Team Coordination and UAV Operations

Nancy J. Cooke
Cognitive Engineering Research Institute
National Academy of Sciences AFRL Associate
ASU East

Research Team Members

Sponsors
Air Force Office of Scientific Research
Air Force Research Laboratory
Office of Naval Research

NMSU Faculty
Peter Foltz

AFRL
Dee Andrews

CERTT Developer: US Positioning
Steven M. Shope

NMSU Graduate Students
Olena Connor
Janie DeJoode
Jamie C. Gorman
Preston A. Kiekel
Rebecca Keith
Harry Pedersen

ASU Students
Pat Fitzgerald
Christy Caballero
Paulette Dutcher

ASU Faculty
Nia Amazeen
Tom Taylor

Cognitive Engineering Research Institute
for Collaborative Innovation

Overview

- CERTT Lab and UAV Synthetic Task
  - Focus on measuring team cognition
  - The synthetic UAV task
  - CERTT capabilities
  - Task fidelity
- Findings relevant to coordination
  - Acquisition and retention
  - Dispersion
  - Workload
  - Expert teams
  - Communication
- Conclusions & Future Directions

CERTT Lab

Cognitive Engineering Research on Team Tasks

Unmanned Aerial Vehicle Synthetic Task Environment

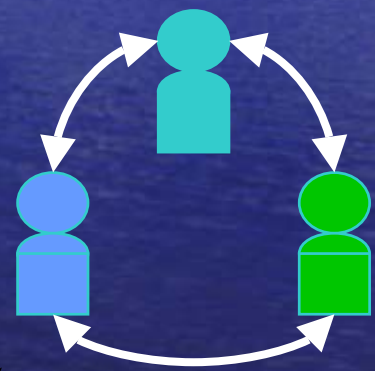
In our UAV STE three operators must coordinate in order to maneuver their UAV to take pictures of ground targets

Cognitive Engineering Research Institute
for Collaborative Innovation

Team Cognition in Practice

Team Cognition

- It is more than the sum of the cognition of individual team members.
- It emerges from the interplay of the individual cognition of each team member (PROCESS IS KEY)
- Further, for heterogeneous teams, individual cognition is also heterogeneous (AVERAGING INAPPROPRIATE)



vs.

Team coordination <u>IS</u> team cognition.

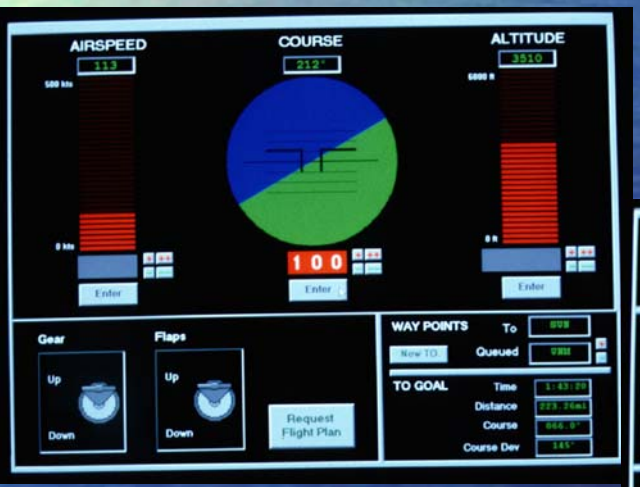
Cognitive Engineering Research Institute
for Collaborative Innovation

The Synthetic Task

Air Vehicle Operator
controls UAV airspeed, heading, and altitude and monitors air vehicle systems

Payload Operator
controls camera settings, takes photos, and monitors camera systems

DEMPC
navigator, mission planner, plans route from target to target under constraints



Based on a cognitive task analysis done on Predator operations at at Indian Springs, NV

Cognitive Engineering Research Institute
for Collaborative Innovation

CERTT Capabilities

- Four participant consoles
  - Integration of seven task applications over local area net
  - David Clark headsets for participants and experimenter

- One experimenter workstation
  - Video and audio recording equipment (including digital audio)
  - Intercom and software for logging communications flow
  - Embedded performance measures
  - Computer event logging capabilities
  - Ability to disable or insert noise in channels of communication intercom
  - Experimenter access to participant screens
  - Experimenter control capability of participant applications
  - Easy to change start-up parameters and waypoint library that define a scenario
  - Software to facilitate measurement of team process behaviors
  - Software to facilitate situation awareness measurement
  - Training software modules with tests
  - Software modules for off-line knowledge measurement (taskwork ratings)
  - Software for administering debriefing questionnaire
  - Software for administering NASA TLX, SART, and other scales
  - Capability for distributed simulation (across intranet and internet)

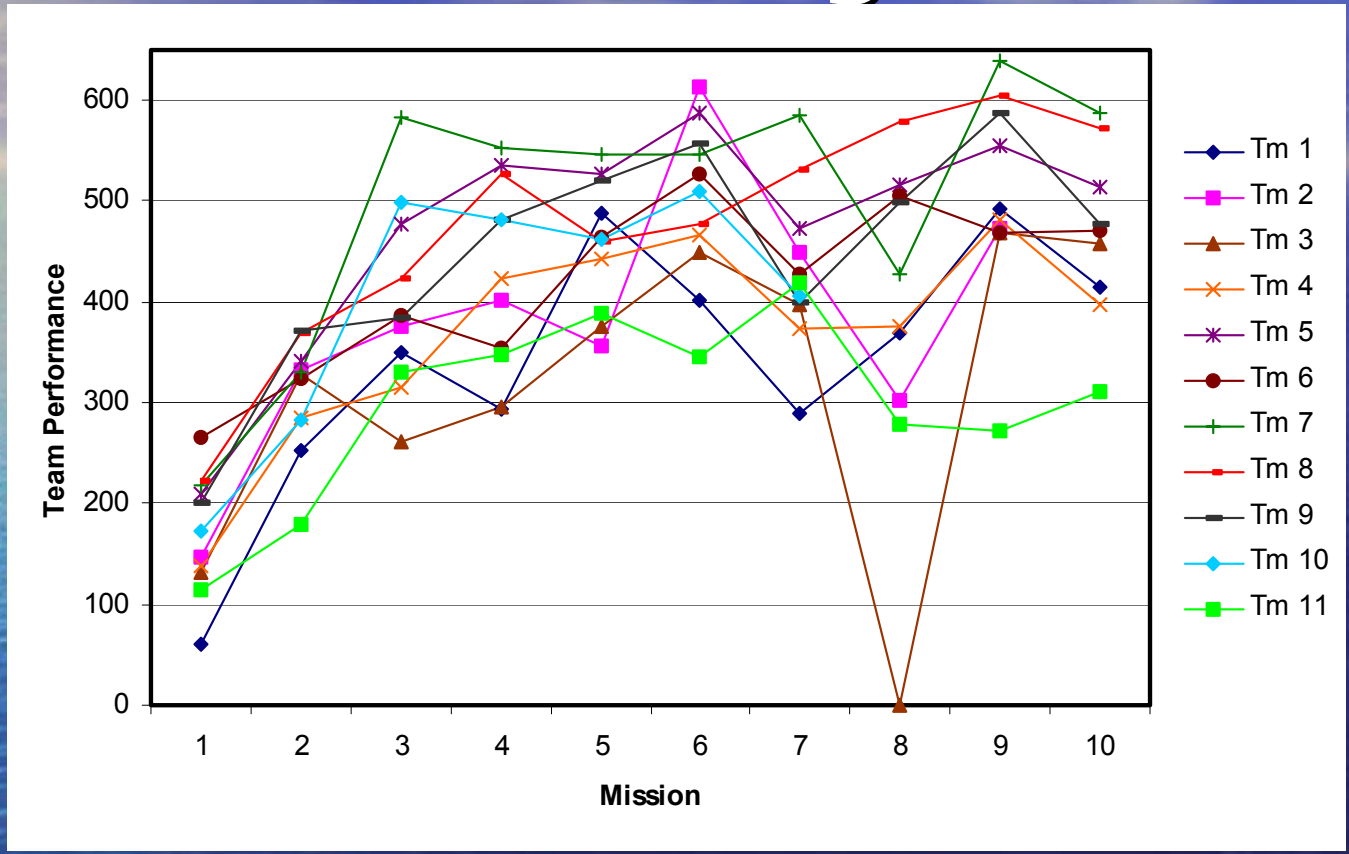
Task Fidelity

- Task based on cognitive task analysis of Predator operations
- Task is faithful to the aspects of the operational task that pertain to team cognition
- Cognitive fidelity vs. physical fidelity
- Validity: face validity and expert benchmarking

Five CERTT UAV Experiments

- Three team members (AVO, PLO, DEMPC) maneuver UAV to take reconnaissance photos
- Independent Variables: knowledge sharing, workload, dispersion
- Primary Measures: performance, process, cognition (teamwork knowledge, taskwork knowledge, SA)
  - Experiment 1: 11 teams, 10 missions
  - Experiment 2: 18 teams, 5 missions, shared vs. unshared
  - Experiment 3: 20 teams, 7 missions, 5-7 high workload, distributed vs. co-located
  - Experiment 4: 20 all-male teams, 5 missions, 5th high workload, distributed vs. co-located
  - Experiment 5: Benchmarking, 5 "expert" teams, 5 missions, 5th high workload

Exp. 1 Acquisition and Retention Findings

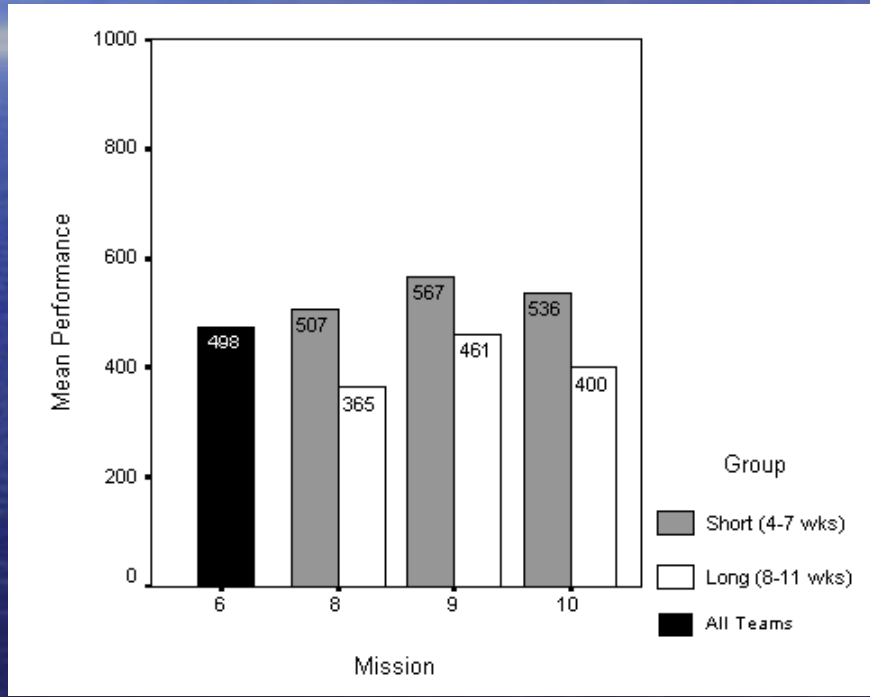


- Asymptotic team performance after 4 40-min missions (robust finding)
- Process improves and communication becomes more standard over time; knowledge is more stable
- Skill loss after 7 weeks

Cognitive Engineering Research Institute
for Collaborative Innovation

Exp. 1 Acquisition and Retention Findings

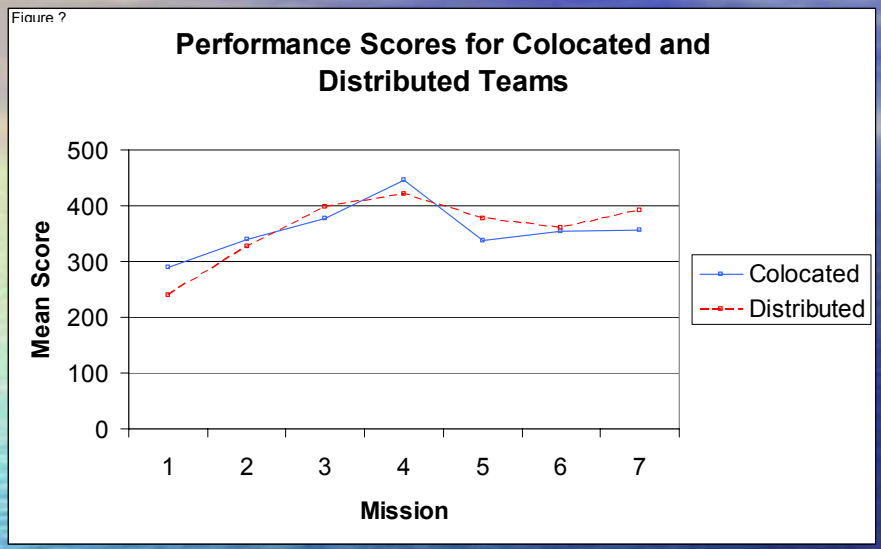
Retention Interval Group	Mean (# of weeks)	Min	Max	N
Short (4-7 weeks)	5.86	4.71	6.57	4
Long (8-11 weeks)	9.63	8.71	10.86	5



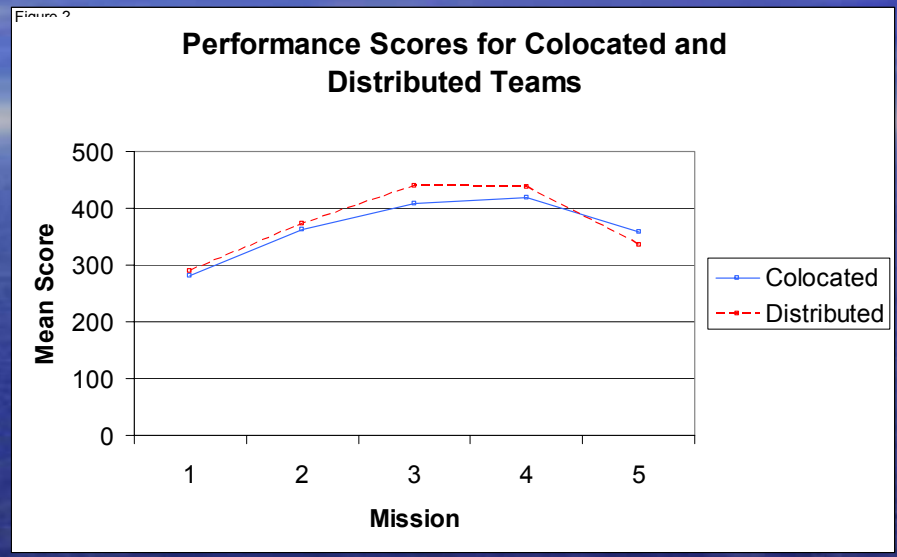
The question of retention of C2 skill is of great practical importance, but little is known.

Cognitive Engineering Research Institute
for Collaborative Innovation

Dispersion IS NOT Detrimental to Team Performance



Experiment 3

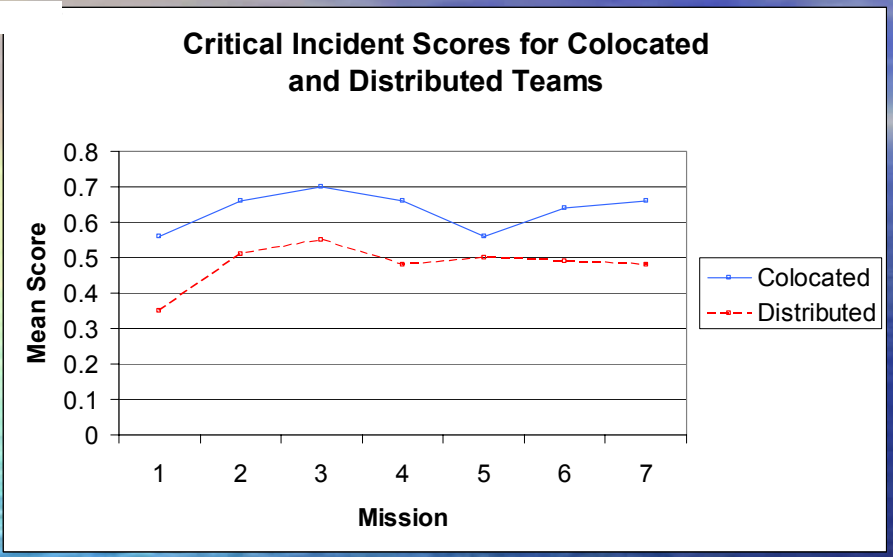


Experiment 4

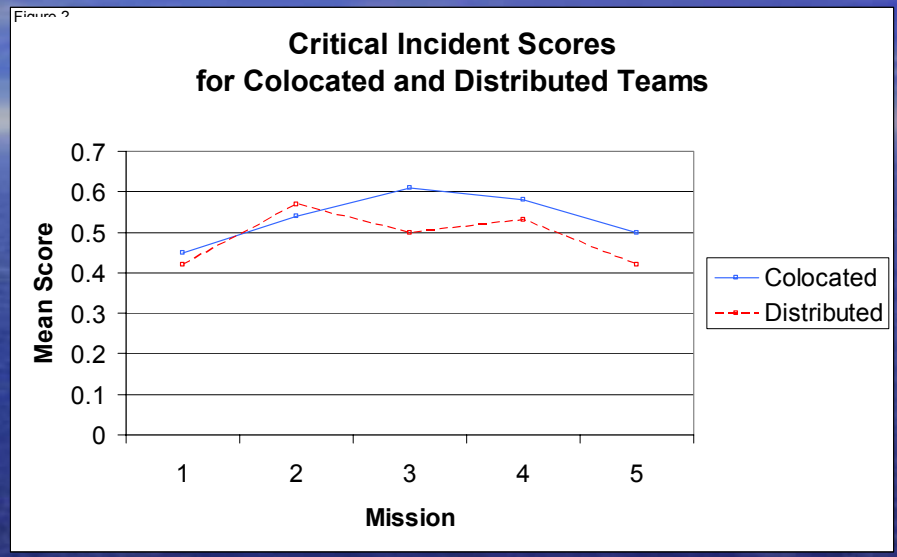
- Team skill is acquired from Mission 1 –4
- Increased workload (M5 and later) is detrimental to team performance
- Distributed teams perform better than co-located under high workload (Exp. 3)

Cognitive Engineering Research Institute
for Collaborative Innovation

Dispersion IS Detrimental to Team Process



Experiment 3



Experiment 4

- Team process improves from Mission 1 –4
- Increased workload (M5 and later) is detrimental to team process
- Co-located teams demonstrate better (or different) team process than distributed teams

Cognitive Engineering Research Institute
for Collaborative Innovation

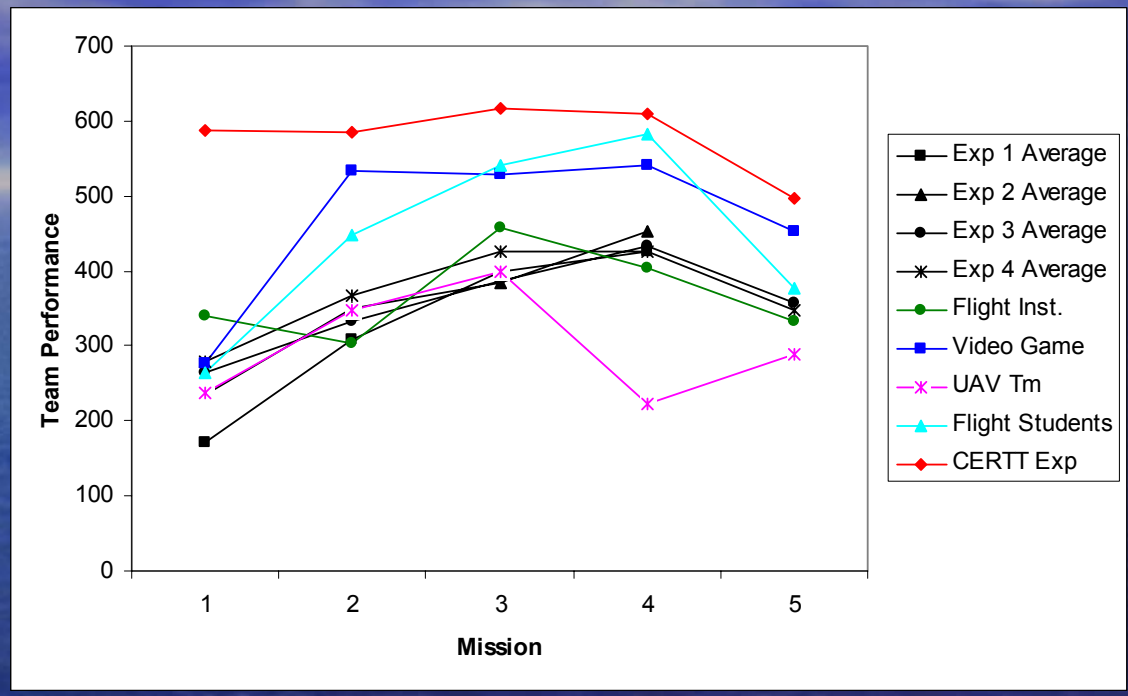
Workload

- High levels of workload are detrimental to team performance and process
- Under high workload teams get fewer photos per minute
- Co-located DEMPCs tend to perform better and perceive greater workload than distributed DEMPCs
- Working memory capacity is correlated with superior DEMPC performance

Exp. 5: Benchmarking Study

Five Expert Teams

1) Flight Instructors
2) Video Game Team
3) UAV Design Team
4) Flight Students
5) CERTT Experimenters



TEAM	Process	Teamwk	Taskwk
Fl Instruc			
Video	X		
UAV			
Fl Student		X	X
Exp		X	X

Cognitive Engineering Research Institute
for Collaborative Innovation

Team Communication

- Communication is a predominant form of team interaction in command-and-control
- Real-time, embedded in the task
- Observable; Think aloud "in the wild"
- Rich, multidimensional (amount, flow, speech acts, content)
- Reflects team cognition at the holistic level; for us this *is* team cognition

Team Communication

- We focus on flow and content
- Differences in communication patterns correspond to team performance differences
- Better performing teams display more consistent patterns of communication than poorer teams
- Automated communication analysis methods make this approach practical

Conclusions

- The UAV-STE provides a semi-controlled realistic environment for the study of team cognition
- The UAV-STE provides a fertile ground for developing and testing measures of team cognition
- Our UAV-STE data suggest that much team cognition occurs in the push and pull of information among team members

Future Directions

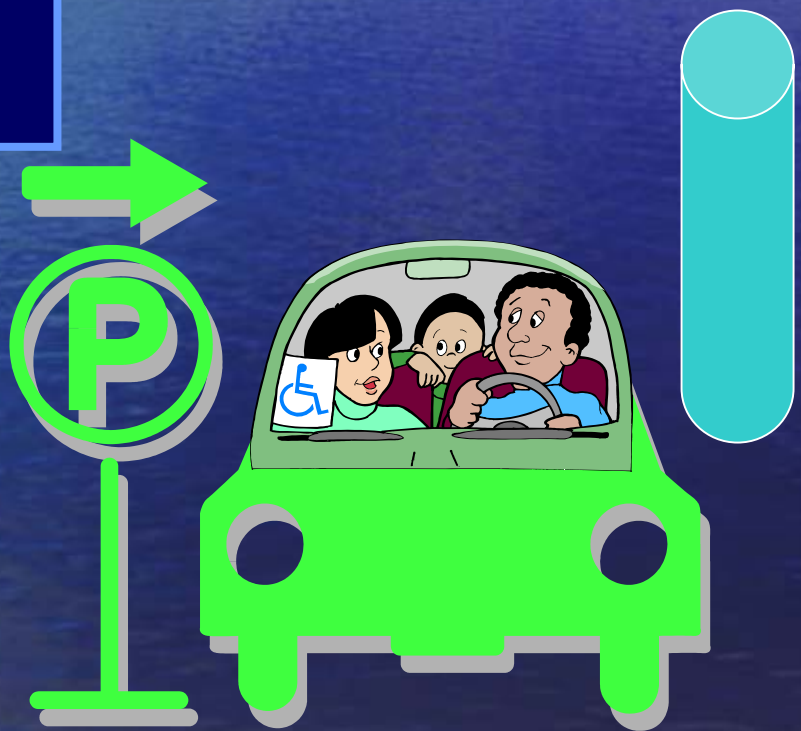
- Acquisition and Retention Studies and Models
- Dynamical Systems models of coordination
- Additional cognitive task analyses of UAV systems
- Command-and-control in emergency response
- Assessment and diagnosis of team performance via communication
- A new measure of coordinated situation awareness

Cognitive Engineering Research Institute
for Collaborative Innovation

Team Situation Awareness

An Example

coordinated perception and action



Cognitive Engineering Research Institute
for Collaborative Innovation

Team Situation Awareness

A Holistic/Ecological Measure of Team SA

- Change is introduced (communication breakdown, enemy in area, storm) that will impact mission
- 2-3 team members are presented cues regarding change
- Team members need to perceive cues in a coordinated way (i.e., connect the dots) to identify the change
- Team members coordinate to take action relevant to the change (e.g., change altitude, communicate indirectly)

Questions or Comments?

email:

ncooke@asu.edu

website:

www.certt.com

Cognitive Engineering Research Institute

Mesa, AZ

www.cerici.org

Cognitive Engineering Research Institute for Collaborative Innovation