Name: Nicholas Morris
University: Purdue University
Lab Site: Jet Propulsion Lab in Pasadena, CA
Mentor: Dr. Yoseph Bar-Cohen
Lab: Nondestructive Evaluation and Advanced Actuators (NDEAA) Technologies lab
Drilling Characterization:
Name of project: Placidus
Research Topic: Characterizing and Analyzing a Piezoelectric components in a Percussive Augmenter of Rotary Drill
Purpose: Industrialize Percussive Augmenter of Rotary Drills for construction use based on previously developed PARoD drills.
Ultimate goal is to prove that the PARoD attachment

Signal Processing:
Name of project: Con Edison
Research Topic: Developing a way to convert frequency of sound into a potential water volume assessment.
Drill Description:

- Consists of combining two forms of drilling: rotation and linear movement. Rotation to remove surface material and percussion to impact surface for scaring.
- **Rotation**
  - Basic commercial drill components as seen in the figure on left in red
- **Percussion**
  - Piezoelectric technology components that consist of turning an applied voltage of electrical energy into mechanical discharge
  - Description of Percussion Components:
    - Housing chamber called the slip ring that encompasses the drill itself
    - Where the drill bit normally is placed is instead replaced by a shaft that connects to the piezoelectric disk stacks that are composed of a certain ceramic material
    - And applied voltage is applied and goes through a transducer that encompassed by the dog bone shaped horn. Purpose of the transducer is to take electrical energy and produce a mechanical discharge of moving a part called the free mass that is vibrated through a cylindrical hollow tube connected to the top of the drill bit. This vibration causes the hammering.
  - As the drill teeth are rotating the piezoelectric components cause deeper material chipping and removal.
Modifications:
- Develop the most effective way of combining the attachments of PARoD and the commercial drill
- Resonant Frequency
  - What is the optimal frequency for the drill to operate at its full potential
  - This is determined by an impedance analyzer where it measures permittivity vs. conductivity ratios to conclude the best possible frequencies ratio
- Duty Cycle
  - The drill is being tested at 50% duty cycle with an ultrasonic frequency input of the resonant frequency chosen by the impedance testing.
  - This duty cycle has been tested at 2 and 5 second intervals where for 2 or 5 seconds of ultrasonic frequency signal to the piezoelectric stacks is 2 or 5 seconds that there is zero input to the drill.
- Axial Load or weight on bit
  - The load has been tested at about 25 kg and 55 kg where weights are interchanged at the rope seen hanging in the figure or at the top of drill.
  - Affects
    - RPMs because of friction between drill bit and surface

- Transducer Temperature
- Wear & Tear
Experiment:

• The drill is operated in 5 minute intervals on a limestone block where during that time I would measure:
  • Drill Depth
    • caliber
  • RPMs
    • Handheld device
  • RMS (Root Mean Square)
    • Connected RMS Power Multimeter
  • Transducer
    • Labview dial
    • Measures ?????
  • Labview Program
    • Resonant Frequency
      • 24,500, 25,8000, and 16,500 Hz
    • Duty Cycle Time Interval
      • 2 or 5 seconds
    • Voltage applied
      • 0.5 Volts

• Ultimate Goal
  • Drill through cement and rebar
As you can see in the graph on the right the data actually shows improvement from rotation only to the attachment of the PARoD component. Unfortunately the prototype broke multiple times with loosening screws and breaking components because the transducer was too much for the drill to handle so a truly effective drilling rate was not developed but from exploration you can see it is worth pursuing. Once the drill structure and attachment are secure improved results will follow.
Signal Processing:

- Examine the possibility of using a simple method of applying impacts to a pipe wall and analyzing the sonic characteristic differences
  - Sound Quality and Differentiation
    - We can hear the difference in sound when a pipe is struck with a hammer just like finding a stud in a wall
  - Resonant Frequencies
    - Transfer and convert the data into amplitudes of frequencies to see if sound difference could be linked to frequency output of collisions
  - Damping
    - Take the basic recording and see if sound over time has a pattern or trend such as impact amplitude and sound deprivation over time
Glass harmonica is the art of performing with glass containers filled with variations in liquid to produce notes for a composition.
• produce resonant frequencies and damping
  • remain consistent as liquid is added or reduced to the confines of the glass.

The initiative was taken to associate the physics of glass harmonica to the investigation of water condensation height measurement in a steam pipe.
Experiment:

• Testing Platform
  • Scaled to a 36” long 16” diameter steel pipe enclosed by two Plexiglas Walls on either side
  • 1” insulation wraps the mid section of the pipe to model the field pipe
  • 1 lb weight is suspended an inch above the crown of the pipe and dropped for recordings
  • Microphone records the impact through a standard computer sound recorder in wav format
  • A program I developed in Matlab read and analyzed the recordings and converted the data into a FFT graph
• Wanted to find a consistency of amplitude of a certain frequency but as you can see in the FFT graph above the graph becomes arbitrary.

Unfortunately a simple method was not developed as we pursued but later complex testing will use my data as basis to later discovery.