ARO Probability & Statistics Program

April 17, 2008

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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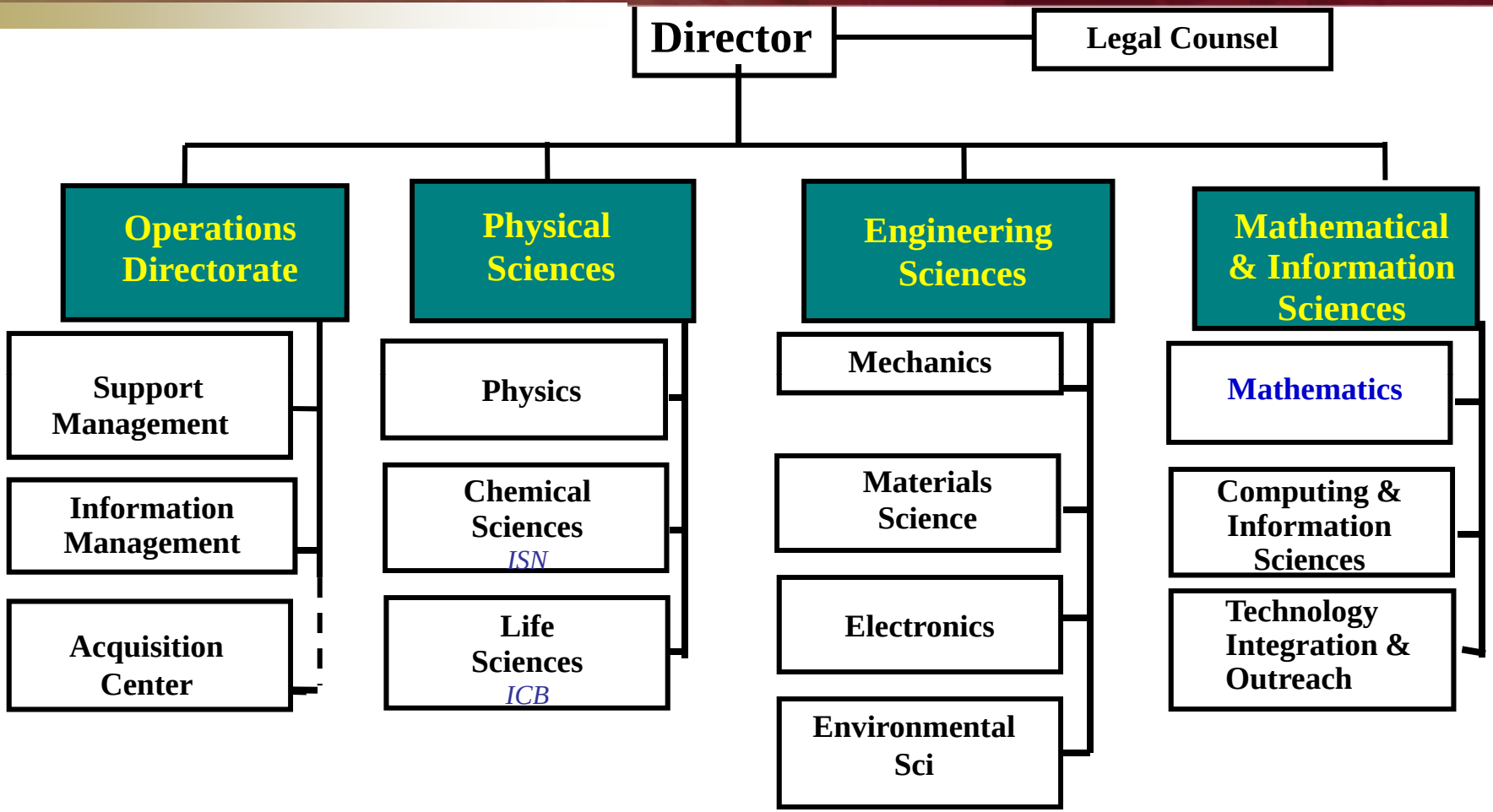
ARO Organization Chart



- *MURI*
- *DURIP*
- *DEPSCOR*

Programs in Mathematics

- **Mathematics Division Chief: Chris Arney**
- **Computational Mathematics: vacant**
- **Modeling of Complex Systems: John Lavery**
- **Discrete Mathematic and Computer Science:**
  Mike Coyle, telephone: 919-549-4256
- **Probability and Statistics: Harry Chang**
  Email: mouhsiung.chang@us.army.mil
  Telephone: 919-549-4229
- **Cooperative Systems: Chris Arney**
  Telephone: 919-549-4254

P & S Program Vision

Establish realistic probabilistic models, robust statistical data analytic methods, and stochastic analysis for the understanding and control of random physical, biological, and information-based systems that are important to the Army and DoD.

Philosophy & Strategy

- **Main Technical Opportunity and Need:**

- Creation of new or extension/modification of existing mathematical theory/results to solve real-world stochastic/statistical problems that are important/relevant to the Army and DoD

- **Assessing Research Risks and Success:**

- Some high payoff, high risk, e.g. stochastic fluid turbulence

- Some immediate payoff, less risk, e.g. statistical experimental design

- More of intermediate level

- **Methods for Achieving the Program Goal:**

- Leverage external funds (such as MURI, SBIR, STTR, DARPA)

- Active interactions with academia and Army/DoD researchers and dissemination of BAA

Research Thrust Areas

I. Stochastics/Statistics for Persistent Surveillance

- spatial-temporal event/behavior pattern recognition
- stochastic pursuit-evasion & antagonistic games

II. Information & Network Sciences

- mobile communication networks
- structures and dynamics of stochastic networks
- heavy tail statistics in multiscale networks & supply chain logistics management networks

III. Statistical Methods for Defense and Security

- experimental designs, statistical decision, data/text/image mining, reliability, statistical machine learning, data stream, very large or very small datasets, time series analysis

IV. Stochastic & Statistical Fluid Turbulence

- stochastic control and large deviation of fluid turbulence

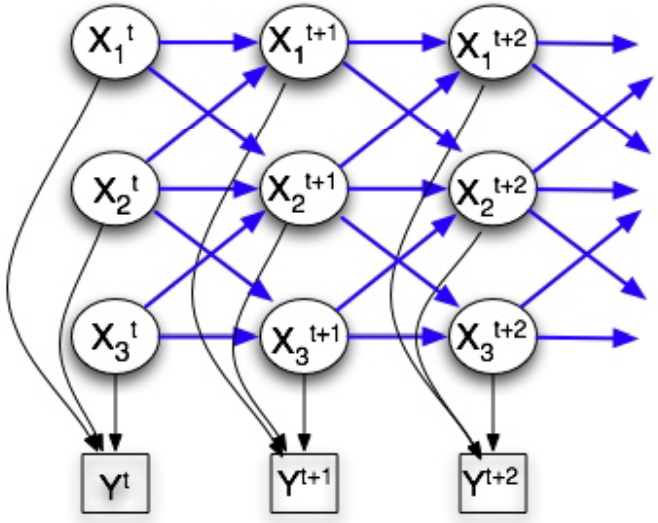
Army/DoD Relevance

The Army/DoD have long/short term needs for:

- Persistent Surveillance (Information assurance, counter-terrorism)
- Novel statistical methods for testing/evaluation and development of weapon systems
- Optimal tactical and strategic decisions under uncertainty
- Statistical analysis and fusion of sensor data from IEDs and land mines, etc
- Design of robust and scalable next-generation mobile communication networks for future network-centric operations
- Stochastic modeling, analysis, and control of complex, multiscale networks
- Stochastic modeling and analysis of informational, biological, and physical phenomena

Thrust Area I: Persistent Surveillance

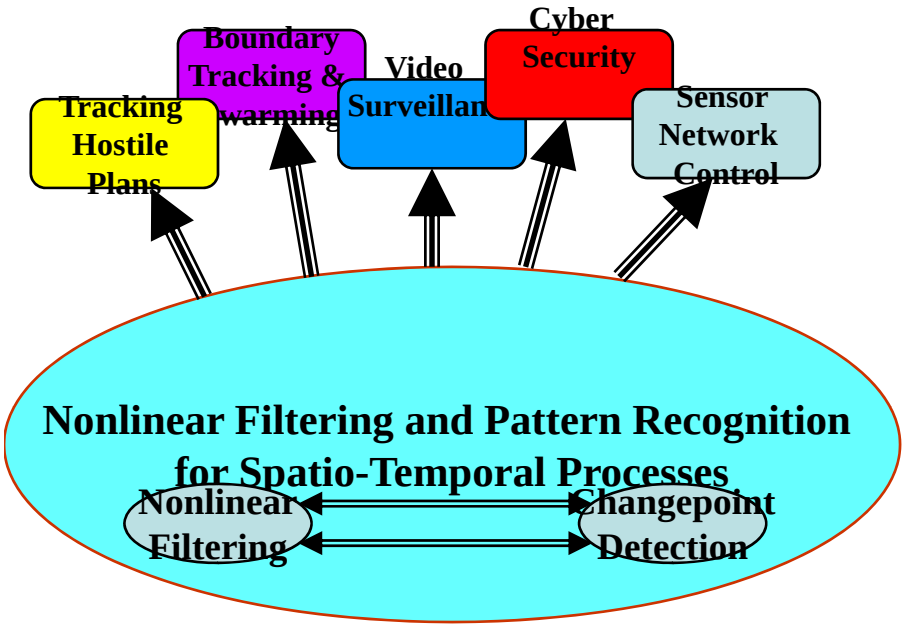
- **A. Spatial-Temporal Event Pattern Recognition (MURI)**
  - **Develop mathematical foundation for event/behavior pattern theory**
  - **Develop spatial-temporal statistical inference algorithms for detecting adversary events/behaviors**
- **B. Stochastic Pursuit-Evasion & Antagonistic Games (SBIR & core)**
  - **Characterize optimal pursuit-evasion strategies and their value functions for continuous- time and multiple players in realistic battle fields**
  - **Develop real-time optimal algorithms for implementation in UAVs and UGVs**



FY07: total=$1.84 M
MURI =$1M (54%)
SBIR II=$750K (41%)
core=$88K (5%)

Customer Interactions
ARL/SEDD, CERDEC, AFRL

Spatial-Temporal Event Pattern Recognition (MURI)



Objectives:

- Develop a general and systematic foundation and algorithms for spatial-temporal statistical inference for fusion of heterogeneous information from multi-source & distributed sensor networks to fight against terrorism and for information assurance
- Solve central problems common in persistence surveillance

DoD Benefit: 1. Will significantly improve the ability to recognize spatial-temporal activities in heterogeneous volume of data; 2. Direct applications to information assurance, MASINT vulnerability assessment, video surveillance, and defense against terrorism; 3. Enable the "optimal" integration of massive amounts of information from multiple intelligence sources and improve automatic correlation and fusion

Research Components:

PI: Rozovsky (Brown)
Tartakovsky, (USC); Veeravalli,(UIUC)
Bertozzi, Brantingham (UCLA)
Cohen & Galstyan (USC)
Medioni (USC), Chan (UCLA)
Papodopolous (CSU)

DoD COLLABORATION

AFRL ATR Center, ARL/SEDD, CERDEC

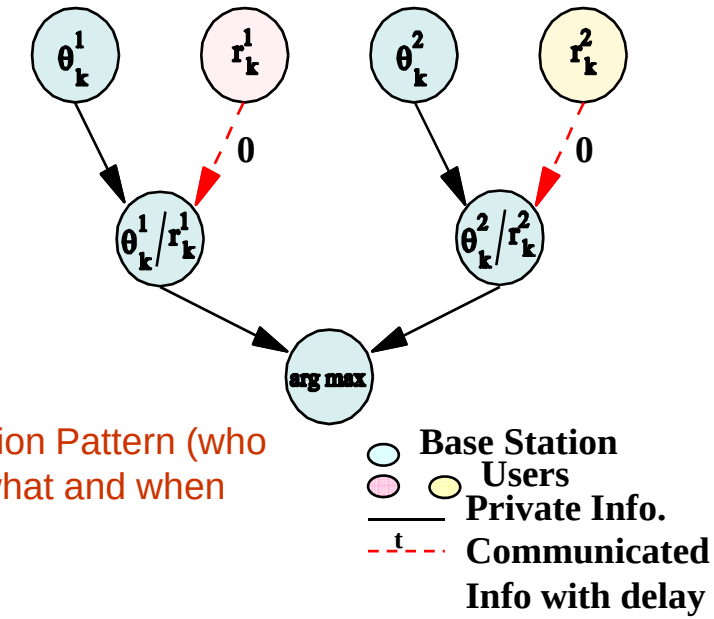
Thrust Area II: Information & Networks Sciences

Next Generation Mobile Communication Networks

- mathematical foundation for optimal design and operation
- dynamic scheduling of frequencies
- control & stability issues

Heavy Tails Statistics in Multiscale Networks & Supply Chain Logistics

- Mathematical models for the long range dependence, self similarity, and burstiness of communication networks
- Optimal control of multscale networks



Information Pattern (who knows what and when

FY07: total=$404K (core)

FY08: 2 MURI projects=$2.5 M/year

Customer Interactions

ARL/SEDD, CERDEC, AFRL

Thrust Area III: Statistical Methods

Reliability and Survivability

- Develop methods to compare systems heretofore incomparable optimization performance and costs

Adaptive experimental design for weapon systems

- Develop novel methodologies in the design and modeling of sensitivity testing and related experiments

Data and text mining

- Extract clustering patterns and statistical inference from large data sets

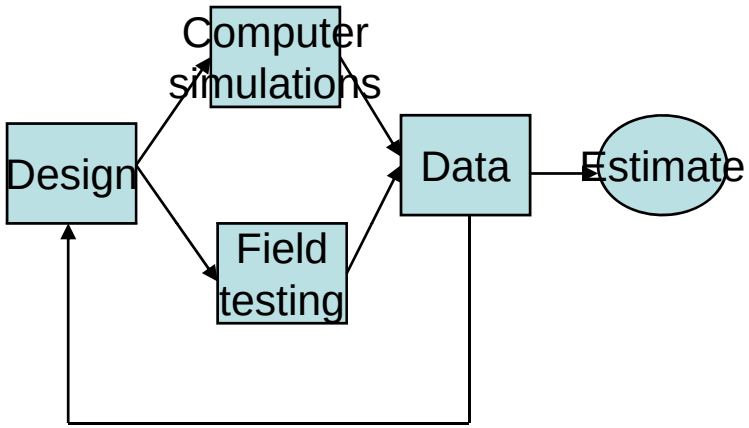
Data streams

- Visualization and representation of large data sets in real-time

Customer Interactions

ARL/CISD, Walter Reeds, ECBE

Adaptive Designs for Sensitivity Testing



FY07: total=$727K

SBIR =$70K (10%)

STTR =$200K (28%)

core=$457K (62%)

Thrust Area IV: Stochastic/Statistical Fluid Turbulence

Understanding & Controlling Turbulence for Rotocrafts

- 3D Navier-Stokes equations perturbed by spatial-temporal Brownian motion or Levy processes
- Stochastic interior and boundary classical and/or Impulse Control

Large deviation

- Navier-Stokes equations with small stochastic perturbation

FY07: total=$33K

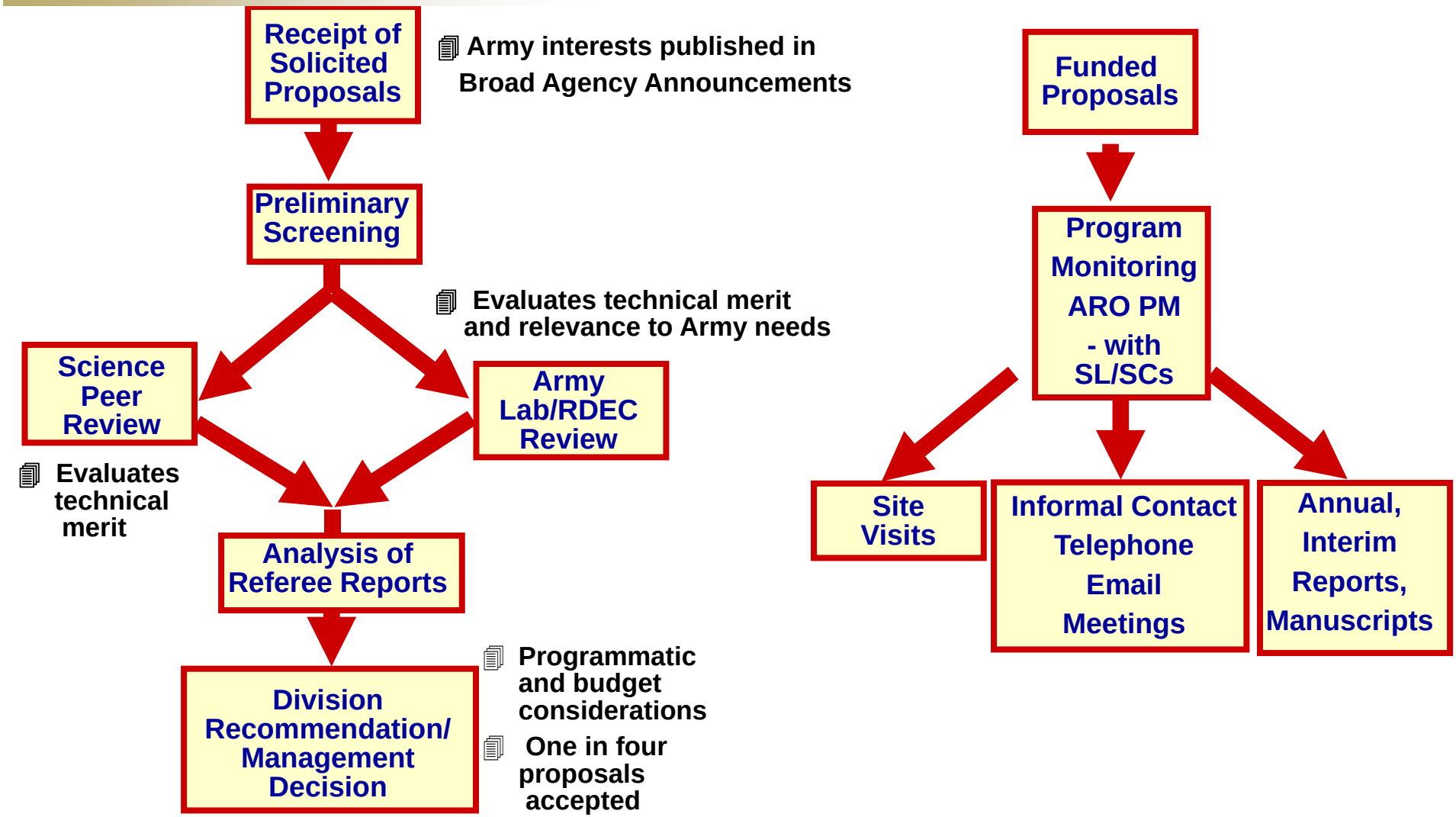
core =$33K (100%)

Customer Interactions

ARL/SEDD, AMRDEC, AFRL

How and When to Apply?

Step 1: Contact PM
Step 2: Six-paged white paper (research objectives, methodologies, Army/DoD relevance, brief CV, summary budget
Step 3: invitational full proposal (format see ARO website www.aro.army.mil)

- **Single-investigator program: 3 years, average $75K per year**
- **No deadline but prefer before December of the FY**

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