A Modular Architecture for Multivariate Investment Decision Support

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11 January 2007
MIDST Goals

• Develop the analytic and algorithmic framework for a tool, the Multivariate Investment Decision Support Tool (MIDST), which assists decision-makers who manage funding programs or portfolios intended to minimize threat-consequences
• Create a feasible system architecture to evaluate modeling, analysis approaches, and user interactions within this framework
• Develop exercises utilizing MIDST analysis
MIDST Design Philosophy

• Utility to the decision maker
  • Tied to key user profiles - flexible in use
  • Used iteratively to fine tune decisions

• Transparency, not a black box
  • Shows the evolutionary process of derived outcomes
  • Illustrates cause and effect relationships through visualization

• Looking for “unexpected outcomes”
  • Adds information – not just obvious outcomes
  • Minimizes the effect of preconceived notions and biases
  • Provides new ideas and perspectives of the problem space

• Tuning is evolutionary
  • Capable of correcting and learning from false outcomes
  • Tool improves with use

• Use in exercises - macro or micro mode
  • High level table top use – at Agency or Program level
  • Capable of integration with JOEF or BioDAC or other M &S incident tools
Use of MIDST

MIDST can be used in a variety of exercises. Each use returns multiple decision options.

Setups include:
- POM Exercises
- M&S interfaces – JOEF
- Acquisition Exercises, etc
MIDST Functionality

- Interfaces
- Databases
- Analysis
- Optimization
- Visualization
- Interactivity
- Logging
- Report Generation
Architecture

Threat Space → Effectiveness Processing → Reduced Conseq. → Investments → Decision Makers
Threat Event Model

- Possibility tree for Event Space
- Prototypes of event classes for analysis
- Multiple components of consequence
- A single event is a set of choices in tree
One Threat Event In Possibility Tree
Threat Event Model

One Threat Event in Possibility Tree
One Threat Event In Possibility Tree

Threat Event Model

- The aircraft is fitted for dispersal.
- The agent is loaded onto the aircraft.
- The aircraft flies to the release point.
  - The aircraft is intercepted before reach
  - The aircraft successfully reaches the release point
  - The aircraft fails to reach the release point
    - because of mechanical failure
    - because of navigation failure
- The agent is released from the aircraft.
  - The delivery uses a watercraft.
  - The delivery uses a ground vehicle.
    - The agent is obtained.
    - A vehicle is obtained.
    - The vehicle is fitted for dispersal.
    - The agent is loaded into the vehicle.
    - The vehicle is driven to the release point.
      - The vehicle is intercepted by security forces
        - The agent is not released.
        - The agent is salvaged and released at a point source.
      - The agent is released from the vehicle.
        - The dispersal is a line release.
        - The dispersal is mechanical.
          - The mechanical dispersal is by a vehicle.
Threat Event Model

One Threat Event In Possibility Tree
One Threat Event In Possibility Tree
Threat Event Model

Threat Space

Prototype Event Set

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Architecture

Threat Space

Effectiveness Processing

Investments

Decision Makers

Reduced Conseq.
Decision Makers and Investments

Threat Space

Effectiveness Processing

Investments

Decision Makers

Reduced Conseq.
Capability leaders and Effectiveness

Threat Space

Effectiveness Processing

Reduced Conseq.

IUs

Capability leaders

Total Funding

Total Funding
Capability Experts and Setup

Threat Space

- CB Event Cards
- IU Capability Cards
- Remediation Cards

Reduced Conseq.

IUs

Capability leaders

Total Funding
Models & Analysis

Threat Space

IUs

Capability leaders

Total Funding
MIDST Analysis Components

• Interpolation
  • Intelligent and Classical Interpolation based on inputs (*Nonlinear interpolation*)

• Data Fusion
  • Fuzzy, probabilistic and other fusion techniques (*Average*)

• Expected consequences
  • Possibility/Probability means of computing expectations (*Likelihood expectation*)

• Optimization and Ranking
  • Multi-objective optimization (*GA*, SA and RM)
  • Rank ordering using fuzzy integrals (*Choquet* and others)

• Sensitivity/Credit analysis
  • Sensitivity of portfolio
  • Credit analysis (scenario exclusion analysis, IU exclusion analysis)
Optimization Loop

Input Parameters

Analysis Framework

Ranked Consequences

Tree  
Likelihoods  
Remediations  
Total budget

Model

Optimization / Ranking Tools

(C, ..., ...)  
(C, ..., ...)  
(C, ..., ...)  
(C, ..., ...)

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Optimization

Allocation of funds to minimize expected consequences

Input Parameters → Analysis Framework → Ranked Consequences

Tree
Likelihoods
Remediations
Total budget

(C, $, ..., ..., $)
(C, $, ..., ..., $)
(C, $, ..., ..., $)
(C, $, ..., ..., $)
MIDST Visualization Features

• Complete visibility into computational model
• Multi-sensorial approach increases comprehension
• Consequence-flow metaphor
• Real-time user adjustable parameters
• Multi-resolution to manage complexity
• Drill-down for more details
• Animation of calculations and optimization
• Sensitivity and Credit analysis
1st Generation Visualization of MIDST

- Consequences per Threat Event
- Threat Event Tree
- Effectivity Matrix
- Expected Consequences
- Likelihood of Threat Event
- Funding Portfolio
- Remediations
Visualization of MIDST Architecture

Multicomponent consequences

Multicomponent effectivities
2\textsuperscript{nd} Visualization Model of MIDST

<table>
<thead>
<tr>
<th>Consequences per Threat Event</th>
<th>Consequence reduction</th>
<th>Funding Portfolio</th>
<th>Expected Consequence</th>
</tr>
</thead>
</table>

- GoSession
- GoPlot
- SaveLog
- Reload

**Threat Events**

**Set of Solutions**

**Effectivity Matrix**

- Expected Consequences:
  - NetFinalConValues[0] = 86.67
  - NetFinalConValues[1] = 82.50
  - NetFinalConValues[2] = 85.00

**Likelihood of Threat Event**

- Scenario 1
- Scenario 2
- Scenario 3
- Scenario 4
- Scenario 5
- Scenario 6
- Scenario 7
- Scenario 8
- Scenario 9
- Scenario 10

**Controller Area**

**TotalFund**

- $270.00M
Visualization of MIDST Architecture

Multi-component consequences

Multi-component effectiveness

Component buttons
Visualization with real data

2D version

3D version
Conclusions

• MIDST that meets the Goals
  • Analytic and algorithmic framework
  • Feasible system architecture
  • Exercises utilizing MIDST analysis

• MIDST further refinement
  • Music and sound
  • Transition between 2D and 3D versions.
  • More drill-down details.
Acknowledgements

- DTRA University Strategic Partnership
- UNM Professors T. Ross and M. Taha
- NMSU Professors H. Nguyen and R. Prasad
- Drs. T. Bott and S. W. Eisenhawer
Thank you!