TCAS alerts from simulated Urban Air Mobility flights along FAA helicopter routes in Dallas-Fort Worth

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Outline

• Problem Overview
• Background
• Vehicle, Routes, and Simulation Setup
• Results and Discussion
• Concluding Remarks
Problem Overview

• Desire to use small, specially built urban air mobility (UAM) vehicles to ferry people and cargo from one location to another through the air
• When operating near or at an airport, there is potential for these vehicles to interfere with existing commercial operations
• One major potential area of interference is triggering TCAS alerts on commercial traffic
What is TCAS?

• Traffic Alert and Collision Avoidance System
  • System to alert pilots to aircraft that are potential collision risks
  • TCAS II Mandated on commercial aircraft
  • TCAS II provides both traffic advisories and resolution advisories

• Traffic Advisory (TA)
  • Alert pilot to location of nearby traffic
  • Do not require a maneuver

• Resolution Advisory (RA)
  • Alerts pilot to imminent potential collision
  • Provides an escape maneuver and requires immediate pilot compliance
  • If both aircraft have TCAS II, RA’s will be coordinated between vehicles

• UAM needs to have a transponder or equivalent
UAM Concept Vehicle Types

- Separate lift and cruise propulsion
- Tiltrotors
- Tiltwings
- Multi-rotors
Objective

Study frequency of RAs produced by TCAS on commercial traffic in response to a UAM flying into or out of DFW airport

- Assume TCAS II on commercial aircraft
- Assume UAM capable of triggering a TCAS alert
- Utilize existing route structure for helicopters
Study Limitations

- Vertiport infrastructure not considered
- UAM-to-UAM interactions out of scope
- This is not a study of separation standards or conflict resolution methods
- No winds
- No uncertainty
- UAM vehicles all identical, flying identical trajectories with different start times
Representative UAM vehicle

- Climb rate: 500 fpm
- Descent rate: 500 fpm
- Cruising speed: 130 kts
- Transition from hovering climb/to hovering descent at 40 ft altitude
- Max turn rate: 6 deg/s (35 deg bank angle)
- Weight: under 10,000 lbs
Download chart at https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/vfr/
Frisco, TX to DFW in South Flow

Flight time 13.0 minutes
Google driving time estimate of 26 minutes to 1 hour
DFW to Frisco, TX in South Flow

Flight time 18.4 minutes
Simulation Setup (1/2)

- Fast-time simulation developed by NASA for the Unmanned Aircraft Systems integration into the National Airspace System (UAS-NAS) project
  - “Play back” capability for traffic files and can fly routes using a kinematic trajectory generator, aircraft models, and a series of waypoints

- TCAS II module
  - FAA supplied TCAS II version 7.1 software
  - Software wrapper developed by NASA Langley for the UAS-NAS project
  - TCAS sensitivity level higher than real system for these results (Lowest automatic sensitivity levels set by radar altimeter)
Simulation Setup (2/2)

• Published FAA map of routes in the DFW area
  • Approved for helicopter use but today used only about 12 times per week
  • Altitude and/or routing restrictions applied for DFW in South Flow configuration
• Commercial flight data interpolated from D10 radar data
• Roughly 700 commercial flights throughout the day (June 3, 2017)
• 900 UAMs flown at a rate of 1 per minute
• Tested UAMs flew from 6:45 am local time until 10 pm
Results
TCAS II alerts triggered by UAM

<table>
<thead>
<tr>
<th>Route</th>
<th>Unique TCAS Resolution Advisories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frisco to DFW approaching from the north</td>
<td>0</td>
</tr>
<tr>
<td>DFW to Frisco taking off to the south</td>
<td>0</td>
</tr>
</tbody>
</table>

0 TCAS RAs, but
- No sensor noise
- No uncertainty or variation in UAM trajectory
- No Wind
Traffic Advisory Example

- 0.4 nmi horizontal separation
- Co-altitude at 1000 ft
Discussion

- Lack of TCAS RAs does not mean route is flyable today
  - FAA will need to approve UAM to fly these routes
  - Controller workload will need to be studied
  - Maximum vehicle density along route is unknown

- Lack of TCAS RAs at DFW does not mean same approach will work at other airports

- Uncertainty, sensor noise, and wind will need to be examined
Concluding Remarks

Flying a representative UAM along existing helicopter routes near DFW resulted in 0 TCAS RAs when UAM flew in the direction of commercial traffic (South Flow)
Next Steps

• Analysis in progress for effect of changing vehicle performance and landing locations at DFW
  • Turn rate
  • Altitude
  • Climb rate
  • Cruise speed

• Repeat analysis for DFW in North Flow

• Alternative routes
  • Based on SME feedback for ATM-X HITL study
  • Includes modifications to existing routes and new suggested routes
  • Any new route will need additional FAA approvals

• Establish width of RA-free “corridors” for routes in each flow condition
Questions?

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Backup
Credits

• All map images derived from FAA Helicopter Routes Map for Dallas-Fort Worth Area.

• Source: [http://aeronav.faa.gov/content/aeronav/heli_files/PDFs/Dallas-Ft_Worth_Heli_7_P.pdf](http://aeronav.faa.gov/content/aeronav/heli_files/PDFs/Dallas-Ft_Worth_Heli_7_P.pdf)

• Images produced by the U.S. Government and in the public domain.
Preliminary Altitude Ranges

- Frisco ground – 774ft MSL
- DFW ground – 607ft MSL
- Parking structure estimated – 640ft MSL

Note: Assumes maintaining minimum 200ft AGL

Lowest floor of Class B

2000ft MSL

1160ft MSL

1200ft MSL

800ft MSL

Even altitude restriction for Westbound on Vista Ridge route

(960ft)
Route Descriptions

• Frisco to DFW
  • Colony at 1600 ft MSL to I-35 east
  • Descend to 1000 ft MSL along I-35 east
  • Turn west at 1000 ft MSL onto Vista Ridge
  • Turn South at 1000 ft MSL onto Spine Road
  • Land at Parking garage (Hyatt Regency, next to D10 TRACON)

• DFW to Frisco
  • South out of DFW along Spine Road at 1000 ft MSL
  • East on Route 183 at 1000 ft MSL
  • Short north on Loop 12 at 1000 ft MSL
  • NW on Grapevine at 1000 ft MSL to North Lake
  • North on Vista Ridge at 1000 ft MSL
  • NW on I-35 East at 1000 ft MSL
  • NE on Colony at 1600 ft MSL
  • North to Frisco at 1600 ft MSL
TCAS Sensitivity Levels

• Dependent on own altitude
• Ranges from level 2 to level 7 (in TA-RA mode)
• TA and RA alert ranges vary depending on sensitivity level
• An RA should generally trigger:
  • (2350 ft to 5000 ft AGL) Other aircrafts range over range rate under 20 seconds AND time to co-altitude under 20 seconds/current vertical separation under 600 ft
  • (1000 ft to 2350 ft AGL) Other aircrafts range over range rate under 15 seconds AND time to co-altitude under 15 seconds/current vertical separation under 600 ft
  • Should not issue an RA below 1000 ft AGL
• UAM flying below 1000 ft AGL might still trigger an RA for a commercial aircraft that is descending