GEM Advanced Maqnetometers
52 West Beaver Creek Road West, Suite 14
Richmond Hill, ON Canada L4B 1L9
Ph. 905-764-8008 Fax. 905-764-2949
info@gemsys.on.ca   www.gemsys.ca

GEM Advanced Magnetometers: 25 Years of Leadership in Innovation and Service

25 years ago, the world of magnetometry was a much different place.

Proton magnetometers, the top technology of that time, had been in use for a decade and had completely replaced fluxgate units. Digital readouts of proton magnetometers were based on light-emitting diodes. Throw-away batteries were a standard. Tie points or tie lines were used to control diurnal variations, and the use of base stations to eliminate diurnals was unknown and about to be introduced in Canadian mining geophysics and GEM proton magnetometers.

Positioning of survey readings was a major issue. Ground surveys had to be prepared by line cutting and picketing of future points of reading. During the survey, the operator would read the magnetometer display and mark it manually in their notebook. On airborne surveys, cameras and tedious flight path recovery procedures were required before survey maps could be made. Software companies that processed data flourished as computer technology slowly made its way to the survey companies themselves.

“Fast-forward” to today, and we see a much different and more refined landscape. Technologies, such as Overhauser, Potassium and Proton; automation; and GPS are leading the innovations in the field. Computerization is virtually complete with end-to-end acquisition, quality control and interpretation / modeling all feasible on today’s high-powered Personal Computers. And, increased competition has led to the introduction of new systems and capabilities that benefit professionals many ways.

Throughout this period, GEM has continued to be a leader in innovation and service; culminating in its 25th anniversary in August, 2005. Now, as GEM looks to the future and new ways to serve its customers more effectively, we take time to review the past 25 years and the promise of the future to come.

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The Early Years – Leading in Innovation

From the outset, GEM focused on unique technologies that were overlooked by other groups. This period featured the rapid ramp-up of advanced Proton Precession systems followed by the development of the revolutionary Overhauser magnetometer. Leading technologies were developed for the ground and the air as well as for base station work.

Leap-Frogging Existing Technologies – GSM-8 and GSM-9

In the early years of magnetometry, magnetometers and gradiometers lacked sophistication. Readings were obtained from LED displays and hand-written into a workbook. Sensitivity was limited to a fraction of a nanotesla. Automation was minimal.

Much of this changed with the development of the GSM-8 – an innovative magnetometer that was to energize the ground magnetometer market.

The first Proton magnetometer with built-in automation (for base magnetometer operations), the GSM-8 streamlined surveys; allowing operators to eliminate the cumbersome process of tie-line leveling -- instead using magnetic values for drift corrections. Other innovations included the first LCD display, rechargeable batteries, and minimized power consumption; all capabilities that we take for granted today.

The GSM-8 was also a trend-setter which facilitated the development of an entirely new technology – the GSM-9 solar powered Overhauser magnetometer. The Overhauser was known for its extremely low power consumption; hence higher survey efficiency as well as its sensitivity which for the first time broke the 0.1 nT sensitivity barrier. The magnetometer also featured other innovations that were pioneered in the GSM-8.

Reaching for the Skies -- GSM-11 and GSM-11 4-Sensor

Determined to offer not only the world's most innovative ground magnetometers but also to lead in the skies, GEM next developed the GSM-11 – a continuous reading, high sensitivity (0.01 nT @ 1 sample per second) magnetometer. This magnetometer was fully funded on its merits by government and became, in fact, the first high sensitivity airborne system in the world.

This development was quickly followed by the GSM-11 4-Sensor gradiometer. Again, GEM found global leadership as this was the first multi-sensor system. It featured high absolute accuracy so that the gradients measured were "true" ones. The system had no drifts as well.

Had it been developed for today's highly active airborne gradiometry industry, the 4-Sensor system would have been very favourably received; however, it was before its time. Currently, GEM continues to seek the skies but with a 4-Sensor optically pumped Potassium system – another proprietary technology from the company's research and development group.

Adding Memory to the Picture - GSM-18 and GSM-10

The GSM-18 was a Proton Precession system developed for ground surveys in cooperation with Lamontagne Geophysics. This system featured the first memory of its day – allowing recording of positions with readings. Sensitivity was 0.1 nT and the system featured an LCD display which was well received by industry professionals.

Similarly, the GSM-10 was an Overhauser version of the GSM-18, also featuring very low power consumption.

The Middle Years – Growth and Service

As the company advanced its technologies, it also grew to better serve the needs of its customers. One of these customers was the Geological Survey of Canada who requested that GEM develop a special system for them. This became the GSM-19 Overhauser magnetometer – perhaps the most relied upon magnetometer / gradiometer system in the world today.

The GSM-19 was initially an observatory (i.e. stationary) system that was adapted for portable use where it became the standard for many applications, including mineral exploration and others.

This period also saw the development of the GSM-19T Proton Precession unit; another standard system known for its low-cost and high data quality.

The company did not rest – it seemed like every day there were new ideas and opportunities to address customer needs. One of these groups was the magnetic observatory community which was soon introduced to a new version of the Overhauser called the EUROMAG or GSM-90. The EUROMAG is now a global standard for magnetic observatories, and is also used in monitoring volcanoes.

This development was twinned with the design of the company's first vector magnetometer, the dIdD system, in conjunction with Hungary's Eotvos Lorand Institute. The vector magnetometer offers monitoring of the inclination and declination as well as total intensity of the earth magnetic field. Resolution is 0.01 nT with a recording interval of 5 samples per second.

The Present and Future – Potassium and GPS

The present and future are the eras of Overhauser, Proton and the newest flavour of magnetometer – the Potassium system. In fact, significant work is being performed with Potassium units, ranging from the ground to the air and in its latest inception, the SuperGrad for earthquake research. It is also the era of the Geographic Positioning System (GPS) which now allows acquisition of correctly positioned data faster and more effectively than ever before.

GEM's initial foray into optically pumped Potassium systems began in 1990 with the transfer of Russian technology to the company. Potassium was adopted as a key direction based on the company's desire to pursue only the top technologies available. Significant effort was invested in Potassium over the last ten years starting with the conversion of the Russian technology to a working version on a laboratory bench and then the development of a real-world, robust portable version.

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Potassium provides exceptional sensitivity (the highest available in an optically pumped magnetometer / gradiometer), minimal heading errors (a challenge for optically pumped cesium systems), and excellent gradient tolerance and absolute accuracy. These factors all contribute to the ability of Potassium to deliver large volumes of high quality data either on the ground or in the air.

In the air, Potassium is a recent entry into the industry, and it is gaining acceptance as more organizations implement the latest technologies into their earth science programs.

Another area in which Potassium is developing is the Potassium SuperGrad. Created originally for the United States Geological Survey (USGS), the technology was further refined through work with the Israel's SOREQ and Geologic Survey groups with financing by a major industrial research coordinating group. This technology has the promise of being able to detect precursors to earthquakes and huge volumes of data were acquired in Israel – demonstrating the feasibility of the approach. New trials are now underway in Mexico where there is significantly more earthquake activity and opportunity to obtain valuable scientific information from the technique.

One of the relatively recent technologies on which GEM is focusing is the GPS. GEM's GPS implementation comprises a complete sensor with 3D navigation on a single embedded board with full differential capability. The sensor is a 12 channel GPS receiver that tracks all in-view satellites. It is fully autonomous such that once power is applied, the system automatically searches, acquires and tracks GPS satellites.

The custom-developed system also features Satellite Based Augmentation System (SBAS) capability. SBAS is a type of geo-stationary satellite system that improves the accuracy, integrity and availability of GPS signals.

With SBAS, accuracy is enhanced through the use of wide area corrections for GPS satellite orbits and ionospheric errors. Integrity is enhanced through the SBAS network quickly detecting satellite signal errors and sending alerts to not use the failed satellite. Availability is improved by providing an additional ranging signal to each SBAS geostationary satellite. SBAS includes the Wide-Area Augmentation

System (WAAS), the European Geo-Stationary Navigation System (EGNOS) and the MTSAT Satellite-Based Augmentation System (MSAS).

GEM also provides external GPS for customers who want to apply real-time differential corrections or those who want to integrate their own GPS within the system.

25 Years in Perspective

From the company's inception to today, the magnetometer / gradiometer industry has become much more sophisticated and refined. Key examples include:

- Development of leading Overhauser, Potassium and Proton units
- Automation, including base station cycling, for efficiency in (computer-based) data reduction
- Integration of high volume memory for very large surveys
- Integration of low-powered magnetometers / gradiometers into survey programs for increased productivity
- Introduction of Geographic Positioning Systems (GPS) to streamline the acquisition of magnetic data and simplify the process as a whole
- Expansion of magnetometry into new areas, including environmental and engineering; observatory, volcanology, earthquake research

We anticipate that the uses of magnetic methods will remain dynamic and will continue to grow based on the effectiveness of this tried-and-true method for acquisition of geophysical data. And GEM will be right on track, poised to take advantage of new technologies as they emerge and to serve the needs of its customers as they seek to address the key earth science challenges of today and tomorrow.