Synthesis Methods to Auralize Rotor Noise for Transitional Flight

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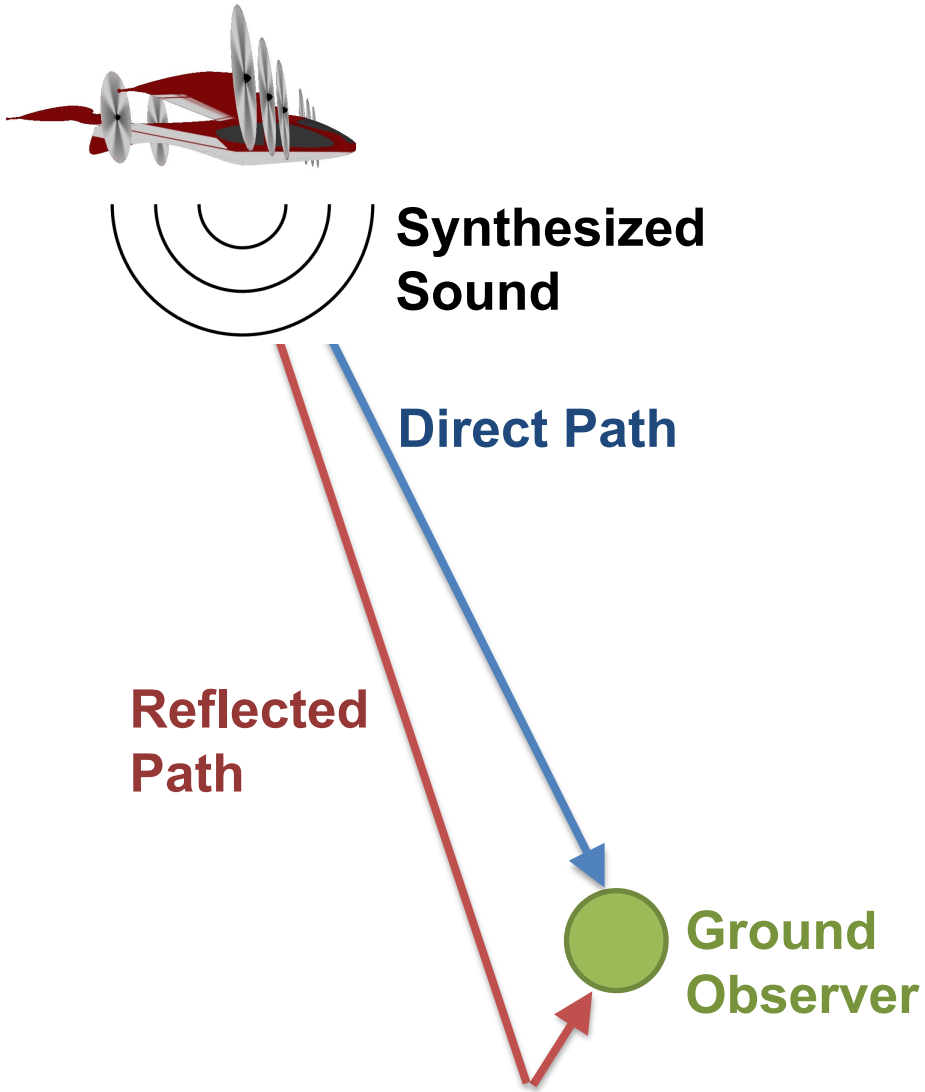
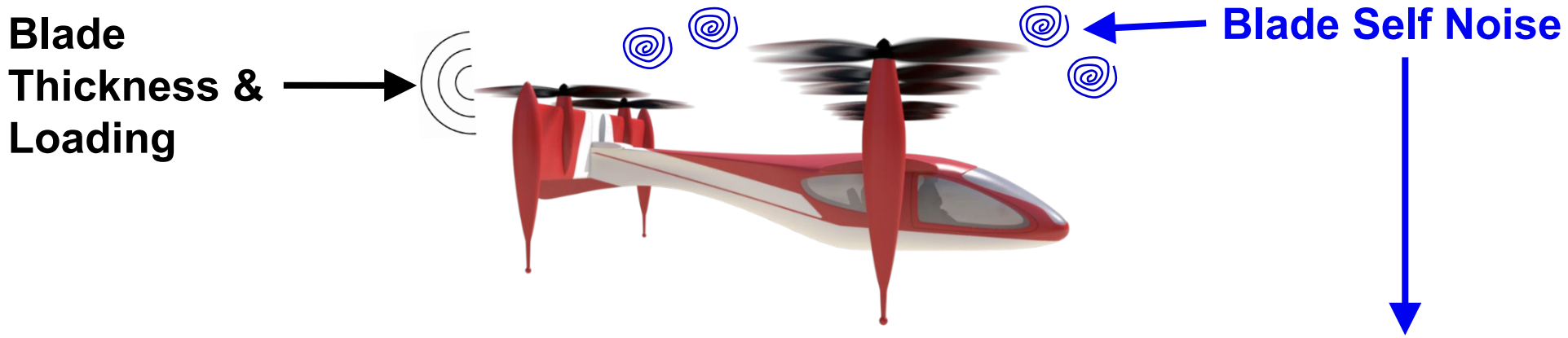
Auralizations can help understand human response to Urban Air Mobility (UAM) vehicles in transitional flight

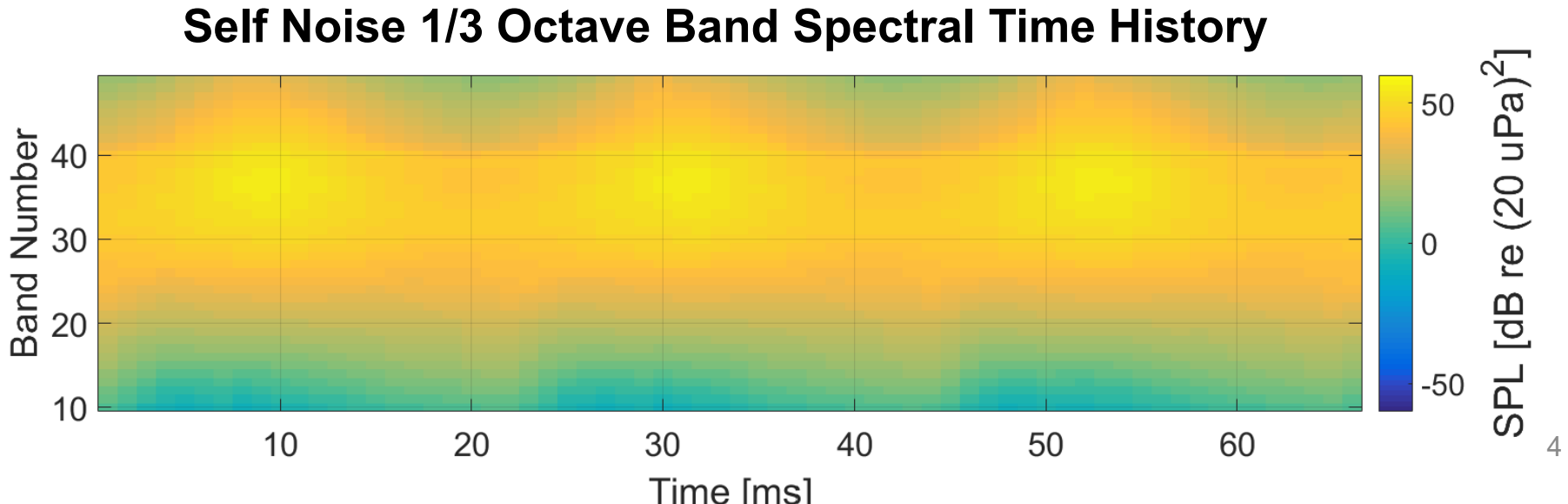
For auralization, sound is synthesized near aircraft (presentation focus) before propagating to a ground observer



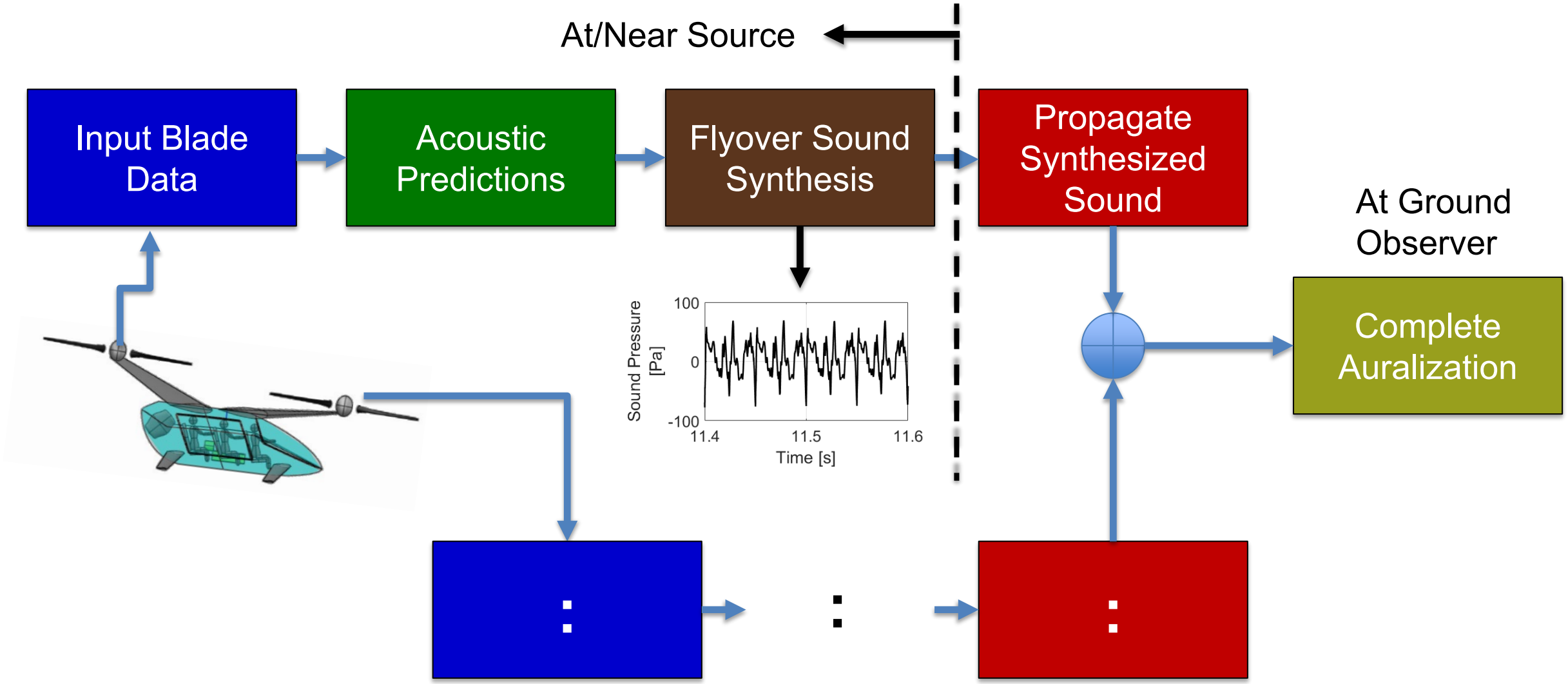
NASA Auralization Framework (NAF) performs sound synthesis and propagation

Methods exist to synthesize loading and thickness (tonal) noise and broadband self noise

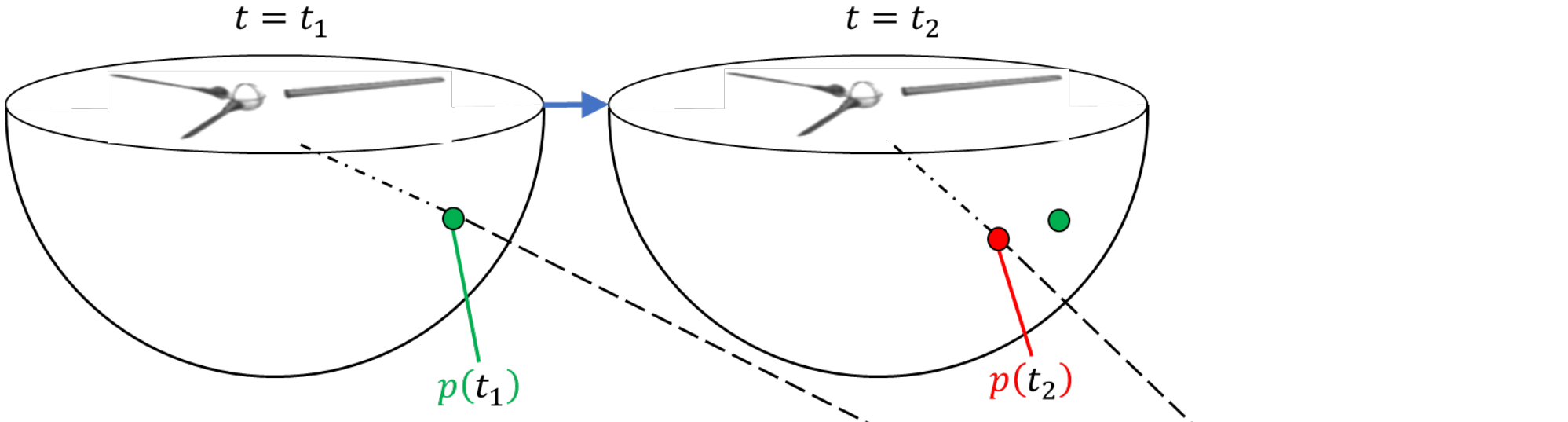




Blade aerodynamics and geometry data are needed for acoustic predictions, which are then used to synthesize sound



NASA Auralization Framework (NAF) Formulation 1A (F1A) Synthesis Plugin generates loading and thickness noise



Inputs

Vehicle Flight Path

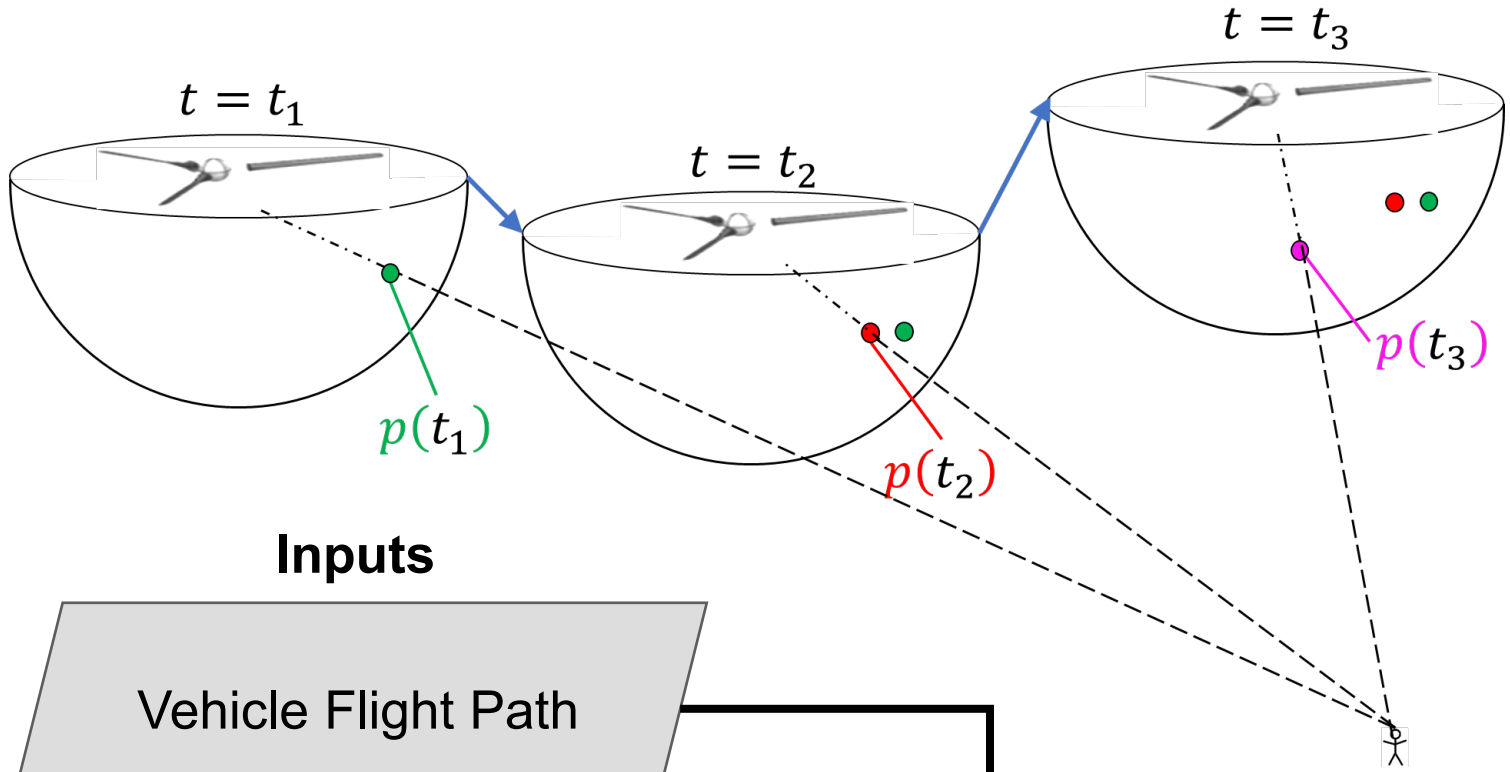
Blade loadings, motions, geometry

NAF F1A Synthesis Plugin

Output

Audible Loading and Thickness (Tonal) Noise

For transitional flight sound synthesis, combine blade aerodynamics and geometry data from many flight conditions



Trimmed State 1 Data

Trimmed State 2 Data

:

Trimmed State N Data

Inputs

Vehicle Flight Path

ANOPP2 Series of Periodic to Aperiodic Interpolated Data (ASPAID)

Interpolated Blade loadings, motions, geometry

NAF F1A Synthesis Plugin

Output

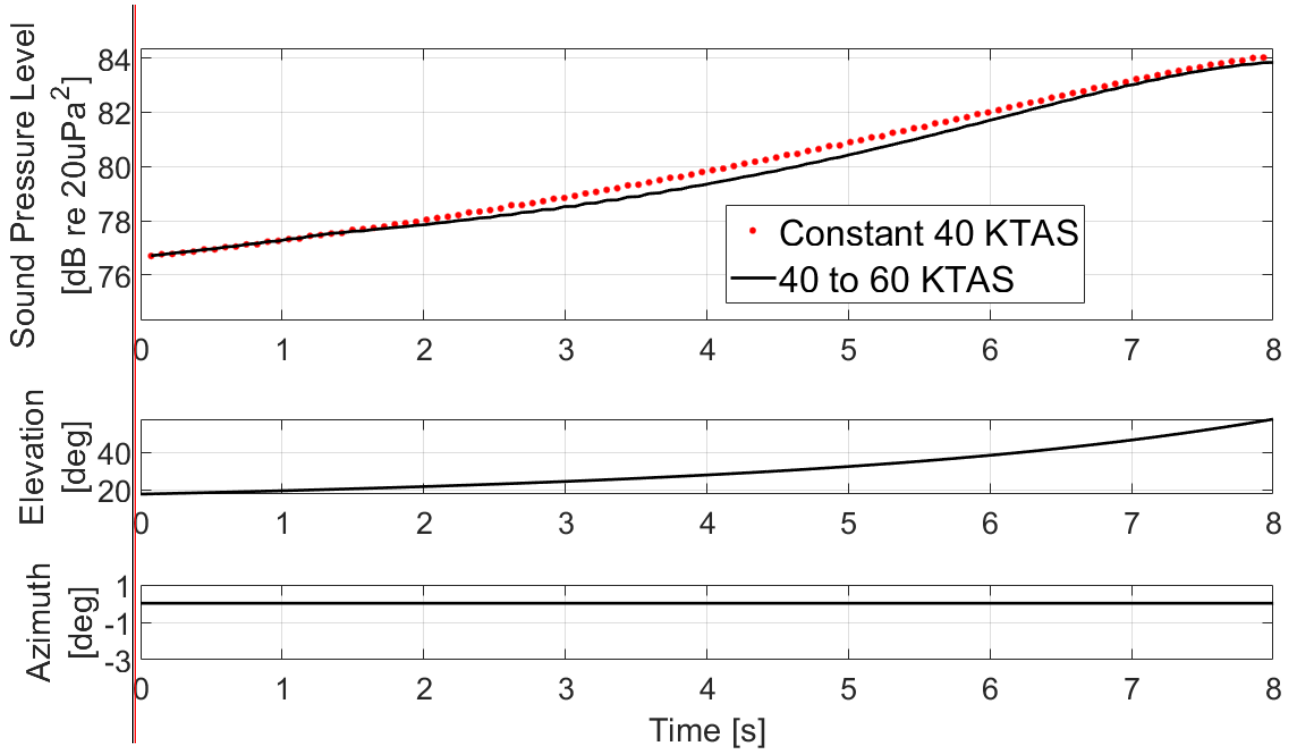
Audible Loading and Thickness (Tonal) Noise

Loading and thickness noise synthesized for transitional flight from interpolated blade loading, motion, and geometry

NASA Urban Air Mobility (UAM) Quadrotor Reference Vehicle

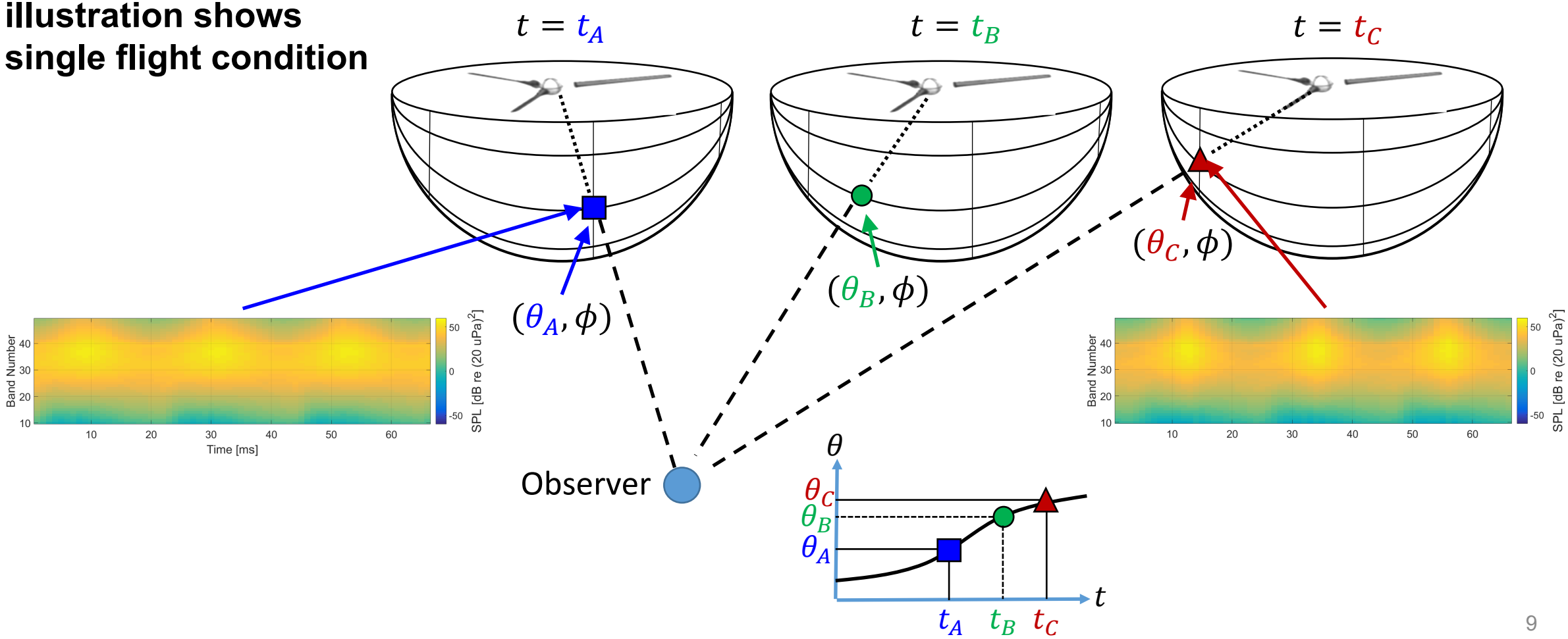
Constant 40 KTAS Airspeed, 5 Degree Climb

Airspeed changing from 40 KTAS to 60 KTAS, 5 Degree Climb

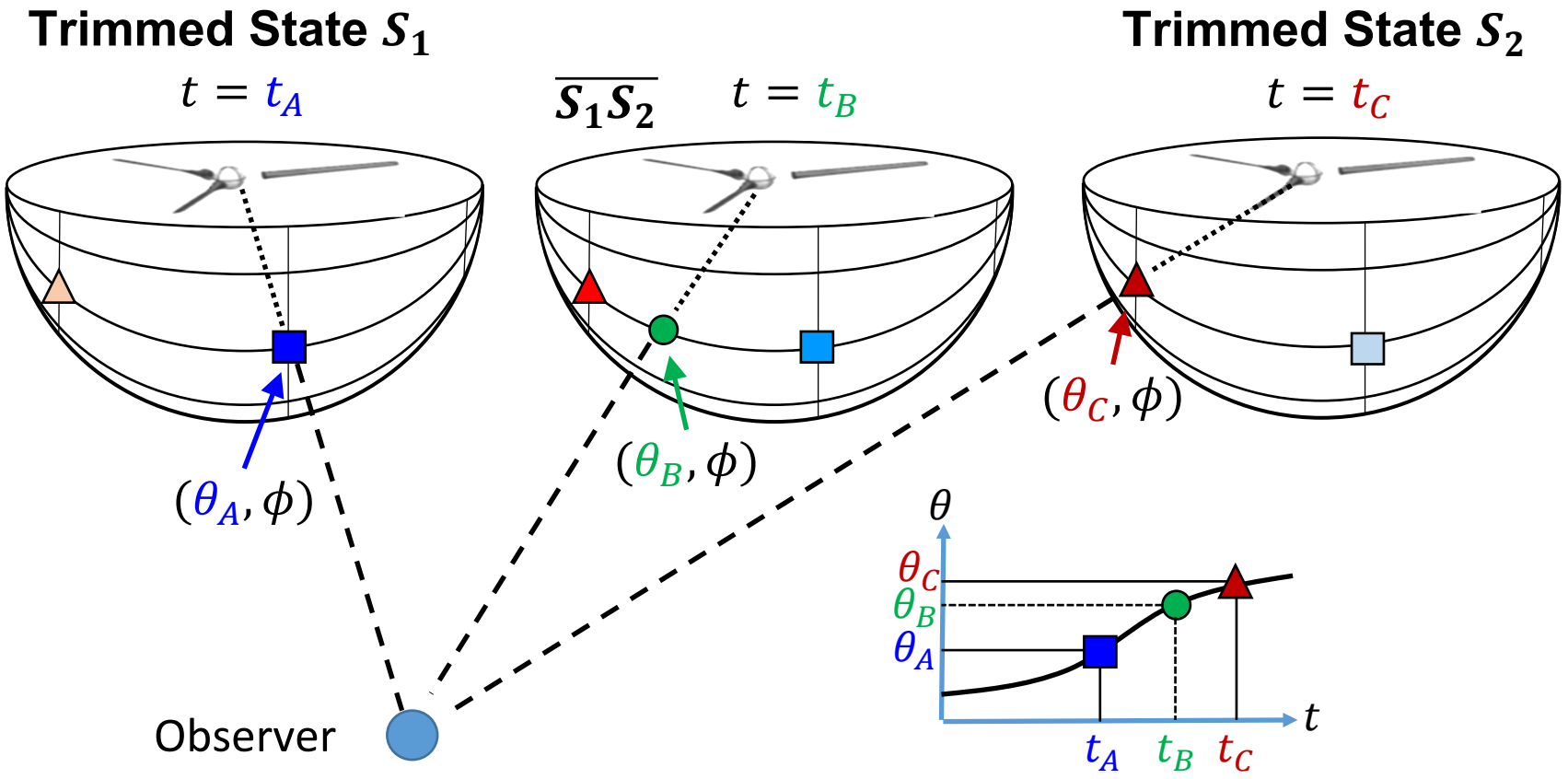


Methods exist to synthesize broadband self noise hemisphere predictions into sound

Exaggerated illustration shows single flight condition



Self noise predictions are interpolated between different hemispheres for transitional flight synthesis

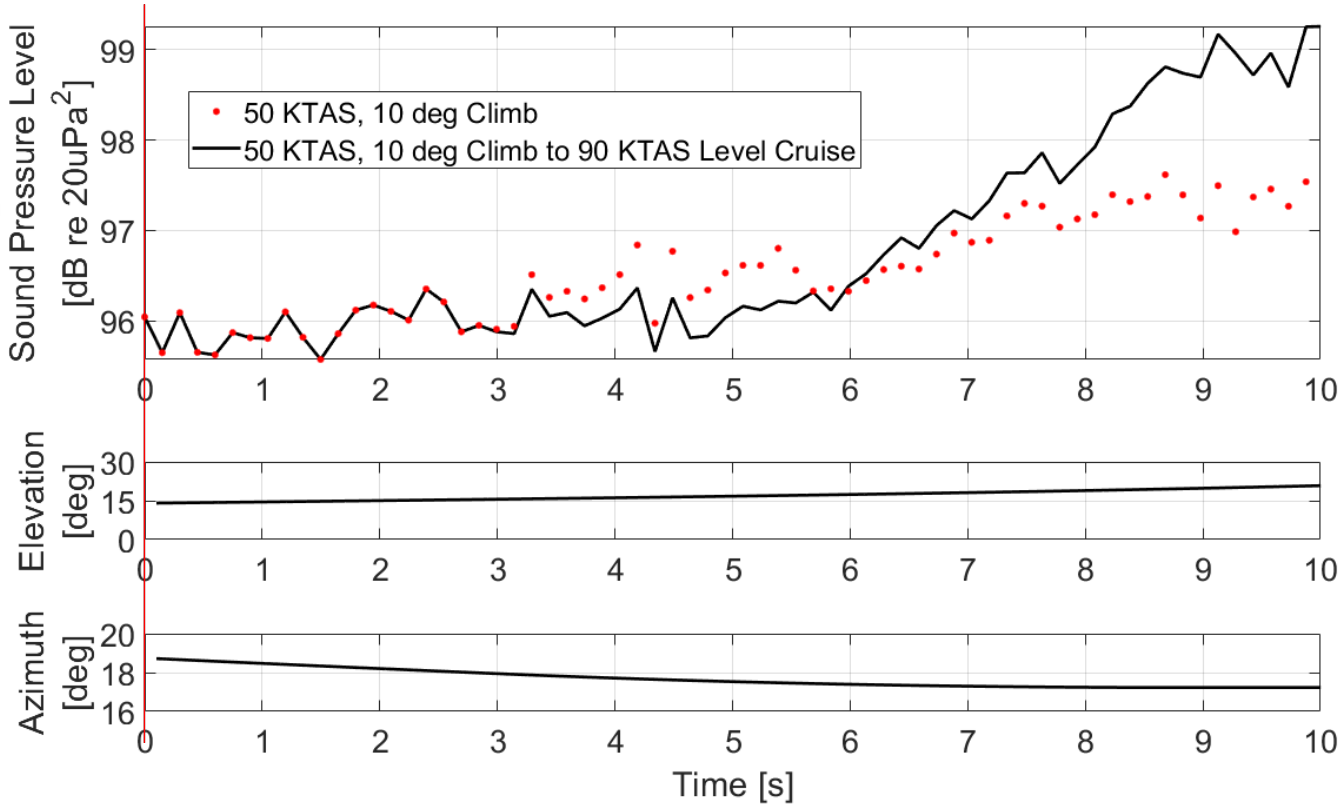


Self noise synthesized for transitional flight from interpolated source noise hemispheres

NASA Urban Air Mobility (UAM) Quadrotor Reference Vehicle

50 KTAS, 10 deg Climb Only

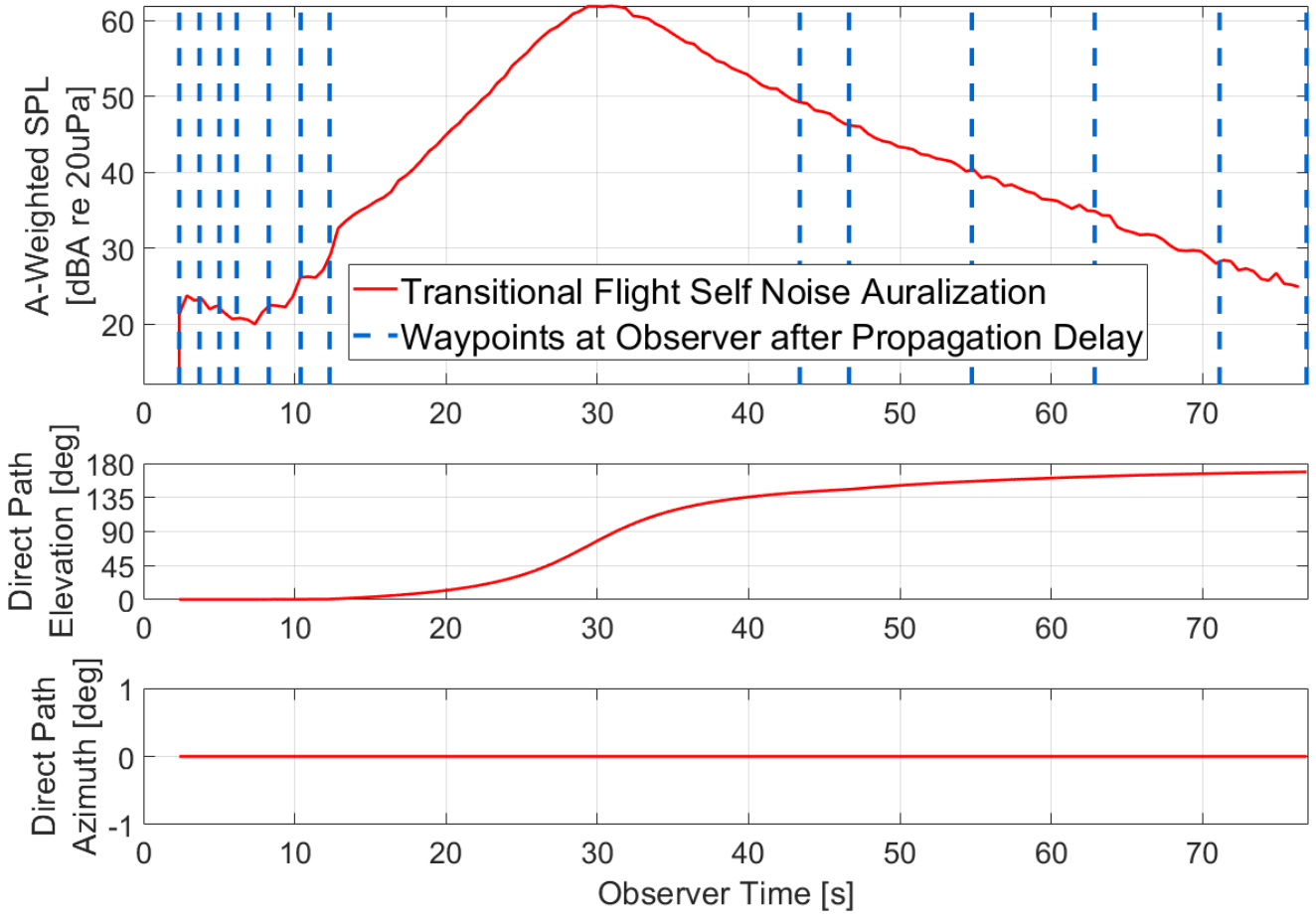
50 KTAS, 10 deg Climb to 90 KTAS Level Cruise



Departure and approach maneuvers with changing flight conditions auralized with self noise

NASA Urban Air Mobility (UAM) Quadrotor Reference Vehicle

Departure Sound Pressure Level (SPL) Time History



Methods developed to synthesize rotor loading and thickness noise and broadband self noise for transitional flight

- Future work includes:
  - Complete departure and approach auralizations with loading and thickness noise
  - Prepare public release of NAF Modulated Broadband Synthesis Plugin for transitional flight
- Experimental data on rotor transitional flight anticipated in the coming year (2024-2025) for comparisons with auralizations

This work is in support of NASA's Revolutionary Vertical Lift Technology Project of the NASA Advanced Air Vehicles Program

Questions?

Image Sources

- All images in this presentation were provided internally by NASA or generated by presenter