Operational Profile of RPA Systems in Nearshore Oil Spill Response

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Abstract

Information about the scale, drifting and behaviour of an oil spill is of vital importance in determining the response strategy and tactics. The effectiveness of the oil spill response actions correlates with the accuracy and correct interpretation of the information. In case of an oil spill incident, situational awareness can be obtained by means of aerial surveillance, satellite imagery and on-site reconnaissance surveys conducted by vessel, vehicle or by foot. This paper represents a comparative study analysing the applicability of aerial, shipboard and onshore surveys in determining the areal extent and degree of contamination of oiled shorelines. The introduced conclusions are derived from a preliminary field test, the objective of which was to examine the utilisation of Remotely Piloted Aircraft Systems (RPAS) as a complementary surveillance technique to on-site field surveys. The field test focused on the performance of the consumer level RPAS and their operational profile within the fire and rescue service conducted operations. The interest lies in the methods of data sharing and interpretation, and the influence they have on incident commanding. One goal of the field test was to demonstrate, what kind of added value, if any, the readily-available RPASs offer in case of an oil spill. The comparative field study was conducted in cooperation between two regional fire and rescue services and an educational institute in May 2017.

Introduction

Recent technical development of Remotely Piloted Aircraft Systems (RPAS) offers an additional surveillance method to be utilised in an oil spill response operation. Several studies on the optimal oil detection sensor technology that meets the payload restrictions of RPAs are in progress (i.e. VTT 2017, Sassi 2016, Honkavaara & Rosnell 2016). However, even the RPAS technology directed at regular consumers, typically equipped with cameras only, shows potential for increasing the efficiency of situation evaluation. Oil on water surface may be difficult to detect if viewed from an oblique angle less than 45 degrees, as oil might blend into dark backgrounds, such as water or shoreline (Fingas 2013). Thus, detecting oil from shore or from a vessel bridge is unlikely when the oil slick is more than few tens of metres apart from the observer (DeMicco et al. 2015). In addition, sun glitter, wave shadows and wind sheens may easily be confused for oil sheens. Thus, the advantage of view from above obtained by aerial observation is apparent. This paper discusses the usability of RPASs in oil spill response visual surveillance when equipped with no other sensors than daylight cameras. The aim is to evaluate the feasibility of cost-effective RPASs readily-available from general stores. The observations presented in the paper are based on the findings of the RPAS field test.

In this paper the term RPAS refers to the remotely piloted aircraft system consisting of the actual aircraft component, sensor payloads, a remote control station operated by a pilot and data processing systems.

RPAS Field Test

In order to assess the applicability of the RPAS technology in oil spill response operation, the North Karelia Fire and Rescue Service, the Kymenlaakso Fire and Rescue Service and the South-Eastern Finland University of Applied Sciences carried out a RPAS field test in May 2017. The test took place near the city of Joensuu in eastern Finland. The test scenario was based on a nearshore barge incident resulting in shoreline oil contamination. An oil drift calculation model was applied in order to predict the spreading of the oil (See Fig. 1). The aim of the test was to assess the actual extent and the degree of contamination of the oiled shorelines. No real oil was used. Degrees of oil contamination were demonstrated with objects of various sizes, such as tarpaulins and canisters, as shown in Fig. 2. Also plastic decoy-ducks were used to represent oiled birds. There were eleven (11) target objects in total placed within the shoreline that was 400 metres in length.

Figure 1. Incident scenario illustrating the oil drift modeling and shoreline contamination. The colours represent the extent of the spreading in given time intervals. On right hand side, the location of the Incident Command Post. (Graphic: J.Kauppinen, maps: ©Liikennevirasto, ©Maanmittauslaitos, ©Boris)

An Incident Command Post was established at the nearby marina at a distance of 300 metres to the cape subjected to on-site reconnaissance surveys (Fig 1). Incident Command Post consisted of a command unit vehicle with management, communication and documentation systems managed by two executive fire officers.


Figure 2. Target objects representing stranded oil (on left) and oil contaminated birds (on right). (Photos: J. Nevalainen)

The test was divided into five parts: i) Comparative study on aerial, shipboard and onshore surveillance techniques ii) Active aerial surveillance by RPAS, iii) Conducting an operation by means of RPAS live aerial images and video feed, iv) Oil drift calculations using data produced by RPAS and v) Utilisation of RPAS Automated flight modes. This paper focuses on the finding from the first part of the test, i.e. the comparative study. The methods included on-site reconnaissance surveys conducted by vessel, foot and cameras mounted on an aircraft. These techniques were evaluated based on the total number of detected targets, the amount of time it took to find and report the observations to the Incident Command Post, and the feasibility of the gained data.

The reconnaissance survey on foot was executed by three trained firemen implementing an established protocol with reconnaissance maps and data sheets. The shipboard surveillance was carried out onboard an air cushion vehicle (due to ice coverage). The aerial surveillance was implemented with DJI Phantom 4 quadcopter (see Fig. 3) with maximum speed of 20 m/s and a flight duration of 20-40 minutes. Quadcopter was instrumented with a daylight camera providing 12 Mpix photos and 4K videos. Both manual and automated flight modes were tested, and the data was shared with the Incident Command Post through live streaming and by sending screenshot photos via email during flights, and by transferring original photos from the SD Card after landing.

Figure 3. DJI Phantom 4 quadcopters used in the RPAS field test and the analysing of RPAS generated data at the Incident Command Post. (Photos: J. Halonen and M. Pitkäaho)

Main Results

The comparison of the different surveillance techniques indicated that the visual RPAS surveillance show superiority to other techniques with respect to the response time (See Fig. 4). The Incident Command Post received first screenshot photos of the target area within five (5) minutes after command. Original photos with higher resolution were in use within 15 minutes, as the RPA returned from the reconnaissance mission. These included photos from altitudes of 30, 50 and 100 metres. Another RPA performing a pre-programmed surveillance flight produced results within 15 minutes, ten (10) minutes of which were spent in programming the flight patterns. The response times of both on-foot and vessel reconnaissance were around 25 minutes. Results of the on-site survey by foot were available to Incident Command Post within one (1) hour and 28 minutes from the command. Correspondingly, the shipboard generated reconnaissance data took 51 minutes to reach the Incident Command Post. However, only the on-foot survey reached a 100% coverage of target detection. By means of RPAS visual surveillance it was possible to detect only the largest objects, which demonstrated the heaviest concentrations of oil. It should be noted that the actual oil appearance differs from the target objects used emphasising the importance of further research with real oil.

Based on the findings of the field test, the Incident Command Post benefited most from the video filmed during the manual flight mode and the still photos taken from altitudes 30 and 100 metres. The latter provided an overall picture of the incident area, the former gave more specific information on the potentially impacted area (Pitkäaho et al. 2017). RPAS imagery data inherently containing geographic information was considered a valuable feature as it enabled geo-referenced photos and generated 2D map layers to be imported to the Situational Awareness System for further analysis (Fig. 5). The advantages of the manual flight mode were related to the flexibility of the surveillance method permitting an active intervention when needed.

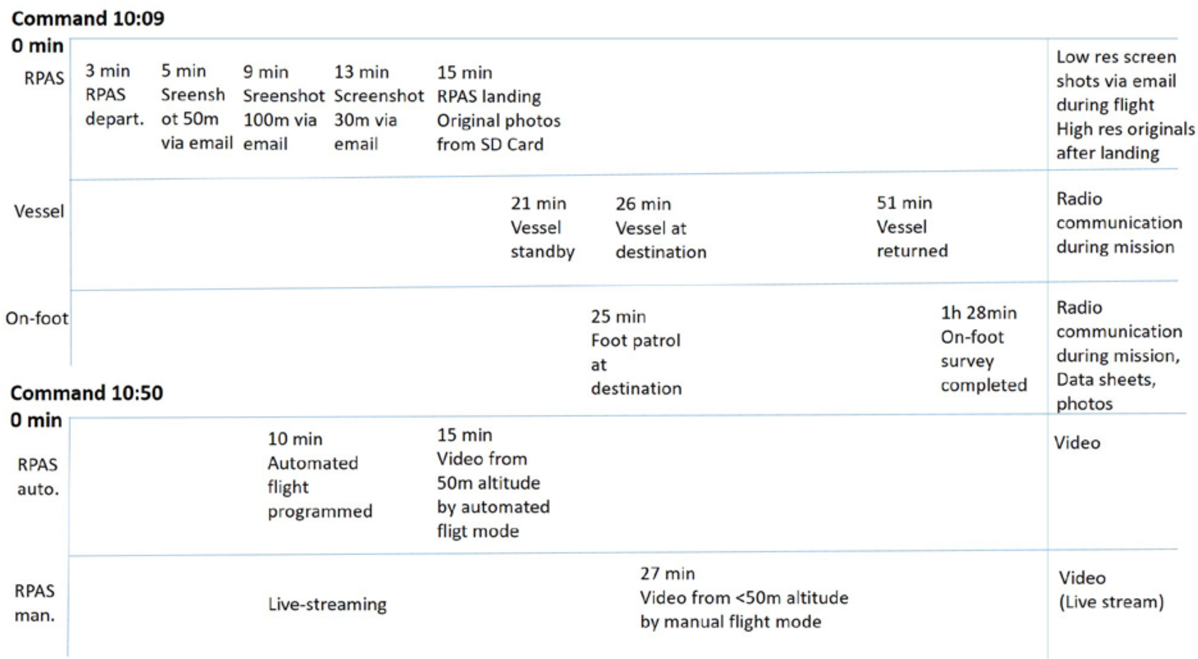

Figure 4. Comparison of the surveillance techniques based on the departure time, the time of arrival and the time after which the surveillance data was available to the Incident Command Post. (Graphic: E. Rantavuo)

The utilisation of RPAS visual surveillance seems to be most beneficial in assessing the areal extent of an on-water oil spill and determining spill trajectories. It also provides valuable data on the operating environment, such as directions of approach and access points to the contaminated shores, as well as, differences of terrain heights affecting the equipment usable on the incident site. In addition, the RPAS visual surveillance serves in directing the oil spill countermeasures, and monitoring and documenting the situation.

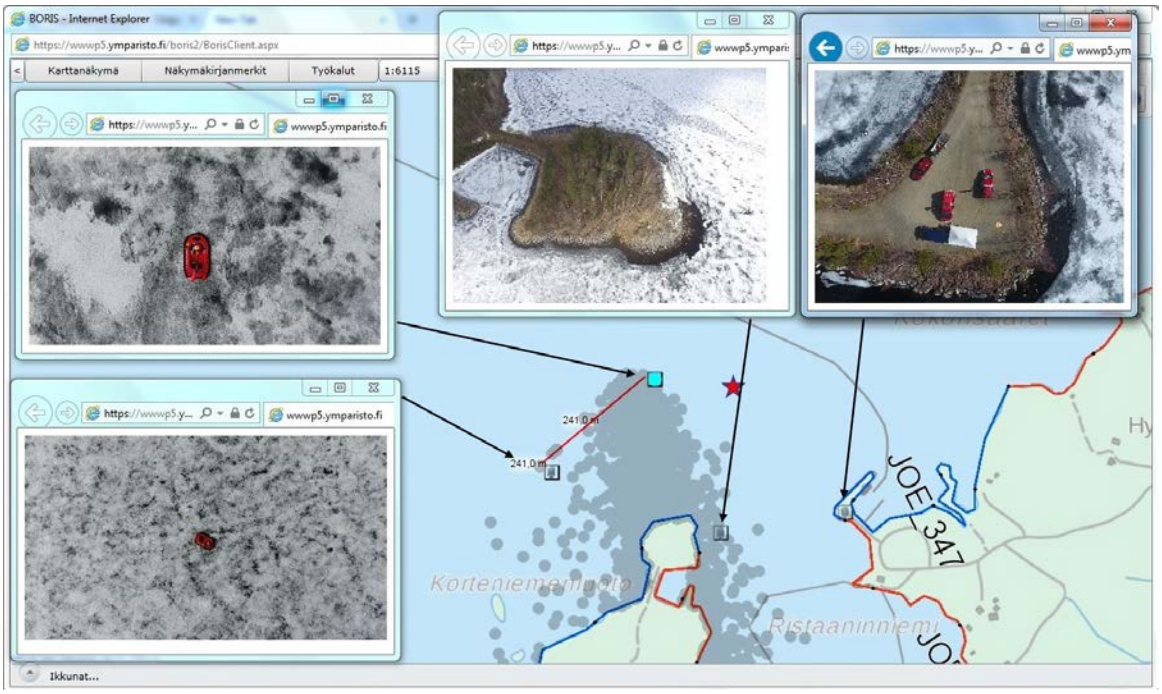

Figure 5. RPAS photos imported into Situational Awareness System BORIS 2.0 (©Boris).

One of the benefits of visual surveillance with RPAS-mounted camera(s) seems to be the relatively fast interpretation of the data, though it requires skilled and experienced observers and RPAS pilots. As Fingas (2015) states, some of the sensors and sensor outputs require extensive processing to make the data useful for oil spill surveillance and detection. Advanced sensoring is however a necessity in case of adverse weather conditions or without daylight.

Conclusions

RPASs offer a viable surveillance technique that complements the conventional reconnaissance techniques by proving high-resolution remote-sensing data and increased operational flexibility. The field test demonstrated the main benefits of RPAS visual surveillance to rest upon the fast response time contributing to a better initial situational awareness enabling more effective response actions. Even the readily-available RPASs for consumer usage show potential for operational oil spill surveillance, monitoring and assessment. In order to create operational models for RPAS oil spill response surveillance and guidelines to analyse RPAS-generated data, more research is needed.

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