

Network Science for Human Decision-Making

13th International Command and Control Research Technology Symposium

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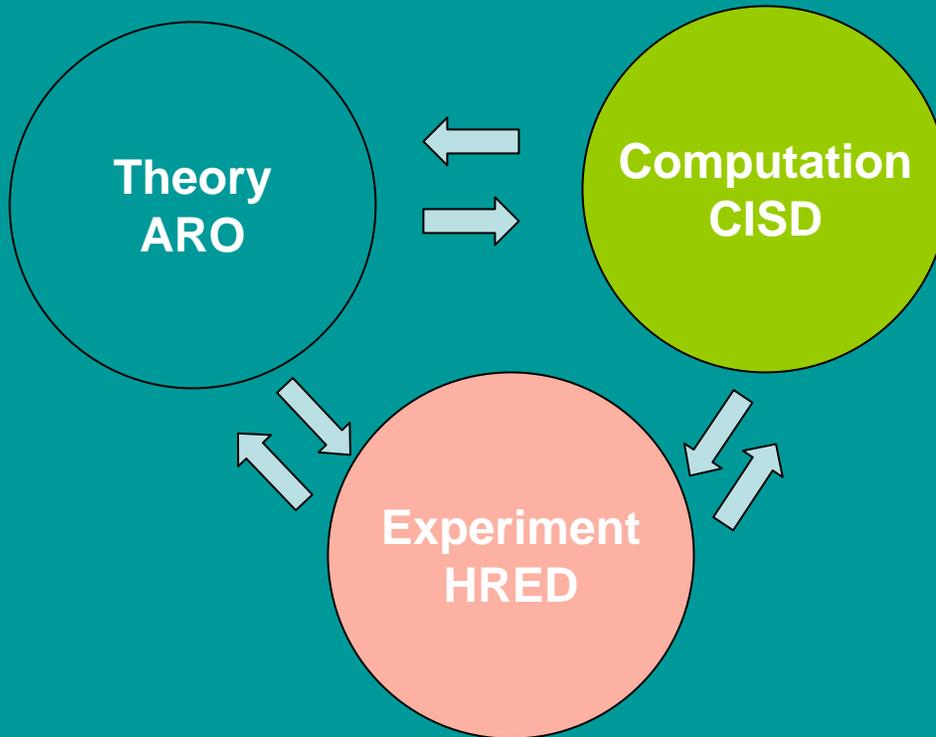
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- **First: What do we want to do?**
 - Determine how networks affect decision-making in NCW.
- **Second: How are we going to do it?**
 - Collaboration across disciplines and directorates
- **Third: What are we going to use?**
 - theory; experiment/observation; computation/simulation
- **Fourth: How are we going to know what works?**
 - archive interactions; regular meetings and workshops

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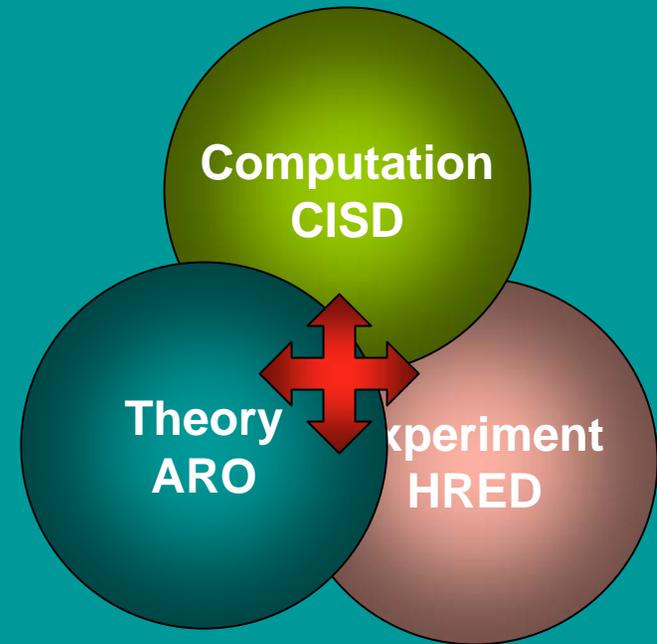
- **What makes this proposal different?**
 - **mandatory collaboration across disciplines and Directorates**
 - **ARO, CISD, SLAD and HRED**
 - **PI from separate ARL Directorate for each technical area**
 - **ARO B.J. West**
 - **CISD B. Rivera**
 - **HRED D. Bassan**
- **Project itself is an experiment**
 - **historical record to monitor successes and failures of collaborations**
 - **summarize what works at yearly workshops**
 - **technology anthropologist records and evaluates group interactions**

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Historical form of collaboration among and between disciplines and ARL Directorates.

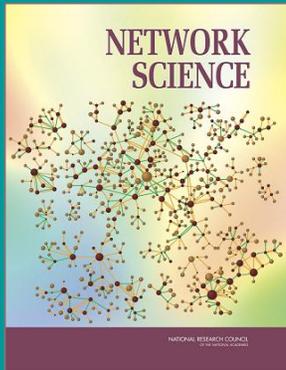
Proposed form of collaboration interleaves the various disciplines and ARL Directorates.



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- **Setting the stage for research projects**
 - **What constitutes a network?**
 - Structure to integrate component contributions
 - Who (what) interacts with whom (what)?
 - The Army
 - Social, cultural, and organizational processes that foster cooperation
 - Ants, bees and termites
 - **All networks are not equivalent.**
 - Node properties – can they learn, adapt; are they mobile..?
 - Link properties – what is being transferred (energy, information)?
 - Embeddedness – what other networks are connected?
 - What are the boundary conditions?
 - What are the constraints?

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Research Challenges related to decision-making

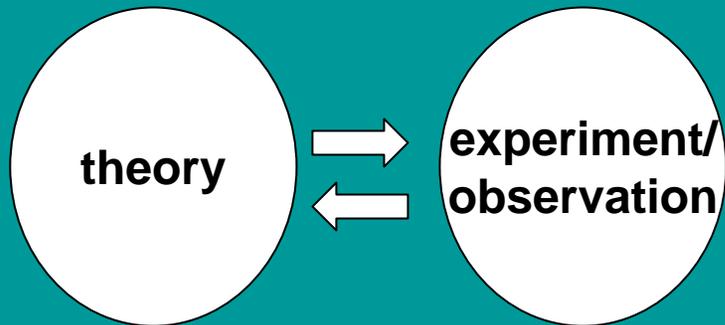
1. Dynamics, spatial location, and information propagation in networks
2. Modeling and analysis of very large networks
3. Design and synthesis of networks
4. Increasing the level of rigor and mathematical structure
5. Better experiments and measurements of network structure
6. Robustness and security of networks
7. Abstracting common concepts across fields

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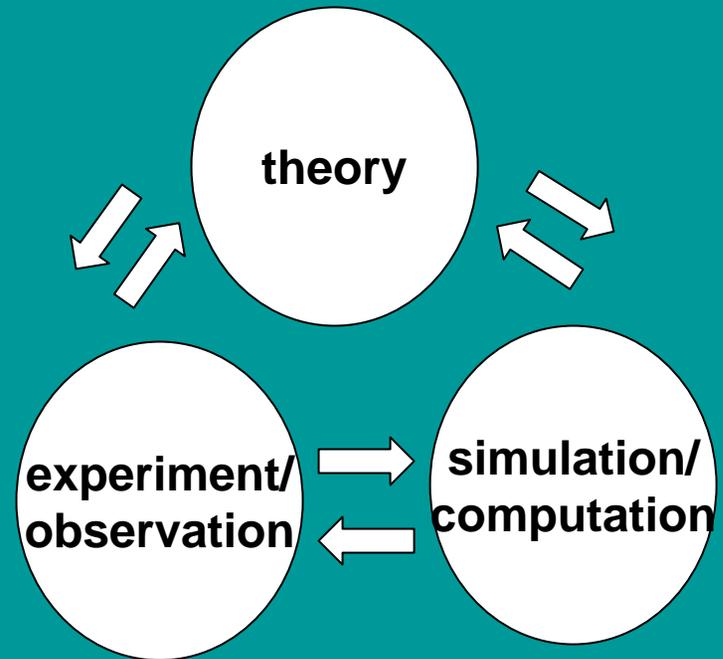
- **Technical Area 1: Network Theory (ARO)**
 - **Project 1.1: Complexity theory and modeling without scales (ARO and HRED)**
 - leadership research based on social networks
 - modeling uncertainty: non-stationary, non-ergodic renewal
 - information exchange between human and other networks
 - **Project 1.2: Information propagation in complex adaptive networks (ARO and CISD)**
 - match information flow between complex networks
 - synchronization of fluctuating elements
 - cognitive model of information dispersal
 - **Project 1.3: Network stability and decision agility (ARO and HRED)**
 - impact of network on decision-making
 - build model of cognitive network to evaluate decision-making

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- Topology of scientific method is fundamentally different



Two-tiered iterative process
TETETE...



Three-tiered iterative process
TCETCE... or TETCETC... or

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- **Technical Area 2: Network Simulation and Computation (CISD)**
 - **Project 2.1: Network Optimization under conflicting constraints (CISD, ARO and HRED)**
 - impact of cognitive measures of performance on network metrics
 - local (subnetwork) versus global (network) optimization constraints
 - generalize control theory to include self-repair
 - **Project 2.2: Mission-based integrated modeling and simulation (SLAD and HRED)**
 - agent-based simulations integrating human, propagation, hardware and software into task-based assessment of mission performance
 - simulate decision-making processes of soldiers, as well as, hardware and software objects
 - carry out a variety of detailed scenarios analyzing task completion within the network

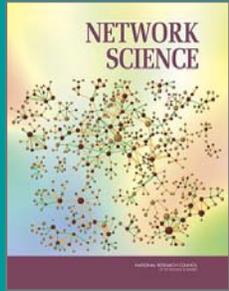
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- **Technical Area 3: Network Experimentation/Observation (HRED)**
 - **Project 3.1: Scenario building and testing (HRED and ARO)**
 - map operational analysis into network analysis
 - explore sensitivity to shared information
 - **Project 3.2; Understanding the network effects of decision-making (HRED and ARO)**
 - extend analysis of influence of uncertainty on decision-making
 - integrate characteristics of nonlinearity, adaptation and network emergence on decision makers
 - **Project 3.3: Measures of human performance in networked operations (HRED, CISD and ARO)**
 - develop metrics for network-of-networks; shared understanding and group synchronization
 - information dispersal from manned and unmanned networks
 - effect of mental effort and frustration compared with physical fatigue on decision-making

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- **Technical Area 4: Workshops and Historical Records**
 - maintain record of social/technical interactions
 - maintain record of successful and failed collaborations
 - organize and document monthly technical one-day meetings
 - Set agenda
 - guest speaker
 - focus on specific problem areas
 - mandatory attendance
 - organize and document annual 2-3 day workshop
 - review successes, dead ends, re-organize, re-orient and re-determine the state-of-the-art in decision-making
 - mandatory attendance
 - achieve growth of shared terminology for network science

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Areas of Military Value related to decision-making

1. Modeling, simulating, testing and prototyping very large nets
2. Command and control of joint/combined networked forces
3. Impact of network structure on organizational behavior
4. Security and information assurance of networks
5. Relationship of network structure to scalability and reliability
6. Managing network complexity
7. Improving shared situational awareness of networked elements
8. Enhanced network-centric mission effectiveness
9. Advanced network-based sensor fusion
10. Hunter-prey relationships
11. Swarming behavior
12. Metabolic and gene expression networks