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# Scientific & Commercial Applications for Small UAS

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The capability of unmanned aircraft systems (UAS) has increased significantly in recent years fuelled by the need to support military troops through the collection of surveillance imagery. This effort has spawned both the number of new systems and the maturing of existing capabilities and has resulted in a second wave of technology being available for non-defence applications. Airborne data collection has been used commercially for many years and ranges from satellites that continuously monitor different aspects of our planet to small, single engine piloted planes or balloons used to obtain specific information about a local areas. UAS are therefore a natural platform for many of these existing sensor based capabilities. The «pilot less» nature of UAS however, brings several advantages to this industry; they can be designed to be small, lower cost and more portable as they do not need to be designed around the physical size of the pilot. If desired, they can fly at lower altitudes than manned systems might want to fly, leading to the potential for higher resolution data collection and more accurate thermal image collections. The UAS can also be linked to operate multiple platforms that might allow for synchronous data collection from locations physically separated in space. The opportunity for UAS for commercial industries is very large and hinges on the development or miniaturization of existing sensors, on-board power and data management, suitable communication links, the unique attributes afforded by autonomous machines and ultimately the stance that will be adopted by the aviation authorities around the world in the policing of safe autonomous flight with manned flight. The following section briefly summarizes the type of activities being explored with UAS and provides examples of some scientific and commercial opportunities in which the Silver Fox (Figure 1) and Manta UAVs (Figure 2) manufactured by Advanced Ceramics Research, have been involved.

Figure 1

## Scientific Applications

Climate and resource data have provided society with an improved prediction capability from weather to resource management and today's governments rely on remote sensing for treaty verification, disaster management, weather forecasting, and resource planning. Much of this data is provided by routine airborne flights by manned vehicles and from satellites as well as from a number of ground based stations and balloons that are released. In the future a significantly greater proportion of this information is likely to be provided by UAS.

One area that promises to benefit from the development of UAVs is the study of volcanoes. In late September, 2004, Mount St. Helens began its first sustained eruption since 1986 and for the first time UAS were sent into an erupting volcano. In October 2004 the Silver Fox UAV was provided by ACR to support the United States Geological Survey (USGS) to collect visual and IR data at the volcano, and to explore additional sensor technology that could be used to monitor volcanoes as shown in Figure 3. One of the major dangers posed by volcanoes worldwide is their ability to inject large quantities of volcanic ash into the air in a relatively short period of time; constituting a significant threat to commercial airliners. It can take only 5 minutes for an ash plume to rise to a height of 30,000 feet, and ash clouds can drift for thousands of miles downwind. Aircraft & rotorcraft are routinely used to collect information on the status of unrest at the volcano but the use of manned aircraft is however, dependent on both weather conditions and the extent of hazards within the crater. In addition, there are only a few pilots with experience flying near active volcanoes. Therefore it can be difficult to ensure that the data is collected when it's needed. A specific task that would benefit volcanologists would be to collect visual, infrared, radar, gas and other remotely sensed data on a more regular schedule and at close range, irrespective of time of day, weather, or hazardous conditions. The use of autonomous vehicles to collect these data has long been discussed as a means of limiting the risk to human life and, to a lesser extent, reducing the overall associated costs.

Figure 2

Figure 3

UAS have been used in similar high risk applications assessing forest fires in the continental United States as a way of

assessing fire spread and coordinating the response of fire fighters in real time. There is a scientific interested in better understanding the spread of fire, the types of vegetation, and the release of certain gases into the atmosphere during these fires. In National Parks in the US such as the National Marine Sanctuaries, UAS are being considered as a way of policing large areas. Wildlife and vegetation can be better mapped in the National Parks and many of the Marine Sanctuaries contain delicate coral reef systems which are not only ecologically important but provide billions of dollars from tourism. Illegal activities such as that from foreign fisheries are also of concern in this 140,000 square mile area. The expense and difficulties of having manned aircraft and boats doing the monitoring activities limits the range and areas that can be covered. By using technologies such as unmanned aerial vehicles (UAS), frequent and widespread monitoring can be afforded. Mapping of the coral reefs using hyperspectral imaging is also being investigated as a way of better determining the effect of global climate change on these delicate coral reef systems.


Figure 4


Figure 5

In March 2006 a UAS campaign was launched from the Maldives by Dr V. Ramanathan to study how human beings are polluting the atmosphere and their impact on climate, including global warming. During this extensive campaign data was collected which better characterized the particles in pollution, clouds while reflected solar radiation was simultaneously measured. The science mission was a great success logging over 120 flight hours that included 55 takeoffs and 18 science missions and collected data on pollution and dust transported from South Asia, Arabian and SW Asian deserts and their impacts on global dimming at the sea surface, the energy absorbed in the atmosphere and cloud properties. The Maldives Airborne UAS Campaign was unique in that it required the movement of three UAS at different altitudes to be synchronized with respect to flying over the same ground position. The target footprint was typically within 60 feet width and within a 100 feet distance in the direction of travel. The above cloud UAV flew at between 10,000 and 12,000 feet, the in-cloud UAV approximately 3,500 feet and was directed manually to the specific region of cloud by the on-board video camera, and the below-cloud UAS at between 1,000 and 2,000 feet. The Manta UAS was selected for these experiments as it has a large payload volume (0.45 $ft^3$, (0.013$m^3$)) that is readily accessible and can accommodate a number of sensors. It is also a «pusher» meaning that the sensors can sample «clean» air at the front of the UAS, uncontaminated with exhaust gases.

Greenland has long been identified as having an important influence on global climate and as being one of the thermometers for climate change. It has recently been suggested that the ice cap at Swiss Camp is moving towards the sea at an astounding rate of 20 inches/day. Other measurements have suggested that the melting of the Greenland Ice Sheet alone could raise sea level by 21 feet. The large amount of freshwater changes density currents regulating the Gulf Stream, disrupting the movement of the North Atlantic waters that regulate weather in Europe. Changes to the Greenland ice cap are critical in understanding better the effects of climate change and there are several requirements for which UAVs have been identified for data collection that will provide a great ability to model these potential impacts. In August of 2007, ACR supported NOAA and CIRES missions to Greenland to collect data on glacial melting. Three primary sensors were evaluated in Greenland - high resolution imagery, HSI and SAR. Figure 4 shows the Silver Fox and Figure 5 the Manta vehicles that were flown for data collection.

**Commercial Applications**

There are a broad set of commercial applications that are undertaken from UAS. Spectral analysis has been used to view through water and discriminate between channels and mud flats otherwise not observable to the human eye in rivers and shallow waters. In the United States multi-spectral analysis in the visual and thermal bands is available to optimize productivity of crops through the management of water and fertilizers as well as to identify disease and insect pressures which might be harmful to the crops. UAS have also been used for mineral exploration and for the tracking of water based contaminants from weeping domestic septic systems or agricultural run-off. Power line and pipeline surveillance, mining exploration, watershed management and whale spotting and tracking are also areas that have been commercially explored as potential markets for future UAS. These cover but a few of the capabilities of this technique but highlight the specificity with which the technique can be employed. Those which remain economical and provide sustained applications will persist over the new few years and establish themselves as commercial operations.

Agrarius LLC, located in Monterey, California, is one of the most experienced companies in the United States using a small Unmanned Aerial System (UAS) in a growing commercial marketplace assessing agricultural crops. Agrarius completed development and fielded the Hawk-Eye Remote Sensing System from the Silver Fox UAS, in 2005 and 2006. It is used today as an agricultural imaging platform for precision farming and crop and irrigation management; and for building thermographic assessments of large areas of crops as shown in Figure 4. The results of these agricultural assessments are rapidly converted into action to support «field drainage routing to avoid silting,» «irrigation application to offset heat stress,» and «spot treatment of a herbicide to control disease.». Agrarius is well practiced in conducting these types of safe and effective UAS data collection operations and in delivering product to customers. The Company is also pioneering other commercial applications that are well suited to small UAS. As Agrarius continues to develop new capability they have found the Hawk-Eye System to be a superb small UAS research and development tool because of the flight characteristics and mass margin of the Silver Fox UAS. Additionally; a unique telescoping aerial mast used for testing engineering models and new sensors, and for technique development is now operational and the mobile computing and communications sub-system that allows Agrarius to quickly and efficiently deploy, operate, and process data in the field is available to support the overall activity.