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

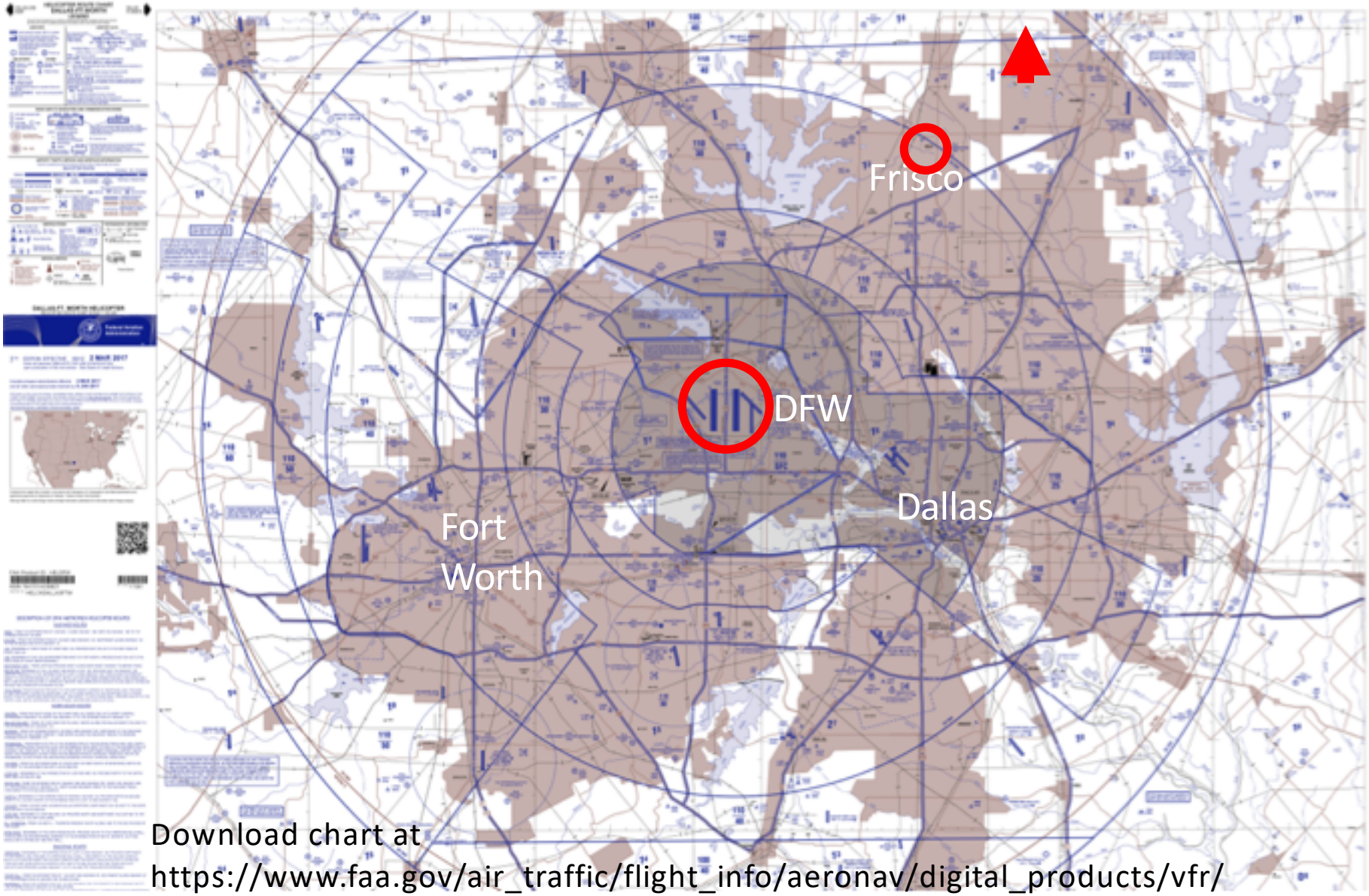
Study Limitations

- 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

Test Vehicle Description

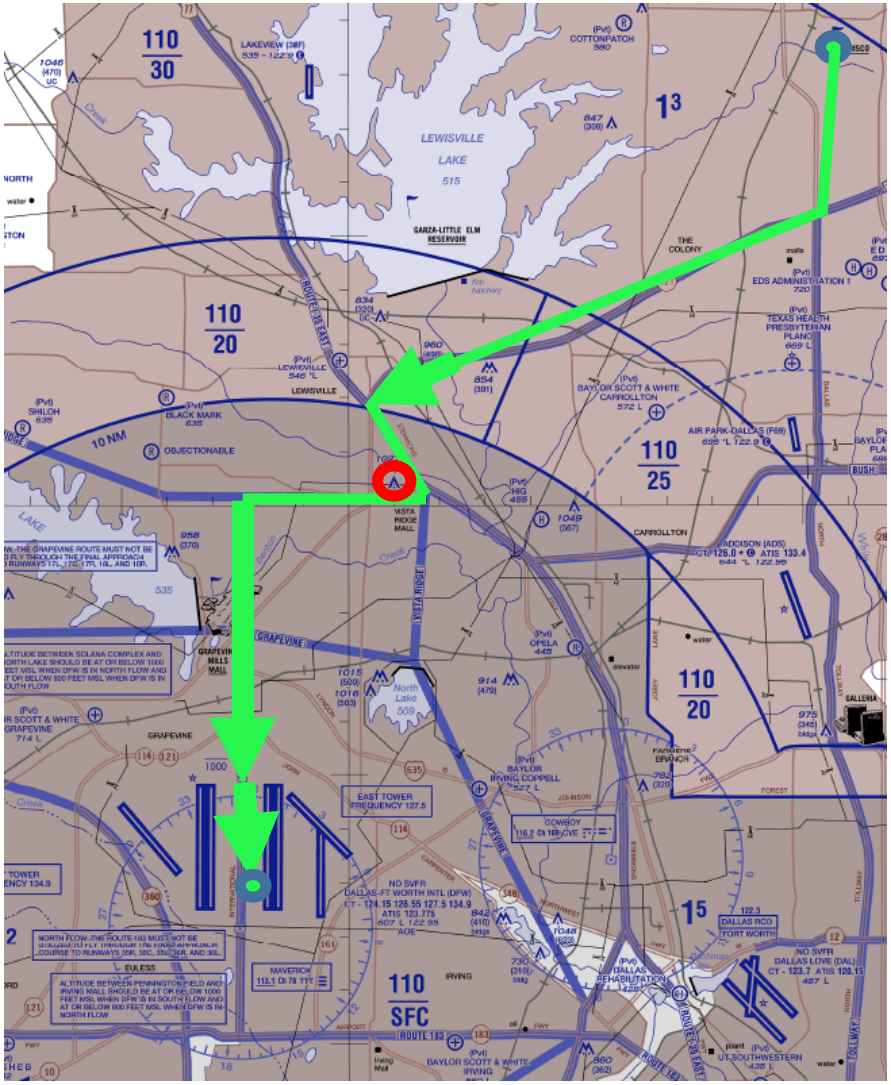
Representative UAM vehicle

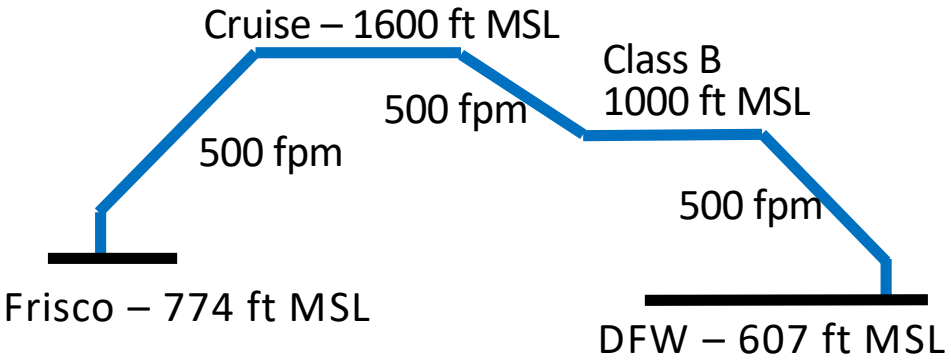
- Climb rate: 500 fpm
- Descent rate: 500 fpm
- Cruising speed: 130 kts
- Transition from hovering climb/to hovering descent at 40 ft altitude
- Max turn rate: 6 deg/s (35 deg bank angle)
- Weight: under 10,000 lbs



Download chart at
https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/vfr/

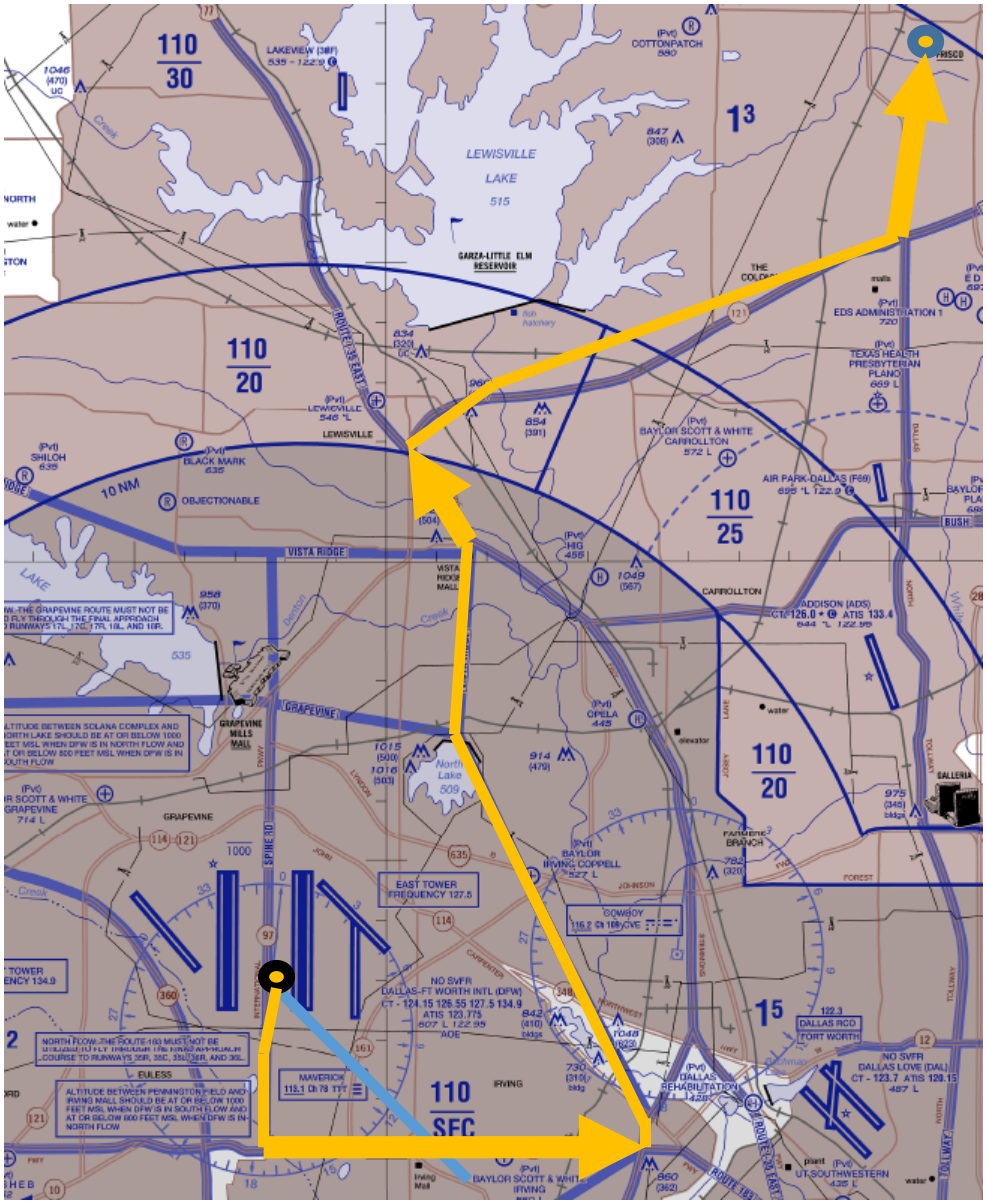
Frisco, TX to DFW in South Flow

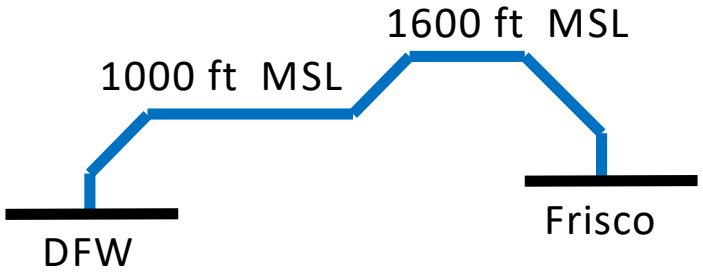




Flight time 13.0 minutes
Google driving time estimate of 26 minutes to 1 hour

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
  - Paper reference: NASA/TM-2017-219507
  - “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

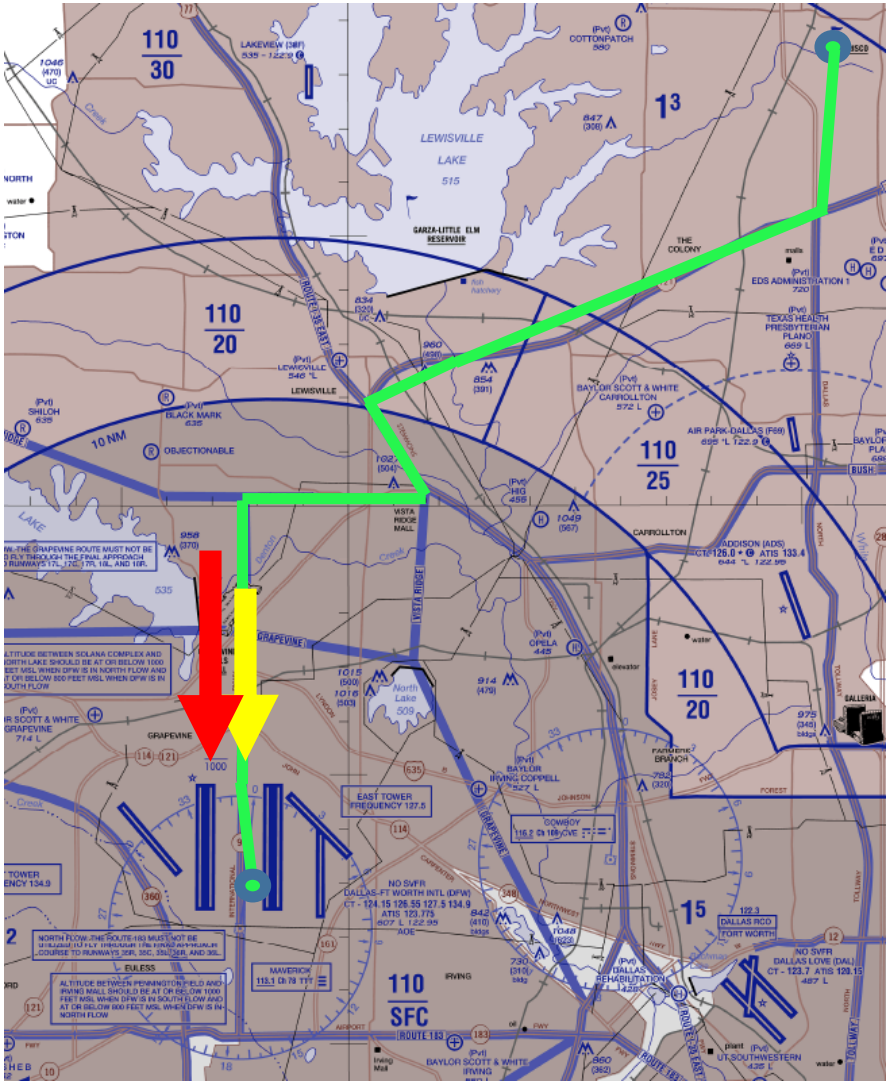
Route	Unique TCAS Resolution Advisories
Frisco to DFW approaching from the north	0
DFW to Frisco taking off to the south	0

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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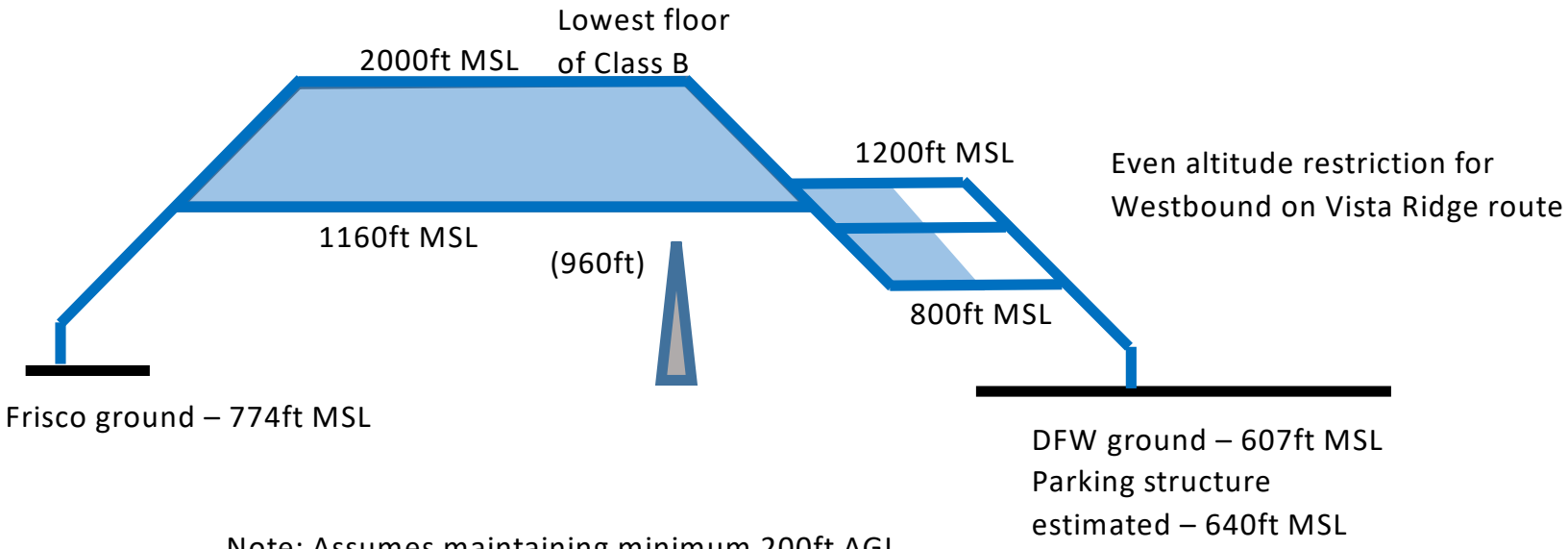
Backup

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
- Images produced by the U.S. Government and in the public domain.

Preliminary Altitude Ranges



Note: Assumes maintaining minimum 200ft AGL

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