ECE 445

Project Proposal

Draft Version #2

# Retrievable, Cheap, & Open Source Radiosonde

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# INTRODUCTION

## [1] Objective

The objective of this project is to build a weather radiosonde which has additional features. The instrument built in this project will feature a GPS tracking unit which will make it trackable and retrievable for repeated use. Typical radiosondes in popular use today lack such tracking capabilities. In addition to this, the sonde will also feature LED and audio aids to further narrow-down its location and to aid its locatability within a radial error range as determined by the GPS unit.

This radiosonde project will be made open-source. The instrument will feature an additional sensor to track carbon-dioxide concentrations in the air to monitor air quality. Researchers may replace this with a sensor of their choice in the future to obtain in-situ scientific observations in the atmosphere.

## [2] Background/Motivation

Radiosondes are used to take upper air measurements (pressure, humidity, temperature) twice a day, 365 days a year in 92 locations across the United States [1]. These are launched from the surface and burst around 100 mb. After descending back to the surface, these instruments are rarely ever recovered although they remain functional.

Often, the radiosondes land in areas from which they can be retrieved easily. However, when found, the radiosondes are either disposed off by finders who do not know what the instrument is used for, or they are sold on eBay for enthusiasts/collectors or they are used for exhibition and novelty purposes. They are rarely ever recovered for reuse as they currently do not currently offer a tracking functionality to the launching party.

We would like to make these radiosondes trackable via GPS (Global Positioning System). This would provide the user or launching party with location coordinates to retrieve the radiosondes for reuse. We will also add audio and light aids to the sonde to make the instrument trackable within a radial range identified by GPS. In addition to this, we would like to add an additional sensor to the radiosonde to support research observations in the future. For our purpose, we will use a carbon dioxide sensor which can be used to monitor air quality levels. The project would be made open-source so that researchers in the future may modify the design as per their need.

The radiosondes currently cost upwards of $300 each, so the retrieval and tracking capability would help launching parties (such as NOAA/NWS) optimize the costs associated with these radiosonde launches. This may lead to a denser radiosonde launch network in the future as radiosonde costs are lowered due to their reusability. The denser network would enable weather forecasters and atmospheric scientists predict and model atmospheric phenomenon more accurately.

## [3] High-level Requirements List

Identified list of quantitative characteristics that this project must exhibit in order to solve the problem:

- The GPS unit on the radiosonde should triangulate the device's location to within 150 ft of its actual location.
- The device can be triggered to emit visual and audio signals to assist in its retrieval within 50 ft.
- The radiosonde should feature a carbon-dioxide sensor that will enable the instrument to gather data on carbon dioxide concentration which may be used to monitor air quality.

# DESIGN

[1] Block Diagram

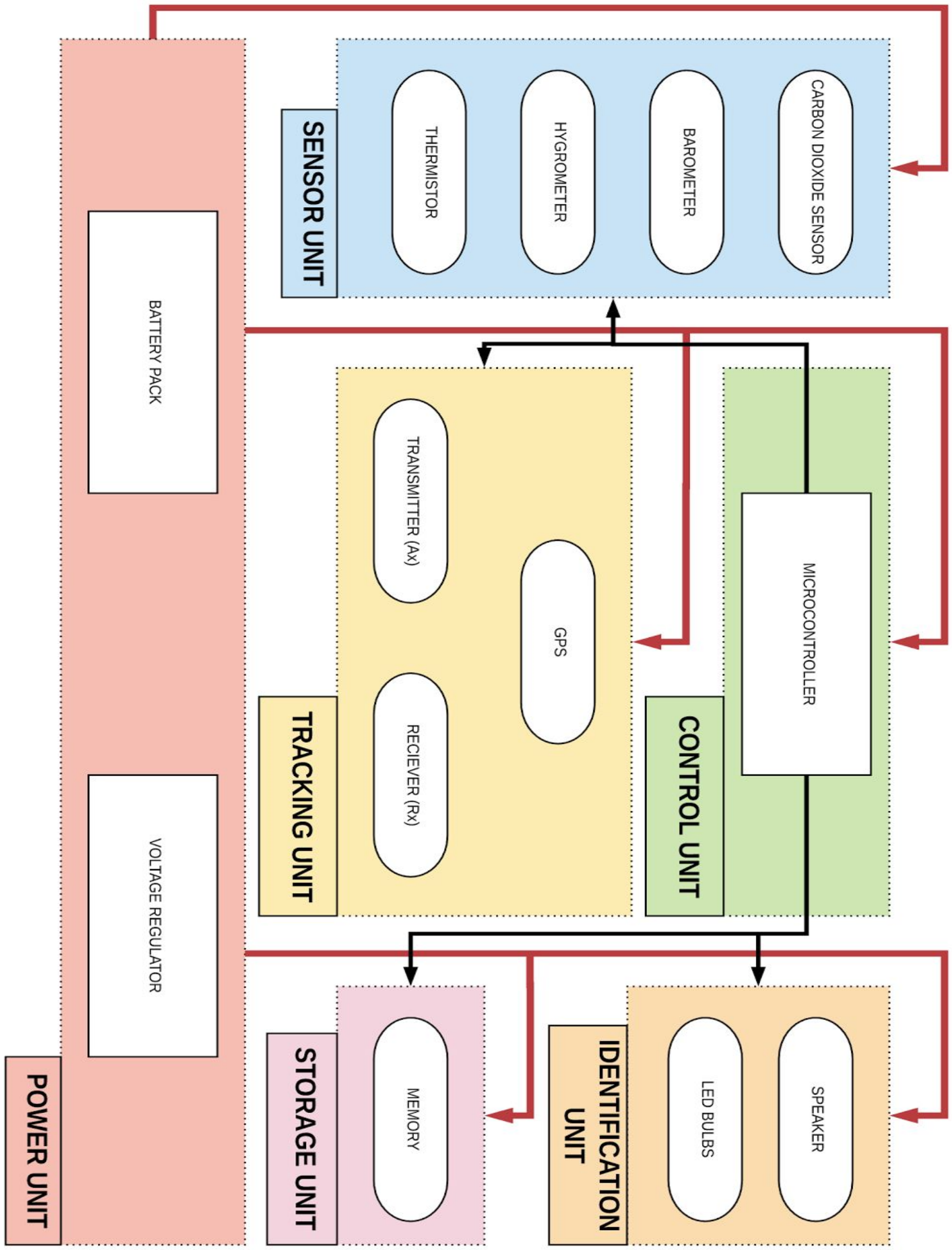


Figure 1: Proposed Block Diagram

## [2] Physical Design

The radiosonde will weigh less than 6 lbs. The hygristor must be capped to avoid the data from being distorted by condensation on its surface.

The electronics of the instrument will be housed in a lightweight Styrofoam-type encasing which is lightweight, somewhat water resistant and economical material.

## [3] Functional Overview

- **Sensor Unit**
  The sensor unit contains temperature, pressure, humidity, and carbon dioxide sensors. These will allow the unit to collect necessary and typical radiosonde data. Each of these sensors can easily be connected to the microcontroller. They produce analog signals which can be measured and converted into discrete values which physical meaning.
- **Control Unit**
  The control unit comprises of a microcontroller. We plan on basing this off of the ATMega328 chip or similar. This chip will be responsible for reading in values from the sensors, communicating with the tracking unit, and storing necessary information in the storage unit. Furthermore, it will also control the identification unit.
- **Tracking Unit**
  The tracking unit is comprised of a GPS receiver as well as a transmitter and receiver. The transmitter receiver pair is responsible for sending and receiving collected data from the radiosonde. It must be able to do this over a long distance and at appropriate frequencies. This is necessary not only for the transmission of weather data but also for the location of the radiosonde itself. The GPS unit is responsible for tracking position and also wind speed. Thus the GPS is not only collecting weather but also tracking its location for later retrieval. It will also be connected to the microcontroller which will read data from the GPS unit and send it to the transmitter.
- **Identification Unit**
  The identification unit includes a speaker and a LED. The purpose of this unit is to add in location of the unit when in close proximity. The unit will receive a command from the control unit to emit a loud noise and a bright light when appropriate.
- **Storage Unit**
  The purpose of the storage unit is to store important data retrieved from the sensors and GPS locally. The data will be stored on an SD card, which can be removed and read from without the radiosonde itself. This is helpful not only for testing but also for data collection in case radio transmission was faulty.
- **Power Unit**
  The power unit is based on off the shelf alkaline batteries. These batteries will be connected to voltage regulators which will ensure that there exist appropriate voltages for each of the different units. Furthermore, as these batteries are off the shelf they will be easily available to purchase and replace.

## [4] Block Requirements

- **Sensor Unit**
  The individual sensors in the sensor unit should be able to track appropriate measurements. We plan on using individual off the shelf sensors to measure carbon dioxide levels, pressure, temperature, and moisture. These sensors will be connected to the microcontroller and will be measured once every 10 seconds or less. Furthermore, each sensor will be accurate within a 10% error. Furthermore, they will be mounted such that they are able to freely measure their respective properties.
- **Control Unit**
  The control unit will read values from the sensors at appropriate refresh rates (samples/second). It communicates with the tracking unit to locate the device via GPS. It also oversees the storage of necessary information in the storage unit at rates that mirror the sampling from the sensors. Furthermore, it will also control the identification unit by triggering the visual and audio detection aids.
- **Tracking Unit**
  The tracking unit is multipurpose. It comprises of the GPS receiver as well as a transmitter and receiver. Using GPS technology, this unit will triangulate the location of the sonde to within a 150 ft of its actual location. The transmitter will allow us to transmit sensor and location data. The receiver will allow us to send a signal to activate the identification unit.
- **Identification Unit**
  The speaker and a LEDs will be triggered when the retriever is within 50 ft of the sonde.
- **Storage Unit**
  The storage unit should be big enough to store data of four sensors at their refresh rate during the entire flight. We plan on using a SD card to store flight and sensor information. This will allows us to easily extract information from the radiosonde.
- **Power Unit**
  The power unit should be able to deliver rated power to all the different components through appropriate dc-dc conversion. In order to accomplish this we will use a battery bank from common alkaline batteries. We will then pass this power through voltage regulators, turning the power into stable and appropriate voltage levels for the rest of the unit.

## [5] Risk Analysis

The greatest risk to our project is the control unit. This unit effectively orchestrates the entire radiosonde. It is responsible for reading in measured data, storing the data, reading in GPS location, controlling transmitting and receiving signals and the identification unit. If this unit were to fail or malfunction the entire radiosonde would be non functional. We must take great care to ensure that the control unit not only works properly but also is reliable.

## REFERENCES


1) https://www.weather.gov/upperair/factsheet
2) https://www.weather.gov/jetstream/radiosondes
3) http://radiosondemuseum.org/
4) https://www.weather.gov/jetstream/skewt


## ETHICS & SAFETY

This project necessitates that specific safety precautions are taken regarding the transmission of long distance radio waves as well as the rise of objects into potential flight paths. In order to transmit radio waves such as is necessary for radiosondes requires that licensing from The National Association for Amateur Radio. We will be attempting to become licensed ourselves to meet this requirement. If this fails we will be able to bring in an already licensed member to oversee our tests. Furthermore, we will need to keep our device under a six pound limit in order to avoid any required approval for launch a high altitude balloon. If and when we test the device and release it into the atmosphere we will alert the FAA a day in advance to make sure that the test does not interfere with any ae