THE DESIGN LAB at Rensselaer

2018-19 Capstone Projects Portfolio

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

O.T. Swanson Multidisciplinary Design Lab
School of Engineering
Rensselaer Polytechnic Institute
110 8th Street, JEC 3232
Troy, NY 12180
(518) 276-2724
https://designlab.rpi.edu

THE DESIGN LAB at Rensselaer

The 2018-19 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, senior engineering students tackled design projects ranging from smart technologies (sensors, manufacturing, augmented reality) for manufacturing applications to energy and sustainability. Some teams worked with entrepreneurs while others provided benefits to the local community through service learning projects.

The Design Lab served 353 students this year who worked on 47 different design projects. The multidisciplinary project teams included students from aeronautical, biomedical, computer and systems, electrical, industrial, materials, and mechanical engineering disciplines. Rensselaer engineering students graduate with the ability to work on diverse teams to solve real problems with multi-faceted constraints and deadlines, due in large part to their Design Lab experience. The Capstone design challenges were solved through the hard work and creativity of the students, as well as the dedication and involvement of our sponsors and partners.

Highlights from the 2018-19 academic year are:

1. The Design Lab welcomed 7 new sponsors: BAE Systems, Stephen Bader Company, Inc., Timken, SolarFi, Double H Ranch, Troy Boiler Works, and Green Enviro Machine, LLC. We also welcomed back a Sponsor who last worked with us in 2011.
2. Several Capstone projects were conducted in support of RPI and its research centers. Examples include robotic welding and in-home assistive robot prototype for CATS (the Center for Automation Technologies and Systems), an HVAC project for RPI Facilities, and a time of flight sensor for LESA (Lighting Enabled Systems & Applications).
3. Four Capstone teams participated in industry days sponsored by CATS, LESA and CFES (Center for Future Energy Systems). The Design Lab received industry recognition for its work with LESA, and was voted "Best Undergraduate Poster" during the LESA 10th Annual Industry – Academia Days event. The work of the Capstone team on the robotic welding project was recognized in the Welding Journal.
4. Brad DeBoer joined the Design Lab team as Senior Project Engineer. Brad's 20+ years of engineering experience in energy, manufacturing and the composites industries is a great asset to the students. We also welcomed two MANE faculty members, Prof. Sandi Mishra and Dr. James Young, serving as Chief Engineers.
5. The Design Lab initiated a recognition program this year for individual and team performance. Three students and three project teams were recognized each semester for exceptional work in the multidisciplinary Capstone course.

Sincere thanks to our sponsors, partners, and friends for providing technical challenges four our students this year. Our faculty and staff are 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.
Director, O.T. Swanson Multidisciplinary Design Laboratory
Professor of Practice, Materials Science and Engineering
School of Engineering, Rensselaer Polytechnic Institute, Troy, NY
Phone: 518-276-8293
Email: DesignLabDirector@rpi.edu

Table of Contents
2018-19 Capstone Design Projects

Energy and the Environment

GE Blade Inspection Robot

Fall 2018 Team: Clare Severance (MECH), Tenzin Tashi (MTLE), Christopher Demeritt (MECH),
Jasper Boland (CSE), Ziyi Lu (CSE), Tianli Cao (ELEC), Shiyan Yang (MECH)

Purpose

Problem Identification:

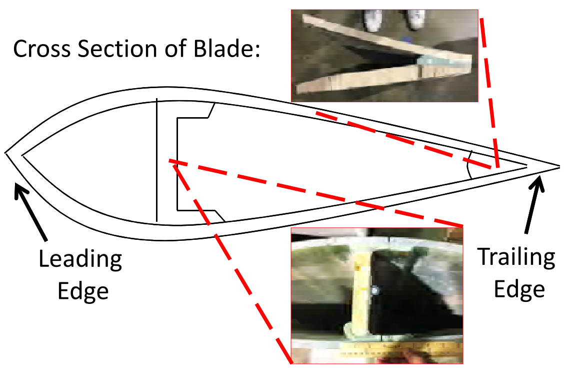
- 35,000+ wind turbines globally require inspection
- Costly, lengthy, and dangerous process

Current Methodology:

- Ground and drone monitoring
- Manual technician inspection via harnessing

Project Goals:

- Motion-controllable robot capable of carrying out inspection via ultrasonic and visual instrumentation



Areas of interest for inspection

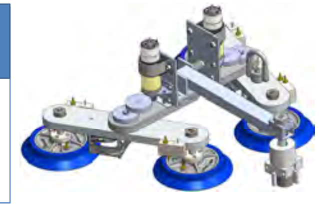
Past Work

Previous Semesters:

- Suction cup based robot design
- Couplant benchmarking
- Vehicle stress analysis

Semester Objectives

- Walk and operate on a vertical blade surface
- Carry non-destructive testing equipment to use at the spar and trailing edge
- Move according to user commands

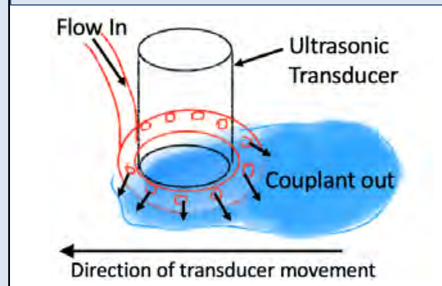


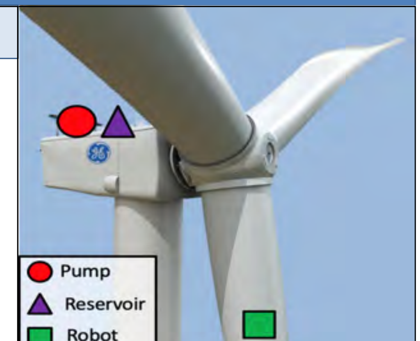
Technical Achievements and Design

Non-Destructive Testing:

- Established inspection plan
- Specified transducer, couplant, and camera
- Designed, tested, and integrated couplant dispersal system (CDS)

Nozzle Design

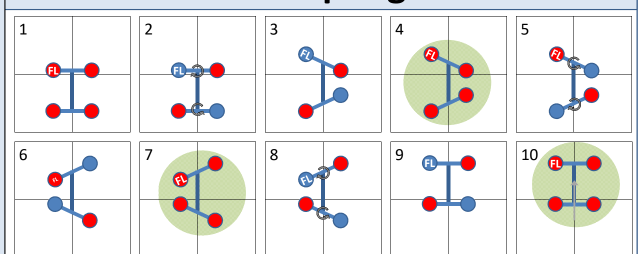




Electrical:

- Replaced and repaired wiring
- Removed unnecessary components
- Installed pressure sensor system
- Implemented new motion procedures

Forward Step Algorithm



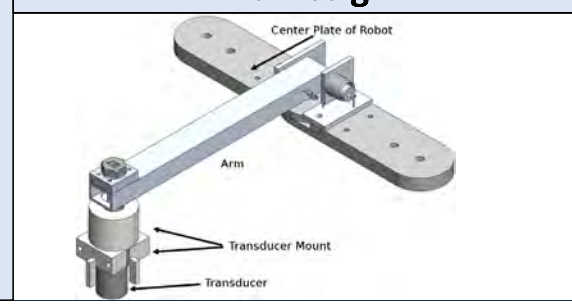
Key:

- Red: Suction cup engaged
- Blue: Suction cup disengaged
- FL: Front left suction cup
- Green Circle: Verify suction before proceeding

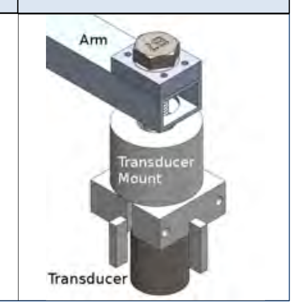
Mechanical:

- Designed, built, and tested Instrumentation Mounting System (IMS)
- IMS controls positioning and orientation of ultrasonic sensor on the wind blade sample section

IMS Design



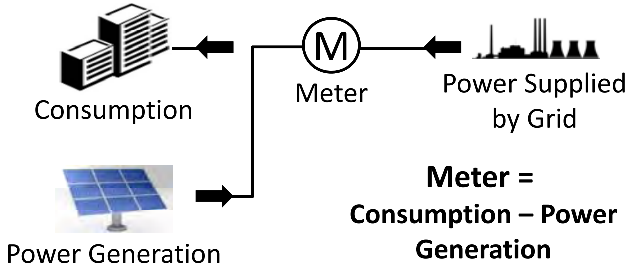
Transducer Mount



GridEd: Behind-Meter Power Estimation

Fall 2018: Brian Kilcullen (CSE & CS), Cavell Teng (CS & CSE), Christopher Presti (CSE & CS),
Grant O'Connor (EE & CSE), Jean M Lam (EE), Joseph Galtman (CSE), Larry Montes (EE)

Purpose and Background



Goal: Day-Ahead Meter Prediction Model
Benefit: Minimize power overproduction, Reduce operating costs
Sponsors: NYISO, EPRI

Project History

- Consumption and Power Generation Models for ECAV Building
- Limitations: Solar Power Generation << Building Consumption, Limited Cloud Coverage Analysis + ANN Integration

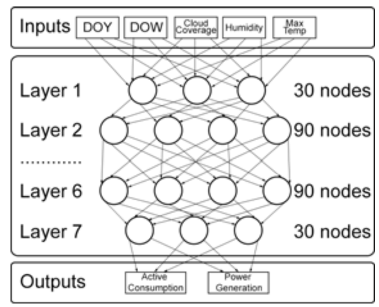
Semester Objectives

1. Improve ANN accuracy with new inputs
2. Host ANN on server to improve performance
3. Improve cloud coverage data collection
4. Implement wireless data transmission (3G)

Technical Approach & Results

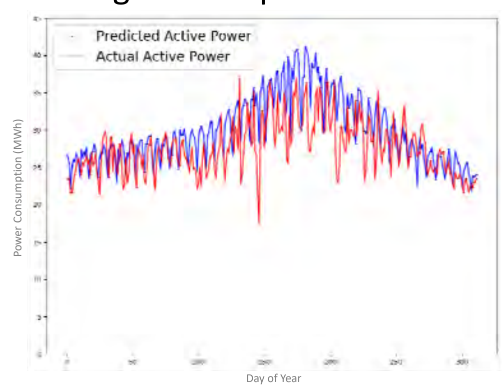
Artificial Neural Network

Fall 2018 Final Network Topology



Input: 5 Weather Data Variables
Output: Predicted Next-Day Building Consumption and PV Generation

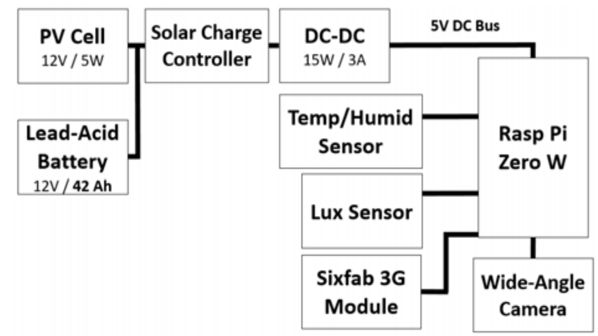
Building Consumption Test Results



- Training Data: 2010 – 2013
- Testing Data: 2014
- **8.58% Average Error**

Weather Data Collection

Data Collection System Diagram



Hardware Improvements:
- Migration to Raspberry Pi Zero Wireless
- Fish-eye camera implemented for sky images
- Enclosure and power system overhauled
- Wireless (3G) data transfer to ANN server

Cloud Coverage Analysis:
- Particle analysis to dynamically distinguish cloud and sky
- Blue/red ratio and HSV saturation thresholds
- Account for direct sun exposure

Raw Image

Thresholding Result

Troy High School Greenhouse

THE DESIGN LAB at Rensselaer

Spring 2019 Team: Michael Allahua (MECL), Yuetong Liu (MECL), Elisabeth Ryan (MECL),
Ruojun Sun (ELEC & CSE), Garrick Tsui (MECL), Reed Woolfson Jarvis (MECL & CSCI), Yunyun Zhang (ELEC)

Purpose

- Extend the growing season
- Add educational tools

Previous Work

- Control system design
- Lighting analysis
- Passive thermal and irrigation system designs

Objective

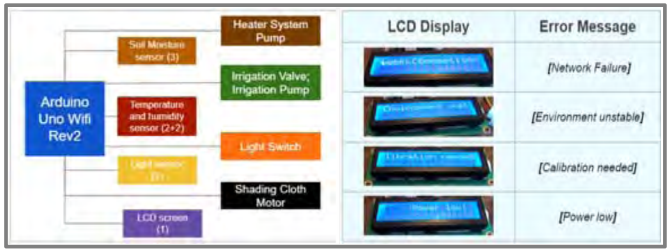
Create an interactive smart system that keeps the THS greenhouse at sustainable conditions from Mar. to Nov.

Spring 2019 Results

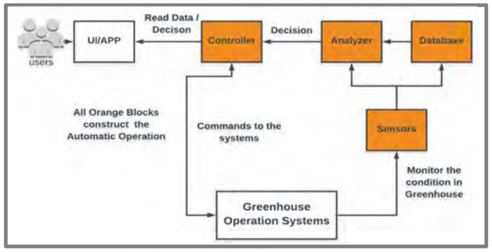
Plans Moving Forward

- Overall power analysis
- Off-grid power Design
- Continued development of
  - UI/APP
  - Smart Operation Algorithm

Sensor Hardware

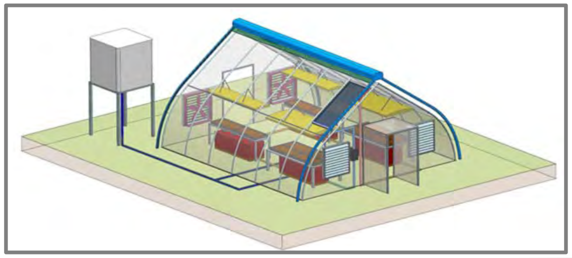


Control Algorithm



Controls System

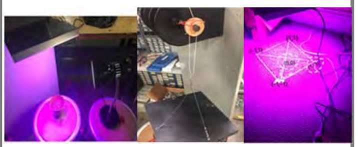
Three Levels of Automation:
Manual
Semi-Auto
Full Auto



UI/ APP

Lighting

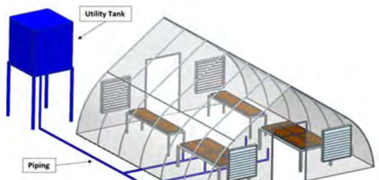
Light Experiments

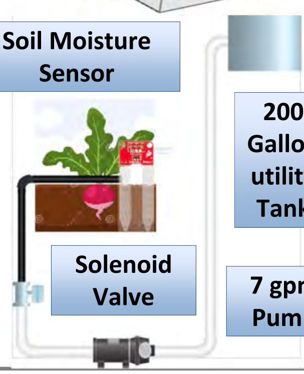


Optimal light mounted height for plants

	Light intensity (Lux)	Light	Height (cm)
Basil	1567	part_shade	~44
Spring Lettuce	3189	part_shade	~34
Leaf lettuce	3189	part_shade	~34
Carrots	1459	full_sun	~35
Cucumber	2756	full_sun	~18
Tomatoes	2864	full_sun	~16
Mesclun	3189	full_sun	~12
Bell Pepper	1891	full_sun	~30
Pumpkin	1405	full_sun	~36
Green Beans	2216	full_sun	~25
Thyme	3027	full_sun	~15

Irrigation





Soil Moisture Sensor

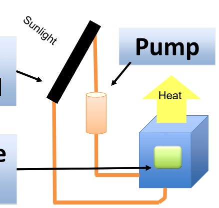
200 Gallon utility Tank

Solenoid Valve

7 gpm Pump

Heating

Thermal Battery

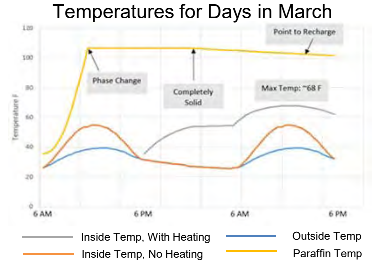


Solar Water Heater Panel

Pump

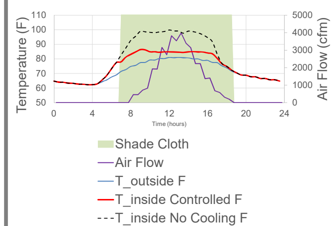
Phase Change Material

2 Day Analysis of Greenhouse Temperatures for Days in March



Cooling

Shade Structure Components



Auto Cooling Example

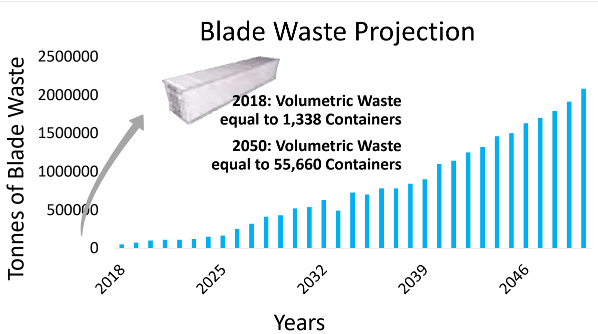
Wind Blade Recycling

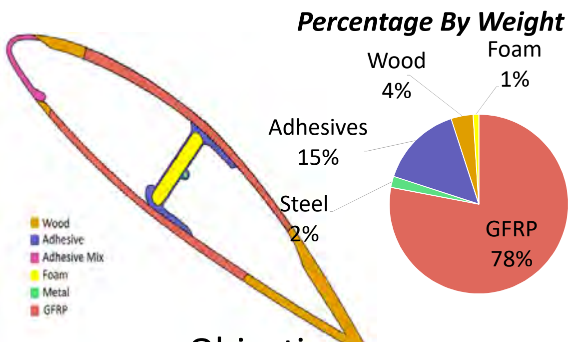
THE DESIGN LAB at Rensselaer

Spring 2019: Cecilia Briggi (ISE), Stephen Chan (MECL), Raymond Chien (MECL), Buhan Jiang (MECL), Joshua Ling (MECL), Cody Madigan (MTLE), Jonathan Mazur (MECL), Yifan Yao (MTLE)

Background

- Significant increase in turbine waste expected in next 20 years.
- Aim to reclaim bulk materials produced through energy-intensive processes, i.e.: GFRP.
  - ➢Blades are 70-75% glass fiber by weight.
- Composites pose a large challenge due to their heterogeneous & anisotropic nature.





Objectives

1. Produce wind-blade deconstruction process
2. Develop methods to process & recycle GFRP component of turbine blade
3. Prototype novel recycling methods
4. Establish commercial application of recyclates

Potential Solutions

1. Pyrolysis--high temperature exposure incinerates materials & generates energy.
2. Reuse as building materials--similar composite decking, requires flattening & resurfacing.
3. Pelletization for Home Boilers--similar to pyrolysis, Requires redesign of pellet stove and off-gas analysis.

Approach

- Develop prototyping experiments.
- Minimize processing to reclaim bulk GFRP.
- Establish requirements for deconstruction process.
- Establish commercial decking requirements.

Goal

Develop GFRP decking materials.

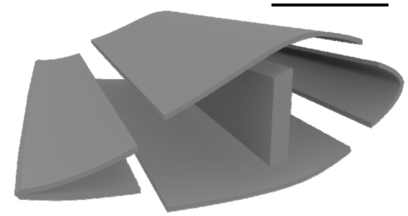
Processes Evaluated

1. Heated Press—heat material to T_g, apply force to flatten.
2. Mechanical Delamination—use force to break material on glass layer boundaries.
3. Solvolysis—use chemical solution to remove resins and expose glass fibers.

Next Steps

1. Evaluate impact of cutting GFRP to size before/after heated press
2. Develop complete laboratory scale prototype
3. Full characterization of mechanical / end of life properties
4. Evaluate industrial scale-up
5. Evaluate potential commercial coatings
6. Consider adaptations to pellet stove

Results



Deconstruction

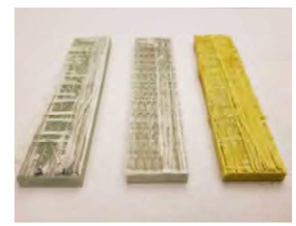
- Separate bulk GFRP
- Transport in 40 foot container
- Shred waste

Heated Press

- Reduce curvature by heating GFRP to T_g & applying pressure until cool

Mechanical Delamination

- Propagate crack between laminate layers to reduce GFRP thickness
- Use an angled wedge for precision



Solvolysis

- Immerse GFRP in chemicals to expose fiber matrix

Property Testing

Material Treatment	Maximum Stress at Outer Fibers (Mpa)	Strain at Failure (mm/mm)
Untreated GFRP	827.3	0.085
Heat-Pressed GFRP	517.3	0.057
Relaminated GFRP (Acetone)	705.1	0.047
Relaminated GFRP (Nitric Acid)	421.2	0.117

JEC HVAC Energy Enhancement

THE DESIGNLAB at Rensselaer

Rensselaer

Spring 2019 Team: Joshua Wood (CSE), Joel Sunny (EE), Sean Scharsig (ME), Preston Veley (ME), Alex Lomakin (ME)

Background Information

- JEC Energy Recovery Ventilators (ERVs) are not functioning optimally
- Leading to occupant comfort complaints and safety issues in labs
- ERVs transfer energy between exhaust and supply air

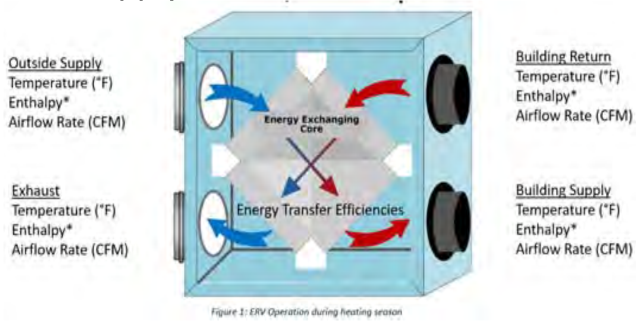


Figure 1: ERV Operation during heating season

Semester Objectives

- Determine minimum energy efficiency and ventilation requirements according to NY Mechanical and Energy Efficiency Code
- Establish a work scope to refurbish existing ERVs for a 10-year service life
- Determine potential replacement ERV options
- Perform return on investment analyses on all options

Technical Approach

- Create spreadsheet of ventilation requirements by room

Room Description	Pz / 1000 sq. ft.	Rp	Ra
Classroom	35	10	0.12
Computer Lab	25	10	0.12
Wood/Metal Shop	20	10	0.18

Table 1: Area Ventilation Classification Table

$$V_{oz} = \frac{R_p P_z + R_a A_z}{E_z}$$

Equation 1: Adjusted ventilation rate formula

V_{oz}= Vent. Rate; A_z = area; E_z = efficiency of vent layout

- Using Bin Method, determine expected energy use

$$E_{bin} = \frac{N_{bin} * Total\ Heat}{\eta}$$

$N_{bin} = Total\ hours\ in\ bin$

Total Heat = Latent heat + Sensible heat

η = system efficiency

- Perform IRR and NPV analysis of expected cash flows

$$NPV = CF_0 + \frac{CF_1}{r^1} + \frac{CF_2}{r^2} + \cdots + \frac{CF_n}{r^n}$$

Equation 3: ROI base formula

NPV = Net Present Value; CF_i=cash flow in period i; r = depreciation rate

Technical Results

- Energy Consumption Results

Type of System:	ERV or HRV	Total Cooling (million BTU)	Total Heating (million BTU)	Total Energy Consumption (million BTU)	% Cooling	% Heating	Energy Saved (million BTU)
No Recovery	-	884	6,001	6,886	12.84	87.16	
Enthalpy Wheel	ERV	416	1,801	2,216	18.75	81.25	4,670
Heat Pipe	HRV	927	2,935	3,862	24.00	76.00	3,024
Plate Exchanger	HRV	947	2,131	3,078	30.77	69.23	3,809

- ROI Analysis Results

	Enthalpy Wheel ERV	Heat Pipe HRV	Plate HRV
Net Present Value	$394,396	$116,666	$286,505
Internal Rate of Return	18.46%	8.32%	15.18%
Incremental NPV	$111,506	($167,802)	Baseline
Simple Payback	7 years	14 years	9 years
Average Sensible Efficiency	67.9%	51.1%	64.5%
Cost per Unit	$105,000	$138,000	$105,000

Final Proposal

- Enthalpy Wheel, ERV provides the greatest energy recovery and overall return on investment
- Provides $111,506 more than next best option

Woodchip Fuel Dryer

Spring 2019: Tnbit Demoz (ME); Wenkai Zhu (ME); Max Hughes (ME); Felicity Kubic (ME);
Bobby Boos (ECSE) ; Rohan Garg (EE) ; Shiyi Huang (EE)

Purpose and Objectives

Adapt an existing woodchip fuel dryer design built by Evoworld to handle commercial output loads. The updated model should be transportable with improved efficiency.

Past Work

- Proof of concept prototype
- Vacuum-assisted
- Batch process = 1 ton/day
- 1.25 hours to complete
- Manual controls

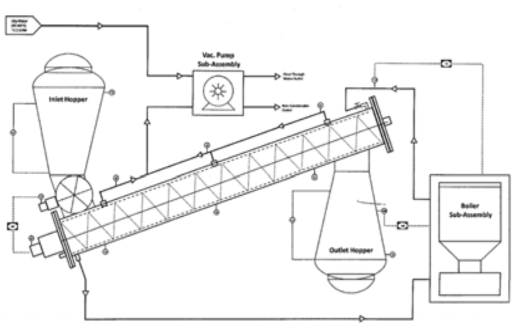


Figure 1: Evoworld/ Troy Boiler Works Prototype

Semester Accomplishments

- Design converted to continuous process
- System throughput increased
- Analysis of vacuum drying
- Control system developed
- Power circuitry developed

Work to Date

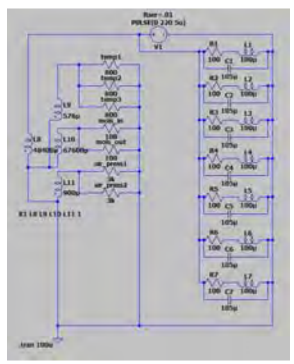


Figure 2: Power Distribution Circuit

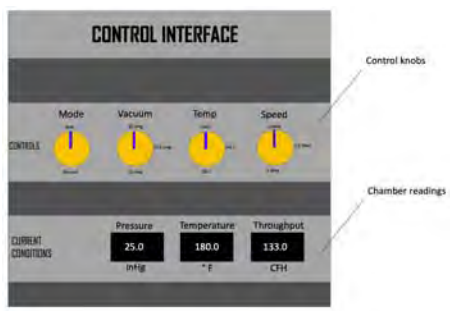


Figure 3: Control Algorithm and Interface Developed

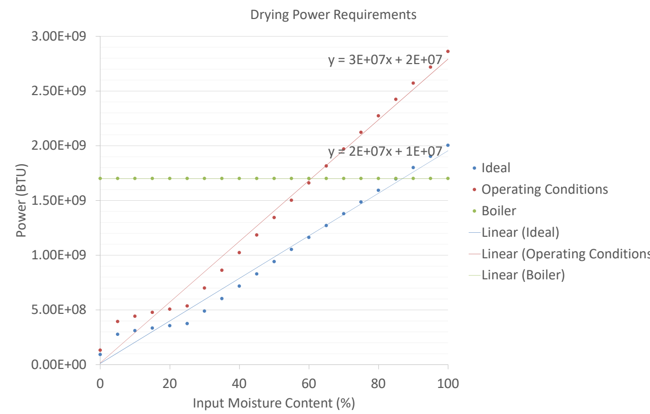


Figure 4: Analysis of Drying Power Requirements

Figure 5: Analysis of Moisture Content During Drying Process

Future Steps

- Mechanical Interface design of feed, airlock and output systems
- Drying data to tune control systems
- Woodchip transport tests
- Packaging Concept

Health/Wellness and Assistive Technologies

Medicine Management

THE DESIGN LAB at Rensselaer

Fall 2018 Team: Leslie Chase (EE/CSE), Collum Holmes (EE), Ziyu Liu (EE/CSE), Courtney Moran (EE/MATH), Krojana Selimi (IME), Wenjia Shou (MSE), Benjamin Spooner (ME), Brendan Zotti (ME)

ALBANY GUARDIAN SOCIETY

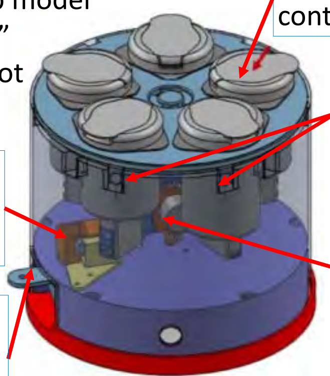
MOTIVATION

- About 50% of the 187 million Americans do not take their prescription medication as prescribed.
- Complex medication schedules and patient reluctance to adhere.
- Patient has difficulty grasping small pills.

PAST WORK

Spring 2018 Prototype

- Table top model
- 12” by 8”
- Screen not attached



Limited to 5 pill containers

Vibration motor mounts

Sweeper arm motor

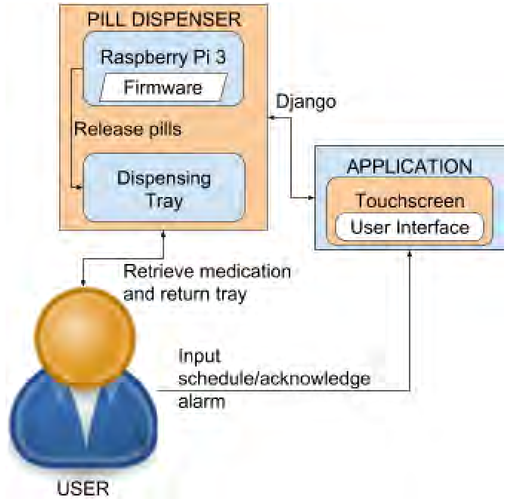
Rack and pinion motor for rotation

Pill tray 50

OBJECTIVES

- Obtain customer feedback by showing prototypes at the Senior Expo.
- Create prototype that can be wall mountable in addition to counter top.
- Integrate touchscreen to prototype.
- Design housing to include access panel to clean.
- Implement alarm system to indicate time to take medication.
- Create a stand alone device that will be able to use directly out of the box.

SYSTEM OVERVIEW



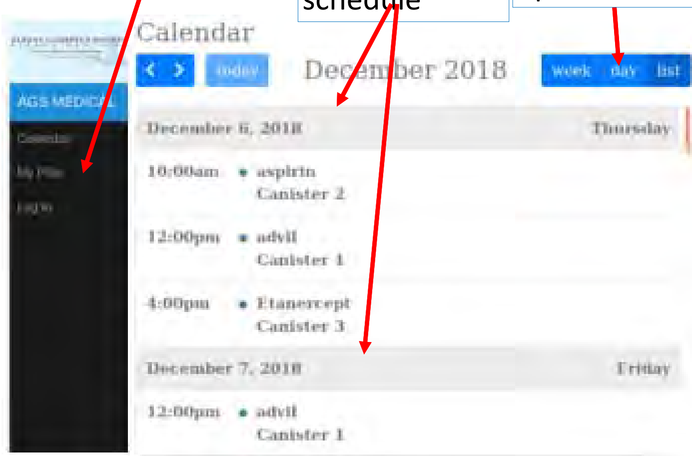
All entities interact with each other in the system.

SOFTWARE

Several medications can be added.

Calendar feature shows schedule

Multiple view options



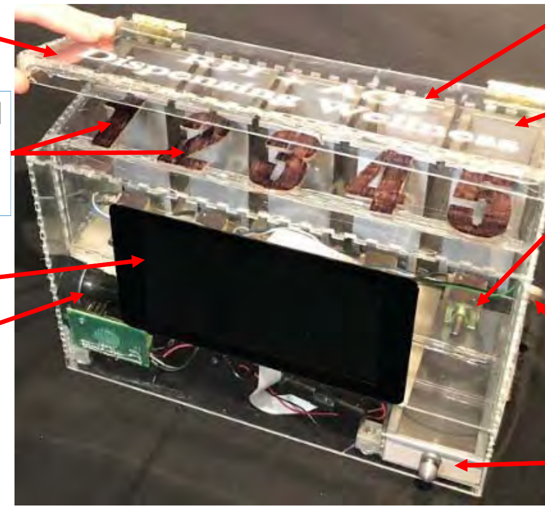
HARDWARE

Hinged lid

Numbered pill containers

7” touch screen

Alarm Speaker



Product logo

Pill containers

Solenoids to actuate dispensing

Cleaning access panel

Pill drawer

Dimensions: 12” long by 7.75” wide by 5” deep

Not pictured: Wall mounting bracket area, dispensing verification system, system for drawer placement verification

ACCOMPLISHMENTS

- Senior Expo results verified preference to wall mountable device, sound feedback, rectangular shape, and touch screen implementation.
- Designed and built rectangular, wall mountable product. 31.3% less volume than previous design.
- Touch screen is implemented to product.
- Access panel created to allowed cleaning ability.
- Implemented speaker system.
- GUI has 3 different styles for user’s preference. Program automatically boots up from power on.
- Reliable pill dispensing mechanism. Works without failure 99.5% of time. Failures do not permanently jammed.

ARC Sensory Feature

THE DESIGN LAB at Rensselaer

Fall 2018 Team: Matthew Boone (MGTE), Matthew Dineen (ECSE), Denver Overend (MECL), Erin Reddy (MECL), Nebill Salih (ELEC), Leili Tootsov (MATL), Ben Wooten (MECL)

The Arc of Rensselaer County ADVOCACY • RESOURCES • COMMUNITY

Semester Objectives

- Develop one of the sensory features for ARC's new sensory room to service individuals with developmental disabilities
- Provide ARC with a unique design that is not commercially available

Customer Requirements

Customer Need	Requirement	Spec
Visual Stimulation	Feature viewable from all angles	360 degrees
Safe for users	High FOS	≥2
Simultaneous users	Multiple individual interactions	≥2
Wheelchair accessible	Interaction height	3'-6'
Different flow paths	Continuous fluid movement of particulate along path	≥2
Aesthetically pleasing	Non-Childlike look	Subj.

Design Process by Subsystem

Motor System:

- Motorized disks will be encapsulated to assist in safety and add 3D aesthetics to design
- 4.7Nm of torque will be provided from a servo motor.

Frame Selection and Calculations:

For Hanging of large load (wheelchair and occupant)

$\sigma = Normal\ Stress\ (psi) = M * \frac{g}{A}$ = 522.46 < 45,000

For Torsion caused by the ramming of a wheelchair

$F = same\ as\ bending$ = 459.278

$B = Bending\ Moment\ (lb * in) = F * w$ = 5,134.73

$\tau_{max} = \text{Max}\ Shear\ Stress\ (psi) = \frac{wB}{I}$ = 3,486.8 <30,000

Aluminum Shear Strength (psi) = 30,000

For Bending caused by the ramming of a wheelchair

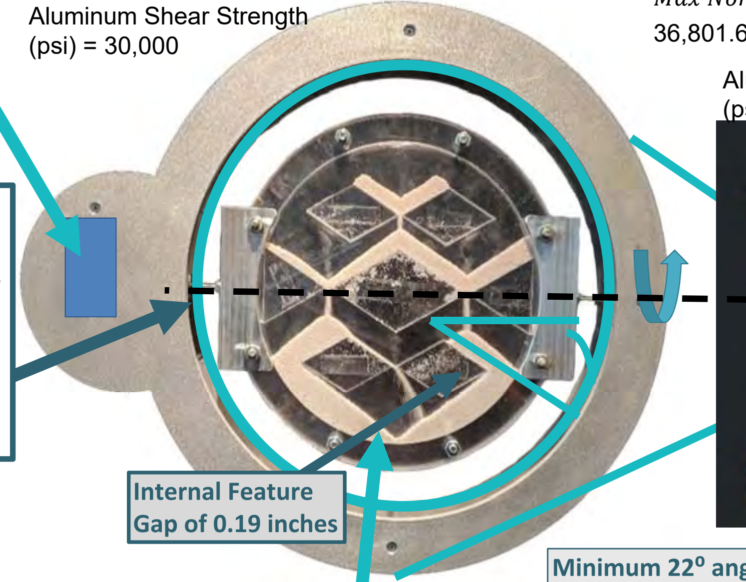
$F = Force\ (lb) = \frac{.5Mv^2}{d}$ = 459.278

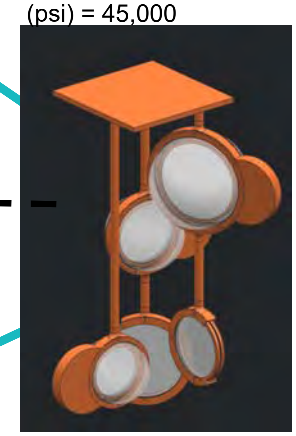
$B = Bending\ Moment\ (lb * in) = F * l$ = 27,097.4

$\sigma_{max} = Max\ Normal\ Stress\ (psi) = \frac{My}{I}$ = 36,801.6 <45,000

Aluminum Tensile Strength (psi) = 45,000

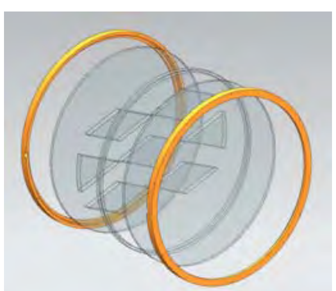
RBG LEDs provide unique lighting patterns





Front View

Disk Casing Exploded View:



Particulate Selection:

	Small size (<0.02")	Medium size (0.02" - 0.05")	Large size (>0.05")
Increasing hardness ↓		-Aluminum balls	-PTFE balls
	-Glass bead blasting media -Powder glass beads	-Standard glass beads -"Airport Quality" glass beads	-Large molded glass beads -Metal beads (hollow)
		-Steel balls	

Next Steps

- Testing Motor
- Select disk sealing design
- Ceiling connection concept generation
- LED diffusor material selection

Smart Monitor System for People with Physical Challenges

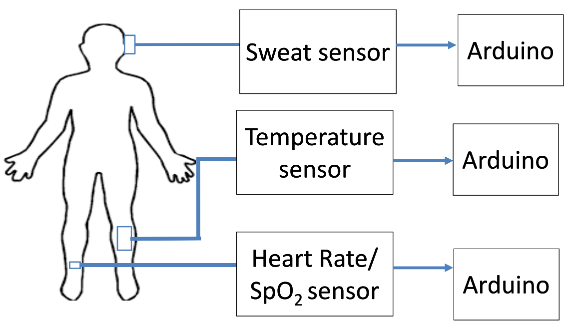
THE DESIGN LAB at Rensselaer

Spring 2019 Team: Rachel Antmann (EE), Alexandra Fearn (ME), Andrew Hebel (ME), Zain Hussaini (ME), Yang Li (CSE/CS), Bingjia Wang (EE), and Zhiyang Xu (CSE)

Purpose

To detect symptoms of automatic dysreflexia or abnormal vital signs through a smart and convenient monitoring system

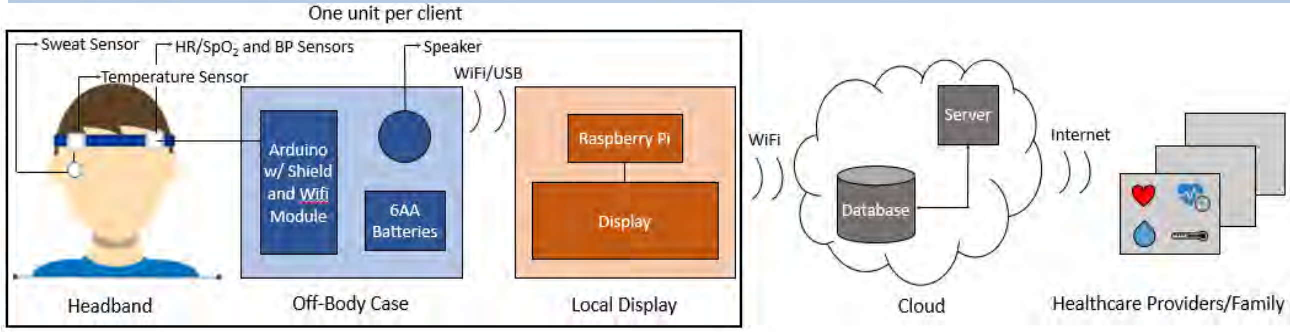
Past Work



Semester Objectives

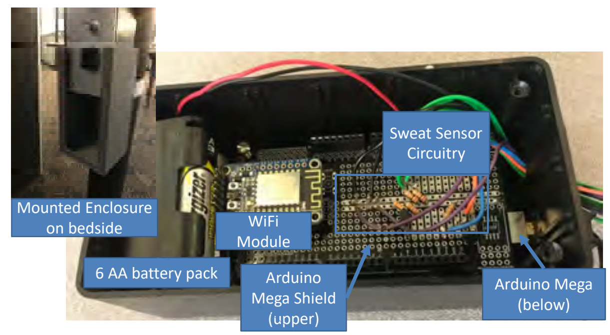
- All sensors operating under singular microprocessor
- Use signal conditioning to interpret and display data for user and caregiver
- Develop method to alert user and caregiver
- Design mount(s) for sensors

Technical Approach



Technical Results

- Interactive Local Display software can be hooked up to any HDMI display

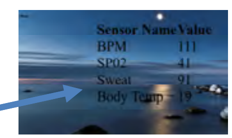


- Enclosure for Sensor Reading circuitry
- Premade box is slid into 3D printed "sheath" where wires are run along bed to the user

- Two enclosures made for Temp and HR/SP02 sensors
- Attached to headband to ensure ease of use and washable

- Speaker alerts patient and caregiver at given values
- Button turns the alarm off

- Data can be accessed over web
- Caregiver/doctor/etc. can read this data in real time



Future Work

- Develop accurate blood pressure sensor
- Investigate applications for daytime use
- Development of mobile app
- Improve signal conditioning to increase accuracy of sensors

Creating the Village in the Capital Region

THE DESIGN LAB at Rensselaer

ALBANY GUARDIAN SOCIETY

Spring 2019: Nick Cella (IME), Edward Der Manouelian (IME), Jake Legatt (IME), Marc Meisiann (IME),
Tyler Beckmann (EE/CSE), Yuan Meng (EE/CSE), Hanyuan Xiao (EE/CSE), Huajun Li (CSE/CS)

What is Village?

- Neighborhood-based membership organization
- Place where seniors receive service while at home

Who is AGS (Albany Guardian Society)?

- To improve the quality of life for seniors
- To develop and support services for seniors
- To create an environment that will maintain the growth of creative and innovative ideas

…

Purposes (Long-term Goals)

- Help Low-income Household
- Build Technology-human Connection
- Improve Village Quality and Efficiency
- Keep Seniors at Own Home
- Help Engage in Social Life
- Keep Safety and Privacy
- Help Stay Healthy

	Objectives (Semester Goals)	Available Technology	Technical Approaches	Results	Accomplishments	Future Work
Service App	• Connect App with **private** database • Provide seniors who are unable to drive with a means of **transportation** • Cultivate **relationships** within village	Google Android 09/2008 Android Studio 05/2013	**Ride Sharing App for Seniors** • Uber • Lyft Creating the App • Android Studio • Google Firebase	• Secure App • Customer and driver profiles • Navigation via Google Maps • Functioning logout button LOGOUT	• Provides seniors with a non-profitable **ride sharing** application • Ensure that the application is **secure** through a **private** database	Integrate with Social Networking; Notification; Tipping Option; Vehicle Description; Map Markers; Location Updates; Group Ride Shares
Social Networking	• Allow villagers to have **own** social network • Provide **communication** between members of the village • Create mobile **App**	Google Firebase 04/2012 Google Maps 02/2005	**Social Networking for Seniors** • Facebook • WhatsApp Development of App • Android Studio • Google Firebase	• Privatized social networking App • Customizable profile • Ability to post comments and pictures • Messaging	• Allow villagers to socialize **without leaving** their homes • Use private database to keep **security** of information of seniors	Integrate with Virtual Conference; Integrate with TieOS; Share Media; Group Feature; Post Videos; Create Events; Service App Elements
Virtual Conference	• Easily create/join virtual **meetings** at **home** • Strengthen **bonding** among villagers • Option to **stay** at home for safety	Amazon Chime 03/2006 Google Hangouts 05/2013 Microsoft Skype 08/2003	Amazon AWS • Amazon for Business • Amazon Chime Amazon Echo • Amazon Alexa **Documentation** • Microsoft Word	App, Desktop, Website; Echo; Dial-in/out; Personalized Link; Meeting PIN; Join; Join; Mobile App; Create; Meeting	• Allow seniors to create, join, and schedule **virtual** meetings on different platforms • Provide senior option to join club meetings **at home**	Integration with TieOS; Other services; Skype; Facetime; Amazon Chime; Hangouts; Webex
TieOS	• Allow seniors to receive information from **listening** • Avoid reading **small** text or image on phone and tablet • Make use of **TV**	Xcode 09/2003 Shortcuts 09/2018	**FaceTime on TV** • Siri • Shortcuts **Image-to-Speech** • Xcode • Image-to-speech library	• Voice-enabled App • Video tutorial • Flyer tutorial • Display text • Adjust speaking rate • Play/Stop/Pause	Transfer **FaceTime** call from iPhone onto Apple **TV** Convert text in image to **larger-font** text and be able to **read out**	Natural Conversion; Better Visualization; Image-to-Speech on TV; Other Platform; Integration with Other Subsystems; Audio User Interface; Simpler Installation Procedure

Adaptive Ropes Chair

Spring 2019 Team: Alison Goldsmith (MECH), Brendon Kondrat (MATL), Candy Zhang (MECH),
Mark Birkbeck (MECH), Michael Pauciulo (MECH), Robby Claude (MECH), Scott Black (MECH)

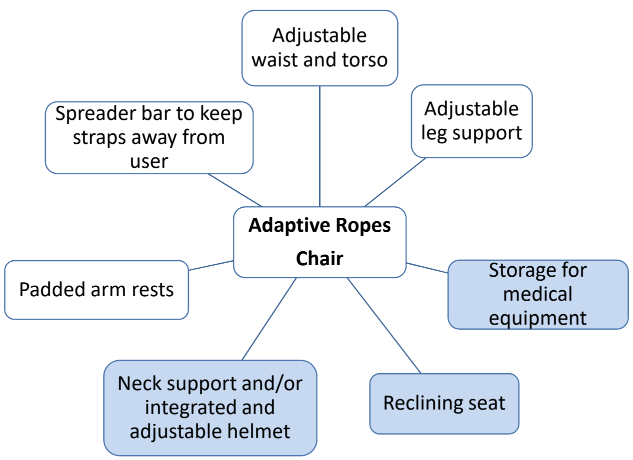
Purpose

- Construct a zip line chair that accommodates the medical needs of terminally ill children
- Enhance the comfort and accessibility of the chair

Semester Objectives

- Prototype upper half of the chair
- Preliminary design and basic analysis of upper half of chair

Requirements



Technical Approach

Head/Neck Support Subsystem

- 3 degrees of freedom
- Detachable if unnecessary


Figure 1: Side View

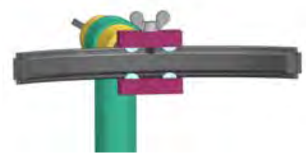


Figure 2: Adjustable Track

Medical Equipment Subsystem

- Ventilator mount on center back of chair
- Provides easy access and minimizes tube length required


Figure 3: Ventilator Mount

Upper Frame Subsystem

Chair

- Easily adjustable vinyl racing chair
- Reclining range ~ 170°

Hinge

- Determine minimum load capacity hinge must withstand
- Compact design to minimize interference

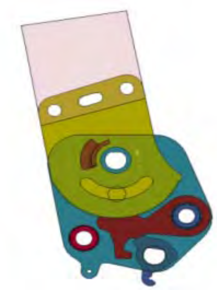


Figure 4: Current Hinge

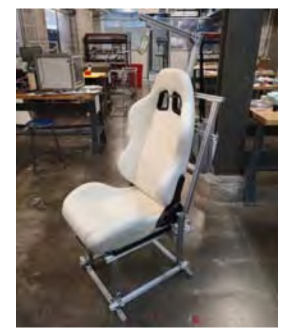


Figure 5: Upper Frame

Moving Forward

- design of lower frame, arm and leg support, and O2 tank storage
- Integrate all subsystems
- Qualifying testing

Labeling and Re-Packaging

THE DESIGN LAB at Rensselaer

Spring 2019 Team: Christopher Bray (MECL), Jenna Dragoo (IME), Connor Hart (MECL), Elizabeth Hwang (IME),
David Tamir (IME), Katherine Uliva (MECL)

NABA Northeastern Association of the Blind at Albany

NABA

- Northeastern Association for the Blind at Albany operates a warehouse to generate funds to provide therapy and educational resources for visually impaired and blind people.
- NABA's workforce is composed of 80% visually impaired and blind employees.

Sponsor Requirements

- Increased accuracy of inventory counts of uniform items
- Organized product layout
- Increased warehouse operations using visually impaired labor
- Increased percentage of blind and visually impaired employees working warehouse operations

Semester Objectives

I. Implementation of barcoding and RFID label system to digitally and automatically count inventory
II. Standardized shelving design to ensure products are placed in optimal locations and clear signage for all products

I. Digitized Inventory: RFID and Barcode

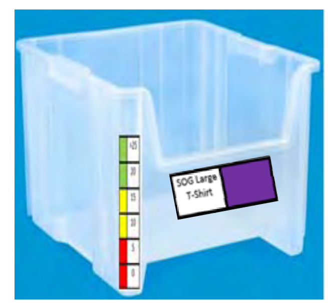
- Barcode scanner enables visually impaired employees to pick items accurately
- Reduce possibility for human error in inventory counting
- RFID readers able to track when inventory is inbound or outbound using RFID tag

RFID Reader in Warehouse

En-Vision America i.d. Mate Galaxy Barcode Scanner

II. Warehouse Design

- Translucent bins with fill lines allow visually impaired to take rough inventory
- Color coded label allows all users to understand product line in bin
- Product layout to be made so all products have a specific, mapped location in warehouse
- Shelf dividers to be put in for products too bulky to fit in bins



Clear Bins Marked With Fill Lines

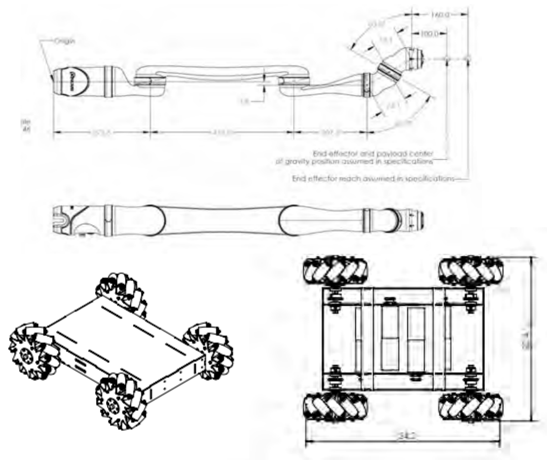
In-Home Assistive Robot Prototype

Spring 2019: Colin Overstreet (MechE), Colin Higgins (CSE), Lance Luther (MechE),
Hao Chang (EE), Junru Zhao (EE), Zach Spina (EE), Luke Dupuis (MechE), Francisco Angers (MechE)

Background

-Develop a way to increase the Z-axis range of the robot. Chosen design: ACME screw with guide bars and plates design
-CATS Lab has provided the team with: Superdroid Wheel Vectoring Robot and Kinova Gen 2 Ultralight 6DOF Curved Wrist Robot Arm

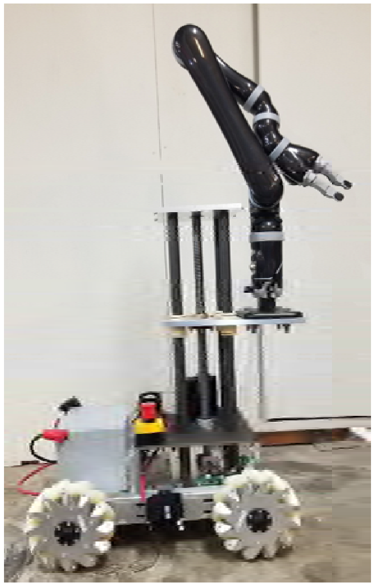
Robotic Arm and Base Diagrams



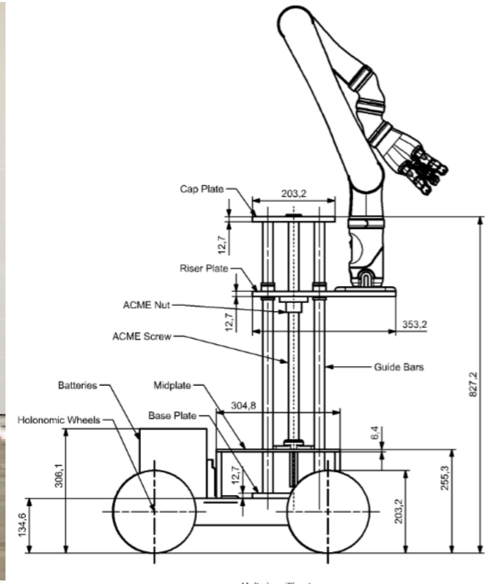
Purpose

To assist physically challenged people by fetching small items and manipulating objects or interfaces.
To give people more independence in their daily lives.

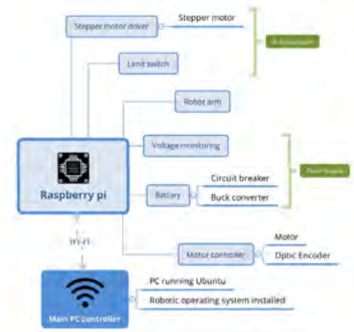
Real Robot



Side View



Control Diagram



Results

-Z-axis riser works without racking
-Riser motors, base motors and the robotic arm are controlled from the same computer over wireless communication to the Raspberry Pi
-Electrical and mechanical safety standards were met
-Feedback systems were integrated into the software to account for travel distance

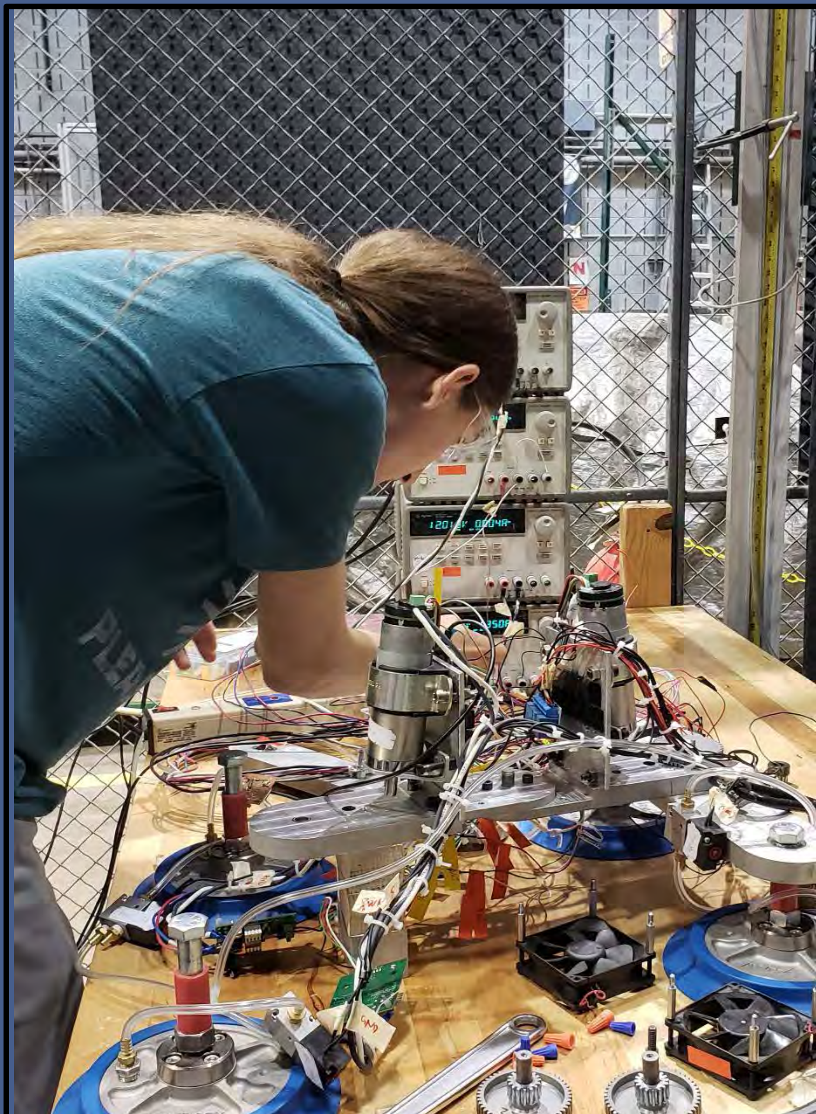
Objective

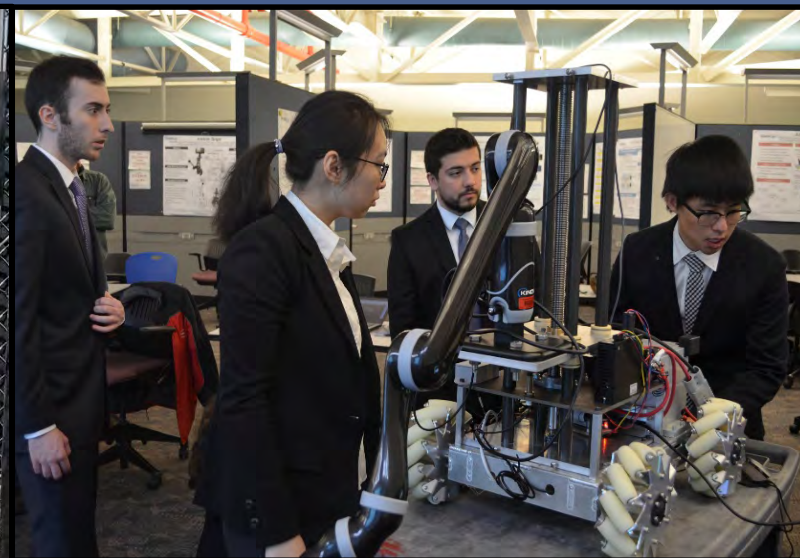
Create a functional assistance robot platform for future development.
- Allows full control through keyboard input:
  6 DOF robot arm + Z-axis riser + base
- Travel across the room
- Move the robot arm along Z-axis 20 inches
- Reach the back of a fridge (≤ 90 cm)
- Be able to pick up something less than 1.4kg off the floor
- Pick up and carry a water bottle (≤ 1.3L) and deliver to the user

Future Work

Future developments for CATS:
-Li-Dar can be integrated in the system to make the base obstacle avoidance possible by using SLAM (simultaneous localization and mapping).
- More user input methods can be developed by connecting more modules to our program API to adapt for more use cases.
- More robot arms can be added to the system to handle more sophisticated tasks.
-Use a camera as an electronic eye for computer vision and object recognition.

Manufacturing, Automation and Control





Serrating Machine Control

Fall 2018: Jake Altabef (CSE), Carissa Ciarlone (CSE), Alexander Elias (ECSE), Tiffany Hsi (EE), Ziye Hu (ME), Zhengqiu Lou (ME), Caitlyn Slezak (ME), Daniel Weiss (EE)

Purpose & Objectives

Purpose: Mitigate risk of machine failure and increase contact wheel throughput

Objective: Provide design plans and cost analysis for two alternatives:

1. Modernized Control System (MCS)
2. CNC Alternative

Past Work

MCS – Information from Bader Co.

- Two serrating machine designs

CNC – U. Michigan Research

Rubber Machining Parameters

- Feed Rate: 5, 15, 25 in/min
- Spindle Speed: 2900 or 4200 rpm

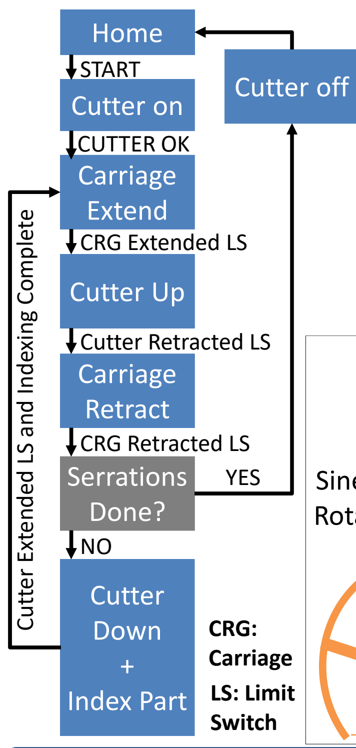
MCS vs CNC Solutions

	MCS $10k (parts only)	CNC 5-AXIS $80k (machine only)
PROS	• Simple installation	• Soft automation allows other processes • Retail support from manufacturer, distributer or 3rd party
CONS	• Hard automation • Custom machine may be more difficult to repair • Manually set mechanisms • Practicing engineer must finalize plans	• Transport / install expenses • Requires CAD/CAM programmer

Recommendation: MCS Solution

Modernized Control System (MCS) Accomplishments

Serrating Flow Diagram



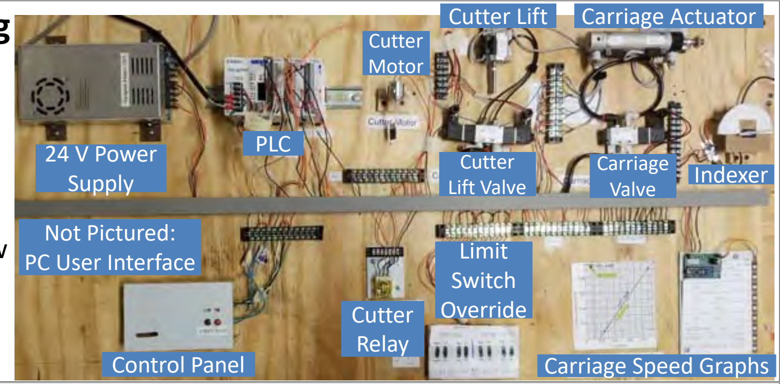
Prototype Testing

Goal: Test system programming logic

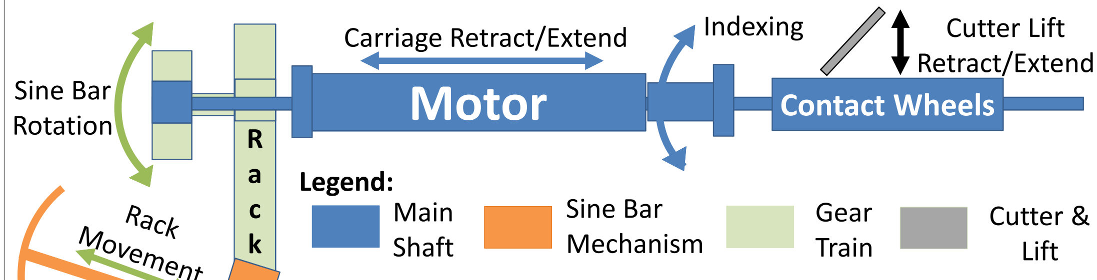
Hardware: Scaled down components

Tests Performed:

- Basic Serrating Flow (see diagram)
- Limit Switch Timing Errors



Serrating Machine Mechanism

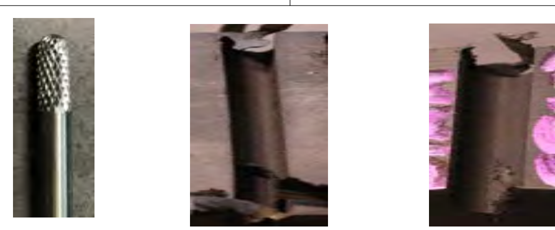


Note: Main shaft rotates via both the rack and pinion and motor rotation.

CNC Alternative Accomplishments

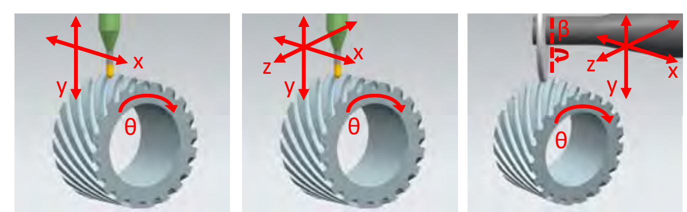
Optimized End Mill Parameters

Cutter Type:	¼'' Diamond Burr
Feed Rate & Speed:	20 in/min, 6000 RPM
Rubber Hardness:	> 70 Durometer



Burr 70 Durometer 90 Durometer

Machine Design



3-axis Custom $$ | 4-axis Buy $$ | 5-axis Buy $$$$

Fiber Spool Tracking

Spring 2019: Connor Brooks (ME), Jacob Doskocil (EE & CSE), Elizabeth Eckhardt (CSE)
Edward Larson (CSE & CS), Pan Yuen Lau (EE), Ryan Rao (CSE & CS), Katherine Rusch (ME), Kevin Yun (CSE & MGMT)

Purpose

- Design, build, and test a working prototype IoT device which can track Corning's fiber optic spools to facilitate supply chain digitalization

Semester Objectives

- Coordinate and control fiber measurement, GPS location, cloud communication and a power management system into a fully integrated prototype

Project History

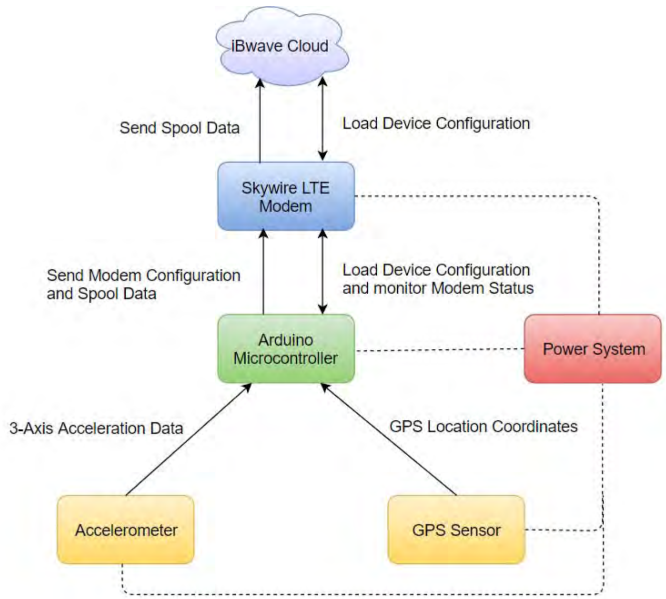
- Prototype measured 3,514 feet of cable with a percent error of 0.15%
- When extrapolated to simulate unraveling the entire spool, percent error was 0.90%
- Device sends measurement and GPS data to a laptop or Android phone via Bluetooth

System Requirements

- Measure remaining fiber within 1%
- Lasts up to 18 months
- Functions in a wide temperature range: -18°F - 110 °F
- GPS Location: within 120 foot radius
- Send/Request data from cloud through Verizon's LTE network

Technical Approach

Overall System Architecture



- **Cloud** – Back-end storage of device data; Managed by iBwave. Holds data logged by device
- **Skywire LTE Modem** – 4G Modem used by the device to connect to the internet via a socket dial
- **Arduino Microcontroller** – Main processing unit of the device. Handles all connected subsystems and processes data into length measurements
- **Accelerometer** – Measures number of rotations of the device. Used to calculate the amount of fiber that is pulled off the spool
- **GPS Sensor** – Responsible for getting current location of the device, managed by the microcontroller
- **Power Management System** – Designed and constructed by our team to last 18 months in the field. Powers all components of the device

Remaining Fiber Testing

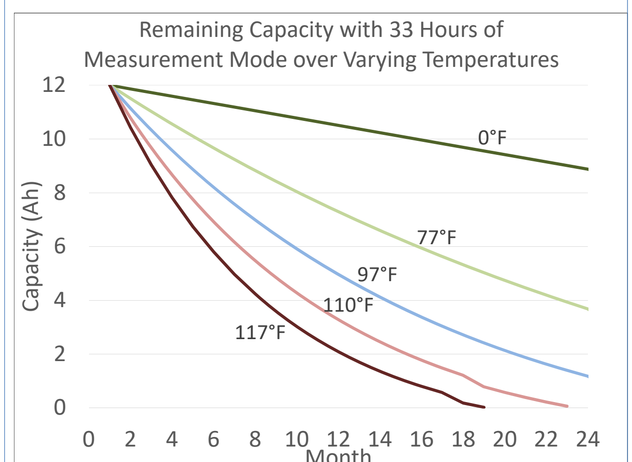
- Team unspooled 5,000 feet and uniformly spooled the fiber back on to best mimic a new spool
- Tested the accelerometer over 2,117 feet and it showed a .19% error
- These results proved to validate the previous testing results and were within the 1 percent specification

Actual Fiber Remaining (ft)	Calculated Fiber Remaining (ft)
7,252	7,252
7,148	7,147
7,040	7,042
6,822	6,826
6,546	6,550
6,372	6,376
6,085	6,089
5,819	5,823
5,561	5,565
5,351	5,355
5,135	5,139

Error = 0.19%

Temperature Range

- Self-discharge for lead acid battery is 3%/month at 77°F
- For every 20°F increase the self-discharge doubles
- As temperature drops below 77°F, self-discharge decreases to below 1%



GE Generator Cooling

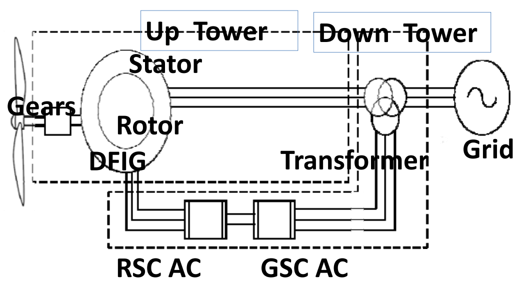
THE DESIGN LAB at Rensselaer

Fall 2018: Sage Parin (MTLE), Nicholas Hoffman (MTLE), Leen Almadani (ECSE) , Dave Burton (MECH), Michael Murphy (MECH), Nicholas Pacifico (MECH), Michael Pasquale (MECH)

GE Renewable Energy

Sponsor Motivation

- Transformer is currently down-tower
- GE wants to reduce cost of installation and maintenance of land-based wind turbines
- Size of nacelle cannot increase due to transportation limits
- Move the transformer up-tower

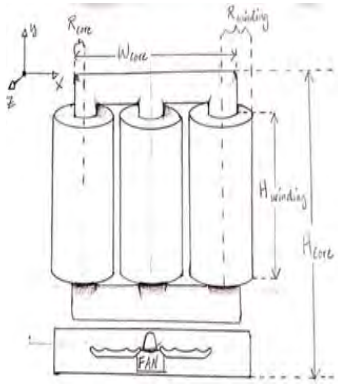


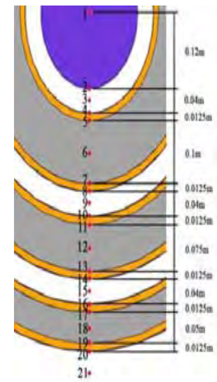
Semester Objectives

- Parametric evaluation of material properties, heat exchange values, and geometric options to reduce doubly fed induction generator (**DFIG**)/transformer volumes
- Design DFIG/transformer geometry so heat generation does not raise operating temperature above material temperature limit

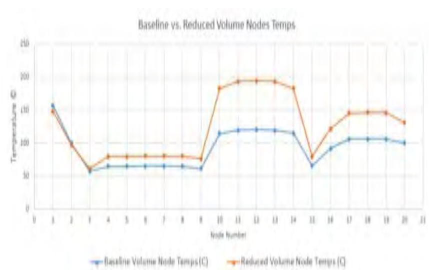
Transformer

Experimental Method





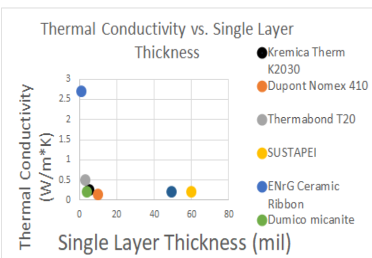
Experimental Results

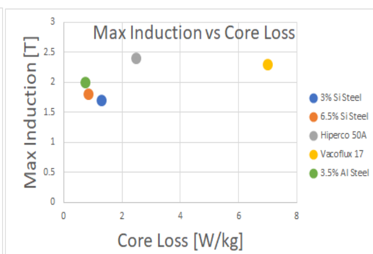


Transformer Volume Reduction ~ 40 %

Max Temp Increase~ 50 C

Materials



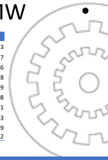


DFIG

Experimental Method

- From 4MW to 5MW
- Reducing DFIG size

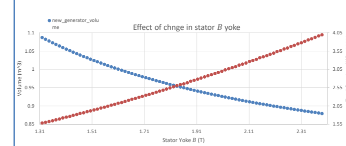
dimensions	4MW	5mw	Column1
r_{shaft}	0.029845	0.033400000000000	11.911543
$r_{rotor\ yoke}$	0.289	0.292500000000000	1.2110727
r_{rotor}	0.379	0.394000000000000	3.9577836
$h_{rotor\ slot}$	0.09	0.101500000000000	12.777778
$w_{rotor\ slot}$	0.01241	0.013098898835919	5.551159
$w_{stator\ slot}$	0.0209	0.022922361504367	9.6763708
$h_{stator\ slot}$	0.06576	0.071446118663652	8.6467741
$r_{stator\ inner}$	0.3825	0.397567731983243	3.9392763
r_{stator}	0.5842	0.604953850646895	3.5525249
volume	1.0132224	1.086491097342580	7.2312542

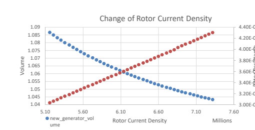


$L = l[1.2: -0.04: 0.8]$	Length of DFIG varied ±20%
$B' = [B^{old}: 0.04: 2.4]$	Flux density increased up to 2.4 T
$J_c' = J_c^{old}[1.0: 0.04: 1.4]$	Current density of stator and rotor increased 40%

Equations	Justification
$r_{sh}' = \sqrt{\frac{r_{sh}^2 \times L}{L(j)}}$	$\tau = 2\sigma\pi {r_{sh}}^2 l$ torque stays constant → $\frac{\tau_2}{\tau_1} = \frac{2\pi\sigma r_2^2 l_2}{2\pi\sigma r_1^2 l_1}$
$A_{Yoke} = \frac{\Phi}{B_y(i)}$ $H_y = \frac{A_{Yoke}}{L(j)}$	Magnetic Flux Densities [B] increases Magnetic flux [Φ] remains constant. Area of the yoke [A_{Yoke}] decreases. Radial yoke height [H_y] decreases. Rotor radius decreases.
$W' = \frac{\Phi}{B' \times L(j)}$	$\Phi = BA$ Magnetic flux [Φ] remains constant.
$H_{cond}' = \frac{I}{W_{cond}' \times J' \times \#of conc}$	$I = J_{slot} \cdot A_{cond}$ Current Density J increases

Experimental Results





Conclusion & Future Direction

- Possible to reduce transformer volume by ~41%
- Possible to reduce DFIG volume by 32.6%
- Next steps: Determine if reduced components fit in nacelle spacial model

Seal Positioning

Fall 2018 Team: Ian Blankenship (MECL), Katie Clark (ELEC), Jacob Huber (MECL),
Matthew Lamport (MECL), Tyler Moore (MECL), William Randall (ISYE), Alec Smith (ELEC)

THE DESIGN LAB at Rensselaer

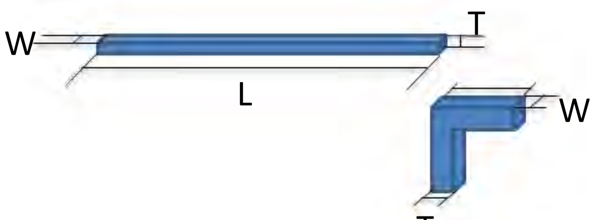
GE Global Research

Purpose

- Automate spline seal installation
- Increase reliability
- Decrease production costs

Semester Objectives

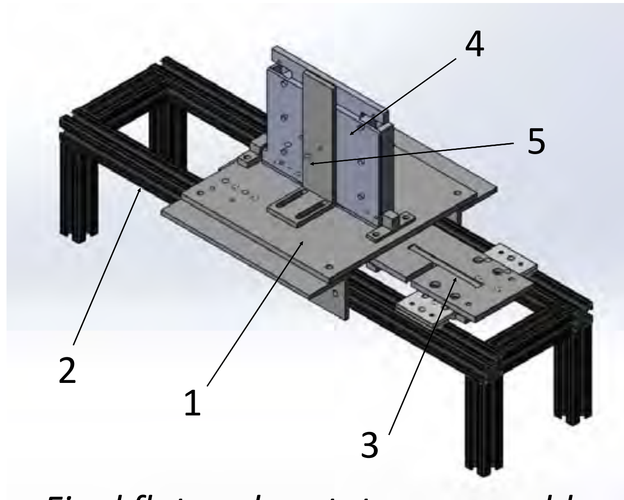
- Cartridge and presenter for each seal
    - Fully functional prototypes
    - Flat and angled seal



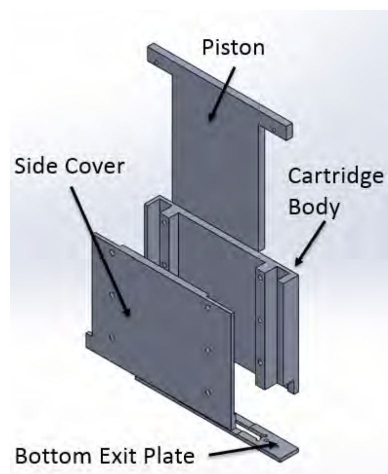
Flat: L=3.509";W=0.254";T=0.040" (left)
Angled: L=0.301";W=0.201";T=0.040" (right)

Customer Needs

- 2 second dispensing time
- Released ≥ 2" from presenter
- Entire system portable
- 99.7% system reliability



Final flat seal prototype assembly. 1. Interface Plate; 2. 80-20 Frame; 3. Carriage; 4. Cartridge; 5. Hall Effect Sensor Mount



Flat seal cartridge exploded view.

Key Mechanical Features

- Pin-stop cartridge lock
- Adjustable for seal thickness
- Rack & pinion drive
- Spring-fed cartridges

Sensors/Error Detection

- Hall Effect sensors for cartridge fill
- IR emitter-detector for PIP
- Limit switches for carriage detect

Technical Results

Need	Desired	Actual (Flat)	Actual (Angled)
Cycle Time	<2 s	1.9 s	0.6 s
Final Pose	>2"	~2.5"	~1"
System Reliability	99.7%	96.15%	90.84%

Results Compared to Desired.

Augmented Reality System

Spring 2019: John Argentino (CS/CSE), Enrique Jimenez (EE/CSE), Christian Lee (CS/CSE), Everett McNair (EE), Christine Osuma (CSE), Shayne Preston (CSE)

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 to improve the accuracy and efficiency of the overall manufacturing process.

Past Work

▪Vuforia Database storing images of CCAs for object tracking
▪ Tesseract code for text recognition
▪ ARS Android application with no UI
▪ Instruction set and assembly images stored locally on the device rather than on a database

Previously developed application

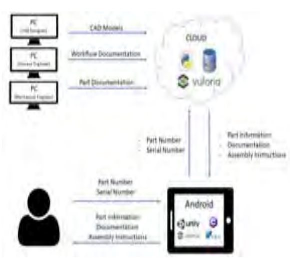
Semester Objectives

▪Create an Augmented Reality Android application to guide the assembly of a 3'x3' radar cabinet assembly
▪ Allow the user to identify parts and access documentation necessary for the assembly of a radar cabinet
▪ Cache previously completed assemblies
▪ Complete assembly trials and record changes in assembly time when using and not using the app

3'x3' Mockup Radar Cabinet Assembly

Technical Approach

▪ Create an SQL database for the storage of models and documentation
▪ Use Vuforia to track and recognize the parts through object recognition and serial or part number identification
▪ Use Unity to create the application's User Interface
▪ Use Unity to query the database and display relevant documentation



System Architecture

Accomplishments

- Updated existing documentation to provide a better baseline for comparing assembly time
- Completed Android application with the capability of guiding a user in the assembly of the 3'x3' mockup assembly
- Ran assembly trials and collected data relevant to demonstrating the benefits of the application

Application Assembly Selection Screen

Future Work

- Expand development into Android wearables, such as the Vuzix
- Implement capabilities for error checking between instruction steps
- Expand functionality for troubleshooting assemblies
- Overlay 3D models onto real-world assemblies

Vuzix M300

MILL Smart Manufacturing

Fall 2018 | Team: Patrick Castel (MECL), Alex Markle (MECL), Francine Pataray (MGTE/DSIS), Lyndon Pisansky (MECL), Dakota Schiffer (MGTE/DSIS), Jacob Scremin (MECL)

Purpose

To standardize procedural information of the RPI Manufacturing Processes and Systems Laboratory I (MPSL I) course to more effectively prepare its engineers for interacting with digital manufacturing industry standards.

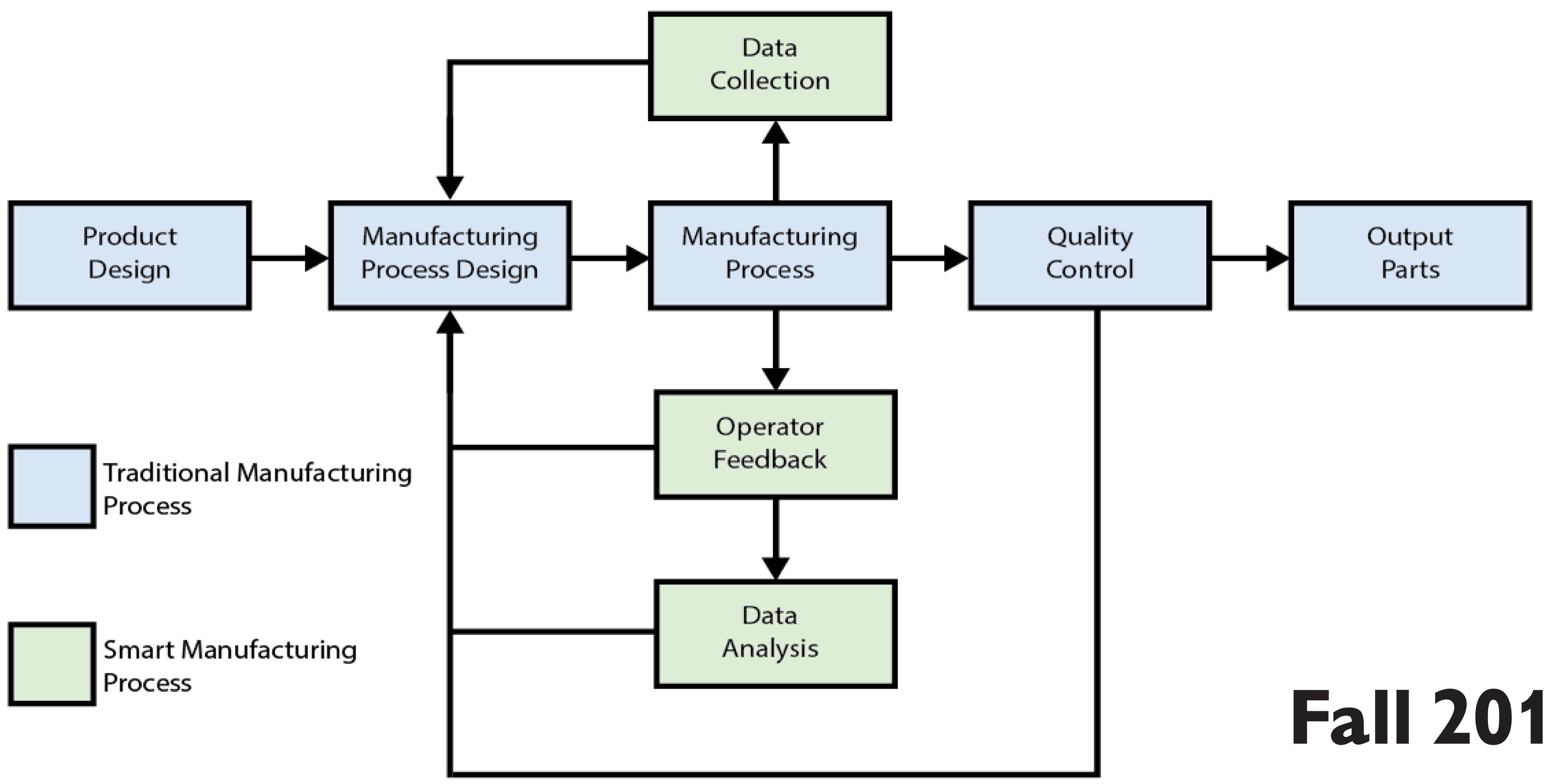


Figure 1 - Smart Manufacturing Diagram

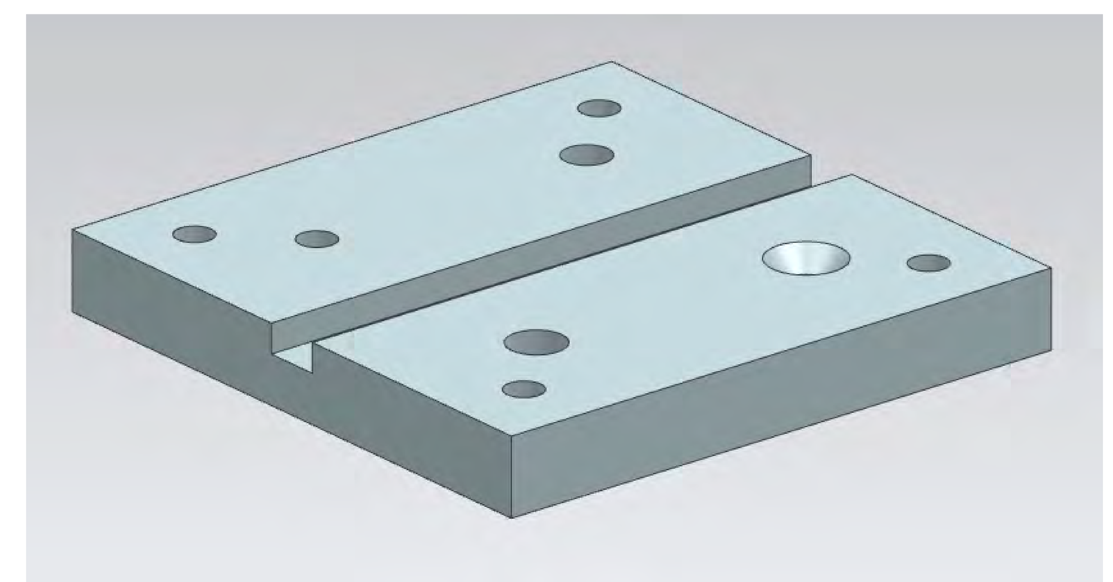


Figure 2 - Machining Lab Milled Part

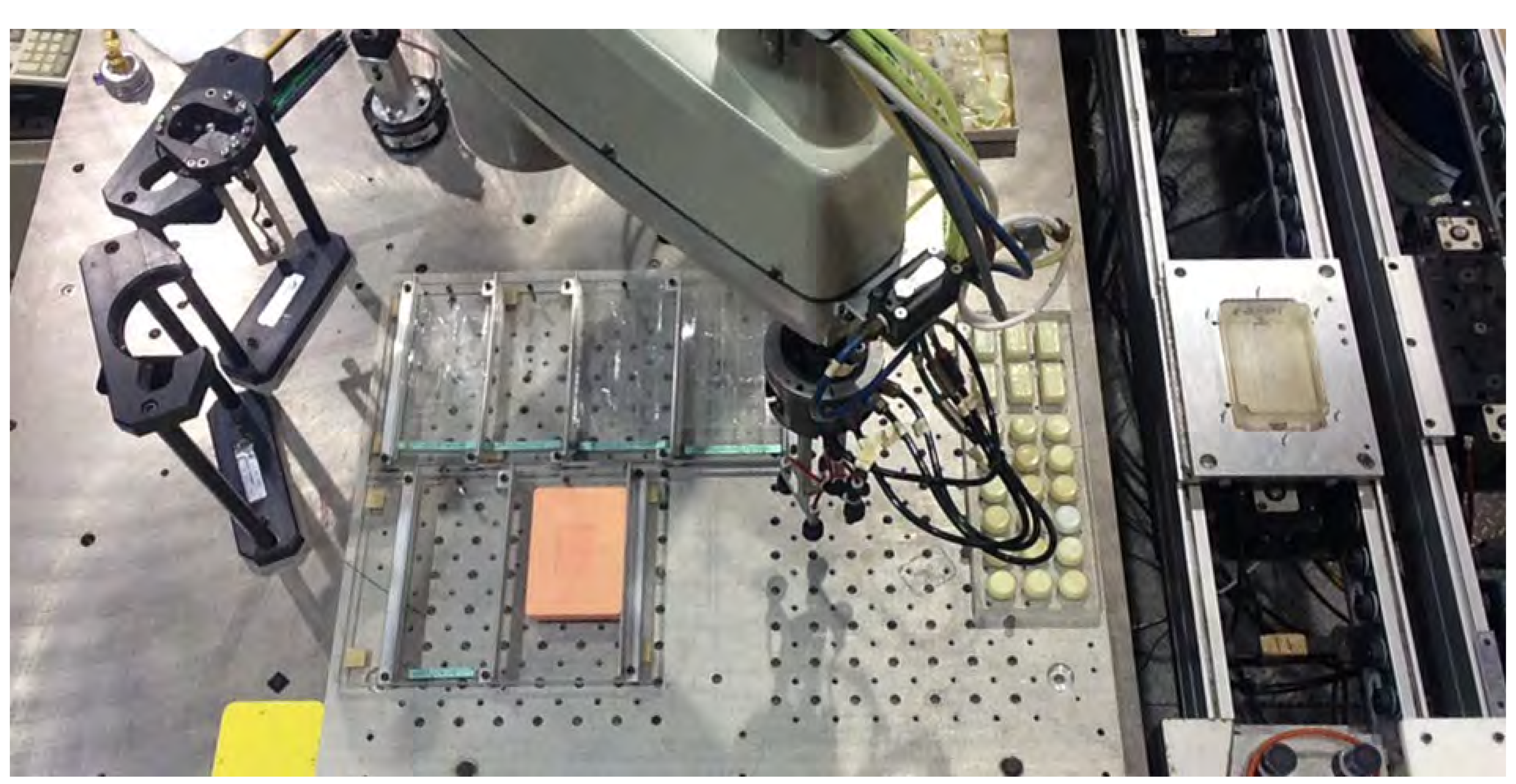


Figure 4 - Candy Box Assembly Lab Layout

Fall 2018 Accomplishments

- Create Interactive VKS Guidebooks
  - Vertical Mill Safety Instruction
  - Drill Press Safety Instruction
  - Machining Lab Day 1 SOP
  - Machining Lab Day 2 SOP
  - Robotics Safety Instruction
  - Robotics Candy Box Assembly Lab SOP
- Update VKS User Manual
- Implement Technologies
  - Drawing Tablet / Touch Screen
  - Bluetooth Calipers
  - Barcode Scanner
- Specialized Toolbox

Spring 2018 Work

- VKS Software Selected
- Unfinished VKS User Manual
- Current Guidelines for Labs (Paper)

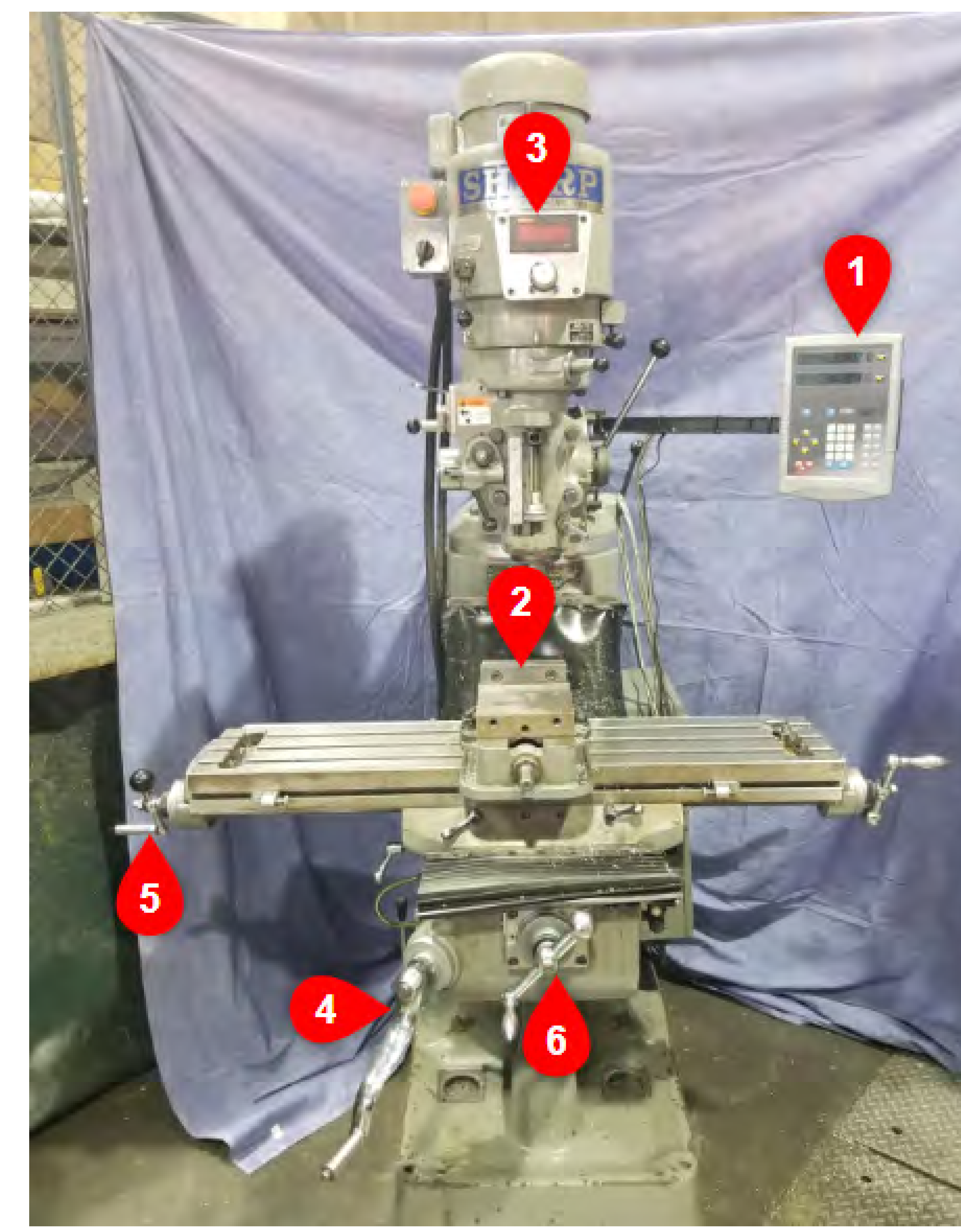


Figure 3 - Machining Lab Vertical Mill

Future Steps

- Working with MPSL II students to create their own guidebooks in Spring 2019
- Gather more student feedback
- Using data for better analytics

Robotic Welding

Spring 2019 Team: Rohan Cherian-Ashe (MECH), Anahit Hovhannisyan (MTLE),
Zhe Jiang (MECH), Leo Leighton (MECH), Paul Miller (MTLE), Jihoo Park (CS/CSE), Eli Pimpao (MECH), Du Wen (EE)

PURPOSE

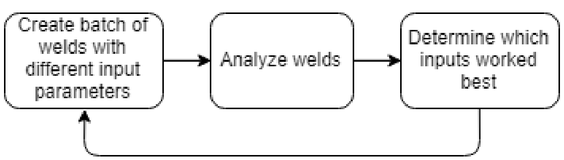
Determine whether Inconel 625, a superalloy typically TIG-welded by hand, can be MIG-welded by a robot.

CHALLENGE

Use a limited number of samples to create the best weld possible in an attempt to meet requirements for aerospace-grade welds.

SOLUTION

An iterative optimization process:



SEMESTER OBJECTIVES

- Implement a design of experiments
- Create SOPs for weld analysis
- Make a prototype welding fixture
- Compare quality of robotic MIG welds to manual TIG welds

WELD PRODUCTION

The toolpath was programmed with the proposed welding fixture in a virtual motion simulation before being implemented. 28 test welds were created using a Fronius® welder and Yaskawa® robotic arm.

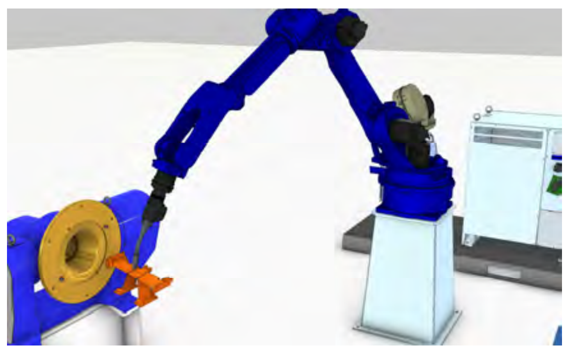


Figure 1: Virtual Simulation of Robot Toolpath

WELD ANALYSIS METHODS

Microscopy was used to quantify and characterize each weld's heat affected zone, porosity, weld penetration, and dimensions. Bend testing was used to characterize welds as passing/failing and to calculate strength data.

RESULTS

The welds were sufficiently improved to meet AWS D17.1 specifications for aerospace applications, and were comparable to manual TIG welds.

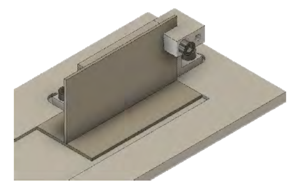


Figure 2: Welding Fixture CAD Design

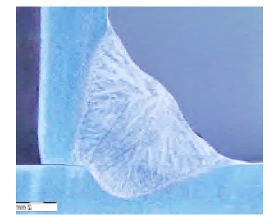


Figure 3: Micrograph of a MIG Weld

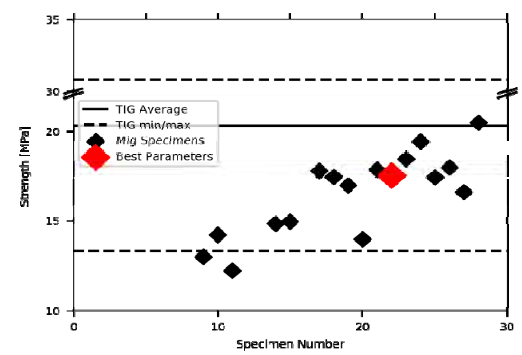


Figure 4: Improvement of Weld Strength Over Time

Input Parameter	Best Value
Welding Mode	Pulsed MIG
Shielding Gas & Flow Rate	75% Argon 25% Helium, 45 CFM
Weld Travel Speed	26 inches per minute
Wire Feed Speed	295 inches per minute
Contact Tip to Work Distance	0.6 inches
Voltage	22.5 V
Arc Length Correction	-4
Pulse/Dynamic Correction	4

Product Development

ID Building Tech Floor Plans

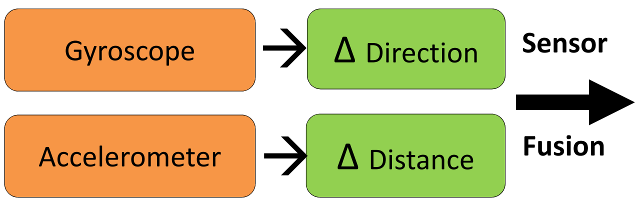
THE DESIGN LAB at Rensselaer

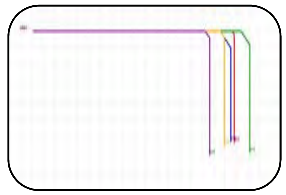
Fall 2018 Team: Aurora Freedman (EE), Connor Moran (CSE), Curran Fahey (CSE), Shane Batcher (CSE), David Raab (EE), Elizabeth Rysavy (CSE), Vincent Altobellis (CSE)

BAE SYSTEMS

Purpose: To use zero-permission cell phone sensors to map an indoor space.

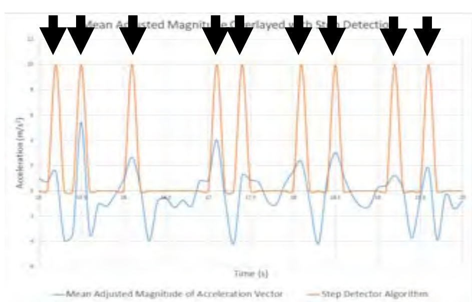
Technical Approach





- Developed algorithms to analyze iPhone sensors
- Applied sensor fusion to determine the path a user walked
- Collected data using SensorPlay from iPhone App Store
- Used the following modes of analysis:
    - Low Pass, High Pass, Butterworth filters
    - Three-axis average magnitude
    - Peak Detection algorithm

Step Identification - Accelerometer



- Distance Calculation: # Steps * Stride Length
- Raw data (blue) was amplified (orange) and peaks were counted to determine # Steps

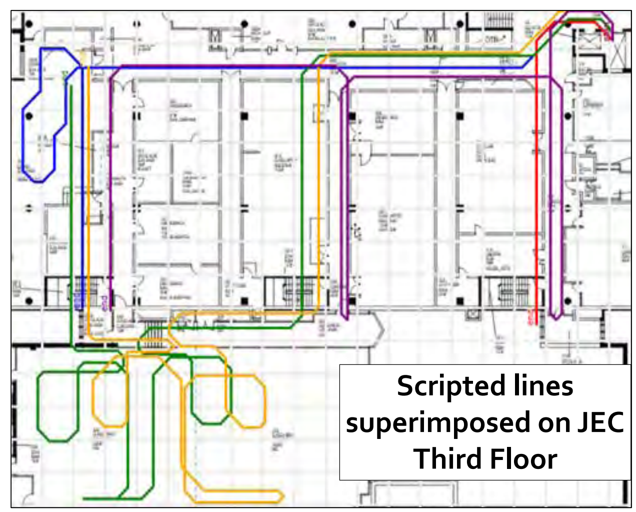
Semester Accomplishments

- Determined distances walked to within 1.2 % margin of error and on average 5 % margin of error
- Counted user's turns with over 90 % accuracy rate
- 45°, 90°, 180° turns successfully identified

Potential Future Work

- Investigate using FFT to determine user pace to increase calculated walking distance accuracy
- Test developed algorithms on Android smartphones
- Use Architectural CAD software for visualization

Final Floorplan Output



Scripted lines superimposed on JEC Third Floor

- Each line is a separate path taken through the building.
- Combined with many users paths, a full floorplan can be derived

Smart Room Lighting

THE DESIGN LAB at Rensselaer

Spring 2019 Team: Vincent Ferrara (CSE), Sam Greenwald (CS/CSE), Akhil Jacob (CSE), Timothy Maguire (EE/CSE), Dario Santelli (EE), Sean Willie (EE)

LEVITON

Purpose

Evaluate and recommend the latest sensor technologies for an improved smart approach for detecting room occupancy.

Past Work

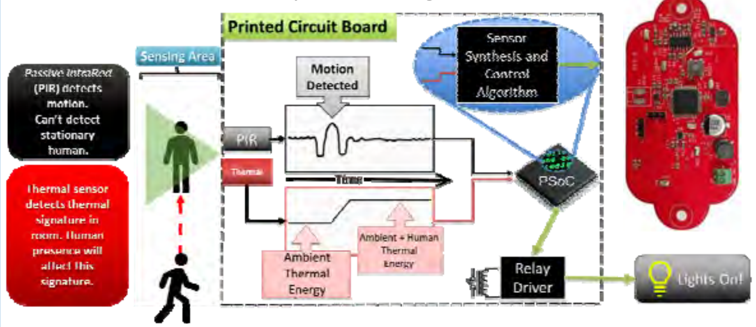
- Evaluated PIR, radar, ultrasonic, and thermal sensors.
- Produced sensor fusion algorithms for two and four sensor solutions.

Current Semester Objectives

- Evaluate Leviton Sensors against the top 1 or 2 sensors previously identified
- Design, fabricate, and build PCB for the chosen sensor(s). Implement Sensor prototype in junction box using PCB.
- Design and implement microprocessor coding/algorithm needed for sensors in order to detect occupancy reliably.

Technical Approach

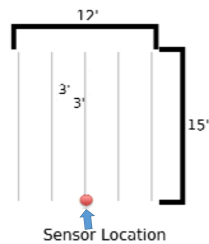
System Diagram



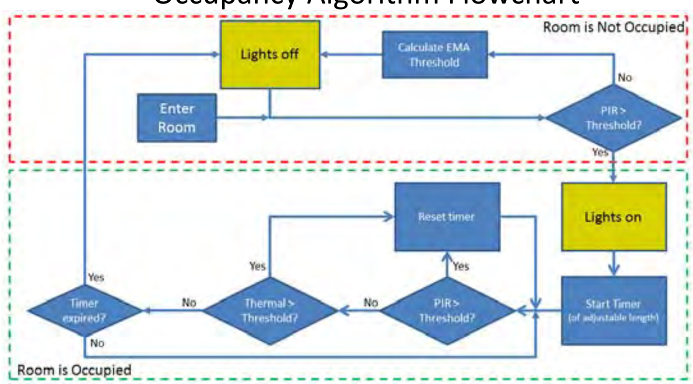
Test Method

Sensor Testing based on NEMA-WD7 Standard

- 12' x 15' room used as test environment
- Motion detection test run for each square.
- Detection rate = percentage of successful detection events over 10 trials in each square.



Occupancy Algorithm Flowchart



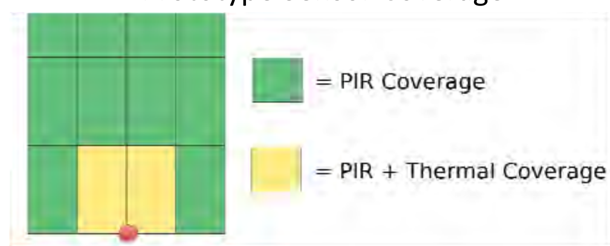
Exponential Moving Average (EMA) calculated on sensor readings to dynamically correct thresholds as room conditions change.

Technical Results and Accomplishments

PIR Sensor Benchmark vs. Prototype Performance

	Leviton IPS02				Leviton IPS15				RPI Prototype			
Major Motion (Movement between squares)	100%	100%	100%	90%	100%	60%	100%	100%	100%	100%	100%	100%
	90%	100%	90%	100%	100%	60%	100%	100%	100%	100%	100%	100%
	100%	100%	100%	90%	90%	100%	100%	100%	100%	100%	100%	100%
	90%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Minor Motion (Movement within squares)	0%	100%	60%	0%	20%	0%	80%	0%	20%	60%	100%	0%
	40%	100%	40%	80%	40%	20%	60%	0%	20%	80%	100%	20%
	20%	80%	40%	0%	20%	60%	40%	80%	100%	100%	100%	60%
	60%	100%	80%	100%	80%	100%	40%	100%	100%	100%	100%	100%
	80%	100%	100%	80%	80%	100%	100%	100%	100%	100%	100%	100%

Prototype Sensor Coverage



Conclusions

- Occupancy detection can be improved with larger range thermal sensor.
- EMA (exponential moving averages) can help eliminate false positives by adjusting to changing room conditions.

Future Work

- Consider/Research alternate thermal sensor options.
- Pursue neural network solution to improve false detection rates.

Nitrogen Tire Inflation for Vending

Spring 2019: David Kim (CSE); Gabriel Osio (MECH); James Lee (ISYE); John Merz (MECH); Ryan Cicchiello (CSE); Taylor Clink (ELEC); Zhen Xu (ELEC/CSE); Zhiqi Lin (ELE/CSE)

Background

KiWi GEM LLC. has developed an entirely consumer operated prototype to vend pressurized nitrogen for car tires.

Nitrogen filled tires provide many benefits including:

- Staying inflated longer
- Increasing fuel efficiency
- Prolonging tire life
- Cost efficient

Semester Objectives

Electrical Subsystem

- Embedded System
- Power Management System
- Electronic Control System

Software Subsystem

- User Interface
- Remote Monitoring
- Database Management
- System Control

Plumbing Subsystem

- Vend Air & Nitrogen
- Provide 150 psi & Handle 3000 psi
- Easy Assembling

Enclosure Subsystem

- CAD Drawing
- Material Selection
- Finite Element Analysis
- Nozzle Security

Technical Approach & Accomplishments

Electrical

- Solar-powered system with line power backup
- Circuit breaker, fuses, diodes, and shutdown procedure for safety
- Realization of inflation control logic and real-time pressure monitoring

Electrical Schematics

Enclosure

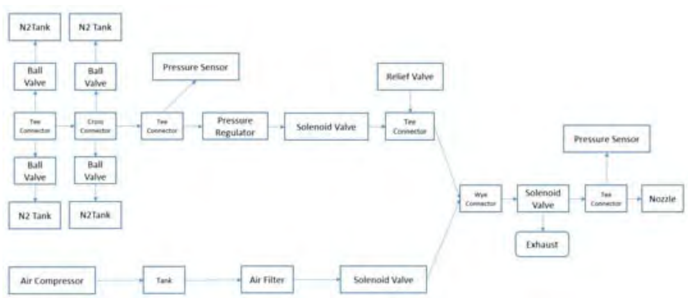
- Design makes for easy manufacturing, transportation, and assembly
- Layout minimizes damage potential

Interior Layout

Enclosure

Plumbing

- Triple redundancy
- Easier tank replacements
- Fill tire in under 1 minute

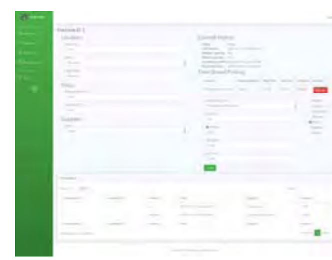


Plumbing Structure

Software

- Graphical User Interface for machine interactions
- Remote monitoring and control of machines
- Email and SMS notifications

Machine GUI



Finalized Website

Time of Flight Sensor Array

Spring 2019 Team: Andrew Turk (ME), Hewitt Hallberg (EE/CSYS), Jacob Hentnik (EE), John Rivera (CSYS), Peter Straub (CSYS), Yongxiang Cheng (EE)

Overview

Project Description

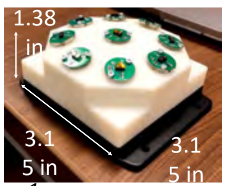
Miniaturize and enhance the existing LESA's Time of Flight (ToF) modules with the intent of counting, locating and tracking occupants.

Problems Addressed

I. Slow (5 Hz) sensor data reading
II. Big and bulky previous design (not market-worthy/industry ready)
III. Slow MQTT broker implementation

Project Goals

I. Miniaturize current design to be close to 1 in x 1 in x 1 in
II. Reduce the processing hardware
III. Choose hardware for 20Hz data polling
IV. Implement wireless data transfer from sensor to a central location for analysis
V. Create 3 or more complete ToF modules



Previous Design 2018

Figure 1

Application Areas

HEALTHCARE

SECURITY

PLANT SCIENCE

EFFICIENT BUILDINGS

Design Highlights

Highlights of Research

I. Replaced 2 Raspberry Pi's with 1 Particle Photon micro-controller (Fig. 2)
II. Tested Particle's Wi-Fi capability
III. Tested data reading limits of hardware with I^2C communication (Fig. 3)
IV. Tested individual sensor reliability
V. Assembled 1st prototype (Fig. 2)
VI. Created code to collect data from multiple sensors
VII. Tested sending data to a broker over Wi-Fi using MQTT
VIII. Designed flexible PCBs and manufacture (Fig. 4 and 5)
IX. Designed 3-D CAD printed structure for flexible PCB (Fig. 4)

MC Mounting Board

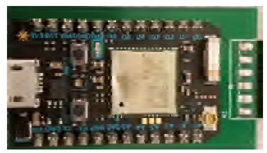


Figure 2

- Particle Photon micro-controller attached to holster board which is placed inside the housing in the final prototype

First Prototype

- First sensor array prototype consisted of 5 ToF sensors for testing purposes
- I2C inconsistencies
- Poor soldering of ToF sensors on boards

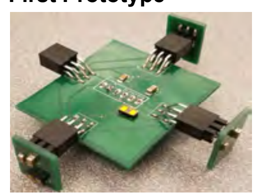


Figure 3

CAD Design for Flexible Sensor PCB

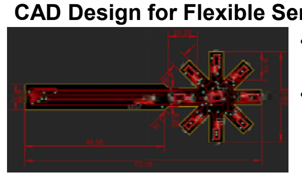


Figure 4

- Flexible PCB design with dimensions
- Includes 9 ToF Sensors, 2 LED's and small filter capacitors

Flexible PCBs Design

- 3-D printed housing with a flexible PCB cutout overlaid on the bottom surface for visual demonstration
- Revision 1 of 3D printed housing includes a hole in one wall

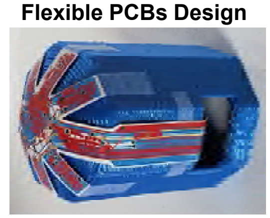


Figure 5

Recent Design Results

3-D Printed Circuit Board Housing

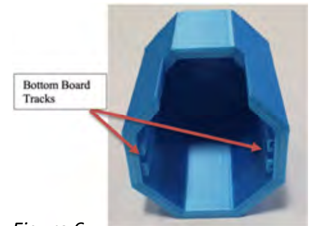


Figure 6

I. Revision 2 of 3D printed housing includes wall cutout instead of a hole for ease of assembly
II. Tracks designed for bottom board insertion
III. Dimensions: 1x1x1.75 inches

Unstable Prototype Rev.1

I. Only 1/3 of sensors identifiable on I^2C bus
II. Single sensor shows 11 separate I^2C addresses

Original Hardware Unreliability

I. Likely due to flexible connectors or soldering issues
II. Acquire a second design to test without placing on housing

Accomplishments

Miniaturize design to be close to 1x1x1 inch	✓
Create 3 or more complete ToF modules	✓
Design must be able to transfer data wirelessly	✓
Choose faster processing hardware	✓
Design a system that can support 20 Hz data polling	✓
Test final product and verify single prototype functions	✗
Test multiple ToF modules and verify mesh network	✗
Design PCB and housing integration	✓

Next Steps

Long Term Milestones

I. Implement a mesh network using Wi-Fi to allow for robust, scalable wireless communication
II. Make ToF sensor array low-energy and battery-powered
III. Analyze data for vector trajectory mapping
IV. Increase sensor range to be implemented in factories and warehouses
V. Design a mounting device to place in ceilings

Drone Payload Project

Spring 2019: Andrew Cao (ME), Jianren Chen (ME), Victor Chen (ME and MS), Madeleine Dwyer (ME), Rory McCarthy (ME), Elise Michell (ME), Abigail Ryan (ME)

THE DESIGN LAB at Rensselaer

Vertical Flight Society

Purpose

Create a pickup and release mechanism to successfully grab and drop off packages in the MAV Challenge

Semester Objectives

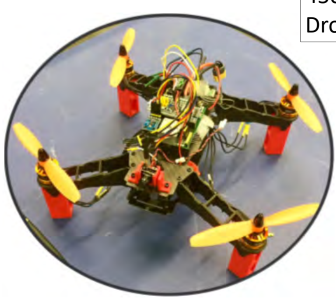
- Design and build two prototypes: hook and clamp
- Integrate one of the prototypes with the drone for the competition

Semester Accomplishments

- Three functioning prototypes and one CAD model
- Working circuit and STM32 uploaded code
- 100% reliability of proposed design for Hook
- Ready for drone integration upon drone completion

Problem Specifications

45cm Maximum Sphere for Drone and Pickup Mechanism



Pickup Mechanism Constraints:
Max Weight
5V Power Supply
Pickup and Release Bag Twice
Size Maximum: 17.78cm x 3.81cm x 7.62cm
Easy to Manufacture and Replace
Can Hold Bag Through Obstacles
Does Not Interfere with Optical Flow, Takeoff, and Landing

Weight of Bag: 25-30g

Technical Approach

Selection Matrix Based On:
- Size/Weight
- Durability
- Ease of Part Replacement
- Integration
- Airflow/Rotor backlash
- Stability/Reliability

Results (Top Two Picked):
Hook Claw Talons
Clamp Scoop
Electromagnet Forklift

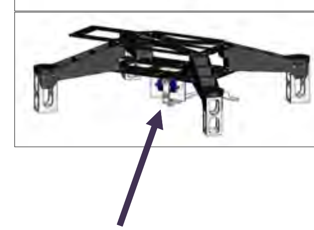
Analysis:
- Motor torque determination
- Hook angle calculations
- Gear design and calculations

Design:
- Material selection
- CAD model
- Circuit diagram
- Psuedo code

Testing:
- Backlash of rotor blades
- Strength of living hinge
- Strength of motor and actuator
- Code to STM32

Create Physical Prototype

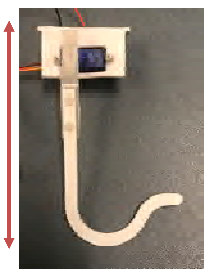
*repeat until it functions 95% reliably



Living Hinge

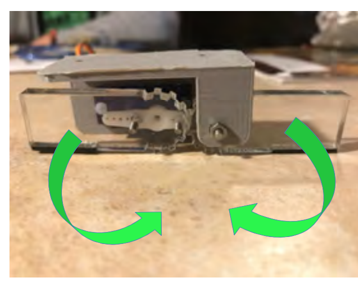
Hook

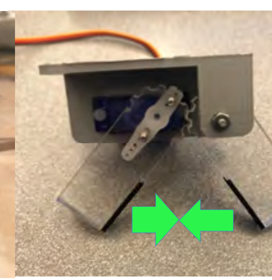
12.3cm

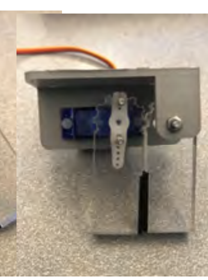


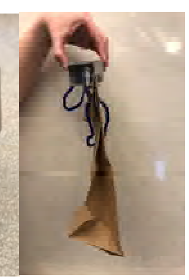
Clamp

3.8cm









Solar Kiosk

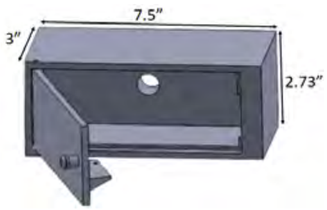
Spring 2019 Team: Karina North (ME), Jade Forman (EE), Julia Denham (CSE), Yan Zhang (CSE/EE), Jonathan Polania (IME), Tim Snyder (IME), Alex Koroglu (ME), Taylor Ross (ME)

Purpose of the Project

Develop a solar powered kiosk that provides a secure place to charge phones and Wi-Fi for it's customers.

Past Work

- Tentative BoM for kiosk
- Payment system



Secure charging locker

Future Work

- Design gas piston mechanism for the moving wall panel
- Integrate locker and payment system
- Finalize component selection
- Create the backend server software

Semester Objectives & Requirements

Deliverables

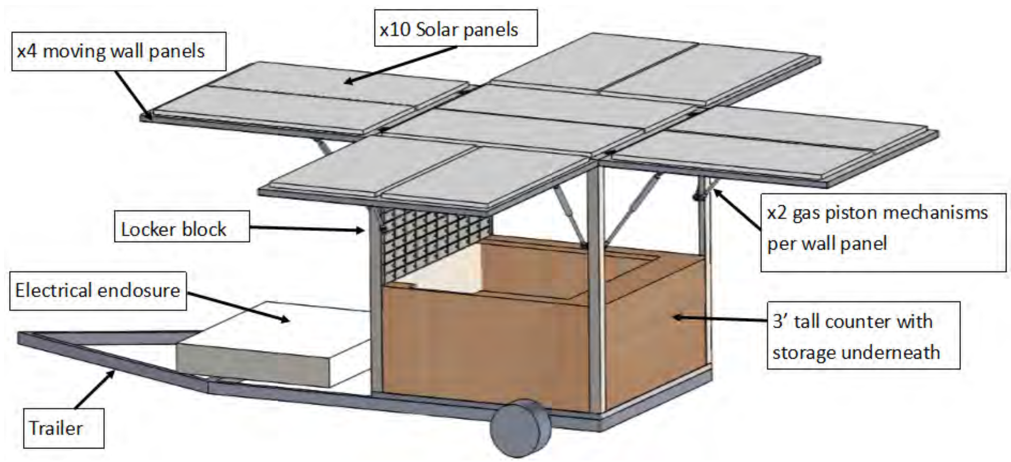
- Proposed bill of materials
- Proposed solar kiosk design
- Proposed power management plan
- Hub Management System (HMS) demo

MVP (Minimal Viable Product) Features

- Solar powered
- Wi-Fi router
- Charges many phones at once
- Compatible with a sandy, beach location (ideal location: Miami)

Technical Results & Accomplishments

Solar Kiosk Design



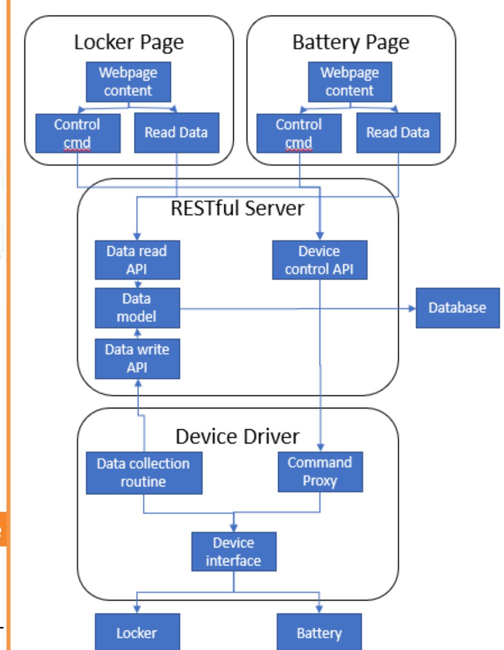
Max Possible Profit (Fixed Price)

Number of lockers	120	Hours per charge	3.5
Price costumer pays to charge phone	$3.00	Revenue brought in per day	$874.00
Revenue brought in per month			$26,229.00
Kiosk monthly cost			$689.00
Kiosk monthly profit			**$19,334.00**

Power Generation and Usage

Power Generation	3350
Power Cost	2296
Power Available	1054

HMS Architecture



Reliability and Test Systems

RCA Of Wind Tunnel Models

THE DESIGN LAB at Rensselaer

Spring 2019: Melody Fan (ME), Andrew Mwakibinga (CSE), Andrew Berger (ME), Byron Barger(AERO,ME), Conor Maddry (EE), Devin Siracuse (ME), Jack Baxley (EE,CSE), Linnea Cajuste (CSE), Noah Grant (ME)

BOEING

Purpose

Boeng is seeking a Remote Controlled Actuator (RCA) system for 1/20th scale ailerons to reduce the cost of wind tunnel testing.

Customer Requirements

Range of aileron motion: -30° to +15° with incremental steps of 5°

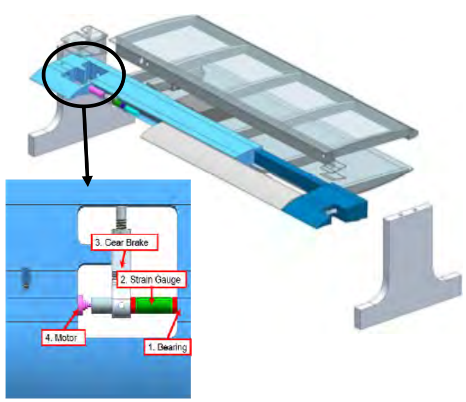
Angular accuracy: 0.1° under 20.9 lb-in of torque produced by wind tunnel

Transition time: 30 seconds between discrete angular positions

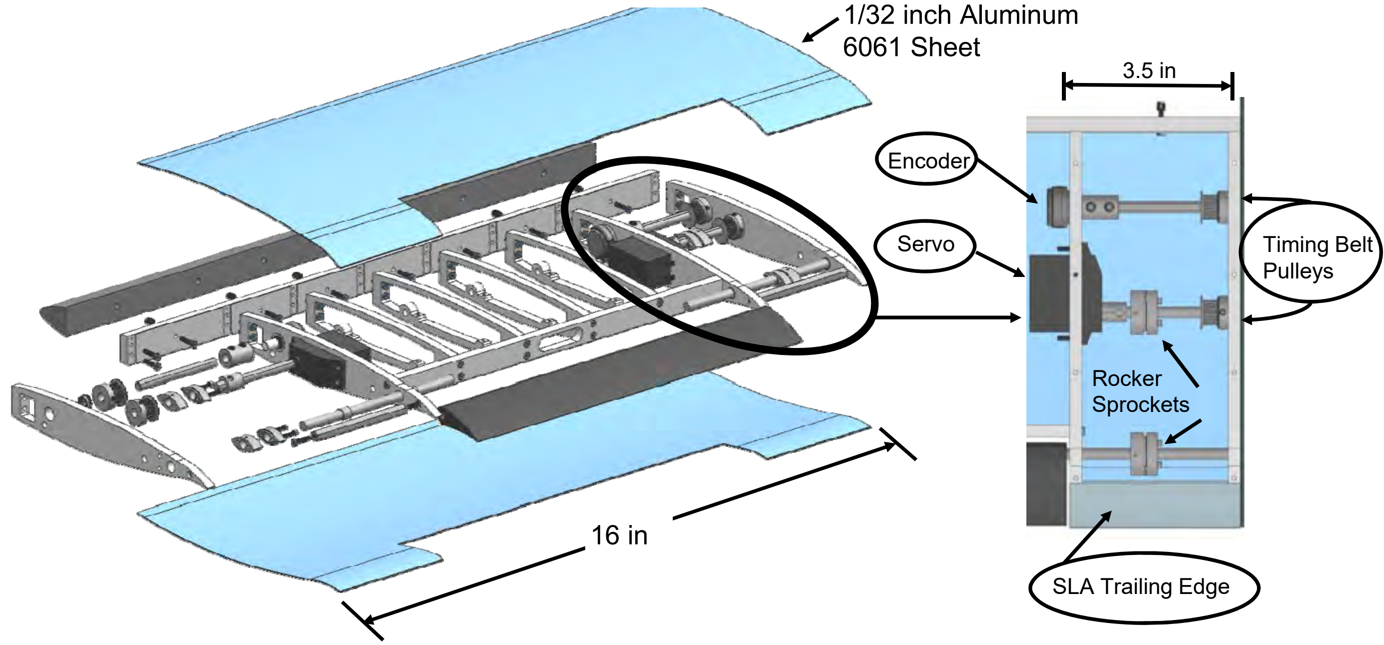
Remote control: Within 10 meters

Torque and pressure measurement

Previous Semester's Work



Design



Accomplishments

- Successful Wind Tunnel Test at 250 fps
- Manufactured and assembled prototype
- Redesigned drive train system
- Optimized manufacturability of model

Future Plan

- Improve wing aerodynamics
- Increase aileron range of motion
- Install pressure sensing components

Digital Image Correlation for MSL

Fall 2018 Team: **Austin Dehnert (ISYE), Junjie Ding (CSE), Baiting Luo (CSE, CS), Ethan Rambacher (CSE, CS), Livinia Williams (MTLE), Naomi Williams (MTLE), Yuheng Zhou (CS, ME)**

Purpose and Objectives

- DIC allows Mechanical Systems Lab (MSL) students to visually understand strain
- Holistic comprehension of mechanical properties of materials
- Objective: Design a working DIC system via identifying key components of DIC

Background

DIC compares a series of specimen images to calculate a strain field.

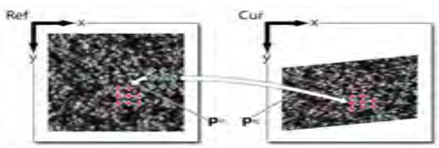


Fig. 1: DIC compares the change in a pattern to calculate strain fields. [1]

[1] Blaber, J. (n.d.). DIC Algorithms. Retrieved from http://www.ncorr.com/index.php/dic-algorithms

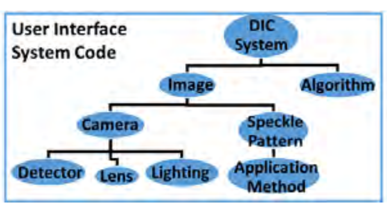


Fig. 2: Technical approach hierarchy of DIC system components

Technical Analysis

Fig. 3: Recommended system integration

Specifications for Application Method	Airbrush	Inkjet Printing	Sublimation Printing
Delamination of ink layer	No	Yes (in plastic region)	No
Durability	Easily scratched	Sensitive to abrasion	Good
Repeatability	Bad	Good	Good
Cost per sample	< $0.05 / sample	< $4.00 / sample	< $0.10 / sample
Print Rate	3 hr / 20 sample Batch	5 min / sample	1 min / 5 sample Batch

Fig 4: Comparison of speckle pattern application methods

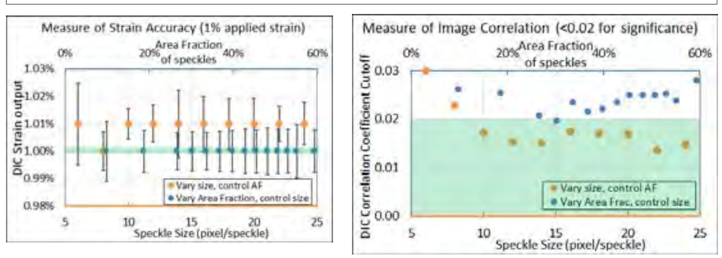


Fig 5: DIC analysis of speckle pattern determined that 14px/spec, 30% AF pattern results in highest quality.

Technical Results

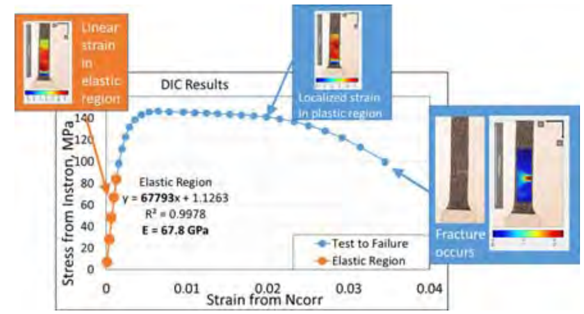


	Image Pixel Density	Young's Modulus	Avg. error
Canon5Diii 21 mm Ext tube	23.3 px/mm	66.9± 6.4 (GPa)	8.7%
Genie M2450 105mm lens	75.2 px/mm	57.0± 7.2 (GPa)	17.4%

Extensometer Young's Modulus: **69GPa**

Fig. 6: Calculation of Young's Modulus from Ncorr Strain result is consistent with literature value of 69 GPa for low-grade Aluminum alloys.

- The Young's modulus result confirms the viability of this DIC system as a tool in MSL

Future Work

- Test effect of sublimation printing heat treatment on mechanical properties
- Investigate wider variety of lensing options
- Consider stamping and lithography methods for speckle pattern application

Bearing Preload Gauge

THE DESIGN LAB at Rensselaer

Spring 2019: Madeline Fabry (IME), Jeremy Peterson (CSE), Alex Sullivan (ME), Andrew Volent (ME), Kangning Wang (ME), Cole Wetzel (EE)

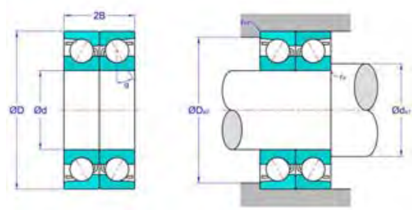
TIMKEN

Project Introduction & Purpose

- Bearing Preload Gauge: Measures load vs. displacement on ball bearing pairs to determine the preload on the bearings.
- Duplex Bearing: A preload method used to decrease radial and axial free play, thus increasing shaft location accuracy, load capacity, and bearing assembly stiffness.
- TIMKEN currently experiences reliability issues with gauge.
    - Causes: Analog output, manual knee point determination, dated system setup, etc.

(Left) External view of duplex bearing

(Right) Internal view of bearing stack

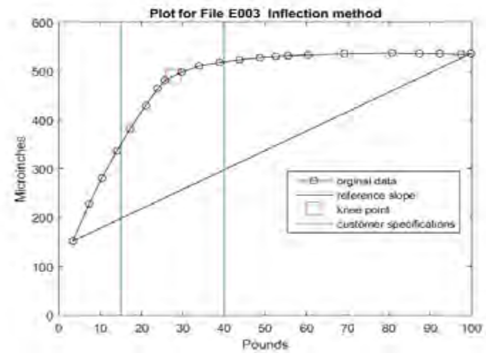


Objectives

- New linear displacement sensor: research & implementation
- Create CAD model for each part on the gauge
- Compile user manual to assist operators with the new gauge
- Compile full gauge manual for maintenance or repair
- Develop computer algorithm that finds the knee point

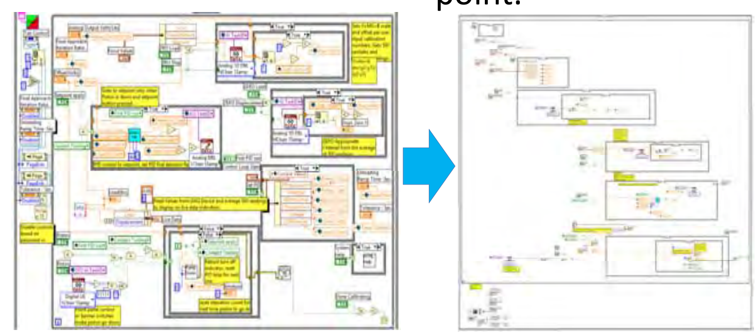
The New Digital Linear Displacement Sensor for the Preload Gauge

Technical Approach and Results



Inflection Preload Calculation Algorithm

- Inflection Method: Finds the preload using the change of 1st derivative and reference slope. Reference slope is found by connecting the first and last data point.



Before & After the computer program upgrade

Sensor	Keyence GT2-P12KL (New Sensor)	Old sensor
Type	Contact	Contact
Resolution	0.1 µm	0.1 µm
Measuring Force	0.1 N	0.049 N
Measuring Range	12 mm	4.5 mm

Old and New Sensor Specifications

Instron Grips

Spring 2019 : Steven Breeding (MECL), Rashad Choudhury (MECL), Kevin Davis (MECL), Anastasia Feraco (MTLE), Anthony Gallo (MECL), Chris Shepherd (MECL), Alexander Smith (MECL/BMED)

THE DESIGNLAB at Rensselaer

Rensselaer

Purpose

To design a set of tensile testing grips for the MDL that are intuitive for inexperienced users, reduce component failure, and allow for varying test methodologies

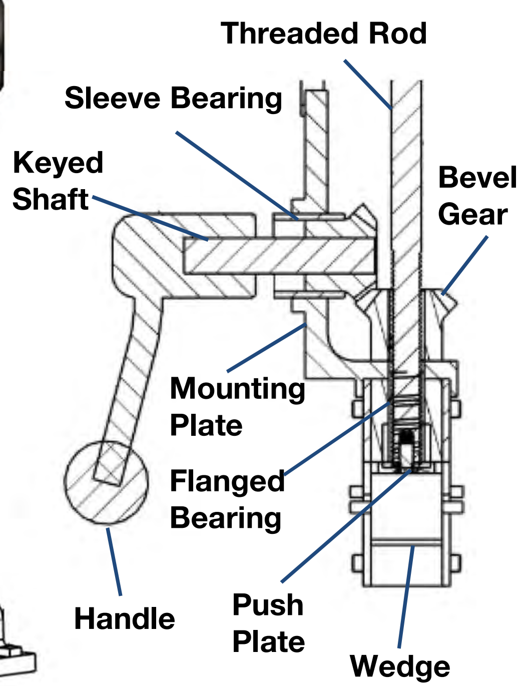
Past Work (Aren Paster)

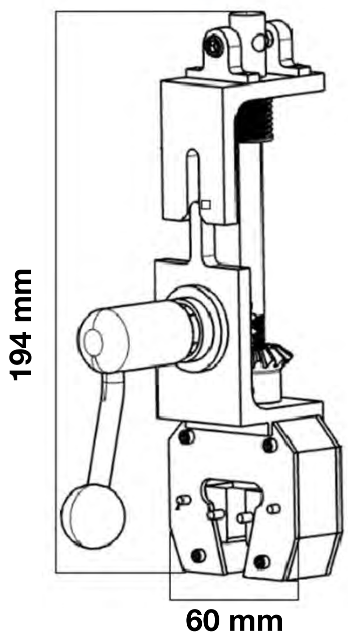
- Retrofit grip with square nut to replace knurled nut
- Stocked replacement for sheared locking pin

Semester Objectives

Prototype meets the following specifications:

- Capable of 2 kN load capacity
- Max clamping force of 3.4 kN
- Allowable rotation of +/- 15°
- < 3 minute loading time
- Up to 6.35 mm specimen thickness
- 0° and 90° mounting





Technical Approach

Research	Benchmark existing products, set technical specifications
Design	Perform engineering analyses, compose drawings and CAD models, purchase materials
Fabrication	CNC components, assemble final product, troubleshoot
Testing	Perform comparative testing to prior design

Technical Results

- Load capacity, sample thickness, mounting specifications met
- User manual implemented
- Component failure eliminated
- Grips able to clamp samples and tighten during tensile testing
  - Aluminum and Polycarbonate

Conclusion and Future Work

- Design modifications required to ensure long-term use in MDL
- Design for manufacturability
- Improve wedge design

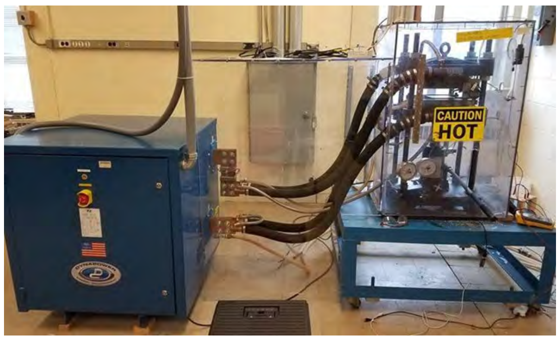
Field Assisted Sintering Technology (FAST) Lab

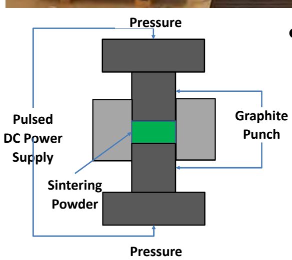
Fall 2018: Dingli Chen (MSE), Tyler Housey (ME), Anurag Kelkar (IME), Amy Reynolds (MSE), John Shaw (ME), Shinnosuke Tamaki (MSE), Jackson Wong (MSE)

Purpose

- Create a FAST student laboratory
- To be used by the MSE department

Background & Past Work





F.A.S.T. Process

- Operating FAST Machine with safety shield and interlocks
- Sintered Tin

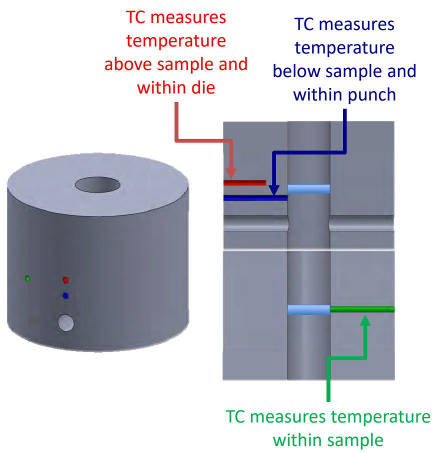
Semester Objectives

- Add temperature, pressure, and displacement sensors
- Select 1 ceramic and 1 metal for sintering
- Write an SOP and DOE

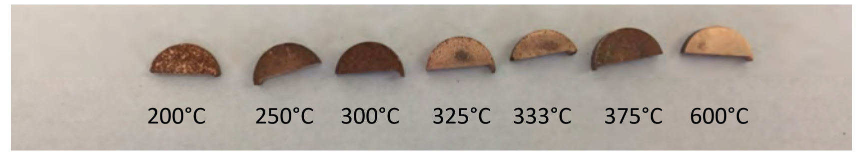
Technical Approach

- Implement sensors and connect with LabView
- Select sintering materials under parameters of machine
- Iteratively sinter and analyze materials to confirm candidates for student laboratory

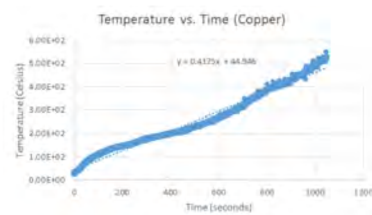
Technical Results

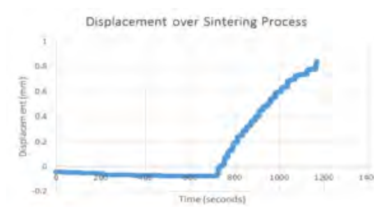


Redesigned die to implement thermocouples close to and within the powder

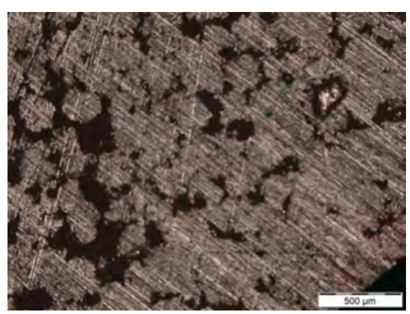


Sintered 7 Copper samples over a range of temperatures





Temperature and Displacement graphs (shown left) of 600 °C show ramp rate and densification



Unetched image of Cu sintered at 600 °C showing porosity and coarsening of grains

Conclusion

- Preliminary student laboratory procedure for sintering Copper
- Implemented DAQ
- Future work on metallography and machine capability

Collaborating With Industry For Over 19 Years

Thanks to Our Sponsors and Partners for Their Support of Engineering Education!

- **Albany Guardian Society**
- **Albany International Corporation**
- **Applied Materials**
- **BAE Systems**
- **Boeing**
- **Center for Disability Services**
- **Comfortex**
- **Convergint**
- **Corning**
- **Cypress Semiconductor**
- **DRS Power Technology, Inc.**
- **Ephesus/Eaton**
- **GE Energy**
- **GE Healthcare**
- **General Dynamics / Electric Boat**
- **General Motors**
- **Gerber Technology**
- **Glaxo Smith Kline**
- **Green Enviro Machine (GEM), LLC**
- **Harris Communications**
- **Hearst Corporation**
- **HJM Precision**
- **IBM**
- **Jabil**
- **Johnson & Johnson**
- **Leviton**
- **Lockheed Martin**
- **MathWorks**
- **MicroAire**
- **MITRE**
- **Momentive Performance Materials**
- **Monotype Imaging**
- **Morgan Stanley**
- **National Instruments**
- **Nexterra Foundation**
- **Northeastern Association of the Blind (NABA)**
- **Northrop Grumman**
- **NY State Dept of Environmental Conservation**
- **New York Independent System Operator (NYISO)**
- **Perkin Elmer**
- **Performance Indicator**
- **Pitney Bowes**
- **Philips Healthcare**
- **Raytheon**
- **SAIC**
- **Schick/Energizer**
- **Soft Armour LLC**
- **St. Peter’s Healthcare**
- **Standard Bank of South Africa**
- **Stephen Bader Co., Inc**
- **The ARC of Rensselaer County**
- **Timken**
- **Ultradian**
- **United Aircraft Technologies, Inc.**
- **UTC Aerospace Systems**
- **Velcro**
- **Waters**
- **WMS Gaming**