Collective Behavior and Socio-Cultural Modeling
10 March 2009

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AFOSR/NL
Air Force Office of Scientific Research

Approved for Public Release.
AFOSR Mission

AFOSR discovers, shapes, and champions basic science to profoundly impact the future Air Force

- Identify Breakthrough Research Opportunities – Here & Abroad
- Foster Revolutionary Basic Research for Air Force Needs
- Transition Technologies to DoD and Industry

TODAY’S BREAKTHROUGH SCIENCE FOR TOMORROW’S AIR FORCE
AFOSR’s Worldwide Coverage

AFOSR

European Office of Aerospace Research & Development (EOARD)

Southern Office of Aerospace Research & Development (SOARD) – Opening soon

Asian Office of Aerospace Research & Development (AOARD)

Conference Support, Window-on-Science, Research Contracts, Newsletter
AFOSR Supports University Individual Investigators

• **Goals:** Provide revolutionary scientific breakthroughs to maintain military air, space, and information superiority
  — Build collaborations between AFRL and universities

• **General Process**
  — Researchers submit white papers to AFOSR program managers
  — Promising white papers lead to request for full proposals
  — Proposals are merit reviewed for excellence and relevance
  — *Individual grants can be proposed up to 5-years in duration*

• **Young Investigator Program (YIP)**

• **Broad Agency Announcement (BAA) is open at all times to innovative ideas** [http://www.wpafb.af.mil/AFRL/afosr/](http://www.wpafb.af.mil/AFRL/afosr/)
AFOSR FY09 Budget

<table>
<thead>
<tr>
<th></th>
<th>FY05</th>
<th>FY06</th>
<th>FY07</th>
<th>FY08</th>
<th>FY09</th>
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<tr>
<td>PE61102F Core</td>
<td>$217M</td>
<td>$224M</td>
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<td>$108M</td>
<td>$104M</td>
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* Include PBD709 increase

FY08 Total Budget: $505M

FY09 Core Budget Breakout

- Aerospace, Chemical and Material Sciences: 30%
- Math, Information and Life Sciences: 34%
- Physics and Electronics: 30%
- International: 6%
- Congressional Interest Item (CII): 9%
- University Research Initiative (URI): 21%
- Small Business (STTR): 8%
- DARPA: 4%
- OSD: 1%

57% Basic Research (Core)
# 60 Years of AFOSR Breakthroughs

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<tr>
<td>Maser/Laser</td>
<td>The Computer Mouse</td>
<td>Chemical Oxygen Iodine Laser (Coil)</td>
<td>Low-Temperature Gallium Arsenide</td>
<td>Self-healing Plastics</td>
<td>Joint Precision Airdrop System</td>
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<td>Kalman Filter</td>
<td>Viterbi Decoding Algorithm</td>
<td>Air Fracture Mechanics Methodology</td>
<td>Laser Diagnostics</td>
<td>Laser Trapping</td>
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**Partial List**
Mathematics, Information and Life Sciences (NL) Directorate

• Unconventional grouping of
  – Biology
  – human performance
  – information sciences
  – advanced mathematics

• Synergy between human cognitive and computer information sciences

• Cross-boundary insights:
  – Unique and exciting science
  – New formal methods

(www.afosr.af.mil)
“Collective Behavior and Socio-Cultural Modeling” (AFOSR 2008-1): collaboration between social, behavioral, cognitive, and biological scientists with computational researchers.

“Socio-Cultural Modeling of Effective Influence” (DCT BAA AFOSR 2008-3): Innovative computationally-based and multi-disciplinary approaches to ill-posed problems involving multiple parameters

- Cyber domain
- Sparse and uncertain data, multi-causality and second order effects.
- Assessment of models (meta-modeling, V&V, generalizability, sensitivity analysis, etc.)

“Terrorist Organizations and Ideologies” (Minerva – Topic #4): DoD-sponsored, university-based social science research program initiated by the Secretary of Defense.
What we know that we don’t know
What are the hard technical issues?

- No standard definitions/taxonomy/ontology for culture; no unified model or theory - embedded in specific social systems
- Multiple possible independent & dependent variables. Multi-factorial causation is the rule, bi-directional causation possible
- Relevant experimental data very sparse – reliance on descriptive studies subject to selection, measurement, confounding biases
- Reliance on observational data – diverse sources, incomplete, multi-lingual, inconsistent coding, non-current, estimated – data sparse data for areas of real interest
  - Automatically extracted data particularly subject to bias and not easily verifiable - sampling bias, echo, etc.
- Multiple possible modeling approaches
  - Dynamic/temporal dimension (order of actions) & spatial dimensions (geography) poorly captured by existing models
- Multi-level problem
- Computational intractability – cumulative uncertainty
Recent NRC Reports
Recommended directions in research

- "Behavioral Modeling and Simulation: From Individuals to Societies" recommended (Project Monitor from AFRL/RH)
  - Multi-disciplinary workshops & conferences
  - Bring data collectors & modelers together
    - Online games are a possible untapped resource
  - A federated models approach

- "Human Behavior in Military Contexts" - recommended doubling DoD 6.1 budget for behavioral & social sciences including emphasis in 6 areas including:
  - Intercultural competence – ability to navigate different cultures
  - Nonverbal behavior
  - Emotion - effects cognition & social behavior
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<tr>
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<th>Typical Computer Science Model</th>
<th>Typical Social Science Model</th>
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<tbody>
<tr>
<td>Philosophy</td>
<td>comprehensiveness</td>
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<tr>
<td>Models</td>
<td>Yes</td>
<td>Yes, but underspecified</td>
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<tr>
<td>Theory-based</td>
<td>partly</td>
<td>Yes</td>
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<tr>
<td># parameters</td>
<td>(\sim 1,000)</td>
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<td>Parameter types</td>
<td>environmental</td>
<td>human internal states</td>
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<tr>
<td>Internal state parameters</td>
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<tr>
<td>forecasting window</td>
<td>near-term</td>
<td>indefinite</td>
</tr>
<tr>
<td>Forecasting output</td>
<td>Rates &amp; numerical values</td>
<td>narrative</td>
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Predicting Collective Behavior
More Difficult than Predicting the Weather?

- Complexity
- # parameters
- People have internal states
- Dangers of data collection (Irbul, Kabul, etc.)
- Human use/IRB
- Adversarial Decisions making and “Theory of Mind”:

US Academics design software to “predict” Hizbullah behavior

“Hizbullah studies everything that it written about it, and takes it very seriously. But this is not going to cause any serious concerns”
Prediction is Important and Hard
How good is “90%”? 

• Near –term operational intelligence vs. structural models with long term predictive power
  – Correlation in massive data will miss cataclysmic events

• Evaluation of predictive claims (DARPA):
  – Forecast window (e.g. next 90 days, 1 year, etc.)
  – General strategy vs. particular event
  – Geographic specificity
  – What is the baseline? e.g. predicting that the weather in 5 days will be the same as today might be 35% accurate

• Meta-modeling: Predictive power of models varies with the application

• Is there basic research here?
  – Are predictive variables stable across time?
  – Theoretical research on explanatory variables
Building a Community of Practice

- Fragmented research community. Social Science Stovepipes
- Barriers at Universities to Multi-disciplinary Research:
  - Dearth of graduate students and training programs focused on this area
  - No recognized forum
  - Few young investigators
- Creating a community of practice:
  - Interdisciplinary research
  - Conferences and workshops
- Insufficient AFRL intellectual capital in social science
Building a Community of Practice
AFOSR Conferences & Workshops

• Second International Conference on Computational Cultural Dynamics (ICCD 2008), September 2008 (UMD).


• Workshop on Mathematics & Socio-Cultural Modeling, 3-4 Sept. ‘08 (UCSB)

• “Social Disorganization and Human Evolution: Media Disruption of Social Transmission”, Belfast (QUB), 2 4 - 2 7 Sept. 2008


• “Culture ABC (Affect, Behavior, Cognition)”, Lankawai Malaysia, 3-4 December 2008, or g ani z ed by AOARD – multi-national data collection effort
Transitions
What is the potential value?

• Data extraction tools (T-REX & SOMA): Joint Warfare Analysis Center (JWAC) training session 20 Dec ’07. Incorporation into DARPA ICEWS in Jan. ’08.

• Opinion Analysis System (OASYS): SentiMetrix Inc. startup to commercialize OASYS - daily analysis of public opinion data for World Bank since Sep. ’07

• Data: Afghan Tribe Data to 10th Mountain Division prior to 2006 deployment. Transition to AMSAA & to TRADOC in ’07. CIA in ’08

• Analysis tools: Extensive transition of social network analysis tools to DoD & Intell Community - JIEDDO, NASIC, Air War College, SOCOM, CIA, etc.

• CrossCat Tool for inferring structural from relational data transitioned to DARPA, Google, & Eli Lilly (*MIT MURI FY-05*). Navia Systems developing this algorithm to improve the power.

• Training & Simulation: Cultural Afghan Village Experience video training game to IARPA Jan ’08

• AFOSR PIs now working on DARPA and DTRA programs
Credible science based policy guidance

- Sacred values - implications for negotiations:
  - (Science, Vol 317, p-1039-40, 24 August 2007)

- Understanding how terrorist cells are created & evolve:
  - The Leaderless Jihad, Dr. Marc Sageman


Not Every Transition is a “Widget”
Portfolio Publicity


US Academics design software to “predict” Hizbullah behavior

The Computer as a Roadmap to Unknowable Territory (*The Washington Post*, 16 February 2009)

How Words Could End a War

*The New York Times*
Future Directions

• This is exploratory/high risk science –
  - Explore computationally-based multi-disciplinary approaches stretching from mathematics to ethnography
  - Model driven data collection in both the cyber and the naturalistic setting
  - Meta-modeling approaches
  - V&V
• AFOSR an early investor in this area and the program has already had many notable transitions
  - Are we near the leading edge of revolutionary breakthroughs in interdisciplinary Social Science?
• Efforts to create a community of practice to bring disparate communities together
  - Facilitate workshops & conferences
  - Encourage young investigators