Quantifying the Military Effectiveness of Persistent ISR

Presented at
Engineering Design Forum 2012
Emerging Software Innovations
15-17 May, San Diego

Mark A. Rivera
Boeing Research & Technology
Studies & Analysis
mark.a.rivera@boeing.com
Agenda

• Persistent ISR Study Objective
• Persistence Defined
• Modeling & Simulation
• Measures of Effectiveness
• Architecture Design Search
• Summary
P-ISR Study Objective

- Develop a process for exploration and design of cost effective Persistent Intelligence, Surveillance, & Reconnaissance (P-ISR) architectures
  - How much persistence is enough to provide critically needed utility?
  - What is the cheapest way to get there?
Needed for the Study

- Means to quickly explore and compare a wide variety of P-ISR architecture designs
  - Includes air and space assets
- Means to quantify the military effectiveness of those designs
- Means to quantify the cost of those designs

Briefing will focus mainly on the second bullet and partly on the first
What is Meant by “Persistent” ISR?

Definition used in analysis:
Persistence matches the frequency of revisit with the "time stability" of the object that you are looking at—the speed with which things change.

John Stenbit, Former Assistant Secretary of Defense for Networks and Information Integration

Example: enemy force build-up over time

100% Persistence captures all critical changes
50% Persistence only captures 50% of critical changes

Revisit rate required for persistence depends on what you’re watching.
How Much Persistence is Enough?

### Approximate Scenario Time Stabilities

<table>
<thead>
<tr>
<th>Target Type</th>
<th>Time Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction of Uranium Enrichment Plant</td>
<td>Months/Weeks</td>
</tr>
<tr>
<td>Build up of Enemy Forces</td>
<td>Weeks/Days</td>
</tr>
<tr>
<td>Movement of Mobile Missile launchers</td>
<td>Minutes/Hours</td>
</tr>
<tr>
<td>Subversive Activity at Infrastructure Sites (Oil pump, Power stations....)</td>
<td>Seconds/Minutes</td>
</tr>
<tr>
<td>Human Detection and ID (i.e., Human Bomb)</td>
<td>Seconds</td>
</tr>
<tr>
<td>Border Crossings (Humans and Vehicles)</td>
<td>Seconds</td>
</tr>
</tbody>
</table>

**Effectiveness levels off at the time stability of key dynamic observables in the scenario**

You don’t want to buy more persistence than you need.
Required M&S

- Persistence required is scenario dependent, so you must first define a specific scenario and mission goals.
- Define quantifiable Measures of Effectiveness (MOEs) for achieving those goals.
- Define force structures, assets, and capabilities of red and blue forces:
  - Blue forces have P-ISR capability.

- Model and simulate to determine a force-on-force outcome:
  - as a function of P-ISR performance:
    - Persistence (Revisit Rate)
    - Data quality (Prob. Of Detection)
    - Data latency (comm/process delays).

You must have a high degree of M&S to capture this response.
Systems Effectiveness & Analysis Simulation

• SEAS is a multi-agent force-on-force reactive simulation
• Blue forces receive P-ISR information in an NCO enabled environment
  – They don’t care where or how the information is originated, only that they get what they need when they need it
• Blue forces still have some capability even with diminished or absent P-ISR information
  – Indigenous capability determines residual effectiveness
  – Also determines response to decreased/increased ISR
• Red forces have some ability to react and counter
  – Adversary capabilities also determine effectiveness of blue force
  – Both residual and ISR enabled

SEAS simulates blue force’s improved response to a capable adversary as a result of acquiring more/better P-ISR information
Mission effectiveness can be determined by “dialing” architecture performance (information) independently of a specific architecture.
Capturing Effectiveness Response

- MOE responses are captured in multi-dimensional look-up tables.
  - The result of 1000’s of SEAS simulation runs
- Variations on level of persistence and accuracy of data can be quickly determined during architecture design searches

Search & Rescue Scenario

- Locate and rescue a handicapped but mobile rescuee in enemy territory
- Evade detection by enemy
- Avoid combat engagements

MOE response surfaces provide a means for rapidly determining mission effectiveness as a result of any given P-ISR architecture
Measures of Effectiveness Types

SEAS / MATLAB Scenarios can Provide These MOEs

• Probability of Mission Success
  – Probability of meeting primary objective(s) i.e. rescue, secure, destroy, etc.
• Mission Duration (Time Improvements)
  – Time to secure an asset or infrastructure under attack
  – Time to neutralize enemy capabilities and assets
• Range of Effectiveness
  – Neutralize enemy from further away (stand-off weapons)
• Cost Effectiveness
  – Required manpower & equipment to achieve a given objective
• Survivability
  – Casualties and Equipment Losses (including those from friendly fire)
  – Duration and probability of survival
• Evasion & Stealth
  – Probability of evading enemy attack assets or danger areas
  – Probability of evading enemy sight
• Lethality
  – Enemy Casualties and Equipment
• Non-combatant Losses
  – Casualties, Assets, Infrastructure, etc.
Architecture Design Search

P-ISR Architecture Performance

- PERSISTENCE (Revisit Rate)
- LATENCY (Age of Data)
- DATA QUALITY (Probability of Detection)

P-ISR Architectures Design Space

- Type of Platforms
- # Platforms
- Sensor FOV/FOR
- Area of Interest
- Communications Bandwidth
- Data Processing
- Human Decision Time
- Sensor Design
- Observation geometry
- Targets of Interest

Cost effective architectures lie along Pareto Front
Summary

• Boeing has developed a means for *quickly* exploring cost effective designs of P-ISR architectures

• Revisit rate required for “Persistent” ISR depends upon the specific scenario and mission goals
  – You don’t want more persistence than you need

• Utility of P-ISR information depends entirely upon a force’s ability to respond to the information
  – The indigenous capabilities of both blue and red forces

• Quantifying increased effectiveness as a result of being provided with P-ISR information requires a high degree of Modeling & Simulation
  – Multi-agent reactive simulation is a must
Questions?