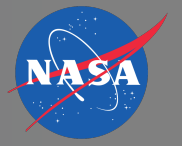
National Aeronautics and Space Administration



Medium-Sized Helicopter Noise Abatement Flight Test

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Background

- Previous research included reducing the noise generated by helicopters with the goal of improving community acceptance of helicopter operations
  - 2014 test to identify low noise maneuvering techniques using the Bell 430 [1]
  - 2017 test for noise abatement approaches for six single-engine lightweight helicopters [2]

- Goals of this test:
  - Generalize previous findings for low-noise approaches and maneuvers to medium-sized class of helicopters
  - Acquire source noise to enable empirical [3] and semiempirical modeling [4]
  - Validate numerical models [e.g., Ref. 5]

[1]Watts et al., "Maneuver Acoustic Flight Test of the Bell 430 Helicopter Data Report," NASA TM 2014-218266, 2014.
[2]Watts et al., "Noise Abatement Flight Test Data Report," NASA TM 2019-220264, 2019.
[3]Page et al., "Advanced Acoustic Model Technical Reference and User Manual," WP-1304, 2009.
[4]Greenwood & Schmitz, J. of the American Helicopter Society, Vol. 63 (3), 2018.
[5]Wachspress, D., Quackenbush, T., Boschitsch, A., J. of the American Helicopter Society, Vol. 48, (4) 2003.

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

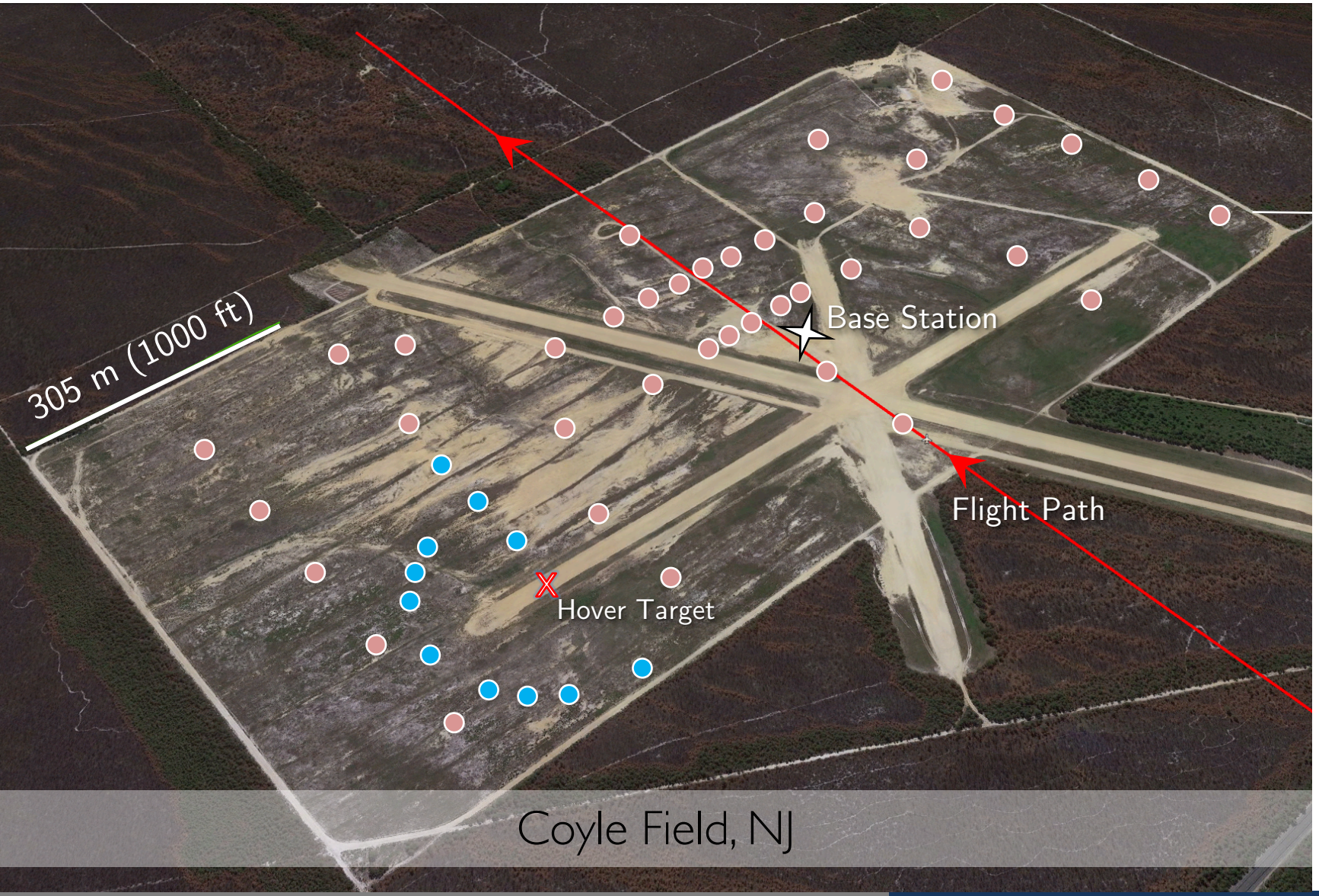
Sikorsky S-76D

Leonardo AW-139

Bell 205

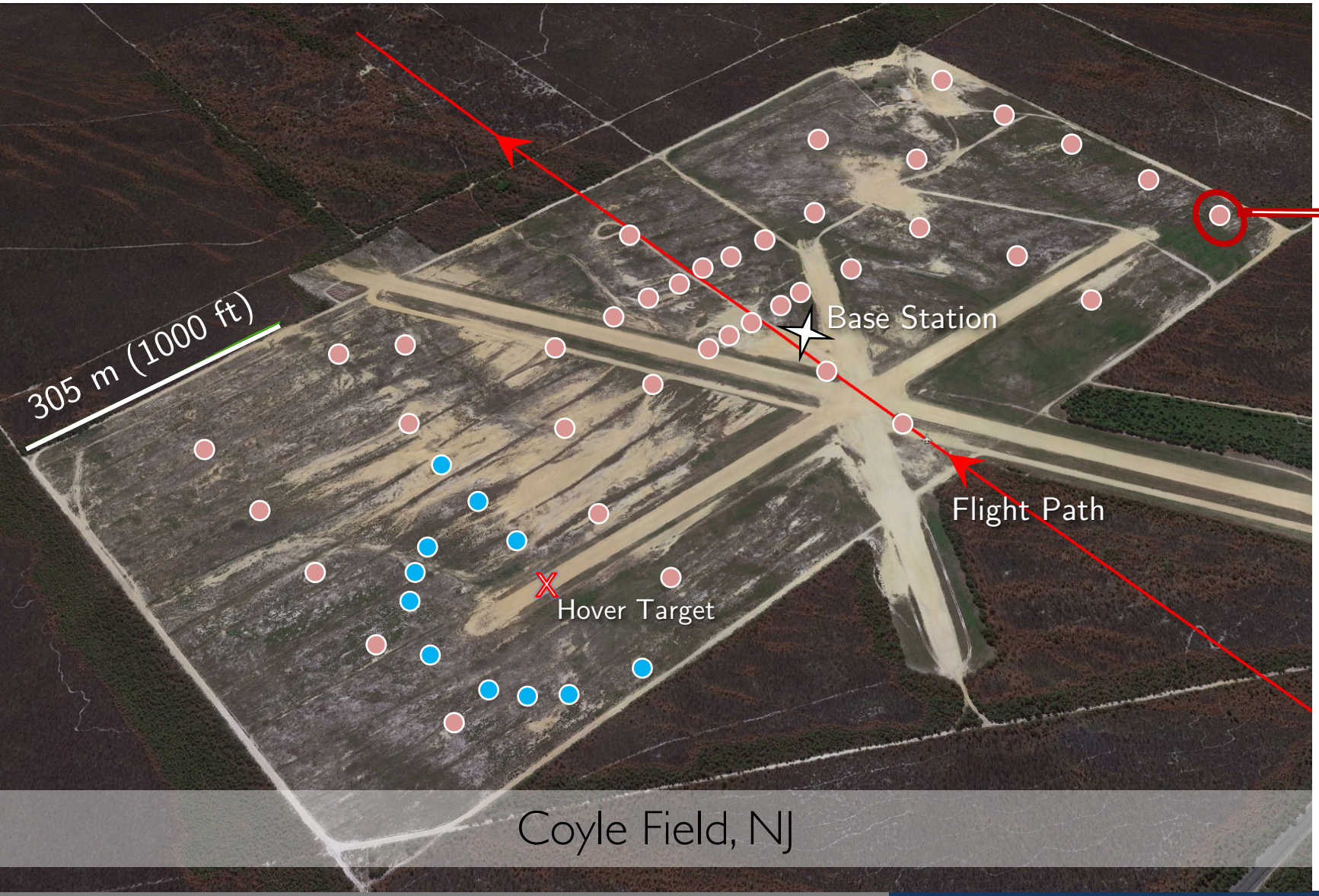
Eurocopter MH-65

Overview


305 m (1000 ft)
Base Station
Flight Path
Hover Target
Coyle Field, NJ

Overview

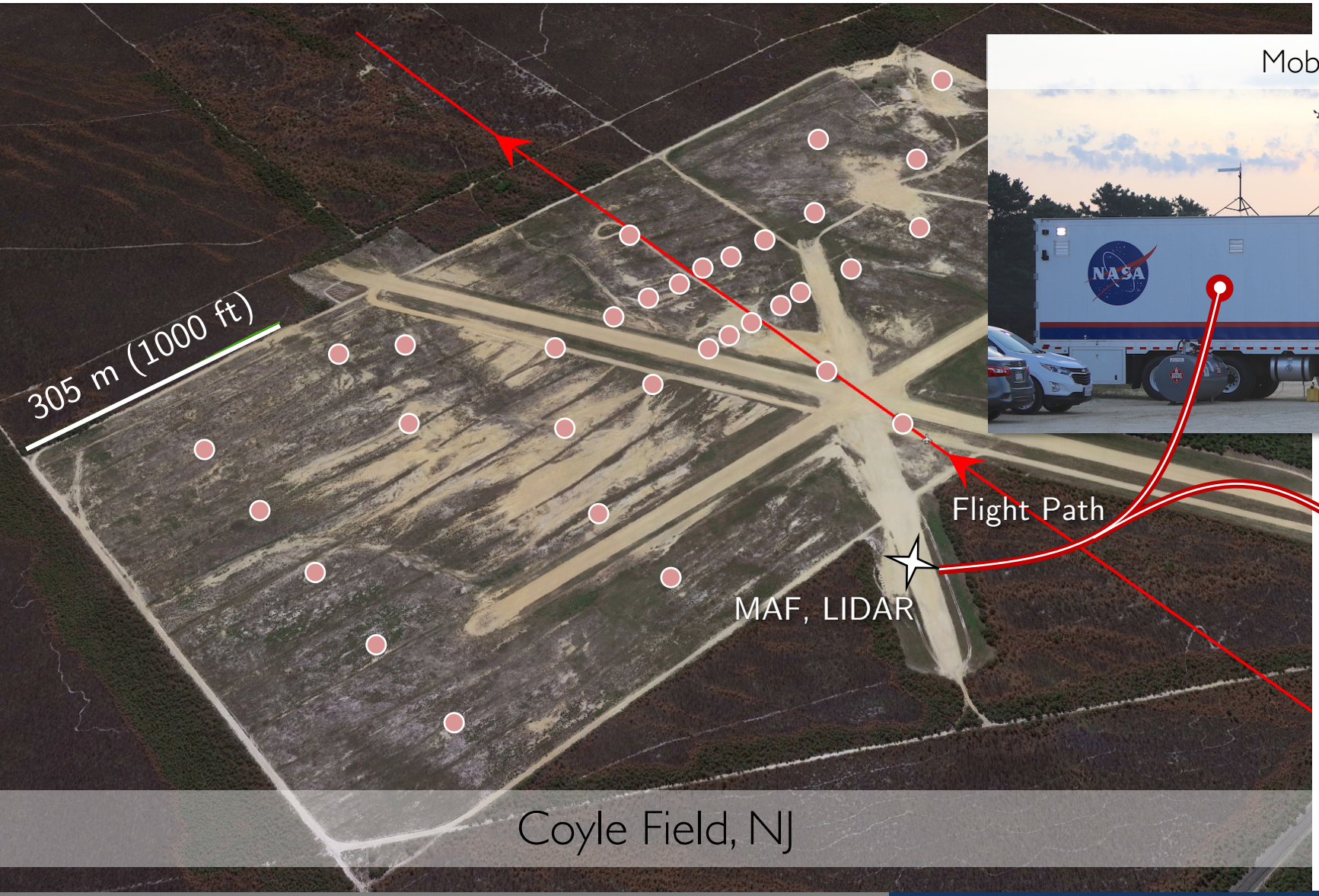
National Aeronautics and Space Administration



1/2" GRAS 67 AX

Overview

National Aeronautics and Space Administration



Mobile Acoustics Facility (MAF)

LIDAR

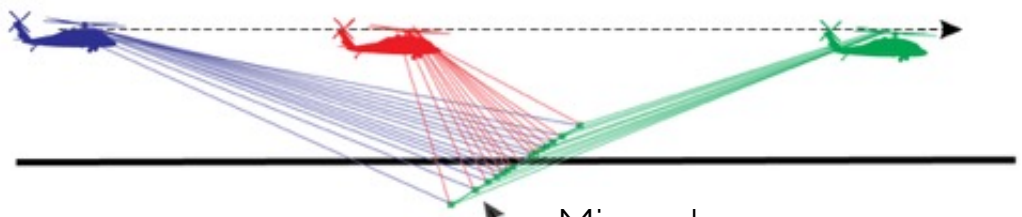
Example of wind profiles here

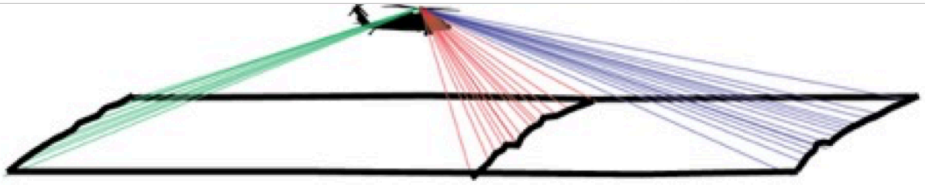
Overview

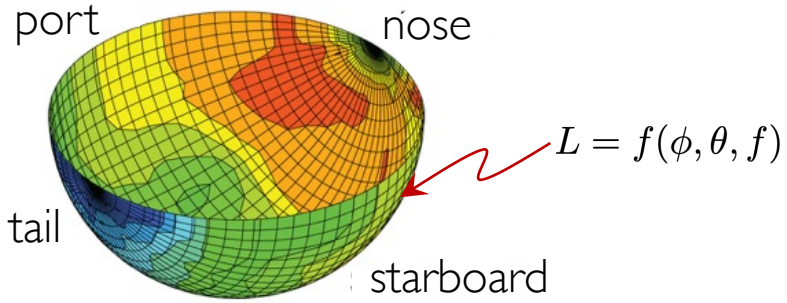
Descent conditions

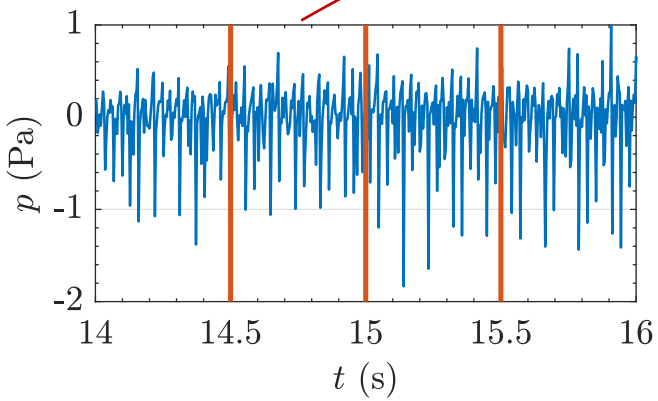
Source hemispheres

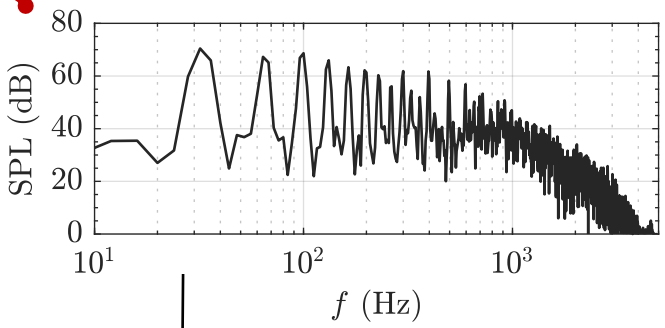
- ART methodology [1]
- Characterize steady flight conditions
- Depropagate signals to hemisphere











Compare to ambient levels
Remove bin if difference < 5dB

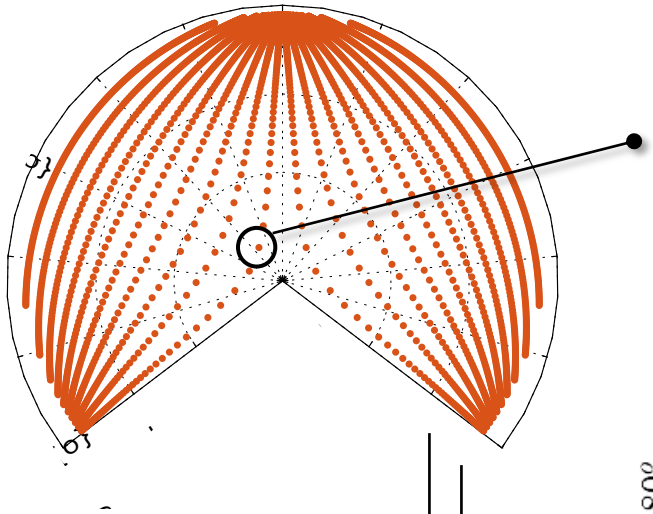
Depropagate

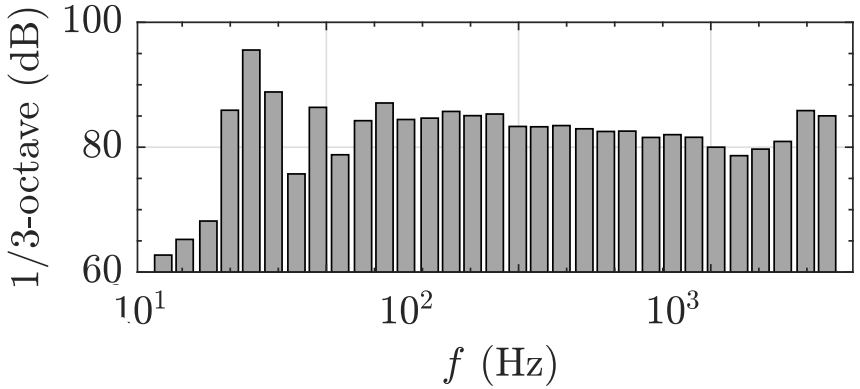
- Atmospheric attenuation[2]
- Ground losses[3,4]
- Spherical spreading

1/3-octave spectra on hemisphere

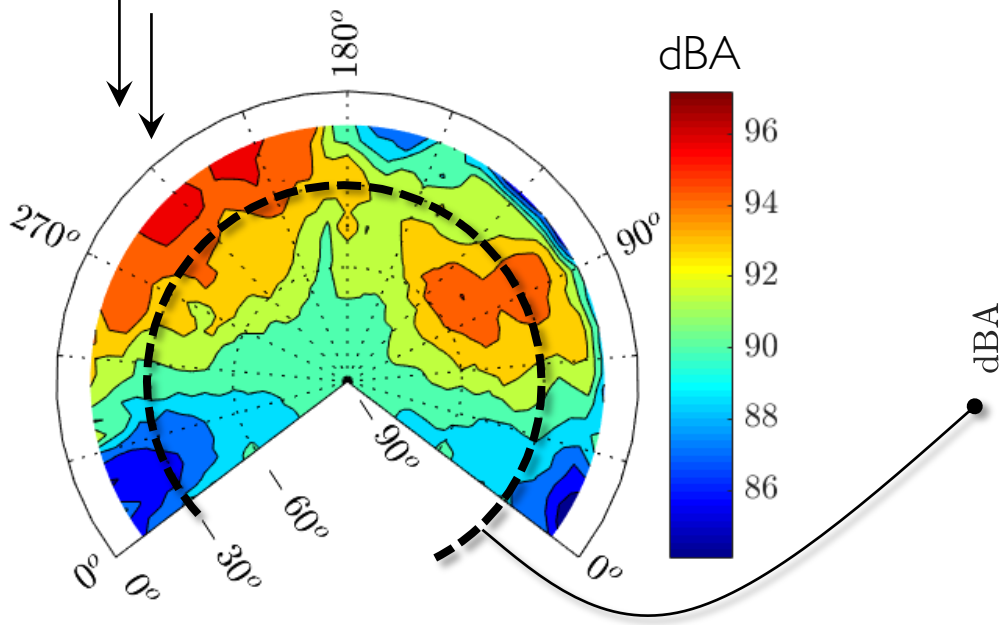
[1] Page et al., "Advanced Acoustic Model Technical Reference and User Manual," WP-1304, 2009.
[2] "Method for the Calculation of the Absorption of Sound by the Atmosphere," Standard ANSI S1.26-1995, 2004.
[3] Delany, M., and Bazley, E., Applied Acoustics, Vol. 3, (2), 1970.
[4] Chien, C., and Soroka, W., Journal of Sound and Vibration, Vol. 43, (1), 1975.

Source hemispheres



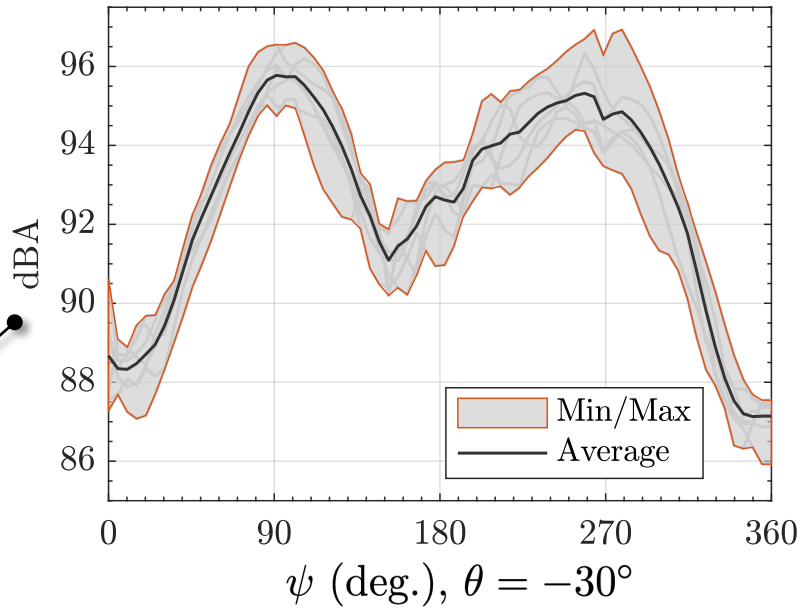


Final sphere interpolated, per frequency band, to uniform grid



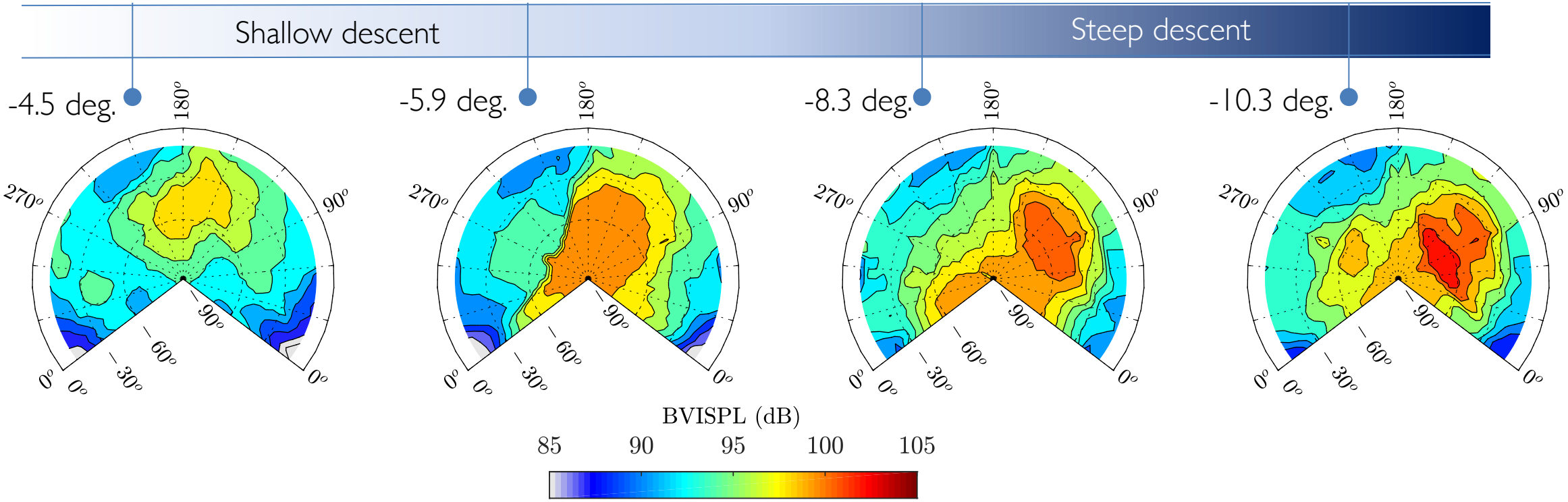
Integrated metrics (e.g., dBA, BVISPL)

Data spread, 7 passes, 4 days



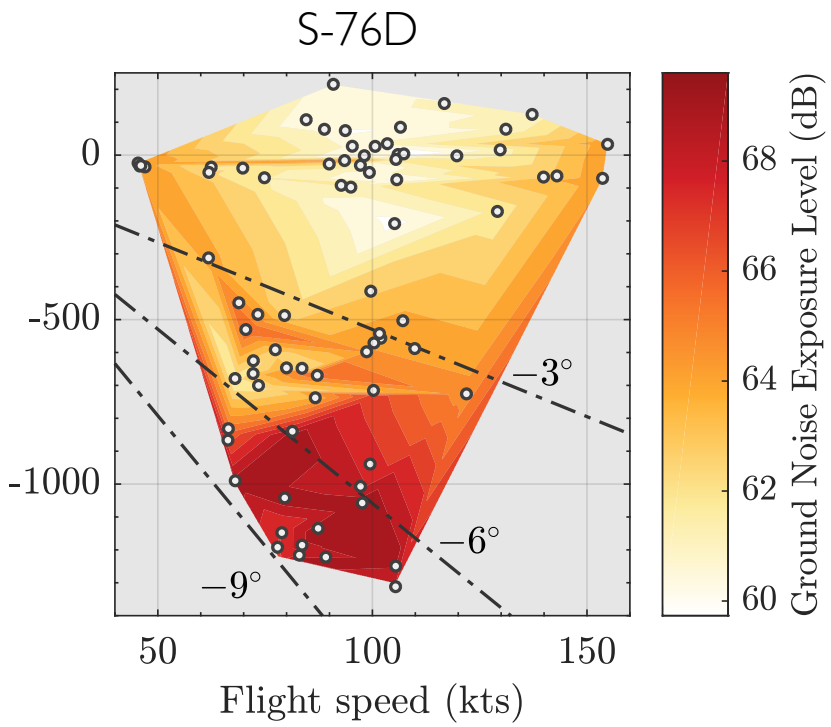
Source hemisphere example

- BVISPL increasing with flight path angle for AW139, 80 kts descents



Operational noise

- Ground noise exposure level to describe vehicle noise during approach
  - Duration weighted
  - Out-of-plane noise ground projected
  - BVISPL frequency range
  - Medium-sized vehicles show BVI dominant at larger descent rates



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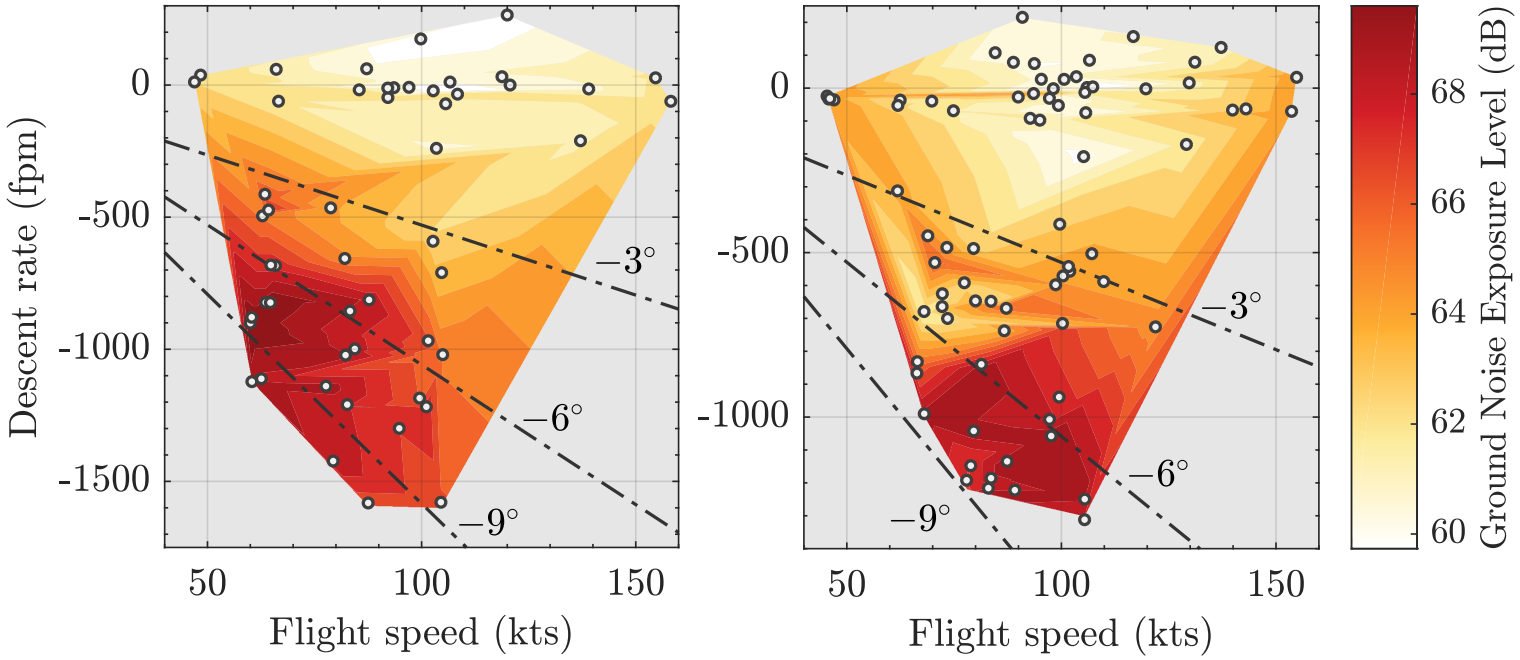
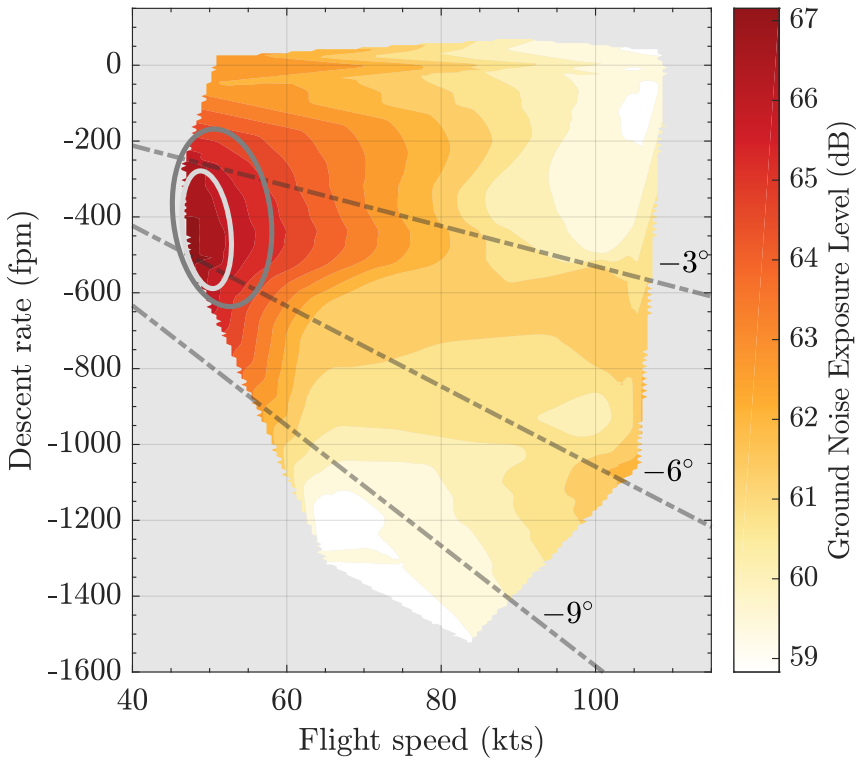
AW139



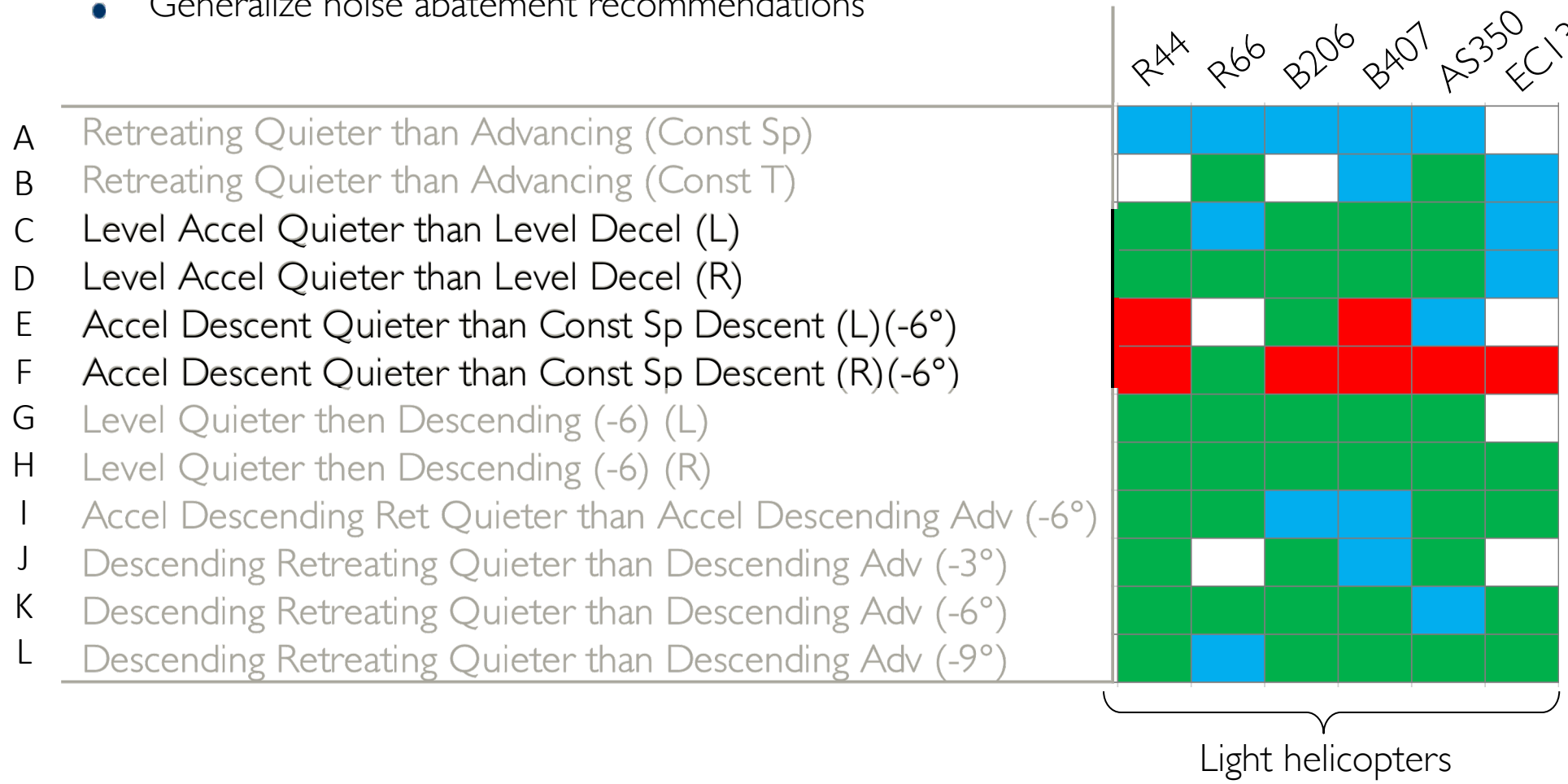
S-76D

R44



Maneuver comparison

- Comparing $L_{A,\max}$, 80 kts
- Generalize noise abatement recommendations



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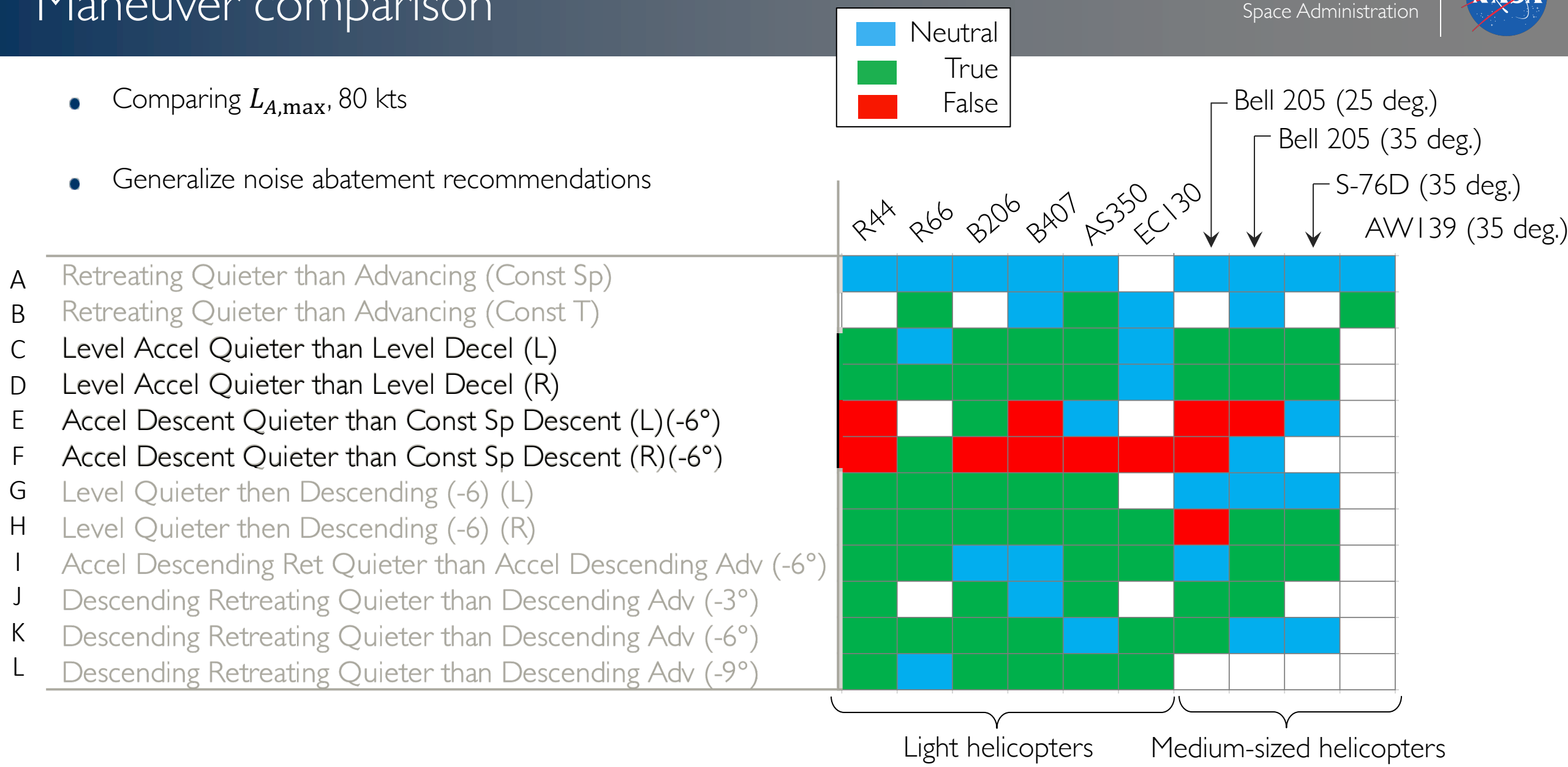


Fly Neighborly

Helicopter Noise Abatement Recommendations

Level Flight:

- Accelerations are quieter than decelerations
- Straight flight is quieter than turning flight

Turning Flight:

- Turning away from the advancing blade (especially when decelerating) is quieter than turning into the advancing blade
- Level turns are quieter than descending turns

Descending Flight:

- Straight-in flight is quieter than turning flight

Decelerations:

- Level flight decelerations are quieter than descending or turning flight decelerations

Maneuvering:

- Smooth and gentle control inputs are quieter than rapid control inputs

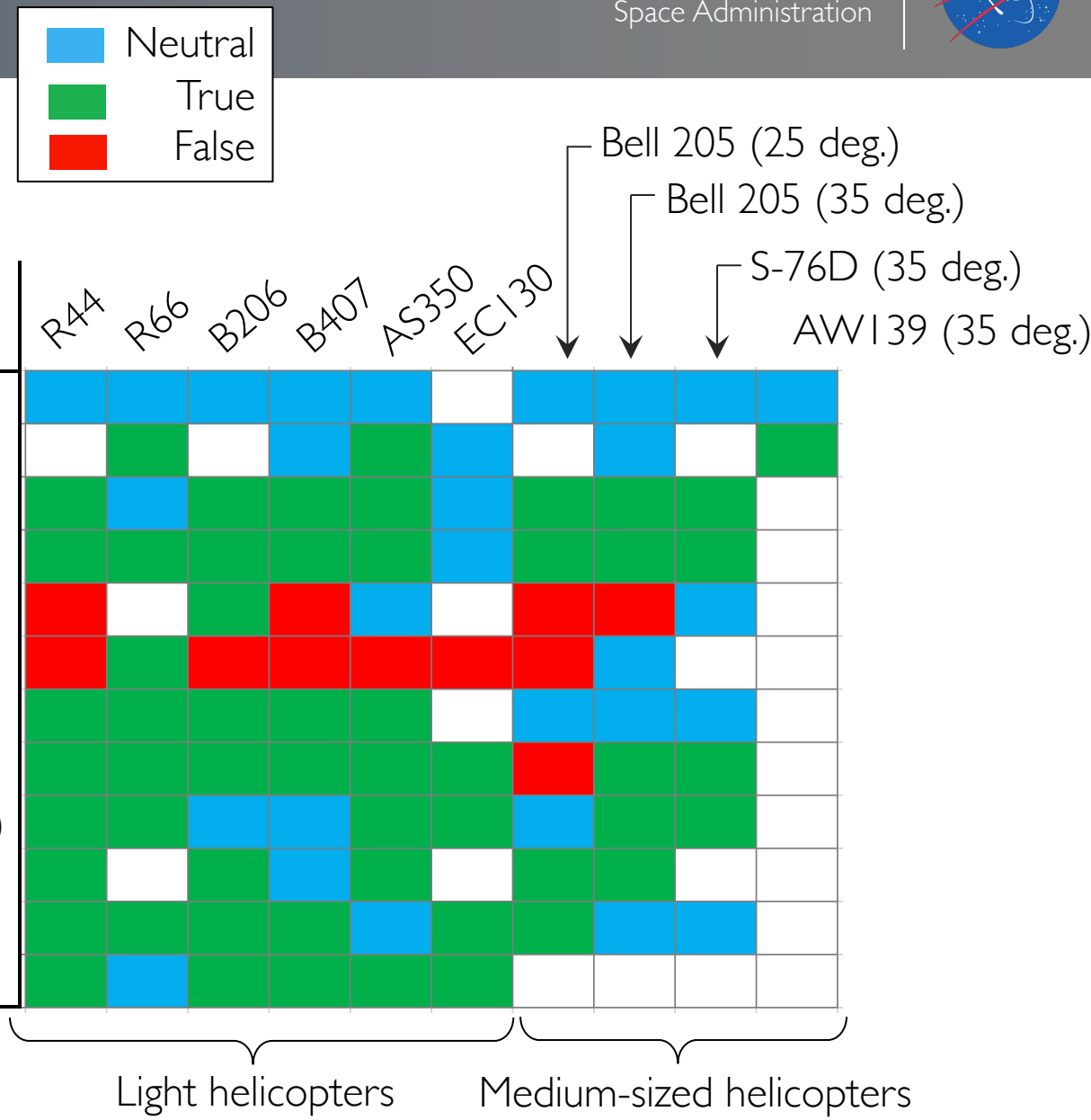
These recommendations are flight tested and scientifically vetted by the U.S. Department of Transportation and NASA to support Fly Neighborly Goals.

Take the Fly Neighborly training at: https://go.usa.gov/xQPCW

Fly Neighborly procedures/recommendations should be executed in the safest manner possible and followed only to the extent that safety is not compromised.

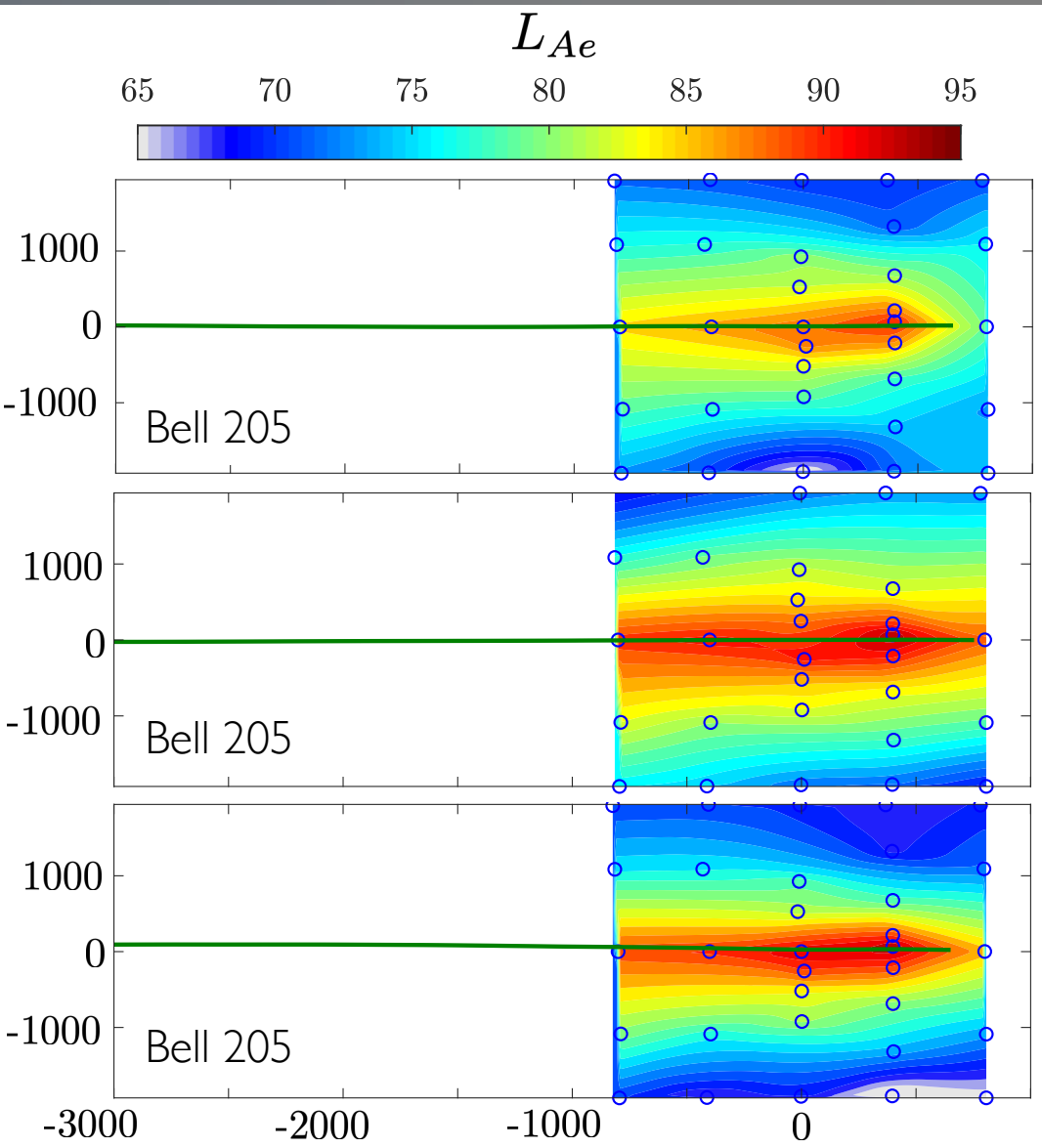
Helicopter Association International

[HAI Fly Neighborly Noise Abatement Recommendations]



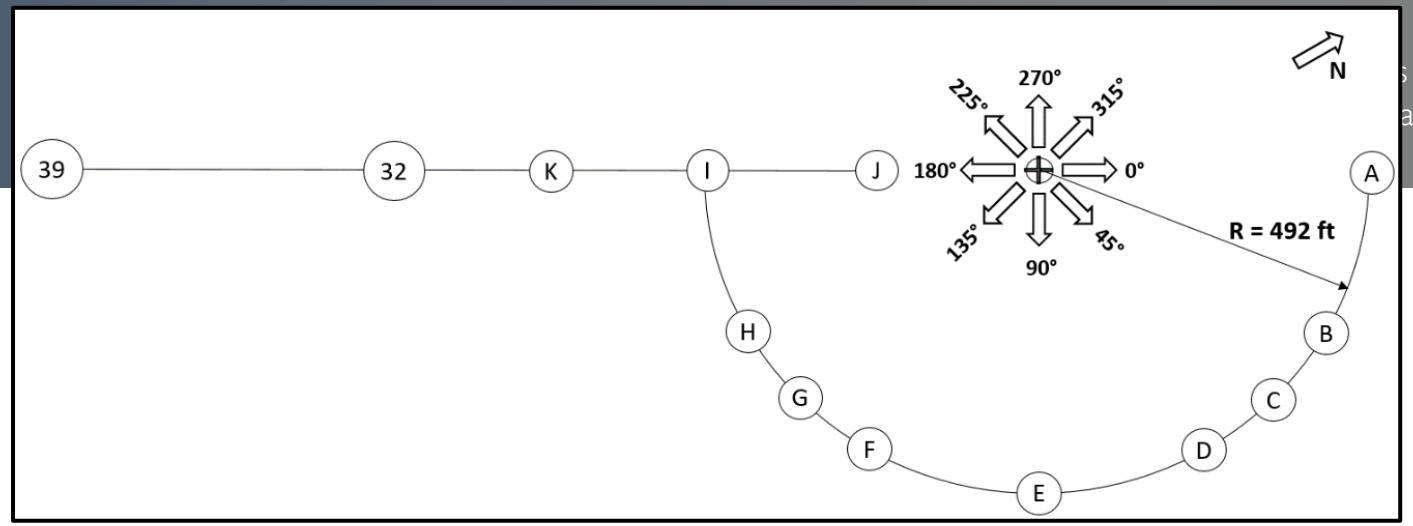
Noise abatement procedures

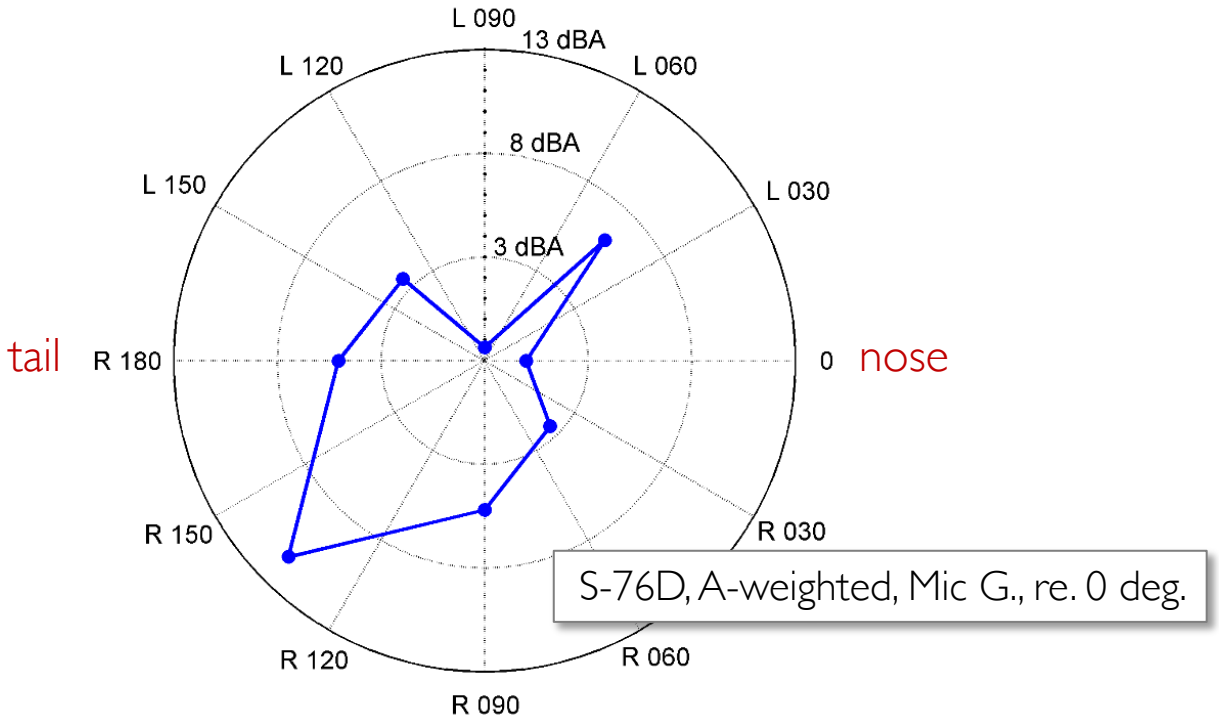
- Descents tested
  - Various deceleration rate
  - Constant flight path angle
- Sound exposure level contours
  - A. Christian - Psychoacoustic analysis
- In general,
  - Moderate speeds better than slow
  - Steep angles better than shallow
- Caveats based on source noise changes with flight conditions



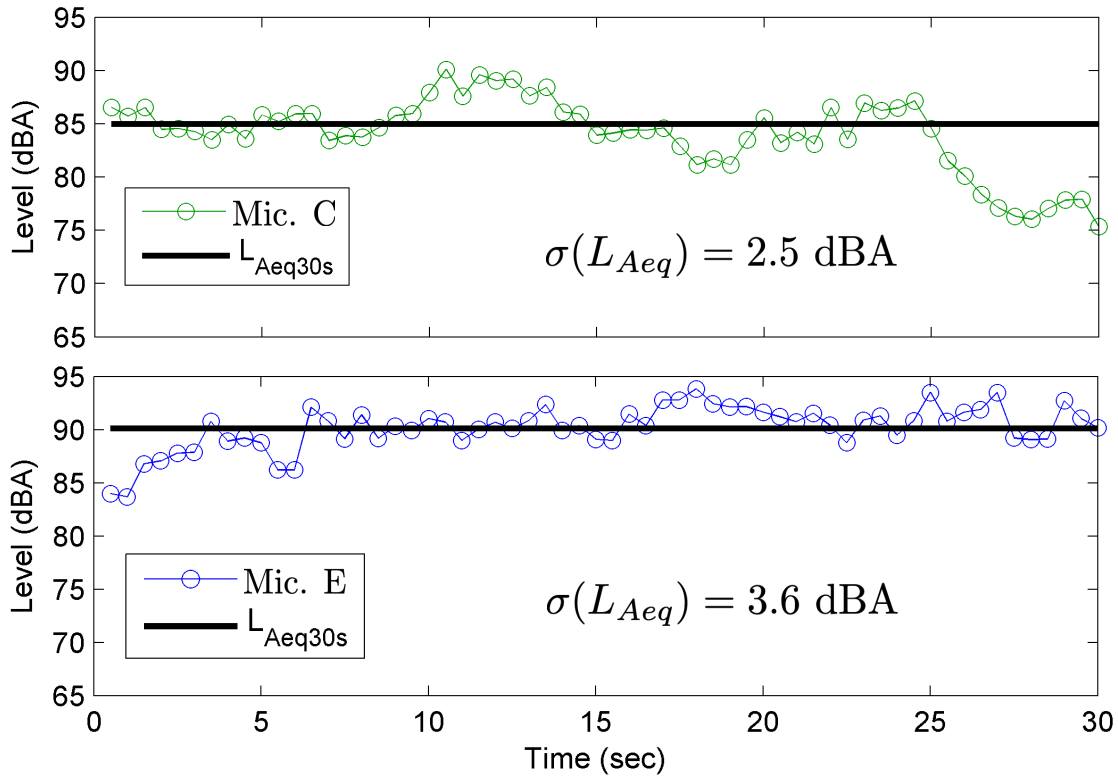
Static measurements

- Input for AEDT
- Conditions tested
  - GIDLE, FIDLE, HIGE, HOGE
  - 108 total events
  - Avg. wind speed 3-7 kts



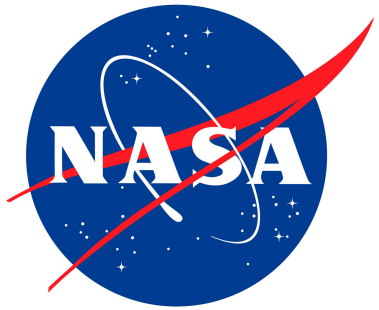


S-76D, A-weighted, Mic G., re. 0 deg.



Thank you.

kyle.a.pascioni@nasa.gov



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