

# Lightweight Precision Altimeter for Application to Remote Drone-based GPR Survey of Ice

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GEOSC597-007: Techniques of Geoscientific Experimentation

# Motivation

MODELING: BRIDGING  
THE DATA GAP

REMOTE SURVEY

UAV SURVEY

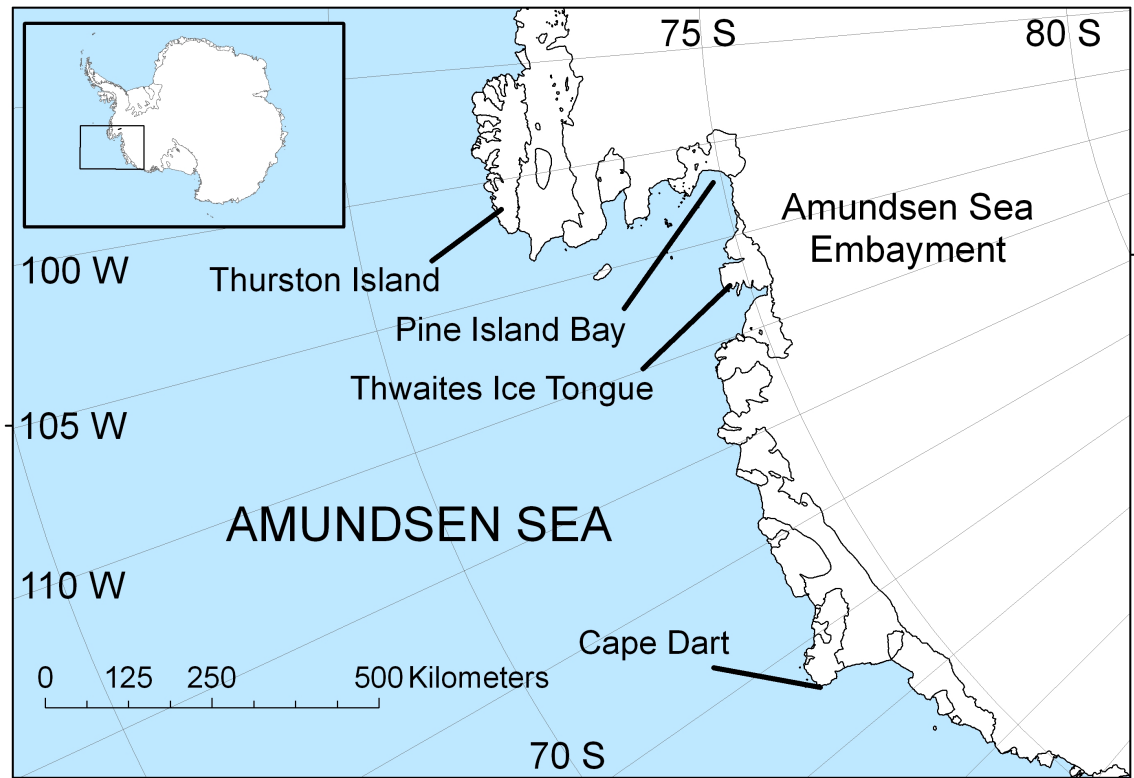
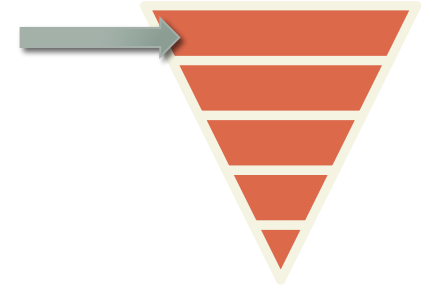
QUADCOPTER  
SURVEY

ALTIMETER

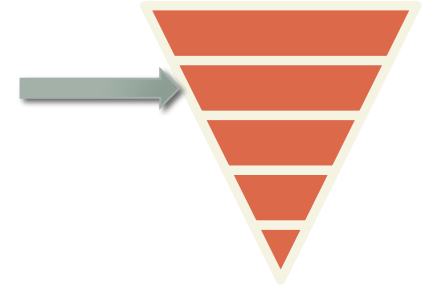


# Data Gap

- Ice sheets: motion
  - Basal topography, drainage, geometry, temperature...
- Hi-res and spatially-extensive data invaluable to inform models, but very expensive
  - Scale
  - Remote location



# Remote Survey



- NASA: IceBridge

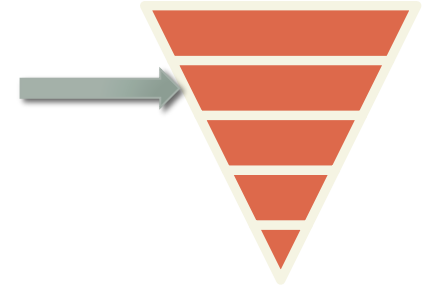
The screenshot displays the NASA IceBridge web application interface. At the top, there are tabs for "Northern Hemisphere", "Southern Hemisphere" (selected), and "Data". To the right are buttons for "Data Details", "Data Filters", "Feedback", "Help", and "Maximize". Below the tabs is a scale bar showing 100 km and 50 mi, and a zoom slider. The current coordinates are "Lat: 80° 53'16.1" S Lon: 95° 36'13.8" W". The main map area shows a grayscale topographic map of Antarctica with several orange flight lines overlaid. A toolbar at the bottom of the map includes "max extent", "reset", "pan/zoom tool", "select tool", and "measure tool". A legend on the right side of the map lists the following layers:

- Base Layer
  - Southern Hemisphere
- Overlays
  - Mosaic of Antarctica (MOA)
  - Antarctic Bedrock DEM
  - Radarsat Antarctic Mapping Project (RAMP)
  - MEaSUREs Velocity Map 2008/2009
  - Flight Lines

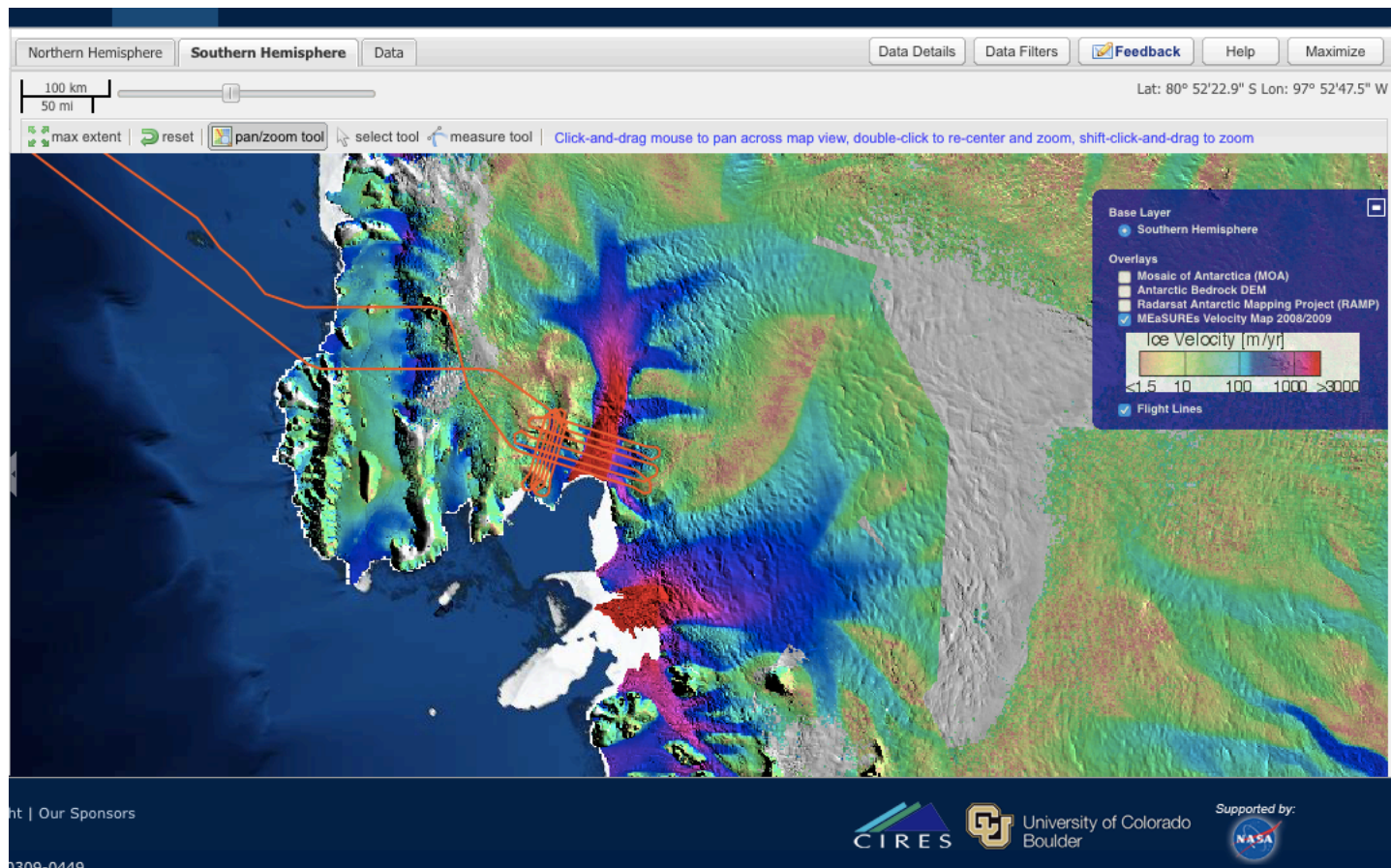
At the bottom of the interface, there is a footer with the text "Our Sponsors" and logos for CIRES, the University of Colorado Boulder, and NASA. The number "0309-0449" is visible in the bottom left corner.



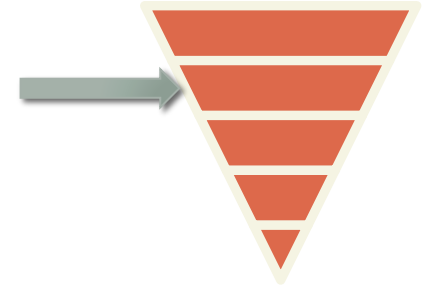
# Remote Survey



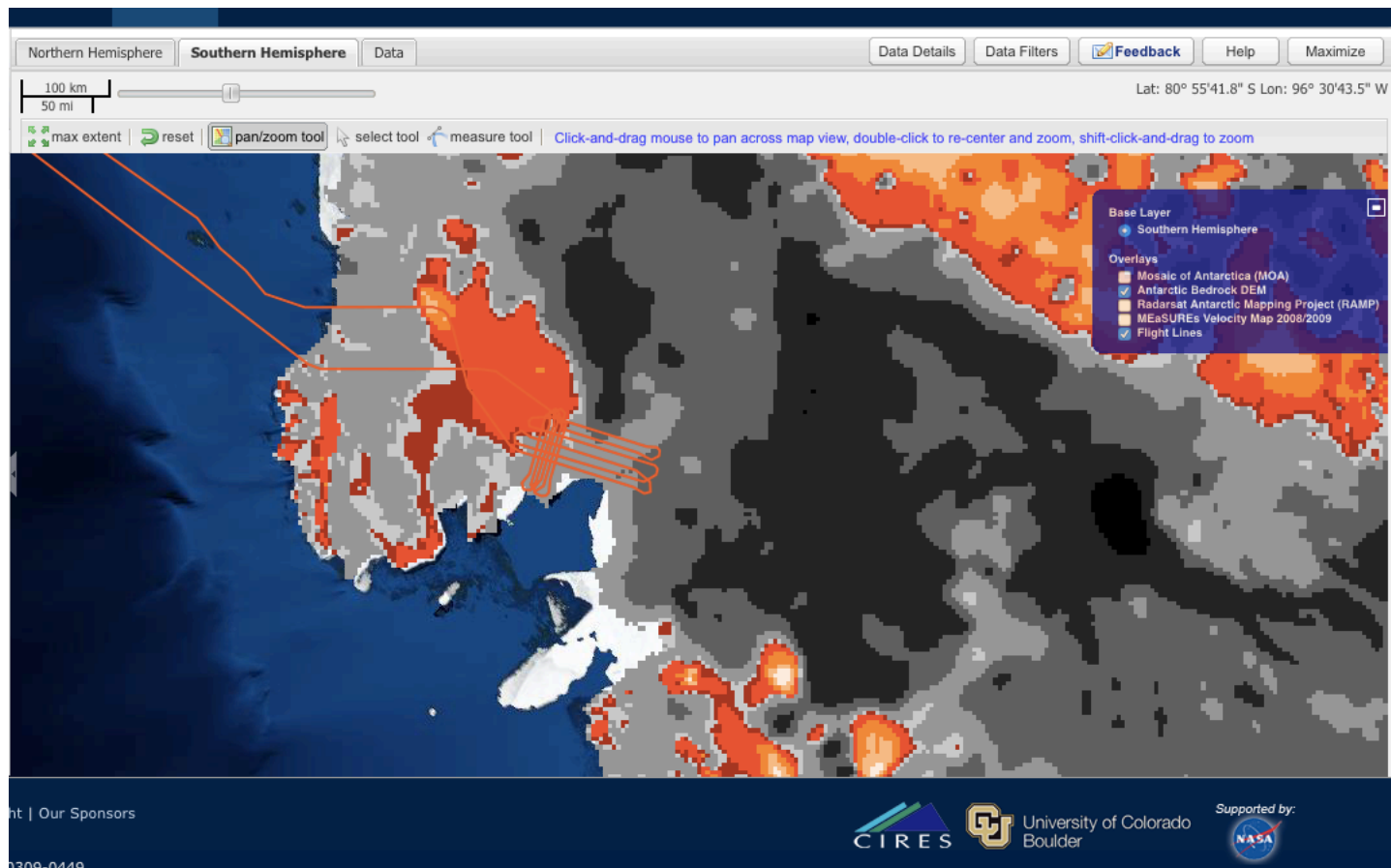
- NASA: IceBridge



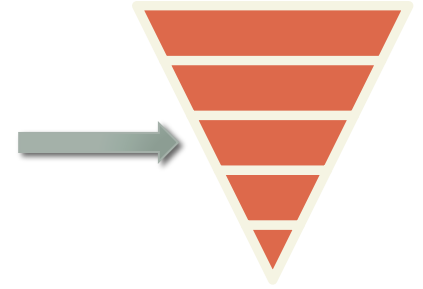
# Remote Survey



- NASA: IceBridge



# UAV Survey



- Rückamp et. al. 2011:
  - UAV-based survey of King George Island, Antarctica (1250 km<sup>2</sup>)
  - GPR → EM energy reflected/transmitted according to properties of interfaces encountered...used to image subsurface.

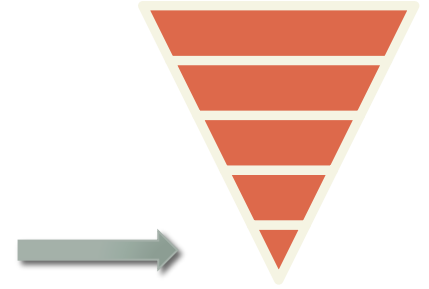






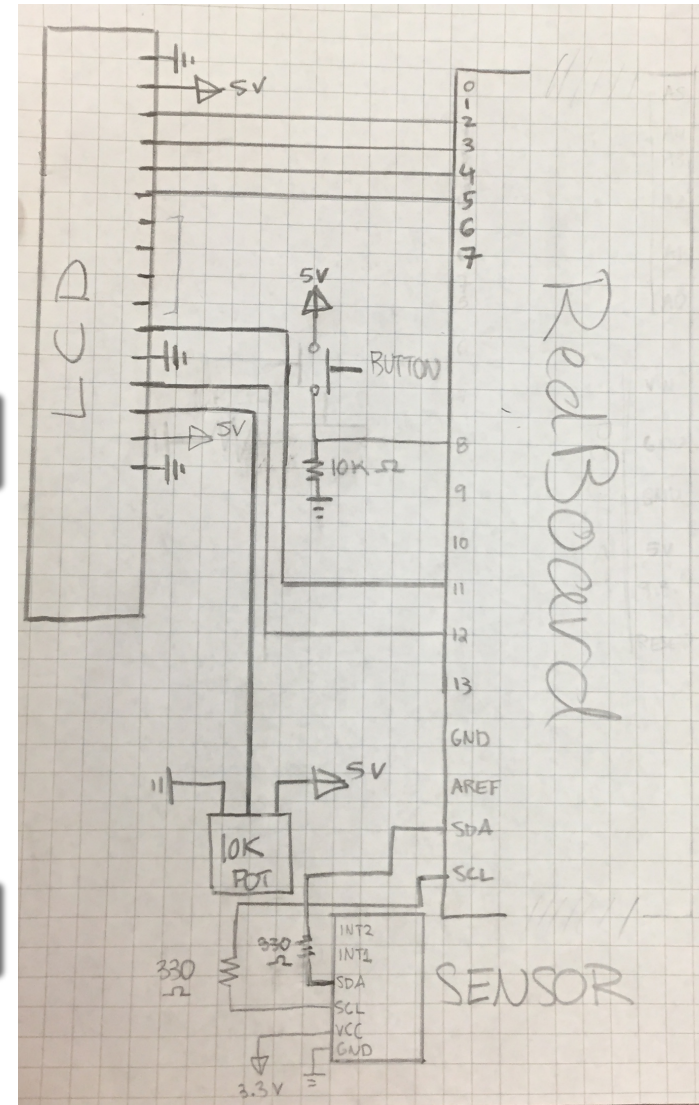
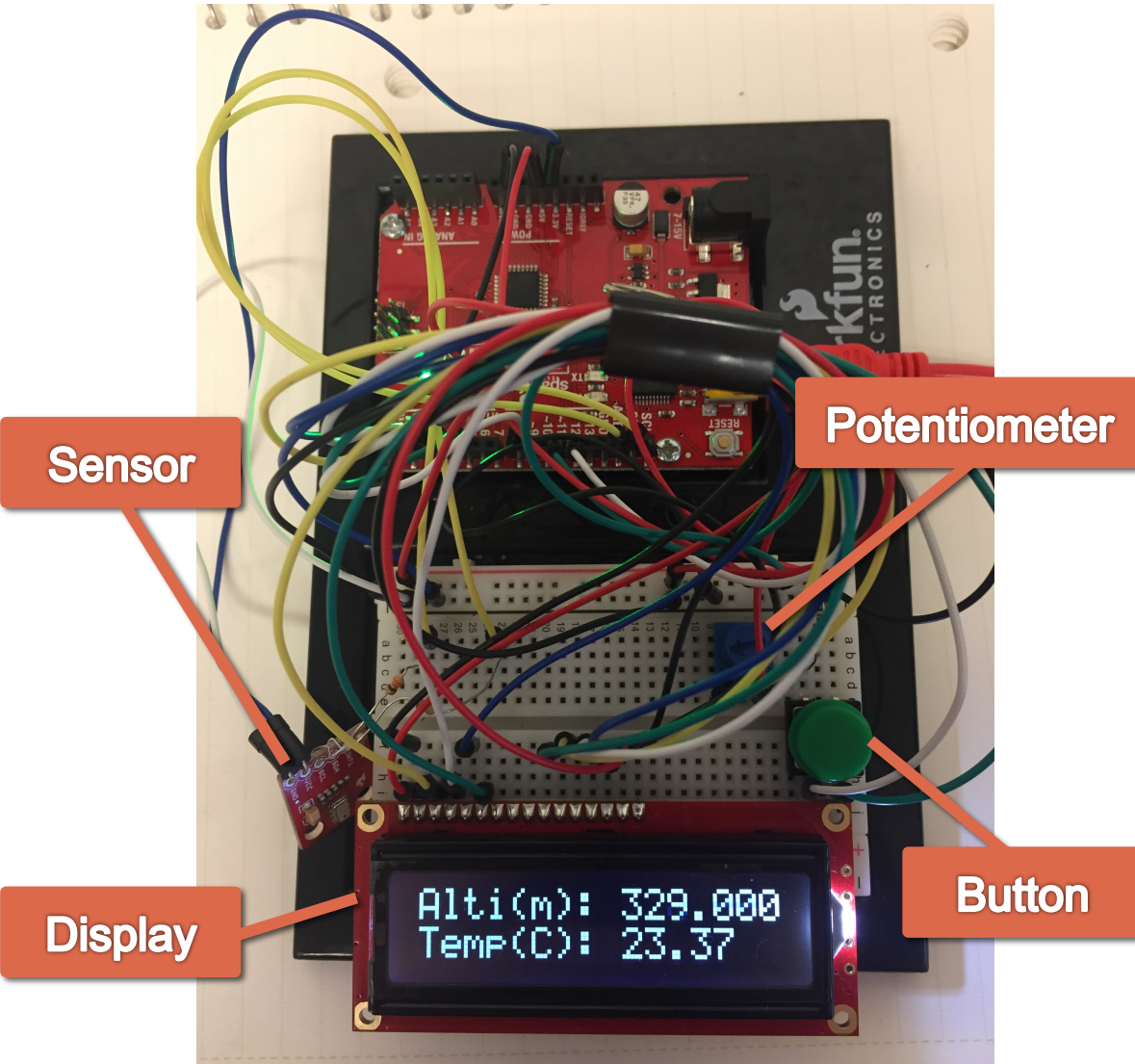


# Altimeter: Design Aspects



- Precision altimeter:
    - Lightweight / compact
    - Continuous data collection
    - Potentially capable of transmission via Bluetooth or WiFi
    - Operational in extreme environments
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- Sensor: MPL3115A2, 3 x 5 x 1.1 mm
    - Temperature op. range: -40°C to 85°C
    - Pressure op. range: 20 to 110 kPa (Siberia: 108.5 record high on Earth; Dead sea: ~85 kPa record low)
    - Acquisition rate: 1 Hz (FIFO), down to 100 Hz (OST mode)
    - Resolution:
      - Barometer: min. 0.25 Pa, typical 1.5 Pa
      - Altimeter: min. 0.06 m, typical 0.3 m

# Prototype: Diagram and Circuitry



# Prototype: State Machine

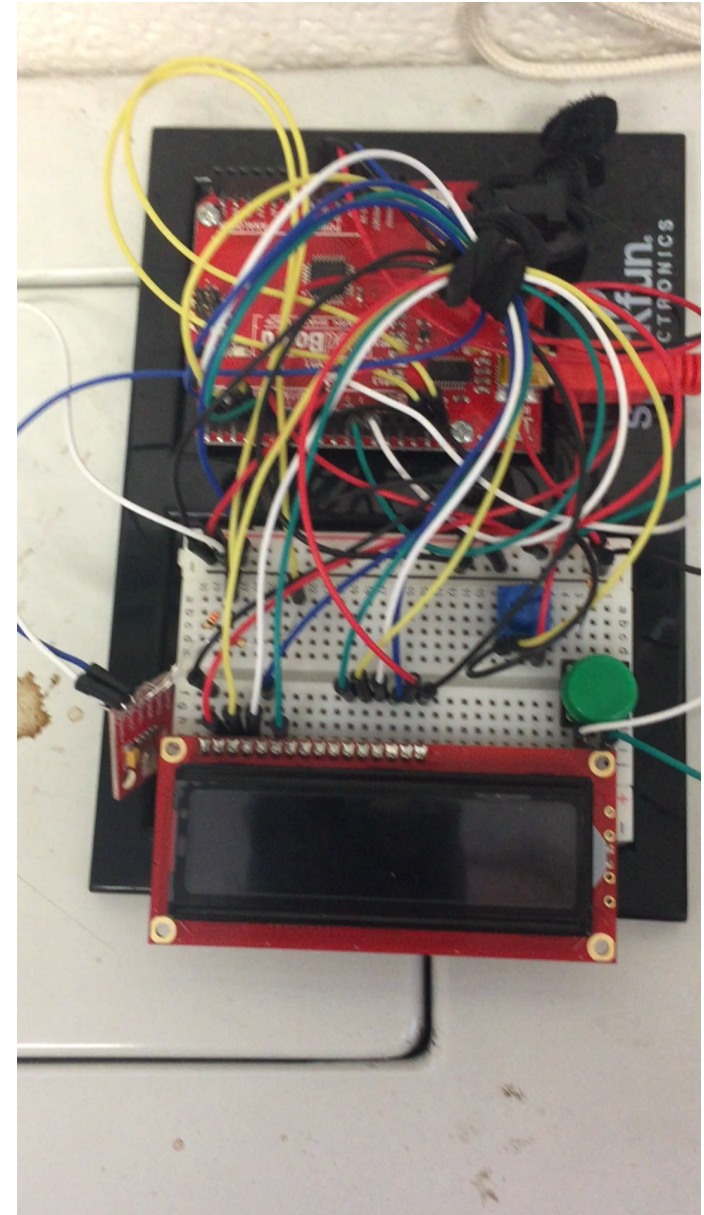
- States:
  - Initialization
    - Sensor startup, baud rate setting
  - Altitude-sensing mode
    - Feet above SL
    - Meters above SL
  - Barometric pressure-sensing mode
  - Shutdown state
    - Outside operation temperature

# Video of mode switch...

- Altitude based on measured pressure, user input of equivalent sea level pressure to compensate for local weather conditions and US Standard Atmosphere 1976 (NASA) to give altitude readings

$$h = 44330.77 \{ 1 - (p/p_0)^{0.1902632} \} + \text{OFF\_H (Reg Val)}$$

Where  $p_0$  = sea level pressure (101326 Pa) and  $h$  is in meters. MPL3115A2 uses this value since offset register is defined as 2 Pascals per LSB.





# Improvements to be made...

- Real-time data logging / transfer
  - Bluetooth / WiFi
- Compactness and ruggedness
  - Arduino ProMini
    - <2 grams, off-board USB
  - Solder components\*
  - Field use: battery-powered, chassis (insulated), standby mode, on/off switch
- Accuracy / drift
  - Overclocking and sampling rates

\*biggest challenge...shaky hands + through-hole soldering = NOT EASY (image of solder-covered sensor not included due to substantial frustration and subsequent rapid disposal)

# Live Demo!

- [http://  
www.usairnet.com/  
weather/maps/current/  
pennsylvania/  
barometric-pressure/](http://www.usairnet.com/weather/maps/current/pennsylvania/barometric-pressure/)
- [http://  
www.convertunits.com/  
from/in+Hg/to/pascal](http://www.convertunits.com/from/in+Hg/to/pascal)
- 0.000295299830714 Hg in 1 Pa
- ELEVATION: 1158 ft
- Reber:  
[https://  
www.topoquest.com/  
place-detail.php?  
id=2103934](https://www.topoquest.com/place-detail.php?id=2103934)
- Hammond:  
[https://  
www.topoquest.com/  
place-detail.php?  
id=2103882](https://www.topoquest.com/place-detail.php?id=2103882)

# Sources

- <http://cdn.sparkfun.com/datasheets/Sensors/Pressure/MPL3115A2.pdf>
- <https://learn.sparkfun.com/tutorials/mpl3115a2-pressure-sensor-hookup-guide>
- <http://www.instructables.com/id/The-Ultimate-Altimeter-A-compact-Arduino-altimeter/>

# QUESTIONS?

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Thank you 😊