## ASCENT Project 49

# Urban Air Mobility Noise Reduction Modeling

**Penn State**

PI: Kenneth S. Brentner

PM: Rick Riley

Cost Share Partner : Penn State

## Objective:

- Develop a first-principles noise modeling system for future UAM aircraft with varied configurations
- Produce noise database for notional UAM configurations for hover, transition, cruise
- Identify configuration changes and operational strategies that minimize acoustic impacts

## Project Benefits:

- Initial capability to analyze UAM acoustics
- Understanding of UAM noise characteristics
- Identification of noise reduction opportunities
- Low noise design tool for the UAM industry
- Initial set of representative UAM noise data for AAM and integration with AEDT

## Research Approach:

- Build on success of helicopter noise prediction system developed under ASCENT Projects 6 & 38:
  - couple flight simulation, aerodynamic modeling (CDI's CHARM), and PSU-WOPWOP
- Tailor approach to unique characteristics of UAM
  - Use PSU Distributed Electric Propulsion Simulation (DEPSim) code to model flight state of multiple propellers and rotors
- Develop low noise UAM trim strategies

## Major Accomplishments (to date):

- Added time-varying broadband noise prediction capability to PSU-WOPWOP
- Noise prediction system coupled for rotors
- Conference publications:
  - 2021 VFS aVTOL Technical Meeting

## Future Work / Schedule:

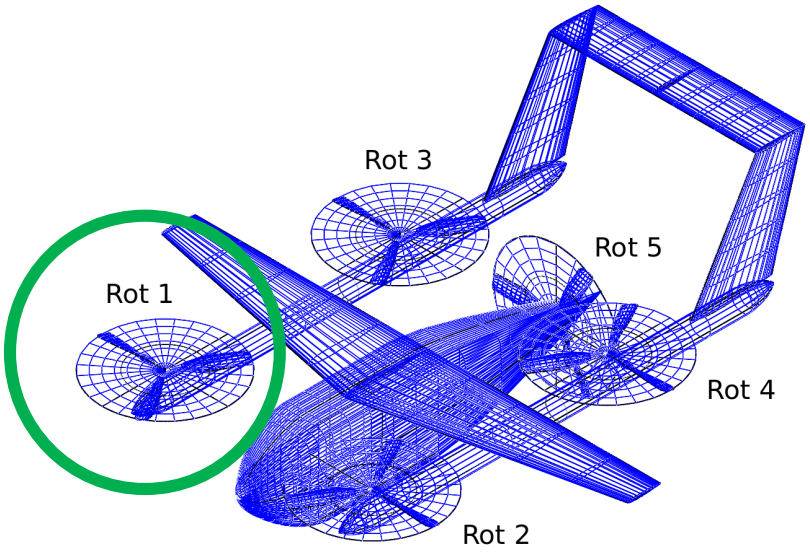
- Validation and verification of system
- Couple non-rotating lifting surfaces
- Development of noise abatement procedures

This research was funded by the U.S. Federal Aviation Administration Office of Environment and Energy through ASCENT, the FAA Center of Excellence for Alternative Jet Fuels and the Environment, project 49 through FAA Award Number 13-C-AJFE-PSU-052 under the supervision of Rick Riley. Any opinions, findings, conclusions or recommendations expressed in this this material are those of the authors and do not necessarily reflect the views of the FAA.

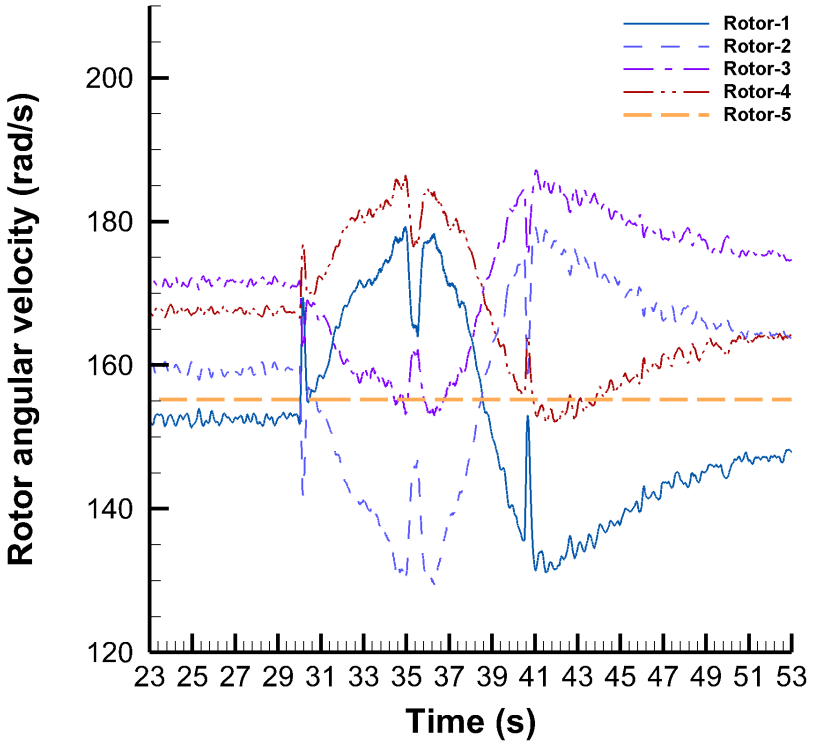
# Noise Prediction System Results

**Lift plus pusher configuration used to investigate rotor speed variation and acceleration rates**

Generic Aircraft Model

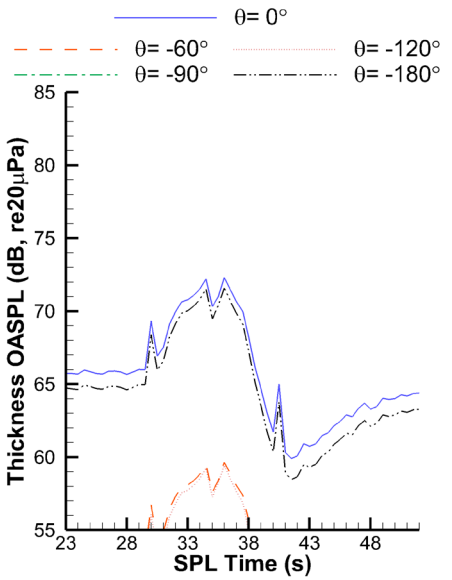



Rotor Speed Responses
(roll doublet maneuver)

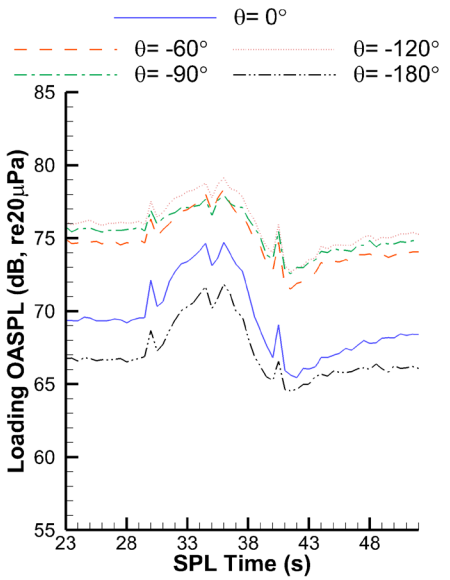


# Noise from Variable RPM Rotors

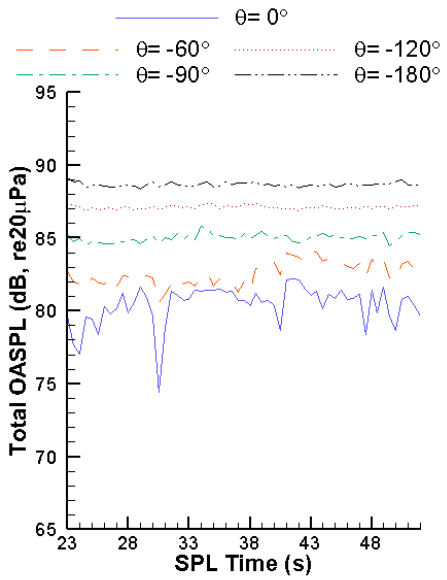
Thickness Noise (OASPL Rotor 1)




Loading Noise (OASPL Rotor 1)




Total Noise OASPL All Lift Rotors

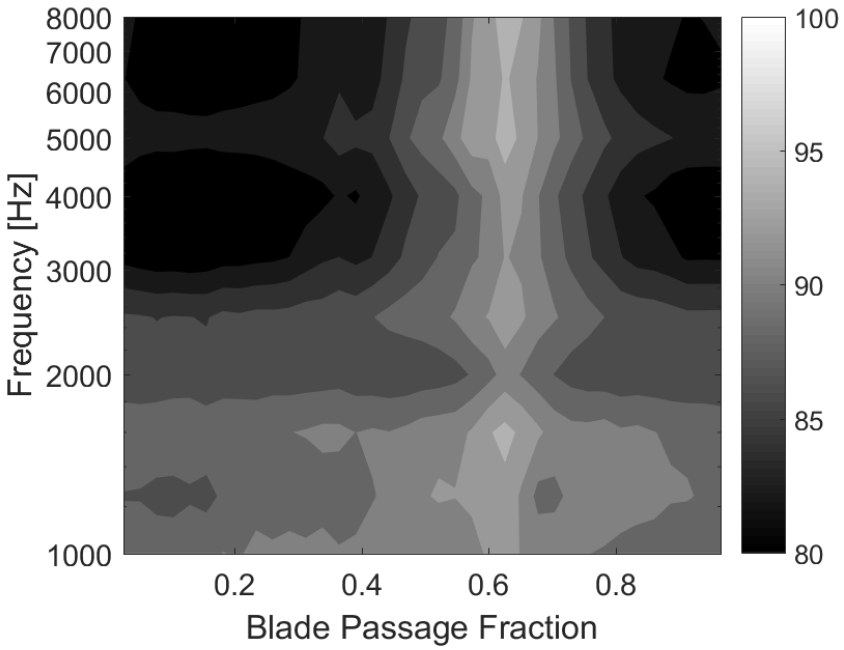



- Significant variation in noise level during maneuver clearly seen for individual rotor(s)
- Less variation when all 4 rotors are added together

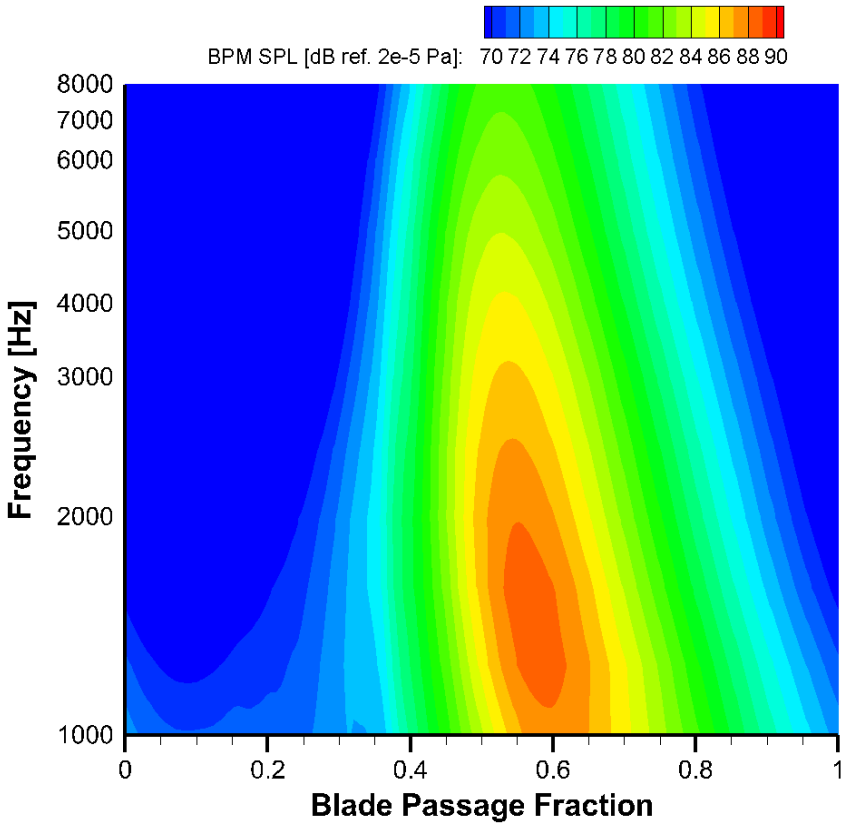
# Time-Varying Rotor Broadband Noise

## Processed Flight Test Data [1]

[1] A. Christian, J. Caston, and E. Greenwood, VFS Forum, 2019.




## PSU-WOPWOP Predictions

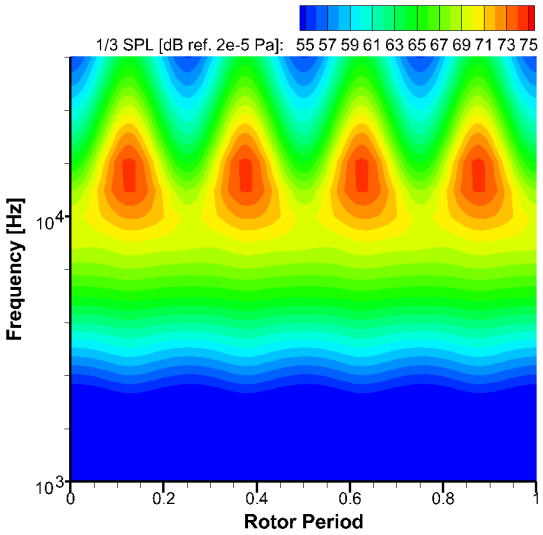



Not meant for direct comparison: similar qualitative features and modulation range

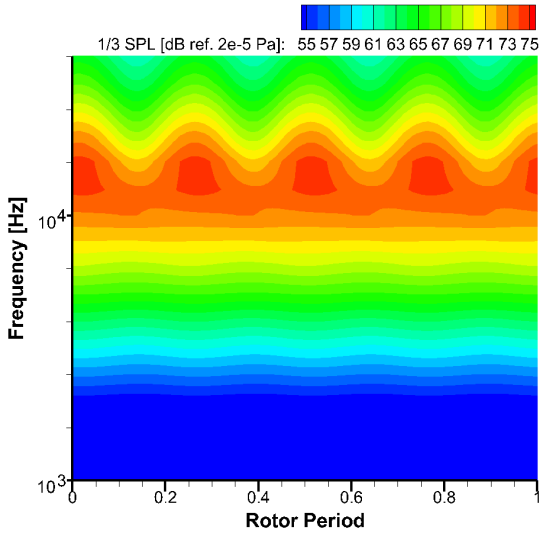
# Physical Mechanisms of Modulation

- Retarded time effects increase modulation range: “sharpen" peaks
- Convective amplification increases levels, but increase in modulation range small compared to retarded-time effects

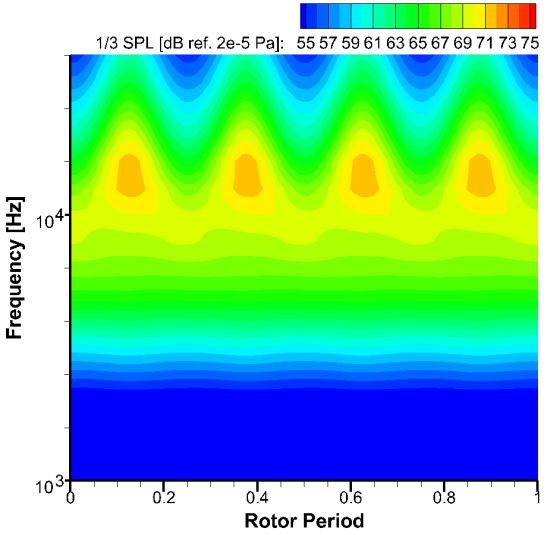
Baseline Case




Retarded-Time Effects Removed




Convective Amplification Effects Removed




Ze Feng (Ted) Gan, Kenneth S. Brentner, and Eric Greenwood, “Time Variation of Rotor Broadband Noise,” Presented at the Vertical Flight Society’s 9th Biennial Autonomous VTOL Technical Meeting, Virtual, January 26–28, 2021.