Humans as Automation Failsafe: HAT Assistant

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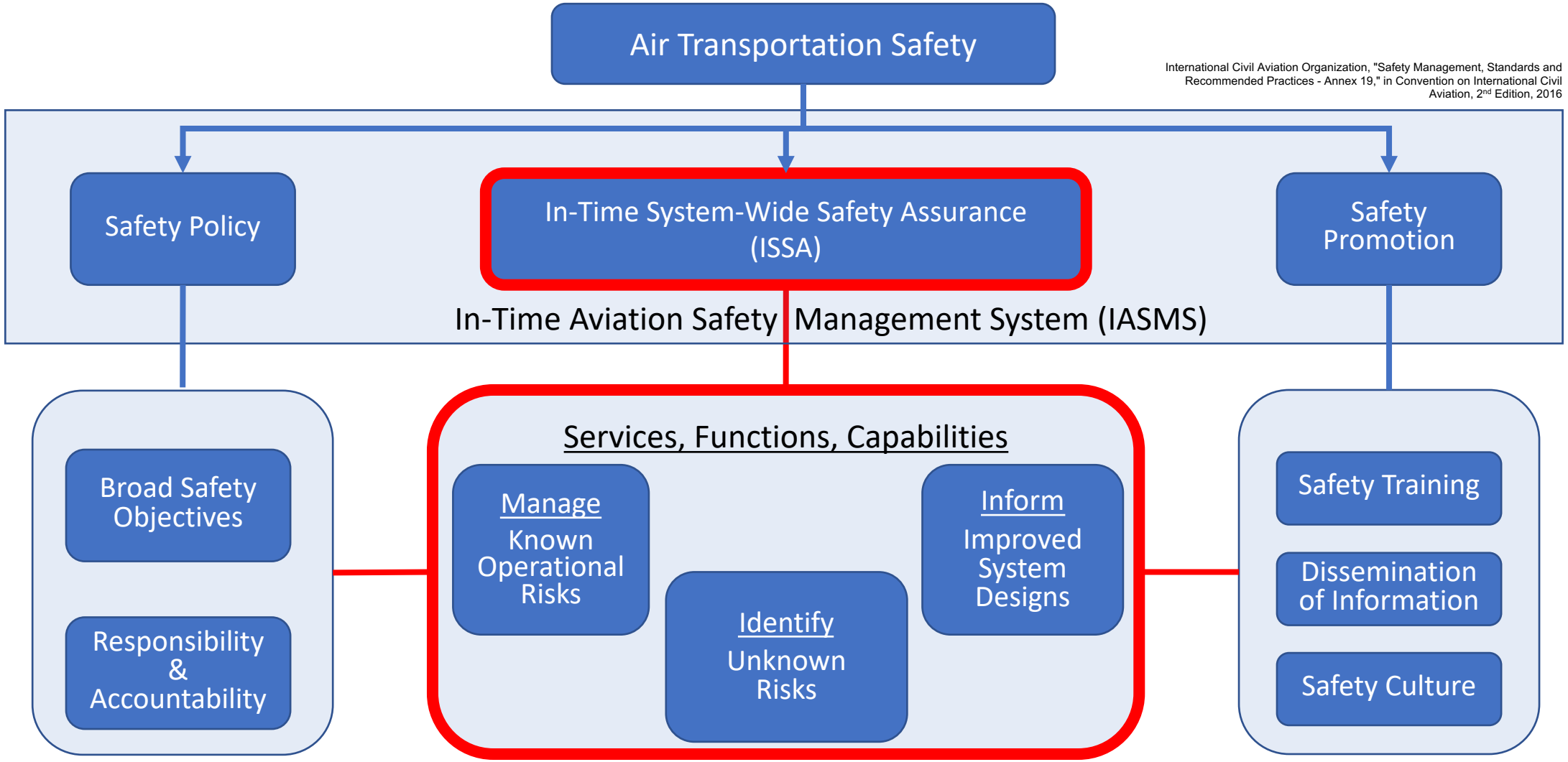
NASA’s System-Wide Safety (SWS) Project

Develop innovative data solutions to assure safe, rapid, and repeatable access to a transformed National Airspace System

- How humans will interact with increasingly autonomous systems is a major challenge facing safety in design and operational assurance

www.nasa.gov/aeroresearch/programs/aosp/sws

How We Achieve Aviation Safety Tomorrow



Quickly manage known operational risks at scale

Quickly identify unknown risks

Quickly inform design

SAFETY DEMONSTRATOR APPROACH

Scheduled Progression

SD-1 Wildland Firefighting

- **!** HIGH — Rural and partially evacuated area
- LOW-MODERATE — Intensive HMI and lack of commercial flights
- **?** LOW-MODERATE — Unknown location of fire; poor visibility

Environment:
Low Visibility, Smoke...

Vehicle & Mission:
sUAS, mid-size UAS/ Short Range

Human Role: High

SD-2 Hurricane Relief and Recovery

- **!** MED — Partially evacuated area
- MODERATE — Numerous agencies coordinating multiple relief efforts
- **?** MODERATE-HIGH — Unknown state of terrain; poor infrastructure

Environment:
Low Visibility, RF/EMF Hazards, Poor Weather…

Vehicle & Mission:
sUAS, mid-size UAS, large UAS/ Multiple Days

Human Role: Medium

SD-3 Emergency Medical

- **!** LOW — Urban area
- MODERATE — Regularly scheduled commercial flights
- **?** MODERATE — All weather operations

Environment:
Urban Airspace, RF/EMF Hazards…

Vehicle & Mission:
sUAS, mid-size UAS, large UAS/ Long Range

Human Role: Low

SD-4 Urban Disaster Relief

- **!** LOW — Urban area
- HIGH - - - - -
- **?** HIGH - - - - -

Environment:
Degraded Infrastructure, RF/EMF Hazards…

Vehicle & Mission:
sUAS, mid-size UAS, large UAS/ Multiple Days

Human Role: Multiple Simultaneous HMI paradigms

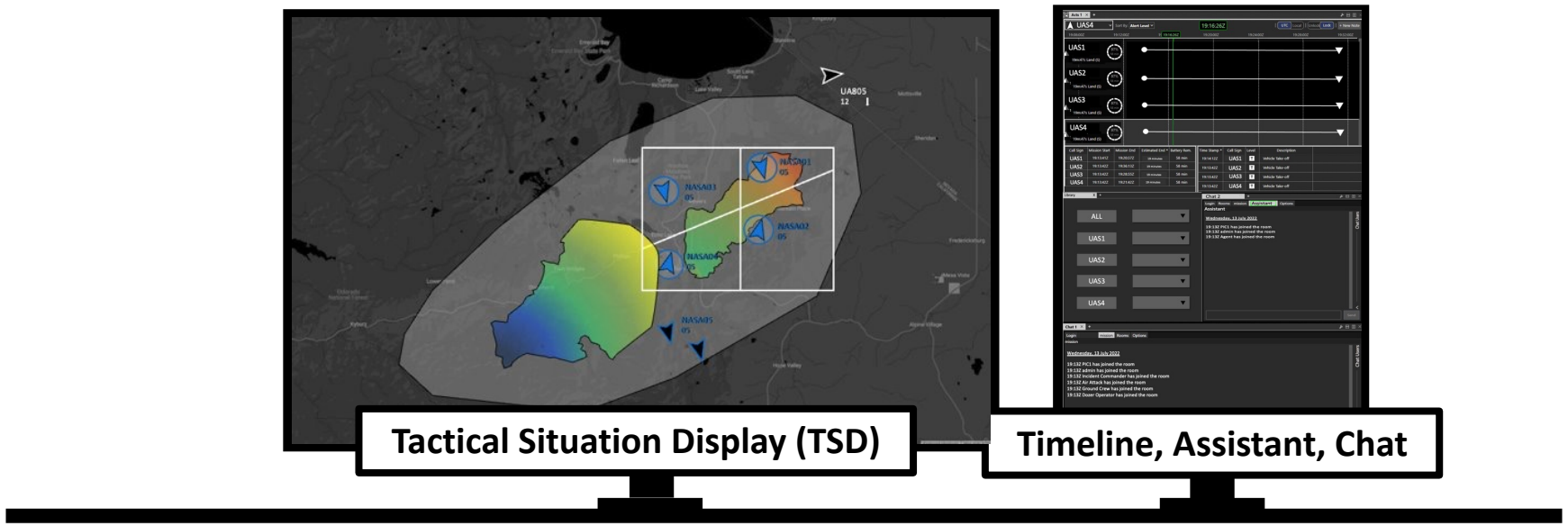
! Risk Tolerance Complexity ? Uncertainty

HAT Assistant

- Goals and approach
  - Develop a system that allows the Human to *anticipate* potential interventions and successfully *mitigate* in a timely, safe and efficient manner
  - Develop a HAT Assistant that assess the current context and trends in the environment, and based on risk, suggests mitigations (i.e., plays)

- Develop ground control station and prototype HAT Assistant capabilities for multi-vehicle control in Wildland Firefighting scenarios
  - Storyboarded a series of scenarios with multi-vehicle control of sUAS
  - Initial ground control station development
  - Spiral development for Assistant
    - Human Factors SME Review (Sept 2022)
    - UAS pilot SME Reviews (October 2022)
    - Part-Task simulations (Spring 2023)

Ground Control Station (GCS) Configuration



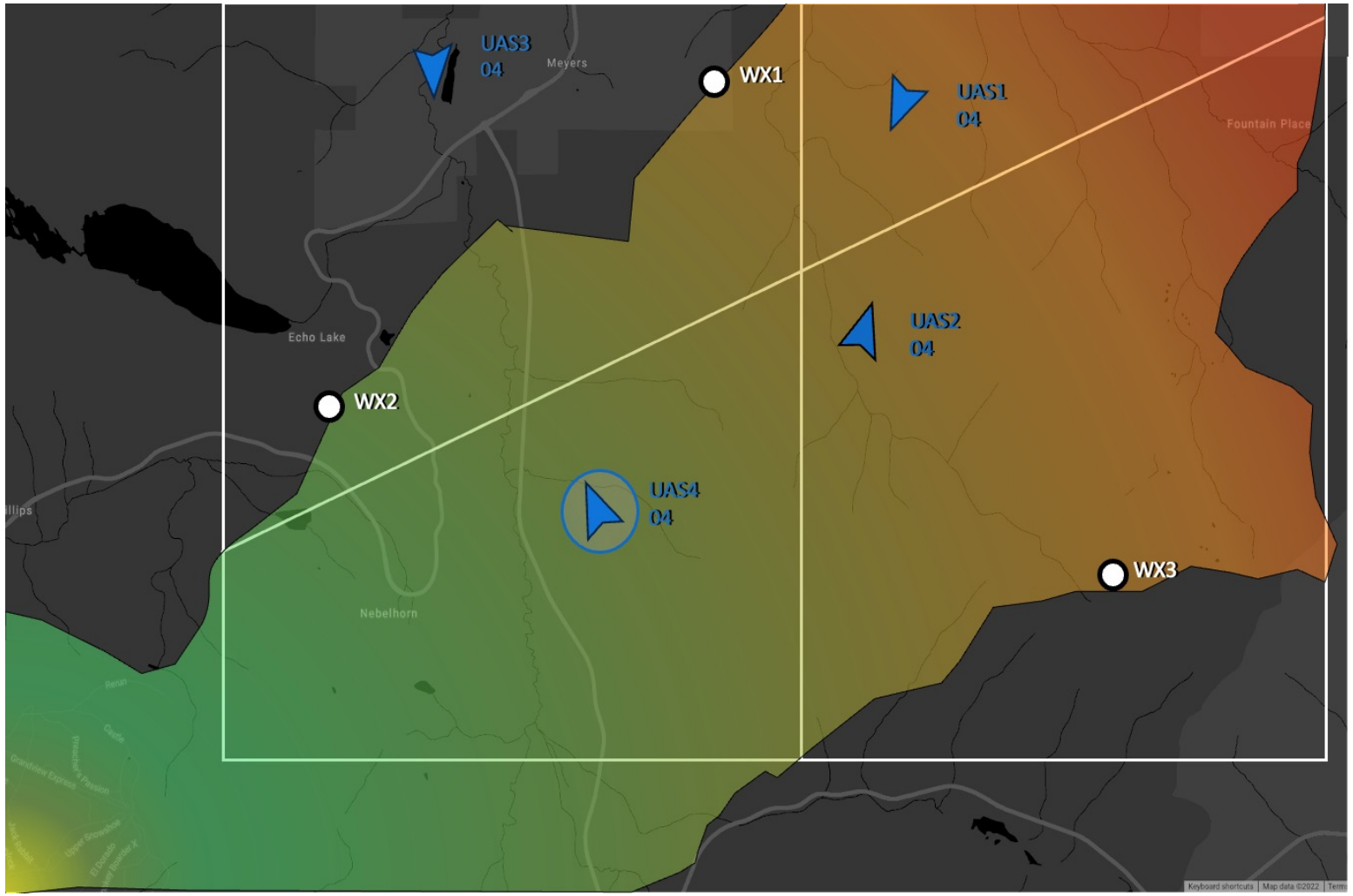
Scenario 1: Power level event (simple)

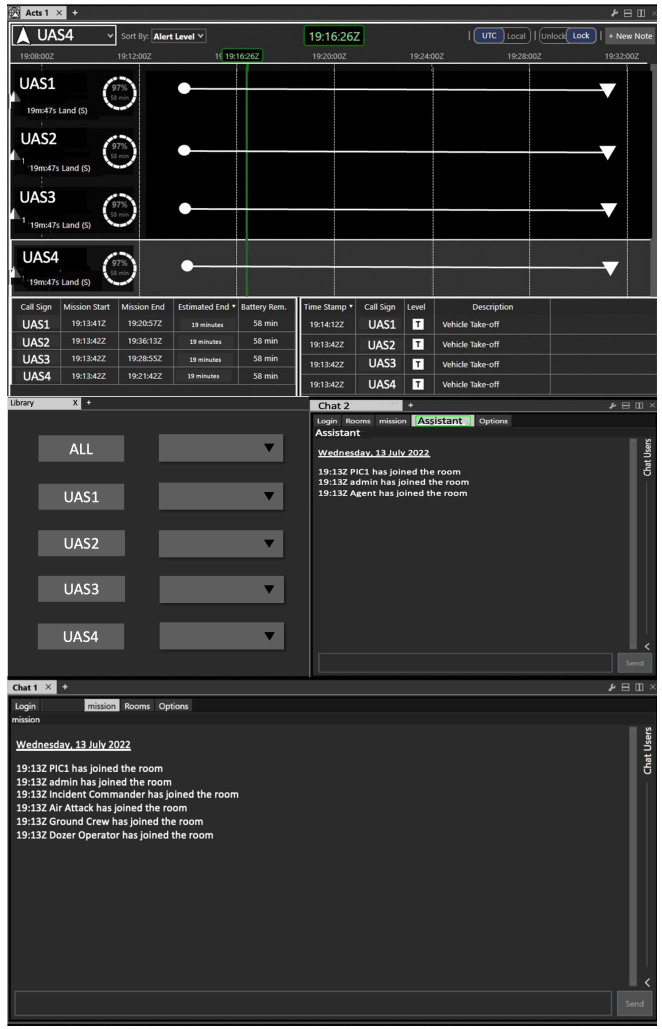
Mission: Map current progress of dozer lines relative to fire progression

Summary

- The scenario starts with 4 vehicles in a nominal state flying a surveillance mission.
- Winds are higher than expected causing concern about required vehicle reserves.
- Fire intensity is growing, and the high winds are pushing fire in the direction of the mission area.
- UAS1 is using more power than expected for an unknown reason.
- As the scenario unfolds, if no action is taken, UAS1 will not be able to complete the mission or return to base.

Nominal GCS view at beginning of scenario.

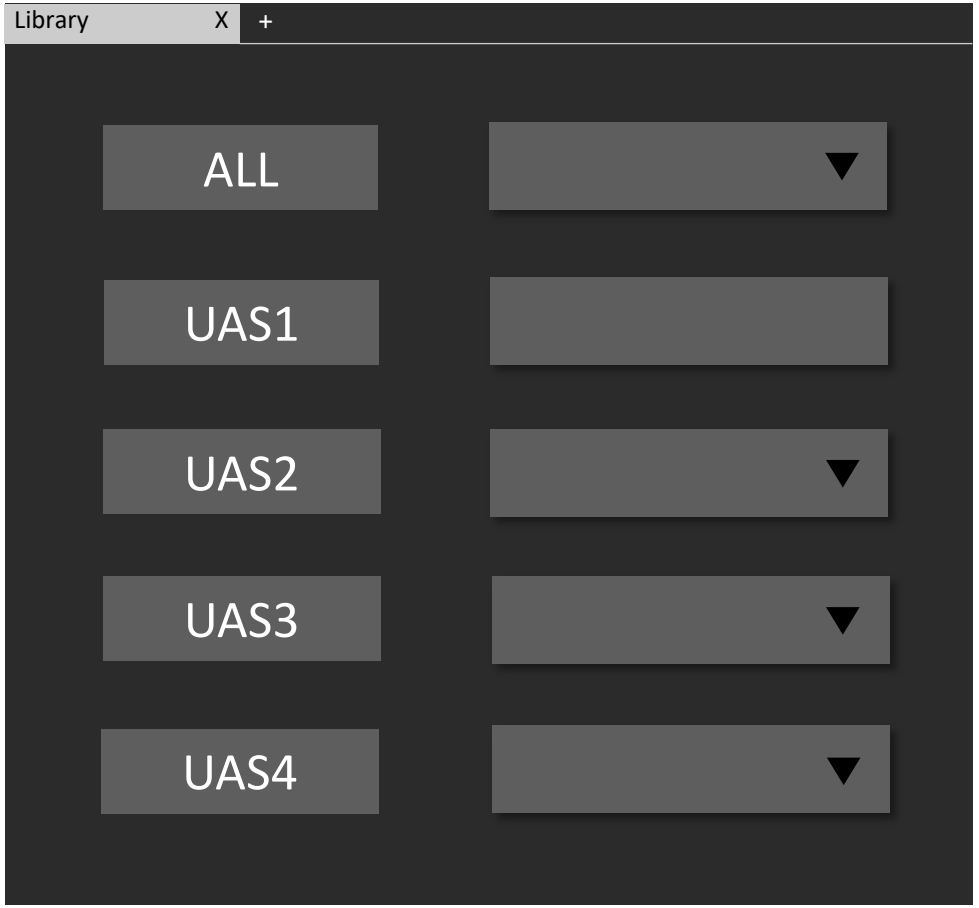


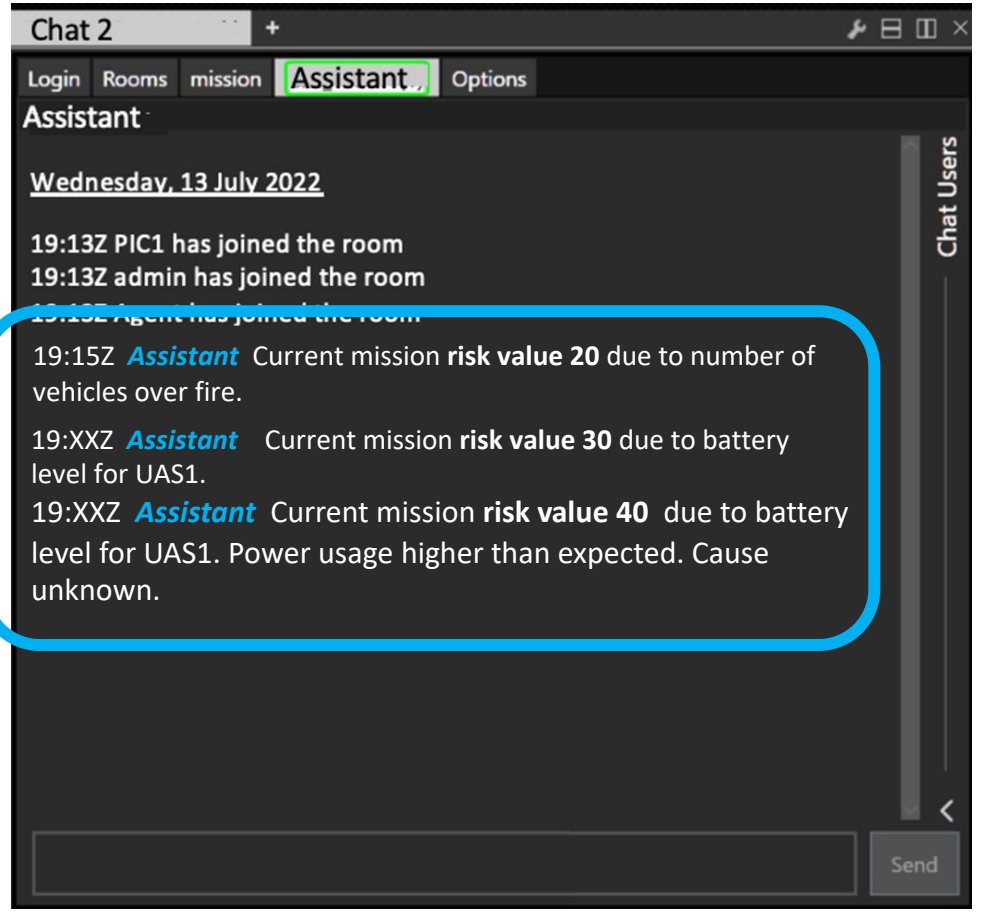


UAS1 battery decreases on Timeline
Percentage is updated, as well as battery time remaining



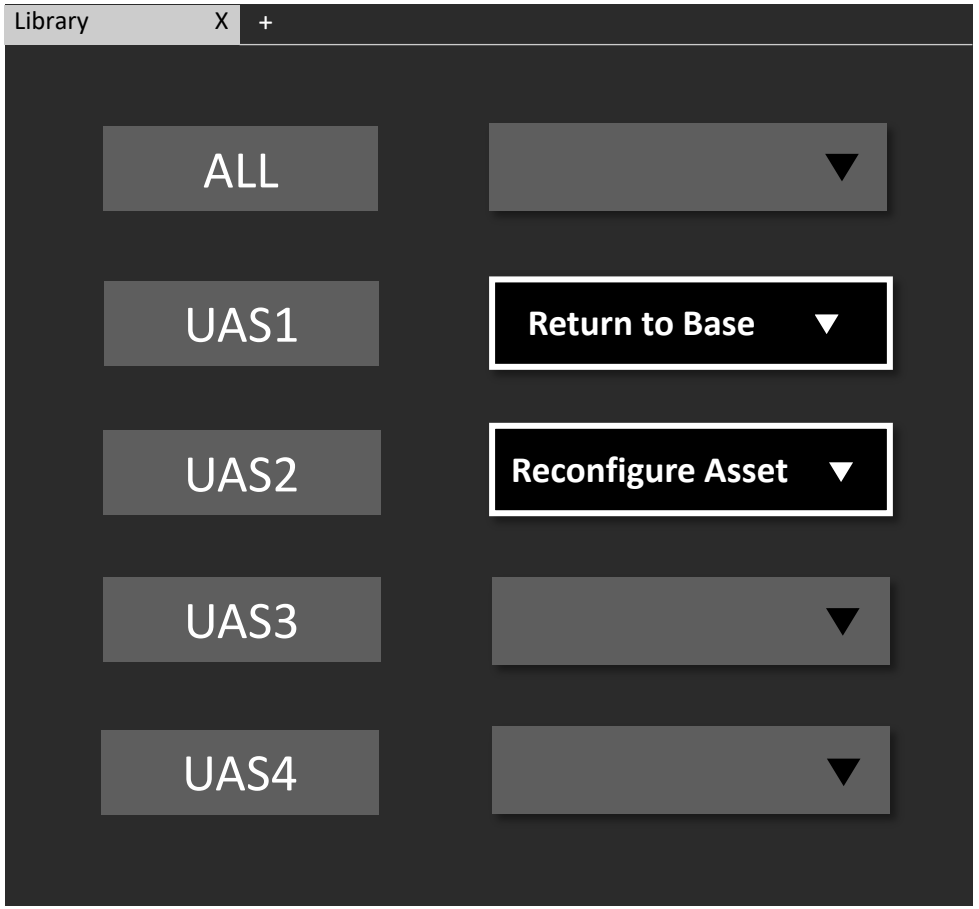
Assistant communicates changes to mission risk as battery drainage for UAS1 increases.

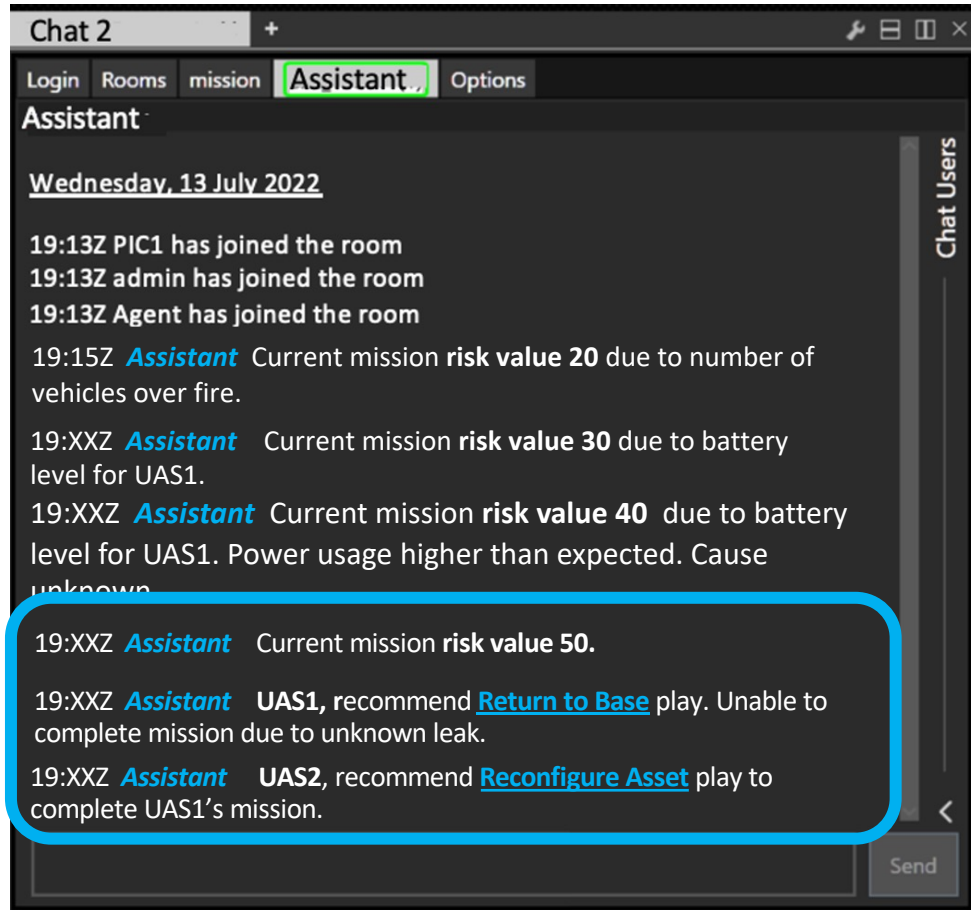




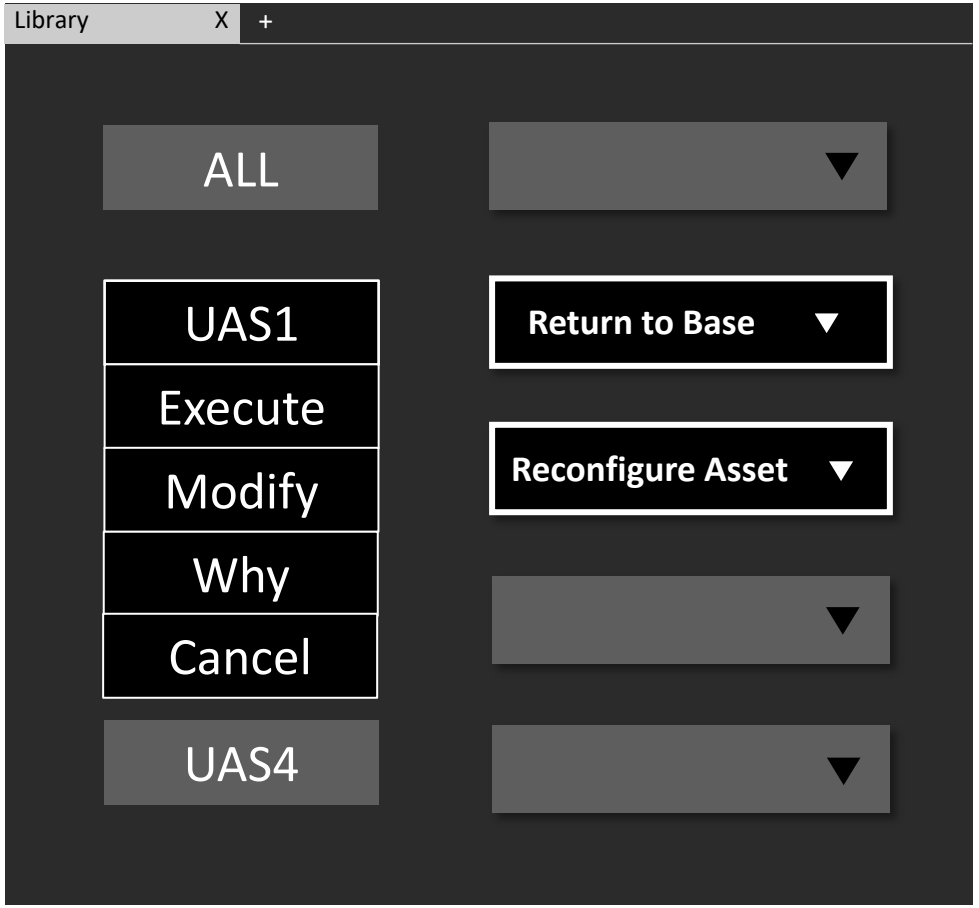
Update to mission risk is communicated by assistant.

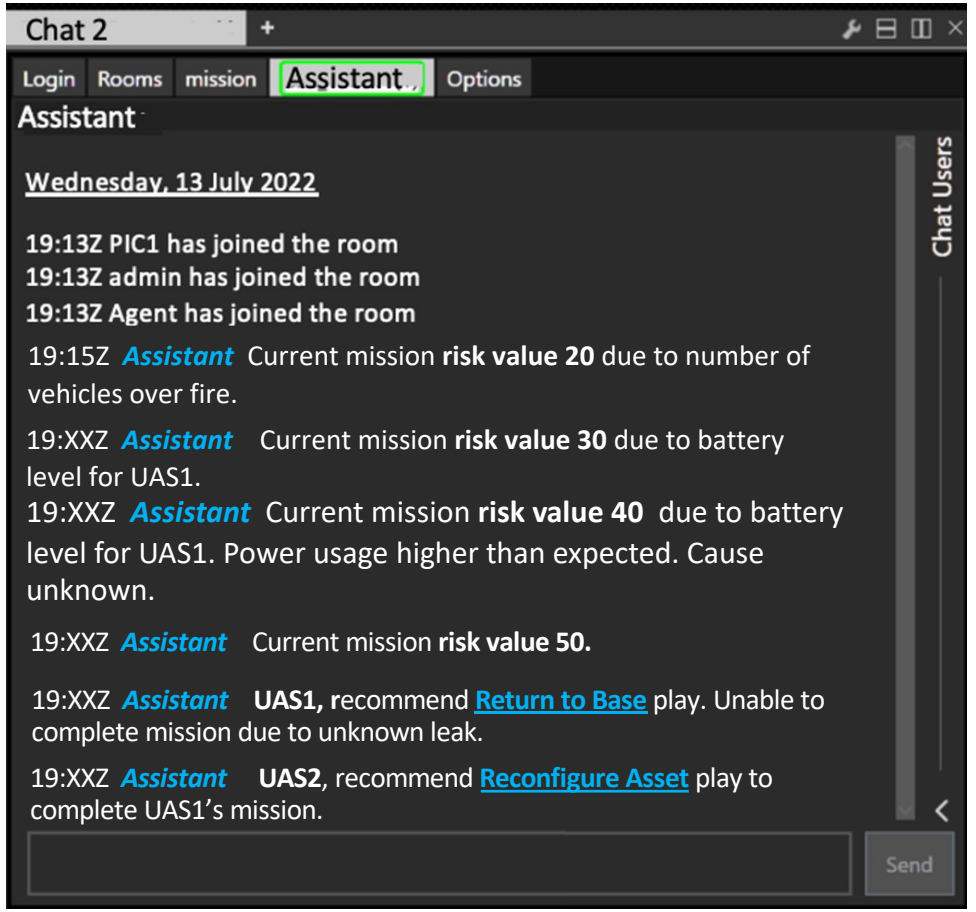
Assistant recommends Return to Base play for UAS1 and Reconfigure Asset for UAS2, which are reflected in the play library.



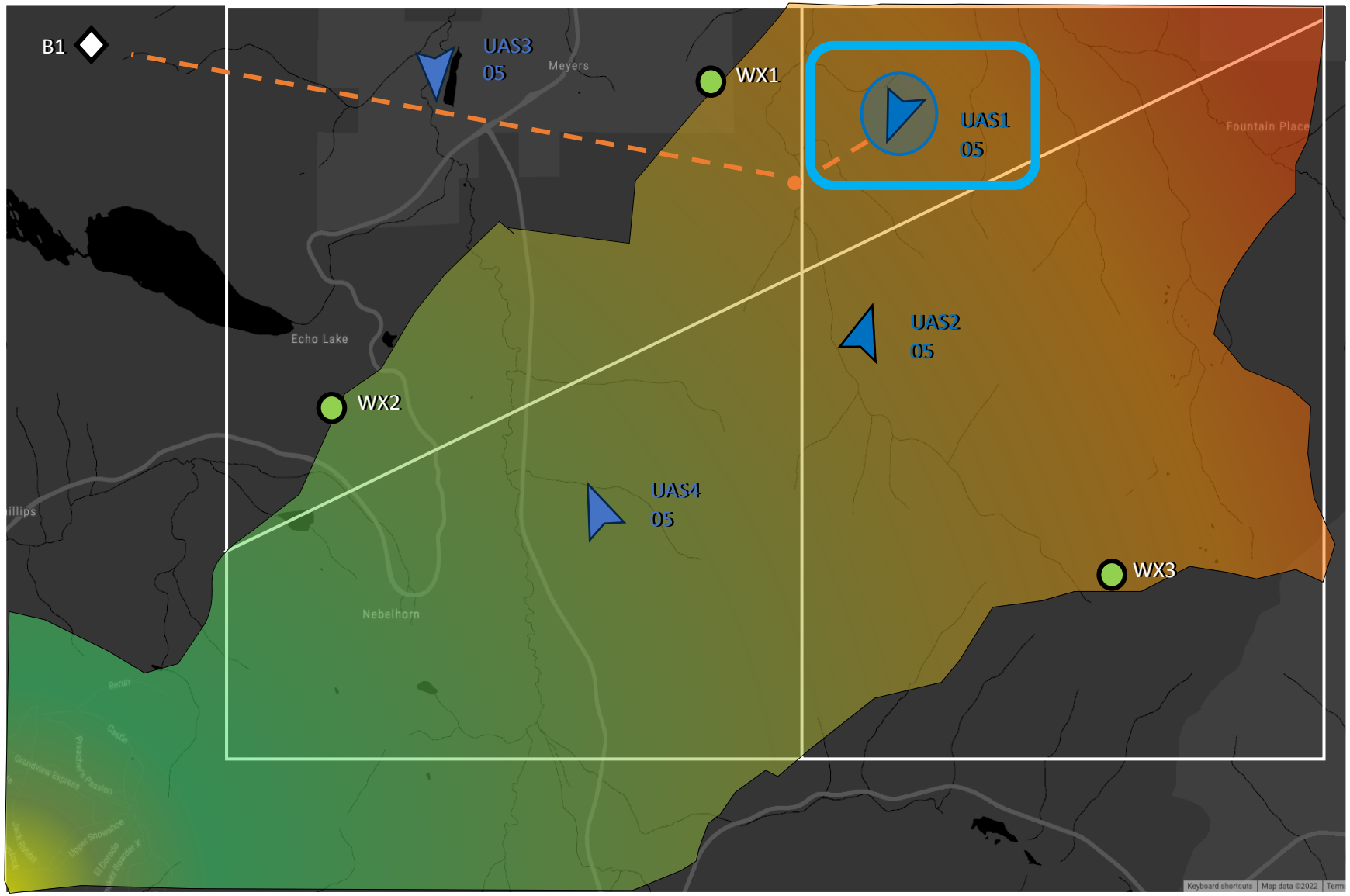


PIC selects asset callsign to bring up dropdown menu options for executing, modifying, or canceling the recommended play.





Recommended route is shown on TSD.
PIC can choose to edit and modify the recommended route, as necessary.



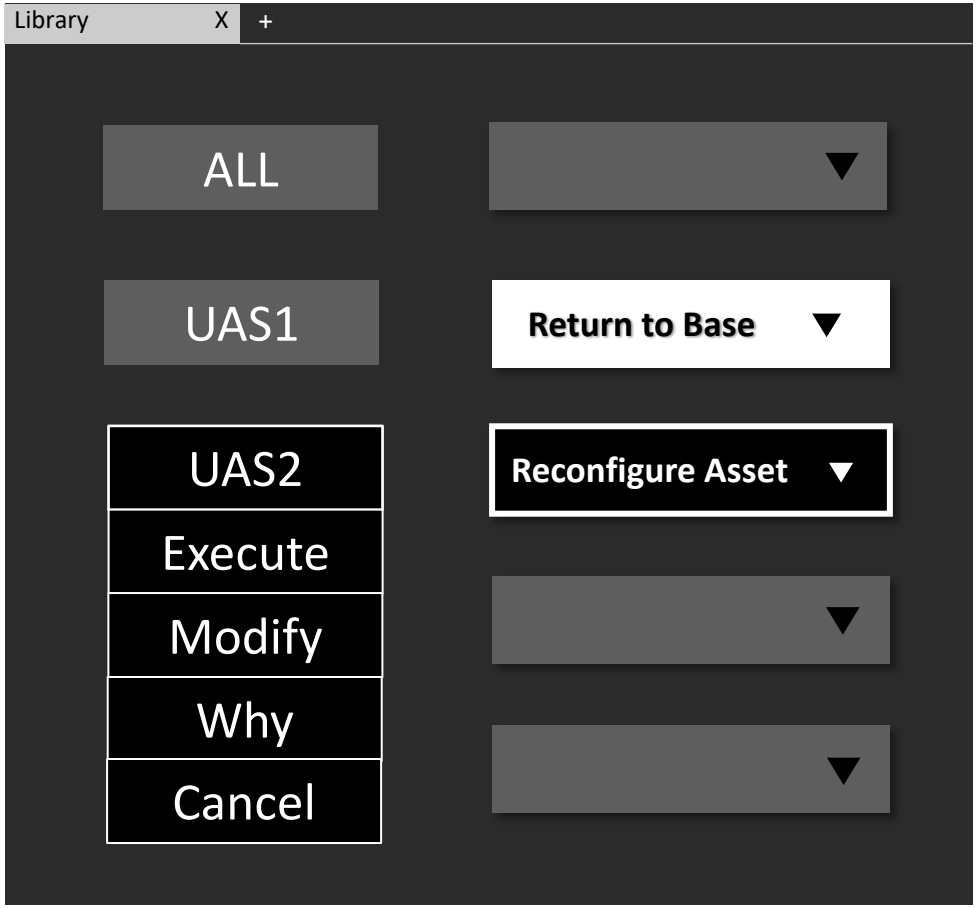
UAS1 shows current play as “Return to Base” on Timeline.

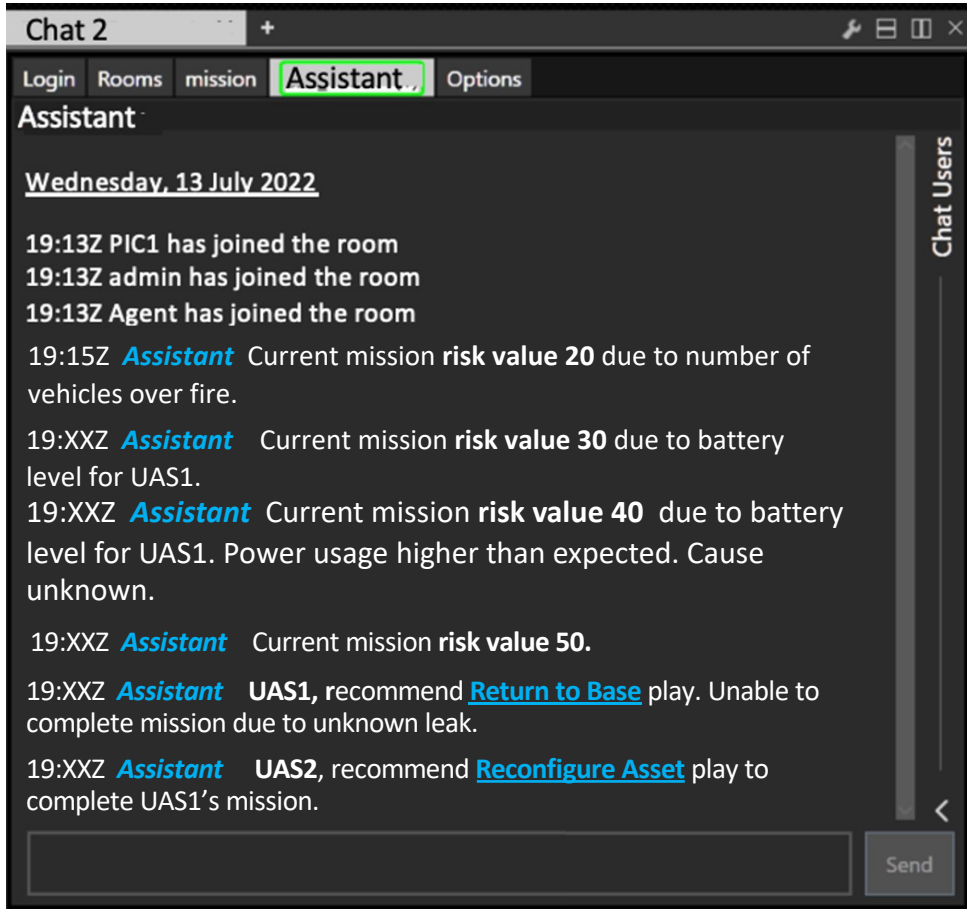
Log is also updated to display time when play was called by PIC.



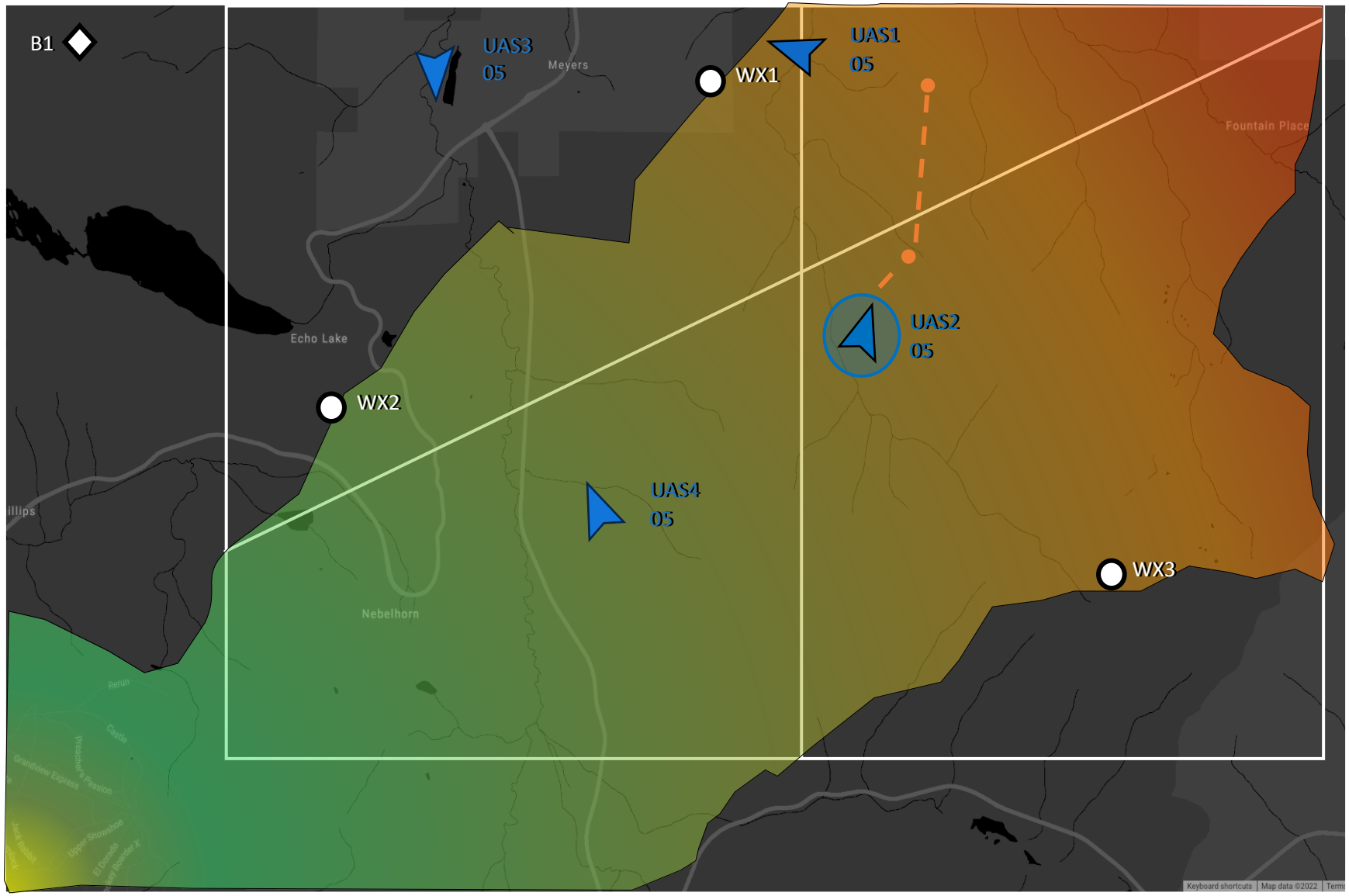
Play library still shows Reconfigure Asset as the recommended play for UAS2.

PIC selects UAS2 callsign in library to bring up preview on TSD and dropdown menu.





Recommended route to resume surveillance mission for UAS1 is shown on TSD.
PIC has option to edit/modify as needed.

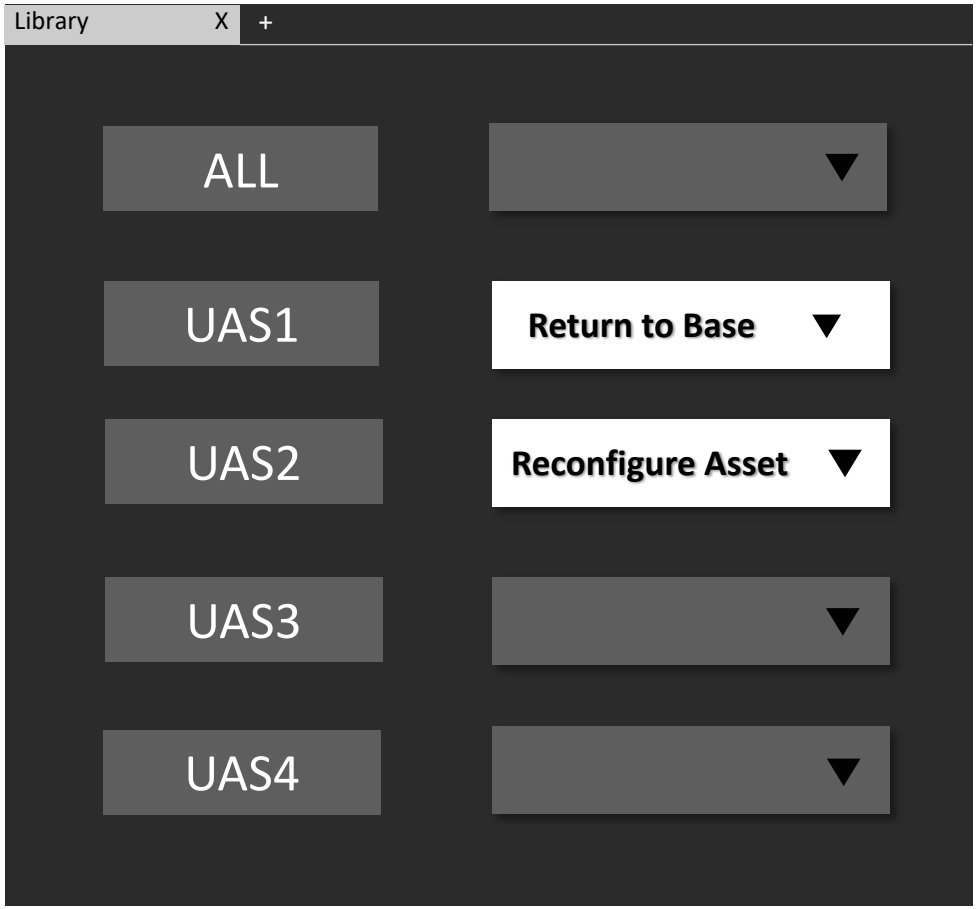


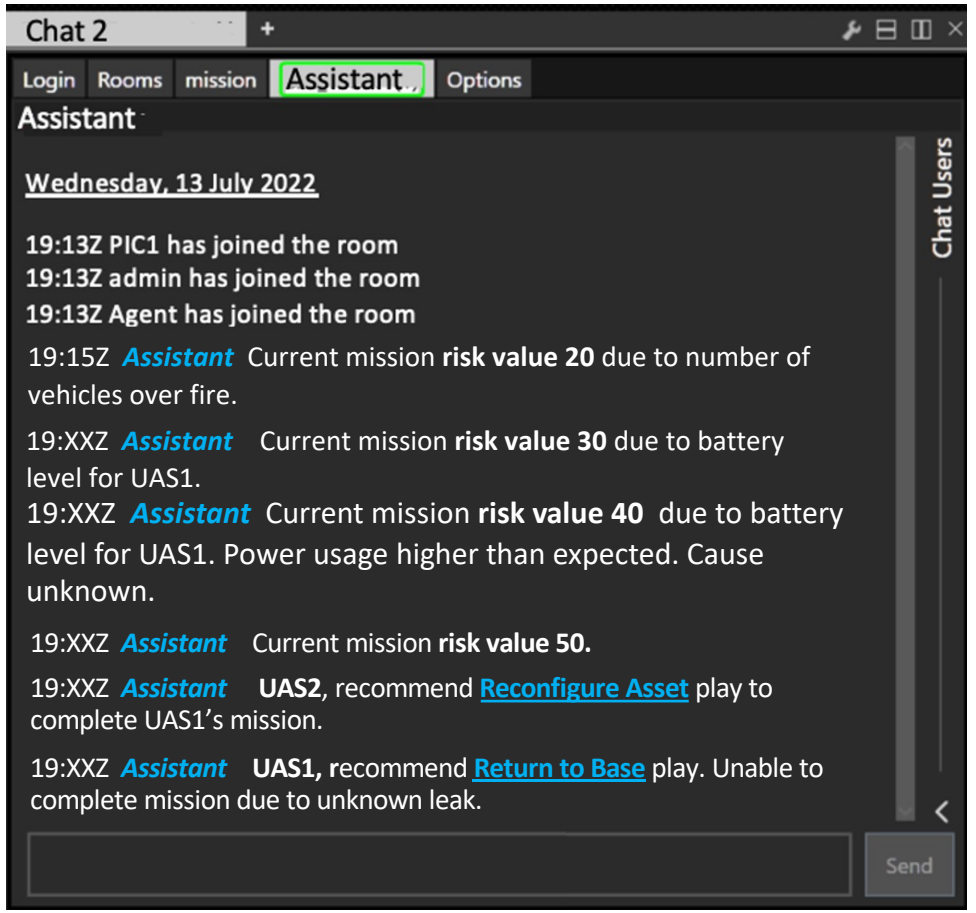
Update in status to indicate currently called play for UAS2 (i.e., Reconfigure Asset) on Timeline.

Log is also updated to display time when Reconfigure Asset play was called for UAS2.



Status for Reconfigure Asset play for UAS2 is updated to indicate it is "Active".





Backup

Vehicle Assumptions

- Type 3 sUAS rotorcraft vehicles
  - Weight: under 55 pounds
  - Endurance: up to 60 minutes
  - Range: currently 5 miles, *likely to expand*
  - Speed: may not exceed 87 knots (100 mph)
  - Altitude: 400 ft AGL
    - USFS/BLM/CAL FIRE currently segregate vehicles with sUAS flying above TFR
    - Our scenarios will assume an integrated airspace with sUAS within a TFR at low altitude
  - Sensor payload included
    - Light-weight camera resolution optimal in daylight at lower altitudes (could also have IR/night vision cameras)
  - Equipped with comm to transmit position information
    - USFS currently *does not* fly ADS-B equipped sUAS
    - ADS-B, V2V cell or other comm capability assumed for our scenarios
- Ground Control Station (GCS) is portable
  - Trailer parked near the operational area houses the GCS and support launch and recover
- Pre-described surveillance flight plan
- Scenarios start after launch with mission in progress

HAT Assistant Assumptions

- Serves as a teammate to remote pilot during m:N operations
- Initial areas of knowledge
  - Context (weather, fire, aircraft, traffic, airspace restrictions)
  - Risk (overall, specific, changing)
  - Plays (prioritized list, monitor execution and changing conditions)
- Information comes from sensors, chat, NOTAM's, ATIS, etc.
- As real-time risk to mission increases, Assistant "calls out"
  - Changes to risk value
  - Trend information about sources of risk
  - Applicable/relevant mitigation plays

Mission Personnel

- Incident Command (IC)
  - manages personnel, agencies, equipment, and communications during emergency response incidents; adjusts strategy and tactics of operational effort to accomplish incident objectives
- Aerial Supervisor
  - establishes standard operational altitudes, flight patterns, virtual fences, holding areas, checkpoint and initial points; on scene, ensures inbound aircraft are following procedures
- **Pilot-in-Command (PIC)**
  - **ensuring vehicles are flying the prescribed routes and managing separation**
  - **HAT Assistant supports PIC**
- UAS Service Provider (USS)
  - approves flight plans, monitors flight conformance, coordinates with IC
- Air and Ground Firefighting personnel
  - dozers, firefighters, other air vehicles…

Mission

Map current progress of dozer lines relative to fire progression

- Pre-Mission
  - IC requests temporary flight restriction (TFR) from the FAA
  - PIC develops flight plans for 4 sUAS and declares intent with USS
  - USS verifies operation against known constrains; upon USS approval, PIC launches vehicles
- **Mission**
  - **PIC monitors 4 vehicles for conformance and separation (with aid of HAT Assistant), all phases of flight**
    - **Vehicles fly pre-determined routes autonomously from takeoff to distribution point where they move into assigned quadrants and begin the surveillance mission**
  - **PIC supports payload operations (e.g., ensures cameras are operating)**
    - **Assume video analysis is conducted elsewhere (by automation or person)**
    - **Loiter vehicle(s) upon request**
  - **PIC manages communications**
- Post-Mission
  - PIC closes out flight plans with USS