Aerial Magnetic Scanning with an Unmanned Helicopter

By Dr. Christoph Eck

It is well-known that during the last decade remotely piloted (RP) helicopters have achieved special recognition for various civil applications. Within a joint project between the Swiss company Aeroscout GmbH (www.aeroscout.ch) and the German company Mobile Geophysical Technologies (www.mgt-geo.com) it has successfully been demonstrated, that the autonomous Scout B1-100 RP helicopter can be used for precise aerial magnetic scanning. A real life test for the integrated system was performed during multiple flight missions in Turkey during February 2011 after an open mining site had collapsed and several workers had been killed. This article will shortly describe the technical challenges of the integration of the highly sensitive magnetic system, the UAs mission planning, and the data analysis. A short section at the end summarizes the lessons learned.

Interfacing Between Engineers and Physicians

The task of aerial magnetic scanning is based on two disciplines which historically have less connection. On the one hand there are the mechanical and electrical engineers as well as computer science specialists which have dominantly influenced and driven the UAV system integration (mechatronics), and on the other hand there are physicians and geo physicians which have strong experience in geophysical data acquisition and data processing, including magnetic data analysis or electro-magnetic signal distribution affected by the Earths' surface or different layers and objects of varying materials. Therefore the first challenge for this project is to understand each other in terms of technical terms, technical requirements, and technical restrictions in general. Again, the question of "real-time" has to be clarified and obviously there are different understandings of sensitivity, noise intensity and noise patterns, or acceptable and non-acceptable disturbances. The open discussion and several flight tests have turned out that there are a few key challenges for a successful unmanned aircraft system (UAS) solution. Two of these challenges are described in more detail below, i.e., the sensor integration and the mission planning. A summary of real field experiences concludes this section.

Sensor Integration

While traditionally the magnetic sensor is carried by a person across the field of interest, it is now relevant that the sensor data acquisition can be performed remotely. During the flight of the RP helicopter a direct access to the sensor and its working conditions is not possible. In addition, it had to be analyzed if and if yes, how the highly sensitive magnetic sensor is affected by the environment of the UAS, including effects from the engine, the onboard computers, the various data links, or other sensors and payload components. Beside the data access from the sensor, powering of the magnetic sensor is not trivial, as varying supply voltages can strongly affect the sensor readings. A special solution had to be found for the sensor in concern of vibration isolation due to the various sources of vibration patterns from the engine, the main rotor, and the tail rotor. The solution developed has placed the sensor in a

certain distance from the helicopter main body, and providing a customized electronics for the sensor power supply and sensor data acquisition.

Mission Planning

In most commercial outdoor UAS applications the flight precision of the UAS can vary between a few meters in altitude and horizontal accuracy. However, the flight accuracy for precise aerial magnetic scanning had to be improved below 0.5m. Due to this requirement a DGPS system was used in parallel with the inertial navigation sensor unit (IMU). Due to the fact that a very close line spacing for the field or region of interest was required, an algorithm has been developed which allows the unmanned aircraft to make turns with respect to its physical limitation. This algorithm also takes into account that the payload (sensor) could also me mounted as a pendulum below the helicopter. The waypoints computed for the flight mission allow to cover the complete flight field and are providing a reference velocity during the magnetic scan depending on the data acquisition rate of the magnetic sensor. Various test flights have been performed with a line-spacing of 1-2m.

Field Experience

Initial flight tests for aerial magnetic scanning with Aeroscouts' Scout B1-100 remotely piloted helicopter have been performed in Switzerland and Germany. It was possible to create a magnetic map of a region of interest based on the flight profile of the UAS. After a landslide at an open-mining in Turkey in February 2011, various cars and vans have been buried. After detailed investigations at the location, the region of interest could be defined. During multiple flight missions, a magnetic map of the region of interest could be created with the

Deployment area in Turkey

In situ deployment

unmanned helicopter equipped with the magnetic sensor. The map has shown various locations of magnetic objects. It is a remaining technical challenge to further analyze the magnetic data in order to decide which kind of object at which distance below the surface can be identified.

Summary and Lessons Learned

The project described above was jointly fulfilled by Aeroscout, Switzerland and MGT, Germany. Fruitful discussions between engineers and physicians have yielded a successful UAS integration which fulfills the flight performance and real-time data acquisition in order to generate a precise magnetic map of a region of interest. The aerial magnetic data acquisition is based on a complete autonomous flight profile as required by the integrated magnetic sensor. During the development process it has turned out that the ability of multiple flight tests with different system configuration was necessary. Also, reference data from other solutions such as traditional walking across the field with the magnetic sensor was helpful. For the UAS mission development it turned out that the real-time data recording and the ability for data post-processing were relevant tools.

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