UAS Integration into the NAS:
Unmanned Aircraft System (UAS) Delegation of Separation

UAS Integration into the NAS

- FAA Modernization and Reform Act of 2012 mandates UAS integration in the NAS by 2015
- Operators must be able to safely maneuver UAS to maintain separation and collision avoidance
- Delegated Separation– the transfer of responsibility for maintaining separation between aircraft or vehicles from the air navigation service provider to the relevant flight operator (JPDO NextGen Integrated Work Plan)

Delegated Separation

- Delegated separation will likely begin in sparsely trafficked areas before moving to more heavily populated airspace

- As UAS operate primarily in areas with lower traffic density and perform maneuvers routinely that are currently managed through special handling (i.e. loitering), they have the advantage of becoming an early adopter of delegated separation (OSED for UAS)

Delegated Separation

- Three levels (Eurocontrol):
  - Limited Delegation
    - ATC in charge of problem and solution identifications. Pilot in charge of implementation of solutions and monitoring
  - Extended Delegation
    - ATC in charge of identifying problems and delegating to pilot identification and implementation of the solution and monitoring
  - Full Delegation
    - Pilots are responsible for all tasks related to separation assurance: identification of problems and solutions, implementation and monitoring
- This experiment will test Extended and Full

Levels of Delegation: Extended

- ATC maintains responsibility of problem identification and notification to UAS operator
- UAS operator is responsible for identification and implementation of solutions and monitoring for clear of traffic after rerouting
- Example:
  - **ATC:** *"PD-1, traffic at 2 o'clock, north bound, FL 280. Advise tracking"*
  - **UAS:** *"PD-1, traffic acquired."*
  - **ATC:** *"PD-1, maneuver to maintain sensory separation from SWA749."*
  - **UAS:** *"PD-1, maintaining sensory separation with SWA749."*
    - UAS makes a reroute to avoid collision and monitors until clear of conflict
  - **UAS:** *"L.A. Center, this is PD-1. Clear of conflict, request to return to original flight path."*
  - **ATC:** *"Roger, PD-1. Permission to return to original flight path."*
    - UAS returns to original flight path

Levels of Delegation: Full

- UAS operator responsible for all tasks related to separation assurance
  - Identification of problems and solutions, implementation of solutions and monitoring for clear of traffic after rerouting
- Example:
  - UAS monitors CSD for potential conflicts
  - UAS identifies a potential conflict
  - UAS makes a reroute to avoid collision and monitors until clear of conflict
  - UAS identifies clear of conflict and resumes original flight path
- No communication with ATC is required

Experimental Question

- Are UAS capable of performing delegated separation?
  - 5 nm horizontal, 1000 ft vertical
  - Extended and full delegation as defined by Eurocontrol
- 2x2 within subjects design
  - Level of Delegation: extended vs. full
  - Traffic display information: basic (only show traffic) vs. alerts (conflict detection based on ballistic information, not trajectory)
- Examine the effects delegating separation responsibilities to the UAS operator in a positively controlled sector

Participants

- Total of 17 participants will be used
  - 12 MUSIM operators
  - 3 pseudo air traffic controllers
  - 2 pseudo pilots
- Experimenters
  - MUSIM
  - ATC
  - Sim Manager

Simulation Environment

- UAS Pilots
  - MUSIM
  - Ames 3D Cockpit Situation Display (CSD)
  - Probe station
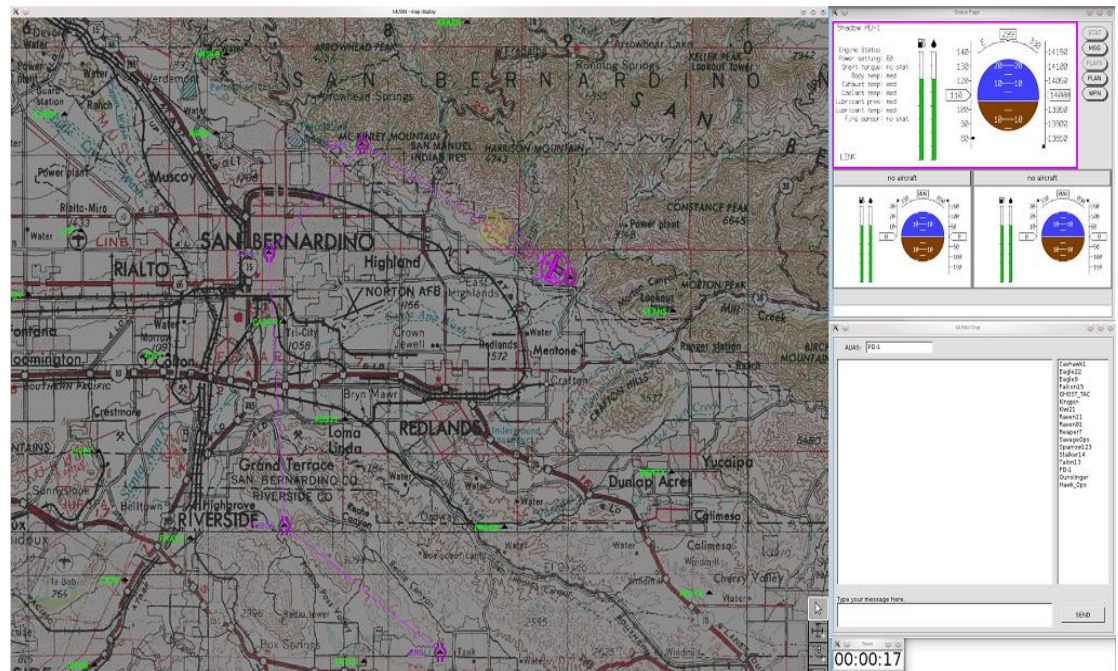
MUSIM

- MUSIM is separated into three main displays to control the UAS
  - Map indicating position and flight path of the UAS in purple waypoints
  - Multi-function Display (MFD) indicating UAS status and behavior, and instructions from your commander
  - mIRC Chat providing periodic situation awareness probes
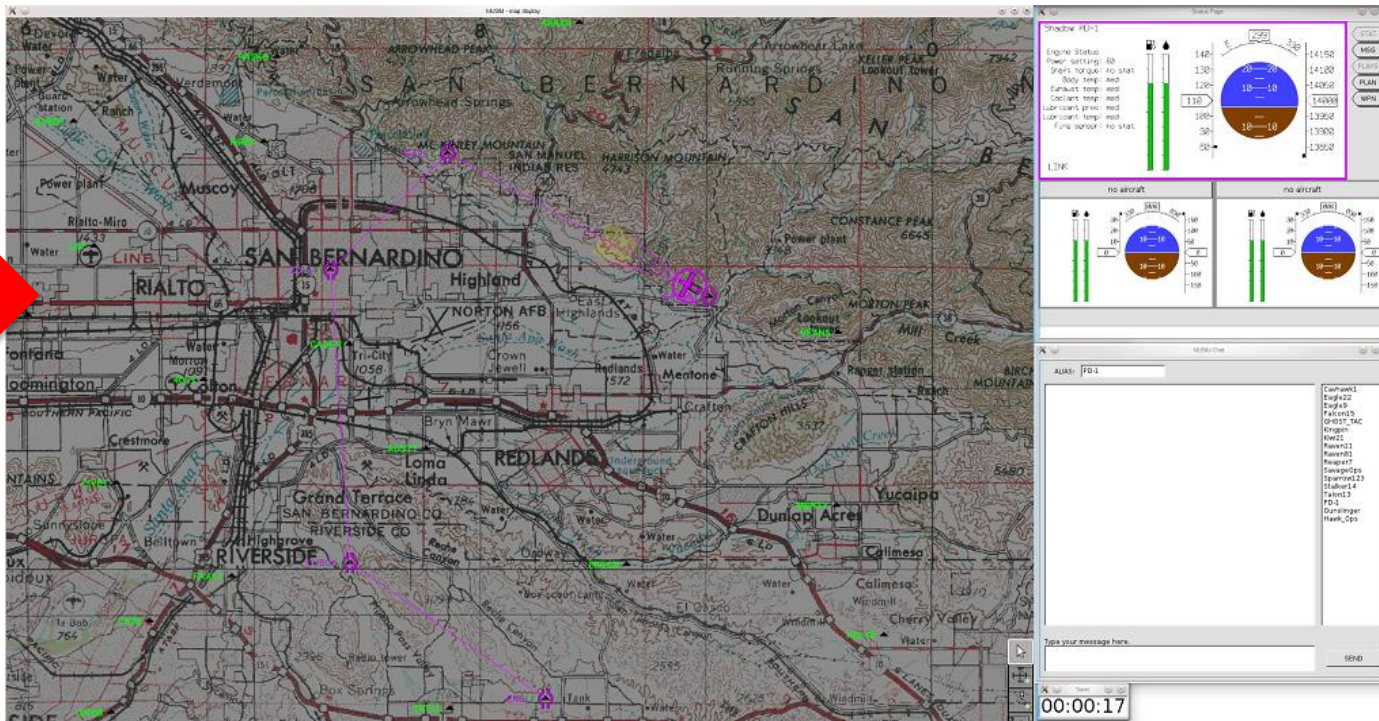
Ames CSD

- Participants will be able to adjust the horizontal viewing distance from 10-640 nm, and to bring up aircraft trajectories

- Aircraft are color coded:
  - <u>Green</u>: aircraft 500 ft or more below ownship
  - <u>White</u>: aircraft within 500 ft above or below ownship
  - <u>Blue</u>: aircraft 500 ft or more above ownship

Simulation Environment

- Air Traffic Controllers
  - Multi-Aircraft Control System (MACS) controller station
  - Probe station

Simulation Environment

- Pseudo Pilots
  - Multi-Aircraft Control System (MACS) pseudo pilot station

Scenarios

- MUSIM operators will operate a generic MALE UAS in support of CO^2 emission monitoring in Southern California Center airspace
  - Based off scenario 3 in OSED for UAS
- ATC will maintain positive control over their sector; only UAS will be given delegated separation
- Four 30 minute long experimental routes with periodic messages assigning a new altitude

Scenarios

- Three mission objectives to be given to MUSIM operators:
  - Follow appropriate level of delegated separation while performing mission
  - Reroute in response to mission messages
  - Communicate with Air Traffic Control as needed, and stay on course

Dependent Variables

- Objective
  - LOS events:
    - Amount, duration, closest point of approach
  - Conflicts and Collisions:
    - Amount, duration, CPA
  - ATC Communications:
    - Amount, length of time, interaction count, was reroute given due to traffic?
  - Did ATC retake spacing responsibility?
  - Route Modifications:
    - Amount, reaction time, time spent rerouting, time spent negotiating with ATC, total time

Dependent Variables

- Subjective
  - Workload
    - Probes
    - Post-scenario TLX
    - Post-block TLX
  - Situation Awareness
    - Online probes via mIRC chat on MUSIM
    - Post-block questionnaire
  - Post-Simulation Questionnaire
    - Comfort and anxiety levels
    - Preference and usability ratings

Expected Results

- Air Traffic Controller
  - Reduced workload with higher delegation levels
  - Reduced radio communications with UAS in higher delegation levels
  - Less ATC interventions with UAS in higher delegation levels
- UAS Operator
  - Increased (but manageable) workload with higher delegation levels
  - Increased SA with higher delegation levels