UAM Fleet Noise Assessments Using the FAA Aviation Environmental Design Tool (AEDT)

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Outline

- Motivation and Approach
- Operational State Determination
- Calculation of NPD data
- Modeling Approach
- Generation-1 Assessment
- Concluding Remarks and Future Work

Goal and Approach

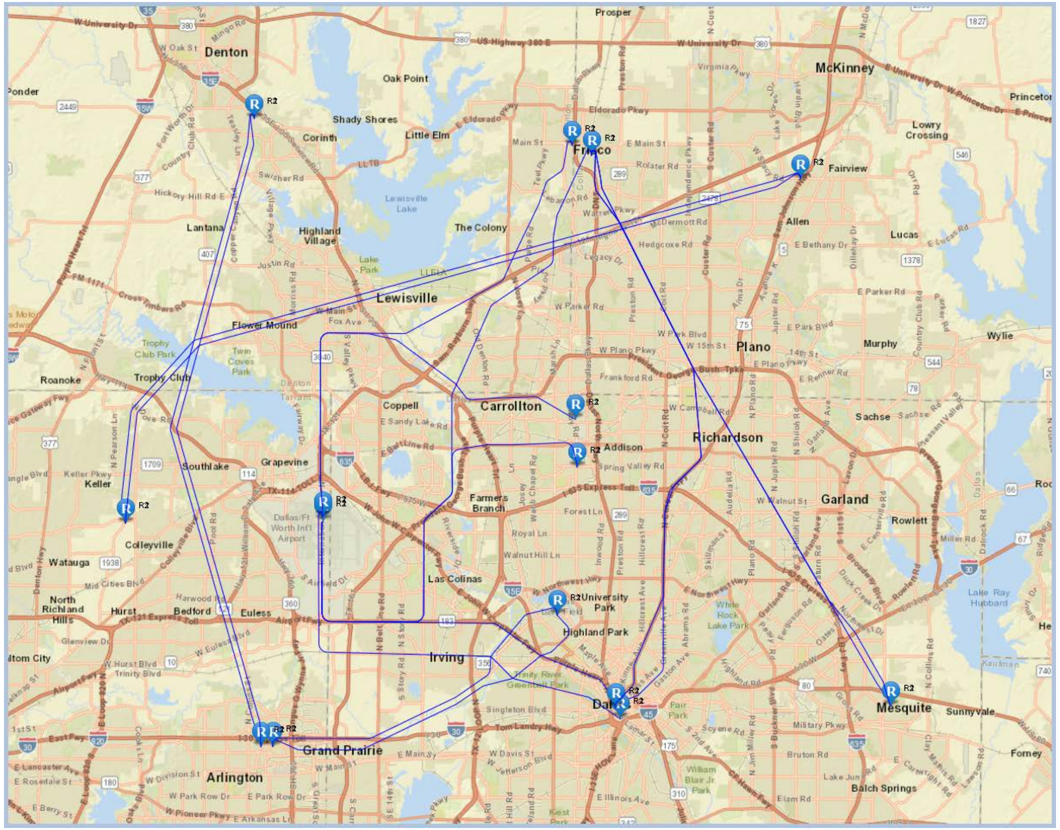
Goal

Assess the effectiveness of current commonly-used tools for the evaluation of UAM community noise.

Approach

- Develop methodology utilizing the FAA Aviation Environmental Design Tool (AEDT).
  - Lack of AEDT Aircraft Noise and Performance (ANP) Model for UAM requires user-supplied Noise-Power-Distance (NPD) data and use of fixed-point flight profiles.
- Demonstrate on representative route case.

Generation-1 Simulated Baseline Routes†



† Routes provided by NASA ATM-X UAM X2 team

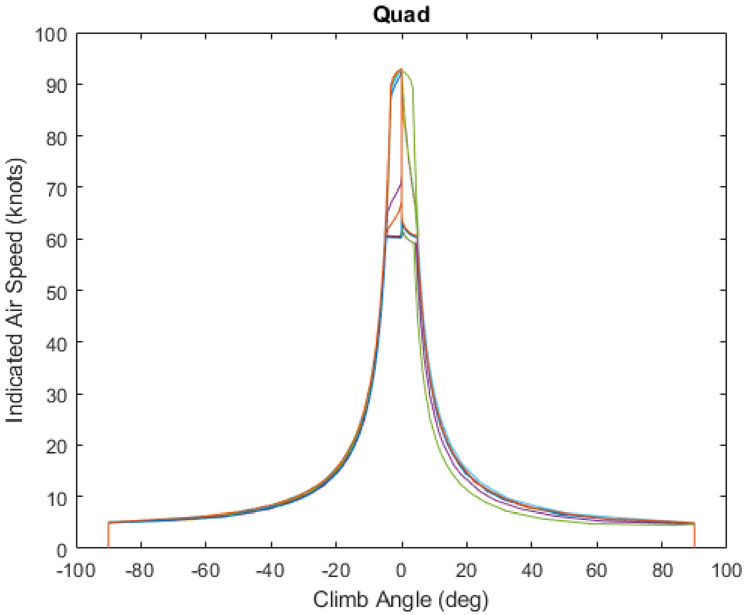
- 16 routes around DFW
- 2 reference vehicles

RVLT Quadrotor

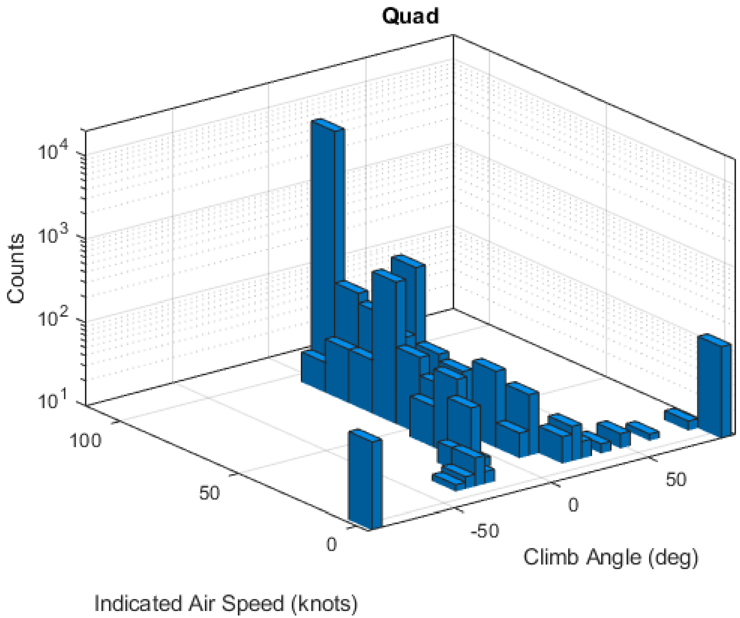
RVLT Lift + Cruise

Operational State Determination

Distribution of X2 Trajectory Data



1 Hz data from 16 routes



42 Operating States for Quadrotor
44 Operating States for L+C

AEDT Noise-Power-Distance Data

Fixed Wing

- NPD data are associated with an engine power (thrust) setting.
- NPD data consist of noise curves for each operational mode – approach, level flight, and departure.
- A performance model is used to determine the thrust setting for a specified operation.
- Source directivity applied using a dipole radiation model applied in the noise fraction adjustment for exposure metrics.

Helicopters

- NPD data are associated with an operational mode, i.e., noise-operational mode-distance data.
- NPD data consist of noise curves for each operational mode procedural step
  - Dynamic and static operational modes
- There is no performance model. The operational mode is specified by the procedural step.
- Source directivity
  - Dynamic: 0°, ±45° azimuth
  - Static: Helicopter-specific directivity

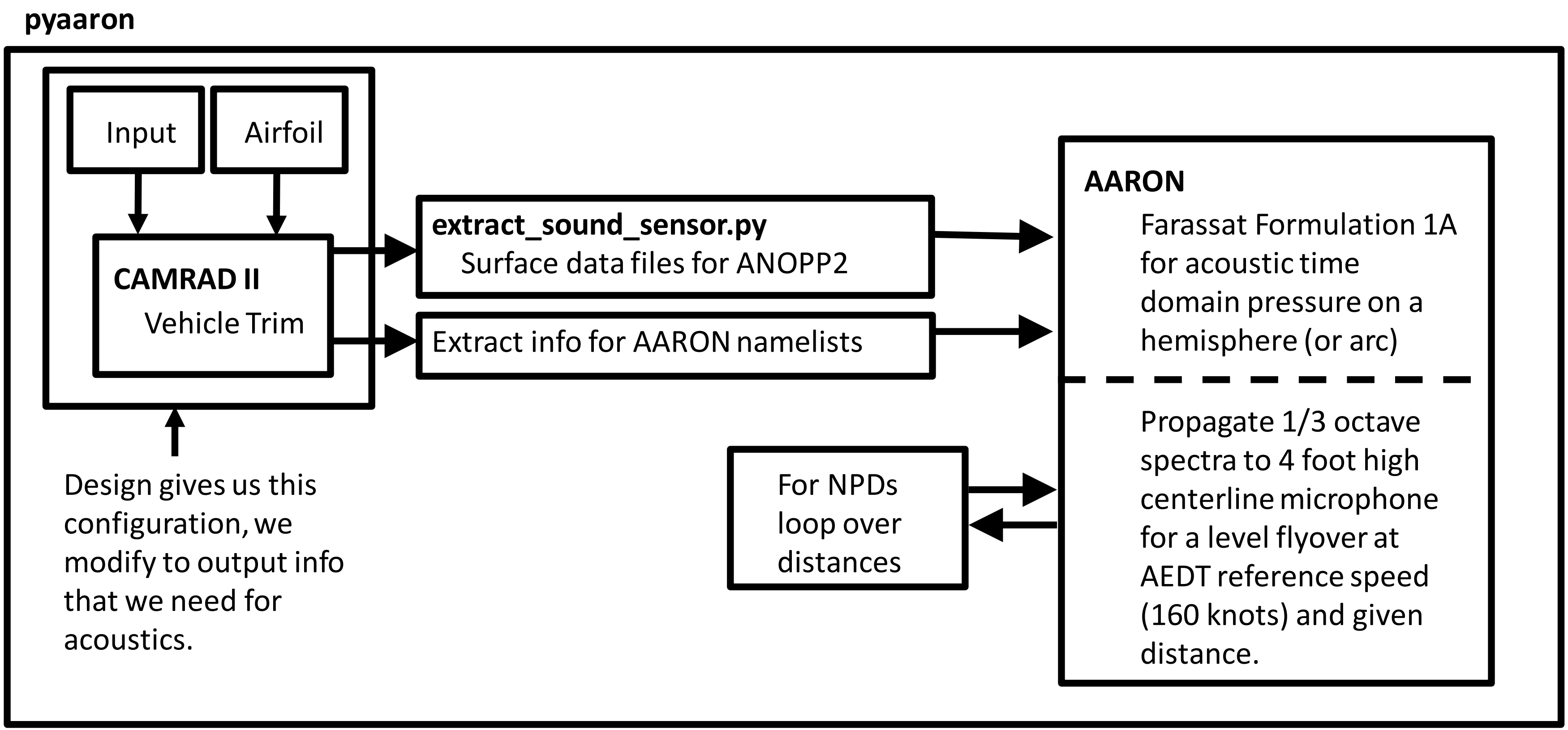
Fixed Point Flight Profile

- We use a 'fixed point' flight profile in AEDT
  - Fixed wing NPDs that bypass AEDT perf. models

- The database links the noise (L_{AMax}, SEL, $PNLT_{Max}$, EPNL) to the vehicle state and distance to observer
  - Vehicle state is an ID used as a surrogate for thrust and represents a particular operating condition defined by combination of indicated airspeed and climb angle.
  - By specifying piecewise constant flight conditions between waypoints, AEDT will interpolate noise between vehicle states (with short transitions), and distance to observer.

- In this scheme, we are hijacking the fixed wing aircraft type in AEDT.
  - NPDs generated by computing 0° azimuth data (normalized to reference flight speed). Directivity of fixed wing aircraft applied as part of noise fraction adjustment within AEDT.

Computation of NPD Data



Quadrotor NPD Data

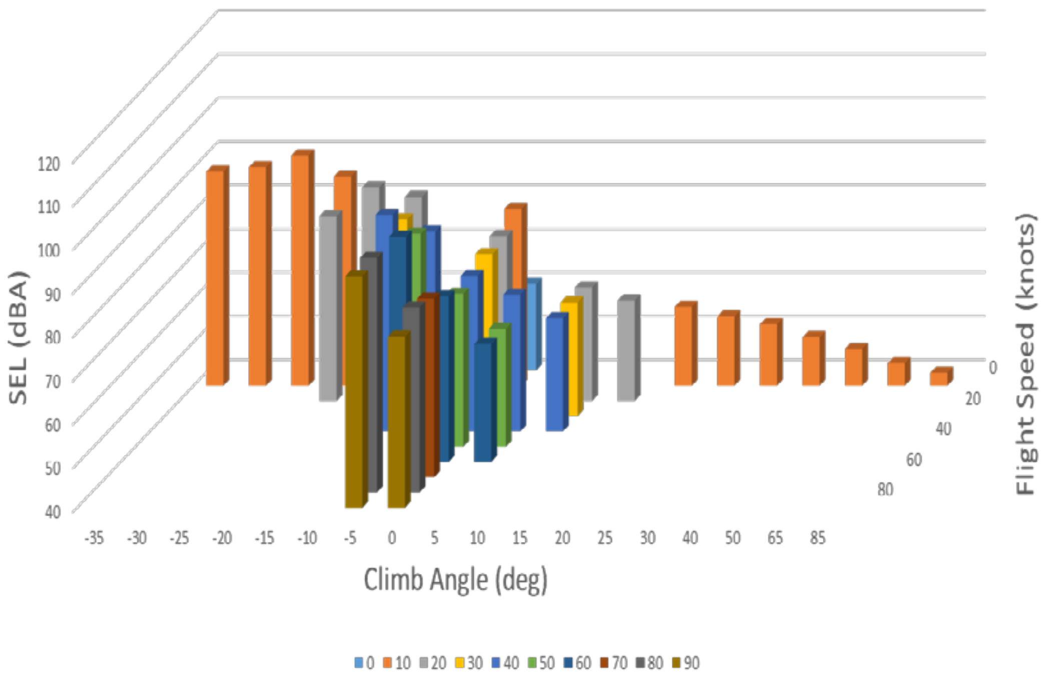
Example:

- Bar chart of SEL [dBA] at a given distance, for all flight conditions

Similar bar charts for:

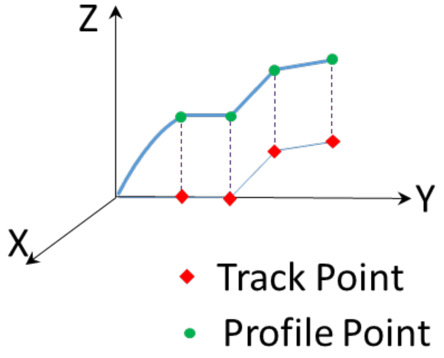
- L_{Amax} [dBA]
- EPNL [EPNdB]
- PNLTM [TPNdB]

SEL [dBA] at a given distance for all flight conditions



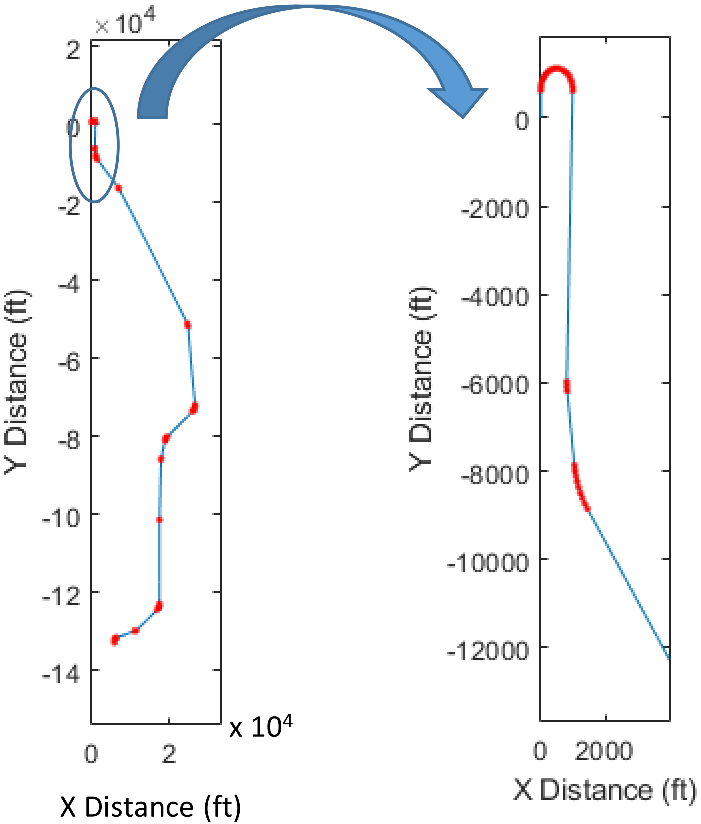
Modeling Approach

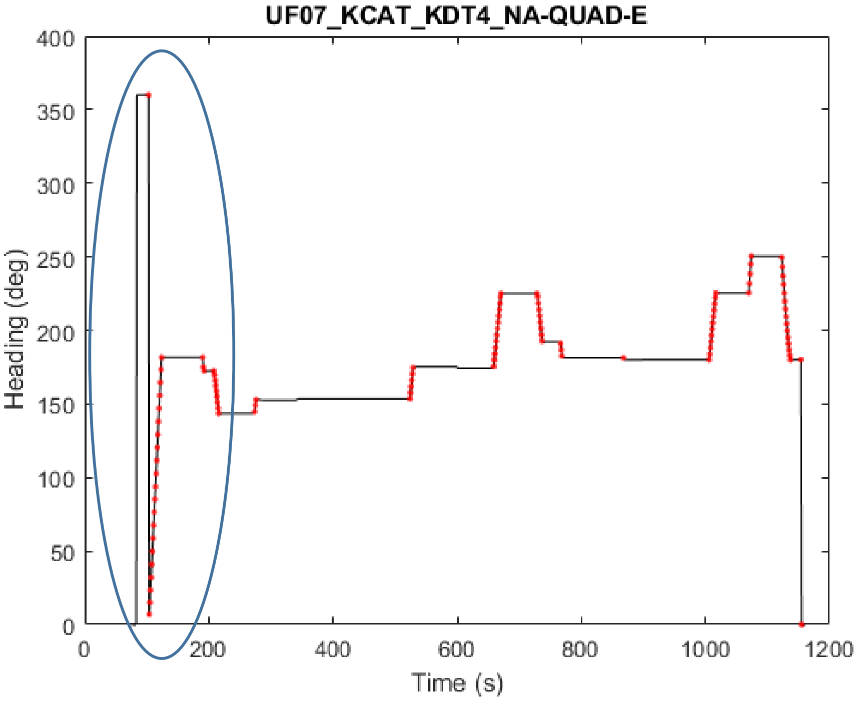
- The following information is needed as input to AEDT to operate in fixed-point profile mode:
  - Lat/long coordinates, elevation of vertiports (direct from X2 data)
  - **Set of track points defining the 2-D (X-Y) routes <u>departing</u> from each vertiport**
  - Aircraft noise and performance data – our calculated NPD data
  - **Set of profile points defining aircraft distance along track, altitude (Z), speed, and thrust set (our operating state index) from start to finish**



- A series of mini-studies were performed to inform development of initial (Generation-1) modeling approach using fixed-point profiles within AEDT, including
  - Guard points – to maintain constant operating state along each segment
  - Track segmentation – as means for reducing number of track and profile pts.
  - Segment velocity – to understand how choice of segment velocity affects results.

Track Point Example





Genaration-1 Assessment

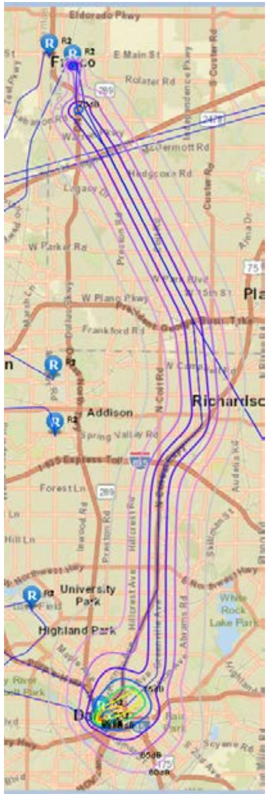
- Uses RVLT Quadrotor NPD data only.
  - Recently found trim error in Generation-1 NPD database for Lift+Cruise (regenerating NPDs as part of Generation-2 database).

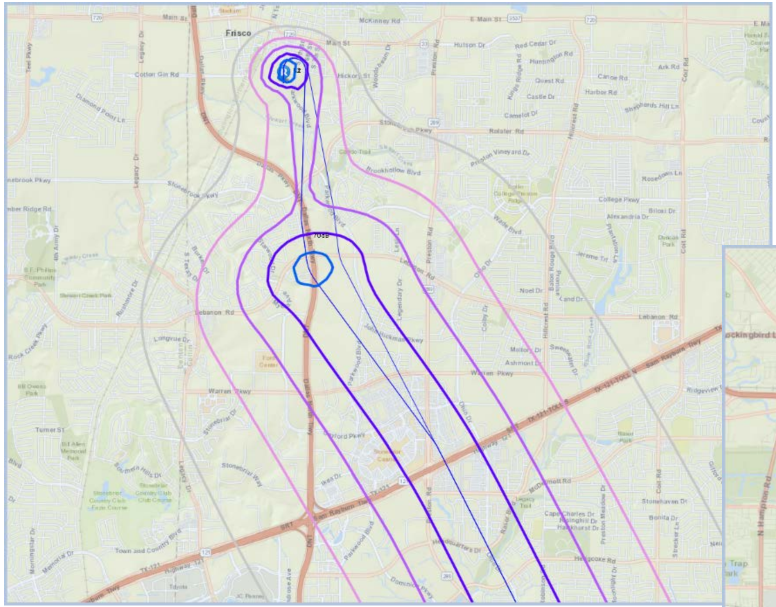
- Selected 100 (takeoff and landing) operations per hour over 12-hour daytime period as baseline (based on communication with Uber in absence of other demand data).
  - No nighttime penalty in DNL calculation.
  - 1200 operations / 2 = 600 departures for each route.

- Computed:
  - Sound Exposure Level (SEL) – single operations from each departure vertiport
  - Day-Night-Level (DNL) – 600 operations from each departure vertiport

Generation-1 Assessment (Example SEL Results)

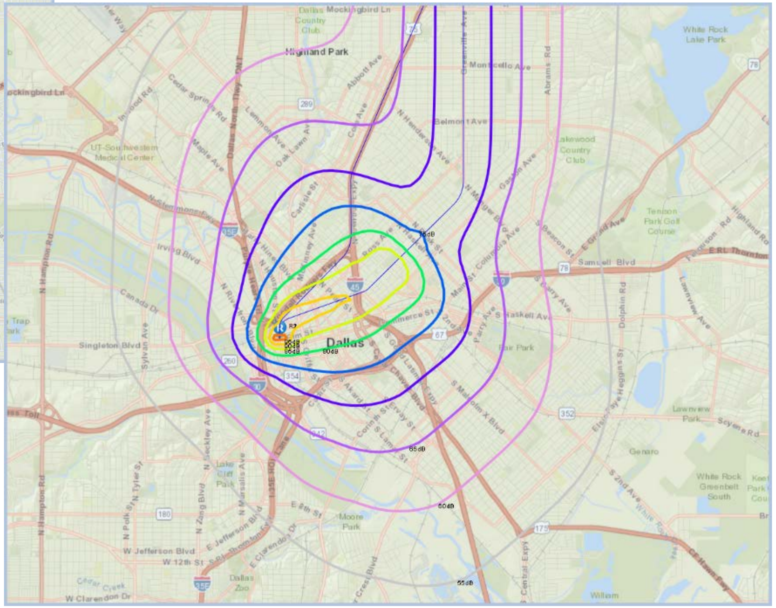
KCAT-KDT4



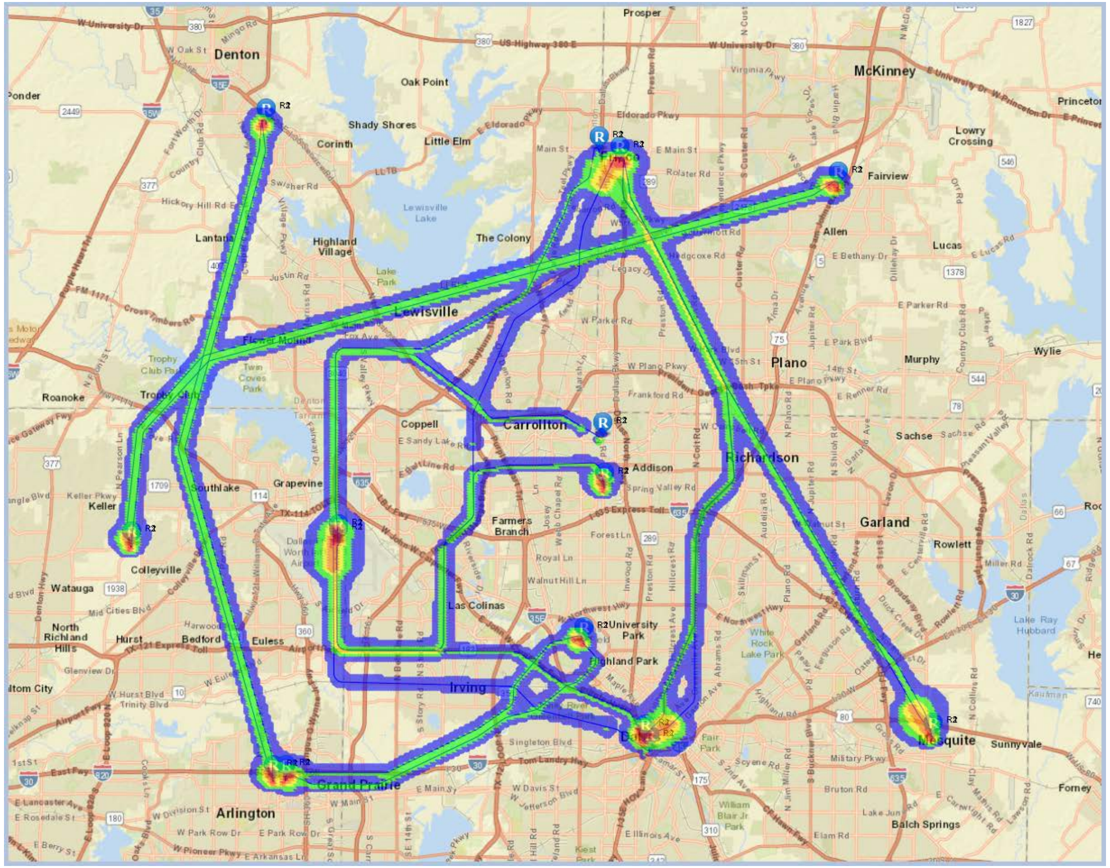


Origin KCAT

Destination KDT4



Generation-1 Assessment (DNL - 600 operations)



Concluding Remarks

What Have We Done –

- Developed a means of performing UAM community noise assessments using AEDT fixed-point flight profiles
  - Some limitations were identified that we will continue to work as part of the Generation-2 assessment (see next slide).
  - Automated method for analysis of routes and development of track and profile data guided by series of mini-studies.
  - Automated methods for generating large and scalable AEDT inputs, e.g., studies and vehicle data.

What Have We Not Done –

- Stated that the results shown are what we might expect of UAM operations in the DFW area.
- Drawn conclusions about UAM fleet noise based on the Generation-1 estimates.

Future Work

- Improve analysis fidelity
  - Investigate use of helicopter mode near vertiports to better capture directivity.
    - Quantify differences between fixed-wing (dipole) directivity, helicopter modes, and full hemisphere.
  - Model NPD data to remove restriction of limited number of discrete states.
  - Add terrain modeling.
- Ease of use
  - Input data directly into AEDT database to facilitate study development.
- Investigate alternative metrics as means of communicating impact
  - Time and number above, audibility, etc.

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