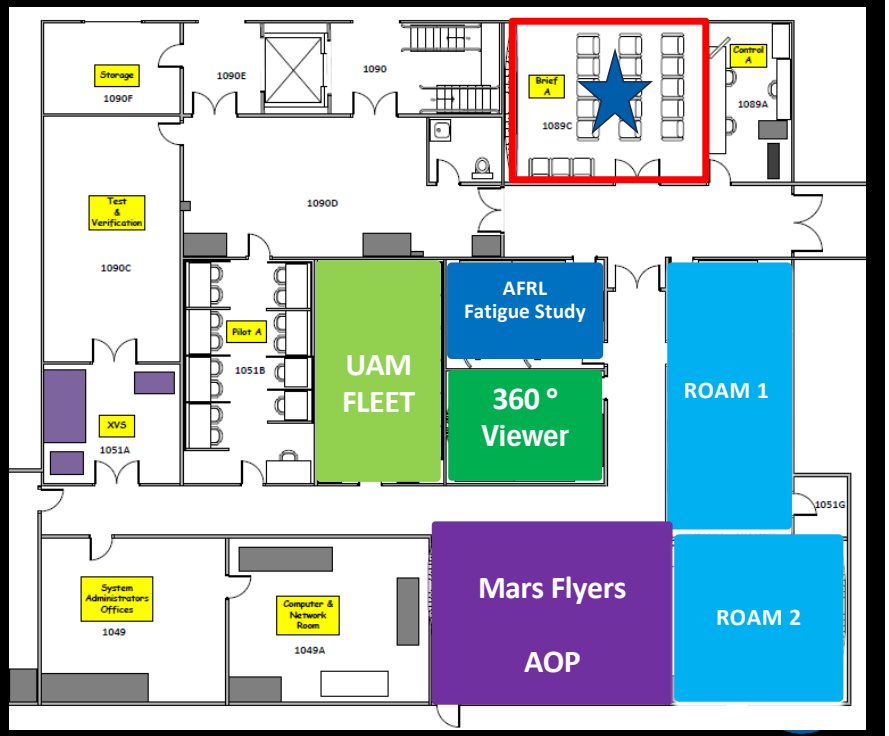

ATOL
Air Traffic Operations Lab, NASA Langley

Air Traffic Operations Lab (ATOL)

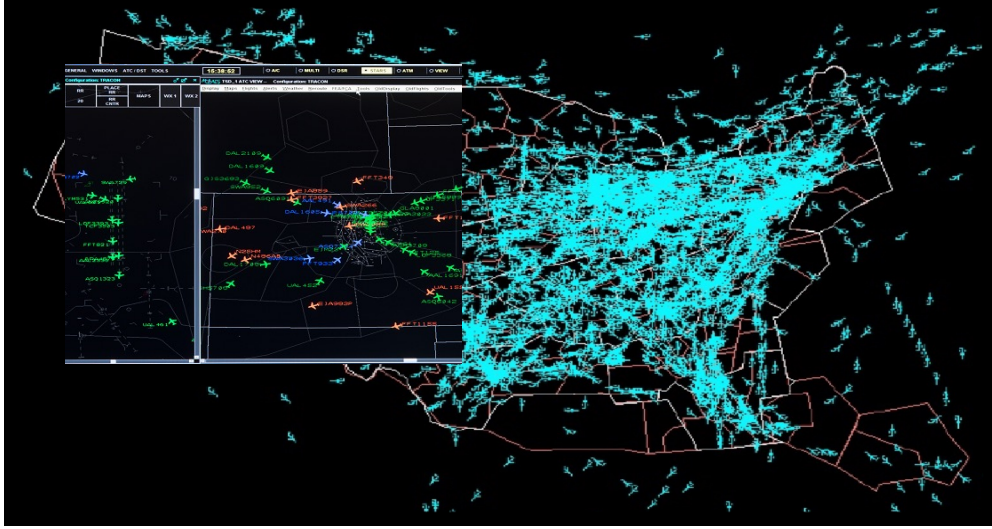
- Theater, Reentry
- Air Force Research Lab Fatigue Study
- 360 ° Viewer
- ROAM - Remote Operations for Autonomous Missions (ROAM)
- Mars Flyers, Autonomous Operations Planner
- UAM FLEET



What is the ATOL?

A flexible, airspace operations simulation facility

We simulate a representative portion of the National Airspace System (NAS)







Full operational environment

- Simulate multiple piloted aircraft at one time
- Increase effectiveness with real radio communications

Simulate multiple air traffic control facilities with real controllers

The ATOL enables research and development of advanced operational concepts and technologies with real human interactions

Air Traffic Management Research

Address growing delays from increasing traffic



Prepare for a paradigm shift in demand

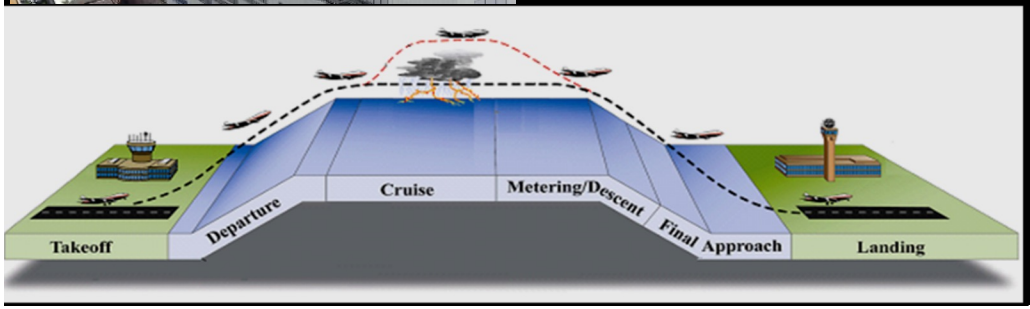




Enable the change from a homogeneous traffic mix to heterogeneous



Enable easy assimilation of new categories of vehicles with dramatically different performance



Handle the potential unprecedented increase in traffic numbers due to proliferation of UAM vehicles

Remote Operations for Autonomous Missions (ROAM) Ground Control Center



Command and Control of Remote UAS Operations for Research

Command Center for research conducted at the City Environment Range Testing for Autonomous Integrated Navigation (CERTAIN) test site



- ROAM is a prototype remote vehicle operations center utilizing small unmanned aerial vehicles as surrogates for larger-scale vehicles to explore:
  - Advanced air mobility operations
  - Roles and responsibilities of remote operators managing multiple vehicles
  - Command and control of remote vehicles in beyond visual line of sight conditions

Crew State Monitoring and Prediction of Fatigue in Pilots

Co-PIs Chad Stephens and Dr. Angela Harrivel, partnering with Naval Safety Command

NASA Langley CSAOB Expertise

- Biosensors and ML experience in the same people
- Real-time state prediction lessons learned
- All the biometric sensing including direct and indirect brain measures such as EEG and fNIRS
- Vigilant attention and a cognitive human performance focus to complement physical performance
- Work closely with flight and lunar lander simulators
- Can apply our expertise in increasingly-autonomous systems as we consider human-autonomy-teaming or cyber-physical-human teaming for ground-independent operations

Fatigue in pilots is a significant concern that can lead to catastrophic mishaps as sorties are getting longer. We employ flight simulation and task batteries and self-report questionnaires to induce and measure fatigue toward predicting it.

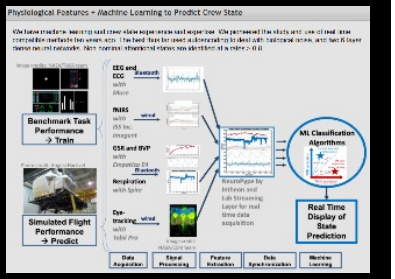
Aim 1: To generate and verify a biometric fatigue dataset for military pilots

Aim 2: To determine the accuracy with which Machine Learning models predict fatigue



Image credits: NASA Langley D318 CSAOB





https://csaob.larc.nasa.gov/nasahrpiws/

Multi-Vehicle (m:N) Operations Research

POCs:

- Dr. Eric Chancey (eric.t.chancey@nasa.gov)
- Mr. Mike Politowicz (michael.s.politowicz@nasa.gov)

Objective:

- Identify generalizable **human-autonomy teaming (HAT)** approaches that will enable **fewer remote operators (m)** to manage **many more increasingly autonomous vehicles (N)** to support scalable **multi-vehicle (m:N) operations**

Key Capabilities:

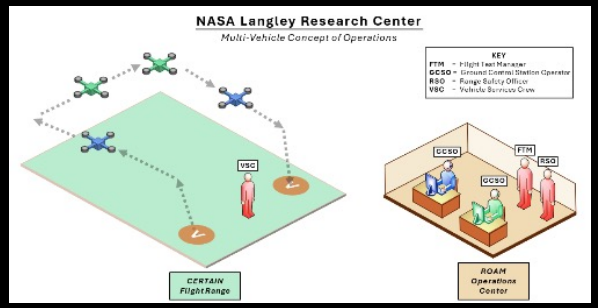
- **MPATH Ground Control Station**
- **ROAM UAS Operations Center**



MPATH Ground Control Station



ROAM UAS Operations Center



Research / Publications:

NASA Multi-Vehicle (m:N) Working Group

- Biannual meeting of government, academia, and industry (since 2021)
- Summary Report (July 2025 meeting): https://ntrs.nasa.gov/citations/20250008934
- Website: https://nari.arc.nasa.gov/ttt-ram/multi-vehicle

Applied Multi-Vehicle (m:N) Research Studies

Human-in-the-Loop (HITL) Studies in ROAM UAS Operations Center

- Separation Method → Workload, Situation Awareness, Trust: https://doi.org/10.2514/6.2021-1176
- Human-Automation Trust Development w/ Exposure: https://doi.org/10.1177/15553434241296573
- Human Factors Assessment of Vertiport Operations: https://doi.org/10.2514/6.2024-0526
- Human/Automation Roles & Case Studies of Off-Nominal Events: https://doi.org/10.2514/6.2023-2656
- Eye Gaze Behavior Analyses: https://doi.org/10.1109/DASC55683.2022.9925872

Design of Multi-Aircraft Ground Control Station (MPATH)

- Initial Version – Design Approach & Usability Results: https://doi.org/10.2514/6.2023-2525
- Multi-Aircraft Control – User-Centered Design Process & Solutions: https://doi.org/10.2514/6.2026-0711

Design of Remote UAS Operations Center (ROAM)

- ROAM Ops Center – Design & Usability Results: https://doi.org/10.2514/6.2023-2526
- New Design Process for Remote Ops Centers: https://doi.org/10.1177/10648046251337757

Concept of Operations (ConOps)

- Preliminary Development – m:N ConOps for NASA Langley: https://doi.org/10.2514/6.2025-0836
- ConOps for m:N Flight Ops at NASA Langley: *Upcoming NASA Technical Memorandum*

Academic Multi-Vehicle (m:N) Research Studies

Situation Awareness & Visual Attention

- Interruptions → Situation Awareness *(presentation)*: https://ntrs.nasa.gov/citations/20240013181
- Mental Models of Automation → Visual Attention Allocation: https://doi.org/10.25777/xske-8625
- Theoretical Approach to Attention Allocation: https://doi.org/10.1016/B978-0-443-29246-0.00011-0

Trust in Automation/Autonomy

- Human-Automation Trust → Visual Attention Allocation: https://doi.org/10.1177/21695067231194333
- Bases of Autonomy → Trust: https://doi.org/10.1177/21695067231194326
- Human-Automation Trust Questionnaire: https://doi.org/10.1177/00187208241263774
- Theory of Human-Automation Trust w/ Mental Models: https://ntrs.nasa.gov/citations/20205003378

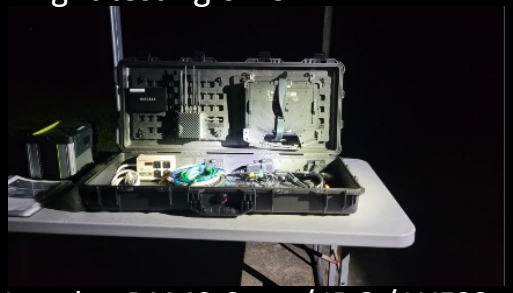
Other Topics

- Task Allocation → Workload: https://doi.org/10.2514/6.2024-4316
- Public Acceptance of Remote Operations: https://doi.org/10.1177/1071181320641251

ACERO



Night testing on CERTAIN



Langley PAMS Case / IDC / WFSS



Overwatch Aero PAMS Integration



Robinson R44 AirTruck PAMS Integration

- TCL-1 PAMS Integration and Testing
- TCL-1 IDC MAVLINK and Overwatch Aero Integration
- TCL-2 WFSS on Wings Design and Initial Implementation
- TCL-2 IDC R44 AirTruck and Sikorsky Integration (in progress)

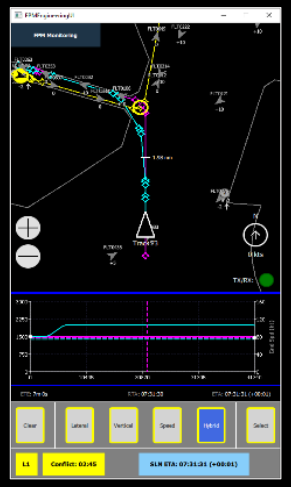
Mars 360° viewer





Langley for drone/UAM research





AOP - Intent based deconfliction for any type of vehicle

Moon to Mars (<3 weeks)



Using Unreal engine

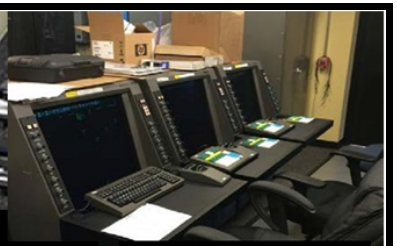


- Google Earth out the window
- Langley Flyer engine modeling a quadcopter with extended Propellers
- Mars environment

NASA and FAA WJHTC Laboratory Integration: NFLITE



FAA Out-The-Window (OTW) Tower Lab

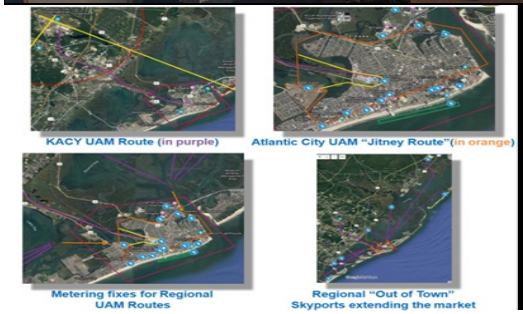


FAA STARS System Capability/TSAS Lab



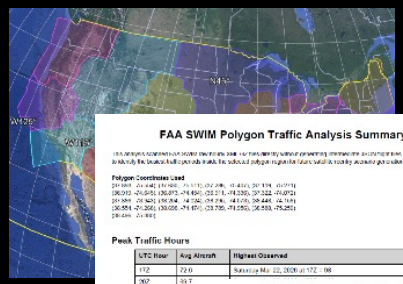
FAA UAM Lab

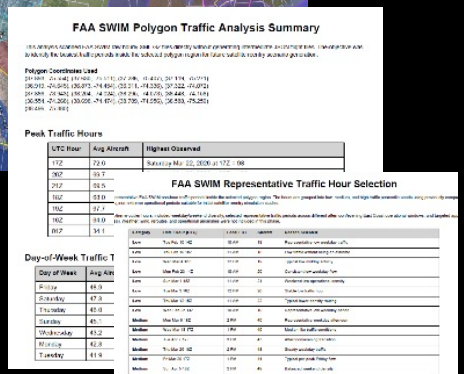


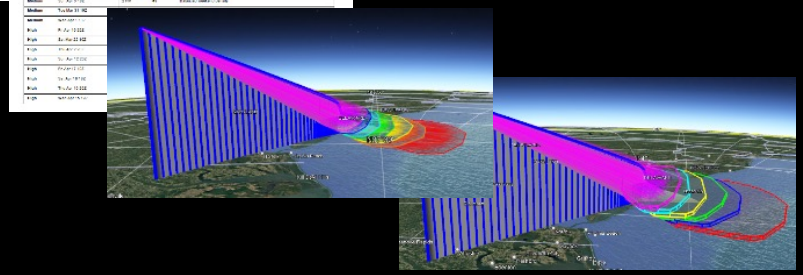


- Partnering with the FAA TC to integrate the ATOL with the FAA TBO Integrated Test Environment (TITE)
  - Created the NASA/FAA Lab Integrated Test Environment (NFLITE)
  - Includes integration with the City Environment Range Testing for Autonomous Integrated Navigation (CERTAIN) facility via ATOL connectivity
  - Dedicated data connection
  - Prepare for future RDT&E supporting the maturation of evolving AAM concepts and technologies
- Initial effort: Validate integration of the components and initial capability:
  - ATM/AAM Integrated Environment use cases
  - Simulated Commercial Airline, AAM, and UAS traffic

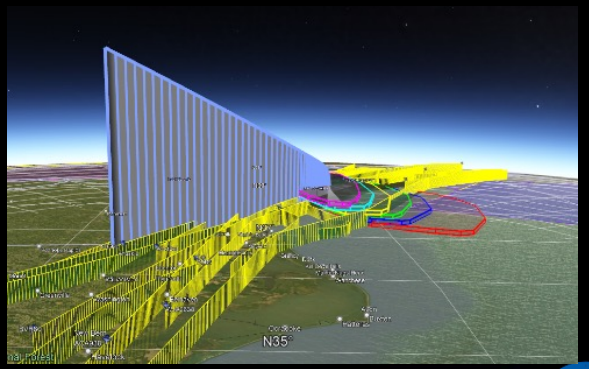
Reentry Down-mass Simulation





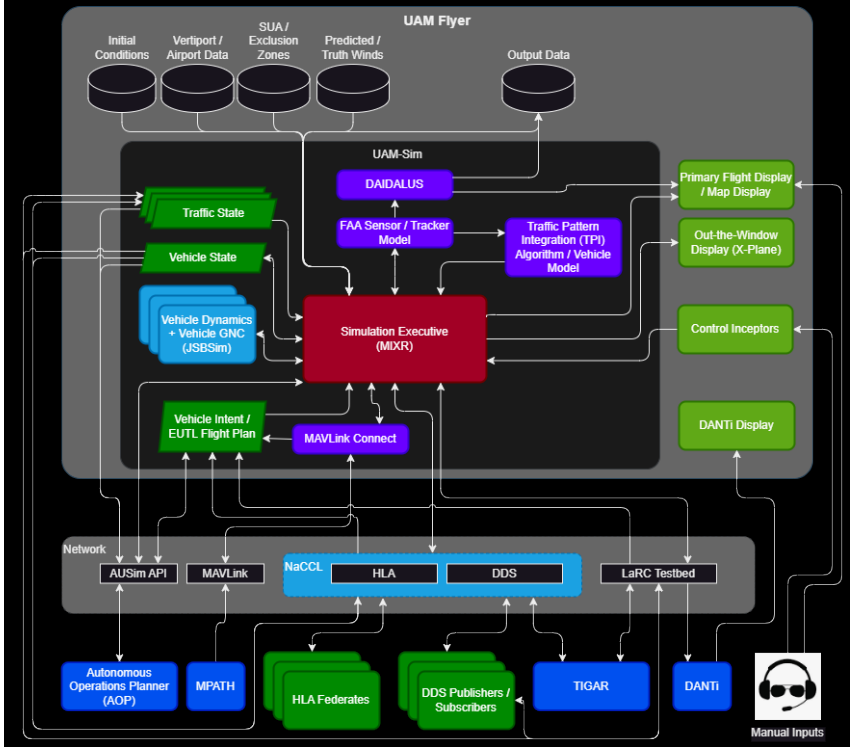


- Utilize FAA SWIM Data
- Perform traffic analysis
- Convert to KML and Scenario data
- Develop Hazard areas
- Run Sim form impact of
  - Day/time
  - Location
  - Proposed trajectory



Use to inform
- Mission design choices
- Policy Makers
- Process Owners

UAM-Sim and Langley Flyer





- Flexible research platform
- Low/Med fidelity transport, GA, UAM, sUAS, HALE models
- Supports HF and airspace research
- Integrated autonomous flight / path planning / deconfliction / DAA
- Supports 100s of AC in distributed sim

ATOS Distributed Simulation Framework

- Real-time simulation framework, built for integration
- Automates installation, configuration, mode control, data collection across distributed nodes
- Supports 100s of federates across separate sims / networks – on-premises, GovCloud, or hybrid
- Generalized real-time communications middleware, built-in support for HLA, DDS, ADRS

