



Fundamental Aeronautics Program

Subsonic Rotary Wing Project

Status of Flight Acoustics Research

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www.nasa.gov



Rotorcraft Flight Acoustics Team

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Army AFDD - David Conner

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Charles Smith, William Leath

Focus Areas

- Mobile Acoustic Facility
- Data analysis and ground noise prediction software development
- 2011 Maneuver Flight Test

Mobile Acoustic Facility

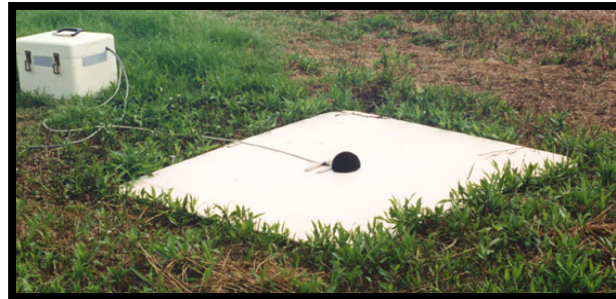


Command & Control Trailer



Wireless Acoustic Microphone Systems (WAMS)

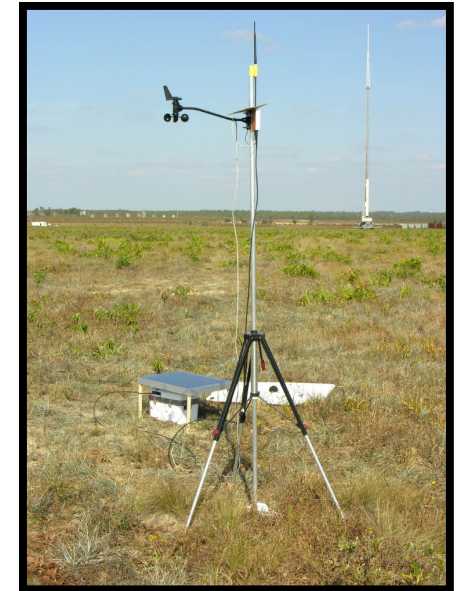
Microphone on Ground
Board & Digitizer Box



Weather Balloon



WAMS Trailer



Physics Based Noise Models

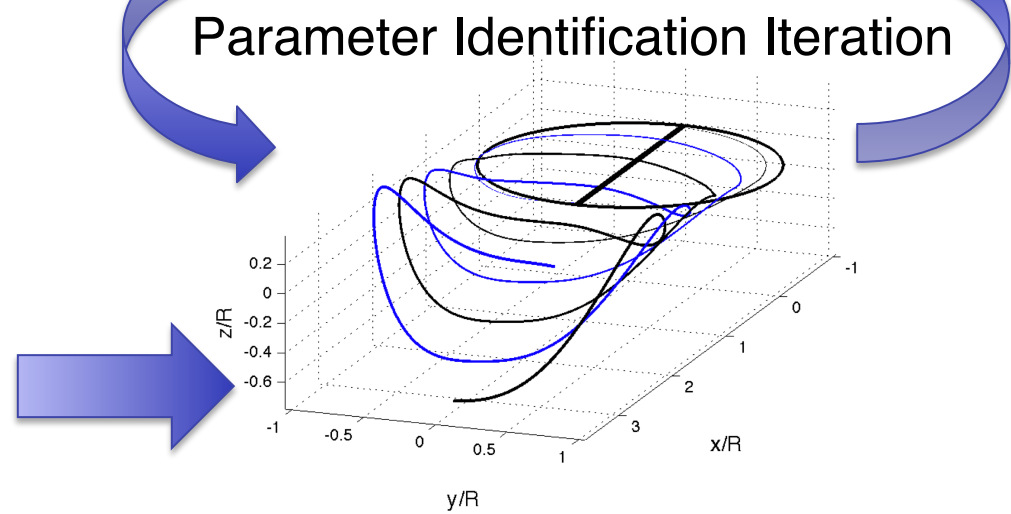
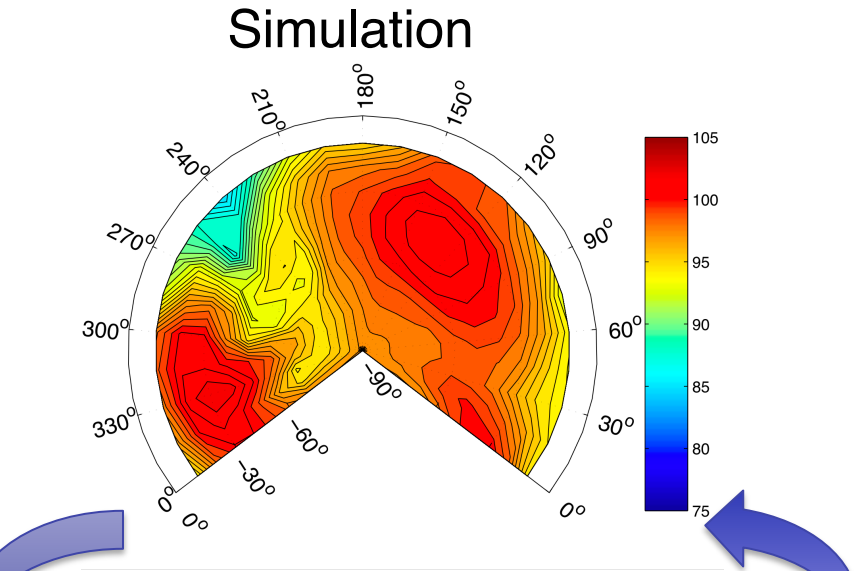
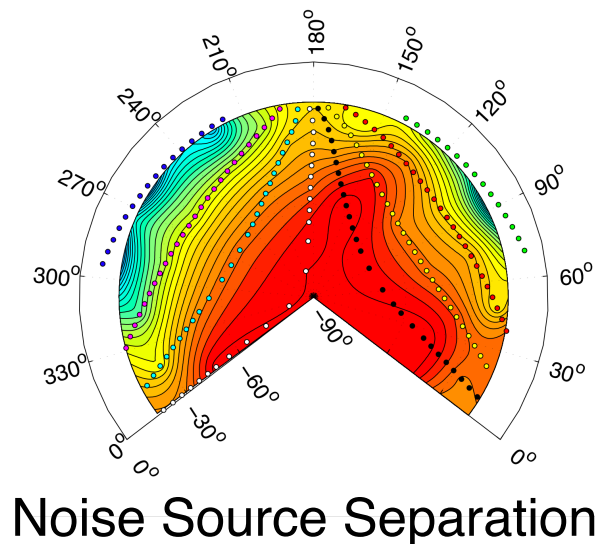
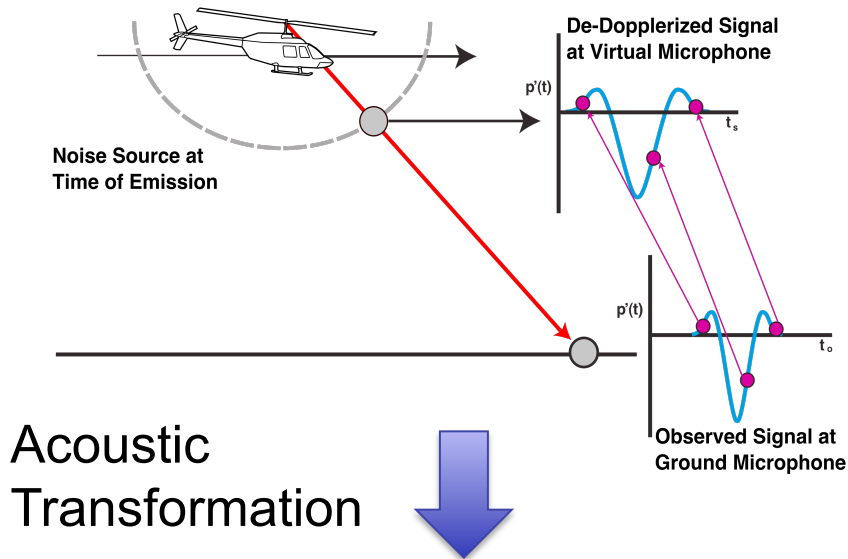


Fundamental Rotorcraft Acoustic Modeling from Experiments (FRAME)

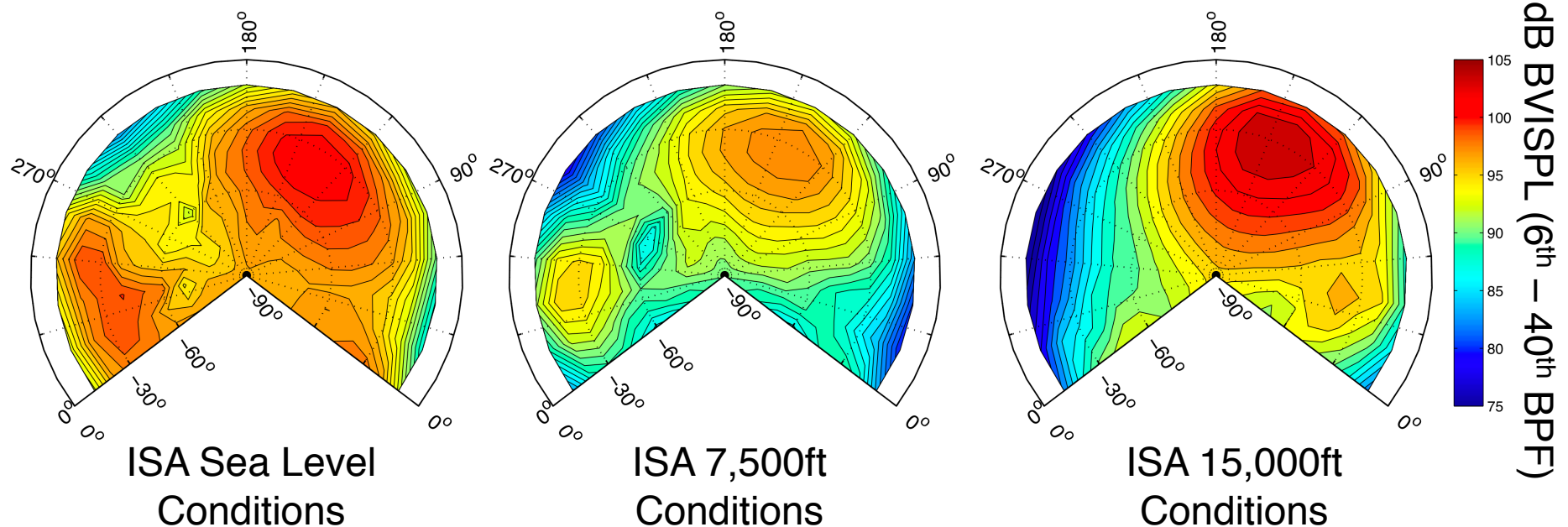
- Purpose:

Improve the generalization of rotorcraft noise measurements by using them to construct physics-based non-dimensional noise models
- Approach:
 1. Classify flight conditions by non-dimensional parameters (e.g. μ , λ , C_T , M_H)
 2. Separate contribution of different noise sources (e.g. MR/TR harmonic) in measurements
 3. Use parameter identification techniques to adapt analytical models to data for each source

FRAME: BVI Noise Model



FRAME: BVI Variation with Altitude



Some other applications:

- Hard-to-measure directions
- Changes in gross weight, RPM, parasite drag
- Moderate turning flight conditions
- Accelerating flight conditions

Noise Footprint and Audibility

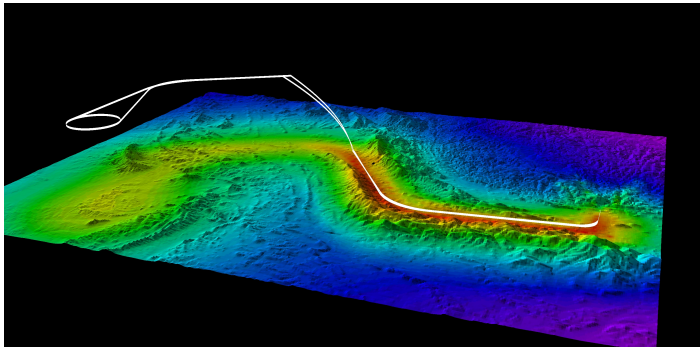


Ongoing work in ground noise footprint and detection development

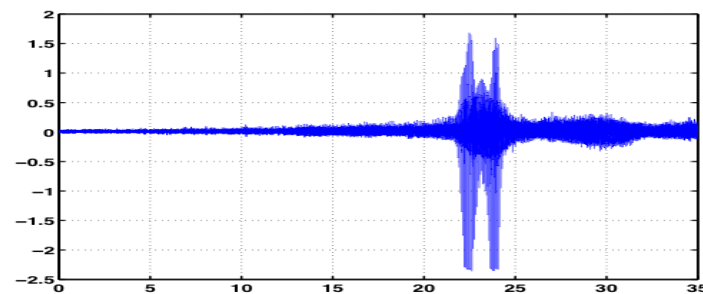
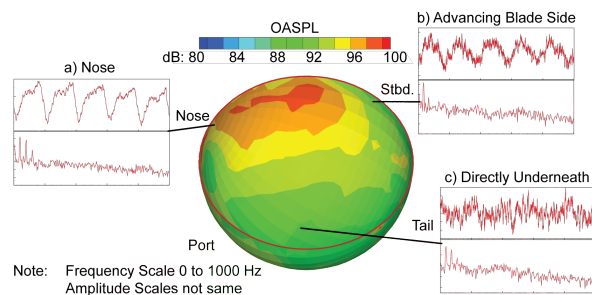
	ICHIN7	ICHIN8*	ADAM	APET**
1/3 octave band (Dprime)		✓	✓	✓
Narrow band (Audib)	✓	✓	✓	✓
2-dimensional	✓	✓		
3-dimensional			✓	✓
Weather		✓	✓	✓
Variable terrain			✓	✓
Variable ground impedance				✓

- * ICHIN8 currently Beta version research tool – not available for distribution.
Note: ICHIN6 is obsolete – ALL ICHIN users should be using Version 7, work supported by non-SRW funding
- ** APET currently Beta version being released to Government and Contractors performing work on Government, work supported by non-SRW funding

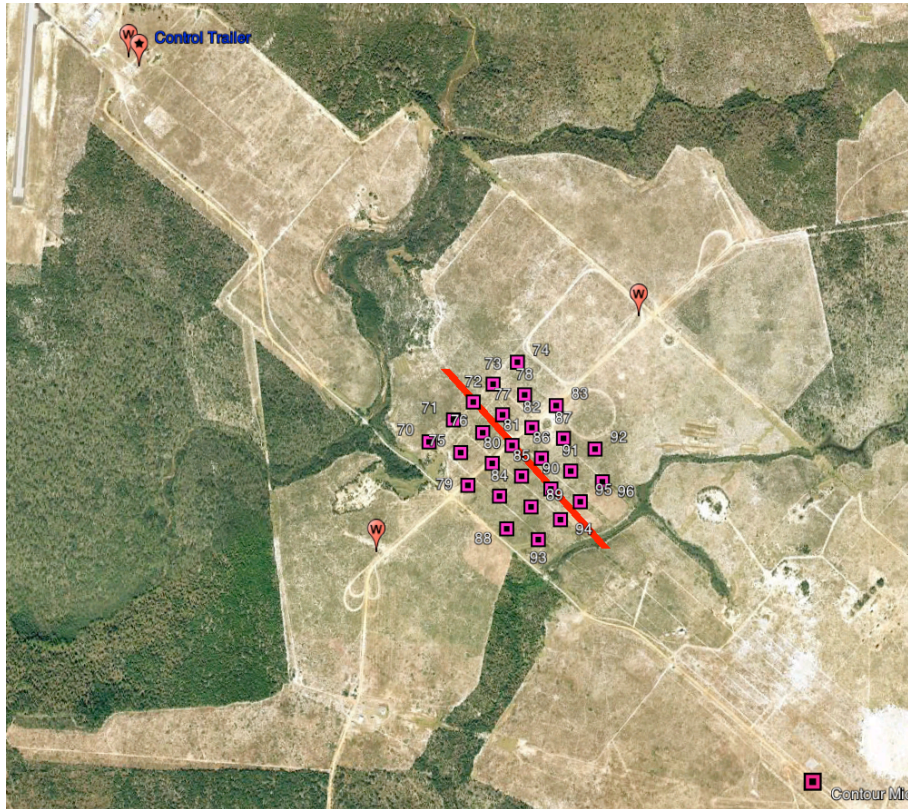
Eglin 2011 NASA/Army/Bell Maneuver Test



- Bell 430
 - 4 Bladed main rotor, 2 bladed tail rotor
 - 9300 lb gross weight
 - 143 ktas max continuous speed @SL
 - Tip Path Plane measurement
- Objectives
 - Validate flight path optimization codes
 - Understand maneuver acoustics
 - Incorporate maneuvers into acoustic ground footprint determination
- Acoustic measurement of
 - Optimized approach profiles
 - Source noise
 - Steady and dynamic maneuvers

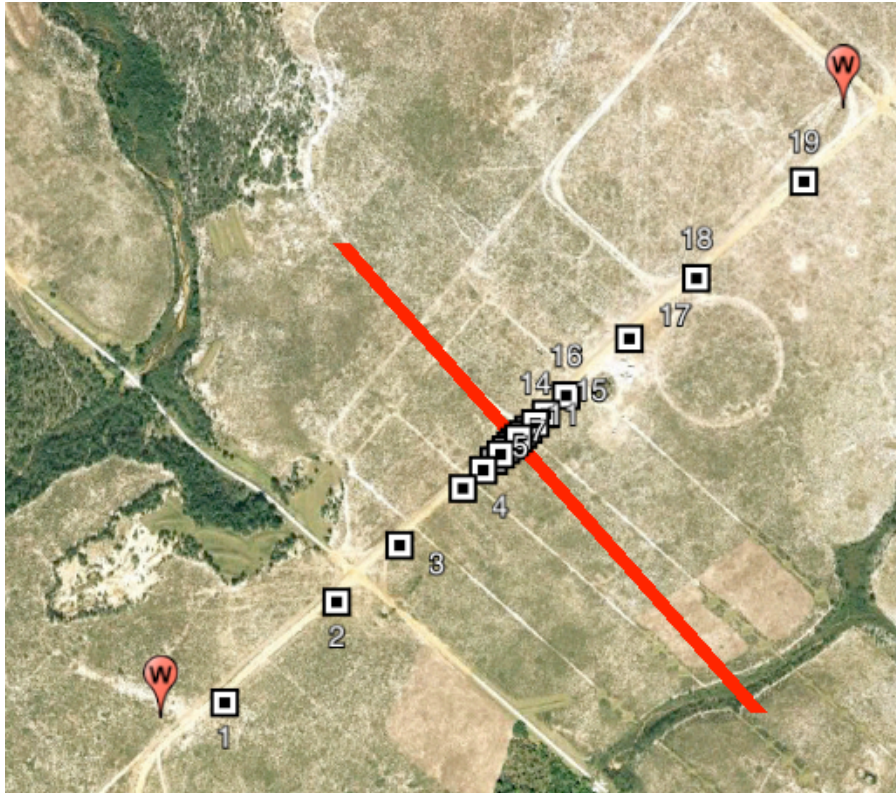


Optimized Terminal Area Approaches



- Purpose is to gather data for validation of ground footprint prediction and flight path optimization codes
- 30 Microphones deployed in grid
- Approaches
 - Standard 6°
 - Segmented linear decelerating
 - Optimized 3 dimensional
 - Pilot's discretion

Source Noise Mapping

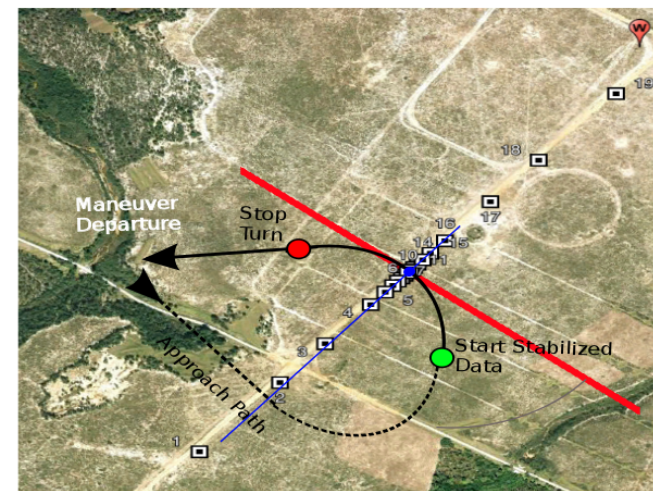
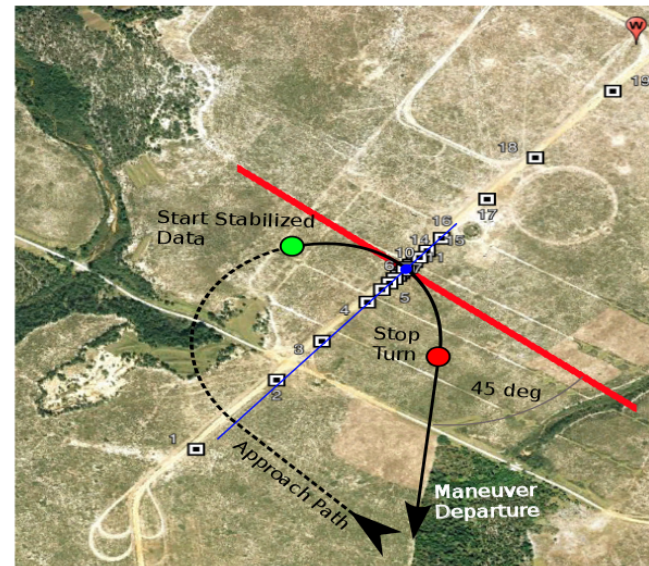
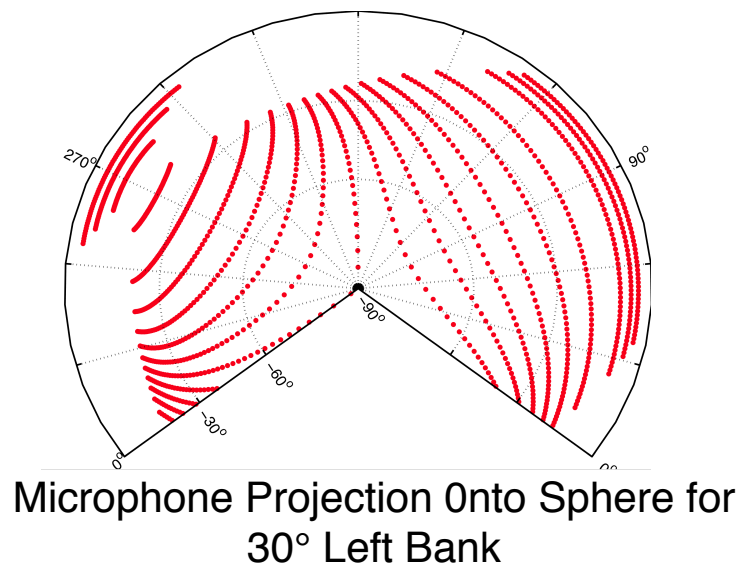


- Acquire detailed hemispheres for use in optimization codes and ground footprint calculations
- Linear array of 19 microphones
- Level flight
- Descents
- Climbs

Steady Maneuvers



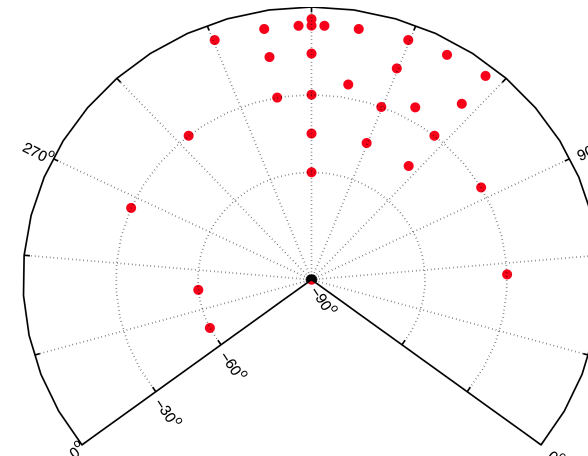
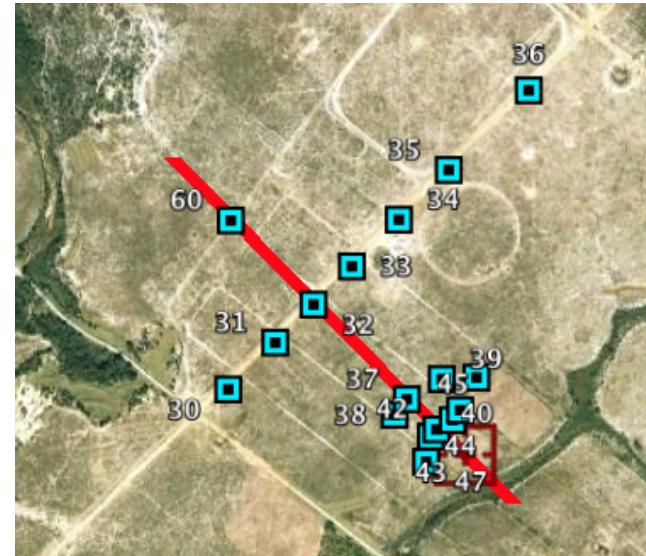
- Acquire data to:
 - Validate acoustic prediction codes
 - Incorporate steady coordinated turns into transition part of terminal area approach predictions
- Left and right steady bank angles
- 15 and 30 deg.
- 19 microphones in linear array



Transient Maneuvers



- Acquire data to:
 - Validate acoustic prediction codes
 - Understand the effect of dynamic changes in flight condition on acoustics
- 30 microphones
- Single control input
 - Collective pull-up
 - Cyclic pitch-up, pitch-down, roll, roll-reversal
- Dual control inputs
 - Constant airspeed collective pull-up
 - Constant airspeed cyclic roll
- Combination maneuvers
 - Quick stop/start
 - Constant airspeed flight path angle change
 - Accelerating flight roll angle change
 - Climbing flight roll angle change



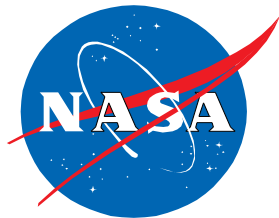
Microphone Projection Onto Sphere at Time of Maneuver Initiation



Conclusion

We are continuing to develop physical understanding and improved modeling of Rotorcraft Noise thru first principles development and experimentation to improve mission planning tools that enable low noise operations.

- Continue to advance field measurement capabilities
 - Weather systems
 - TPP System
 - Flush mounted microphones
- Developing semi-empirical modeling capabilities
 - Non-dimensional parameter variations
 - Turns
 - Accelerations
- Developing improved ground modeling
 - Advanced weather
 - Improved terrain
 - Ground impedance
- Maneuver flight test focused on acquiring necessary experimental data



Acoustic Instrumentation



WAMS (wireless)

- 36 channels available
- Data storage on compact flash card
- System health monitored in real time
- GPS card provides time code as well as position
- Simult. sampling on all channels (<8 μ sec diff)
- Up to 50 mile range
- Onboard embedded controller
- 80 kHz max. sample rate
- 96 dB dynamic range
- Battery operation w/solar power augmentation
- Weather data at each microphone location

Microphones

Manufacturer	Model	Response	Diameter	Sensitivity, mV/Pa	Frequency Range, Hz	Polarization	Preamp Model
B&K	4134	Pressure	1/2"	12.5	4 to 20k	200 V	2639
B&K	4189	Free-field	1/2"	50	6.3 to 20k	0 V	2669
PCB	377B11	Pressure	1/2"	50	3.15 to 10k	0 V	426E01