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Sandia National Laboratories current socio-cultural behavior modeling

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Arlo Ames alames@sandia.gov 844-3210
Deborah Belasich dkbelas@sandia.gov 844-3911

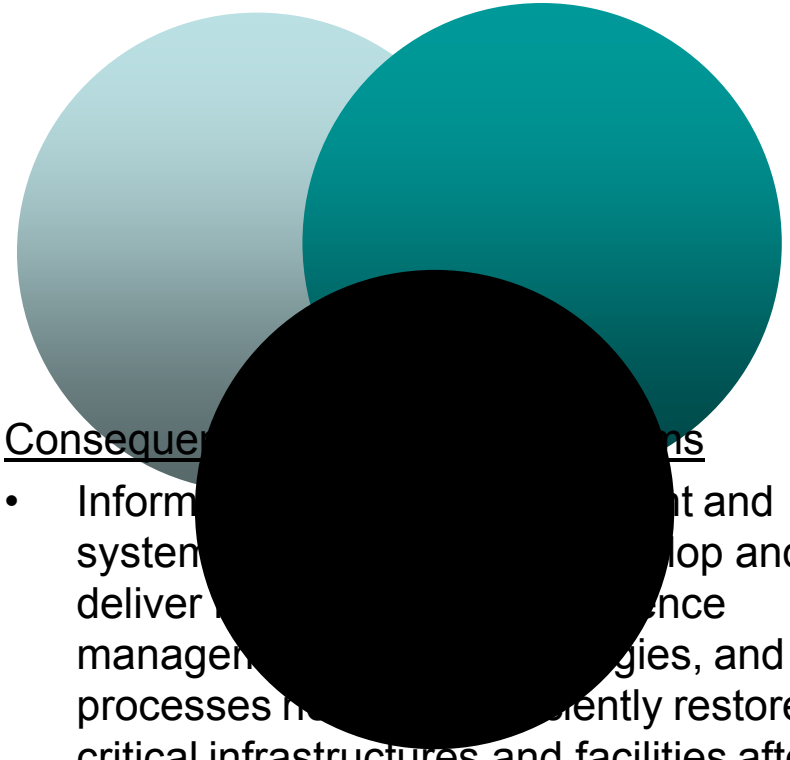
Presentation to AFRL/RDTA

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Proposed Agenda

- Objective of the meeting: exchange ideas and information
- Brief overview of Systems Engineering & Analysis Center (SEA)
- Brief overview of AFRL/RDTA—Beth Nayder
- Arlo's current work for John Salerno AFMC AFRL/RIEA
- Discuss AFSOR BAA 2008 Collective Behavior and Socio-cultural modeling
- Other items??

Our Thrust Areas Provide Focus



Applied Computer Science Solutions

- Using quality practices with proven verification and validation methods, we deliver software systems that meet the customers needs. This begins with a detailed analysis of their domain, followed by design and implementation of a well architected computer science based solution

Conseque[illegible]ns

- Inform[illegible]t and syste[illegible]lop and deliver [illegible]nce manage[illegible]gies, and processes [illegible]iently restore critical infrastructures and facilities after catastrophic events (naturally occurring and intentional).

Complex Systems Analysis & Risk

- To promote our Citizen's well-being and global security, we analyze complex systems or interaction of systems using advanced science-based tools to enable decision makers to take informed actions to reduce the probability, frequency and/or consequences of disruptions to our nation's infrastructure and social fabric

Integrated Capabilities

1. Software Engineering & Quality
2. Knowledge & Data Management
3. Risk-based Systems Analysis & Studies
4. Policy Options Decision Support
5. Decontamination & Restoration Solutions
6. Resilience Science
7. Global/National/Regional Infrastructure Expertise
8. Cognitive Science
9. Intercultural communications
10. V&V of human social cultural behavioral models-new

Examples of On-going Projects in Complex Systems (Lead or Significant Participation

- National Infrastructure Simulation and Analysis Center (NISAC) – DHS
- Complex Events Modeling, Simulation, and Analysis (CEMSA) – DHS
- Chemical Sector Supply Chain Economic Study – DHS
- Chemical Economic Criticality Analysis – DHS
- Integrated Stockpile Optimization Under a Resource Constrained Enterprise (iSOURCE) – NNSA NW/NA-11
- Transportation Resource Integrated Planning System (TRIPS) –NNSA NW/NA-15
- VA Healthcare System Threat Analysis – VA
- Interagency Biological Restoration Demonstration (IBRD) - DHS and DTRA
  - Develop end to end process for restoration urban area following a biological agent release
- Aerosol Decontamination Project - DTRA
  - Develop method to deliver liquid decontaminants in aerosol form to contaminated spaces

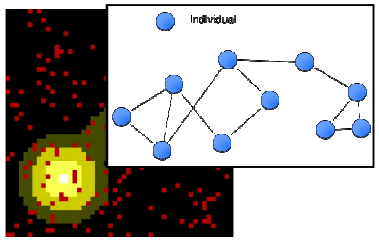
New OSD V&V Project:

Interactive Verification and Validation Environment for Human, Social, and Cultural Behavior Models

Develop Methodology

Provide methods for V&V of HSCB Model components

Validate
Improve
Generalize

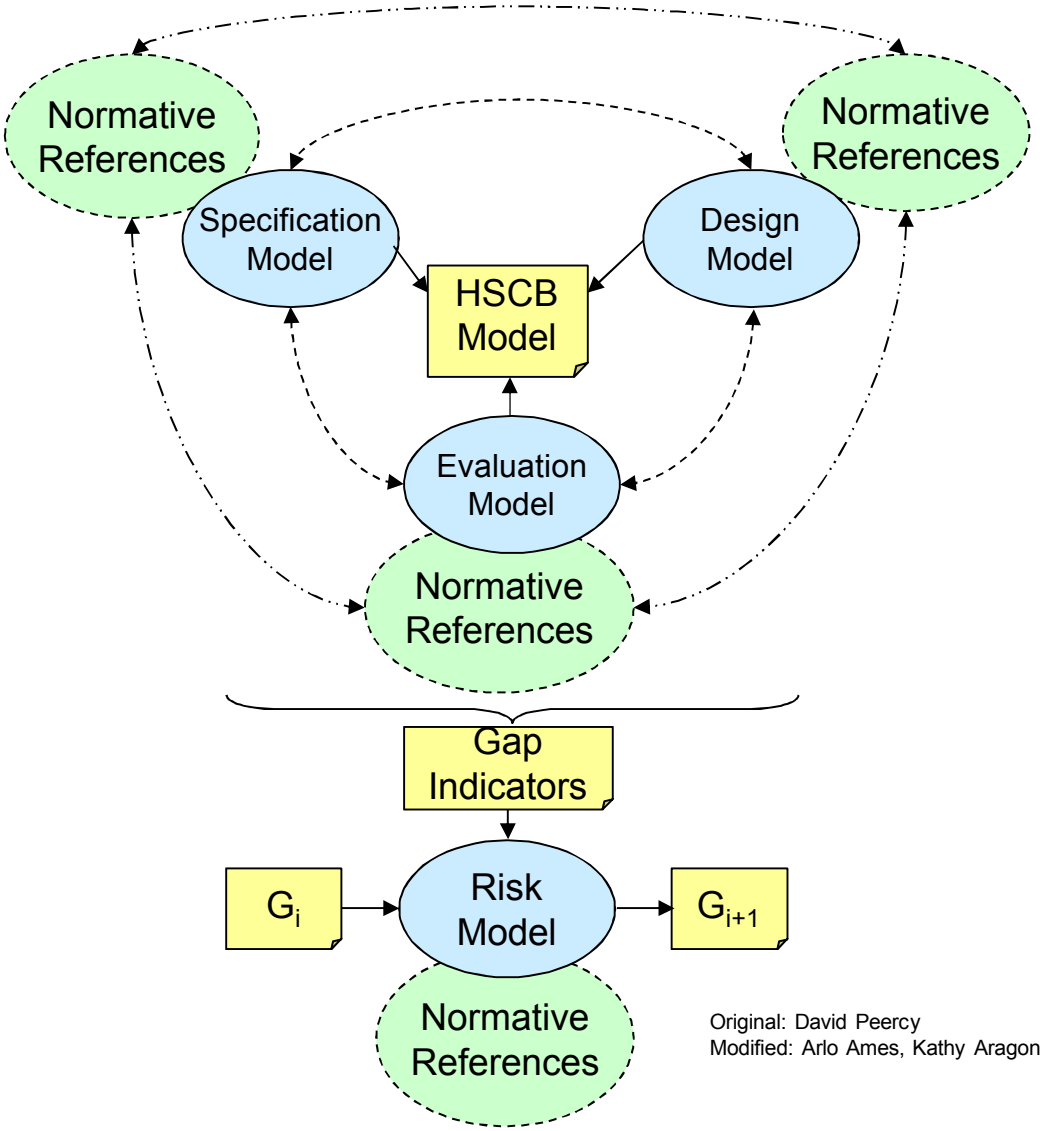


Help HSCB Program meet Military objectives.

- V&V of social science models is a difficult problem. Addressing this problem will take OSD far beyond the state of the art.
- This methodology will be developed to be generalized to the whole range of model types.
- Our goal is to support the OSD program, government, and performers with future federated models.

Applied Engineering Framework

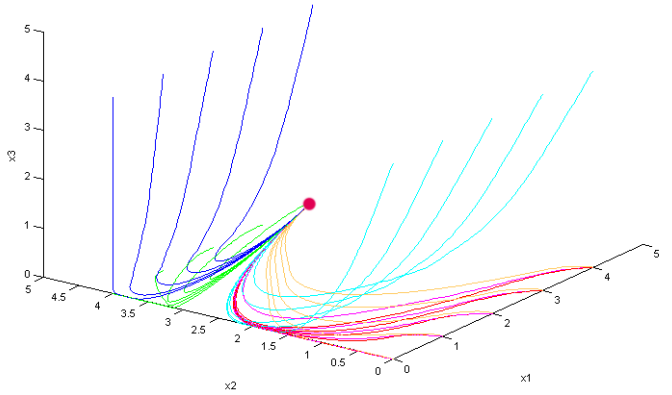
- A means of thinking holistically about the problem
- Can capture diverse considerations such as functional, ethical, legal, societal concerns
- Framework derived from nuclear weapons surety
- Formal method to address gaps throughout the product development lifecycle
- Gaps evaluated in terms of risk to product success
- Normative references provide a formal representation of a basic difference between “hard” and “soft” science
- Has been applied to nuclear weapons and cognitive models

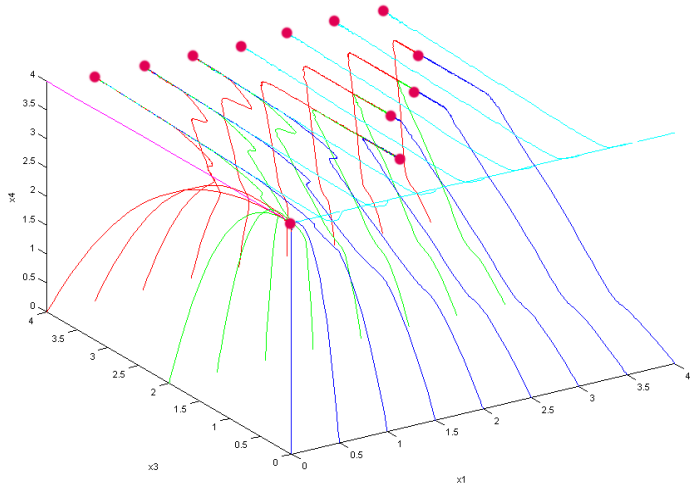


Dynamic Behavior Analysis

- Illuminates model behavior
  - identifies various behavioral regimes
  - sensitivity of behavior to parameter change
  - fundamental behavior changes
- Phase Space, Bifurcation and Model Checking analyses are formal processes that provide thorough understanding of dynamic systems
- Verification: confirm model has intended behavior regimes and doesn't have unintended behaviors
- Validation: minimize number of regimes to compare with real-world behavior

Two models of an economic system that were designed to have identical behavior. Phase portraits showed otherwise.





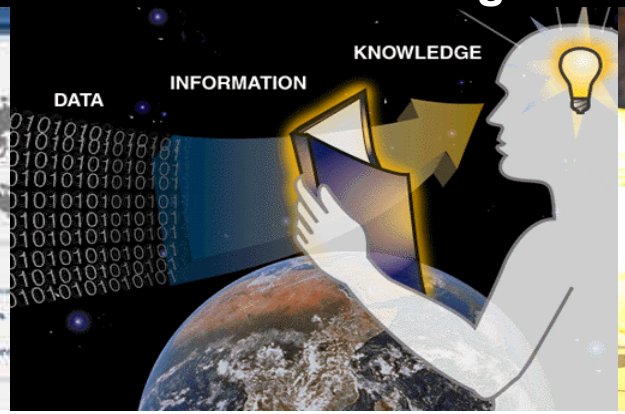
FLTC #1 Anticipatory Command, Control & Intelligence (C2I)

Anticipate Enemy Actions and Respond with Synchronized Management of Battlespace Effects

- Find Threatening Systems & Objects
- Predict Adversary Behaviors
- Perform Near-Real Time Decision Management
- Assure Fully Effective C2I Operators

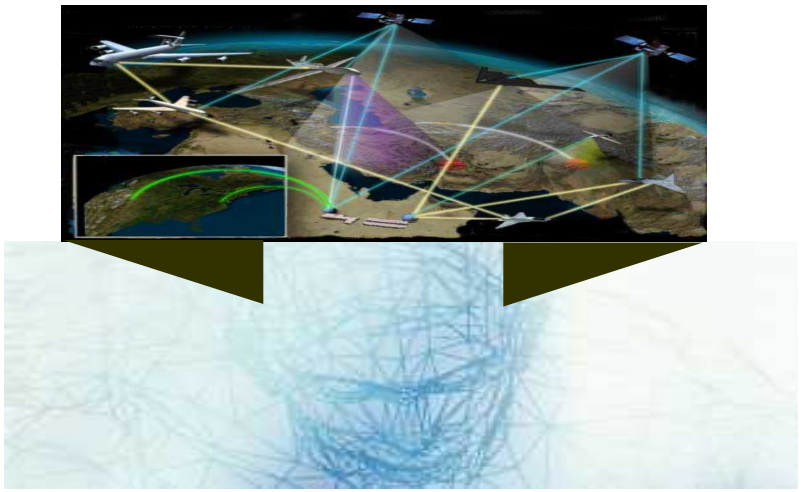
Building

Understanding



Strategizing

FLTC 1.2.1: Anticipation



Future Operational Capability Vision

Provide commanders and their staffs with the ability to forecast outcomes/ramifications of any potential actions on their part within a complex operational environment.

- **Produce expected futures based on current trends and expectations.**
- **Support evaluation of proposed "Blue" actions by providing forecasted outcomes of actions (both kinetic and non-kinetic) based on projected short and long term adversarial and nation-state/regional behavior.**

Current Capability

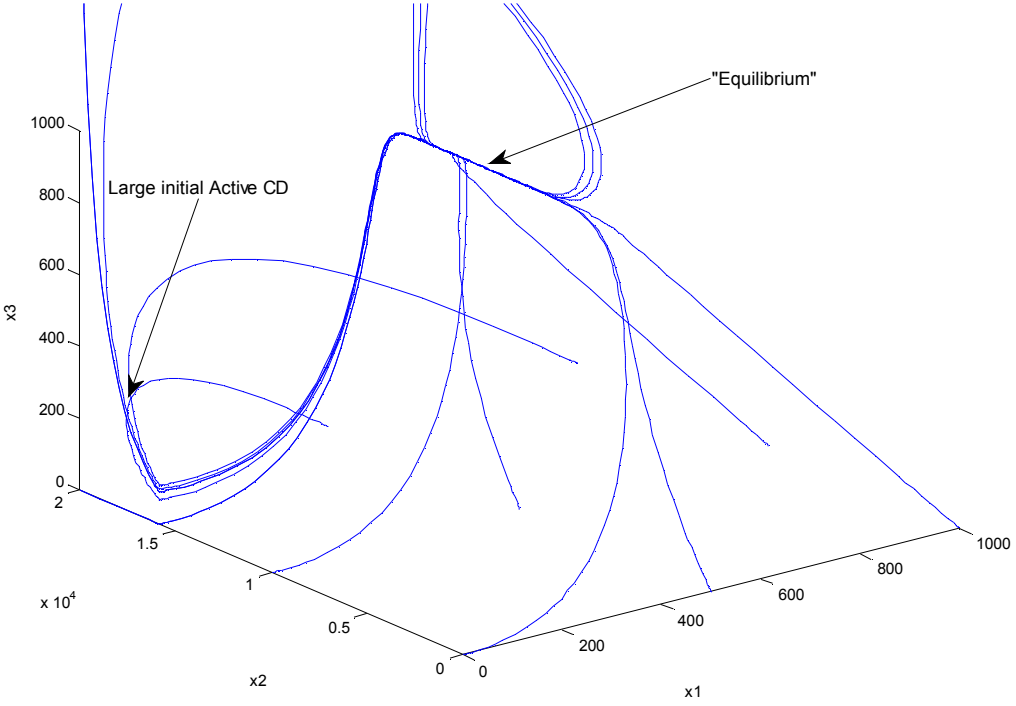
- Limited fidelity, understanding of individuals, societies and their cultures (social) and their interdependencies with regional infrastructures (i.e. a Holistic view)
- Limited Analysis tools to identify and forecast the likelihood of actions (including both hostile and non-hostile) and their intentions

Mid Term Experiment/Demo Capability (2015)

- An integrated computational envrionment that describes the Operational Environment in terms of both physical (Hard) and behavioral (Social) attributes and their "complex" inter- relationships
- Given a situation and potential Adversary project a set of possible futures (integrated and coordinated) ranked by most likely and most dangerous. Provide a prioritized set of collection requirements.

NOEM (SROM) Behavior Analysis Results

- Complex Behavior separable from overall trends
- System largely behaves as a simple linear system with single equilibrium
- Located a strange behavior relative to recruiting



AFOSR-BAA-2008-3

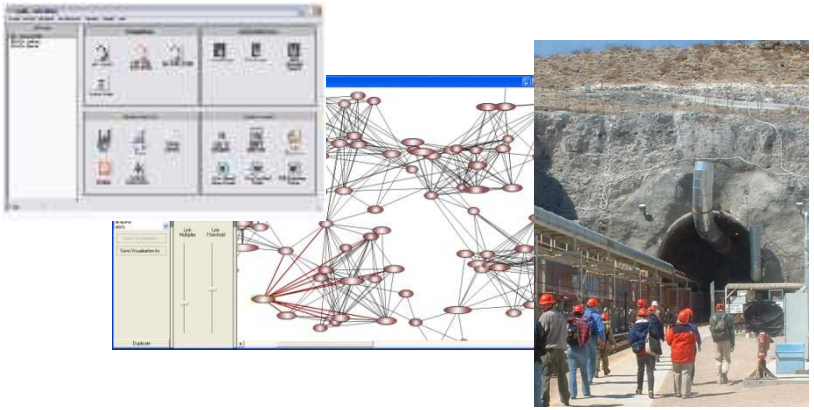
- Understanding, Simplification, Verification and Validation of Behavioral Models
- ~$150K / year for 3 years
- **Objectives:**
  - Investigate and develop validation of large complex models by transitive validation of small, simpler models.
  - Develop capability for validation of model interconnection coverage by bounding possible contribution of additional interconnections.
  - Apply these techniques to NO-EM/FutureCaster model as proof of concept.
  - Investigate applicability to other modeling paradigms.

Examples of Sandia Cognitive systems applications

Augmented Cognition Systems

DARPA/ONR/USMC

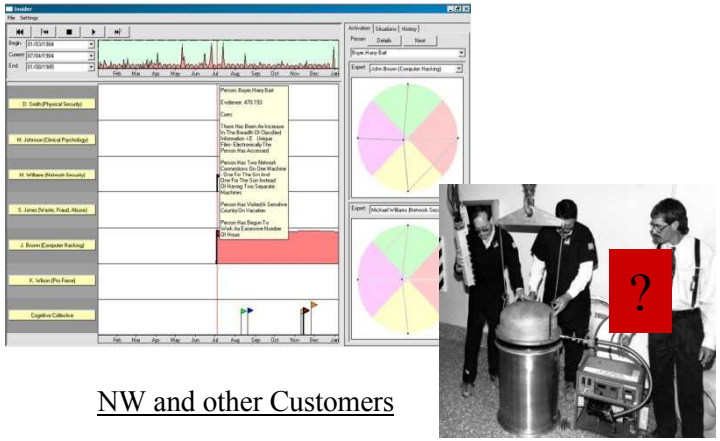
License Defense Tools (STANLEY)



DOE/Yucca Mtn.

Delivered Capabilities

Insider Threat Analysis

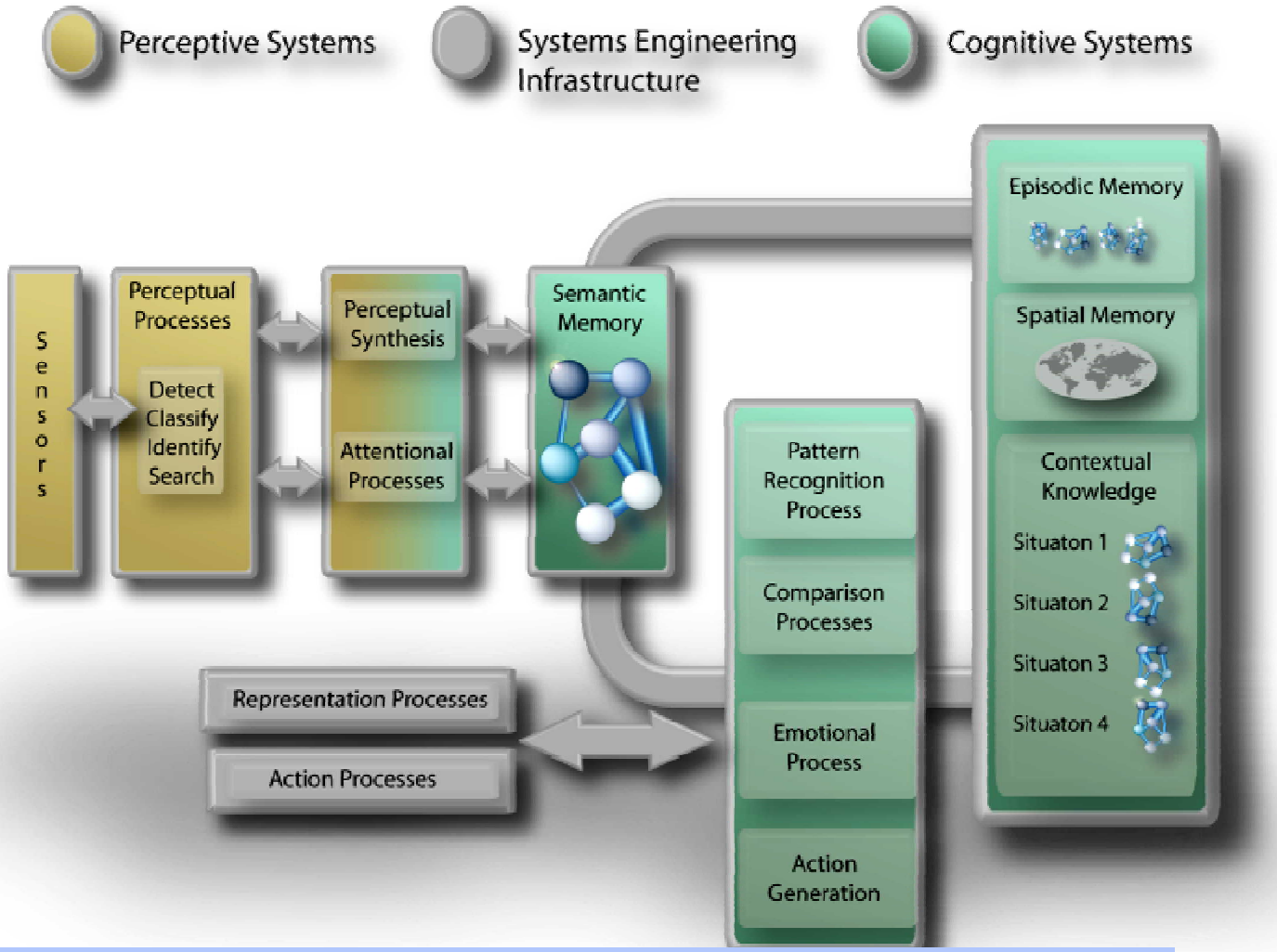


NW and other Customers

Adaptive Leadership Training (DARWARS-NK)

US Special Forces

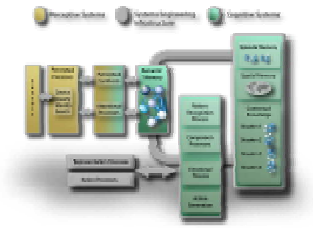
We have developed an architecture that integrates human perceptive and cognitive processes



This enables psychologically and physiologically based models of INDIVIDUALS

Cognitive framework and automated knowledge capture provide the basis for integrated products

Cognitive Framework

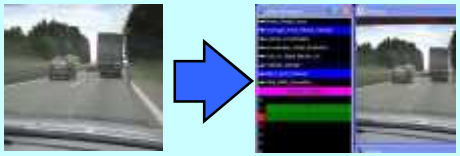


Generic cognitive engine employed with each product

Automated Knowledge Capture

Text Sources

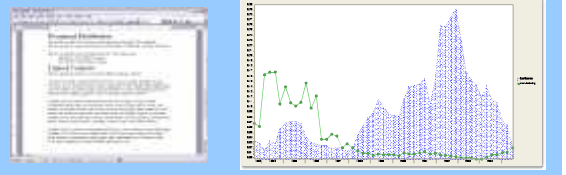
Machine Transactions



Spatial Domains

Acquire model of individual through observation of everyday activities

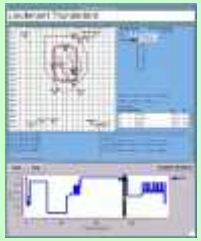
Products



Understand the Model

Use the Model

Dynamic Adaptation



Automated After Action Review

Simulation Human Behavior

AFSOR BAA 2008 Collective Behavior and Socio-cultural modeling
Develop a Basic Research Foundation for using computational approaches to study group behavior
example topics requested--

- Exploring the structure of cultural knowledge, beliefs, and social norms either broadly, in factor models, or more narrowly, within the framework of a computational cognitive architecture
- Reasoning and decision-making processes in cultural context
- Self-organization and adaptation of culturally defined entities or groups, including models of group competitive and cooperative interactions
- Game-theoretic modeling of interactive agents with imperfect and incomplete information regarding other agents
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- New approaches to automated reasoning about belief, knowledge, obligation, time, and preference
- Characterization of interacting dynamics at multiple scales, from individual to nation-state.

BAA 2008 other interests by AFSOR

- Fundamental constraints and limits of socio-cultural prediction and rigorous mathematical approaches that will help us assess this.
- *What is the appropriate data upon which to base such models? What are the theoretical justifications for the models proposed? What can such models reasonably be expected to accomplish?*
- How can the different ontologies and models of the various relevant disciplines best be integrated?
- To predict group behavior do we need to understand the effects of individual level cognition on group decision making and neuroscience correlates of socio cultural behavior*?*
- Are multi-level approaches required?
- How generalizable are socio cultural models to other sub populations?
- How should we validate such models?