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Joint Intelligence, Surveillance, and Reconnaissance Mission Collaboration with Autonomous Pilots

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Systems That Work for Humans

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Agenda

- Promise of Autonomous Pilots
- Human AI Interaction in Specialized aviation missions
- Intelligence, Surveillance, and Reconnaissance (ISR)
- Nature of the ISR task
- Joint ISR Wargame Task Design
- Autonomous Pilot Modes
- Design of Experiment
- Results
- Takeaways
- Future Work

Autonomous Pilots

Autonomous Pilots: Aviate, Navigate, Communicate

- Integration of latest AI advances into Autopilots
- Active area of research by airlines, manufacturers, and military R&D
- Trends indicate that autonomous pilots could soon “aviate, navigate, communicate” without human input

Humans and AI in Specialized Aviation Missions

- Teaming
  - Specialized missions today require a “front of the aircraft” and “back of the aircraft” heterogeneous crew, e.g.:
    - Medical Evacuation
    - Law enforcement
    - Search and Rescue
- Interaction
  - Tightly coupled tasks between crew members
    - Communication
    - Cooperation
    - Collaboration
  - Onboard human aircrew may soon team with AI-enabled Autonomous Pilots

Guiding Research Question:

What are the elements of interaction that impact the effective teaming of an autonomous pilot with an onboard human aircrew?

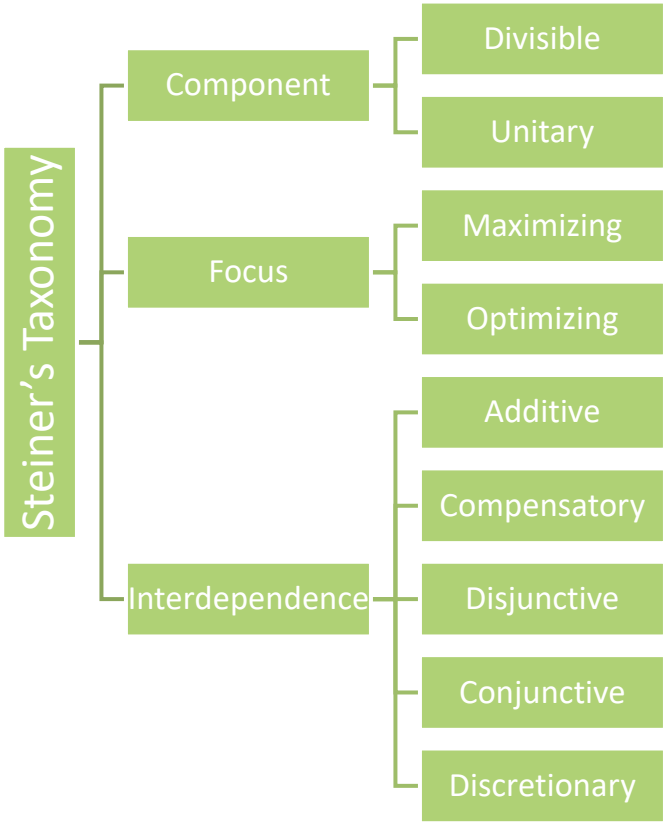

Intelligence, Surveillance, and Reconnaissance

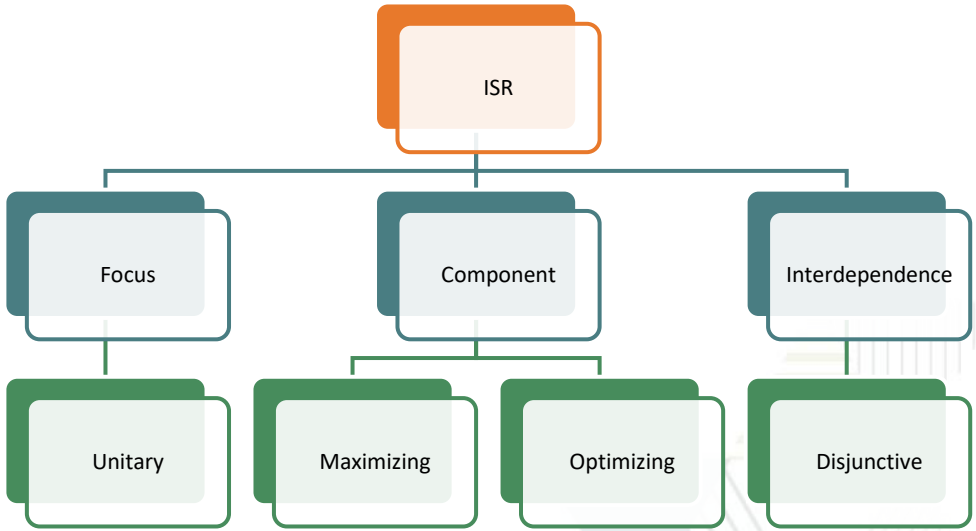
Intelligence, Surveillance, and Reconnaissance: Crewed Airborne ISR

- Crewed ISR aircraft perform operations which involve
  - “tasking and synchronizing ISR sensors, platforms and exploitation resources to characterize the operational environment, adversary activities, and infrastructure, and to target entities in the battlespace”

(U.S. Air Force Doctrine 2-0 Intelligence, 2023).

Nature of the Task





Requires specialized mission knowledge, experience and judgment

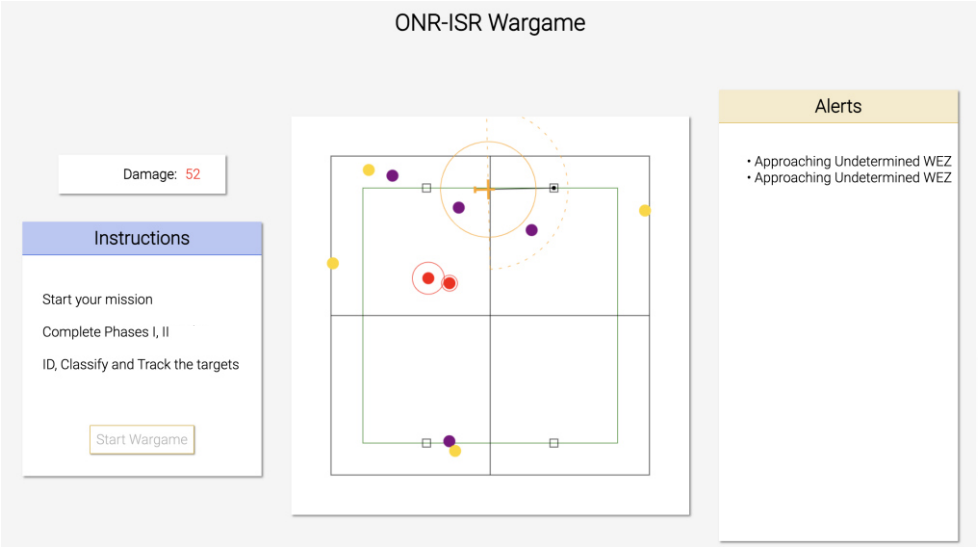
Joint Collaborative ISR

Task Design: find, fix, track,


VTOL

ISR Wargame Simulator and Operator Station

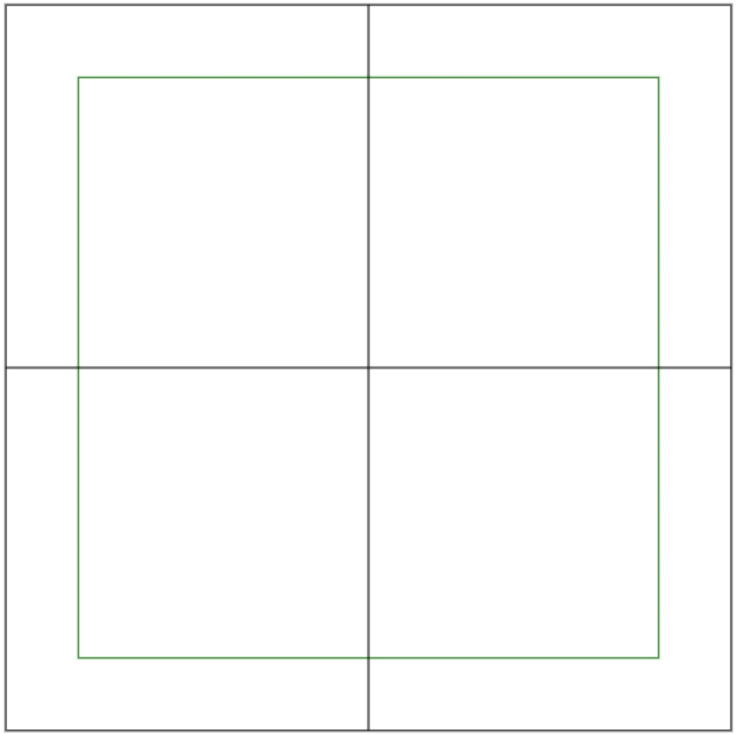
- Simulation of airborne maritime ISR off the coast of San Diego
- Intelligence Analyst teamed with an autonomous pilot
- Task is to patrol assigned Surveillance Area to find adversary ships hiding amidst fishing and cargo ships
- Fly within sensor range of targets to identify, classify, and track adversary ships



https://github.com/gt-cec/onr-isr

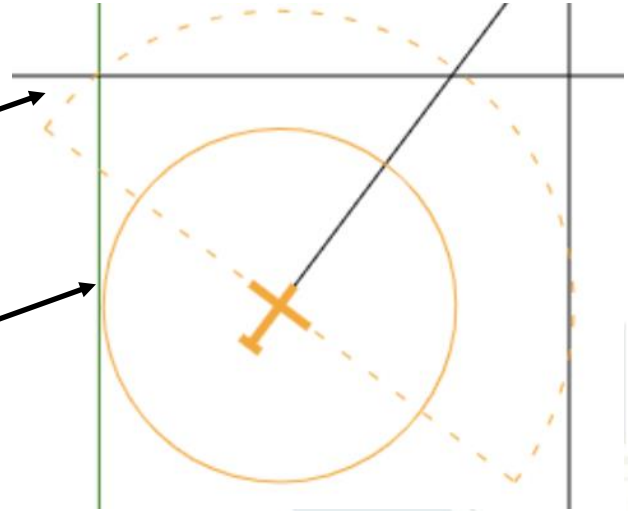
Objectives

- Collaborate with Autonomous Pilot to complete mission
- Optimize trajectory
- Minimize time
- Minimize damage
  - Avoid flight through red targets' weapon employment zones (WEZ)



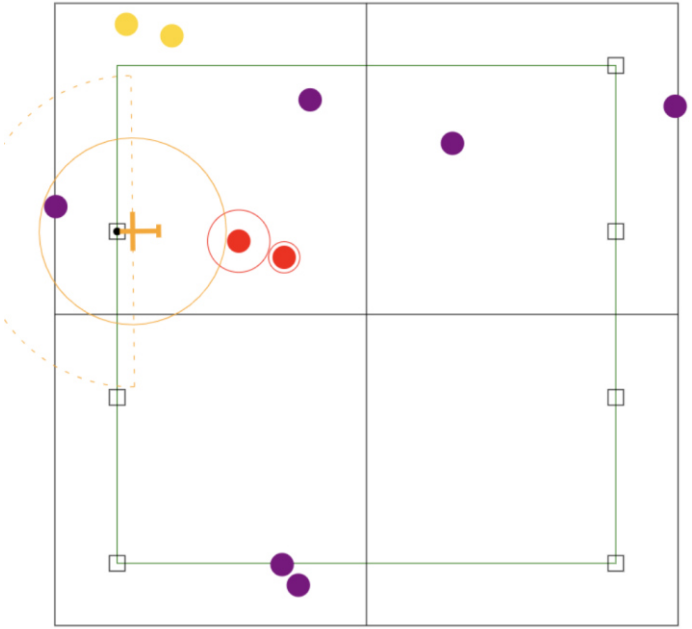
Phases

- Phase I
  - Identify all targets on the ISR Control Station display: hover cursor over each target in surveillance area to get target ID (Radar)
- Phase II
  - Classify all targets:
    - Get the target class: fly so that each target is within the dotted line surrounding the aircraft (Long range EO/IR Camera)
    - Get the threat class: fly so that each target (all targets) is within the solid line surrounding the aircraft (High Resolution Camera)

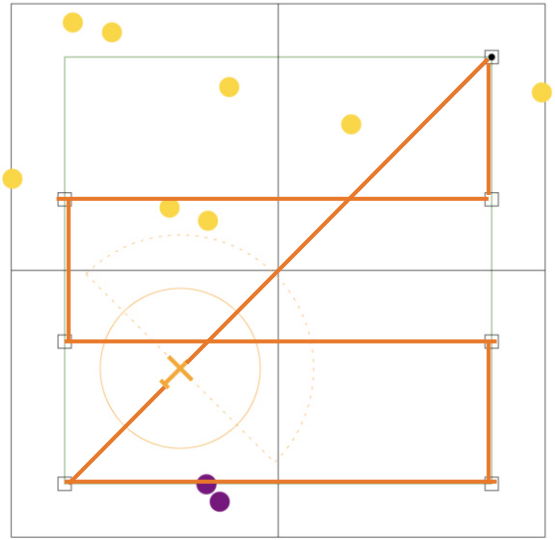


Target Symbology

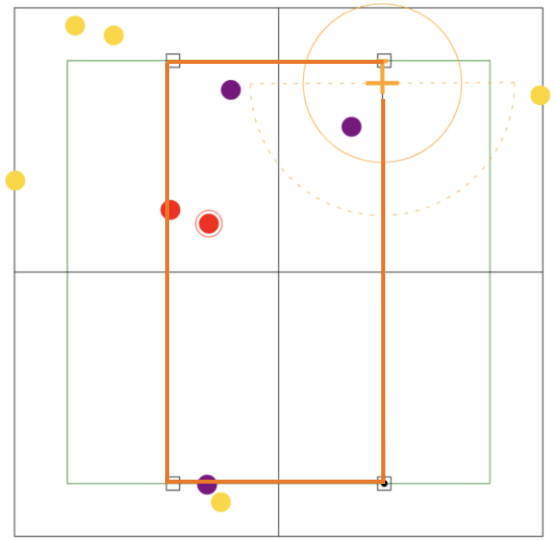
- Unidentified target
- Neutral target
- Enemy target – Weapon Employment Zone (WEZ) is the thin ring around



Autonomous Navigation Patterns

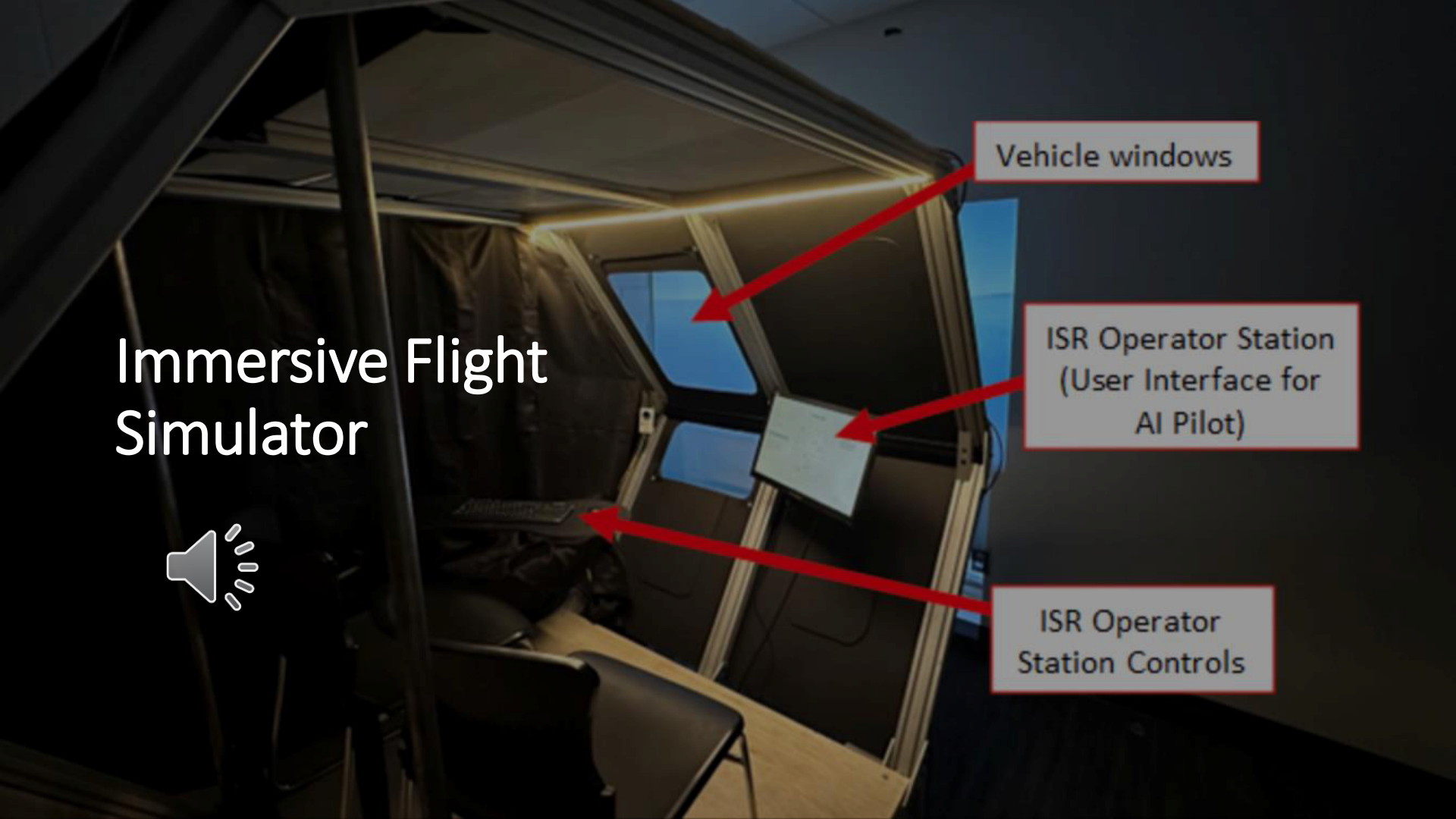


Ladder



Hold

Immersive Flight Simulator



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Autonomous Pilots

Modes of behavior

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Autonomous Pilot Modes

	Behavior	Team Dynamics
Waypoint	• Flies one of the two autonomous navigation patterns • Autonomous Pilot always deviates to user waypoints	• Human has authority over aircraft navigation • Human has responsibility for avoiding enemy WEZ
Collaborative	• Autonomous Pilot accepts or denies user waypoints • Does not provide explanation	• Human and Autonomous Pilot share authority over navigation • Human has responsibility for avoiding enemy WEZ
Collision Avoidance	• Autonomous Pilot suggests obstacle avoidance waypoints to user • Without user input, proactively avoids enemy WEZ • Blends in user waypoints with collision avoidance	• Human has authority over aircraft navigation • Human and Autonomous Pilot share responsibility for avoiding enemy WEZ
Search Optimization	• User can request suggestions for navigation pattern optimizations • User accepts or rejects Autonomous Pilot suggestions	• Human has authority over aircraft navigation • Autonomous Pilot offers assistance with navigation • Human has responsibility for avoiding enemy WEZ

Design of Experiment

- Exploratory study
- Within-subjects
  - 27 participants
- Full-factorial
  - 4 levels of Autonomy Mode
  - 2 levels of Task Load
- Counter-balanced

using Latin Square

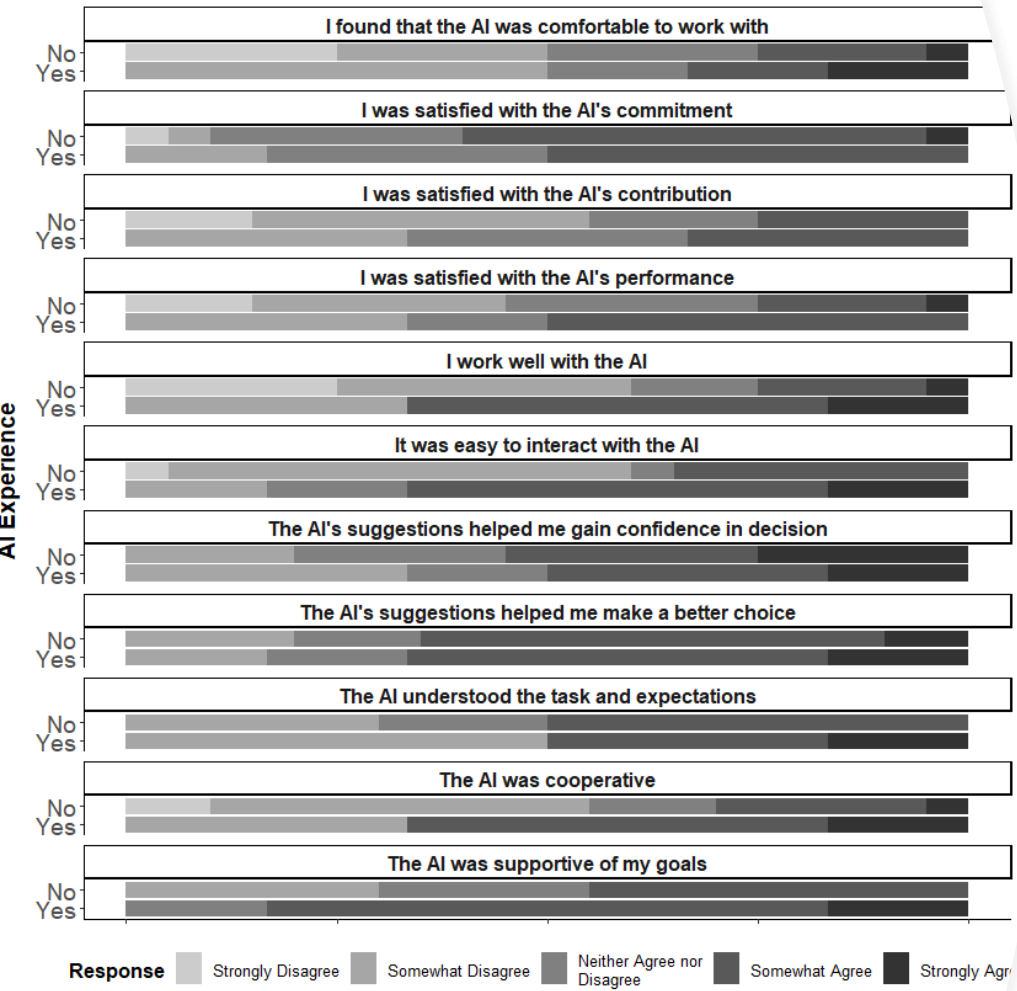
Scenario Order	1	2	3	4	5	6	7	8
Participant %								
1	A0	B0	B3	A1	A3	B1	B2	A2
2	B0	A1	A0	B1	B3	A2	A3	B2
3	A1	B1	B0	A2	A0	B2	B3	A3
4	B1	A2	A1	B2	B0	A3	A0	B3
5	A2	B2	B1	A3	A1	B3	B0	A0
6	B2	A3	A2	B3	B1	A0	A1	B0
7	A3	B3	B2	A0	A2	B0	B1	A1
8	B3	A0	A3	B0	B2	A1	A2	B1

Metrics

- Demographics
  - Flight Experience
  - AI Experience
- User Interface Usage
- Questionnaire
  - Teamwork
- Debrief Interview
  - Perceptions

Results

Questionnaire and Debrief Interview



Autonomy's Teamwork

- Questionnaire aimed to assess both task work and teamwork
- Participants without AI experience tended to be less satisfied with the AI's performance, contribution, and how well it works with them
- Participants without AI experience expressed that they came in with a higher expectation of the AI's capabilities

Perceptions of the Autonomy Modes

Waypoint	Collaborative	Collision Avoidance	Search Optimization
(baseline) • Neutral perception • Participants desired the ability to modify the pattern	(AI can reject user input) • Negative perception • Participants disliked the lack of explanation of the autonomy's decisions	(AI avoids enemy WEZ) • Clear favorite • Participants appreciated that they retained full navigation authority while receiving WEZ assistance • Enabled them to focus on longer term planning	(search pattern assistance) • Neutral perceptions • Participants desired that the suggested search patterns avoid WEZ

Study Objective:

Identify the elements that impact the effective teaming of an autonomous pilot with an onboard ISR crew

Takeaways

- Joint ISR task was completed with reasonable performance by heterogenous human-AI team
- Participant's AI experience influenced perception of autonomy
- Participants wanted to retain authority while receiving AI assistance through shared responsibility for vehicle health
- Validated presence of underlying human factors elements in quality of interaction in a human-AI team collaborating on a Joint ISR mission

Next steps

- Limitations
  - Imbalance in participant demographics
  - Comparison of autonomous modes limited by experimental design
- Future Work
  - Control for AI Experience and Flight Experience in recruitment
  - Increase levels of task load to isolate effect of autonomy modes on mission outcomes
  - Measure trust comprehensively

From Research to Practice

- In addition to dynamic adaptive autonomy behaviors, consider dynamic autonomy transparency based on:
  - mission sensitivity
  - team alignment

Questions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