Australian Marine Mammal Centre

Final Report

(subclause 9 and Schedule Item 5 of the Funding Agreement)

- **Project No**. – 0708/14
- **Title -** Using Unmanned Aerial Vehicles for surveys of marine mammals in Australia: test of concept
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- **Organisation** – University of Queensland

Activity Period – 28 March 2008 to 31 May 2009

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1. Activity Summary

A clear summary of approximately 500 words outlining the work undertaken and any significant findings (for publication on the Department's web site)
The conservation and management of many marine mammal species is largely dependent on monitoring population status by conducting aerial surveys from manned aircraft. We investigated the use of Unmanned Aerial Vehicles (UAVs) for marine mammal surveys considering their potential to: (1) reduce costs, (2) reduce human risk, (3) increase the accuracy of detection, location and identification of species, and/or (4) provide a permanent record of the survey. We reviewed the UAV systems

and companies providing UAV services in Australia and found that developments in this field are occurring rapidly, with new companies that offer greater capabilities than were available to us emerging during the course of this project. We conclude that considering the permits, approvals, maintenance costs and technical skills involved in operating UAVs, hiring a company that operates UAVs would be the most cost-effective and logistically sensible way to trial this technique at such an early stage of development.

We tested the ability of a small UAV (the Warrigul from *V-TOL Aerospace*) to fly transects precisely and accurately. When comparing one UAV scoping flight with one manned flight, the UAV maintained the desired altitude and transect line better than the manned aircraft under the same low-wind conditions, although the UAV deviated more from the transect line under higher wind conditions. We conducted manned flights with a 'typical' UAV imaging system with relatively low resolution (1024 × 768 pixels) with the aim of capturing images of humpback whales and dugongs. We found that at normal manned survey heights this resolution did not allow us to identify whales to species or clearly differentiate between dugongs and dolphins.

We then directly compared the sighting rates obtained from (1) human observers, (2) a stills camera (4 megapixels), and (3) high definition video, by using all observation platforms simultaneously from a manned plane. We conducted two short surveys for dugongs in Shark Bay at altitudes of 900 and 500 ft. The sighting rate from the stills camera was significantly better than the human observers by 251% at the altitude of 900 ft. However, at 500 ft the performance of the stills camera was reduced by 42% to be equivalent to the human observers. The video system performed relatively worse than human observers across both altitudes with a sighting rate of 60% that of human observers. More data would be needed to investigate this result further. However it is evident that using high resolution imaging systems in UAVs has the potential to provide accurate data for marine mammal surveys.

If capturing one image per second, each kilometre of survey images took 3.2 min to analyse post-flight. With the aid of the Australian Research Centre for Aerospace Automation, we tested a computer algorithm designed to detect animals within the images and therefore automate the image analysis process. The algorithm showed promising results but requires more development to reduce the false-positive detections and animals missed to a rate equal to or better than human observers. The development of this algorithm, would significantly reduce the post-flight analysis time and therefore the overall costs of surveys using UAVs.

In conclusion, it is apparent that the capabilities of UAVs will continue to improve. There appears to be great potential to develop this technology for marine mammal surveys, particularly in Australia where there are currently fewer limitations than in the US for flying UAVs in civilian airspace.

2. The Outcomes/Objectives

The degree to which the Activity has achieved the objectives

This project has met all of the objectives as outlined below:

Objective 1: **Provide a review of current UAV capabilities and potential use for marine fauna surveys**

We reviewed all UAV companies providing UAV services for hire or UAV systems to purchase. A new company, *CyberTech*, can now provide a UAV with enough range and endurance to conduct trial surveys (that were beyond the reach of this project) at reasonable cost for future research initiatives involving marine mammals. This UAV also has an image stabilised camera system, a necessity recognised by other UAV research.

Silvertone Electronics has the most promising UAV airframe for purchase, for which researchers would need to source their own payload, autopilot, data link and ground station. The option of purchasing a UAV would require a large commitment to the development of UAVs by a single research institute, due to the permitting requirements, maintenance costs and the need to retain personnel with the skills to operate the systems.

Objective 2: **Test the basic capabilities of UAVs for viewing and surveying marine mammals**

(a) using small UAVs

We used the Warrigul UAV operated by *V-TOL Aerospace* to conduct scoping flights over both land and water. This UAV was small (1.5 m wingspan) but robust as it was made out of polypropylene materials and could withstand relatively high impacts with minimal damage. Warrigul had limited endurance and control range however, so flights were restricted to within 10 km maximum distance from the base station.

When comparing one UAV scoping flight with one manned flight, the UAV maintained the desired altitude and trackline (average 0.04 m and 5 m deviance respectively) better than the manned aircraft (average 4.5 m and 158 m deviance respectively) under the same low-wind conditions. During our over-water scoping flight, the wind speed reached 15 knots and the UAV deviated more heavily from the trackline under these conditions.

The Warrigul could transmit images in real-time back to the base station and its flight path could be diverted at any time. However the video images obtained had limited resolution. We were able to depict two dolphins (which were sighted by land-based

spotters first) and a manta ray using the real-time footage.

The Warrigul gave the advantage of providing records of the field of view and angle of the camera, together with the exact altitude, pitch, roll, heading and GPS track. These records could be used to determine the exact proportion of the survey area sampled more precisely than can be obtained from manned flights, and consequently provided more accurate population estimates.

(b) using manned planes mounted with UAV systems

The Australian Research Centre for Aerospace Automation (ARCAA) assisted us in conducting manned flights using a Partenavia mounted with their UAV data acquisition system. Images were captured at 1 frame per second and at a resolution of 1024 × 768 pixels, with the camera angle being changed during flight according to where the animals were located.

One flight was conducted over a large dugong herd in shallow water in Moreton Bay. At all altitudes tested (1000, 750 and 550 ft) the dugongs were visible in the images captured. However we felt we could only reliably count the dugongs visible because they were in a large herd and we had prior knowledge that they were dugongs. If surveying animals in deeper water where they might be more obscured by the water, we felt this camera system would not be reliable.

We also conducted scoping flights over humpback whales in Moreton Bay and the results were similar to dugongs. In images captured at 1000 ft we could depict whale but couldn't have identified them to species. At 1500 ft, whales could not be reliably depicted.

The combination of the typical UAV imaging system we used and the altitudes we trialled did not provide images of high enough resolution to reliably detect dugongs or

whales. Rather than continuing with this system and conducting further trials at lower altitudes, we converted to with higher resolution imaging systems.

Objective 3: **Directly compare the capabilities of UAV imaging systems with human observer marine mammal counts from a manned plane**

We used a manned aircraft to directly compare the sighting rates of dugongs from three observation platforms: (1) four human observers, (2) two high definition video cameras, and (3) a digital still camera capturing 4 megapixel images. A small line transect survey was conducted at Shark Bay, Western Australia, where there is a high density of dugongs which offers a good opportunity to compare these platforms.

The overall sighting rate per platform was analysed within a log-linear model framework. This analysis showed that the still platform's sighting rate was significantly better than the human observers by 251% at the altitude of 900 ft. However, at 500 ft the performance of the still camera was reduced by 42% to be equivalent to the human observers. The video system performed relatively worse than human observers across both altitudes with a sighting rate of 60% that of human observers. More data would be needed to investigate this result further.

Two possible explanations for the different relative performance of stills and observers at the different heights are: (1) the poor sea-state conditions experienced at the low altitude flight may have been better compensated for by the human observers who could spend more time viewing each sighting compared to the single snapshot obtained from the stills, or (2) the observers' sighting rate may have been poorer at 900 ft than at 500 ft because they had a greater search area to observe in a limited time frame.

The poor performance of the video platform was because of the low resolution these images compared to the stills, but may be improved if flying lower and pointing the

cameras vertically downwards rather than obliquely. Video should not be discounted as it produces a higher frame rate than the stills providing benefits such as: (1) increasing the probability of capturing animals surfacing, (2) providing some information about the animal movement (e.g. multiple surfacing of dolphins or the white-water produced when dugongs exhale), and (3) increasing the probability of capturing animals outside of the zone of glare within the images.

Overall, if capturing one image per second, each kilometre of survey takes 3.2 min to analyse post-flight. With the aid of ARCAA we tested an image analysis computer algorithm which has the potential to automate this process. The algorithm showed promising results but requires more development to reduce the false-positive detections and most importantly decrease the animals missed to a rate equal to or better than human observers. If this algorithm could at least limit the number of images needing manual analysis, it would reduce the time for analysing images substantially.

3. Appropriateness

The appropriateness of the approaches used in the development and implementation of the Activity

The three objectives stated above represent the three approaches we used to determine the efficacy of using UAVs to survey marine mammals. We had to take these approaches because there were no UAVs available/affordable that met our requirements to directly trial UAV capabilities for surveying marine mammals. The approaches were therefore appropriate for the resources available to us at the time of the project. Our use of the Warrigul provided an excellent insight into the flight capabilities of a UAV and the precision at which a UAV adhere to a transect-style flight path. It showed that UAVs have a strong potential for further development for use in marine mammal surveys. The flights conducted using a typical UAV camera

system on a manned plane made it clear that high resolution images were needed to successfully identify marine mammals to species when flying at similar altitudes as manned surveys would normally be flown. We used high resolution imaging systems in a full manned aerial survey and successfully identified dugongs and other animals. By directly comparing the sighting rates of human observers with two types of imaging systems we have shown that UAVs mounted with camera systems have the potential to provide accurate data during marine mammal surveys.

4. Effectiveness

The degree to which the Activity has effectively met its stated objectives
The approaches we took to meet our objectives were effective as we clearly showed the potential for UAVs to be used for aerial surveys, but have highlighted the current limitations on using this method in Australia. We have produced a detailed summary of the UAVs available and indicated those companies/systems with the most potential to be used for further investigations into UAVs. We have shown that still cameras are more effective “observers” than human observers, and that there is potential for the image analysis process to be automated. Ultimately we have provided insight into the best way forward for developing UAVs to conduct marine fauna surveys.