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

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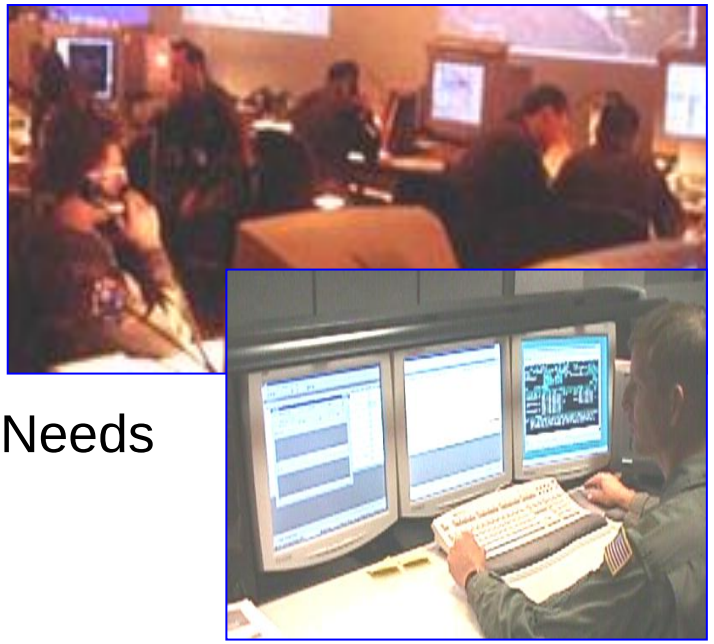
Domain: Military Transportation Planning

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

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- 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

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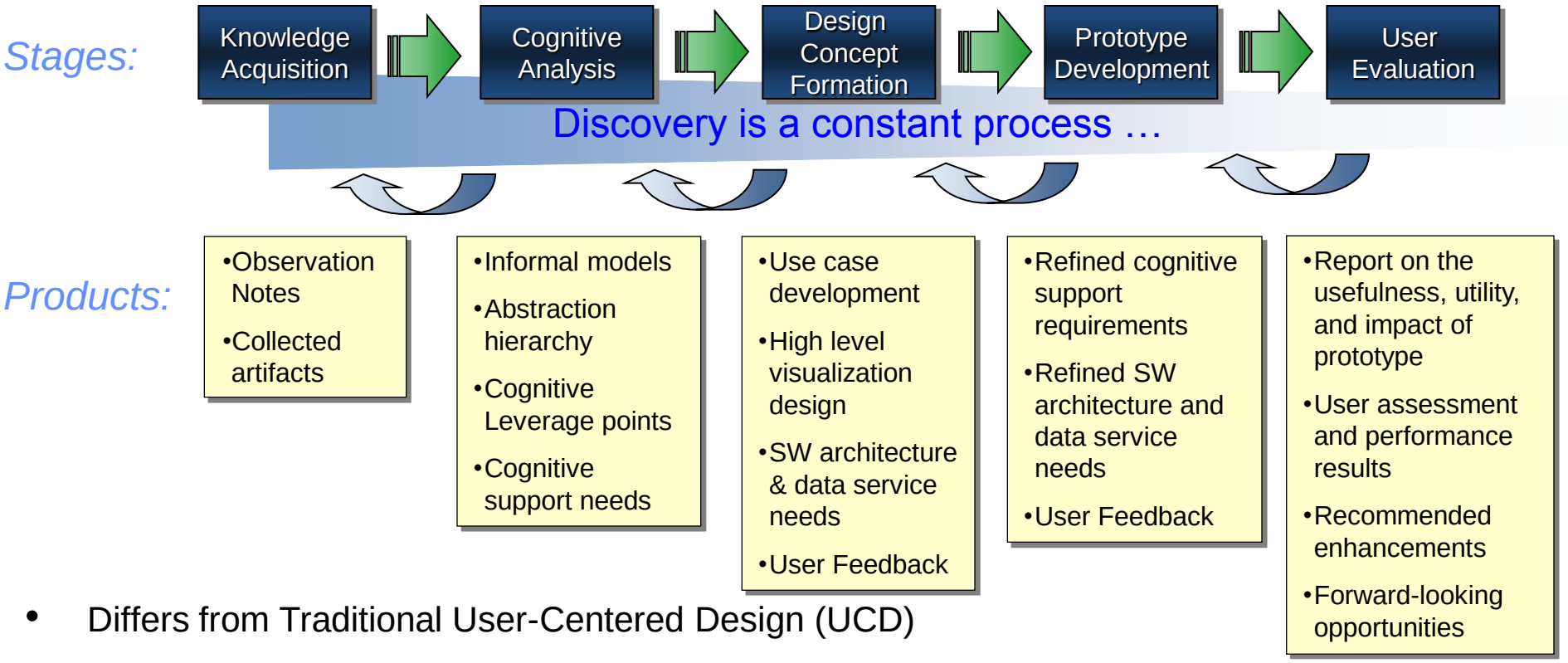

- Differs from Traditional User-Centered Design (UCD)
- Focus on the work domain from a user's perspective, rather than on specific task/process
- GOAL - make constraints and complex relationships in the work environment perceptually evident (e.g. visible) to the user in an easily accessible and coherent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

This approach accelerates implementation of features that significantly reduce cognitive burden

Rapid Course of Action Analysis Tool (RCAT) Prototype

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- 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

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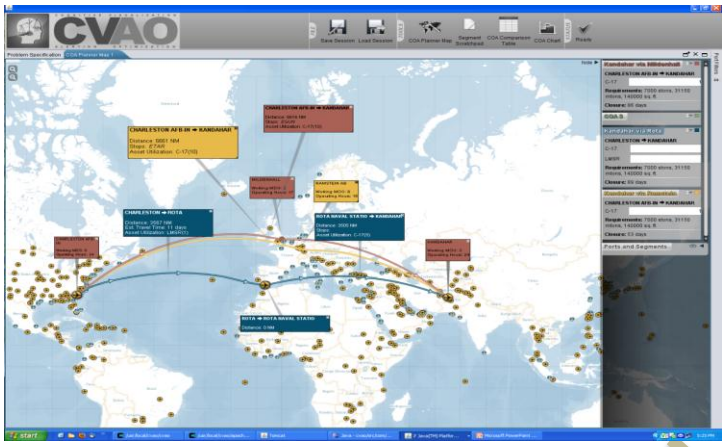

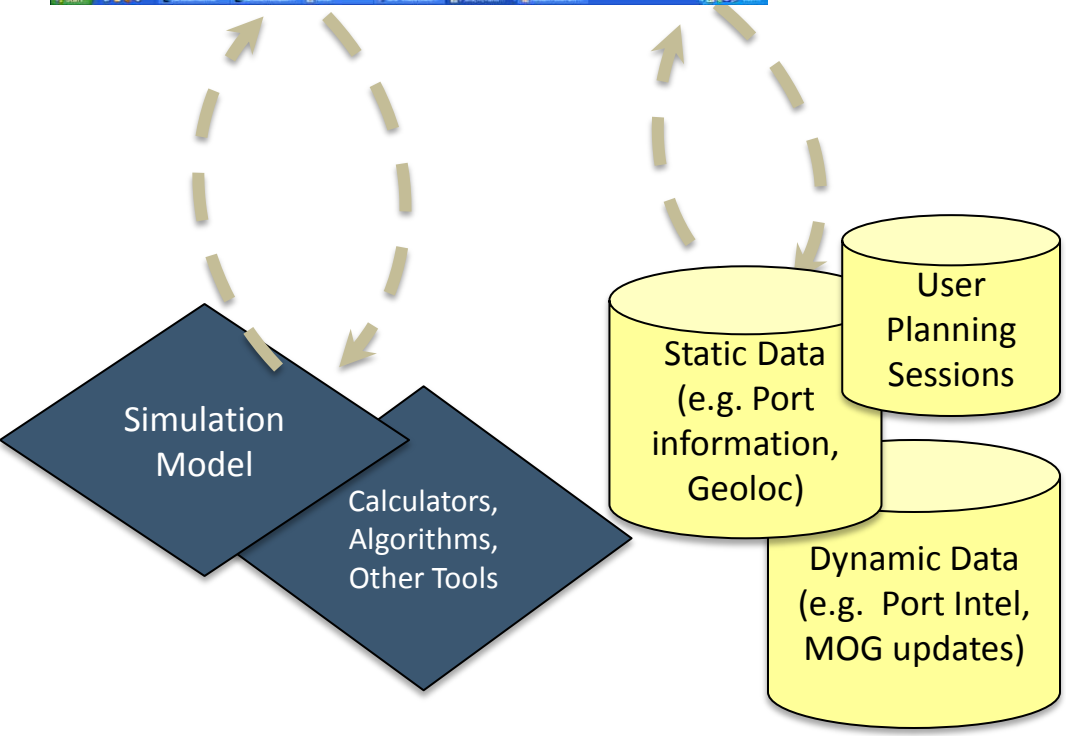

- User gestures trip automated data retrieval and model invocation processes
- Inputs/Outputs from data sources, algorithms, and models managed by the infrastructure
- Results from multiple underlying data and model sources are seamlessly displayed in the same user interface
- Response from sources must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

Rapid Transportation COA Development: An Example

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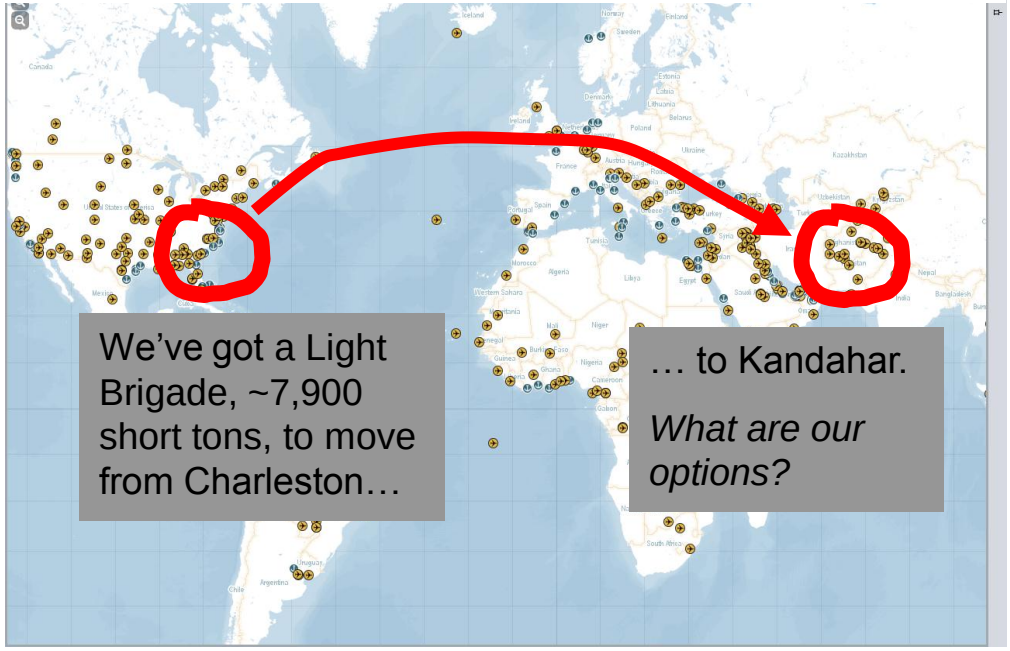
- Collaborative activity often conducted by a **Joint Planning Team**
- Requires consideration of multiple factors:
  - Mode of movement (air, sea, multi-modal)
  - Ports to be used
  - Number & mix of vehicles
  - Time to first delivery / total closure date
  - Cost
- Current process labor and time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



RCAT Prototype Overview

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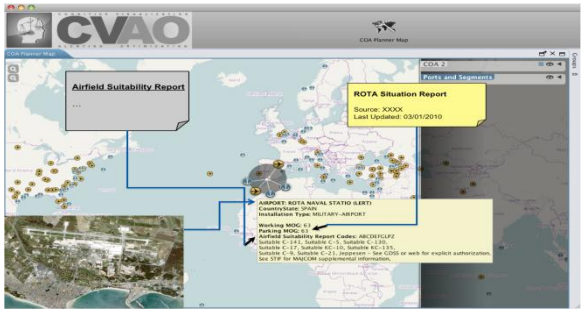
MISSION ANALYSIS

COA DEVELOPMENT

COA ANALYSIS

COA COMPARISON

Port Infrastructure Browser

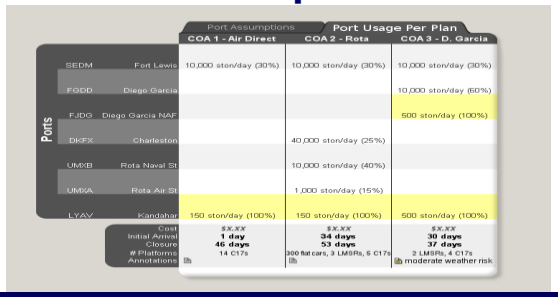


Segment Exploration

COA Mapping

Graphical Port Utilization

COA Comparison



Components designed around decision making aspects of COA cognitive work

Rapid Development and Comparison of Multiple Alternative COAs

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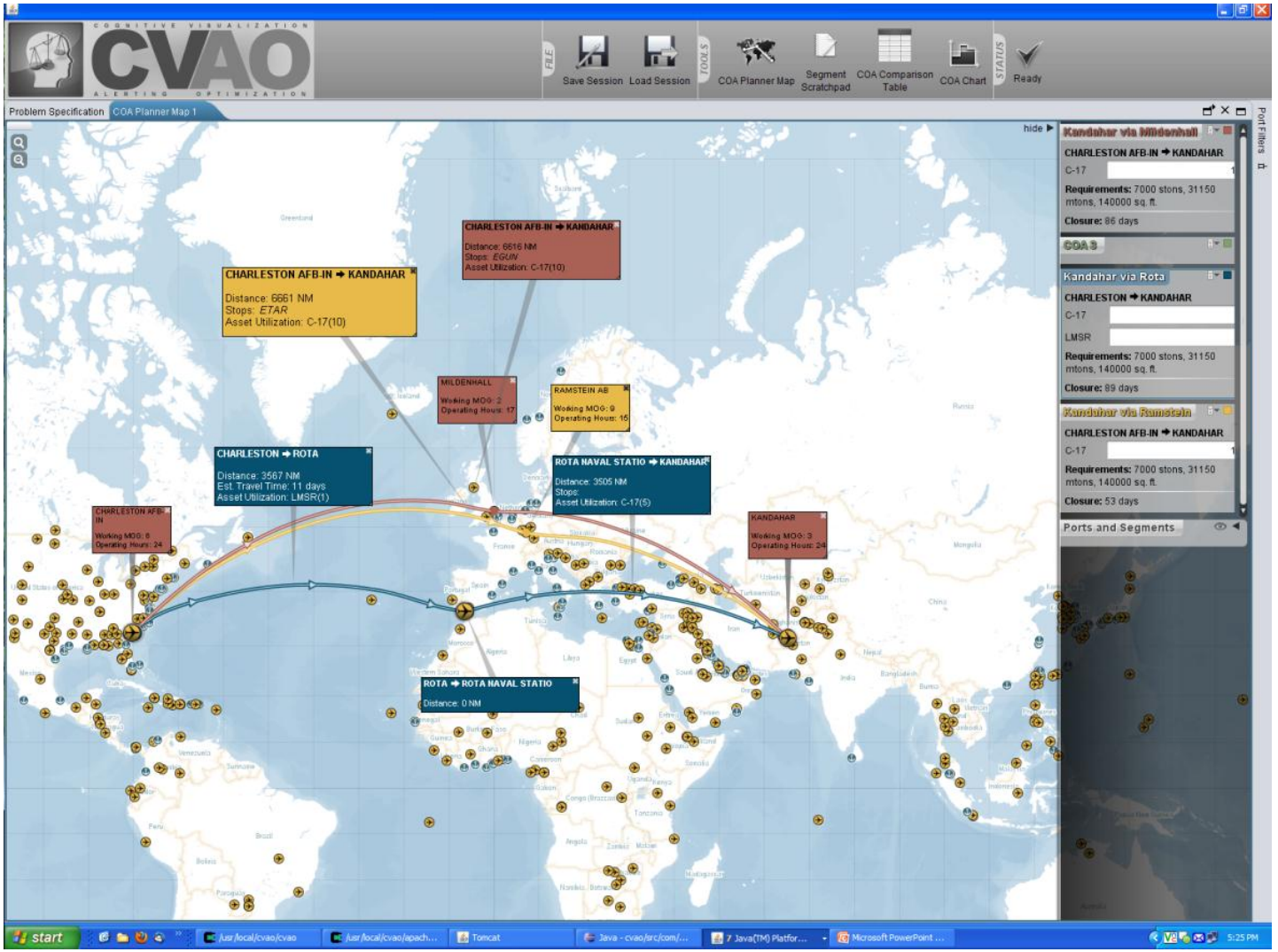

Defining a Movement (Problem) Using Varying Detail

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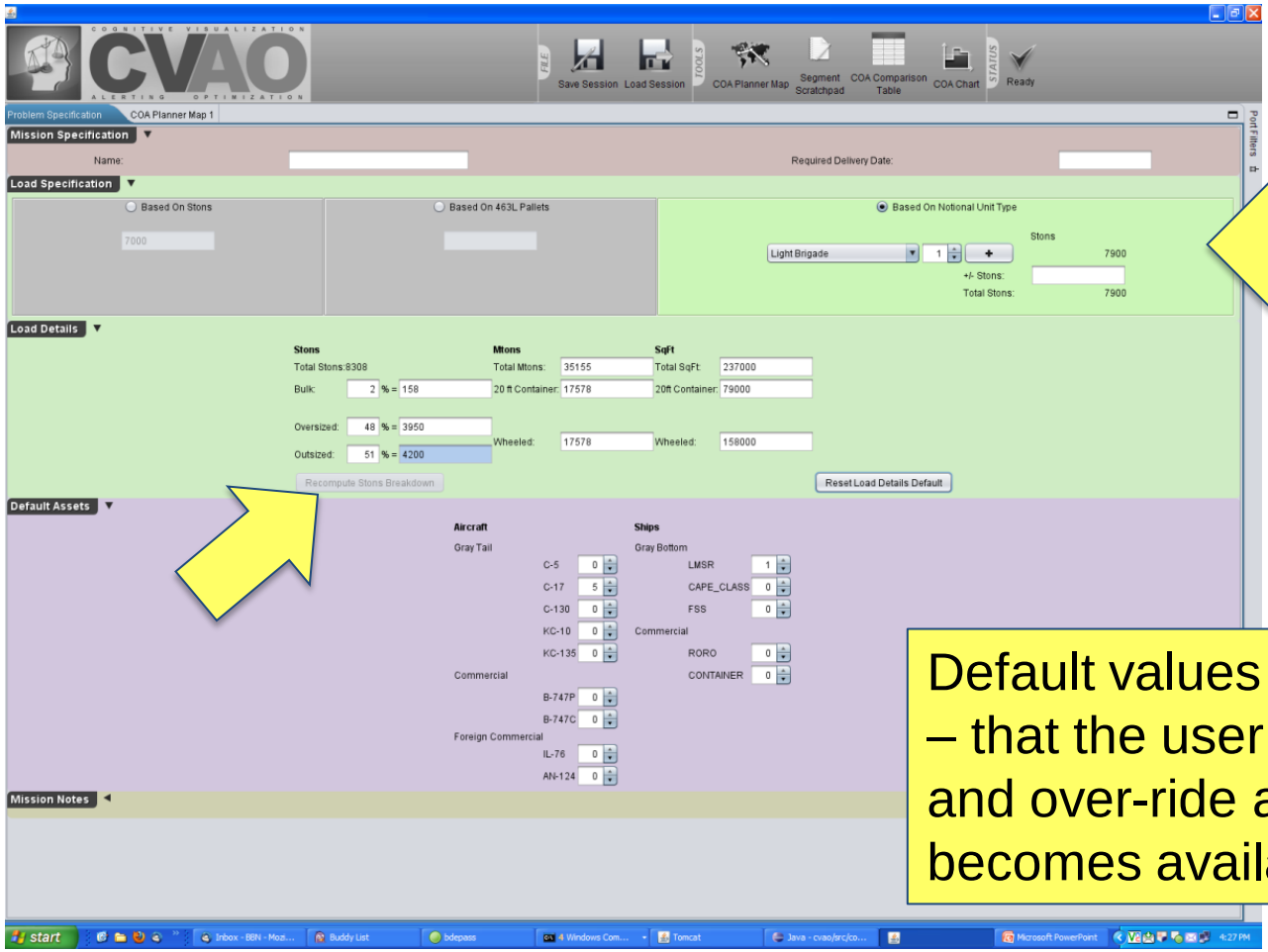
Allows users to enter problem specification at the level at which it is known



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

Port Browsing and Segment Exploration

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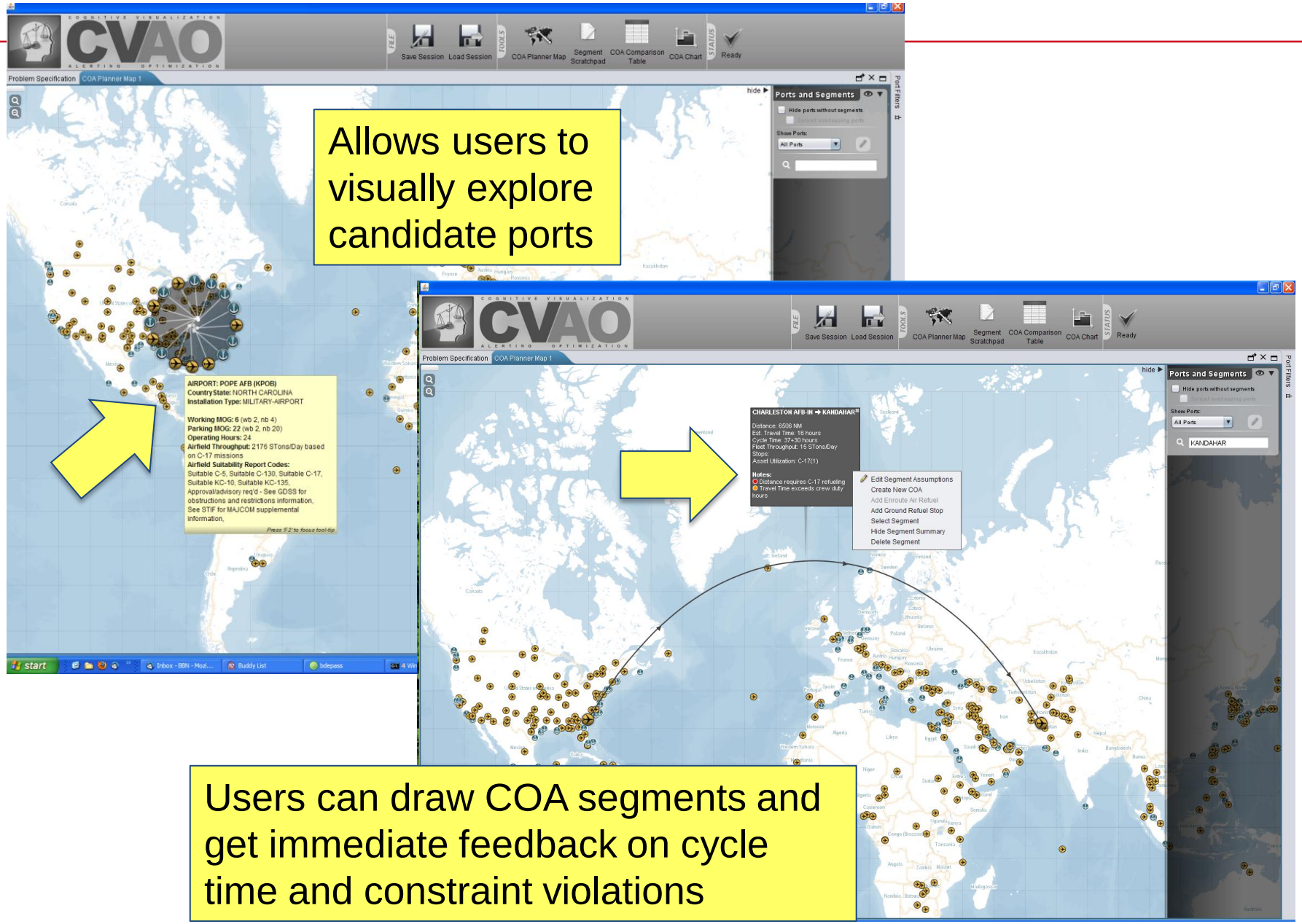

Allows users to visually explore candidate ports

Users can draw COA segments and get immediate feedback on cycle time and constraint violations

Rapid Development of COAs

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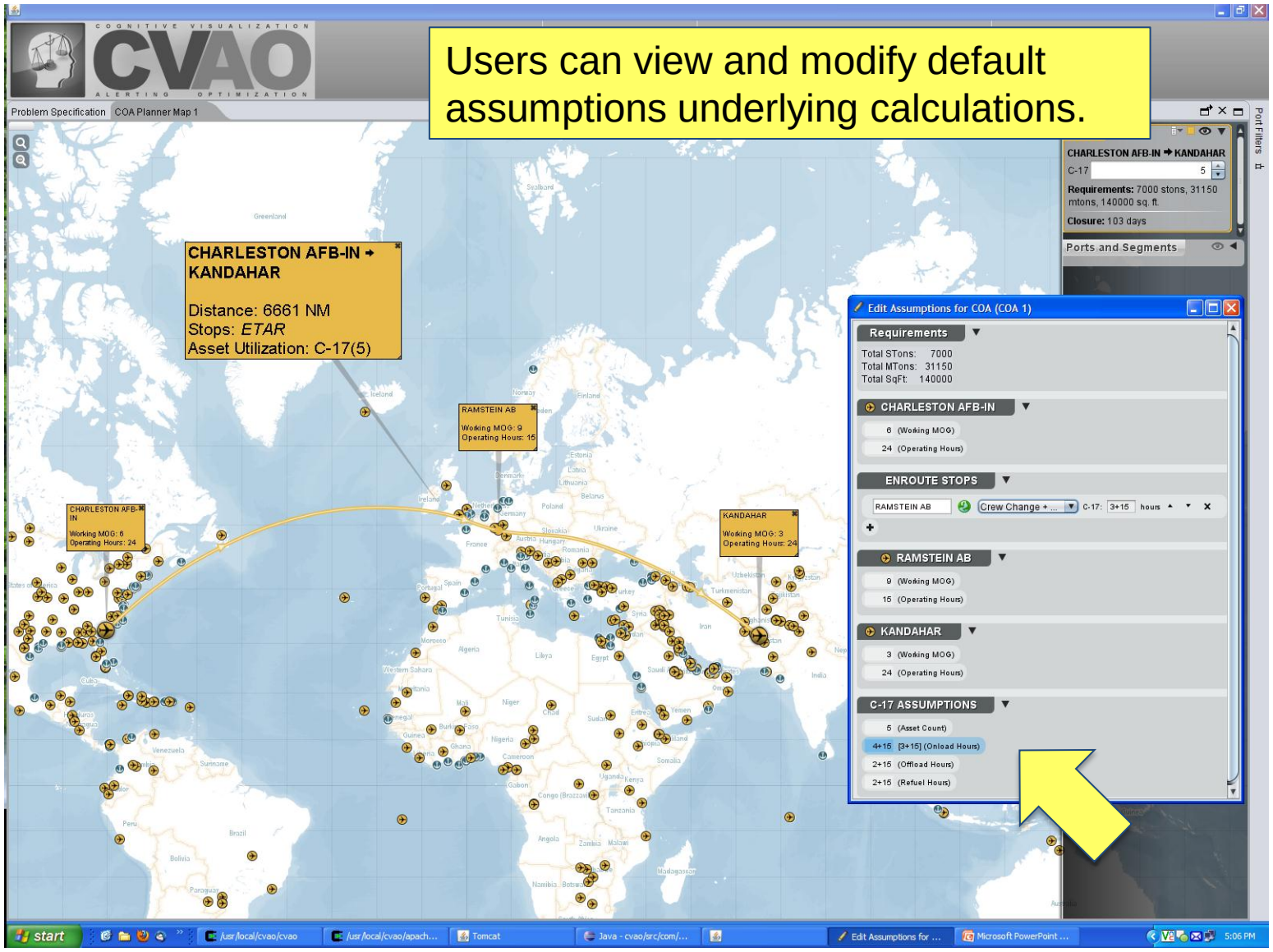

Rapid Development and Comparison of Multiple Alternative COAs

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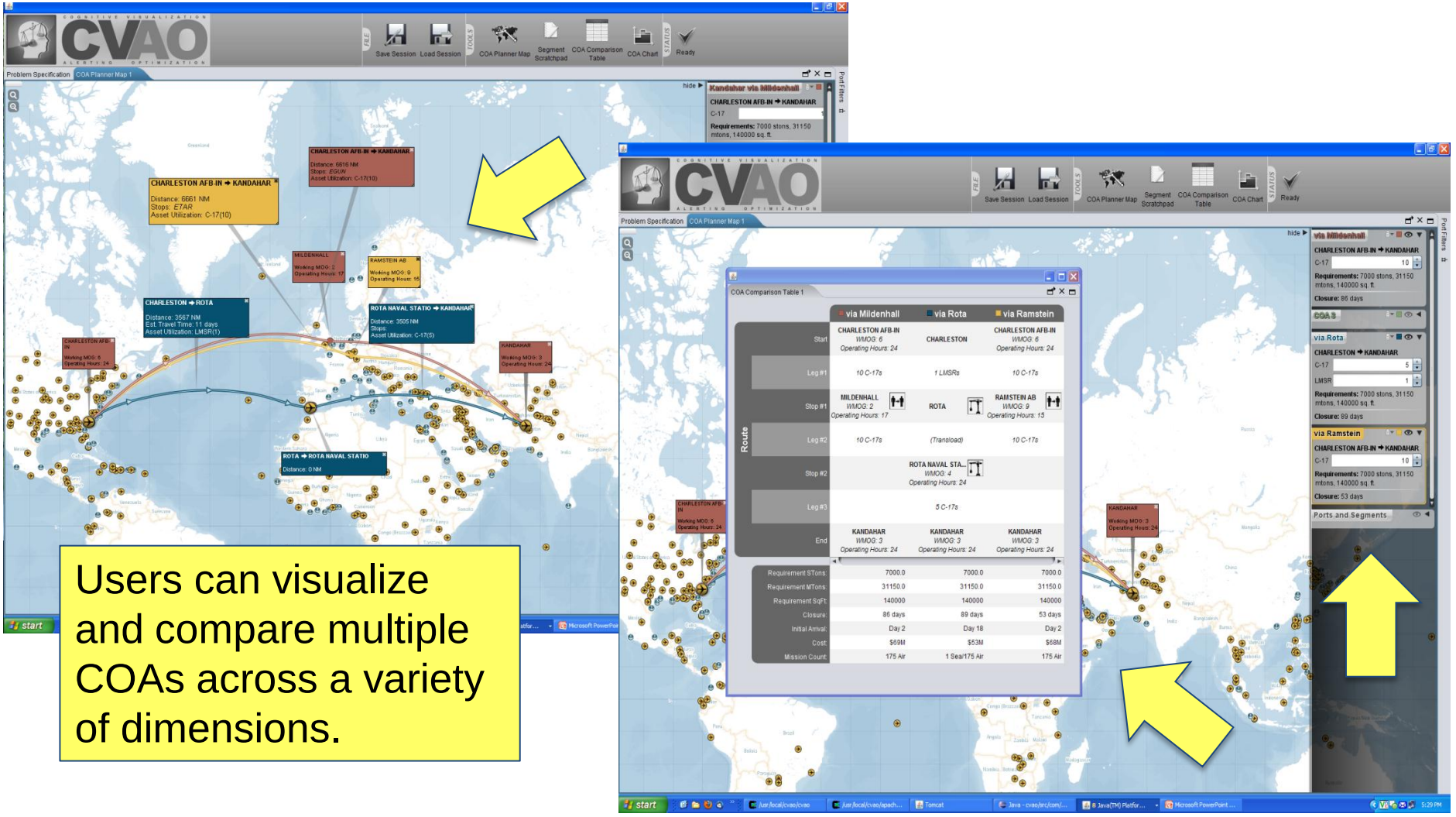

Users can visualize and compare multiple COAs across a variety of dimensions.

Supports collaborative COA development and presentations to leadership

Graphical Port Utilization

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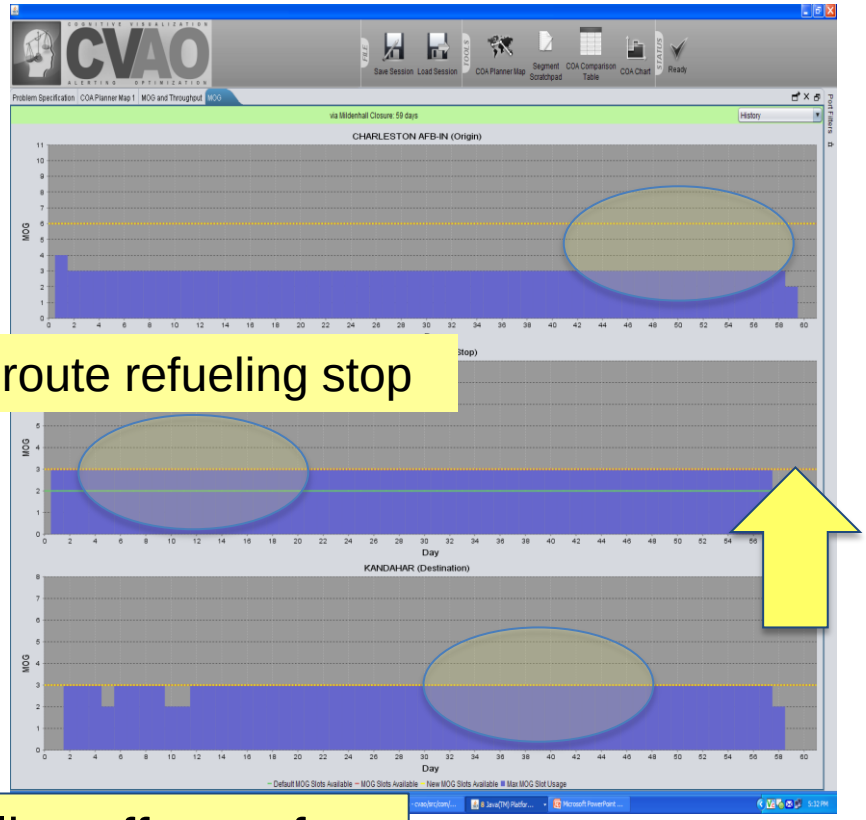
Includes tools for identifying transportation ‘bottlenecks’ and ‘direct manipulation’ features to support ‘what if’ analyses

Increase the MOG at the enroute refueling stop



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

Formal User Evaluation

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- **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

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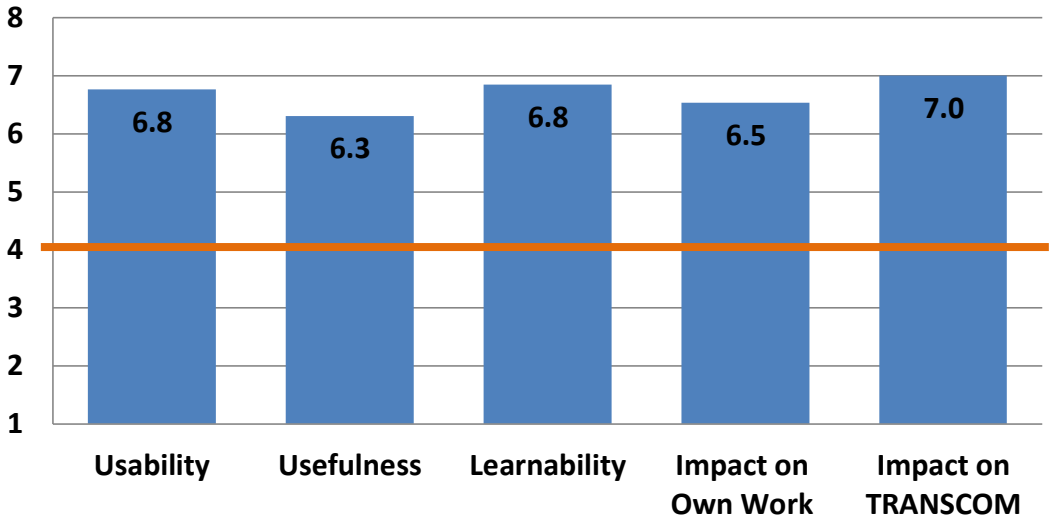
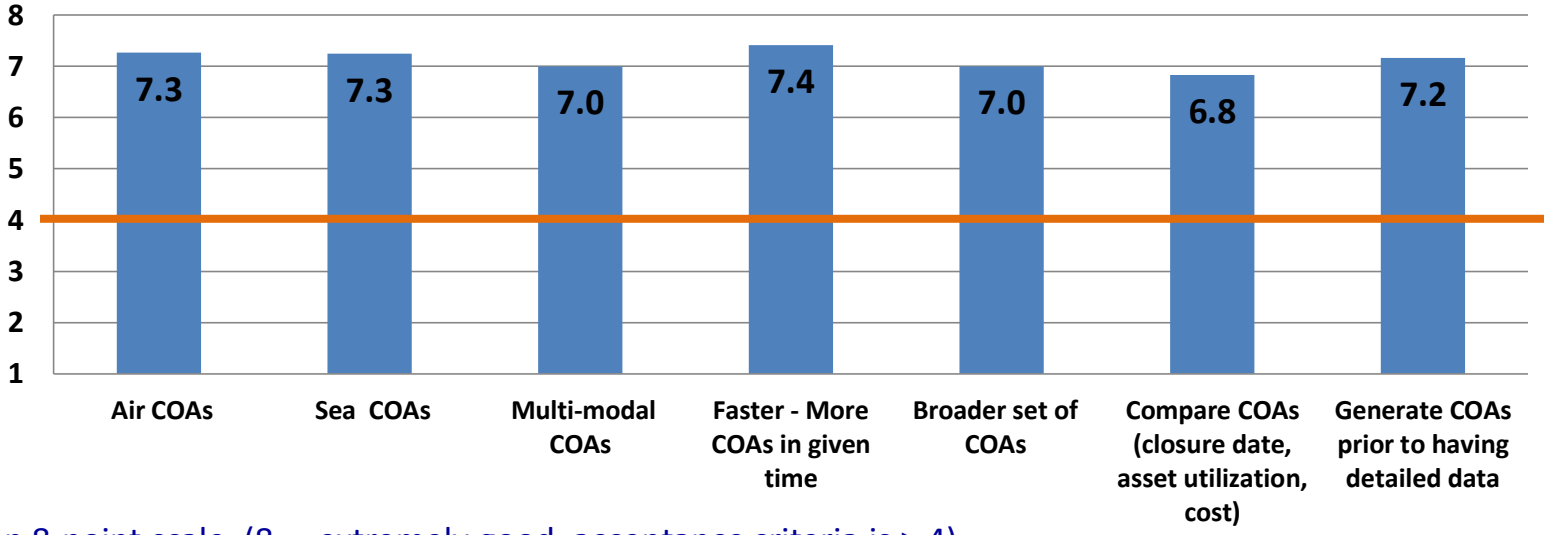


Feedback: Usable, Useful, and Positive Impact on TRANSCOM Operation

Feedback: Enables faster, better COAs



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

Summary and Conclusions

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- 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)

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- 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

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- **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