Airborne surveying is used by many exploration and mining companies to ascertain the geophysical aspects of an area with a potential resource. There are a variety of ore deposit types around the world that can have similar or unique geophysical characteristics depending on the location of the geology.

Using fixed-wing aircraft or helicopters, aerial surveying can provide information on areas conducive to mineralisation that may be difficult to access from the ground in a remote, rapid, non-invasive manner.

Techniques such as aeromagnetic surveying, electromagnetic surveying, gravimetric surveying or light detection and ranging (LiDAR) may be used, and each method has its own advantages. Since different geophysical methods measure different physical properties, certain methods may be better suited than others depending on the geologic conditions and the survey objective.

Magnetic surveys, for example, are a low-cost method for mapping the underlying geology and depth to basement of large areas, as they detect changes in the magnetic concentration of near-surface rocks, reflecting a change in rock type. The size, shape, strike and depth of the orebody can be estimated from the magnetic anomaly. Electromagnetic (EM) surveys, for example, work well for geophysical targets that are electrically conductive.

“Since iron-containing rocks can preserve a magnetic history that can be mapped with the magnetic method, some lithology can be differentiated based on the remanence direction,” explains Christina Clark, geophysicist at MPX Geophysics. “For example, this is often useful when locating specific types of kimberlite pipes for diamond exploration. Magnetics can be sampled at high resolutions and are also very useful for mapping out structure such as faults and folds, so they are an excellent component to any survey plan.”

Radiometric surveys measure the concentration of radioelements such as potassium (K), uranium (U) and thorium (Th) from the top 10-60cm of the Earth’s surface with little or no vegetation. Changes in the concentration of these elements indicate changes in lithology, and can thus be used to map out alteration zones. There is a greater cost involved in radiometric surveying, but the additional information garnered can make it worthwhile. In addition, radiometric surveys can directly detect the presence of uranium.

Clark adds: “We have found that most clients have readily used radiometrics in exploration for uranium, gold, tin and tungsten deposits where the primary mineralisation process is often related to K metasomatism.”

However, the value of the radiometric data can be negatively affected by higher altitudes; it is lost completely at altitudes above 300m. It also cannot be used off-shore or in areas with permanent ice/snow cover as the radiometric signal is attenuated by water.

Multiple gravity survey methods are available, depending on the purpose of the survey. Conventional airborne gravity surveys are more appropriate for large basin-wide studies where the objective is to map deep geological structure. Gravity gradiometry surveys provide more detail on the geologic structure, especially closer to the surface. Ground gravity can be used for regional surveys, but is most efficient for delineating detailed targets that may have originally been detected in airborne data. Gravity methods also only work if the ground has measurable density contrasts.

Full tensor gravity (FTG) gradiometry can rapidly acquire high-resolution gravity (density) information even in remote areas. Bell Geospace says that it has approximately ten times greater resolution than conventional airborne gravity surveys, and it has much greater acquisition efficiency than ground gravity surveys, especially for larger survey areas.

ADVANTAGES OVER GROUND-BASED SURVEYS
Airborne geophysical techniques have various advantages over ground-based surveys. They can cover a large area rapidly and efficiently, thereby reducing the time to acquire data. Using airborne survey techniques has significant benefits

Precision Geosurveys aeromagnetic survey on Vancouver Island, Canada

“Aerial surveying can provide information on areas conducive to mineralisation that may be difficult to access from the ground”

Up in the air
Different types of airborne surveying are common in mineral exploration. Ailbhe Goodbody looks at what is available
AIRBORNE SURVEYING

for exploration companies as it enables development to take place on much shorter timescales, reduces costs and improves efficiency. Many areas are simply inaccessible to ground-based exploration work without costly infrastructure investment.

Harmen Keyser, president of Precision GeoSurveys, says: "Airborne surveys offer uniform data coverage over remote and difficult terrain, without the hazards and logistical challenges associated with ground based surveys."

Clark adds: "Airborne is far more economical when presented with large unexplored areas that have poor or no infrastructure."

"Many of our clients have enjoyed designing a large-scale survey, and once they receive daily preliminary results they have chosen to infill areas of interest with higher-resolution data while the survey is still in progress. This allows all data to be collected under the same conditions, which provides a better data set."

It also avoids any ground access issues, as airborne surveys do not require access permission from land owners, and they can be acquired in remote areas where logistical and safety concerns would make land acquisition difficult and expensive.

Airborne surveying provides evenly spaced data, which aids interpretation and minimises the environmental impact on the ground.

However, airborne surveying can be used to complement ground-based surveying, and in cases of easy land access or for very detailed surveys, ground-based surveys may be preferable. An airborne survey helps to identify areas to focus on with later ground-based follow-up work. It can provide information about regional wide-scale structure and geology that will allow a company to better narrow down the search for its target mineral.

Some types of geophysical surveys can only be ground-based (such as IP and SP), and as a result, it is common for large airborne surveys to be followed up with more detailed ground geophysics in selected areas. Ted Urquhart, president of New-Sense Geophysics, explains: "Airborne surveys are a very cost-effective method for reducing large concession areas into smaller high-value zones, where more costly ground-based options, such as drilling and IP surveys, can be applied."

ACCURACY AND RESOLUTION

Different survey methods will give different results, in both accuracy and resolution. These can vary based on the underlying geology, the terrain, aircraft selection, the specific instrument used, the flying speed, the flying height above ground and the spacing of the survey lines.

John Mims, director of sales at Bell Geospace, says: "The amount of usable information for different methods depends on the geological characteristics of the target area. One method that provides greater insight into the geology than another method in one area may be less appropriate in another area."

"The various geophysical methods act like tools in a toolbox. It might be possible to use pliers to remove a bolt, but picking the right wrench makes the job much easier. I have noticed that for mineral exploration, some exploration managers are comfortable with one geophysical method, for example airborne EM surveys. These managers often want to fly EM for every project regardless of the target. EM might provide useful data, but in many cases another method, such as gravity gradiometry, would have been able to provide more information for the money invested in the survey."

"Each type of geophysical technology responds to very different geophysical features, so it is important to understand the local geology and the type of deposit being sought before selecting a survey method. Terrain, access and budgets will also affect the type of survey technology that is appropriate. Keyser recommends: "All types of geophysical surveys should be reproducible, as in the same data should be collected on multiple flights."

Survey providers will usually work with clients to ensure that the selected technique or techniques and the survey design are appropriate for the target of interest.

FLIGHT PATTERNS

It is important that terrain is taken into account in the airborne survey design. For example, flying closer to the ground will acquire higher-resolution survey data. Selecting an appropriate line direction and pattern is fundamental to the effective and safe operation of a project; the survey design or flight pattern chosen will depend on the geological target. Normally, the survey alignment is chosen in relation to the geological structure to maximise the number of times that the survey crosses the favourable target area. For a ‘plug-like’ target, the line orientation is not significant. For elongated targets, the survey line should ideally cross the feature.

Clark explains: "For example, if a company is interested in identifying structure in an orebody that runs north-south, then it should plan the survey lines to run perpendicular in the east-west direction, so that the structure is not accidentally under-sampled if the designed survey lines do not fall directly on top of it. Similarly, the line spacing should be small enough to properly image the extent of the anomaly of interest while still keeping the survey economical."

TYPE OF AIRCRAFT

Fixed-wing aircraft or helicopters may be used for airborne surveys, depending on the terrain and the size of the survey. Mineralisation does not have a large influence on the choice of aircraft.

Clark explains: "Fixed-wing aircraft are preferred for large-scale and/or lower-resolution surveys in areas of suitable moderate to flat terrain elevations, when longer flights lead to greater daily production. Helicopters are often preferred for small infill surveys during diamond exploration to collect higher-resolution data at very low heights over suspected kimberlite target areas."

Malcolm Argyle, marketing/project manager at Sander Geophysics, agrees: "Fixed-wing aircraft are generally better suited to surveys that are relatively large, require less close terrain following and have a longer distance from the base to the survey area (ferry distance). However, there are exceptions, and the appropriate choice is made by considering all of the relevant factors of an individual survey."

In areas with rapid elevation changes, especially when low heights above the terrain have been requested, helicopters have an advantage over fixed-wing aircraft. A fixed-wing aircraft cannot contour terrain with rapid elevation changes due to its more restricted climb rate. As a result, a helicopter would be more suitable for rugged topography or

"Airborne is far more economical when presented with large unexplored areas that have poor or no infrastructure.”

MPX Geophysics has done airborne magnetic/radiometric surveys in the Cajamarca region of Peru
for small blocks located far from a suitable airport. A helicopter can fly lower, slower, and at a more constant ground clearance than a fixed-wing aircraft, so it can offer some advantages in data quality.

Helicopters have higher hourly operating costs than fixed-wing aircraft, and have less endurance and internal carrying capacity, but they require less distance to turn and can operate without a runway. Argyle says: “Whether any of these attributes are positive, negative or neutral depends on the individual survey. In general, helicopters are better suited to surveys in mountainous terrain that require close terrain following, where the overall size of the survey is not very large, and where there is no suitable runway nearby.”

Clark recommends: “Choosing helicopters with enough power, range and operational ceiling is essential to make the project successful, efficient and most importantly safe. The International Airborne Geophysics Safety Association (IAGSA) risk analysis is completed for each job during the quoting stage, and is reviewed and improved through consultation with the client prior to the start-up of each survey.”

**CHOOSING A TECHNIQUE**

When choosing a technique, companies should consider their objectives and their budget. Urquhart explains: “Exploration is a costly venture and every type of survey depends on the local geology, the size of the project area, the physical characteristics of the target and the surrounding rock types, the size of the target, depth of the target, purpose of the survey, orientation of the target, location and access to the survey area, terrain, weather conditions and the budget. All of this information can be used to create a model of the geology to estimate the response from the target, and then the economics of various survey methods can be considered. It is very common to use more than one technique. With deposits becoming more difficult to find, integrated interpretation using multiple survey methods is becoming more important.

For example, it should be considered whether there is enough of a rock-propensity contrast between the host rock and ore of interest for the potential technique to be useful when the target is remotely measured. The data resolution is controlled by the height above the terrain, line spacing, flight speed and sampling rate, so the resolution required to image the target will affect the technique choice. The weather can also have an effect; Clark explains: “You would not plan a radiometrics survey to occur during typhoon season, because you would be paying standby days while you wait for the rain to end.”

Not all airborne technologies are applicable to all types of mineral deposits either. Keyser elaborates: “For example, an expensive EM survey is much better suited to volcanogenic massive sulphide (VMS) targets than to porphyry targets. Clients also need to be aware that using more than one type of geophysical technology on a survey can affect the data in some instances. For example, magnetics and radiometrics can be flown together without compromising either data set, but if you add an EM system then the mag and spec data won’t be as good.”

**COST**

Several factors are considered when calculating the cost of airborne surveying for the customer. The major factors are the overall size of the survey (economies of scale), the technique/s being used, the survey platform (fixed-wing or helicopter) and the expected productivity, which depends on aspects such as the weather, the distance from the base to the survey area and the length of individual lines. Some companies calculate the price based on the aircraft hours required to complete the survey. As a result, the distance from the base airport to the survey block and line length have a great effect on the costs per kilometre – the shorter the line, the greater percentage of flight hours will be dedicated to turns rather than data collection. A radiometric survey requires daily calibrations that can consume up to 10-20% of the total aircraft time.

Other companies charge per kilometre flown, or by actually planning out all of the time and material costs that would be associated with the project, based on actual location costs and past experience with regards to performance. Associated costs will include factors such as mobilisation, fuel price, shipping, permits, vehicles, aircraft, crew accommodation, communications, personnel and health/safety. Urquhart explains: “If multiple options are available – such as aircraft type – companies will typically present all options, with pros and cons, to the client. Wherever possible, an attempt to minimise costs is made by positioning the aircraft strategically.”

Clark says: “Many projects can fail after they have been awarded if proper planning and cost estimation was not done. We have an in-house costing matrix to ensure all aspects of a project are accounted for properly, and that MPX can offer a competitive price. This estimating tool has been improved regularly based on past experience, and is strengthened by the input of staff involved at all levels.”

Clark adds: “Often clients’ budgets do not allow for high mobilisation costs, therefore we regularly work with multiple clients to split or eliminate mobilisation costs during multi-client surveys.”

**SPECIALIST COMPANIES**

Airborne geophysical technology is expensive and complex, and requires considerable expertise in system design, maintenance and operation. As a result, the global airborne geophysical market is dominated by specialist airborne contractors.

Survey companies have the benefit of efficiency by working for multiple clients within an area. Companies that have past experience in certain situations are more likely to be prepared for the rigours and realities of projects operating in a similar situation. Having several potential providers competing for your business can realise cost efficiencies and also allows the opportunity to take advantage of innovations that any one of a number of providers may have developed.

Airborne geophysics is an important but relatively small part of the overall exploration cycle, so an exploration or mining company would have to be quite large and active in order to justify the expense of having its own dedicated survey aircraft, airborne geophysical equipment, pilots and geophysicists. Most
mining or exploration companies do not need an airborne survey more than periodically, so it makes little sense to tie up the resources it would require maintaining such a department.

Even if a mining company made that considerable investment, the aircraft and equipment might not be suitable for all the different surveys it might wish to fly. If a company has projects all over the world, and often only has one or a few airborne systems, so the resulting mobilisation costs can be quite high. Local and system expertise is crucial when operating in zones where flights and the inability to fly are extremely costly – knowledge of import/export/safety/fuel/environmental permits can often be limited and may cause long project delays.

Some of the largest mining companies have developed and maintained their own systems for airborne surveying, and have enough resources and available work to justify this.

Scott Hammond, president and CEO of Bell Geospace, says: “However, other operating companies may hesitate to hire a direct competitor to survey their projects. Companies that specialise in data acquisition usually remain independent, and can work for multiple companies without any conflicts of interest.”

**THE FUTURE**

The past 20 years have seen huge improvements in airborne geophysical technology, thanks to GPS navigation and the digital revolution. These advances mean that geophysical data collected by airborne methods are often as good as data collected on the ground.

The companies that MM spoke to say that they do not see any entirely new techniques revolutionising the industry, but expect that improvements to resolution and accuracy will continue. Argyle explains: “In the end, the techniques that can be used are restricted by the laws of physics, which are well known, so it is unlikely that a fundamentally new technique will be developed. It is important to remember this limitation when someone presents a ‘black box’ and claims to be able to do something that wasn’t previously possible.”

Keyser opines: “It is unlikely that there will be much advancement in aeromagnetic and radiometric survey systems in the future. However, there is a lot of room to advance EM and gravity survey systems.”

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"We expect the use of unmanned aerial vehicles (UAVs) to increase in the future" - Argyle

Companies

**MM spoke to a number of companies that provide services in airborne surveying**

**BELL GEOSPACE**

Bell Geospace primarily offers airborne FTG gradiometry surveys. The company usually acquires airborne magnetic data simultaneously and has the capability to acquire LiDAR and radiometric data. However, these other techniques would be in addition to the primary gravity gradiometry survey, and the company does not acquire them as stand-alone surveys. The company states that it has also developed unique data processing methods that take advantage of the characteristics of FTG data.

Bell Geospace only uses fixed-wing aircraft, which it has found to be more than adequate in most circumstances; it has only had problems acquiring data in extremely mountainous areas. In a few instances, such as iron-ore or kimberlite exploration, the primary purpose of the survey has been for direct detection of mineralisation. In most cases, the FTG data has been used to map geological structures that would be associated with a deposit rather than direct detection.

Although Bell Geospace has proprietary software, most of its work is done using Geosoft’s Oasis. Data is delivered as a Geosoft database or as ASCII files that can easily be imported into GIS software.

Bell Geospace offers data interpretation at two levels. The first level, included with the data delivery, includes different methods of displaying the data to aid in a more detailed interpretation. For the second level of interpretation, a Bell geoscientist works with the client to integrate the acquired data with other geological and geophysical data to obtain a clearer interpretation of the geological structure. Bell Geospace says that in many cases its clients prefer to incorporate the data into their own interpretations.

Bell Geospace operates worldwide, and has found that many exploration and mining companies in Canada tend to go for EM surveying. Most of Bell Geospace’s upcoming work is for oil exploration projects; however, it expects to obtain more mining exploration projects, possibly later this year.

**FUGRO GEOSPATIAL**

Fugro Geospatial has been providing airborne survey services to the mining industry for over 40 years.

Fugro uses satellite imagery to assist with desktop feasibility studies for site selection. Further definition is provided by airborne surveys, from either fixed-wing or helicopter platforms. With more than 20 aircraft equipped with a broad range of cameras and sensing technologies, the company has completed photographic, mapping and LiDAR surveys of mining sites around the world, including surveys for mining companies in South Africa, Tanzania, Sierra Leone, Mozambique, Zambia and Guinea, as well as to various governments and engineering firms.

The resulting imagery and derived mapping and terrain data are used to design and connect infrastructure to new projects; however, it expects to obtain more mining exploration projects, possibly later this year.

**Case study: North American Nickel**

Time-domain electromagnetics (TDEM) is a generic term that can refer to borehole, surface or airborne EM systems. For its Maniitsoq project in western Greenland, North American Nickel (NAN) used two helicopter TDEM systems: SkyTEM and VTEM. NAN states that it chose TDEM as it has greater depth penetration than other airborne EM methods.

The company used each type on different parts of the project because it chose whichever system was available at the time; it costs a lot of money to mobilise the systems. SkyTEM was available in 2011, and VTEM was available in 2012.

SkyTEM and VTEM are similar in the way that they operate and in the data they produce, although they differ in their technical specifications. Both systems consist of EM transmitter and receiver loops, which are towed beneath a helicopter. Up to three magnetometers are also towed beneath the helicopter and measure the earth’s magnetic field. Differential GPS units and laser/radar altimeters mounted in the helicopter provide an accurate 3-D co-ordinate for each EM and magnetic reading taken by the system. Readings are collected many times a second as the helicopter is in flight.

The helicopter TDEM technology detects conductive material buried in the ground. The nickel and copper sulphides that NAN seeks are conductive and produce anomalies in the TDEM data.

Data from modern helicopter TDEM surveys such as VTEM and SkyTEM are of high enough quality that NAN can typically model interesting anomalies in three dimensions, which allows it to position drill holes accurately. Not long ago, airborne TDEM data was not good enough to accurately position drill holes, so follow-up ground-based surveys were required prior to drilling, greatly increasing both the time and the expense of exploration programmes.

The helicopter TEM system travels over the ground (and water) at 50-70km/h; in contrast, a couple of kilometres surveyed per day. NAN’s two surveys at Maniitsoq total over 6,700 line-kilometres – that data would have taken many years and an enormous amount of money to collect on the ground.

TDEM allowed NAN to get effective geophysical coverage over a very large belt of prospective rocks in relatively rugged terrain. In mid-2012, the airborne TDEM system identified a strong, buried surface-based survey crew would be lucky to get a couple of kilometres surveyed per day. NAN’s two surveys at Maniitsoq total over 6,700 line-kilometres – that data would have taken many years and an enormous amount of money to collect on the ground.

The helicopter and transmitter loops at North American Nickel’s project at Maniitsoq, Greenland

The helicopter TDEM system was able to spot the buried 0.34% Cu. Previous historical shallow drilling in the area had intersected some weaker mineralisation over narrow intervals (the best intersection was 12.9m assaying 0.52% Ni and 0.26% Cu), but the TDEM system was able to spot the buried higher-grade mineralisation at depth.

“Gravity gradiometry can provide an important part of this integrated approach to exploration by mapping density structure associated with geological features, faulting and alteration.” - Bell Geospace
AIRBORNE SURVEYING

sites, such as road, rail and power lines, and preclude the need to procure separate ground-based topographical surveys.

Fugro is currently working for African Minerals on its flagship project – the Tonkolili iron-ore deposit mine in central Sierra Leone. The company is acquiring LiDAR and aerial imagery of the mine site and the port area to assist the engineers in planning the integrated mine, rail and port infrastructure.

LiDAR is a rapid, highly accurate and nonintrusive method to capture and create a detailed model of the terrain, infrastructure or vegetation. In the case of Fugro’s FLI-MAP system, millions of points can be acquired within each square kilometre, plus the system has the benefit of being able to measure ground height underneath dense vegetation.

Fugro’s airborne mapping capabilities serve a range of infrastructure management, site planning and design, stock pile calculations and volumes, hydrology modelling and environmental monitoring activities. Fugro suggests that in future spatial data will increasingly be delivered as integrated packages, and the company is working with a major mining company in Australia to provide a web-based service environment for easy inclusion in the client’s information systems.

GOLDAK AIRBORNE SURVEYS

Goldak provides aeromagnetic (including two- and three-axis gradiometer), radiometric and VLF-EM surveys from a fixed-wing platform.

Goldak says that it operated the first three-axis gradiometer system in North America, and it was the first company to rotate measured gradients based on aircraft attitude – standard methodology assumed that the aircraft was always straight and level. Other operators have now adopted these methods.

Goldak uses in-house software for aircraft navigation and data collection. It processes and presents the data with Geosoft’s Oasis montaj software. Oasis montaj allows for the exportation of data and images to several GIS formats.

The company does not offer interpretation services; it has a list of consultants that it can refer a client to if they are looking for this service. Goldak tells MM that from its experience, most companies either do their own interpretation or have their own consultants.

The bulk of Goldak’s work takes place in northern Canada, but it has also operated throughout North America, as well as in North Africa and western Europe. The company has undertaken several large-scale surveys sponsored by the Canadian government, including a 120,000 line-kilometre, two-axis gradiometer survey off the west coast of Newfoundland.

MPX GEOPHYSICS

MPX Geophysics specialises in offering gamma-ray spectrometry (radiometrics) and magnetic geophysical surveys, though gravity, TDEM and LiDAR techniques are also available.

MPX offers low-altitude, high-resolution, high-density LiDAR data collection.

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services to acquire accurate digital elevation model data for topographic mapping. MPX’s X-LiDAR system consists of a high-resolution Reigl VQ-480 full-waveform scanning laser rangefinder and integrated GPS/INS system. The system has proven accuracies to 8cm and point densities of up to 40 raw measurements per square metre.

MPX offers both fixed-wing and helicopter services, including the use of AS350 B, BII, BIII, Bell Jet Ranger B/BII, Bell Long Ranger B3, Aérospatiale Lama 315B and Piper Navajo PA31 aircraft. All MPX aircraft and survey platforms are equipped with ‘Guardian 3’, which is an on-board flight-following system configured for real-time position updates every two minutes.

Clark says: “Knowing where our aircraft and crews are during survey operations is just one example of how we prioritise safety at MPX. The flight-following system also aids efficiency since the daily production path can be observed before the crew returns.”

The data is collected in-flight using the Pico Envirotec AGIS or Kroum VS Instruments SDAS computer systems. The data is reviewed, processed and presented using Geosoft’s Oasis montaj software. MPX presents the data in numerical ASCII format, as geo-referenced grids and maps that can be imported into virtually any GIS program.

“We have also worked with clients to format the end product so that it can be used in software that has specific formatting requirements,” says Clark. “Transferring the data to GIS programs allows the client to build common earth models so that all available data for their region can be reviewed in 3-D space alongside the collected data. The target can then be better examined and evaluated.”

If interpretation services are required, then geophysical experts at one of its partner consulting firms are available and can obtain the collected data from MPX’s secure FTP site.

MPX operates throughout South America, but most often in Colombia and Peru. MPX also operates systems in North and Central America and Indonesia, though systems may operate in other areas as required.

One recent project was an airborne magnetic/radiometric survey in the Cajamarca region of Peru. Geophysical data acquisition involved the use of precision differential dual-frequency GPS positioning system, a Pico-Envirotec GRS-10 multi-channel gamma-ray spectrometer system, and a high-sensitivity Scintrex CS-3 magnetometer installed in a stinger on a Eurocopter AS350 B3 helicopter. This was an exploratory project in a remote area with little or no information available, so a north-south line spacing of 250m at a height of 70m above terrain was planned.

Unmanned aerial vehicles (UAVs) can be used for a number of applications, including geophysical surveying.

Orbit GeoSpatial's microdrone UAV

ORBIT GEOSPATIAL

Orbit GeoSpatial says that its microdrone UAV has some advantages compared with more conventional aerial photogrammetry techniques, including the ease of operation and overall usability. In contrast to the use of aircraft that requires a competent and licensed pilot along with expensive maintenance, a UAV may be suitable for companies on a tighter budget.

When using a UAV, a single pilot can operate the flight while also taking pictures, as it can follow a pre-programmed GPS flight plan and take aerial imagery from pre-calculated positions. The stability of the UAV is controlled automatically using sensors and firmware. Due to the lower altitude of a UAV compared with other aircraft, it can result in higher accuracy than conventional aerial photography.

The microdrones are rotary-winged VTOL Mini UAS propelled by four rotors, with a maximum take-off mass of less than 25kg. Currently, microdrones provides two product lines: the compact microdrone md4-200, which stays in the air up to 30 minutes, carries 200g, flies in wind speeds of up to 8m/s, measures 540mm from rotor shaft to rotor shaft and has a maximum take-off weight of 1.1kg.

The larger microdrone md4-1000, stays in the air up to 88 minutes, carries 1.2kg, flies in wind speeds of up to 16m/s, measures just over 1m from rotor shaft to rotor shaft and has a maximum take-off mass of 5.5kg. Both microdrone models are equipped with flat-core, low-rpm and high-torque motors for a highly efficient drive system, computational fluid Dynamics (CFD) optimised propellers and a closed carbon-fibre-reinforced polymer (CFRP) body for all-weather deployment.
With fixed-wing aircraft, tail and wing-tip assembly options are offered. New-Sense has developed an automated system that allows pilots to easily navigate a block without diverting attention from flying the aircraft safely. With fewer people required on board, performance of the aircraft is improved and risk factors are lowered. New-Sense’s iDAS acquisition system operates at 50Hz, allowing for the detection and removal of systemic noise created by both aircraft and cultural anomalies, such as power lines, buildings and vehicles.

The scalability and modularity of the system allows New-Sense to complete projects of all scales and sizes, and also lengths, from days to months.

Urquhart explains: “The use of an automated navigation system allows New-Sense to reduce the operational weight of the helicopter, which has led to expertise in flying surveys in high-altitude and steep-gradient terrains. Because stinger assemblies are used, New-Sense is able to safely offer a significant improvement in drape performance compared with others aircraft- or helicopter-towed bird assemblies.”

“Integrity in customer service and transparency of processing and procedures are paramount to operations at New-Sense Geophysics,” explains Urquhart. “All data is collected in a time-stamped ASCII and blocked-binary format. The client is always presented with the raw data in combination with processed data, to allow the possibility for the further investigation and different processing methods to be applied. After being collected, data is processed in Geosoft Oasis montaj, and is presented to the client in their preferred GIS formats.”

New-Sense Geophysics does not perform any interpretation of its data. If the client does not have its own QC/QA/interpretation expert, recommendations for contracted personnel and companies can be made.

New-Sense offers its services worldwide and has operated in North America, South America and parts of Europe and Africa. The majority of New-Sense’s recent operations have been in South America, flying blocks in the Andes in Chile and Peru.

**PRECISION GEOSURVEYS**

Precision Geosurveys offers magnetic, radiometric and EM surveys, with data collection and processing techniques developed specifically for mountainous terrain. As it specialises in mountainous-terrain surveys, the company only uses helicopters. Keyser says: “We are developing new passive and EM technologies that will offer improved target detection in these areas.”

Precision uses Geosoft packages combined with proprietary algorithms and software to process its airborne data. All data delivered to its clients is compatible with GIS software. Precision offers in-house interpretation of geophysical data from many sources, and works with clients’ geophysicists and independent geophysicists in data interpretation.

Precision specialises in collecting high-resolution geophysical data in the mountainous terrain of western North America, with most of its experience in Alaska, Yukon and British Columbia. The company has also worked in Africa, Europe and across North America.

** SANDER GEOPHYSICS**

Sander Geophysics (SGL) offers high-resolution airborne gravity, magnetic, EM and radiometric surveys, using fixed-wing aircraft and helicopters. It can also provide scanning LiDAR data as an add-on to its geophysical surveys.

SGL offers several unique techniques, including AIRGrav, which is its purpose-built airborne gravimeter, and SGFEM, which is its fixed-wing frequency domain.

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SGL acquires gravity data using AIRGrav. The data quality is not affected by the air turbulence normally encountered on airborne surveys, even in hot and windy environments. The stability of the AIRGrav system also allows surveys to be flown under normal daytime conditions and survey heights. Argyle explains: “The fact that we do not fly at night is a major safety advantage, and also allows us to fly low enough to provide high-resolution magnetic data when required.”

SGL’s SGFEM system was previously owned by the Geological Survey of Finland (GTK). This system is intended for very high resolution at relatively shallow depths, and can be flown in conjunction with magnetics, gravity and radiometrics to provide simultaneous multi-parameter data from a single platform.

SGL owns and maintains its own aircraft (15 fixed-wing and two helicopters), and designs and fabricates all the modifications to the aircraft. It also operates a full aviation department to train its pilots and develop safety programmes.

“We use acquisition and processing software that we have developed in-house,” comments Argyle. “We have refined this software over many, many years, and we find that using our own software allows us greater control and flexibility, which ultimately benefits our clients. All of our data is geographically referenced and can easily be imported into any GIS programme or other data viewing/manipulation software, as we support all common data formats and can customise for any defined format.”

SGL also offers interpretation services, ranging from simple transforms of the data to 3-D modelling and fully integrated interpretation using other available data.

The company recently started flying a very large gravity, magnetic and radiometric survey in Africa. The survey is in support of mineral development and will provide the country’s national geological survey with data to encourage and manage growth in the mineral industry. Since this survey is so big, SGL is using three identically equipped aircraft to acquire the data.

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A Sander Geophysics Twin Otter on a magnetic radiometric and EM survey in Ireland

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