SUPPORTING COURSES OF ACTION PLANNING WITH INTELLIGENT MANAGEMENT OF BATTLE ASSETS

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PRESENTATION OUTLINE

• INTRODUCTION
• RATIONALE
• EXISTING DECISION AIDS
• ACAD DESIGN & SIMULATION OUTPUT
• ACAD EVALUATION EXPERIMENT
• RESULTS
• CONCLUSION & FURTHER STUDIES
Supporting Courses of Action Planning with Intelligent Management of Battle Assets

- Terrain
- Troops
- Time
- Equipment
- Logistics
- Weather

- Decision & Judgment
- Cognitive Information Processor
- Command, Control, Communication & Information
- Overwhelming Commander’s Environment

- Military Decision
  - Mission Analysis
  - COAD
  - COAA
  - RFR Actual
  - RFR Estimated
  - Attrition:
    - Troops
    - Equipment
RATIONALITY

• TOO MUCH INFORMATION, BUT FIXED COGNITIVE ASSET OF THE COMMANDER

• INFORMATION PROCESSING REQUIREMENT
  • PERCEIVING & RECEIVING
  • FILTERING & COMPRESSING
  • FUSING
  • MAKING SENSE OUT OF PROCESSED DATA (JUDGMENT)
  • DECIDING
RATIONALE

• DYNAMIC ENVIRONMENT:
  • CHANGES IN INFORMATION
  • INFORMATION VOLUME & DENSITY
  • HETEROGENEITY OF INFORMATION
  • INFORMATION SPEED

• UNCERTAINTY:
  • INCOMPLETE INFORMATION
  • UNAVAILABLE INFORMATION
  • UNRELIABLE SOURCE OF INFORMATION
  • FUZZINESS IN INFORMATION DESCRIPTION
RATIONALE

• BURDEN OF PROOF:
  • OPPORTUNITY FOR HUMAN ERROR
  • COGNITIVE WORKLOAD
  • TIME & DECISION ACCURACY

• SOLUTIONS:
  • COMPUTERIZED DECISION AIDS
    • Simulation & Modeling Tool
    • Predict, Forecast, Estimate Average Policies
    • Used for Anticipation & Envisioning
SOME EXISTING DECISION AIDS

- FOX-GA: COA MODEL USING GENETIC ALGORITHM
- CORAVEN: INTELLIGENT COLLECTION MANAGEMENT USING BAYESIAN BELIEF NET
- OWL: A DECISION-ANALYTIC WARGAMING USING REAL-TIME STATISTICAL DATA MINING
- SCAT: SENIOR COMMANDER AUTHORING TOOL USED FOR PLAN FRAMING
- MODSAF: 3D SIMULATION WARGAME WITH METT-T
- BVP: BATTLE PLANNING & VISUALIZATION TOOL
  - There are many other tools available*
  - Tools are task dependent, assumption-driven
ALTERNATIVE COURSES OF ACTION DISPLAY (ACAD)

• COA SIMULATION
• DRIVERS:
  • ANALYTICAL MODELS
  • COL DUPUY’S COMBAT MODEL (Refined)
  • BEHAVIORAL MODELS
ALTERNATIVE COURSES OF ACTION DISPLAY (ACAD)

• DRIVERS:
  • TABLES OF ORGANIZATION & EQUIPMENT
  • INTUITIVE GUI
  • MEET-T (MISSION, ENEMY, TROOPS, TERRAIN, & TIME)
    • Drilled-down, granular information level
    • C2 Intangibles (often ignored in other models)
ALTERNATIVE COURSES OF ACTION DISPLAY (ACAD)

• OUTPUTS:
  • Relative force ratio
  • Composite attrition factors
  • Troop advance rate
  • Time base performance data
  • Graphical displays
  • Battle state postures *(Attack, defend, etc.)*
SUPPORTING COURSES OF ACTION PLANNING WITH INTELLIGENT MANAGEMENT OF BATTLE ASSETS

Mission
Terrain
Weather
Time
Surprise
Mobility factors:
Road quality
Road density
Minefield

(Fixed input)

Force & Equipment Composition
Intangible C2 factors:
Morale,
Training Leadership
(variable)

INPUT

TOE

VIE: A model for Visualizing Enfolding battle events

CADIV: Collection Asset Display & Intent Visualization

Heuristic refinement of Dupuy’s Combat models

Resource Decision Model

ACAD SYSTEM
C++, Visual Basic
EXCEL

OUTPUT

Attrition
Mobility factor
Relative force ratio
Advance rate
Posture
Graphics
SUPPORTING COURSES OF ACTION PLANNING WITH INTELLIGENT MANAGEMENT OF BATTLE ASSETS

SAMPLE APPLICATION
SUPPORTING COURSES OF ACTION PLANNING WITH INTELLIGENT MANAGEMENT OF BATTLE ASSETS

SAMPLE APPLICATION
SAMPLE APPLICATION

Results in time-based information on attrition, combat ratio, and advance

Selection of this
SAMPLE APPLICATION

Writing ACAD Output to remote Machines
MAIN HYPOTHESIS:

• TASK FAMILIARITY & COMMAND EXPERIENCE HAVE EFFECT ON USER’S TRUST ON ACAD

PARTICIPANTS

6 Military Officers

5 Males

1 Female
Lt. Col
Air Force Commander

4 Lt Col
2 Retired
1 ROTC Command

2 Majors
1 retired
1 ROTC Instructor

2. Korean War
1 Desert Storm
1 Kosovo
Field artillery/
Infantry Bat.
Command
113 Man-yrs.
STUDY PERIOD: June – September 2000

DESIGN: Within-Subject study

TRAINING: MIN (40 min.) – 55 Min.

PRIOR INFORMATION: Decision Aid Expectation Form Questionnaire.

TASK COMPLEXITY: Based on information on enemy surprise
* Completely Known (LOW COMPLEXITY)
* 50% Known (MEDIUM COMPLEXITY)
* No Information (HIGH COMPLEXITY)
EXPERIMENT 1: Paper & pen (Manual) (Option of 5 trials)

EXPERIMENT 2: Decision Aid (Using ACAD) (Must perform 5 trials).

TIME LIMIT: Sufficient, open-ended time allowed.

POST TEST: Rate ACAD on given trust metric

SCENARIO PRESENTATION: Random on different days and trials.
GIVEN: Mission description, Military asset for friends and enemy, and posture.

DETERMINE: Favorable COA/ Asset combination to minimize composite attrition/
## RESULTS

### COA COMPLETION TIMES

**DATA ON ACAD ONLY**

<table>
<thead>
<tr>
<th>Experience level</th>
<th>Low uncertainty COA</th>
<th>Medium uncertainty COA</th>
<th>High uncertainty COA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experts (Lt.Col.)</td>
<td>2.18 (std=0.26)</td>
<td>3.51 (std=0.62)</td>
<td>3.937 (std = 0.51)</td>
</tr>
<tr>
<td>Novices (Majors)</td>
<td>3.94 (std =1.03)</td>
<td>5.76 (std = 0.93)</td>
<td>8.43 (std = 1.27)</td>
</tr>
</tbody>
</table>
RESULTS

COA COMPLETION TIMES

DATA ON ACAD ONLY

![Chart showing COA complexity and completion times for experts and novices.](chart.png)
RESULTS

COA COMPLETION TIMES

DATA ON ACAD ONLY

• 2 (Expertise) X 3 (COA Complexity) Within-subject ANOVA:
  • Significant differences between Cols. & Majors (F = 249; p = 0.018)
  • Information Complexity has effect on task times: F = 19.45, p = 0.003)
RESULTS

COA COMPLETION TIMES

DATA ON MANUAL VS ACAD

• 2 (Expertise) X 3 (COA Complexity) X 2 (Tool: Manual vs ACAD):

• ACAD VS. MANUAL Task: F = 252, p = 0.0003)
• ACAD Times were between 40-62% less

• ACAD vs MANUAL & Level of Complexity: No significant
  • Task complexity affected COA development equally
  • May be due to preprocessing time required
  • Need further analysis
RESULTS
ACAD PERCEPTION AS A COA ASSISTANT: LOW COMPLEXITY
(t = 3.98, p = 0.0009: Differences between Cols. & Majors)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Expert Score</th>
<th>Novice Score</th>
</tr>
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<tbody>
<tr>
<td>Information content/management</td>
<td>0.72</td>
<td>0.93</td>
</tr>
<tr>
<td>Reliability of decision</td>
<td>0.56</td>
<td>0.87</td>
</tr>
<tr>
<td>Personal dependency of decision aids</td>
<td>0.40</td>
<td>0.58</td>
</tr>
<tr>
<td>Robustness of decision aid</td>
<td>0.675</td>
<td>0.90</td>
</tr>
<tr>
<td>Confidence on decision aids</td>
<td>0.82</td>
<td>0.85</td>
</tr>
<tr>
<td>Trust score</td>
<td>0.913</td>
<td>0.966</td>
</tr>
</tbody>
</table>
## RESULTS

### ACAD PERCEPTION AS A COA ASSISTANT: HIGH COMPLEXITY

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Expert Score</th>
<th>Novice Score</th>
</tr>
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<tbody>
<tr>
<td>Information content/management</td>
<td>0.64</td>
<td>0.83</td>
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<tr>
<td>Reliability of decision</td>
<td>0.56</td>
<td>0.87</td>
</tr>
<tr>
<td>Personal dependency of decision aids</td>
<td>0.35</td>
<td>0.65</td>
</tr>
<tr>
<td>Robustness of decision aid</td>
<td>0.62</td>
<td>0.81</td>
</tr>
<tr>
<td>Confidence on decision aids</td>
<td>0.72</td>
<td>0.89</td>
</tr>
<tr>
<td>Trust score</td>
<td>0.82</td>
<td>0.93</td>
</tr>
</tbody>
</table>
RESULTS
Expertise and Task Complexity affect trust on Decision Aid

Graph showing the percentage trust for Majors and LT. Col. across Low, Medium, and High scenario levels.
CONCLUSIONS

• STUDY SEEKED TO ANSWER:

  • Does Decision Aid Help Commanders in COA Planning?
  • Do Expertise & Task Experience Affect Commander’s Perception of Decision Aid Trust?

• FINDINGS:

  1. Decision Aids Support COA:
     • Time reduction (observed)
     • Judgment errors (observed, to be analyzed)
     • Real-time asset combination
     • Robust—”What if” & “What next”
     • Can generate multiple COAs
CONCLUSIONS

• STUDY SEEKED TO ANSWER:
  • Does Decision Aid Help Commanders in COA Planning?
  • Do Expertise & Task Experience Affect Commander’s Perception of Decision Aid Trust?

• FINDINGS:
  • 2. Commanders with COA expertise and command experience consistently performed better than those with less expertise & experience:
    • Dependency on mental model
    • Comparative judgment (subject ACAD performance to rigorous field-value judgment)
    • Seek for information not known, or, if known, need
CONCLUSIONS

• STUDY SEEKED TO ANSWER:
  • Does Decision Aid Help Commanders in COA Planning?
  • Do Expertise & Task Experience Affect Commander’s Perception of Decision Aid Trust?

• FINDINGS:
  • 3. Commanders with more experience tend to show conservative trust on ACAD while those with less command experience tend to show over reliance (more trust):
    • Look for estimates that “make sense”
    • Attrition factor watched with “passion”; need every asset and logistics to minimize attrition.
CONCLUSIONS

FURTHER STUDY:

• **Meta cognition** study on what commanders really look for in computer decision aids. It is not sufficient to simulate. How the result of simulation is used is important. May help to reduce the magnitude and scalability of simulation models.

• More **“Intelligent Interface”** for the novice user. Avoid raising hopes. Allow the user to use “**INQUIRY**” methods within the interface to “**EXPLORE**” strategies.

• Enhance **Fuzzy data fusion** in ACAD.

• Extend war game board to **multiple objectives** or area of interest. Current capability is one objective at a time.
ACAD-FOX COLLABORATION SYSTEM

• Models operate independently
• Models share objective variables
• Models collaborate to modify each other’s behavior

ACAD DOMAIN

Model Input-Output
<table>
<thead>
<tr>
<th>Time (hrs)</th>
<th>COA 1</th>
<th>RFR</th>
<th>Eff</th>
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<tbody>
<tr>
<td>1</td>
<td>1.70189</td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3.5</td>
<td>74%</td>
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<tr>
<td>3</td>
<td>2.68</td>
<td>88%</td>
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</tr>
<tr>
<td>4</td>
<td>1.39211</td>
<td>78%</td>
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</tr>
<tr>
<td>5</td>
<td>1.4065</td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2.3305</td>
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</tr>
<tr>
<td>7</td>
<td>0.88</td>
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</tr>
<tr>
<td>8</td>
<td>1</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>2.33</td>
<td>90%</td>
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</tr>
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<td>3</td>
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<td>13</td>
<td>2.6</td>
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<td>1.71041</td>
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<td>23</td>
<td>1.1801</td>
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<tr>
<td>24</td>
<td>3.5</td>
<td>95%</td>
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