Distributed Threat Evaluation in Naval Tactical Battle Management

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Outline

• Threat Evaluation in the context of Naval Tactical BM
• Collaborative Threat Evaluation
• Overview of the System
  – Automation
  – Testbed
  – Advisory Capability
• Coordination Modes
• Future Work
Context

- Wide range of sophisticated threats with different modes/guidance systems (cruise missiles, bombs, shoulder-launched rockets, etc.)
- Threats may originate from the sea, land or air, or a combination thereof
- Requirement to operate in littorals, jointly and in coalitions, has increased the complexity of operations and introduced additional challenges to the Navy
Threat Evaluation and C2 Functions

Picture Compilation

Threat Evaluation

Engageability Assessment

Combat Power Management
(Response Planning & Execution)

Sensors

Softkill, Hardkill,
Deterrence, Navigation
Threat Evaluation: Definition

**Intent assessment**: determine the goal and/or the plan (course of actions) of the threat.

**Capability assessment**: evaluate whether the threat has sufficient resources to achieve its goal or execute its plan.

**Opportunity assessment**: verify whether the tactical environment provides the required preconditions for the threat’s plan to succeed.

**Output:**
- Threat List
- Classification
- Ranking
Threat Evaluation Inference Model

- A priori knowledge (e.g., intelligence, operational constraints and restraints, evaluation criteria, etc.)

- Dynamically acquired and inferred information (based on various indicators observed/obtained from various sources)
Threat Evaluation Challenges

**Overload**

- Large amount of data
- Time pressure
  - Information gathering & processing vs. Decision/action

**Situation Analysis**

- **Uncertainty**
  - Imperfection of information sources
  - Ambiguity in human behaviour
- **Dynamic environment**
  - Validity of information
Distributed TE: Advantages

- Information superiority (multiplying the information sources)
- Enhanced real-time response (deploying observers and processors close to the threat)
- Functional separation
- Robustness and resilience (tolerant to failure and bias of individual entities)
Distributed TE: Challenges

**Overload**
- Data overload
- Time pressure
- Coordination overhead
- Double-hatting

**Situation Analysis**
- Red force
  - Uncertainty
  - Dynamic environment
- Blue force
  - Reference point different than own ship
  - Awareness of other units' capabilities & limitations

**Collaborative Decision Making**
- Information exchange, sensemaking
  - Interoperability
  - Connectivity - Security
  - Remote communication
  - Multiple (conflicting) decision nodes
- Coordination
  - Synchronization of activities
  - Resource planning
• Testbed
  – Simulates the world

• Automation Algorithms
  – Threat Evaluation
    o Classifies threats (H, M, L)
    o Ranks threats in each class
  – Engageability Assessment
    o Generates feasible actions

• Advisory Capability
  – Displays automation algorithms results
  – Supports mixed-initiative interaction
FLEET Architecture

Layer 1: Scenario
Generation and Control

Layer 2: Task Group Operations
Modelling & Simulation

Layer 3: Automation and Coordination

Unit and Force TE Algorithms

Layer 4: Decision Aids and Collaboration
Automation: Rules

- Speed
- IFF
- Identity
- CPA
- Conformance to civilian airlines
- Manoeuvres
- Coordinated threats
- Deceptive behaviour
Automation: Plan Recognition

- $a, b, c...$ are observations from which actions of the observed agent are inferred.
- A plan specification also includes (not shown in the figure):
  - Observation probabilities: $p(\text{observation} | \text{actions})$
  - Subgoal selection/decomposition probabilities
  - A priori goal selection probabilities.
Example of a Plan: Attacking an asset

- **AttackShip** (track, target)
- **SetUp** (track, target)
- **Target** (track, target)
- **HeadTowards** (track, target)
- **InWeaponRange** (track, target)
- **Engage** (track, target)
- **LoadASM** (track)
- **Locate** (track, target)
- **LocateVisually** (track, target)
- **ReceiveLocation** (track, friend, target)
- **GetBelowRadar** (track)
- **LaunchASM** (track, target)
- **HeadAway** (track, target)
Advisory Capability
Coordination Modes

• Spectrum of coordination modes
• Can be performed along 2 axes: PC and TE
  – CC: Centralized PC / Centralized TE
  – DC: Decentralized PC / Centralized TE
  – DD: Decentralized PC / Decentralized TE
• Adapt to requirements (command structure) or evolving situation (degradation/loss of communication; changes to force composition)
Coordination: Mode 1 (CC)

A common Tactical Picture
A common Threat List

Unit 1
- Local Picture Compilation
- No Threat Evaluation

Unit 2
- Local Picture Compilation
- No Threat Evaluation

Unit 3
- Local Picture Compilation
- No Threat Evaluation
- Centralized Threat Evaluation Coordination

Centralized Picture Compilation
Coordination: Mode 2 (DC)

A common Tactical Picture
De-conflicted Threat Lists

Unit 1
- Decentralized Picture Compilation
- Local Threat Evaluation

Unit 2
- Information Exchange & Picture De-Confliction
- Decentralized Picture Compilation
- Local Threat Evaluation

Unit 3
- Decentralized Picture Compilation
- Local Threat Evaluation
- Centralized Threat Evaluation Coordination
Coordination: Mode 3 (DD)

Unit 1
- Decentralized Picture Compilation
- Decentralized Threat Evaluation

Unit 2
- Decentralized Picture Compilation
- Decentralized Threat Evaluation

Unit 3
- Decentralized Picture Compilation
- Decentralized Threat Evaluation

De-conflicted Tactical Pictures
De-conflicted Threat Lists
### Adaptive/Robust Coordination Approach

<table>
<thead>
<tr>
<th>Mode 1</th>
<th>Mode 2</th>
<th>Mode 3</th>
<th>Mode 4</th>
<th>Mode 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centralized PC</td>
<td>Centralized PC</td>
<td>Decentralized PC</td>
<td>Decentralized PC</td>
<td>Independent Ops</td>
</tr>
<tr>
<td>Centralized TE</td>
<td>Decentralized TE</td>
<td>Decentralized TE</td>
<td>Decentralized TE</td>
<td>No real-time coordination</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With Central Authority</td>
<td></td>
<td>Use static rules</td>
</tr>
</tbody>
</table>

#### Context

- **Bandwidth Availability**
  - +
  - -

- **Reaction Time**
  - -
  - +
Future: Adaptive/Robust AAD Capability

Link units, share information, coordinate activities, adapt to context

Provide a **robust and optimized coverage to all units** within the force and **protect** assets in theatre