Effects-Based Operations: A historical perspective for a Way Ahead

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OVERVIEW

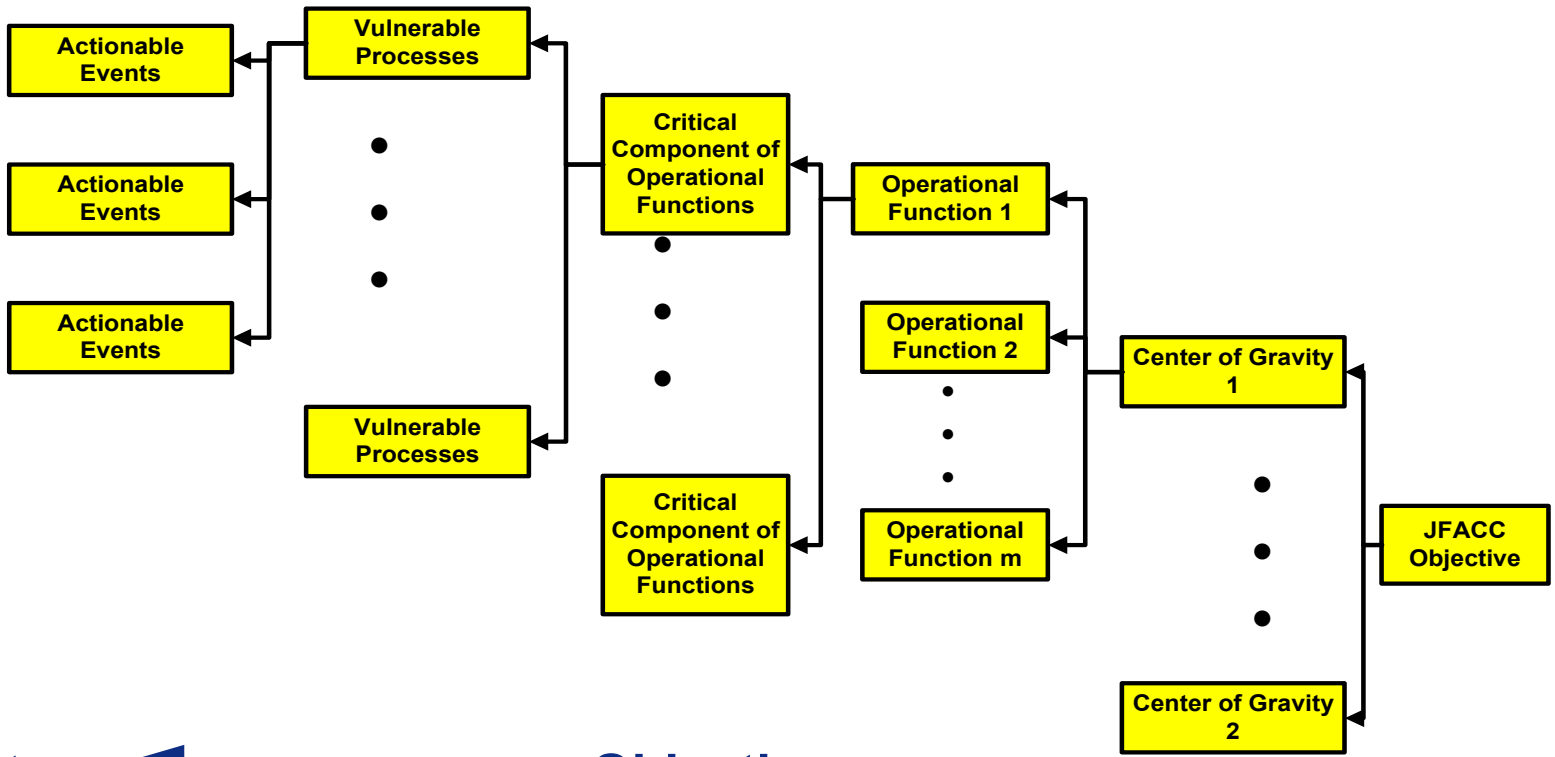
- Purpose: to focus on the directions that the R&D community should take to provide enable the warfighters and the civilian and military leadership to analyze the complex situations, determine desired effects, and develop alternative courses of action that can be compared and evaluated
- Approach
  - to look backwards, to the developments that have already taken place over the past decade, both by R&D and operators and determine key requirements
  - Deduce future directions for the R&D community
- Outline
  - Effects Based Operations and Capabilities
  - Evolution of Technology
  - Lessons Observed Toward a Way Ahead
  - Conclusions

BEGINNINGS

- For years the military has relied on the decomposition of objectives to determine the actions that it will take to achieve objectives. (Strategies to Tasks approach)
- In the 1990's increase precision of weapons, stealth, improved ISR and information technology enabled network has caused a shift toward an effects based approach
  - Rapid surgical strikes against key elements of an adversary's systems to achieve overall effects with minimum collateral damage. All done with a minimum of assets.
- Closely related is a shift in emphasis on platforms to capabilities

TRADITIONAL PLANNING (Objectives Based)

- The planning methodology follows a Functional Decomposition Approach – from objectives to functions to detailed functions that can be affected by actions

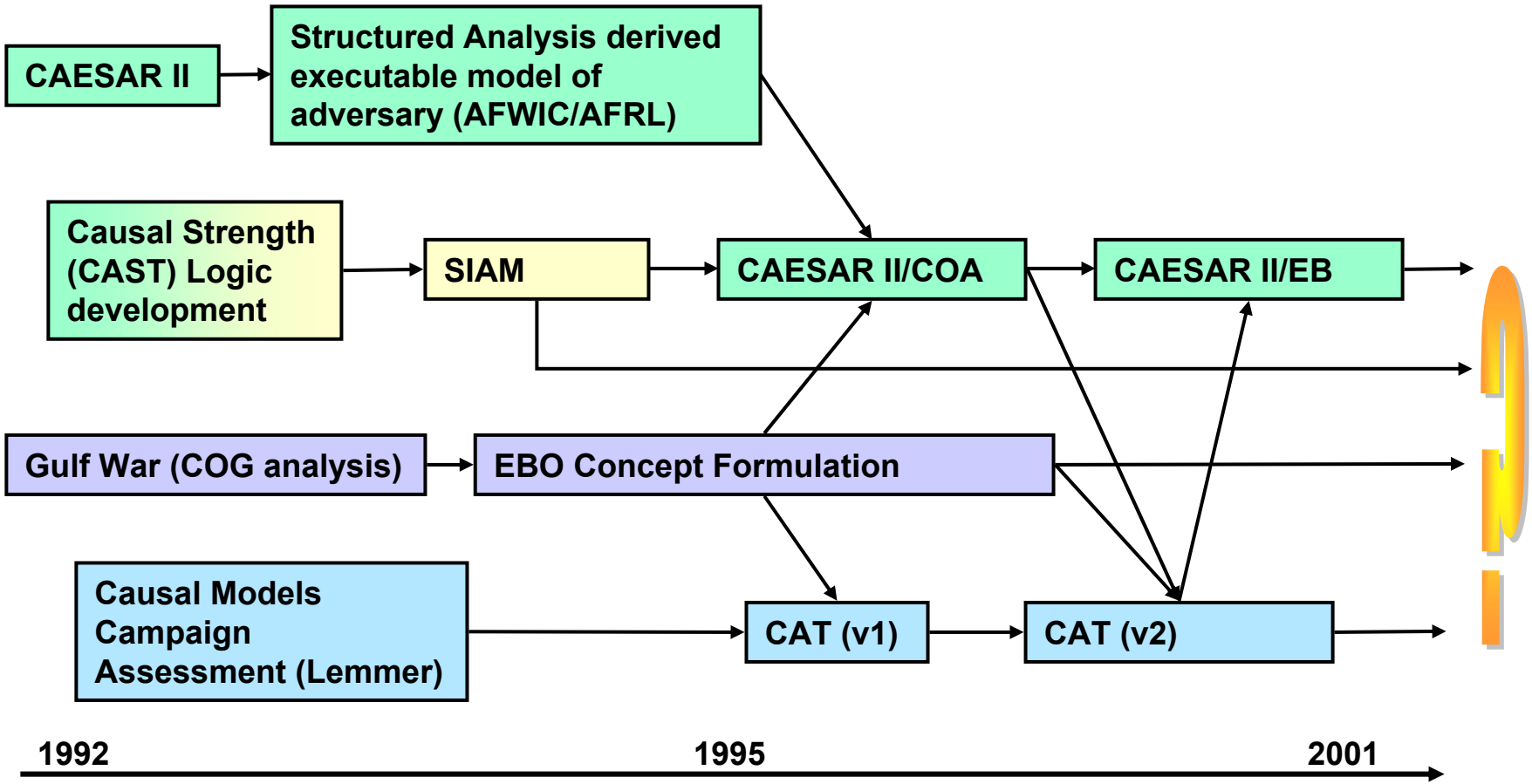


Event ⟵ Objective

Effects Based Operations Modeling Approach

- In contrast, the Effects Based Operations modeling approach starts with the definition of a desirable Effect (or Effects) on the Adversary (Red)
- Then we work backwards (from right to left) to the Centers of Gravity of Red that influence the desired Effect(s) – the arrows show the cause to effect relationships (left to right)
- Then we identify the Operational Functions of Red that affect the COGs, which in turn influence the Effect(s)
- We continue "unfolding" backwards till we arrive at actionable events that can be carried out by Blue
- Finally, we include other external events, not controlled by Blue, that influence the achievement of the desired Effect(s) on Red
- There are also cause-effect relationships that affect the strength of the influences

EVOLUTION

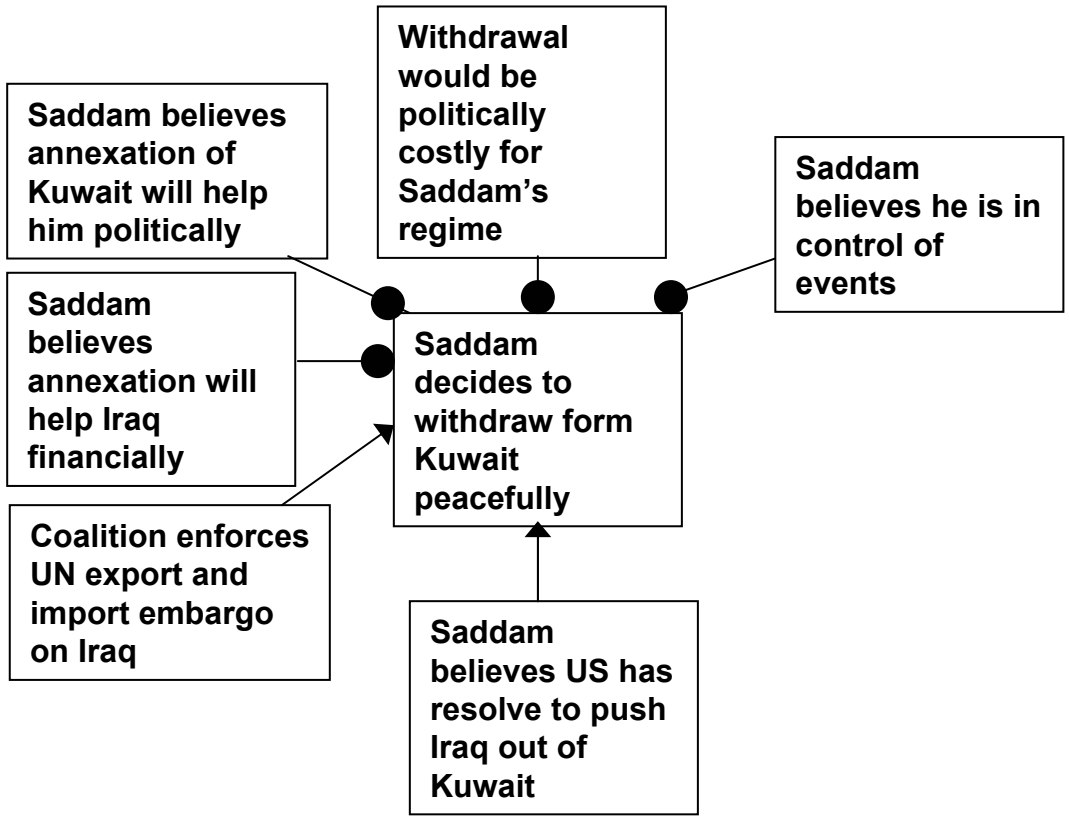

CAESAR II
Structured Analysis derived executable model of adversary (AFWIC/AFRL)
Causal Strength (CAST) Logic development
SIAM
CAESAR II/COA
CAESAR II/EB
Gulf War (COG analysis)
EBO Concept Formulation
Causal Models Campaign Assessment (Lemmer)
CAT (v1)
CAT (v2)
1992
1995
2001

SIAM: INFLUENCE NETS

- Developed with DARPA resources to to assess socio-political influence strategies
- Objective: extract empirical expertise and knowledge about adversaries and place it in an analytical framework.
- Tool designed toward five requirements
  - Model Based
  - Support Collaboration amongst domain experts
  - Support mathematically rigorous analysis such that actions could be compared against the effects those actions could influence
  - Be usable by analysts without the need to understand complex Bayesian mathematics of require large quantities of conditional probability values that may be difficult to obtain
  - Provide an intuitive understanding of the complex interaction of cause and effect relationships to decision makers who would select courses of action based on the analysis

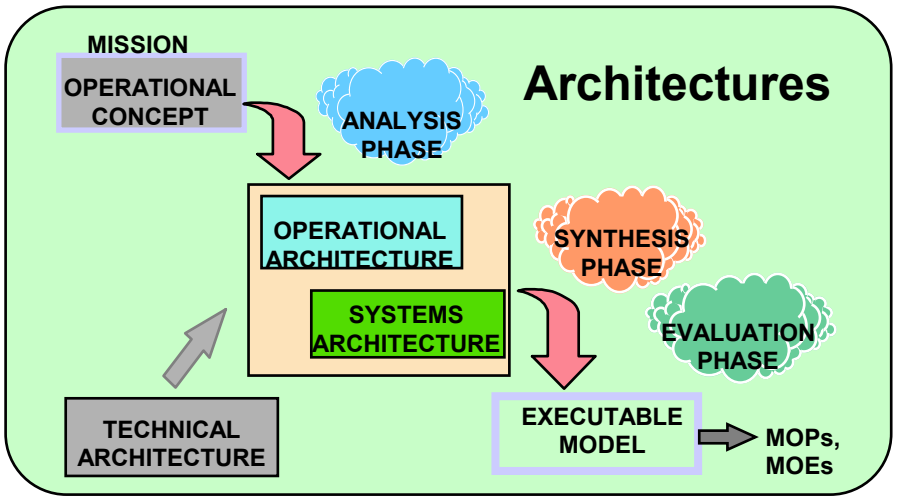
SIAM: INFLUENCE NETS

- The structure of the Influence Net Contains a great of information
  - Reasonably intuitive
- Adding influencing "strength" values enables mapping to the Bayesian mathematical model
  - Causal Strength (CAST) Logic incorporated to simplify elicitation
- Bayesian probability propagation supports analysis
  - Sensitivity analysis functions added



ARCHITECTURE TECHNIQUES

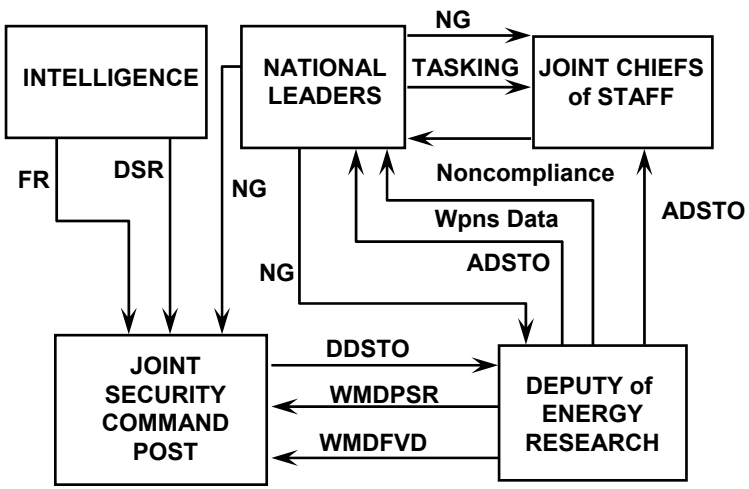
- 1995, AFIWC desires an analytical approach to evaluating COAs for information operations
- Supports effort to employ architecting techniques to model an adversary's decision making processes and systems so that its responses to stimuli can be evaluated
- Case study example used to develop and illustrate the technique



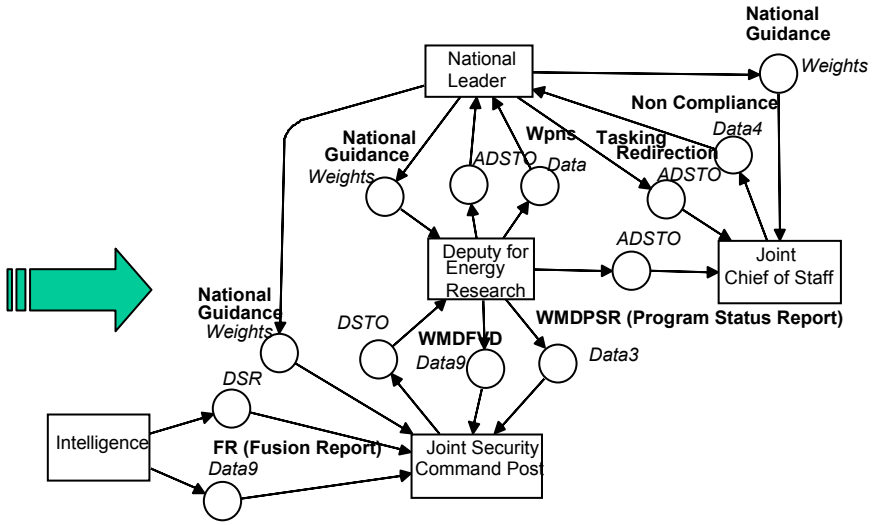
Scenario: Fictitious country of Witmania is developing WMDs Develop a COA to deceive the Witmanian Decision making process so that it moves forces to enhance the success of a surgical strike.

ARCHITECTURE TECHNIQUES

- Object Oriented Architecting approach used to create the static logical and physical architecture
- Conversion to Colored Petri Net to evaluate the response of the Witmanian system to ten stimuli
  - Sequence of stimuli key to achieving desire effect

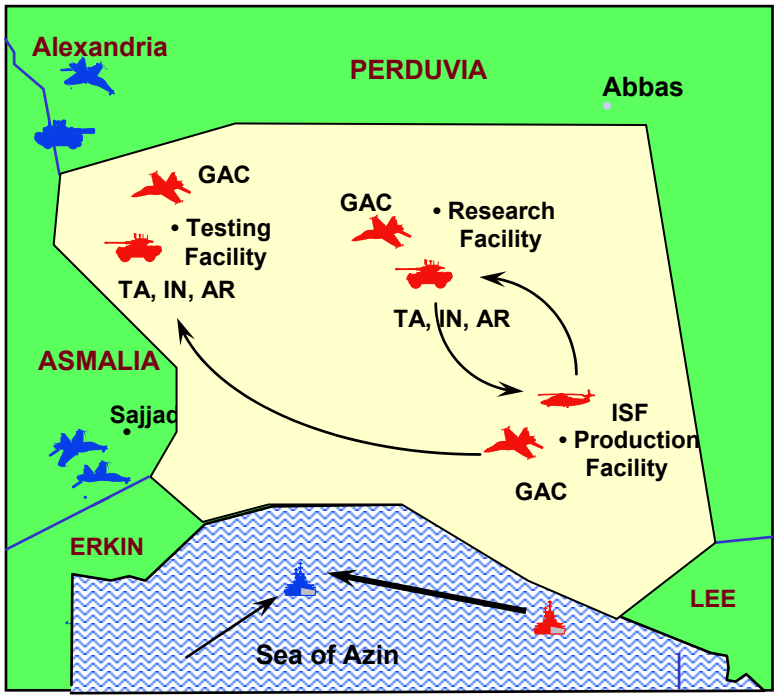


High Level Class Model of the Witmanian C2 System



Colored Petri Net Model of the Witmanian C2 System

ARCHITECTURE TECHNIQUES



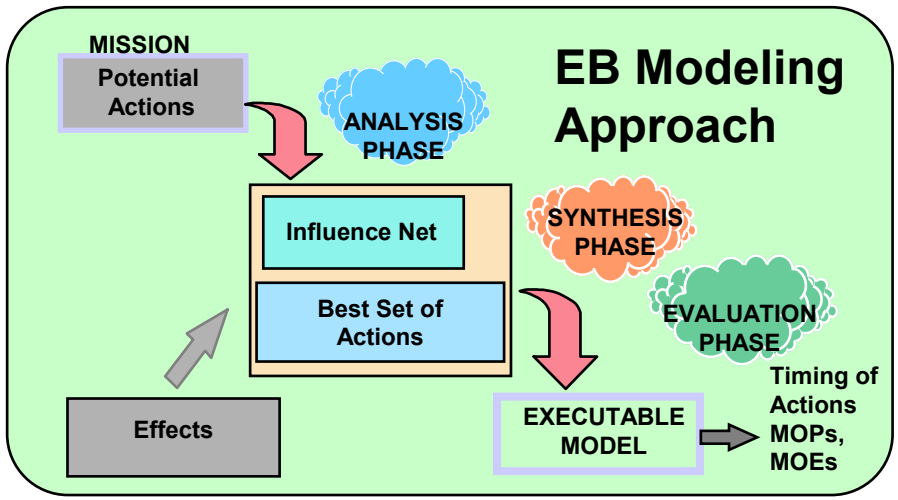
- Visualization of analysis results of the Witmanian Decision Making C2 system
- Shows the effect of the COA that causes Witmania to react in a way that is favorable to Blue

Findings

- The approach validated that it is possible to use models of the adversary's decision making processes to evaluate likely Adversary reactions to a sequence of Blue actions that comprise a COA
- Requires a great deal of information about the Adversary's procedures and rules that may not be available or reliable

Combined Approach

- Based on the AFIWC research, the CAESAR II/EB research tool was created for developing and evaluating Courses of Action (COAs) by creating dynamic models of situations
- Modified the architecture procedure to allow the creation of the influence net for static analysis and its automatic conversion to the executable model for dynamic temporal analysis
- ✓ Collaboration with AFRL/IF (Dr. John Lemmer and Maris "Buster" McCrabb) on development of the Campaign Assessment Tool (CAT)



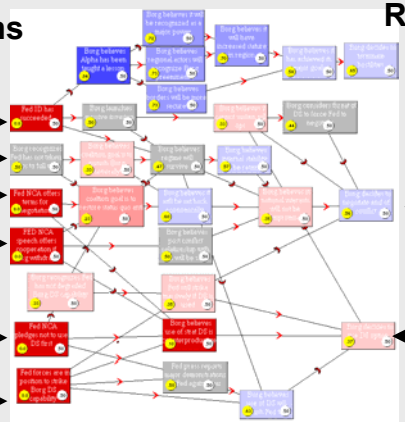
CAEASR II/EB PROCEDURE

STATIC ANALYSIS

Lead to

Blue Actions

Red Decisions

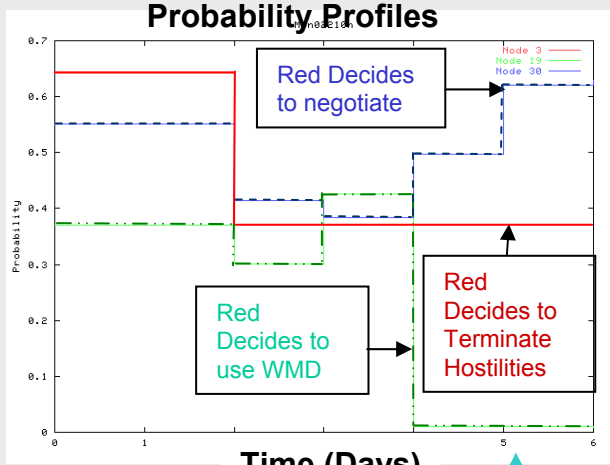


Influence Net

Text file

Best Set of Actions

TEMPORAL ANLYSIS

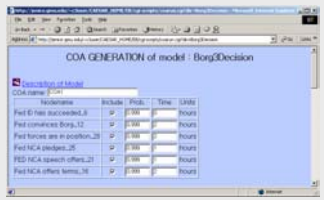


Sequence and Timing of Actions

When to task ISR

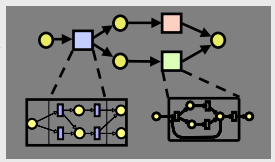
When effects may occur

Time windows of Risk

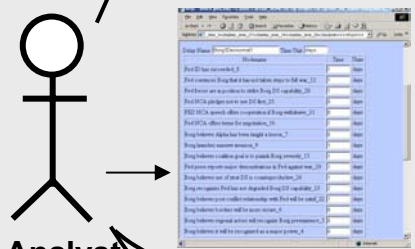


COAs (actions with times)

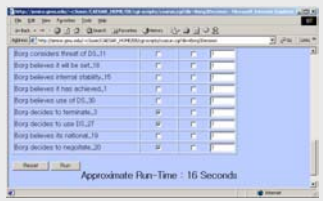
EXECUTABLE



Stored Probability Profile for COAs



Analyst



Time Delays

Nodes for Display of Probability profile

COA Comparison Probability profiles

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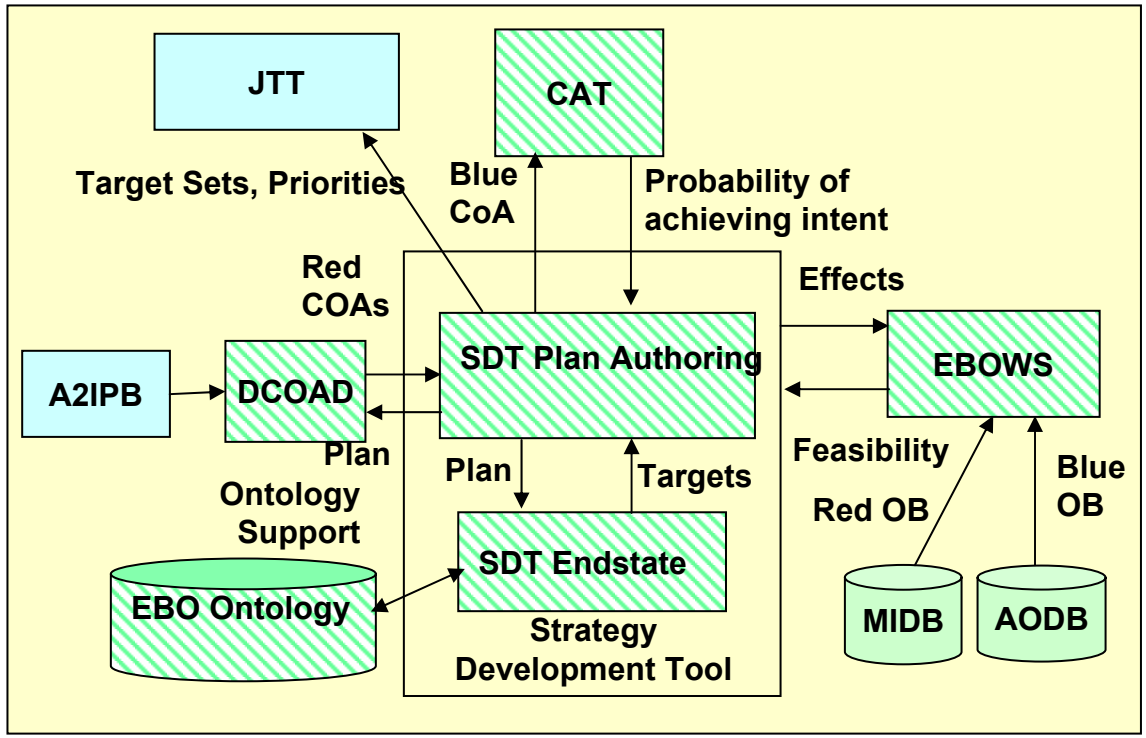
EBO ATD

- Initiated by AFRL/IF at Rome, NY in 2001
- The objective is to develop and integrate a set of technologies to support Effects Based Operations for Air Components.
- This ATD is designed to demonstrate to users the capability to plan, execute, and assess air campaigns using the EBO construct.
- A series of demonstrations are planned over the three-year period

System Architecture Interface Diagram SV-1



CHALLENGES

- The goal is to bring suitable, useful tools to the hands of planners and operators in command centers
  - trade off hard and soft kills
  - choose a proper mix of kinetic and non-kinetic weapons
  - embed military action in the context of political, diplomatic, and social actions.
- There are a set of technical challenges for the R&D community
  - Temporal Analysis Challenges
    - Rigorously handle timing of actions, time delays for communications and processes, duration of actions, and persistence
  - Analysis techniques
    - Sensitivity Analysis to determine the "best" set of actions
    - Modeling of adversary belief, reasoning, and decision making
    - Prescriptive process for determining the "best" sequence and timing of the set of actions
  - Visualization approaches for decision making

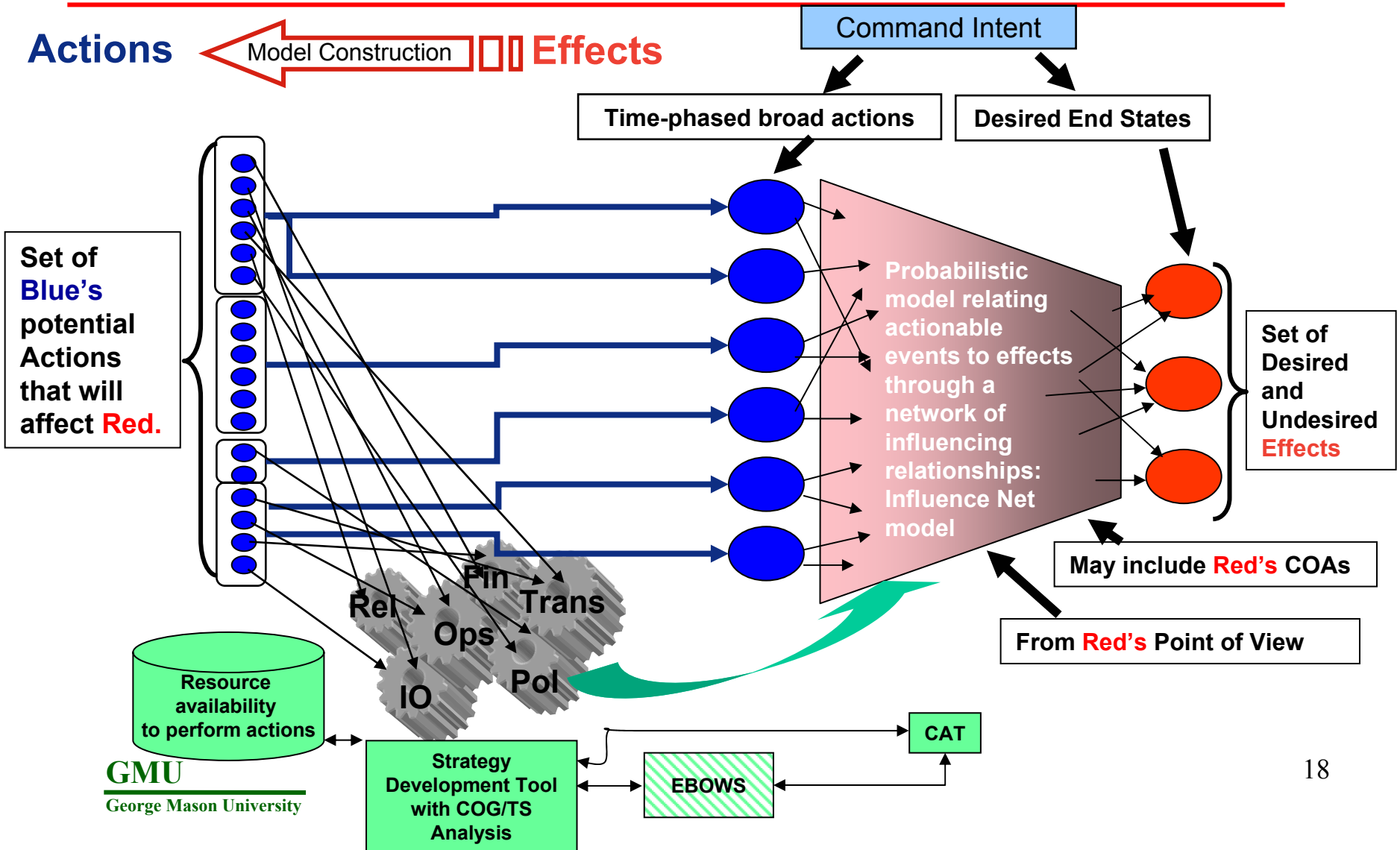
OBSERVATIONS FROM WARGAMES

- The EBO concept spans *multiple echelons and disciplines*.
- A model based approach to relating actions to effects is appropriate
- Building the models is a challenging task (even with tool support)
  - Generally a collaborative effort is required (SIAM lesson)
- So far, models have focused at the Strategic and Operational levels
  - We need to determine applicability at the tactical level
- There are least two tempos in operations that impact model development and evaluation: deliberate planning and quick reaction
  - Tools and techniques must support the rapid morphing of existing models as well as the assessing of the new information that is needed to build new models
- To be effective, the modeling and the models must be incorporated into the overall planning, execution, and assessment process.
  - Strategy and planning cells, current operations cells, and commander and staff must be aware and support the modeling efforts.
  - The output of the models must be part of the COA development and the planning processes.
  - Having a separate stand alone EBO modeling activity is not very effective.

MORE OBSERVATIONS

- Effects are physical or psychological. We must be able to model both
- The goal is to create a trajectory from the current state to the desired end state through the set of coordinated (timed and synchronized) actions we take.
- It is not sufficient to determine a set of actions and generate orders to carry them out.
  - The operators in command centers such as a CAOC need a complete EBO capability. The CAEASSR II/EB or CAT tools only provide part of the analysis of an EBO based plan. In addition, we need to be able to perform Center of Gravity and Target Systems analysis to determine the functions and components of the adversary's systems that are vulnerable to actions and thus are potential targets. These components and functions become the objects of effects that are contained, sometimes in an aggregated way, in the causal model that links actions to effects. In addition, we need tools that can identify and schedule the resources needed to carry out the actions and provide feasible time windows when those resources can be available to conduct the actions.

Effects Based Modeling for COA Development



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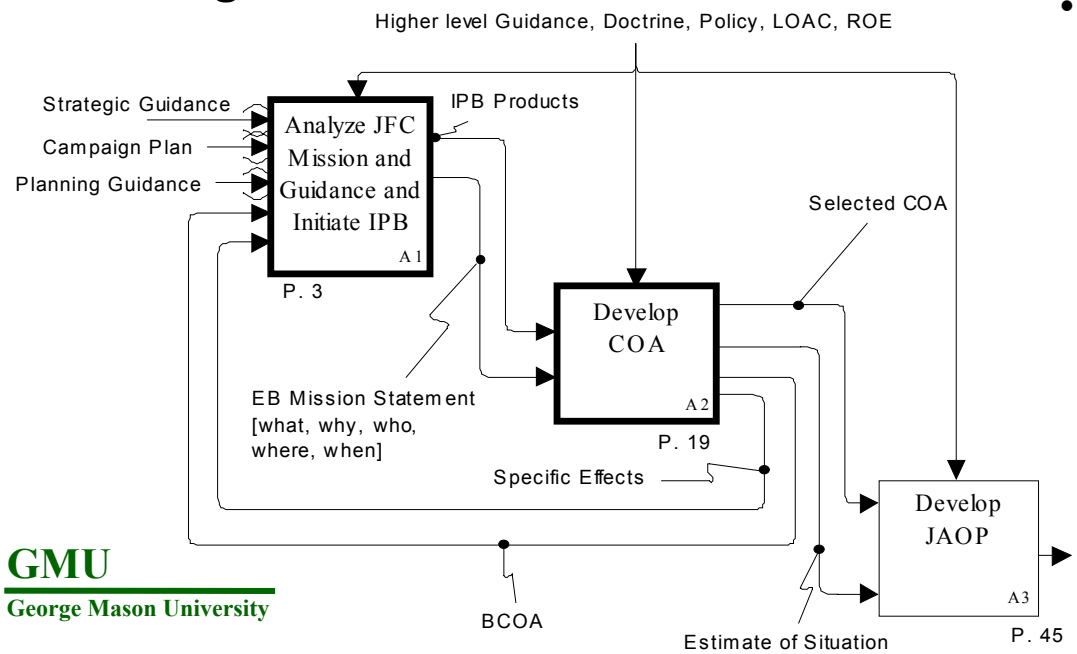
A WAY AHEAD

- **Both the R&D and the operational communities are learning a great deal from their on-going collective experience with EBO**
- **GMU has learned that it is imperative that the tools developed be fully incorporated into the planning, execution, and assessment process, if they are to make a difference.**
- **A systems engineering approach may provide the answers that we are seeking.**



- **Developing Operational and System Architecture Views of the EBO operational concept**
  - **Defines interfaces between the systems that will enable operators to conduct EBO according to their operational concept.**
  - **Reveals gaps in technology developments and opportunities for new efforts.**

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CONCLUSIONS

- As we have discovered, EBO is a complex undertaking with potentially high payoff.
- Both the operational and R&D communities need to refine their thinking and create new tools and techniques to manage this complexity.
- The tools and techniques must be incorporated in an overall process that is used for planning, execution, and assessment across domains and levels.
- We need to devise better ways to help operators and analysts develop good models rapidly. There is considerable room for improvement in this arena such as the use of templates and approaches for pruning models.
- We need ways of rapidly finding information and data that can be used in developing the models and methods for transforming the information into the constructs of the models.
- Since more than one modeling technique is appropriate, we need to determine how to import the information derived from one model into another. We need to determine what the interactions between these models should be in order to enhance the EBO process.
- We only partially succeeded in our goal for highlighting the way ahead. More hard work needs to be done.