TESTING OF SUAS GROUND-PENETRATING RADAR FOR NON-CONTACT MEASUREMENT OF RIVER BATHYMETRY

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Abstract

The U.S. Geological Survey (USGS) is developing and testing tools and methods to enable fully “non-contact” stream-discharge estimates to improve streamgaging methods, efficiency, and safety. Current efforts include development and testing of sensors mounted on small unoccupied aircraft systems (sUAS) to provide increased deployment flexibility compared to fixed sensor installation. USGS previously demonstrated that helicopter-mounted ground-penetrating radar (GPR) was useful for non-contact measurement of river bathymetry; however, the cost and complexity of low-altitude heliborne GPR precluded routine application of the method. Due to advancements in sUAS technologies, sUAS increasingly are being used for surveys involving conventional geophysical sensors, such as magnetometers, electromagnetic induction, and radar. The USGS has successfully tested a light-weight, self-contained GPR system mounted on an sUAS for non-contact freshwater bathymetric surveys. Bathymetry collected with sUAS GPR could provide stream profile and water-depth measurements that can be used to estimate stream discharge.

USGS tested multiple MALÅ sUAS-GPR prototypes through a Cooperative Research and Development Agreement (CRADA) with ABEM AB (now Guideline Geo). The initial sUAS GPR objective was to rapidly and accurately image the stream bottom in fresh water (electrical conductivity <800 microsiemens per centimeter) through water column thicknesses up to 10 meters. Long-term goals include mapping of the subsurface below the stream bed during stream surveys and below land surface during flights over land. To enable deployment on hexacopters available for USGS use, payload weight was limited to about 4 kilograms.

Two prototype systems initially were tested via boat, cableway, and bridge. Results were positive but indicated that the 160-MHz center frequency was too high to meet the measurement criteria. Improvements also were needed in antenna design to address the deployment of airborne GPR, which is not earth-coupled like a traditional ground-based system.

The USGS then flew and tested three updated 80-MHz dipole antenna prototypes over multiple rivers in the United States. The GPR instrument is self-contained and communicates in real-time via WiFi to an external radar control unit (console) managed by a radar operator, when the aircraft is within the range of the console. The updated 2019 sUAS GPR system was able to successfully image stream bottoms at multiple sites in streams up to about 10 meters deep, and the water depth estimates were consistent with bathymetry gathered using other methods.

Results demonstrate non-contact bathymetry gathered with sUAS-borne GPR is feasible, although additional work is needed to optimize field operations and to improve the reliability of WiFi communication and missed trace recovery with the GPR system. Testing also indicates several challenges, including clear identification of shallow water depths and bank edges, and imaging steep stream banks. Initial field results from sUAS GPR suggest that additional applications currently in the domain of conventional ground-based GPR may also be possible.