# ACOUSTIC SENSOR:
## FOR FAILURE DETECTION OF INDUSTRIAL ROTATING EQUIPMENT

BY

ALEKSANDAR NESKOVIC

BRENDEN BRADSHAW

JESSE MITCHELL

RYAN BAERG

NICOLAS PERALTA

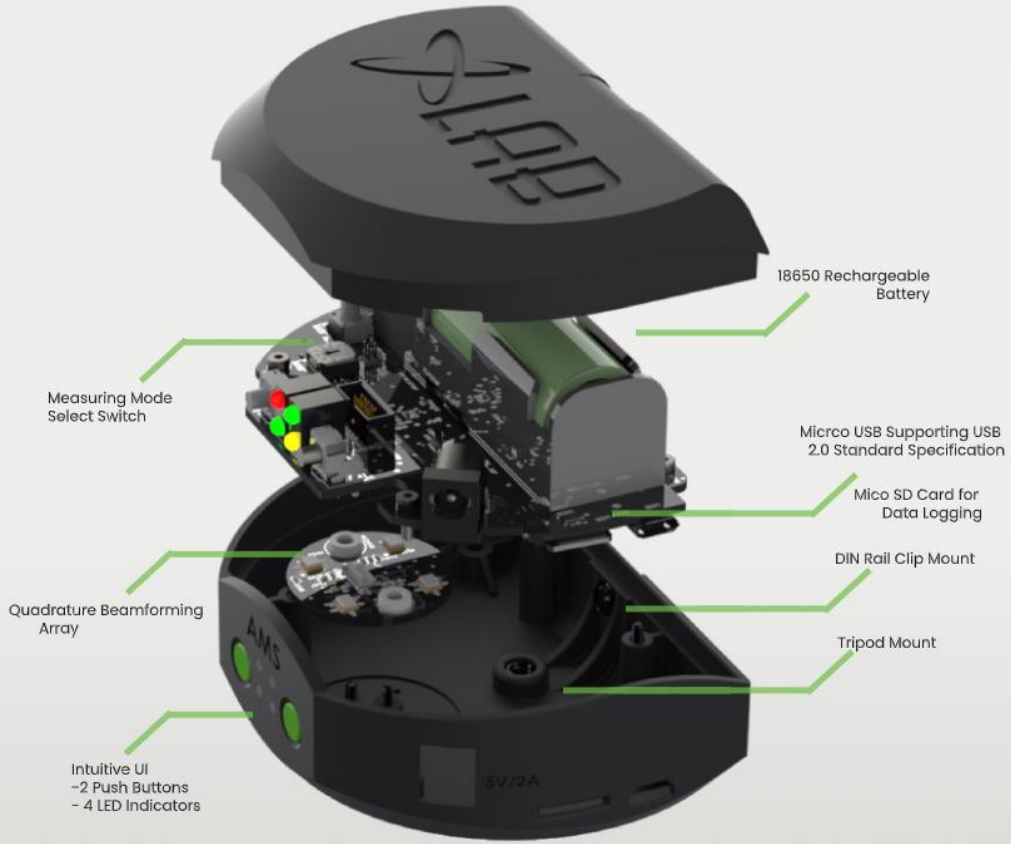
# Acoustic Sensor

**Noninvasive Sensor for Monitoring Industrial Rotating Equipment**

ONTARIO POWER GENERATION

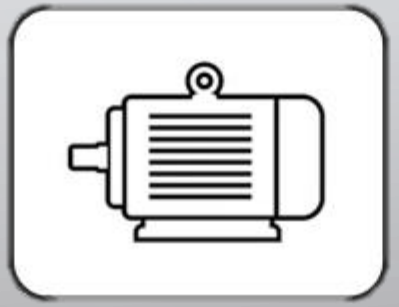
LAB

## Sensor Technical Specifications



# TODAY'S PROCESS

Daily Operator Rounds



Engineering Walkdowns

Condition Reporting

Data Trending

Equipment Reliability

# TODAY'S PROCESS

SLOW

TIME CONSUMING

EXPENSIVE

# CURRENT SOLUTION

- Vibration Sensing
  - Invasive
  - Expensive
- Other Options
  - Long Approval Process

# ACOUSTIC SENSING

CONSTANT MONITORING

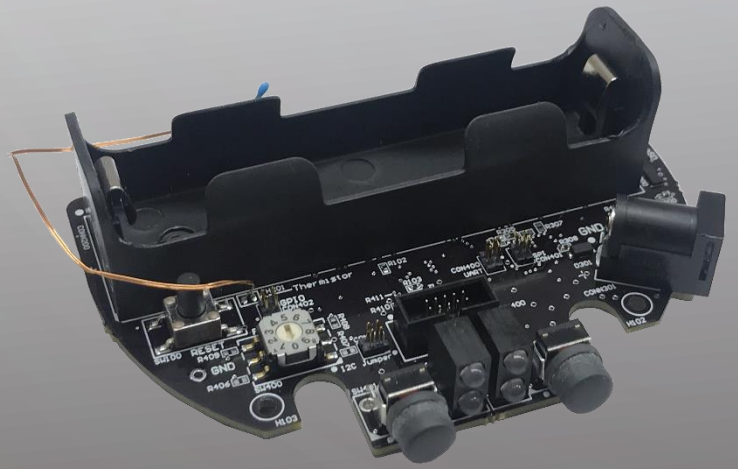
FASTER REACTION

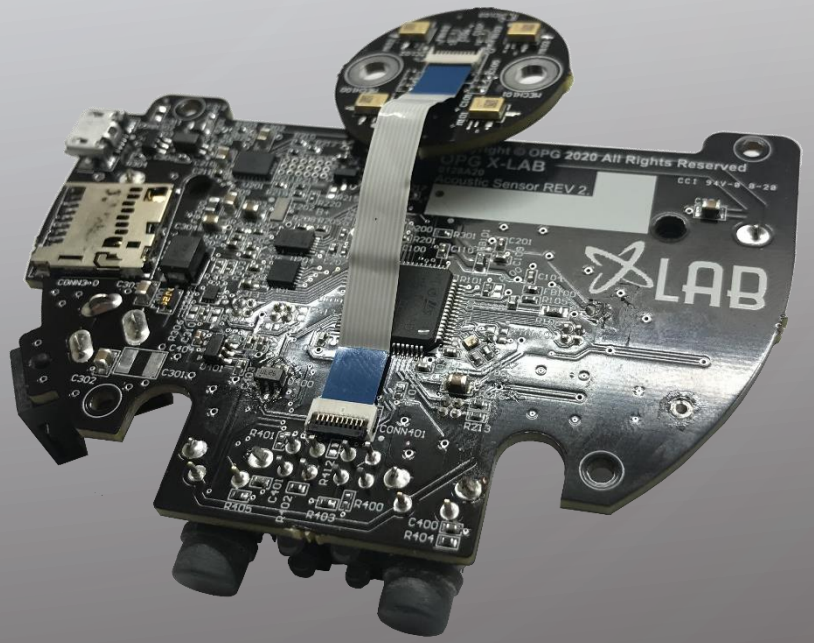
CHEAPER

NON-INVASIVE

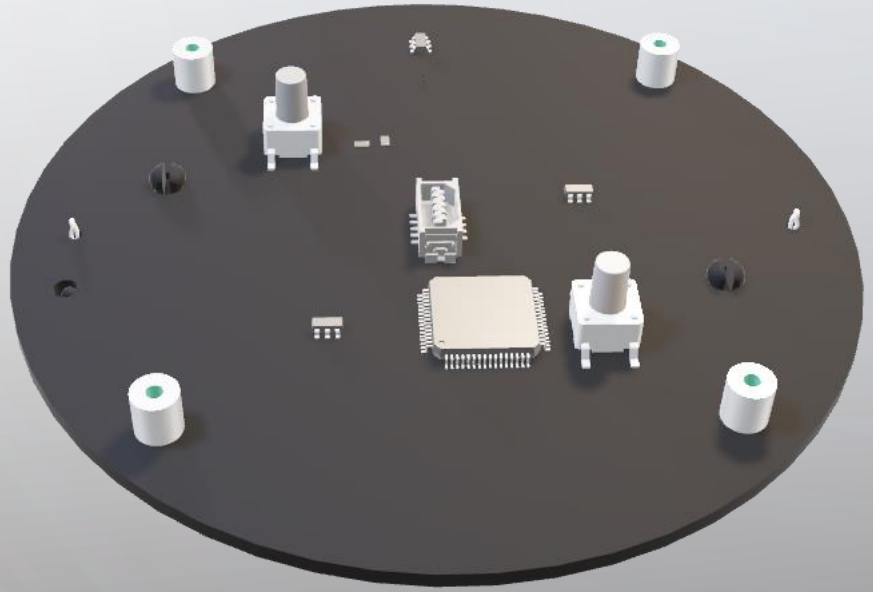
# DESIGN PROCESS - HARDWARE

- Microphone Board
- STM32 MCU, SD Card Slot, USB, Battery Fuel Gauge, Program Selector Switch

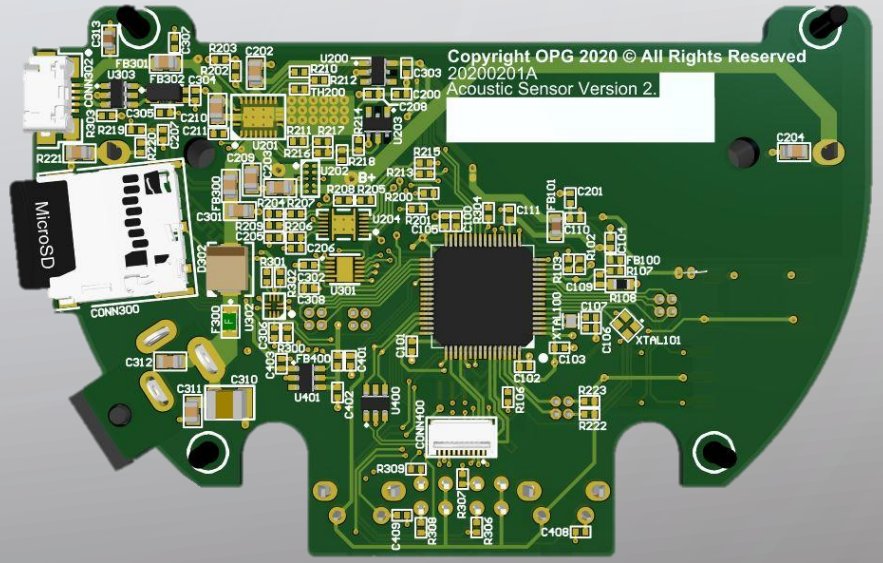




# EVOLUTION OF DESIGN



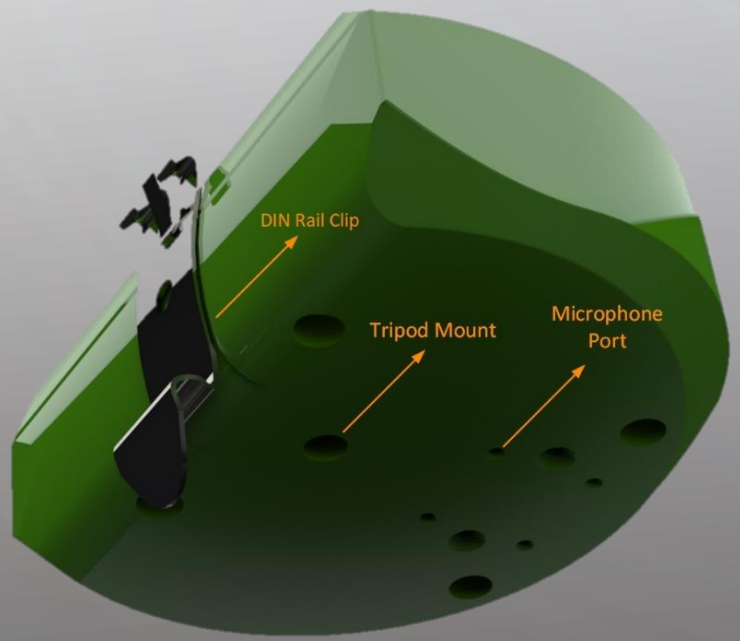
Preliminary PCB render

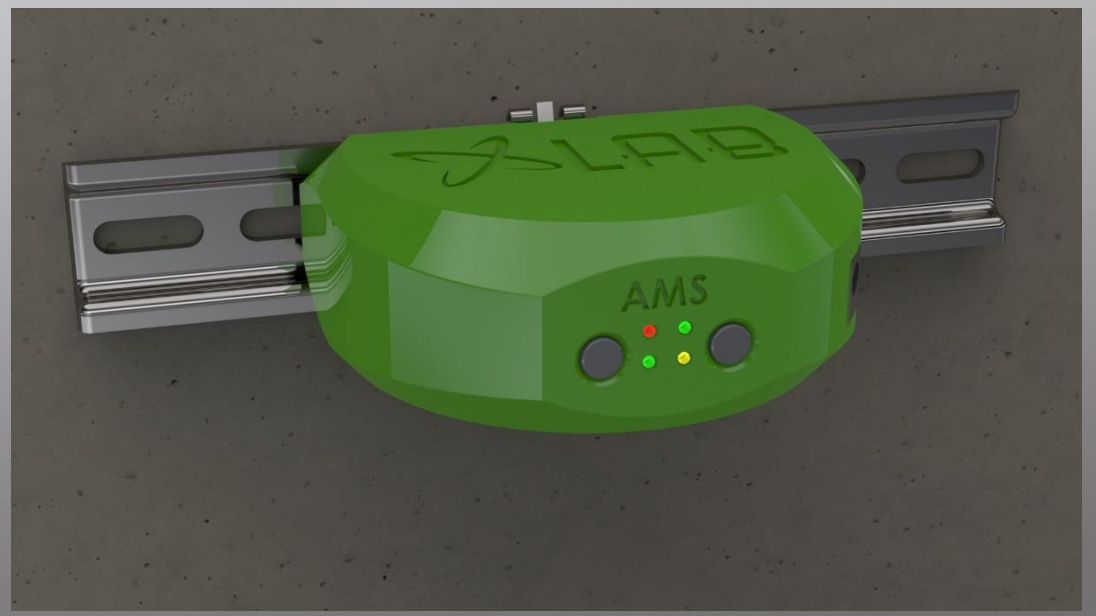



Print of PCB used for sensor

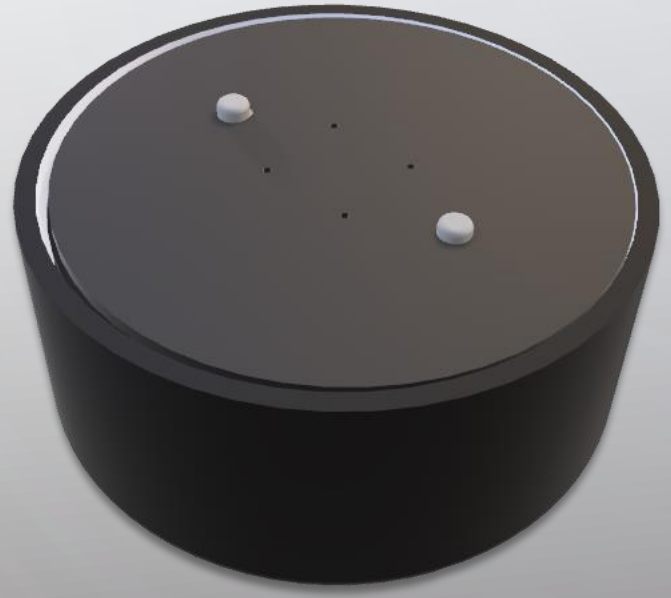
# DESIGN PROCESS – INDUSTRIAL DESIGN

- Allows for easy din rail and tripod mounting
- User interface consisting of 2 push buttons and 4 LED status indicators
- Final enclosure is 3D printed using a PolyJet SLA printer



# EVOLUTION OF DESIGN



Preliminary acoustic sensor render

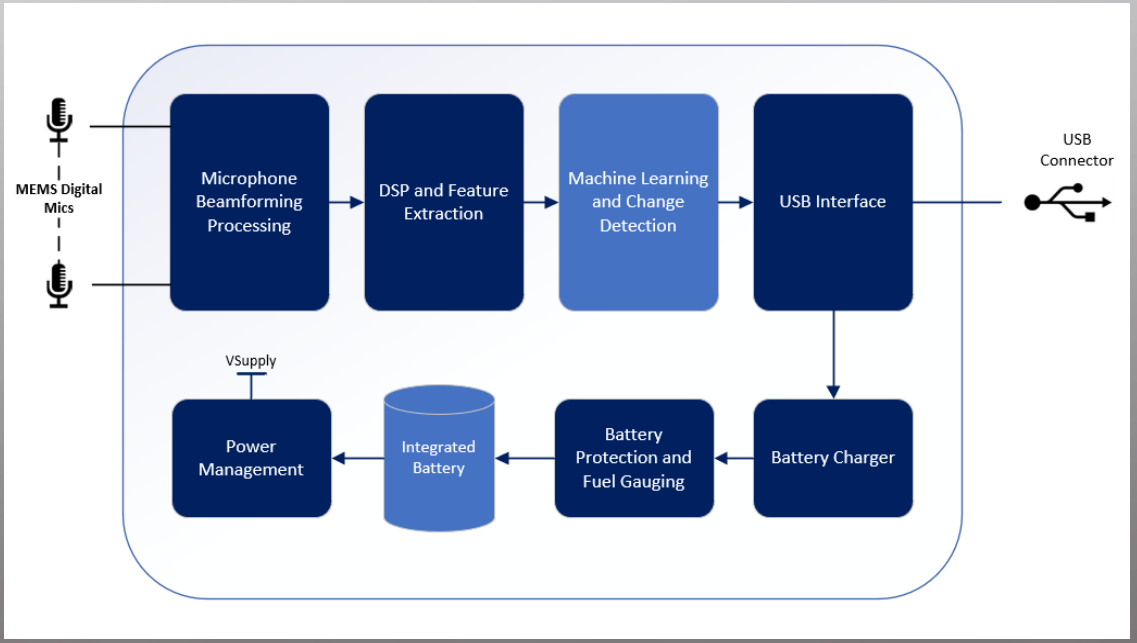
3D print of final enclosure

# DESIGN PROCESS - SOFTWARE

- Algorithms
  - Shaft Imbalance Detection
  - Motor and Pump ON/OFF detection
  - General Peak Detection
- SD Card
- Real time clock
- Communication
  - UART, USB, SPI, $I^2C$

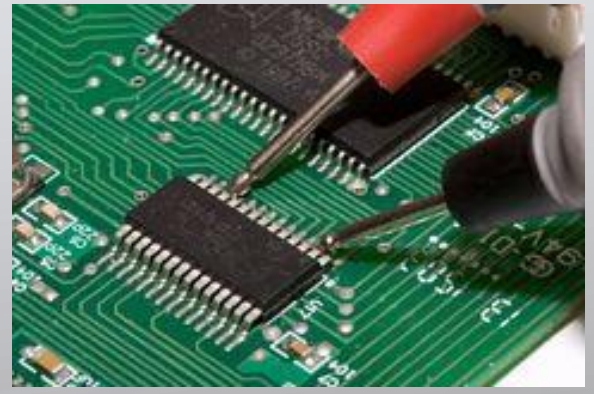
# TECHNICAL SUMMARY

- Measuring once a minute yields a battery life of one year
- Four microphones with eight listening angles
- 60 to 180 degree selectable beam width for beamforming

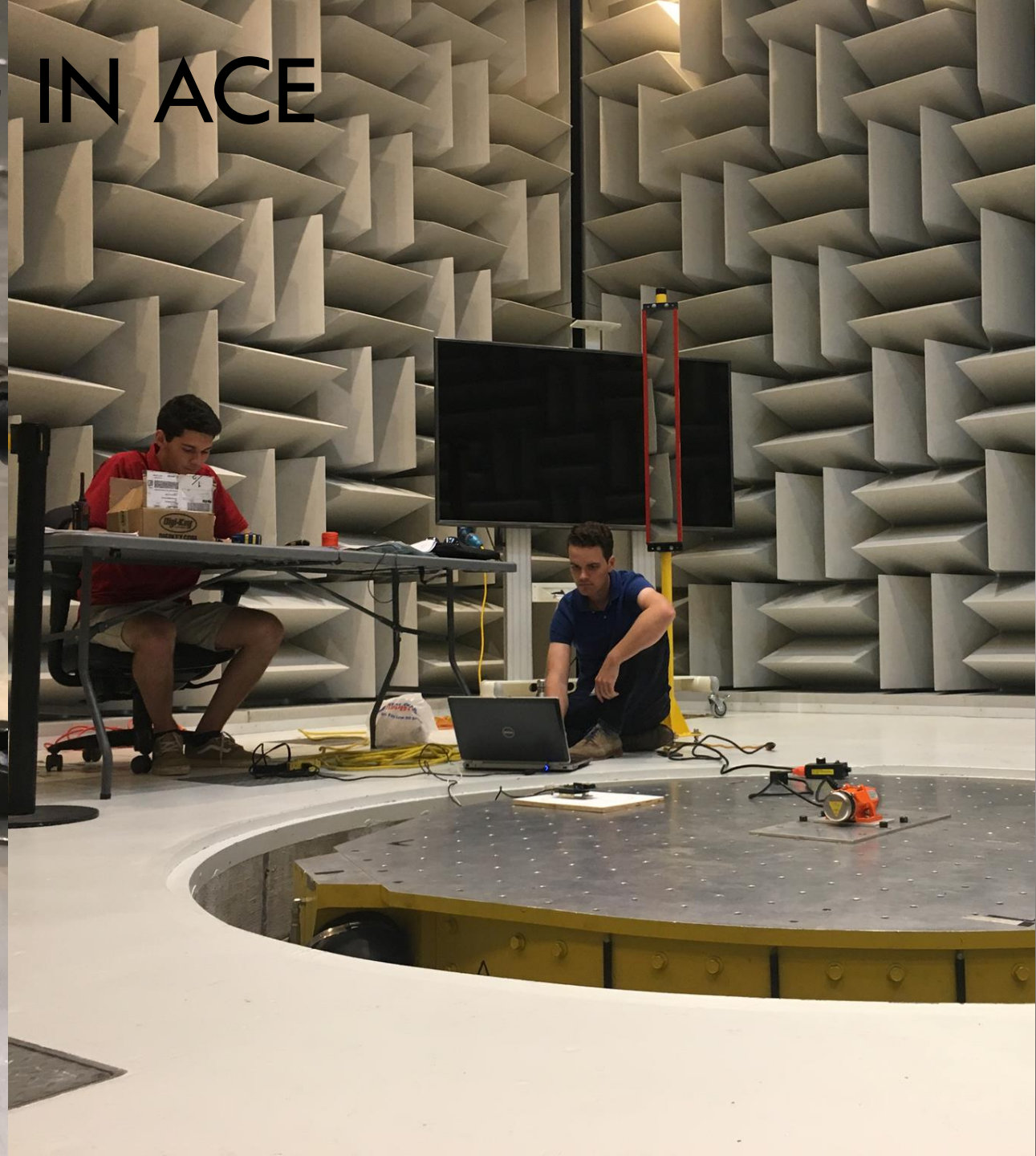


# SYSTEM VERIFICATION & VALIDATION

- Board Testing
  - Functionality
  - Safety from ESD
- User Interface
  - LEDs
  - Buttons
- Algorithms
  - ACE Testing
- System Validation
  - In-plant OPG testing



# TESTING IN ACE



# TESTING IN ACE

- Test #1
  - Beamforming Validation
- Test #2
  - Algorithm Development
- Test #3
  - System Verification

# STAKEHOLDER REQUIREMENTS

- Device should:
  - Be non-invasive
    - Acoustic Sensor
  - Be cost effective
    - Focuses on acoustic measurement as main sensing parameter to maintain cost effectiveness
  - Support stand-alone operation
    - MCU capable to interface with all of the PCB core services
  - Have low power consumption
    - Power management and fuel gauging to maintain control over power consumption

# FUTURE STEPS

- Pilot project of sensor in OPG station
- Applying acquired data from sensors to make data set for machine learning algorithm
- Adding additional features such as wireless capabilities and additional algorithms