A Modular Architecture for Multivariate Investment Decision Support

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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
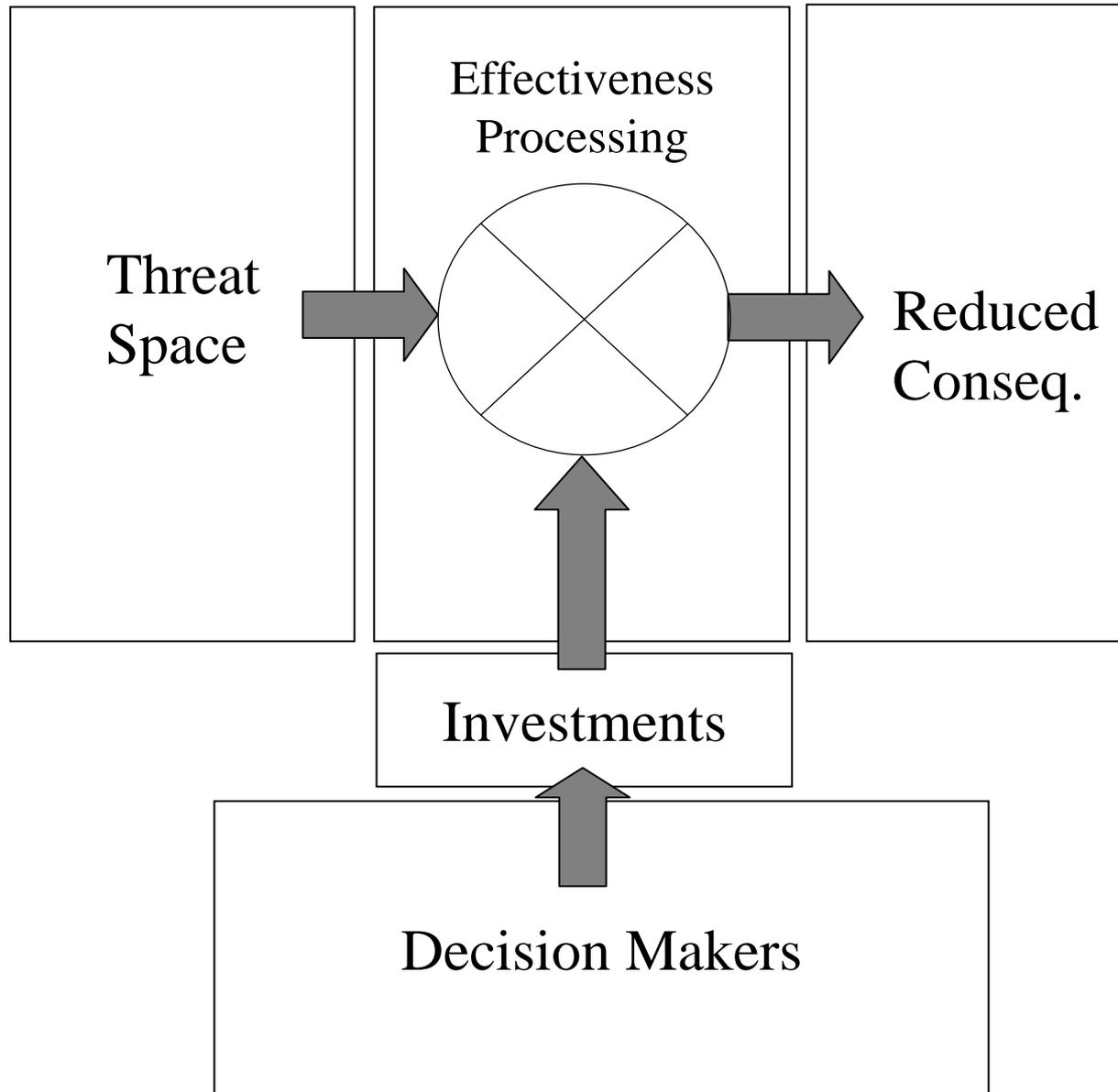
Use of MIDST

Setups include:
POM Exercises
M&S interfaces – JOEF
Acquisition Exercises, etc
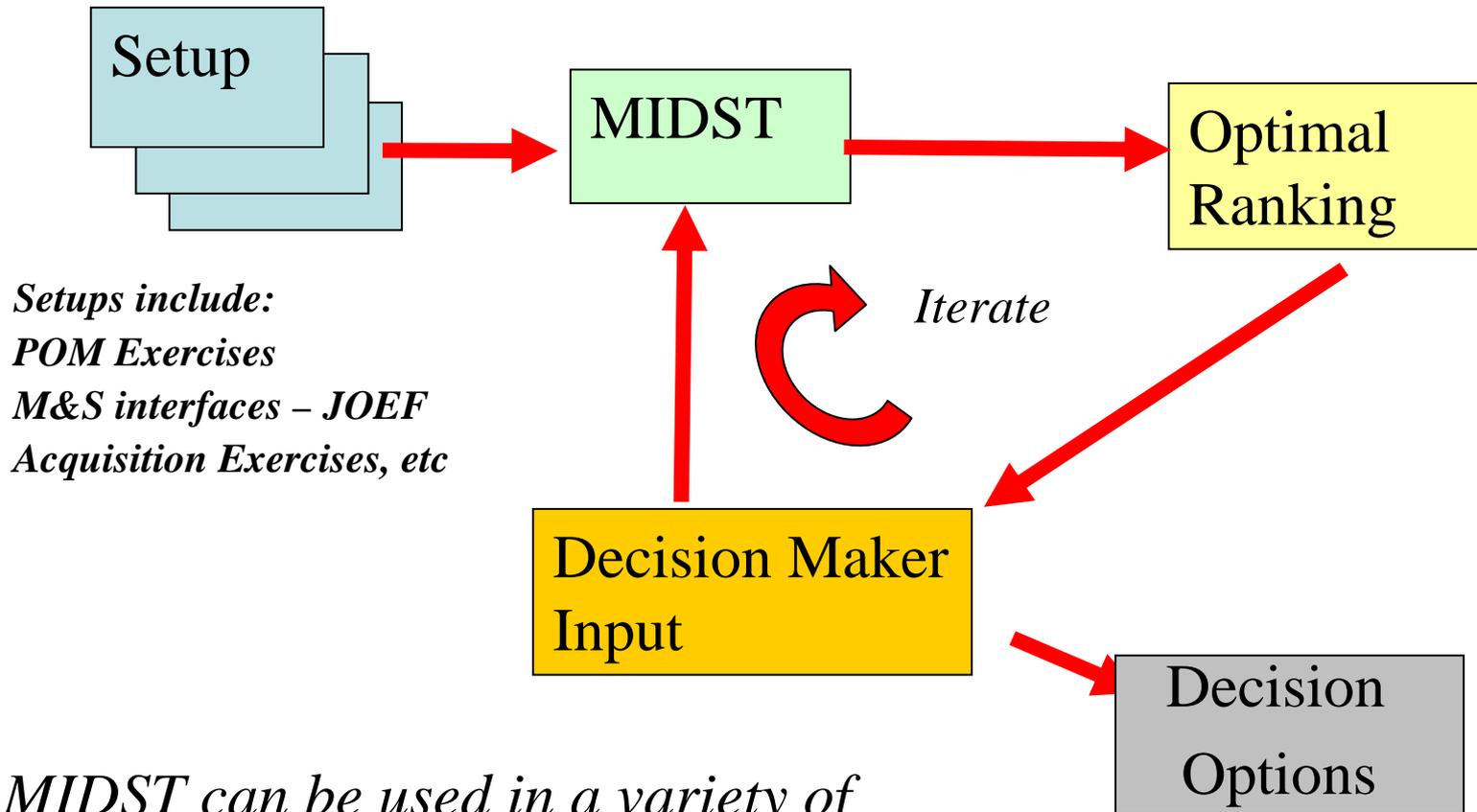
MIDST can be used in a variety of exercises. Each use returns multiple decision options.
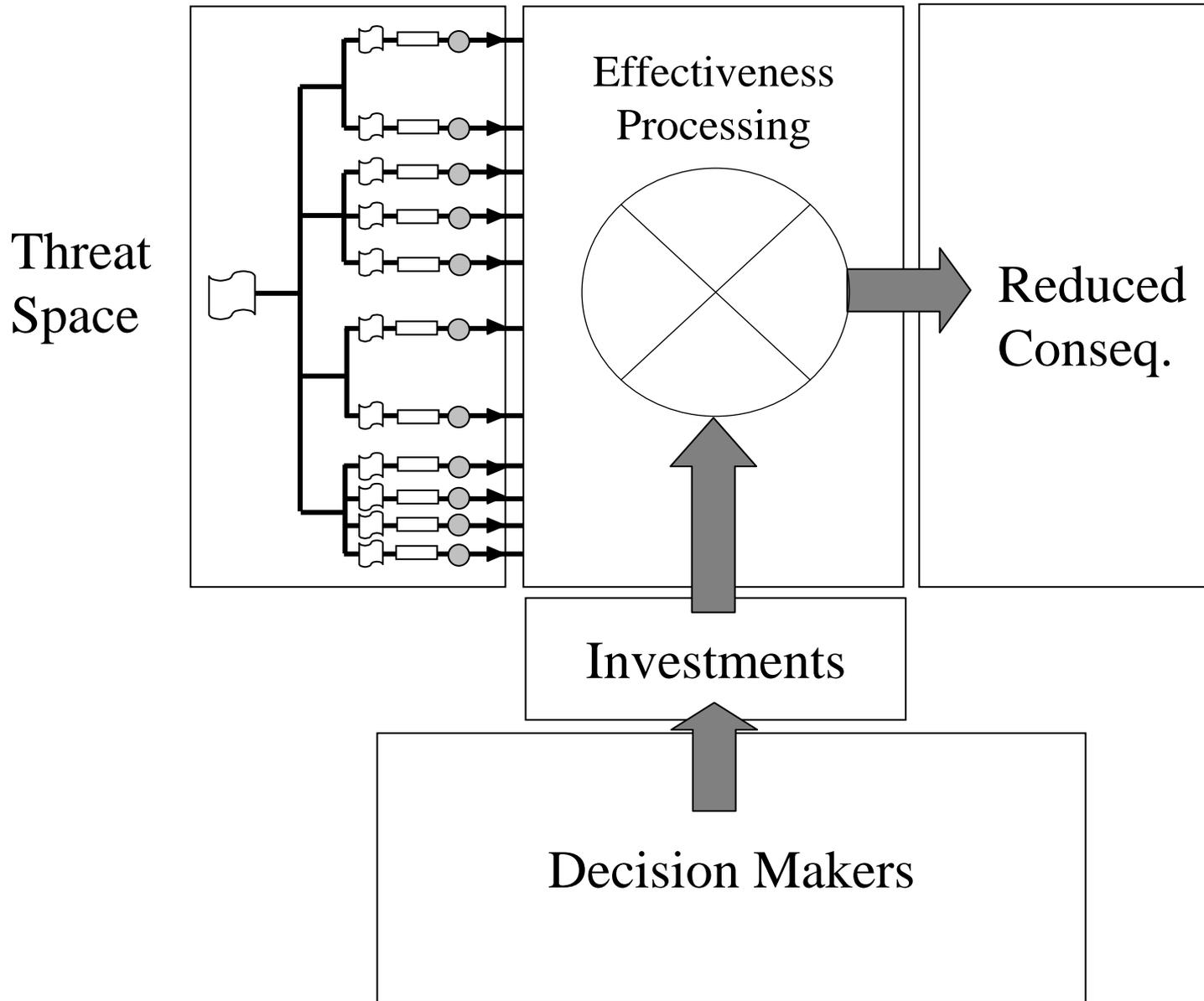
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MIDST Functionality

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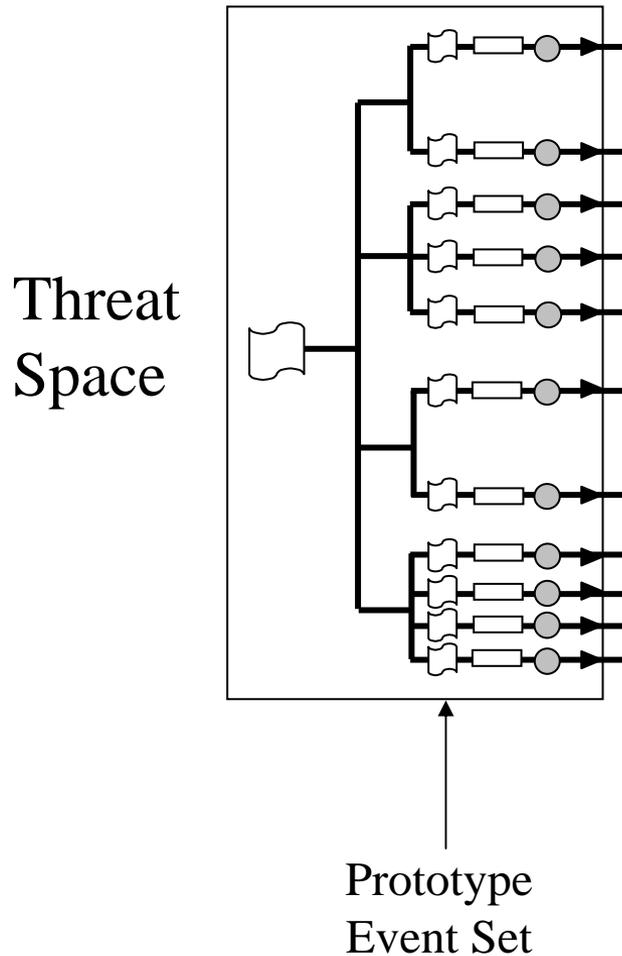- Logging
- Report Generation

Architecture

Effectiveness
Processing

Threat
Space

Reduced
Conseq.

Investments

Decision Makers

Architecture

Threat Space

Effectiveness Processing

Reduced Conseq.

Investments
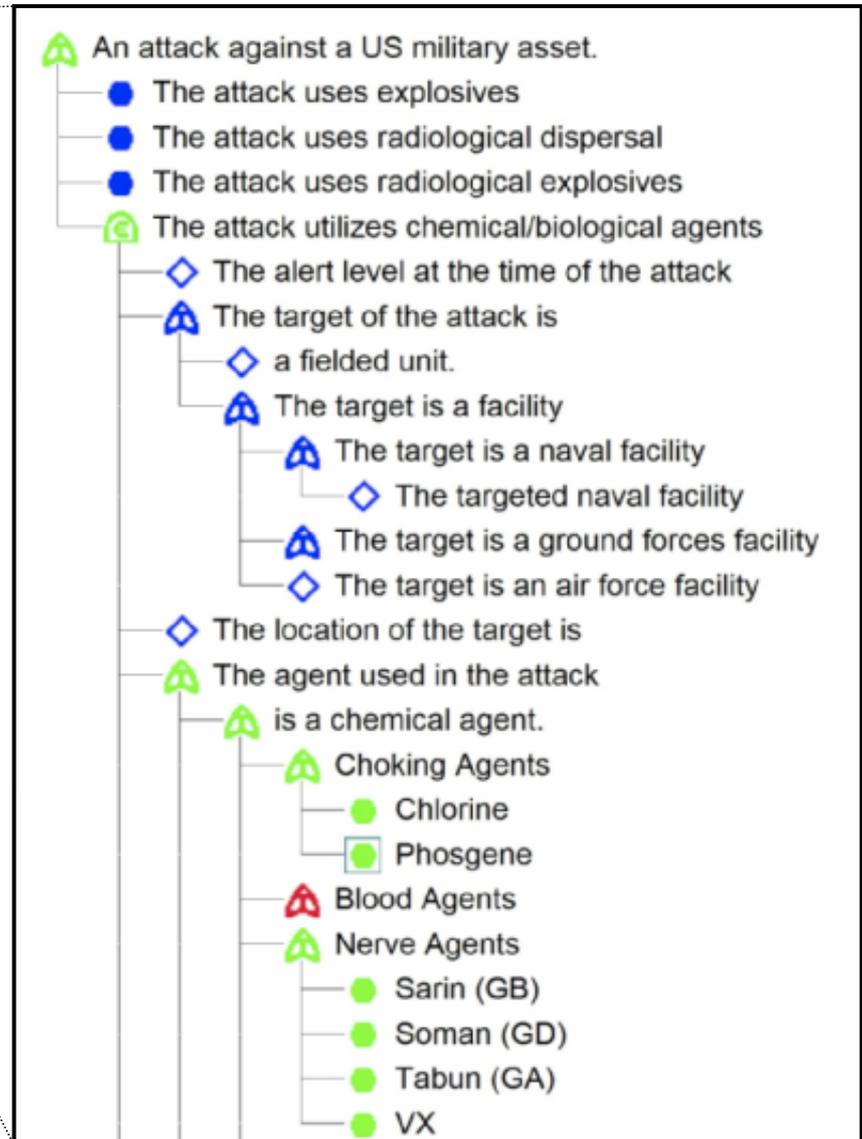
Decision Makers

Threat Event Model

Threat Space

Prototype Event Set

- 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
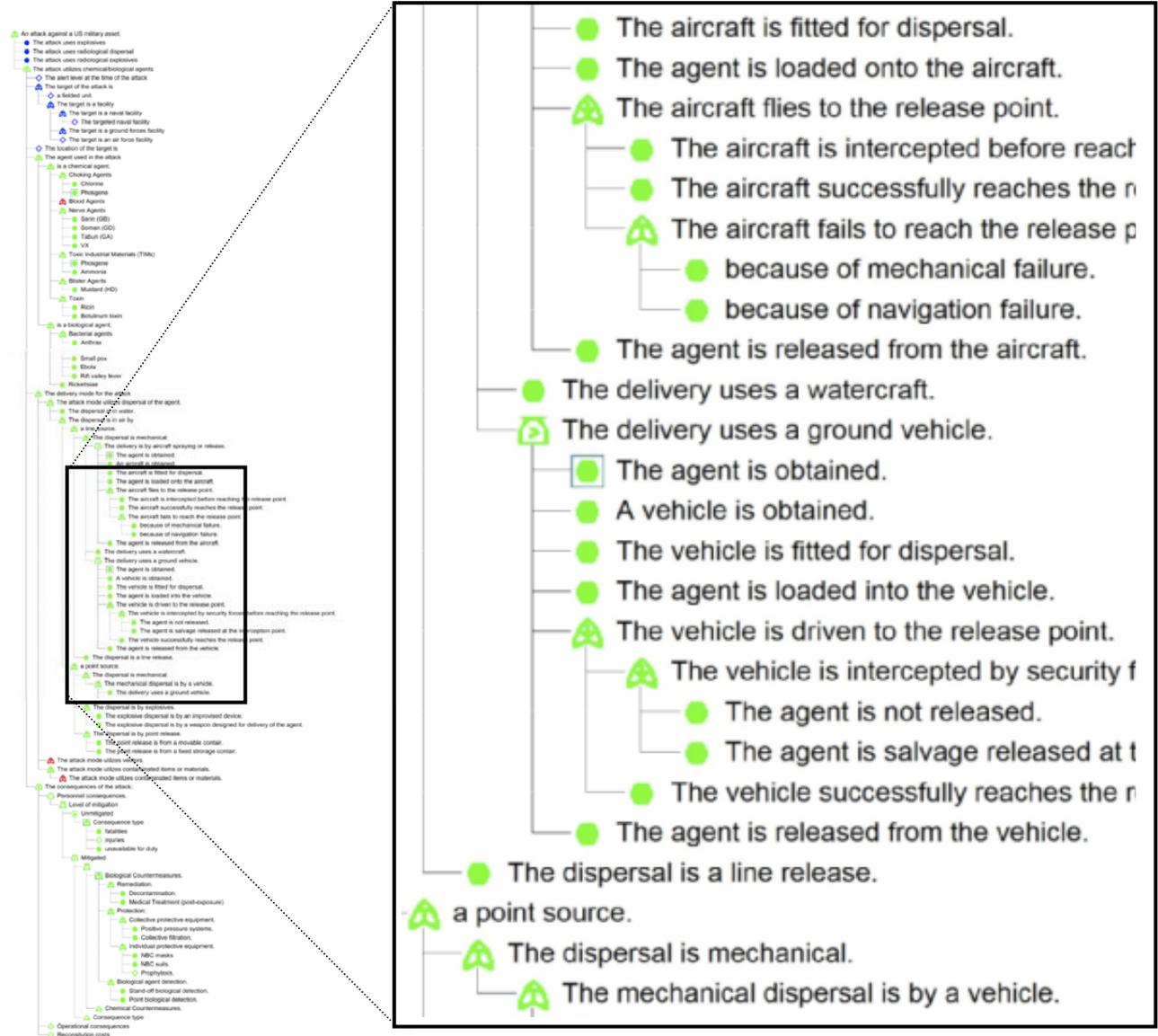
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Threat Event Model

One Threat
Event
In
Possibility
Tree

Threat Event Model

One Threat
Event
In
Possibility
Tree

Threat Event Model

One Threat
Event
In
Possibility
Tree

Threat Event Model
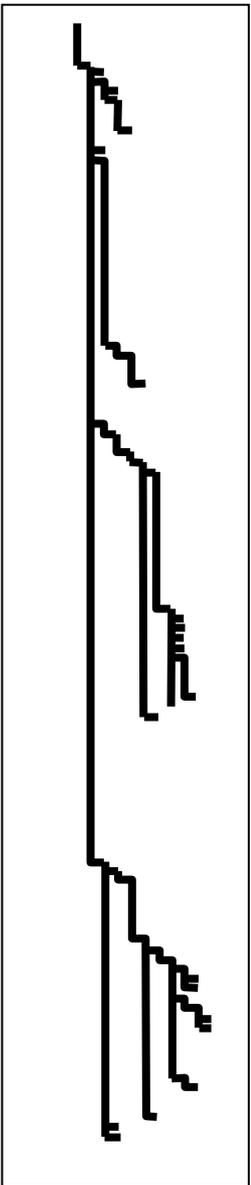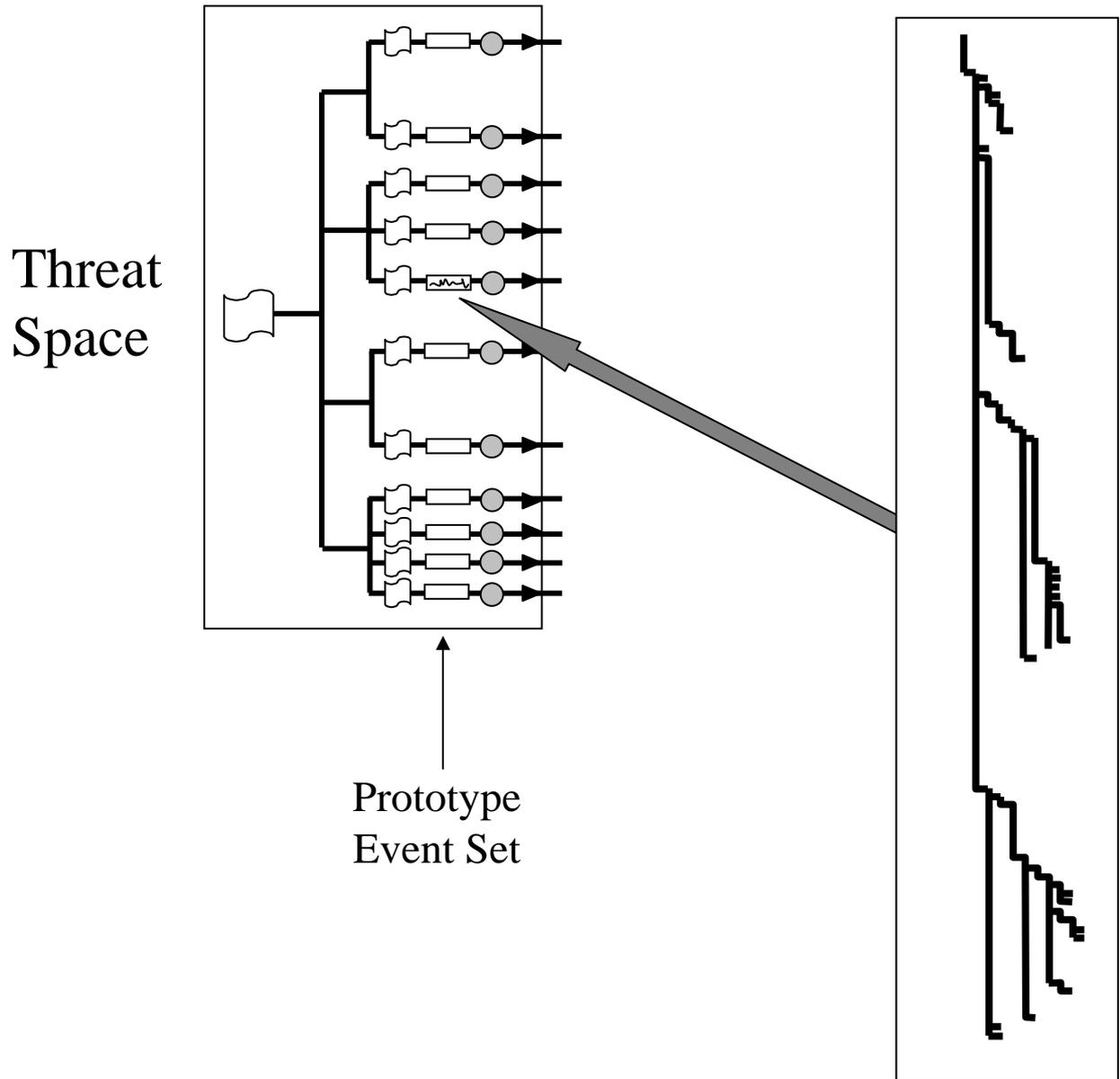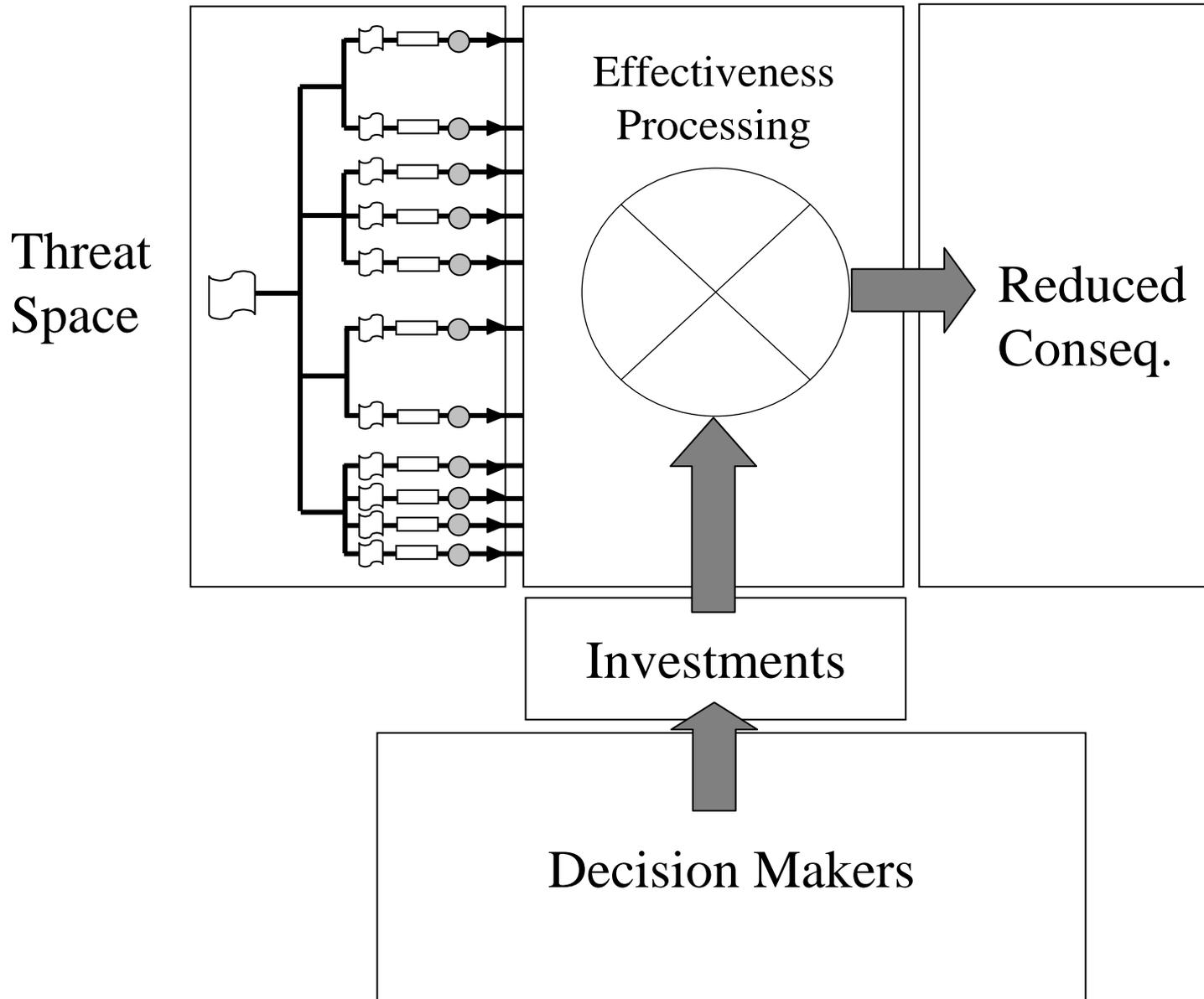
One Threat
Event
In
Possibility
Tree

Threat Event Model

One Threat
Event
In
Possibility
Tree

Threat Event Model

Threat
Space

Prototype
Event Set

Architecture

Threat Space

Effectiveness Processing

Reduced Conseq.

Investments

Decision Makers

Decision Makers and Investments

Threat Space

Effectiveness Processing

Reduced Conseq.

Investments

Decision Makers
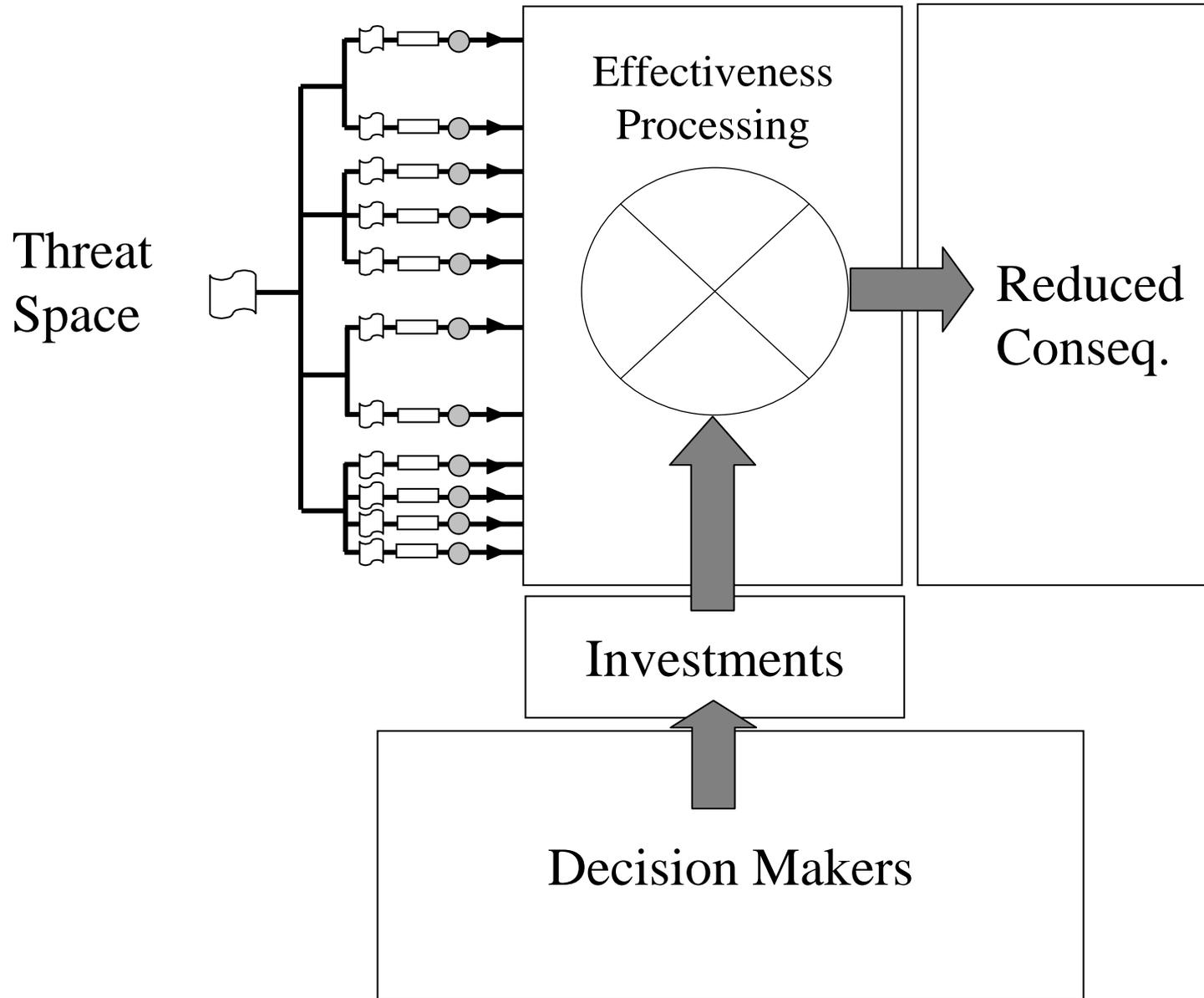
Capability leaders and Effectiveness

Threat Space

Effectiveness Processing

Reduced Conseq.

IUs

Capability leaders

$ Total Funding
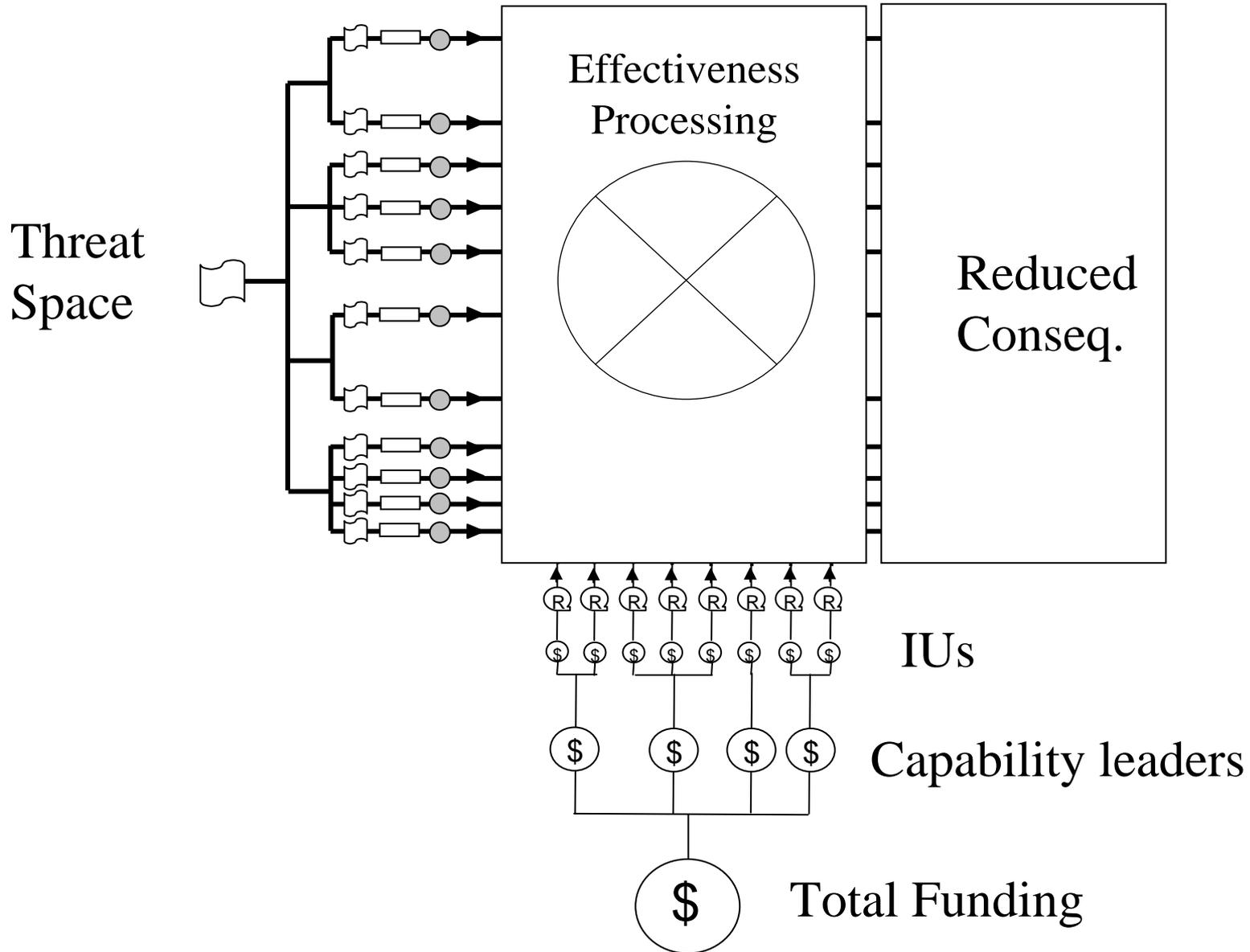
Capability Experts and Setup

Threat
Space

Reduced
Conseq.

R R R R R R R R

$ $ $ $ $ $ $ $ IUs

1

$ $ $ $ Capability leaders

• CB Event Cards
• IU Capability Cards
• Remediation Cards

$ Total Funding

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Models & Analysis

Threat Space

Reduced Conseq.

IUs

Capability leaders

$ Total Funding

Models & Analysis

Threat
Space

IUs

Capability leaders

$

Total Funding
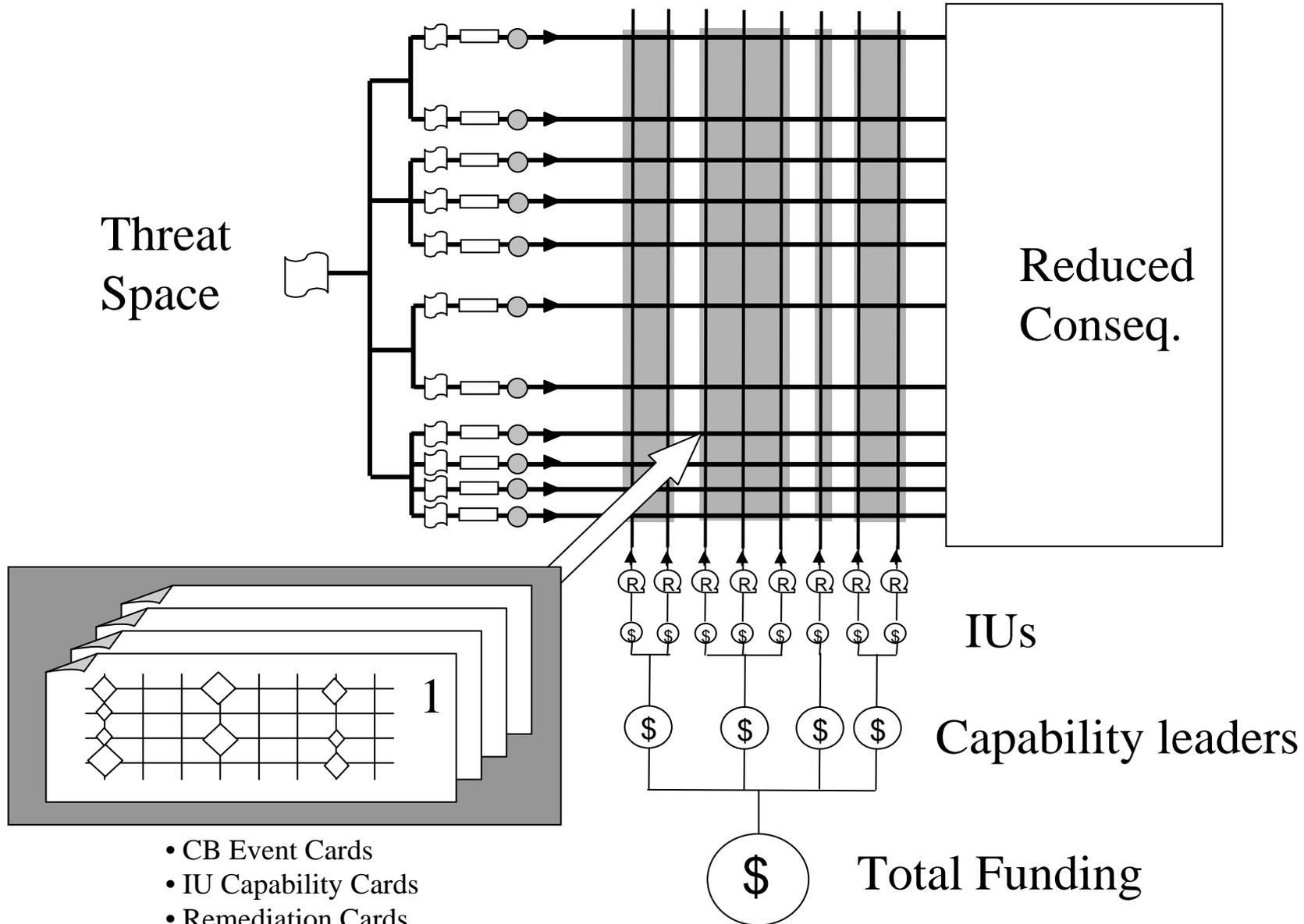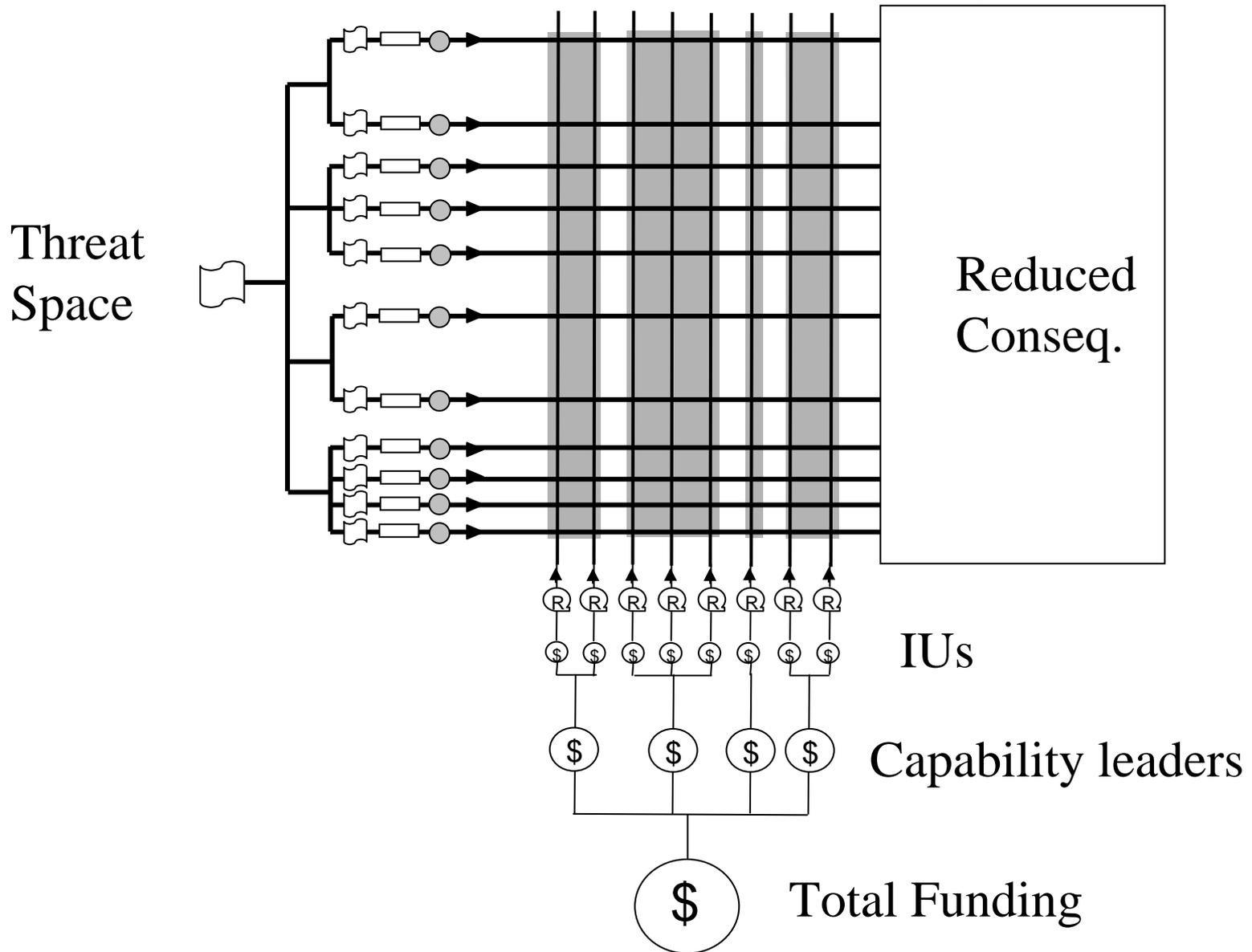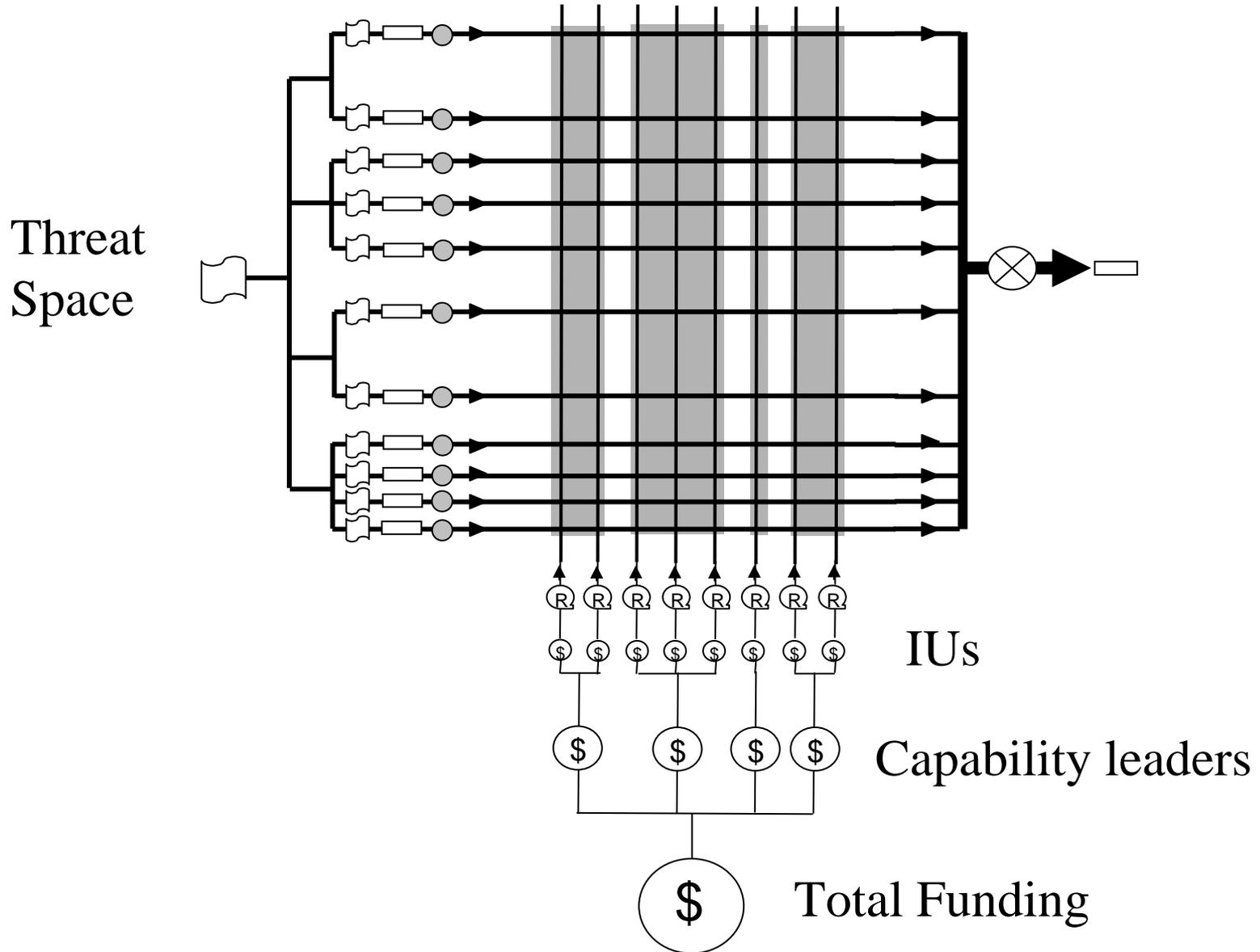
MIDST Analysis Components

- Interpolation

  - Intelligent and Classical Interpolation based on inputs (*Nonlinear interpolation*)
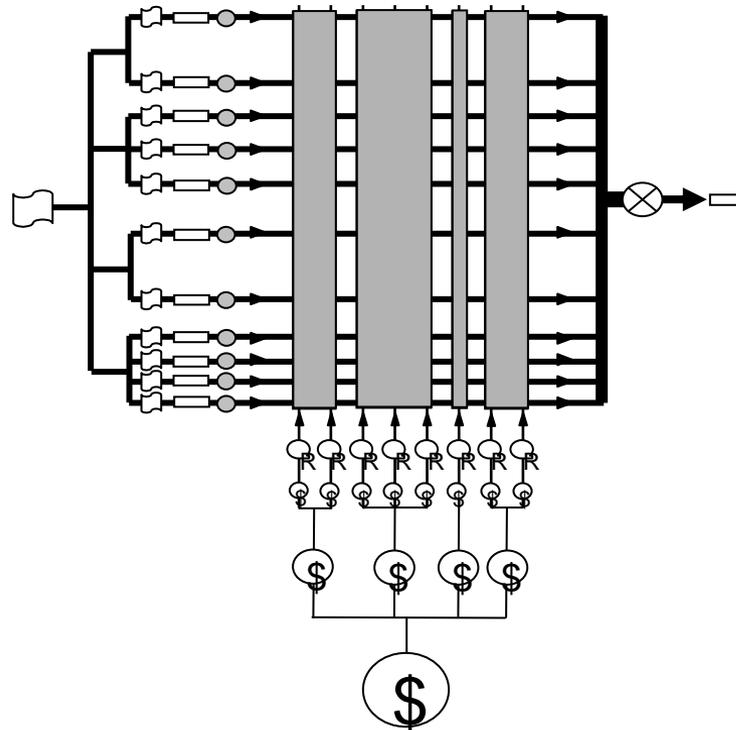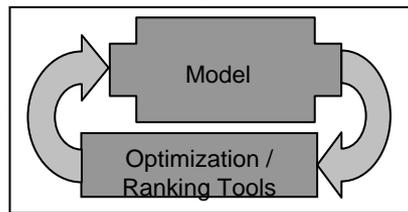
- Data Fusion

  - 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

Tree

Likelihoods

Remediations

Total budget

Analysis Framework

Model

Optimization /
Ranking Tools

Ranked Consequences

22

Optimization

Allocation of funds to minimize expected consequences

Tree

Likelihoods { ○○○ }

Remediations { ⓡ ⓡ }

Total budget ($)

Model

Optimization / Ranking Tools

Input Parameters

Analysis Framework

(C, ⑤ , … , …. , ⑤)
(C, ⑤ , … , …. , ⑤)
(C, ⑤ , … , …. , ⑤)
(C, ⑤ , … , …. , ⑤)

Ranked Consequences

System Architecture

IUs

Capability leaders

Total Funding
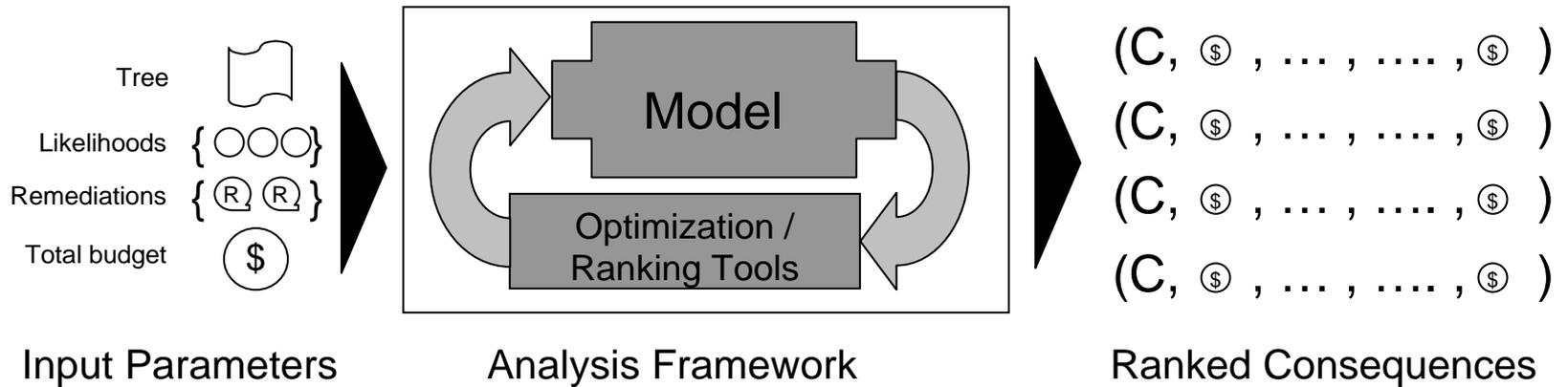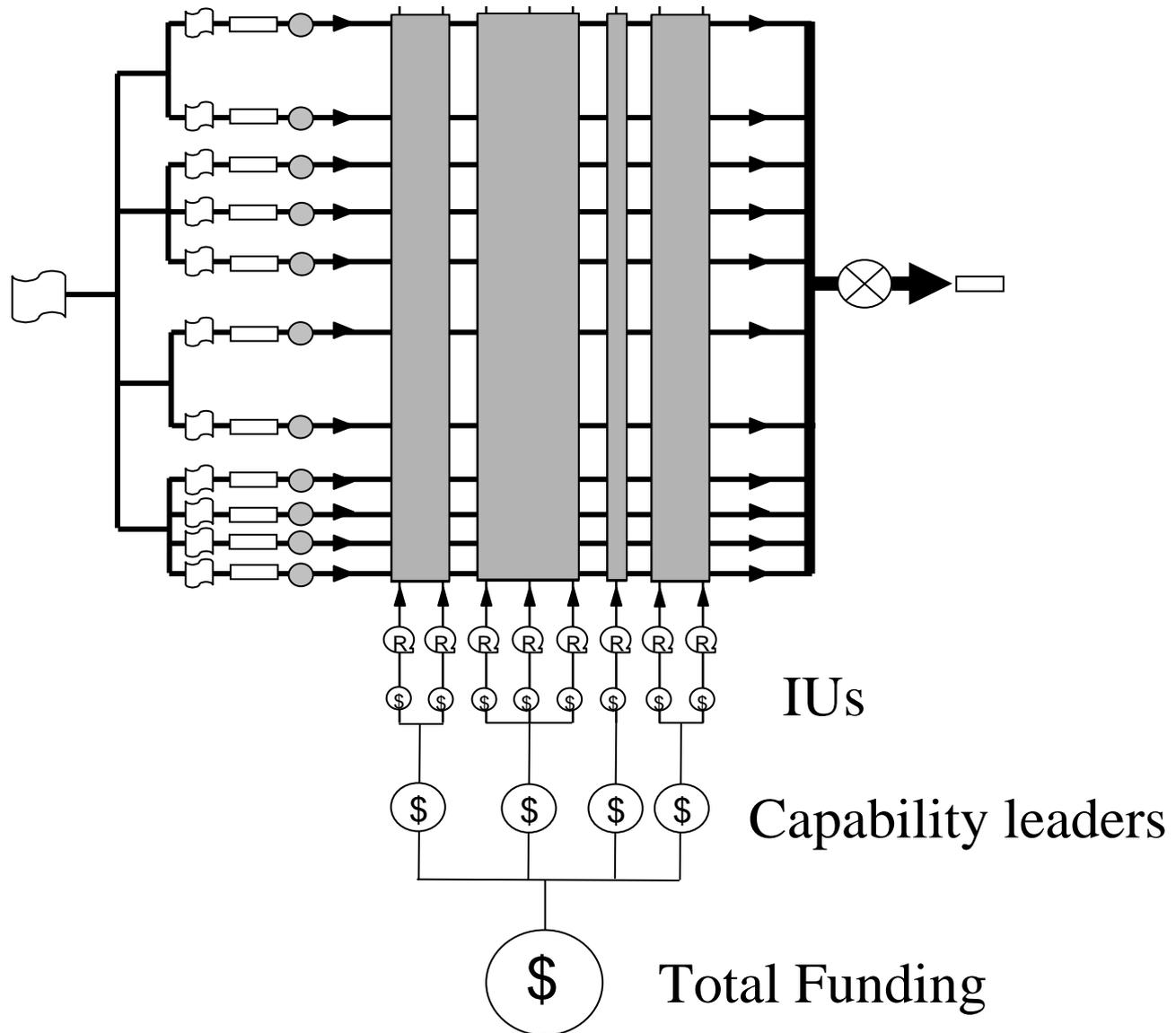
MIDST Visualization Features

- 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
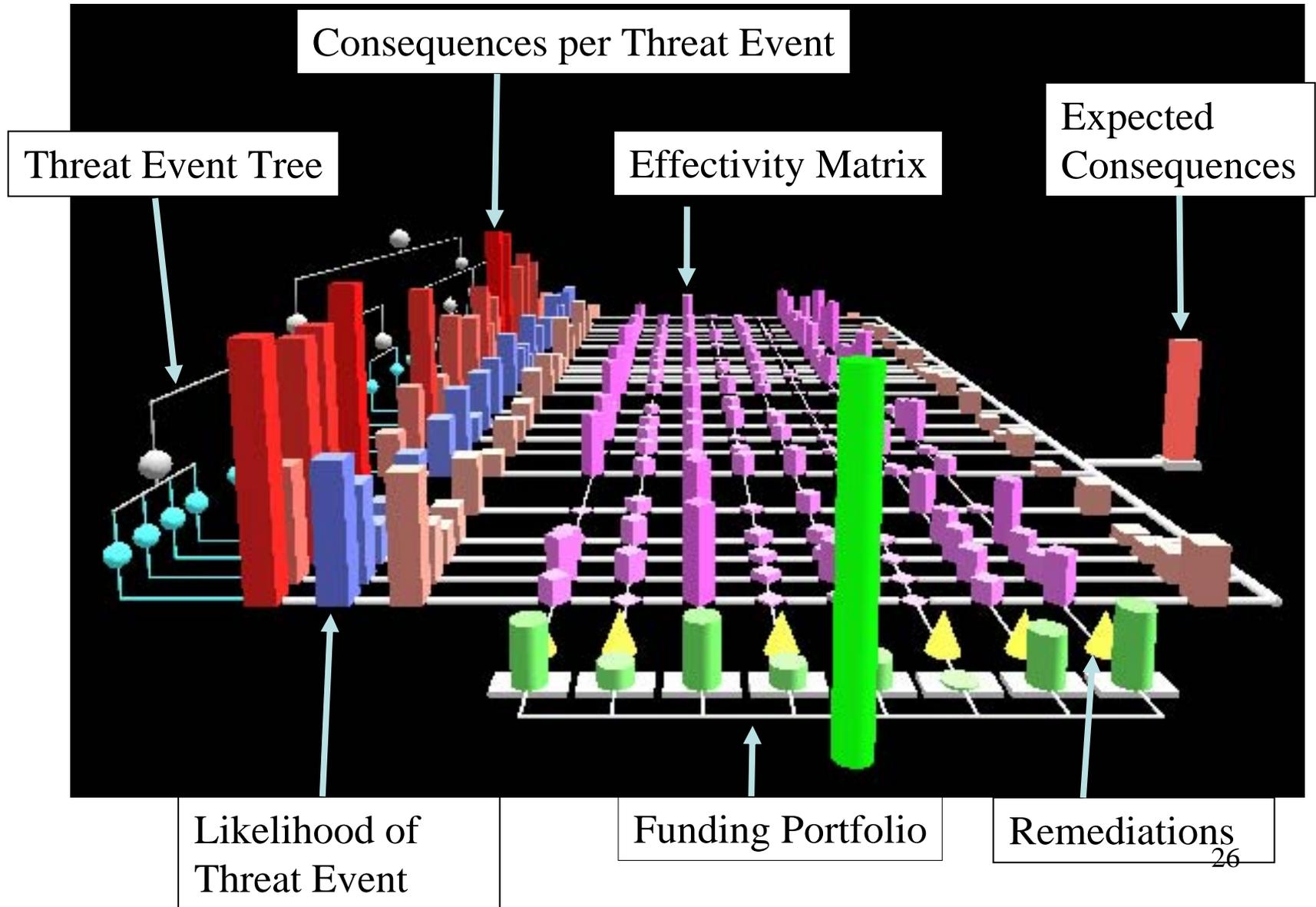
Consequences per Threat Event

Threat Event Tree

Effectivity Matrix

Expected Consequences

Likelihood of Threat Event

Funding Portfolio

Remediations

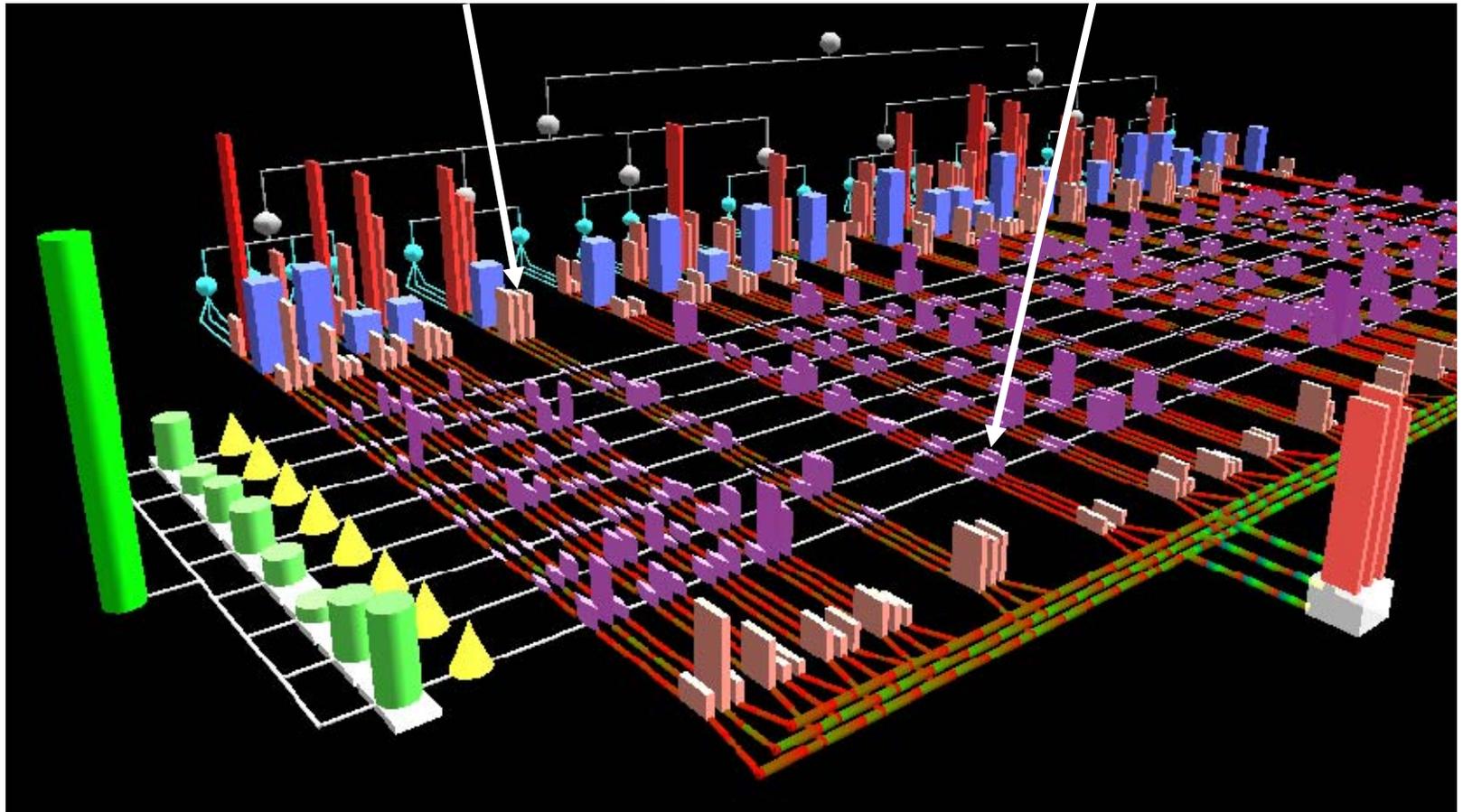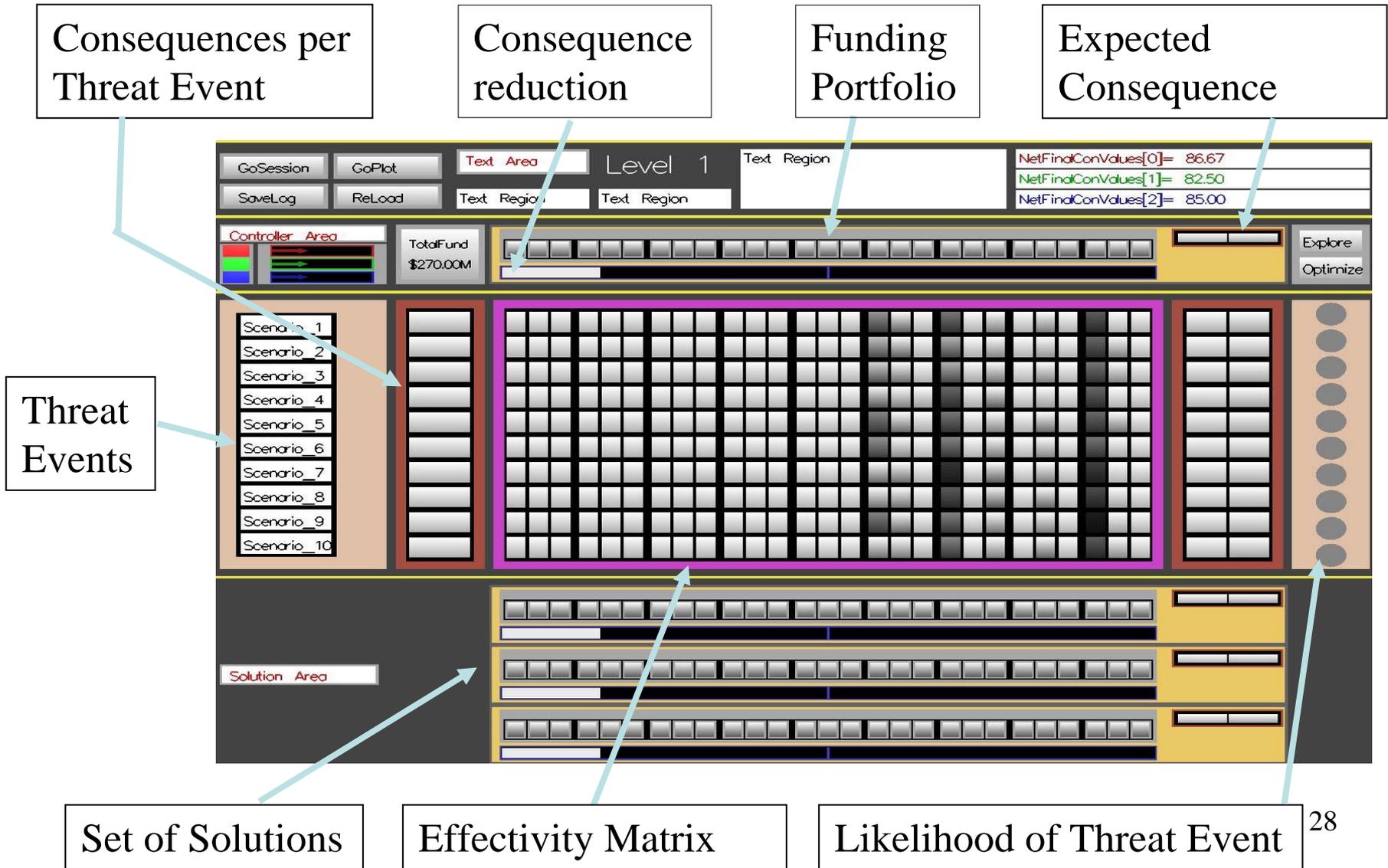# Visualization of MIDST Architecture

Multicomponent consequences

Multicomponent effectivities

2nd Visualization Model of MIDST

Consequences per Threat Event

Consequence reduction

Funding Portfolio

Expected Consequence

Threat Events

GoSession	GoPlot	Text Area	Level 1	Text Region	NetFinalConValues[0]= 86.67
SaveLog	ReLoad	Text Region	Text Region		NetFinalConValues[1]= 82.50
					NetFinalConValues[2]= 85.00

Controller Area

TotalFund $270.00M

Explore

Optimize

Scenario_1
Scenario_2
Scenario_3
Scenario_4
Scenario_5
Scenario_6
Scenario_7
Scenario_8
Scenario_9
Scenario_10

Solution Area

Set of Solutions

Effectivity Matrix

Likelihood of Threat Event
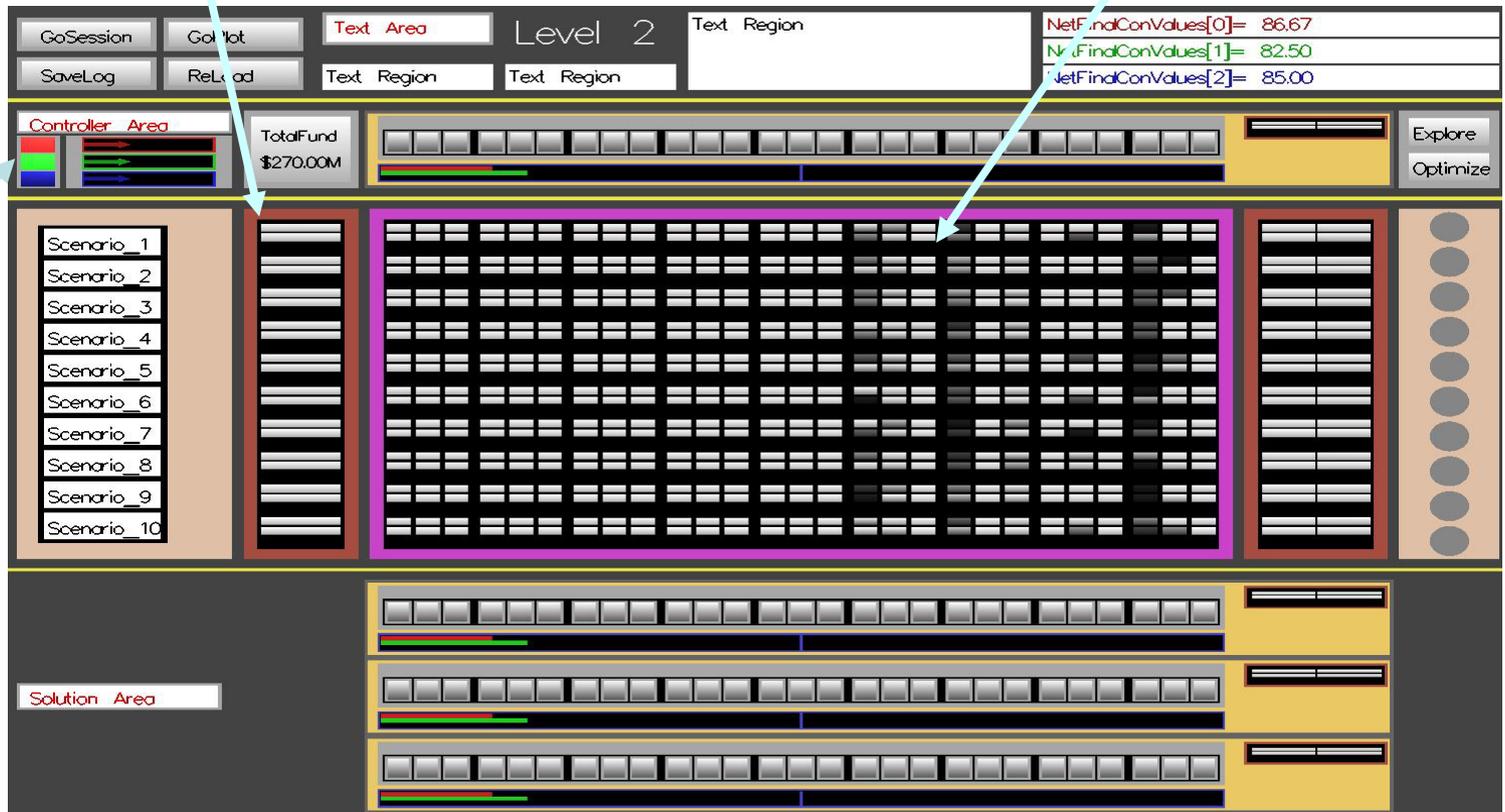
Visualization of MIDST Architecture

Multi-component consequences

Multi-component effectiveness

Component buttons

GoSession	GoPlot	Text Area	Level 2	Text Region
SaveLog	ReLoad	Text Region	Text Region	

NetFinalConValues[0]= 86.67
NetFinalConValues[1]= 82.50
NetFinalConValues[2]= 85.00

Controller Area

TotalFund $270.00M

Explore

Optimize

Scenario_1
Scenario_2
Scenario_3
Scenario_4
Scenario_5
Scenario_6
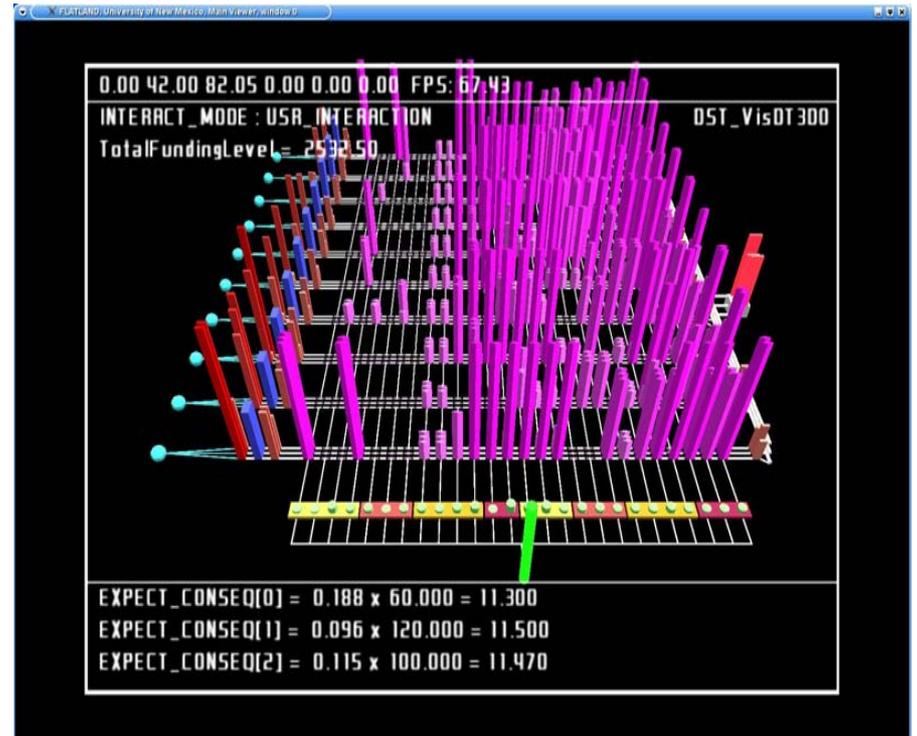Scenario_7
Scenario_8
Scenario_9
Scenario_10

Solution Area

Visualization with real data
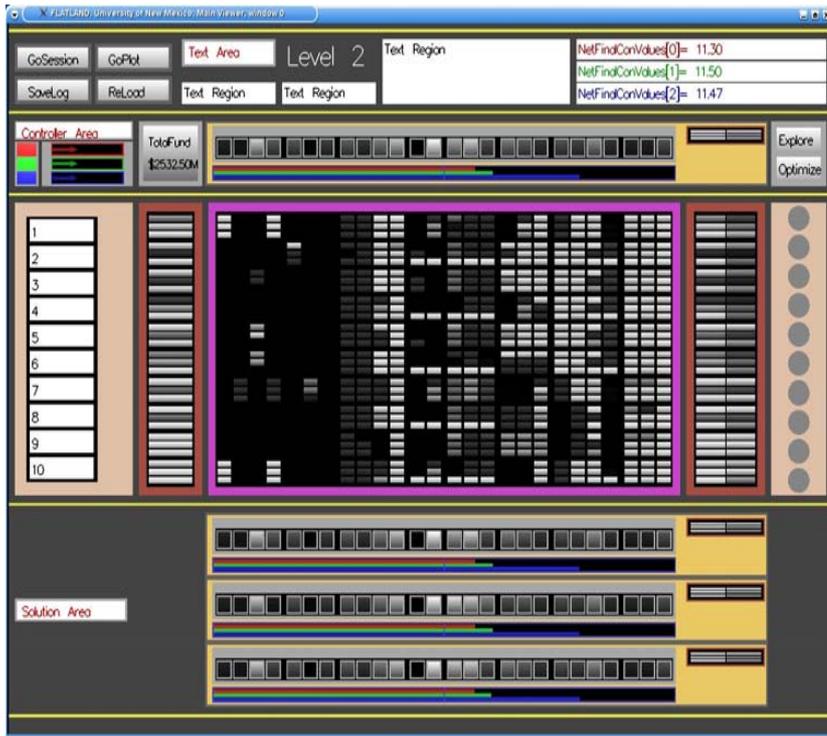
| 2D version | 3D version |

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.

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