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Toward the Goal of Continuous Track and Identity

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Outline

- Long Poles that have been Shortened
- Applications of Sensor Nets
- Long Poles that Remain



Conventional Tracking and Fusion From Platform-Based Sensors: The State-of-the-Art

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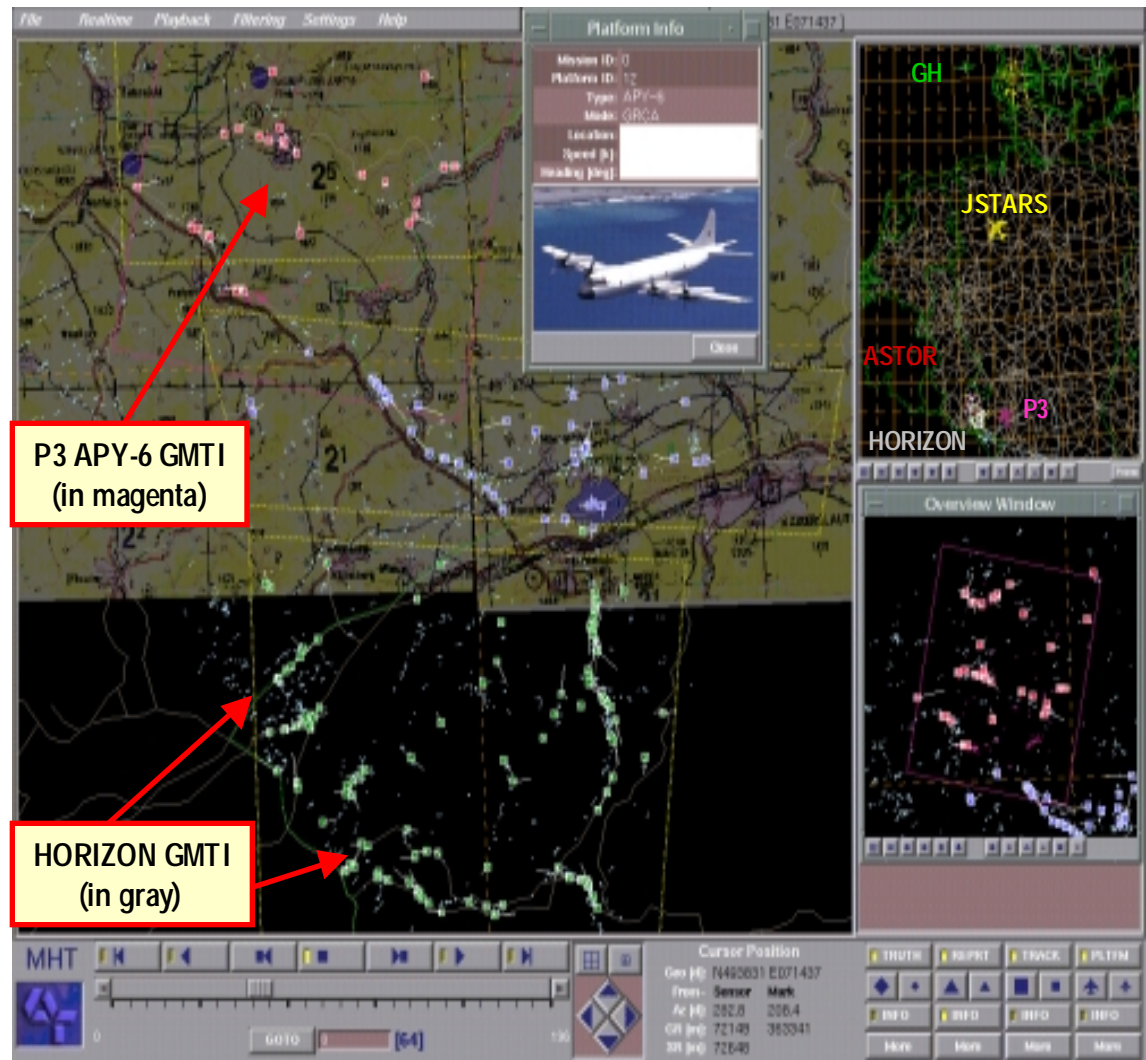
Relevant Science and Technology	Evidence of Advanced Capability
<ul style="list-style-type: none"> Detection, estimation, data association (including distributed and constrained cases) 	<ul style="list-style-type: none"> GMTI and SIGINT tracking, imaging, fusion Seminal papers by Sandell and Tenney
<ul style="list-style-type: none"> Generation and management of large hypothesis spaces and extraction of consistent global hypotheses 	<ul style="list-style-type: none"> BMD programs, ARPDD, JSTARS CGS, DDB Multiple Hypothesis Tracking (MHT)
<ul style="list-style-type: none"> Exploitation of road networks, signature features, and terrain features as tracking aids 	<ul style="list-style-type: none"> DDB, D2, MTE, AMSTE, FAT Parallel processing
<ul style="list-style-type: none"> Multi-platform, multi-sensor data fusion in large-scale complex scenarios 	<ul style="list-style-type: none"> DDB, DMTIFE, DMIF, ASF, SSIFRT, ADFT Fusion Engines: MICOR, ATIF
<ul style="list-style-type: none"> Tracking through complex vehicle maneuvers (move-stop-move, crossing tracks, dense traffic, groups) 	<ul style="list-style-type: none"> DDB, D2, MTE, AMSTE
<ul style="list-style-type: none"> Dynamic resource management 	<ul style="list-style-type: none"> AIM, DDB-AIM, CT, MTE
<ul style="list-style-type: none"> Operational concepts, demonstrations, and evaluations (in the field and on a test bed) 	<ul style="list-style-type: none"> Programs: CAESAR, MPTE, CGS Platforms: JSTARS, U-2, Global Hawk, JSF



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Coalition Aerial Surveillance and Reconnaissance (CAESAR)

- **Customers**
 - OSD; NC3A; AF (ESC, AFRL)
- **Objectives**
 - Interoperability of Air & Ground Assets
 - GMTI (and SAR) Exploitation
 - CONOPs, TTPs
- **US and Coalition Assets**
 - SEP/GH, JSTARS, P3 APY-6
 - UK ASTOR
 - French HORIZON
 - Italian CRESSO
- **Common GMTI Data Format**
 - NATO Ex 2.01
- **Numerous Exercises**
 - Stand-Alone Demo in JEFX '99
 - RT Demo in JPOW V / Clean Hunter 2000 Exercises



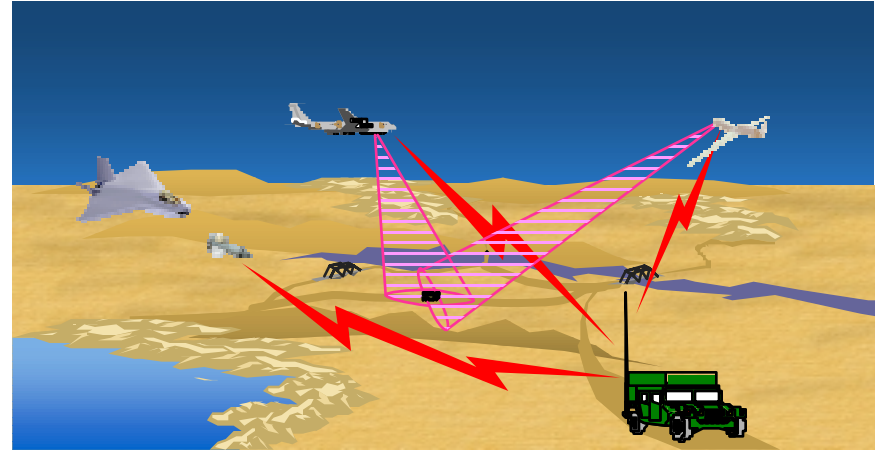


Precision Multiple Hypothesis Tracking

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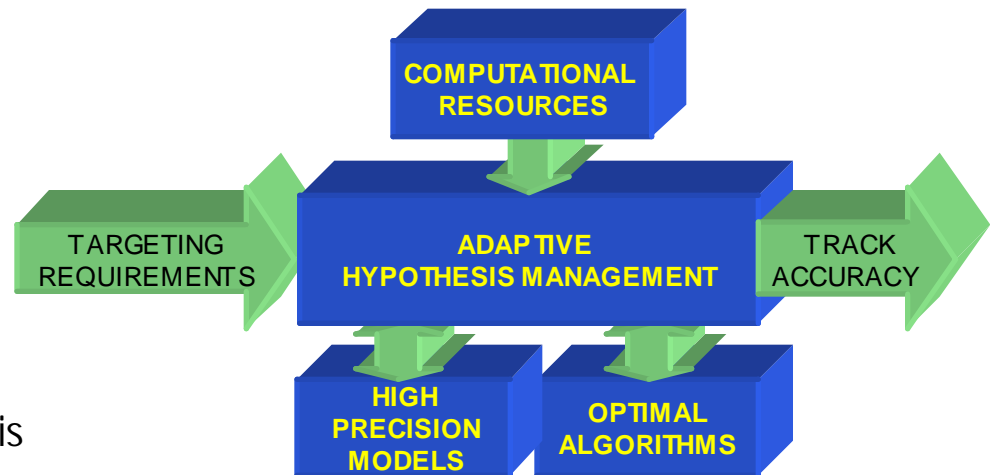
- **Produce Accurate, Continuous Tracks on Critical Targets from One or More GMTI Sensors**

- **Goal:** Automated Algorithms to Register, Geo-locate, Track, and Project Moving Surface Targets
- **Status:** Algorithms Developed and Evaluated
 - Interacting Multiple Model Filtering
 - GMTI Registration
 - Dwell-Based MHT
 - Move-Stop-Move Tracking
 - Hypothesis Management
 - Abstract Feature-Aided Tracking
 - Targeting Projection



- **Adaptively Focus Computation and Algorithms on Critical Targets**

- **Goal:** Develop a Single System that can Perform Both Surveillance and Fire Control Tracking
- **Status:** Adaptive Hypothesis Management is the Enabling Technology

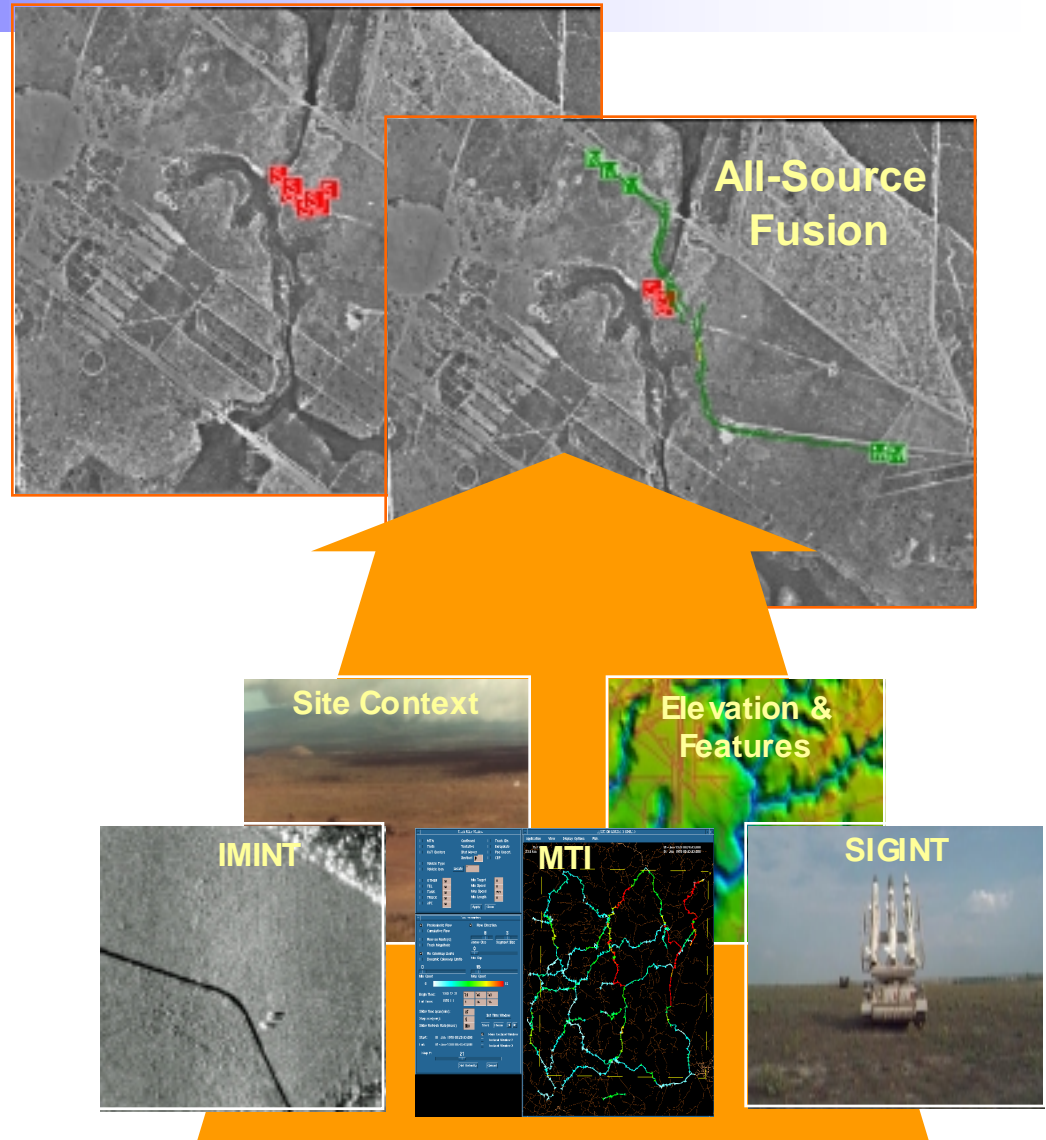




All-Source Track & Identity Fusion (ATIF)

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- **Objective**
 - Improve ability to maintain ground vehicle track and identity by fusing MTI, IMINT, and SIGINT
- **Operational Payoff**
 - Breaks the “stovepipes”
 - Reduces the workload
 - Provides a single, integrated, self-consistent ground picture
 - More continuous vehicle tracks (e.g., thru move-stop-move cycles)
 - Improved position estimates and identification
- **Example**
 - Stationary targets detected, located and identified via SAR imagery and superimposed on an EO image
 - ATIF tracks and maintains identity as some vehicles move out and others remain stationary

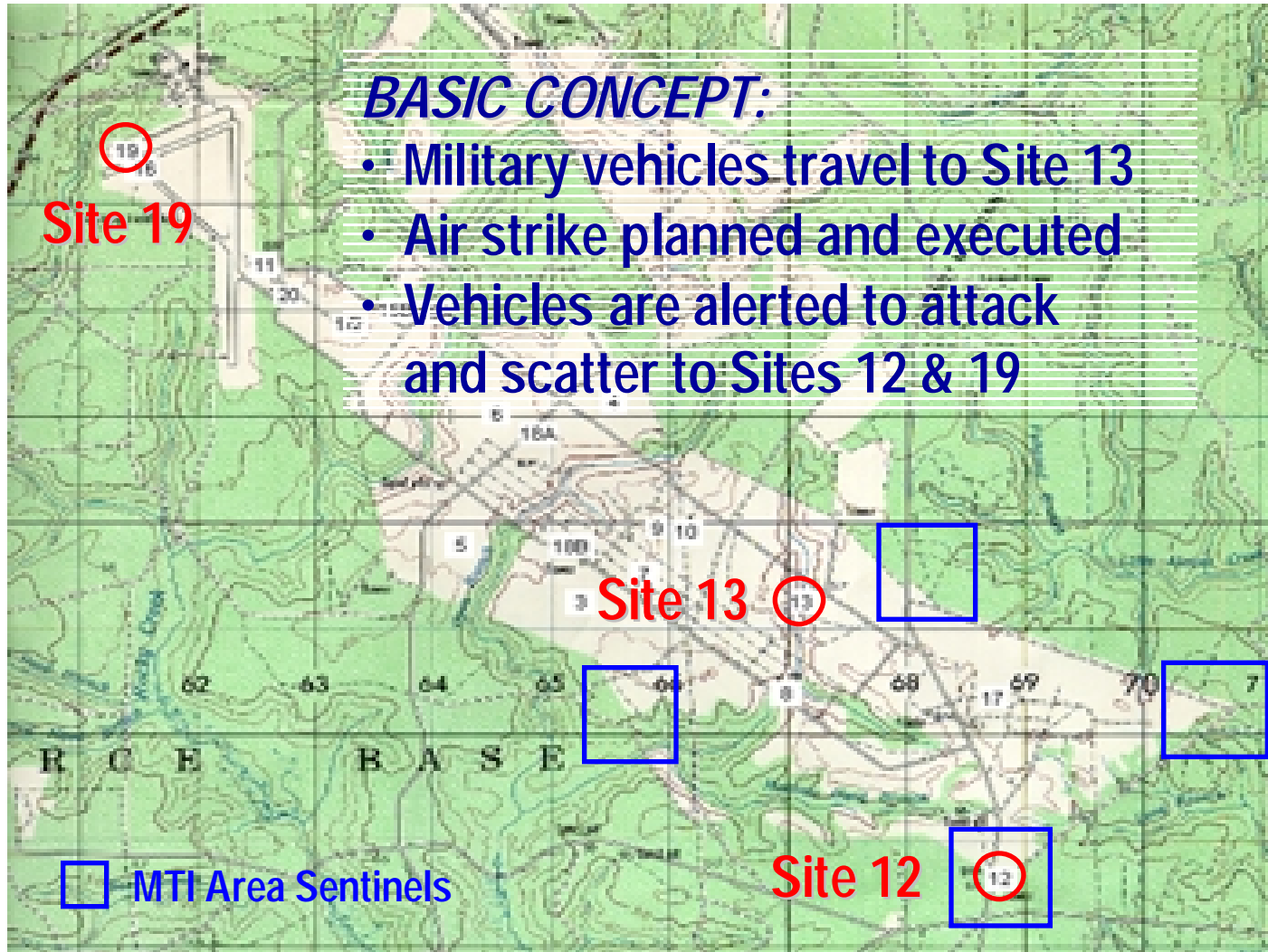


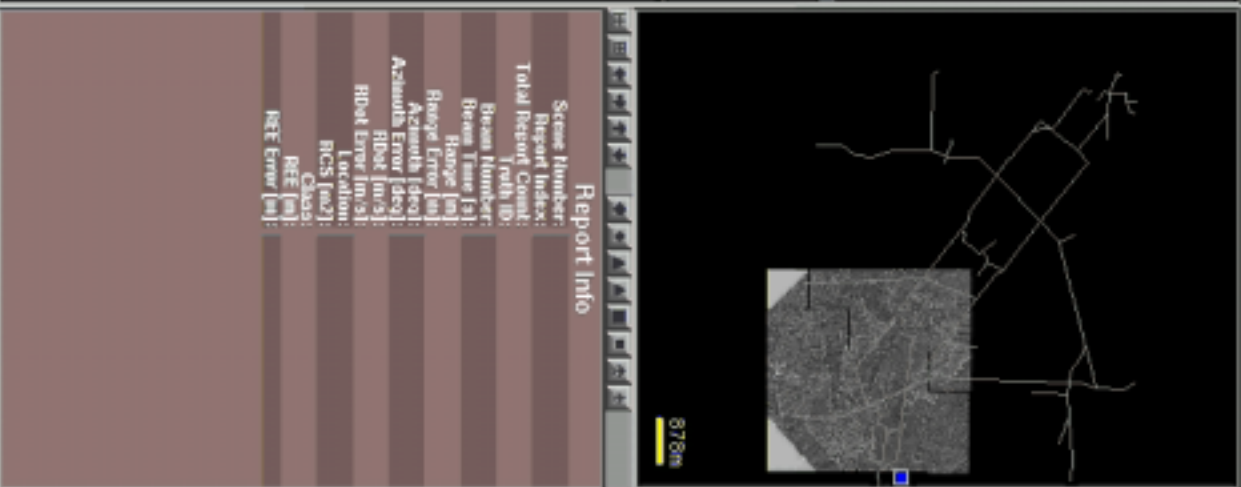


Multi-Thread "Cockroach" Scenario

Go to Next Slide and Click on Image to Begin Movie

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Report Info

Screen Number:
 Report Index:
 Total Report Count:
 North ID:
 Screen Number:
 Screen Time (s):
 Range (m):
 Range Error (m):
 Azimuth (deg):
 Azimuth Error (deg):
 Blob (m/s):
 Blob Error (m/s):
 Location:
 RCS (m2):
 RCS (m):
 RCS (m):
 RCS Error (m):

DDB

00:30:00.000 01:54:00.000
 101 00:30:00.000
 Location: France/Trat



Cursor Position

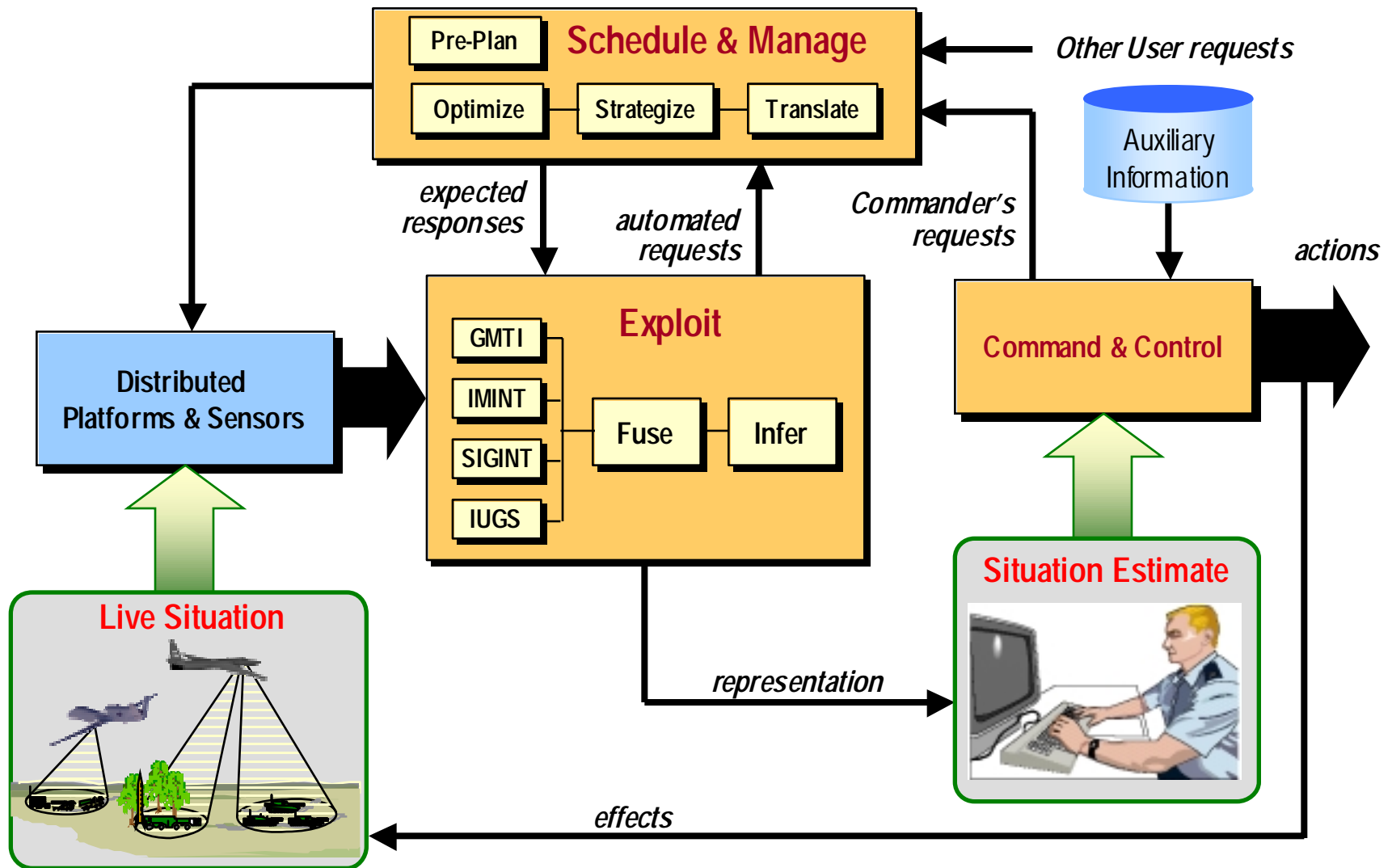
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 From - Sensor Mark
 Az [id]: 216.7 232.2
 GR [m]: 156123 142064
 SR [m]: 156736

TRUTH REPT TRACK PLT M
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Automated Sensor Management

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Potential Applications of Sensor Nets

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- **What are the applications of sensor nets?**
 - When conventional platform-based sensor systems simply cannot do the job
 - When sensor nets can do the job better—faster, cheaper, longer, with greater accuracy, with less risk

- **What are some current examples?**
 - Targets Under Trees (TUT)
 - Foliage penetrating radar is just one perceived solution
 - Terrain masking
 - Cannot always meet requirements by adding another platform-based sensor
 - Military operations in urban terrain (MOUT)
 - Unpredictable, inaccessible, and poorly modeled
 - Special Unit Operations (SUO)
 - Too small a force to command use of high cost ISR platforms
 - Sensor nets are more appropriate to mission



Remaining Intellectual Long Poles

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- **Challenges you are already thinking about**
 - self-organization of an *ad hoc* sensor network
 - system trades between
 - sensor capability (cost) and number of sensors
 - power allocations to processing and communications
 - communications bandwidth and distributed estimation performance

- **Challenges you may not be thinking about**
 - reorganization after drop-outs (power loss or damage)
 - optimization over a distribution of non-homogeneous sensor types
 - exploitation of *a priori* knowledge
 - identification of stable discriminant features
 - clutter rejection in reverberative environments
 - sensor, target, and background models sufficient to capture the dominant aspects of the problem
 - group tracking



Operational Long Poles

- How do you emplace the sensors
- How do you exfiltrate the data
- **What is the concept of operations (CONOPS)**
 - How is a sensor net embedded in a real operational system
 - What is the connectivity with other parts of an integrated sensing system
 - How do you do things like cross-cueing, hand-off, and fusion
 - How do you adapt to the operations tempo
 - When do you do I&W vice track and ID



Summary

- **Capabilities for continuous track and ID have advanced**
 - consistent global hypotheses over large hypothesis spaces
 - use of road networks, signature features, and terrain features as aids
 - multi-platform, multi-sensor data fusion over large complex scenarios
 - all emphasize platform-centric rather than network-centric approaches
- **There remain gaps that sensor nets have the potential to fill**
 - targets under trees
 - terrain masking
 - military operations in urban terrain
 - special operations forces
- **But there are hurdles to overcome**
 - technical challenges
 - operational concepts



Acronyms

- Adaptive Data Fusion Technology (ADFT)
- Adaptive Sensor Fusion (ASF)
- Advanced Battlespace Awareness (ABA)
- Advanced ISR Management (AIM)
- Advanced Radar System Tracker (ARS)
- Affordable Moving Surface Target Engagement (AMSTE)
- All-Source Track and Identity Fusion (ATIF)
- Automatic Radar Periscope Detection and Discrimination (ARPDD)
- Coalition Aerial Surveillance and Reconnaissance (CAESAR)
- Continuous Tracking of High-Value Targets (CT)
- Discoverer II (D2)
- Distributed MTI Fusion and Exploitation (DMTIFE)
- Dynamic Database (DDB)
- Dynamic Multi-Sensor Information Fusion (DMIF)
- Feature Aided Tracking (FAT)
- Integrated Broadcast Service (IBS)
- Moving and Stationary Target Acquisition and Recognition (MSTAR)
- Moving Target Exploitation (MTE)
- Multi-Platform Tracking and Exploitation (MPTE)
- Off-Board Augmented Theater Surveillance (OBATS)
- Precision Fire Control Tracking (PFCT)
- Precision Multiple Hypothesis Tracking
- Semi-Automated IMINT) Processing (SAIP)
- Sensor-to-Shooter Information Fusion for Rapid Targeting (SSIFRT)