Reduction of Decision-Making Time in the Air Defense Management

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Overview of Air Defense

• Detection
• Identify
• Intercepts
• Destroys
C2 functions for air defense

- Target detection,
- Target tracking,
- Target identification/classification,
- Threat evaluation,
- Weapons assignment:
Real-time decision system

- Information management and data fusion,
- Situation assessment,
- Evaluation of alternatives,
- Decision
Prominent studies

• Tactical Decision Making under Stress

• Evaluating the Performance of TEWA Systems

• Threat Evaluation and Weapon Allocation
Threat Analysis Parameters

• Proximity parameters
  – CPA,
  – Time to CPA,
  – CPA in units of time,
  – time before hit,
  – Distance,

• Capability parameters,
  – target type,
  – weapon type,
  – fuel capacity,
  – max. radius of operation,

• Indent parameters,
  – target’s kinematics,
  – number of recent maneuvers
Threat Analysis

**Step 1**
- Problem Identification

**Step 2**
- Create Value Hierarchy

**Step 3**
- Develop Evaluation Measures

**Step 4**
- Create Value Functions

**Step 5**
- Weight Value Hierarchy
Problem Identification

• Determining the threat levels that gathering from sensors
Threat Analysis

Step 1 • Problem Identification

Step 2 • Create Value Hierarchy

Step 3 • Develop Evaluation Measures

Step 4 • Create Value Functions

Step 5 • Weight Value Hierarchy
Create Value Hierarchy

- Threat Evaluation
  - Threat Parameters
  - Target Parameters
  - Capability Parameters
  - Support Parameters
Threat Analysis

Step 1 • Problem Identification

Step 2 • Create Value Hierarchy

Step 3 • Develop Evaluation Measures

Step 4 • Create Value Functions

Step 5 • Weight Value Hierarchy
Develop Evaluation Measures

- **Threat Parameters**
  - Altitude
  - Speed
  - Distance
  - Type
  - Weapon Load
  - Origin
  - Intel
  - IFF

- **Target Parameters**
  - CPA
  - Time to CPA
  - Time to Target

- **Capability Parameters**
  - Electronic Warfare
  - Stealth

- **Support Parameters**
  - Existence
  - Number
Threat Analysis

Step 1
• Problem Identification

Step 2
• Create Value Hierarchy

Step 3
• Develop Evaluation Measures

Step 4
• Create Value Functions

Step 5
• Weight Value Hierarchy
Create Value Functions

- **Speed**
  - Graph showing value increasing as speed increases.

- **Distance**
  - Graph showing value decreasing as distance increases.

- **Origin**
  - Bar chart showing value distribution with categories A, B, C, D, E.
  - Values: 0.00, 0.05, 0.10, 0.60, 1.00.

- **CPA**
  - Graph showing value decreasing as CPA increases.
Threat Analysis

- **Step 1**: Problem Identification
- **Step 2**: Create Value Hierarchy
- **Step 3**: Develop Evaluation Measures
- **Step 4**: Create Value Functions
- **Step 5**: Weight Value Hierarchy
# Weight Value Hierarchy

<table>
<thead>
<tr>
<th>Measure Name</th>
<th>Weight (True or Relative)</th>
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<tbody>
<tr>
<td>İrtifası</td>
<td>0,07875</td>
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<tr>
<td>Sürati</td>
<td>0,07875</td>
</tr>
<tr>
<td>Rota</td>
<td>0,045</td>
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<tr>
<td>Uçak Tipi</td>
<td>0,0225</td>
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<tr>
<td>Silah Menzili</td>
<td>0,045</td>
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<tr>
<td>Kökeni</td>
<td>0,09</td>
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<tr>
<td>İstihbarat</td>
<td>0,09</td>
</tr>
<tr>
<td>CPA</td>
<td>0,09</td>
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<tr>
<td>CPA'ya Olan Zaman</td>
<td>0,07</td>
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<tr>
<td>CPA'dan hedefe olan zaman</td>
<td>0,04</td>
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<tr>
<td>EH kabiliyeti</td>
<td>0,125</td>
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<tr>
<td>Görünmezlik</td>
<td>0,125</td>
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<tr>
<td>Destek Varlığı</td>
<td>0,05</td>
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<tr>
<td>Destek sayısı</td>
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Threat Analysis

Step 6 • Alternative Generation Value Model
Step 7 • Alternative Scoring
Step 8 • Deterministic Analysis
Step 9 • Sensitivity Analysis
Step 10 • Conclusions & Recommendations
Step 6 • Alternative Generation Value Model

Step 7 • Alternative Scoring

Step 8 • Deterministic Analysis

Step 9 • Sensitivity Analysis

Step 10 • Conclusions & Recommendations
Threat Analysis

- Step 6: Alternative Generation Value Model
- Step 7: Alternative Scoring
- Step 8: Deterministic Analysis
- Step 9: Sensitivity Analysis
- Step 10: Conclusions & Recommendations
Threat Analysis

Step 6 • Alternative Generation Value Model
Step 7 • Alternative Scoring
Step 8 • Deterministic Analysis
Step 9 • Sensitivity Analysis
Step 10 • Conclusions & Recommendations
Sensitivity Analysis

Sensitivity Analysis for Altitude

Value

T1    T2    T3    T4    T5    T6
Threat Analysis

Step 6 • Alternative Generation Value Model

Step 7 • Alternative Scoring

Step 8 • Deterministic Analysis

Step 9 • Sensitivity Analysis

Step 10 • Conclusions & Recommendations
Conclusions & Recommendations

EW Capability  Stealth  Intel  IFF  Altitude
Origin  Speed  Distance  CPA  Weapon Envelope
Time to CPA  Support Existance  Number of Support  Type  Time to Target

T4 0.317
T2 0.316
T3 0.272
T5 0.272
T1 0.233
T6 0.184
Value Analysis

**Protection Capability** 0.188
- Radar Covering 0.150
- SAM Covering 0.450
- Interception Hotline 0.150
- Location 0.250

**Importance** 0.813
- Worth 0.600
- Availability of Alternative 0.250
- Repair Time 0.150

**Location** 0.250
- Geographical Situation 0.300
- Distance to Border 0.700
Value Analysis

S1: 0.548
S2: 0.501
S3: 0.545

Legend:
- Economic Worth
- Availability of Alternative
- Repair Time
- SAM Covering
- Distance to Border
- Radar Covering
- Interception Hotline
- Geographical Situation
## Value Analysis

<table>
<thead>
<tr>
<th>Threat</th>
<th>TA Value</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>Total</th>
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<tbody>
<tr>
<td>T1</td>
<td>0.23</td>
<td>45</td>
<td>80</td>
<td>90</td>
<td>7.03</td>
<td>2.33</td>
<td>1.27</td>
<td>10.63</td>
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<td>T2</td>
<td>0.32</td>
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<td>72</td>
<td>75</td>
<td>9.08</td>
<td>4.51</td>
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<td>60</td>
<td>60</td>
<td>7.82</td>
<td>5.45</td>
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<tr>
<td>T4</td>
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<td>3.61</td>
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<td>13.10</td>
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<tr>
<td>T6</td>
<td>0.18</td>
<td>94</td>
<td>80</td>
<td>56</td>
<td>0.66</td>
<td>1.84</td>
<td>4.42</td>
<td>6.92</td>
</tr>
</tbody>
</table>
Weapon Assignment

- Minimize the threat’s survival value,
- Minimize the defended asset’s damages,
- Maximize the all survivability of assets.

\[
Minimum \ Cost = \sum_{i=1}^{T} \left[ C_i \prod_{k=1}^{A} \varepsilon_{ik} \prod_{j=1}^{w} (1 - P_{ij})^{X_{ij}} + \sum_{j=1}^{w} C_w X_{ij} \right]
\]
Discussion and Results

• TE: A model was created and it is seen that process is much faster than classical methods. It is detected that a thousand threat data can be evaluated in 148 milliseconds.

• WA: If heuristic algorithms aren’t used there are $4^{14}$ (268,435,456) possibilities at solution model. It takes 58 hours to solve this process with a computer.
• Questions