Advanced Visualization for Operational Assessment

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
JUN 2006		**00-00-2006 to 00-00-2006**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Advanced Visualization for Operational Assessment (Briefing Charts)	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Science Application International Corporation,10260 Campus Point Drive,San Diego,CA,92121**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**		**18**	

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

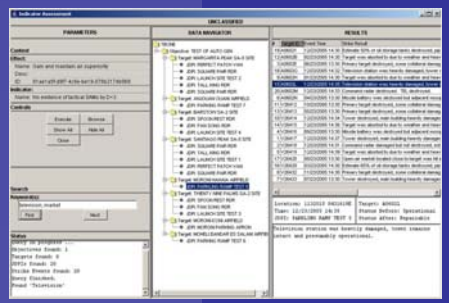
Benefits to Warfighter

- 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

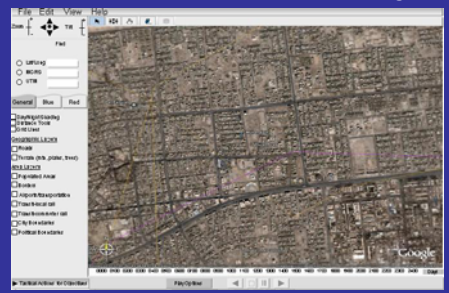
- Information Visualization
- Knowledge Management
- Intelligent Interface Agents
- Advanced Search/Data Mining

Evidence Accrual

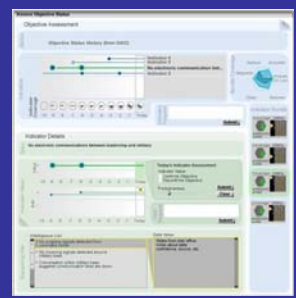


Operational Assessment

Prediction & Forecasting

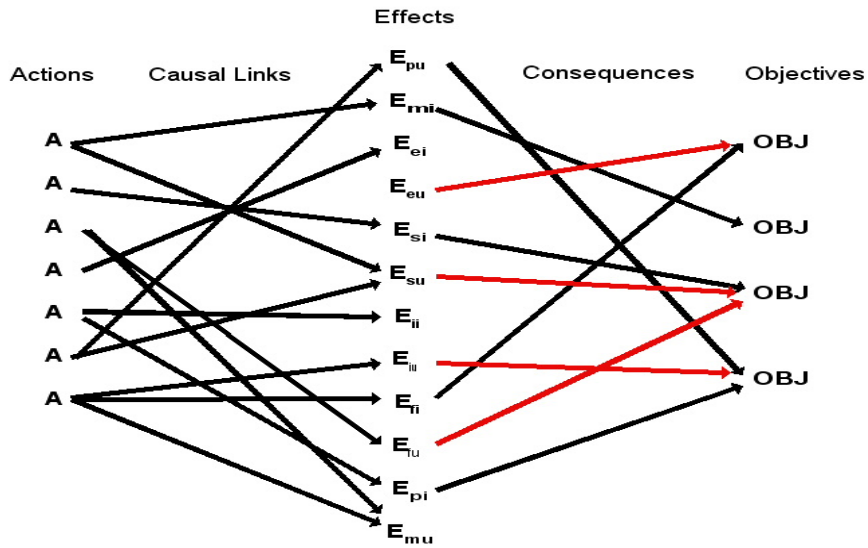


Indicator Mgmt



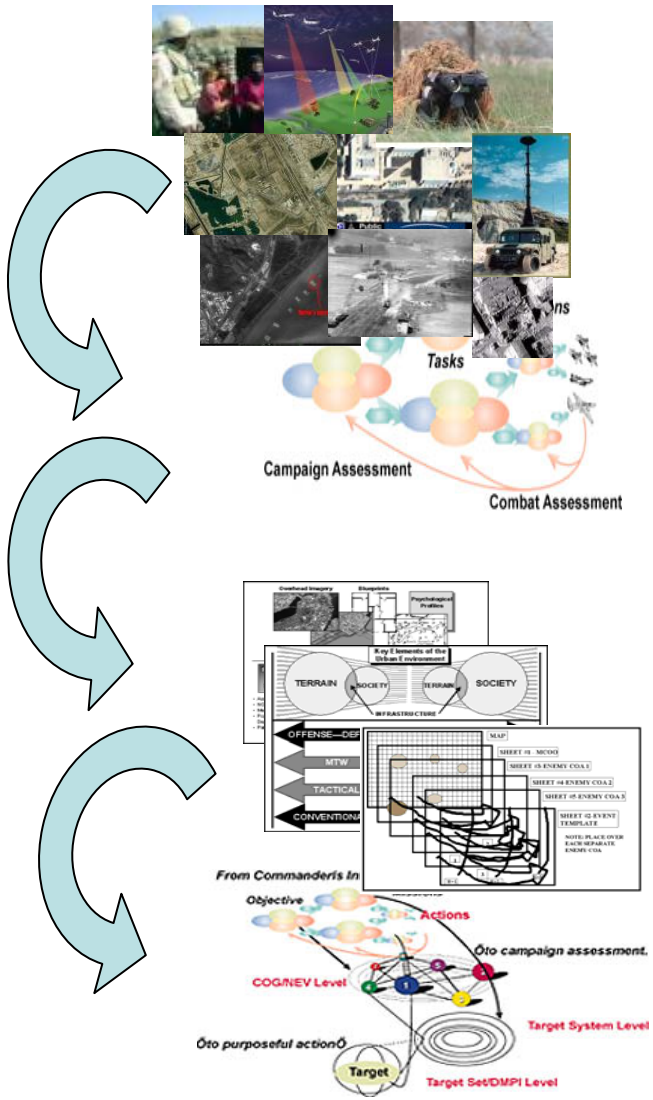
Effects-based Assessment: Operational Issues

- All operations have complex effects.
  - Desirable and undesirable effects
  - 1st, 2nd and 3rd 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



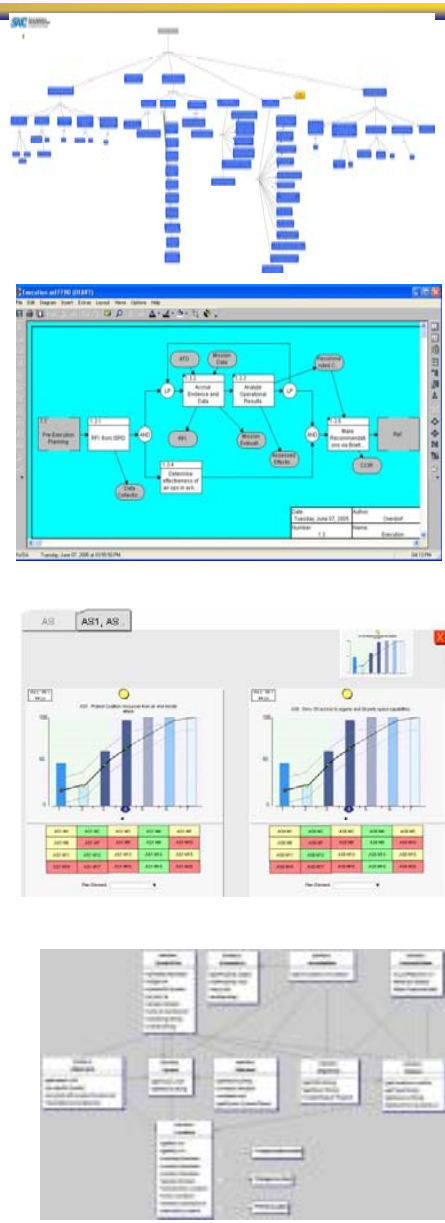
Effects-based Assessment: Human Performance Issues

- **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?



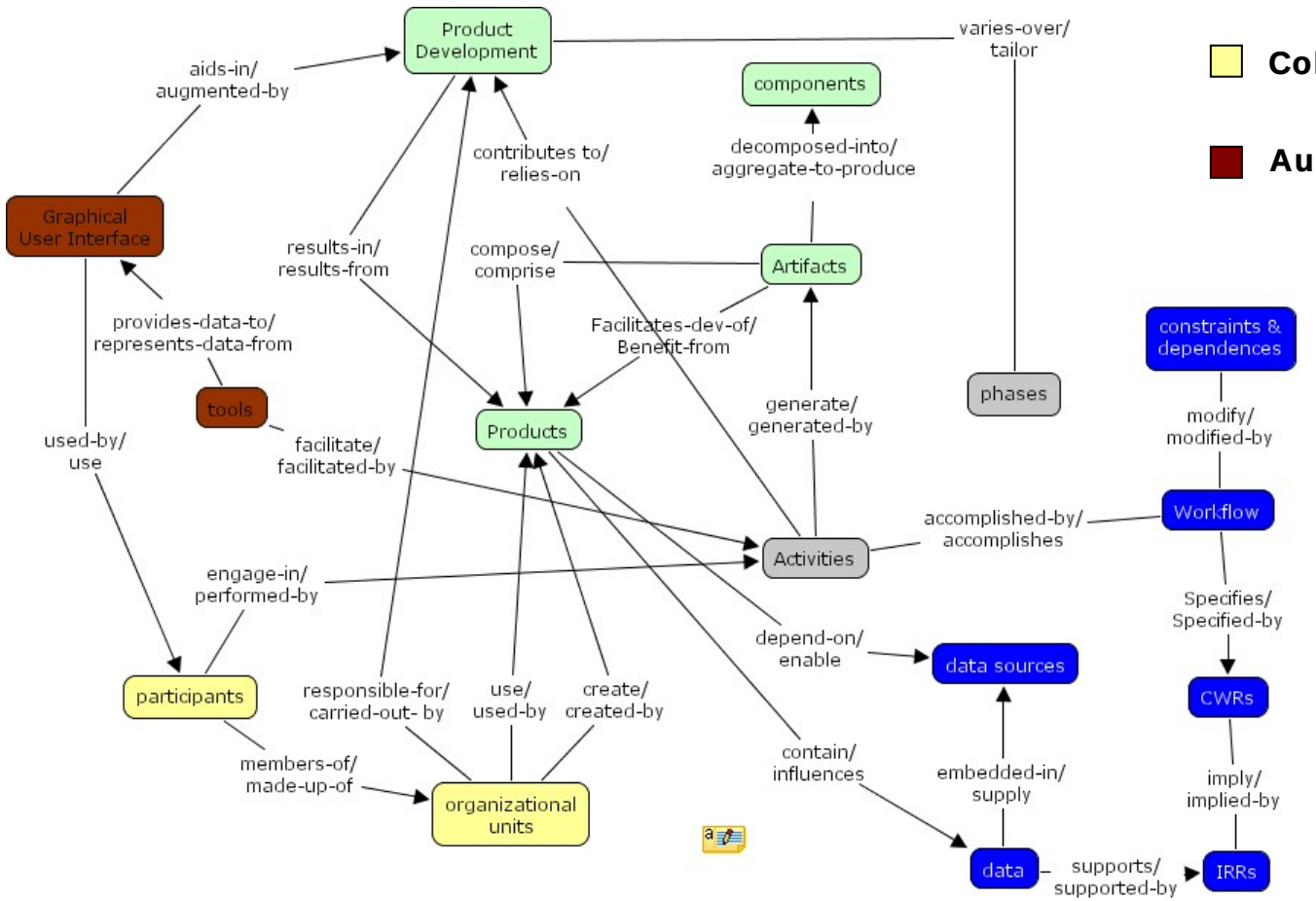
Cognitive System Engineering

- 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**



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

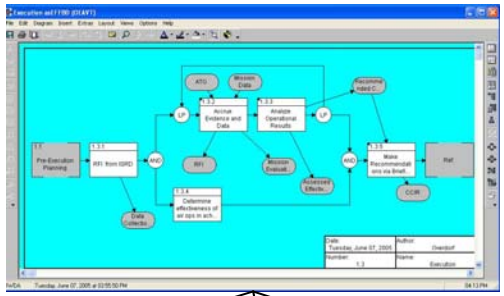
Critical Cues	Critical Decisions	Actions	Common Errors	Tools Used	Communicates with	Data Used	Requirements
*Change in pathways *Change in weather *Etc.	*Determine when changes have been made in ongoing air ops	*Monitor activity trends in areas indicated by critical cues *Monitor indicators against predictions and time		*TBMCS	*ISRD *Plans team	*MISREPS *INTSUMS *DISUMS *Combat assessment	*The system shall allow and aid in recognizing actionable changes in ongoing air ops
•WOE • Time •Guidance •Resource profiles	*Determine if resources available for corrective actions *Determine what to change & amount of change *Determine WOE for each objective *Determine priorities	*Make recommendation *Predict intended and unintended effects of changes *Infer 1st, 2nd, 3rd order effects associated with potential changes		*IWPC *TBMCS	*ISRD *Plans team *Combat Ops	*TPFID *ATO *Guidance	*The system shall determine if resources are available for corrective actions *The system shall determine amount of change to plan, and what to change

CORE Systems Analysis

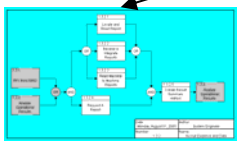
- CORE: Commercially available CASE tool
  - Allows management of the whole project
  - A wide range of information
  - DES supports tradeoff & what-if analysis
  - DoDAF compatibility
- What information we put into it
  - All concept map and CDA information
  - Other information specified by SMEs
-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

CORE Diagram Examples

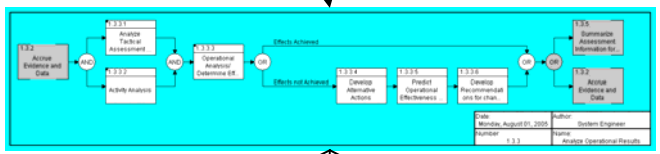
Execution



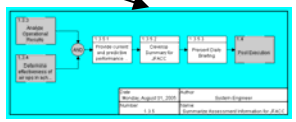
Can be used to generate SV-4 descriptions



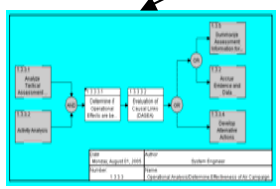
Accrue evidence and data



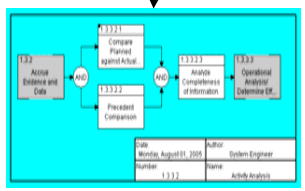
Analyze operational results



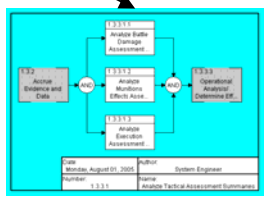
Make recommendations



Activity analysis



Determine effectiveness of air campaign



Analyze tactical assessment summaries

Visualization Interface Concept Development

Scenario Element

Operational execution

Operational Requirement

Indicator Management

Evidence Accrual

Prediction and Forecasting

Operational Assessment

Reporting

Capability/Support Requirement

Intelligent queries

Data mgmt

Cascading effects

Plan troubleshooting

"Live" briefing capability

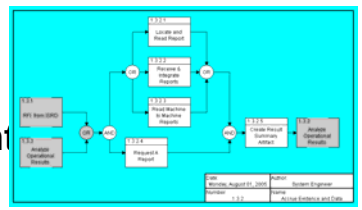
Data mining

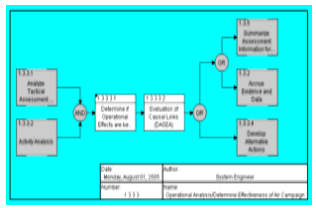
Temporal assessment

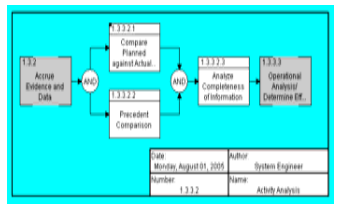
Causal link analysis

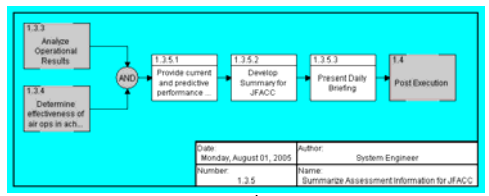
Uncertainty visualization

Functional Requirement

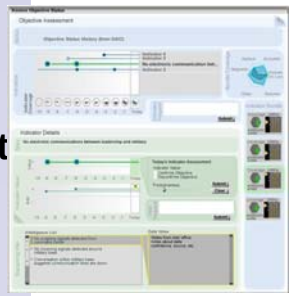


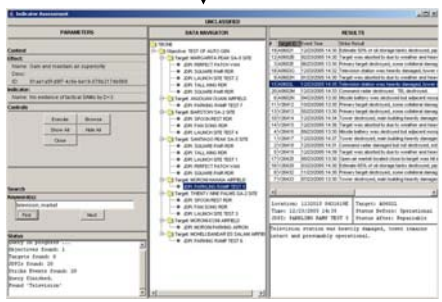






Concept






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
S1: 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
MOE: No significant loss of PDAL assets; No prohibitive losses of friendly assets
AS1A. Defeat enemy fixed and rotary-wing attacks into NV
MOP: No sucessful 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
MOE: 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 Califon's ground offensive NLT D+14 and then render CN unable to defend effectively
File Edit View Help
Zoom
Tilt
Find
General
Geographic Layers
Area Layers
Tactical Actions for Objectives

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	- Hierarchical task network with recursive task blocks - 3-D rendering - Fisheye view on demand
Intelligent queries	- Queries for spatial, temporal and probabilistic content - Intelligent, automated data acquisition
Causal link analysis • between actions and effects •cause – effect latencies; latencies in observing effects • temporal effects	- Influence nets - Colored Petri Nets - Hybrid dynamical systems - Temporal causal graphs - Causal graphs & event calculus - Timed failure propagation graphs
N^{th}-order effects	-Temporal causal graphs - Causal graphs & event calculus

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Questions