# HAT m:N Activity

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**Transformational Tools and Technologies Project**

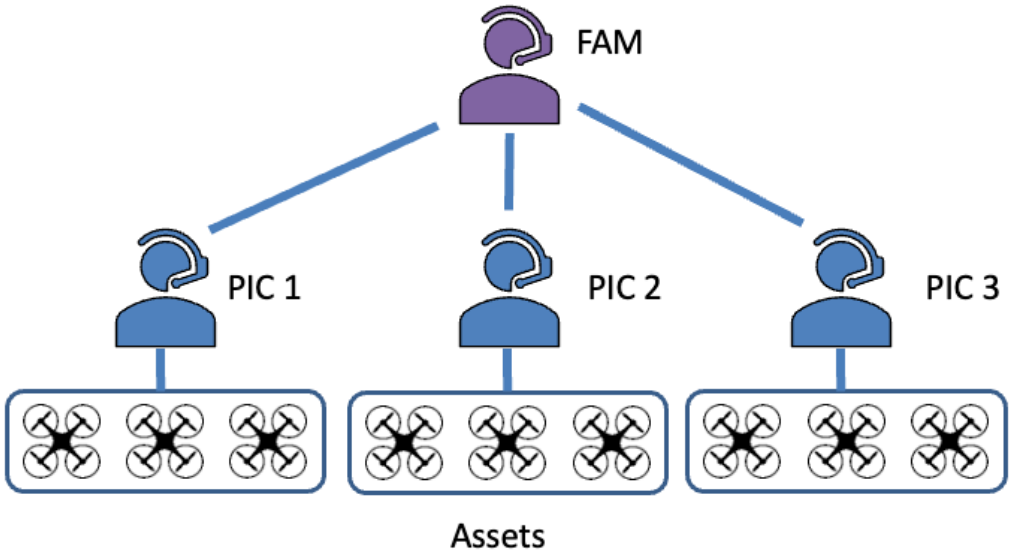
Innovative solutions through foundational research and cross-cutting tools

Tuesday, November 29, 2022 | m:N Working Group F2F

# HAT m:N Overview

- m:N Human-Autonomy Teaming (HAT) Activity
  - Conducts ***human-in-the-loop (HITL) simulation research*** for NASA Ames
  - Focus on how ***human performance can be augmented*** by increasingly autonomous systems
  - Create a relationship between human operator and autonomous systems that ***replicate a teammate relationship***
  - ***Goal:*** test and enhance the safety and efficiency for novel, proposed operations in the National Airspace System

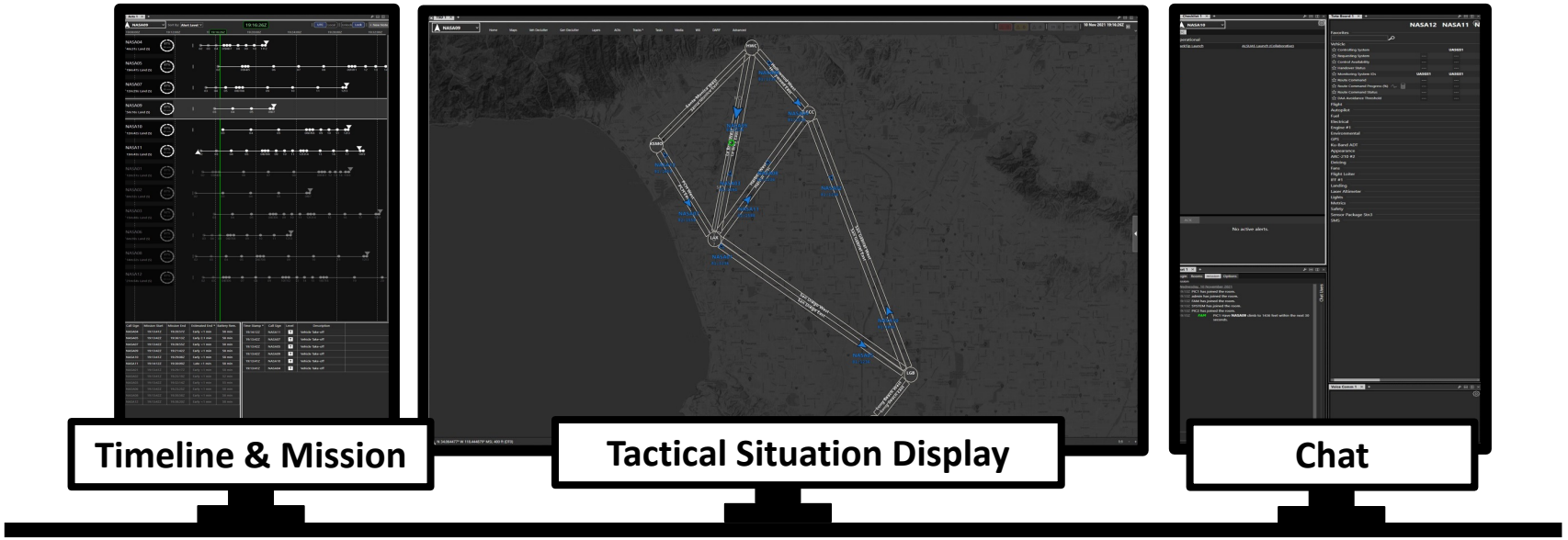
- m:N Paradigm
  - Multiple operators collaboratively managing multiple vehicles, where:
    - m = # of operators
    - N = # of vehicles



# To-date, the HAT m:N Activity has conducted 5 studies on m:N Ops

| Study Date | Study Title | Context | Scope & Description |
|---|---|---|---|
| July 2020 | m:N ConOps Cognitive Walkthrough | sUAS Food Delivery | Initial study on m:N concept of operations |
| October 2020 | m:N HF Task Analysis | GCS Design | Small task analysis reviewing GCS design, displays, and features |
| January 2021 | m:N ConOps/Roles & Responsibilities Remote HITL | sUAS Food Delivery | HITL based off the cognitive walkthrough, conducted remotely due to COVID-19 restrictions |
| November 2021 – January 2022 | m:N Handoff HITL | UAM, Airtaxi | Study examining handoffs of UAM vehicles between GCS pilots during contingency situations |
| September 2022 | m:N UAM Comms HITL | UAM, Airtaxi | Study examining communication systems and procedures for m:N |

# Vigilant Spirit Control Station




- Highly configurable Ground Control Station (GCS) software
- Based on software created by Air Force Research Laboratory
  - Capability for single and multi-vehicle control and management
- Includes:
  - Moving map display
  - Vehicle timeline
  - Chat system
  - Avionics display
  - Digital checklists
- Can simulate UAM, large UAS, sUAS, and low SWaP scenarios

# CONOPS/R&R SIM

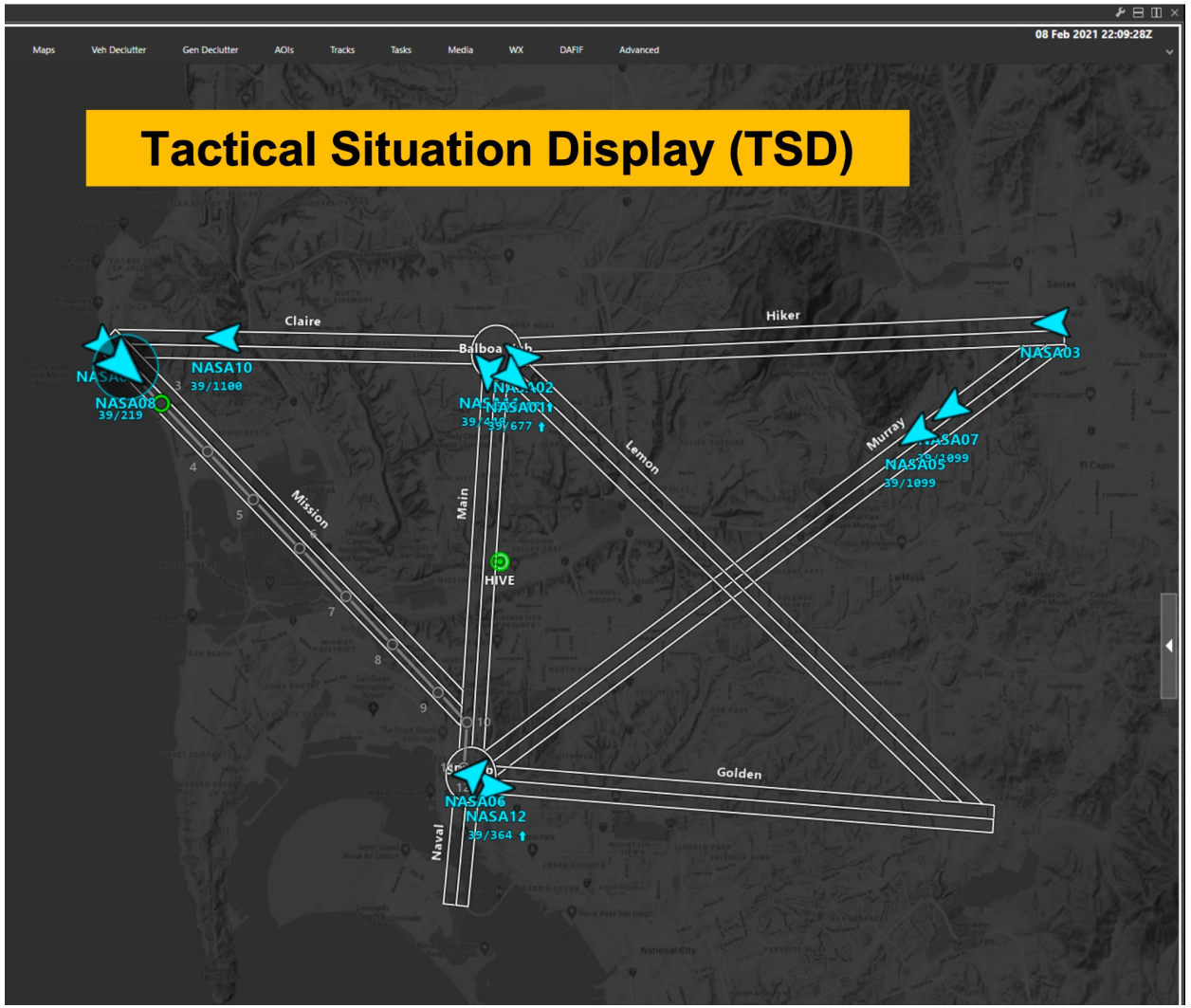
# m:N ConOps/R&R HITL

**Goal:** investigate the effect of automation support level on pilots' performance and workload while controlling multiple (12) vehicles

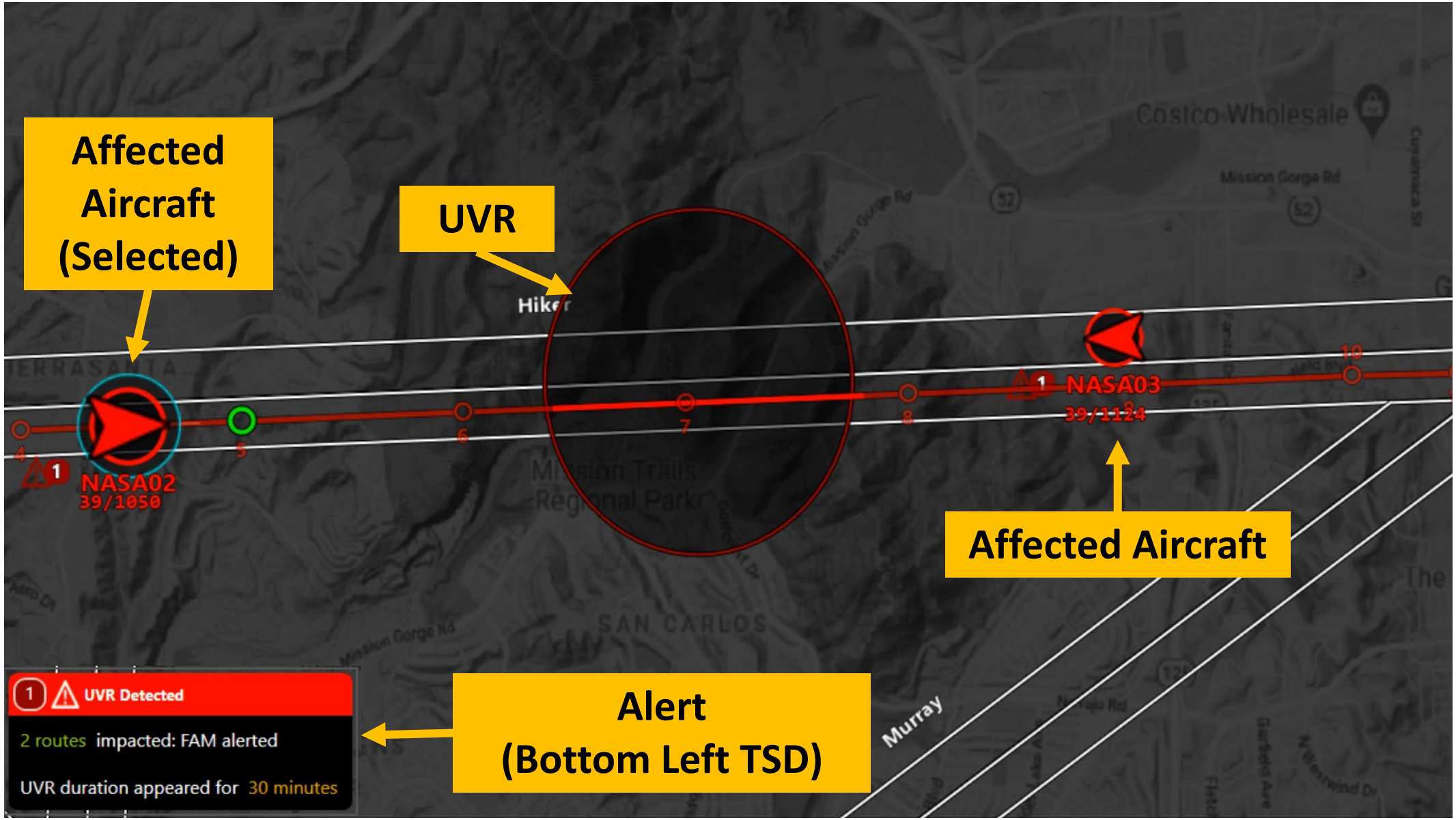
**Pilot Task:** re-routing a subset of their vehicles around unplanned restricted airspace: UAS Volume Reservation (UVR)

**Experiment Design**

- Automation Support: 2 levels, within-subjects
  - Manual reroutes
  - Automated reroutes generated by the GCS
- Number of Affected Vehicles: 2 levels, within-subjects
  - 2 Vehicles require reroute
  - 4 Vehicles require reroute
- Within-trial manipulation
  - 25% of all vehicles affected by the UVR also required an altitude adjustment due to nearby terrain conflicts



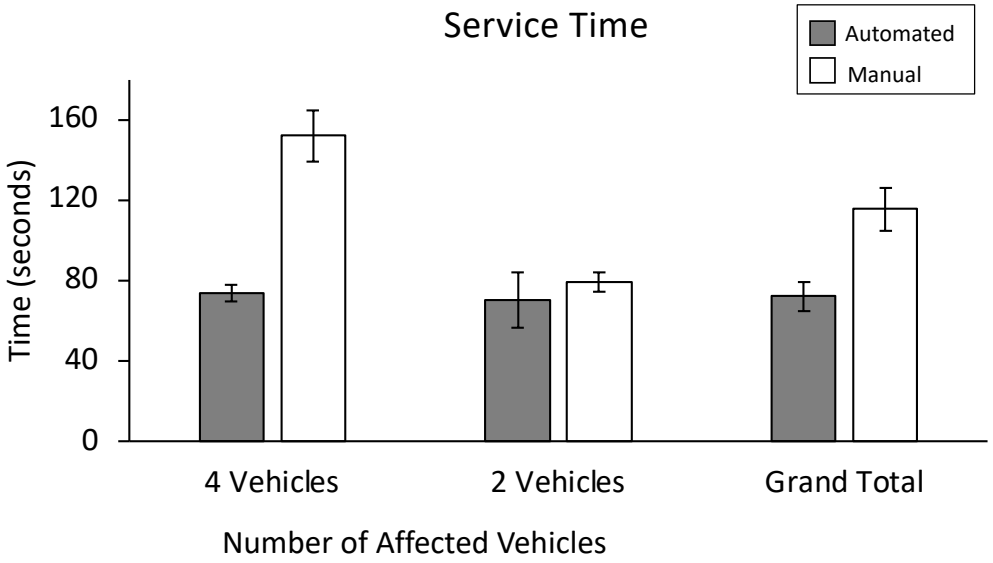
# Screenshot of Active UVR & Affected Vehicles

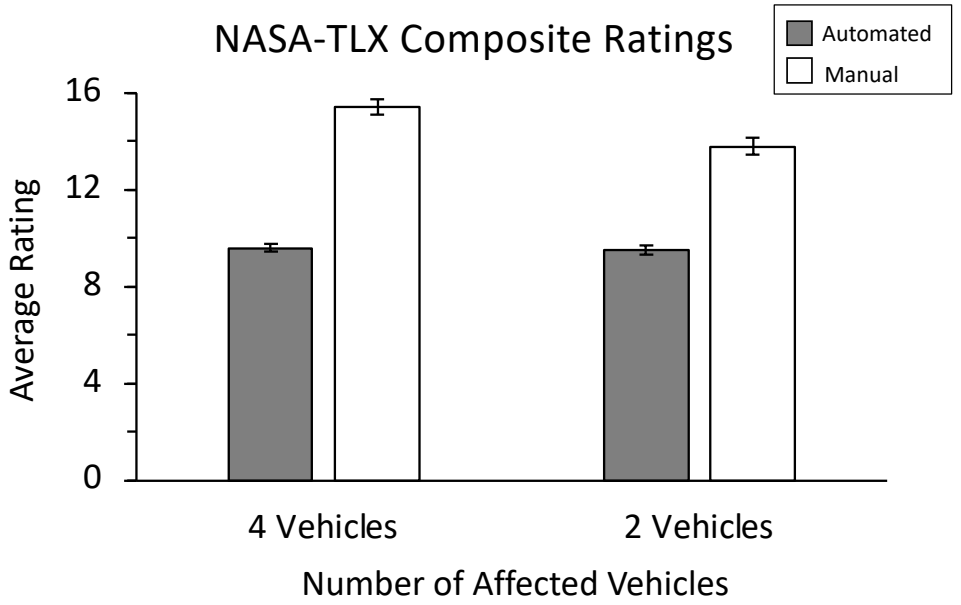


# Key Results

- Pilots were able to successfully reroute vehicles in all conditions with UVR violations < 1% of the time

- Provision of automation significantly decreased subjective workload and improved efficiency.




**Paper:** Sadler, G., Chandarana, M., Rorie, R.C., Tyson, T., Keeler, J., Smith, C., Shyr, M., Wong, D., Scheff, S., Dolgov, I., 2022. A Remote Human-in-the-Loop Evaluation of a Multiple-Drone Delivery Operation. In AIAA Aviation 2022 Forum.

# HANDOFF SIM

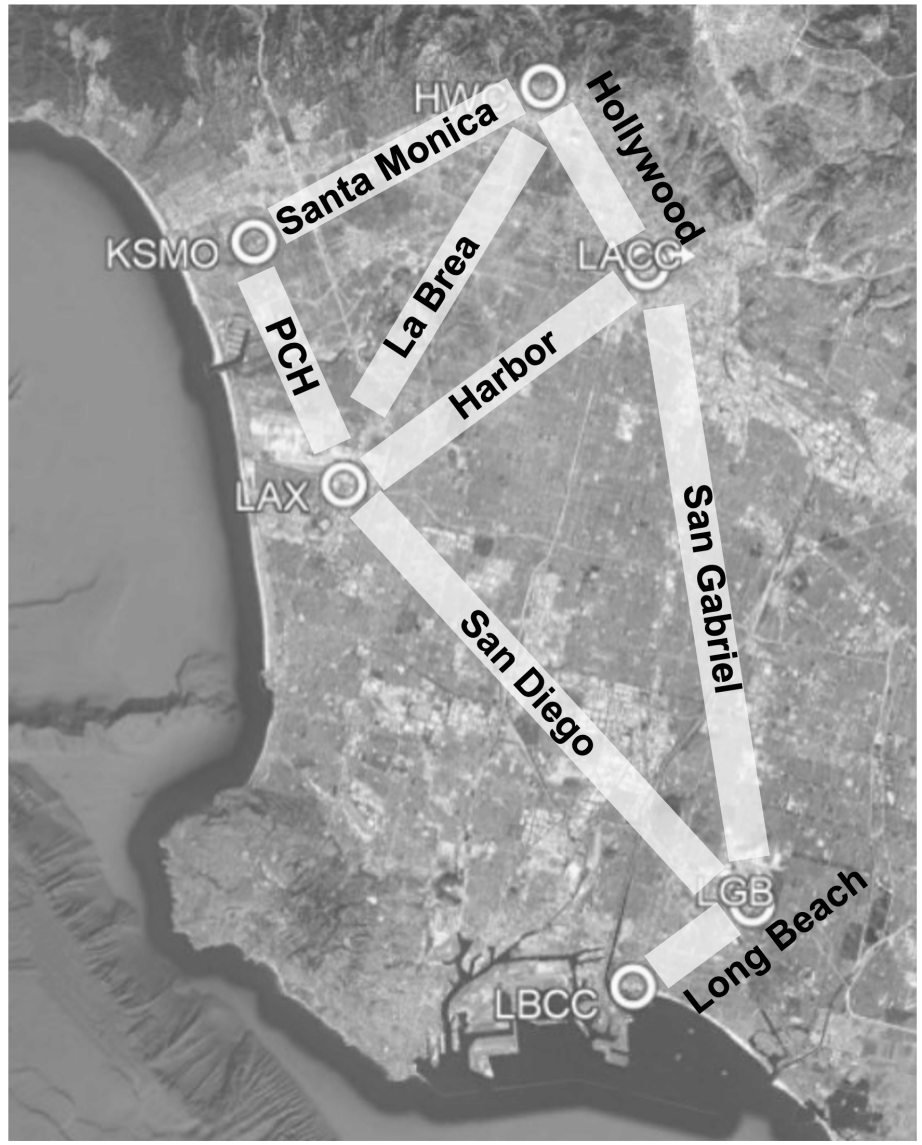
# m:N Handoff HITL

**Goal:** collect data on remote operators' use of the handoff capability in an m:N Urban Air Mobility (UAM) context. The primary focus of the current study was how participants manage **unplanned handoffs** – i.e., did handoffs occur when one or more vehicles in their fleet experienced an emergency?

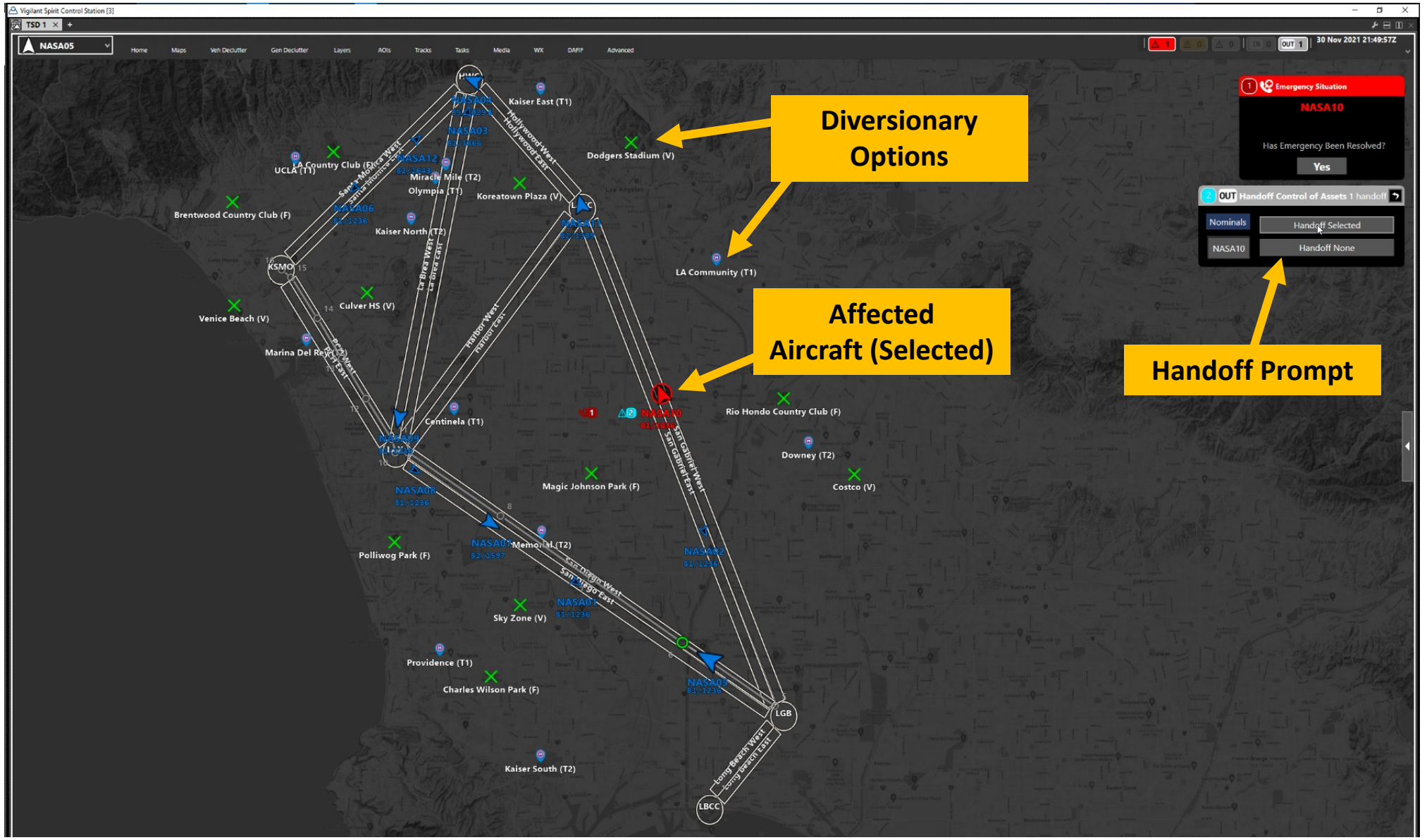
**Pilot Task:** divert emergency aircraft to appropriate landing sites (hospitals, helipads, open fields)

**Experiment Design**

- Workload Level – 2 levels, within-subjects
  - *Low* = 1 vehicle experiences emergency
  - *High* = 2 vehicles experience emergencies simultaneously
- Handoff Assist Level – 2 levels, within-subjects
  - *Manual* = operator must manually select and handoff asset(s)
  - *Assisted* = system prompts handoff at onset of contingency; operator can handoff all nominal aircraft or subset of off-nominals with single click



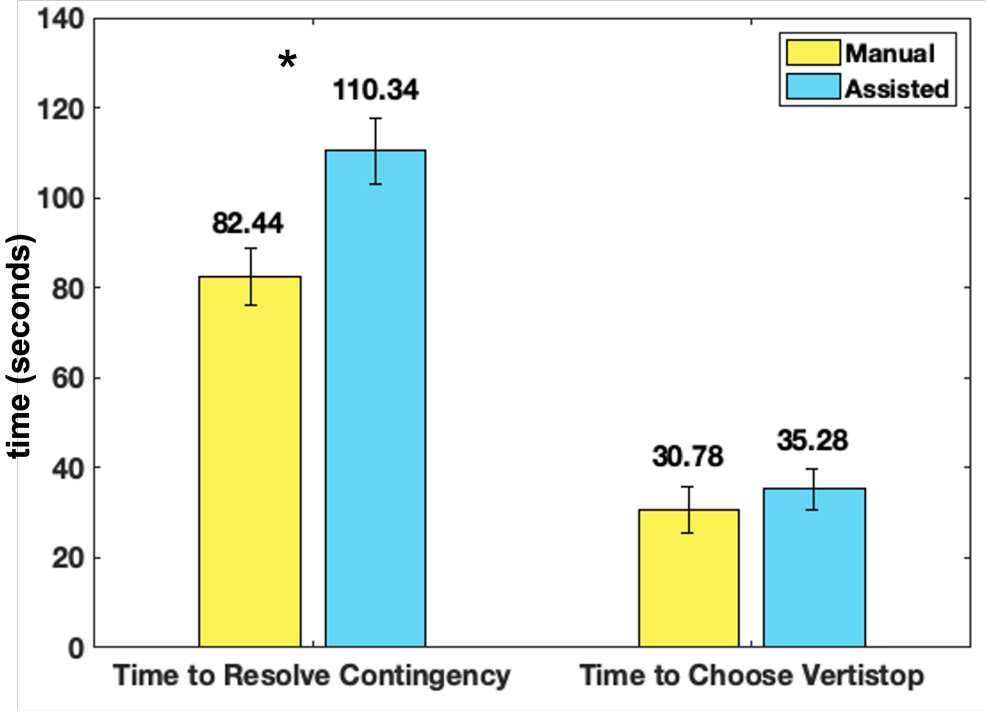
# Screenshot of Contingency and Handoff Prompt



# Key Results

- Most of the time, subjects chose to handoff no vehicles or only nominal vehicles
- Time to resolve a contingency was longer in the assisted automation condition

| Type of Vehicles Handed off | % of Time |
|---|---|
| No vehicles | 39% |
| Nominal Vehicles only | 39% |
| Contingency Vehicles only | 16% |
| Mixed (nominal + contingency) | 6% |




**Paper:** Chandarana, M., Sadler, G., Keeler, J., Smith, C., Rorie, R.C., Wong, D., Scheff, S., Pham, C., Dolgov, I., 2022. Streamlining Tactical Operator Handoffs During Multi-Vehicle Applications. IFAC HMS 2022

# UAM COMMS SIM

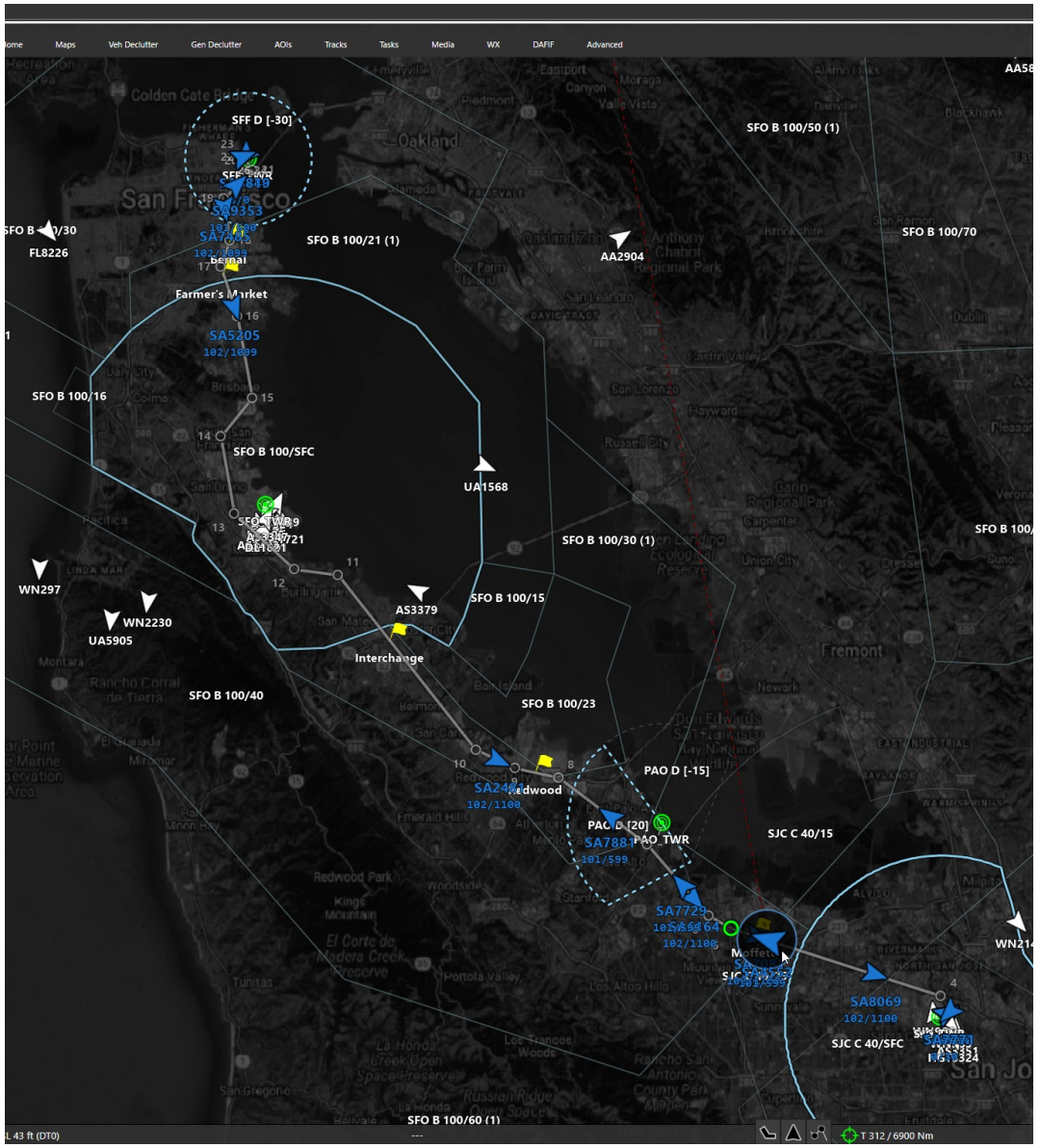
# m:N UAM Comms HITL

**Goal:** determine effects of communication system and vehicle load on pilot coordination with ATC

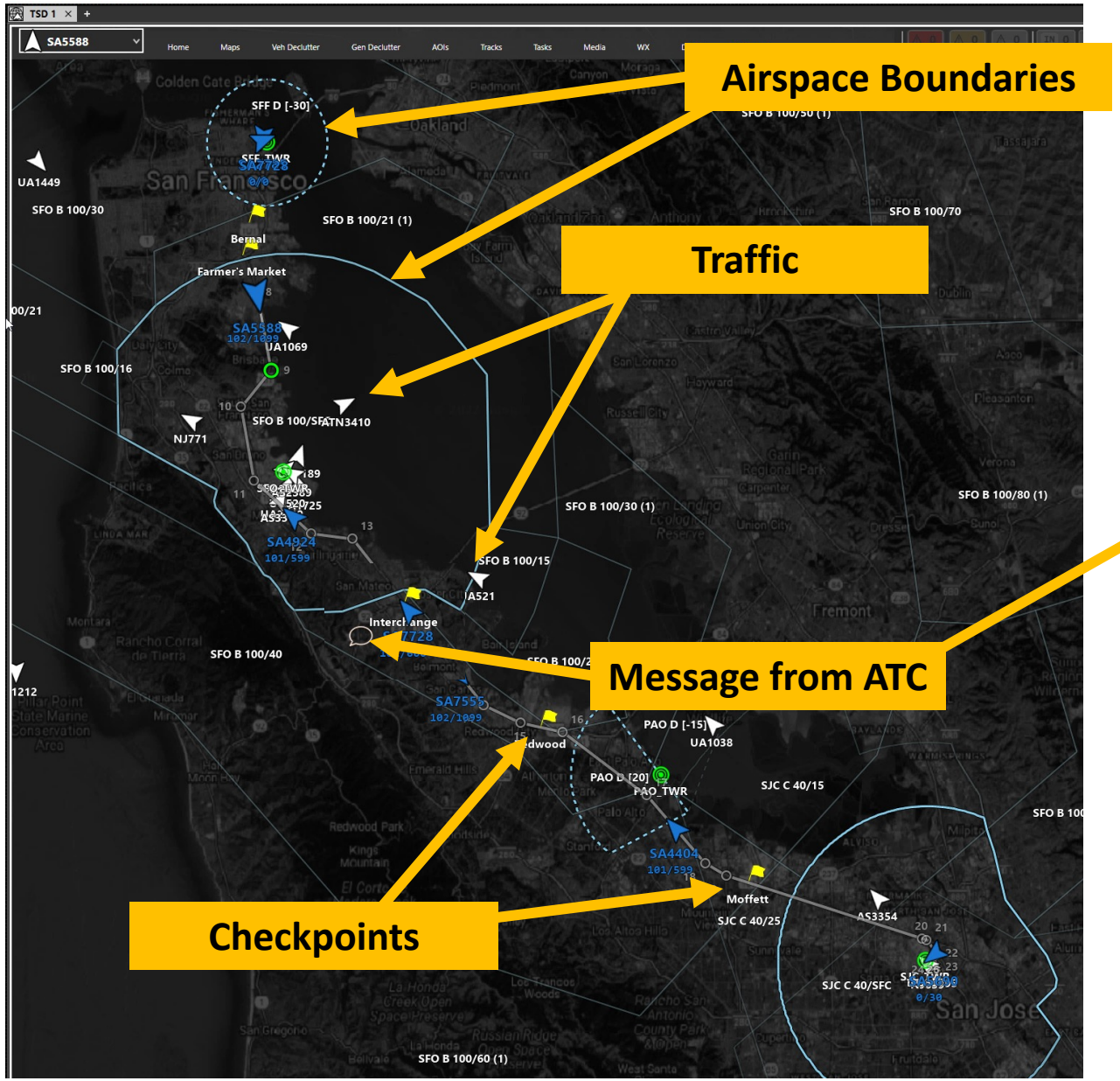
**Pilot Task:** coordinate flight activity for multiple, simultaneous flights in a hypothetical airtaxi service. Pilots were required to request departure, arrival, and transition clearances as well as comply with ATC instructions

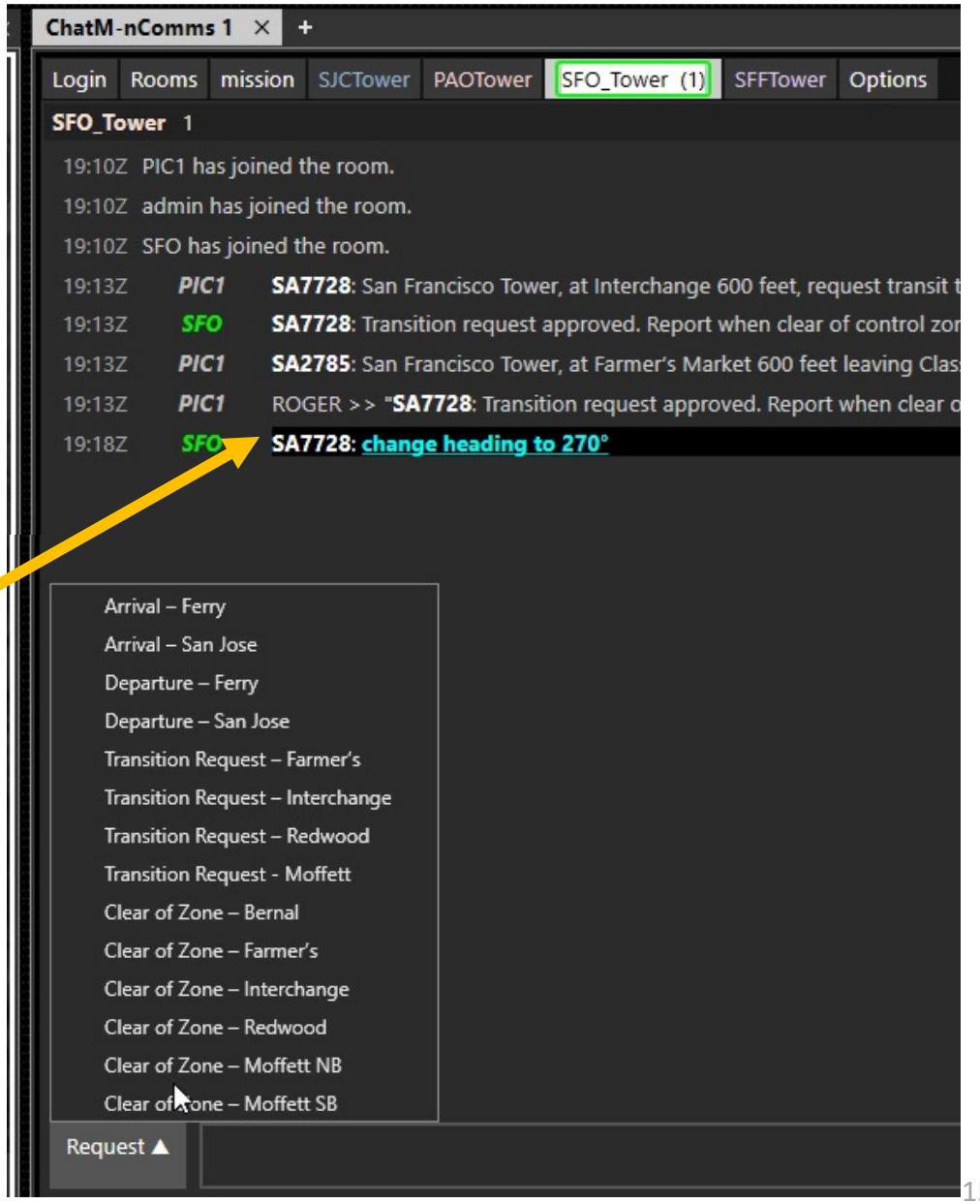
## Experiment Design

- Comm Modality – 3 levels, within subjects
  - *Voice* = participant will communicate with ATC using simulated radio frequencies
  - *Datalink+* = participant will communicate with ATC using a digital chat interface
    - Digital messages allow clearances/parameters to be “auto-loaded”
  - *Hybrid* = participant will communicate with ATC using both Voice and Datalink modes
    - Messages mapped to comm modality by category
      - “Auto-loadable” clearances over Datalink
      - Transition clearances over Voice
- Vehicle Load – 2 levels, within-subjects
  - *Low* = 4 vehicles
  - *High* = 12 vehicles



# Screenshot of “Datalink” Comms



# UAM Comms Metrics

- Dependent Variables
  - Performance
    - Comm transaction time
    - Response time to complete instructed action
    - Accuracy:
      - Correct readback?
      - Clarifications requested?
      - Did the action match the instruction?
  - Situation Awareness
    - Response time and accuracy to SA prompts
  - Subjective Ratings
    - Workload – NASA TLX (Post-Trial)
    - Display/Information Acceptability – ratings on availability & utility of interface elements (Post Trial & Post Sim)
    - Procedural Acceptability – utility of the procedures and confederate roles during the sim (Post Sim)

- Two-way ANOVAs will be conducted to determine if Vehicle Load and/or Comm Mode impacted:
  - Workload ratings (NASA TLX)
  - Communication transaction time
  - Communication errors
  - Clearance execution times
  - SA prompt accuracy
  - Post Trial ratings

# Upcoming Research Efforts

## *m:N sUAS GCS HITL*

- **Goal:** explore different GCS configurations and their impact on remote RPICs' ability to manage vehicles under their control

- **Pilot Task:** Coordinate flight activity for a fleet of sUAS delivery vehicles operating in the NAS. Pilots will be required to manage reroutes when necessary.

- **Experiment Design**
  - GCS Mode – 3 levels, within-subjects
    - *Manual* = Current VSCS GCS that requires manual vehicle reroutes
    - *Auto* = Partner GCS that will have auto reroute capability and minimum operator interaction
    - *Hybrid* = Auto GCS + 2-3 additional operator interaction capabilities (waypoint modification, waypoint addition/deletion, etc.)
  - Airspace Density - 2 levels, within-subjects
    - *Low* = Few vehicles in surrounding airspace
    - *High* = Large number of vehicles in surrounding airspace

## *High Complexity Sim*

- **Goal:** test and evaluate a high-fidelity, fully-integrated m:N capability operation
- **Timeline:** FY24

# Thanks!

Thank you!

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