Conceptual Design of Aerial Cattle Management System

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Abstract

The Sky Shepard proposes innovations and improvements to the current methods of bovine cattle management. Much of modern agriculture is completed with automated processes, however, cattle management is largely done on foot as modern equipment has been found to frighten and cause herd stampeding. Traditional quadcopter Unmanned Aerial Vehicles (UAVs) that are used for small ranch applications operate at a frequency that cattle are most receptive to. Through conversations with cattle ranchers and by searching through scholarly sources, a Vertical Takeoff and Landing (VTOL) UAV design was proposed. The proposed UAV will feature an innovative solid-state battery and an aeroacoustically optimized propeller which reduces the noise emitted by the UAV and shifts the frequency to peak outside ranges cattle are sensitive to. This concept will allow ranchers to have access constant herd position and health data, allowing for quicker veterinary response times and reduced labor.

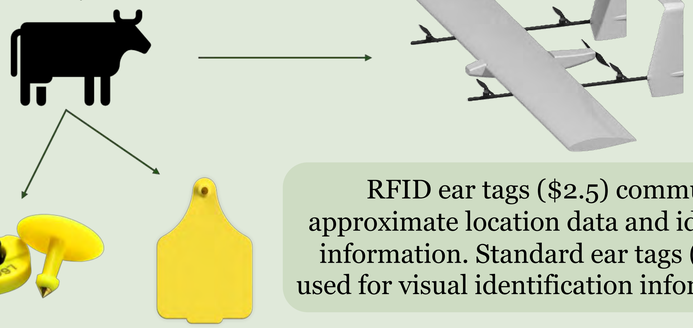
Problem Identification

Cattle are most receptive to noises in 27 Hz to 37 kHz range, with peak sensitivity in the 8 kHz range.

Existing quadcopter technology operates around 4,000-11,000 RPM, where the Blade Passing Frequency (BPF) is in the range of frequencies cattle are most susceptible to.

Location and Health Monitoring

CowTraq Neck Collars ($120) track health data including signs of heat and rumination which provide indicators of early signs of a decline in health. Collars can also provide location data.

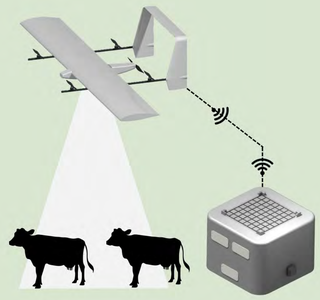


RFID ear tags ($2.5) communicate approximate location data and identification information. Standard ear tags ($0.05) are used for visual identification information only.

Conceptual Operations

Autonomous Aerial Cattle Monitoring

Passive & Active RFID Collects Health & Location of Cattle



Radio Transmission for Navigation occurs on 5,030-5,091 MHz Spectrum Band for FCC Compliance

Fixed-Wing UAV used to Increase Monitoring Range and Reduce Noise compared to Quadcopter

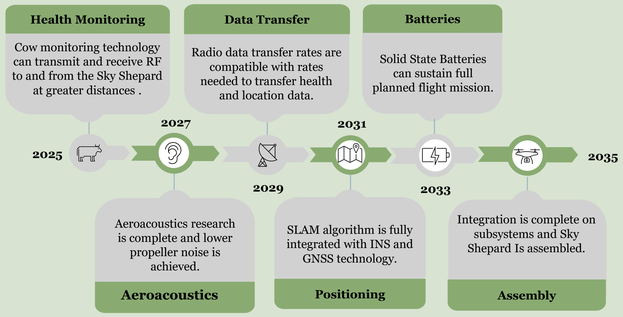
SLAM Algorithm interfaces with onboard sensors and fixed base to provide robust navigation in areas of limited connectivity

Aeroacoustically optimized cruise propellers operate with minimal interference with spectrum of frequencies cattle are sensitive to for low-stress cattle management.

Internal Payload:
- RF Transceiver
- GNSS Module
- SLAM Application Module
- Solid State Battery (SSB)
- 5 Brushless Motors
- Sony IMX 415 Sensor *(Camera)*

Flight Operations:
- 400 ft Altitude
- 60 kts Cruise Speed during Conventional Flight
- 5-6 hr Flight Duration

Timeline for Deployment



Battery Technology

The Sky Shepard utilizes Solid State Batteries (SSBs) to provide lengthened performance and energy capabilities. SSBs are comprised of a solid electrolyte instead of a liquid electrolyte for ionic conduction between battery electrodes. This new battery technology provides potentially over double the energy density of liquid batteries, leading to greater cycle lifespan and increased flight time.

Less material is required for an SSB

Solid Electrolyte (center) replaces a liquid Electrolyte.

SSB's have yielded high energy density capacity.

High energy density comes with a charging cycle behavior tradeoff, however, research in cycle losses is being conducted.

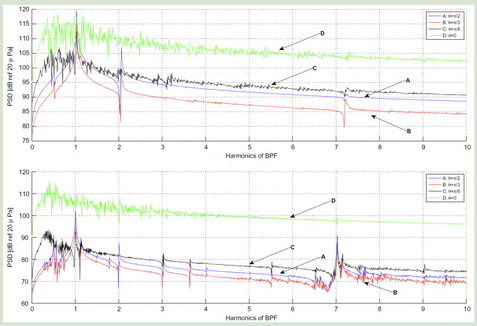
Propeller Acoustics

Existing research on airfoil geometry was used to obtain optimal aerodynamic loading for minimum propeller noise emissions. It was found that decreasing the angle of attack on the inner radius of the propeller, increasing the chord length between the 60% and 80 % span, and adding serrations to the trailing edge.

Overall Reduction in SPL Across Spectrum

Vibrations Occur at Higher Power Settings

Further Effects can be Studied in Anechoic Test Chamber



Giorgia Sinibaldi and Luca Marino. Experimental analysis on the noise of propellers for small UAV. Applied Acoustics, 74(1):79–88, January 2013.

The location and health monitoring devices used are customizable based on needs of the user, and budget. Cow Traq collars do not have to be placed on each animal. It can be decided which animals wear the collars based on the needs of the client. Their purpose is to give the user an overall understanding on the health or breeding cycles of their herds. An ear tag of the user's choice must be placed on all animals for identification purposes.