Cross-Domain ISR
Maritime Awareness Demonstration

Ken Gregson

HPEC Conference

22 September 2009
ISR Cross-Mission Operation

Environmental Monitoring

Fishing Zone Enforcement

Accessible, Discoverable, Available, Information and Services using Open Standard Interfaces

Regional Air Defense

Air Traffic Control

Maritime Awareness

MIT Lincoln Laboratory
ISR Maritime Domain Awareness Demonstration

- Cross-Domain ISR Motivation
  - System Concept Scenario Walk-through
  - Net-Centric Architecture and Execution
  - Technical Highlights and Summary
ISR Capability Development and Demonstration

ISR Operations

- Maritime Surveillance
- Time Sensitive Targeting
- Urban Combat
- Search and Rescue
- Border Patrol

ISR Demonstration Architecture

Common Key Capabilities Across ISR Operations

- Dynamic tasking of ISR assets in response to events
- Real-Time interoperation to prosecute ISR engagements
- Automated analysis using software agents

MIT Lincoln Laboratory

20090220-4
KLG 10/1/2009
Net-Centricity for ISR

**Stovepipe Systems**

**Sensors on Network**

**Net-Centric Evolution**

**Present Conditions**

- **Limited information access**
  - Point-to-point connections

- **Expensive integration**
  - Custom proprietary interfaces

- **Predetermined needs**
  - Hardwired functionality

- **Security barriers**
  - Negotiated need to know

**Objective Future**

- **Shared authoritative sources**
  - Network search and discovery

- **Interoperability**
  - Fully open standards

- **Unanticipated uses**
  - Dynamically compose-able applications

- **Mandated need to share**
  - Authenticated credentials
Service-Oriented ISR Architecture

Adapts to Changes in Sensor Mix

Sensor-Independent ISR Data Requests
(Effects Based Tasking)
- Users can receive requested data types without ID’ing specific sensor sources
- Data request satisfied by any available sensor or archive that can meet user requirements

Tasking Optimization
- Sensor tasking plans visible to user, allows tasking optimization across DoD ISR enterprise
- Prioritized, policy-based multi-user task brokering

Composable Apps
- Simplified construction of adaptable mission-specific user applications

MIT Lincoln Laboratory
ISR Identification of Maritime Threat

Key Net-Centric Functions and Services
- Autonomous Alert Agent
- Automation of Sensor C2
- Machine-to-Machine Tasking
- Backtracking
- Threat Assessment Decision Support

Emulated Airborne Threat Scenario

ISR Assets
- Persistent
- Hi-res

Intruder

Backtrack

Keep-Out Zone

Mission Domains

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Homeland Defense</th>
<th>Maritime</th>
<th>Intelligence, Surveillance and Reconnaissance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FAA ATC</td>
<td>AIS Service</td>
<td>MIT/LL</td>
</tr>
<tr>
<td></td>
<td>ERSA* EO</td>
<td>Hawkeye</td>
<td>Proxy SkyRaider</td>
</tr>
<tr>
<td></td>
<td>Sentinel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Info Source</th>
<th>Air Picture</th>
<th>EO ID</th>
<th>Track, RF ID</th>
<th>Ship Tracking, Vessel “ID”</th>
<th>Vessel Registry</th>
<th>Hi-resolution EO CCD Imager</th>
<th>Wide Area Video Camera</th>
</tr>
</thead>
</table>

*Enhanced Regional Situational Awareness System, Deployed by MIT/LL in Washington, D.C. National Capitol Region
ISR Maritime Domain Awareness Demonstration

- Cross-Domain ISR Motivation
- System Concept Scenario Walk-through
- Net-Centric Architecture and Execution
- Technical Highlights and Summary
ISR Tactical Engagement Cycle

- **Alert**
  - Indications and Warnings
  - Mission defined conditions
  - Shared notification service

- **Assess**
  - Sort threats from false alarms
  - Integrate all source information
  - Task available resources

- **Analyze**
  - Determine intent
  - Information fusion and inference
  - Establish courses of action

- **Engage**
  - Command and control
  - Monitor successful conclusion

**Observe → Orient → Decide → Act**
Air and Maritime Picture

Warning Alert

Icons

Normal
- Aircraft
- Vessel

Threat
- Aircraft
- Vessel

Keep Out Zone

Financial District Roll Intruder: ERSA track 20670
Cruise Missile Launch Scenario:

>>Alert: Detect and Notify<<

1. Generate ALERT!

![Map Image]
Cruise Missile Launch Scenario:

>>Assess: ID and Backtrack<<

1. Generate ALERT!
2. EO Camera ID
3. Backtrack to Origin
Cruise Missile Launch Scenario:

>>Analyze: Cross Domain Association<<

1. Generate ALERT!
2. EO Camera ID
3. Backtrack to Origin
4. Locate Vessel
5. Conjunction Analysis

MIT Lincoln Laboratory

20090220-13
KLG 10/1/2009
Cruise Missile Launch Scenario:

>>Engage: ISR Tasking and Intercept Notification<<

1. Generate ALERT!
2. EO Camera ID
3. Backtrack to Origin
4. Locate Vessel
5. Conjunction Analysis
6. Task ISR Collection
7. Intercept

ISR products pushed to operator display

"Launch" Ship

MITRE Backtrack Tool
## ISR Demonstrator Test Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Location</th>
<th>Runs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emulated Airborne Threat</td>
<td>Emulated airborne threat launched from vessel to trigger alert in Boston ADIZ</td>
<td>Financial District</td>
<td>3</td>
</tr>
<tr>
<td>False Alarm</td>
<td>Visual ID confirms no threat to Hanscom</td>
<td>HAFB</td>
<td>3</td>
</tr>
<tr>
<td>VIP Event</td>
<td>Aircraft intrudes in FRZ for special event</td>
<td>MIT</td>
<td>3</td>
</tr>
<tr>
<td>9-11</td>
<td>Plane departing Boston for London breaks from flight plan and heads back to Boston</td>
<td>Logan Outbound</td>
<td>3</td>
</tr>
<tr>
<td>Fishing Zone</td>
<td>Vessel illegally enters restricted fishing zone</td>
<td>Cape Ann</td>
<td>3</td>
</tr>
<tr>
<td>Protected Vessel</td>
<td>Dynamically entered ROI to protect vessel delivering valuable material to Marblehead</td>
<td>Moving Vessel</td>
<td>1</td>
</tr>
<tr>
<td>Coastal Surveillance</td>
<td>Image coastal areas for environmental enforcement and targets of opportunity in Boston Harbor</td>
<td>As Tasked</td>
<td>15</td>
</tr>
</tbody>
</table>
ISR Maritime Domain Awareness Demonstration

- Cross-Domain ISR Motivation
- System Concept Scenario Walk-through
- Net-Centric Architecture and Execution
- Technical Highlights and Summary
ISR Demonstration Components and Architecture

Net-Centric Toolkit (NCT)

Domain Services
- ISR
  - UDOP
  - Imagery
  - Video
  - Threat Detection
  - Threat ID
  - Backtracking
  - Object Association
  - Data Archive
- FAA
  - Air Picture
  - Aircraft Information
- DHS
  - Maritime Picture
  - Vessel Information

Common
- Threat Alert

Common Services
- Data Delivery
- Resource Registry
- Resource Broker
- UDOP

NCES Services
- Security
- Messaging
- Federated Search
- Collaboration

User Defined Operational Picture (UDOP)

Command Center
Decision Support

C2 Nodes

Secure LAN
Communications Backbone ↔ MIT/LL GiG

- Maritime Picture
- EO Camera
- Radar Air Picture
- Flight Plan Data
- Target ID and Intent
- Proxy Video
- MIT/LL EO Imager
- Data Archive
- One Way Link
- Sentinel Radar

Data Archive

Functional 9/2008

MIT Lincoln Laboratory

20090220-17
KLG 10/1/2009
Lincoln Net-Centric Test Bed

Test bed for all communities, unified by common architecture and services
Enables testing/validation of NCO architectures
# ISR Demonstration Execution Schedule

<table>
<thead>
<tr>
<th>Kickoff: 8 Feb 08</th>
<th>FY08</th>
<th>FY09</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PHASE I</strong></td>
<td>5 Apr 08</td>
<td></td>
</tr>
<tr>
<td>Alert</td>
<td>Intruder (Sim)</td>
<td>ERSA FAA</td>
</tr>
<tr>
<td></td>
<td>Trigger alert from airspace intrusion</td>
<td></td>
</tr>
<tr>
<td><strong>PHASE II</strong></td>
<td></td>
<td>Live Fly: 10-19 Sep 08</td>
</tr>
<tr>
<td>A: 2 Jun 08</td>
<td>Task, ID, Notify</td>
<td>Task sensor, visual ID, backtrack intruder, and associate with maritime vessel</td>
</tr>
<tr>
<td>B: 23 Jul 08</td>
<td>AIS Receiver</td>
<td>RF ID, ISR collect on candidate launch vessels</td>
</tr>
<tr>
<td></td>
<td>ERSA Sentinel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ERSA Camera (FF)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HawkEye Database</td>
<td></td>
</tr>
<tr>
<td><strong>PHASE III</strong></td>
<td></td>
<td>Metrics and Assessments in FY’09</td>
</tr>
<tr>
<td>10 Sep 08</td>
<td>Assess, Engage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ERSA Camera (GB)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intruder (F-20)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MIT/LL Hi-Res EO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SkyRaider</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Launch Vessel (MITRE)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interceptors (USCG)</td>
<td></td>
</tr>
<tr>
<td><strong>PHASE III+</strong></td>
<td>Confirm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MASIVS EO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HAX SATB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intercept (G-II)</td>
<td></td>
</tr>
</tbody>
</table>

From 0 to Live Fly in 7 Months!
External Collaborators

MITRE
- Walter Kuklinski
- Stephen Theophanis
- Anthony Lawrence

USCG
- LCDR Chris Kluckhuhn
- CDR Stephen Torpey
- LT Brendan Blain
- LT Bennie Wenban
- Crew of Morro Bay

Proxy Aviation
- Jim Carter
- Gus McLeod
- Mike Meador
- Larry Belella
- Bob Arseneault

BAE Systems
- Arie Kronfeld
- Greg Couch
- Andre De Liso
- Charles Yee
- John Santillo
- John Parkes

Cloudcap TASE Duo Sensor

SkyRaider (Proxy Aviation)
ISR Maritime Domain Awareness Demonstration

- Cross-Domain ISR Motivation
- System Concept Scenario Walk-through
- Net-Centric Architecture and Execution
- Technical Highlights and Summary
Machine-to-Machine Automation Demonstration

>>3-Click Tasking<<

Click-1: Backtrack
Click-2: Area Search
Click-3: Collection

• Auto-generated requests
• Human authorization
• Provides basis for future choreography of composed services

Track History
Association
Imagery

MIT Lincoln Laboratory

20090220-23
KLG 10/1/2009
Demonstrates Key Feature of Service Oriented Architecture:
Rapid composability due to loosely coupled, well defined interfaces
Automated Resource Brokering Demonstration

>>Uniform Tasking Interface<<

Federated Resource Broker

ERSA

AdvCCD

Proxy (DEVELOPED)

MASIVS (FUTURE)

Early validation of Resource Broker Tasking Interface
Architectural Principles Validated

- Technology growth continues to lower barriers to net-centric performance and interoperability
  - Network bandwidth, latency improvements enable tactical uses of commercial standards
    - XML messaging
    - Web Services

- Service Oriented Architecture simplifies system integration, upgrade and extension at low cost and on short time-scale

- Standard formats and service interfaces facilitate uniform tasking and data access
Summary

• Demonstrated Technical Accomplishments
  – Integrated Air, Maritime, and ISR situational awareness services using XML messaging with latencies supporting tactical operation
  – Uniform ISR sensor tasking interface for dissimilar systems
  – Machine generated requests with human authorization for execution

• Advanced Lincoln Net-Centric Vision
  – Implemented Service Oriented ISR sidecars for legacy systems and SOA network adaptors for new systems
  – Initial demonstration of laboratory Test Bed with potential future extension to regional, and national activities

• Successful Program Execution
  – Demonstrated ability to integrate new capabilities on very short time-scale