Remote Piloted Drone for Cenote Water Collection

Noah Reid[1], Matthew Sebek[1], Jacob Sampson[2], Nestor Alvarez-Popoca[3]
Department of Electrical Engineering[1]
Department of Mechanical Engineering[2]
College of Art and Design[3]
Northern Illinois University
Dekalb, United States

Dr. Sachit Butial
Department of Mechanical Engineering
Northern Illinois University
Dekalb, United States
sbutial@niu.edu

***Abstract*—Due to the difficulties and dangers associated with collecting water and data samples from areas of interest, unmanned aerial vehicles (UAV) have been used to reduce risk and increase efficiency of geological surveillance. This document provides both the design and development of a high durability, high payload capacity UAV. This drone will operate by combining power control systems, flight control systems, and data and sample collection systems in order to provide operators with a modular device that can operate in a variety of environments and assist in various forms of geological sampling.**

I. Introduction

Over the past several decades, human development and its subsequent pollution levels have increased dramatically, and effect even the most remote areas. One indicator of the ecological health of a specific environment is the quality of water within. While water sampling is rather easy in urban areas with modern infrastructure, it can difficult and dangerous in environments with a large amount of vegetation, such as forests or jungles. The difficulties are amplified when cenotes, large chasms in the ground filled with water, are the intended areas of sample collection.

A sample collecting drone operating in an undeveloped area raises some immediate design concerns. It must have a high payload capacity, be susceptible to high-speed impacts and collisions, be able to implement a variety of information collecting technologies, and be modular in design to adapt to future missions. Essentially, this drone is a hybrid between long endurance agricultural drones or package delivery drones, and nimble hobbyist drones that focus on easily modifiable firmware and maneuverability. This paper will detail how the combination of these two drone families provides a functional design for a modular drone to assist in water sampling and data collection.

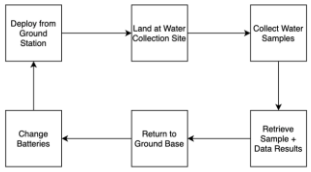

Figure 1: Mission Deployment Summary

II. Prototype Design

There were two main pillars for design development. The first is a limited budget of $1000, with additional funds used to expand upon base features of the drone. Secondly, specific parameters were given for the design, including technical features and a minimum desired sample load. The prototype implements several systems that build on top of each other in order to achieve the desired performance. This design is such that many of the components can be purchased, replaced, or repaired from a local hardware store. Because of this, only a limited number of 3-D printed CAD designs were utilized.

Figure 2: CAD Model of Drone

A. *Frame and Body*

The frame consists of aluminum arms notched to create an X formation. Centered on the cross-section of the arms is a water-resistant box housing the onboard electronics

B. *Power and Flight Control*

Power is provided by two large, high voltage and high-capacity batteries to a step-down circuit ship which redistributes power to the flight control system, data collection system, and peripherals. Flight is governed by an IC connected wirelessly to an RC remote. This IC handles onboard flight adjustments and provides instructions for each of the four onboard motors. The combination of power, computational instruction form user input, and subsequent motor spinning allows for the drone to achieve flight.

C. *Sample and Data Collection*

Water is collected by decoding a signal sent from the RC remote and using this to activate a servo motor which opens a PVC container. The data collection is managed by an onboard microcontroller connected to mission specific probes. This data is adjusted and stored to the microcontroller's onboard memory.

D. *Optional Peripherals*

The addition of several peripherals is intended to provide more data on the areas of deployment and increase ease of use. An FPV (first person view) module is connected to the flight control system to provide a constant perspective from the drone's nose to the pilot. Additionally, a GPS chip has been installed to enable a real-time location of the drone.

III. RESULTS

Based on preliminary simulations, it was determined that roughly 8 minutes of flight time could be achieved by using dual battery operation.

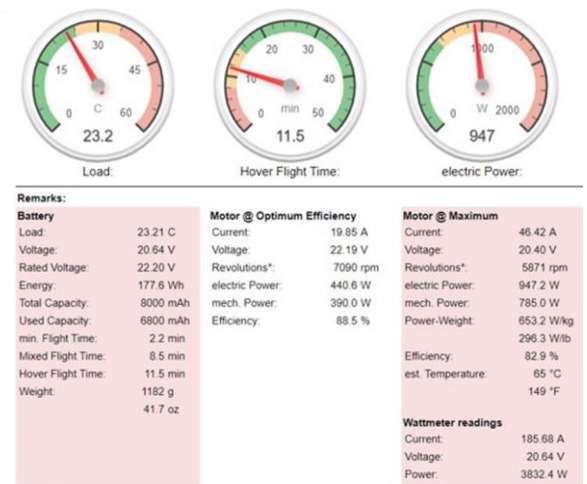

Figure 3: Preliminary Flight Simulations

Testing primarily involved verification of each of the subsystems. The frame and body coupled with the power and flight control systems acted as expected; fully functional flight from a distance of roughly. Similarly, collection of water data and operational function of the water collector were. Peripheral systems were successfully integrated before flight. While functional operation of peripheral systems was not achieved along with flight and sample collection, operation can be achieved through the implementation of another video transmitter IC.

```
ORP Average:          0349.6200
O2 Average:           0006.2200
PH Average:           0003.6789
Conductivity Average: 5801.8890
Temperature Average:  0052.2785
```

Figure 4: Data Collected from Sensors

IV. DISCUSSION

While complete operation of all systems was not achieved simultaneously, this can be easily remedied. Instructions assistance to reach this completion will be provided. Therefore, the design has been validated and will be successfully used within the coming months.

Significant discussion has been given as to additional design ideas that could be implemented in a second phase of the project. One of the limiting factors in development was the budget constraint. This allows for the possibility of improved design elements. One addition would include the ability to adjust the depth of the water collector via the RC remote through implementation of a winch. Secondly, rotor guards would provide more protection to the carbon fiber rotors and increase overall design durability. Due to the modularity of this design, it possible to upgrade many of the current features to improve functionality wherever is necessary after field deployment.

V. CONCLUSION

Based on testing, this drone does provide a reliable tool to assist in the gathering of water samples and data, although this prototype can be further improved upon with the help of an increased budget and better understanding of infield shortcomings.

VI. ACKNWOLDEGEMENTS

The authors would like to thank Dr. Sachit Butail and German Ibarra for their continued oversight and advice for the design of this drone. Additionally, Dr. Donald Peterson and the College of Engineering at Northern Illinois University for providing the funds and facilities that allowed for the development. Lastly, Dr. Melissa Lenczewski and the Department of Geology and Environmental Geosciences for additional funding which allowed the success of this project.