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**Using the TARDEC Acoustic Ground Array
to Determine the Characteristics
of the Band Track**

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DISTRIBUTION STATEMENT A
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INTRODUCTION

Input forces for flexible composite Band Track are reduced

Leads to lower vibration amplitudes inside the hull.

Significant reduction in acoustic signature was expected.

$$\text{Track Laying Frequency (Hz)} = \frac{17.6 * \text{Vehicle Speed (mph)}}{\text{Track Shoe Length (in)}}$$

For M113, T 130 track shoe length of 6 inches:

Track laying frequency (Hz) = 3 * vehicle speed (mph).

For Band Track cleat separation of 4.5 inches:

Track laying frequency (Hz) = 3.9 * vehicle speed (mph).

The primary signatures of track and engine exhaust is a tonal set of radiated energy that show up as harmonic lines.

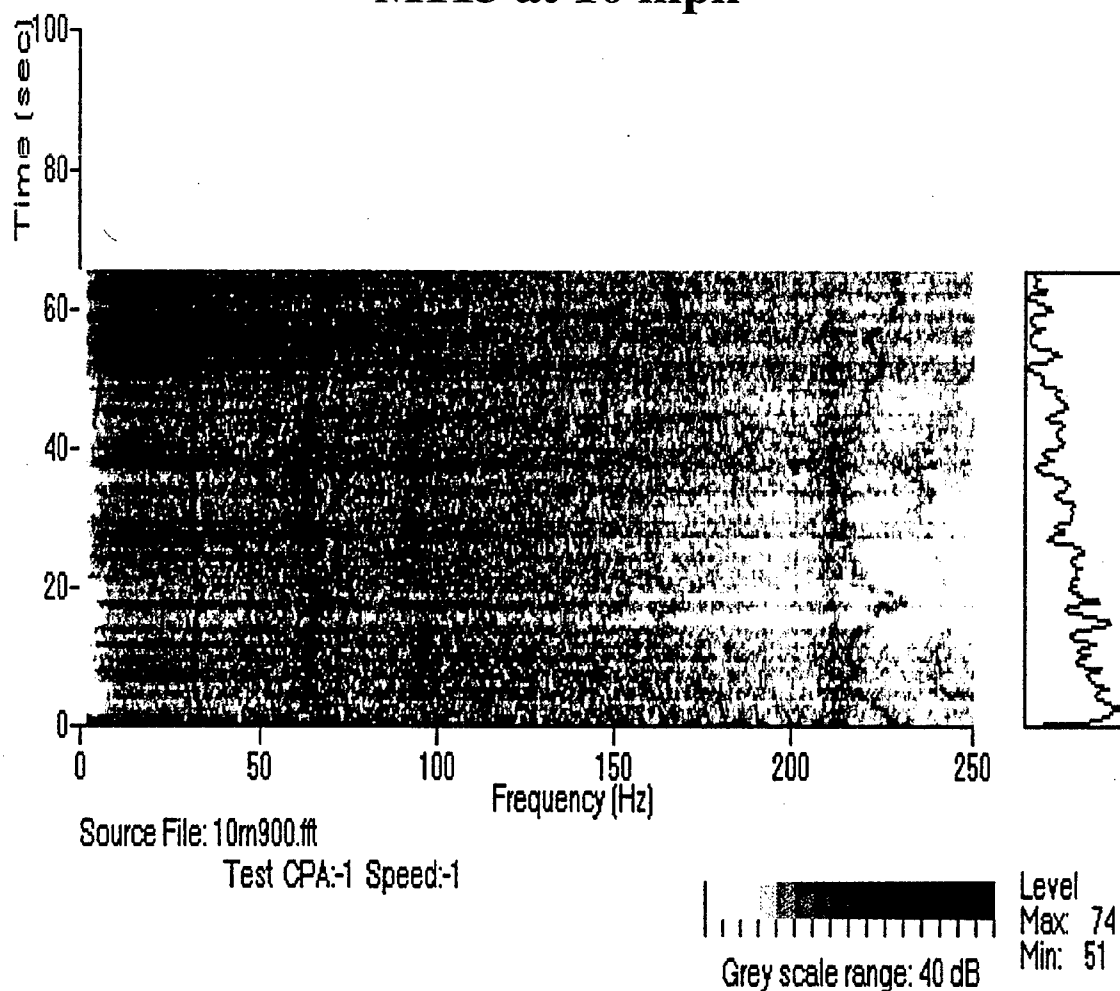
The TARDEC acoustic ground array detects the harmonic set superimposed on broad band track and engine energy

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**Spectrum of T-130 Steel Track Measured at 900 ft
--M113 at 10 mph--**



Ground Array is 900 feet from vehicle path.

Fundamental of track laying tonal is 30 Hz.

Harmonics of track signature at 60, 90 and 120 Hz.

Faint engine harmonics at 75, 150, and 225 Hz. All are lower in amplitude and shown in lighter shades.

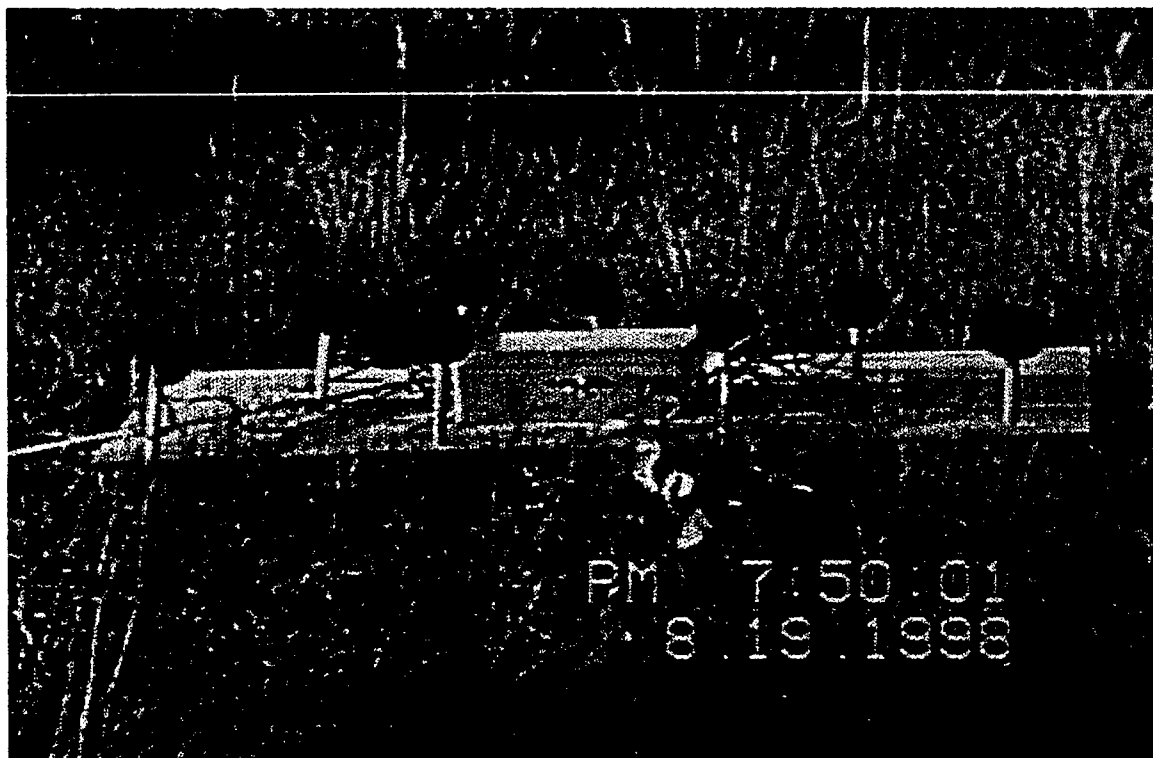
Track tonals are the key signature.



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Ground Acoustic Array With 8 Microphones



Single System detects line of bearing of moving ground vehicles

Vehicle motion is found relative to sensor array axis.

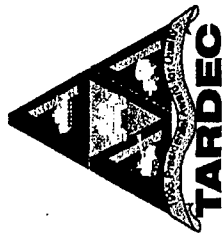
System is a delay sum beamformer.

Two systems locate the coordinates of the vehicle.

Detection has 3 second position updates.

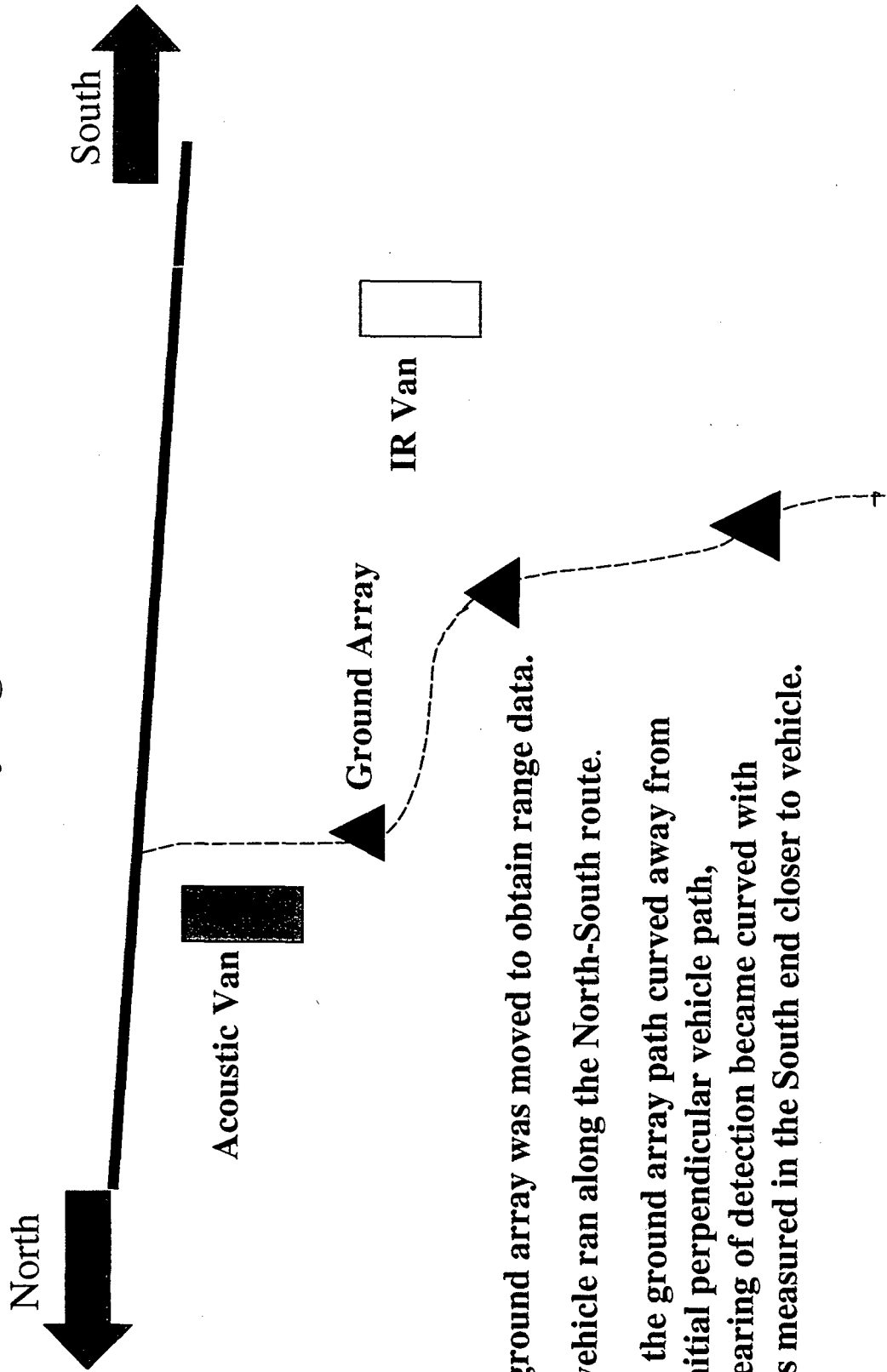
A single array can be moved to different locations to find range versus speed data.

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Grayling Test Track



The ground array was moved to obtain range data.

The vehicle ran along the North-South route.

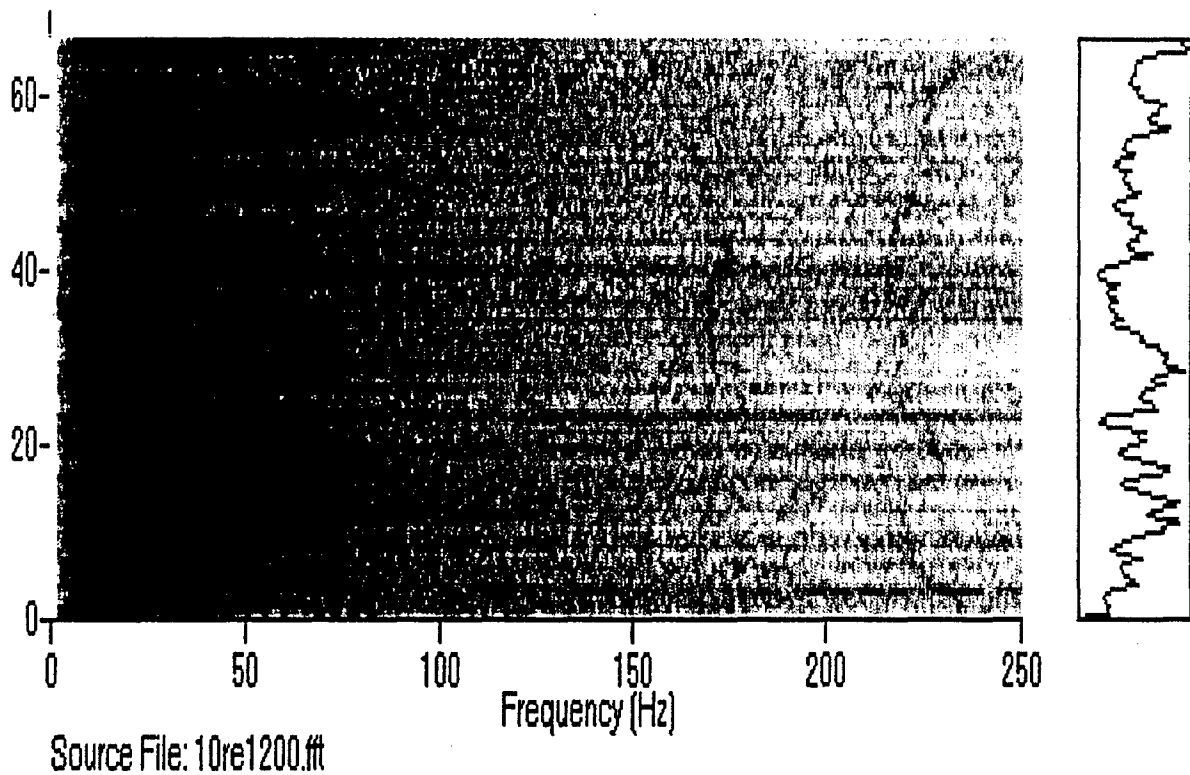
Since the ground array path curved away from the initial perpendicular vehicle path, the bearing of detection became curved with points measured in the South end closer to vehicle.



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T-130 Harmonic Set at Range of 1200 ft --M113 Moving at 10 mph--



At ranges greater than 1000 feet, the engine harmonics are absorbed by the atmosphere.

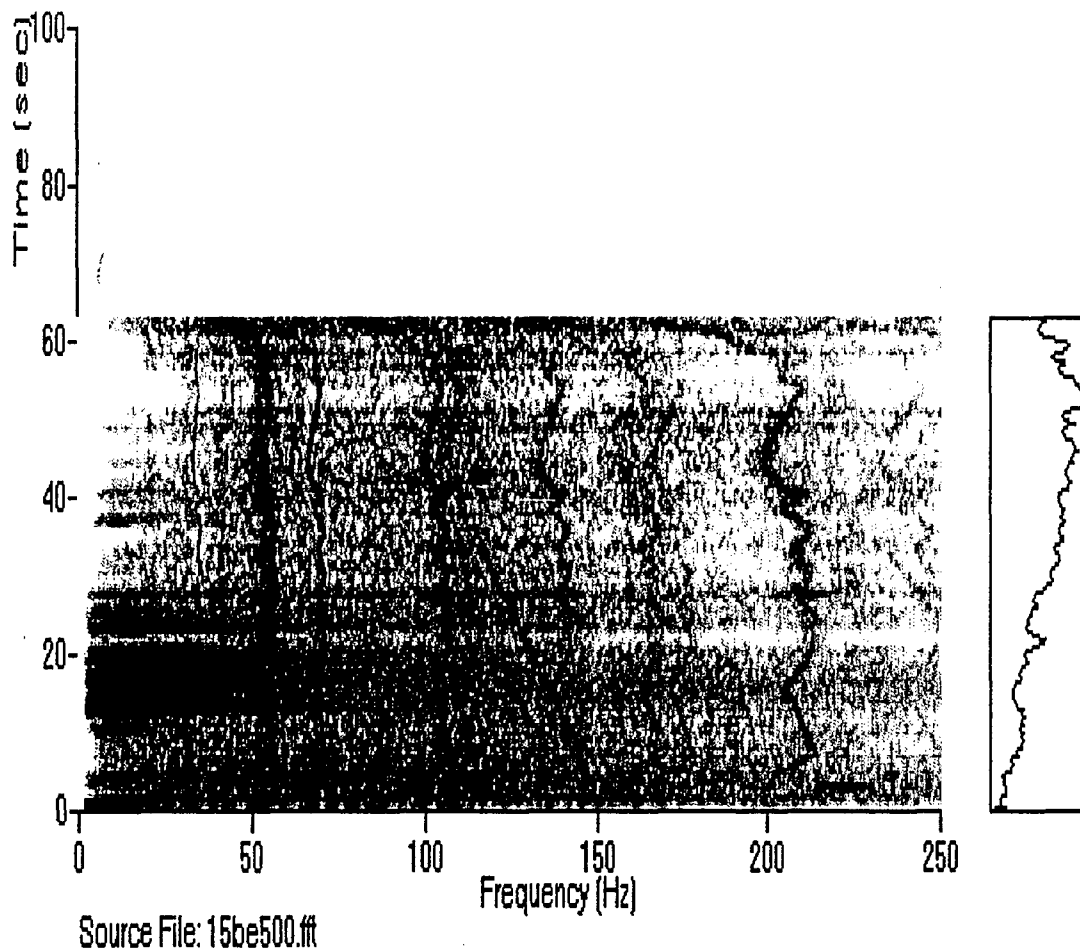
Track harmonics remain a significant signature for detection.

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**Spectrogram of Band Track Detected at 500ft
--M113 at 15mph--**



Cleats in band track function as track shoes and provide acoustic signature.

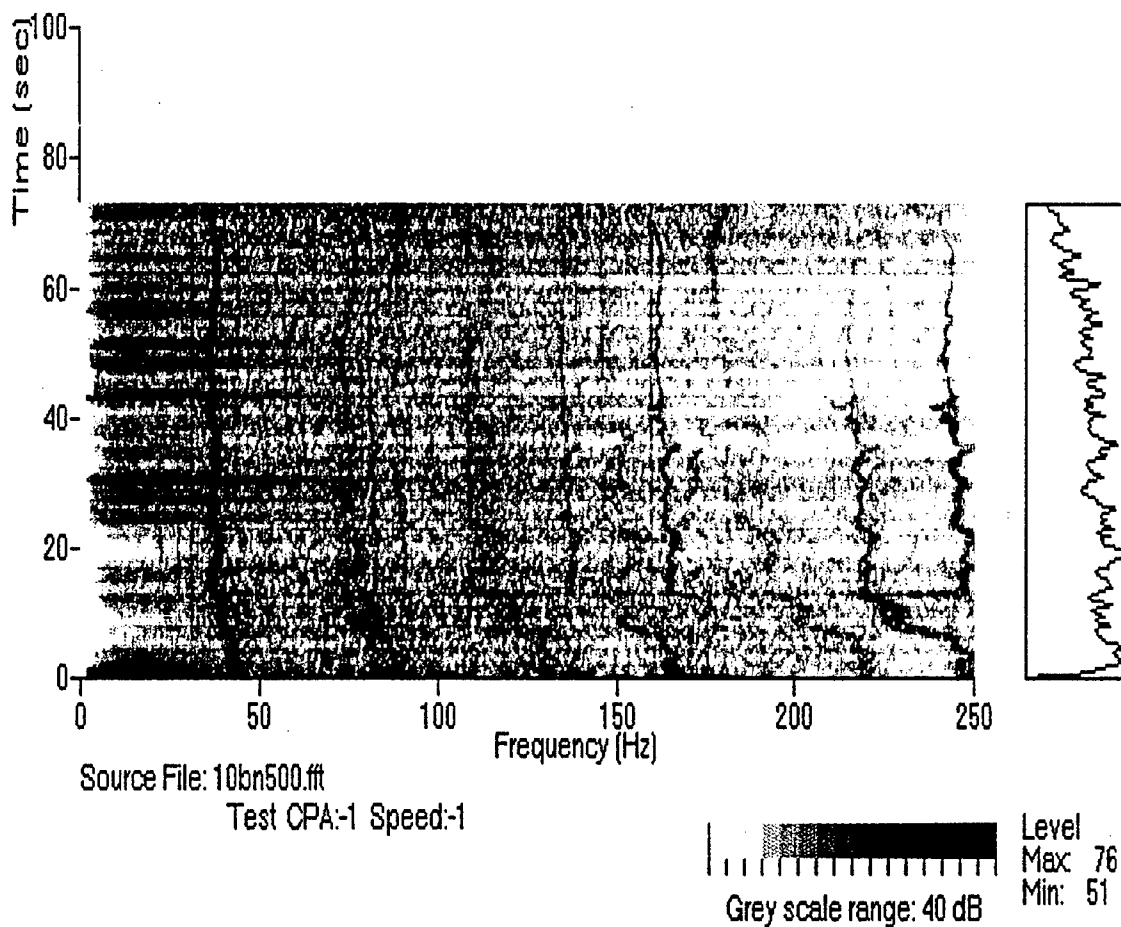
Track tonals at 50 and 100 Hz.

Engine Harmonics at 75, 150 and 225 Hz.



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Band Track Line Structure --M113 at 10 mph--



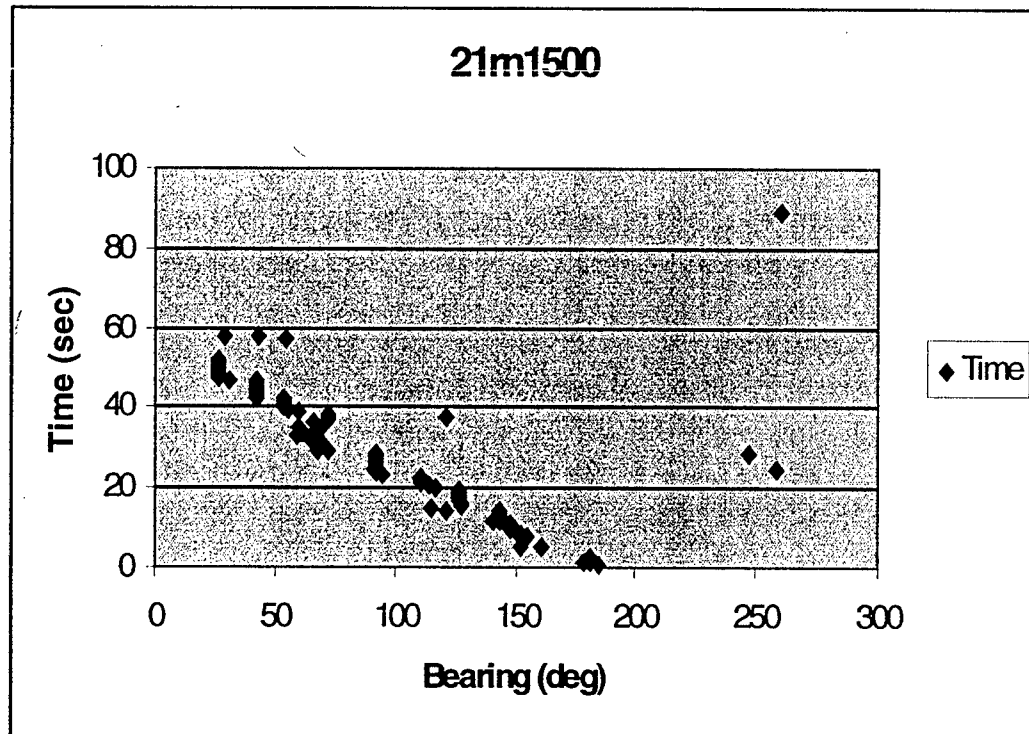
Band Track line structure at 40,80, and 120 Hz for 10 mph.

Even though the exhaust is facing away from the array, the exhaust tones can be detected above 150 Hz.



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Detection of T-130 Track at 1500 feet --M113 at 21 mph--



Vehicle is heading north at 21 mph.

Each data point represents a single detection.

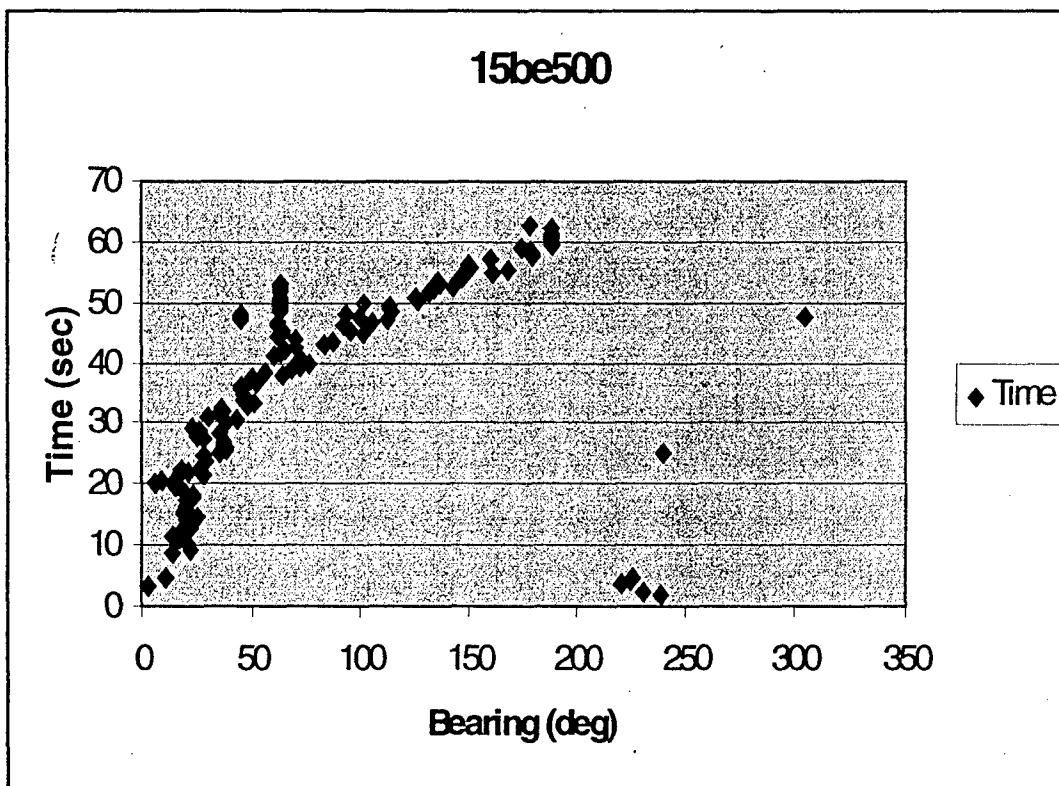
The number of detection points that were within 25 % of the vehicle's path, were added.

Procedure leads to a percentage of detection for tested speed and range.



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**Detection of Band Track at 500 ft
--M113 at 15mph--**



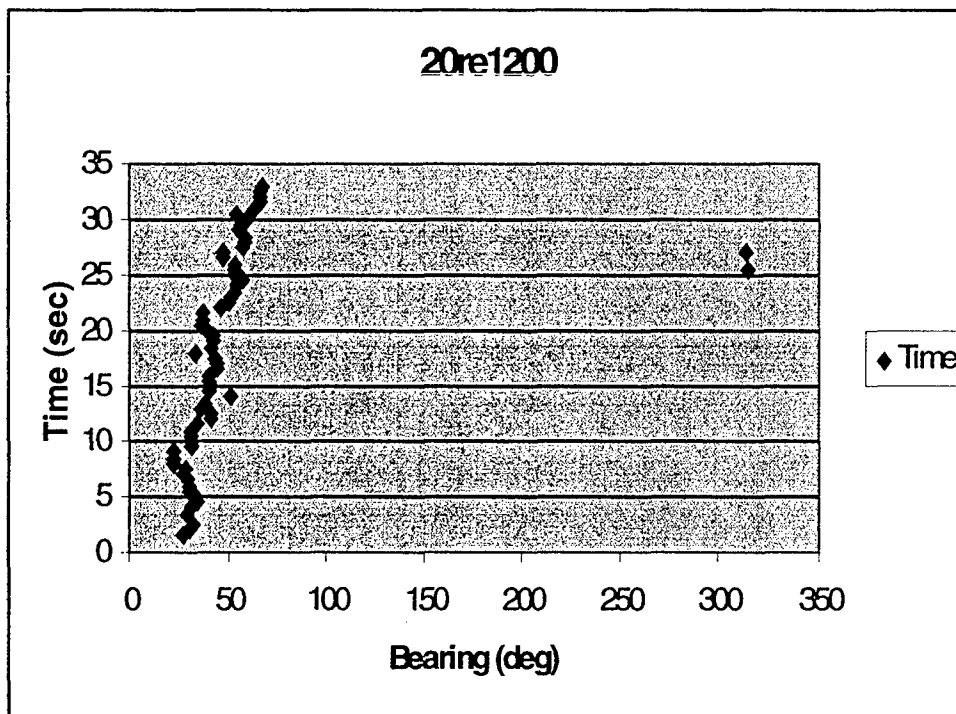
Detection provided by band track cleats.

Track signature detection was reduced, but not eliminated.



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**Detection of T-130 Steel Track
--M113 at 1200 feet--**



Vehicle heading south.

Wind gusts scattered the detection points.

Lower exhaust amplitudes scattered the bearing of detection.

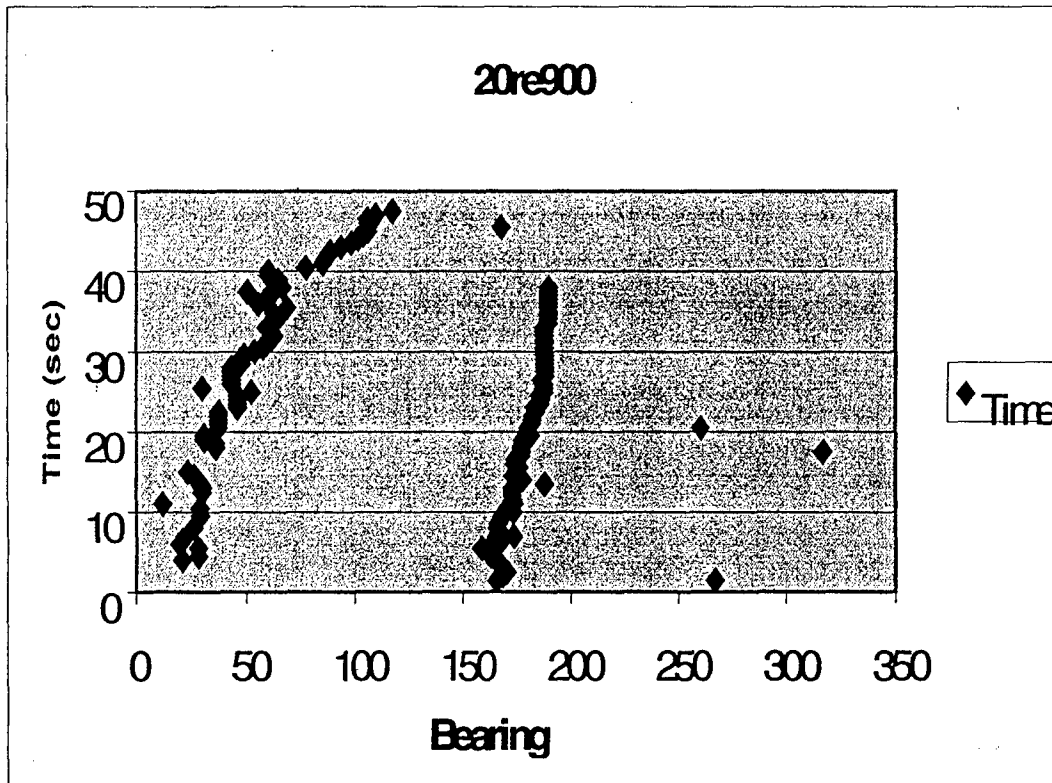
Detection procedure calculated 77 % detection for this range data set.

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Simultaneous Tracking of Two Sources T-130 M113(Left) and CUCV(Right)



Array can track more than one source at the same time.

Airplanes, wheeled vehicles and other sources in the test area where detected.

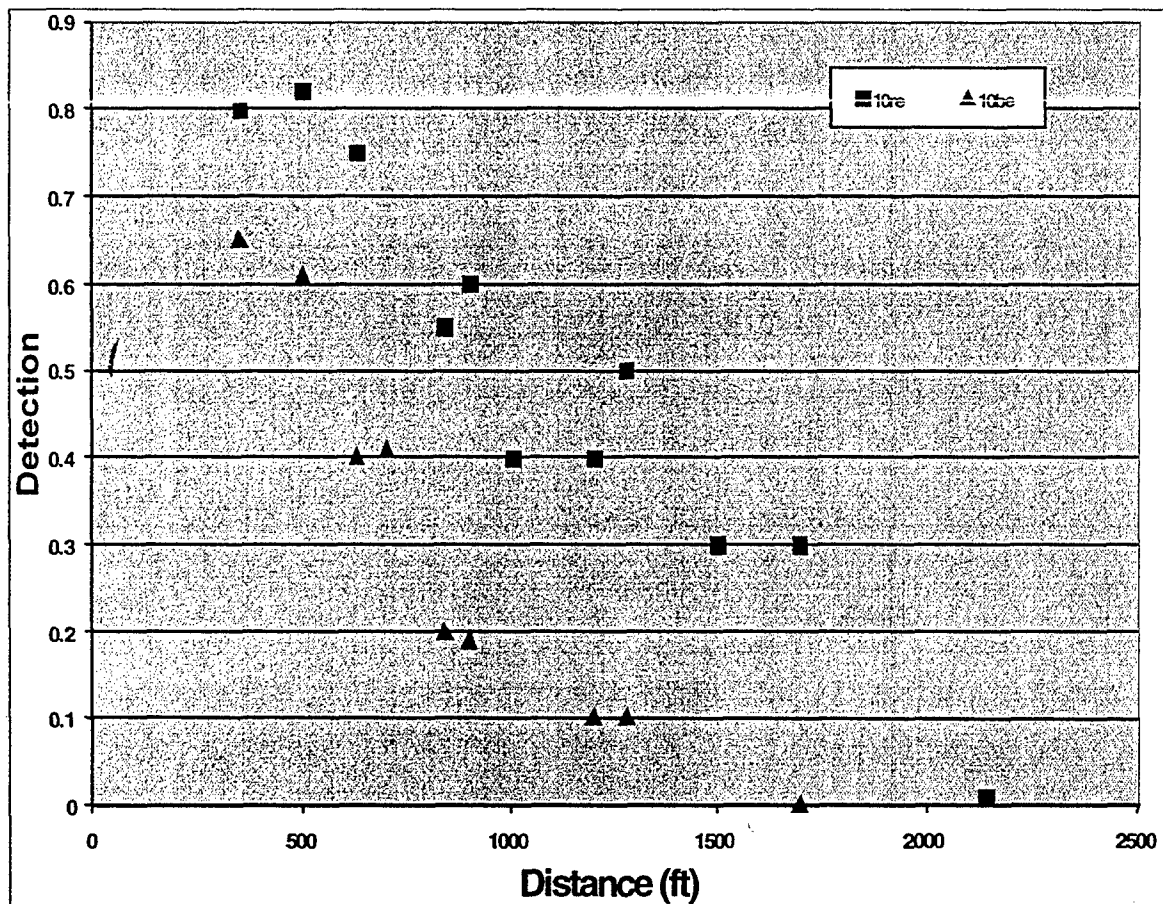
M113 with T-130 track traveling south is detected on left side.

CUCV traveling south on the same road to pick up test personnel is shown on the right side.



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Detection of T-130 Steel Track vs Band Track --M113 at 10 mph (Exhaust side)--



Detection versus range for two sets of track at 10 mph.

Vehicle exhaust facing the ground array.

Band Track (red data points) is quieter by 25 %.

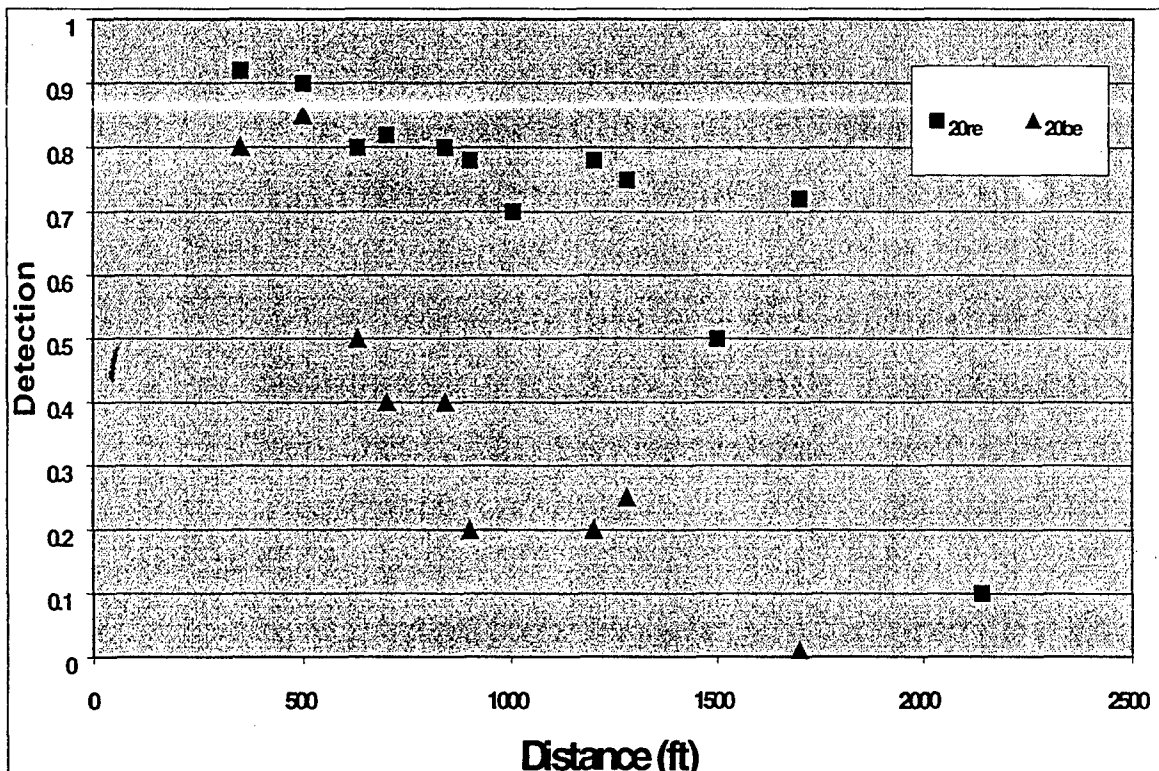
Regular track in black.



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Detection of T-130 Steel Track vs Band Track --M113 at 20mph (Exhaust Side)--



Detection versus range for regular track and band track at 20 mph with exhaust facing the array.

Band track (red data) is quieter by 35 %.

The T-130 standard track signature is significant at higher vehicle speeds. This is also where the band track shows real reduction in detection.

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CONCLUSION

The Acoustic Ground Array detects the two primary sources of ground vehicle signature—the harmonic line structures of the track and the engine exhaust.

Track tonals are the dominant signature for vehicle speeds above 15 mph. For distances greater than 1500 feet, the engine tonals have been absorbed by the atmosphere.

Signature reduction offered by the band track increases with vehicle speed, with 25 % reduction at 10 mph and 35 % at 20 mph.

Track tonals, due to their low frequencies below 100 Hz, will propagate across hilly terrain and make the vehicle vulnerable at greater distances.

Track tonals are not eliminated by the band track due to the existence of cleats. The cleats are the limiting factor for band track signature reduction.

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OPSEC REVIEW CERTIFICATION

(AR 530-1, Operations Security)

I am aware that there is foreign intelligence interest in open source publications. I have sufficient technical expertise in the subject matter of this paper to make a determination that the net benefit of this public release outweighs any potential damage.

Reviewer: Wallace R. Mick GS14 Mechanical Engineer
Name Grade Title

Wallace R. Mick 13 Aug 99 AMSTA-TR-5
Signature Date

Description of Information Reviewed:

Title: "Using the TARDEC Acoustic Grand Array to Determine the Characteristics of the Band Track"

Author/Originator(s): Ed Shalis, Douglas Freese

Publication/Presentation/Release Date: Presentation at the GTMEV Conf.

Purpose of Release: Aug 99

An abstract, summary, or copy of the information reviewed is available for review.

Reviewer's Determination (circle one): 1. Unclassified Unlimited. The presentation presents test data on the commercially available Band Track. Because the track is not a detection avoidance component and is commercially available the acoustic data and detection range estimates can be released as unclassified unlimited release. ~~release~~ This non-classified hardware and release guidance has been established by Dave Thomas and the proposer of the Band Track hardware on the Propulsion Track + Suspension Lab.

2. Unclassified Limited, Dissemination Restrictions IAW

3. Classified. Cannot be released, and requires classification and control at the level of _____

Security Office (AMSTA-CS-S):

Concur/Nonconcur [Signature] 16 Aug 99
Signature Date

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Signature Date