A low-cost aerial radio tracking system for avian conservation: preliminary results

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Introduction

In May 2009, biologists from the Commonwealth of the Northern Mariana Islands (CNMI) Division of Fish and Wildlife carried out a pilot project to introduce 50 Tinian-native Bridled White-eyes (*Zosterops conspicillatus*) to the uninhabited island of Sarigan. The purpose of the project was to test the feasibility of, and develop techniques for future introductions of threatened or endangered avian species to safe and undisturbed islands within the Mariana archipelago.

A key goal of the Sarigan translocation project was to develop and improve techniques for monitoring released birds attached with radio location tags. In a previous 2008 Sarigan translocation it was determined that conventional (i.e., manual) radio tracking techniques can be used, but that the dense vegetation on the island made it extremely difficult and time consuming. Manual tracking techniques are particularly problematic for the project goal of locating large numbers of tagged birds on a daily basis.

As part of the 2009 Sarigan translocation project, we tested a possible solution for the tracking dilemma: an autonomous aerial tracking system, developed by J. Burt, that could theoretically locate all tagged individuals daily (weather permitting) by flying over the habitat in a search pattern. Such a system could enhance or even eliminate ground tracking efforts and could potentially be used in many other difficult terrain radio tracking scenarios.

The island of Sarigan, Northern Marianas

Aerial Tracking System Description

The aerial platform consists of an electric motor powered glider (Multiplex Cularis), under autopilot control (Paparazzi open source autopilot). The autopilot is capable of fully autonomous flight (for safety purposes, take-off and landing are under manual control), and can be programmed to fly any route desired by assigning a series of course waypoints for the plane to traverse. During a flight, the aircraft maintains continuous contact with a ground station laptop via a radio modem link (Figure 1). The ground station software allows pilots to adjust course waypoints in-flight and instruct the plane to return to a "home" position at the end of a mission. The entire system was designed to be inexpensive, light weight, rugged, and extremely portable.

A custom-built radio tracking pod mounts onto the top of the aircraft fuselage. The tracking pod contains a very sensitive radio receiver that can be programmed to tune into a repeating sequence of radio tag frequencies. The receiver output feeds into a custom radio direction finder (RDF) device (Picodopp RDF, Robert Simmons), that outputs the compass direction (relative to the plane's heading) of every tracking transmitter pulse received. Each tag pulse compass angle, and all GPS data are stored on an on-board data logger for post-flight analysis. Tracking tag positions are determined by combining several tag pulse compass angle determinations taken while the plane flies.

Figure 1: Tracking system ground station. Flight control modem antenna pole at left, and laptop shade box at right. Station was located on a small hill overlooking the ocean and the testing area (see Fig 4), allowing safe launches and unobstructed views of the aircraft. A nearby patch of low sawgrass proved an excellent landing zone.

May 2009 Deployment on Sarigan & Testing Methods

The aerial system was originally scheduled to be deployed to Sarigan with pilot/operator J. Burt from May 4-10. Our goal was to conduct multiple flight tests and to locate birds mounted with transmitters. Delays due to bad weather reduced the deployment dates to May 7-10, and high winds on some days reduced flight testing to several flights without the locator pod on board, and one test flight with the locator pod on the plane. Furthermore, our radio tag mounting procedure was faulty, causing tags to fall off the birds after release. Therefore, instead of tracking tagged birds as planned, we tested the system by placing two tracking transmitters in trees at known locations. Results of the single radio tracking test flight in the late afternoon of May 9, 2009 are reported here.

<u>Ground station setup and location:</u> After scouting about the upper plateau near the camp site we located a suitable place to install the ground station and launch the aircraft. A ground station modem antenna pole was mounted on a small hill near a ridge that offered an unobstructed view and an ideal launch/landing zone (See Figures 1-3, Sarigan map).

<u>Radio tracking test flight methods</u>: Two transmitters (Holohil BD-2N 0.43g, 148.558 and 148.758 MHz) were placed in trees at approximately 2m height. The placement was intended to simulate a bird perched in the upper canopy of the habitat. Transmitter locations were determined to within 5m accuracy using a standard GPS receiver. The tracking pod receiver scanner was programmed to alternate listening at each of the transmitter frequencies every six seconds.

After the transmitters were placed in trees and turned on, J. Burt launched the aircraft with the tracking pod attached. The airplane was manually flown to the transmitter test area and climbed to about 90m above ground level. At this point the autopilot was switched on, allowing the plane to fly several pre-selected route patterns over the upper plateau of the island. The flight patterns were designed to repeatedly traverse a range of distances from the two test transmitters. After about 10 minutes, J. Burt switched the autopilot back to manual control and landed the plane in a patch of sawgrass near the launch site.

Photo courtesy of Paul Radley

Figure 2: Side view of aircraft and radio tracking pod. The four vertical antennas are used by the system to detect radio tag transmissions and generate an angle to the signal source relative to the nose of the plane. Multiple tag pulse detections at different aircraft locations allow the signal source to be triangulated.

Figure 3: Launching the aircraft near ground station (at right). After launch, pilot flies plane to safe altitude and then switches control to autopilot. The ground station software displays current airplane location on a map and allows in-flight switching of autopilot to different route patterns, as well as command plane to return home.

Photo courtesy of Paul Radley

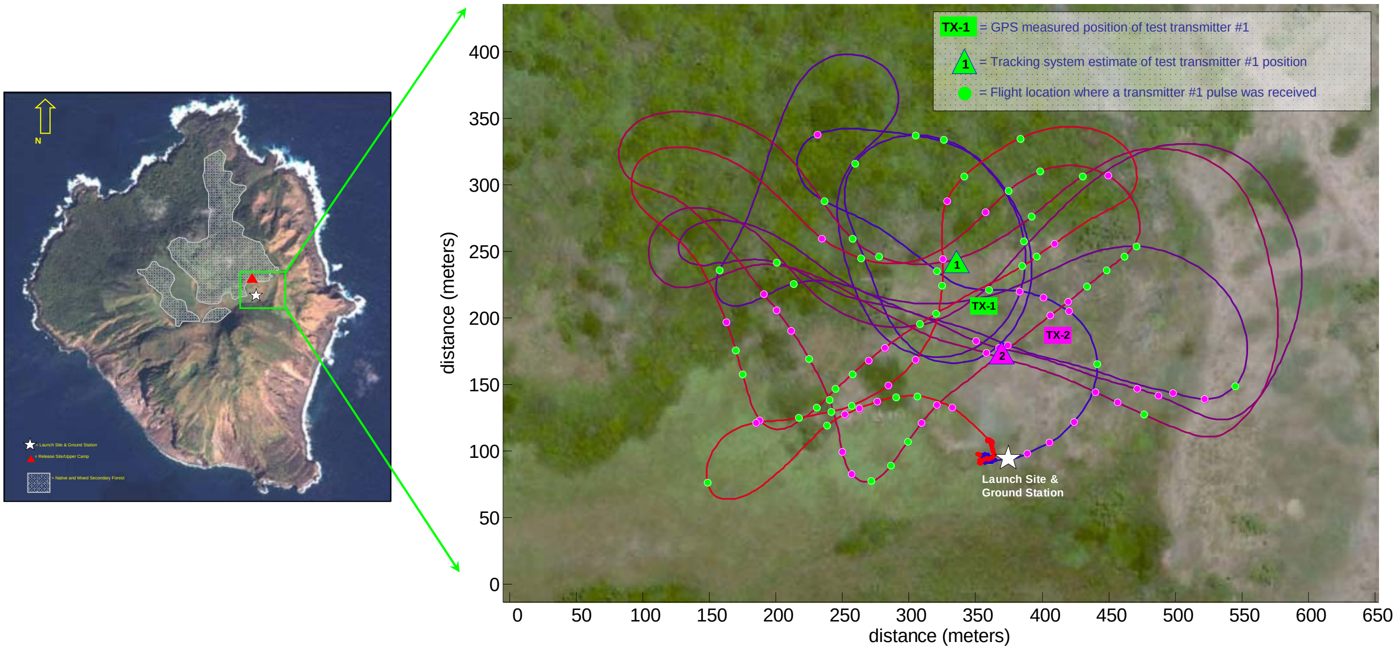

Figure 4: Radio tracking flight results. Blue-red line is the flight path (color shifts from blue at launch to red at landing). Colored circles along the flight path indicate places where a transmitter tag pulse was received (color coded to tag#). The tracking pod receiver was programmed to alternate between the two tag frequencies, hence alternation between green (tag #1) and pink (tag #2) pulse detections. By combining these pulse detections, the tracking system was able to locate each transmitter to within approximately 35m.

Results

Custom software was used to analyze the tracking flight log data stream (GPS position, altitude, speed, heading), and the direction angles and frequencies of detected transmitter pulses. The post flight analysis combined the pulse detection angles for each tag to generate multiple triangulation-based location estimations, and then averaged these to create a single estimation of each transmitter tag location (Figure 4).

During the flight, the tracking pod detected 93 transmitter pulses (49 from tag #1, 44 from tag #2). The farthest pulse detected was 239m for tag #1, and 240m for tag #2. The uniform range distance for both transmitters indicates that this is close to the absolute range for detection of this transmitter type in these conditions. Given that range, an effective tracking flight path would traverse the habitat in 200m transects.

Location estimate error was 33m for tag #1 and 37m for tag #2, based on averaged triangulation estimates from the detected tag pulses.

Conclusions

The results of this single test flight on Sarigan show that an aerial radio tracking platform is a feasible alternative, or enhancement to manual radio tracking on the ground. This technology is especially helpful in difficult or impassible terrain, as found on Sarigan. The system's main drawbacks are the need for at least occasional mild weather conditions, an area for takeoff/landing, and a radio control airplane pilot.

This autonomous aerial tracking system was a first-version prototype and cost approximately $12,000 to design, test, and deploy. Subsequent versions will be less expensive. Cost-wise, this tracking method can be thought to lie between manual tracking (cheap) and other much more expensive tracking methods, such as manned full-size aircraft, and fixed position autonomous tracking stations like those used by STRI on Barro Colorado Island in Panama.

The relatively short 240m range of the tracking system for these tags is disappointing but not surprising: the tags used for very small birds like Bridled White-Eyes necessarily sacrifice transmit power for reduced size and weight. Larger tags have much higher output power and should be detectable at greater range (this remains to be tested).

The position estimate error results for the tags were 33m and 37m. These estimates may not reflect error under real conditions given that they were based on many more pulses/tag than would likely be detected in an actual tracking flight. We are currently working on reducing this location error with a combination of analysis refinements, and electronics upgrades.

Source Links

For more information about this project, email John Burt at quill@uw.edu

A PDF file version of this poster can be downloaded at: www.burtsoft.com/uav/sarigan09aou.pdf

Holohil systems BD-2N transmitter tag: http://www.holohil.com/bd2.htm

Doppler DF Instruments PicoDopp Direction Finder: http://www.silcom.com/~pelican2/PicoDopp/PICODOPP.htm

Paparazzi Open Source Autopilot: http://paparazzi.enac.fr

Multiplex Cularis electric glider: http://www.multiplexusa.com/models/kits/cularis_.php

Acknowledgments

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