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

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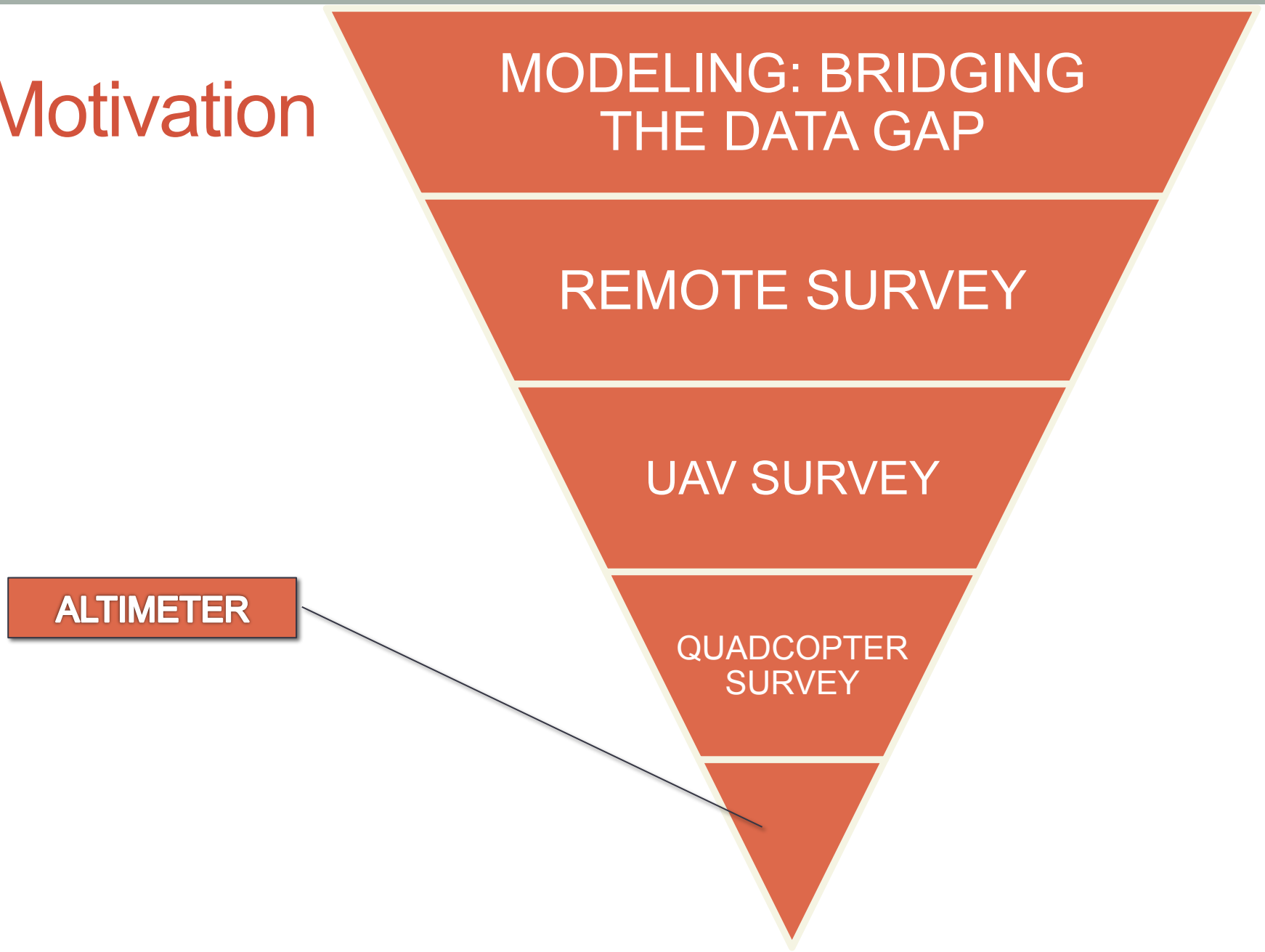
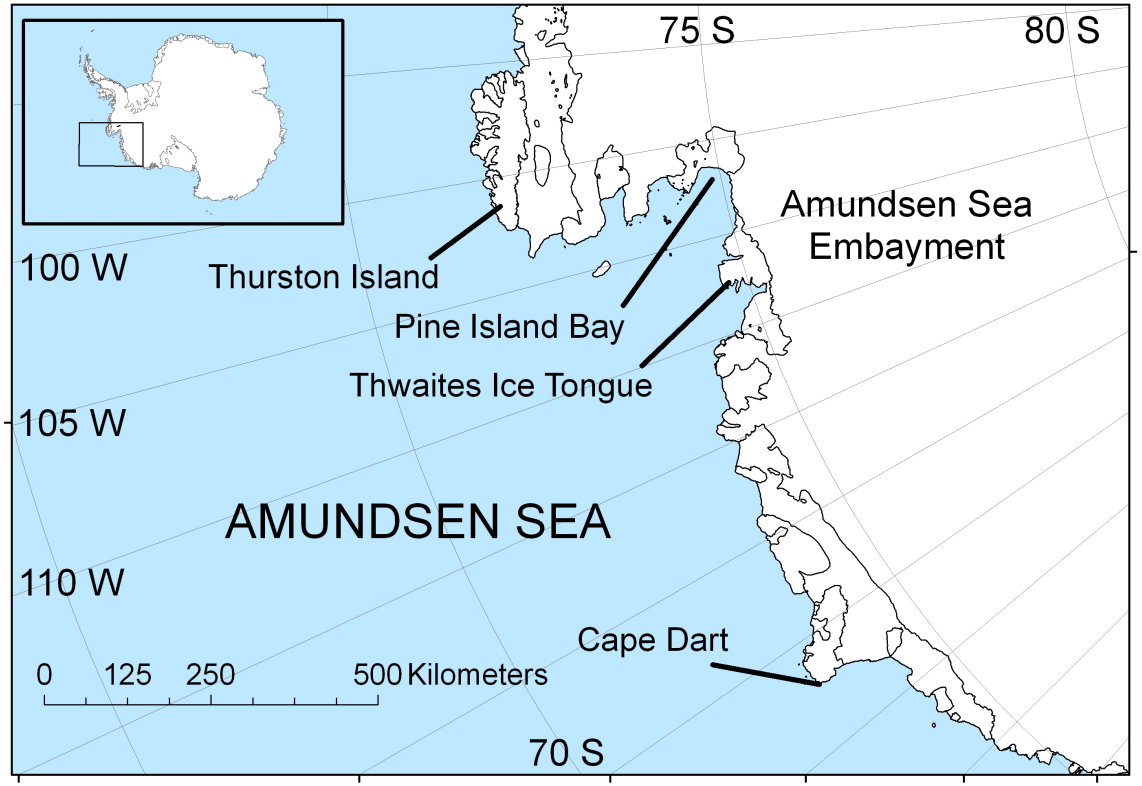
GEOSC597-007: Techniques of Geoscientific Experimentation

Motivation


MODELING: BRIDGING THE DATA GAP
REMOTE SURVEY
UAV SURVEY
QUADCOPTER SURVEY
ALTIMETER

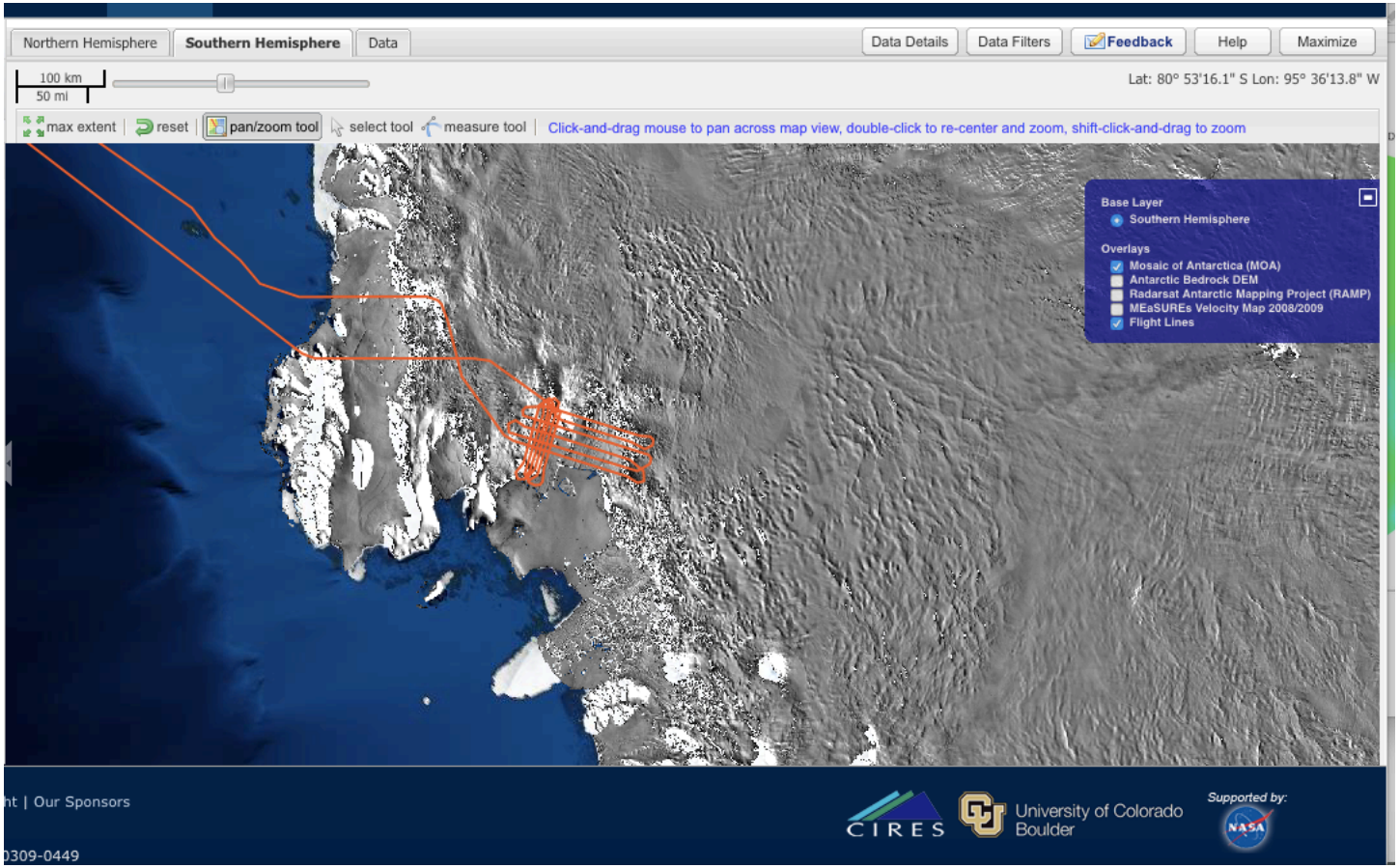
Data Gap

- 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



Remote Survey

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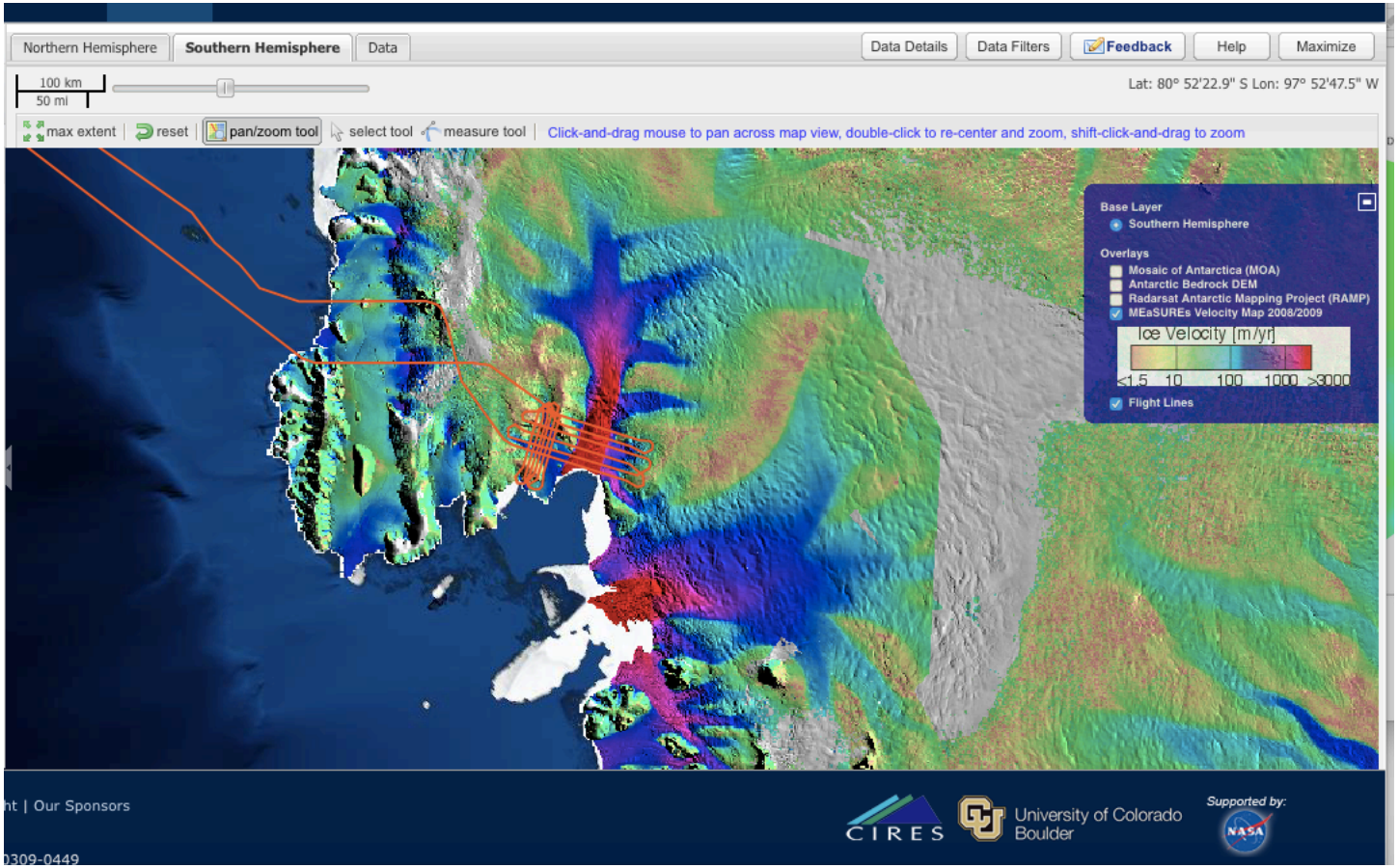
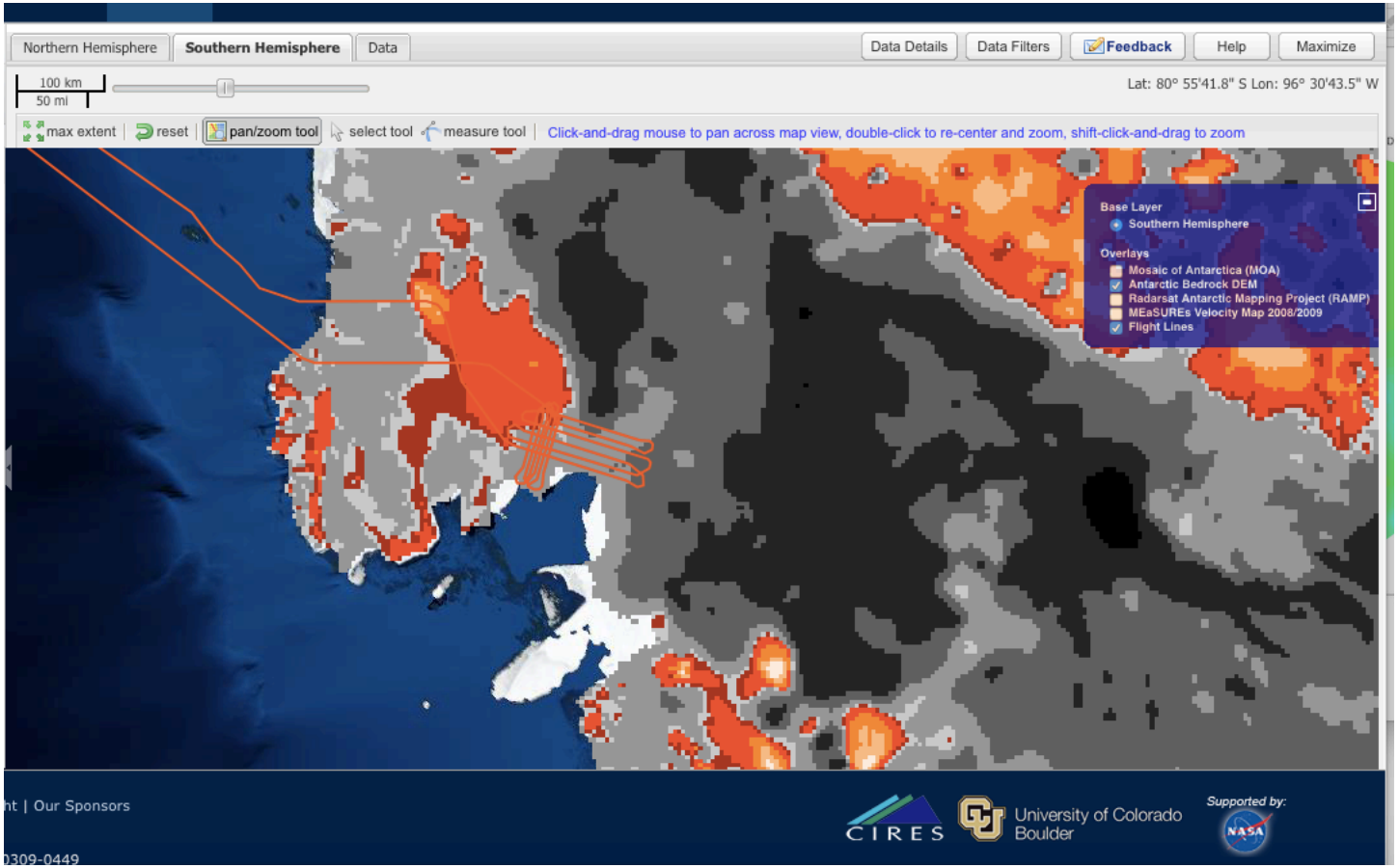


Remote Survey

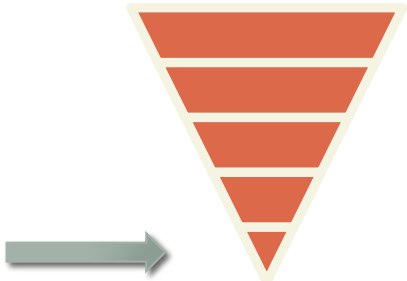
- NASA: IceBridge



UAV Survey

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

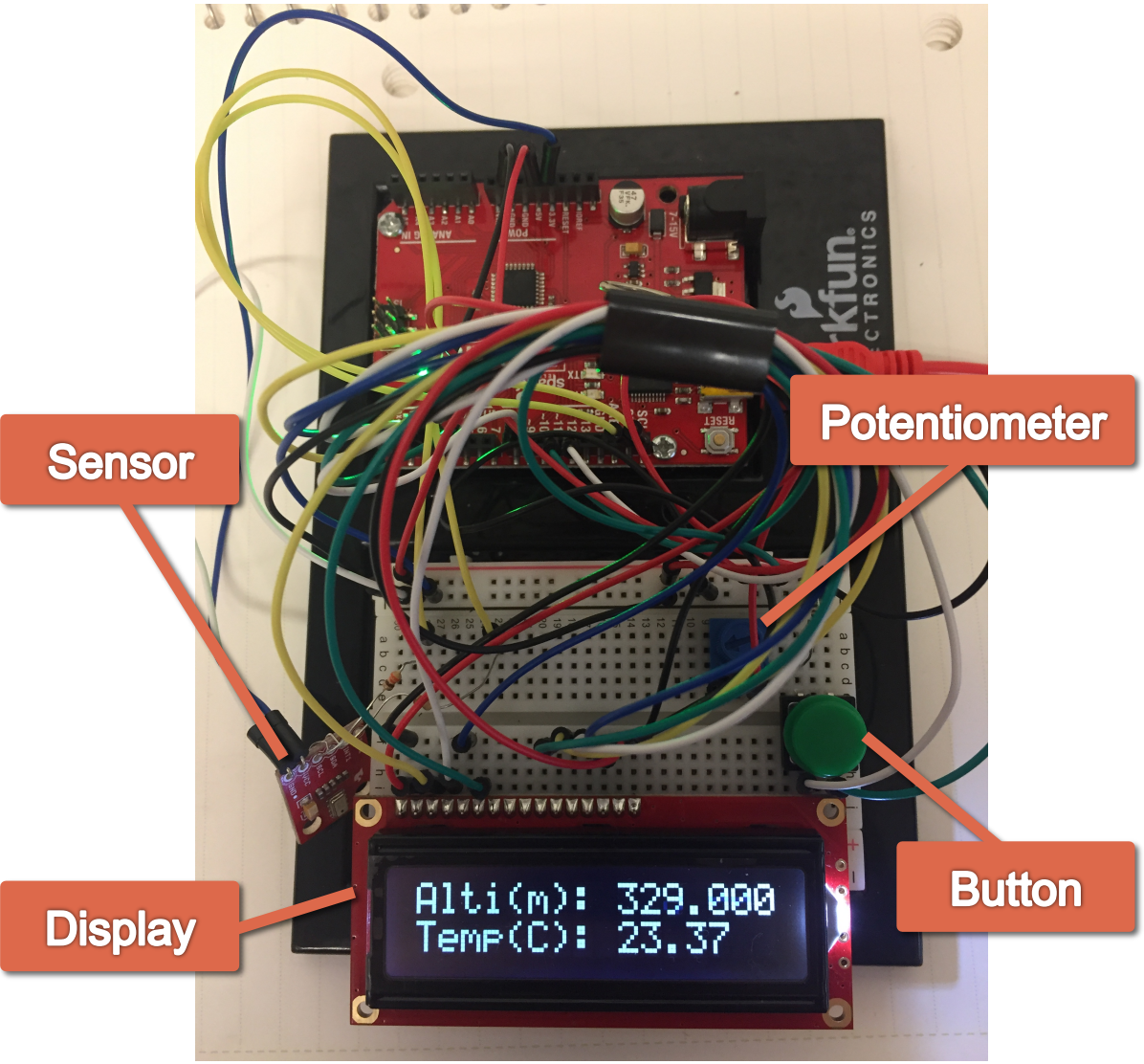
Altimeter: Design Aspects

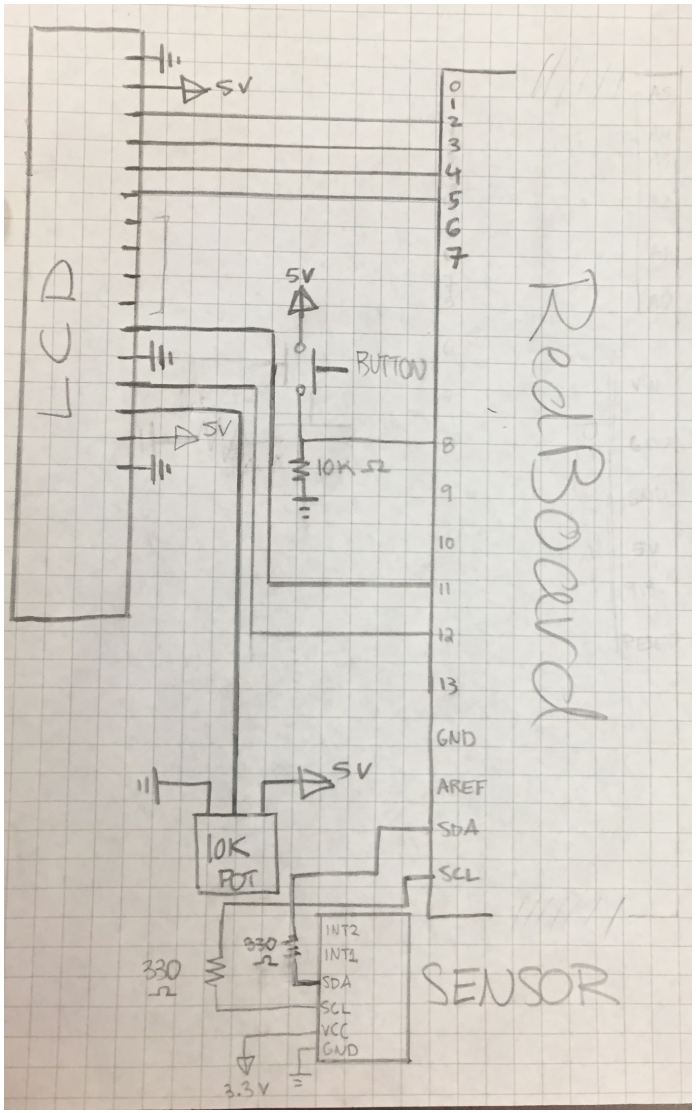


- Precision altimeter:
  - Lightweight / compact
  - Continuous data collection
  - Potentially capable of transmission via Bluetooth or WiFi
  - Operational in extreme environments

- 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

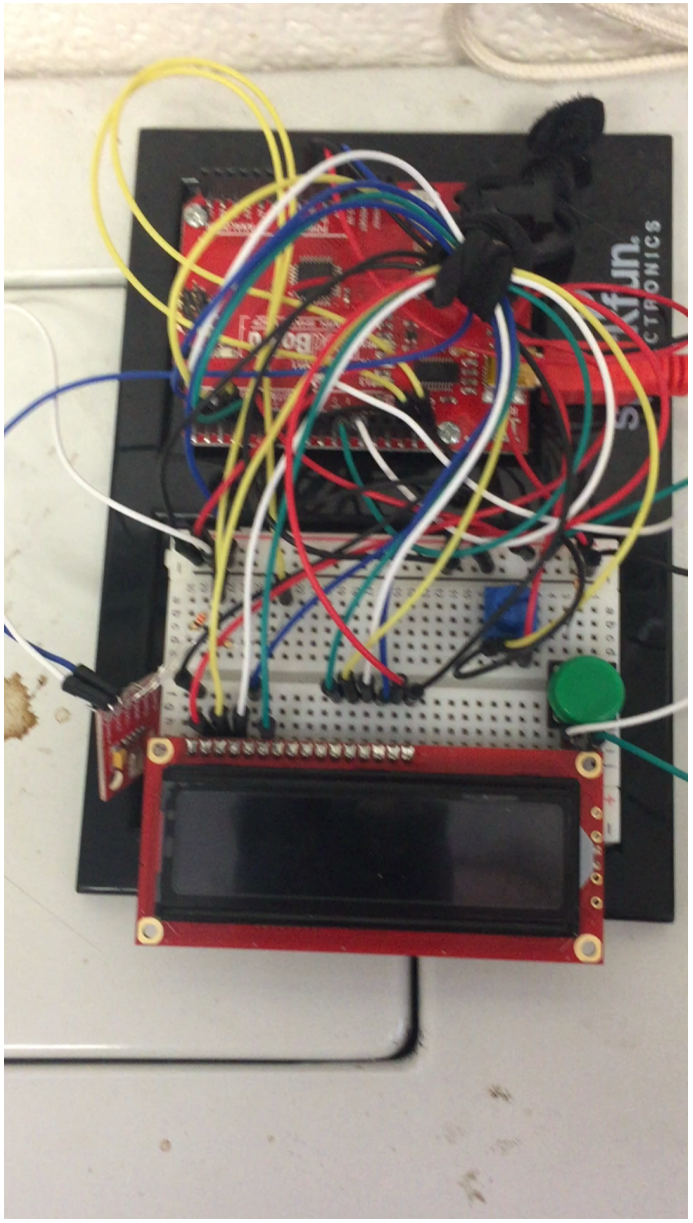
- States:
  - Initialization
    - Sensor startup, baud rate setting
  - Altitude-sensing mode
    - Feet above SL
    - Meters above SL
  - Barometric pressure-sensing mode
  - Shutdown state
    - Outside operation temperature

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

$$h = 44330.77\{1 - (p/p0)0.1902632\} + OFF\_H\ (Reg\ Val)$$

Where p0 = 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.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
- Hammond: 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?

Thank you ☺