DRAWING A LINE

LOW-ALTITUDE UAV SURVEY MISSIONS REQUIRE AN EXTRA SET OF OPERATOR SKILLS, TRUSTWORTHY EQUIPMENT AND PROFESSIONAL SOFTWARE FOR MISSION PLANNING. BUT HAVING A MAGNETOMETER ATTACHED ON A LONG TOW CABLE TO YOUR UAV CREATES AN EVEN GREATER CHALLENGE! SABINE MARKUS REPORTS

UAVs equipped with magnetometer sensors represent a leap in technology for remote mineral exploration. They are well suited to mapping mineral deposits, mapping pipelines, UXO surveys and other tasks. Missions that require them often take place in areas that are hard to reach, with rough terrain, and where safety and supply challenges can limit conventional airborne or ground survey techniques.

For magnetic surveying, a UAV carries a sensor on a very low altitude flight – usually between 5m to 50m above ground level (AGL). Some manufacturers produce special payloads for such tasks, such as GEM Systems' AirBIRD.

To carry out a successful and safe low-altitude mission, the following are vital during planning:

1. A precise altitude over the ground and other obstacles
2. The sensor's heading control
3. The prevention of pendulum motion from UAV-towed sensors

Initial planning

Initial planning is usually quite straightforward. Customers ordering a survey usually provide a KML file or other description of the boundaries of the survey area. This can be imported into a mission planning program such as UgCS to define the boundaries of the survey mission or you can manually set the mission boundaries.

The main parameters to define are: altitude, distance between survey lines, directional angle and altitude tolerance. The altitude is defined primarily by the type of survey and the capabilities of the sensor, such as the photo overlap requirements or the client's specifications for the geophysical survey. The distance between survey lines is defined by the customer's requirements and type of survey – for magnetic surveys, it can vary from 5m to 200m, depending on the geological or environmental target being surveyed.

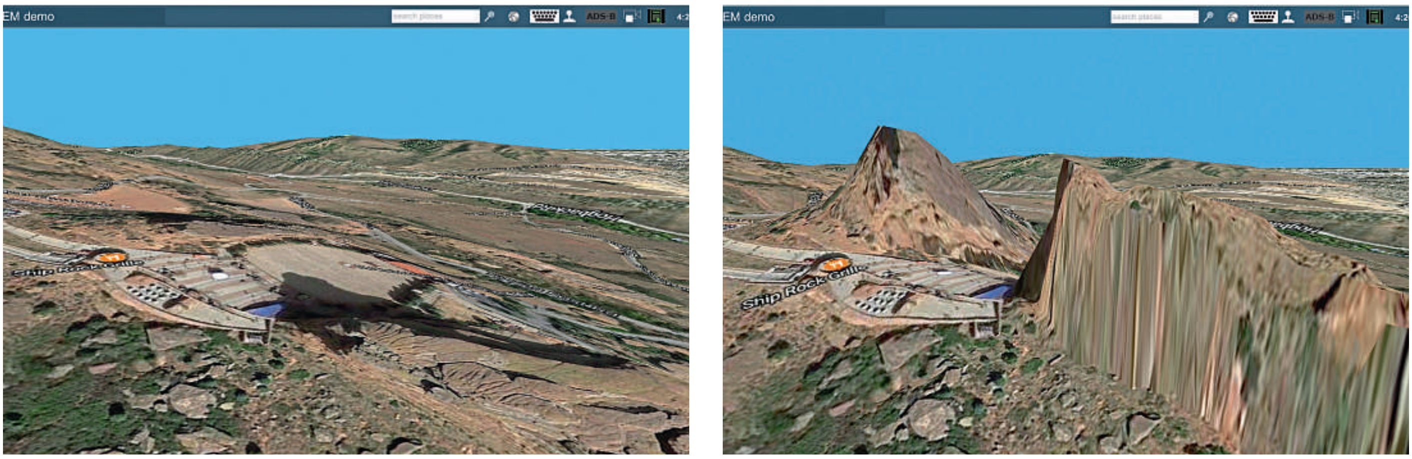

Figure 1. Elevation data for the Amphitheater in Red Rocks CO in the US imported into UgCS from two different sources: a) open-source SRTM elevation data and b) more precise DEM data

Altitude

Use precise DEM data

Most UAVs will fly at an altitude specified in the flight plan and relying on take-off position, as they have no information about their real altitude above the ground or obstacles. It is a task of the mission planning software to calculate the UAV's flight altitude based on the required altitude above the ground and elevation data (or digital elevation model).

Globally available, free elevation data can be outdated or imprecise, especially in distant and rural areas – which is where most magnetic surveys are conducted. The differences in precision between diverse sources are usually obvious after being imported into your planning software (see Figures 1a and 1b).

There are many sources for better DEM data, such as the publicly available ArcticDEM (www.pgc.umn.edu/data/arcticdem/) and the commercial dataset, Airbus WorldDEM (www.intelligence-airbusds.com/worlddem/).

Defining flight altitude

Figure 2 shows the typical magnetic survey flight of a UAV (DJI M600) with a magnetometer (GSMP-35U from Gem Systems), managed and controlled in UgCS. It's clear that the following parameters have to be considered:

- The required altitude of the sensor over ground
- Length of the rope towing the sensor
- The maximum height of trees and obstacles in the survey area

A parameter often overlooked but very

Figure 2. A magnetic survey flight

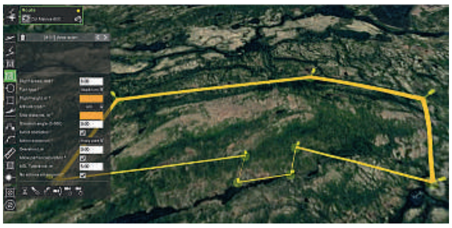

Figure 3. Setting survey area boundaries using the UgCS AreaScan tool

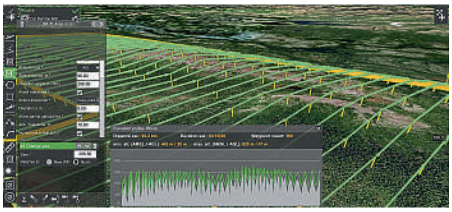

Figure 4a. AGL altitude tolerance value of 10m adds 360 waypoints

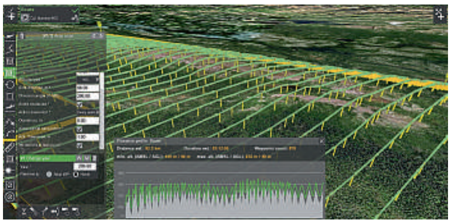

Figure 4b. AGL altitude tolerance value of 1m adds 876 waypoints

important for safe missions is the maximum barometer drift during flight time. Most UAVs use a barometric altimeter to calculate their own altitude relative to the take-off position. Unfortunately, these devices will always have some drift, depending on their quality, air temperatures and other factors.

In our experience, the maximum drift above or below the true altitude for a 30-minute flight can reach up to 5m. The safe altitude of the UAV over the ground therefore is the specified survey height plus the maximum height of any obstacles plus 5m for barometer drift. You can add a safety margin as well, depending on the terrain, winds and local site issues, such as line of sight and survey area access. And for UAVs with specialised payloads such as a towed magnetometer, it is necessary to increase this further by the length of the tow.

Precision of altitude

There is trade-off between maintaining the altitude within a certain range and the number of generated waypoints. Maintaining a more precise altitude means a safer flight and better data, but it increases the number of waypoints and UAV autopilots have a maximum number of waypoints that they can handle at once.

For example, the DJI M600 can handle no more than 99 waypoints at once, which means if your route consists of more than 99 waypoints, intermediate landings are needed to upload the waypoints for the next part of the route.

Therefore, you must set the value of the altitude tolerance so that the number of waypoints doesn't exceed the maximum number for a single mission. For a 40m AGL altitude with a 1m altitude tolerance, UgCS will generate hundreds of waypoints (876 in Figure 4b) to keep the UAV's altitude between 39m and 41m; increasing the tolerance to from 1m to 10m will reduce that to 360 (see Figure 4b).

Comparing Figures 4a and 4b, you can see that if you use a DJI M600 and an altitude tolerance 1m, you will need to fly nine flights; with a tolerance of 10m, that drops to only four flights.

The DJI's autopilot can, in theory, be enabled so that you can upload a new route while aircraft is airborne, but this should obviously be used with caution and it is better to keep the number of waypoints reasonable instead.

Heading and pendulum motion

For some surveys, it is important to maintain a constant heading of the UAV (and sensor) during the flight. This can be ensured with the UgCS 'change yaw' feature.

The standard speed for magnetic surveys is around 5m/s to 8 m/s. A UAV performing a U-turn at the end of a survey line at this speed will cause its towed magnetometer to perform a pendulum-like motion. Adding a 15m to 20m overshoot segment to the path and reducing the UAV's speed to around 2m/s for this segment, in combination with an adaptive bank turn, will prevent this motion.

Optimising for a safer route

After initial flight planning, the route can be optimised for a safer flight. This is especially important for magnetic surveys because the survey area can be quite large and requires multiple flights to complete.

First, make sure that emergency return altitude is set high enough in the route parameters. This should be high enough to ensure a safe way back from any point of the route, taking account of obstacles and variations in terrain.

Second, the route's initial waypoint should be always set very close to the take-off point. It should be high enough to safely fly to any other point of the survey mission, to give you the option of setting a new starting point after, for example, swapping the UAV's battery in the middle of the mission – the UAV will climb to a sufficient altitude and then fly straight to the selected 'resume point'.

Third, it is highly recommended that you set an additional last waypoint for the route, close to the desired landing point, which in most cases will be the take-off point. This will ensure the safe return of the UAV to the home position, even if there are problems with a handheld remote controller, the ground station computer or the radio link with the ground station, as the UAV will still continue its mission as programmed.

Carrying out the mission

A magnetic survey mission with the UAV flying with a towed sensor 5m above the ground differs from a classic photogrammetry mission in which the UAV flies at an altitude of 100m. The UAV operator needs to control the clearance between magnetometer sensor and ground and/or obstacles and to be ready to take over the control of UAV with remote controller.

Modern, commercially available UAVs, sensors and software together create a new, effective and economic way of acquiring high-quality magnetic survey data. Effective use of these technologies requires training, good knowledge of all components and very accurate planning. Combining these elements, surveyors will benefit from this modern and fast emerging technology.

IN OUR EXPERIENCE, THE MAXIMUM DRIFT ABOVE OR BELOW THE TRUE ALTITUDE FOR A 30-MINUTE FLIGHT CAN REACH UP TO 5M

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