



## EM39 CONDUCTIVITY

The EM39 Borehole Induction Probe provides measurement of the electrical conductivity of the soil and rock material surrounding a borehole or monitoring well using the inductive electromagnetic technique. The unit employs coaxial coil geometry with an intercoil spacing of 50 cm to provide an effective radius of exploration of 1 m into the formation while maintaining excellent vertical resolution. Measurement is unaffected by conductive borehole fluid or the presence of plastic well casing.

The combination of a large conductivity range, high sensitivity and very low noise and drift, allows accurate characterization of geologic conditions. Typical applications include groundwater contamination monitoring, groundwater and mineral exploration, and geotechnical investigations, to depths of 500 metres.

The 4-conductor EM39 probe can be used with many commercially available borehole logging systems, or with a dedicated winch and console system from Geonics.

Measurements can be viewed and recorded in real-time with either the DAS70-CX Data Acquisition System or any appropriate field computer.

### Specifications

<b>MEASURED QUANTITIES</b>	Apparent conductivity in millisiemens per metre (mS/m)
<b>PRIMARY FIELD SOURCE</b>	Self-contained dipole transmitter
<b>SENSOR</b>	Self-contained dipole receiver
<b>INTERCOIL SPACING</b>	50 cm
<b>OPERATING FREQUENCY</b>	39.2 kHz
<b>MEASURING RANGES</b>	± 100, 1000, 10,000 mS/m
<b>DEPTH</b>	200 m (500 m cable optional)
<b>MEASUREMENT RESOLUTION</b>	0.1 % of full scale
<b>MEASUREMENT ACCURACY</b>	± 5 % at 30 mS/m
<b>NOISE LEVELS</b>	<0.5 mS/m
<b>POWER SOURCE</b>	10 disposable "D" cells, or 12 VDC external power source
<b>DIMENSIONS</b>	Probe: 3.6 cm diameter, 163 cm length
<b>WEIGHTS</b>	Probe: 2.2 kg, Console: 7 kg Shipping: 90 kg (2 boxes)

## GAMMA39 NATURAL GAMMA

The EM39 Borehole Induction Probe was designed, in part, for rapid, accurate assessment of groundwater contamination in the soil and rock material surrounding monitoring wells. Because clay materials can produce an electrical conductivity response similar to some groundwater contaminants, however, Geonics introduced the Gamma39 Natural Gamma Probe to resolve ambiguity in interpretation. For example: whereas a conductivity high with a coincident high gamma count often indicates the presence of clay materials, a conductivity high without an associated high gamma count can be expected to be due to the contamination of groundwater.

Like the EM39 conductivity probe, the Gamma39 is unaffected by the presence of plastic casing in the well. No special license is required, it can be used anywhere, and is simple to operate. The unit, of course, can also be employed to detect radioactive wastes in the ground.

### Specifications

<b>MEASURED QUANTITY</b>	Naturally occurring gamma-radiation, in counts/second
<b>SENSOR</b>	Thallium-activated sodium iodide crystal
<b>COUNTS RANGE</b>	100, 300, 1000 counts/second
<b>DEPTH</b>	200 m (500 m cable optional)
<b>MEASUREMENT PRECISION</b>	one count/second
<b>POWER SOURCE</b>	10 disposable "D" cells, or 12 VDC external power source
<b>DIMENSIONS</b>	Probe: 3.6 cm diameter, 100 cm length
<b>WEIGHTS</b>	Probe: 1.6 kg

## EM39S MAGNETIC SUSCEPTIBILITY

The EM39S Magnetic Susceptibility Probe provides measurement of the magnetic susceptibility of the soil and rock material in the vicinity of a borehole or monitoring well. With an intercoil spacing of 50 cm, the EM39S provides good vertical resolution while still achieving a reasonable range of investigation into the surrounding medium. High sensitivity and low noise ensure an excellent range of measurement for most geological applications.

The susceptibility response is unaffected by plastic casing and, unlike conventional magnetometers, is unaffected by variations in either the remnant magnetization of the surrounding soil and rock, or the strength of the earth's magnetic field.

### Specifications

<b>MEASURED QUANTITY</b>	Magnetic susceptibility in parts per thousand (ppt)
<b>PRIMARY FIELD SOURCE</b>	Self-contained dipole transmitter
<b>SENSOR</b>	Self-contained dipole receiver
<b>INTERCOIL SPACING</b>	50 cm
<b>OPERATING FREQUENCY</b>	39.2 kHz
<b>MEASURING RANGES</b>	± 30, 300 ppt
<b>DEPTH</b>	200 m (500 m cable optional)
<b>MEASUREMENT RESOLUTION</b>	0.1 % of full scale
<b>MEASUREMENT ACCURACY</b>	± 5 % at 30 ppt
<b>NOISE LEVELS</b>	0.02 ppt
<b>POWER SOURCE</b>	10 disposable "D" cells, or 12 VDC external power source
<b>DIMENSIONS</b>	Probe: 3.6 cm diameter, 163 cm length
<b>WEIGHTS</b>	Probe: 2.2 kg Shipping: 90 kg (2 boxes)

# GROUND CONDUCTIVITY METERS



## EM31-MK2

Using a patented electromagnetic inductive technique that allows measurement without any requirement for either electrodes or ground contact, the EM31-MK2 Ground Conductivity Meter maps soil materials, groundwater contaminants or any subsurface feature associated with changes in conductivity. With this inductive method, surveys can be conducted over any surface conditions, including those with high resistivity materials such as sand, gravel and asphalt.

Ground conductivity (quad-phase) and magnetic susceptibility (in-phase) measurements are read directly from an integrated field computer. Enhanced data collection, with real-time graphics and integrated GPS compatibility, is available by connecting the DAS70-CX Data Acquisition System or other appropriate field computer directly to the RS-232 output.

The effective depth of exploration is about six metres from the instrument, making it ideal for environmental and engineering site characterization. Important advantages of the EM31-MK2 over conventional resistivity methods include: speed of operation; high-volume, continuous data collection; high spatial resolution of data; and the precision with which small changes in conductivity can be measured. Additionally, the in-phase component is particularly useful for the detection of buried metallic structure and waste material.

## EM31-SH

The EM31-SH is a "short" version of the standard EM31-MK2 providing an effective depth of exploration of about four metres. With a smaller coil separation (2 m) and lighter weight, the EM31-SH offers improvements in sensitivity to smaller near-surface targets, lateral resolution and portability, while maintaining the high levels of accuracy and stability provided by the standard EM31-MK2. Where field conditions allow, a supporting wheel assembly is an option.

## Specifications

<b>MEASURED QUANTITIES</b>	1: Apparent conductivity in millisiemens per metre (mS/m) 2: In-phase ratio of the secondary to primary magnetic field in parts per thousand (ppt)
<b>INTERCOIL SPACING</b>	3.66 metres
<b>OPERATING FREQUENCY</b>	9.8 kHz
<b>MEASURING RANGES</b>	Conductivity: 10, 100, 1000 mS/m; In-phase: $\pm 20$ ppt
<b>MEASUREMENT RESOLUTION</b>	$\pm 0.1$ % of full scale
<b>MEASUREMENT ACCURACY</b>	$\pm 5$ % at 20 mS/m
<b>NOISE LEVELS</b>	Conductivity: 0.1 mS/m; In-phase: 0.03 ppt
<b>DATA STORAGE</b>	512 MB internal disk storage; PC card compatible
<b>POWER SOURCE</b>	8 disposable alkaline "C" cells (approx. 20 h continuous)
<b>OPERATING TEMPERATURE</b>	Instrument: $-40^{\circ}$ C to $+50^{\circ}$ C Datalogger: $-20^{\circ}$ C to $+60^{\circ}$ C
<b>DIMENSIONS</b>	Boom: 4.0 m extended, 1.4 m stored Shipping Case: 145 x 38 x 23 cm
<b>WEIGHTS</b>	Instrument: 12.4 kg; Shipping: 28 kg



## EM34-3

Using the same inductive technique as the EM31-MK2, the EM34-3 Ground Conductivity Meter incorporates three intercoil spacings – 10, 20 and 40 m – to provide variable depths of exploration to 60 metres. With three intercoil spacings, and two dipole modes (horizontal as shown, and vertical) available with each spacing, a total of six measurements can be associated with a single location. With appropriate software (e.g. IX1D, EMIGMA, etc.), multiple measurements can be used to model the geologic profile.

Simple to operate and cost-effective, the EM34-3 is an instrument for the geologist and hydrogeologist alike. Common applications include the detection and delineation of groundwater contamination and the exploration for sources of potable groundwater; in the vertical dipole mode specifically, the EM34-3 is particularly sensitive to vertical geologic structure, and is widely used for applications within fractured and faulted bedrock systems.

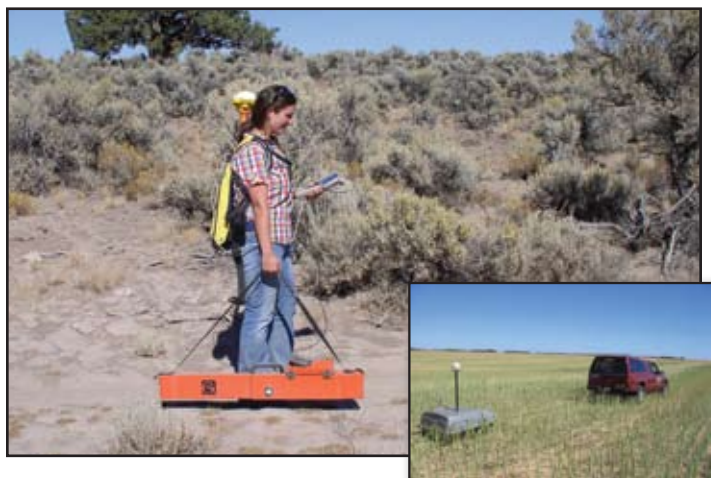
In regions of particularly high cultural and / or atmospheric noise, the EM34-3XL – including a larger transmitter coil and increased transmitter power – improves the signal-to-noise ratio by a factor of 10 at the 40 m spacing, and a factor of four at the 10 m and 20 m spacings.

The standard EM34-3(XL) provides an analog output signal; a real-time (RT) modification for conversion of the output signal from analog to digital, required for data collection with the DAS70-CX Data Acquisition System or any computer-based acquisition device, is available as an option.

## Specifications

<b>MEASURED QUANTITIES</b>	Apparent conductivity in millisiemens per metre (mS/m)
<b>PRIMARY FIELD SOURCE</b>	Self-contained dipole transmitter
<b>SENSOR</b>	Self-contained dipole receiver
<b>REFERENCE CABLE</b>	Lightweight, 2 wire shielded cable
<b>INTERCOIL SPACINGS &amp; OPERATING FREQUENCY</b>	10 m at 6.4 kHz 20 m at 1.6 kHz 40 m at 0.4 kHz
<b>CONDUCTIVITY RANGES</b>	10, 100, 1000 mS/m
<b>MEASUREMENT RESOLUTION</b>	$\pm 0.1$ % of full scale
<b>MEASUREMENT ACCURACY</b>	$\pm 5$ % at 20 mS/m
<b>NOISE LEVELS</b>	0.2 mS/m (can be greater in regions of high power line interference)
<b>POWER SOURCE</b>	Transmitter: 8 disposable "D" cells; rechargeables (optional) Receiver: 8 disposable "C" cells; rechargeables (optional)
<b>OPERATING TEMPERATURE</b>	$-40^{\circ}$ C to $+50^{\circ}$ C
<b>DIMENSIONS</b>	Receiver Console: 19 x 13.5 x 26 cm Transmitter Console: 15.5 x 8 x 26 cm Receiver & Transmitter Coil: 63 cm diameter EM34-3XL Transmitter Coil: 100 cm Shipping Case: 27.5 x 75 x 75 cm
<b>WEIGHTS</b>	Instrument: 20.5 kg; XL: 26.5 kg Shipping: 43 kg; XL: 51 kg

# GROUND CONDUCTIVITY METERS



## EM38-MK2

The EM38-MK2 provides measurement of both the quad-phase (conductivity) and in-phase (magnetic susceptibility) components, within two distinct depth ranges, all simultaneously, without any requirement for soil-to-instrument contact. With a maximum effective depth of exploration of 1.5 m, the EM38-MK2 will be of value to those with an interest in the very near surface: applications in agriculture, archaeology and general soil science are common.

The standard EM38-MK2 includes two receiver coils, each in the vertical dipole orientation, separated by 1 m and 0.5 m from the transmitter, simultaneously providing data within effective depth ranges of 1.5 m and 0.75 m, respectively; the instrument can be rotated such that both coils are in the horizontal dipole orientation, with effective depth ranges then of 0.75 m and 0.375 m, respectively. By comparison, the EM38-MK2-1 model includes one receiver coil only, in the vertical dipole orientation, at a distance of 1 m from the transmitter.

New coil technology, supported by temperature compensation circuitry, markedly improves temperature-related drift characteristics associated with the 1 m separation as compared with the previous series of EM38 instruments (which included a 1 m separation only).

Supporting both walking and trailer-mounted survey methods, external power sources can be connected for extended field operations; an optional, lightweight, rechargeable external battery pack provides for 25 hours of continuous operation. For trailer-mounted operations, a protective capsule, constructed of durable plastic materials, is an available option.

Bluetooth interface is a standard feature, providing reliable wireless communication with a compatible computer-based acquisition device within a 10 m distance.

An optional, collapsible calibration stand supports automation of the instrument calibration procedure. Once positioned within the stand, the instrument can be calibrated within seconds, without any requirement for iterative adjustments.

## Specifications

<b>MEASURED QUANTITIES</b>	1: Apparent conductivity in millisiemens per metre (mS/m) 2: In-phase ratio of the secondary to primary magnetic field in parts per thousand (ppt)
<b>INTERCOIL SPACING</b>	1 and 0.5 metres
<b>OPERATING FREQUENCY</b>	14.5 kHz
<b>MEASURING RANGE</b>	Conductivity: 1000 mS/m In-phase: $\pm 28$ ppt for 1 m separation In-phase: $\pm 7$ ppt for 0.5 m separation
<b>MEASUREMENT RESOLUTION</b>	$\pm 0.1$ % of full scale
<b>MEASUREMENT ACCURACY</b>	$\pm 5$ % at 30 mS/m
<b>NOISE LEVELS</b>	Conductivity: 0.5 mS/m; In-phase: 0.02 ppt
<b>DATA OUTPUT</b>	RS-232 serial port, Bluetooth
<b>POWER SOURCE</b>	9 V disposable battery; external rechargeable battery pack (optional)
<b>BATTERY LIFE</b>	Up to 5 h continuous for MN1604; 12 h continuous for L522; 25 h for rechargeable battery pack
<b>OPERATING TEMPERATURE</b>	-40° C to +50° C
<b>DIMENSIONS</b>	Instrument: 107 x 17 x 8 cm Shipping Case: 114 x 20 x 26 cm
<b>WEIGHTS</b>	Instrument: 5.4 kg; Shipping: 14 kg



## DAS70-CX DATA ACQUISITION SYSTEM

The DAS70-CX Data Acquisition System is available as an option for all models of Ground Conductivity Meters with the real-time (RT) modification for digital signal output, and all models of the original EM61 and EM61-HH Metal Detectors. A complete DAS70-CX system includes a rugged, waterproof Allegro CX field computer; interface cables; and utility software with programming for data transfer and management.

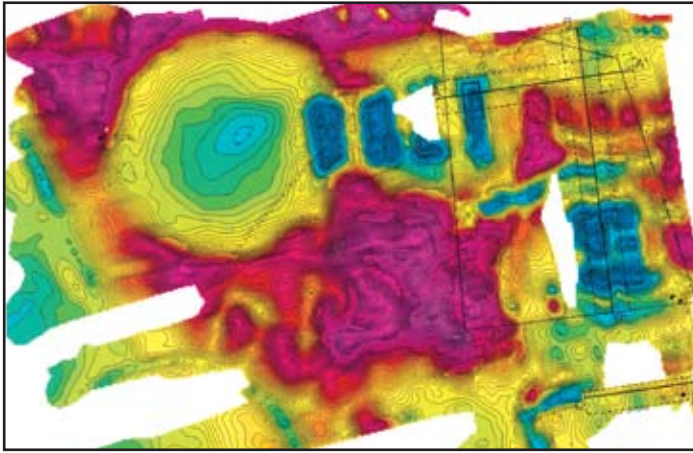
The Allegro CX field computer provides several benefits for field operations including a real-time graphic display of collected data for quality control; high capacity (512 MB) internal data storage; PC card compatibility and NiMH batteries for extended survey time; and an additional input connector to support the simultaneous collection of EM and GPS data.

Important specifications of the Allegro CX include the Intel XScale 400 MHz processor; 128 MB RAM; the intuitive Windows CE operating system; and an active matrix TFT colour display that is highly visible in direct sunlight. Included Bluetooth can be used to develop custom applications. Optional third party applications, including real-time, colour-scale mapping, can further increase functionality.

For survey applications that include the use of multiple (e.g. EM61-MK2) units within an array configuration, the DAS70CX-ML Data Acquisition System, including the Allegro CX field computer, supports simultaneous EM and GPS data collection through six available input connections.

## Specifications

<b>PROCESSOR</b>	Intel XScale 400 MHz
<b>OPERATING SYSTEM</b>	Windows CE.NET 4.2
<b>DATA STORAGE</b>	512 MB internal disk storage; PC card compatible
<b>COMMUNICATIONS</b>	Two 9-pin RS-232 ports
<b>DISPLAY</b>	High visibility active matrix TFT colour display (320 x 240 pixels)
<b>KEYBOARD</b>	Large keys for use with gloved hands; Touchscreen enabled
<b>POWER SOURCE</b>	Rechargeable NiMH high capacity battery pack
<b>OPERATING TEMPERATURE</b>	-30° to +54° C
<b>DIMENSIONS</b>	25 x 15 x 3.8 mm
<b>WEIGHT</b>	<1 kg



Geonics recommends any mapping application that supports multiple mapping and presentation formats, which can each be readily customized. Gridding algorithms should be best suited to line-based data of high density and high dynamic range. The following are popular third party options:

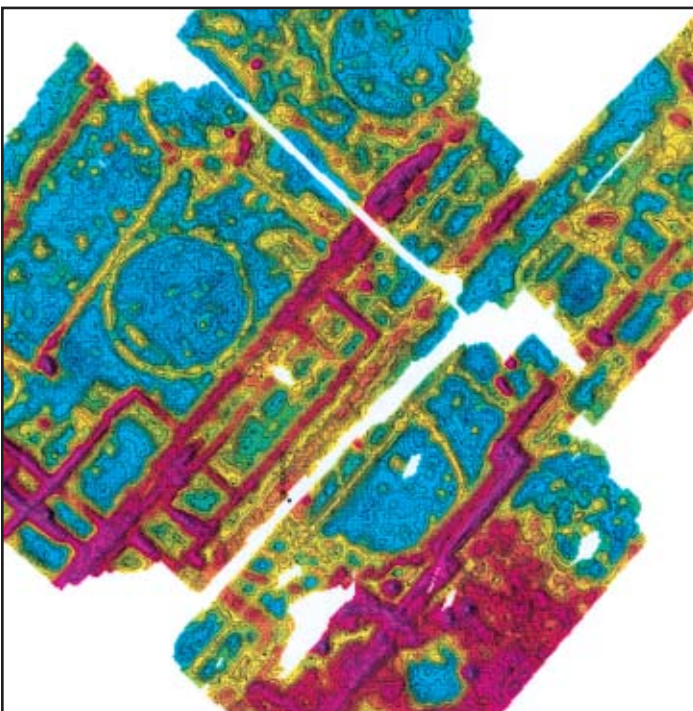
## Surfer

Surfer is a powerful gridding, contouring and surface mapping program developed by Golden Software, Inc. Data is quickly and easily converted into outstanding contour, 3D surface, 3D wireframe, vector, image, shaded relief and post maps. Virtually all aspects of your maps can be customized to produce exactly the presentation desired. The production of publication quality maps has never been quicker or easier.

## OASIS montaj

A leading exploration technology solution, Oasis montaj provides a scalable environment for efficiently importing, processing, viewing, analyzing and sharing large volume geophysical, geochemical and geological data, all within one integrated environment.

Manage your advanced earth mapping projects. Process, map, integrate, QA and interpret all your ground and airborne survey data. This powerful mapping and processing software is designed to support and streamline your daily problem solving needs, with a rich set of easy to use features that meet and exceed rising global standards.



## EM61-MK2A

The EM61-MK2A is a high sensitivity, high resolution, time domain metal detector suitable for the detection of both ferrous and non-ferrous metal. Typical target response is a single, sharply defined peak, facilitating quick and accurate determination of location. Achievable depth of detection will depend on several target characteristics, with the surface area and orientation of the target of particular importance. A single 200 litre (55 gal.) drum can be detected at depths greater than three metres.

In comparison with the previous-standard EM61-MK2, the EM61-MK2A provides the same feature and performance specifications. Differences between the two models are ergonomic: because the A-model does not include a backpack for system components, the electronics console is mounted on the U-handle, and the battery is positioned in the centre of the coils.

Data from multiple time gates – three or four, user-selectable – are recorded to provide a description of the response decay rate, supporting both the characterization and limited discrimination of targets. Data collection is supported by the DAS70-CX Data Acquisition System.

The system can be pushed or pulled as a trailer, by person or vehicle, as either a single unit or an array of multiple units; for multiple unit configurations, options are available to customize component specifications and layout. As may be required, with the addition of a backpack and associated cable set, the system can be carried by a single person with a belt harness.

## High Power (HP) Modification

To increase the depth at which any target is detectable, the high power (HP) modification increases the amount of signal received by eight times, resulting in significant improvements in the signal-to-noise ratio. Compared to the standard EM61-MK2A, the depth of detection for any target will increase between 45% and 80%, depending on target characteristics.

## Specifications

<b>MEASURED QUANTITIES</b>	Four time gates of secondary response in mV
<b>EM SOURCE</b>	Air-cored coil, 1 x 0.5 m size
<b>CURRENT WAVEFORM</b>	Unipolar rectangular current with 25 % duty cycle
<b>EM SENSORS</b>	a) Main: Air-cored coil, 1 x 0.5 m in size, coincident with EM source b) Focusing: Air-cored coil, 1 x 0.5 m in size 30 cm above main coil
<b>MEASURING RANGE</b>	10,000 mV
<b>DYNAMIC RANGE</b>	18 bits
<b>OUTPUT MONITOR</b>	Colour TFT active matrix LCD (320 x 240 pixels), and audio tone
<b>DATA STORAGE</b>	512 MB internal disk storage; PC card compatible
<b>POWER SOURCE</b>	12 V rechargeable battery for 4 h continuous operation
<b>OPERATING TEMPERATURE</b>	-30° C to +60° C
<b>OPERATING WEIGHT &amp; DIMENSIONS</b>	41 kg in trailer mode; 100 x 50 x 5 cm (bottom), 100 x 50 x 2 cm (top)
<b>SHIPPING WEIGHT &amp; DIMENSIONS</b>	90 kg with trailer-mode components; 106 x 61 x 33 cm (box 1), 54 x 45 x 56 cm (box 2)



## EM61S

For applications in marine environments, the EM61S (Submersible) is a submersible coil and cable system capable of operation to depths of more than 60 metres. The feature and performance specifications of the EM61S are the same as the standard EM61-MK2A; the high power (HP) modification is an available option.

The EM61S is available as either a complete stand-alone system, or as an attachment to an EM61-MK2A (or EM61-MK2), to be operated either as a single unit or in multiple unit configurations; customized component specifications and layout are available.

## EM61HH-MK2A

The EM61HH-MK2A is a "hand-held" complement to the EM61-MK2A, providing greater sensitivity to smaller targets at shallow depths. A single 20 mm projectile can be detected to a depth greater than 0.5 m; a single 200 litre (55 gal.) drum can be detected to depths of greater than two metres.

With a narrower spatial focus than the standard EM61-MK2A, the EM61HH-MK2A is relatively less sensitive to sources of potential interference. As a result, data can be collected in closer proximity to cultural features such as fences and buildings. Additionally, the narrower focus provides for enhanced target resolution and, by consequence, improved discrimination of multiple targets.

The EM61HH-MK2A can be operated either with or without wheels. In either mode of operation, the smaller, more portable design offers improved access to areas of particularly difficult terrain and dense vegetation.

## EM61HH-MK2A Specifications

<b>MEASURED QUANTITIES</b>	Four time gates of secondary response in mV
<b>EM SOURCE</b>	Air-cored coil, 17 cm diameter
<b>CURRENT WAVEFORM</b>	Unipolar rectangular current with 25 % duty cycle
<b>EM SENSORS</b>	Air-cored coil, 17 cm diameter
<b>MEASURING RANGES</b>	10,000 mV
<b>DYNAMIC RANGE</b>	18 bits
<b>OUTPUT MONITOR</b>	Colour TFT active matrix LCD (320 x 240 pixels), and audio tone
<b>DATA STORAGE</b>	512 MB internal disk storage; PC card compatible
<b>DATA OUTPUT</b>	RS-232 serial port
<b>POWER SOURCE</b>	15 V rechargeable lithium battery for 4 h continuous operation
<b>OPERATING TEMPERATURE</b>	-30° C to +60° C
<b>OPERATING WEIGHT &amp; DIMENSIONS</b>	Sensor Assembly: 2.8 kg (7.5 kg with wheels); 33 x 20 cm
<b>SHIPPING WEIGHT &amp; DIMENSIONS</b>	17.5 kg (36 kg with wheels); 142 x 25 x 25 cm (sensor), 55 x 50 x 55 cm (wheels)



## EM63-3D-MK2

With three orthogonal receivers each simultaneously measuring the complete transient response associated with each of three orthogonal transmitters, the EM63-3D-MK2 represents our most advanced instrumentation for the characterization and classification of near-surface metallic objects.

Any one transmitter coil generates a pulsed primary magnetic field that induces eddy currents in any nearby metallic objects. The decay of these eddy currents with time generates a secondary magnetic field with a specific rate of decay that is determined uniquely by the object characteristics: size, shape, orientation, composition, etc. Measurement of the secondary field decay (the transient response), therefore, will provide important information toward a more complete characterization and classification of all objects; the identification and rejection of the characteristic response from certain geologic materials (e.g. magnetite); and, for applications associated with the interrogation of unexploded ordnance and similar items of explosive concern, an important reduction in target selection error (the "false positive" rate). And with three orthogonal transmitter coils, the EM63-3D-MK2 provides the further benefits associated with the illumination of an object from multiple directions.

The EM63-3D-MK2 accurately measures the complete transient response over a wide dynamic range of time: measurements are recorded at 26 geometrically spaced gates, covering a time range from 180µs to 25ms. Continuous, high-volume data acquisition in walking mode is supported by the Panasonic Toughbook field computer, which can simultaneously record both EM and GPS data.

In the event that the full capabilities of the EM63-3D-MK2 are not required, the EM63-MK2, with three orthogonal receiver coils, includes a single vertical-dipole transmitter only.

## Specifications

<b>MEASURED QUANTITIES</b>	26 time gates of secondary response in mV; time range from 180µs to 25 ms
<b>EM SOURCE</b>	Three air-cored coils, nominally 1 x 1 m size each
<b>CURRENT WAVEFORM</b>	Bipolar rectangular current
<b>EM SENSORS</b>	Four air-cored coils, compensation plus three orthogonal signal coils, nominally 30 x 30 cm each
<b>MEASURING RANGES</b>	10,000 mV
<b>DYNAMIC RANGE</b>	18 bits
<b>OUTPUT MONITOR</b>	10.4 inch TFT active matrix colour LCD
<b>DATA STORAGE</b>	Solid-state memory with 2000 h capacity
<b>DATA OUTPUT</b>	USB port, network connection
<b>POWER SOURCE</b>	12 V rechargeable battery for 4 h continuous operation
<b>OPERATING TEMPERATURE</b>	-20° C to +60° C
<b>OPERATING WEIGHTS</b>	EM63-3D-MK2: 103 kg; EM63-MK2: 87 kg
<b>SHIPPING WEIGHT &amp; DIMENSIONS</b>	EM63-3D-MK2: 140 kg; EM63-MK2: 124 kg 110 x 110 x 30 cm (box 1), 107 x 60 x 55 cm (box 2)

# PROTEM TIME DOMAIN EM SYSTEMS



## PROTEM RECEIVER

The primary purpose of any time domain electromagnetic receiver is to record the transient signal generated by the decay of induced eddy currents in the subsurface. As the received voltage will span a very large amplitude range, often more than six decades from early to late times, the receiver must accurately record both high amplitude, rapidly changing voltage at early times, and very small amplitude, slowly changing signal at late times.

The PROTEM Receiver divides the transient into time windows, then converts the voltage in each window into a digital value. During this process, to ensure the highest quality of data in all operating environments, PROTEM offers a number of important design benefits:

- A large (270 kHz) input bandwidth to avoid distortion of early time signals
- Seven selectable gain settings in binary steps from 104 to 6,656
- Optimized window specifications for each of seven base frequencies: early time windows, as narrow as 1.4  $\mu$ s for accurate measurement of fast-changing signal; wide late time windows to reduce noise levels before stacking
- Stacking of >550,000 transients at 25 Hz base frequency, or >700,000 transients at 30 Hz (incl. repeats) to further reduce any noise
- Up to 99 repeat readings to support "smart stacking" during post-processing of data
- A true, proprietary 24-bit ADC optimized for transient measurements: smaller responses are resolved with less amplification such that very weak signal can be measured in the presence of high amplitude noise

As the principal component of the modular PROTEM system, the receiver can be used with any of five standard TEM transmitters to cover a broad range of exploration depths; both single- and three-component data collection is available with any transmitter, supported by any of several induction coils or fluxgate magnetometers available from Geonics, or compatible SQUID sensors.

## Specifications

<b>MEASURED QUANTITIES</b>	Rate of decay of magnetic field along 3 axes, in nV/m <sup>2</sup>
<b>CHANNELS</b>	1 channel used sequentially for 3 components; optionally, 3 channels for 3-component simultaneous operation
<b>TIME GATES</b>	20 gates covering 2 time decades, or 30 gates covering 3 time decades
<b>DYNAMIC RANGE</b>	24 bits (144 dB) at a single gain
<b>BASE FREQUENCY</b>	0.3, 0.75, 3, 7.5, 30, 75 and 285 Hz, or 0.25, 0.625, 2.5, 6.25, 25, 62.5 and 237.5 Hz
<b>INTEGRATION TIME</b>	0.5, 2, 4, 8, 15, 30, 60 or 120 s
<b>DATA STORAGE</b>	Solid-state memory for 25,000 data records
<b>DATA OUTPUT</b>	RS-232 serial, USB ports
<b>SYNCHRONIZATION</b>	Reference cable or, optionally, highly stable quartz crystal
<b>POWER SOURCE</b>	12 V rechargeable battery for 8 h continuous operation
<b>OPERATING TEMPERATURE</b>	-40° C to +50° C
<b>DIMENSIONS</b>	34 x 38 x 27 cm
<b>WEIGHT</b>	15 kg



## TEM47 TRANSMITTER

Small and lightweight, the battery-powered TEM47 transmitter is ideal for rapid resistivity surveys of the near surface. Single turn transmitter loops, from 1 to 100 m on a side, with turn-off times as short as 0.5  $\mu$ s can be used to provide maximum near-surface resolution. An output current of 3 A into a 100 x 100 m loop gives a good response and resolution to depths of 150 metres. The PROTEM 47 (incl. PROTEM receiver, TEM47 transmitter) is most commonly used for shallow resistivity sounding applications.

When used as part of a PROTEM 47 system for profiling, the TEM47 supplies 2.5 A to an 8-turn, 5 x 5 m moving transmitter loop to provide a dipole moment of 500 Am<sup>2</sup>. With base frequency of 75 Hz, and 20 gates from 49 $\mu$ s to 2.9 ms, this configuration is optimal for Slingram (horizontal loop) surveys for mineral exploration to shallow depths, and for groundwater exploration in bedrock fractures. Electrical sounding is performed simultaneously with the search for fault or dike-like targets.

The TEM47 uses a reference cable to achieve the high synchronization accuracy required for shallow sounding. Regardless of application, a high-frequency 1D or 3D induction coil is used with all PROTEM 47 systems – the high-frequency coils have the bandwidth necessary to capture the earliest portion of the transient decay with minimal distortion. For best consideration of structural response within complex geologic environments, the 3D induction coil is recommended.

## High Power (HP) Modification

With the addition of the high power (HP) modification, output voltage is increased to as much as 48 V (with external batteries), and maximum current to 8 amps. As a result, achievable exploration depths are increased considerably. A PROTEM 47 HP system is ideal for magnetotelluric static correction surveys, or applications where near-surface resolution is required, but also greater depths than are possible with the standard TEM47. A common use of the PROTEM 47 HP is for the in-mine mapping of water saturation zones, with a small, multi-turn transmitter loop.

## Specifications

<b>CURRENT WAVEFORM</b>	Bipolar rectangular current with 50 % duty cycle
<b>BASE FREQUENCY</b>	30, 75, or 285 Hz (powerline frequency 60 Hz) 25, 62.5 or 237.5 Hz (powerline frequency 50 Hz)
<b>TURN-OFF TIME</b>	2.5 $\mu$ s at 3 A into 40 x 40 m loop. Faster into smaller loop
<b>TRANSMITTER LOOP</b>	1 x 1 to 100 x 100 m single turn loop, or 5 x 5 m 8-turn loop
<b>OUTPUT VOLTAGE</b>	TEM47: 0 to 9 V, continuously adjustable, with internal 12 V battery TEM47 HP: 12 to 48 V with external batteries
<b>OUTPUT CURRENT</b>	TEM47: up to 3.5 A with internal 12 V battery TEM47 HP: up to 8 A with external batteries
<b>POWER SOURCE</b>	Internal 12 V rechargeable battery; optionally, up to four external 12 V batteries
<b>BATTERY LIFE</b>	5 h continuous operation at 2 A output
<b>OPERATING TEMPERATURE</b>	-35° C to +50° C
<b>DIMENSIONS</b>	TEM47: 10.5 x 24 x 32 cm; TEM47 HP: 14 x 24 x 32
<b>WEIGHT</b>	TEM47: 5.3 kg; TEM47 HP: 6.5 kg

# PROTEM TIME DOMAIN EM SYSTEMS



## TEM57-MK2 TRANSMITTER

The design and performance of the TEM57-MK2, with a power output of 1,650 W from an internal power supply, makes it a highly portable, mid-power time domain transmitter. The internal power supply, with a continuously variable voltage range from 18 to 60 V, can be perfectly matched to the transmitter loop for optimum performance. A practical number of external batteries can increase these specifications to 4,500 W of power output, and a voltage range to 160 volts.

The TEM57-MK2 is an ideal mid-power transmitter for sounding the depth, thickness and conductivity of layers to depths of 500 m or more. Common applications include the mapping of geologic sequence and structure, and the characterization of freshwater resources. In coastal areas, the PROTEM 57-MK2 system (incl. PROTEM receiver, TEM57-MK2 transmitter) can accurately define the depth(s) at which saltwater intrudes into local aquifer systems.

The PROTEM 57-MK2, with a short reference cable, portable transmitter and 3D receiver coil, can detect and delineate complex ore bodies within 200 m of surface. Deeper conductors can be characterized by profiling with a crystal-synchronized receiver and a large, fixed transmitter loop. Modeling provides conductivity, thickness, dip and extent of the ore body.

For measurements during the turn-off (T/O) ramp, an optional T/O controller, connected externally to the transmitter, can variably increase the turn-off time, typically within the range of 200–1000 microseconds.

## Specifications

<b>CURRENT WAVEFORM</b>	Bipolar rectangular current with 50 % duty cycle
<b>BASE FREQUENCY</b>	0.3, 0.75, 3, 7.5, or 30 Hz (powerline frequency 60 Hz) 0.25, 0.625, 2.5, 6.25, or 25 Hz (powerline frequency 50 Hz) Rates below 1 Hz available through cable reference; through crystal reference with modification
<b>TURN-OFF TIME</b>	20 to 115 $\mu$ s, depending on size, current and number of turns in transmitter loop
<b>TRANSMITTER LOOP</b>	Single turn: any dimension; minimum resistance is 0.7 ohms, up to 300 x 600 m 8-turn: 5 x 5 or 10 x 10 m
<b>OUTPUT CURRENT</b>	28 A maximum
<b>OUTPUT VOLTAGE</b>	18 to 60 V continuously adjustable; up to 160 V (4,500 W) with external power source
<b>SYNCHRONIZATION</b>	Reference cable or, optionally, highly stable quartz crystal
<b>POWER SOURCE</b>	1,800 W, 110/220 V, 50/60 Hz single-phase motor-generator or, optionally, multiple 12 V batteries
<b>OPERATING TEMPERATURE</b>	-35° C to +50° C
<b>TRANSMITTER PROTECTION</b>	Electronic and electromechanical protection
<b>TRANSMITTER SIZE</b>	43 x 25 x 25 cm
<b>TRANSMITTER WEIGHT</b>	15 kg



## TEM67 TRANSMITTER

For applications at greater depths, the TEM67 and TEM67Plus transmitters provide the power necessary for exploration to 1000 m or more, with a component-based flexibility not previously available with time domain transmitters.

The standard TEM67 transmitter is comprised two components: a complete TEM57-MK2 transmitter; and a single TEM67 power module (with the requirement for a larger (4,500 W) generator). Such modular design allows for easy upgrade of a TEM57-MK2 transmitter, when required, by the addition of a TEM67 power module and generator only. Conversely, when the full (4,200 W) power of the TEM67 is not required for a particular application, the system can be conveniently scaled down to make use of the TEM57-MK2 only.

With a 1D low frequency induction coil, the PROTEM 67 system (incl. PROTEM receiver, TEM67 transmitter) is ideal for soundings to 1,000 m or more for applications in regional groundwater and geologic research. When used with a 3D induction coil or 3D fluxgate sensor, it is then ideal for profiling deeply buried conductive ore bodies to depths in excess of 500 m. With the BH43-3D induction borehole probe or MAG43-3D fluxgate probe, mineral exploration to depths of 2500 m is possible.

## TEM67Plus

To further increase the depth of exploration, the addition of a second power module increases the maximum output voltage and power to 240 V and 6700 W, respectively. The PROTEM 67Plus is the high-power system needed for deep mineral exploration under conductive cover: with the 1000 m<sup>2</sup> rigid coil, resistivity sounding for deep geologic mapping or geothermal exploration is possible to depths well in excess of 1500 metres.

## Specifications

<b>CURRENT WAVEFORM</b>	Bipolar rectangular current with 50 % duty cycle
<b>BASE FREQUENCY</b>	0.3, 0.75, 3, 7.5 or 30 Hz (powerline frequency 60 Hz) 0.25, 0.625, 2.5 or 25 Hz (powerline frequency 50 Hz) Rates below 1 Hz available through cable reference; through crystal reference with modification
<b>TURN-OFF TIME</b>	20 to 750 $\mu$ s, depending on transmitter loop size, current and number of turns
<b>TRANSMITTER LOOP</b>	Up to 2,000 x 2,000 m maximum
<b>OUTPUT CURRENT</b>	28 A maximum
<b>OUTPUT VOLTAGE</b>	TEM67: 18 to 150 V continuously adjustable TEM67Plus: 18 to 240 V continuously adjustable
<b>SYNCHRONIZATION</b>	Highly stable quartz crystal and reference cable
<b>POWER SOURCE</b>	TEM67: 4,500 W, 115 or 110/220 V, 50/60 Hz, single phase motor generator TEM67Plus: 6,700 W, 115 or 110/220 V, 50/60 Hz, single phase motor generator
<b>OPERATING TEMPERATURE</b>	-35° C to +50° C
<b>TRANSMITTER PROTECTION</b>	Electronic and electromechanical protection
<b>TRANSMITTER SIZE</b>	TEM57-MK2: 43 x 25 x 25 cm; TEM67 Power Module, each: 42 x 20 x 31 cm
<b>TRANSMITTER WEIGHT</b>	TEM57-MK2: 15 kg; TEM67 Power Module, each: 12 kg



3D-3M

## INDUCTION COILS

Six induction coils are available, each most appropriate for certain depths and applications. For shallow resistivity soundings, the high bandwidth of the high frequency coils is needed for the rapidly changing early-time signal. Comparatively, for deeper soundings, or for measuring late-time signal from conductive ore bodies, the larger effective area of the low frequency coils amplifies the very low amplitude late-time signals to measureable levels.

When the stratigraphy of the survey environment is effectively flat-lying, a single component coil is generally appropriate. The response from sub-vertical structure, however, is three dimensional; in these environments, the measurement of all three components will result in an easier and more accurate interpretation. Both high and low frequency coils are available in both single component (1D) and three component (3D) versions.

Geonics induction coils are air-cored, rather than ferrite-cored, offering two significant advantages: most ferrite materials exhibit some self-response when subject to strong primary magnetic fields, which can unnecessarily add noise to the data. Second, ferrite-cored coils are long and thin in design which tends to make them sensitive to noise from wind-induced vibration; air-cored coils with "flat" geometry are much less sensitive to this effect.

## FLUXGATE SENSORS

Some ore bodies can be so conductive that induced eddy currents decay exceedingly slowly, in which case voltage induced in an induction coil may be too small to measure. The actual magnetic field amplitude associated with such ore bodies, however, will be quite high. Overburden or other lesser conductors will produce relatively weak magnetic fields that decay rapidly leaving, by late time, only fields from the more conductive targets. For such circumstances, a three component (3D) fluxgate magnetometer sensor is available.

### Specifications

<b>EFFECTIVE AREA</b>	HF Coil: 31.4 m <sup>2</sup> HF-3D Coil: 31.4 m <sup>2</sup> for each sensor LF Coil: 100 m <sup>2</sup> 3D-3 LF Coil: 200 m <sup>2</sup> 1,000 m <sup>2</sup> (rigid) Coil: 1,000 m <sup>2</sup> 10,000 m <sup>2</sup> (flexible) Coil: 10,000 m <sup>2</sup>
<b>BANDWIDTH</b>	HF Coil: 800 kHz HF-3D Coil: 500 kHz for each sensor LF Coil: 32 kHz 3D-3 LF Coil: 30 kHz 1,000 m <sup>2</sup> (rigid) Coil: 3 kHz 10,000 m <sup>2</sup> (flexible) Coil: 3 kHz 3D-3M Fluxgate Sensor: 3 kHz for each sensor
<b>MEASURING RANGE</b>	3D-3M Fluxgate Sensor: +/- 100 microTesla ( $\mu$ T)



## BH43-3D TDEM PROBE

In conjunction with a ground-based PROTEM system, the BH43-3D provides three-dimensional time domain electromagnetic data from boreholes. With a 500 x 500 m transmitter loop at surface, data can be received from boreholes to depths of 2.5 kilometres. (At developed mines, the transmitter loop can be laid out within the underground workings.)

The BH43-3D probe has three sensors that measure orthogonal components of decay. Measurement intervals are determined by the resolution required; along the hole, spatial resolution as fine as 1 m can be obtained.

The wide bandwidth of the probe, coupled with the excellent temporal resolution and large dynamic range of the PROTEM system, provides maximum diagnostic information and a high degree of rejection of powerline and other sources of noise.

The BH43-3D probe is available separately, or as a complete borehole system with cable, main winch, dummy probe, test cable and winch, and retrieval tools.

## MAG43-3D FLUXGATE PROBE

MAG43-3D probe is an ideal tool for the survey of highly conductive targets such as nickel sulphide ore bodies. While such targets may produce very little decay to measure with an induction coil, strong secondary magnetic fields can be readily detected with a fluxgate sensor. As with the BH43-3D, measurements from depths to 2.5 km are achievable.

### Specifications

<b>SENSOR</b>	BH43-3D: three orthogonal coils (one axial and two radial) MAG43-3D: three orthogonal low-noise fluxgate sensors
<b>SENSOR AREA-TURNS PRODUCT</b>	BH43-3D: 5,000 m <sup>2</sup> for axial coil and 1250 m <sup>2</sup> for radial coils (with amplification)
<b>SENSOR BANDWIDTH</b>	BH43-3D: 10 kHz for all coils MAG43-3D: 3 kHz for all sensors
<b>PROBE ROTATION CORRECTION</b>	Two orthogonal tilt meters with range from $\pm 1^\circ$ to $\pm 80^\circ$ (from vertical)
<b>MEASURING RANGE</b>	MAG43-3D: +/- 100 microTesla ( $\mu$ T)
<b>CONTROL BOX</b>	Channel selection, impedance and gain matching network between probe and PROTEM receiver (normalizes sensor effective area to 100 m <sup>2</sup> for all three sensors); includes VLF filter
<b>POWER SOURCE</b>	Rechargeable nickel cadmium battery sealed pack for 20 h continuous operation
<b>CABLE</b>	Two-conductor shielded; polyurethane jacket; Kevlar strength membrane; 5.6 mm diameter; weight: 40 kg/km; breaking strength: 500 kg
<b>OPERATING TEMPERATURE</b>	-30° C to +80° C
<b>WEIGHT</b>	BH43-3D: 9.5 kg; MAG43-3D: 4.7 kg Control Box: 1.5 kg
<b>DIMENSIONS</b>	BH43-3D: 3.8 x 234 cm; MAG43-3D: 3.8 x 138 cm Control Box: 22 x 13.5 x 8 cm



# VLF RECEIVER / TRANSMITTER



## EM16 / EM16R / TX27

The EM16 VLF Receiver is the most widely used EM geophysical instrument of all time. Local tilt and ellipticity of VLF broadcasts are measured and resolved into in-phase and quadrature components of VLF response. The EM16 has discovered several base and precious metal ore bodies and many water-bearing faults.

The EM16R Resistivity Attachment uses a pair of electrodes to measure the apparent resistivity of the earth. The combined EM16/16R instrument can detect a second earth-layer if the layer occurs within the VLF skin-depth. In addition, the EM16/16R can map resistive alteration for gold exploration.

The TX27 is a portable VLF transmitter supplying a VLF field for surveying with either the EM16 or EM16/16R if remote broadcasts are weak, intermittent or poorly coupled with the target. For EM16 surveys, the TX27 antenna consists of a long (typically 1 km) grounded wire.

## EM16/16R Specifications

<b>MEASURED QUANTITIES</b>	EM16: In-phase and Quadrature components of the secondary VLF field, as percentages of the primary field EM16R: Apparent resistivity in ohm-metres, and phase angle between Ex and Hy
<b>PRIMARY FIELD SOURCE</b>	VLF broadcast stations
<b>SENSOR</b>	EM16: Ferrite-core coil EM16R: Stainless-steel electrodes, separated by 10 m; sensor impedance is 100 M $\Omega$ in parallel with 0.5 pf
<b>OPERATING FREQUENCY</b>	15 to 28 kHz, depending on VLF broadcasting station
<b>MEASUREMENT RANGES</b>	EM16: In-phase: $\pm 150\%$ ; Quadrature: $\pm 40\%$ EM16R: 300, 3000, 30000 $\Omega$ -m, Phase: 0-90°
<b>POWER SOURCE</b>	EM16 or EM61/16R: 9 V battery
<b>OPERATING TEMPERATURE</b>	-30° C to +50° C
<b>DIMENSIONS</b>	EM16 or EM16/16R: 53 x 30 x 22 cm
<b>WEIGHT</b>	EM16: Instrument: 1.8 kg; Shipping: 6.2 kg EM16R: Instrument: 1.5 kg; Shipping: 6 kg

## TX27 Specifications

<b>PRIMARY FIELD SOURCE</b>	Grounded wire or 500 x 500 m loop, current adjustable, 0 to 2 A
<b>OPERATING FREQUENCY</b>	18.6 kHz
<b>POWER SOURCE</b>	120/220 V, 350 W motor generator
<b>DIMENSIONS</b>	Transmitter and loop: Shipping: 89 x 29 x 39 cm Generator: Shipping: 50 x 27 x 36 cm
<b>WEIGHT</b>	Transmitter and loop: Shipping: 32.5 kg Generator: Shipping: 17 kg



## GEONICS LIMITED

A Canadian-owned company, located in Mississauga, Ontario, Geonics Limited is a world leader in the design, manufacture and service of electromagnetic geophysical instrumentation.

Incorporated in 1962, Geonics originated with the development of the patented EM16 VLF Receiver, which became an exploration industry standard for ground VLF instrumentation. Equipment manufactured in the early years included surface, fixed wing and helicopter EM systems, primarily for applications in natural resource exploration.

From the commitment to specialize in electromagnetic methods, Geonics has been able to develop a broad range of unique EM instrumentation for an ever-increasingly diverse range of applications. With the introduction of the EM31 Ground Conductivity Meter in 1976, Geonics began to service those industries, such as geotechnical engineering and the environment, with a particular interest in near-surface characterization. Subsequent development of the EM34-3 and EM38 series of Ground Conductivity Meters – for relatively deeper and shallower exploration, respectively – expanded the range of application fields to include groundwater exploration, and agriculture and archaeology.

Using more than 15 years of experience in the design and development of time domain electromagnetic (TDEM) systems, Geonics introduced, in 1987, the versatile, digital PROTEM TDEM systems. With a single receiver and, now, five interchangeable transmitters, the modular PROTEM systems cover a full range of applications from shallow environmental and groundwater studies, to deep resistivity soundings and three-component surface and downhole exploration for mineral and geothermal targets.

From this tradition of research and engineering excellence, Geonics continues to move forward with the development of new, more advanced instrumentation: the second generation of the successful EM61 Metal Detector has been recognized by the North American military community as a standard sensor technology for the detection of unexploded ordnance (UXO); applications in resource exploration have been further supported by the recent introduction of surface and downhole fluxgate sensors; and custom-build solutions are available to address many customer-specific requirements.

Used extensively throughout the world, in many varied and demanding survey environments, Geonics instrumentation has earned the field-tested reputation for superior data quality and reliable, cost-effective operation.