



Anticipatory Understanding of Adversary Intent: A Signature-Based Knowledge System

Paper 163

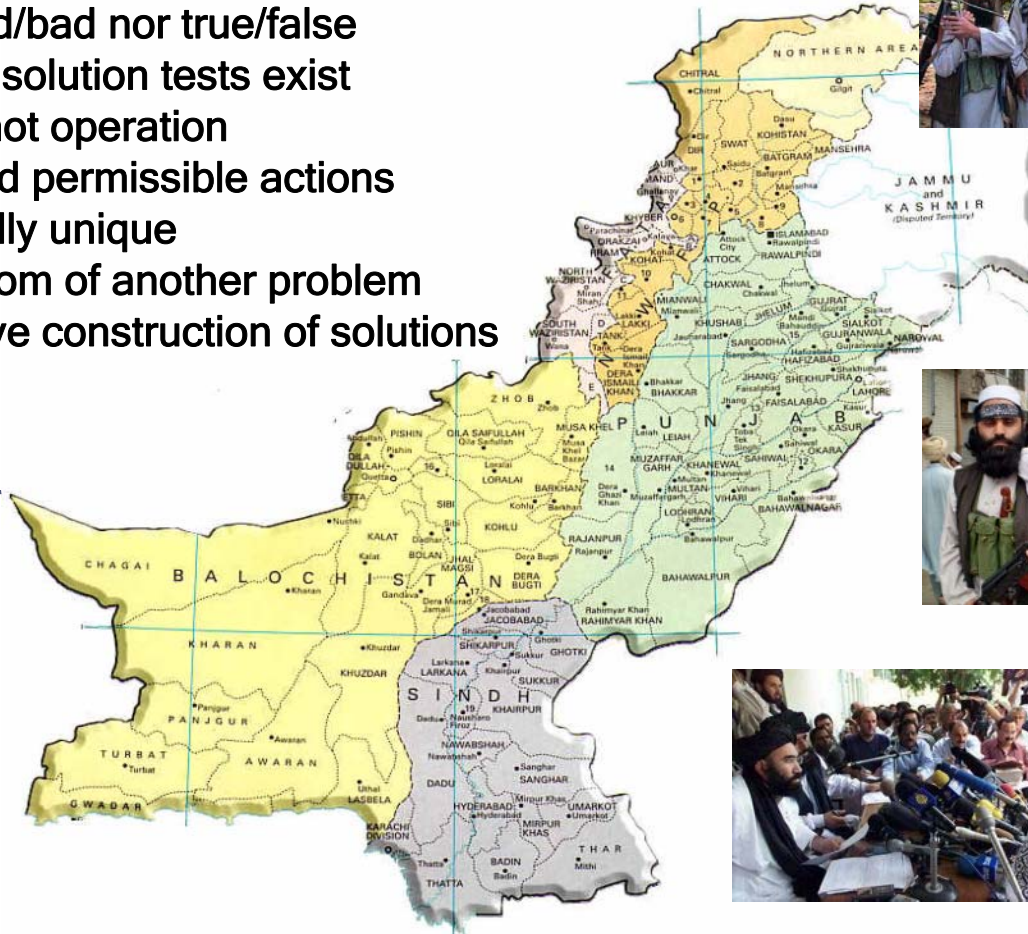
Dennis K. Leedom, Ph.D., Evidence Based Research, Incorporated
Robert G. Eggleston, Ph.D., U.S. Air Force Research Laboratory

14th ICCRTS “C² and Agility”
Washington, DC, 15-17 June, 2009

Wicked Operational Problems

1. No definitive formulation of the problem
2. No stopping rules
3. Solutions are neither good/bad nor true/false
4. No immediate or ultimate solution tests exist
5. Every solution is a one-shot operation
6. Infinite set of solutions and permissible actions
7. Every solution is essentially unique
8. Every problem is a symptom of another problem
9. Problem explanations drive construction of solutions
10. No right to be wrong

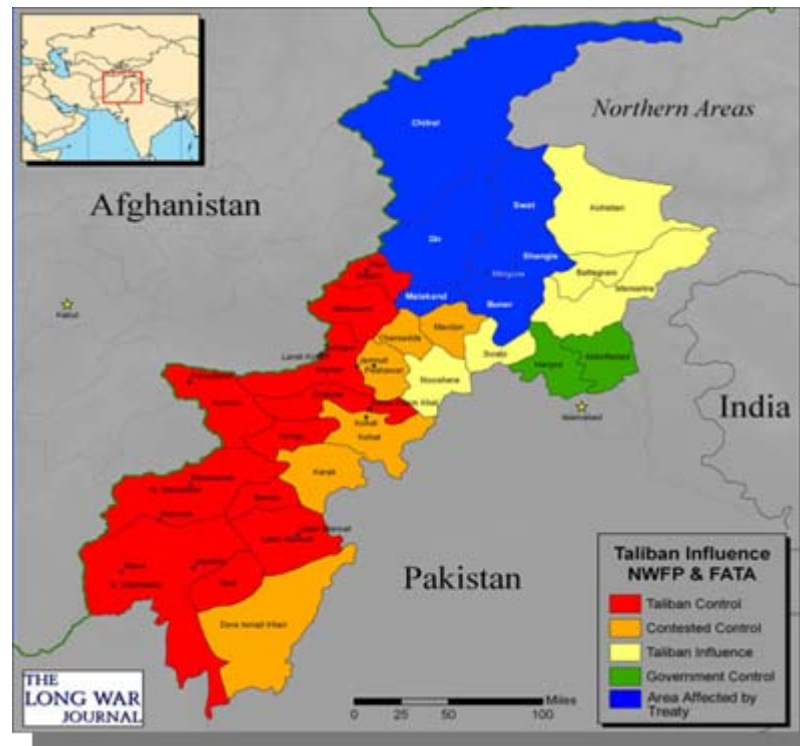
MODELING
REPRESENTATION ?



Complex Adaptive Systems

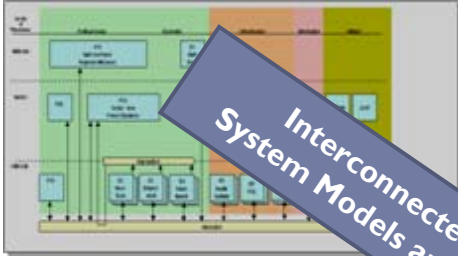
Complex Adaptive System

Comprised of diverse, interconnected elements and actors
Capacity to change and learn from operational experience
Organized to achieve a cohesive, strategic purpose



New Modeling Approach

System Dynamics Models



Interconnected Network of System Models and State Variables

Social Network Models



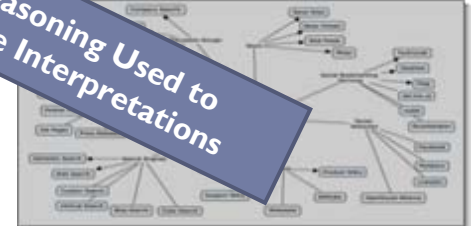
Patterns of Emergent Behavior Shaped by Social Interaction

Agent-Based Models



Learning Behavior Defined by Explicit Representation of Intentionality

Information Mining Models

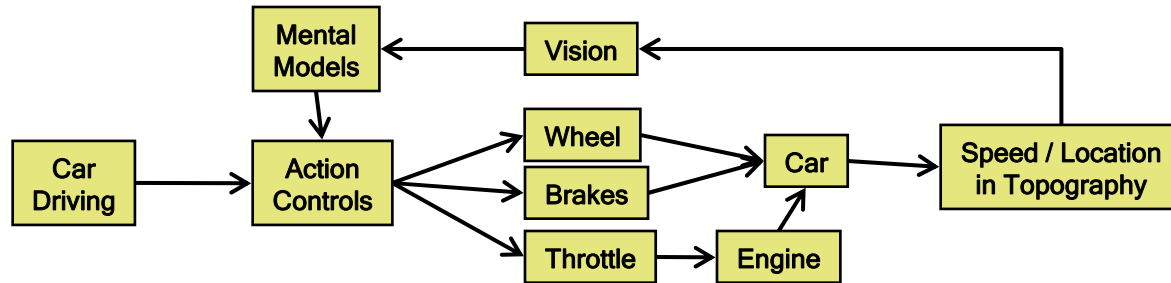


Abductive Reasoning Used to Create Plausible Interpretations

COMPLEX ADAPTIVE SYSTEMS

Motivation: Work Abstraction Theory

WORK DECOMPOSITION (*Industrial Age Paradigm*)



WORK ABSTRACTION (*Knowledge Age Paradigm*)

- Goals, Purposes, and Constraints
- Definitions of Value/Progress
- General Functions and Effects
- Physical Work Processes
- Physical Object Characteristics

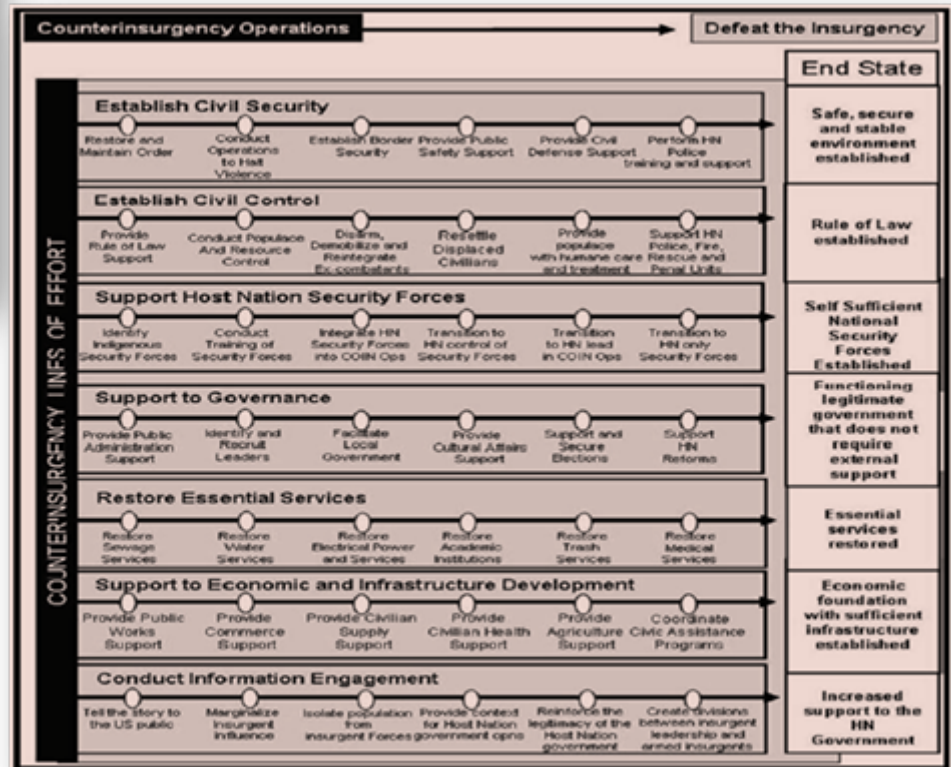
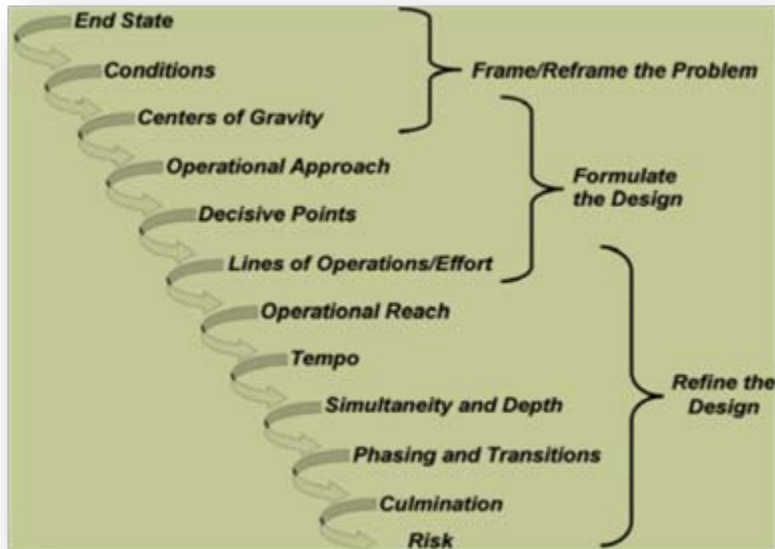
- *Organizational Intentions*
- *Environmental Transformation*
- *Cause-Effect Mechanisms*
- *Work Capabilities*
- *Environmental Artifacts*

- *Multiple stakeholders / perspectives*
- *Adaptive / opportunistic organizations*
- *Unintended consequences*
- *Multiple (PMESII) work dimensions*
- *Selective attention / interpretation*

Knowable Environments

Wicked Environments

Motivation: Operational Design Doctrine



Motivation: Narrative Knowledge Theory

LOGICO-SCIENTIFIC KNOWLEDGE

- Objective: Establish a body of universal truths
- Nature: Empirically validated truths, objective definition
- Method: Formal reasoning using predicate logic and proofs
- Application: Theory-driven, context-free, objective, ahistorical



BRUNER, 1986



RATIONAL ENGINEERING MODELS

NARRATIVE KNOWLEDGE

- Objective: Endow experience with meaning and intentionality
- Nature: Plausible explanations, bracketed by experience
- Method: Abductive just-in-time reasoning using story-telling
- Application: Meaning-driven, context sensitive, intentional, paradoxical



ACTION/EFFECTS LINKED WITH MEANING

Complementary, but irreducible !

Four Basic Elements of Knowledge

**LOGICO-SCIENTIFIC
KNOWLEDGE**



**NARRATIVE
KNOWLEDGE**

**BASIC
ARTIFACTS**

- Defines key objects and features of the region in terms of basic characteristics and state variables
- Represents the decomposition of the region into work-related abstraction

**PMESII
SYSTEMS**

- Structurally composes basic artifacts into meaningful PMESII models and organizational work systems
- Functionally links state variables via system dynamics equations (*used to propagate 2nd-order effects*)

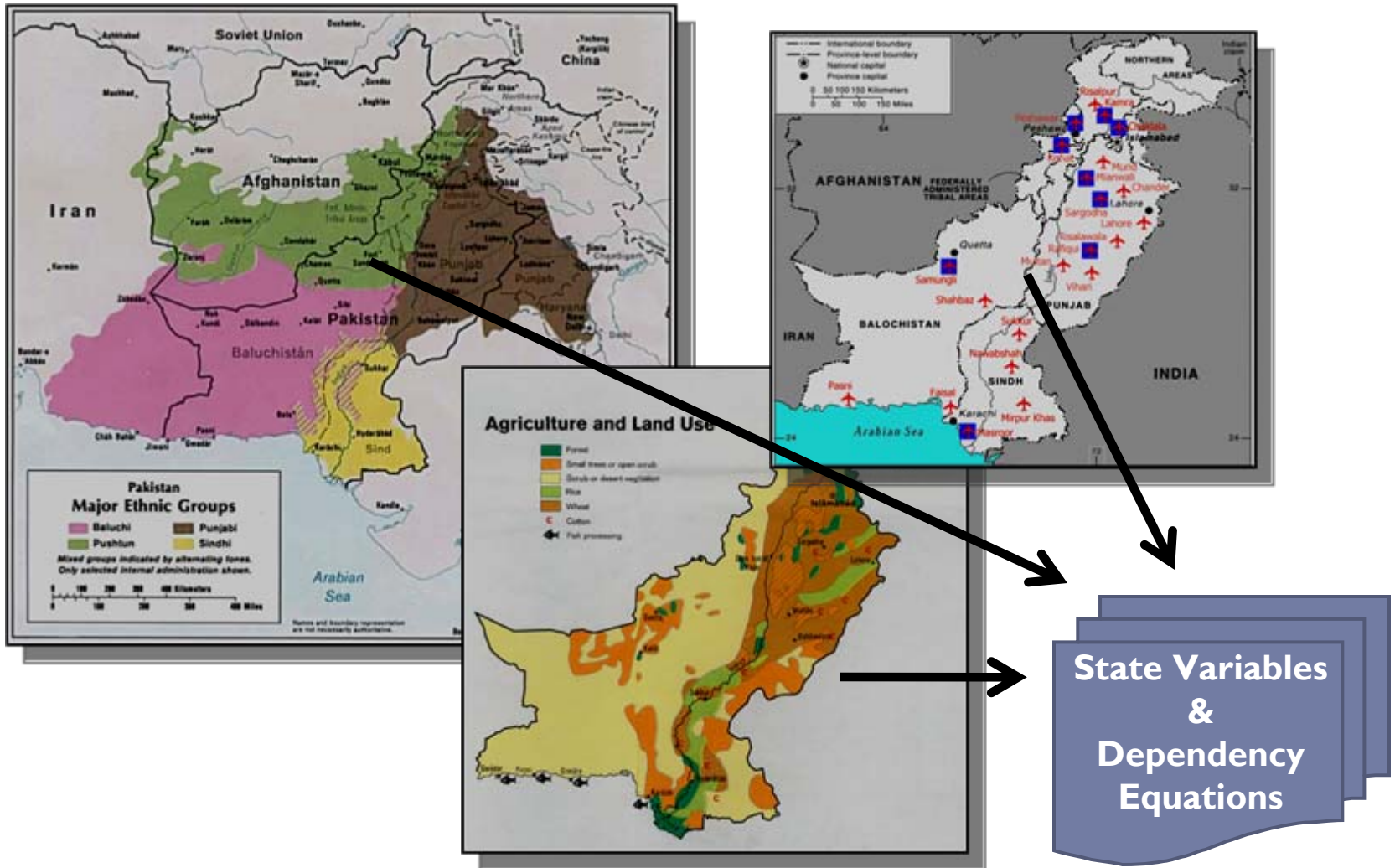
**TACTICAL
EPISODES**

- Associates actions, events, and emergent conditions with PMESII systems and strategic agendas
- Triggers state variable changes in the form of direct effects (*2nd-order effects arise via PMESII models*)

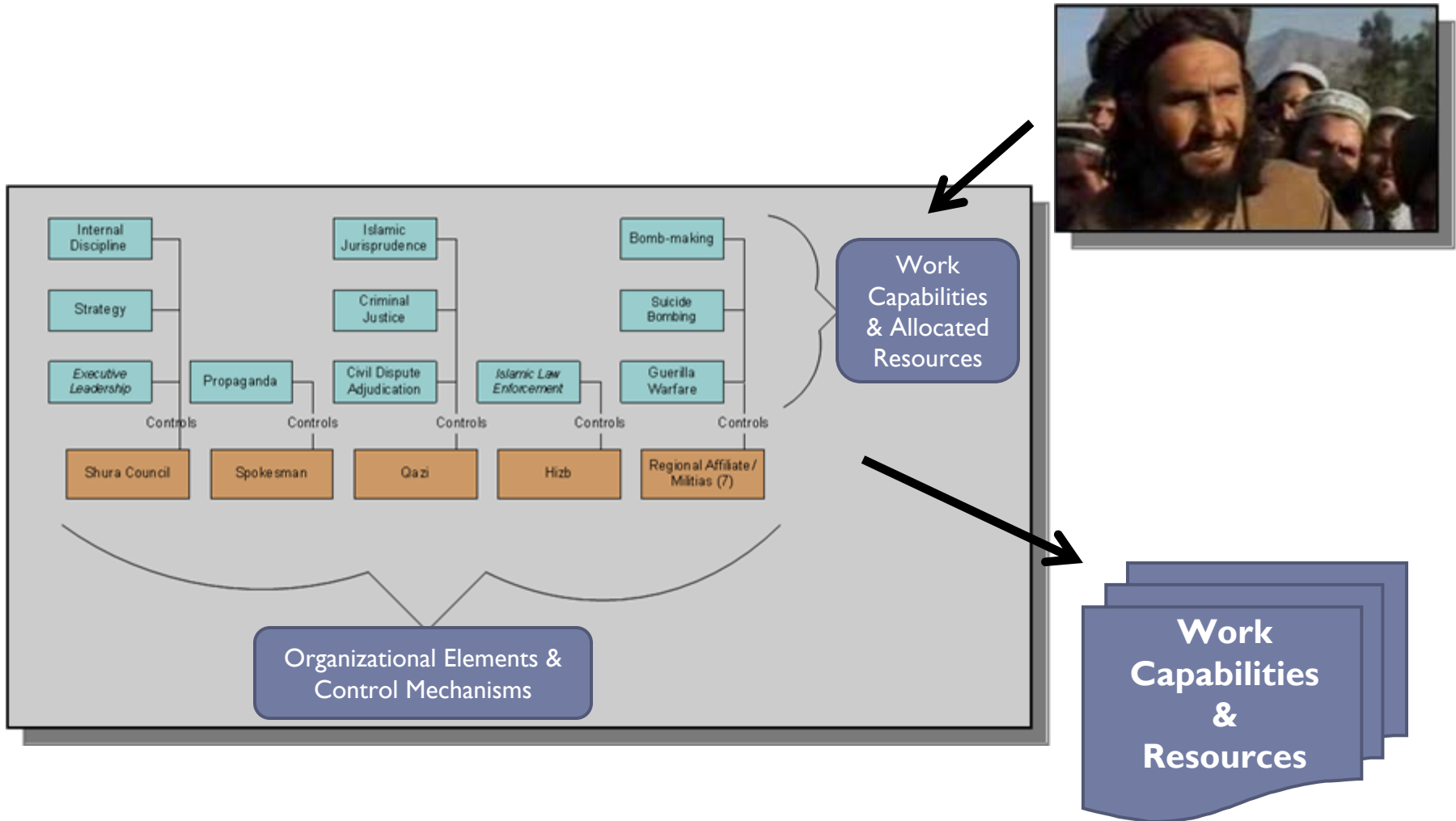
**STRATEGIC
AGENDAS**

- Connects a line of effort hypothesis with a center of gravity (PMESII system) and objective (state variables)
- Enables tracking of operational progress and contextual assessment of operational relevance)

Constructing Artifacts & Systems



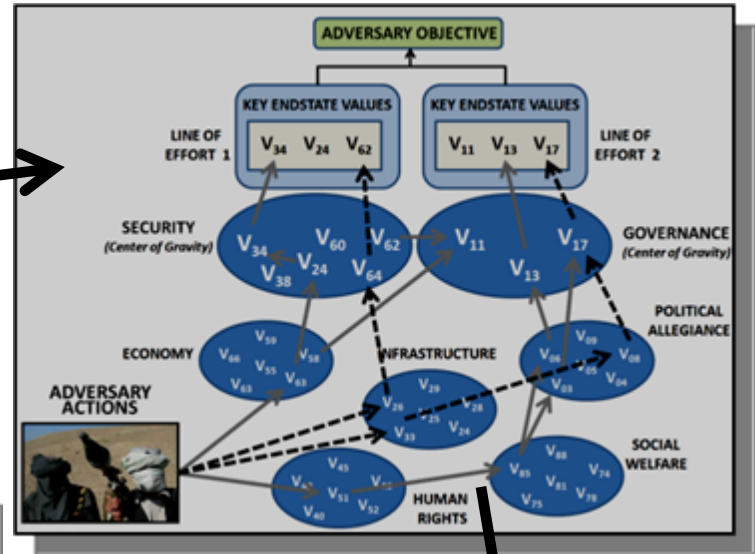
Constructing Adversary Work Systems



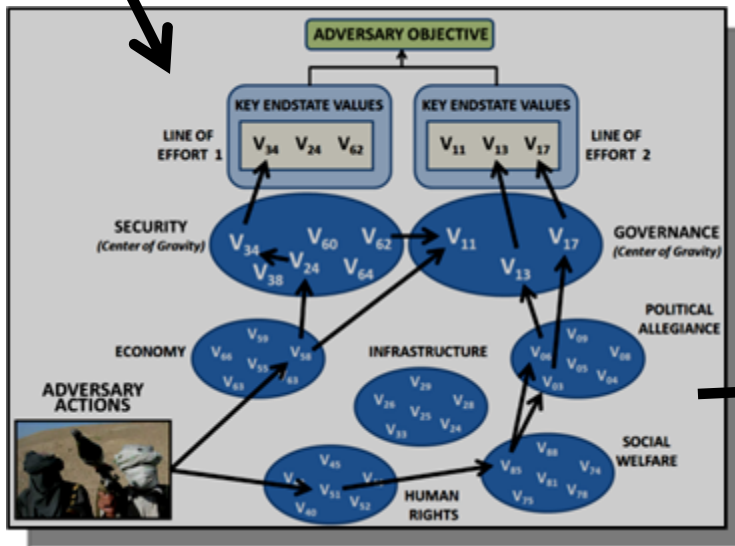
Constructing Tactical Episodes



Time t_2



Time t_1



Direct Effects
&
2nd-Order
Consequences

Behavior Signature

A behavior signature is a ***dynamically constructed narrative*** that uniquely characterizes an adversary at a given point in time in terms of a ***hypothesized strategic agenda*** that is (1) organizationally supported by a ***defined work system***, (2) functionally associated with ***systemic cause-effect relationships*** within the battlespace ecosystem, and (3) instantiated over time by a series of ***observable tactical episodes***. A behavior signature enables the anticipation of future adversary intentions and actions to the extent that the contextual framework of knowledge underlying its construction remains valid over time.



Use of Morphological Tables

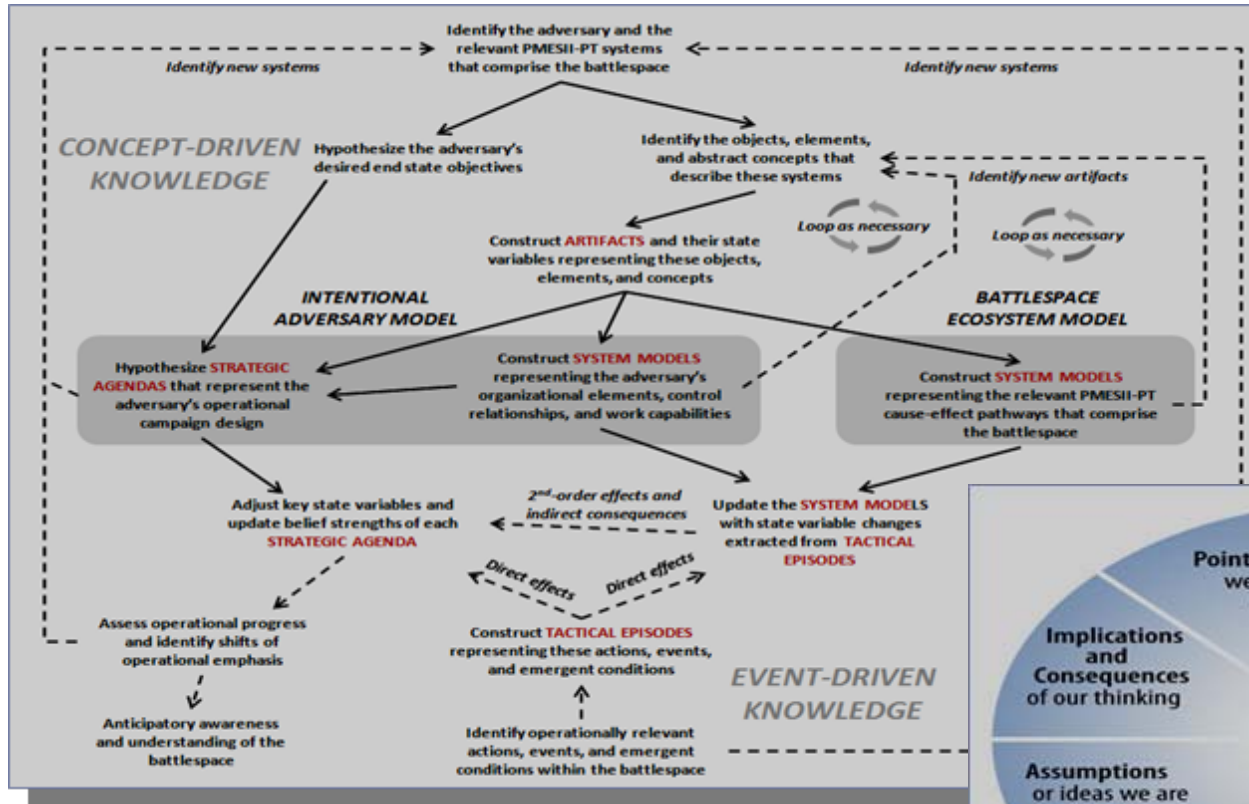
Strategic Agenda	Organizational Element	Operational Work Capability	Center of Gravity System	Key Battlespace Artifact	Tactical Episode
Agenda 1 Operational Approach Belief Strength	Org Element A Leadership and C ² Resources	Work Capability 1 Classes of Effects Belief Strength	Battlespace Sys A Constituent Artifacts	Artifact 1 State Variables	Tactical Episode A State Variable Changes Evidence Likelihoods Ratios
Agenda 2 Operational Approach Belief Strength	Org Element B Leadership and C ² Resources	Work Capability 2 Classes of Effects Belief Strength	Battlespace Sys B Constituent Artifacts	Artifact 2 State Variables	Tactical Episode B State Variable Changes Evidence Likelihoods Ratios
Agenda 3 Operational Approach Belief Strength	Org Element C Leadership and C ² Resources	Work Capability 3 Classes of Effects Belief Strength	Battlespace Sys C Constituent Artifacts	Artifact 3 State Variables	Tactical Episode C State Variable Changes Evidence Likelihoods Ratios
Agenda 4 Operational Approach Belief Strength		Work Capability 4 Classes of Effects Belief Strength	Battlespace Sys D Constituent Artifacts	Artifact 4 State Variables	Tactical Episode D State Variable Changes Evidence Likelihoods Ratios
Agenda 5 Operational Approach Belief Strength		Work Capability 5 Classes of Effects Belief Strength	Battlespace Sys E Constituent Artifacts	Artifact 5 State Variables	Tactical Episode E State Variable Changes Evidence Likelihoods Ratios
		Work Capability 6 Classes of Effects Belief Strength	Battlespace Sys F Constituent Artifacts	Artifact 6 State Variables	Tactical Episode F State Variable Changes Evidence Likelihoods Ratios
			Battlespace Sys G Constituent Artifacts	Artifact 7 State Variables	
Shaded cells connected by arrows define an adversary behavior signature			Battlespace Sys H Constituent Artifacts	Artifact 8 State Variables	
				Artifact 9 State Variables	
				Artifact 11 State Variables	
				Artifact 12 State Variables	
				⋮	

Anticipating Future Actions and Events

Strategic Agenda	Organizational Element	Operational Work Capability	Center of Gravity System	Key Battlespace Artifact	Tactical Episode
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				Artifact 9 State Variables	
				Artifact 11 State Variables	
				Artifact 12 State Variables	
				⋮	

Associate strategic agenda emphasis with organizational element, work capability, center of gravity, and relevant battlespace artifacts

Building Frameworks of Understanding

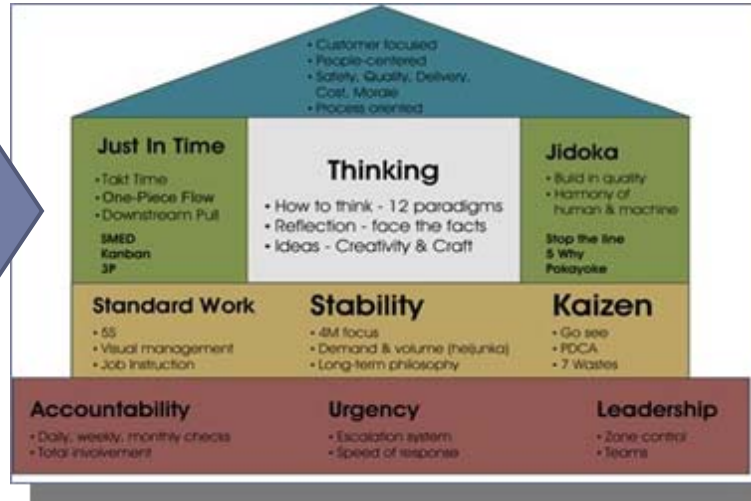


LEEDOM & EGGLESTON, 2009

PAUL & ELDER, 2002

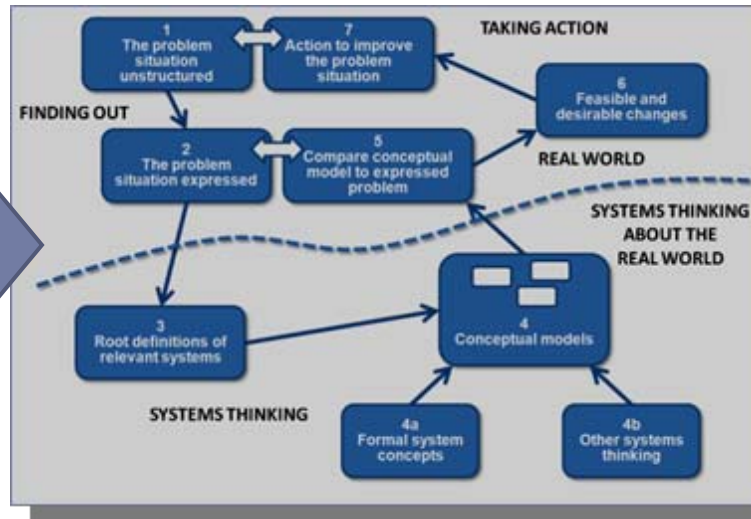
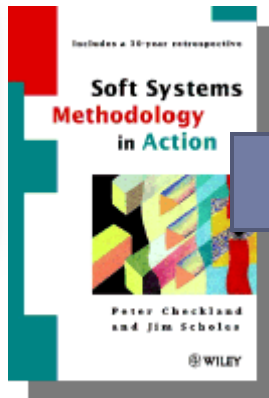
Motivation: Conceptualization Strategies

TAIICHI OHNO



**HOLISTIC,
CONTINUOUS
LEARNING**

CHECKLAND, 1999



**ITERATIVE,
CONCEPTUAL
MODELING**



Conceptual Shaping Tasks

DIAGNOSTIC TASKS

1. Key assumptions check
2. Quality of information check
3. Indicators or signposts of change analysis
4. Analysis of competing hypotheses

CONTRARIAN TASKS

5. Devil's advocacy analysis
6. Team A / Team B analysis
7. High-impact / Low-probability analysis
8. "What if?" analysis

IMAGINATIVE TASKS

9. Brainstorming
10. Outside-in thinking
11. Red team analysis
12. Alternative futures analysis



Taming Hard System Problems

Hard Modeling Paradigm

- Construct well-formed, stable system representations
- Assume problem representations are universal
- Model predicts future states → action recommendations
- Focus externally on utility of model to end user



**Brittle, cannot account for adaptive behavior
Requires fitting questions to model structure
Lacks end user trust and support**

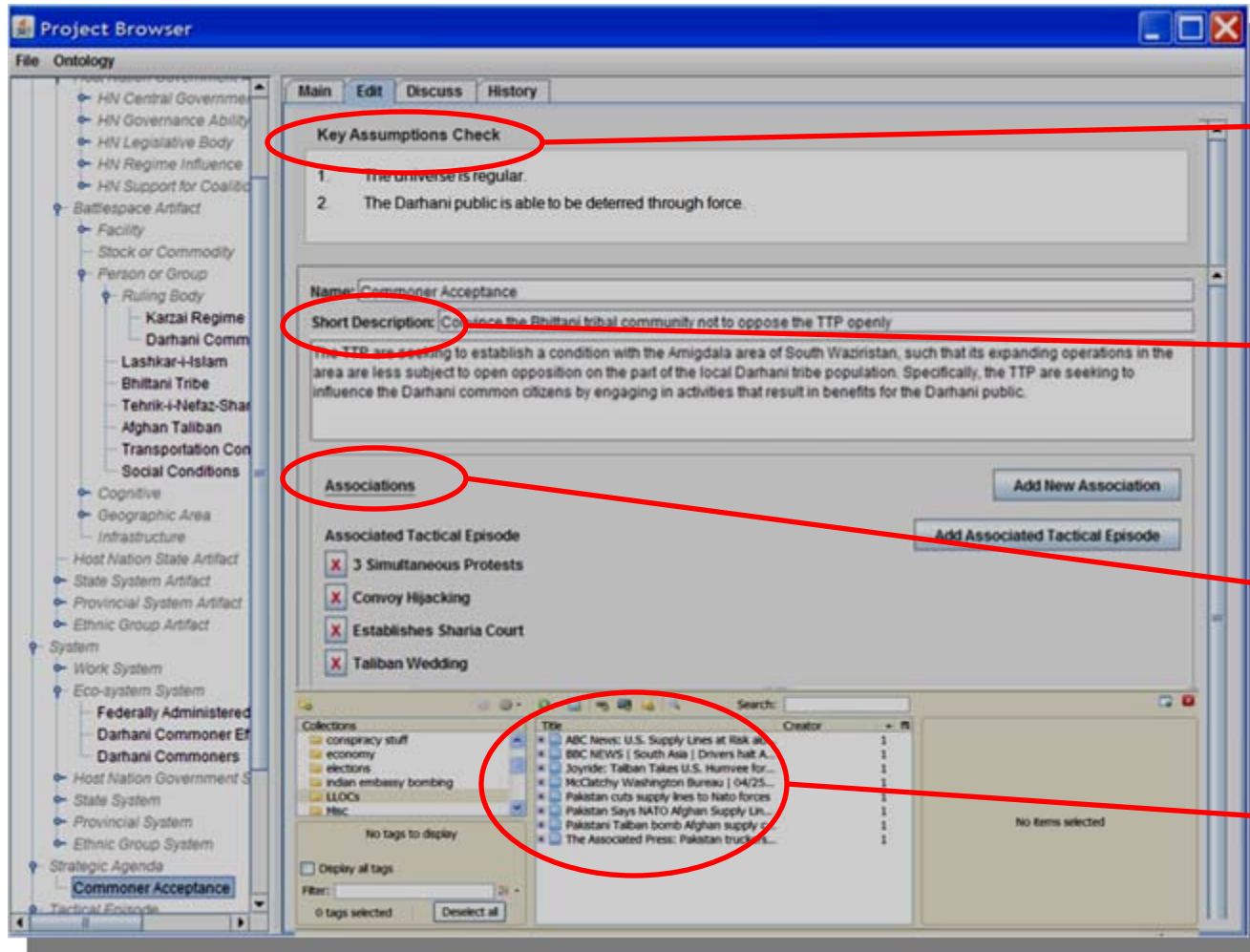
Soft Modeling Paradigm

- Create flexible modeling environment with standard grammar
- Evolve problem framework to match operational questions
- Model supports learning → increased problem understanding
- Focus internally on model refinement and adaptation



**Flexible, places behavior in intentional context
Fits model structure to operational questions
Involves end user in model management**

User Interface Facilitates Collaboration



Key Assumptions Check

Narrative Descriptions

Episode Associations

Quality of Information

Interactive Model Adaptation

The screenshot displays the 'Project Browser' application window. The title bar reads 'Project Browser - resources\project.xml'. The menu bar includes 'File', 'Ontology', 'Morphological Table', 'System View', and 'Evidence Likelihood Table'. The current ID is 'ID: dleedom Status - Online'. The interface is divided into several sections:

- Left Panel:** A tree view of the ontology. The 'Action' category is expanded, showing 'Raid on fort', 'Event', and 'Emergent Condition'.
- Top Panel:** A menu with 'Main', 'Edit', 'Discuss', and 'History'. The 'Discuss' tab is selected and circled in red.
- Form Fields:** 'Name: 3 Simultaneous Protests' and 'Short Description:'.
- Text Area:** A text box containing a hypothesis: 'It is possible that the TTP could facilitate demonstrations in Peshawar, Miran Shah, and Amigdala. The demonstrations could be organized through regional pirate radio broadcasts. What should be monitored is the widely popular and extreme "Radio Mullah" broadcast of Maulana Fazlulah and his grassroots supporters.'
- Associated Work System:** A table with columns for 'Tehrik-i-Taliban Pakistan', 'Shura council', 'Spokesman', 'Gazi judges', 'Brigade', 'Pirate Radio', and 'Technicians'. The 'Broadcast' element is selected.
- Diagram:** A flow diagram showing '3 protests' (red box) connected to 'Broadcast' (blue box), which is connected to 'Pirate Radio' (orange box).
- Bottom Panel:** Buttons for 'Save Changes', 'Discard Changes', and 'Lobby'. A status bar shows 'Lobby Lt. Mult'.

Historical Analysis

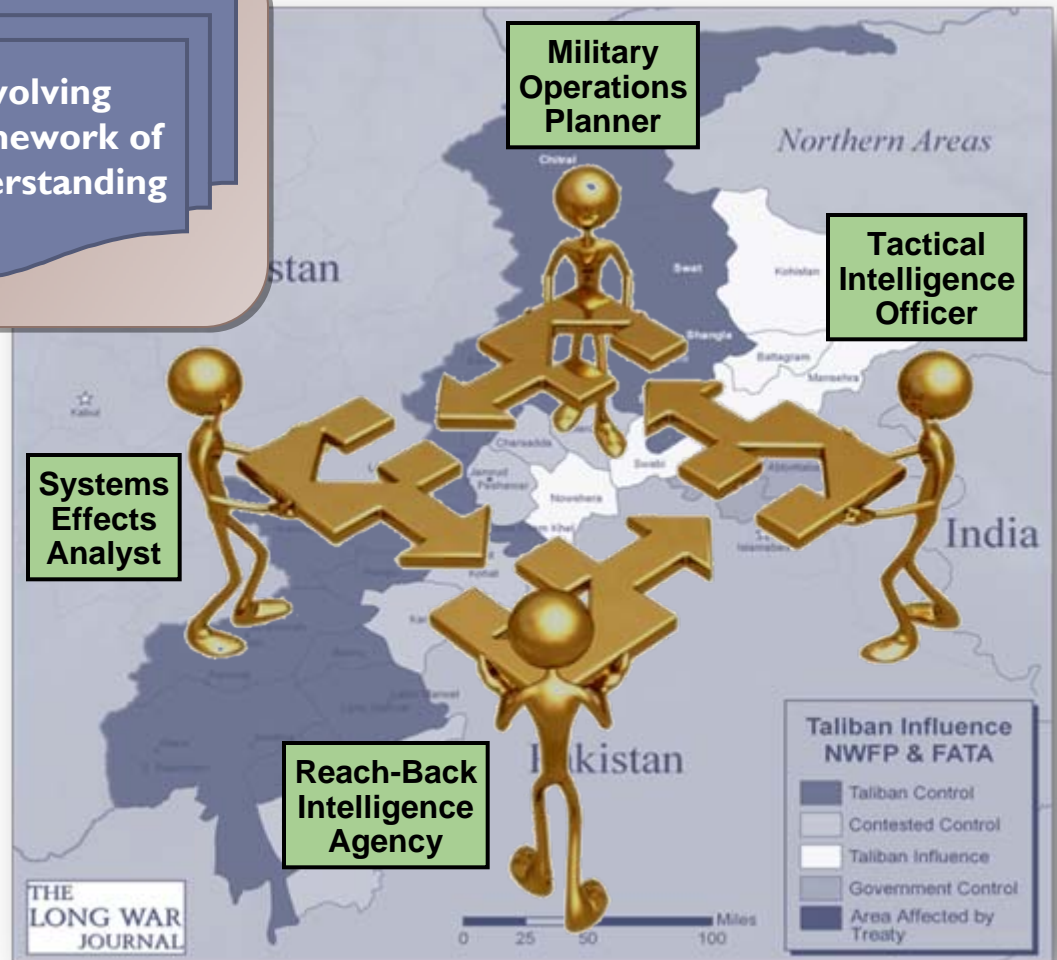
"What If?" Hypothesis Analysis

Summary

Formal Knowledge Grammar
Dynamic Association Graphs
Abductive Reasoning Tools
Behavior Signature Framework
Wiki Interface for Collaboration
State Variable Backplane

**Evolving
Framework of
Understanding**

**Soft Systems Approach
to Modeling Complex
Adaptive Adversaries**



Questions ?

