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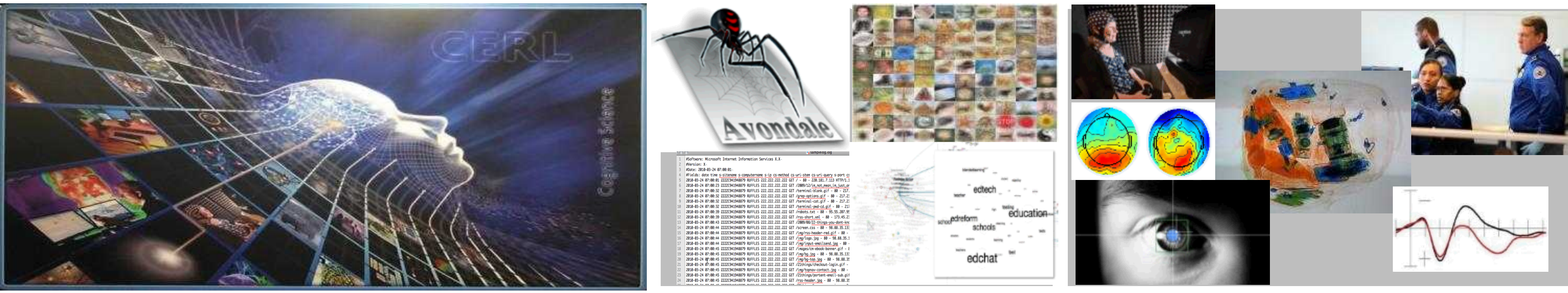


# Human Dimension work at the National Laboratories

Phil C. Bennett, Manager

Cognitive Science and Systems

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

CCR Center for Computing Research

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# BLUF:
# Engage the National Labs in Human Systems

- Substantial R&D at DOE's National Laboratories
  - DOE Investments
  - Done at National Laboratories, primarily Federally-Funded Research and Development Centers (FFRDCs)
  - Significant DoD and other Agency R&D at National Laboratories

- There is HSI-Relevant work at many of these Laboratories
- A conversation has begun and a COI is forming among the DOE Laboratories on the topic of Human Systems/Human Dimension.
- Laboratory consensus is to continue to build the COI, map future goals and activities, and apply the expertise more broadly to national security and other needs.

# National Laboratories of the U.S. Department of Energy


Source: U.S. Department of Energy
http://energy.gov/maps/doe-national-laboratories

# National Laboratories with identified active human dimension activity

**Participating in the HS COI discussion as of Aug 2016:**

# Nascent DOE National Laboratory HS COI

Sandia National Laboratories

NDIA Human Systems Division


NDIA Human Systems Division

**DOE Lab Connections Initiated**
- October 15
- Initial contact/invitation to engage
- 5 Laboratories Respond: ANL, INL, LBNL, ORNL, SNL

**NDIA Human Systems Conf. '16**
- February 16
- Proposal to bring DOE Human Dimension players to the table

**SNL/ANL Exchange**
- May 16
- Exchange HD briefings for ANL ***Systems Science Center***

**Resilience Week Conf. '16**
- August 16
- Organized Track on DOE Lab Human Dimension Work
- SNL, INL, ANL, LANL, ORNL, PNNL, Ames
- Labs excited to continue
- Invited to help organize entire 2017 Resilience Week

**Brief DoD HS COI Seniors**
- September 16

**DOE Lab Dedicated Issue**
- February 17
- Journal of Human Performance in Extreme Environments
- Purdue University Press

**NDIA Human Systems Conf. '17**
- March 7-8

**DOE Discussions**
- 2Q-4Q FY17
- Approach DOE PMs as multi-lab Team
- Lab workshop to precede this to lay out goals, best message, approach

**Resilience Week Conf. '17**
- August 17

# Laboratory Participants and Topics: Resilience Week ‘16 (18 Aug 16)

| Laboratory | Participant | Presentation | Abstract |
|---|---|---|---|
| Ames Lab | Kenneth “Mark” Bryden, Director, Simulation, Modeling, and Decision Science (Zachary Reinhart) | An Overview of the Ames Lab Simulation, Modeling, and Decision Science Program | Bryden & Reinhart |
| | Cameron MacKenzie, Simulation, Modeling, and Decision Science | Integrating Narrative into Engineering Decision Making | MacKenzie et al. |
| ANL | Pam Sydelko, Director, Systems Science Center (SSC), Global Security Sciences | Resiliency is a Wicked Problem | Sydelko |
| | Michael North, Integrated Analytics, SSC | A Brief Survey of Methods to Analyze Human Decisions for Infrastructure Resilience Applications | North |
| | Ignacio J. Martinez-Moyano Behavioral & System Dynamics, Social & Behavioral Systems, SSC (Michael North) | Using a Dynamic Modeling Approach to Understanding Resilience | Martinez-Moyano |
| | Diane J. Graziano, Global Security Sciences | Human dimensions of infrastructure interdependency and resilience | Graziano et al. |
| INL | Ronald L. Boring, Resilience Research Team, Resilient Control & Instrumentation Systems (Roger Lew) | The Driver’s Missing Windshield: Enabling the Operator’s Forward View Through Predictive Displays for Process Control | Boring & Lew |
| | Roger Lew (U. Idaho) | Track Co-Chair | |

# Laboratory Participants and Topics: Resilience Week '16 (18 Aug 16)

| Laboratory | Participant | Presentation | Abstract |
| --- | --- | --- | --- |
| ORNL | Georgia D. Tourassi, Director, Biomedical Sciences & Engineering Center | Digital Cancer Surveillance | Tourassi & Yoon |
| | Hong-Jun Yoon<br>Biomedical Sciences & Engineering Center<br>(Georgia D. Tourassi) | Computational Modeling of Visual Search Behavior | Yoon et al. |
| | Amy K. Wolfe, Renewable Energy Systems Society-Technology Interactions, Renewable Energy Systems | Striving to achieve resilience across social, environmental, and technical systems | Wolfe |
| LANL | David Mascareñas, LANL Engineering Institute | Human-Machine Interface Research at the Los Alamos National Laboratory Engineering Institute | Mascareñas |
| PNNL | Mark Rice, Energy Infrastructure Group | Enabling Situation Assessment/Awareness for Utility Operators and Cybersecurity Professionals | Rice et al. |
| SNL | Phil C. Bennett, Cognitive Science & Systems, Center for Computing Research | Track Co-Chair | |
| | Judi E. See, NW Systems Analysis | Incorporating Human Readiness Levels at Sandia National Laboratories | See & Morris |
| | Glory Emmanuel Aviña, Data Science & Cyber Analytics<br>(Victoria Newton) | Real-time Data Collection through Wearable Devices to Quantify Attributes Related to Health and Performance in Extreme Conditions | Aviña et al. |
| | Laurie Burnham, Electric Power Systems Research | To Err is Human: How Automation of the Grid Is Impacting Operator Performance and System Resilience | Burnham et al. |

# Observations: Labs capabilities

(Preliminary, based on HS presentations to date)

| | Ames Lab | ANL | INL | LANL | LBNL | LLNL | ORNL | PNNL | SNL |
|---|---|---|---|---|---|---|---|---|---|
| Sociotechnical modeling | X | X | | | | | X | X | X |
| Experimental human studies | | | X | | X | X | X | X | X |
| Traditional human factors | | | X | | X | | | X | X |
| Immersive Visualization | X | X | X | | | | | | |
| Visual cognition | | | | | | | X | X | X |
| Simulation | X | X | X | X | | X | | X | X |
| Learning Enhancement | | | | X | | X | X | | X |
| Big data | | | | | | | X | | |

# Observations

- Many of the examples presented were energy oriented, but the lab representatives had difficulty identifying DOE Human Systems (HS) enthusiasts.
- The majority of HS work seems to be funded by non-DOE sponsors.
- All labs reported struggles with acceptance/integration of human system activities into traditional physical science missions.
- There was unanimous interest in continuing to develop the National Laboratory HS COI.

# Begin mapping to Third Offset

| | Ames Lab | ANL | INL | LANL | LBNL | LLNL | ORNL | PNNL | SNL |
|---|---|---|---|---|---|---|---|---|---|
| Artificial intelligence (AI) and autonomy | | | X | X | | | X | | X |
| Human-machine collaboration | | | | X | X | X | | X | X |
| Machine-assisted human operations | | | X | | | | | | X |
| Human-machine combat teaming | | | | | | | | | |

# Questions?

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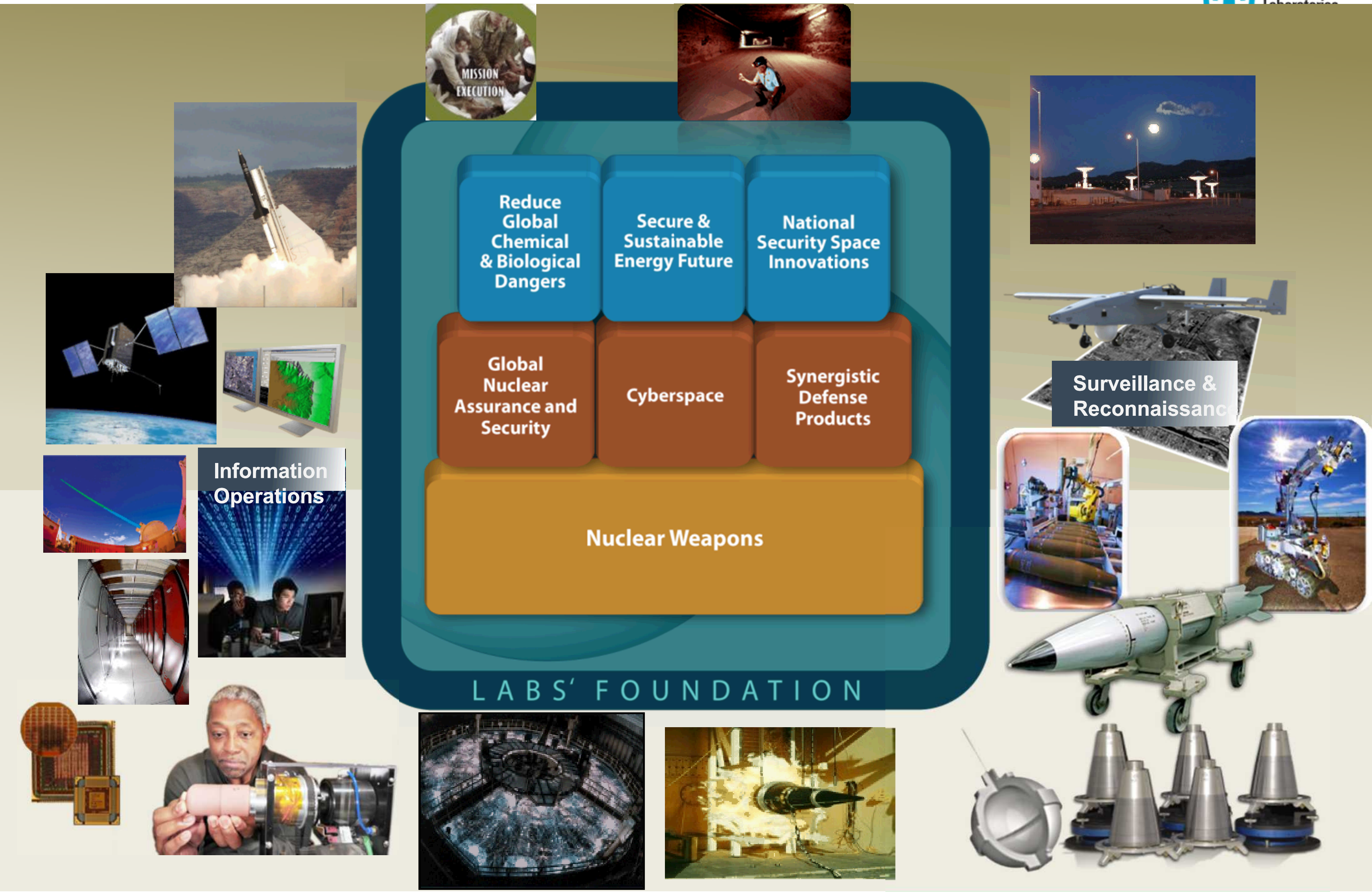
# Sandia's National Security Missions



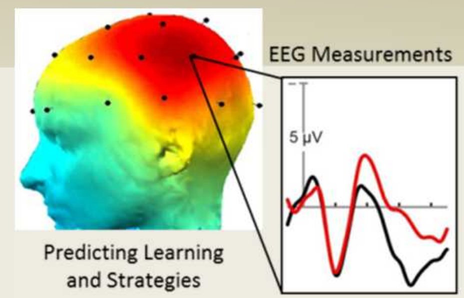
# Exploring Human Cognition


Data visualization, Pattern Analytics to Support High-Performance Exploitation and Reasoning (PANTHER)

1. Study strategies of visual information foraging in novices vs. experts
2. Develop algorithms to predict strategies
3. Informed by basic visual cognition research, enhance data visualizations (e.g. graphs), visual representation software etc.


Working Memory, Human Performance Lab (HPL)

1. Study neural signatures of memory via EEG
2. Study impacts of tDCS
3. Test memory training strategies

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# The Human System Simulation Laboratory (HSSL)


- Reconfigurable full-scale control room simulator facility
- Operator workstations for performance analysis.
- Technologies to measure human response:
  - -audio and visual surveillance,
  - -heart rate,
  - -breathing
  - -skin conductivity
  - -eye-tracking)
- Instrumental in nuclear power plant control room modernization in the U.S

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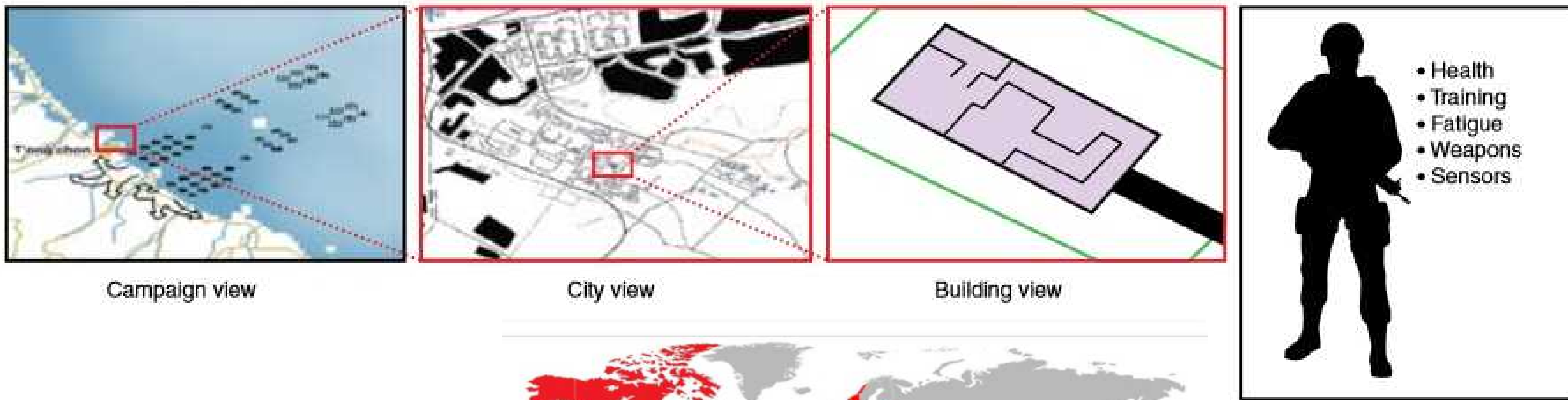
# Joint Conflict & Tactical Simulation (JCATS)




Campaign view | City view | Building view | Soldier view


Planning and rehearsal capabilities that extend from the Joint Task Force level to that of individual soldier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# Gesture Interpretation & Environmental Control

Energy efficiency

- Basic research on how people interact with energy technology

Ex: Gesture-sensing Thermostats

-Thermal Confidence Index (TCI)

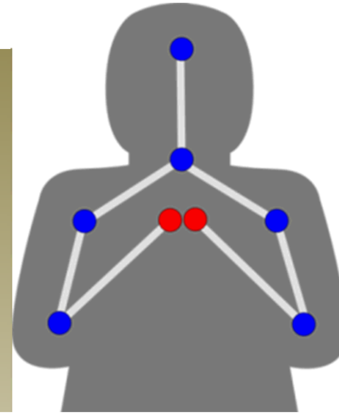
Real-world applications:

- Application of machine-learning (e.g. TCI) to energy technologies

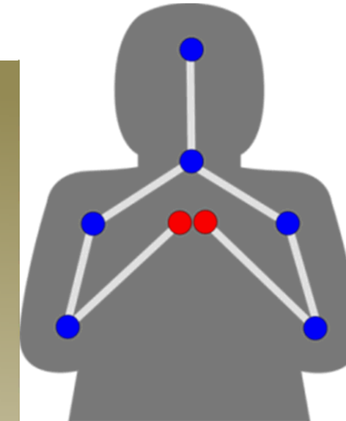
-Nest thermostats (smart thermostats that learn a user's habits)

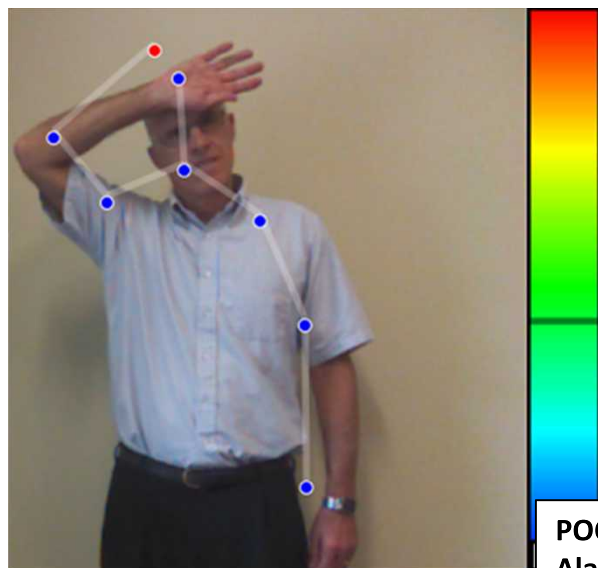
-Goal:

1. Create technologies that make energy saving user-friendly thereby…
2. Encouraging the user to save energy.



Examples from library of outward signs of thermal discomfort to inform machine-based "Thermal Comfort Index"





| time | gesture | conf. | event | TCI |
|---|---|---|---|---|
| 10:30:02 AM | Shirt Tug | 80% | | 8 |
| 10:30:22 AM | Wipe Brow | 80% | | 12 |
| 10:30:24 AM | Button Up | 80% | | 3 |
| 10:30:26 AM | Wipe Brow | 75% | | 10 |
| 10:30:33 AM | Shirt Tug | 80% | | 16 |
| 10:30:35 AM | Wipe Brow | 75% | heat | 23 |

TCI predicts comfort/discomfort with 75%-80% confidence

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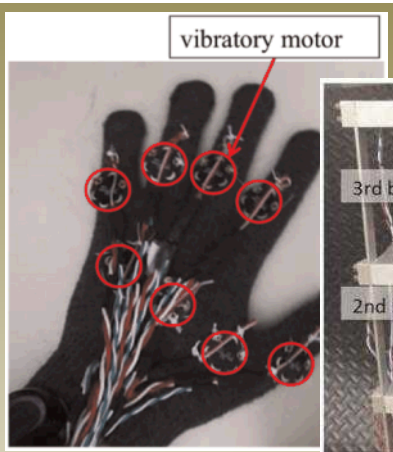
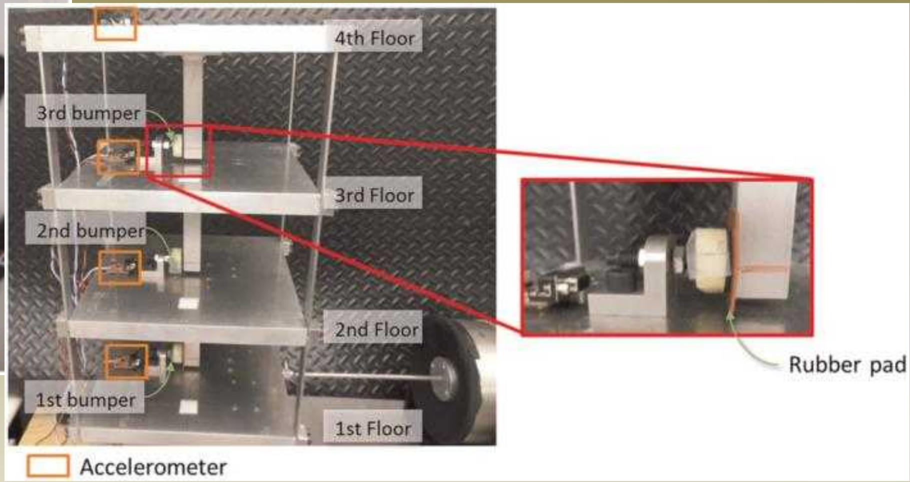
# Turning Data into Sensations

*Engineering Institute of the National Security Education Center*




Experimental 3-story structure with 1 accelerometer per floor




Vibro-haptic gloves

A proof of concept to…

1. Place accelerometers on building floors provide data on harmonic base excitation – maybe an earthquake.
2. Data is preprocessed.
3. Data is then encoded as vibro-tactile stimulus which human subjects feel through a glove.
4. Humans asked to characterize the damage to the structure.

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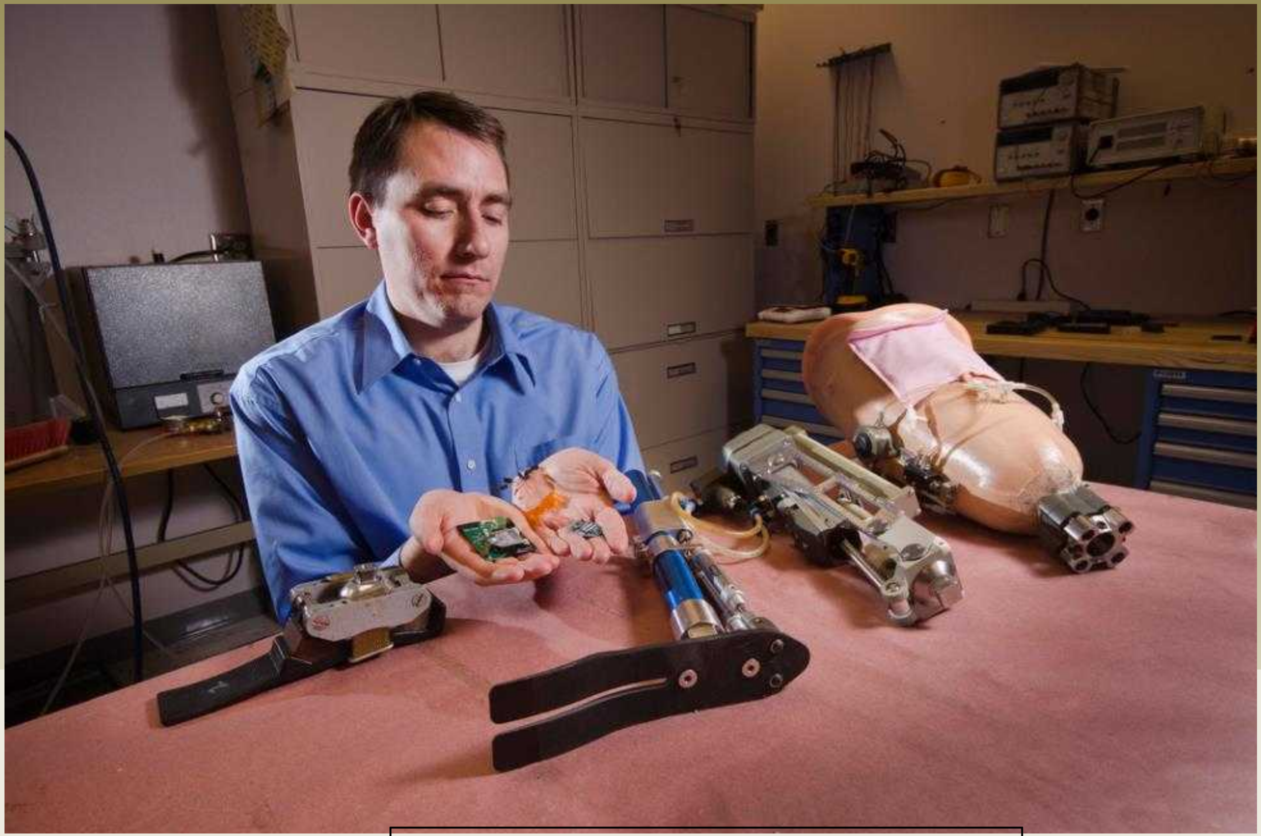
# Implantable and Wearable Neural Interface Electronics

Objective:
- Enhanced neural control of prosthetics for amputees

Proof of concept designed to:
- Match flexible, biocompatible, conductive materials to nerve fibers so they can integrate with nerve bundles.

Example:
- Thin evaporated metal or patterned multi-walled carbon nanotubes



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**Intelligent Systems Controls**
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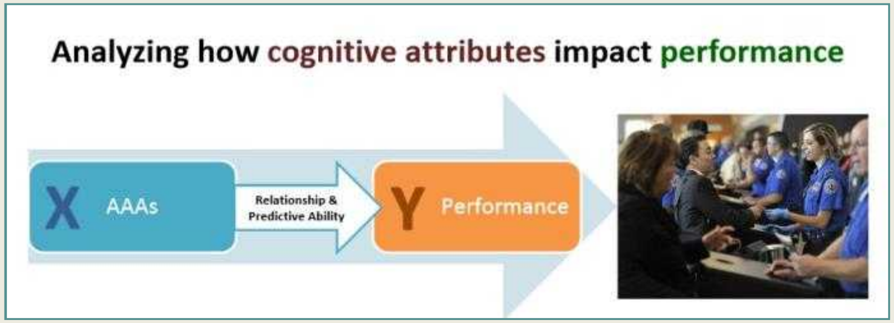
# Human Performance in Threat Detection

Transportation Security Administration (TSA), understanding human decision-making during threat detection by…

- observing officers' behaviors and accuracy
- in representative, non-laboratory samples (e.g. in actual airports, actual TSA officers)

Possible effects on behavior and accuracy: supervisor emphasis (accuracy or throughput), image resolution, officer experience/training, cognitive attributes ….

Cognitive psychologist and TSA research team lead Ann Speed conducts research aimed at quantifying human behaviors.





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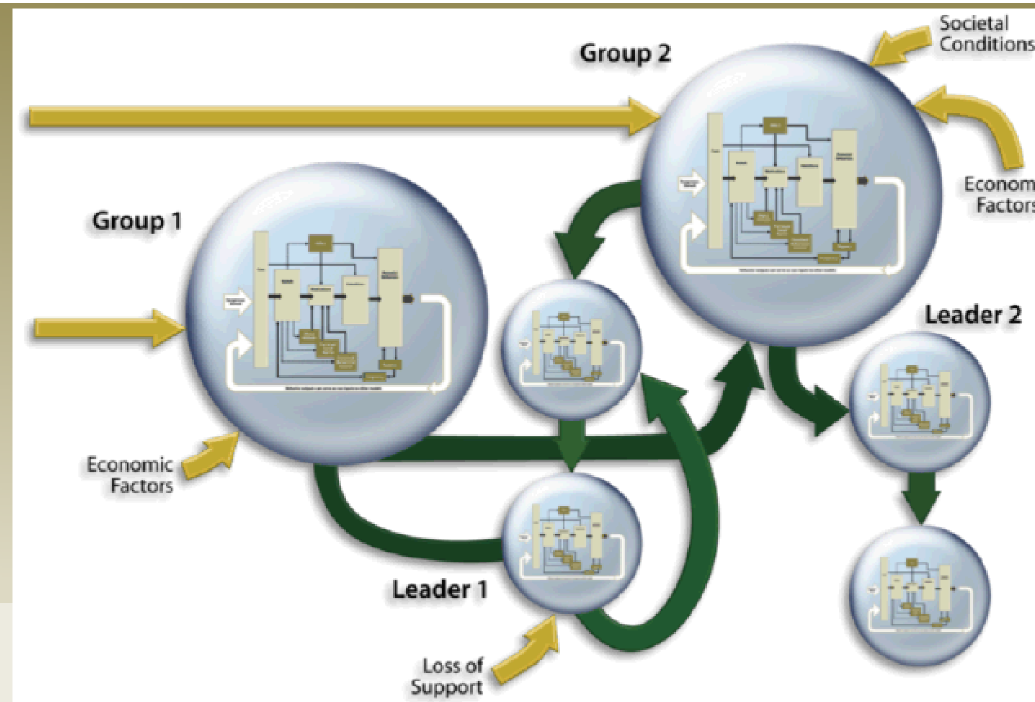
# Decision Calculus

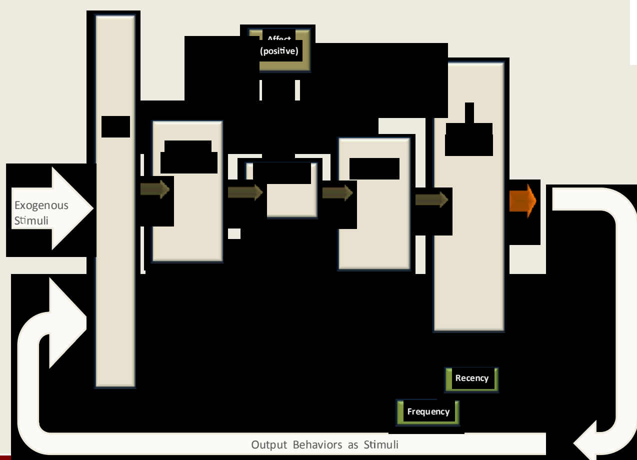
Theory-based framework

Individual and group/organizational decision-making

Informs High Consequence Decisions

- Likely range of outcomes of potential courses of actions or events
- Assess higher-order (cascading) effects
- Track confidence levels
- Transparent

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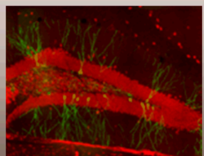
# Neuromorphic computing at SNL leverages a broad research foundation

Sandia National Laboratories

## *Neural Theory*

- **Modeling and Simulation**
- **Computational Neuroscience**
- **Neuro-informatics**



***IARPA MICrONS Government Team for Test & Evaluation of Neural Models and Machine Learning***

## *Neural-enabling hardware*

- **Memory technology**
- **Micro-sensors**
- **Non-von Neumann architectures**

***MESA Fabrication Facility provides materials and design research capabilities for next generation neural systems***

## *Neural Computing Capabilities*

- **Neural Machine Learning Algorithms**
- **Formal Neural Computing Theory**
- **UQ / SA of Neural Algorithms and Neural Architectures**
- **Configurable CMOS Neural Architectures**
- **Adaptive post-CMOS Neural Architectures**


***HAANA Grand Challenge – Flagship LDRD across computing, materials, and cyber security centers***

**<u>Deployable National Security Applications</u>**

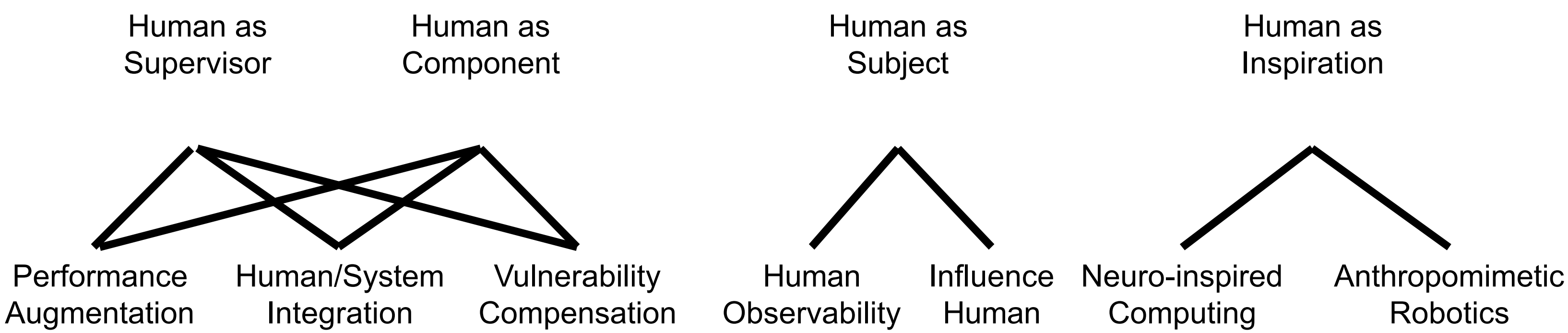
- Cyber Defenses
- Embedded Pattern Recognition Systems
- Smart Sensor Technologies

**<u>Enabling Advanced Scientific and Data-driven Computing</u>**

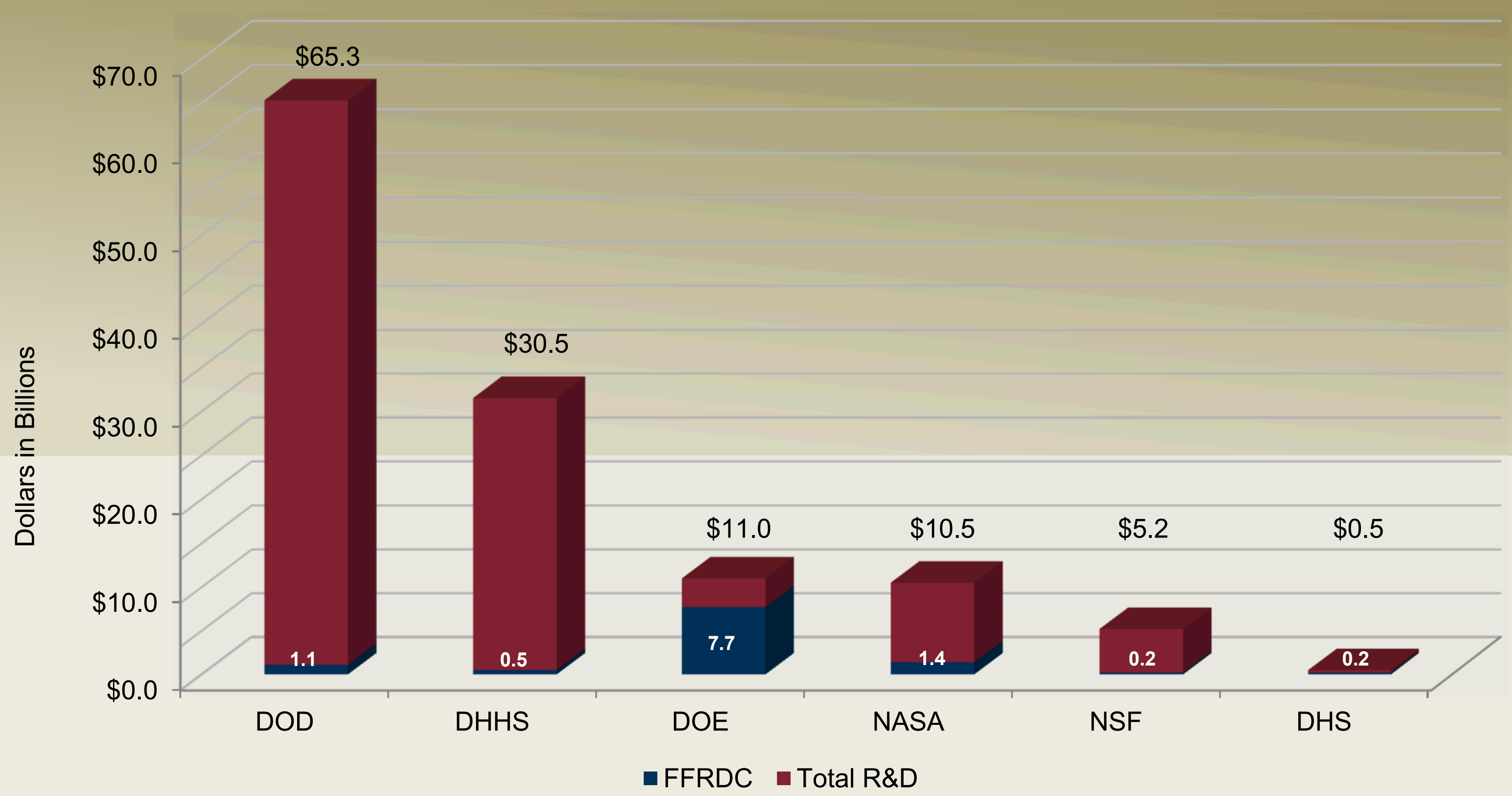
- Neural-inspired communication paradigms
- Adaptive memory management
- Robust machine learning

# Why does the nation need FFRDCs?

- **Comprehensive knowledge of sponsors needs** – mission, culture, expertise and institutional memory regarding issues of enduring concern to the sponsor
- **Adaptability** – ability to respond to emerging needs of their sponsors and anticipate future critical issues
- **Objectivity** – ability to produce thorough, independent analyses to address complex technical and analytical problems
- **Long-term continuity** – uninterrupted, consistent support based on a continuing relationship
- **Broad access to sensitive government and commercial proprietary information** – absence of institutional interests that could lead to misuse of information or cause contractor reluctance to provide such information
- **Quick response capability** – ability to offer short-term assistance to help sponsors meet urgent and high-priority requirements

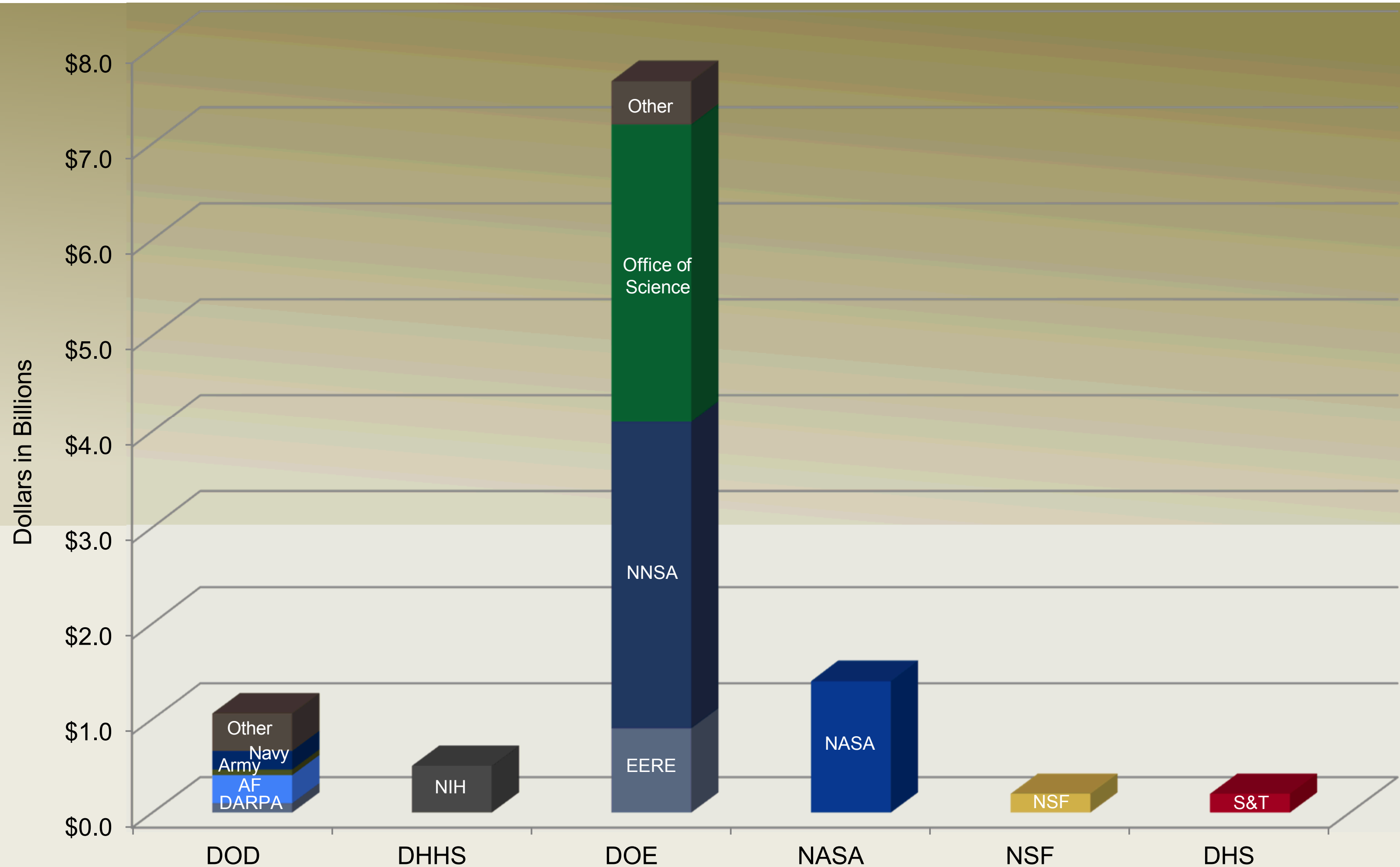

Human as Supervisor
Human as Component
Human as Subject
Human as Inspiration
Performance Augmentation
Human/System Integration
Vulnerability Compensation
Human Observability
Influence Human
Neuro-inspired Computing
Anthropomimetic Robotics

# FY 2015 Federal Obligations for R&D with FFRDC Proportions




Source: National Science Foundation, Federal Funds for Research and Development, http://www.nsf.gov/statistics/2015/nsf15324/#chp1&chp2, Table 4, Table 13

# FY 2015 Federal Obligations for R&D to FFRDCs




Source: National Science Foundation, Federal Funds for Research and Development, http://www.nsf.gov/statistics/2015/nsf15324/#chp1&chp2, Table 13

# What makes FFRDCs unique?

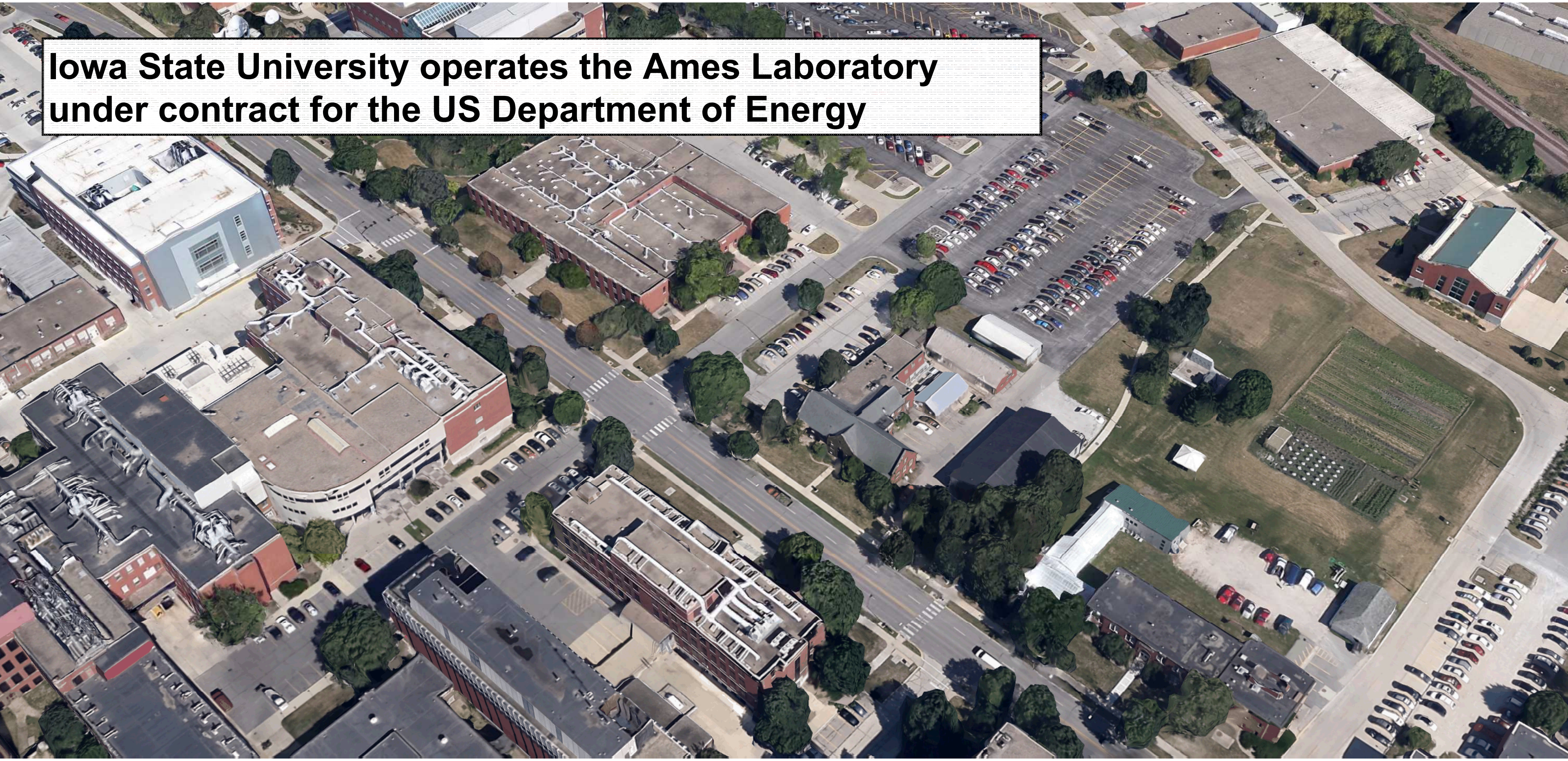
- A **special relationship** between the federal government and an FFRDC which is significantly different in nature than other government contractors
- Meet special **long-term research or development needs** that cannot be met as effectively by existing in-house or contractor resources
- FFRDC contractors have:
  - **Enhanced access** to privileged government **information**
  - Access to government **personnel, facilities**, and other resources
- Long-term relationships between the Government and FFRDCs ensure:
  - Familiarity with the needs of the sponsor(s)
  - Currency in field(s) of expertise
  - Objectivity and independence
  - Continuity to attract high-quality personnel
  - A quick response capability

# FFRDCs have special requirements

Sandia National Laboratories

- All work must be within the FFRDC's purpose, mission, general scope of effort, or special competency
- An FFRDC's sponsor determines if work may be accepted from other than the sponsor and approves all work
- Must conduct its business in a manner befitting its special relationship with the Government:
  - **Operate in the public interest** with objectivity and independence
  - Be **free from organizational conflicts of interest**
  - **Cannot** use privileged information or access to **compete with the private sector**
  - **Fully disclose** its affairs to the sponsoring agency
- Intellectual Property generally remains property of the U.S. Government

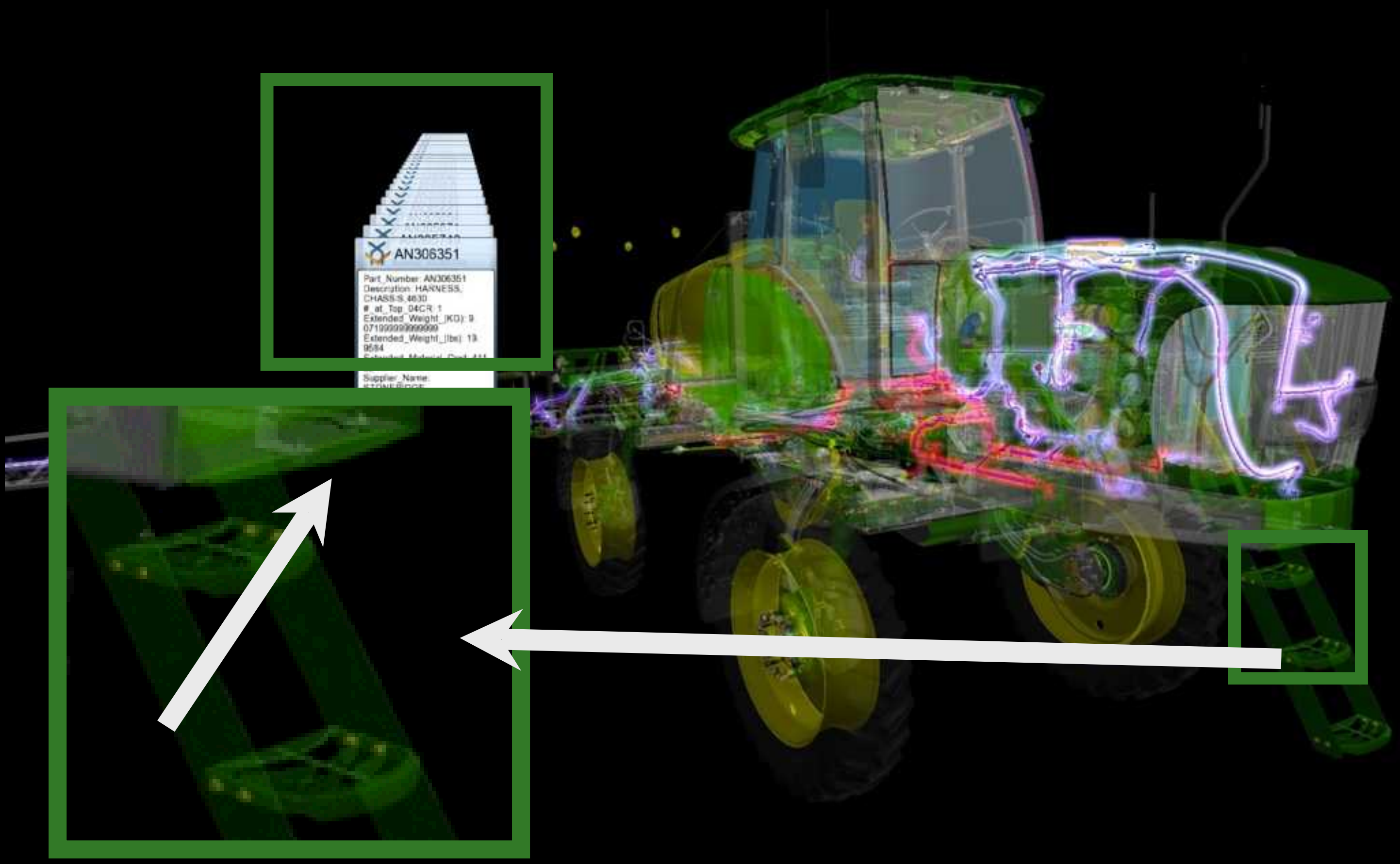
**Iowa State University operates the Ames Laboratory under contract for the US Department of Energy**



Fundamental Research Question

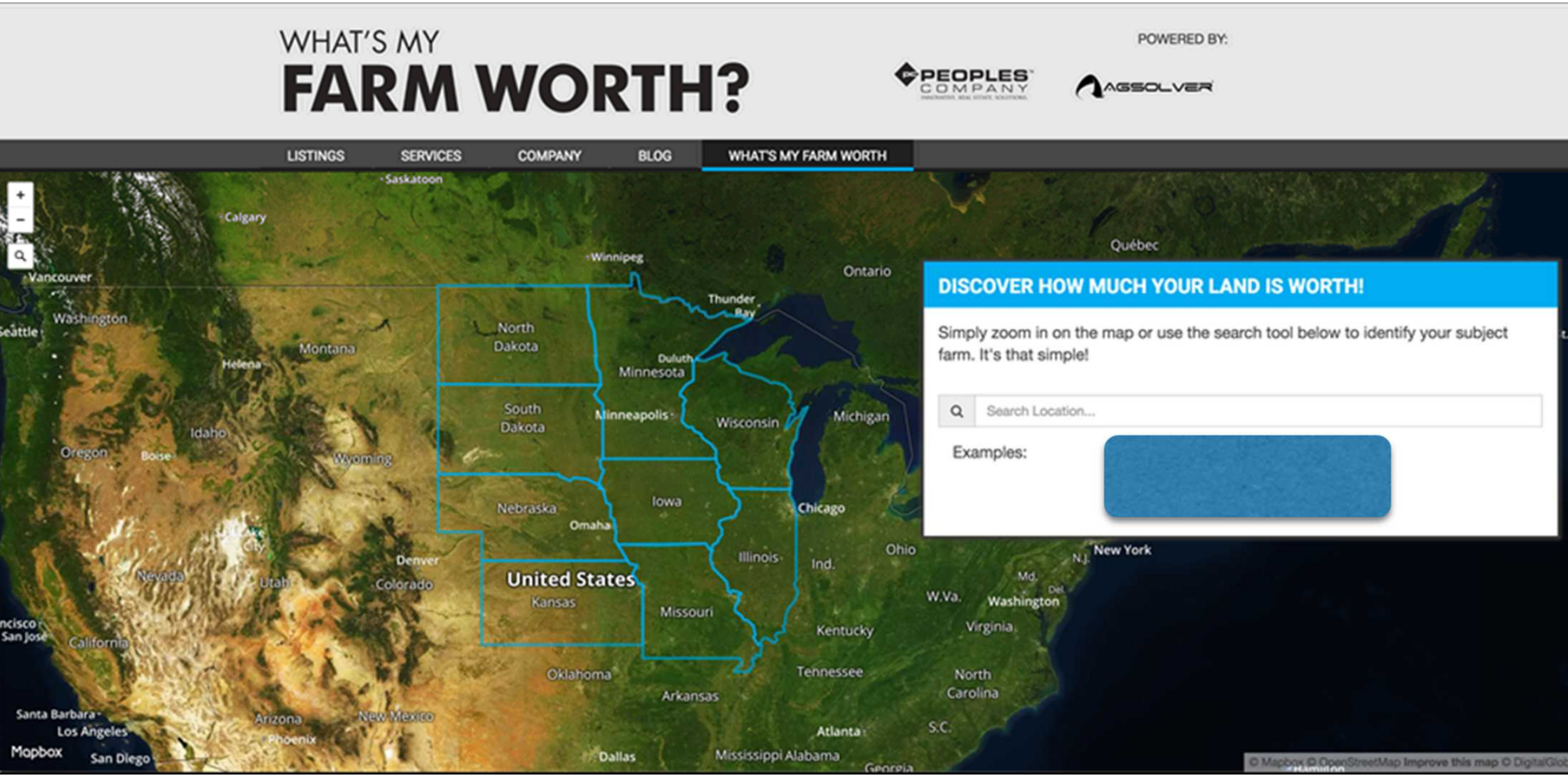
How can we improve decision making and learning in complex systems in which energy, people, and the environment meet?

- How do we readily integrate information together to represent and make decisions about complex systems?
- How can we integrate analytical decision making and natural, user-centered decision making?




# Manufacturing management

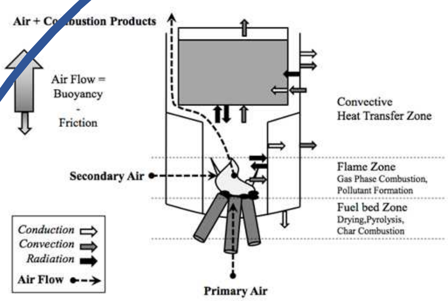
- Paint trainer developed to reduce the cost, time, and waste associated with painting.
- ~50% reduction in cost
- Improved product performance
- VE-Suite “under-the-hood”

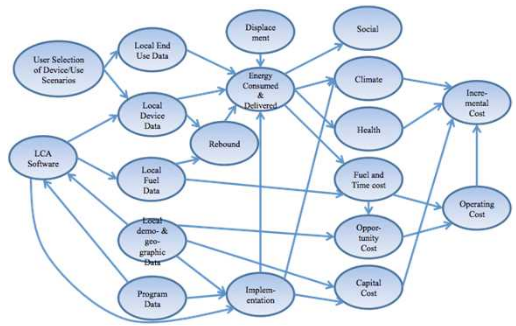


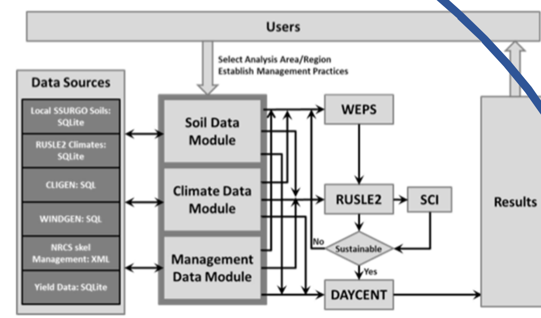

https://peoplescompany.com/whats-my-farm-worth

What's my farm worth?

## Narrative




### Components

- Cookstoves
- Solar hot water
- Lights

\+

### Village Energy Model

- Rebound
- Climate impacts
- User acceptance

\+

### Agronomic Model

- Erosion
- Fertility
- Crop yield

# Systems level design

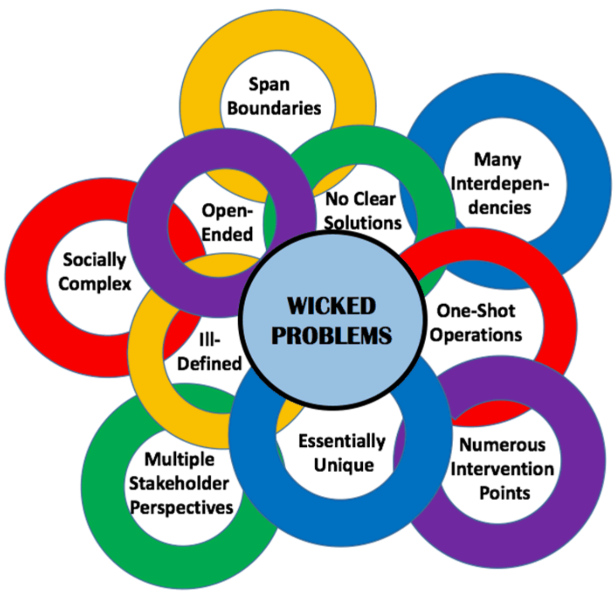
- How can we improve decision making and learning in complex systems in which energy, people, and the environment meet?

- How do we readily integrate information together to represent and make decisions about complex systems?

- How can we integrate analytical decision making and natural, user-centered decision making?

# WHAT IS A WICKED PROBLEM?

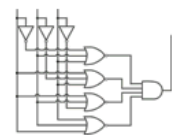
- The term “wicked problem” was first used by Horst W.J. Rittel and Melvin M. Webber[1] as a way to describe and characterize social planning problems that are open-ended, contradictory, and have many stakeholders.
- Also called “tangled problems” or “messy problems”




Rittel, H.J., Webber, M., 1973. Dilemmas in a general theory of planning. Policy Sciences 4, 155-169.

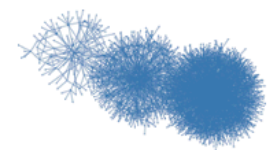
## COMPLICATED VS WICKED PROBLEM?

- “Complicated (Tame) Problems



- Originate from isolated causes that are clearly identifiable and fall within distinct bureaucratic categories
- Can be dissected into isolated chunks addressed, and pieced back together;
- Consequences are generally proportionate to their causes (for every input, there is a proportionate output);
- Fixtures can be put in place for permanent solutions.

- Complex (Wicked) Problems



- Result from concurrent interactions among multiple systems of events, and they erode the customary boundaries that differentiate bureaucratic concepts and missions;
- Cannot be broken apart and solved piece-by-piece. They must be understood and addressed as a system;
- Do not automatically stabilize, but intrinsically unravel into chaos if not systemically managed;
- Cannot be permanently solved. Instead, they morph into new problems as the result of interventions to deal with them.”

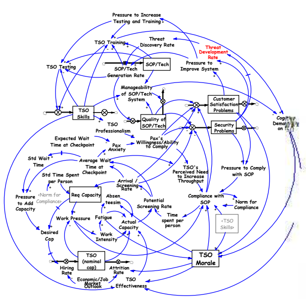
Fuerth and Faber, 2012

# HARD AND SOFT SYSTEMS THINKING

## Hard Systems (Quantitative)

- Deterministic and mechanistic
- Assumes problems are well-defined and clearly bounded
- Reliant of the judgment of “experts”
- Scientific approach to problem-solving
- Seeks to find the optimal solution

$$y' + P(x)y = Q(x)y^n$$



**<u>Example Hard System Approaches:</u>**

- **System dynamics**
- **Systems analysis**
- **Systems engineering**
- **Physical infrastructure models**
- **Environmental models**

**HISTORICAL DIVIDE**

## Soft Systems (Qualitative)

- Philosophical foundation is *Interpretivism* as opposed to *functionalism* (*positivism*)
- Holistic and human factors are important
- Explores the system boundaries (inclusion and exclusion)
- Models as ‘transitional objects’ for use in structuring complex problems
- Sophisticated in its understandings of power and how to address it through intervention

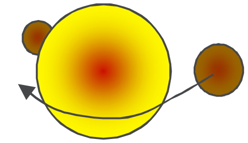
**<u>Example Soft Systems Appraoches:</u>**

- **Participatory Problem Structuring**
- **Critical Systems Thinking**
- **Distinctions, Systems, Relationships and Perceptions (DSRP)**
- **Second Order Cybernetics**
- **Anticipatory Systems**
- **Systemic Intervention**

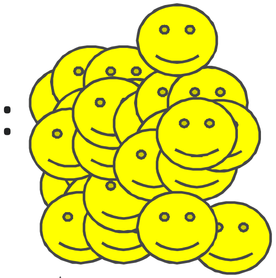
# THE PROBLEMS FACED BY THOSE SEEKING INFRASTRUCTURE RESILIENCE ARE COMPLEX

- Human decisions are often the lynchpin
- Many analytic methods have been proposed to study the aspects of human decision-making relevant for infrastructure resilience
- According to INFORMS, analytics is ”the scientific process of transforming data into insight for making better decisions”
- Major analytics categories identified by INFORMS include:
  - Simulation
  - Optimization
  - Probability and statistics

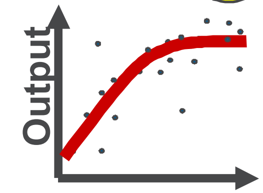
# SELECTED ANALYTICAL METHODS (1 OF 2)



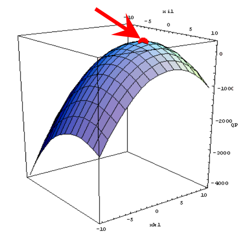
- Analytical modeling develops provable statements:
  + Produces proofs
  - "Heroic" assumptions required



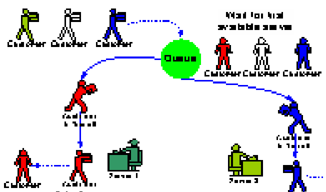
- Agent-based modeling works bottom-up using local rules:
  *Simulation*
  + Ties micro to macro and back again
  - Many details needed




- Statistical modeling finds how outputs depend on inputs:
  *Probability and Statistics*
  + Bounded uncertainty
  - Produces black boxes



- Optimization modeling finds mathematically minimize or maximal solutions:
  *Optimization*
  + "Best" solutions are found
  - "Best" is often ambiguous



- Discrete Event Simulation uses top-down system rules:
  *Simulation*
  + Can model many situations
  - Top-down orientation

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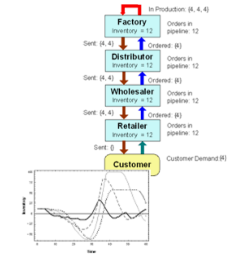
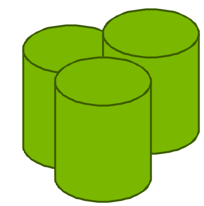
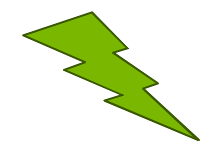
# SELECTED ANALYTICAL METHODS (2 OF 2)



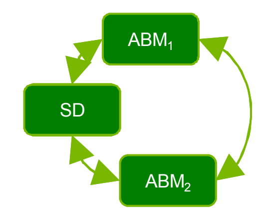

- System Dynamics uses differential equations:
  *Simulation*
  \+ Simple system-level specifications
  \- Limited individual variation



- Big Data uses large amounts of information to overwhelm variations in data:
  *Probability and Statistics*
  \+ Straightforward approach that can leverage existing datasets
  \- Limited ability to deal with completely novel behaviors



- Machine learning uses automated algorithms to extract models from data
  *Probability and Statistics*
  \+ Potential to automatically discover complex patterns
  \- Limited ability to verify what was actually learned




- Hybrid modeling combines two or more methods:
  *Various*
  \+ Flexible
  \- Must carefully consider model compatibility requirements

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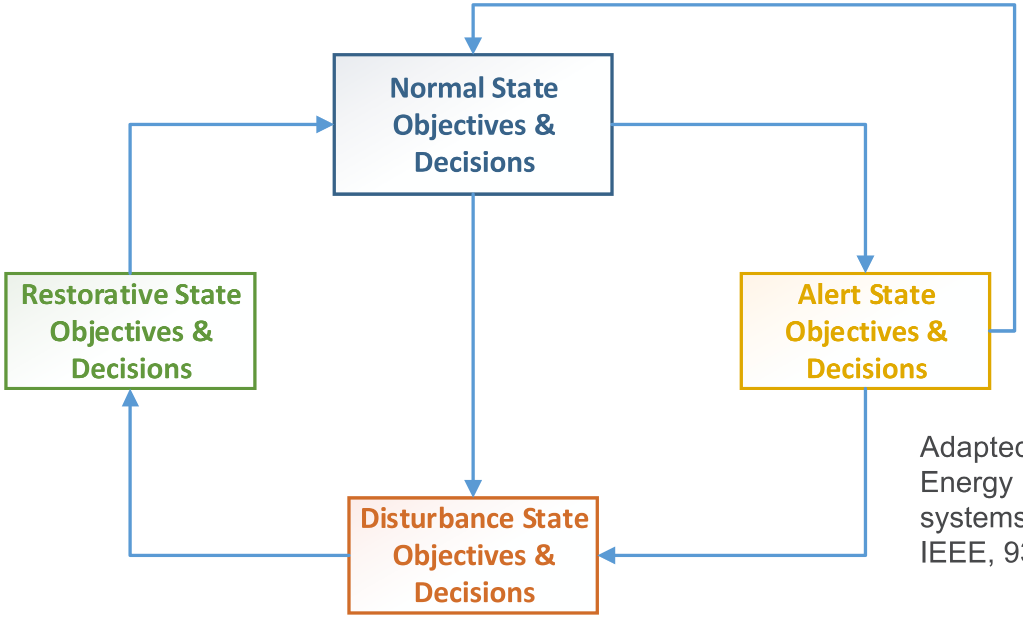
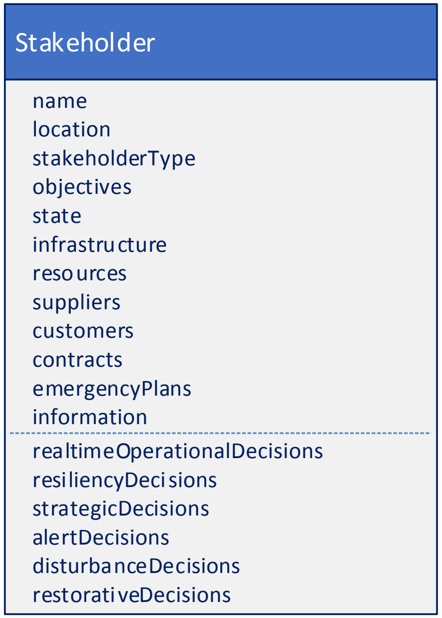
# WHAT AFFECTS DECISION MAKING BEHAVIORS?

- Stakeholders' **objectives** drive their **decisions**
- Stakeholders' objectives depend on their circumstances or "**state**" at the point of decision
  - ***Normal state:*** planning, operations & investment decisions and actions
    - **Real-time decisions** [e.g., deliver services to meet variable demand while maintaining reliability and cost control]
    - **Resiliency decisions** [e.g., improve adaptive, adsorptive & recoverability capacity]
    - **Strategic decisions** [e.g., adapt to technological, climate, demographics, and economic change]
  - ***Alert state:*** decisions and actions to prepare for potential disturbance
  - ***Disturbance state:*** decisions and actions to stabilize operations and minimize cascading impacts
  - ***Restorative state:*** decisions and actions to restore disrupted systems

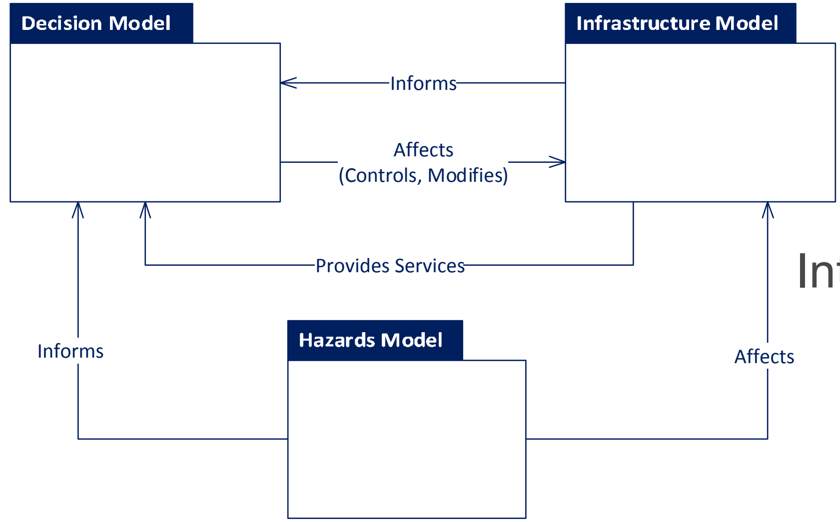



Adapted from: Amin, M. (2005). Energy infrastructure defense systems. Proceedings of the IEEE, 93(5), 861-875.

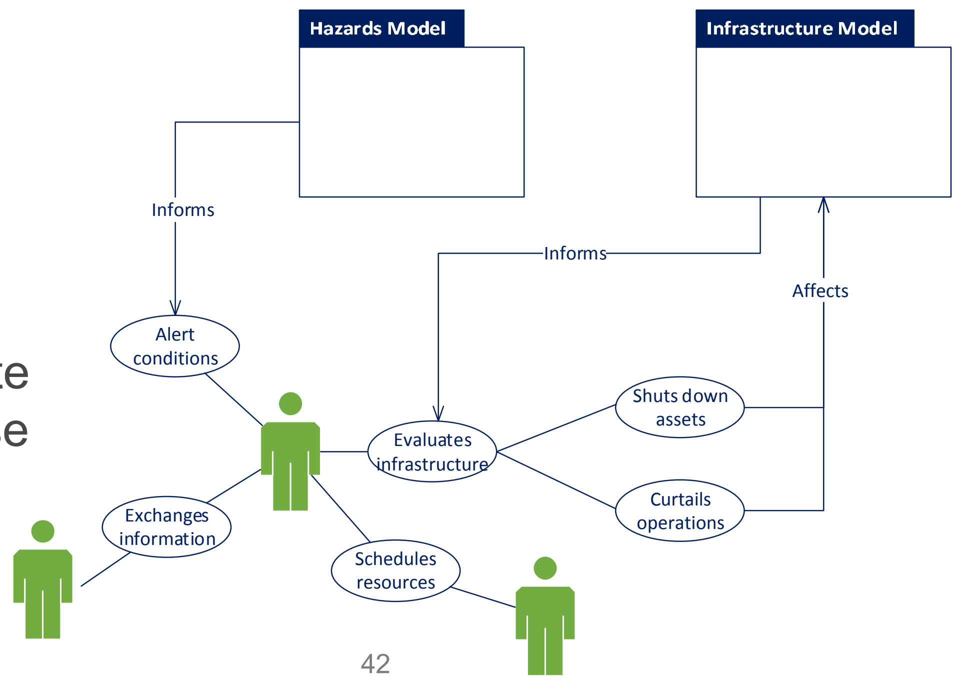
# DECISION BEHAVIOR MODELING




Agent Design



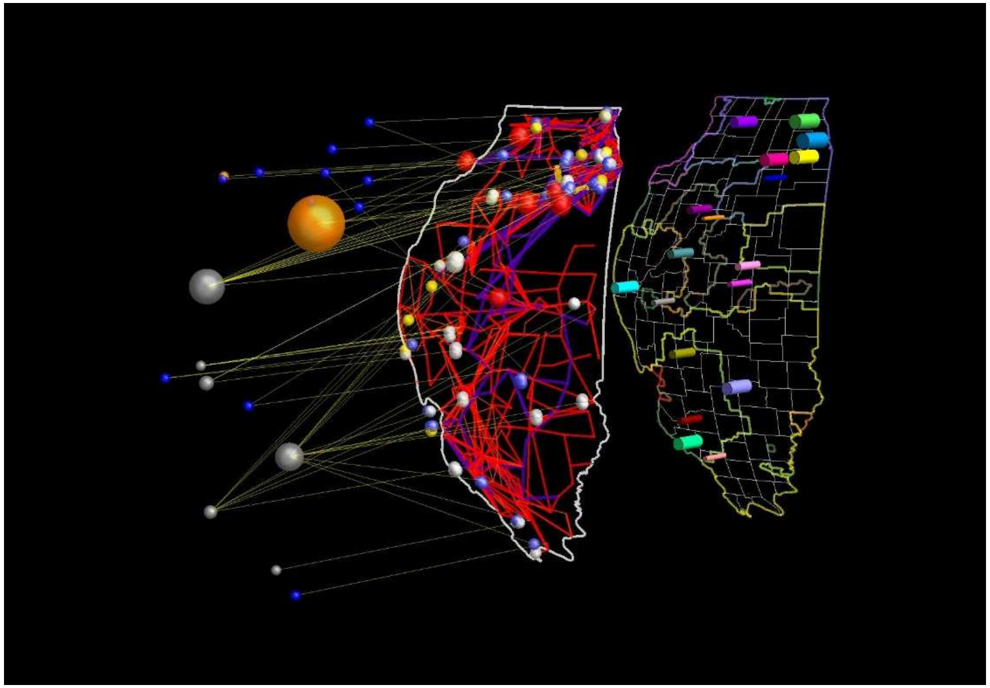

Interdependent Models




Alert State Use Case

# INFRASTRUCTURE DECISION MODELING – EXAMPLE:
## ELECTRICITY MARKET COMPLEX ADAPTIVE SYSTEMS (EMCAS)

- Decentralized generation companies and ownership relationships [left]
  - Attributes (e.g., power plants owned)
  - Objectives (e.g., maximize net revenues)
  - Behaviors (e.g., submit risk adjusted bids to day ahead markets)
- Electric generators and transmission network [center]
  - Physical infrastructure (DC flow model)
- Service area loads, consumers [right]
  - Attributes (e.g., nominal hourly loads)
  - Objectives (e.g., satisfy power needs)
  - Behaviors (e.g., establish price dependent loads)



Veselka, T., Boyd, G., Conzelmann, G., Koritarov, V., Macal, C., North, M., Schoepfle, B. and Thimmapuram, P., 2002. Simulating the behavior of electricity markets with an agent-based methodology: the Electric Market Complex Adaptive Systems (EMCAS) model. *Vancouver, Canada*.

Behavioral Influence Assessment (BIA)

DYMATICA

Dynamic Multi-scale Assessment Tool for Integrated Cognitive-behavioral Actions

Sandia National Laboratories

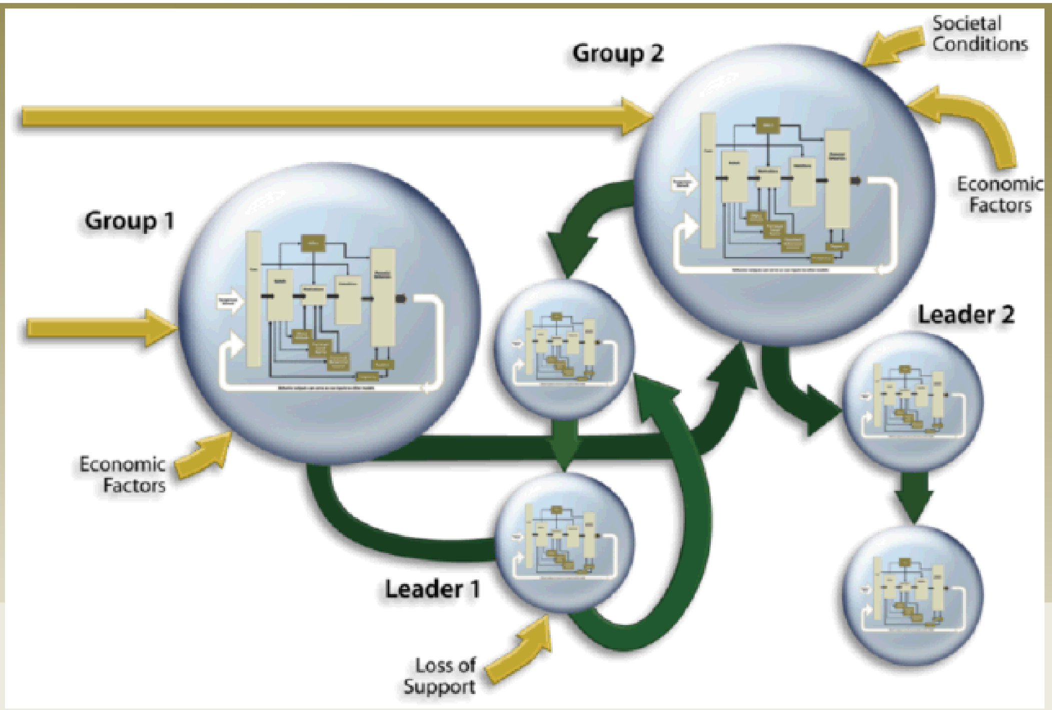
# Decision Calculus

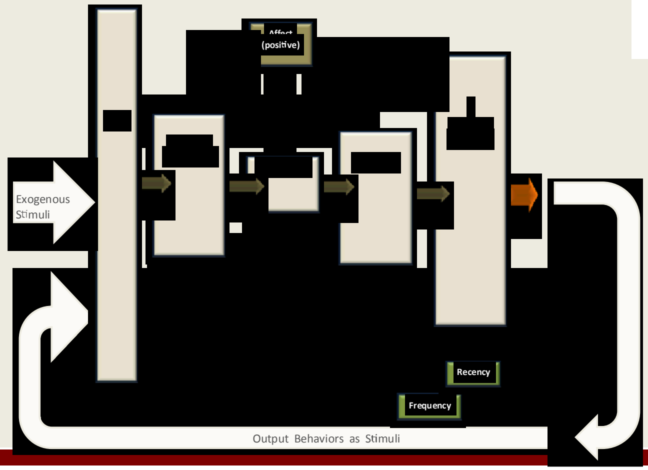
Theory-based framework

Individual and group/organizational decision-making

Informs High Consequence Decisions

- Likely range of outcomes of potential courses of actions or events
- Assess higher-order (cascading) effects
- Track confidence levels
- Transparent





**POC**
**Mike Bernard**
**Cognitive Science & Systems**
**Sandia National Laboratories**
mlberna@sandia.gov

# What is the HSSL?

Human Systems Simulation Laboratory

*a reconfigurable,*

*full-scale,*

*full-scope*

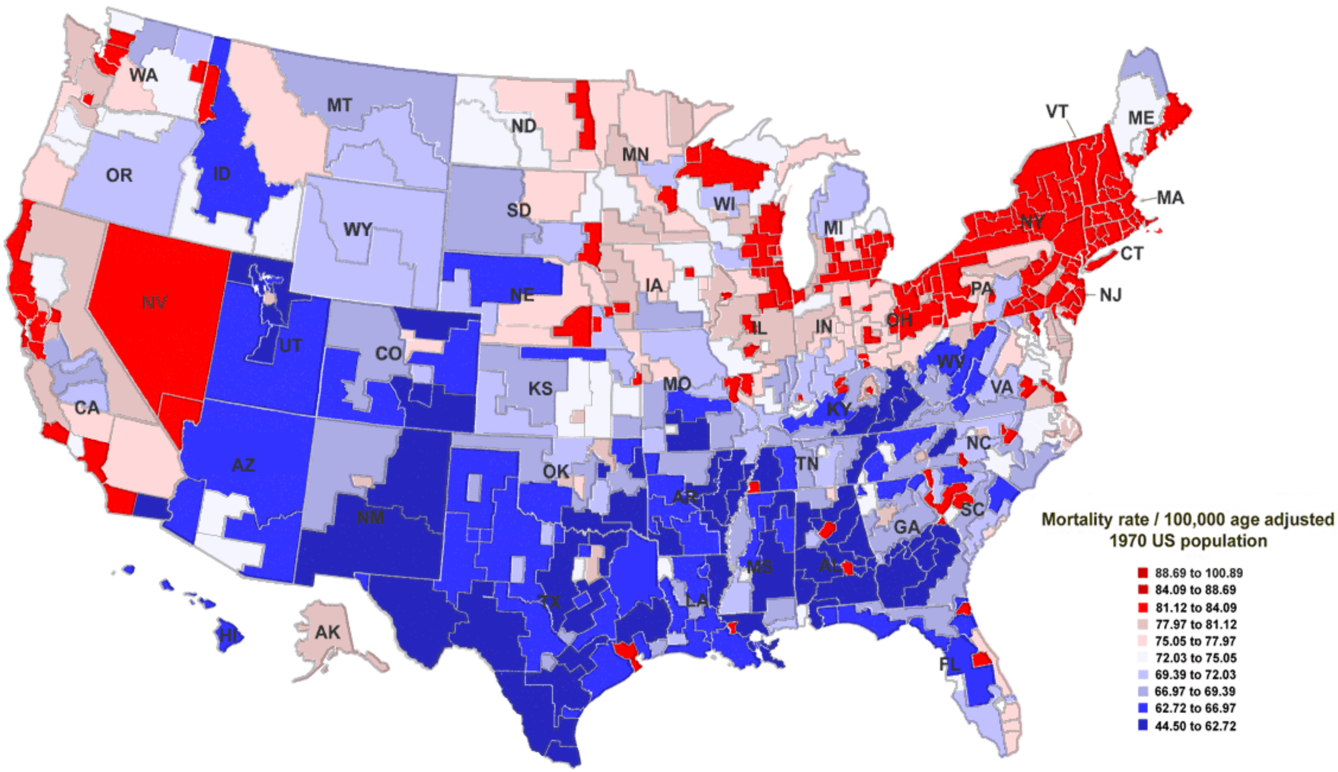
*research simulator*

# adapted nureg-0711 process

| Planning and Analysis | Design | Verification and Validation | Implementation and Operation |
| --- | --- | --- | --- |
| HFE Program Management | New Control Panel Layout* | Human Factors Verification and Validation | Design Implementation |
| Operating Experience Review | Human-Machine Interface Style Guide* | Summative Benchmark Evaluation* | Human Performance Monitoring |
| Baseline Usability Evaluation* | Human-System Interface Design | | |
| Baseline Ergonomic Assessment* | Formative Evaluation* | | |
| Staffing & Qualification | Training Program Development | | |
| Treatment of Important Human Actions | | | |

***Steps we've added to the regulatory guidance to assist plants in completing upgrades within the same framework.**

# Case Study: US Cancer Mortality Trends (2008-2012)



Oak Ridge National Laboratory

# Data Source: Obituaries


Websites (e.g. online US newspapers)

Web Crawler

Parser

- Age
- Gender
- Cause of Death

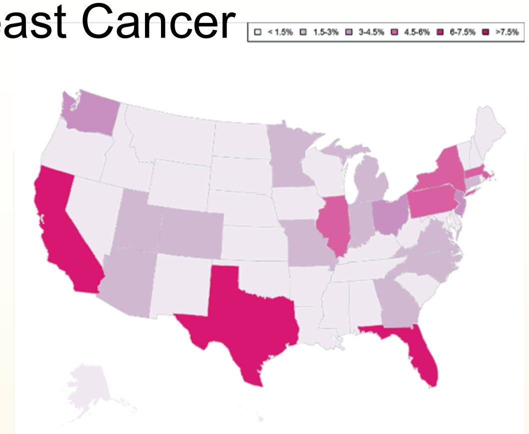
Oak Ridge National Laboratory

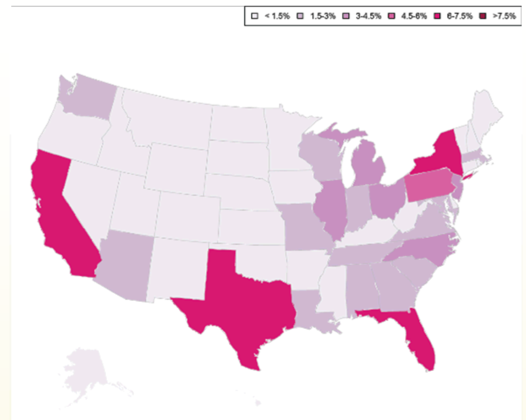
# Distribution of Cancer Deaths by State

Breast Cancer

Correlation: 0.939

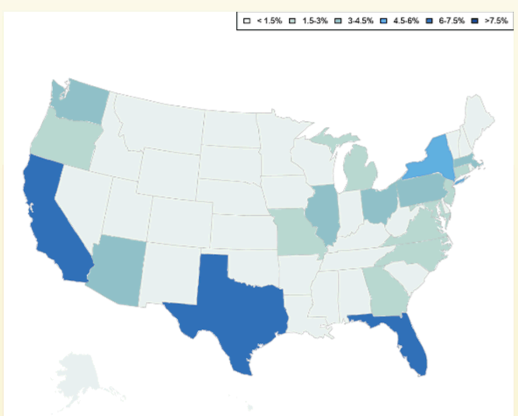
## Breast Cancer

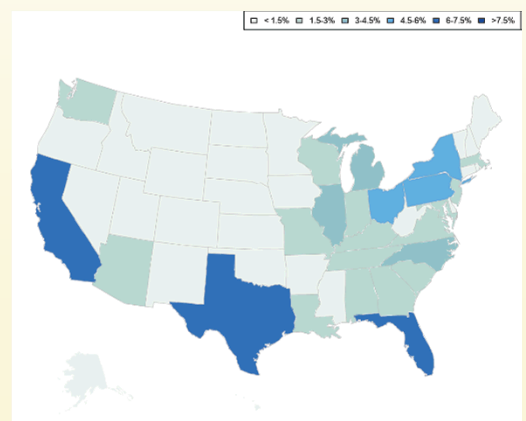



## Lung Cancer

Correlation: 0.881



# Summary

- Web mining is a cost-effective way for epidemiological knowledge discovery
- Well suited as a hypotheses generator
- Monitoring trends in a dynamic way by continuously parsing and analyzing new online content

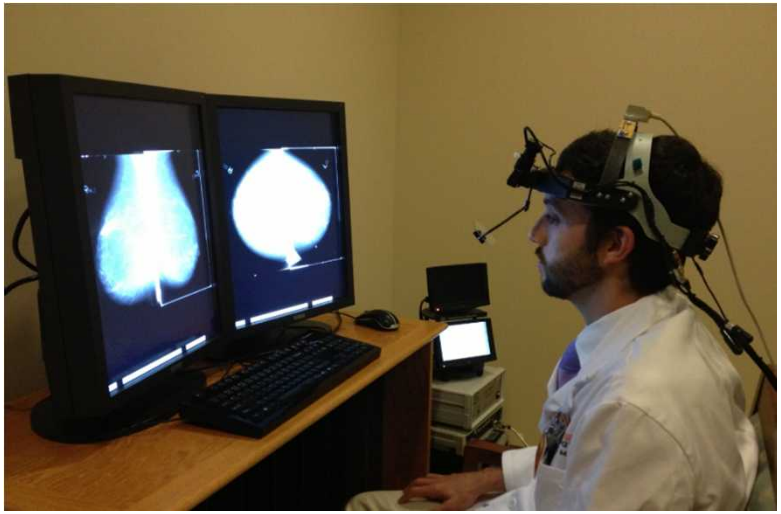
# Application: Breast Cancer Screening

## Proposed Solution: User-driven adaptive decision support

- First, we determine radiologists' user-specific behavior
  - Leverage eye-tracking and user modeling to characterize individual perceptual and cognitive behavior
- Secondly, we apply machine learning techniques to develop predictive models
  - Provide real-time user support through guided interpretation
  - Predict human error on a per case basis
  - Adaptive fatigue/workload modulation to improve performance
- Finally, leverage data for training and feedback
  - Leverage aggregate data from expert behavior for resident training
  - Data-driven user-specific training or feedback

# Experiments

- Experimental data collected under clinically conditions
  - 10 users with varying experience levels
  - 100 digitized screen-film mammograms
  - Readers diagnostic decision including markings, and BIRADS rating
- Hardware
  - Dual-head 5MP mammo-grade Totoku LCD monitor calibrated using DICOM display standards
  - Applied Science Laboratory (ASL) H6 head-mounted eye tracker



Radiology resident during experimental protocol

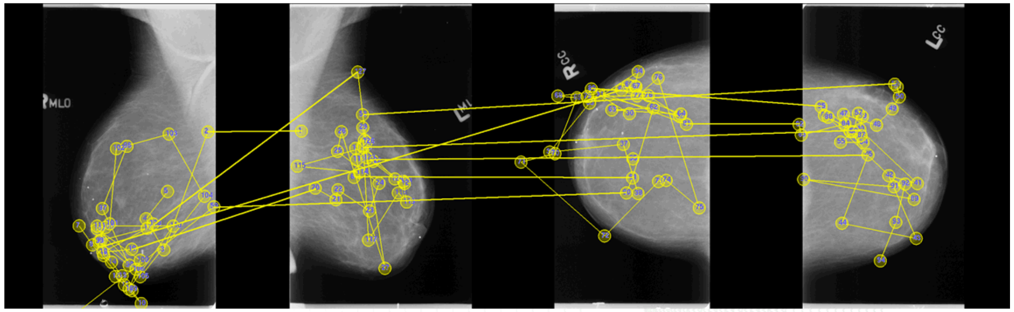


Illustration of 4-view mammogram with gaze data overlay

# Sustainable Systems and Social Sciences Group at a glance

*…achieving resilience across social, economic, environmental, & technical systems*

We are multidisciplinary

- Agricultural engineering
- Anthropology
- Ecology
- Economics, equity, & ethics
- Geography
- Planning & policy analysis

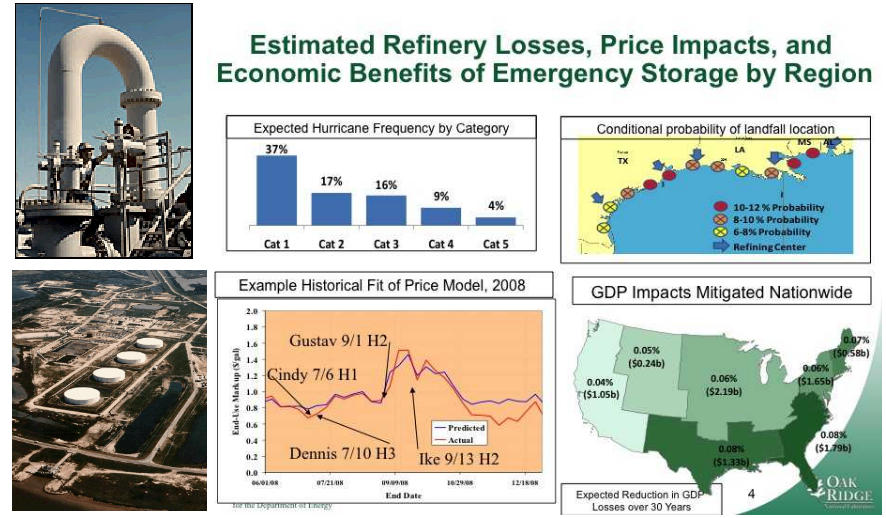
# Bioenergy Resources & Engineering Systems

*Economic & engineering analysis of biomass feedstock resources, logistics, and impacts to advance national goals*



# Energy Analysis

*Economic systems-analysis of energy markets, seeking efficient policies to advance societal benefits & energy security*



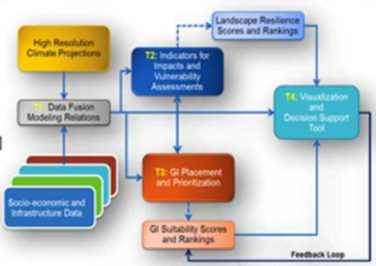

URBAN DYNAMICS INSTITUTE
OAK RIDGE NATIONAL LABORATORY

URBAN CLIMATE ADAPTATION TOOL

## ORNL Urban-CAT

**Urban Climate Adaptation Tool**

- **Issue:** Mid-size cities house ~50% of urban dwellers and typically lack the resources to address climate-related vulnerabilities.
- **Goal:** Help Cities decide where to place green infrastructure (GI) to best alleviate urban flooding and costly storm water management under different climate and population growth scenarios. Develop tool prototype with City of Knoxville decision makers to increase urban resilience.





PI contacts:
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Esther Parish, ESD (parishes@ornl.gov)

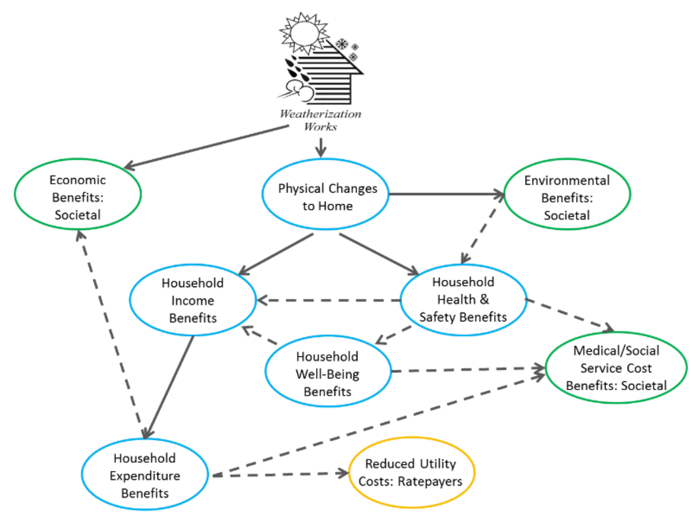




**Figure 3.3. Framework for Understanding Non-Energy Benefits**

# Landscape Ecology & Regional Analysis

*Multi-faceted analysis of ecological interactions, focusing on spatial patterns & processes to inform decision-making*

# Society-Technology Interactions

*Social & institutional analyses to anticipate, plan, manage, & understand energy & technology programs & policies*

# Understanding and affecting behavior in organizations— “imperatives” & behaviors vary; interventions are *not* obvious

## BEHAVIORAL ENERGY OPERATIONS DEMONSTRATION (BEYOND)

**Imperative**

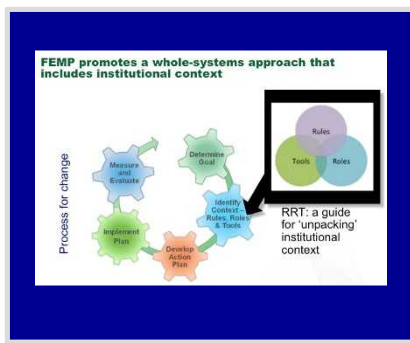
- Extending days before re-supply improves mission capabilities, reduces casualties

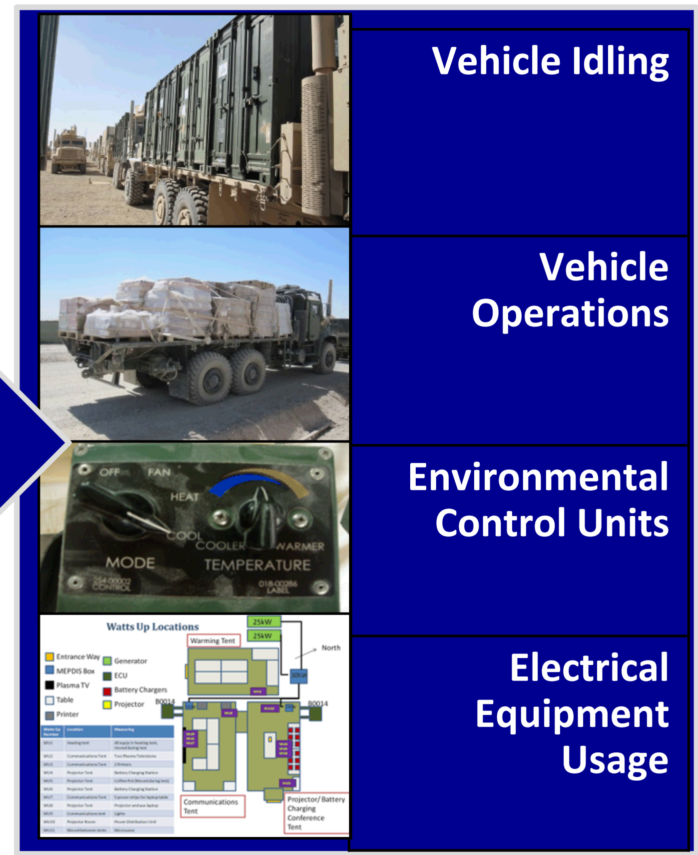
**Goal**

- Reduce ground-based fuel use by 10% through behavior change

**OBSERVATIONS + INTERVIEWS**

- Combination of methods essential
- Linked systems, typically NOT “wasted” fuel
- Fuel sometimes mattered, but not highest priority, not basis for behavior




Sponsor: Naval Surface Warfare Center, Carderock Division, tasked by Assistant Secretary of Defense, Environment, Installations, and Energy

Team: NSWCCD: E. Shields, S. Sadlier; ORNL team: A. Wolfe, E. Rose, J. Reed; Many others

# Enabling Situation Assessment/ Awareness for Utility Operators and Cybersecurity Professionals

Mark Rice[1], Jean Scholtz[1], Lyndsey Franklin[1], Katya Le blanc[2]

Pacific Northwest National Laboratory[1], Idaho National Laboratory[2]

# Bulk Electric System Control Rooms



Photo Credit: Jodi Heintz Obradovich

# Laboratory Capabilities

- User Experience Group
  - Work on visual analytics of large heterogeneous data

- Scalable Reasoning System
  - Used in power grid for Shared Perspective Project

- Electricity Infrastructure Operations Center
  - Representative Control Room

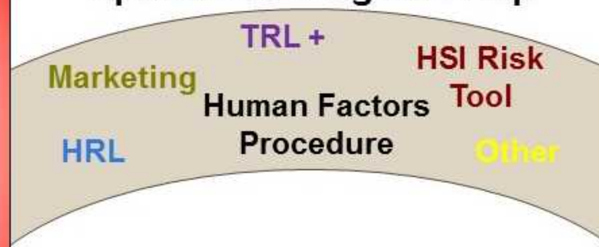
# Possible Options for Sandia

## Plan for the Human Element throughout Lifecycle

**Current Sandia**

- Reactive and ad hoc
- Minimal or no requirements
- Low recognition of HSI
- Varied application of human factors principles
- Successful HSI is the exception

**Options to Bridge the Gap**




**Future Sandia**

- Proactive and planned
- Robust requirements
- High recognition of HSI
- Systematic and broad application of human factors early and often
- Successful HSI is the norm

| Option | Description |
| --- | --- |
| TRL+ | Redefine “technology maturity” in existing TRL scale to include maturity for human use and add considerations relevant to maturity for human use to existing TRL exit criteria |
| HRL | Add separate HRL scale to supplement existing TRL scale during design |
| HSI Risk Tool | Add tool to characterize HSI risks, consequences, and mitigations early in design |
| Human Factors Procedure | Develop procedure to incorporate human component during product realization; add references to the human factors procedure in existing product realization procedures |
| Marketing | Plan and launch a campaign to market Sandia Human Factors Department |
| Other | Identify alternative approaches through staff and manager discussions |

*Exceptional service in the national interest*

Sandia National Laboratories

August 18, 2016

# WEARABLES AT THE CANYON FOR HEALTH (WATCH)

"Real Time Data Collection Through Wearable Devices to Quantify Attributes Related to Health and Performance in Extreme Environments"

Presenter: Victoria Newton

PI: Glory Emmanuel Aviña, PM: Catherine Branda

Sandia National Laboratories-NM & CA

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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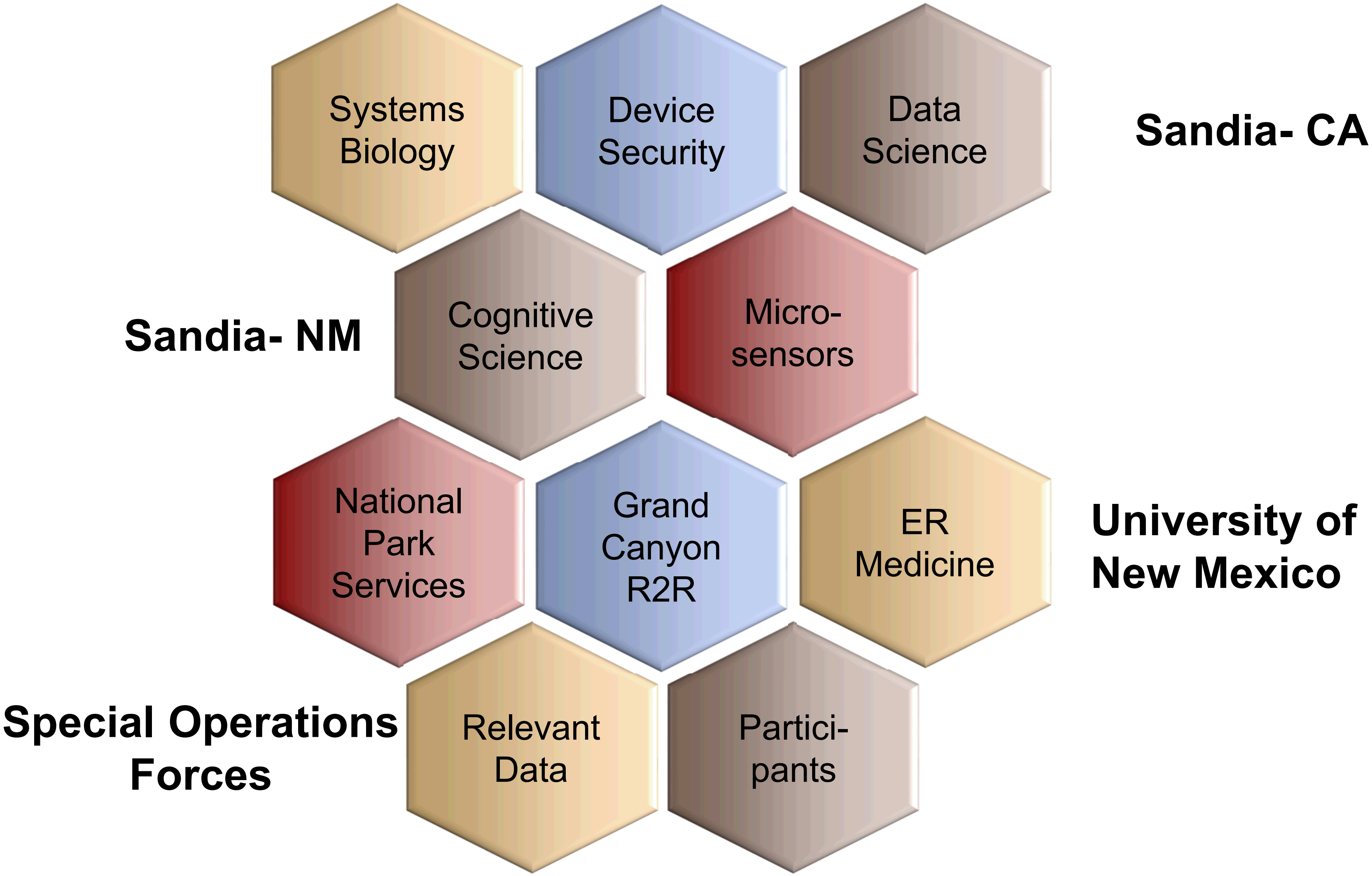
# Purpose of this Study

1) **Markers for Health:**
   identify physiological, cognitive markers most related to health and task performance

2) **Data Processing:**
   determine key methodologies for data processing from GOTS/COTS devices

3) **BSVE Integration:**
   integrate data into the Biosurveillance Ecosystem (BSVE)

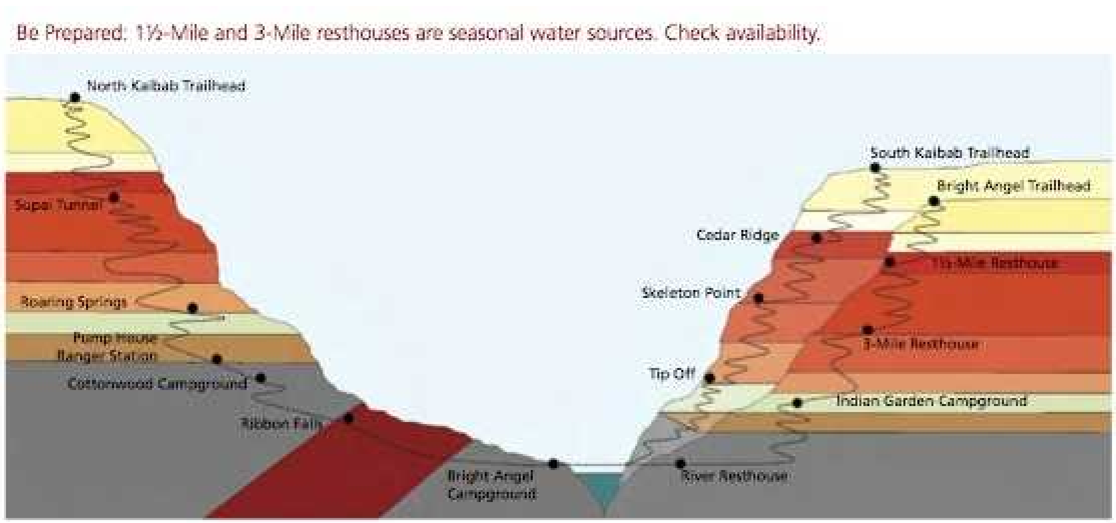
# Interdisciplinary Approach



# Grand Canyon Rim-2-Rim Hike

- Altitude and Temperature Change
- Extreme Environment
- Physical Strain
- 14.3 miles, 6,000 feet to the bottom
- 9.6 miles, 4,500 feet back to the South Rim


Figure 1. Signage at Bright Angel Trailhead, October 2015.




Source: https://www.nps.gov/grca/index.htm

# To Err is Human: Grid Automation and Operator Performance

Laurie Burnham,

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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# Human Dimension Is Essential to Grid Modernization


- Grid architecture is rapid transforming: smarter and more decentralized

- This transformation to a “smart grid” is enabled by advanced automation, some of which—e.g., FLISR software, supports self-healing

- But the grid will remain a human-in-the-loop critical infrastructure for the foreseeable future

# "Improving Grid Resilience (through) Informed Decision-making," or IGRID Project

Pilot Study with Three Objectives:

1) Identify causal relationships between automation (FLISR) and grid operator performance;
2) Develop measures of human performance as a function of automation; and
3) Instantiate the impact of 1) and 2) on grid performance through the development of a cause-effect model