

50 Mall Road Burlington, MA 01803-4901 781-273-3388  
2101 Wilson Boulevard Arlington, VA 22201-3062 703-524-6263

*ALPHATECH, Inc.*

# Toward the Goal of Continuous Track and Identity

Donald F. Herrick  
herrick@alphatech.com  
(781) 273-3388 x286

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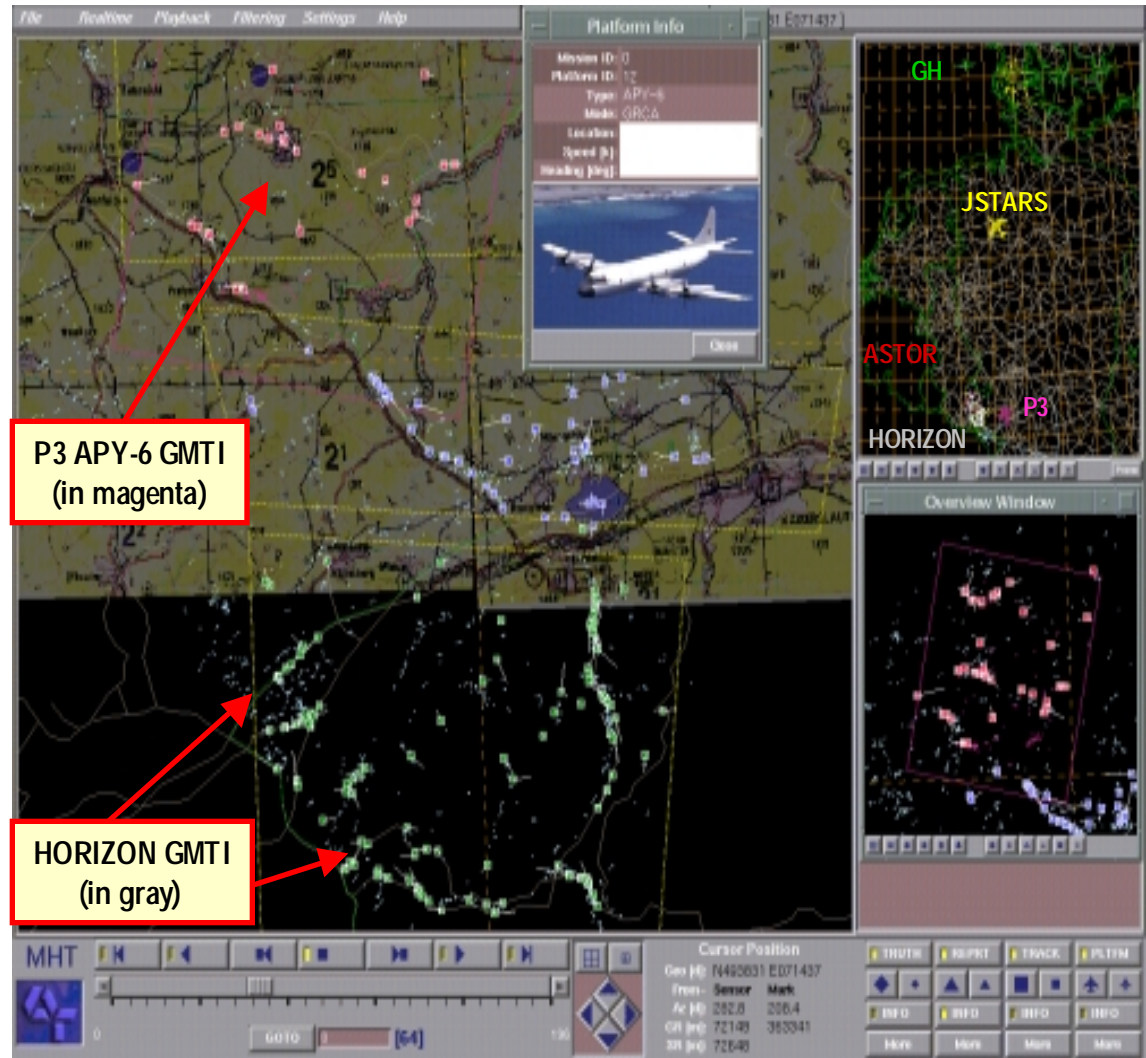
Relevant Science and Technology	Evidence of Advanced Capability
<ul style="list-style-type: none"><li>Detection, estimation, data association (including distributed and constrained cases)</li></ul>	<ul style="list-style-type: none"><li>GMTI and SIGINT tracking, imaging, fusion</li><li>Seminal papers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



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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



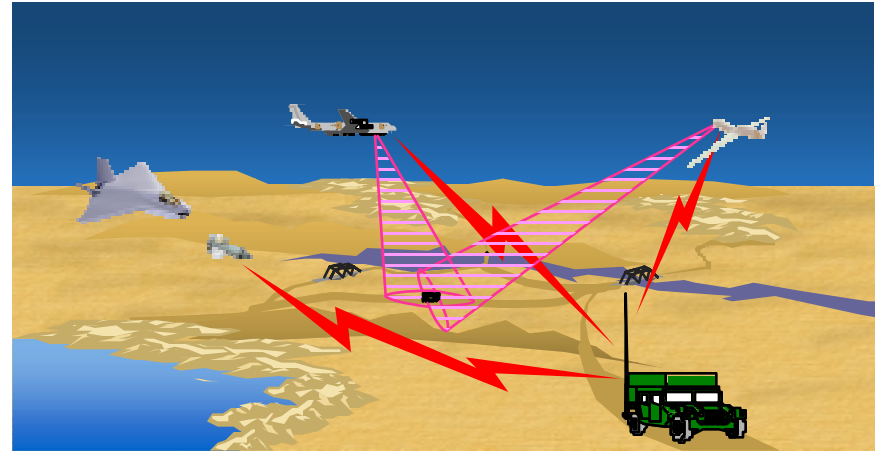


# Precision Multiple Hypothesis Tracking

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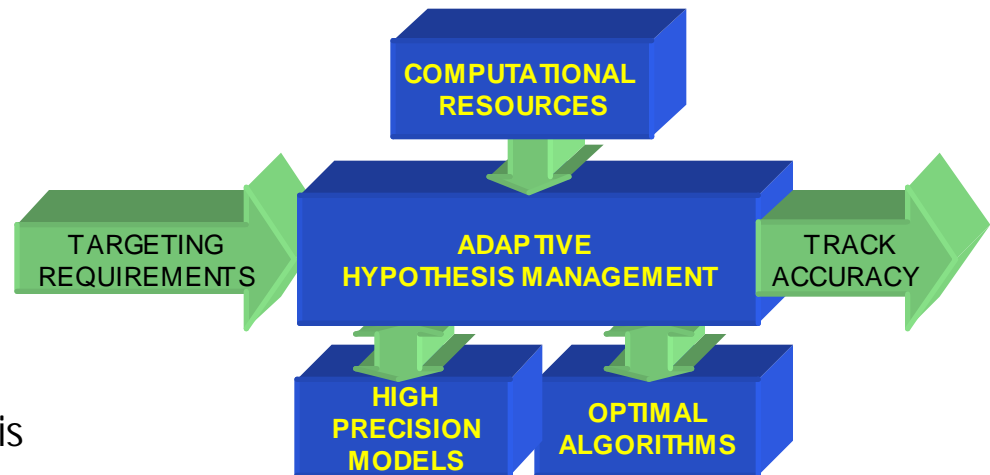
- **Produce Accurate, Continuous Tracks on Critical Targets from One or More GMTI Sensors**

- **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

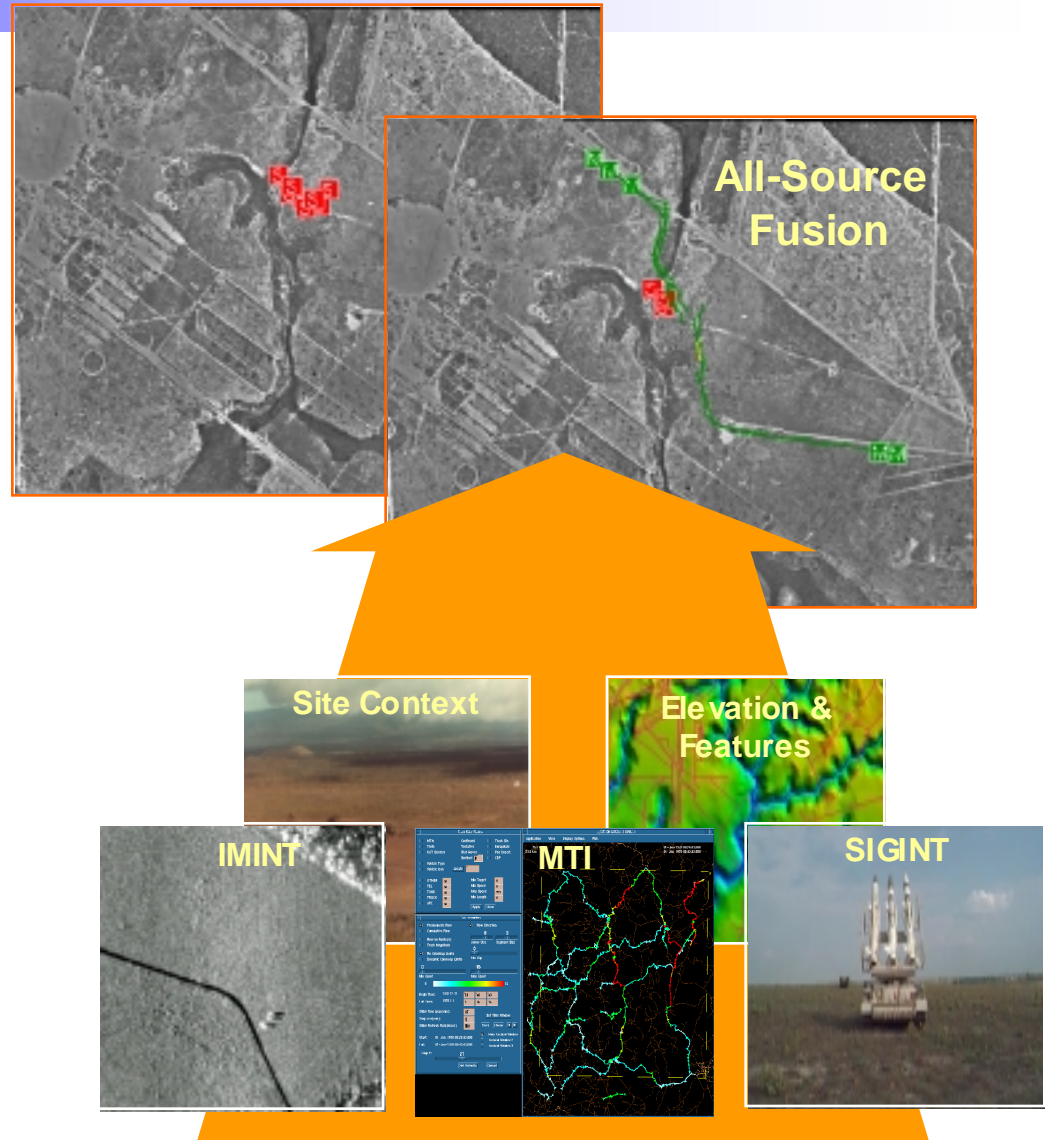




# All-Source Track & Identity Fusion (ATIF)

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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

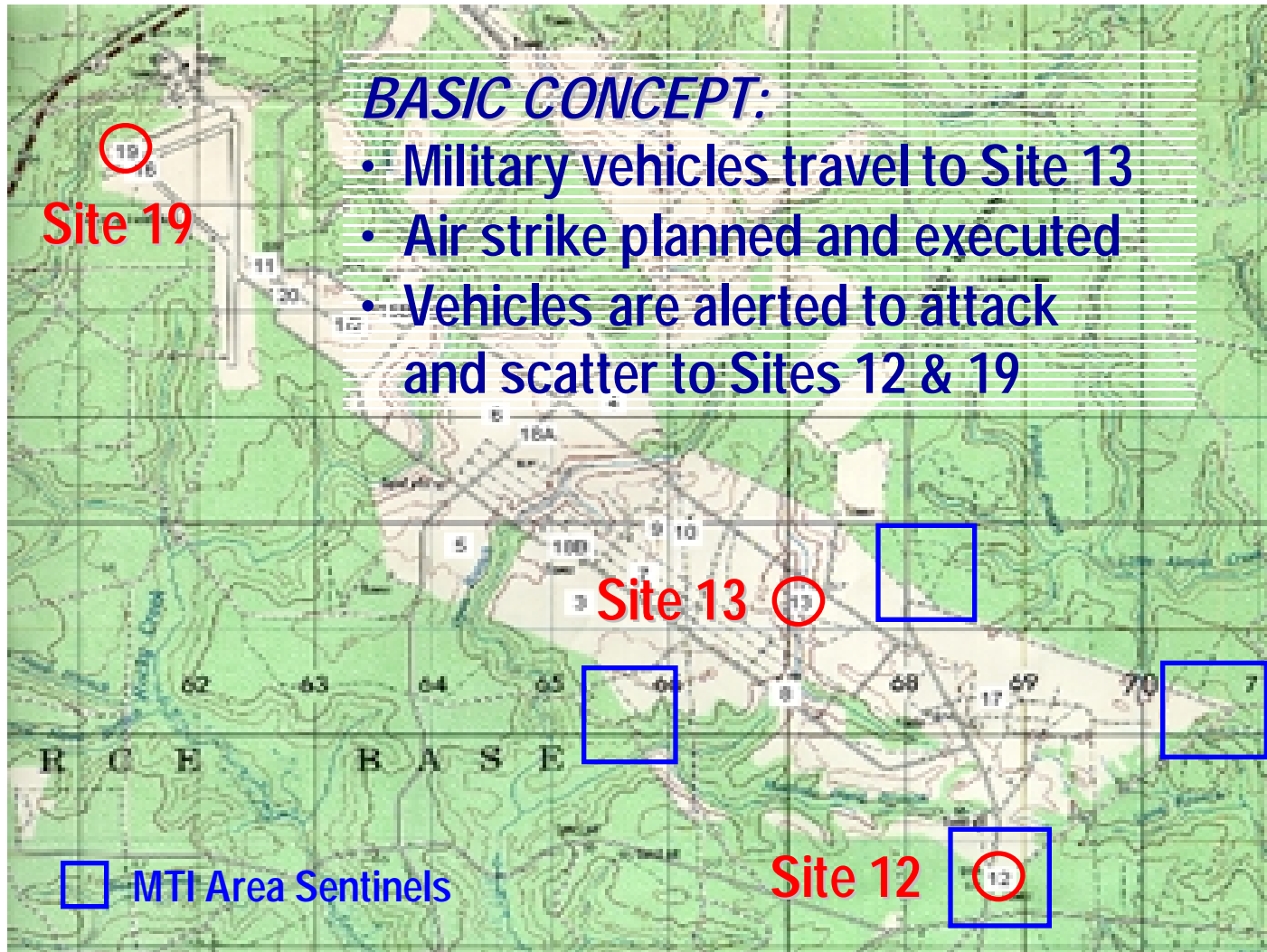


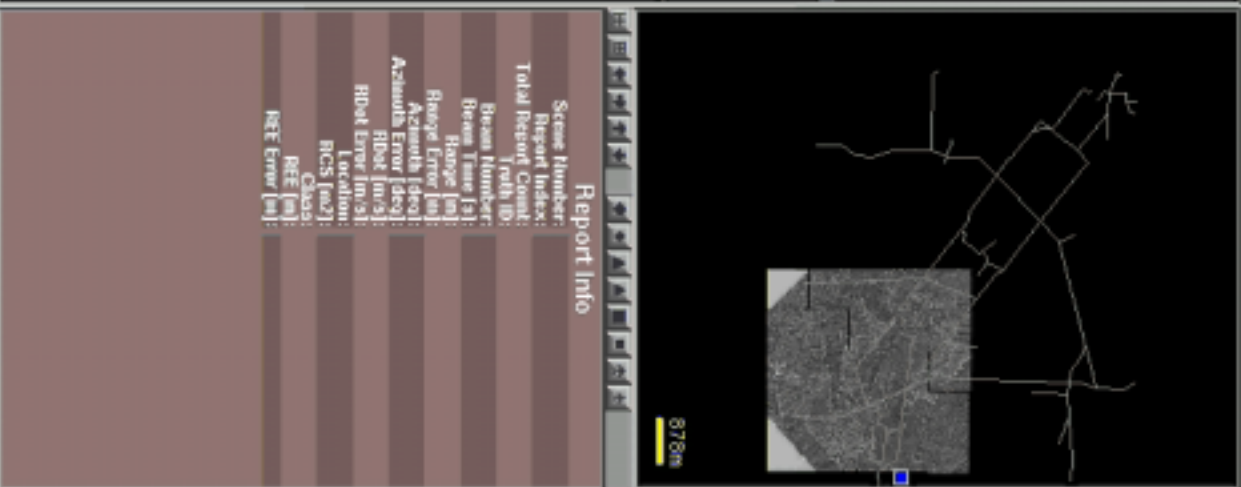


# Multi-Thread "Cockroach" Scenario

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 Name [s]:  
 Range [m]:  
 Range Error [m]:  
 Azimuth [deg]:  
 Azimuth Error [deg]:  
 Blob [m/s]:  
 Blob Error [m/s]:  
 Location:  
 RGS [m/s]:  
 Class:  
 RBE [m]:  
 RBE Error [m]:

Cursor Position

Geo [id]: 30 83713, -88 29627  
 From - Sensor Mark  
 Az [id]: 216.7  
 CR [m]: 156123  
 SR [m]: 156736

DDB

00:30:00.000  
 01:54:00.000  
 101:00:30:00.000

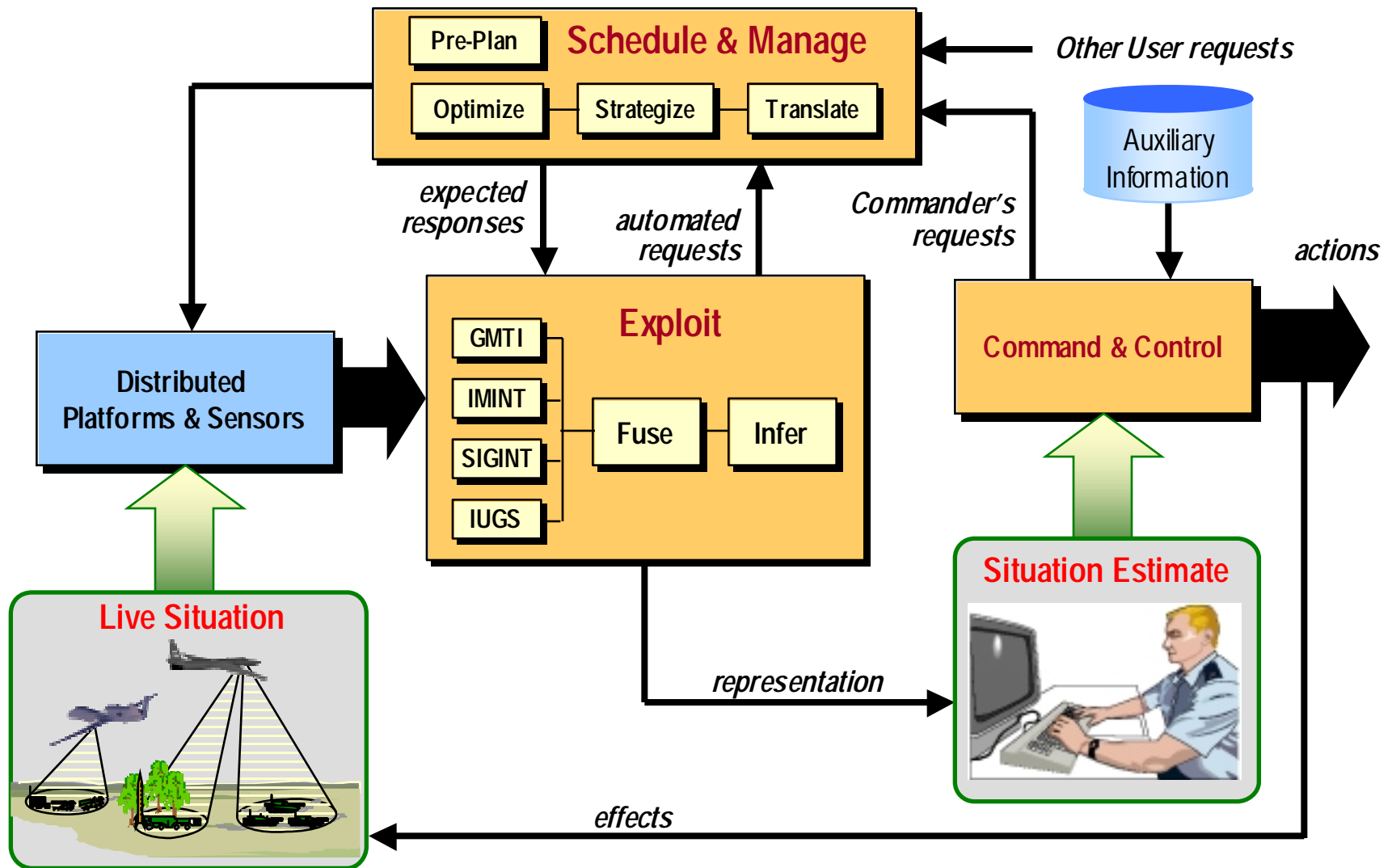


TRUTH REPT TRACK PLT M  
 INFO INFO INFO INFO



# 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)