Summary of Unmanned Aerial Vehicle trials for use in UK Overseas Territories 2018-2020

Katie Morton – Senior Marine Technology Manager

Date: January 2021

Blue Belt Programme

Enhancing marine protection across 4 million square kilometres of marine environment in the UK Overseas Territories.

Marine Management Organisation

Centre for Environment Fisheries & Aquaculture Science

UK Government

Since 2018 the Marine Management Organisation (MMO), as part of the Blue Belt programme and in partnership with The Zoological Society of London (ZSL) has been developing a low cost Unmanned Aerial Vehicle (UAV) for use in UK Overseas Territories (OTs). The overall aim is that the UAV will assist in identifying and gathering evidence against illegal vessels operating within OTs marine waters.

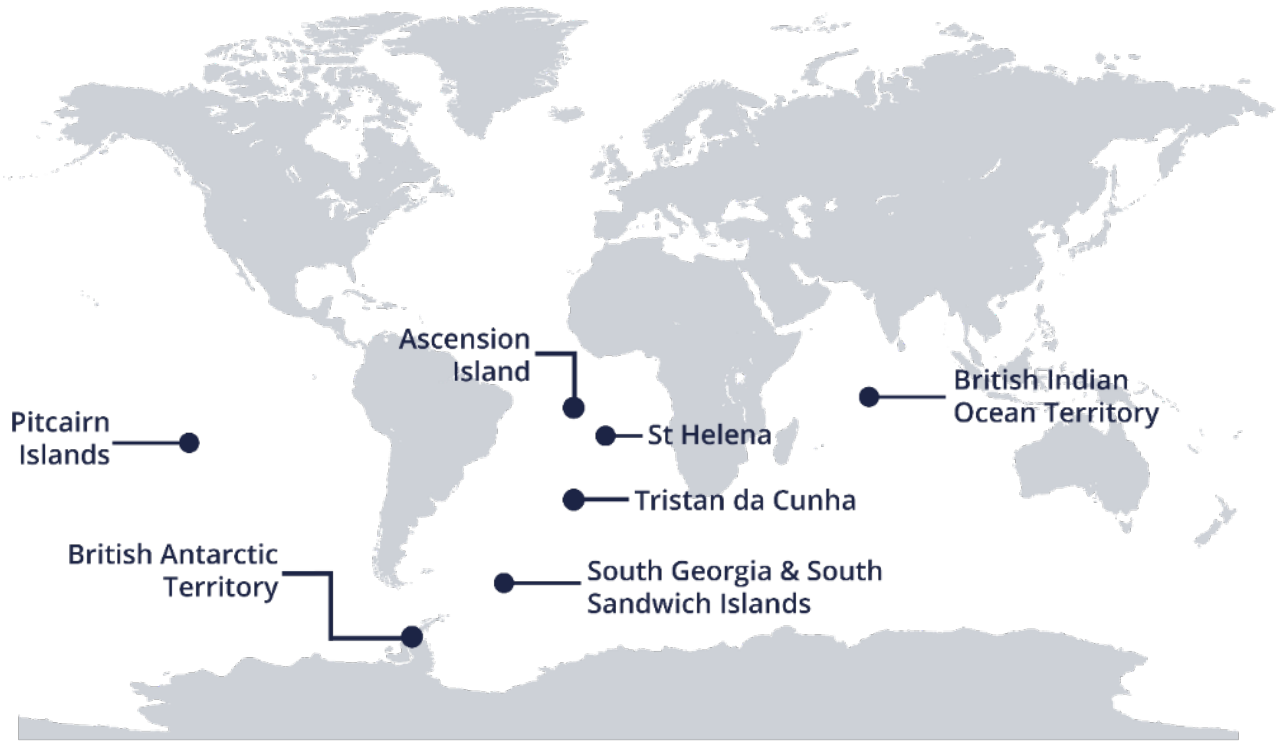
Background of Blue Belt Programme

The Blue Belt programe supports delivery of the UK Goverments commitment to provide long term protection of over four million square kilometres of marine environment across the OTs.

The project aims to:

- Improve scientific understanding of the marine environment.
- Develop and implement evidence-based, tailored marine management strategies including surveillance and enforcement.
- Ensure management is sustainable and long term.

The project is currently working with the below Overseas Territories and their dependencies:



The UAV trial is focussed mainly in BIOT but may have application in the other OTs going forward.

UAV technology

Tackling Illegal, Unreported and Unregulated (IUU) fishing in the OTs is a key objective of the Blue Belt programme. However, the OTs have vast marine areas and often have limited on-island resource and capability for an effective compliance and enforcement response to this threat. There is unlikely to be one solution to this challenge and effective compliance and enforcement will require a 'toolkit' of technologies and approaches to effectively manage these marine waters.

The Blue Belt programme has an overarching strategy with regards to technology and innovation:

- Use information from various sources to build an intelligence picture of IUU fishing to allow OTs to target their resources more effectively.
- Use technology to provide surveillance and where possible gather direct evidence which may help support further investigation and enforcement action.

Drone or UAV technology is the most advanced technology available which meets the OT needs. UAVs are capable of gathering direct evidence (i.e. providing images of vessels, locations, gear etc) as opposed to intelligence.

In late 2017 MMO held a meeting with ZSL who are working on a project in BIOT to use UAV technology to identify large ray and megafauna. The specification of the UAV had some enforcement applicability. BIOT is considered to be the OT that could benefit the most from this technology in the short term, given the presence of a patrol vessel and the unique IUU fishing threat from small vessels not easily detected using other technologies (such as satellite surveillance). As the development of the UAV in BIOT was of mutual interest MMO and ZSL agreed to work in partnership.

Aims of compliance and enforcement trials

The aim of the compliance and enforcement trials is to test the capabilities of the UAV and assist with the following:

1. Approaching a suspicious vessel

Provide aerial surveillance from the BIOT patrol vessel in order to gather evidence of fishing vessels in the process of fishing. The patrol vessel will also be targeting this vessel.

Is there value in launching the UAV as the patrol vessel approaches a suspicious vessel?

- Does the UAV give increased tactical options to the enforcement officers?
- Can the UAV gather information more quickly and effectively than the patrol vessel or add value in terms of evidence that can be collected?
- Can the UAV gather images of the suspicious/illegal vessel before it cuts it gear and/or attempts to leave the area?

- Is the process of launch and recovery efficient enough to add value to this scenario?
- Are images of sufficient standard to support the legal due process?

2. Beyond the line of sight surveillance to target a suspicious vessel

Using the UAV to target surveillance of a suspicious vessel identified on Automated Information System (AIS), or other satellite data. The patrol vessel would not be targeting this vessel.

The purpose of this is to see whether the UAV can allow the patrol vessel to target multiple targets in different locations.

- Can the UAV effectively follow target coordinates?
- If the target moves can the UAV change flight path?
- Will the UAV be able to collect effective images of the vessel including ID/gear in the water while outside the line of sight?
- What level of control does the operator have?
- Is it possible for the UAV to gather information on one target while the patrol intercepts a second target? Do UAV operations outside line of sight limit patrol vessel operations?
- Can the UAV be easily recovered?

3. Use of UAV to increase patrol vessel surveillance capability

Using the UAV to provide beyond line of sight surveillance from the BIOT patrol vessel in order to identify suspicious fishing vessels. This will enable the SFPO to target the vessel for boarding inspection.

This test is to see whether the UAV can gather information in a different location to the patrol vessel in order to increase the vessel's surveillance 'reach'

- Can the UAV follow a flight path?
- What information will the UAV gather on route?
- Can the UAV be easily recovered?
- Do UAV operations outside line of sight limit patrol vessel operations?

Trialling

In 2018 the Aeromao UAV was first tested in BIOT. In the remote location under tropical marine conditions the UAV was not able to meet the compliance and enforcement objectives. As such, it was decided further trials and developments were required before returning to BIOT.

The testing was done in the following phases:

- Phase 1: Proof of fundamental requirements: Canada (Aeromao HQ) (December 2018).
- Phase 2: Testing beyond visual line of sight (BVLOS) and in tropical maritime environment: Belize (Turneffe) (February 2019).
- Phases 3: Testing in open water and from a vessel: Uganda (October 2019).
- Phase 4: Testing operationally from BIOT patrol vessel: BIOT (January 2020).

In all cases we chose locations which would either mimic conditions found in BIOT or allow us to trial specific functions (such as beyond line of sight testing, which is restricted in some countries). We also aimed to provide multiple outcomes such as sharing knowledge with fisheries authorities in Belize and Uganda and supporting ongoing ZSL environmental surveys.

Outcome of trials

Phase 1

Phase 1 involved fundamental improvements made by UAV supplier (Aeromao) followed by testing with MMO at Aeromao's Canada HQ to ensure the requirements were met.

Specific UAV functionality tests included:

- Safe landing procedure, demonstrated throughout.
- Immersion test – submerge in water, check UAV is still operational afterwards for multiple flights.
- Undertake multiple flight cycles.
- Launch procedure – demonstrate can be completed in 30 minutes.
- Flight in varying wind speeds.
- Image data storage process.
- Swap-ability of parts/maintenance.

All the improvements were implemented and demonstrated.

Phase 2

Phase 2 took place in Belize within the Turneffe Marine Atoll, to test beyond line of sight and in a tropical maritime environment. The team worked with the Turneffe Atoll Sustainability Association, with two of their Conservations Officers receiving training in UAV deployment, flying and transect planning.

Key achievements:

- 24 flights completed.

- Maintained full waterproofing allowing for multiple flights per day.
- The live front camera link made it possible to detect vessels, fishing gear and habitat.

Further development needs identified:

- It was not possible to power-on and calibrate the UAV on the vessel, as the movement was too much for the gyros and GPS components.
- The UAV reached a maximum distance of 11.3km; it needs to fly further to effectively increase the surveillance area of a patrol vessel.
- Limitations to telemetry and live link radio. The UAV has a system which should be capable of 30km+ but was disrupted by high mangrove trees and potentially, humidity.

Phase 3

Phase 3 took place in Uganda and planned to test the UAV in open water and from a vessel. Unfortunately, this phase of the trial was unable to proceed as planned. The Ugandan Authorities unexpectedly revoked the flight permissions on arrival in Uganda. Although some camera footage was obtained using a smaller drone and was used for analysis of Vessel ID detection, key objectives of this trip were not possible to achieve:

- Launch at sea. Testing the concept that boat momentum will assist the launch of the UAV and ensuring calibration is consistently achievable from a moving platform.
- Dynamic home positioning. Testing the UAV's ability to return to launch site when the launch site (vessel) has moved.

Testing of these objectives was moved into Phase 4.

Phase 4

Phase 4 took the UAV back to BIOT to test operationally from a patrol vessel.

Key achievements:

- Average length of flight 13.8km which is 2.9km further than tests in previous trials.
- Transects flown at differing heights to test detection ability.
- The UAV reached its furthest point beyond visual line of sight.
- Three novel persons were trained in flying the UAV at sea.

Further development needs identified:

- Telemetry link between the UAV and the computer, to extend beyond 10km range.

- Extended range beyond the current capabilities of the UAV to effectively increase the surveillance area of the patrol vessel.
- Ability to live link to the battery as to no longer need to rely on estimates of remaining battery.
- Set up and deployment times need to be reduced to effectively utilise the UAV in responding to a detection.
- The live link and the image quality of the front facing camera are insufficiently reliable, stable, or high enough resolution to be able to use during a live flight.
- The nadir camera has higher resolution but has no live link and limitations in terms of field of view.
- The process of taking an image and then retrospectively adding a geotag could complicate the presentation of evidence.
- The implementation of dynamic home positioning requires simplification.

Summary

Really useful lessons have been learnt from each stage of the trialling process with steps taken to address identified limitations. Improvements were seen in waterproofing, average length of flight and flying beyond visual line of sight.

However, the trialling of the UAV has not been without some challenges. Phase 3 of the trial was unsuccessful due to the UAV flight permissions changing and Phase 4 was delayed due to repeated flight delays. The team also encountered issues returning to the UK at the outbreak of Covid-19. As well as logistical issues, the performance of the UAV deteriorated between Phase 2 in Belize and Phase 4 BIOT. This is possibly due to wear and tear and the natural shelf life of some of the components, which may have been exacerbated by the challenging maritime environment the UAV was working in. Challenges experienced during trialling are to be expected, especially when using novel equipment in remote, difficult to reach locations. Although frustrating at the time, dealing with these challenges now will ensure that the UAV is technically capable with effective maintenance measures in place.

The UAV has two potential primary applications in a compliance and enforcement scenario:

- Reconnaissance
- Gathering evidence

For the UAV to add value to the patrol vessel operational activity, it must extend the capability of what the vessel can do already. The UAV needs to extend the surveillance footprint (reconnaissance) or intercept a contact within that footprint to gather evidence more rapidly than a response vessel (evidence gathering). Further development is needed before it can be considered operational for either of these applications.

The UAV has demonstrated, with further development, it has a clear application in providing a crucial bridging capability between the low-resolution, high spatial coverage of

satellite imagery available, coupled with the high resolution but low spatial coverage of a patrol vessel.

Next steps

Since October 2019 Loughborough University have been custodians of the UAV and are now able to add significant value in terms of engineering expertise. Work is now required to understand component longevity and to address fundamentally important engineering issues with better suited components and smarter internal design.

Work has begun on requirements analysis and the development of a roadmap to enhance drone operation performance.

The ambition for the future of the project will involve MMO (through the Blue Belt Programme) and Loughborough University working together on a project which will:

- Build on lessons learnt for the 2018-2020 trail to address fundamental improvement requirements needed to establish the UAV as a valuable asset for UKOTs
- Design, construct and evaluate a new prototype UAV, based on the existing Aeromao Talon airframe
- Review the internal component choice and understand the longevity
- Develop more robust components and frame
- Undertake trialling, initially in UK waters, then in suitable international waters, followed by return to BIOT when operationally ready.