

MICHIGAN STATE UNIVERSITY COLLEGE OF ENGINEERING FALL 2020

# DESIGN DAY



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# Welcome to the MSU College of Engineering Design Day Booklet!

On behalf of Michigan State University Federal Credit Union (MSUFCU) in partnership with the College of Engineering, and Michigan State University, we **welcome** you to explore this booklet to see the **extraordinary** work of MSU students.

MSUFCU is **proud** to partner with MSU on many programs, especially those that highlight the talents of MSU's outstanding students. As you look through this booklet, you will see the work of MSU students demonstrating their abilities to be **creative, innovative, and problem solve** - traits that we all seek in our next generation of employees.

Design Day projects showcase the students' unique skills exhibited in their **intellect, ingenuity, teamwork**, and core engineering knowledge learned during their academic tenure in the MSU College of Engineering. The students' projects this semester provide insight into their **inspiring solutions** to the real-world challenges presented. As a result, we have great confidence in their futures as engineers and **leaders** in our global workforce.

We wish everyone our **congratulations** on your successes and accomplishments. And, a special **thank you** to the parents, families, faculty, and staff that have supported the students as they **achieve their dreams**.

Sincerely,

April M. Clobes, President/CEO, MSUFCU



[www.msufcu.org/careers](http://www.msufcu.org/careers)



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MICHIGAN STATE UNIVERSITY COLLEGE OF ENGINEERING SPRING 2021

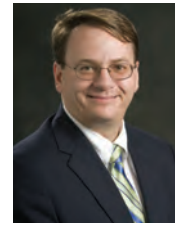
# DESIGN DAY

**Look for Spring Design Day  
projects coming in April 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 ways.

We are pleased to acknowledge Michigan State University Federal Credit Union as our Design Day Executive Partner Sponsor and Amazon as our Design Day Directing Partner Sponsor. Our Design Day Supporting Partner Sponsors include Auto-Owners Insurance, Ford Motor Company, MaxCogito, Meijer and TechSmith. 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  
Dennis P. Nyquist Endowed Professor of Electromagnetics  
Michigan State University





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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 949 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 Design, and (v) CoRe Industry-Sponsored Projects. CoRe Industry-Sponsored Projects involved collaborations with BorgWarner on Hydrogen Fuel Cell System Requirements and GE Renewable Energy on Wind Turbine Gearbox Life Extension.

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

### Fall 2019 EGR 100 Project Poster Award Winners



*l-r: Tim Hinds, Anthony Miller, Henry Gruber, Noah Darcy, Jenahvive Morgan*



*l-r: Tim Hinds, Kenneth Gordon, Brooke Osterkamp, Jenahvive Morgan*





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# The Capstone Projects



**Mr. Anthony Ingle**  
Teaching Specialist

**Faculty Advisors:**  
Professors Haider, Hashsham, Ingle, Kodur and Li



Haider



Hashsham



Ingle



Kodur



Li

## 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.

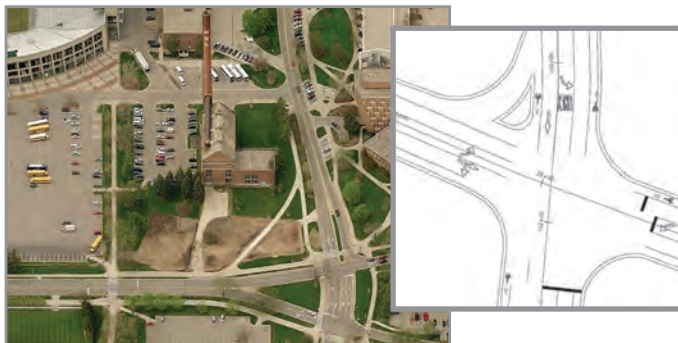
Each team is responsible for developing a design that addresses environmental, hydrological, pavement, structural, and transportation issues for the project. A student project manager coordinates each team. Design reports are judged by the faculty; progress reports and the oral presentations are judged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







**Team 1:**  
**G & W Engineering**

Owen Brenneman: (S)  
Benjamin Cady: (PM)  
Joey Decristofaro: (T)  
Tianze (Jerry) Ga: (P)  
Collin High: (E)  
Haylee Lewis: (H)  
Zherui (Jared) Xu: (E)



**Team 5:**  
**Mitten Made Infrastructure**

David (Liam) Armstrong: (S)  
Dobromir (Dobe) Bonev: (E)  
Emma Davis: (E)  
Lauren Foyteck: (PM)  
Marta Gappy: (E)  
Anna Keller: (H)  
Zuodong (Tracy) Niu: (T)



**Team 2:**  
**Hockle Engineering**

Joshua Cole: (T)  
Alexis Edge: (PM)  
Erik Hicken: (P)  
Alexander Kepreos: (S)  
Xilai Lin: (E)  
Evan Offerle: (H)



**Team 6:**  
**Spartan Builders**

Yiru Bao: (E)  
Robert Caldwell: (S)  
Noah Droste: (P)  
Ryan Eisley: (H)  
Alexis Ly: (PM)  
Sam Malatesta: (E)  
Josh Meyers: (T)



**Team 3:**  
**JEQS Tech**

Joshua Benson: (T)  
Jacob Cairl: (P)  
Qiyuan Lan: (H)  
Sam Morgan: (S)  
Emily Renn: (E)  
Edward Weng: (PM)



**Team 7:**  
**Superior Spartan Engineering**

Tommy Grahf: (T)  
Ben Guertin: (S)  
Morgan Hutchins: (PM)  
Tyler Koch: (E)  
Jillian Pelzer: (P)  
Hannah Watts: (H)



**Team 4:**  
**Mitten Made Consultants, Inc.**

Daniel Freeman: (H)  
Gus Heinrich: (T)  
David Mickevich: (P)  
Maria Milan: (E)  
Phuong Ton: (PM)  
Brady West: (S)

**KEY**

E = Environmental, H = Hydrology,  
P = Pavements, PM = Project Manager,  
S = Structures, T = Transportation

## CE 495 SENIOR DESIGN IN CIVIL & ENVIRONMENTAL ENGINEERING

---

### PROFESSIONAL SEMINAR SPEAKERS

**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

**Erik Carlson, P.E.**  
Michigan Department of Transportation

**Rick Chelotti, P.E.**  
Bergman Associates

**Dan Christian, P.E.**  
Tetra Tech MPS

**Jim Corsiglia, P.E., S.E.**  
Harley Ellis Devereaux

**Brian Davies, P.E.**  
Hubbell, Roth & Clark

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

**David Hayden**  
Bergman Associates

**Cindy Irving, P.E.**  
Lansing Board of Water & Light

**Matt Junak, P.E.**  
HTNB

**Al Kaltenthaler, P.E., S.E.**  
C2AE

**Yogesh Kumbarger, Ph.D.**  
Soil & Materials Engineers

**George McKenzie, P.E.**  
Consumers Energy

**Jordan Phillips, P.E.**  
RS Engineering

**Stephen Subu**  
Consumers Energy

**Phillip Vogelsang, P.E.**  
AECOM

**Jon Ward, P.E.**  
ROWE Professional Services



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We thank the following companies for their generous support of the computer science capstone course.



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Dearborn, Michigan



Detroit, Michigan



Mountain View, California



Zeeland, Michigan



Louisville, Kentucky



Ann Arbor, Michigan



Littleton, Colorado



Frederick, Maryland



Grand Rapids, Michigan



East Lansing, Michigan



Redmond, Washington



Mountain View, California



East Lansing, Michigan



Sunnyvale, California



Detroit, Michigan



Okemos, Michigan



Chicago, Illinois



Detroit, Michigan



Royal Oak, Michigan



Auburn Hills, Michigan



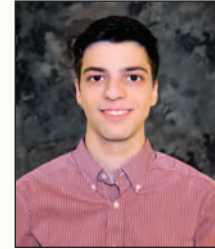
# The Capstone Projects



**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, AppDynamics, Atomic Object, Auto-Owners Insurance, Bedrock Detroit, Bosch, Dow, Evolutio, 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 Maestro

Founded in 1994 as an online bookstore, Amazon is the largest online retailer in the world. Amazon has seen tremendous growth and success, making history by becoming the second U.S. company to be valued at \$1 trillion. A key factor in Amazon's rise to the top is their e-commerce platform, which accounted for nearly 50% of all online retail purchases last year.

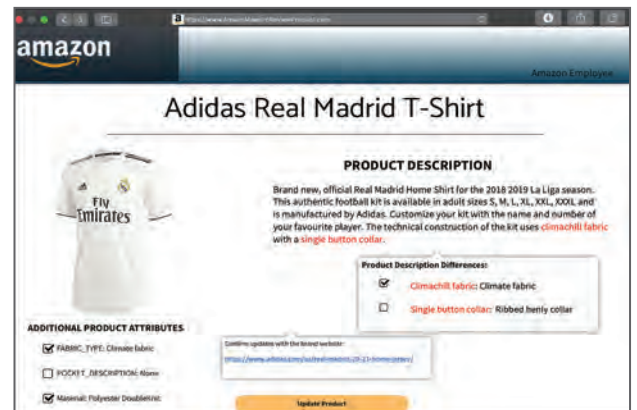
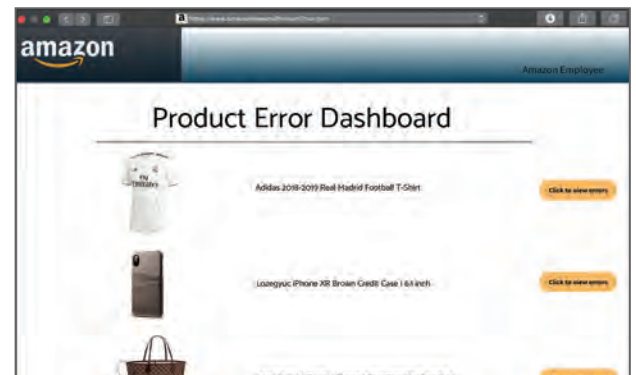
At Amazon's scale, individual products often have numerous different sellers. Each seller provides a description and specification list for their product, making it Amazon's job to compile every seller's contribution into a comprehensive overall product description. Issues arise when multiple sellers provide separate, sometimes conflicting, descriptions for the same product, leading to inaccurate product descriptions.

Our Maestro system combats this problem by comparing and correcting the product descriptions from many sources, including the information from the seller, the manufacturer's website, as well as third-party websites such as Target or Walmart. Maestro collects all of this information in the background, and does not require any work from the seller.

Maestro analyzes all of this data using natural language processing (NLP) and determines the best description for all products sold on Amazon. If any difference is detected between a seller's description and Maestro's description, the seller is notified and given the chance to change their description.

Our Maestro application reduces the number of inaccurate product descriptions presented to customers, who get exactly what they expect. This leads to greater sales and customer satisfaction.

Maestro is built with React for the front end, AWS Lambda for the back end, pre-trained SpaCy models for NLP, Amazon S3 buckets to hold files for inaccurate product descriptions, and AWS DynamoDB for holding product data provided by Amazon.



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

**Kasidet Meteeputti**  
Bangkok, Thailand

**Scott Macpherson**  
Novi, Michigan

**Ruchika Gupta**  
Kurukshetra, Haryana, India

**Mo Almoamen**  
Dearborn, Michigan

**Sawyer Ruben**  
Cheyenne, Wyoming

### Amazon Project Sponsors

**Garret Gaw**  
Detroit, Michigan

**Derek Gebhard**  
Detroit, Michigan

**Detroit Leadership**  
Detroit, Michigan

**MaryAnn Schummer Gaw**  
Detroit, Michigan

**Valtcho Valtchev**  
Seattle, Washington



# AppDynamics Insider Threat Detection

AppDynamics is an application performance management and IT operations analytics company based in San Francisco. The focus of their work and applications is to manage the performance of client's applications across cloud computing environments and data centers.

To further provide aid to clients, AppDynamics looks at the security side of applications, considering how their users may be a threat. Half of all data breaches occur because of "trusted insiders," either via compromised credentials or malicious actions by authenticated users. Currently there are no commercial tools that track user actions to expose potential insider threats.

Our Insider Threat Detection system collects and stores actions performed by users. Using this data, our system works on a case-by-case basis to find each end user's tendencies.

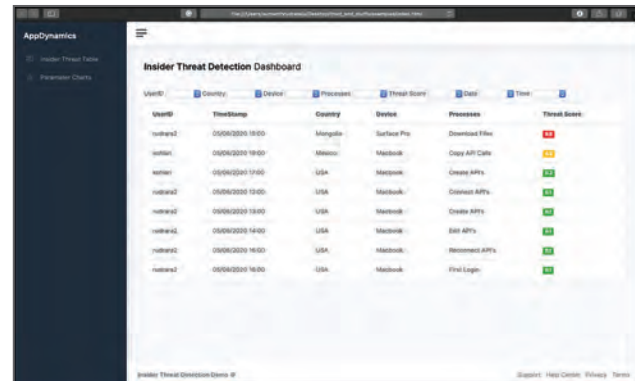
When an end user's actions stray from their tendencies, it is evidence that their behavior could be a security threat. These potential threats are shown on a dashboard. Threats are shown in order of the time of occurrence, rated from high risk threat to minor disruption in pattern.

From the dashboard, a system administrator can take action against any detected potential threat.

Our system automatically takes action against users who are determined to be a definite threat. A system administrator is contacted if the threat is determined to be high risk. They are informed of both the threat and the action taken.

Our software detects and flags suspicious behavior and brings it to the attention of administrators for quick and easy handling, allowing security leaks from insiders to be caught early.

Our threat detection algorithm is created using Python and utilizes AppDynamics APIs to acquire the data. The dashboard is built using HTML and Flask.



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

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# Atomic Object PlanIt Capacity Tracking Tool

Atomic Object is a custom software design and development consultancy based out of the Midwest cities of Ann Arbor, Grand Rapids and Chicago. Since its founding in 2001, Atomic Object has been creating unique software solutions for a variety of companies spanning multiple different industries, including Ford, John Deere and Herman Miller.

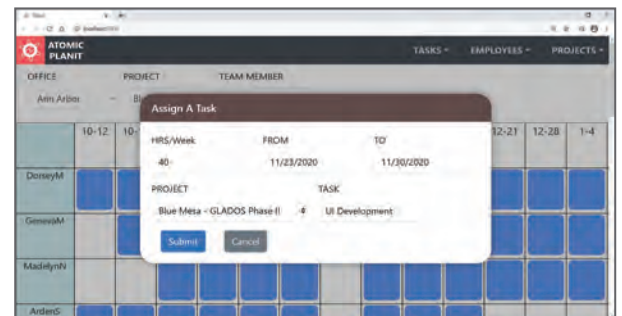
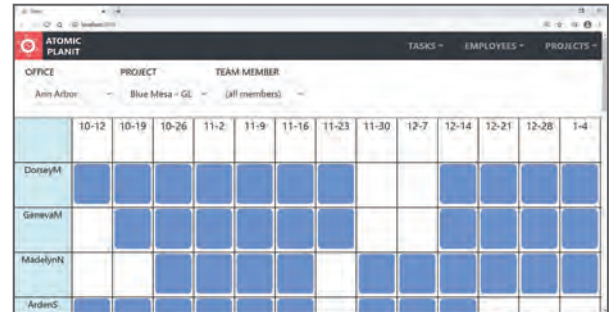
A capacity tracking application called PlanIt is currently used by Atomic Object to organize and schedule different employees and teams to help allocate their time and resources efficiently. While the current PlanIt application has worked well for years, it is starting to show its age. Its user experience is lacking in a few key areas and was built with old technologies that do not support modern features.

Our PlanIt Capacity Tracking Tool is a ground up rebuild of Atomic Object's current PlanIt tool, with improved user experience and the power of modern development frameworks. Our PlanIt tool offers new and intuitive ways for managing capacity while maintaining the core functionality of the original PlanIt application.

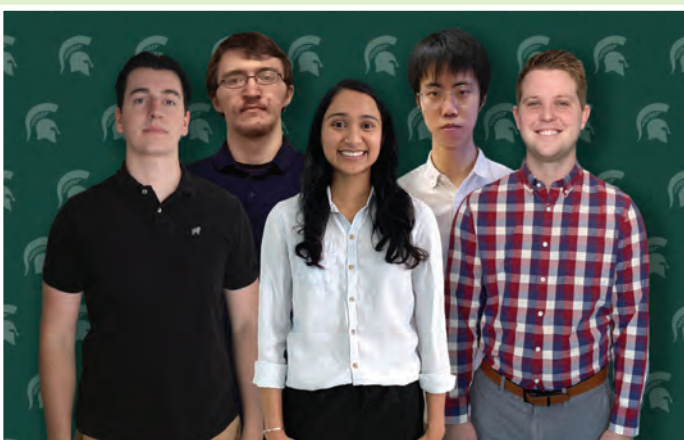
PlanIt's central feature is its timeline view, which allows users to easily see which projects are active, funded, who is assigned to them, and their projected end dates. Users can easily add and remove projects and assign roles and dates all through our new modal boxes and navigation tools. Existing projects and assignments can also be manipulated through a new drag-and-drop feature, which allows for faster and easier planning.

PlanIt helps Atomic Object quickly and efficiently schedule their employees and projects, leading to higher customer satisfaction and less wasted time.

The PlanIt Capacity Tracking Tool is a single-page application and uses front-end frameworks ReactJS, Redux, and Bootstrap, and back-end services Node.js, Heroku, PostgreSQL, and GraphQL.



**ATOMIC OBJECT**



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# Auto-Owners Insurance Coverage Crisis: Covering Your Assets

Headquartered in Lansing, Michigan, Auto-Owners Insurance is a Fortune 500 company that is represented by over 47,000 licensed insurance agents across 26 states. Auto-Owners provides automotive, home, life and business insurance to nearly 3 million policyholders.

Insurance is a complicated topic, with many terms and concepts that can be a struggle to learn. Auto-Owners is innovating new methods to teach associates and third parties about insurance to enable them to learn insurance concepts in an engaging manner.

Our software, Coverage Crisis: Covering Your Assets, is a role-playing game that presents the player with opportunities to learn about insurance. The goal of the game is to earn as many coins as possible as well as maintain the happiness of the player character.

Players select their level of education and career, determining their salary and student loans. They can use coins to purchase assets such as vehicles and homes, which can increase happiness. When purchasing assets, insurance policies are offered to protect against damage that may occur randomly throughout the game. A large component of gameplay is choosing whether or not to buy insurance, thereby selecting which risks to take with one's property.

When the game ends, the player's score is calculated based on their current coins, the value of their assets and any achievements they have earned. This score is posted to a leaderboard, allowing the player to compare their scores and decisions to those of high scoring players. Administrator users can access a secured website to see more detailed information about the decisions a player made during the game.

Our game is made in Unity, written in C#, and is playable through WebGL. Leaderboard and logging data are communicated to and from a MySQL database using PHP server-side scripts. The administrator tool also uses PHP and runs on the same server.



## Auto-Owners INSURANCE



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# Bedrock Detroit Shared Parking Access

Bedrock Detroit is the largest full service commercial real estate firm in Downtown Detroit. With a portfolio of more than 100 properties totaling over 18 million square feet, Bedrock Detroit specializes in the strategic redevelopment of urban cores.

The COVID-19 pandemic revealed that employees working for the Rock Family of Companies benefit from working in a hybrid model, using a combination of working from home and in the office, as it increases productivity and community morale.

We have developed a new space planning strategy that focuses on the rotating nature of team members' in-office schedules.

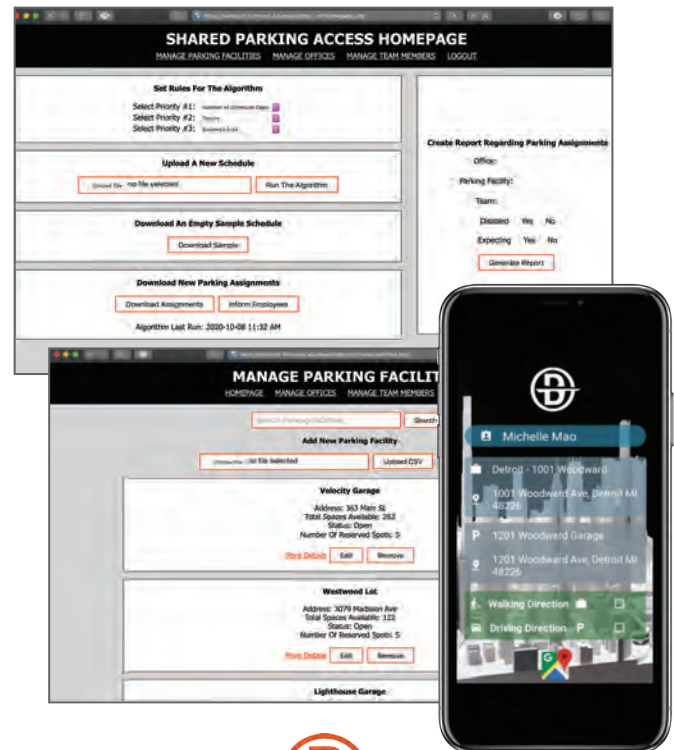
Our Shared Parking Access system optimizes shared parking assignments by maximizing the number of team members assigned to walkable parking without exceeding the number of spaces allocated to each parking facility.

Bedrock administrators can use the web application to manage team members, parking facilities, and office buildings. They can upload employee schedules and run an algorithm that determines parking assignments. Then, employees are informed via SMS or email about their new parking assignment.

Employees can use the mobile application to view information regarding their parking assignment, including facility name, driving directions to the facility, and walking directions to their office.

The Shared Parking Access application allows quick and efficient scheduling of employee on-campus parking, leading to less wasted time and better optimized assignments.

The front end of the Shared Parking Access website is built using PHP, HTML5, JavaScript and CSS while the mobile application is built using Java and Kotlin. The API and algorithm are both implemented using Python. SQLite is used to host the database and Microsoft Azure is used to host both the front end and back end of the application.



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# Bosch

## Automated Retrieval of ADAS Driving Environments

Bosch is a global engineering and technology company with products sold in 150 countries worldwide. Founded in Germany in 1886, Bosch is the world's leading supplier of automotive components.

In the testing and development of advanced driver assistance systems, Bosch collects thousands of hours of video footage and radar data from their vehicles. This data is later used to simulate tests on newly developed software without the need to send a vehicle out into the field.

Certain vehicle software is affected differently by specific environments, so for any new software, it is important for Bosch to conduct a range of tests on these various environments. However, Bosch employees must first manually search through their immense volume of data to locate the proper footage, which can be time-consuming and difficult.

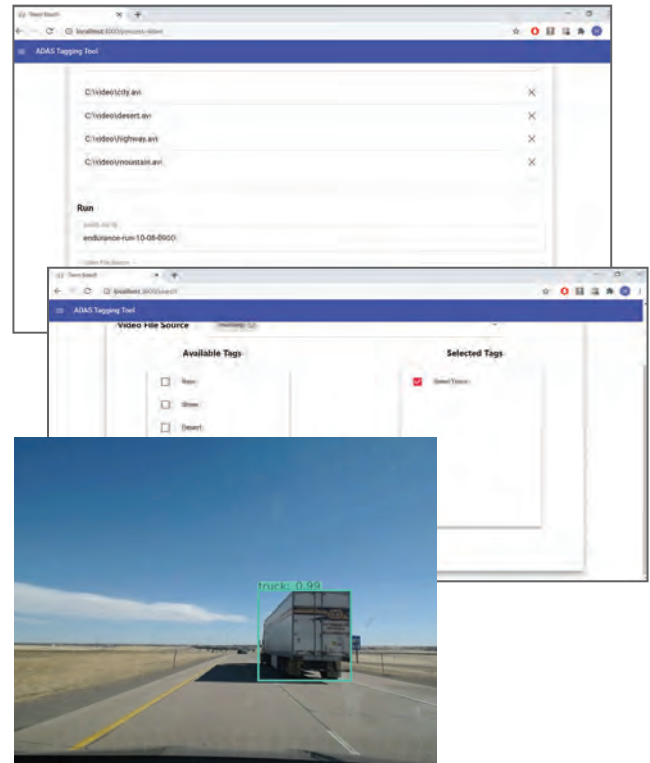
Our Automated Retrieval of ADAS Driving Environments alleviates this issue by automating the task of processing and searching through the video data.

Using computer vision and machine learning, footage is tagged and categorized based on features in the environment (such as rain, night, bridge, highway, etc). Once the videos have been processed, the tags and associated videos are saved for later searching.

Bosch employees can then search for videos containing specific conditions simply by selecting the desired tags and clicking 'search.'

Our software saves Bosch employees time by automatically tagging video environments and provides easy searching through large quantities of video.

Our front-end web application is built with React.js and Material-UI. The back end is built with Flask and utilizes the OpenCV library and YOLOv3 algorithm. The SQLite database holding the processed video and tags is built with SQLAlchemy.



# BOSCH

Invented for life



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# The Dow Chemical Company Artificial Intelligence Project Matcher

With over 100 years of success and industry-leading innovation, Michigan-based Dow is a global leader in specialty chemicals, plastics, and advanced materials. From paper to plastic, Dow provides a state-of-the-art collection of cutting-edge, sustainable, and dependable products.

Recently, Dow began investing resources towards alternative means to drive efficiency and growth within the company. Among these means is artificial intelligence (AI). Artificial intelligence is among the fastest growing fields at Dow, and ensuring the right skillsets are assigned to the right projects has become difficult due to the distributed nature of AI expertise.

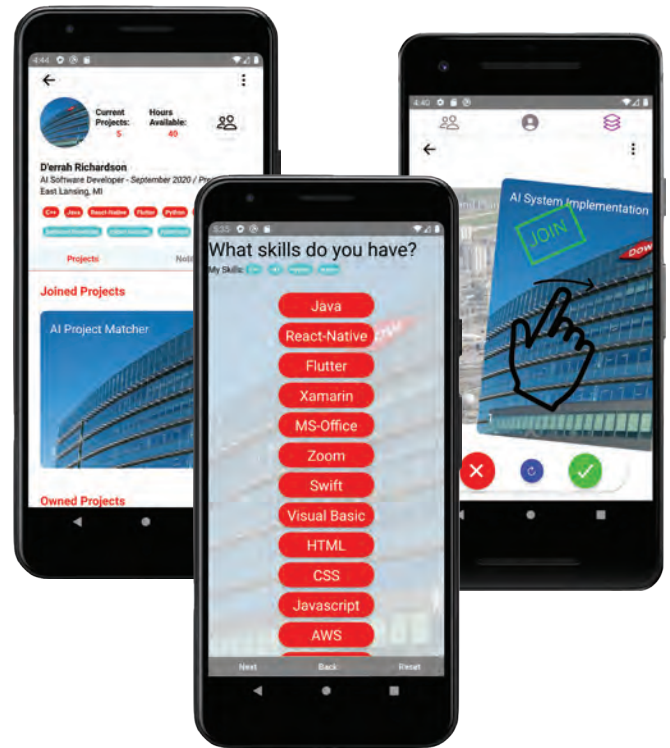
Our AI Project Matcher eliminates these difficulties by matching skilled employees with innovative AI projects, as well as matching AI projects with qualified employees. This is accomplished with our advanced recommendation algorithm.

Using our mobile application, an employee is able to search through projects that may interest them. Similarly, a project sponsor can search through available employees that are qualified to work on their project.

Once an employee and a project sponsor both select that they are interested in each other, they are matched. After matching, the talent and sponsor contact information is shared, expediting the project recruitment process.

Through the use of our simple yet powerful application, Dow employees can now quickly discover projects to join and project sponsors can rapidly acquire the talent needed to complete their project.

Our mobile application is built using Visual Studio Code. The front end is implemented in React Native and the back end utilizes Node.js. All user information is stored and accessed through a MySQL database.



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# Evolutio

## #BIKES4ERP Tracking Initiative

Evolutio is a group of technology professionals convinced that business problems have significantly simpler solutions than the market is led to believe. Evolutio works with the non-profit Elephants, Rhinos and People (ERP), on its #BIKES4ERP initiative. #BIKES4ERP provides bikes to rural students in South Africa.

The bikes provided by ERP help students get to school faster and with more energy to learn. The students that receive bikes from ERP have commutes of up to 10 miles to get to and from school. A bike makes this four times faster and less strenuous for the students.

There are currently hundreds of bikes in use by #BIKES4ERP, and a single mechanic currently handles all bike repairs. As the #BIKES4ERP project continues to expand, the current pen-and-paper method of tracking their bikes becomes less and less viable.

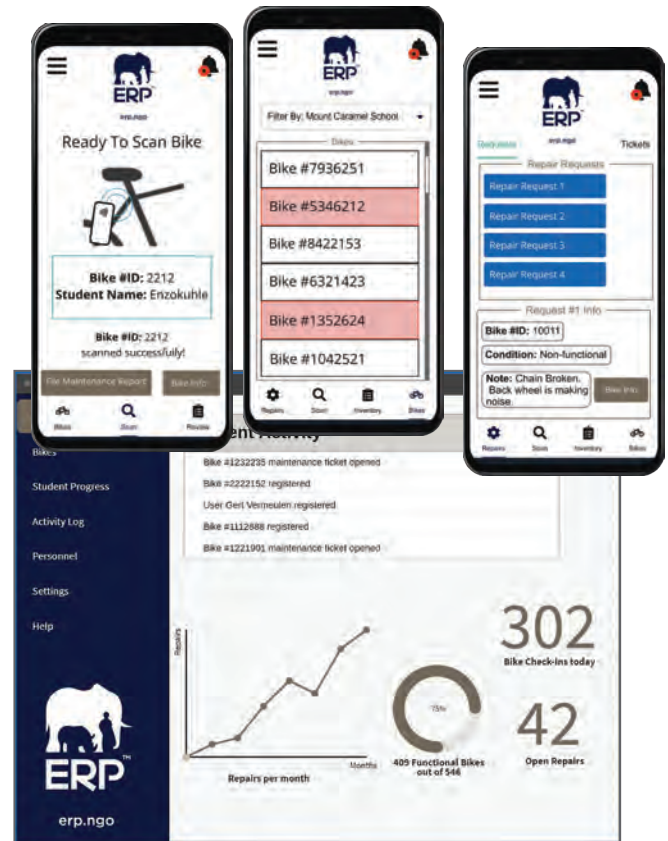
Our #BIKES4ERP Tracking Initiative includes a suite of mobile and web apps that assist teachers, mechanics, and ERP administrators in facilitating and maintaining their fleet of bikes.

The ERP teachers' Android app is used to log daily bike check-ins and submit maintenance requests for any broken bikes.

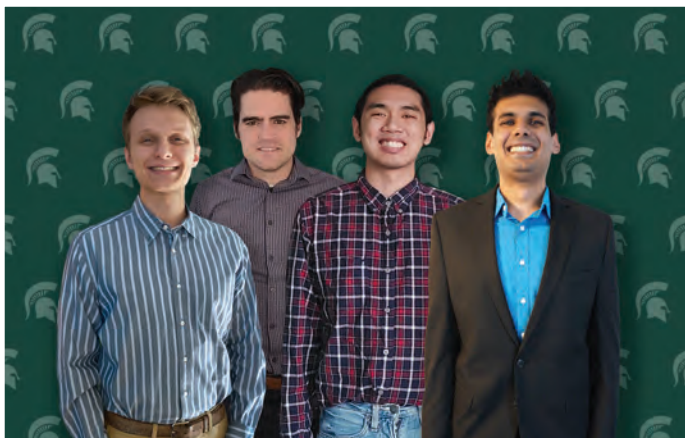
The ERP mechanics' Android app is used to keep track of maintenance requests from teachers, organize the mechanics' digital inventory, and order any needed bike parts.

The ERP administrators' web app is an interface for ERP administrators to look at various analytics. The web app uses data from the teachers, mechanics, and schools to show bike performance and data relating to student academic performance to help understand the link between having a bike and succeeding in school.

Our ERP teacher and mechanic client applications are built using Java. The ERP administrator web app uses the ReactJS framework. The apps use Firebase services to store information and handle reliable data sync in poor network connectivity areas.



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# Ford Motor Company Ford Accelerate Monitor

Ford Motor Company is a multinational automotive manufacturer headquartered in Dearborn, Michigan, employing 199,000 employees and producing a total of 5.9 million vehicles in the last recorded year. 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 delivering software in the mode of continuous integration/continuous deployment (CI/CD) – that is, frequently adding to a project in small ways. To achieve this, teams must be highly coordinated and communicate their progress continually. However, the COVID-19 pandemic has resulted in development teams being distributed across residences, making it challenging for teams to keep track of their progress.

Our Ford Accelerate Monitor provides team members with an easy way to monitor projects. This includes lead time, deployment frequency, mean time to restore, and change fail percentage.

Users can register projects consisting of various CI/CD products including Jenkins and GitHub. They can also track incidents through our web portal.

Once registered, members can connect to the application through a Google Assistant device to ask for statistics about any specific team or project, for example, “What is the change fail percentage for Team Viking over the last 28 days?” Additional statistics like build frequency and build failure notifications are also available.

Our system makes it easy for teams to track their progress remotely, leading to increased productivity.

Our back end is a SpringBoot application written in Java, while our front-end portal is built using VueJS. Our data is stored in a Firebase database, and a REST API framework is used to connect everything together.



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# General Motors

## Automotive Specific Dark Web Threat Intelligence

General Motors is one of the world's top automotive manufacturers, having sold over 10 million vehicles worldwide. GM is headquartered in Detroit, Michigan and is known for brands like GMC, Buick, Chevrolet and Cadillac.

The dark web is a place where people are able to share confidential information with low risk of being recognized. GM is committed to the security of their data, products and employees, and is aware that unauthorized parties may find methods of acquiring private GM assets.

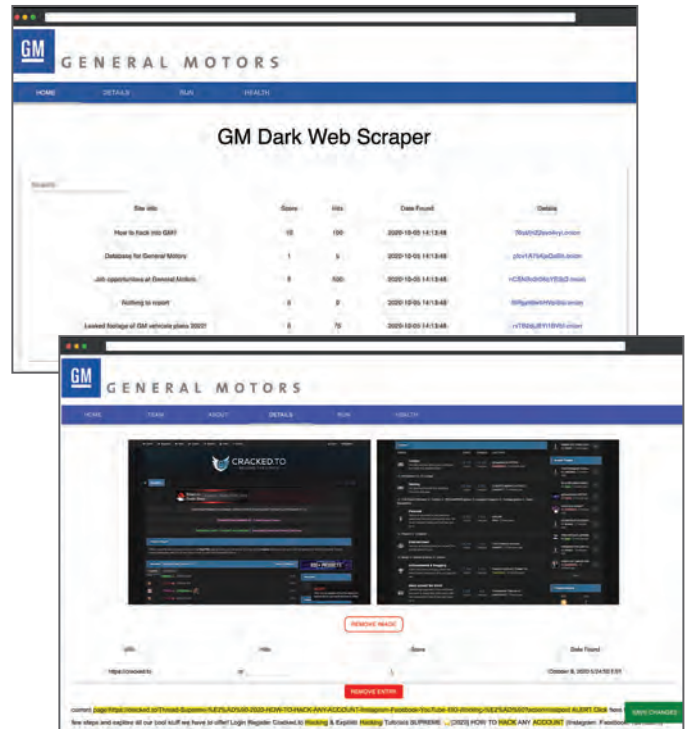
Our Automotive Specific Dark Web Threat Intelligence system provides a method of identifying and analyzing unusual activity by crawling through suspicious websites on the dark web and scraping the information for further investigation.

The Dark Web Threat Intelligence app is scheduled on a server to run at specific intervals. As it runs, it references a specified list of websites to scan for confidential GM information. When information is found, it takes a screenshot of that page and scrapes the text for analysis by the GM security team.

The information from dark web sites is stored in our database where it is referenced for ranking. The application compares scraped information to a set of terms and assigns the url a threat level based on its contents. GM IP addresses and employee credentials are given high threat levels, whereas mentioning the GM name or brands yields a low threat level.

The GM security team uses this information to identify information leaks and threats to company security.

Our Dark Web Threat Intelligence app uses AWS to host our web app, the database, and run the scraping algorithm. The scraper is run using Python scripts and the scraped information is stored in a MySQL database. Our web app uses React to display the database information and update the data when needed.



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# Google Self-Service Support Chatbot for Google Cloud

Google's mission is to organize the world's information and make it universally accessible and useful. To make powerful computing tools accessible to all, Google offers the Google Cloud Platform (GCP) suite of cloud computing products. This platform includes products that assist in data management, artificial intelligence, and application security.

When a GCP customer encounters an issue and contacts support, manually collecting error logs and project details is time-consuming. Additionally, many problems can be quickly fixed by pointing the customer to public documentation about the product. These types of problems take significant time and slow down customer support for other users.

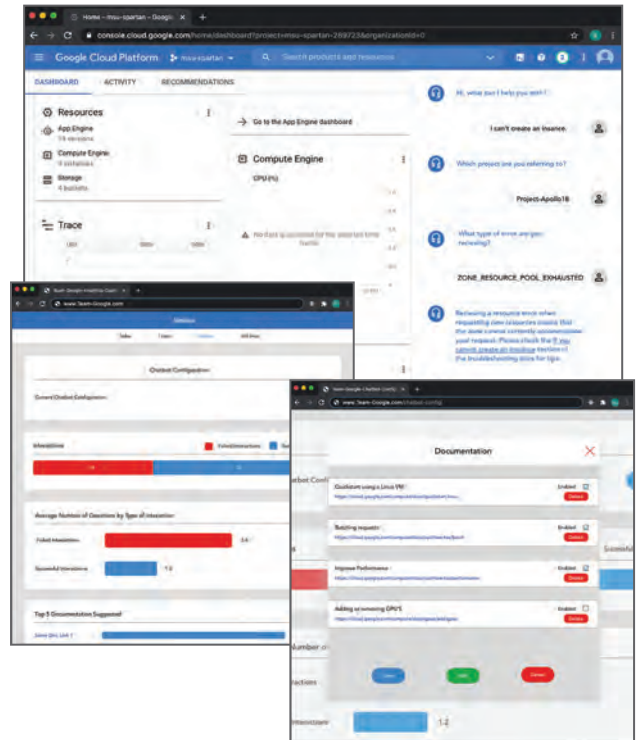
Our Self-Service Support Chatbot for Google Cloud is a suite of tools, including a customer support chatbot that automatically gathers information about errors in order to identify and provide relevant documentation available on the web.

Our chatbot parses and analyzes a user's question using natural language processing (NLP) and provides relevant information that might help with their problem. However, if the chatbot cannot solve the problem, the chatbot organizes the information it has collected and refers them to human support.

The user contacting human support then submits the information the chatbot has collected. This significantly cuts down on the support engineer's time spent on error information collection and the overall time to issue resolution.

Our chatbot uses machine learning to improve document recommendations over time and tailors its resolution recommendations based on feedback from users.

Our chatbot is built using GCP's Dialogflow and Google's NLP API. React serves the front end for the chatbot and Flask hosts the back end on Google App Engine.



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# Herman Miller

## Live Platform Real-Time Occupancy Status

Based in Zeeland, Michigan, Herman Miller has produced office and home furnishings for over 100 years. Known for its history of design innovation, Herman Miller dedicates research to office space quality to quantify the effectiveness of different workspace layouts.

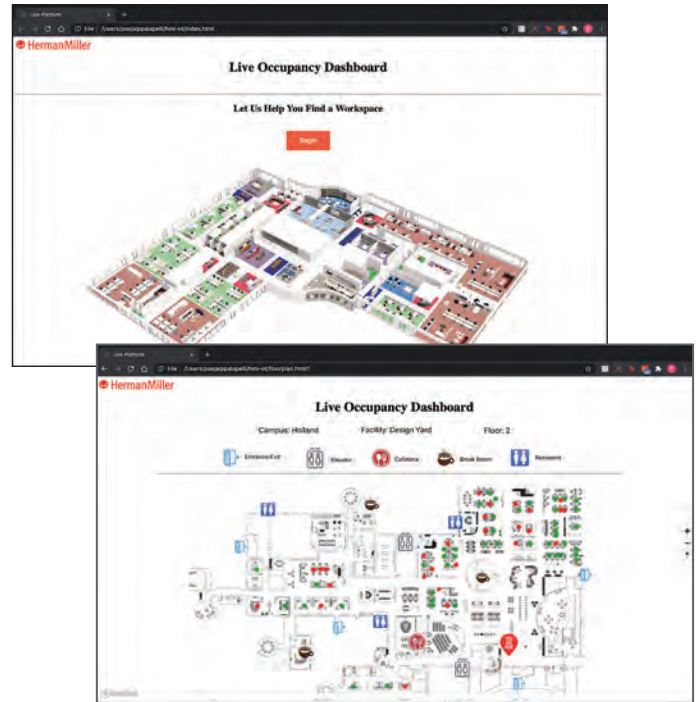
One technology service developed by Herman Miller is the Live Platform. Currently, Live Platform gathers data from desk sensors in open offices to provide space utilization analytics. One feature that the desk sensors provide is the availability of a desk.

Open offices are spaces where there are little to no assigned desks. Instead, staff manually seek out a new workstation each day. One issue regarding open offices is determining seat availability. The process of searching for unoccupied desks becomes time-consuming as employees look through various spaces.

Our Live Platform Real-Time Occupancy Status dynamically displays occupancy status on a given floorplan allowing users to pinpoint available desks. The website dashboard offers users access to near real-time open seating availability and provides a streamlined process for determining workspace availability. Our dashboard also displays points of interest throughout a map for users to seamlessly locate a desired workspace.

Our system makes it simple and intuitive for employees to quickly find an open desk in near real time and minimize time spent searching.

Our software solution employs Amazon Web Services to collect and query IoT data from DynamoDB and MySQL RDS using Lambda functions. This data is then exposed through REST API Gateway. Using customer-provided floorplans, a map is generated from MapBox GL JS and availability markers are shown using GeoJSON coordinates.



## Herman Miller



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# Humana Internship Success App

**H**umana is a health insurance company with nearly 46,000 employees and 13 million members in the United States. The company provides a variety of health cares including Medicare, dental, vision, Medicaid, and pharmaceutical.

While growing within the insurance industry, Humana strives to create employment opportunities for young leaders. Humana hires roughly 50 interns each summer with a 12-week duration. Throughout the internship, interns are expected to set and accomplish goals while completing their summer assignment.

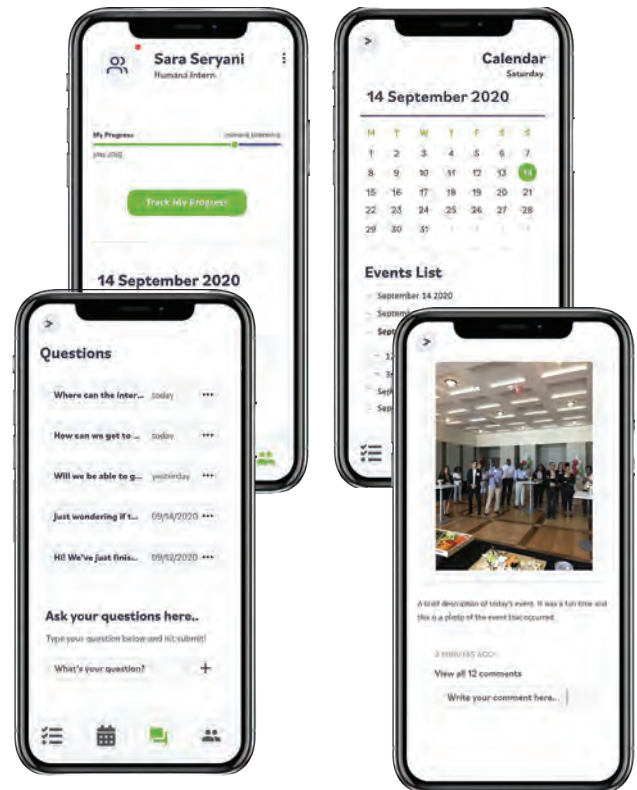
Humana utilizes several platforms for interns to access information during the internship such as calendar invitations, resources, and general inquiry. However, there is not one central location for the interns to guide them throughout the internship.

Our Internship Success App streamlines the internship experience by supplying interns with the necessary tools to succeed in one location. The interns are able to organize internship information, set personal goals, and communicate with other interns and staff.

Upon logging into the application using their Humana credentials, interns can log and track their personal or professional goals. They can create an unlimited amount of goals and track them at their own pace.

The calendar allows users to view Humana event information. Interns can ask the Humana administrative team private questions about their internship and project feedback. To avoid repeated questions, the team may respond to questions and select which ones to make public.

Our application is available on mobile devices running on iOS or Android. Additionally, the front end is designed on Adobe XD and the back end is hosted through React Native. The data is stored using Firebase.



# Humana



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# Learning A-Z

## Vocab Slinger Word Definition Game

**L**earning A-Z, one of the leading companies in virtual learning, provides administrators and teachers with learning materials for pre-kindergarten to sixth grade students. Their digital curriculum is used in classrooms worldwide. They provide students with the resources and skills they need in the classroom and beyond.

In light of the current COVID-19 pandemic, Learning A-Z is meeting the demands for remote learning with their online resources. Students are learning even while away from school.

Our Vocab Slinger Word Definition Game is a web application game that teaches grade school students new vocabulary words and their definitions.

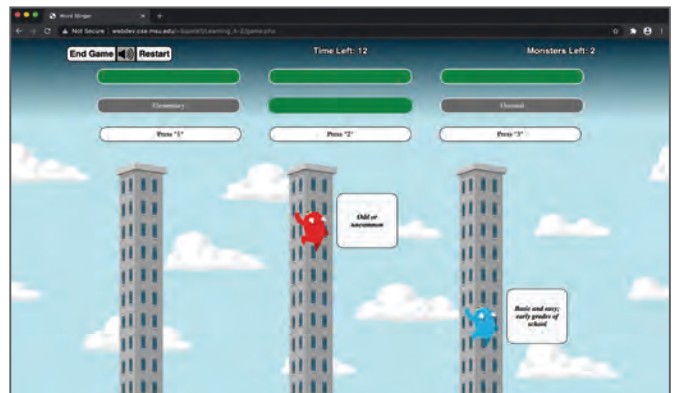
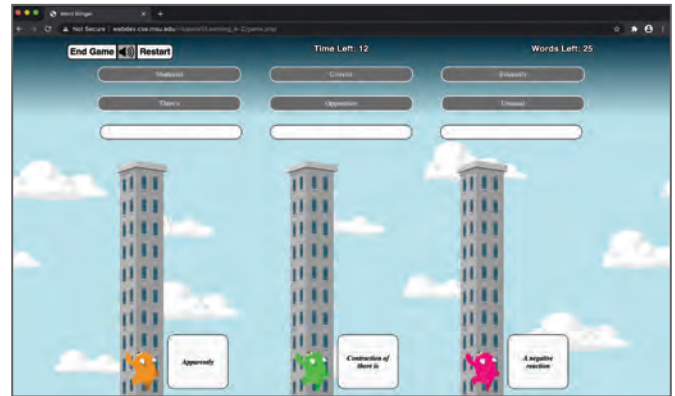
After a difficulty level is selected, the students are presented with three “enemies” who are trying to reach the top of the page. These enemies each have a definition attached to them. These definitions must be matched to the corresponding words from the word bank featured on the page. The complexity of these words and the inclusion of a timer depends on the selected difficulty.

Failing to match the proper word or allowing a set timer to reach zero causes the enemies to rise towards the top. Successful matching “defeats” the enemy, and it is replaced by a new enemy with a new definition at the bottom of the page. The used word is also replaced in the word bank.

The game ends when an enemy reaches the top of the page. The student is then awarded in-application currency corresponding to their performance.

Our software teaches new vocabulary to children in a fun and engaging way that is customized to that child’s ability.

The front end of our web application is made using AngularJS and HTML/CSS, the back end is written in PHP with Composer to manage dependencies. The PHP code sends requests to a MySQL database to get word-definition pairs.



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# Lockheed Martin Space SmartSat™ Heterogeneous Computing in Space

Lockheed Martin Space is one of four subdivisions of Lockheed Martin, an American defense contractor that receives over \$40 billion in defense revenue, the most of any defense contractor. Lockheed Martin Space builds and deploys satellites that have various military and commercial applications. SmartSat™ is a suite of tools designed by Lockheed Martin Space to support and deploy software to their satellites.

Lockheed Martin Space's satellites are constantly gathering data, such as images of Earth's surface, which then need to be analyzed. Currently, most of this processing occurs on ground stations, which requires massive amounts of data being sent from satellites to earth over very slow network connections. This transfer of data can take hours or even days before it can be fully processed.

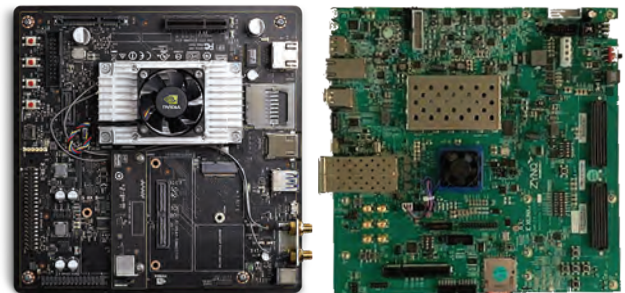
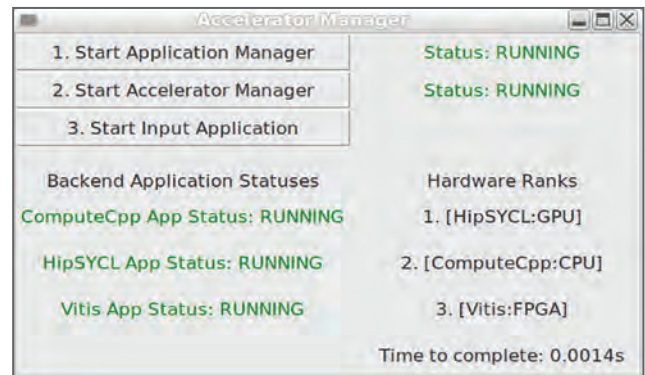
Our SmartSat™ Heterogeneous Computing in Space system combats this issue by allowing data to be processed directly on satellites, instead of requiring data to be sent all the way to earth.

Compared to a ground station, a satellite has less computation capacity, and therefore has to utilize its limited hardware in parallel, running multiple applications at the same time on different hardware components.

An integral part of our system is the Accelerator Manager, which decides what hardware should be used to complete certain tasks. Depending on the current status of the satellite, different hardware should be used in different scenarios. Our system assigns tasks to hardware in a way to minimize processing delay.

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

The back-end applications are built using Lockheed Martin's SmartSat™ SDK. The application uses SYCL and Vitis to run accelerators on available hardware. The software utilizes CPUs, GPUs, Xilinx FPGAs and NVIDIA TX2 boards.



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# Malleable Minds

## Review Aggregator for Educational Programs

**M**alleable Minds is an early-stage startup company dedicated to allowing families to easily manage and share educational resources in order to connect them to global educational opportunities.

The company's mission is to connect parents to the best possible educational programs in and around their local area and to receive continuous feedback from reputable sources.

With their many other duties, parents may not have the time or resources to research programs specific to their children's needs.

Our Review Aggregator for Educational Programs provides a solution to this by aggregating certified educator reviews in addition to reviews from other parents to make a one-stop shop for K-12 educational program browsing.

Parents can "like" programs, which will then be saved to their favorites page. They can also opt to receive notifications about a specific program. Educators and parents alike can rate programs, and then the ratings are displayed to all users browsing programs. Parents can also follow educators to see their ratings on other programs.

Understanding the experiences of previously enrolled children and the ability to compare educator ratings serves a critical function for parents in their search to provide enriching, educational experiences for their children.

Our solution supports a growing community of educators and educational providers, allowing parents to make informed decisions based on relevant and current information.

Using a lightweight, contemporary technology stack, we built a responsive user interface so that users can access the application from any personal computer or mobile device. Our software is written in a combination of Python and React, and our system is deployed using Amazon Web Services.



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# Meijer Support Desk Chatbot

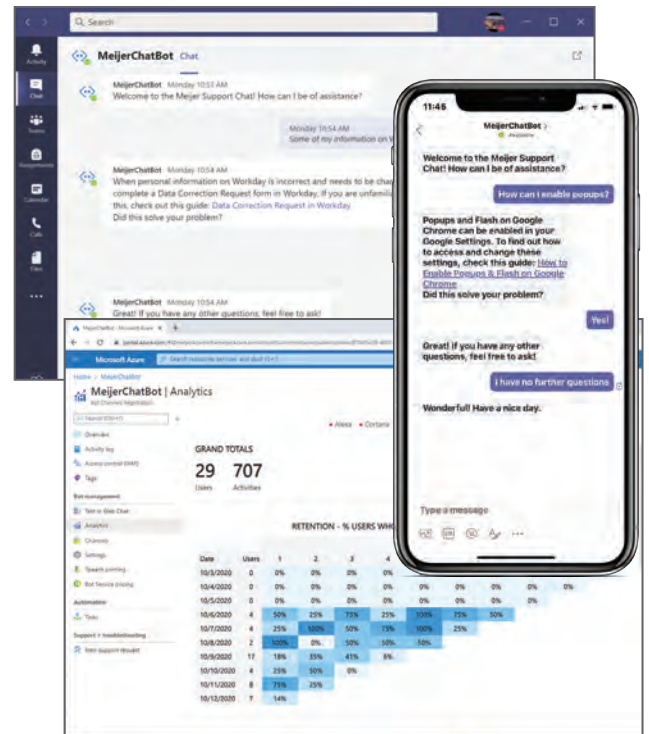
**M**eijer, one of the country's largest supercenter chains, provides high quality groceries and merchandise to several states across the Midwest. Meijer has over 240 stores, 77,000 team members and is continuously improving today's shopping experience with cutting-edge technology like curbside pickup and online grocery ordering.

Over the past decade, Meijer has focused on solidifying their e-commerce presence and moving towards a more data-driven process in making business decisions. The IT Support team is located at the Grand Rapids headquarters where they manage all technical issues faced by the internal associates working within the company. The team regularly receives over 500 phone calls a day, often about issues that have already been resolved.

Our Support Desk Chatbot is a tool that can solve common, repeatedly occurring issues without the need for human interaction. Our chatbot is available 24/7 on Microsoft Teams to assist Meijer team members. When a team member asks our chatbot a question, we use natural language processing (NLP) to parse and analyze the question, and then search through a repository of questions to give suggestions on how to resolve the issue.

If our chatbot is unable to resolve an issue, it automatically generates a support ticket, including all relevant information collected by the chatbot. This allows the support team to quickly solve problems without duplicating effort. Our system allows IT support team members to focus on solving higher priority issues without being bogged down with common issues.

Our chatbot is developed using the .NET Core Framework and is hosted in Microsoft Azure. QnA Maker hosts the knowledge base and provides built-in NLP. The knowledge base is regularly updated, which further assists the helpdesk associates save more time to resolve other escalated problems.



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# Michigan State University ITS

## Explore: Discover Sports on Campus

Michigan State University is a public research university with around 50,000 students. MSU Information Technology Services is responsible for developing and maintaining technological resources for all students, faculty, and staff across MSU's campus.

There are many sporting events on campus each year. Each sport has a varying frequency of home games on its schedule. As a result, students do not have an easy, unified way to find out about and keep track of all of these events.

Our Explore: Discover Sports on Campus application provides an easy way for students on campus to find sporting events and related information. Our solution provides three different options for students: a web application, as well as iOS and Android mobile applications. The feature set is the same for all platforms.

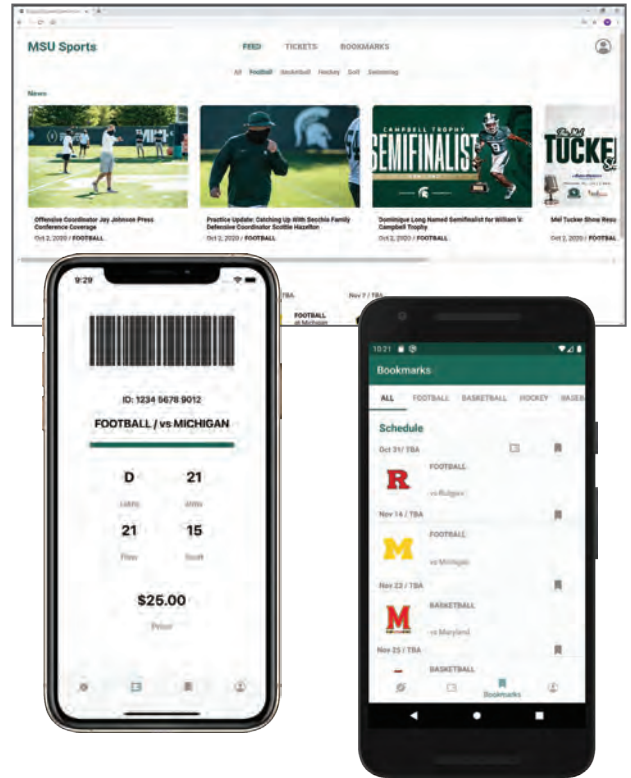
After logging in, users are presented with a feed displaying current sports news and a schedule of games for the upcoming season. Users can click on an upcoming game to view its date, time, location, ticket prices, available seating, and parking information.

The tab bar along the bottom of the page allows users to navigate between the feed, tickets, bookmarks, and profile. They can view their purchased tickets and seating information. A schedule of events that they have bookmarked or have purchased tickets to attend is also available.

Upon visiting the profile tab, users can quickly update their profile or view event history, payments, and a help page.

Our application makes it simple and intuitive to keep track of all sporting events on campus, discover new events to attend, and plan to attend future events.

Explore: Discover Sports on Campus is developed with Vue.js for web, Kotlin for Android, and Swift for iOS. It accesses information stored in a DynamoDB database using an AWS API Gateway via Lambda functions written in Node.js.



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# Microsoft Feedback Analysis Hub for Microsoft Intune

Microsoft is an American multinational technology company that manufactures, licenses, supports, and sells computer products and services. Since its founding in 1975, Microsoft has been listed as one of the 'Big Five' technology companies. They boast the second highest valuation of any company in the world at over \$1 trillion.

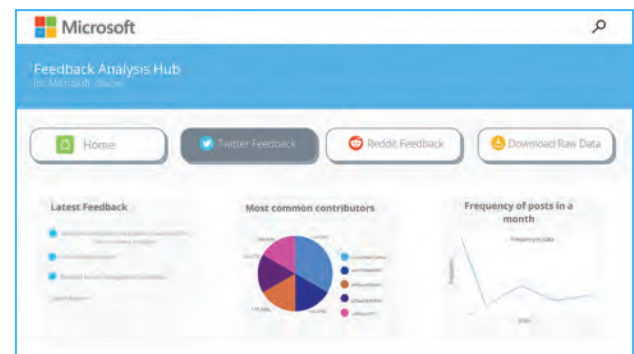
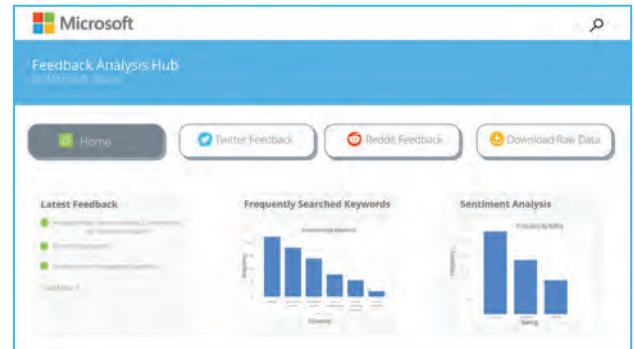
Microsoft Intune is a cloud-based endpoint management system that allows Microsoft clients to securely manage their devices and private information. This tool simplifies the modern workplace, allowing employees to use their personal devices to access private corporate resources in a secure manner.

As Intune grows and is being adopted by more and more people, it has become harder to gather and analyze user feedback about the successes and failures of Intune. Additionally, many users have taken to posting on public forums about their experience with Intune, which provides a valuable source of feedback for Microsoft.

Our Feedback Analysis Hub for Microsoft Intune collects data related to Intune from public forums, such as Twitter and Reddit, in one central hub to be analyzed. This collected data provides Microsoft engineers with feedback on features and bugs that can improve the Intune experience for customers.

Using our hub, Microsoft employees can filter feedback by sentiment, keywords, and date. They can also analyze data through graphs and charts based on the data. This new source of feedback helps Microsoft quickly stay in touch with the needs of their customers.

The Feedback Analysis Hub is deployed through Microsoft Azure. Our data is stored through an Azure SQL server and is pulled to the website through PHP. The data is shown on the user interface using HTML and CSS. Graphs and visualizations are created through Power BI.



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# Mozilla Corporation

## Making Firefox's Picture-in-Picture Even More Awesome

**M**ozilla is the company behind Firefox, one of the world's largest web browsers with well over 200 million users. They are a non-profit, mission-driven organization that emphasizes open-source development to keep the web open and accessible to all, meaning anyone can submit contributions to Firefox by participating in their online community for developers.

Multi-tasking has always been difficult, but has gotten easier with Firefox's Picture-in-Picture (PiP) feature. PiP allows videos to be "popped" out of the browser into a dedicated window that is always on top of all other windows. This is perfect for keeping an eye on sports, or even taking notes while watching a lecture.

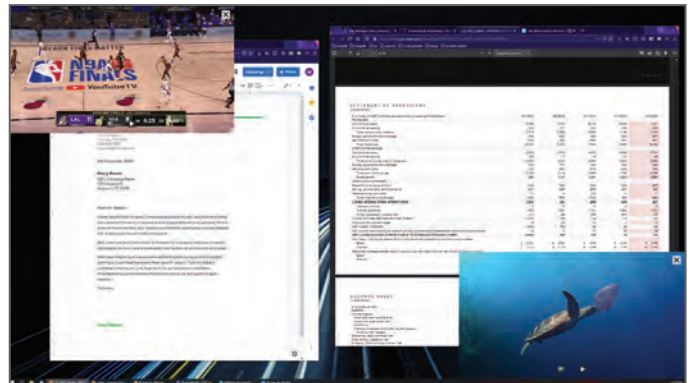
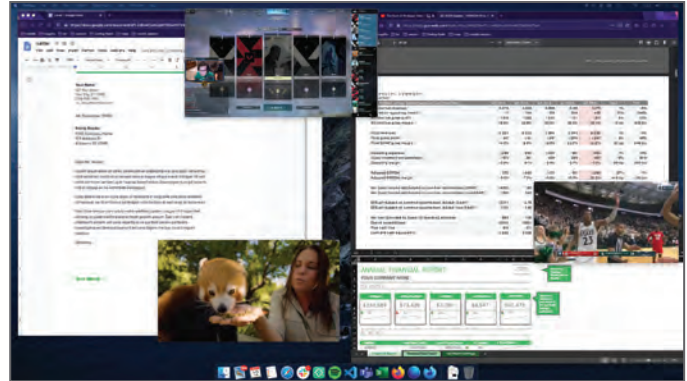
Since the release of Picture-in-Picture, many users have requested that the feature be expanded, improved, and made "even more awesome."

Previously, users could not have multiple PiP windows open at the same time. This is particularly useful for events that benefit from multiple perspectives like Formula 1 races, where multiple cockpit camera views can be viewed simultaneously.

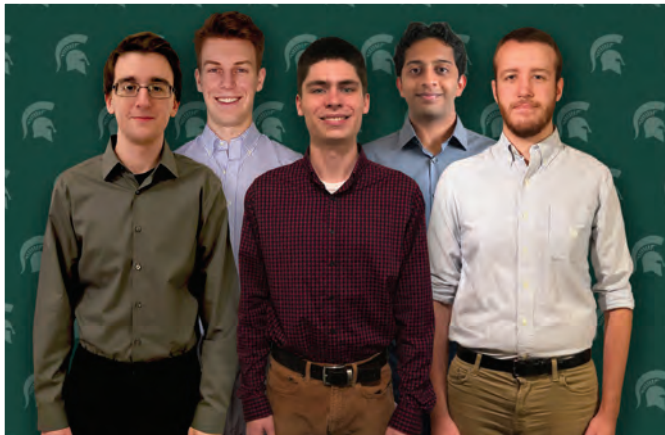
Our Making Firefox's Picture-in-Picture Even More Awesome project addresses this issue, while additionally improving the overall user experience of Firefox's PiP.

In addition to multiple PiP support, our project introduces smart snapping to corners: simply flicking the window towards a corner of the screen will snap it there. Additionally, PiP windows now have a "memory" and open with the position and size last set by the user. Our additions to Firefox's PiP feature improve the user experience and functionality of one of Firefox's best features.

Picture-in-Picture is a feature that lives entirely within the Firefox codebase; a vast piece of software spanning multiple languages like C++, HTML, and JavaScript. The feature itself uses almost exclusively HTML and JavaScript.



## Firefox Browser



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# MSU Federal Credit Union Member Digital Help Center

Founded in 1937, Michigan State University Federal Credit Union provides a variety of financial services to students, faculty and staff at Michigan State University and Oakland University. With over 288,000 members, it is the largest university-based credit union in the world.

MSUFCU provides an outstanding customer experience. A critical part of the customer experience is self-service, where customers should be able to find information and answers to their questions at any time of the day or night.

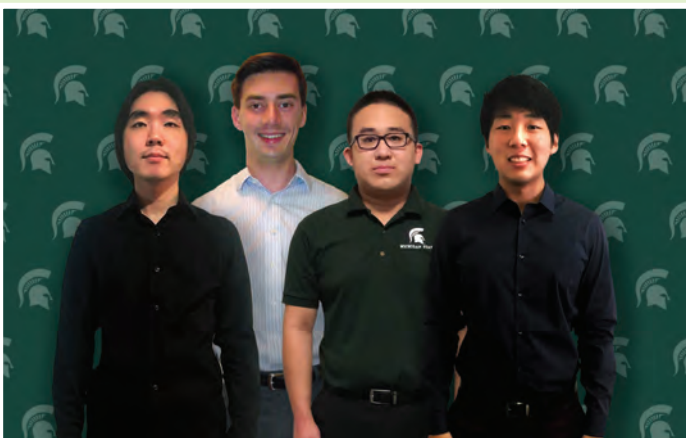
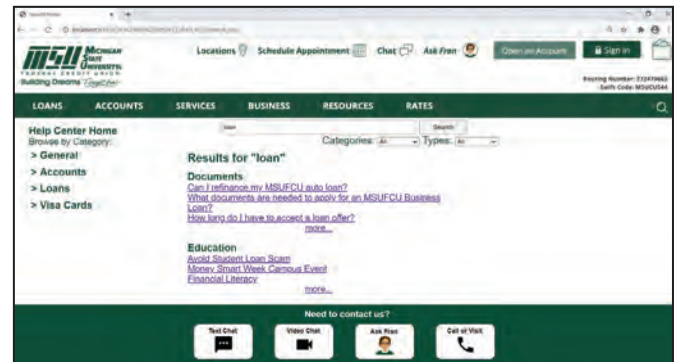
Our Member Digital Help Center serves as a comprehensive “one-stop shop” for MSUFCU customers to get their questions answered, learn about personal finance, and find resources that MSUFCU offers.

Our Help Center includes FAQs, videos and general information pages. Users can find information by searching for what they would like to learn, filtering the results, and browsing by category. The Help Center also provides access to various forms of personalized assistance, such as a chatbot and live chat with an MSUFCU employee by messaging or video chat.

A key characteristic of our Help Center is the wiki-style structure. On each page, select terms are hyperlinked and redirect the user to a page containing a definition and information about that term. Every page also features a “recommended” section, which contains links to other relevant pages. For example, information about gap insurance is recommended in FAQs about auto loans.

Our search and recommended articles are constantly updated by user feedback through a thumbs up/thumbs down rating system. Based on user feedback, our system provides continually improving service to MSUFCU’s customers.

Our Help Center is designed using PHP, HTML, CSS and JavaScript. The back-end database is managed with phpMyAdmin.



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# Proofpoint

## Leveraging SPAM to Make Bold Societal Predictions

Proofpoint, headquartered in Sunnyvale, California, is a cybersecurity company that provides solutions to top research universities, banks and over half of the Fortune 100 corporations. Proofpoint protects sensitive data across every domain including email, the web, the cloud, social media and mobile messaging.

Proofpoint shields their clients from millions of spam emails per day. By analyzing terabytes of email data, Proofpoint can predict future cyber security attacks and prevent them before they happen, increasing the security and reliability of their system and the web.

Our Leveraging SPAM to Make Bold Societal Predictions project utilizes the large amount of spam Proofpoint collects to make predictions about real-world events.

Our system analyzes the data from spam emails via various machine learning techniques and all spam emails about a particular topic to look for underlying patterns that might indicate the outcome of a particular event.

The trends in spam data, as well as any predictions our system makes, are available to be viewed on our web dashboard. The dashboard highlights any interesting data trends, and also various predictions, including the 2020 presidential election, stock prices and consumer sentiment.

Proofpoint analysts use our dashboard to help predict future cyber security risks before they happen, allowing them to provide superior security to their clients.

Our back end runs locally on Proofpoint's secure data server to collect information stored in spam .EML files and anonymizes the data so that customer privacy is protected, while still not compromising the information we are able to use from those files.

Our web dashboard consists of a React front end with a Django and SQLite back end that is being hosted on an Apache web server. Our machine learning model is implemented in Python with Flair.



# proofpoint™



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# Quicken Loans Rally OKR (Objectives and Key Results)

Headquartered in the heart of Detroit, Michigan's financial district, Quicken Loans is the United States' largest online mortgage lender. For ten years they have been a Primary Mortgage Organization, and for seven years a Primary Mortgage Servicing company.

As Quicken Loans has expanded, they have developed the need for a system that not only tracks goals, but also makes them actionable and measurable. This is accomplished by breaking them down into smaller parts, referred to as Objectives and Key Results (OKRs).

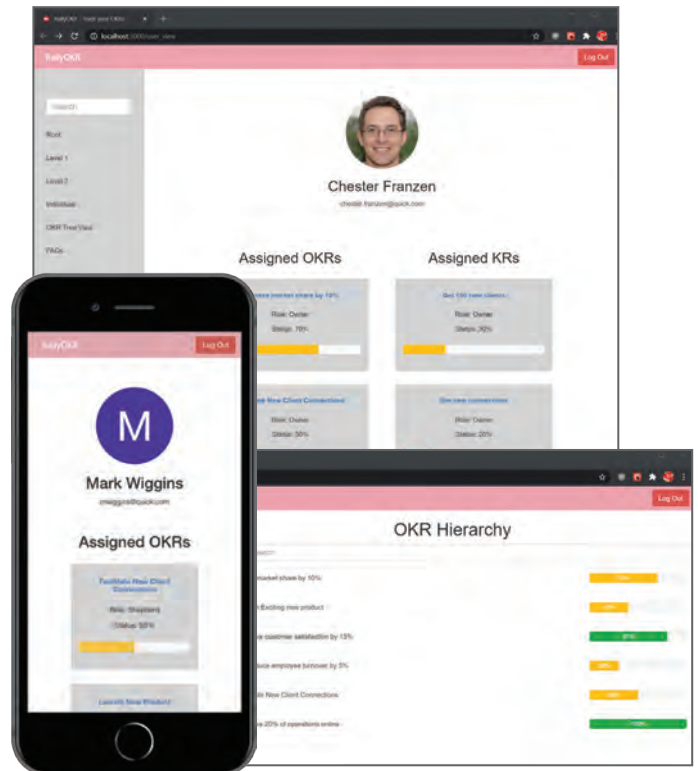
Our Rally OKR software is a fully responsive web-based application that allows users to easily track objectives and key results in an intuitive user interface. Dynamic progress updates within the application improve company-wide awareness of overarching goals.

With our system, users can view and manage objectives and key results based on their role, which is determined by Quicken Loans. Upon login, users can view their current assigned objectives and key results, as well as their progress and user's role.

When selecting either an objective or a key result, its details are displayed. Furthermore, users can write comments to discuss updates for the goals. They can also grade key results anonymously, which then updates the associated objective's grade as well. Objectives are easily viewable in a hierarchy within the application, showing how each objective is linked.

Our system allows Quicken Loans' teams to track their progress toward goals in smaller, more manageable pieces and visualize them intuitively, as well as increase company-wide communication, increasing productivity in the workplace.

Our application uses .NET Core for the API with a MySQL database hosted on Amazon Web Services. The API is hosted on Heroku, and the front end utilizes ReactJS.



**Quicken Loans®**  
Engineered to Amaze®



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# TechSmith

## TechSmith Video Summarizer

TechSmith provides software that empowers people to communicate more effectively by easily creating visual content such as images and video. Their flagship products, Snagit and Camtasia, are used by more than 30 million people worldwide.

The way people learn has drastically changed over the past year, with more and more people relying on video content for education. With this shift to online learning, a few glaring issues with video teaching arise, namely that long videos are hard to navigate and find relevant information.

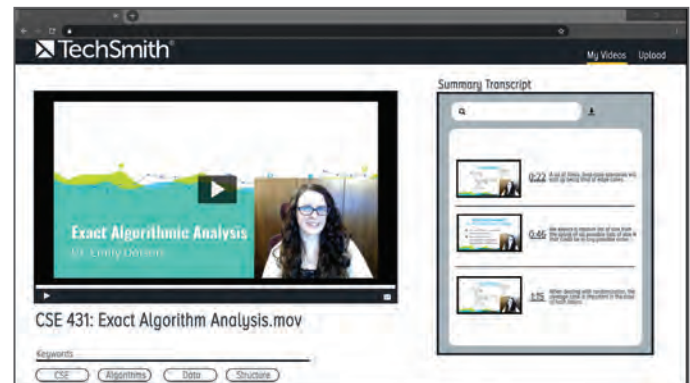
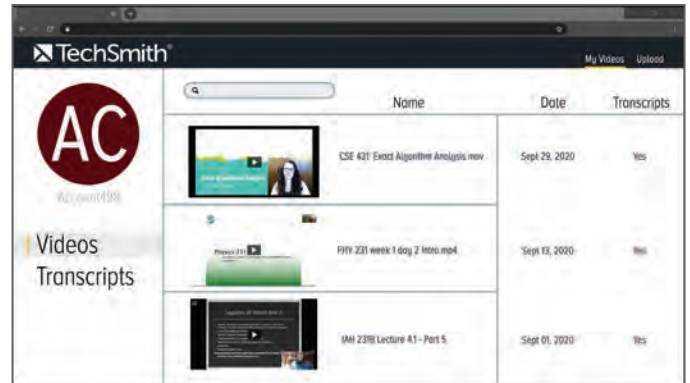
Our TechSmith Video Summarizer solves this issue by automatically segmenting and summarizing any video into small, easy-to-navigate segments that the user can search through and view based on what they are seeking.

The TechSmith Video Summarizer uses speech-to-text techniques to extract the words spoken in a video into a transcript. We then use natural language processing (NLP) on this transcript to extract the main ideas of a video, and to find segments of a video all related to the same topic.

Our Video Summarizer then segments a video into a number of “mini” videos based on our NLP. Each of these segments has its own summary and keywords. Users can effortlessly determine if the content in a given segment is what they are seeking.

Allowing users to browse keywords and summaries of video segments gives them complete control over their learning and video watching experience. Users are no longer burdened with searching through hours of video to find the particular content of interest.

The front end of our web application uses HTML, CSS and React while the back end uses C# and .NET Core framework. The web application and SQL database are both hosted on Microsoft Azure. FFmpeg is used to render and break down the video.



# TechSmith®



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# United Airlines Mobile GSAP and QC Audit Center v2.0

United Airlines is the world's second-largest airline, currently operating approximately 2,200 flights a day out of 250 airports around the globe. To maintain its fleet of aircraft and ensure successful and safe flights, it is crucial to identify and resolve safety concerns and hazards.

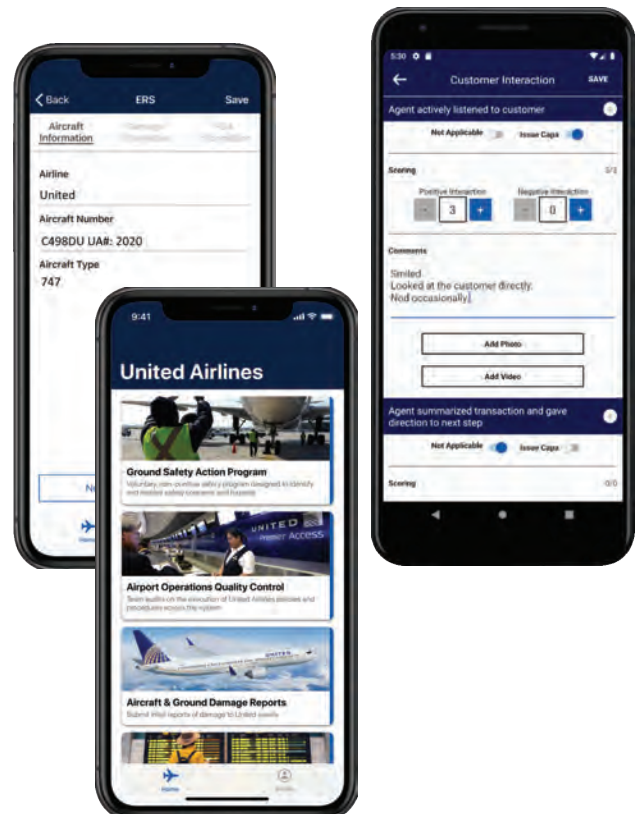
With safety being a top priority for United Airlines, many reports and audits need to be filed each month. However, form submissions can only be done on a desktop computer. The user must jot down notes using pen and paper before heading inside the facility to file the report. Mobile GSAP and QC Audits is a mobile version of the desktop application designed to be used in the field.

Our Mobile GSAP and QC Audit Center v2.0 builds off the first version by providing more features. In addition to both types of reports supported by the previous application, our system supports three more. These include Management Observed Compliance and Hazard Assessment (MOCHA), Line Operation Safety Assessment (LOSA), and Aircraft and Ground Damage Reports (ERS). Each user has access to reports based on their department and position.

Our updated mobile application is more user-friendly, allowing a simple and intuitive submission process, including autofill name, drop-down lists, and the ability to include a real-time photo or video. Furthermore, users can create, save, and submit forms as they inspect an aircraft or audit an employee. Upon saving a form, users can access it later through a mobile device or desktop for review and editing.

Reports and audits can now be quickly completed in real time using our system. This reduces time spent filing reports and expedites the entire process.

Our front-end software is written using Swift for iOS and Kotlin for Android, while our back-end system is written in Python and Django for the API and a Microsoft SQL Server database.



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# United Airlines Airport Lounge Management System

United Airlines is a major international air carrier, currently operating 2,200 flights per day from 250 airports. United Airlines operates 45 United Club lounges as well as Polaris lounges in Chicago, Houston, Los Angeles, Newark and San Francisco, with several more on the way.

Currently, qualifying customers from United and partner Star Alliance airlines can access amenities such as dining, daybeds and showers in the Polaris lounges. Because of the large number of amenities offered at these lounges, lounge staff spends a lot of time maintaining them.

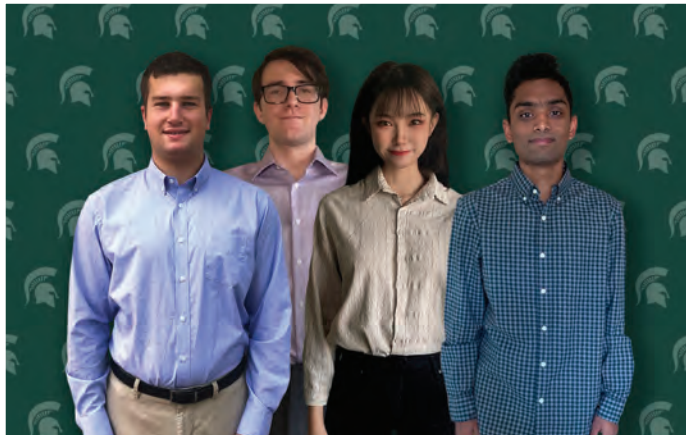
Our Airport Lounge Management System is a web application that automates certain tasks, allowing lounge attendants to spend more time interacting with customers.

Waitlists for amenities are managed by our system, which sends a text message to customers when their spot is available. A dashboard also displays customer flight information and departure time, allowing staff to adjust the waitlist order accordingly. Real-time updates are provided on the status of individual amenities, including which are in use, being turned over, are vacant, and out of order.

Our system also provides actionable data to United and lounge staff - performance metrics that indicate how efficiently each lounge is being run and strategic data on the type of customers who use these lounges.

Waitlist management and amenity status tracking is automated, allowing lounge staff to spend more time with guests and improve customers' enjoyment of these lounges.

Our Lounge Management System is built with ReactJS, ASP.NET Core and a Microsoft SQL Server database. The web app is accessed through a United-owned iOS device and is hosted on Windows server in AWS.



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# United Airlines Tech Ops Training Content Management System

United Airlines is a major international air-carrier, currently operating 2,200 flights per day from 250 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 aircraft. To supply this training, United Airlines currently maintains a vast encyclopedia of training documents and videos.

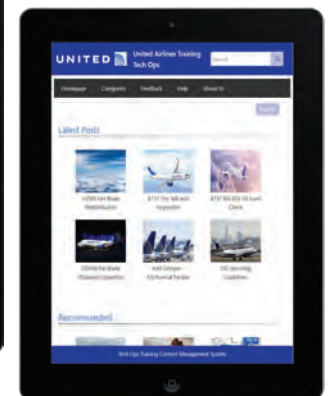
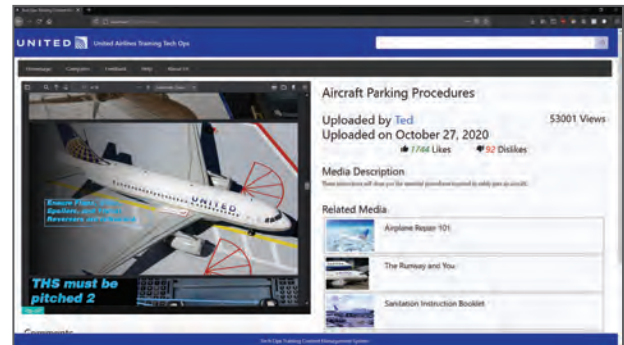
Our Tech Ops Training Content Management System provides access to this encyclopedia of training content through an intuitive desktop and tablet-based website.

When users access our website through United Airlines’ employee portal, they are greeted with customized media content based on their previous activity. Our analytics determine videos and documents most relevant to an individual’s needs. Users are shown media that is popular with all users and media that is recommended by United Airlines administrators.

Employees may leave feedback on media items and the system as a whole. This feedback is provided to United Airlines administrators who can change their activities accordingly.

United Airlines administrators can create, edit, and remove media content from the site’s collection. Furthermore, they can approve comments, view feedback, and flag media items. Flagging a media item displays that item on the homepage for a subset of users selected by the administrator.

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



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# Urban Science Purchase Score Application

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

One of the problems that Urban Science seeks to solve for its clients is how to convert sales leads (potential buyers of a product or service) into successful sales. With Urban Science's lead-scoring solutions, clients are able to have leads displayed as low, medium, or highly likely buyers. Though this feature is extremely useful, there is currently not a straightforward solution for allowing dealers to easily input lead information and receive a score for a specific lead.

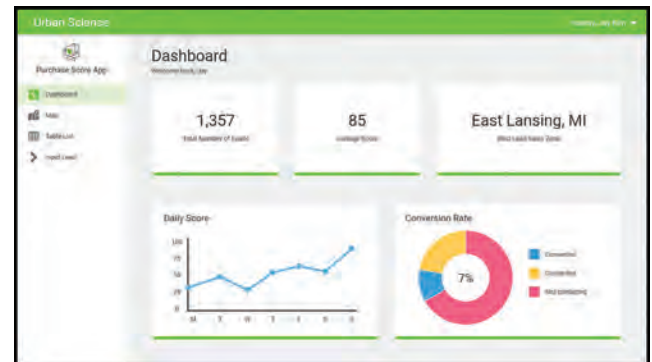
Our Purchase Score Application is a web platform that provides an easy and straightforward interface for dealers to input lead information, score each lead, and create informative reports based on lead information.

Our Purchase Score Application is designed to allow users to easily navigate our website and view pertinent information. Dealers can input their collected lead information automatically through a file upload, or manually with just the press of a button.

After lead information has been provided by the dealer, analytics reports can be easily generated to suit the dealer's needs. These analytics reports present dealers with metrics and useful information to help in the sales process. High-quality leads and suggestions are shown in an engaging and easy-to-read format.

Each report helps increase dealer sales with information on top leads, lead trends, and other helpful metrics.

The Purchase Score Application front end, built on React and Node.js, makes calls to Urban Science's APIs for scoring capabilities. The information produced using the Purchase Score Application is stored in a SQL Server database.



Name	Car Model	Date	Status	Score	Action
Jason Morgan	2018 BMW X1	26 Jun 2019	Completed	95	
Emilia Pickett	2014 KIA Niro	14 Aug 2019	Waiting for action	32	
Mattie Brown	2018 Mercedes-Benz C300	01 Oct 2019	Completed	86	
Evan Wright	2014 Honda Accord	07 Jul 2019	Waiting for action	28	
Allen Goodman	2014 Mini Cooper	04 Jan 2020	Waiting for action	44	
Kevin Shaw	2018 Volkswagen Tiguan	16 Jun 2020	Completed	91	
Jimmy Foster	2018 Nissan Altima	24 Feb 2019	Completed	67	
Wage Davidson	2017 Chevrolet Impala	01 Nov 2019	Completed	19	



URBAN SCIENCE™



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

**Jay Kim**  
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**Isaac Mayers**  
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**Kyle Schmitz**  
Perry, Michigan

**Marcus Minardi**  
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## Urban Science Project Sponsors

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**Elizabeth Klee**  
Detroit, Michigan

**Steven Lewnau**  
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**Matthew Menzies**  
Detroit, Michigan

**Abbott Wang**  
Detroit, Michigan

# Vectorform Self-Improving Assistant

Since its founding in 1999, Vectorform has provided a platform to a wide variety of organizations wishing to solve big problems with inventions emerging at the forefront of technology. This approach has grown Vectorform into a truly worldwide company, with offices in Seattle, Detroit, Mumbai, and Hyderabad. Vectorform combines expertise in hardware engineering, internet of things, augmented and virtual reality, and user-experience focused design to their solutions.

Our Self-Improving Assistant platform acts as a framework to allow Vectorform and its clients to easily create custom support chatbots for any purpose. The system is explicitly designed to be domain-independent, meaning it can be configured to provide automatic customer support in any field, if provided with relevant training data. Each chatbot resides in a Microsoft Teams channel, allowing easy access to anyone in an organization.

To achieve these goals, the chatbot framework takes loosely structured text (FAQ pages, call logs, product manuals, etc.) and uses natural language processing to extract the underlying answers to any questions from a customer seeking support.

Our system is designed to learn and improve as it experiences more customer interaction. As customers ask questions and get answers, the quality of the feedback is collected and analyzed. If a correct solution is achieved, the bot learns that a particular solution is valuable to a certain type of question.

If the user's question is not answered, the user is directed to human support, and the steps the bot took in its unsuccessful resolution of a question will not be repeated for similar questions.

The Self-Improving Assistant uses a C#.NET Core application which queries Microsoft Azure Cloud Services. MS Cognitive Services processes user queries. The MS Graph API handles permissions and support channels.



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**Jeff Meador**  
Royal Oak, Michigan

**Josh Parmenter**  
Seattle, Washington

# Volkswagen Group of America

## VW Car-Net Electric Vehicle Route Planner

Volkswagen Group of America is the North American operation headquarters and subsidiary of the Volkswagen Group, one of the world's leading automobile manufacturers. They are comprised of 8,000 employees in the United States and sell their vehicles through a 1,000-strong dealer network.

Electric vehicles are one of the latest innovations in the automobile industry. Volkswagen, who just released their first electric vehicle, the ID.4, want a way to show potential customers the benefits of electric vehicles compared to gas powered vehicles as well as address and correct some of the common misconceptions many people have about electric vehicles.

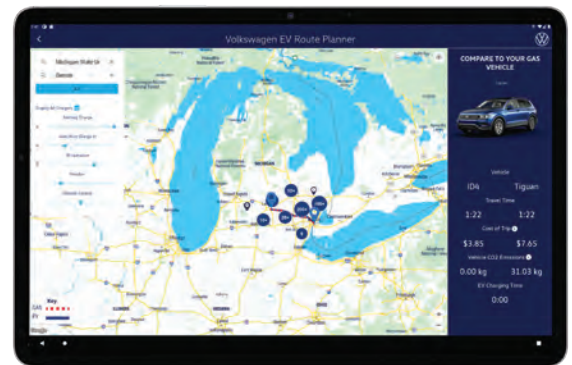
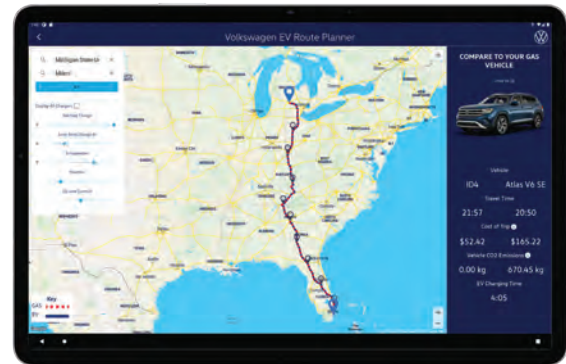
Our VW Car-Net Electric Vehicle Route Planner application is displayed in Volkswagen dealerships and educates potential car buyers about the benefits of buying an electric vehicle.

A major concern many buyers have about electric vehicles is the car's range and charging options available on the road. Our application generates driving routes for gas vehicles and electric vehicles that stop at charging stations. Buyers can compare these various routes with respect to route length, route path, fuel costs and carbon emissions.

Our application also allows for extensive customizability including sliders to adjust starting battery charge, climate control, temperature and weather conditions to account for the effects these factors have on battery consumption.

Our Electric Vehicle Route Planner helps assuage the fears of potential electric vehicle buyers by showing them that their daily routine will have minimal disruptions, and significant benefits if they switch to an electric vehicle.

Our Electric Vehicle Route Planner is developed as an Android application that utilizes API calls to handle route altering attributes and route generation. Our application is written in Kotlin.



### Michigan State University

#### Team Members (left to right)

**Joey Kelly**  
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**Andrew Smigielski**  
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**Zosha Korzecke**  
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**Michael Lin**  
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**Erich Hairston**  
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### Volkswagen

#### Project Sponsors

**Shelly Desmet**  
Auburn Hills, Michigan

**Igor Efremov**  
Auburn Hills, Michigan

**Frank Weith**  
Auburn Hills, Michigan



# Design Day Awards

CSE 498, 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 spring of 2020.

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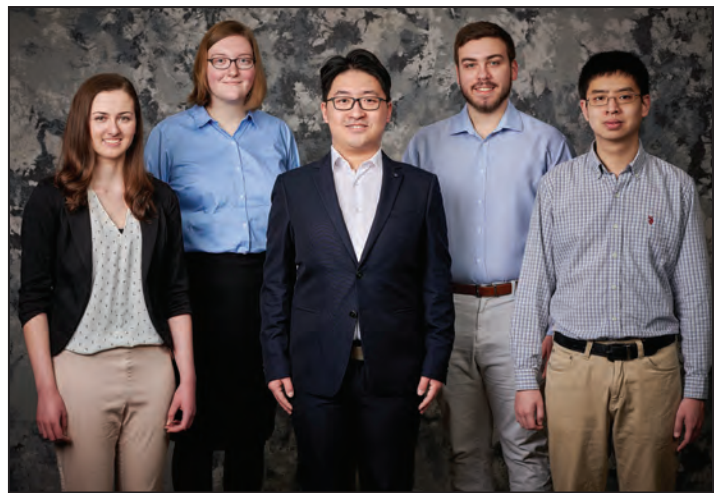
## Auto-Owners Insurance Exposition Award



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 United Airlines Safety  
Virtual Reality Aircraft Walkaround



Caitlin Brown, Ellie Locatis, Jiachen Lin, Jacob Turcano, Cheney Wang  
Presented by Tony Dean, Ross Hacker and Scott Lake

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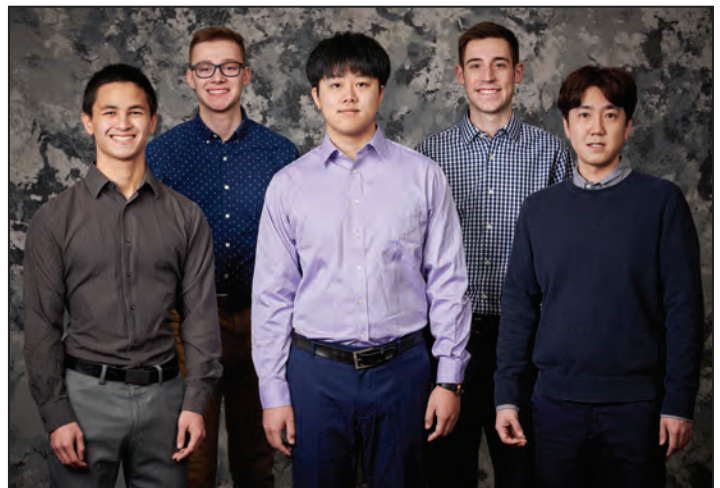
## MSU Federal Credit Union Praxis Award



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 MaxCogito  
Identity Based Communication and Content Services



Harrison Samoy, Bryan Hitchcock, Tengjiao Wang, Conor Sands, Andrew Kim  
Presented by April Clobes and Ben Maxim

# Spring 2020

All of the awards have their principal focus, but they also measure and weigh each team's success in designing, developing, documenting and delivering a comprehensive software system. They also take into consideration the written and oral skills displayed by the teams presenting, explaining and defending their project work.

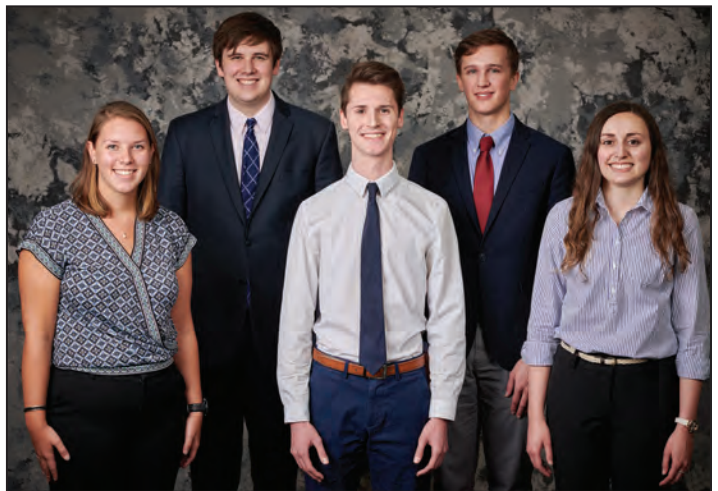
## TechSmith Screencast Award



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 Auto-Owners  
Phish Phinder



Madison Bowden, Jacob Loukota, Hunter Hysni, Alex Larson, Gabi Singher  
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 Michigan State University ITS  
Degree Navigator



Tony Fedewa, Chad Capuzzi, Christian Velkovich, Sarah Johanknecht  
Presented by Robby Buttery, Mike DeRiso and Elizabeth Klee



## Introduction to Electrical and Computer Engineering

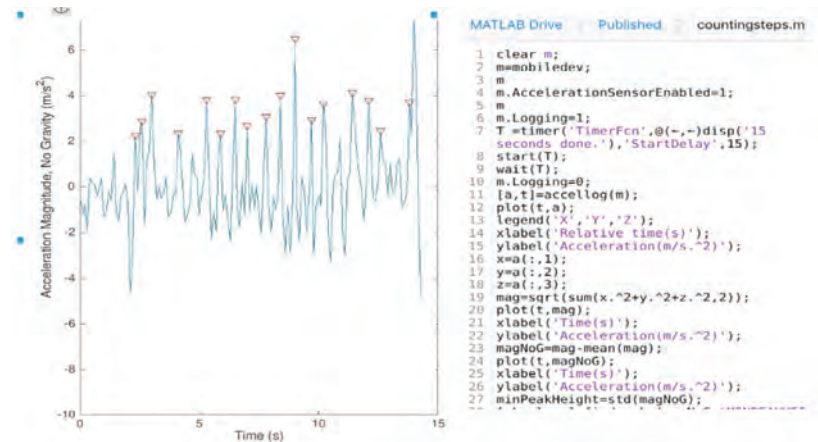
**Dr. Dean M. Aslam**

**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 i-Phone, (d) Built-in Smartphone-Sensors: Plotting Angular Velocity and Device Orientation by MATLAB Mobile, and (e) Other Smartphone Sensors.

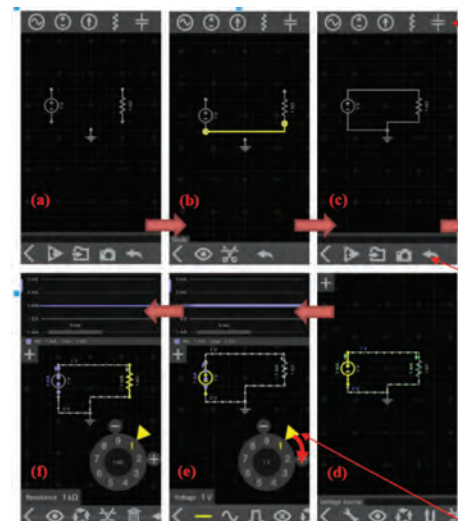
**Graduate Student Assistant:**  
**Saad Alzahrani**



**Acceleration Data From Smartphone:**  
**Counting Steps**

**C-Code**

Team Members	Project Title
<b>Team #1:</b> Miles Bixler Max Burchi	Smartphone Blood Testing
<b>Team #2:</b> Lilli Meng Drake Pettit Remy Vanwert	Smartphone Health Monitoring
<b>Team #3:</b> Jeremy Raymond Tabitha Stanton Nick Stark	Smartphone Blood Testing
<b>Team #4:</b> Carols Tyus Brittany Walton Rick Wieczorek	Smartphone Health Monitoring



**Ohm's Law Simulation**



## The Capstone Projects



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



**Dr. Lalita Udpa**  
Professor of  
Electrical and  
Computer  
Engineering

### Faculty Advisors: Aslam, Aviyente, Deng, Fan, Mahapatra, Mitra, Morris, Radha, Ren, Tan, Zhang, Zhu



Dean Aslam



Selin Aviyente



Yiming Deng



Qi Hua Fan



Nihar Mahapatra



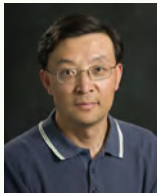
Joydeep Mitra



Daniel Morris



Hayder Radha



Jian Ren



Xiabo Tan



Mi Zhang



Guoming Zhu

## 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.

We gratefully acknowledge the support of this semester's project sponsors: Consumers Energy, MSU Department of Electrical & Computer Engineering, MSU Department of Mechanical Engineering, MSU Human Augmentation Technologies Lab, MSU Mobility Center, MSU Office of the VP for Auxiliary Enterprises, MSU Resource Center for Persons with Disabilities, MSU Solar Racing Team, NASA, Smart Microsystems Laboratory, and Texas Instruments.

# Smart Microsystems Laboratory

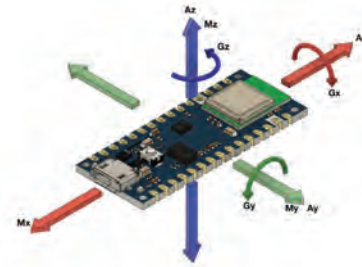
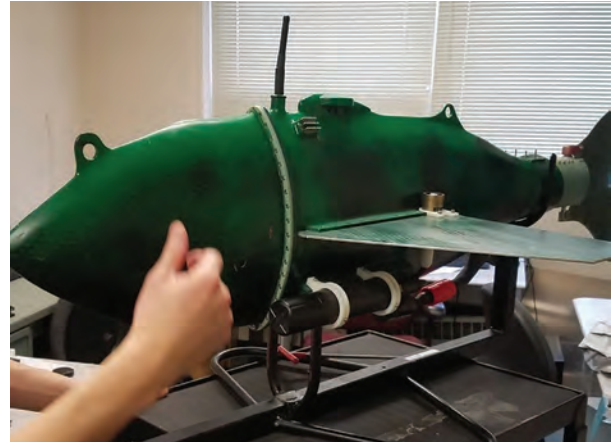
## IMU-Based Navigation with Dead Reckoning

Established in Fall 2004, the mission of Smart Microsystems Laboratory (SML) is to enable smarter, smaller, integrated systems by merging advanced modeling, control and design methodologies with novel materials and fabrication processes. Their research spans the general areas of control, dynamics, robotics, mechatronics, and smart materials. Research in SML is focused on electroactive polymer sensors and actuators, modeling and control of smart materials, soft robotics, bio-inspired underwater robots, and underwater mobile sensing.

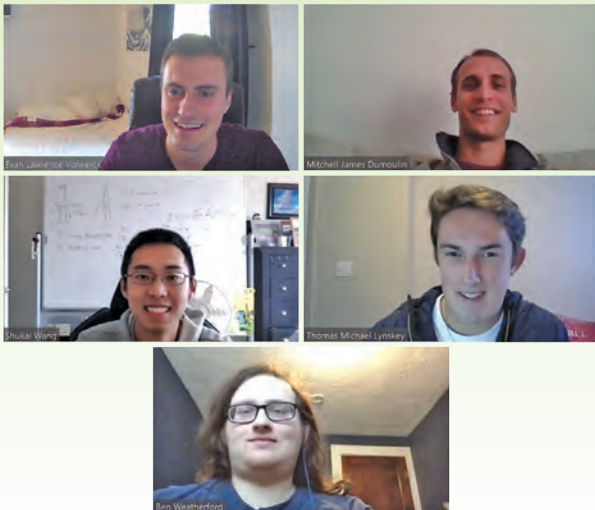
Vast development of global network makes today's world seem minuscule. However, there are still many instances where signals can be lost while a strong barrier is present between the source and the receiver, causing an object's positions to be inaccurately measured. A solution to this could be the addition of a hardware component that predicts the position based on the object's movements.

Our group was tasked with creating an Inertial Measurement Unit-based dead reckoning system. Inertial Measurement Units (IMUs) are electronic devices that measure an object's force, angular rate and orientation using a combination of tools like gyroscopes and accelerometers. When GPS signal is lost and an absolute position cannot be achieved, an estimated location can be determined using an IMU and a technique known as dead reckoning. Over long periods of time, dead reckoning cannot be relied upon for proper positioning and will produce inaccurate location estimates. Dead reckoning requires double integration and as a result of this mathematical step, the slightest inaccuracy will be exacerbated. Inexpensive IMUs are inadequate without first filtering the data they produce. Common techniques for fixing this data include Extended Kalman and complementary filtering.

The system is being designed for use in a robotic fish that is owned by the Smart Microsystems Laboratory.



College of Engineering  
MICHIGAN STATE UNIVERSITY



### Michigan State University

#### Team Members

(left to right, top to bottom)

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#### Mitchell Dumoulin

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#### Shukai Wang

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#### Thomas Lynskey

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#### Ben Weatherford

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### Smart Microsystems Laboratory

#### Project Sponsor

#### Dr. Xiaobo Tan

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#### Project Facilitator

#### Dr. Jian Ren

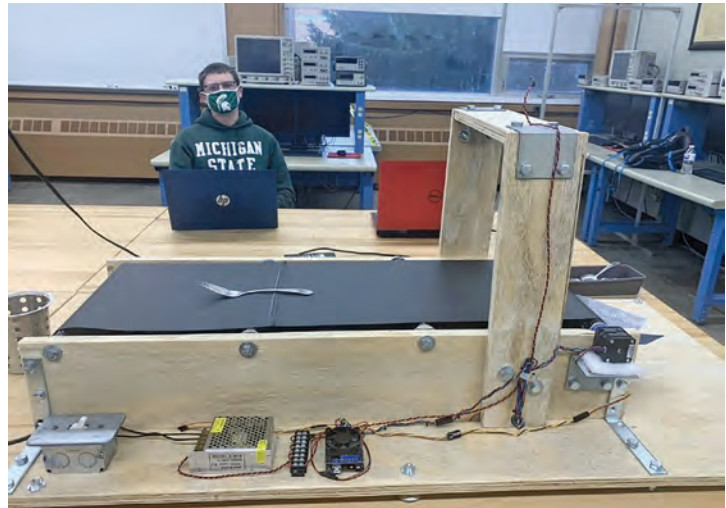
# MSU Office of the VP for Auxiliary Enterprises Robotics in a Residence Hall Dish Room 3.0

The Michigan State University's Brody Cafeteria provides roughly 1.6 million meals per year.

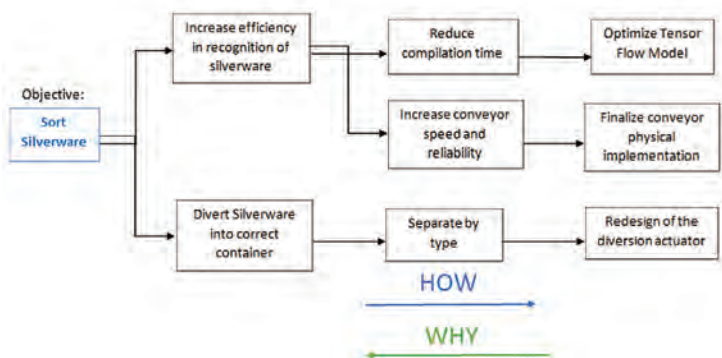
The current process of sorting silverware can occupy several employees at a time in a wet and humid environment. With Brody Cafeteria being short-staffed, this task can cause mayhem in the work environment. Using automation, staff members can divert their energy elsewhere, thus creating a better work environment.

Our project, which is a continuation of a Spring 2020 project, is to improve an existing robot that will help reduce human error when washing and sorting the silverware.

There are a few technical problems that still need to be addressed: improving the efficiency and accuracy of the sorting process by developing automated object recognition software, and redesigning the robotic system to remedy the conveyor belt slipping issue.



**FAST Diagram**



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**Mark Brown**  
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**Nick Coury**  
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**MSU Office of the VP for  
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**Project Facilitator**

**Dr. Yiming Deng**



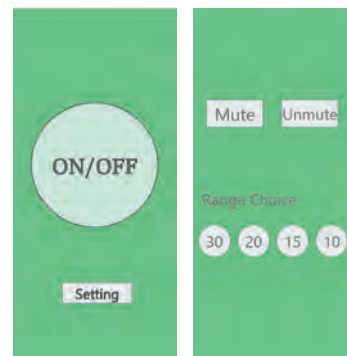
# MSU Resource Center for Persons with Disabilities Roadside Electric Scooter Detection and Alert System

The introduction of electric scooters on Michigan State's campus is a huge convenience for many students. However, these scooters have created a real danger to visually impaired people on campus. While trained assistance animals may be able to detect and avoid these new walkway obstacles, people who use canes may not know they are there until it is too late.

When presented with this problem by the project sponsor (partnered with the scooter company Gotcha), our team began working on a solution. We recognize the usefulness of scooters on campus, which solves the problem of affordable and fast individual transport, but we were certain we could find a solution that did not create a danger to the visually impaired. After all, a true solution is one that does not create other problems.

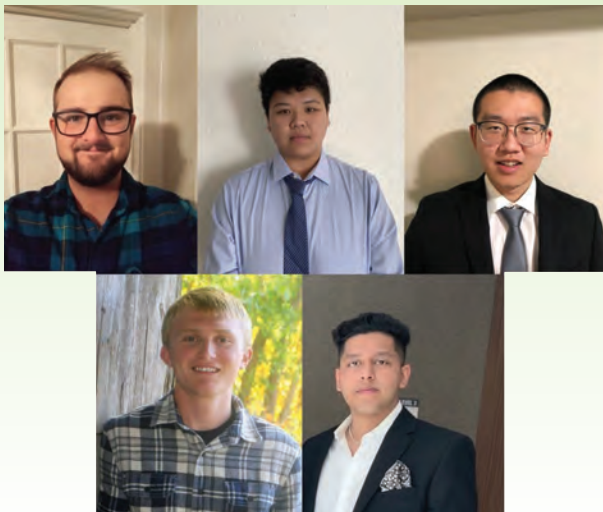
The solution is to use a combination of GPS and Bluetooth technology. We have implemented our own hardware for research and development purposes. This way, Gotcha would not be open to any additional security risk during the development process, and we would be able to create software to match the original design concept. To accomplish this, a device consisting of a Bluetooth receiver and a speaker needed to be constructed. Our application was then able to communicate with this device by sending a Bluetooth signal indicating that the scooter should emit a chirping noise.

By creating an easily heard noise when approached by a visually impaired person, the scooter is easily detected and avoided. This greatly reduces the possibility of collision and injury.



MICHIGAN STATE  
UNIVERSITY

gotcha



## Michigan State University

### Team Members

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#### Chenyang Cai

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#### Travis Hamp

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#### Harry John

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## MSU RCPD

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#### Michael Hudson

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### Project Facilitator

Dr. Mi Zhang

# Consumers Energy Simulation to Optimize Power Grid Performance

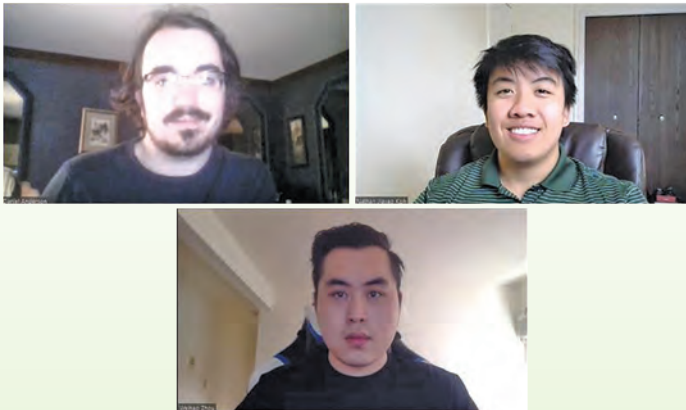
**C**onsumers Energy (CE) is preparing for an increase in Distributed Energy Resources (DER) penetration on its Low Voltage Distribution system. With the increase in distributed resources, such as Solar and Battery Storage, CE is planning new methods of management and control for two-way power flows.

Our project is to assist CE in their pursuit of increasing their DER penetration on the Low Voltage Distribution system by developing and executing a series of power grid simulations utilizing different DER placement designs, while staying within different constraints in order to optimize the power grid's performance over a set of different criteria.

This set of criteria includes, but is not limited to, voltage, load, and frequency management, contingency analysis, islanding scenarios, and managing external constraints such as cost.

The simulations run during this project are modeled off the real-world design of a solar garden in Kalamazoo and are based on the work done by a Spring 2020 design team.

In addition to developing and running optimization simulations, the project also includes developing a genetic algorithm to aid in finding the optimal parameters for Volt-VAr curves for use in Voltage Management optimization scenarios.



## **Michigan State University**

### **Team Members**

(left to right, top to bottom)

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## **Consumers Energy**

### **Project Sponsors**

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**Rosanna Kallio**  
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**Leo Martinez**  
Jackson, Michigan

### **Project Facilitator**

**Dr. Joydeep Mitra**

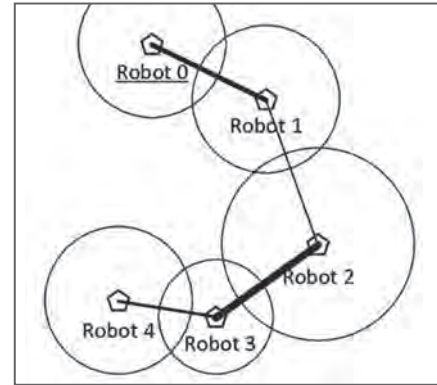
# MSU Department of Electrical & Computer Engineering

## Human-Aerial-Swarm Interaction System

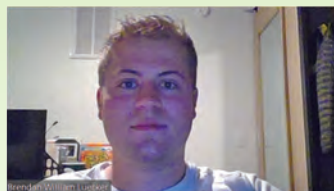
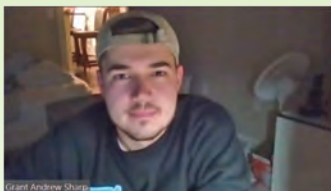
The main objective of this project is to design and control a swarm of aerial robots in a moving formation with the capability of performing different maneuvers. The swarm can be simulated in any state-of-the-art software. The team has chosen to utilize Mission Planner for both controlling the drones, as well as simulation. One of the simulated drones will be assigned as the leader, while the rest of the drones in the swarm will be designated as followers. The flight pattern of the swarm will be controlled by a human pilot operating a joystick/controller. This controller will then communicate with a computer and simulated swarm through either Bluetooth or Wi-Fi. These objectives integrate well with Mission Planner, as the software has a built-in swarm function, as well as controller support and Bluetooth compatibility. Many of the calculations and signals sent to the drones will also be conducted through written Python scripts, which can be uploaded to Mission Planner and run in parallel with simulation.

In addition to the simulation aspect of the project, our team has also decided to construct two physical drones. This was decided in order to achieve a physical realization of the leader-follower protocol that will also be implemented in simulation. These physical drones will still be operated with user input through Mission Planner, Python scripts, and a controller.

Upon the completion of this project, we plan to showcase the ability of the software to take user input in terms of desired formation and the actual rendering of aerial team motion, as well as the effectiveness of the joystick interface, which should be smooth with little to no delay in action execution. We also plan to showcase both the simulation aspect with multiple formations of drone swarms, as well as the physical realization with one leader drone and one follower drone.



College of Engineering  
MICHIGAN STATE UNIVERSITY



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#### Team Members

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#### Brendan Luecker

Saint Charles, Illinois

#### Joel Chirackal

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#### Sergio Sanchez

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#### Malik Zeeshan Riaz

Karachi, Pakistan

### MSU Department of Electrical & Computer Engineering

#### Project Sponsor

#### Dr. Vaibhav Srivastava

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#### Project Facilitator

#### Dr. Xiaobo Tan



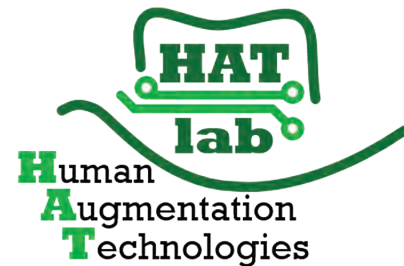
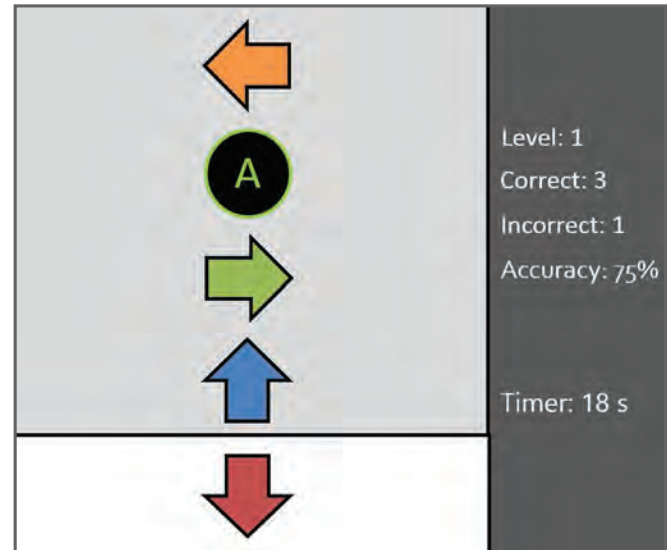
# MSU Human Augmentation Technologies Lab (HATlab) Platform to Assess Tactile Communication Pathways

The Human Augmentation Laboratory, or HATlab, at Michigan State University seeks to develop integrated circuits and microsystem approaches that branch between nano- and micro-sensor technologies and macroscale biomedical and environmental applications. By focusing on autonomous sensory microsystems, HATlab aims to design devices which assist with human health and safety.

HATlab is currently researching a new device which bypasses visual and audio mediums, relying solely on bioelectrical impulses to stimulate tactile sensor pathways. This device could be used in a variety of situations, including amputee prosthetics or arthritis and nerve damage treatments.

As a stepping-stone for their new device, HATlab designed a project to create an application which utilizes tactile feedback through controllers in lieu of bioelectrical impulses. Additionally, the project includes the design of a sequential task game, or STG, for testing the application created. The application will include a method of transmitting a signal to two remote locations to test interpretation of tactile feedback.

The solution includes two applications, an “observer” and an “actor.” The observer application consists of a sequenced input game as well as the relevant testing information, an example of which is displayed to the right. The actor application consists of relevant testing information, as well as visuals of signals for each of the potential buttons available at a given level. The two applications are connected by a cloud service, integrated into the game. This enables the transmission of the button pressed by the observer, which then vibrates the controller of the actor. The actor then interprets the vibration signal and presses the corresponding button. This solution allows the STG to be quickly adapted to read bioelectrical impulses and be tested with the new device HATlab is creating.



## Michigan State University

### Team Members

(left to right, top to bottom)

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Fountain, Michigan

#### Pavan Patel

Oakland, Michigan

#### Michael McGibbon

West Bloomfield, Michigan

#### David Geisler

Grand Blanc, Michigan

#### Jeremy Cowelchuk

Holland, Michigan

## MSU HATlab

### Project Sponsors

#### Andrew Mason

East Lansing, Michigan

#### Sina Parsnejad

East Lansing, Michigan

### Project Facilitator

Dr. Selin Aviyente

# MSU Mobility Center MSU Green Mobility App

**M**SU Mobility is a group on campus with a goal of becoming a primary source for research and development that revolve around the concept of human-centric multi modal mobility. MSU Mobility focuses on creating systems of communication and transportation that provide knowledge and safety to all students on campus.

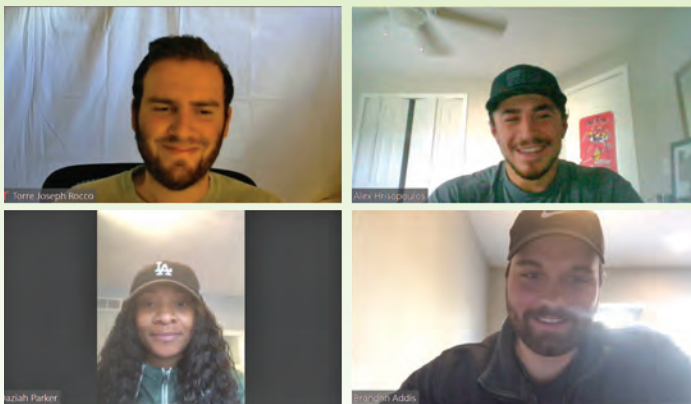
MSU Mobility has been researching sociomobility and the use of autonomous vehicles to connect to a larger part of the transportation system, and to try and become a greener community. With partners like MSU Bikes, MSU Mobility is focusing on becoming more eco-friendly with all transportation on campus.

Our application, MSU Green Mobility App, puts together everything MSU Mobility is about, along with providing more “Green” modes of transportation. Green transportation is any form of transport that does not use or rely on the burning of natural resources. Green transportation helps preserve our environment and ecosystems.

The MSU Green Mobility App will provide users with an easy-to-use interactive map providing green modes of transportation around campus. By connecting to already existing apps and companies like Gotcha and the CATA bus service, users will be able to find the “greenest” mode of transportation available. The user will be able to see how far their destination is, how long it will take to get there and how “green” their mode of transportation is.

Whether the user decides to walk, bike, take an e-scooter or take the bus, all options will be available to view.

The goal of the MSU Green Mobility app is to provide users with a simple, yet effective way, to navigate campus in the most environmentally friendly way possible.



## Michigan State University

### Team Members

(left to right, top to bottom)

**Torre Rocco**  
Rochester, Michigan

**Alex Hrisopoulos**  
Shelby Twp., Michigan

**Daziah Parker**  
Detroit, Michigan

**Brandon Addis**  
Clarkston, Michigan

## MSU Mobility Center

### Project Sponsors

**Nihar Mahapatra**  
East Lansing, Michigan

**Tim Potter**  
MSU Bikes Service Center

### Project Facilitator

**Dr. Nihar Mahapatra**

# NASA

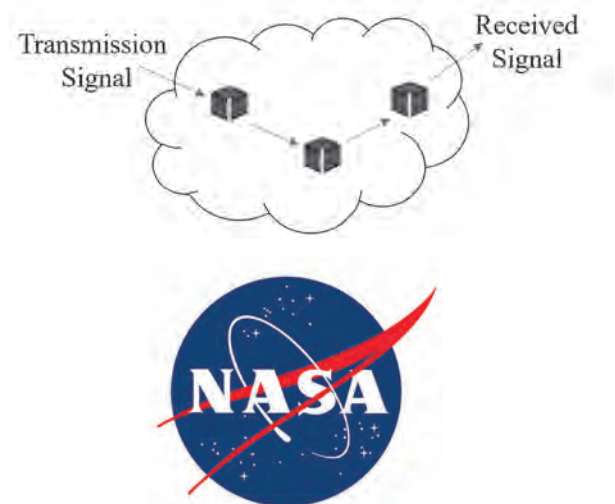
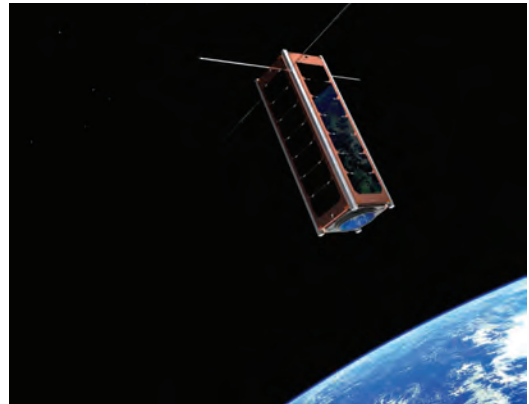
## Solar System Communication Network

The National Aeronautics and Space Administration (NASA) is an independent agency of the United States Federal Government that was established in 1958. NASA is responsible for the civilian space program, along with space and aeronautics research. The civilian rocketry and spacecraft propulsion research for NASA is conducted at the Marshall Space Flight Center (MSFC).

With expanding space research and technology, it has become essential to create a network of nanosatellites for communicating between satellites and Earth. Partnering with the MSFC, our team was tasked with designing a communication relay 6U CubeSat that is able to receive and transmit information at a distance of 1000 km. The design of the 6U CubeSat was based on the limiting size and weight constraints placed upon the satellite while meeting the technical requirements.

The blueprint our group created for the design of the satellite targeted three key technical areas: power, communication, and computation. The trade study conducted by our team highlights the optimal conditions and hardware to provide a communication network of 6U CubeSats that transmits and receives data, such as telemetry and images.

Components of the communication system for the CubeSat include utilizing proper signal processing techniques and selecting an antenna system that meets signal frequency requirements. The hardware components of the 6U CubeSat, including the flight computer and communication system circuitry, end up creating power requirements that will be met by the satellite's solar cells. Our overall design of the 6U CubeSat harmoniously incorporates all necessary components, while meeting the challenging conditions presented by outer space and complying with standard regulations.



### Michigan State University

#### Team Members

(left to right, top to bottom)

**William Ng**  
Canton, Michigan

**Nicholas Butzke**  
Brighton, Michigan

**Schukou Tsunoda**  
Ann Arbor, Michigan

**Lauren Kaliszewski**  
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**Kanishka Wijewardena**  
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**Logan Coles**  
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### NASA

#### Project Sponsor

**Eric Eberly**  
Huntsville, Alabama

#### Project Facilitator

**Dr. Hayder Radha**



# MSU Department of Electrical & Computer Engineering

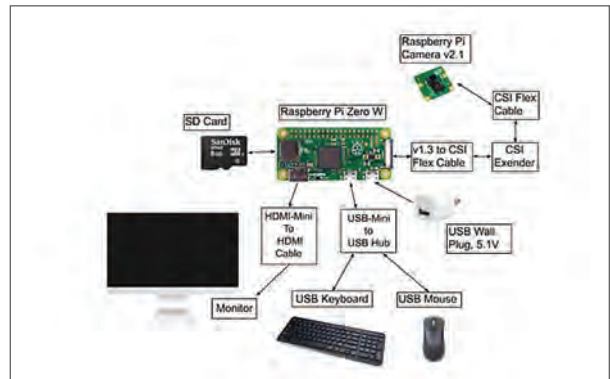
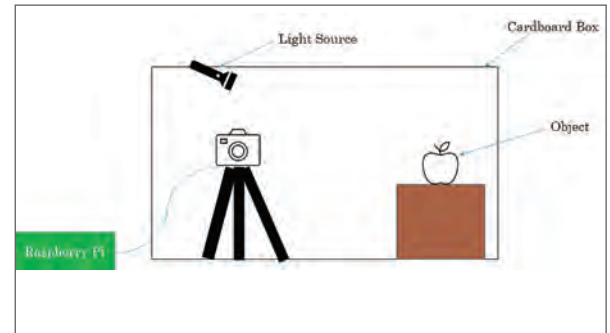
## Diffuser Camera

Nearly all modern-day camera sensors are paired with a lens, and light is concentrated through the lens onto the sensor uniformly. However, these lenses are expensive, large, and heavy. Recent research has shown diffusers are able to be used in place of a lens by applying image processing techniques. This allows diffuser cameras to be made cheaper, smaller, and lighter than their lensed counterparts. Our sponsor Ryan Ashbaugh, a graduate student at Michigan State University, was intrigued by these findings and designed a project to further develop this new imaging system.

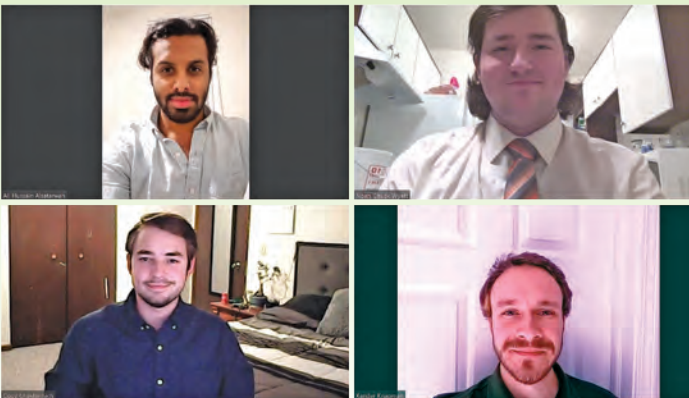
Although diffuser cameras are not that practical for commercial picture taking, they do have a variety of other uses and functions that normal lens cameras cannot perform. For example, since the diffuser camera uses a rolling shutter to capture a line of the image at a time, we can essentially recreate a short video from a 2D image. The camera is also very good at recreating a 3D model from a 2D image. This is due to the fact that our camera does not use a lens. Lensed cameras have one focus plane, meaning things that are out of focus are blurred, whereas our camera does not have this blurring effect. This allows us to get depth information from the whole image. So, by using compressed sensing to make some assumption about the photo, we can reconstruct a 3D image.

This allows the technology to be very useful in the field of microscopy, more specifically in neural activity tracking. Currently researchers use giant cumbersome microscopes to do neural tracking, but the diffuser camera's size will allow them to implant the device directly onto their subject's brain for testing, making the process of studying neural activity more efficient and easier.

For our project, we plan to expand upon the current research and knowledge of diffuser cameras to create a device that has improved resolution. To accomplish this, we are going to try using different types of diffusers as well as more advanced algorithms.



College of Engineering  
MICHIGAN STATE UNIVERSITY



### Michigan State University

#### Team Members

(left to right, top to bottom)

#### Ali Alsatarwah

East Lansing, Michigan

#### Noah Wyatt

Mt. Pleasant, Tennessee

#### Cody Sich

Imlay City, Michigan

#### Xander Knapman

Holt, Michigan

### MSU Department of Electrical & Computer Engineering

#### Project Sponsor

#### Ryan Ashbaugh

East Lansing, Michigan

#### Project Facilitator

Dr. Daniel Morris

# Michigan State University Solar Racing Team

## Vehicle Race Data Telemetry System

A real-time telemetry system is vital to all automotive races. With a real-time telemetry system implemented, pit lane crews can monitor vehicle data such as battery temperature and voltage on the go with only a laptop in hand. In solar car racing, every milliwatt of energy is crucial and can be the difference between a win and a loss. Designing a telemetry system that can continuously deliver data with a robust connection and wide bandwidth from the racecar to the pit lane is challenging with limited budgets and time.

To strike a balance between design time, budget, and energy consumption, our team decided to implement the race data telemetry system with a LoRa module, a low power, wide area network communication protocol. The LoRa module has several merits, including low power consumption, stable connection between receiving and transmitting nodes, and long-range (1.2-1.8 miles) capability. The LoRa module connects to an Arduino board that is programmed to process CAN data from the race vehicle CAN bus.

The team designed the telemetry module to be a “Plug and Go” device installed onto the racecar without any existing system redesign. The LoRa transmitter is on the racecar while the receiver is in the pit. Due to the LoRa module’s nature, the module’s transmitter can be relatively small, causing little to no effect to the existing vehicle structure. The receiving LoRa module will be equipped with a large antenna to maximize the vehicle’s connection during laps.

Lastly, with the data acquired on the laptop, an Excel sheet will process all the incoming data and further visualize the data into real-time updating graphs. The graphs will store on the laptop for later review for the team and the driver. We believe that with this telemetry system installed on the Michigan State University solar racecar, MSU SRT will be adding another strong ability to its arsenal.



### Michigan State University Team Members

**Morgan Beadlescomb**  
Algonac, Michigan

**Drake Davis**  
Beverly Hills, Michigan

**Andrew Fuge**  
Virginia Beach, Virginia

**Ryan Khatib**  
Saginaw, Michigan

**Douglas Sabin**  
Suner, Michigan

**Jun Zhang**  
Kaohsiung, Taiwan

### MSU Solar Racing Team Project Sponsor

**Peter Litsey**  
East Lansing, Michigan

### Project Facilitator

**Dr. Qi Hua Fan**

# MSU Department of Mechanical Engineering

## E-Bike Dynamometer

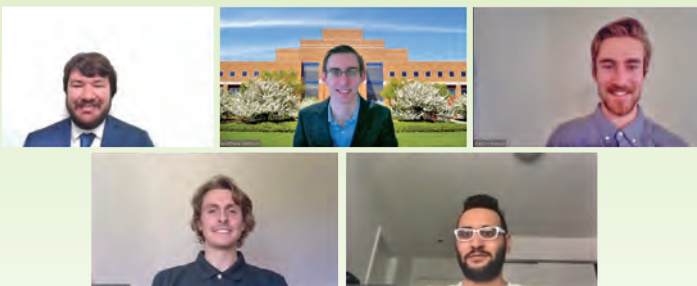
Our team is comprised of Michigan State University Electrical Engineering Department and Mechanical Engineering Department students working together on a project involving an electric bike dynamometer. This project is a continuation of a project which began in the Fall of 2019. The goal of this project is to measure the power output of the rider input and the motor input and evaluate the data compared to real-world examples. This would include testing conditions such as varying incline simulation and different speed simulations. This will allow for the ability to simulate a balance between the bike motor activation and rider input to create a seamless riding experience.

The tasks presented in this project are a continuation of what the previous groups have already completed, to build on the progress, and to make some revisions.

One of the first tasks was to create a stable platform that allows for stable mounting of a bike's wheels to keep it from shifting while on the dynamometer. The ability to access the bike, via a platform, while it is mounted to the dyno was also needed. Along with this, the mounting of the load cell to the dynamometer to allow for power readings from the rear wheel of the bike needed to be assessed. The revision of the coding to run the motor and gather readings was also investigated.



Department of Mechanical Engineering  
MICHIGAN STATE UNIVERSITY



### Michigan State University

#### Team Members

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**Matthew Watson (ECE)**  
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**Aaron Pekrul (ME)**  
Rockford, Michigan

**Andrew Schultz (ME)**  
South Lyon, Michigan

**Khalid Almahameed (ECE)**  
Oak Park, Michigan

### MSU Department of Mechanical Engineering

#### Project Sponsor

**William Resh**  
East Lansing, Michigan

#### Project Facilitators

**Dr. Dean Aslam (ECE)**

**Dr. Guoming Zhu (ME)**



# Texas Instruments

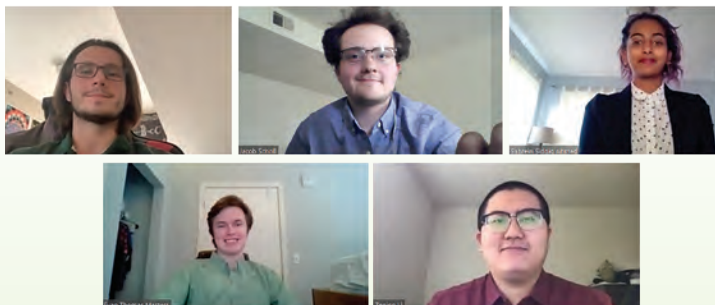
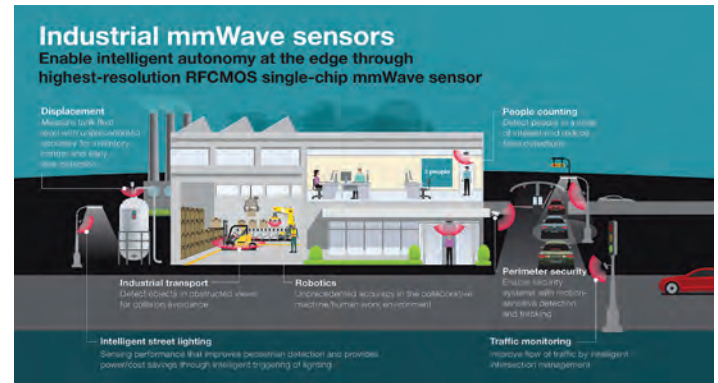
## Classification with Millimeter-Wave Sensors

Millimeter waves, as classified by the International Telecommunication Union, are EM waves with frequencies ranging from 30 to 300 GHz. In use today most commonly as a communication frequency, mostly for short-range high-bandwidth data transfer, there are other applications for using mmWave. These include radar in weapon systems, autonomous vehicle sensors, and the scanners in place at security checkpoints across the US.

For this project, we will be using a board donated by Texas Instruments which operates between 60 and 64 GHz and is ideal for object identification and tracking in indoor environments. For this project we will be using this board to detect people and distinguish humans from other sources of movement in home and office environments.

A radar system transmits an electromagnetic wave signal that is reflected by objects in its path. MmWave sensing is a unique category of radar systems technology. The captured reflected signal is used to determine the range, velocity, and the angle of arrival of the objects. Using these data sets, our goal with this project is to create an algorithm we can use to distinguish and separate people from background information.

We will leverage work already done by TI in their mmWave SDK and mmWave Studio, along with some example code to help us with the tracking layer of processing. Using sample datasets captured by our team, we will train a machine learning algorithm to identify humans, distinguish between multiple humans in a scene, and separate human targets from non-human moving objects in the scene. The goal is to have a working algorithm that can reliably detect and track two humans doing different tasks and identify a third non-human dynamic object as inanimate.



### Michigan State University

#### Team Members

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#### Zening Li

ShanDong, China

#### Jon Ryan

Troy, Michigan

#### Jacob Scholl

Royal Oak, Michigan

#### Sabreln Ahmed

Dubai, UAE

#### Evan Masters

Northville, Michigan

### Texas Instruments

#### Project Sponsor

#### Muhammet Yanik

Dallas, Texas

#### Project Facilitator

#### Dr. Daniel Morris



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## ME 412 Heat Transfer Laboratory

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

### Water Desalination Study

Freshwater supply is essential to a thriving society. In the past century, with the water consumption rate continually growing, more regions around the globe have experienced water shortage. In response to water scarcity, many countries rely on desalinization plants to provide fresh water out of brackish or the most abundant ocean water. For this project, students in ME412 are expected to understand the water desalination process through two parts of work. For the major part, each team will design, analyze, build, and test a simple desalinator based on a thermal cycle. The objective of the design is to maximize the freshwater production from a given amount of salt water (~35g/L), while cost and weight are also considered as a factor in evaluation. For the secondary part, each team will choose a specific type of water desalination system and conduct a review on its design, technology, performance, and energy analysis as well. Due to the special situation this semester, each team will test their device at home, prepare a short demo video, and then present the design, test results and thermal analysis of their device to the whole class on the presentation day.

### Competition Schedule

#### Team 1

Alena Chapdelaine  
Max Herzog  
Travis Wesley

#### Team 2

Jonathan Borgiel  
Jack Campbell  
Andrew Hallam  
Alaura VanNest

#### Team 3

Jake Nevin  
Randall Sawyer  
Audrey Schroeder  
Neil Stump

#### Team 4

Antonino Destasi  
Emily LeBlanc  
Sarah Nold  
Vanessa Wang

#### Team 5

Tyler Koizumi  
Justin Roelant  
Nic Weller

#### Team 6

Matthew Bradford  
Jacob Jyawook  
Connor Quigg  
Ryan Stawarta

#### Team 7

Trevor Hofman  
Josh Peckens  
Natalie Schleisinger  
Alex Vu

#### Team 8

Evan Chechack  
Parker Dukus  
Cam Lewis

#### Team 9

Matt Razz  
Jacob Staal  
Kepler Tiedje

#### Team 10

Will Book  
Matthew Covert  
Nick Lacross  
Collin Lynch

#### Team 11

Matthew Donahue  
Anna Graffeo  
Robert Gustke  
Mike Pastoria

#### Team 12

Alexis French  
Zachary Myers  
Daniel Nicklowitz  
Aaron Pekrul

#### Team 13

Brett Hahne  
Rolanda Hutson  
Alex Pritchard  
Christian Stack

#### Team 14

Artea Azizi  
Kyle Evans  
Emma Malik

#### Team 15

Nick Mascone  
Abby Swasey  
Dennis Volostnykh

#### Team 16

Jim Graham  
Kyle Nouhan  
Blake Schmidt  
Mark Sicoli

#### Team 17

Tyler Davis  
David Demeo,  
Jackson Honeycutt

#### Team 18

Matthew Koenig  
Steven Smith  
Gregory Vitous  
Cody Zorn

#### Team 19

Jacob Bruner  
Kevin Calson  
Scott Kelley  
Austin Smith

#### Team 20

Aaron Kaplan  
Adam Lyons  
Josh Saluk  
Andrew Schultz

#### Team 21

Mathew Flegel  
Houduo He  
Greta Myran  
Derek Raymond

#### Team 22

Andrew Dolenga  
Megan Phanrisvong  
Heidi Theisen

#### Team 23

Ryan Babiarz  
Nathan Buchweitz  
Jacob Palmer

#### Team 24

Brandon Barker  
Paige Hartman  
Michael Townsend  
Madeline Warner

#### Team 25

Yuxin Chen  
Boyuan Li  
Josh Meyer  
Dillon Shimmel

#### Team 26

Joseph Auty  
Colton Jennings  
Andrew Scott  
Jacob Wallace

#### Team 27

Noah Dudley  
Sicheng Ni  
Zhiquan Qu  
Alex Sickelsteel

#### Team 28

Dominick Ferro  
Samantha Halaby  
Jarod Miller  
Lena Wuensch

#### Team 29

Jose Alcantar  
Dom Long  
Ethan Mekjian  
Brandon Twiehaus

#### Team 30

Michael Brooks  
Cody Chalk  
Ryan Garman  
Jessica Lypka

#### Team 31

Matt Archambo  
Ben Merrill  
Robert Miller  
Jack Schlegel

#### Team 32

Cameron Papson  
Kyle Peters  
Sarah Tumavitch  
Evelyn Zielinski

#### Team 33

Evan Alvanas  
Jack Aman  
Michael Brannon  
Sean Gielow

#### Team 34

Lindsay Mau  
Andrew Sare  
Christian Tasich  
Victor Wang



## ME 470 Mechanical Design & Manufacturing II



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

### Bottle Labeler

The goal in this project is to design a machine that can move a linkage in an approximate straight line motion at a near constant velocity to apply paint to bottles on a continuously moving conveyor at 80 bottle/min. The teams will utilize mechanisms such as 4-bar linkages, gear sets and cam-follower systems. The project is all virtual, with no build, but with the materials used and manufacturing techniques utilized as part of the design. Performance will be measured by the number of bottles labeled per minute, positional accuracy, deviation from constant velocity, and the weight of the mechanism.

#### Team 1A

Dan Bojanowski  
Derek Donnelly  
Michael Hayward  
Brad McMahon  
Bryce O'Neill

#### Team 1B

Fritz Hittner  
Colton Jennings  
Jimmy Muscato  
Max Smith

#### Team 2A

Alec Smerage  
Katie Treloar  
Patrick Tucker  
Lena Wuensch

#### Team 2B

Matt Mayer  
Patrick McCormick  
Austin Meisel  
Jacob Richmond  
Andrew Sare

#### Team 3A

Adam Childress  
Kyle Nouhan  
Alex Sicklesteele  
Connor Steffens  
Ryan Wade

#### Team 3B

Marissa Grazioli  
Jackson Honeycutt  
Grace Warmann  
Jacob Wescott

#### Team 4A

Thomas Corner  
Dante Minatel  
Kyle Schreur  
Jacob Staal  
Brian Yemc

#### Team 4B

Daniel Jansen  
Anson Leung  
Adam Speaks  
Christian Stack

#### Team 5A

Mark Esper  
Scott Pinkham  
Christopher Steers  
Nate Sudek

#### Team 5B

Emily LeBlanc  
Shaya Master  
Autumn McLane  
Svoboda  
Blake Schmidt

#### Team 6A

TJ Krawczyk  
Sicheng Ni  
Yutao Shen  
Mark Sicoli  
Kyle Tomaszewski

#### Team 6B

Savanah Matras  
Matt Razz  
Calvin Smith  
Matt Terry

#### Team 7A

Cody Chalk  
Zak Harwood  
Griffin Jones  
Bryce Sutton  
Yiming Wang

#### Team 7B

Junchi An  
Zhiyuan Qu  
Jason Zhang  
Jack Zhao

#### Team 8A

Carl Banerian  
Enrique Infante  
Nolan Martin  
Drew Skedel  
Abdullah Sribaya

#### Team 8B

Jim Graham  
Mike Pastoria  
Justin Thind  
Suhail Turkistani

#### Team 9A

Evan Hardy  
Michelle Herring  
Sloan Kanat  
Scott Lohman  
Qinda Wang

#### Team 9B

Nolan Kerwin  
Jacob Klocko  
Hannah Scott  
Evelyn Zielinski

#### Team 10A

Natalie Bobowski  
Tommy Coughlin  
Michael Maes  
Reid McDonnell  
Zach Petroelje

#### Team 10B

Sean Gielow  
Aaron Rakowski  
Chase Rojeck  
Cody Zorn

#### Team 11A

Jack Aman  
Brody Burke  
Jack Campbell  
Conner Curnutte

#### Team 11B

Kaushik Kothakonda  
Jacob Nelson  
Preston Rashkov  
Austin Rhodes

#### Team 12A

Arjun Balakrishnan  
Denny Blaschko  
Devin Kotal  
Nick Lacross

#### Team 12B

Vik Athreya  
Thomas Brandell  
Michael Brooks  
Aaron Kaplan

#### Team 13A

Lazerick Hill  
Ailohi Izirein  
Dom Long  
Gavan Sarrafian

#### Team 13B

Jack Beddow  
Haram Gil  
Christopher Jakubik  
Rob Kolpasky

#### Team 14A

Matt Bradford  
Adam Piper  
Steven Stine  
Bryan Wilson

#### Team 14B

Jamie Beck  
Josh Ciaccio  
Jack Dailey  
Emily Suchoski

#### Team 15A

Nathan Kinner  
Jacob Palmer  
Sarah Piotrowicz  
Carter Reeds  
Emily Valentine

#### Team 15B

Luke Chrisman  
Kole Gilbert  
Jacob Martin  
Valentin Zilkovski

#### Team 16A

Hannah Jacobs  
Jenny Lam  
Sarah Nold  
Vanessa Wang

#### Team 16B

Sarah Angold-Stephens  
Emily Fitzsimons  
Alexia Swiat  
Madeline Warner

## The Capstone Projects



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

**Faculty Advisors: Anthony, Baek, Brereton, Engeda, Feeny, Grimm, Jaber, Koochesfahani, Lee, Mueller, Nadimpalli, Naguib, Pence, Petrasch, Roccabianca, Schock, Segalman, Wichman, Wright, Xiao, Zayernouri**



Rebecca  
Anthony



Seungik  
Baek



Giles  
Brereton



Abraham  
Engeda



Brian  
Feeny



Michele  
Grimm



Farhad  
Jaber



Manoochehr  
Koochesfahani



Lik-Chuan  
Lee



Norbert  
Mueller



Siva  
Nadimpalli



Ahmed  
Naguib



Thomas  
Pence



Joerg  
Petrasch



Sara  
Roccabianca



Harold  
Schock



Dan  
Segalman



Indrek  
Wichman



Neil  
Wright



Xinran  
Xiao



Mohsen  
Zayernouri

## Mechanical Engineering Design Projects

Mechanical engineers make the world move and harness 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 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 the capstone course in the ME Design Program. The course provides students with a team-based design experience in which they:

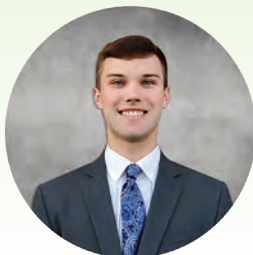
- Use the technical expertise, communication skills, and teaming methodologies they have learned throughout their mechanical engineering curriculum, together with their creativity, to solve real world problems,
- Collaborate with practicing engineers to address problems sponsored by industry,
- Develop 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: ArcelorMittal, Flash Steelworks, Inc, Heartwood School/Ingham ISD, Holt Public Schools/Ingham ISD, McLaren Greater Lansing, Michigan AgrAbility, MSU Adaptive Sports and Recreation Club, MSU Department of Mechanical Engineering, NASA Marshall Space Flight Center, Toyota Motor North America, The Ultimax Group, Inc, and Walraven Solutions, LLC.

# Energy and Automotive Research Laboratory Hybrid Powertrain for VTOL Aviation

**V**ehicular congestion is a significant problem in almost every major city in the United States. Commuters who work within major cities lose over 100 hours on average annually due to traffic-based congestion. One solution being extensively explored across the transportation industry is a vertical takeoff and landing vehicle (VTOL). These vehicles not only address congestion but also serve as a means of reducing noise and air pollution. Many concepts and prototypes currently in development are focused on electric systems, aligning with the transformation of the automotive industry. Dr. Harold Schock, Director of the Energy and Automotive Research Lab, acknowledges the potential of the VTOL in the coming years, but believes that an all-electric power plant greatly limits both market expansion and performance. Until the energy density improves dramatically within batteries, the potential for these vehicles is far greater when utilizing combustion engines.

To better showcase the untapped potential of the VTOL, our team, together with Dr. Schock, developed a VTOL design utilizing a hybrid power plant. The design features a combination of components inspired by VTOLs on the market, as well as small passenger aircrafts. The power plant packaged within this vehicle aims to minimize the weight of the electric power supply, while maximizing both the propulsion performance and energy capacity. It does so using lithium-ion batteries, axial flux electric motors, and a combustion engine featuring Jetfire ignition technology. The unique hybrid powertrain design provides an efficient and robust foundation for future VTOL aircraft.



## **Michigan State University**

### ***Team Members***

(left to right, top to bottom)

#### **Antonino Destasi**

Macomb Township, Michigan

#### **Andrew Dolenga**

Rochester, Michigan

#### **Matthew Donahue**

Shelby Township, Michigan

#### **Mathew Flegel**

Caledonia, Michigan

## **Energy and Automotive Research Laboratory**

### ***Project Sponsor***

#### **Harold Schock**

East Lansing, Michigan

## **ME Faculty Advisor**

**Dr. Harold Schock**



# Heartwood School/Ingham ISD

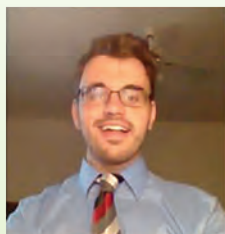
## Revision of Therapeutic Mechanical Pony

**H**earthwood School is a local school for children with moderate to severe cognitive & physical impairments and autism spectrum disorders, with ages ranging from 3-26 years old. Heartwood School has its own specialized curriculum, with one aspect of it incorporating the MOVE program. MOVE is an activity-based program that combines the individual's present abilities along with instructional process during motivational activity. The goal is to help improve the mobility skills of sitting, standing, walking, and transitioning. One approach to develop motor skills in a fun and engaging way is through therapeutic horseback riding known as hippotherapy. Hippotherapy has been shown to have a great impact on improving motor skills; however, with many students it is impractical for each to have time with a real horse. Thus, Heartwood has proposed a mechanical pony to be designed to simulate horseback riding. The project began in the Spring of 2017 and has gone through revisions in 2019 and 2020.

Our team was tasked to complete and improve upon the current mechanical components. The main areas of concern were safety, functionality, and reliability. Being a device intended use for by children, and designing for safe unintended use played a large role. Also, the ability for the pony to be easily maintained, repaired, and portable was desired to ease troubles for school staff. Testing regimens developed by previous teams helped address areas of concern and future improvements.



**Ingham Intermediate  
School District**  
Heartwood School



### Michigan State University

#### Team Members

(left to right, top to bottom)

**Dillon Shimmel**  
Rockford, Michigan

**Joe Auty**  
Novi, Michigan

**Mike Townsend**  
Northville, Michigan

**Matt Archambo**  
Cheboygan, Michigan

**Scott Kelley**  
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### Heartwood School/ Ingham ISD

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# NASA Marshall Space Flight Center

## Portable Tensile Testing for Thermal Protection Systems

The National Aeronautics and Space Administration (NASA) is a U.S. government agency in charge of science and technology related to air and space exploration. NASA's Space Launch System (SLS) uses foam insulation for thermal protection. To ensure the Thermal Protection System (TPS) meets vehicle requirements, portable tensile testing of the TPS is performed on witness panels or on flight hardware. The portable tensile testing is performed using a plug-pull machine. These plug pullers are heritage tools from NASA's External Tank project from the Space Shuttle Program. Because the current plug-pull machine was developed several decades ago, an issue of outdated technology and irreplaceable parts has arisen.

Our team focused on designing and prototyping a new plug-pull machine with updated electrical and mechanical components to create a new generation of plug pullers using current technologies and readily available parts. The newly developed plug-pull machine must be easily portable, battery powered, able to export test data via USB, and be more ergonomic than its predecessor. Furthermore, this device needs to seamlessly replace the current plug-pull machine and match the pulling force on the tab as well as the reaction force created by the machine.



### Michigan State University

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# McLaren Greater Lansing Rehab Gym Adjustable Car

**M**cLaren Greater Lansing, an acute care hospital split between two campuses in Lansing, is in the process of building a new hospital facility adjacent to Michigan State University. This new facility will feature a rehabilitation gym used for occupational therapy services to help patients achieve the highest level of independence possible with everyday tasks. Ideally, this is done in a way that accurately and realistically represents tasks patients will face outside of a hospital setting. An aspect of the rehabilitation gym that McLaren would like to improve is the simulation of entering and exiting a vehicle to better prepare patients for this action with their own vehicle, regardless of height. A height adjustable simulator would assist patients in gaining the necessary skills and knowledge in their practice sessions for a successful transfer upon discharge.

The goal of this project was to design and assemble a car transfer simulator that could be raised or lowered to different standard car heights. We accomplished this by designing a mounting mechanism for a truck cab that was donated to the hospital for attachment to a hydraulic lift. The team researched and purchased a lift that would properly support the donated truck cab, mounting mechanism, and patient according to the listed weight capacity. To account for other safety concerns, emergency supports were made in the case of lift failure, and pinch points were reduced across the simulator. The cab was mounted with these safety considerations and delivered to the hospital for installation.



## Michigan State University

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**Special Acknowledgement:**  
**Peter and Daniel Renzulli**  
**Spartan Engineering**  
**Endowment Fund**



# Michigan AgrAbility Pull Cord Foot Starter

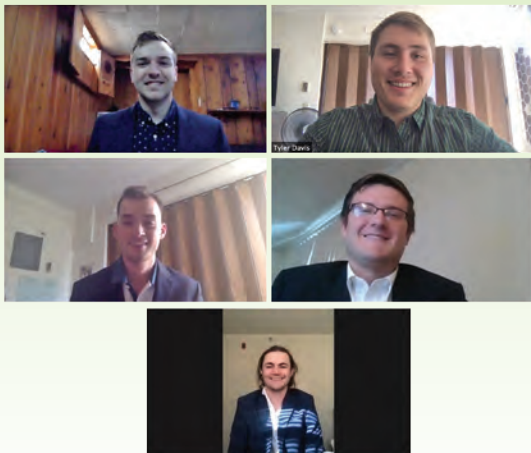
**M**ichigan AgrAbility provides assistance to those in the agricultural industry with an injury, illness, or disability, enabling them to continue working.

Many farms use small engine equipment such as chainsaws, lawnmowers, and string trimmers, which require a pull cord to start. These pull cord engines require a quick “jerk” motion to start them, which can be difficult to achieve if the user has upper extremity impairments. To help aid those with upper extremity impairments, our team was tasked with designing a fully mechanical device that allows the user to start the pull cord engines with their foot, rather than their arm.

Despite calling for the design to integrate some sort of motion that is carried out by the foot, with the permission of Michigan AgrAbility, we were able to come up with a design that limits any sort of quick motion, whether that be via the arm or leg. The design uses a tension spring in order to build up and store potential energy, which is then transformed into kinetic energy through the release of the spring. This quick release of the spring mimics the quick “jerk” motion necessary to start the pull cord engine, in turn starting the engine without any exhausting physical exertion to the user.

With easily accessible parts and a step-by-step build guide, the device was designed carefully and thoughtfully so that any farmer can create the device in the comfort of their own home. Not only is the device easy to assemble, but the device is also universal in that it can start all sorts of small engine equipment besides just chainsaws.

Our fully mechanical device will allow farmers to get back on their feet, rid them of any worries of further injury, and will give them back their independence.



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# MSU Department of Mechanical Engineering

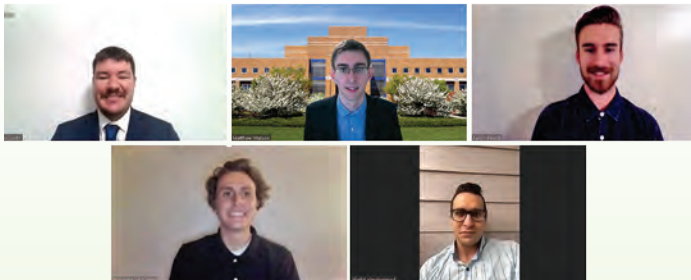
## E-Bike Dynamometer

Michigan State University departments of Electrical Engineering and Mechanical Engineering students worked together on a project involving an electric bicycle dynamometer. This project was first introduced in the Fall of 2019. Being the third team to pick up the project, this year's joint engineering team had goals to measure the power input of the rider and the required motor response to simulate various real-world scenarios. These include testing conditions such as simulating varying inclines and different speeds through mixed terrain. This will allow for the future ability of an E-bike design engineer at MSU to achieve a balance between an E-bike's motor input and rider input to enable a seamless riding experience under many circumstances.

The tasks presented in this project were a culmination of things the previous groups had not fully completed: improving mechanical structure, electronic controls, instrumentation, and both mechanical and electronic user interfaces. A dynamometer frame designed by the team allowed for greater stability when affixing the bicycle to the dyno, and ease of mounting and dismounting by the rider. Implementation of a load cell allowed the team to improve controls with a direct measurement of the load experienced by the dyno, which in turn was used to simulate the scenarios outlined in the project description.



Department of Mechanical Engineering  
MICHIGAN STATE UNIVERSITY



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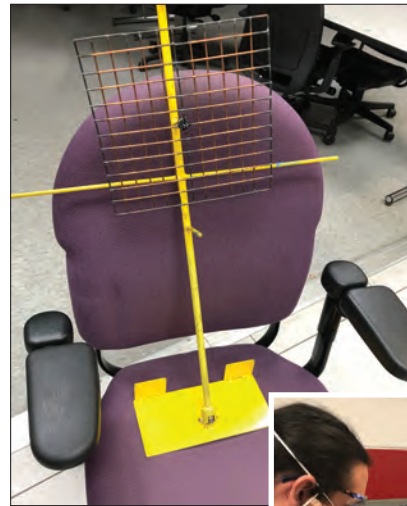
**Dr. William Resh**

# Toyota Motor North America Automated Velocity Grid Measurement Tool

Toyota Motor North America (TMNA) creates some of the most advanced and safe vehicles through their management principles and management philosophy. It is TMNA's belief that its cars should do more than help you go places on the road, they should also help you go places in life.

TMNA's Research and Development is located in Ann Arbor and Saline, Michigan and was established in the 1970s. Its initial purpose was to collaborate with the Environmental Protection Agency on emissions quality. There are three main focuses at this location, including product development, advanced research, and evaluation. It is this location where HVAC systems innovation occurs. R&D makes an impact that its customers experience through enhanced quality, adoption of new technologies, and even greater value of the vehicles it produces. TMNA requires a system to measure air velocity at all points in a grid centered at varying heights.

Our team designed and built an automated grid to measure air velocities at variable throat heights with a single sensor and a 240 x 240 mm grid with 20 mm increments. This grid is affixed to TMNA's current measurement manikin. The development of the current fixture will significantly improve the process of measurement while simultaneously mitigating human involvement of the process. Measurement location accuracy will also significantly increase with the use of automation, which will eliminate human error in sensor positioning and data recording.



**TOYOTA**



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# Walraven Solutions, LLC

## Automated Climbing Device

**W**alraven Solutions, LLC, located in Bay City, Michigan, is an advanced construction company that focuses on supplying solutions for contractors during the early construction phase of projects. The technology provided by Walraven Solutions, LLC is patented and is the most unique, cutting-edge technology available. One current problem faced by contractors relates to the insulation shell that needs to be installed around the construction site for protection. This insulation is needed to provide a stable climate for curing concrete, to protect the contractors from the elements, and to prevent any other negative weather impacts on the site's ongoing work. Current technology limits these tarps to manual installation using manlifts and single-use fasteners. This process is wasteful not only in a material sense but in labor and time as well.

Walraven Solutions, LLC provided an idea patent for a system of automated climbing devices that will drastically reduce the insulation tarp installation time. Each device will climb up a vertical I-beam, and a steel cable will hang a tarp between each device pair. This will eliminate the need for operators to use manlifts to manually attach the insulation tarps to the ceiling of the construction site. Our team has taken this idea patent and further refined it into a final design using engineering controls and solutions. The device must be adjustable for I-beams of varying size, remain on the I-beam for one to three months, be light enough for a person to carry, and be resistant enough to withstand the tarp's weight and wind loads for different sized tarps. With these parameters and constraints as guiding factors, we designed, analyzed, and manufactured a prototype. The success of this project will have considerable impact on construction time and safety for contractors during the early phases of construction.



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# MSU Department of Mechanical Engineering

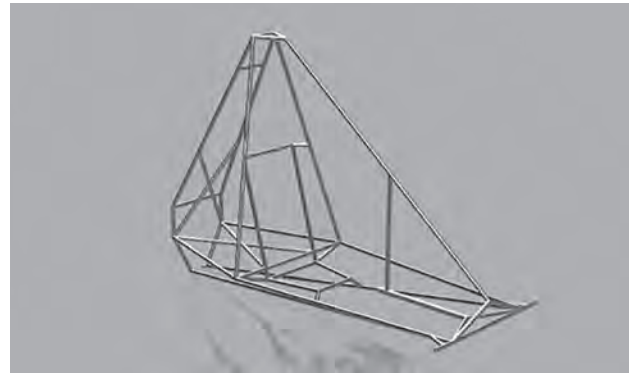
## HPVC Bike Frame Truss

**A**SME's Human Powered Vehicle Challenge (HPVC) is an engineering design and innovation competition that college students participate in each year. This competition offers students the opportunity to apply engineering principles through the design, fabrication, and racing of human powered vehicles.

The Human Powered Vehicle Challenge team has two capstone teams working together to complete a frame and powertrain design. The frame team is responsible for improving the design which was developed in the spring. This design (a truss design) is inspired from Baha and Formula SAE teams.

The overall scope of the project is to improve the frame design to meet requirements of the competition, integrate powertrain components, test the frame for load cases with Finite Element Analysis, and obtain multiple quotes for manufacturing. At the end of the project, the proposals from different companies will be presented to the Human Powered Vehicle Challenge leadership team. In response, the leadership team will decide where to manufacture the frame. This will result in a successful project handoff.

Additionally, the specific requirements for adjusting the frame design are to design to an adequate factor of safety for all loading cases; create an adjustable steering column; and create an adjustable seating system for all riders, removing parts of the frame that impair a rider's view, and removing unnecessary material to ensure the frame is light and requires less material to manufacture. The final CAD design will be a collaboration with the powertrain capstone team to ensure that the powertrain and frame are cohesively designed and attachment points are built into the frame. This will also ensure attachment points are strong enough to handle any load that is applied during trials and competition.



Department of Mechanical Engineering  
MICHIGAN STATE UNIVERSITY



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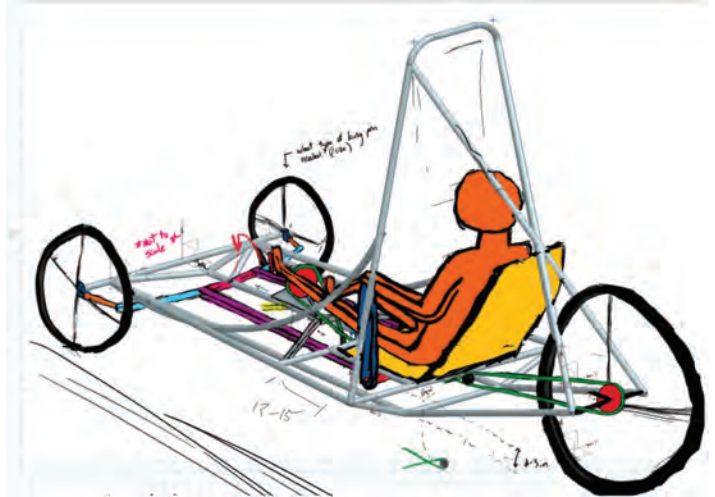
# MSU Department of Mechanical Engineering

## HPVC Drivetrain Design and Build

The Human Powered Vehicle Challenge (HPVC) is an internationally recognized organization of mechanical engineering students. This challenge focuses on designing and manufacturing a bicycle vehicle variant that is capable of competing in drag races, obstacle courses, cargo transportation and various other events. This semester, the HPVC team at Michigan State University has reached out to our group to design the drivetrain for their vehicle.

The primary goal that the HPVC team has laid out for our team is to map out a blueprint for a functional and capable drivetrain system. The independent systems include the transmission, shifters, wheels and tires, steering and brakes. These systems allow the vehicle to be fully functional as well as safe. The HPVC team has also asked that we research component choices from the industry leaders in bicycle technology. A final budget has not yet been determined, however, the price-to-performance ratio will be a key factor in our decisions. Included in the stipulations set by the HPVC team of a reliable drivetrain design and components, our team must also adhere to the rules set forth by the HPVC organization.

The project will be primarily design focused with little to no assembly or manufacturing. A high level of intra-team integration with the frame team will be necessary for any success within our design. As per the wishes of the customer, we will be advising the frame team on our component choices, required dimensions and mounting locations. Proper intra-team communication will ultimately result in a fully functional final product with which the HPVC team will be happy.



Department of Mechanical Engineering  
MICHIGAN STATE UNIVERSITY



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# ArcelorMittal Proximity Alert System

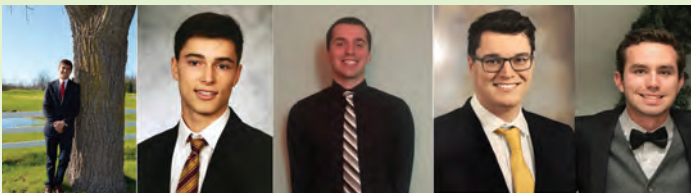
ArcelorMittal is the world's leading integrated steel and mining company and the largest supplier of quality steel products in the Americas, Europe, and Africa. ArcelorMittal continues to push boundaries by investing in research to produce smarter steels that are more efficient, use less energy, and emit significantly less carbon.

As iron ore is melted down into sheets, it is then rolled into coils that can weigh between 50,000 and 80,000 pounds. These coils are loaded onto rhinos and frontloaders (pictured to the right). Currently, the operators are having challenges seeing around the coils, which is causing the operators to hit structures, damaging both the structures and the coils.

Our team has been given the opportunity to determine a "Proximity Alert System" and design the mount for the hardware that will be able to be used on any and all mobile equipment that is to be employed. This system will need to be very robust and ensure that the Alert System hardware will not be easily damaged, as well as being as compact as possible. Ideally, the mount will allow easy access if the hardware needs to be repaired or replaced.



ArcelorMittal



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# ArcelorMittal

## Steel Coil Storage Racks

ArcelorMittal is the world's leading steel and mining company. Present in over 60 countries, ArcelorMittal is the leading supplier of quality steel products in all major markets including automotive, construction, household appliances, and packaging. ArcelorMittal was founded on three core values: sustainability, quality, and leadership. Each of these values builds the foundation for its force for positive change while prioritizing safety. ArcelorMittal manufactures steel in the form of large coils, which are placed on wood saddles for storage prior to being shipped to customers for further manufacturing. The large stress from the weight of each coil placed on the saddle causes significant wear and ultimately failure of each saddle, compromising the company's value of a safe work environment.

Our team has been tasked to create a new storage solution to replace the current wood saddles. ArcelorMittal's wood saddle system has a short lifespan, where saddles need to be replaced annually, posing a significant burden to the company's finances and resources. The team focused on researching and designing a new solution for steel coil storage that removes the need for annual replacement, while maintaining the previous design's modular attributes and movability. We focused on a solution that is cost-effective, safe and reliable. With this newly implemented storage solution, ArcelorMittal can store steel coils without concern of reliability, safety or maintenance on its storage saddles.



# ArcelorMittal



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# Flash Steelworks, Inc. Lightweight Steel Utility Trailer

**F**lash Steelworks, Inc. is an R&D firm specializing in the development of advanced high strength steel. Its patented Flash process is a heat treatment method in which steel is heated from room temperature to over 1000°C in just seconds, then is immediately quenched. Flash Steelworks has used US DOE funding to construct a processing line to produce industrial scale coils of world-leading high strength steel. Similarly, it has built equipment to produce tubing and armor plating using internal funding. The next step for Flash Steelworks is to develop applications that could take advantage of Flash Steel in a wider range of markets.

The purpose of this design project is to demonstrate the capability of Flash Steel. Our team has been asked to design a lightweight steel utility trailer that is as durable and rigid as current market options, while taking advantage of Flash Steel's superior strength to reduce weight. Since Flash Steel is a stronger material than the galvanized steel used in most trailers, the design needs less material to meet the same demands as normal steel trailers.

Our team created preliminary CAD models of various designs and analyzed them in FEA using load cases that the trailer will encounter. The trailer is expected to be able to handle potholes/bumps, high lateral and longitudinal acceleration, and uneven cargo distribution. Based on the preliminary results, the team iterated on the designs to accommodate industry-standard safety factors for the load carrying capacity and stiffness. By creating a lightweight trailer design, we will reduce emissions from the vehicles hauling Flash Steel trailers, as well as lower the amount of CO<sub>2</sub> produced during the manufacturing process. The final design will demonstrate Flash Steel's potential as a widely adoptable material.



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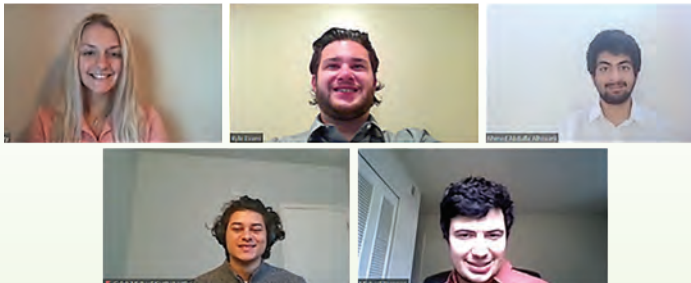


# Flash Steelworks, Inc.

## Flash Tubing Lightweight Steel Utility Trailer Design

**F**lash Steelworks, Inc. is a research and development firm located in Washington, Michigan. Flash Steelworks has developed a process in which steel is quickly heated in excess of 1000 °C and then rapidly cooled. The resulting steel possesses material properties unique in the steel industry. This process creates a steel with high toughness while still being easily weldable. The other benefit of this process is that it can be done to lean, low-cost steel. The resulting product outperforms titanium when subjected to strength and toughness testing. Because of the steel's material properties, The Departments of Energy and Defense have investigated using both plates and tubing in armor applications. Their testing indicated that the Flash Steelworks process allows thinner steel plates and small diameter tubing to be used while still achieving the same protection that conventional steel armor provides, drastically reducing weight. Flash Steelworks realized that due to the steel being stronger than conventional steel while using less material, there must be more opportunities to integrate this steel in order to create lightweight options of existing products.

Our team was contacted to develop a lightweight utility trailer utilizing tubing that has been treated at Flash Steelworks. The idea is to design a fifteen-foot, open cargo trailer. The trailer is to be as lightweight as possible while still having the same payload capacity as existing steel trailers. By doing so, the trailer's lifespan will increase because of the materials properties of the treated steel, and less strain will be placed on the towing vehicle due to the lighter weight of the trailer. We implemented unique trailer geometry compared to the traditional cross-members design to strengthen and reduce the weight of the trailer while still being able to attach it to a vehicle using a conventional ball and receiver.



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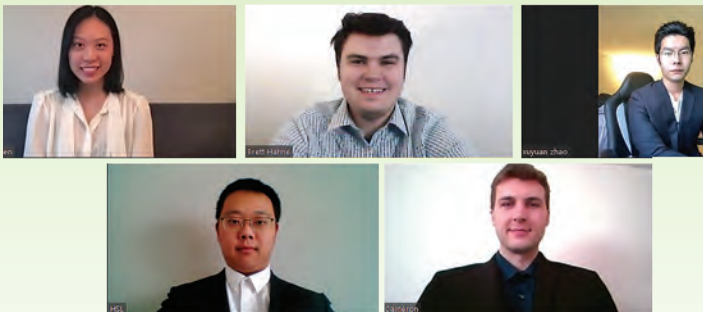
### ME Faculty Advisor

**Dr. Thomas Pence**

# Holt Public Schools/Ingham ISD Lift Device Design

The sponsor for this project is the Holt Public Schools/Ingham Intermediate School District. Ingham ISD serves as a shared community resource that creates networks of support and enhances educational opportunities for all learners in this service area. This project is designed to help Zeke, a motivated, intelligent, and outgoing sophomore student at Holt High School. He is diagnosed with a condition called Quadramelia or Amelia, which means he was born with no arms or legs. Most of his activities require the assistance of one or more caretakers. His power wheelchair can be controlled by a joystick and he enjoys this independence.

The purpose of this project is to build a lift machine to make Zeke's activities easier. The design combines the previous team's work and further enhances the practicality. The lift device would allow Zeke to safely move out of his wheelchair with the assistance of only a single caretaker. The design will protect the skin and keep the body comfortable. By using this lifting device, Zeke could be easily moved between the floor and the wheelchair and from the wheelchair to a toilet. The footprint of the device will be minimized, and it will be portable so that it can be easily used at home. This design will be optimal for home use and will be as simple as possible while maintaining all the constraints.



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# Holt Public Schools/Ingham ISD

## Zeke Lifting Device

**Z**eke is an intelligent and outgoing freshman student at Holt High School, who was born without any arms or legs — a debilitating condition known as Amelia. He is dependent on an aide for most of his day-to-day physical activities, including using the restroom. While he loves the sense of independence that his current power wheelchair offers him, transitioning from one seat to another is a great challenge. Zeke weighs over 50 pounds, so two adults are required to execute a safe lifting technique. Having two adults present to help him is not always possible at home or at school. This task is made even harder by the fact that he is still growing. Another issue for Zeke is that he is unable to easily shift his weight or reposition his body when in his wheelchair. Weight shifting is necessary to prevent breakdown of skin, avoid forming pressure ulcers, and regulate body temperature to stay comfortable. In short, Zeke would benefit greatly from any time he can spend out of his wheelchair to move around leisurely on the floor.

A previous project completed by an MSU engineering team addressed this need through a mechanical device capable of lifting Zeke from the floor to a chair. The device built from this project has since struggled to meet Zeke's evolving needs, and was completely redesigned in the spring of 2020 (although it was never prototyped). Current work aims to address moving Zeke with a more compact, storable, and lightweight lift, modeled off of the spring 2020 redesign, the compact nature of the design being a particular feature of emphasis. Major added improvements are the incorporation of more device movements such as rotation of his lift seat and lateral seat extension. A secure wheelchair docking mechanism is also needed to provide stability for when Zeke decides to transfer from his wheelchair to the lift device. This project overall is expected to provide him with the extra mobility he desires in a manner that is both safe and intuitive.



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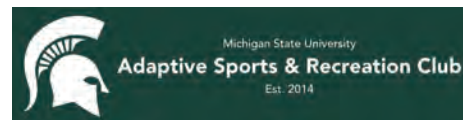
**Dr. Abraham Engeda**



# MSU Adaptive Sports and Recreation Club Inclusive Wheelchair Design

The MSU Adaptive Sports and Recreation Club aims to assist and include people of all disabilities in adaptive team sports. Wheelchair sports, although they're a great social outlet and source for exercise, unfortunately don't allow ambulatory people with disabilities to participate to the same extent as those without disabilities. The adaptive sports and recreation club hopes to provide an opportunity for those who may not possess the upper body function required to operate a sport wheelchair to compete in able-bodied sports. Ultimately, the club hopes to increase the quality of life of its members through competition.

Our team has designed a modified sports wheelchair to be more accessible to people who have disabilities that impact the function of their arms, wrists or hands, as well as lacking sufficient lower body function to participate in non-wheelchair sports. A durable propulsion method has been created so users can use their legs in order to propel the wheelchair, while keeping their dominant hand free for sport. Additionally, an improved braking system has been designed to allow users more control over their wheelchair without losing the ability to use their dominant hand. Lastly, the wheelchair has been designed so these new features are universal, enabling the user's dominant arm to be free. These new additions will enable the club to allow more ambulatory members to join their club and improve their quality of life.



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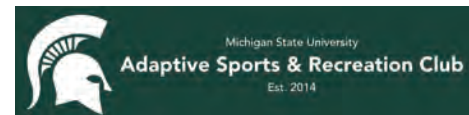
**Dr. Ahmed Naguib**

# MSU Adaptive Sports and Recreation Club

## Sled Hockey Transfer Platform

Established in 2014, the MSU Adaptive Sports and Recreation Club is a Registered Student Organization (RSO) at Michigan State University. It is a free program that is open to adult athletes with physical disabilities, able-bodied volunteers, and academic projects personnel, who are MSU students, employees, alumni, or members of the greater community. 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, which uses sports to validate the disability experience by eradicating inaccurate societal stereotypes and invalid self-perceptions about disability. Additionally, it aims to proactively promote the physical health, social behavior, and psychological wellness benefits of physical activity to individuals with physical disabilities by ensuring consistent access to a wide range of quality wheelchair and adaptive sports opportunities, helping the athletes make positive lifestyle choices that lead to the attainment of personal health goals. The program adopts a self-determination approach that focuses on athlete autonomy, competence, and relatedness as key facilitators in the process of acquiring self-efficacy in the area of sports and physical activity.

To promote the self-determination approach, our team focused on the previous work done on a transfer platform that helps the athletes get to and from their personal assistive mobility equipment to the roller hockey sled. Furthermore, the design had to increase the safety and independence during these transfers. We had to take into consideration the mobility of the design so that it was portable, compactable, and most importantly, universal (accommodating for a wider range of users presenting various levels of physical function).



### Michigan State University

#### Team Members

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### MSU Adaptive Sports and Recreation Club

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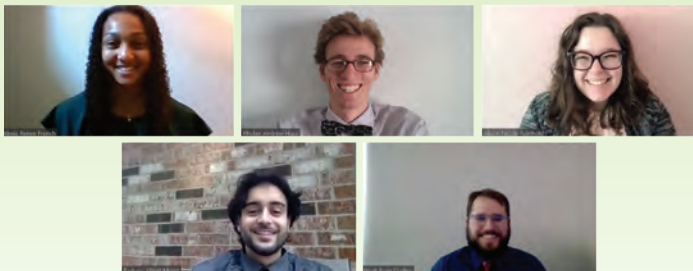
# Michigan AgrAbility Manlift Swing Arm

**I**t is estimated that 250-300 U.S. farmers annually experience permanent spinal cord injuries while encountering further injuries/conditions that leave them with limited mobility. The limited mobility of these farmers leads to difficulties accessing the seats of farming equipment such as combines, tractors, and log forwarders.

Michigan AgrAbility, a USDA-funded partnership of Michigan State University Extension and Easterseals Michigan, focuses on developing methods and tools to help farmers with disabilities and challenges. Many farmers have built their own manlifts to provide easy access to their equipment. These manlifts are hydraulic or winch-driven lifting devices that can be attached to the equipment itself or a separate trailer. The lift is operated through a remote, which controls the 12-volt cable winch or hydraulic cylinder. These homemade manlifts are priced around \$1,000 compared to commercial lifts ranging from \$12,000 to \$17,000.

Despite the success and feasibility that Michigan AgrAbility has seen with its manlifts, problems arise during the farmer's transition from the lift to the seat of their equipment. A great divide exists between the farmer's lifted position and the seat of their equipment. This setup provides multiple safety and exertion concerns for the transfer from the manlift seat to the equipment.

The project is to design a powered swing arm that is affordable and simple enough for farmers to recreate. The swing arm will consist of two rotational joints to provide a greater field of motion, capable of transporting the farmer from his/her wheelchair to the lift, from the lift to the seat of their equipment, and around any equipment obstacles, e.g., vehicle door. The swing arm will take into consideration all safety concerns and be durable enough to be used in all weather and load conditions. This would enable farmers to build their own lift and safely swing to reach the seat of their equipment.



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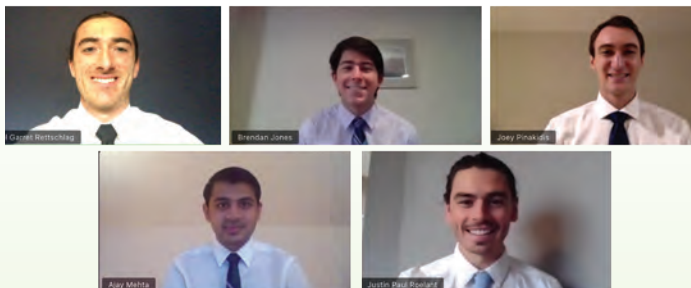
**Dr. Norbert Mueller**



# Michigan AgrAbility Manlift Swing Arm

**M**ichigan AgrAbility provides critical assistance to enable people in the agricultural industry with an injury, illness, or disability to continue working. By working closely with the unique challenges of various clients, Michigan AgrAbility is able to develop functional equipment and tools to better assist farmers in their daily tasks. Providing opportunities for employment in production agriculture, access to assistive technology, and evidence-based information for treatment and rehabilitation of disabling conditions are all forms of success for Michigan AgrAbility. The ultimate goal is to help keep farmers working, pursuing the lifestyle they enjoy, and enable them to provide stable income for their family.

Our team was tasked with aiding farmers with disabilities, who have lost functionality of their legs, get into and out of the cabin of their tractors. This is being achieved by a swing arm attached to a lifting device. Our team has been assigned the development of only the swing arm portion of this mechanism. The design of the swing arm must be simple to manufacture as farmers will assemble the swing arm on their farms. Furthermore, the swing arm will have a high degree of safety, as the manlift mechanism will raise the swing arm and farmer several feet off the ground. With this product, the quality of life for farmers with disabilities can be improved by making their tractor more accessible for them.



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# The Ultimax Group, Inc.

## Geoengineering for Mitigating Climate Change

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Global climate change is a pressing problem that scientists and engineers around the world are trying to solve. One of the approaches to solve global climate change is geoengineering, but there are a lot of other techniques. This project is devoted to trying to understand the pluses and minuses of the full spectrum of geoengineering techniques that are all designed with the single goal of mitigating climate change. These techniques can alter the amount of solar radiation reaching the earth or avoid/reduce or remove carbon dioxide from the earth's atmosphere through solutions in space and on earth.

Our team formed a side-by-side classification of 50 geoengineering techniques in terms of cost/scale, impact on global warming, speed, and risk of implementation. This analysis will be synthesized into a paper which will be entered into international journals such as the Journal of the International British Planetary Society (IBIS).



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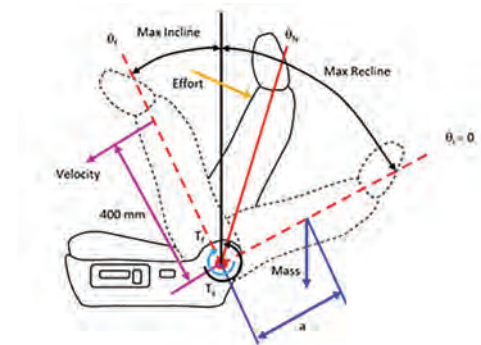
**Dr. Rebecca Anthony**

# Toyota Motor North America Automotive Seat Back Performance Model

**T**oyota is Japan's largest automaker and the second largest in the world. The automotive manufacturer is the first to produce 10 million cars per year. Operating out of Ann Arbor, Michigan is the Toyota Motors North America Research and Development Vehicle Performance Division. This group focuses on a variety of areas, one of which is technical research that is responsible for validating designs that will meet customer needs. The facility houses resources that allow for vehicle development projects to be undertaken.

Toyota is one of the few automakers that still produces the minivan as many other manufacturers have removed it from their lineups. One key aspect in the minivan is having comfortable seats for passengers of all types. Toyota has reached out to Michigan State University with the opportunity to improve the reclining feature of their seats. With these modifications, the current automatic system would allow for increased safety and customer satisfaction.

Our team's project was to further enhance Toyota's reclining seat system while meeting two specific requirements. One of the first adjustments that we made was adjusting the spring torque, to allow the seat to return to its starting position. However, the spring torque should not allow the seat to exceed the maximum return velocity and does not require the user to apply additional effort. A secondary goal was to create a universal seat design that could be applied to any vehicle they produce. This universal model would greatly reduce the production cost, and help maintain Toyota's quality standards.



# TOYOTA



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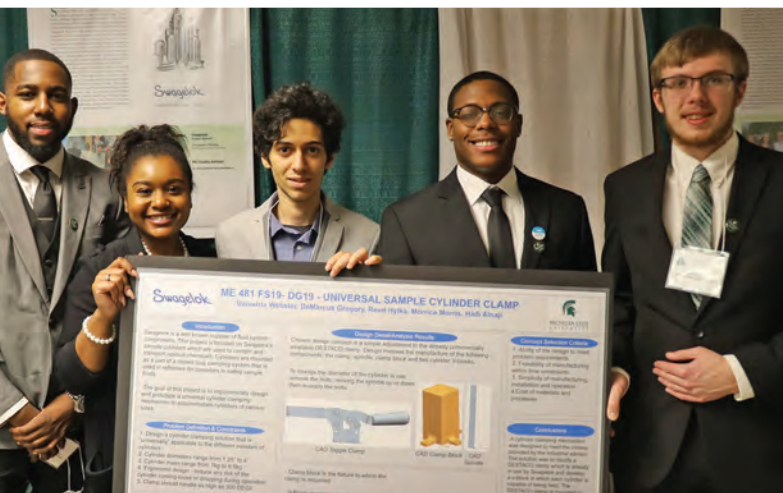
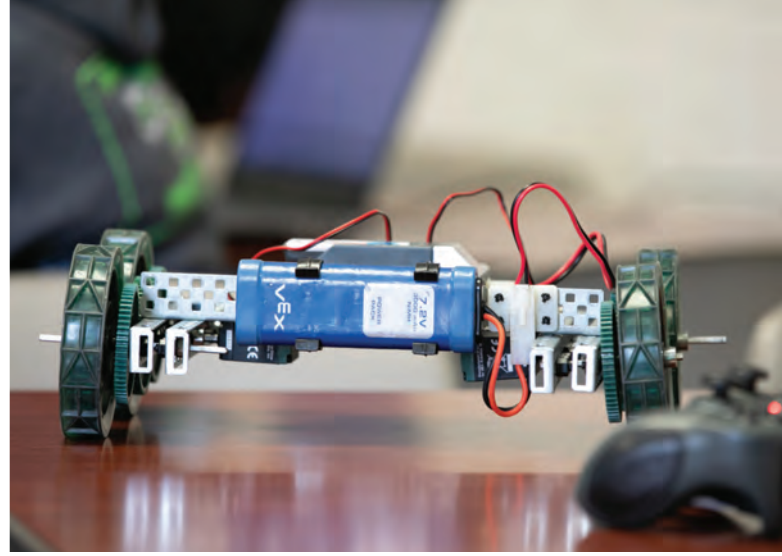
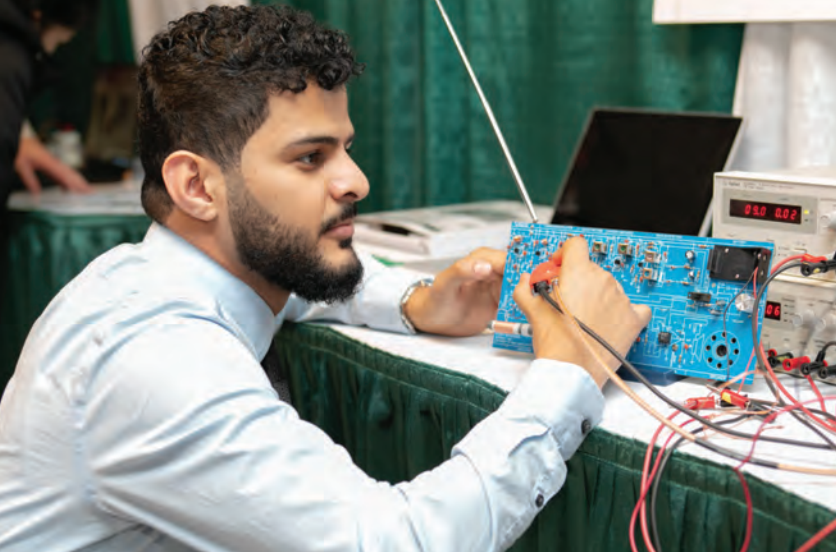
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