Group Collaboration Technology Development

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Sandia National Laboratories

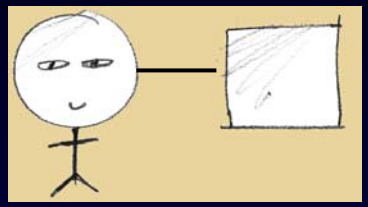
Sandia's Interest: National and Global Security

We must improve the performance of people in situations with

- High cognitive loads and high consequence decisions
- High stress and time-critical operations
- Unpredictable, ambiguous, and non-recurring environments
- Challenges for realistic training
- Multiple people and machines

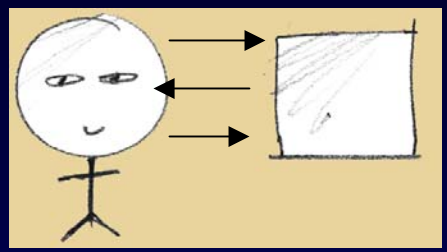
Examples: security operations centers, long-duration duty crews, team training simulators, crisis operations teams

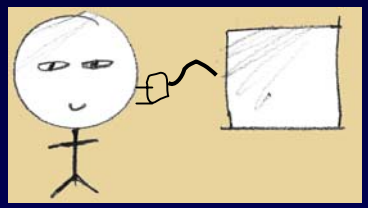
Brain/Machine Collaboration



Today we kluge two complex systems together with an interface

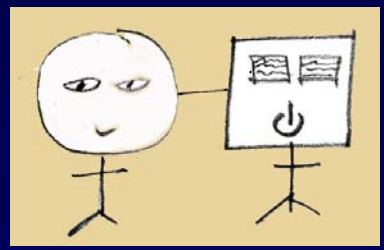
We improve interfaces





We make the person a part of the machine

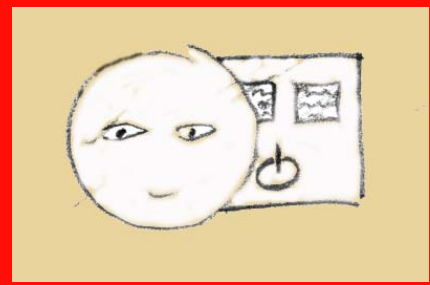
?



We make machines that mimic human sensitivity and behavior

With biometrics & agent-based modeling, we try to turn people into algorithms

This Work :



A systems approach enabling the objective (rather than the person or the machine) by leveraging the strengths of both in an intimate collaboration

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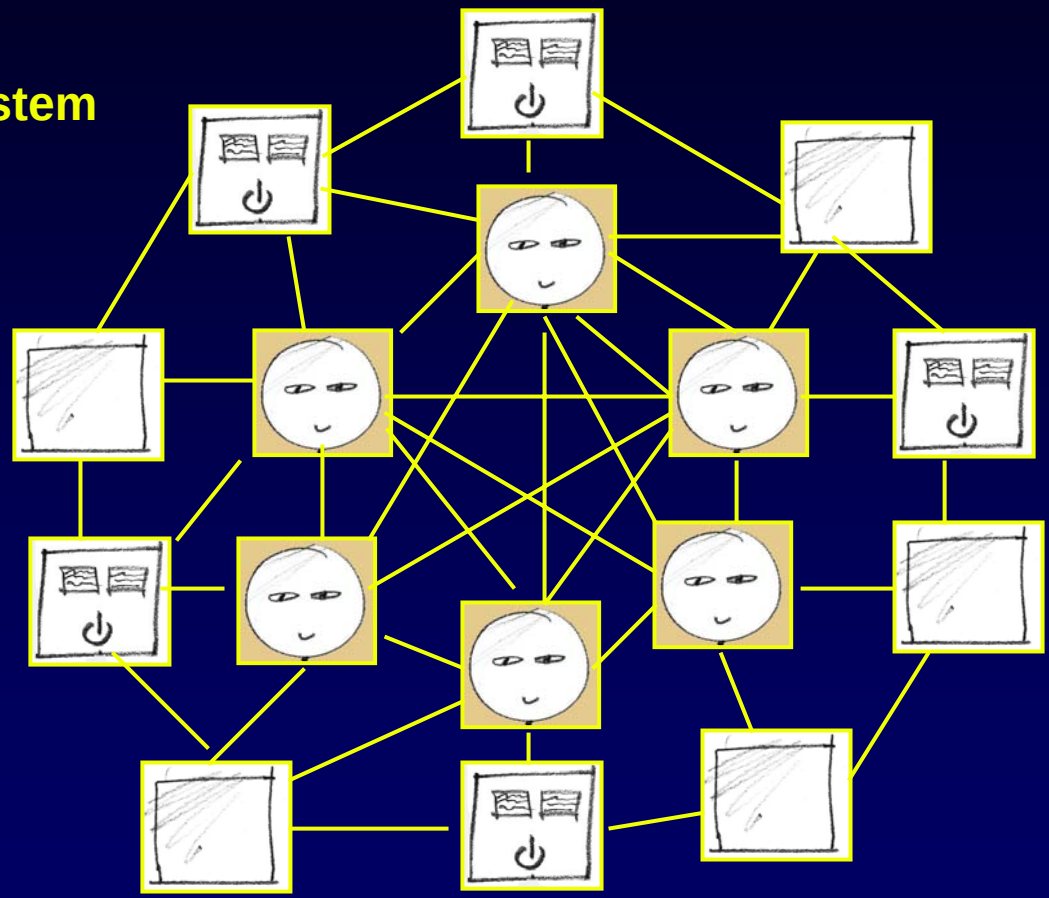
HuMachine© Collaboration

An intimate collaboration of people and machines will be a complex adaptive system with emergent properties.

These properties cannot be predicted or engineered "into" the system.



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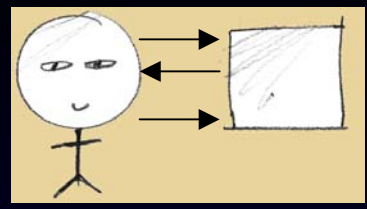

Brain – Body – Machine

People to people: high bandwidth (language, nonverbal)

Hypothesis: Improve machine “reception” without explicit communication from people via:

- Ubiquitous flow: 24/7, anywhere (wireless)
- Capturing audio, video
- Providing natural interfaces (voice, gesture)

Sense the Body, Sense the Brain:

- Recording physiologic data from a small group
- Analysis and feedback in real-time
- Customizing and adapting machines to an individual and a persistent group in a “co-evolving” relationship

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MENTOR/Pal© Prototype

a.k.a. “QuadPod”

A Future: The MENTOR/Pal© System

Everyone has a Pal, a wireless wearable IT appliance and sensor array gated for privacy and security

The Pal is customized and adapts to the individual, who has a realistic understanding of its nature and capabilities

The Pal executes directed tasks and autonomous functions:

- Collect, relay data on A/V and physiologic bands
- Portable to other MENTOR systems
- Self-customizing to long-term traits
- Adapt to short-term conditions (stress, fatigue, people)

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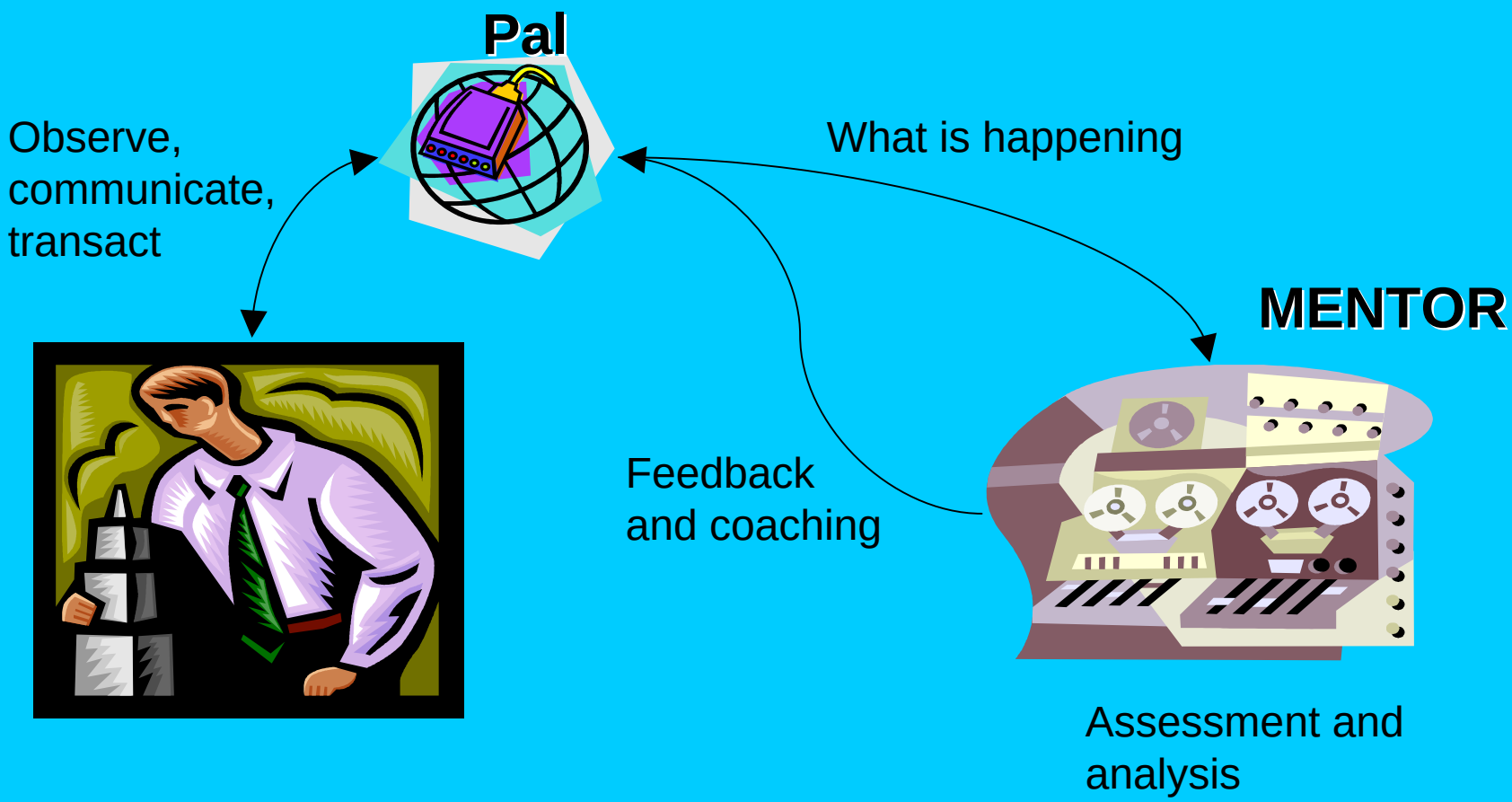
Performance Enhancement



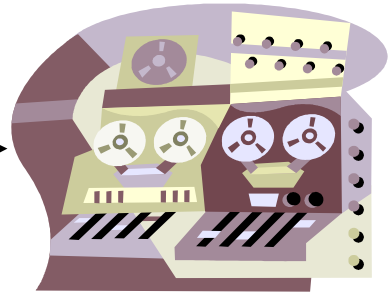
Individual performance enhancement

The MENTOR

MENTOR is the collective machine support to the system. Information allowed through PaI gates may be available to MENTOR and the team as desired. MENTOR can “assist” a collaborative human team, facilitating via tasked and autonomous functions.

- Collect and analyze PaI data, networks PaIs
- Supports human teams and individuals
- Provides knowledge management services
- Universal server capability (bit field, other teams/ humans)
- No AI required or desired

MENTOR



Assessment and analysis

Pal

Pal

Feedback, coaching

Feedback, coaching

Interaction templates, strategies

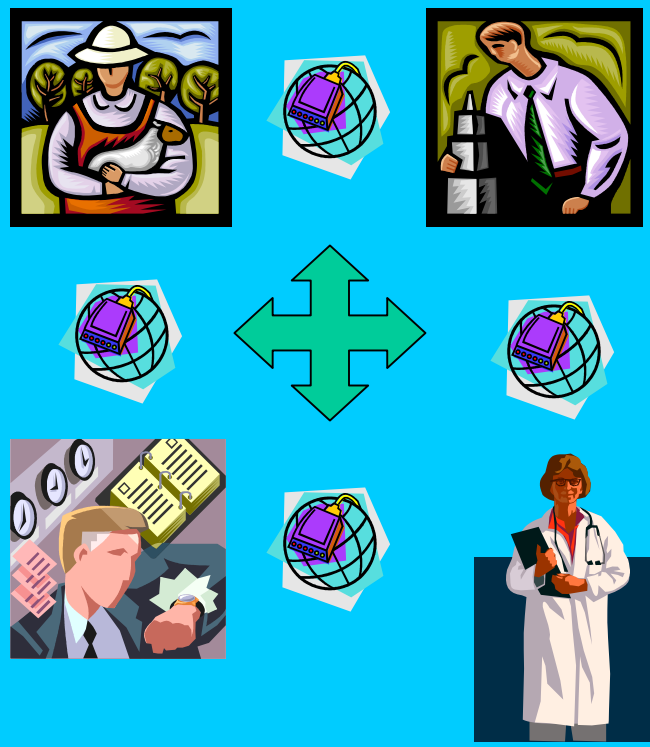
Group Leader

Most Important

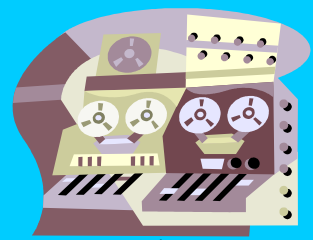
Interpersonal performance enhancement

Pals

Group dynamics
and characterization



MENTOR



Group assessment
And analysis

Group Leader

Group performance enhancement

MENTOR Cannot Be “Designed”

We think any such system will have to be “grown” from initial conditions from a “seed team” by continuous use.

While we can realize the framework in actual hardware and software by a system design...

- Human behavior is unconstrained within the system.
- The system will learn and change itself from experience.

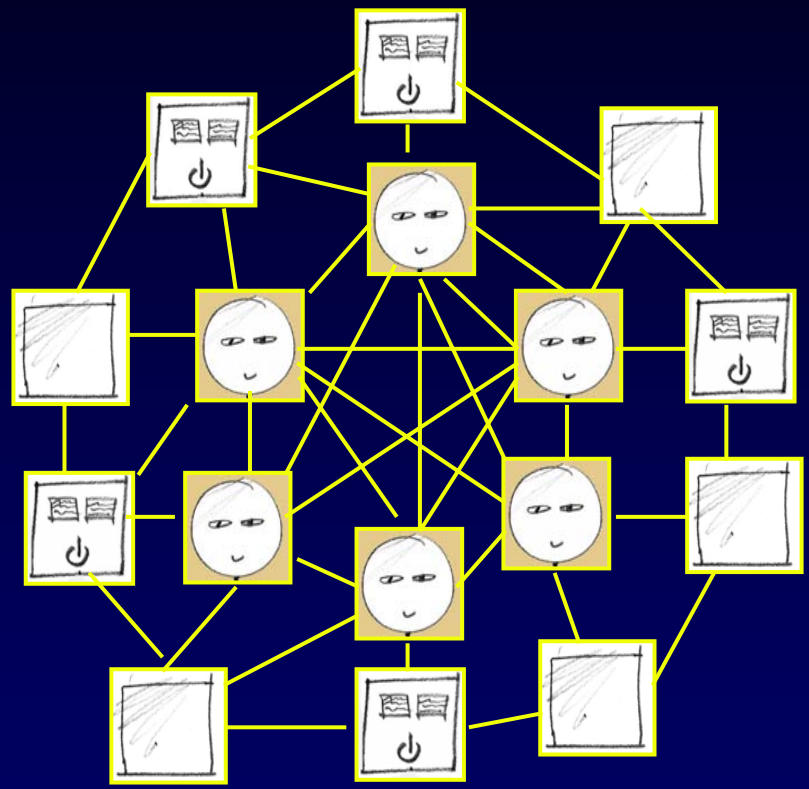
The MENTOR/Pal© has no static definition apart from the context of the actual membership of its Small Group Team.

The Goal of MENTOR/Pal ©

Allow people to do what they do best
- Leap to valid conclusions
- Intuit from almost no data
- Decide what is important

Allow machines to do what they do best
- Relay, sort, filter, find information
- “Crank” on the “bit field”
- Remember things for you

MENTOR will enable new outcomes
- Unpredictable...emergent...desirable



Current MENTOR/Pal© Research

We built a four-person test bed for controlled observations

- Laptop network and human sensors: A/V, physiologic, motor
- Multiplayer action game: Rainbow Six ™ Raven Shield
  - Realistic A/V effects, complex task, teamwork, scoring, high stimulus

Primary observation is necessary to form testable hypotheses about

- Utility of physiologic data: “sports medicine for the brain”
- Human-machine interaction in high-cognitive work
- Compatibility of Pal technology in human group activity
- Potential for learning, adaptation, evolution

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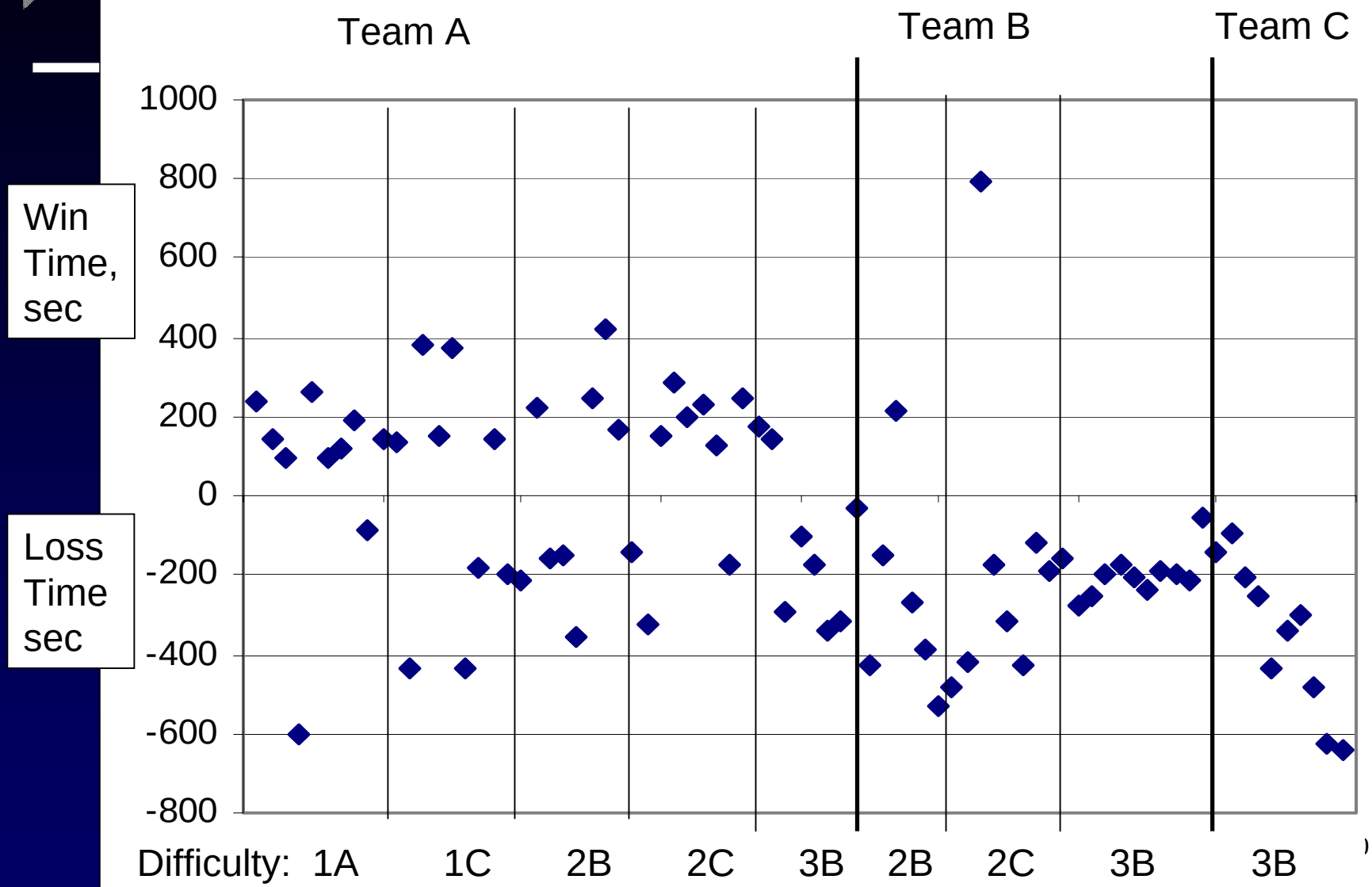
MENTOR/Pal© Prototype

- Accelerometry
- GSR
- Pulse oximetry
- EMG
- EKG
- Respiration
- Voice
- Face video
- keystroke
- Mouse x, y, click
- Voice recognition
- EEG


C1
C2
C3
C4

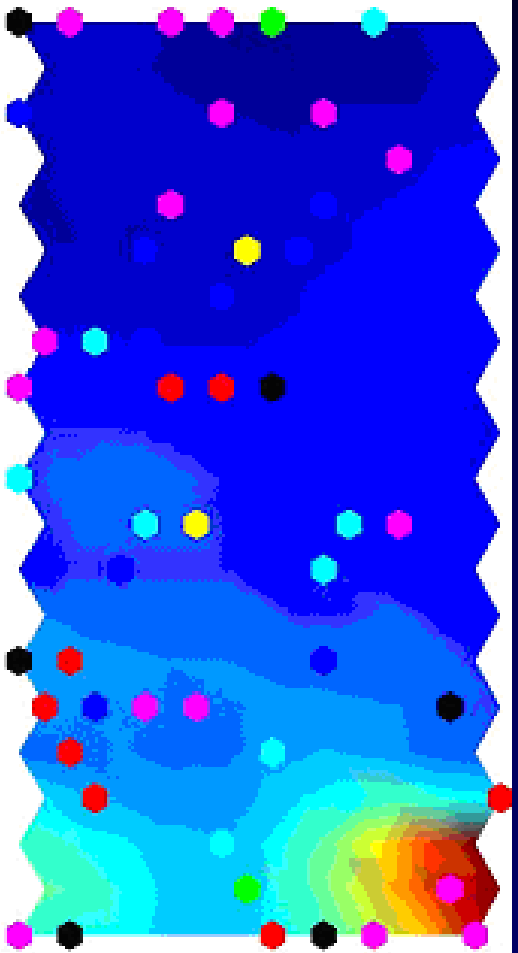

C1
C2
C3
C4

Team Game Performance by Level of Difficulty and Team Composition



Group Self Organizing Maps

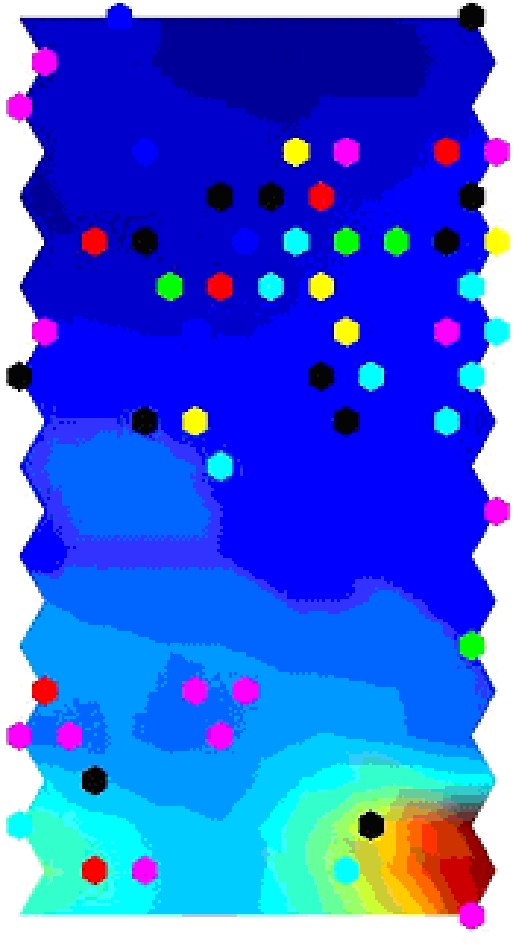
SESSION 3



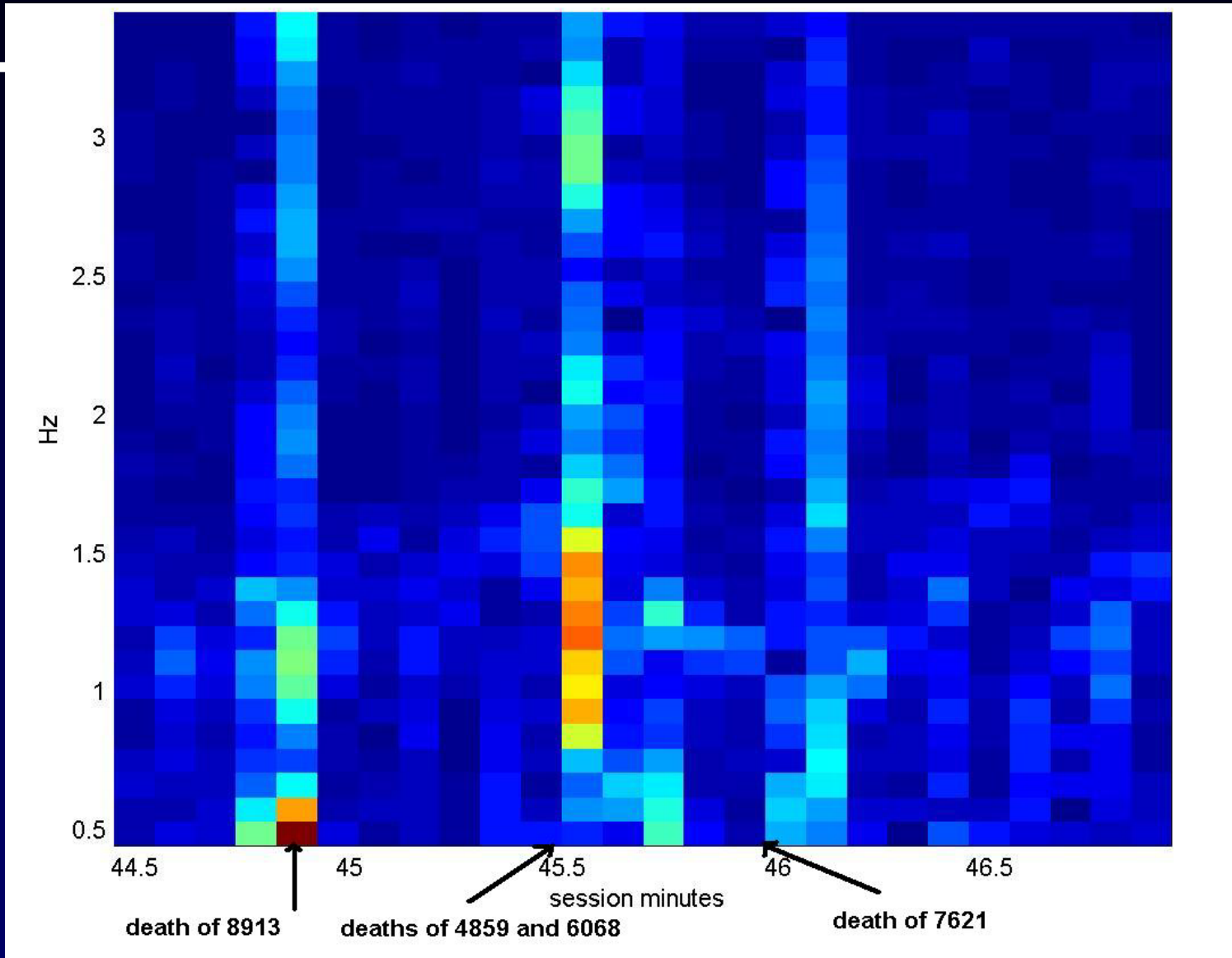
- Self death
- Other's death after self
- Start of new game
- Conflict with other
- Commanding or following
- Cooperation to aid others
- Following events passively

Preliminary analysis suggests that the group map may migrate away from a high stress region with cumulative group experience.

SESSION 6



Informal Leader's BVP Response



Sandia ACG Program Activities

- Develop hypotheses for real-time feedback, further experiments exploring dynamic SOM tracking algorithms
- Evaluate and prototype application environments
  - Critical team: emergency security operations center
  - Distributed collaboration systems: mobile PaI units
- Continue exploratory data analysis and group observations
- Forming partnerships with government, academia, industry to advance novel human-machine systems
  - Akaysha Tang, UNM: EEG studies
  - Christof Koch, Cal Tech CNSE student fellowship

Project Team

www.sandia.gov/ACG

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