Further information about mine detection

ERA Technology is developing hand held and vehicle mounted mine detection systems, for both civilian and military applications. ERA's proven ground penetrating radar technology forms the basis for these systems, but with improved performance and functionality by using data fusion of the output of GPR and other types of sensor.

Mine infestation limits economic growth in many countries where conflicts have occurred, burdens a weakened medical infrastructure and causes devastating injury and death to the population. Hand held mine detectors are of particular importance in such situations, as they can be used in areas where access is difficult, and can detect small anti-personnel mines as well as larger anti-vehicle mines.

Vehicle mounted mine detection systems are designed for rapid detection of mines specifically targeted at vehicles. These systems can be used to mark out safe routes for both military and humanitarian aid traffic. Hand held and vehicle mounted mine detection systems thus have both combat and peace-time roles.

Index and links

Background information on ground penetrating radar

Ground penetrating radar can be applied to the detection of buried bodies, hostage situations (through wall radar) building and site surveying as well as the detection of pipes and cables. Ground penetrating radar radiates a packet of electromagnetic energy into the ground and detects the backscattered energy from the buried target. In the case of impulse radar the radiated pulse is typically a wavelet of several nanoseconds duration and in the frequency domain, covers a wide range of frequencies over the range several hundred MHz to several GHz. The power radiated per spectral line is in the order of a few nanowatts.

For close-in systems the radar antenna beam is moved in a known pattern over the surface of the ground and an image of the ground can be generated, in real time, on a display either in grey scale or in colour. The image can be a cross-section or a plan view. The radar image is not identical to an optical image because the wavelengths of the illuminating radiation are similar in dimension to the target. This results in a much lower definition in the radar image and one that is highly dependent on the propagation characteristics of the ground. In addition the beam pattern of the antenna is widely spread and this degrades the spatial resolution of the image, unless corrected. Suitable single channel radar systems are based on ERA Technology's field-proven, standard commercial impulse radar.

The high performance radar provides a state-of-the-art performance by virtue of advanced antenna and transmitter-receiver design. ERA Technology has supplied single channel systems for the following national mine research and development programmes: UK, Swedish, German, French, Swiss, Belgian and Dutch. A modified version of the radar has been used in trials in Cambodia. Designs for multi-channel radar systems are available for vehicle use. The low power, impulse radar technology offers cost effective technology and can detect metallic and minimum-metal buried mines in realistic conditions.

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Hand held mine detection – Minetect

Sensor head of the Minetect hand held mine detection system

The UK Department for International Development is supporting the development by ERA Technology for an effective, simple and low cost detector. This is marketed by ERA under the name Minetect.

The metal detection loop and the ground penetrating radar antenna are integrated in a lightweight sensing head – shown on the left. Combining these two detection methods offers considerable improvements in detection performance and significant reductions in false alarms.

A key feature of the design is a special (Patented) man-machine acoustic interface This approach utilises inherent capabilities of humans to "process" information and keeps the "man-in-the-loop".

Advantages of the Minetect system

- Minetect is a low cost hand held mine detection system.
- It combines the output from a metal detector and ground penetrating radar.
- A special acoustic man-machine interface presents the operator with information in a familiar format.
- Training time and costs are thus minimised.

The Minetect hand held mine detection system offers a realistic improvement in detection capability. It uses existing methods of operation, minimising training time and costs. Additionally, the production costs of this equipment should be significantly lower than the majority of current designs that use a display image.

Minetect has been assessed under operational conditions in Bosnia – see on the right.

- Read the full report on the Bosnia trials (pdf)
- View the presentation given at 3rd Demining Technologies Information Forum (DTIF)
  (PowerPoint - may take a long time to download)
- Hand held mine detection – Minetect Brochure (pdf)

MINETECT under assessment by SFOR in Bosnia

Vehicle mounted mine detection systems

ERA Technology is active in the development of vehicle mounted mine detection systems. These are based on proven ground penetrating radar technology, also used in the Minetect hand held mine detector. Vehicle mounted systems are designed to detect, identify, mark and in some cases neutralise mines and other ordnance over larger areas than hand held systems. They can be used to mark out safe routes for traffic and produce detailed plans for subsequent clearance by other techniques.

ERA multi-channel ground penetrating radar mounted on a specialist vehicle

Features of ERA's vehicle mounted system

- Electronic rather than mechanical scanning permits high rate of advance.
- Combination of different sensor technologies, with data fusion of outputs, can be used to achieve high detection and low false alarm rates.
- Transceiver and signal processing electronics up to 9m from the antennas, and so can be protected from accidental detonation.
- Ruggedised commercial off-the-shelf components.
- Physically robust system designed for ease of repair.
- Graphical output in a choice of formats, with remote telemetry.

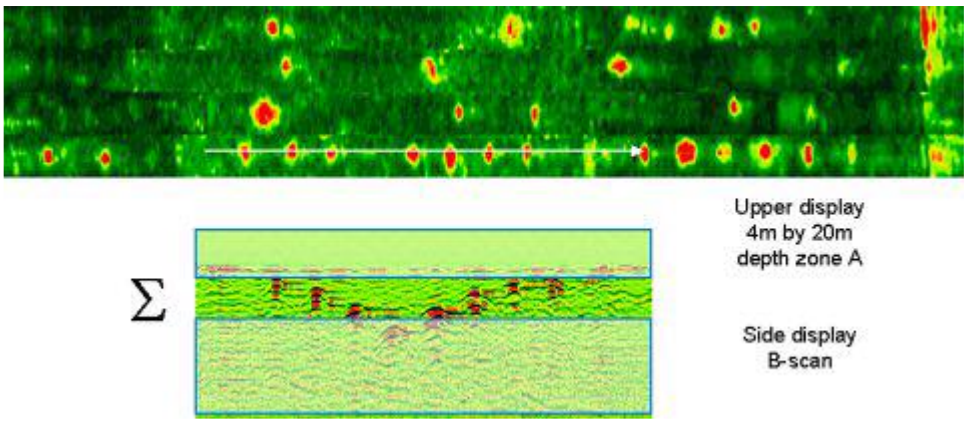
ERA Technology has designed and built multi-channel radar systems specifically for mine detection. A 4m wide swathe radar system uses 32 antenna elements. The architecture of the system is based around 16 receivers each of which sequentially samples the signal incident on receive antenna elements. Antenna spacing is chosen to provide adequate resolution of all likely targets, and sophisticated signal processing is used identify and display their position.

Over-view of ground penetrating radar array systems

One of the best methods for identifying mines on vehicle routes is to use multi-channel ground penetrating radar. This ensures complete coverage of the area traversed with a high rate of advance. Imaging of targets is required to facilitate classification and automatic detection. This requires either an array with high lateral antenna density or lateral mechanical scanning of the antenna. Sufficient samples must be taken across the width of the target to satisfy the Nyquist sampling criteria. Mechanical scanning fundamentally limits the speed of advance, so electronic scanning is preferred. Electronic scanning requires an antenna element density that is proportional to target size.

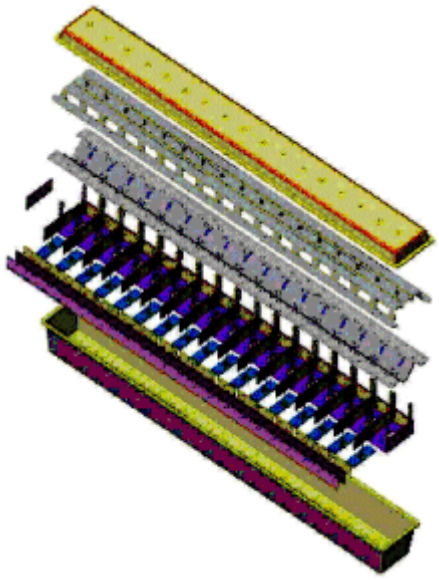
Anti-tank mines can be buried up to 300 mm deep in a wide range of ground types. In highly conductive or very wet clay soils operation at frequencies above 1 GHz results in a lack of penetration and so deep targets can be missed. Frequencies above 1 GHz also increase surface clutter effects. To achieve good ground penetration requires a lower frequency, in the region of 500 MHz, but resolution is compromised and the radiating antenna elements must be physically larger with greater spacing. Increased spacing means that even moderately sized targets are poorly imaged. High-density arrays, with a large number of channels, increase both cost and system complexity. In mine detection applications damage is highly likely, so system reliability, robustness and speed of repair are key factors. Excessive cost and complexity must be avoided.

ERA's current array system is a time domain impulse radar optimised for anti tank mine detection, with moderate performance against anti personnel mines. It operates with an antenna array element spacing of 125 mm and a centre frequency of 1 GHz. The antenna arrays are based on a wide band resistively loaded dipole antenna element. The design has been optimised to minimise loading and near field resonance effects when used close to dielectric surfaces. ERA believes that the chosen antenna element spacing and operating frequency is the best compromise when all the conflicting requirements are considered. Trials have shown good performance against a range of targets in soil conditions including: sand, crushed dolomite, wet clay and conductive soils.



Typical graphical output from a 4m multi-GPR system

The above shows an example of the rolling map output from such a system when tested on ERA's mine test track. The upper view is a collapsed area view of one depth slice of the data set. The lower view shows a side view through the track marked by the white line in the upper view.



16 channel antenna array segment

ERA's system is currently configured for 32 channel operation with an array width of 4 m in two 16 channel 2 m long segments. However, the system is fully scaleable from 1 to 64 channels and the array segment size can be varied to suit the customers logistic support needs. The antenna arrays are designed to be as simple as possible to minimise replacement costs. The diagram on the left shows an exploded view of one 16 channel segment.

To enable accurate pinpointing and speed dependent display updating of targets the system will accept navigation data from the host vehicle.

The radar transceiver and signal processing electronics are housed in 19" sub-racks, designed for mounting inside a vehicle at up to 9 m away from the actual antennas. The interconnections are high quality coaxial cables. This approach ensures that the radar and signal processing sub-systems can be protected from the effects of blast should a mine be initiated. The signal processing output can be supplied in a variety of forms depending on customer requirements. Graphical data can either be displayed locally using a dedicated display sub-system or passed to a display system in a remote vehicle using data modems. The whole system operates from a standard unconditioned 28V vehicle supply.

It is recognised that physical robustness is a key feature of any vehicle mounted system. ERA's system has been designed with robustness and ease of repair in mind.

Radar Transceiver

Dual channel impulse radar transceiver

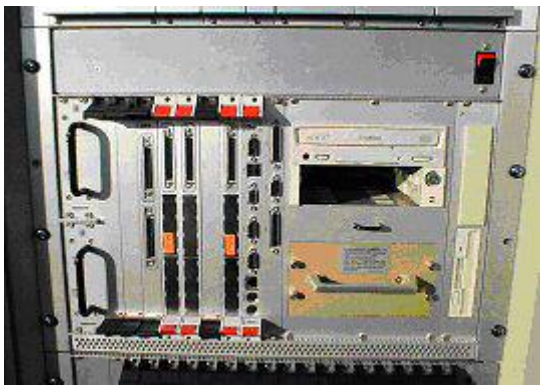
The heart of ERA's array radar system is a dual channel impulse radar card. This is shown on the left. Up to 16 of these can be fitted into one 6U 19" rack to implement a 32 channel system. A common timing and synchronisation card is used to assign each radar card a dedicated time-slot to avoid mutual interference.

If more than 32 channels are required then two racks can be linked together to provide up to 64 radar channels. In conjunction with two staggered 32 channel antenna arrays this provides adequate density for the detection of AP mines over a 4 m swath width.

Signal Processing

The signal processing platform utilises commercial off-the-shelf (COTS) cPCI cards fitted in an 8U 19" EMC shielded sub-rack as shown on the right.

Depending on the processing requirements, either Texas TMS320C6700 or Motorola G4 Altivec signal processors can be used.



Signal Processing sub-rack

Using ruggedised COTS technology on an industry standard bus ensures that long term service support is available with a clear upgrade path via technology insertion. This is a vital consideration where military equipment can have a 20 year lifetime and yet signal processing components can be obsolescence in less than five years. Using ruggedised COTS hardware also permits greater flexibility in the choice of ruggedisation level for a given application.

In addition to the provision of high performance signal processing devices at least 30 Gb of ruggedised disk storage can be provided for data logging.

The signal processing sub-system is forced cooled to permit the use of lower cost convection cooled COTS hardware and operates from an unconditioned 28V vehicle supply. BITE can be provided to card level to aid fault finding and system repair.

The signal processing algorithm set is selected and optimised for each application. Algorithm sets can be provided for both "man in the loop" and automatic target detection. We would be pleased to discuss the options for your particular requirements.

Specification summary - ERA ground penetrating radar array systems

No of channels	Up to 64 in two 4m long staggered banks. Standard configuration is one 4m long array.
Nominal frequency range	200 MHz to 4 GHz. Response rolls off at approximately 6 dB/octave either side of the centre frequency of 1 GHz.
Antenna element spacing	125 mm.
Pulse repetition frequency	1 MHz.
Swath width	Up to 4 m in 1 m increments.
Time range	12 ns to 50 ns
Radar sub-system size	6U 19" sub-rack, 350 mm deep. (32 channel system)
Signal processing unit size	8U 19" sub-rack, 350 mm deep.
Power source	18 - 30V DC.
Operating temperature	Radar and signal processing sub-racks -20^{o}C to + 50^{o}C. Antenna arrays -40^{o}C to + 50^{o}C.
Antenna sealing	IP66 with integral pressure relief valves for air transport.

The MINDER CAP project

The latest generation of anti-tank and anti-personnel land mines poses a significant threat to UK armed forces, as they are difficult to detect and destroy using conventional means. MINDER is a project to assess the technology capability of vehicle-mounted mine detection system that use multiple sensors to detect a wide range of metallic and non-metallic mines, both anti-personnel and anti-tank. Sensors evaluated included ultra-wide band and ground-penetrating radar, thermal imaging and metal detection. A variety of detection technologies, with data fusion to combine the sensor outputs, achieved high detection and low false alarm rates. The development team was led by Ultra Electronics, with ERA responsible for identifying and assessing the suite of mine detecting sensors to be used. The programme was part of a UK MoD SMART procurement programme to assess technology readiness levels.

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