

# Medium-Sized Helicopter Noise Abatement Flight Test

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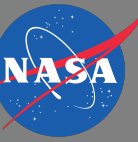
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Aviation & Missile Center

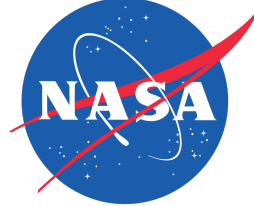
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# Acknowledgments

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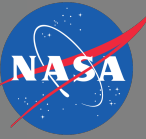


Federal Aviation Administration  
Rick Riley



Federal Aviation Administration  
William J. Hughes Technical Center  
Charles (Cliff) Johnson





- Previous research focused on flying helicopters more quietly to improve community acceptance
  - 2011 – identify low noise maneuvering techniques using the Bell 430 [1]
  - 2017 – maneuvers and noise abatement approaches for six single-engine lightweight helicopters [2]
- Goals for this test:
  - Generalize findings from previous tests to medium-sized class of helicopters
  - Acquire source noise to enable empirical [3] and semiempirical modeling [4]
  - Provide guidance to pilots on low noise procedures, i.e., maneuvers and approaches

<sup>1</sup>Watts et al., "Maneuver Acoustic Flight Test of the Bell 430 Helicopter Data Report," NASA TM 2014-218266, 2014.

<sup>2</sup>Watts et al., "Noise Abatement Flight Test Data Report," NASA TM 2019-220264, 2019.

<sup>3</sup>Page et al., "Advanced Acoustic Model Technical Reference and User Manual," WP-1304, 2009.

<sup>4</sup>Greenwood & Schmitz, J. of the American Helicopter Society, Vol. 63 (3), 2018.



- Test overview
  - Vehicles
  - Instrumentation
  - Operational noise (summary of dataset)
- NICEOPS prediction method for approaches
  - Methodology
  - Implementation
- Concluding Remarks

# Vehicles and conditions

- Medium-sized vehicles

TOGW 7,400-14,200 lbs

2 x Turboshaft engine (B205 single)

- Conditions tested

- Steady source (level, descents)
- Turns
  - Variable load factor
  - Constant torque
  - Turn w/ accel
  - Turn from climb/descent
  - Turn from descent w/ accel
- Noise abatement approaches
- Hover

Sikorsky S-76D

11,400 lbs



Leonardo AW-139

14,200 lbs



Bell 205

7,400 lbs



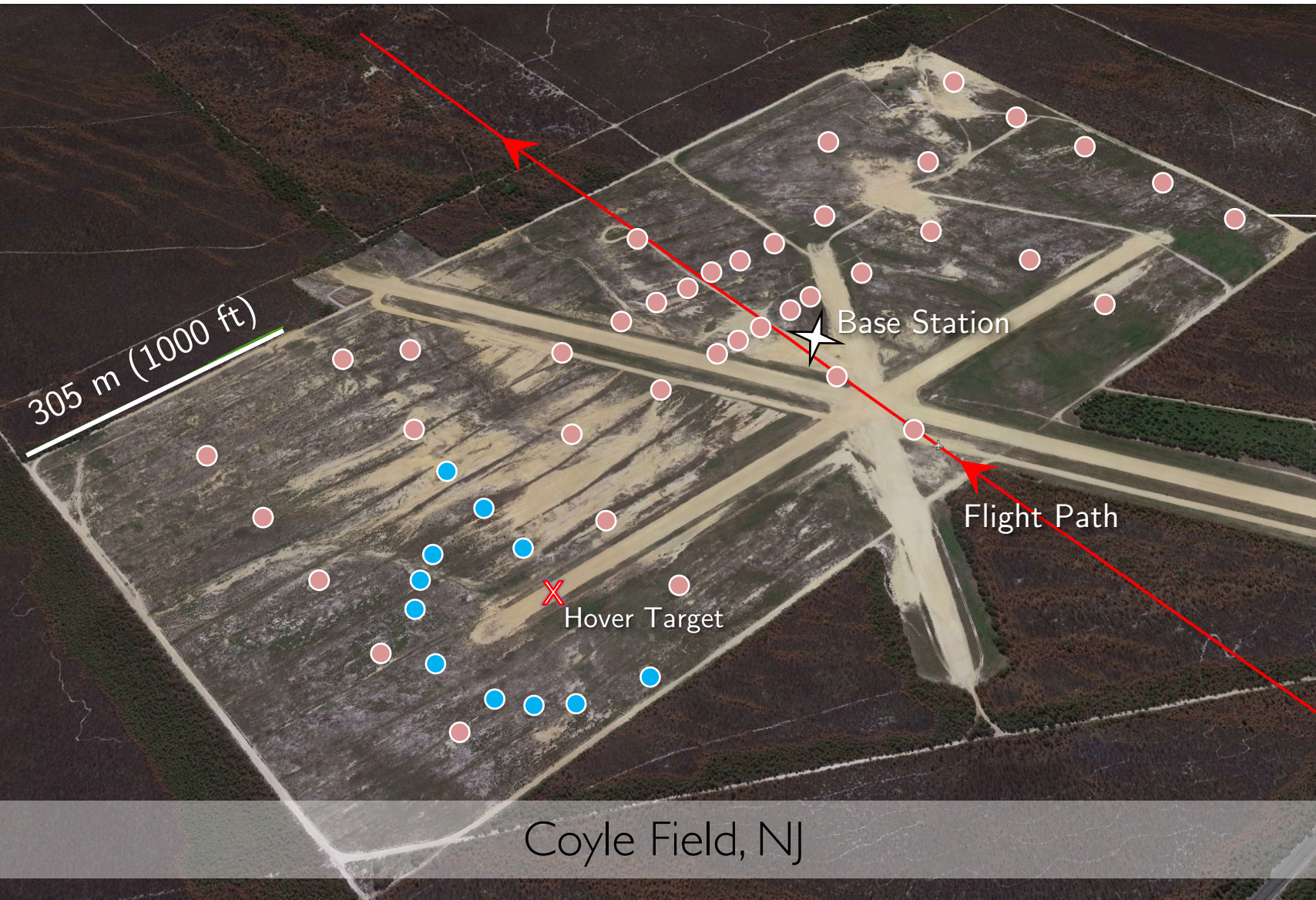
Eurocopter MH-65

9,500 lbs



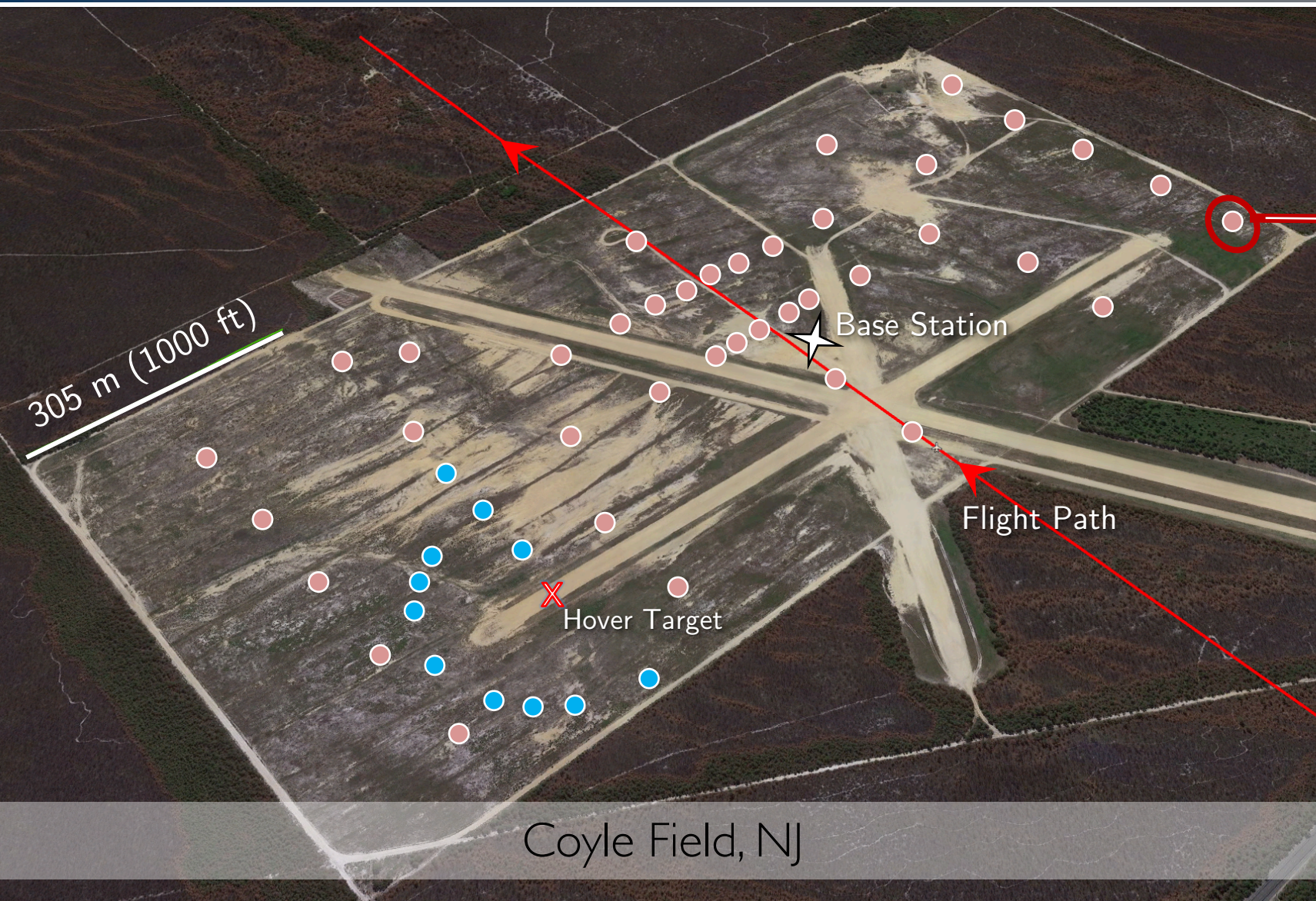
\*In this presentation





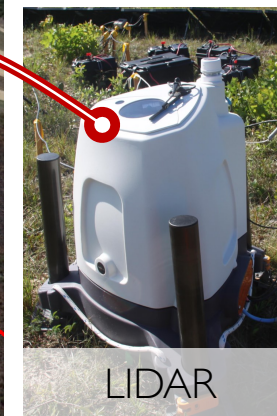
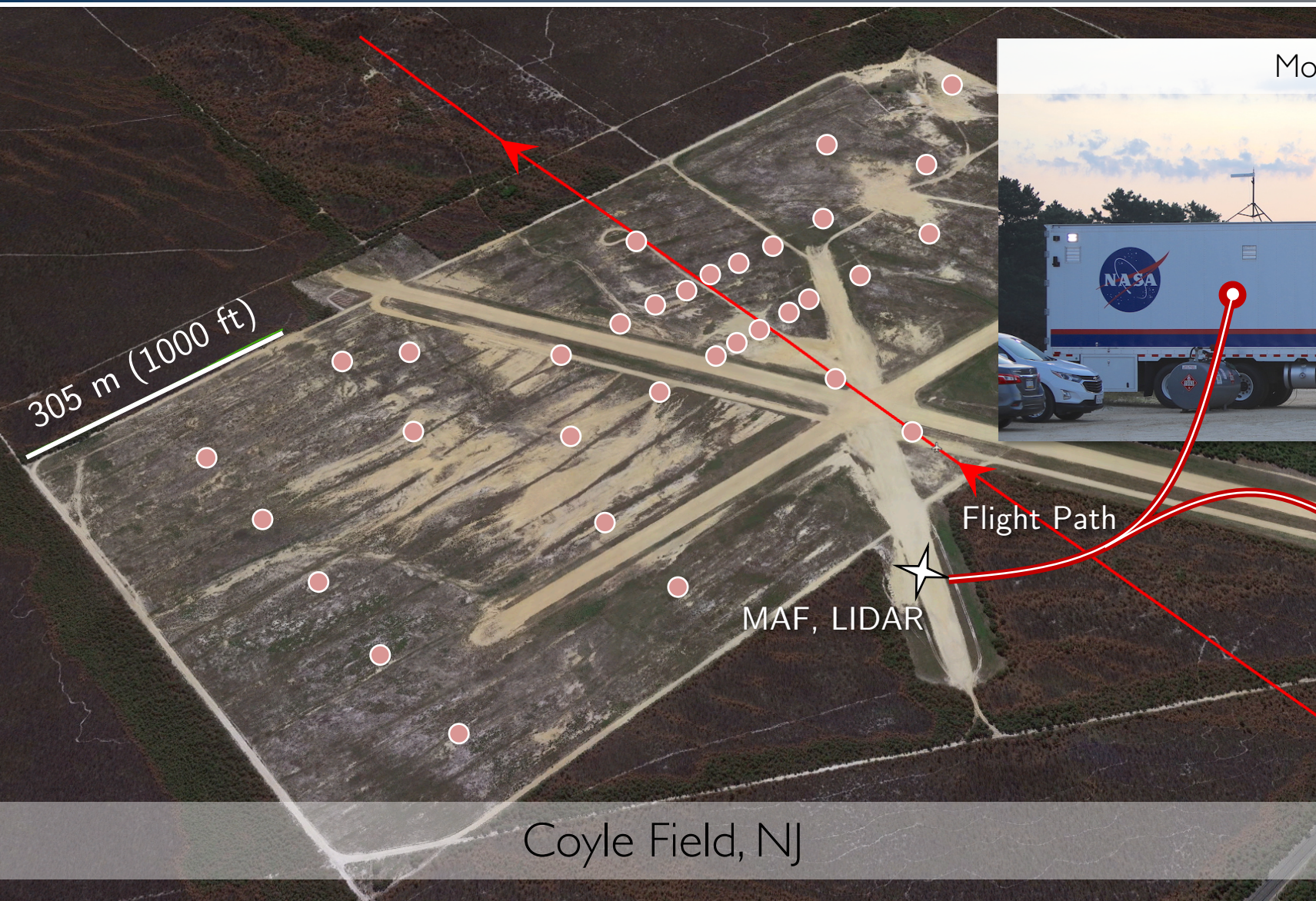


# Overview

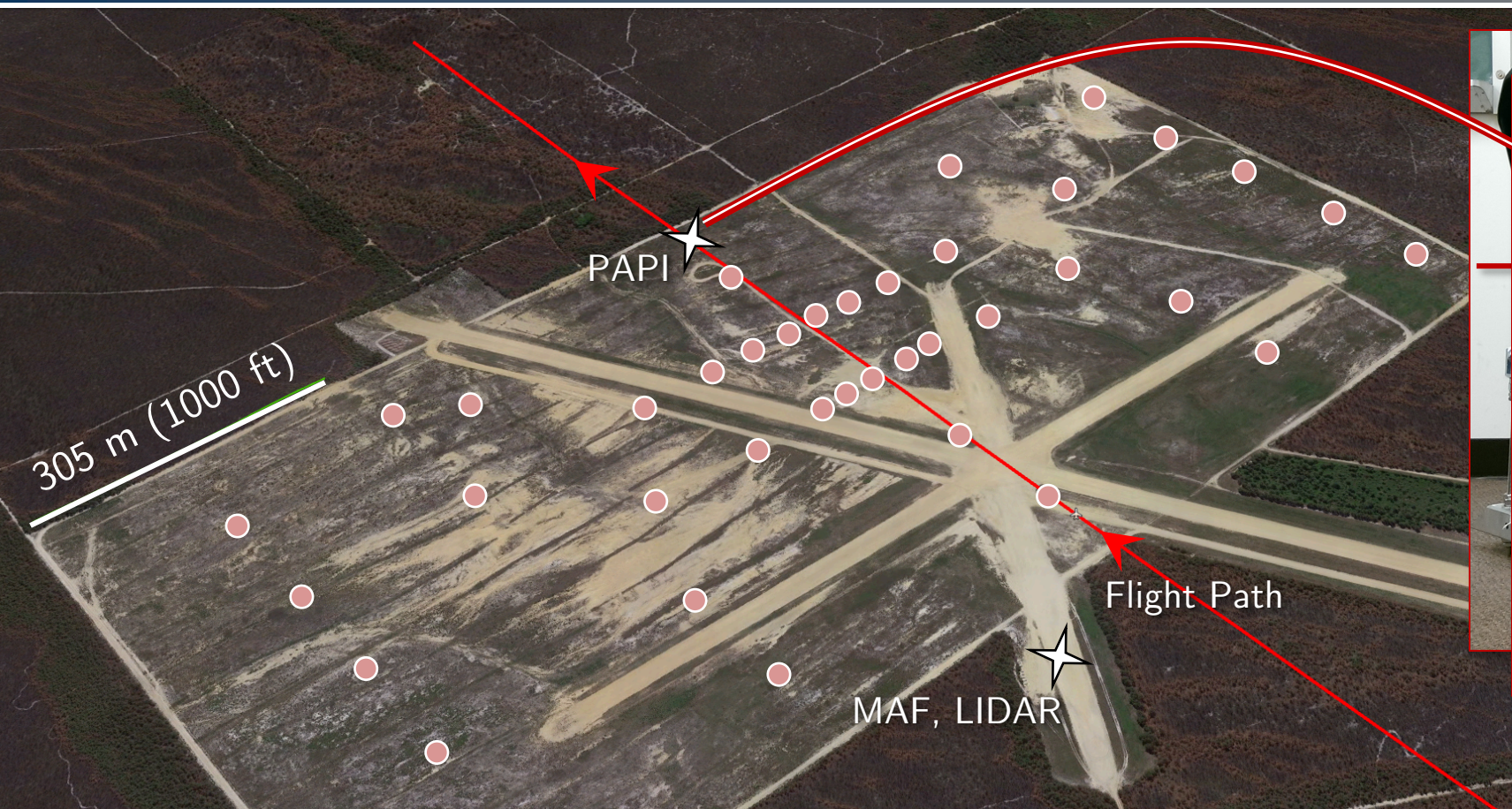


1/2" GRAS 67 AX









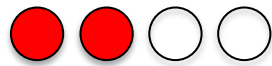
Descent conditions



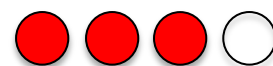
Too High



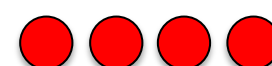
Slightly High



On Slope



Slightly Low

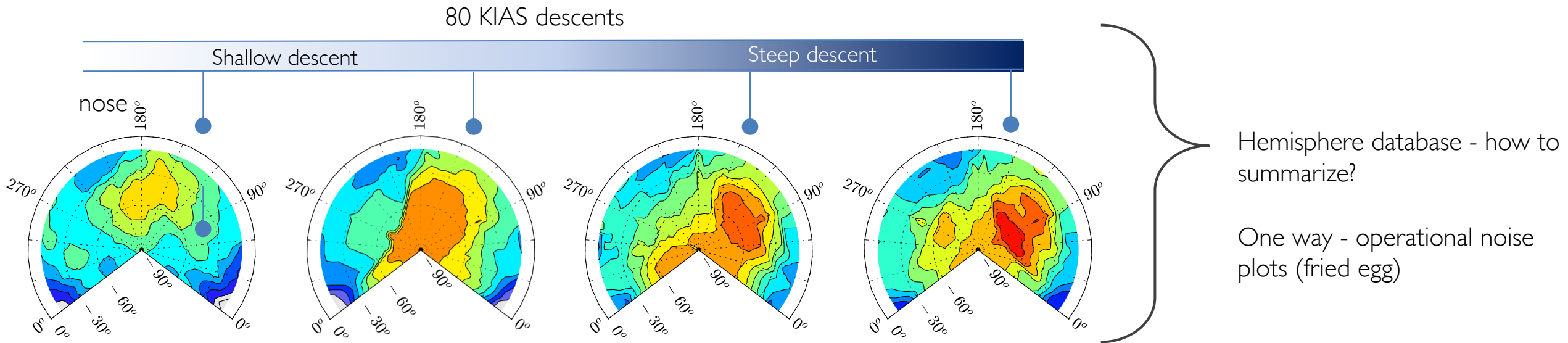
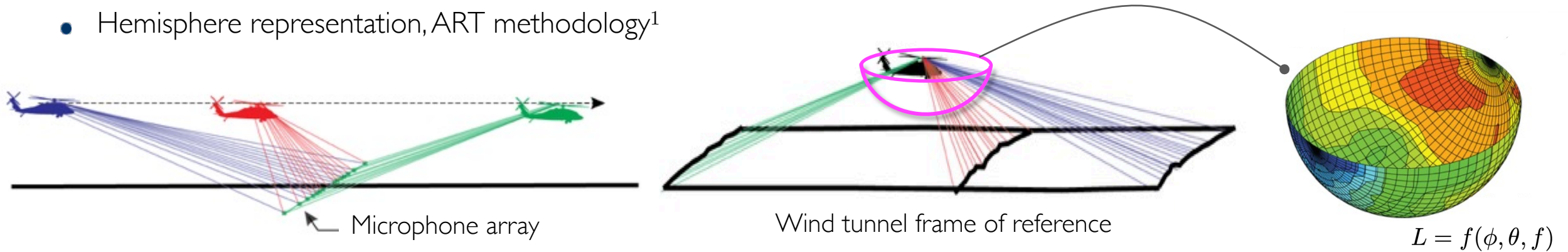


Too Low



# Source hemispheres

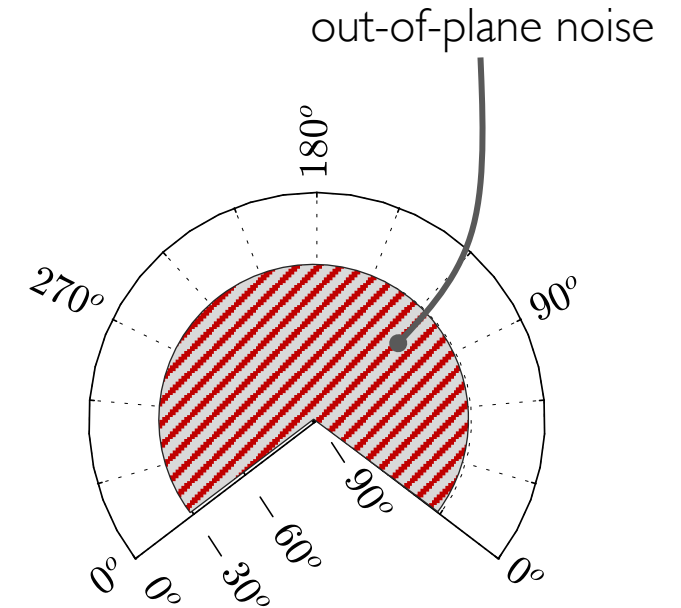
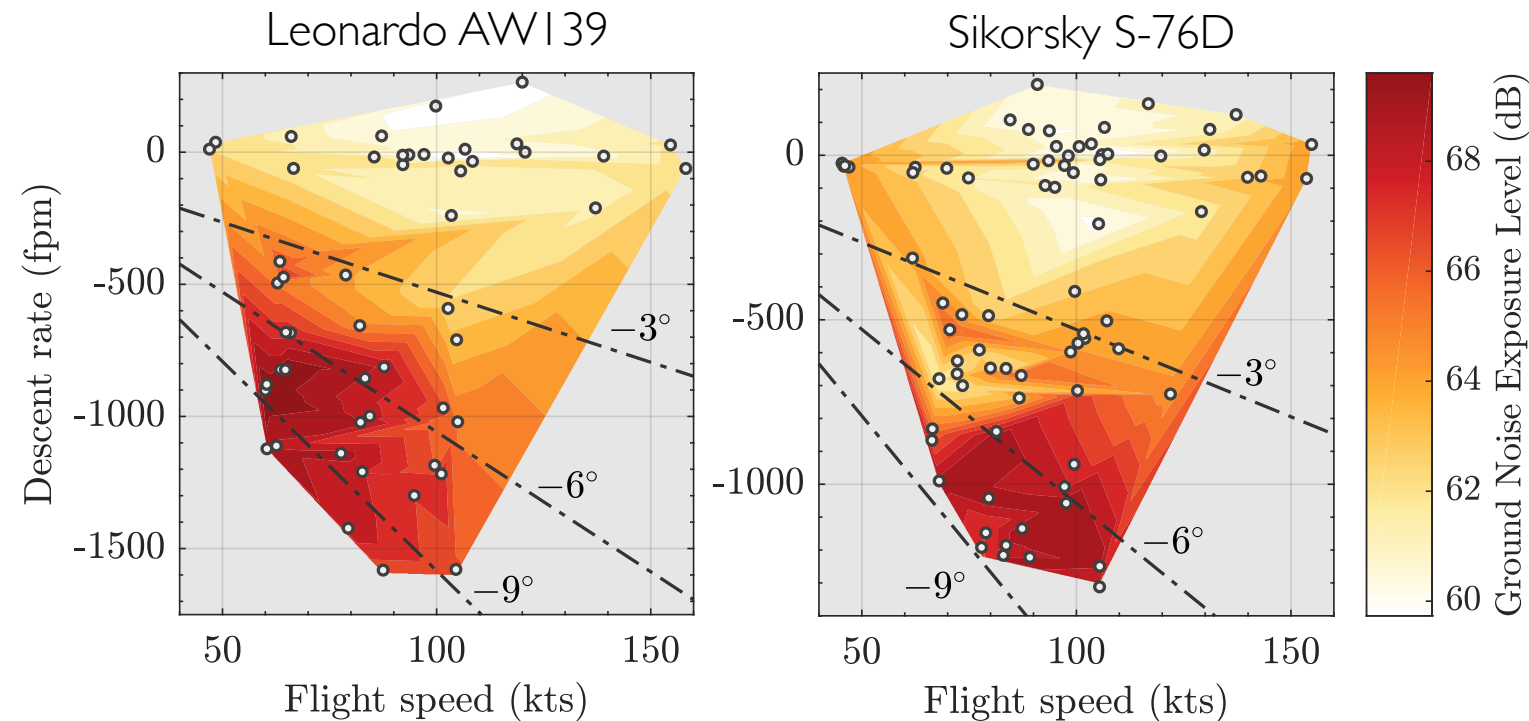
- Hemisphere representation, ART methodology<sup>1</sup>



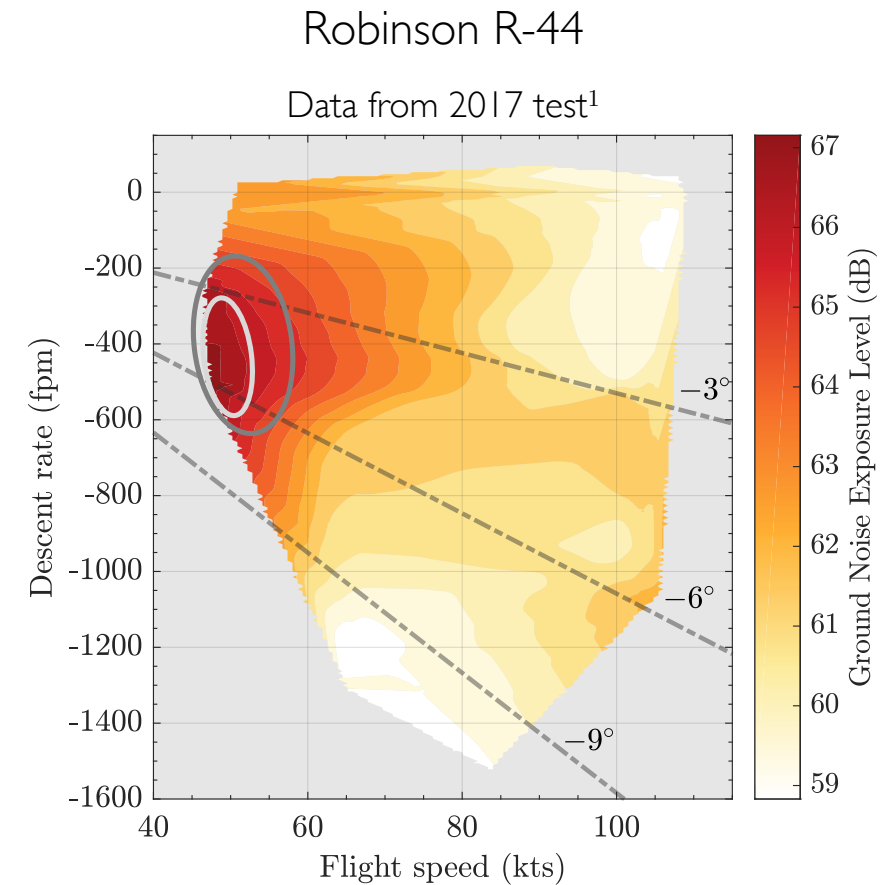
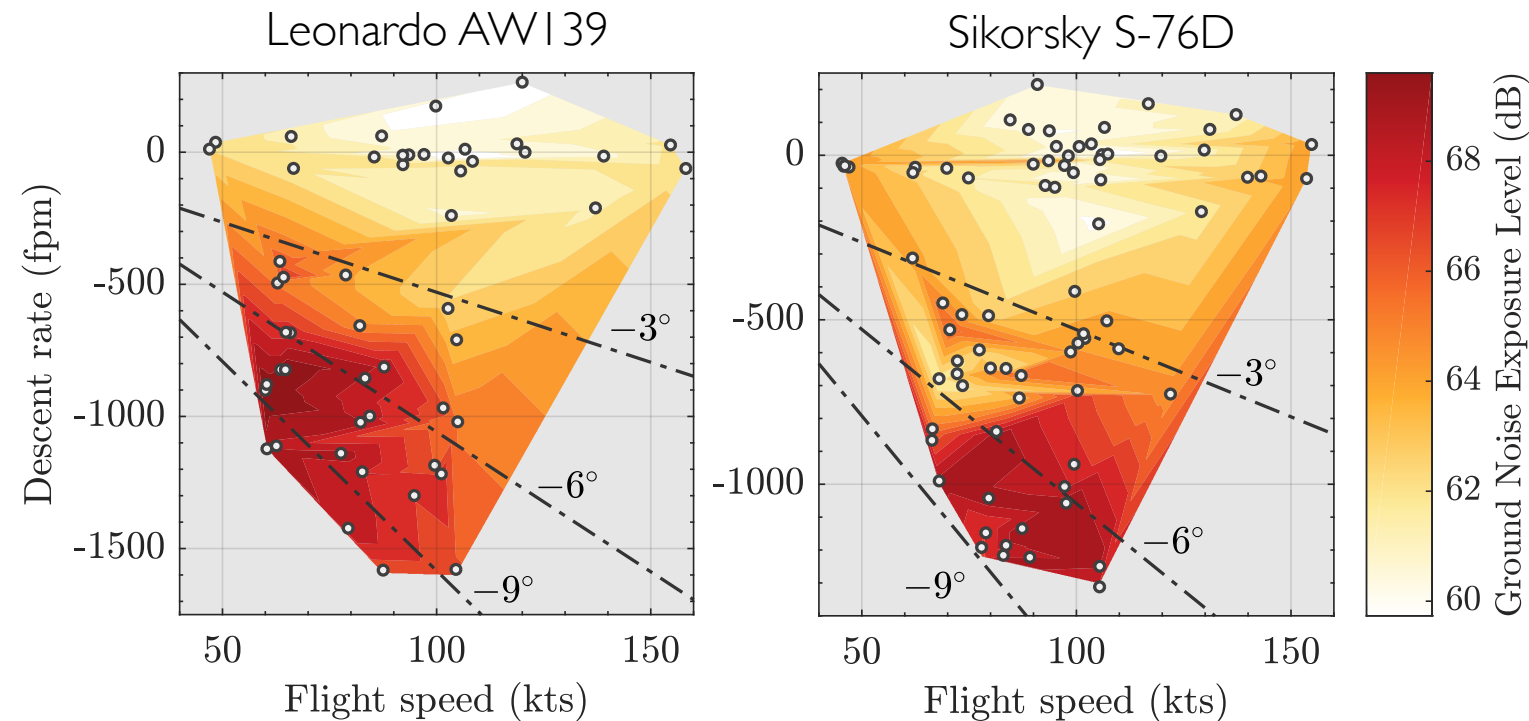
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- Ground noise exposure level to describe vehicle noise during level flight and constant speed descents
  - Duration weighted, e.g.,  $10 \log_{10}(V_{ref}/V)$
  - Out-of-plane noise projected to ground plane
  - Band-limited to mid-frequency range (5<sup>th</sup>-60<sup>th</sup> MR harmonic)
  - Medium-sized vehicles show BVI dominant at larger descent rates

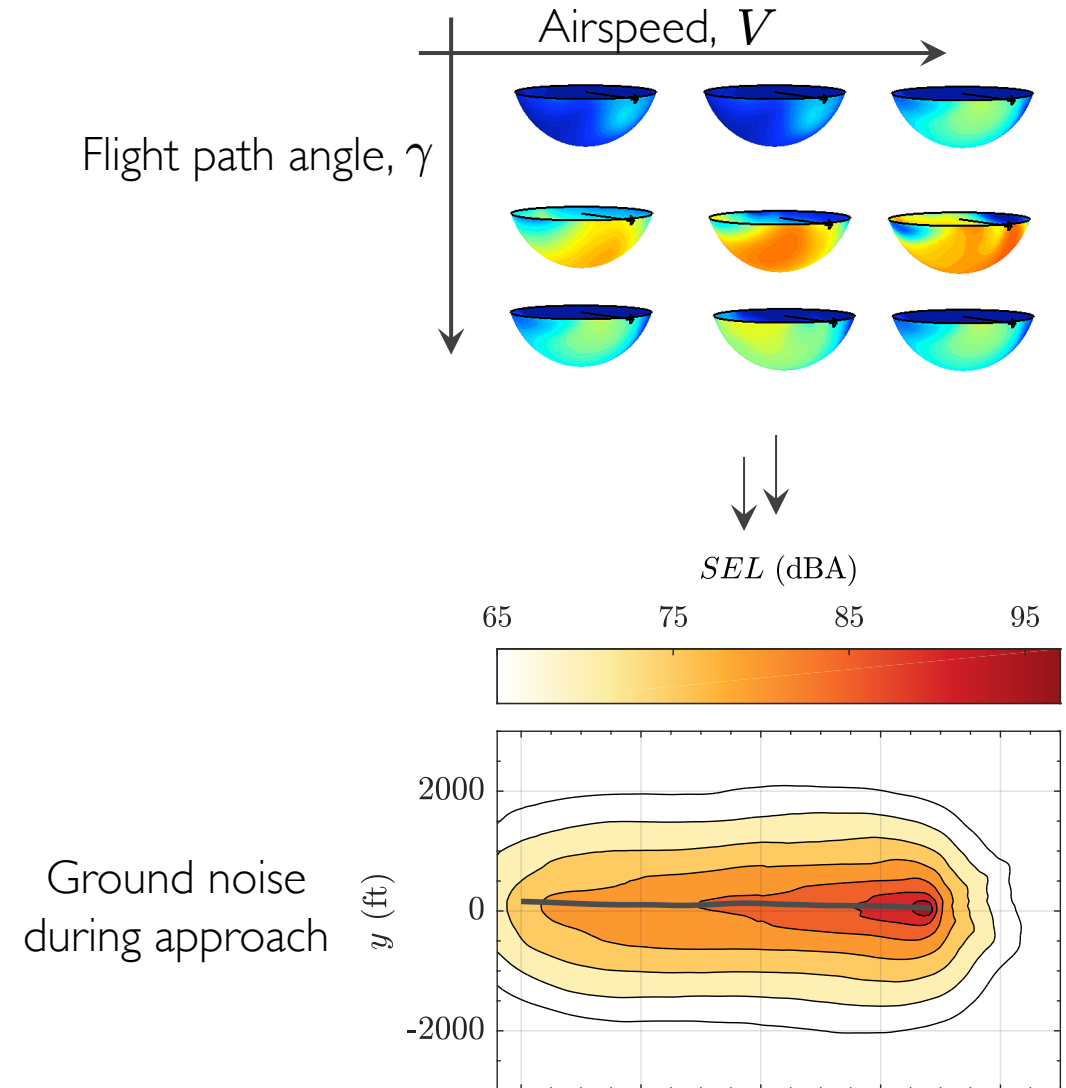


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t al., "Noise Abatement Flight Test Data Report," NASA TM 2019-220264, 2019.

- NICEOPS – Noise Informed Community Environment Operations Planning System
  - Aircraft noise prediction method, currently under development at Penn State
  - Computationally efficient, employs flight test data
- **Goal** - to estimate how changes in operating procedures impact noise exposure
  - Across approaches and maneuvers not measured
  - Near-real-time optimization of procedures



## 1. Steady flight test data

- Source hemispheres
- Nondimensionalize conditions

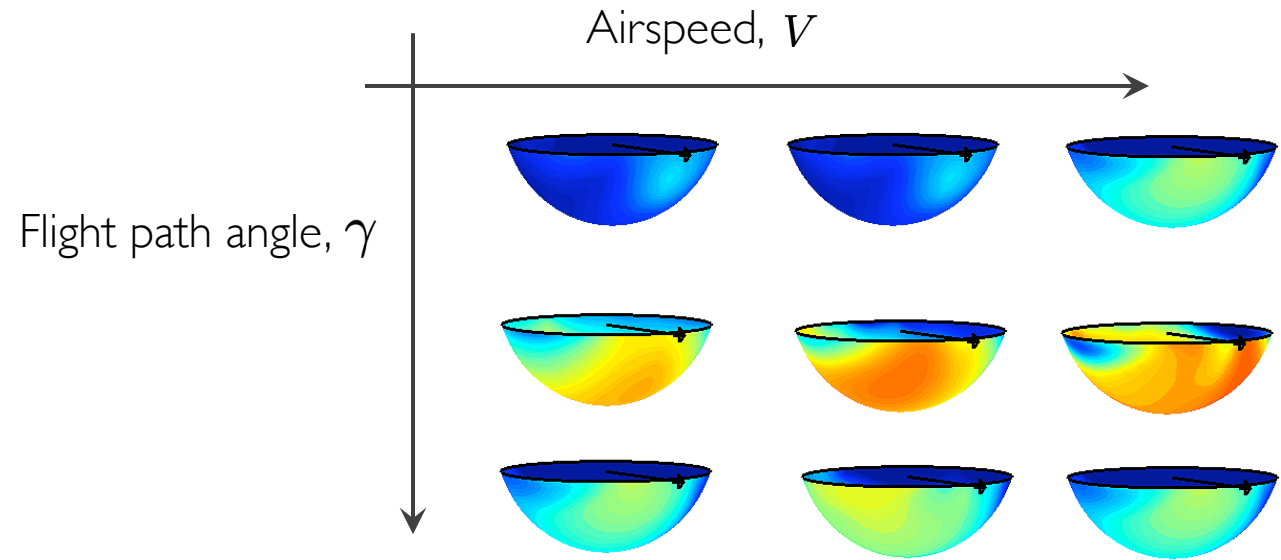
$$\mu, C_T, \gamma, M_H$$

## 2. Heuristics to extend database

- Operating envelope closure
- Loading noise scaling

## 3. Simulate approach

- Determine effective flight path angle
- Propagate to ground



$$\mu = \frac{V}{\Omega R} \quad C_T = \frac{T}{\rho_o A (\Omega R)^2} \quad M_H = \frac{\Omega R}{a_0}$$

4-D hemisphere database,  $f(\mu, C_T, \gamma, M_H)$

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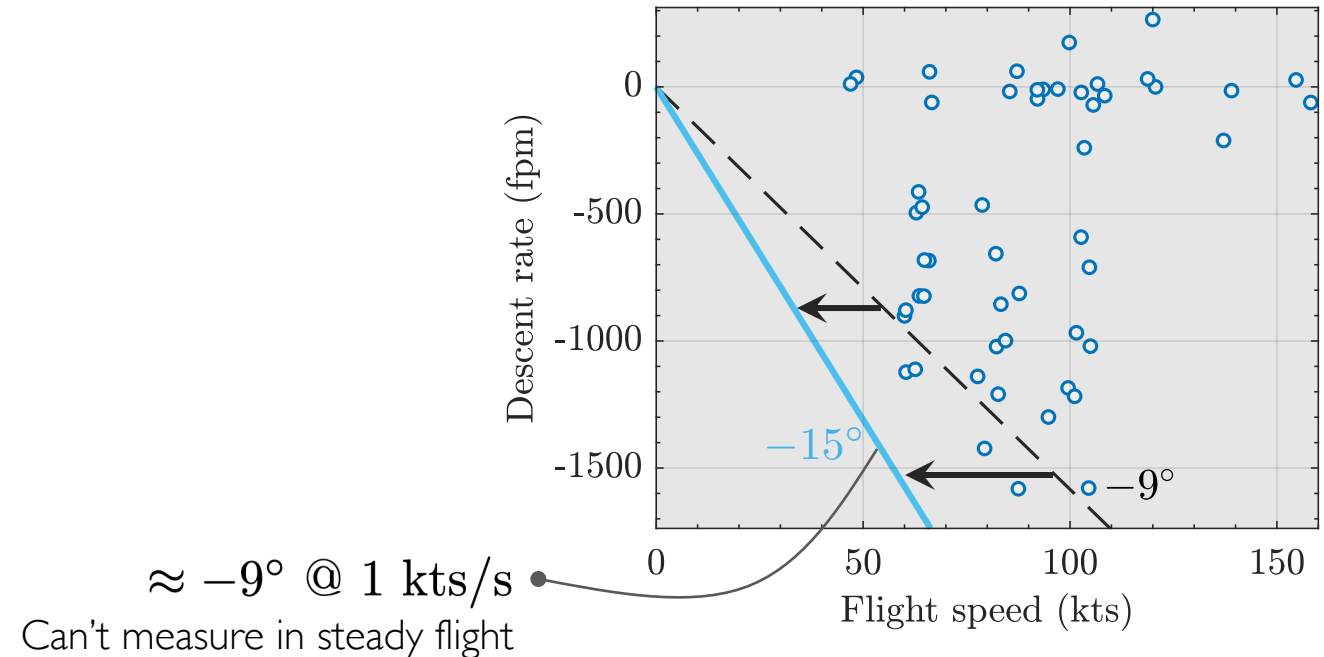
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### ➤ To account for change in loading noise during decelerating flight,

$$\Delta SPL = 20 \log_{10} \frac{C_T}{C_W}$$

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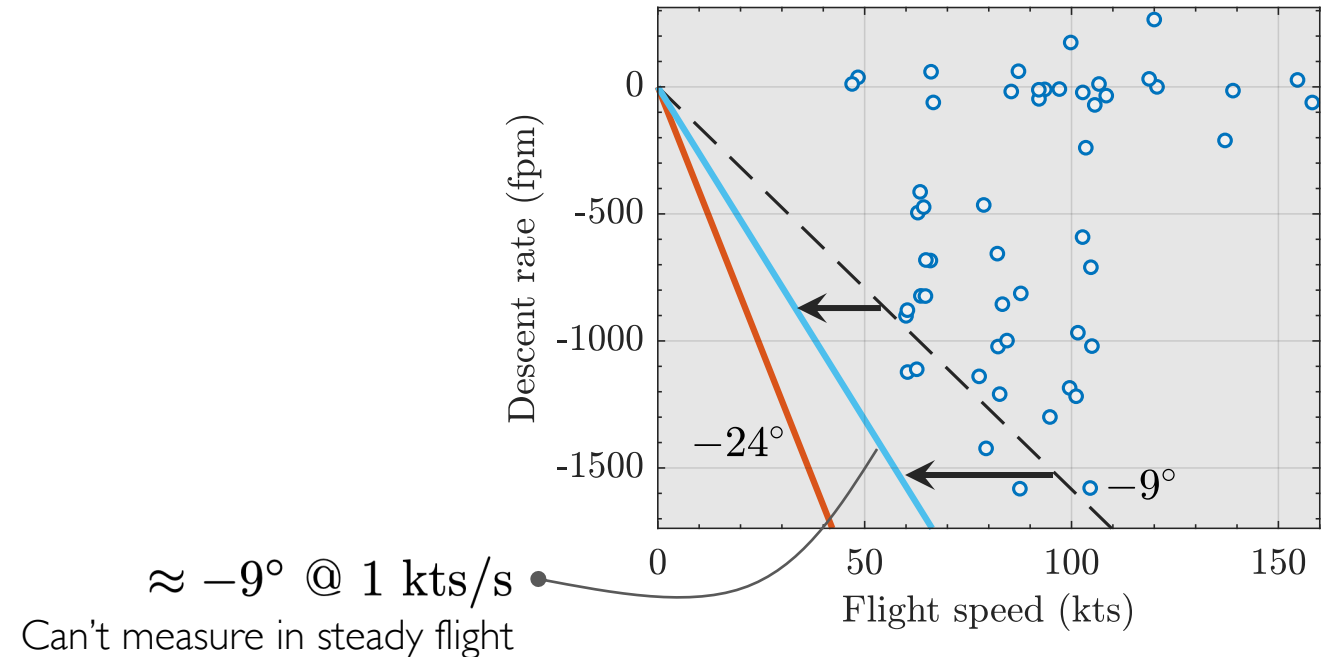
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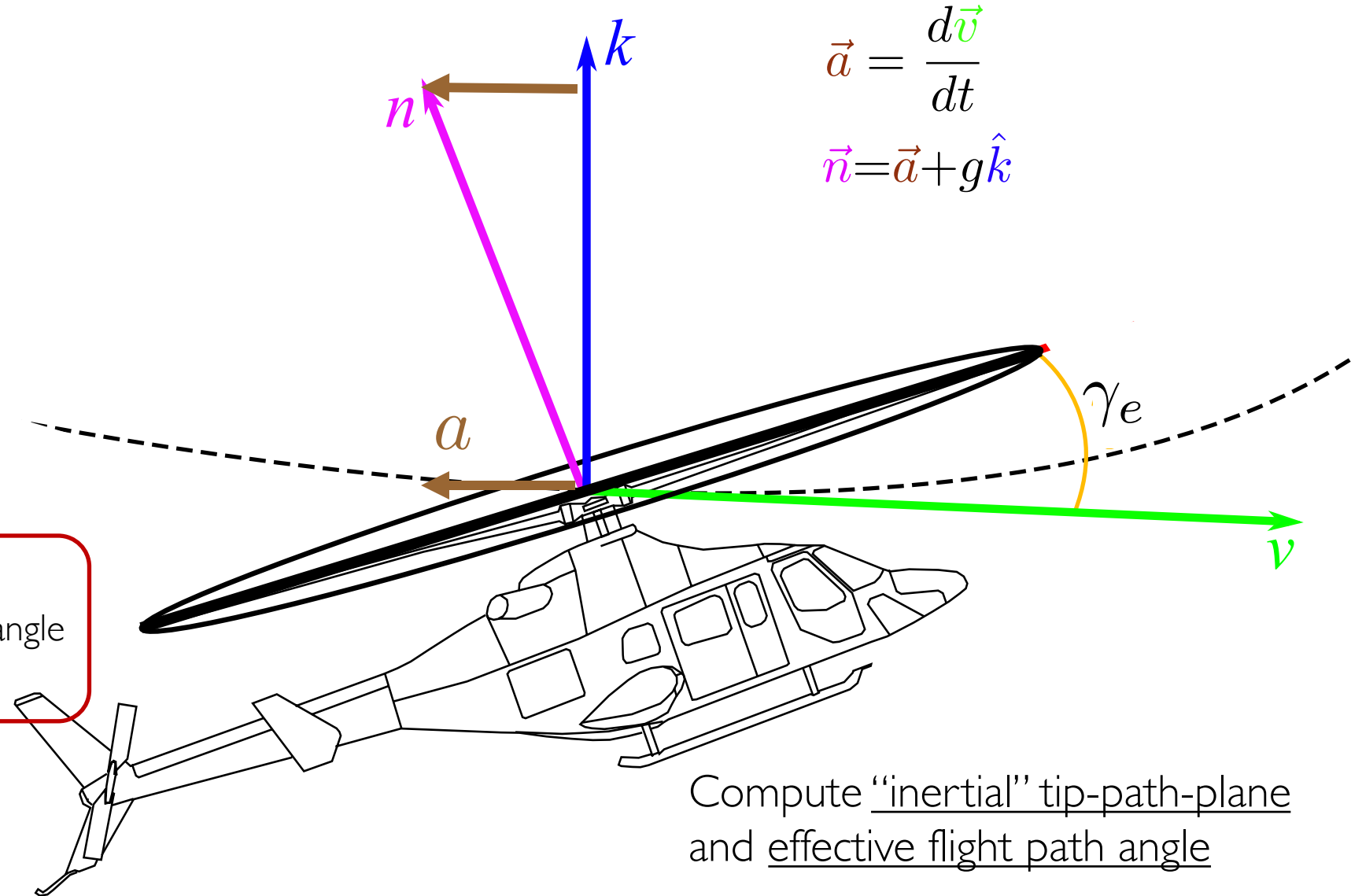
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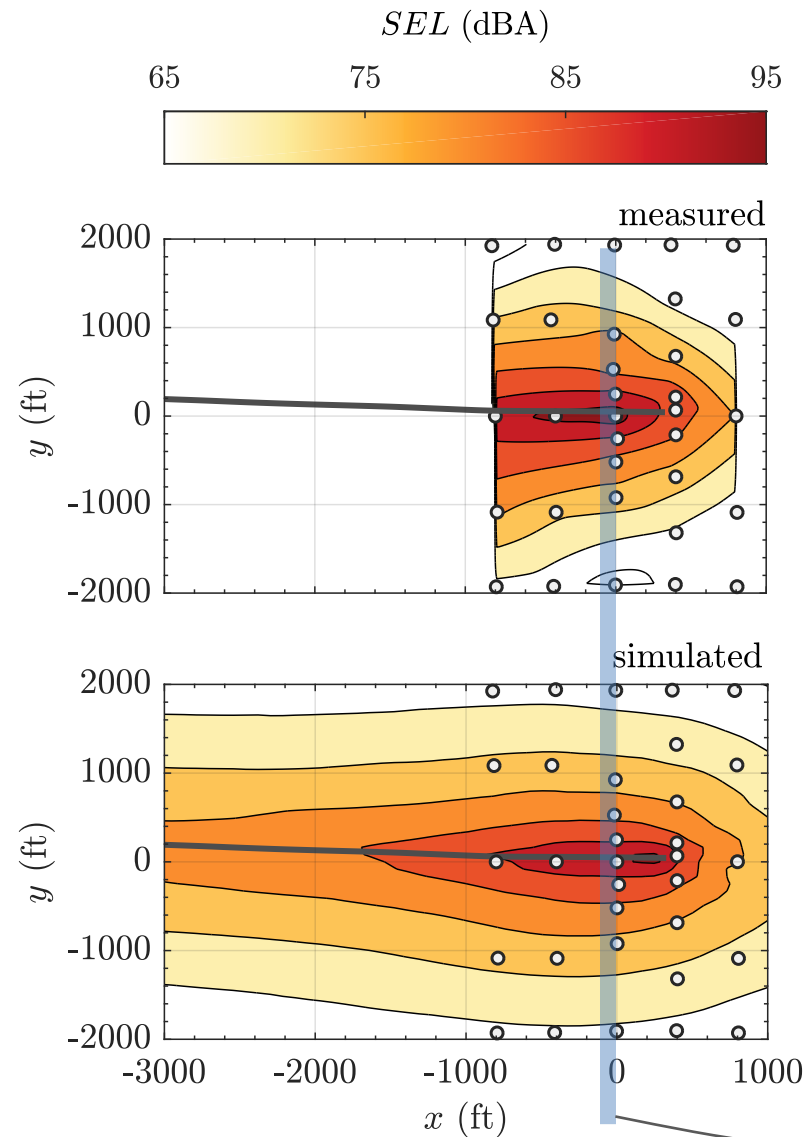
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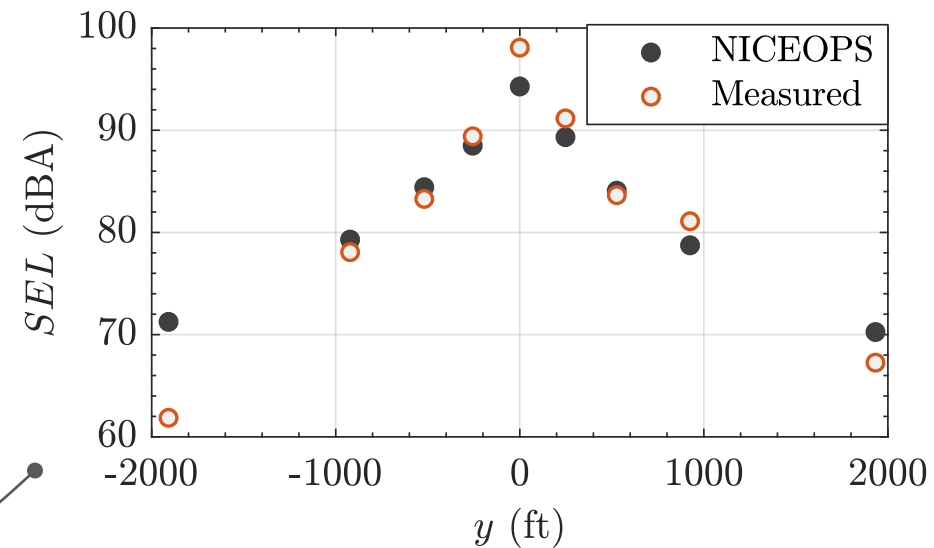


$$\vec{a} = \frac{d\vec{v}}{dt}$$
$$\vec{n} = \vec{a} + g\hat{k}$$

Compute “inertial” tip-path-plane  
and effective flight path angle

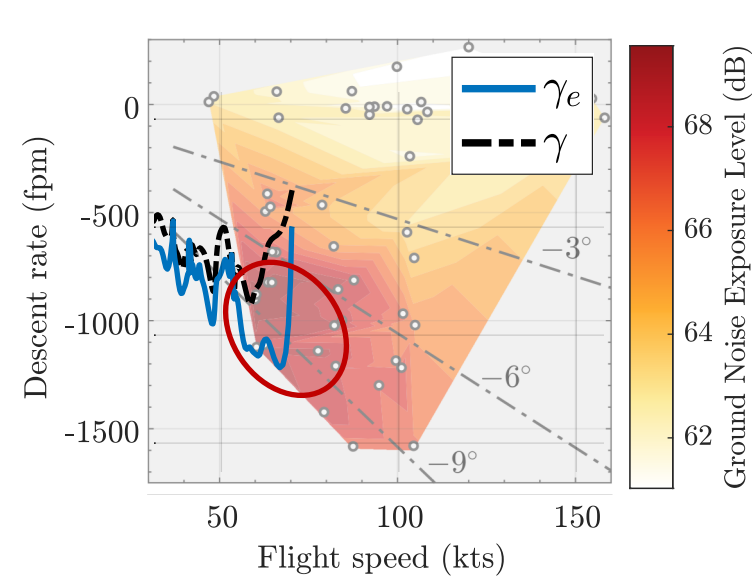
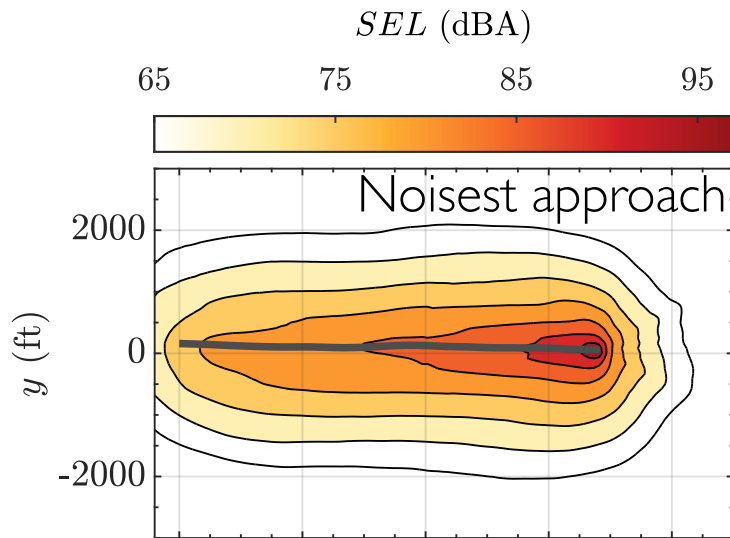


- Condition:
  - S-76D, -7.5 deg. decelerating approach from 60 KIAS
- Good agreement between simulated and measured contours
  - Within 2 dBA with few exceptions
  - Higher uncertainty at large lateral distances



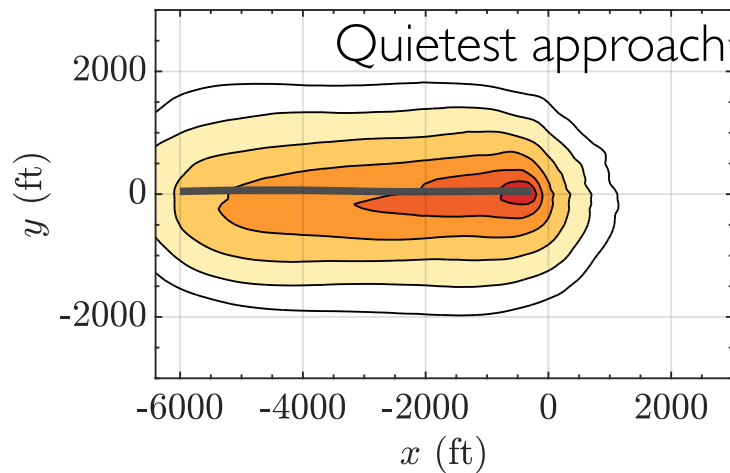
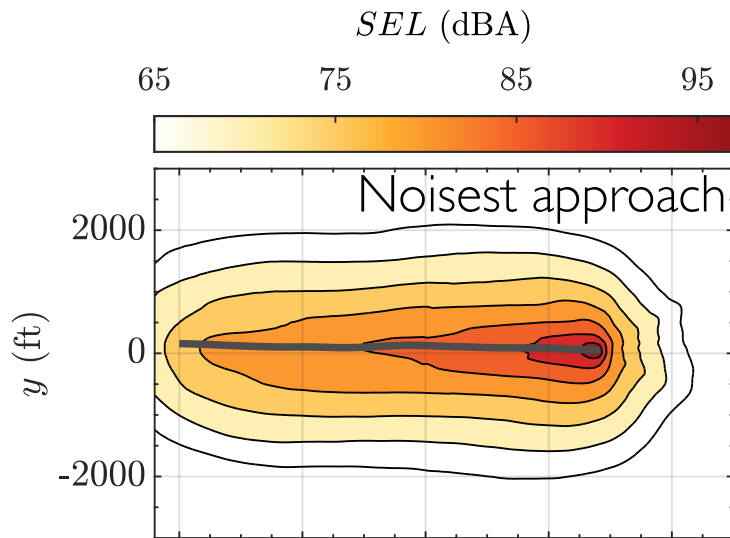


# Simulated Results

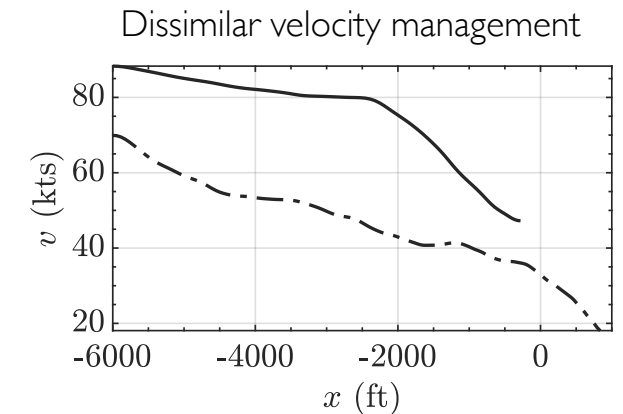
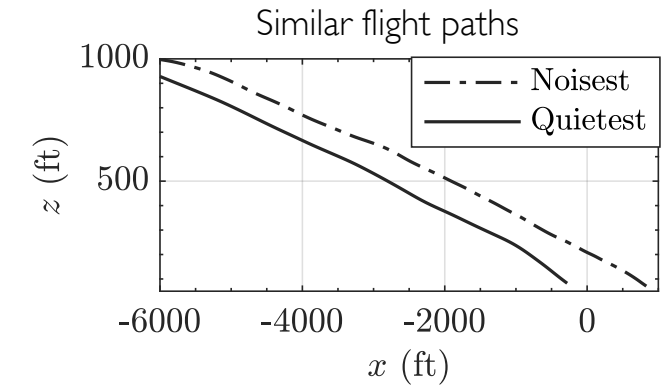
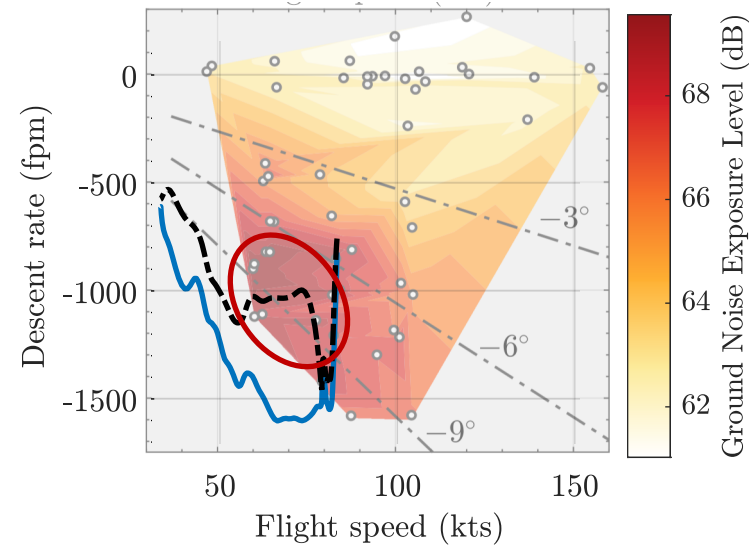
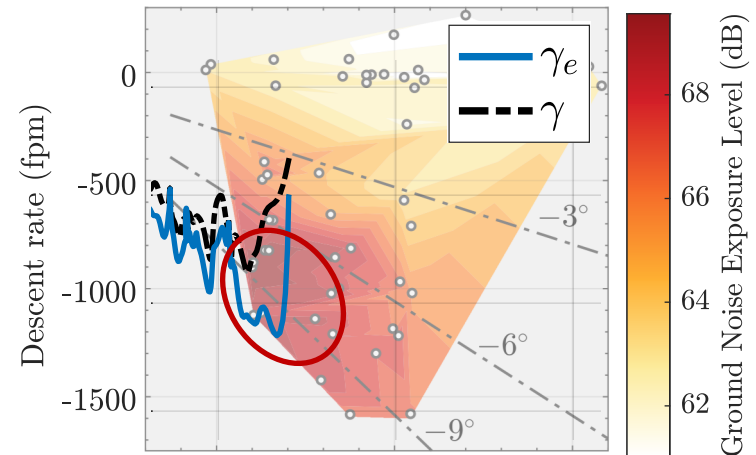


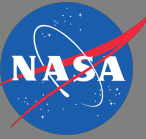
Vehicle: AWI 39

# Simulated Results



Vehicle: AWI 39



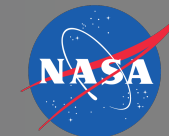


- Medium-Sized Helicopter Noise Abatement Flight Test conducted in 2019
  - Operational noise plots summarize noise during steady level and descending flight
  - Full test data report – **Medium-Sized Helicopter Noise Abatement Flight Test Report**, NASA TM (currently under internal review) – nearing completion
- NICEOPS
  - Noise prediction method based on nondimensional source hemispheres
  - Includes heuristics expand database range beyond conditions measured in steady flight; needed b/c can't measure during steady flight
  - Longitudinal acceleration has a powerful effect on the aerodynamic, and therefore acoustic, state of the helicopter



Volpe/FAA

National Aeronautics and  
Space Administration



NASA

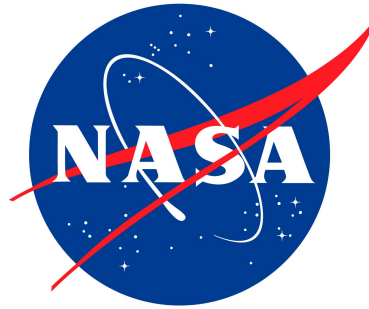


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# Thank you.



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