A 501(C)(3) NONPROFIT FOR WILDLIFE

Project Echo Mike 2

Post-Release Tracking Device for Small Mammalian Species

ELECOMP Capstone Design Project 2024-2025

Sponsoring Company:

SANCTUARI
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Company Overview:

SANCTUARI is a 501(c)(3) nonprofit wildlife care organization improving wildlife survival rates by leveraging modern technology. We are privately supported without federal, state, or municipal funds and are unaffiliated with other Rhode Island wildlife organizations.

Technical Directors:

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Project Motivation:

(Reference for further detail and credit - https://sanctuari.org/wp-content/uploads/2021/01/2021-01-08_Rev_A_Post-Release_Tracking_and_Identification.pdf)

Historically, wildlife rehabilitators accept that contact will be lost when releasing animals back into their natural habitats after providing care throughout the animal's youth or critical recovery period. However, the ability to track and monitor released animals can increase their chances of their survival. Monitoring in aggregate also provides valuable biological and ecological data capable of fundamentally advancing various core conservation efforts. Wildlife tracking technology is evolving, but the most reliable and available systems still involve radio and satellite telemetry. Microchips and PIT (passive integrated transponder) tags can be useful in recognizing a given individual, but they typically provide no location data.

Anticipated Best Outcome:

Successful design, prototyping, and testing of a small, lightweight, wearable, long-service-life tracking architecture (electronics and battery power source) suitable for smaller mammalian species such as fox, raccoon, skunk, opossum, rabbit, and more. A "stretch goal" is to include smaller species should the basic architectural design be suitable.

Project Details:

Overall System Concept: (Reference for foundational detail and credit - https://sanctuari.org/wp-content/uploads/2021/01/2021-01-08_Rev_A_Post-Release_Tracking_and_Identification.pdf)

From originating project, Echo Mike 1, 2023-2024:

Many wildlife carers are puzzled by the lack of tracking devices suitable for smaller species, given the ubiquity of cellular phone technology and newer products like AirTags. This project is intended to begin from first principles to create the most elegantly simple battery-powered electronics architecture, even if such includes borrowing from or licensing existing designs.

Engineering students will have wide latitude to adjust and expand the project scope and to specify logical workflows, block diagrams, and system elements, including battery form factor and chemistry, charge regeneration methods, if any (ex.: possibilities for converting kinetic energy to electrical), and communications modes (ex.: Apple/AirTag Bluetooth may be viable for urban/suburban releases but not rural, whereas Amazon's Fire device network, Starlink, 4G/5G cellular networks, and others will also evidence relative advantages and disadvantages).

The final design should be superlative with respect to size, weight, and battery life. Current leading examples to draw from could include various cellular phone subsystems, SwitchBot's (and competitors') temperature and humidity monitoring devices, AirTags, and the like. The design should also have modest onboard data storage capacity for preserving data when unable to communicate remotely.

The design will be user-adjustable, at a minimum in terms of trading signal strength, signaling frequency, and battery life. The optimal design will function properly under wide-ranging temperature and humidity conditions. Prevention of excess heat generation and minimization of risk of battery fire is included in scope, along with means for device recovery alert when it is nearing the end of its service life. The design will be compatible with broader systems enabling users to set alerts based on multiple parameters and conditions (such as signal loss over a given timeframe, lack of motion over a given timeframe, and so forth). Each system will be uniquely self-identifying and will be capable of reporting location and timestamp data to standard mapping platforms and systems (ex.: Google Maps).

Cost will remain only a secondary consideration relative to ergonomics, particularly overall size, weight, and signaling performance. While any accompanying software/mobile app is outside the scope of this project, students herein can absolutely assist in creating specifications for related apps, software, and firmware.

"Stretch goals" subject to early success of the team include power budgeting for, and optional accommodation of, video and audio monitoring as well as optional thermal, vibration, orientation, and/or similar sensing. These could be especially useful in prevention of abuse and poaching and identification of any abusers.

Results of Project Echo Mike 1, 2023-2024:

- The Echo Mike 1 team researched multiple methods for location tracking and chose to pair both GPS and cellular radios, where the GPS radio determines location and pushes that data to the cellular radio for relaying to a cloud service.
- The team chose and acquired a development kit and wrote firmware to prove basic capabilities, posting data to the Thingsboard IoT platform for inspection and mapping over time.
- Operational energy usage was modeled and measured to enable an intelligent battery capacity choice.
- An enclosure was identified to hold the electronics, antennas, and battery.
- A fully integrated unit was demonstrated, but due to schedule constraints, a fully deployable system was not completed.

Some of the limitations of the Echo Mike 1 design that the new Echo Mike 2 team will overcome, with the assistance of contracted URI mechanical and possibly industrial engineering students, include:

- The Thingsboard IoT platform is not as economical to use as desired.
- The packaged tracker is larger and heavier than desired.
- The battery is physically larger than desired.
- The housing is not ergonomically designed for animal mounting.
- No attachment system was yet chosen for safe, suitable tracker attachment to animals.

Current Echo Mike 2 Project Details

The Echo Mike 2 team will build upon the work completed by the Echo Mike 1 team and expand it to create field-usable trackers. The work consists of electronics, firmware, software, and mechanical/industrial elements as follows.

Electronics

Using the dev kit at a reference, a custom PCB will be developed to be as small and lightweight as possible while containing:

- a microcontroller with BTLE radio to run the tracker at very low power (recommend Silicon Labs EFR32BG22, EFR32BG24, or EFR32BG26),
- a Quectel BG77 LPWA IoT module and associated circuitry (means to drop the device into low power mode),
- a battery clip or similar means to secure it,
- a cellular radio antenna (may be separately purchased if designing an antenna from PCB traces is too challenging), and
- any additional circuitry needed for a Bluetooth chip antenna, support for a button to wake Bluetooth (if not using accelerometer or RF waking methods), and debugging.

Stretch goal related content can include:

- circuitry to aid in the releasing of any harnessing,
- temperature & humidity sensors to assess animal health,
- accelerometer to assess animal health and to possible reduce battery size via dynamic sensing, where rapid shaking wakes BTLE,
- energy harvesting circuitry (which could reduce battery size), and
- a microphone to assess animal health.

Optional components add weight and size and use more power, so tradeoffs may be required.

Other electronic components include:

- the battery, sized to achieve a minimum of 2 weeks' operation,
- a GPS active antenna,
- a cellular antenna if one is not designed onto the PCB,
- a harness release solenoid (stretch goal, though the harnessing design needs to be settled regardless, so as to properly complete the electronics work), and
- cabling to connect the battery, wake-up switching, and for debugging.

Firmware

Firmware must be developed to run on the microcontroller to implement tracker functionality. Development tasks:

- sending periodic wake-up, sample location, transmit location, and other sensor data to cloud,
- providing driver access to BG77,
- waking up Bluetooth by rapid shake (accelerometer), button press, or RF Wake (Silicon Labs feature),
- configure tracker through Bluetooth, setting sampling location period, sampling start, sampling stop, and enabling/disabling use of sensors,
- providing drivers access to optional sensors, sensor sampling, and data storage,
- minimize energy draw from battery (*challenging*: need to drop the processor and cellular radio into energy savings mode, turn off devices when not in use, and find other ways to reduce energy usage such as dynamic sampling based on accelerometer data, i.e. slower sampling if no movement is detected), and
- track battery energy used to know energy remaining, possibly using this to reduce location sampling to extend operating life (also, a low battery signal could be used to trigger a harness disconnect if under firmware control).
- *Stretch goal*: Implement a TinyML application to monitor animal health based upon sensor data, possibly transmitting a health grade to the cloud. See this link: https://sensiml.com/wp-content/uploads/SensiML-Solution-Brief-Silabs.pdf. This may involve characterizing healthy and non-healthy animal tracker data.

Software

BaaS (Backend as a Service) will be set up to receive tracker data. While Appwrite is the recommended backend, the team will conduct due diligence on alternatives. Appwrite can self-hosted on charity-bought hardware to avoid high usage fees and can also be scaled up using Digital Ocean.

Apps will be developed for viewing cloud data. These will:

- directly inspect location and sensor data,
- plot current and historical locations on maps to show tracked animal paths, and
- plot sensor data over time, such as movement and temperature.

It is recommended that an app be developed using Flutter that can be deployed for:

- enhancing SANCTUARI's web site so users can log in to the service to view tracker information,
- running on any Windows PC to access tracker data,
- running on Andriod and iOS devices, such as smartphones, to access tracker data, and
- interacting directly with trackers through Bluetooth to set configurations as described in firmware above.

Mechanical

The housing, which contains electronics, battery, antennas, and antenna mounting (to be optimized for best signal strength for animals in walking postures) must be as small and light as possible, durable, resistant to at least the IP67 standard, and ergonomic for multiple species.

The harness must hold the tracker for selectable amounts of time and provide means for complete detachment, with options including:

- engineering for deliberate failure upon a certain level of exposure to sunlight/water (rain or immersion),
- a solenoid system which triggers detachment,
- glue designed to decay,
- a piezoelectric device "buzzes the harness off,"
- or other ideas conceived by the team.

Composition of the Team:

1-2 Electrical Engineers

2-3 Computer Engineers

(Preference will be given to the engineers who can also undertake the mechanical engineering tasks.)

Skills Required:

Electrical Engineering Skills Required:

- Quick learning; high curiosity; comfort with various sensing technologies/schemes.
- Propensity for meticulous analysis and testing, especially with power system design and power budgeting.
- Self-motivation respecting research of existing, relevant solutions; capability to aggregate and compare strengths/weaknesses of "competitors" and useful related tech.
- Accountability and willingness to "own" the system design as a good startup CEO would.
- Desire to be hands-on with testing and drive to optimize and wring out design performance, allowing the hardware system to "tell the designers what it needs next."
- Understanding of various battery technologies and chemistries.
- Understanding of various wireless communication technologies and networks (cellular networks, WiFi, Bluetooth, etc.) and related testing standards and methodologies.
- Understanding of engineering for compliance, especially with respect to radiative emissions and signal integrity.
- While not "electrical engineering skills," students with demonstrable compassion for animals and deep concern for animal welfare are desired.

Anticipated Best Outcome's Impact on Company's Business & Economic Impact:

Successful execution will allow us to rapidly produce and distribute devices to our network of carers, from veterinarians to licensed rehabilitators. This will help us to learn how to release animals of various species most safely in various environments all over the planet.

Broader Implications of the Best Outcome on the Company's Industry:

Saving one animal, or expediting their recuperation, along with proper documentation and communication, can quickly lead to the saving of thousands more. This project will generate data enabling carers to correlate, aggregate, publish, and refine best practices, giving each animal the best possible chance to thrive.