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Small unmanned aerial systems to determine slick thickness

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ABSTRACT

Small unmanned aerial systems (sUAS) are especially useful at detecting and monitoring the environment. A novel use for these highly mobile systems is for marine oil spill response (OSR) vessels. ExxonMobil is developing a system to use sUAS to both detect oil slicks and map their relative thickness. This is accomplished by tethering a small floating wedge to the sUAS. The wedge is made of a clear plastic and has space for a small high-definition (HD) camera inside. The sUAS is used to first spot the location of a slick and then tow the wedge through the slick in a series of transects. The HD camera collects video of the interfaces between the oil-water-air and immediately sends this video to responders on an OSR vessel. In this way, the responders get an immediate and direct visual determination of the slick thickness that allows decisions on where to conduct response operations.

Basin testing showed that a sUAS can detect the thick oil using the camera system and simple techniques. Recent basin testing indicated the system and communications links are potentially seaworthy. This system could be positioned on oil spill response vessels to provide a real-time solution to locate oil slicks and then map the thickness.

Introduction

There are currently no simple methods to both remotely identify and determine the thickness of marine oil slicks. Determining oil slick thickness is important for oil spill response for all response techniques. Mechanical recovery and *in situ* burning are more efficient on thick oils. The rule of thumb for marine oil slicks is that 90% of the oil resides in 10% of the area. Currently available techniques are challenged to identify portions of oil slicks more than 0.1 – 0.3 mm thick as slicks tend to respond similarly to all detection method (including visible) when they are greater than 0.1 mm in thickness. Further, it is also challenging to identify oil slicks that are more than a few tens of meters away from vessels at sea. Aerial assets including airplanes and helicopters using multispectral imaging, thermal imaging, synthetic aperture radar, side-looking radar can be used but carry with them additional burden of safety clearance and logistical considerations[1]. Satellites have been used to characterize oil slicks but their use can be restricted by clouds and fog for visible cameras, be prone to false positives, and be even less capable of identifying thick oil.

In recent years the use of Unmanned Aerial Systems (UAS, aka Unmanned Aerial Vehicles - UAV) has increased beyond military usage to research and industry applications[2]. Mission needs should drive the decision on which UAS is applicable for use. An initial consideration of UAS can be made between fixed-wing and rotary (VTOL, Vertical Take Off and Landing) platforms. A fixed-wing UAS is likely more appropriate for rapid transport between distant sites, whereas a rotary UAS is more appropriate hovering over closely grouped sites. A secondary consideration of UAS is made between gas-powered (greater range, more carrying capacity and

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[1] Gair, S., Salt, D. 2012. Aerial surveillance technology and capability. Interspill 2012.
[2] Parscal, B., Ziska, M., Williams, J. 2014. A field evaluation of unmanned aircraft systems for oil sill response. International Oil Spill Conference, Savannah, Georgia.

provide more power to onboard sensors) and battery-powered (tend to require less overall maintenance and operate with less noise) systems. The choice of UAS is also dependent upon onboard sensors. Current off the shelf sensors available to UAS include high definition cameras and video as well as infrared and visible multispectral sensors, with other sensors currently being researched and developed.

UAS can perform two aspects of marine oil spill response. Detecting oil slicks from the bridge of a vessel at sea is challenging. Oil located only a few tens of meters from the vessel can go unnoticed. Therefore, it could be beneficial for aerial observation tools to be included in the vessel based response equipment. Traditionally, these tools have utilized manned aircraft (primarily fixed-wing airplanes but also helicopters) with trained observers to identify the location of individual oil slicks and then to guide on-water responders to the oil. For a large spill, this can be cumbersome because of airspace limitations, which may lead to one plane directing multiple vessels. This splitting of observer attention can result in less efficient response. Depending on the circumstances, it may be advantageous for a response vessel to have its own aerial observation system and this is what UAS can provide.

Another aspect of marine oil spill response is to differentiate thick from thin oil. As mentioned, there is a “rule of thumb” for oil slicks that says 90% of the oil is in 10% of the area. Although there have been recent important advances, currently, methods of identifying oil thickness greater than 0.2 – 0.3 mm remains a challenge. Thicker oil slicks can be accurately mapped but their absolute thickness cannot be determined[3]. Identifying oil >0.2 mm from sheen would be an important advance and may enhance response efforts. Tools to do this, however, are expected to require complicated processing techniques and would therefore, require a trained operator, which could greatly delay the delivery of actionable information, and as a consequence have limited use during a large offshore spill.

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[3] Svejkovsky, J., Muskat, J., Mullin, J. 2008. Mapping Oil Spill Thickness with a Portable Multispectral Aerial Imager. 2008 International Oil Spill Conference, May 2008, pp. 131-136.

In oil spill response, the information is often needed in real-time to determine the appropriate course of action to take because slick movement is very dynamic. Further, marine skimming vessels often have a very large geographic area to cover. Current practice is for spotter aircraft to focus oil spill response vessels to the area of a surface slick.

Others have described the value of using small UAS for aerial observation during oil spill response[4]. In this paper, the concept of extending the capabilities of small UAS beyond just aerial observation to allow this same tool to be a platform for slick thickness determination for thicknesses > 0.2 mm is discussed. By targeting the thickest oil first, a more efficient response can potentially be achieved.

Concept

Remote detection of oil slick thickness has been a goal for the last several decades. There has been some recent success using electromagnetic techniques [4,5], however, in the near future it is expected that these instruments will be relatively complex, require a well-trained responder, and the number of platforms may be limited.

The concept of using sUAS is to move away from remote detection systems in the traditional sense, i.e., to move away from electromagnetic techniques. A small UAS can be set up to take direct measurements of slick thickness remotely utilizing visual observation of the air-water-oil interface (Figure 1).

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[4] Lehr, W. J. 2008. The potential use of small UAS in spill response. 2008 International Oil Spill Conference, May 2008, No. 1, pp. 431-433.

[5] Allen, J., Walsh, B. 2008. Enhanced oil spill surveillance, detection and monitoring through the applied technology of unmanned air systems. 2008 International Oil Spill Conference, May 2008, No. 1, pp. 113-120.

Development

2013 Feasibility Study with Prototype Alpha

A feasibility study was carried out in 2013 to determine what challenges a potential system would face in regard to the visual observations needed to determine slick thickness. The objective was to have a UAS (Figure 2), to carry a platform with onboard cameras positioned inside of a plexiglass wedge attached a frame with skis mounted for stability (Figure 3). Field tests were carried out in 2013 and provided sufficient data to warrant further investigation and development of this technology. Testing was carried out in a small manmade basin. The camera systems performed well but it was evident that a more stable platform would be advantageous.

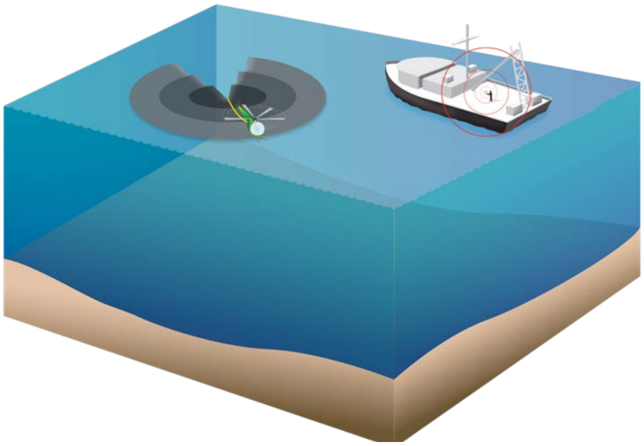

Figure 1. Detection of slick thickness using a towed platform

Figure 2. UAS system used to perform field trials

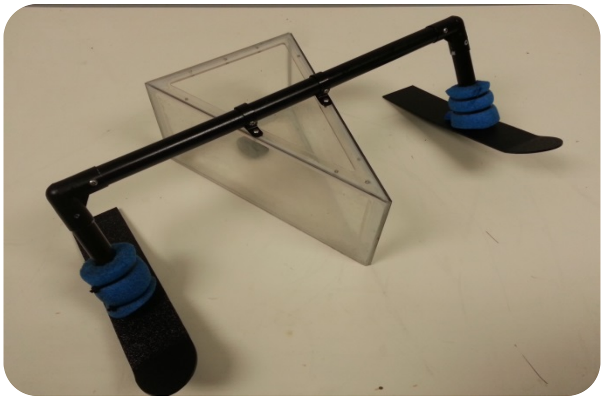

Figure 3. Prototype Alpha

2014 Field Trials with Prototype Beta

Using lessons learned from the 2013 field trials, a new platform was constructed using a trimaran design (Figure 4). The architecture of the platform consisted of carbon fiber and aluminum to reduce weight. For additional stability, a movable ballast system compensated for any changes made to the electronics within the main hull and two outriggers. Testing occurred in a wave basin to simulate how well the design performed in waves. During flat and rolling waves, the platform performed well and the operators were able to discern when the wedge was in open water, in a thin slick, or in a heavy slick. Breaking waves challenged the platform to remain steady and it was decided to further stabilize the platform and reduce the overall weight.

Figure 4. Trimaran Design: Prototype Beta in test basin

2015 Field Trials with Prototype Gamma

Building on the learnings from 2013 and 2014, the field program for 2015 is to include open water deployment to determine seaworthiness in natural conditions. Additional field trials to establish the performance characteristics of the optics and the resulting detection thresholds with a range of crude oils in a closed system is also scheduled.

Conclusions

Real-time identification and mapping of thick versus thin portions of an oil slick can potentially enhance the effectiveness of offshore oil spill response operations. Unmanned aerial systems (e.g., small helicopters) and high-definition cameras have undergone significant technical advances in the last decade. Testing indicates that these vehicles can provide slick locations and thickness mapping to support marine and freshwater oil spill response operations. This is accomplished by placing high-definition cameras inside a clear, floating, waterproof wedge that can be tethered to a UAS and pulled through a slick to transmit via video the interfaces formed by the water, oil, and air. Observations of these interfaces can allow operators to identify thick and thin portions of oil slicks in order to direct operations to the thick portions first. In addition, cameras on the UAS will allow monitoring of an area to identify slicks that can then undergo thickness measurements. These systems are compact enough for launch and recovery from oil spill response vessels to provide dedicated real-time oil slick remote detection and mapping capabilities.