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# **Modeling Support of Effects-Based Operations in War Games \***

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**George Mason University**

**\* This paper was originally presented at  
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# OVERVIEW

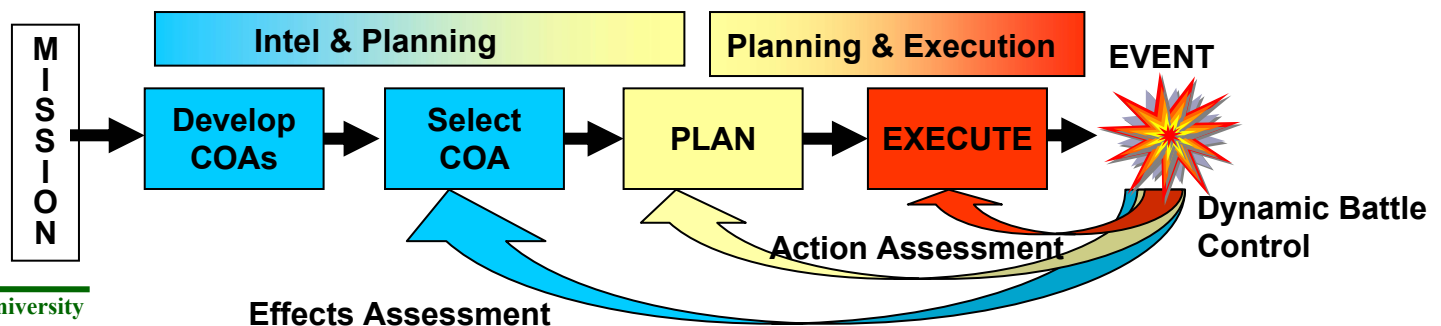
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- **Purpose: to describe an effects based modeling tool (CAESAR II/EB) and its experimental use in war games**
- **CAESAR II/EB (Effects Based) concepts**
  - **Motivation**
  - **Process**
  - **Influence nets**
  - **Colored Petri Nets**
- **CAESAR II/EB in Global 2000 and 2001**
- **Future Directions and Conclusions**

# COURSES OF ACTION FOR EBO

- The nature of many military operations is such that there is need to develop multiple Courses of Action (COAs) to respond quickly to changing situations. Furthermore, there is:
  - Strong and explicit coupling between desired effects and actions that can be taken to achieve them
  - Wide visibility of operations across instruments of national and coalition power which is forcing almost real time effects monitoring and assessment with concomitant consideration of alternative courses of action
  - Change in the way Intelligence, Planning, and Execution are inter-related: not only the integration of Planning and Execution but of Intelligence and Planning as well.



# EBO PROBLEMS

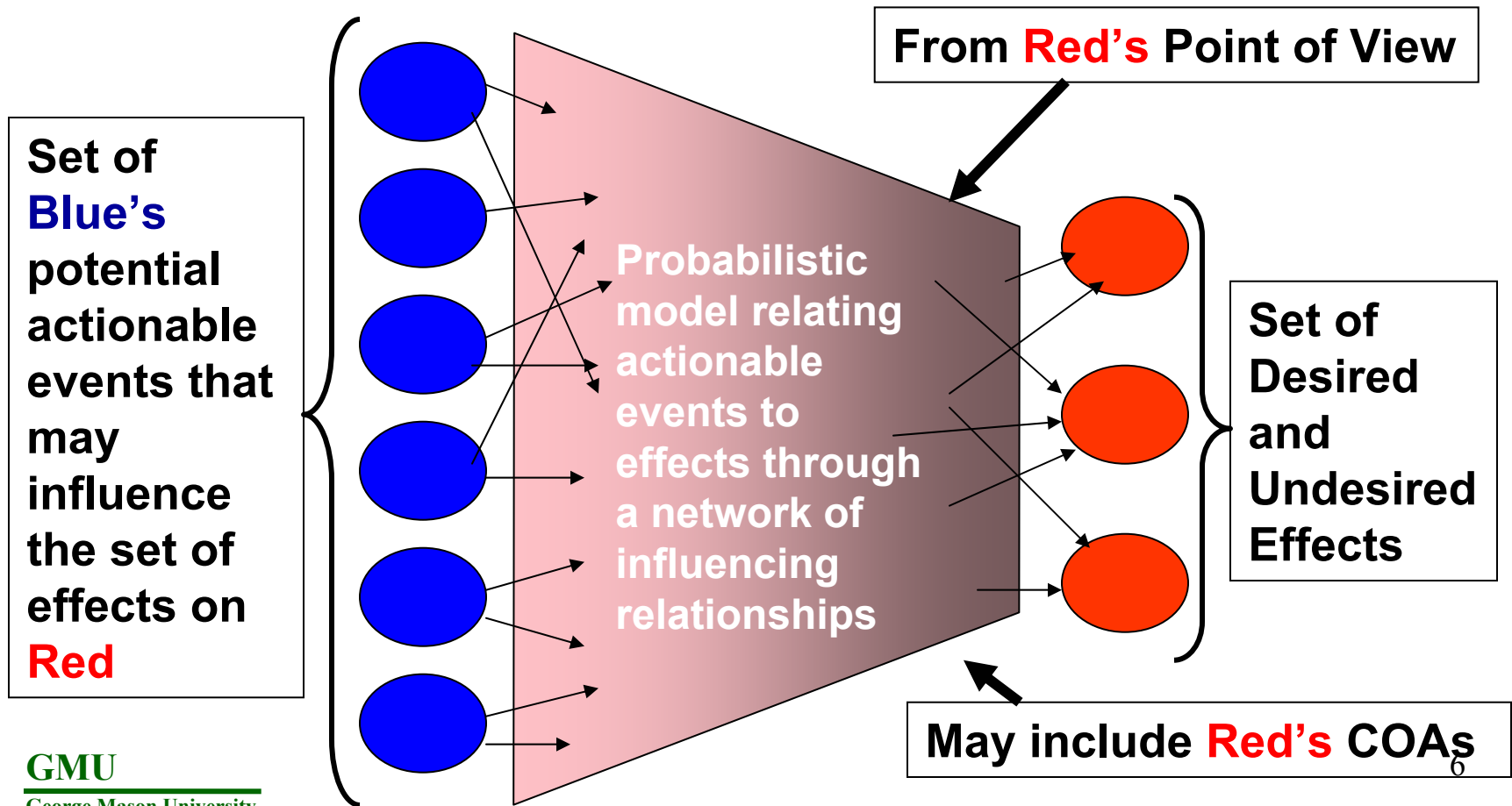
- **EBO Problem:** Relating Effects (desired and un-desired) to Actionable Events through cause-effect relationships
- **COA Problem:** Selecting, sequencing, and timing actions that will achieve the desired effects and suppress the un-desired effects in a timely manner
- **ISR Problem:** Determining the indicators of effects and determining what and when to look for those indicators
- **Evaluation Problem:** Determining metrics by which MOPs and MOEs can be formulated so that COAs can be compared
- **Execution Assessment Problem:** As plans that implement selected COAs unfold and ISR provides status of indicators, calculate the degree of success and determine if changes should be made to COAs

# TECHNICAL APPROACH

- **CAESAR II/EB is a research tool for developing and evaluating Courses of Action (COAs) by creating dynamic models of situations**
  - Leveraged from 10 years of basic research in organizations, architectures, and discrete event systems
  - It is based on the integration of two modeling formalisms
    - **Influence nets**, a form of Bayesian networks
    - **Colored Petri Nets** (Discrete event dynamical models)
  - It allows **evaluation** of sets of actions and how they impact desired effects and undesired consequences
  - It provides **visualization** of the impact of the **timing** and synchronization of actions on outcomes
- **How to incorporate this type of tool in existing C2 **processes** to support EBO is an active area of research being address by experimentation in war games**

# INFLUENCE NET MODELS

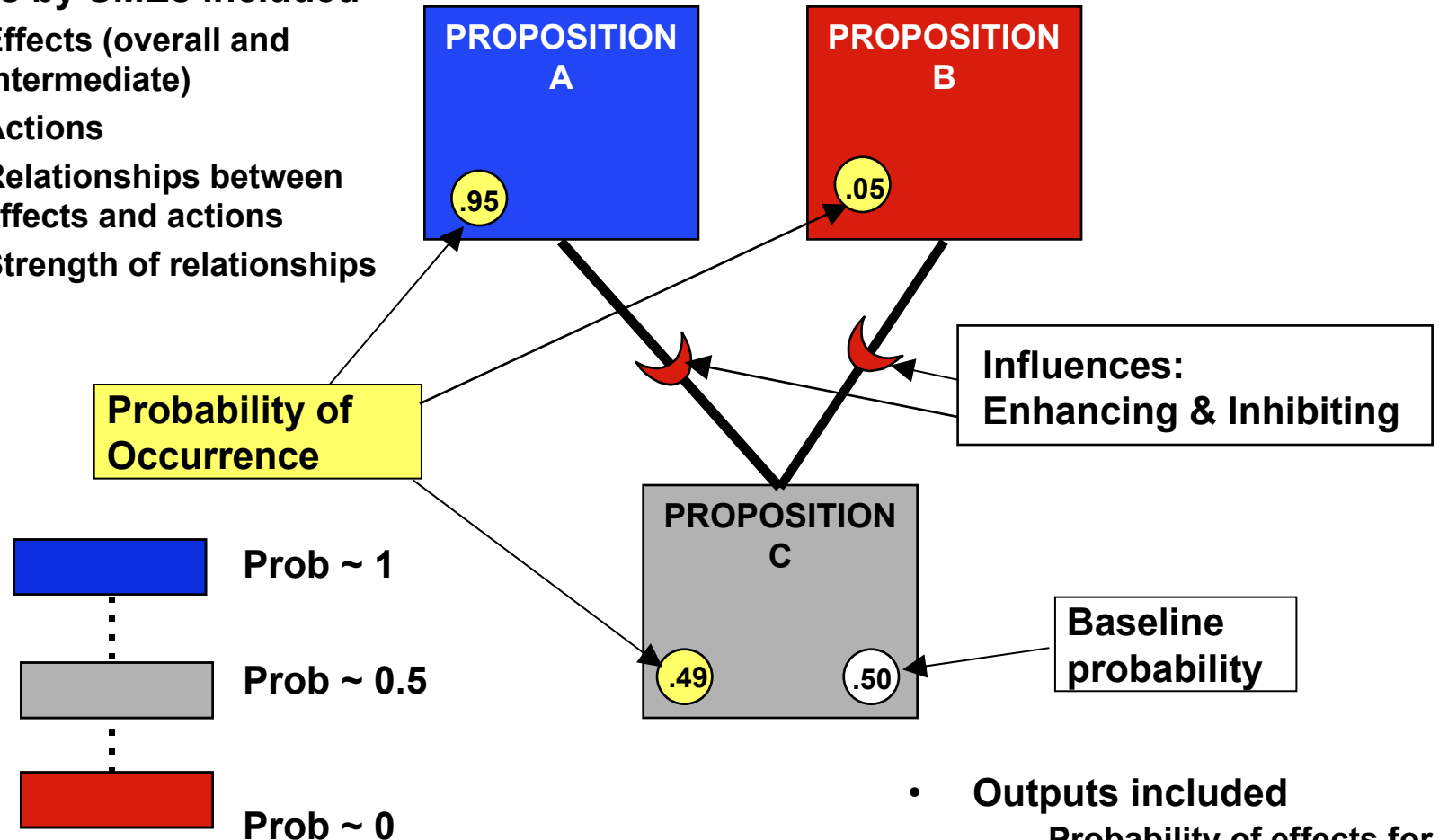
- Relate actionable events by **Blue** to effects from the point of view of **Red**



# INFLUENCE NET INPUTS

## Inputs by SMEs included

- Effects (overall and intermediate)
- Actions
- Relationships between effects and actions
- Strength of relationships



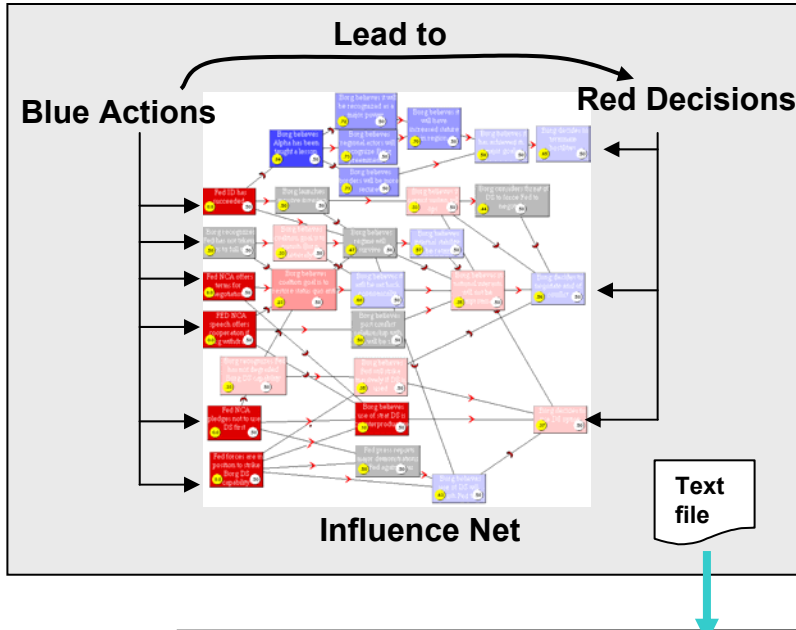
## Outputs included

- Probability of effects for a given set of actions<sup>7</sup>

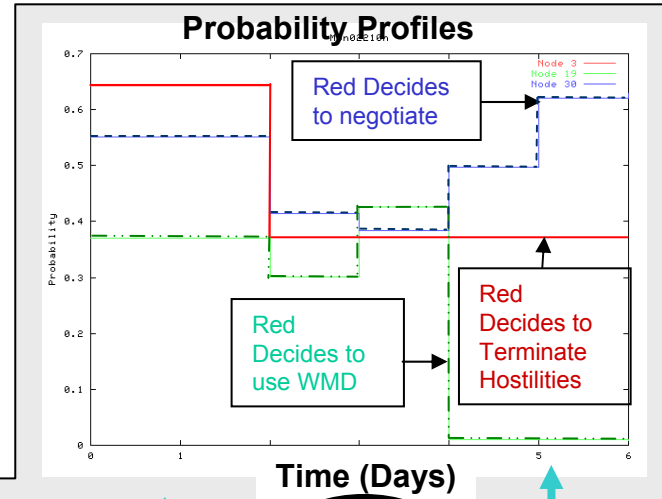
# CAEASR II/EB PRODUCTS



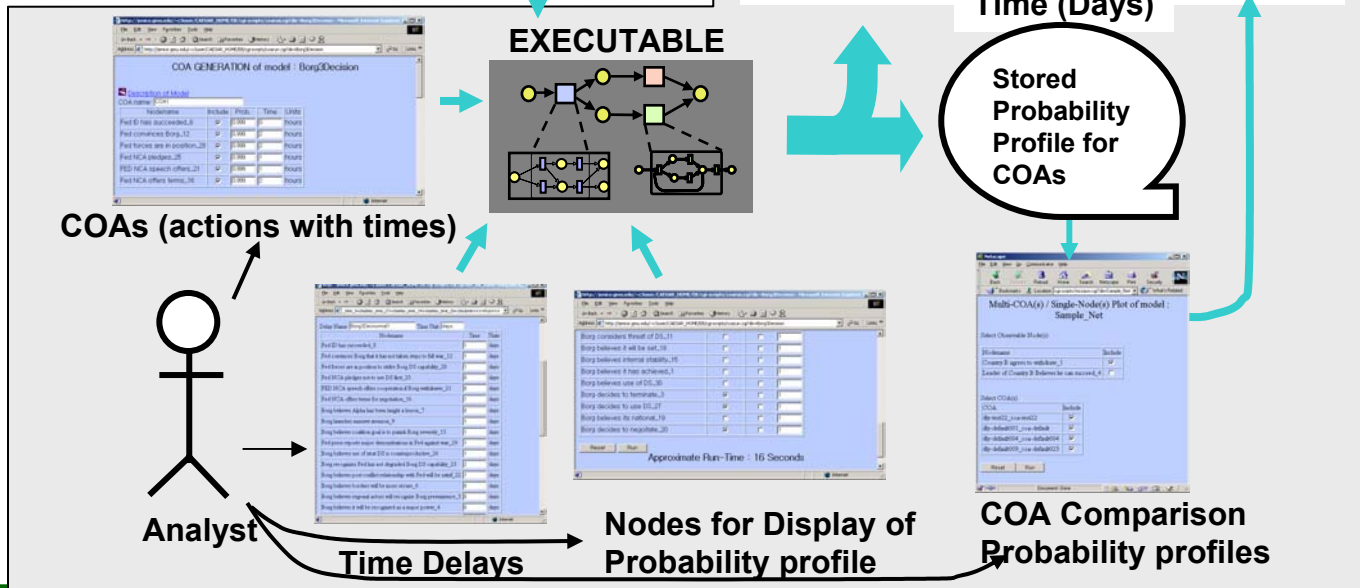
## STATIC ANALYSIS



## TEMPORAL ANALYSIS



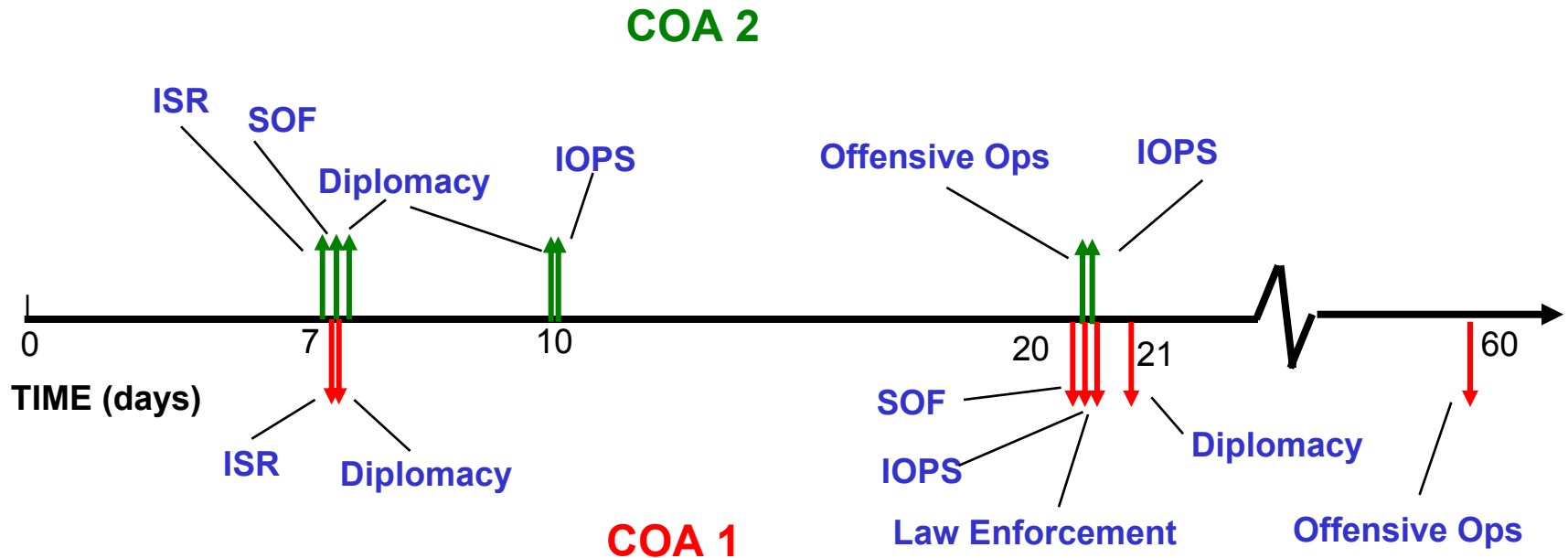
- Sequence and Timing of Actions
- When to task ISR
- When effects may occur
- Time windows of Risk





# TEMPORAL ANALYSIS

- Compare COAs



- Two Courses of Action (COA)

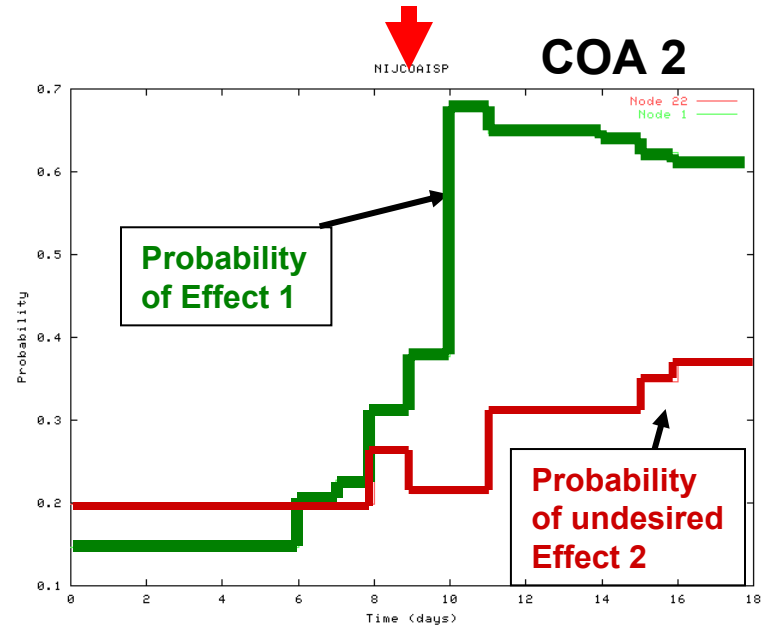
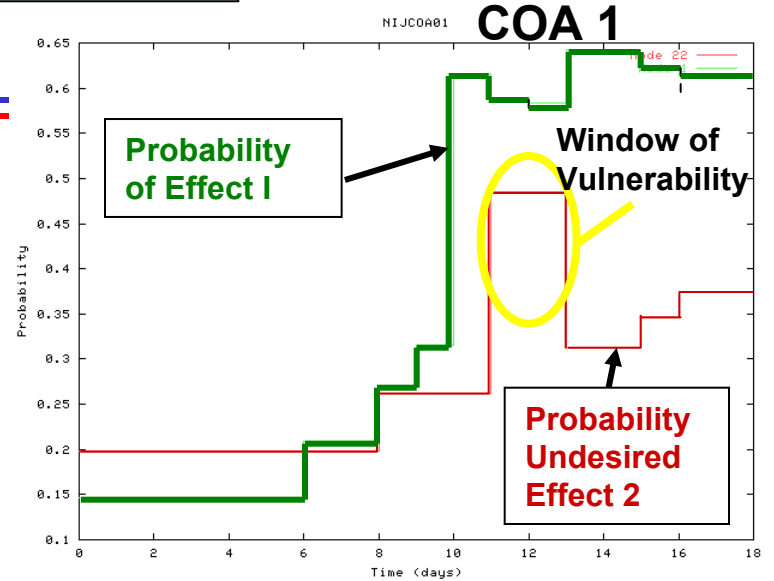
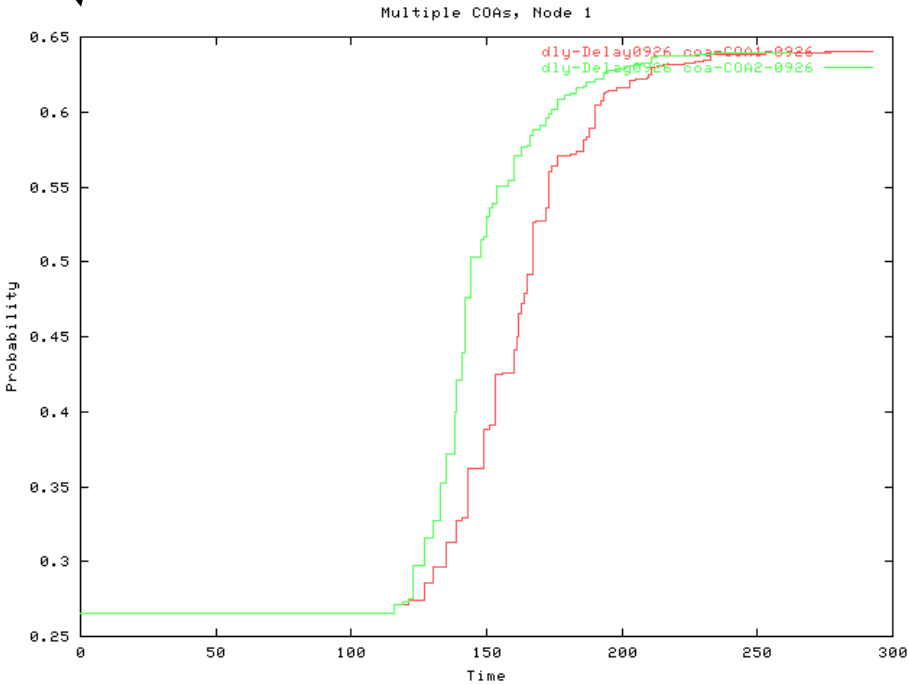
- Same Actions

- Different Timing

*Issue: Where do these sequences and timings come from?*

# TEMPORAL ANALYSIS

- Compare COAs
- Identify and fix timing problems



# CAESAR IN GLOBAL 2000 and 2001

- CAESAR II/EB was used in the Naval War College's Global 2000 and 2001 War Games to test the usability of the tool
- Two questions were addressed:
  - What traditional activities of a war game can the tool support
  - *Organizationally*, where should the tool be located
- Participated in two distinct activities with different “rhythms”
  - Support to *COA development and planning* prior to Game Play
    - Six models of the complete battle plan linked planned actions to overall effects; several days devoted to building each model
    - No single organization identified; adhoc support to planners
  - Support to *analysis of Adversary Actions and Reactions* to Blue Actions during game play: rapid reaction capability required
    - Models build each day (three to four hour to complete model and analysis)
    - Organizationally, the CAESAR II modeling and analysis capability was locate in the reach back cell that contained Blue's Red Assessment Team (BRAT) during game play

# RAPID REACTION EFFECTS ANALYSIS



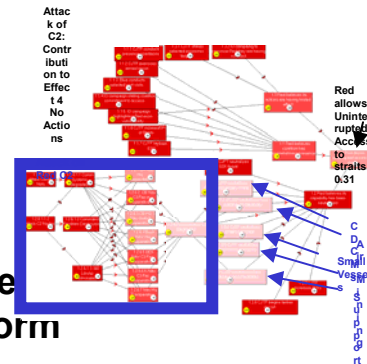
0800 BRAT Director briefs Support Cell on urgent problems/issues



0900 Develop questions and effects of model; collaborate with SMEs



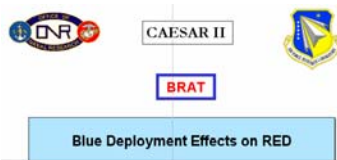
1100 Build Influence net model and perform sensitivity analysis



1330 Post analysis results on Game Web



1200 Create Analysis reports



1300 Present analysis results to BRAT Director



# REACTION FROM RADM CURTIS KEMP

- "The blue red assessment team (**BRAT**) provided a high level of area expertise during the execution of the war game. However, they **were not available during the planning process**. During game play, there was disconnect between the effects defined by the effect directives constructed by the GARP/ CJTF staff and those suggested by the BRAT. **EBO is intelligence intensive; understanding the adversary is absolutely key to assigning effects that will reach stated objects**. The BRAT can provide the requisite knowledge level to help formulate effects and define "decisive" points. As this information would be generated from the CINC, they should be included in the earliest formulations of the effect directive, and then folded into the planning effort.
- **Recommendation: Make the BRAT available to the planners** to assist in development of enemy centers of gravity and help to define what effects will result in probable changes in enemy behavior."

# FUTURE DIRECTIONS/PAYOFFS

- **Next steps**
  - Experience with two Global war games has demonstrated the need for enhancements in three areas
    - the **tools** (e.g. CAESAR II/EB, CAT)
    - the **modeling** and analysis techniques
    - the **process** for using the tool within the C2 environment to support Effects Based Operations
- **FY 2002 Plans**
  - Improve the CAESAR II/EB the expedite model development and analysis (data entry)
  - Incorporate backward propagation, both static and dynamic, for execution assessment
  - Refine the operational concept and the operational architecture
    - Account for nesting of effects at different levels and different points of view within the C2 hierarchy
  - Improve the visualization techniques for presentation of analysis results

# CONCLUSIONS

- **Participation in Global provided a valuable opportunity to test the use of new technology in a realistic environment**
- **Issues of how to incorporate the tools to support EBO within existing C2 processes and procedures**
  - **What is the type of inputs needed to produce useful models**
  - **What is the nature of the outputs that will be given to the Decision Makers?**
  - **What are the visualization techniques that need to be selected or created to provide that output**
    - **Cognitive Models of adversary reasoning?**
    - **Temporal representations of COAs (movies?)**
  - **Issues of purpose and point of view of EBO models remain to be worked out**
    - **POTUS/SECDEF, CINC, CJTF, COMPONENTS have different points of view, but must work from congruent EBO models**

# SEQUEL

- **We have continued to expand the research into Effects Based Modeling and Evaluation**
- **Participation in Millennium Challenge 02 resulted in further refinement of modeling techniques**
- **Supporting JEFX04 Effects Based Operations Initiative that is testing the use of these techniques at the operational/tactical level**
- **Further refinements to the modeling tools**
  - **Backward propagation for execution assessment**
  - **Persistence features**
  - **Interfaces to other planning tools**
- **EBO is a hard, complex undertaking**
  - **Need a suite of tools that support the complete planning, execution, and assessment process**
  - **Need to be able to develop and analyze good models rapidly and provide actionable advice to decision makers**
- **Stay tuned; there is more to come.**