SJSU SAN JOSÉ STATE UNIVERSITY

Incorporating UAS Traffic Management into Wildland Firefighting Operations:

Initial Findings of Subject Matter Expert Interviews

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Uncrewed Aircraft Systems (UAS) in Wildland Firefighting

UAS in Wildland Firefighting:

- Real-time video
- Thermal imaging
- Aerial ignition in prescribed burns

Benefits of UAS:

- Remove human pilot from risk
- Operate in low-visibility
- Maneuverability
- Cost-effective technology application

Challenges and Tradeoffs

Wildland Firefighting: Conducted under adverse conditions, limited/no communications infrastructure.

BVLOS can make it challenging for the 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 (ACERO)

ACERO's Goal is to:

Develop → Demonstrate → Transition-to-Operation

Emerging NASA and Industry Aviation Technologies

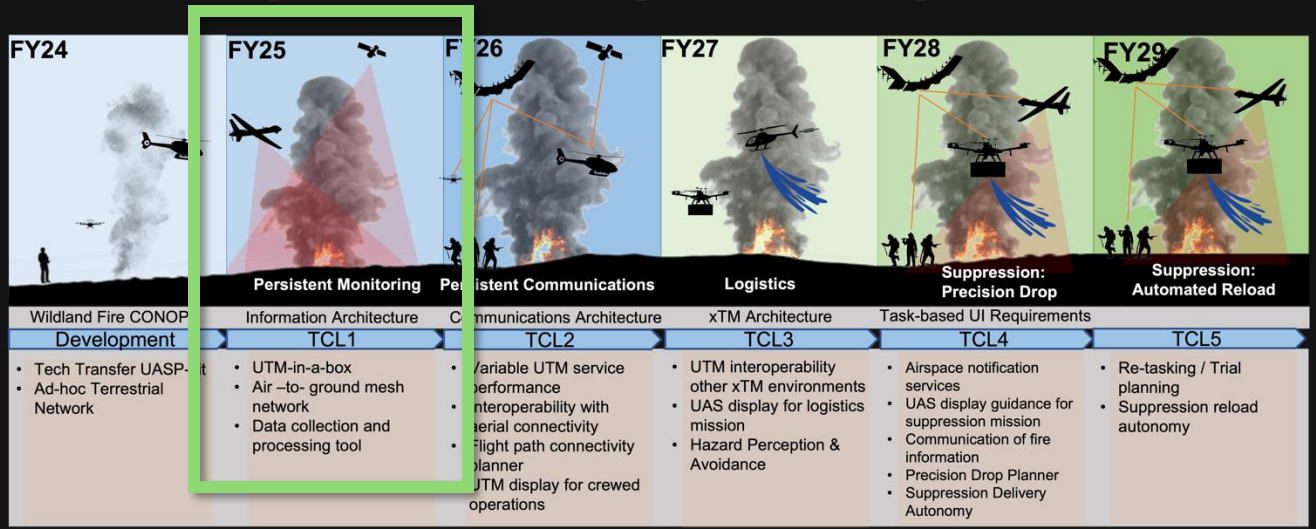
that can

- Identify
- Monitor
- & Mitigate

wildland fires

as a means to **enhance safety** and improve the efficiency of operations.

Advanced Capabilities for Emergency Response Operations (ACERO)



Technical Capability Level (TCL) demonstrations test increasingly complex missions needed for suppression in degraded visual environments

ACERO: Airspace Management in Wildland Firefighting

UAS Operations today:

- Adhere strictly to well-established safety procedures
- But use **manual coordination** to deconflict/use airspace

ACERO: Airspace Management

- Develop capabilities to support:
  - Enhanced planning
  - Monitoring
  - Deconfliction
  - Situation Awareness

ACERO: Airspace Management in Wildland Firefighting

Human Factors team:

- Conducted group interviews with Subject Matter Experts (SMEs):
  - **UAS Pilots (UASPs)** who fly wildland fire UAS missions
- Initial thoughts about an **Airspace Management system** in the wildland fire environment:
  - Current-day practices
  - Constraints

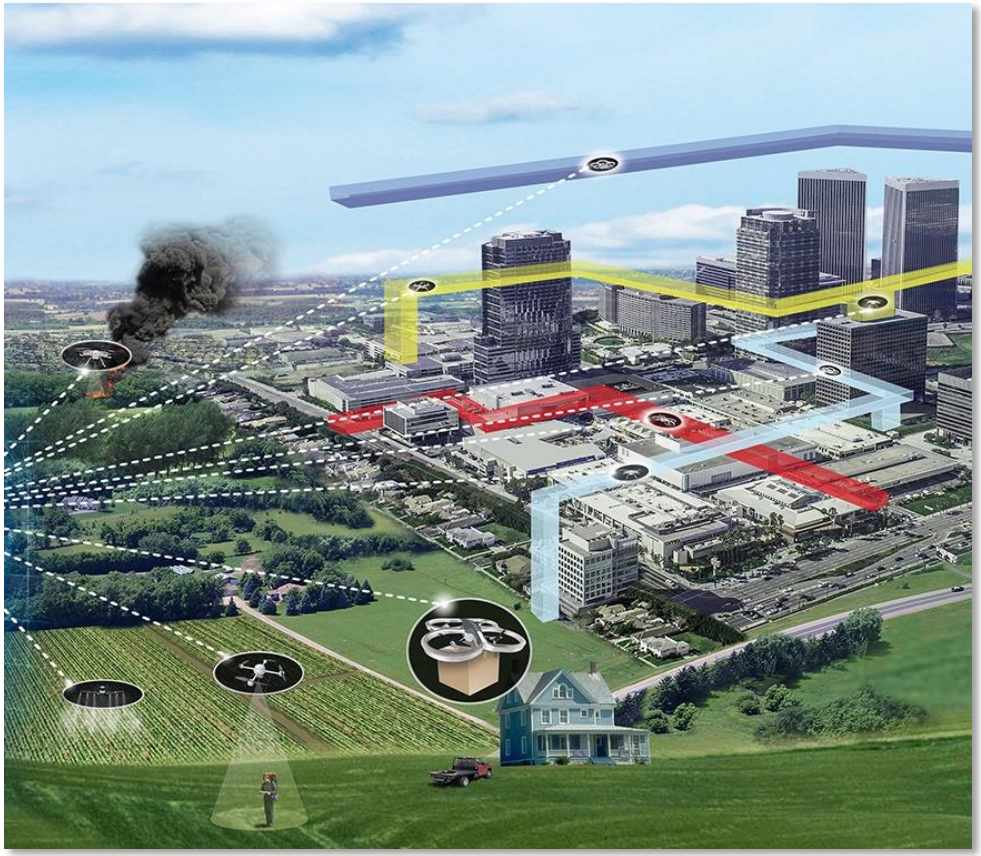
Background: Foundational NASA Research

UAS Traffic Management (UTM)

Scalable Traffic Management for Emergency Response Operations (STEReO)

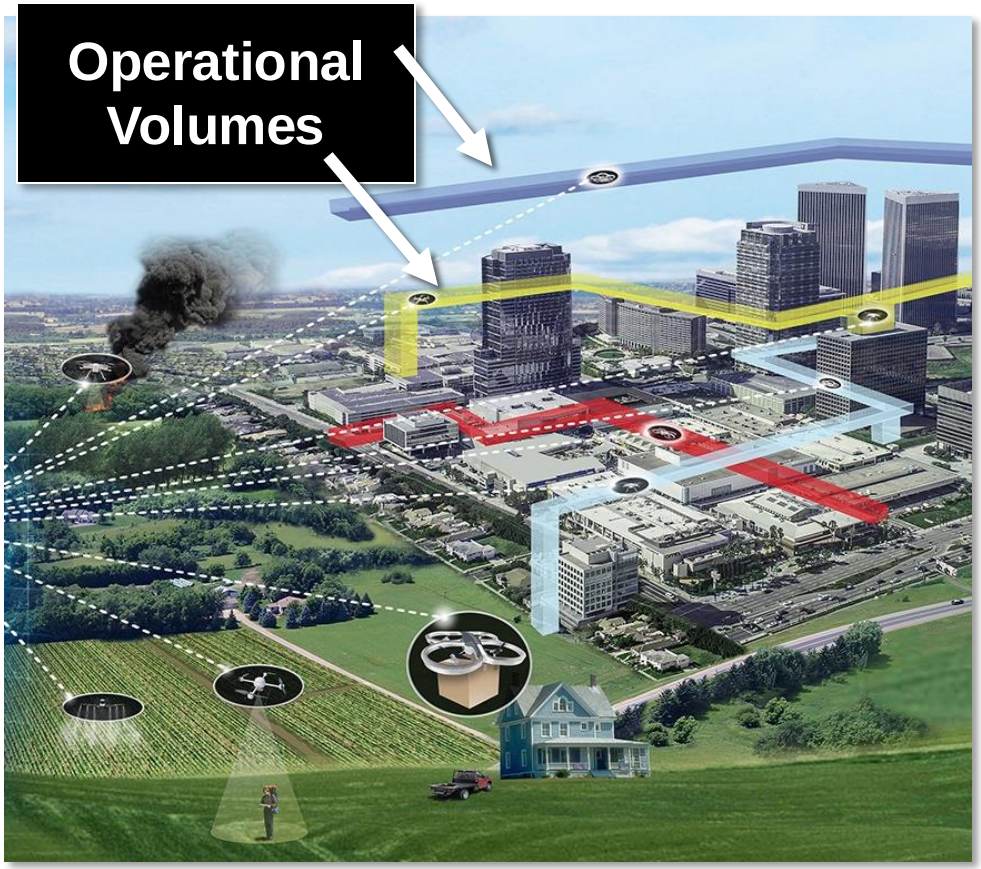
UAS Traffic Management (UTM)

- Arose from the need to **safely manage** a high number of small UAS, below 400 ft
- Necessitated a new, **cooperative approach** for air traffic management
- Operators will use third-party **service suppliers** for:
  - Connecting with other operators, sharing intent information, planning, deconflicting, and monitoring conformance.



UAS Traffic Management (UTM)

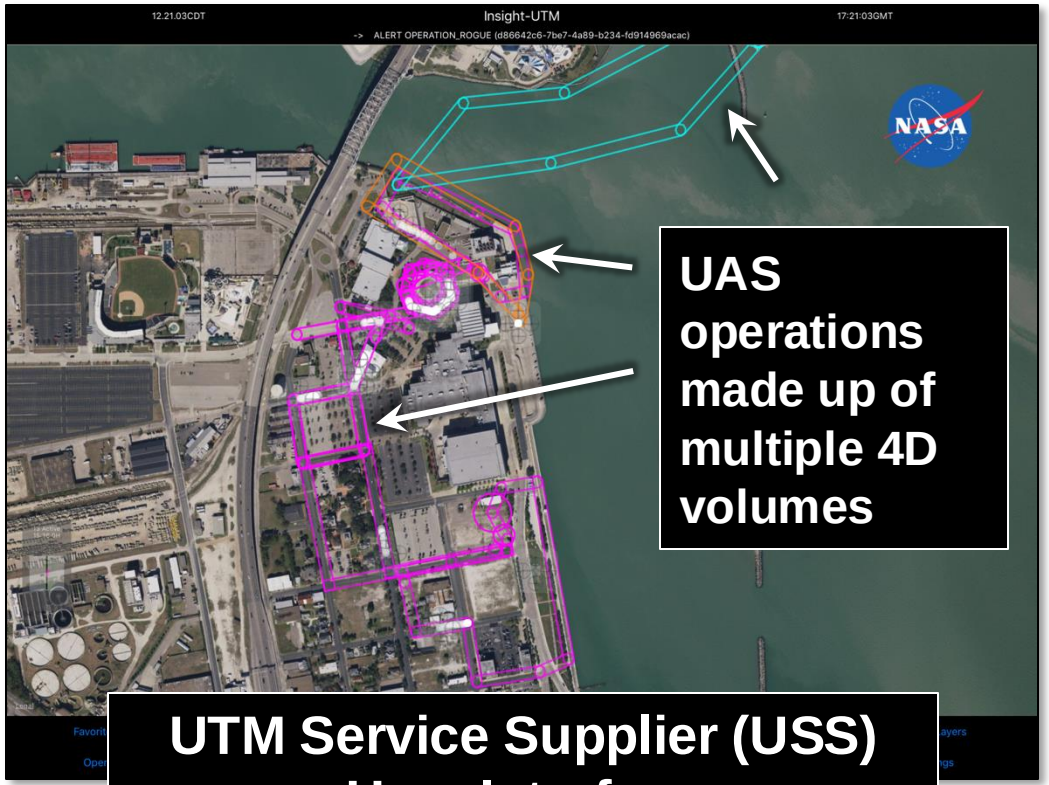
- Operators “define” the area in which they plan to operate:
  - **4D volumes of airspace**
  - Lat/long, altitude, and time
- A flight plan can be made up of a series of contiguous volumes:
  - A “tunnel” through the airspace
- The **UTM system** uses these 4D Volumes for:
  - Defining Intent
  - Planning / Deconfliction
  - Conformance Monitoring



UAS Traffic Management (UTM)

How does the human operator interact with the UTM system?

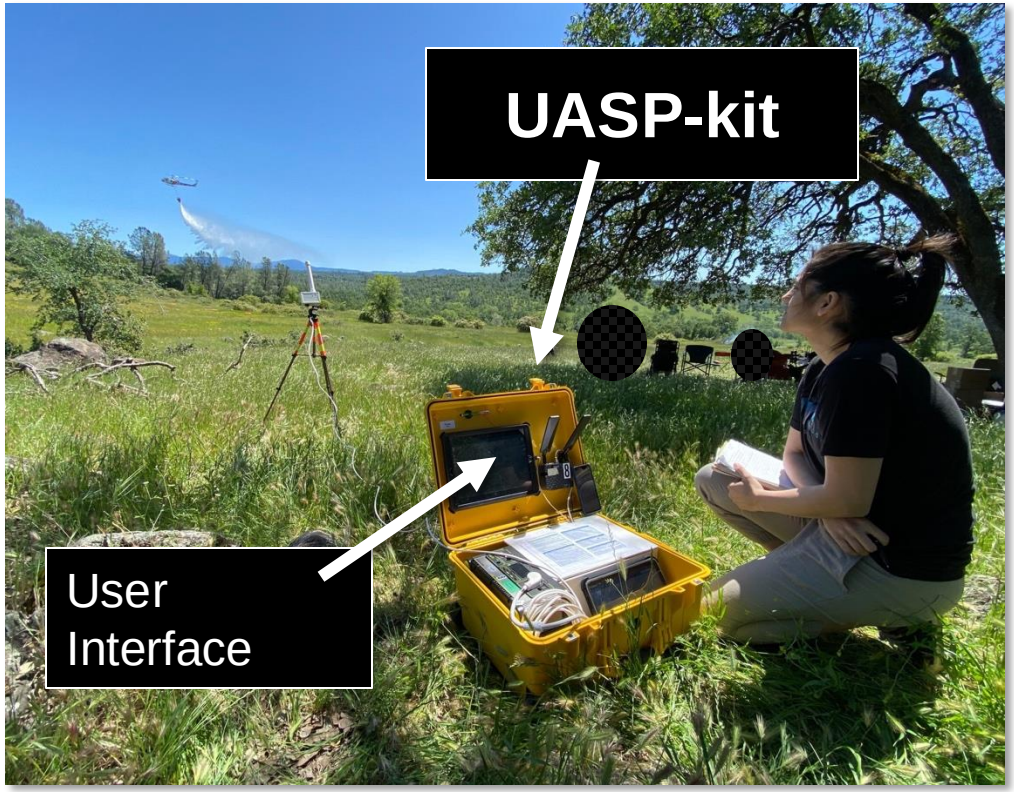
- UTM Service Supplier (USS)
- The USS tool enabled operators to:
  - Participate in the UTM system
  - Input their 4D volumes
  - Receive approval/feedback
  - Visualize UAS operations



Scalable Traffic Management for Emergency Response Operations (STEReO)

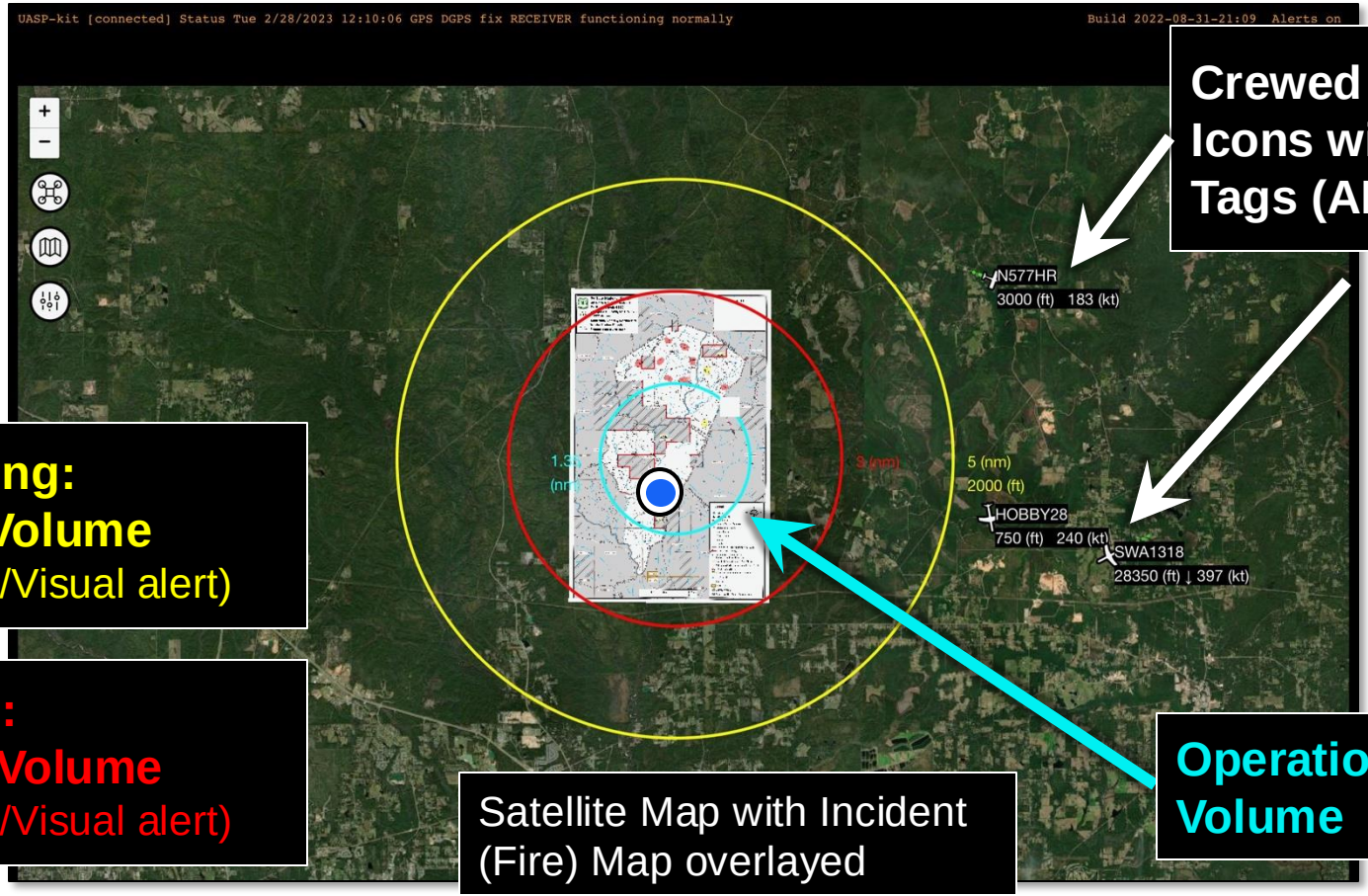
STEReO

- UAS traffic management in **wildland firefighting**
- More effectively integrate UAS operations with crewed aircraft
- Build a tool to support:
  - Data exchange
  - Improve situation awareness
  - Facilitate common awareness
  - Without increasing workload or distraction



STEReO: UASP-kit User Interface

- Support Situation Awareness of Airspace



Crewed Aircraft Icons with Data Tags (ADS-B)

Yellow Ring: Caution Volume (with Audio/Visual alert)

Red Ring: Warning Volume (with Audio/Visual alert)

Satellite Map with Incident (Fire) Map overlayed

Operational Volume

STEReO: UASP-kit

Real-world field testing (2022):

- Spring prescribed burns
- Active fires during fire season

Usability ratings:

- Supported improved **situation awareness** of the airspace
- Operators found the audio alert useful

2024 Fire Season:

- UASP-kits are still being used by UAS crews at wildland fire incidents to continue to collect data to further improve the tool.

UASP-kit

Background: Foundational NASA Research

UAS Traffic Management (UTM)

STEReO

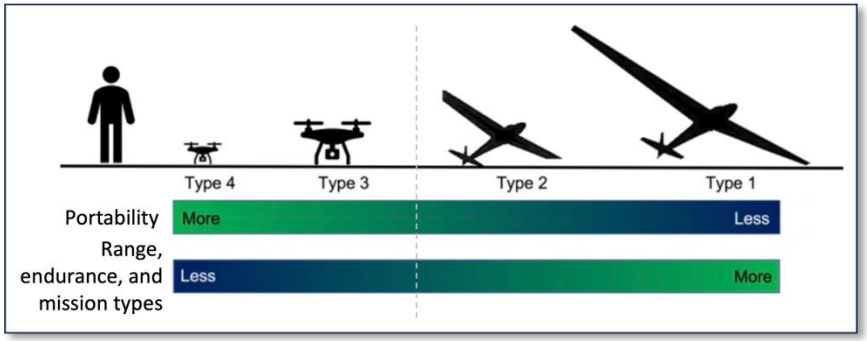
Advanced Capabilities for Emergency Response Operations (ACERO)

UAS Pilot Interviews

- Conducted group interviews with **Subject Matter Experts (SMEs)**
- Five UAS Pilots (UASPs) who fly wildland fire UAS missions:
  - Background in wildland firefighting roles: hotshot firefighters, engine crew, helitack firefights, and Air Tactical Group Supervisor (ATGS)
- Initial thoughts about an Airspace Management system in the wildland fire environment:
  - Current-day practices
  - Constraints

UAS Vehicle Overview

- **UAS Vehicles used in Wildland Firefighting operations**



Type 3 / Type 4 UAS

- Smaller, more maneuverable, and easier to transport, but because of limited battery power can only operate for ~30 min
- Operations are more **tactical** in nature
- "Ground-based aviation resource/asset" driven by the needs on the ground
- A request could originate from an Engine Captain or a Hotshot Superintendent

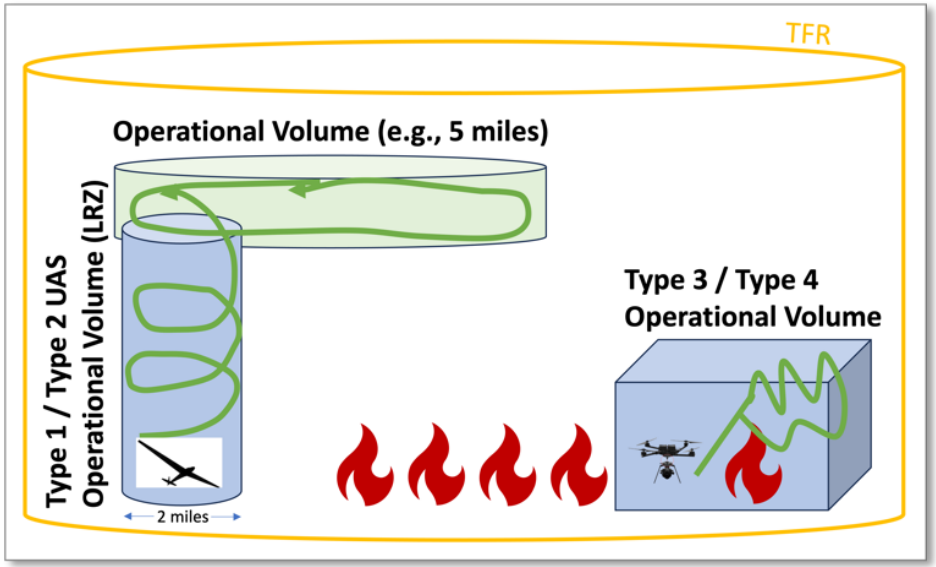
Type 1 / Type 2 UAS

- Larger, fly longer missions, and can carry more equipage/sensors, but more cumbersome to transport and require assembly at their destination
- Missions are more **strategic** in nature
- Require more pre-planning
- The data they collect often requires processing before it can be disseminated

UAS Pilot Interviews: Initial Findings

Operational Volumes

- UAS Pilots: In a wildland fire setting, **Operational Volumes** would be larger, and fewer volumes would be needed by each operation
- In wildland fire operations, UASs generally work in their own well-defined areas
- Expect **Type 1/Type 2** UAS to use <u>two</u> volumes
- **Type 3/Type 4** UAS operations could be contained in a **single volume**

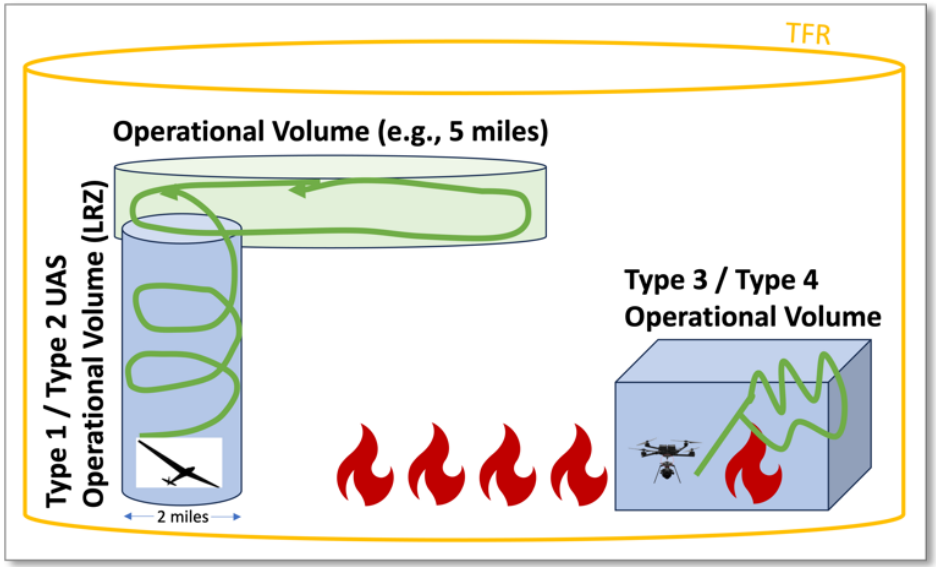


UAS Pilot Interviews: Initial Findings

Operational Volume Size

- UAS Pilots favored a volume size large enough to accommodate the mission, but leaving enough room for other operations

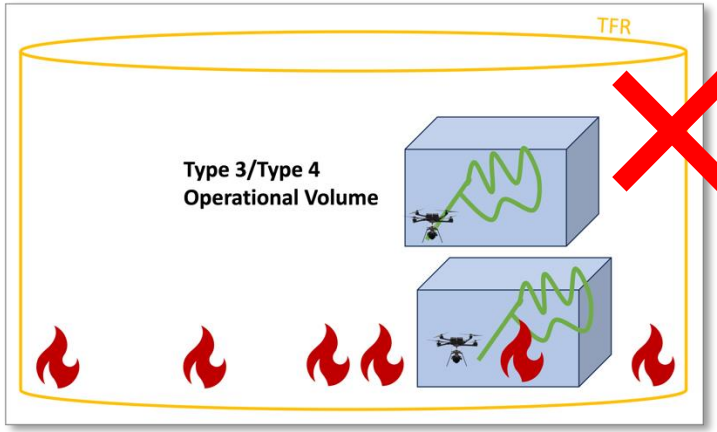
"The whole idea is to keep as much airspace open for other people to use as possible."

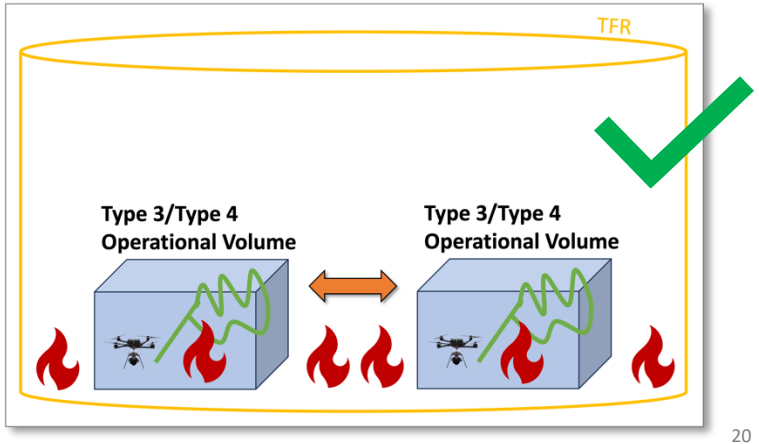


UAS Pilot Interviews: Initial Findings

Organization of Airspace Volumes

- UAS Pilots: Multiple UAS operations should **not** be vertically "stacked" on top of each other.
- Ensure safe separation by continuing to organize UAS operations ***laterally***, as they do in current-day wildland fire operations.
  - If one UAS vehicle has a mechanical or communications issue and makes an emergency descent, it is less likely to impact other UAS vehicles.
- **Spacing between volumes** of different operations (a buffer) is **critical for safety**.

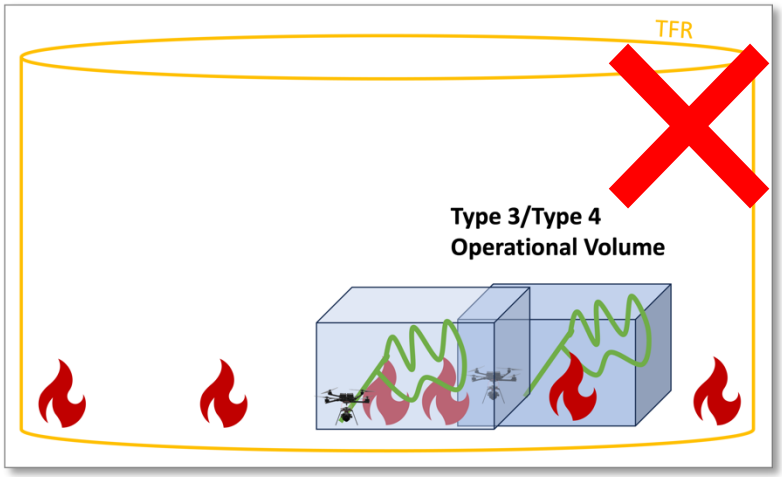




UAS Pilot Interviews: Initial Findings

Overlapping Volumes

- The UTM demonstrations also included a method for allowing two operators to **share an airspace**, provided that the vehicles were equipped for vehicle-to-vehicle data transfer.
- UAS Pilots: Feel strongly that overlapping intents are **not** feasible in the wildland fire environment



UAS Pilot Interviews: Initial Findings

User Interface (Map) Information Needs

- UAS Pilots: The **most important information** to display is **the location of all traffic – both crewed and uncrewed aerial vehicles.**
  - Safety issue
  - Crucial for situation awareness
  - Traffic **in the area of their operation** is the highest priority

" ... knowing what's happening [with respect to other traffic] in this geographical area that we have, that's the number one priority."

Map Information Needs

UAS Pilot Interviews: Initial Findings

User Interface (Map) Information Needs

- UAS Pilots: UAS operations in their **planning** stage, before Submitted and Verified by the UTM system

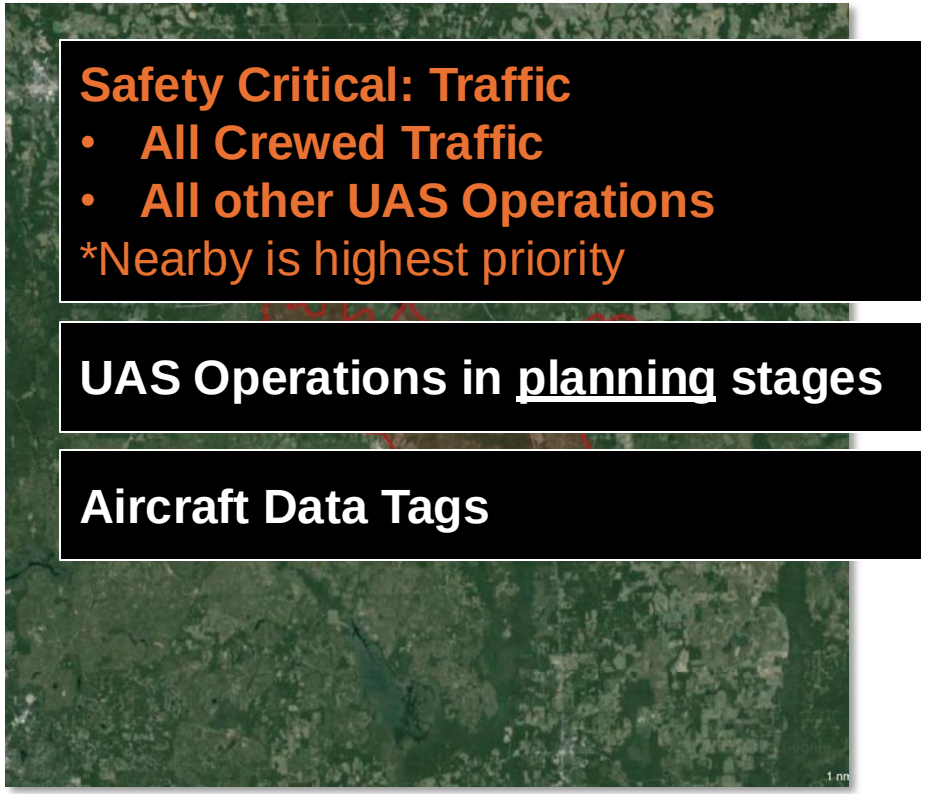
Map Information Needs

UAS Pilot Interviews: Initial Findings

User Interface (Map) Information Needs

- UAS Pilots: The most important information for Data Tags includes:
  - Callsign
  - Heading
  - Airspeed
  - Altitude
  - UAS mission type
  - Pilot name
  - Battery %
  - Aircraft type
  - UAS state (on ground, flying, lost link)

Map Information Needs

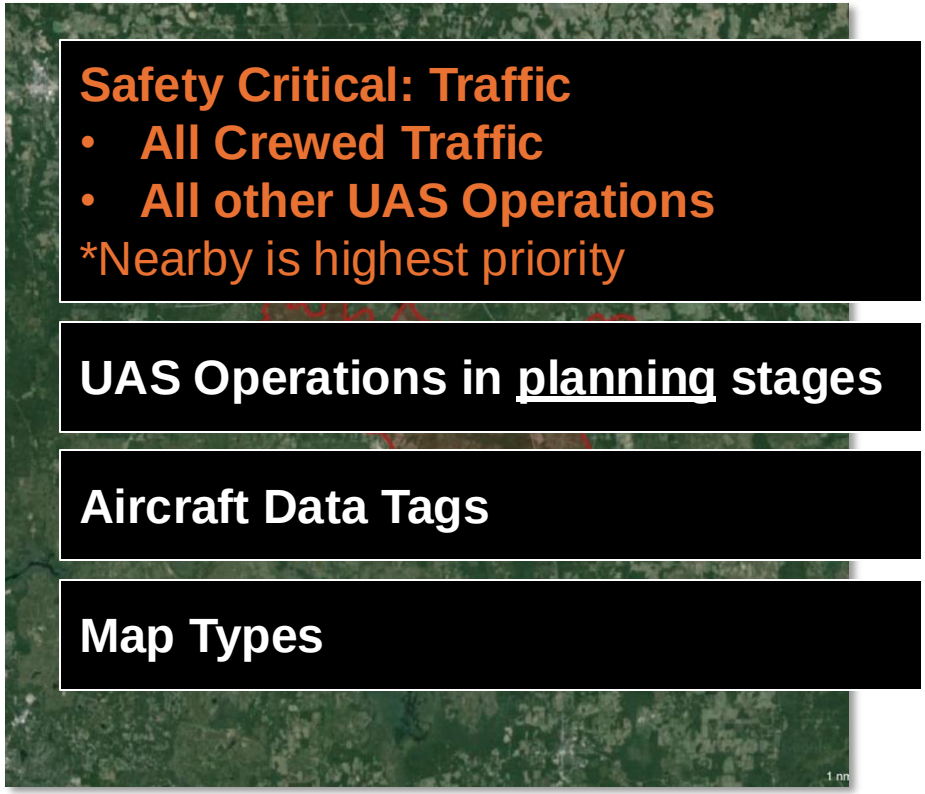


UAS Pilot Interviews: Initial Findings

User Interface (Map) Information Needs

- UAS Pilots: The following map types are needed:
  - **AirOPS** map that typically covers the entire TFR area and includes dip sites
  - **OPS** map that covers the entire fire
  - **Incident/Fire** map
  - **Topographic** map
  - **Visual Flight Rules (VFR) sectional**

Map Information Needs

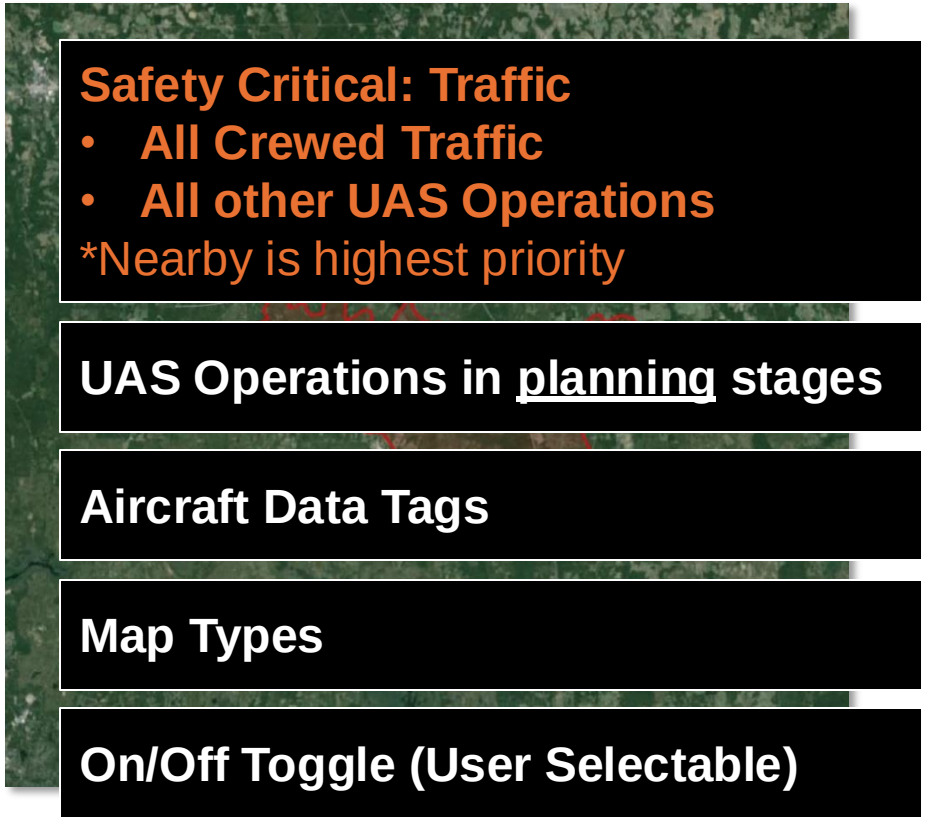


UAS Pilot Interviews: Initial Findings

User Interface (Map) Information Needs

- UAS Pilots: Map features should be **user-selectable** so they can be toggled on and off as needed for **de-cluttering**

Map Information Needs



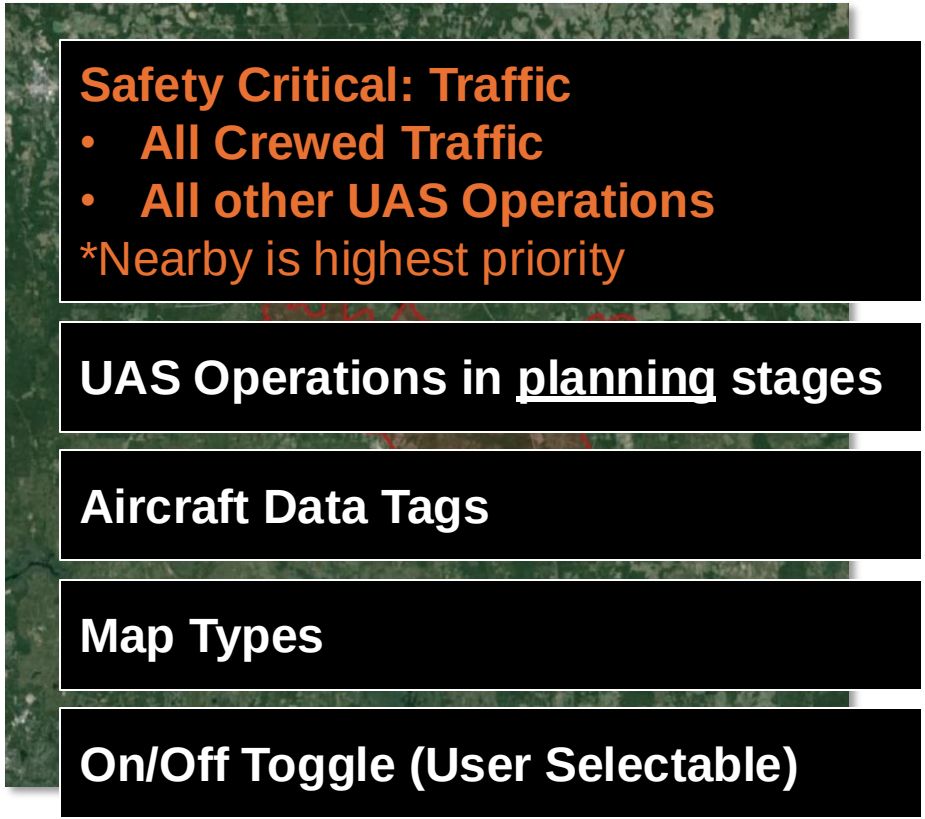
UAS Pilot Interviews: Initial Findings

User Interface (Map) Information Needs

- UAS Pilots: Map features should be **user-selectable** so they can be toggled on and off as needed for **de-cluttering**

- The importance of **up-to-date information**
- Displaying old, inaccurate information can cause a user to lose **trust in the system**

Map Information Needs



UAS Pilot Interviews: Initial Findings

Information Sharing

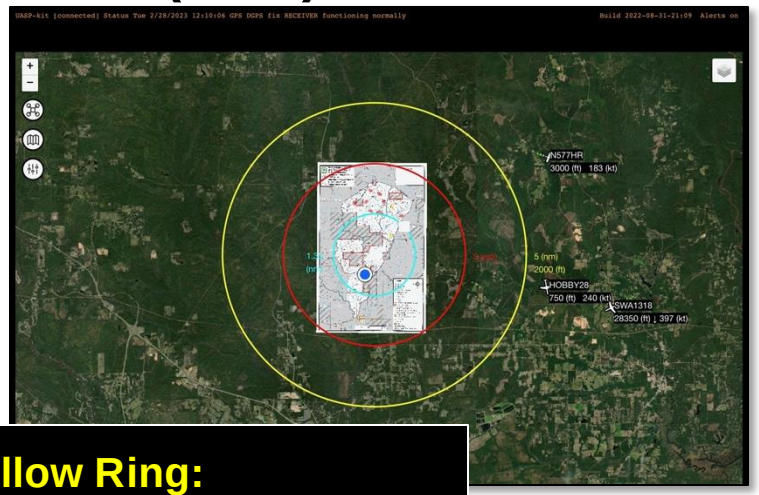
- UTM ConOps (FAA):
  - “UTM is predicated on layers of information sharing and data exchange ... ”
- UAS Pilots agreed that they would be willing to **share all operation information** (e.g., location, speed, altitude, heading, mission intent).
- Knowing where other vehicles are is a **safety** issue and crucial for **situation awareness**.

UAS Pilot Interviews: Initial Findings

Alerting

- UAS Pilots: Unanimously agreed that users should be alerted if **another UAS or crewed aircraft comes within proximity** of their operational volume
- UAS Pilots: Useful to receive an alert if their vehicle drifts outside of their own Operational Volume **(Non-Conforming state)**

UASP-kit (2022)



Yellow Ring:
Caution Volume
(with Audio/Visual alert)

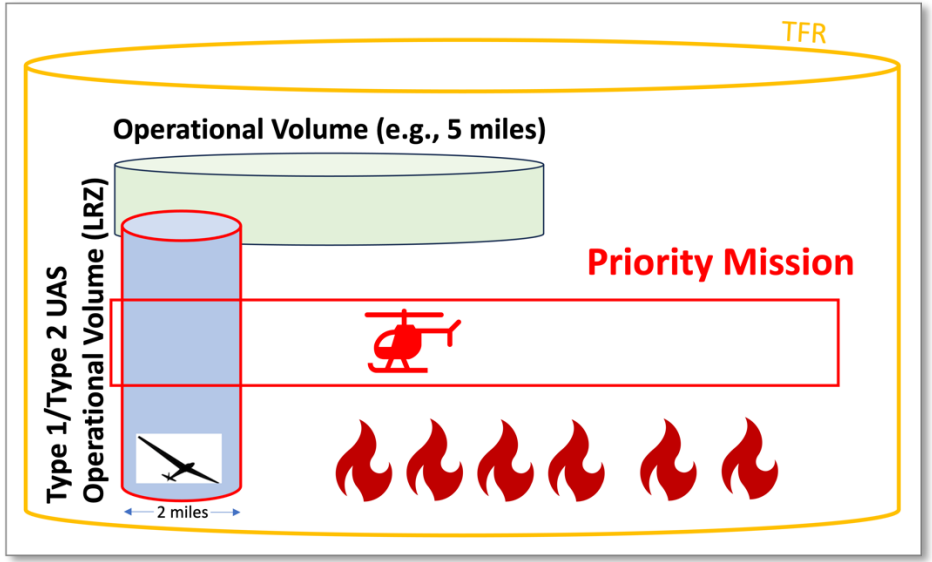
Red Ring:
Warning Volume
(with Audio/Visual alert)

UAS Pilot Interviews: Initial Findings

Right-of-Way Guidelines

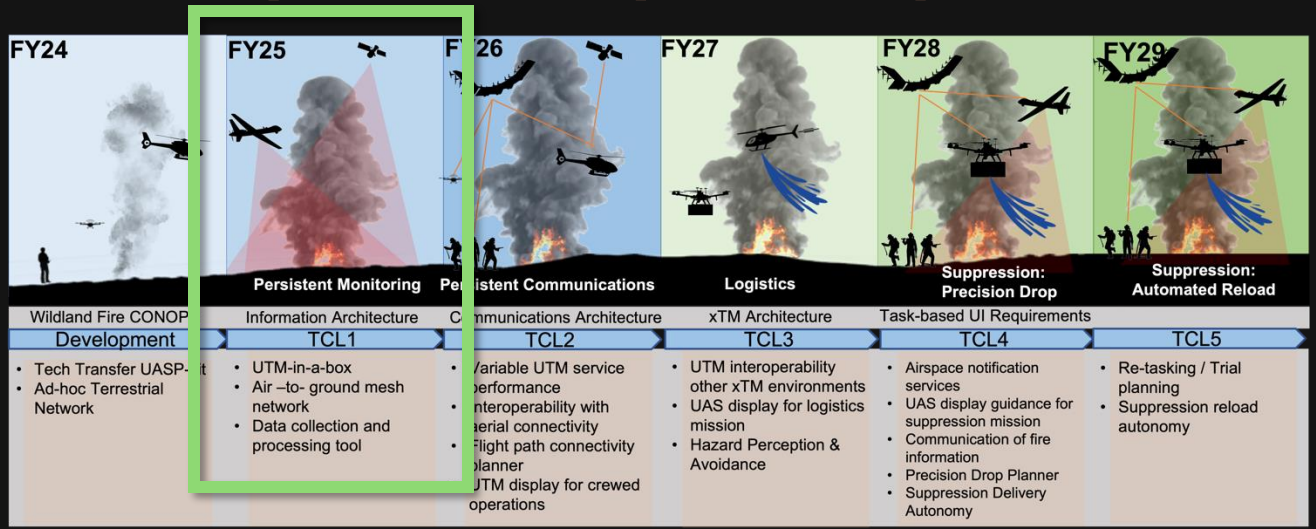
- **Priority Aircraft:** Some aircraft with *priority missions*, such as EMS, could be routed through a UAS operation.
  - If it did occur, then the UAS crew would respond by creating distance between the priority aircraft and their UAS (e.g., by descending and moving toward the GCS or by delaying their launch).
- **UAS and UAS**
- **UAS and Crewed Aircraft**

Implications for UI Design



Looking Forward: TCL1

Advanced Capabilities for Emergency Response Operations (ACERO)



Technical Capability Level (TCL) demonstrations test increasingly complex missions needed for suppression in degraded visual environments

Looking Forward: TCL1

- TCL1
- Spring 2025
- **3 UAS vehicles:**
  - 2 smaller UAS
  - 1 larger UAS
- **xERO Cases (3)**
- **UTM System**
- Human Factors:
  - questionnaires, debriefs, observations

*in development/testing

SJSU

NASA

Thank you!
Questions?

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