"How Drones will change Exploration Geoscience"

This presentation was given at the monthly luncheon meeting of the RMAG on July 1 by Ronald S. Bell, President of Operations at International Geophysical Services, LLC. The talk was an updated version of a presentation given for the Denver International Petroleum Society (DIPS) on March 13. Mr. Bell received his BS degree in applied physics from Michigan Technological University, and has over 35 years of geophysical industry experience in mineral, groundwater, and hydrocarbon exploration; environmental subsurface site characterization; and marketing and sales of geophysical software, instrumentation, and services. Last year, Mr. Bell founded a company called Aerobatic Geophysical Systems (AGI), which manufactures Unmanned Aerial Vehicles (UAVs) equipped with geophysical sensors. About 18 months ago he started to work with drones with the intent to find a better, faster and cheaper way to acquire ground geophysical data. His objective has since expanded to include a geophysical mapping mission.

Drones are essentially airborne robots that can be asked to acquire large volumes of data. The advantages of drones for data collection are:

- Low altitude operation
- Programmable flight path
- Lower data point cost
- Improved productivity
- Higher definition
- Greater sensitivity
- Access to difficult and risky areas
- Generation of more data
- Reduced risk to personnel and public safety.

The disadvantages are:

- Low altitude operation
- Small payload capacity
- Concerns about conflicts of airspace.
- Concerns about privacy

Some typical applications for drones include resource exploration, subsurface characterization, buried UXO (unexploded ordinance) location, and subsurface infrastructure determination. The type of sensors used includes magnetometers, RF EM, and both visible and infrared spectrometry. These sensors are becoming lighter and cheaper. AGI has developed a light weight, low power fluxgate magnetometer especially for use on drones.

The AGI "Sparrow" has a 6-foot wing span, weighs less than 5 kilograms, and has a top speed of 100 km/hr and uses an electric motor. Their "Hummingbird" is a multiple rotor helicopter from which hang magnetometers. Drones have been used to find unexploded ordinance in the Kuwaiti oilfields damaged by Saddam Hussein.

As drones are essentially robots, they can be programmed to perform a particular function and return to base. Mr. Bell's examples of drone work included a magnetic survey of a maar volcano in Germany that had been flown partly with an ultra-light and partly with a drone. The good quality match between the technologies illustrated the drone's ability to make an accurate detailed survey. Another case history from Europe demonstrated that drones are effective in searching for UXO that remained from WW11. In another case, drones equipped with thermal imaging were able to locate malfunctioning solar panels in a solar farm. A large drone made by the Japanese Company, Yamaha, has been used to spray agricultural chemicals. A winery in California received permission to use it on their crops.

The FAA has three categories for unmanned aircraft systems: public use, civil use, and use by hobbyists. In the public sphere, drones have been used to collect geoscience data for 30 years, and the USGS has stated that it will be using unmanned aircraft systems for geoscience purposes. Collection of data by private firms for commercial purposes is considered civil use. The FAA issued rules for civil use on February 15, 2015, which had a comment period of 60 days and concerned small UAVs (under 55 pounds) conducting non-recreational operations. The rules would limit flights to daylight and visual-line-of-sight operations. They also address height restrictions, operator certification, optional use of a visual observer, aircraft registration and marking, and operational limits. The maximum airspeed would be 100 mph and the maximum height 500 ft. To fly above 500 ft. would require the permission and the need to be in contact with the air traffic control system; the height limit could then be raised to 18,000 ft. An operator would be required to be at least 17 years old, pass an aeronautical knowledge test, and obtain an FAA UAS operator certificate. Drones would not need an airworthiness certification, but would have to be registered.

The FAA did not address the use of autonomous drones as they could prove politically problematic. However autonomous operation is permitted under the control of an operator to allow manual control if a problem arises. With line of sight operation only relatively small blocks (I km by I km) can be surveyed at one time.

Mr. Bell mentioned a rule called Exemption 333, which has been in place for two months. It allows for civil use across the entire United States at 200 ft. without informing the FAA. Certain locations such as airports are off limits, but the altitude can be increased from 200 ft. to 500 ft. by notifying the FAA. One operator is required per aircraft. 90% of the current use is for photo imaging. Drone professionals would like to see the FAA weight limit for small UAVs increased to 100 pounds. Mr. Bell feels that the air traffic control system should be upgraded to integrate drones into the airspace.

Design considerations for drones include fixed wing versus rotary and electric versus internal combustion power. A solar powered drone has also been built. Fixed wing drones have been manufactured in Colorado (the “Tempest” made in Longmont) and New Mexico. Rotary wing drones (helicopters) tend to be slower with a shorter flight time, but are more stable and can track the ground better. Three rotary wing drones have been made in Denver by a company called Leptron. An electric motor has less impact on the sensors than a gas engine. Another advantage of electric engines over gasoline is that there is no loss of power at altitude. A drone made by a Chinese company called DJI, which is the largest drone manufacturer in the world, sells for $2,000. US products are slightly more expensive.

Leptron Helicopter Drone

Mr. Bell believes that preliminary mapping by drones will allow a geologist to focus on areas of most interest. He pointed out the difficulties caused by the line of sight regulations and emphasized that in many cases drones operate autonomously for most of the time. In low population places such as Nevada there may not be as much cause for concern in terms of safety. "Detect and avoid” capabilities will become available from the technology developed in driverless cars.

Mr. Bell received numerous questions from the audience. The first concerned the accuracy of the UAV GPS System. He replied that it was accurate to less than a meter. Regarding the effect of wind on UAVs, there is an influence, but the more expensive models have a self-stabilizing system. In reply to a question about battery technology, Mr. Bell said that there will be advances, but there are energy density limitations with

batteries. They currently last from ¼ to ½ an hour. When asked about gravity measurements, he said that the existing sensors are very heavy and power hungry, and deployment is not probable in the near future. Concerning the FAA line of sight rules, they impose definite limitations, especially with pipeline surveys, and with technical advances, hopefully will be modified. An audience member asked about infrared methane gas detection and Mr. Bells replied that he was currently working on a project using this technique. Gamma ray spectroscopy sensors are still in the development stage.

In conclusion, Mr. Bell said he felt that drone technology in mapping would be used by geologists, geophysicists and geochemists. Drones should reduce the cost of mapping considerably, and algorithms will integrate the visual, geophysical and geochemical mapping data, which should allow for more collaboration among disciplines.