

Cognitive Support for Transportation Planners: A Collaborative Course of Action Exploration Tool 16th ICCRTS

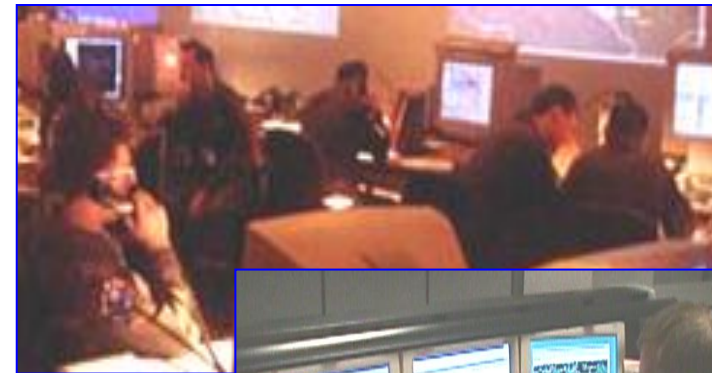
Beth DePass
Raytheon BBN Technologies

Collaborators:
Ron Scott, Chris Guin, Rob Truxler - Raytheon BBN
Technologies
Emilie Roth - Roth Cognitive Engineering
Jeffrey Wampler - AFRL Human Effectiveness
Directorate

Domain: Military Transportation Planning

Objective: Prototype a tool to support development of transportation Courses of Action (COAs) for USTRANSCOM

- **COA:** A transportation plan to move sets of cargo and passengers throughout the world.
 - What vehicles?, What routes?, What ports?
- USTRANSCOM directs 3 transportation component commands that cover air, sea, and ground movements
 - > 1500 air missions / week
 - > 10,000 ground shipments / week
 - 25 ships around the world
- Long Range Transportation Needs Planning
- Rapid Response to Emerging Transportation Needs



Research Challenge

- Develop a rapid COA exploration tool, uniquely *designed around the cognitive workflow* of experienced planners
- Allow a planner to *quickly and effortlessly* investigate multiple potential plans
- Extend work-centered approach to design of *collaborative systems* that rely on *opaque automated problem-solving* technologies
- In our case: A tool that automatically evaluates transportation plans based on *simulation technology*

Work-Centered Design and Symbiotic Planning

- The Human Effectiveness Directorate of the Air Force Research Lab (AFRL/RH -Wright-Patterson) has been successfully demonstrating Work-Centered Support Systems (WCSS) since 2001.
- Work-Centered Design is based on principles of Cognitive Engineering, coming out of the realm of cognitive psychology and human factors.
- Symbiotic Planning focuses on building systems in which human operators collaborate with opaque automated support tools to produce solutions better than either one could do alone.

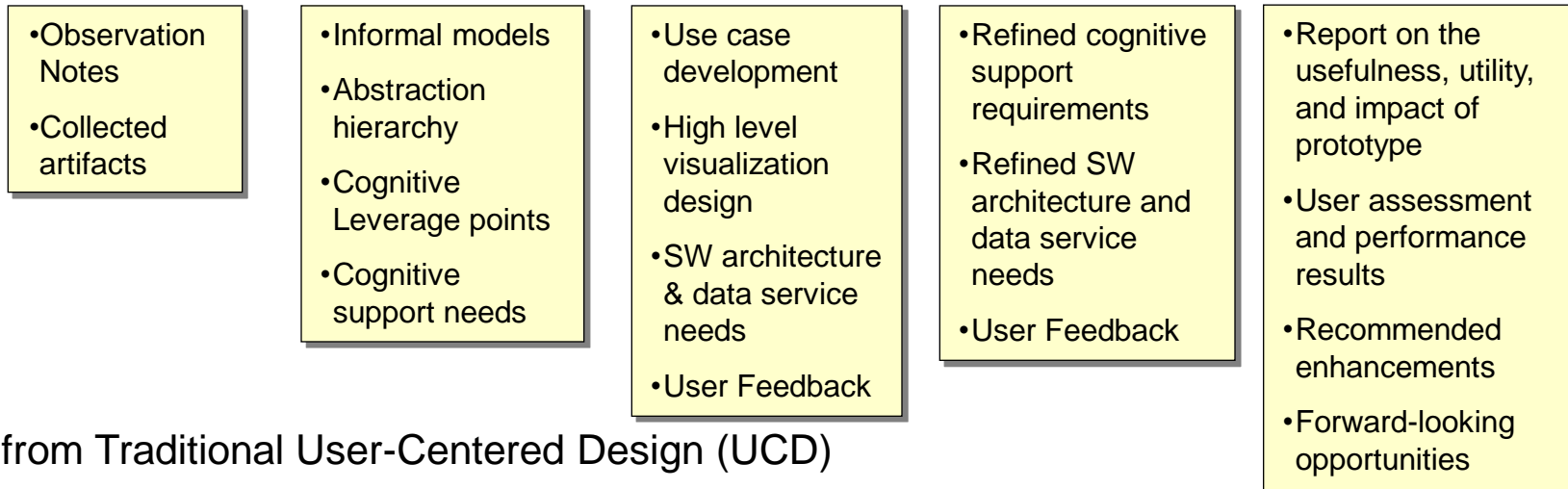
Work Centered Design Process

Stages:



Discovery is a constant process ...

Products:



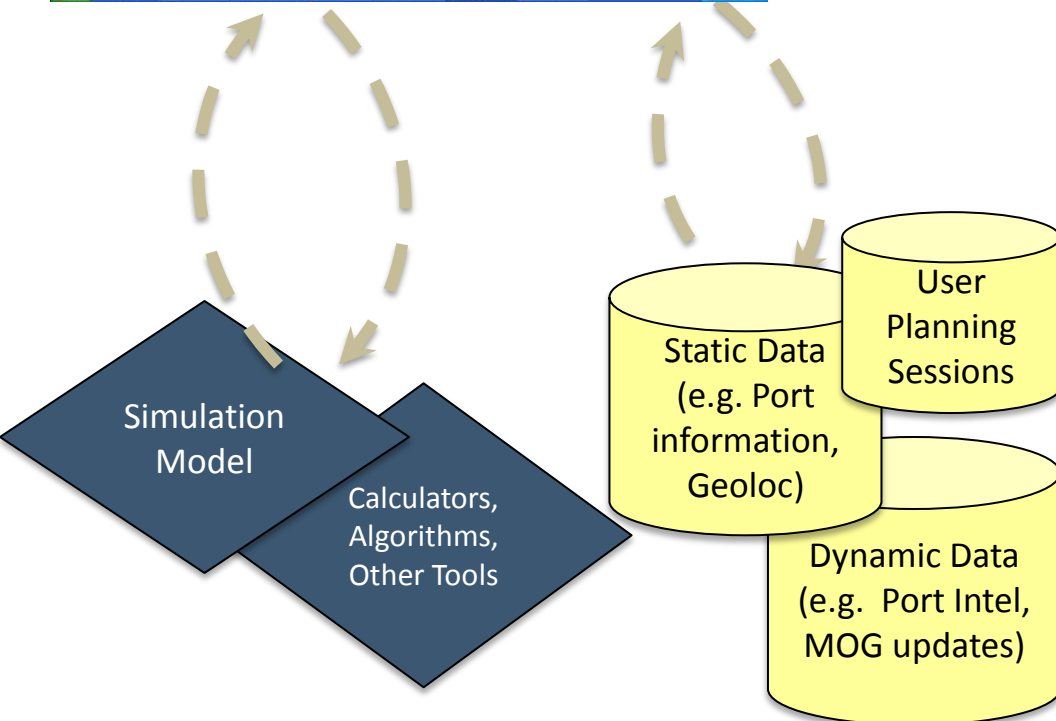
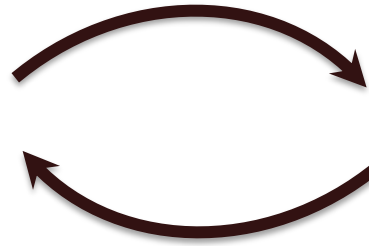
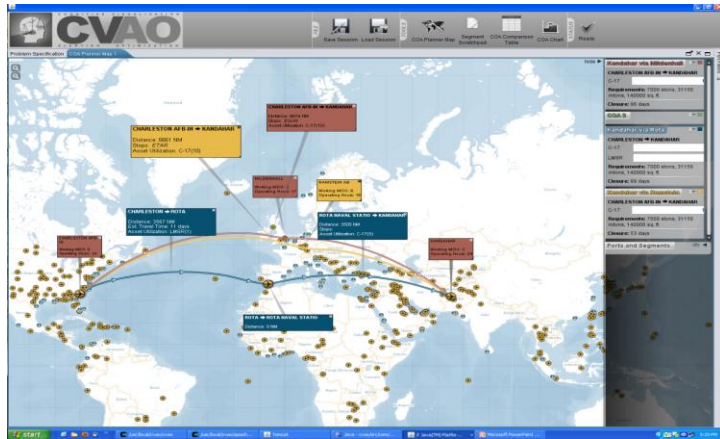
- Differs from Traditional User-Centered Design (UCD)
- Focus on the work domain from a user's perspective, rather than on specific task/process
- GOAL - make constraints and complex relationships in the work environment perceptually evident (e.g. visible) to the user in an easily accessible and coherent fashion

This approach accelerates implementation of features that significantly reduce cognitive burden

Rapid Course of Action Analysis Tool (RCAT) Prototype

- Leverages existing simulation models of strategic air and sea movements (originally developed for long term planning)
- Overcomes model limitations:
 - Require significant expertise to set up and run
 - Require extensive precise data inputs (cargo details)
 - Take on the order of hours to run
 - Highly opaque (no ability to view or modify planning assumptions)
- Adapted to enable rapid COA exploration in situations where:
 - Emerging events require rapid response
 - There may be gaps in knowledge and expertise (e.g., unfamiliar parts of the world)
 - Details of movement requirement are not known at the start (dynamically emerging)
 - ‘Rough’ (macro-level) planning is sufficient to support decision-making
 - Model assumptions may need to be modified

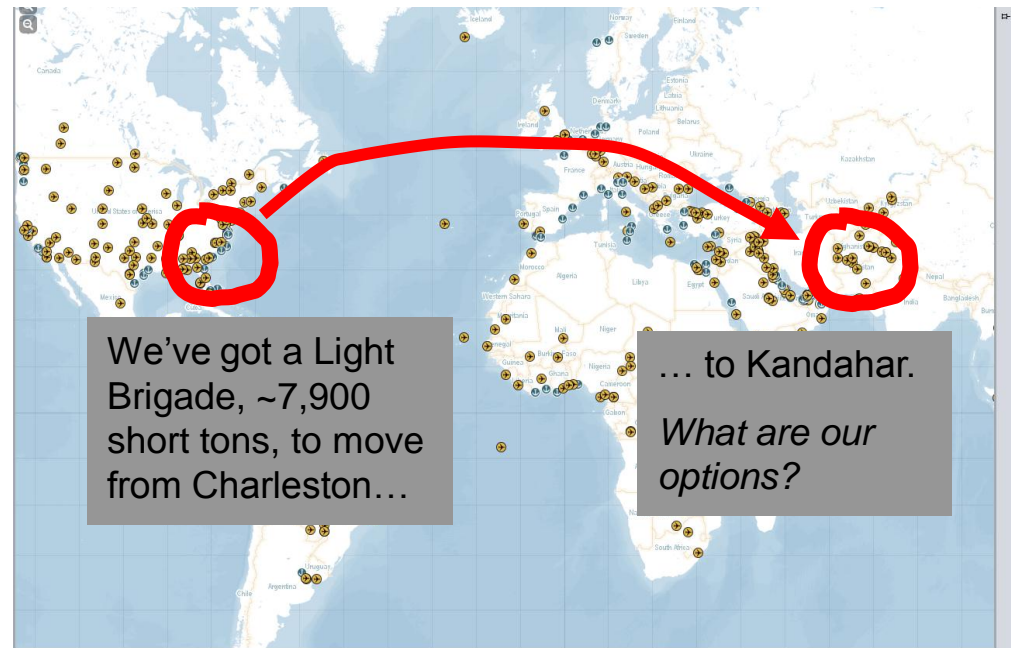
Rapid COA Analysis Human-System Interaction Model



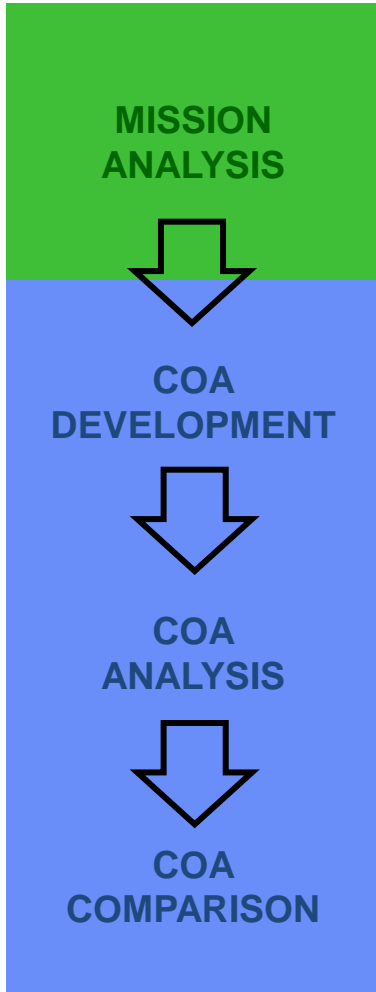
- User gestures trip automated data retrieval and model invocation processes
- Inputs/Outputs from data sources, algorithms, and models managed by the infrastructure
- Results from multiple underlying data and model sources are seamlessly displayed in the same user interface
- Response from sources must be **immediate** (seconds)

Rapid Transportation COA Development: An Example

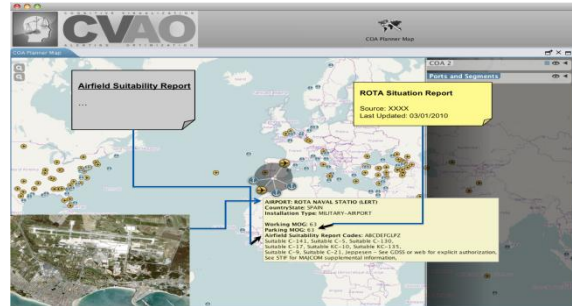
- Collaborative activity often conducted by a **Joint Planning Team**
- Requires consideration of multiple factors:
 - Mode of movement (air, sea, multi-modal)
 - Ports to be used
 - Number & mix of vehicles
 - Time to first delivery / total closure date
 - Cost
- Current process labor and time intensive
 - Can take hours to days to generate and compare multiple options.



RCAT Prototype Overview



Port Infrastructure Browser



COA Mapping



COA Comparison

Ports	Port Assumptions			Port Usage Per Plan		
	COA 1 - Air Direct	COA 2 - Rota	COA 3 - D. Garcia	COA 1 - Air Direct	COA 2 - Rota	COA 3 - D. Garcia
BEEM - Fort Lewis	10,000 ston/day (80%)	10,000 ston/day (80%)	10,000 ston/day (80%)			
FOED - Diego Garcia			10,000 ston/day (80%)			
FJGG - Diego Garcia NAF			500 ston/day (100%)			
DKFK - Charleston		40,000 ston/day (25%)				
UMCB - Rota Naval St		10,000 ston/day (40%)				
UMSA - Rota Air St		1,000 ston/day (15%)				
LYAV - Kandahar	150 ston/day (100%)	150 ston/day (100%)	500 ston/day (100%)			
	Cost: \$3.3K	Cost: \$3.3K	Cost: \$3.3K			
	Initial Arrival: 1 day	Initial Arrival: 34 days	Initial Arrival: 30 days			
	Closure: 46 days	Closure: 53 days	Closure: 37 days			
	# Platforms: 14 C-17s	# Platforms: 300 B-52s, 3 L-10s, 5 C-17s	# Platforms: 2 L-10s, 4 C-17s			
	Annotations:		moderate weather risk			

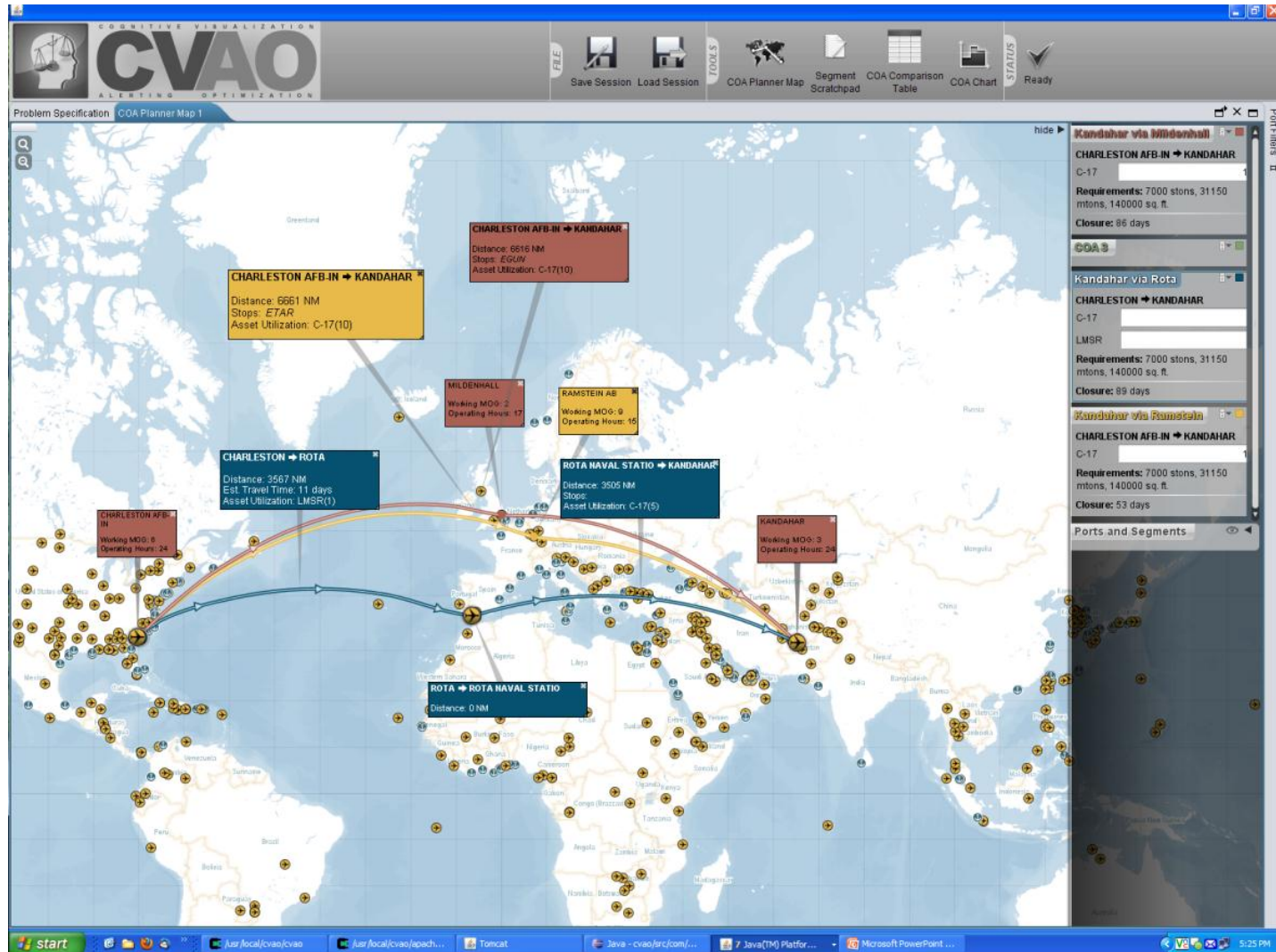
Segment Exploration



Graphical Port Utilization



Rapid Development and Comparison of Multiple Alternative COAs



Defining a Movement (Problem) Using Varying Detail

Allows users to enter problem specification at the level at which it is known

The screenshot displays the CVAO (Cognitive Visualization and Analysis) software interface. The main window is titled "COA Planner Map 1" and is divided into several sections:

- Mission Specification:** Includes fields for "Name" and "Required Delivery Date".
- Load Specification:** Features three radio buttons: "Based On Stons", "Based On 463L Pallets", and "Based On Notional Unit Type". The "Based On Notional Unit Type" option is selected, showing a dropdown menu set to "Light Brigade" with a value of "1" and a "Stons" field set to "7900". Below this, there are fields for "+/- Stons" and "Total Stons", both set to "7900".
- Load Details:** A table showing breakdowns for "Stons", "Mtons", and "Soft".

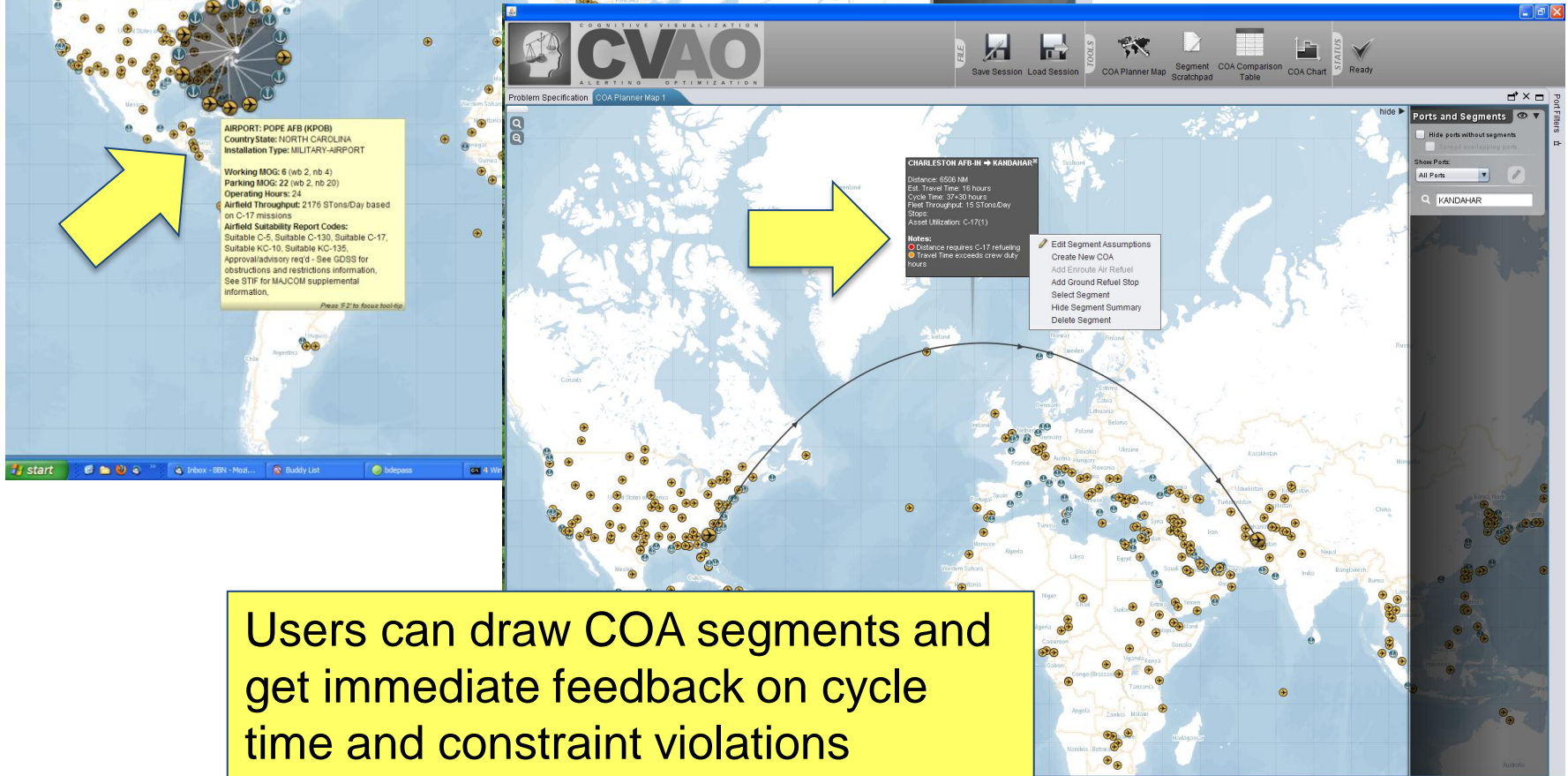
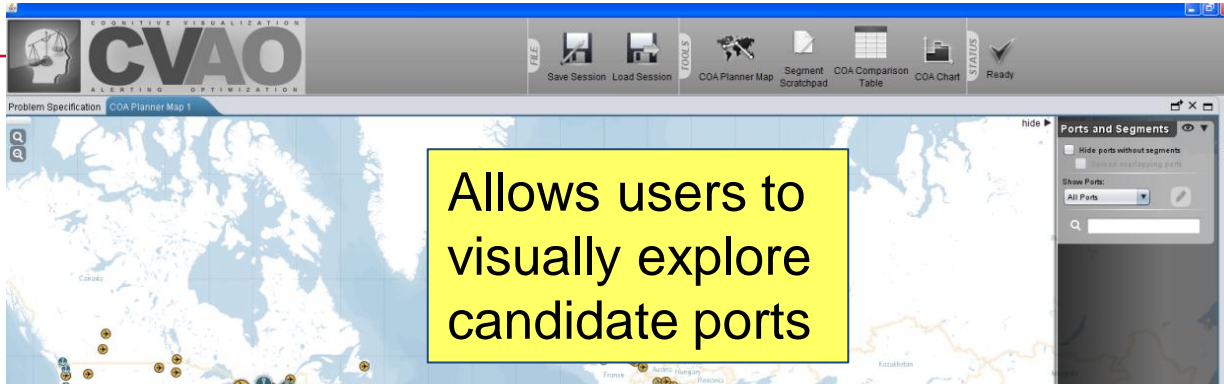
Category	Value	Category	Value	Category	Value
Total Stons	8308	Total Mtons	35155	Total Soft	237000
Bulk	2 % = 158	20 ft Container	17578	20ft Container	79000
Oversized	48 % = 3950	Wheeled	17578	Wheeled	158000
Outsized	51 % = 4200				
- Default Assets:** A section for selecting assets, divided into "Aircraft" and "Ships".

Aircraft	Value	Ships	Value
Gray Tail		Gray Bottom	
C-5	0	LMSR	1
C-17	5	CAPE_CLASS	0
C-130	0	FSS	0
KC-10	0	Commercial	
KC-135	0	RORO	0
Commercial		CONTAINER	0
B-747P	0		
B-747C	0		
Foreign Commercial			
IL-76	0		
AN-124	0		
- Mission Notes:** A section for entering notes.

Two yellow arrows point to the "Based On Notional Unit Type" section and the "Default Assets" section, highlighting the default values provided.

Default values are provided – that the user can inspect and over-ride as information becomes available

Port Browsing and Segment Exploration



AIRPORT: POPE AFB (KPOB)
Country/State: NORTH CAROLINA
Installation Type: MILITARY-AIRPORT
Working MOG: 6 (wb 2, nb 4)
Parking MOG: 22 (wb 2, nb 20)
Operating Hours: 24
Airfield Throughput: 2176 STons/Day based on C-17 missions
Airfield Suitability Report Codes: Suitable C-5, Suitable C-130, Suitable C-17, Suitable KC-10, Suitable KC-135,
Approval/Advisory req'd - See GDS3 for obstructions and restrictions information. See STIF for MAJCOM supplemental information.

CHARLESTON AFB-IR → KANDAHAR
Distance: 8206 NM
Est. Travel Time: 16 hours
Cycle Time: 27-30 hours
Fleet Throughput: 15 STons/Day
Status: Asset Utilization: C-17(1)
Notes:
• Distance requires C-17 refueling
• Travel Time exceeds crew duty hours

- Edit Segment Assumptions
- Create New COA
- Add Enroute Air Refuel
- Add Ground Refuel Stop
- Select Segment
- Hide Segment Summary
- Delete Segment

Rapid Development of COAs

CVAO
COGNITIVE VISUALIZATION
ALERTING OPTIMIZATION

Problem Specification COA Planner Map 1

CHARLESTON AFB-IN → KANDAHAR
Distance: 6661 NM
Stops: ETAR
Asset Utilization: C-17(5)

RAMSTEIN AB
Working MOG: 9
Operating Hours: 15

CHARLESTON AFB-IN
Working MOG: 6
Operating Hours: 24

KANDAHAR
Working MOG: 3
Operating Hours: 24

CHARLESTON AFB-IN → KANDAHAR
C-17: 5
Requirements: 7000 stons, 31150 mtons, 140000 sq. ft.
Closure: 103 days

Edit Assumptions for COA (COA 1)

Requirements
Total STons: 7000
Total Mtons: 31150
Total SqFt: 140000

CHARLESTON AFB-IN
6 (Working MOG)
24 (Operating Hours)

ENROUTE STOPS
RAMSTEIN AB Crew Change +... C-17: 3+15 hours

RAMSTEIN AB
9 (Working MOG)
15 (Operating Hours)

KANDAHAR
3 (Working MOG)
24 (Operating Hours)

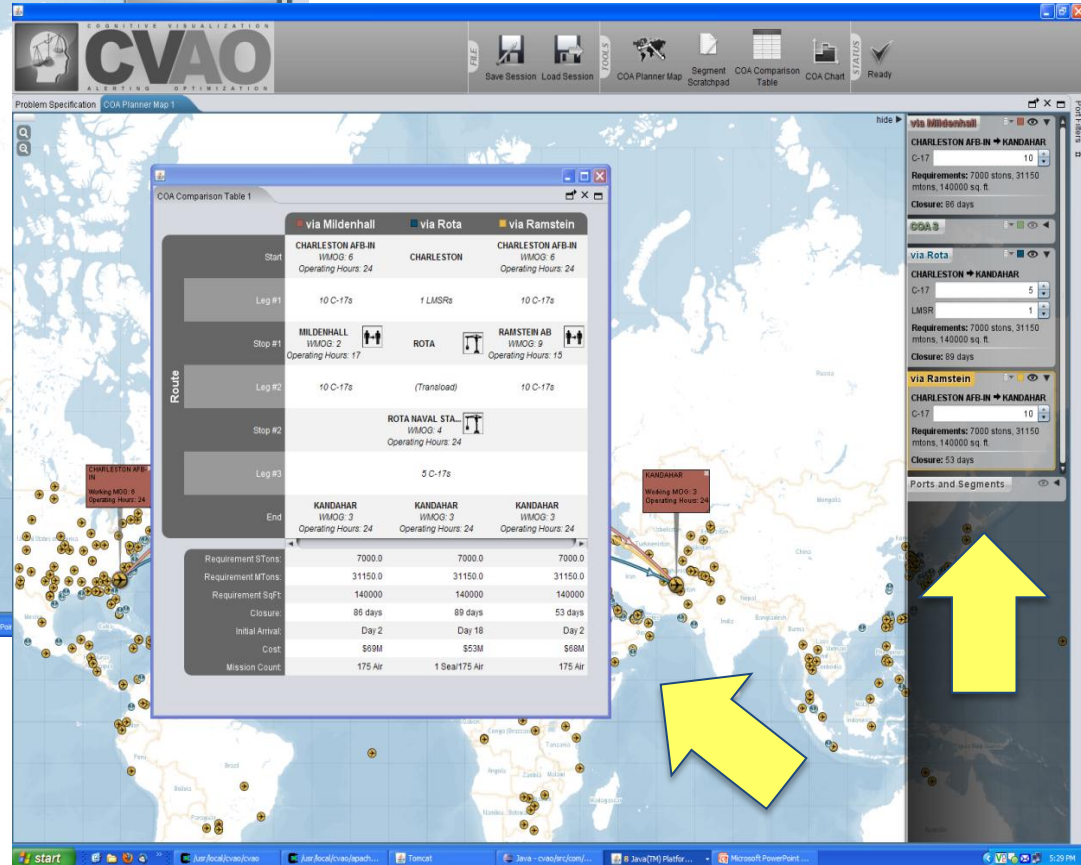
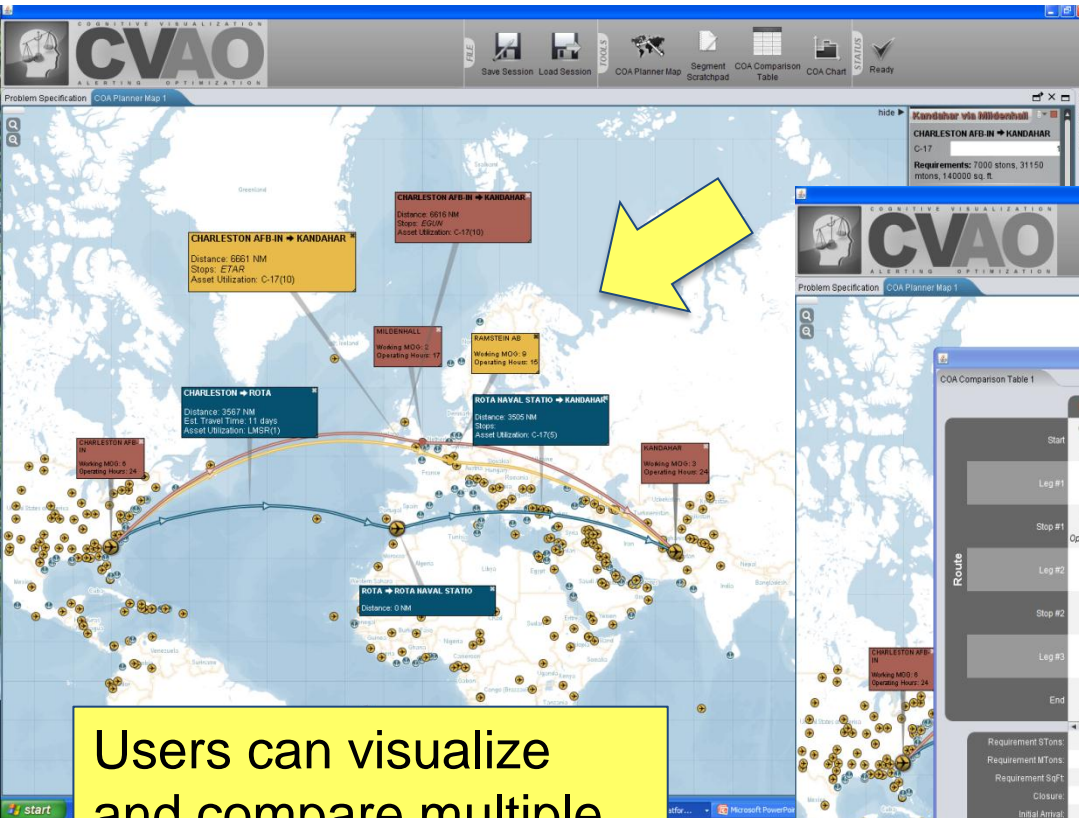
C-17 ASSUMPTIONS
5 (Asset Count)
4+15 [3+15] (Onload Hours)
2+15 (Offload Hours)
2+15 (Refuel Hours)

start | Just focal/cvao/cvao | Just focal/cvao/apach... | Tomcat | Java - cvao/farc/com/... | Edit Assumptions for ... | Microsoft PowerPoint ... | 5:06 PM

Users can view and modify default assumptions underlying calculations.



Rapid Development and Comparison of Multiple Alternative COAs

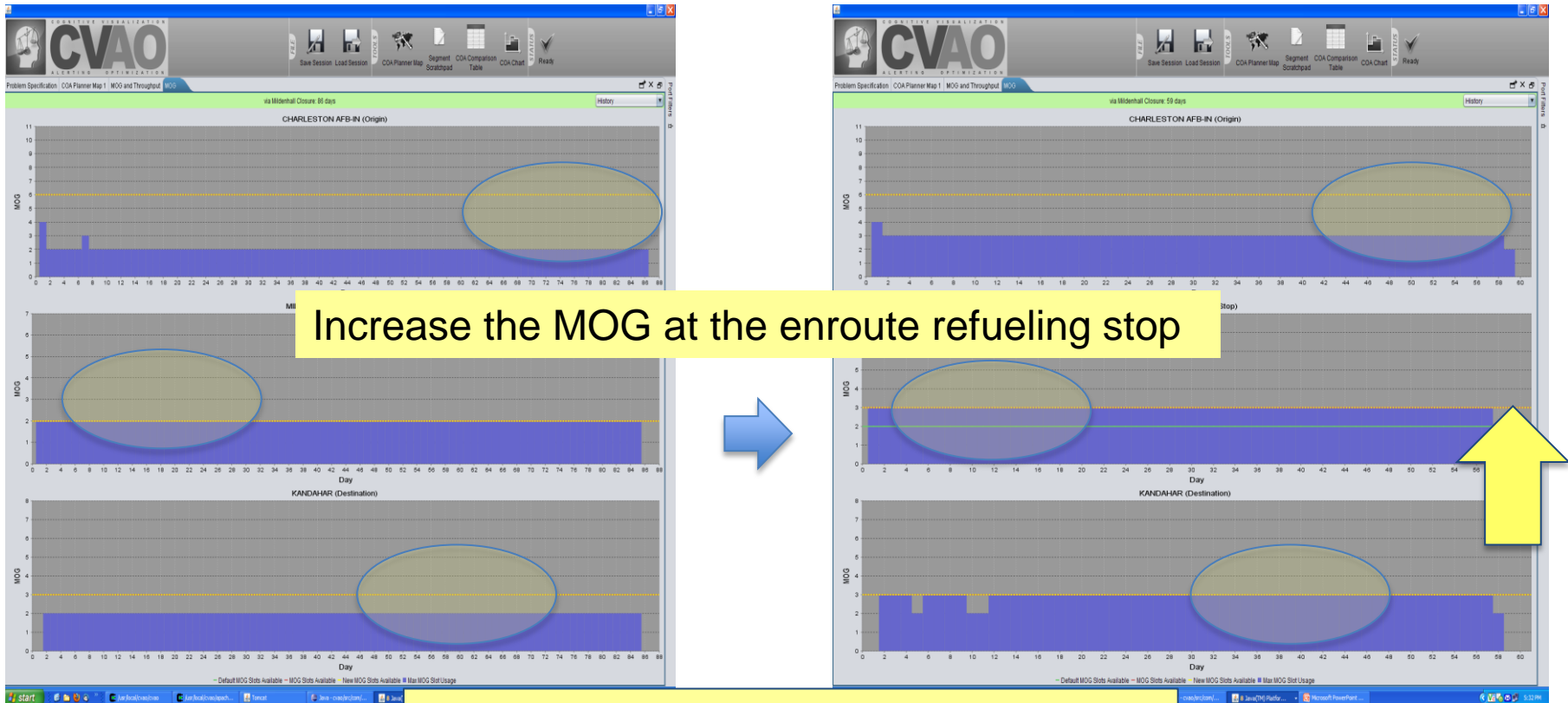


Users can visualize and compare multiple COAs across a variety of dimensions.

Supports collaborative COA development and presentations to leadership

Graphical Port Utilization

Includes tools for identifying transportation 'bottlenecks' and 'direct manipulation' features to support 'what if' analyses

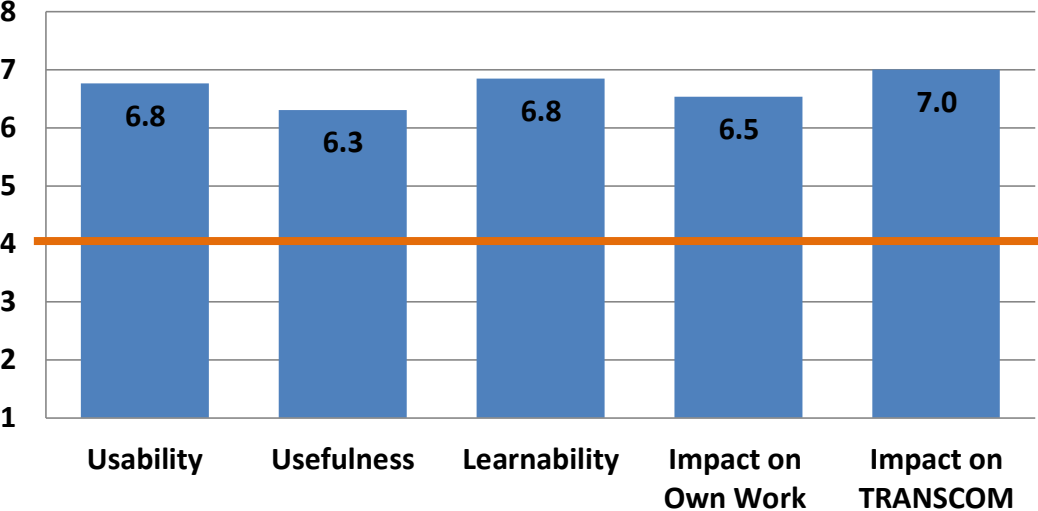


Increase the MOG at the enroute refueling stop

Users can visualize effects of limiting factors and perform what-if explorations to minimize.

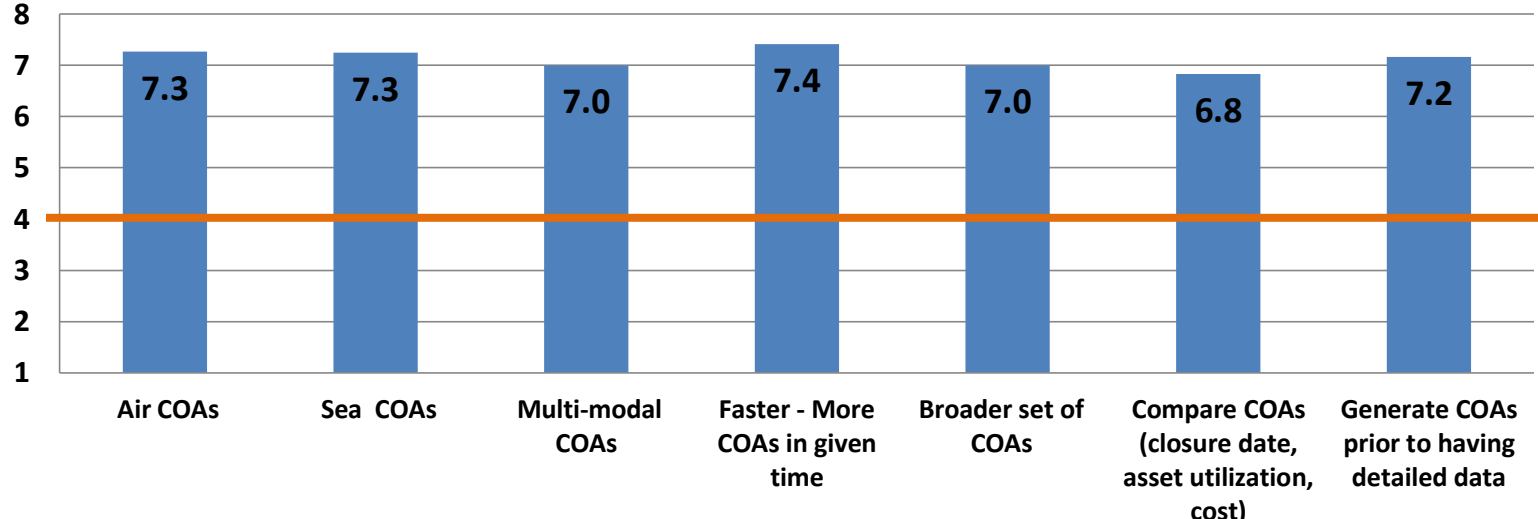
- **13 current planning staff participated in the study**
 - 4-5 Participants per session
 - Mix of Action Officers, Air, and Sea Movement Planners
- **Three Evaluation Sessions (3 to 3 ½ hours each)**
 - Demonstration of prototype capabilities
 - ‘Hands-on’ practice
 - *‘Mini’ Joint Planning Team COA development scenario:*
 - *Objective: Move 11,000 stons to a specified country (which they don’t normally go into).*
 - Collaboratively develop and compare 3 COAs (at least one multi-modal)
- **Verbal and formal written questionnaire feedback**

Questionnaire Feedback



Feedback: Usable, Useful, and Positive Impact on TRANSCOM Operation

Feedback: Enables faster, better COAs



Mean Rating Score on 8-point scale, (8 = extremely good, acceptance criteria is > 4)

Summary and Conclusions

- Cognitive analysis indicated a need for a tool that supports a planner in quickly analyzing the feasibility of multiple COA's.
 - As opposed to an automated COA generator or detailed COA analysis tool
- By allowing rapid exploration of multiple variants of each plan, the user is able to get a more complete appreciation of the overall decision space
- Understanding effects (even small) and related possibilities leads to better COA choices

Summary and Conclusions (2)

- RCAT extends ideas we've previously described as symbiotic planning – a particular variety of mixed-initiative planning in which the user is enabled to directly task and observe an automated process.
- This paradigm supports the user in integrating the results of the automated process into their own workspace and workflow.
- It points to ways that even opaque automation technologies can be deployed more collaboratively

Implications for Design of Effective Collaborative Automation

- **Importance of enabling users to be active partners:**
 - ***Observability:*** A shared representation enables both the user and the automation to understand and contribute to the problem specification
 - ***Directability:*** Multiple mechanisms are provided to modify default assumptions and guide problem solution
- **Importance of fostering better solutions than would be possible by either element of the Joint-Cognitive System working alone:**
 - ***Broadening:*** Broadening the set of candidate solutions explored and the range of factors considered in evaluating these solutions
 - ***Adaptability:*** Enhancing the ability to adapt to characteristics of the situation