THE DESIGN LAB at Rensselaer

2017-18 Capstone Projects Portfolio

Biomedical
Computer & Systems
Electrical
Industrial & Systems
Materials
Mechanical
Engineering Programs

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http://eng.rpi.edu/mdl/

The 2017-18 Projects Portfolio of the O.T. Swanson Multidisciplinary Design Laboratory (The Design Lab) at Rensselaer highlights the achievements of our students in solving real-world design challenges. This year, our senior engineering students tackled design projects ranging from applying technology to improve the sustainability of a public garden to automating the Field House horn to technology applications with voice activation, gesture recognition and augmented reality systems.

The Design Lab is experiencing the effects of Rensselaer's increasing enrollments. Our numbers increased to 405 students and 55 design projects this year – a record number in our 18-year history. The multidisciplinary project teams included students from biomedical, computer and systems, electrical, industrial, materials, mechanical and nuclear engineering disciplines. Rensselaer engineering students graduate with the ability to work on diverse teams to solve real problems with multifaceted constraints and deadlines, due in large part to their Design Lab experience. They solve their Capstone design challenges through hard work, intellect, and creativity, as well as the dedication and engagement of our sponsors.

Here are some highlights from the 2017-18 academic year:

1. The Design Lab welcomed 5 new industry sponsors: GE Global Research Center, Johnson and Johnson, Leviton Manufacturing Co., Inc., Synqware, United Technologies. We also welcomed Boeing back to the Design Lab.
2. We obtained a grant from the Electric Power Research Institute (EPRI) for a Capstone project in conjunction with NYISO.
3. Several Capstone projects were conducted in support of RPI research centers and STEM outreach. This included two projects with the Materials Science and Engineering Dept, another with LESA (Lighting Enabled Systems & Applications) and others to enhance technology for specific engineering courses, labs and the Engineering Ambassadors program.
4. The Design Lab welcomed 7 undergraduate students from Rensselaer's Lally School of Management. They teamed with engineering students on several Capstone projects, creating a more realistic experience for both groups. The management students applied their skills and expertise in marketing analyses, business development strategies, and cost models to assess the impact of cost on engineering designs. We are excited about the new Capstone collaboration with the Lally School.
5. We also welcomed two new Professors of Practice. Prof. Manoj Shah joined the ECSE Dept following a long, successful career with GE. Prof. Gopal Sundaramoorthy is affiliated with the Lally School. His executive experiences at GE and Philips Healthcare, and his engineering education, benefitted both management and engineering students.

Sincere thanks to our sponsors, partners, and friends for providing technical challenges for our undergraduate engineering and management students this year. Our staff and faculty are also gratefully acknowledged for their dedication to the students, and the Design Lab mission of creating future engineering leaders. I look forward to collaborating with you on future Design Lab projects. Your input is always welcomed as we strive to improve the Capstone experience for our students and better serve our industry partners,

Kathryn A. Dannemann, Ph.D.
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2017-18 Capstone Design Projects

Energy and the Environment

Generator Cooling

Spring 2018 Team: Robert Ballard (MECL), Alex Carandang (MECL), Diego Cuitino (MECL), Aidan Curtin (MECL), Casey Darling (ELEC), Junyu Huo (MECL), Grace Rabinowitz (MATL), Michael Tivinis (ELEC)

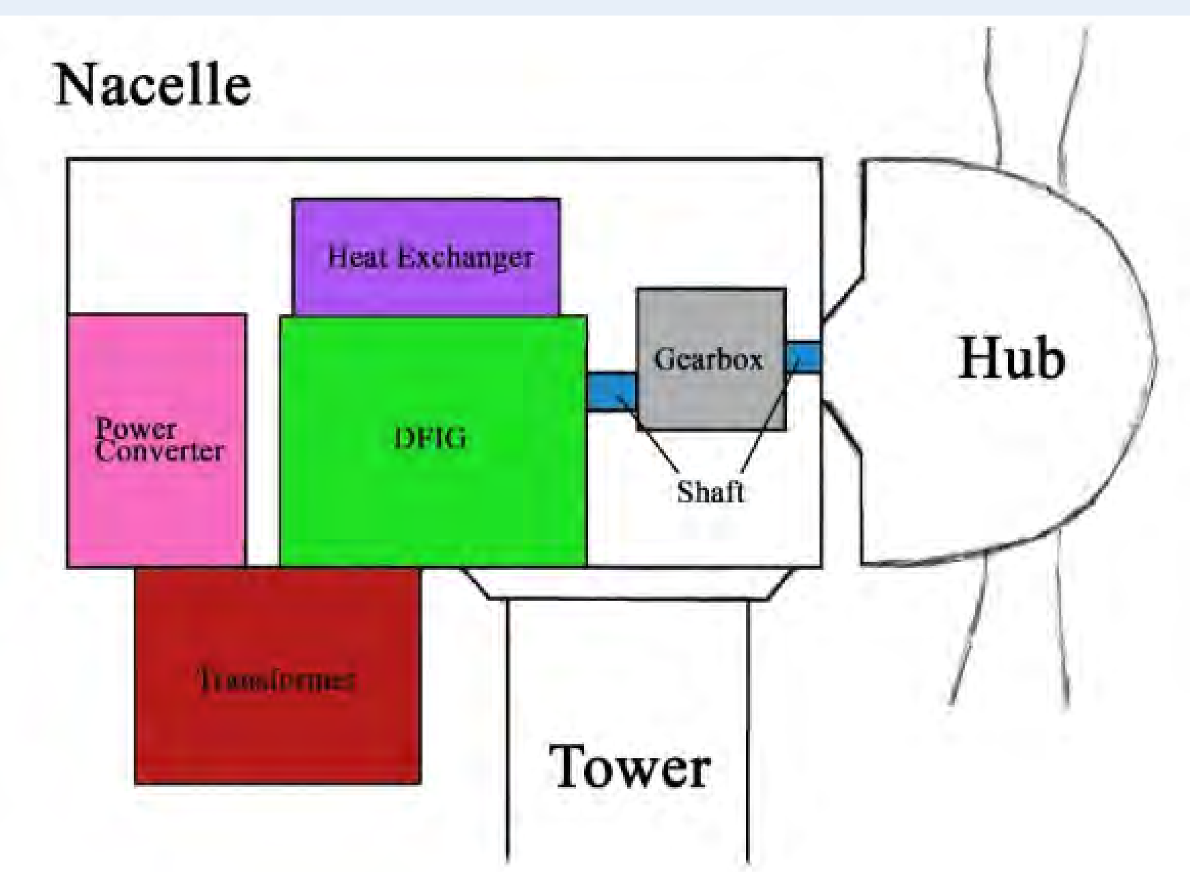
THE DESIGN LAB at Rensselaer

GE Energy Renewable Energy

Purpose: Fit the transformer into a wind turbine nacelle by size reduction of the transformer and DFIG

Background:

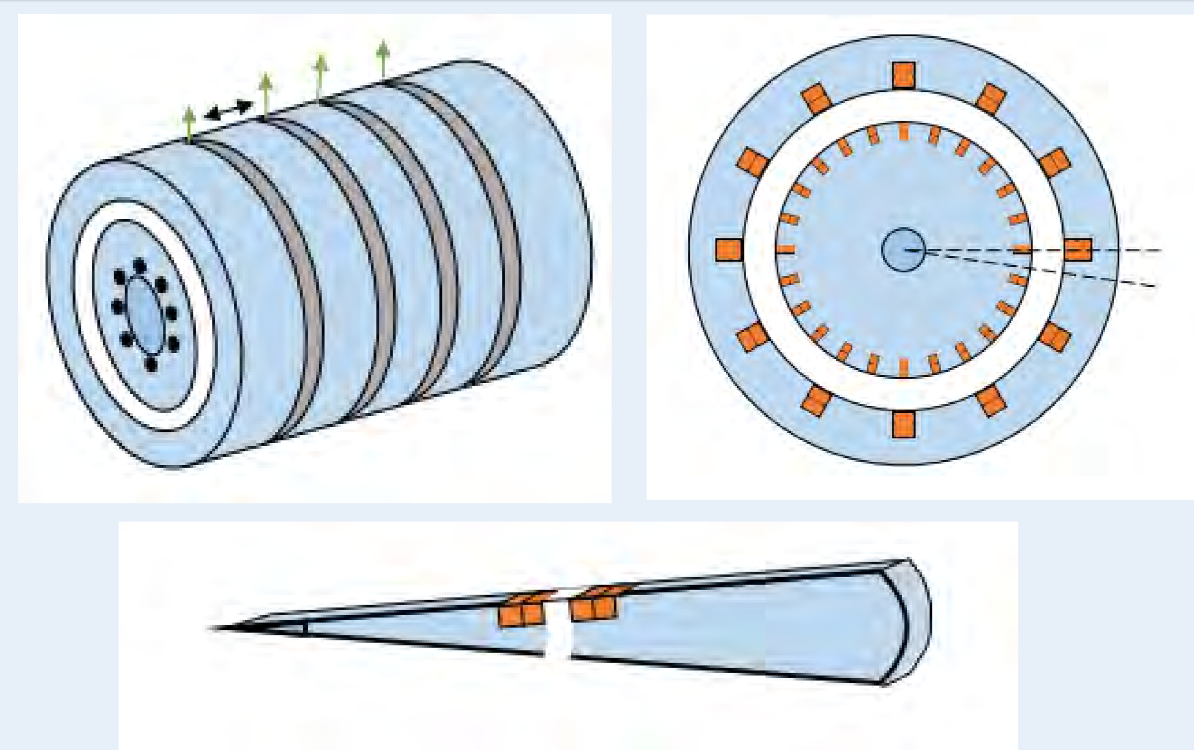
- Components of interest: DFIG and Transformer
- If components can be shrunk, they may all fit in the nacelle
- GE Renewables developing ways to stay competitive in the market
- Reduce Installation and shipping costs for larger machines



Semester Objectives:

- Develop a thermal model to analyze cooling concepts
  - DFIG
  - Transformer
- Develop size reduction model for DFIG and Transformer
  - Enabled by temperature reduction
  - Enabled by insulation classes and core material properties
- Determine the volume reduction of each proposed system

DFIG Thermal Model:



Nodal Network

$$Q = \frac{\Delta T}{R} = \frac{T_2 - T_1}{R_{1-2}}$$

Radial: $R = \frac{\ln(\frac{r_2}{r_1})}{2\pi k L}$

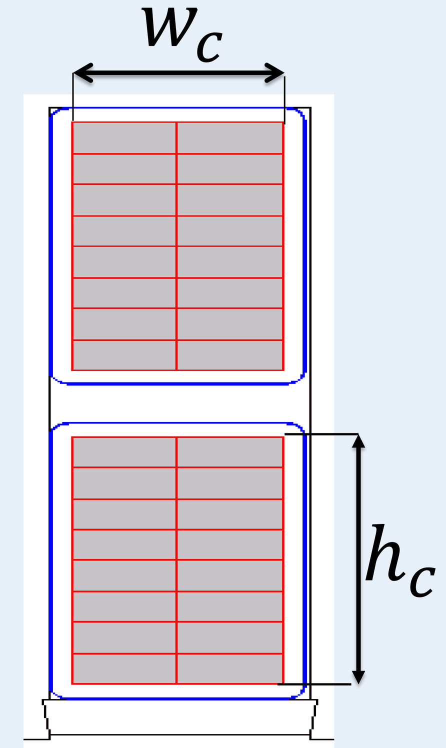
Axial: $R = \frac{D}{kA}$

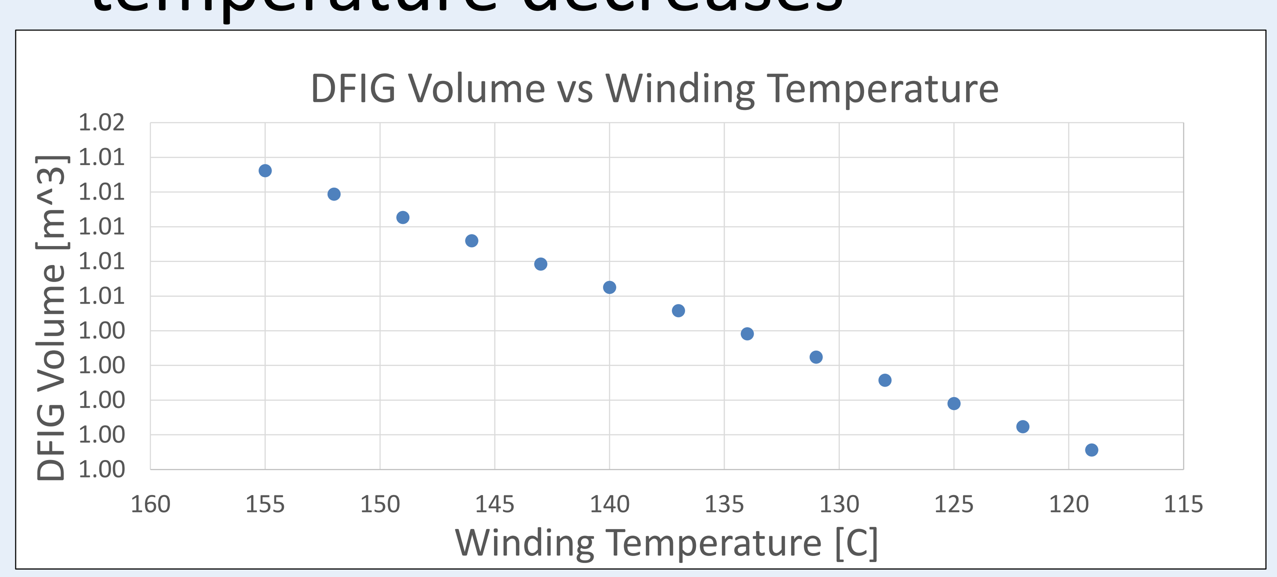
Convection: $R = \frac{1}{hA}$

For any node: $\sum Q_{generated} - \sum Q_{removed} + \sum Q_{transferred} = 0$

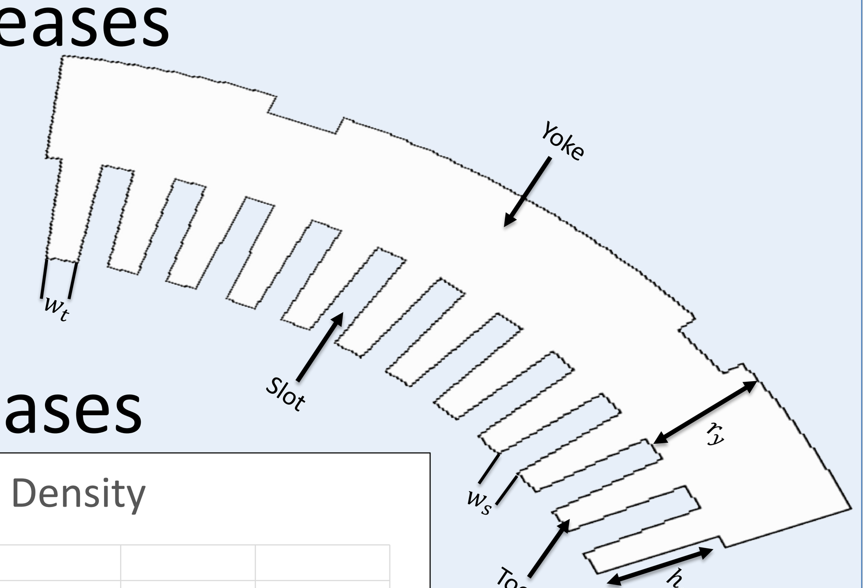
Generator Size Reduction:

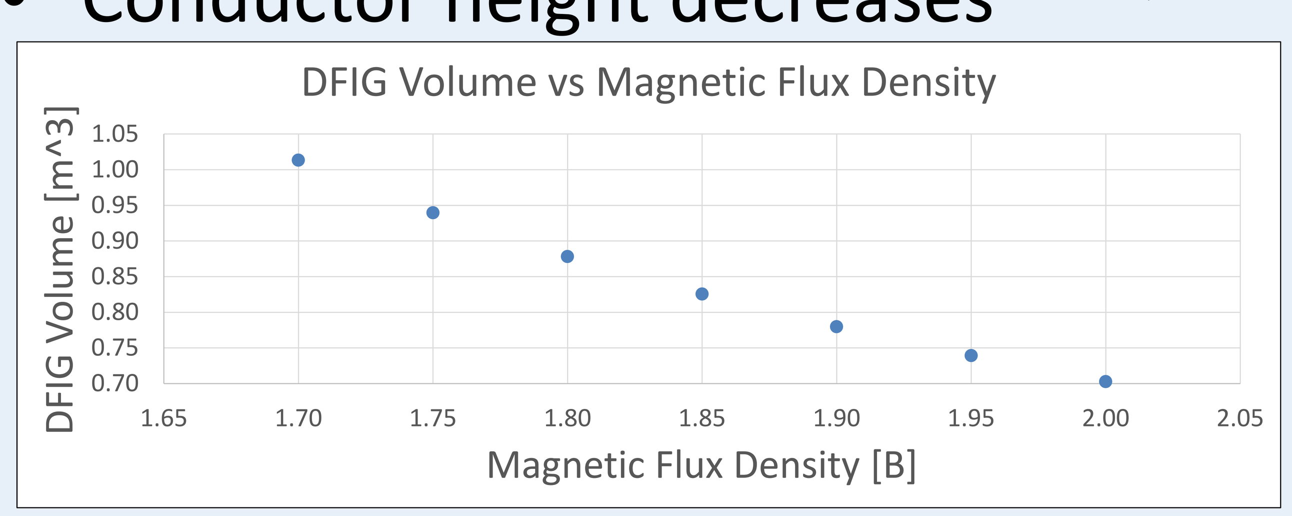
- Conductor height $[h_c]$ decreases as temperature decreases





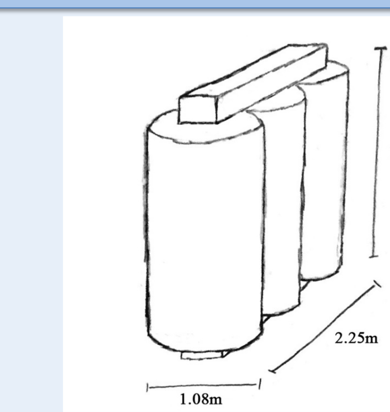
- Grain oriented steel allows 15% greater magnetic flux density [B]
- Radial yoke height decreases
- Tooth width decreases
- Slot & conductor width decreases
- Conductor height decreases

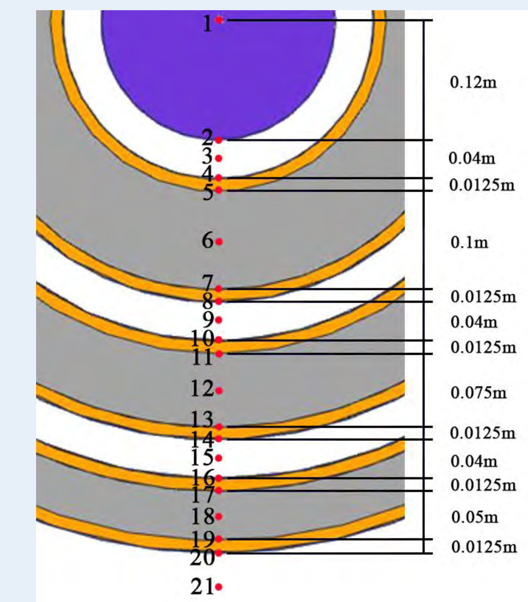


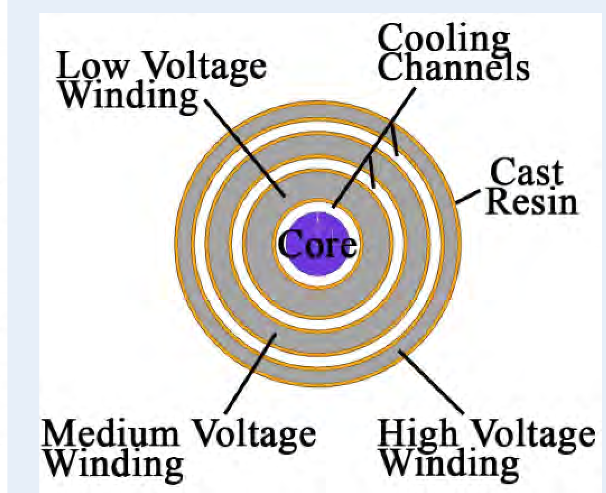


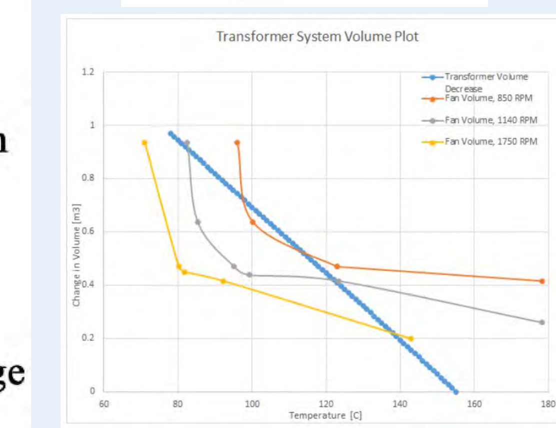
Transformer:

- 3 Phase, 3 winding transformer
- Forced air convection



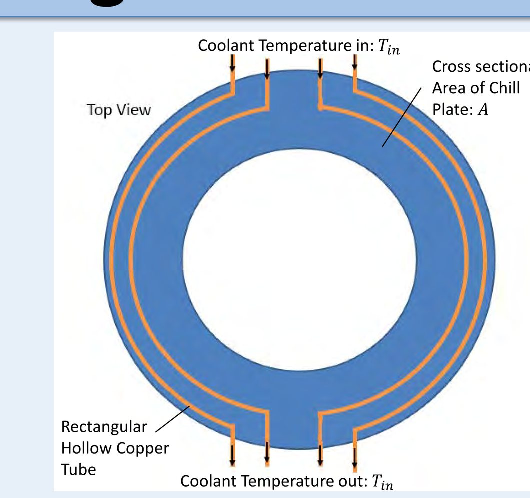


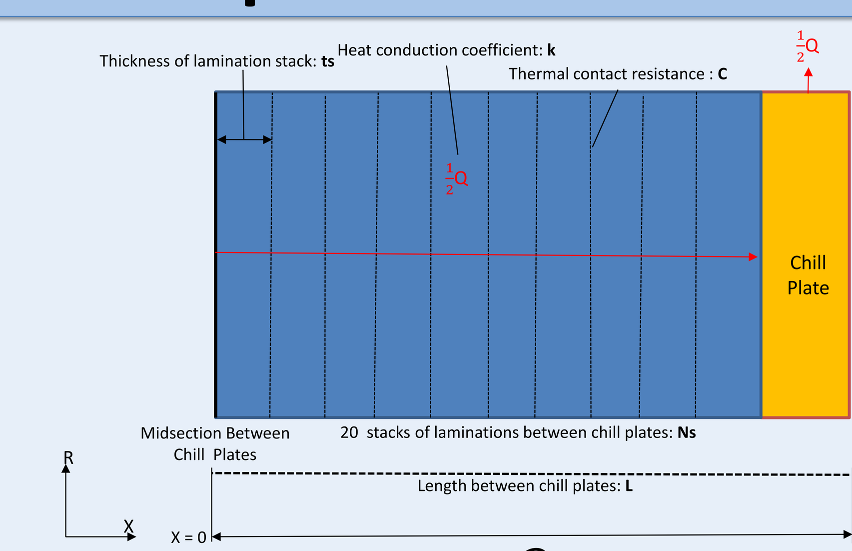


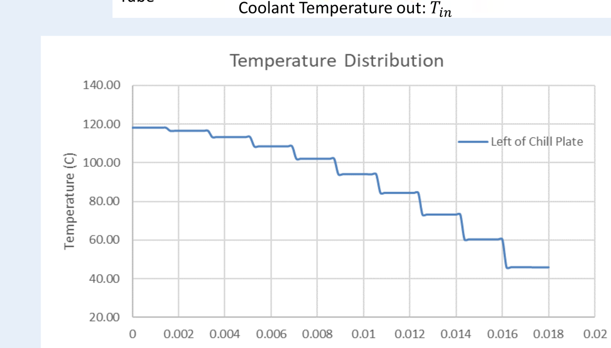


- The radius of each phase decreases with temperature decrease
- Grain oriented steel reduces the volume by 3.5%

Cooling Method DFIG - Chill plate:





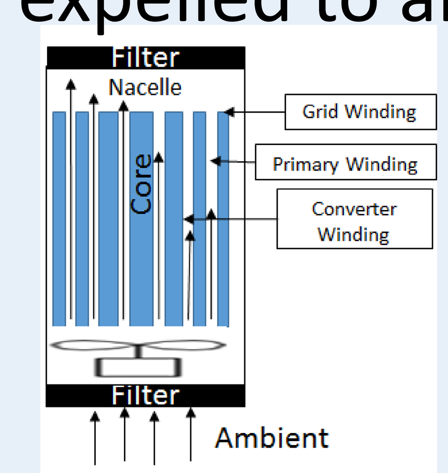


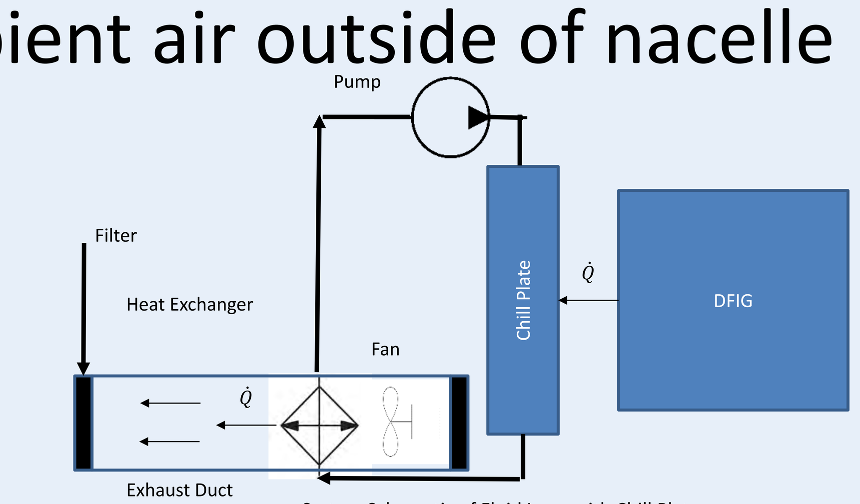
$$Tout = Tin + \frac{Q}{\rho C_p \upsilon}$$

$$T(x) = Tout + Q_v\left[\frac{\left(\frac{L}{2}\right)^2 - x^2}{2k} + \frac{C\,\Sigma x_{Ns}}{2}\right]$$

Heat Exchangers:

- Liquid to air exchanger in DFIG
- Fan cooling in transformer
- Heat expelled to ambient air outside of nacelle





GE Blade Inspection Robot

Spring 2018: Enxhi Marika (MTLE), Erika Tischbein (MECL), John Forbes (MECL), Marvin Cosare (MGTE), Matt Tice (MECL, BMED), Matthew McConnell (ELEC), Matthew van Rhyn (MECL), Yifan Xu (CSCS)

Project Purpose & Background

Turbine Blade Specifications
- 40 meters long (and increasing)
- 128 accidents/year (2007- 2011) due to defects

Current Inspection Processes
- Manual Rope Access Inspection
- Drone Visual Inspection
- Ground Based Camera

Manual Blade Inspection

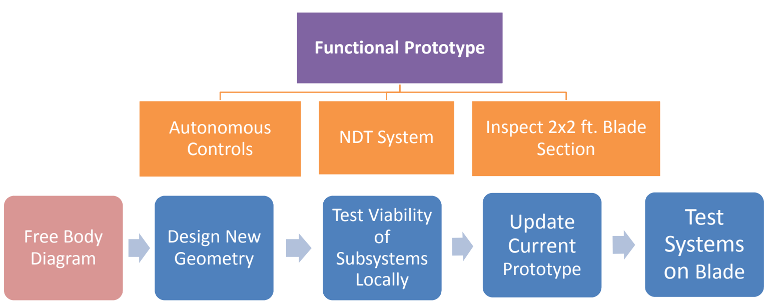
GE Needs
- An autonomous robot capable of inspecting wind turbine blades through non-destructive testing techniques.
- An increase in efficiency, accuracy, and safety over current testing procedures.

Past Work

- Operational robot with vacuum powered suction cups
- Robot Controlled Manually
- Dirty blade suction cup testing
- Market and cost analysis
- **Disadvantages: "**Zigzag" Motion, not much room for inspection package

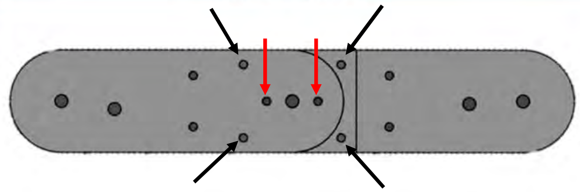
Gecko Chassis Design

Current Objectives/ Technical Approach



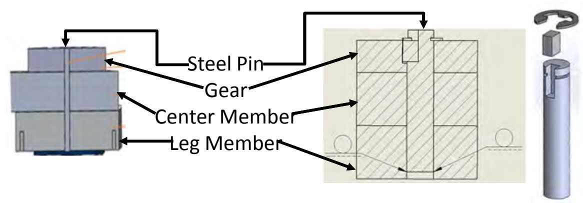
Technical Results and Accomplishments to Date

Chassis Update



- NDT Mounting Holes
- Fixed Central Member

Gear Shaft Design



Fall 2017 Design **Spring 2018 Design**

Non-Destructive Testing – Ultrasonic Testing

Ultrasonic Testing

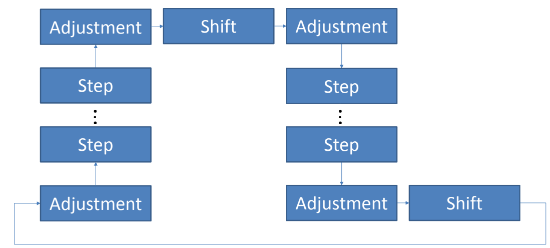
The use of sound waves to identify blade defects.
- Ultrasound does not travel well through air so a coupling system is required – usually a gel/ couplant

Couplant Testing
- Couplant Application, Clean Up, Wet Blade Inspection, Gravity Analysis, Fouling Testing, Suction Cup Interaction, Safety, Ultrasonic Reading, Temperature Range, Cost

Recommended Couplant: Sonoglide FE20

Recommended Transducer: Olympus Rollerform

Control System



State Diagram

Movement Type	Time (s)	Parameter	Length (ft)
One Forward / Backward Motion	5	One Step	0.75
		One Transducer	0.168
2ft Forward / Backward Motion	13.3	Total Width	2
		Total Height	2
One Left / Right Shift (1 transducer length)	14	**Total Time**	
Error Recognition	5	= total width/transducer length*(one straight time *total height/one step+one shift time)	
Full Path Follow (2ft x 2ft)	206	= 2 ft / 0.168 ft * (5*2/0.75 +14) s = 206 s	

Command Manual

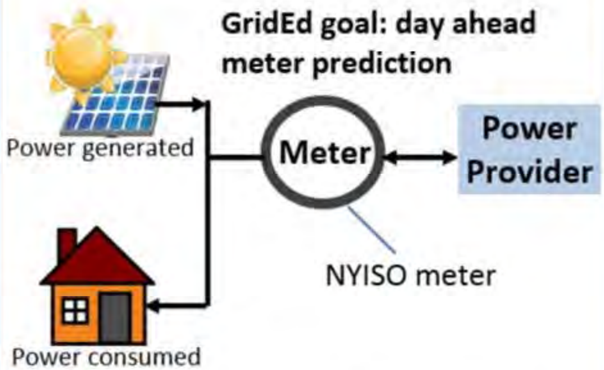
Feature	Command	Output	Action
Safety Lock	-	"The suction cups are not in suction"	The robot should stop and wait for inspection. All suction cups should be in suction.
Initial Position Configuration	I, k	"The robot should go through initialization before in use"	The user should use commands to set up the initial position for robots.
Emergency Stop	p	"The robot has stopped"	The robot should stop and wait for inspection. All suction cups should be in suction.
2ft x 2ft scan	o	"Start scanning…"	The robot will start scanning from desired position.

GridEd: Power Production Prediction

Spring 2018: Alexander Mehner (EE), Ashley Saadatmand (EE), Wenhui Chen (EE), Bingsheng Yao (CSE), Zhengzhi Wang (EE/CSE), Robert Hazell (ISYE)

Purpose and Background

Customers: NYISO, EPRI, RPI



Power prediction must include renewables

Project History

- Linear Regression model
- ECAV power generation ANN model
- Weather data collection

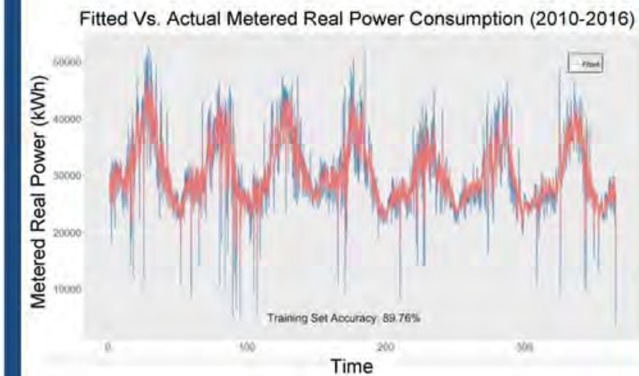
Semester Objectives

- Model grid power supplied to EVAC
  - -Statistical Analysis
  - -Artificial Neural Network
- Upgrade weather data collection system
  - -Record partial cloudiness
  - -Wirelessly transfer weather data
  - -Powered for a week long operation

Technical Approach and Results

Statistical Analysis

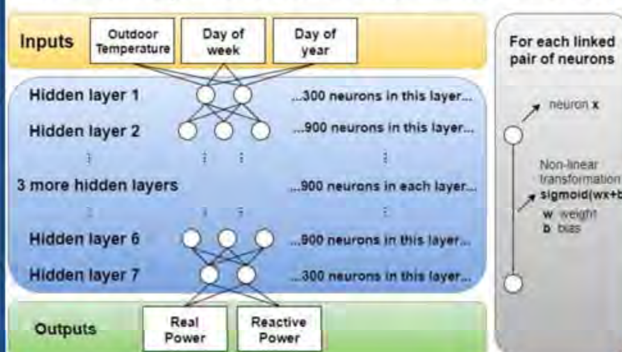
- ARIMA(50,0,1) Model Implemented



- 2017 test sets (1/1-1/30, 3/16-4/14)
- At least 90% forecasting accuracy

Artificial Neural Network

- Training data: 2010 ~ 2016
- Forecasting: 2017
- Accuracy: 78% for real 84% for reactive

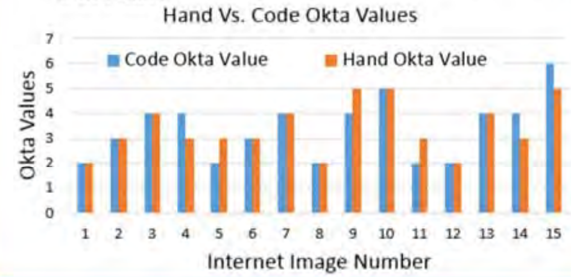


Weather Data Collection System

Partial Cloudiness Reading

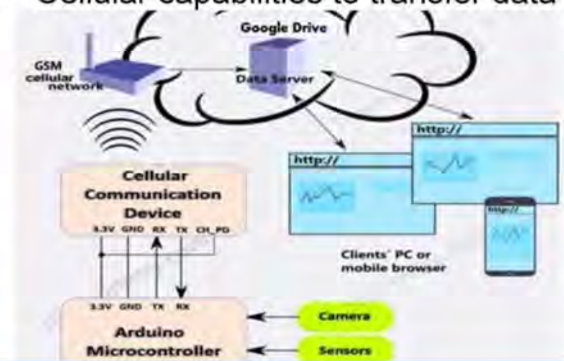
- Okta used as standard measurement

$$\frac{\sum \%\text{Cloud per Pixel}}{\#\text{ of Pixels}} = \%\text{Cloud Coverage} \rightarrow \text{Okta Value}$$



Wireless Communication

- Cellular capabilities to transfer data



Battery System

- Battery capacity > 30, 000 mAh
- Battery Charge Monitoring System

$$\text{Charge } \% = \frac{\text{Battery}_{\text{Capacity}} - (\text{AVG}_{\text{Current}} \times \text{Time})}{\text{Battery}_{\text{Capacity}}} \times 100$$

Smart Dimming Control

Spring 2018 Team: Wen Gu (CSE/EE), Tianjian Huang (EE/Math), David Kerr (EE),
Sean Thammakhoune (CSE/EE), Eric Tran (CSE/CS), Qing Yu (EE), Chenjun Zhou (CSE/CS)

Purpose: Eliminate visible flicker in LEDs with use of Leviton dimmers

Semester Objectives/Requirements:

- Determine characterization method to differentiate bulbs by flicker behavior
- Create algorithm to classify bulbs by electrical performance to predict flicker

Future Work:

- Determine root cause of flicker
- Develop dimmer circuit to compensate for flicker

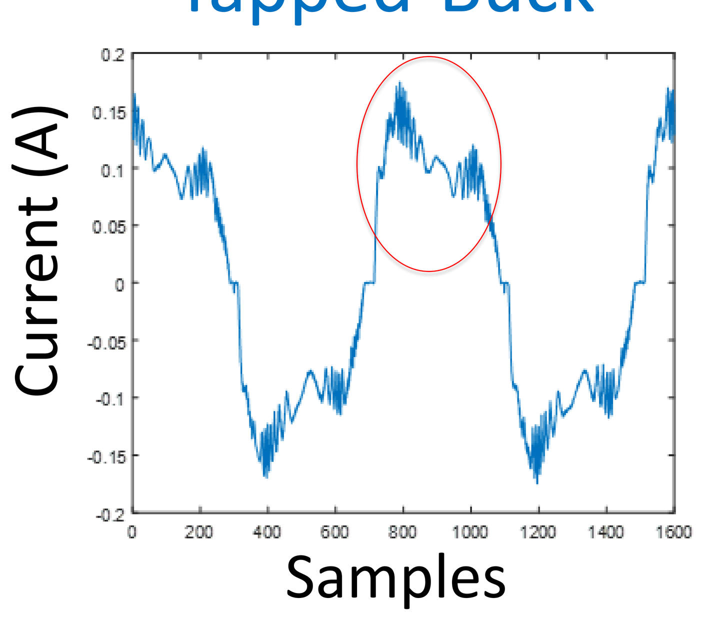
Technical Approach & Results

Bulb Characterization

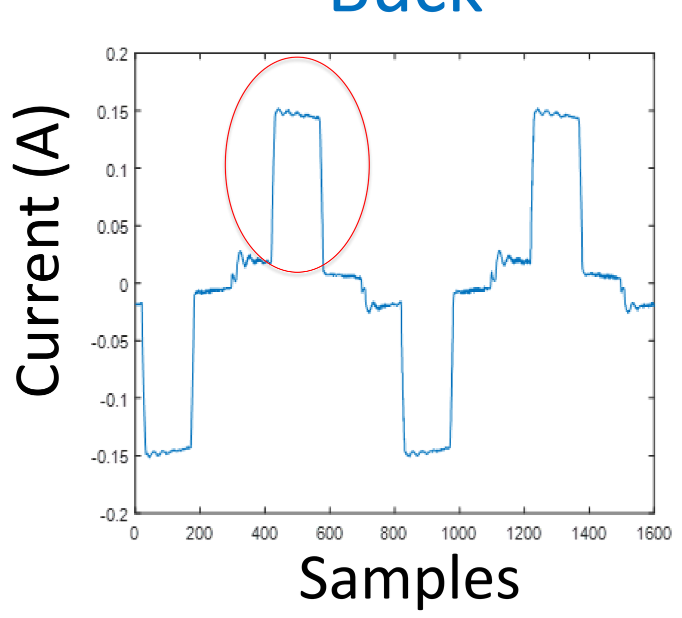
Hypothesis: There are different electrical components that drive LED's, causing different flicker behavior

Notable Differences between Electrical Current Waveforms in Time Domain

Tapped-Buck



Buck



Bulb Type	Characterization
LED	Tapped-Buck, Buck, Buck-Boost, & Flyback Converters
Incandescent	Sinusoidal Wave*
CFL	Triangle Wave*

*shape of electrical current

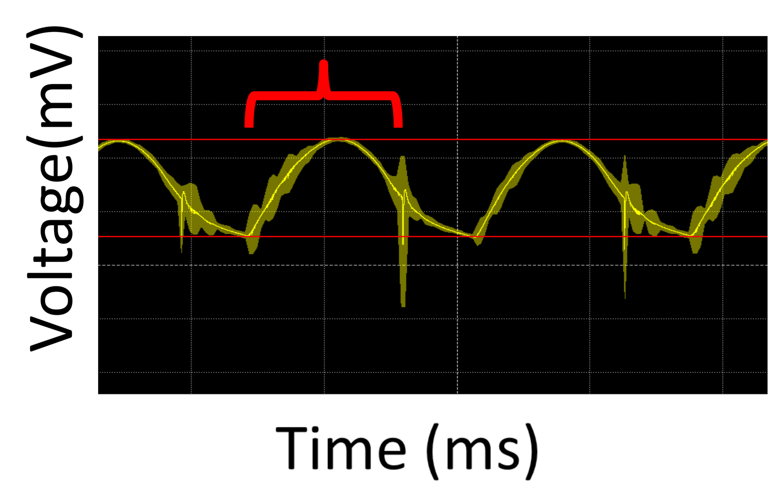
Conclusion: There are four different sets of driving circuits that can drive an LED

LED Flicker Association

Flicker Output

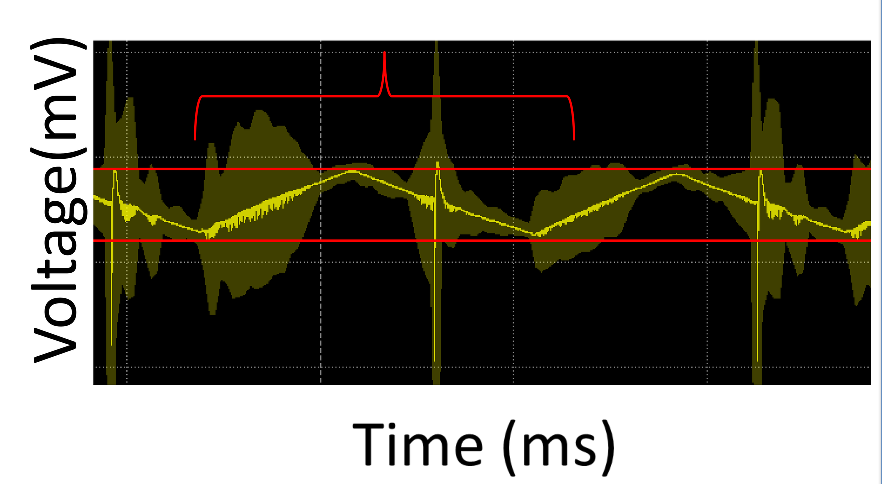
- Output dependent on driver

Tapped buck produces RC like output



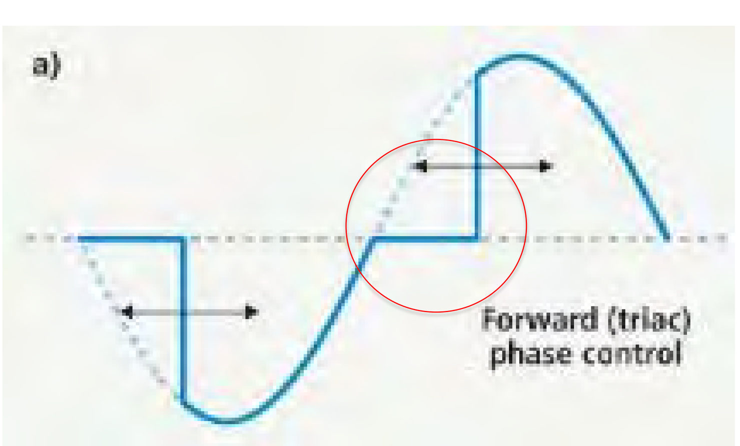
Flicker from Tapped Buck

Buck produces distinct triangle wave



Flicker from Buck Converter

LED Effects on Zero-Cross Line of Phase Control



Ideal Triac Phase Control

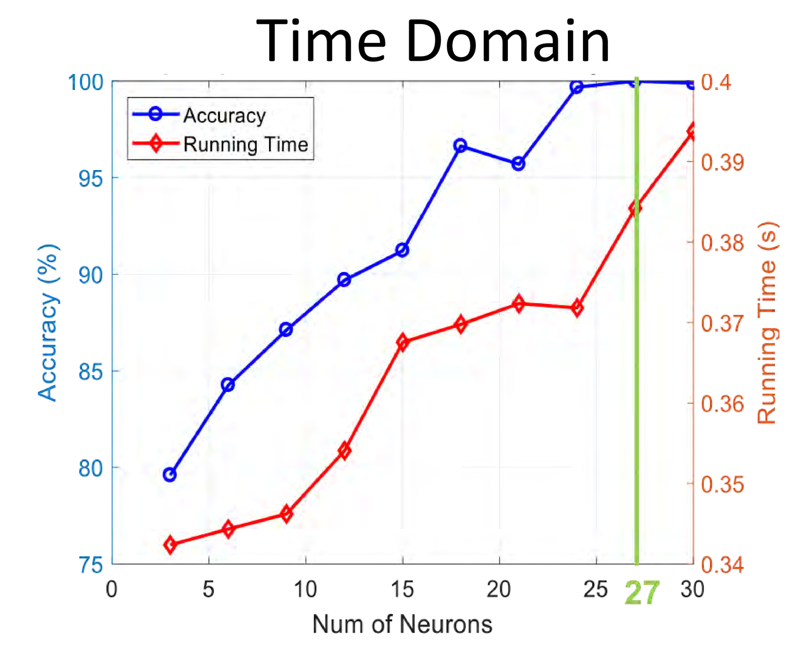
https://knightsoundandlighting.com/2015/06/01/why-do-reverse-phase-dimmers-work-better-than-traditional-forward-phase-dimmers-for-led-lighting/

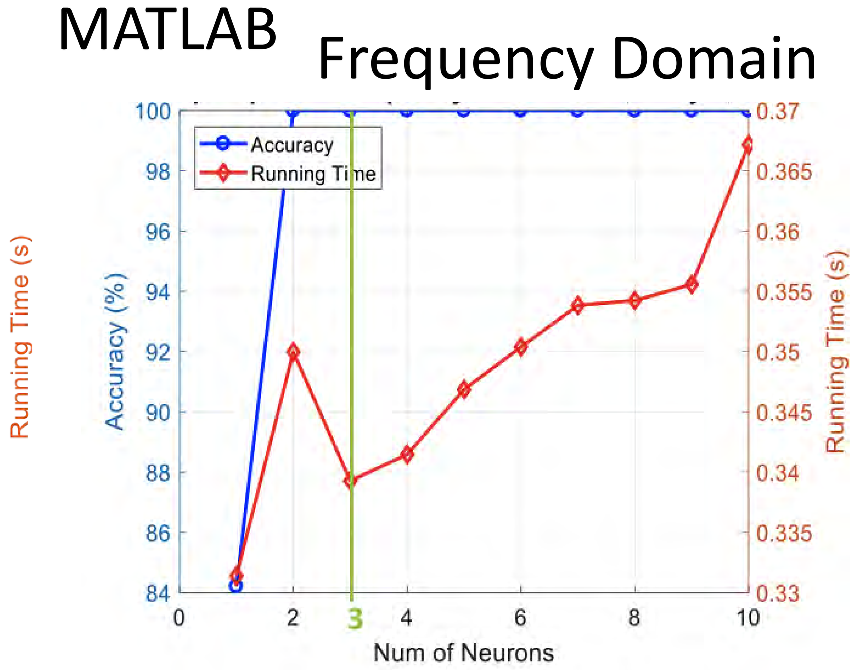
Experimental Phase Control Buck Converter

Conclusion: Buck converter interferes with phase control, causing flicker

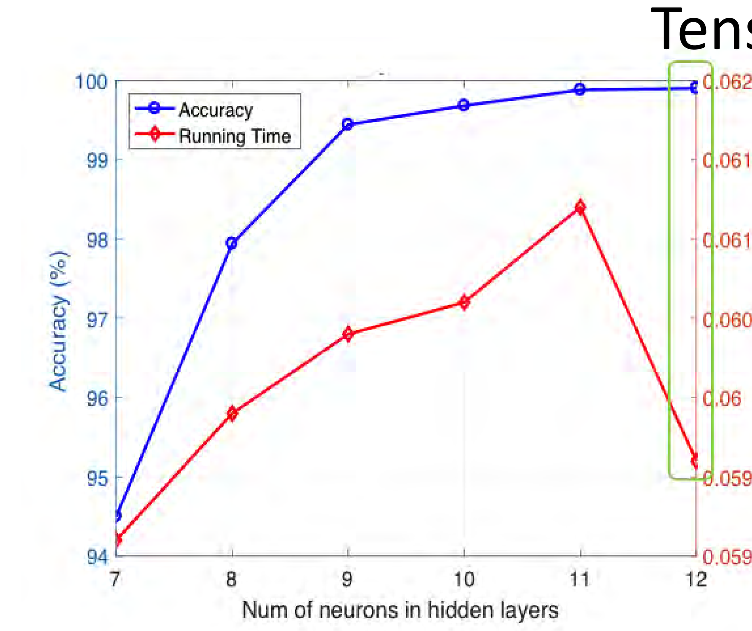
Machine Learning Development

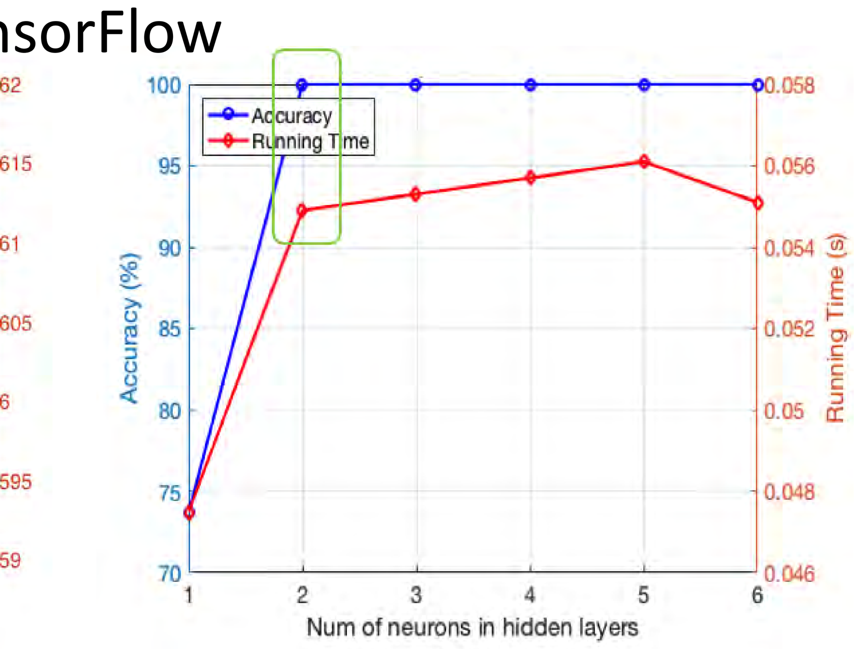
MATLAB





TensorFlow





Freq Domain	MATLAB	TensorFlow
Accuracy (%)	~100	~100
Running (s)	0.340	0.055

Time Domain	MATLAB	TensorFlow
Accuracy (%)	>99	>99
Running (s)	0.385	0.060

Conclusion: Use frequency domain data to train neural network in TensorFlow

Health/Wellness and Assistive Technologies

Medicine Management

Fall 2017 Team: John Aldana (MECL), Andrea Duncan (BMED/MATL), Matthew Freeberg (CSYS), Rachel Godusky (BMED/MECL), Cassidy Saal (MECL), Kenneth Schmitt (CSYS), Swetha Sriram (IME)

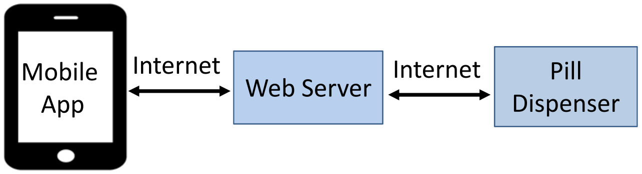
Project Purpose

To develop a device that is able to improve adherence to prescribed medication regimens by improving medication organization, managing complex schedules, and adherence monitoring. It will improve quality of life by increasing independence and reducing emergency healthcare costs.

Semester Objectives

- Develop physical system to aid in the organization and dispensing of medication
- Develop Internet of Things (IoT) system and accompanying mobile application to manage prescriptions, scheduling, and adherence
- Integrate physical system and IoT system

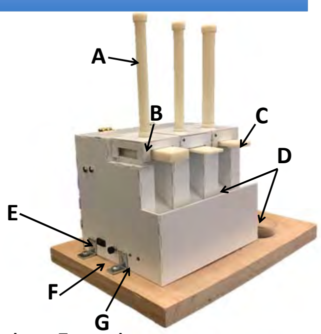
System Overview



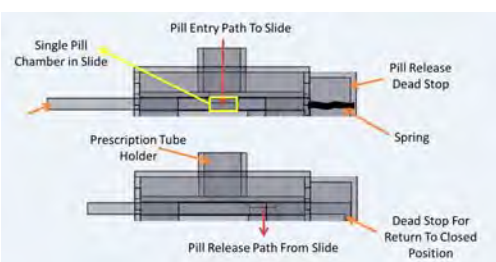
Input medication schedule data into system from mobile user interface with Wi-Fi connection	Medication data storage	System alerts user at designated times and appropriate medications are taken

Pill Dispenser

A. Pre-sorted pill tubes
B. Medication indicators
C. Dispensing buttons
D. Ramp for pill collection
E. Alert mute switch
F. Update schedule button
G. System status indicators

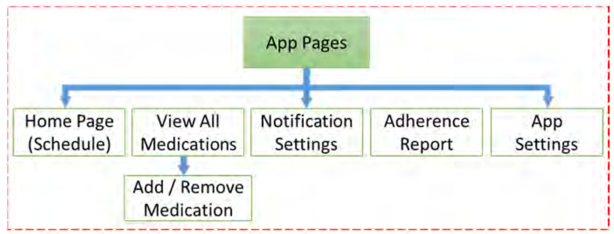


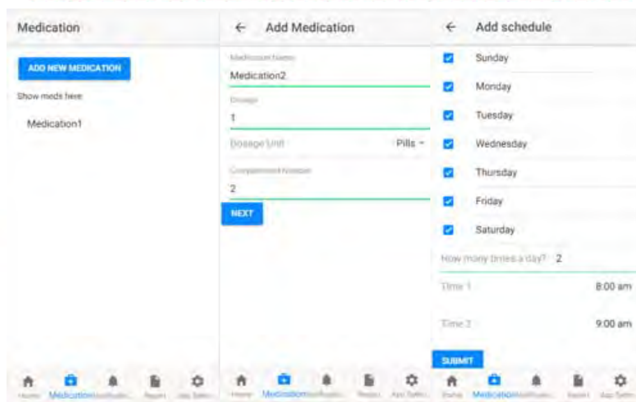
Dispenser Mechanism Function



Mobile Application

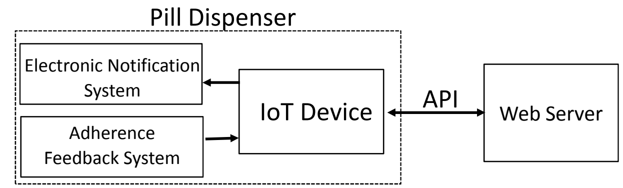
- Implemented using Ionic Cross-Platform Mobile Application Framework
- Provides user interface for the system
  - View and manage medications, schedule, and adherence data
- Creates mobile notifications at time to take medication





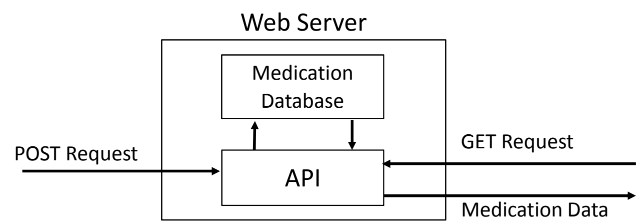
IoT Device

- Implemented using Raspberry Pi 3
- Electronic notification system: LEDs and Buzzer
- Adherence Feedback System: Buttons pressed by slides



Web Server

- Contains database to store medication data
  - Patient information, Medication prescription, Medication schedule, and Adherence data
- Custom Application Programmable Interface (API) to communicate medication data
- Implemented using Django Web Server Framework
- API built with Django REST API Framework



Accomplishments

- Developed fully functioning prototype
  - Integrated IoT system and pill dispenser
  - Implemented mobile application as user interface
- System can manage 3 medications independently
- Successfully monitors and logs medication adherence

Recommendations

- Compatibility with more pill sizes and geometries
- Medication interaction checker and missed dose remediation instructions
- Automated pill dispensing
- Notification system for caregivers and doctors

Aids for People with Physical Challenges

Spring 2018: Kyle Riccardi (ME), Brian Planz (ME), Andrew Dumont (ME/BME), Erika Nelson (EE),
Jay Luppino (ME), Michael Cuozzo (ME), Joseph Vengen (ME)

Purpose:

- Assist patient with gripping motion
- Serve as a therapeutic device
- Establish working proof of concept for future semesters

Semester Objectives:

- Design a system that would allow certain fingers to move and satisfy force requirements of the customer
- Using a pre-existing brace/glove, create a soft robotics device that would allow a pinching motion using the index finger, middle finger, and thumb in order to pick daily activity objects with addition of grip aid
- Incorporate a hands free control system using either EMG technology, noise activation software or Amazon Alexa Technology with haptic feedback
- Revitalize the "gripper" in order to test new control systems
- An out of scope goal would be to add a wrist rotation feature to the brace

Requirements:

- Pick up object of <1.8lbs, with addition of Grip Aid (Common Assistive Device)
- Response time of <1 s
- Lightweight Wrist Support (<1 LB.)
- Supportive Hand Accessory to help straighten fingers

Testing:

- Pinch-force testing
- Actuator pressure testing
- Actuator bending force analysis testing
- Noise activation testing based upon several voice samples
- Actuator-glove assembly testing
- Power system testing

Figures 1&2: Final design of device

Figure 3: Dynamometer device used to test pinching force

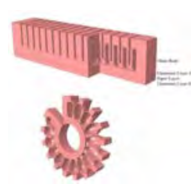


Figure 4: Pneumatic Bending Actuator

Final Design:

- Two individual pneumatic bending actuators
- Noise activation control system
- Pre-existing support glove/brace to offer surface of adhesion for actuators as well as wrist support
- Sil-Poxy adhesive used to bond silicone actuators to glove fabric
- Wheelchair-compatible hard shell case used for housing of electronics
- 24V power supply used to power device

Figure 5: Hard shell housing case compatible with wheelchair

Future Work:

- Adapting power system
    - Portable Battery
    - Power system as a whole
- Actuator Force creation
- Design own glove
    - Easier to put on
- Improve hardware
- Simpler/More reliable control interface

NABA Voice Assistant Technology

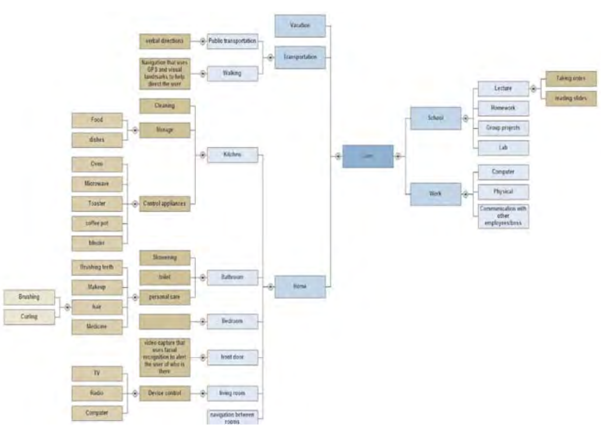
Spring 2018: Christopher Andre(CSE) , Spencer Davis(BME/MTLE), Michael Manogue(EE) Erik Ostergren(EE) Anthony Spinelli(EE), Meng Jie Ye(CS/CSE) and Xiaochuang Yuan(CSE)

Purpose

- Customers of this project are blind and visually impaired individuals in the Albany area that could utilize this project to help in their everyday life.
- Users of this project are not the stakeholders, but should be accommodating to the average blind or visually impaired populace.
- The motivation for NABA is to assist the blind or visually impaired achieve independence and growth, so this project's goal is to make everyday tasks easier for those who cannot rely on their sense of sight.

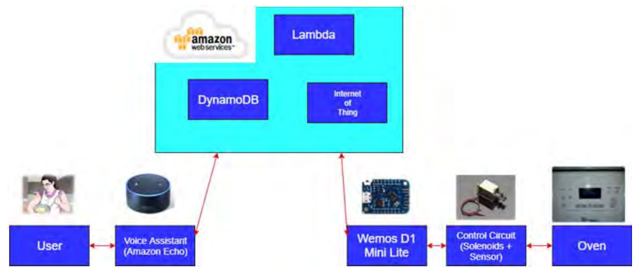
Past Work and Project History

- Customer Needs: Interactive, promotes self independence , safe installation
- Requirements: Feedback ability, voice Input, mount device externally/ no installer wireing required
- Conept Generation: Area of interest is smart home automation thorugh amazon alexa



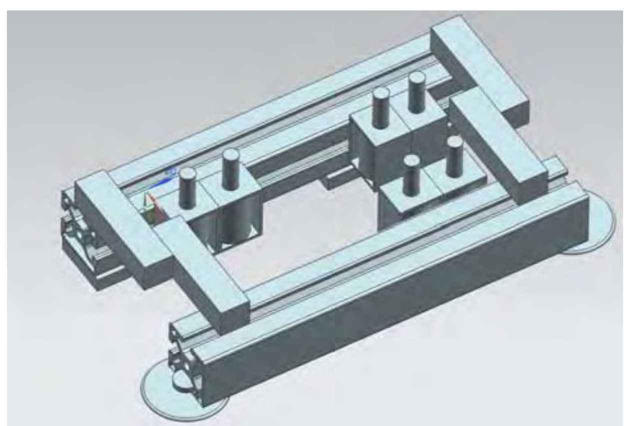
Semester Objectives

- Create a simulation and demo for one(or multiple) certain type voice-controlled appliance
- Present the system architecture and final concept to our customer



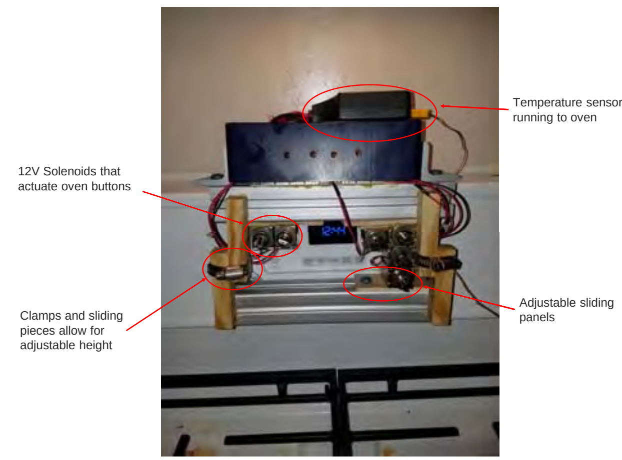
Technical Approach And Plan

- Identify problems with adjustability and different interface setups.
- Test each individual subsystem and then integrate the connection from the hardware to the Amazon Web Services (AWS)



Technical Results

- Subsystems include: Alexa skill code, recipe narrator, database, Wemos microcontroller, and physical solenoid rig
- After working through the engineering design process each subsystem was tested to prove that the desired output of that system is given.



Future Development

- Develop feedback loop so if oven temperature read by thermocouple is too high the signal will be sent to the cancel button on the oven.
- Improve the connection of the Alexa skill app to the AWS shadow so it can update faster and get an immediate response

Neck Tab Ironing and Radio Pocket Attachment

Fall 2017 Team: Rachel Dass (**ME**), Greg Lerner (**ME**), Bogdan Monyuk (**ME**), Andrew Nicholas (**ME**), Senkun Ruan (**ME**), Jack Sullivan (**ME**), Zoe Westwater (**ME**)

About NABA

- Not-for-profit created to serve blind community
- Provides services and jobs for visually impaired
- Focused on meeting individual needs

Project Purpose

- Reduce neck tab ironing waste
- Transform radio pocket hemming and sewing to visually impaired task

Semester Objectives

- Create a tool and process for visually impaired workers to more accurately and consistently iron **neck tabs**
- Design and build processes and hardware to allow blind workers to sew **radio pockets** on MTA Metro North vests

Customer Needs/Technical Specifications

Table 1: Neck tab

Customer Needs:	Requirement	Specification (metric)
Aid in alining ironed seam	Seam Precision	±1/16" from seam to edge
Easy to iron with (heat proof)	Heat resistant	Max Temperature>(600°C)
Improve ironing accuracy	Reduce ironing rework	<10% rework
Robust design	High FOS for stress and strain	FOS > 2
User friendly for blind people	Easy to learn	Takes 1-2 training session
Affordable and easy to reproduce	Low cost	Under $50
Efficient in ironing	Can be ironed in at most 2 passes	2 strokes of the iron
Safe	Plate cannot get too hot	<130°F after initial ironing

Table 2: Radio pocket

Customer Needs:	Requirement	Specification (metric)
Precise hem sizes	Accurate dimensions	See Figure 1 (right)
Affordable	Low cost	Under $500 all fixtures
Safe	No sharp edges (chamfer)	45° angle for edge
Robust design	No deformation when dropped from 1 meter	FOS > 2

Figure 1: Radio pocket precision tolerances

Final Designs Radio Pocket

- Three subsystems: Double hem, Side hem, Pocket alignment
- Overall cost $301.66
- Allows for visually impaired workers to complete hemming and sewing tasks

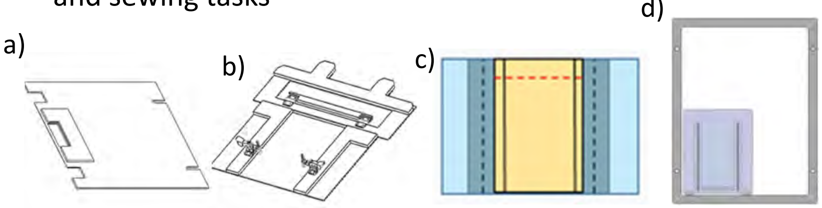


Figure 2: a) Double Hem Prototype b) Velcro Fixture, c) Side hem folding for ironing, Sliding plate and Guided sewing bars

Final Design Neck tab

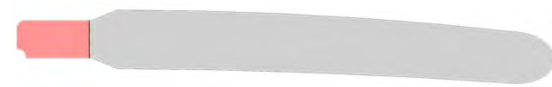


Figure 3: Flat Plate Prototype

- FOS 1.1 with 4lbf
- Cools from 131ºF to 105ºF after 60s
- Cost: $15-$20/plate
- Plasti dip coated handle

Conclusions/Recommendations

Neck tab

- Design allows for double the output while decreasing rework
- Actual FOS greater than FEA analysis
- Look into variety of cooling options
- Train workers with user manual

Radio Pocket

- Manufacture and assemble prototypes from CAD files
- Adjust existing equipment to accommodate design
- Obtain feedback about design from visually impaired workers
- Modify design in accordance to feedback
- Train workers with user manual

Arc Wheelchair Accessory

Spring 2018 Team: Daniel Seo (Mech E), Chris Bertram (ISYE), Daniel Lapidus (Mech E),
Eghosa Aiyevbomwan (MGMT), Matthew Sterlina (Mech E), Michael Borra (Mech E), Patrick Montolio (Mech E), Teddy Xu (ISYE), Xinan Huang (EE)

Purpose

The wheelchair accessory improves the quality of life for a wheelchair user by creating a secure and convenient storage space.

Past Work

The wheelchair accessory has been in development since the spring semester of 2017. A semi- functional prototype was developed by the fall 2017 team, but further improvements were necessary to meet all customer requirements.

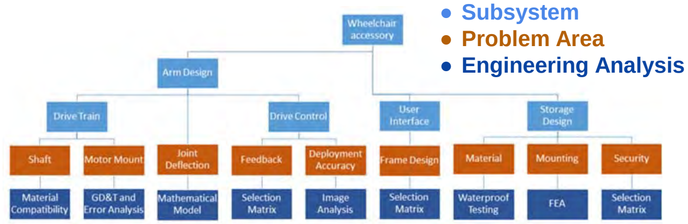
Customer Requirements

- Secure and water resistant storage
- Range of motion: Behind wheelchair to parallel beside wheelchair in 15 seconds.
- Easily accessible storage for textbook and laptop
- Battery can last at least one day of use
- At least 5 year lifetime
- Cost: $300 or less

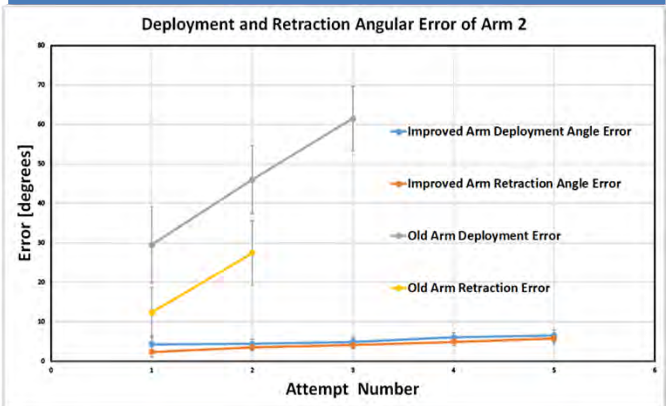
Semester Objective

- Fix the problems that have been identified
  - Reduce error in angular displacement
  - Improve security for storage
- Have a functioning prototype
  - Reliable deployment of arm
  - Deploys within 15 seconds
  - Secure storage
  - Waterproof
- Produce an installation manual

Technical Approach



Technical Accomplishment



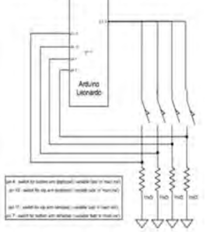
Future Plans

- Implement motor control using the encoder
- Conduct power consumption analysis
- Implement solenoid lock for security
- Reduce weight
- Implement additional safety measures for corner cases (provide wire shield to prevent accidental short)
- Professionally designed bag including newly designed mounting system

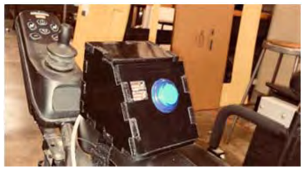
Specific Accomplishments

- Storage Design
  - Integrated frame with improved mounting
  - Upgraded security: latching/deception

- Arm & Gear
  - Changed the shaft material and the top arm only deflects by 0.04in
  - Reduction of unwanted angular play by 70%
- Motor Control
  - Refined gain to reduce deployment and retraction error from 15° to 1° per cycle
  - Limit switches used to create a physical limit for the arm movement. Allows for more headroom so the motor control stays within working margin.

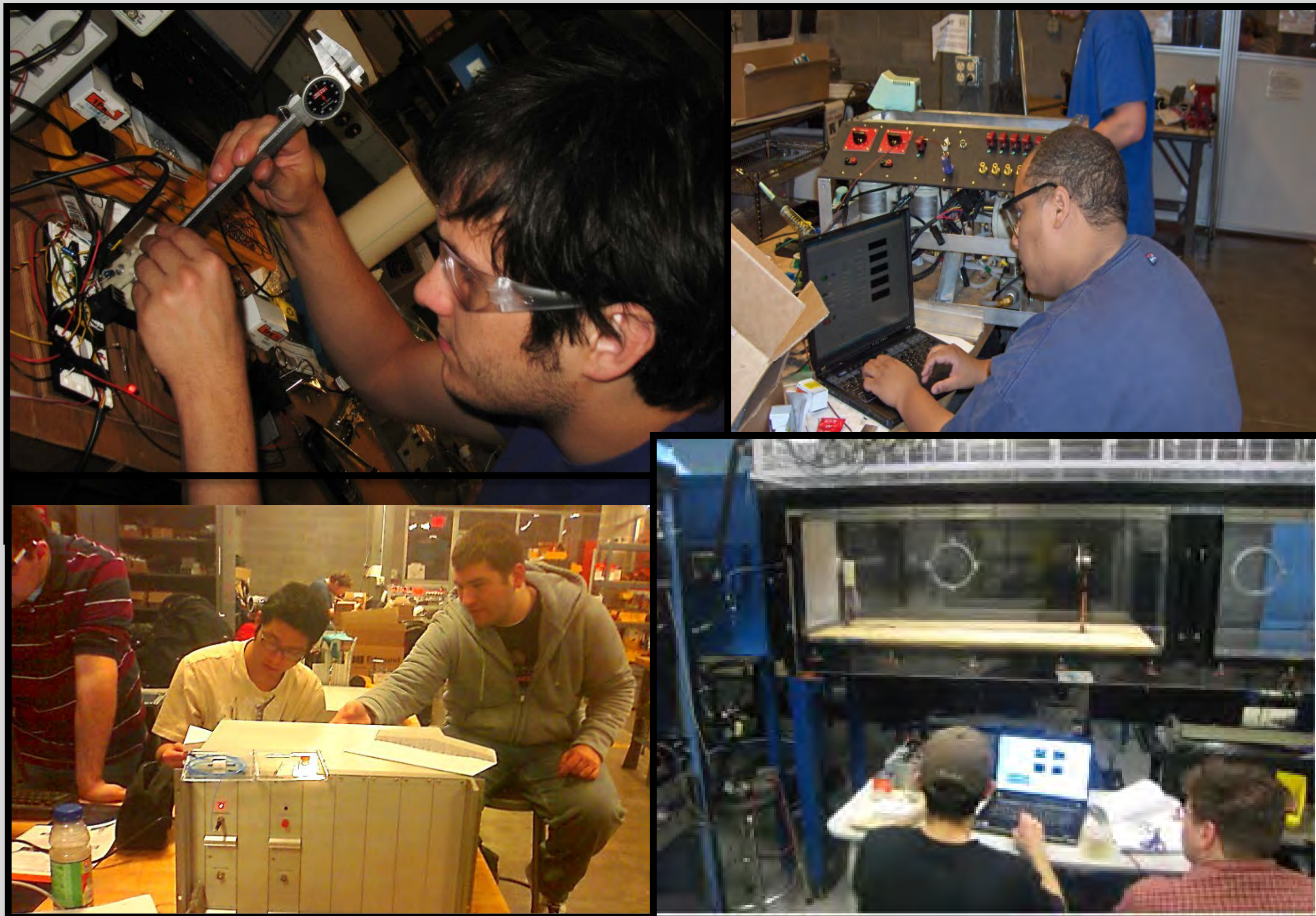


- UI box



- Improve fabrication
  - Laser cutting (lower cost)
  - ABS
  - Friction fit
- Improved ergonomics
- USB charging

Manufacturing, Automation and Control



RCA Of Wind Tunnel Models

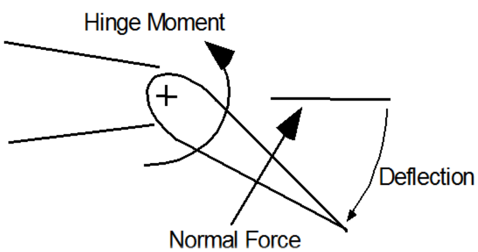
Spring 2018: Alex Frost (EE/CSE), James Harkenrider (EE), Zishan Huang (CSE/CS), Raymond Lanzillo (MECH), Greg Oberhausen (MECH), Vikram Shah (MECH), Zichu Wang (MECH)

Purpose

Boeing is seeking a 1/20th scale Remote Control Actuator System to actively control ailerons and reduce the cost in wind tunnel testing.

Customer Requirements

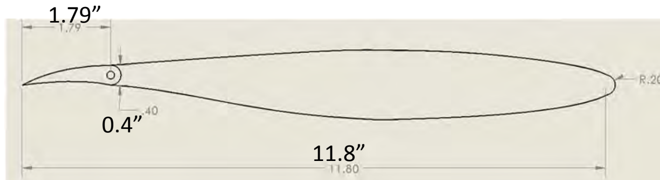
- Range of motion: -30° to +15° with incremental steps of 5°
- Desired angular accuracy: 0.1°
- Transition time: 30 seconds
- Must withstand aero loading



Side View of Aileron Loading and Motion

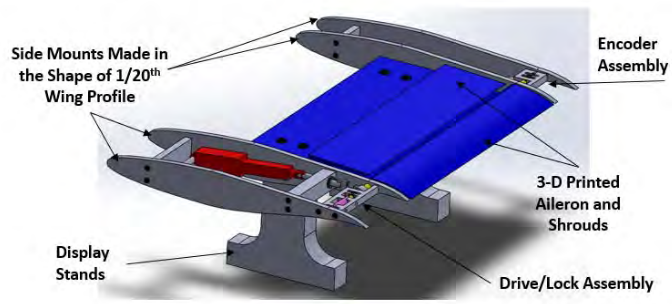
Semester Objectives

- Build the RCA System for a 1/20th scale aileron model
- Model shows proof of concept and will not be wind tunnel tested

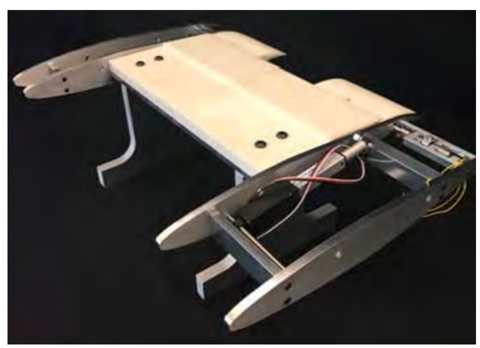


Side View of 1/20th Scale Wing Profile

Design



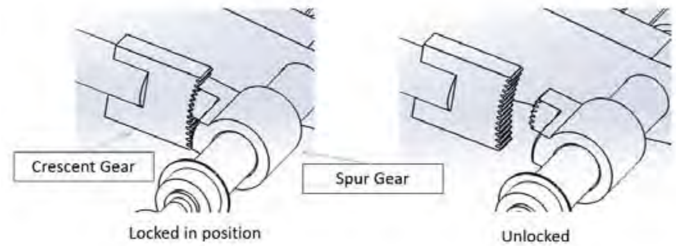
CAD Model



Built Prototype

- Aileron rotated by direct drive with Micromo Stepper Motor
- Flap seal between aileron and wing

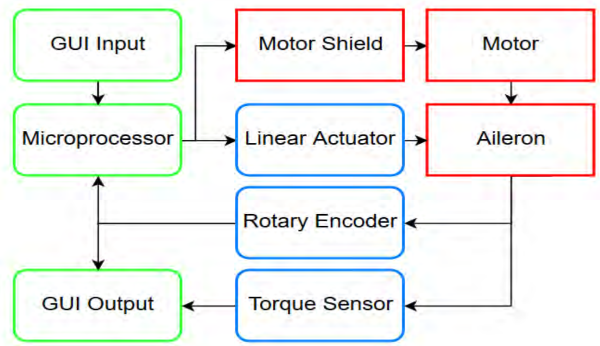
Lock



Crescent Gear Design

- Improves accuracy of ±0.4° to ± 0.1°
- L16 Linear Actuator to engage and disengage the lock system

Control



Closed-loop Control System

- Rotary encoder for angle adjustment
- Strain gauges to measure torque
- Python Graphical User Interface
- Emergency Stop Button

Seal Positioning

Spring 2018 Team: Justin Massey (MECL), Jack Frey (MECL), Nick Grocki (MECL)
Donjie Jia (MECL), Aaron Kalish (IME), Yiteng Lu (MECL), Haocheng Yun (ECSE), Lanxin Zhang (ECSE)

THE DESIGN LAB at Rensselaer

GE Global Research

Purpose

- To investigate non-'machine vision' type methods to orient and present individual seals from bulk to robot in 'pick-up ready poses'.

Customer Needs

- Minimal human involvement
- Speed and reliability
    - <10 second part feed
    - 99.99% reliability

Accomplishments

- Demonstrated a fully functioning prototype that mechanically positioned the long rectangular seal in a pick-up ready pose from an initial bulk set.
- Demonstrated individual concepts to feed, sort, and position each of the remaining seal geometries.

Semester Objectives

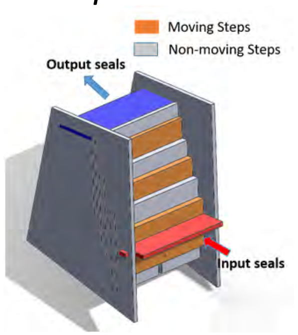
- To design, build, and test a fully functioning, batch-load-to-pickup system prototype for one seal geometry.
- To design conceptual systems for the three remaining seal geometries.

Technical Approach

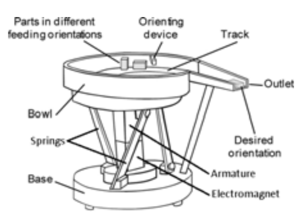
- Benchmark
- Experiment
- Integrate

Feeding

Step Feeder

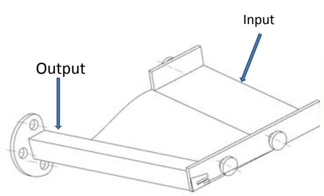


Bowl Feeder



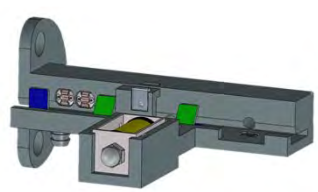
Sorting

Shake Table

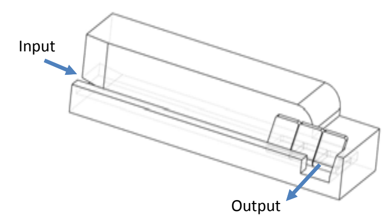


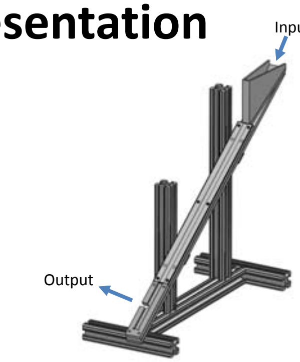
Bowl Feeder Tooling

Electric Sorting Rail

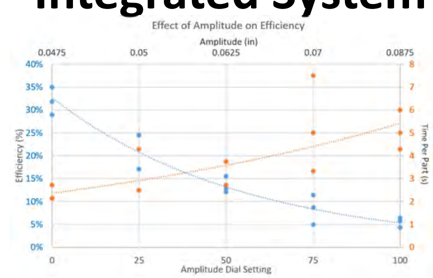


Queuing & Presentation





Integrated System



Auto Etch Module

THE DESIGN LAB at Rensselaer

Spring 2018: Yu Chen (ELEC) Kenneth Creasy (MATL), Francis Guzikowski (MECL), Destiny Lopez (MATL), Ryan Reedy (MECL), Arianno Schneider (MATL), rank Sinapi (CSYS), Yichunan Wan (CSYS)

MSE/LEWIS

Purpose: Produce an automated system to safely prepare and image a Ti-6Al-4V sample to create a 3D model of the microstructure.

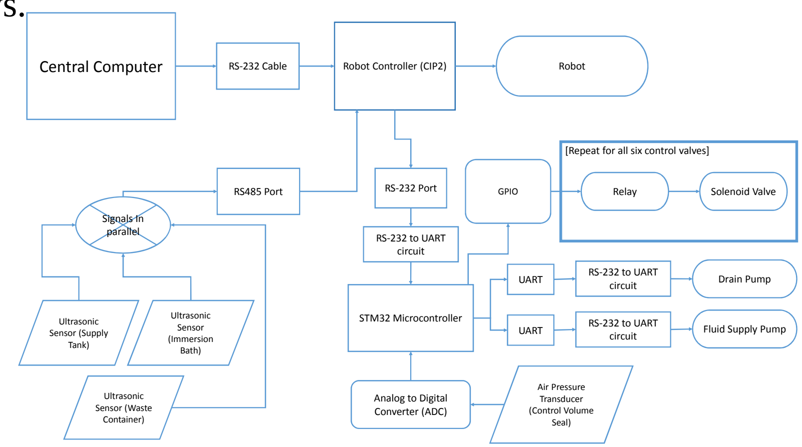
Past work: Existing system for grinding, polishing, and imaging other (non-Ti) alloys.

Semester Achievements: Designed a new serial sectioning system, capable of acquiring images from Ti-6Al-4V 1" cube sample through selective chemical corrosion with Kroll's reagent (92% Distilled Water, 6% Nitric Acid, 2% Hydrofluoric Acid).

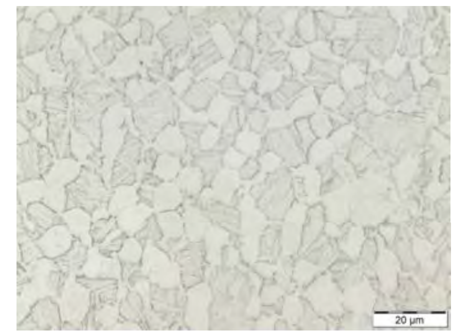
Technical Results:

- Devised process to produce the desired microstructural feature contrast.
- EH&S approval of ventilation, fluid delivery, and seal design.
- CAD representation of conceptual design.
- Successful automation and control of system and processes.

Control Architecture

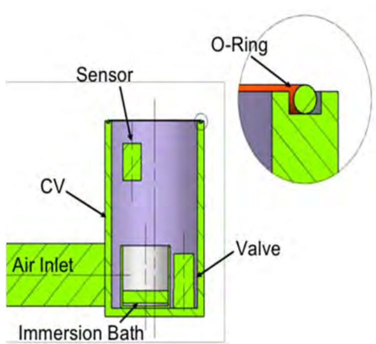


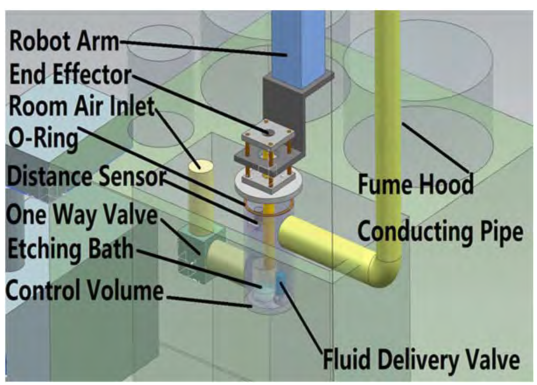
Resultant Microstructure

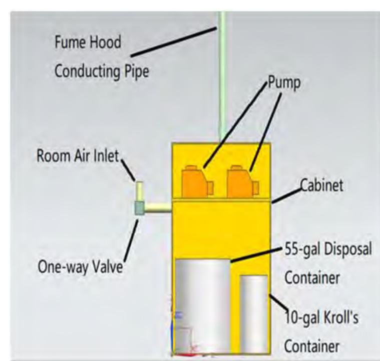


Microstructure after polishing with an attack polish (5:1 ratio 0.06 μm collodial silica to 30% hydrogen peroxide) and etching with Kroll's reagent

Module Conceptual Design & Containment Cabinet







Future Direction:

- Construct first generation prototype
- Integrate etch module into existing serial sectioning machine
- Test under close supervision
- Replace associated MRC ducting.

Controllable Lighting System

Spring 2018: Charpentier, Chris (CSE), D'Accolti, Anthony (EE), Diebold, Gwen (EE/CSE), Joseph, Malik (BMGT), Marshall, Kyle (CS/CSE), Strollo, Joseph (ME), Qu, Ziyi (ME)

Purpose

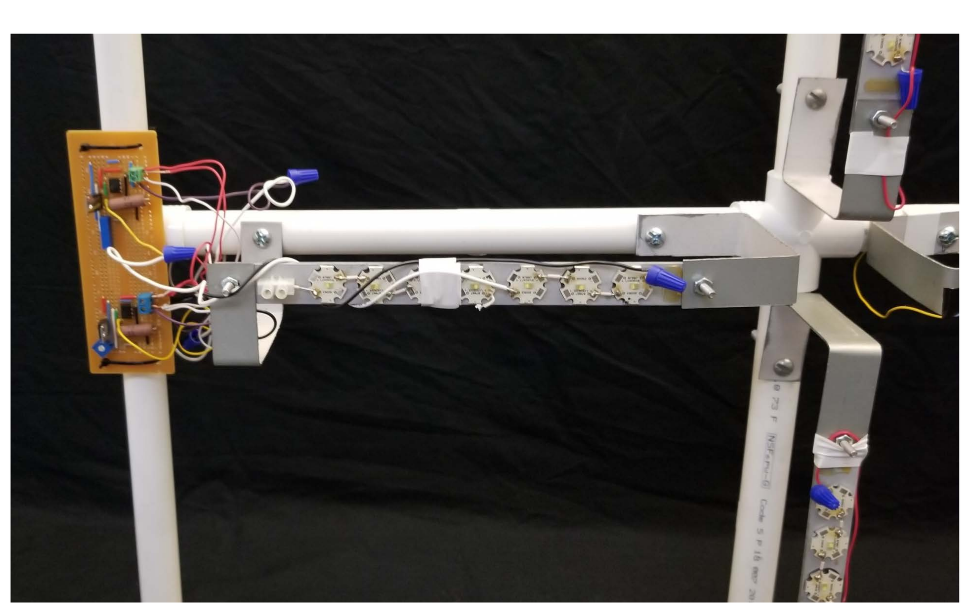
- Design and prototype an easy-to-use, controllable lighting system for main use with Image Processing Projects

Past Work

- On the market solutions do not meet the Capstone customer needs of automated controllability

Semester Objectives/Requirements

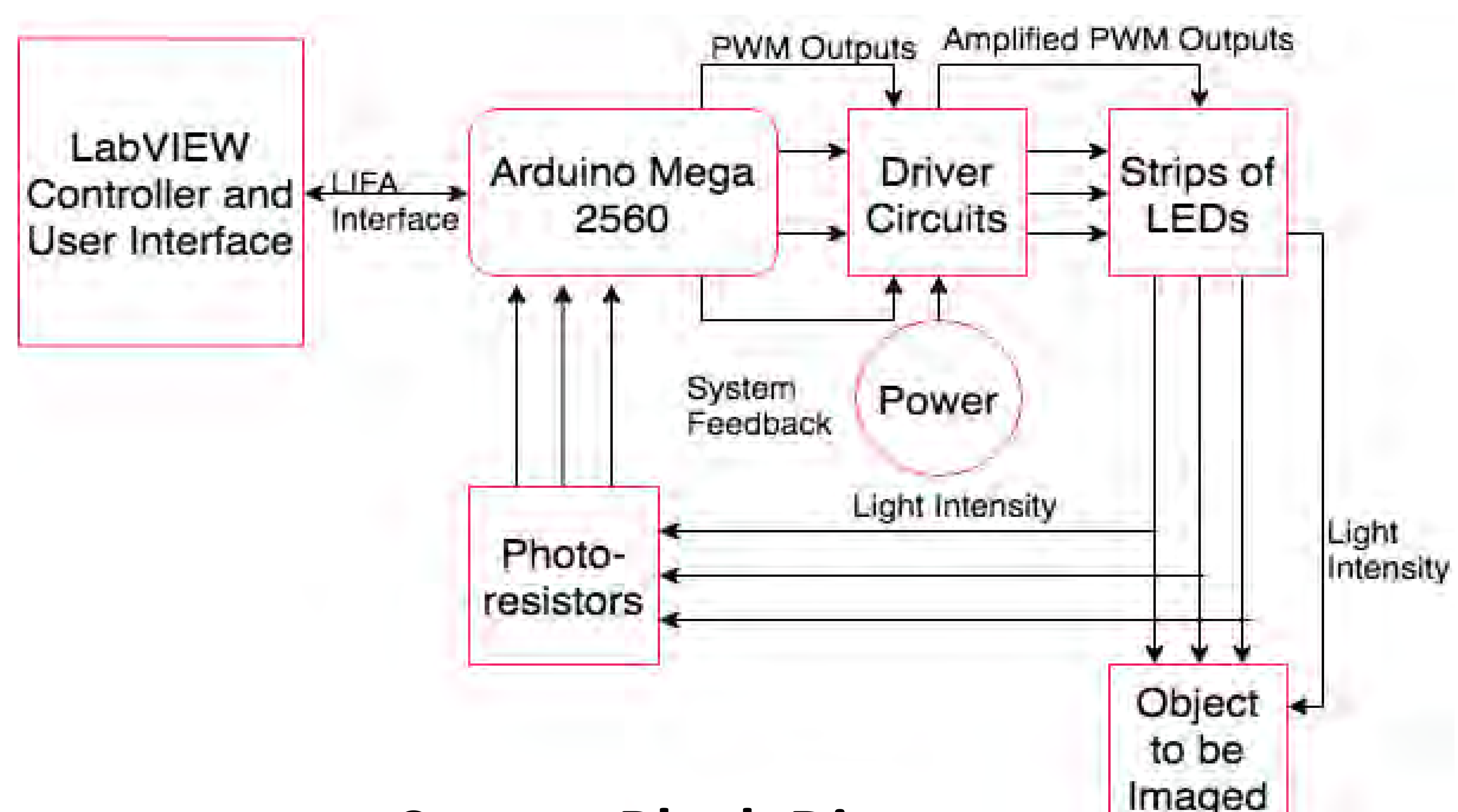
- Lightweight, Portable, Collapsible
- Deliver 1k Lux
- Operating Temperature Below 45C
- Save and Recall 4 Configurations
- Easy to Use Interface



LED Arm and Driver Circuit

Results and Accomplishments

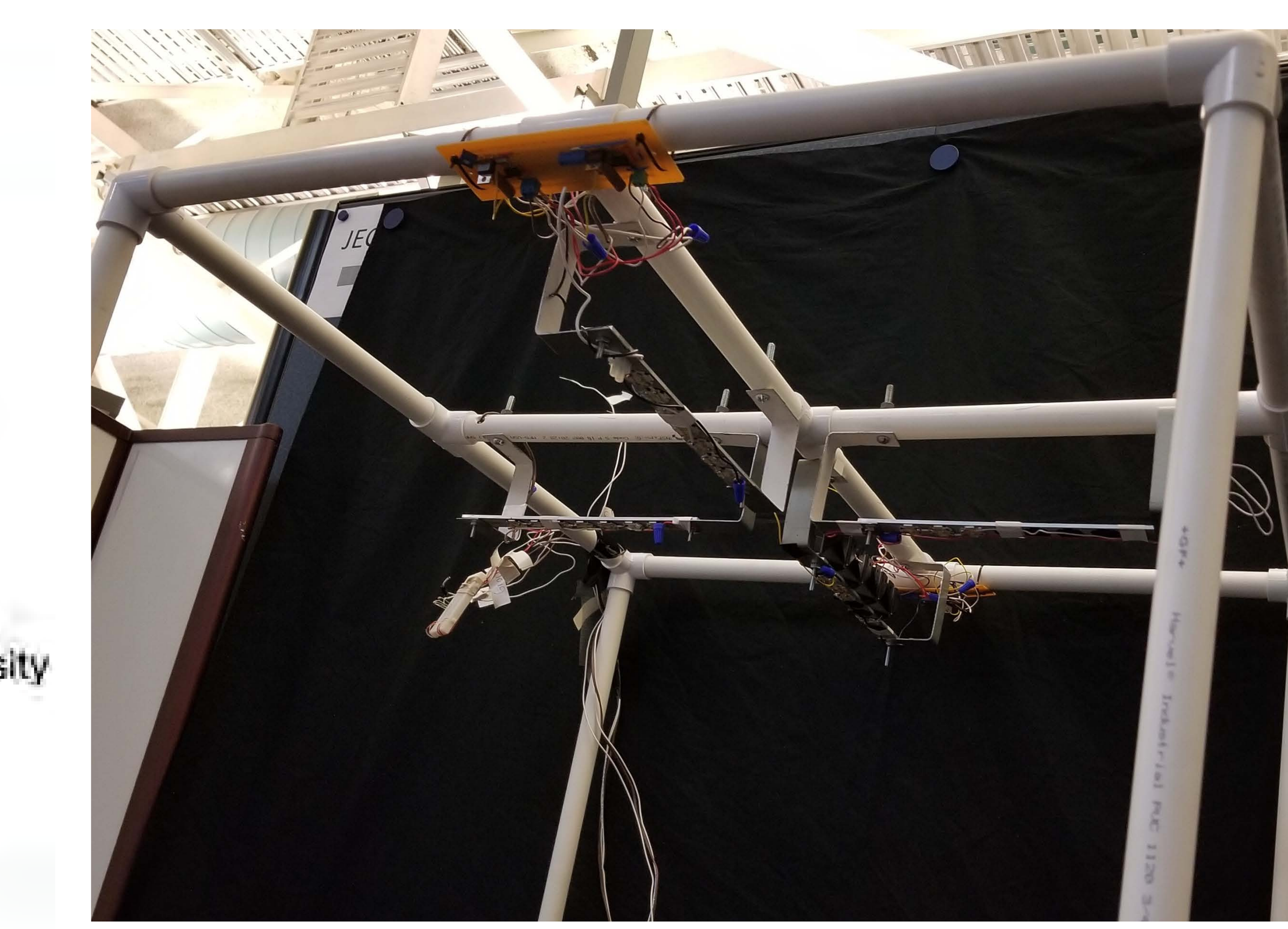
- Working prototype designed and fabricated to customer requirements.
- LED driving Circuit designed and fabricated
- UI controller design and implementation in LabVIEW
- Developed State-Space Model of System
- Developed SubVI to Convert Photoresistor Reading to System Lux Value
- Developed SubVI to Enable Manual Control of Light Intensity



System Block Diagram

Future Work

- Develop Advanced Control Strategy to Account for Effect of Object to be Imaged
- Increase density of lights and adjust spacing along structure
- Allow for adjusting color temperature of Lights
- Dedicated Object Stand for System
- Dedicated system Camera
- Increase size of structure



Controllable Lighting System

Autonomous Robot for Testing Wi-Fi & Cellular Networks

THE DESIGN LAB at Rensselaer

Spring 2018 Team: Nicholas Busby (EE), Andrew Lessieur (ME), Peilu Ouyang (EE),
Matthew Raczak (EE), Anna Stephenson (EE), Shu-Nong Wu (ECSE), Yinsu Zhang (ME), Xinyi Zhuang (ECSE)

CORNING

Purpose

Corning ONE Wireless Platform increases Wi-Fi and LTE (cellular data) coverage and strength.

GORDON aims to:

- Reduce labor costs and installation time
- Assess signal coverage and strength

Past Work

- Designed and assembled GORDON
- Developed the function to commission Remote Antenna Units (RAUs)

Semester Objectives

- Upgrade GORDON's processor
- Produce a network signal strength heat map
- Create an upgraded second GORDON unit

Technical Approach and Plan

- Compare various processors with concept selection matrix
- Evaluate size and weight requirements to support new processor
- Determine required signal data resolution
- Update path planning algorithms
- Develop signal strength detection method

Technical Accomplishments

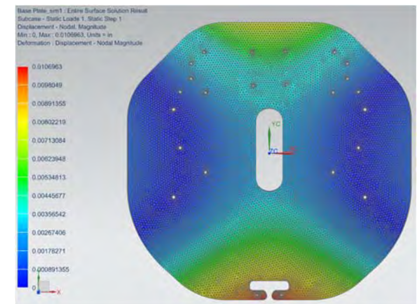
New GORDON Processor

Processor Upgrade:

- Replaced single-board computer with laptop
- On board screen removes connection issues and makes troubleshooting more convenient
- Faster processor allows output to update closer to real time

Structural Redesign:

- Designed base plate to support new laptop
- Conducted finite element analysis to test material strength
- Distributed load to simulate weight of laptop



FEM of New Baseplate

Sample Map with Planned Path in Red

Data Collection:

- Developed algorithm to minimize distance traveled while maximizing hallway coverage
- Produced a list of synchronized position data and Wi-Fi strength data or LTE strength data

Heat Mapping:

- Displayed signal strength data in heat map
- Integrated interpolation algorithm to fill missing data points

Sample Heat Map
Green - Strong Blue - Weak

Big Data Warehouse Management

Spring 2018: Francois Gerday (ECSE), Victoria Greco (ISYE), Alejandra Jaime Rodriguez (ECON/ISYE), Vibhav Kalaparthy (ECSE), David Kang (ISYE), Alexandra Koller (ISYE/PSYC), Bendik Larsen (ISYE), Christopher Pessolano (ISYE), Alexa Stewart (ISYE), Fei Tong (ISYE)

THE DESIGN LAB at Rensselaer

CORNING

Purpose

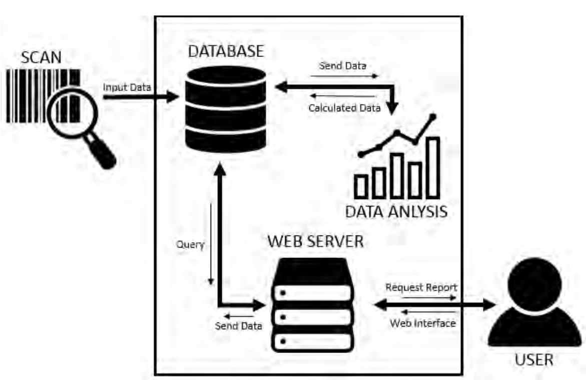
To equitably evaluate picker productivity with proposed performance metrics and to suggest warehouse improvements

Semester Objectives

- Formulate performance metrics to evaluate picker productivity
- Evaluate and display picker performance
- Recommend new data collection methods,
  layout, and routing

Technical Approach

- Identify factors that effect picker performance based on data analysis
- Simulate routing pick paths
- Evaluate layout algorithms
- Utilize Appery platform along with JavaScript and CSS for a picklist smart phone application



Enterprise Information Architecture Diagram for the Warehouse Management Module

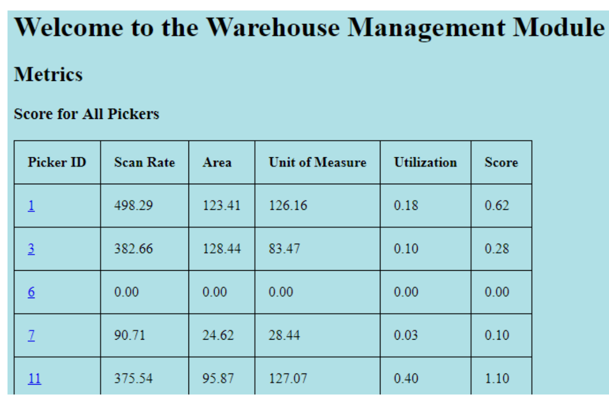
Technical Results

- Developed a metric to evaluate pickers that accounts for pick area, utilization, and unit of measure (cases and pallets)
- Integrated data analytics within a warehouse management website created in a Django framework with a MySQL database
- Created a digitized picklist delivery system developed in Appery platform
- Created a layout tool that uses CORELAP and ALDEP algorithms and determined a new layout to minimize the distance traveled

Metric Validation Results

Easy Picking	Hard Picking
Picker ID: 288	*Picker ID:* 288
Easy areas: 301,302,303,2	*Hard areas:* 1,6,7,104,201,503
Week: 22	*Week:* 22
Total picks: 536	*Total picks:* 368
New Score: 0.5419	*New Score:* 0.5025
Current metric: 297 scans/hour	*Current metric:* 147 scans/hour

The proposed metric normalizes picking parameters which affect a pick's difficulty.

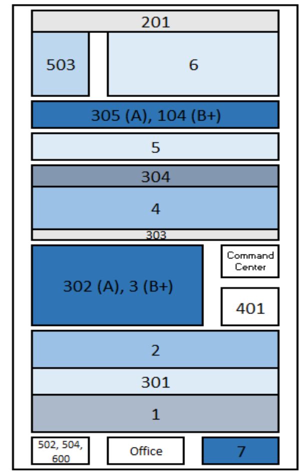

Welcome to the Warehouse Management Module

Metrics

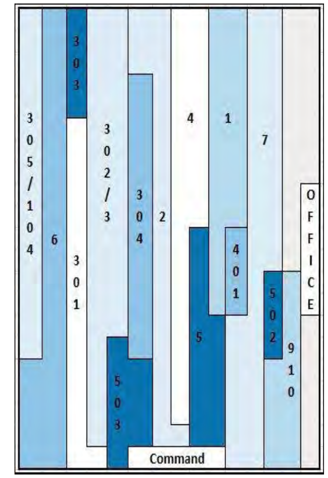
Score for All Pickers

Picker ID	Scan Rate	Area	Unit of Measure	Utilization	Score
1	498.29	123.41	126.16	0.18	0.62
3	382.66	128.44	83.47	0.10	0.28
6	0.00	0.00	0.00	0.00	0.00
7	90.71	24.62	28.44	0.03	0.10
11	375.54	95.87	127.07	0.40	1.10

Website Screenshot Displaying Picker Performance Metrics

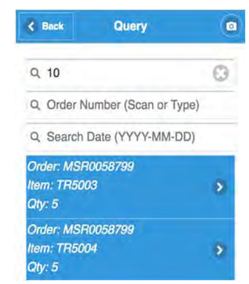


Current Layout



Proposed Layout

A picker may access all of their details by filtering through order number and date-to-pick; order number query is easily accessible through the scan barcode function.



Picklist for Picker Number 10

Next Steps

- Develop a tool that automates construction of optimal layouts
- Include additional metrics in website
- Develop platform to analyze equipment usage data with RFID scanners
- Incorporate additional picklist application functions
- Integrate picklist application with Corning's warehouse management system

Smart Manufacturing for the MILL

THE DESIGN LAB at Rensselaer

MILL MANUFACTURING INNOVATION LEARNING LAB @ RENSSELAER

Team: Sean Egan (MECL), Evan Engisch (MECL), Brianne Murphy (MECL), Adam Pomeranz (MECL/MATH), Jeremy Sohan (MECL), Will Tasman (MECL)

Purpose

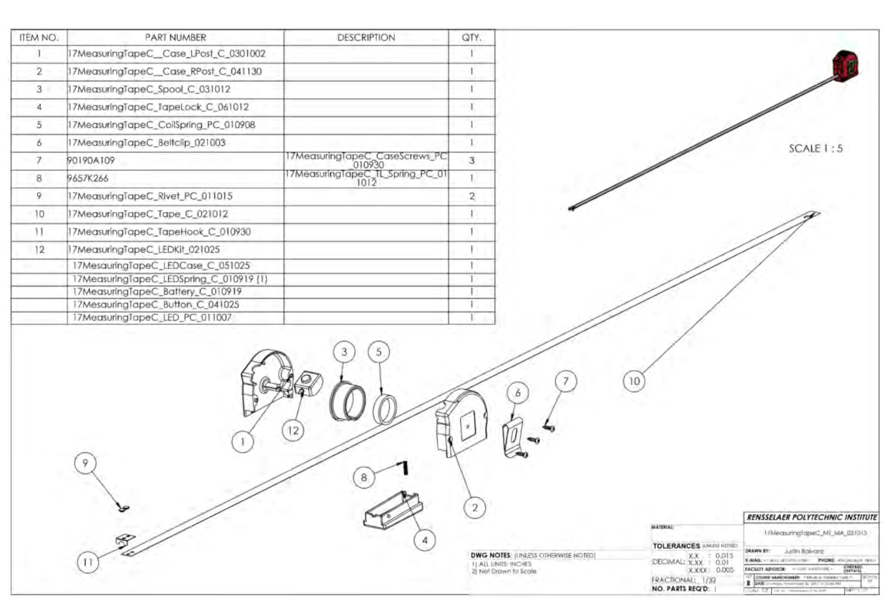
Create a digital framework for 21st century manufacturing in a dynamic environment.

Semester Objectives

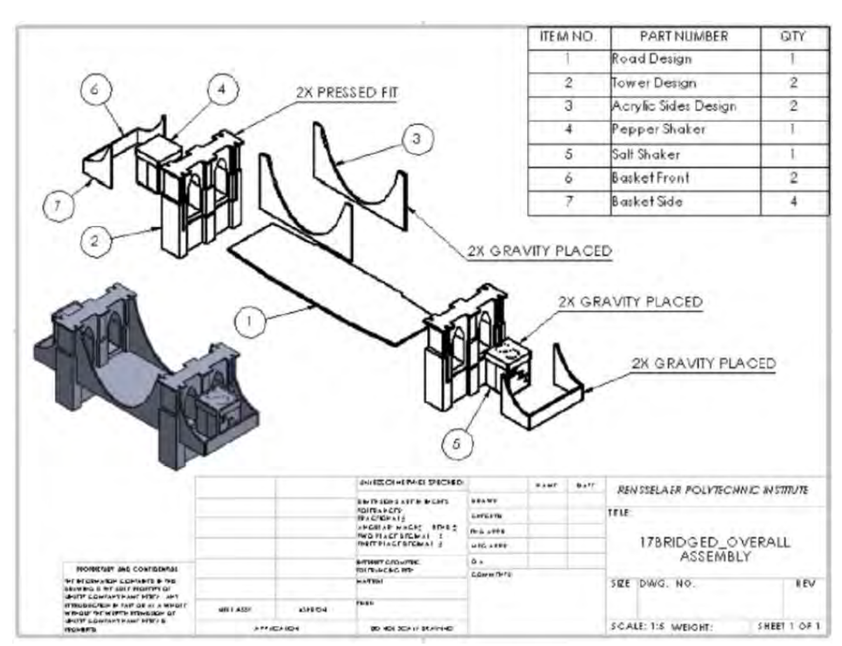
- Implement prototype MPS SOPs into VKS software
- Improve SOPs for reliability and efficiency
- Initialize plan for machine integration
- Create manual for VKS use

Past Work

- Paper-copy work instruction packages
- Preliminary MPS manufacturing/assembly designs



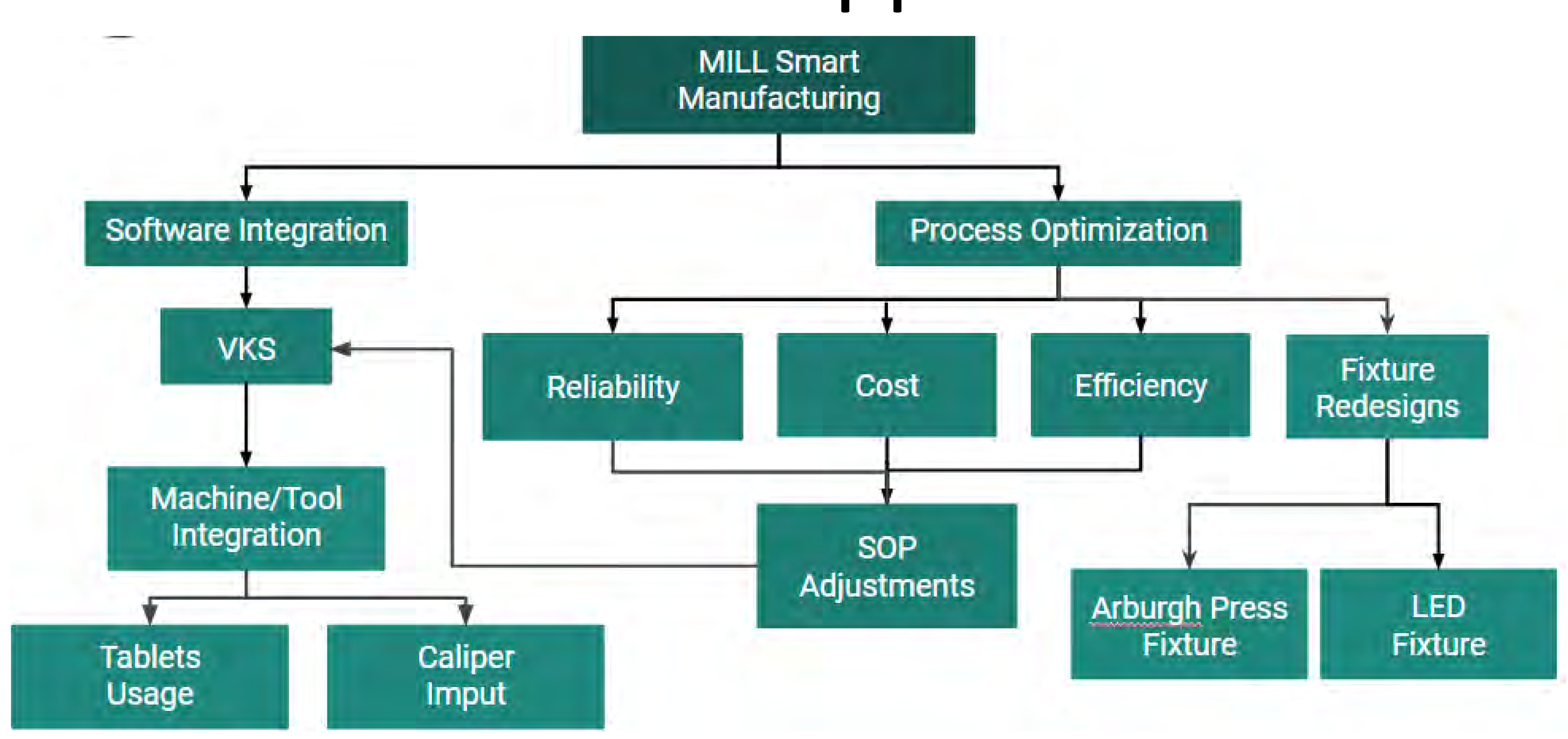
Assembly Drawing for Measuring Tape



Assembly Drawing for Brooklyn Bridge Napkin Holder

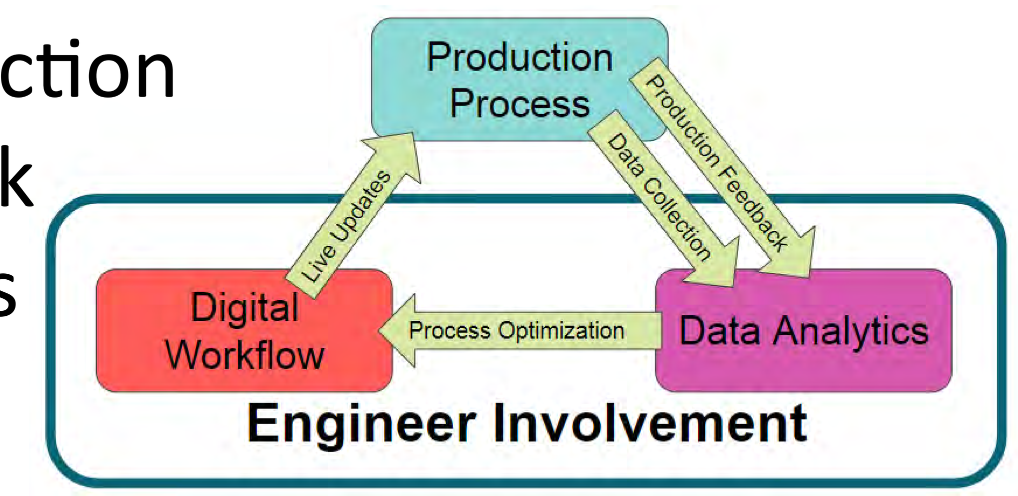
Bookshelf of Old Work Instruction Packages

Technical Approach



What is Smart Manufacturing?

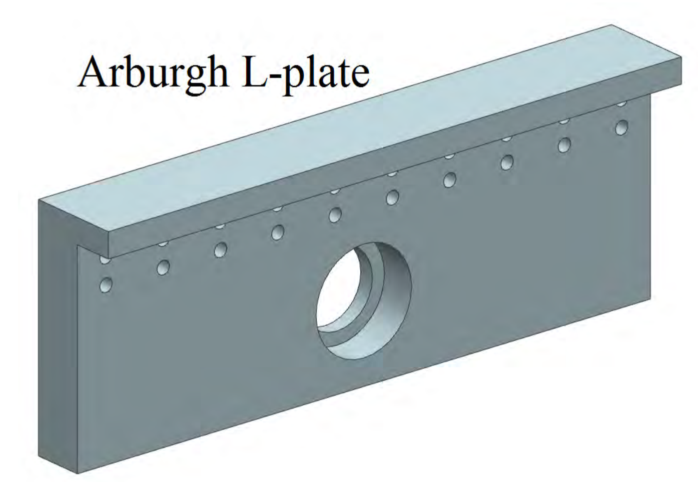
- Optimize concept generation and production
- High level of adaptability/ user feedback
- Use productivity data for improvements



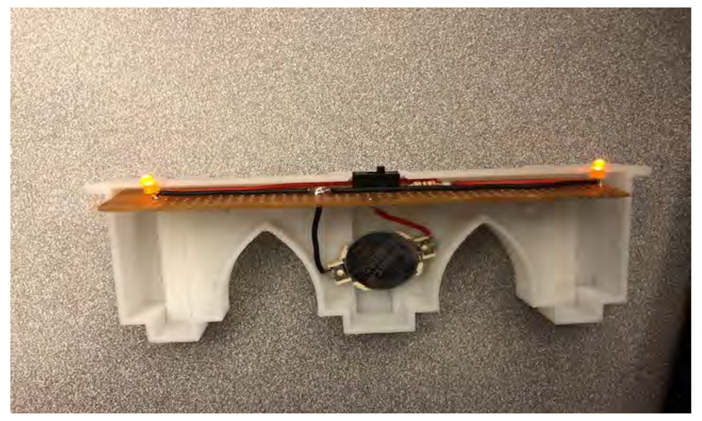
Technical Results

Measuring Tape: Tape Hook

- Redesigned Arburgh press L-plate
- Designed Arburgh press insert plate
- Designed/modeled parts using NX



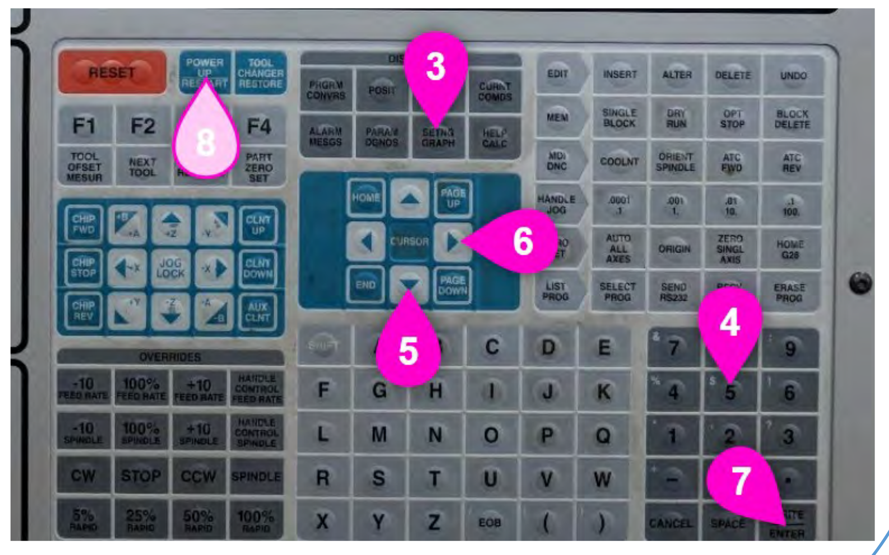
Brooklyn Bridge Napkin Holder: LED Assembly



- Resistor added to circuit
- PCB used to hold circuit elements
- Switch pin directionality

Brooklyn Bridge: Salt & Pepper Caps

- Included Mastercam simulation of lathe
- Attached CNC mill and CNC lathe manuals
- Indicated specific buttons to press for each step



Summary and Conclusions

- VKS introduces MPS students to industry caliber workflow
- Smart manufacturing affords unique insight into process limitations

Augmented Reality System

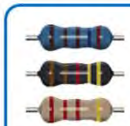
THE DESIGN LAB at Rensselaer

Spring 2018: Shamus Cardon (CSE/CSCI), Matthew D'Arcangelo(EE/CSE) , Oumar Datt(EE/CSE), Emily Lamport (EE), Benjamin Litwack(EE/CSCI), Jamie Smith (EE/CSE), Christopher St. Onge (MECH)

Raytheon Integrated Defense Systems

Purpose

Improve the efficiency of the manual assembly process of Circuit Card Assemblies and Radar Control Cabinets through the use of an augmented reality system. This is to improve the accuracy and efficiency of the overall manufacturing process.

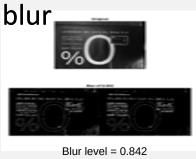
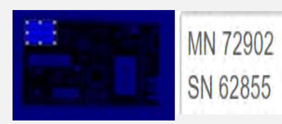
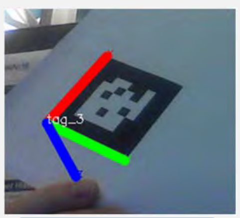

Chips, Resistors, capacitors


CCA's

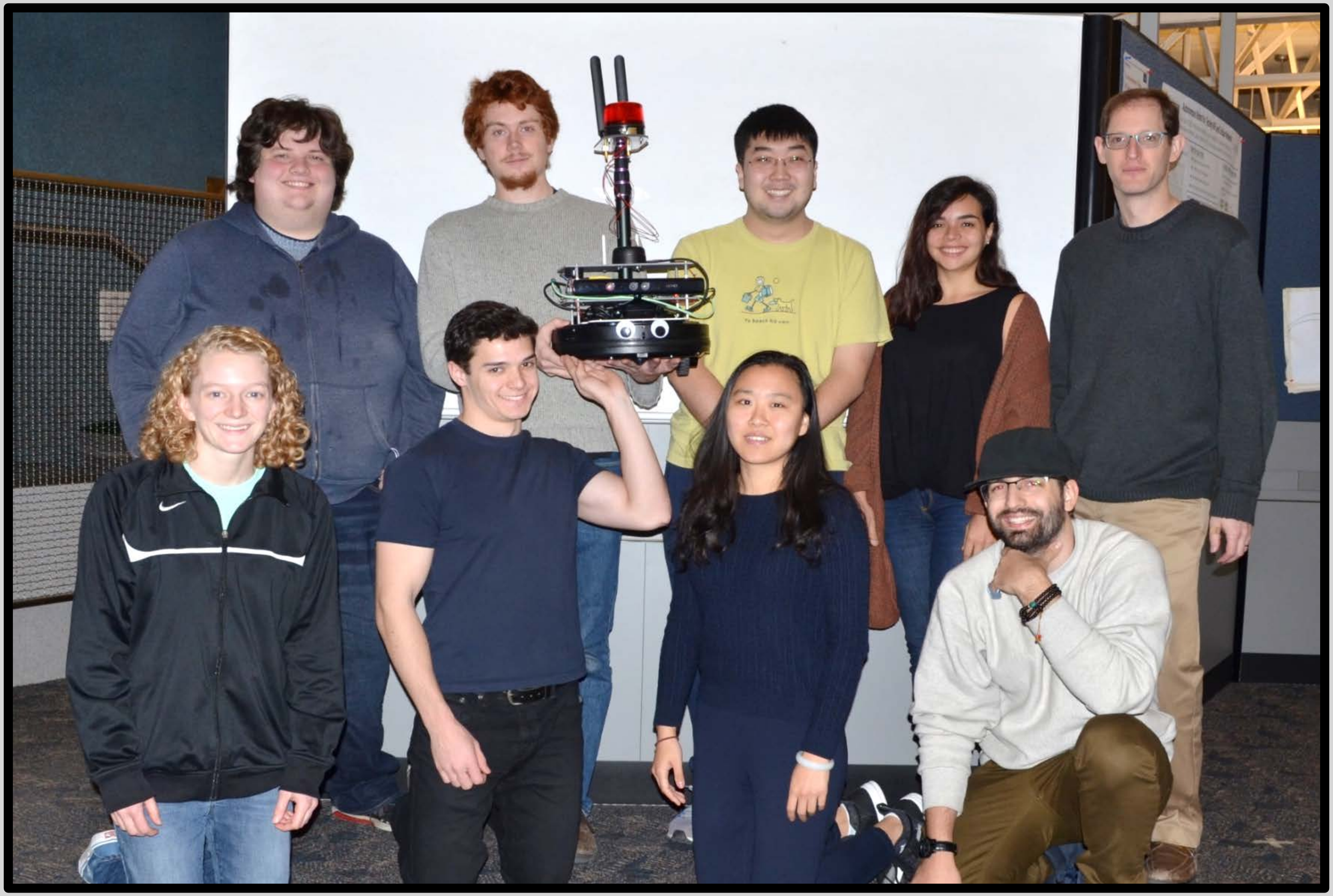

Radar Control Box


Electric Panel


Trailers

Subsystem	Past Work	Semester Objectives	Technical Approach	Completed	Future work
Circuit Card Assemblies	•Preliminary lighting setup: two CFL bulbs with adjustable horizontal distance and pitch •Automatic color-thresholding •Automatic board recognition	•Design experiments to determine important lighting parameters •Design preliminary lighting setup •Improve accuracy of reading text, with a focus on blur 	•Experiments designed: •Color v. Type •Diffusivity v. Intensity •Position v. angle v. quantity •Optical polarization •Used MATLAB to determine the text behind the a blurry image	•OCR tests run on photos captured during experiments •Procedures written •Characterized blur •Created MATLAB de-blur program 	•Develop Experiments that test effect of beam throw on OCR •Implement MATLAB de-blur into ARS app
Radar Control Box	 •Basic demo showing capabilities of Vuforia and HoloLens •Demo for 3D fiducial tracking	•Develop app to show incorrect part placement •Allow the user to access documentation during operation. •Chilitags and ARS integration •Tracking Multiple objects •Overlay 3D model using real-world tag position	•Use Unity framework for rendering objects •Vuforia enables the tracking of parts with image targets •Used Qt 3D (Qt 5.9) to render 3D image •Used Chilitag library to track movement of real-world object	•Highlights incorrectly placed parts. •Movable instruction overlay •3D model movements accurately follow real-world object 	•Evaluate other methods of object tracking for the HoloLens •Provide overlays of 3D model over Chilitag marker

Product Development



ARC Sensory Feature

Spring 2018 Team: Jamie Barone (MECL), Akash Chandani (MGTE), Laura Christie (MECL), Sebastian Garcia (MECL & DSIS), Yi He (ELEC), Junyi Li (ELEC), Brandon Swenson (MECL) & Shuxian Zhao (MECL)

Purpose and Background

To develop a **sensory feature** for the Arc of Rensselaer to use with individuals with **developmental disabilities**

- Feature will be part of a **sensory room**, which stimulates users & reduces stress

Background

- Arc worked with Russell Sage College to specify objectives of the sensory room and define the problem space and constraints

Semester Objectives

Our team will propose, design, and test a sensory feature to deliver to the Arc for installation.

Customer Requirements

Customer Need	Requirement	Spec
Visual stimulation	Continuous flow	Subj.
	Color-changing lights	>50 colors
Safe for users	High FOS	≥2
Auditory stimulation	Noise levels	≤60 dB
Tactile stimulation	Interaction dimensions	≥2
Wheelchair accessible	Interaction height	3'-6'
Accessible to users w/ limited motor skills	Motor driven	≥1 motor
Multiple interaction	Dimensions	5' x 8'

Technical Achievements

Sand Feature:

- Five devices: three rotate about x-axis, two rotate about z-axis
- Each features flow path that pile the sand in different designs

X-axis prototype

Z-axis prototype

Lighting System:

- RGB LEDs line the perimeters
- Arduino with Bluetooth mate

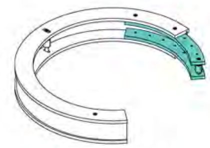
Circadian Light slider cycles through daylight & evening colors

Color Spectrum offers full RGB control through color wheel or cycle mode

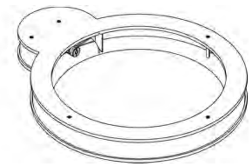
Motor Control features different angle presets for rotating the panels

Support Frame:

- 6061-Al frame arranges the panels in bubble design
- Heights designed to be accessible to those standing or in wheelchairs
- Frame prototypes:



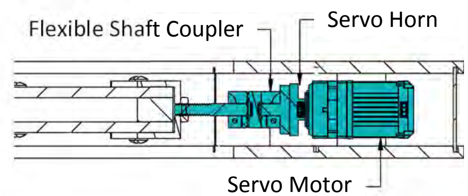
Z-axis tests grip angle



X-axis tests motor

Drive System:

- Manual control for z-axis
- Motor control for x-axis for clients with limited motor skills



Technical Approach

- Empirical approach for selecting the **flow solid**, **panel material**, and **lighting**
- Kinematic & static analysis for the **drive system**
- Analytical approach to **geometry** via ADA Standards

Recommendations

- More concise lighting circuitry
- More in-depth with solid selection
- Revisit path designs for longer flows
- Design for manufacturing

Monomer Measurement

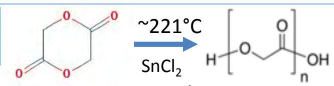
THE DESIGN LAB at Rensselaer

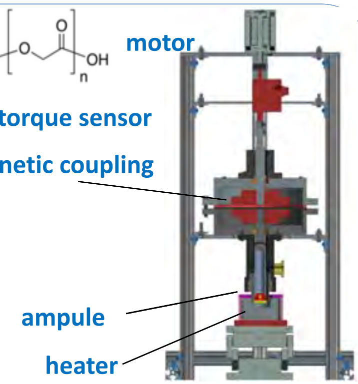
Spring 2018 Team: Jordan Charest (MECL), Mohammed Ghani (MECL), Zachary Holowchak (MECL), Monica Mazur (MATL), Kyle McNeil (ECSE), Steven Pierson (MECL), Yue Zhai (MATL)

Johnson & Johnson

Purpose: To assemble, test and improve a viscometer for use in J&J's in-house glycolide production process to improve quality assurance and processing of J&J's Vicryl brand bio absorbable sutures.

Project History





- Glycolide polymerization (moisture sensitive)
- Viscosity is measure of monomer quality
- Viscosity range 10^3 cP - 10^6 cP
- Falling ball viscometer (FBV), not predictive of quality.
- Fall 2017 - Designed cone rotational viscometer
  - Continuous viscosity during polymerization
  - Insensitive to non-Newtonian effects

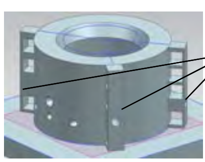
Semester Objectives

- Complete assembly and instrumentation
- Measure viscosity continuously at 221 °C in clean environment
- Qualify performance with material surrogates
- Demonstrate repeatability of 10%, reproducibility of 20%

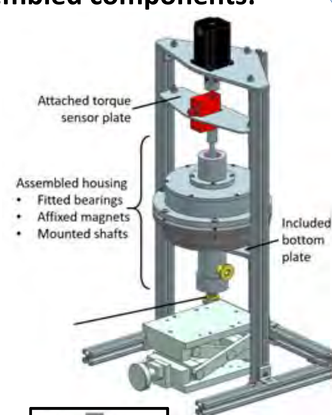
Analysis & Assembly

Current assembled components:

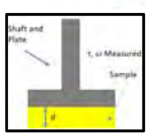
- ✓ Vacuum/purge pipeline assembled
- ✓ Insulated heater & developed PID control



Assembled clamps for wire assembly

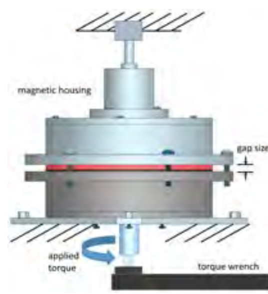


Spindle Specifications	Cone Plate	Parallel Plate	Cup & Bob
Tight Gap Size	Yes	No	No
Complicated Sample Placement	Yes	Yes	No
Newtonian Factor Needed for direct Viscosity	No	Yes	Yes
Major Changes to Fall 2017 Design	No	No	Yes

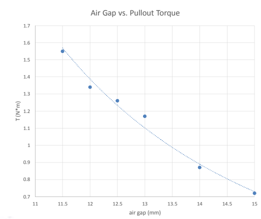


✓ Switched cone spindle to parallel plate spindle

Test Results & Accomplishments

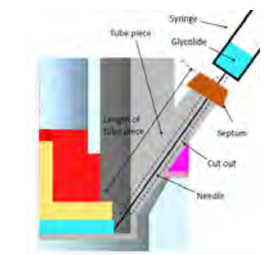


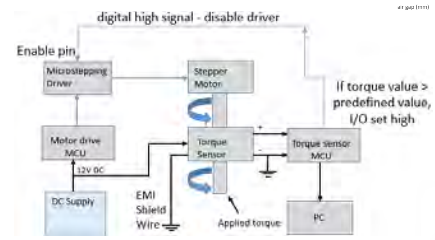
Pullout torque tests
→ Set housing air gap



- ✓ Charging method developed
  - Using syringes and septa
  - Tests were performed

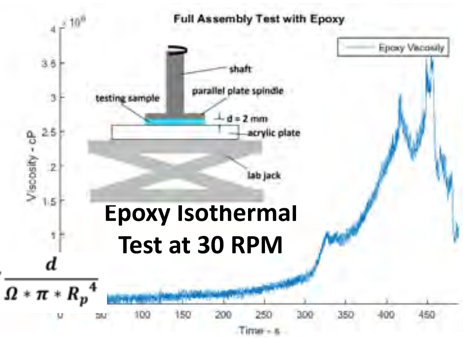
Proposed charging design:





- ✓ Subsystem test: Power & Drive Sy
  - Ran motor & micro-step tests
  - Torque sensor testing
  - Measured torque of surrogate materials
  - Converted to viscosity

$$\eta = T\frac{d}{\Omega * \pi * R_p^{4}}$$



Epoxy Isothermal Test at 30 RPM

Recommended Future Work

- Look into Cup & Bob Method
- Centerline alignment for lower friction
- Incorporate vacuum/purge system once viscometer is sealed
- Perform tests on heated materials and glycolide surrogates

NASA JPL Cube Satellite SADA

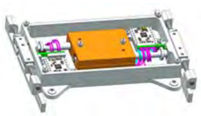
THE DESIGN LAB at Rensselaer

Spring 2018: Ben Anderson (ME), Greg Berube (ME), Josh Bostick (ME), Marcello DeLuca (ME), Aaron Harmon (MSE), Kang Sinhyung (ME), Rebecca Kienz (ME)

Overview

Project History

- CubeSat: 10cm x 10cm x 10cm
- Secondary payload to large scale launch missions
- Completed prototype design



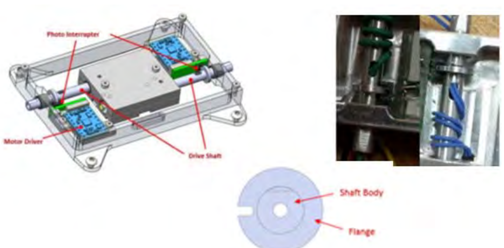
Spring 2017

Spring 2018

Purpose

Provide JPL with a proto-flight ready CubeSat Solar Array Drive Assembly (SADA) module design.

Requests for Action from JPL



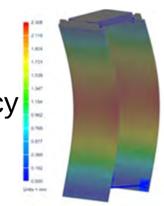
Semester Objectives

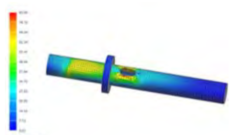
- Comprehensive Mechanical Analysis
- Comprehensive Thermal Analysis
- Deliver Flight Ready Hardware for Test
- Deliver Flight-like Algorithm

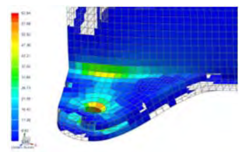
Mechanical Technical Approach

Launch Loads

- 14g static load + random vibration
- Fatigue driven by panel 1F mode
- Chassis modified to raise frequency
- Shaft modified for stress reduction
- Bushing material change to increase strength

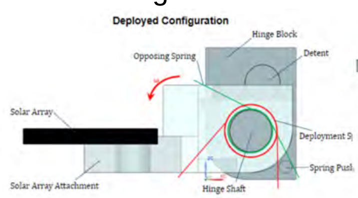


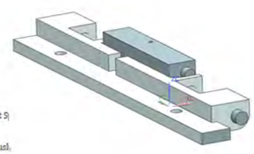




Deployment Impact and Loading Analysis

- Determine impact loading from solar panel deployment on hinge/SADA
  - 5% margin on force for a 1.25 FOS

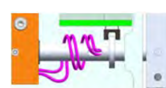


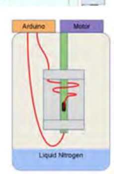


Wire Testing

- Determine lifespan of coiled wires during operation

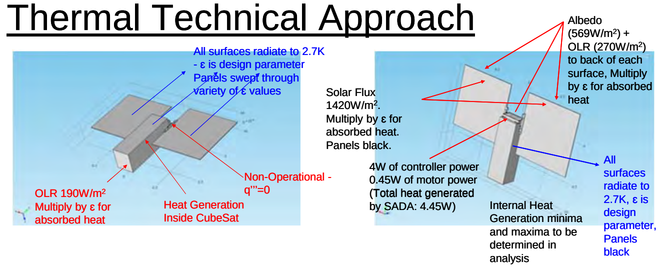
Test	# of Turns	Lifespan	Margin
1	1460	3 months	-87.5%
2	12800	2.2 Years	*10%

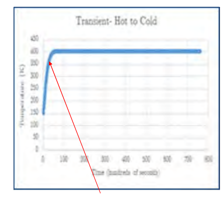




- Reduce friction by epoxying cables
- Reduce stress by reducing wire bend radius

Thermal Technical Approach

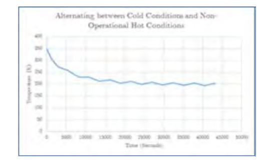




45 minutes to 0.9 * Tmax - reasonable to expect in one orbit. Conclusion: Use SS values

Steady state cold is a reasonable expectation without active heating / if CubeSat must be shut down for an extended period of time (more than three hours).

Conclusion: Design to Steady State Cold Temperatures



Need to design to steady state values in order to ensure survival

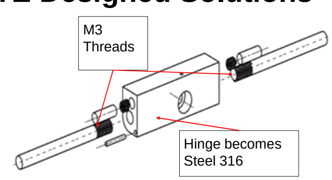
Coatings	Power Low (W)	Power High (W)	High Temperature	Low Temperature
Aluminum	15	15	478	280
Aluminized Kapton	15	15	322	184
Silvered Teflon	15	15	277	184
Silvered Kapton	15	15	364	235
Silvered Teflon SADA Only	4	4	373	237
Aluminized Kapton	36	90	370	235

Example Temperature Profile of CubeSat

CTE Analysis Concerns

- Solar panel rods and transmission shaft into hinge loses contact and
  - Requires large pre-stress for press fit (sunny side up)
- Tolerance uncertainty requires even larger pre-stress for press fit (sunny side up)
- Teflon bushing losing contact with chassis (eclipse)

CTE Designed Solutions



Bushing:iglide® X6, sleeve bearing
(Rated for -100C to +250C)

Engineering Ambassadors Wind Tunnel

Spring 2018 Team: Daniel Snyder (IME), Jorge Elizagaray (IME), Omar Alshaye (IME), Matthew Gott (MECL), Connor Laliberte (MECL), Jacob Moreland (MECL), Jiachen Yang (MECL), Renato Carvalho (EE), Nina Kovari (MGMT)

Purpose and Background

- Engineering Ambassadors (EA) is an RPI organization of engineers
  - Goal is to inspire high school students with hands on activities
  - Exploration of the role of engineers in society
- Redesign a tabletop wind tunnel used to demonstrate importance and consequences of drag force
  - Ensure high level of interactivity to spark student interest in engineering
  - Allow for students to measure drag coefficients within 15% of actual values
  - Explore alternatives for schools to obtain their own model

Semester Deliverables

- Designed and built a tabletop wind tunnel that measures drag force, wind speed and temperature
- Developed instructional video to demonstrate wind tunnel operation
- Created lesson plan to guide students through the experiment
- Produced a manual for manufacturing and assembly of the wind tunnel
- Provided cost and market analysis along with marketing plan for final product

Future Plan

- Adding system to measure lift force
- Permanent lighting solution
- Simplify manufacturability
- Finite element analysis

Technical Approach

- JEC SLS Wind Tunnel Comparison
  - Determine fan specifications
- Gage R&R Analysis
  - Quantify Accuracy and Reproducibility
- Von Mises Stress Analysis
  - Ensure durability of the housing
- CFD analysis for wind flow
  - Simulate flow conditions (2700 RPM)

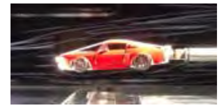


Fig 1: Model car in JEC SLS Wind Tunnel

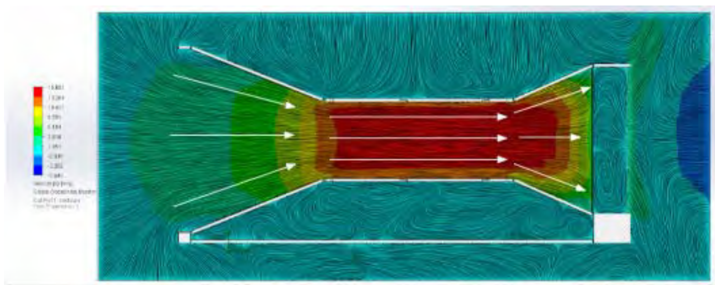


Fig 2: Flow simulation for concept model

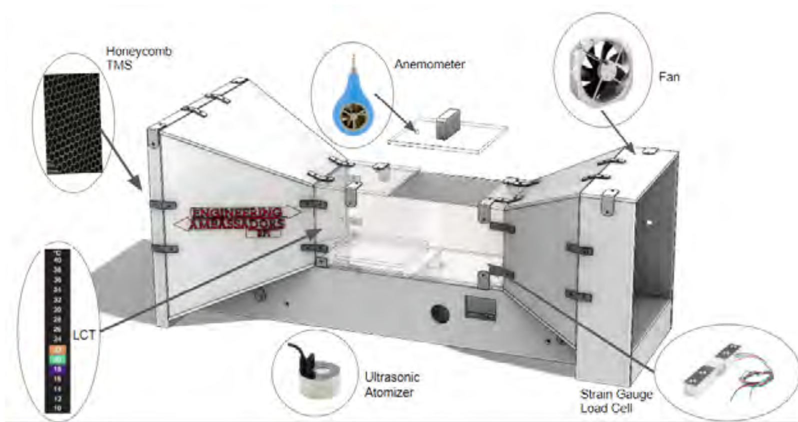


Fig 3: Final model with subsystem integration

Technical Results

- Velocity Relationship Comparison

$$F_D = \frac{1}{2}\rho C_D V^2 A$$

Wind Tunnel	Velocity Exponent	Percent Error
Old	2.61	30.7
JEC SLS	1.98	1.04
New	1.97	1.64

Fig 4: Experimental Fan Comparison

- Accuracy & Reproducibility Results

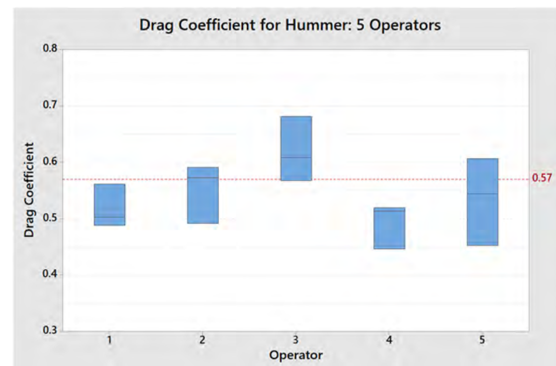


Fig 5: Gage R&R study

Marketing Proposal

- Total Cost
  - Raw Materials - $525
  - Labor cost - $120
- EA Drag Force Educational Kit
  - Wind Tunnel Materials
  - Manufacturing and Assembly Guide
  - Instructional Video
  - Student Lesson Plan

GE Ultrasound Haptic Feedback

Spring 2018: Daniel Southwick (EE/MATH), Douglas Piazza(ME), Harrison Eichler(IME), Jesse Castellana(ME/ECON), Joshua Stricker(ME), Kun Yuan (EE/MATH), Zhenming Liu(EE/ME)

Purpose:
- Allow an untrained operator to perform an ultrasound exam with remote guidance from a trained professional
- Measure and remotely communicate the normal force and orientation of an ultrasound probe during an exam

Past Work:
- Fall 2017 project demonstrated that haptic feedback on probe can be used to guide an operator's hand
- The prior art in ultrasound force sensing includes several patents held by MIT

Semester Objectives:
1. Build prototypes of two design concepts for force-sensing US probes
2. Output real-time data of force readings and probe orientation in space

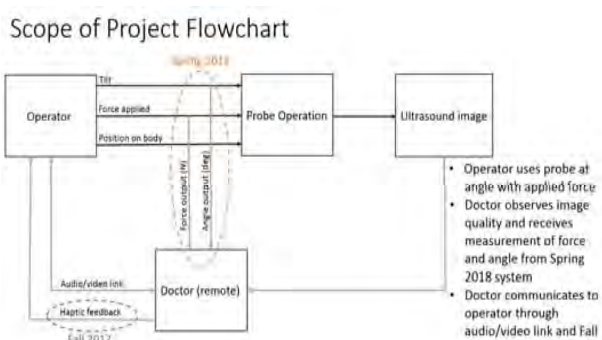


Figure 1: Project Scope

Technical Accomplishments to Date:
- Built two functional prototypes: Over-case design *(Fig 2)*, Internal sensor design *(Fig 3)*
- 3D visualization *(Fig 4)* gives real-time view of probe orientation in space as well as force values (numerically and via heat map)

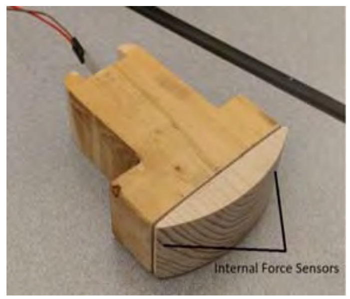


Figure 2 : Internal sensor prototype

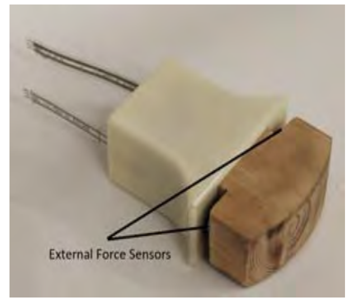


Figure 3: Over-probe case

Technical Approach:
- Over-probe case 3D printed from ABS, Internal design made from wood
- Normal force measured with ADC calculation on PSoC4
- Probe instrumented with accelerometer and two force sensors
- Live probe orientation and force value data processed in Python and displayed via visualization in MATLAB
- Measurement accuracy tested using a Gauge R&R study by applying known forces using Instron Testing System

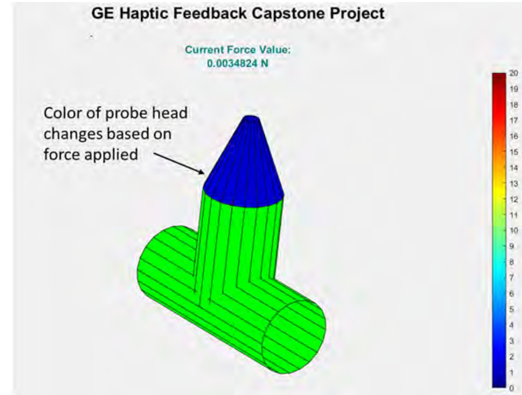


Figure 4: 3D visualization of probe

Recommended Next Steps:
Determine how to convey the position (location and angle relative to skin) of the probe on the patient's body to the remote doctor

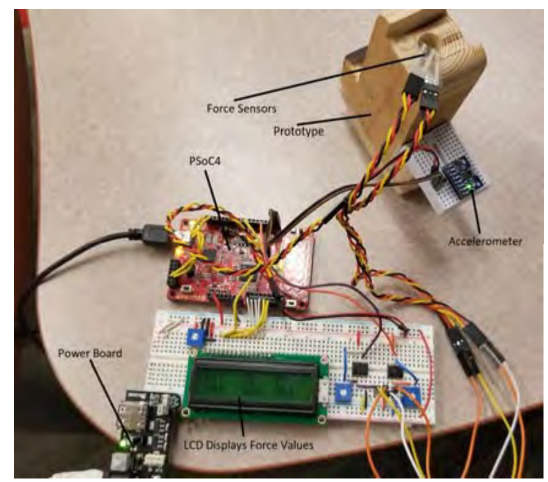


Figure 5 Final System

Battle Control System – Fixed (BCS-F)

THE DESIGN LAB at Rensselaer

Spring 2018 Team: James Anderson (CSE/CS), Laura Antoniello (IME/EMAC), Eric Eastman (CSE), Ellie Mees (EE), Timothy Stankewicz (MECH), Devin Sullivan (CSE), Dina Zaslavsky (CSE)

MITRE

Purpose

The BCS-F is a tool used by NORAD to monitor North American skies for airspace defense. The purpose of this project is to improve BCS-F operator alertness and efficiency.

Past Work

- Preliminary desk and smart lighting research
- Occupational Control Center (OCC) layout
- 2D, 3D, VR applications

Semester Objectives

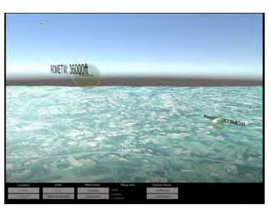
- Create and test prototype of the OCC dynamic workstation
- Improve server stability
- Add new features to aid threat assessment
- Present at EADS, Rome, NY site

Semester Achievements - Software

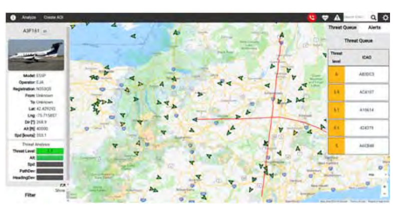
- Improved server stability
- 2D Application: Drawing of full flight paths, UI improvements, integration with 3D app
- 3D Application: Display live data, UI improvements, running in web browser
- Conducted testing to show faster threat assessment in 3D

54% faster identifying 2 planes in close proximity

42% faster identifying planes descending too quickly



3D Application



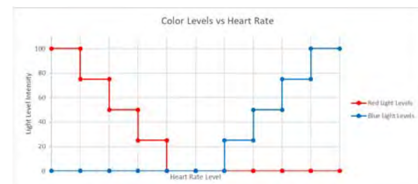
2D Application

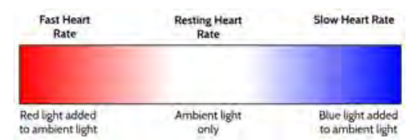
Semester Achievements - OCC

- Developed prototype dynamic workstation with height-adjustable desk, ergonomic keyboard and mouse, and dynamic lighting
- Conducted testing to show benefits of height-adjustable desk

38.5% faster reaction to threats

31% fewer errors made





Heart rate integration with lighting output

Feedback & Future Direction

- Incorporate feedback from EADS trip into new dynamic workstation to leave behind at EADS for operator trial period
- Conduct additional testing to study effects of red and blue lighting
- Improve user controls and camera positioning in 3D
- Display more information in 3D, e.g. speed and pitch indicators

Ocular Dosimeter

Spring 2018 Team: Karl Nasrallah (EE/PHYS), Nicolas Cheng (EE/ECON), Steven Baena (MECH), Caiti Vinopal (MECH), Yao Shang (EE/MATH), Jingyu Su (EE/CSE)

Purpose

- LESA researchers need to measure wavelength & intensity of daily light incident on human eyes
- *Ultimate Goal*: Create head-worn spectrometer with mobile app for LESA's studies on circadian rhythm

Semester Objectives

- Complete code development for STM32-based dosimeter (*Fig. 3*)
- Design and print fully-working prototype PCB
- 3D print two enclosures
- Obtain data from the device
- Demonstrate two working, assembled systems

Past Work

- One frame concept model
- Incomplete spectrometer interface
- Pre-STM32 PCB layout

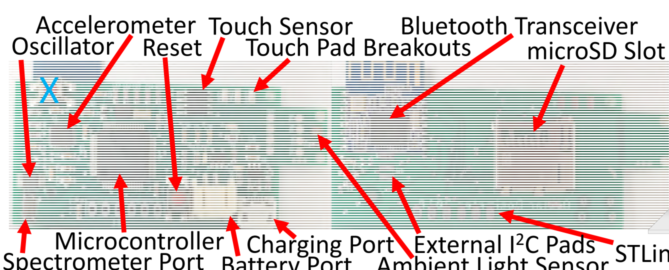


Fig. 1: Dosimeter Prototype PCB

Technical Results

- Current PCB printed and populated (*Fig. 1*)
- Next PCB version created and peer-reviewed
- Mechanical designs created (*Fig. 2*)
- Software functionally complete
- Dosimeters assembled and tested

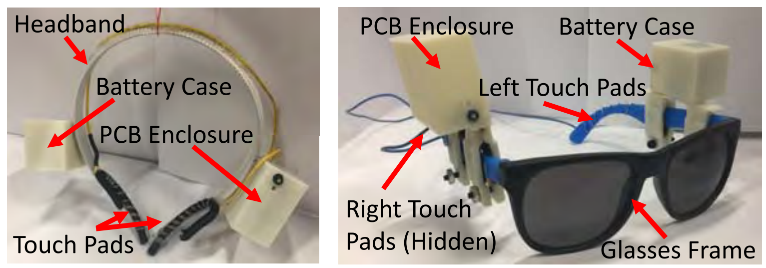


Fig. 2: Assembled Dosimeter Prototypes

Technical Approach

- Make hardware kits mimicking PCB layouts for testing code
- Convert raw sensor data to human-readable form
- Design enclosures in NX
- Employ RPI resources to make parts (MILL, Mercer Lab)

Future Work

- Develop smartphone app
- Add power switch and touch sensor locations to enclosure
- Use faster ambient light sensor
- Print PCB with fixes & new BT chip

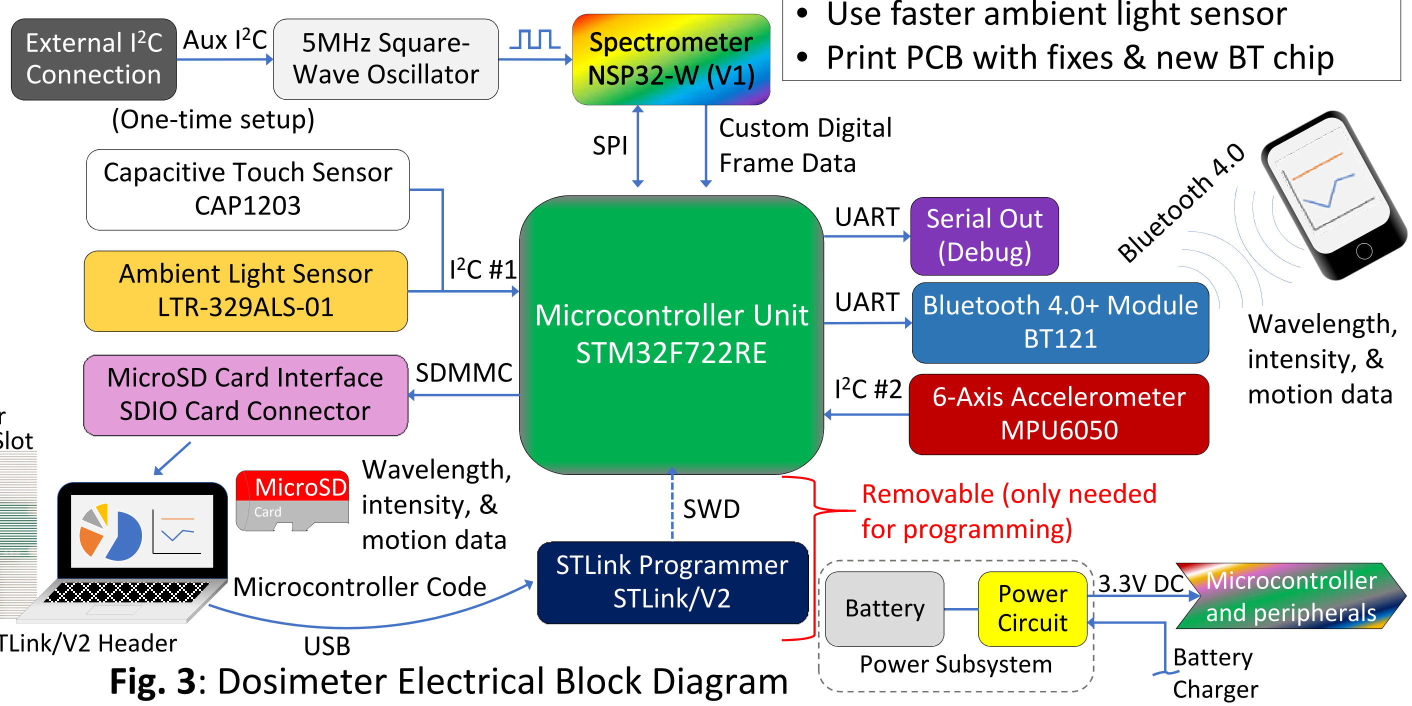


Fig. 3: Dosimeter Electrical Block Diagram

UTC Event Logistics

Spring 2018 Team: Karl Anderson (IME), Janey Hoefler (IME), Theodore Lesiak (IME), Zach Lukas (IME), Bailey McLaughlin (IME), Nabil Romero (IME), Joshua Smith (IME), John Wilt (IME)

THE DESIGN LAB at Rensselaer

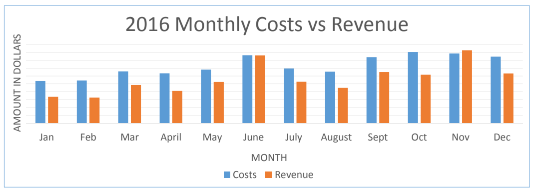
United Technologies

Purpose

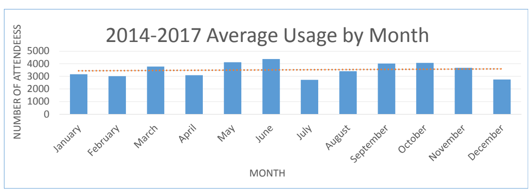
- Improve the profitability and system efficiency of the UTC Leadership and Technical Education Centers.

Past Work

- **Inefficient Reservation Process**
    - Some reservations can take up to 4 hours to book
- **Facility is Currently Operating at a Loss**



- **Underutilization of Facility**
    - Current average utilization of both centers is 52% for 2017



Semester Objectives

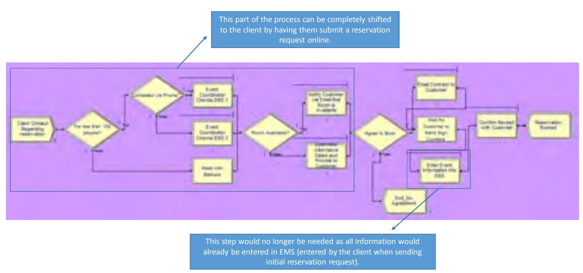
- Reduce reservation transaction time
- Minimize operating deficit
- Promote customer growth

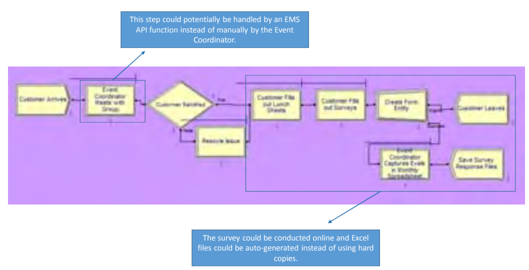
Technical Approach

- Create a simulation of proposed system improvements using Arena
- Develop a pricing model using Microsoft Excel
- Conduct a marketing analysis
- Design a social media marketing plan

Technical Result

- **Solutions for System Improvement**:
    1. EMS Upgrade
    2. Online Surveying
    3. APIs for Welcome Screen





Technical Result

- **Recommended Price Model:**

Model:	Expected Revenue:	Revenue Increase:	Revenue Increase:	% of 2016 Deficit :
Phase Pricing	$3.43 MM	+ $ 190 K	6 % $ 190 K	19 % of 1MM Deficit
Seasonal	$3.56 MM	+ $ 310 K	10 %	31% of 1MM Deficit
Package Based	$3.94 MM	+ $ 640 K	17 %	56 % of 1MM Deficit
Hourly Based	$2.11MM	+ $ 433 K	13 %	43 % of 1 MM Deficit

- **Marketing Analysis:**
    - UTC has competitive advantage

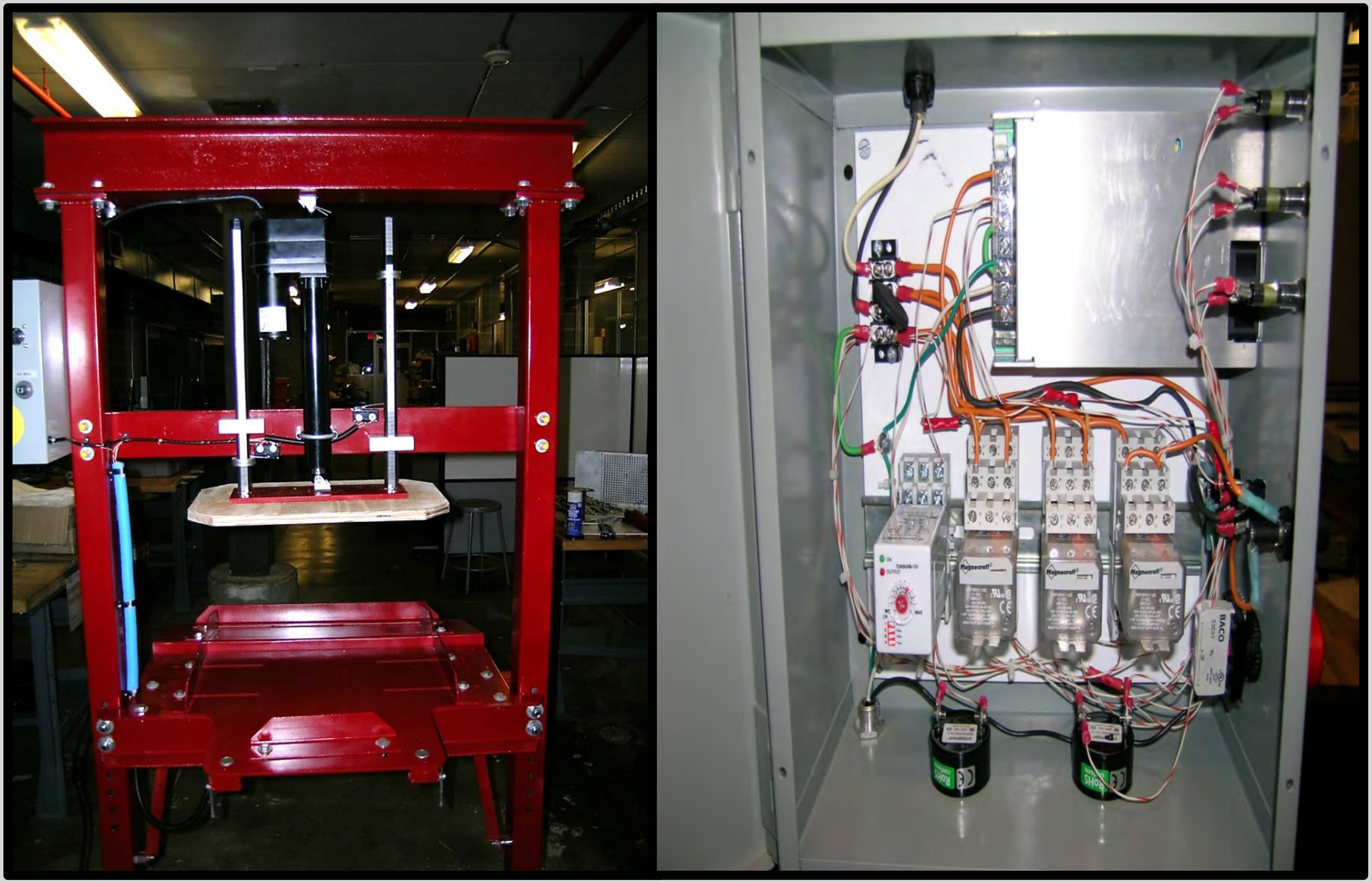
Facility	Flexibility of Meeting Space	Catering Services	Free WIFI	Networking Spaces	Outdoor Area	Team Building Activities	Video Conferencing
UTC Leadership Center	✓	✓	✓	✓	✓	✓	✓
UTC Technical Center	✓	✓	✓	✓	✓	✓	✓
Hampton Inn	✓	✓	✓				
Avon Old Farms Hotel	✓	✓	✓	✓	✓	✓	
Hilton Garden Inn	✓	✓	✓				
Courtyard Marriot	✓	✓	✓				
Courtyard Marriot	✓	✓	✓	✓			✓
Inn at Middletown	✓	✓	✓	✓		✓	
Radison Hotel	✓	✓	✓	✓			
Hartford Marriot	✓	✓	✓	✓			✓
Sheraton Hotel	✓	✓	✓				

- **Social Media Plan:**
    1. Facebook Posting Strategy
    2. Social Media Posting Schedule
    3. Facebook Insights Data Analysis

Conclusion

- Implementing the proposed EMS solutions will save **4.92 hours per week**.
- A price increase could generate between **$200,000** and **$400,000** in increased revenue.
- Customer outreach can potentially increase yearly revenue by up to **$322,436** through increased utilization.

Reliability and Test Systems

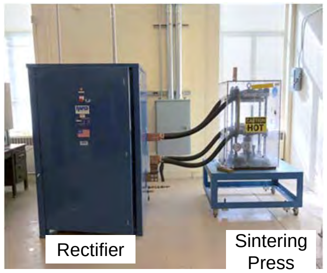


Field Assisted Sintering Technology (FAST) Lab

Spring 2018 Team: Tom Feenstra (MECHE), Tim Rice (MECHE & DIS), Xuanyi Ding (MTLE), Daniel Williams (MTLE), Robert Schroeder (MTLE), Alex Pedersen (EE), Gavin Dowse (MECHE), Michael Bielecki (MECHE)

Purpose & Background

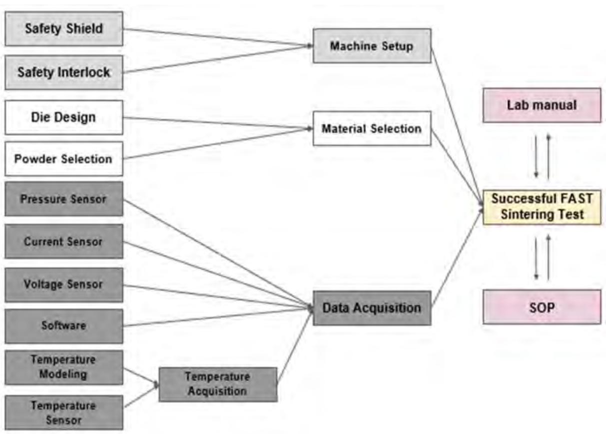
- FAST via rectifier and sintering press
- Undergrad student lab experience
- New manufacturing technology at RPI



Semester Objectives

- Setup sintering machine
- Develop data acquisition system
- Develop standard operating procedure
- Develop lab manual

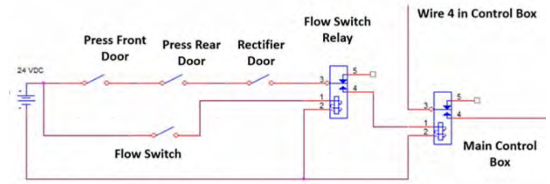
System Overview



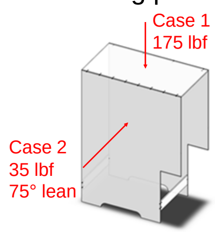
Technical Results

Machine Setup

Interlock relay prevents operation of machine until all safety measures are in place.



Shielding prevents contact with energized rectifier

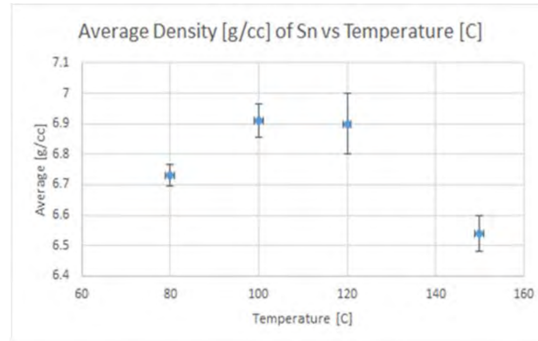


FEA Results

Case 1	
Peak Stress	2,000 psi
Peak Deflection	0.288 in

Case 2	
Peak Stress	2,100 psi
Peak Deflection	0.249 in

Tin Sintering Results

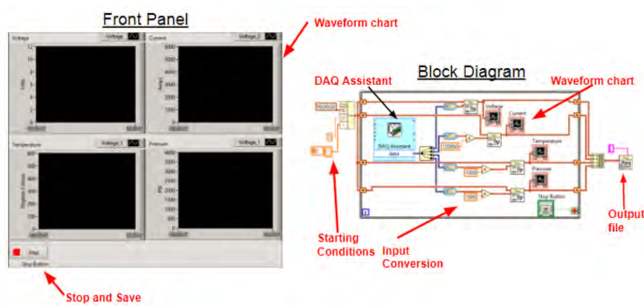


12 powdered tin samples were sintered at varying temperatures resulting in varying densities. Greater density at 100°C indicates an optimal sintering temperature.

Data Acquisition

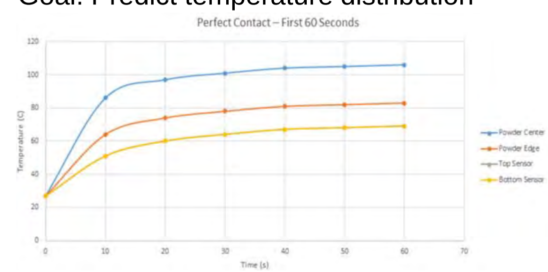
Labview software interface to record and save data as .CSV file:

- Press pressure
- Die Temperature during sintering
- Rectifier Current and Voltage during sintering

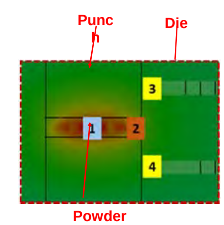


Thermal Anaylsis

Goal: Predict temperature distribution



- Temp. dist. highly dependent on thermal resistance between punch and die
- Transient portion is short relative to steady state



Data Acquisition System

Spring 2018: Shane Casey (MANE), Christopher Fernald (ECSE), Xinyang Liu (ECSE), John McHugh (ECSE), Chidiadi Onyeukwu (ECSE), Perrine Papillaud (MANE), Shenrui Zhang (ECSE)

Project Goal

To create a DAQ system that collects data from a variety of measurement instruments, thus expediting the data-driven design process for RPI design lab projects

DAQ Design Evolution

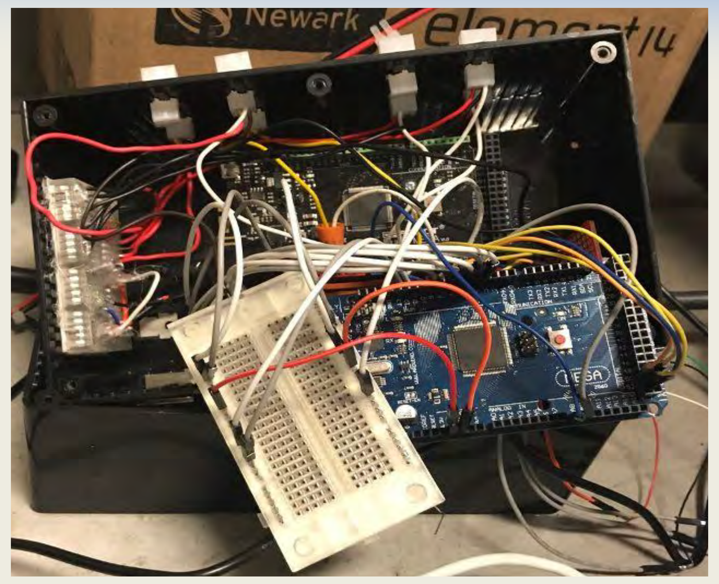


Figure 1: Final prototype from Fall 2017

Figure 3: NI USB-6009 used in Spring 2018 prototype

Figure 2: Final prototype from Spring 2018

Semester Objectives

DAQ System with the following features:

- 5 analog input channels ✔
- 12 bit A/D conversion ✔
- Signal conditioning ✔
- Data export & GUI ✔
- Real time configuration ✔
- Adjustable sample rate ✔
- User friendly ✔

Technical Approach & Plan

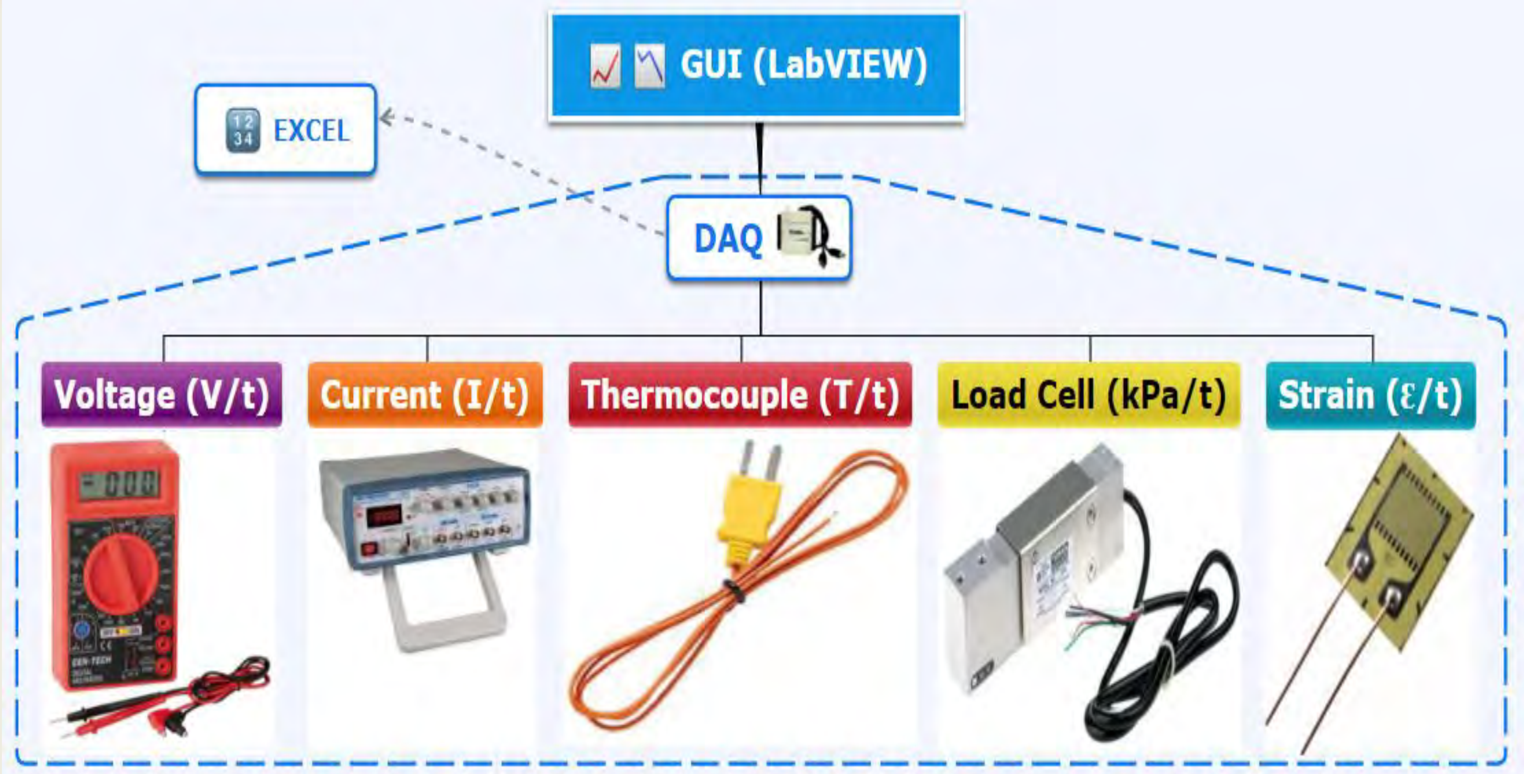


Figure 3: Organization Chart for Data Acquisition System

	A	B	C	D
1	Time	1_Voltage	Time 1	2_Thermocouple
2	2/23/2018 13:52:18.04718	1.997799	2/23/2018 13:52:18.04718	25.433416
3	2/23/2018 13:52:18.05718	1.997832	2/23/2018 13:52:18.05718	25.304718
4	2/23/2018 13:52:18.06718	1.997836	2/23/2018 13:52:18.06718	25.167009

Figure 4: DAQ Exported Data Format

Table 1: Benchmarking of DAQ Software Approaches

	LabVIEW	MATLAB	PASCO
Comes with RPI Software	✓	✓	✓
Real time signal processing	✓	✓	✓
Industry standard	✓	✓	✗
Compatible with most hardware	✓	✗	✗
Programming language is intuitive	✓	✗	✓
Extensive help directory	✓	✓	✗
No previous coding knowledge required	✓	✗	✓
Powerful signal processing capabilities	✓	✓	✗
Easy GUI Design	✓	✗	✓
Small learning curve	✗	✗	✓

Table 2: Benchmarking of DAQ Hardware Approaches

	NI USB-6009	Arduino	Raspberry Pi
Device available to students	✓	✗	✗
Robust and durable system	✓	✗	✗
Easily integrates with LabVIEW	✓	✗	✗
Meets project specifications with no additional hardware	✓	✗	✗
Compact system	✓	✗	✗
Has external enclosure	✓	✗	✗
Customizable hardware	✗	✓	✓

Technical Results

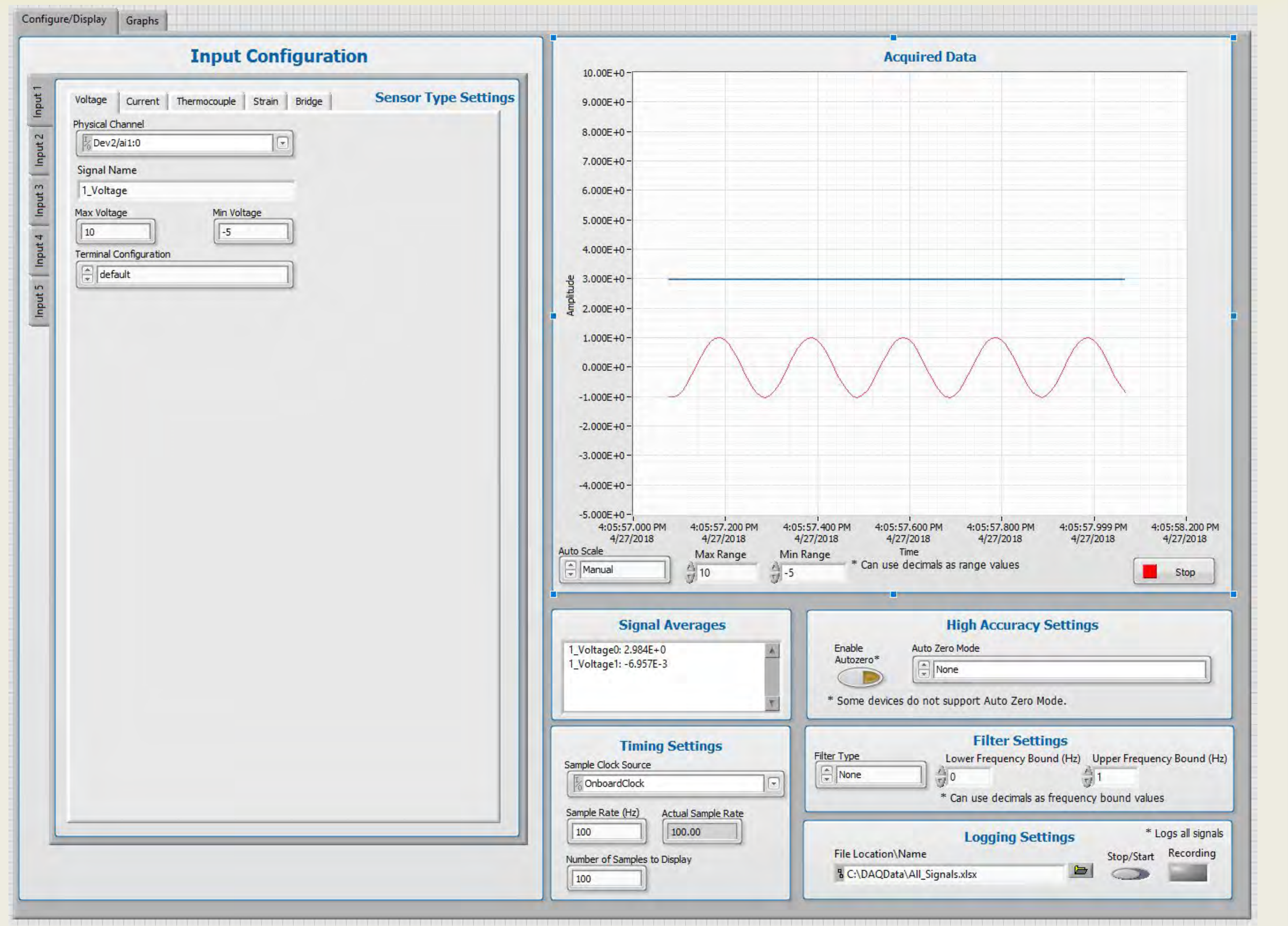


Figure 5: Front Panel of LabVIEW GUI with 5Hz sine wave input and 2V DC input

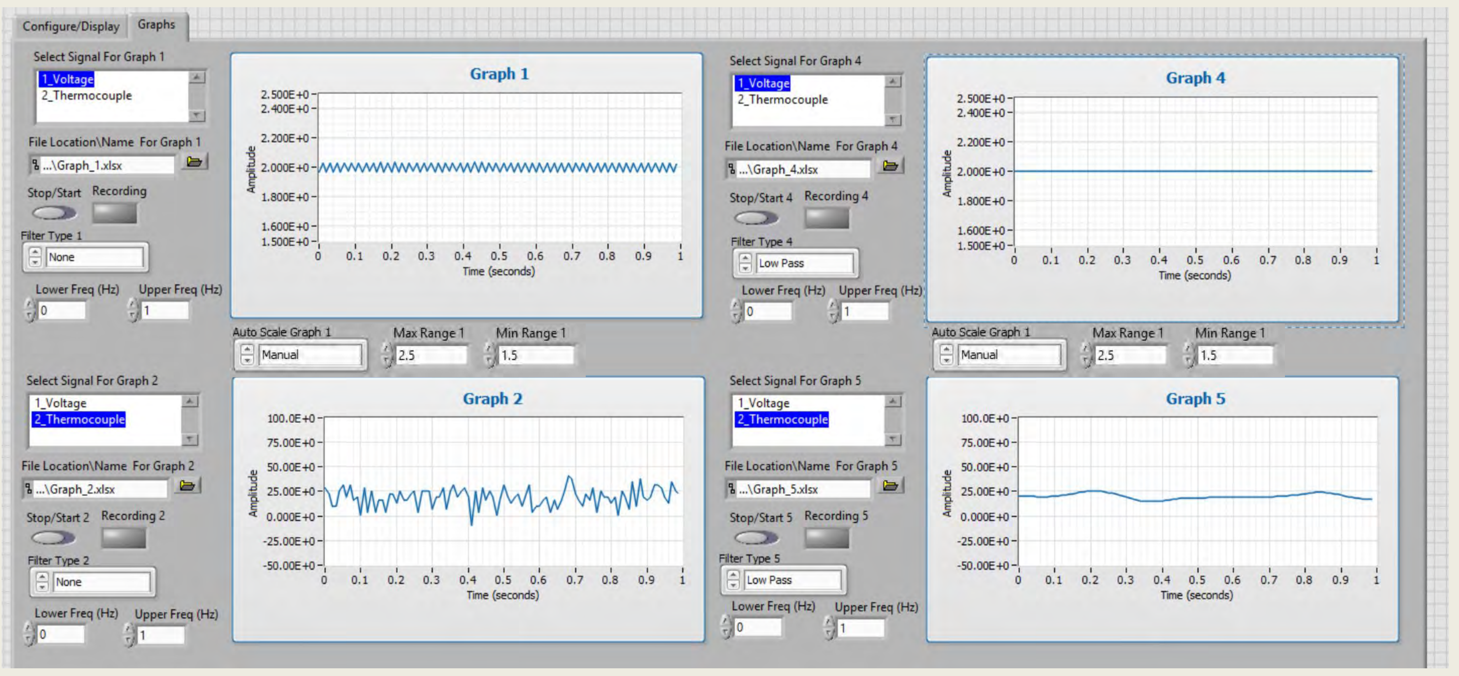


Figure 6: Graph Panel of LabVIEW GUI
Graph 1: 2V DC signal with 50 Hz noise
Graph 2: Thermocouple at room temperature(℃)
Graph 4: Filtered 2V DC signal with 50 Hz noise
Graph 5: Filtered thermocouple at room temperature (℃)

Future Outlook

- Add more measurement instruments (accelerometer, sound pressure, RTD, thermistor)
- Add support for other non-NI devices

Sponsor: Jeff Morris; Project Engineer: Darryl Michael (ECSE); Chief Engineer: Partha Dutta (ECSE)

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