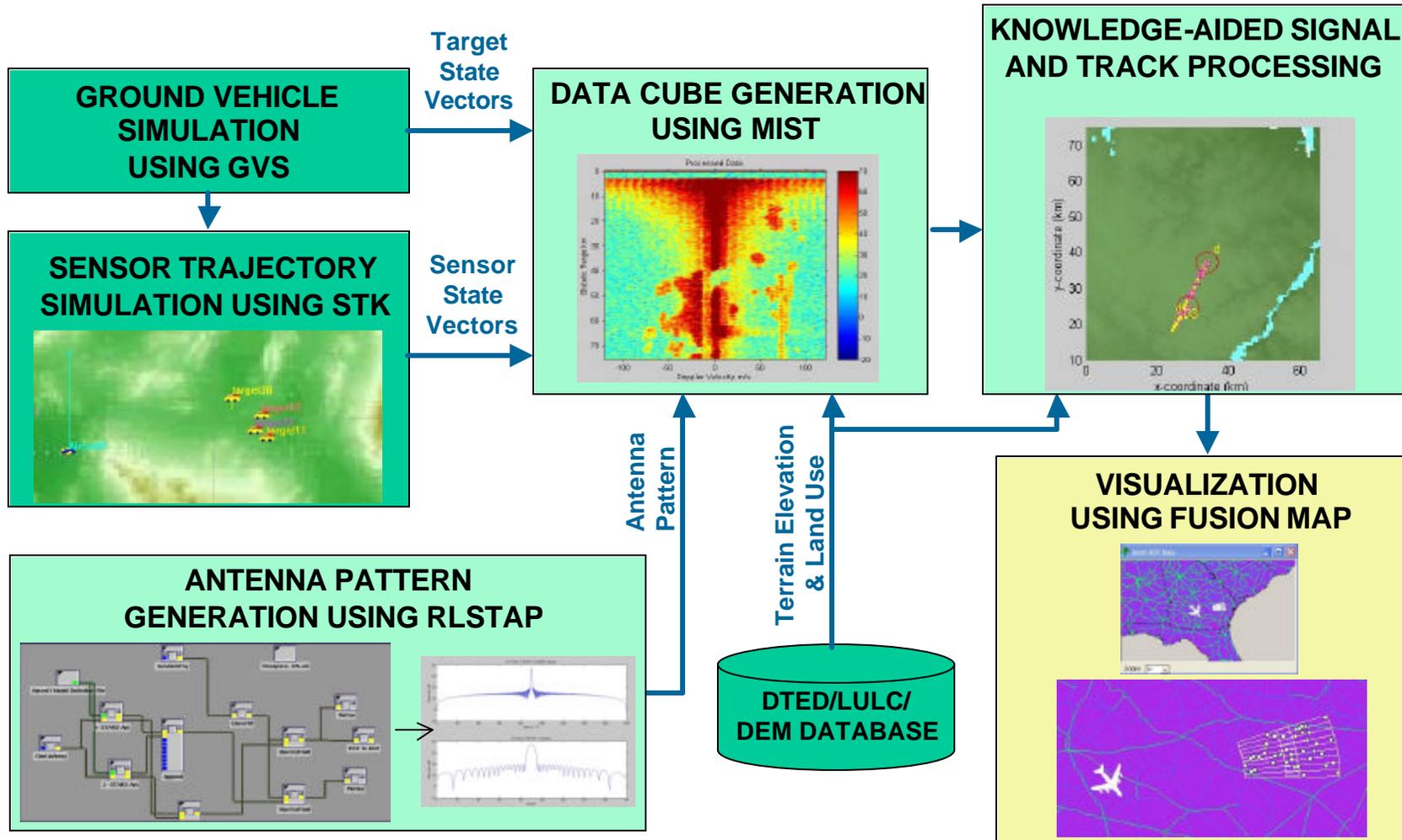


MTIX accepts streaming GMTI detections in NATOEX format, populates an MTI database and serves the detections to the Kinematic Auto-Tracker. Output tracks are stored in a KAT database.

Integrated Simulation Models

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Evaluations of Measured Targets Immersed in Synthesized Clutter



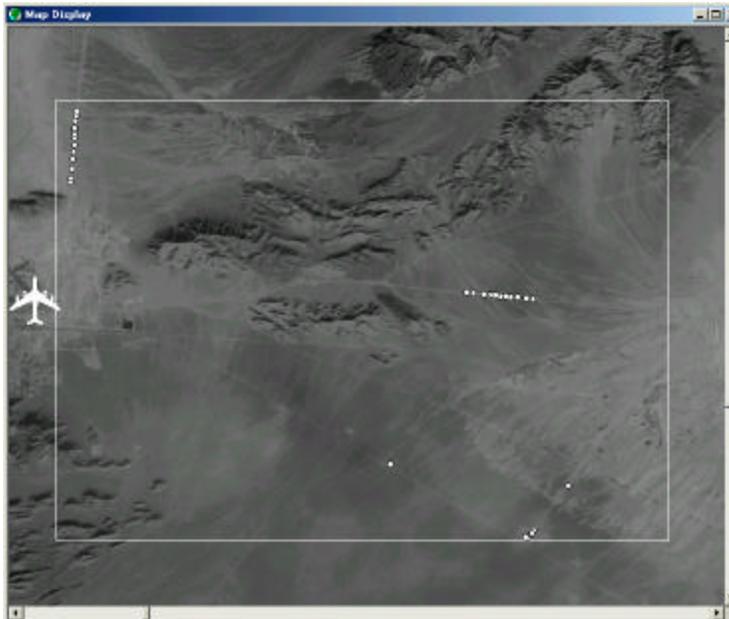
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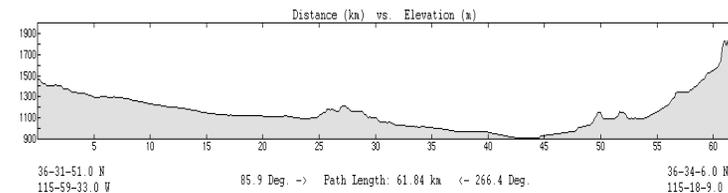
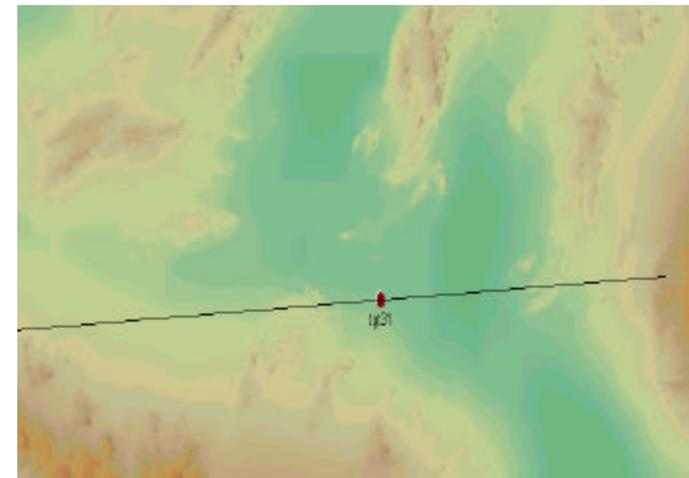
Indians Springs, NV Scenario

GVS Scenario

- 5 Minute Duration
- 33 Ground Targets
- 1 Sec Update Rate



**Tracking Evaluation Using TSPI
Measured Targets Inserted in
Synthetically Generated Background**



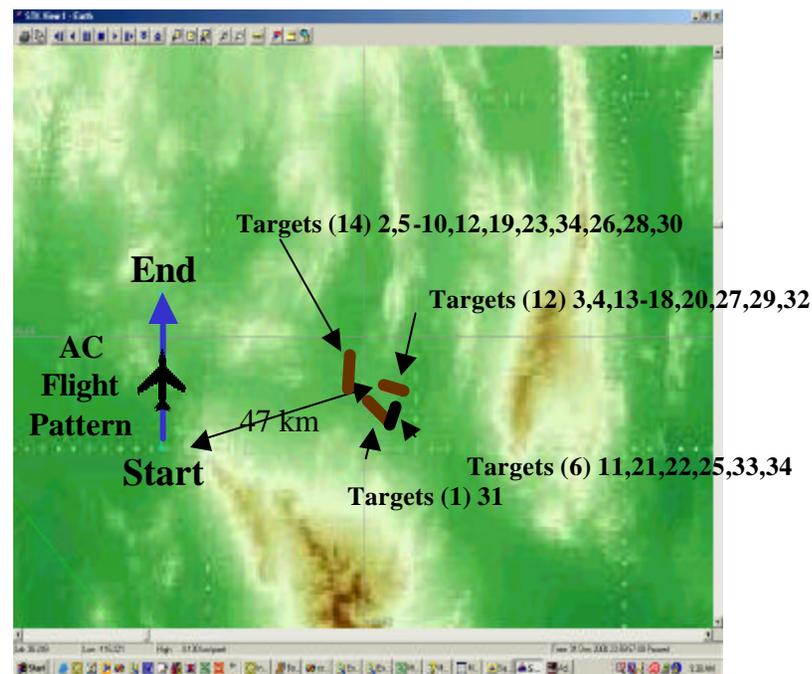
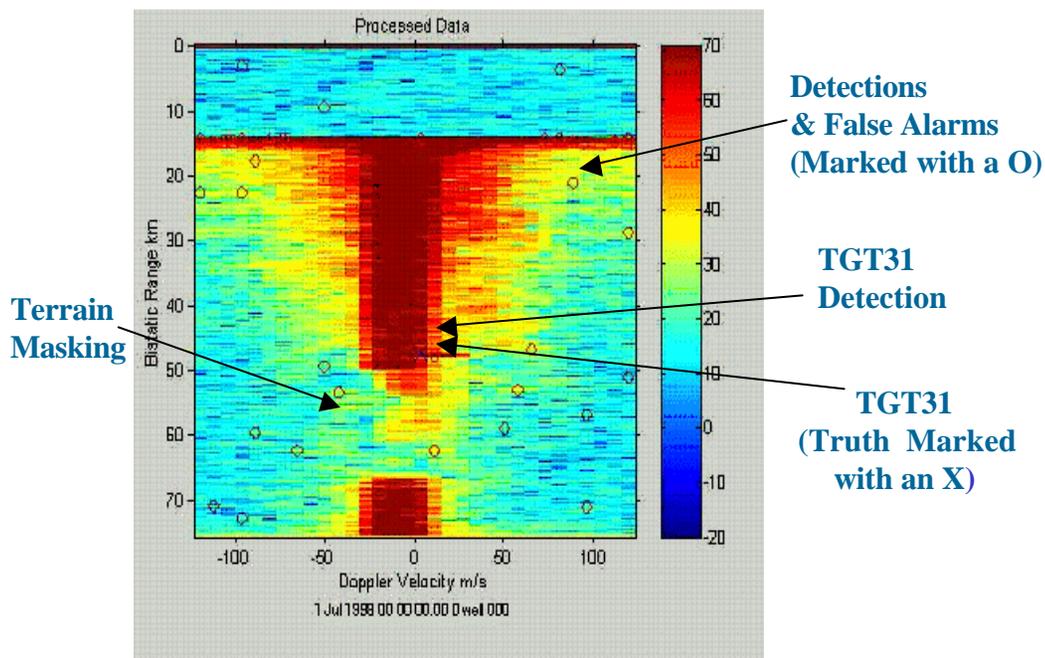
**Terrain Elevation Effects
in Detection and Tracking**

Visualization of Detections & Tracks



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Target Detection Evaluation

Target Tracking Evaluation

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MOPs Evaluation

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- **Signal Processing MOPs Typically Inadequate for Characterizing End-to-End (signal and data processing) Sensor Improvement**
 - Misleading / Subject to Interpretation
 - Confusing to User / Operator

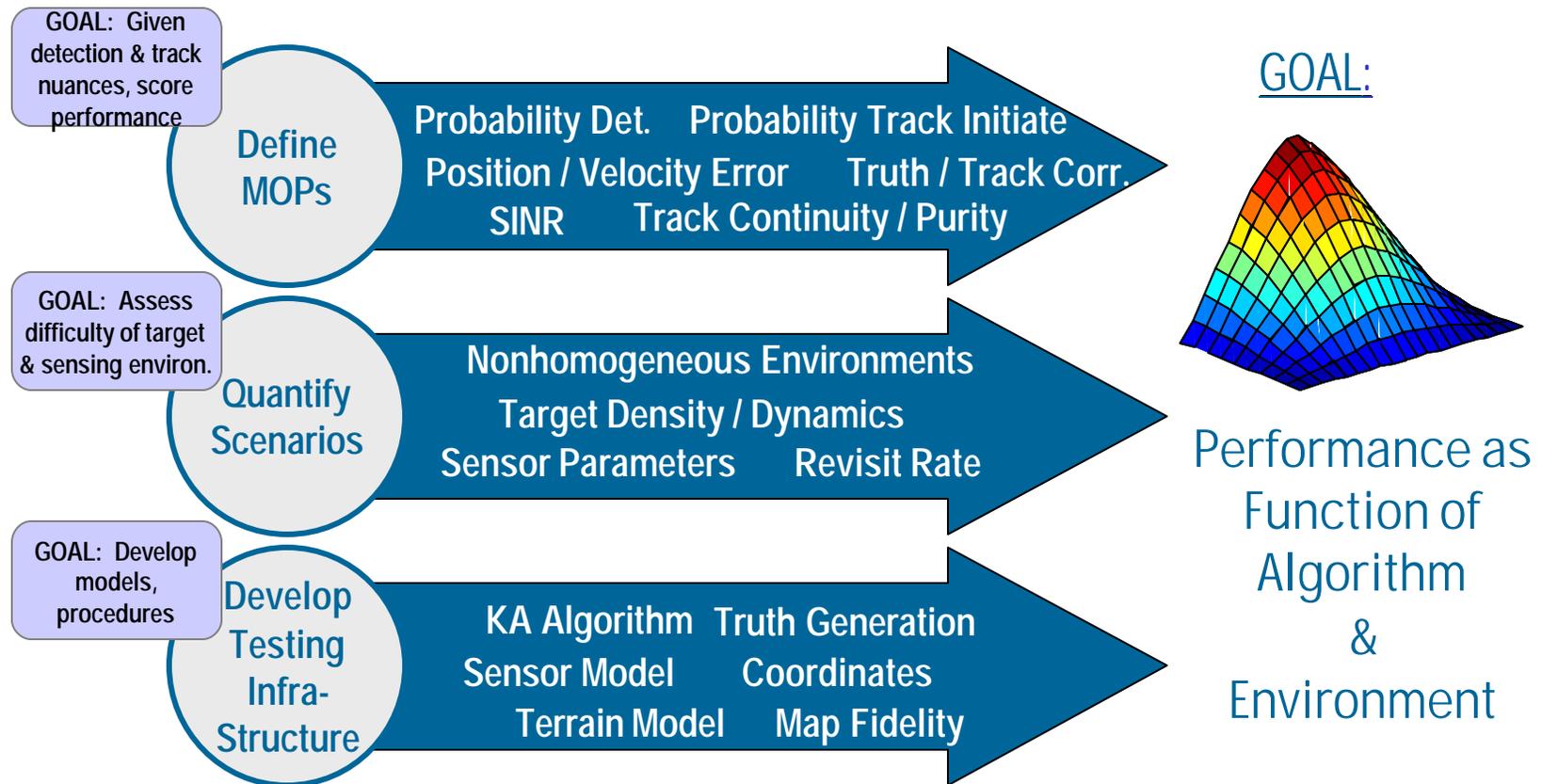
- **Tracking / Exploitation MOPs Most Useful to Users**

- **Devise Testbed That Provides Processing-to-Exploitation MOPs Translation**

Approach to Evaluation

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Courtesy of Mr. Jon Jones, AFRL IFEA

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All three efforts required for evaluation

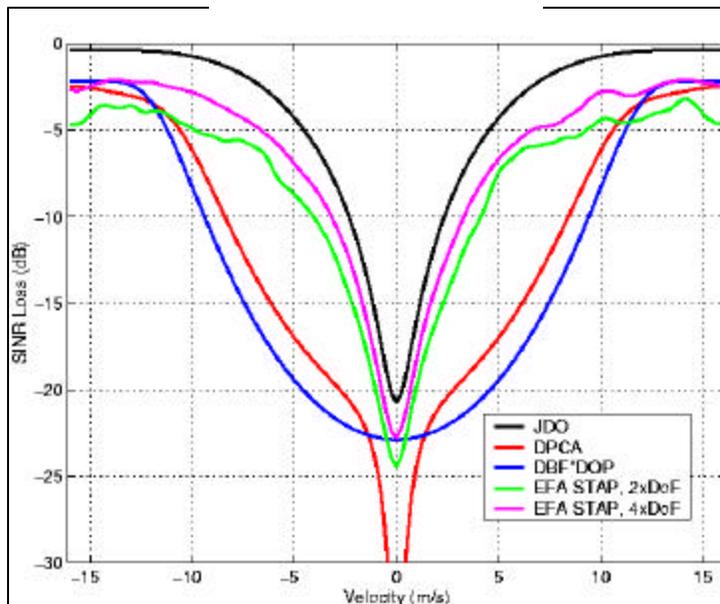
Detection Measures of Performance



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**SINR Loss
STAP Algorithms¹**



- SINR – Signal-to-Interference Plus Noise Ratio
- MDV – Minimal Detectable Velocity
- Pd – Probability of Detection
- FAR – False Alarm Rate
- SCV – Sub Clutter Visibility
-
-
-

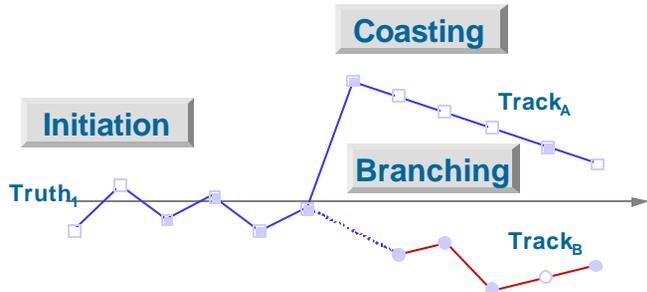
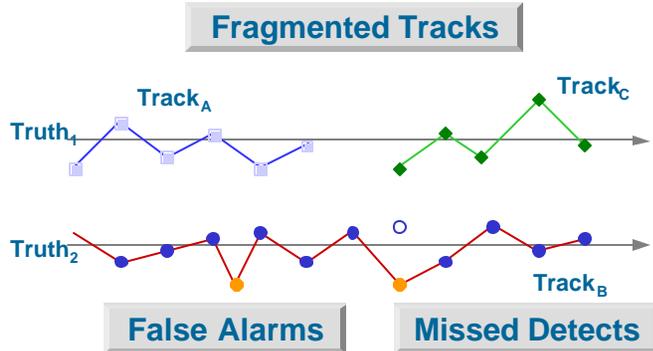
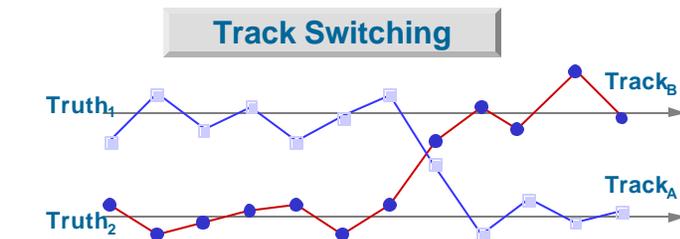
1. Dr. W. Melvin, “Introduction To Adaptive Radar”

Tracking Measures of Performance



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Precision

- Horizontal Track Location Error
- Track Location Error
- Track Speed Error
- Target Heading Error
- Kolmogorov-Smirnoff Covariance Test (KS)

Assess Situation

- Target Continuity
- Target Purity
- Track Continuity
- Track Purity
- Target Identity Lifetime
- Probability Maintain Initial Target ID
- Average Track Life
- Track Redundancy

Sensing Capability

- Probability of Declaration
- Probability of False Declaration
- Track Initiation Time

Deploy

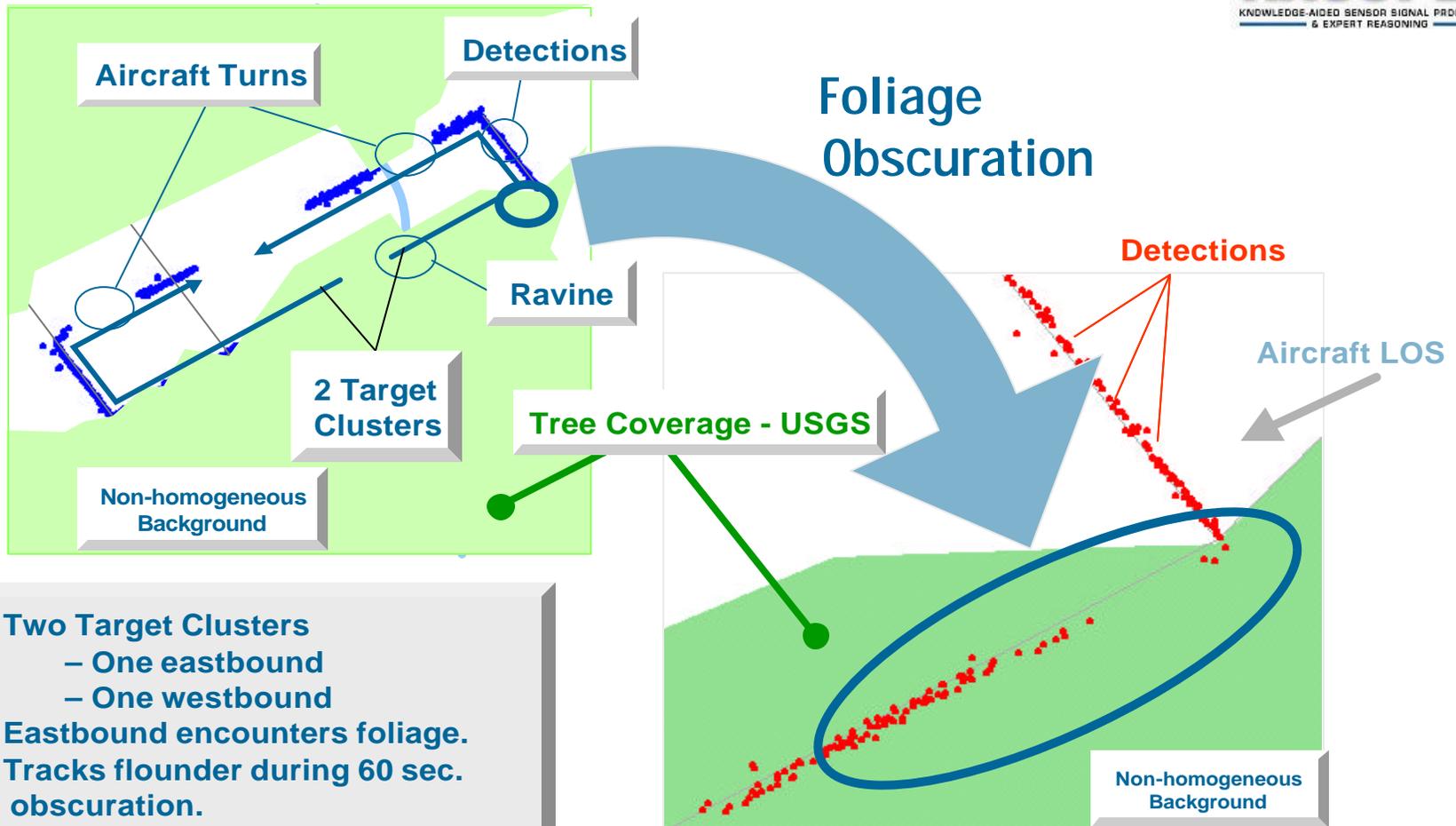
- Normalized Throughput
- Average Latency

Track Evaluation Example



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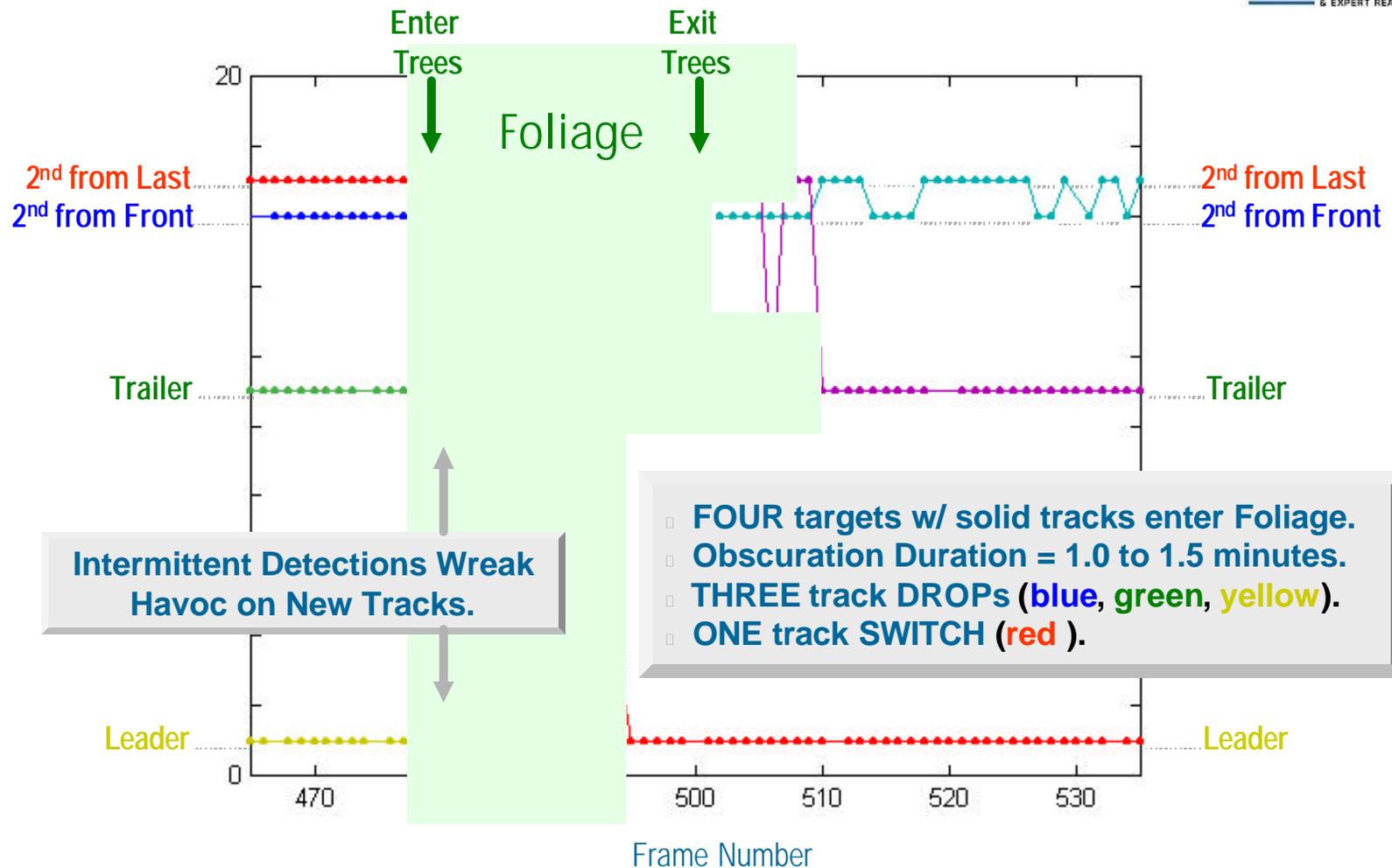


- Two Target Clusters
 - One eastbound
 - One westbound
- Eastbound encounters foliage.
- Tracks flounder during 60 sec. obscuration.
- Gaps due to Aircraft turns offer good track coast reference.

Track History

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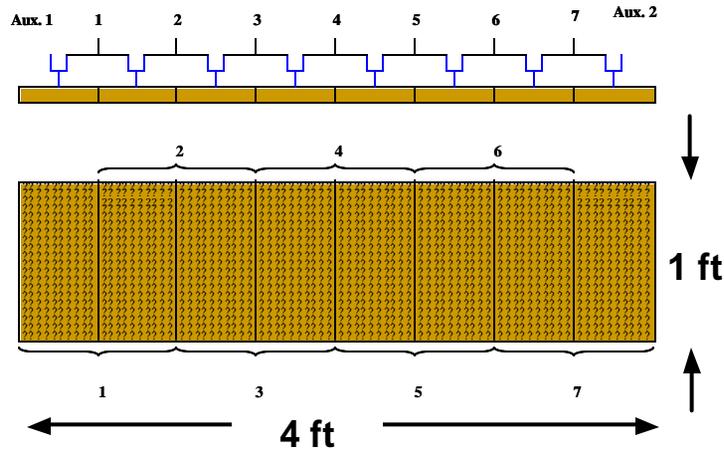
KASSPER Airborne Testbed



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ANTENNA ARRAY



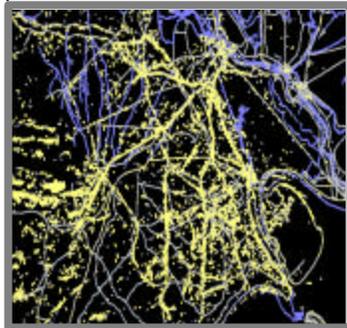
PARAMETERS	
Frequency	10 GHz
PRF	1.2 kHz
Sample Rate	20 MHz
Range	112 km
Pulses	32
Duty Cycle	10%

- **9 Channels at X-band**
 - 7 Overlapping Subarrays
 - 2 Auxiliary Subarrays
- **IQ & Parameter Data**
- **Challenging Clutter Environments**

JSTARS Flight Data

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Where
is the
target?

- IQ & Radar Parameters
- Indian Springs, NV & Eglin
- Mountainous Desert & Littoral
- Scripted Targets – Challenge to K-A Processing
- Dense Target Environment
- Nonhomogeneous Environment
 - Discretes
 - Road Traffic

JCIET Flight Data Collection

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- IQ & Radar Parameters
- High Resolution Interferometric SAR
- Slow GMTI
- Off-board HSI
- Scripted Targets – Challenge K-A Processing
- Fixed, Calibrated Targets
- Nonhomogeneous Environment
 - Discretes
 - Road Traffic
- Mississippi Test Site
- Late April, 2002

Outline

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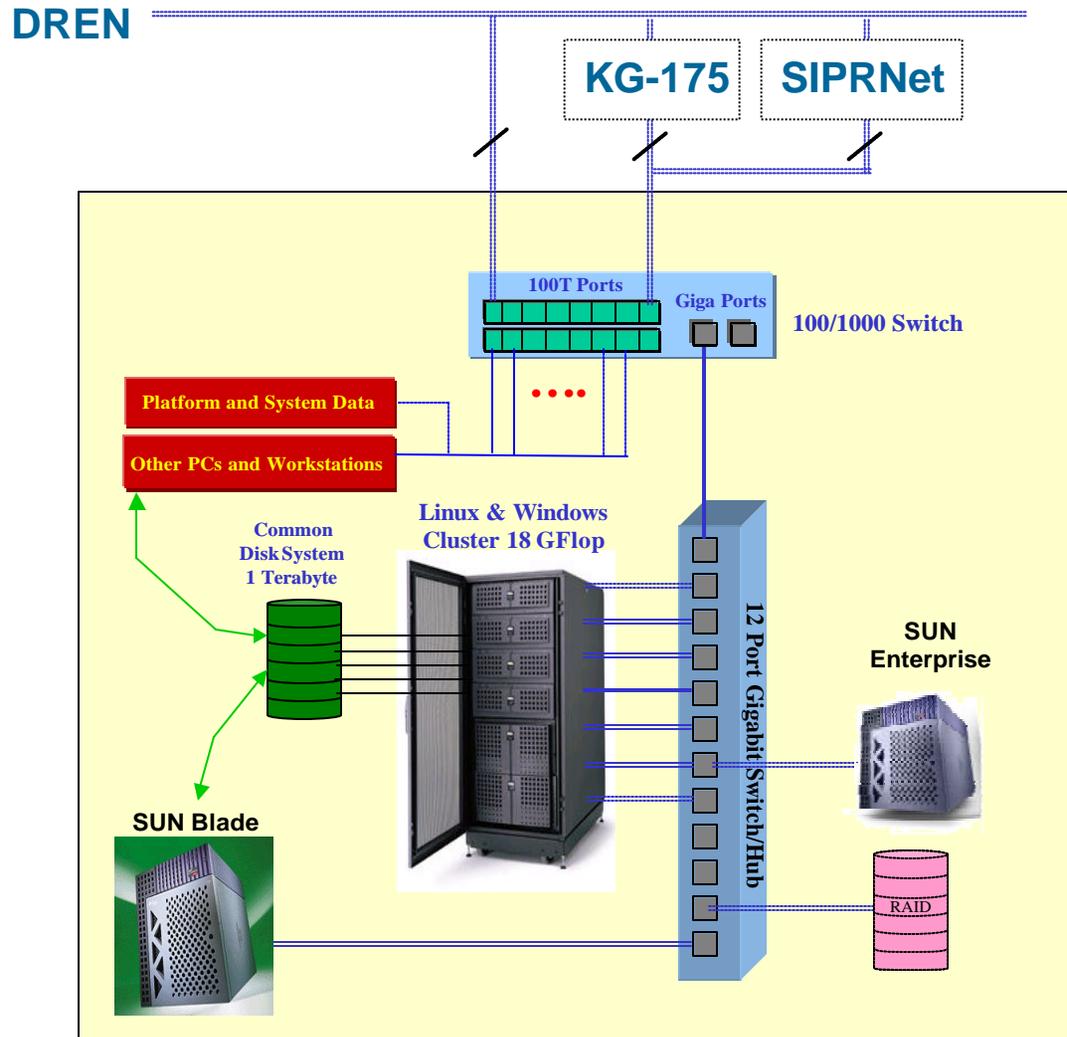


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Facilities

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- **AFRL Will Utilize Its Integrated Testbed Capability to Evaluate End-to-End KASSPER K-A Algorithm Performance**
- **K-A Algorithm Performance Will Be Related to System Operational Tracking Performance**
- **AFRL Testbed Will Demonstrate Improvements Offered by Integrated K-A Techniques**