Final copy as submitted to The Leading Edge for publication as:
Lane, J.W. and Stoll, J.B., 2017, Introduction to this special section: Unmanned autonomous vehicles: The Leading Edge, vol. 36, no. 7, p.550, http://dx.doi.org/10.1190/tle36070550.1.

Introduction to this special section: Unmanned autonomous vehicles

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Over the past decade, enormous improvements have been made in the capabilities, performance, and applications of unmanned autonomous vehicle (UAV) systems (airborne, marine, and terrestrial). Although unmanned underwater vehicle systems are used extensively in the oil and gas industry and have been around for decades, the advent of unmanned aircraft systems (UAS), popularly referred to as drones, is relatively new. Previously the exclusive purview of military and high-tech civilian agencies, small unmanned aircraft systems (sUAS) are widely available today and are used increasingly in the public and commercial sectors. The price tag for a capable UAS system now ranges from less than US$5000 to more than US$1 million, with sustained flight times (endurance) ranging from about 20 minutes to five hours.

The UAS tsunami is upon us. As of May 2017, more than 770,000 sUAS weighing less than 55 pounds have been registered with the U.S. Federal Aviation Administration (FAA), and more than 37,000 individuals have obtained remote pilot certifications (FAA, 2017a). Annual drone-sector revenues already exceed $1 billion, and it is estimated that more than 3.4 million sUAS will be sold in the United States in 2017 (FAA, 2017b). Compared to hobbyist usage, the commercial sUAS sector is small but growing rapidly. In 2016, the estimated size of the U.S. commercial sUAS fleet was 42,000 systems; it is forecast to grow to more than 400,000 systems by 2021 (FAA, 2017c).

Drones provide the means to acquire spatially exhaustive, high-resolution data in less time, at lower costs, and in smaller areas than has previously been possible. Today, most commercial applications of sUAS involve aerial photography for real estate, construction, industrial/utility purposes, and agriculture applications (FAA, 2017c). However, innovations in the UAV sector are simultaneously driving reductions in sensor size, weight, and costs, while increasing sensor capabilities. Today, an sUAS can be equipped with high-definition, multispectral, and thermal-imaging cameras; laser, magnetometer, and electromagnetic instruments; and an array of other sensors, dramatically reducing the costs for small- to medium-scale airborne surveys and opening new markets for mineral exploration, geotechnical surveys, unexploded ordnance detection, and periodic monitoring. Marine UAVs outfitted with seismic sources, hydrophone arrays, and other sensor packages provide new and exciting possibilities for offshore exploration and production monitoring.

In this first-ever special section of *The Leading Edge* on UAVs, we present papers showcasing applications of airborne and marine UAV systems for geophysical exploration, forestry assessment, and geohazard monitoring. Two of the papers in the special section are tied directly to geophysical exploration. In their paper, Malehmir et al. report the use of a helicopter sUAS and a commercial off-the-shelf magnetometer to acquire high-resolution, low-cost magnetic data over an iron-oxide deposit in central Sweden. Moldoveanu et al. demonstrate the potential of marine UAVs to support three-dimensional seismic surveys and explore how autonomous vehicle operations open up new possibilities for marine seismic data acquisition.

Drone technology can address tasks otherwise poorly suited for manned aircraft missions (e.g., tasks that are slow, repetitive, dull, or dangerous). In their paper, Morsdorf et al. use UAS-based LiDAR to map forest canopy and ground surface topography in Switzerland. The ability of the UAS to rapidly provide high- resolution digital elevation models (DEM) from digital camera or LiDAR system data is important and should not be overlooked. Routine UAS monitoring and DEM-differencing procedures can potentially reveal actionable information about ground deformation processes (e.g., permafrost thaw or aquifer depletion) impacting critical infrastructure (e.g., roads, pipelines, levees, or canals) prior to catastrophic failure. Similarly, in their paper Rothmund et al. address the opportunities for UAV technology to monitor geo- hazards, using a UAS to monitor a slow-moving landslide in southeastern France.

The leading edge of the UAV revolution has arrived and already has begun to permeate many aspects of geophysical exploration. UAVs are here to stay. With a predicted order-of-magnitude increase in the number of available commercial UAV systems in five years (FAA, 2017c), these systems and their associated sensor technologies are a game changer with the potential in very short order to forever change our concepts of exploration and monitoring in the applied geosciences. Embracing UAV platforms and their associated technologies has the potential to benefit the geophysical industry and provide new opportunities and methodologies to facilitate the accomplishment of many of our current and future exploration and monitoring tasks.

References

Federal Aviation Administration, 2017a, FAA TV: UAS Symposium opening remarks, https://www.faa.gov/tv/?mediaId=1547, accessed 1 June 2017.

Federal Aviation Administration, 2017b, FAA TV: UAS Symposium Secretary's welcome, https://www.faa.gov/tv/?mediaId=1552, accessed 1 June 2017.

Federal Aviation Administration, 2017c, FAA aerospace forecast 2017-37: Unmanned aircraft systems, https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/Unmanned_Aircraft_Systems.pdf , accessed 1 June 2017.