Detection of Subsurface Facilities Including Non-Metallic Pipes

US DOE NETL Contract DE-FC26-01NT41315

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Detection of Subsurface Facilities Including Non-metallic Pipes

This presentation summarizes the results achieved to date in the development of a Ground Penetration Radar (GPR) for the detection of subsurface facilities, especially buried non-metallic pipes that are filled with natural gas or air. The design is based on the Ground Penetration Radar (GPR) equipment that has been developed for the US Army Hand Held Standoff Mine Detection System (HSTAMIDS). This work has been partially funded by the DOE-NETL at Morgantown, WV.

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Detection of Subsurface Facilities Including Non-metallic Pipes

GOALS:

Detection of all subsurface facilities / utilities

First step: Location of buried plastic pipe from 0.5”-12” diameter, buried 6 foot, deeper if possible.

The pipe is filled with natural gas or air.

The locator indicator is audio with an option of visual image.

The device is low cost and light weight (handheld), battery operation.

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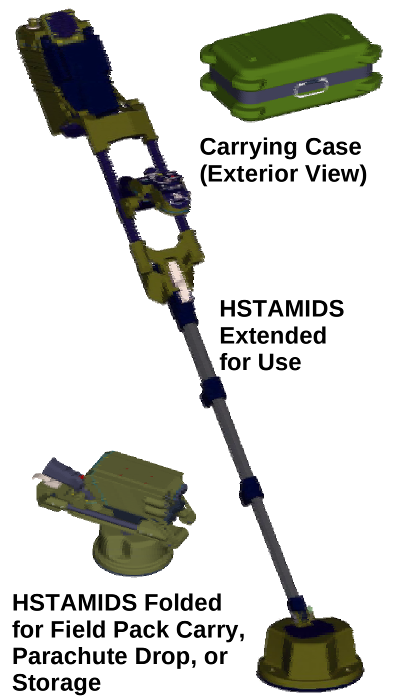
Background: Hand Held Standoff Mine Detection System (HSTAMIDS)

COMBINING GROUND PENETRATING RADAR AND ELECTROMAGNETIC INDUCTION

DESIGN	DEPLOYMENT	DETECTION



- Metal
- Plastic
- Non-metallic

- Near 100% Detection
- Near Zero False Alarm Rate
- Human Factors Engineered

- Available CY2002
- Sensor Fusion
- AN/PSS-12 Replacement

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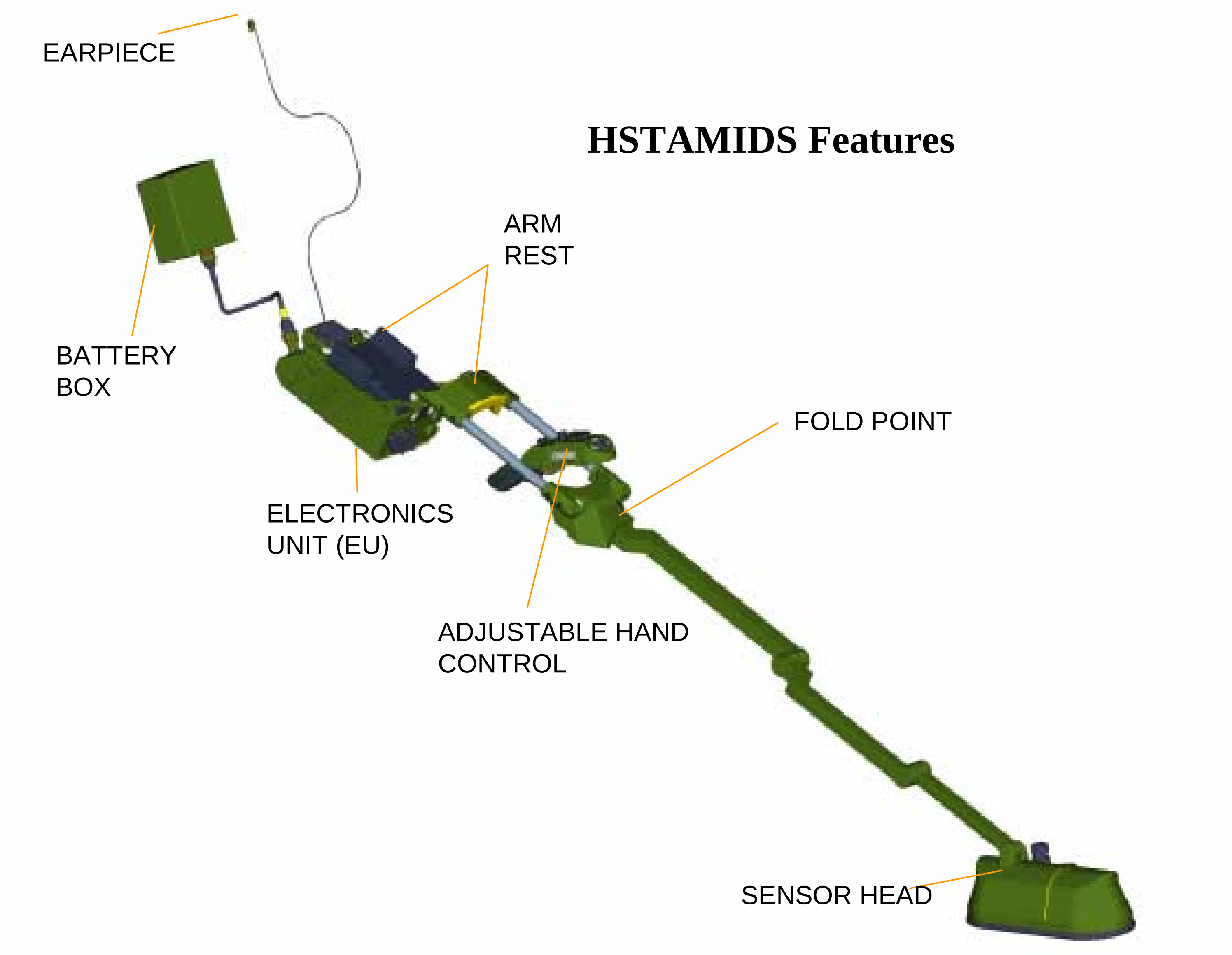
In production supporting Operation Enduring Freedom

HSTAMIDS Features



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Initial System Built For Test

• Radar type	Frequency stepped
• Antennas	9-inch cavity backed spirals
• Frequency band	400–1500 MHz
• Step size	10 MHz
• Switching speed	100 microseconds / frequency
• Measurement Rate	90 HZ
• Power output transmit	30 milliwatts, maximum
• Power	12 Vdc, 3 amps

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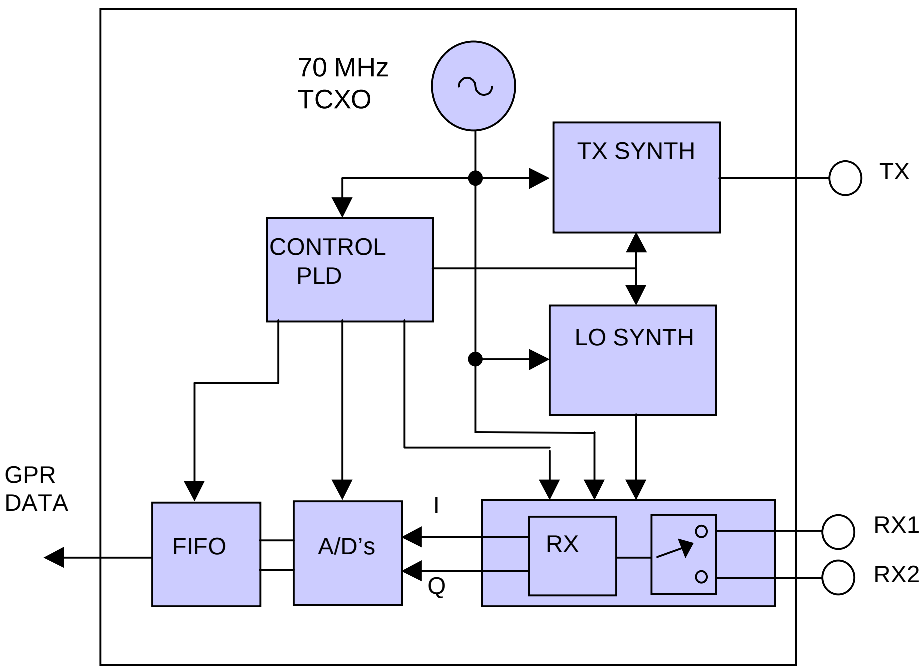
Small electronics package (3.5”x6”x2”)

GPR Synthesizer Block Diagram



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The plastic pipe location unit has antennas that are sized to transmit the desired lowest frequency.

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The unit is designed to fold up without removal of any components

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Sand Box: Test Area 1

A small elevated test area has been constructed with buried plastic/metal pipes in dry sand. The sand has a relative dielectric constant of 4 and provides one of the most difficult soils to detect plastic pipe in because of the small reflection coefficient between sand and air.

Sand box: 8'x16'x 4' deep.

Pipes: 1", 2", 3", 4"& 6"

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Florida Soil (Sandy): Test Area 2

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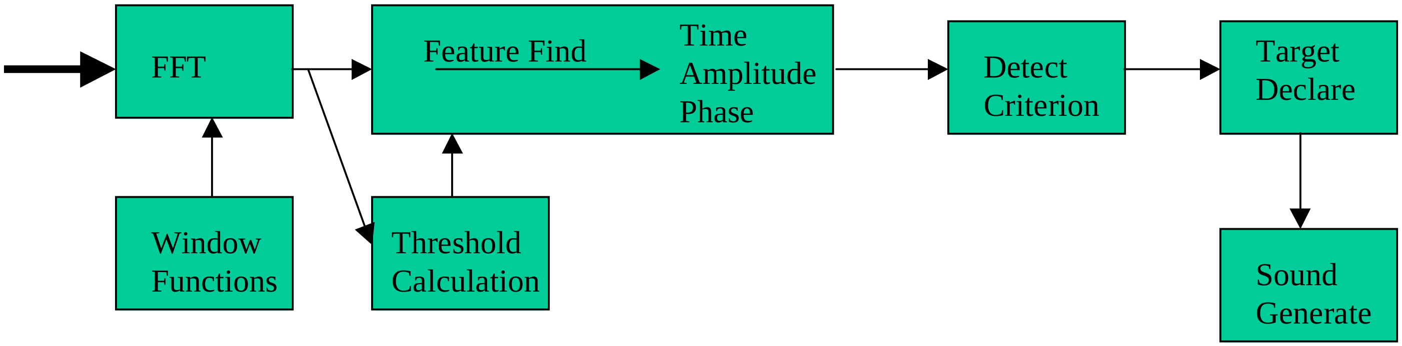
Basic Algorithm Process



Software components:

- **Relate time, amplitude, and phase for non-metallic/metallic facilities,**
- **Statistical PCA approach developed under HSTAMIDS.**

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Sand Box: Test Area 1

Transmit LHC, Receive: LHC & RHC
bandwidth: 400Mhz-1500Mhz, 10MHz steps

SURFACE RETURN

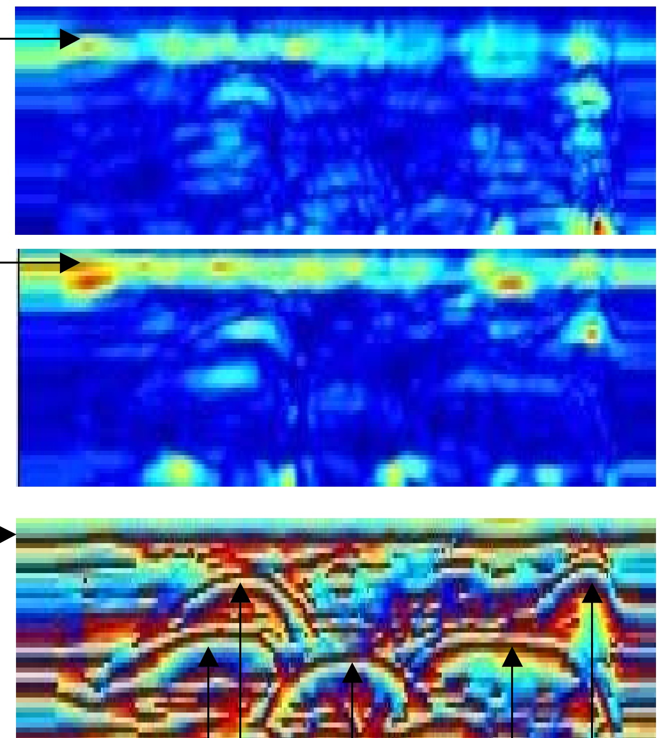
CO-POLARIZATION

SURFACE RETURN

CROSS-POLARZATION

SURFACE RETURN

PRELIMINARY
PROCESSING



PLASTIC PIPE LOCATIONS

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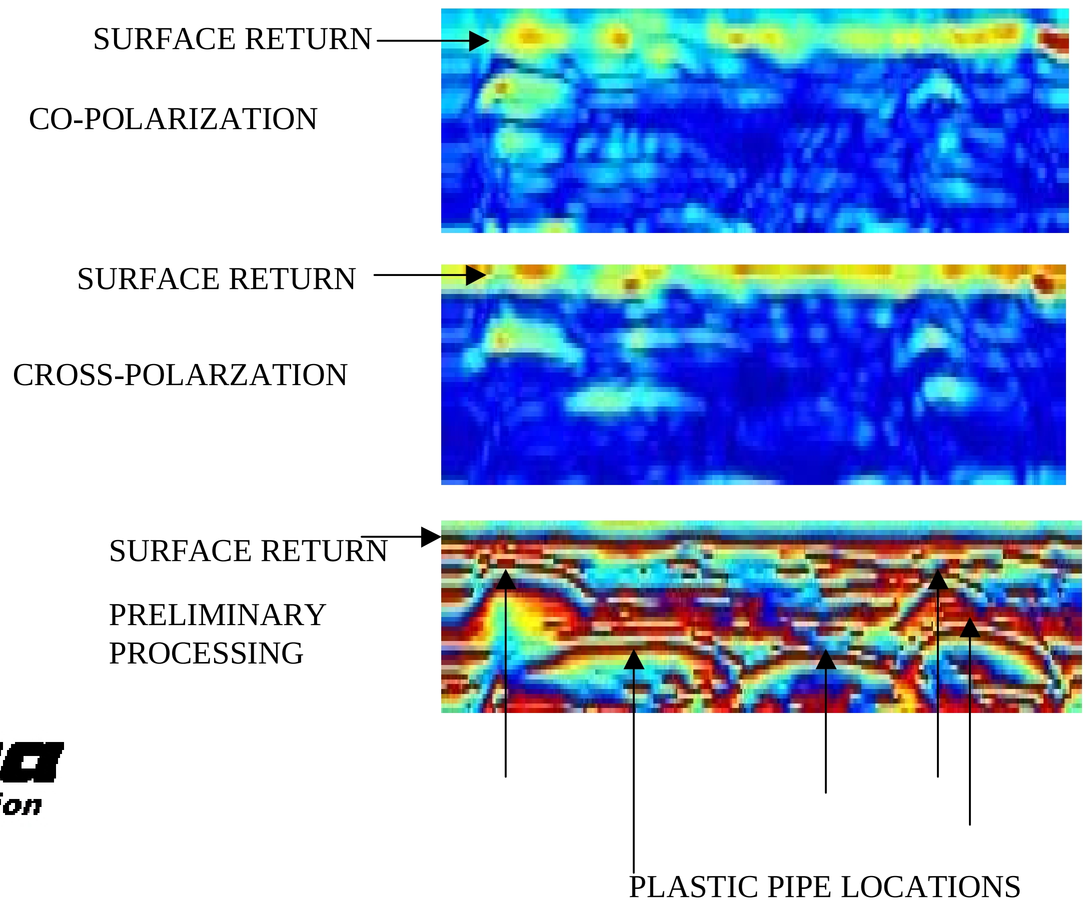
Sand Box: Test Area 1

Transmit LHC, Receive: LHC & RHC
bandwidth: 400Mhz-1500Mhz, 10MHz steps



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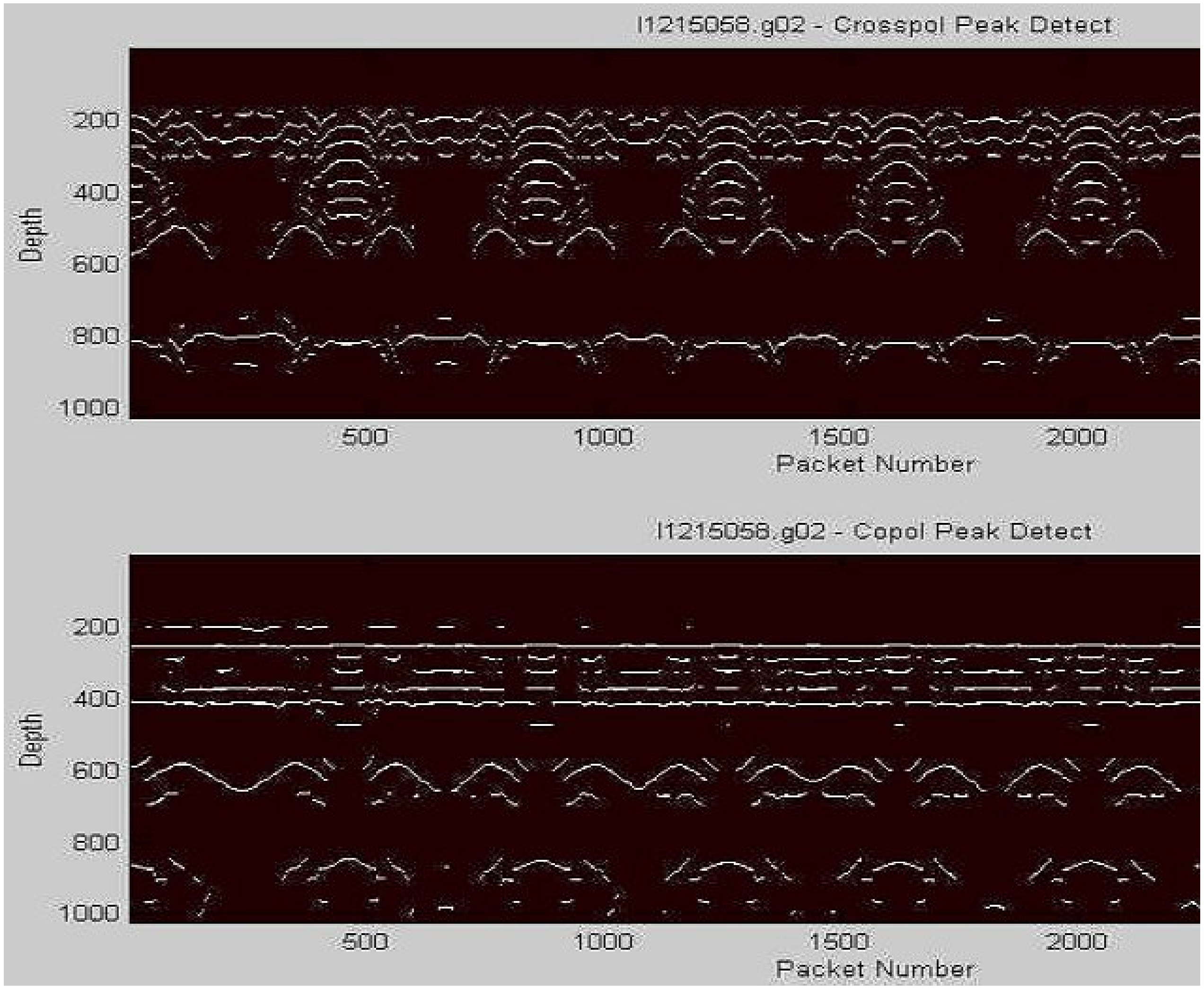
Processing for peak detection was applied to the data taken while scanning back and forth over two air filled plastic pipes.

One 2" diameter plastic pipe buried 2' deep, and a 3" diam. Plastic pipe buried 3' deep.

In both Cross- & Co-Polarization data the pipe peak signal returns are visible.



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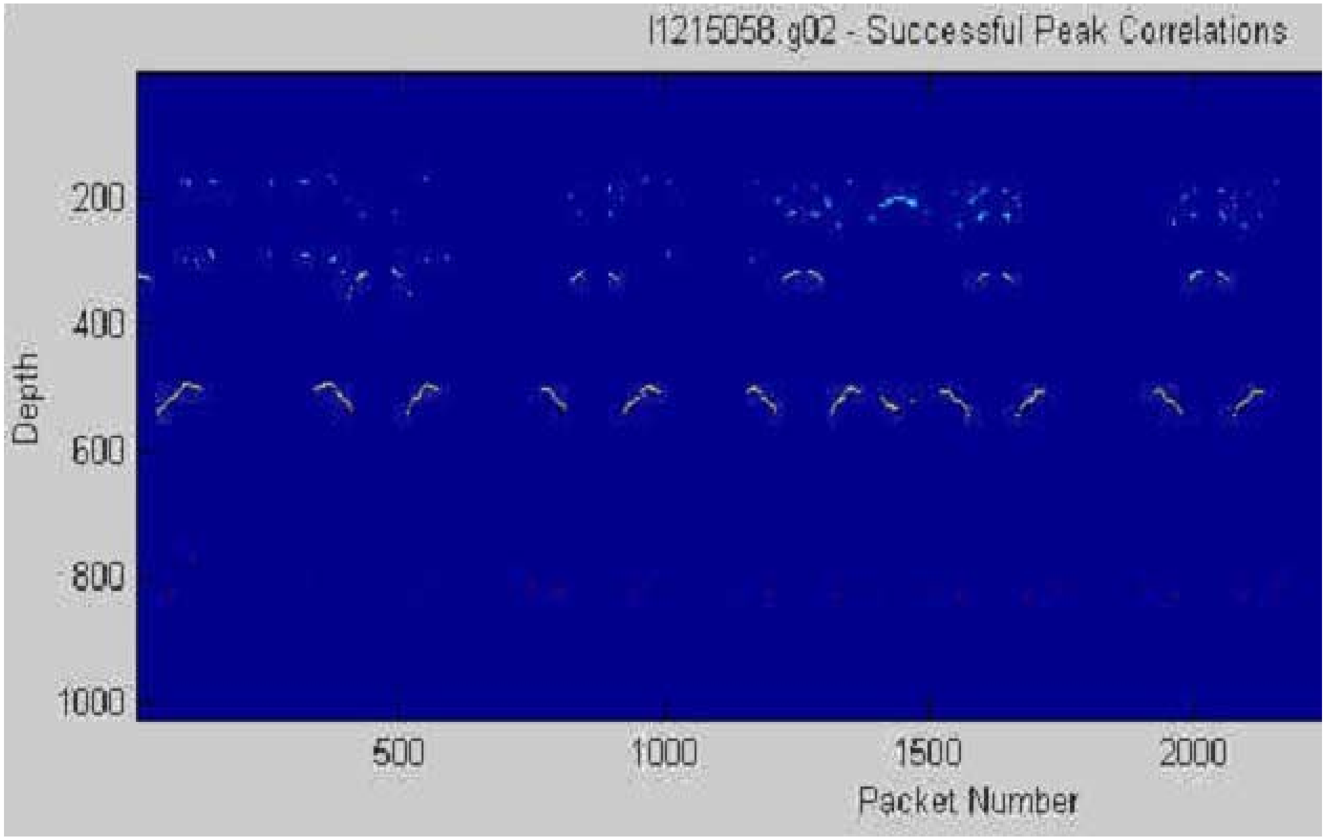

Processing for correlation of the cross- & co-polarization peaks detected was applied to the data taken while scanning back and forth over two air filled plastic pipes.

This eliminates clutter and leaves possible pipe locations better resolved.

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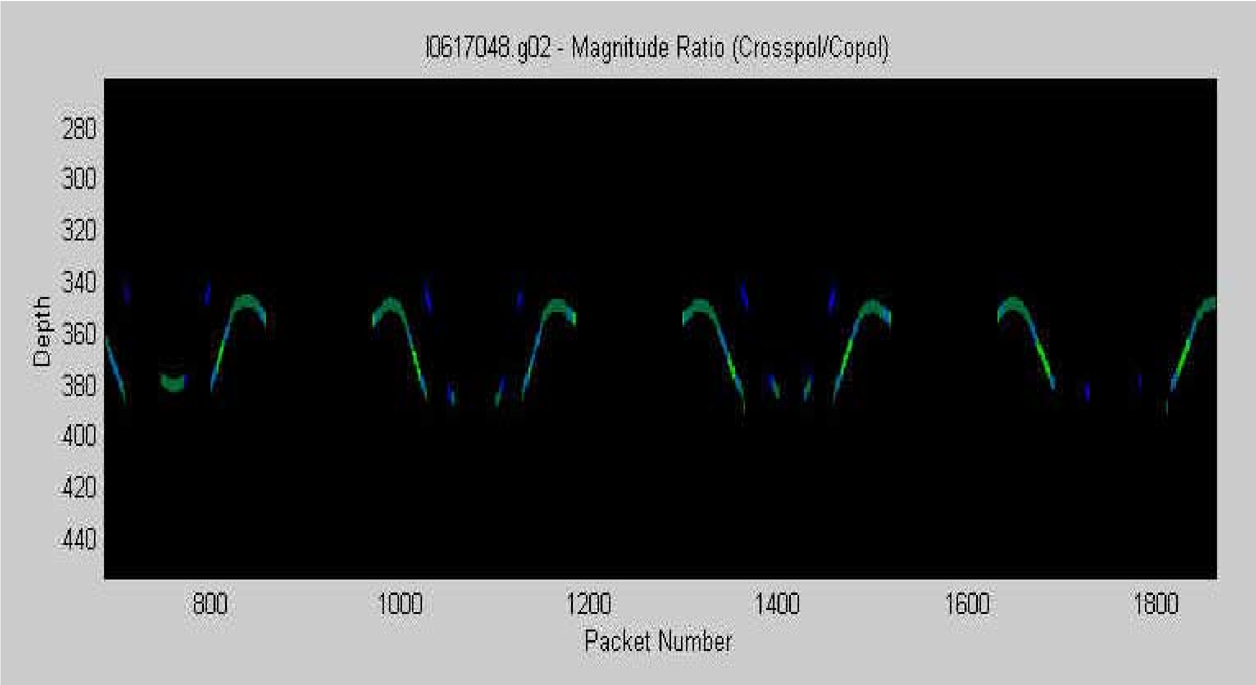
Processing for the ratio of the magnitude of the cross- & co-polarization peaks detected was applied to the data taken while scanning back and forth the 2” air filled plastic pipe buried 2’ deep.

The sweeps demonstrate a consistent magnitude ratio between co-polarization and cross-polarization antennas while scanning directly over the pipe.



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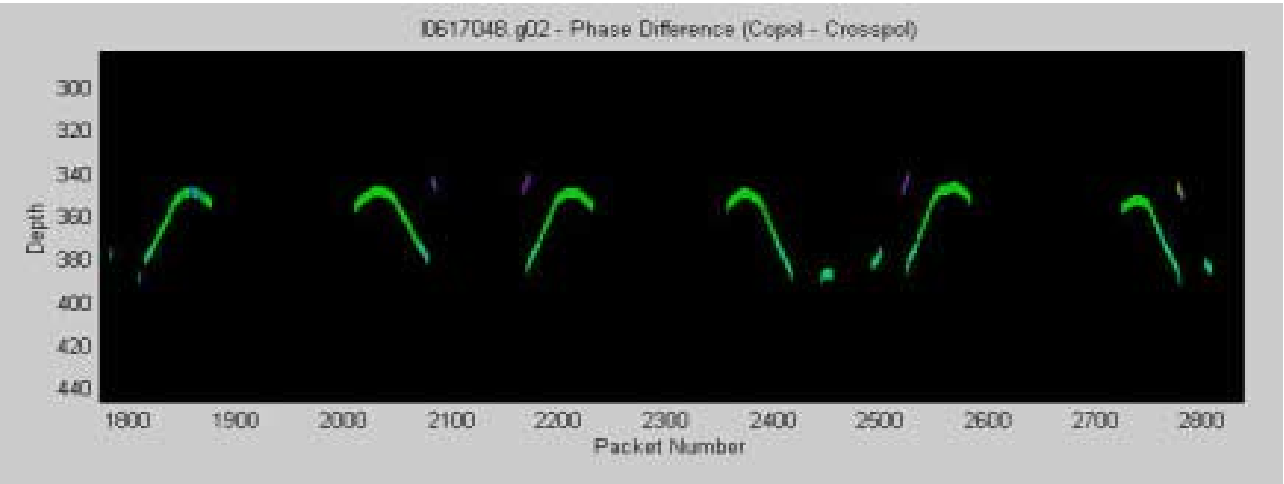
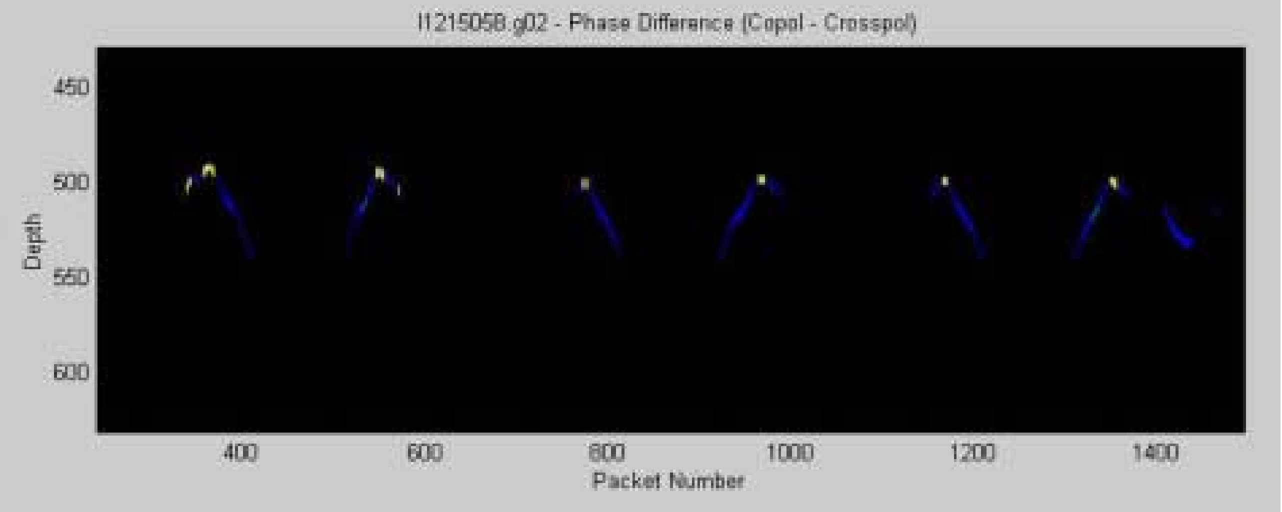
Processing for the phase difference of the cross- & co-polarization peaks detected was applied to the data taken while scanning back and forth over a 2” air filled plastic pipe buried 2’ deep and a 2” metal pipe buried 3’ deep.

Both plots show a consistent phase difference between the cross- & co-polarization data for multiple sweeps over a plastic pipe.





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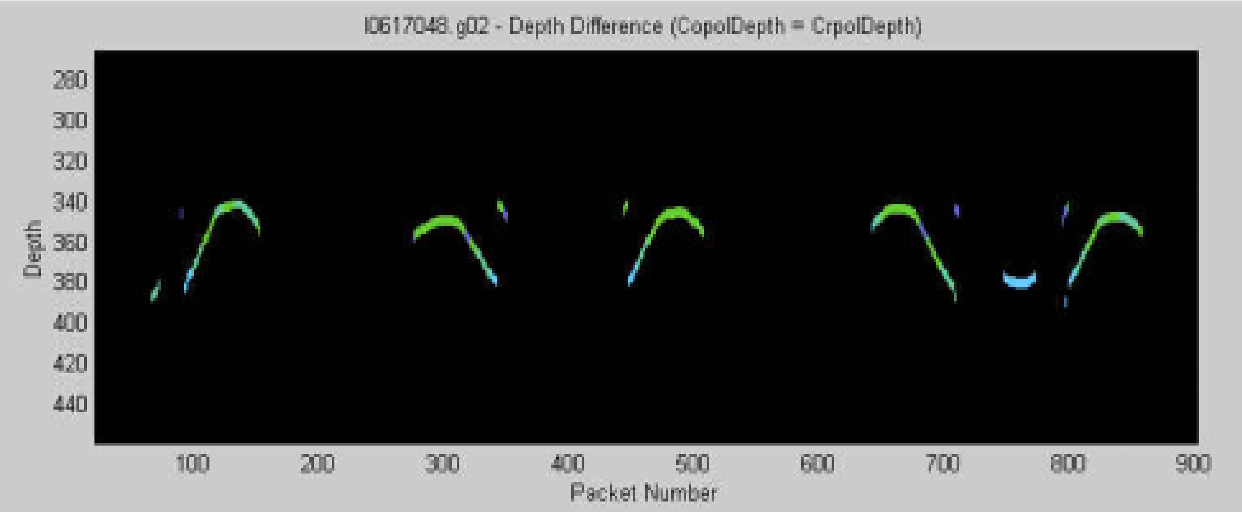
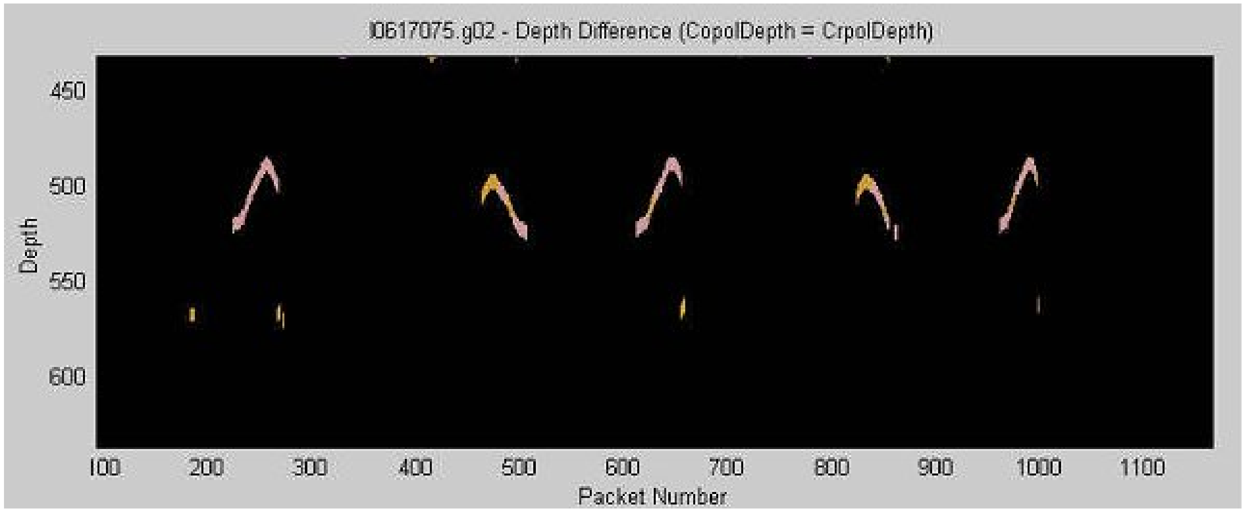
Processing of the time/depth difference of the cross- & co-polarization peaks detected was applied to the data taken while scanning back and forth over a 2” air filled plastic pipe buried 2’ deep and a 6” buried plastic pipe buried 3’ deep.

The sweeps demonstrate a consistent time difference between co-polarization and cross-polarization data.





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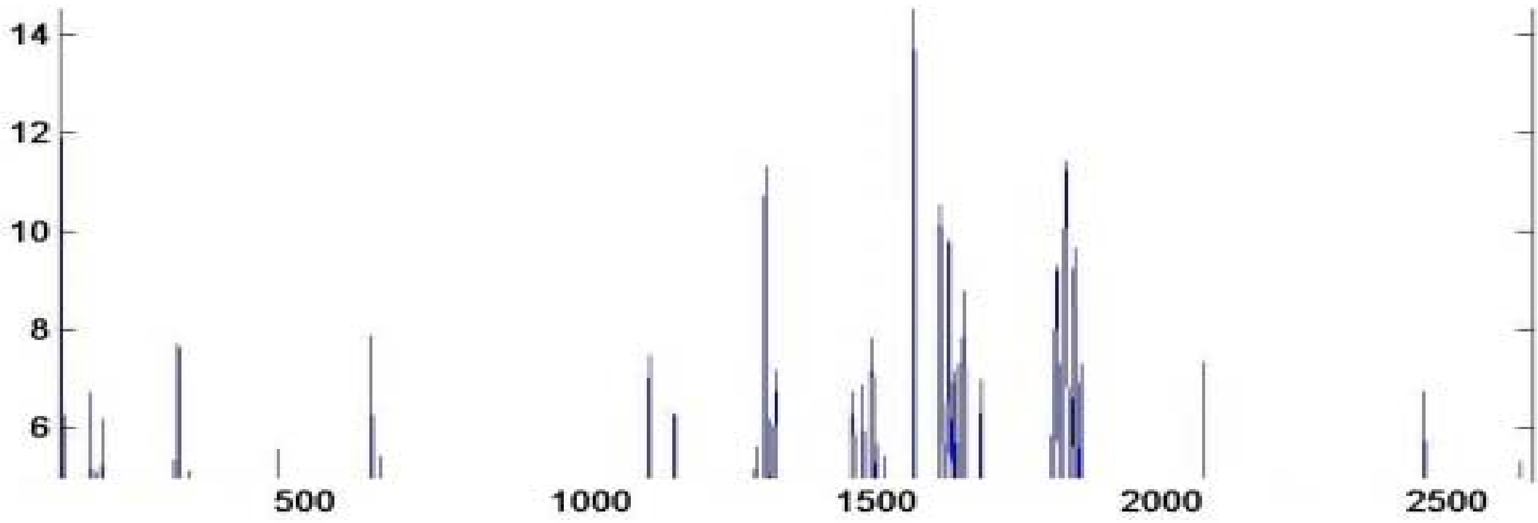

This data is the result of applying the HSTAMIDS Principal Component Analysis software to the magnitude of the cross- & co-polarization data while scanning over the 4” pipe buried 3.5 feet deep in the Test Area 2.

The data was taken in a clear area initially and then 4 scans over the pipe were made. This was followed by more scanning in a clear area. The four dense groups of signals indicate the detection of the buried plastic pipe. Clearly, there are false alarms while scanning in the clear area.

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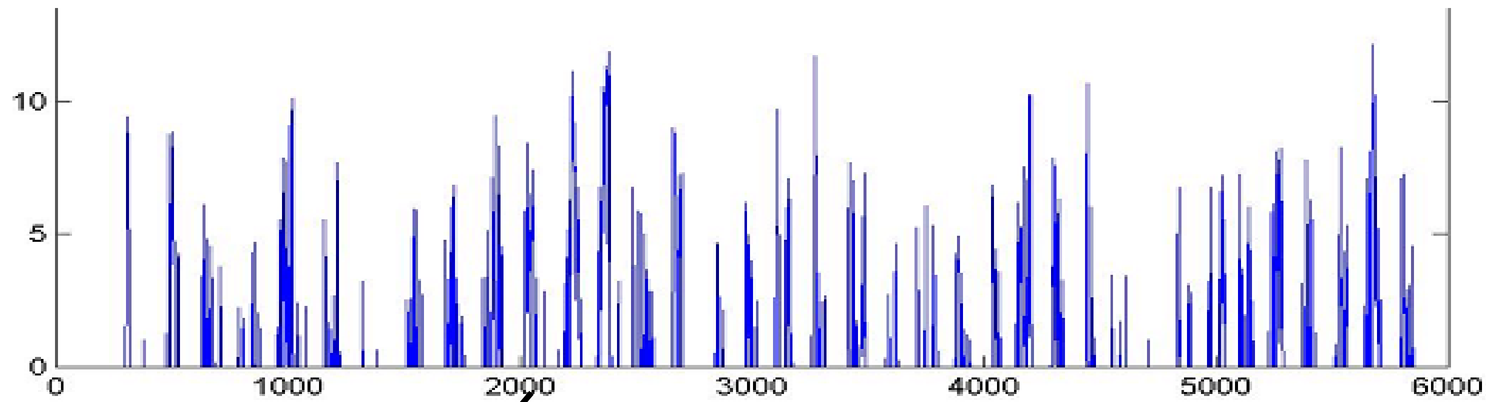

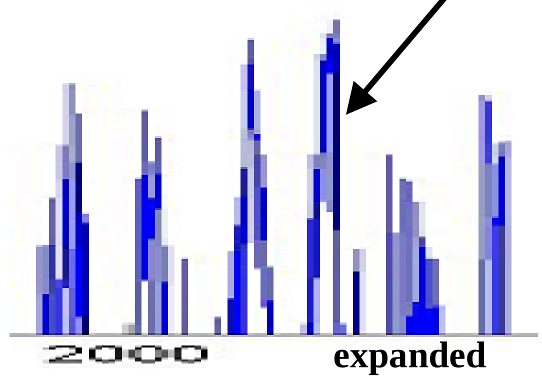

expanded

This data is the result of applying a slightly modified PCA software to the magnitude of the cross- & co-polarization data while scanning over the 4” pipe buried 3.5 feet deep in the Test Area 2. The data was taken while walking. Approaching the pipe from one end and scanning back and forth over the pipe. Also, ‘turning the corner’ when the pipe diverted at a right angle.

Consistent detections of the buried plastic pipe are indicated.

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Summary

Prototype hardware has been built – handheld, battery operated
- RF performance is excellent, design based on HSTAMIDS
- Configuration is easy to use, but heavy
- Investigate designs for single antenna, size & weight reduction

Software development in early stages
- Basic measurements indicate good capability for detection
- Discrimination of non-metallic facilities achievable
- Combine magnitude, phase and time features with PCA
- Real-time processing algorithm developed over next 3 months

Follow-on production implementation possible
- Production design needed, goal of lowest possible cost
- Analysis of industry needs determines final configuration

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