Blast Noise Measurements and Community Response

April 16, 2015

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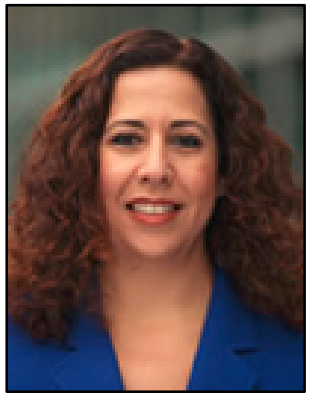
Welcome and Introductions

Rula Deeb, Ph.D.
Webinar Coordinator



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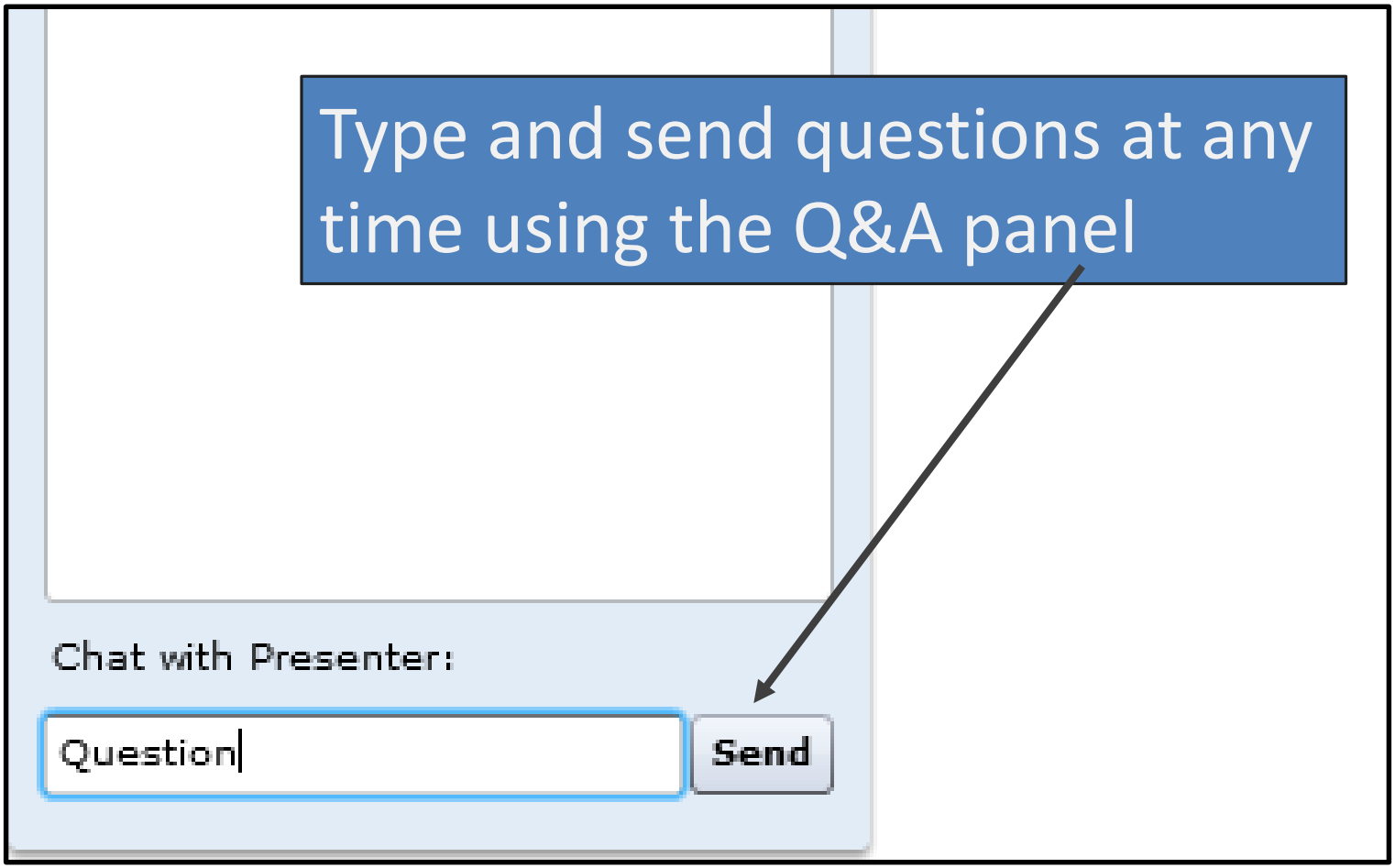
Webinar Agenda

- Webinar Overview and ReadyTalk Instructions
  Dr. Rula Deeb, Geosyntec (5 minutes)
- Overview of SERDP and ESTCP
  Dr. Robin Nissan, SERDP and ESTCP (5 minutes)
- A Network of Remote Sensors for Military Noise Monitoring
  Mr. Jeffrey Allanach, Applied Physical Sciences Corporation (20 minutes + Q&A)
- Investigation of Community Attitudes towards Military Blast Noise
  Dr. Edward Nykaza, U.S. Army Engineer Research and Development Center (35 minutes + Q&A)
- Final Q&A session

How to Ask Questions



SERDP and ESTCP Overview

Robin Nissan, Ph.D.

Weapons Systems and Platforms Program Manager

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SERDP

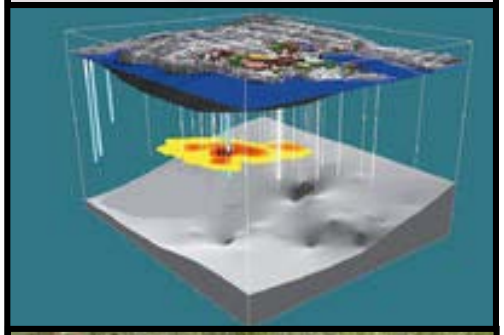
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

Program Areas

1. Energy and Water
2. Environmental Restoration
3. Munitions Response
4. Resource Conservation and Climate Change
5. Weapons Systems and Platforms


Weapons Systems and Platforms

- Manufacturing and maintenance
  - Green materials and processes (principally related to corrosion mitigation)
  - Control and monitoring
  - Depots, field, shipyards and OEMs
- Green energetics
  - New materials
  - Alternative manufacturing
- Air and noise emissions
  - Gas turbine and diesel engines
  - Weapons and munitions
  - Ship and industrial

SERDP and ESTCP Webinar Series

DATE	Topics
May 7, 2015	Factor Affecting Munitions Mobility and In Situ Measurements
May 28, 2015	Managing Munition Constituents on Training Ranges
June 11, 2015	LED-ing the Way: Sophisticated and Energy Efficient Exterior Lighting Systems for DoD Installations
June 25, 2015	Energetics: Colored Smokes and Flares
July 16, 2016	Watershed Assessment and Stormwater Management Optimization Tools
August 20, 2015	Characterization and Remediation in Fractured Rock Environments
September 17, 2015	Munitions Response: Water Geophysical Sensors
October 1, 2015	Hexavalent Chrome Elimination from Hard Chrome Surface Finishing
October 15, 2015	Remote Methods for Water Conservation
October 29, 2015	Assessment and Treatment of Contaminated Sediments
November 12, 2015	Munitions Response: Land Based Program Closeout
December 3, 2015	Emerging Contaminants: DoD Overview and State of Knowledge on Fluorochemicals and 1,4-Dioxane
December 17, 2015	Resource Conservation and Climate Change

SERDP & ESTCP Webinar Series

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

A Network of Remote Sensors for Military Noise Monitoring

Jeffrey Allanach

Applied Physical Sciences Corporation

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A Network of Remote Sensors for Military Noise Monitoring

ESTCP WP-201117

Jeffrey Allanach
Applied Physical Sciences Corporation

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Agenda

- The need for military noise monitoring
- Technical challenges
- Technology solution
  - ***Blast Noise Bearing and Amplitude Measurement and Analysis System (BAMAS)***
- System design
- Demonstration
- Test results
- Technology transfer

Military Blast Noise

- Blast noise is an unintended consequence of military testing and training activities
- Blast noise is intense sound created by large weapons, heavy artillery and explosives
- U.S. military bases use noise monitoring systems to measure the amplitude and frequency of blast noise events
- Noise monitors are a vital component for monitoring and planning testing activities

Military Noise Monitors

- Continuous and unattended noise monitoring is challenging
- Wind can overwhelm the user with thousands of false recordings
- Military testing is a 24/7 operation so noise monitor must work in ALL weather conditions
- In 2003, SERDP identified the need for an improved noise measurement system

Technology Solution

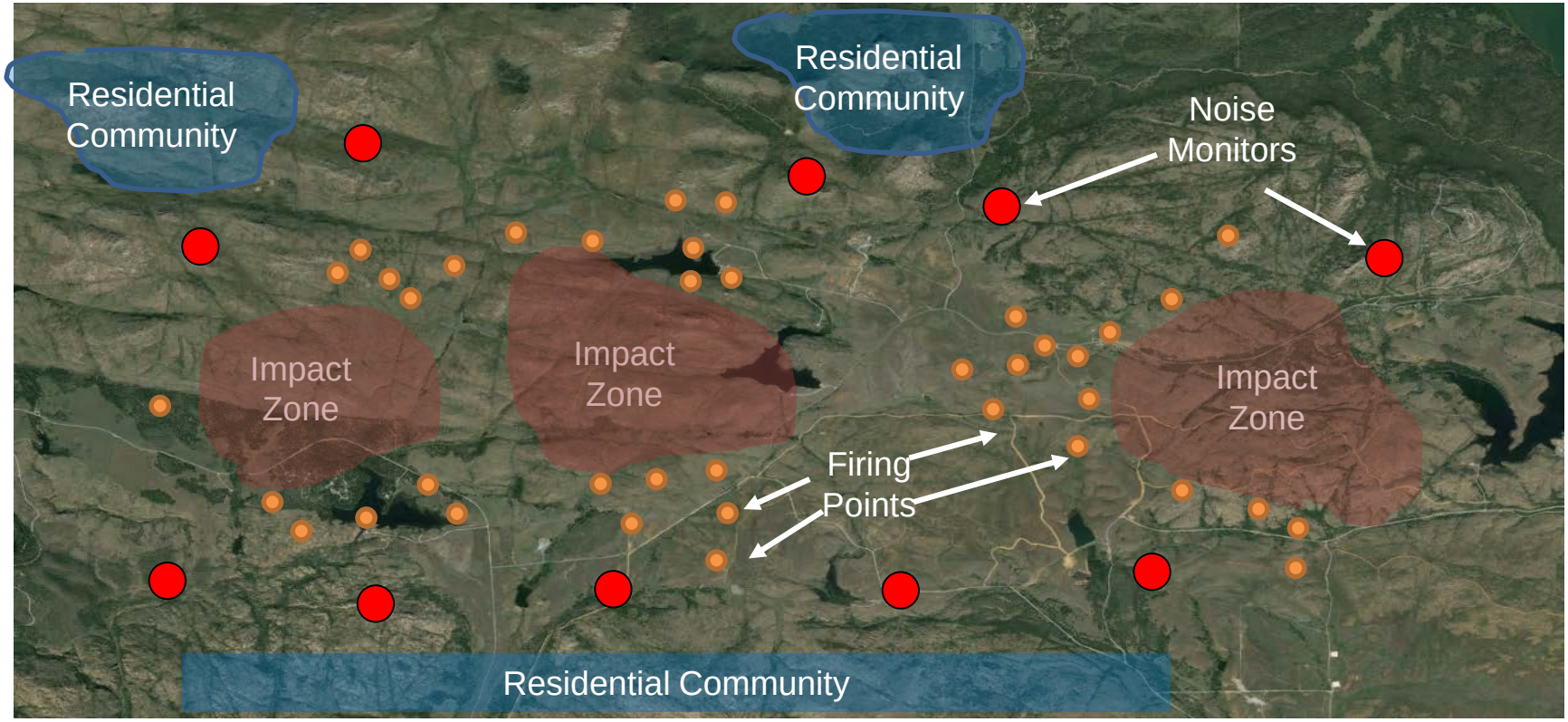
Blast Noise Bearing and Amplitude Measurement and Analysis System (BAMAS)

- Wind mitigation
  - Microphone array
  - Measure wave propagation speed and reject events below speed of sound
- Noise classification
  - Employ neural net-based classification algorithm to distinguish between different sounds
- Other desirable features
  - Sound localization
  - Improved user interface
  - Improved reliability noise monitor

BAMAS Noise Monitor

Hypothetical Scenario

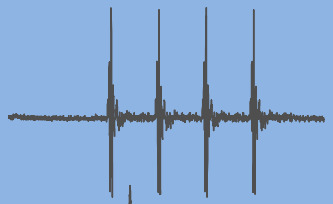
- The problem of blast noise is compounded by the encroachment of residential communities around military lands
- Noise monitors need to be installed around the perimeter of a very large area (~100 miles^2) to maintain coverage



BAMAS Technology Overview

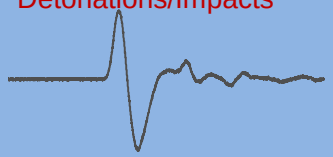
- Advanced noise monitoring system for U.S. military installations
- Real-time signal detection and classification software
- Noise source localization
- Automated recording and email notifications
- Data outputs to Google Earth, Excel
- Web tool for data analysis, verification, and visualization
- Cellular data communications
- Solar powered

Small Arms Fire



Artillery Fire

Detonations/Impacts

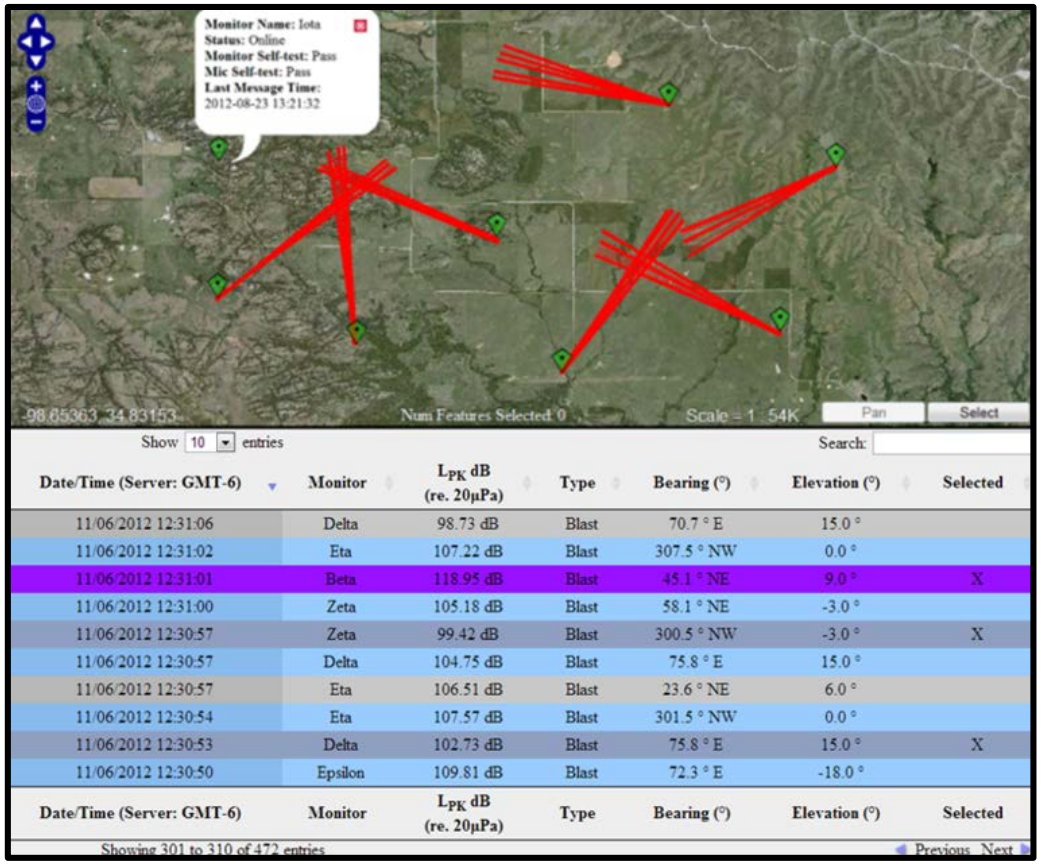


BAMAS Technology Overview

- Data from multiple noise monitors are fused together on a GIS map and dynamic table to aid analyst in determining the noise source location

Network of BAMAS Noise Monitors

BAMAS Website



Date/Time (Server: GMT-6)	Monitor	L_{PK} dB (re. 20µPa)	Type	Bearing (°)	Elevation (°)	Selected
11/06/2012 12:31:06	Delta	98.73 dB	Blast	70.7 ° E	15.0 °	
11/06/2012 12:31:02	Eta	107.22 dB	Blast	307.5 ° NW	0.0 °	
11/06/2012 12:31:01	Beta	118.95 dB	Blast	45.1 ° NE	9.0 °	X
11/06/2012 12:31:00	Zeta	105.18 dB	Blast	58.1 ° NE	-3.0 °	
11/06/2012 12:30:57	Zeta	99.42 dB	Blast	300.5 ° NW	-3.0 °	X
11/06/2012 12:30:57	Delta	104.75 dB	Blast	75.8 ° E	15.0 °	
11/06/2012 12:30:57	Eta	106.51 dB	Blast	23.6 ° NE	6.0 °	
11/06/2012 12:30:54	Eta	107.57 dB	Blast	301.5 ° NW	0.0 °	
11/06/2012 12:30:53	Delta	102.73 dB	Blast	75.8 ° E	15.0 °	X
11/06/2012 12:30:50	Epsilon	109.81 dB	Blast	72.3 ° E	-18.0 °	
Date/Time (Server: GMT-6)	Monitor	L_{PK} dB (re. 20µPa)	Type	Bearing (°)	Elevation (°)	Selected

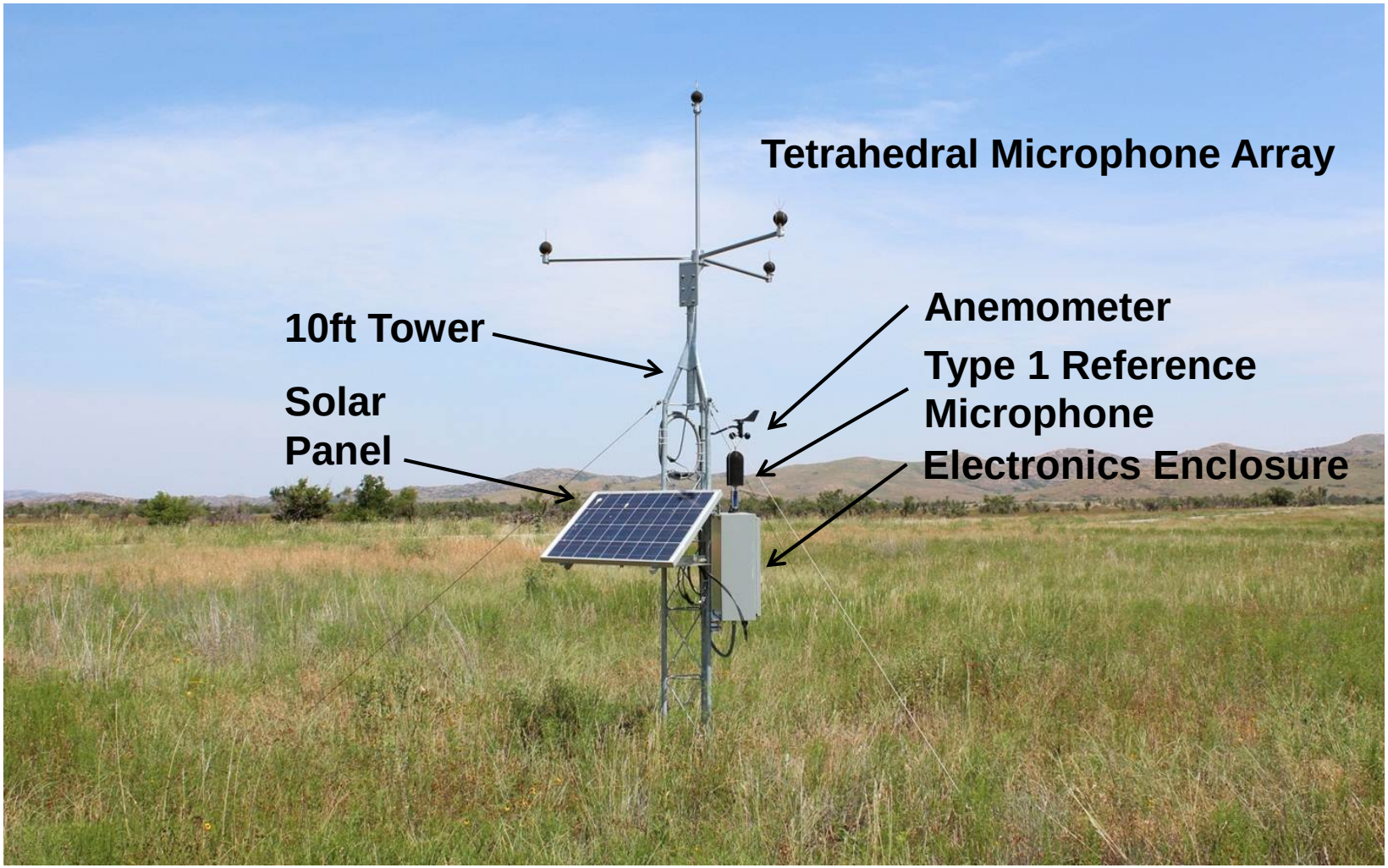
Technology Demonstration

- Under SERDP funds, we developed the initial technology
- Under ESTCP funds, we demonstrated that it can work in a real operational environment
- Demonstration objectives
  - Demonstrate robust and reliable system in all weather conditions
  - Demonstrate system can run continuously and unattended over a long period
  - Validate blast noise detection and classification algorithms
  - Develop user-friendly website
  - Transfer the technology

Technology Demonstration

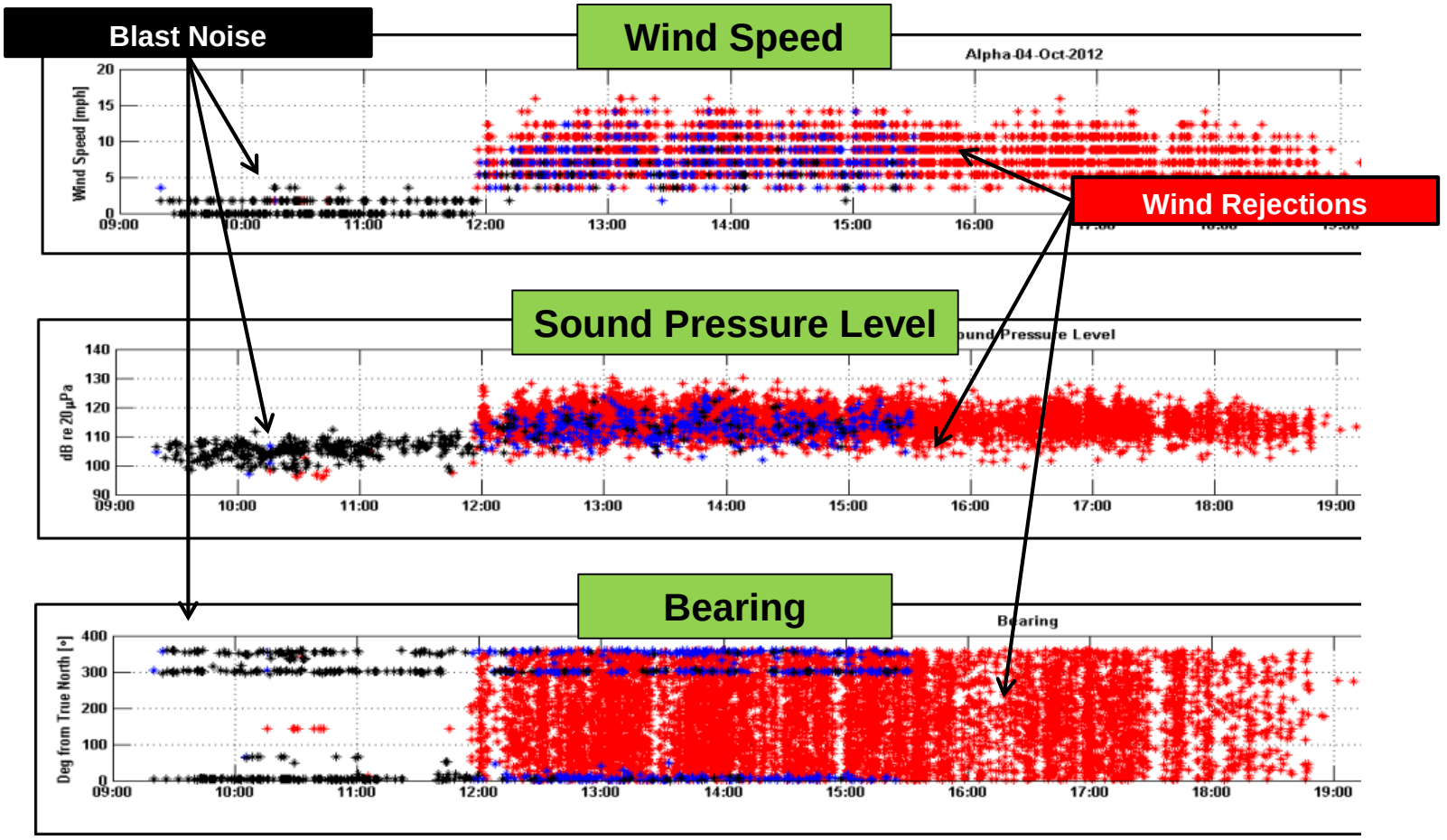
- Built and deployed a network of 9 BAMAS noise monitors at a large U.S. military installation (~100 square miles)
- Collected and then analyzed noise recordings over a 12 month period
- System analyzed >33 million noise events above 95dB
- Recorded >450,000 military blast, aircraft and small arms fire events exceeding 95dB re. 1µPa during that time
- Provided end-users with access to website for feedback on capabilities potential improvements

BAMAS Noise Monitor



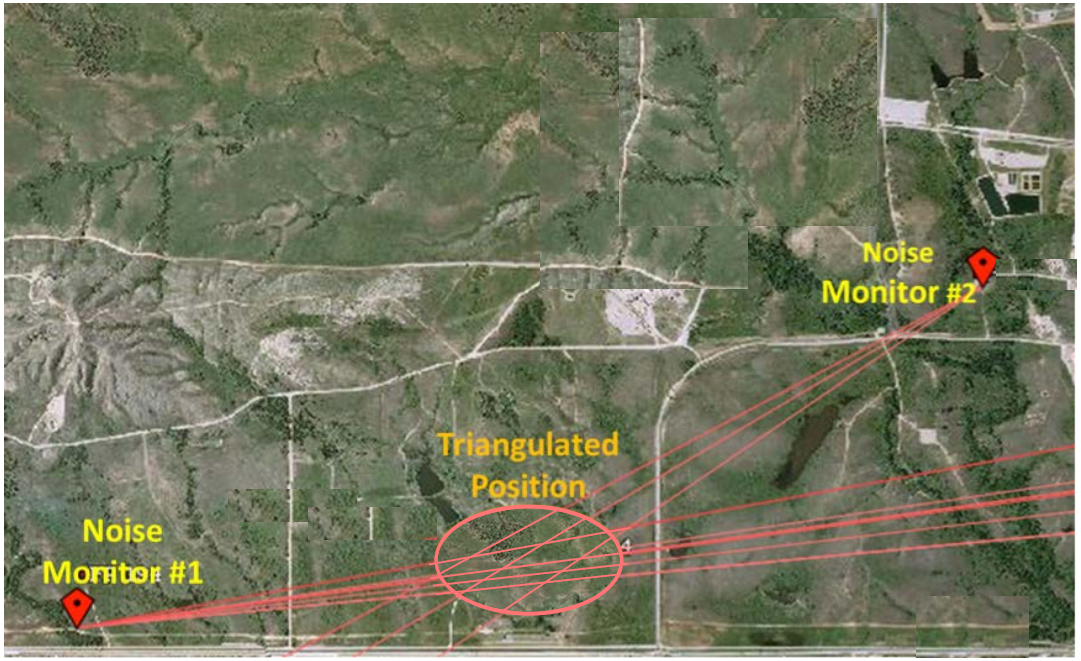
Wind Trigger Rejection

- Demonstrated BAMAS noise monitors reject > 99.9% of wind trigger



Blast Noise Localization

- Two or more BAMAS noise monitors can be used to triangulate the position of a blast event
- Accuracy of triangulated position mostly a function of environmental conditions (in particular wind)
- Experimental results show 2 noise monitors can be used to identify the firing point or even the impact point



User Interface

- Display historical AND real-time noise data
- GIS map
- Time, sound level, location, sound type
- Noise signature display, playback and download
- Export data to Excel, Google Earth or other analysis program

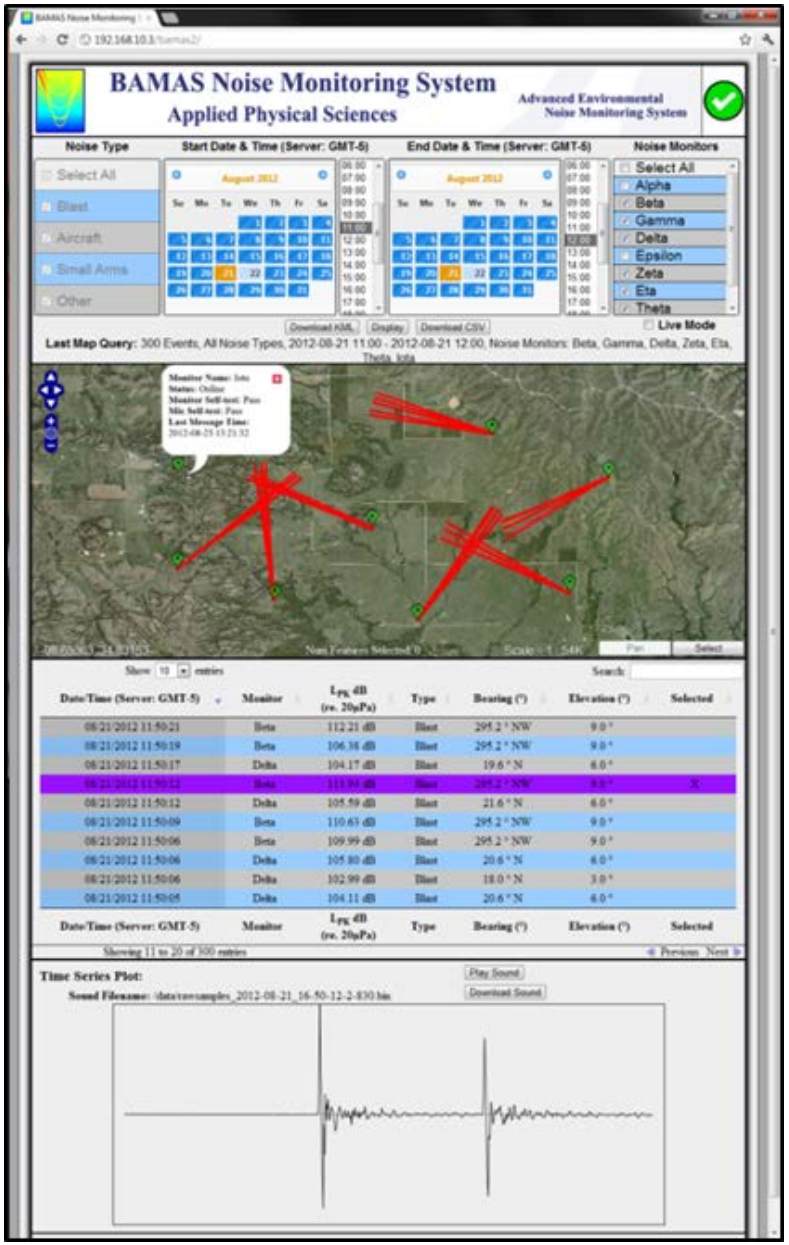
Health Monitor:

Show 10 entries Search:

Id	Monitor Name	Status	Self-test	Mic. Self-test	Battery Voltage	Logic Voltage	Array Mic. Voltage	Ref. Mic. Voltage	Last Heard Time (Server: GMT-5)
1	Alpha	Online	Pass	Pass	13.547	3.286	8.987	11.843	2012-10-19 14:48:19
2	Beta	Online	Pass	Pass	13.477	3.269	8.955	11.189	2012-10-19 14:49:23
3	Gamma	Online	Pass	Pass	13.524	3.291	8.999	11.743	2012-10-19 14:49:54
4	Delta	Online	Pass	Pass	13.513	3.283	8.979	11.508	2012-10-19 14:50:00
5	Epsilon	Online	Pass	Pass	13.641	3.298	9.018	11.417	2012-10-19 14:49:29
6	Zeta	Online	Pass	Pass	13.681	3.297	9.014	11.353	2012-10-19 14:48:53
7	Eta	Online	Pass	Pass	13.606	3.274	8.949	11.555	2012-10-19 14:49:15
8	Theta	Online	Pass	Pass	13.606	3.285	8.983	11.551	2012-10-19 14:49:20
9	Iota	Online	Pass	Pass	13.631	3.287	8.986	11.377	2012-10-19 14:48:37
Id	Monitor Name	Status	Self-test	Mic. Self-test	Battery Voltage	Logic Voltage	Array Mic. Voltage	Ref. Mic. Voltage	Last Heard Time (Server: GMT-5)

Showing 1 to 9 of 9 entries Previous Next

Website: Applied Physical Sciences, 2012



Conclusions

- Military noise monitors are a vital tool for real-time feedback of blast noise levels and the planning of testing/training activities
- Conducted a large scale demonstration of the BAMAS technology at U.S. military installation
- This technology is now being used at several bases to improve their monitoring of blast noise and aircraft overflight events
- BAMAS noise monitors available online at GSA Advantage (Contract #GS-07F-393AA)

For additional information, please visit:
https://www.serdp-estcp.org/Program-Areas/Weapons-Systems-and-Platforms/Noise-and-Emissions/Noise/WP-201117/WP-201117

Jeffrey Allanach
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Q&A Session 1

Investigation of Community Attitudes Towards Military Blast Noise

Dr. Edward Nykaza
U.S. Army Engineer Research and Development Center

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Investigating Community Attitudes Towards Military Blast Noise

SERDP WP-1546

Dr. Edward T. Nykaza
ERDC-Champaign

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Agenda

- Background
- Results
- Conclusions
- Recommendations
- Implementation

Blast noise is a *persisting* problem

- U.S. Military interest in understanding how humans respond to blast noise:
  - Obligation to inform public
  - Concern about loss of training lands
  - Curfews and restrictions due to negative community reaction
  - Costs the military time and money

Blast Noise

- High-intensity impulsive noise emitted by large weapons, heavy artillery and explosions
  - Occurs intermittently
  - Low frequency acoustical energy
  - Can travel up to 20 kilometers
  - Received levels can vary by 50 dB

Predicting Community Response to Blast Noise

- Notoriously difficult problem
  - Annoyance to noise is a subjective psychological phenomenon
  - Circumstances that drive someone to complain are often numerous and complex
  - Non-acoustical factors often have the highest correlation with community response
  - Each community has unique tolerance to noise

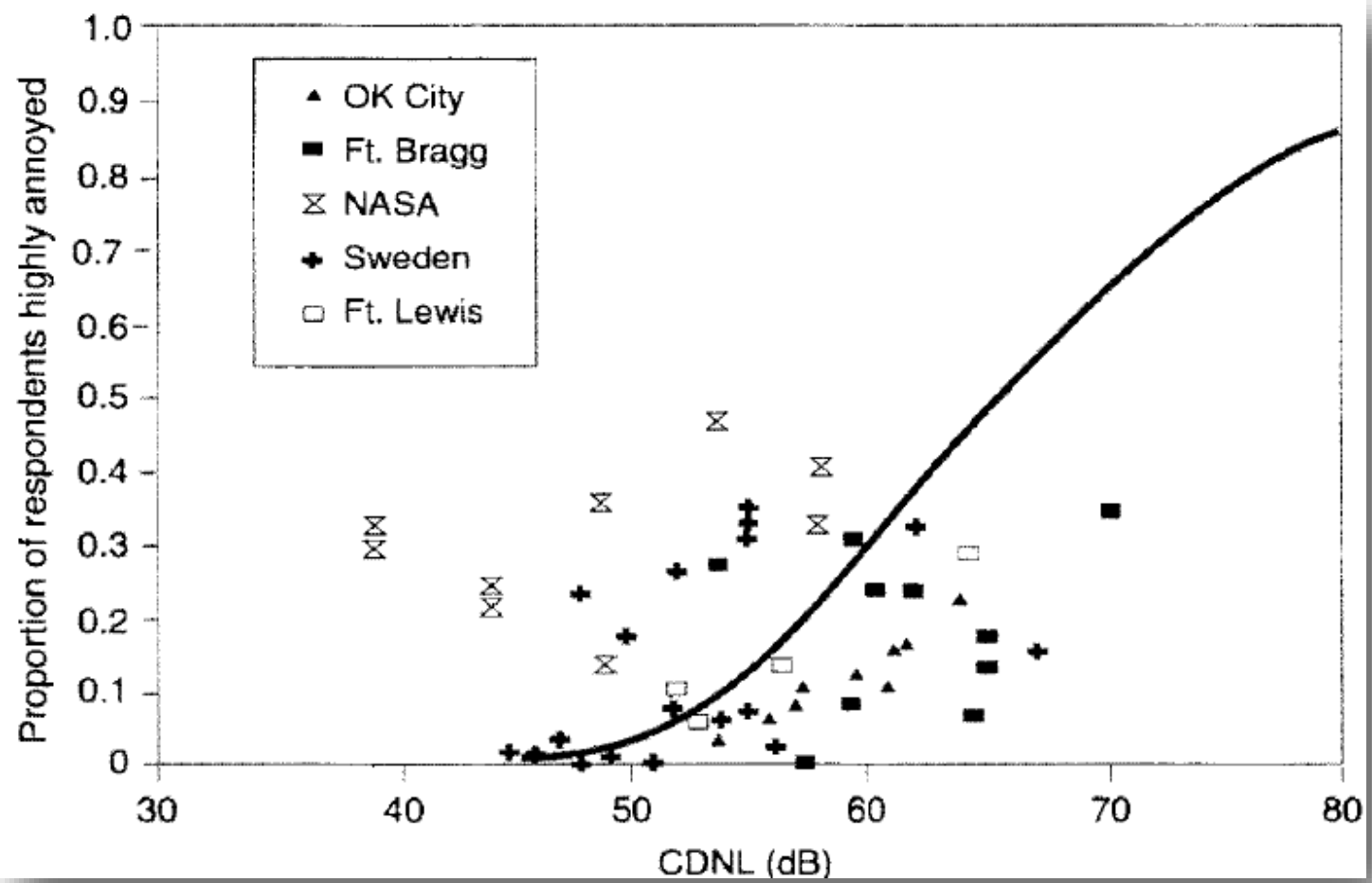
Technical Objectives
SERDP Statement of Need (2006)

1. Investigate the metrics currently used by the U.S. military to assess high-energy impulsive noise (i.e., blast noise) and assess whether these metrics adequately account for the intermittent, impulsive, nature of blasts

- Current methods/metrics
  - Annoyance predicted by yearly (≥ 250 day) time-averaged noise level (CDNL or L_{Cdn})
  - Complaint risk predicted by the maximum single event peak pressure level (L_{Zpk})

Current Blast Noise Assessment Methods

Percent highly annoyed predicted by L_{Cdn}



Reference: CHABA 1996, AR 200-1

Current Blast Noise Assessment Methods

Risk of complaints predicted by L_{Zpk}

Risk of blast noise complaints	Single Event L_{ZPk} (dB)
Low	< 115
Moderate	115-130
High	> 130
Risk of physiological damage to unprotected human ears and structural damage claims	> 140

Technical Objectives
SERDP Statement of Need (2006)

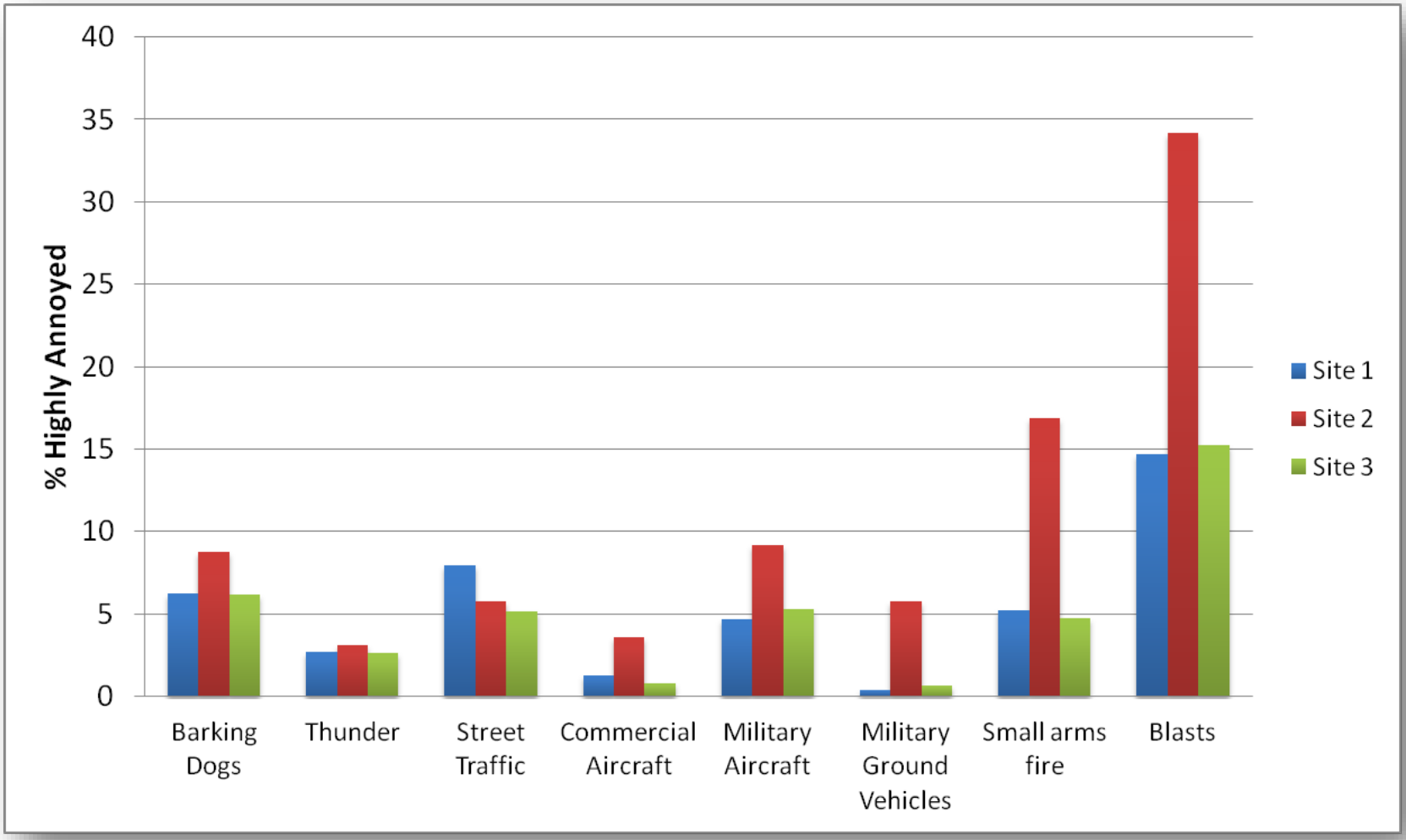
2. Examine the extent to which individual complaints are indicative of general community annoyance
3. Recommend criteria that can be used to actively manage noise at an installation so that the sustainability of testing and training is ensured

Measurement Based Approach

Study Site	CONUS Region	Start Date	End Date	Complaint Studies	*in situ*	GCS
A	Northeast	09/2008	03/2009	X		X*
B	Southeast	08/2009	07/2010		X	X
C	Midwest	08/2011	07/2012		X	X

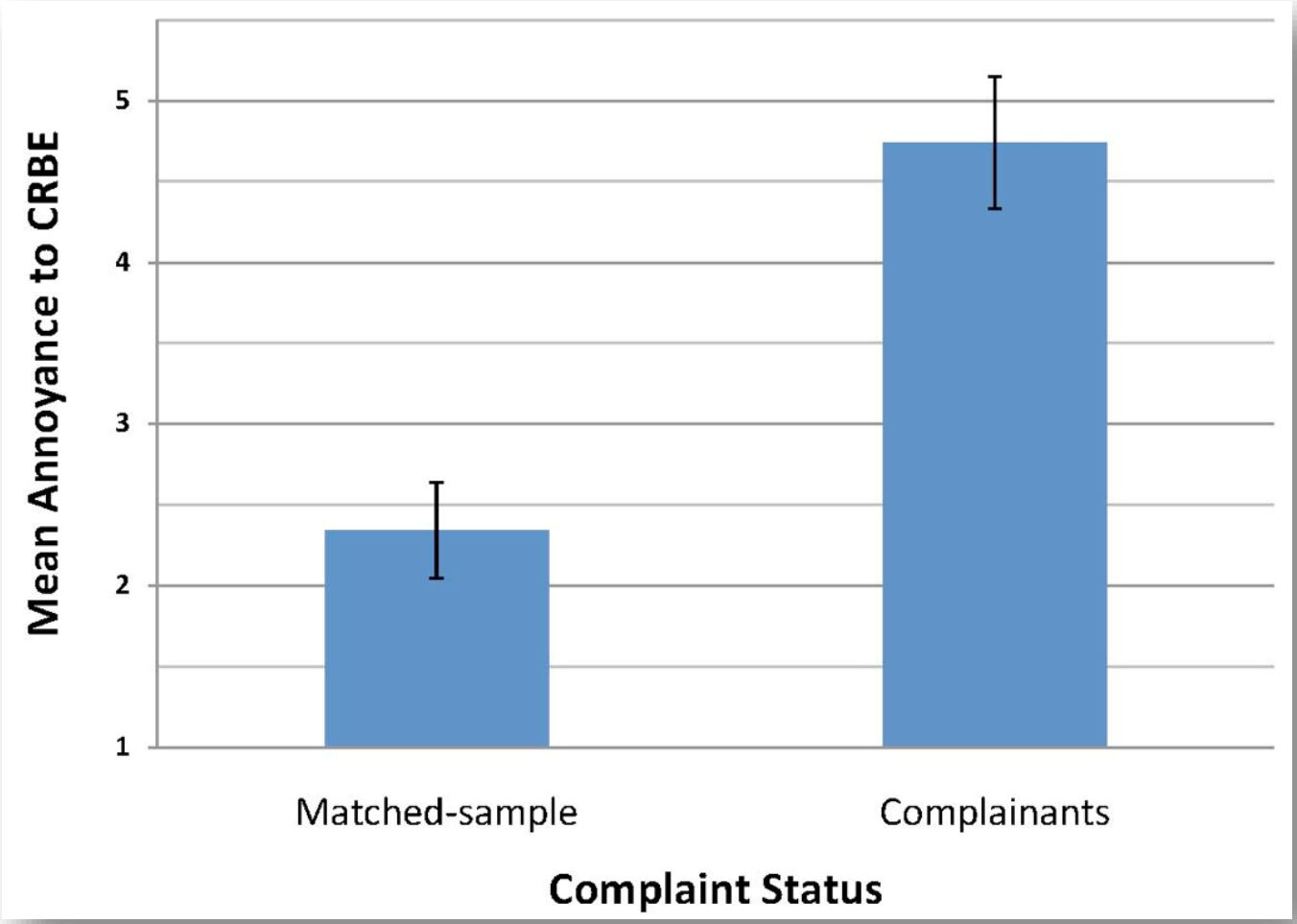
- Complaint survey/study
  - Determine the relationship between complaints and annoyance
  - Determine the probability of receiving blast noise complaints
- *In situ* survey
  - Determine how individuals respond to individual blast events
- General community annoyance survey
  - Determine how communities respond to changing noise environments

Blast noise is the most annoying source at every study location



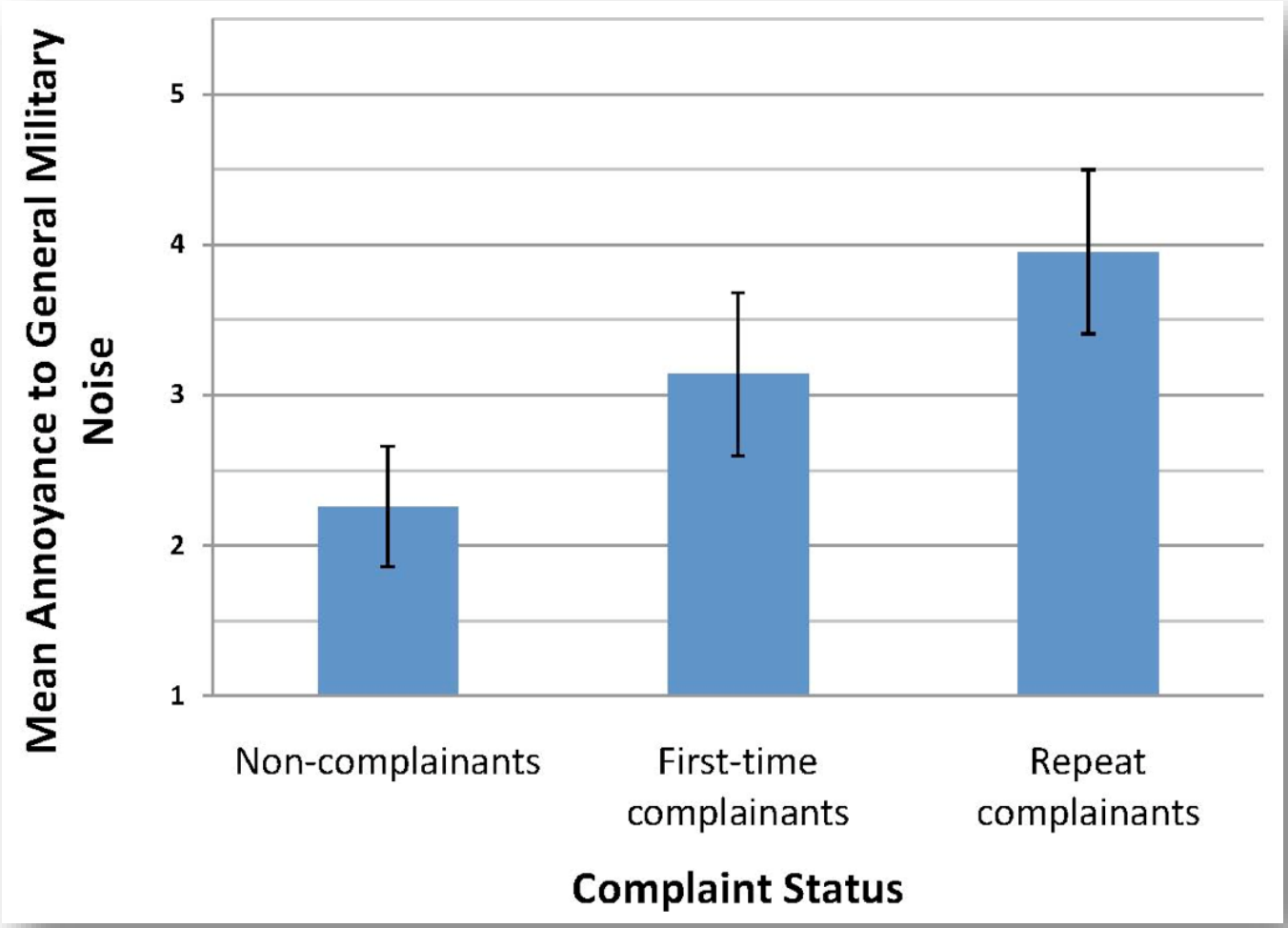
Complainers more annoyed than neighbors

Complaint referenced blast event (CRBE)

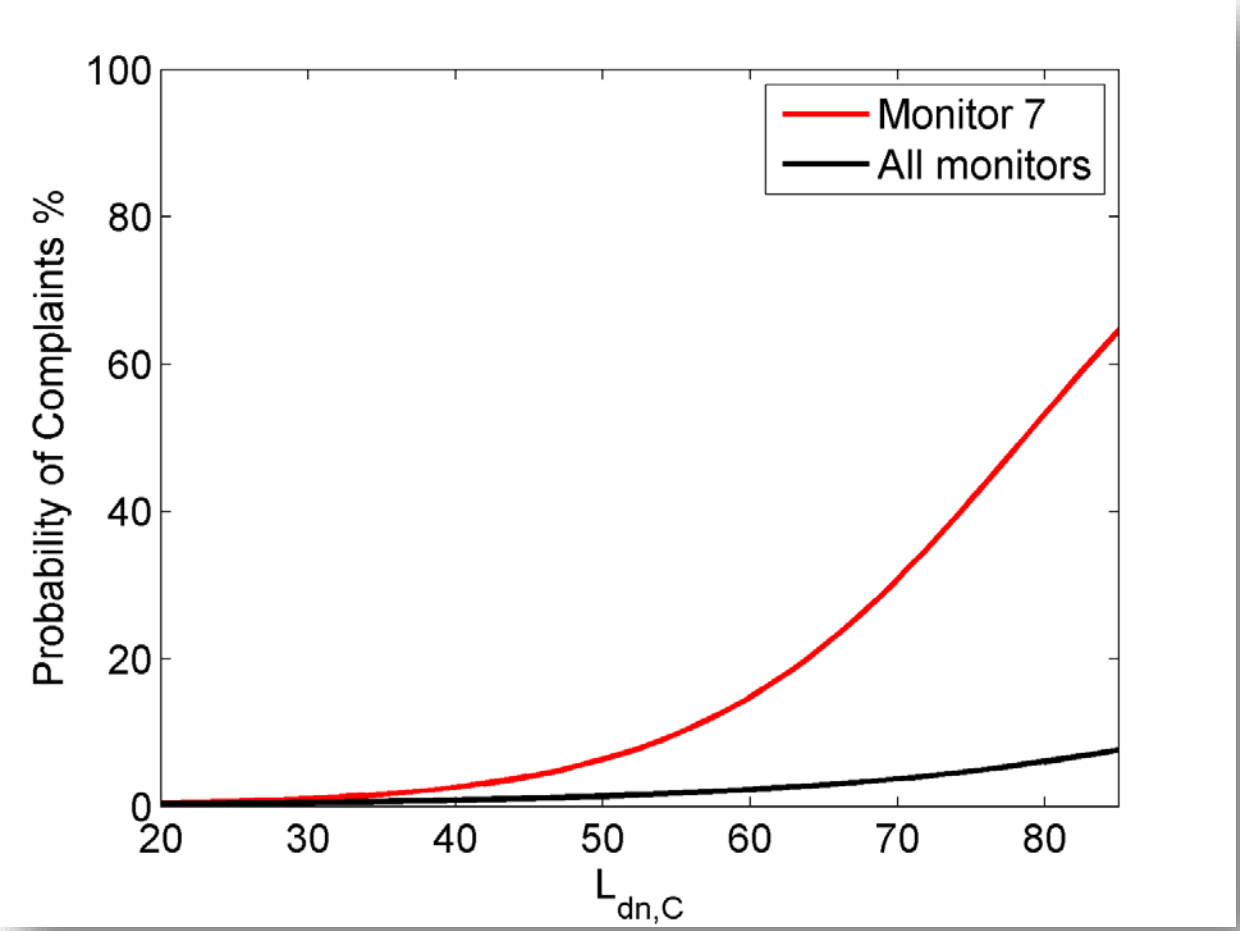


Repeat complainers are more annoyed

General military noise

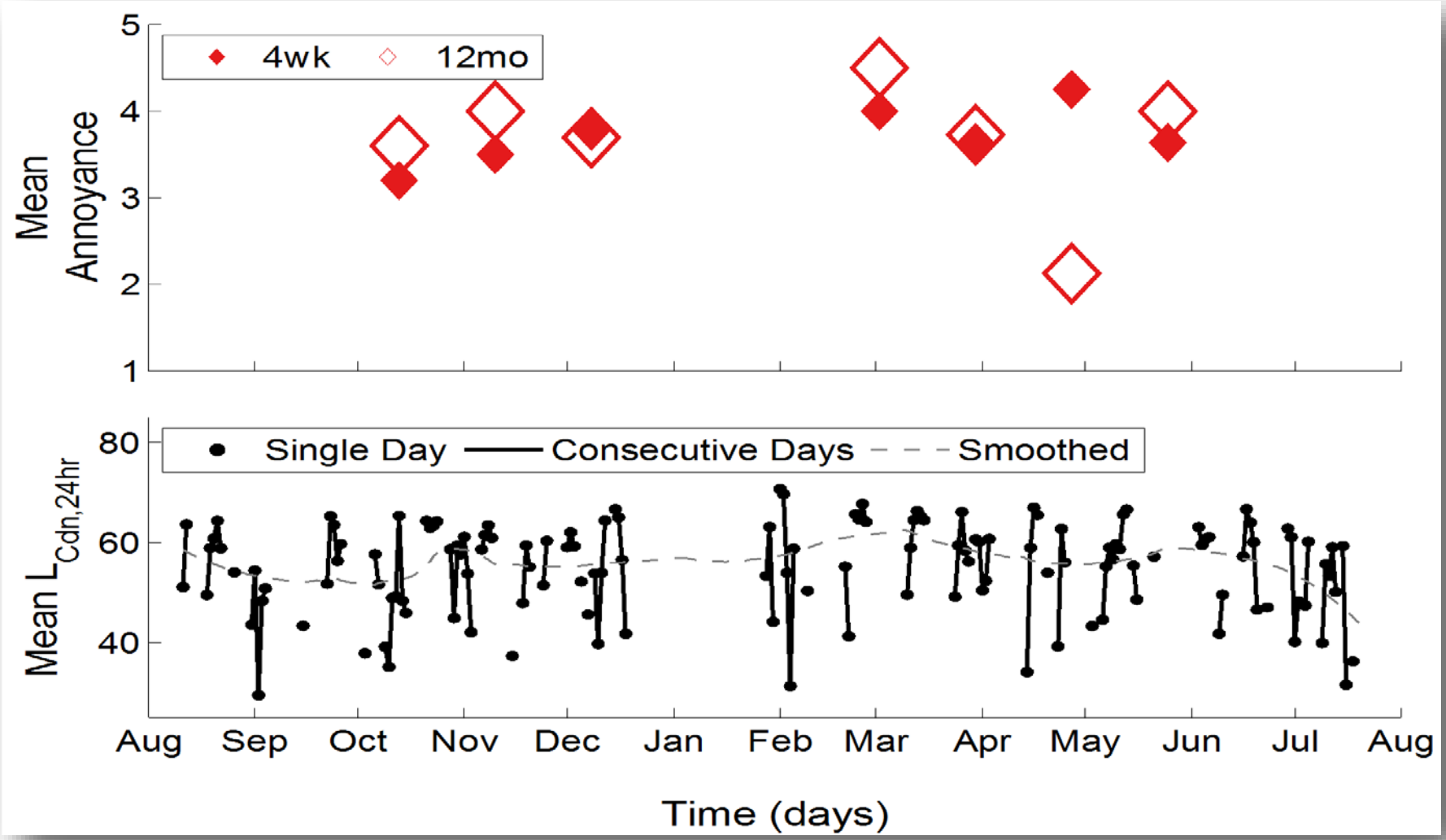


Low probability of blast noise complaints
Results vary by neighborhood

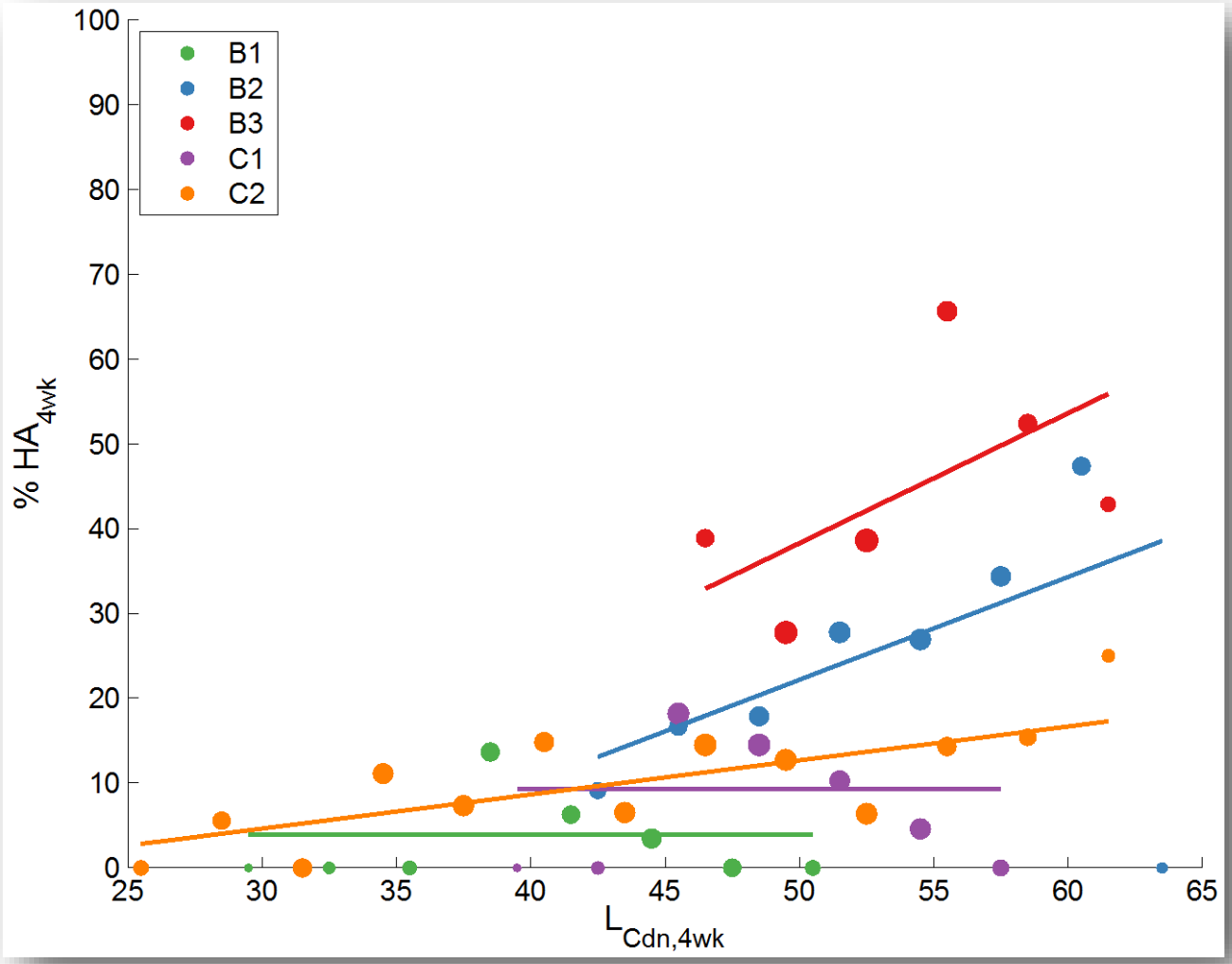


Blast noise environment is highly variable

Data from community B3



Each community has a unique tolerance to noise* over 4-week time period



*Non-acoustical factors are NOT accounted for in this model

Non-Acoustical Factors
Contribute to community annoyance

1. Time of day
2. Time at home (6PM to 10PM)
3. History of being disturbed by noise
4. Hear blast noise frequently
5. Neighborhood is excellent place to live
6. Experienced rattle from blast noise

Non-Acoustical Factors
Contribute to community annoyance

7. Number of adults per household
8. Installation importance
9. Housing type (single-family attached)
10. Habituation to noise

Conclusions
Addressing SERDP Statement of Need

1. Investigate the metrics currently used by the U.S. military to assess high-energy impulsive noise (i.e., blast noise) and assess whether these metrics adequately account for the intermittent, impulsive, nature of blasts

   - Metrics in AR 200-1 do not adequately characterize blast noise environments
     - Low predictive validity
     - Do not account for the intermittent and dynamic nature of the blast noise environments that occur on and around military installations

Conclusions
Addressing SERDP Statement of Need

1. Investigate the metrics currently used by the U.S. military to assess high-energy impulsive noise (i.e., blast noise) and assess whether these metrics adequately account for the intermittent, impulsive, nature of blasts

   - No evidence to abandon use of the L_{Cdn} if/when measured over short time periods
   - Discontinue use of the L_{Zpk} for complaint risk

Conclusions
Addressing SERDP Statement of Need

2. Examine the extent to which individual complaints are indicative of general community annoyance

   - Opinions of individual complainants do NOT represent the general community opinion of blast noise
   - However, blast noise complaints should still be dealt with in a timely manner in order to defuse the situation (Luz, 1983)

Conclusions
Addressing SERDP Statement of Need

3. Recommend criteria that can be used to actively manage noise at an installation so that the sustainability of testing and training is ensured
   - Assess/manage blast noise on a community-by-community basis over a shorter time window (e.g., 4 weeks)
   - Use $L_{Cdn,\ 24hr}$ to manage complaints
   - Use L_{CE} to quantify single event levels

Recommendations

- Assess/manage blast noise on a community-by-community basis
- Use L_{Cdn} over shorter time window (e.g., 4 weeks) to assess community response
- Use noise monitor technology recently demonstrated in ESTCP project WP-201117

Recommendations (Cont'd)

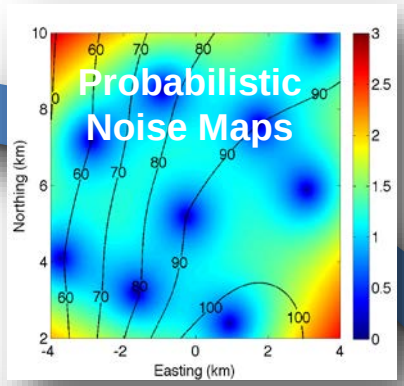
- Use $L_{Cdn,\ 24hr}$ to manage complaints
- Discontinue use L_{Zpk}
- Increased annoyance $L_{Cdn,\ 24hr} > 60$ dB
- Decreased annoyance $L_{Cdn,\ 24hr} < 45$ dB
- Build a centralized noise and complaint database to develop community specific complaint risk criteria

Recommendations (Cont'd)

- Use L_{CE} to quantify single event levels
- Discontinue use L_{Zpk}
- No single event L_{CE} >118 dB
- Exercise caution if single event levels L_{CE} approach/exceed 112 dB

Implementation

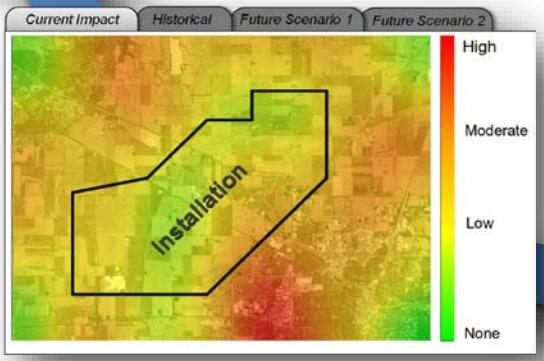
Predict



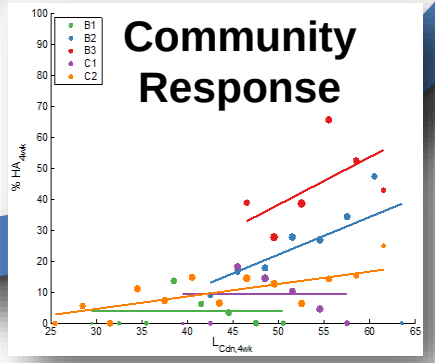
Measure

Real-Time Feedback and Forecasting Tools

Assess



Adapt



For additional information, please visit: https://www.serdp-estcp.org/Program-Areas/Weapons-Systems-and-Platforms/Noise-and-Emissions/Noise/WP-1546/WP-1546

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Q&A Session 2

The next webinar is on May 7, 2015

Factors Affecting Munitions Mobility and In Situ Measurements

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Survey Reminder

Please take a moment to complete the survey that will pop up on your screen when the webinar ends