Recent Lessons Learned from UAS Field Activities for Shoreline Oiling Survey Applications

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Introduction

Unmanned Aerial Systems (UAS) have significant potential as tools for aerial surveillance of shoreline oiling providing high spatial resolution video and still imagery products to support delineation of a variety of oiling classes. In particular, the small UAS (sUAS) class (small multi-rotors and fixed wing platforms that are <55 lb) are a relatively easy-to-use and practical support tool for Shoreline Cleanup Assessment Technique (SCAT) oiling assessment surveys on shorelines and river banks. The paper presents: (a) lessons from field trials of both sUAS and a larger UAS system conducted by Chevron in 2016 and 2017, and ExxonMobil in 2017; (b) lessons from real-time use of an sUAS on a river spill response in 2016; and (c) recommendations on applications in which current UAS vehicles and technology can support SCAT programs.

Chevron Field Trials 2016

An Aerovironment Puma (a hand launched, 3-m wingspan, fixed wing sUAS with four hours endurance that can land on land or water) and a Lockheed Martin Indago quadcopter (sUAS with ~50 mins endurance) were deployed in field trials in northern San Francisco Bay in October 2016 to detect various artificial "oil" targets located on different shoreline substrates. The trials clearly demonstrated that the sUAS can provide high-quality, high spatial resolution, real-time full motion video (FMV) for the detection and delineation of these targets. Calibrated, but not SCAT-trained, observers consistently located and described surface oil targets to distributions as low as 5% on sand 15% on gravel/cobble sediments where the light and contrast conditions were favorable (Figure 1b). It was possible to quickly (<1 hour) train the non-technical observers as the surface oil detection process primarily is one of recognizing patterns and anomalies.

The trials demonstrated: (1) that FMV can be viewed in a remote "command post" and elsewhere (Figure 1a) and that the flight path and camera can be directed from these remote locations, and (2) the FMV can be processed in real-time to provide a roughly geo-registered hybrid video/map product with a geo-positioning accuracy sufficient to enable generation of a "sketch map" of a site or area for immediate use; this removes the need for data download and offline aerial photogrammetric processing to a QA/QC'ed orthorectified data product.

Figure 1 (a) Screen shot of "oiled" shoreline close-up video streamed real-time to a "command post"; (b) ground view 1-m wide band of 15% "oil" distribution on a sand beach

North Saskatchewan River Spill Response 2016

A commercially available DJI Phantom 3 - Professional sUAS was deployed on a river spill response in Canada as part of the SCAT survey program. The data generated from this sUAS supported both the field observations surveys in remote areas with difficult or unsafe access (Figure 2) and vertical video frame images generated on a rectilinear low altitude grid pattern that were used for the development of Shoreline Treatment Recommendations (STRs) field maps for Operations (Figure 3). The mosaics were generated with software to match overlaps without ground control or photogrammetric processing.

Figure 2 Left - Oblique 45°-angle view, 10-m eye level. Right - post processing zoom of same image

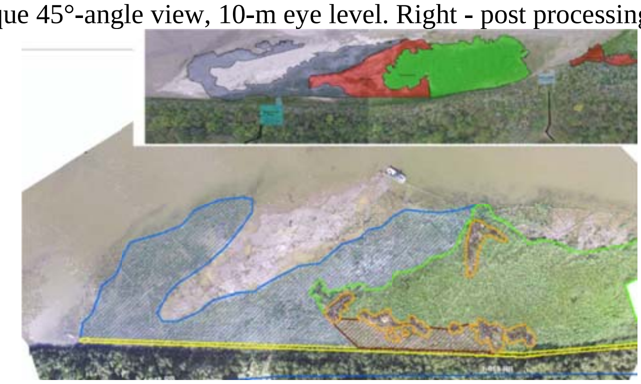

Figure 3 "Stitched" photomosaic STR map created using non-rectified sUAS data

The positive lessons learned included:

- A valuable resource for localized, small scale (<5000 m^2) base map production; or larger areas if multiple batteries are used, the flight path is heightened, and the image quality is decreased.
- A valuable, if not the only, option in access-restricted areas.
- Ability to cover extensive areas in a short time frame.
- May be used where the likelihood of oiling is considered low, so that ground (foot or boat) access may not be warranted but to validate that no obvious or significant oiling is present.

Challenges included:

- Potentially less effective for low oil concentrations, such as tar balls, or small (<20 cm) patties, depending on altitude, ground cover, and speed. The detection capability for low oil concentrations can be increased by lower flying altitudes and slower flight speeds; with the commensurate reduction of areal coverage per flight.
- Required additional personnel, resources and logistical inputs including permitting, hardware, software, and training

ExxonMobil Field Trials 2017

In coordination with National Oceanic and Atmospheric Administration, US Coast Guard and Washington Department of Ecology, multiple sUAS flight operations were completed for two shorelines in Neah Bay, WA. Three UAS, each with a different sensor were deployed to 1) determine applicability to support SCAT, and 2) provide persistent, real-time situational awareness of the environmental surroundings. The data were reviewed in real-time providing the ability for interaction between the environmental assessors and the pilots.

The first set of surveys was completed for the high-energy, exposed, sand beach in Hobuck Bay. The survey used a Lockheed Martin Indago quadcopter equipped with a high-definition (HD) camera capable of a 30x optical zoom. This survey visualized targets placed on the beach which consisted of man-made objects of various sizes and coloration, as well as natural objects placed in unique patterns to simulate "oil" components. The UAS was flown along a pre-determined path while video was reviewed in real-time by nearby shoreline assessors. Objects were identified and communication between shoreline assessors and pilots occurred that allowed the assessment team to direct the UAS to locations and to zoom in as needed.

The second set of UAS surveys was completed for a low-energy mixed shoreline adjacent to the Makah Marina and used the same methodology as Hobuck Bay. This operation also included two more UAS, a tethered DJI Inspire 1 equipped with an HD camera with 7x optical zoom and a 3DR Solo equipped with a Kodak 360° camera. The Solo360° data provided information for situational awareness required for an emergency response. This is particularly valuable for personnel required to make decisions who are working remotely from the operations and do not have first-hand knowledge of a region. The tethered Inspire and Indago were flown safely during simultaneous operations (SIMOPS). SIMOPS are usually not considered for UAS operations and required the addition of an additional pilot and observer. The scenario was a response that required both persistent monitoring capability (tethered UAS) and mission-specific needs (untethered UAS).

Chevron Field Trials 2017

An Arcturus Jump 20 (a 6-m wing span, hybrid fixed-wing/multirotor UAS with heavy payload capabilities and with endurance up to fifteen hours and a long-range up to 50 miles from the ground control station), and an Aerovironment Puma sUAS were deployed in October 2017 trials. Among a range of other over-water activities, the trials successfully field tested a "rapid SCAT" survey tactic that could be used during a first shoreline response. After securing special permissions (Certificate of Authorization – COA) from the US Federal Aviation Authority (FAA) to perform beyond visual line of sight (BVLOS) operations, the Jump 20 was used to perform surveys over 40 km of shoreline in the region of Santa Barbara, CA with the objective of detecting artificial "heavy oil" concentration targets that had been set on primarily sandy beaches. For this mission, high-resolution was less critical than the data capture and image turn-around time to a remote "command post".

The Jump 20 platform was flown at 1000 and 2000 feet respectively over the 40 km length of coastline in the study area using a high resolution still camera, with 10 and 20 cm spatial resolution visible imagery. The imagery was transferred in real-time to the remote command post and then rapidly post-processed to create GIS-ready image services in ~10-30 minutes from image collection. Based on this data, a new, short SCAT "Shoreline Oiling Aerial Reconnaissance" (SOAR) form then a new Rapid Response Treatment Recommendation (RRTR) form were completed for selected accessible Heavy/Moderate "oiling" locations. The RRTR form was "reviewed by the Environmental Unit" for potential Endangered Species Act and National Historic Preservation Act issues and at the same time "transmitted to Operations" – which had already been "alerted" and was in motion to deploy to the locations before the paperwork was completed. The scenario was played out to the decision approval stage and demonstrated that high priority, first response shoreline treatment recommendations can be generated within two hours of receiving images from the UAS at the "command post". This process can significantly shorten the time to direct the first shoreline cleanup actions before large "heavy oil" concentrations are redistributed by the next high tide. Traditional field surveys may take 4-6 hours before that information would be initially available for review. In a "traditional" SCAT/IAP process, the decisions and the recommended actions typically would not be available to Operations until the following day. The data capture/processing system developed for this trial demonstrated that it is possible to initiate same-day decisions and field cleanup actions within the required environmental review and chain of command process. Real-time full motion video was also obtained over local coastal areas (~2 km of coastline) using the Aerovironment Puma sUAS platform to demonstrate the triage of higher altitude and longer range UAS for BVLOS reconnaissance level surveillance and local, within visual line of sight (VLOS) UAS operations, for more targeted and higher resolution mapping/inspection of oiled shoreline.

At the outset of a response there is a very real competition for resources, both in terms of equipment and people. Firstly, it may be difficult to get a helicopter when people are engaged primarily with over-water aerial surveillance. Secondly, an experienced observer may not be available or, even if that person is available, it might take an hour or more to travel to an airport, up to an hour to brief and be airborne, an hour+ to fly, an hour or more to return to the Command Post, and then perhaps go straight into a briefing or strategy meeting. In reality, the turn-around time from image capture to a decision could be anything between 3 to 6+ hours. This field exercise demonstrated that the interval from image capture to decision and implementation could be in the range of 1 to 2 hours. That is a significant difference during the first phase of a response and means that, realistically, it would be possible to have same-day shoreline treatment actions by Operations.

Conclusions and Discussion

Field tests and spill response experience with both sUAS and larger UAS systems have demonstrated that it is possible to survey shorelines or areas that are physically difficult to access (cliffs, thickly-vegetated river banks, tidal flats, wetlands, etc.). These platforms can be used to “fill in” where a ground SCAT team chooses to “pass by” and/or only can partially survey a segment/reach because of access difficulties or because of long transit distances for potentially a brief survey (Figure 2). The collection of full motion video or aerial photography from pre-programmed grid pattern surveys coupled with the collection of sufficient metadata to enable rapid geo-registration and photo-mosaicking provides high spatial resolution imagery that can, quickly and easily, be used to delineate and map oil concentrations for Operations activities (Figure 3).

UAS survey tactics have readily identifiable niche applications to support SCAT, including aerial reconnaissance, SCAT Operations Liaison, and monitoring missions. If the mission is to simply detect Heavy and Moderate oiling categories, then the use of aerial visual observers may be adequate under most circumstances. Although, the advances in larger, long-endurance UAS systems and future potential for BVLOS operations does offer potential for using these platforms to perform these types of aerial surveillance missions; this would have benefits in terms of freeing up and providing longer endurance than a manned aerial asset whilst generating GIS-ready image products for analysis back in the command center.

If the mission is to detect Light and Very Light oiling categories, then aerial visual observations are a low confidence technique compared to sUAS platforms that have the potential to fly at low altitudes, can loiter, and through the use of zoom cameras provide very high resolution imagery (down to mm/pixel) for confirmation of shoreline oiling. Additionally, both sUAS and larger UAS systems may be able to fly when other platforms are grounded due to weather (e.g. the first 2 days of the 2007 *Cosco Busan* initial response in San Francisco Bay). The field trials also demonstrate that a UAS reconnaissance survey tactic can significantly reduce the data capture and decision turn-around time during the initial response phase. Although an aircraft can fly faster and longer, and can cover more shoreline currently than sUAS systems that must generally operate within visual line of sight (VLOS), there is potential for larger UAS with longer endurance/range to start competing with the traditional approaches. In addition, the use of both sUAS and larger UAS systems to collect georeferenced video and imagery has number of advantages over traditional aircraft-based techniques during this first phase of a response:

What Next?

The experiences to date identify clear and valuable applications for UAS, and in particular the sUAS class of platforms for shoreline and riverbank oiling assessment surveys. More information can be gained from operating these platforms to understand what can be accomplished under a greater range and variety of environmental conditions. This can be achieved by additional field trials with different target types and environment (substrate) conditions and is more about learning to operate and apply a system rather than developing new survey concepts. A useful tool would be Job Aid or Field Guide for sUAS techniques to support SCAT to pass on knowledge and experiences gained to date.