COAction: Enabling Collaborative Option Awareness for Joint Actions

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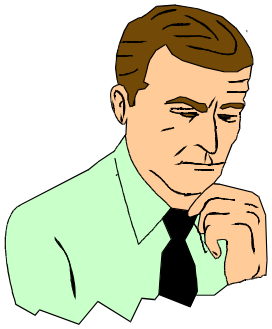
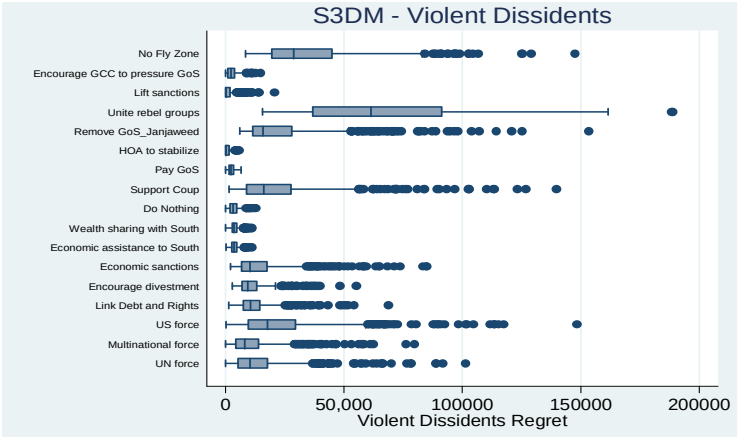
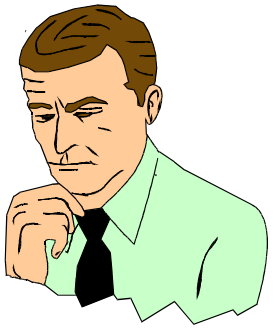
Core Idea

Let decision makers *jointly* visualize more futures and choose an option that will work in them







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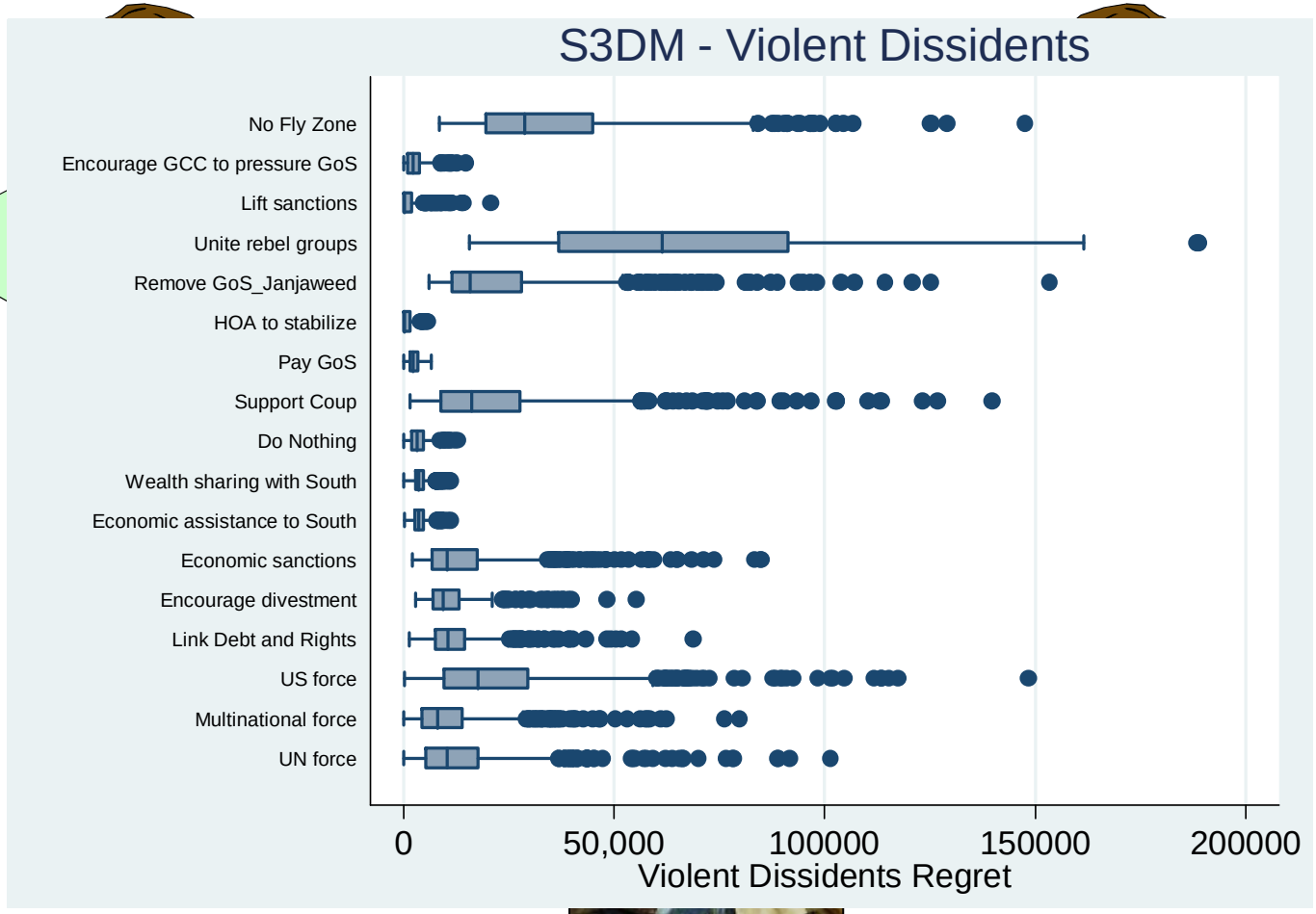
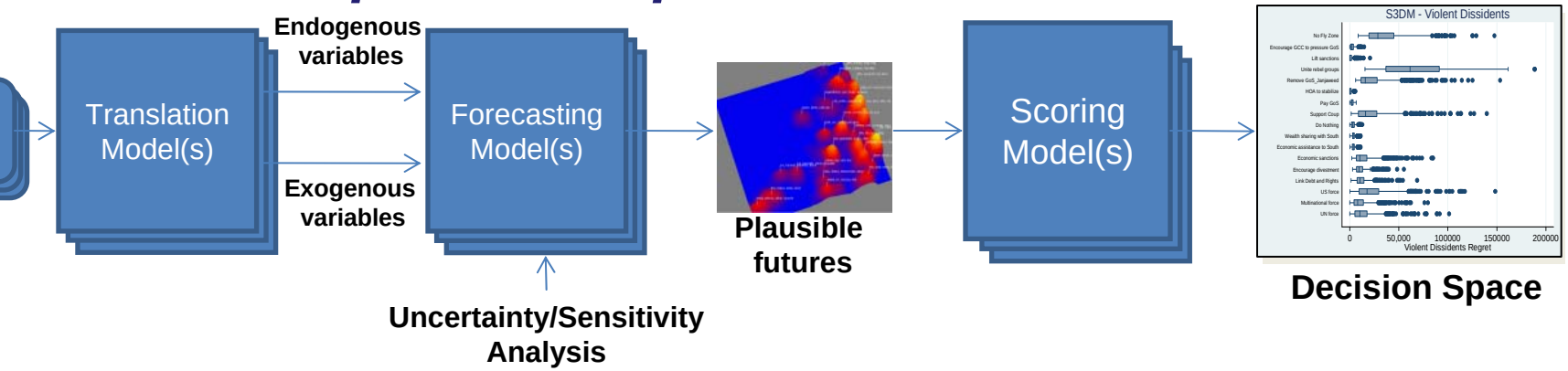


Consider the usual military decision-making process (MDMP)…

- 3 options for courses of action
- Assumptions regarding the conditions that are beyond decision-makers' control
- A handful of projected outcomes

Photo: Army Joint Support Team, usacac.army.mil/cac2/AJST

A landscape of plausible futures
A *Decision Space* for *Option Awareness*



Translate options into endogenous and exogenous variables for forecasting model

- For Joint Intelligence Preparation of the Environment these would be factors of interest
- For option development/analysis these would be expressions of alternative options
- Endogenous variables express options and factors
- Exogenous variables are uncontrolled but interact with endogenous variables according to model

Design and run an exploratory modeling experiments to generate a landscape of plausible futures:

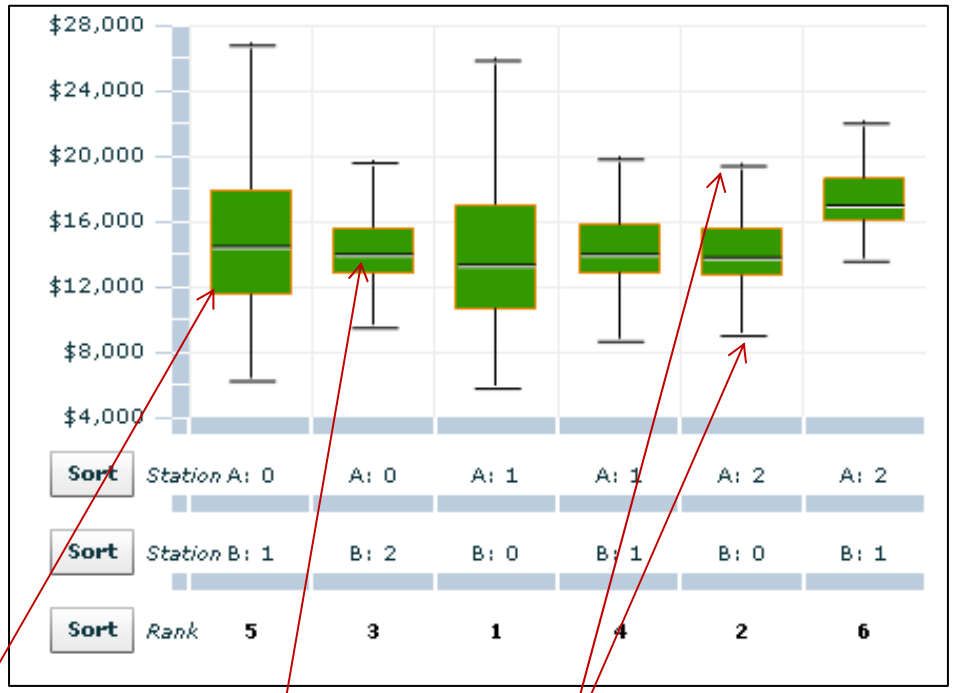
- Explore different models to express Human Social Culture Behavior relationships
- Explore translation of options into variables
- Sensitivity/Uncertainty Analysis to explore probability distributions of values for variables

Score model outputs, translating into common Measure of Force/Policy Effectiveness

- Multiple scoring models can also be explored
- Decision Space enables option awareness

Displaying outcome frequencies not probabilities

- **Reduces decision "biases"**
- **Scoring futures by cost – emergency response example**
  - **sending the trucks**
  - **the immediate damage that occurred**
  - **damage that might occur elsewhere in the near future because the committed trucks are now unavailable**
- **Provides the ability to compare options and ultimately understand the underlying factors – "Option Awareness"**



Box defines range of costs for cases in 25th – 75th percentiles (inter-quartile range, or IQR)

Line in box indicates cost of median case

Upper and lower whiskers indicate costs of 1.5 * IQR

n emergency response example:
ow many resources and from where?

User Inputs

Event Description

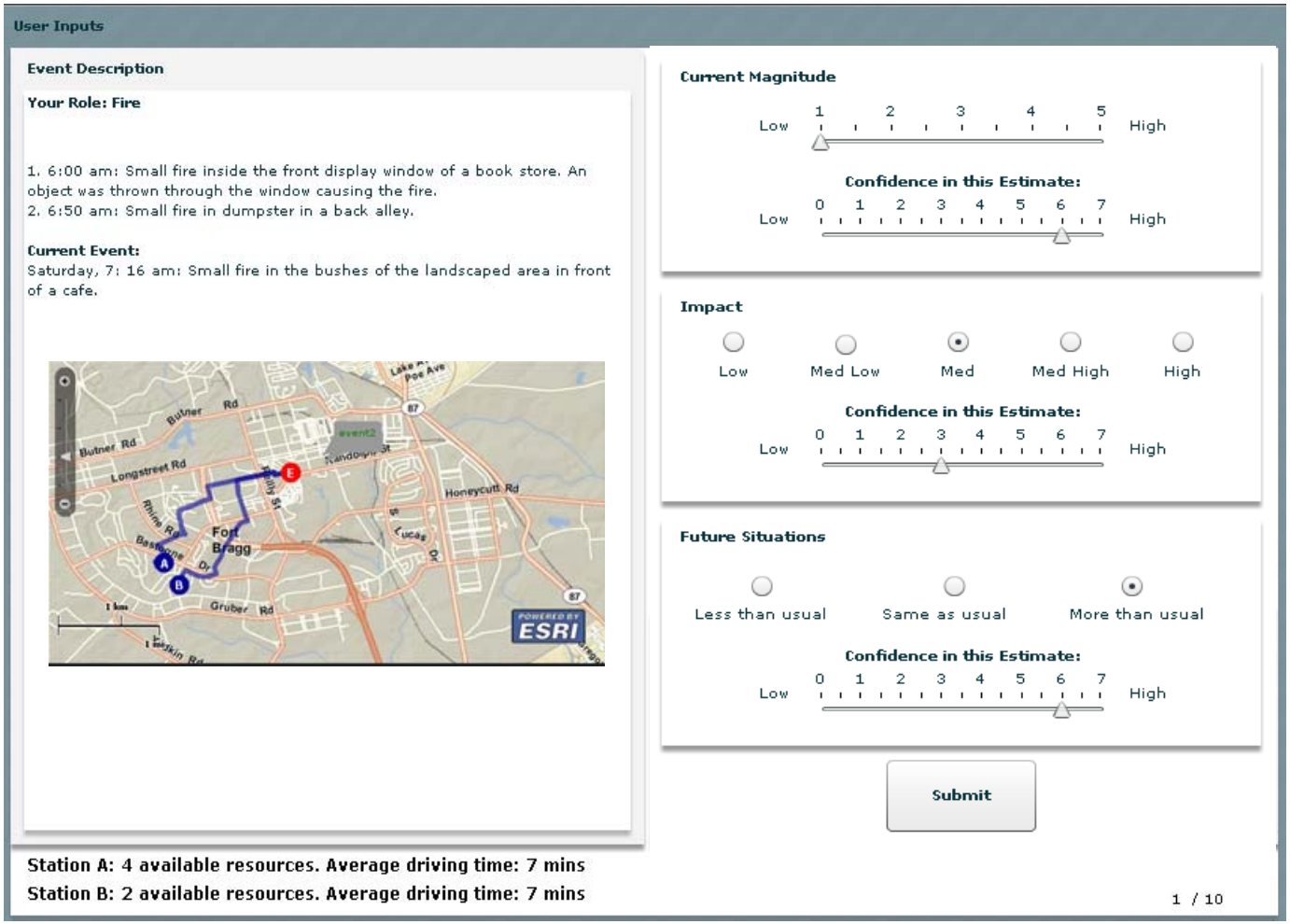
Your Role: Fire

1. 6:00 am: Small fire inside the front display window of a book store. An object was thrown through the window causing the fire.
2. 6:50 am: Small fire in dumpster in a back alley.

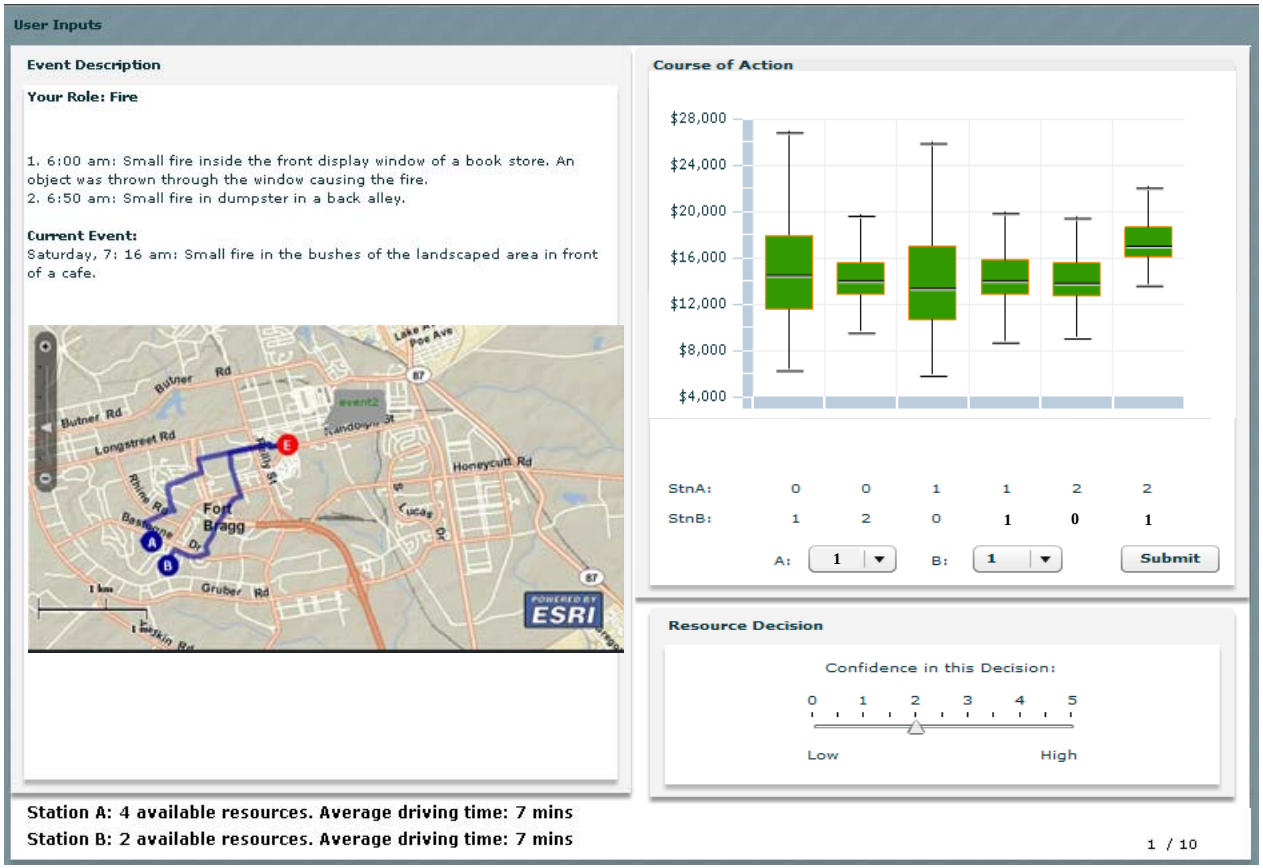
Current Event:
Saturday, 7: 16 am: Small fire in the bushes of the landscaped area in front of a cafe.

Station A: 4 available resources. Average driving time: 7 mins
Station B: 2 available resources. Average driving time: 7 mins

uman judgment and experience translates the ualitative situation space into forecasting put values

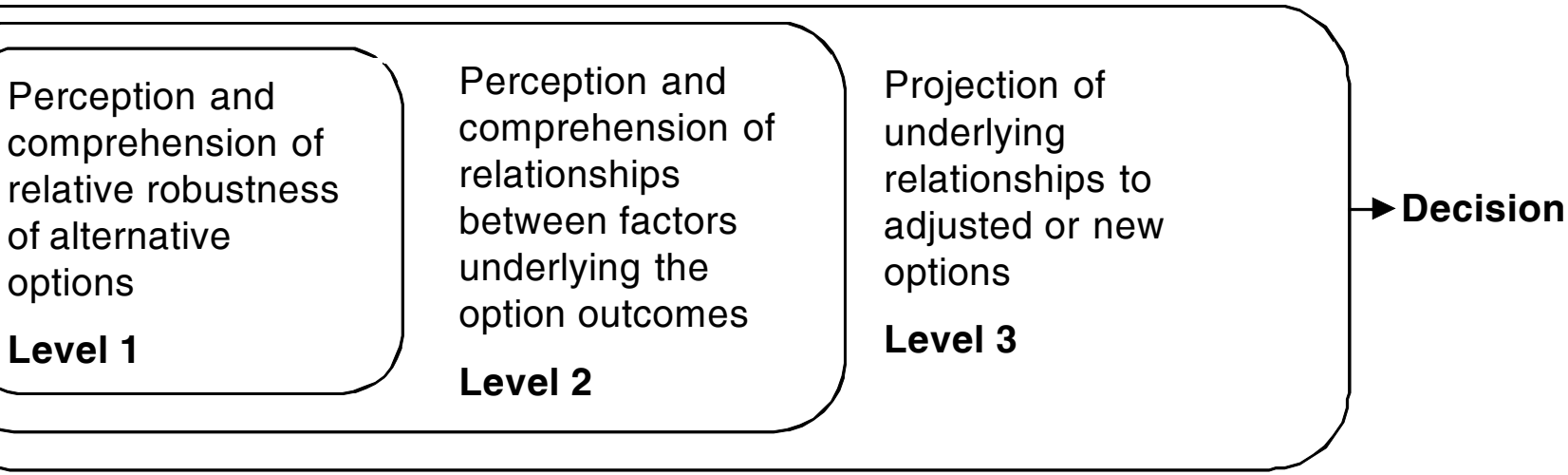


he computer generates the landscape
he decision maker assesses the terrain



There are 3 levels of Option Awareness Level

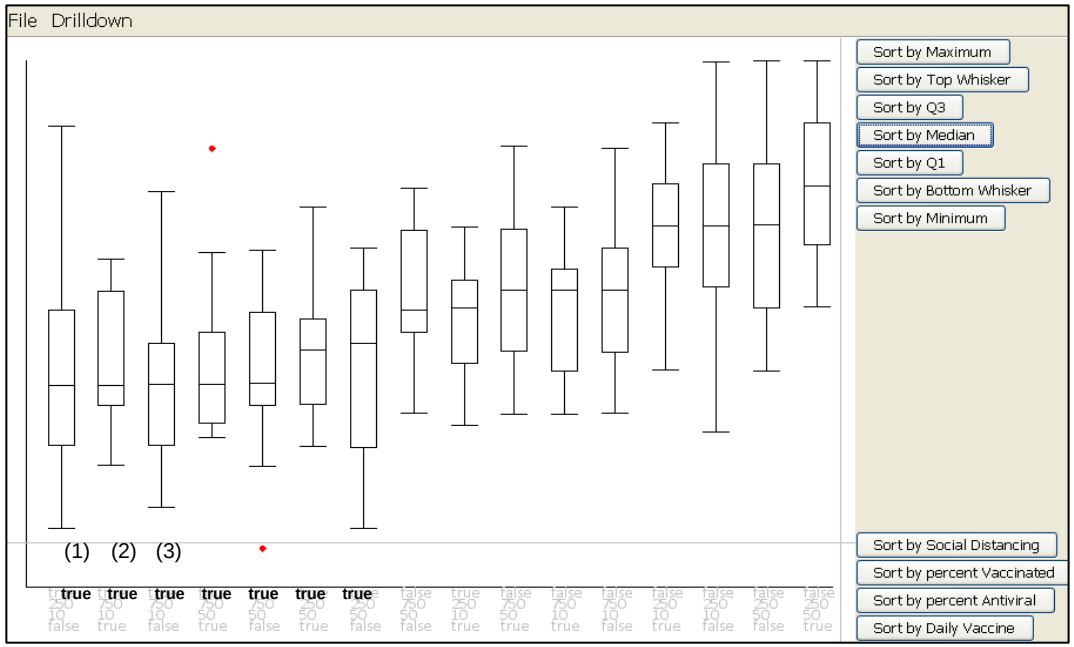
- **The examples so far have described only Option Awareness Level-1**
- **Our most recent work has led to defining 3 levels**
- **These are analogous to the levels of Situation Awareness defined by Endsley (2000)**



Supporting Levels 2 & 3 have significant implications for interface designs

Enabling Levels 2 & 3 to support human creativity
A disease spread model example

- ial distancing clearly leads to er cost outcomes (Level-1)
- uld one choose the est median cost option (1) or est max cost option (2) or re robust" option (3)?
- down enables an loration of conditions erlying outcomes (Level-2)
- The (red) outlier on option (1) received less than targeted antivirals
- atively modifying option (1) ld mitigate this condition vel-3):
  - Quality assurance to ensure antivirals > 10%
  - Set antiviral target to 10.5%
- running the model with lified options can assess r impact



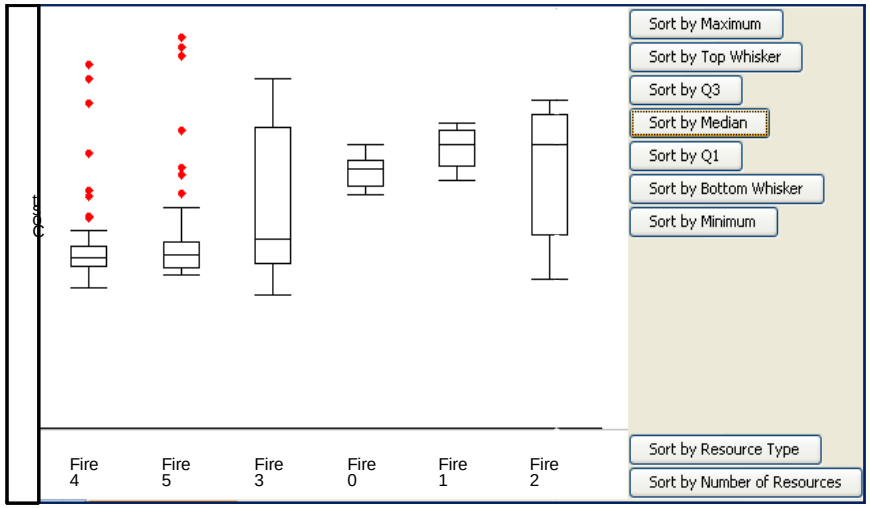
he next step is *collaborative* option awareness

Example: fire at a Medical Center

- **Magnitude-3**
- **5:37 pm on Saturday, just as the football game is ending**
- **The traffic will create significant congestion en route to the fire**

Fire Chief's individual decision space is below (right)

- **Implies sending 4 trucks is the most robust option**



Traffic congestion from police perspective

Meanwhile, the Police Chief must decide how many squad cars to send to handle the football game traffic

Sending 2 squad cars is the most robust choice from the Police Department's point of view

Police Chief's Individual decision space

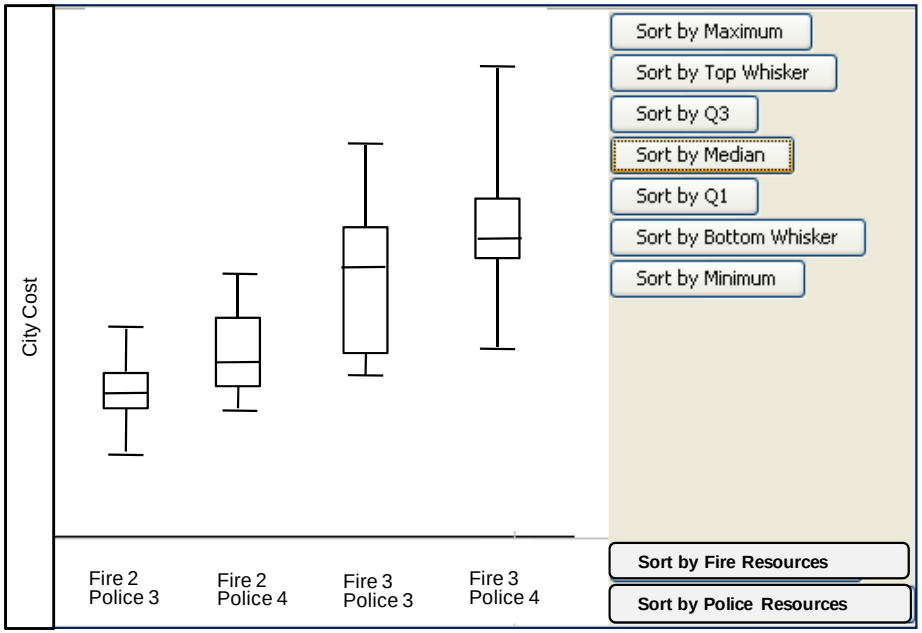
ut sending 4 fire trucks and 2 squad cars ignores the two departments' interdependence and possible synergy

Joint action decision space → synergy

Sending at least 3 squad cars can result in diminishing the traffic to ensure that fire trucks can get to the fire quickly

Thus only 2 fire trucks are needed in this joint decision space

Result is lower total cost and safer *city*



Fire and Police joint decision space

COAction Human-in-Loop research

Forecast Model Fidelity	Interface	Decision Support
High	Situation Estimates	Situation Only
		Situation + Decision
High	Situation Estimates Decision Space	Situation + Decision

Individual Decision Space	Collaborative Decision Space: Yes	Collaborative Decision Space: No
Yes	Both Decision Spaces	Only Individual Decision Space
No	Only Collaborative Decision Space	Only Situation Space

- **Experiment 1:**
  - **Single decision maker in a single department coordinates resources across multiple sub-units**
  - **Interdependence among the sub-units will introduce the complexity of synergistic joint action**
  - **The outcomes will be scored from a single perspective**
- **Experiment 2:**
  - **Two decision makers in different departments**
  - **Collaborative decision spaces based upon a super-ordinate scoring model**
  - **Scenarios can be designed so that the most robust option for joint action will conflict with the most robust options in the individual decision spaces**

Evaluation completed so far

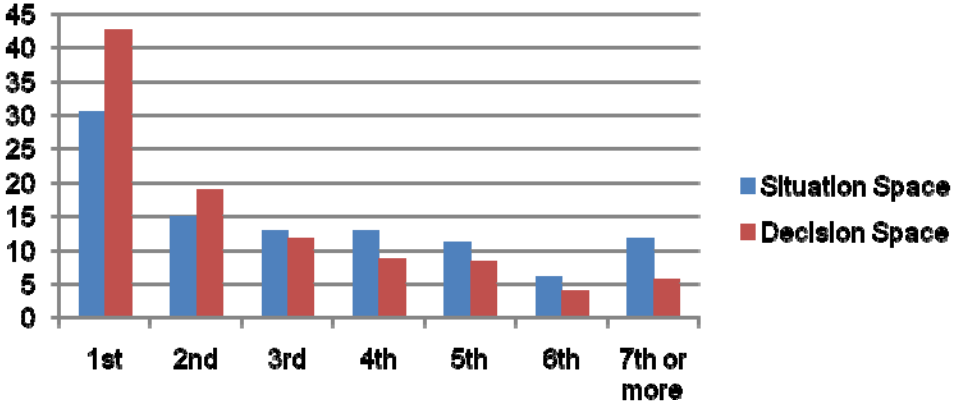
Exper. #	Forecast Model Fidelity	Interface	Decision Support
1a	High	Situation Estimates	Situation Only
			Situation + Decision
1b	High	Situation Estimates Decision Space	Situation + Decision

- **Mixed design**
  - **Between subjects: One group (the SS group) received text + map; the other group (the DS group) received text, map, and a box plot visualization of the decision space**
  - **Within subjects: All participants received 10 complex and 10 simple scenarios**
- **Procedures**
  - **Training – written material and interactive practice environment**
  - **Estimating input parameters and confidence, choice and confidence**
  - **Post-evaluation survey of subjective impressions of decision support plus cognitive traits possibly affecting decisions**

Results

H1: The DS group will choose more robust options than the SS group

- **Supported**
- **DS group selected the first-ranked option 42.67% of the time vs. 30.56% for SS group**
- **DS group selected options not among the top six 5.67% of the time vs. 11.67% for SS group**



H2: the DS group will be more confident in their decisions

- **Not supported**

H3: simple decisions will be made faster than complex decisions

- **Supported**
- **Decision times for simple events were much faster (*M* = 9.42 (12.45 seconds), *SE* = 0.07) than those for complex events (*M* = 9.63 (15.16 seconds), *SE* = 0.07), *F*(1,22) = 14.75, *p* < .001**

Results, cont.

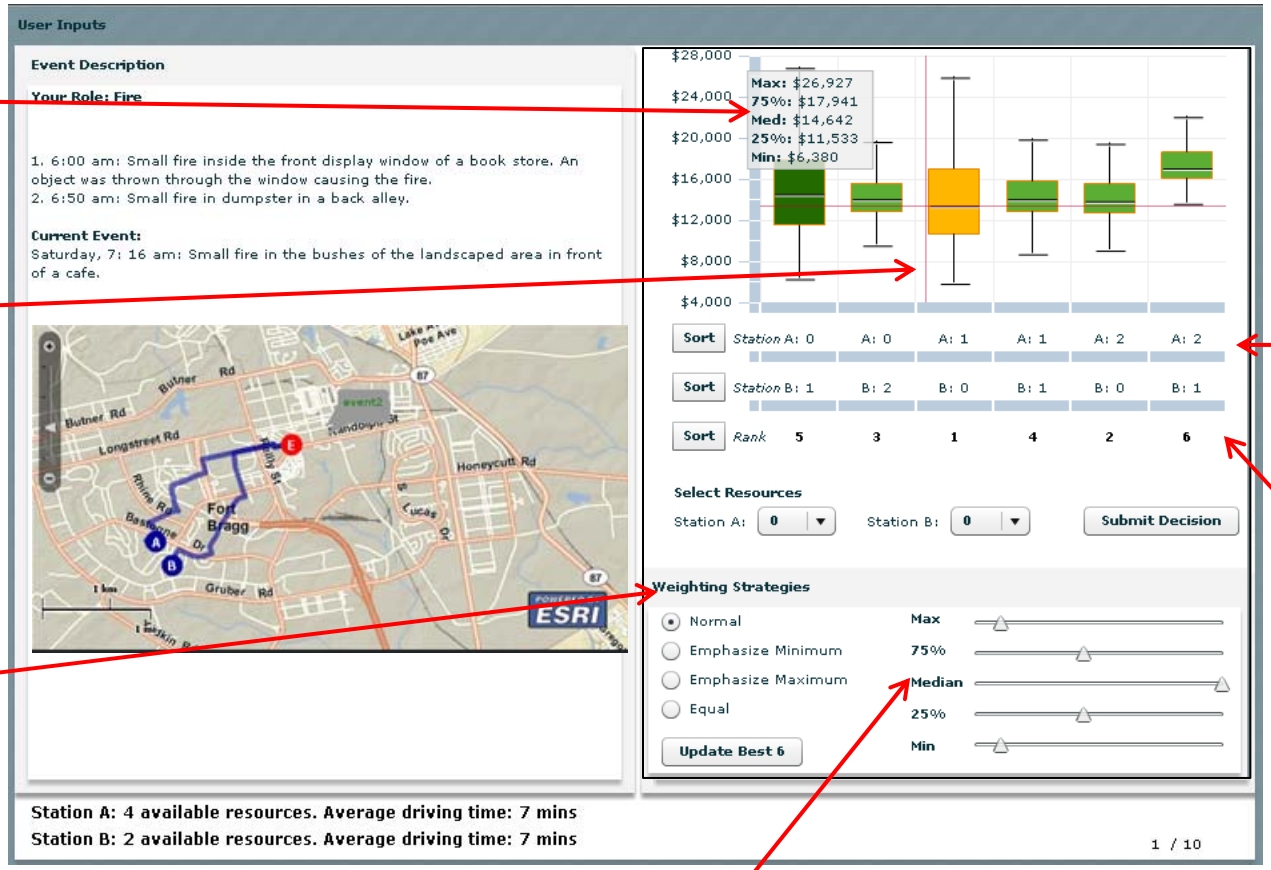
H4: the DS group will give higher scores for the quality of the event information than the SS group

- **Supported**
- **Higher ratings in the DS condition (*M* = 5.46, *SE* = 0.22) than the SS condition (*M* = 4.37, *SE* = 0.29), *F*(1,20) = 8.10, *p* < .05**

Massachusetts State Police review building diagrams during an active-shooter drill. Photo by MSgt Scott Crossman, 6 SWS First Sergeant.

- **H5: participants will under-allocate resources in anticipation of future events**
  - **Supported**
  - **Events rated as having "less than usual" likelihood of future events were only slightly under-allocated (*M* = -0.09, *SE* = 0.17), while under-allocation was much more pronounced for those rated "same as usual" (*M* = -0.50, *SE* = 0.16) and "more than usual" (*M* = -0.55, *SE* = 0.15), *F*(2,476) = 3.50, *p* < .05**

xperiment 1b provided additional training and reater ability to interact with decision space



b data with etails

hairs

ring

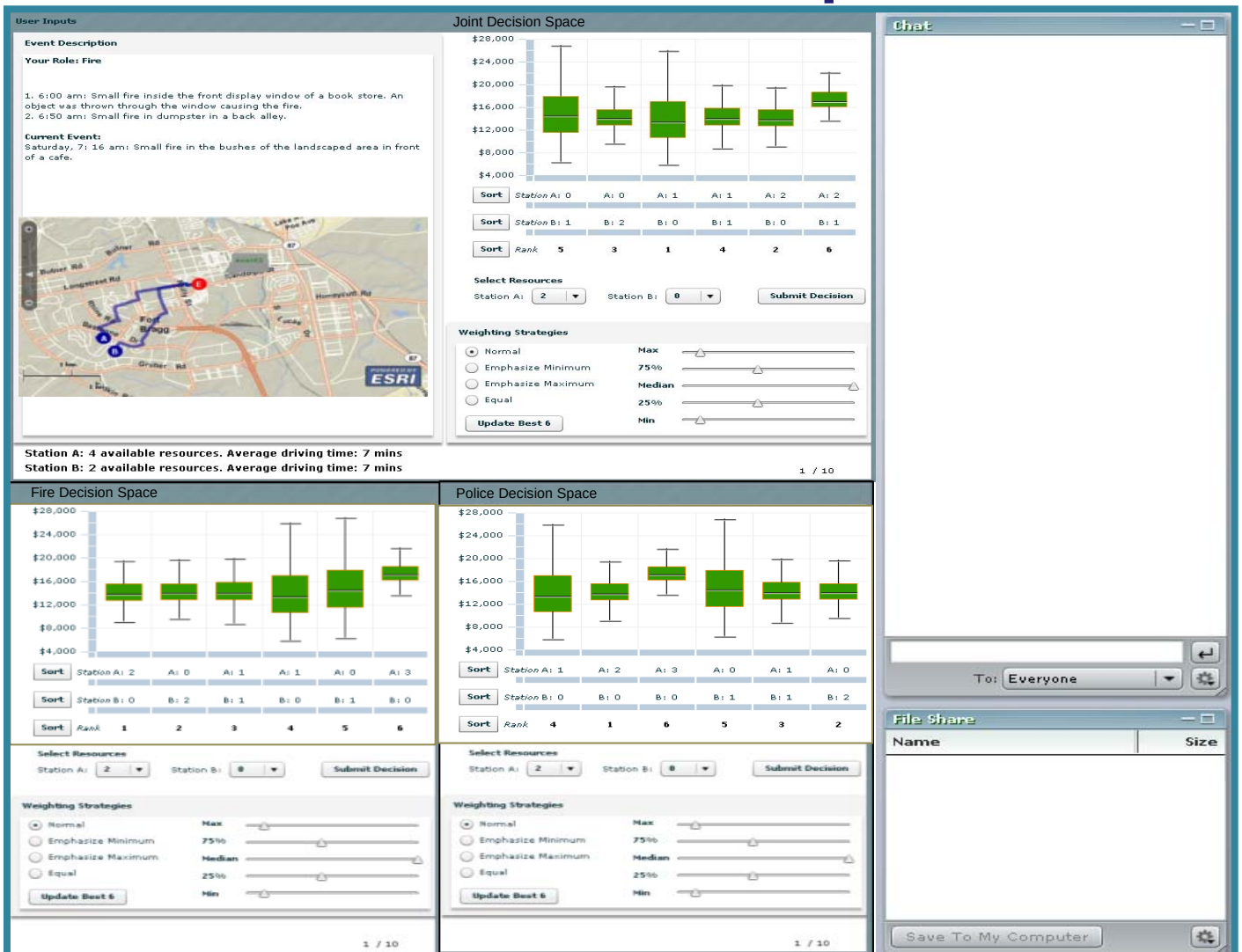
t ting gies

Sort order of the box plots is user selectable

The rank of each option is given here

Note that sliders graphically indicate the relative weighting of each of the box plot elements and can customize pre-sets

Collaborative Joint Action Interface will extend interactive decision space



Summary

- **Collaborative decision making should focus more on the decision space rather than (solely) the situation space**
- **We described the theoretical underpinnings for collaborative option awareness**
- **The research experiments will provide empirical data on whether collaborative decision spaces will yield collaborative option awareness that will result in more correct and confident collaborative decision making**
- **The goal is to enable more robust tactical collaborative decision making even under the most difficult conditions**