DEFENCE R&D DÉFENSE

# Distributed Threat Evaluation in Naval Tactical Battle Management

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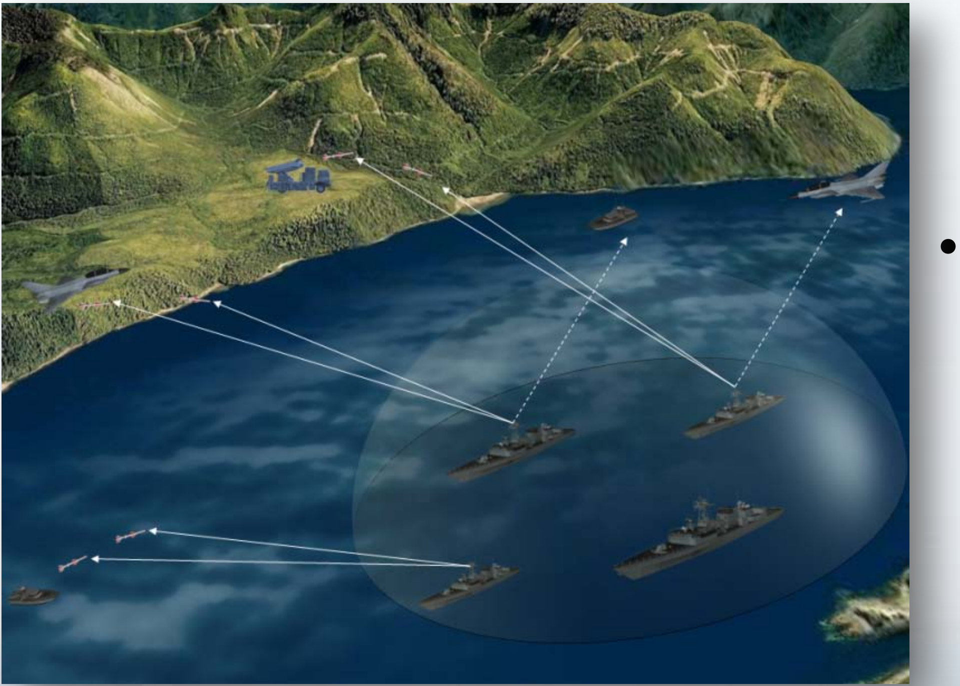
# Outline

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

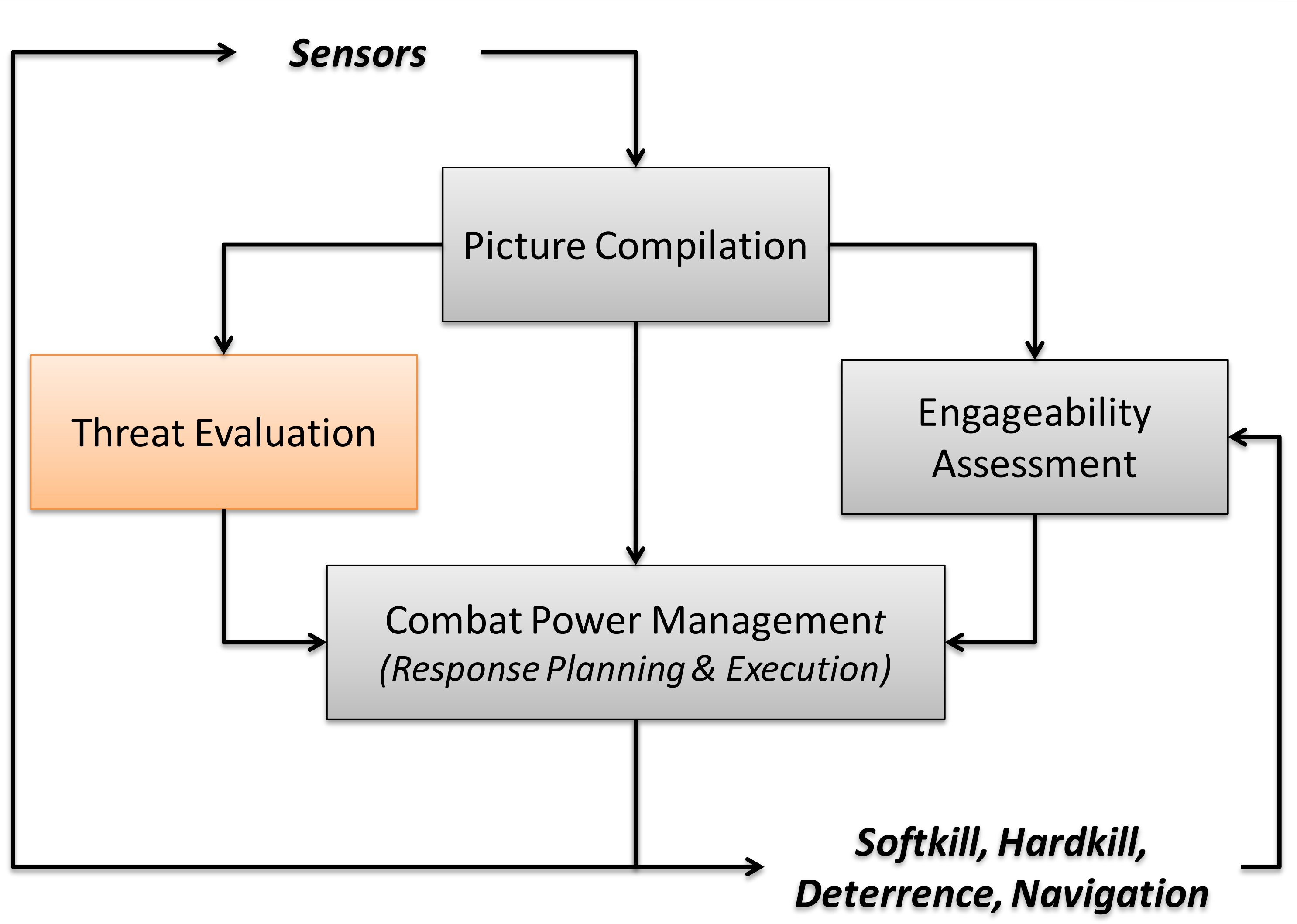
# Context

- 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

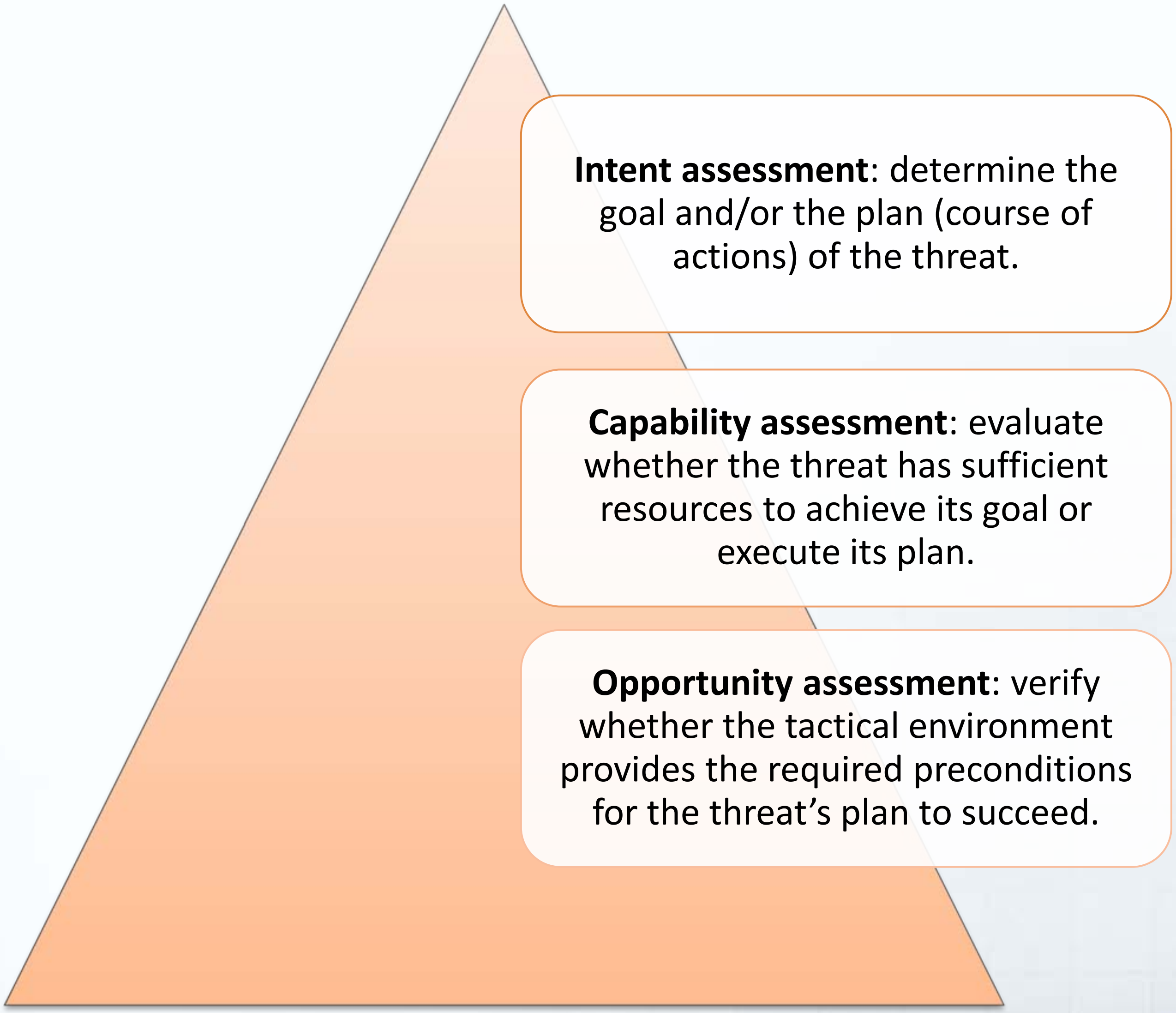


- Requirement to operate in littorals, jointly and in coalitions, has increased the complexity of operations and introduced additional challenges to the Navy

# Threat Evaluation and C2 Functions



# 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.

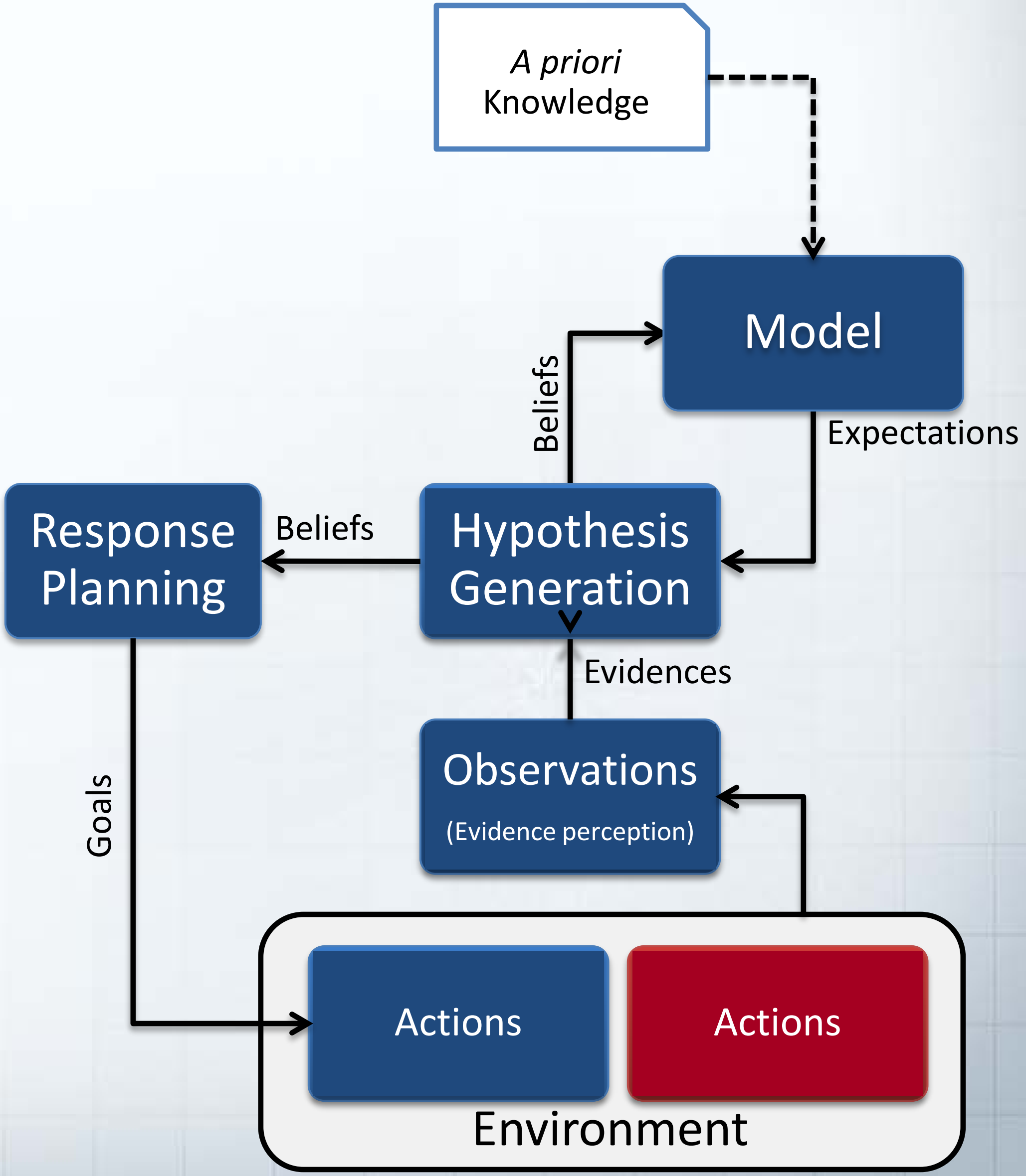
**Opportunity assessment**: verify whether the tactical environment provides the required preconditions for the threat's plan to succeed.

**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

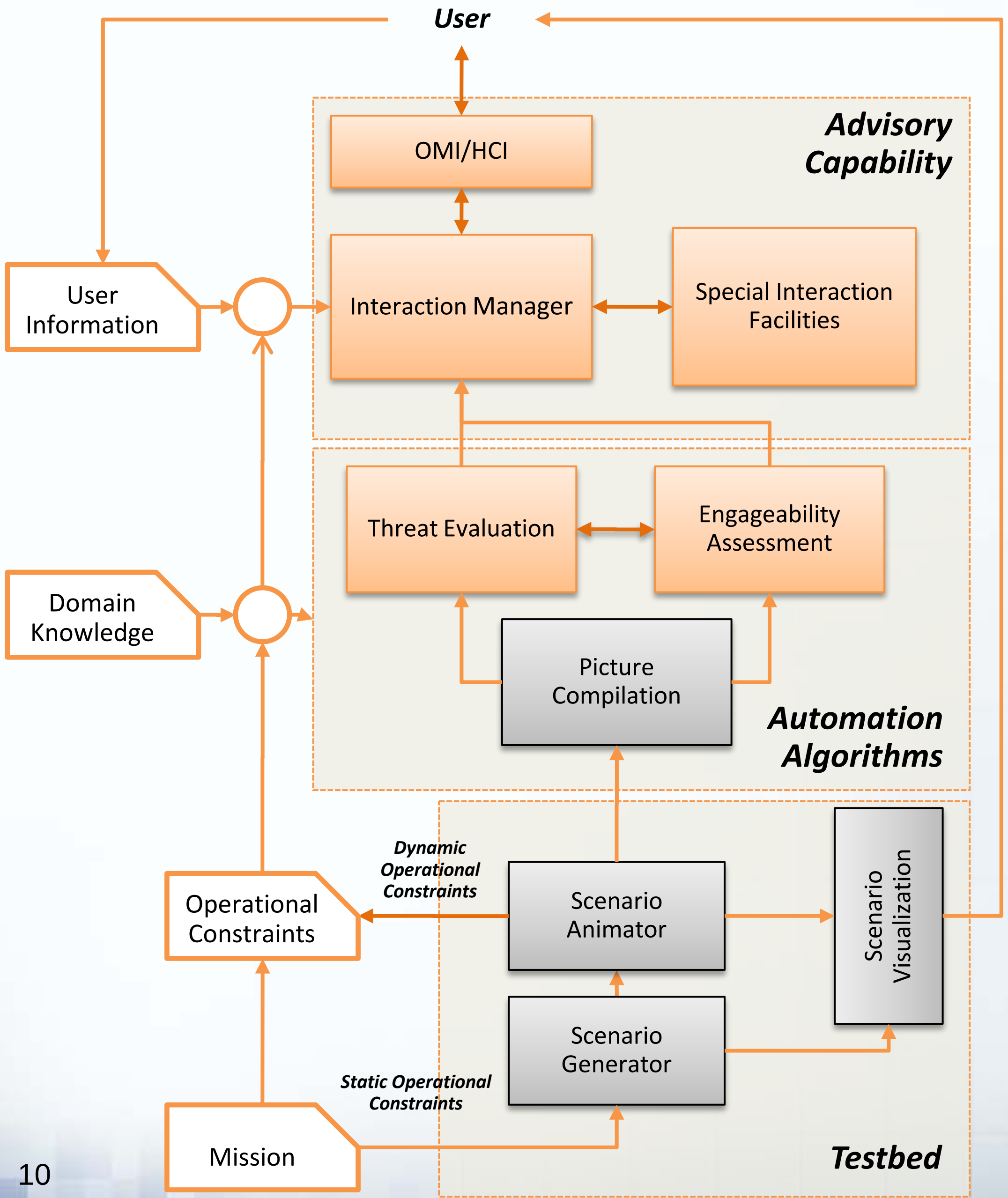
**Information exchange, sensemaking**

- Interoperability
- Connectivity - Security
- Remote communication
- Multiple (conflicting) decision nodes

**Coordination**

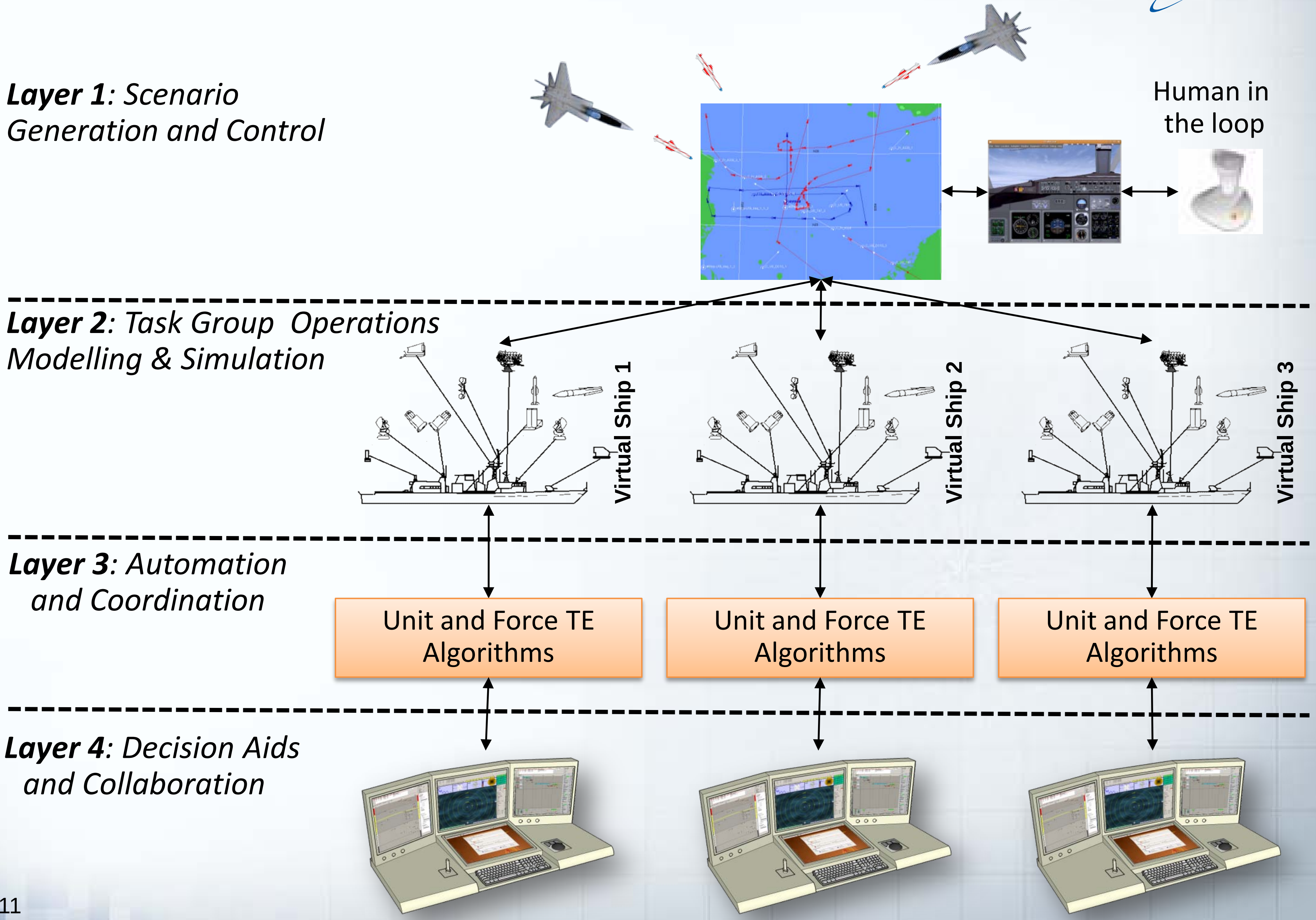
- Synchronization of activities
- Resource planning

# FLEET Decision Support System



- **Testbed**
  - Simulates the world
- **Automation Algorithms**
  - Threat Evaluation
    - Classifies threats (H, M, L)
    - Ranks threats in each class
  - Engageability Assessment
    - Generates feasible actions
- **Advisory Capability**
  - Displays automation algorithms results
  - Supports mixed-initiative interaction

# FLEET Architecture



***Layer 1**: Scenario Generation and Control*

Human in the loop

***Layer 2**: Task Group Operations Modelling & Simulation*

Virtual Ship 1

Virtual Ship 2

Virtual Ship 3

***Layer 3**: Automation and Coordination*

Unit and Force TE Algorithms

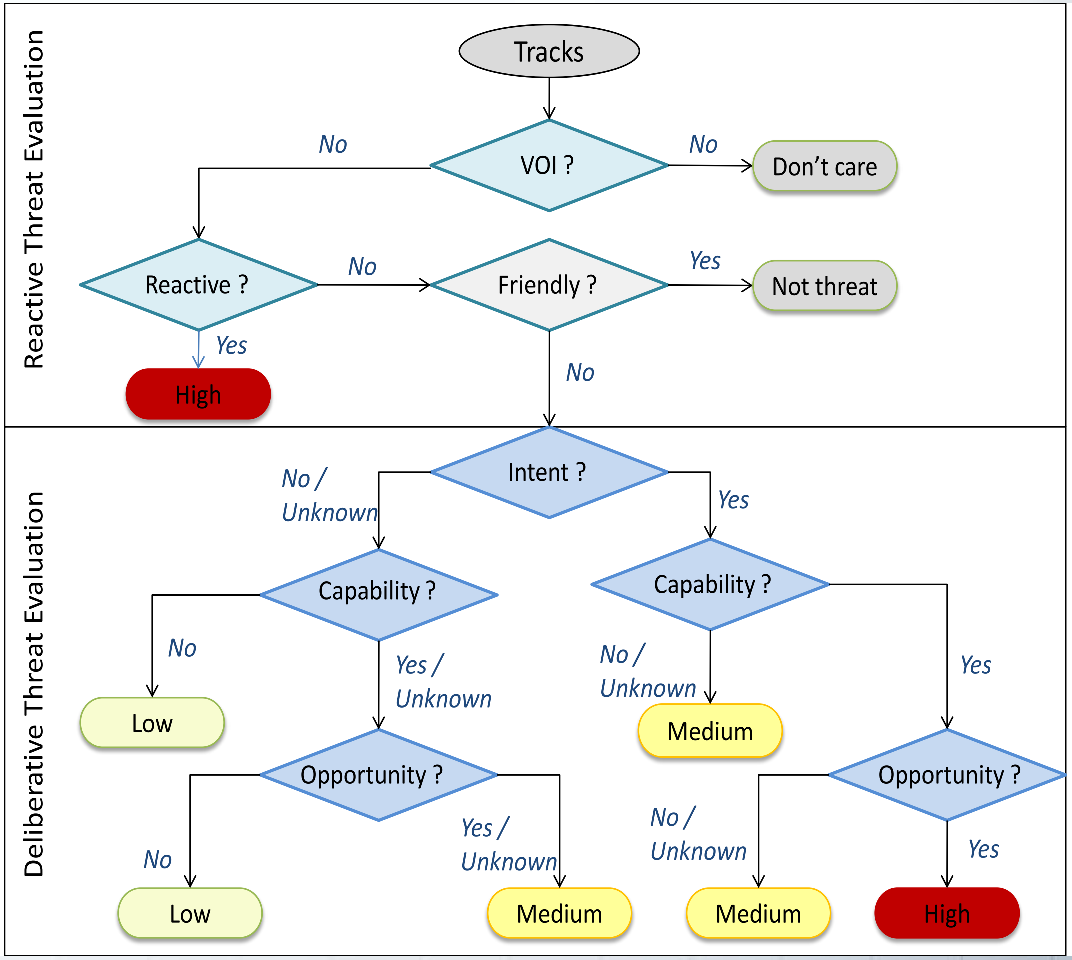
Unit and Force TE Algorithms

Unit and Force TE Algorithms

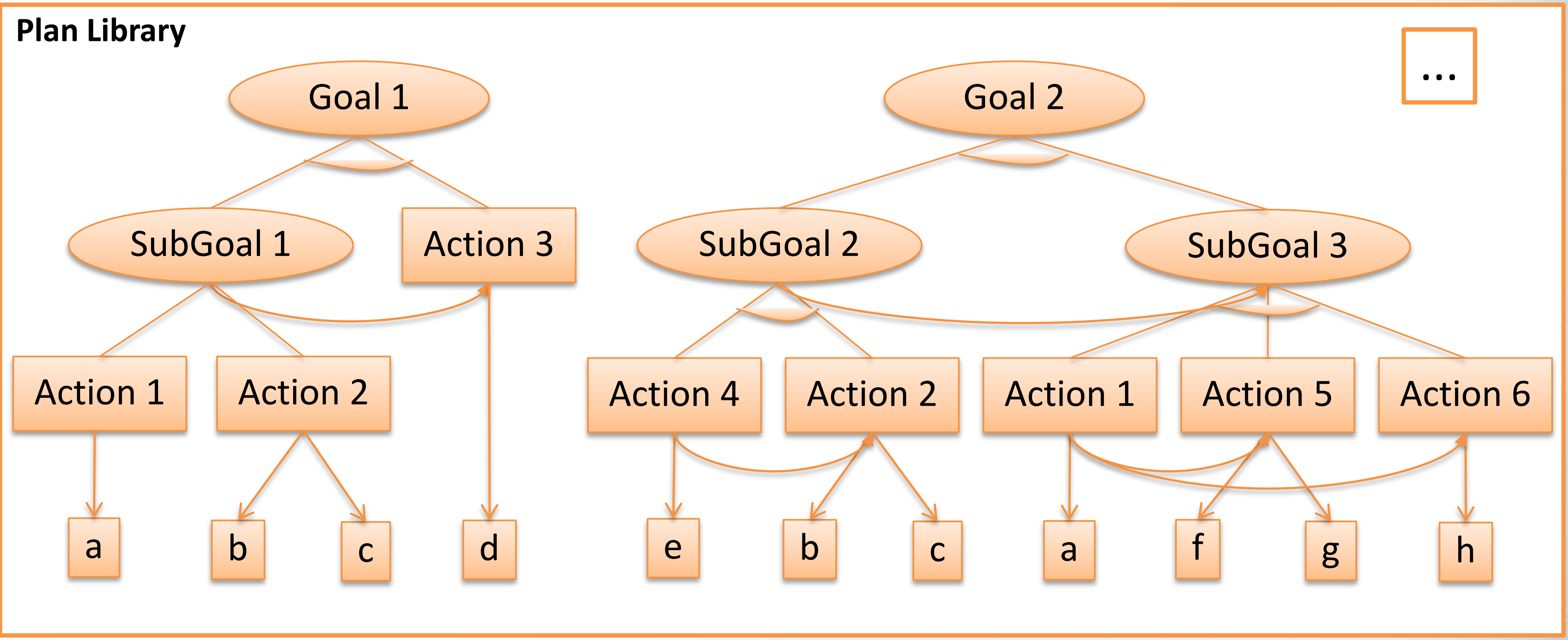
***Layer 4**: Decision Aids and Collaboration*

# Automation: Rules

- Speed
- IFF
- Identity
- CPA
- Conformance to civilian airlanes
- Manoeuvres
- Coordinated threats
- Deceptive behaviour

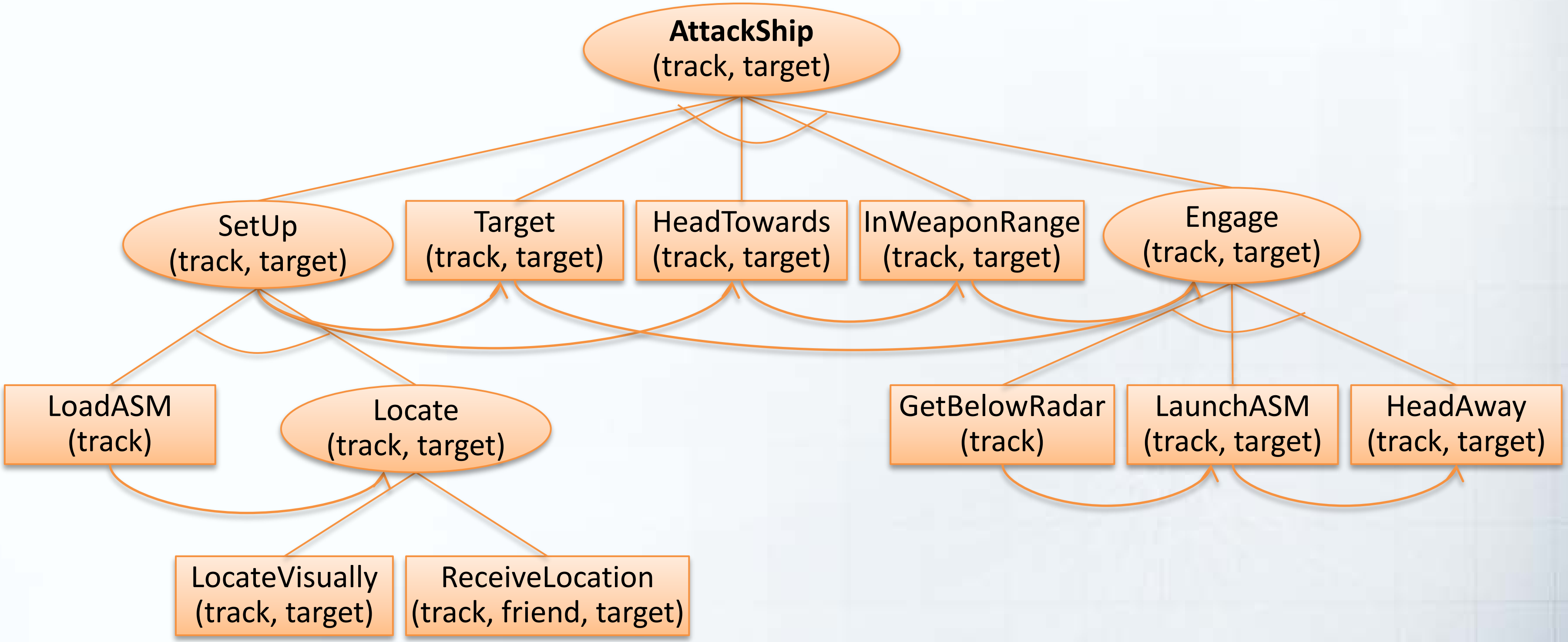


# Automation: Plan Recognition

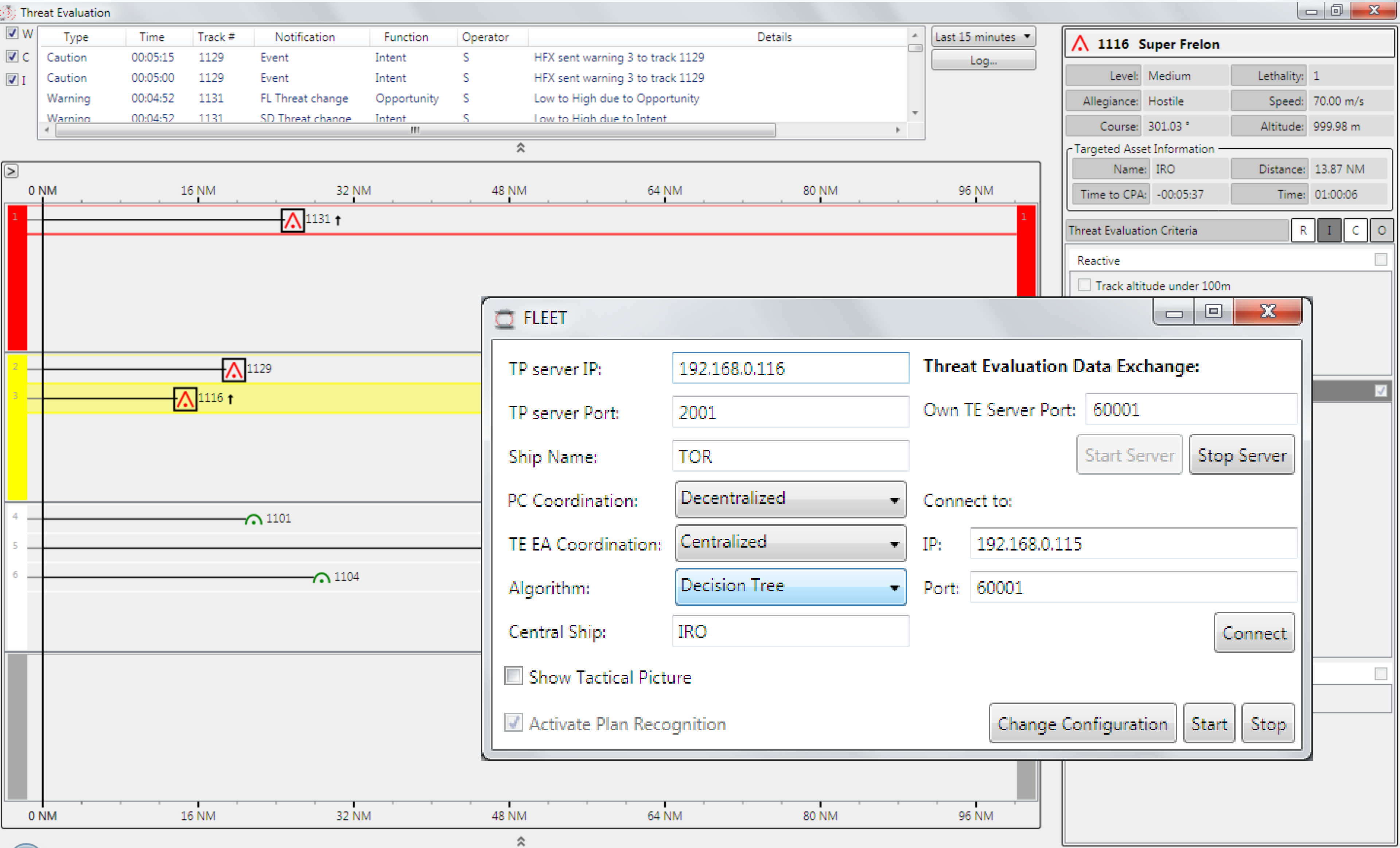


- a, b, c... are observations from which actions of the observed agent are inferred.
- A plan specification also includes (not shown in the figure):
  - Observation probabilities : p(observation| actions)
  - Subgoal selection/decomposition probabilities
  - A priori goal selection probabilities.

# Example of a Plan: Attacking an asset



# Advisory Capability



Threat Evaluation

☑ W ☑ C ☑ I

| Type | Time | Track # | Notification | Function | Operator | Details |
|---|---|---|---|---|---|---|
| Caution | 00:05:15 | 1129 | Event | Intent | S | HFX sent warning 3 to track 1129 |
| Caution | 00:05:00 | 1129 | Event | Intent | S | HFX sent warning 3 to track 1129 |
| Warning | 00:04:52 | 1131 | FL Threat change | Opportunity | S | Low to High due to Opportunity |
| Warning | 00:04:52 | 1131 | SD Threat change | Intent | S | Low to High due to Intent |

1116 Super Frelon

| | | | |
|---|---|---|---|
| Level: | Medium | Lethality: | 1 |
| Allegiance: | Hostile | Speed: | 70.00 m/s |
| Course: | 301.03 ° | Altitude: | 999.98 m |

Targeted Asset Information

| | | | |
|---|---|---|---|
| Name: | IRO | Distance: | 13.87 NM |
| Time to CPA: | -00:05:37 | Time: | 01:00:06 |

Threat Evaluation Criteria

Reactive □

□ Track altitude under 100m

FLEET

| | |
|---|---|
| TP server IP: | 192.168.0.116 |
| TP server Port: | 2001 |
| Ship Name: | TOR |
| PC Coordination: | Decentralized |
| TE EA Coordination: | Centralized |
| Algorithm: | Decision Tree |
| Central Ship: | IRO |

**Threat Evaluation Data Exchange:**

Own TE Server Port: 60001

Connect to:

IP: 192.168.0.115

Port: 60001

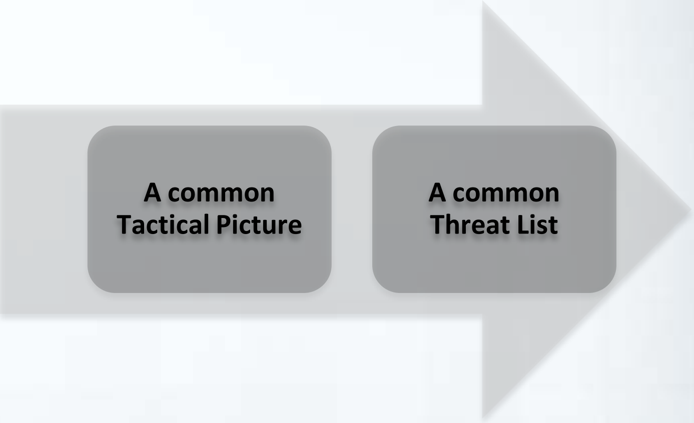
□ Show Tactical Picture

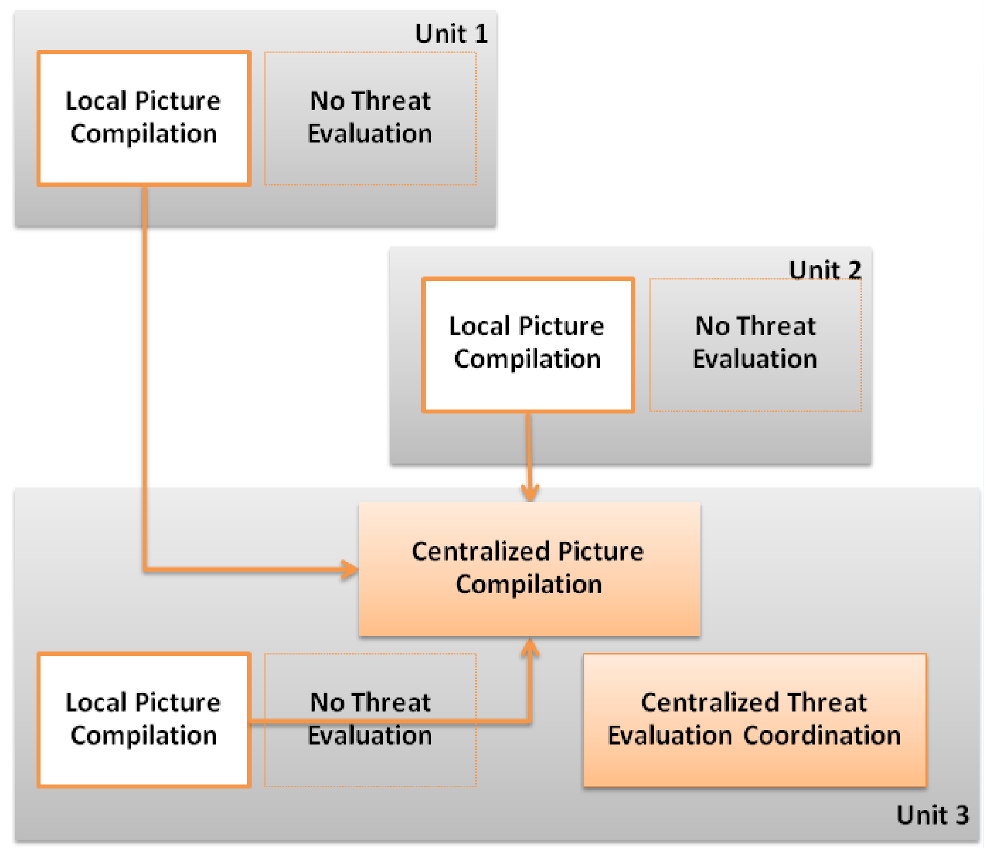
☑ Activate Plan Recognition

# 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)

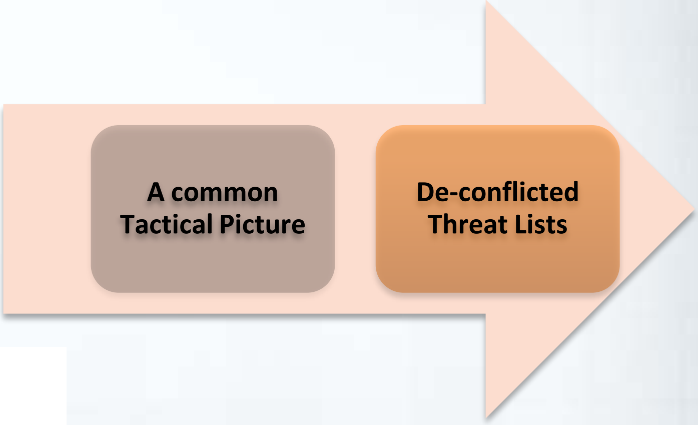
# Coordination: Mode 1 (CC)





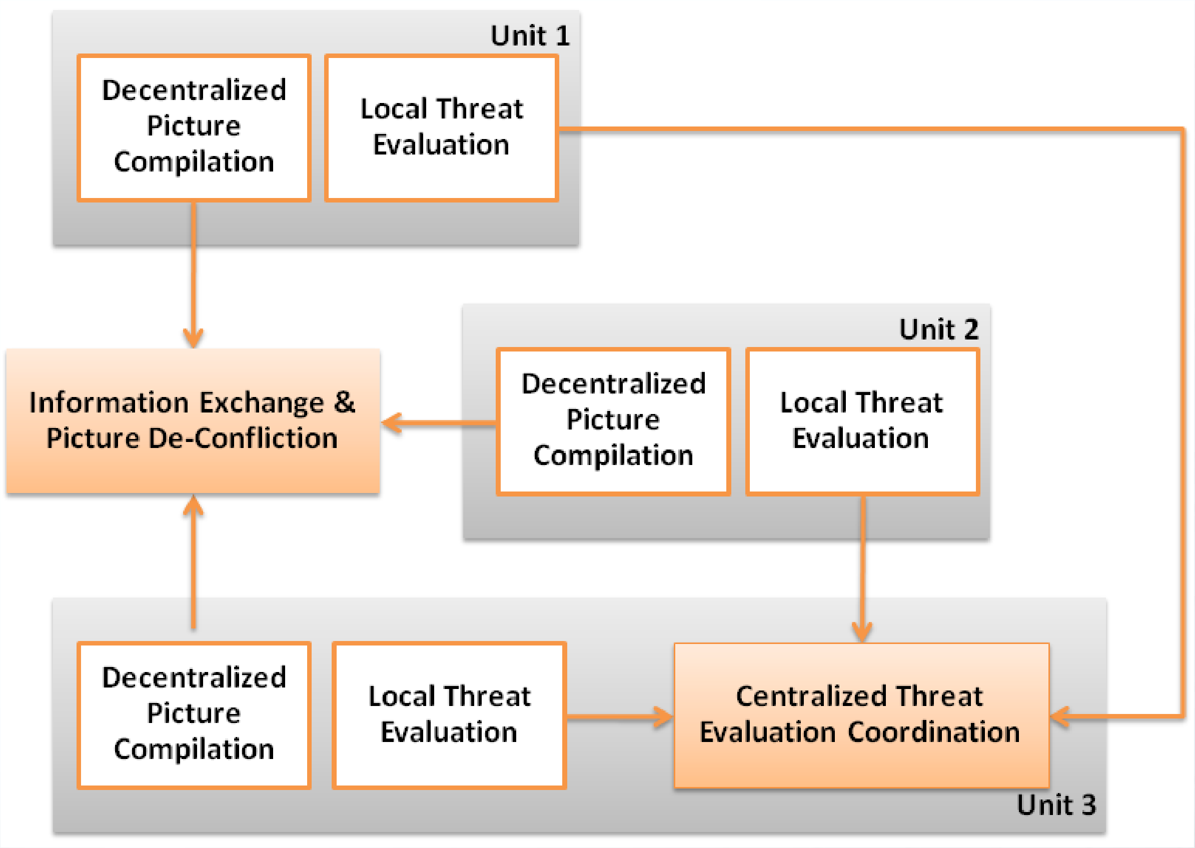
Unit 1
Local Picture Compilation
No Threat Evaluation
Unit 2
Local Picture Compilation
No Threat Evaluation
Centralized Picture Compilation
Local Picture Compilation
No Threat Evaluation
Centralized Threat Evaluation Coordination
Unit 3

# Coordination: Mode 2 (DC)



A common Tactical Picture

De-conflicted Threat Lists



Unit 1

Decentralized Picture Compilation

Local Threat Evaluation

Unit 2

Decentralized Picture Compilation

Local Threat Evaluation

Information Exchange & Picture De-Confliction

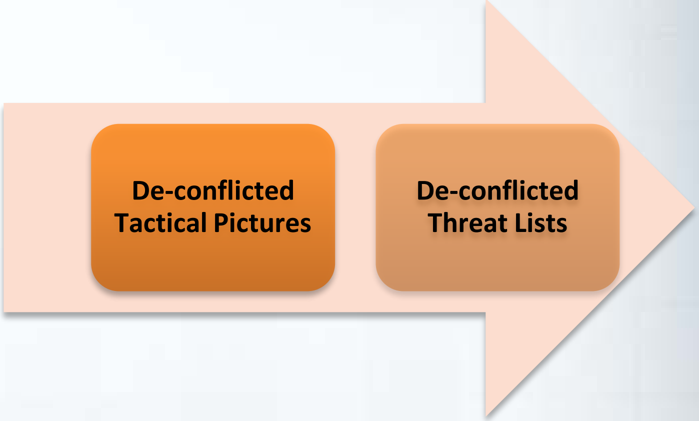
Decentralized Picture Compilation

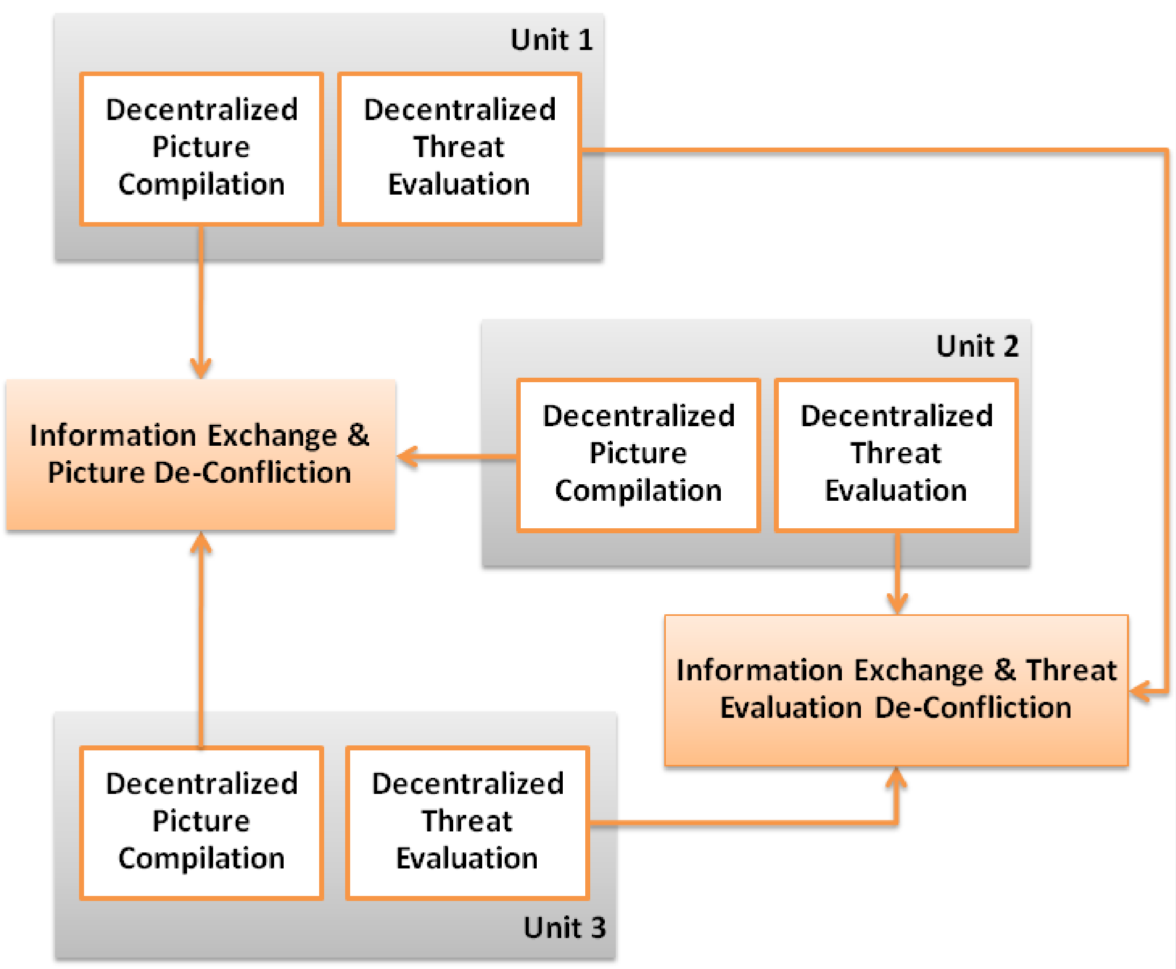
Local Threat Evaluation

Centralized Threat Evaluation Coordination

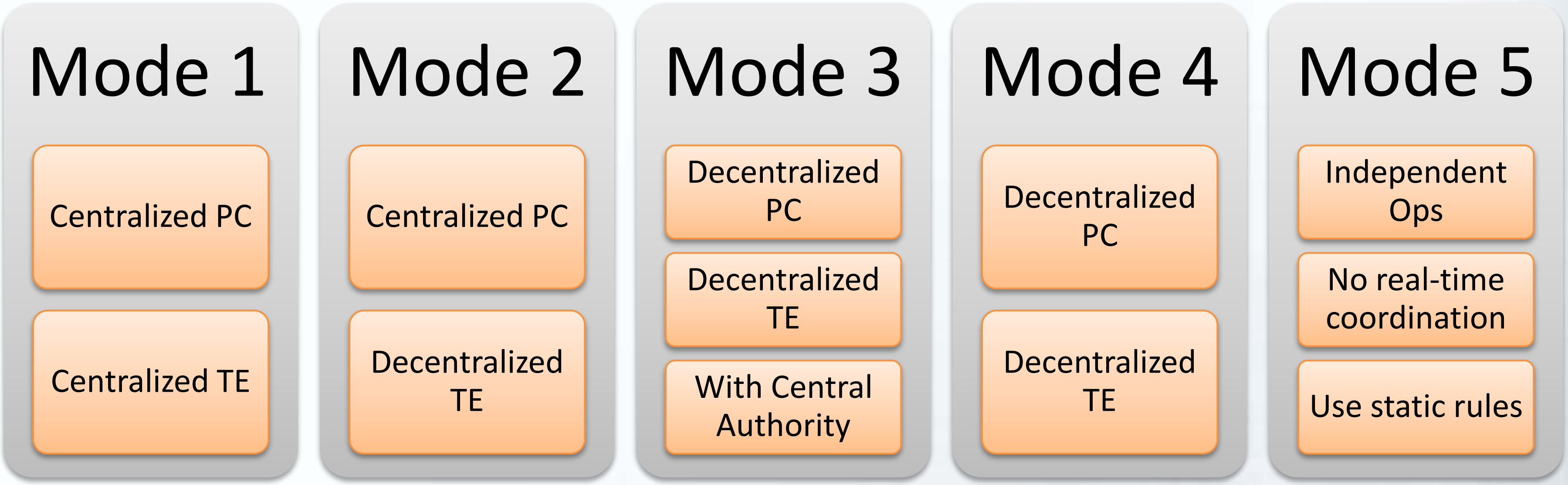
Unit 3

# Coordination: Mode 3 (DD)




Unit 1
Decentralized Picture Compilation
Decentralized Threat Evaluation
Unit 2
Decentralized Picture Compilation
Decentralized Threat Evaluation
Information Exchange & Picture De-Confliction
Information Exchange & Threat Evaluation De-Confliction
Decentralized Picture Compilation
Decentralized Threat Evaluation
Unit 3

# Adaptive/Robust Coordination Approach



Mode 1

Centralized PC

Centralized TE

Mode 2

Centralized PC

Decentralized TE

Mode 3

Decentralized PC

Decentralized TE

With Central Authority

Mode 4

Decentralized PC

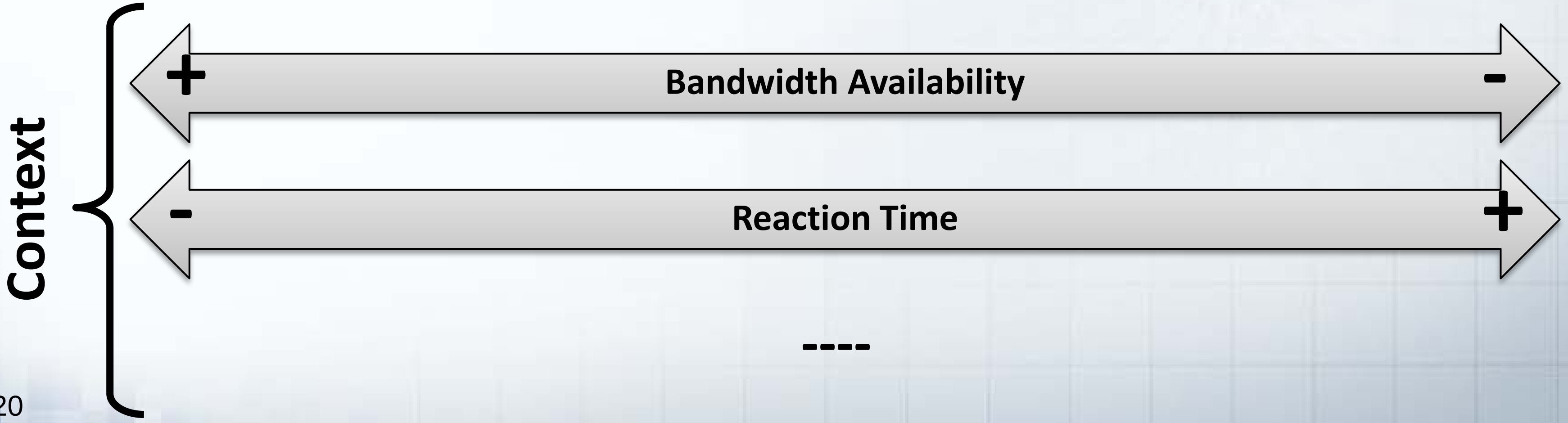
Decentralized TE

Mode 5

Independent Ops

No real-time coordination

Use static rules



Context

+ Bandwidth Availability -

- Reaction Time +

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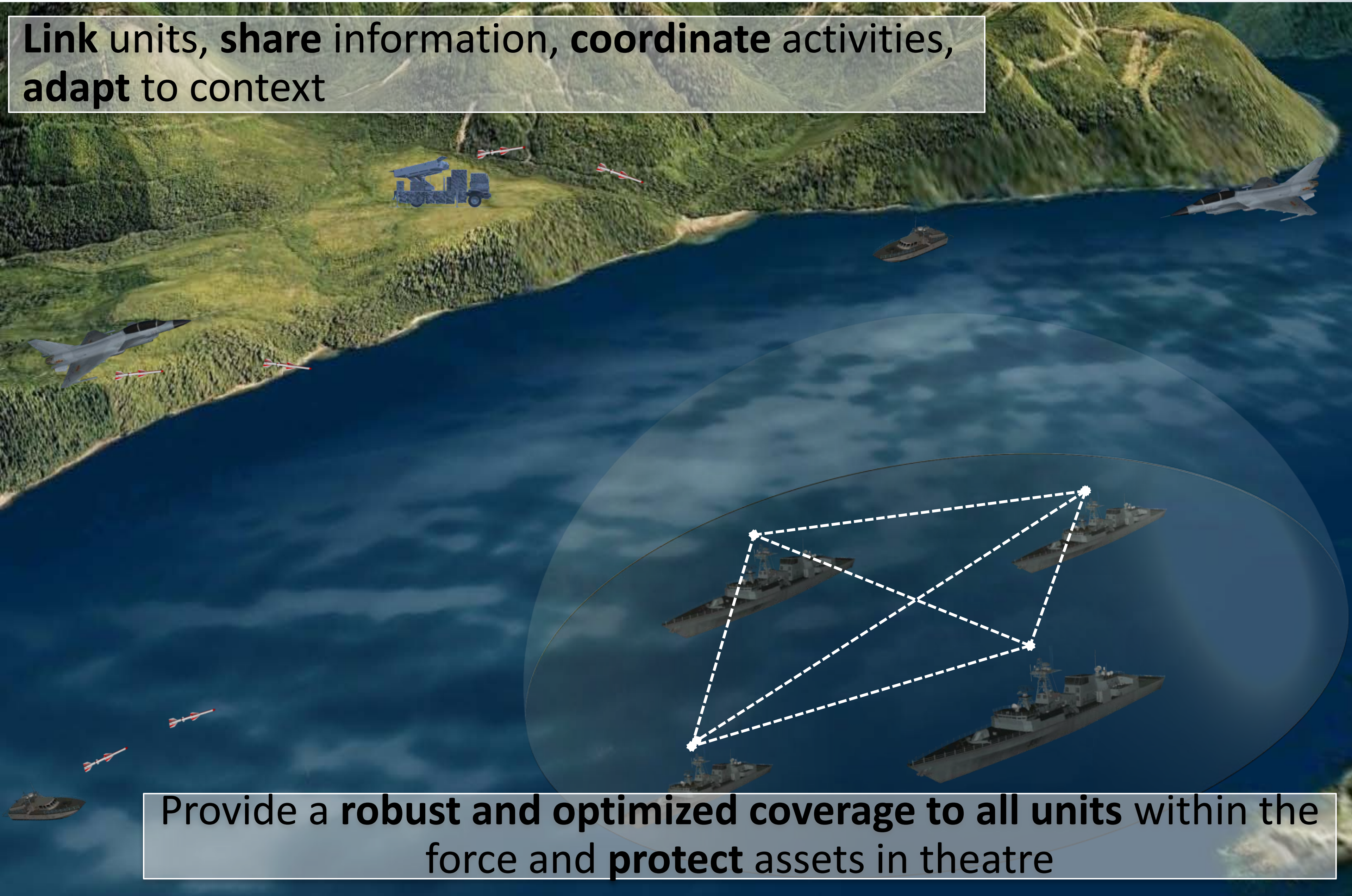
# Scenario

# 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

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