

# Human-Autonomy Teaming Assistant to Support Small Uncrewed Aircraft Systems for Wildland Firefighting Operations

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- Aerial firefighting is effective at fighting wildland fire under certain circumstances
  - Allows fire crews to access remote locations, gather information, secure fire perimeters, save structures and reduce fire intensity
- Integration of small Uncrewed Aircraft Systems (sUAS) with existing aerial operations remains a challenge in wildland firefighting
- NASA's System-Wide Safety project seeks to
  - Develop systems and capabilities to address risks and hazards introduced with new entrant operations (e.g., sUAS in disaster response)
  - Modernize the safety management system processes of existing operations to incorporate safety information from new entrant systems
- Engagement with wildland fire community points to the need for new technology, and future concepts may warrant increasing use of automation

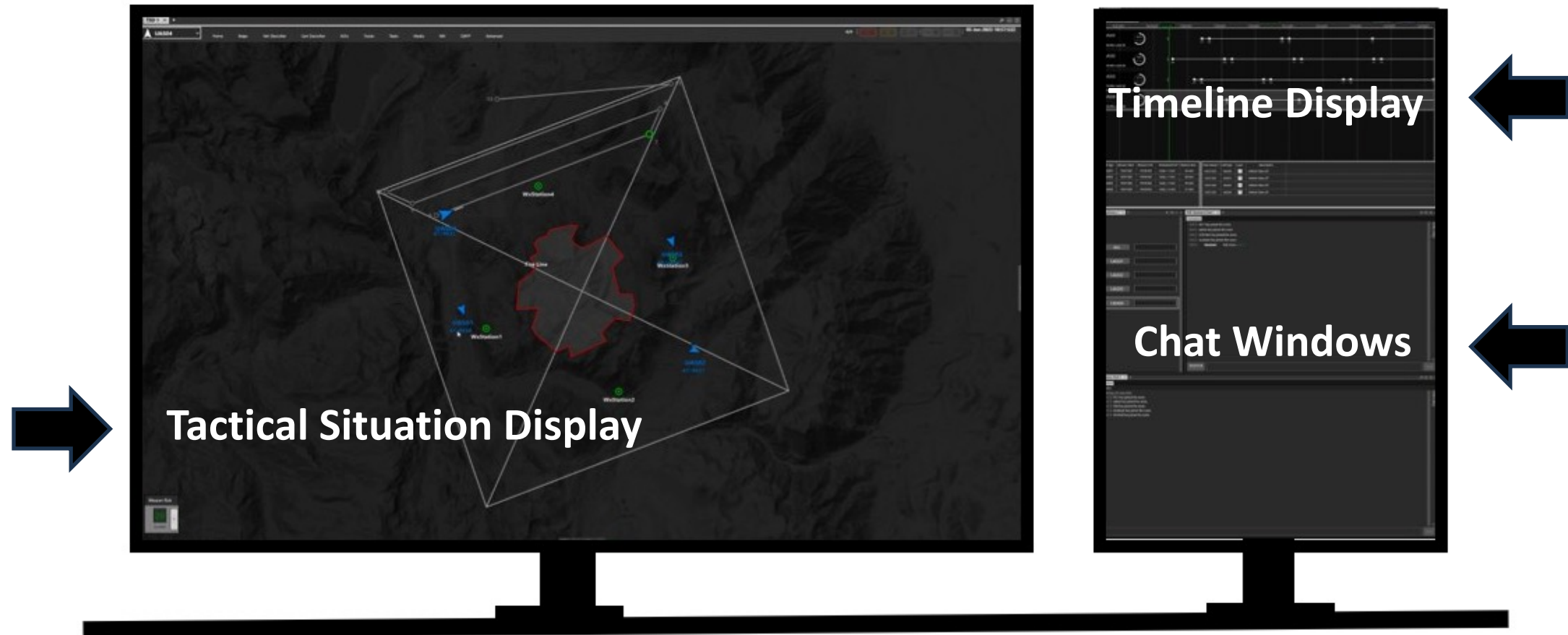


- Increased automation may significantly reduce operator workload
  - However, there may be unexpected consequences:
    - When conditions fall outside design envelope, human becomes the fallback
    - Brittle failures may leave the human out of the loop
- Our approach to HAT is to adapt principles of good human teamwork to human interaction with automation
- The HAT Lab researches techniques and procedures for optimizing the relationship between humans and automation. Our previous research has shown benefits of applying these principles
  - Improving transparency of data and information sharing between operator and automation.
  - Allowing for communication from operator to automation and vice versa
  - Maintaining meaningful human control

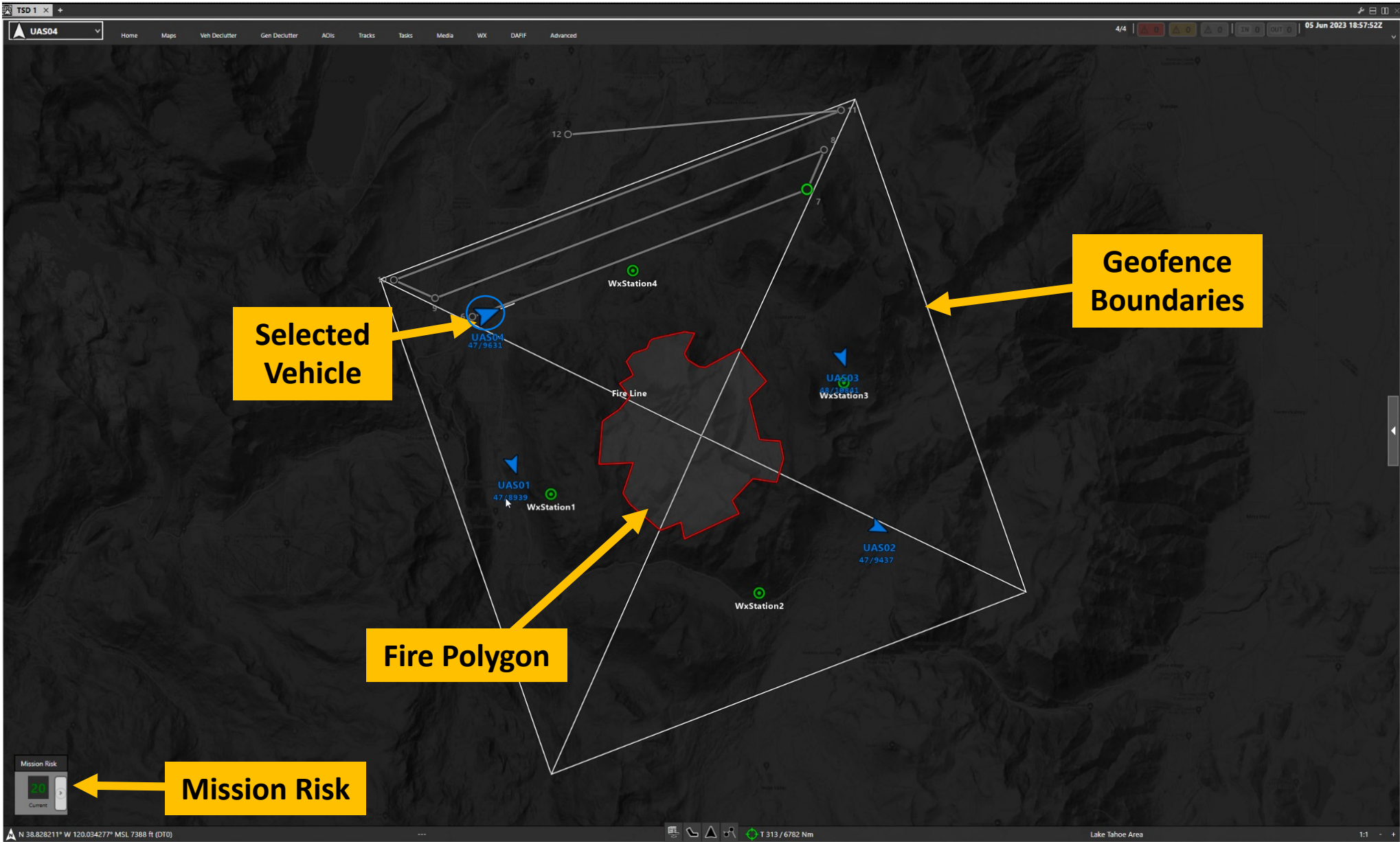


- Exploratory initial investigation of a GCS assistant designed with the HAT principles to aid the operator
  - Multi-vehicle control of sUAS in wildland firefighting operation
  - Management of four sUAS on a transect mapping mission to map progress of bulldozer lines and fire progression
- To characterize operator performance and to investigate the effect of the Assistant on operator subjective experience
- Exploration of metrics and methods for follow on research

- Vigilant Spirit Control Station
  - Developed by the Air Force Research Laboratory (AFRL)



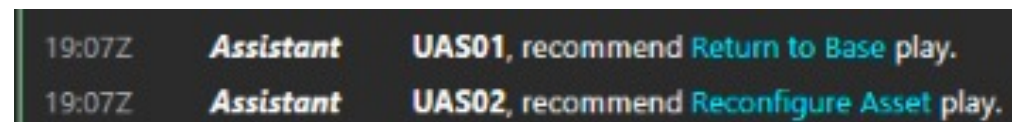
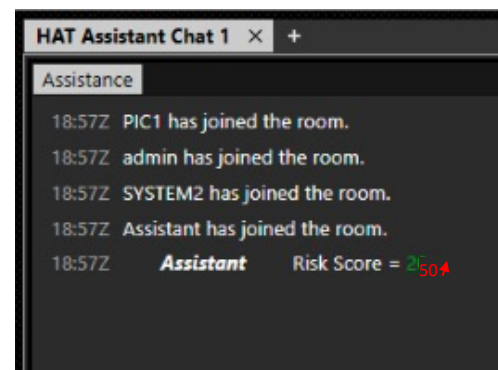
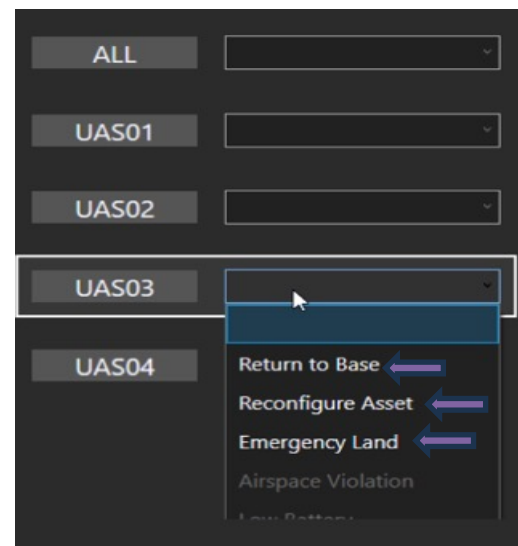
*Significantly modified the UI for the current study*





- Risk defined as completing the mission successfully with
  - No loss of life
  - No loss of vehicle
  - Within time allowed and with acceptable workload
- Risk categories:
  - 0-49 : Low mission Risk **Green**
  - 50-79: Moderate **Yellow**
  - 80-100: High **Red**

- Play Library: explore and execute a limited set of actions for single or multiple vehicles
  - Return to Base
  - Emergency Land
  - Reconfigure Asset
- In the Chat, the Assistant provides:
  - Changes to the overall Mission Risk
  - Trend information and sources of risk
  - Suggested mitigations (i.e., Plays)



- 2 X 2 Within Subjects Design
  - Contingency Complexity:
    - *Low Complexity*: Single asset with depleted battery
    - *High Complexity*: Multiple assets affected by weather change
  - GCS Mode:
    - *Assisted Mode*:
      - Assistant provides chat message with updates to Mission Risk value due to contingency event(s)
      - Assistant provides play recommendations to mitigate risk
    - *Unassisted Mode*:
      - The participant is responsible for recognizing onset of contingency events and changes in mission Risk
        - » No Mission Risk Indication provided
      - The participant must choose the mitigation by selecting a Play from the Play library

- Participants

- Ten sUAS pilots with Part 107 certification (avg. age = 30 years old)
- 115 hours avg. uncrewed flight time

- Experimental Trials

- 4 trials, 15 minutes each
- Blocked by GCS mode & counterbalanced across all participants

- Performance Metrics

- *Missed Detection*: proportion of events where pilots failed to detect event
- *Response Time*: Time elapsed from onset of contingency event to execution of play

- Subjective Metrics

- *Workload* – NASA TLX (HART, 2006)
- *Situation Awareness Rating Technique* (SART; Taylor, 2017)
- *Trust* – Merritt's Trust Scale (Merritt, 2011)



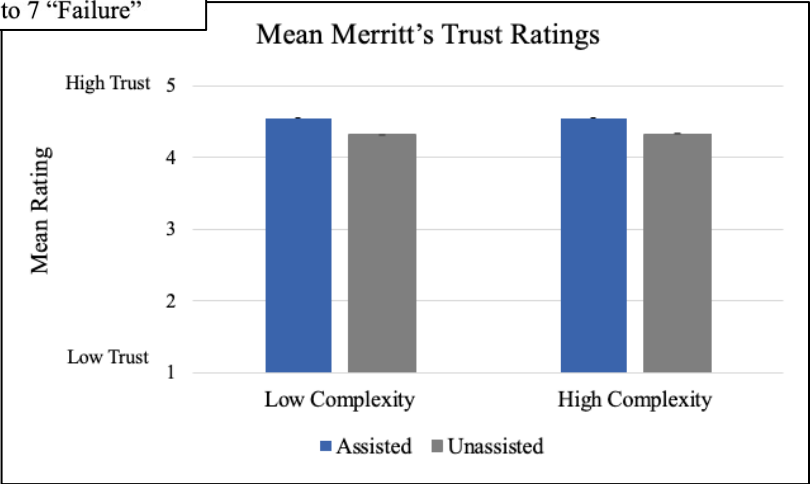
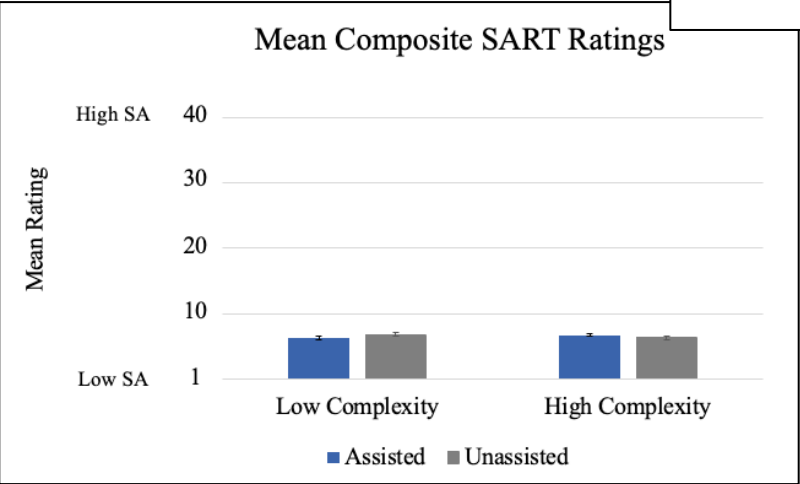
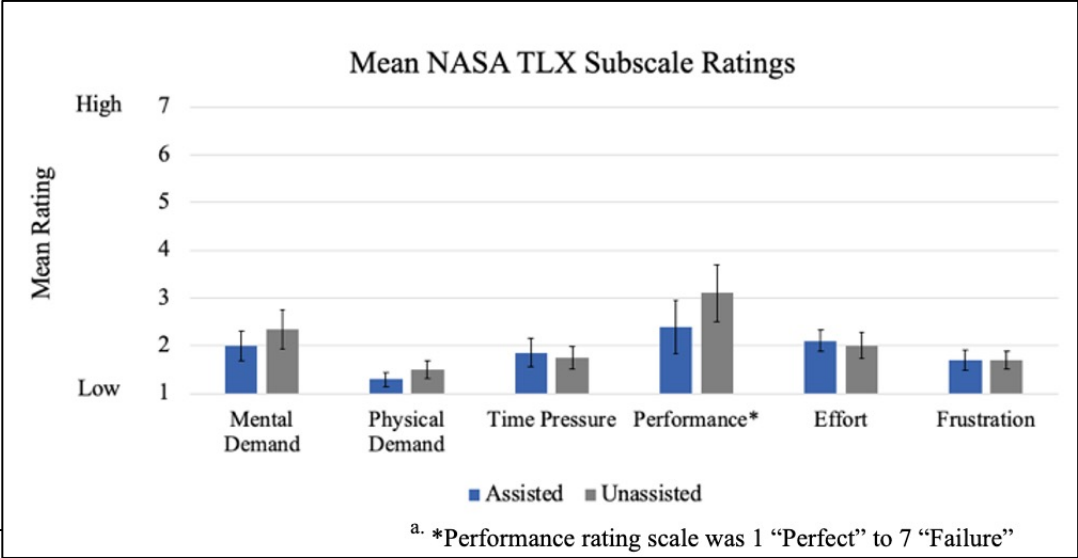
# FINDINGS

## Participants were generally *faster* and *more consistent* when responding in the Assisted Mode

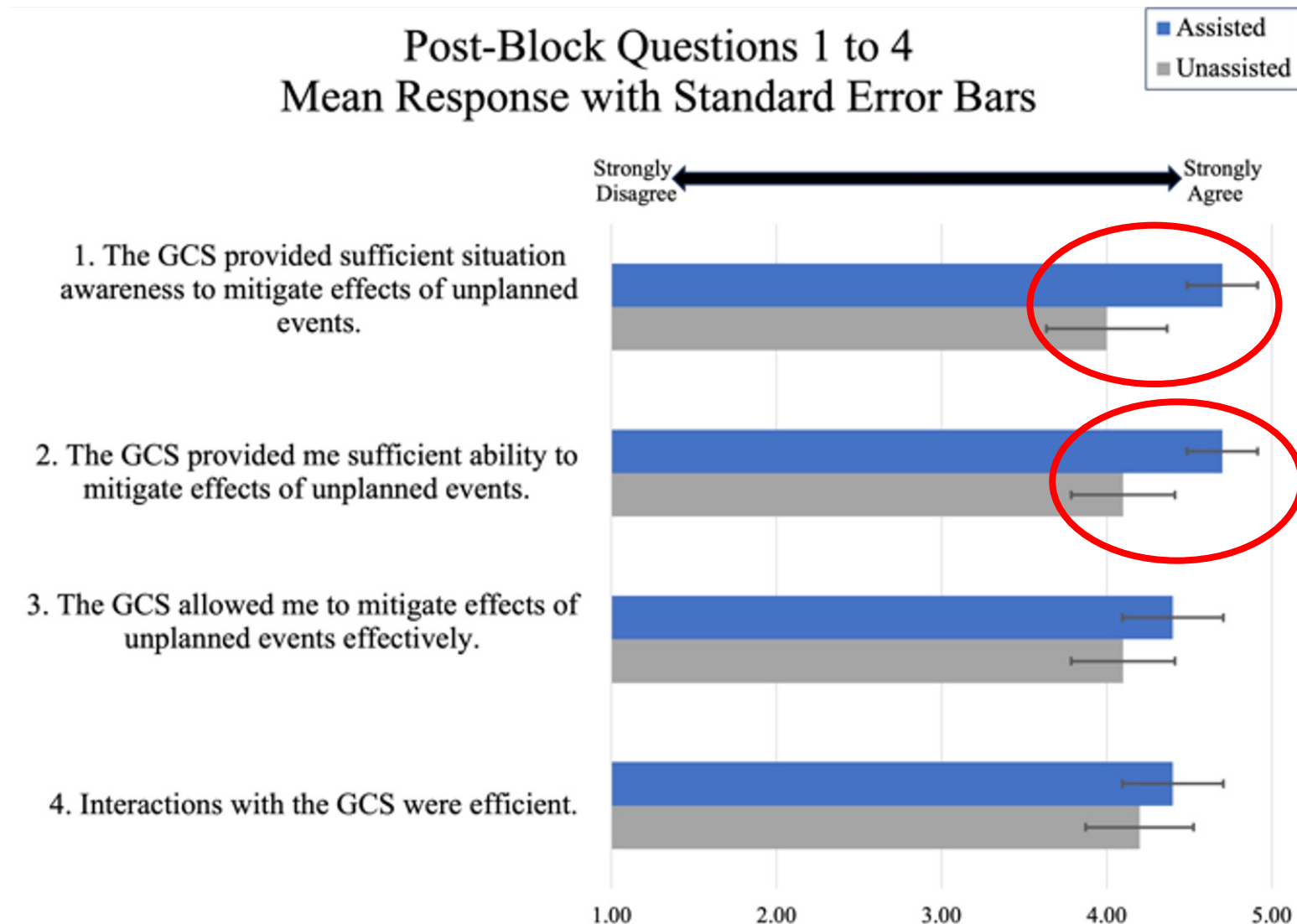
- In the Unassisted mode it was more difficult for the participants to detect the risk
  - Low Complexity: 2/10 participants previewed and executed a play, with the majority failing to notice the power loss event unfolding
  - High Complexity: 5/10 participants noticed the weather event and executed return to base for all assets
- In the Assisted Mode
  - For both Low and High Complexity: 0 participants failed to notice the onset of the contingency event
  - Assisted mode found to reduce response times by 45-50%

| Time From Contingency Onset to Play Execution |                              |                             |
|-----------------------------------------------|------------------------------|-----------------------------|
|                                               | Assisted Mode                | Unassisted Mode             |
| Low Complexity                                | 43.00s<br>(15.53s)<br>N = 5  | 77.50s<br>(15.50s)<br>N = 2 |
| High Complexity                               | 33.50s<br>(11.57s)<br>N = 10 | 66.80s<br>(28.09s)<br>N = 5 |

- GCS mode not found to have significant effect on pilot ratings of workload, situation awareness, or trust



- Pilot usability ratings suggest a slight preference for using GCS with the Assistant



- This work was an initial exploration of a human-autonomy assistant for the remote operator of multiple sUAS
  - Participants were generally faster and more consistent in responding to the contingency event in Assisted Mode
  - No statistically significant differences found between Assisted and Unassisted Modes in subjective ratings of Workload, SA, and Trust
  - Some usability results point to preference for Assistant
- Future work will include the development of an assistant to support the remote operator managing multiple vehicles with the plan to include a greater number of participants, and a greater number of scenarios and data collection runs.
  - Continued development of an Assistant with the Integration of functionalities into the system to apply these principles
    - Transparency
    - Two-way communications
    - Ability for human to override



# THANK YOU!



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## Questions?

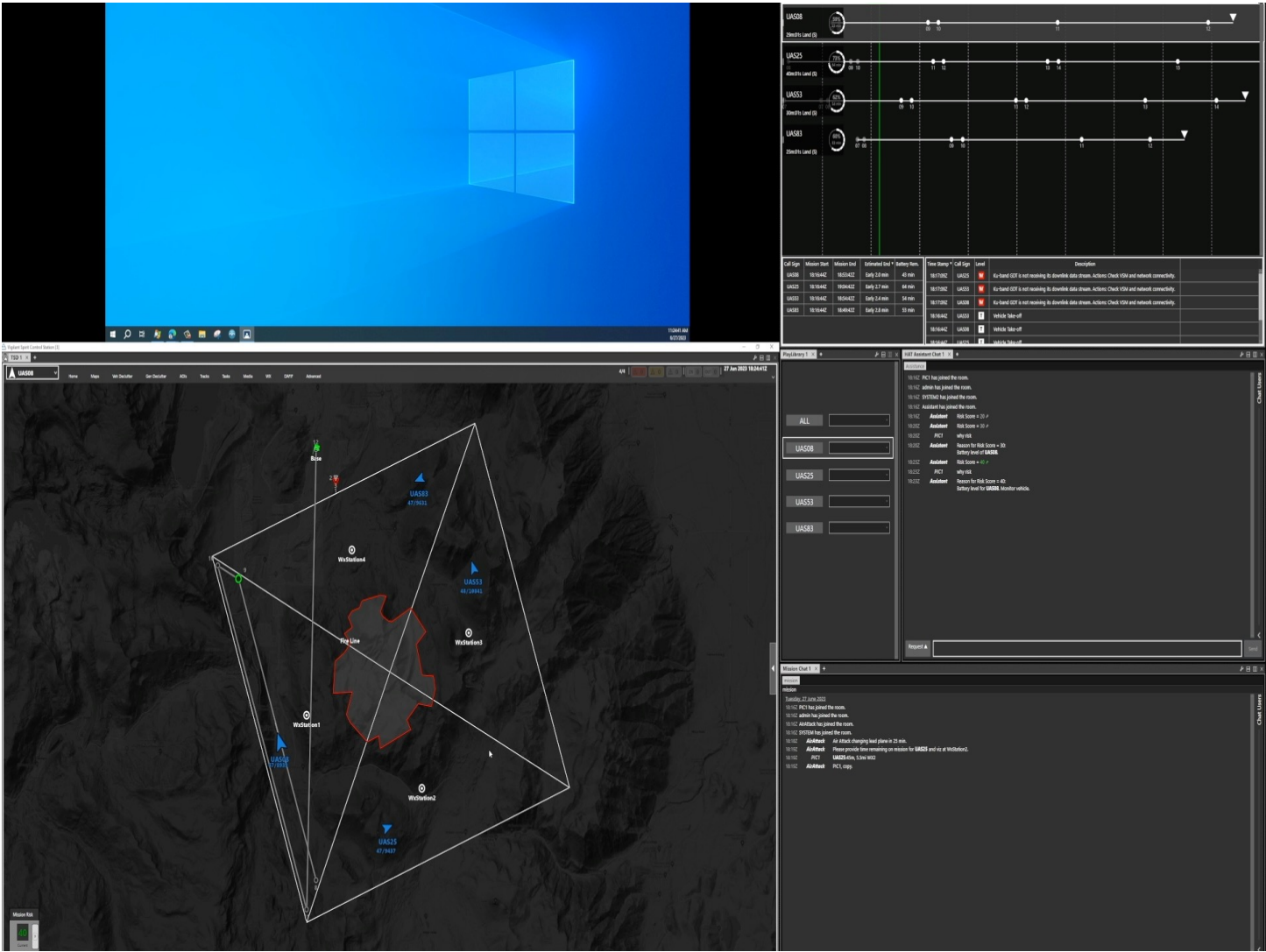
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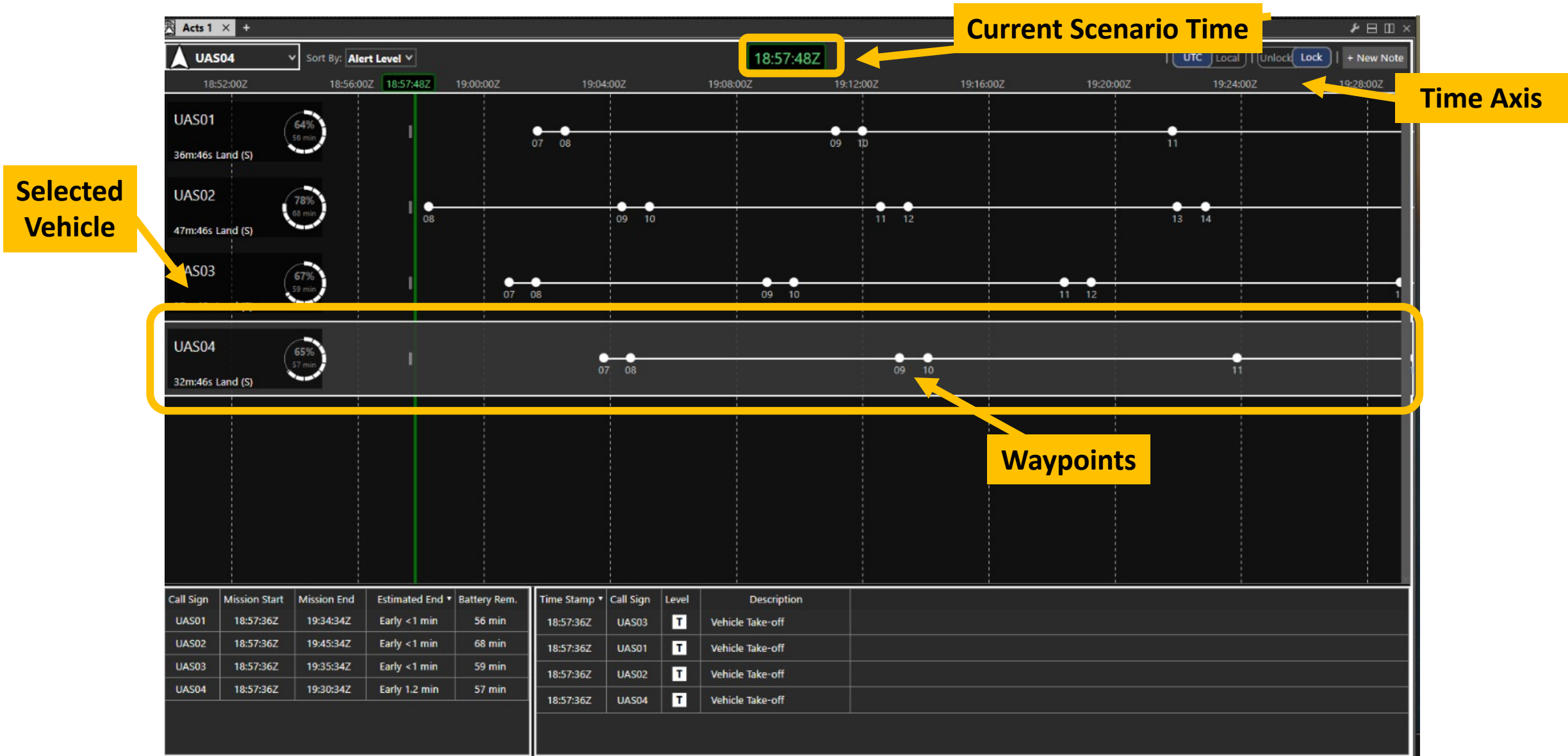


**BACK UP SLIDES**



# HAT Assistant Demo







- **Design for safe and trusted human-autonomy teaming**
  - technological aids for verifiable artificial intelligence (AI) decisions; trust modeling, measures, and management, and fundamental issues of trust and barriers to adoption of AI-enabled autonomy in complex socio-technical systems.