**Aerial surveillance options in a spill – what's available and when to use them**

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## Introduction

The importance of surveillance has long been recognised as a critical part of oil spill response, acknowledged through the IPIECA-IOGP Joint Industry projects (JIP). Surveillance delivers accurate, relevant and timely information to the Incident Command to facilitate strategic decision making improving situational awareness or to allow the tactical support of operational assets.

Surveillance tools can provide both a wide view and tactical support for response operations offshore and on the shoreline. Wide view surveillance tools provide a broad coverage of a spill area while tactical tools give a close-up view of the response, directing operations on-site. This paper concentrates on the use of surveillance tools for tactical support to operations offshore and on the shoreline.

## Tactical surveillance tools

It is critical to understand what tactical surveillance tools are available for use in a spill response and how and when they can be applied to add value to the clean-up operations. Some surveillance tools can be used for multiple purposes – to provide a wide view of the oiled area i.e. track the direction of the spill, and tactically to support response operations in the immediate area. It is important to highlight that there should be a number of surveillance tools in the 'toolbox' to choose from so the most appropriate tool(s), can be chosen based on the spill scenario. No one surveillance tool is likely to be suitable for every spill scenario.

The typical tactical surveillance tools that may be used by Oil Spill Response Organisations (OSROs) and their Members include manned aircraft (fixed wing and rotary), aerostats (tethered balloons) and Unmanned Aerial Systems (UAS's), both fixed wing and rotary. Traditionally, manned aircraft are the main tool used, but now technology allows alternative options.

*Satellites have not been included as a tactical surveillance tool as the time taken to task the satellite, acquire the image, and download and interpret the image takes some time resulting in the information from the imagery being out of date and no longer useful for tactical response decision making.*

Tables 1 to 3 below list the advantages and limitations of manned aircraft, aerostats and UAS's.

| **Manned Aircraft**<br>Fixed wing or rotary manned aircraft can come with pre-integrated sensors or host portable packages. | |
|---|---|
|  |  |
| **Advantages** | **Limitations** |
| Large areas can be surveyed from a wide variety of altitudes in a relatively short time scale. | Aircraft have limited endurance so will only be able to spend limited time on-scene before needing to re-fuel. |
| Most sensors can be deployed and operated from fixed wing aircraft. Portable handheld sensors can be operated from both fixed and rotary aircraft. | Unless the aircraft is an oil spill response dedicated aircraft already mounted with sensors or an aircraft utilised for other survey work using similar sensors, it takes time to gain approvals to mount sensors. |
| Manned aircraft operate in a mature regulatory environment, therefore there is confidence in operational safety, unlike UAS's. | Manned aircraft pilots operate under strict regulations and cannot exceed flight hours. If a pilot has been on duty before being mobilised for an incident this will reduce the hours the pilot can fly during the incident. |
| Aircraft usually have multiple navigation aids that can assist in pinpointing locations. | Aircraft are subject to weather limitations for deployment, especially wind conditions during take off and landing. |
| Relatively short mobilisation time. | Busy airports can delay the mobilisation time of an aircraft. |
| Helicopters are usually very manoeuvrable. | |
| Observers on-board can both survey and interpret the data. | |

*Table 1 – Advantages and limitations of manned aircraft*

| **Unmanned Aerial Systems (UAS's)**<br>An UAS has three components including the platform, the sensors and the ground control system/communication system. Models include both rotary and fixed wing. | |
|---|---|
|  |  |
| **Advantages** | **Limitations** |
| Large and small areas can be surveyed in a relatively short time scale. | Rotary UAS's have a limited battery life (10-50mins). Fixed wing UAS's are limited by fuel reserves. |
| A variety of sensors can be mounted on the UAS i.e. optical and Infra-Red. | Spare lithium batteries are restricted on aircraft creating challenges when transporting batteries to a spill location. |
| The day rate of a UAS team compared to the cost of flying and crewing a manned aircraft is likely to be very much lower. | The regulatory environment is still developing (or is not in place in some countries) and requires refining. The application for permissions to fly is variable and can take days, weeks or months depending on the Countries permissions process. |
| Rotary UAS's are usually very manoeuvrable. They can hover easily for many minutes in one position to gain good video footage – helicopter pilots prefer to avoid hovering at low level when unnecessary because it adds risk. | UAS's are very weather dependent, restricted by high wind speeds and rainy conditions. |
| Permissions to fly commercially in some countries can be applied for in advance to reduce mobilisation times. | |
| The UAS produces minimum noise compared to a helicopter i.e. for wildlife surveys. | |

*Table 2 – Advantages and limitations of UAS's*

| **Aerostats**<br>An aerostat is a balloon filled with high grade helium. The aerostat is tethered and has any number of cameras mounted onto the balloon. | |
|---|---|
|  |  |
| **Advantages** | **Limitations** |
| Aerostats give a continuous 'birds eye view' of the incident with a visible camera range of 1-4nm or 2-8km approx. (depending on weather visibility) | Towing an aerostat from a vessel reduces the vessels mobility. Ideally the aerostat would have its own vessel and be able to operate independently. If vessel availability is limited it may need to be deployed from a vessel also deploying boom/spraying dispersant which could reduce the effectiveness of the operations. |
| Multiple and a variety of sensors can be mounted on the aerostat i.e. optical and Infra-Red as standard | Permissions (in the UK) are required over 60m or 196ft from ground level. If the aerostat is needed to operate over this height it could take time to gain permissions. |
| The day rate of an aerostat/team compared to the cost of flying/crewing a manned aircraft is likely to be lower. | Initially, expensive to purchase, ranging from £90k-150k. |
| The imagery/video can be viewed on multiple vessels operating in the area by setting up a WIFI hotspot and creating a password protected log-in to share the footage. | If operating in a remote location there may not be a phone signal and satellite communications may be required which are expensive. |
| The camera batteries mounted on the balloon can last up to 10hrs and can be quickly swapped out. | Spare lithium batteries are restricted on aircraft creating challenges when transporting batteries to a spill location. |
| Depending on the size of the balloon/gas bottles five or so gas bottles can provide enough helium for roughly one week's operation (continuous day and night). | The supply of high grade helium at short notice can be challenging. Re-supply of helium, past the first few bottles, could involve a long lead time. |

*Table 3 – Advantages and limitations of aerostats*

**Why and how should tactical surveillance tools be used during a spill response?**

The objective of tactical surveillance tools during a spill response is to support the operations on the ground to be more effective and efficient. How the surveillance tools are applied and why they improve the efficiency and effectiveness of the spill response both offshore and on the shoreline, is explained below.

<u>Offshore operations</u>

The objective of a tactical surveillance tool offshore is to support the response vessels to improve encounter rates by targeting the thickest patches of oil. Referring to the Bonn Agreement Oil Appearance Code, used to estimate oil volume, the oil target during response operations should be Continuous True Oil Colour, Discontinuous True Oil Colour and Metallic (oil thicknesses range from *more than 200µm to 5.0µm*). Even with the most efficient and effective offshore boom and skimmer systems unless vessels can be directed to the thickest parts of the oil, experience shows that recovery rates will still be low at approximately <20%. The same applies when targeting oil with dispersant sprayed from a vessel.

Tactical surveillance tools offshore should include both optical and Infra-Red (IR) sensors to detect the thick oil. Optical and IR sensors are seen as standard sensors for offshore oil spill response. Optical sensors will give a visual of the oiled area and IR will be used to effectively detect thick oil (typically over 50 microns) by using temperature variations between the thicker oil patches and the sea water.

Manned aircraft, are utilised as a tactical surveillance tool offshore by acting as a 'spotter' aircraft' to direct vessels towards the thickest patches of oil, once identified, containment and recovery operations or dispersant spraying commences. Aircraft are normally mobilised to verify and quantify the spill but they can complete a dual role by also acting as a spotter aircraft. Aircraft are particularly valuable for this task if covering a large area offshore.

Aerostats and UAS's are deployed from vessels and as with manned aircraft, are used to survey the oiled area looking for thicker patches of oil. The decision to utilise aerostats or UAS's offshore is based on a variety of factors but should include the consideration of whether or not a 'constant stare' is required from an aerostat or if a rotary UAS deployed in short, sharp intervals is more applicable. A fixed wing UAS could be deployed to fly in a constant circular pattern above the area but this has not been well tested.

<u>Shoreline operations</u>

The objective of tactical surveillance tools on the shoreline is to improve the efficiency and effectiveness of the shoreline surveys and shoreline clean-up operations.

Manned aircraft, are utilised as a tactical surveillance tool on the shoreline by completing shoreline surveys to assess the level of oiling (scaling the incident) and prioritising segments along the shoreline that require a more immediate clean-up i.e. thicker oil or oil that will easily remobilise. Aircraft are especially valuable for this task if covering a long shoreline area. The use of aerostats on the shoreline is very limited and not yet well exercised, with the only likely use being an 'eye in the sky' to assist in identifying the most effective placement of protection and containment booms.

UAS's can support the Shoreline Clean-up Assessment Technique (SCAT) teams completing shoreline surveys to segment the shoreline and document the oiling conditions. The rotary UAS team works with and under the direction of the SCAT team targeting difficult to reach shoreline i.e. rocky shores or sites of sensitivity (salt marshes, mud flats, mangroves). Fixed wing UAS's can also be used to complete shoreline surveys to assess the level of oiling (scaling the incident). Rotary UAS's are particularly suitable for this task if there are segments of shoreline with sensitive areas and difficult to access shoreline. Fixed wing UAS's, like manned aircraft, can cover a wide area.

**Offshore Case Study – Aerostats**

This case study describes the use of an aerostat during a 'real oil on water exercise'. An 'oil on water exercise' is where a controlled volume of oil is released and successfully cleaned up. This oil on water exercise focused on validating, under controlled scientific conditions, remote sensing technology for the detection of oil spills at sea including satellites and an aerostat. 500 litres of oil were released offshore South-west of the Isle of Wight (England, UK). An aerostat, provided by Maritime Robotics, was deployed on the exercise to tactically support dispersant spraying from a response vessel.

*Figure 1 – shows the aerostat launched from the Earl 2 vessel and the optical camera showing the location of the thicker patches of oil (to the west of the vessel)*


*Figure 2 – shows the viewing screen, on the bridge of the Earl 2 vessel, illustrating the outputs of the Infra-Red sensor. The image shows two vessels and two lines of oil in the water (as the oil was released from the vessels).*

The use of the aerostat in tactically supporting the Earl 2 to improve encounter rates worked well and demonstrated that the surveillance tool could assist in improving the efficiency of dispersant spraying operations. Although containment and recovery equipment was not deployed, the use of the aerostat to improve the efficiency of containment and recovery operations is assumed as the tasking of the aerostat is the same. The integration of the aerostat team and the OSRL Earl 2 skipper worked very well and a method of working together was quickly established. Once an area of interest was identified, the aerostat heading was relayed directly to the vessel skipper, this allowed the vessel to be directed and carry out operations.

**Shoreline Case Study – Unmanned Aerial Systems**

In conjunction with the Shoreline Clean-up Assessment Technique (SCAT) element of a shoreline exercise, Oil Spill Response Ltd ran a proof of concept demonstration to test how a *rotary* UAS could support a SCAT team on the shoreline. The objective of SCAT is to collect and record data on oiled shoreline conditions in a rapid, accurate and systematic fashion. Shoreline surveys can be conducted by different methods; both aerial and ground level, and on different scales depending on the size of the affected area, the character of the coastline and the level of detail that is required.

The objective of the demonstration was to assess how using a UAS could improve the efficiency and safety of the SCAT team.

- Quick surveying – instead of by foot or helicopter (efficiency/cost)
- Access - surveying coastline difficult/not accessible by foot (safety/efficiency)

A UAS company (Sky Futures) offered to provide a UAS and a Remote Pilot team for the demonstration, the UAS specifications are in Table 4 below.

| Function | Astec Falcon 8 |
|---|---|
| Primary use | High end professional UAS used in offshore environments |
| Motors | Rotary |
| Batteries | Lithium Polymer batteries |
| Flight time (flight time dependent on wind, temp, how the system is flown) | 12-15 min |
| Wind limitation | Cannot fly above 23 knots (GPS flight mode), 29 knots (Height flight mode). Gust Limitation – 5 knots. |
| Rain limitation | System is not waterproofed. Flight in snow, fog or rain not permitted. |
| Temperature limitation | Minus 10 to 35 degrees C |
| Dimensions | 650 x 600 mm |
| Camera | Interchangeable, gyro-stabilised. Still images. HD video 30x zoom. Forward looking infrared (no zoom). |
| Sensors | Optical and Infrared (IR) |
| Downlink (from the UAS to the pilot's screen) | Yes |
| Ascend/Descend rate | Max Ascend Rate – 3 meters per second, Max Descend Rate – 1 meter per second |
| Radio frequency | 2.4Ghz (Data), 5.8Ghz (Video) |
| Take off weight | 2kg-2.2kg |
| Approx. cost | High end |

*Table 4 – UAS specification*

*Figure 3 - UAS and Mobile Control Station (MCS) provided by Sky Futures – the MCS screen on the controls allows you to see what the UAS camera is filming*

Three locations were identified with a variety of shoreline types including;

- Medium sandy beaches
- Coarse to medium sandy beaches
- Mixed sand and gravel
- Gravel beaches
- Riprap i.e. manmade concrete structure
- Salt marshes
- Exposed rocky shore

The following was tested;

- SCAT segmentation
- Overview of surface oiling conditions - scaling the incident: over a large area, in a relatively short time (to direct the initial deployment of response resources)
- Completion of the 'Oiled Shoreline Assessment' (OSA) form - document shoreline oiling conditions in all segments; providing the primary source of data

*Figure 4 - The UAS team launching the UAS*

*Figure 5 - The SCAT team and UAS team working together – the scenario is the SCAT team is standing on a cliff top with no access to the beach below. A SCAT team member (Alex) is viewing the UAS camera through the goggles as the UAS is hovering out at sea with the camera facing the cliff. Alex is asking the UAS team to either move the UAS into a different position i.e. fly further along, or to use the camera to zoom in or pan east or west (30 x zoom). Alex is translating what he is seeing to Nicola who is recording it on the Oiled Shoreline Assessment (OSA) form (SCAT form).*

<u>SCAT segmentation - results</u>

The first step of a SCAT survey is to divide the coastline into working units called segments, within which the shoreline character is relatively uniform in terms of physical features and sediment type. Segment lengths are typically 0.2 - 2.0 km. Segmentation can be completed from the air or by foot, although preference is by air to increase the speed of the task.

The information required when recording a description of a segment includes a start and finish latitude and longitude and the total length. The SCAT team found that the UAS easily identified the boundaries between the segments i.e. geological features/access points. The technology on the UAS trialled did not have the capability to measure the length of the segment or take a latitude and longitude of the start and finish of the segment but this is an option.

Overview of surface oiling conditions – results

The information generated by the SCAT surveys is an important part of the decision-making process for setting response priorities. Scaling the incident over a large area from the air, to direct the initial deployment of response resources needs to be completed in a relatively short time. While there was no oiling to record during the demonstration it was thought that the UAS provided an excellent aerial view of the shoreline and it would be able to provide the ability to assess the level of oiling, similar to what a helicopter could view.

Completion of the 'Oiled Shoreline Assessment' (OSA) form – results

The OSA form is what the SCAT team completes for each segment during their surveys and is a fundamental part of recording information; it has seven sections plus space for noted sensitivities, a sketch map and additional comments. While we found the UAS could assist the SCAT team in recording most of the data for the OSA form there was some information it could not collect which would likely only be achieved by personnel on the ground, this data included;

- Load bearing capacity – this has implications for the Operations teams not knowing what vehicles/machinery they would be able to deploy to the segment.
- Subsurface oiling –the UAS (optical sensor) would not be able to view subsurface oiling unless there was a part of the oiling exposed on the beach or in shallow water. A foot survey would need to be completed. Not knowing this information could mean subsurface oiling is present and could be re-mobilised.
- Shoreline gradient - the gradient of the shoreline was difficult to gauge and when we compared it to a ground view it was not always correct. This has implications for the clean-up teams accessing the segment.

**Conclusion**

It is critical to understand what tactical surveillance tools are available for use in a spill response and how and when they can be applied to add value to the clean-up operations on the shoreline and offshore. Understanding the advantages and limitations to each surveillance tool is key to applying the right tool(s) to the spill scenario.

Opportunities to demonstrate the effectiveness of aerostats and fixed wing and rotary UAS's as tactical surveillance tools should be encouraged on exercises and spills to help define how the tools can be used most efficiently in the future.

**Reports to Reference**

IOGP-IPIECA funded an Oil Spill Response (OSR) Joint Industry Project (JIP) to improve the industry's capabilities for oil spill response. The report highlighted below forms part of work package 2 within this JIP, and focuses on identifying capabilities and gaps associated with surveillance monitoring from aircraft. This is linked to recommendations from the American Petroleum Institute (API) in their assessment of remote sensing for oil spill response.

*An Assessment of Surface Surveillance Capabilities for Oil Spill Response using Airborne Remote Sensing, IPIECA and IOGP, May 2015 (pg.29 – 41)* http://www.oilspillresponseproject.org/wp-content/uploads/2016/02/RR-OGP-WP2-airborne-report.pdf

*Remote Sensing in Support of Oil Spill Response, API Technical report 1144, September 2013 (pg.26- 27)* http://www.oilspillprevention.org/~/media/oil-spill-prevention/spillprevention/r-and-d/oil-sensing-and-tracking/1144-e1-final.pdf