Effects of Terrain and Manmade Structures on Aircraft Noise Prediction

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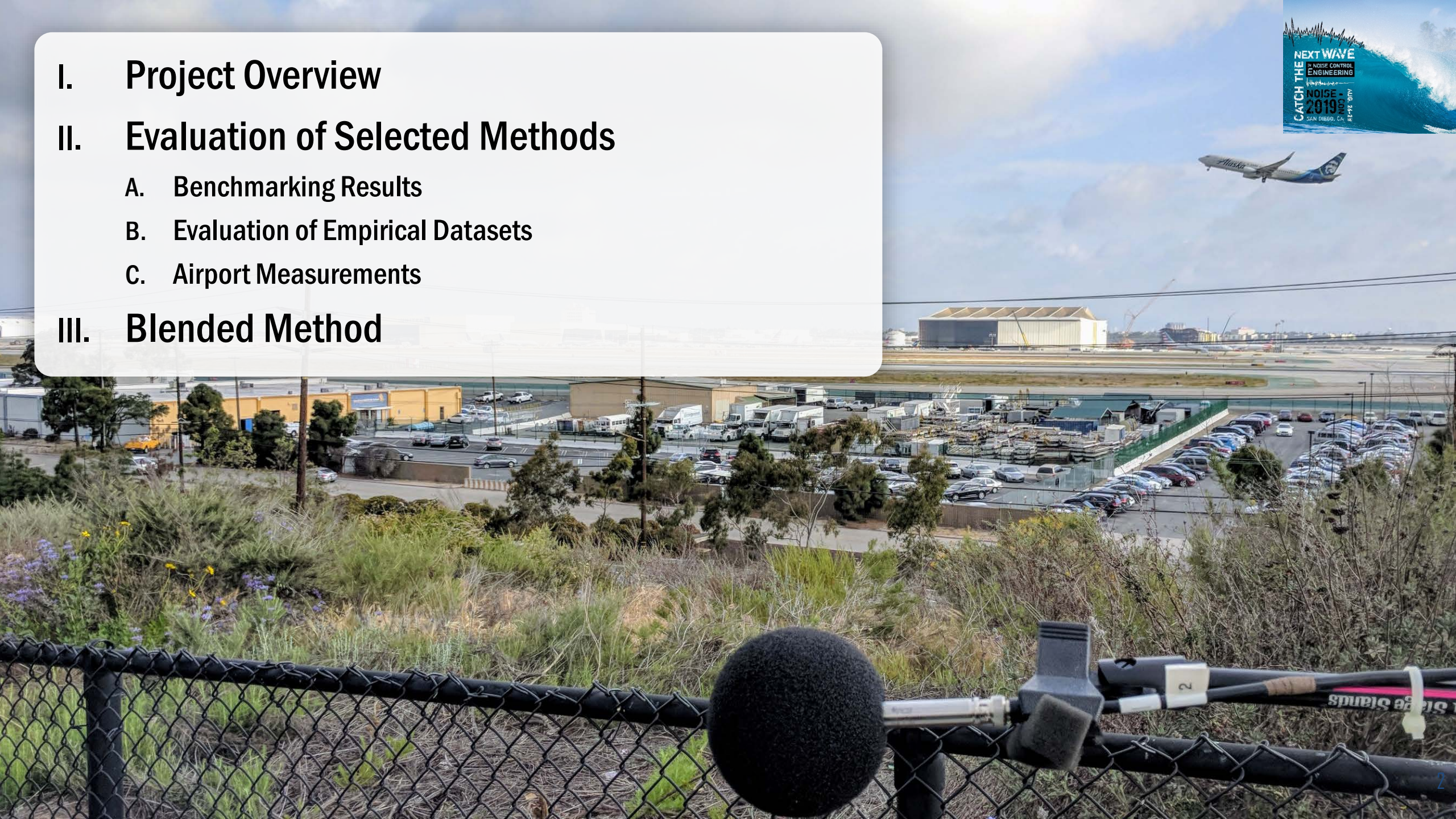


I. Project Overview

II. Evaluation of Selected Methods

A. Benchmarking Results

B. Evaluation of Empirical Datasets

C. Airport Measurements

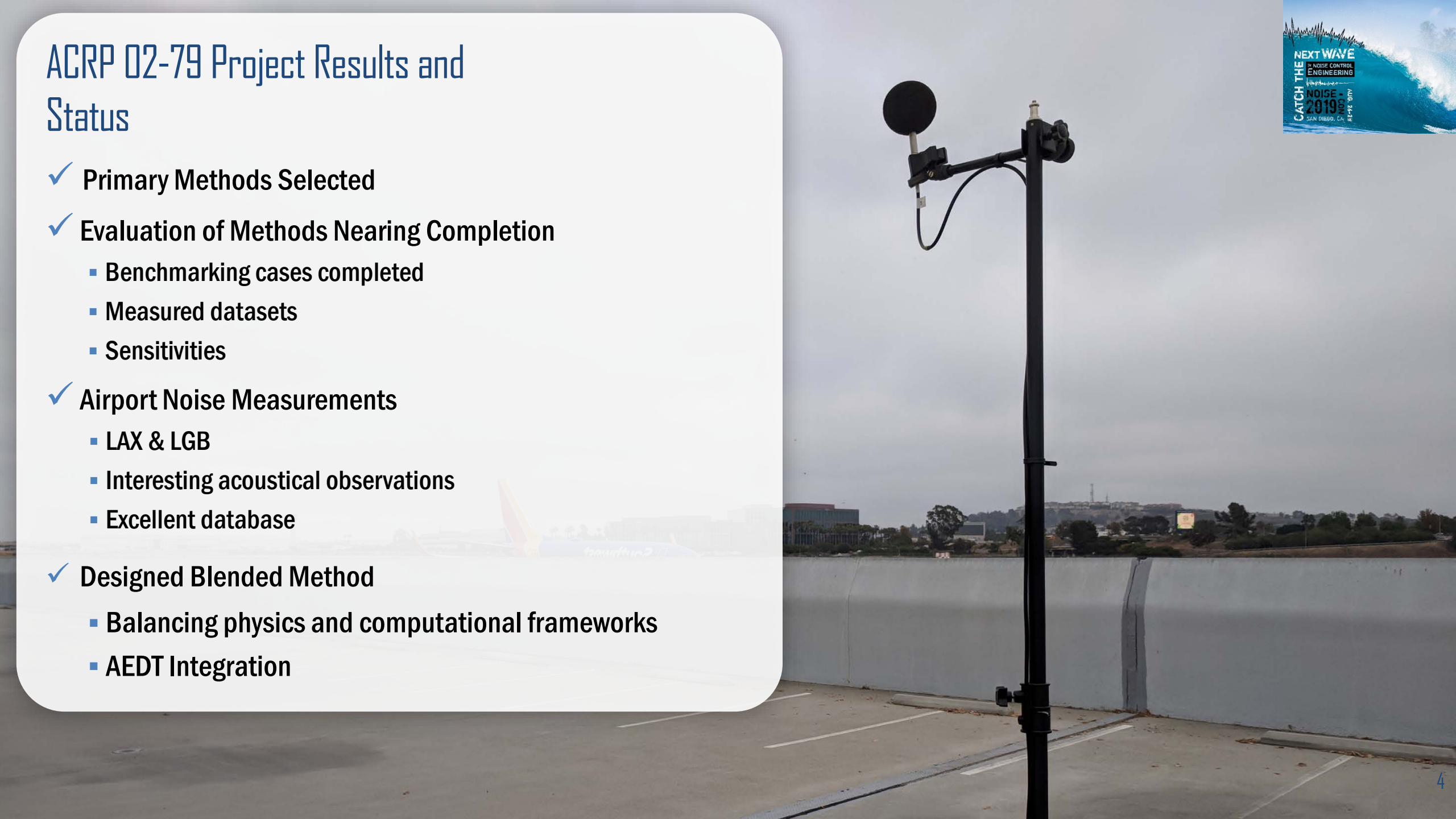
III. Blended Method

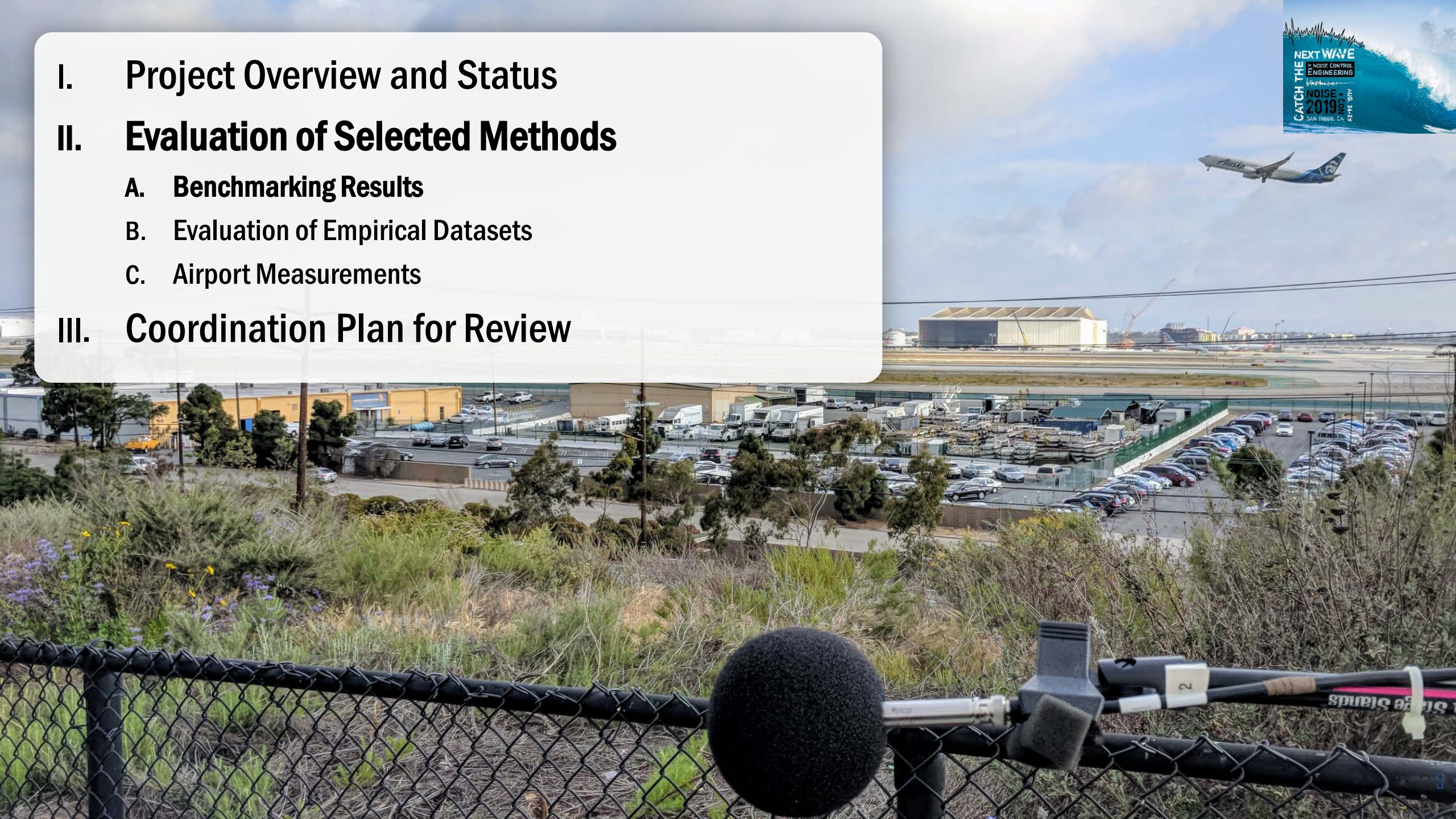
ACRP 02-79 Project Overview

- **Develop and Evaluate Noise Propagation Methods**
  - Aircraft noise reflection and diffraction from terrain and manmade structures
  - Both ground and airborne aircraft operations
- **Recommend Methods for Inclusion into AEDT**
  - Both the physics and the software integration process
  - Influence these methods will have on AEDT's data input requirements, computational load, while considering uncertainty
- **Provide Recommendations for Potential Additions to the AEDT User Guide**
  - Influence terrain and manmade structures have on aircraft noise at receivers
  - Applications these new methods have for airport noise analyses
  - Guidance on when these methods should be employed

ACRP 02-79 Project Results and Status

- ✓ Primary Methods Selected
- ✓ Evaluation of Methods Nearing Completion
  - Benchmarking cases completed
  - Measured datasets
  - Sensitivities
- ✓ Airport Noise Measurements
  - LAX & LGB
  - Interesting acoustical observations
  - Excellent database
- ✓ Designed Blended Method
  - Balancing physics and computational frameworks
  - AEDT Integration





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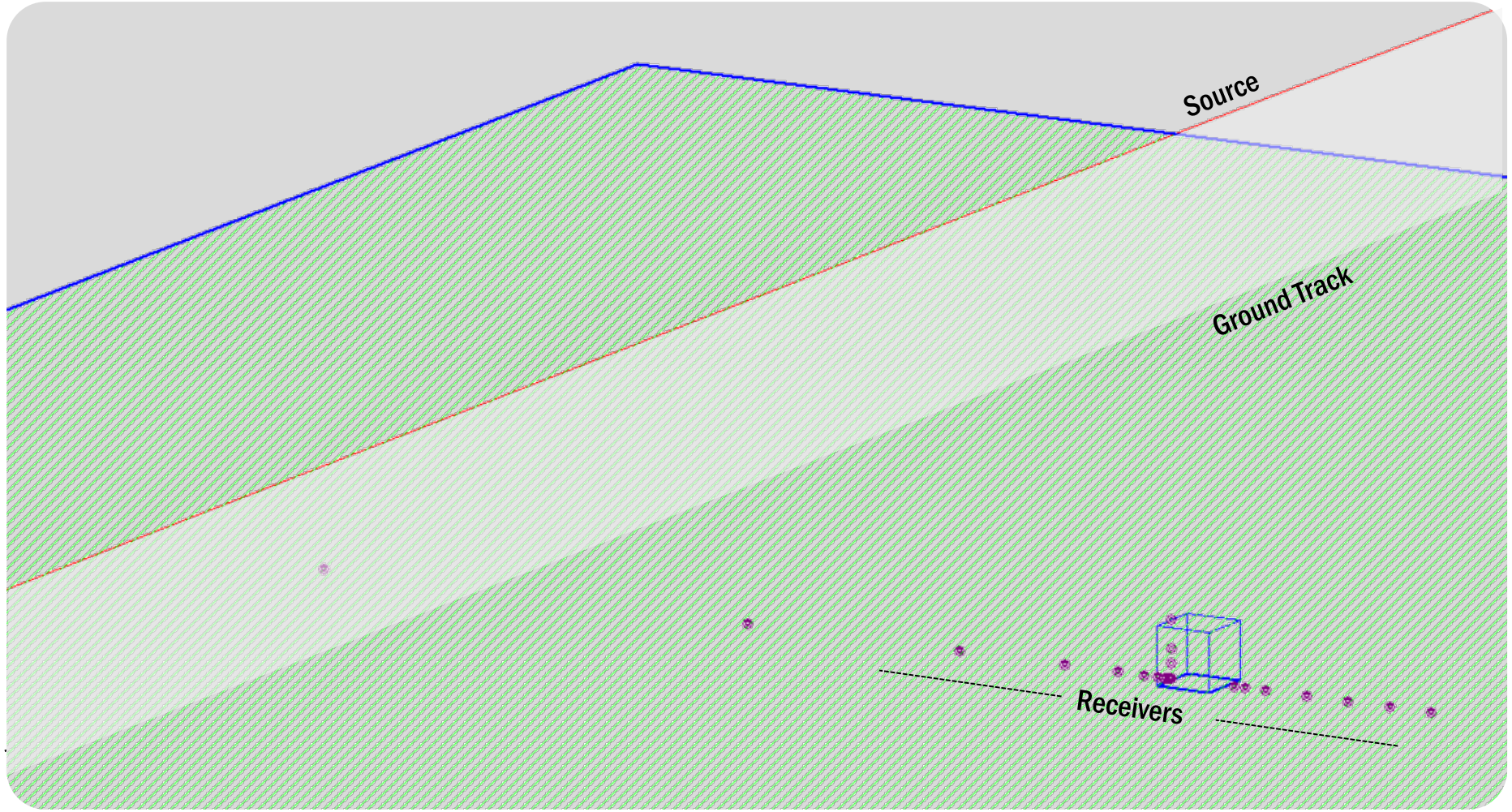
Benchmarking Dataset



Benchmarking Dataset

ISO 9613-2 | NORD2000 | TNM | AAM | Barrier Reflection Tool

Source	
Heights (m)	Distance from Façade (m)
1.5	25
12.5	100
50	400
100	2000
400	
800	

Receiver		
Heights (m)	Distance from Façade (m)	Distance from Rear (m)
0	1	12.5
1.5	2	25
	4	50
	8	100
	...	150
	2048	200
		250
		500

Building		
Height (m)	Width (m)	Depth (m)
8	8	8
8	16	8
8	32	8
8	64	8
64	8	64
64	16	64
64	32	64
64	64	64

Pink Noise: 100 dB/OTOB

Results in ΔdB (With – Without Building)

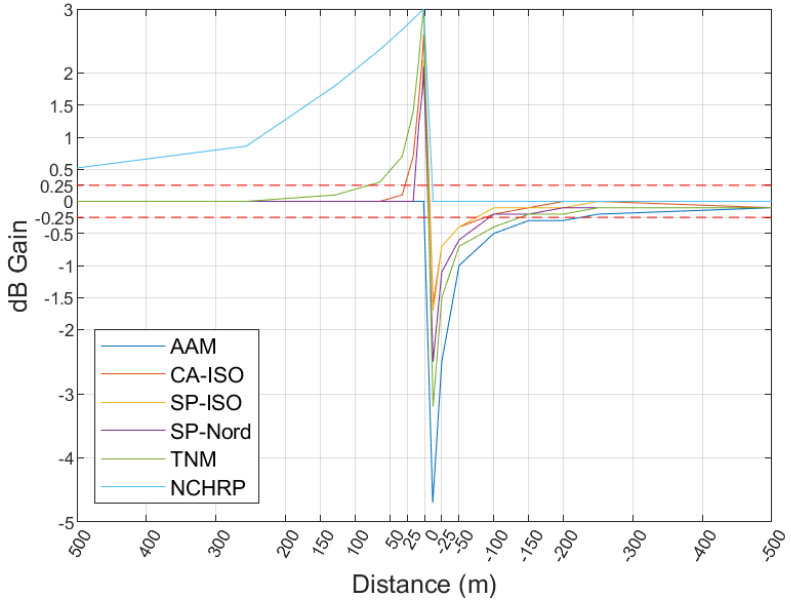
BRRC BLUE RIDGE RESEARCH AND CONSULTING | Volpe | Cross-Spectrum Acoustics | ATSConsulting acoustics, transportation + strategy

Benchmarking Dataset

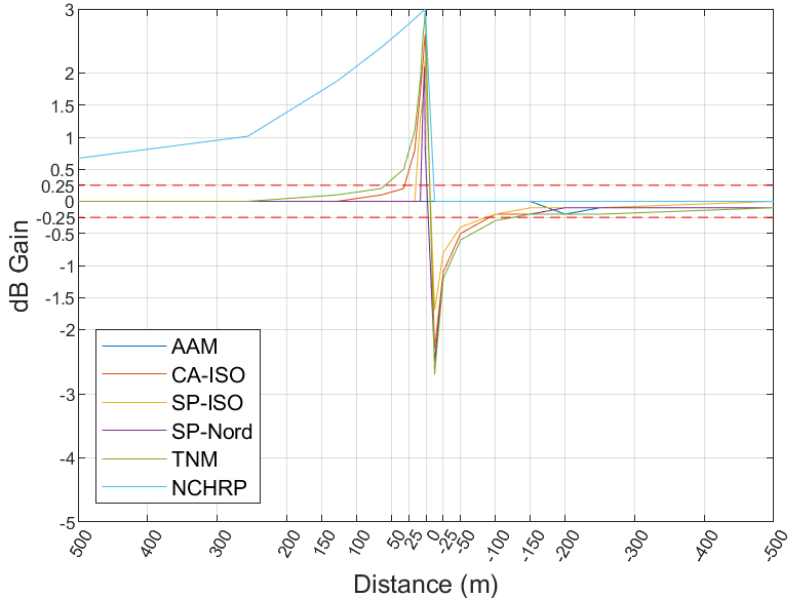
Comparison of Model & Methods Results

Building (64 H x 16 D x 64 W), Source Distance at 400 m

Source Height: 1.5 m



Source Height: 100 m



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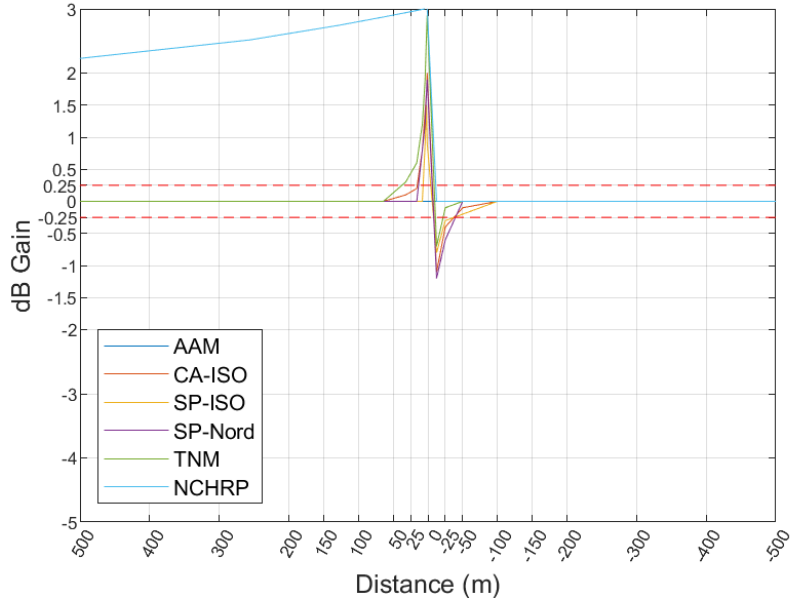
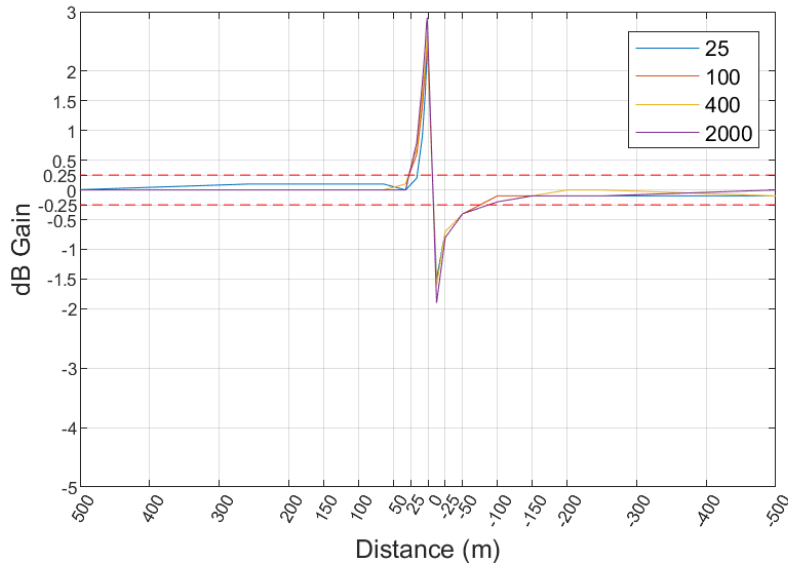


Benchmarking Dataset

Effect of Source Distance

Building (64 H x 16 D x 64 W), CadnaA ISO 9613-2

Source Height: 1.5 m



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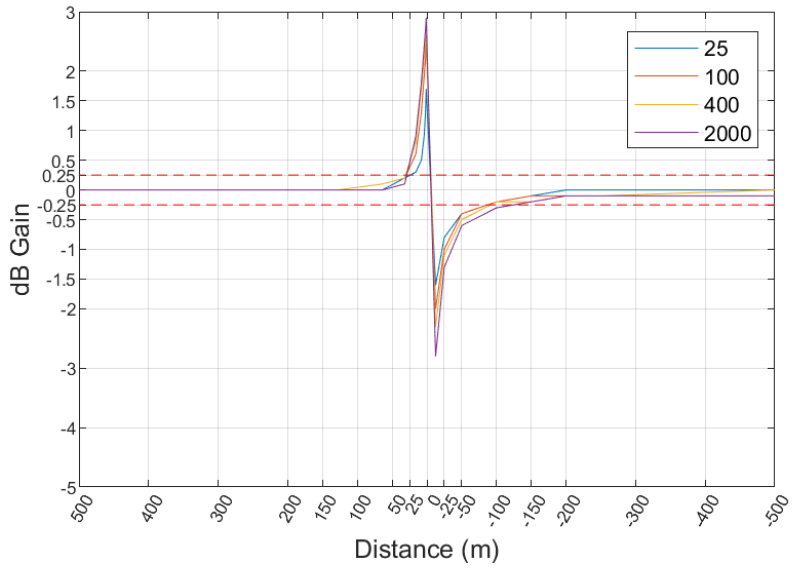

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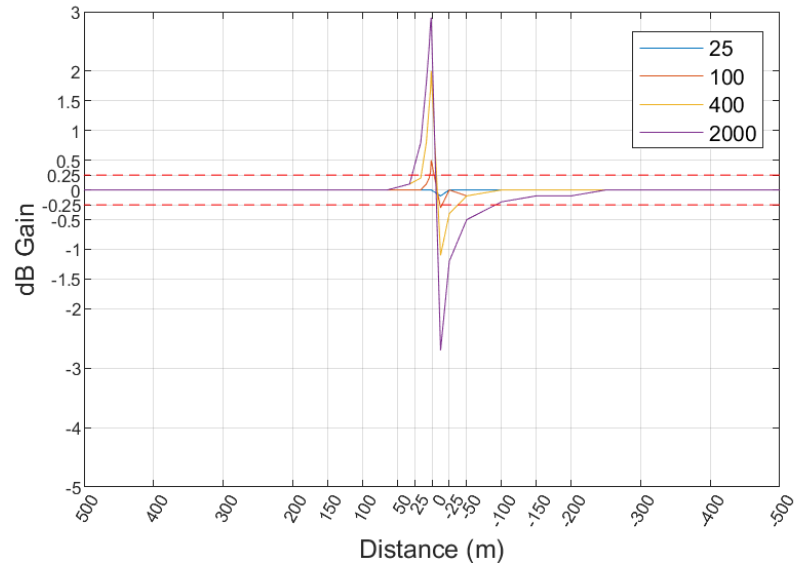
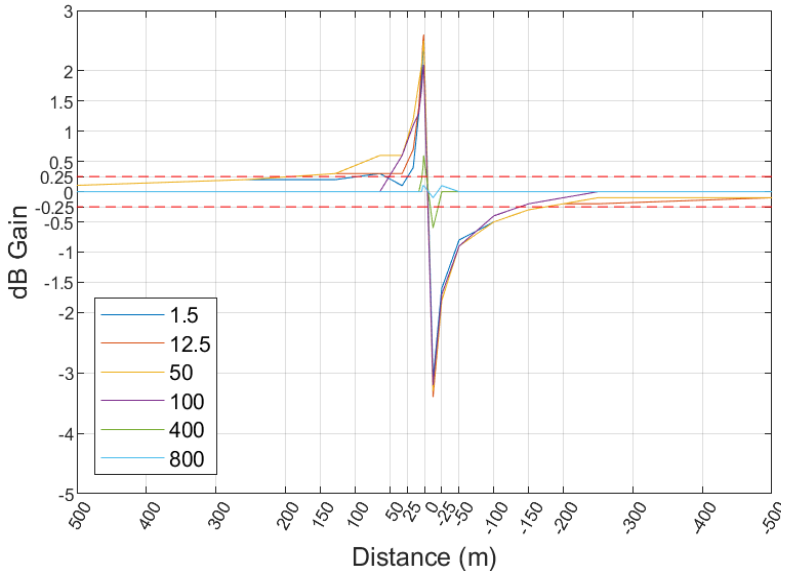


Benchmarking Dataset

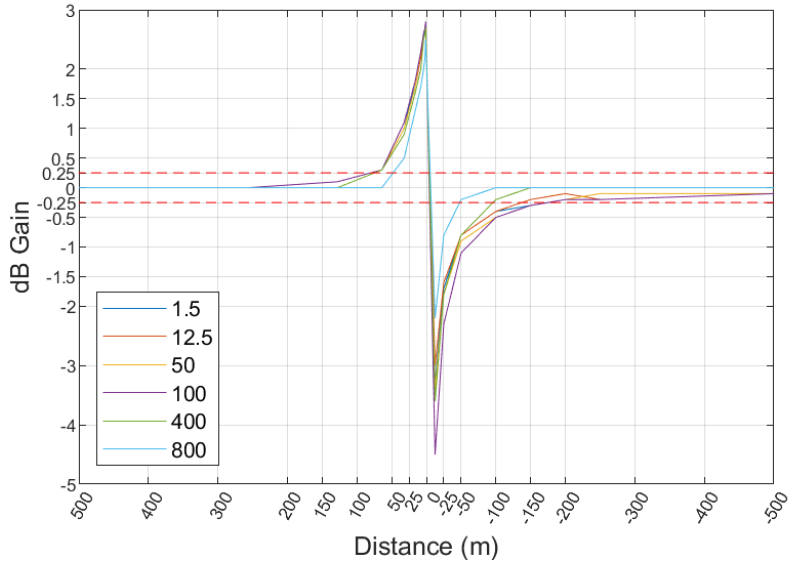
Effect of Source Height

Building (64 H x 16 D x 64 W), CadnaA ISO 9613-2

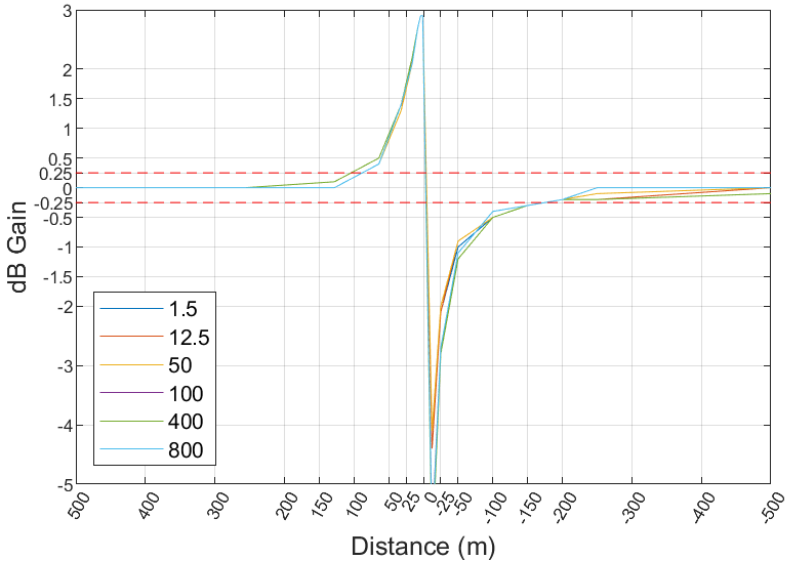
Source Distance: 25 m



Source Distance: 400 m



Source Distance: 2,000 m

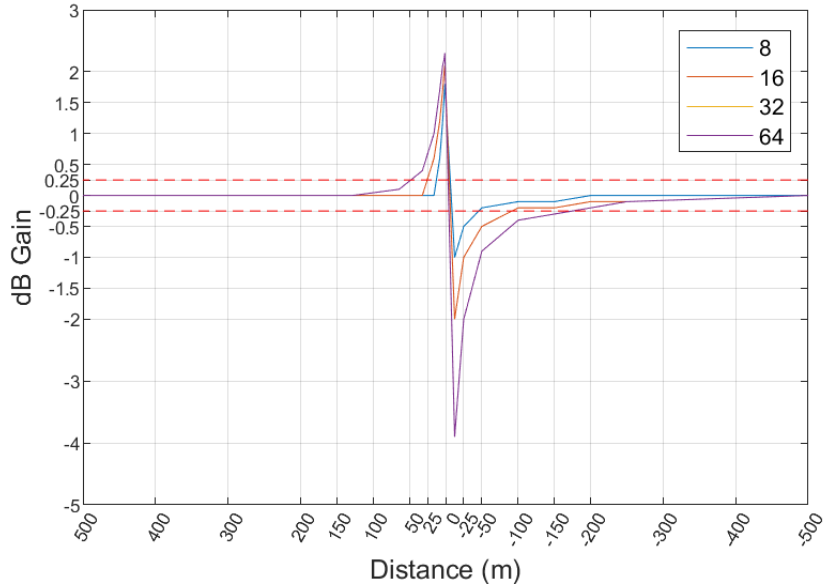


Benchmarking Dataset

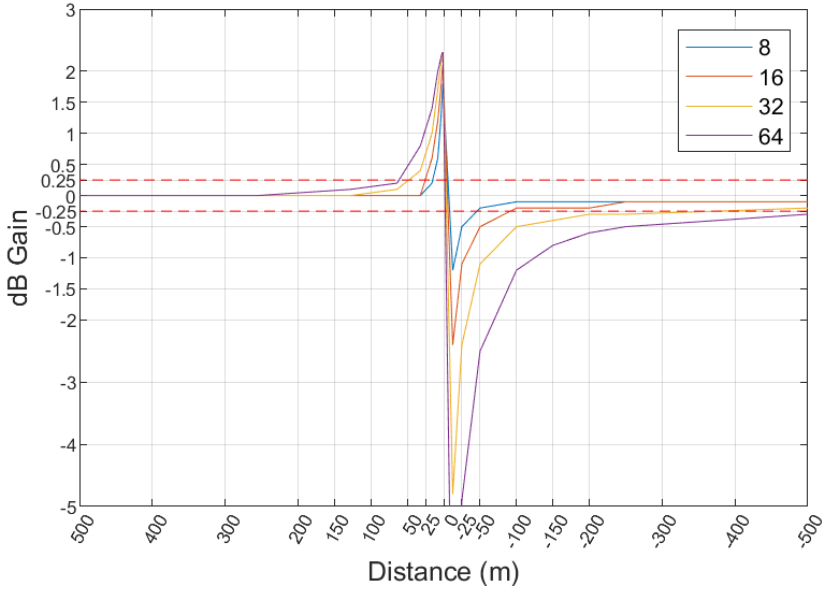
Effect of Building Width

Source at Distance of 100m and at Height of 12.5m, SoundPLAN NORD2000

Building: 8 m H x *W x 8 m D



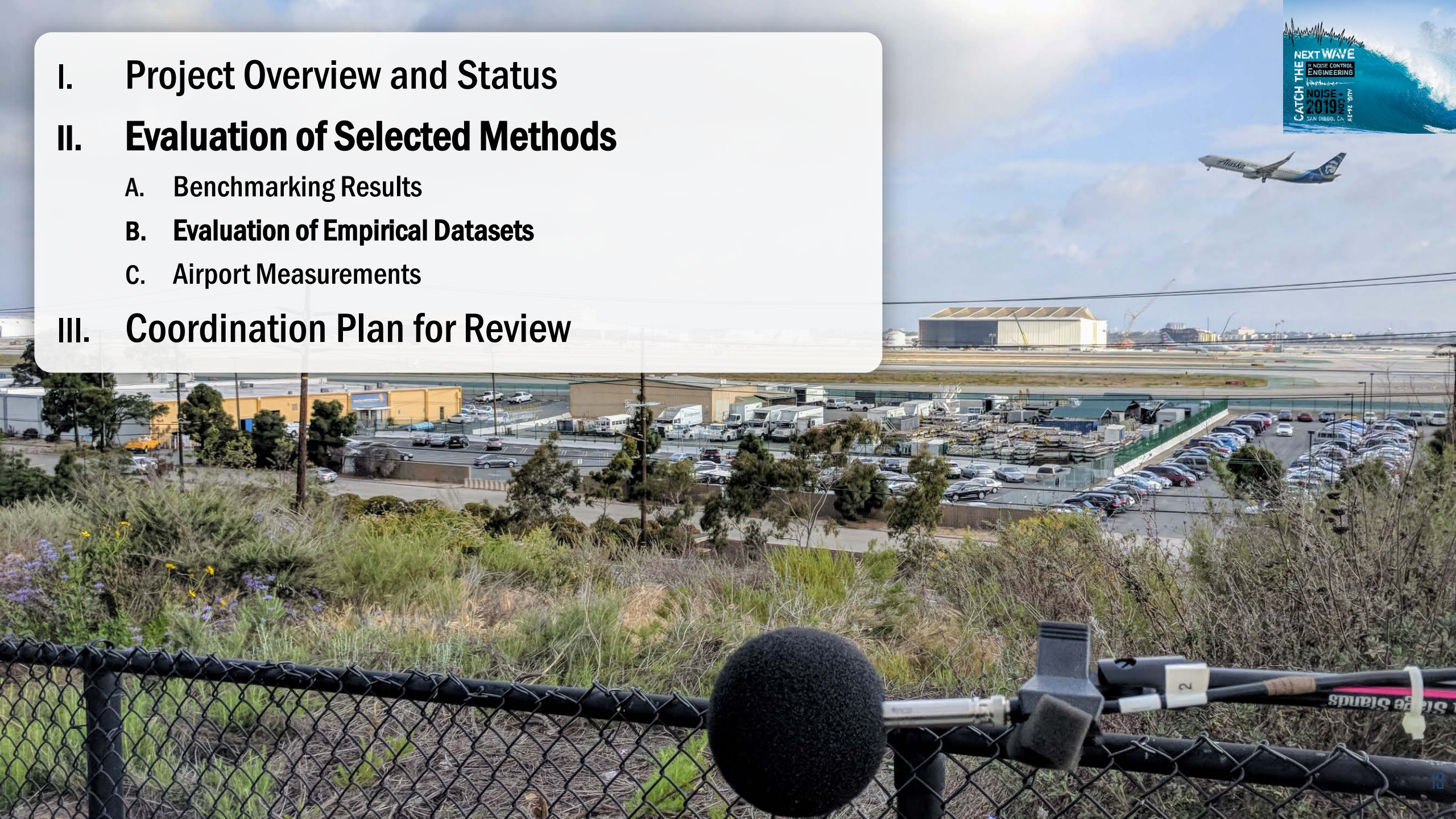
Building: 64 m H x *W x 64 m D



Benchmarking Dataset

Summary

- Provides a detailed comparison of models and methods
- Demonstrates general trends
- Provides an initial estimate of the region of influence for buildings
- Will be compared with measured airport data
- Aid in defining the transition regions for the blended method



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Empirical Datasets

Models/Methods evaluated by comparing predictions to legacy empirical datasets

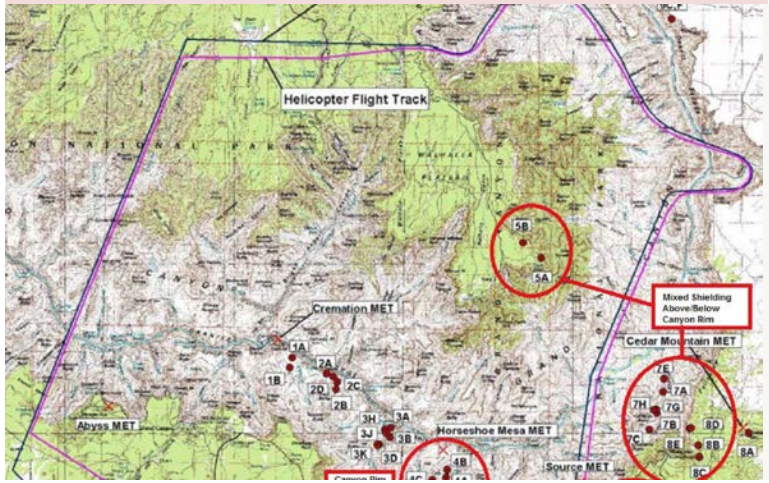
- Focused on reflection and shielding effects
- Examined with and without effect implemented

Empirical Datasets

Terrain

Narvik

Grand Canyon



Empirical Datasets

Terrain – Summary

Airborne Elevated Sources:

ISO 9613-2 | NORD2000 | AAM | NoiseMap

Ground-To-Ground Propagation:

ISO 9613-2 | NORD2000 | AAM | NoiseMap

Empirical Datasets

Manmade Structures and Barriers

NYC Urban Helicopter

NCHRP Highway

TNM Validation

Empirical Datasets

Manmade Structures – Summary

Building Reflection from Distant Source:

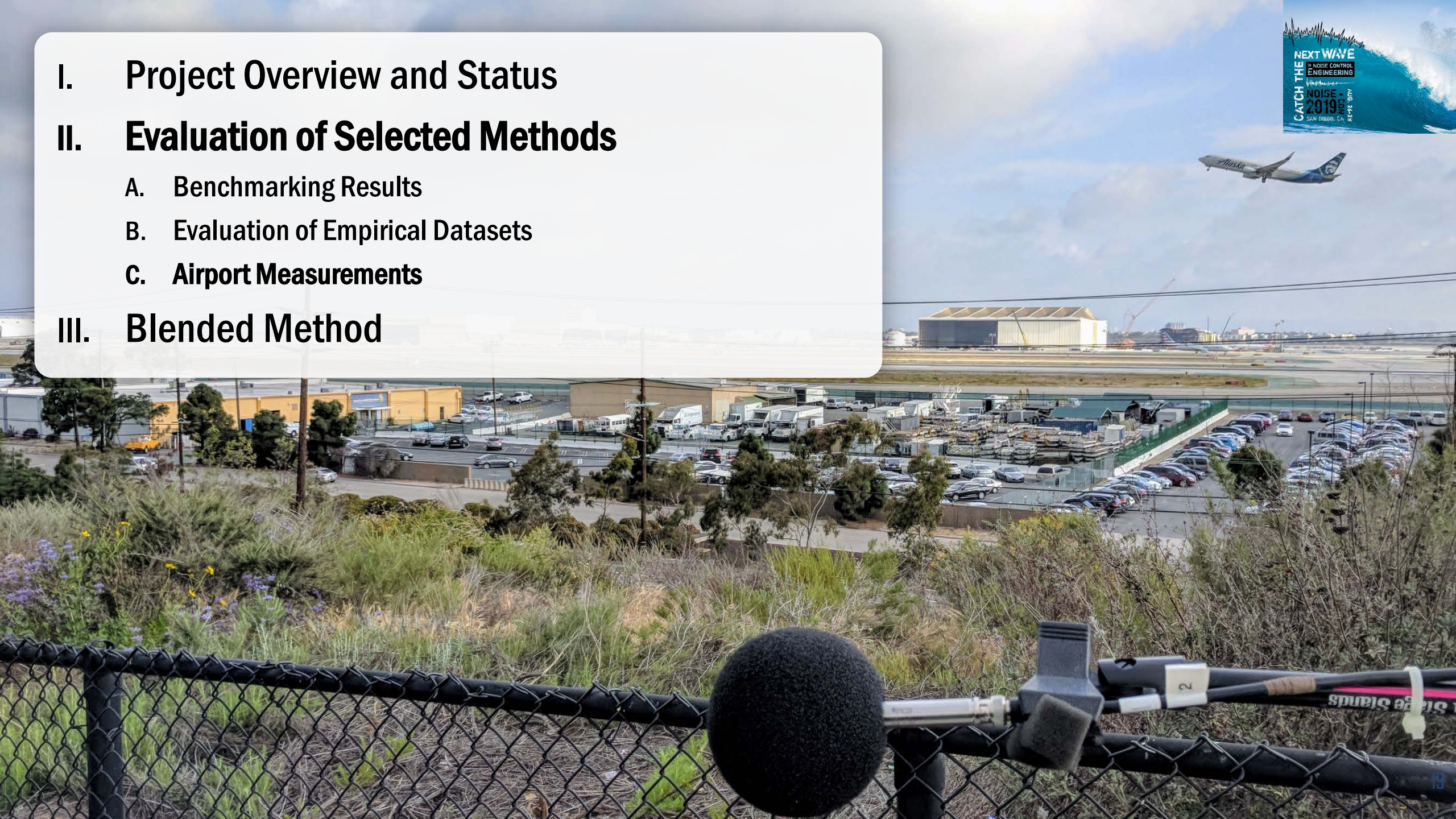
- ISO 9613-2
- NORD2000
- TNM
- Barrier Reflection Tool

Noise Wall Reflection:

- ISO 9613-2
- TNM
- Barrier Reflection Tool

Diffraction Over Noise Walls:

- ISO 9613-2
- TNM



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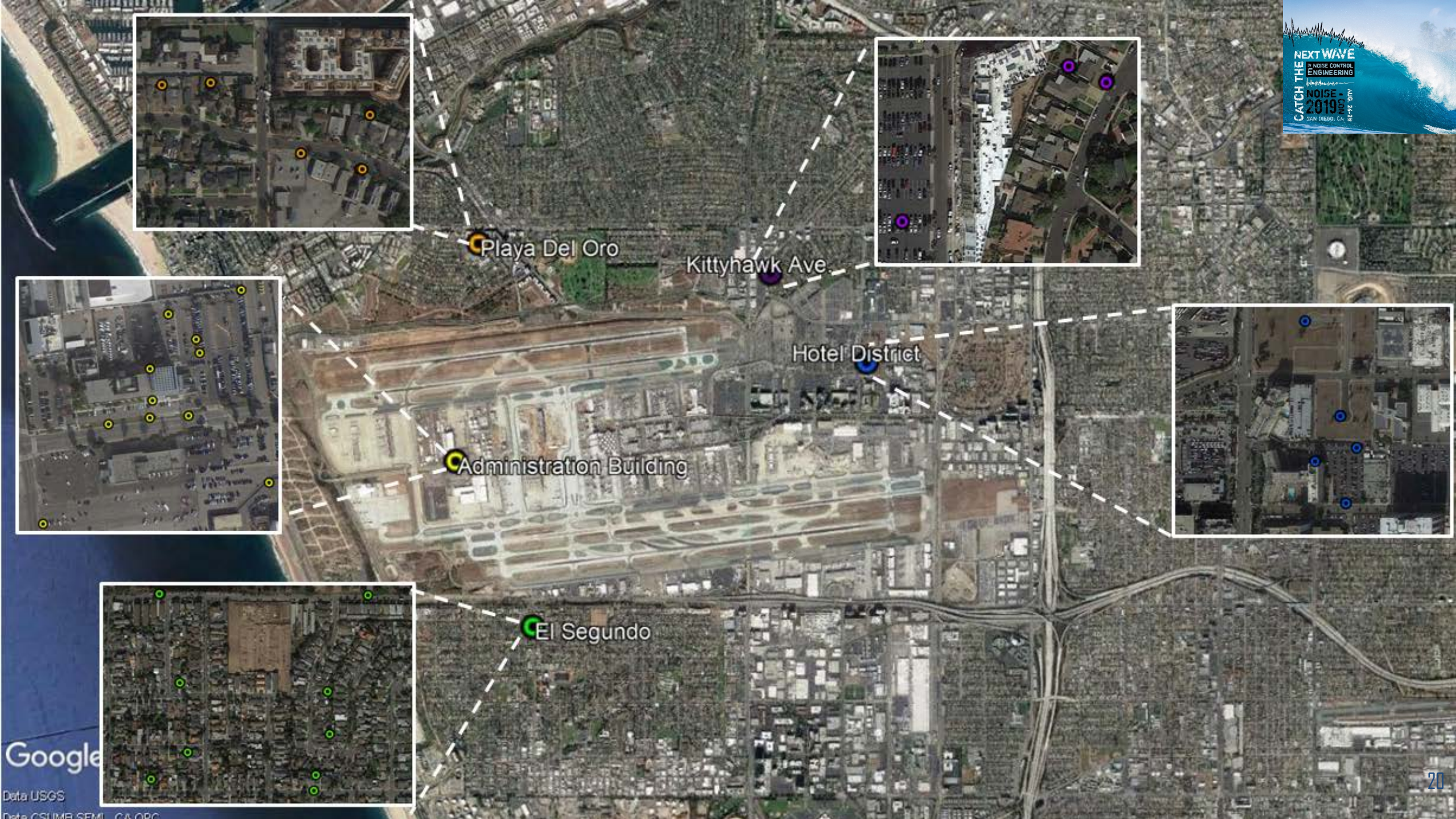
C. **Airport Measurements**

III. Blended Method


Playa Del Oro
Kittyhawk Ave
Hotel District
Administration Building
El Segundo
Google
Data USGS

Evaluation of Selected Methods: Airport Measurements

El Segundo

Measurement Notes

Most sites provide shielding and reflections from one-story houses

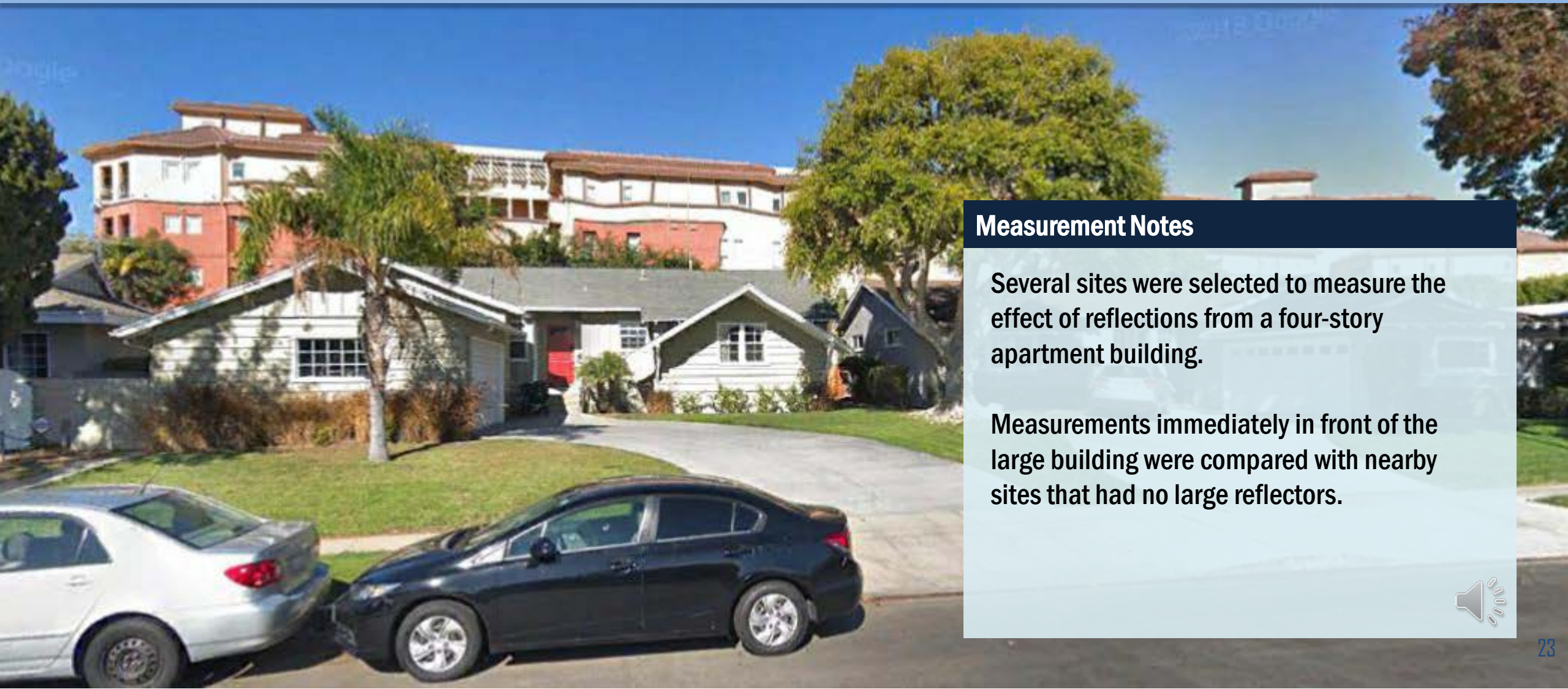
Aircraft were readily localized even when not visible

Evaluation of Selected Methods: Airport Measurements

Kittyhawk Ave

Evaluation of Selected Methods: Airport Measurements

Playa del Oro



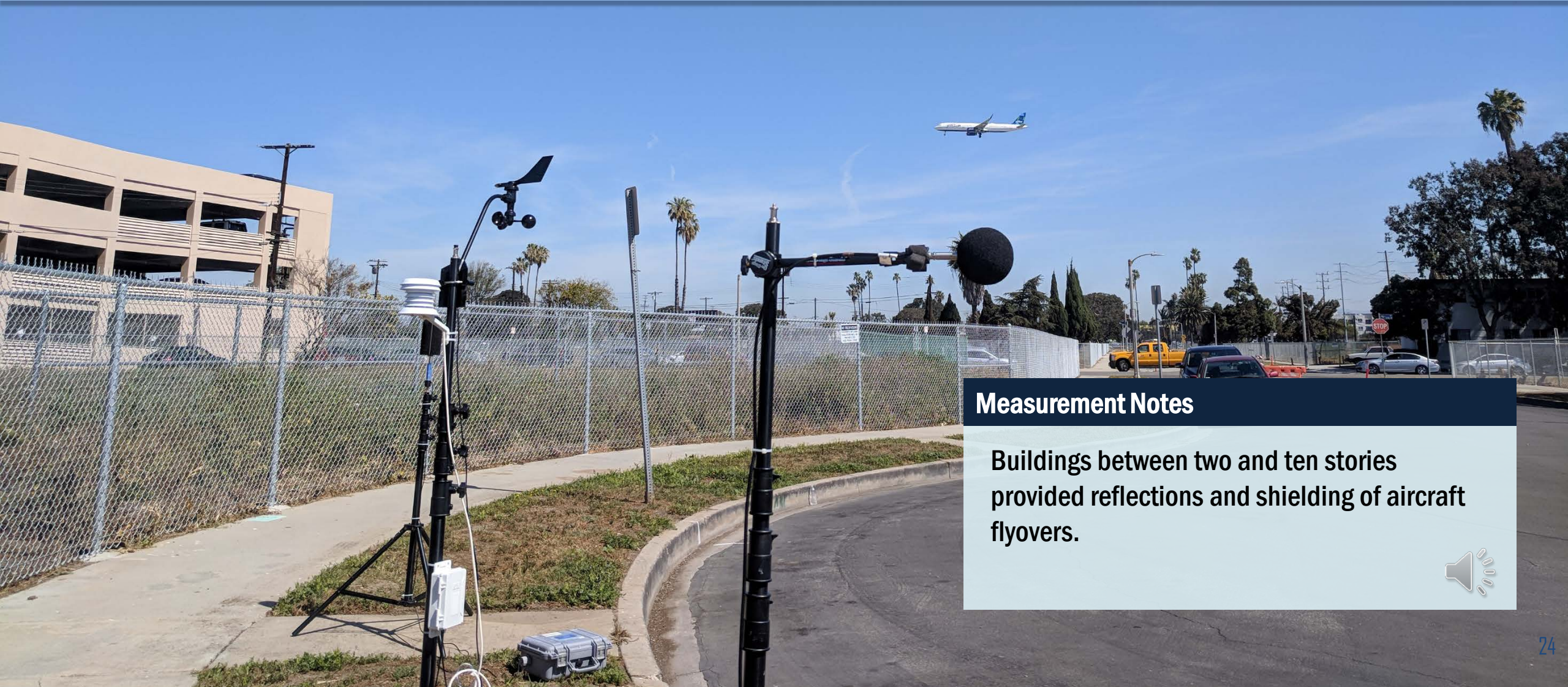
Measurement Notes

Several sites were selected to measure the effect of reflections from a four-story apartment building.

Measurements immediately in front of the large building were compared with nearby sites that had no large reflectors.

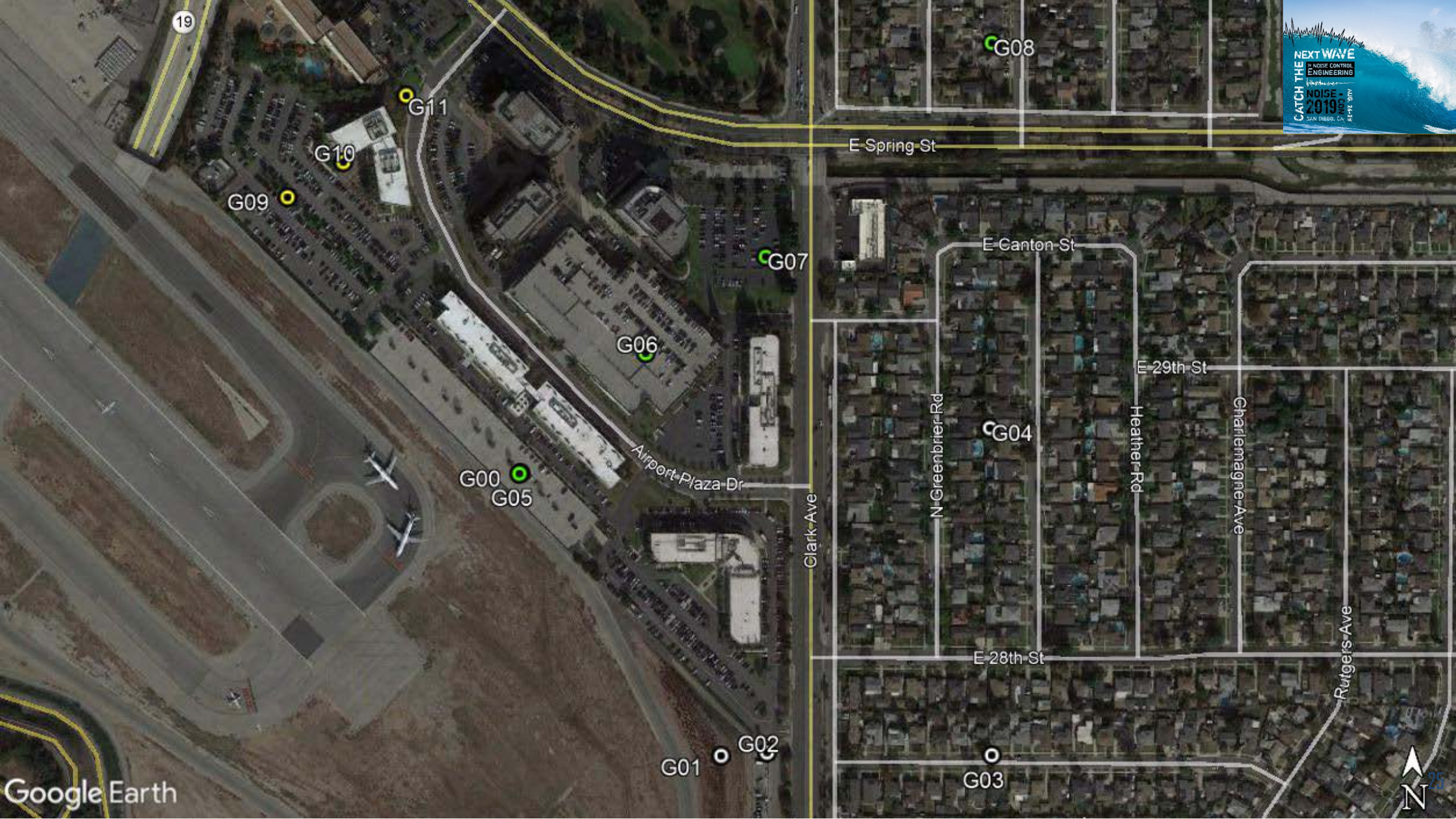
Evaluation of Selected Methods: Airport Measurements

Hotel District



Measurement Notes

Buildings between two and ten stories provided reflections and shielding of aircraft flyovers.


19
G11
G10
G09
G08
E Spring St
G07
E Canton St
G06
E 29th St
N Greenbrier Rd
G04
Heather Rd
Charlemagne Ave
Airport Plaza Dr
G00
G05
Clark Ave
E 28th St
Rutgers Ave
G02
G01
G03
Google Earth
N

Data Analysis

- Isolated events by aircraft type and airline, where possible
- 566 individual measured SEL events

Site Name	Number of Flights	Number of Sites	Number of Individual Recordings Removed	Total Measured Data Points
LGB	30	11	32	298
El Segundo	20	9	4	176
Kittyhawk	14	3	0	42
Playa del Oro	10	5	0	50

- 46 comparison events on average, grouped by operation type and shielding/reflection effect
- Calculated SEL and L_{Amax} for each event with AEDT
- Calculated difference between average measured values ($\boldsymbol{M_{SEL}}$) versus predicted ($\boldsymbol{P_{AEDT}}$)
- Compared the calculated Gain/Loss ($\boldsymbol{GL_{BM}}$) with the differences

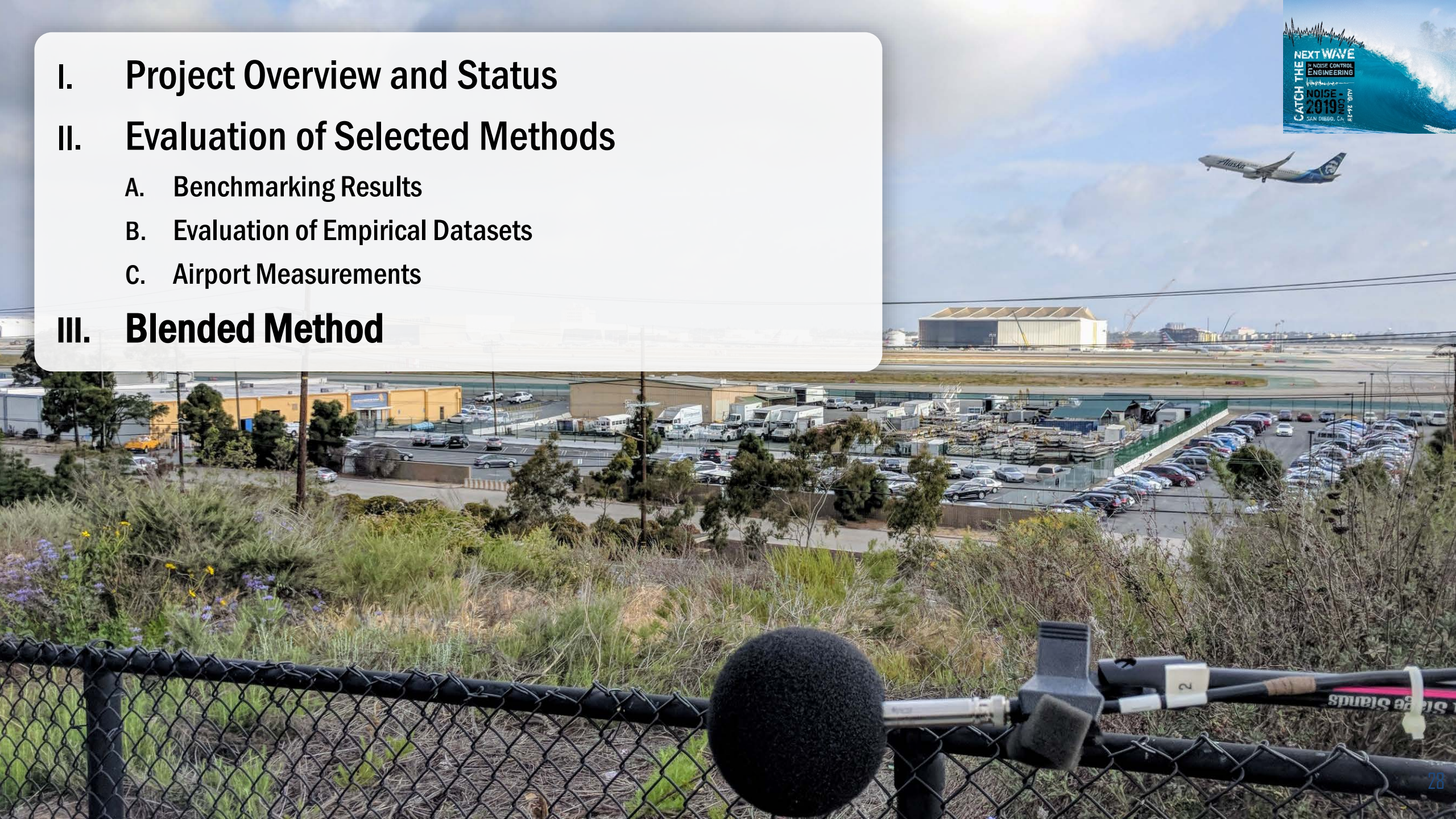
Summary of Results

- Overall SEL Comparisons

Operation Type	Measured-AEDT		Offset TNM		Offset ISO 9613-2	
	Ave	St Dev	Ave	St Dev	Ave	St Dev
All	-1.9	4.8	0.9	3.9	0.1	4.4
Arrival	-0.1	2.7	0.2	2.8	-1.2	3.8
Departure	-2.3	4.9	1.4	3.9	0.6	4.2

- Grouped SEL Comparisons

Op Type	Effect	Measured-AEDT		Offset TNM		Offset ISO 9613-2	
		Ave	St Dev	Ave	St Dev	Ave	St Dev
Arrivals	Shielding	-0.9	3.5	-0.3	3.7	-1.8	5.3
	Reflection	0.3	2.3	0.5	2.4	-0.9	3.2
Departures	Shielding	-5.8	4.6	2.0	5.0	2.1	5.2
	Reflection	0.6	3.3	0.6	3.1	-0.6	3.1



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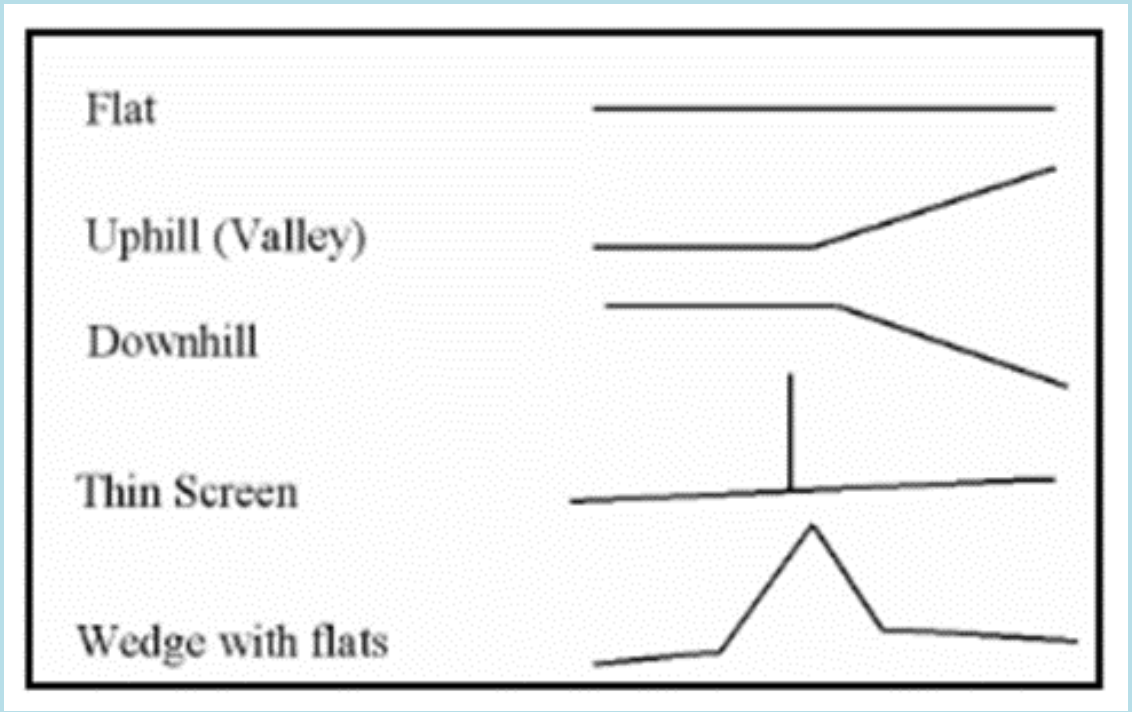
Overview of Blended Method

Terrain

Buildings

Blended Method

➢ AAM Terrain Algorithms



- NoiseMap integration method
- Included over entire calculation region

Overview of Blended Method

Terrain

Buildings

Blended Method

➢ TNM 3.0

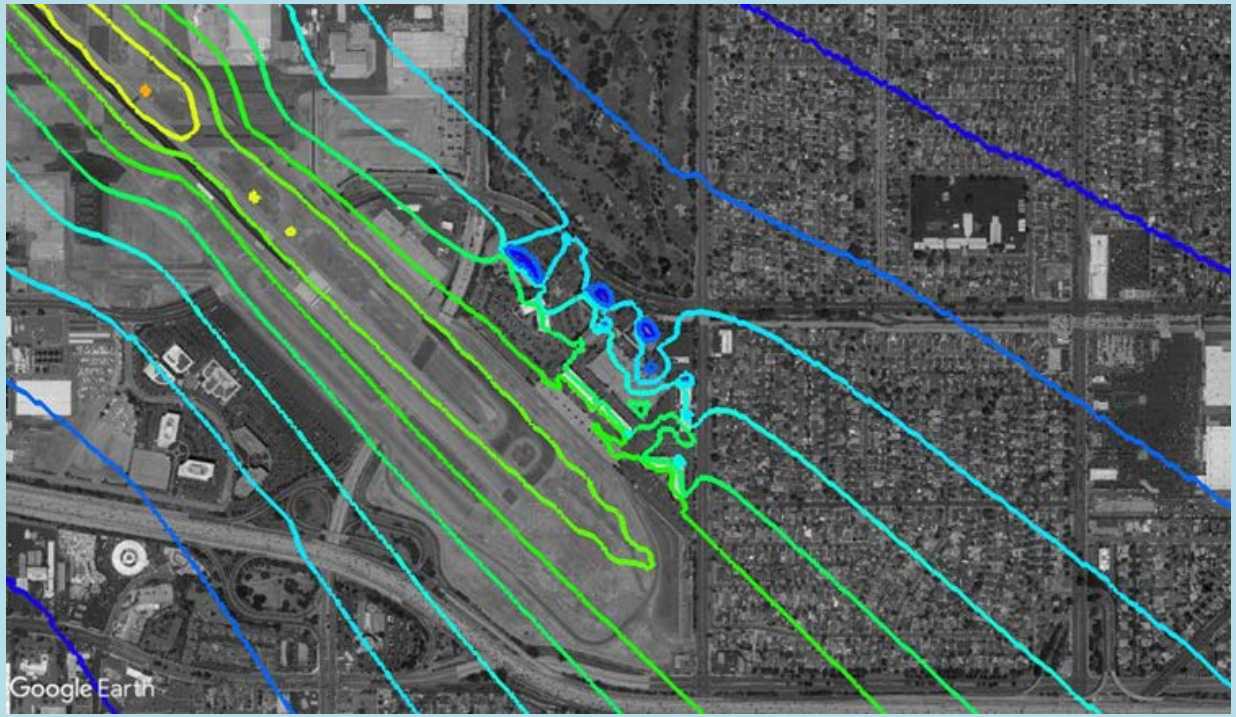
- Populate with building data

- Each unique trajectory
- Calculate OTOB gain/loss factors
- Dense array

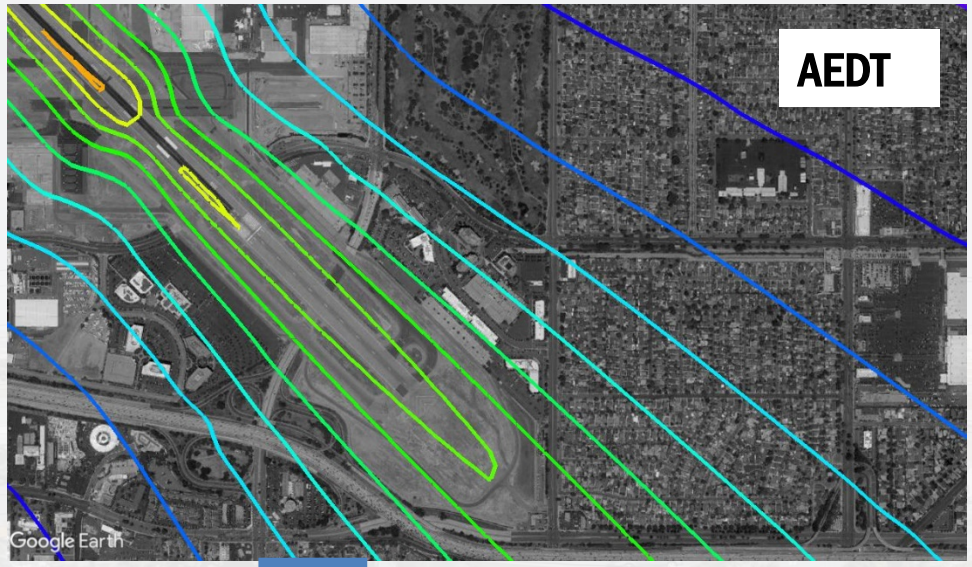
Overview of Blended Method

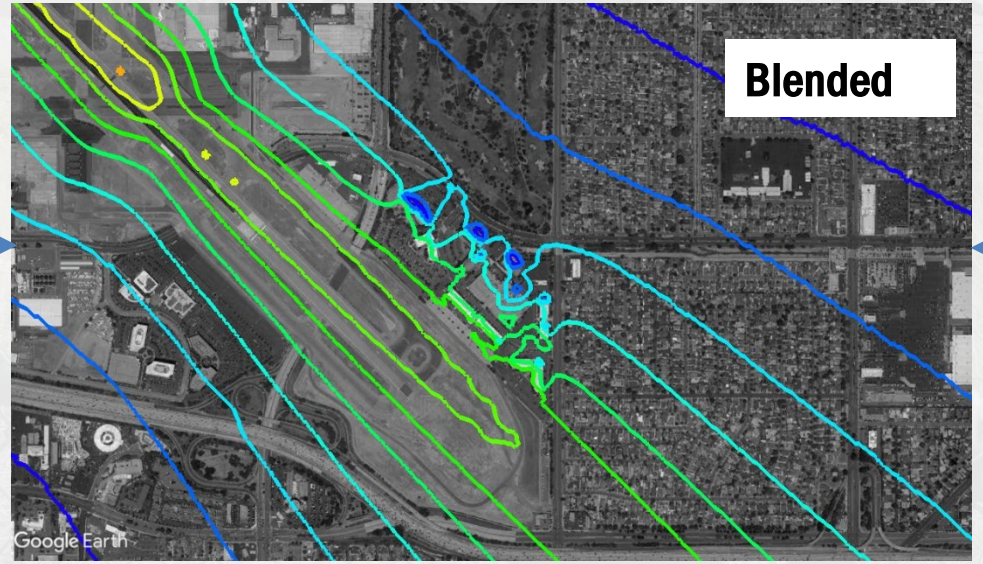
- Terrain
- Buildings
- **Blended Method**

Utilizing linear acoustics, predictions obtained in the existing AEDT integrated framework can be combined with reflection gains and insertion loss from nearby structures



Blended Method Calculation





Building Effect: Stand-Alone Calculation

TNM 3.0

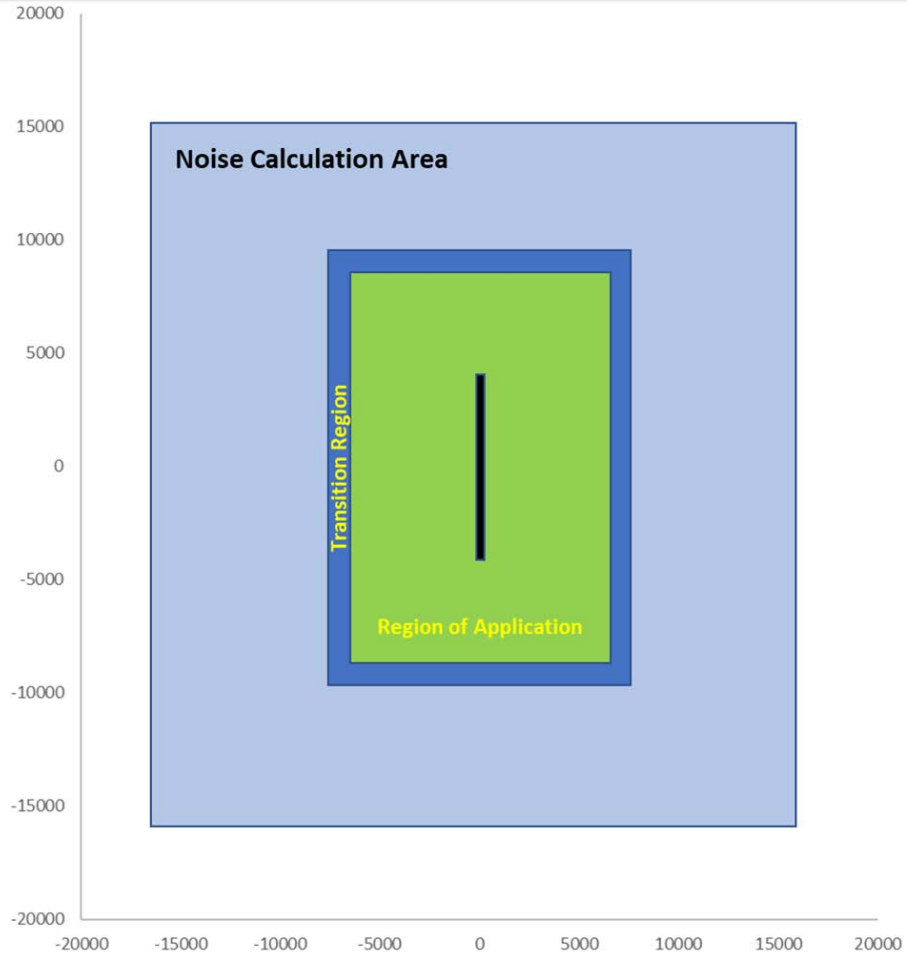
AAM/NoiseMap

Advantages

- One-time calculation of gain/loss on a 1/3-octave band basis
- Develop a library of gain/loss factors that can be applied to AEDT results
- Toggle results on/off
- Provide efficient computations
- Capture localized building effects

Blended Method Region of Influence

- **Based on Magnitude of Effects**
  - Driven by shielding loss
  - Driven by arrivals
- **Extent**
  - Based on <0.5 dBA shielding effect
  - Based on 152 m AGL
  - 2,621 m along extended runway centerline
  - 2,200 m lateral to runway
- **Transition Region**
  - Simple linear interpolation
  - 1,000 ft distance (<0.5 dBA change)




Questions
Google Earth

AEDT Integration

- **Interface with AEDT**
  - Operations defined using current AEDT input method
  - Buildings imported via 3D layers and/or direct user input
- **TNM 3.0 (modified) calculates building gain/loss**
- **Returns a library of gain/loss grids to AEDT**
- **AEDT applies gain/loss grids to output to account for building gain/loss (blended method)**