



# Advanced Visualization for Operational Assessment

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# Structure of the Talk



- Introduction
- Cognitive Systems Engineering
- Systems Engineering Analysis
- Visualization Interface Concept Development
- Concept Evaluation
- Conclusions and the Way Ahead



# Operational Effects Assessment Visualization Tool (OEAVT)

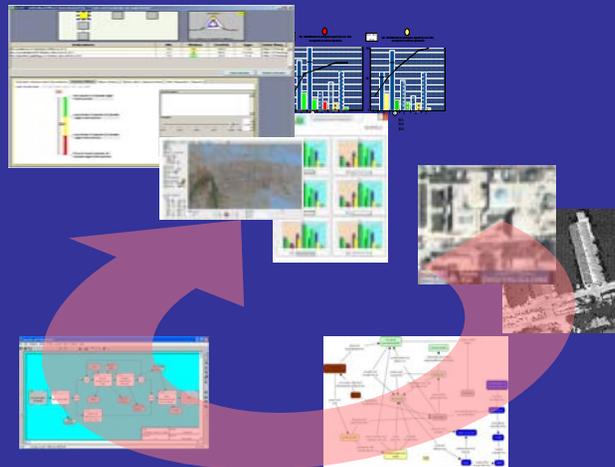


## Objective

Decision-quality support to assessment team in defining critical indicators, managing assessment data, determining operational effectiveness, visualizing/understanding complexity and uncertainty.

## Approach

- Analysis of assessment domain
- ID assessment functions
- ID requirements
- Design/Refine-Prototype
- Build
- Operational test



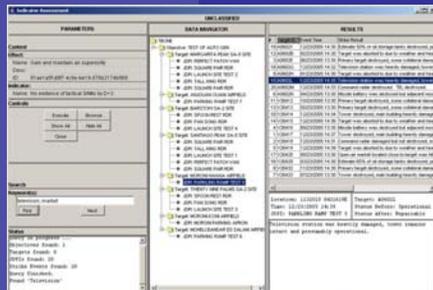
## Benefits to Warfighter

- Decision-quality knowledge to the commander
  - Continuous operational assessment tied to objectives
- Sensemaking of battlespace effects
  - Uncertainty management
  - nth-order causal understanding
- Faster decision times

## Technologies

- Information Visualization
- Knowledge Management
- Intelligent Interface Agents
- Advanced Search/Data Mining

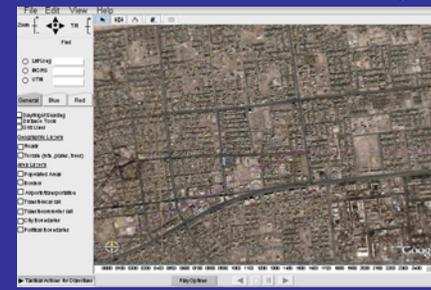
Evidence Accrual



Operational Assessment



Prediction & Forecasting



Indicator Mgmt

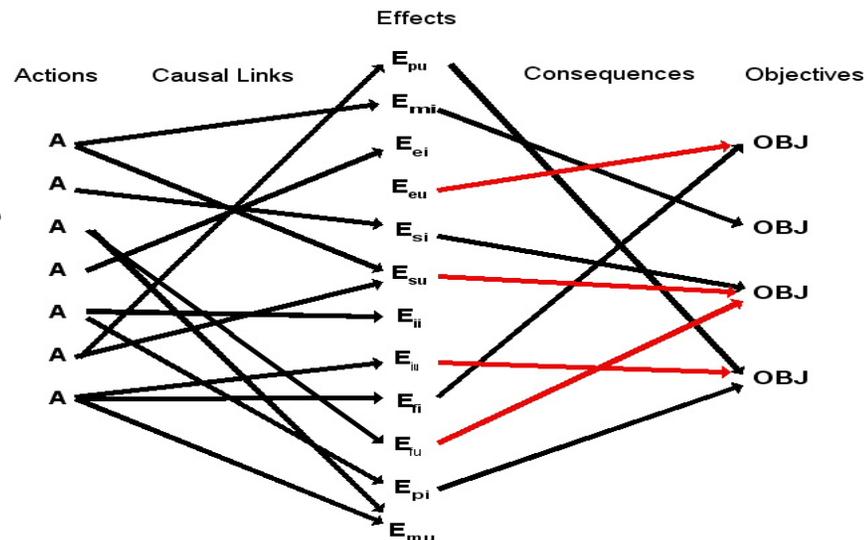




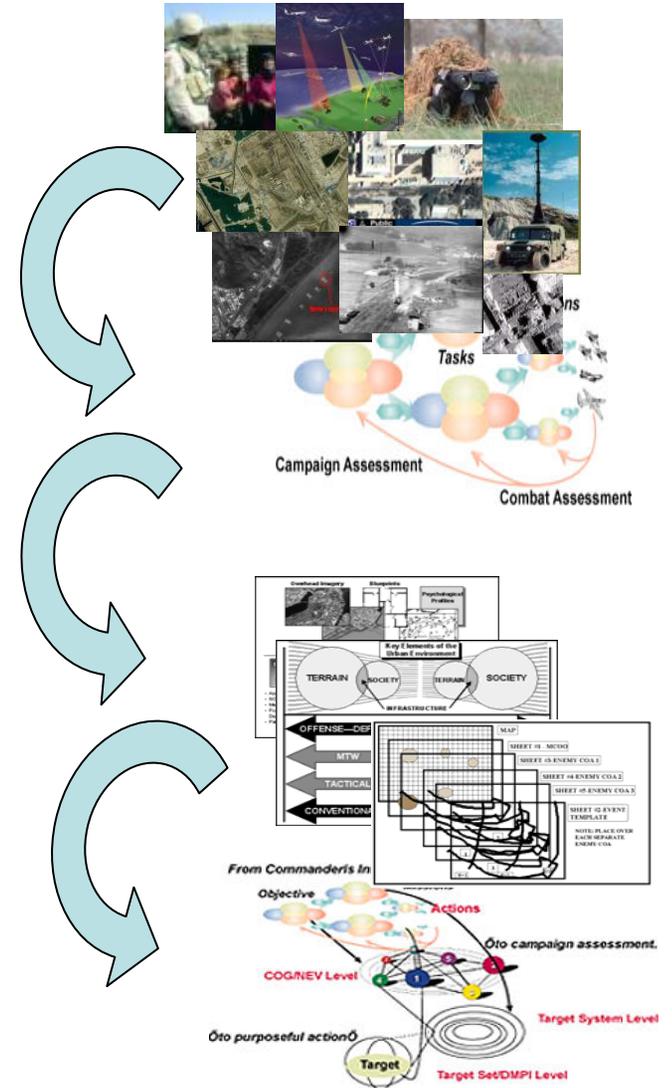
# Effects-based Assessment: Operational Issues



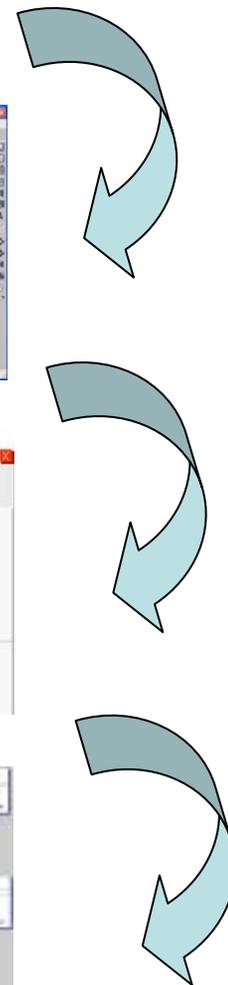
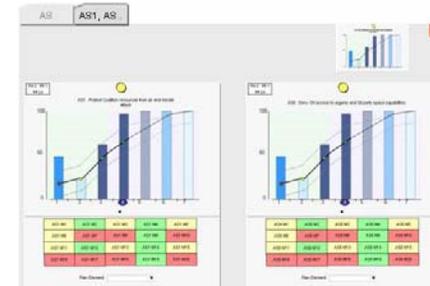
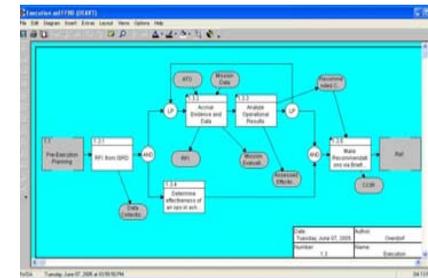
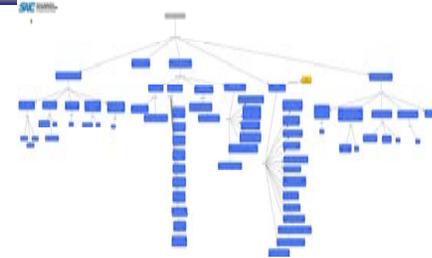
- All operations have complex effects.
  - Desirable and undesirable effects
  - 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> order effects
  - Time delays introduce uncertainty and risk
- Understanding the implications of operations is a multidimensional problem.
  - Effects can be strategic, operational, physical, psychological, ...
  - System of systems is a major conceptualization & modeling challenge



- **Data management**
  - What to measure, when to measure, how often to measure?
- **Dynamic assessment**
  - Finding appropriate indicators and measures
  - Integrating results in real time: A data aggregation problem, an interpretation problem.
- **Plan troubleshooting**
  - How does one decide when to “stay the course” or to recommend changes the strategic plan?
  - How to evaluate the efficacy of potential changes?



- EBA Domain analysis and cognitive system engineering
- System engineering analysis and requirements
- Visualization concept development
- Develop prototype

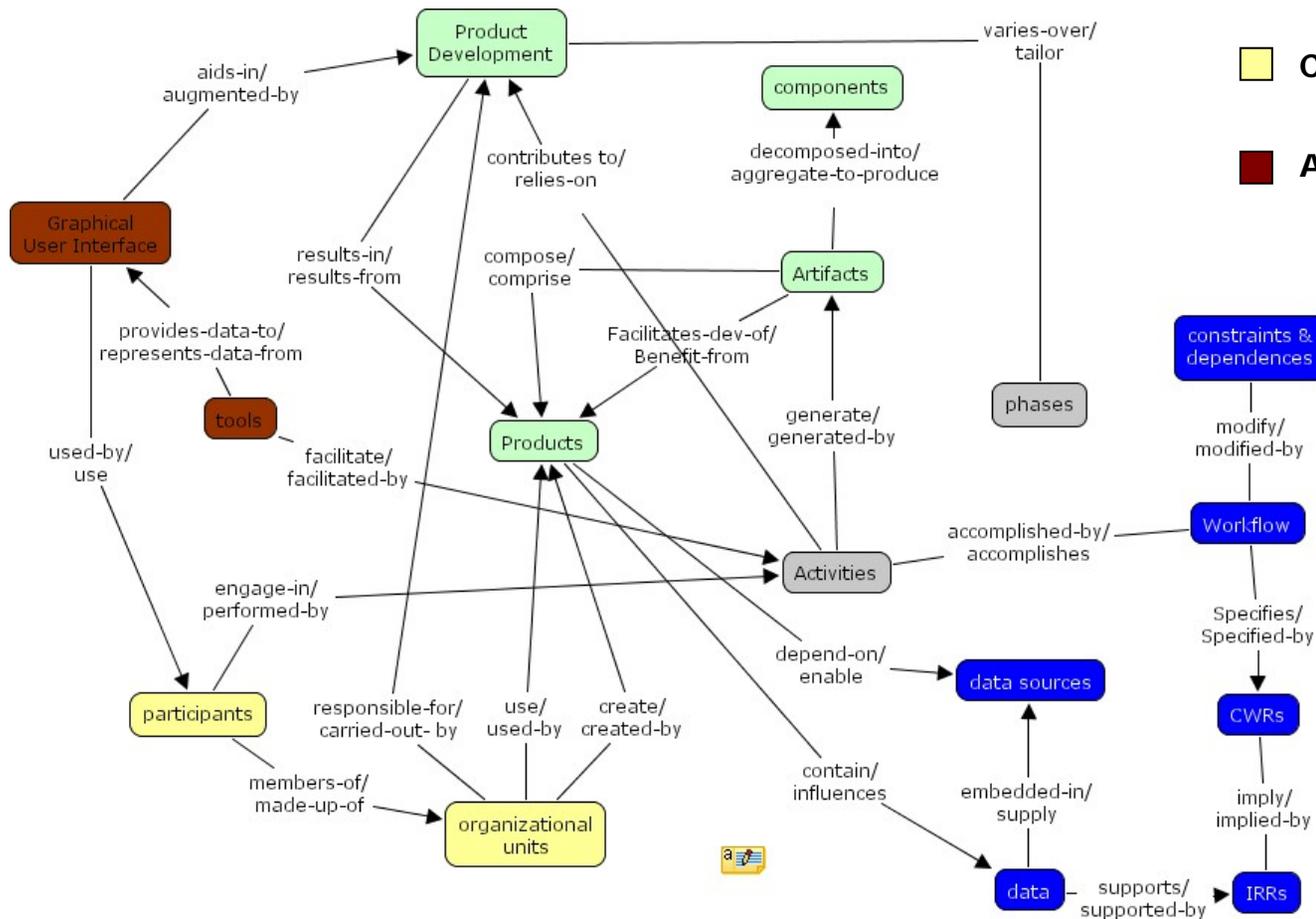




# Concept Mapping: Basic Information

- Five “views”
- Some overlap

- Work management
- Cognition
- Products
- Collaboration
- Automation





# Concept Mapping

Identified the following cognitive work for EBA:

## Pre-execution

- **Assessment planning**
- **Determine adversary capabilities & likely COA**
- **Develop JAOP**
- **Develop STTM**
- **OAT mgmt of EBA**
- **Predict ops effectiveness**

## Execution

- **Accrue evidence**
- **Analyze ops results**
- **BDA**
- **Execution tracking**
- **Functional damage assessment**
- **Integrate mission assessment**
- **Mission assessment**
- **PDA**
- **Target system assessment**

## Post-execution

- **Inter-division feedback**



# Decision Requirements Tables

- Identify and characterize assessment decisions that will drive visualization requirements
  - Task
    - Critical cues
    - Critical decisions
    - Common errors
    - Actions
    - Tools used
    - Collaboration and communication
    - Data used
    - Requirements



# DRT Example

- Recognize actionable changes in ongoing air ops
- Assess feasibility of plan changes

| Critical Cues  | Critical Decisions   | Actions  | Common Errors | Tools Used  | Communicates with  | Data Used   | Requirements  |
|--|--|--|---------------|---|--|---|---|
| <ul style="list-style-type: none"> <li>*Change in pathways</li> <li>*Change in weather</li> <li>*Etc.</li> </ul>         | <ul style="list-style-type: none"> <li>*Determine when changes have been made in ongoing air ops</li> </ul>  | <ul style="list-style-type: none"> <li>*Monitor activity trends in areas indicated by critical cues</li> <li>*Monitor indicators against predictions and time</li> </ul>   |               | <ul style="list-style-type: none"> <li>*TBMCS</li> </ul>                | <ul style="list-style-type: none"> <li>*ISR/D</li> <li>*Plans team</li> </ul>                      | <ul style="list-style-type: none"> <li>*MISREPS</li> <li>*INTSUMS</li> <li>*DISUMS</li> <li>*Combat assessment</li> </ul> | <ul style="list-style-type: none"> <li>*The system shall allow and aid in recognizing actionable changes in ongoing air ops</li> </ul>  |
| <ul style="list-style-type: none"> <li>• WOE</li> <li>• Time</li> <li>• Guidance</li> <li>• Resource profiles</li> </ul> | <ul style="list-style-type: none"> <li>*Determine if resources available for corrective actions</li> <li>*Determine what to change &amp; amount of change</li> <li>*Determine WOE for each objective</li> <li>*Determine priorities</li> </ul> | <ul style="list-style-type: none"> <li>*Make recommendation</li> <li>*Predict intended and unintended effects of changes</li> <li>*Infer 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> order effects associated with potential changes</li> </ul> |               | <ul style="list-style-type: none"> <li>*IWPC</li> <li>*TBMCS</li> </ul> | <ul style="list-style-type: none"> <li>*ISR/D</li> <li>*Plans team</li> <li>*Combat Ops</li> </ul> | <ul style="list-style-type: none"> <li>*TPFID</li> <li>*ATO</li> <li>*Guidance</li> </ul>                                 | <ul style="list-style-type: none"> <li>*The system shall determine if resources are available for corrective actions</li> <li>*The system shall determine amount of change to plan, and what to change</li> </ul> |



# CORE Systems Analysis

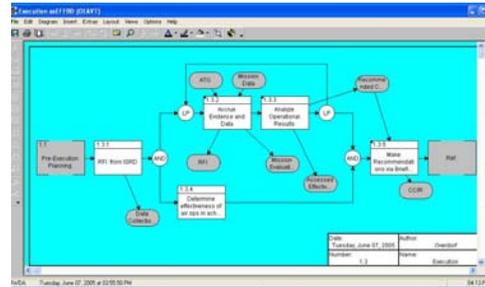


- CORE: Commercially available CASE tool
  - Allows management of the whole project
  - A wide range of information
  - DES supports tradeoff & what-if analysis
  - DoDAF compatibility
- What information we put into it
  - All concept map and CDA information
  - Other information specified by SMEs
- Vetted with SME input
- 108 functions

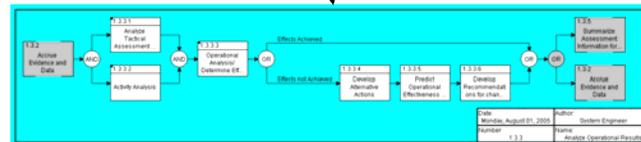
# CORE Diagram Examples

Can be used to generate SV-4 descriptions

## Execution



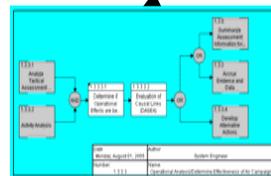
Accrue evidence and data



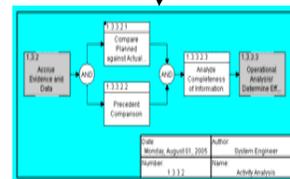
Analyze operational results



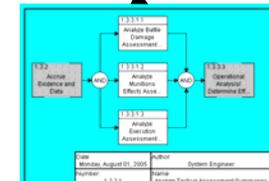
Make recommendations



Activity analysis



Determine effectiveness of air campaign



Analyze tactical assessment summaries



**OEAVT**  
File Edit View Window Help

New Evidence: 10

- AS. Gain and maintain air and space superiority to ensure freedom of action for Coalition forces
  - SI: Air superiority is achieved over designated ZOCs (ZOCs 3, 4, 2, and 1 in that order) and eventually over the entire air space of CN by D+24
  - AS1. Protect Coalition resources from air and missile attack
    - MDE: No significant loss of PDAL assets; No prohibitive losses of friendly assets
    - AS1A. Defeat enemy fixed and rotary-wing attacks into NV
      - MOP: No successful air attacks on PDAL assets; no loss of HVAA; CN offensive air capability is minimally effective NLT D+7
      - AS1B. Defeat enemy SSM attacks
        - MOP: PDAL assets are effectively defended from SSM attacks NLT D+1
    - AS2. Disrupt/Degrade CN IADS
      - MDE: CN defensive air capability is minimally effective NLT D+10; Coalition air can provide CAS in the PMF without prohibitive losses on D+1
    - CL. Support CFLCC's operations to culminate Calfon's ground offensive NLT D+14 and then render CN unable to defend effectively



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Zoom  TRT 

Out/Log  MORS  OUTM

Find

General

- Day/Night/Sliding
- Distance Tool
- Grid Lines
- Geographic Layers**
  - Roads
  - Terrain
- Area Layers**
  - Populated Areas
  - Borders
  - Transportation

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Tactical Assets for Objectives

0000 0100 0200 0300 0400 0500 0600 0700 0800 0900 1000 1100 0300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400

Day Time D+1500



# Concept Evaluation



- Purpose: Demonstrate visualization concepts for an integrated ops assessment system
  - Feedback on concept
  - Feedback on implementation



# Conclusions

- This methodology enables a meaningful integration of cognitive systems analysis with accepted system engineering and technology development practice.
- The cognitive and perceptual work involved in EBA can be captured by a limited, manageable number of hierarchically structured functions.
- Visualization technologies must be both broad and deep for success in an EBA domain.



# The Way Ahead: Potential Long-term Direction

| Development Focus  | Potential Technology Solutions  |
|--|---|
| PMESII visualization   | <ul style="list-style-type: none"><li>- Hierarchical task network with recursive task blocks</li><li>- 3-D rendering</li><li>- Fisheye view on demand</li></ul>   |
| Intelligent queries  | <ul style="list-style-type: none"><li>- Queries for spatial, temporal and probabilistic content</li><li>- Intelligent, automated data acquisition</li></ul>   |
| Causal link analysis <ul style="list-style-type: none"><li>• between actions and effects</li><li>• cause – effect latencies; latencies in observing effects</li><li>• temporal effects</li></ul> | <ul style="list-style-type: none"><li>- Influence nets</li><li>- Colored Petri Nets</li><li>- Hybrid dynamical systems</li><li>- Temporal causal graphs</li><li>- Causal graphs &amp; event calculus</li><li>- Timed failure propagation graphs</li></ul> |
| N <sup>th</sup> -order effects   | <ul style="list-style-type: none"><li>- Temporal causal graphs</li><li>- Causal graphs &amp; event calculus</li></ul>   |



# Questions