Outline

1. Introduction
2. Simulation Infrastructure
3. Simulation Goals
4. Simulation Scenarios & Results
5. Conclusion
Objective

- NASA investigates concepts, aircraft, and operations related to Advanced Air Mobility (AAM)
- Most challenging scenario for AAM – enabling safe routine access in densely populated urban centers
- Requires a moderately high-fidelity simulation capability for development and evaluation of autonomy technologies in the urban environment while utilizing AAM concept vehicle dynamics
- Essential to simulate air and ground-based sensors, such as radar and LiDAR
- Enables the evaluation of NASA research concepts in autonomy for urban AAM operations on the path toward flight test evaluation
AAM Challenges

• Traditional surveillance and landing systems - not practical for AAM operations
• AAM concepts require higher accuracy and performance compared to the current National Airspace System
• Cannot use GPS for self-reporting surveillance and navigation technologies in GNSS degraded environments as GPS can be highly unreliable in urban areas with high raised building and skyscrapers
Distributed Sensing Goals

• DS concepts enable continuous and real-time monitoring of the physical and environmental conditions from overlapping sensors through the entire length of the flight

• Develop a framework for incorporating geographically distributed (non-co-located) sensors and remote observations

• Address sensor drop-outs from degradation

• Provide persistent estimates across observations that meet minimum quality requirements and continuous evaluation of quality from each observation source (cross-validation and confidence)
Problem Statement

• Not practical to flight test all the AAM operations without proof of concept

• Simulating the state-of-the-art sensors in a distributed framework
  • Provides a proof of concept
  • Saves time and money

• This simulation architecture -
  • Helps test various normal to adverse flight situations
  • Fuses all the sensor modules for the RVLT aircraft model in an urban scenario
  • Follows the proposed guidelines of the Federal Aviation Administration
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Simulation Architecture (RVLT)
Simulation Architecture (Octocopter)
Simulation Software Toolchain
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Simulation Goals

• Create a DS simulated environment for experiments and real-world applications and include hardware for field tests
• Implement multiple autonomous vehicles operating at the same time without any collisions
• Precision Approach and Landing (PAL) - Vision-based navigation provides a solution for vertiport approach and landing.
• Detect and Avoid (DAA) - Enable a collision avoidance system for reliable and safe UAM vehicles in urban areas with hazard detection and mapping during cruise, approach, and landing. Fusing onboard and ground-based sensors to ensure safe operations.
• Integrity Monitoring - Provide real-time evaluation and cross-validation of all sensors and estimates using EKF.
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Simulation Scenarios

1. AAM regional operations simulation in San Francisco bay area
   • Middle Harbor Park (MHP) to Fifth and Mission Garage (FMG) scenario
   • Fifth and Mission Garage (FMG) to Middle Harbor Park (MHP) scenario

2. AFRC Vertiport Mockup – Precision Approach, Landing, and Terminal Area Operations
   • Parallel flight test activity at NASA AFRC supporting validation

3. Ames Smart Mobility Build 1 Flight Test Scenarios
   • Parallel flight test activity at NASA Ames supporting validation
AAM regional operations simulation in San Francisco bay area

- Landing pads with landing lights on top of the Fifth and Mission Garage (FMG) building in SF and the Middle Harbor Shoreline Park (MHP) both
- cruise AGL altitude of 500 ft
- 50 knots for the approach path
- a 9-degree glidepath angle essential for vision-based PAL
- Other vertiports are available (not utilized yet)
MHP and FMG Vertiport Configurations

- Vertiports follow the FAA Advisory Circular on Heliport Design [1].
- X-Plane uses a 2D editing software called World Editor (WED) that has the capability to install and modify scenery graphics, airports and vertiports, and helipads into X-Plane.
- MHP landing lights configuration - orientation of 71 degrees clockwise from north as it comes out of the water.
- FMG - orientation of 45 degrees clockwise from north.

Full-scale Lights Configuration [1]

- 28 Final approach and takeoff area (FATO) Edge lights
- 16 Touchdown and liftoff area (TLOF) Edge lights
- 5 omnidirectional lights
- 7 helipad lights
- 24 wing and edge bars

Full-scale Lights Configuration [1]

6-10 Heliport Approach Light System (HALS) light bars.

MHP and FMG Ground Sensor Stations

Onboard sensors may not be sufficient. Simulating ground-based sensor stations with sensors such as cameras and RADAR help improve the tracking accuracy.

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<th>Altitude (ft MSL)</th>
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</table>

Table 2 The location of all the ground sensor stations in the simulation
The vertiport and the landing lights use the same configuration as that of MHP.

Since the physical installation of the lighting system could be time consuming and expensive, AFRC flight test uses cones to replace the landing lights, which provides fiducials for vision-based AAM PAL [2,3].

Simulation descent begins at an altitude of 498 ft with a speed of 70 knots which gradually reduces until touch down.


AFRC Vertiport Mockup X-Plane view
Ames Smart Mobility Build 1 Flight Test Scenarios

- Takes place in a region referred as "DART site" inside the NASA Ames Research Center for corridor surveillance.
- The flight cruises at an altitude of 50 feet AGL.
- 4 ground sensor stations - each has a camera and a radar.
- The post processing EKF in Matlab utilizes the outputs from these ground stations along with the onboard sensor suite [4, 5]

Current work involves updating the scenery of the DART site in X-Plane
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Conclusion

• The DS simulation framework enables testing of different scenarios under AAM concepts and operations while utilizing AAM/UAM vehicles.

• Adequate simulations reduce the costs associated with flight testing in difficult urban areas.

• Serves as a baseline for scientists and engineers to experiment multiple ideas and algorithms.

• Future work
  • Expanding the simulated environment
  • Simulating multiple vehicles flying simultaneously
  • Integrating hardware testing platforms for flight tests.
References


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Thank you for listening! Questions?