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OTAN

# A State-Space Formulation for Effects Based Operations

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# Presentation Content

- **Conceptual mapping between the Effects-Based Approach to Operations (EBAO) and classical Control Systems Engineering.**
- **Illustrations from C2 and analytical tools used in Multinational Experiment 4 (MNE-4), Feb-Mar 2006.**
- **Suggested augmentation of current EBAO elements.**

# Definitions (I)

## ● The MNE-4 EBO definition:

Operations that are planned, executed, assessed and adapted based on a holistic understanding of the operational environment in order to influence and change system behaviour or capabilities using the integrated application of selected instruments of power to achieve directed policy aims, (*the desired end-state*).

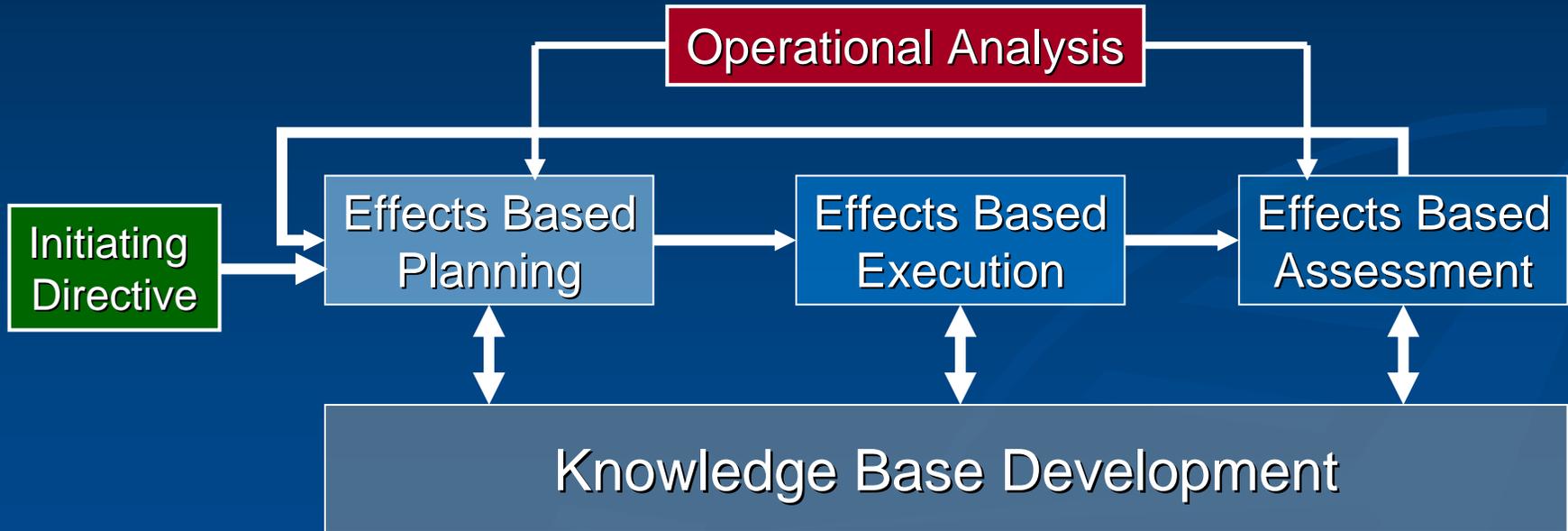
## ● The NATO EBAO definition:

The coherent and comprehensive application of the various instruments of the Alliance, combined with the practical cooperation along with involved non-NATO actors, to create effects necessary to achieve planned objectives and ultimately the NATO end-state.

## ● Key feature of EBO/EABO:

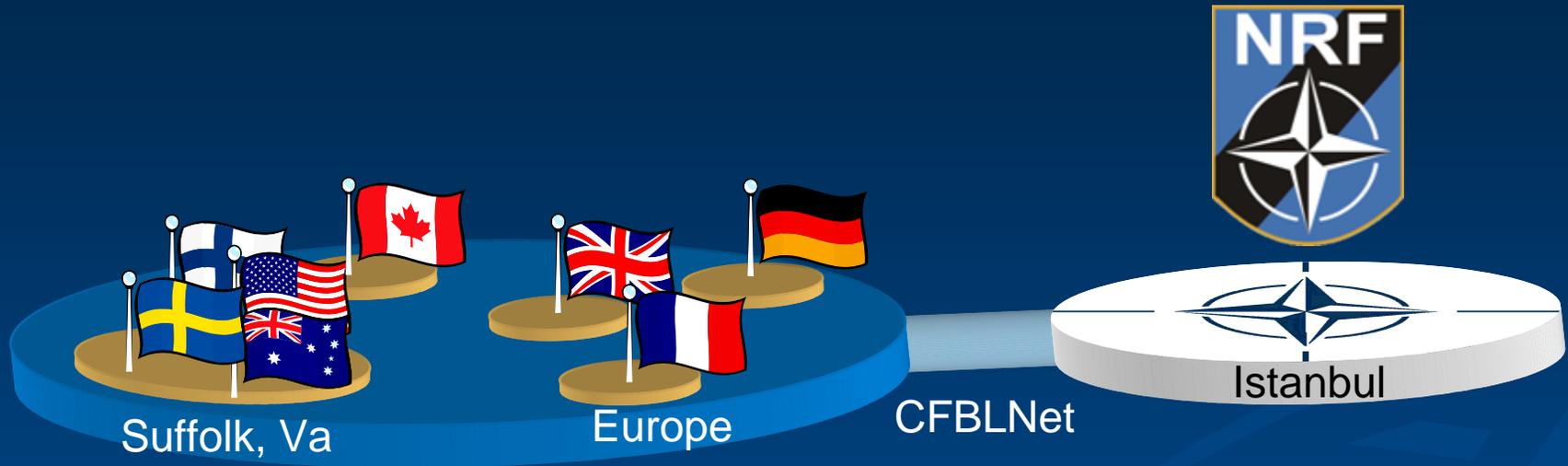
- The systems approach to the understanding of the operational environment for the planning and assessment of the operation.
- Explicit expansion of the dimensions of the operational environment to include non-military as well as military factors and means.

# EBAO Key Elements





# MNE-4 Participants & Purpose

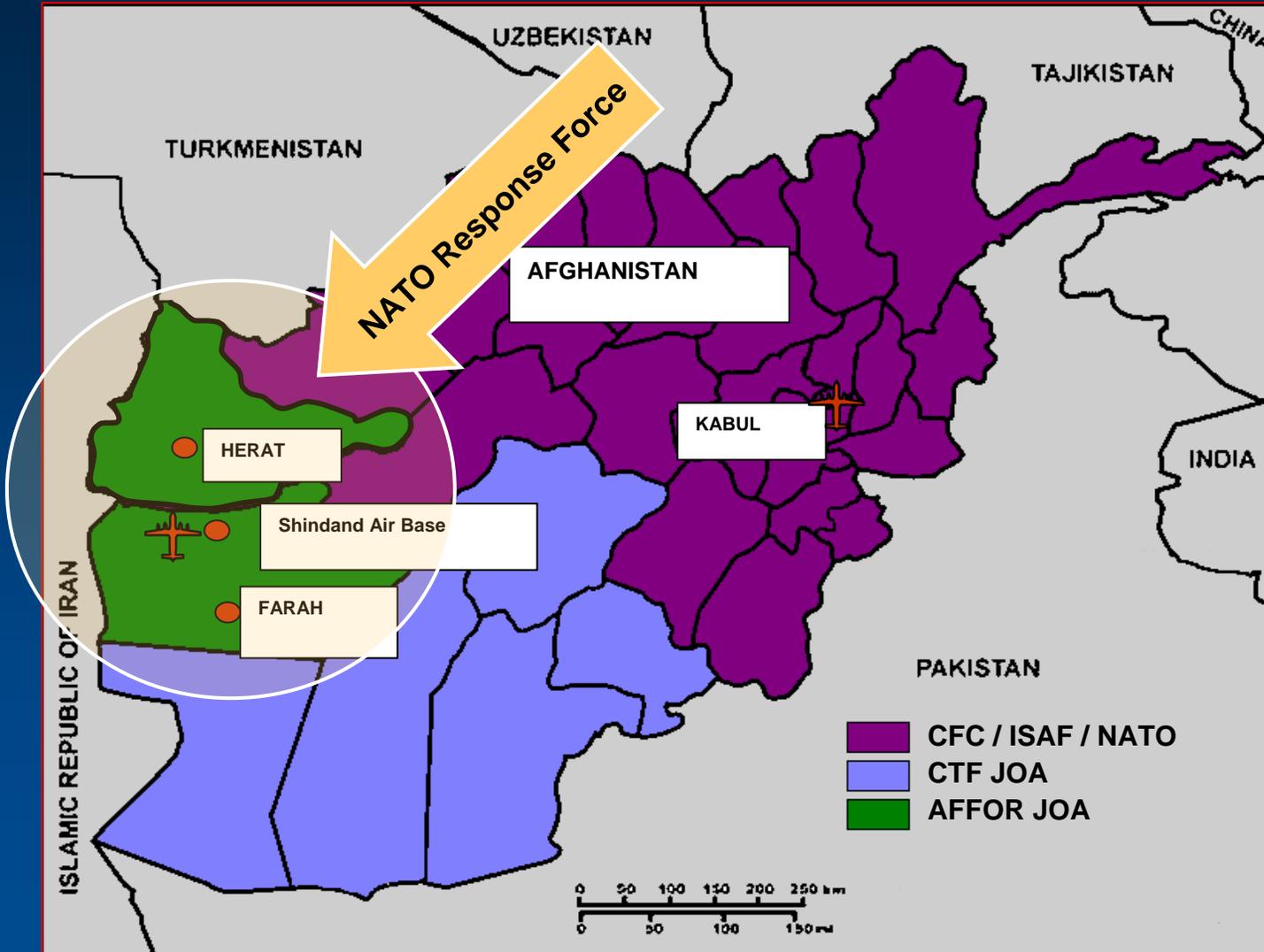


Coalition Task Force  
(CTF) HQ

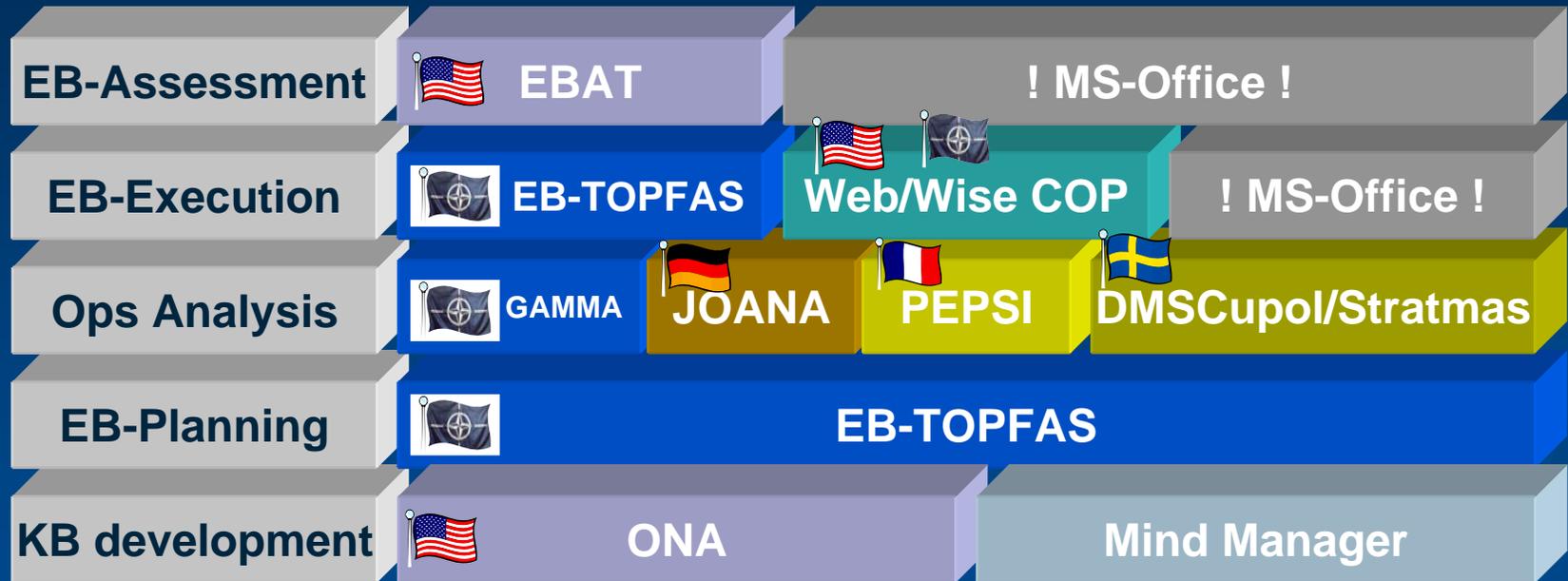
NATO Response Force  
HQ with  
NRF-7 Resources

Exploration of Concepts and Tools for EBAO

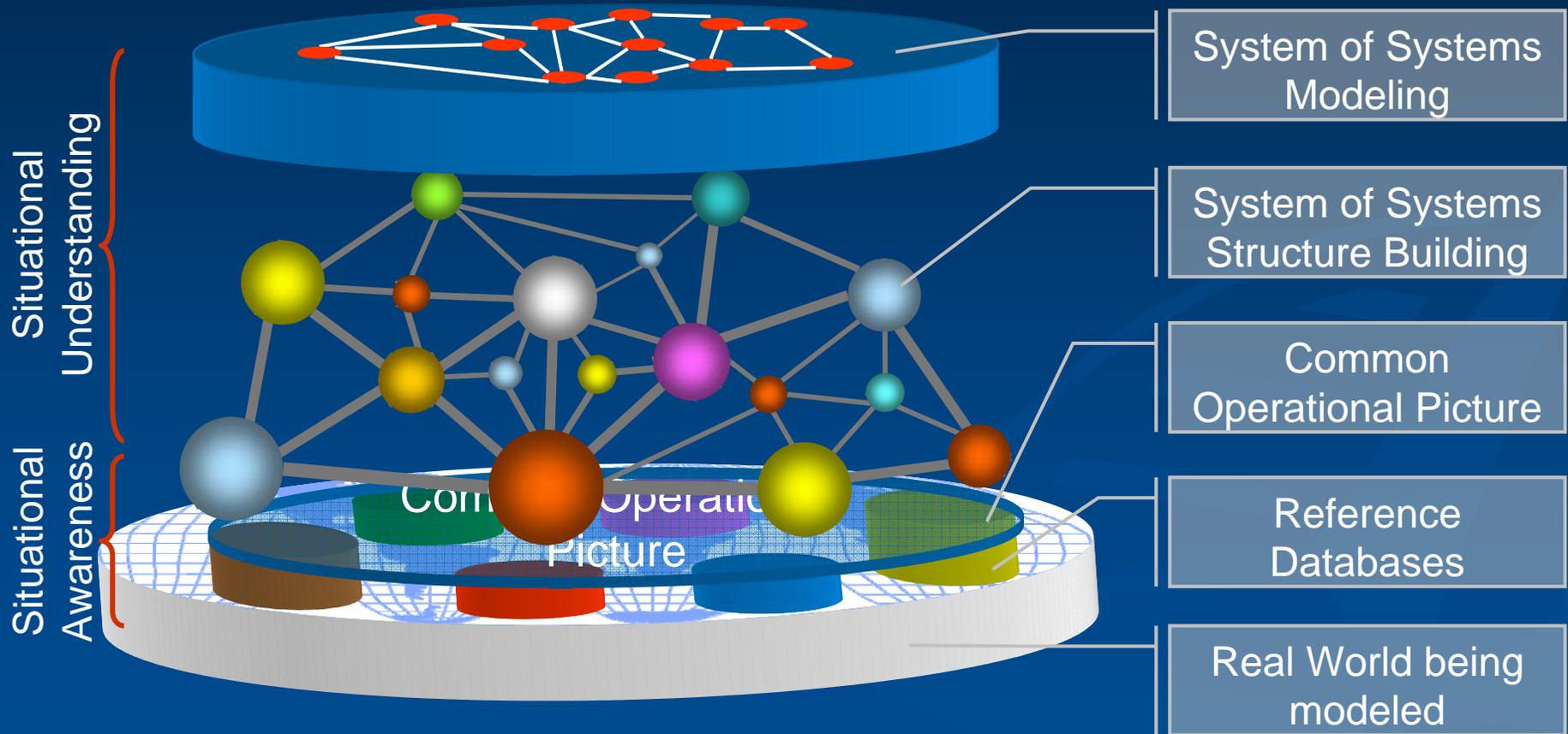
# MNE-4 Scenario



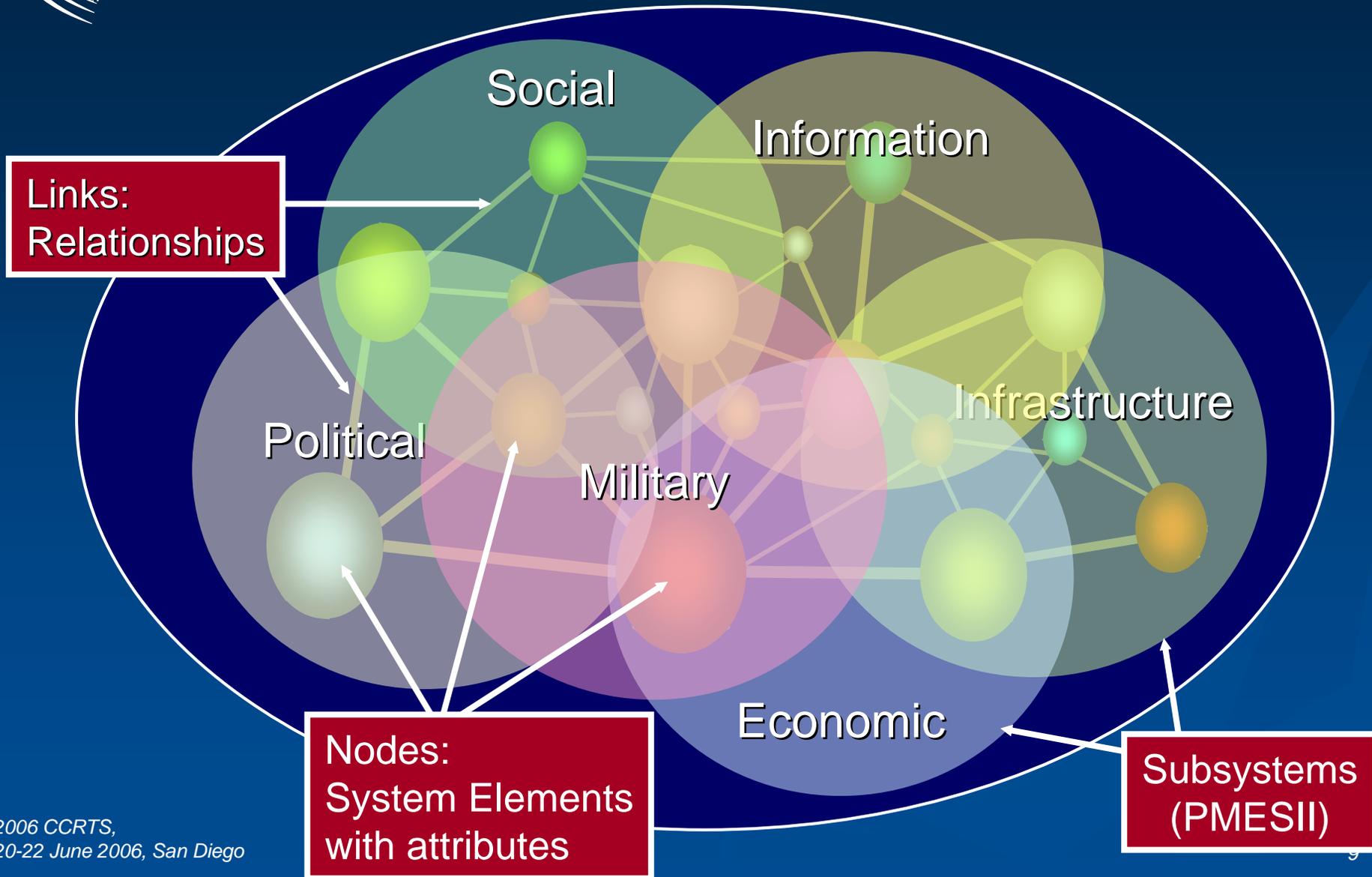
# Experimental Tools for EBAO in MNE-4



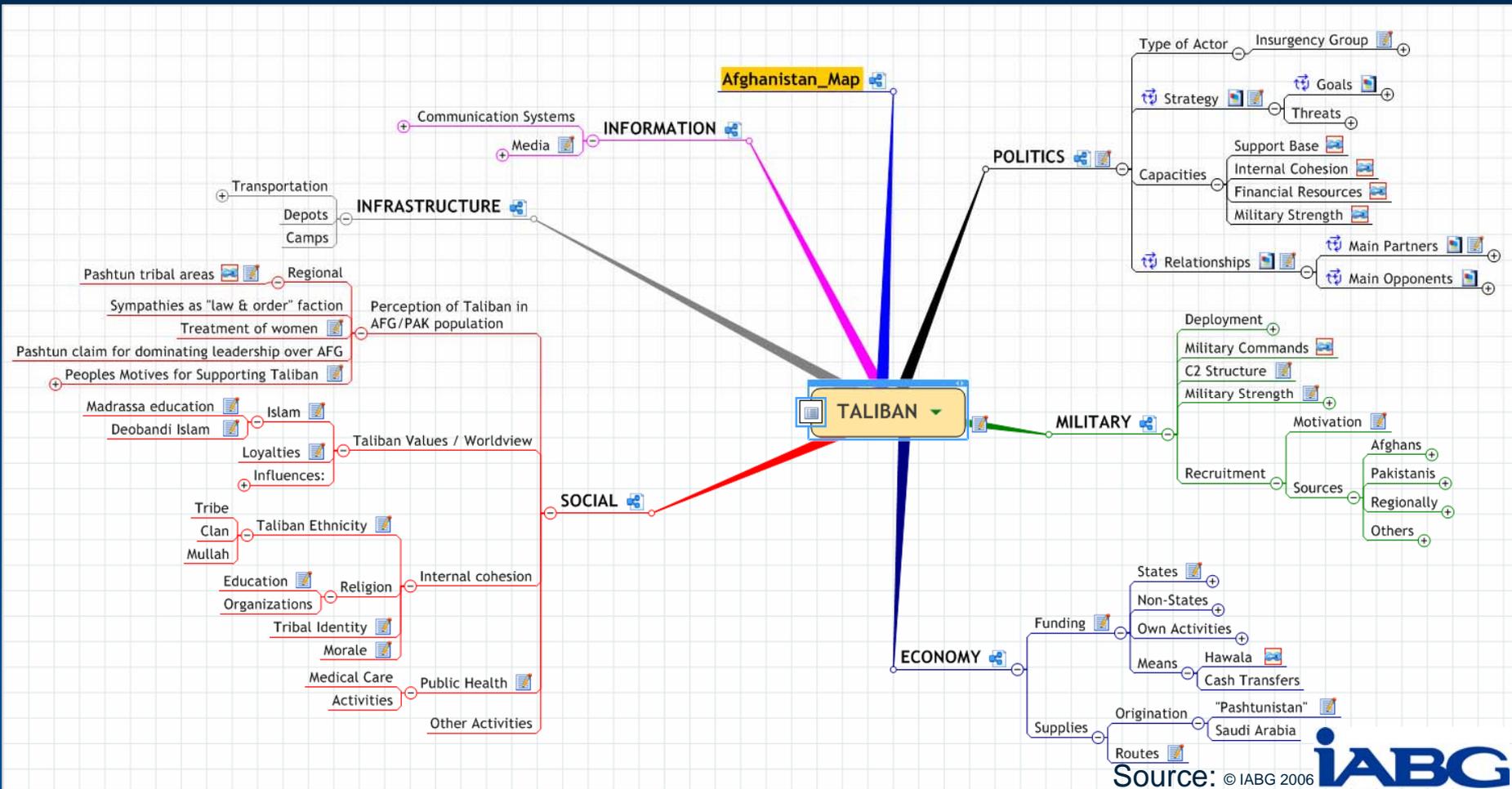
# Knowledge Base Development



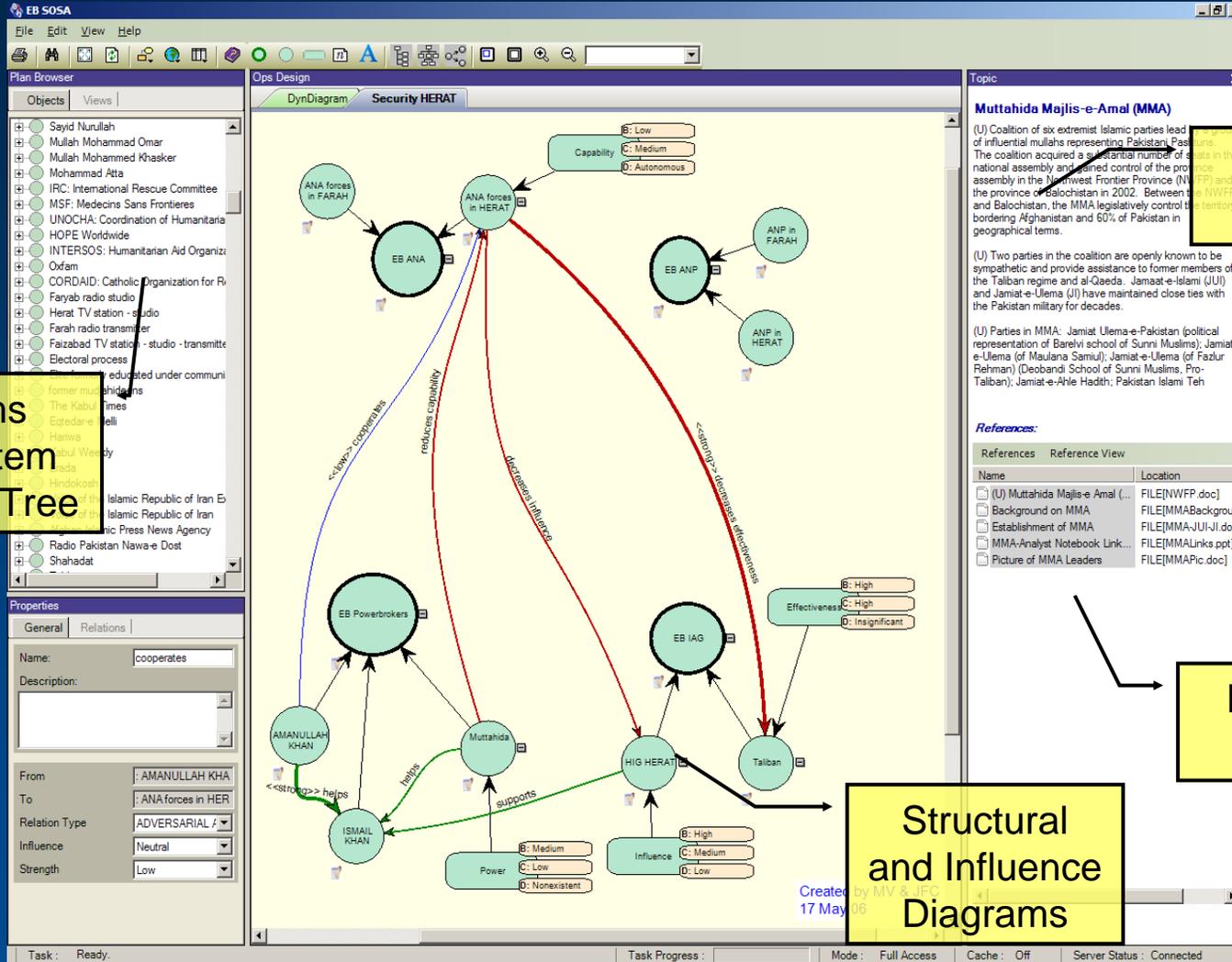
# System Elements and Relationships



# Sample: Knowledge Base Development (Mind Manager: Structural Diagrams)



# Sample: Modeling of Relationships (EB-SAT: System Analysis Tool)



Systems  
And System  
Elements Tree

Narrative  
Description

Reference  
Links

Structural  
and Influence  
Diagrams

**Muttahida Majlis-e-Amal (MMA)**

(U) Coalition of six extremist Islamic parties lead of influential mullahs representing Pakistani Pashtuns. The coalition acquired a substantial number of seats in the national assembly and gained control of the province assembly in the Northwest Frontier Province (NWFP) and the province of Balochistan in 2002. Between the NWFP and Balochistan, the MMA legislatively control the territory bordering Afghanistan and 60% of Pakistan in geographical terms.

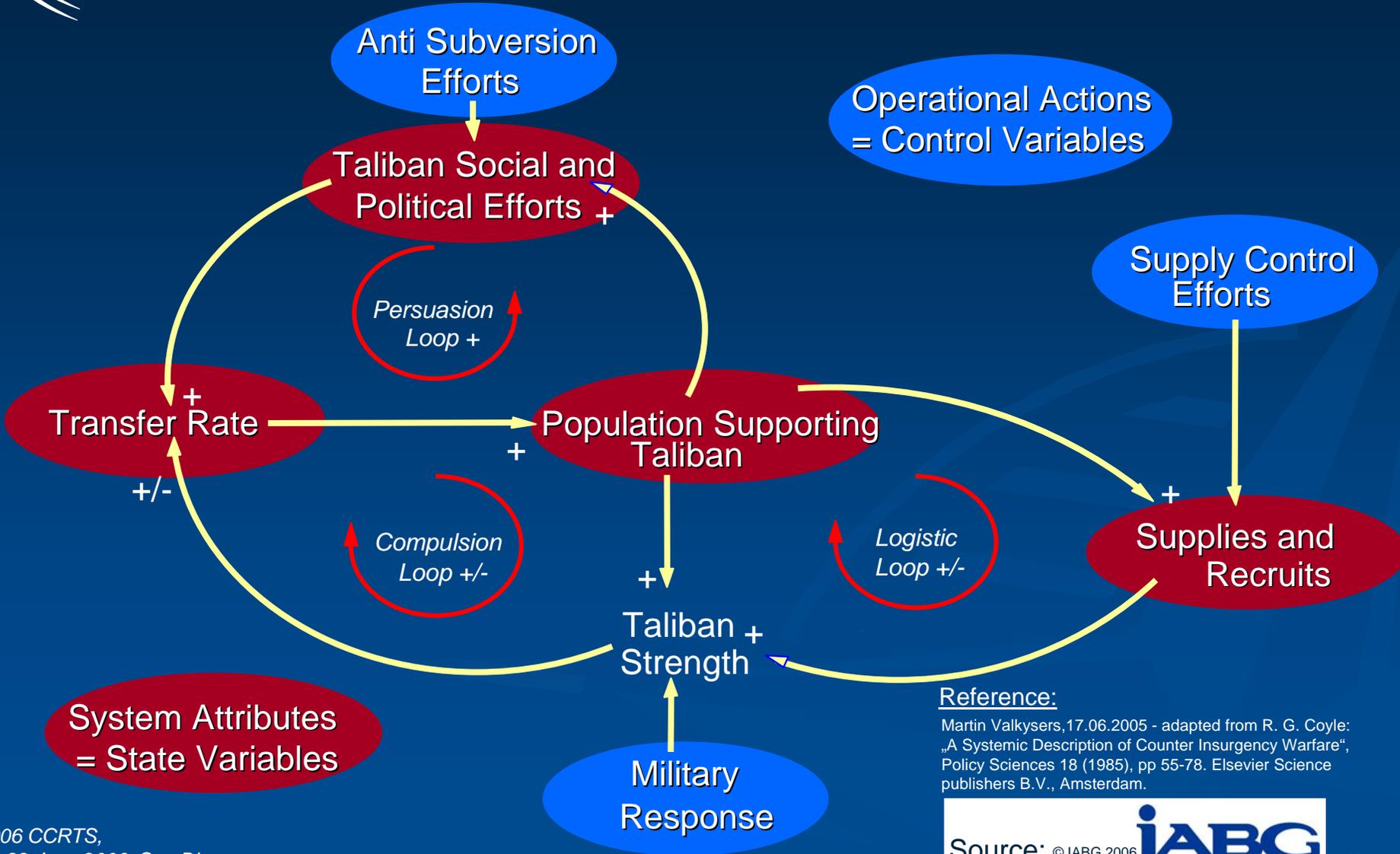
(U) Two parties in the coalition are openly known to be sympathetic and provide assistance to former members of the Taliban regime and al-Qaeda. Jamaat-e-Islami (JI) and Jamiat-e-Ulema (JI) have maintained close ties with the Pakistan military for decades.

(U) Parties in MMA: Jamiat Ulema-e-Pakistan (political representation of Bareilly school of Sunni Muslims); Jamiat-e-Ulema (of Maulana Samiul), Jamiat-e-Ulema (of Fazlur Rehman) (Deobandi School of Sunni Muslims, Pro-Taliban); Jamiat-e-Ahle Hadith; Pakistan Islami Teh

**References:**

Name	Location
(U) Muttahida Majlis-e-Amal (...)	FILE[NWFP.doc]
Background on MMA	FILE[MMABackground]
Establishment of MMA	FILE[MMA-JUI-JI.doc]
MMA-Analyst Notebook Link...	FILE[MMALinks.ppt]
Picture of MMA Leaders	FILE[MMApic.doc]

# Sample: Modeling of Relationships (System Dynamics / Influence Diagrams)

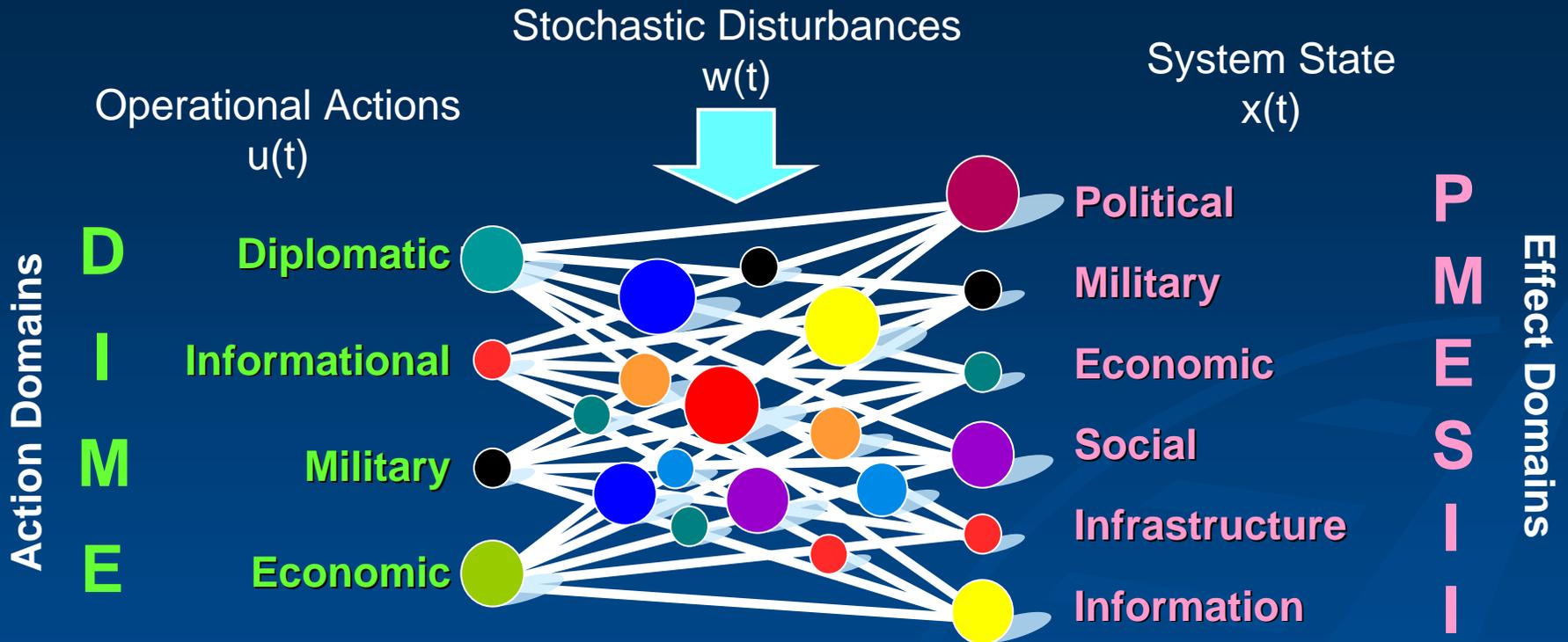




## Definitions (II)

- **Effects are changes in the state of the attributes of the system elements caused by the mutual relationships, disturbances (Acts of God) and operational actions designed to bring the system to the desired end-state.**
- **Actions are performed by the resources (“selected instruments” including military forces) that have been made available for the operation**

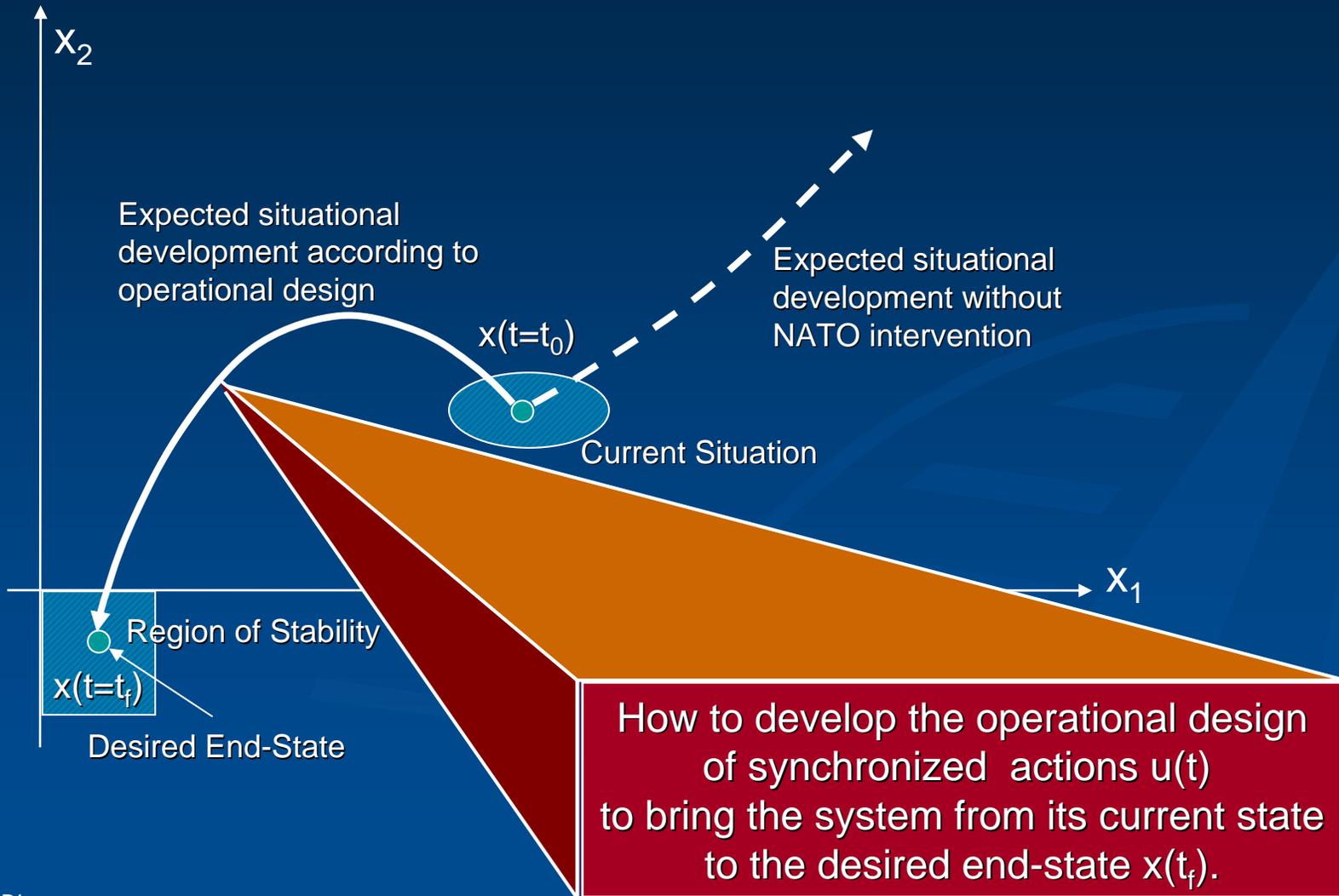
# Operational Dynamics (I)



$$\dot{x} = dx/dt = f \{x(t), w(t), u(t), t\}$$

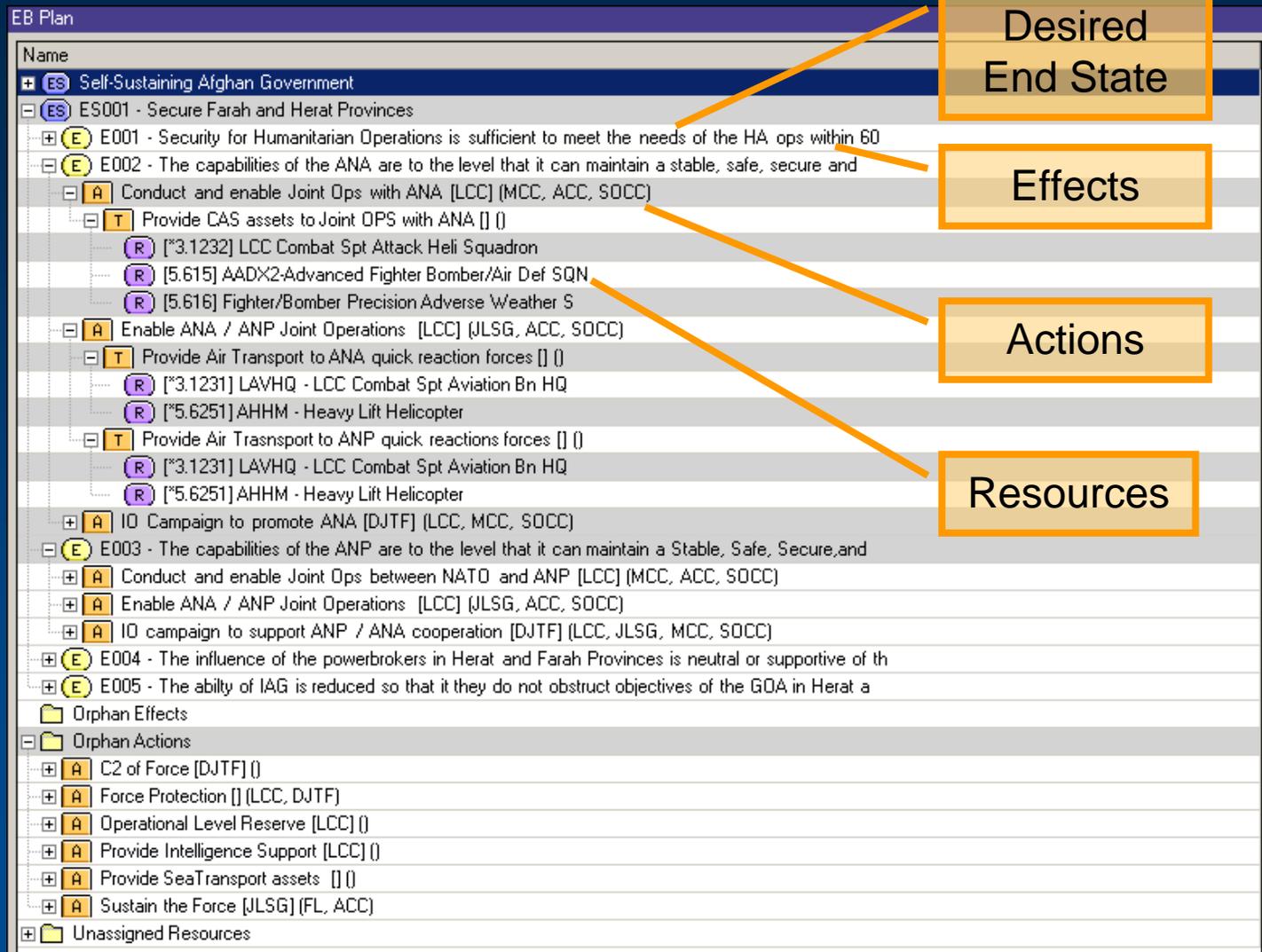
- Notes: 1) Opposing forces and their actions are integral with the operational environment.  
 2) In NATO terminology DIME + PMESII = PMCE (Political, Military, Civil, Economic).

# Operational Dynamics (II)



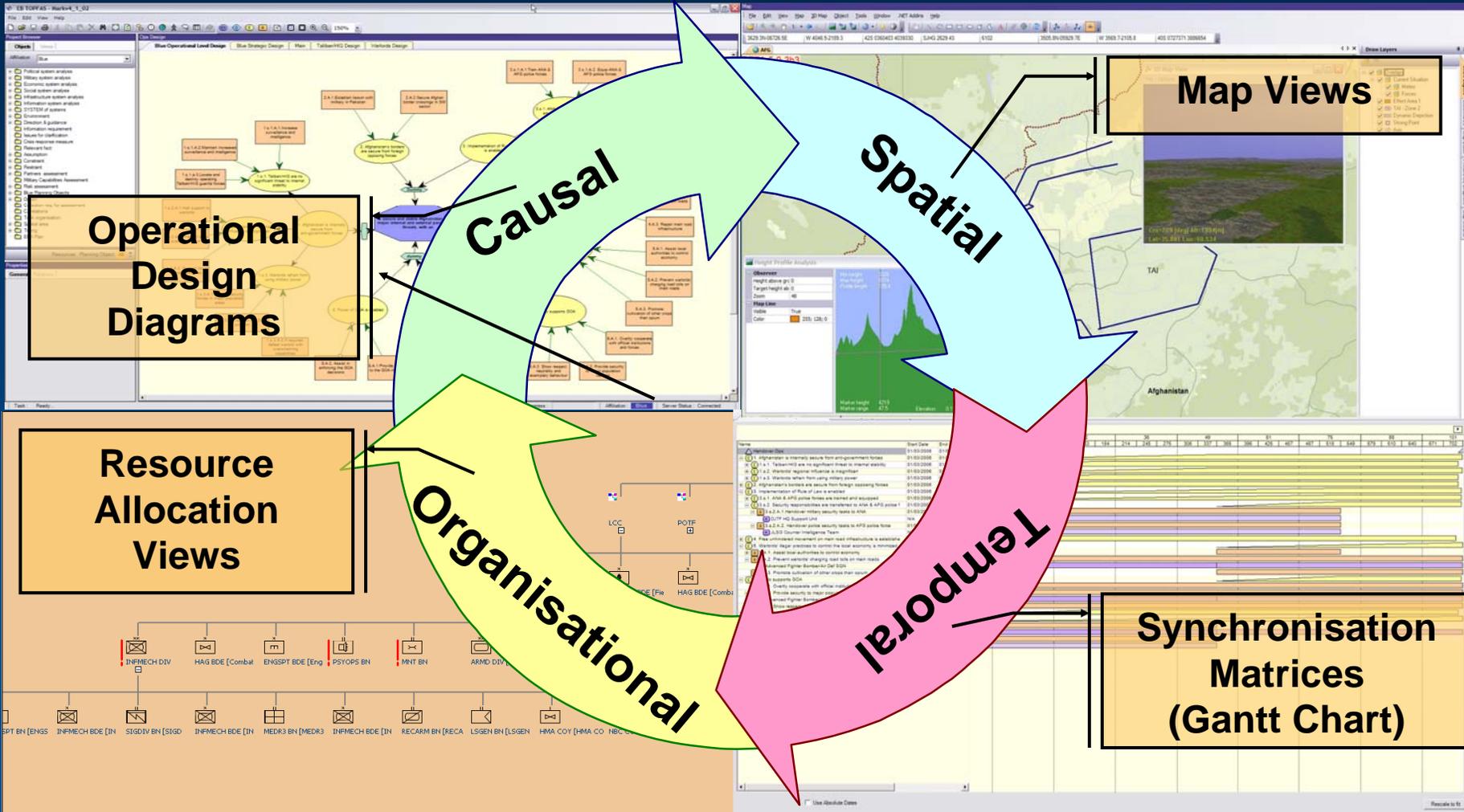


# Sample: EB-Plan Hierarchical View (EB-TOPFAS)



# Sample: Tool support for EBP

(EB-TOPFAS: Tool for Ops Planning Force Activation and Simulation)



# Monitoring the Operational Environment for Effects Based Assessment

Real-world Elements and Relationships  
of the Operational Environment

Models of ...

... the dynamic relationships  
 $\dot{x} = f \{x(t), w(t), u(t), t\}$

Uncertainty

... the measurement process  
 $z(t) = h \{x(t), v(t), t\}$

Real-world Observation of Events and Developments  
in the Operational Environment

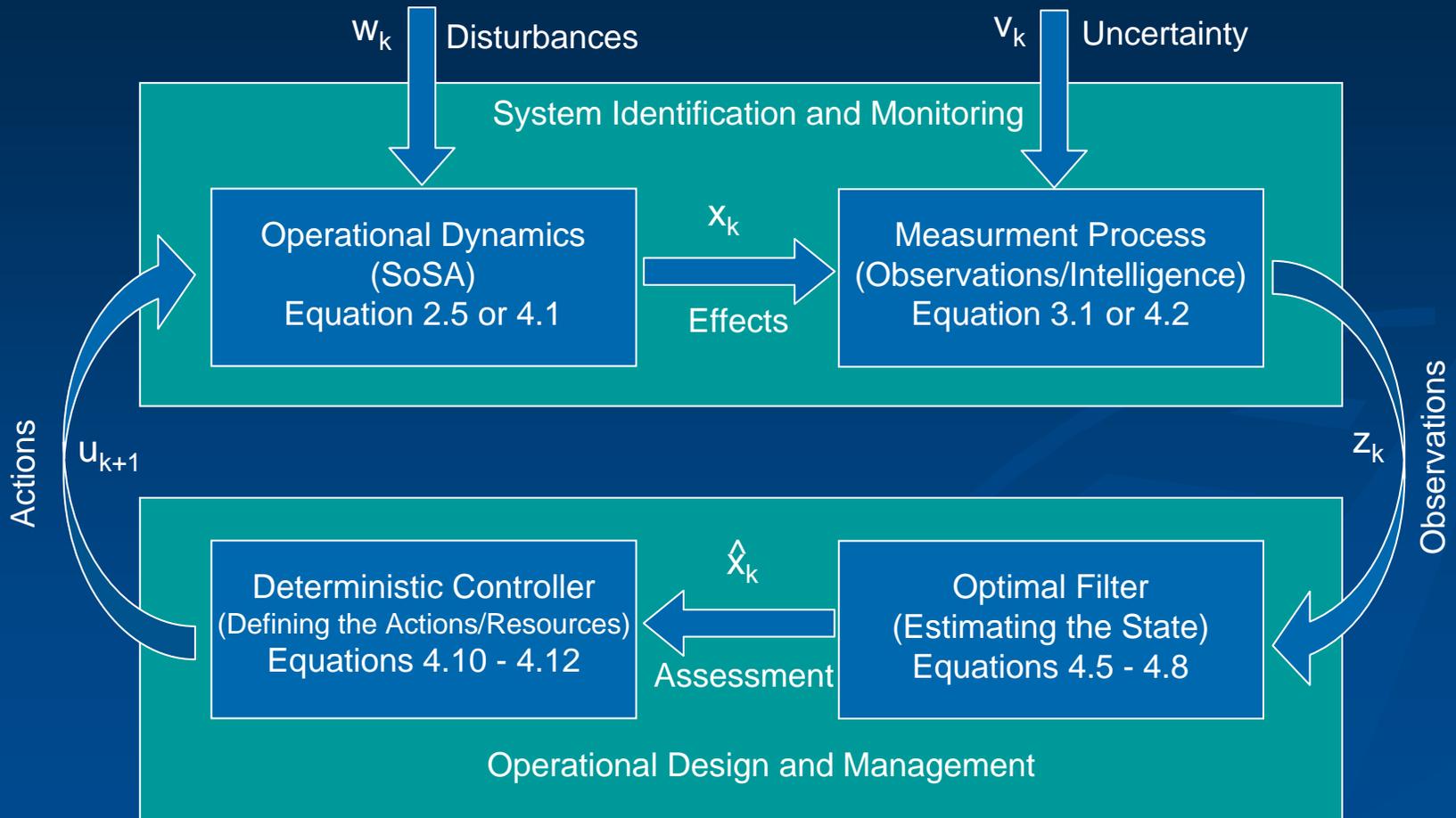


## Development, refinement and revision of the Planned Course of Action

1. Based on the postulated system dynamics and the measurement process, define the best estimator for the state variable values.
2. From the state estimates, the desired end-state, the operational objectives, the restraints and the constraints, define the nominal Course of Action (COA).
3. In each operational decision cycle, reappraise the postulated relationships as well as the state variable estimates and the COA for the remainder of the operation.

Further details on the optimal control approach in the paper

# The optimal control representation of Assessment, Planning and Execution



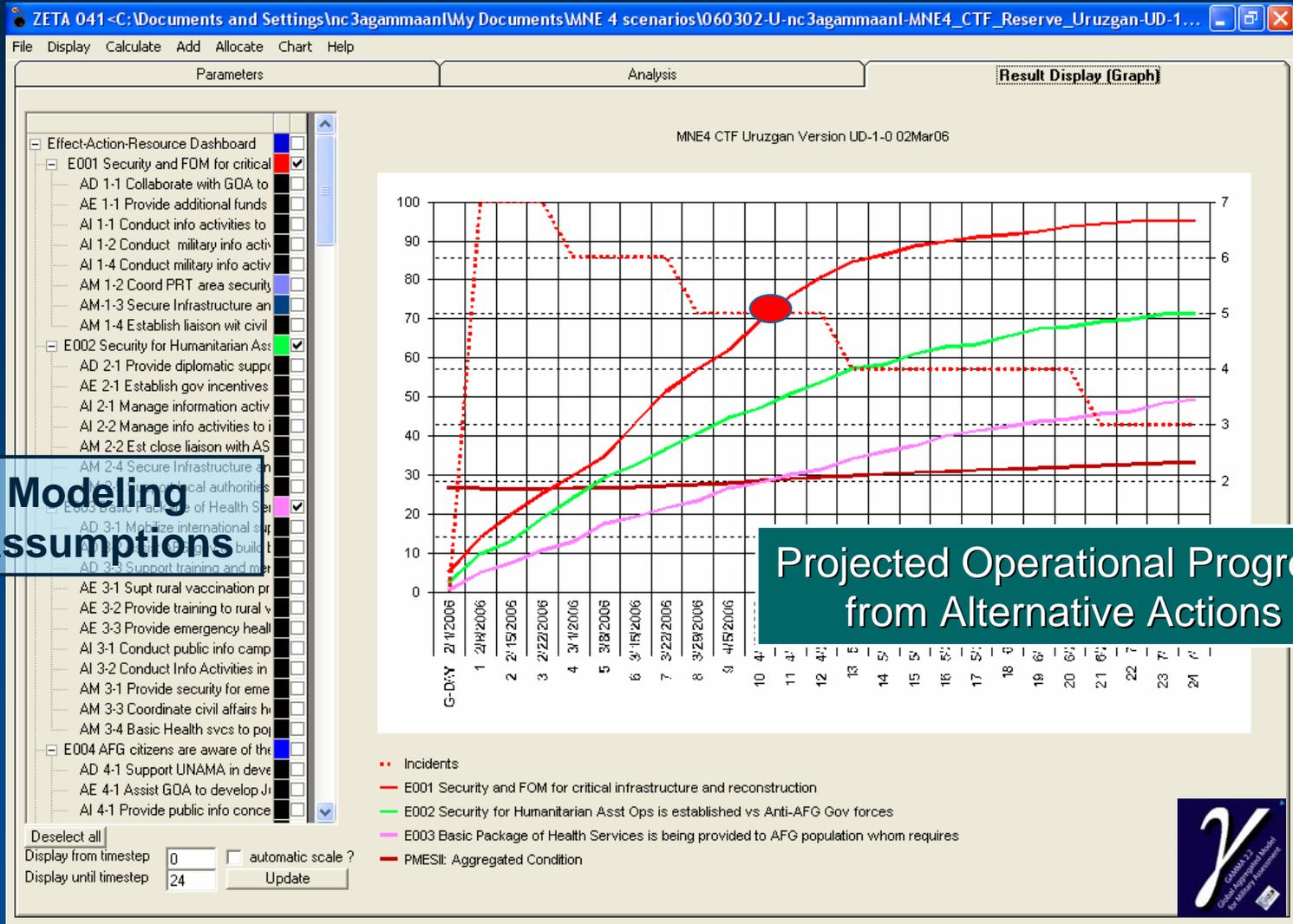


# The practical vs the theoretical

- The theoretical optimal control formulation (in the paper) is a framework for the analytical support; - not a feasible method for the “calculation” of plans.
- Use of the System Dynamics quantitative relationships in a “what-if” stochastic simulation model is a practical way-ahead.



# Sample: COA "what-if" Analysis (GAMMA: Agent based modeling)



# Summary

- **EBAO in its current form needs to be augmented by:**
  - Postulated quantitative analytical dynamic relationships between the elements of the operational environment and between the operational system elements and the observable factors.
  - Explicit representation (modelling) of uncertainties and stochastic disturbances.
  - Designated group(s) of Operational Analysts for direct support to the Effects-Based Assessment and Planning.



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