

MICHIGAN STATE UNIVERSITY COLLEGE OF ENGINEERING **SPRING 2021**

# DESIGN DAY



MICHIGAN STATE  
UNIVERSITY

**amazon**

Executive Partner Sponsor

**We at Amazon are honored to partner with the College of Engineering and Michigan State University to highlight the amazing work of MSU Students for Design Day Spring 2021.**

Amazon has witnessed innovation, creativity and solution-focused ideas from previous Design Days, and we know this one will be no different. MSU students work relentlessly to solve real-world problems using their skills and knowledge acquired while in the College of Engineering at MSU. These skills will help propel them into the workforce, where they will be our future engineers, leaders, innovators, entrepreneurs, and outstanding co-workers.

At Amazon, we use our leadership principles every day to guide our decision making, problem solving, and discussing new ideas. We see those leadership principles integrated in the projects presented in this Design Day booklet. Students are customer obsessed as they work backwards from the customer to solve for what is really needed. They work hard to invent and simplify on behalf of customers, trying new and different experiments before finding the best simplified solution. All student teams delivered results in their projects to showcase for Design Day, and we are excited for them to be our future.

Congratulations and best of luck to all the students, faculty and staff who helped make this Design Day a success for MSU and all its partners. We at Amazon Detroit are proud to be included and look forward to working with these students in corporate jobs.

**Amazon is always looking to hire and develop the best. If you are interested in joining our team please visit [amazon.jobs](https://amazon.jobs).**

Sincerely,  
Garret Gaw  
Director  
Selling Partner Experience  
Amazon Detroit





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MICHIGAN STATE UNIVERSITY COLLEGE OF ENGINEERING FALL 2021

# DESIGN DAY

**Look for Fall Design Day  
projects coming in December 2021!**



# Welcome from the Dean



## **Design Day is one of our premier undergraduate academic events of the semester. Now in our 27th year, Design Day highlights the creativity and ingenuity of our Spartan engineers.**

As you would expect, due to the current health situation in our country and our community, all in-person Design Day activities have been cancelled. Instead, each of our participating academic programs will be celebrating Design Day virtually in their own unique way.

We are pleased to acknowledge Amazon as our Design Day Executive Partner Sponsor and Auto-Owners as our Design Day Directing Partner Sponsor. Our Design Day Supporting Partner Sponsors include Anthropocene Institute, CSAA Insurance, Delta Dental of Michigan, Ohio and Indiana, MSU Federal Credit Union, TechSmith and Urban Science. We thank our sponsors for their generosity and their ongoing commitment to Design Day, especially during these challenging times.

As you explore the contents of this Design Day booklet, you will see that our students are an incredible group of talented young people who share a common enthusiasm for engineering. What they have accomplished during the challenges of a global pandemic with all the associated changes in how they interact with themselves and sponsors and how they meet the requirements of each project is inspiring.

Starting in their first semester, the freshmen in our Cornerstone and Residential Experience for Spartan Engineers programs learn about the importance of engineering and the positive impact that engineers make on society and the world around them. Our students innovate, communicate and perform at the highest levels in an increasingly global and demanding world.

Our graduating seniors are the headliners of our Design Day program. Their projects represent the capstone of their educational career. Every senior capstone team has created a video about their project. Links to these project videos can be found on our Design Day website. As you read about their projects in this booklet and watch their project videos online, you will see that our MSU engineers are ready to lead, create and innovate.

Our capstone programs and Design Day would not be possible without the continued support of our capstone project sponsors who provide both funding and a professional experience for our capstone design teams. We appreciate their generosity and their time.

We are confident that our in-person Design Day tradition will continue again in the not too distant future.

A handwritten signature in black ink, appearing to read 'Leo Kempel', with a long, sweeping horizontal line extending to the right.

**Dr. Leo Kempel**

Dean of the College of Engineering

Professor of Electrical and Computer Engineering

Dennis P. Nyquist Endowed Professor of Electromagnetics

Michigan State University





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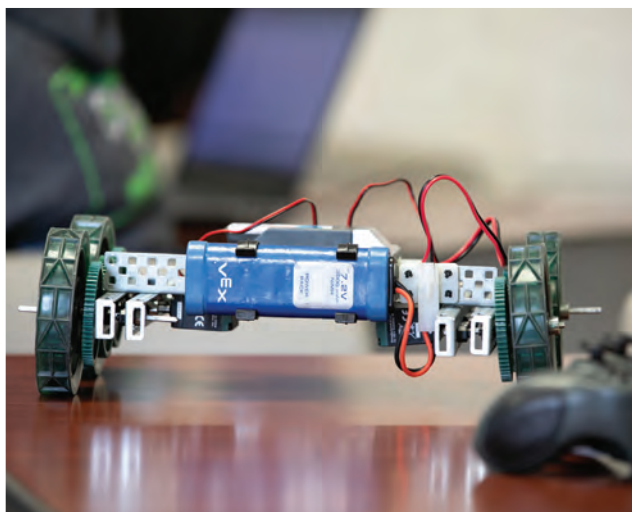
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## EGR 100 Introduction to Engineering Design

**Dr. Jenahvive Morgan**  
Course Instructor

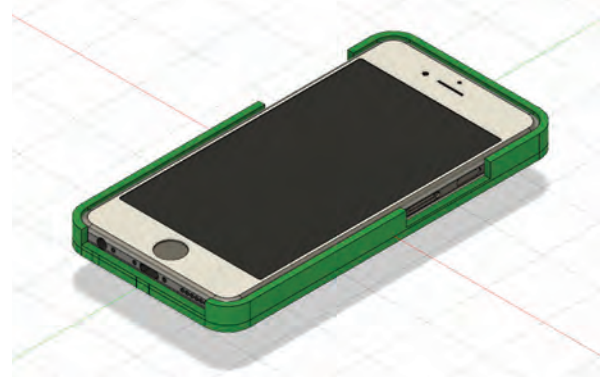
### Course Project

EGR 100, Introduction to Engineering Design, is a college-level course required of all incoming first-year engineering students. It is an integral part of the CoRe (Cornerstone and Residential) Experience. The course introduces students to the engineering profession and the engineering design process through team-based, interdisciplinary design projects and assignments. There are 674 students enrolled in EGR 100 this semester.

For the final course project, the student teams selected from five project types: (i) Design of a Heat Exchanger, (ii) 3D Printing CAD Drawing, (iii) Design of a Water Filtration System, (iv) Costa Rica Community Designs, and (v) CoRe Industry-Sponsored Projects. CoRe Industry-Sponsored Projects involved collaborations with BorgWarner on Hydrogen Fuel Cell System Requirements.

<http://www.egr.msu.edu/core/>

### Fall 2020 EGR 100 Project Designs



3D Printing CAD Drawing Project:  
Student Phone Case Design



Costa Rica Community Design Project:  
Student Educational Cell Phone App



## Applied Engineering Sciences

# Capstone Course Sponsors

We thank the following sponsors for their generous support of the Applied Engineering Sciences senior capstone course. We gratefully acknowledge the Supply Chain Council for their project support.

American Axle & Manufacturing, Inc.



John Deere



Asahi Kasei Plastics North America



KLA Corporation



Blueair



L3Harris



BP PLC



MSU Infrastructure Planning & Facilities



Caterpillar



NASA/ASU



Clariance Technologies



Parker Hannifin



Consumers Energy



Smith+Nephew



Gerdeau



Smithfield Foods



Hanson Logistics



Trane





## Applied Engineering Sciences The Capstone Projects



**Dr. Laura J. Genik**  
Director  
Applied Engineering Sciences



**Dr. Srinivas (Sri) Talluri**  
Professor of Operations  
and Supply Chain Management  
The Eli Broad Graduate  
School of Management

### Graduate Teaching Assistants

---



**Ishaan Anand**  
MBA (2022)



**Akash Mehrotra**  
MBA (2022)



**Shraoni Rangnekar**  
MBA (2021)



**Sugandhi  
Sawhney-Cox**  
JD/MBA (2021)

## AESC Engineering Program

Since its inception, the Applied Engineering Sciences program has been successful in attracting students with diverse interests and varied backgrounds. Employers have especially responded positively to the graduates who bring a unique blend of courses and experiences to the workplace. These students are heavily recruited by a wide range of organizations with starting salaries commensurate to those of other engineering programs.

## AESC 410 Senior Capstone Project Course

The culmination of course work in engineering and business, the Capstone course for Applied Engineering Sciences focuses on a semester-long project from a sponsor (industry or non-profit) typically at the confluence of modern business operations and engineering or technical issues. The course has been taught interdisciplinary with Supply Chain Management, SCM 472, since 2015.

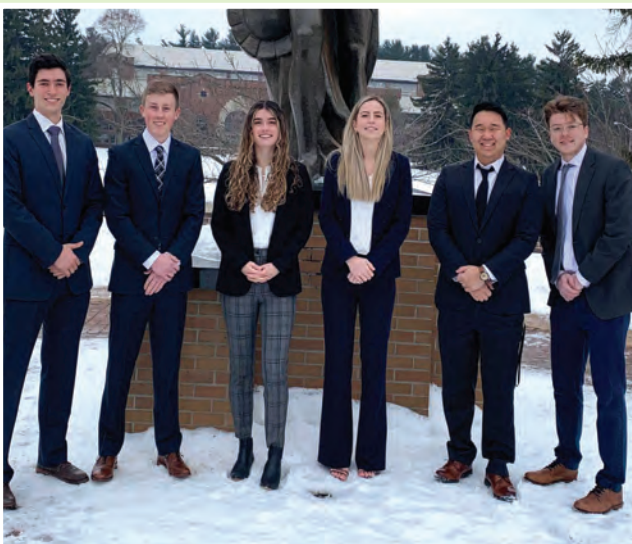
# American Axle & Manufacturing

## AAM NA Transportation Network Optimization

American Axle and Manufacturing is a tier one automotive supplier, dealing in driveline and drivetrain components and systems. AAM is based in Detroit, Michigan, with over 80 locations spanning from the Americas to Asia and Europe, generating a global presence. Contained within AAM's locations is a complex transportation network of freight, ranging from raw materials to finished goods. A combination of different transportation methods are utilized by the company, such as Truckload, LTL, LTL Consolidation, International Air and Ocean, and Premium Transportation. The team's main focus revolved around analysis of American Axle's North American transportation routes.

Our team worked on a project towards optimizing the transportation network of American Axle. Although the project focused on transportation specifically in North America, there was an emphasis placed on transportation within the United States. The team acted as a fresh set of eyes on transportation data and trends within AAM, with plans of identifying areas where AAM could improve its network and add value within their organization.

Project opportunities focused on determining why specific types of transportation modes were used based on individual scenarios. Important metrics included shipment weight, shipment frequency, transportation mode, and asset utilization. These key indicators were targeted when analyzing the transportation mode utilized. When looking deeper into the data and trends, different applications could be utilized to assess which areas had high concentrations of spend to find cost saving opportunities. Certain transportation modes and suppliers are utilized more frequently than others and being able to consolidate or capitalize on certain opportunities could lead to unseen savings. Each factor analyzed aimed to reduce American Axle's total spend on transportation. The team's analysis hopes to help AAM further their cost savings in a rapidly changing logistical environment.



### **Michigan State University** *Team Members* (left to right)

**Aidan Fox**  
Barrington, Illinois

**Andrew Barton**  
Rockford, Michigan

**Kate Cousino**  
Plymouth, Michigan

**Andrea Vortriede**  
Grosse Pointe, Michigan

**Daniel Sim**  
Clarkston, Michigan

**Victor Szymanski**  
Plymouth, Michigan

### **American Axle & Manufacturing** *Project Sponsors*

**Ryan Etherton**  
Detroit, Michigan

**Ray Hatfield**  
Detroit, Michigan

**Faith Wandrie**  
Detroit, Michigan

### **Teaching Assistant**

**Sugandhi Sawhney-Cox**



# Asahi Kasei Plastics North America

## Raw Material Planning & Stock Replenishment Strategy

Asahi Kasei Plastics North America operates two facilities that manufacture plastic compounds. One facility is in Fowlerville, Michigan and the other is in Athens, Alabama. The planning team for Asahi Kasei Plastics oversees monthly forecasts for sales of finished goods, but the ongoing COVID-19 pandemic has made it difficult to be prepared for the continuous fluctuation in demand's effect on raw materials. As their purchasing team currently orders raw material based on its historical usage, this dramatic fluctuation in demand causes frequent raw material shortages, as well as instances of excess inventory.

Asahi Kasei Plastics partnered with Michigan State University to create a processing tool to better estimate the future usage of raw materials, and make sure the plant has an appropriate inventory of raw materials on hand. This tool also aids Asahi Kasei Plastics in reducing their inventory discrepancies and improving their stock replenishment efficiency.

With the data provided from Asahi Kasei Plastics, we created a data analysis tool in Excel with the ability to use the changes in demand forecast of finished goods and lead times of raw materials to predict the upcoming use of raw materials, as well as to create an efficient order schedule for raw materials. This was done by converting finished goods forecasts to raw material forecasts, and calculating appropriate lead times, reorder points, safety stock, and lot sizes.

The tool was created with emphasis on integration and flexibility. This means inputs to the tool can be altered or added, and the tool still calculates desired outputs.



**AsahiKASEI**



### Michigan State University

**Team Members** (left to right)

**Meredith Detweiler**  
Marion, Ohio

**Antonia Cinnamond**  
Grosse Pointe, Michigan

**David Setterlun**  
Taylor, Michigan

**Alexis Burrows**  
Utica, Michigan

**Brandon Shilgalis**  
Naperville, Illinois

**Mack Daniels**  
Livonia, Michigan

### Asahi Kasei

**Project Sponsor**

**Abhishek Jindal**  
Fowlerville, Michigan

### Teaching Assistant

**Sugandhi Sawhney-Cox**

# BLUEAIR

## Air Purifier Refurbishment

Blueair was founded in 1996 as a producer of air purification solutions for both home and professional use. The company is headquartered in Stockholm, Sweden. Blueair delivers innovative, best-in-class, energy-efficient products with the purpose of improving the health and well-being of people everywhere.

For this project, Blueair has enlisted the team to help create a standard process for refurbishment for three of its air purifier models. Our team has been tasked with developing a unique set of standard operating procedures for each model. We will also be creating a cost analysis for each unit and utilizing a decision-tree style model for determining whether parts should be replaced, reused, or if the returned unit should be scrapped altogether. The completed guide will assist Blueair employees with decision-making through each step of the refurbishment project, from receipt defective/damaged units to the repacking of fully refurbished units.

The team has disassembled each unit and reviewed part lists and pricing information for every component included within the air purifiers. All of this information will be combined and used moving forward to develop the necessary standard operating procedures and cost analysis. The standard operating procedures will be a thorough, step-by-step list guiding the entire refurbishment process. It will be written clearly enough that anyone unfamiliar with the product and process could follow the steps and complete the procedure successfully.

This project will benefit the company by increasing profitability and reducing waste. Currently, there is not an established procedure for this process, so this will increase efficiency. By enabling the company to reuse more components, this set of procedures will serve to eliminate waste and increase sustainability.

### We love our planet

Inspired by our Swedish heritage, sustainability and quality are at the heart of everything we do.

It drives us to develop products that exceed industry standards for performance without losing sight of sustainability. We aim to use materials that minimize environmental impact whenever possible.



#### Michigan State University

**Team Members** (left to right)

**Richard Smalldon**  
Port Huron, Michigan

**Brad Heier**  
Miami, Florida

**Owen Diller**  
East Lansing, Michigan

**Cole Nelson**  
Caledonia, Michigan

**Savi Singh**  
Royal Oak, Michigan

#### BLUEAIR

**Project Sponsors**

**Kate Craft**  
Chicago, Illinois

**Elliot Lourie**  
Chicago, Illinois

#### Teaching Assistant

**Akash Mehrotra**

# BP: Measuring the Carbon Footprint of Complex Global Supply Chains

BP is one of the world's seven largest oil and gas superpowers and supplies energy globally with operations in almost 80 countries. BP can trace its roots back over 100 years and continues to provide energy solutions in traditional and innovative ways.

As energy needs grow and the environmental impact of traditional energy sources comes under the global spotlight, BP is seeking to reduce their greenhouse gas (GHG) emissions. These efforts will pave the way to a more sustainable and efficient future of energy.

In order to effectively reduce emissions, our project seeks to understand impactful methods for measuring and reporting GHG emissions. One of the most difficult areas of carbon footprinting for an organization is mapping its upstream and downstream supply chain emissions. Traditionally, these solutions are complex and global, following “make-use-dispose” models that do not take disposal or recycling into account.

As of January 1, 2021 BP has combined reporting for their upstream and downstream supply chain emissions. Since they were previously separate, they lacked cohesive emissions tracking initiatives. BP aims to be net-zero by 2050, and a large step towards achieving that goal is decarbonization of their supply chain.

By reviewing current supply chain emission measurement methods used by industry leaders, primarily those outside of the oil and gas industry, our team will analyze best practices of carbon footprinting. This will result in an outline for supply chain emission modeling practices for BP. By applying these best practices to BP's supply chain, the company will have the capabilities to target areas of the supply chain that carry the biggest footprint.



## Michigan State University

**Team Members** (left to right)

**Grant Laramee**

Huntington Woods, Michigan

**Jake Zanolli**

Beverly Hills, Michigan

**Joel LaBruzzy**

Clarkston, Michigan

**Trevor Hopman**

Brighton, Michigan

**Ben Anderson**

Allegan, Michigan

**Jack Watza**

Ann Arbor, Michigan

## BP

**Project Sponsor**

**Aya Abouhoussein**

Cairo, Egypt

## Teaching Assistant

**Ishaan Anand**



# BP

## Asset Re-purpose Hub – Net Zero 2050

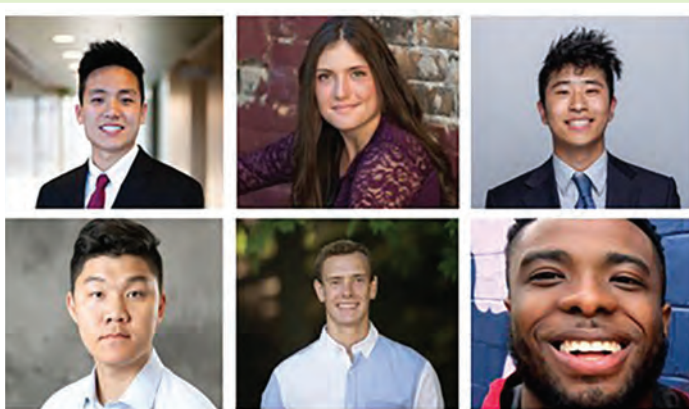
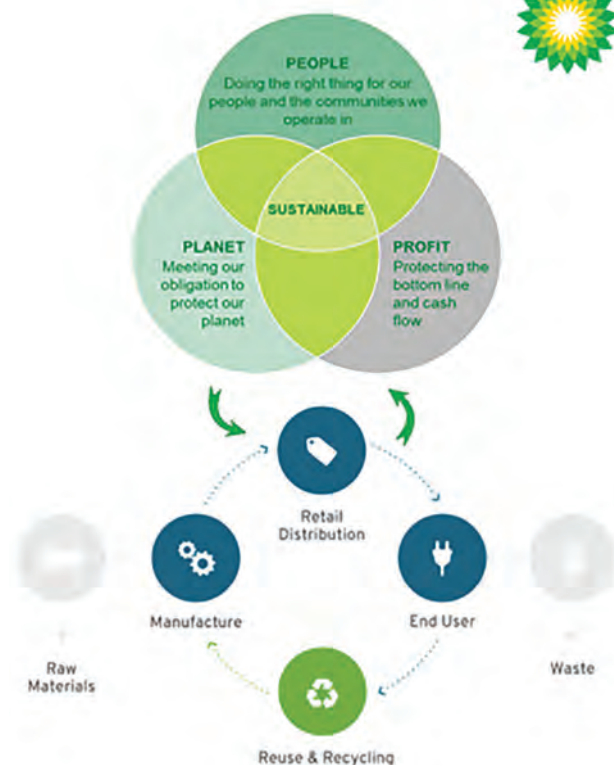
BP is a British multinational oil and gas company headquartered in London, England. It is one of the world's major oil and gas firms. A main challenge that BP currently faces is that there is no standard way to re-use, re-sell, or recycle assets when a business unit has a move or change event. Everything is done manually and there is disconnect between the Property Management organizations. With this challenge, the BP Supply Strategy & Innovation Team has identified an opportunity to run a beginning proof-of-concept for re-use of office furniture & other assets. The long-term goal for the “BP Asset Repurpose Hub” is to become a centralized portal to re-use, re-sell, or recycle BP's assets. This portal will enable them to increase the circularity of their current assets, consequentially reducing the use of virgin resources and decreasing resource intensity. In addition to reducing costs that could otherwise be reallocated, utilizing a centralized portal aids in reducing emissions, thus facilitating BP's goal to be net-zero by 2050.

One key deliverable for this project is to develop a functioning prototype portal that enables users at BP to upload assets from select sites for internal repurposing or external sales. The minimum capabilities required of the portal include the ability to upload an image, description, and current location of the asset. The other deliverable is a process map detailing the steps required to re-purpose an asset beginning with placing an asset in the portal and ending with delivery to the end customer.

Low-risk assets, such as office furniture and conference room equipment are in-scope for this project. Direct materials, such as oil, and operating assets like turbines and heavy machinery, are out of scope. The scope is limited to 1-2 office sites that will serve as pilots for the prototype hub. These sites will be selected by the project sponsor. Also, in-scope is an assessment of the viability of third-party platforms and BP's internal technology for use as the long-term host of the hub. Internal financial processes associated with the hub are out-of-scope.

With the development of the Asset Re-Purpose Hub, BP will now have a tool to assist with their sustainability initiatives and bring specific benefits in areas such as financial, non-financial, and carbon reduction. In addition to these benefits, the portal will be another powerful resource for the entire organization to utilize.

#bpNetZero



### Michigan State University

**Team Members** (left to right)

**Charles Zhou**  
Rochester Hills, Michigan

**Caroline Szabo**  
Midland, Michigan

**Andrew Chen**  
Rochester Hills, Michigan

**Shiqi Chen**  
Shanghai, China

**Oliver DeYoung**  
East Lansing, Michigan

**Ike Nnanabu**  
Lansing, Michigan

### BP

**Project Sponsors**

**Tony Bliazis**  
Houston, Texas

**Erik McMillan**  
Houston, Texas

### Teaching Assistant

**Shraoni Rangnekar**

# Caterpillar: Integrating Sustainability into a Global Supply Chain & Logistics Operations

Caterpillar is the world's leading manufacturer of construction and mining equipment, diesel and gas engines, diesel-electric locomotives, and industrial gas turbines. Caterpillar has been working toward building a better world through innovation and sustainability progress on every continent.

The focus of the project was to identify and analyze sustainability efforts and ideas that will allow Caterpillar to continue to provide service and products to its customers while at the same time minimizing global impact. Through analyzing and identifying sustainability risks and opportunities within the logistics infrastructure at the Lafayette, Indiana plant, the project gave Caterpillar the tools needed to enable economic growth and protect the planet.

Some initiatives developed by the team to improve Caterpillar's sustainability included opportunities to drive reductions in BPM, CO2 Emissions, and water consumption. Also, the team analyzed and suggested volunteer opportunities to engage employees of all job types and generations. While investigating the sustainability opportunities already in place, the team ensured that Caterpillar's sustainability council was focused on the right sustainability efforts.

Caterpillar's company mission statement is "to enable economic growth through infrastructure and energy development, and to provide solutions that support communities and protect the planet."

Throughout the semester, we focused on investigating, analyzing, and comparing sustainability efforts within Caterpillar itself and the surrounding industries to minimize the environmental footprint.



## CATERPILLAR®

### Michigan State University Team Members (left to right)

**Hunter Lukes**  
Highland, Michigan

**Michael Bress**  
Allen Park, Michigan

**Urara Kaneko**  
Canton, Michigan

**Joe Shuster**  
Caledonia, Michigan

**JP Gurgel**  
Lake Orion, Michigan

### Caterpillar Project Sponsors

**Jon Allchin**  
Stafford, UK

**Betsy Williams**  
Peoria, Illinois

### Teaching Assistant

**Shraoni Rangnekar**





# Caterpillar Forecasting Method Proposal

Caterpillar receives forecasting estimates from its customers and uses a coded process with 40 iterations based on each customer to determine what the customer order will be. With this current process, the forecast determined from the customer predictions is often unreliable and inaccurate. As a result of this, Caterpillar experiences shortages or excess in inventory due to the inaccuracy of the forecast. Our team will use their analytical skills to help improve this process.

Caterpillar provided crucial data for this project which included forecasting projections and actual orders for five customers, each customer containing 100 parts. Caterpillar and our team agreed that they needed to examine samples of five customers in order to be able to analyze and make meaningful assumptions to help improve the process.

We will be working to create a model that will improve the forecast accuracy by changing and implementing weighted averages and combining the data of all customers. The goal is to make the system and formulas more simplified which will create a more efficient system for Caterpillar to improve the forecasts for their customers. Along with this, we will work to reduce the number of iterations used in the forecasting analysis to create a more productive process with less variability between the forecasted data and actual demand.

Our team will use platforms such as Excel, Tableau, PowerBI and R Studio to analyze Caterpillar's data. Excel will be used to find the variability between Caterpillar's forecast and actual demand data, and the other platforms will be used to create a dashboard that can easily be managed and turned into a more efficient process for Caterpillar to monitor their customer(s).



## Michigan State University Team Members (left to right)

**Natalie Herrington**  
Milford, Michigan

**Erica Drobny**  
Kalamazoo, Michigan

**Alexandria Soule**  
Mason, Michigan

**Christina Crane**  
Troy, Michigan

**Sabrina Giamarese**  
Novi, Michigan

**Alyssa Harvey**  
Novi, Michigan

## Caterpillar Project Sponsors

**Laura Cronkleton**  
Morton, Illinois

**Chris Fink**  
Morton, Illinois

## Teaching Assistant

**Ishaan Anand**



# Clarience Technologies Telematics Project

Clarience Technologies began in 1955 with an ingenious idea that sparked a revolution in truck and trailer safety lighting. Clarience is comprised of a family of brands with the mission of providing total visibility to the transportation industry. Their family of brands includes Truck-Lite, Davco, Road Ready, Rigid, Lumitec, and most recently ECCO and Code 3. With data and insights provided through advanced technology, Clarience Technologies is able to provide customers a complete fleet management solution, streamline supply chains, and enhance safety both on and off the road.

This project focuses on Clarience's Road Ready telematics division, which provides fleets with real-time, exception-based reporting and allows for improved fleet control. Road Ready's solutions include GPS location, mileage and speed tracking, light out detection, ABS and tire inflation warning, temperature, standard and volumetric cargo, door status, TPMS, wheel end condition, and more.

Currently, Clarience's Road Ready products are prominent in the heavy-duty tractor trailer market. This market has over 6 million trailers with only an estimated 30% having telematics capability. This provides Clarience with a large growth opportunity. To capture additional markets Clarience Technologies is looking to expand the Road Ready solution into three adjacent markets: final-mile, rail, and ocean.

We will conduct market research and SWOT analyses on the three respective markets (final-mile, rail, and ocean) to uncover potential growth opportunities with the introduction of Road Ready products. Macro-level and micro-level market research will identify the key industries and major companies within each market segment. In parallel, company surveys will be administered to locate current gaps in supply chain visibility and opportunities to help customers maximize asset utilization and boost operational efficiency.



## Michigan State University Team Members (left to right)

**Lauren Lee**  
Canton, Michigan

**Anuj Malavia**  
Rochester Hills, Michigan

**John Foy**  
Grand Rapids, Michigan

**Jack Uecker**  
Grand Rapids, Michigan

**Ken Krolicki**  
Canton, Michigan

## Clarience Technologies Project Sponsors

**Nada Jiddou**  
Southfield, Michigan

**Angela Kupchella**  
Southfield, Michigan

**David McKean**  
Southfield, Michigan

## Teaching Assistant

**Akash Mehorta**

# Clarience Technologies

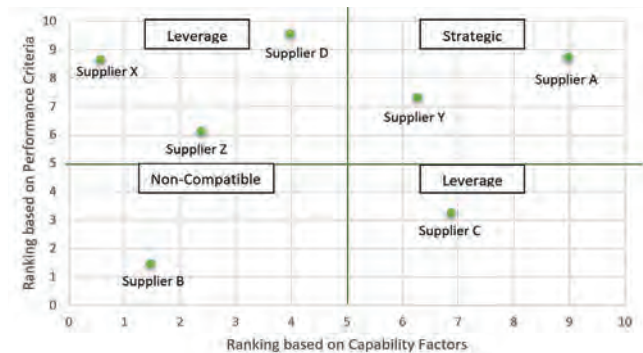
## Supply Base Size, Capability and Footprint

Clarience Technologies is a leader in vehicle electronics with an international presence. Established in 2020, Clarience Technologies utilizes its 8 divisions that include Truck-Lite, Road Ready, Davco, Rigid, and Lumitec to provide total visibility to transportation. With these divisions, Clarience Technologies specializes in lighting, wiring, sensors, and filtration products for the commercial vehicle, military, recreational, and marine industries.

Our project is focused on developing a supplier capabilities matrix and survey that will be used across all 8 divisions of Clarience Technologies. The survey will act as a template to gather qualitative and quantitative data on current and future suppliers to be used in the matrix. The matrix will provide relevant capability data for an easy and accurate evaluation of all suppliers. With over 1,000 suppliers, this matrix will help Clarience Technologies identify and optimize its supply base.

Our team will create this matrix by sending the survey that we create to all suppliers of Clarience, and using the gathered data the team and Clarience will be able to make educated decisions about the present and future of their supply base. There will be questions to determine general knowledge about the suppliers, and also tailored category questions based on the division of Clarience with which the supplier is working. On top of this, we will use our matrix to make our own recommendations about the supply base for a few specific categories of Clarience based on a category-unique weighting system that we create.

With the completion of this project, Clarience Technologies will have a supplier survey and capabilities matrix that will greatly reduce sourcing time for new parts. The supplier matrix will also serve as a long-term template for future supplier capabilities analysis.



### Michigan State University Team Members (left to right)

**Davis Dikker**  
Glen Ellyn, Illinois

**Andrew Hamel**  
Richmond, Michigan

**Steven McPeck**  
Brighton, Michigan

**Weston Youngblood**  
Charlotte, North Carolina

**Zachary Shafer**  
Shelby Township, Michigan

**Madison Zettler**  
Gladwin, Michigan

### Clarience Technologies Project Sponsors

**Kevin Krause**  
Southfield, Michigan

**Ben Lee**  
Southfield, Michigan

**David McKean**  
Southfield, Michigan

**Jeffery Parmerlee**  
Southfield, Michigan

**Alan Risko**  
Southfield, Michigan

### Teaching Assistant

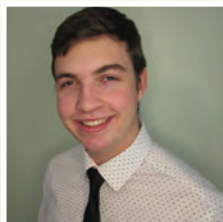
**Akash Mehorta**

# Consumers Energy Supplier Diversity Workstream and Vendor Analysis

In 2019, Consumers Energy committed to spending \$7.5 billion over a five-year period within Michigan-based businesses and doubling the allocated budget spent on diverse suppliers. This commitment led to Consumers Energy wanting to build a better connection with aspiring suppliers, which created a pathway for this project. Every company that applies to be a supplier at Consumers Energy must go through a bidding process and is referred to as an “aspiring supplier.” This means that they have finished their application but have yet to be offered a vendor contract. Consumers Energy identified a gap in this supplier journey and asked the team to come up with three or four implementable strategies to improve this supplier experience. More specifically, these solutions will help close the gap in this process and keep CE suppliers engaged before they’re offered a contract.

Our team began the project by conducting industry research on loyalty and membership programs. In order to gather data on expectations/desires, we conducted multiple Empathy Interviews with aspiring suppliers in the Consumers Energy database. These interviews allowed us to better understand the needs and wants of the aspiring suppliers without making assumptions. It also helped guide us as to what process improvements would be most effective. A Pareto chart was then used to organize and analyze the data so we could identify the most prevalent expectations and desires from the aspiring suppliers. A survey and second round of interviews were conducted with the same aspiring suppliers, in which our team presented the recommendations and gathered feedback on the ideas.

The team then finalized their strategies, and a process map was created. The implementation of these strategies will improve the process experience for aspiring suppliers and will allow Consumers Energy to reach their commitment of diversifying spend and working with Michigan-based businesses.



## Michigan State University Team Members (left to right)

**Montserrat Lewin Meija**  
Mexico City, Mexico

**Allana Huttenlocher Cunha**  
São Paulo, Brazil

**Nicole Harmsen**  
Hudsonville, Michigan

**Ayodeji Jubreel**  
Lagos, Nigeria

**Joseph Schultz**  
Lapeer, Michigan

## Consumers Energy Project Sponsors

**Jennifer Dreffs**  
Jackson, Michigan

**Lynn Wilson**  
Haslett, Michigan

## Teaching Assistant

**Akash Mehrotra**



# **Gerdau: Design an Order Management Process for Finishing Capacities**

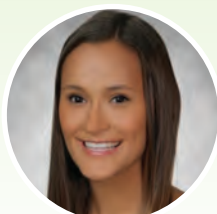
**G**erdau is one of the largest suppliers of steel in the world. Their core business is to transform steel scrap and iron ore into product. While promoting sustainable development, Gerdau converts millions of tons of automotive packaging and appliances scrap into new steel products to ship all around the world.

Currently, Gerdau's facility in Jackson, Michigan relies on paper tags and manual intervention to ensure the right material is loaded and shipped. This process often results in human error, reduces customer satisfaction, and can be costly. Due to human error, customers have received correct material with incorrect tags as well as incorrect material altogether. Gerdau's focus is on improving their shipping department by designing an order management process.

The order management process Gerdau is looking to implement will utilize Radio Frequency Identification (RFID) technologies. RFID technology ensures that a manufacturer can track exactly what products are leaving their facility and their status. Since RFID does not rely on manual intervention, this will help mitigate human error, improve efficiency, and increase customer satisfaction.

The goal of the project is to propose two possible solutions for implementing RFID within a specific department in Gerdau's Jackson facility. One solution will be a low capital investment that may not yield the most optimal results but will reduce the likelihood of a shipping mistake. The other solution will be an increased capital investment that will drastically reduce the likelihood of a shipping mistake occurring.

In order to propose the best solutions, it is vital to understand Gerdau's current tagging system, conduct extensive research, and contact potential suppliers of RFID tags and systems.



## **Michigan State University**

**Team Members** (left to right)

**Angelina Alexopoulos**  
Troy, Michigan

**Sophie Kanar**  
Redford, Michigan

**Amy Mingija Liu**  
Troy, Michigan

**Angelina Tisma**  
Arlington Heights, Illinois

## **Gerdau**

**Project Sponsor**

**Nicholas Schweickart**  
Jackson, Michigan

## **Teaching Assistant**

**Akash Mehrotra**

# Gerdaul

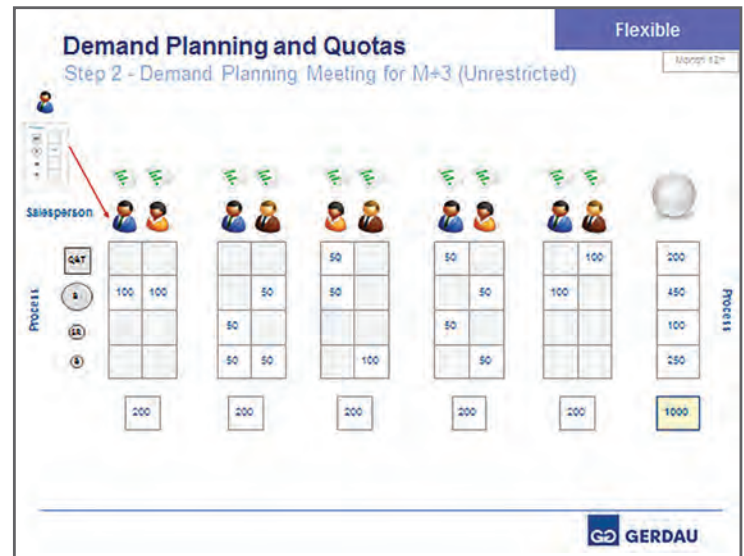
## Order Management Process | Data Analysis

Gerdaul is a steel manufacturing company offering a range of long steel and specialized steel products from mills across the United States. This project is supporting the Sales and Operation Planning division of the Supply Chain Management department within Gerdaul to improve upon the current process for order management. The current order management system is a manual Excel process consisting of multiple data sources that require manual extraction and cleansing. This project is focused on cleansing, organizing, and automating multiple data analysis processes to provide an improved system for order management.

Utilizing PowerBI, our team was able to automate the data extraction process for inventory levels, thus removing the manual data updating and cleansing processes. The consolidation of multiple data sources provides a more user-friendly streamline of information. This resulted in an 86% increase in efficiency, as well as the ability to better forecast customer demand.

To better assess inventory capacity and reduce overbookings, comparisons between past due finished goods and current bookings data were made to assure customers do not overbook on current orders when they have yet to retrieve their past due orders.

By formatting and consolidating data from numerous sources, we were able to develop a comparative analysis of long lead products at Gerdaul facilities. Utilizing this comparison, supply chain analysts can more clearly visualize the production levels and possible bottlenecks in various factories. It also functions as an effective tool to forecast increasingly accurate delivery estimates for customers.



### Michigan State University Team Members (left to right)

**Caleb Van Loon**  
Caledonia, Michigan

**Sydney Smith**  
South Lyon, Michigan

**Noah Krupiczewicz**  
Byron Center, Michigan

**Jonathan Pereira**  
Big Rapids, Michigan

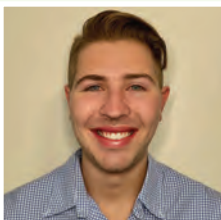
**Madison Skene**  
Lapeer, Michigan

### Gerdaul Project Sponsor

**Jordan Webber**  
Jackson, Michigan

### Teaching Assistant

**Sugandhi Sawhney-Cox**





# Hanson Logistics

## Cold Storage Facility Layout & Design

Hanson Logistics is an all-encompassing transportation, warehousing, and temperature-controlled distribution company headquartered in Saint Joseph, Michigan. With the demand of cold storage on the rise, more than 250 Hanson associates work across 8 locations to provide end-to-end supply chain solutions, making them one of the largest providers in the US. With a business model that deals with case pick operations on a daily basis, the focus for the project is to improve the process of consolidation of the outbound shipments in an effort to decrease unnecessary movement and save time.

The objective of this project is to collaborate with the Hanson team to reformat the layout and positioning of products within their Hobart, Indiana facility. In doing this we will be able to minimize the amount of distance forklift drivers travel throughout the facility, thus maximizing efficiency. Through analysis of facility layout and pick operation data, an improvement plan will be created, laying out the steps that need to be taken to implement the improved processes.

Specifically, we will identify the top 20 customers at the Hobart facility to assess where the fastest moving products are stored. From there, a new process plan will be implemented to reallocate products with higher inventory turnover to more optimal locations throughout the warehouse. This will allow products with high case pick frequency to be stored closer to the loading docks, leading to a drop in cumulative distance traveled for forklift drivers. In doing so, both energy and time will be saved, increasing performance and saving money.



### Michigan State University Team Members (left to right)

**Jack Connolly**  
Bloomfield Hills, Michigan

**James Ruotsala**  
Grand Rapids, Michigan

**Taylor Battaglia**  
Macomb, Michigan

**Brendan Bauer**  
West Bloomfield, Michigan

**Ryan Langwerowski**  
Brighton, Michigan

### Hanson Logistics Project Sponsors

**Jeff Andersen**  
Hobart, Indiana

**Mike Pethe**  
Hobart, Indiana

### Teaching Assistant

**Akash Mehrotra**

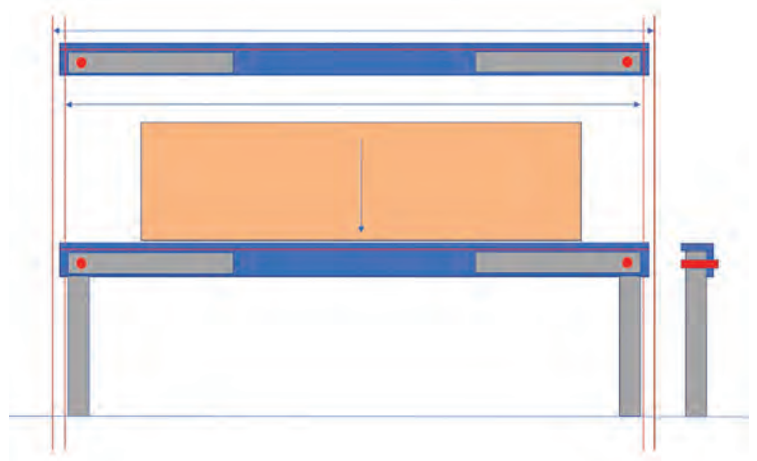
# John Deere Consolidated Warehouse Packaging Solution

John Deere has tasked our team with finding a solution regarding consolidating warehouse packaging. John Deere ships under two conditions: either weighing out the load, or cubing out the load of a shipping container. Our project is focused primarily on cubing out the load. Currently, this proves to be difficult as it increases costs the better the container is “cubed.” The company has explored various solutions such as wooden boxes, higher stacking, reusable packaging, and several more that have all proved to be either inefficient or expensive.

The goal of this project is to come up with a pressing packing issue at John Deere; that is, find a way to efficiently consolidate a sea container. Our team is tasked with building a shelf. This shelf must be able to maximize density of the shipping container while doing so cost effectively, ergonomically sound, as well as allowing flexibility for various shipping loads.

With the presentation of multiple prototypes and their respective cost analyses, the goal is to successfully pack the shipping container to reduce John Deere’s shipping costs and strive to meet their sustainability goals.

This project is focused only on shipping overseas with specific sized shipping containers, and primarily cardboard boxes, ultimately maxing out the weight at 40,000 pounds.



## Michigan State University Team Members (left to right)

**Anna Buko**  
Saginaw, Michigan

**Christina Buko**  
Saginaw, Michigan

**Natalie Courney**  
South Lyon, Michigan

**Jack Gillespie**  
Mount Pleasant, Michigan

**Jacob Murphy**  
Northville, Michigan

**Jacob Russell**  
Plymouth, Michigan

## John Deere Project Sponsor

**Philip Weshnevski**  
Buffalo, North Dakota

## Teaching Assistant

**Ishaan Anand**



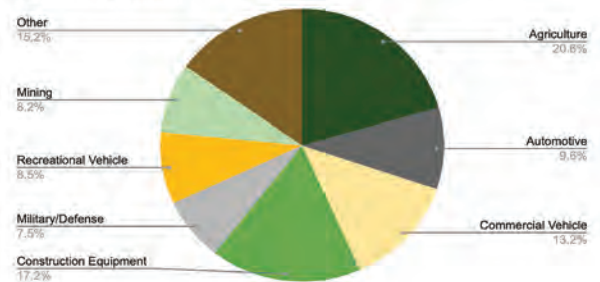
# John Deere Supplier Performance Predictability Tool

John Deere is an American corporation that manufactures construction equipment, diesel engines, agricultural machinery, axles, transmissions, and gearboxes that are used in heavy equipment and tools. This diverse supplier network combined with cyclical and seasonal business cycles has led John Deere to experience difficulties predicting supplier delinquency. The current system in place collects supplier performance and reliability data biannually. The infrequency in data collection causes supplier information to become out of date almost immediately. This creates a gap in the accuracy of the information, requiring John Deere to spend more time directly communicating with suppliers to meet business needs. Additionally, there is a need to relate current industry trends to John Deere's own supply base to produce a more lean and robust supply chain.

The Supplier Performance Predictability Tool uses specific metrics and equations to relate John Deere's internal supplier survey to external industry trends. These external data sources include the following industries: construction, raw materials, mining, commercial and recreational vehicles, automotive, military, and agriculture, as well as unemployment trends. This tool has in-depth pages for each industry respectively, and a home summary page that captures the most significant changes across the various industries. This home page will also flag suppliers most susceptible to risk, based on the current industry trends. Therefore, John Deere can take precautionary actions to mitigate risk across the supply chain.

The supplier predictability performance tool will provide John Deere with a centralized location to evaluate and act on supplier disruptions. Furthermore, the tool reduces dependence on direct supplier communication, which creates a more efficient process.

**John Deere Suppliers Involved in Other Industries**  
Suppliers share of industry



## **Michigan State University** *Team Members* (left to right)

**Nikhita Khare**  
Novi, Michigan

**Emma Lee**  
Grand Rapids, Michigan

**Anna Kolb**  
Grand Rapids, Michigan

**Caleb Randall**  
DeWitt, Michigan

**Shannon Torpey**  
Holly, Michigan

**Austin Smith**  
DeWitt, Michigan

## **John Deere** *Project Sponsors*

**Mark Ripple**  
Moline, Illinois

**Nathan Stoflet**  
Moline, Illinois

## **Teaching Assistant**

**Ishaan Anand**

# KLA: Michigan and Midwest Region Supply Chain Opportunities

Headquartered in Milpitas, California, KLA is a multinational company that was formed in 1997 and has around 10,500 employees and 19 global locations. KLA specializes in the semiconductor and yield management industry and strives to build innovation through factors such as communication and culture. KLA is new to the Midwest, having recently opened a site in Ann Arbor, and are looking to expand their footprint in the area. KLA is requesting three suppliers for multiple commodities including high precision machining, sheet metal, bales/harnesses, PCBAs, and contract manufacturing. Our team is responsible for researching and evaluating suppliers in the Michigan/Midwest region to present best-in-class vendors to KLA. The goal is to increase the company's presence in the local community through the creation of jobs and increased spend in the region, reduce lead times and cost, and improve quality.

KLA's business model consists of high mix, low volume products. The products they make are very specific and unique, so their suppliers must be able to accommodate with specialized components. The suppliers must also meet manufacturing KPI expectations regarding time to market, reliability, improved quality, reduced cost, and delivery performance. The suppliers will be asked to provide valid data and metrics regarding each KPI. Each potential supplier will also have to meet KLA's supply chain sustainability program requirements, supply chain human rights policy, supply chain product compliance requirement, and supplier diversity guidelines to be considered.

The overall goal of this project is to create long-term supplier relationships with Michigan/Midwest suppliers. The team will formulate a standardized scorecard that will evaluate multiple suppliers at once. At the end of the semester our findings will be presented to KLA, and from there they will choose their preferred supplier(s).



## Michigan State University

**Team Members** (left to right)

**George Panoutsos**  
Chicago, Illinois

**Kate Irwin**  
Bloomfield Hills, Michigan

**Tucker Haerle**  
Sutton, Massachusetts

**Shanna Chupick**  
Macomb, Michigan

**Adam Sellers**  
Birmingham, Michigan

**Ryan Yarberry**  
Birmingham, Michigan

## KLA

**Project Sponsors**

**Jairo Gutierrez**  
Ann Arbor, Michigan

**John Kalvelage**  
Ann Arbor, Michigan

## Teaching Assistant

**Akash Mehrotra**



# L3Harris – Combat Propulsion Systems Transmission Ball Piston Supply System Design

L3Harris is an innovative defense contractor and information technology service provider that strives for the best solutions and even better results. L3Harris meets needs across air, land, sea, space, and cyber domains – while holding onto the core values of integrity, excellence, and respect.

L3Harris builds transmissions for combat vehicles. Inside the transmissions for U.S. tanks and other fighting vehicles, a very high degree of precision is needed to fit the piston balls into the cylinder blocks. With such little room for failure and a crucial customer base, this is an issue that needs a solution. As an example of how tight tolerances can be, a 1-degree shift in temperature may prevent the product from being assembled correctly.

With the high precision that is needed, this is the core problem that the team is trying to solve. L3Harris needs a way to get the suppliers' process yields to match what they require day by day. The current ordering process relies on weekly meetings with supply chain and manufacturing to order products on a weekly basis. Currently, they also don't have a way to determine the exact products they are using, which results in instability and excess inventory.

The team's goal for the project is to design a production system that will streamline operations by creating a more efficient system for ordering, fulfillment, and managing inventories for a product that requires very high precision. Our team needs to figure out how to reduce waste, eliminate excess inventory, and free up working capital. Within this project, costs for both the supplier and the buyer should be minimized.



**L3HARRIS™**  
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## Michigan State University Team Members (left to right)

**Nic Underwood**  
Bellaire, Michigan

**Alek Grishaj**  
Shelby Township, Michigan

**Matt Sinelli**  
Dexter, Michigan

**Mary Graves**  
McGregor, Texas

**Risa Wethington**  
Yokosuka, Japan

## L3 Harris Project Sponsors

**Chase Kloka**  
Muskegon, Michigan

**Thomas Traska**  
Muskegon, Michigan

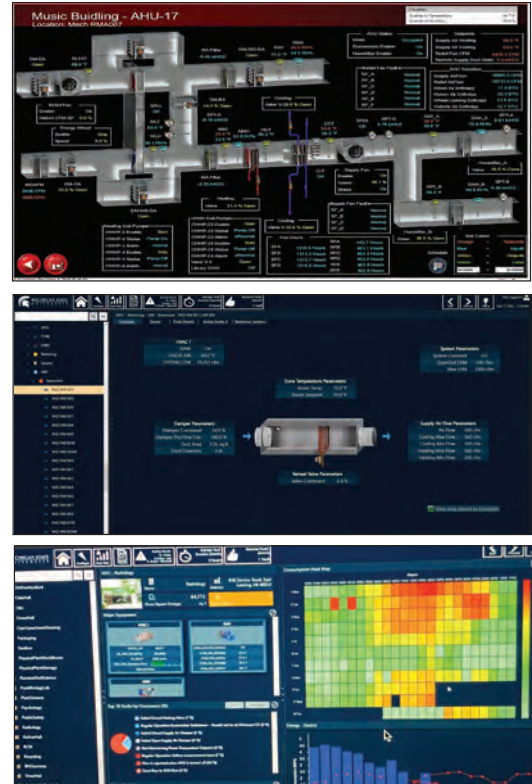
## Teaching Assistant

**Shraoni Rangnekar**

# MSU Infrastructure Planning and Facilities Energy Efficiency and Operations Dashboard

Michigan State University's Infrastructure Planning and Facilities Department covers all of the things that keep MSU running smoothly and efficiently. The Building Performance Department oversees all of the buildings on campus and monitors how they are running and where there are problems, if any. Currently there are approximately 150 main campus buildings that are being monitored with direct controls, 25% of which have control and monitoring at the room level. The IPF Building Performance Services Central Control team is currently preparing to implement an Automatic Fault Detection and Diagnostics (AFDD) system, using a platform known as ICONICS. Operational data monitoring, virtual metering, automated fault rule development and utility data visualization development are underway. However, the creation of an all-encompassing dashboard is an area that needs improvement.

This project is aimed at developing a campus-wide dashboard for the purpose of displaying energy efficiency and operations. The final dashboard will ideally have the ability to identify where reductions can be made in overall energy usage by the heating, ventilation, and air conditioning (HVAC) systems in buildings. The dashboard will also include new ideas proposed to improve quality of life for people on campus. It was decided, based on sponsor suggestions, to highlight a few particularly insightful buildings on campus on the dashboard, which could in the future be rolled out for all buildings campus-wide. The chosen spotlight buildings encompass the many types of rooms that MSU has to offer including classrooms, lecture halls, labs, student dorms, dining halls, and study areas, as well as sports arenas. This dashboard is intended to highlight past sustainability efforts, as well as ideas for potential new efforts through improved facility operational efficiency. Various dashboard models will be proposed for consideration by the various stakeholders across MSU (students, faculty, Administration, IPF, RHS, etc.).



## INFRASTRUCTURE PLANNING AND FACILITIES



### Michigan State University Team Members (left to right)

**Michaela Glass**  
Bad Axe, Michigan

**Lexi McFall**  
Milford, Michigan

**Kate Wesche**  
Saline, Michigan

**Sydney Carmack**  
South Lyon, Michigan

**Josh Elias**  
West Bloomfield, Michigan

### MSU Infrastructure and Planning Facilities Project Sponsors

**Yuanji Li**  
East Lansing, Michigan

**Jared Parker**  
East Lansing, Michigan

**Jason Vallance**  
East Lansing, Michigan

### Teaching Assistant

**Sugandhi Sawhney-Cox**



# MSU Infrastructure Planning and Facilities: Preventative Maintenance Program on Airflow Measuring Stations

**M**SU Infrastructure and Planning Facilities (IPF) oversees the maintenance of all buildings across Michigan State University's campus. One of MSU IPF's responsibilities is to monitor the airflow measuring stations (AFMS) in over 700 heating, ventilation, and air conditioning (HVAC) systems across campus. These systems can become uncalibrated over time, however routine maintenance of airflow measuring stations is costly and time-consuming, especially when it is unnecessary.

The overall goal of the project is to determine the most cost-effective methodology for maintaining devices that control the correct amount of airflow for each facility across campus. The proposed methodology would reduce overall costs of the HVAC systems by allowing them to operate as efficiently and sustainably as possible. It would also decrease the need for maintenance by transitioning from a time-based maintenance approach, suggested by the AFMS manufacturers, to a demand-based maintenance approach by utilizing fault detection and diagnostic technologies. These changes would provide value by lowering the energy consumption of the HVAC systems, ensuring healthy indoor air quality, and maintaining a more accurate system operation.

The final deliverable of the project is a proposed business case presented to IPF with cost and efficiency comparisons between new AFMS options, recommendations on how to better control pressurization, as well as methods for leveraging fault detection and diagnostics technology to ensure calibration of the AFMS devices.



**INFRASTRUCTURE PLANNING  
AND FACILITIES**



## **Michigan State University Team Members** (left to right)

**Grace Deerwester**  
Massillon, Ohio

**Justin Kainz**  
Canton, Michigan

**Alexandra Kocovski**  
Rochester, Michigan

**Qiancheng Wang**  
Wuhan, China

## **MSU Infrastructure and Planning Facilities Project Sponsor**

**Jason Vallance**  
East Lansing, Michigan

## **Teaching Assistant**

**Akash Mehrotra**

# NASA Psyche Mission NASA Creativity Competitions

The NASA Psyche Mission is scheduled to launch in late summer 2022. Since the appearance of the 16 Psyche asteroid remains unknown, NASA is looking to host a competition to give the public an opportunity to imagine and share their interpretations of what the asteroid will look like. Our team has been tasked with conducting research and analysis on previous NASA creative competitions to make recommendations about how the Psyche mission can develop a similar competition that will reach a wide audience and increase public awareness. To make the best recommendations, we will compare the procedures, rules, promotional efforts, and the outcomes of various past competitions. Identifying methods that have been most effective in the past will allow us to deliver the best suggestions for the Psyche Mission competition.

This project grants our team the opportunity to inspire people about the possibilities of space exploration and science. There is also the prospect of generating awareness and interest in the NASA Psyche Mission. Through the completion of this project, the team aims to get the public's input on what they believe the Psyche asteroid looks like and simultaneously engage students to push their creativity and learn more about space exploration.



## Michigan State University

**Team Members** (left to right)

**Louis Rolland**  
Rochester Hills, Michigan

**Adam Dion**  
Northville, Michigan

**Alec White**  
Macomb, Michigan

**Jorge Dominguez Rodriguez**  
Clarkston, Michigan

**Kaushik Kothakonda**  
Canton, Michigan

## NASA

**Project Sponsor**

**Cassie Bowman**  
Tempe, Arizona

## Teaching Assistant

**Ishaan Anand**



# NASA Psyche: Mission to a Metal World

## Launch Lead-Up Analysis

The NASA Psyche mission is a unique space endeavor to a metallic asteroid between Mars and Jupiter known as 16 Psyche. For the first time, NASA will explore a world made largely of metal rather than rock or ice. Psyche could possibly reveal how the Earth's core and the cores of other terrestrial planets were formed. Psyche is the only known place in our solar system where we can directly examine what may be remnant core material from an early planet. The goal of the Psyche mission is to understand previously uncharted territory: early planetary formation. NASA plans to launch the robotic Psyche orbiter in August 2022. The orbiter would travel to Psyche, arriving in early 2026, where it would then orbit for a primary mission of almost two years, collecting data.

The Psyche mission is led by Arizona State University and 15 additional partners. For the past five years, university students from all over the United States have taken part in capstone projects relating to the Psyche mission. Each capstone team plays a unique part in the overall mission of Psyche. Our team will contribute to this project by delivering the NASA Psyche mission a comprehensive list of marketing strategies validated through a research-backed criteria system. By conducting market research of specified cohorts of the target audience, the general public, this validation system for assessing marketing strategies and potential efficacy will assist the Psyche teams and future space endeavors in appraising future launch lead-up and coverage engagement campaigns.

The proposed ideas should encompass the mission Principal Investigator's statement: "Inspire people to be bolder." The engagement activities and strategies should seek to encourage individuals to be bolder in their own lives, much like the heart of the Psyche mission itself, a bold and innovative space endeavor.



### Michigan State University Team Members (left to right)

**Anna Mae Crowley**  
Northville, Michigan

**Julie Walczak**  
Novi, Michigan

**Morgan Tasch**  
Oxford, Michigan

**Xi Chen**  
Shanghai, China

**Victoria Lanktonn**  
Lansing, Michigan

### NASA Psyche Mission Project Sponsor

**Cassie Bowman**  
Tempe, Arizona

### Teaching Assistant

**Shraoni Rangnekar**

# Parker Hannifin

## The Indirect Course

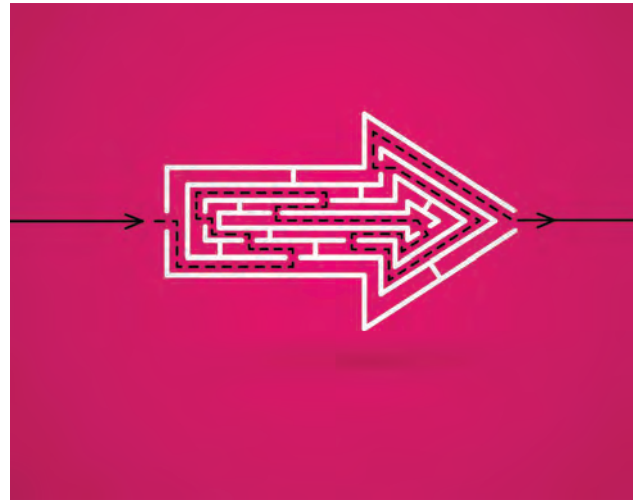
Parker Hannifin, founded in 1917, started as a control system company for automobiles and newly invented aircrafts, but has since transformed into a world leader in not only the manufacturing of motion and control technologies and systems, but also in providing precision-engineered solutions for a wide variety of mobile, industrial, and aerospace markets. Recently, Parker Hannifin celebrated its 100th anniversary and is looking towards the next century in every way! Highlighting this with the saying “Engineering your success,” supporting its promise to customers to increase their productivity and profitability.

However, along with the continued rise in success of the company, the cost of indirect materials has also risen to staggering levels. Parker Hannifin recently started utilizing a business-2-business sourcing tool called Ariba that presents multiple purchasing options when procuring these indirect materials. Our team has been tasked to develop or improve a new or existing way to calculate these indirect savings that Ariba finds.

The project is focused on the evaluation of Ariba’s capacity to determine savings, develop methodologies to determine savings gained through the use of Ariba vs using open sourcing from various distributors, and providing calculated savings sheets to justify the use and operations of Ariba.

In other words, our team is going to provide a system that will accurately determine if Parker Hannifin is saving money on indirect materials through Ariba.

The project will be completed by designing and implementing a scheme that will compare the past purchase history of the company, through Ariba, against the current market prices that can be found through multiple different distributors, resulting in a calculated savings sheet. Through the implementation of this system, key variances between indirect spending and potential cost savings will be better identified and will result in a better way to track, report, and hopefully further reduce spending.



### Michigan State University Team Members (left to right)

**Christian Garza**  
La Grange Park, Illinois

**Qingqing Sun**  
Jiangsu, China

**Seth Rozin**  
Saginaw, Michigan

**Nick Barrientes**  
Ann Arbor, Michigan

**Zixuan Huang**  
Wenzhou, China

**Liam Ryan**  
Plymouth, Michigan

### Parker Hannifin Project Sponsor

**Mark Anzelc**  
Cleveland, Ohio

### Teaching Assistant

**Ishaan Anand**

# Smith+Nephew

## Replenishment Optimization Initiative

Established in 1856 in England, Smith+Nephew has been designing and producing medical equipment for hospitals for 165 years. Smith+Nephew is a publicly traded company that is a well-respected leader in their industry. Their products are categorized into three larger franchises: Advanced Wound Management, Orthopedics & Trauma, and Sports Medicine. They produce an innovative range of products, such as their Hip and Knee Implants from Orthopedics, used in replacement and trauma surgeries. Smith+Nephew operates and ships products to every continent except Antarctica. Their goal is to restore people's bodies and their self-belief by removing limits to living.

Our team was tasked to develop a more efficient replenishment system that optimizes the current Smith+Nephew replenishment process. We focused on optimizing the replenishment of certain orthopedic products, such as hip or knee implants, within a given district. Being focused on certain products in a certain district will allow us to produce a fully vetted replenishment optimization solution that can be adopted into supply chains of their other products and districts. The ultimate goal of the initiative is to produce various cost reductions by reducing on-hand inventory. The reduction in on-hand inventory will generate a higher inventory turnover for Smith+Nephew, which will allow them to reach their goal of a more optimized supply chain. This process will be the model for a more efficient process and will have a positive impact across the entire Smith+Nephew's supply chain.



# Smith+Nephew



### **Michigan State University** *Team Members* (left to right)

**Varoun Bajaj**  
New Delhi, India

**Aaron Gooyandeh**  
Lafayette, California

**Megan Greer**  
Midland, Michigan

**Grant Peters**  
Saline, Michigan

**Emily Schutt**  
Grosse Ile, Michigan

**Aaron Szczepanski**  
Naperville, Illinois

### **Smith+Nephew** *Project Sponsors*

**Madison Binsfeld**  
Memphis, Tennessee

**Zach Vanderweide**  
Memphis, Tennessee

### **Teaching Assistant**

**Sugandhi Sawhney-Cox**



# Smithfield Foods

## Automated Trailer Loading Savings Potential

Smithfield Foods is a pork producer and food-processing company located in Smithfield, Virginia. Since being founded in 1936, Smithfield has grown to become the world's largest pork processor in the world, the largest hog producer in the United States, and a leader in several packaged meats categories.

Smithfield's long-term deliverable is enhanced customer service at the reduction of direct labor. Smithfield aims to achieve this by reducing both trailer load times and damaged goods, together with an increase in customer order accuracy. Along with this, through the use of automated machinery, direct labor is reduced.

Smithfield's current trailer loading process takes about an hour. Because of this slow process, Smithfield has searched for and identified a piece of machinery, the Ancra Skateloader (shown at the right), that would load trailers in under 10 minutes, resulting in potential time savings of nearly 40-50 minutes. Similar to a conveyor belt, the machine would gently place a trailer's worth of pallets down at once.

Smithfield has tasked our team with the proposal of implementing this automated loading machine into their distribution facility. Our team's responsibility is to research and analyze whether the equipment aligns with Smithfield's current goals, future goals, and their long-term customer service deliverable. With the identification of the automated machinery, our team must conduct a cost-benefit analysis weighing direct labor wages against the purchase, installation, and general maintenance cost of the Skateloader. The cost-benefit analysis will determine whether or not the machinery eliminates the cost of enough labor. Along with this, our team must decide whether or not the implementation of the Skateloader accomplishes the quantitative goals within order accuracy, trailer turn times, and the percentage of damaged goods that the sponsor is striving to achieve.

With the implementation of the machinery, our team must also account for the rework of the process flow map and outbound dock layout.



### Michigan State University *Team Members* (left to right)

**Charlie Wade**  
Grand Rapids, Michigan

**Luke Evangelista**  
South Lyon, Michigan

**Munzer Elsir**  
Khartoum, Sudan

**Abbey Rhodes**  
Grand Blanc, Michigan

**Austin Tanner**  
Whitmore Lake, Michigan

### Smithfield Foods *Project Sponsors*

**Jordan Lashmett**  
Smithfield, Virginia

**Jim Younce**  
North East, Maryland

### Teaching Assistant

**Ishaan Anand**

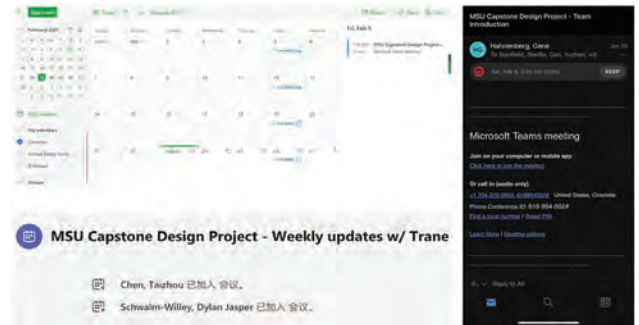
# Trane Technologies Indoor Air Quality Category Approach

Trane Technologies is a company that focuses on solving sustainability challenges through innovation in the heating and cooling industry. Trane Technologies develops commercial HVAC systems, residential HVAC, and transportation refrigeration systems. Serving many different industries including the hospitality industry, the Federal Government, commercial real estate, data centers, healthcare, restaurants, and education, Trane Technologies has a great opportunity to provide customers with needed value through environmentally responsible products and services.

Before COVID-19 interrupted normal business processes, HVAC companies had focused a great deal on energy efficiency and comfort with respect to the systems they developed. With the emergence of the virus, a shift in focus towards indoor air quality (IAQ) has emerged. This great shift in demand and mix of IAQ solutions has forced Trane Technologies as well as competitors in the industry to make rapid adjustments.

In order to assist Trane Technologies in their goal to provide customers with much needed solutions to solve IAQ challenges, our team was assigned a project to propose an overall category approach for IAQ products. The goal of the category approach is to provide Trane Technologies with insights on how to optimally source IAQ products in order to leverage global spend and meet business objectives and innovation.

This project required a great deal of research in terms of understanding the current spend of the company in relation to IAQ products. It also took an understanding of the company's supply market for IAQ products. Putting together all of the insights gained from data, conversations with internal members of Trane Technologies, as well as conversations with external suppliers, has allowed us to develop an overall category approach and provide external insights to Trane Technologies on how to optimally source and manage IAQ products.



## Michigan State University Team Members (left to right)

**Zijiao Xu**  
Zhengzhou, China

**Eric Hedman**  
Commerce Township, Michigan

**Shellbi Stanfield**  
Detroit, Michigan

**Taizhou Chen**  
Shanghai, China

**Sophie Guo**  
Shanxi, China

**Dylan Schwalm-Willey**  
Traverse City, Michigan  
(Not pictured)

## Trane Technologies Project Sponsors

**Wayne Gerbrandt**  
Clarksville, Tennessee

**Nick Gerrits**  
Charlotte, North Carolina

**Gene Hahnenberg**  
Davidson, North Carolina

**Mark Ramsingh**  
Macon, Georgia

## Teaching Assistant

**Sugandhi Sawhney-Cox**

# AESC Awards 2020

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## **The AESC 2020 Most Impactful Award:**

MSU Resource Center for Persons  
with Disabilities  
“Gotcha – Electric Scooter Revolution”

Left to right: Nate Olson, Bailee Droste, (Mike Hudson),  
Mamdhur Muridi, Sophia Venticinque, AJ Shaw  
Presented by: Mike Hudson

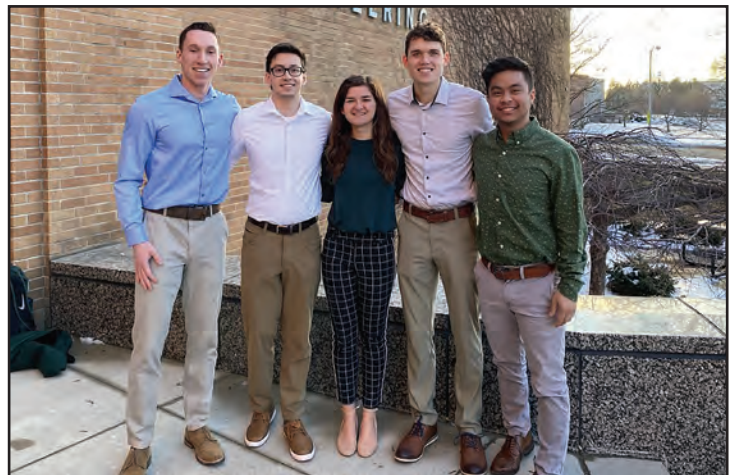


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## **The AESC 2020 Most Sustainable Award:**

Team Ingersoll Rand  
“Long-Term Strategy for  
Sustainability in Logistics”

Left to right: Adam Rowlands, Phillip Conrad, Erin Bahm,  
Winter Romeyn, Joshua Gonzalez





# AESC Awards 2020



**As punter for Michigan State University's football team, Mike Sadler was well known**

**for giving his team a competitive edge by flipping the field with perfect punts that pinned the opponents back near their own end zone.**

In addition to being well known as an outstanding punter, Mike was also well known for being an outstanding scholar, exemplifying what it means to be a true student-athlete.

Mike was the first football player in Spartan history to earn Academic

All-America honors four times. He was a two-time first-team Academic All-American, a National Football Foundation Scholar-Athlete, and a William V. Campbell trophy finalist.

Mike completed an undergraduate degree in Applied Engineering Sciences in just three years and then went on to earn a master's degree in Public Policy. After graduating from MSU in 2015, he was excited to begin Stanford Law School.

The Mike Sadler Competitive Edge Award is presented annually to the Applied Engineering Sciences capstone team that strives to achieve the highest possible outcome in order to attain the next level of success. The winning project

is considered to have "flipped the field" with an innovative and creative solution that results in a competitive edge that not only solves the problem but distances itself from the competition.

"I am very proud to call myself an Applied Engineering Sciences alumnus. The program has fostered within me maturity, discipline, leadership, and a worldly sense of systems thinking."

- Mike Sadler



**AESC 2020 Mike Sadler Competitive Edge Award:**

Team BP

"Effective Usage of Producer Price Indexation Analysis"

Left to right: Mikey Geiger, Nick Hughes, Julia Rios, Louis Wyre, Tre Lee



**Dr. Dana Kirk, PE**  
**Asst. Professor**  
**Biosystems &**  
**Agricultural Engineering**



**Dr. Luke Reese**  
**Assoc. Professor**  
**Biosystems &**  
**Agricultural Engineering**

## About the Program

Graduates of the MSU Biosystems Engineering (BE) Undergraduate Program are expected to succeed in diverse careers where they integrate and apply principles of engineering and biology to a wide variety of globally important problems. MSU Biosystems Engineering graduates are expected to attain that success by:

- identifying and solving problems at the interface of biology and engineering, using modern engineering techniques and the systems approach;
- analyzing, designing, and controlling components, systems, and processes that involve critical biological components; and
- demonstrating vision, adaptability, creativity, a practical mindset, effective communication skills for technical and non-technical audiences, the ability to work in diverse, cross-disciplinary teams, and a commitment to sustainability, continuing professional growth, and ethical conduct.

## BE 485 / BE 487 Courses

Biosystems Engineering student teams, enrolled in the two-semester biosystems design capstone experience, BE 485/487, develop, evaluate, and select design alternatives in order to solve real-world problems. Projects are diverse, but each reflects systems thinking by integrating interconnected issues affecting the problem, including critical biological constraints. The engineering design process is documented in a detailed technical report. Teams present project designs to engineering faculty and a review panel of professional engineers for evaluation. Each BE 485/487 capstone design team prepares and presents a design solution in report, poster, and oral formats to industry, faculty, peers, and the public that:

- Requires engineering design
- Combines biology and engineering
- Solves a real problem
- Uses a holistic approach
- Interprets data
- Evaluates economic feasibility

## 2020/21 Projects

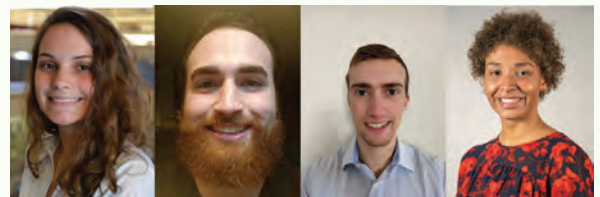
### Reduction of Anaerobic Conditions in an Industrial Wastewater Pumping Station

Team Name - Team Abbott Labs

Sponsor - Abbott Labs (project under Non-Disclosure Agreement)

Faculty Advisor - Dr. Steve Safferman, PE

Abbott Nutrition's facility in Sturgis, Michigan pretreats industrial wastewater before discharging to the local municipal treatment plant. The pumping station for Abbott's pretreatment plant has experienced anaerobic conditions, which lead to hydrogen sulfide production, resulting in additional costs associated with pH neutralization. Team Abbott Labs evaluated multiple opportunities to improve the system, including adding baffles to the wet well, modifying or replacing the outlet pumps, and using a reverse osmosis system to treat boiler feedwater. The team recommended adding baffles and pump extensions and installing a reverse osmosis system. The payback periods of these designs are under two years.



(L to R) Raina Gregg, Nathan Lorence, Joe Riordan, & Iana Wolff

### Design of a Small-Scale Food Waste Anaerobic Digester

Team Name - Team FireKeepers  
Sponsor - FireKeepers Casino Hotel  
Faculty Advisor - Dr. Yan “Susie” Liu

FireKeepers Casino Hotel in Battle Creek, Michigan wants to implement a small-scale anaerobic digester for their pre- and post-consumer food waste. The primary goal is to divert food waste away from landfill to beneficial reuse as feedstock for anaerobic digestion to generate energy and electricity. The team began by analyzing food samples from FireKeepers in order to size the digester. Then they developed a basic process flow diagram, approximated land requirements, and performed an economic analysis of the capital and operational costs, and maintenance costs and benefits.

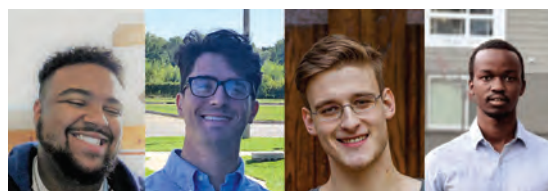


(L to R) Gus Aburto Vazquez, Emma Dester, Brandon Driscoll, & Drew Smith

### Production of Methane via Carbon Dioxide

Team Name - Team Methanation  
Sponsor - Consumers Energy (project under Non-Disclosure Agreement)  
Faculty Advisor - Dr. Dana Kirk, PE

Due to the intermittent nature of renewable energy generation, a storage method for excess energy is necessary to balance supply and demand timing issues. Methanation provides a way to store excess energy as carbon-neutral gas. Methanation combines the use of waste carbon dioxide with hydrogen gas to form methane. Hydrogen gas is obtained from an alkaline electrolysis process and is powered with the energy generated from renewable energy. With the combination of these technologies, it is possible to store renewable energy.



(L to R) Anthonee Caston, Nate Ciaravino, Daniel Kagerer, & Raymond Lesiyon

### Designing a System to Create Renewable Natural Gas from the South Campus Anaerobic Digester

Team Name - Team CMS – RNG  
Sponsor - Consumers Energy (project under Non-Disclosure Agreement)  
Faculty Advisor - Dr. Dana Kirk, PE

The team worked with Consumers Energy (CMS) to design a refinement facility utilizing the biogas produced from MSU's South Campus Anaerobic Digester to produce renewable natural gas (RNG). This project aids the client in achieving net zero carbon emissions and meeting 90% of Michigan's energy needs with clean resources by 2040. The design utilizes membrane permeation to bring biogas with a methane content of 65% to 97%. Following refinement, the RNG will be injected into CMS' existing natural gas pipelines.

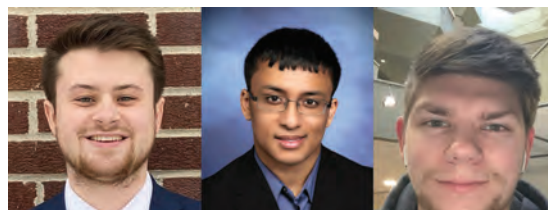


(L to R) Noah Carlson, Scott McCallum, Lindsey Moran, & Vincent Nguyen

### Weyerhaeuser Thermal Oil Filtration

Team Name - Weyerhaeuser Thermal Oil Team  
Sponsor - Weyerhaeuser (project under Non-Disclosure Agreement)  
Faculty Advisor - Dr. Ajit Srivastava, PE

Weyerhaeuser is a timberland company located in Grayling, Michigan. They use thermal oil to heat resins for their oriented strand board (OSB). Repeated bearing failure in the thermal oil pumps has required Weyerhaeuser to incur significant costs for bearing replacements. This reoccurring issue has caused our team to evaluate Weyerhaeuser's oil quality, leading to a proposed solution of a kidney loop filtration unit to be attached to the system's reservoir.



(L to R) Deryk Atkins, Andrew Joseph, & Brandon Lippert  
(not pictured, Mackenzie Cook)



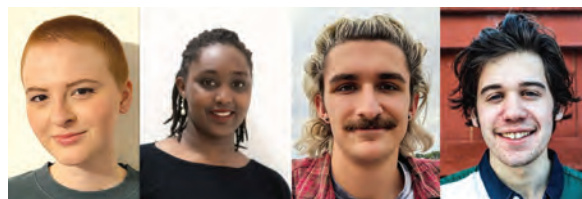
## **Feasibility Study of Utilizing Hog Fuel for Onsite Heat Production**

Team Name - The Woody Wonders

Sponsor - Weyerhaeuser (project under Non-Disclosure Agreement)

Faculty Advisor - Dr. Dawn Reinhold

Weyerhaeuser is a multinational lumber company that manufactures oriented strand board (OSB) at their mill in Grayling, Michigan. The mill produces a large amount of hog fuel, a waste stream comprised mostly of chipped wet bark, as a byproduct. The Woody Wonders have been tasked with determining a suitable outlet for the hog fuel that is economically viable and environmentally friendly. After evaluating several biomass combustion technologies and offsite mulching opportunities, the team chose to implement an on-site fluidized bed boiler that burns the hog fuel for heating Weyerhaeuser's thermal oil. This boiler was evaluated for feasibility.



(L to R) Meg Curtin, Miriam Kaburu, Kiran Lantrip & Liam Parlmer

## **Portable Electrocoagulation Unit for Wastewater Treatment on Remote Army Bases**

Team Name - Team Clean Drinking

Sponsor - Department of Defense

Faculty Advisor - Dr. Wei Liao, PE

The Department of Defense (DOD) wants to employ a small-scale wastewater treatment system on remote U.S. Army bases. Team Clean Drinking designed an electrocoagulation unit, which is the initial step in wastewater treatment. This unit proceeds the ultrafiltration advanced membranes treatment to convert wastewater into water that meets the EPA treated wastewater discharging standard. The system needs to be portable within a skid and serve up to 150 soldiers. The system was designed to be set up quickly and operate in a wide range of climates with minimal labor.



(L to R) Armani Altomonte, Rachel Shapin, Mary Squire, & Elaina White

## **Lifecycle Assessment of PET with Multiple End-of-Life Scenarios for BIGGBY® COFFEE**

Team Name - Just Brew It

Sponsor - BIGGBY® COFFEE (project under Non-Disclosure Agreement)

Faculty Advisor - Dr. Chris Saffron

The team worked with BIGGBY® COFFEE, a coffee company headquartered East Lansing, Michigan with franchises across the Midwest. Team Just Brew It worked to determine the ecological footprint of BIGGBY®'s cold cups composed of the plastic polyethylene terephthalate (PET), which will aid the company's sustainability efforts. A lifecycle assessment was performed on four different end-of-life alternatives, including landfilling, physical recycling, chemical recycling, and combustion, to quantify the company's ecological impact and determine the optimal disposal method.



(L to R) Akash Divecha, Chelsea Keane, Sophie Nowak, & Ethan Tobiczky

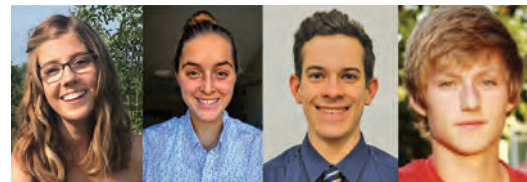
## **Cleaning Koppert's Bee Bottles to Recycling Requirements**

Team Name - Bee-duce, Bee-use, Bee-cycle

Sponsor - Koppert Biological Systems, Inc.

Faculty Advisors - Dr. Dan Guyer & Mr. Phil Hill

Koppert, located in Howell, Michigan, raises bumblebees for commercial-scale pollination and is looking to reduce their environmental footprint. Koppert feeds their bees a sugar solution from high density polyethylene (HDPE) bottles. Due to the sticky nature of the sugar and bee residues, the bottles are not meeting the requirements of the local recycler. Through research and experimentation, a pressurized water system was developed. Based on experimentation, the process cleans 97% of the bottles with a single pass. After installation and final adjustments, 100% of Koppert's bottles will be clean enough for recycling.



(L to R) Emily Dettloff, Aleah Hahn, Kieron Moller, & Eli Toliver

### Shelf-Life Extension of Sweet Cider to Achieve Clean Label Status

Team Name - Blake's Cider Fighters

Sponsor - Blake's Hard Cider

Faculty Advisor - Dr. Ilce Medina Meza

Blake's Hard Cider tasked Blake's Cider Fighters with modifying the production of their sweet cider to extend the shelf life from 28 days to 45 days. To achieve a clean label, design solutions were constrained to meet natural label standards. The team considered diverse options for meeting Blake's Hard Cider's needs. The final project design included sourcing, preliminary implementation, and an economic analysis. This shelf-life extension allows the company to expand its supply chain and provide sweet cider to a wider array of customers.



(L to R) Alex Kravaritis, Brandon Laird, Kelsey Pabin, & Katie Simon

### Industrial Compressed Air Optimization and Automation to Achieve Energy Reduction

Team Name - Team Perrigo

Sponsor - Perrigo (project under Non-Disclosure Agreement)

Faculty Advisor - Dr. Pouyan Nejadhashemi

Perrigo is an over-the-counter pharmaceutical manufacturing company based in Allegan, Michigan. Each of Perrigo's manufacturing plants uses compressed air for automation, quality control, and bottle orientation purposes. Compressed air can be inefficient because of its poor energy conversion, leakage, and continuous run time. Team Perrigo analyzed compressed air use in air knives for one production line at the Allegan facility. The team identified visible compressed air waste, collected data on compressed air usage, and developed system autonomy to reduce air consumption when the line was not operating. Future system autonomy suggestions were provided to enable further savings.



(L to R) Neil Kauffman, Brianna Lemmink, Matthew Smith, & Cooper Van Maele

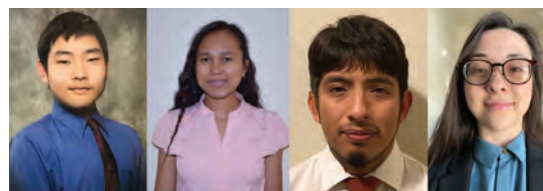
### Improvement of a Potato Storage Ventilation System Using Modified Air Cup Design

Team Name - Team Techmark

Sponsor - Techmark, Inc.

Faculty Advisor - Dr. Wei Liao, PE

Techmark, Inc. is a multi-industry agricultural corporation based in Lansing, Michigan that specializes in root crop storage. Techmark, Inc. designs conditioned air handling systems at a specified velocity through a piled potato storage facility. Improper ventilation contributes to pressure bruising causing product (food waste) and revenue loss. The hypothetical cause is shearing forces at sharp-edged orifices at air cup inlets. The team performed a computational fluid dynamics (CFD) analysis of a single air duct with 28 air cups using 4 design alternatives. Design alternatives to the air cup inlet that increased air velocity and prevented pressure bruising were analyzed.



(L to R) Quinn Marchie, Narindra Randriamiarintsoa, Walter Will, & Sarah Yee

# Industry Advisory Board & Project Evaluators

The purpose of the Industry Advisory Board is to facilitate the exchange of ideas between Board members, faculty, and students of the BE program. Its function is to improve continuously the BE program quality by keeping it current and relevant to industry needs. Regular and adjunct board members also serve as external project evaluators.

## Board

Ms. Janelle Boosi - Kellogg  
 Ms. Holly Bowers (Chair) - Consumers Energy  
 Ms. Jessica Bruin - Nestlé Nutrition  
 Ms. Lisa Buchholz - Corteva Agriscience  
 Mr. Matt Burt - AbbVie  
 Ms. Shelley Crawford - Jiffy  
 Ms. Michelle F. Crook, PE - MDNR  
 Ms. Laura Doud, PE - MDARD  
 Mr. Cassaundra Edwards - Tillamook Creamery  
 Mr. Gene Ford - Standard Process  
 Mr. Jeremy Hoeh, PE - MEGLE  
 Mr. Eric Iversen, PE - LSG Engineers and Surveyors  
 Mr. Kevin Kowalk, PE - EA Engineering, Science, and Technology (MI) PLC  
 Mr. Jeffrey Mathews, PhD - PepsiCo Global Beverage R&D  
 Mr. Mitch Miller - General Mills-Yoplait  
 Mr. Eric Van Middendorp, MSE - Spectrum Health Innovations, LLC  
 Mr. Nate Wood - Perrigo  
 Mr. Rob Yoder - BDI, Inc.


## Board (Ex-officio)

Mr. Larry Walker, PhD - Cornell Emeritus Faculty  
 Mr. Michael Wozniak, PE - MDARD

## Project Evaluators

Mr. Matt Barnhart - Weyerhaeuser  
 Mr. Mike Clark - Weyerhaeuser  
 Mr. James Dusenbury, PhD - US Army  
 Mr. Sam Effa - Techmark, Inc.  
 Mr. Todd Forbush - Techmark, Inc.  
 Mr. Gaurav Hosur - Consumers Energy  
 Mr. Nathan Hough - Abbott Labs  
 Mr. Nick Jennings - Koppert Biological Systems  
 Mr. Matt McAlpine - Blake's Hard Cider Co.  
 Mr. Steve Radke - JBT Corporation  
 Mr. Ian Sanwald - BIGGBY®  
 Mr. Jordan VanDyke - FireKeepers Casino Hotel

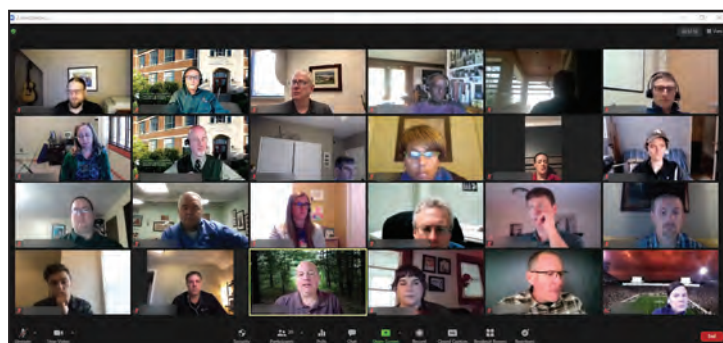
**2020 Senior Design Projects and Teams**  
**Ice Cream Inclusion Analysis and Process Optimization (project under Non-Disclosure Agreement)**  
**Team Name – Team Tillamook**



(L to R) Esha Jain, Alicia Ziegler, & Stephanie Gardner  
 Sponsor – Tillamook Creamery (project under Non-Disclosure Agreement)  
 Faculty Advisor – Dr. Yan "Susie" Liu

Team Tillamook worked with Tillamook Creamery; a farmer owned dairy co-op located in Oregon. Tillamook is interested in improving their customer satisfaction, specifically related to quantity and distribution of inclusions in their ice cream. Research conducted by the team identified that inclusion distribution was not uniform throughout the ice cream cans. The team identified several design improvements to enhance handling and distribution throughout the manufacturing process. Two solutions, to maintain temperature and improve mixing, were recommended by the team and were tested. These solutions improved inclusion distribution and will help maintain company quality standards for less than 10% of the client's project budget.

Click Thumbnail for full pdf version of Team Tillamook Poster.

BAE 2020\_21 Industry Advisory Board Meeting October 15, 2020

**If you are interested in sponsoring a BE 485/487 capstone project for the 2021\_22 Senior Design teams, please contact Dr. Dana Kirk at [kirkdana@msu.edu](mailto:kirkdana@msu.edu) or Dr. Luke Reese at [reesel@msu.edu](mailto:reesel@msu.edu).**



Inspiring students.

Transforming our  
community.

And providing opportunities  
for young adults to  
dream big.

Delta Dental of Michigan is proud to support the Michigan  
State University College of Engineering's Design Day.



Building healthy, smart, vibrant, inclusive communities for all.



## The Capstone Projects

**Mr. Anthony Ingle**  
Teaching Specialist

**Faculty Advisors: Professors Chatti, Hashsham, Ingle, Jashami, Kodor, Li and Pantangi**



Chatti



Hashsham



Ingle



Jashami



Kodor



Li



Pantangi

## CE 495 Senior Design in Civil & Environmental Engineering

Undergraduates in civil and environmental engineering must take CE 495. This capstone course prepares students for the workplace by providing an experience with the following challenges:

- A project with multiple issues that must be resolved using civil and environmental engineering knowledge;
- Formulation of conceptual solutions and resolution of conflicting design elements;
- Development of plans that comply with regulations and provide a basis for cost estimates;
- Balancing individual responsibility and group participation in a team based effort;
- Preparation of written reports and oral presentations.

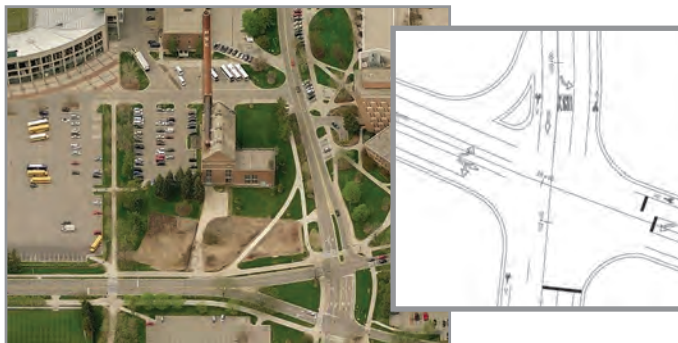
Each team is responsible for developing a design that addresses environmental, geotechnical, hydrological, pavement, transportation, and structural issues for the project. A student project manager coordinates each team. Design reports are judged by the faculty; progress reports and the oral presentations are judged by a board of practicing professionals.

## CE 495 SENIOR DESIGN IN CIVIL & ENVIRONMENTAL ENGINEERING

# Michigan State University Shaw Lane Power Plant Renovation

Michigan State University is in the process of implementing components of its campus master plan. As a part of the 2020 Vision: Campus Master Plan Report, a new academic building was envisioned at the location of the now decommissioned Shaw Lane Power Plant. A recent update to the campus master plan suggested the option to renovate the existing building and add a substantial expansion to the building footprint. In conjunction with this project, the segment of Shaw Lane between Chestnut Rd and Red Cedar Rd will be reconstructed. Both the street reconstruction and the academic building expansion must be congruent with the overall campus master plan.

The project emphasizes implementation of green infrastructure. Green infrastructure refers to systems and practices that use or mimic natural processes to infiltrate, evapotranspire, or harvest stormwater at its source. The competition requires proof-of-concept level designs that examine how green infrastructure could be integrated into an on-campus site to meet multiple environmental, educational, and economic objectives.



Aerial photograph and renderings of Shaw Lane and Red Cedar intersection







### A Plus Group Team

Matthew Paquin, Environmental  
Tyler Koch, Environmental  
Joel Thorne, Geotechnical  
Brendan O'Rielly, Hydrology  
Ethan Nida, Pavements  
Noah McNulty, Project Manager  
Bryan Carie, Structures  
Dakota Oneill, Transportation



### Allied Engineering

Grace Kelbel, Environmental  
Noah Schoenberger, Geotechnical  
Alexandra Burt, Hydrology  
Jackson Friend, Pavements  
Jenn Pozanc, Project Manager  
Zac Osaer, Structures  
John Pynnonen, Transportation



### Full Circle Engineering

Alexia Nagy, Environmental  
Daniel Thomas, Environmental  
Matthew Hagan, Geotechnical  
Adrienne Conigliaro, Hydrology  
James Hunt, Pavements  
Anthony Sperrazza, Project Manager  
Kwadwo Oppon, Structures  
Zihao Yao, Transportation



### JKLM Engineering

Kalyssa Klausing, Environmental  
Mitchell Walton, Geotechnical  
Liam Conlan, Hydrology  
Jamie Jordan, Pavements  
Kelsey Pratt, Project Manager  
Jason Seegert, Structures  
Michael Porcaro, Transportation



### Mite Solutions

Aurora Mlsna, Environmental  
Remi Gonety, Environmental  
Austin DeVries, Geotechnical  
Darren Langendorf, Hydrology  
Jarod Parker, Pavements  
Austin DeFries, Project Manager  
Rodney Emerick, Structures  
Angelina Placido, Transportation



### Red Cedar Engineering

Callaghan TysonMayer, Environmental  
Jack Lawton, Environmental  
Nazeef Aiman Abdulrazak, Geotechnical  
Keith Sheridan, Hydrology  
Luiz Arreguin, Pavements  
Justin Pauken, Project Manager  
Collin Parker, Structures  
Caitlyn Cavicchiolo, Transportation



### Stag-Lap Solutions

Abby DeWeerd, Environmental  
Tyler White, Geotechnical  
Layne Bader, Hydrology  
Philip Henricks, Pavements  
Griffin Sheline, Project Manager  
Aaron Hipshier, Structures  
Sercan Yildiz, Transportation



### Student Engineering Services

Avery Dykman, Environmental  
Gabe Gaskin, Geotechnical  
Caitlin Commissaris, Hydrology  
Emily EStructuresada, Pavements  
Quinn Phelps, Project Manager  
Matthew Chiavetta, Structures  
Jayson Ambabo, Transportation



### Summit Engineering

Jacob ArmStructuresong, Environmental  
Michael Anderson, Environmental  
Victor Ankley, Geotechnical  
Hannah Pascual, Hydrology  
Joseph Lawnicki, Pavements  
Katie Grant, Project Manager  
Ryan Heleski, Structures  
Morgan Zainea, Transportation

## **CE 495 SENIOR DESIGN IN CIVIL & ENVIRONMENTAL ENGINEERING**

---

### **PROFESSIONAL SEMINAR SPEAKERS**

**Jill Bauer, P.E.**

Rowe Professional Services

**Michele Buckler, P.E.**

Detroit Diesel

**Mark Dubay, P.E.**Michigan Department of  
Transportation**Brad Ewart, P.E.**Soil & Materials  
Engineers, Inc.**Megan Jacobs, P.E.**Soil & Materials  
Engineers, Inc.**Leanne Panduren, P.E.**

Rowe Professional Services

**Robert Rayl, P.E.**

RS Engineering LLC

**Charles Rolfe, P.E.**

OHM Advisors

**Jon Stratz, P.E.**Michigan Department of  
Transportation**Dan Thome, P.E.**

Nicholson

**Roy Townsend, P.E.**Washtenaw County Parks  
and Recreation**Brad Wieferich, P.E.**Michigan Department of  
Transportation

---

### **PROFESSIONAL EVALUATORS**

Engineers and scientists associated with the following firms, municipalities, and companies donated time to provide students with a practicing professional's perspective. We gratefully acknowledge their generous contributions.

**Juan Alcantar, P.E.**

Michigan Department of Transportation

**Sam Baushke, P.E.**

Geosyntec Consultants

**Michele Buckler, P.E.**

Detroit Diesel

**Ryan Butler, P.E.**

Consumers Energy

**Erik Carlson, P.E.**

Michigan Department of Transportation

**Dan Christian, P.E.**

Tetra Tech MPS

**Jim Corsiglia, P.E., S.E.**

Harley Ellis Devereaux

**Brian Davies, P.E.**

Hubbell, Roth &amp; Clark

**Tyler Dawson, Ph.D., P.E.**

NTH Consultants

**Mike Ellis, P.E.**

Barr Engineering

**David Hayden**

Bergman Associates

**Matt Junak, P.E.**

HTNB

**Al Kaltenthaler, P.E., S.E.**

C2AE

**Yogesh Kumbarger, Ph.D.**

Soil &amp; Materials Engineers

**Peter Margules, P.E.**

NTH Consultants

**Jon O'Brock, P.E.**

MTC Testing

**Jordan Phillips, P.E.**

RS Engineering

**Stephen Subu**

Consumers Energy

**Roy Townsend, P.E.**Washtenaw County  
Parks and Recreation**Phillip Vogelsang, P.E.**

AECOM

**Jon Ward, P.E.**

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# ChE Process Design and Optimization



**Dr. Mark Worden**  
Class Instructor and Professor  
of Chemical Engineering and  
Biomedical Engineering



**Ziwei Wang**  
Graduate Student &  
Teaching Assistant of  
Chemical Engineering

## Course Description

Chemical Engineering's capstone design sequence includes Process Design and Optimization I and II (ChE 433 and 434, respectively). In these courses, students integrate content from earlier courses for complex, open-ended design assignments. As the students progress through ChE 433, their assignments require increasingly more effort, initiative, knowledge and individual responsibility. The capstone design experience culminates in ChE 434, when students design a proposed commercial-scale chemical plant and use economic analyses to optimize the plant's profitability.

For over 50 successive years, MSU's ChE 434 students have spent about 30 days working intensively on the annual American Institute of Chemical Engineering (AIChE) Student Design Competition problem. The Chemical Engineering and Materials Science Department uses these industry-based problems to enhance chemical engineering students' capstone design experience for three reasons: 1) they provide real-world, open-ended design experiences

typical of those students are likely to face after graduation; 2) they require self-directed active learning, including project-specific research to obtain information needed to solve the problem; and 3) they serve as a national benchmark for MSU chemical engineering students to demonstrate excellence in their professional skills.

ChE 434 students are allowed to solve the Student Design Competition problem either as individuals or in teams of two. Team solutions are expected to contain roughly twice as much analysis as individual solutions. For example team solutions would be expected to analyze the impact of more process variables on the expected profitability of the chemical plant.

As the Chemical Engineering program's contribution to Design Day, several ChE 434 students present posters describing their solutions to this year's AIChE Student Design Competition problem. Names and pictures of the presenters are provided at the end of this article.

## National Awards in 2020 Design Competition

Since 1968, MSU has had the best record nationally for awards in the AIChE Student Design Competition, and the AIChE national win streak continues. In 2020, chemical engineering senior **Benjamin Farris** won the **A. McLaren White Award** for Best Overall Design (individual category). In his project, entitled "Modular Ammonia Production for Minnesota Fertilizer Market," he designed a small-scale gas-processing plant that produces ammonia from natural gas and atmospheric nitrogen.

**Christine Mason**, another chemical engineering senior, won the **Walter Howard Design Award** for Best Applications of the Principles of Chemical Process Safety (individual category). Her winning project offered a business model for modular distributed ammonia synthesis. Both **Farris** and **Mason** received recognition during the student design competition session at the 2020 Virtual AIChE Annual Student Conference on Nov. 16, 2020.



**Benjamin Farris and Christine Mason**

**AIChE®**

## Upgrading petroleum to higher value products

In 2021, the AIChE Student Design Competition problem related to a classic chemical-engineering challenge: how to upgrade petroleum to higher value chemical products. However, this project featured an international element, in that the plant should be designed for construction in a Middle-Eastern country. Thus, competitive design solutions had to incorporate global factors.

Students were assigned to design a plant that integrated chemical reactions and multistep separations processes to a petroleum fraction (naphtha) into the value-added chemicals benzene, toluene and xylene (BTX), as well as transportation fuel (gasoline and diesel).

Students are allowed considerable flexibility in how the chemical plant would be laid out in these open-ended capstone design assignments. One example of a (greatly simplified) process flow sheet is shown below. The naphtha and hydrogen gas would be delivered to a reactor vessel, where the naphtha is converted in to a mixture of products. A distillation column is used to separate the products emerging from the reactor into three streams: (1) unreacted hydrogen gas, which is recycled to the reactor, (2) a mixture of compounds that are well suited as transportation fuel, and (3) a mixture of chemicals rich in the desired BTX products. A solvent-extraction process is then used to remove additional transportation fuel, and then three distillation columns are used separate the BTX mixture into three the final products. One column is used to recover the solvent,

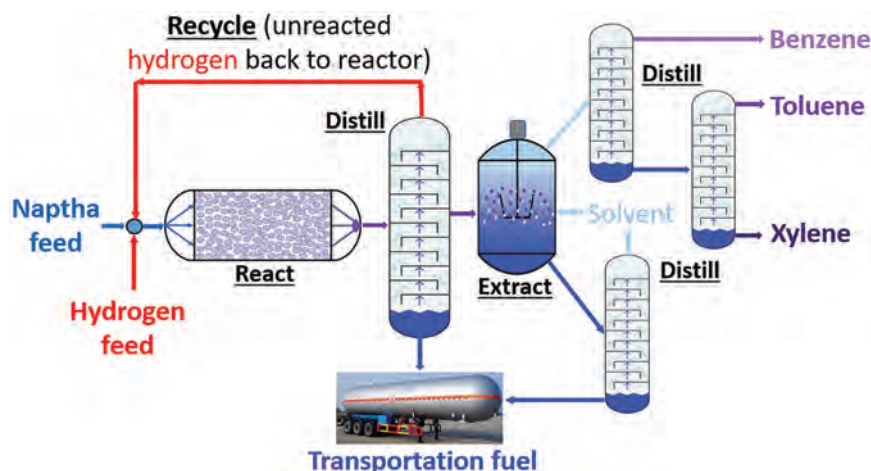
which is reused, the second is used to purify the benzene, and the third is used to separate the toluene from the xylene.

An important requirement of the project is a detailed economic analysis that predicts the profitability of the chemical plant. To account for changes in the value of money over time, a discounted cashflow rate of return on the company's investment is determined. By integrating this economic analysis with a comprehensive, predictive mathematical model of the chemical plant, students can optimize their designs by determining the values of key design parameters that maximize the profit.

However, the economic optimization must be done within the constraints of multiple other factors, most notably safety and environmental compliance. Each report is required to include detailed analyses of safety and environmental risks and strategies implemented to mitigate those risks.

Each final report is required to specify details required to build and operate the plant the student designed, including the specifications for the plant's equipment, operating conditions, personnel needs, capital investment, working capital, utilities needed, etc. While these reports have historically been allowed to be up to 225 pages long, this year, for the first time, AIChE imposed a length limit of 50 pages. This new constraint required ChE 434 students to not only be strong technically but also be able to write a report that is well-organized, clear, and concise.

### Process Flowsheet for Upgrading Petroleum to Higher Value Products





## Team-Solution Design Day Poster Presenters

For Design Day, several ChE 434 students present posters on their solutions to the AIChE Design Competition problem. Due to COVID-19 restrictions, this year the poster presentations will be given virtually, rather than in-person. The students who will present team-solution posters are shown below.



Nicole Mancina

Mitchell Pellow

## Team-Solution Poster Presenters



Kellie Mullany



Trevis Majtara



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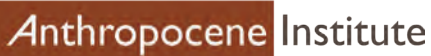
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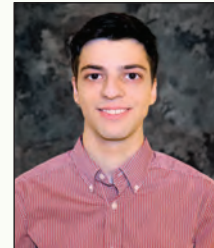
# The Capstone Projects



**Dr. Wayne Dyksen**  
**Professor of Computer Science and Engineering**



**James Mariani**



**Luke Sperling**

**Teaching Assistants**

## CSE 498 Collaborative Design

CSE 498, Collaborative Design, provides the educational capstone for all students majoring in computer science. Teams of students build software systems for a variety of clients.

During the capstone experience, students

- design, develop, debug, document, and deliver a comprehensive software system,
- work in a team environment,
- become proficient with software development tools and environments,
- develop written and oral communication skills,
- build and administer computer systems, and
- consider issues of professionalism and ethics.

Our clients are local, regional, and national including Amazon, Anthropocene Institute, Authoritek, Auto-Owners Insurance, Bedrock Detroit, Bosch, CSAA Insurance Group, Delta Dental of Michigan, Ohio and Indiana, Dow, Ford, General Motors, Google, Herman Miller, Humana, Learning A-Z, Lockheed Martin Space, Malleable Minds, Meijer, Michigan State University, Microsoft, Mozilla, MSU Federal Credit Union, Proofpoint, Quicken Loans, TechSmith, United Airlines, Urban Science, Vectorform, and Volkswagen.

# Amazon Sentinel

Founded in Bellevue, Washington in 1994, Amazon is a Fortune 500 company that provides a variety of services to customers and is the world's largest cloud services provider and online retailer.

Amazon's online marketplace handles millions of orders every day from over a million unique sellers. With an operation of such magnitude, it is inevitable that some buyers and even some sellers engage in fraudulent activities. Amazon's current fraud detection system requires individual sellers to detect and recognize unusual activity themselves, which can lead to undetected fraud and extra work for sellers.

Our Sentinel system helps to resolve these issues by automatically detecting fraudulent transactions and notifying sellers in real time.

Sentinel uses machine learning to detect patterns from historical transaction data, then applies these patterns to all incoming transactions to determine when a fraudulent transaction has occurred. Once Sentinel has detected fraud, the seller is notified immediately.

Using our mobile application, sellers can manage all of their orders, including any fraud detected by Sentinel. Our application gives sellers options to freeze their account, cancel any fraudulent orders, or to explore more transactions before making a decision.

Sentinel helps Amazon sellers save time and money by detecting and mitigating fraudulent purchases automatically, giving sellers much needed peace of mind.

Our machine learning models are built using Amazon SageMaker, trained on user data and transactions stored in Amazon S3. AWS Lambda is used to detect instances of fraud in real time and the cloud platform sends a notification to the merchant's mobile device. The iOS application is written in Swift.



amazon



### Michigan State University Team Members (left to right)

**Terry Chen**  
Guangzhou, Guangdong, China

**Dakota Tyrrell**  
New Baltimore, Michigan

**Daewoo Maurya**  
New Delhi, Delhi, India

**Ray Jung**  
Mokdong, Seoul, South Korea

**Shobith Kalal**  
Troy, Michigan

### Amazon Project Sponsors

**Garret Gaw**  
Detroit, Michigan

**Derek Gebhard**  
Detroit, Michigan

**John Miklus**  
Detroit, Michigan



# Anthropocene Institute

## Siting of Marine Turbines for Power Generation

The Anthropocene Institute is a non-governmental organization that drives and facilitates innovation in clean energy to address the urgency of climate change. It supports start-ups and universities to develop emerging and disruptive energy technologies that are clean, safe, and reliable. It is also involved in raising public awareness for 'one-cent' electricity as a key goal for the power grid.

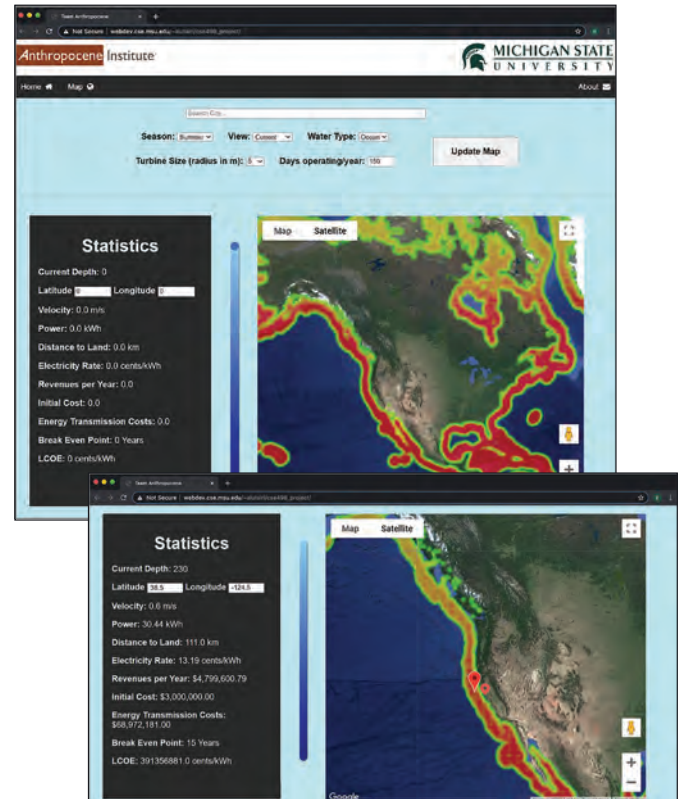
The Anthropocene Institute has started to look at aquatic turbines as a promising new type of renewable power generation. However, a major hurdle to overcome is determining the best placement for the turbines that maximizes their power generation and minimizes costs.

When placing a water turbine, many factors have to be considered, including the depth of the water, the velocity of the current, and the distance to the nearest coast. However, current data on oceans and rivers are incomplete, meaning accurate predictions for turbine placement cannot be achieved.

Our Siting of Marine Turbines for Power Generation project solves this issue by using machine learning to fill the gaps of the currently incomplete data. Our models use historical data to predict the water conditions in any area without sufficient data, allowing Anthropocene to give accurate power generation and cost estimates for turbine placement.

Our web application provides an easy-to-use interface designed for policymakers, utilities, and investors who are looking for clean energy solutions. Users simply search for an area, and our application provides them with statistics and recommendations relating to the cost and power generation potential of a water turbine placed in that area.

The machine learning models were developed in Google CoLab, using the scikit-learn library. The user interface is a Flask-based web server with data visualization by the Google Maps API.



Anthropocene Institute



### Michigan State University Team Members (left to right)

**Charles Ye**  
Shenzhen, Guangdong, China

**Ben Robbins**  
Novi, Michigan

**Lindsay Guare**  
Riverwoods, Illinois

**Ahmed Alutairi**  
Yanbu, Al Madinah, Saudi Arabia

**Andrew Rebits**  
Troy, Michigan

### Anthropocene Institute Project Sponsors

**Richard Chan**  
Palo Alto, California

**Frank Ling**  
Palo Alto, California

**Tracy McSherry**  
Palo Alto, California

**Carl Page**  
Palo Alto, California

# Authoritek Crisis911 Emergency Communication

**A**uthoritek is a software consultant company that provides their clients with purpose driven software that manages their data. They are located in the Grand Rapids area of Michigan.

Emergency situations are stressful, both for those involved and their loved ones. During times like these, the ability to stay informed and inform others is key. It is vital that the user experience is quick and simple so precious time is not wasted.

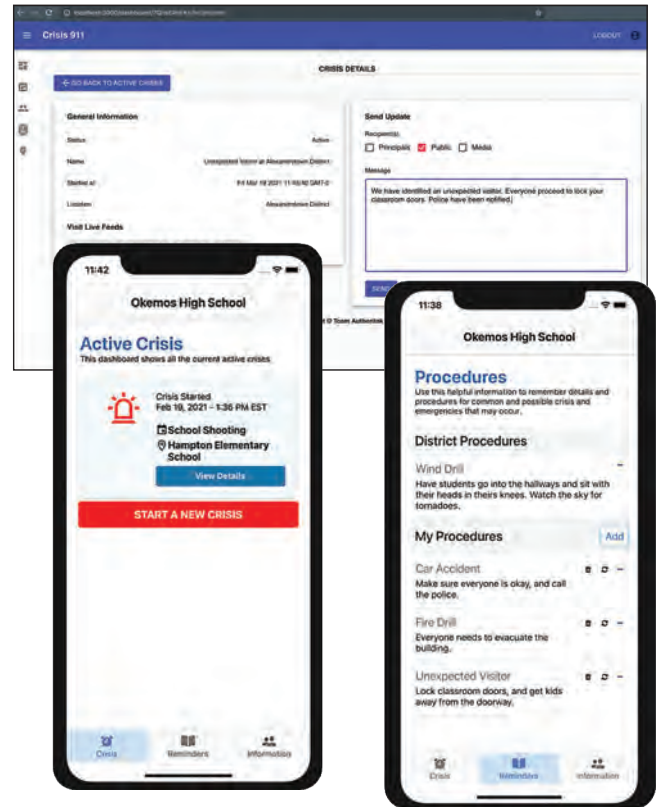
Our software, Crisis911 Emergency, is used in schools when staff encounters an emergency situation that puts them or students in danger. With the help of this application, users can notify loved ones or other faculty in the school of the situation. The software is simple yet effective in notifying individuals who need to be updated about a crisis.

The application has a live feed for crisis updates that can be sent out to whomever the user wants to notify. That feed contains updates of the situation and continues to be updated until the crisis has ended. This allows parents, faculty and guardians to be aware of what is happening in the school without being present.

A key element of Crisis911 Emergency is the ability to have live updates on the crisis at hand, which the user can select when starting the event. This means users in the system receive all information and everyone can be kept safe.

A mobile and web application are available for users to operate, with both being able to indicate the start and end of a crisis. Users can choose who they want to notify by adding contacts through the web application and creating new events to further articulate what type of crisis is happening. Crisis911 Emergency keeps all parties updated about crises in real time.

Our application's back-end database is managed through Google Firebase. The design and functionality of the application is accomplished with React Native, ReactJS, HTML, CSS and Twilio.



### Michigan State University Team Members (left to right)

**Alyssa Bossman**  
Farmington Hills, Michigan

**Eddy Li**  
Shenzhen, Guangdong, China

**Afstone Afoutou**  
Atakpame, Region Des Plateaux, Togo

**Jennifer Browning**  
Traverse City, Michigan

### Authoritek Project Sponsors

**James Lund**  
Hudsonville, Michigan

**Ben St. John**  
Hudsonville, Michigan

# Auto-Owners Insurance AO Sidekick

Auto-Owners Insurance is a Fortune 500 company headquartered in Lansing, Michigan. With over 48,000 licensed insurance agents in over 26 states, Auto-Owners provides automotive, home, life, and business insurance to nearly 3 million policyholders.

With over 600,000 visits to their website every month by a broad base of both agents and policyholders, Auto-Owners strives to ensure that their products and resources are easily accessible to everyone, including those who have difficulty using a web browser.

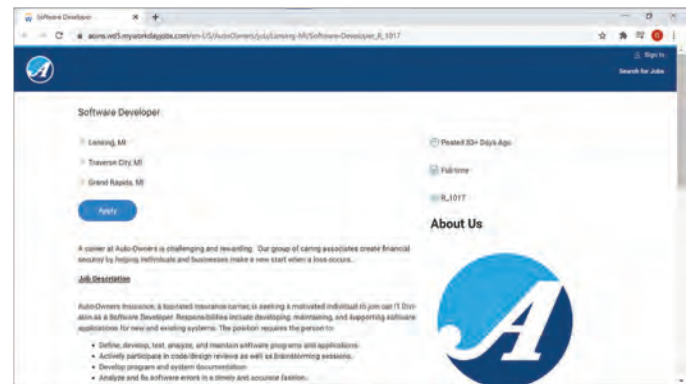
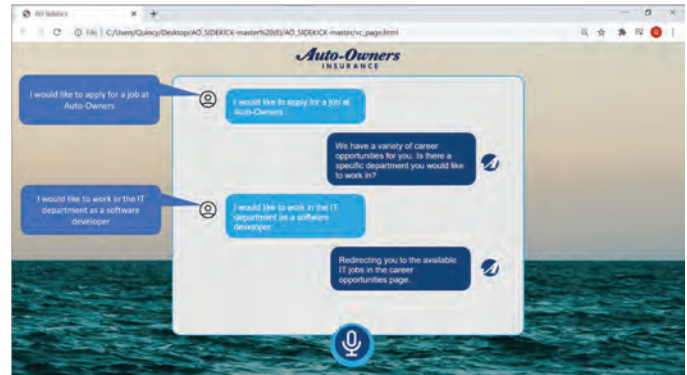
The AO Sidekick is an accessibility application offered to users trying to access the Auto-Owners' website. The Sidekick directs users to pages across the site quickly and simply using only voice input.

When a user arrives at the AO Sidekick homepage, they are greeted with links to common pages on the AO website, as well as a description of what the Sidekick can do. From there, the user can navigate to the Sidekick page where the communication interface is located. Here, the user can see their correspondence with the Sidekick displayed in a text message style format. At the press of the microphone button, Sidekick interprets the user's query and directs them to where they want to go.

If the user's intent is unclear or their request too vague, our system asks follow-up questions for clarification.

Information gathered from this phase is stored and displayed in an intuitive manner on the dashboard page. AO employees can use this insight to facilitate further improvements in the future.

AO Sidekick is developed as a web application hosted by Azure. Azure provides the MS SQL database as well as the LUIS natural language processing API. The front end was developed using HTML, CSS and the ReactJS framework.



**Auto-Owners**  
INSURANCE



## Michigan State University Team Members (left to right)

**Cao Zhang**  
Huangshi, Hubei, China

**Quincy Manson**  
Marquette, Michigan

**Jack Moran**  
Troy, Michigan

**Nihar Kummetha**  
Hoffman Estates, Illinois

## Auto-Owners Project Sponsors

**Tony Dean**  
Lansing, Michigan

**Ross Hacker**  
Lansing, Michigan

**Scott Lake**  
Lansing, Michigan



Bosch is a German-based international technology and service provider employing approximately 395,000 employees worldwide. Bosch specializes in integrated technology, such as smart devices and automobiles, generating almost 72 billion euros in sales in 2020.

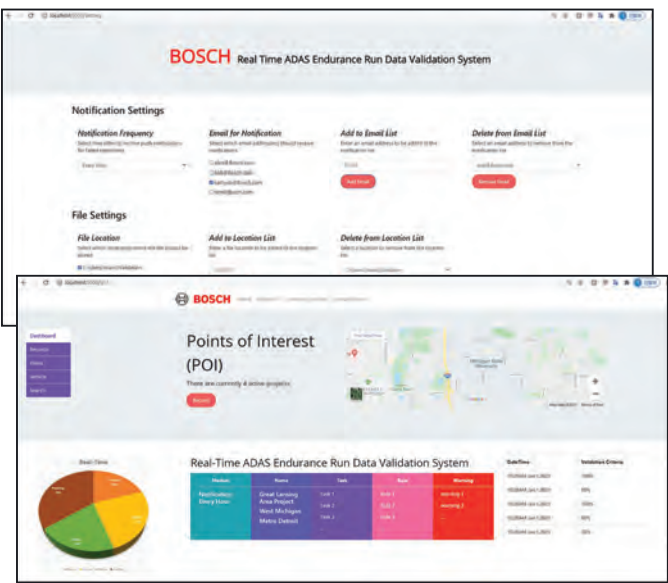
Bosch uses test vehicles to gather data from vehicle systems as they drive along a variety of roads and highways across the world. These vehicles collect data from specific areas where the driving environment generates conditions of special interest to Bosch engineers for use in improving their systems.

Presently, these vehicles drive and gather data for up to a month before the data is delivered en masse to engineers for analysis. This timeline generates a problem when the data contains errors of some form and the test vehicle is distant from where the error occurred.

Our Real-Time Advanced Driver Assistance System (ADAS) Endurance Run Data Validation platform solves this problem by ensuring the data collected is error-free in near real time. Any time errors are present in the data collection, the test vehicle drivers are notified, allowing the driver to repeat the test in a timely manner.

Our software system achieves this goal by validating data upon completion of the data collection process, utilizing a computer embedded within the test vehicle. This verification program then communicates with other infrastructure to allow drivers and engineers to view the status of this verification software in a web application. The website contains capabilities which allow individuals to easily view and update information regarding the verification process.

Our Real-Time ADAS Endurance Run Validation platform uses a Python script to read and validate vehicle data as soon as data collection has been completed. A web application then allows users to view, update, and manage the data validation process.



**Michigan State University**  
*Team Members* (left to right)

**Callie Kimble**  
Livonia, Michigan

**Brendan Zuk**  
West Bloomfield, Michigan

**Don Jayaweera**  
Boston, Massachusetts

**Xinyi Liu**  
Shanghai, Shanghai, China

**Bosch**  
*Project Sponsors*

**Wisam Bunni**  
Plymouth, Michigan

**Maggie Hayes**  
Plymouth, Michigan

**Nate Kesto**  
Plymouth, Michigan

**Steve Koski**  
Plymouth, Michigan

**Matt Lee**  
Plymouth, Michigan

**Troy McCormick**  
Plymouth, Michigan

**Ryan Rummer**  
Plymouth, Michigan

# CSAA Insurance Group Insurance Coverage Wizard

CSAA Insurance Group (CSAA) is a subsidiary of AAA Insurance operating out of Walnut Creek, California. CSAA offers auto, homeowners, and other lines of insurance in twenty-three different states and the District of Columbia.

Purchasing insurance is a time-consuming and difficult process that often leaves customers annoyed and confused. CSAA is always innovating insurance and wants to educate their customers on possible insurance coverage options.

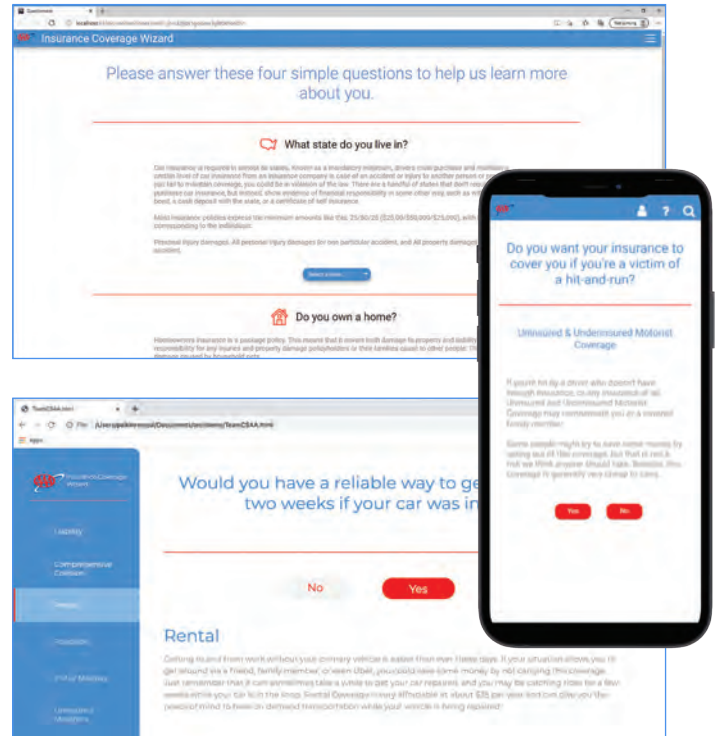
Our Insurance Coverage Wizard is a tool designed to help customers quickly and easily receive a personalized insurance quote. The wizard consists of a series of questions to help it learn more about the user and their insurance needs. The wizard then guides the user through various types of insurance coverages to better inform the customer of their insurance options.

The Insurance Coverage Wizard includes eight steps, each of which educates the user about a specific coverage and how it pertains to them. Using the knowledge from the wizard, users can confidently build an insurance plan that is right for them.

Our wizard is accessible from any computer or smartphone and is designed to keep the user engaged with the material to provide them the best experience possible.

To achieve the best experience for their customers, CSAA collects data on how users interact with the wizard. This data is available to CSAA employees in a PowerBI dashboard. With this user engagement information, CSAA constantly updates the wizard to improve the insurance buying process for their customers.

Our software uses a ReactJS front end to communicate user input to the .NET Core back end. Data is hosted in a MySQL database. All of this is deployed on an Amazon EC2 Instance.



## Michigan State University Team Members (left to right)

**Evan Shoup**  
Howell, Michigan

**Palkin Rampal**  
Troy, Michigan

**Akhil Alluri**  
Northville, Michigan

**Aaron Kovanda**  
Highland, Michigan

## CSAA Insurance Customer Experience Project Sponsors

**Erron Al-Amin**  
Walnut Creek, California

**Linda Goldstein**  
Walnut Creek, California

**Suzanne Meraz**  
Walnut Creek, California

**Kyra Peyton**  
Walnut Creek, California

**Emeri Zhang**  
Walnut Creek, California

# CSAA Insurance Group

## Eye in the Sky: Intelligent Drone Video Processing

CSAA Insurance Group, headquartered in Walnut Creek, California, is a AAA insurer, one of the top insurance groups. They offer auto, homeowners and other lines of insurance in twenty-three states and the District of Columbia.

One major area of CSAA's business is home insurance. With the increasing number of wildfires in recent years, it is important for both the insurer and homeowners to accurately assess property risk from wildfires.

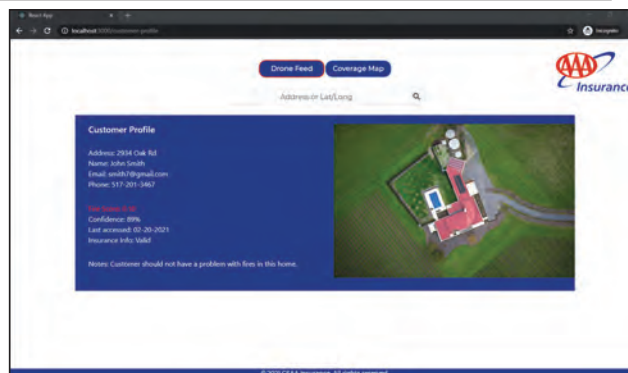
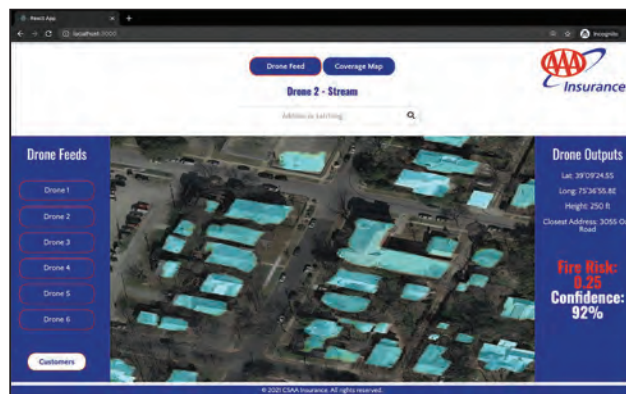
Our Eye in the Sky: Intelligent Drone Video Processing project uses drone footage to determine high fire risk areas as well as the risk of specific homes, providing key information for CSAA in determining the necessity of action and risk associated with insurance throughout California.

To determine the fire risk of a home, a drone is sent to collect images of its surrounding area which are then sent to our web application, Eye in the Sky. Our application processes these images using computer vision to detect objects of risk, including things like dry brush, concrete and trees. Based on the different properties of surrounding objects, the property is given an overall fire risk score.

CSAA employees use our web dashboard to assess the overall fire risks of potentially vulnerable areas. A large coverage map allows employees to easily view the fire risk of large areas, as well as the specific fire risks of an individual property.

Based on these fire-risk scores, employees can take appropriate action either by providing recommendations based on the surroundings to mitigate fire risk or investigate further using drones or by an in-person inspection.

The front end of our Eye in the Sky project is written in React, HTML and CSS. The back end is written in Python using Flask to link the two. MongoDB is used as the database and the entire web application is hosted on AWS.



### Michigan State University Team Members (left to right)

**Adam Wing**  
Howell, Michigan

**Ryan Purrenhage**  
Troy, Michigan

**Yiou Wang**  
Qingdao, Shandong, China

**Brian Tang**  
Macomb, Michigan

**Kilosh Mike Kamwana**  
Solwezi, Northwestern, Zambia

### CSAA Insurance Innovation Project Sponsors

**Beti Cung**  
Walnut Creek, California

**Anthony Duer**  
Walnut Creek, California

**Victor Jin**  
Walnut Creek, California

**Emeri Zhang**  
Walnut Creek, California



# Delta Dental of Michigan, Ohio and Indiana Smart Dental Benefit Recommendation Engine

Delta Dental is the largest dental system in the United States, which operates two of the nation's largest networks of participating dentists. Delta Dental provides dental and orthodontic coverage to more than 78 million people in all 50 states, Puerto Rico and other U.S. territories, including small businesses, government entities, and professional organizations of all kinds.

Underwriting is the process of how Delta Dental determines the best dental insurance plan for their clients. In addition to crafting insurance plans for new clients, underwriters also spend a significant amount of time recommending benefit changes for current customers. This time-consuming process requires aggregating data from several sources and significant domain knowledge to properly recommend benefit updates.

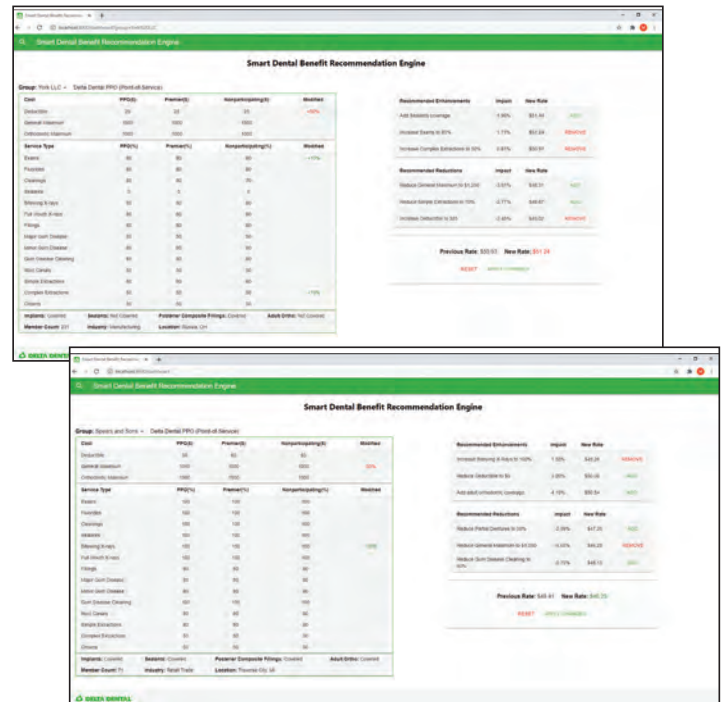
Our Smart Dental Benefit Recommendation Engine helps automate the underwriting process to improve benefits for customers and save underwriters time.

Our system uses machine learning to look at historical data to help determine the best insurance plan for a given individual or family. Based on this analysis, our system recommends additions or reductions to the customer's current plan.

Our web dashboard aggregates all of the information needed by underwriters in one convenient location, including the benefit changes recommended by our machine learning model.

Using our system, Delta Dental underwriters can offer customers faster and more efficient service, and it allows them to focus their valuable time on more important issues.

The recommendation and prediction algorithms are written in Python in Jupyter Notebook, the web application is written in ReactJS. Our data is hosted on Snowflake from Delta Dental's Microsoft Azure databases. Docker is used to containerize our engine and host it on Microsoft Azure.



## Michigan State University Team Members (left to right)

**Jorel Singleton-Cochran**  
Detroit, Michigan

**Kenglung Hsu**  
Taipei, Taipei, Taiwan

**Andy Hu**  
Chongqing, Chongqing, China

**Mitchell Hawkes**  
Grand Rapids, Michigan

## Delta Dental Data Science Project Sponsors

**Mukundan Agaram**  
Okemos, Michigan

**Jonathan Culbert**  
Okemos, Michigan

# Delta Dental of Michigan, Ohio and Indiana Rule Engine Command Line Interface

Delta Dental is the nation's leading provider of dental insurance, serving more than 80 million Americans, with the core purpose of advancing the oral health of their customers, partners and consumers. Delta Dental of Michigan, headquartered in Okemos, Michigan, is at the forefront of utilizing rule-based solutions within their business operations and intelligence, with over 15 years of excellence in this domain.

When a Delta Dental developer wishes to engineer a rule-based solution, a non-trivial amount of setup must be completed first. Prototyping and testing of rule-based solutions are slowed down significantly by the setup process.

Our Rule Engine Command Line Interface provides an intuitive and interactive interface to Drools, the rule-based computing engine that Delta Dental's developers use on a daily basis.

Using our software, developers interact with every part of the Drools engine. The interface is organized into various modules, each of which handles a core function of rule-based computing. Our modular design makes it easy to update or even swap out various components when Drools is updated, or new software is needed.

The Rule Engine Command Line Interface streamlines the development process for rule-based computing, saving Delta Dental a significant amount of time and resources.

For the convenience of Delta Dental developers, our software functions as a command-line shell program. Our software is written in core Java, and therefore runs on any computer that has a Java runtime environment. The external libraries, including the core Drools library, and build process are managed by Maven. Version control and collaboration management were provided by Gitlab.

```
RECLI> RuleSet 0
Loading ruleSet module for session 0.
RECLI> RuleSet: load patient_rules.drl
Loading rules from file patient_rules.drl...
Done.

RECLI> RuleSet: view log4j(WheelApp)
rule "updateNextAppt"
salience 20
when
  $p : Patient()
  ($a : Appointment()
  <nextAppt $p.id == $a.patient_id)
then
  $p.setNextAppointment($a.date);
  System.out.println($p.name) + " appt updated: ";
  System.out.println($a.toString());
end

RECLI> RuleSet: create filterPatients 10
when
  $p : java.util.Calendar()
  $a : Patient(nextAppointment() > $c.getTime())
then
  delete($a);
  System.out.println($p.name() + " removed.");
end
New rule filterPatients created with salience 10.

RECLI> RuleSet: halt
RECLI>
```

```
RECLI> RuleSet 1
Loading working memory module.
RECLI> RuleSet: create Patient
Patient 1
{
  <int> id: 250003
  <String> first_name: Michael
  <String> last_name: Wellinger
  <localDate> next_appt: 2021-06-18
}
New Patient created with ID 5.

RECLI> RuleSet: list Patient
0) {
  id: 204176,
  first_name: "Tara",
  last_name: "Palacios",
  next_appt: 2021-01-22
}
1) {
  id: 212978
  first_name: "Jorge",
  last_name: "Palacios",
  next_appt: 2020-07-23
}
2) {
  id: 250003,
  first_name: "Michael",
  last_name: "Wellinger",
  next_appt: 2020-06-12
}

RECLI> RuleSet: halt
RECLI>
```

```
RECLI> Runtime 2
Loading runtime module with ID 2.
RECLI> Runtime-2: insert 5
Fact (5) inserted into the runtime.
RECLI> Runtime-2: load -ruleset 0
Ruleset 0 loaded.
RECLI> Runtime-2: fire
Firing rules...
Michael Wellinger appt updated: 2021-04-14 00:00AM
Tara Johnson appt updated: 2021-07-08 02:30PM
Jorge Palacios removed.

RECLI> Runtime-2: waitUntil 1
Switching to Runtime 1.
RECLI> Runtime-1: load ruleset 1
Ruleset 1 loaded.
RECLI> Runtime-1: fire
Firing rules...
Updated appointment /num: Jorge Palacios

RECLI> Runtime-2: halt
RECLI>
```



**Michigan State University  
Team Members** (left to right)

**Aihong (Ella) Chen**  
Nanning, Guangxi, China

**Nick Guthrie**  
Okemos, Michigan

**Liam Bohl**  
Marshall, Michigan

**Mac Catrambone**  
Riverside, Illinois

**Johnny Svigelj**  
Crystal Lake, Illinois

**Delta Dental Knowledge Science  
Project Sponsors**

**Mukundan Agaram**  
Okemos, Michigan

**Chang (Charlie) Liu**  
Okemos, Michigan

# The Dow Chemical Company

## Improving the Performance of the Corporate Computer

With over a century of experience, Michigan-based Dow is a global leader in the innovation, creation, and distribution of specialty chemicals, advanced materials, and plastics.

As a large company with 54,000 employees worldwide, Dow has a massive collection of computers and devices which employees use. The computers are of varying operating systems, models and generations. Dow collects computer usage and performance data on the computers in order to efficiently use their resources.

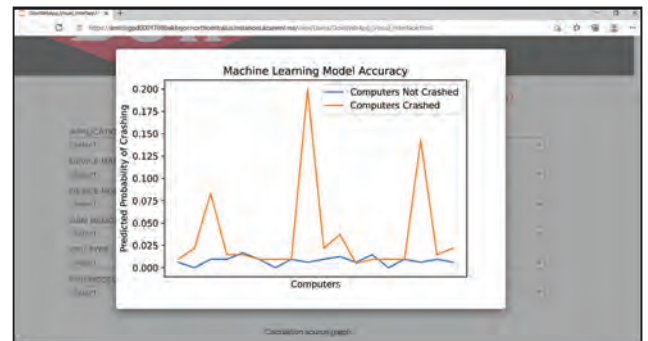
Our Improving the Performance of the Corporate Computer system analyzes the data so that events such as application crashes, blue screens and application hang times can be minimized. Data analysis reveals the optimal parameters for computers so that Dow employees can determine which are best to use. Data analysis also reveals applications most susceptible to crashes so that potential workflow improvements can be made.

Using the collected data, our system uses a machine learning model that predicts the performance of a computer given a set of properties.

We developed a web application where employees from Dow can visually input computer specifications and other parameters. Then, the application runs this input through our machine learning algorithm and visually displays the result for the employee to see.

This helps Dow easily determine whether it is worth investing money to upgrade or purchase different computers or components. Employees can use the web application to determine whether they should make changes to their system and what the expected outcome would be. In the long run, this helps Dow be more efficient with costs and its employees be most productive.

Data analysis is conducted using Python in Jupyter notebooks. The machine learning algorithm is developed using Python and Microsoft Azure. The web application is developed in Python Flask.



### Michigan State University Team Members (left to right)

**Yunxuan Du**  
Shanghai, Shanghai, China

**Logan Shuck**  
Arlington Heights, Illinois

**Jordan Bakke**  
Evansville, Indiana

**Connor Barker**  
Palatine, Illinois

### Dow Project Sponsors

**Josh Ackerman**  
Midland, Michigan

**Chris Anderson**  
Chicago, Illinois

**Fernando Favato**  
São Paulo, Brazil

**Ron Ross**  
Troy, Michigan

**Kurt Sherman**  
Midland, Michigan

**Scott Way**  
Midland, Michigan

**Matthew Zarazua**  
Midland, Michigan



# Ford Motor Company

## Ford Team View

Ford Motor Company is a multinational automotive manufacturer headquartered in Dearborn, Michigan, with operations in over 125 countries and a worldwide workforce of 199,000 employees. Ford designs and manufactures a full line of cars, trucks, SUVs and electric vehicles under both the Ford and Lincoln brands.

Ford is committed to promoting a work environment that supports and benefits from collaboration across multiple teams. However, due to the COVID-19 pandemic, team collaboration has been made more challenging. Instead of working side by side, teams are now working in their own private residences, making it difficult to locate other teams or make contributions to their projects.

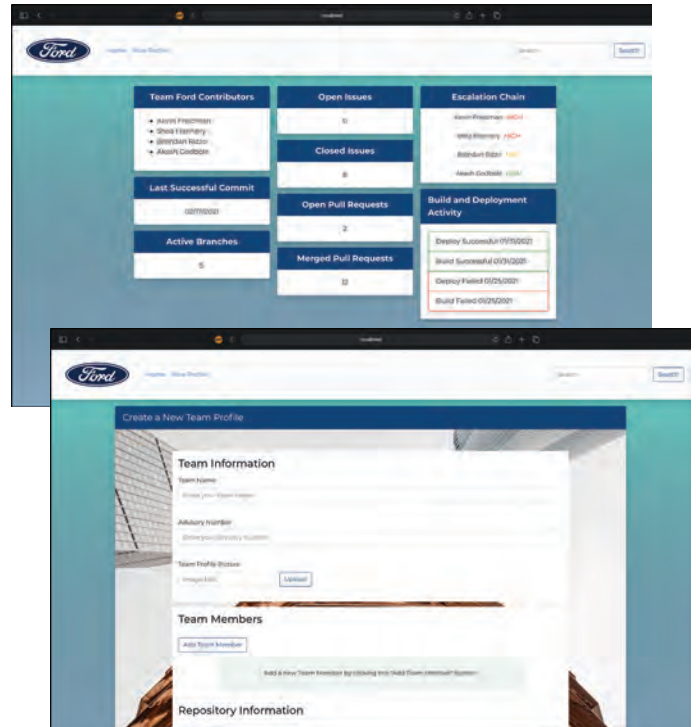
Our Ford Team View web application provides a convenient way for users to locate other teams by either searching for a team name, advisory number, or an individual. Once a team is found and selected, their team profile is displayed.

In the team profile, a user can see every team member and their contact information, any incidents and issues the team is facing, the projects the team is working on, and a hierarchical chain of team members to contact when an issue arises.

Our application also allows users to search for a project by either entering an API name, base path, or contributor. When a project is clicked on, a user can view the number of times code was added to the project, the project's build and deployment history, and the contributors to the project.

Team View makes it easier for teams to collaborate and work together while working remotely, thereby increasing productivity.

The front end of our web application is created with the REACT framework, while our back end uses the Spring framework. Our application uses a MongoDB to store the team profiles and project information, which is retrieved by a REST API.



### Michigan State University

*Team Members* (left to right)

**Brendan Rizzo**  
Macomb, Michigan

**Kevin Friedman**  
Oak Park, Michigan

**Akash Godbole**  
Pune, Maharashtra, India

**Shea Flannery**  
Traverse City, Michigan

### Ford

*Project Sponsors*

**Adam Haas**  
Dearborn, Michigan

**Marcus Harold**  
Dearborn, Michigan

**Phill Simone**  
Dearborn, Michigan

**Matt Tarnowsky**  
Detroit, Michigan

**Michael Volk**  
Dearborn, Michigan

# General Motors Malware Reverse Engineering Platform

**G**eneral Motors (GM) is a multinational automotive manufacturer headquartered in Detroit, Michigan. GM is ranked #18 on the Fortune 500 for total revenue and is the largest auto manufacturer headquartered in the United States.

GM is committed to maintaining corporate security and the security of their customers. For this reason, effectively sharing information about malware and indicators of compromise within their organization is critical.

Our Malware Reverse Engineering Platform is a web application that provides a unified and easy-to-use interface that allows users to submit suspicious samples for analysis.

These samples may be files the user already has, or they may be scraped from web sources. The user can submit local files by either dragging a file and dropping it into an indicated box, or by selecting a file. They can submit a website to scrape by simply entering the URL and selecting the start button.

The analysis returns a report about the sample's behavior, such as what files it modifies, what it attempts to do on the network, and other potentially malicious activities. The report is visible within the interface after the analysis, and the user may download the report to their local machine. The report is also automatically sent to their organization's database for storage and for other members to view.

This platform automates and greatly simplifies a currently manual process that requires the user to interact with multiple programs. This gives GM's security analysts greater flexibility and efficiency in analyzing malware and sharing results.

The malware analysis incorporates Cuckoo. The samples and analyses are stored in a Malware Information Sharing Platform (MISP) instance. For integrating these tools, we are using the PyMISP library. The web interface uses Flask built off of Adobe XD.



## Michigan State University

**Team Members** (left to right)

**Andrew Jalbert**  
Farmington Hills, Michigan

**Shafee Mustafa**  
Detroit, Michigan

**Allen Janyska**  
Atlanta, Georgia

**Alessandro Zakolski**  
Riverview, Michigan

## GM

**Project Sponsors**

**Justin Bingham**  
Warren, Michigan

**Vinny Hoxha**  
Warren, Michigan

**Fred Killeen**  
Warren, Michigan

**Wade Kirschner**  
Atlanta, Georgia

**Matthew Meyer**  
Austin, Texas

**Michael Milnarich**  
Warren, Michigan

# Herman Miller Scout 2.0: Dynamic Data Visualization for Dealers

With over 100 years of experience, Herman Miller is a globally recognized provider of furnishings, related technologies and services headquartered in Zeeland, Michigan.

Herman Miller uses the Atlas Suite, an online suite of applications meant to make their users' experience as fluid as possible. Users leverage an application called Scout in the Atlas Suite to help potential customers visualize ideas, select commercial furniture and textiles, and build custom proposals.

The underlying data in the application, like clicks and hits, are monitored and recorded. However, substantial analysis of this data has not been done and potential insights were going unrealized.

To overcome this, our Scout 2.0 application dynamically visualizes the data for users through various interactive models.

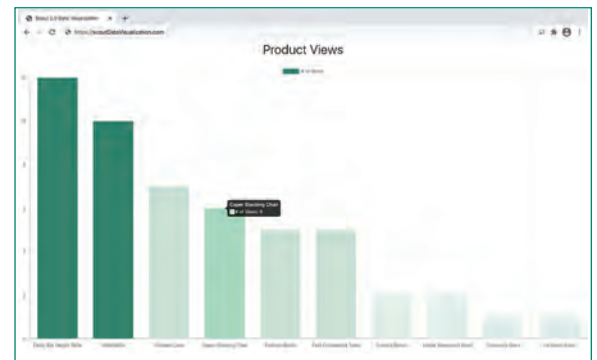
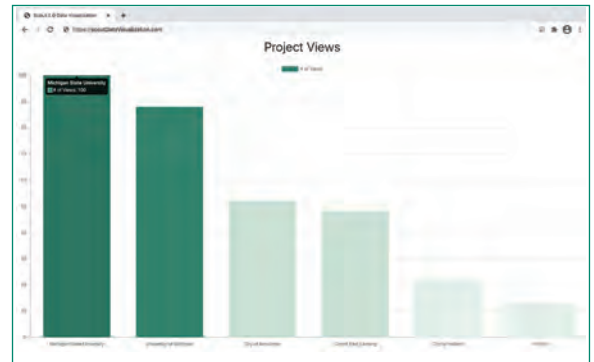
The customer acquisition tab displays website traffic throughout the month, week, and day. Any user can hover over the diagram to get more specific data on all of the different tabs.

The popular content tab displays the projects and products views. The user can use the pagination feature which allows them to move back and forth between the most and least viewed items.

The customer locations tab provides insight into the geographical data recorded by Scout, ranging from country to region to city. Knowing this information gives dealers a better understanding of the state of their sale.

Our models provide various ways to visualize the data and help users understand different variables such as when and where the product is viewed, and the projects and products views. This aids dealers in selling products to customers, improving productivity.

The front end of Scout 2.0 is built through Visual Studio Code using AngularJS. The back end is implemented using several Amazon Web Services, including Lambda, Simple Storage Service, AppFlow, and Athena.



**HermanMiller**



### Michigan State University Team Members (left to right)

**Marc Colucci**  
Cranford, New Jersey

**Pooja Panguru**  
Novi, Michigan

**Albert Asta**  
West Bloomfield, Michigan

### Herman Miller Project Sponsors

**Mark Buikema**  
Zeeland, Michigan

**Andrew Furman**  
Zeeland, Michigan

**Nate Mackovjak**  
Zeeland, Michigan

**Harvey Schaefer**  
Zeeland, Michigan

**Matt Vanopstall**  
Zeeland, Michigan



# Learning A-Z

## Definition Station Word Matching Game

Founded in 2002, Learning A-Z is a technology company dedicated to expanding literacy through an extensive collection of thoughtfully designed educational tools. Catering to grades PreK-6, Learning A-Z's resources assist a wide variety of learners.

In the age of COVID-19, Learning A-Z's devotion to creating engaging online resources has become more crucial than ever. As a forward-thinking company, Learning A-Z is always developing new ways to keep students of many different abilities and interests excited to learn.

Our Definition Station Word Matching Game is a web game that teaches and reinforces vocabulary to children. The game empowers students to further their education in spelling and definition recognition. In addition, our game is customizable to fit the diverse needs of students at many different learning levels.

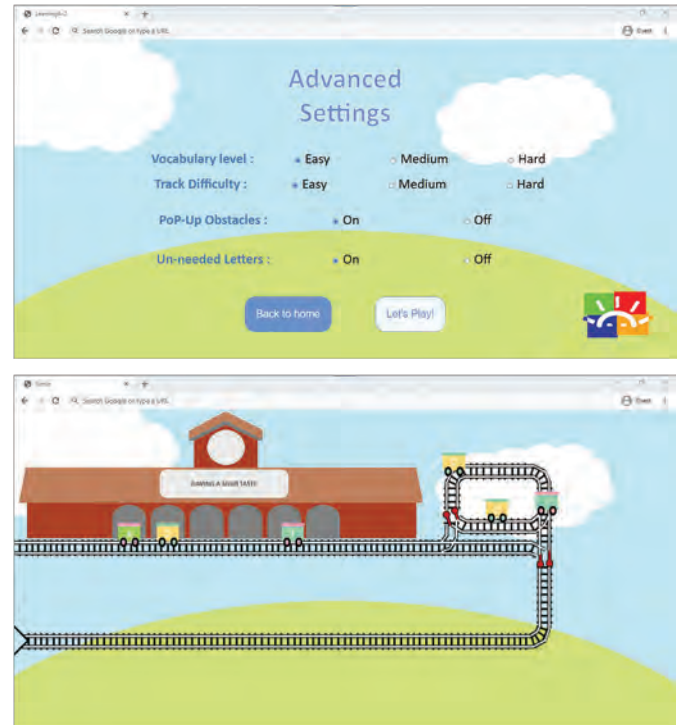
Upon beginning the game, a deck consisting of ten vocabulary words is created. The student is presented with one definition at a time until they complete all ten words in their deck or until they make three spelling errors.

The student is given a few seconds to process each definition, at which point train cars carrying letters begin rolling down the train track. The student is tasked with using switches to control the train cars' routes to the train station. A round is won when the student leads the train cars to the station in the correct order, meaning their word matches the definition and is spelled correctly.

Students choose their difficulty level from the home page before they begin playing. Parents, teachers, and older students can use the advanced settings page to further customize the difficulty.

Our game teaches new words and definitions to students in a fun and interactive way.

The software for this game is developed using JavaScript for the front end, which communicates with a MySQL database via PHP.



### Michigan State University Team Members (left to right)

**Sydney Hickmott**  
Ortonville, Michigan

**Yirong Bao**  
Ningbo, Zhejiang, China

**Jess McCoy**  
Beverly Hills, Michigan

**Clare Kinery**  
Elk Rapids, Michigan

### Learning A-Z Project Sponsors

**Paul Fonte**  
Ann Arbor, Michigan

**Kent Kanipe**  
Ann Arbor, Michigan

**John Lucas**  
Ann Arbor, Michigan

**Rick Sansburn**  
Ann Arbor, Michigan

**Alex Selleke**  
Ann Arbor, Michigan

**Jeff Weakland**  
Ann Arbor, Michigan

# Lockheed Martin Space SmartSat™ Heterogenous Computing in Space

Lockheed Martin, headquartered in Bethesda, Maryland, is the largest defense contractor in the world and receives \$60 billion in revenue annually. Lockheed Martin Space is a division of Lockheed Martin which specializes in building and deploying satellites and spacecraft for both commercial and military use.

The SmartSat software infrastructure, designed by Lockheed Martin Space, facilitates the development and deployment of software for spacecraft, which have historically leveraged all the power of the flight computers running the software that is responsible for operation of the spacecraft with little room to spare. Now that more powerful computers are available for the space domain, there is additional capacity that can be leveraged.

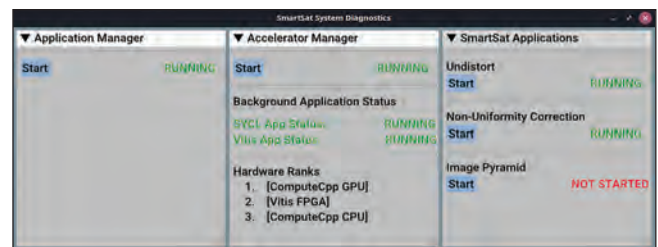
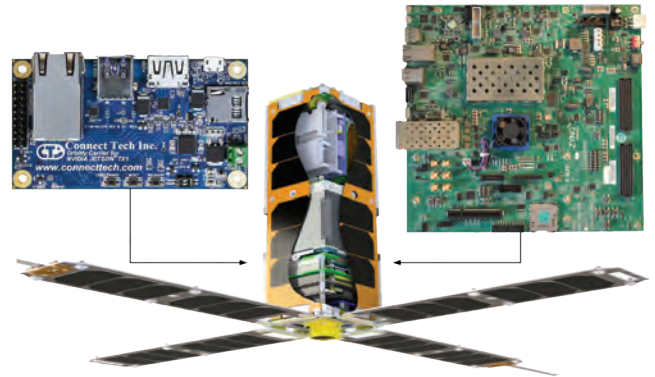
Our SmartSat™ Heterogenous Computing in Space system enables data to be processed on the satellite, reducing the need to send information over slow network connections. This reduces the bandwidth usage of the satellite by keeping raw data in orbit.

Because a satellite has significantly less computation power than computers on Earth, our system introduces clever hardware allocation schemes that can speed up image processing times on the satellite. One such optimization includes taking advantage of the wide variety of computers that exists onboard the satellite to run multiple applications at the same time.

Our system constantly analyzes the available hardware on the satellite, then assigns different SmartSat image processing applications to the hardware based on the best available option at any given time.

Our system reduces the time it takes to analyze data from satellites and ensures that the hardware onboard is used to its full capacity.

We use SYCL and Vitis to accelerate OpenCV computer vision applications on CPU, GPU and FPGA hardware.



## Michigan State University Team Members (left to right)

**Grant Youngs**  
Otsego, Michigan

**Lev Knoblock**  
Kinde, Michigan

**Anna Pastyrnak**  
Ada, Michigan

**Mason Brouwer**  
Wylie, Texas

**Eric Tyson**  
Freeland, Michigan

## Lockheed Martin Space Project Sponsors

**Josh Davidson**  
Littleton, Colorado

**Brandon Hearn**  
Littleton, Colorado

**Adam Johnson**  
Littleton, Colorado

# Malleable Minds

## Improving Access to PreK-12 Educational Opportunities

**M**alleable Minds is an emerging startup building the world's most extensive collection of PreK-12 programs, from the arts to the sciences, so students can further develop academic, interpersonal, and communication skills. Malleable Minds is breaking barriers to educational opportunities and empowering families to create a tailored educational roadmap for their children, leading them to bright futures.

Malleable Minds continually strives to bring the best user experience when designing their application. They currently have a review aggregator for educational programs.

Our Improving Access to PreK-12 Educational Opportunities project builds many features on top of the existing review aggregator website and improves site performance.

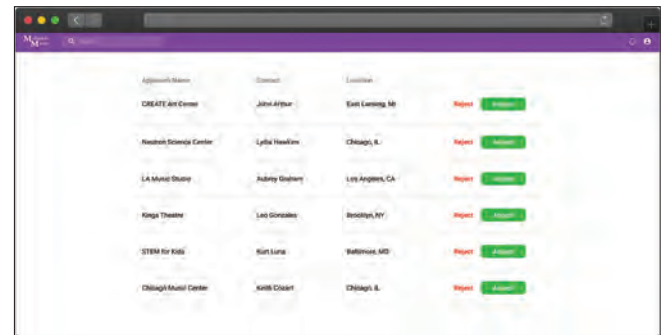
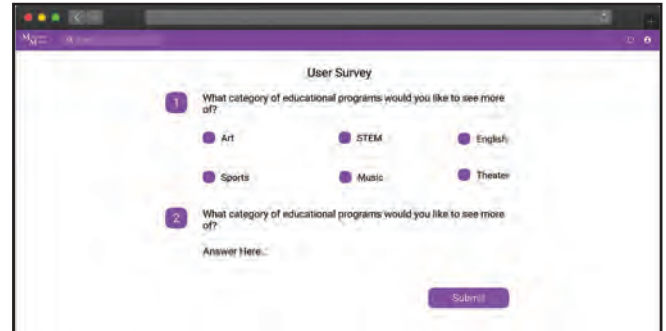
The site's users benefit from several new additions. When a user creates an account, a walkthrough shows key site features. Users are kept up to date through customized notifications based on type of user profile, location, and what areas they are interested in. User surveys capture feedback about the site's features and potential future improvements.

Administrative users also gain additional functionality. The administrative workflow page allows for authentication of applicants requesting either a program owner or educator account.

Site administrators can view a user dashboard with details about how the site is being used. The dashboard provides data such as when users log in, search for programs, write reviews, and more.

Our enhanced site is more efficient, faster, and includes more features that enhance the user experience and track usage metrics and user feedback, allowing Malleable Minds administrators to continually improve the site.

Our software uses React on the front end and Python on the back end. We host our software on Amazon Web Services.



Malleable  
Minds



**Michigan State University**  
**Team Members** (left to right)

**Kathryn Pereira**  
Brighton, Michigan

**Tianrui Liu**  
Hefei, Anhui, China

**Osama Altwil**  
Detroit, Michigan

**Silayman Nagi**  
Hamtramck, Michigan

**Malleable Minds**  
**Project Sponsors**

**Ripple Goyal**  
Los Angeles, California

**Cathalina Juarez**  
Frederick, Maryland

**James Pita**  
Frederick, Maryland



# Meijer Meijer Store Wayfinding

Meijer is a major supercenter chain headquartered in Grand Rapids, Michigan, with locations throughout the Midwest. There are a total of 253 Meijer Supercenter stores, making it the 26th largest retailer in the United States. The Supercenter store layout is an idea that was pioneered by the Meijer Corporation, which combines groceries and department store goods all in one store.

Meijer is constantly at the forefront of innovation, especially when it comes to offering customers the optimal shopping experience. Because of the inherent size of Meijer supercenters, customers may find it difficult to locate the specific product they are looking for in an efficient manner. In addition, the layout of Meijer stores can vary greatly by location and are periodically changed, adding to shopper confusion.

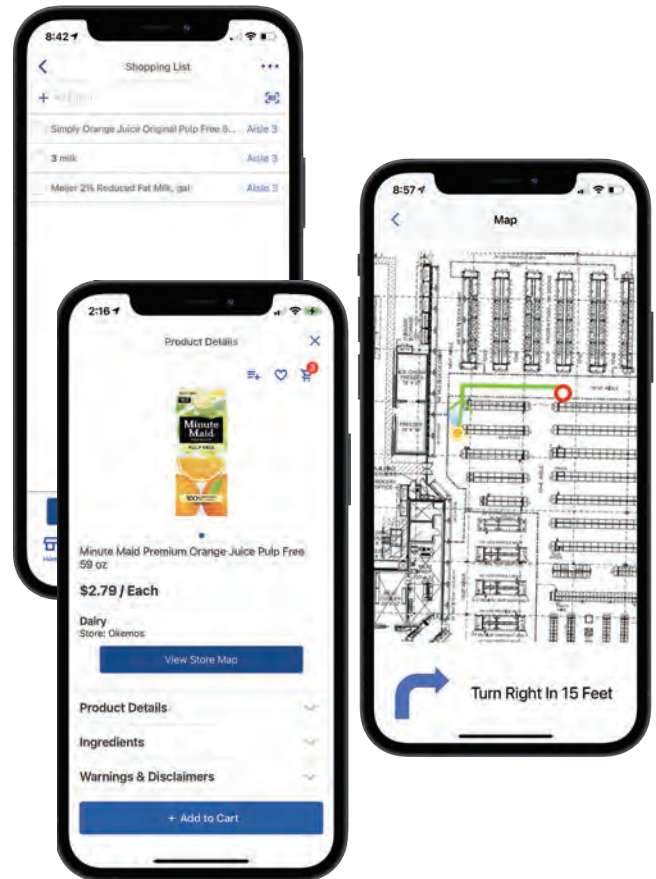
Our Meijer Store Wayfinding functionality offers Meijer shoppers a solution to this problem by integrating an intuitive and easy-to-use navigation interface in the Meijer mobile application.

Using our mobile application, customers are given a full map of their Meijer store, including a dot showing their current location in the store. This is achieved using MIST wireless access points that Meijer is introducing to their stores.

In addition to this mapping feature, our application offers turn-by-turn navigation of Meijer stores. Users input an item or list of items into our application and are shown the optimal path through the store to each item on their list. Directions to each item are shown on the map screen, similar to how Google Maps works while driving a car.

Meijer Store Wayfinding enhances the customer experience of all Meijer shoppers and allows them to feel more in control of their shopping experience.

Our software is written in Swift and is integrated with Mist Access Points to get live location data of shoppers.



### Michigan State University Team Members (left to right)

**Minhal Ansari**  
West Bloomfield Township, Michigan

**Nathan Holdom**  
Clinton Township, Michigan

**Jacob Sak**  
Traverse City, Michigan

**Avni Avdulla**  
St Clair Shores, Michigan

### Meijer Project Sponsors

**Bill Baer**  
Grand Rapids, Michigan

**Chirag Ghimire**  
Grand Rapids, Michigan

**Phil Kane**  
Grand Rapids, Michigan

**Dominic Lanzillotta**  
Grand Rapids, Michigan

**Chris Laske**  
Grand Rapids, Michigan

**Terry Ledbetter**  
Grand Rapids, Michigan

**Nick Widenmier**  
Grand Rapids, Michigan

# Michigan State University Animal Science Pesticide Management for Sustainable Vineyards

Michigan State University is a public research university boasting approximately 50,000 enrolled students. Originally founded as an agricultural college, the MSU Department of Animal Science remains a pioneer in agricultural research.

Michigan is home to a very large grape-growing industry. Vineyard owners and workers must cooperate to manage, track and control insect infestations and disease outbreaks as they arise.

Our Pesticide Management for Sustainable Vineyards system provides a solution for workers in both the field and in the office.

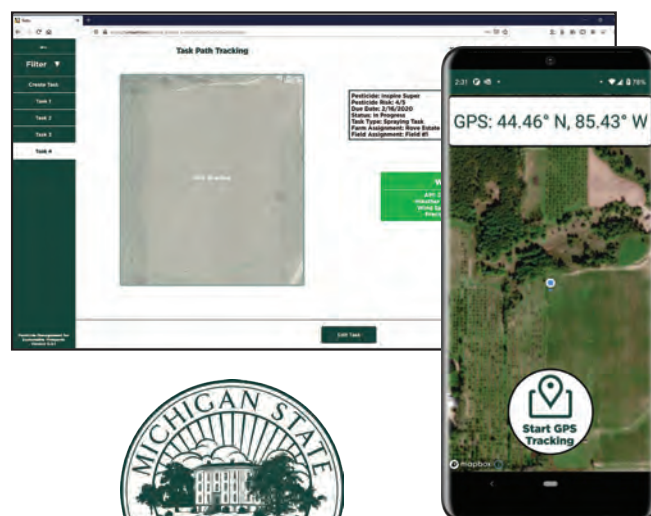
When a field worker opens the app on their Android or iOS device, they can immediately view upcoming tasks, such as spraying a new pesticide onto their crop. When performing these actions, pertinent information like weather conditions and GPS location is collected. While in the field, workers can take pictures of new infestations as they arise, reporting them to management.

Vineyard managers can view this information on our system webpage, as well as automatically generate records of pesticide use for the USDA or MDARD. They can view maps of their field with up-to-date information about current infestations and outbreaks, and assign new tasks to their workers to mitigate them.

Our system also calculates a risk factor for each pesticide based on the unique circumstances of each vineyard and field. This allows vineyard owners to select pesticides that are effective, sustainable, and safe for both their employees and their consumers.

Our software streamlines the process of identifying, mitigating, and reporting pests and chemical usage for the grape-growing industry, and creates a repository of information for further research into Michigan's ecology.

The Pesticide Management for Sustainable Vineyards back end is a server utilizing a LAMP stack. The application is written in PHP for web, Java for Android, and Swift for iOS.



## Michigan State University Team Members (left to right)

**Melanie Harju**  
Grand Rapids, Michigan

**Mohammed Al-Tameemi**  
Zayoona, Baghdad, Iraq

**Yiteng Zhang**  
Dongying, Shandong, China

**Matt Davis**  
Battle Creek, Michigan

## MSU Animal Science Project Sponsors

**Karen Chou**  
East Lansing, Michigan

**Dennis Phillips**  
East Lansing, Michigan

**Cara Robison**  
East Lansing, Michigan



# Mozilla Corporation Pushing Picture-in-Picture towards Perfection

Mozilla is the company behind Firefox, the world's leading open-source web browser with over 200 million monthly active users. Mozilla is a non-profit organization headquartered in Mountain View, California, that has long been on a mission to keep the internet open and accessible to all people to enrich lives and foster innovation.

Firefox has introduced many tools to help their users better manage their multitasking. At the forefront is their Picture-in-Picture (PiP) feature that allows multiple videos to be “popped” out of the browser into dedicated windows that are always on top of all other windows. PiP is ideal for taking notes during a lecture or even watching multiple YouTube or Netflix videos at once.

Since the release of Picture-in-Picture, many users have requested that the feature be expanded, improved, and pushed “towards perfection.”

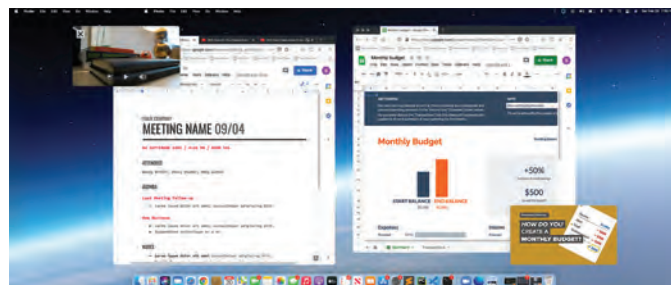
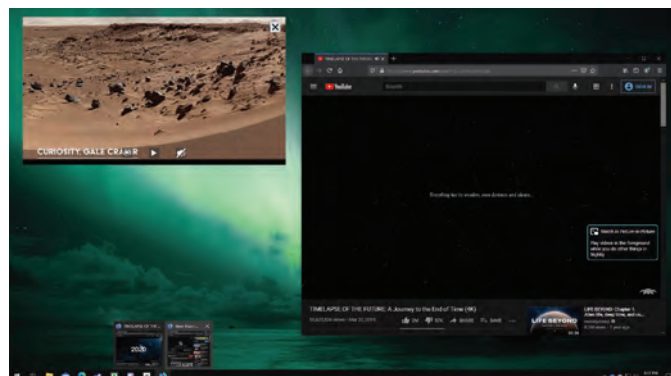
Previously, users had limited control over the PiP window when it was “popped” out of the web browser, which could lead to frustrations when trying to interact with the video.

Our Pushing Picture-in-Picture towards Perfection project mitigates these issues by giving the user greater control of their PiP windows and improves the overall user experience of Firefox's PiP.

Our additions to PiP include allowing captions in the PiP window and allowing for keyboard control of things like timing, volume and size, as opposed to forcing the user to use the mouse in the browser.

These additions reduce the need for the user to interact with the browser and allow for more seamless multitasking while using Firefox.

Running with multiple languages (C++, HTML, JavaScript), PiP lives within the Firefox codebase. However, as a feature, PiP is primarily based on HTML and JavaScript.



## Firefox Browser



### Michigan State University Team Members (left to right)

**Swapnik Katkoori**  
Okemos, Michigan

**Tony Froman**  
Eagle, Michigan

**Oliver Pope**  
St. Joseph, Michigan

**Guanlin Cheng**  
Huang Shi, Hu Bei, China

**David Hefty**  
Holt, Michigan

### Mozilla Project Sponsors

**Mike Conley**  
Toronto, Ontario, Canada

**Molly Howell**  
Portland, Oregon

**Gijs Kruitbosch**  
Hinckley, Leicestershire, United Kingdom

**Micah Tigley**  
Toronto, Ontario, Canada

**Jared Wein**  
Burton, Michigan



# MSU Federal Credit Union Augmented Reality Financial Education

Founded in 1937 in East Lansing, MSU Federal Credit Union provides a variety of financial services to students, faculty and staff at Michigan State University and Oakland University. With 21 branches and over 300,000 members, it is the largest university-based credit union in the world.

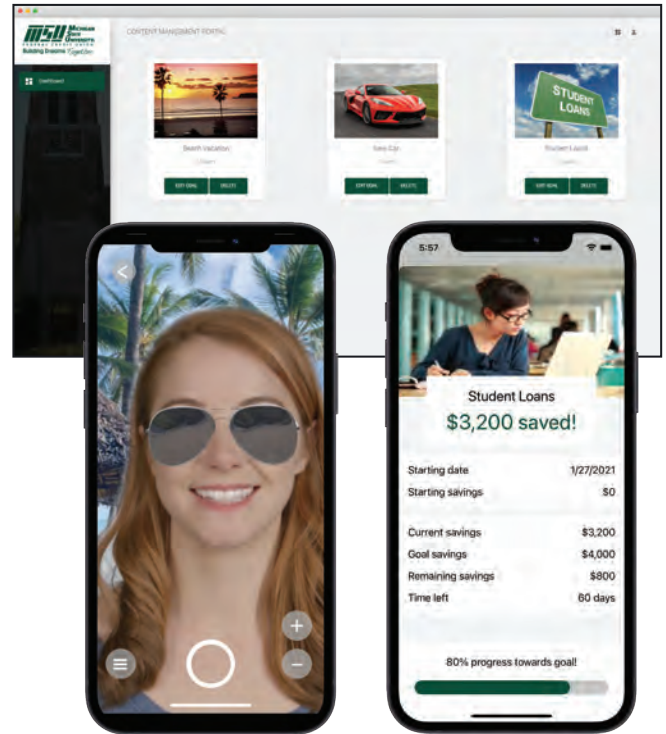
MSUFCU provides a variety of financial education resources to its customers to ensure they are making the best monetary decisions. Our Augmented Reality Financial Education application serves to gamify saving money and provide encouragement to their customers throughout the process.

Our mobile app teaches customers about saving money through a new feature called goal journeys, which includes various savings goals that a user can choose from, such as saving for a beach vacation, paying off student loans, or buying a house.

After a user selects a goal journey, they are asked to set aside a certain amount of money for the goal, as well as determine what their overall savings goal is and how long they want to save. Once this information is gathered, our application offers detailed savings reports and their overall progress towards their goal.

As the user progresses towards their goal, they have the option of using our augmented reality view, which helps them visualize their progress towards their goal. For example, as the user saves money, the augmented reality view for the beach vacation goal journey shows the user with a beach towel, then with sunglasses and a surfboard, until they eventually reach their savings goal, and the augmented reality view shows them on vacation. This visualization of progress helps fully immerse the customer in their savings goal.

Our Augmented Reality Financial Education mobile app is built using Swift for iOS and Java for Android. The web app is built using ReactJS. The back end for all applications is built using PHP and PHPMyAdmin.



## Michigan State University Team Members (left to right)

**Nick Snider**  
Petoskey, Michigan

**Aiden Tang**  
Guangzhou, Guangdong, China

**Destiny Ong**  
Lansing, Michigan

**Malik Arachiche**  
Boston, Massachusetts

## MSU Federal Credit Union Project Sponsors

**April Clobes**  
East Lansing, Michigan

**Ben Maxim**  
East Lansing, Michigan

# Proofpoint

## Predicting the Future through Spam Signal Intelligence

Founded in 2002, Proofpoint is a cybersecurity company based in Sunnyvale, California, that safeguards their clients and their clients' data from online threats. Proofpoint identifies and filters threats from email, the web, the cloud, social media and mobile messaging. They protect banks, research facilities, universities and numerous companies across the world.

To this end, Proofpoint has accumulated terabytes of spam and analyzed it to predict potential risks and provide improved security.

Our Predicting the Future through Spam Signal Intelligence system analyzes this spam email data for patterns to help users predict real-world events.

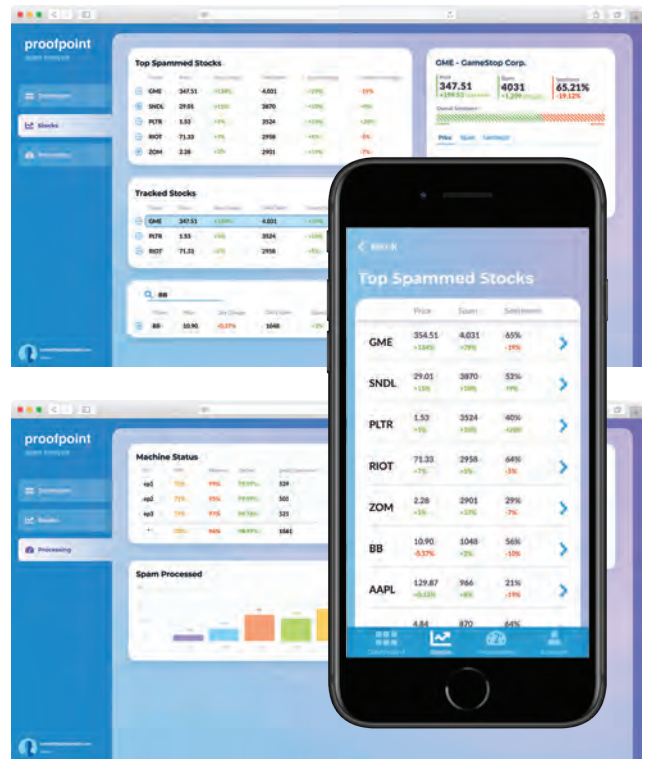
Our system sorts emails by topic and sentiment with machine learning, analyzes them for underlying patterns, then charts them against real-world outcomes to hone the predictive algorithms. These methods can be used to anticipate wide societal events such as election outcomes and stock market fluctuations.

The resulting predictions and data are viewable from our web dashboard. The dashboard can be configured to view statistics such as spam volume, general sentiment regarding a topic, changes in sentiment over time, and projected future sentiment.

Proofpoint analysts evaluating future risks use our dashboard to forecast potential events and take measures early on to ensure they are well-prepared to protect their clients. This allows Proofpoint to provide improved security.

Our back end runs a PostgreSQL database server to store information gleaned from the spam email files. We use Flair and scikit-learn for machine learning and an email parser to extract information from the spam.

Our web dashboard is built on the Django framework and Apache server. It displays information from the database through a React user interface.



# proofpoint™



### Michigan State University Team Members (left to right)

**Caleb Kish**  
Saginaw, Michigan

**Raymend Zheng**  
Guangzhou, Guangdong, China

**Chris Lu**  
Plymouth, Michigan

**Michael Giovinnazzo**  
Lake Orion, Michigan

### Proofpoint Project Sponsors

**Yash Patel**  
Sunnyvale, California

**Mercedes Sanchez**  
Sunnyvale, California

**Brad Woodberg**  
Plymouth, Michigan

# Quicken Loans Project Relo

Headquartered in the heart of Detroit, Michigan's financial district, Quicken Loans is the nation's largest online mortgage lender. They have been providing affordable mortgages and award-winning client service for more than 30 years.

Employee relocation can be complex and stressful, especially the home mortgage acquisition process. Unfortunately, enterprise relocation agents must complete this process manually for multiple employees concurrently. This can be time-consuming and leaves room for data entry errors.

Our Project Relo software is a web-based application that allows agents to easily store employee data and distribute it to partnered mortgage companies. Within our website, mortgage request update messages keep the agent and mortgage bankers aware of the requests' statuses.

Upon login, relocation agents can view their currently active employee relocations and mortgage requests, shown in the top artwork. They can add new relocations and requests to the website through a simple form.

When selecting an employee relocation, the details are displayed, shown in the bottom artwork. From here, the agent can create new mortgage requests and complete the mortgage process on the employee's behalf. Agents can select a mortgage request to view progress updates with timestamps. Completed relocations are archived and can be searched for by name or ID.

Our website also supports an admin user. They can add mortgage companies and agents into our software. If either of these users have their access revoked, their information is archived, and the admin can search for it by name or ID.

Our front-end web application is built with ReactJS while the back end utilizes Node.js, GraphQL and DynamoDB. All components of Project Relo are hosted on Amazon Web Services.



**Quicken Loans®**  
Engineered to **Amaze**™



## Michigan State University Team Members (left to right)

**Jihwan Kim**  
Rochester, Michigan

**Akshar Korlepara**  
Bangalore, Karnataka, India

**Gabby Kelsch Bledsoe**  
Lees Summit, Missouri

**Jewelyan Bradley**  
Detroit, Michigan

**Miaoyu Yang**  
Changsha, Hunan, China

## Quicken Loans Project Sponsors

**Jason Bock**  
Detroit, Michigan

**Chris Woodruff**  
Detroit, Michigan



# Quicken Loans Rocket DevRel Tracker

Headquartered in the heart of Detroit, Michigan's financial district, Quicken Loans is the United States' largest online mortgage lender. Rocket Mortgage was launched in 2015 to serve as Quicken Loans' online mortgage lending platform.

Rocket Mortgage recently created a Developer Relations team that participates, sponsors, and speaks at virtual or in-person conferences and events to help communicate supported products and services. This has resulted in the need to collect and share relevant information and data.

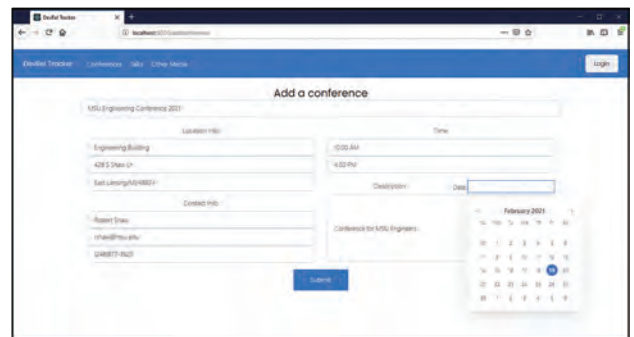
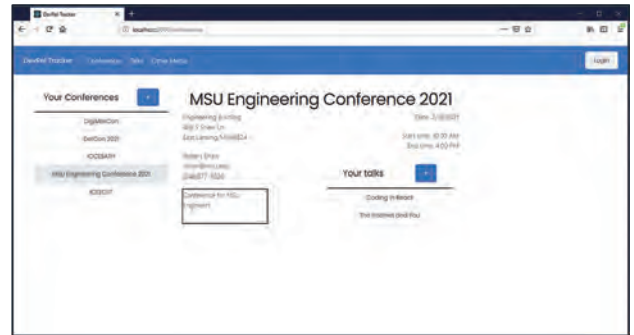
Our Rocket DevRel Tracker is a responsive web-based application that allows the Developer Relations team to track upcoming conferences, view submitted talk details for discussion, and store related personal media.

Users can view future conference details along with whether Rocket Mortgage has obligations such as operating booths or speaking at any given event. Conferences are stored so that ratings can be given to past events for leadership to evaluate if the team should return the following year.

Within our system, speakers can store, track and submit talk details for acceptance at conferences and events. The Developer Relations team reviews talk details and decides whether to approve them. Other users can then view accepted talks and their information, such as location and time.

Our system automates much of the work currently done manually by the Developer Relations team in order to free their time. This allows them to focus on the conferences and events themselves, improving efficiency and productivity.

Our web application uses Google's Firebase hosting platform for the API as well as the document-oriented database, Cloud Firestore. In addition, the front end of the application utilizes ReactJS.



**ROCKET**  
Mortgage  
by Quicken Loans



### Michigan State University Team Members (left to right)

**Shihao Wang**  
Wenzhou, Zhejiang, China

**Ethan Fulcher**  
Troy, Michigan

**Tyler Benyukhis**  
Buffalo Grove, Illinois

**Trent Belanger**  
Lake Orion, Michigan

### Rocket Mortgage Project Sponsors

**Jason Bock**  
Detroit, Michigan

**Cassandra Faris**  
Detroit, Michigan

**Chris Woodruff**  
Detroit, Michigan

# TechSmith

## TechSmith Answers

Headquartered in Okemos, Michigan, TechSmith provides software that empowers people to communicate more effectively by easily creating visual content. Their flagship products, Snagit and Camtasia, are used by more than 30 million people worldwide.

TechSmith also offers TechSmith Knowmia, a platform where content creators can upload and share collections of media for other users to watch. One common use case of Knowmia is that of instructor and student within an educational institution.

Instructors often upload large collections of videos for students to watch, such as a set of videos that covers a module within a course. Because there are such a large number of videos, students often find it difficult to find videos to answer their question, or a video on a particular topic.

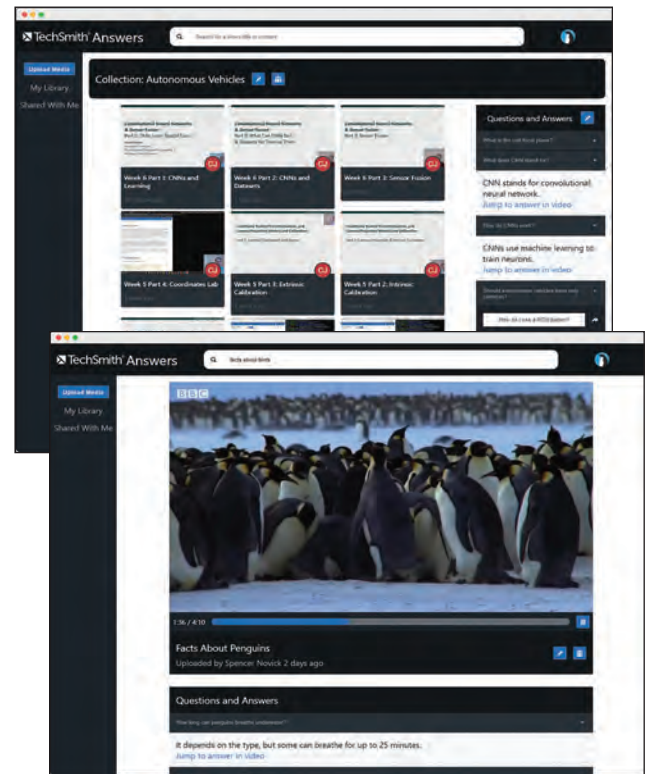
Our TechSmith Answers platform provides a solution to this problem through an intuitive web dashboard that allows users to easily search and navigate large collections of media without any additional effort by video creators.

TechSmith Answers uses speech-to-text software to create subtitles for every video uploaded to our system. Using these subtitles, our system uses natural language processing to determine questions that can be answered by the video.

When a user searches for a video on a particular topic, TechSmith Answers directs them to the exact minute of a particular video that helps solve their problem.

Our system improves the learning experience of students by allowing them to spend their time studying instead of searching through videos for hours on end.

TechSmith Answers uses Microsoft Azure for data storage, speech-to-text generation, natural language processing, search, and sign-in. The front end is built using ReactJS, and the back end is built using .NET Core.



**Michigan State University**  
**Team Members** (left to right)

**Zhehao Zhou**  
Shanghai, Shanghai, China

**Spencer Novick**  
Bloomfield Hills, Michigan

**Rachel Allen**  
Manchester, Michigan

**TechSmith**  
**Project Sponsors**

**Jake Hall**  
Okemos, Michigan

**Wendy Hamilton**  
Okemos, Michigan

**TJ Kelly**  
Okemos, Michigan

**Tony Lambert**  
Okemos, Michigan

**Dave Norris**  
Okemos, Michigan

**Scott Schmerer**  
Okemos, Michigan

# United Airlines Turn Management Analyzer

United Airlines, Inc. is a leading American airline headquartered in Chicago, Illinois. In 2019, United and United Express operated more than 1.7 million flights carrying more than 162 million customers to their destinations safely.

Safety is United Airlines' number one priority on every flight. An aircraft turn accounts for the time it takes for a series of safety procedures to be carried out by United Airlines' employees from when the aircraft arrives at the gate to when it clears for departure.

Auditors conduct live audits of aircraft turns to determine whether the arrival and departure steps are compliant or non-compliant per standard operating procedure. United Airlines is exploring ways to automate the recognition of some of these aircraft turn tasks.

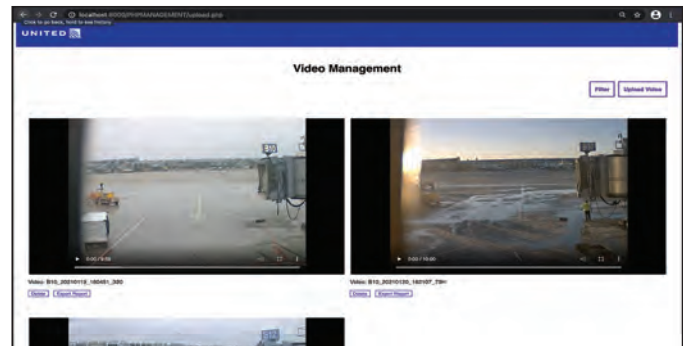
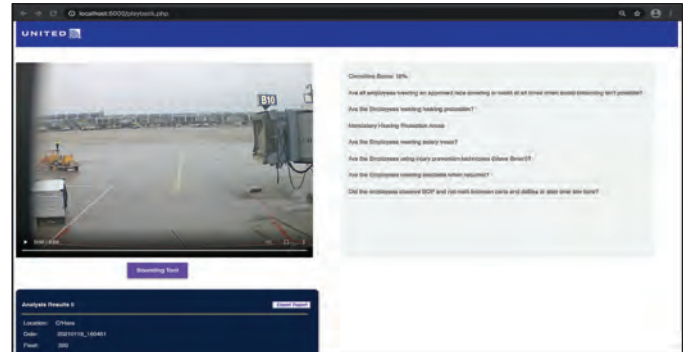
Our Turn Management Analyzer automatically identifies and evaluates the aircraft turn using the video camera feeds at each airport gate.

When an aircraft begins a turn, our system uses computer vision algorithms to track any objects and people working on the aircraft to determine if they are compliant with all safety protocols and complete the proper steps for a safe aircraft turn.

If our system detects a task that is performed incorrectly, out of sequence, or any employee not following safety protocols, it flags this action for review by a United Airlines auditor who can evaluate the situation.

Our software helps auditors ensure that United Airlines always provides their customers with the safest flight possible.

The front end is written in HTML, JavaScript and CSS. The back end consists of a MySQL database and PHP scripts to process data. The computer vision analyzer is developed with PyTorch, TensorFlow, OpenCV and Python.



### Michigan State University Team Members (left to right)

**Xavier Reinders**  
Canton, Michigan

**Zack Liu**  
Beijing, Beijing, China

**Amtullah Naalwala**  
Mississauga, Ontario, Canada

**Peter Ro**  
Bloomfield Hills, Michigan

**Morgan Sandler**  
Novi, Michigan

### United Airlines Airport Operations Project Sponsors

**Ken Allen**  
Chicago, Illinois

**Adriana Carmona**  
Chicago, Illinois

**Christine Clarida**  
Chicago, Illinois

**John Kleberg**  
Chicago, Illinois

**Juan Munoz**  
Chicago, Illinois

**Chris Ritzert**  
Chicago, Illinois

**Moin Siddiqui**  
Chicago, Illinois

**James Walker**  
Chicago, Illinois



# United Airlines Training Multimedia Content Management System II

United Airlines is a major international air-carrier headquartered in Chicago, Illinois. In 2019, United Airlines operated 4,900 flights a day from 362 airports. Running an airline requires diligence in all logistical and technical aspects to ensure the best flight experience for “Every customer. Every flight. Every day.”

Within United Airlines, the TechOps training division is responsible for teaching United’s technicians how to operate and maintain their wide variety of aircrafts. To supply this training, United Airlines currently maintains a vast encyclopedia of training documents and videos.

Our Tech Ops Training Content Management System II builds off a previous capstone project and provides quick access to this training content through an intuitive, easy-to-use website.

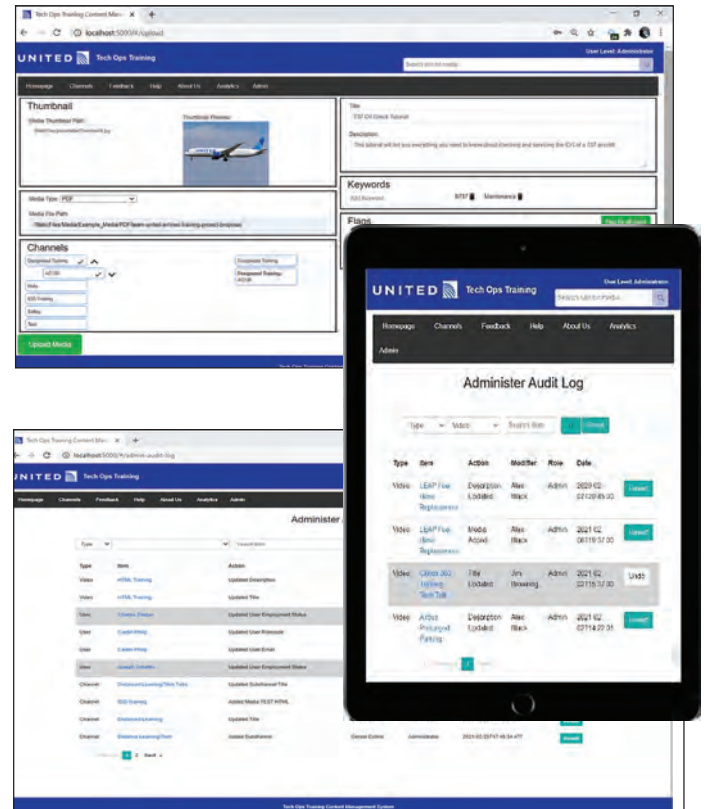
Our work expands an already existing website to give United Airlines employees and administrators a better user experience and greater control of their training media needs.

When employees use our system for training, they are given many tools to track and assess their training progress. An engagement report is generated for each user, which includes a collection of their recently viewed content, bookmarked videos, comments and likes.

United Airlines administrators are given improved tools for content upload and management, including options for bulk import and export of training content. Additionally, administrators are given an audit log to track any requested changes.

Our system greatly improves content management, saving employees and administrators significant time and effort.

Our system is optimized for both tablet and desktop use and is built using ASP.NET Core 3.1, Angular 10, Node.js, Entity Framework, and an Azure SQL Database. The web app is hosted on a Microsoft IIS server.



## Michigan State University Team Members (left to right)

**Yu Sun**  
Qingdao, Shandong, China

**Spencer Cassetta**  
Grand Rapids, Michigan

**Madelaine Brownley**  
Canton, Michigan

**Alex Black**  
St. Clair Shores, Michigan

## United Airlines Training Project Sponsors

**Craig Bennett**  
Chicago, Illinois

**Rick Brown**  
Chicago, Illinois

**Lynda McDaniel**  
Houston, Texas

**Tom Wilson**  
Chicago, Illinois

# Urban Science Service Flash Mobile

Headquartered in Detroit, Urban Science is internationally renowned for providing data-driven, science-based solutions to problems in the automotive industry. With strong industry knowledge, Urban Science provides meaningful solutions for companies from GM to Ferrari.

Currently, dealership field workers, who go from dealership to dealership analyzing data, must set up a work environment to access key metrics in every dealership they visit. This manual process takes time that could be used devising sales strategies.

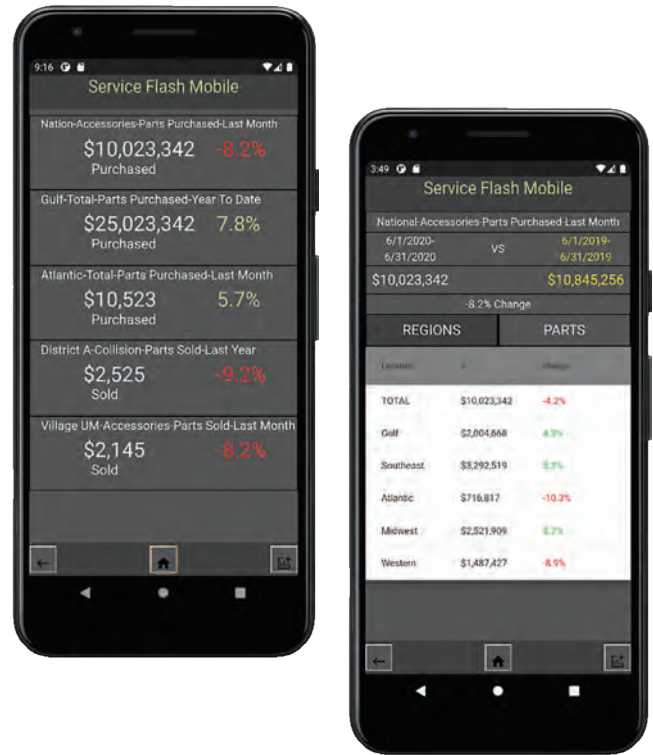
Our Service Flash Mobile application provides an easily digestible interface for field workers to choose what metrics they would like to view in order to help with sales strategy.

When a user first logs in they are met with a customizable home page. Metrics can be added to the home page by selecting the filters that are desired. The filters range from geography, part type, sold or purchased, and time.

Our software is designed to let users access each metric to view more details about that metric. Details about the metric are broken down further on the metrics page. Depending on the filters applied, users can compare the data selected to either a target goal or the previous year's data. This allows executives at Urban Science to identify areas of opportunity and track progress towards goals quickly, allowing them to act early enough to meet their goals.

Our mobile application allows Urban Science clients to access key metrics intuitively and in a timely manner, which increases communication and productivity in the workplace.

The front end of our application uses Angular, which is a framework that entails HTML, CSS and Typescript, wrapped in Cordova for iOS and Android integration. The back end uses C# and a SQL database hosted on Microsoft Azure. The API is hosted on Microsoft Azure.



URBAN SCIENCE.



### Michigan State University Team Members (left to right)

**Olivia Mikola**  
South Lyon, Michigan

**Matt Alex**  
Hamburg, Michigan

**Parker Kirby**  
Ionia, Michigan

**Jack Ying**  
Wuhan, Hubei, China

### Urban Science Project Sponsors

**Robert Buttery**  
Detroit, Michigan

**Mike DeRiso**  
Detroit, Michigan

**Elizabeth Klee**  
Detroit, Michigan

**Timothy Scogin**  
Detroit, Michigan

# Vectorform

## Remote Teams AR Training

Vectorform was founded in Detroit in 1999 and has provided a platform for many leading brands to solve big problems with inventions emerging at the forefront of technology. They work with a variety of technologies including hardware engineering, Internet of Things, augmented reality and virtual reality in their solutions.

COVID-19 has caused an unprecedented number of employees worldwide to work from home. This has created many problems that need to be solved. One such problem is that of providing interactive learning in a remote environment.

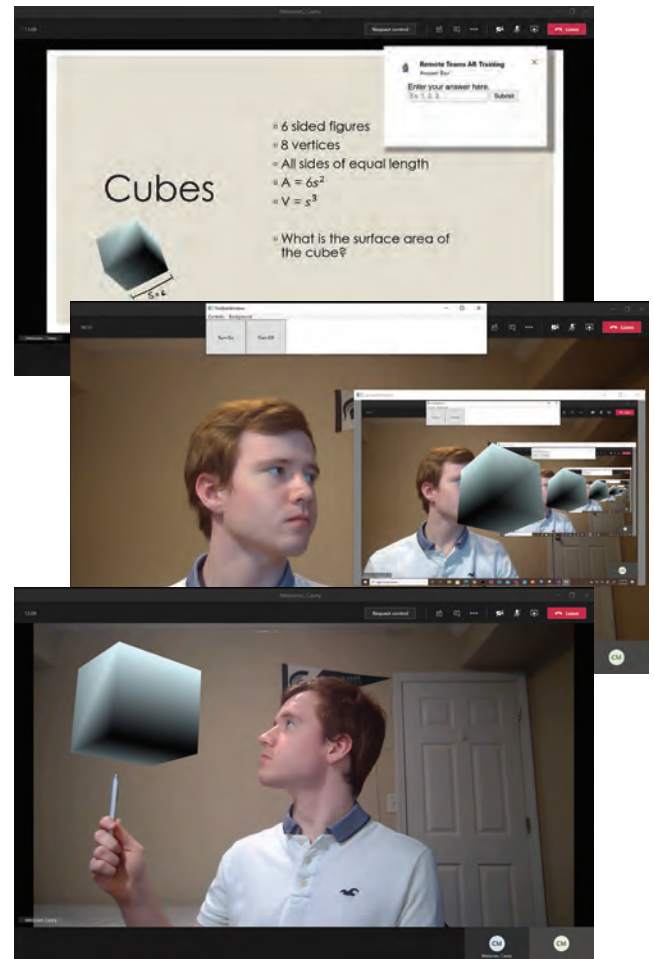
Our Remote Teams AR Training platform helps mitigate these problems with a Microsoft Teams application that gives instructors and students the tools needed to succeed in a remote learning environment.

Our instructor application allows educators to display 3D objects in a Microsoft Teams video stream (shown on the right), and provides a framework to present questions in real time to trainees that are saved for analysis of trainee progress.

When planning a lecture, instructors are given an intuitive interface to select and test various 3D object files on their video feed. Instructors can then present these 3D objects with themselves and other training materials in the background when they hold a live lecture to make their lecture more engaging to the trainees.

Our software also allows instructors to quiz trainees on the topics being discussed, which can then be analyzed to make sure that trainees are learning the material properly.

The 3D object manipulation aspect of our program is implemented as a C# program which interfaces with the camera feed for Microsoft Teams. The quiz portion of our program utilizes JavaScript to make a custom Microsoft Teams module. Both of these sides of the program connect to a SQLite database, which stores the quiz and 3D object information.



### Michigan State University Team Members (left to right)

**Charlie Meissner**  
Royal Oak, Michigan

**Billy Pan**  
Saginaw, Michigan

**Emily Westrick**  
Holland, Michigan

**Ao Ma**  
Beijing, Beijing, China

### Vectorform Project Sponsors

**Chris Cornish**  
Royal Oak, Michigan

**Woody Floyd**  
Royal Oak, Michigan

**Jeff Meador**  
Royal Oak, Michigan

**Josh Parmenter**  
Seattle, Washington



# Design Day Awards

CSE498, Collaborative Design, is the senior capstone course for students majoring in computer science. Teams of students design, develop and deliver a significant software system for corporate clients. The CSE capstone teams compete for four prestigious awards. Here are the winners from the fall of 2020.

---

## Auto-Owners Insurance Exposition Award

***Auto-Owners***  
INSURANCE

CSE 498 capstone teams present their projects on Design Day in a variety of ways. Teams create and set up an exhibit where they demonstrate their software systems and answer questions from Design Day attendees. Each team plays their project videos and answers questions for a panel of judges.

The CSE capstone team with the best overall Design Day performance is honored with the Auto-Owners Exposition Award, which is sponsored by Auto-Owners Insurance Company of Lansing, Michigan.

Team Malleable Minds  
Review Aggregator for Educational Programs



Cody Carter, Becky Henning, Brian Martin, Jerry Cortez  
Presented by Tony Dean, Ross Hacker and Scott Lake

---

## MSU Federal Credit Union Praxis Award



One of the hallmarks of CSE 498 capstone projects is that of praxis, the process of putting theoretical knowledge into practice. Teams apply a wide variety of information technologies to produce solutions to complex problems in areas such as business, engineering, computing, and science.

The CSE capstone team that engineers the software system that is the most technically challenging is recognized with the MSU Federal Credit Union Praxis Award, which is sponsored by MSU Federal Credit Union of East Lansing, Michigan.

Team Bosch  
Identity Based Communication and Content Services



Alex Norris, Sam Richardson, Adam Gongol, Hannah Striebel  
Presented by April Clobes and Ben Maxim



---

## TechSmith Screencast Award



Each CSE 498 capstone team produces a video that describes and demonstrates their software product. Starting with a storyboard and a script, teams use Camtasia Studio to synthesize screen recordings, video, audio and other multimedia to produce their project videos.

And the TechSmith Screencast Award goes to... the CSE capstone team with the best project video. The award is sponsored by the creators of Camtasia Studio, TechSmith of Okemos, Michigan.

Team United Airlines Training  
Tech Ops Training Content Management System



Chris Nosowsky, Brendan Walsh, Jeremy Zhu, Shawn Pryde  
Presented by Wendy Hamilton, Tony Lambert and David Norris

---

## Urban Science Sigma Award



The CSE 498 experience represents the capstone of the educational career of each computer science major. An intense semester of teamwork produces impressive deliverables that include a formal technical specification, software, documentation, user manuals, a video, a team web site, and Design Day participation. The resulting sum, the capstone experience, is much greater than the parts.

The capstone team that delivers the best overall capstone experience is recognized with the Urban Science Sigma Award, which is sponsored by Urban Science of Detroit, Michigan.

Team Volkswagen  
VW Car-Net Electric Vehicle Route Planner



Joey Kelly, Andrew Smigielski, Zosha Korzecke, Michael Lin, Erich Hairston  
Presented by Robby Buttery, Mike DeRiso and Elizabeth Klee

# ENGINEERING AT



## {DEVELOP} with us

We're always on the lookout for software engineers who are passionate about technology, who care about the work they do and the people they work with. People who aren't put off by a wild idea (in fact, they crave other perspectives) and love working with a team.

From Quality Assurance to Software Development, TechSmith Engineers get the chance to work on multiple software products, in a variety of languages, and on different operating systems (Windows, Mac, iOS, and Android, plus Cloud products)



## Benefits {DEVELOP}ed to support you



### Health, Vision, Dental & More

TechSmith offers excellent health, dental and vision coverage for employees and their dependents. We also offer long-term and short-term disability coverage and life insurance at no cost.



### Paid Time Off

TechSmithies get generous paid time off (about 18 days the first year), with more days off added the longer you're here. You also get a paid day off for your birthday, in addition to the major holidays, and a paid day off each year to volunteer for a cause you love.



### Paid Family Leave

TechSmith offers up to three weeks of paid family medical leave to employees following Family and Medical Leave Act (FMLA) qualified and approved leave.



### Tuition & Loan Assistance

TechSmith supports a portion of loan repayment and pays  $\frac{2}{3}$  of any tuition and books for qualified classes taken by full-time employees to improve their job skills, up to \$5,250 per year.



### Investment Plan

TechSmithies can participate in the company's 401(k) investment plan. TechSmith will match employee contributions up to 3% of your salary, and 50% matching for the next 2% of your salary you contribute.



### Profit Sharing

TechSmith offers quarterly and annual bonuses to full-time employees based on company profitability and increase in sales from the previous year for the same period.

Explore open positions and submit your application at [techsmith.com/careers](https://techsmith.com/careers).









ECE 101 Introduction to Electrical and Computer Engineering

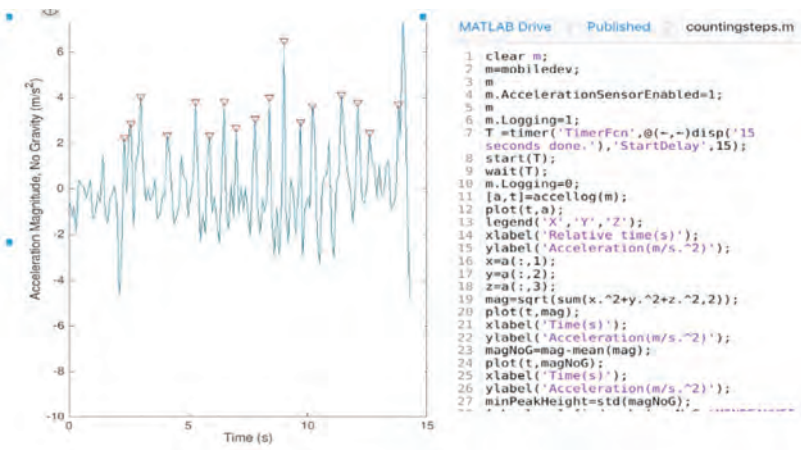
Dr. Dean M. Aslam  
Professor of Electrical and Computer Engineering

Problem Statement

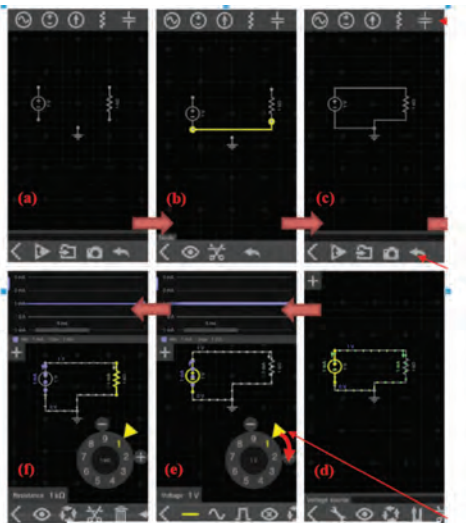
ECE 101 is an elective course introducing freshman students to Electrical and Computer Engineering through a series of unique/innovative online hands-on flipped laboratory experiments linked to Smartphone and research-oriented teaching approaches. The experiments include (a) MATLAB Mobile on Smartphone; Import and Plot Data from Built-in Smartphone-Sensors, (b) Study Ohm’s Law using Simulation Apps, (c) Create Smartphone App Using MIT’s App Inventor or similar software for iPhone, (d) Built-in Smartphone-Sensors: Plotting Angular Velocity and Device Orientation by MATLAB Mobile, and (e) Other Smartphone-Sensors.

Student Assistant: Mohammed Alshammari

Team Members	Project Title
<b>Team #1:</b> Moez Fraz Ahmed Simon Alstrom Armand Castro	Smartphone Blood Testing
<b>Team #2:</b> Chris Charles Dylan Curtis Raul Dsouza	Smartphone Health Monitoring
<b>Team #3:</b> Jaden Hanold Ethan Labelle Zainub Larji Eric Lopez	Smartphone Blood Testing
<b>Team #4:</b> Stephen Moussiaux Marcell Taylor Dejon Wilson	Smartphone Health Monitoring
<b>Team #5:</b> Artur Cholewa Javi Contrerasorantes Carter Ellis Megan Fazio	Smartphone Health Monitoring
<b>Team #6:</b> Alyssa Magyar Lochlyn Reed Craig Stebbing	Smartphone Health Monitoring
<b>Team #7:</b> Julius Stuhec Michael Wu	Smartphone Health Monitoring



Acceleration Data From Smartphone: C-Code Counting Steps



Ohm's Law Simulation

## The Capstone Projects



**Dr. Subir Biswas**  
Professor of Electrical  
and Computer Engineering



**Dr. Yiming Deng**  
Associate Professor of Electrical  
and Computer Engineering

**Project Facilitators: Albrecht, Aslam, Aviyente, Baryshev, Chakrapani, Fan, Goodman, Grotjohn, Hogan, Li, Mahapatra, McGough, Mitra, Morris, Udpa, Zhang**



Albrecht



Aslam



Aviyente



Baryshev



Chakrapani



Fan



Goodman



Grotjohn



Hogan



Li



Mahapatra



McGough



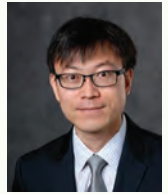
Mitra



Morris



Udpa



Zhang

## ECE 480 Senior Design

ECE 480 is required of all electrical engineering or computer engineering majors at MSU. It prepares students for the workplace, or for graduate school, including:

- Putting into practice the technical skills learned in the classroom, on industrially sponsored team projects, under faculty guidance, doing open-ended design, giving them experience in teamwork, project management, product life cycle management, intellectual property, accommodation issues and entrepreneurship;
- Polishing their communication skills – individual and team – on proposals, reports, résumés, evaluations, posters, web pages, and oral presentations; and
- Requiring each student to complete four individual hardware/software laboratory assignments.

Team sponsors are local and national, including General Motors, MSU 3D Vision Lab, MSU Brody Square, MSU College of Engineering Machine Learning Lab, MSU Electromagnetics Research Group, MSU Formula Racing Team, MSU Human Augmentation Technologies Lab, MSU Mobility Center, MSU Nondestructive Evaluation Laboratory, MSU Resource Center for Persons with Disabilities, MSU Spartan Innovations, MSU Unmanned Systems, NASA, NDE Lab, Orphans International Helpline, PUMA Lab, Smart Microsystems Laboratory, and Texas Instruments. Thank you to each of these team sponsors.



# Smart Microsystems Laboratory

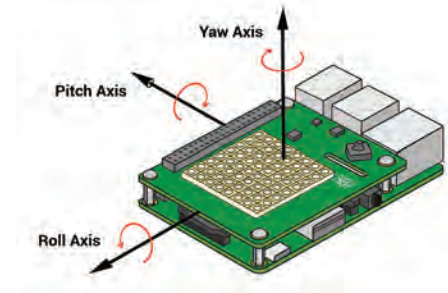
## IMU-Based Navigation with Dead Reckoning

Inertial Measurement Units (IMUs) are collections of sensors capable of determining an object's change in location, orientation, or pose, in three-dimensional space. IMUs are a useful navigational tool. For example, IMU sensor data may be used in conjunction with Global Positioning System (GPS) sensors to determine an object's coordinates more accurately. IMUs can also be used independently to estimate pose in locations where GPS data is not consistently available, e.g., tunnels, underwater, etc.

Dead reckoning refers to the use of pose estimates (such as those provided by IMUs) when navigating in three-dimensional space, often without authoritative third-party information such as GPS location. Dead reckoning has many potential commercial applications, including autonomous cars, unmanned aerial systems, remotely operated vehicles, and biometric sensor vehicles, such as those being developed at the Smart Microsystems Laboratory.

The overall goal of this project was to evaluate various inexpensive, off-the-shelf IMUs; compare the performance of several denoising/filtering algorithms when applied to IMU data; and determine the potential capabilities of these IMUs and algorithms when applied to simple dead reckoning algorithms.

In order to meet these objectives, a device was designed which integrates a platform base, IMU, and a camera into a single system; acquires IMU sensor data and AprilTags ground truth data; and offloads that data to a base station computer. This base station then applies denoising, filtering, and processing algorithms to accelerometer and gyroscope data from the IMU; estimates pose using the "cleaned" data; and displays the data in a custom three-dimensional data visualization inside a web application.



College of Engineering  
MICHIGAN STATE UNIVERSITY



### Michigan State University Team Members (left to right)

**Adam Jablonski**  
Howell, Michigan

**Benjamin Kittendorf**  
Milan, Michigan

**Mark Poirier**  
Buffalo Grove, Illinois

**Pat Moran**  
New Fairfield, Connecticut

**Ahmed Nasher**  
Detroit, Michigan

**Isaac Salinas**  
Canton, Michigan

### Smart Microsystems Laboratory Project Sponsor

**Demetris Coleman**  
East Lansing, Michigan

### Project Facilitator

**Dr. Daniel Morris**

# Smart Microsystems Laboratory

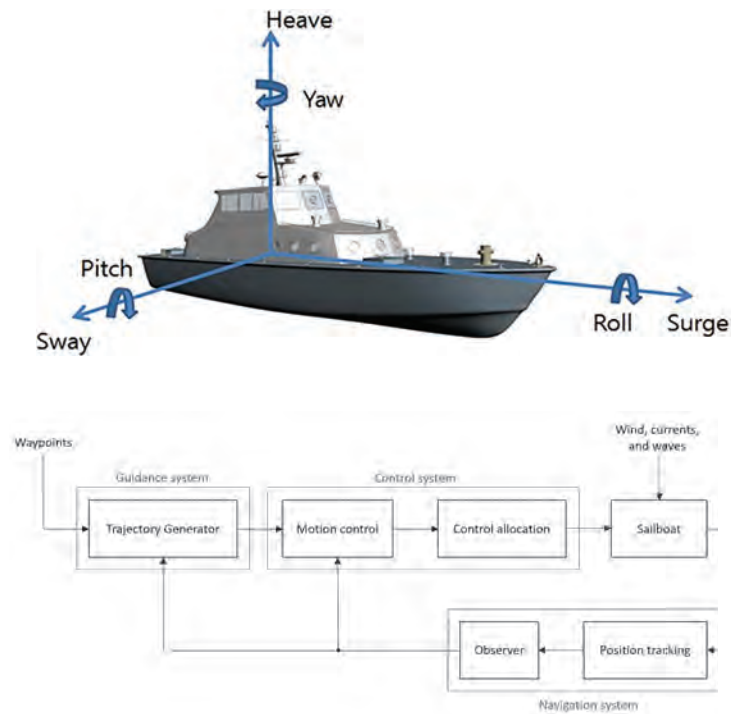
## Autonomous Sailboat

The Smart Microsystems Laboratory (SML) was established in the Fall of 2004. SML focuses on improving integrated systems by incorporating advanced modeling, control and design methodologies with novel materials and fabrication processes. SML research plans span the wide-ranging areas of control, dynamics, robotics, mechatronics, and smart materials. SML's research concentrates on electroactive polymer sensors and actuators, modeling and control of smart materials, soft robotics, bio-inspired underwater robots, and underwater mobile sensing.

One aim of the SML is to create a network of unmanned aquatic surface vehicles, specifically autonomous sailboats, primarily intended to be used for mobile sensing. These applications include, but are not limited to, weather data acquisition, population monitoring, or geological observations. The concept is to create a device that can autonomously observe the surrounding environment while adapting itself allowing unaffected data.

Our team was assigned to advance the waypoint tracking control of the sailboat in an indoor setting. Given the desired waypoints and the current wind conditions, we developed a control strategy that is implemented in hardware to properly steer the sail and the rudder. Our team will fashion a graphical user interface enabling inputs of waypoints and visualization of waypoint tracking.

Due to the nature of the aquatic environments, maintaining a sailboat may disturb the observable data acquisition process. Understanding the dynamics of a sailboat, wind direction and water currents are two of the most vital aspects to adapting to the environment.



College of Engineering  
MICHIGAN STATE UNIVERSITY



### Michigan State University Team Members (left to right)

**Saiyam Kothari**  
South Lyon, Michigan

**William Balfour**  
Saint Clair, Michigan

**Asha Rogers**  
Mount Clemens, Michigan

**Paul Leo**  
Rochester Hills, Michigan

**Will Devancy**  
San Diego, California

**Mitchell Tetreau**  
Port Huron, Michigan

### Smart Microsystems Laboratory Project Sponsors

**Eric Gaskell**  
East Lansing, Michigan

**Xiaobo Tan**  
East Lansing, Michigan

### Project Facilitator

**Dr. Nihar Mahapatra**

# MSU Formula Racing Team

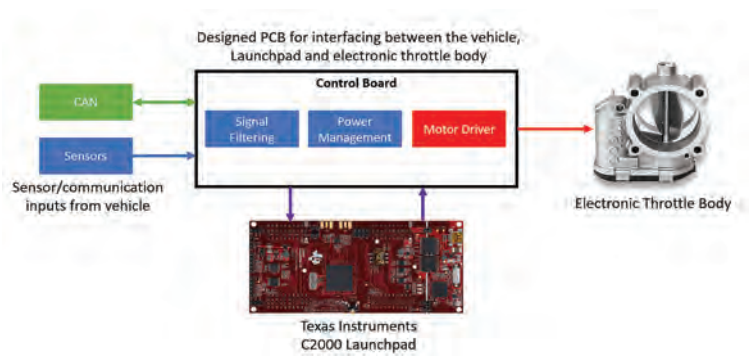
## Electronic Throttle Body Controller

Formula SAE is a global collegiate design competition that challenges students to design, manufacture, and race small, open-wheel racecars against other universities around the world. The competition is focused around five dynamic events: skid pad, acceleration, autocross, endurance, and efficiency.

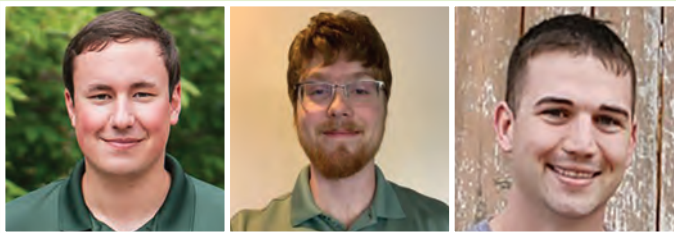
The objective of the Electronic Throttle Controller (ETC) is to increase performance and drivability of Michigan State University's Formula SAE racecar. Benefits of an ETC system over a traditional cable driven system include more precise throttle control, programmable throttle curves, and the ability to include control algorithms. The ETC system is made of various sensors, a controller, and an electronic throttle body (ETB). Sensors in the system include accelerator pedal position, throttle blade position, and brake pressure. These sensors are needed to ensure the functionality and safety of the system. The focus of this project lies in the design of the control board.

The control board integrates with the rest of the MSU Formula Racing Team's vehicle via a Controller Area Network (CAN) communication bus. Using data from the vehicle and sensors, the controller uses control algorithms programmed via Simulink to control the ETB to the correct position.

By creating a custom ETC system, rather than buying off-the-shelf systems, the MSU Formula Racing Team has more control over the functionality of the system. The custom design of the ETC controller allows for complete integration with the rest of the systems on the vehicle.



Michigan State University  
**Formula Racing Team**



**Michigan State University**  
*Team Members* (left to right)

**Nick Kopec**  
Freeland, Michigan

**Ron Hodge**  
Grand Haven, Michigan

**Zach O'Connor**  
Caledonia, Michigan

**MSU Formula Racing Team**  
*Project Sponsor*

**Gary Cloud**  
East Lansing, Michigan

**Industry Advisor**

**Tianyu Ni**

**Project Facilitator**

**Dr. Sunil Chakrapani**

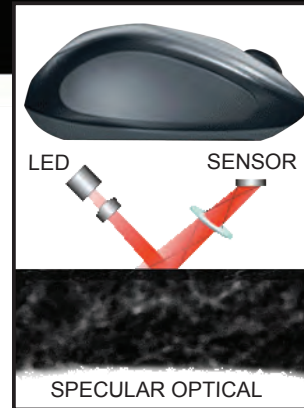
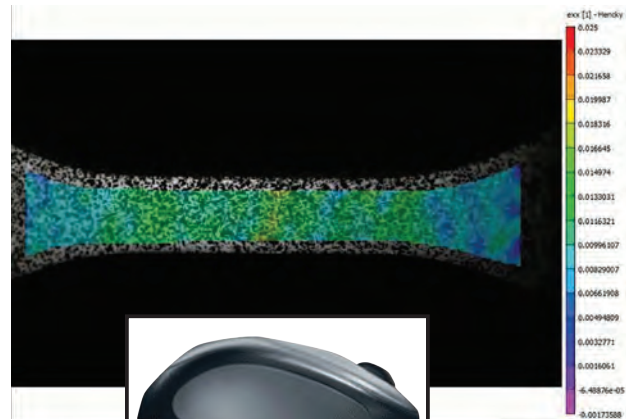


# PUMA and NDE Labs Low-Cost Digital Image Correlation

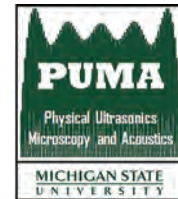
Digital image correlation is a technique that is used for measurement of deformation and strain in materials. The technique combines image registration as well as tracking methods for accurate and efficient measurements of changes in images. Deformation and strain measurement are key components of materials testing and DIC allows visualization of strain maps in critical components. This will allow engineers to predict the behavior of a part made from a material during process operations.

One of the fundamental and basic concepts of DIC is comparing two images of a component before and after deformation. Before the DIC process begins, a speckle pattern (or tracking pattern) is first applied to get a reference image, and a subset of this pattern is selected for tracking. The center of the subset on the reference image will be the location where the displacement will be calculated. Once the material has been deformed from the reference image's initial position, the subsets from both the deformed image and reference image are matched. After this, the DIC will calculate the displacement between the two images.

The purpose of this project is to develop a low-cost alternative to current DIC modules used for strain testing. The goal is to use the functionality of an optical mouse to efficiently and effectively develop hardware and software to detect and track speckle patterns as the mouse travels along a surface. The mouse and laser have built-in hardware that is capable of DIC as the tracking of movement is already incorporated in its design. Our project will involve making use of this technology to develop a small and inexpensive yet effective DIC module for our customer. The approach involves use and implementation of a microcontroller in conjunction with C++ programming as well as DirectX software to model the displacement of the speckle pattern.



Nondestructive Evaluation Laboratory



## Michigan State University Team Members (left to right)

**Vincent Marinas**  
DeWitt, Michigan

**Charles Moshier**  
Beverly Hills, Michigan

**Camron Barksdale**  
Detroit, Michigan

**Kyle Downey**  
Westland, Michigan

**Avit Tailor**  
Saint Charles, Illinois

## PUMA and NDE Labs Project Sponsor

**Sunil Chakrapani**  
East Lansing, Michigan

## Project Facilitator

**Dr. Lalita Upa**

# MSU Mobility Center

## MSU Green Mobility App

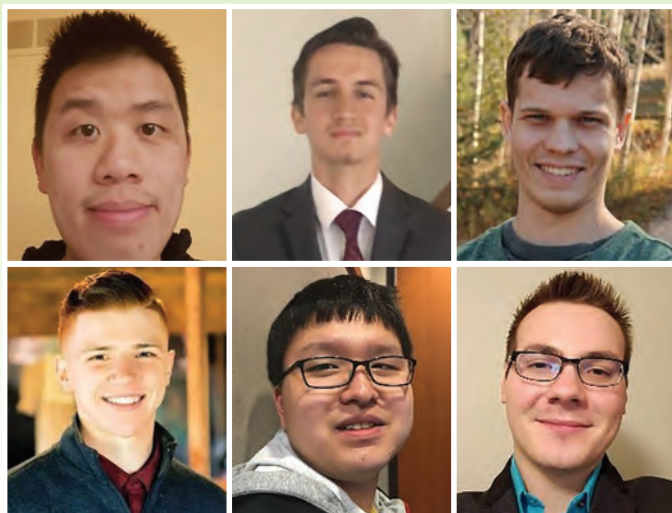
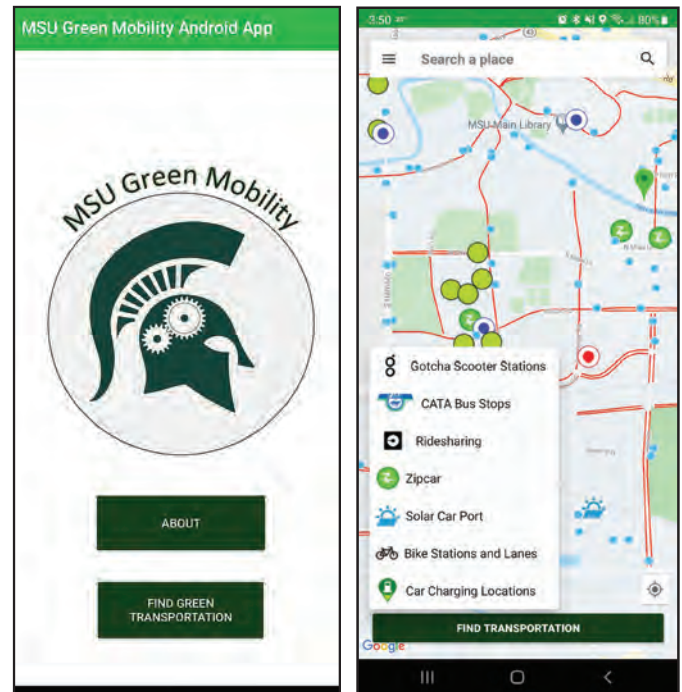
The MSU Mobility Center monitors the flow of people and vehicles across campus, focusing on creating systems of transportation to ensure students and faculty stay safe and move efficiently while on campus. They currently aim to reduce CO<sub>2</sub> emissions and vehicle count on campus while increasing student flow especially between class periods.

Our MSU Green Mobility App provides a way for the MSU community to learn about and utilize “green” modes of transportation. “Green” modes can be characterized as a method of transportation that does not rely on burning fuels or other natural resources. This helps control the releasing of greenhouse gas and therefore control the pollution and protect our living environment and ecosystems.

Some of the primary milestones for this project consist of implementing a routing feature to make the app more practical in day-to-day activities, adding Lyft as a ridesharing option, and polling accurate, real-time information for both the CATA buses as well as the Amtrak train station.

With the MSU Green Mobility App, the user can easily interact with the local map which provides several options for green transportation on campus. For each option, the user can determine the distance, the “greenest” way, the cost, and how long it will take to reach the destination. Depending on the option that the user selects, all possible routes will be displayed.

The ultimate goal for our MSU Green Mobility App is to make MSU more eco-friendly by providing students and faculty with information about the “green” modes of transportation available on campus and how they can utilize them. If just 5% of people start utilizing these options instead of driving, CO<sub>2</sub> emissions would go down, MSU could save money on parking structures, and students choosing to walk will be able to get across campus much easier.



### Michigan State University Team Members (left to right)

**Steven Liang**  
Farmington Hills, Michigan

**Conner Rash**  
Livonia, Michigan

**Nathan Rogers**  
Jackson, Michigan

**Jacob Rumpitz**  
Canton, Michigan

**Shuchong Wang**  
Ningbo, Zhejiang, China

**Paul Zeman**  
Clinton Township, Michigan

### MSU Mobility Center Project Sponsor

**Tim Potter**  
East Lansing, Michigan

### Project Facilitator

**Dr. Erik Goodman**

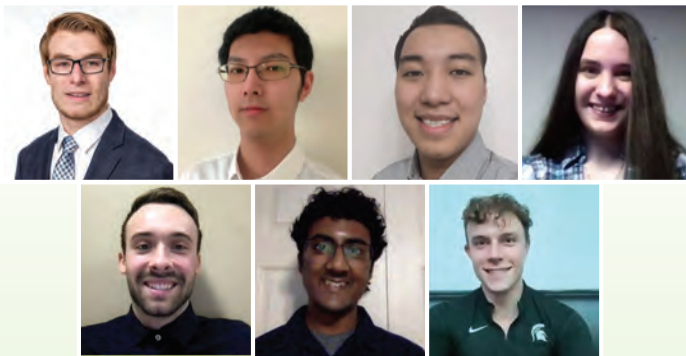
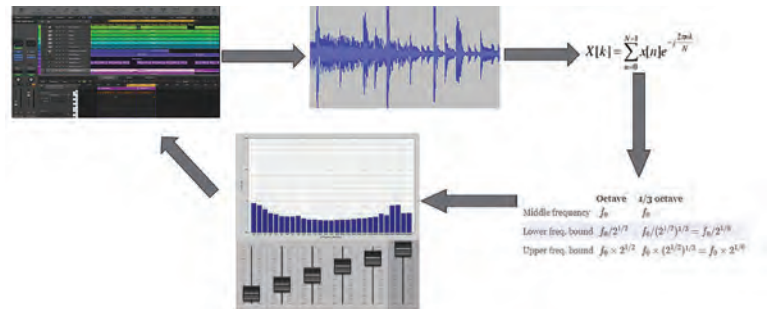
# General Motors One-Third Octave Band Equalizer

With electric vehicles across the horizon, General Motors' mission is to bring everyone into an all-electric future by 2025, leading the world in EV research and assembly. GM is headquartered in Detroit, Michigan and is also known for brands like GMC, Buick, Cadillac, and Chevrolet, selling 7.7 million automobiles combined in 2019.

Sound is one of the most important characteristics of vehicle safety for pedestrians, and all hybrid and electric vehicles must adhere to minimum audible sound requirements established by global regulations. While next-generation vehicle sounds are produced with those regulations in mind, equalizers built into digital audio workstations (DAW) lack the necessary precision to amplify and attenuate specific frequency bands to better accommodate for pedestrian safety and driver comfort.

The focus of our one-third octave band equalizer tool will be to provide an easily integrable plugin for DAWs like Logic Pro that will analyze a waveform audio file format (WAV) file, modify their response via an equalizer with 1/3 octave precision, and export the modified audio data as a WAV file without loss of quality. The analyzer displays frequency response in a linear scale to provide the necessary precision needed by GM and streamline the audio creation process for sound engineers.

The equalizer plugin is developed in C++ using JUCE for the front end interface and back-end functionality, while a separate, standalone program is developed using Python scripts to simulate the user interface and functions developed within the JUCE framework.



## Michigan State University Team Members (left to right)

**Steven Faxlanger**  
Newtown, Connecticut

**Siqi Luan**  
Jingdezhen, Jiangxi, China

**Andrew Tran**  
Holt, Michigan

**Shaya Master (ME)**  
Waterford, Michigan

**Denny Blaschko (ME)**  
Jackson, Michigan

**Arjun Balakrishnan (ME)**  
Canton, Michigan

**Thomas Brandell (ME)**  
East Jordan, Michigan

## General Motors Project Sponsor

**Douglas Moore**  
Milford, Michigan

## Project Facilitator

**Dr. Robert McGough**



# MSU 3D Vision Lab

## In-Farm Livestock Monitoring (SIMKit v.2)

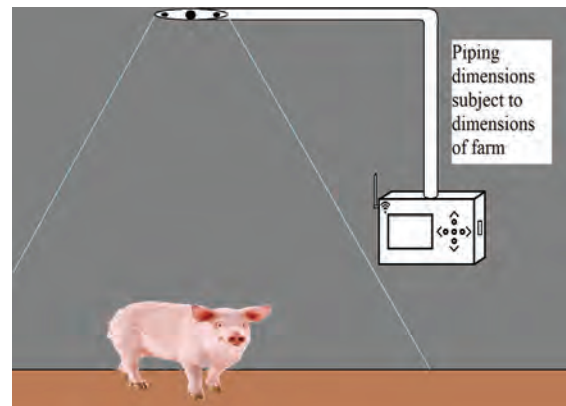
3D Vision Lab is based out of Michigan State University and focuses on research involving Automated Vehicles, Smart Agriculture, and Tremor Tracking technologies.

Our team has designed a livestock monitoring system to be used in barns to monitor the health of pigs. The device monitors livestock gait and body size in order to be analyzed by a third-party lab. This device is the second of its kind and offers a higher resolution and framerate than the previous design, as well as the ability to upload data to a cloud storage via Wi-Fi.

In addition to adding Wi-Fi capabilities to our device, this newer SIMKit will feature an Azure Kinect RGB-D camera to enable us to get high framerate output footage.

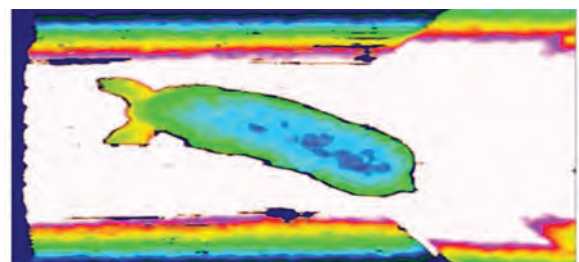
Upon completion, the tool will greatly reduce the amount of time and effort needed to transport this data to be analyzed, as well as offer better data points for farmers, leading to better care of their livestock.

We will create a 3D printed box to hold the screen, computer, buttons and Wi-Fi module in a watertight enclosure.



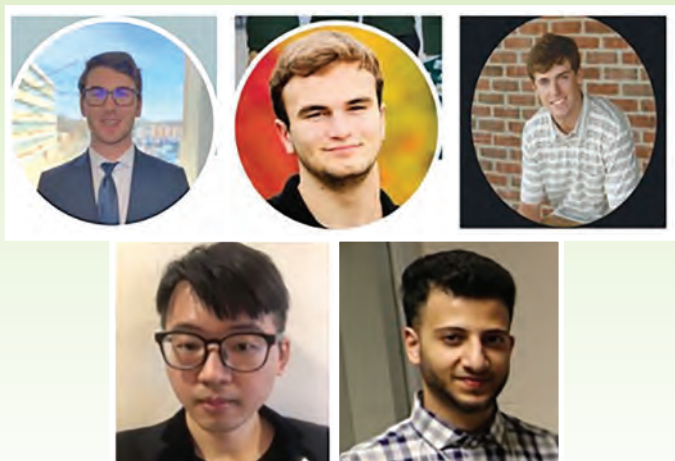
**Figure 1: Example Design and Product Layout**

A pig will walk underneath and through the camera's FOV to get a good capture of its gait.



**Figure 2: Camera Data Example**

Shown above is a depth image of a little piggy doin' a strut



### Michigan State University

**Team Members** (left to right)

**Peter Litsey**

The Woodlands, Texas

**Ross Talbert**

Troy, Michigan

**Sam Williamson**

Detroit, Michigan

**Junqin Tang**

China

**Anwar Mohamed**

Detroit, Michigan

### MSU 3D Vision Lab

**Project Sponsor**

**Daniel Morris**

East Lansing, Michigan

### Project Facilitator

**Dr. Tongtong Li**

# MSU Unmanned Systems

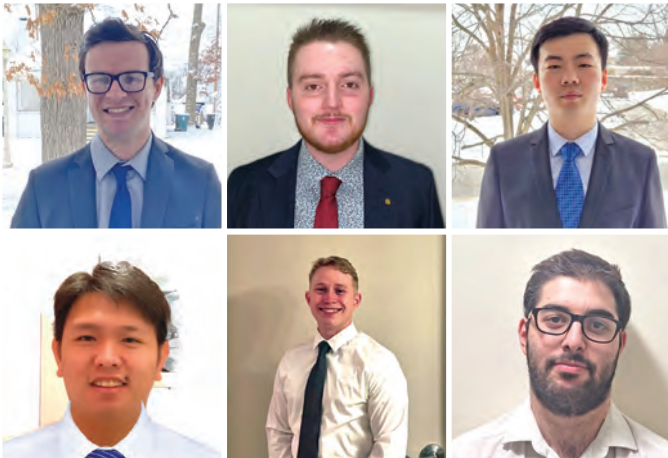
## Aerially Deployable Autonomous Ground Robots

The objective of this project is to build a dropping mechanism that deploys an autonomous ground vehicle. The dropping mechanism will attach to a prebuilt drone provided by the Unmanned Systems team. The system will be used in the 19th Annual Student Unmanned Aerial Systems Competition (SUAS). One of the goals of this competition is to help further the field of autonomous package delivery.

The total payload drop cannot exceed 64 ounces, while 8 ounces of that is dedicated to carrying a water bottle. The drop mechanism will be a servo that releases a pin. The ground vehicle will then descend to the ground with a parachute slowing the fall. Once the ground vehicle has landed safely it will release the holding device for the parachute and then drive to its coordinates provided on competition day.

The main hardware for the ground vehicle will include a body, treaded tires, motors, Raspberry Pi, GPS system, suspension systems, gyroscope sensor, and other basic parts for the RC style operation. The components will mainly communicate through Python and include ROS library. The main risks involved in this overall mission include the ground vehicle not landing safely and the vehicle not being able to drive to its provided coordinates. To ensure neither of these situations occurs there was rigorous testing on the release system and parachute as well as the program functioning. The weather conditions will also be a factor, so the system was tested in various winds to ensure successful deployment.

Successful development of this system will lead to a deployment from 150 feet in the air and a short autonomous drive to the final coordinates. This will be showcased in the SUAS competition for Michigan State's Unmanned Systems team and will have the opportunity to place against other developed autonomous systems competing.



### Michigan State University Team Members (left to right)

**Justin Watkins**  
Royal Oak, Michigan

**Bradie Reary**  
Mariesville, Michigan

**Faxing Xie**  
Zhengzhou, HeNan, China

**Dong Hae**  
Manila, Philippines

**Sean DePalma**  
Lake Orion, Michigan

**Dorukan Yildirim**  
Ankara, Turkey

### MSU Unmanned Systems Project Sponsor

**MSU Unmanned Systems**  
East Lansing, Michigan

### Project Facilitator

**Dr. Joydeep Mitra**

# Texas Instruments

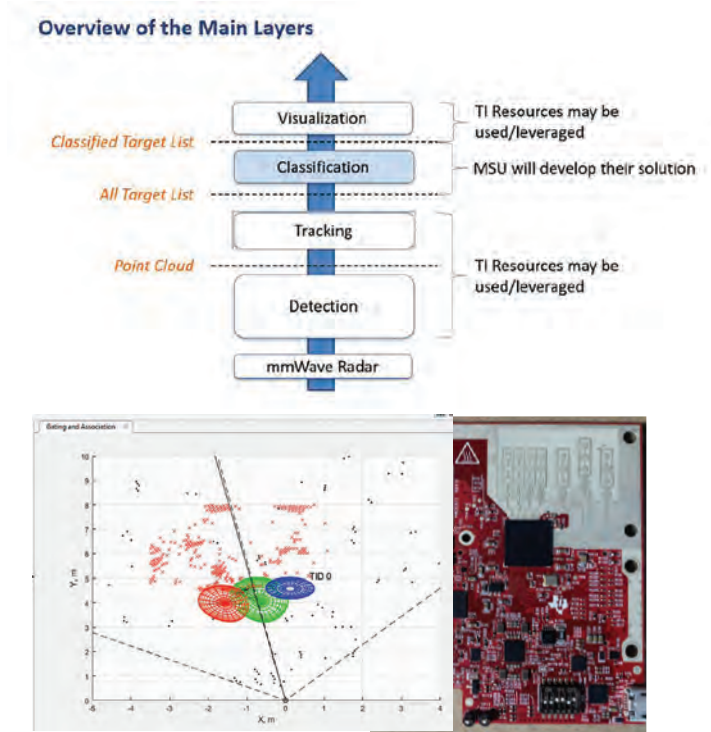
## Classification with mmWave Sensors

The goal of this project is to improve and expand upon the Texas Instruments mmWave radar tracking technology. This mmWave radar technology operates by radiating an electromagnetic wave signal (60 – 64 GHz), which reflects off various objects within reach of the device. This reflected signal contains information about the object from which it was reflected, such as the velocity of the object, the angle relative to the sensor, and the range from the sensor.

mmWave sensors are effective in detecting moving objects in a scene but alone are incapable of determining the type of object detected. Algorithms can be developed to work in coordination with mmWave sensors to successfully classify such objects.

Based on this information, the sensor in coordination with the algorithm can categorize the object as human or as another object in motion. Further development of mmWave technology will allow this to have widespread applications in aerospace radar systems, autonomous driving, ethical surveillance systems where privacy is of concern, and more.

We are expanding upon the work previously completed by TI and previous senior design teams at MSU. This involves improving the Support Vector Machine algorithm to enhance object classification performance and accuracy. Additional data is captured to continue training the algorithm. Object classification is being expanded from a binary system where moving objects are classified as human/non-human to a multi-class system where moving objects can be classified as either human, pet, and neither. Each classification category requires its own collection of data to train the algorithm. This data allows the algorithm to familiarize itself with features and characteristics of like objects to group them into labeled categories.



<p><b>Michigan State University</b>  <b>Team Members</b> (left to right)</p> <p><b>Breanna Allen</b>          Dearborn Heights, Michigan</p> <p><b>Zoe Dittman</b>          Brighton, Michigan</p> <p><b>Josh Dye</b>          Canton, Michigan</p> <p><b>Weikang Peng</b>          Jiangsu, China</p> <p><b>Jason Spaulding</b>          Freeland, Michigan</p>	<p><b>Texas Instruments</b>  <b>Project Sponsor</b></p> <p><b>Yanik Muhammet</b>          Dallas, Texas</p> <p><b>Project Facilitator</b>  <b>Dr. Selin Aviyente</b></p>
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# MSU Resource Center for Persons with Disabilities

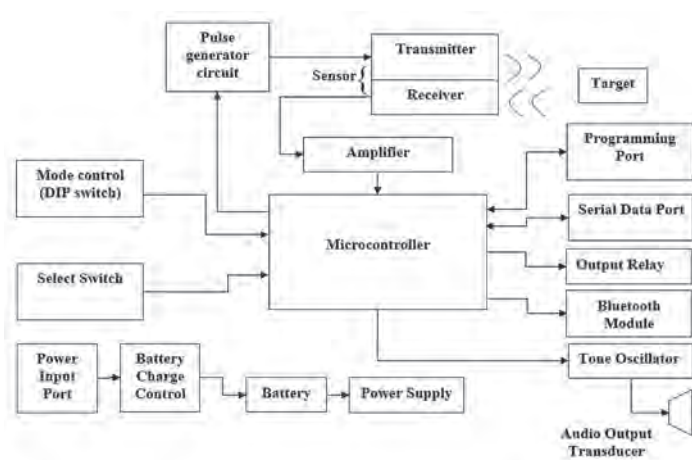
## SCATIR Switch for People with ALS

The MSU SCATIR (Self Calibrating Auditory Tone Infra Red) Switch is an assistive technology that is currently in use particularly by people with ALS. The SCATIR Switch was invented by Stephen R. Blosser and John B. Eulenberg. The SCATIR Switch's eye sensor detects "blinks" from the user wearing wire glasses. This Switch can then be connected to an output (switch closure or relay) so that the user can perform various tasks.

Our team is creating additional accessibility and compatibility features on the SCATIR Switch. We are adding a wireless Bluetooth output to allow for wireless connection. This will allow the user to connect to other devices such as computers and phones to perform a 'left click' function. This will increase the scope of use and accessibility for the SCATIR Switch.

Additionally, we are adding a micro-USB/USB-C charging port to make charging more compatible for users. The device currently uses a wall transformer for charging, so replacing it with a USB charging port will increase ease of charging for the user.

We are creating additional features on the SCATIR Switch to increase availability and functionality for users.



### Michigan State University Team Members (left to right)

**Nicholas Boblet**  
Kalamazoo, Michigan

**Claire Kendell**  
Huntington Woods, Michigan

**Don Gorton**  
Lansing, Michigan

**Jessica Stevens**  
Rochester Hills, Michigan

**Sean Arnoldt**  
Chicago, Illinois

**Brennan Koehler**  
Novi, Michigan

### MSU Resource Center for Persons with Disabilities Project Sponsor

**Stephen Blosser**  
East Lansing, Michigan

### Project Facilitator

**Dr. Joydeep Mitra**

# MSU RCPD/OIH/Tesla Inc./Lansing SDA Church Off-Grid Hospital Power System

In Bombardopolis Haiti, a hospital and training center is being developed where little to no electricity is available. Our task is to design a power system with specific components such as batteries, inverters, solar panels, wind generators etc. Lithium batteries are to be used as opposed to lead-acid batteries for a variety of reasons.

We have also been tasked with designing and building a monitoring system that will measure the status of the batteries and other potential variables and monitor these statuses on an app that will allow one to monitor the hospital power system. We will be using Solar Edge components to design our system.



## Michigan State University Team Members (left to right)

**Madison Ampunan**  
Novi, Michigan

**Taylor Weimer**  
Rochester, Michigan

**Jodi Meads**  
Milan, Michigan

**Ronald Carr II**  
Southfield, Michigan

**Vasaf Soofi**  
Farmington Hills, Michigan

**Cameron White**  
Rockford, Michigan

**MSU Resource Center for  
Persons with Disabilities/  
Orphans International  
Helpline/Tesla Inc./  
Lansing SDA Church  
Project Sponsor**

**Stephen Blosser**  
East Lansing, Michigan

## Project Facilitator

**Dr. Joydeep Mitra**

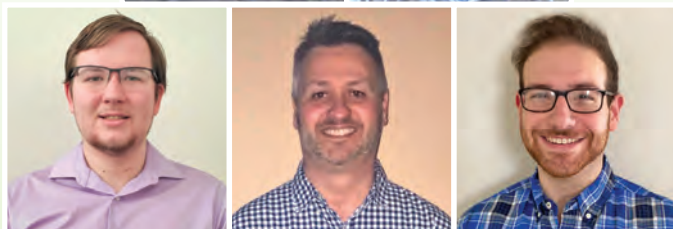
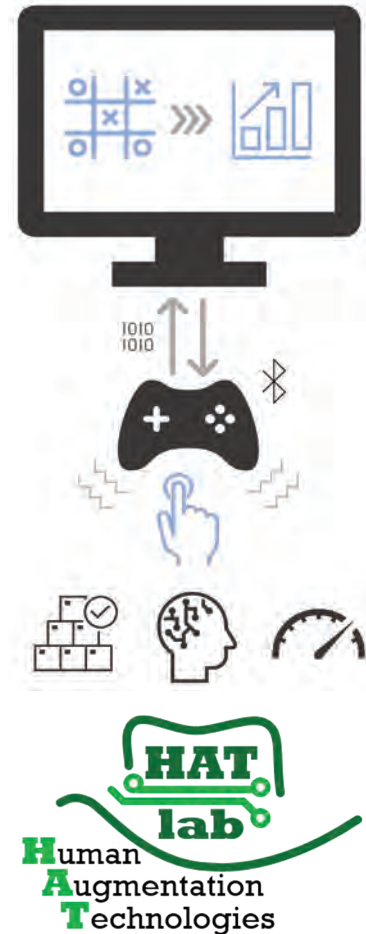
# MSU Human Augmentation Technologies Lab (HATlab) Platform to Assess Tactile Communication Pathways

The Michigan State University Human Augmentation Technologies (HATlab) seeks to develop a new device that bypasses visual and audio sensory channels to enable high-speed, machine-to-human communication via tactile (skin) sensory pathways. Broadly speaking, it is believed that by focusing on autonomous sensory microsystems, HATlab can integrate these technologies into a diverse range of external fields to provide maximum benefit for a targeted user base.

Building on the success of the Fall 2020 semester capstone team's project, our team focused on developing a new testing platform suitable for increasing tactile message comprehension to 20 discrete inputs. We then assessed the performance humans exhibit in decoding tactile messages while completing game-like tasks to quantify the degree to which these competencies can proliferate in a controlled environment.

As a stepping-stone for emerging technologies, this project delivers an application which utilizes tactile feedback through game controllers to support the axiom research goals for the HATlab team. To accomplish this, the project included the design of a sequential task game, or STG, for training users how to recognize and decode tactile messages into assigned game inputs. Combining game theory and the psychologies associated with retention and learning, the STG environment was designed to maximize the memory potential for the user in order to optimize player memory retention.

In testing human retention, this project sought to quantify the limitations (if any) to tactile communication pathways for the average individual. By doing so, the data and platforms provided by our team will inform future research to allow for greater expansion into this exploratory field of neural engineering.



## Michigan State University Team Members (left to right)

**Forrest Bennett**  
Kalamazoo, Michigan

**Avery Mcmillan**  
Rochester Hills, Michigan

**Jamie Lock**  
Farmington Hills, Michigan

**Derek Marshall**  
Highland, Michigan

**Kyle Polidori**  
Dearborn, Michigan

## MSU HATlab Project Sponsors

**Andrew Mason**  
East Lansing, Michigan

**Sina Parsnejad**  
East Lansing, Michigan

## Project Facilitator

**Dr. Tim Hogan**



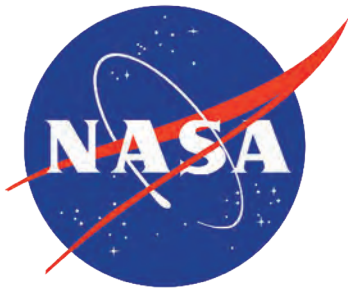
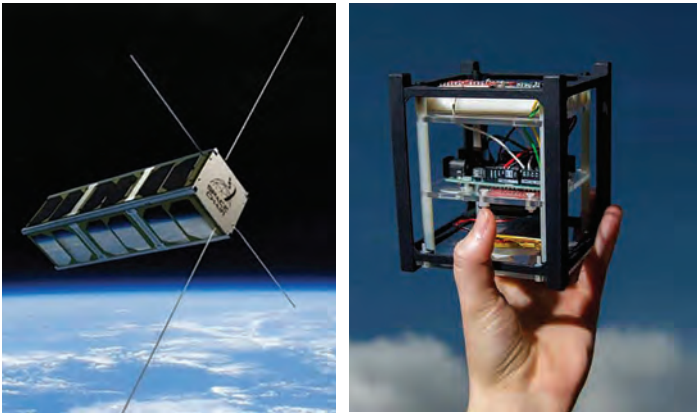
# National Aeronautics and Space Administration (NASA) Inner Solar System Array for Communications (ISSAC)

The National Aeronautics and Space Administration, otherwise known as NASA, is no longer the sole American actor in the exploration and execution of missions in space. Commercial partners like SpaceX, Lockheed Martin Space, and Astrobotic are all investing in hardware intended for operation off Earth. These kinds of operations require long distance communications that can rely on existing networks, often competing for limited availability.

In order to create a demo for this project within this semester's timeframe, we propose creating a Unity simulation of the CubeSat network. The network will be an array of many satellites in an ad-hoc configuration, and we plan on creating a simulation of said network which can be used by future groups working on this project.

We will create this scale simulation that will allow users to input parts such as antennas, power, and RF modulation coding scheme, just to name a few. The simulation will allow users to see the advantages and disadvantages of using certain parts. With outputs like range, number of CubeSats required to reach a certain point, data rate, and link margin, users will be able to easily find the perfect part for their CubeSat build.

The most important output of our simulation is the link margin between two points of communication. The link margin is the difference between the minimum power received by the receiver and the receiver sensitivity. This difference determines if the current configuration will work at a given distance. NASA requires a minimum link margin of 3 dB in all of their links to meet data rate requirements and improve resistance to dropped packets.



**Michigan State University**  
*Team Members* (left to right)

- Nick Flammini**  
East Lansing, Michigan
- Dezmond Brooks**  
Farmington Hills, Michigan
- Jaeeun Kim**  
Seoul, Korea
- Ethan Gallagher**  
Midland, Michigan
- Brian Daugherty**  
Richardson, Texas

**NASA**  
*Project Sponsors*

- Darren Boyd**  
Huntsville, Alabama
- John Carr**  
Huntsville, Alabama
- Eric Eberly**  
Huntsville, Alabama
- Project Facilitator**  
**Dr. John Albrecht**

# MSU Brody Square

## Robotics in a Residence Hall Dish Room 4.0

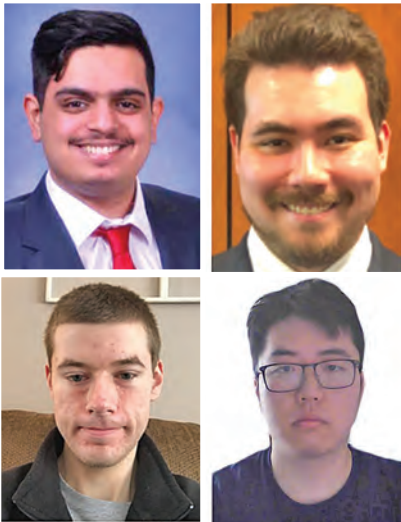
Michigan State University's Brody Cafeteria provides upwards of 1.6 million meals per year. As a result, the current process of sorting silverware requires several employees at a time in a chaotic and humid environment. With automation, staff members can divert their energy elsewhere creating both a better work environment and customer experience.

Our project, which is a continuation of previous semesters' projects, is to improve on an existing prototype by increasing sorting efficiency and accuracy.

The current prototype utilizes a conveyor belt in order to transport silverware underneath a camera. The camera then transmits the image to a computer which runs vision-based object recognition in order to determine the type of silverware.

In order to improve the efficiency of the machine, our team has proposed both hardware and software designs. From a hardware perspective, the sorting efficiency can be improved by increasing the speed of the conveyor belt. In order to achieve this, an additional motor circuit would be installed on the side opposite from the initial motor. Another benefit of the motor would be that the force on the belt will be equalized, preventing an issue of the belt slipping and becoming stuck.

From a software perspective, in order to improve sorting accuracy, possible changes involving the sorting algorithm would need to be implemented. Currently, the software detects the length of the silverware and classifies it as either a fork, knife or spoon. Issues with accuracy arise from situations with silverware in different orientations and multiple pieces at once. Proposed designs include modifying the parameters of the silverware classifications and implementing image comparison software. Image comparison would utilize a directory of still images of silverware and compare it with footage captured by the camera module.



### Michigan State University Team Members (left to right)

**Ahmed Abusharifah**  
Abha, Saudi Arabia

**Sean Hansen**  
New York, New York

**Max DeYoung**  
Lansing, Michigan

**Calvin Liu**  
Novi, Michigan

### MSU Brody Square Project Sponsor

**Stacey Dawson**  
East Lansing, Michigan

### Project Facilitator

**Dr. Sergey Baryshev**

# MSU Electromagnetics Research Group

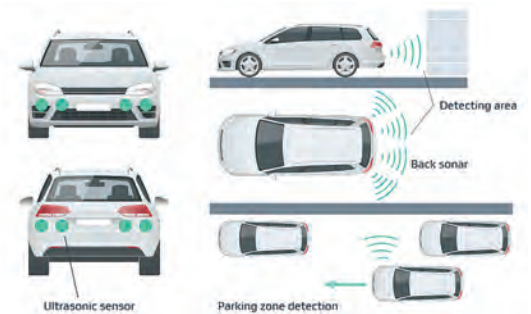
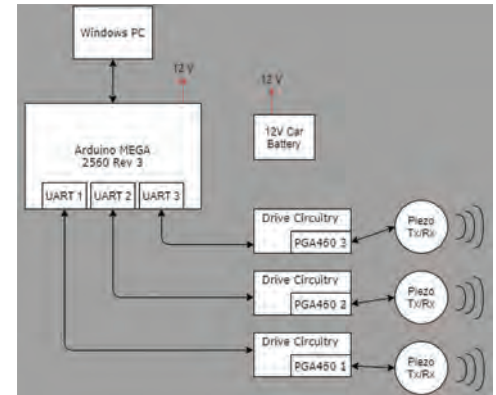
## Object Triangulation using Ultrasonic Sensors

The Electromagnetics Research Group (EMRG) at Michigan State University conducts research across a broad range of both fundamental and applied topics, including projects that are focused on developing computational methods for analysis of fields across the electromagnetic spectrum. They also analyze and research sensors and antennas to develop new techniques that help improve electromagnetic field analysis. This project has been sponsored by MSU EMRG in order to further their work in the field of ultrasonic sensing and triangulation.

Ultrasonic-based accurate sensors for direct 3D positioning and orientation measurements are needed for a range of applications, such as autonomous vehicles, liquid flow sensors, industry settings, robotics, etc. For a platform (e.g., automobile) that requires knowledge of the object's detailed position for virtual mapping of the environment, such as an autonomously mobile robot, triangulation is required for the robot to move safely and accurately.

The goal of this project is to provide a triangulation solution to track an object's location using ultrasonic transducer sensors. These transducers are used to triangulate the location of an object within a specific area. The location of the object should then be mapped onto a computer display that accurately maps the object's position.

This project primarily utilizes piezoelectric transducers that are able to both transmit and receive signals for object tracking. Piezoelectric sensors are devices that can produce electricity when exposed to changes in the environment, usually in form of vibrations. After transmitting a signal, the transducers will then listen for the vibration of that signal response. The vibrations then get converted into electrical power to be used to map the object's position onto a display. The use of three piezoelectric sensors for object triangulation improves sensor accuracy in comparison to more common systems designed with only one or two sensors.



### Michigan State University Team Members (left to right)

**Aditya Purandare**  
Troy, Michigan

**Ana Flávia Borges De Almeida Barreto**  
São Paulo, São Paulo

**Cullen Davison**  
Grand Haven, Michigan

**George Michael Andraous**  
Lansing, Michigan

**Ashleigh Gray**  
Blissfield, Michigan

**Gregory Tarnowski**  
Algonquin, Illinois

### MSU Electromagnetics Research Group Project Sponsor

**Prem Chahal**  
East Lansing, Michigan

### Project Facilitator

**Dr. Dean Aslam**



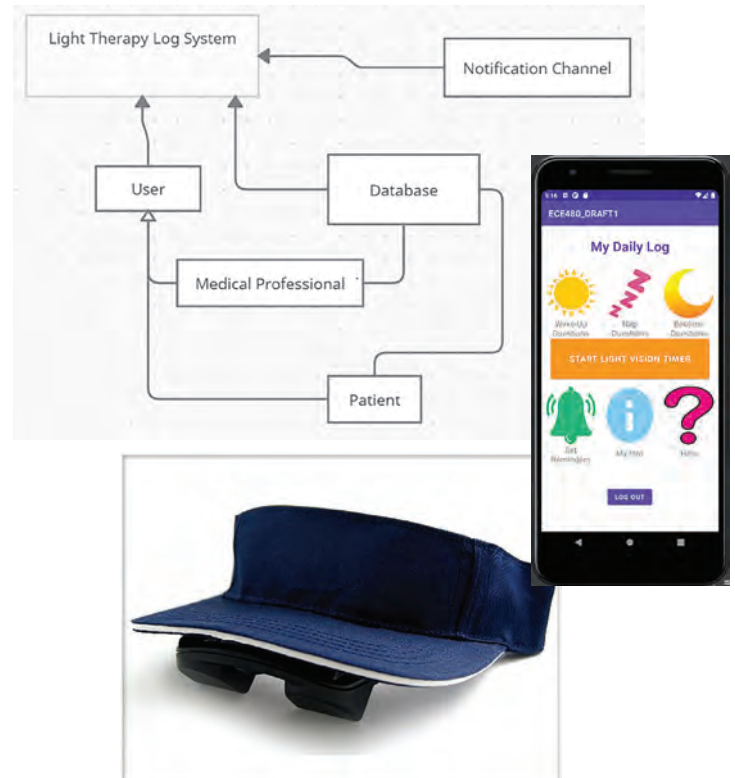
# Machine Learning Systems

## Smart Phone App for Cancer Symptom Management

**M**achine Learning Systems (MLS) is a group at Michigan State University that works on topics at the intersection of systems and Artificial Intelligence (AI), with current focus on On-Device AI for mobile, AR, IoT (TinyML), Automated Machine Learning (AutoML), Federated Learning, Systems for Machine Learning, Machine Learning for Systems, and AI for Health. The director of MLS, Dr. Mi Zhang, partnered with our team to create an Android app for cancer symptom management.

Sleep/wake disturbance and fatigue, two of the most debilitating symptoms, commonly occur in cancer, especially during chemotherapy. These two symptoms are known consequences of circadian rhythms disruptions due to cancer. Because light is the most potent external cue coordinating circadian rhythms, it can be used to help relieve sleep/wake disturbances and fatigue resulting from disruption of these rhythms. A personalized bright light therapy will offer cancer patients a non-pharmacological option in managing sleep/wake disturbance and fatigue.

This app contains an automated alert functionality to help monitor and enhance adherence to the prescribed light therapy. Specifically, the smartphone app can be programmed for the time of the day the individual is prescribed to receive the light intervention. A text reminder is sent through the app at the prescribed time each day. Real-time data is provided by a touch-screen timer that records start and end times of each light therapy session.



College of Engineering  
MICHIGAN STATE UNIVERSITY



### Michigan State University Team Members (left to right)

**Josh Kalich**  
Cleveland, Ohio

**Max Huang**  
Troy, Michigan

**Jugan Ghuman**  
Shelby Township, Michigan

**Danny Dodge**  
Parma, Michigan

**Raghav Gaur**  
Ann Arbor, Michigan

**Dan Pinto**  
Saint Charles, Illinois

### Machine Learning Systems Project Sponsors

**Hong-Shiunn Wu**  
East Lansing, Michigan

**Mi Zhang**  
East Lansing, Michigan

### Project Facilitator

**Dr. Timothy Grotjohn**

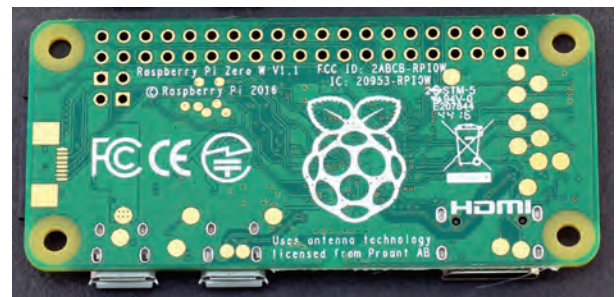
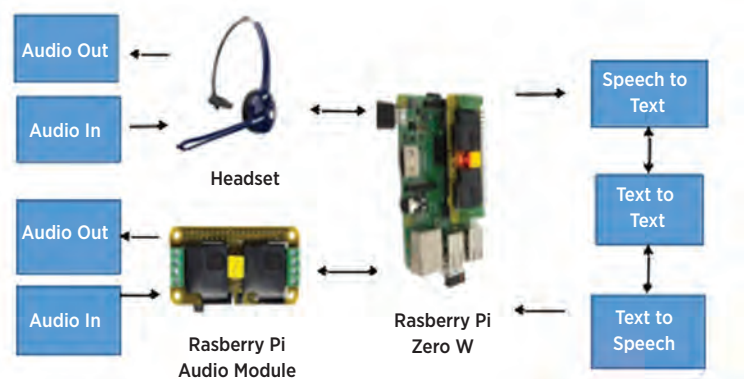
# MSU Spartan Innovations Mobile Universal Translator

Spoken language is one of the defining characteristics of human beings. Humans have used it to communicate for over 60,000 years. Throughout that time many different languages have emerged in different parts of the world. Today there are over 7,000 languages, and if you add up the number of people who speak the 23 most popular languages, you only account for half of the world's population. This creates a need for translation devices especially in today's ever-connected world.

The goal of this project is to create a device that allows for quick and easy translation between languages. The device should be able to work both with and without a Wi-Fi connection depending on the circumstances of the user. The device is meant to be used in both situations of leisure and emergencies. For example, it should be able to be used by medical professionals and law enforcement in instances where a human translator cannot be located quickly.

The device will use a Raspberry Pi to hear and translate what is being spoken to the user. The translation will then be played by a Bluetooth earpiece the user is wearing. The user will then talk into the earpiece, and the audio will be translated and played via the Raspberry Pi.

This project is the first of its kind for the College of Engineering. Jacoria Jones, an MSU student in ESHP 170, Business Model Development, had the vision but not the technical background to complete the project. She presented the idea to the university who brought it to us.



## Michigan State University Team Members (left to right)

**Ethan Clifford**  
Troy, Michigan

**Ethan Regulinski**  
Metamora, Michigan

**Neel Surti**  
Aurora, Illinois

**Daniel Fox**  
Rochester Hills, Michigan

**George Pauls**  
Macomb, Michigan

## MSU Spartan Innovations Project Sponsor

**Sean Fochtman**  
East Lansing, Michigan

## Project Facilitator

**Dr. Qi Hua Fan**

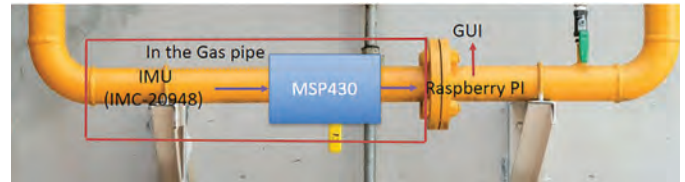
# MSU Nondestructive Evaluation Laboratory

## Raspberry Pi Controlled IMU Based Positioning System

Natural gas makes up almost a third of energy production in the United States. Natural gas pipes are abundant and used to move gas from production to plant or even into consumers' homes for heating. With all of these gas pipes laid underground, upkeep and evaluation become imperative for properly functioning natural gas systems. The Natural Gas industry uses small remote industrial inspection robots that enter the buried pipes and can navigate and look for cross-bores, defects, and wear. However, since these robots are underground, they lose a large amount of their connectivity, similar to a car entering a tunnel and losing GPS signal. This means that they cannot count on accurate GPS readings.

Our team's solution to this problem will be to design a low-cost and low-power positioning system using an Inertial Measurement Unit (IMU), microcontroller, and Raspberry Pi 4. This system will allow for accurate location estimates to be displayed to the user based on filtered and manipulated IMU sensor data. Using this system, the industrial inspection robot will be able to navigate the gas pipes with precise location information without the use of a GPS.

The IMU that our team will be using has a 3-axis accelerometer, 3-axis gyroscope, and 3-axis magnetometer that will allow for 9-axis measurement sensor data that can be combined for maximum location accuracy. This raw data will be processed using an algorithm developed by our team to filter out noise, integrate the various sensor data, and generate an accurate location estimate that will be displayed using a graphical user interface through the Raspberry Pi. The algorithm will be based on a Kalman filter with additional improvements made from modern research conducted in the area.



### Michigan State University Team Members (left to right)

**Jacob Buys**  
Carbondale, Illinois

**Will Chrisholm**  
Six Mile, South Carolina

**Nathan Nicevski**  
Owosso, Michigan

**Dillon Carrington**  
Detroit, Michigan

**Arthur Vico**  
Birmingham, Michigan

### MSU Nondestructive Evaluation Laboratory Project Sponsors

**Jaioyang Li**  
East Lansing, Michigan

**Guanya Piao**  
East Lansing, Michigan

### Project Facilitator

**Dr. Peng Zhang**





### ME 412 Heat Transfer Laboratory

**Yuping Wang**  
**Academic Specialist**  
**Department of Mechanical Engineering**

## Understanding Thermal Energy Storage System

Thermal energy storage (TES) has become an essential part in renewable energy production systems, such as a solar thermal power plant or a wind farm. It can also be found in building heating systems. TES helps to provide a flexible energy supply, improves the overall system efficiency, and leads to better economics. In the project, students in ME412 are expected to understand the thermal energy storage process and technology through two parts of work. For the major part, each team will design, analyze, build, and test a simple thermal battery with phase change material (candle wax). The objective of the design is to achieve an efficient “charging” (heating) process and to retain the stored energy for a longer time, while cost and weight also being considered. For the secondary part, each team will choose a specific type of thermal energy storage system and conduct a review on its application, technology, operation, and performance analysis as. Due to the special situation this semester, each team will test their device at home, prepare a short demo video, and then present their device, and test results, as well as thermal analysis to the whole class on the presentation day.

## Competition Schedule

### Team 1

Sydney Rehr  
Emily Valentine  
Julia Walter

### Team 2

Yutao Shen  
Qinda Wang  
Yiming Wang

### Team 3

Julia Beach  
Brody Burke  
Marissa DePolo  
Austin Rhodes

### Team 4

Jacob Genaw  
Michelle Herring  
Nate Holloway  
Adam Speaks

### Team 5

Garrett Armock  
Adam Childress  
Brandon Phan

### Team 6

Sarah Angold-Stephens  
Aimee Desai  
Nate Sudek  
Alexia Swiat

### Team 7

Taylor Burris  
Marissa Grazioli  
Michael Maes  
Jacob Nelson

### Team 8

Alec Bailey  
Kyle Schreur  
Abdelrahman Zebdi

### Team 9

Josh Ciaccio  
Jenny Lam  
Anthony Su  
Emily Suchoski

### Team 10

Derek Donnelly  
Mark Esper  
TJ Krawczyk  
Matt Terry

### Team 11

Jamie Beck  
Annalea Hanslits  
Anson Leung

### Team 12

Kole Gilbert  
Nolan Martin  
Justin Thind  
Valentin Zilkovski

### Team 13

Zach Atkins  
Savanah Matras  
Adam Richards

### Team 14

Hannah Jacobs  
Devin Kotal  
Katie Treloar  
Grace Warmann

### Team 15

Zak Harwood  
Griffin Jones  
Abdullah Sribaya  
Nathan Ward

### Team 16

Vik Athreya  
Thomas Brandell  
Michael Hayward  
Shaya Master

### Team 17

Carl Banerian  
Gavan Sarrafian  
Patrick Tucker  
Bryan Wilson

### Team 18

Luke Chrisman  
Sloan Kanat  
Zach Petroelje

### Team 19

Tommy Coughlin  
John Jaaska  
David Lawless

### Team 20

Rahmi Khalil  
Annah Mullinax  
Preston Rashkov

### Team 21

Junchi An  
Thomas Corner  
Jack Hasselbring  
Jason Zhang

### Team 22

Natalie Bobowski  
Lexi Dewey  
Reid McDonnell  
Connor Steffens

### Team 23

Denny Blaschko  
Jacob Klocko  
Bryce Oneill  
Hannah Scott

### Team 24

Jacob Martin  
Abner Martinianobarbosa, Jr.  
Jacob Richmond  
Kyle Tomaszewski

### Team 25

Christopher Jakubik  
Nick Kerby  
Patrick McCormick  
Jacob Turner

### Team 26

Carter Reeds  
Mark Vanbuskirk  
Jack Zhao

### Team 27

Enrique Infante  
Jimmy Muscato  
Adam Piper  
Calvin Smith

### Team 28

Dante Minatel  
Christopher Steers  
Ryan Wade

### Team 29

Evan Hardy  
Alex Ifkovits  
Ethan Lau

### Team 30

Lily Craigmalich  
Jack Dailey  
Nathan Kinner  
Sarah Piotrowicz

### Team 31

Nattida Jubju  
Matt Mayer  
Scott Pinkham  
Bryce Sutton

### Team 32

Arjun Balakrishnan  
Jeremy Busch  
Ethan Curtiss  
Samantha Halaby

### Team 33

Nathan Cascarelli  
Douglas Mcnanney  
Drew Skedel

### Team 34

Daniel Jansen  
Katianne Rausch  
Alec Smerage  
Brian Yemc



## **ME 456** **Mechatronic System Design**

**Dr. Guoming Zhu, Professor**  
**Department of Mechanical Engineering**

### **Learning Objective:**

The learning objective of ME456 is for students to understand the entire process of developing a mechatronic system. This includes a) system modeling, b) PID control, c) control implementation to the Arduino platform using Simulink, and d) experimental validation. The class will also help students to understand the principles of commonly used mechatronic system hardware, such as rate gyro and accelerometer sensors, DC motor actuators, micro-controllers, etc., basic Simulink program development for Arduino compatible hardware, analyze system output performance, and tune PID controller to satisfy certain output performance in simulations and experiments.

### **Mechatronic System Used for the Lab Sessions:**

An Arduino-based Mini Segway robotics (see figure) will be provided to each student who may use his/her own laptop (with installed Matlab/Simulink and Arduino library developed by MSU) to interface with the Mini Segway through Wi-Fi network. The Mini Segway is equipped with two geared DC motors and position (speed) feedback used to balance and drive the vehicle, and it is also equipped with gyro and accelerometer sensors to measure the Mini Segway angular position and velocity. Note that the gyro and accelerometer signals will be processed to generate Mini Segway pendulum angular position. Students will program the Arduino microcontroller in Simulink and compile the Simulink-based software into Arduino automatically. The only programming knowledge required for the class is Simulink that will be taught in Lab 1. For interested students, a GUI (graphic user interface) can be created in Simulink to be used to control the Mini Segway and tune the PID gain in real-time. Please use this link (<https://youtu.be/fa6hp2grxrk>) or scan the QR code below for a Mini Segway demo.



## ME 470 Mechanical Design & Manufacturing II



**Michael Lavagnino**  
**Academic Specialist**  
**Department of**  
**Mechanical Engineering**

### Walking Robot

In honor of the summer 2020 Olympic Games that will occur this summer, students will design and build a walking robot to compete in time trials to complete a straight-line course. Students will utilize 4-bar linkage systems attached to a provided gear motor to propel their robot to victory. Students will be able to utilize 3D printers and premade components to build their design.

#### Team 1A

Jose Alcantar  
Andrew Debaker  
Andy Fulbright  
Tucker Hendrie

#### Team 1B

Noel Dyde  
Alec LeVasseur  
Devon Pung  
Drew Tyrrell

#### Team 2A

Douglas McNanney  
Daniel Reynolds  
Karisa Rodeghiero  
Yang Xu

#### Team 2B

Abigail Bowman  
Lehomm Pickard  
Alain Sotolongo  
Emma Turkmani  
Bobby Vette

#### Team 3A

Tadiwa Childuma  
John Royston  
Deshawn Schwan  
Andy Zhao

#### Team 3B

Jack Hasselbring  
Nelson Huynh  
Oliver Larroquette  
Nick Masini

#### Team 4A

Vince Cushing  
Allison Fox  
Sean Lishawa  
Kanglin Ma

#### Team 4B

Andrew Emery  
Ethan Kalkman  
Adam Sliwinski  
Mackenzie Wagner

#### Team 5A

Jessica Gothro  
Drew Hubbard  
Samar Shiekh  
Justin Yan

#### Team 5B

Daniel Blondell  
Stacy Fakhoury  
Race Piontkowski  
Chris Sadler  
Dayana Villagran

#### Team 6A

Drew Boudreau  
Jack Sikkema  
Martin Stokes  
Mike Wichman

#### Team 6B

Paige Cordts  
Veronica Giordano  
Annalea Hanslits  
Alex Ifkovits

#### Team 7A

Cayla Coury  
Alyssa Lafeir  
Ryan Langan  
Santos Lopez

#### Team 7B

Justin Helmer  
Katlyn Knudsen  
Hammer Shalawlyo  
Jessica Thomas

#### Team 8A

Claudia Chen  
Bobby Dipanni  
Noah Hubbard  
Jason Scott

#### Team 8B

Ameya Bokil  
Jimmy Provax  
Zhihao Xu  
Tahha Zahid

#### Team 9A

Colin Hachey  
Sean Martella  
Tom Ott  
Robert Pedder

#### Team 9B

Yuandalei Cao  
Lily Craigmlich  
Kelsey Karasek  
Jessica Lypka

#### Team 10A

John Jaaska  
Garrett Novak  
Kaianne Rausch  
Matt Schram

#### Team 10B

Hernan Brarda  
Jared Ludacka  
Nathan Vigneau  
Garrett Watson

#### Team 11A

Drake Deming  
Marvin Haddad  
Andrew Hall  
Jarod Miller

#### Team 11B

Brandon Burlage  
Chelsey Ely  
Nate Farhat  
Hailey Swamy

#### Team 12A

Ethan Curtiss  
Douglas Heine  
Andrew McNamara  
Ryan Rowe

#### Team 12B

Matt Greene  
Drew Larson  
David Patton  
Noah Terech

#### Team 13A

Delano Dalfonsi  
Roman Grishin  
James McDonald  
Yu Zheng  
Xichen Zhu

#### Team 13B

Jacob Genaw  
Jared Koekkoek  
Jacob Pawloske  
Andrew Retzlaff

#### Team 14A

Jake Coffey  
Matthew Good  
Justin Kowalchik  
Jacob Zettle

#### Team 15B

Oriol Canellassalles  
Jake Frelich  
Mitch Leblanc  
Kepler Tiedje





## **ME 478 Product Development**

**Patrick Kwon**  
**Professor of Mechanical Engineering**

### **3D Printing Machine**

The objective is to design, produce and demonstrate a ‘conceptual design’ of a ‘metallic’ 3D printing machine whose requirements are: 1) The part must be printed in a 10cm x 10cm x 10cm envelope; 2) The powder must be deposited in a layer-by-layer fashion with the maximum thickness of each layer of 1mm; 3) The system must generate a full density part.

There is complete freedom over how to approach this design project. However, one default approach is to develop an automated mixing and depositing system of a photopolymer – metal powder mixture which can be adopted by 3D printing machine.

The requirements of the system are as follows: 1) The system should be capable of combining and homogeneously mixing a solution of 1:4 weight ratio of olive oil and sand (i.e., 5 grams of oil

and 20 grams of sand) instead of photopolymer and metal powder; 2) The olive oil mixed with sand should be deposited on a 10cm x 10cm platform in a weight controlled manner.

Presumably, the system might consist of 1) A material supplying module: This module is capable of adding sand and oil into the mixer with a specific weight ratio; 2) A mixing module: Blend the oil and sand together until the solution is homogeneous; 3) A deposition module: Deposit a certain amount of the mixed solution (20 grams) onto a platform; 4) A printing module: Digital Light Projector to selectively cure photopolymer; 5) A release module (concept): A part must be free from the base or powder-liquid resin mixture.

### **Teams and Team Members**

---

#### **Team BJP1:**

Vik Athreya  
Abigail Bowman  
Dom Long  
Bobby Vette

#### **Team BJP2:**

Arjun Balakrishnan  
Daniel Blondell  
Sicheng Ni  
Kepler Tiedje

#### **Team BJP6:**

Jack Beddow  
Matt Bradford  
Paul Sacharski  
Christopher Steers

#### **Team BJP7:**

Oriol Canellassalles  
Zhiyuan Qu  
Yutao Shen  
Anthony Su

#### **Team FDM1:**

Denny Blaschko  
Brandon Burlage  
TJ Krawczyk  
Jacob Richmond  
Cody Zorn

#### **Team FDM3:**

Cody Chalk  
Jake Coffey  
Justin Kowalchik  
Chase Rojeck

#### **Team FDM5:**

Derek Donnelly  
Enrique Infante  
Jacob Martin  
Dante Minatel  
Max Smith

#### **Team STL1:**

Carl Banerian  
Sky Bunker  
Colton Jennings  
Jacob Staal  
Bryan Wilson

#### **Team STL2:**

Dan Bojanowski  
Griffin Jones  
Nolan Martin  
Ryan Stawara

#### **Team STL4:**

Alex Hughes  
Jenny Lam  
Ben Oak  
Samah Shoubah

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**Dr. William Resh**  
**Professor of Mechanical Engineering**

**Faculty Advisors: Anthony, Baek, Benard, Brereton, Engeda, Feeny, Grimm, Jaberi, Koochesfahani, Lee, Mueller, Nadimpali, Naguib, Petrasch, Pence, Roccabianca, Schock, Toulson, Wichman, Wright, Xiao, Zayermouri, and Zhu**



Anthony



Baek



Benard



Brereton



Engeda



Feeny



Grimm



Jaberi



Koochesfaani



Lee



Mueller



Nadimpali



Naguib



Petrasch



Pence



Roccabianca



Schock



Toulson



Wichman



Wright



Xiao



Zayermouri



Zhu

## ME 481 Mechanical Engineering Design Projects

Mechanical engineers make the world move and provide the energy for it to do so. One goal of the MSU Mechanical Engineering Program is to educate engineers who are prepared to lead, create, and innovate as their professional or graduate careers evolve. The Mechanical Engineering Design Program is the key element of the curriculum that supports this goal. There are five required design courses in the program which provide our students with eight hands-on team-based design projects, and numerous opportunities to practice and refine their written, oral, poster, and video presentation skills. The Design Program in Mechanical Engineering has attracted national recognition on many occasions and helps to distinguish the ME program as one of the best in the country.

ME 481 is a required course for mechanical engineering majors at MSU. The course provides students with a team-based capstone design experience in which they:

- Use the technical expertise, communication skills, and teaming methodologies they have learned throughout their mechanical engineering curriculum, together with their creativity, to solve real world problems,
- Collaborate with practicing engineers to address problems sponsored by industry,
- Develop new products or redesign existing products to reduce costs or enhance reliability and functionality,
- Work on projects from large, medium, and small companies across a broad range of industries, as well as projects from government agencies.

We gratefully acknowledge the support of this semester's project sponsors: Cleveland-Cliffs, Inc., Consumers Energy, Flash Steelworks, Inc., General Motors, Heartwood School/Ingham ISD, Holt Public Schools/Ingham ISD, Meritor, Inc., Michigan AgrAbility/Heroes to Hives, MSU Adaptive Sports and Recreation Club, MSU Department of Mechanical Engineering, MSU Department of Theatre, NASA/Arizona State University, Sistema.bio, Steelcase, and Westrock.

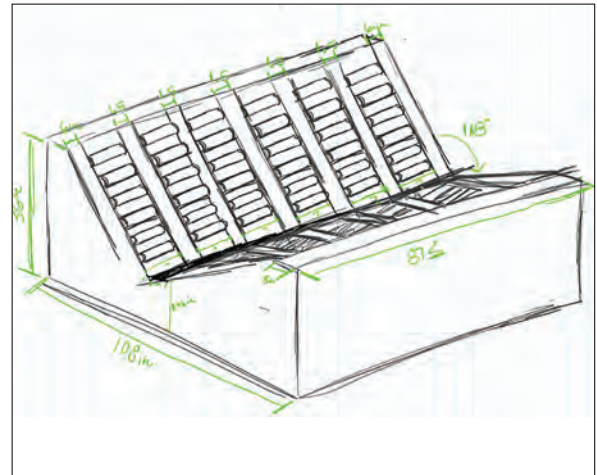


# Cleveland-Cliffs, Inc. Steel Coil Banding Station

Cleveland-Cliffs is the largest flat-rolled steel company and the largest iron ore pellet producer in North America. The company is vertically integrated from mining through iron making, steelmaking, rolling, finishing, and downstream with hot and cold stamping of steel parts and components. One of the main products that Cleveland-Cliffs manufactures and sells is steel coils. They are made from mined iron pellets that are melted down into slabs, rolled to a thickness of .05 inches with an average length around 10,000 feet long, and then rolled into a coil for further processing. These steel coils are extremely heavy, ranging from 10,000 pounds to 80,000 pounds but average 50,000 pounds, with the width of the coils ranging from 32 inches to 75 inches. The coils are held together by bands, which are uniquely oriented for the customer receiving the coil.

Movement of the coils requires using a crane, and the coils are moved frequently around the plant to be put into storage or moved to another location for further processing. Due to the frequent movement, the bands will occasionally break, causing the coils to unravel. These coils then need to be placed down and re-banded.

Our team has designed a station for Cleveland-Cliffs so that if a band breaks, there is a safe way for the coils to be re-banded. The designed station creates a safe way to allow for the coils to be recoiled with the help of some polyurethane covered rollers. These enormous steel coils can now be re-banded efficiently without the risk of a life-threatening injury to the operators on the floor.



## Michigan State University

**Team Members** (left to right)

**Madeline Warner**  
Vicksburg, Michigan

**Sarah Angold-Stephens**  
Ann Arbor, Michigan

**Emily Fitzsimons**  
Richmond, Michigan

**Alexia Swiat**  
Brookeville, Maryland

**Aimee Desai**  
Okemos, Michigan

## Cleveland-Cliffs, Inc.

**Project Sponsor**

**Lauren Hart**  
Burns Harbor, Indiana

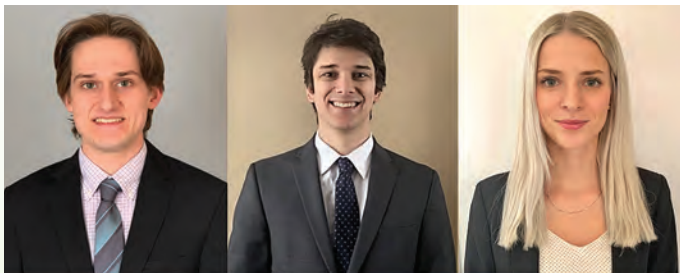
## ME Faculty Advisor

**Dr. Rebecca Anthony**

# Cleveland-Cliffs, Inc. Steel Coil Banding Station

Cleveland-Cliffs, Inc., headquartered in Luxembourg, Luxembourg, is the world's leading steel and mining company. With more than 190,000 employees and steel manufacturing plants in 18 countries, it is the leading supplier of quality steel products in the North American, Asian, and European markets. These include automotive, machinery, pipe and tube, construction, container, and appliance. Its foremost goal is to build a better world by inventing smarter steels. Cleveland-Cliffs manufactures steel in the form of large coils that are moved by a crane to different locations up to ten times and are then placed in storage areas with other coils. Due to the vast amount of movement, the band holding the coil together will occasionally break.

Currently, there is no safe way to re-band these coils before they are transported to the next station. There are safety concerns with operators standing near the coil when it is being moved by the crane. Our team's project is to design a station where these un-banded coils can be safely re-banded without putting workers in unnecessary danger. Since Cleveland-Cliffs' coils come in different sizes, the re-banding station supports any size coil. Another important feature is that the re-banding station can re-band the coil in as many orientations as possible since customers prefer different types. We focused on a solution that is cost-effective, can be manufactured out of steel, and is safe and reliable. With this newly implemented steel coil re-banding station, Cleveland-Cliffs can easily transport its re-banded steel coils to the next location.



## Michigan State University Team Members (left to right)

**Ryan Garman**  
Rochester Hills, Michigan

**Nathan Cascarelli**  
Howell, Michigan

**Lena Wuensch**  
Lake Orion, Michigan

**Christopher Jakubik**  
Plymouth, Michigan

**Brody Burke**  
Pinckney, Michigan

## Cleveland-Cliffs, Inc. Project Sponsor

**Lauren Hart**  
Burns Harbor, Indiana

## ME Faculty Advisor

**Dr. Seungik Baek**

# Cleveland-Cliffs, Inc. Wrapped Weld Reprocess Station

Cleveland-Cliffs, Inc. is an integrated steel mill located in East Chicago which mines iron ore pellets out of the ground and melts them down into slabs of steel. These slabs are then rolled out into steel coils 0.5 inches thick. These coils of steel can weigh anywhere between 10,000 and 80,000 lbs, and measure anywhere between 32 and 75 inches wide. To have the coils efficiently run on a process line, they are welded together with the tail end of one coil welded to the head of the next coil. Currently, there is a station at the end of the process line where an operator cuts the weld, resulting in the separation of the two coils. However, the operator sometimes will miss the cut, and the weld will be rolled into the outer loops of the coil. Once this happens, the coil then needs to be transported, using cranes and tractors, to the reprocess line where it will be fixed, and then returned to where it came from on the process line. This whole process can take up to two weeks, resulting in a major setback in delivering the product to the customer.

Our team has been tasked with creating a station at the end of the process line that would be able to unroll the coils where missed cuts occurred to a position where the weld could then be successfully cut by an operator using a hand torch. To do this, the coil will need to be able to roll out about three laps. After the weld is cut, the station would then need to be able to roll the coil back up. Another requirement for the station is the ability to hold any size coil with a minimum factor of safety of 1.5. The station will be made out of structural steel and designed using CAD and FEA software to ensure the requirements are met and are feasible. The resulting impact of the project would be to save Cleveland-Cliffs money, time, and improve customer satisfaction.



## Michigan State University *Team Members* (left to right)

**Evan Hardy**  
Ann Arbor, Michigan

**Mark Esper**  
Royal Oak, Michigan

**Scott Pinkham**  
Cornwall, New York

**Charles Colton**  
Wixom, Michigan

**Christopher Steers**  
Grand Rapids, Michigan

## Cleveland-Cliffs, Inc. *Project Sponsor*

**Lauren Hart**  
Burns Harbor, Indiana

## ME Faculty Advisor

**Dr. Farhad Jaber**



# Consumers Energy Uninterrupted Service Replacements

The primary objective of this project is to create a method of maintaining gas service a customer's home while the existing service line to the meter is being replaced. The team will essentially be designing a jumper device to transfer service from an old gas line to a new gas line without stopping service to the house.

Currently, before a field worker begins to replace the existing service line, Consumers Energy shuts off gas to the meter. Thus, all gas appliances downstream of that meter will no longer be supplied with gas. In order to restart these appliances once the new line is installed, the field worker must go into the building to relight each gas appliance, which can be challenging if the building owner is not available, to let the field worker inside. There are no current methods in place that allow continuous service to the meter while the service line is being replaced.

Constraints for this project include the need to regulate the pressure of the gas, have proper seals to prevent a gas leak and prevent oxygen from entering the fuel lines, and be safe to use with live natural gas. In addition, the team must ensure the design fits between the house and the meter and design a solution that is ergonomic for the field worker to operate. The design should also take into consideration the company's goal to reduce cost by eliminating the need for a return trip to relight appliances.

The expected deliverables for the project include a completed 3D model of the team's design in CAD and a detailed economic comparison between the team's design and the original cost of returning to the building to relight appliances.



## Michigan State University Team Members (left to right)

**Jenny Lam**  
Okemos, Michigan

**Heidi Theisen**  
Almont, Michigan

**Jacob Bruner**  
Falls Church, Virginia

**Nick Kerby**  
Almont, Michigan

**Natalie Bobowski**  
Macomb, Michigan

## Consumers Energy Project Sponsors

**Jeffrey Parker**  
Lansing, Michigan

**Peter Pryson**  
Kalamazoo, Michigan

## ME Faculty Advisor

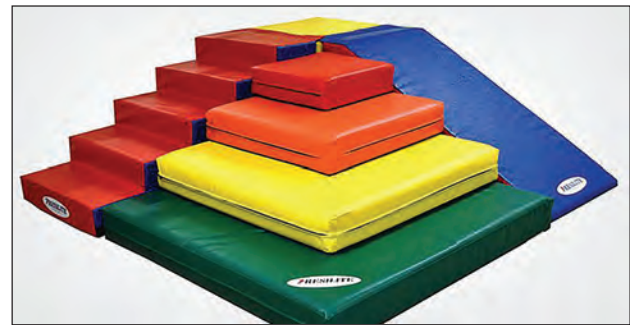
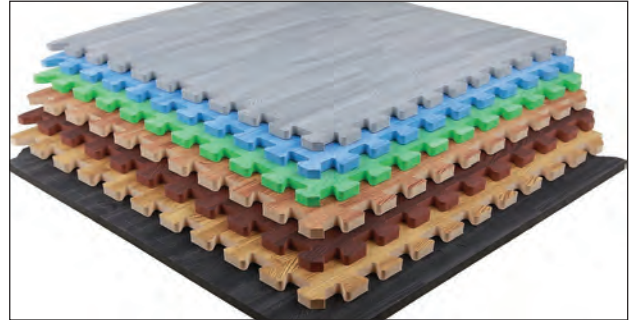
**Dr. Abraham Engeda**

# Heartwood School/Ingham ISD Adjustable Obstacle Course

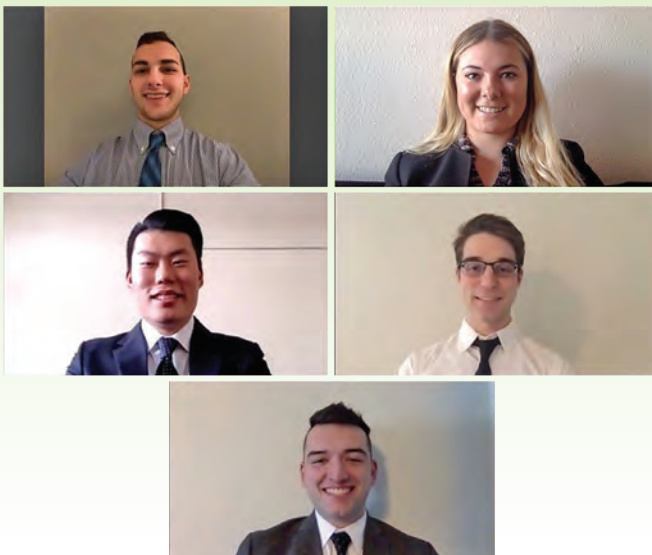
Heartwood School is a school that works within Ingham Intermediate School District focusing on serving students with moderate to severe cognitive disabilities, autism spectrum disorders, and physical disabilities. Many of these students have difficulty navigating and accessing everyday obstacles such as stairs and different surface types. To help these students, Heartwood School often sets up obstacle courses through which the students can try to maneuver. However, these obstacle courses can be difficult to set up and take time to rearrange for students with different levels of mobility.

Our project is to design, test, and build an obstacle course that is simple to assemble, customizable to meet different students' needs, and able to simulate different types of surfaces. This obstacle course would be built with the aim of allowing teachers at Heartwood to easily set up the course in a way that simulates a real-world environment within the safety of Heartwood's walls. In addition to this, we would like to make the obstacle course in a way that allows students to make their own courses in the comfort of their own home. This feature is extremely important, as some students are unable to attend Heartwood Schools in person due to the risk of health complications from the current pandemic. With this in mind the course would need to be built sturdily enough that students could not take apart small pieces of the course and potentially swallow them, leading to choking hazards.

The design of this obstacle course would allow students with all types of disabilities to better navigate the world around them so they can live more comfortable and safer lives.



Ingham Intermediate  
School District  
Heartwood School



## Michigan State University Team Members (left to right)

**Matthew Razz**  
New Baltimore, Michigan

**Savanah Matras**  
Linden, Michigan

**Calvin Smith**  
Marshall, Michigan

**Ryan Wade**  
Marshall, Michigan

**Matt Terry**  
Marshall, Michigan

## Heartwood School/ Ingham ISD Project Sponsor

**Heather Vogt-Frechette**  
Mason, Michigan

## ME Faculty Advisor

**Dr. Manoochehr Koochesfahani**



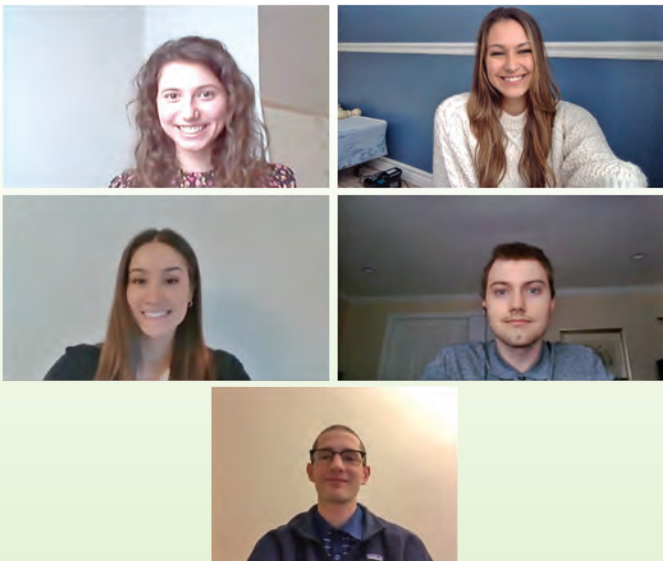
# Heartwood School/Ingham ISD Outdoor Movement Story Path

**H**earthwood School is a center-based program located in Mason, Michigan and is part of the Ingham Intermediate School District. Heartwood serves students from 2.5 to 26 years old with moderate to severe cognitive impairments, severe multiple impairments, autism spectrum disorders, and physical impairments. Heartwood School has its own specialized curriculum, which incorporates a program called MOVE. This program adapts to individuals' present abilities with an instructional process to incorporate motivational activities for improvement of mobility skills such as sitting, standing, walking and transitioning. The Outdoor Movement Story Path is a fun and interactive approach to the MOVE program to integrate mobility and sensory activities throughout a student's day. Multiple outdoor stations need to be able to withstand weather elements corresponding to interactive stories for development of literacy, mobility, social, and sensory skills. Each station has a place for two letter sized portions to be added that allow for different book or exercise pages along with a smaller window for a communication CORE word. Additionally, each station will correspond to themes such as sound, touch, exercise, and cognitive stimulation.

Our project is to provide blueprints for the Outdoor Movement Story Path concept for improvement of the MOVE program. The main risk for this project is injury to the students. Hence, the design does not include any protruding material, and the detachable top board contains a safety locking mechanism. To adapt to outdoor weather conditions, all components are weatherproofed. The stands are also able to withstand the force of students pushing down or leaning on them. Sanitizing of stations is essential in maintaining the health and safety of the students and faculty.



Ingham Intermediate  
School District  
Heartwood School



## Michigan State University Team Members (left to right)

**Emily Suchoski**  
Shelby Township, Michigan

**Evelyn Zielinski**  
Milford, Michigan

**Emily LeBlanc**  
Plymouth, Michigan

**Jack Dailey**  
Grosse Ile, Michigan

**Josh Ciaccio**  
Chelsea, Michigan

## Heartwood School/ Ingham ISD Project Sponsor

**Heather Vogt-Frechette**  
Mason, Michigan

## ME Faculty Advisor

**Dr. Elisa Toulson**



# Heartwood School/Ingham ISD Indoor Movement Path

Heartwood School serves students in the Ingham ISD service area who are eligible to receive services under the categories of moderate and severe cognitive impairments, severe multiple impairments, and autism spectrum disorders. Heartwood staff work with local school districts and families to provide center-based programs and services to students, as determined through the IEP process. Heartwood School does not enroll students independent of local involvement. Children who attend Heartwood School are between the ages of 3 and 26.

Heartwood students need more opportunities to incorporate mobility and sensory activities throughout their day to have more practice and development of their skills. This project involves developing a plan for a motor/sensory engagement inside with various stations to incorporate more motor/sensory opportunities within the school environment together with literacy and CORE opportunities as appropriate and possible.



Ingham Intermediate  
School District  
Heartwood School



## Michigan State University *Team Members* (left to right)

**Zhiyuan Qu**  
ShanDong, China

**Yutao Shen**  
Suzhou, China

**Sichen Ni**  
Beijing, China

**Junchi An**  
Shandong, China

**Jason Zhang**  
Guang Zhou, China

**Jack Zhao**  
Shenzhen, China

## Heartwood School/ Ingham ISD *Project Sponsor*

**Heather Vogt-Frechette**  
East Lansing, Michigan

## ME Faculty Advisor

**Dr. Lik Chuan Lee**

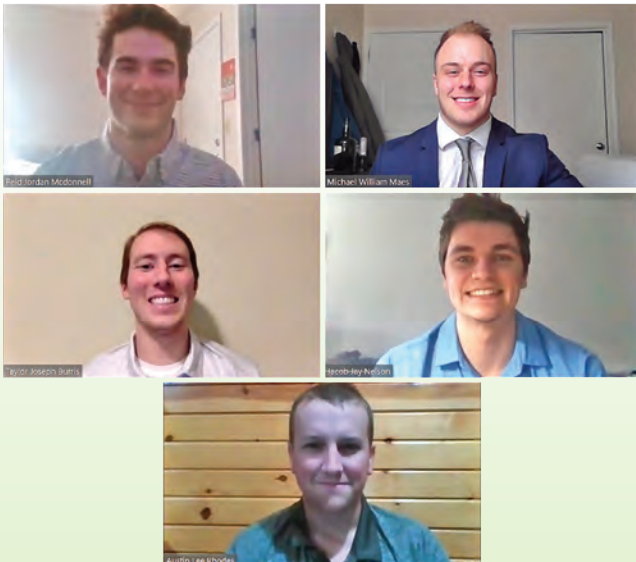
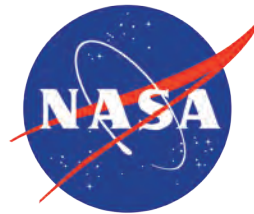
# NASA/Arizona State University Sampling System for Hypothesized Surfaces

A space mission called Psyche is set to launch in 2022. This mission is targeted to learn more about the building blocks of planet formation. Psyche is an asteroid in the asteroid belt between Mars and Jupiter that is likely made largely of metal from the core of an early planet. The goal of the mission is to determine if this hypothesis is true and figure out the makeup of the surface of this asteroid. Psyche is the only known place in our solar system where we can examine directly what may contain metal from the core of an early planet. If this mission is a success, it is possible engineers and scientists might want to propose a follow-on mission to land on the asteroid for an actual sample of the surface.

Such a mission would involve collecting samples from the asteroid and transferring them back to Earth for further analysis. For this analysis to be successful, an efficient and reliable sampling system must be engineered to ensure the quality of asteroid samples.

One of the challenges of this project is the lack of knowledge of what Psyche's surface consists of because it is believed to be some mixture of metal and rock. This system must include a proper extraction device along with an organized caching system to store the samples as the spacecraft travels back to the Earth in the future.

The deliverables that are needed for this mission to be successful include a fully operable 3-dimensional computer-aided design program, along with proper testing while considering all potential constraints listed in above sections.



## Michigan State University

**Team Members** (left to right)

**Reid McDonnell**  
Canton, Michigan

**Michael Maes**  
Canton, Michigan

**Taylor Burris**  
Canton, Michigan

**Jacob Nelson**  
Macomb, Michigan

**Austin Rhodes**  
Beaverton, Michigan

## NASA/Arizona State University

**Project Sponsor**

**Cassie Bowman**  
Tempe, Arizona

## ME Faculty Advisor

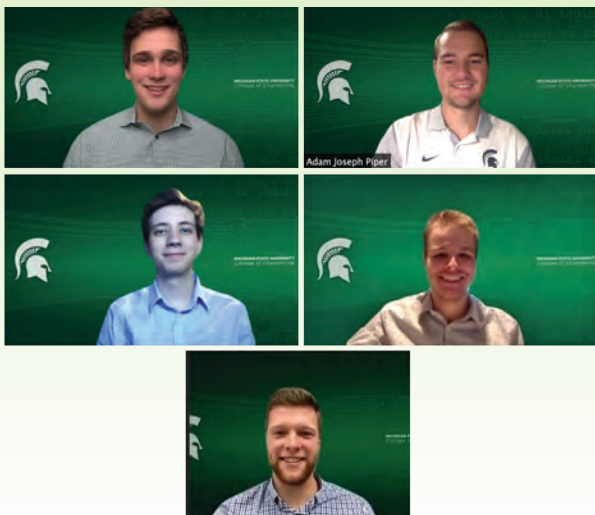
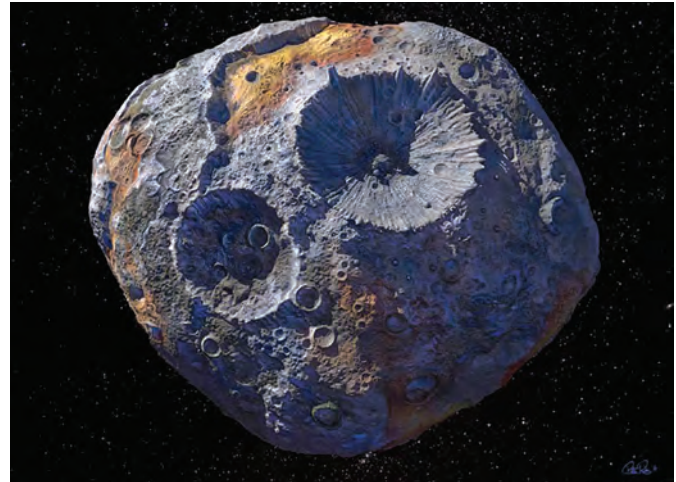
**Dr. Norbert Mueller**

# NASA/Arizona State University Sampling System for Hypothesized Surfaces

The NASA Psyche Mission is set to launch in 2022 and arrive at the asteroid in 2026. It is an orbiter mission and will not land on the surface. It is possible to imagine, however, that after learning about Psyche from orbit, there may be scientists and engineers interested in proposing a subsequent mission to actually land on the asteroid and sample its surface. In this capstone project, we are that team!

Designing to the range of hypothesized surfaces that might be found at Psyche (and keeping in mind other constraints such as its gravity), the team has been asked to design a sampling system capable of effectively extracting scientific samples from each of the hypothesized surfaces and, potentially, a single caching system able to cache each type. Hypothesized surfaces may include mostly flat metallic surface, flat metallic with metal and/or rocky debris, rough/high-relief metallic and/or rocky terrain high relief metallic crater walls.

Over the course of the project, the team will create preliminary and final designs of the Psyche sampling system. These deliverables include computer aided designs of the sampling and caching systems along with finite element analysis on all load-bearing components. Additionally, a theoretical control system is to be designed to model autonomous control of the sampling system to account for communication latency from Earth.



## Michigan State University

*Team Members* (left to right)

**Matthew Bradford**  
Commerce, Michigan

**Adam Piper**  
Commerce, Michigan

**Bryan Wilson**  
White Lake, Michigan

**Daniel Nicklowitz**  
Rockford, Michigan

**Kyle Peters**  
Brighton, Michigan

## NASA/Arizona State University

*Project Sponsor*

**Cassie Bowman**  
Tempe, Arizona

## ME Faculty Advisor

**Dr. Siva Nadimpalli**

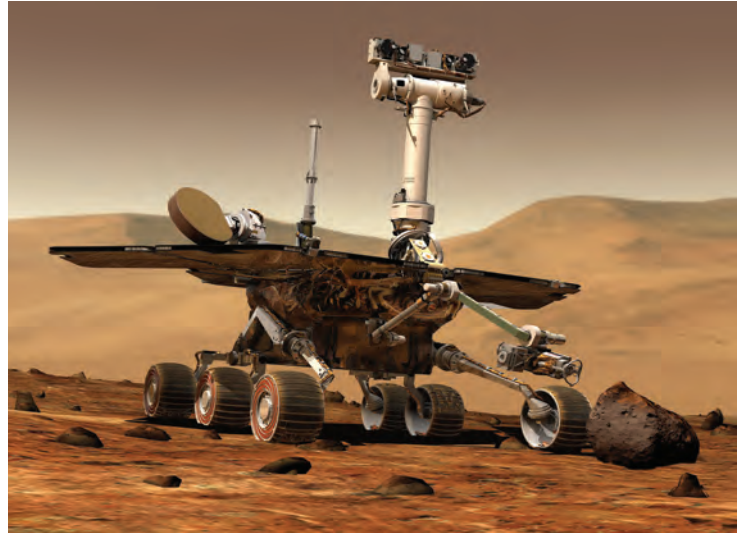


# NASA/Arizona State University Robotic Explorer for Hypothesized Surfaces

The National Aeronautics and Space Administration (NASA) is an independent agency of the U.S. federal government responsible for the civilian space program, as well as aeronautics and space research. NASA's mission is to "drive advances in science, technology, aeronautics, and space exploration to enhance knowledge, education, innovation, economic vitality and stewardship of Earth. Core Values: We share a set of core values—safety, integrity, teamwork, excellence, inclusion—and they are evident in all that we do." Currently, NASA is attempting to explore smaller bodies in space.

The Psyche mission is a journey to a unique metal asteroid orbiting the Sun between Mars and Jupiter. The mission is led by Psyche Principal Investigator Lindy Elkins-Tanton of Arizona State University. NASA's Jet Propulsion Laboratory is responsible for the mission's overall management, system engineering, integration and test, and mission operations. Maxar Technologies is providing a high-power solar electric propulsion spacecraft chassis.

Our team was responsible for designing a rover that could potentially be used to traverse the asteroid Psyche during a future surface mission. Psyche presents many unique challenges including low gravity, low solar radiation, and lack of an atmosphere. Utilizing a unique propulsion system accompanied by an innovative ground movement system, our design allowed the rover to traverse across many different hypothesized surfaces, ranging from a flat, metallic surface to rocky terrain with high-relief crater walls.



## Michigan State University

*Team Members* (left to right)

**Adam Speaks**  
Sterling Heights, Michigan

**Christian Stack**  
Sterling Heights, Michigan

**Jacob Wallace**  
Brighton, Michigan

**Jacob Klocko**  
Wixom, Michigan

**Hannah Scott**  
Milford, Michigan

## NASA/Arizona State University

*Project Sponsor*

**Cassie Bowman**  
Tempe, Arizona

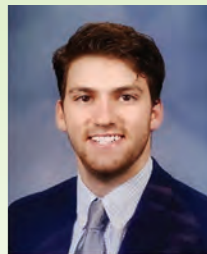
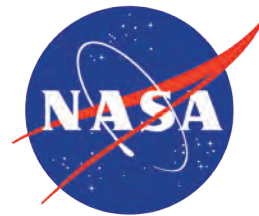
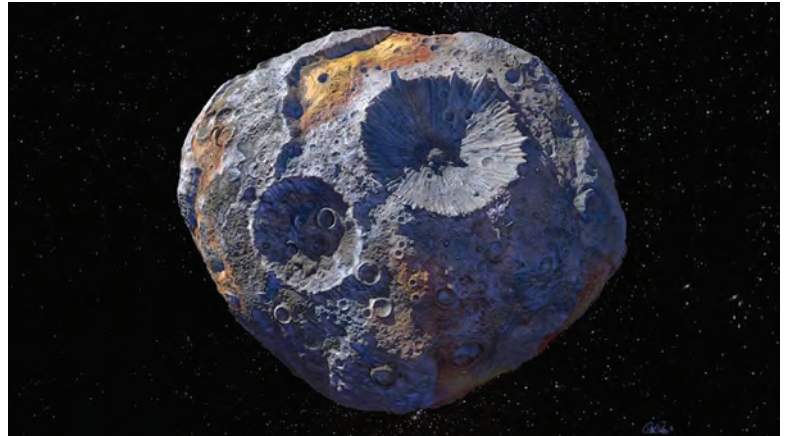
## ME Faculty Advisor

**Dr. Brian Feeny**

# NASA/Arizona State University Robotic Explorer for Hypothesized Surfaces

NASA is the U.S. government agency responsible for science and technology related to air and space. In collaboration with Arizona State University, located in Tempe, Arizona, NASA's Psyche Mission team has asked mechanical engineering capstone teams to design a rover capable of traversing the complex terrain of the Psyche asteroid's surface. The NASA Psyche Mission is set to launch in 2022 and arrive at the asteroid in 2026. It is an orbiter mission and will not land on the surface. After learning about Psyche, scientists and engineers may be interested in proposing a subsequent mission to land on the asteroid and explore its surface.

Our team designed a robotic explorer capable of traversing the range of hypothesized surfaces and ideally adapt to each of them mid-traverse. The project is collaborative to engineer the method of movement and chassis design to effectively collect and analyze data. The surface of Psyche is largely metallic and rocky with large hill gradients to take into account. The overall shape, design, weight, power, and other parameters were designed to account for the overall mission and ensure flawless performance. An understanding of the environmental conditions such as the temperature, sunlight, gravity, and lack of atmosphere are clear parameters that will constrain our design.



## Michigan State University *Team Members* (left to right)

**Vikram Athreya**  
Troy, Michigan

**Michael Hayward**  
Bay City, Michigan

**Aaron Kaplan**  
Birmingham, Michigan

**Enrique Infante**  
Kalamazoo, Michigan

**Nattida Jubju**  
Nonthaburi, Thailand

## NASA/Arizona State University *Project Sponsor*

**Cassie Bowman**  
Tempe, Arizona

## ME Faculty Advisor

**Dr. Joerg Petrasch**

# Steelcase

## Conference Room Table – Passive Damping System

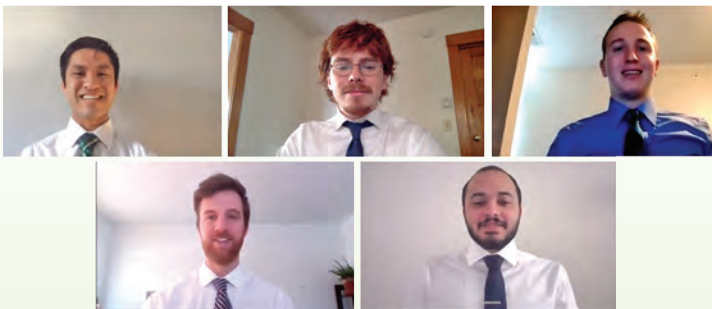
Steelcase, located in Grand Rapids, Michigan with additional locations and dealers around the world, is a developer of architecture, furniture, and technology products. First producing metal wastebaskets in 1912 to reduce the number of office fires, their goal is to continue to innovate the workplace.

Steelcase's catalogue ranges from classroom desks to conference room and casual living room tables. It is commonly considered that the quality of a table/desk can be related to its stability. While there are many structurally sound tables on the market, they are often supported by materials that increase the weight of the table and reduce the space of the user. Creating a product that reduces the need for such supports may lower the cost and ease the process of manufacturing. Developing cheap, yet reliable tables would be beneficial to schools, small businesses, and other organizations with limited funding.

Our team has been tasked with designing, manufacturing, and testing a passive damping system for desks and tables to reduce the oscillation and settling time due to horizontal impacts. Since Steelcase produces a variety of products, the device must be tunable and modular in order to adapt to different leg sizes and table masses. In order to maintain the table's visual appeal and the user's space, the product must also be concealable and aesthetically pleasing. The device should enable the table to meet industry standards, which include reducing initial displacement by 90% after six seconds. Benefits of this device include increased user comfort, enhanced perception of the table's quality, and increased lifespan. There are very little downsides or risks associated with the addition of this device, aside from waste caused by premature disposal of old tables. The success of this project may allow Steelcase's products to be designed differently with implementation of our accessory in mind.



Steelcase®



### Michigan State University

**Team Members** (left to right)

**Ethan Lau**  
Mission Viejo, California

**Sean Gielow**  
Rochester Hills, Michigan

**Patrick Tucker**  
Brighton, Michigan

**Nick Holda**  
Ann Arbor, Michigan

**Abdullah Sribaya**  
Jeddah, Saudi Arabia

### Steelcase

**Project Sponsors**

**Reid Culberson**  
Grand Rapids, Michigan

**David Jones**  
Grand Rapids, Michigan

**Bradley Youngs**  
Grand Rapids, Michigan

### ME Faculty Advisor

**Dr. Sara Roccabianca**



# Holt Public Schools/Ingham ISD Lift for Zeke

Ingham ISD creates a space for all students/learners in the community offering support, resources, and enhanced education. Zeke is an intelligent and outgoing sophomore student at Holt High School who has a condition called Quadramelia/Amelia, meaning he was born with no arms or legs. He is dependent on one or even two aids/caregivers who assist him in his day-to-day activities including using the bathroom. Zeke enjoys the sense of independence when being in his wheelchair and in full control, but when it comes to transitioning from different chairs, Zeke loses much independence. Transitioning from one chair to another is also a big challenge for Zeke and his caregivers. Zeke now weighs over 70 pounds and needs a lift that provides him more independence during his transitions and can safely lift him without the strain on caregivers. This project is designed to meet those goals.

Project designs completed by multiple former MSU engineering teams addressed the need of helping Zeke move from his wheelchair onto another chair and maneuver him onto the ground. This evolving device was redesigned in Spring 2020 and Fall 2020 but never had the opportunity to be prototyped and tested on Zeke. Current design work revolves around the most recent redesign with a few tweaks to ensure Zeke has full mobility on his own as he transitions from his wheelchair to another chair. To help with storage and maneuverability within Zeke's house, making this lift as compact as possible is one of the main goals for the build, along with providing more options for movement such as 360-degree rotation. A stable attachment system from Zeke's wheelchair to the lift is necessary to ensure Zeke's safety during transition.

This project is expected to reach the build phase to provide Zeke a prototype with added mobility and independence.



## Michigan State University Team Members (left to right)

**Emily Valentine**  
Lake Orion, Michigan

**Jacob Palmer**  
Traverse City, Michigan

**Sarah Piotrowicz**  
Beverly Hills, Michigan

**Carter Reeds**  
South Lyon, Michigan

**Nathan Kinner**  
West Bloomfield, Michigan

## Holt Public Schools/Ingham ISD Project Sponsor

**Joanne Janicki,**  
Mason, Michigan

## ME Faculty Advisor

**Dr. Indrek Wichman**

# Meritor, Inc.

## Carrier Pinion Retention Feature

**M**eritor, Inc. is a global corporation that designs and manufactures commercial truck components. More specifically, Meritor product offerings include axles, brakes, drivelines, and suspensions.

For the purpose of our design project, we are focusing solely on the assembly and disassembly process relating to drive axles. A drive axle is the core shaft involved in making a vehicle's wheels turn, and support vehicle weight. At the heart of typical axle designs is a bevel gear set, which consists of a ring gear and a pinion gear. This gear set is constantly under varying amounts of load, meaning that the design of the axle systems is critical in ensuring proper performance and durability. One component found in axle designs is a pinion nut, which maintains preload to the pinion bearing system, while preventing any movement of the pinion within the axle. Therefore, retaining the pinion nut is an essential part of a successful axle design.

Although Meritor's current design of such nuts provides sufficient performance while in service, complications can arise during disassembly, either during service procedures or adjustments commonly used during manufacturing of the axles. Our challenge this semester is to design a new and improved pinon nut retention feature that meets the load and durability requirements, while also allowing easy removal without damage to the axle system and with minimal cost increase.



### Michigan State University *Team Members* (left to right)

**Val Zilkovski**  
Sterling Heights, Michigan

**Luke Chrisman**  
Sterling Heights, Michigan

**Kole Gilbert**  
Clarkston, Michigan

**James Graham**  
Norwell, Massachusetts

**Mark Vanbuskirk**  
Clarkston, Michigan

### Meritor, Inc. *Project Sponsors*

**Nick Bofferding**  
Troy, Michigan

**Brian Hayes**  
Troy, Michigan

### ME Faculty Advisor

**Dr. Giles Brereton**

# Michigan AgrAbility/Heroes to Hives Back-support Brace for Women

Michigan AgrAbility, headquartered in Grand Rapids, Michigan, is a program that partners Michigan State University Extension with Easterseals, a non-profit disability assistance organization, in an effort to support the advancement of agricultural workers that have disabling injuries and illnesses. Michigan AgrAbility devises individualized solutions for their clients across the state, restoring them with the productivity and freedom that their disabilities took away.

Recently, the need of a back brace arose to support women beekeepers that spend extended periods of time bending over to inspect hives. Ned Stoller, an Assistive Technology Professional with Michigan AgrAbility, has had previous success assisting clients who have debilitating back pain with a device called the Springzback. The Springzback, developed by Mike Babcock, is a spring loaded device capable of supporting its user in a variety of bent over positions by distributing the stress away from the back muscles. The problem is that its frontal chest plate can be uncomfortable for women to use.

With the sponsorship of Heroes to Hives, a Veterans Beekeeping Program with MSU Extension and Michigan AgrAbility, our team has been tasked with designing and building an upper-body support piece for the Springzback that will be comfortable for women beekeepers to use. In order to design a comfortable and effective product, the team must consider the beekeeper's range of motion needs and device size, as well as load distribution and the material limits of the device's components. A successful solution will be able to transcend beekeeping and provide women around the world with comfortable back support and improve their quality of life.



## Michigan State University Team Members (left to right)

**TJ Krawczyk**  
Portage, Michigan

**Kyle Tomaszewski**  
El Dorado Hills, California

**Julia Beach**  
Troy, Michigan

**Derek Donnelly**  
Troy, Michigan

**Bryce O'Neill**  
Vicksburg, Michigan

## Michigan AgrAbility/ Heroes to Hives Project Sponsors

**Adam Ingrao – Heroes to Hives**  
Newberry, Michigan

**Ned Stoller – Michigan  
AgrAbility**  
Grand Rapids, Michigan

## ME Faculty Advisor

**Dr. Michele Grimm**

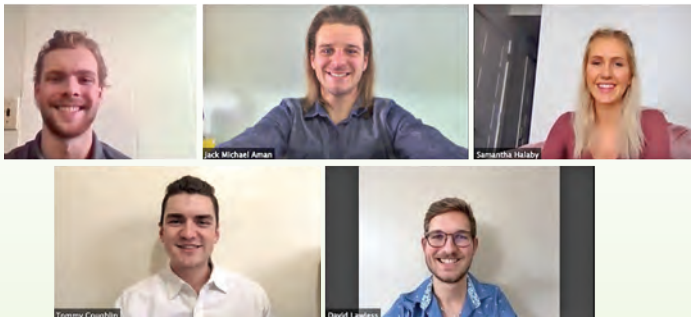


# Michigan AgrAbility/Heroes to Hives Powered Trolley and Boom for Beehive Crane

Michigan AgrAbility was founded in 1992 in order to aid Michigan farmers that are affected by injury, disease, or disability. Aid for farmers in need is provided in the forms of modified farming tools, special equipment, or new methods to allow the farmers to partake in all operations necessary to upkeep their business. A current focus of Michigan AgrAbility is finding a solution for disabled farmers to be able to properly care for their bees, due to the increase of diseases within beehives and the decreasing honeybee populations in the region.

In order to successfully raise bees, beekeepers are required to regularly inspect their hives. This has been a challenge for Bob Bernard of Earthwork Farm in Moorestown, Michigan who was paralyzed from an illness over 40 years ago. Bob is able to get around using crutches, but trying to lift and inspect a 90-pound beehive is not something of which he is capable. To solve this issue, Bob began modifying a John Deere lawn tractor to suit his needs. The tractor needs to feature an overhead crane capable of lifting hives off of the ground and moving them to a position next to Bob's seat on the tractor for personal inspection.

Our team was given the challenge of assisting Bob with this crane by designing a powered trolley to travel the length of the crane boom after a hive has been lifted. Controls to operate the trolley also need to be implemented in a position where Bob can access them while operating the tractor. Upon successful testing of the boom and trolley, the team will prepare construction drawings and instructions to provide to other beekeepers, with the expectation that other small-scale honey producers will utilize our technology.



## Michigan State University Team Members (left to right)

**Alex Sickelsteel**  
South Lyon, Michigan

**Jack Aman**  
Highland, Michigan

**Samantha Halaby**  
South Lyon, Michigan

**Thomas Coughlin III**  
Brighton, Michigan

**David Lawless**  
Wixom, Michigan

## Michigan AgrAbility/ Heroes to Hives Project Sponsor

**Ned Stoller**  
Grand Rapids, Michigan

## ME Faculty Advisor

**Dr. Xinran Xiao**

# Michigan AgrAbility/Heroes to Hives Tongs for Lifting Beehives

Michigan AgrAbility provides critical assistance to enable people in the agricultural industry with an injury, illness or disability to continue working. Beekeepers with back, leg, and arm injuries cannot lift hive bodies to inspect for queen health, mites, and viruses. With the increase of diseases in beehives and reduction in honeybee populations, it is more important than ever for beekeepers to perform frequent inspections of their hives. Cranes mounted on trucks and trailers are used by commercial beekeepers to lift pallets of hives. There is no device available in the USA for the hive-lifting cranes to grip and lift the individual hive bodies.

Our team has designed and manufactured a crane attachment capable of lifting single or multiple hive bodies with minimal manual labor. The tongs are suspended from a crane and lowered into position for the desired number of hive bodies. The unique, inverse scissor design uses mechanical advantage to convert the tension from the weight of the hives into horizontal pressure that grasps the finger-pockets on the sides. The length of the tongs and tension angle are adjustable to accommodate various hive configurations and weights.

We focused on making an easily manufacturable, yet rigid design that can be replicated by beekeepers around the country. This product will eliminate the need to manually lift hives that can weigh up to 90 lbs, enabling any beekeeper to manage their hives in an accessible and safe manner.



## Michigan State University Team Members (left to right)

**Cody Zorn**  
White Lake, Michigan

**Chase Rojeck**  
Dexter, Michigan

**Nate Sudek**  
Livonia, Michigan

**Adam Richards**  
Lansing, Michigan

**Michael Brooks**  
Almont, Michigan

## Michigan AgrAbility/ Heroes to Hives Project Sponsor

**Ned Stoller**  
Grand Rapids, Michigan

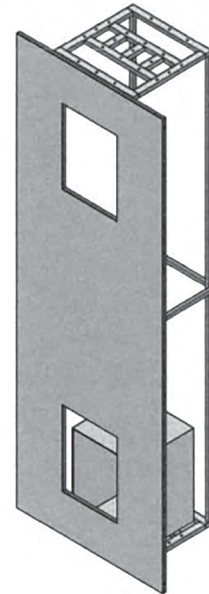
## ME Faculty Advisor

**Dr. Manoochehr Koochesfahani**

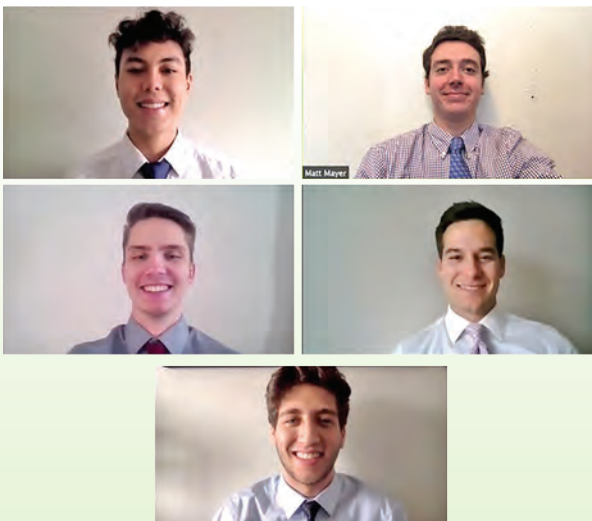
# MSU Department of Theatre Dumbwaiter Design

The MSU Department of Theater is participating in the Stage Machine Design challenge, where teams of students compete to design a dumbwaiter lift mechanism. The dumbwaiter itself is used during theater productions to move props from the first floor to the second floor and vice versa. Organizers of the competition provide teams with the shaft in which the dumbwaiter cab will travel and sizes of the openings on each floor with which the cab must align.

Our team has been asked to create a mechanism that will raise and lower the dumbwaiter cab including any components that help stabilize the cab as it travels in the shaft. We will also design a cab that fits into the specific dimensions of the given shaft. The mechanism must be capable of lifting various weights of up to 120 pounds and travel from floor to floor at different speeds. It will also be a person-driven mechanism that the average student would be able to easily operate.



DEPARTMENT OF THEATRE  
[www.theatre.msu.edu](http://www.theatre.msu.edu)



## Michigan State University *Team Members* (left to right)

**Andrew Sare**  
Rochester Hills, Michigan

**Matt Mayer**  
Buffalo, New York

**Patrick McCormick**  
Encinitas, California

**Jacob Richmond**  
Sparta, Michigan

**Gavan Sarrafian**  
Des Plaines, Illinois

## MSU Department of Theatre *Project Sponsor*

**Mark Willoughby**  
East Lansing, Michigan

## ME Faculty Advisor

**Dr. Mohsen Zayernouri**



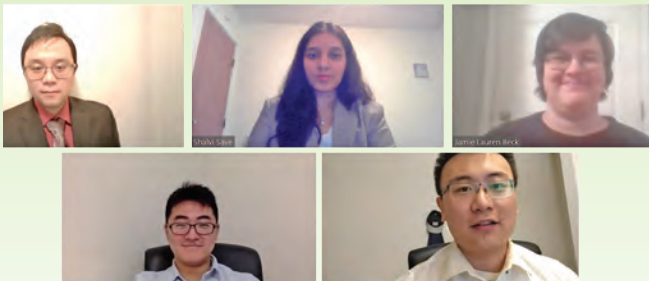
# MSU Department of Theatre Dumbwaiter Device

The Michigan State University Department of Theatre is located on the Michigan State University campus in East Lansing, Michigan. The department has been challenging the traditional and fostering innovation in order to create something that is new, unique, and fresh. This is being done by utilizing the most advanced stage technology to allow designers the opportunity to defy conventional design. One such technology that the department is currently looking to implement during their productions, is that of a dumbwaiter. A dumbwaiter is like a small elevator, typically used to carry smaller items between the floors of a building or a tall structure with different speeds. The implementation of a stage machine dumbwaiter will increase efficiency, minimize physical strain, and save time.

Our team has been tasked with designing a dumbwaiter device for raising and lowering a given dumbwaiter shaft. This would allow for easy transfer of props between two floors within a short amount of time. The device is manually operated (person-driven) and can transfer objects with weights and velocities ranging from a 14-pound bowling ball in a bag within 15 seconds (traveling both up and down), to a 120-pound bag of dog food within 2 seconds. This device must be compatible with the given dumbwaiter shaft and wall dimensions. It also must include any elements that will prevent lateral movements of the dumbwaiter cab when operating the mechanism. The dumbwaiter mechanism is designed to be operated by a typical college student; so in other words, the person has a maximum force of 40 pounds, and a sustained force of 25 pounds.



DEPARTMENT OF THEATRE  
[www.theatre.msu.edu](http://www.theatre.msu.edu)



## Michigan State University *Team Members* (left to right)

**Anson Leung**  
Rochester Hills, Michigan

**Shalvi Save**  
Pune, India

**Jamie Beck**  
Macomb Twp., Michigan

**Qinda Wang**  
Beijing, China

**Yiming Wang**  
ZhengZhou, China

## MSU Department of Theatre *Project Sponsor*

**Mark Willoughby**  
East Lansing, Michigan

## ME Faculty Advisor

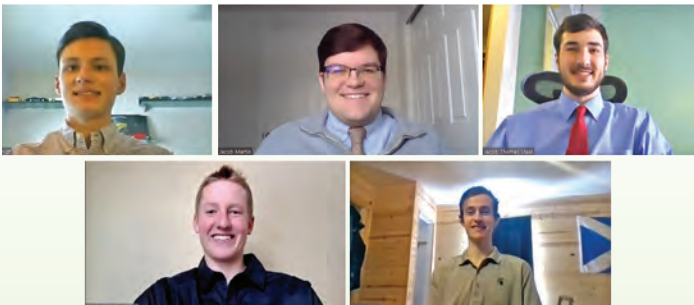
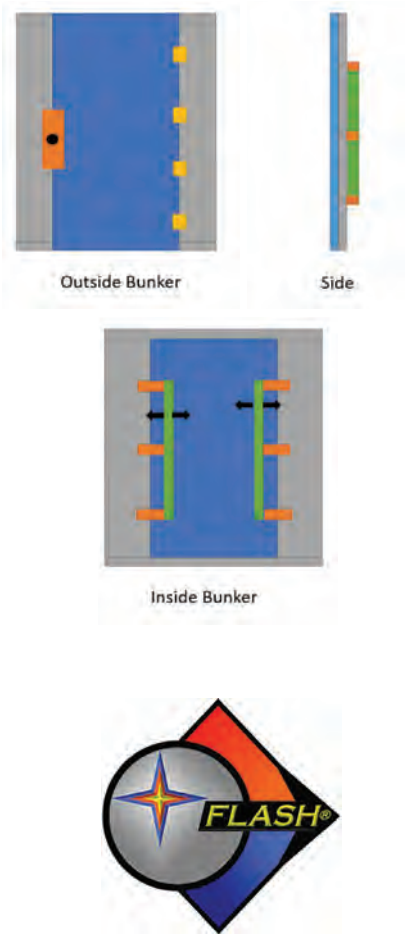
**Dr. Seungik Baek**

# Flash Steelworks, Inc. Shelter Door

Flash Steelworks, Inc is an R&D firm specializing in the development of armor plate and advanced high strength steel. While this is a crowded field in which 10,000 metallurgists work annually, the US Dept of Energy's website has called Flash "the world's leading performing material for lighter and stronger vehicles." Work with US DOE is based on prior research with the US Army that has been scaled down in thickness from 6.3mm thick plates to sheet metal from 0.5mm to 2.0mm thick for use in civilian applications.

It is the proposed scope of this project to design an armored shelter door using Flash Armor, Tubing, and Sheet. A rudimentary design has been concepted while our team is tasked with analyzing and refining the initial door's performance.

A doorframe is proposed based on welded I-beam construction to encapsulate the door and locking attachments. We will analyze best methods for connecting the door to existing construction and make recommendations for installation in new construction, including in panic rooms, tornado shelters, and bunkers. Hinges, bolts, vapor seals, and other non-Flash components can be recommended from commercially available sources. Information will be provided to analyze theoretical blast forces and the impact on the door, frame, and surrounding structure using CAE. This will include modelling of both the environment and components of the overall construction. Ballistic data, as provided by US Army Research Lab, will be provided if appropriate. This project will utilize rigorous FEA modeling to insure a robust design for maximum protection. While important, aesthetics, door closing rate, and pinch points are secondary.



**Michigan State University**  
*Team Members* (left to right)

- Blake Schmidt**  
Troy, Michigan
- Brian Yemc**  
Annapolis, Maryland
- Jacob Martin**  
Lansing, Michigan
- Jacob Staal**  
Holland, Michigan
- Kyle Schreur**  
Holland, Michigan

**Flash Steelworks, Inc.**  
*Project Sponsor*

**Gary Cola**  
Washington, Michigan

**ME Faculty Advisor**

**Dr. Thomas Pence**

# Flash Steelworks, Inc. Flash Safety Door Design

Flash Steelworks, Inc is one of the leading companies in the armor steel plate industry. With their field, leading heat-treatment technology, they have developed a low-cost process to create lightweight and stronger steels. The process of heat treatment is unique to Flash Steelworks. The steel is heated to over 1000 degrees Celsius in seconds, and once it reaches that temperature the steel is quickly quenched. This technology is currently being used in military and civilian projects all over the country. With their patented Flash Processing, Flash Steelworks has the ability to create lower cost safety equipment and mechanisms for the public.

Flash Steelworks has asked our team to incorporate their sheet steel and Flash Armor to create an affordable bulletproof door that can easily replace a standard school or office door. Our task is to implement readily available products such as locks, peepholes hinges, door assists, and foam to absorb bullet fragments within the door. This product will be able to protect offices and classrooms from a range of bullets including armor piercing and AR-15.

Our team's hybrid solution will involve bringing together multiple products to combine with Flash Steelworks' leading Flash Armor, to create a powerful low-cost bulletproof door. This design will provide Flash Steelworks with a product that is capable of replacing standard doors with no or limited modifications to the existing frame.

When implemented, we expect that this door can be used to save the lives of hundreds of people in school and office shootings.



## Michigan State University

**Team Members** (left to right)

**Katie Treloar**  
Sterling Heights, Michigan

**Preston Rashlov**  
Traverse City, Michigan

**Devin Kotal**  
Macomb, Michigan

**Nicholas LaCross**  
Sault Ste Marie, Michigan

**Hannah Jacobs**  
Midland, Michigan

## Flash Steelworks, Inc.

**Project Sponsor**

**Gary Cola**  
Washington, Michigan

## ME Faculty Advisor

**Dr. Thomas Pence**



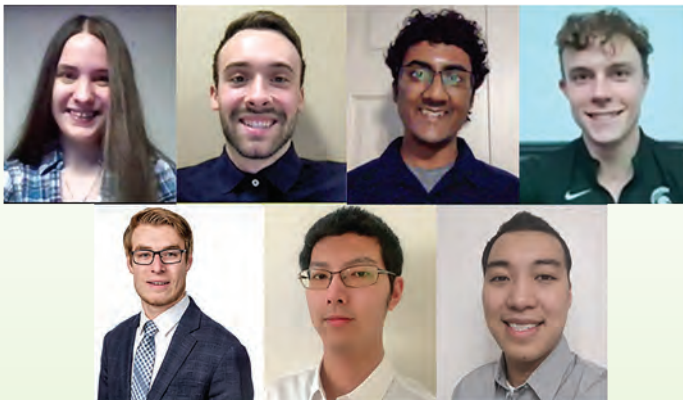
# General Motors

## Octave Band Equalizer Tool

GM, headquartered in Detroit, is a global leader in automotive manufacturing. With over 85 thousand employees and 122 facilities in the US, GM is at the forefront of the automotive industry. Safety is at the center of everything GM does. One consequence of electric vehicles is the need to provide audible sound from the vehicle to provide information to pedestrians about the vehicle's location and movement. Minimum external sound is now required to satisfy US federal and other global regulations for all hybrid and electric vehicles.

Our team has been asked to create software that can produce a sound that is compliant with federal regulations. This software needs to receive a .WAV (waveform audio file format) file and break it into one-third octave bands. The software will be able to adjust the level of each of these octave bands. After this, the software will be able to output the final sound, which will be 3-5 seconds, as a .WAV file.

The final goal is for this plugin to be compatible with Logic Pro. This tool will improve the workflow speed and accuracy for GM sound engineers, as well as improve the safety of GM vehicles.



### Michigan State University Team Members (left to right)

**Shaya Master (ME)**  
Waterford, Michigan

**Denny Blaschko (ME)**  
Jackson, Michigan

**Arjun Balakrishnan (ME)**  
Canton, Michigan

**Thomas Brandell (ME)**  
East Jordan, Michigan

**Steven Faxlanger (ECE)**  
Newtown, Connecticut

**Siqi Luan (ECE)**  
Jiangxi, China

**Andrew Tran (ECE)**  
Holt, Michigan

### General Motors Project Sponsor

**Doug Moore**  
Milford, Michigan

### ME Faculty Advisor

**Dr. Guoming Zhu**

# MSU Department of Mechanical Engineering

## ISD E-Bike Fabrication and Development

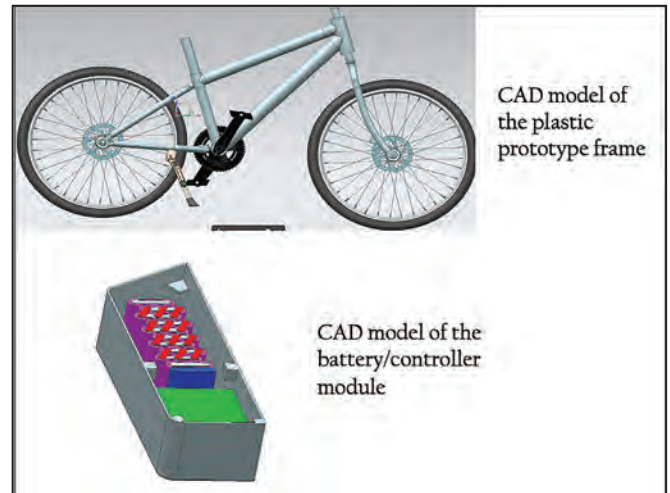
Transportation in society today is constantly changing. New methods for transportation are developed daily. Whether it involves electric vehicles or ride-sharing programs, the future of transportation is in the hands of today's engineers and innovators.

In the past few semesters, ISD teams have spent countless hours on designing the frame and manufacturing a prototype of the e-bike. Now, our team is responsible for identifying issues with the current prototype and finding solutions in order to fabricate the final prototype of the e-bike.

Some of the key challenges we face during the design process are performing the frame fabrication, implementing the battery/control module, and resolving some clearance issues with the frame and crankset. Once these issues are resolved and the manufacturing of the bike is complete, we will focus on some of the aesthetic qualities of the e-bike. The problem and solution are relevant to Michigan State Engineering because it requires the engineering design process and will lead to developing an electric commuter bike.

The most well-known bike companies such as Trek have e-bikes in the market. Although the team considered these products and processes, the bike is already a work in progress and, therefore, it was deemed more important to compare to previous work already performed on the bike. Nonetheless, comparing with corporate producers will allow the team to learn about different classes of e-bikes already in the market and the different functions they serve.

Completing the design and manufacturing process for this e-bike will not only benefit the team's understanding of the engineering design process, but it will also display an understanding of what future transportation could look like on Michigan State's campus.



Department of Mechanical Engineering  
MICHIGAN STATE UNIVERSITY



### Michigan State University *Team Members* (left to right)

**Sloan Kanat**  
Beverly Hills, Michigan

**Michelle Herring**  
Freeland, Michigan

**Santi Hermida**  
Miami, Florida

**Mike Pastoria**  
Beverly Hills, Michigan

**Nathan Holloway**  
Northville, Michigan

**Alec Smerage**  
Dexter, Michigan

### MSU Department of Mechanical Engineering *Project Sponsor*

**William Resh**  
East Lansing, Michigan

### ME Faculty Advisor

**Dr. Neil Wright**

# Energy and Automotive Research Laboratory Hybrid Power System for VTOL Aviation Vehicles

To diminish common traffic existing on our current highway systems, project sponsor Dr. Harold Schock proposes a possible solution via a Hybrid Vertical Take-Off and Landing (VTOL) Aviation Vehicle. The intended purpose of the vehicle is to be capable of transporting up to six passengers, including a pilot. By utilizing this vehicle in modern transportation, a significant decrease in road congestion is possible. Similarly, the production of noise and air pollution produced by automobiles would also decrease.

As current transportation companies research fully electric VTOL systems, several common issues emerge, primarily the minimal energy capacity current electrical systems can store. Current battery technology limits electric VTOL systems from achieving long range flights. The addition of an Internal Combustion Engine (ICE) allows for an increase in flight duration, speed, and overall capability. While this includes the addition of a fuel system resulting in the production of air and noise pollution, the amount of pollution generated by the vehicle is significantly less than byproducts generated by automobiles in traffic.

This is a continuation of a Fall 2020 Mechanical Engineering Design Project. The objective of the team is the completion and confirmation of previous assumptions to finalize the internal, external and powertrain designs. This will contribute to the accuracy of the simulated flight plans regarding flight duration, speed, and safety. The finalization of the project is a completely functional design, capable of cruise speed of 150 mph, and a flight duration of two hours with enough remaining power for 30 minutes of reserve time. All design criteria must also comply with current FAA flight requirements.



Department of Mechanical Engineering  
MICHIGAN STATE UNIVERSITY



## Michigan State University

*Team Members* (left to right)

### Abner Barbosa

Manaus, Amazonas, Brazil

### Adam Childress

Grand Rapids, Michigan

### Brandon Phan

Grand Rapids, Michigan

### Connor Steffens

Grand Rapids, Michigan

### Garrett Armock

Rockford, Michigan

## Energy and Automotive Research Laboratory

*Project Sponsor*

### Harold Schock

East Lansing, Michigan

## ME Faculty Advisor

Dr. Harold Schock



# Energy and Automotive Research Laboratory

## Aerodynamic Analysis of VTOL Aviation

In recent years, traffic-based congestion within major cities has cost commuters an average of 100 hours annually. In order to combat this issue, many companies have started investigating commercial vertical takeoff and landing vehicles (VTOL). These aircraft are specialized, capable of reaching flight altitude without the need of a runway. Many VTOL aircraft in development are being designed with electric propulsion systems. This would significantly reduce the noise and air pollution associated with automotive transportation. However, the technology required to commercialize fully electric VTOL systems is not yet feasible.

Dr. Harold Schock, Director of the Energy and Automotive Research Lab, supports the potential of VTOL but acknowledges that in order to commercialize these vehicles, a hybrid propulsion system must be used. By utilizing both electric and mechanical propulsion, VTOL aircrafts can reduce noise and air pollution, as well as support longer flight times and realistic cabin sizes.

With the help of Dr. Farhad Jaber, the base VTOL aircraft design created in the previous semester will be analyzed utilizing multiple different software, including flow simulation, in order to optimize the aerodynamic performance of the wings, fuselage, and propellers. This will lead to a robust design that minimizes drag forces and maximizes the aircraft's performance.



Department of Mechanical Engineering  
MICHIGAN STATE UNIVERSITY



### Michigan State University *Team Members* (left to right)

**Bryce Sutton**  
South Lyon, Michigan

**Adam Lyons**  
South Lyon, Michigan

**Joshua Saluk**  
Rochester Hills, Michigan

**Houduo He**  
Mudanjiang, China

**Kyle Nouhan**  
Saline, Michigan

### Energy and Automotive Research Laboratory *Project Sponsor*

**Harold Schock**  
East Lansing, Michigan

### ME Faculty Advisor

**Dr. Farhad Jaber**

# MSU Department of Mechanical Engineering

## HPVC Aerodynamic Fairing Design

Michigan State University's Human-Powered Vehicle Competition Team (HPVC) is a student-led racing team consisting of Mechanical Engineering undergraduate students. It was started in 2018, and the team competed in their first American Society of Mechanical Engineers (ASME) Engineering Festival in April of 2019. Since the first season, the team has focused on improvement and innovation in vehicle design.

The focus of this project is to design and test an aerodynamic fairing for the vehicle that increases the speed of the vehicle by reducing the overall drag force. This fairing was requested by the HPVC team in order to improve their performance in the drag race portion of the ASME Engineering Festival. The team earns points in the competition in three categories: design, the drag race, and the endurance race. This project impacts two out of the three critical categories.

In order to meet the HPVC team's objectives, we have designed and tested an aerodynamic fairing that fully encapsulates the rider in the vehicle and is also easily removable if the team needs to make adjustments to the vehicle or decides to take it off for the endurance event. By fully encapsulating the rider, the airflow over the fairing stays attached longer, and the rider is protected from any spilled air or turbulence coming off of the edges. Our design was tested both virtually and in a wind tunnel in the Engineering Building in order to determine both the integrity of the design as well as the impact this fairing will have on vehicle performance.



Department of Mechanical Engineering  
MICHIGAN STATE UNIVERSITY



### Michigan State University Team Members (left to right)

**Sarah Nold**  
Livonia, Michigan

**Derek Raymond**  
Canton, Michigan

**Alaura VanNest**  
Canton, Michigan

**Julia Walter**  
Lake Orion, Michigan

**Marissa DePolo**  
Highland, Michigan

### MSU Department of Mechanical Engineering Project Sponsor

**Geoffrey Recktenwald**  
East Lansing, Michigan

### ME Faculty Advisor

**Dr. Abraham Engeda**

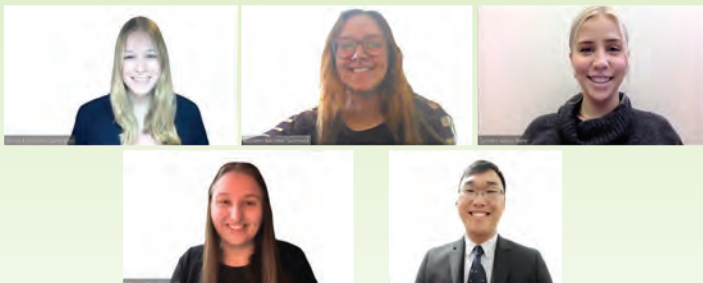
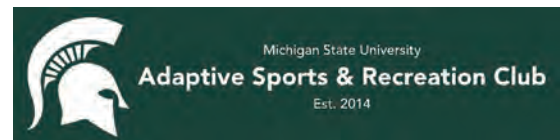
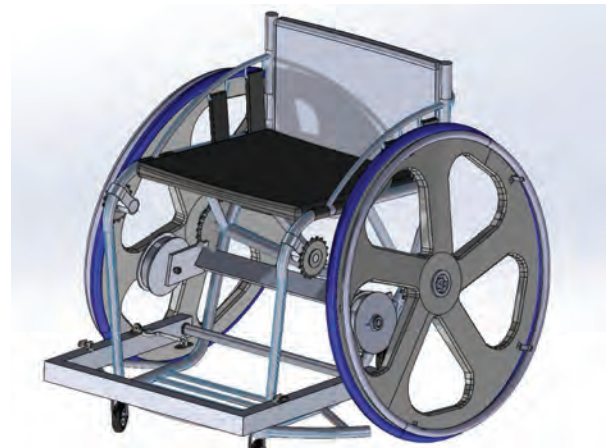
# MSU Adaptive Sports & Recreation Club Inclusive Wheelchair Design Phase IV

Wheelchair sports offer an enriching social and physical outlet for people with disabilities, however they unintentionally exclude certain ambulatory disabilities. The MSU Adaptive Sports & Recreation Club aims to develop an inclusive sports wheelchair for people with disabilities that have muscle imbalances affecting their upper limb range of motion. These individuals cannot participate in able-bodied sports and face the challenges of using standard wheelchairs that are present in wheelchair sports.

The inclusive sports wheelchair provides individuals the opportunity to engage in social sports from which they would otherwise be excluded. Proposed features such as a wheelchair propulsion method, increased steering control, and accommodations for either arm will allow players to participate in games with greater ease. This project will help the MSU Adaptive Sports & Recreation Club increase the satisfaction of its members.

Phase I of the project began in Fall 2017 and has since been through two prototype modifications, with Phase III being an entirely virtual design.

Our team was tasked with moving the Phase III design into the manufacturing stage by first evaluating the current design of the wheelchair (Phase II) and then implementing the main desirable components from the virtual design. Areas of concern include reliability, durability, and safety of the wheelchair user. Additionally, hands-free steering of the inclusive sports wheelchair and improving the working conditions were the end goal. Research and designs by previous teams aided in the production of an improved and inclusive wheelchair.



## Michigan State University *Team Members* (left to right)

**Grace Warmann**  
Plymouth, Michigan

**Autumn McLane-Svoboda**  
Fowlerville, Michigan

**Sydney Rehr**  
Kalamazoo, Michigan

**Marissa Grazioli**  
Northville, Michigan

**Haram Gil**  
Grand Rapids, Michigan

## MSU Adaptive Sports & Recreation Club *Project Sponsors*

**Stephen Blosser**  
East Lansing, Michigan

**Piotr Pasik**  
East Lansing, Michigan

## ME Faculty Advisor

**Dr. Ahmed Naguib**



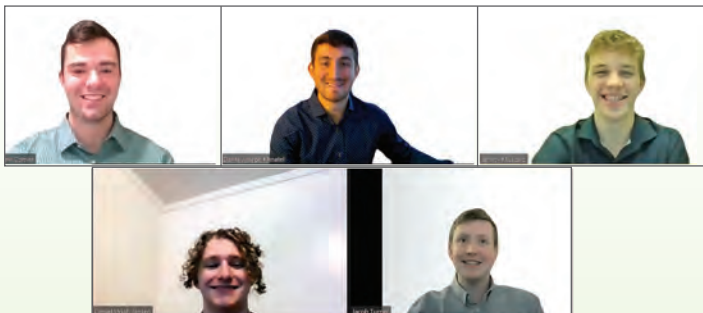
# MSU Adaptive Sports & Recreation Club

## Sled Hockey Transfer Platform

The MSU Adaptive Sports & Recreation Club, established in 2014, is a group at Michigan State University that aims to be able to provide all people with the opportunity to partake in sports and recreational activities. The program seeks to create and continually cultivate a physically and socially accessible space where athletes with physical disabilities and able-bodied volunteers come together to establish an integrated community of peers that will use sports and recreational activities to validate the disability experience by eradicating inaccurate societal stereotypes and invalid self-perceptions about disability. This club also aims to promote physical health, social behavior, and psychological benefits to individuals with physical disabilities. The program focuses on self-autonomy, competence, and relatedness as key facilitators in the process of acquiring self-efficacy in the area of sports and physical activity. This can then help the athletes transfer these qualities to their outside life to improve their quality of life.

One of those activities is Sled Hockey. Sled Hockey is played on sleds where the person is sitting down to glide across the ice or the floor. A previous team attempted to facilitate independence in the transfer process by employing a lift in their sled hockey transfer platform design and adding features to it. Our team will carry out the next phase of the design aimed at further improving safety and facilitating independence.

The goal of this project is to design a way for all people, regardless of ability, to be able independently transfer themselves onto the sled that is on the ground. Currently, it takes a lot of people to help someone with this transfer process, and it is not as safe as needed for people to be able to perform this transfer independently. To achieve this goal, there will be different designs and features included from this project that will ensure safety for all people, especially those with physical disabilities.



### Michigan State University Team Members (left to right)

**Thomas Corner**  
Holt, Michigan

**Dante Minatel**  
Fenton, Michigan

**Jimmy Muscato**  
Pinckney, Michigan

**Daniel Jansen**  
Pinckney, Michigan

**Jacob Turner**  
Dearborn, Michigan

### MSU Adaptive Sports & Recreation Club Project Sponsor

**Piotr Pasik**  
East Lansing, Michigan

### ME Faculty Advisor

**Dr. Indrek Wichman**

# WestRock

## Evaluate the Location of the Upper Deck and Carousel

WestRock, located in Lansing, Michigan, is a leading paper and packaging company. WestRock's goal is to be the premier partner and unrivaled provider of winning solutions for their customers. One sub-division within WestRock's Multi Packaging Solutions is horticulture. The horticulture sub-division has over 18,000 custom plant tags within their inventory and believes they have outgrown some of their processes and layouts.

Our team has been tasked with the analysis of the current layout and inefficiencies in how WestRock manages their multiple stock-keep units across a wide variety of customers. We provided innovative designs to improve the flow, order fulfillment process, and physical layout of their inventory. One focus of our project was to deliver a better shelving system for their inventory that eliminates waste and implements lean engineering practices.

Another focus was to create a system that is easy to learn and use. This was beneficial for new and temporary employees but also decreased the errors made in the order fulfillment process.

Lastly, the team focused on the use of machines like the currently implemented carousel to find possible alternatives or other uses for the limited space on the upper deck. With these implementations, WestRock's process is faster, easier, and cost-effective.



### Michigan State University

*Team Members* (left to right)

**Jarod Miller**  
Fowlerville, Michigan

**Kerry Stensen (Sponsor)**

**Annah Mullinax**  
Canton, Michigan

**Scott Lohman**  
Northville, Michigan

**Andrew Skedel**  
Northville, Michigan

**Mark Sicoli**  
South Lyon, Michigan

### WestRock

*Project Sponsor*

**Kerry Stensen**  
Lansing, Michigan

### ME Faculty Advisor

**Dr. Xinran Xiao**

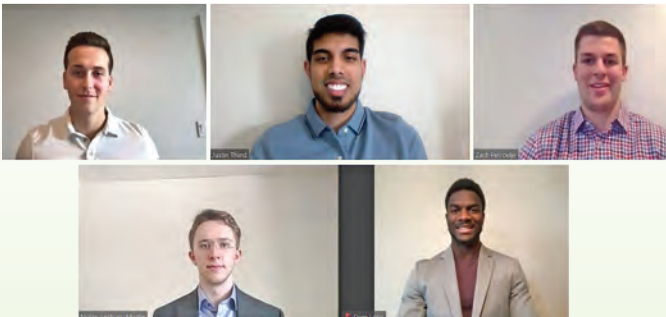
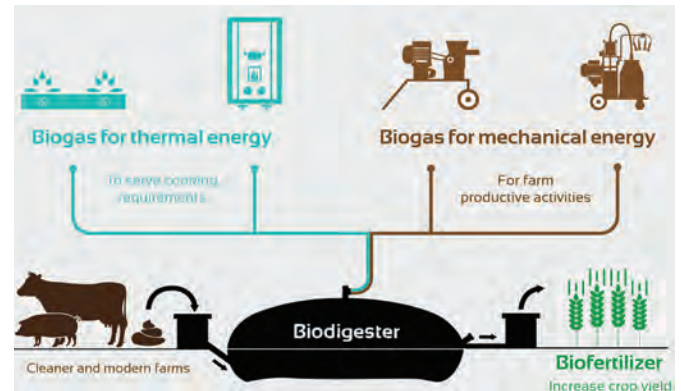
# Sistema.bio

## Bio-Digester Solids Movement Processing Design

Sistema.bio is an international company that empowers farmers in third-world countries by turning organic waste into a viable resource through the use of biodigesters. Sistema.bio designs, manufactures, sells, and installs biodigesters for farmers in need. In implementing the biodigester, farmers gain access to fertilizer and a variety of biogas-powered appliances like stoves and heaters. Over 17,000 digesters have been installed throughout the world, providing over 104,000 people with clean, renewable energy. Additionally, the biodigesters have mitigated over 211,000 tons of CO<sub>2</sub>, and saved over 3 million trees.

In simple terms, a biodigester is a bag with one input and two outputs. Farmers will load organic waste into the input with a shovel, which then enters the biodigester where the waste is processed. As the organic waste gets processed, biogas and fertilizer are released from the outputs for use. However, some design flaws have led to waste flow efficiency issues, along with an overall lack of mobility of the biodigester. The biodigesters were solely designed to handle organic waste, but it is often difficult and time-consuming for farmers to adhere to this. As a result of loading the biodigester with indigestible solids, biodigesters fill up with heavy, thick sludge that cannot be removed. Not only does this hinder the flow of solids within the biodigester, it also makes the biodigester impossible to move in a third-world setting. Our objective is to address both of these issues in this project.

Since a majority of biodigesters are used in third-world countries, the solutions for the flow efficiency and overall mobility must be of rudimentary nature. The solutions will be universally applicable to all sizes of Sistema.bio's biodigesters. Additionally, it is imperative that they are affordable for all users. As a result, the solution would have to avoid implementing advanced equipment. Instead, a reliance on manual labor and basic tools is the priority.



### Michigan State University

**Team Members** (left to right)

**Carl Banerian**  
Birmingham, Michigan

**Justin Thind**  
Macomb, Michigan

**Zach Petroelje**  
Grand Rapids, Michigan

**Nolan Martin**  
Macomb, Michigan

**Dom Long**  
Columbus, Ohio

### Sistema.bio

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**Lee Andre (Harvest Solar)**  
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Mexico City, Mexico

**Stephanie Zayed (Sistema.bio)**  
Mexico City, Mexico

### ME Faculty Advisor

**Dr. Andre Benard**



# MSU Adaptive Sports & Recreation Club

## Accessible Cutting Board

The MSU Adaptive Sports & Recreation Club is an inclusive club that promotes health, wellness, and teamwork through sports for individuals with physical disabilities. During the COVID-19 pandemic, the organization had to find new ways to stay connected with operations moving online. One activity the club added was virtual cooking sessions.

Members who attend the virtual cooking sessions experience a range of physical disabilities. These disabilities impact balance, range of motion, fine motor skills, muscle control, and endurance. As a result, cooking can be very frustrating and time-consuming. The lack of accessible assistive technology for the kitchen is detrimental to the independence of individuals with disabilities.

The club provided its members with adaptive kitchen supplies for the virtual cooking sessions. Among these items was a foldable cutting board. For some individuals this cutting board can be difficult to handle when transferring food to its next destination.

The goal of this project was to design a new accessible cutting board that increases user functionality and efficiency during meal prep, while simultaneously maximizing both safety and independence. The new model makes meal prep more enjoyable for people with physical disabilities as its features limit possible blunders during food transfer and cutting. The design is universal and lightweight to serve the widest range of users.



### Michigan State University *Team Members* (left to right)

**Cody Chalk**  
Pinckney, Michigan

**Zak Harwood**  
Pinckney, Michigan

**Griffin Jones**  
Pinckney, Michigan

**Nathan Ward**  
Livonia, Michigan

**Travis Wesley**  
Lansing, Michigan

### MSU Adaptive Sports & Recreation Club *Project Sponsors*

**Stephen Blosser**  
East Lansing, Michigan

**Piotr Pasik**  
East Lansing, Michigan

### ME Faculty Advisor

**Dr. Manoochehr Koochesfahani**

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Director, Design Day  
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