An Architecture Analysis Model Developed for the Evaluation of Forward-Based Sensors

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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18
Outline

• Background and Problem Statement
  - Missile Defense Agency Mission Statement
  - Role of MDSET (Missile Defense System Engineering Team)
  - Driving Requirements for Forward-Based Sensor Modeling

• Overview of Architecture Analysis Model
  - Event-Driven vs. Time-Stepped Modeling
  - Modeling Environment
  - Interface Description

• Notional Scenario
  - Scenario Setup and Visualization
  - Utilizing Architecture Analysis Model
  - Sample Analysis and Results

• Summary
Missile Defense Agency
- Role of MDSET -

• Missile Defense Agency (MDA) Mission Statement—“To develop and field an integrated, layered BMDS to defend the United States, deployed forces, allies and friends against all ranges of enemy ballistic missiles in all phases of flight”

• MDSET explores advanced concepts and performs trade studies of components, elements, and architectures not yet clearly defined
  - Architecture-level models are ideal for high-level performance assessments of various combinations of systems

• MDSET must incorporate all elements of the BMDS to provide a system-of-systems analysis
  - Ballistic missile threat launches
  - Interceptor launch, commit, and engagement timelines
  - Sensor performance and threat coverage
  - Command and control system and operating concept development

Role of MSDET requires ability to develop and utilize innovative and flexible tools
Analysis Problem
- Driving Requirements for Forward-Based Radar Modeling-

Model Forward-Based Radar Functionality

Driving Requirements
• Radar Slewing Capability

Fixed (360°) FOV
- Both threats in 360° FOV
- Only one threat in physical FOV

Mechanically Steered FOV
- Physical FOV (slews in time)
Analysis Problem
- Driving Requirements for Forward-Based Radar Modeling-

Model Forward-Based Radar Functionality

Driving Requirements
- Radar Slewing Capability
- Radar Resource Allocation

More energy required off-boresight

Constant energy at given range

Total resources limited

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Analysis Problem
- Driving Requirements for Forward-Based Radar Modeling-

Model Forward-Based Radar Functionality

Driving Requirements
- Radar Slewing Capability
- Radar Resource Allocation
- Varying Operating Concept
- Time-stepped Scenario Visualization

Time-Stepped (vs. Event-Driven) Modeling Environment
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• Summary
Event-Driven vs. Time-Stepped Model

Threat → Sensor → Weapon

Computer Run Time
Event-Driven vs. Time-Stepped Model

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Event-Driven vs. Time-Stepped Model

An Architecture Analysis Model Developed for the Evaluation of Forward-Based Sensors
Event-Driven vs. Time-Stepped Model

An Architecture Analysis Model Developed for the Evaluation of Forward-Based Sensors
Time-Stepped Model

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Time Step
An Architecture Analysis Model Developed for the Evaluation of Forward-Based Sensors
An Architecture Analysis Model Developed for the Evaluation of Forward-Based Sensors

Overview of Architecture Analysis Model
- Modeling Environment-

Threat Trajectory Generation
- Threat Model
  • Position (x,y,z)
  • Velocity (x, y, z)
- Forward-Based Radar
  • SNR
  • Elevation
  • Azimuth
  • Range
  • Track Time
  • Threat Priority
- Mechanical Steering
  • Radar boresight Az/El
- Tracking Radar
  • SNR
  • Elevation
  • Azimuth
  • Range
  • Track Time
  • Threat Priority

Radar Parameter Plotter
- Radar Parameters
  • SNR
  • Elevation
  • Azimuth
  • Range
  • MSK Az/El

3-D Globe Visualization
- Output Data
  • Output File

Output File
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Notional Scenario
- Scenario Setup -

HEADLINE NEWS

Country Orange has developed the capability to launch long-range threats from sea-based platforms and is poised to strike from the Atlantic. Possible threat to Country Blue’s Pacific Assets. Country Blue’s military leaders respond with a defense system involving two sea-based radars.
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**Notional Scenario**
- Scenario Visualization -

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**Adversary: Country Orange**
- Three long-range threats
- Atlantic Ocean launch points
- Pacific Ocean aimpoints

**Friendly Forces: Country Blue**
- Two defense sensors
  - Forward-based radar
  - Tracking radar
- Forward-based radar tasked to view and track each threat for a portion of ballistic flight
Notional Scenario
- Modeling of Radar operating concept -

1) Radar starts at nominal boresight

2) Radar slews left to track threats 1 and 2

3) Radar repositions to track threat 3

In a raid, radar slews to track threats in current FOV in sequential order (of received Launch Alerts)

Scenario Time

Radar boresight is at nominal azimuth location when it receives a Launch Alert

Radar will slew to follow and finish tasks on all raid threats if possible

An Architecture Analysis Model Developed for the Evaluation of Forward-Based Sensors
Notional Scenario
- Forward-Based Radar Coverage -

Time-stepped model can show coverage for dynamically slewing FB Radar

Graphics Legend
- Threat Time of Flight
- FB Radar Coverage
- Tracking Radar Coverage

Fixed Field of View
360° Field of View
360° Field of Regard

An Architecture Analysis Model Developed for the Evaluation of Forward-Based Sensors
Notional Scenario Results
- Radar Coverage Timelines -

- The output file from the model can be used to extract data that is useful for assessing the radar’s performance in a raid
  - Timelines can be used to validate handover between radars and determine length of track
  - This notional scenario shows no radar handover capability, but forward-based radar does complete tasks on all threats

Timeline Legend

- Threat Time of Flight
- FB Radar Coverage
- Tracking Radar Coverage

Threat 1
- FB Radar Coverage
- Required Track

Threat 2
- FB Radar Coverage
- Required Track

Threat 3
- FB Radar Coverage
- Required Track

NOTIONAL
• When forward-based radar is tracking threats far in range, at far edge of FOV, or on multiple threats simultaneously, radar resource loading will be affected.
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Summary

- MDSET is tasked to solve analysis problems for MDA
  - Requires innovative and flexible tools
- Time-based vs. event-based model provides solution to current analysis problem
  - More accurate representation of a mechanically steered forward-based radar
  - Dynamic viewing of radar slewing and performance parameters

Time-Stepped Analysis Models Allow Dynamic Interactions Between Components and Increase Accuracy When Modeling Dynamically Driven Events