HUMMINGBIRD

Helicopter-borne 5-Frequency Electromagnetic System

FEATURES:

- Good contouring in mountainous terrain
- NO COMPENSATION of data required
- Accurate anomaly positioning
- Measurement of 5 EM frequencies ranging from 900Hz to 35 kHz
- All digital samples generated by the EM system are supplied as in-phase and quadrature measurements
- Simultaneous high-resolution magnetic and (optional) gammaray spectrometer measurements
- DGPS navigation with pilot guidance
- Radar and/or laser altimeter, barometric altimeter & digital colour imaging system

APPLICATIONS:

- Ground Water exploration / Aquifer mapping
- Mapping of fresh water/salt water interfaces
- Base & precious metals exploration
- Minerals exploration
- Kimberlite exploration
- Geothermal mapping
- Environmental engineering surveys
- Sand and Gravel mapping
- Shallow Sea bathymetry
- Sea-ice thickness mapping
- Permafrost mapping

McPHAR INTERNATIONAL

AIRBORNE GEOPHYSICAL SERVICES

CANADA • SINGAPORE • INDIA

A Neterwala Group Company

www.mcpharinternational.com

The depth in the earth to which a single frequency can penetrate is a function of the frequency and the conductivity of the earth. [Skin Depth » 503 / (frequency x conductivity)$^{1/2}$] Lower frequencies penetrate deeper into the earth than higher frequencies. The higher frequencies are more sensitive to weakly conductive geology, and to subtle changes in the conductivity of the ground.

A HUMMINGBIRD EM system measures the in-phase "I" and quadrature "Q" (sometimes called out-of-phase) components of the total EM field. The amplitude of these components are always given as a value that is relative to the transmitted primary. The ratio of in-phase to quadrature (I/Q) depends mostly on the conductivity of the geology and the operating frequency; the amplitude depends mostly on the depth of the conductor below the sensor. (While this description of the relationship is only an approximation, it is a good start from which to understand changes in I and Q measurements.)

HUMMINGBIRD sensors undergoing preparations for the field

Operator's screen/keyboard assembly – HUMMINGBIRD EM system

Undoubtedly, helicopter-borne electromagnetics (EM), combined with total field magnetics and often gamma-ray spectrometry, have been one of the most productive and useful of airborne system developments to date, and have accounted for the discovery of billions of dollars worth of mineral resources, tapped into numerous ground water reservoirs and provided immense volumes of data for environmental site evaluations. These systems are ideally suited for working in rugged, mountainous terrain, or over small claim block sized properties.

Currently, electromagnetics (EM) combined with a high-sensitivity magnetometer are the techniques of choice to detect and map aquifers and groundwater, and to locate and define diamondiferous kimberlite pipes and base and precious metal deposits.

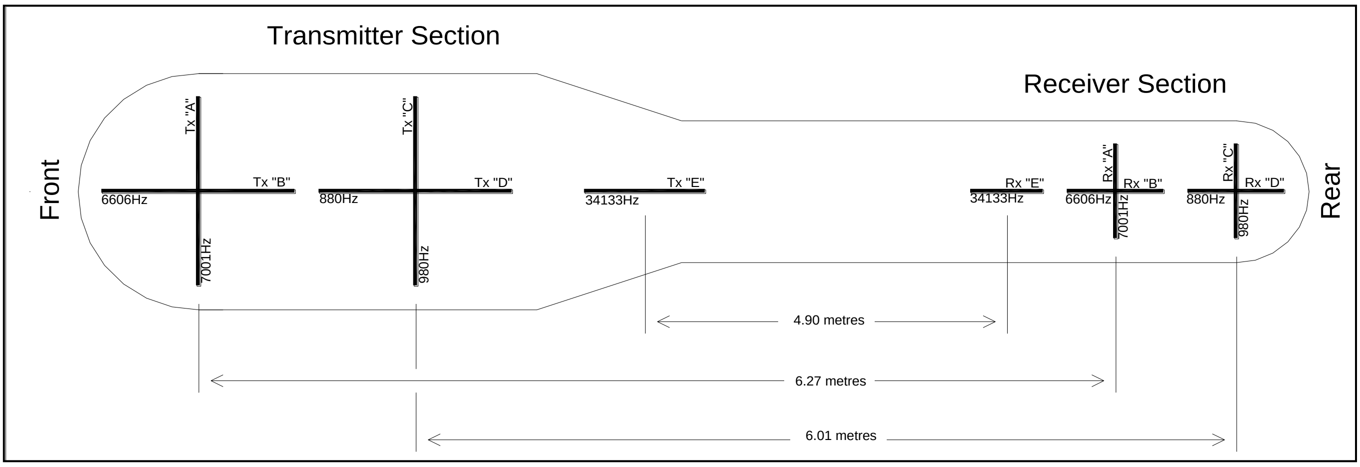
McPhar's frequency domain EM survey systems are integrated around the HUMMINGBIRD sensor, which is available in a 5-frequency configuration. The **HUMMINGBIRD** sensor, which is the heart of this system, can be simply described as a multi-frequency, multi-coil electromagnetic system, which measures the in-phase and quadrature responses from a number of coil-pairs installed in a tubular bird, towed beneath a helicopter.

All components of the HEM instrumentation are digitally controlled. The HUMMINGBIRD is currently the only operating HEM system that is 100% digital from front to back. All digital samples generated by the instrumentation are supplied as inphase and quadrature measurements.

Data is telemetered on a lightweight serial cable to the data acquisition console onboard the helicopter, where it is displayed on a LCD colour screen and recorded on a removable hard disk.

Pilot guidance and DGPS navigation systems are integrated into the package together with a gammaray spectrometer (optional). Other flight control instruments include radar and laser altimeters, a barometric altimeter and a digital colour video imaging system.

COIL FREQUENCY	COIL ORIENTATION	COIL SEPARATION	CHANNELS
880 Hz	Coplanar	6.0 meters (19.5ft)	I, Q
980 Hz	Coaxial	6.0 meters (19.5ft)	I, Q
6.6 kHz	Coplanar	6.3 meters (20.5ft)	I, Q
7 kHz	Coaxial	6.3 meters (20.5ft)	I, Q
34 kHz	Coplanar	4.9 meters (16ft)	I, Q



Layout and dimensions of the transmitter and receiver coils in the HUMMINGBIRD EM sensor

SPECIFICATIONS

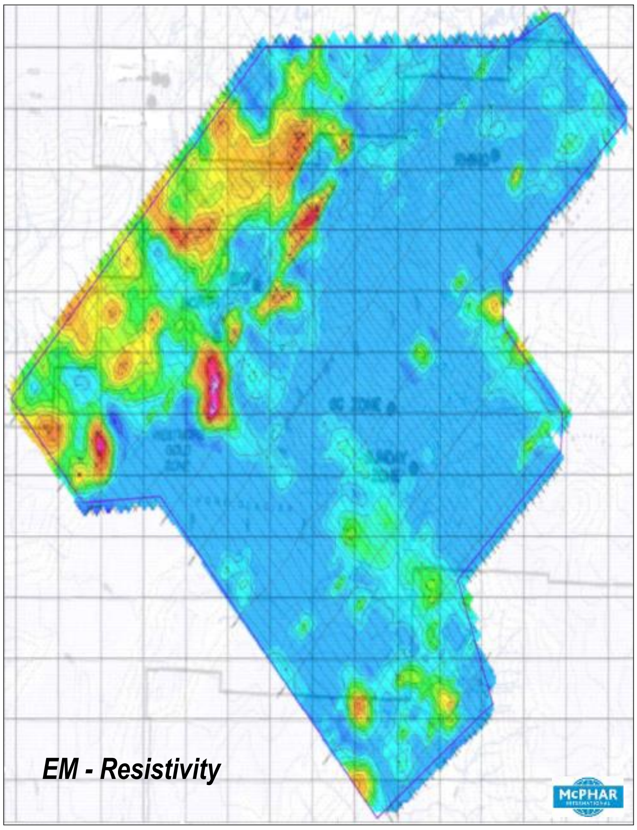
Frequency Range: 5 frequencies, 880 Hz, 980 Hz, 6.6 kHz, 7 kHz, 35 kHz
Coil Orientations: Horizontal coplanar and vertical coaxial coil-sets
Output: Inphase and Quadrature samples (ppm)
Sampling Rate: 10 Hz
Noise Levels: 2 – 4 ppm under ideal conditions
Time Constant: 0.1 second
Filters: 50/60 Hz power line, spheric rejection, 4^{th} order digital,
15Hz 2^{nd} order analog and 5Hz Low Pass 6^{th} order digital
Data Recording: On removable hard disk or flash card
Data Acquisition: Pentium-PC based
Display: Sunlight visible colour TFT back-lit LCD
Power Requirements: 12-36 VDC, maximum 30 Amps
Temperature Range: -40°C to +40°C
Bird/Cable Weight: Approx. 190 kg (425 lb) including tow-cable
Bird Length: 7.5 meters (3 joined sections each of approx. 2.5 m)

Cockpit displays for the pilot - HUMMINGBIRD EM system

QC & DATA PROCESSING & INTERPRETATION

McPhar is dedicated to undertaking QC of data in the field. For this purpose all our airborne systems are sent to the field with a geophysicist and a PC-based data processing system to support them. The Field Data Verification Workstation (FWS), as this system is known, can process airborne magnetic, radiometric and EM data, and produce plots and maps in full-color of the survey data, often within hours of the survey flight ending.

The FWS software, which is the core of this system, permits our field geophysicists to differentially correct the GPS navigation data; carry out flight path recovery; perform magnetic compensation and leveling; undertake radiometric corrections and preliminary processing; electromagnetic processing; and generally to perform filtering, gridding and contouring of data, imaging of selected data and plotting to any map scale and layout.

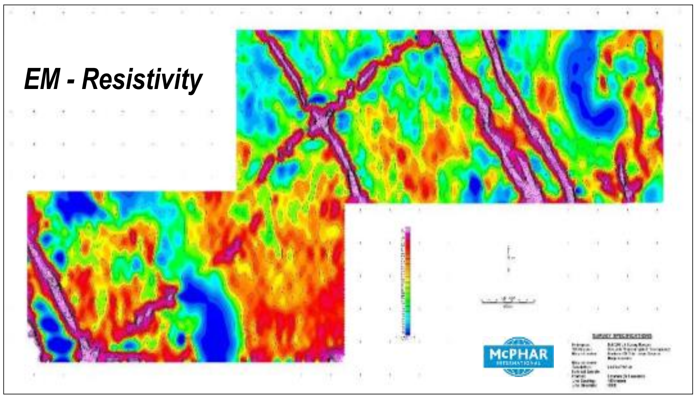


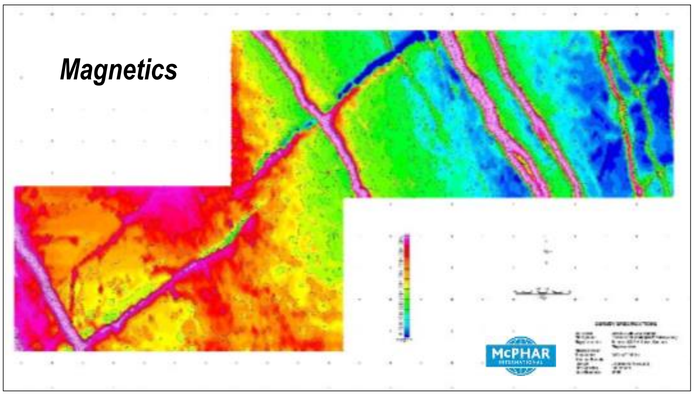
The interpretation of geophysical results into meaningful geological parameters is the prime function of any of our interpreters.

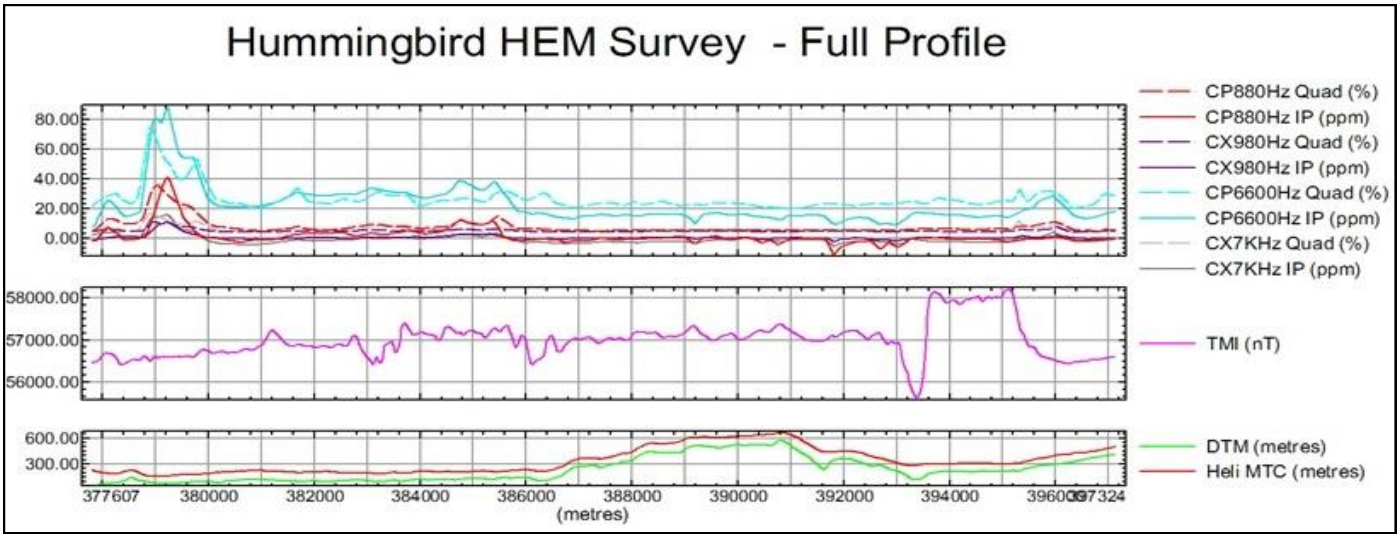
The many highly qualified geophysicists and technicians on our staff share a strong geological back-ground. The manipulation of geophysical data is only a means to an end, and the final product of the interpretation is the compilation of a series of maps showing interpreted geological parameters. The data processing routines and mathematical operators applied to the data are not the end product of the interpretation; they help delineate geologic and economic targets to be discussed in the final report.

We bring many techniques to bear on an interpretation project in order to determine depths to causative sources, to delineate discontinuities and boundaries, and to draw conclusions regarding geological structure beneath the survey.

A wide variety of contour and interpretation maps, profiles, cross-sections and models, and a written report are the result of the interpretation.







Flight line profile,Hummingbird EM and magnetic data