

A mixed-initiative advisory system for threat evaluation

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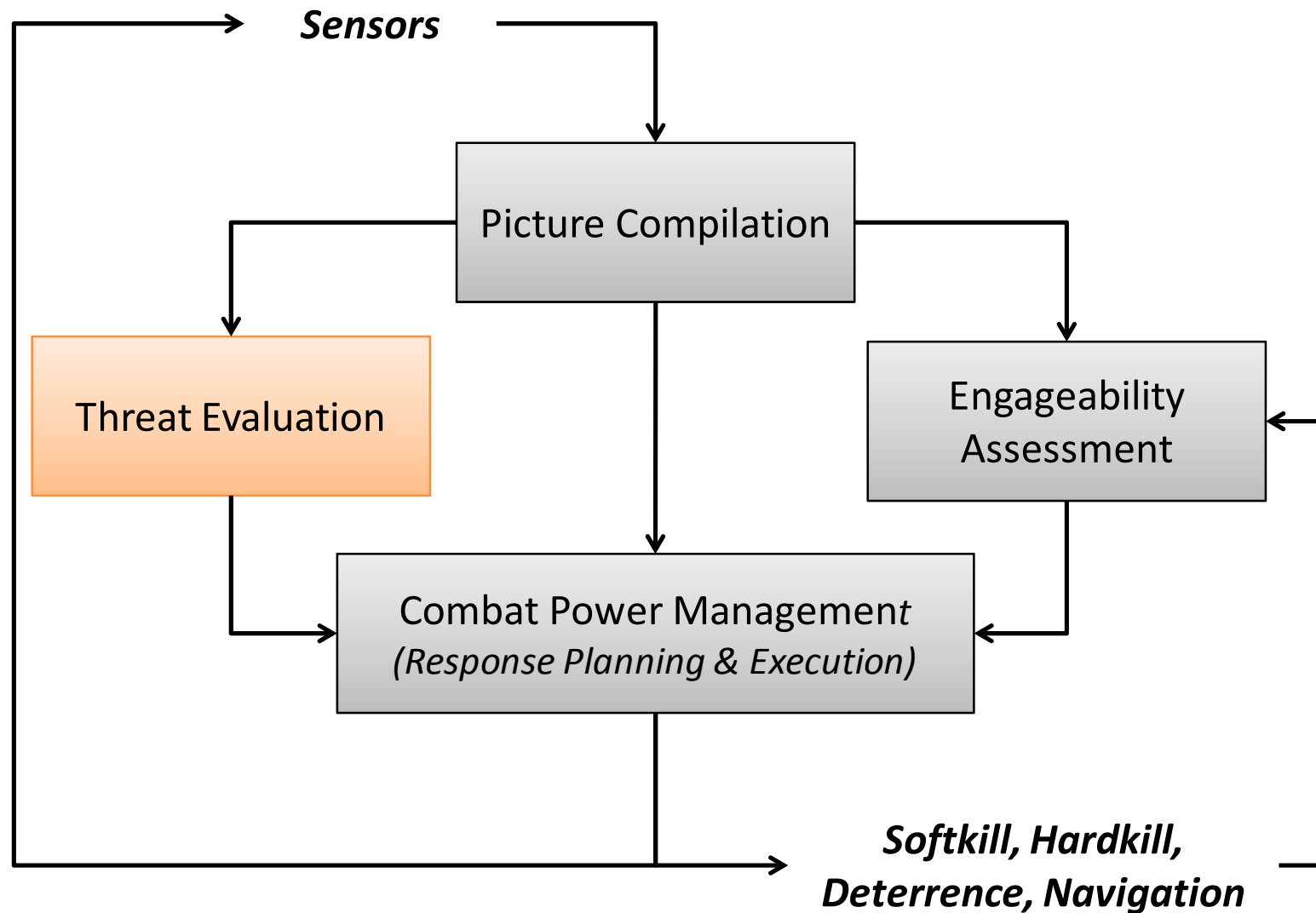
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Threat Evaluation in C2

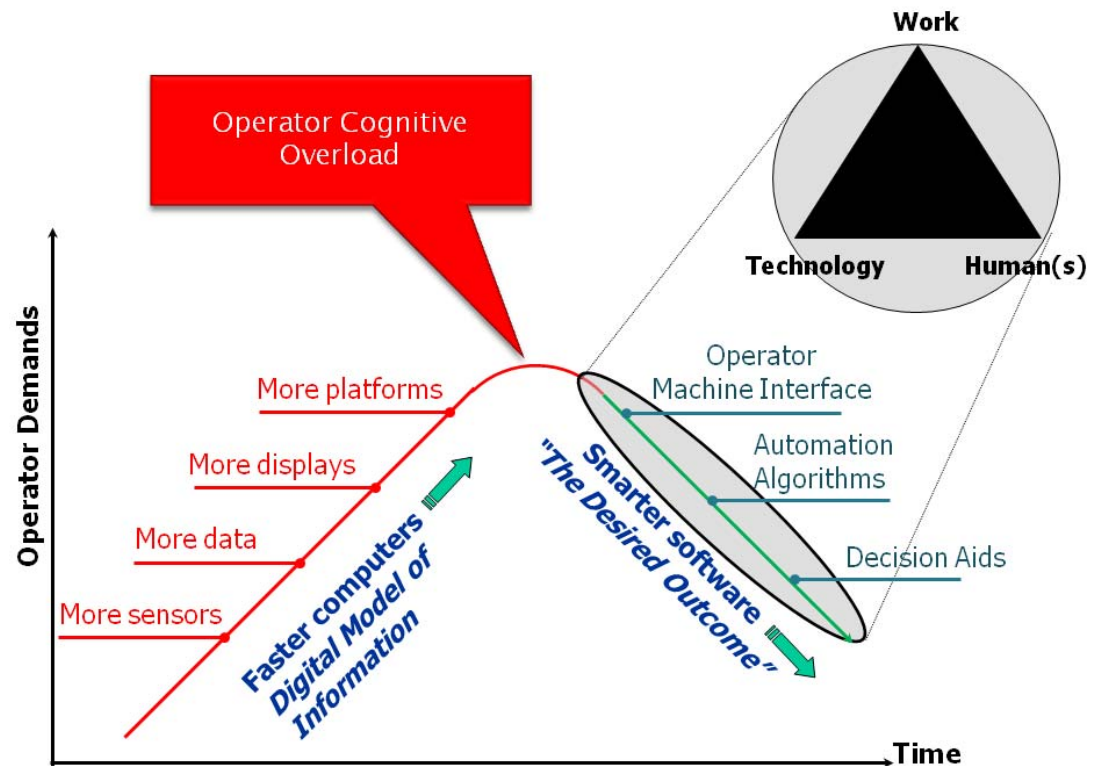


Threat Evaluation Process

- ▶ Threat evaluation is an ongoing process that determines:
 - If an entity intends to harm (intent)
 - If an entity has sufficient resources to harm (capability)
 - If the environment provides the preconditions for the entity's plan to succeed (opportunity)
- ▶ Classifies threats into categories
 - E.g., high, medium and low
- ▶ Ranks threats within each category

Cognitive Demands

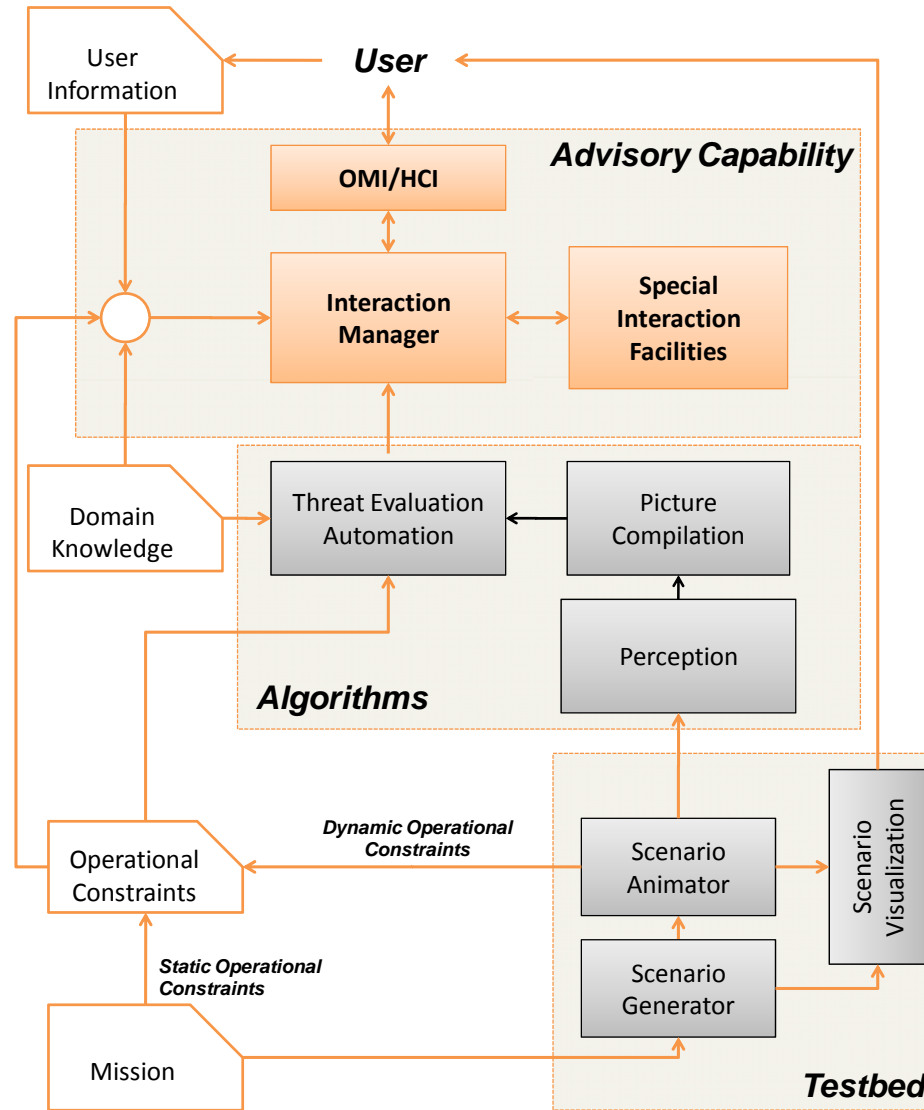
- ▶ Threat Evaluation is a highly demanding cognitive task for human operators
 - Huge amount of data to be analysed
 - Level of uncertainty characterizing the data
 - Short time available
 - Various errors can be made



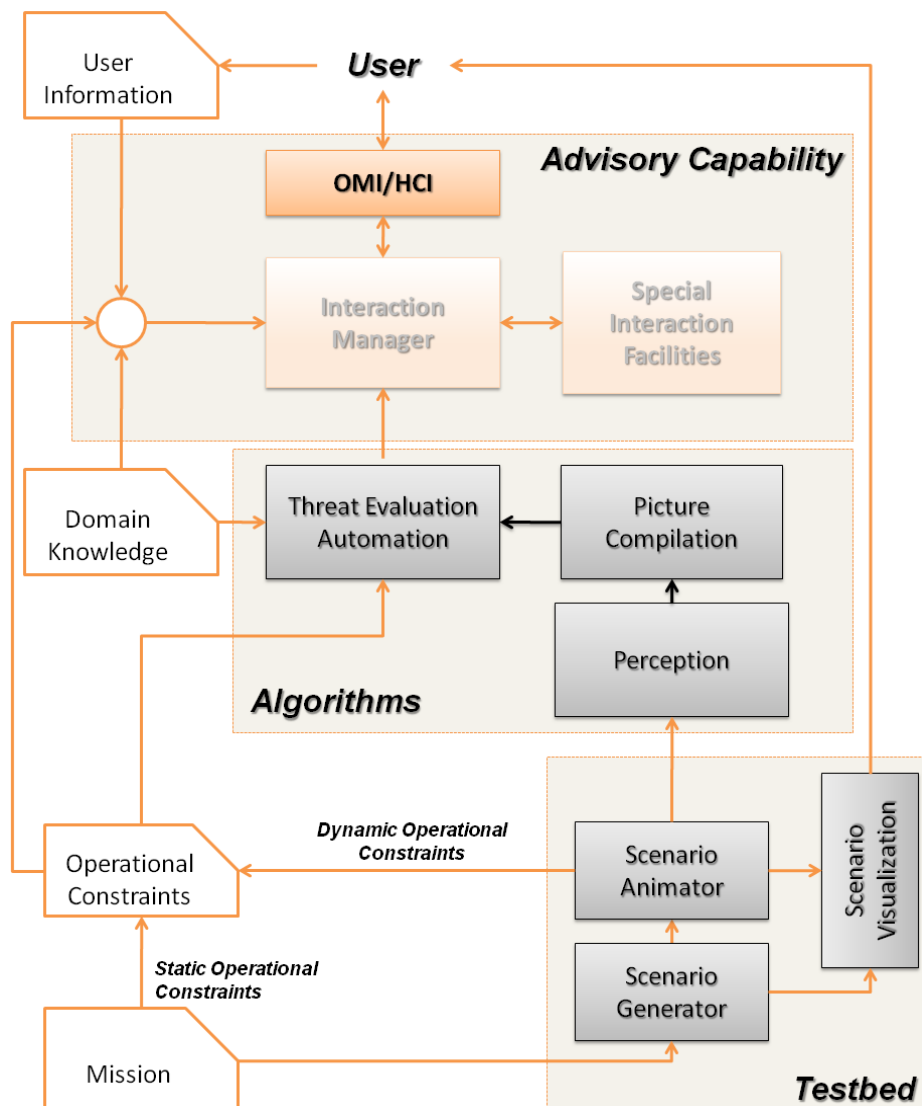
TESS Overview

- ▶ Threat Evaluation Support System (TESS) provides decision support
 - Supports for situation awareness
 - Displays useful contextual information
 - Draws operator's attention to neglected information
 - Reduces operator workload
 - Automate significant aspects of threat evaluation
 - The operator remains in charge
 - Can override or keep automated threat evaluations
 - Builds operator trust in decision support recommendations
 - Provides explanations and arguments

TESS Architecture



Operator-Machine Interface (OMI)



Functional Display – Design philosophy

Help situation awareness

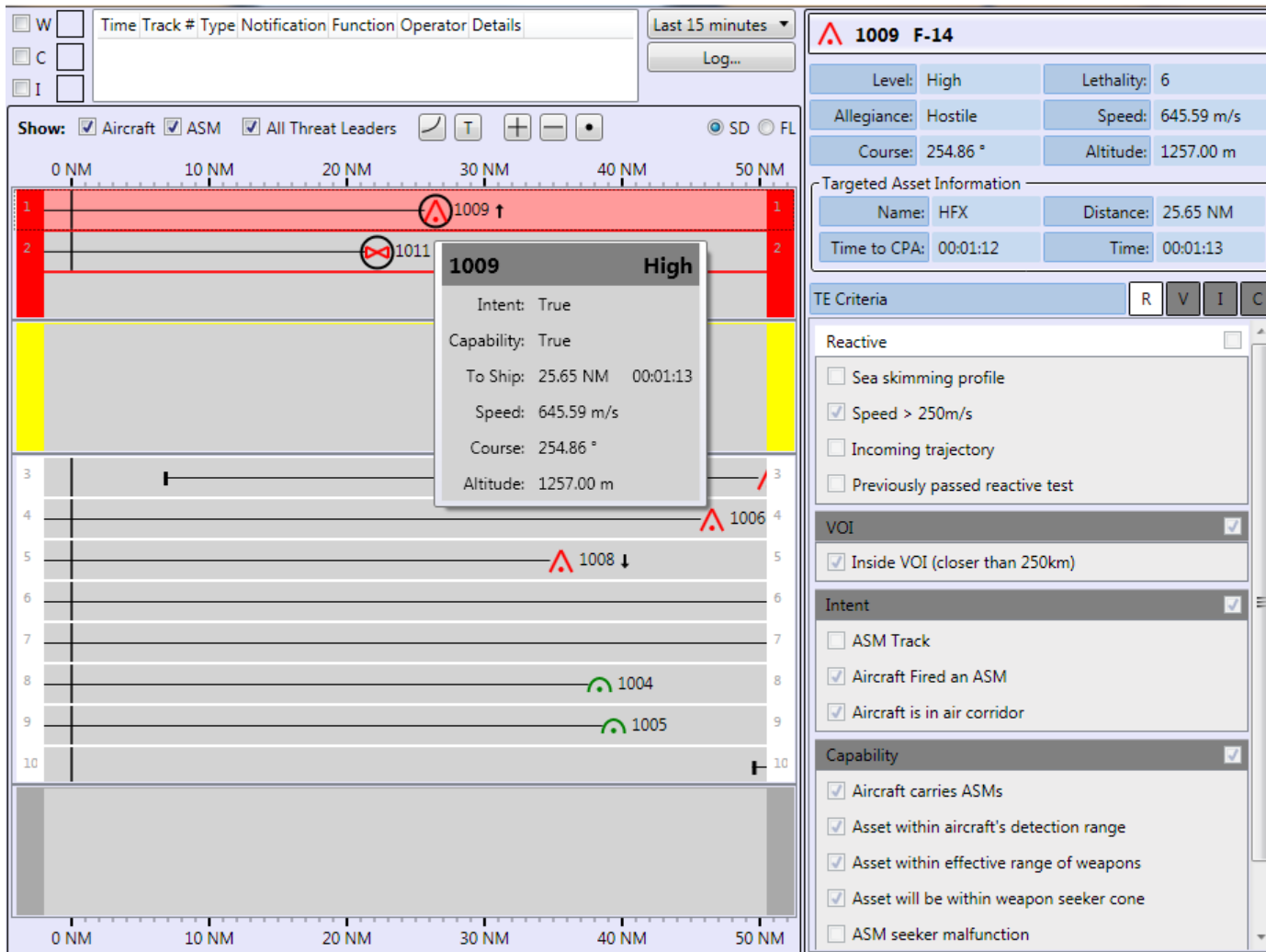
Group related information together

Provide rationale for system recommendations

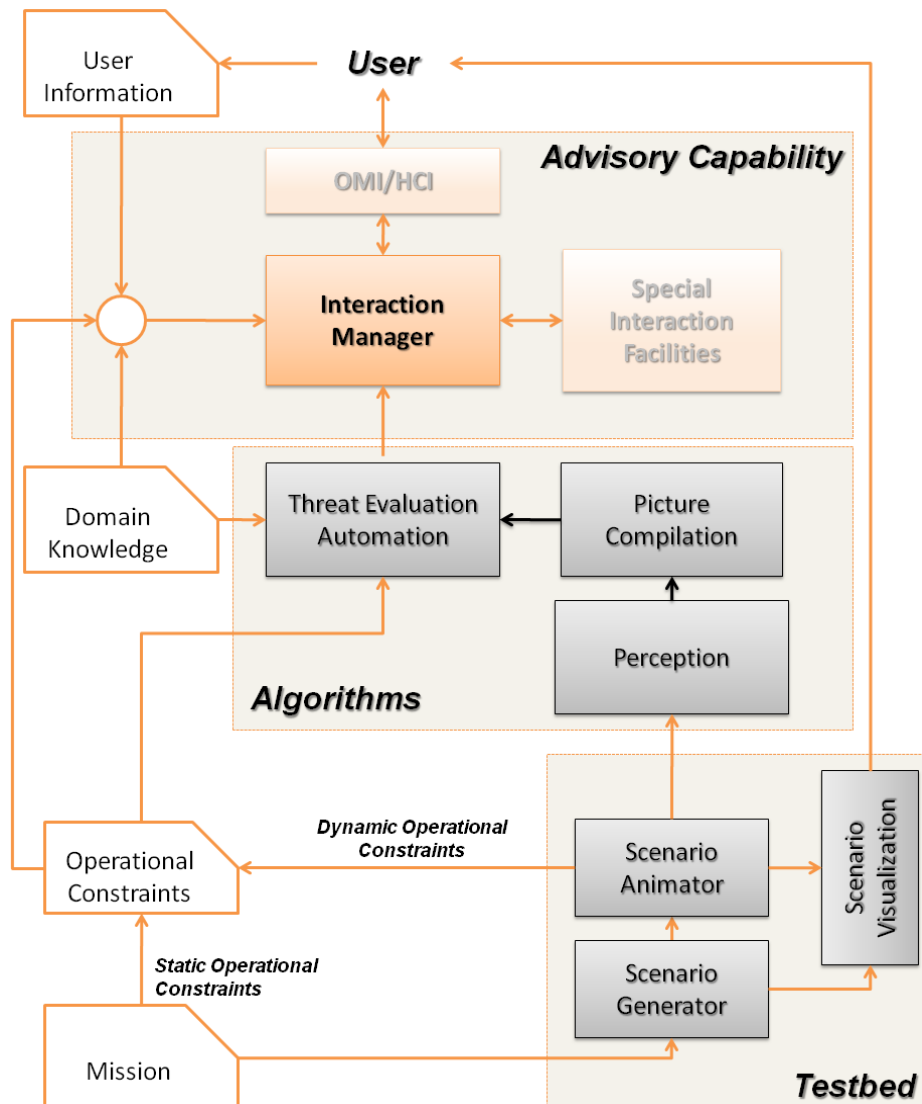
Keep operator engaged in the decision loop

Help to address saturation and recovery
phenomenon

Functional Display



Interaction Manager



Interaction Manager

Monitors the user and determine his needs for information

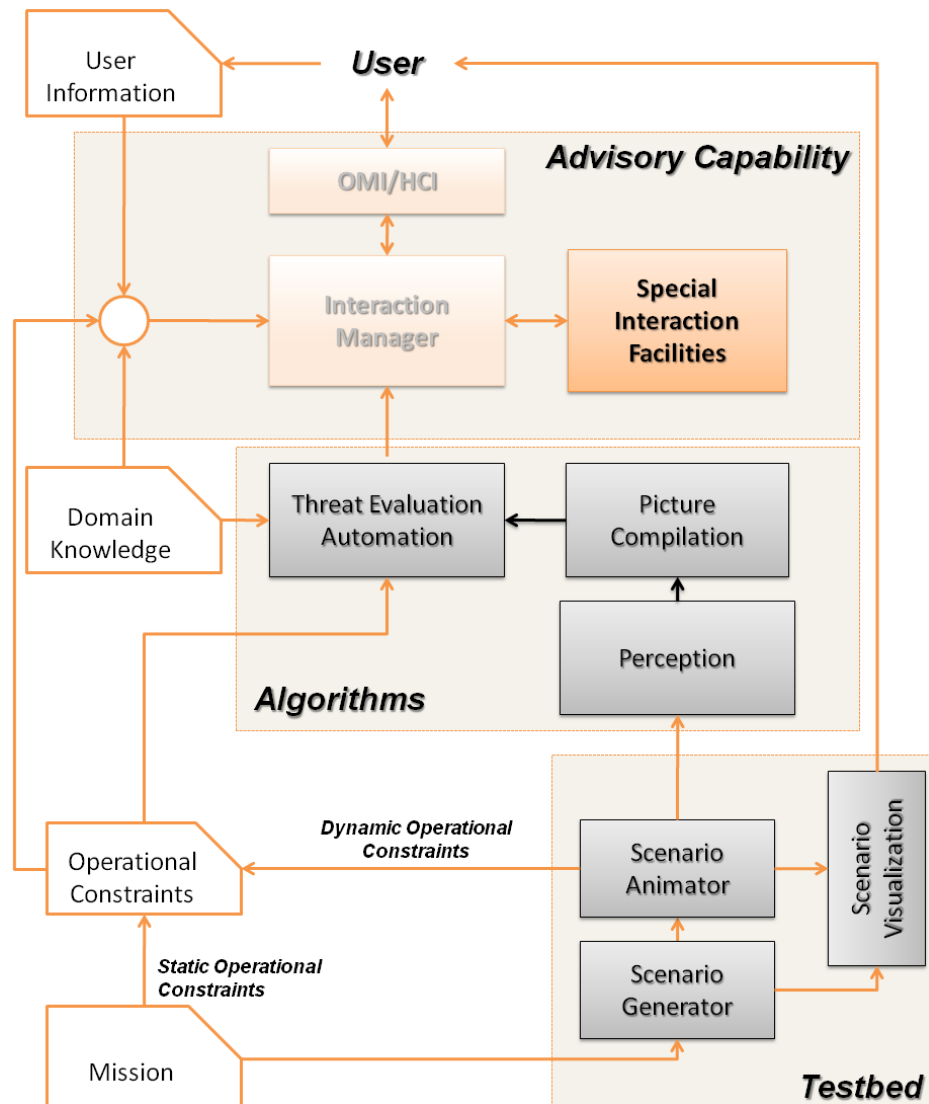
Analyzes the user's input and hypotheses

Analyzes the operational situation

Evaluates the data on which the automation solution is based

Decides on the feedback to be given to the operator

Interaction Facilities



Interaction Facilities

Used to justify the automation's assessment to the operator.

- Operator disagrees with the automation's result
- Operator wants to understand how the result was reached

Purpose is not to resist the operator, but to make sure he considered all information

- The system accommodates to operator's input, but verifies that the operator understands automation rationale first to prevent errors and biases

Argumentation

TESS builds argument when the system's conclusion is based on a combination of different pieces of information and needs to be presented in textual form

Used when the indicators are not informative enough by themselves

Built using a deductive expert system with certainty factors.

Interaction Example – System Assessment

The screenshot displays a system assessment interface with a radar display on the left and a detailed asset information panel on the right.

Top Panel: Includes filters for W, C, and I, a search bar with columns: Time, Track #, Type, Notification, Function, Operator, Details, and a "Last 15 minutes" filter with a "Log..." button.

Left Panel (Radar): Shows a radar display with a scale from 0 NM to 50 NM. A pop-up window for asset 1009 is visible, showing:

- 1009 High**
- Intent: True
- Capability: True
- To Ship: 25.65 NM 00:01:13
- Speed: 645.59 m/s
- Course: 254.86 °
- Altitude: 1257.00 m

Right Panel (Asset Information): Shows details for **1009 F-14**:

- Level: High
- Lethality: 6
- Allegiance: Hostile
- Speed: 645.59 m/s
- Course: 254.86 °
- Altitude: 1257.00 m

Targeted Asset Information:

- Name: HFX
- Distance: 25.65 NM
- Time to CPA: 00:01:12
- Time: 00:01:13

TE Criteria: Includes buttons for R, V, I, and C.

Reactive: Includes checkboxes for:

- Sea skimming profile
- Speed > 250m/s
- Incoming trajectory
- Previously passed reactive test

VOI: Includes checkboxes for:

- Inside VOI (closer than 250km)

Intent: Includes checkboxes for:

- ASM Track
- Aircraft Fired an ASM
- Aircraft is in air corridor

Capability: Includes checkboxes for:

- Aircraft carries ASMs
- Asset within aircraft's detection range
- Asset within effective range of weapons
- Asset will be within weapon seeker cone
- ASM seeker malfunction

Interaction Example – Operator Override

The interface displays a track list on the left and a detailed information panel on the right. The track list shows 10 tracks, with track 1009 highlighted in yellow. A tooltip for track 1009 is visible, showing the following information:

1009 Medium	
Intent:	True
Capability:	True
To Ship:	20.63 NM 00:00:59
Speed:	645.59 m/s
Course:	254.85 °
Altitude:	1257.00 m

The detailed information panel on the right shows the following data for aircraft 1009 F-14:

1009 F-14			
Level:	Medium	Lethality:	6
Allegiance:	Hostile	Speed:	645.59 m/s
Course:	254.85 °	Altitude:	1257.00 m

Targeted Asset Information:

Name:	HFX	Distance:	20.63 NM
Time to CPA:	00:00:58	Time:	00:00:59

TE Criteria:

Criteria	R	V	I	C
Reactive				
<input type="checkbox"/> Sea skimming profile				
<input checked="" type="checkbox"/> Speed > 250m/s				
<input type="checkbox"/> Incoming trajectory				
<input type="checkbox"/> Previously passed reactive test				
VOI				
<input checked="" type="checkbox"/> Inside VOI (closer than 250km)				
Intent				
<input type="checkbox"/> ASM Track				
<input checked="" type="checkbox"/> Aircraft Fired an ASM				
<input type="checkbox"/> Aircraft is in air corridor				
Capability				
<input checked="" type="checkbox"/> Aircraft carries ASMs				
<input checked="" type="checkbox"/> Asset within aircraft's detection range				
<input checked="" type="checkbox"/> Asset within effective range of weapons				
<input checked="" type="checkbox"/> Asset will be within weapon seeker cone				
<input type="checkbox"/> ASM seeker malfunction				

Interaction Example – Argument

The screenshot displays a military tracking interface. At the top left, there are filter buttons for 'W', 'C', and 'I', and a search bar with a 'Log...' button. Below this is a 'Show:' section with checkboxes for 'Aircraft', 'ASM', and 'All Threat Leaders', along with zoom and pan controls. The main display is a radar plot with a 50 NM range and 10 vertical tracks. Aircraft 1009 is highlighted in yellow, and a tooltip for it is shown. The tooltip contains the following information:

1009	Medium
Intent: True	
Capability: True	
To Ship: 20.63 NM	00:00:59
Speed: 645.59 m/s	
Course: 254.85 °	
Altitude: 1257.00 m	

Other aircraft shown include 1011 (red), 1006 (red), 1004 (green), and 1005 (green). On the right side, a detailed data panel for aircraft 1009 F-14 is visible:

1009 F-14	
Level: Medium	Lethality: 6
Allegiance: Hostile	Speed: 645.59 m/s
Course: 254.91 °	Altitude: 1257.00 m

Targeted Asset Information:

Name: HFX	Distance: 15.64 NM
Time to CPA: 00:00:43	Time: 00:00:44

TE Criteria: R V I C

Reactive:

- Sea skimming profile
- Speed > 250m/s
- Incoming trajectory
- Previously passed reactive test

VOI:

- Inside VOI (closer than 250km)

Intent:

- ASM Track
- Aircraft Fired an ASM
- Aircraft is in air corridor

Capability:

- Aircraft carries ASMs
- Asset within aircraft's detection range
- Asset within effective range of weapons
- Asset will be within weapon seeker cone
- ASM seeker malfunction

Arguments for System Recommendations

- Likelihood of ASM reload

- Aircraft disappeared from picture close to home base
- Period of non-detection sufficient for reload
- Record of previous cases

Conclusion

TESS is intended to increase operator's ability to anticipate potential threats and View details of each threat

Key features:

- Visualization of the threat environment through a functional OMI.
- Automation of aspects related to threat evaluation: Intent, capability and opportunity assessment; threat ranking
- Automation in a mixed-initiative approach: the operator is in charge; explanations are provided.

Human Factors experimentation on a previous version validated the system design, increase in situation awareness, improved decision making in threat evaluation, and easy to use.



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