# Overview of a Comprehensive MD530F Acoustic Flight Test

James Stephenson[†] Kyle Pascioni[*] Mary Houston[*]
Colin Stutz[*] Preston Martin[†]

[†] U.S. Army Combat Capabilities Development Command
Aviation & Missile Center

*NASA Langley Research Center

Vertical Flight Society's 81st Annual Forum & Technology Display
Virginia Beach, VA
21 May 2025

# Motivation and objectives

## Motivation

There is a need to develop measurement techniques and data processing methods to characterize AAM/UAM and FVL aircraft

## Objectives

- Explore snapshot array designs
- Increasing flight test efficiency using DoE methods
- Acquiring phased array data for rotating source separation and localization
- Determine appropriate methods to investigate unsteady flight

# The team

## NASA
Kyle Pascioni
Mary Houston
Colin Stutz
Max Reid

## US Army DEVCOM AvMC
James Stephenson
Preston Martin

## Analytical Mechanics Associates
Jeffrey Davis
David Ridgway

## Helicopter Technology Company
Jay Wigginton - Pilot
Charles Dean – Chief Engineer
Jack Rajcic
Gary Budorf
Brian Cicerone

## Sierra Army Depot
Margarita Gonzalez-Venegas
Michael Foley
Michael Gray

## Additional support
- Oliver Wong
- Shawn Naigle
- Tom Maier
- Jacob Wilson
- Noah Schiller
- Benny Lunsford
- Michael Doty
- Stan Mason
- Nikolas Zawodny
- Tony Humphreys

# Test aircraft

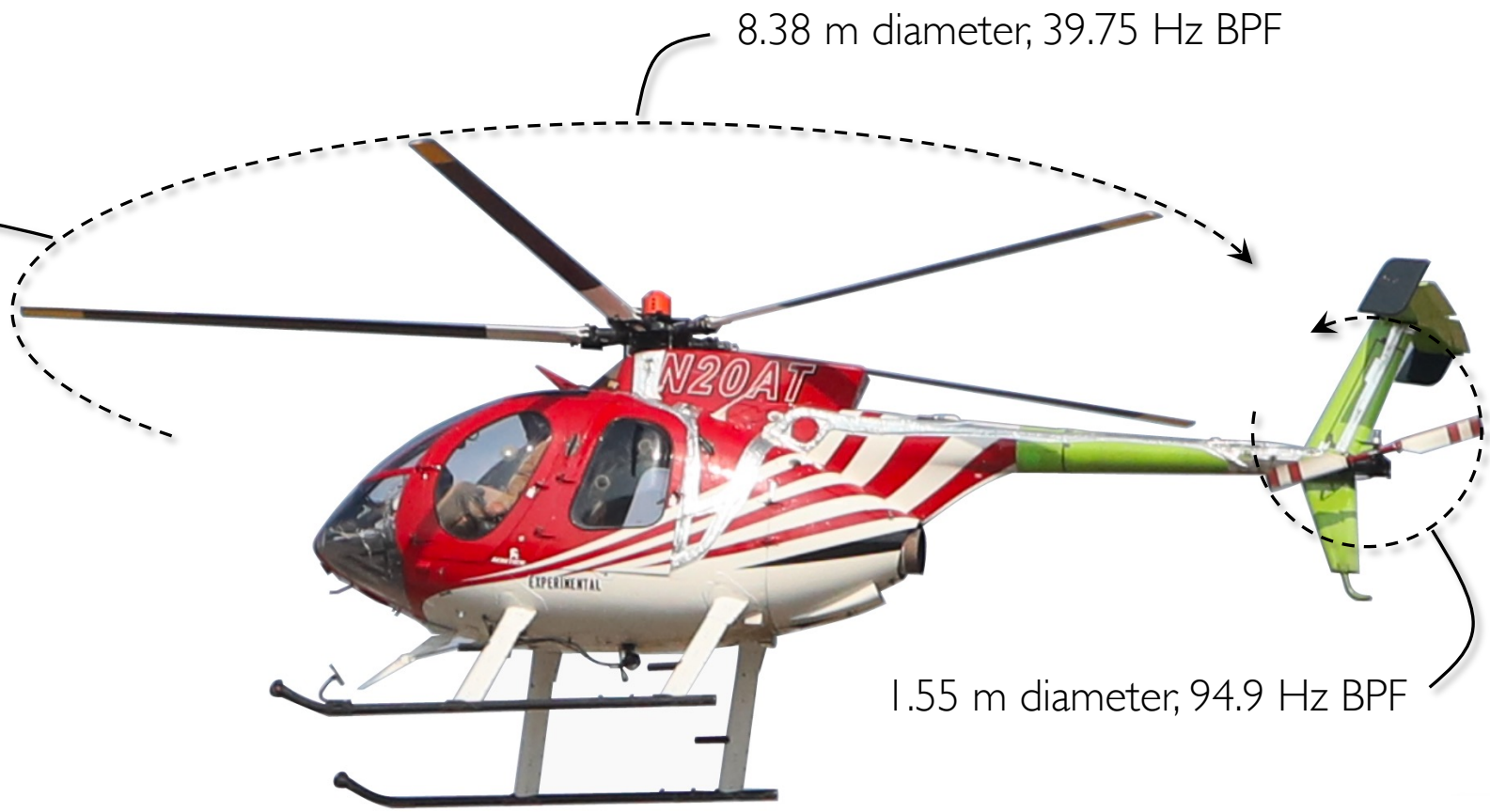
## MD530F Helicopter

3,550 lb (1,520 kg) take-off weight

1,720 lb (780 kg) empty weight

# Test aircraft

## MD530F Helicopter




Test at a glance:

- Amedee Airfield, Sierra Army Depot
- July 7-July 29, 2024
- 6 days of testing
- 11 sorties
- 21 flight hours
- 476 test points
- Level speed sweep, ascents, descents, maneuvers

# Test aircraft state data

| Description | Variable Name | Units |
|---|---|---|
| Main rotor speed | ROTOR_RPM | RPM |
| Longitudinal mast bending at waterline station 68.25 | MASTLONUPR_68_25 | in-lbf |
| Lateral mast bending at waterline station 68.25 | MASTLATUPR_68_25 | in-lbf |
| Engine torque | ENGINE_TORQUE | ft-lbf |
| Throttle control position | THROTPOS | % |
| Longitudinal link axial load | LOADLINK | lbf |
| Collective control rod axial load | COLLROD | lbf |
| Longitudinal mast bending at waterline station 73.0 | MASTLONUPR_73 | in-lbf |
| Lateral mast bending at waterline station 73.0 | MASTLATUPR_73 | in-lbf |
| Longitudinal cyclic stick control position | LONCONPOS | % |
| Lateral cyclic stick control position | LATCONPOS | % |
| Pedal position (directional control) | DIRCONPOS | % |
| Collective control position | COLLCONPOS | % |
| Pitch change link axial load | PCLINK | lbf |
| Damper rod axial load | DAMPER | lbf |
| Drive shaft torsion | SHAFTTOR1 | in-lbf |
| Tail boom torsion at waterline station 258 | TBTOR258 | in-lbf |
| Tail boom torsion at waterline station 211 | TBTOR211 | in-lbf |
| Vertical stabilizer middle | VERTMID | in-lbf |
| Vertical stabilizer upper | VERTUP | in-lbf |
| Horizontal stabilizer bending fwd & right | HZFWDRH | in-lbf |
| Horizontal stabilizer bending aft & right | HZAFTRH | in-lbf |
| Horizontal stabilizer bending fwd & left | HZFWDLH | in-lbf |
| Horizontal stabilizer bending aft & left | HZAFTLH | in-lbf |
| Tail boom vertical bending at waterline station 211 | TBVERT211 | in-lbf |
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| Tail boom lateral bending at waterline station 211 | TBLAT211 | in-lbf |
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| Rotor azimuth channel 1 | ROTOR_AZ1 | volts |
| Rotor azimuth channel 2 | ROTOR_AZ2 | volts |

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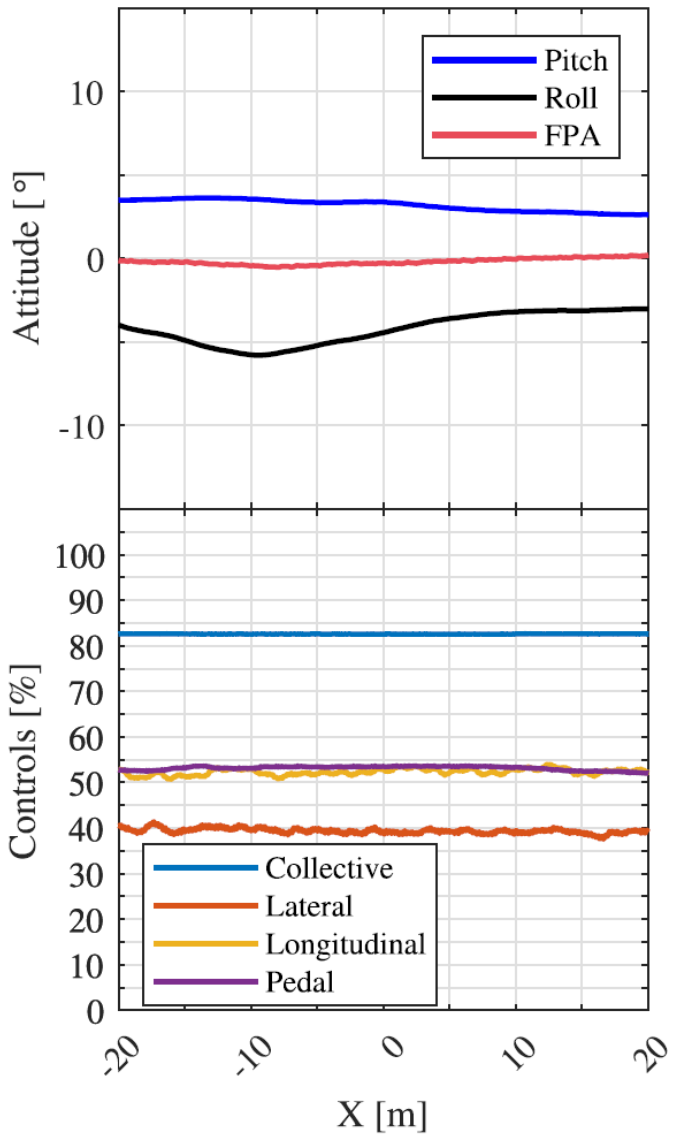


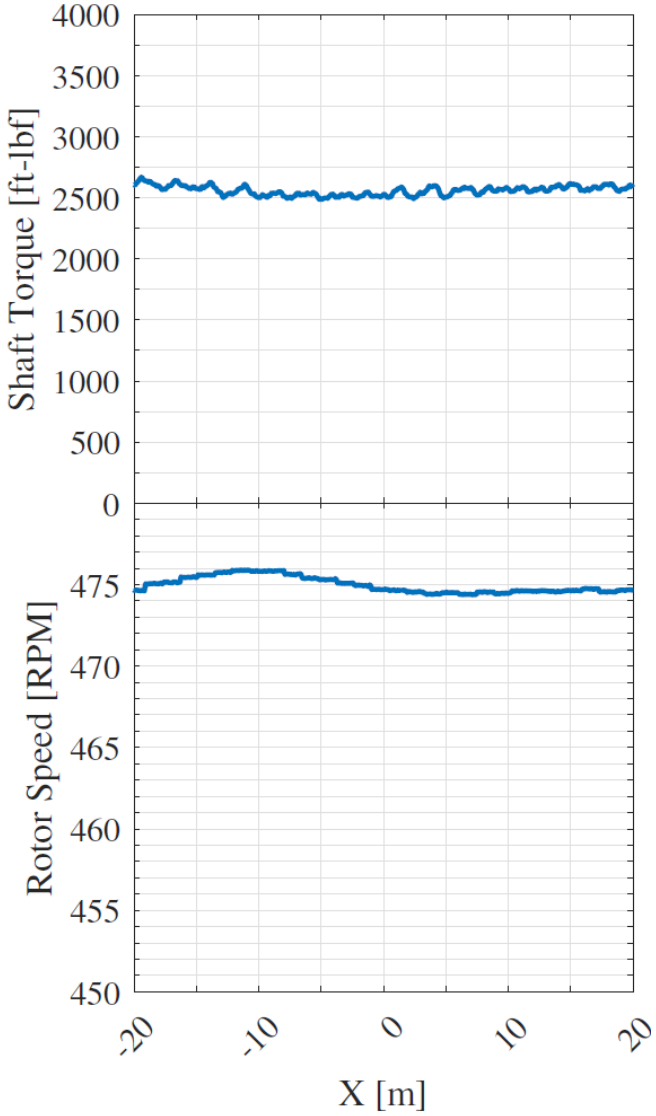

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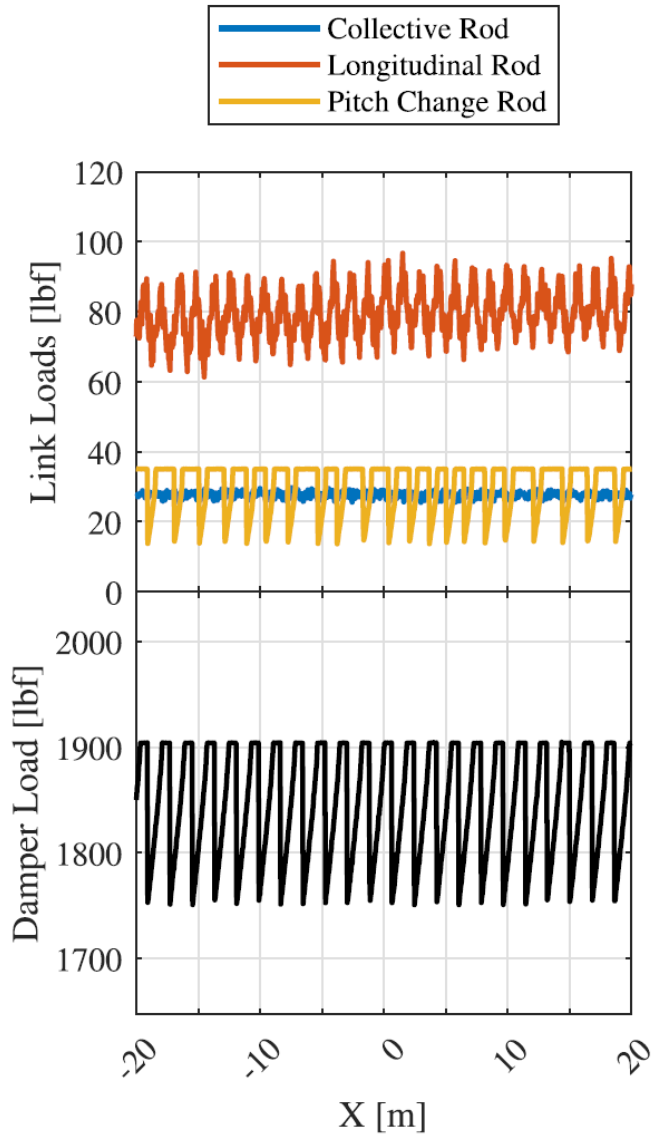
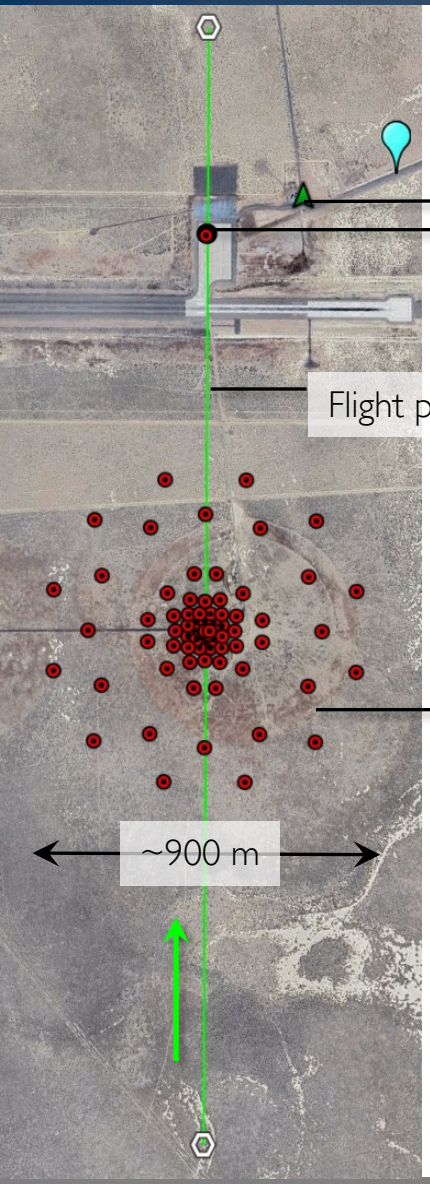
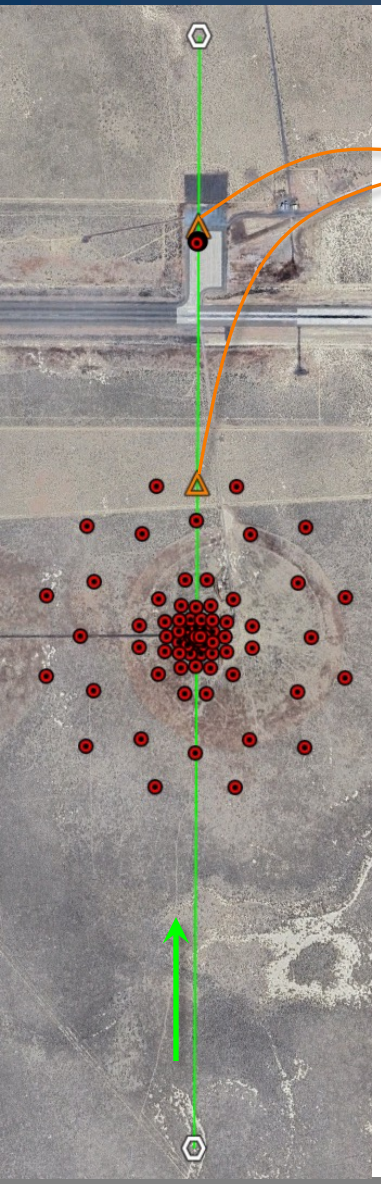


# Instrumentation layout



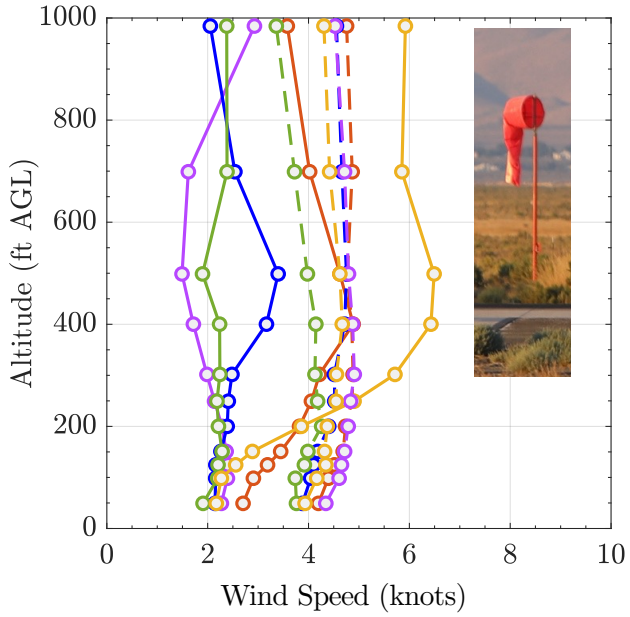

Mobile Acoustics Facility (MAF)

# Weather instrumentation

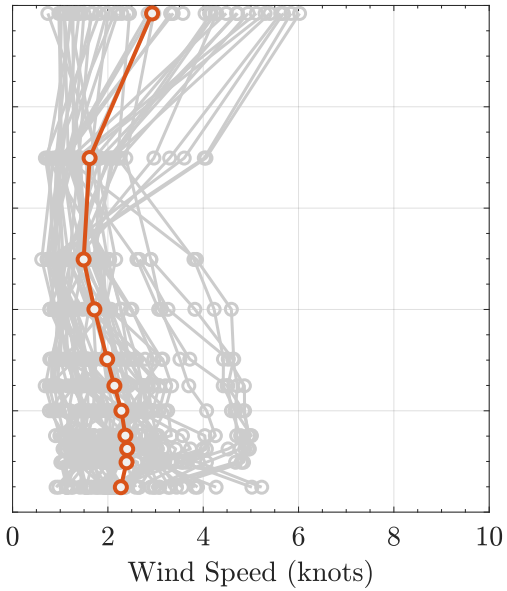


LiDAR vertical wind profilers

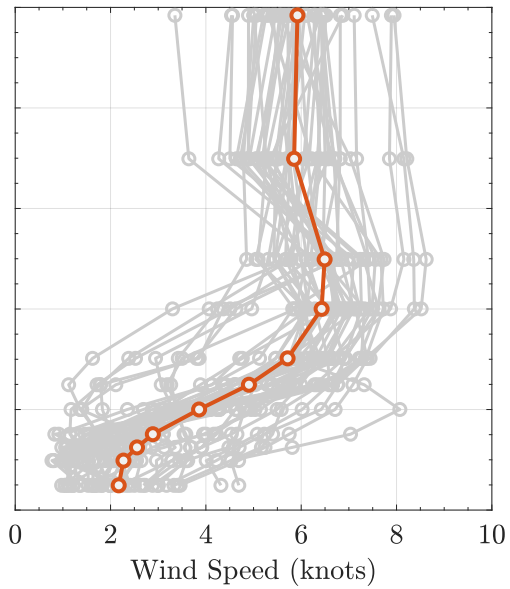
Mean wind profile per sortie




Calmest sortie




Windiest sortie



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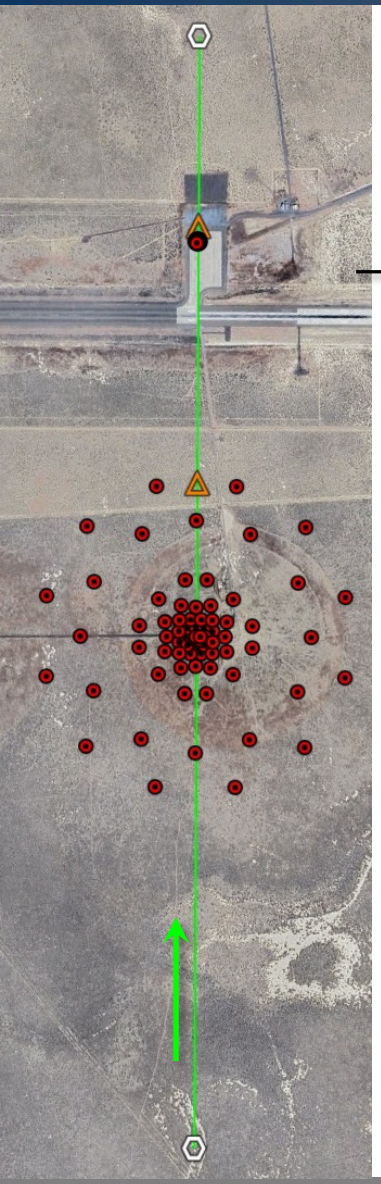
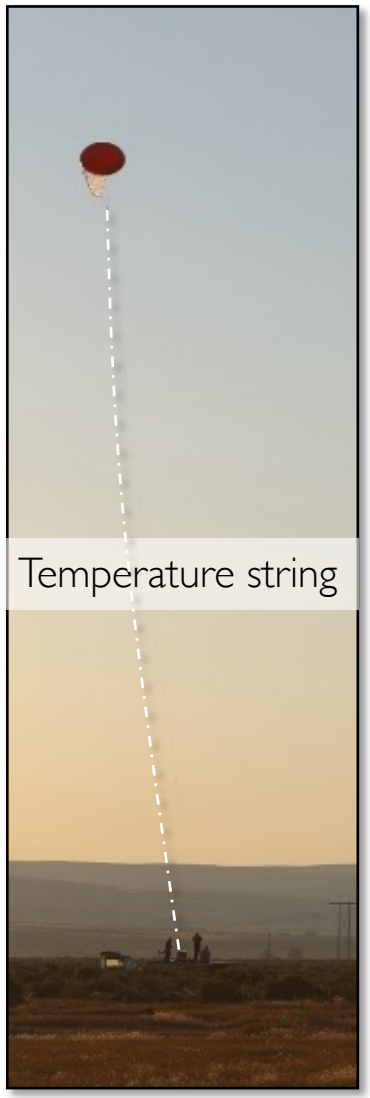
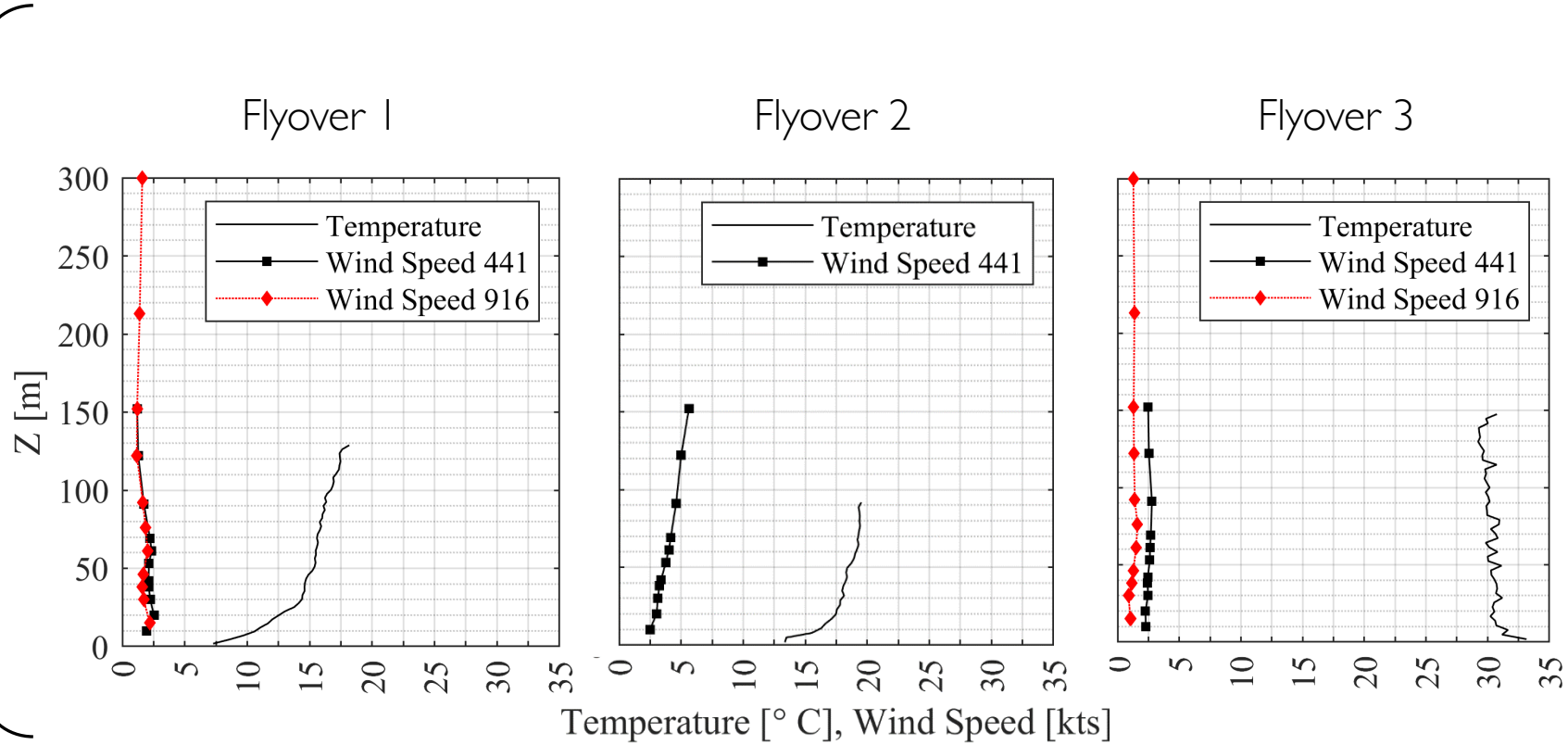
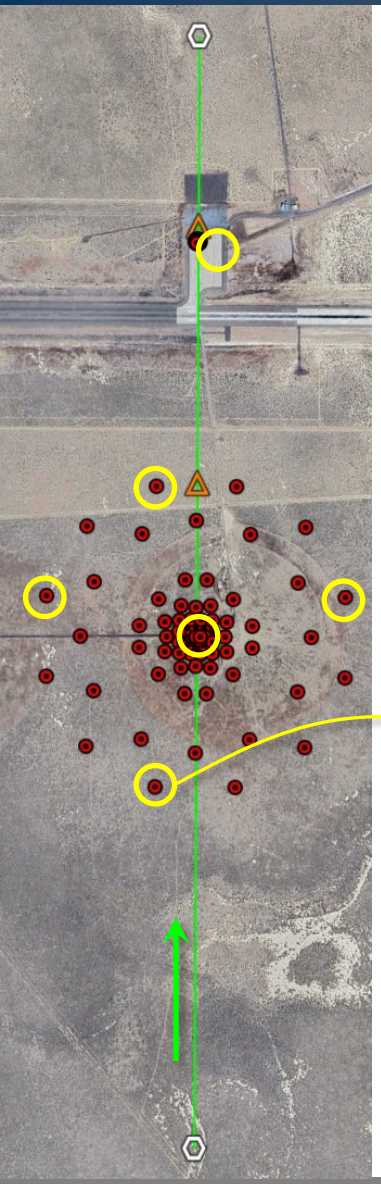




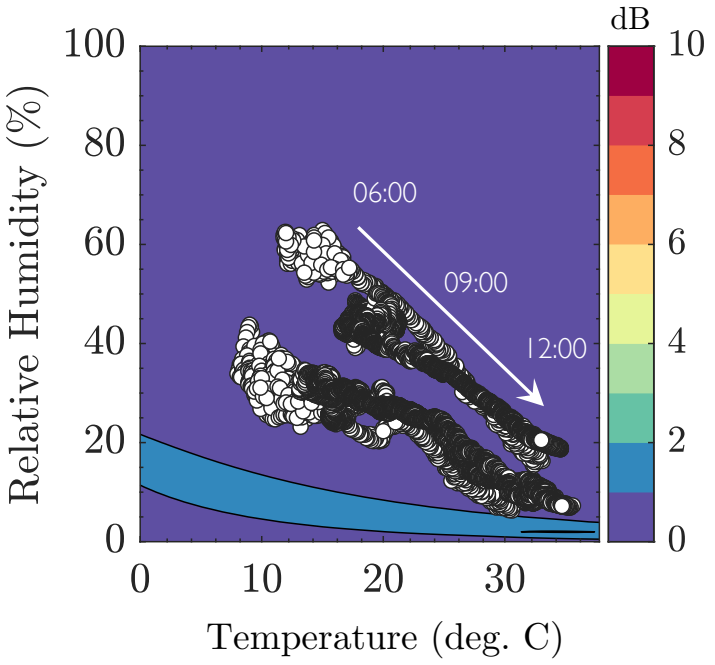
# Ground weather instrumentation



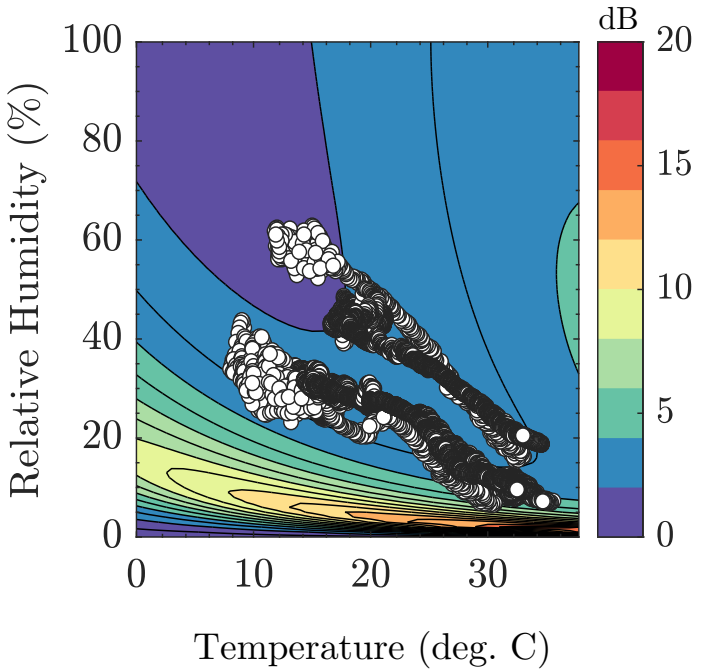
Ground weather stations

Contours: atmospheric attenuation at 1 kHz

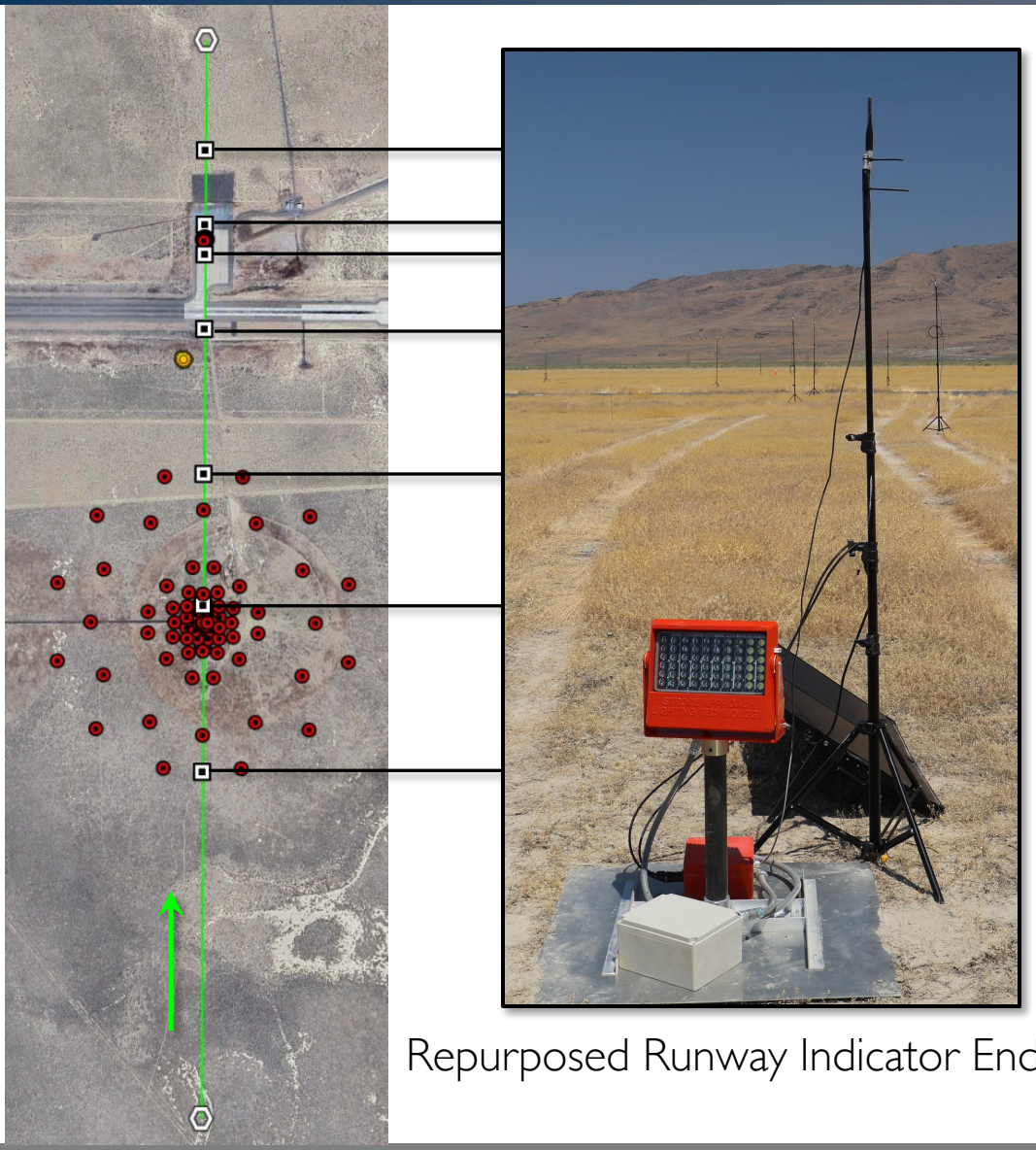
60 m propagation




450 m propagation



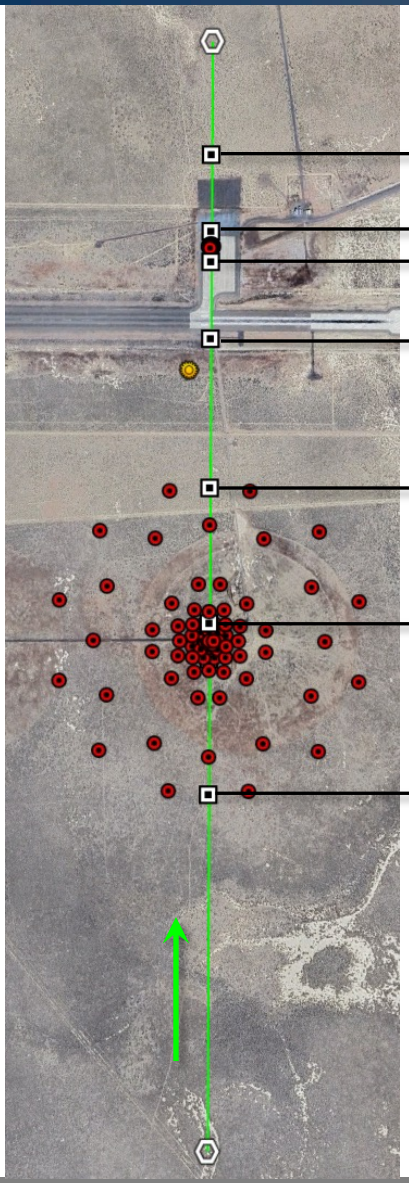
# Pilot ground guidance systems





Repurposed Runway Indicator End Lights

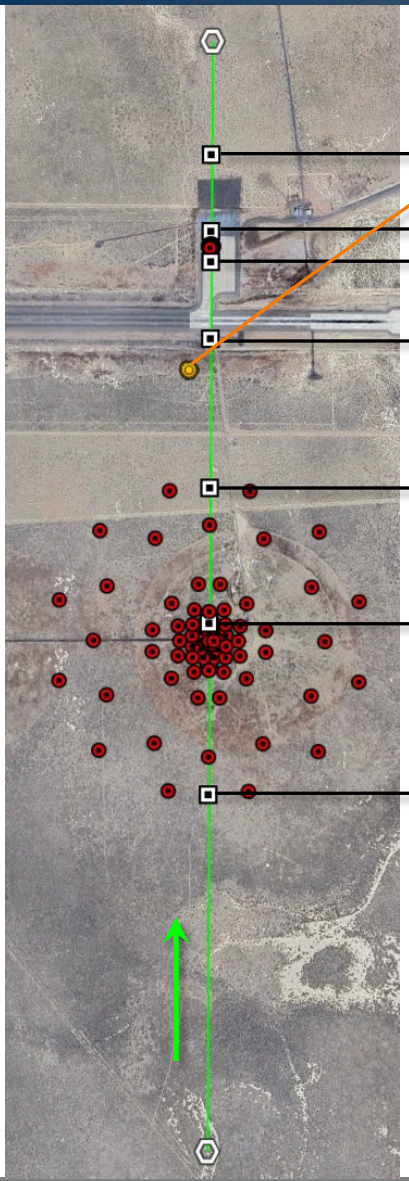
# Pilot ground guidance systems



Repurposed Runway Indicator End Lights

High-visibility banners

# Pilot ground guidance systems

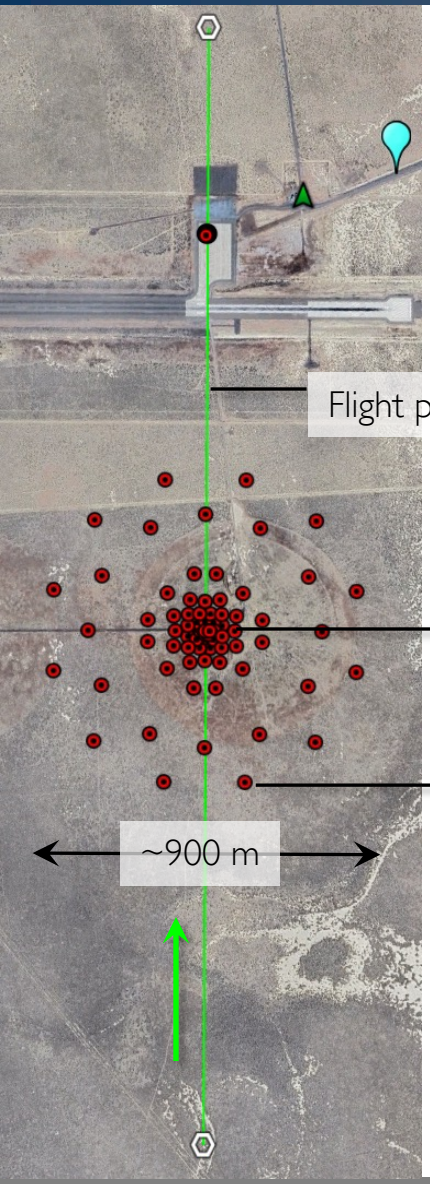


Repurposed Runway Indicator End Lights

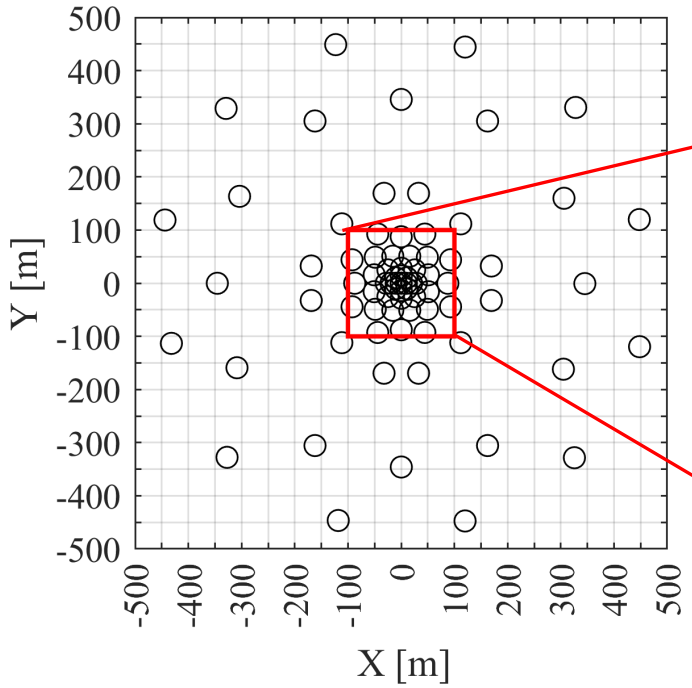
High-visibility banners

Precision Approach Path Indicators (PAPI)

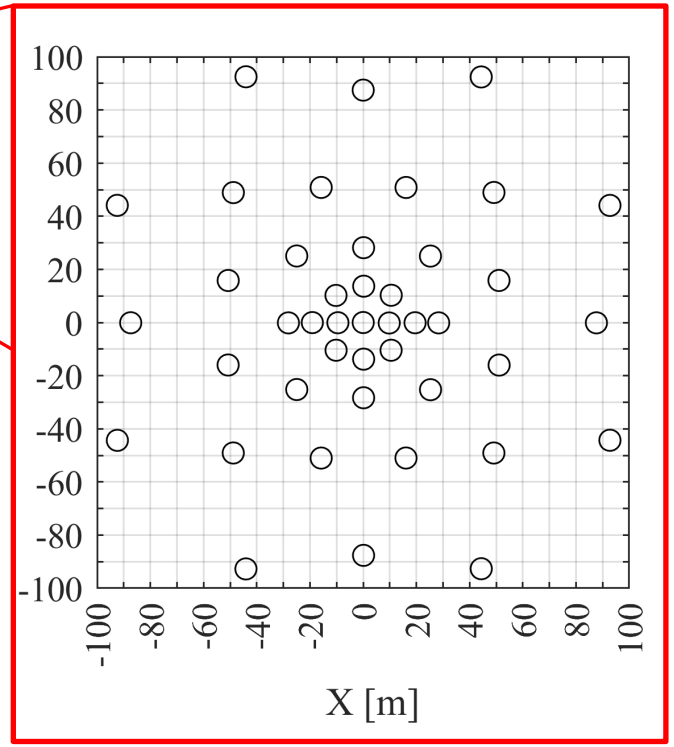
# Instrumentation layout - snapshot array




Snapshot array center




Snapshot array outskirts



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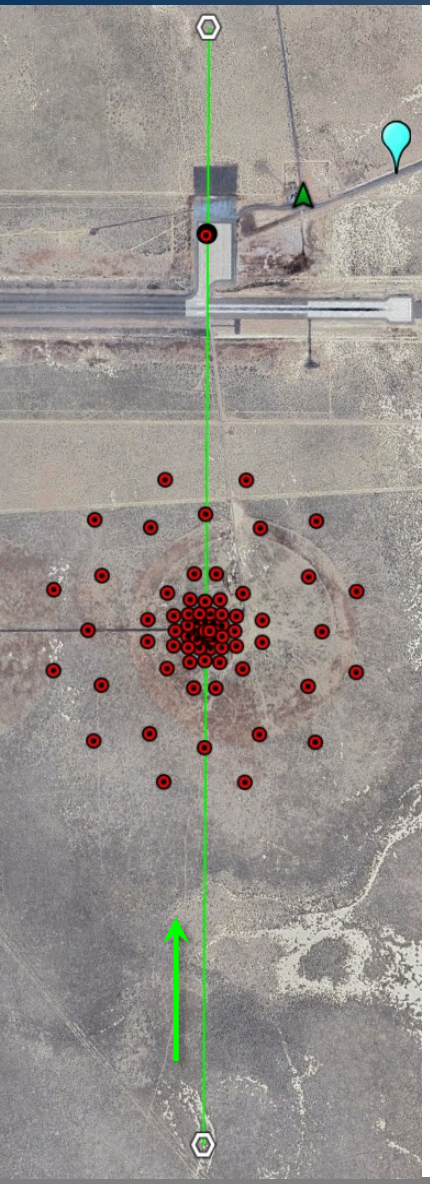
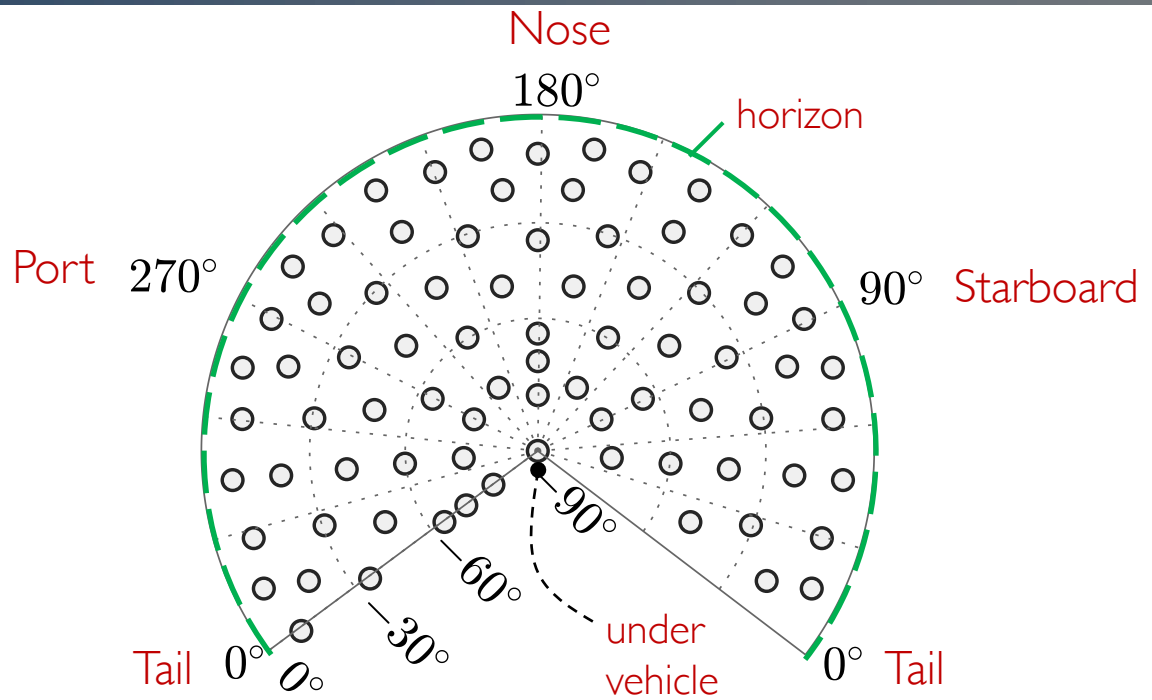
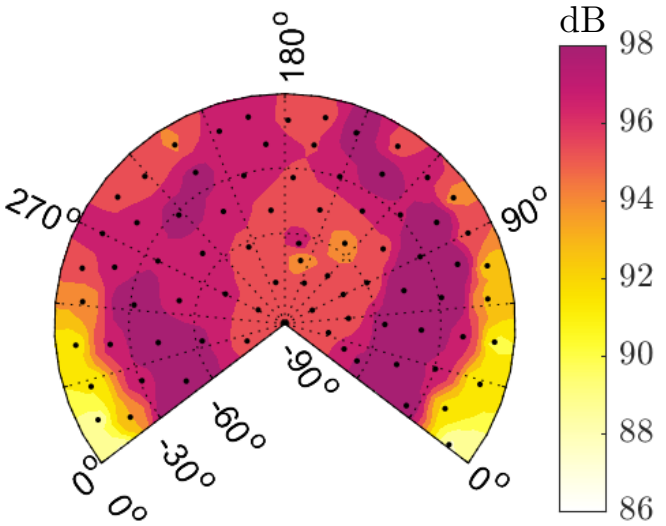
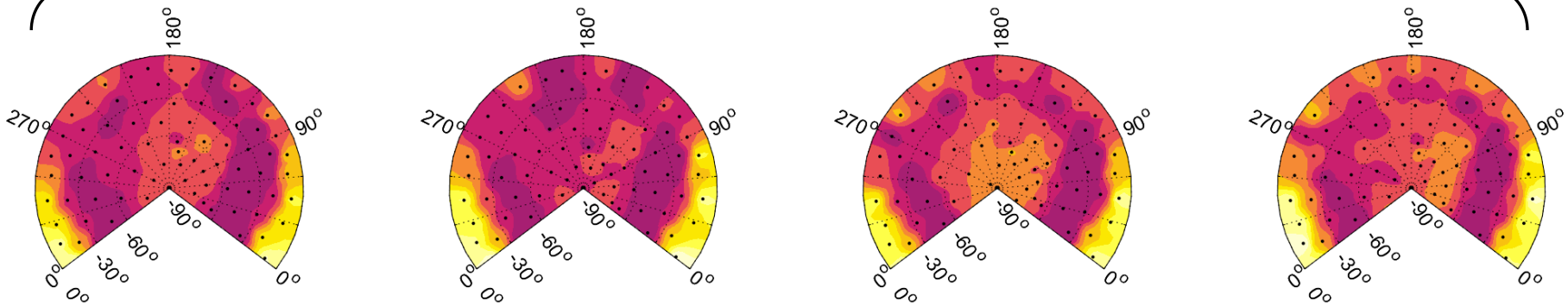





90 kt, 60 m altitude level flyover
4 runs



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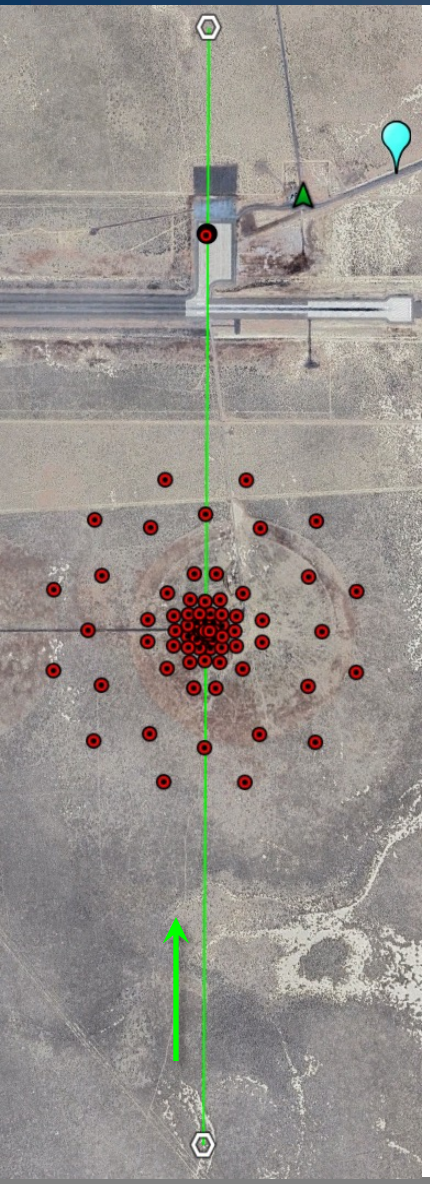
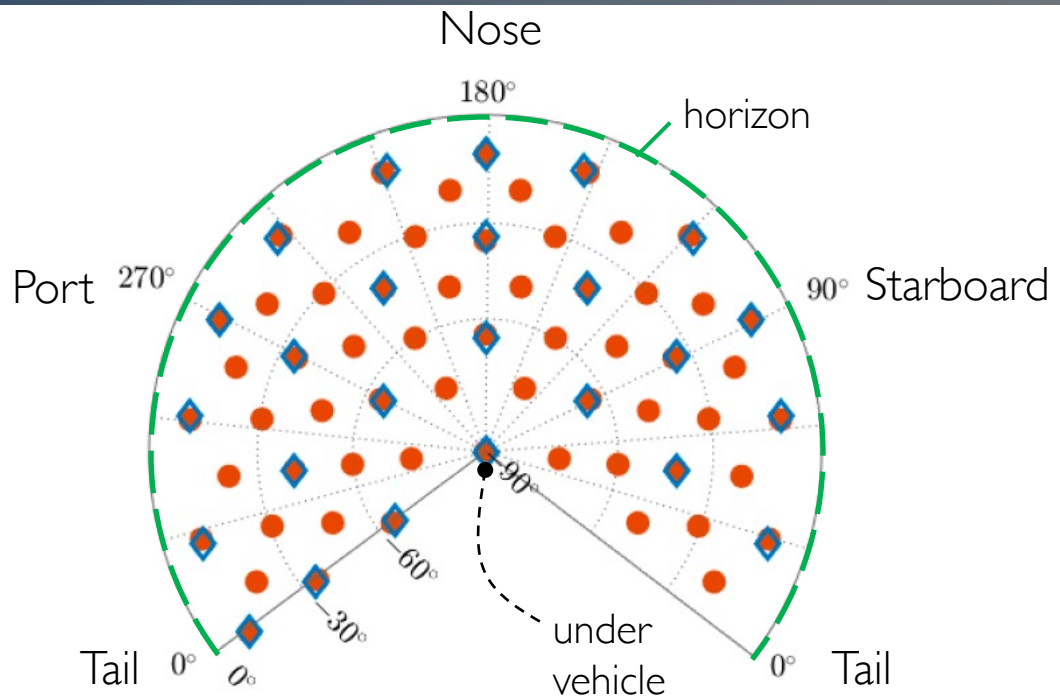
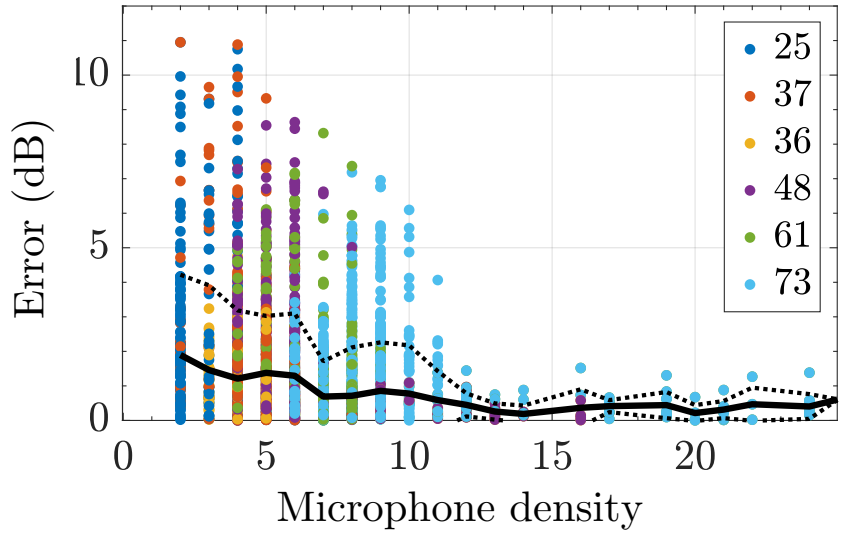





Snapshot array design details in:

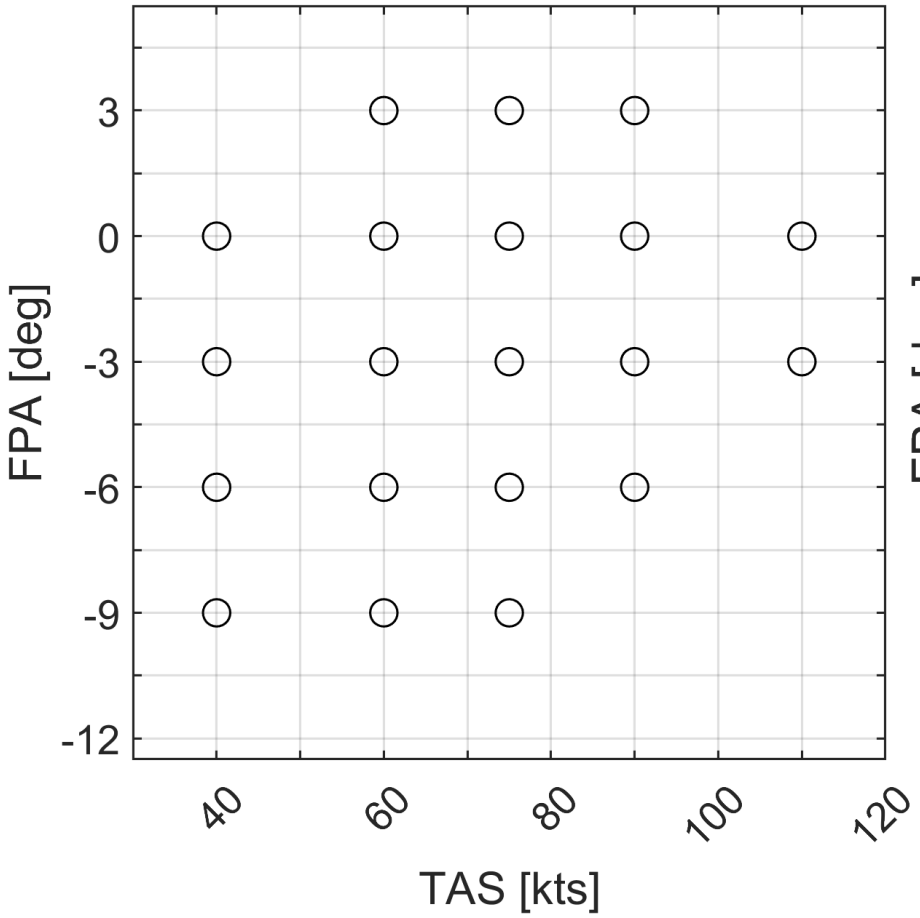
Houston et al., "**Snapshot Array Design Considerations for Rotorcraft Noise Characterization**," VFS 81, 2025.

**Objective**

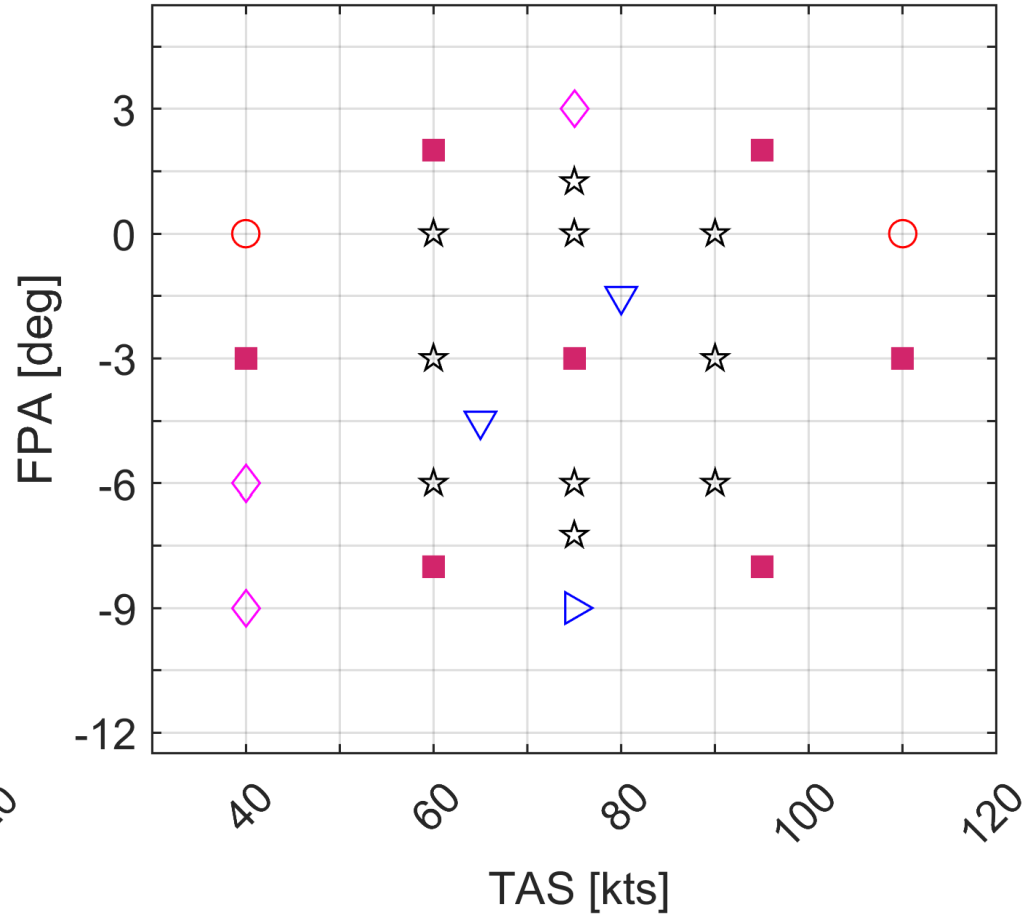
Understand array design considerations, i.e., the effect of channel count

# Design of experiments approach

Standard approach




Combined design




| | | |
|---|---|---|
| ☆ | DOE F/CCD | [10] |
| ■ | DOE Hexagonal | [7] |
| ○ | Standard Priority 1 | [2] |
| ◇ | Standard Priority 2 | [3] |
| ▷ | Standard Priority 3 | [1] |
| ▽ | Interpolation | [2] |

DoE analysis in:

Stephenson, J., Pascioni, K., "Design of Experiments Development for Rotorcraft Acoustic Flight Testing," VFS 81, 2025

**Objective**

To mature flight test planning tools and increase flight test efficiency

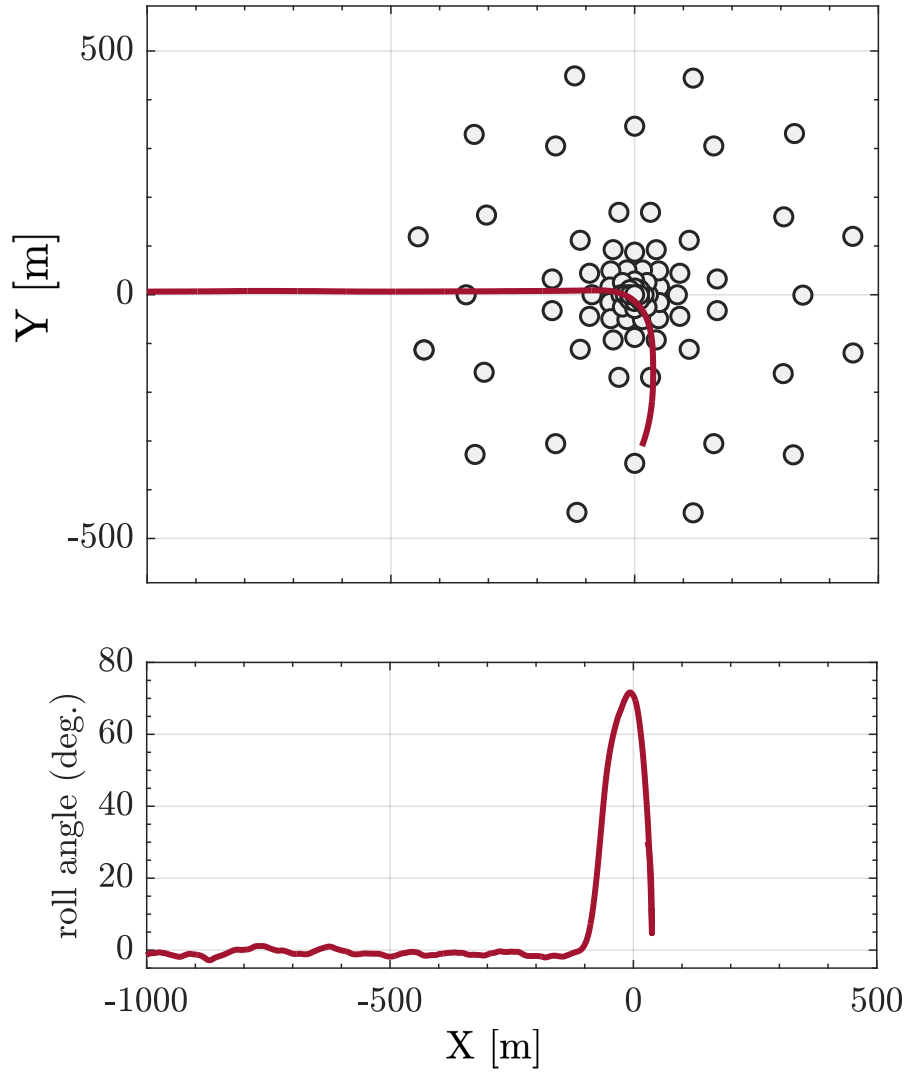
# Maneuvers

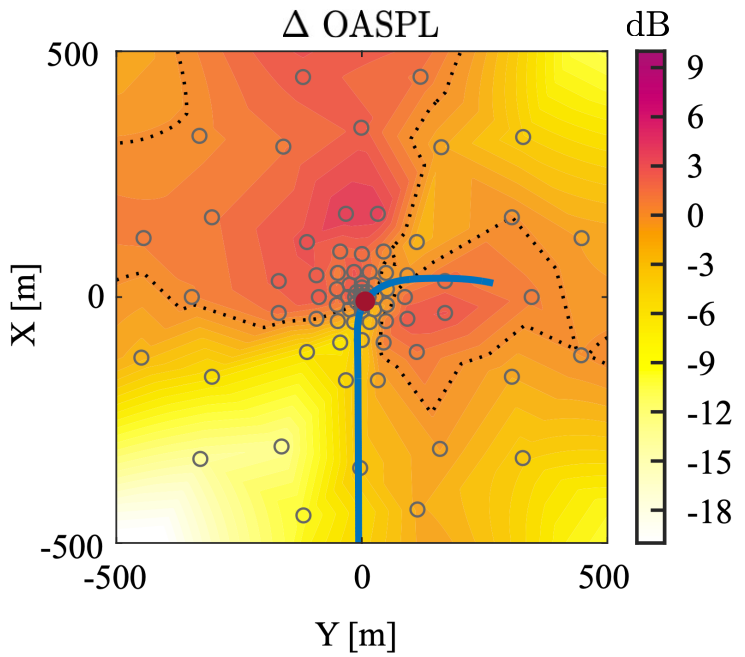
Maneuver noise analysis in:

Stutz et al., "**Acoustic Assessment of an MD530F Helicopter in Maneuvering Flight**" VFS 81, 2025

**Objective**

Determine appropriate methods to investigate unsteady flight



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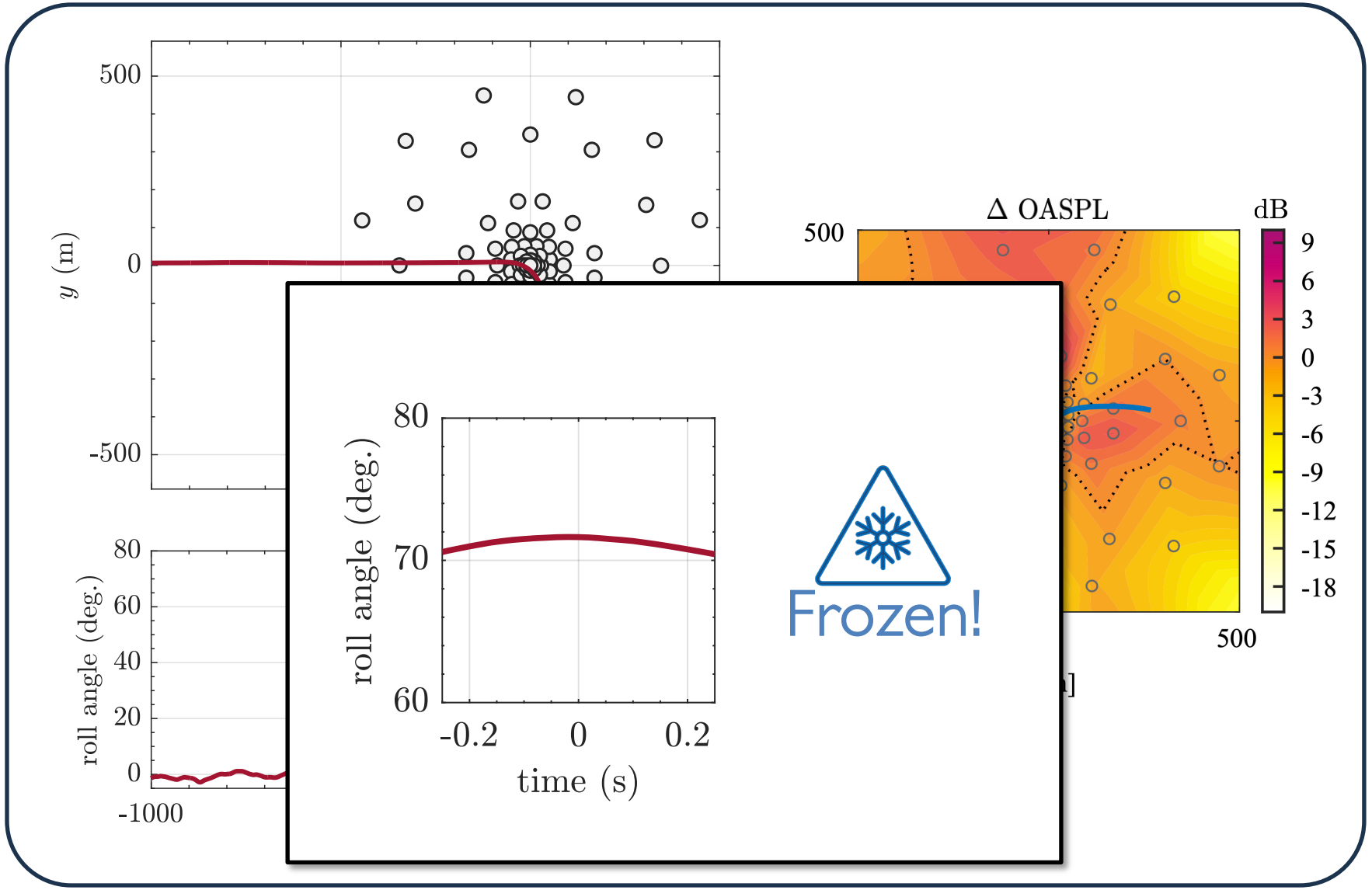
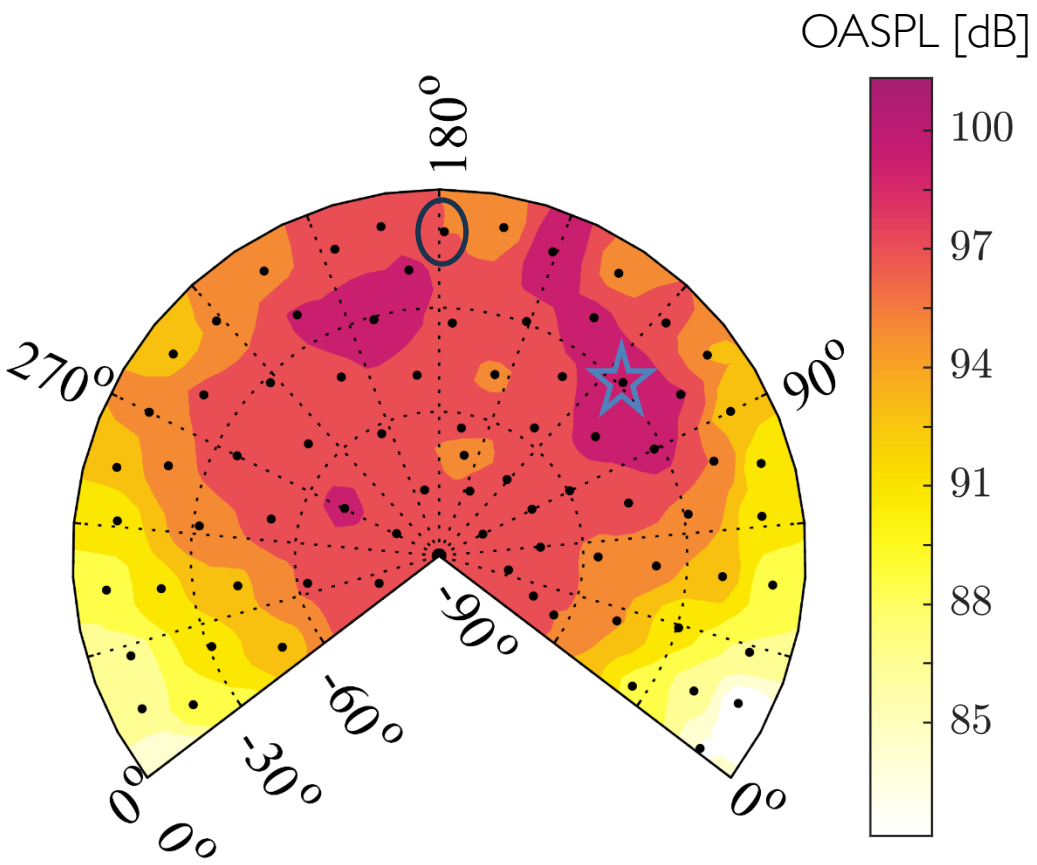
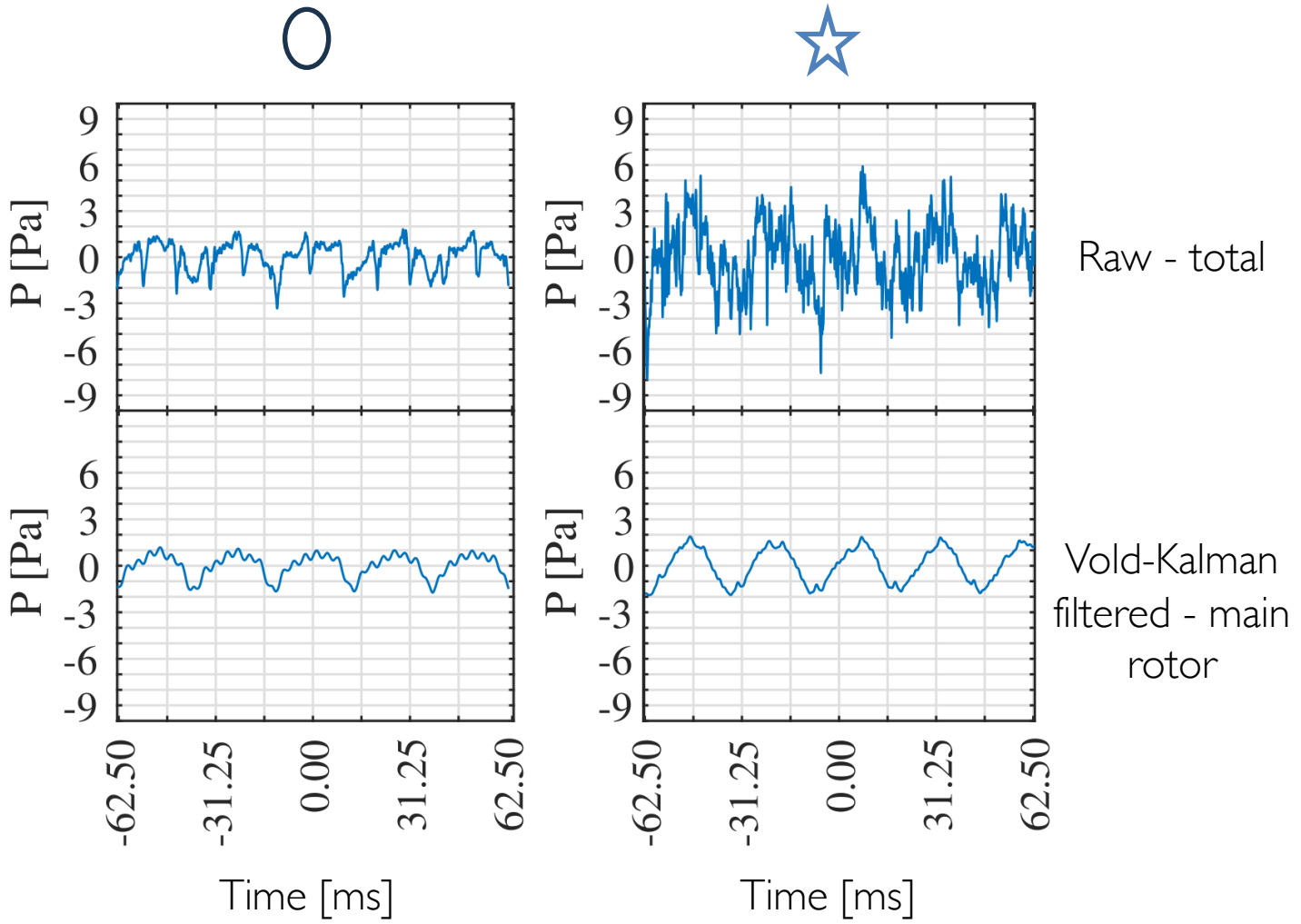
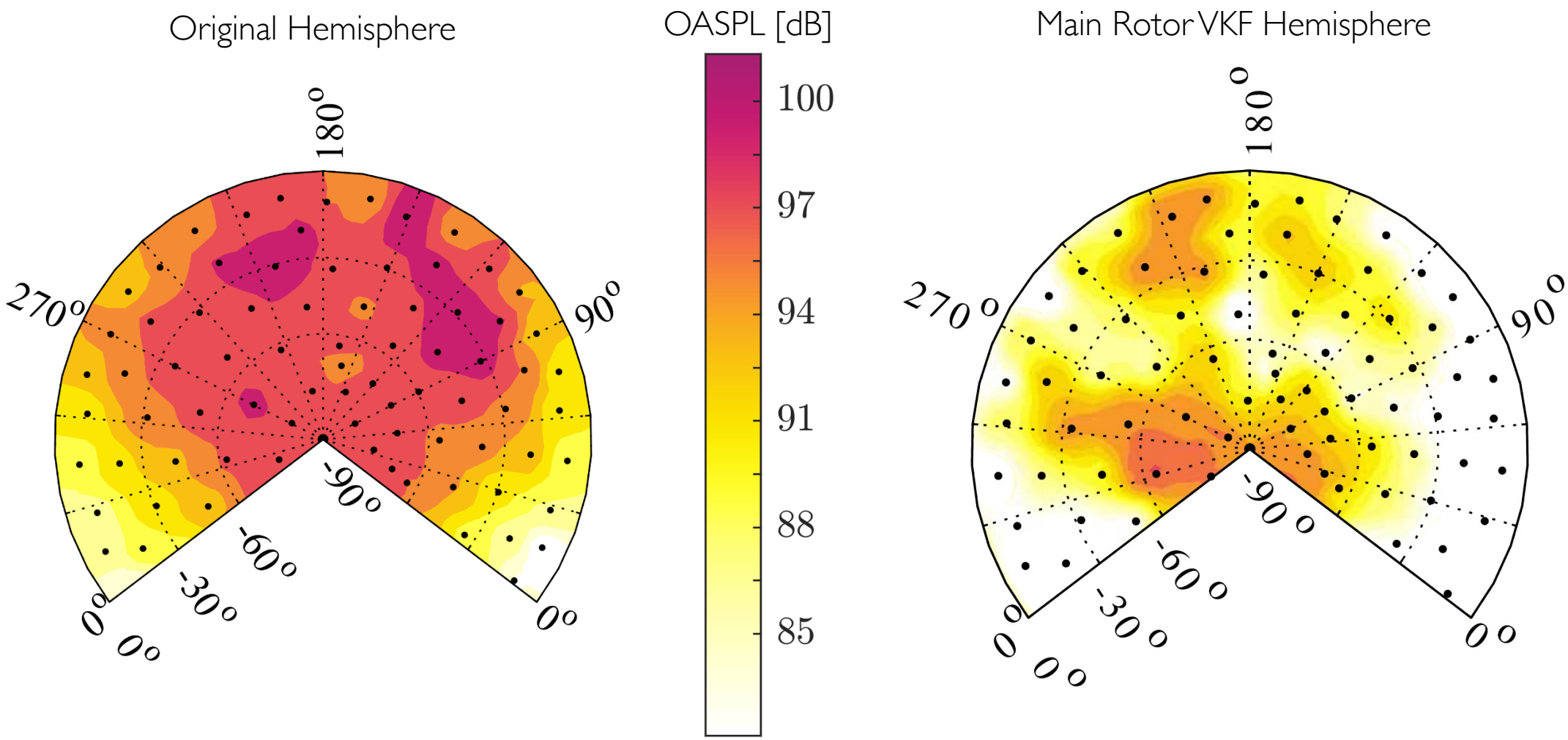


# 90-knot level flight – snapshot array

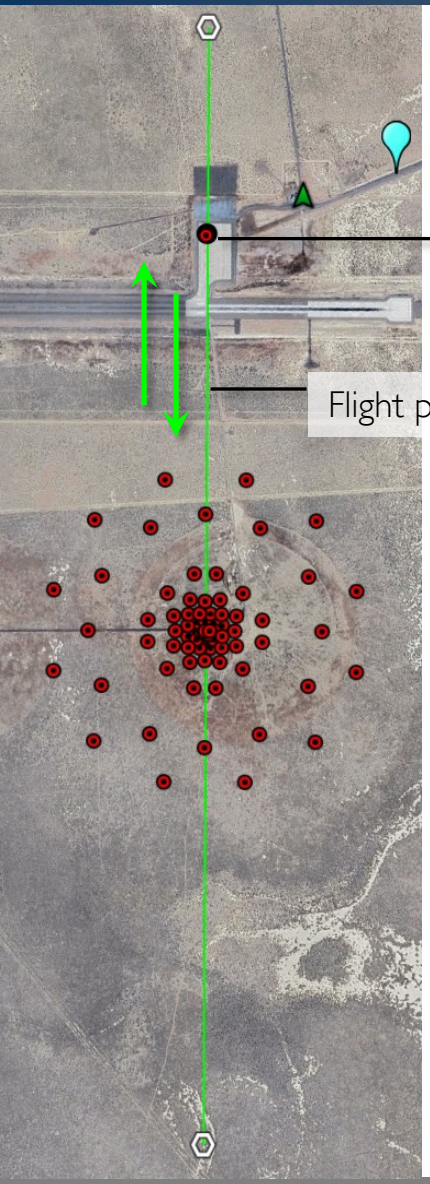


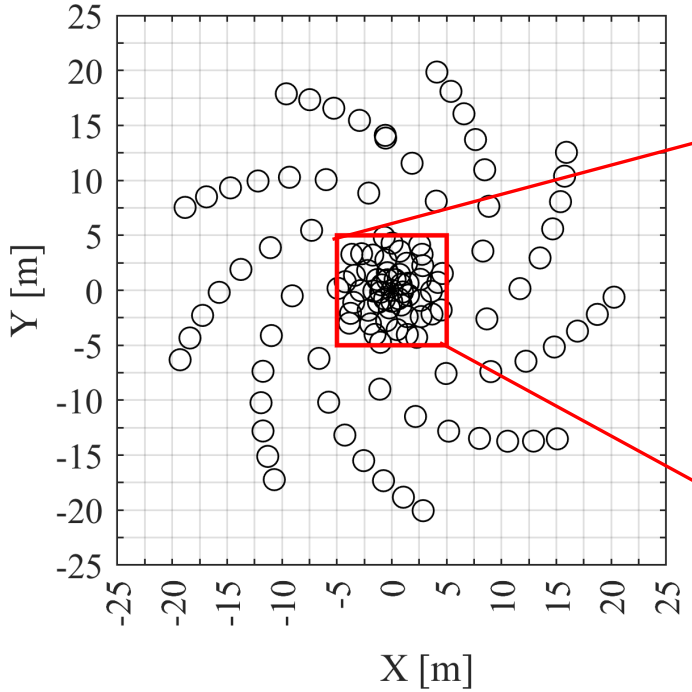
# 90-knot level flight – VKF extracted

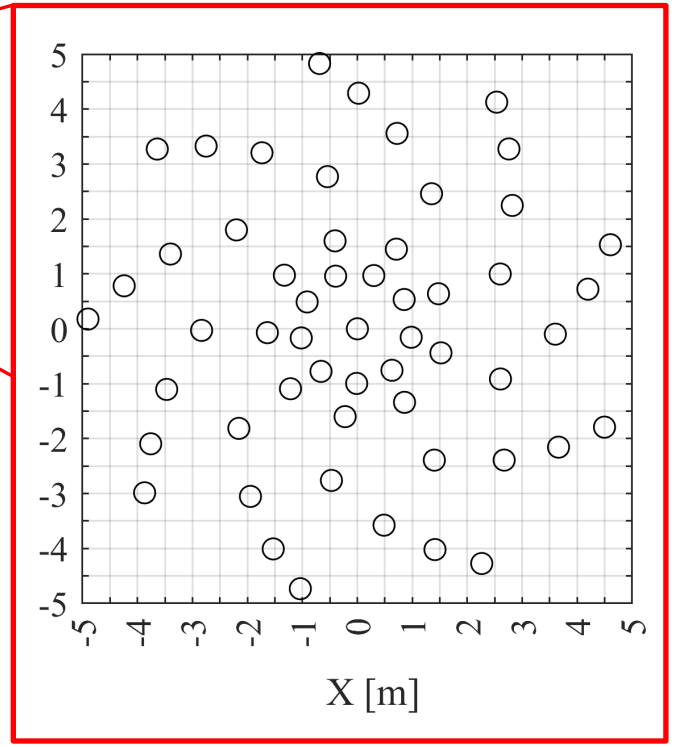


# Instrumentation layout - FLT 201 phased array

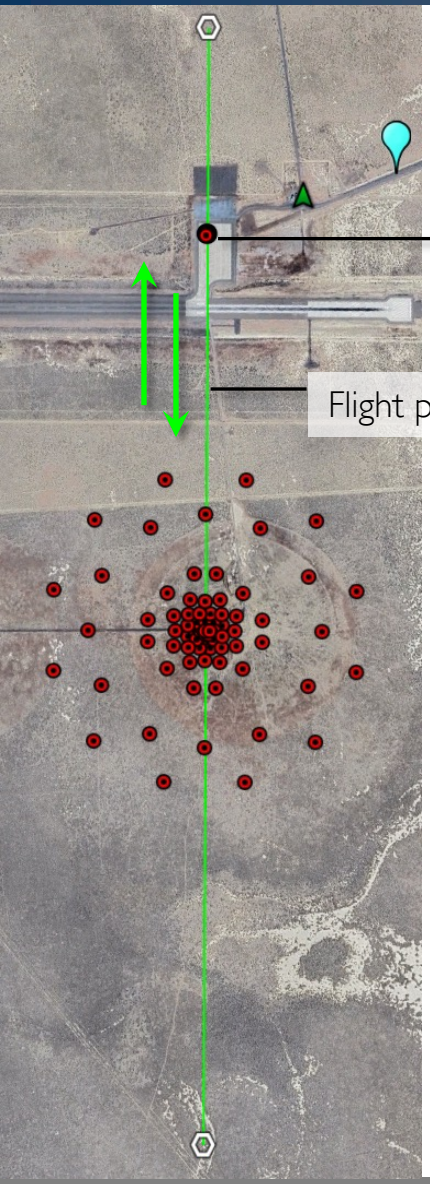


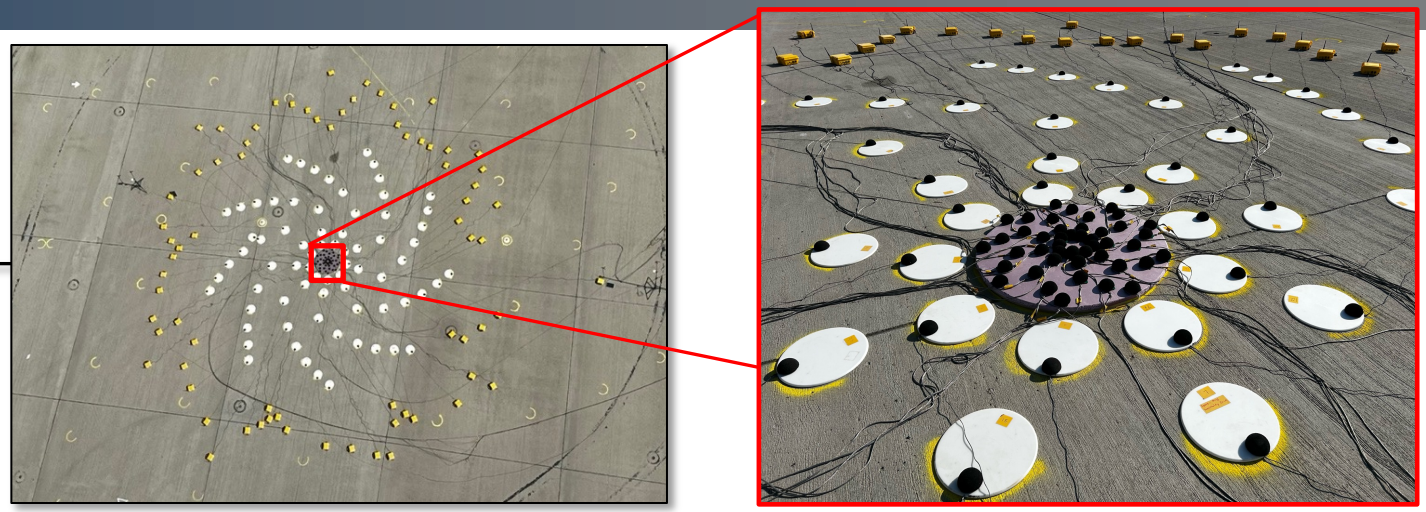
Phased array (aircraft perspective)



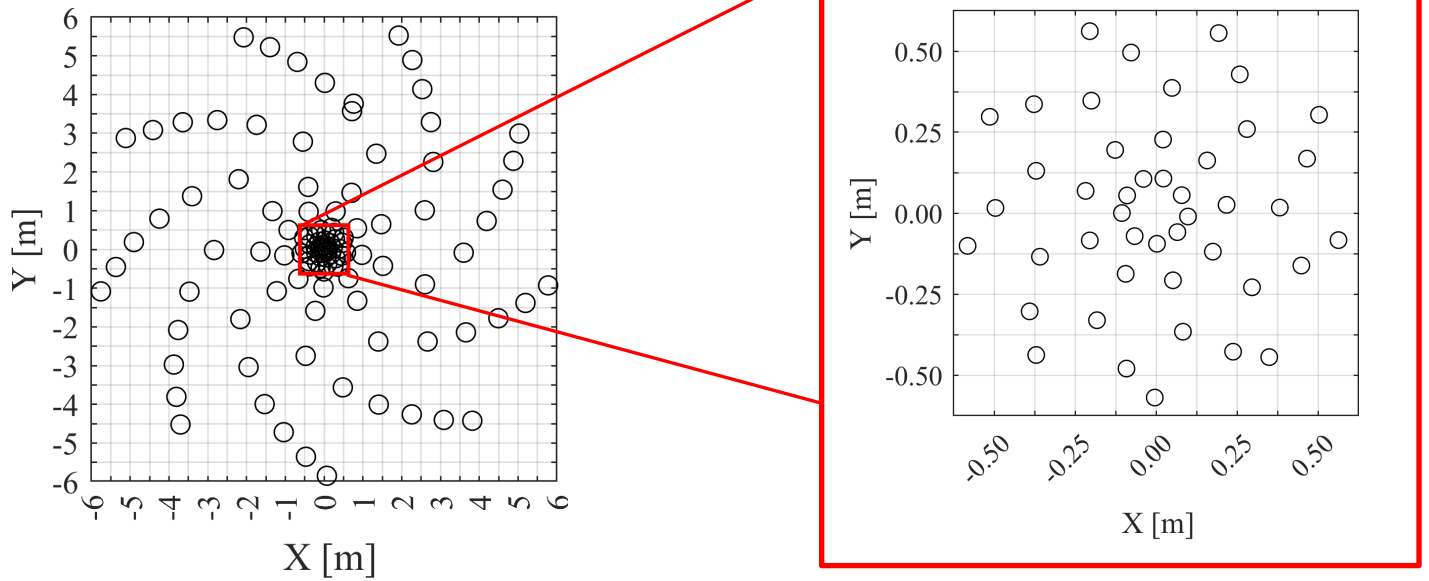



# Instrumentation layout - FLT 209 phased array



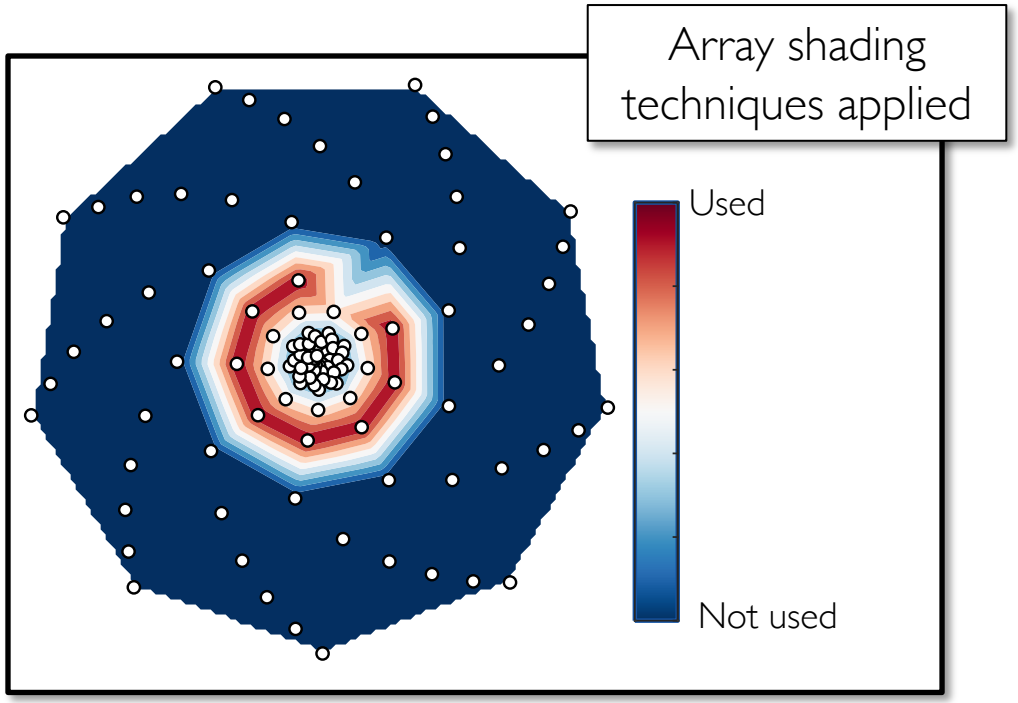



Phased array (aircraft perspective)

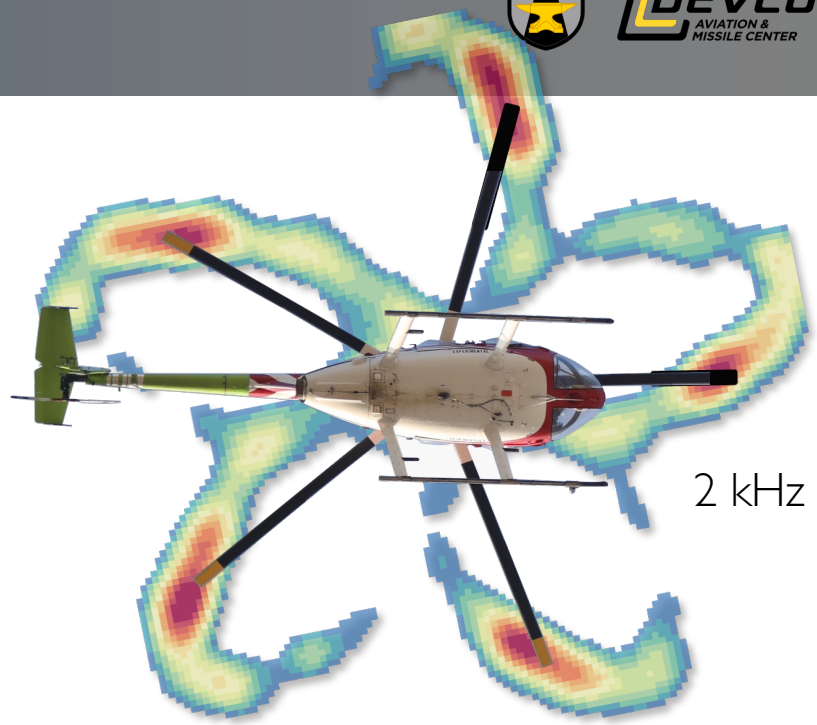


# Phased array results

- Rotating Source Identifier (ROSI) by Sijtsma [1]
- Scan grid rotation synchronized with main rotor
- 20 kt forward flight (40 rotor revolutions)




[1]Sijtsma, Oerlemans, & Holthusen, AIAA 2001-2167.



2 kHz 1/3-octave

Phased array analysis in:

Pascioni et al., "**Phased Array Measurements of a Full-Scale Helicopter,**" VFS 81, 2025

**Objective**

Assess feasibility of rotating beamforming algorithms to separate nondeterministic noise, per propulsor

This work was supported by the the U.S. Army, Combat Capabilities Development Command Aviation & Missile Center, and the NASA Aeronautics Research Mission Directorate, Revolutionary Vertical Lift Technology Project.