

## **INTRODUCTION**

Landmines and unexploded ordnance (UXO) are a legacy of war, insurrection, and guerilla activity. Landmines kill and maim approximately 26,000 people annually. In Cambodia, whole areas of arable land cannot be farmed due to the threat of landmines. United Nations relief operations are made more difficult and dangerous due to the mining of roads. Current demining techniques are heavily reliant on metal detectors and prodders.

Technologies are used for landmine detection are:

- Metal detectors--- capable of finding even low-metal content mines in mineralized soils.
- Nuclear magnetic resonance, fast neutron activation and thermal neutron activation.
- Thermal imaging and electro-optical sensors--- detect evidence of buried objects.
- Biological sensors such as dogs, pigs, bees and birds.
- Chemical sensors such as thermal fluorescence--- detect airborne and waterborne presence of explosive vapors.

In this discussion, we will concentrate on Ground Penetrating Radar (GPR). This ultra wide band radar provides centimeter resolution to locate even small targets. There are two distinct types of GPR, time-domain and frequency domain. Time domain or impulse GPR transmits discrete pulses of nanosecond duration and digitizes the returns at GHz sample rates. Frequency domain GPR systems transmit single frequencies either uniquely, as a series of frequency steps, or as a chirp. The amplitude and phase of the return signal is measured. The resulting data is converted to the time domain. GPR operates by detecting the dielectric contrasts in the soils, which allows it to locate even non metallic mines.

In this discussion we deal with buried anti-tank (AT) and anti-personnel (AP) landmines which require close approach or contact to activate. AT mines range from about 15 to 35 cm in size. They are typically buried up to 40cm deep, but they can also be deployed on the surface of a road to block a column of machinery. AP mines range from about 5 to 15cm in size. AT mines which are designed to impede the progress of destroy vehicles and AP mines which are designed to kill and maim people.

## HARDWARE DESCRIPTION

The impulse GPR system developed in the International Research Centre for Telecommunications-transmission and Radar (IRCTR). Impulse GPR system comprises a Impulse generator, Transmitter, Receiver, Pulse extender, A/D converter, Processor and Visual display.

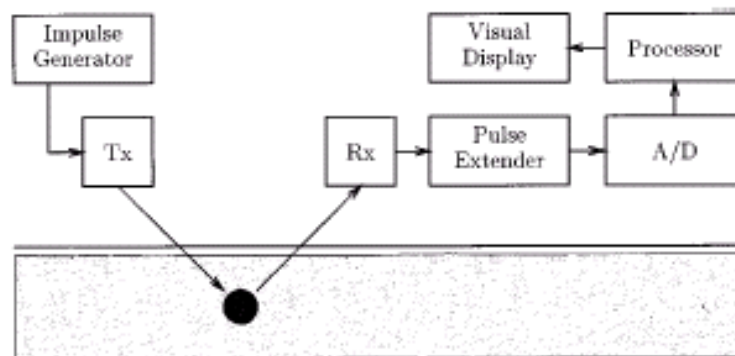


Figure 1. Block diagram

- **IMPULSE GENERATOR**

The pulse generator delivered by SATIS Co. produces 0.8 ns monocycle pulses. The unique feature of this generator is its small trailing oscillations, which are below 2.4% of maximum amplitude during the first 2 ns and below 0.5% afterwards. The advantage of a monocycle in

comparison with a mono pulse is that the frequency spectrum of the first one decreases to zero at low frequencies, which cannot be efficiently transmitted via the antenna system, while the frequency spectrum of the second one has a global maximum there. As a result, the magnitude of the field radiated by an antenna system fed by a monocycle is considerably larger than the magnitude of the field radiated by the antenna system fed by a monopulse with the same magnitude.

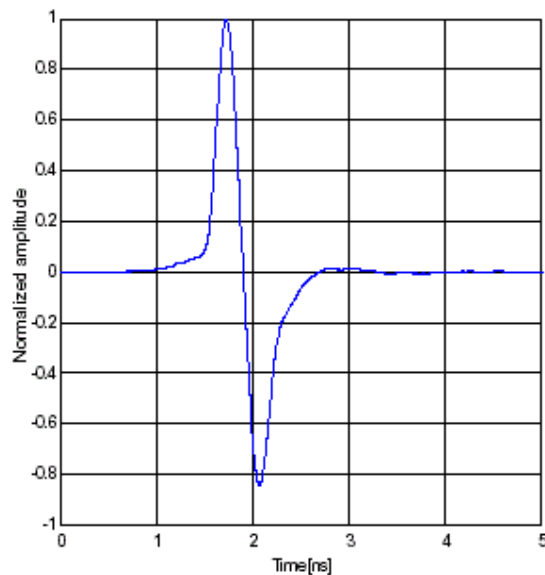


Figure 2. output signal from the 0.8ns generator

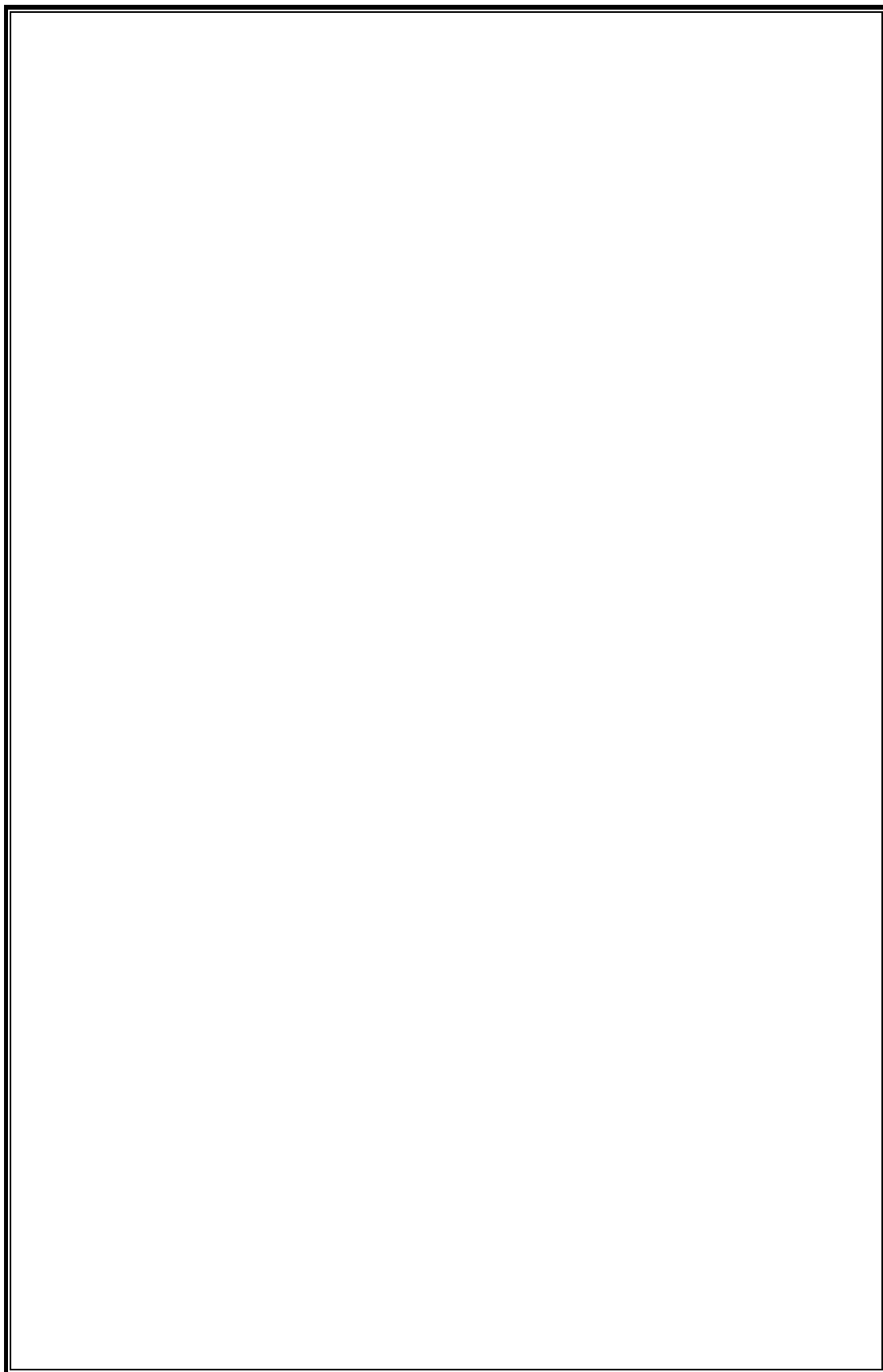
The generator spectrum covers a wide frequency band from 500MHz till 2GHz on 3dB level. At frequencies below 1GHz, attenuation losses in the ground are small and considerable penetration depth can be achieved. However, landmines detection requires down-range resolution of the order of several centimeters, which can be achieved using frequencies

above 1GHz. It was found experimentally that the 0.8ns monocycle satisfies penetration and resolution requirements. This output signal from 0.8ns generator is shown in figure. The spectrum of this pulse has a maximum at frequencies where the attenuation losses in the ground start to increase. So the spectral content of the monocycle below this maximum penetrates deep into the ground and the spectral content above this maximum provides sufficient down-range resolution.

- **ANTENNA SYSTEM**

The antenna system is one of the most critical parts of GPR system, because its performance depends strongly on the antenna system. The antenna system should satisfy a number of demands. The antenna system contains transmitter and receiver. The transmit antenna should:

- Radiate short ultra-wide band (UWB) pulse with small ringing.
- Radiate electro magnetic energy within a narrow cone in order to filter out undesirable back scattering from surrounding objects.
- Produce an optimal footprint on the ground surface and below it.
- The waveform of the radiated field on the surface and in the ground should be the same.
- The waveform of the radiated field in the ground should not depend on type of the ground.



The receiver antenna should:

- Allow time windowing to isolate the direct air wave from the ground reflection.
- Provide sufficient sensitivity in order to receive very weak fields.
- Receive the field in a local point; effective aperture should not be larger than  $1\text{cm}^2$ .
- Be elevated at least 10cm above the ground surface.

Additionally a possibility to measure simultaneously backscattered field in two orthogonal polarizations is desirable.

- **PULSE EXTENDER**

Pulse extender will amplify the ground reflection signal up to the maximum level acquired by A/D converter.

- **A/D CONVERTER**

The transmitter sends out a series of electromagnetic pulses then listens with the receiver connected to high speed sampler which in turn feeds A/D Converter. A dielectric anomaly in the soil may cause the signal to be reflected back to a separate receiver antenna. This information is converted from nanoseconds to milliseconds so that it may be digitized by a

conventional A/D converter for processing and display. The center frequency and band width of the transmitted pulse can be varied by changing the antenna and are chosen with respect to the required depth of penetration, soil type and size of the object to be detected. In this experiment, we used antennas with a center frequency 1.4GHz and 80% band width. The precision of sampling converter is sufficiently high to do accurate measurements of scattered transient field. This A/D converter 12 bit accuracy. This provides 66 dB linear dynamic ranges. A/D converter converts the signal into digital signal which passes to the processor.

- **PROCESSOR**

A/D converter converts the signal into digital signal which passes to the processor. Processor filters the signal. This signal shows presence or absence of surrogate mine in the soil. Processor allows passing the presence of mine detecting signal. Processor selects the mine detecting signal and passes to the visual display.

- **VISUAL DISPLAY**

Visual display helps to see the range of targets. It displays the exact position of landmine.

## **SENSORS EMPLOYED**

If all mines were cased or had substantial metallic content, all that would be required for detection are metal detectors. The widespread use of plastic landmines necessitates development and deployment of additional detection technologies. Because there is no such thing as a plastic detector, other sensors attempt to exploit ancillary disturbances in the background, such as thermal, chemical, or dielectric.

### **GROUND PENETRATING RADAR**

Because of the difficulty detecting the tiny amounts of metal in a plastic landmine with a metal detector, technology development has been funded in other areas. Ground penetrating radar (GPR) has been used for nearly 70 years for a variety of geophysical subsurface imaging applications including utility mapping and hazardous waste container location and has been actively applied to the problem of landmine detection for nearly 20 years. When parameters such as frequency range, antenna size, antenna separation, and system timing are optimized for detection of mine-sized objects in the near subsurface, GPR is quite effective in detecting both

metal and plastic landmines in a variety of soils. The depth of penetration is a function of both the frequency range produced and the soil attenuation. Lower frequency components penetrate further, but it is a higher-frequency component that is necessary to image and resolve smaller targets. Both impulse-based and swept frequency GPR systems have been employed in Army-sponsored research programs. Generally a system with a bandwidth of roughly 1 to 4GHz is effective for detection of landmines.

Ultimately, GPR images the dielectric properties of the soils, and any discontinuities appear as a signal. If soil were perfectly homogeneous, a discontinuity caused by a land mine would stand out as an anomaly against the background. Unfortunately, even under near-ideal test track conditions, soil itself is a remarkably inhomogeneous medium, and false alarms are easily generated from the background itself .

Because of this, automatic target recognition (ATR) algorithms employed by impulse-based GPR systems typically calculate and remove background and try to detect the hyperbolic signatures that are characteristic in size and shape of landmine targets in GEO-CENTERS 400 Series energy in focusing ground penetrating radar (EFGPR), we employ a fuzzy logic-based algorithm that use prototypes, or feature sets, for landmines, and prototypes than to clutter. At each location in a data set, we

look inside a neighborhood of adjacent points, extract a feature set, and calculate if the features set is closer to the mine prototypes .The output is a plan view of the confidence, at each point along a test lane, that there is a land mine .A blob detector then runs on this confidence plane view, outputting target reports when a blob is of an appropriate size and shape.

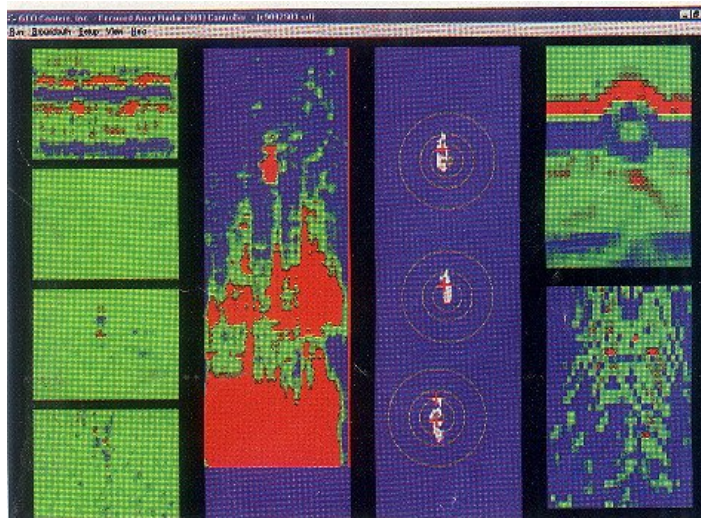


Figure 3. Screen shot of host software from GEO-CENTERS

Although GPR has been shown to be effective on the test track against a variety of land mines in a range of soil conditions, it is technologically complex . The weight and power requirements are not overwhelming, but they make GPR most easily deployed on a vehicular platform .Through NVESD at Fort Belvoir, the U.S Army is deploying GPR in a variety of hand held and vehicular land mine detection technology development programs .

## OVERVIEW OF THE SYSTEM

A series of measurements has been taken using a set of targets buried in the various types of soil. An FR-127-MSCB impulse ground penetrating radar (ImGPR) system developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia, has been used for these measurements. The system collects 127 returns, or surroundings, per second, each composed of 512 samples with 12 bit accuracy. The sounding range may vary from 4 ns to 32ns. The GPR system uses bistatic bow-tie antennas which transmit wideband, ultrashort duration pulses.

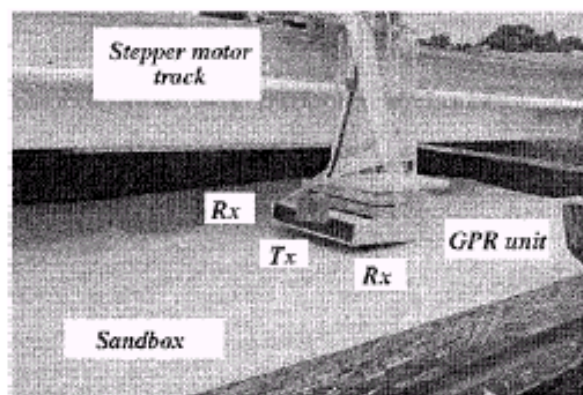


Figure 4. ImGPR unit running over a sandbox.

The GPR unit is suspended above the ground surface at a height of between 0.5 to 2cm. Its motion is controlled by a stepper motor unit running along a track at a constant velocity as shown in fig.4. Since the motion of the GPR is controlled by a stepper motor, with constant speed, running on a straight track, these samples corresponds to distances from starting point of the run.

GPR images the dielectric properties of the soil and any discontinuities appear as a signal. If the soil were perfectly homogeneous a discontinuity caused by a land mine would stand out as an anomaly against the background. Automatic targets recognition (ATR) algorithms employed by impulse based GPR system.

The measurements form a two dimensional matrix, referred to as a radargram or B scan and A scan are used for visual inspection of data on the acquisition computer and in laboratory analysis.

- A SCAN

Impulse GPR produces measurements of electromagnetic field scattered from the subsurface. This is detecting the graph as shown in figure.

A scan is a method for detecting the presence and absence of surrogate mine in clay soil. The electromagnetic field is scattered by the GPR. Scattering pulses are detecting by the graph. This graph is Amplitude Vs Time. This graph is helpful to find the landmine and is used for visual inspection. The normal pulses are showing the absence of mines. The amplitude of the pulses are large as compared to other area. This shows the presence of mine. So we can detect the presence of mine in that clay soil.

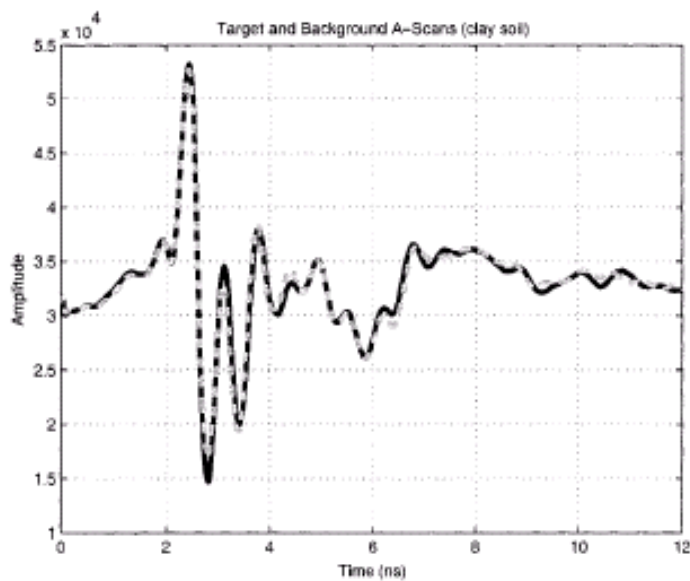


Fig. 5. A scans in the presence (dashed) and absence (solid) of a surrogate mine in clay soil.

- **B SCAN**

A scan shows the presence of mine but we cannot expect the exact target. This problem is solving in B scan. B scan or Radargram is used to visualize the target of surrogate mine. A sample radargram is shown in

figure. This showing the targets at approximately 55 cm and 100 cm. B scan calculating the distance from the soil to the mine. In this sample radargram showing the exact position.

A scan and B scan is used for laboratory analysis. A return at a certain position along the distance axis is called an A scan. B scan is a graph which is Time delay Vs Distance. So B scan helps to calculate the penetration length. This graph helps to calculate the distance from ground to the mine.

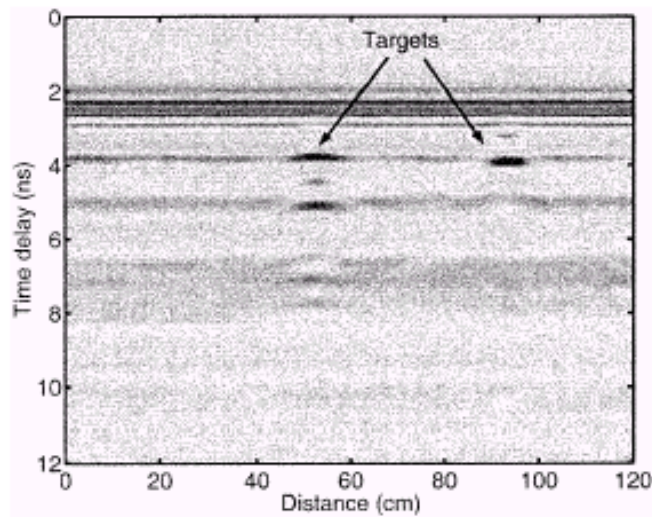


Fig. 6. Radargram showing target positions.

## **DEPLOYMENT PLATFORM**

US army handheld standoff mine detection system that is a self propelled cart with GPR system. As technological development for land mine detection tends to be a vehicular based system. This vehicular based system is shown in figure. 7.



Figure 7. self propelled cart with GPR system

This vehicle is self propelled so it can use in war places. This is a vehicular based system because vehicle can carry the weight and supply the

power. This does not mean, though, that handheld systems are limited to metal detectors. There are platforms that are smaller than full vehicles but larger than man deployable devices. This vehicle comprises a pulse generator, transmitter, receiver, pulse extender, A / D converter, processor and a visual display. This vehicle is passing through the soil, the pulse generator produces pulses and the transmitter transmits this signal to the ground. The soil contain the land mine, the receiver receives the ground reflecting signal. The A / D converter converts the signal nanoseconds to milliseconds. This signal is digital signal and this signal amplifies and filtering by the processor. The signal contains presence of land mine, passes to the visual display. This visual display helps to display the exact target of land mine. This helps to calculate the distance from the soil to the mine. This system is very useful to the war places. This vehicle is self propelled so it can make easy detection.

### **TESTING AND EVALUATION**

The U.S Army performs objective blind and scored testing at their testing facilities, which include carefully constructed mine lines. In this testing and evaluation environment, land mines are live (filed with explosive) because certain detection technologies such as Quadropole Resonance rely on detection of the actual explosive charge. However, on

this test lines, the mines are unfused and thus do not detonate if they are run over by detection system. Dirt and gravel lanes are maintained. Typically, the lanes are very smooth, largely free of bumps and ditches that would cause the sensor arrays to maintain an inconsistent sensor height that would substantially affect data quality. Off-road lanes are also used. They are not as pristine as dirt or gravel lanes but are still a substantially more controlled environment than a Jeep train through the Khyber Pass.

Each lane has an associated calibration lanes where the ground truth is known and contactors may run and rerun their system to iteratively optimize detection performance. GPR systems typically need calibration or timing alignment, and infrared cameras generally need bore sighting. The feature extraction and ATR algorithms on the individual sensor subsystems usually need to be tweaked to maximize the detection rate and minimize the false alarm rate for the particular environment. This can entail adjusting detection thresholds or determining optimum blob sizes. When acceptable performance is achieved on the calibration lane, the contractor is ready to run the blind, scored section of the lane.

## **ADVANTAGES**

- GPR has accurate measurements.
- GPR locates even small targets.
- It has been well founded by the defense.
- GPR operates by detecting the dielectric soils which allows it to locate even no metallic mines.
- Biological sensors can only operate for limited periods, but in GPR has no such limits.
- GPR has been tested in different environmental conditions.

## **DISADVANTAGES**

- The sensor such as GPR is larger and heavier.
- GPR is more power hungry.
- GPR can suffer falls alarm rates as high as metal detectors.

## **CONCLUSION**

Impulse GPR system is using for detecting anti-tank and anti-personal mines. Anti-tank mines are using for destroying the vehicles and anti-personal mines, which are designed to kill and maim people. Currently, very little technology is used in real-world demining activities. Active programs by the U.S Army in both land mine detection sensor development and systems integration are evaluating new technologies, incrementally improving existing technologies, increasing the probability of detection, reducing the false alarm rate, and planning out useable deployment scenarios. Through iterative design, build test cycles, and blind and scored testing at Army mine lanes, steady progress is being made.

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## **ABSTRACT**

Landmines are affecting the lives and livelihood of millions of people around the world. The video impulse ground penetrating radar system for detection for small and shallow buried objects has been developed. The hardware combines commercially available components with components specially developed or modified for being used in the system. The GPR system has been designed to measure accurately electromagnetic field backscattered from subsurface targets in order to allow identification of detected targets through the solution of the inverse scattering problem. The GPR has been tested in different environmental conditions and has proved its ability to detect small and shallow buried targets.

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