Integration and Testing of a UAS Airspace Management System in the Wildland Firefighting Environment

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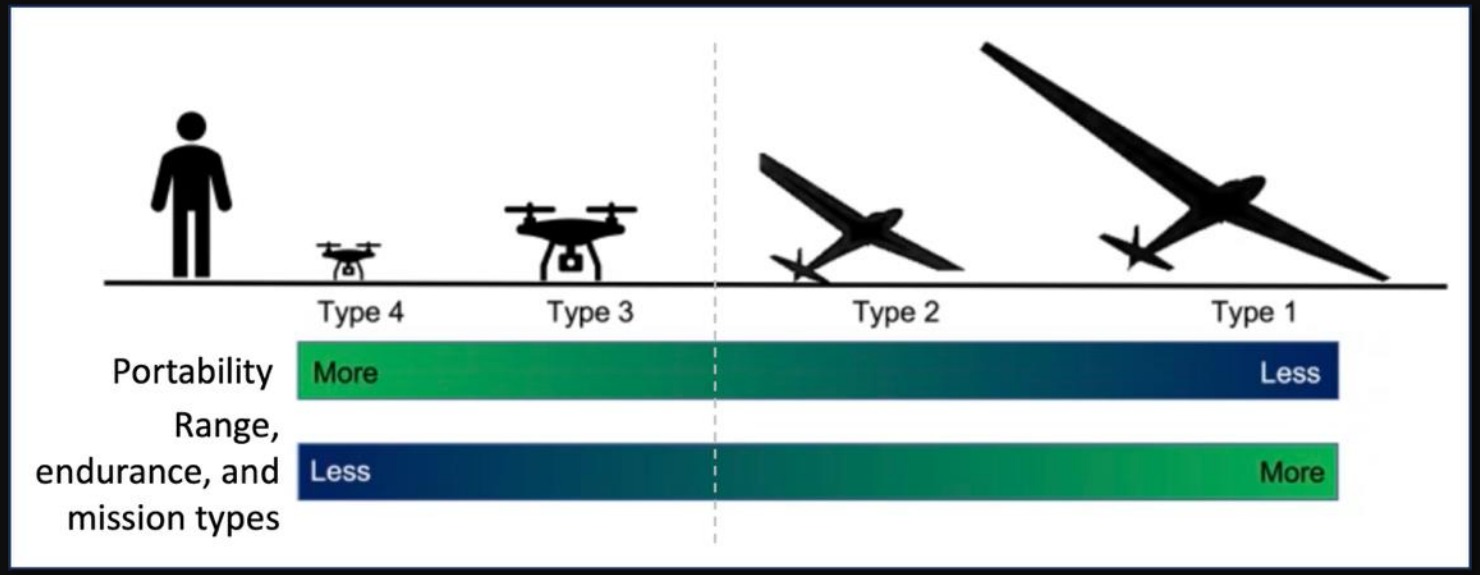
Wildland Fires

- Wildland fires are growing in number of acres burned each year, 8.9 million acres in 2024
- In the western US, the incidence of large forest fires has increased
- NASA is looking at how technology can be used to provide additional support in fighting wildland fires

National Wildfire Coordinating Group (NWCG)

Uncrewed Aircraft System (UAS) in Wildland Firefighting



- Real-time video capture
- Locating “hot spots”
- Aerial ignition
- Lower altitudes
- Fly for less than an hour

- Equipped with thermal imaging equipment to map the fire perimeter
- Higher altitudes
- Fly as long as 12 hrs

UAS Benefits

Reduced risk for the human pilot; though UAS are not without risk

Potentially operate in low-visibility conditions (nighttime, smoke)

Operate in areas that are difficult for helicopters to reach, around terrain, at lower altitudes

UAS Challenges

Wildland firefighting is conducted under adverse conditions, limited/no communications infrastructure

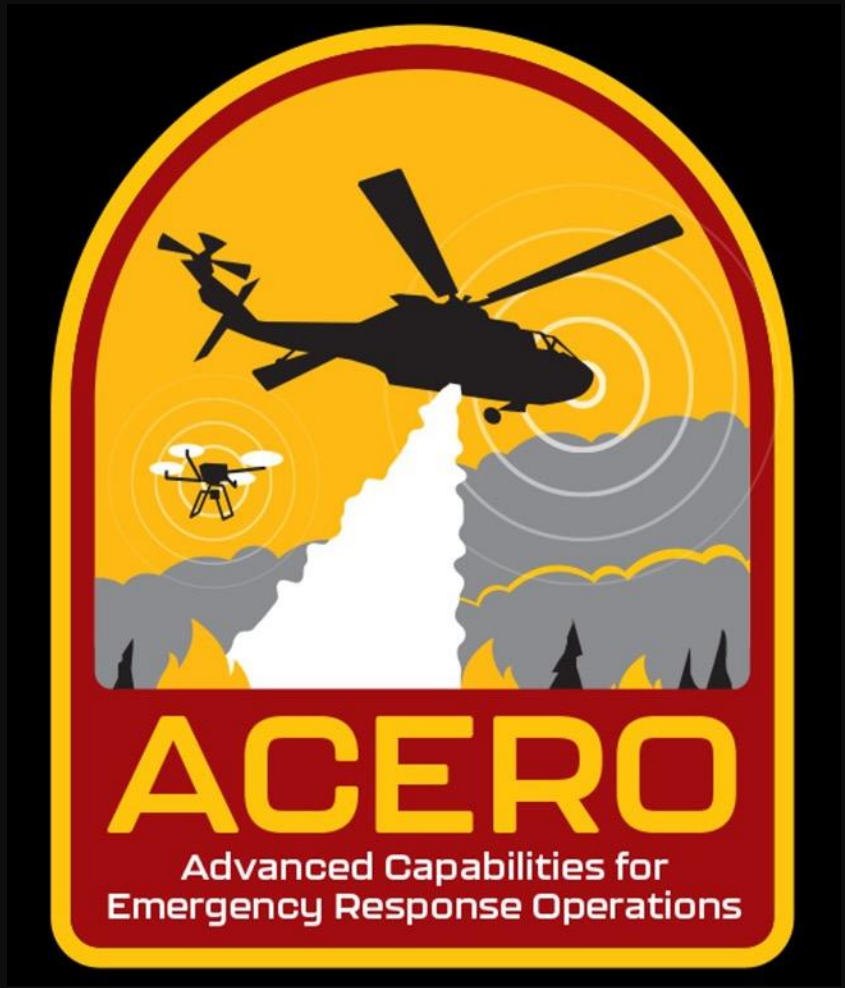
BVLOS makes it challenging for UAS crews to develop good **situation awareness** about the airspace

UAS crews generally rely on radio communications to build **situation awareness** of the airspace

Crewed aircraft pilots may have limited **awareness** of where each UAS is operating

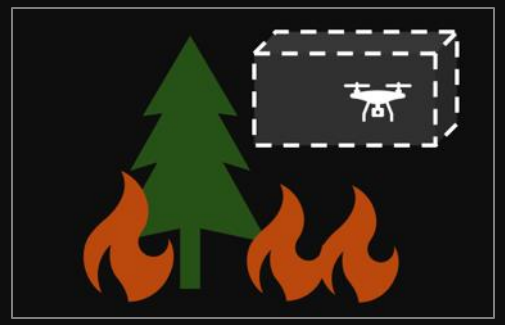
Advanced Capabilities for Emergency Response Operations

- Multi-year project, launched in 2023
- Led by NASA Ames Research Center
- Develop, demonstrate, and transition-to-operation emerging aviation technologies that will enhance the safety of wildland fire management
- Address challenges that UAS operators face at wildland fires
- Use UAS to extend aerial support in visually degraded environments



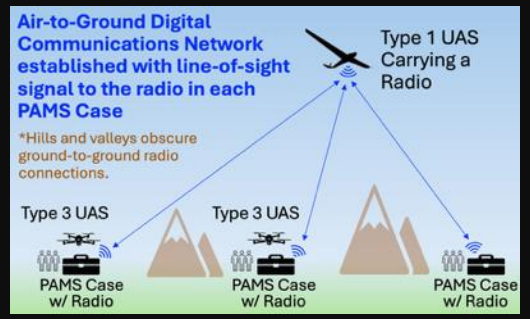
ACERO's Portable Airspace Management System (PAMS)

- Field-deployable research prototype
- Allows users to digitally coordinate multiple UAS operations
- Supports information exchange in challenging terrain
- Supports situation awareness, a common picture of the airspace



WFSS Airspace Management System

PAMS Cases



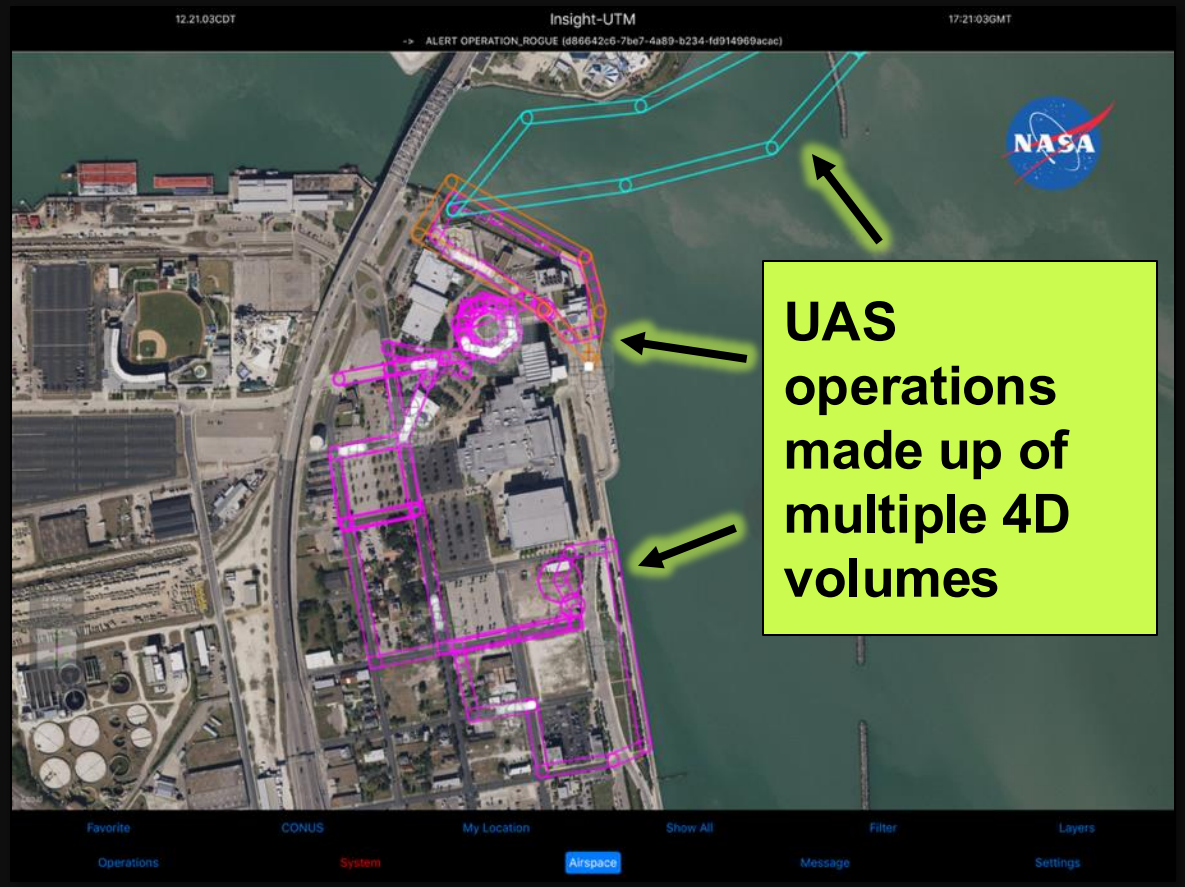
Air-to-ground Digital Communication

User Interface

Decision Support Tool

UAS Traffic Management (UTM)

- New paradigm for airspace management
- Intent sharing using a community-based approach
- Operators define a 4D volume of airspace (location, alt, time)
- UTM Service Supplier (USS):
  - Submit 4D volumes
  - Check for volume conflicts
  - Receive approval/feedback
  - Monitor conformance



UTM Service Supplier (USS) User Interface

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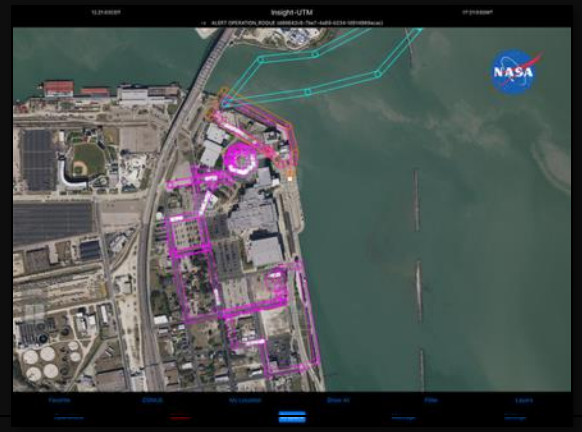
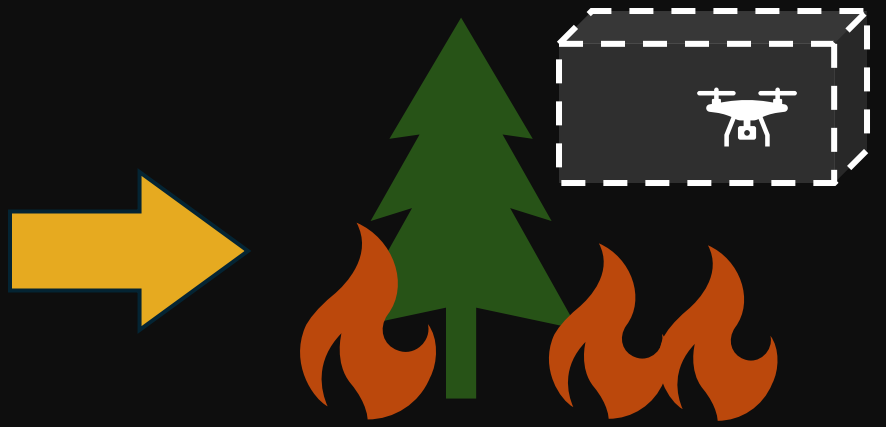
- WFSS Airspace Management System
- PAMS Cases
- Air-to-Ground Digital Radio Communication
- User Interface
- Decision Support Tool



UTM Service Supplier (USS)



Wildland Fire Service Supplier (WFSS) "wolfs"

- Ensures that 4D volumes are deconflicted
- Monitors conformance to the 4D volumes
- Checks for violations of airspace constraints (Temporary Flight Restriction)

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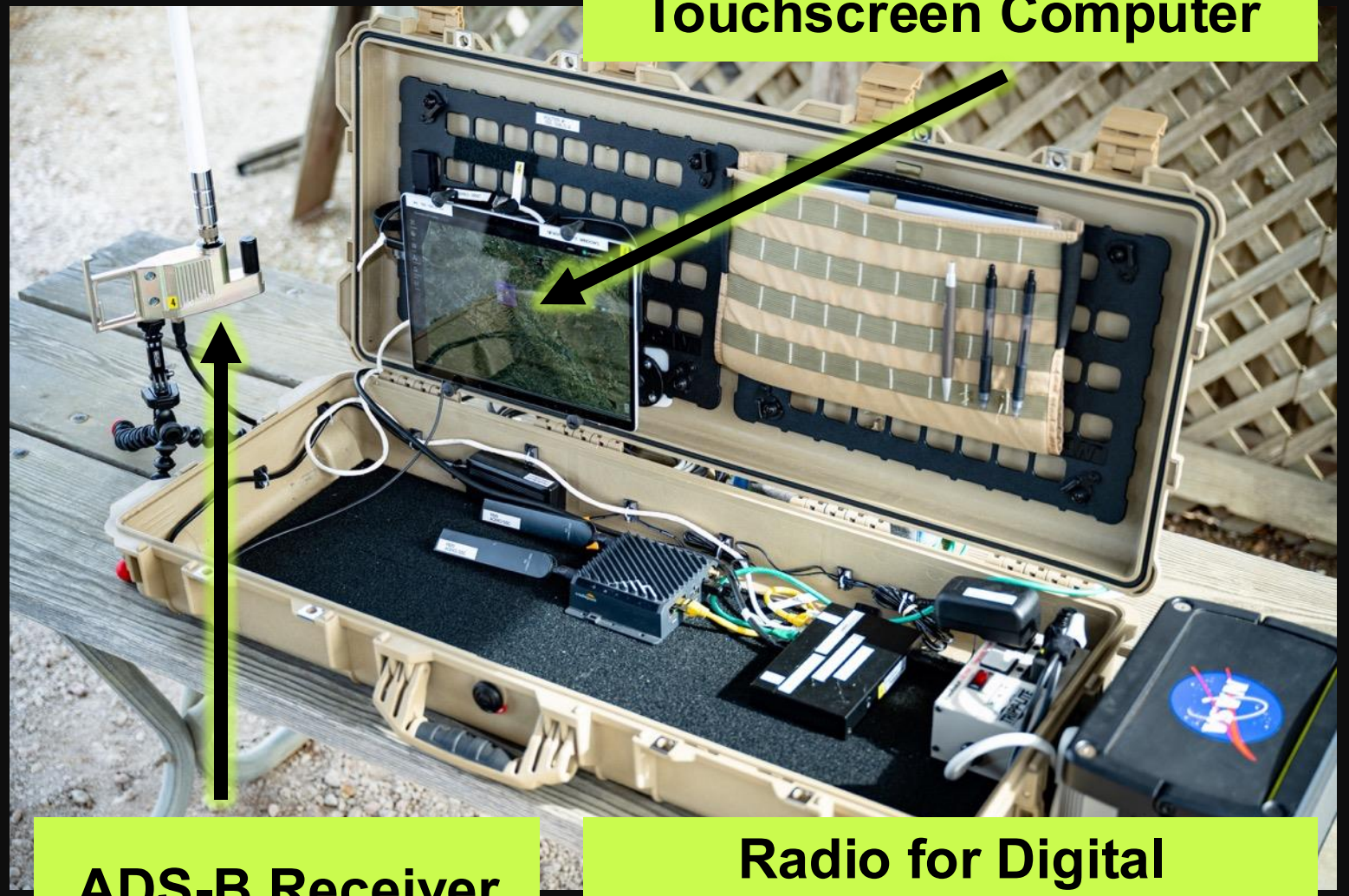

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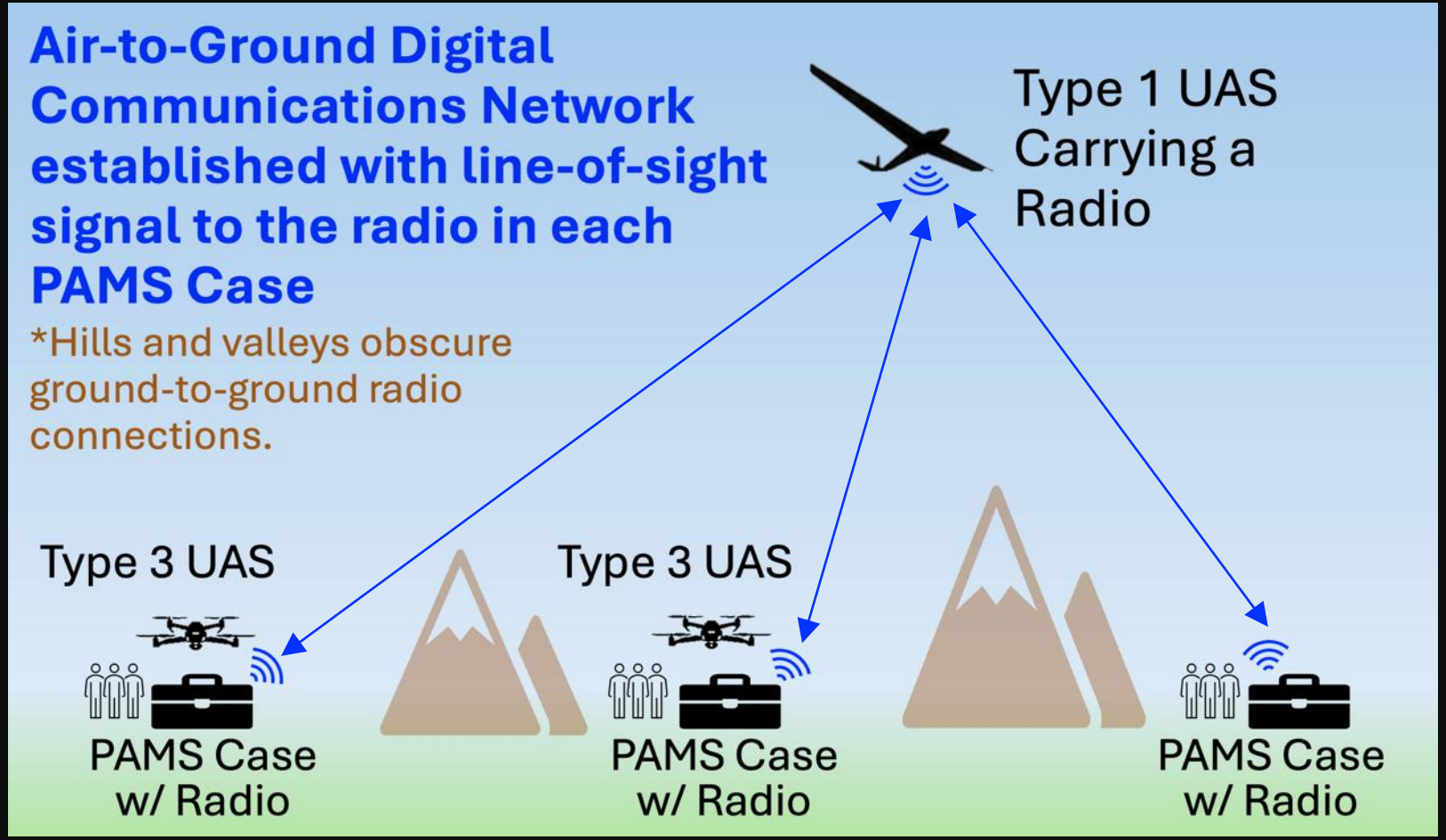

- Airborne radio establishes line-of-sight connection with PAMS cases

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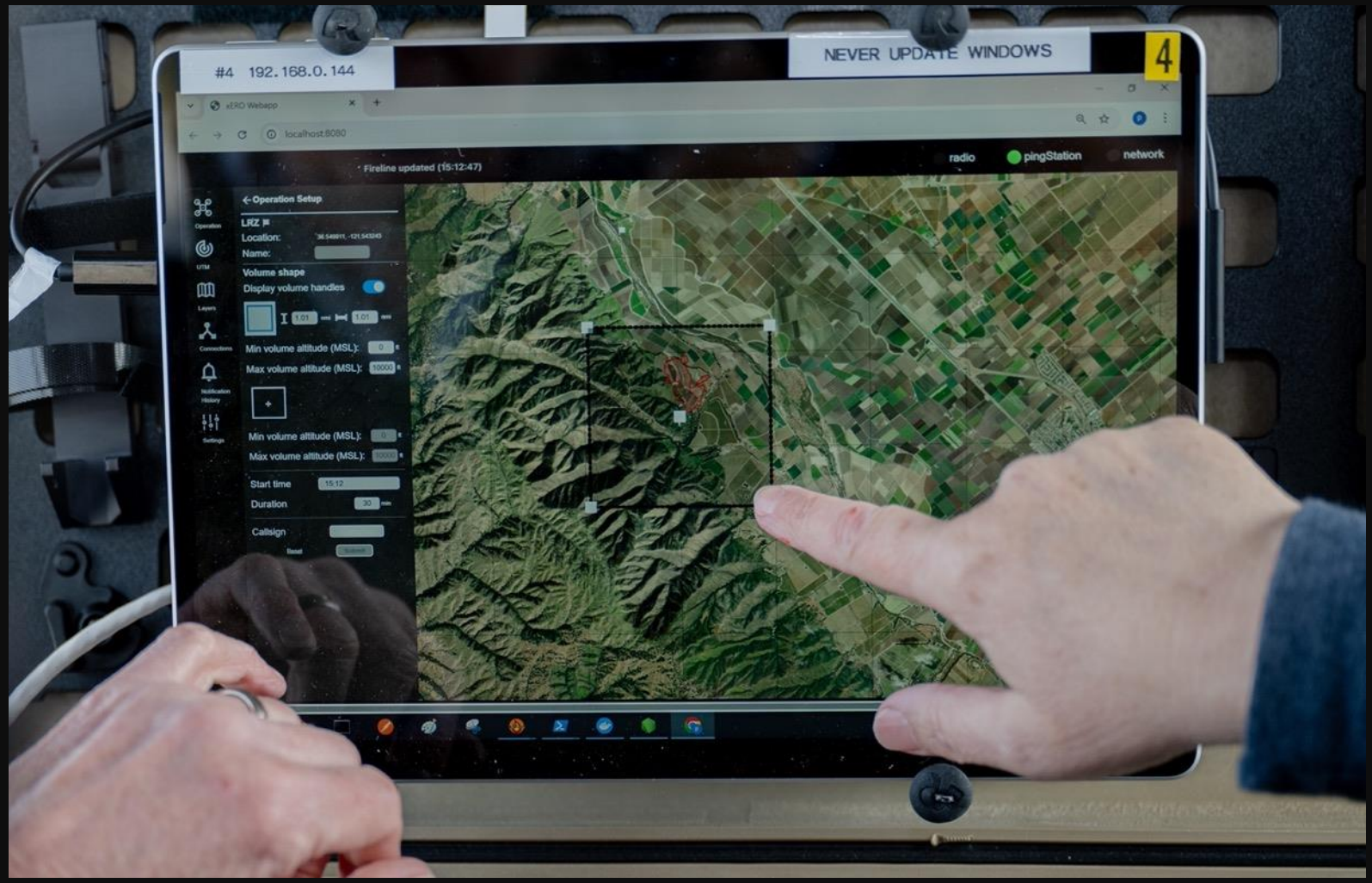

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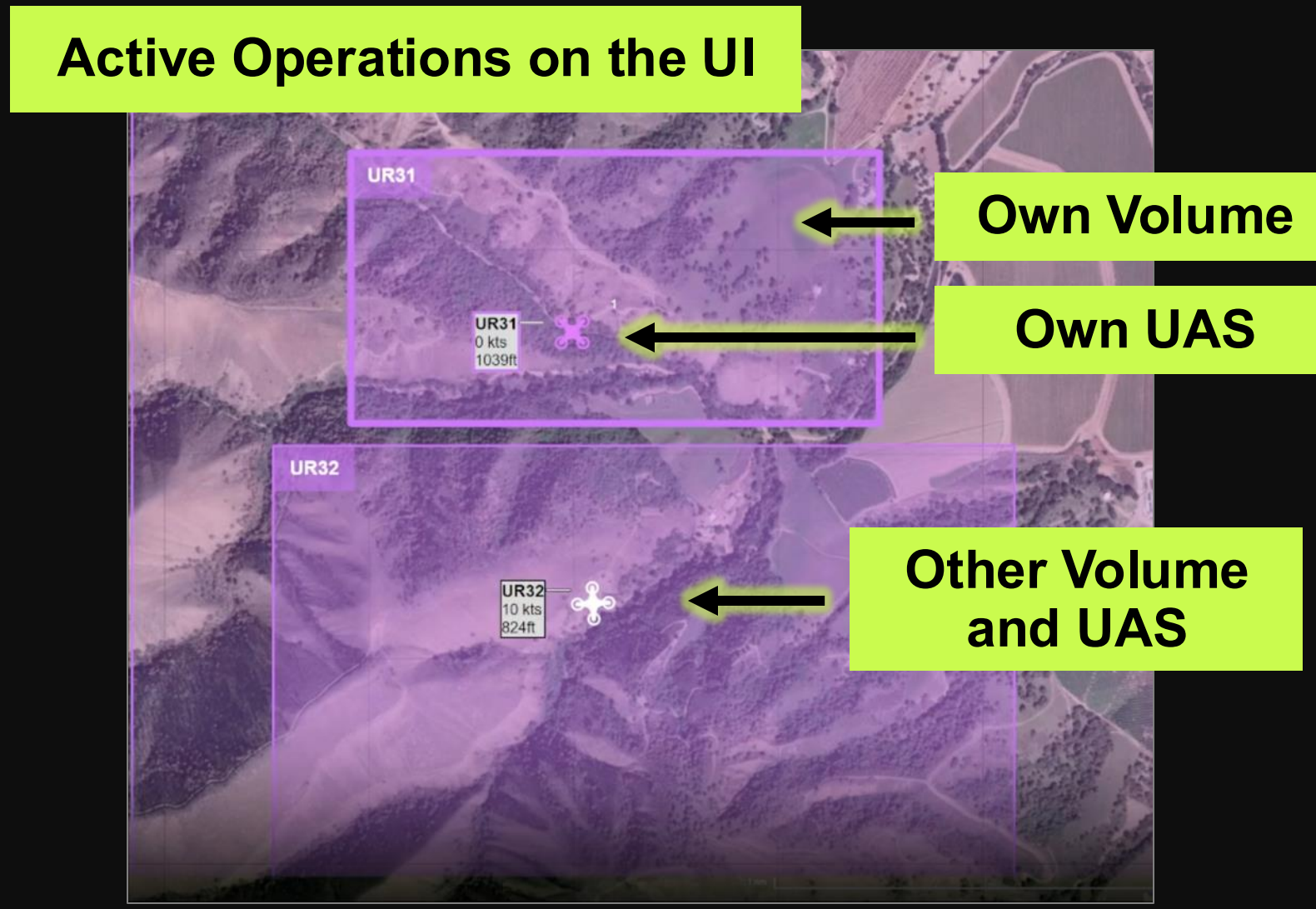

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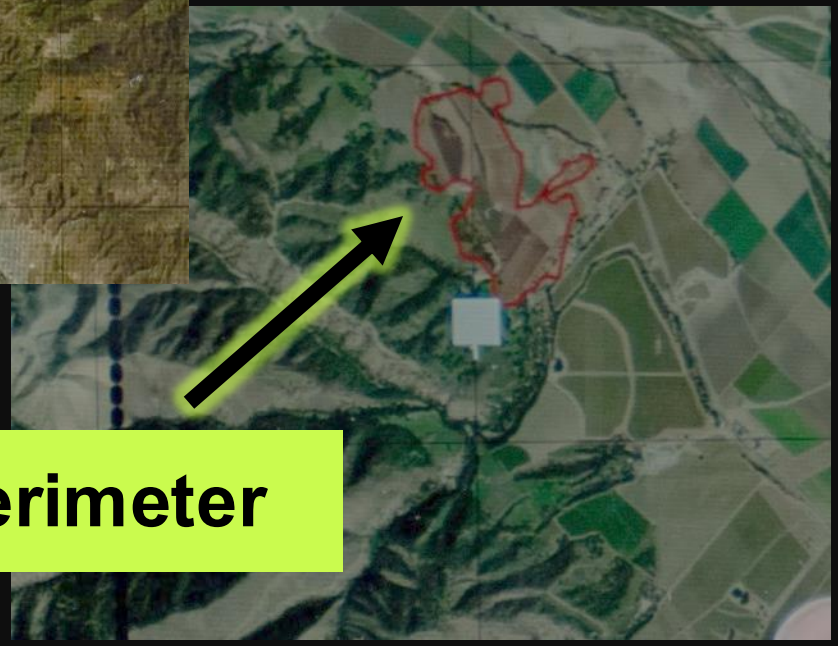
Crewed Aircraft (ADS-B messages)



Fire Perimeter

ACERO's First Field Demonstration (TCL-1)

- Salinas, CA, March 2025
- Foothills of the Sierra de Salinas mountains
- Terrain that made radio communications challenging
- No ground-to-ground comm between cases
- Relied on the radio carried by the Type 1 UAS

Gregory Costedoat

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ACERO's First Field Demonstration (TCL-1)

- Two Type 3 UAS

- One Type 1 UAS equipped with a digital radio (alternated)

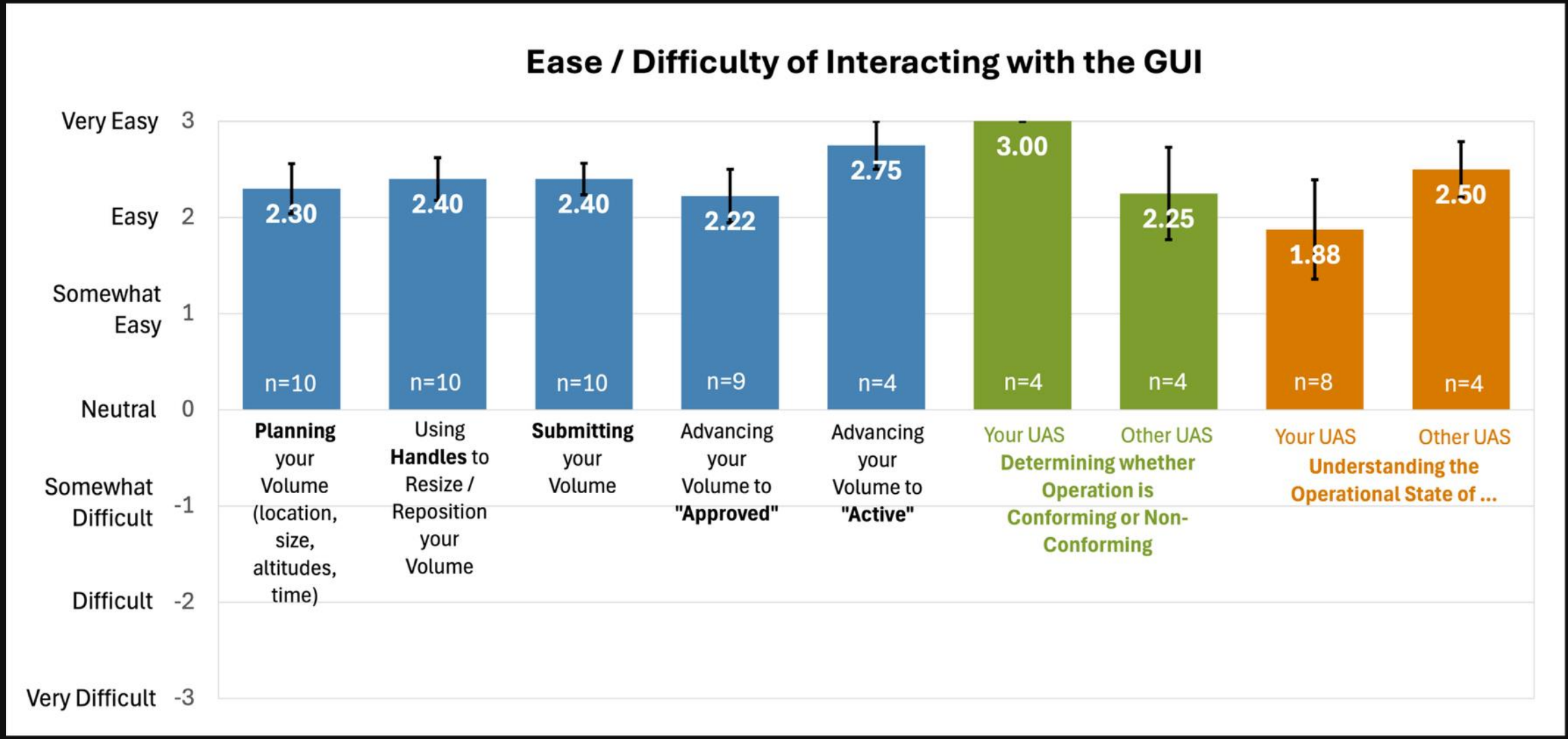
FVR90 Overwatch Aero

NASA's Supervolo

ACERO's First Field Demonstration (TCL-1)

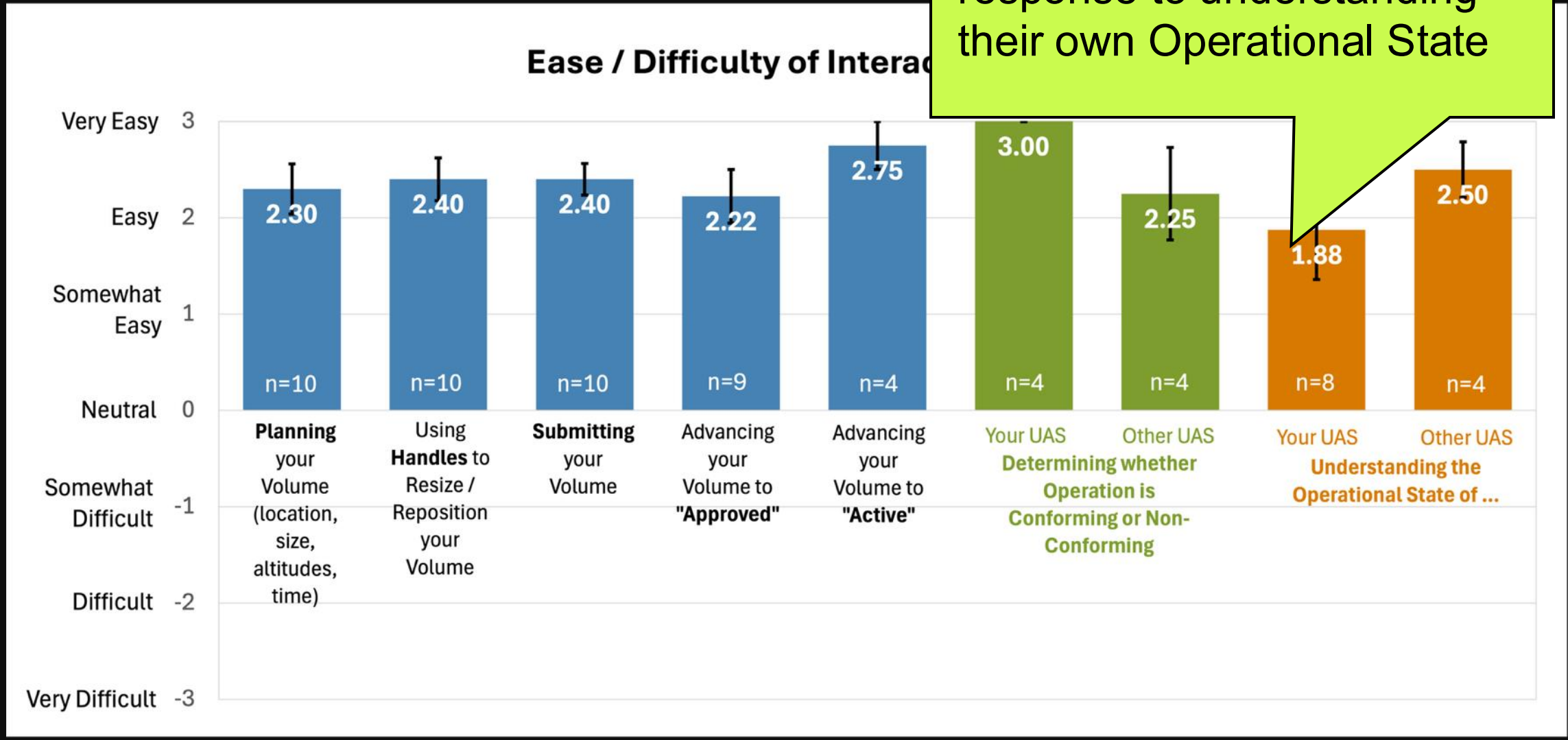
- Subject Matter Experts (SMEs) from the wildland firefighting community
- 11 operational runs over a 2-week period
- Included nominal runs and functional tests of WFSS
- SMEs completed questionnaires to assess ease of use, usability, and situation awareness

Qualitative Results: Interacting with the UI



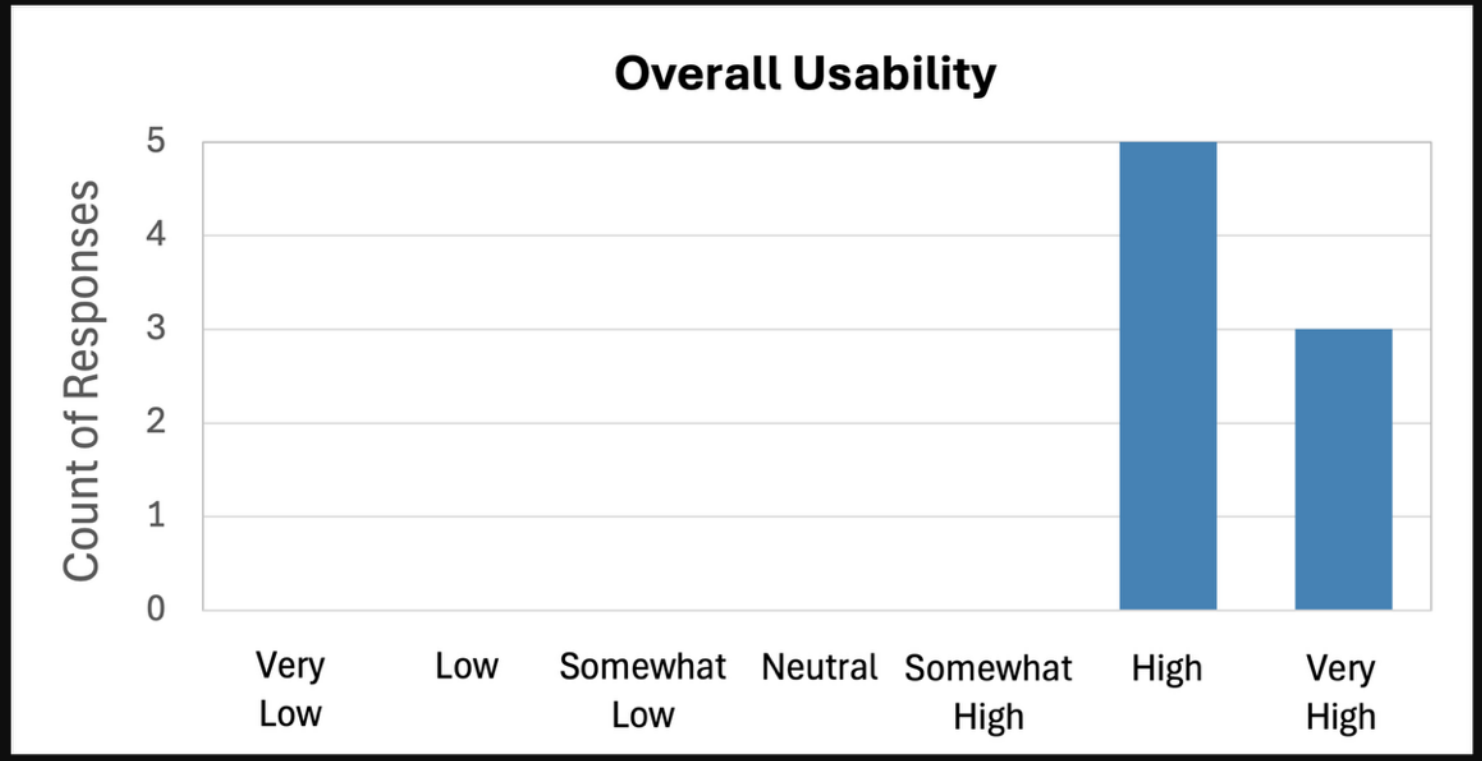
Qualitative Results: Intera

"**Somewhat Difficult**" in response to understanding their own Operational State



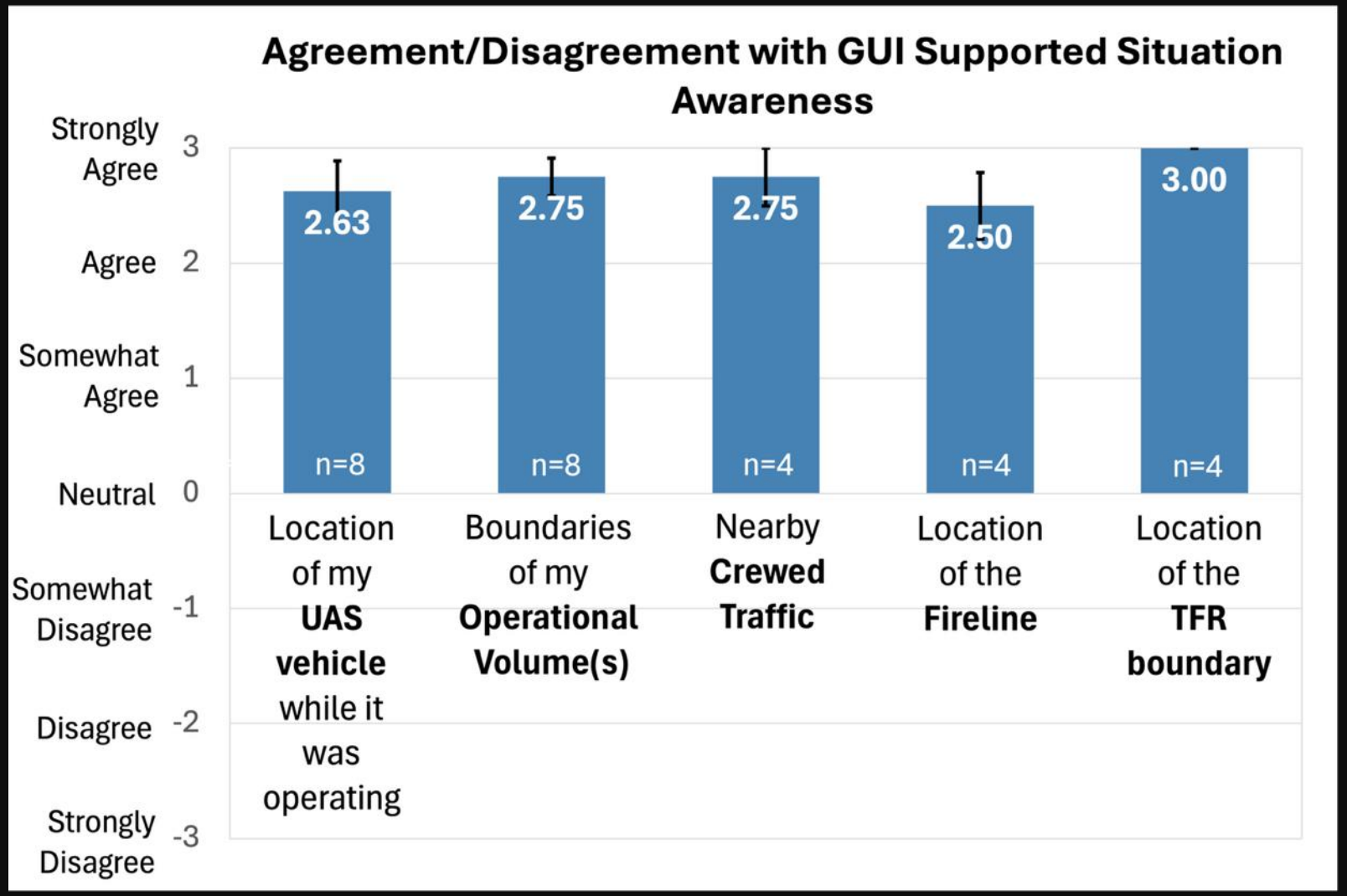
Qualitative Results: Usability

- Overall, high ratings of usability (*n*=8)
- Continue to improve usability by:
- Increasing the saliency of notifications / alerts
- Adding a profile (side) view to the map
- Provide more direct access to information



Qualitative Results: Situation Awareness

- On average, high ratings of Situation Awareness
- Continue to improve Situation Awareness by:
- Adding more vehicle telemetry
- Adding range rings for notification of nearby aircraft



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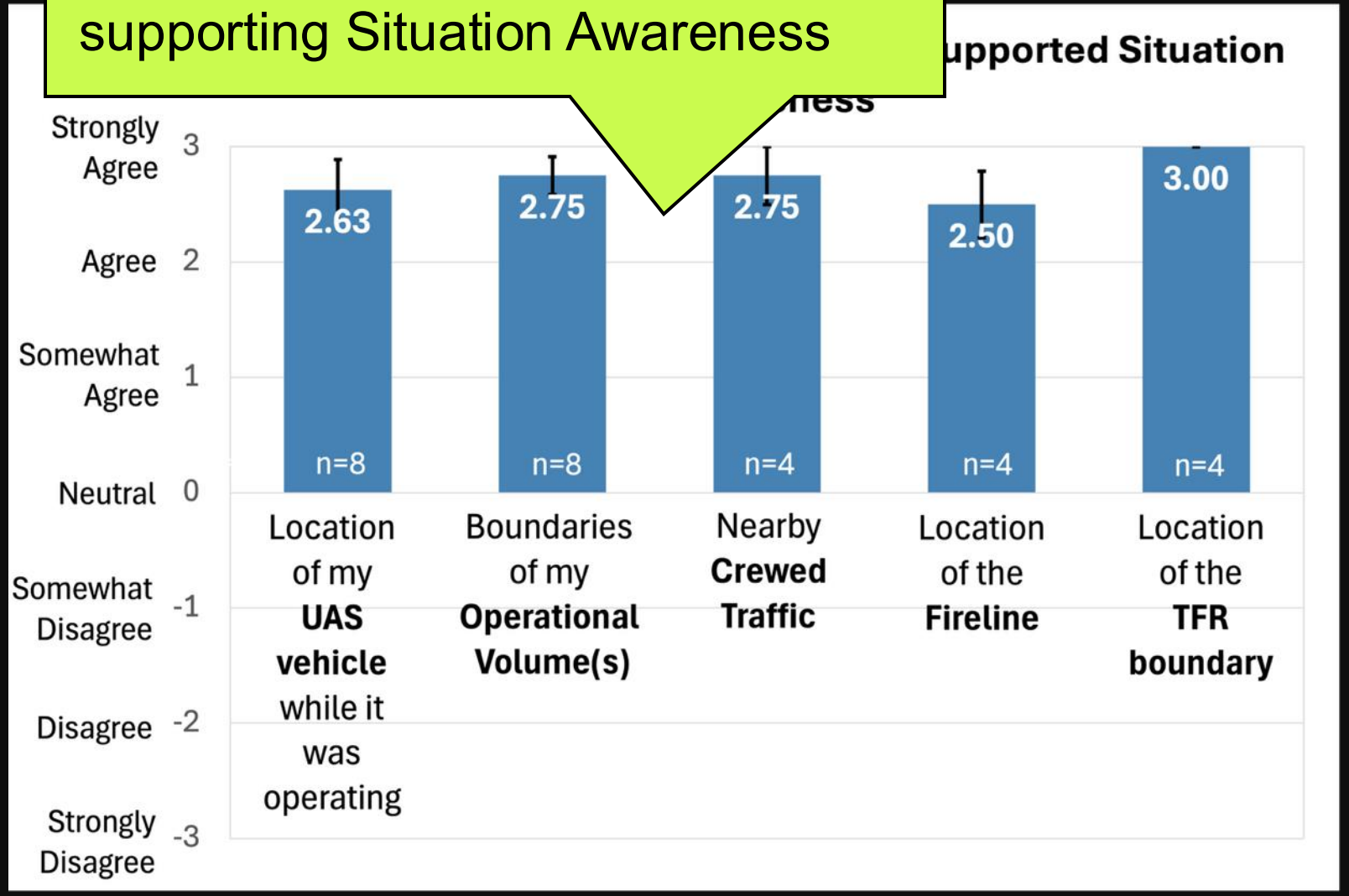
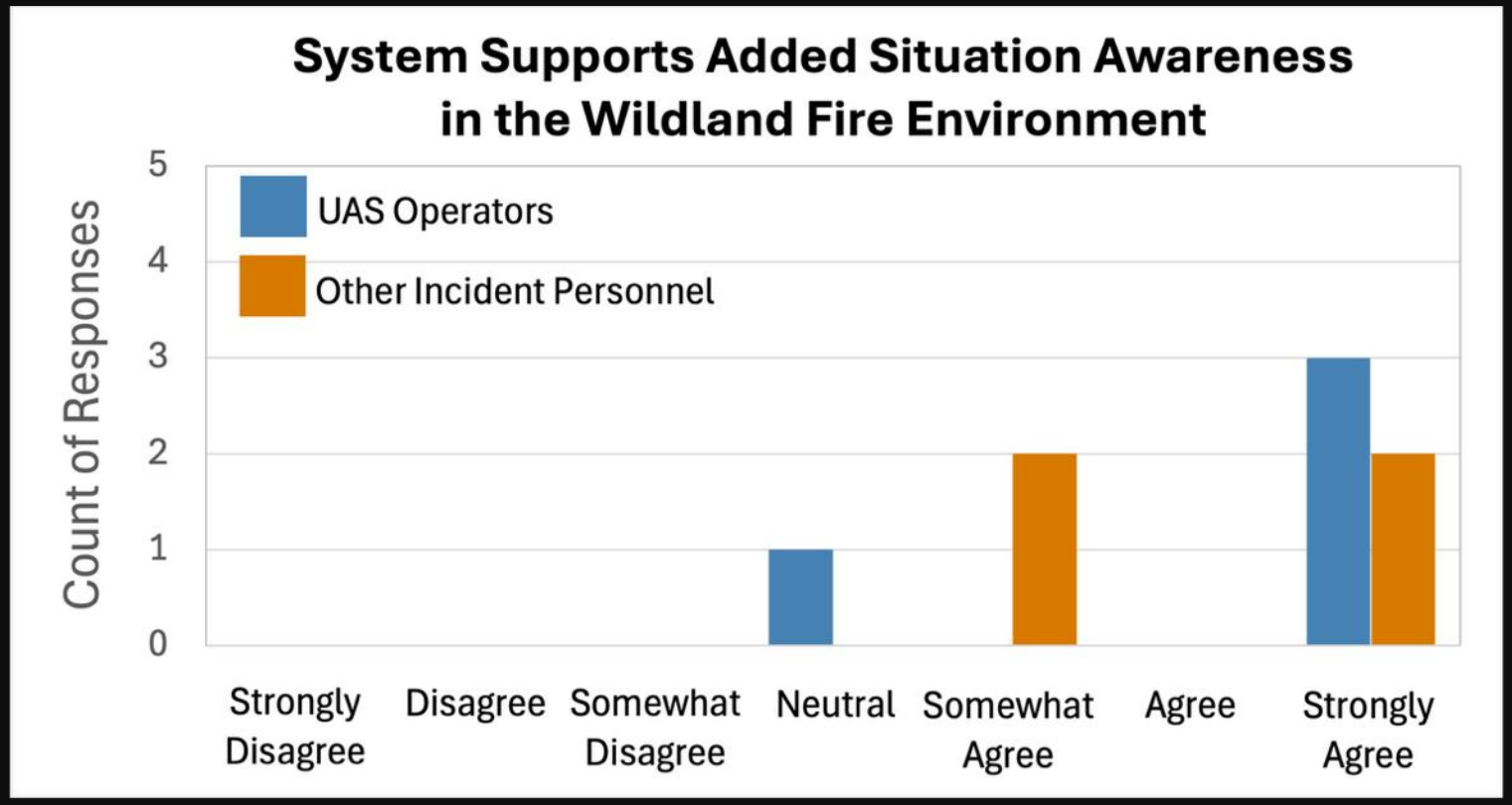
SMEs rated the **location of UAS and crewed traffic** on the map as the most important factors for supporting Situation Awareness



Qualitative Results: Situation Awareness

- Mixed ratings of Situation Awareness for the real-world fire environment
- Continue to improve supporting Situation Awareness by:
- Need to simplify setup procedures
- Support additional real-world roles



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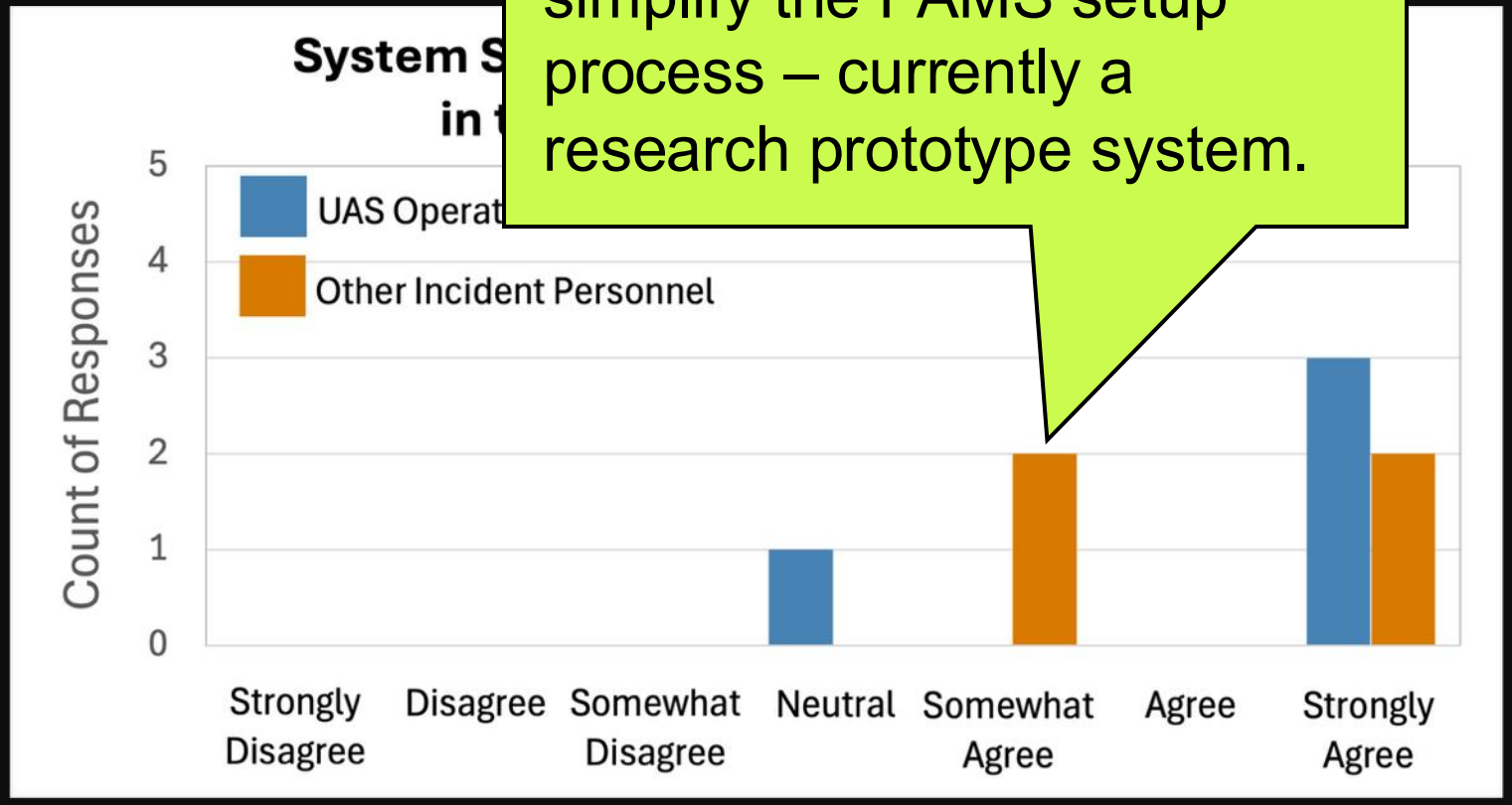
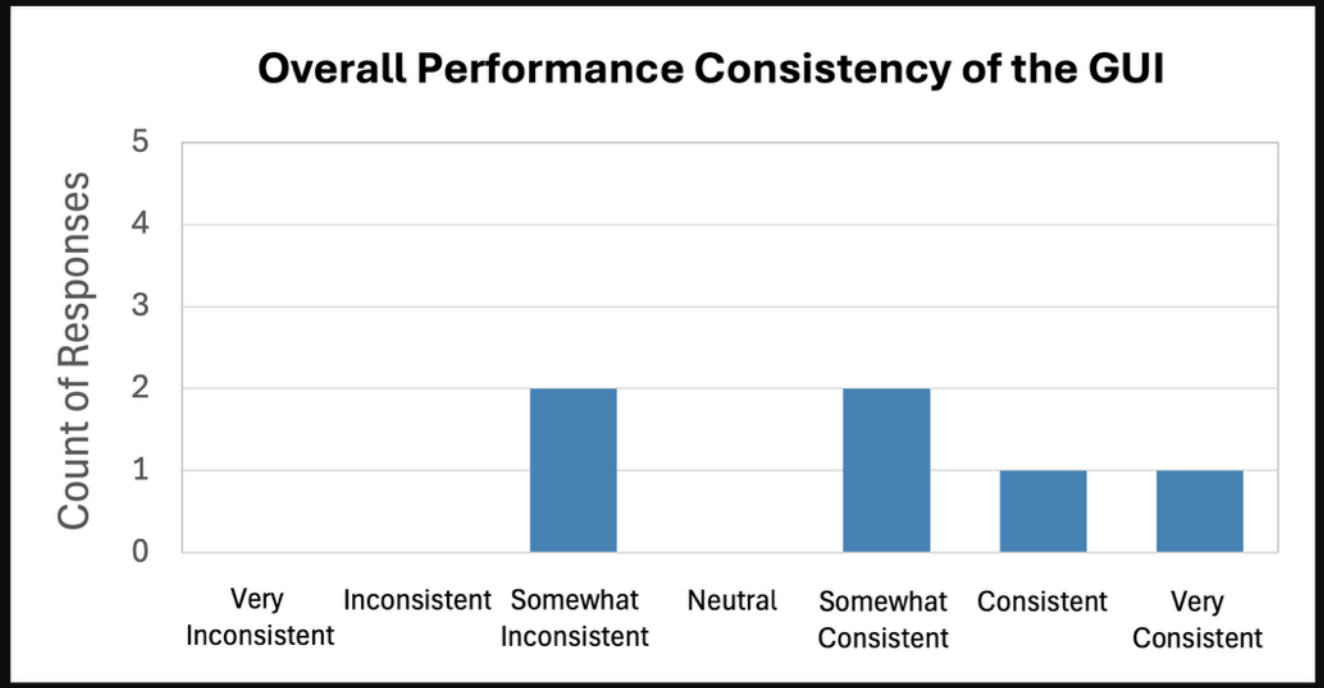
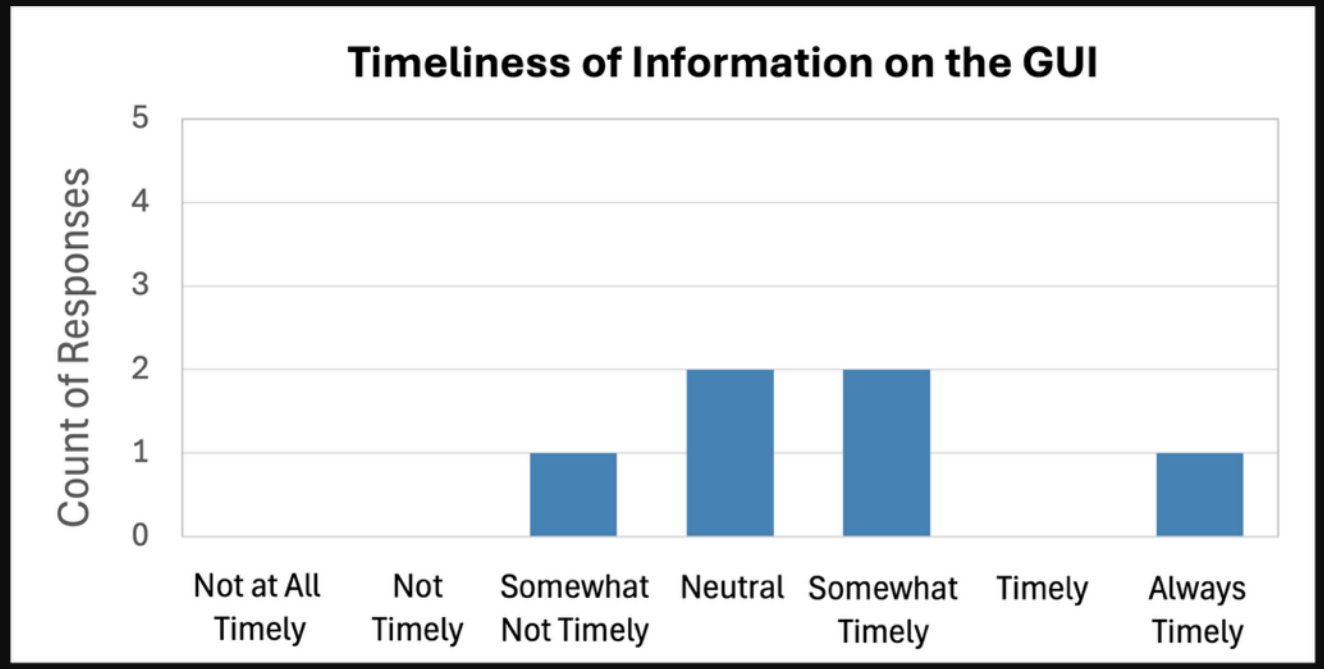


"**Somewhat Agree**" (*n*=2) may reflect the need to simplify the PAMS setup process – currently a research prototype system.

Qualitative Results

- During some runs, updates about other UAS operations were not displayed as quickly as expected
- Disruption of network activity attributed to:
- A *single* aerial relay radio did not support all of the ground radio nodes (4)
- Distance between ground radios and the aerial relay radio was too great





Toward ACERO's Second Field Demonstration

- Incorporating improvements to the UI
- Addressing the latency in updating information on the display
- Adding additional information and features to the UI, weather and terrain
- Additional support for flight planning

Advanced Capabilities for Emergency Response Operations