Human – Machine Teaming for Human-Centered Intelligent Machines

Nancy J. Cooke
Arizona State University

ASU Global Security Initiative
Arizona State University

Center for Human, Artificial Intelligence, and Robot Teaming

BOHSI Webinar: Future Trajectories of Human-AI Collaboration and Teaming
May 28, 2025

Taking Teaming Seriously In HMT

Team Definition

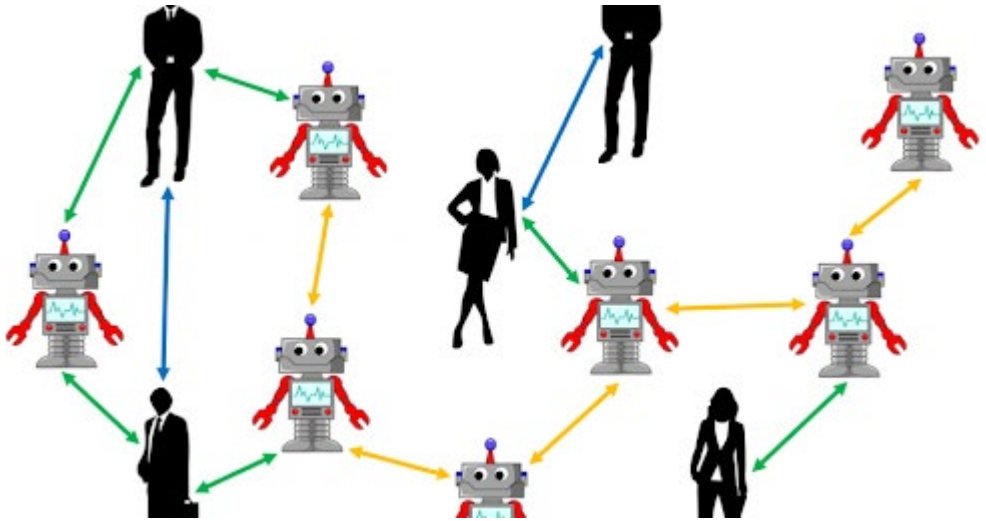
- A team is “a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and values goal/object/mission, who each have been assigned specific roles or functions to perform, and who have a limited life span of membership” (Salas, Dickinson, Converse, & Tannenbaum, 1992, p. 4)

- Salas, E., Dickinson, T. L., Converse, S. A., & Tannenbaum, S. I. (1992). Toward an understanding of team performance and training. In R. W. Swezey & E. Salas (Eds.), Teams: Their training and performance (pp. 3–29). Norwood, NJ: Ablex

- Cooke, N. J., Cohen, M.C., Fazio, W.C., Inderberg, L. H., Johnson C. J., Lematta, G. J., Peel, M., Teo, A. From Teams to Teamness: Future Directions in the Science of Team Cognition. (2022). *At the Forefront of Human Factors/Ergonomics, Human Factors.*

Taking Teaming Seriously for Human-Machine Teaming Means…

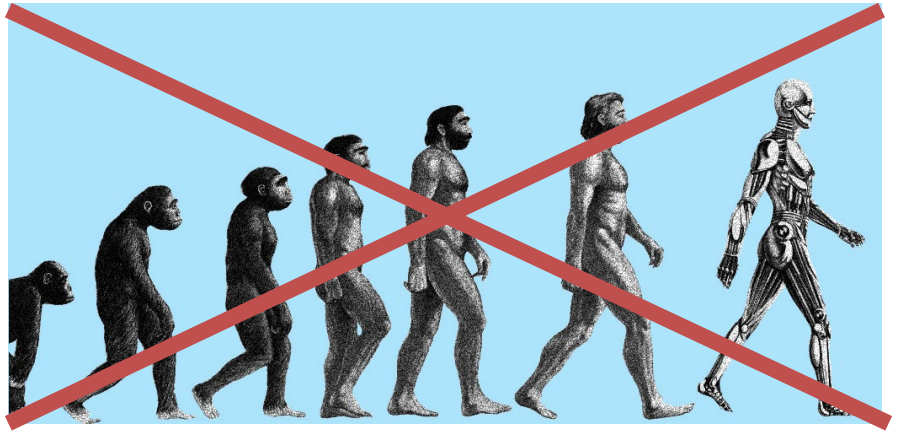
- Team Composition & Role Assignment
- Team Processes for Human-Machine Teams
- Team Development
- Team Effectiveness Measurement



A team is a special type of system, thus HSI

Taking Teaming Seriously for Human-Machine Teaming Does Not Mean…

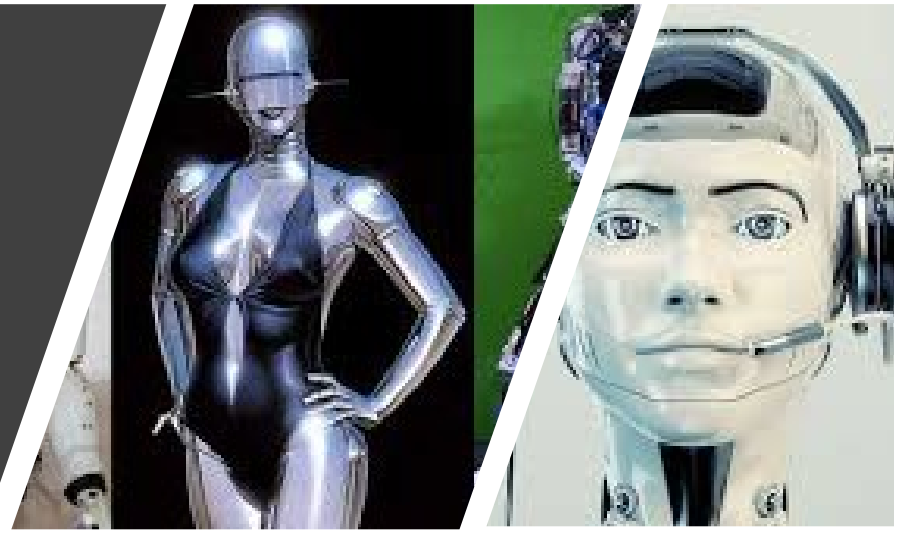
- Machines are in control
- Machines are human or human-like
- The machine is not human-centered



Designing an AI system to work well as a teammate increases human-centeredness.

Taking Teaming Seriously in Human-Machine Teams

Team members have different roles and responsibilities – do not replicate humans and their roles. Exceptions?



Taking Teaming Seriously In Human-AI Teams

Humans should do what they do best and AI agents should do what they do best and what humans do not want to do.

For example, big data analytics and visualization for human decision maker

Exceptions: social robotics; synthetic teammate

COMPLEMENT humans rather than REPLACE them

Taking Teaming Seriously in Human-Machine Teams

Effective teams understand that each team member has different roles and responsibilities and avoid role confusion, but back each other up as necessary - autonomy needs understanding of whole task. What does this mean?

RPAS Research Testbed

RPAS-STE: Remotely Piloted Aircraft System (ground control station) Synthetic Task Environment

In our RPAS-STE three operators must coordinate over headsets or text chat to maneuver their RPA to take pictures of ground targets

Three team members with inter-dependent tasks

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

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

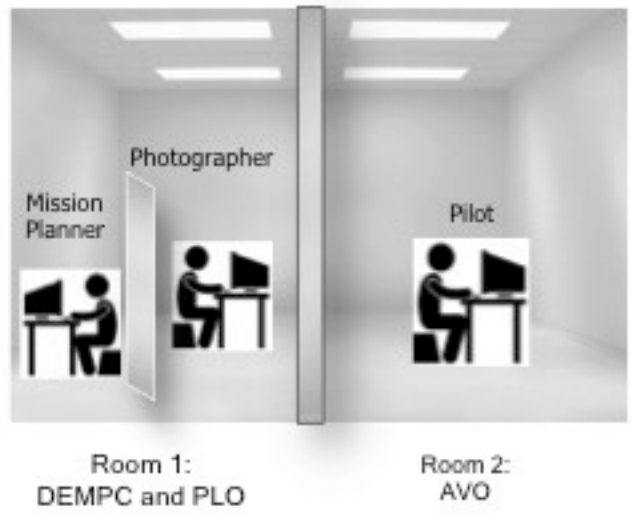
Air Vehicle Operator
controls RPA airspeed, heading, and altitude and monitors air vehicle systems

Interdependence requires interaction, communication, & coordination

Synthetic Teammate Validation Experiment

Procedure

Sessions		Procedure
1	Welcoming	Consent forms.
2	Interactive Training	Interactive Training PowerPoint Slides
3	Training Mission	Hands on Training
4	Mission 1	Mission 1 is conducted
5	NASA TLX/ Knowledge Measures	Session 1: Conducting taskwork and teamwork questions, and administering the workload questions
6	Mission 2	Mission 2 is conducted
7	Mission 3	Mission 3 is conducted
8	Mission 4	Mission 4 is conducted
9	Mission 5	Mission 5 is conducted
11	NASA TLX/ Knowledge Measures	Session 2: Conducting taskwork and teamwork questions, and administering the workload questions
12	Demographics/ Debriefing	Conducting demographic questions, and giving debriefing
13	Post Checklist	



Manipulation

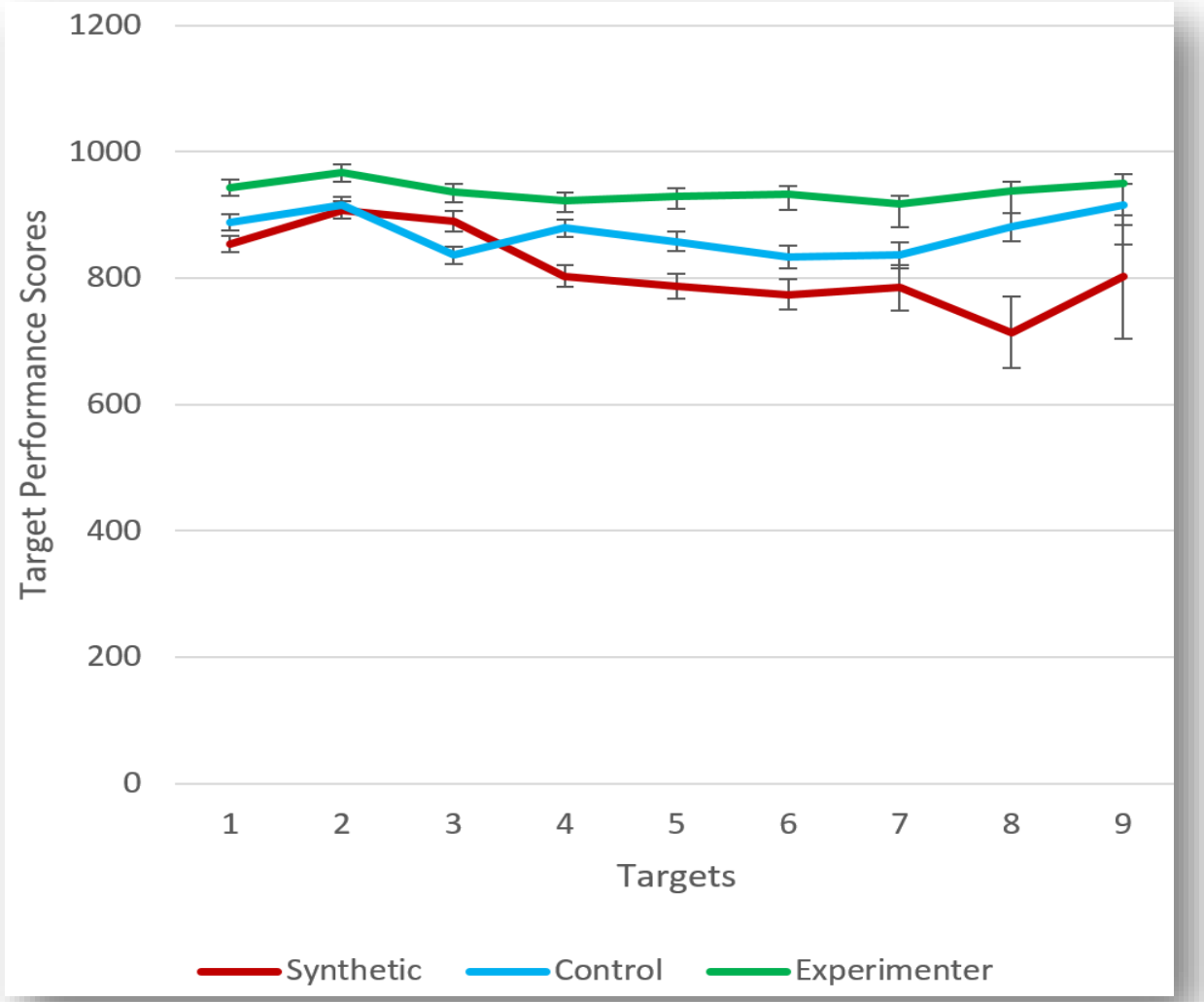
- Control Teams vs. Synthetic Teams vs. Experimenter Teams

Measures

- Team performance
- Team process (process ratings, communication flow, coordination, situation awareness, verbal behavior)
- Workload, NASA TLX

McNeese, N. J., Demir, M, Cooke, N. J., & Myers, C. (2018). Teaming with a Synthetic Teammate: Insights into Human-Autonomy Teaming. *Human Factors*, 60, 262-273.

Synthetic Teammate Findings



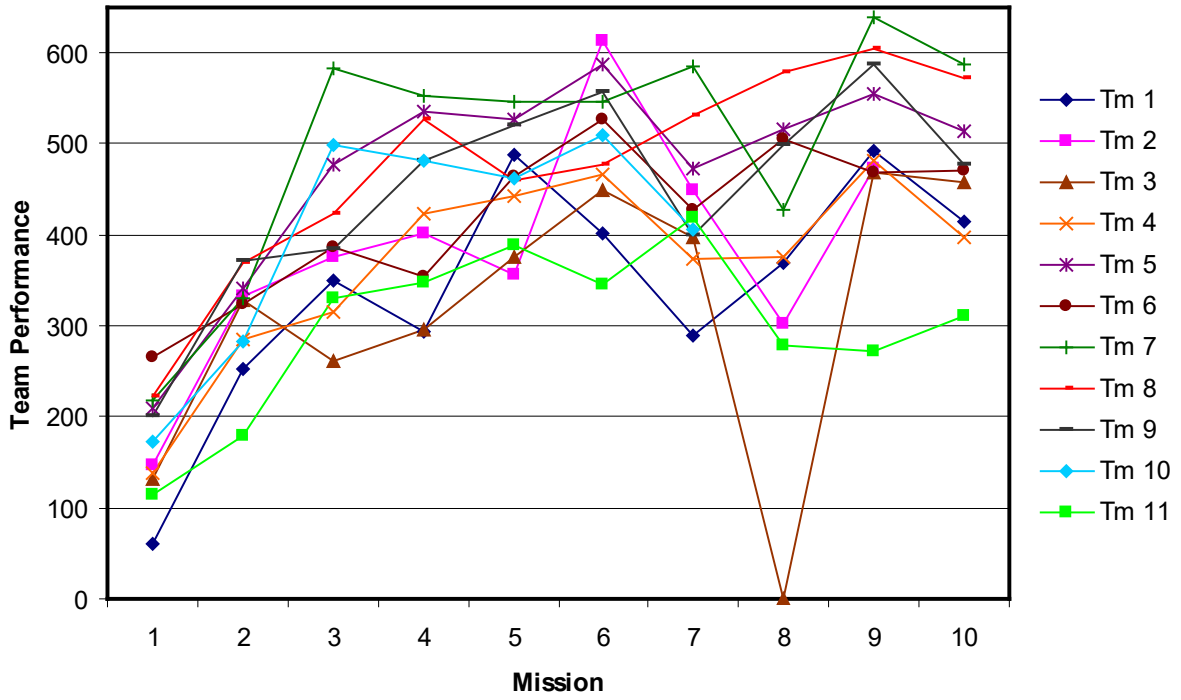
Synthetic < Control < Experimenter

- Synthetic Teammate failed to anticipate the information needs of human teammates
- Only provided information when asked
- Over time the human teammates entrained to synthetic teammate
- As a result coordination suffered

Taking Teaming Seriously in Human-Machine Teams

Effective teams share knowledge about the team goals and the current situation and this facilitates coordination and implicit communication – human-autonomy team training?

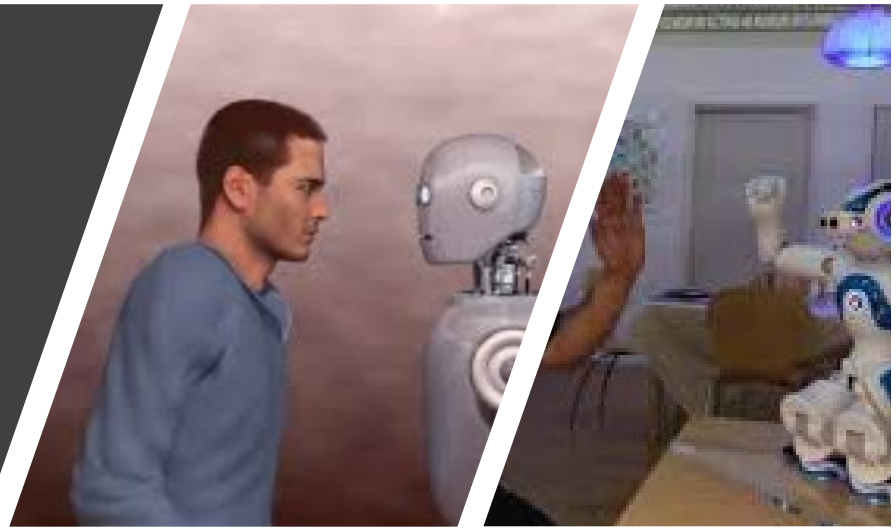
Taking Teaming Seriously In Human-AI Teams

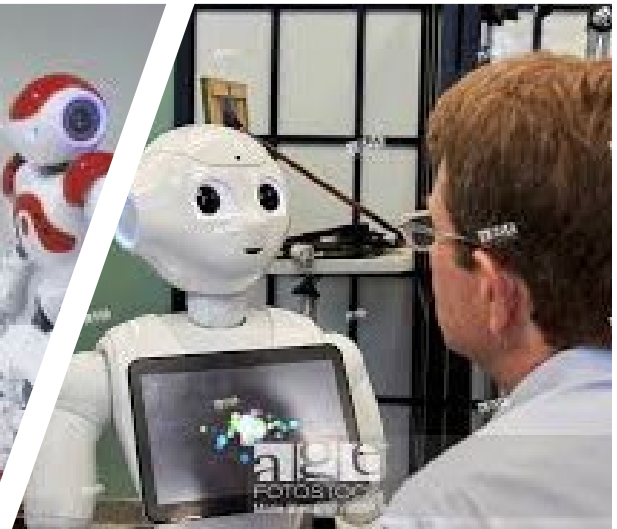


Team Experience Matters

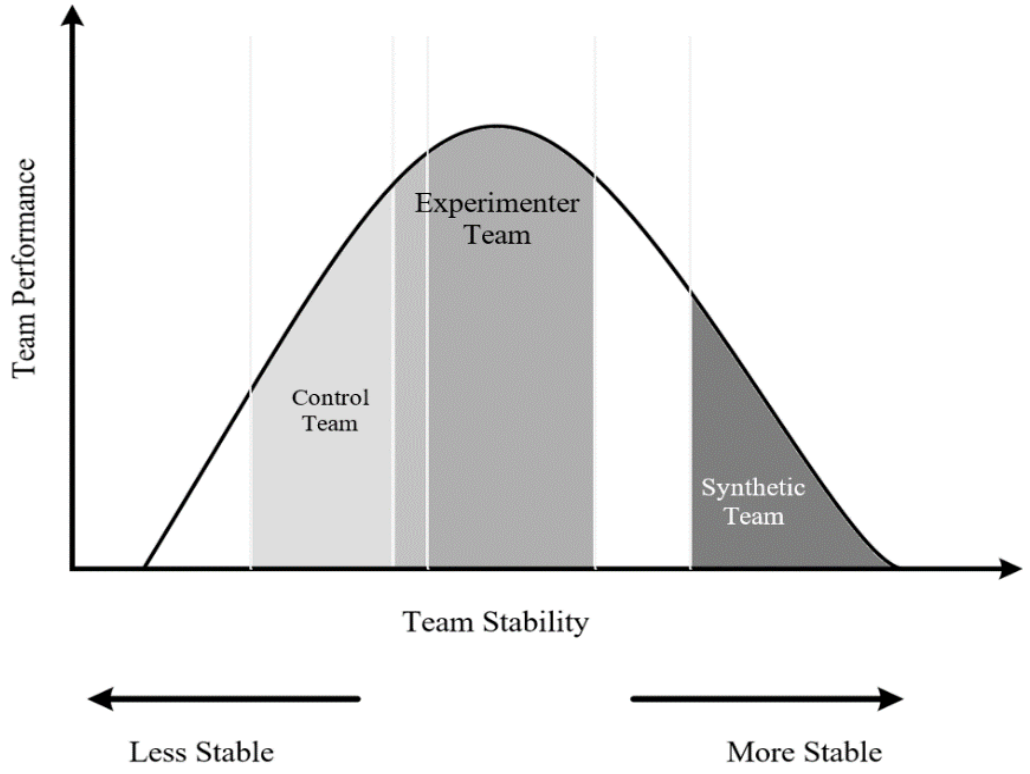
Taking Teaming Seriously in Human-Machine Teams

Effective teams have team members who are interdependent and thus need to interact/communicate even when direct communication is impossible– some other communication model than natural language?





RELATION BETWEEN TEAM PERFORMANCE AND COORDINATION



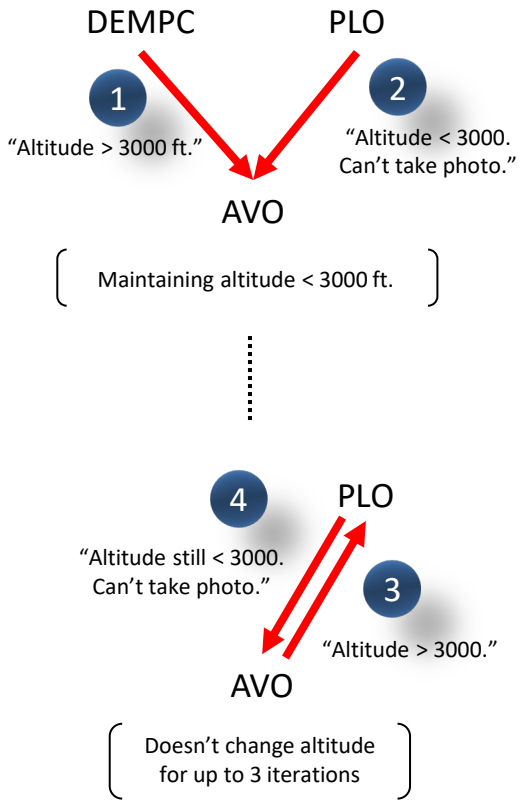
From Demir dissertation 4/2017; Coordination stability “sweet spot” discovered

Taking Teaming Seriously in Human-Machine Teams

Interpersonal trust is important to human teams – autonomy needs to explain and be explicable. But how much and is that enough? Should it be trusted?

Over-Trusting the Synthetic Teammate

Autonomy Failure Types I & III: *Comprehension Failure*



- Overcoming this failure requires consistency and persistence on the part of PLO in correcting the AVO
  - Calibrated trust, Attitudes, Disposition, Anthropomorphism
- Failure to overcome due to:
  - Giving up
  - Moving on to next target
  - Lying to each other (e.g., "good photo; let's go")
  - PLO reacts too slowly
- Locus of resilience is primarily role-related

Effective Human-Machine Teaming for the Future of Work requires Human Systems Integration throughout the lifecycle of systems development

HSI for human-machine teaming