



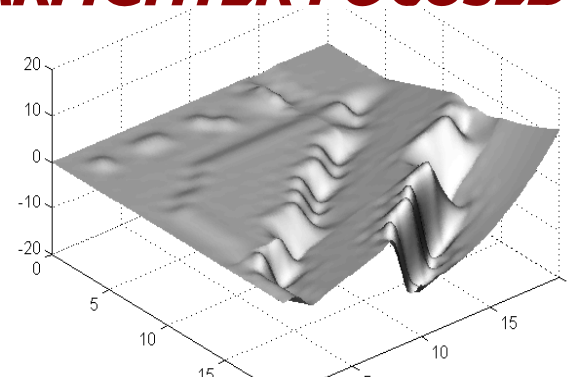
26 August 2008

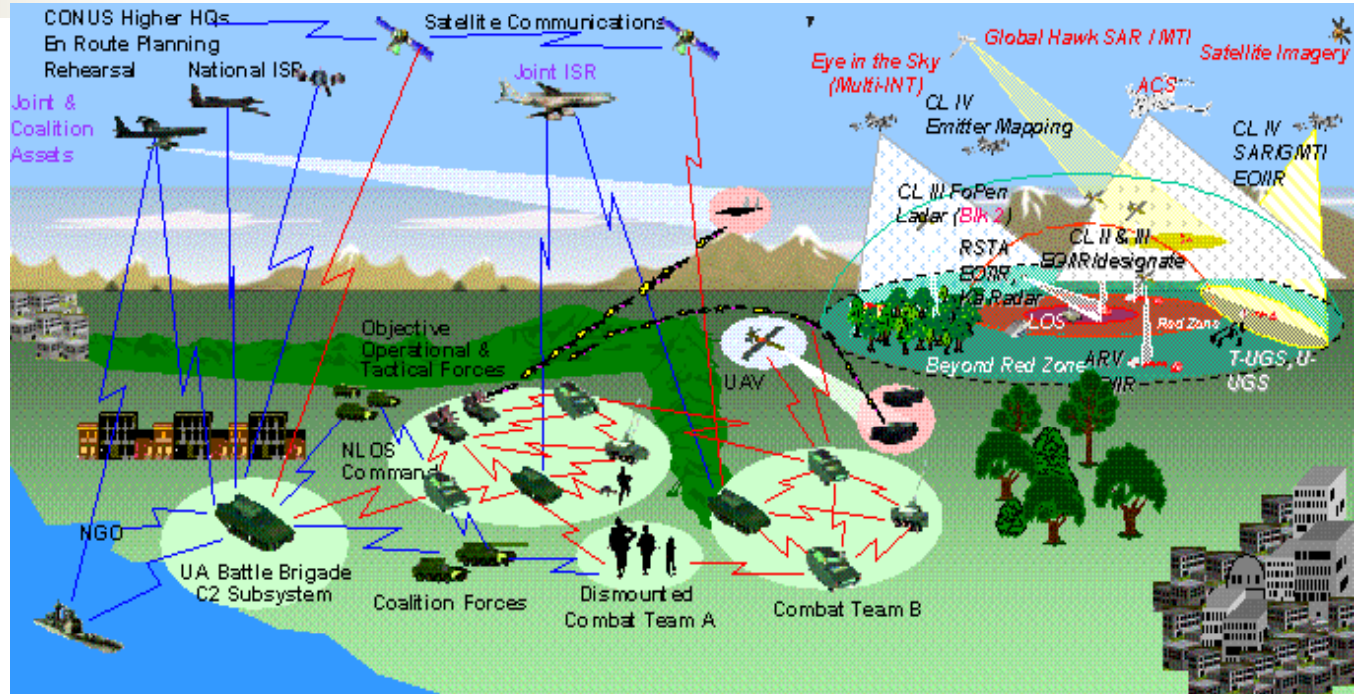
ARO Mathematics Division



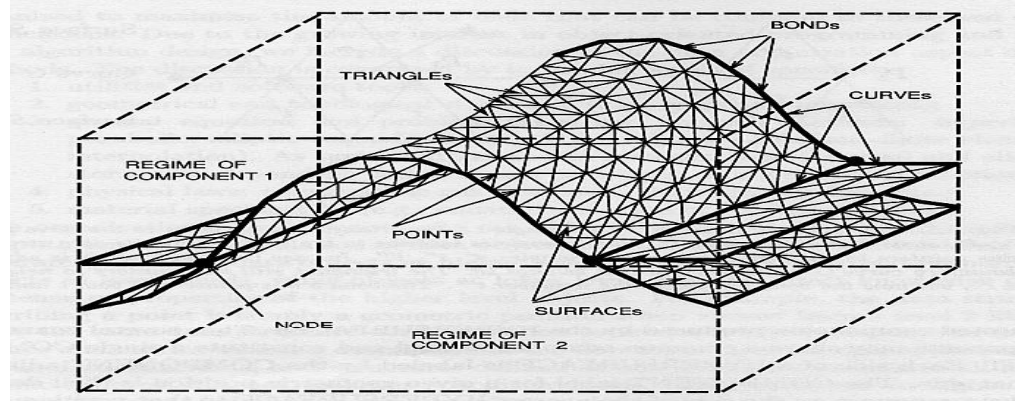
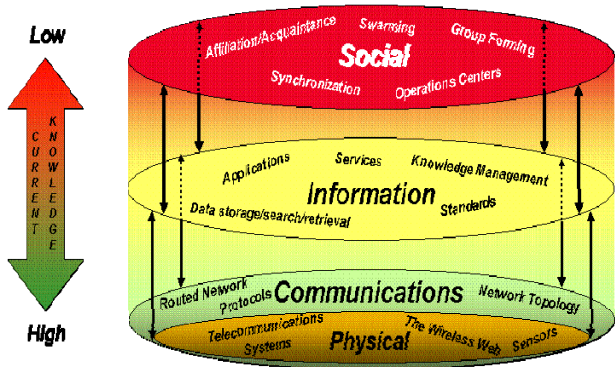
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Dr. Chris Arney
Division Chief
Army Research Office
david.arney1@us.army.mil
919-549-4254





Command and Control ↔ Collaborate and Connect



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ARO Mathematics Vision



To identify and enable basic research opportunities in the **mathematical sciences** that have the potential to transform Army capabilities and help maintain U.S. technological superiority

To lead the Army by embracing long-term, high-risk, high-payoff opportunities with special emphasis on **complex systems, computational mathematics, discrete mathematics, probability, statistics, and cooperative systems.**

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ARO Mathematics Program

Modeling of Complex Systems

Discrete Mathematics

Computational Mathematics

Probability & Statistics

Cooperative Systems

Program Manager

Dr. John Lavery

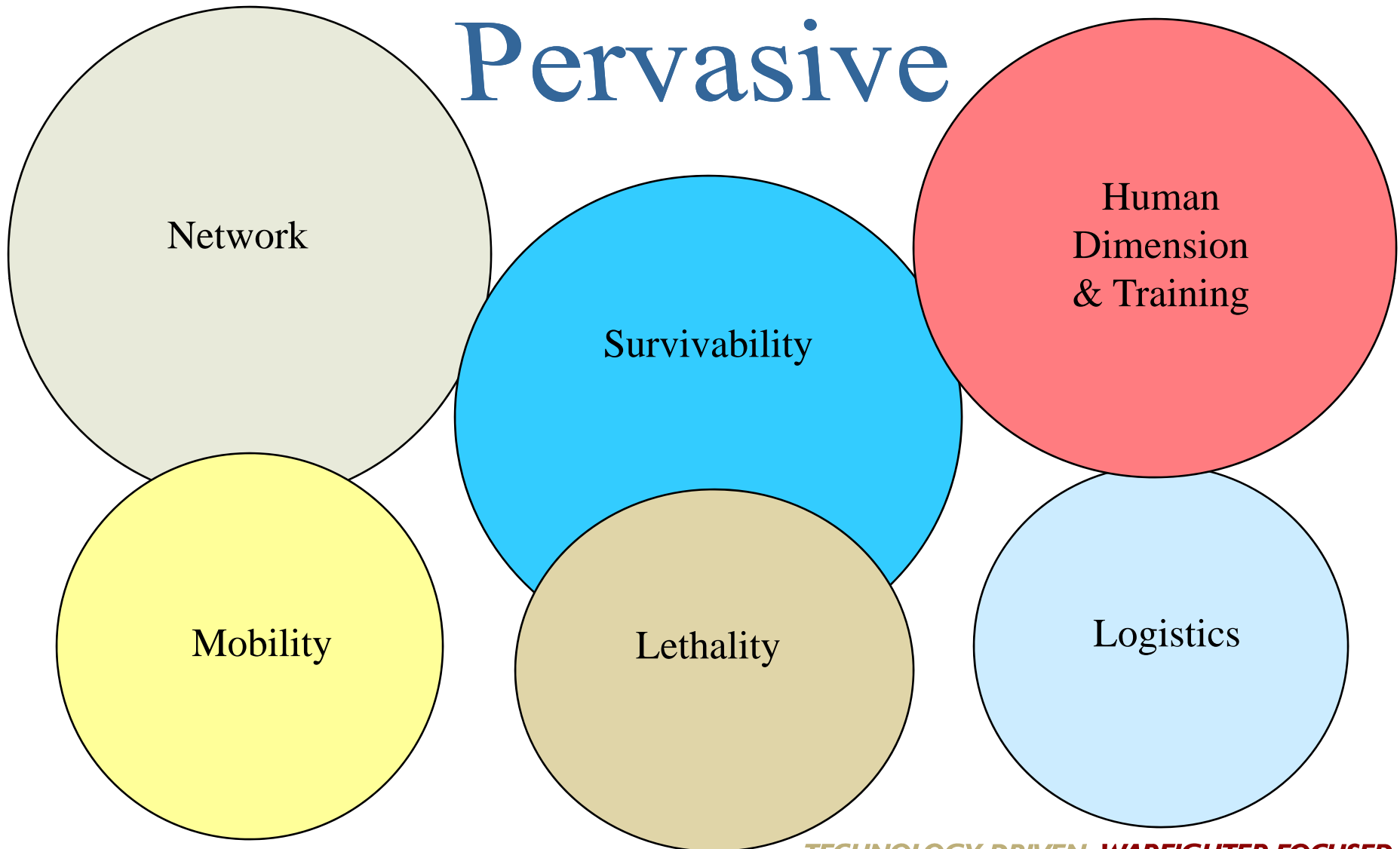
Dr. Mike Coyle

Dr. Janet Spoonamore

Dr. Harry Chang

Dr. Chris Arney

Pervasive





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ARO Mathematics



Modeling for Complex Systems

Develop quantitative models of complex, often human-based, systems by identifying unknown basic principles and related human-goal-based metrics. Specific thrusts include:

- Analysis for Sensor & Communication Networks
- Urban Terrain and Object Recognition
- Human Cognitive and Behavioral Modeling
- Applied Analysis for Physical Systems

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Modeling of Complex Systems Opportunities



- Develop methods for information fusion in sensor networks and enhance the quality of service of wireless networks.
- Develop models of 3-D urban regions up to 100 km x 100 km and develop systems that provide object recognition from partial information in cluttered urban situations.
- Develop models for human training and behavior and systems for quantifying “soft” human-factors elements and linking them with “hard” physics-based elements.
- Develop methods for predicting material failure under extreme dynamic loading.

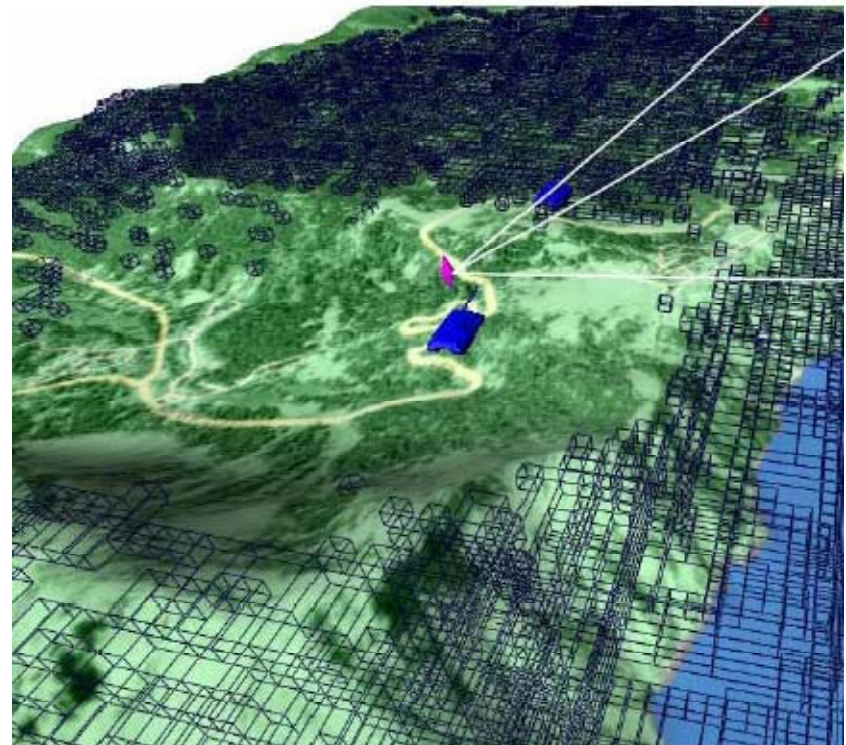
Eye-Point-Dependent Metric for Multiresolution Terrain Analysis

William Ribarsky, University of North Carolina, Charlotte

Developed terrain
representation & analysis
system with control of
accuracy/resolution vs. time
tradeoff

Faster than other methods

Locally based, scalable
representation with line-of-sight
and region visibility
metrics





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Computational Mathematics

Develop fast, accurate, reliable numerical computation methods that are easy to implement for design, analysis and prediction. Specific thrusts include:

- Solutions of Partial Differential Equations
- Development of Nonlinear Numerical Methods
 - Building of Supporting Technologies and Tools

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UNCLASSIFIED Computational Mathematics Opportunities

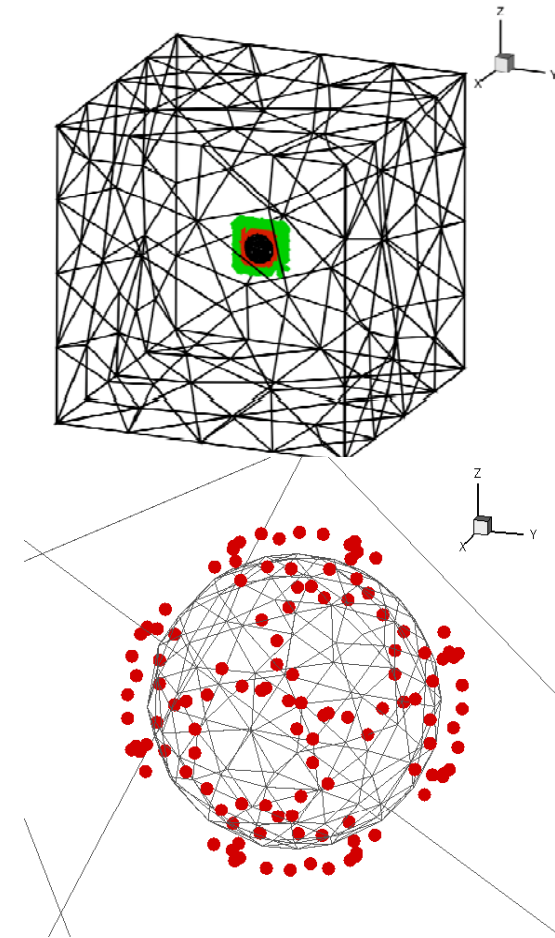


- Develop Partial Differential Equation Solvers that involve
 - High Order Methods for Shock Problems
 - Meshless Methods
 - Multiscale Methods
 - Implicit Interface Methods
- Develop Nonlinear Numerical Methods for
 - Optimization
 - Inverse Problems
- Build Supporting Technologies for
 - High Order Visualization
 - Adaptive Multiscale Gridding.

Adaptive Multiscale Analysis of Deposition Processes

Mark Shephard, Joseph Flaherty, RPI

- Developed adaptive framework for multiscale modeling which automates decisions:
- Choice of models
- Coupling information between scales
- Solution methods at each scale
- Determination of solution accuracy



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Discrete Mathematics

Build the foundational theories for the development, application and dissemination of the interrelated fields of discrete mathematics and theoretical computer science. Specific thrusts include:

- Interactive Simulation and Visualization
 - Large Data Set Management
 - Discrete Modeling

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Discrete Mathematics Opportunities



- Develop interactive simulation and visualization algorithms that establish virtual environments, build distributed gaming tools, and utilize GPU acceleration (GPUs as co-processors)
- Develop methods for Large Data Set management as related to terrain data, large-scale 3D solid models (urban environments), and situation awareness
- Build Modeling Tools for load balancing, network performance, and multi-core processing

Multiresolution Algorithms for Processing Giga-Models: Real-time Visualization, Reasoning, & Interaction

Ming Lin & Dinesh Manocha, University of North Carolina

- Developed code that transitioned to OneSAF, one of the most commonly used current simulation technology in the Army/DoD
- Technology used for event prediction, disaster response, and strategy analysis
- Developed technology and tools for graphics and gaming





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ARO Mathematics



Probability & Statistics

Develop probabilistic models, robust statistical data analytic methods, and stochastic analysis for understanding and control of random physical, biological, and information-based systems. Specific thrusts include:

- Stochastics/Statistics for Persistent Surveillance
- Information & Network Sciences
- Statistical Methods for Defense and Security
- Stochastic & Statistical Fluid Turbulence

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UNCLASSIFIED Probability & Statistics Opportunities



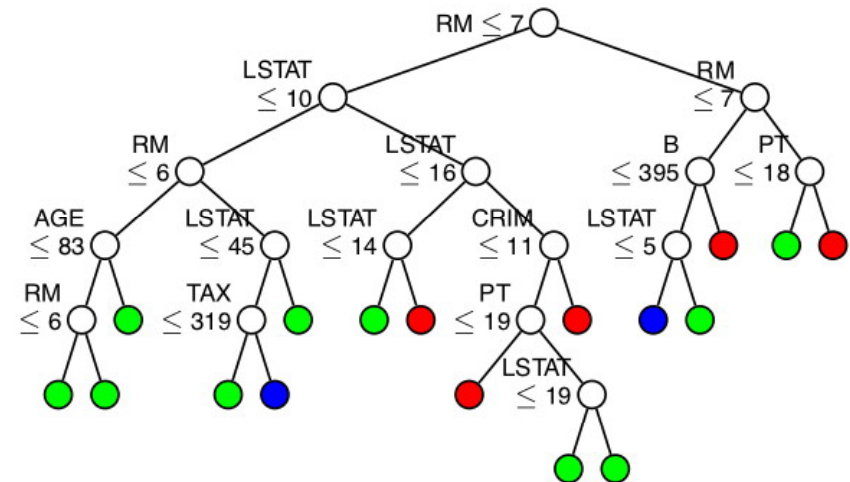
- Develop methods for Stochastics/Statistics for Persistent Surveillance by using spatial-temporal event/behavior pattern recognition and stochastic pursuit-evasion games.
- Build theory for Information & Network Sciences in the areas of mobile communication networks, stochastic networks, supply chain logistics networks.
- Develop Statistical Methods for Defense and Security applications including experimental design, statistical decision-making, data/text/image mining, reliability, machine learning, and very large or very small datasets.
- Develop models for Fluid Turbulence using stochastic control

Decision Tree and Data Visualization

Wei-Yin Loh, University of Wisconsin-Madison

Developed decision tree algorithms for prediction & visualization of data, with emphasis on high prediction accuracy, ease of interpretation, and fast computation speed

Produced the GUIDE software package for accurate classification -- applicable to least-squares analysis and missing data problems.





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Cooperative Systems

Develop systems with effective cooperation to accomplish missions greater than the capabilities of individual entities and develop measures, structures, processes for cooperation. Specific thrusts include:

- Theory of information & network science
- Modeling the transfer of data to intelligence
- Understanding of cooperative teams and swarming
- Collaborative decision-making

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UNCLASSIFIED Cooperative Systems Opportunities



- Build theoretical framework for information & network science: imaging, cognition, learning, pattern analysis, collaborating, communicating, & decision-making.
- Develop models for system network transfer: data → information → intelligence. Develop measures for system information and cooperation (selflessness, trust, value, communication, shared vision, and situation awareness).
- Understand the power & limitation of cooperative teams, autonomous systems, and swarming phenomena
- Develop systems for large data set manipulation & fusion for collaborative decision-making



ARO Mathematics Cooperative Systems



Sensor to Commander Metric Development Darryl Ahner, Naval Postgraduate School

System uses the Commander's intelligence requirements and a cognitive model to improve situational understanding by increasing reliability through adaptive deployment of sensors and by controlling information flow / filters to answer commander's questions.

Developed a computational model that accounts for the interaction between technological systems and human cognitive process as applied to Army operations.



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Complimentary RDECOM Mathematics Research



Modeling of Complex Systems

- ARO Information Sciences Division
- ARL WMRD
- ARL CISD
- ARL HRED
- ARL SEDD

Probability & Statistics

- ARO Physics
- ARO Information Sciences Division
- ARL CISD
- ARL WMRD
- AMRDEC
- ECBC

Computational Mathematics

- ARO Environmental Sciences Division
- ARL CISD
- ARDEC (Benet)
- AMRDEC

Cooperative Systems

- ARO Information Sciences Division
- ARL HRED
- ARL CISD
- ARL WMRD
- ARL VTD
- AMRDEC

Discrete Mathematics

- ARO Environmental Sciences Division
- ARL CISD
- ARL SLAD
- ARL SEDD
- STTC

<http://www.aro.army.mil>

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ARO Mathematics



Modeling of Complex Systems

Dr. John Lavery

John.Lavery@us.army.mil

Computational Mathematics

Dr. Janet Spoonamore

Janet.Spoonamore@us.army.mil

Discrete Mathematics

Dr. Mike Coyle

Joseph.Michael.Coyle@us.army.mil

Probability & Statistics

Dr. Harry Chang

Mouhsiung.Chang@us.army.mil

Cooperative Systems

Dr. Chris Arney

David.Arney1@us.army.mil

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