TEAM 18: PENETROMETER

Sponsor: National Park Service - Dr. Russo
Advisor: Dr. Shih
Instructors: Dr. Gupta, Dr. Frank

CARREN BROWN – ME
DENEUVE BRUTUS - CPE
PETER HETTMANN - ME
SEAN KANE - EE
NATALIE MARINI - ME
MITCHELL ROBINSON - EE
MARITZA WHITTAKER - ME

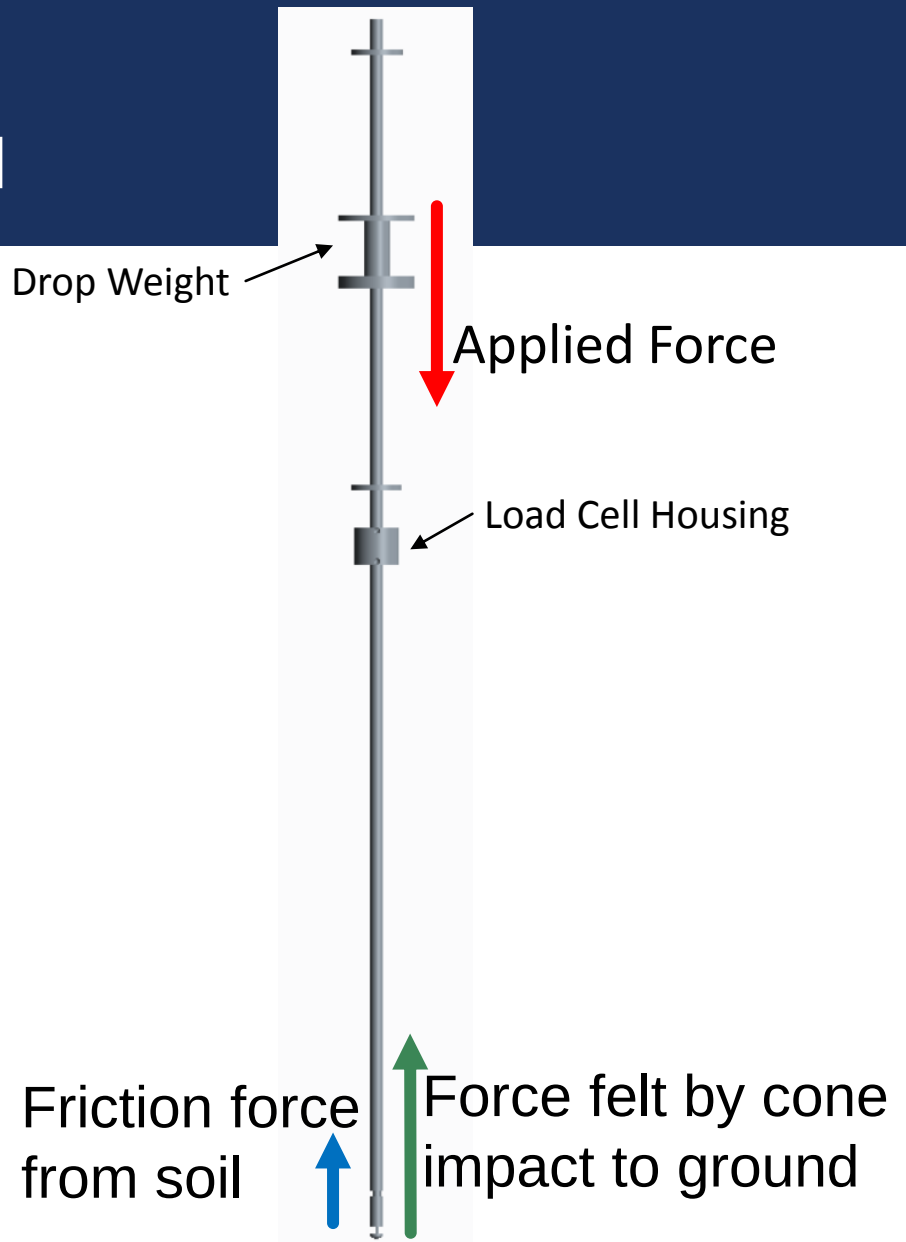
INTRODUCTION: NATIONAL PARK SERVICES

- Create a device that can identify midden and differentiate soil types
- Penetrometers originally measured compaction
- Current technique vs. improved penetrometer
- Portable and user-friendly

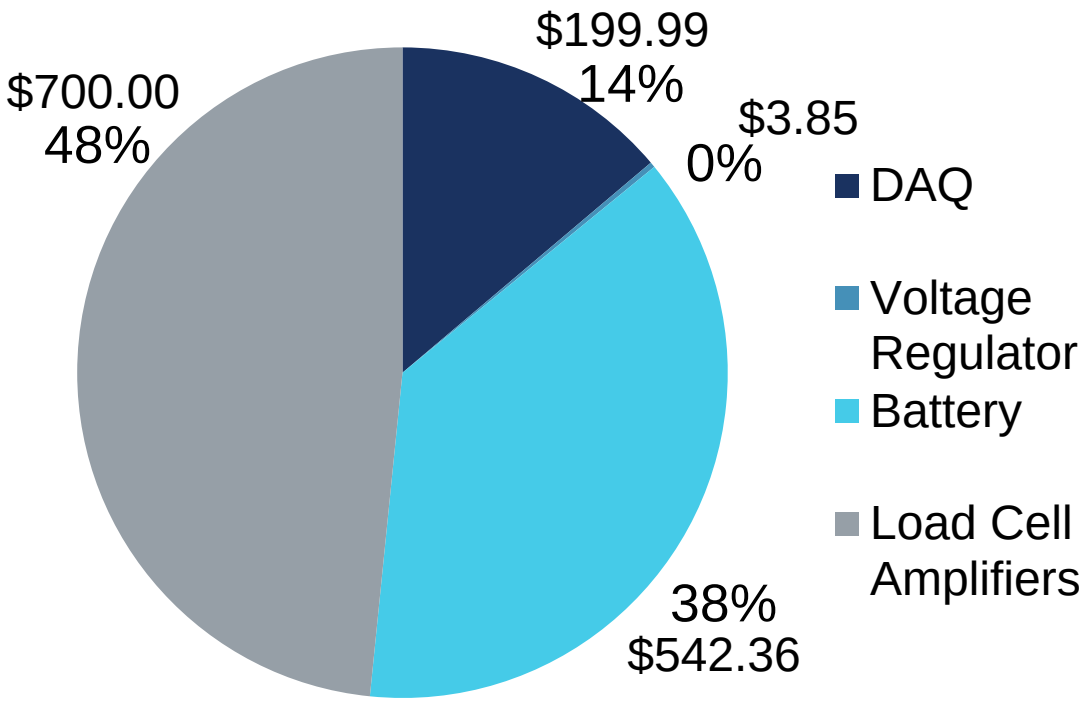
PROJECT OVERVIEW

- Objectives
  - Ability to identify midden
  - Weight not to exceed 50 lbs
  - Be portable
  - Display results on a handheld device
  - Low maintenance
- Constraints
  - Ease of use
  - Strong under compressive loads
  - Transmit reliable data

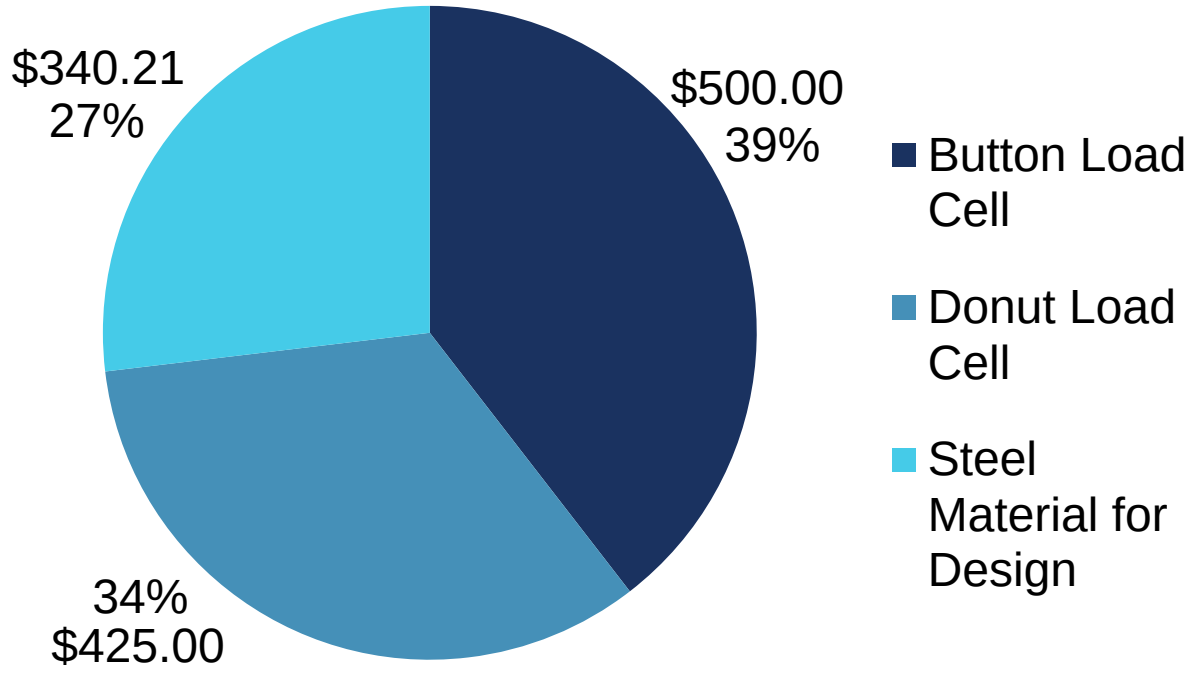
FORCE DIAGRAM



PROCUREMENT



Electrical Components



Mechanical Components

LOAD CELLS

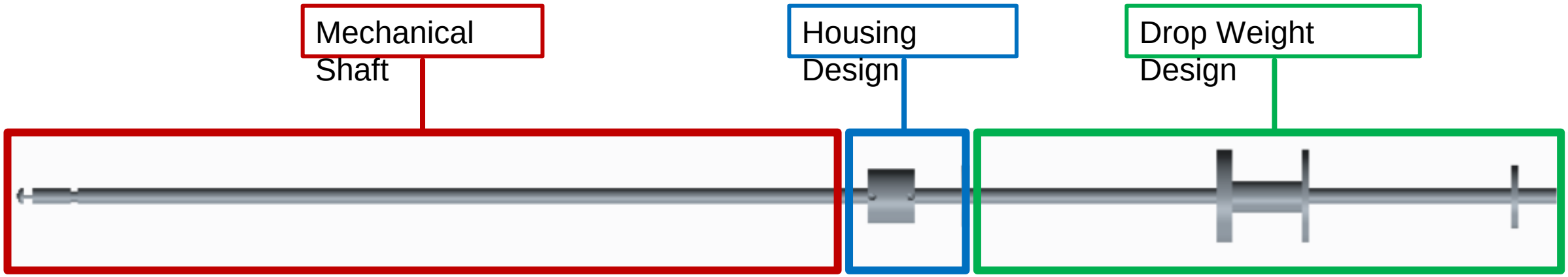
Load Cell Configuration

- 2 mv/V Rated Output
- 18 Volt max input
- 250 lb Capacity
- 150% safety overload

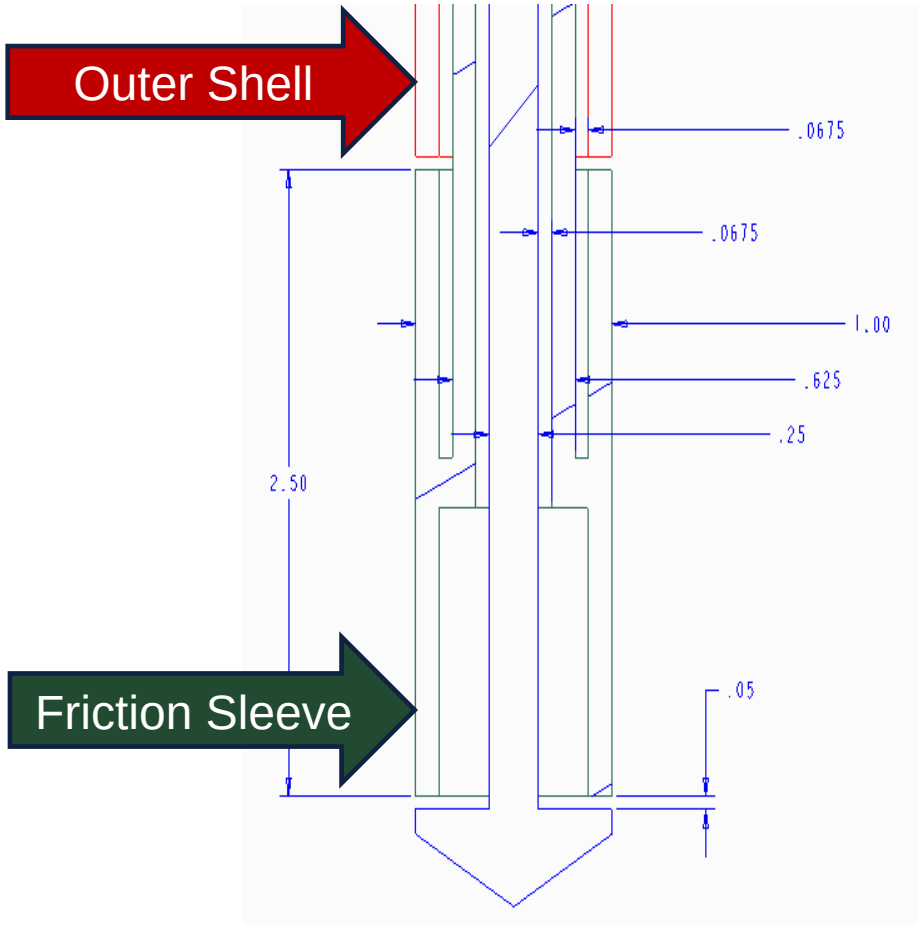
Voltage Output

- 15 V Excitation input
- Rated Output: $(15\ V) * \left(2\frac{mV}{V}\right) = 30\ mV$
- $\frac{1\ lb}{250\ lb} * 30\ mV = 0.12\ mV$

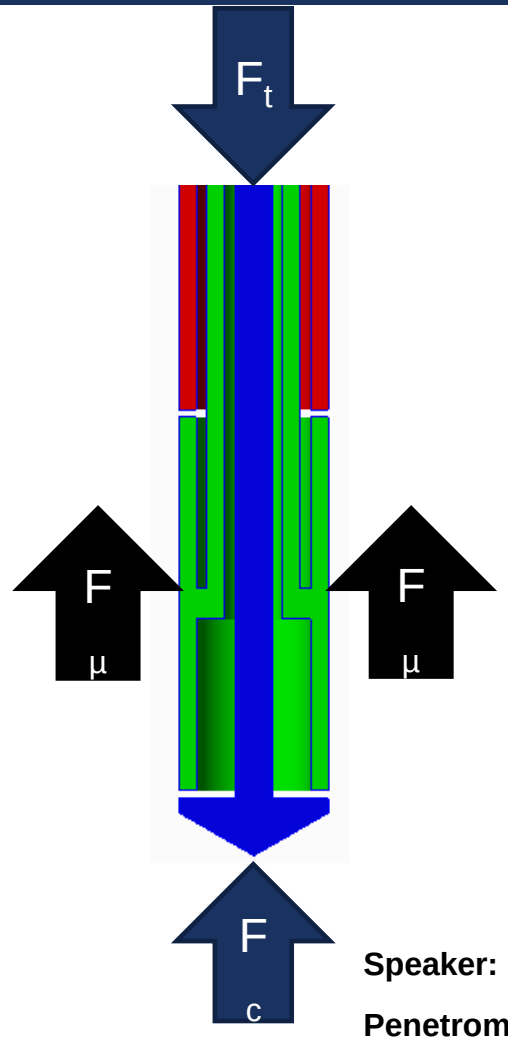
MECHANICAL DESIGN



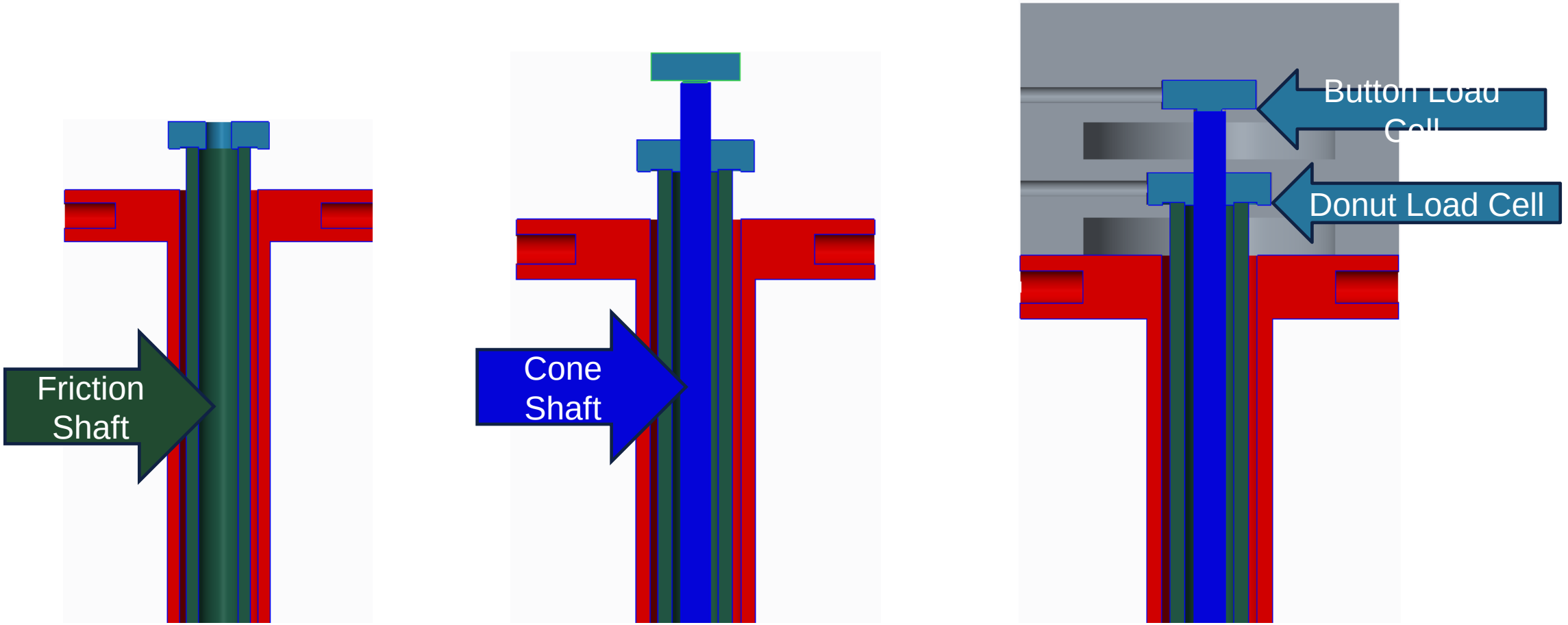
MECHANICAL SHAFT DESIGN



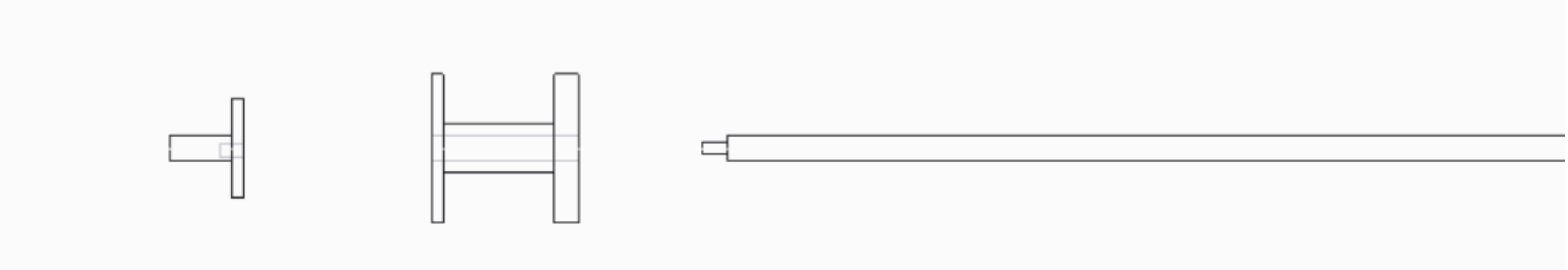
- Total Force = F_t
- Cone Tip Force = F_c
- Soil Friction Force = F_μ



HOUSING DESIGN



DROP WEIGHT DESIGN

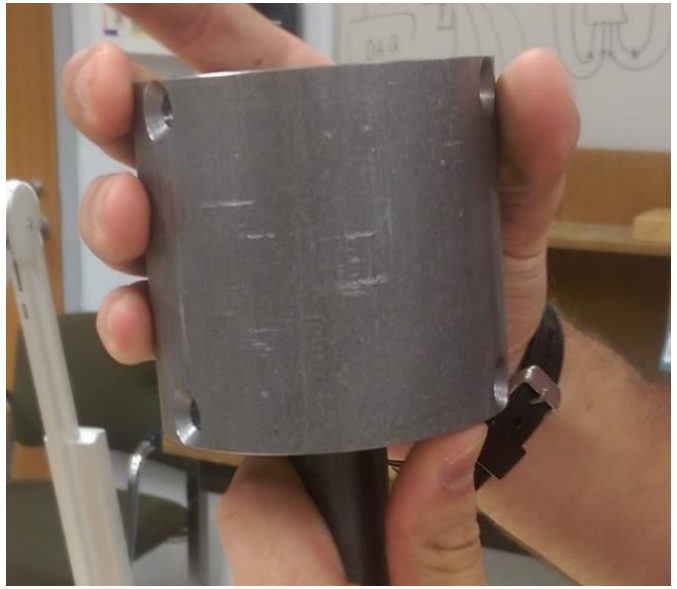


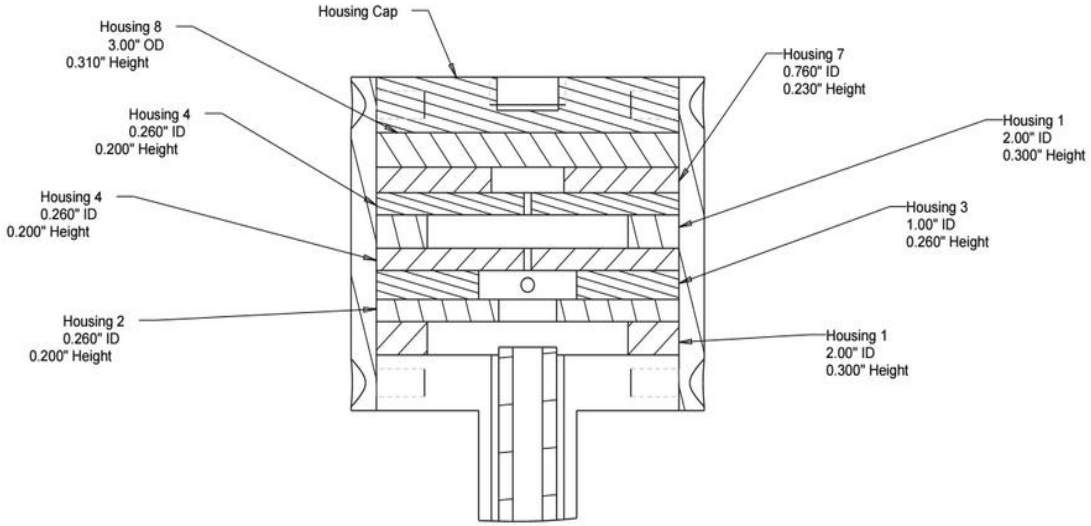
- 15 lb. or 25 lb. drop impact weight
- Constant force vs varying load impact

MANUFACTURING: MECHANICAL SHAFT

- Cone tip attached to center rod
- Friction Sleeve
- Securing disc screwed on to top for calibration

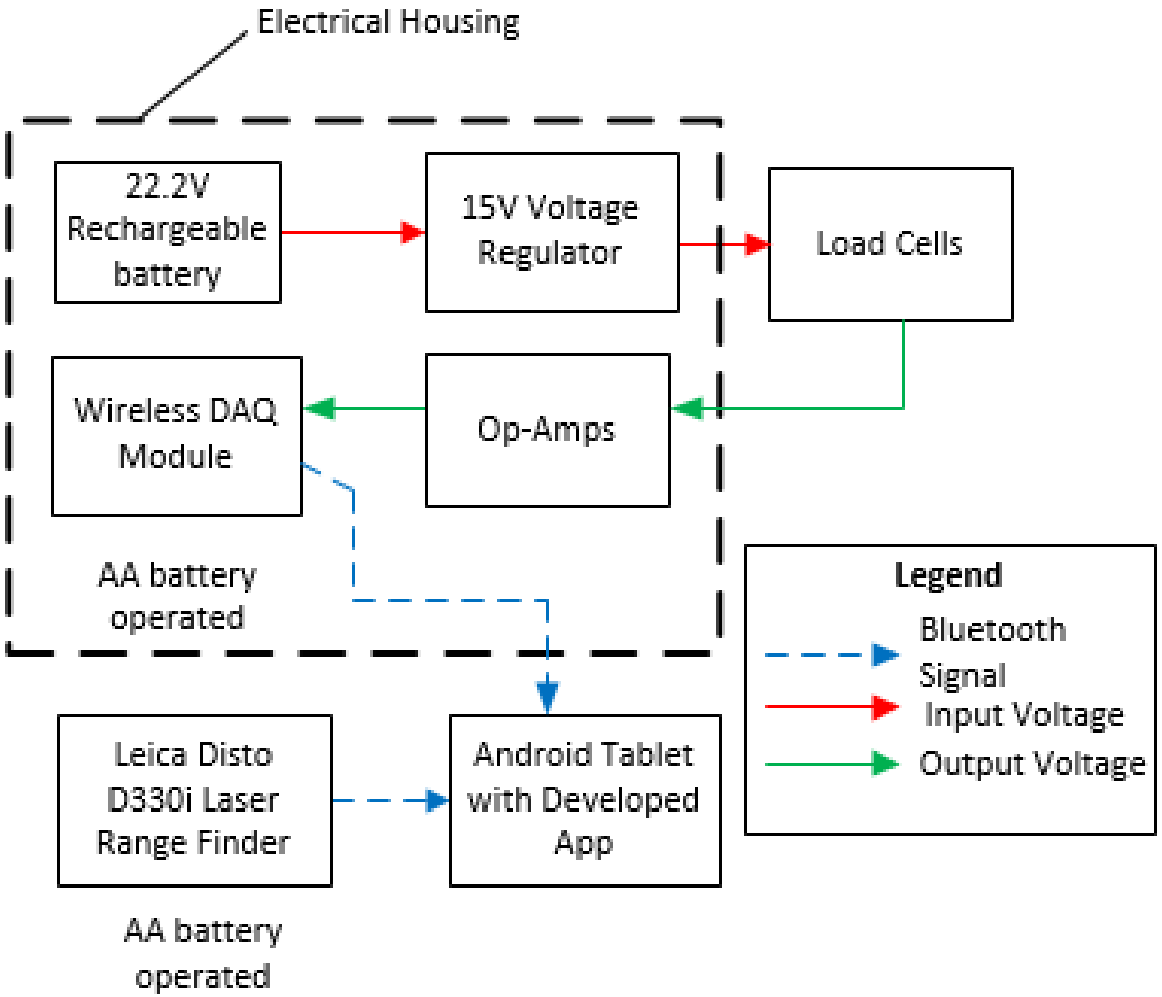
MANUFACTURING: HOUSING





MANUFACTURING: DROP WEIGHT

ELECTRICAL DESIGN



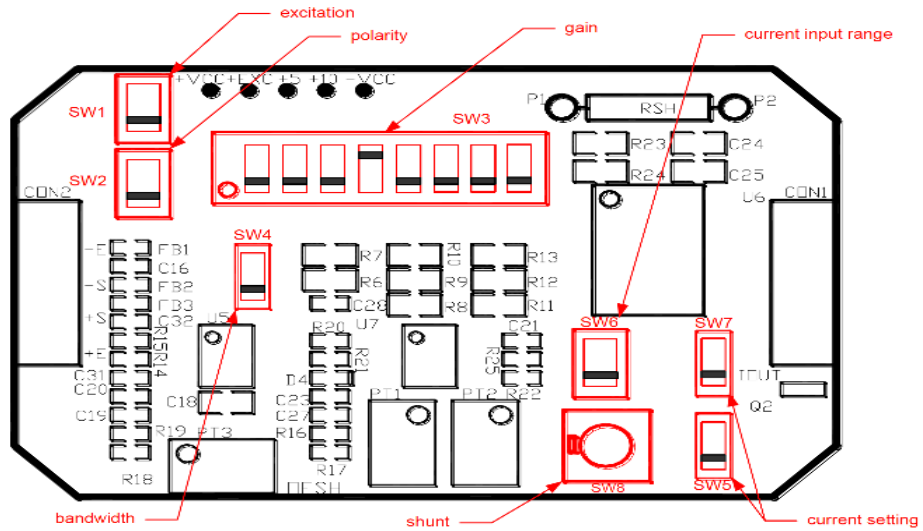
22.2V RECHARGEABLE LI-ION BATTERY PACK

- Composed of 18 2.6Ah cylindrical 18650 Li-Ion cells with PCB and poly switch for full protection
- Capacity: 7.8 Ah
- Voltage: 22.2 V (Peak at 23.4 V)
- Weight: 1.9 pounds
- Over current detection: 7~10 A
- Cut-off Voltage: 18 V
- Built-in IC chip to prevent battery pack from over charge and discharge

TI780-15 VOLTAGE REGULATOR

- Minimum Input Voltage: 17.5 V
- Maximum Input Voltage: 30 V
- Fixed Output Voltage: 15 V
  - 4% accuracy
- Max Output Current: 1.5 A
- Over current and reverse voltage protection

CSG110 LOAD CELL AMPLIFIER

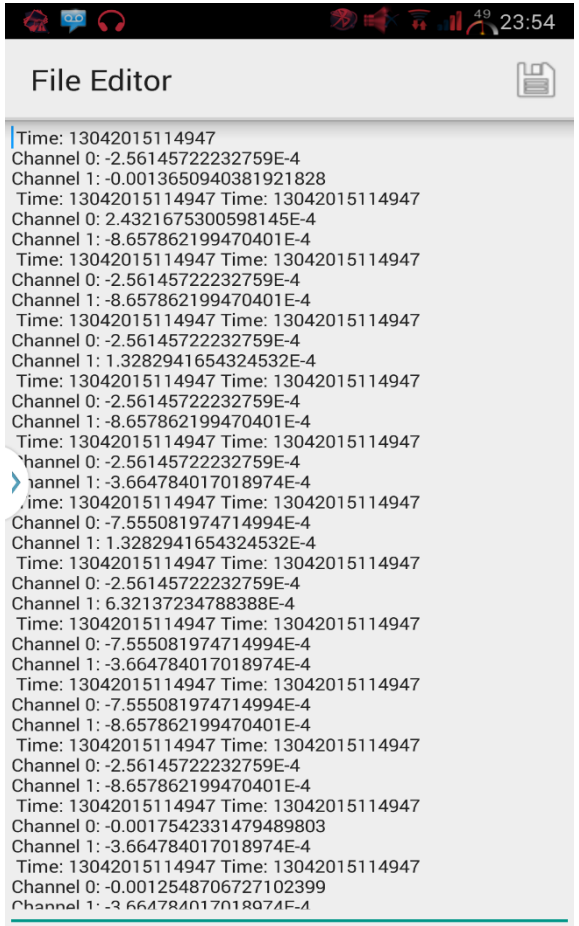


- Designed for any full-bridge strain gauged sensor with a mV/V output
- 10 kHz bandwidth
- Output: ±5V or ±10V
- DIP switches to vary the gain
  - Excel spreadsheet provided by Futek
- Power supply: 14V – 26V
- Typical Current draw: 30mA

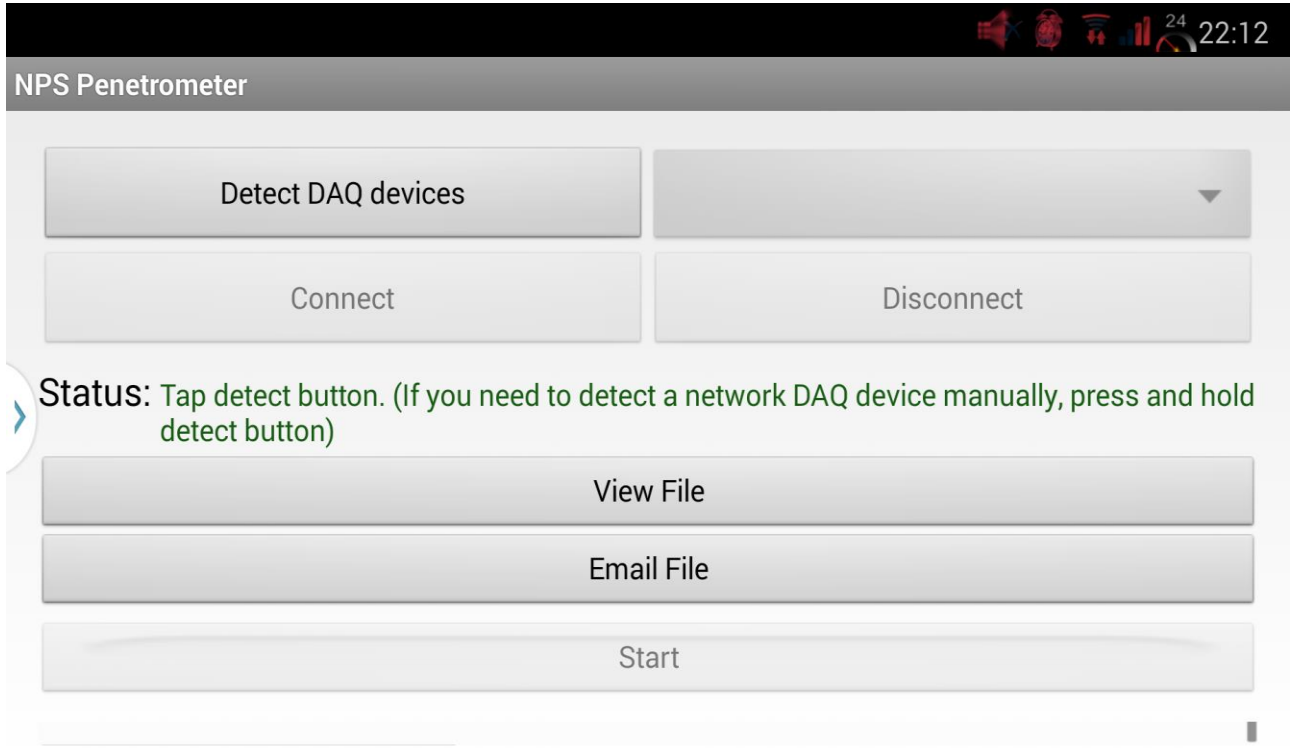
BTH-1208 WIRELESS DAQ

Analog Input	
Sample Rate:	47 kS/s
Number of Channels:	8 SE/ 4 DI
Range, Bipolar:	-20 to 20V, -10 to 10, -5 to 5, -4 to 4V, -2.5 to 2.5, -2 to 2, -1.25 to 1.25, -1 to 1
Resolution:	12 bit
Analog Output	
Resolution:	12 bit
Number of Channels:	2
Range, Unipolar:	0 to 2.5V
Digital I/O	
Number of Channels:	8
Counter Timer	
Counter Inputs:	1
Counter Resolution:	32 bit
Measurement Type	
Measurement Type:	Voltage Output , Counter , Digital I/O , Multifunction
Interface List	
Interface:	Wireless

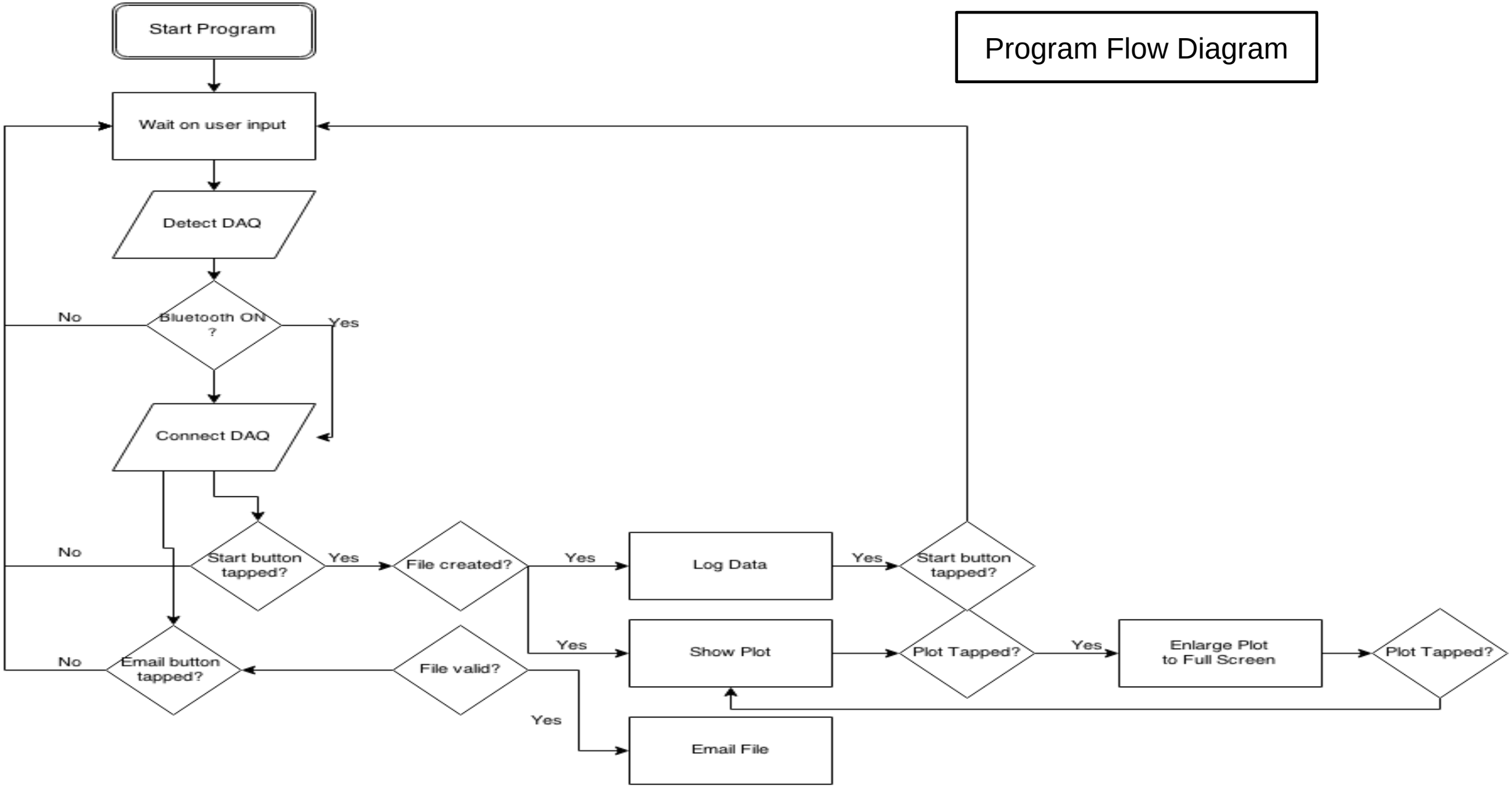
PROGRAMMING AND SIMULATION



- Simple graphic user interface
- Time stamped, data logging of both load cells



Program Flow Diagram

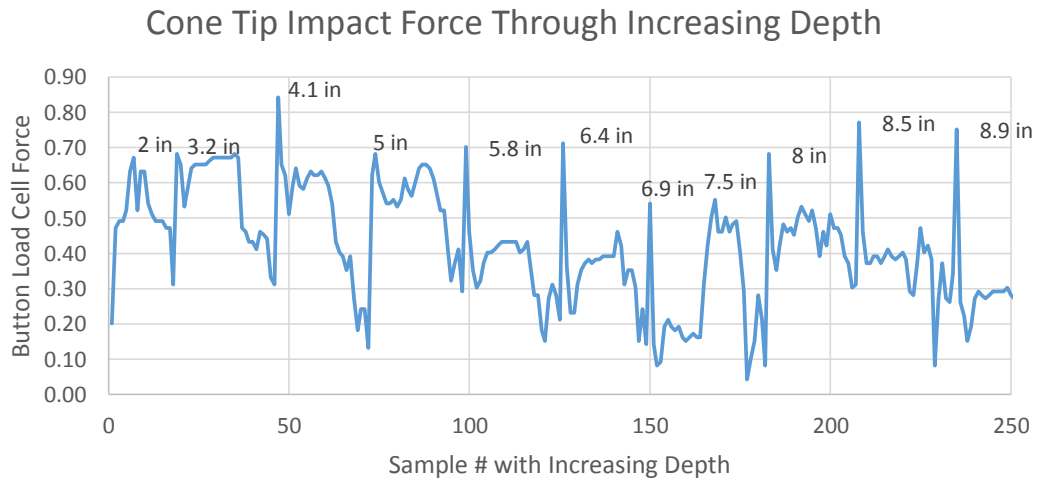


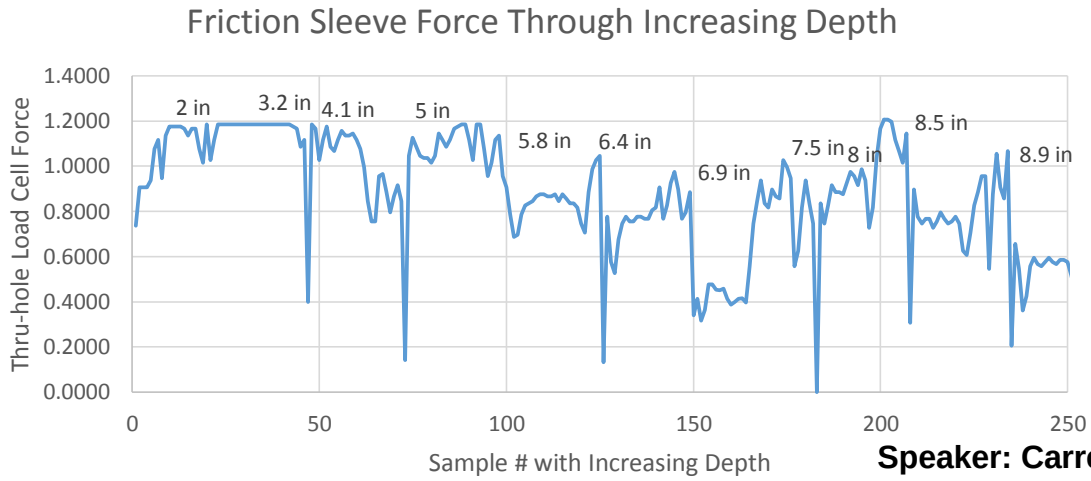
TESTING

- Perform multiple bucket soil tests
  - Clay
  - Sand
  - Top Soil
  - Wet Sand
  - Midden
- Use results to calibrate the system
- Test for accuracy and measurability

TEST RESULTS

- $$Friction\ Coefficient = \frac{Top\ Load\ Cell - Bottom\ Load\ Cell}{Bottom\ Load\ Cell}$$
- Friction coefficient for midden
  - Test 1: 0.3966
  - Test 2: 0.39906





TEST RESULTS

Table of ultimate friction factors for dissimilar materials

Values of the angle δ for different interfaces (according to the NAVFAC standards)

Interface material	Friction factor $tg(\delta)$	Friction angle $\delta°$
Mass concrete on the following foundation materials:		
Clean sound rock	*0,70*	*35*
Clean gravel, gravel-sand mixtures, coarse sand	*0,55 - 0,6*	*29 - 31*
Clean fine to medium sand, silty medium to coarse sand, silty or clayey gravel	*0,45 - 0,55*	
Clean fine sand, silty or clayey fine to medium sand	*0,35 - 0,45*	*19 - 24*
Fine sandy silt, nonplastic silt	*0,30 - 0,30*	*17 - 19*
Very stiff and hard residual or preconsolidated clay	*0,40 - 0,50*	*22 - 26*
Medium stiff and stiff clay and silty clay	*0,30 - 0,35*	*17 - 19*
Steel sheet piles against the following soils:		
Clean gravel, gravel-sand mixtures, well-graded rock fill with spalls	*0,40*	*22*
Clean sand, silty sand-gravel mixture, single size hard rock fill	*0,30*	*17*
Silty sand, gravel or sand mixed with silt or clay	*0,25*	*14*
Fine sandy silt, nonplastic silt	*0,20*	*11*

PROJECT FUTURE RECOMMENDATIONS

- Mechanical
  - Plan ahead and start early
  - Smaller shaft diameter
  - Rod extensions
- Electrical
  - Signal processing to filter out noise
  - Integrate laser range finder into the same app
  - Continued app development

SUMMARY

- Create a user-friendly penetrometer for NPS
- Top heavy load cell design
- Easily accessible housing
- Portable and light design
- Gathers reliable, accurate data
- Efficient data manipulation displayed on a tablet

REFERENCES

- [1]http://www.finesoftware.eu/help/geo5/en/table-of-ultimate-friction-factors-for-dissimilar-materials-01/

ANY QUESTIONS?

Visit Our Website

http://eng.fsu.edu/me/senior_design/2015/team18/