

***Army Acoustics Needs***  
**DARPA Air-Coupled Acoustic  
Micro Sensors Workshop**

by

**Nino Srour**  
**Aug 25, 1999**

**US ARMY RESEARCH LABORATORY**

Attn: AMSRL-SE-SA  
2800 Powder Mill Road  
Adelphi, MD 20783-1197  
Tel: (301) 394-2623  
Email: [nsrour@arl.mil](mailto:nsrour@arl.mil)

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>25 AUG 1999</b>		2. REPORT TYPE <b>N/A</b>		3. DATES COVERED <b>-</b>	
4. TITLE AND SUBTITLE <b>Army Acoustic Needs</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Army Research Laboratory Adelphi, MD</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>DARPA, Air-Coupled Acoustic Microsensors Workshop held on August 24 and 25, 1999 in Crystal City, VA., The original document contains color images.</b>					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>UU</b>	18. NUMBER OF PAGES <b>15</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

- To research, explore, and develop innovative and state of the art signal processing techniques in acoustics and other passive sensor technologies
- To apply these techniques to perform detection and classification of ground troops, ground vehicles, airborne vehicles, artillery and sniper
- To transition real-time and robust algorithms to on-going Army acoustic programs

**Army Battlefield Acoustics Research  
conducted at ARL, ARDEC and CRREL**



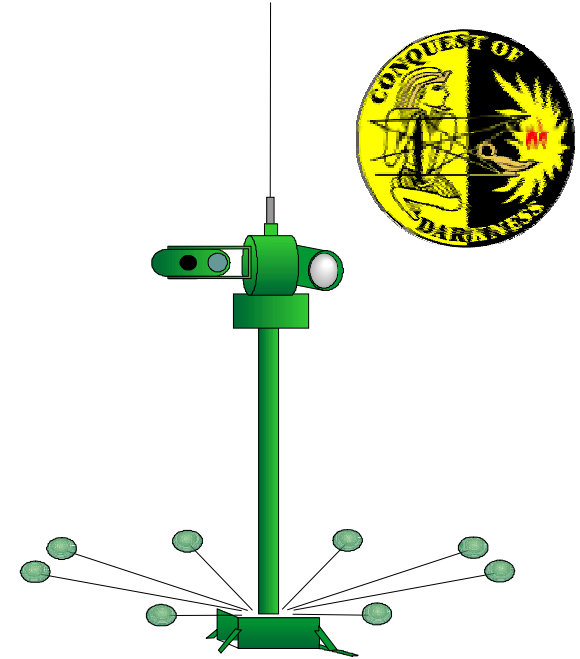
ARMY RESEARCH LABORATORY

# Acoustic Advantages



BATTLEFIELD ACOUSTICS

- Attractive technology for the Army
  - Passive
  - Non-line of sight (NLOS)
  - Low cost
  - Small and rugged
  - Provides 360° coverage
  - Target signatures are hard to suppress
- Capability includes target detection, bearing estimation, tracking, localization, classification and ID
  - Provides wake-up and cueing of optical sensors



Real-time capability due to advances in CPU and DSP technology



ARMY RESEARCH LABORATORY

# Army Applications



BATTLEFIELD ACOUSTICS

## Detection, tracking and classification

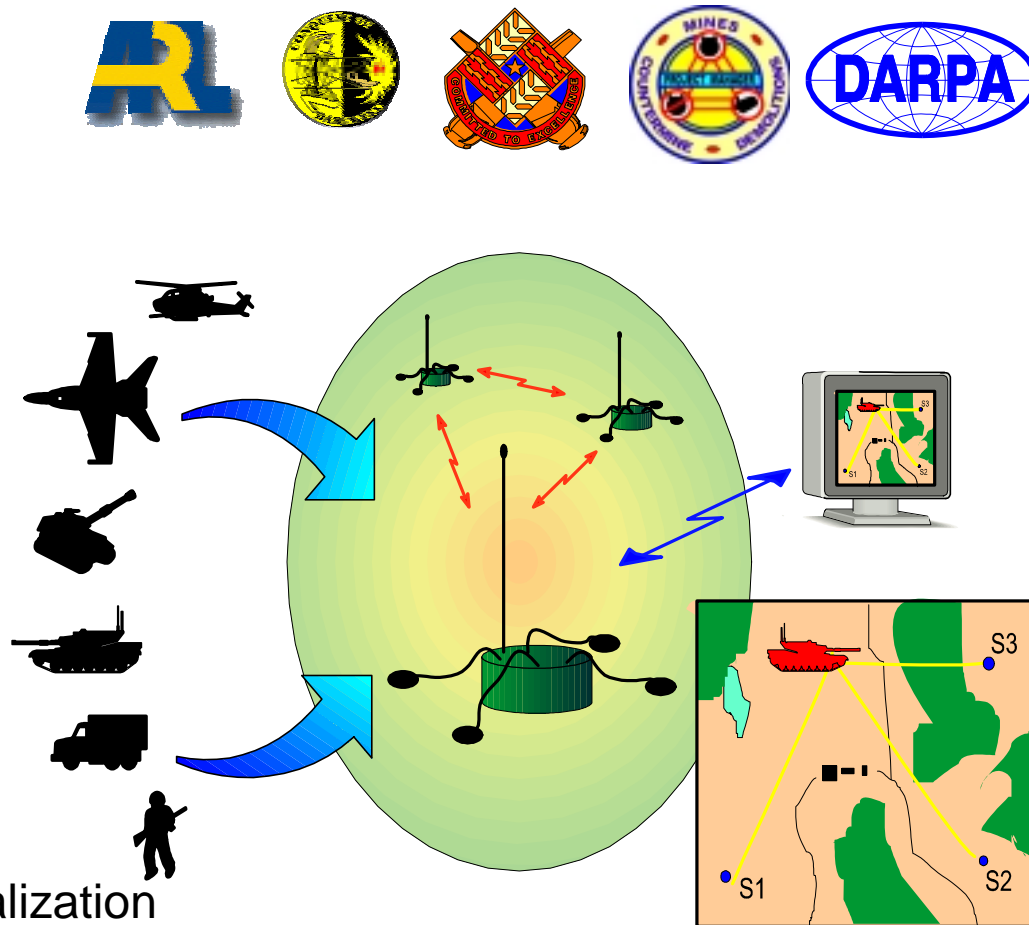
- Ground vehicles
- Troop movements
- Fixed and rotary wing aircraft's

## Surveillance and monitoring

- 360° field of view coverage
- Excellent “wake-up” and cueing sensor
- Tactical decision aid

## Other Applications

- Infrasonic detection and localization
- Physiological monitoring of soldiers
- Detection and localization of gun fire (e.g., sniper), artillery / mortar fire, rocket launch, etc.



- Noise Cancellation:
  - Need to cancel out platform noise for acoustic sensors mounted onto idle or moving vehicles to allow detection and identification of surrounding targets.
  - Need to cancel out wind / flow noise from acoustic sensors positioned on the ground or on top moving vehicles.
- Lack of data from acoustic sensors mounted on top vehicles.
- Lack of research conducted in this topic





ARMY RESEARCH LABORATORY

# Current Army Needs



BATTLEFIELD ACOUSTICS

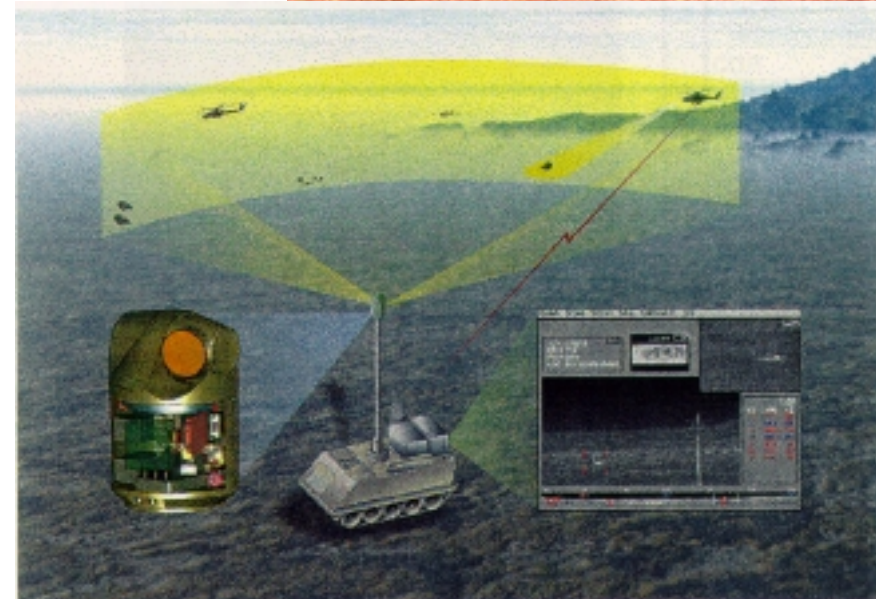
- **Research Issues**

- Noise cancellation / Platform and Wind
- Multi Target Recognition
- Sensor fusion
- MEMS Acoustic / Seismic



- **Programs**

- MFS3 / FSV
- DEMO III Robotics
- Sniper Detection Systems
- Unattended Ground Sensors





ARMY RESEARCH LABORATORY

# R&D Transition / Programs



BATTLEFIELD ACOUSTICS

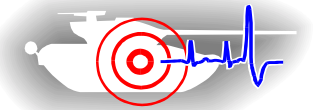
- **Transition R&D into future Army programs in support of RDECs and Battle Labs**
  - Infrasonic research
  - Modeling of acoustic sensors
  - Anti-Personnel Landmine Alternatives (APLA)
  - Warrior Extended Battlespace Sensors (WEBS)





ARMY RESEARCH LABORATORY

# Infrasonic Research

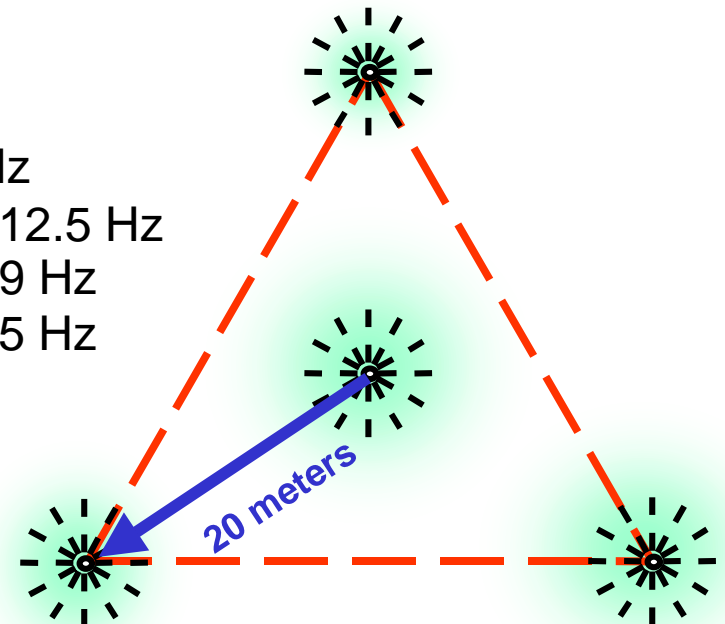


BATTLEFIELD ACOUSTICS

- **Objective:** to develop state-of-the art infrasonic sensors and signal processing algorithms to detect, classify, localize of impulsive signals below 20 Hz
- **Army applications**
  - Artillery and mortar firings
  - Missile and rocket launches
- **Other infrasonic signals of interest:**

– Nuclear tests:	0.02 Hz - 4 Hz
– Earthquakes:	0.125 mHz - 12.5 Hz
– Volcanoes, meteors:	23 mHz - 0.29 Hz
– Winds, tornadoes, etc.:	10mHz - 0.125 Hz

- Six 20 ft. porous hose lengths at each sensor
- Met sensors located with central microphone.



Los Alamos





ARMY RESEARCH LABORATORY

# Infrasonic Detection

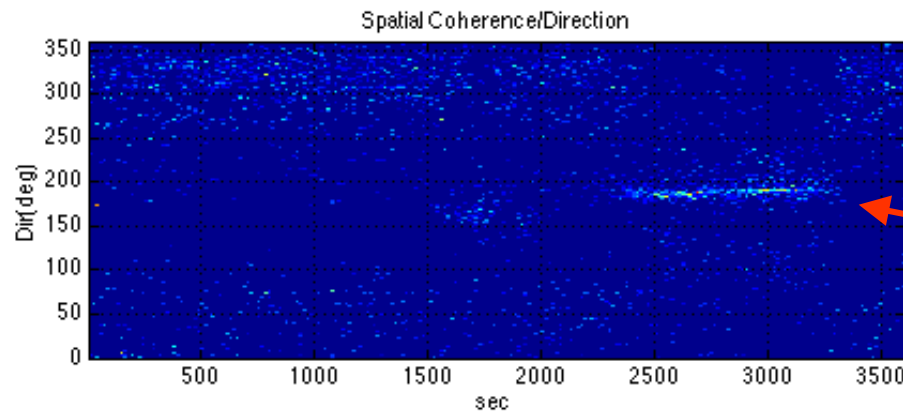
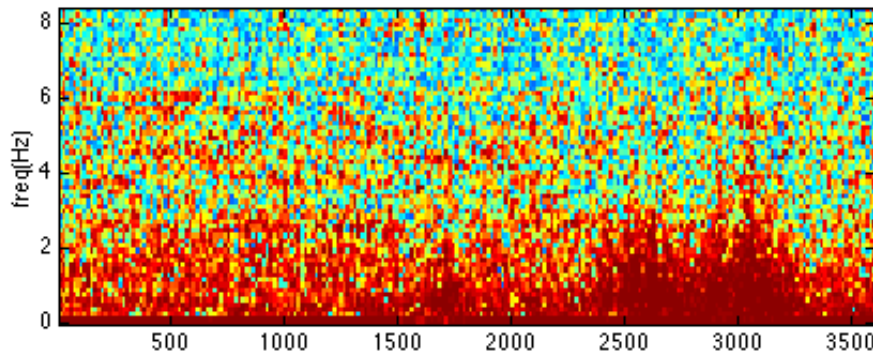


BATTLEFIELD ACOUSTICS



**Space Shuttle Launch  
4 Dec 98  
From Blossom Point, MD**

Date: 12/4/98 Time: 3:54:28

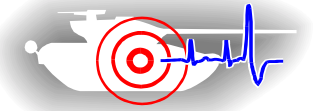


**1200 km  
1 hr delay**

**Direction of arrival**



# Modeling of Acoustic Sensors



## Objective:

- Database: to centralize acoustic data archives from various programs & organizations, to expedite data access and to ease data maintenance
- ATR Lab: to expedite algorithm development & performance evaluation against various battlefield conditions

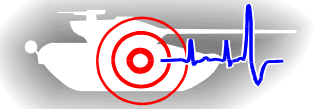
The screenshot displays a web-based application interface for an acoustic database. The interface is divided into several sections:

- Navigation Tabs:** Files, Targets (selected), Sensors, Data Collections, SQL Commands.
- Select table:** A dropdown menu showing "Ground\_Info" and an "Open Table" button.
- Form Fields:** A series of input fields for target details:
  - Target\_ID: 5
  - Target: 2.5-Ton Truck
  - Class: light wheeled
  - Country: USA
  - Weight (kg): 5900
  - Length (m): 6.7
  - Width (m): 2.4
  - Height (m): 2.92
  - Engine: 6-cylinder in-line multi-fuel diesel, 140 hp @ 2600 rpm
  - Transmission: manual gearbox with 5 forward and 1 reverse gears
  - Max\_Speed (mph): 21.6
  - Crew: 1+2
  - Picture: 2-5ton\_1.gif; 2-5ton\_2.gif
  - Signature: y
- Move record:** Buttons for First, Prev, Next, Last.
- Sort by:** A dropdown menu set to "Target\_ID" and a "Sort" button.
- Edit:** Buttons for Add, Add/C, Modify, Update, Clear, and Delete.
- Search by:** A dropdown menu set to "Target\_ID", an "Enter text:" input field, and a "Go" button.
- Print Record:** A button to print the current record.
- Image:** A small image of a 2.5-ton truck with the caption "2.5 TON TRUCK".
- Footer:** A status bar showing "acoustic database" and "# Records: 6".

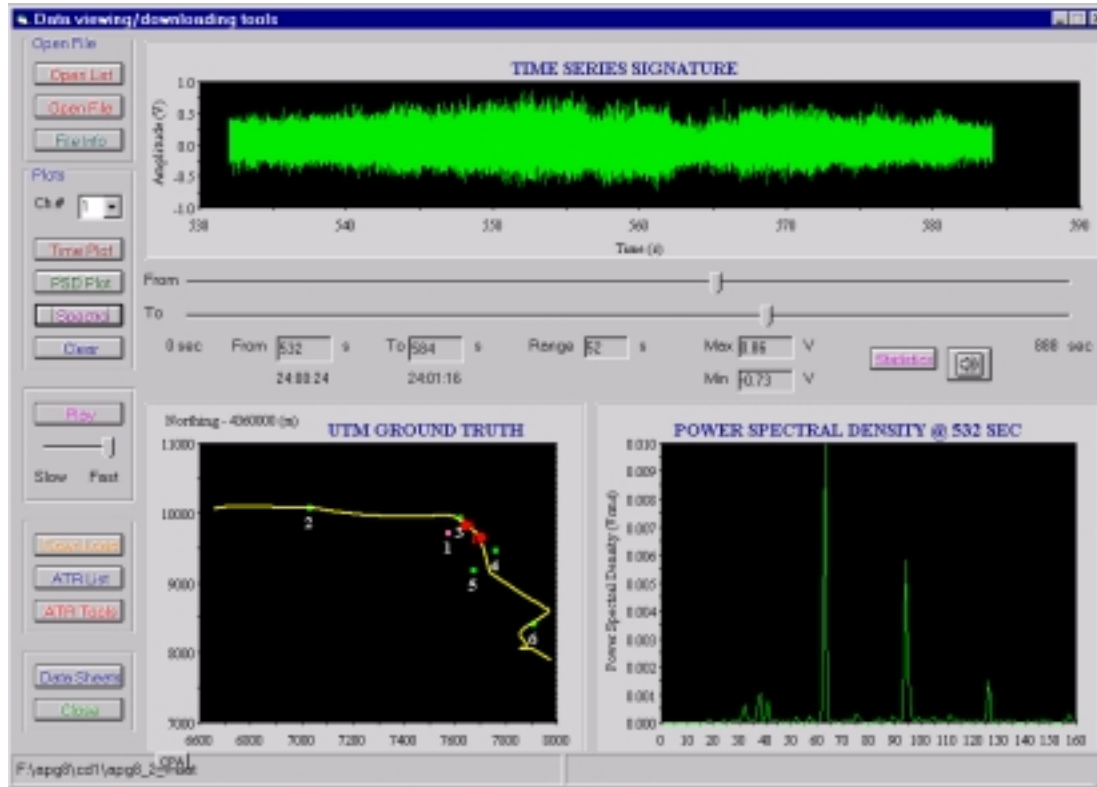


ARMY RESEARCH LABORATORY

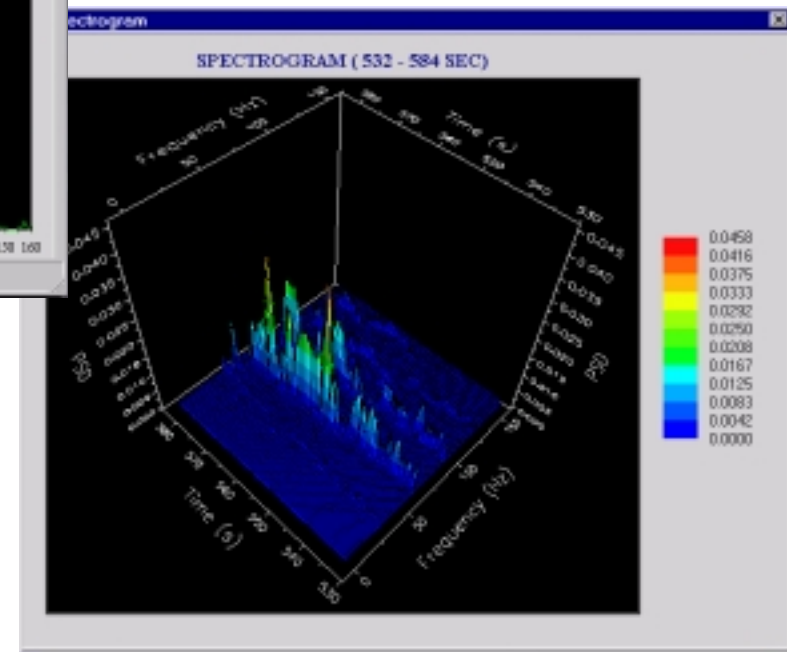
# Data Management and Processing



BATTLEFIELD ACOUSTICS



Large selection of trucks, tanks and helicopter signatures collected at different environment and time of year



Server - Client environment will allow user to access data on-line.



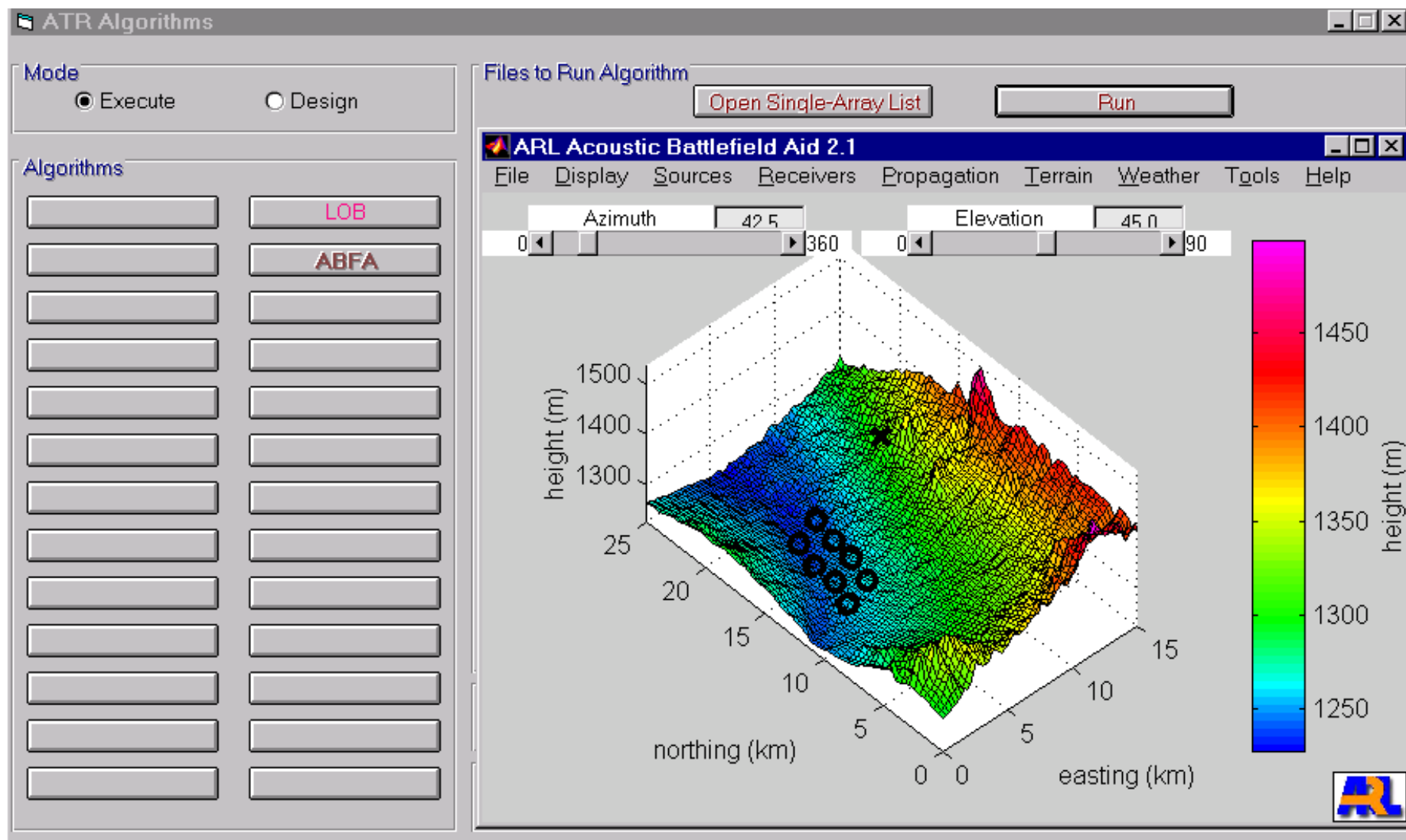


ARMY RESEARCH LABORATORY

# ATR Lab and Decision Aid



BATTLEFIELD ACOUSTICS





ARMY RESEARCH LABORATORY

# Anti Personnel Landmine Alternative (APLA)



BATTLEFIELD ACOUSTICS

- **Current Progress**

- Experimenting with existing small, sensor systems capable of detecting personnel using acoustic / seismic / magnetic sensors.



- **FY00**

- Research and evaluate personnel detection algorithms with low false alarm.
- Use fusion techniques between suite of orthogonal sensors to enhance detection and recognition



ARMY RESEARCH LABORATORY

# Warrior Extended Battlespace Sensors (WEBS)



BATTLEFIELD ACOUSTICS

*A network of sensor nodes using multiple types  
of sensors can accurately locate and identify battlefield targets*

*Small  
Passive  
Real Time  
Very Low Cost  
Non-line of sight  
360° Coverage*



**Acoustic**  
**Magnetic**  
**Day imager**  
**Others . . .**

**Seismic**  
**Low cost IR**  
**Passive RF**

*Wide Range of Sensors*



***The vision:***  
**Small, expendable sensors**

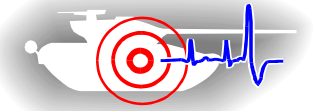


*Wide Range of targets*

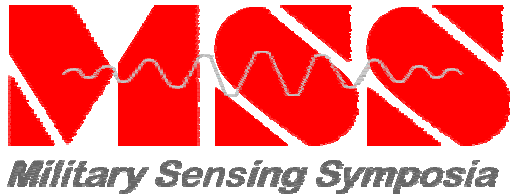


ARMY RESEARCH LABORATORY

# Upcoming Symposia



BATTLEFIELD ACOUSTICS



Yearly event, established to share battlefield acoustic research knowledge between government, industry and universities.

**Battlefield Acoustic Symposium Sept 13 - 15, 1999**  
**Johns Hopkins University, MD, Security Clearances Required**

**National Symposium Nov 16 - 19, 1999**  
**SPAWAR Systems Center, SC**

***SPIE - The International Society for Optical Engineering***

**Sensor Technology for the Urban Battlefield**  
**Orlando, FL April 24 - 28, 2000**