MICHIGAN STATE UNIVERSITY COLLEGE OF ENGINEERING SPRING 2022

DESIGN DAY

MICHIGAN STATE UNIVERSITY

amazon

Executive Partner Sponsor

We at Amazon are honored to partner with the College of Engineering and Michigan State University to highlight the amazing work of MSU Students for Design Day 2022.

Amazon employees use Leadership Principles every day to guide our decisionmaking, problem solving and discussing new ideas. We see those leadership principles integrated in the projects from this year's Design Day. Projects are Customer Obsessed as they work backwards from the customer to solve what is really needed. Students worked hard to Invent and Simplify on behalf of customers, trying new and different experiments before finding the best simplified solution. All students Delivered Results in their projects to showcase solutions for Design Day and we are excited for them to continue to see success.

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

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

Amazon is always looking to hire and develop the best. If you are interested in joining our team please visit amazon.jobs

Sincerely,
Garret Gaw
Director
Selling Partner Experience

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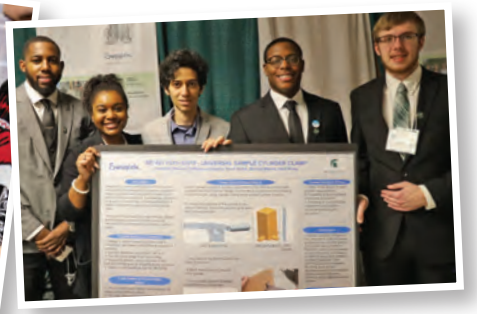
MICHIGAN STATE UNIVERSITY COLLEGE OF ENGINEERING **FALL 2022**

DESIGN DAY

Look for Fall Design Day projects coming in December 2022!



Welcome from the Dean

Design Day is one of our premier undergraduate academic events of the semester. Now in our 28th year, Design Day highlights the creativity and ingenuity of our Spartan engineers.

After a three-semester hiatus of in-person activities, we are pleased to welcome you back to our traditional Design Day! Our senior capstone courses will be showcasing their projects throughout the hallways on all three floors of the Engineering Building. A few will be giving project presentations as well. As you read about their projects in this booklet, you will see that our MSU engineers are ready to lead, create and innovate.

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

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

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

Our 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.

Dr. Leo Kempel

Dean of the College of Engineering

Professor of Electrical and Computer Engineering

Dennis P. Nyquist Endowed Professor of Electromagnetics

Michigan State University

Events Schedule Friday, April 29, 2022

CAPSTONE COURSES	
All Capstone Posters for most projects, including BE485/487 and ChE 434	1st Floor 1200/1300 Hallway 8:00 a.m. - Noon for ME. BE, ChE and ECE on 2nd Floor and CSE on 3rd Floor
AESC 410/ SCM 472 Project Presentations	Engineering Rooms 2320, 2400 and 3400 8:00 a.m. – 11:30 a.m.
CE 495 Project Presentations	1st & 2nd Floors – Rooms 1225, 1230, 1234 & 2243. 8:00 a.m. - Noon
ECE 480 Project Presentations	2nd Floor Rooms 2245 and 2250 8:00 a.m. - Noon
ME 481 Project Presentations	1st & 2nd Floor Rooms 1202, 1220, 1300, 2205 7:30 a.m. - 11:30 a.m.
MSE 466 Project Presentations	1st Floor , Room 1145 8:00 a.m. – 11:20 a.m.

Social Media Links:

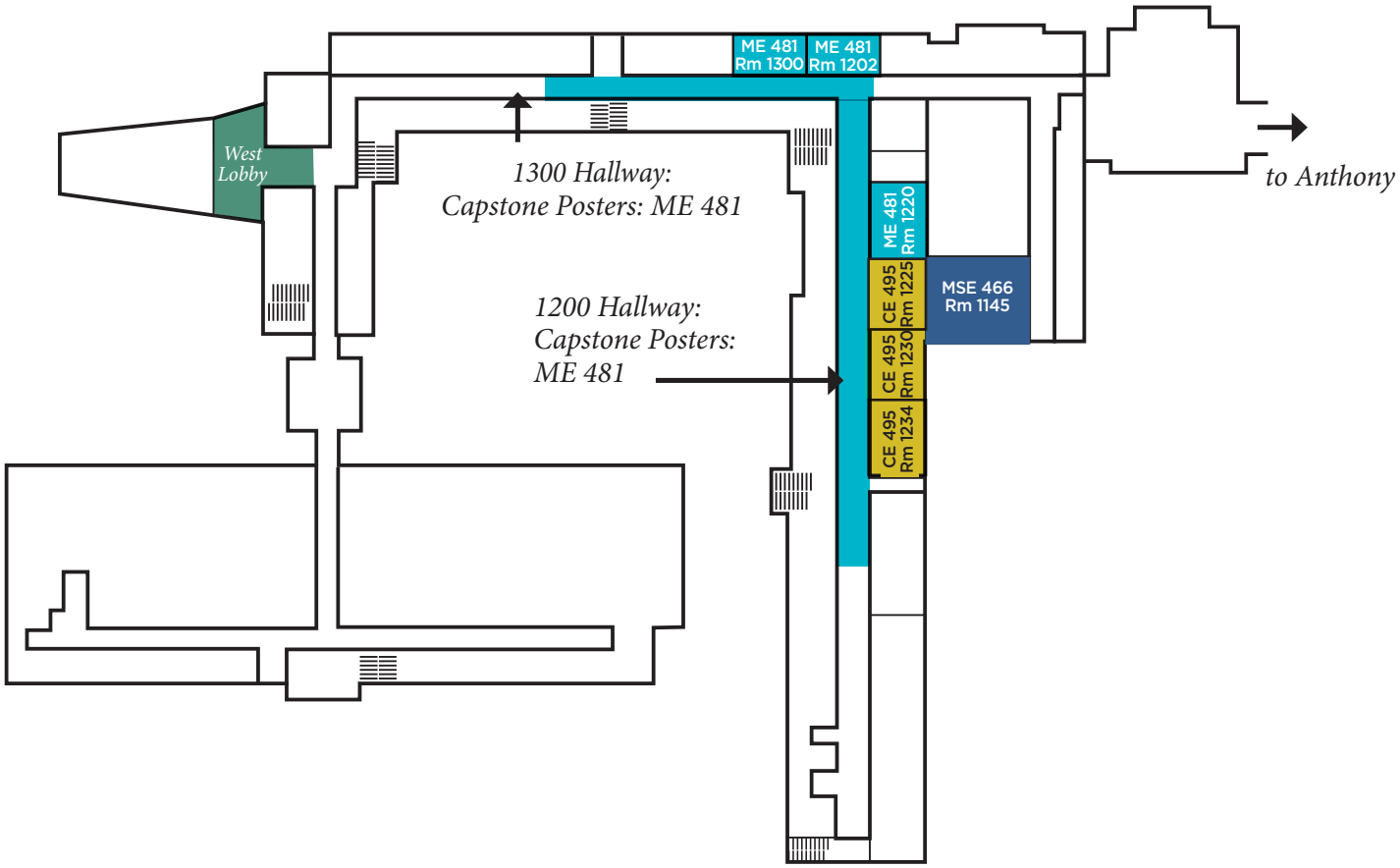
"Like" the College: https://www.facebook.com/SpartanEngineering "Follow" the College: https://twitter.com/msu_egr_news

To stay up to date w/Careers in Engineering:

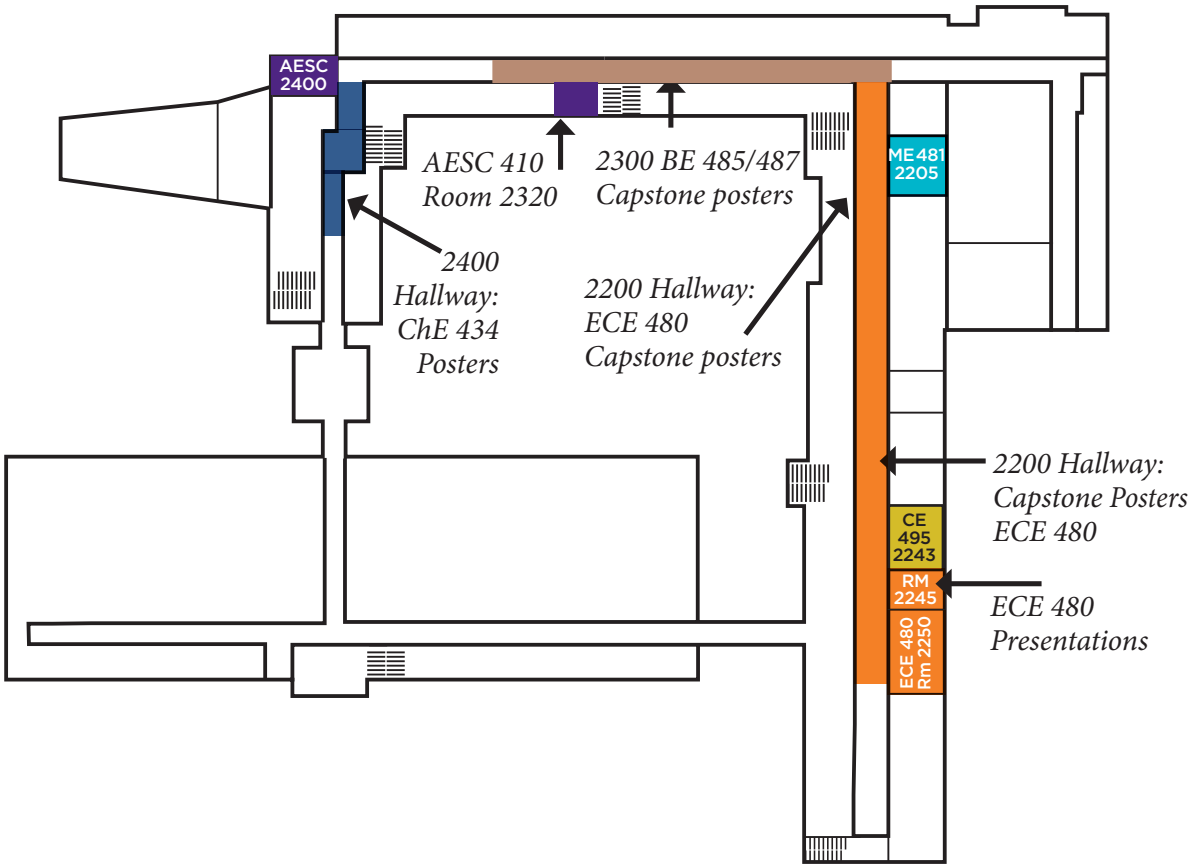
"Like" Us http://www.facebook.com/pages/The-Center-for-Spartan-Engineering/226159694117936

"Follow" Us: https://twitter.com/msuengineer

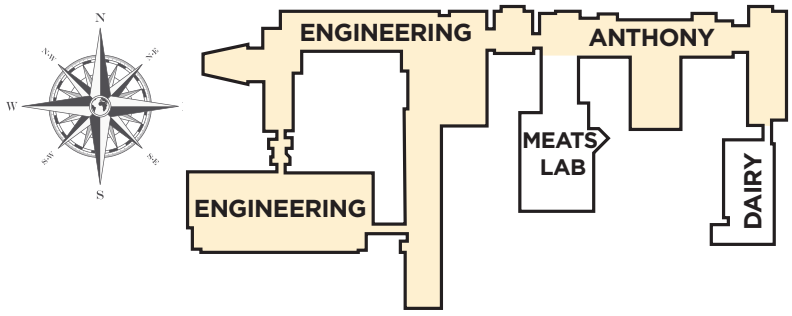
1st Floor Engineering



2nd Floor Engineering

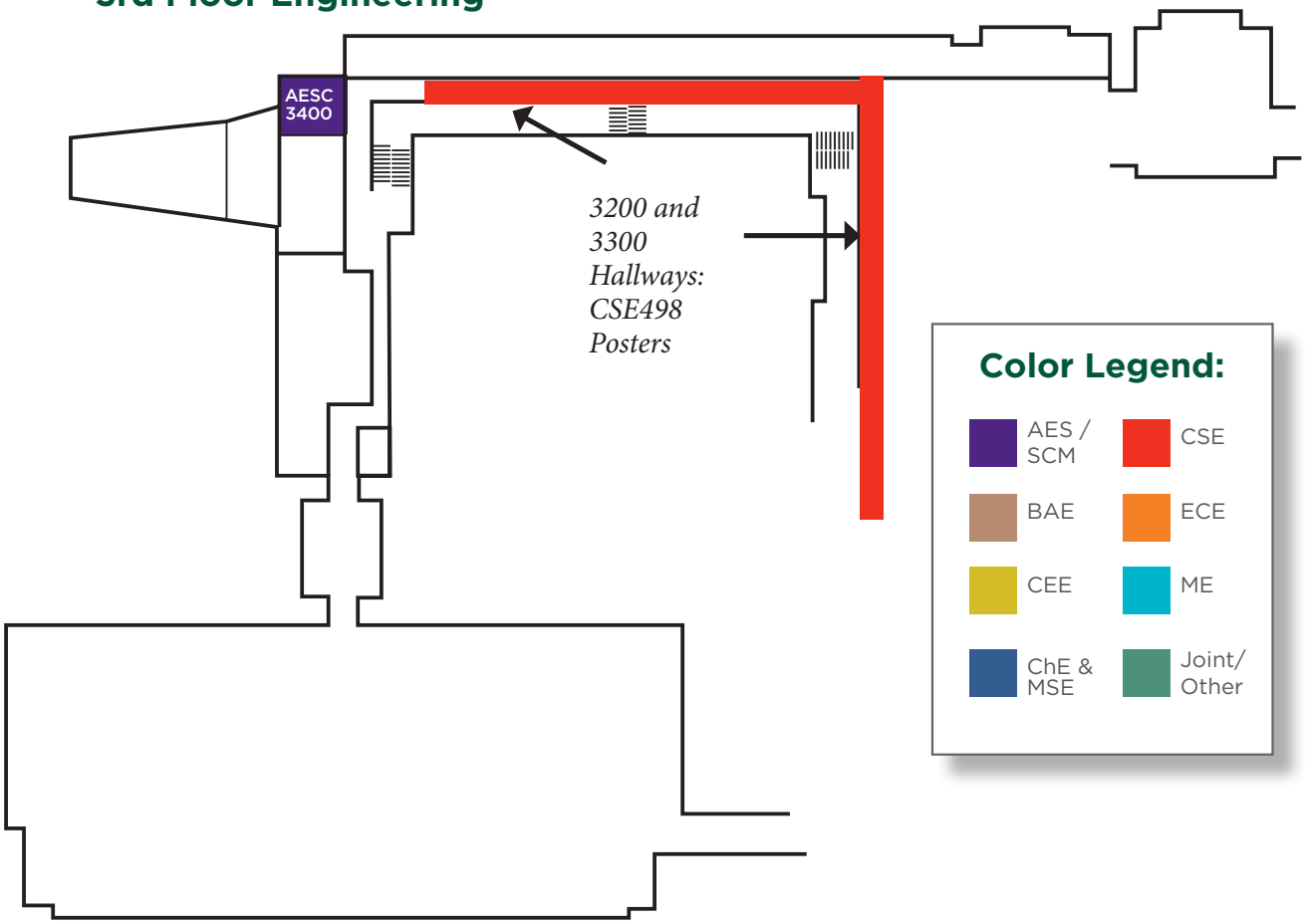


Overview



Design Day Floor Plans of the MSU Engineering Building

3rd Floor Engineering



EGR 100 Introduction to Engineering Design

Dr. Jenahvive Morgan
Course Instructor

Course Project

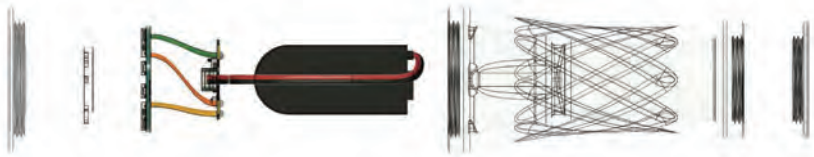
EGR 100, Introduction to Engineering Design, is a college-level course required of all incoming first-year engineering students. It is an integral part of the CoRe (Cornerstone and Residential) Experience. The course introduces students to the engineering profession and the engineering design process through team-based, interdisciplinary design projects and assignments. There are 720 students enrolled in EGR 100 this semester.

For the final course project, the student teams selected from seven project types: **(i) Create a Phone App, (ii) 3D Printing CAD Drawing, (iii) Design a Mini Solar Car, (iv) Water Filtration System Design, (v) Create an Arduino LED Circuit, (vi) Design of a Heat Exchanger, and (vii) Costa Rica Community Designs.**

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

Fall 2021 EGR 100 Project Designs

Phone App Design Project: Student Mental Health Cell Phone App



Arduino LED Design Project: Student Arduino LED Circuit Design with 3D Printed Case

Applied Engineering Sciences

Capstone Course Sponsors

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

Applied Materials

Asahi Kasei Plastics North America

BASF

Bell Flight

bp

Catepillar

Clarience Technologies

Dow, Inc.

General Motors

Genpact

Guardian Glass

Intel

RENK

Rockwell Automation

RPM Freight Systems

Snackwerks

Tenneco

The Capstone Projects

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Dr. Srishti Banerji
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MBA (2022) Supply Chain Management & Analytics

Sneha Abhyankar
MBA (2023) Supply Chain Management

Akash Mehrotra
MBA (2022) Supply Chain and Finance

Jose Naime
MBA (2023) Supply Chain and Finance

Presentation Schedule – 2nd Floor Engineering Buliding, Room 2320

Time	Team Sponsor	Project Title
8:00 a.m.	Intel	Consolidated Shipping Project
8:25 a.m.	Intel	Common Items Bulk Buy Strategy
8:50 a.m.	BASF	Herbicide Data Visualization and Forecasting
9:15 a.m.	Bell Flight	Supplier Risk Analysis and Prediction Model
9:35 a.m.	BREAK	
9:50 a.m.	bp	Identify Top Suppliers' Carbon Emission Data
10:15 a.m.	bp	Identify Best Approach to Buying Emerging Technology
10:40 a.m.	GM	Supplier Risk Assessment and Key Risk Indicators
11:05 a.m.	Tenneco	Cost Modeling and Verification in the Global Automotive Market

AESC 410 Senior Capstone Project Course

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

Intel
Consolidated Shipping Project

Intel is a driver of innovation across industries in creating world-changing technology. Intel has been one of the world leaders in computer technology since its founding in 1968. As an industry leader, Intel seeks to optimize and increase efficiency throughout its business model to meet customer needs. Shipping efficiency is critical to meeting those needs.

Intel has encountered a similar problem that many other companies are facing during the COVID-19 pandemic. The worldwide shipping shortage and ever-growing lead times have had a negative impact on the production and efficiency of Intel's shipping. Shipping container costs have risen 300% per container and lead times have gone from 30 to 100 days for ocean shipping. To combat these growing costs and lead times, Intel plans to consolidate shipping transactions and lower the number of shipping containers needed to transport their capital goods from suppliers to Intel factories.

Intel has tasked our team with looking into the future of Intel shipping through 2026 to lower shipping costs. This was done by creating processes and procedures for consolidating shipments from multiple suppliers in the same geographical areas within similar time zones, as well as similar shipped-to and shipped-from locations. We conducted exploratory and predictive analyses on transaction data through Excel, Tableau, and Data Studio to find which strategy fits Intel's shipping best.

Our end goal is to propose a consolidation strategy to Intel that will lower ocean shipping costs through 2026 and can be used for future Intel shipments. We intend to present a thorough consolidation program as well as a cost analysis to demonstrate the savings the program will provide.

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Intel
Common Items Bulk Buy Strategy

Intel is an American multinational corporation and technology company headquartered in Santa Clara, California. Aside from being the world's largest semiconductor chip manufacturer by revenue, Intel also manufactures and supplies microprocessors, motherboard chipsets, and other processing components for computer manufacturers like Dell, Lenovo, and HP. With technology advancing at an exponential rate along with the crippling effects of Covid-19 on the semiconductor industry, Intel is looking for inventory solutions to close the gap between supply and demand.

Intel has a subset of Tier 2 suppliers who provide ancillary equipment in alignment with production equipment installation. Often, these Tier 2 suppliers provide several common items across multiple OEM production machine sets. Our team has been given past, present, and future purchasing data for one production facility. Intel has tasked our team with evaluating the commonalities of items across OEM production machine sets to identify significant correlation. Further, we are expected to propose Common Items Bulk Buy Forecasting and Hedging based upon machine sets with the greatest commonality, longest lead time, and most often late tender from the supplier.

Our team will use methods including but not limited to Economic Order Quantity, ABC categorization of inventory, and Excel models and analysis. Once commonalities have been identified, we will use Tableau to graphically display their data and findings to the company. The displays will include interactive dashboards that Intel will be able to utilize in the present and future. We will identify the best dates and optimum quantities to purchase parts, with the goal of improving Intel's purchasing efficiency and reducing inventory costs.

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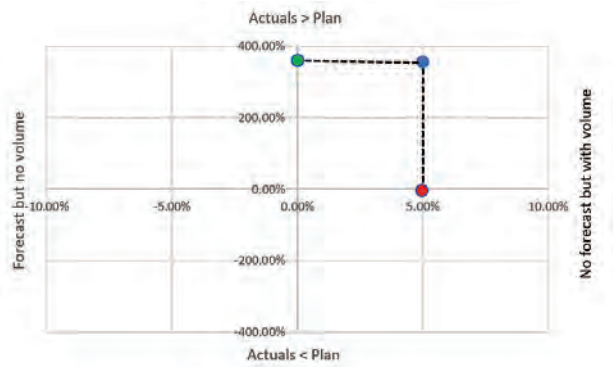
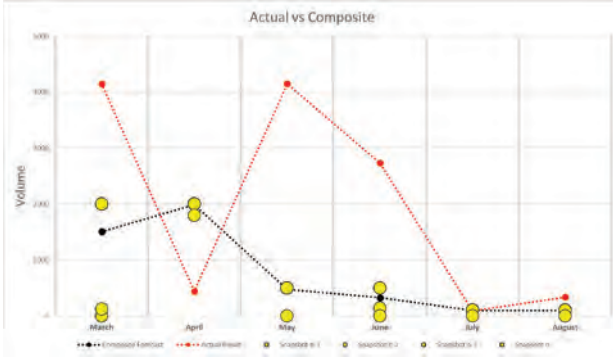
BASF
Herbicide Data Vizualization and Forecasting

BBASF is a multinational chemical company headquartered in Florham Park, New Jersey focused on innovating chemistry for the future. Because of their wide array of products, BASF is in many different industries spanning from agriculture and health to consumer goods and transportation. By combining economic success with environmental protection and social responsibility, BASF's agrichemical business has made a name in the world's top 10. BASF has been providing the agriculture industry with weed control solutions to help not only with yields and quality, but also resistance management. In this strong market, BASF is seeking a fresh perspective on current herbicide forecasting techniques and how to gain an orderly and concise plan for future sales.

` Our team was tasked with evaluating forecasting behaviors through data processing and visualization techniques to support BASF's journey to build improved forecast management. The outputs will be used to discover forecast tendencies, such as over or under forecasts and the extent of discrepancy. We worked to develop user-friendly data visualizations tools that can summarize and consolidate findings at SKU and category level in different time frames (month, season, year). Through a coupling of data-driven insights made accessible through data visualization, MSU and BASF teams will successfully see the effectiveness and weaknesses of the current forecasting methods, the first step into the development of new and improved forecasting techniques.





BASF
We create chemistry

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Bell Flight
Supplier Risk Analysis and Prediction Model

The Covid-19 pandemic created unprecedented logistic issues, especially regarding supply chain security and supplier reliability. Prior to the pandemic, Bell Flight did not have a system in place to analyze individual supplier information and predict the overall security of suppliers. This issue resulted in the loss of several of Bell Flight's suppliers. To prevent an event like this in the future, Bell Flight has partnered with our team to develop a comprehensive risk analysis and management model.

The model will allow Bell Flight to see the comprehensive risk status of their suppliers. This tool will be used to analyze potential risk factors pertaining to suppliers, provide an overall risk score for each supplier and prescribe actions to mitigate negative impacts to the company's supply chain. Data for individual suppliers is broken down into a collection of categories. Coefficients associated with risk factors are then assigned to each category using the data envelopment analysis method. The coefficient values are used to calculate the risk score for a particular metric and combined in the overall risk score of a supplier. The processed data will be displayed through a dashboard, providing Bell Flight with a high-level overview of the company's suppliers, along with the capability to pinpoint specific risk factors that are contributing the most to a supplier's overall risk score.

Bell Flight does not have a system to analyze the risk of their suppliers. The tool developed by our team focuses on calculating the overall risk of individual suppliers by utilizing multiple individual risk factors that are identified as potential threats to Bell Flight. The benefits include the early identification of high-risk suppliers along with mitigation strategies. This allows Bell Flight to act preemptively by either locating a new supplier or working with the current supplier to mitigate risk and improve reliability.

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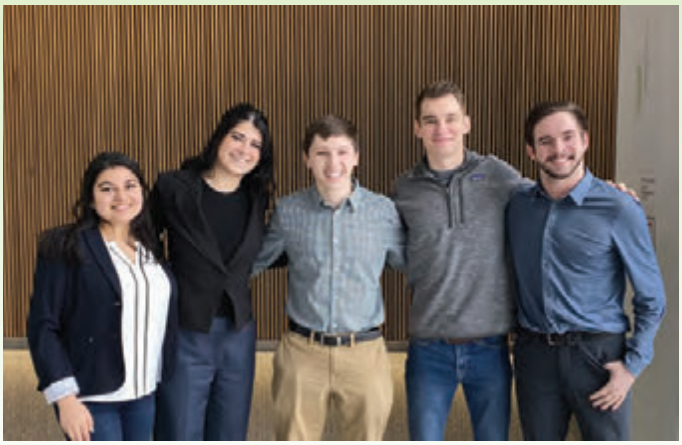
bp
Identify Top Suppliers' Carbon Emission Data

bp is a multinational oil company that is headquartered in London, England. Since 1908, when oil was discovered in Persia, bp has been one of the world leaders in the global energy industry. bp continued to grow over the next century while more oil was found worldwide, and they have now massed a workforce of over 14,000 employees. Along with their company growth, their supply chain has rapidly developed to over 46,000 suppliers over 60 different countries. This causes bp to have a large global footprint at a scope 3 level, and therefore they have developed a net zero carbon emissions goal by 2050.

In pursuit of this goal, our team worked with bp's Digital and Talent Procurement team to identify top suppliers and their alignment with the net zero ambition. After identifying a comprehensive list of suppliers in collaboration with category leads within bp, the MSU team honed in on fifteen suppliers to begin data collection over a two-week sprint. Through research into each supplier's published sustainability report and collaborative discussions with each supplier, we compiled carbon emission data used to establish a carbon baseline, breakout data by Scope 1, 2, and 3, and identify emissions specifically attributed to bp. This baseline will be used to track each supplier's progress with reducing carbon emissions. In addition, the team looked into how frequently suppliers measured and reported these metrics.

Our team also collected information regarding the largest sources of carbon emissions within the suppliers' supply chains, current initiatives to reduce their global footprint, and milestones along the way to reaching their carbon reduction goals. These metrics provided bp with clarity on how they align with their supply base on aspirations to become environmentally sustainable and identified areas that needed more focus. The data collected by our team will be used to create a central dashboard within bp to assess the overall carbon impact of the company on an ongoing basis.



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Ashford, United Kingdom

Kathleen Silverman
Houston, Texas

Teaching Assistant

Ishaan Anand

bp
Identify Best Approach to Buying Emerging Technology

bp, a multinational company, is headquartered in London, England. bp has been one of the world's largest oil and gas companies since 1910. Now also regarded as an energy company, bp recognizes the impact emerging technology can have on operations and sustainability.

bp defines a robot as a machine capable of carrying out a complex series of actions automatically. The increasing use of robotics has opportunities to improve safety, increase efficiency, and drive sustainability. bp currently utilizes machine hardware, robots that perform work independently, and service robots, robots that perform a service via drone or in person. A majority of the robots currently used in bp include quadrupeds, telecommunication robots, cleaning robots, and marine robots. Demand and deployment of robotics at bp are both fragmented and decentralized; there is currently no standard way of buying and leasing robots internally.

Our team is conducting a fiscal analysis comparing buying, leasing, and contracting these robots to give bp a recommendation for bp's future state. The team is also presenting a Porter's Five Forces analysis of the market landscape characteristics and key suppliers of the robotics market. A more informed analysis of the suppliers in the global market of robotics will be used to help bp source strategically and therefore improve their competitive positioning in the energy industry.

With the robotics industry evolving rapidly, bp is looking to explore new opportunities by partnering with companies that provide innovative opportunities to maintain a competitive advantage. Our team is researching and presenting interesting ventures that will become influential in the upcoming years of robotics and will help improve bp's overall strategic positioning in their industry. Additionally, we are conducting a SWOT analysis to determine the benefits and risks of engaging in new enterprises.

Telepresence Robots

Cleaning Robots

Knspection Robots

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Ryan Spencer
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Larissa Diarra
Ann Arbor, Michigan

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bp
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Nikita Sejpal
Ashford, United Kingdom

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General Motors
Supplier Risk Assessment and Key Risk Indicators

General Motors has tasked our team to develop inferences about their supply chain. These inferences are to be developed from key risk indicators within their supply chain that our team will further discover, analyze, and explain from quantitative metrics. To create a cohesive analysis of General Motors' supply chain, the team will focus on models exclusively produced and sold in North America. Specifically, the focus of this project is on the supply chain related risks for two of General Motors' highest selling vehicles, the Chevrolet Silverado and GMC Sierra half-ton pickup trucks. Within these two models, the team will be identifying primary risk drivers in the supply chain network through the quantitative analysis of different variables, such as an Analytical Hierarchy Process model. These different variables will be broken down into three specific sectors. The first will pertain to COVID-19 and how the global pandemic could further impact the General Motors supply chain network. Next, the team will research the lead times, delays, reasons for delay, etc. between the manufacturing facilities and the dealerships to understand the logistical risks that are involved in the production of these two vehicles. Finally, the team will dive into the production and plant operations for each vehicle to determine impediments potentially associated in the making of these pickup trucks. Overall, the overarching goal is to present General Motors with a visual representation of these key risk indicators, and their corresponding metrics. In turn, these metrics and key risk indicators will help General Motors on their supply chain resiliency journey and drive meaningful change throughout the enterprise.

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Tenneco: Cost Modeling and Verification in the Global Automotive Aftermarket

Tenneco became their own entity in 1999. It all started with a conglomerate consisting of six different businesses: chemicals, automotive, shipbuilding, gas transmission, farm, and construction equipment. This was until the company decided to divest in their businesses, leaving Tenneco Automotive as the remaining business of the original company. Tenneco remains strong with their original businesses and aftermarket brands due to keeping their roots with brands such as Monroe and Walker.

In 2005, Tenneco decided to rebrand their company so that they could best represent the expanding number of markets they are serving. The company had expanded their global footprint to keep up with the evolving world of automotive to become one of the first automotive suppliers to have the opportunity to work with China.

Headquartered in Lake Forest, Illinois, Tenneco has a global annual turnover of $4.4 billion and more than 19,000 employees. Tenneco is one of the world's leading designers, manufacturers and marketers of automotive products for original equipment and provides services of high quality for aftermarket customers. By pushing advancements in global mobility, Tenneco delivers technology solutions in their four business groups, Motorparts, Performance Solutions, Clean Air, and Powertrain. These advancements are key to Tenneco's involvement in diversifying global markets.

Tenneco's purchasing team is enlisting the help of our team to perform a "Should - Cost" model to analyze the performance and cost of three of Tenneco's top product lines – Spring Coils, Back Plates, and Hub Assemblies. The team has created an eRFP to help Tenneco review current suppliers, along with proposals for benchmarking with new suppliers.

Our team will be using our extensive knowledge of Excel, Tableau, PowerBI, and RStudio to enhance Tenneco's competitive advantage and generate market share growth opportunities for the company.

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Presentation Schedule – 2nd Floor Engineering Buliding, Room 2400

Time	Team Sponsor	Project Title
8:00 a.m.	Rockwell Automation	Warehouse Manufacturing and Bin Optimization
8:25 a.m.	Clarience Technologies	Strategic Sourcing
8:50 a.m.	Dow, Inc.	Replicating Supply Chain Inventories and Policies
9:15 a.m.	Genpact	Improving Supply Chain Processes
9:35 a.m.	BREAK	
9:50 a.m.	Caterpillar	End-to-End Kit Process Optimization
10:15 a.m.	Caterpillar	Kit Assembly Automation
10:40 a.m.	Caterpillar	Small Part Distribution Optimization
11:05 a.m.	Guardian	Stock Level Optimization Tool

AESC Engineering Program

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

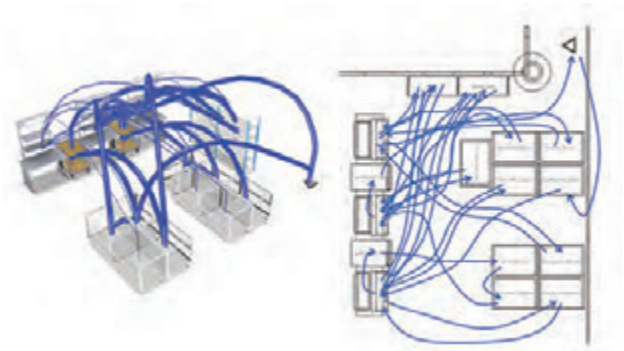
Rockwell Automation
Warehouse Manufacturing and Bin Optimization

Founded in 1903, Rockwell Automation is a Fortune 500 company headquartered in Milwaukee, Wisconsin. The company's mission is to improve the quality of life by making the world more productive and sustainable by providing industrial automation and digital transformation.

Rockwell is facing warehouse utilization issues in its Mequon plant due to a lack of efficiency with the company's internal material movement and tracking metrics. This results in unnecessary downtime, lost profit and/or late shipments. Our team was tasked to build an inventory movement tracking platform under the preferred Power BI program. This tool is user-friendly and can be easily understood by Rockwell's employees. To create this, we analyzed warehouse movement data and investigated the warehouse layout to enhance the overall efficiency of its product movement. Rockwell's SAP and ERP system data are not involved in this project.

Another aspect of this project is optimizing bin storage within the Mequon plant. Because the warehouse is on the smaller side, it is important that every bit of storage is being used. Within the team's created system, any product that has not been used in a certain time will be recognized and potentially relocated to the larger plant in Milwaukee.

With our finalized project, Rockwell is able to improve distribution routes and reduce its production downtime in the Mequon warehouse. Reducing its downtime benefits the company by distributing more of its products to their customers as well as saving time and energy within the plant..



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Clarience Technologies
Strategic Sourcing

Clarience Technologies LLC, owns a variety of brands within the transportation industry, which aims to provide customers with maximum visibility. Formerly Truck-Lite Holdings, the name was changed to Clarience Technologies, which is a combination of the words clarity and science. The organization known as Truck-Lite is now within Clarience Technologies' family of brands. Brand subsidiaries include companies like RIGID, which makes high-end light attachments such as light bars on Jeeps. Other company brands include Echo, specializing in the production of emergency amber lighting, and Code 3, which produces the red and blue emergency lights used by firetrucks and police cars. Clarience Technologies prides itself as a leader in transportation visibility. It is not surprising that each of the company's subsidiaries is number one in its market.

Clarience Technologies is looking for options closer to final manufacturing sites to source components. The Covid-19 pandemic has led to an increase in freight prices and lead times. Tariffs and political tensions have inflated costs throughout the supply chain as well. In addition, the visibility of certain products is very limited. By sourcing major components closer to final manufacturing sites, visibility should increase throughout the supply chain.

Our team is responsible for building a business case related to sourcing components to reduce costs and increase supply chain visibility. To achieve this, the team will contact a list of suppliers provided by Clarience to send Request For Quote. The commodities included in this Request For Quote are wire harnesses and diecasts. The business case provided will include a recommendation of suppliers that are capable of achieving Clarience's goals.

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Dow Inc.
Replicating Supply Chain Inventories and Policies

Founded in 1897 by chemist Herbert Dow, after he discovered how to extract bromine from the ground, Dow started selling bleach and potassium bromide. Since then, Dow has grown to become the most innovative, inclusive, and sustainable materials science company, with a purpose to deliver sustainable solutions for the future of the world. Operating in 31 countries with 106 manufacturing sites and over 35,000 employees, Dow is a global powerhouse in their industries. From supplying chemicals to plastics to agricultural products, Dow produced about $39 billion in sales in 2020.

Dow has provided the amazing opportunity to replicate supply chain networks for inventory simulation and policy design. The data which Dow supplies will be run through a newly designed supply chain simulation system coded with Julia, a new coding language. This provides the team opportunities to learn about Dow's supply chain policies, automate network building, and to explore replenishment policies. With these opportunities Dow is providing, it specifically focuses on learning about inventory management policies, data interpretation and cleanup, and echelon structured inventory strategies.

The work and reflection that goes into the inventory simulation and policy design will undoubtedly improve the overall efficiency of the supply chain network for Dow's inventory. Inputs into the simulation, such as the bill of materials, Replenishment Policy type, lead timetables, and the inventory policy will help in analyzing and proctoring the continuous changes in market demand, inventory levels, total pipeline, and many more, which are paramount to the businesses operation. Also, we will be able to locate best reorder points for product inventories as well as identify best policies and strategies for inventory management for certain products, which will be deemed a very useful and crucial supply chain tactic for Dow.

Seek Together™

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Genpact
Improving Supply Chain Processes

Genpact, based out of New York, NY, is a global professional services firm focused on business transformation. Founded in 2005, Genpact currently has over 80,000 employees in more than 25 countries working to solve supply chain issues in multiple industries.

Genpact's client, acting under the alias, "G-Mart," has pervasive problems throughout its supply chain resulting in higher costs and client satisfaction issues. G-Mart's issues stem from a lack of inventory level visibility. There have also been issues with merchandising, rising costs, stockouts, port congestion, transportation capacity issues, siloed operations, and other supply chain operations. As these concerns continue, customer service and satisfaction are suffering tremendously. To address these issues, our team has decided to focus on reforming G-Mart's current supply chain processes. This will create a more cohesive flow in the organization's procedures, which will address issues such as the siloed operations and capacity limitations, as well as many other supply chain issues.

Our team developed new procedures for the company, as well as cost savings analyses to mitigate new supply and capacity planning issues. We also constructed a roadmap to help G-Mart execute initiatives that implement the new strategies in both qualitative and quantitative approaches. The scope of the project is to stabilize G-Mart's supply chain by executing improved operational processes. The results of the processes and roadmap being implemented will improve demand planning in order to improve all supply chain operations. Increased supply chain functionality will improve the forecasting of demand for customers and increase customer satisfaction. Once this roadmap has been implemented, G-Mart will have a highly responsive and well-planned supply chain that will be able to handle fluctuating demand from customers. This approach will improve supply chain operations for the company and will increase customer satisfaction in the long run.

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Caterpillar
End-to-End Kit Process Optimization

Caterpillar is a leading manufacturer of construction and mining equipment, highway diesel and natural gas engines, industrial gas turbines, and diesel-electric locomotives. To provide additional value to customers, Caterpillar assembles aftermarket service kits for their products. This allows the customer to purchase an entire kit for their service needs rather than tediously buy all the necessary parts individually.

Caterpillar is partnered with Michigan State University to improve the assembly process of such kits within Caterpillar's Midwest Logistics Center, located in Champaign, Illinois. Further, it is hoped that investigation into the kitting process will help to reduce downtime and the reliance on labor in an increasingly competitive labor market. The kitting process primarily consists of a manual operation with the use of several heat sealers, autobaggers, and both line and pack station style assembly.

Provided data includes aftermarket kit demand, packaging data for each kit, and a CAD drawing of the current facility layout. Our team plans to focus on three major areas of investigation: organizing part storage via a zoning system; reducing the overuse and subsequent downtime of autobaggers by strategically grouping parts within a kit; and improving process flow via layout change.

To establish the zoning system, we will use the kit demand data to better prioritize storage and reduce physical labor. Kit parts will be zoned based on their demand volumes. Additionally, the team has divided the kitting data equally to establish a sub-kitting system and other grouping parameters. This grouping will result in a reduction of autobags per kit. Finally, given the CAD drawing, we will investigate various layouts and utilize the Arena simulation tool to test their effectiveness.

Implementing these changes will allow Caterpillar to optimize their end-to-end kitting process in a realistic, simple, and efficient manner.

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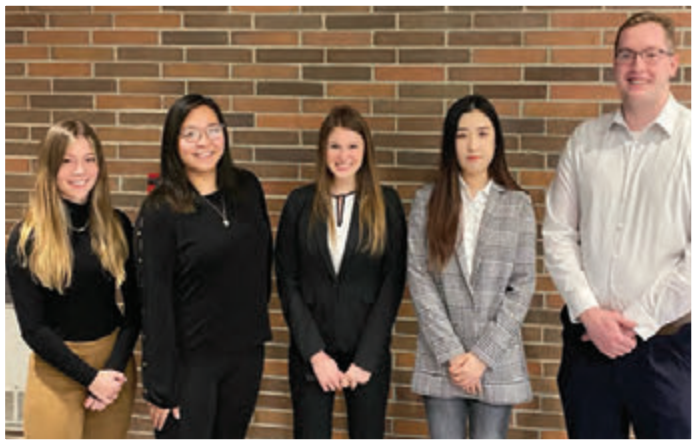
Caterpillar
Kit Assembly Automation

Caterpillar is one of the world's leading manufacturers of construction and mining equipment, engines, turbines, and locomotives. The company's Product Support and Logistics Division assembles engine gasket repair kits that dealers order to support maintenance and repair of equipment in the field. On the main production line, there are 25 different kits of various demand that share 64 consistent part numbers. The parts are organized in drawers on the shelves above the line, and the full process of assembling these kits currently takes seven full-time employees to operate, with an average of 590 kits per day.

The sponsor is looking to incorporate some automation into the current kit assembly process in order to improve efficiency and lower labor costs. Our team has been tasked with finding creative solutions and opportunities to integrate automation which can then be presented to Caterpillar's upper management. The goal is to propose equipment and processes, along with other relevant deliverables, to automate the assembly in order to maximize the reduction of the manual labor component and to increase productivity.

By calculating the cost of integration and through the implementation of various robotics, we have developed a floor plan that not only automates this current assembly kit process, but increases both productivity and efficiency as well. Our plan is set to take the place of the current manual setup and will provide Caterpillar the necessary tools it needs to better meet the demand of its customers.



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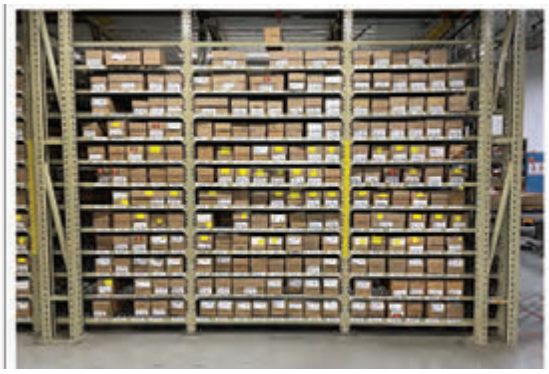
Caterpillar
Small Part Distribution Optimization

Caterpillar is an American Fortune 100 company that is a leader in manufacturing construction equipment. This project is based on Caterpillar's ability to distribute and store common parts used in assembly lines across the globe. The Caterpillar Manufacturing Parts Nodes (MPN) Network uses a cardboard box as the main method and the goal is to determine if there is another method to use for distribution and storage. Typical parts stored in these boxes are nuts, bolts, and seals. Pieces per box can range from 2 to 10,000. The box quantities are determined by size and usage of each part. Currently, some boxes are packed completely full, while others are 90% empty. These boxes still take up the same amount of space, regardless of how many parts are in the box. This project will evaluate if a box is the optimal storage and distribution method for all common parts and investigate ways to reduce overall space requirements for the warehouse and/or the assembly line.

The opportunity our team is focusing on for this project is finding a more efficient way to store parts that do not utilize the entire box capacity. The parts that do not utilize the entire box and are not used frequently could be moved to a bin storage system, freeing up space on the gravity runs to store more frequently used parts. This would in turn reduce overall space requirements for the warehouse, and potentially the assembly line, while also decreasing transportation costs by reducing shipments of regularly used parts. With fewer orders, there could also be a decrease in the labor needed to fill orders and stock warehouse shelving.



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Guardian Glass
Stock Level Optimization Tool

Guardian Glass is one branch of the globally expansive Guardian Industries. Guardian Glass is a privately held glass manufacturer headquartered in Auburn Hills, Michigan. They manufacture approximately 500 km of float glass each day for commercial, residential, and automotive applications. With more than 160 countries served across five continents, they are one of the world leaders in glass production.

Guardian Glass has completed some of the most spectacular buildings in the world while maintaining a zero net energy consumption, notably, the VISA Headquarters in Dubai; Le Cristallin in Boulogne-Billancourt, France; and the Bioengineering Research Facility at Michigan State University.

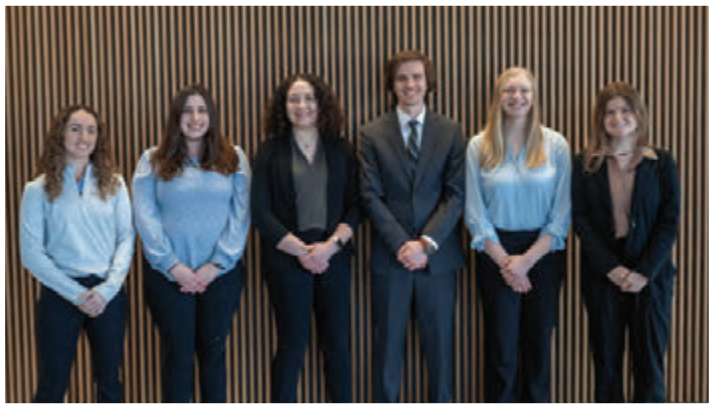
Managing and evaluating necessary inventory is only a fraction of the work done at Guardian's plant in Carleton, Michigan. However, it is one of the most important tasks for their success. For this project, the team was tasked with developing an automated tool that enables real-time calculations and evaluation of min and max stock levels. Our team will also create a statistical method to determine which products should be used as "make-to-stock."

The analysis will consider historical sales data and consumption data to provide insight into how Guardian should be stocking different SKUs across manufacturing facilities. Production cycles and variability will also be factored. The intent is to update inventory levels based on future demand. This tool is one that hopefully will impact not only Guardian's plant in Carleton, but also their worldwide facilities.

The tool will be easily adaptable to integrate with a future ERP and will be an input for Guardian's scheduling and planning processes. A visual representation of the data, created in PowerBI, will also be constructed as a secondary element of the tool. This project will reduce Guardian's working capital, identify opportunities for SKU rationalization, and enable them to better serve clientele.costs for both the supplier and the buyer should be minimized.

GUARDIAN® GLASS

See what's possible™



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Presentation Schedule – 2nd Floor Engineering Buliding, Room 3400

Time	Team Sponsor	Project Title
8:00 a.m.	RPM	Reducing the Carbon Footprint
8:25 a.m.	RPM	Streamlining the Home Delivery & Pick-Up Processes
8:50 a.m.	RPM	Capacity Aggregation
9:15 a.m.	Applied Materials	Commodity Hedging Program
9:35 a.m.	BREAK	
9:50 a.m.	Asahi Kasei Plastics	Line Capacity & Rebalancing Dashboard
10:15 a.m.	Snackwerks	Single Station Automation Project
10:40 a.m.	RENK	Best-in-Class Key Performance Indicators
11:05 a.m.	RENK	Purchase Order Compliance Package Process

Applied Engineering Sciences Awards

The Applied Engineering Sciences Design Program presents three awards on Design Day. The Most Impactful Award is given to the team whose project will potentially have the most immediate impact on their sponsor. The team whose project will produce the most sustainable results for their sponsor receives The Most Sustainable Award. Finally, The Mike Sadler Competitive Edge Award is given to the team that strives to achieve the highest possible outcome in order to attain the next level of success. The winning project is considered to have "flipped the field" with an innovative and creative solution that results in a competitive edge that not only solves the problem but distances itself from the competition.

RPM Freight Systems
Reducing the Carbon Footprint

For this project, RPM asked our team to attack the biggest issues facing the company as well as the environment, CO_2 emissions. The importance of reducing CO_2 emissions has been brought to light for a while now but as far as for a logistics company, where they own none of the vehicles and only oversee them, this has never been done before.

Since RPM does not own any of the vehicles that are transporting the cargo, our team must find a creative solution to solve this. Before reducing any of the emissions, we must get a baseline of RPM's CO_2 emissions to calculate a feasible reduction. Gathering data from the sponsor as well as educated assumptions, our team will be able to estimate the emissions released from trucks for a given trip, as well as the yearly emissions released.

One of the many ideas we came up with was to team up with a company specializing in offsetting emissions and process some of the payments to drivers through them. This would provide the company with some reductions in the total emissions they produce, as well as making the world more sustainable for generations to come.

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RPM Freight Systems
Streamlining the Home Delivery & Pick-Up Processes

RPM Freight Systems (RPM), founded in 2012, is one of the fastest-growing private logistics companies in North America. The company operates as one of the nation's top quality logistics brokerages and facilitates on-demand transportation services for businesses that are experiencing unexpected insufficiencies. RPM has a large transportation network of freight systems partnering with 30,000+ carriers across the United States and Eastern Europe. Currently, RPM transports 30,000+ automobile units a month and is looking to expand upon that market.

With auto-manufacturers adopting e-commerce automobile sales, and the direct delivery to consumer market growing, RPM is seeking to capitalize on the home delivery and pickup of vehicles using their vast logistics network. Our team is tasked with developing an in-depth market study of the home delivery and pick-up processes to further aid RPM's goals.

In order to generate an impactful project for RPM, the team delivered various reports including cost analysis breakdowns, quantitative and qualitative data, Porter's Five Forces models, market research reports, SWOT analysis reports, and other market measures. With these reports, we provided a data driven breakdown of RPM's competitive position to enter this direct-to-consumer car market, as well as generated a measurable standard from which RPM can gauge their market opportunities alongside customer satisfaction and areas of vulnerability.

By applying the best market practices outlined in this project, the company will be able to effectively utilize their current model of operations and capitalize on the supply chain of the growing online auto retail market.

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RPM Freight Systems
Capacity Aggregation

RPM Freight Systems is a logistics company that specializes in freight and finished vehicle transportation. They currently have over 2000 customers and partner with more than 30,000 carriers.

RPM is currently looking to identify industry-preferred communication methods in order to employ standard communication processes between RPM and carriers, as well as optimize carrier capacity. Our team has been working with RPM and researching the carriers' current methods of communication to gain perspective on which methods are currently being utilized and how they can be improved.

Communication plays a vital role in how and with whom RPM does business. Inconsistencies in communication methods are a problem across the logistics industry, and RPM is looking to identify which communication method carriers prefer to use across the board. One of the first steps of this project was the creation of surveys that would gather various perspectives from both external carriers as well as RPM's employees. Using survey data from carriers around their communication obstacles and successes, we are conducting an analysis of different methods to allow RPM to reach as many carriers as possible and ultimately optimize carrier capacity.

By finding a method of communication that is preferred by carriers, RPM will be able to create stronger relationships with those carriers. As a result of stronger relationships, RPM will be able to become a preferred shipper in the industry.

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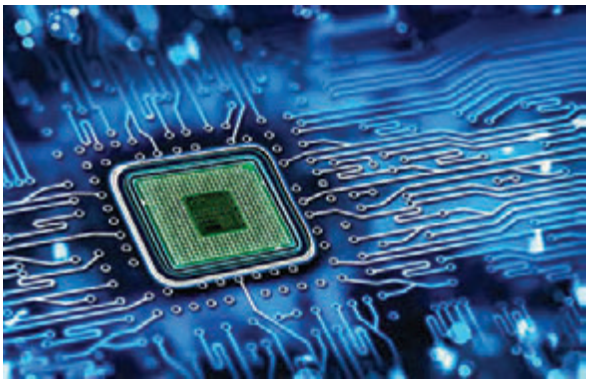
Applied Materials
Commodity Hedging Program

Applied Materials is a corporation that specializes in supplying manufacturing equipment for semiconductor companies. The commodity hedging program for Applied Materials focused on developing a tool that can protect the company's margins and provide suggestions on pricing strategy based on timing and external factors that affect cost. By using research on best-known methods (BKM) for sourcing various raw materials as well as pricing trends, the team condensed the data to create a tool to predict pricing trends in Microsoft Excel and Tableau.

The project was based on developing a management approach of raw materials that consisted of aluminum, copper, and hot rolled steel/cold rolled steel. By looking at pricing trends and connecting them with relevant events (geo-political, fiscal, and more), direct links were drawn and used to draw conclusions on the reasoning behind why prices fluctuate. With the help of regression analysis, the team linked certain causal evidence for pricing which would later be useful for predicting best times to secure base prices on materials. The team researched BKMs that automotive and aerospace companies use for procurement of raw materials and used this information to provide suggestions to Applied Materials. This research was the foundation for a compilation of the findings to create a price prediction tool for Applied Materials' sourced raw materials. By using research from past years' pricing, the tool will give rough estimates for future pricing and aid the procurement team in purchasing decisions moving forward.

Ultimately, this project will help Applied Materials with their decision-making regarding sourcing strategy. This way, the company will be able to secure base prices at times in the year that are optimized by solidifying purchase dates and prices for the year. These saved resources can be reinvested into improving other aspects of the supply chain for both short and long-term benefits.



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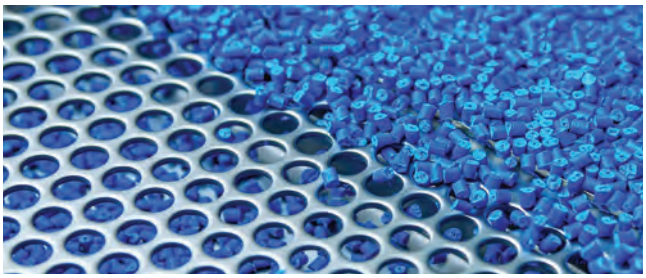
Asahi Kasei Plastics North America
Line Capacity & Rebalancing Dashboard

Asahi Kasei Plastics North America is a leading manufacturer of innovative, high performance, engineered polymers and advanced polypropylene compounds. These high-performance plastic compounds can be found in most segments of life. With roots in the automotive industry, on average about 11 pounds of plastics on cars today are sourced from Asahi Kasei Plastics. It can also be found in various other segments: pool and spa, industrial, furniture, housing, construction and many more.

Asahi Kasei Plastics has partnered with Michigan State University on a line capacity and rebalancing dashboard. Asahi Kasei has ten manufacturing lines at their Fowlerville, Michigan plant and three at their Athens, Alabama plant, all producing plastic compounds. Different materials are produced on different lines, and some materials can be produced on multiple lines. The planning team for Asahi Kasei Plastics takes monthly forecasts, purchase orders, and historical data to assign how much material needs to be produced on each line. The current COVID-19 pandemic has resulted in raw material shortages and high fluctuations in demand, which is causing frequent changeovers and unplanned downtime in the plants. As a result, Asahi Kasei is often in shortage of supply or has excess inventory.

To solve these issues, we created a dashboard that visually displays a 12-month window of supply and demand for each plant that can filter down by line, plant, month, and week. This will allow Asahi Kasei to prepare for any "what if..." scenarios and create efficiency goals per line. Our team investigated variables such as max line capacity, sales orders, and line utilization to help us throughout this semester. This dashboard was created with a stagnant data set but will be used as a template for Asahi Kasei's planning team to connect to SAP and serve as a live dashboard following completion of our project.



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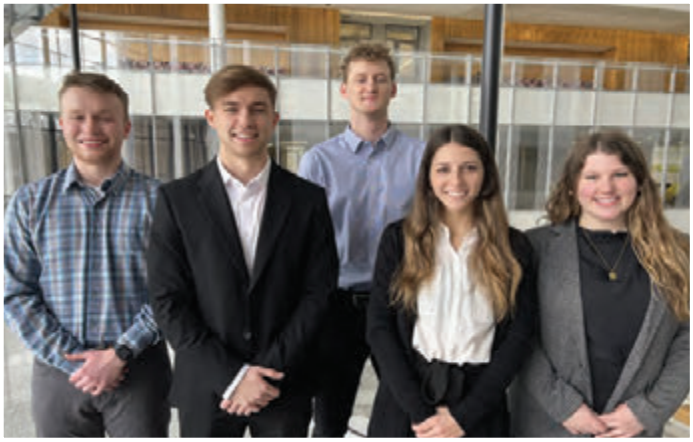
SNACKWERKS
Single Station Automation Project

Snackwerks is a contract food manufacturing company devoted to producing high quality products, upholding strong safety standards, and maintaining lean processing lines. Providing an exceptional, first-class experience to all customers is Snackwerks' number one goal.

To produce with maximum efficiency, maintain customer satisfaction, and increase profitability, Snackwerks must reevaluate their manufacturing practices. Currently, the snack packaging process at Snackwerks is done completely manually. This mundane and routine process is utilizing scarce human resources and preventing higher order work from being done elsewhere in the plant. For throughput to match demand rate and to increase efficiency of the assembly line, an automated solution is ideal. This would allow for a more consistent production process without the potential of human error.

The automated solution is to completely replace the work of two or more humans. This includes handling various pouch sizes, collection of various products into the pouch, and placing the pouch onto a conveyor for sealing. To successfully do this, proper planning and analysis must take place. This involves determining the weaknesses of the current setup, evaluating potential suppliers of automated solutions, ensuring operational and technical capacity can be met, financial analysis, and most importantly, compatibility with food safety standards. Safety is of huge concern because the production line operates three shifts a day, five days a week with interchanging products. This means it is necessary to have the ability to properly clean all machinery with ease. The success of this project will further Snackwerks' growth as a premier contract manufacturer in the food industry.



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RENK
Best-in-Class Key Performance Indicators

RENK was founded in 1873 by Johann Julius Renk, who started as a trainee mechanic and ended as a pioneer in the industrial age through development of revolutionary drive technology. RENK started as a production company producing wheel gears and quickly made it into the military scene as World War II started. The company gained notoriety for building the first reversing gear units for marine applications and achieved a record for building the fastest gear in the world. RENK has continued to evolve and is a military contractor performing on the global market.

Today RENK America is a leading global supplier of best-in-class mobility solutions. They specifically work with military combat vehicles to manufacture engines and transmissions for tanks. This project helps define and elevate key performance indicators based on importance and supply chain best practices in the industry. As a company that is continually evolving, these indicators are being tracked through internal reporting and Sisense, a data analytics software that helps visualize and organize data.

Utilizing Sisense has been an integral part of visualizing RENK's KPIs and providing a user-friendly dashboard to key stakeholders. Sisense serves as a central database for RENK's KPIs and firm information and then utilizes visualizations to tell a story with this information. Through both automatic uploads from their ERP and manual entries from Excel, this dashboard incorporates critical reports into Sisense and provides RENK with a centralized dashboard that offers transparency to the procurement team. The final dashboard shows the procurement team the most critical information which will affect their day-to-day operations, offering direction for their work in the immediate future. In turn, this information can be used to increase throughput, reduce costs, and improve execution.

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RENK
Purchase Order Compliance Package Process

RENK is a worldwide company that leads manufacturing in the production of defense vehicle transmissions and components. Due to its involvement in federal vehicle production, the purchase order process at RENK is heavily documented and time-consuming, requiring a "package" of paperwork documenting the process in detail. It involves many variables which, due to the detail required, increases the possibility of error with every step.

Our team was asked to decrease risk throughout the purchasing process by simplifying it. We first took a trip to RENK's location in Muskegon, diving firsthand into the process. This allowed us to determine the thoroughness needed, as well as the excessive complication of the problem. Following this, we worked on their deliverable; a simplifying tool for RENK to implement in their everyday work.

By combining experience learned in classes, as well as researching current purchasing process innovations, our team collaboratively created a tool to improve the efficiency of the purchase order compliance package creation process at RENK. The tool included using Microsoft Excel to combine all documentation into one checklist, which could easily be edited and summarized.

Throughout the semester, we made progress in streamlining the purchase order compliance package creation process, reducing time requirements for buyers, and cutting costs for RENK. Our team delivered a smart checklist to provide a concise template for the purchase order package creation system and provide a foundation for further improvements to the purchasing process.

Michigan State University
Team Members (left to right)

Cole Gibbs
Bloomfield Hills, Michigan

Kory Ernster
Novi, Michigan

Addison Dunham
Leslie, Michigan

Maggie Lear
St. Joseph, Michigan

RENK
Project Sponsors

Sarah Batchelder
Muskegon, Michigan

Rick Douglas
Muskegon, Michigan

Chase Kloka
Muskegon, Michigan

Ryan Norwood
Muskegon, Michigan

Mark Zelek
Muskegon, Michigan

Teaching Assistant

Akash Mehrotra

AESC Awards 2021

The 2021 AESC Most Impactful Award:

Team NASA Psyche:
Mission to a Metal World
"Launch Lead-Up Analysis"

Left to right: Anna Mae Crowley, Julie Walczak, Morgan Tasch, Xi Chen, Victoria Lankton

The 2021 AESC Most Sustainable Award:

Team American Axle & Manufacturing
"AAM NA Transportation Network Optimization"

Left to right: Aidan Fox, Andrew Barton, Kate Cousino, Andrea Vortriede, Daniel Sim, Victor Szymanski

AESC Awards 2021

As punter for Michigan State University's football team, Mike Sadler was well known for giving his team a competitive edge by flipping the field with perfect punts that pinned the opponents back near their own end zone.

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

Mike was the first football player in Spartan history to earn Academic All-America honors four times. He was a two-time first-team Academic All-American, a National Football Foundation Scholar-Athlete, and a William V. Campbell trophy finalist.

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

The Mike Sadler Competitive Edge Award is presented annually to the Applied Engineering Sciences capstone team that that strives to achieve the highest possible outcome in order to attain the next level of success. The winning project is considered to have "flipped the field" with an innovative and creative solution that results in a competitive edge that not only solves the problem but distances itself from the competition.

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

- Mike Sadler

AESC 2021 Mike Sadler Competitive Edge Award

Team Consumers Energy

"Supplier Diversity Workstream and Vendor Analysis"

Left to right: Montserrat Lewin Meija, Allana Huttenlocher Cunha, Nicole Harmsen, Ayodeji Jubreel, Joseph Schultz

The Capstone Projects Biosystems & Agricultural Engineering

Dr. Dana Kirk, PE
Assoc. Professor
Biosystems &
Agricultural Engineering

Dr. Luke Reese
Assoc. Professor
Biosystems &
Agricultural Engineering

About the Program

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

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

BE 485 / BE 487 Courses

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

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

2021/22 Projects (title, client & team)

Full descriptions, short videos, and project posters are at:
www.egr.msu.edu/bae/SS22NewsBEShowcase

Sterilization of male sea lamprey with Bizair
United States Geological Survey *(project under Non-Disclosure Agreement)*
Team USGS - Madalyn Allen, Catherine Christenson, Ryan Snyder, & Jacob Soullier
Faculty Advisor - Dr. Ilce Medina Meza

Ingham County Fairgrounds and Potter Park Zoo organic waste management
Ingham County
Team The Red Pandas - Brian Bilan, Sidney Fenton, Erica Peer, & Alex Seybold
Faculty Advisor - Dr. Dawn Dechand

Nitrogen stripping and ozonation columns for wastewater treatment at remote army bases
Department of Defense
Team DOD - Skijlar Howerzyl, Arun Kammanadiminti, Jack Kivi, & Melanie Stoughton
Faculty Advisor - Dr. Wei Liao, PE

Reducing labor with an improved red swamp crayfish capturing device
Michigan Department of Natural Resources
Team InCraysive - Adam Harris, Michael Kaven, Alayna Peterson, & Brenna Tiernan
Faculty Advisor - Dr. Wei Liao, PE

Whey protein and lactose recovery
Tillamook *(project under Non-Disclosure Agreement)*
Team Whey Stream - Peyton Carroll, Hannah Craig Malich, Stephanie Starr, Zach Tonnerre, & Sierra Veenkant
Faculty Advisor - Dr. Bahar Aliakbarian

Residual product recovery from manufacturing tanks for Unilever
Unilever *(project under Non-Disclosure Agreement)*
Team Unilever -Yassah Bah-Deh, Julie Celini, Aubrie McCleery, & Tyler Stump
Faculty Advisor - Dr. Yan "Susie" Liu

Mobile decentralized treatment system for domestic septage utilizing innovative aeration
Greener Planet Systems *(project under Non-Disclosure Agreement)*
Team Greener Planet Systems - Conor Crennell, Annaliese Marks, Jacob Mears, & Molly Robles
Faculty Advisor - Dr. Steve Safferman, PE

Microscale biogas plant design
Goloka Ecology Model
Team Goloka - Trenten Beemer, Zachary Buhro, Kaitlin McHenry, & Jordan Neal
Faculty Advisor - Dr. Dana Kirk, PE

Optimizing an ozone processing system against *E. coli* on whole-muscle beef
E W Grobbel *(project under Non-Disclosure Agreement)*
Team Grobbel - Tala Abdulqader, Ian Klug, Andrea Ma, & Kase Nelson
Faculty Advisor - Quincy Suehr

BIGGBY® COFFEE store-level environmental assessment: Data analysis and visualizations
BIGGBY® COFFEE *(project under Non-Disclosure Agreement)*
Team Go BIGGBY® or Go Home - Emily Ajemian, Taryn Hanses, Ashley Hestad, & Chris Wentworth
Faculty Advisor - Dr. Christopher Saffron

Sterilization analysis of evaporator coil using UVC light for industrial food processing freezers
John Bean Technologies (JBT) Foodtech *(project under Non-Disclosure Agreement)*
Team JBT - Nyilah Congress, Shreyas Ramachandran, Nick Saba, & Ashley Xu
Faculty Advisor - Dr. Sanghyup Jeong, PE

Improved hydraulic-powered plastic mulch removal implement for MSU Student Organic Farm
MSU Student Organic Farm
Team Student Organic Farm - Ian Chesla, Kristin Danz, Brenden Kelley, & Lisa Zou
Faculty Advisor - Dr. Ajit Srivastava

Packaging line improvement using Arena simulation software at a pharmaceutical plant
Perrigo *(project under Non-Disclosure Agreement)*
Team Perrigo - Chehak Arora, Katie Blouin, Maryam Ezz, & Nicolas Scamardi
Faculty Advisor - Dr. Kirk Dolan

Industry Advisory Board & Project Evaluators

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

Board

Janelle Boosi - Kellogg
Holly Bowers - Consumers Energy
Jessica Bruin - Nestlé Nutrition
Lisa Buchholz - Corteva Agriscience
Matt Burtt - AbbVie
Shelley Crawford (Chair) - Jiffy
Michelle Crook, PE - MDNR
Laura Doud, PE - MDARD
Cassaundra Edwards - Tillamonk Creamery
Gene Ford - Standard Process
Jeremy Hoeh, PE - MEGLE
Eric Iversen, PE - LSG Engineers and Surveyors
Kevin Kowalk, PE - EA Engineering, Science, and Technology (MI) PLC
Jeffrey Mathews, PhD - PepsiCo Global Beverage R&D
Mitch Miller - General Mills-Yoplait
Steve Radke, PhD - John Bean Technologies (JBT)
Nate Wood, PE - Perrigo
Rob Yoder - BDI, Inc.

Board (Ex-officio)

Todd Forbush, Techmark, Inc. (ASABE MI Section)

BE Showcase Public Presentations - April 28, 2022
www.egr.msu.edu/bae/SS22NewsBEShowcase

Virtual BAE 2021_22 Industry Advisory Board Meeting
October 21, 2021

If you are interested in sponsoring a BE 485/487 capstone project for the 2022_23 Senior Design teams, please contact Dr. Dana Kirk at kirkdana@msu.edu or Dr. Luke Reese at reesel@msu.edu.

The Capstone Projects

Mr. Anthony Ingle
Teaching Specialist

Faculty Advisors: Professors Dickinson, Engle, Haider, Hashsham, Ingle and Li


Dickinson


Engle


Haider


Hashsham


Ingle


Li

Presentation Schedule – Room 1225

Time	Team	Room
8:00 a.m.	Team 1 – Spartan Design Group	First Floor Room 1225 EB
9:20 a.m.	Team 2 – Endpoint Civil and Environmental Engineering Firm	First Floor Room 1225 EB
10:40 a.m.	Team 3 – Engineering by Nemo	First Floor Room 1225 EB

Presentation Schedule – Room 1230

Time	Team	Room
8:00 a.m.	Team 4 – Midwest Civil Design, LLC	First Floor Room 1230 EB
9:20 a.m.	Team 5 – G & W Consulting Group	First Floor Room 1230 EB
10:40 a.m.	Team 6 – RCE Consulting	First Floor Room 1230 EB

Presentation Schedule – Room 1234

Time	Team	Room
8:00 a.m.	Team 7 – J.L. Engineering	First Floor Room 1234 EB
9:20 a.m.	Team 8 – Agent of Construction	First Floor Room 1234 EB
10:40 a.m.	Team 9 – Precision Engineering	First Floor Room 1234 EB

Presentation Schedule – Room 2243

Time	Team	Room
8:00 a.m.	Team 10 – White Pine Engineering Group	Second Floor Room 2243 EB
9:20 a.m.	Team 11 – Titan Engineering	Second Floor Room 2243 EB
10:40 a.m.	Team 12 – GLA Engineering Services	Second Floor Room 2243 EB

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, transportation, and structural issues for the project. A student project manager coordinates each team. Design reports are judged by the faculty; progress reports and the oral presentations are judged by a board of practicing professionals.

CE 495 SENIOR DESIGN IN CIVIL & ENVIRONMENTAL ENGINEERING

TechSmith New World Headquarters

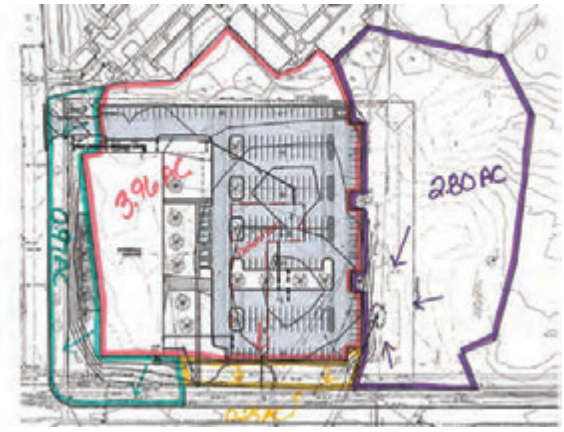
Michigan State University continues to implement its vision of redeveloping the 140-acre Spartan Village into a technology and innovation campus. Recently Michigan's governor and the MSU president were among others who announced the construction of a new headquarters for Techsmith, a software development company previously located nearby. The new 62,500 square-foot headquarters is being developed in partnership with the MSU Foundation on approximately 5 acres of land at the corner of South Crescent and Harrison Road.

The project should emphasize 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 university is seeking proof-of-concept level designs that examine how green infrastructure could be integrated into the particular site to meet multiple environmental, educational, and economic objectives. The development must be consistent with MSU's campus master plan.

Aerial photograph of site location

Architectural rendering of proposed building
- $15 million capital investment
- 330+ employees and student interns

- 62,500-square-foot, two-story building
- Located on 5 acres of land in Spartan Village
- Groundbreaking was in June 2021 and completion by June 2022



TechSmith New World Headquarters

KEY TO TEAM ROLES

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

Team 1: Spartan Design Group
Left to right: Evan Huckins (H), Tanner Cronin (S), Nathan Melasi (E), Katelyn Kubalanza (T), Elizabeth Kleinschmidt (G), Cara Bonshak (P), Tyler Ball (PM)

Team 2: Endpoint Civil and Environmental Engineering Firm
Left to right: Caitlin Woolsey (S), Connor Merchant (E), Rick Fu (P), Caitlin Colsia (PM), Drew Frenzel (G), Dani White (T), Ryan Poe (H)

Team 3: Engineering by Nemo
Left to right: Eli Costerisan (G), Brendan Holbrook (P), Josh Steed (E), Erinn Costello (PM), Aditi Mahantesh (E), Kyra Gerlofs (H), Wendy (Ruowen) Xu (S), Lauren Hull (T)

Team 4: Midwest Civil Design, LLC
Left to right Francisco Campos-Iannacone (S), Mason Manuszak (H), Michael Gatz (P), Jack Fiegl (PM), Jacob Barth (G), Hannah Pfeiffer (T), Molly Weiblen (E)

Team 5: G & W Consulting Group
Left to right: Obaid Tahnon (T), Steven Taormina (P), Vincenzo Finazzo (PM), Brennan Swix (S), Benjamin Schwalbach (G), Chase Fedolak (H), not pictured: Kelly Jardine (E)

Team 6: RCE Consulting
Left to right: Ryan Shafer (G), Holly Demers (E), Sabreen Alado (S), Elvis Gibbs (PM), Hank Zhang (P), Bob Apoian (T), Paige Tompsett (H)

TechSmith New World Headquarters

KEY TO TEAM ROLES

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

Team 7: J.L. Engineering
Left to right: Justice Lewis (PM), Vincent Marinelli (H), Nathan Bessey (P), Sydney Hilbrandt (T), Robert Kowalczyk (T), Robert Mooney (S), Jared Gailitis (G)

Team 8: Agent of Construction
Left to right: Nikolas Bauer (G), Cara Luckett (PM), Bryan Reppenhagen (T), Ashley Mckibbon (E), Liam Coleman (S), Ritwik Verma (H), Lavelle Washington (P)

Team 9: Precision Engineering
Left to right: Anna Fischer (G), Jacob Steenburg-Sorrell (S), Noah DeBrot (T), Greyson Meyers (PM), Areli Cardenas (P), Tage Heyn (H), Courtney Turner (E)

Team 10: White Pine Engineering Group
Left to right: Brendan Ryder (G), Andrew Cummings (E), Evan Martin (H), Ali Lazzara (P), Matt Pfeiffer (PM), Claire Wojno (S), Nichole Richards (T)

Team 11: Titan Engineering
Left to right: Thomas Alsobrooks (G), Matthew Henkey (S), Matthew Parran (E), Elise Spohn (P), Elizabeth Pozza (PM), Casey Meyer (T), Katherine Miller (H)

Team 12: GLA Engineering Services
Left to right: Madeline Robison (H), Bridget Pliska (P), Tammy Le (S), Grant Gardella (G), Phyllis Feldpausch (E), James Guest (T), Emily Spranger (PM)

CE 495 SENIOR DESIGN IN CIVIL & ENVIRONMENTAL ENGINEERING

PROFESSIONAL SEMINAR SPEAKERS

Michele Buckler, P.E.
Daimler Automotive Group

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.

Jill Bauer, P.E.
ROWE Professional Services

Sam Baushke, P.E.
Geosyntec

Dani Booms, P.E.
HTNB

Michele Buckler, P.E.
Daimler Automotive Group

Erik Carlson, P.E.
Michigan Department of Transportation

Dan Christian, P.E.
Tetra Tech MPS

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

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

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

Mike Ellis, P.E.
Barr Engineering Co.

David Hayden
DLZ

Megan Jacobs, P.E.
Soil & Materials Engineers, Inc.

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

Peter Margules, P.E.
NTH Consultants

Giovanni Mauro, P.E.
Mauro Engineering

George McKenzie II, P.E.
Consumers Energy

Cole Moody, P.E.
HTNB

Jon O'Brock, P.E.
Materials Testing Consultants

Maurio Quagliata, P.E.
Bergmann Associates

Lauren Roller, P.E., S.E.
Harley Ellis Devereaux

Sarah Ross, P.E.
Practical Engineers, Inc.

Steven Sorensen, P.E.
PEA Group

Stephen Subu
Consumers Energy

Michael Thelen, P.E.
Consumers Energy

Phillip Vogelsang, P.E.
AECOM

Jon Ward, P.E.
ROWE Professional Services

Emily Warners, P.E.
Consumers Energy


MARBLE

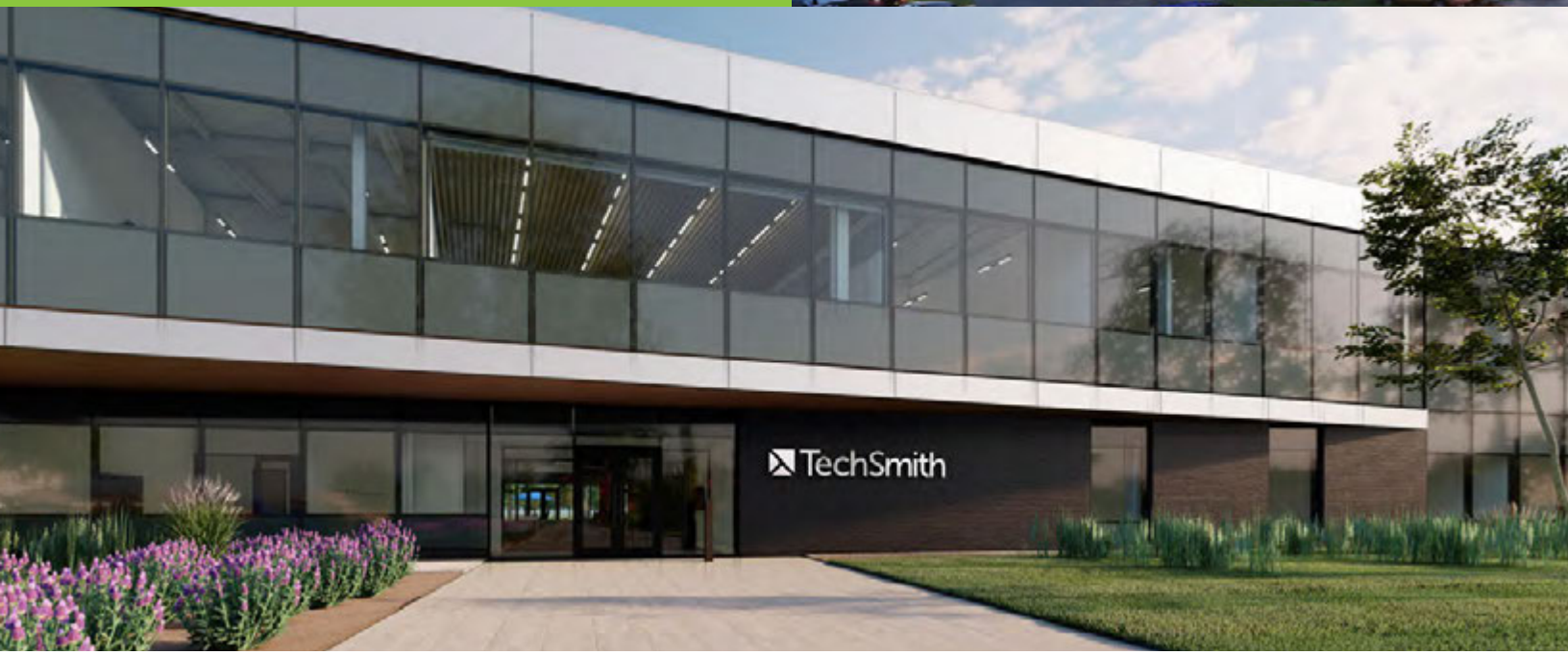

engineering
SPARTANS
WILL.


CSE
Computer
Science &
Engineering

ABOUT US

The MSU Foundation drives economic development by supporting grant programs, venture creation, venture investment, and placemaking initiatives across Michigan.

MICHIGAN STATE UNIVERSITY
FOUNDATION



Driving an Innovation Ecosystem

The Michigan State University Foundation is a nationally recognized 501(c)(3) nonprofit research Foundation dedicated to advancing education and research. Our mission is to serve Michigan State University and provide solutions to the specific needs of our partners. In addition to our venture creation activity including $30M in venture funds, we're proud to be working with TechSmith and McLaren Greater Lansing to drive the development of innovation communities and state-of-the-art facilities for greater collaboration with Michigan State.

www.msufoundation.org

SPARTAN INNOVATIONS

RED CEDAR VENTURES

MICHIGAN RISE

MSU INNOVATION NETWORK

ChE Process Design and Optimization

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

Ziwei Wang
Graduate Student & Teaching Assistant of Chemical Engineering

Course Description

The Chemical Engineering Program's capstone design sequence includes Process Design and Optimization I and II (CHE 433 and 434, respectively). In these courses, students integrate content from earlier courses for complex, open-ended design assignments. As the students progress through ChE 433, their assignments require increasingly more effort, initiative, knowledge and individual responsibility. In CHE 434, students design an entire commercial-scale chemical plant and use detailed economic analyses to optimize the plant's profitability. For over 50 successive years, MSU's CHE 434 students have worked intensively one to two months to develop a solution to the annual American Institute of Chemical Engineering (AIChE) Student Design Competition problem. MSU's Chemical Engineering Program uses these realistic, industry-based problems to enhance chemical engineering students' capstone design experience for three reasons: 1) the AIChE problems provide real-world, open-ended design experiences typical of those students are likely to face after graduation; 2) they require students to do self-directed, active learning, including project-specific research, to solve the problem; and 3) they serve as a national benchmark for MSU's chemical engineering students to demonstrate excellence in their professional skills.

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

National Awards in 2020 Design Competition

Since 1968, MSU has had the best record nationally for awards in the AIChE Student Design Competition. In the 2020-2021 competition, four MSU students won national awards. In the individual category, **Evan Litch** won first place, receiving the A. McLaren White Award for best overall design. **Austin Alexander** won first place in the Best Applications of the Principles of Chemical Safety, receiving the Walter Howard Design Award in the individual category. Alexander also took second place in the best overall design category, receiving the A.E. Marshall Award. Additionally, two MSU students were awarded with the top honor in this year's team category. **Austin Jenner** and **Ian Scheper** won the Jack Wehman Design Award in the Best Applications of the Principles of Chemical Process Safety team category. All four students graduated in 2021 with degrees in chemical engineering.

AIChE®

Evan Litch (left) and Austin Alexander

Austin Jenner (left) and Ian Scheper

Gas-to-Liquid-Fuel Modular Manufacturing Plant

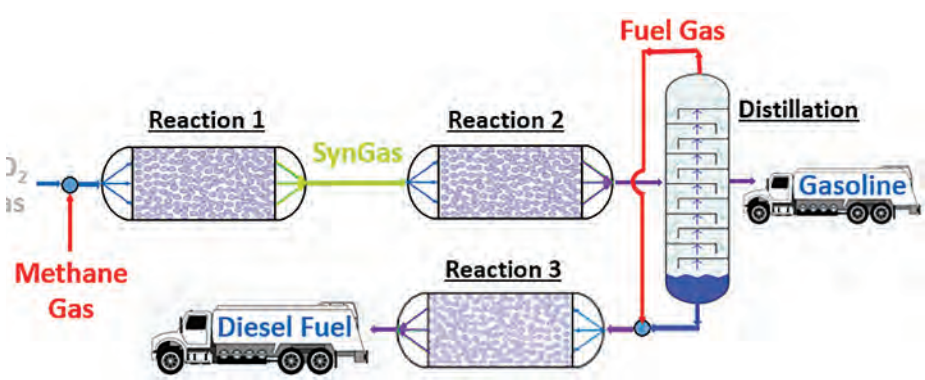
This year's AIChE Student Design Competition problem is to design relatively compact, "modular" chemical plants to produce liquid transportation fuels, such as synthetic gasoline and diesel fuels, from the gases methane (CH_4) and carbon dioxide (CO_2). The novel modular approach is optimal for recently discovered natural gas deposits in remote locations, where it would not be cost-effective to build full-scale petrochemical processing plants. At these remote sites, the energy contained in the natural gas (predominantly methane) would be concentrated in the form of liquid transportation fuels and then transported to a central distribution facility. Simultaneously, the greenhouse gas CO_2 would be captured in a useful product, rather than being released into the atmosphere.

The process flowsheet for this problem is shown in Figure 1. First, the methane and carbon dioxide gases are combined and converted in Reaction 1 into a synthesis gas (SynGas), which is a mixture of carbon monoxide and hydrogen gases. Then, the SynGas is converted in Reaction 2 into a mixture of gas and liquid products. Next, the mixture is separated by distillation into a fuel gas stream, a synthetic gasoline product, and a heavier liquid stream. Finally, the heavier liquid and fuel gas streams are combined and converted in Reaction 3 into a synthetic diesel fuel product.

While the chemical reactions involved in this design challenge problem are not novel, the increased emphasis placed on minimizing the modular plants' energy consumption and environmental impact is. In addition, an increased emphasis is placed on having students base their design decisions on a broad range of public health, safety, and welfare concerns, as well as make informed judgments considering the impact of their engineering solutions in global, economic, environmental, and societal contexts.

Students submit their solutions to the AIChE Student Design Competition problem as reports up to 150 pages long. These reports include details of the manufacturing plant's equipment, operating conditions, personnel needs, capital investment, and a complete economic analysis that gives the expected discounted-cash-flow rate of return on the company's investment. The reports are graded based on both their technical quality and their communication effectiveness. Because design reports in industry must be understandable by high-level decision makers having various academic backgrounds, the reports must communicate effectively with a wide range of audiences.

Gas-to-Liquid-Fuel Process Flowsheet for 2021-2022 AIChE Student Design Competition Problem

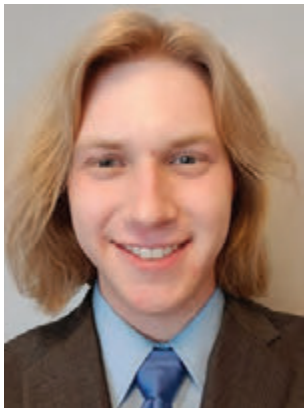


Student Poster Presenters on Design Day

The CHE 434 students below are presenting a lay-level poster of their design solutions to the AIChE Design Competition problem and discussing with visitors the advantages of careers in chemical engineering.

Students Presenting an Individual Solution to the AIChE Team Competition Problem

Students presenting an Individual Solution to the AIChE Team Competition Problem include Auden Chase (shown right) and Nishan Rankothge (picture unavailable).



Auden Chase

Students Presenting an Individual Solution to the AIChE Team Competition Problem Not pictured:

Nishan Rankothge

Students Presenting a Two-Person Solution to the AIChE Team Competition Problem

Students presenting a Two-Person Team Solution to the AIChE Team Competition Problem include Shay and Emma Smith (both shown right) and Mercy Crocker and Carson Malhado (picture unavailable).

Shay Ladd (above left), Emma Smith (above right)

Students Presenting a Two-Person Solution to the AIChE Team Competition Problem Not Pictured:

Mercy Crocker,
Carson Malhado

The Capstone Projects

Dr. Martin Crimp
Professor of Chemical Engineering and Materials Science

JoAnn Bellor
Graduate Teaching Assistant

Tyler Johnson
Graduate Teaching Assistant

Course Description

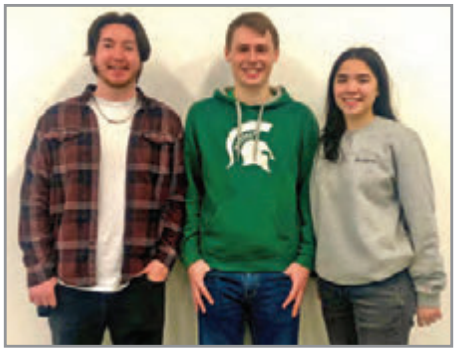
MSE466 is a senior level course for Materials Science & Engineering majors providing students with a team-based capstone design experience. A major aspect of this course is to have students apply their course-learned background knowledge and skills in materials science and other disciplines to real-life design problems. A failure analysis investigation (FAI) fits this context. Failures are a major motivating factor for promoting more innovative designs or design changes. A failure analysis investigation provides a unique platform to design and to solve real-world engineering problems via a systematic engineering approach. By focusing on a specific design failure, the student teams learn how to confront an open-ended problem that requires them to develop a strategic design plan and to execute the methodology for assessing how and why the failure occurred. The analysis is conducted using established investigative procedures and constraints for conducting failure analysis investigation. This semester, there are ten 3-member teams working on ten real engineering failures.

Presentation Schedule – First Floor Room 1145

Time	Team	Project
8:00 a.m.	Axlerod Analyzers	Honda Axle Failure Analysis
8:20 a.m.	The Icebreakers	Failure Analysis of a Hopkins Snowbrush Bearclaw Fracture
8:40 a.m.	The Case Closers	Fracture Analysis on a Cast Aluminum Chain Link Gate Closer
900 a.m.	East Lansing Vice	Examining the Failure of a Swordfish 100mm Bench Vise
9:20 a.m.	Engine Turm-oil	Failure Analysis of a Rotary Oil Pump
9:40 a.m.	Wrench in the Plans	Failure Analysis of a Torque Wrench Driver
10:00 a.m.	Porosity Prosecutors	Analysis of a Lift Truck Transmission Case
10:20 a.m.	Facts and Pinions	Analysis of a Failed Pinion Gear
10:40 a.m.	Unhinged	Failure Analysis o fa Residential Cabinet Hinge
11:00 a.m.	Wheely Worn Out	Analysis of a Failed Wheel Bearing

MSE 466 Fracture and Failure Analysis

Successfully completed team projects culminate in a comprehensive written final report and a strategic redesign plan to improve the design and mitigate future failures. For Design Day the teams present their findings in twenty-minute presentations. For 2022, the ten teams are conducting the following failure analysis investigations:



Left to Right: Joseph May, Nathan Grain, Juliana Malinowski

Time: 8:00 a.m. | Team Name: The Axlerod Analyzers
Project Name:Honda Axle Failure Analysis

Failure analysis methods were used to determine the cause of failure for a 2003-2005 Honda front axle that was broken in half. Examining the topography and doing research on the product's history of the specimen is key in getting details on the specimen. The initial step to determining the most likely cause of failure was documentation of the specimens. Macrophotos and micrographs were taken using a DSLR camera and a stereomicroscope, respectively. The sample was then sectioned into smaller pieces so the specimens could be further examined through testing methods, like metalography, scanning electron microscopy, hardness testing and X-ray spectroscopy. These techniques revealed characteristics of the fracture surfaces, including surface roughness and patterns, how ductile or brittle the fractures were, and chemical makeup. ASTM handbooks were also used to gain a better understanding of the material and its properties. These tools for analysis indicated how the axle ultimately failed.

Left to Right: Samantha Lawlis, Claudia Kramer, Robert Kuphal

Time: 8:20 a.m. | Team Name: The Icebreakers
Project Name: Failure Analysis of a Hopkins Snowbrush Bearclaw Fracture

Ice scrapers and snow brushes are a common necessity for individuals living in climates that experience winters with temperatures below freezing. This report analyzes the failure of a plastic ice scraper that was broken into two pieces after several years of use. The type of plastic had to be identified in order to understand the nature of its mechanical properties and why the failure occurred, and several test methods were performed, including both destructive and non-destructive testing. The fracture surfaces were observed using stereomicroscopy and SEM. Finite element analysis was performed in order to test whether the failure occurred at an area of high stress.

Left to Right: Katherine Diederich, Ryan Ostrander, Conor McKinney

Time: 8:40 a.m. | Team Name: The Case Closers
Project Name: Fracture Analysis on a Cast Aluminum Chain Link Gate Closer

A chain link gate closer broke in a residential backyard in metro-Detroit during the summer of 2021. Its failure was analyzed using various techniques to determine why it failed. Initially, macroscopic and microscopic images were taken using a camera and stereomicroscope. Then, non-destructive testing techniques, including dye penetration and creation of a replica, were used to analyze the fracture surfaces. Scanning electron microscopy was used to understand the nature of the porosity and examine the fracture surface morphology. Microhardness testing was performed along with density testing for material characterization. With the use of other techniques, the gate closer's failure was identified.

Left to Right: Eric Harding, Jacob Vantol, Madelyn Anderson.

Time: 9:00 a.m. | Team Name: East Lansing Vice
Project Name: Examining the Failure of a Swordfish 100mm Bench Vise

Vises are used both in industrial settings and home workshops to firmly restrict any part that needs work done, such as grinding, cutting, or bending. The part is secured by bringing the two sides of the vise together with a lever and screw. A Swordfish 100mm bench vise featured a complete fracture from the base of the vise. The fracture surface and surrounding area were thoroughly documented and an array of analysis techniques were utilized to better understand what caused the vise to fail, including stereomicroscopy, chemical analysis, and scanning electron microscopy (SEM). Details surrounding the chemistry and microstructure of the material revealed a more complete story of what eventually led to the vise fracturing.

Left to Right: Jon Leasure, David Lambert, Max Finazzo

Time: 9:20 a.m. | Team Name: Engine Turm-oil
Project Name: Failure Analysis of a Rotary Oil Pump

An off-brand GM rotary oil pump was selected for analysis after the rotary gear mechanism failed, causing catastrophic engine failure. Oil pumps are critical for internal combustion engines. They provide lubrication and cooling to the rotating assemblies inside the engine. The failure occurred when the engine control unit (ECU) failed to limit the RPM of the engine. The part was studied using stereomicroscopy and macrophotography to study the part's fracture surfaces. Energy dispersive X-ray spectroscopy (EDS) was used to find the part's chemical makeup. Hardness testing was used to characterize the materials inside the pump. Several cross-sections were taken to determine the processing technique used to manufacture the part. This data was compared to an exemplar part that was known to meet GM specifications.

Left to Right: Chloe Arana, Kevin Dunne, William Lee

Time: 9:40 a.m. | Team Name: Wrench in the Plans
Project Name: Failure Analysis of a Torque Wrench Driver

A torque wrench driver is a bolt that transfers an applied torque from a lever to a socket. On its first use, a new chrome-vanadium (CrV) steel torque wrench driver failed while loaded below the rated maximum torque. Finite element analysis was used to render a model in three dimensions and simulate the stresses and failure under the approximate loading conditions. Metallography and chemical analysis were used to analyze the microstructure, while scanning electron microscopy (SEM) and stereomicroscopy were used to investigate the fracture surfaces and help identify reasons for failure.

Left to Right: Brenden Maedel, Matthew Adams, Conner Bastien

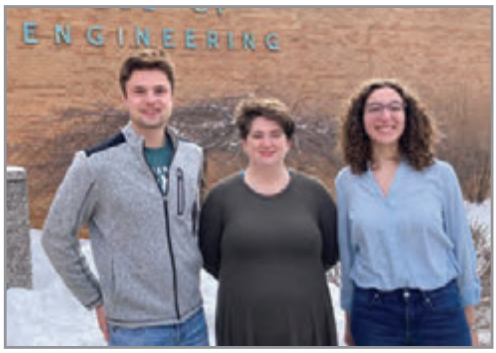
Time: 10:00 a.m. | Team Name: Porosity Prosecutors
Project Name: Failure Analysis of Lift Truck Transmission Case

Quality control during the production process is critical to ensure that no faulty products are sent to the consumers. Transmission casings for a lift truck produced in an Ohio foundry failed to meet these standards during a routine inspection. In order to gain more information about the manufacturing process, consultation was conducted with the manufacturer in regards to the casting specifications and failure criteria. The casings showed multiple signs of porosity within its surfaces. To establish a testing procedure, the surfaces of the casting were examined and documented followed by further research into the field of metallurgy. The cause of the manufacturing failure was determined through a series of tests, including, ultrasonic, dye penetrant, microstructural and chemical analysis, SEM, hardness testing and more.

Left to right: Roberto Lara, Hannah Huff, and Emily Kelly.

Time: 10:20 a.m. | Team Name: Facts and Pinions
Project Name: Failure Analysis of a Failed Pinion Gear

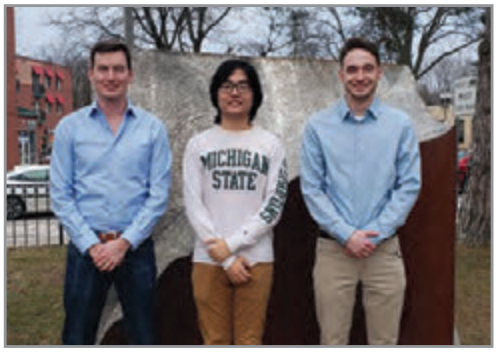
The purpose of this study was to determine the reasons responsible for the failure of a pinion gear in a 1992 Mazda Miata. Stereomicroscopy was used to investigate the macroscopic aspects of the fracture and acquire a 3-dimensional model for further in-depth inspection. To identify the metal that the pinion gear was composed of, a chemical analysis was done.This was complemented with sectioning of the pinion gear followed by scanning electron microscopy, which allowed assessment of the micromechanical failure mechanisms. A replica was created to capture loose surface debris and the fracture was cleaned to allow further inspection of the surface. Metallography was used to assess the microstructure in conjunction with microhardness testing to determine if the pinion gear was carburized. Macrohardness testing was also done to assess the general mechanical behavior.



Left to Right: Ryan Bray, Sarah Beth Holles, Bonnie Stolt

Time: 10:40 a.m. | Team Name: Unhinged
Project Name: Failure Analysis of Residential Cabinet Hinge

A crucial part of the materials science discipline is the ability to determine the causes and mechanisms of failure, which enables the development of safer products. This project sought to determine the cause of fracture in a residential kitchen cabinet hinge. Many techniques such as microscopy, chemical analysis, and metallographic analysis yielded insight into the microscopic anomalies, chemical composition, and microstructure of the part respectively. This knowledge was compiled to create a robust summary of the composition and high-stress areas of the hinge, which allowed us to determine the cause of failure for this part.



Left to Right: Gavin Reid, Shuai Liu, Nathan Fleming

Time: 11:00 a.m. | Team Name: Wheely Worn Out
Project Name: Analysis of Failed Wheel Bearing

Are your car's wheels squawking, wobbling, or making some other kind of weird noise? If so, it is probably time to replace the wheel bearing. Wheel bearings can fail in a wide variety of scenarios. This project focused on discovering the main failure mechanism for the wheel bearing. The bearing was sealed so the first step was to carefully disassemble it without causing further damage. Once the bearing had been disassembled, all of the parts were analyzed through microscopic analysis, hardness testing, and a few non-destructive techniques. These tests led us to determine the cause of failure and possible improvements for future bearings.

Computer Science and Engineering

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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 Ally Financial, Amazon, Anthropocene Institute, Auto-Owners Insurance, Caxy Interactive, CSAA Insurance, Bosch, Delta Dental of Michigan, Ohio and Indiana, Dow, Evolutio, Ford Motor Company, General Motors, Google, Kellogg's, Kohl's, Lockheed Martin Space, Malleable Minds, MaxCogito, Meijer, Microsoft, Mozilla, MSU Federal Credit Union, Rocket Companies, Scout, TechSmith, Union Pacific, United Airlines, Urban Science, Vectorform, and Whirlpool.

Ally Financial
Ally P2P Lending Platform

Ally Financial is a financial services company based in Detroit, Michigan, operating as one of the largest car finance companies in the United States. Ally offers online banking and online trading, bolstering the services they provide for their customers.

Acquiring loans is an important utility Ally provides its clients. However, sometimes customers desire to borrow a small sum of money and don't want to go through a potentially lengthy process of submission and approval to do it.

Our P2P Lending Platform enables Ally clients to quickly loan each other money without the need for a bank to be a middleman.

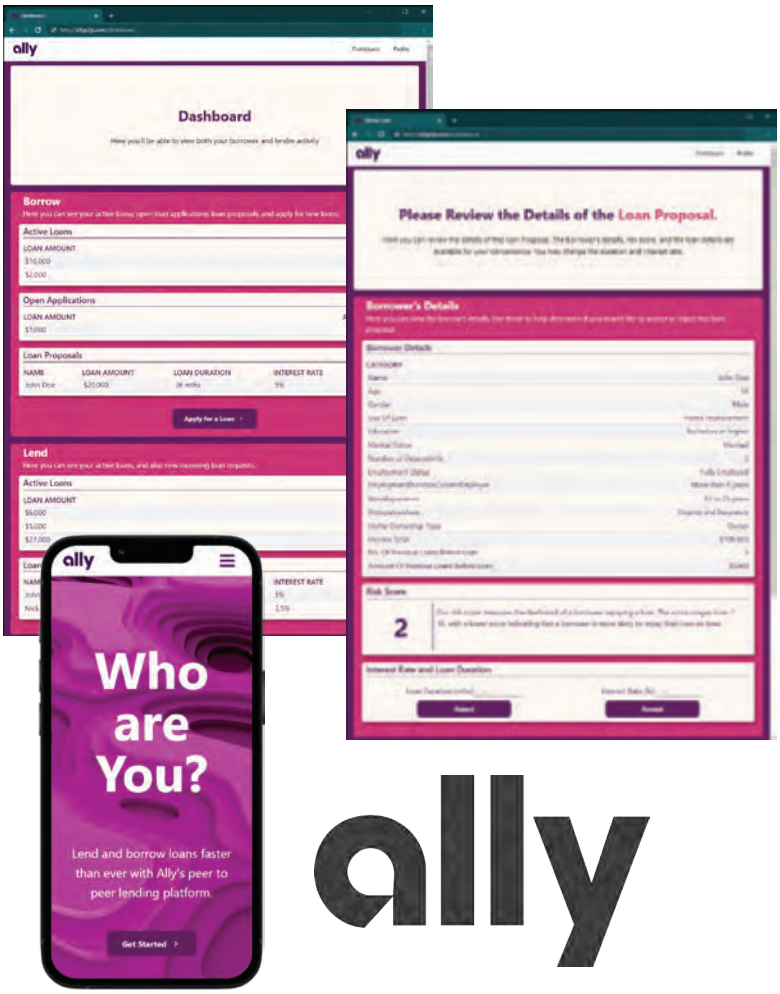
Both lenders and borrowers can enroll in the platform. If a borrower is looking for a loan, they can simply post a loan request. Lenders can view this request and choose whether to accept it or not. Competitive interest rates are charged, and instant loan payout is supported.

The ability to combine loans ensures the best possible rate, granting even more flexibility. Lenders earn money by funding these loan requests from interest when clients repay their loans. Our software calculates risk scores for each loan to help lenders understand how likely the borrower is to be able to repay the money.

Our system facilitates quick and streamlined moneylending between users in a decentralized system, providing clients a quick way to acquire a loan.

Our front end is created using React and backed by Node.js, enabling us to manage and communicate among different software technologies.

Our back end is handled over the Ethereum blockchain to ensure quick and private ether transfers. This decentralized approach makes it possible for clients to use our P2P Lending Platform anywhere.



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Amazon

Amazon Shop Smart: Web Extension for Shopping

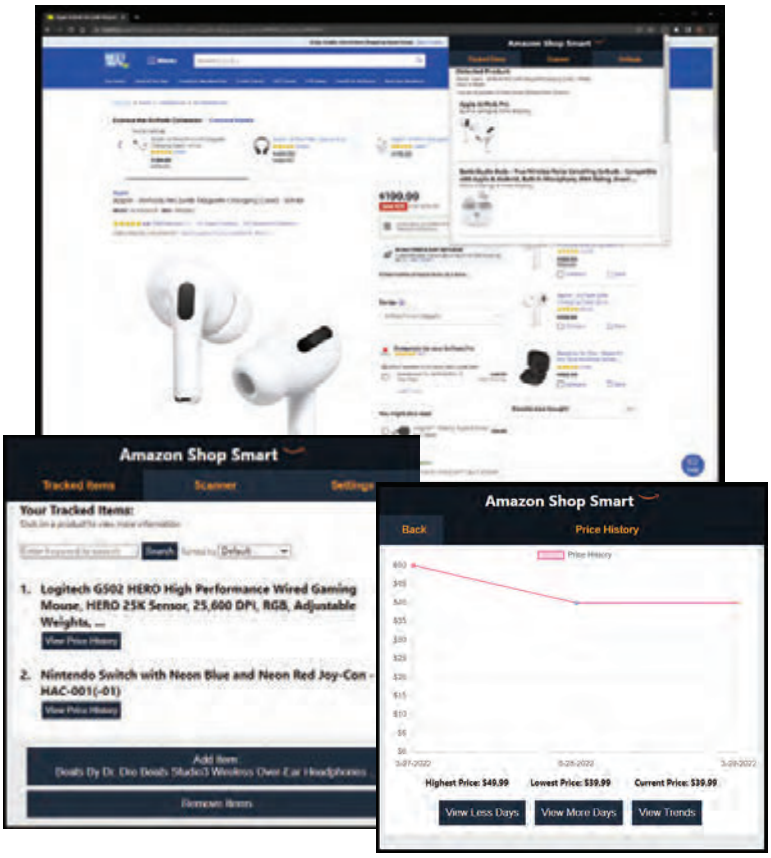
Headquartered in Seattle, Washington, Amazon is a Fortune 500 company that started out as an online bookstore but has grown to become one of the world's largest online retailers and cloud services providers with Amazon Web Services (AWS). Amazon also provides various services such as audio and video streaming through their subsidiaries: Amazon Music and Prime Video.

Amazon works tirelessly to provide products to their customers that offer the best variety, price and convenience. As part of this endeavor, Amazon wants to ensure its customers are taking full advantage of Amazon's prices and services when shopping on Amazon and other retail sites.

Our Amazon Shop Smart: Web Extension for Shopping is a browser extension that aids customers in finding the best deals on Amazon. Amazon Shop Smart tracks products indicated by customers, then periodically checks for price drops on Amazon's marketplace. A notification is sent to the customer when their desired product is being sold at their ideal price point. Graphs of a product's price history can be viewed to determine the optimal time to buy.

While browsing any supported E-commerce website, our Amazon Shop Smart extension provides customers with links to similar items that can be found on Amazon, as well as detailed information such as savings and shipping costs.

The front end of our Amazon Shop Smart: Web Extension for Shopping is built using HTML, CSS, and JavaScript, while the back end is implemented using AWS tools, including DynamoDB, Elastic Compute Cloud, Lambda, and Cognito. Our extension is available on Google Chrome and Microsoft Edge web browsers.



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Anthropocene Institute
Wildfire Risks Forecasting Tool

The Anthropocene Institute is a non-profit organization located in Palo Alto, California. They unite entrepreneurs, thought leaders and investors to advance clean energy technology and climate policy.

The National Interagency Coordination Center reports that in 2020, 58,950 wildfires burned 10.1 million acres (about twice the area of New Jersey), the second-most acreage impacted in a year since 1960. Nearly 40% of these acres were in California. A vital component of wildfire safety is public awareness and education.

Our Wildfire Risks Forecasting Tool provides users with an interactive web application that helps them understand the impacts of wildfires in their communities. Our tool provides visualizations of wildfire spread, as well as educational information about damages posed by wildfires and strategies for wildfire mitigation.

Our tool utilizes decades of research conducted by the US Forest Service to create an accessible, physics-based wildfire simulation interface that shows how a wildfire might spread.

Individuals can simulate fires under a wide variety of conditions, including current or historic weather conditions, and can also manually adjust parameters such as temperature, humidity, wind speed, and wind direction. In addition to wildfire spread, users can view estimates of damage caused by these fires as well as footprints of historic fires. Our tool provides users with strategies to enhance their own safety and the safety of their communities.

The simulation model is based on FARSITE, utilizing weather and fuel data curated by US Government agencies. The tool is fully implemented in Python. Our back end uses the robust geospatial data frameworks of Xarray and netCDF, as well as the numerical efficiency of NumPy and Numba. Our front end is a Flask-based web server utilizing Plotly for visualization.

Anthropocene Institute

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Auto-Owners Insurance
RecruiTrack

Auto-Owners Insurance is one of the largest insurance companies in the United States. Operating in 26 different states, along with the corporate office based in Lansing, Michigan, Auto-Owners services almost 3 million policyholders.

With such a large company, there is a plethora of employees throughout the states of operation. Every one of these employees must perform to the standards of the company, and the recruiting team plays a significant role in this. This team works diligently to find the best people for the numerous positions that exist at Auto-Owners. With so much potential talent, there is a great deal of work involved in finding the best candidates.

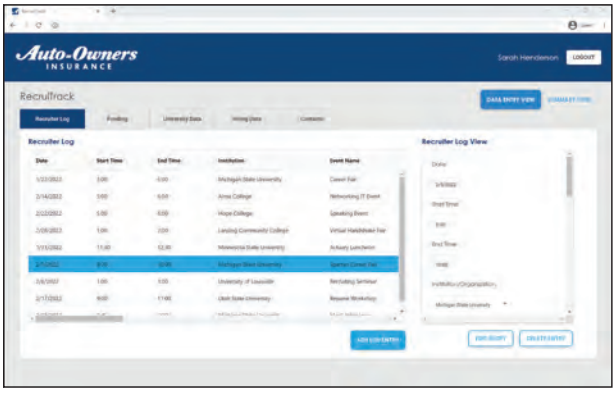
Our RecruiTrack system is a web application that alleviates the amount of labor that recruiters must use to keep track of all the different places from where they recruit talent, as well as tracks the information that must be noted to make sure all the recruiting events they attend are properly staffed and fully funded.

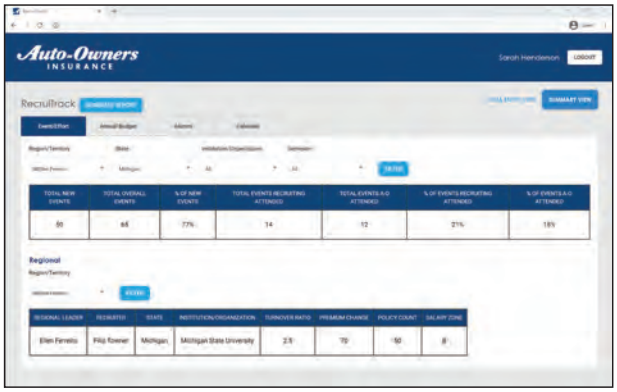
As RecruiTrack is populated with the data that recruiters at Auto-Owners must keep track of, this application becomes a one-stop shop for all things recruiting. It can be accessed through any device that has a web browser.

The app automates reports that must be generated by recruiters to get funding approved for all the events that they organize each year, provides accessible, easy-to-read tables with all the essential recruiting data they currently have, and enables users to manually input and edit data in the application.

With RecruiTrack, recruiters spend less time on manual data entry and writing reports, instead spending more time out in the field finding the best, new talent through this intuitive website.

RecruiTrack is hosted on a Windows server with our front-end software built with Angular, our back-end software built with Java, and a Microsoft Azure SQL Server Database for database hosting.





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Caxy Interactive
Remote Energy Distribution Payment Platform

Caxy Interactive is a full-stack digital development company based in Chicago, Illinois. For over 20 years, they have offered solutions for a variety of sectors, including non-profits, startups, and educational programs.

Reliable energy access is not only essential but also fundamental, for developing regions. Caxy Interactive's focus is to provide accessible energy for central African regions where energy is needed, such as in Cameroon, where less than 27%, or 8 million rural Cameroonians, have minimal access to energy.

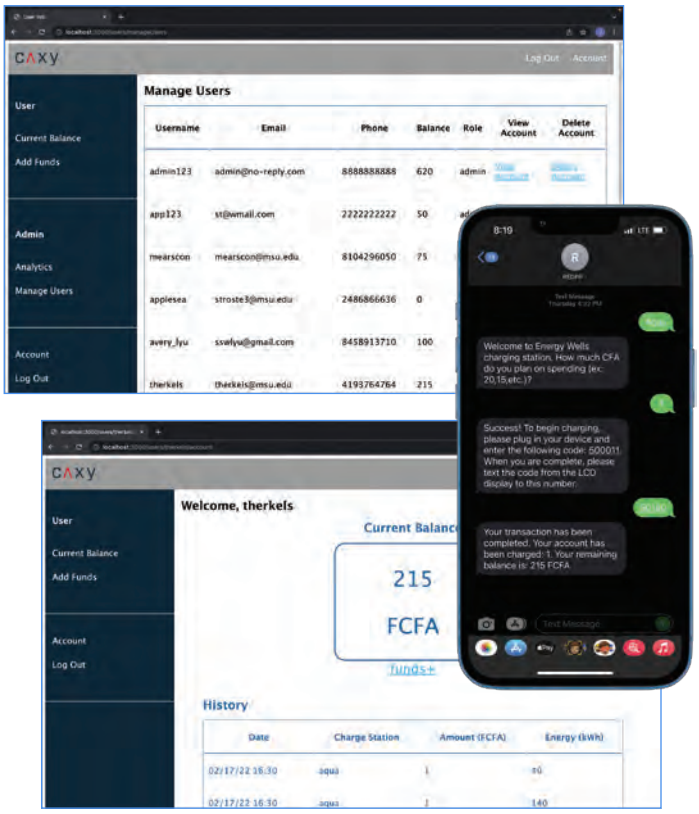
Our Remote Energy Distribution Payment Platform (REDPP) offers a lightweight solution for hardware charging stations to support off-grid charging by providing the ability to access, track, and manage energy transactions with SMS and an online interface.

REDPP provides a customer with the capability to credit an account by text. Preloaded with a balance, customers send text messages to the server to withdraw funds for charging electronic devices.

The web application provides different insights depending on the type of the user account. Customers can view their transaction history and add funds. System administrators can set rates, view information about customers, and manage charging stations.

Our application aids in the mission of providing rural regions access to energy sources to support the development of those areas.

Express supports the back end, while the front end uses Pug, an HTML pre-processor. Web app sessions use Firebase Authentication to manage users' web interactions. Non-sensitive account information and transactions use MongoDB. Stripe is used to process fund additions to accounts by using secure API calls. The cloud application platform, Heroku, provides the server to host the web application. SMS is connected to the server through the Twilio API.



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CSAA Insurance Group
3D Scene Reconstruction of Vehicle Accidents

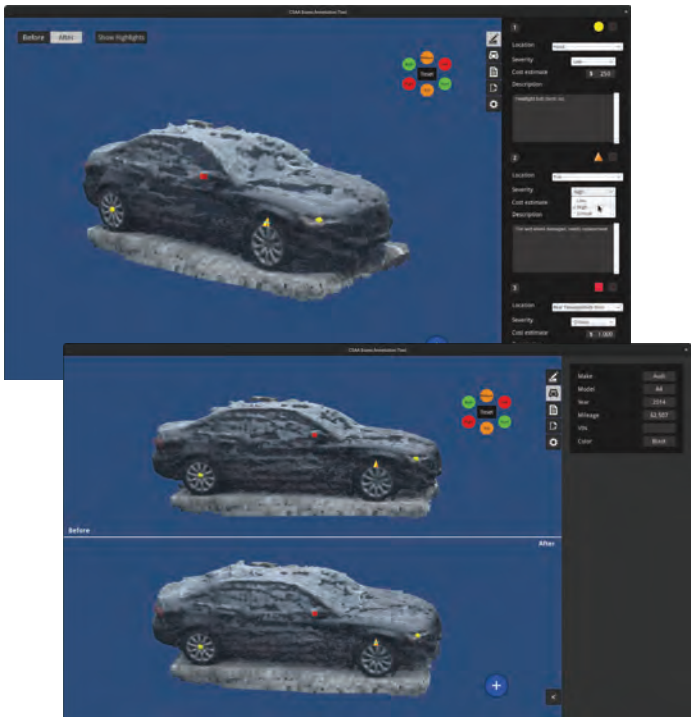
CSAA Insurance Innovation, a subsidiary of AAA Insurance operating out of Walnut Creek, California, is a top-tier insurance group dedicated to aiding clients in the prevention, preparation, and recovery from life's uncertainties, challenging itself to serve with the utmost care. Advocating for vehicle and road safety since 1907, they now offer home, auto, and other lines of insurance across 23 states.

To support members, CSAA analysts must accurately investigate auto claims. Improper analysis slows member recovery and planning by presenting a poor understanding of vehicular damage.

Our 3D Scene Reconstruction of Vehicle Accidents provides thorough annotation and damage analysis capabilities within an interactive 3D environment. This augments CSAA's current system by increasing the speed, detail, and precision with which analysts produce cost estimations.

Using a virtual reality headset or desktop application, analysts can rotate and pan within the generated scene to better examine vehicle conditions, while comparing the original and claimant vehicles as the tool highlights damages. Analysts can create and place annotations on the vehicle to include information regarding the location, severity, cost, and description of damages. Alongside annotations, analysts have access to vehicle and claimant information, a menu for conclusions, the ability to export results, and multiple options regarding screen preferences. Our application improves the ability of analysists to accurately assess vehicular damage for precise analysis of claimants' vehicles.

The Unity-built user interface leverages a Python back end. It uses API endpoints to verify claimant data against CSAA's databases, highlights vehicle damages, and reconstructs a 3D model from claimant vehicle videos through NeRF Modeling, producing an interactive OBJ file for analysts.



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Delta Dental of Michigan, Ohio and Indiana
General RAte Calculation Environment IDE

Delta Dental is the leading provider of dental insurance in the United States. They operate in all 50 states and provide high-quality and cost-effective coverage for nearly one in four Americans.

Professional underwriters and actuaries collect and analyze data to quantify risk for insurance policies in a process called "rate calculation." In the past, Delta Dental employees performed these calculations manually, which was time-consuming.

Delta Dental's solution to modernizing this system is the General RAte Calculation Environment (GRACE). GRACE uses a specialized programming language where users can easily process insurance data.

Our GRACE integrated development environment (IDE) assists Delta Dental developers in effectively writing code for the GRACE system by making it easier to develop programs.

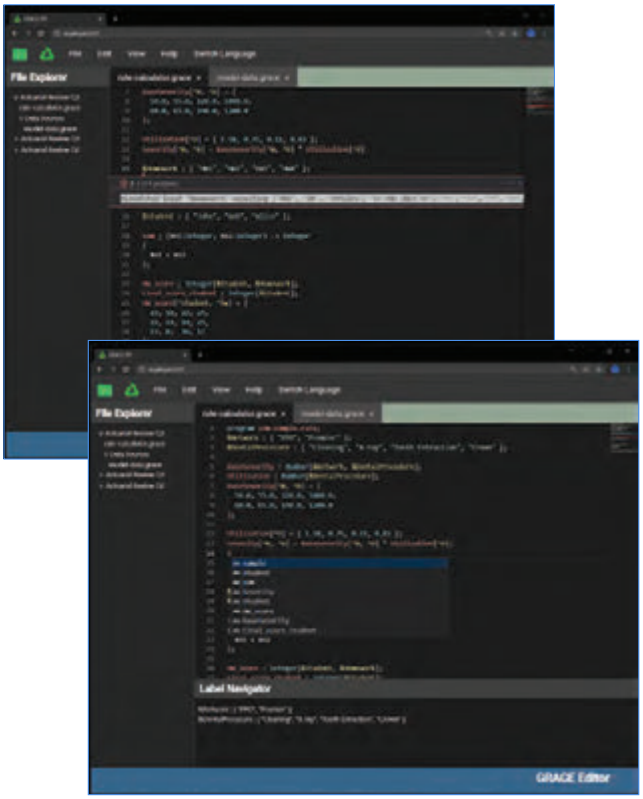
Our software colors important areas of code and underlines errors while typing. Additionally, GRACE IDE suggests variable names and common code structures to save time writing code.

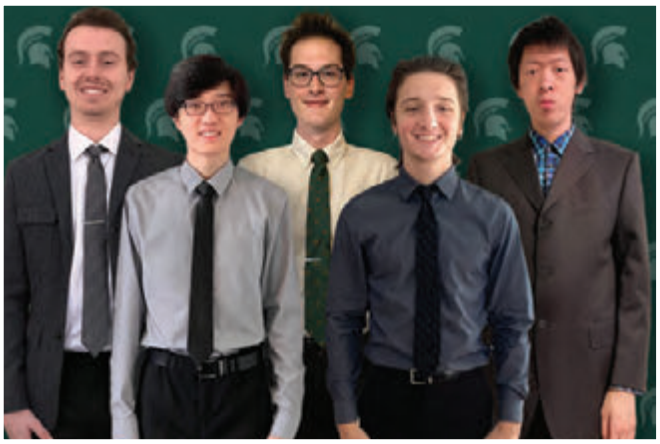
An outline of variables appears alongside the code editor as a quick reference for what kind of information the variable holds. Users can also select one of these variables to instantly go to where the variable first appears in the file.

Our software uses a workspace system for users to quickly navigate between related code files while working on projects. As users open a folder in our software, the files and subfolders add to the workspace. New files created in the software are saved to the workspace at a user's option.

Our system provides the tools needed in order to expedite GRACE program development, increasing productivity.

Our GRACE IDE is a client-side browser application built with Angular for its user interface, Antlr4 for language processing, and the Monaco Editor for the code editor component.





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Delta Dental of Michigan, Ohio and Indiana
General RAte Calculation Environment Shell

Covering more than 78 million Americans, Delta Dental operates one of the largest dental plan administrators in the United States. Over the past 70 years, Delta Dental has created innovative, data-driven technology that increases quality of care while decreasing customer costs.

As an insurance company, Delta Dental continuously compiles and analyzes insurance data to build better plans that decrease costs to their customers and partners. This is achieved through the General RAte Calculation Environment (GRACE), which enables insurance data to be processed efficiently.

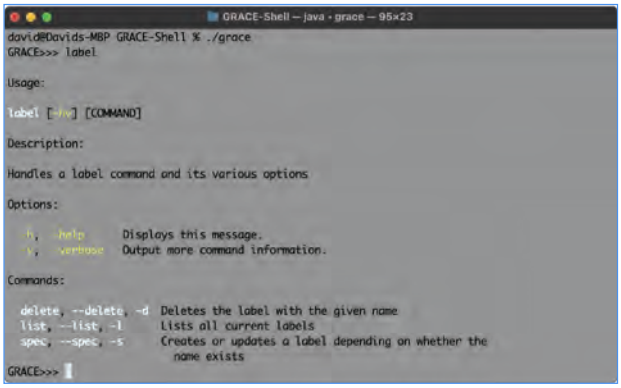
Our GRACE Shell enables users to streamline their development inside of Delta Dental's vast ecosystem of tools with an emphasis on utility and accessibility.

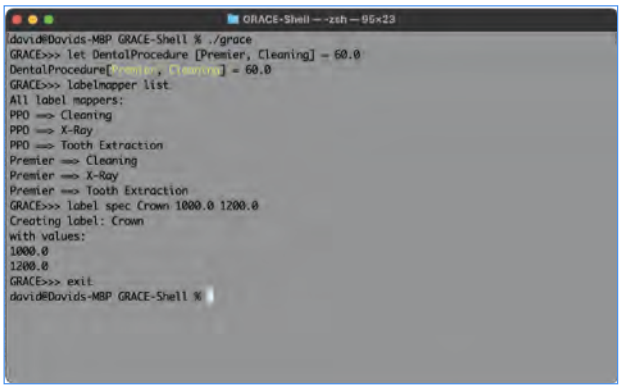
Our command line interface offers a powerful but simple tool to enable fast prototyping, testing, and debugging across the complex rate calculation domain. Programs can be run, tested, and debugged quickly through intuitive commands. Furthermore, the simplicity of our software enables non-technical users, such as actuaries or underwriters, to easily navigate and build models.

The GRACE shell creates an environment where users can dynamically build their prototypes. As the user develops, they can easily create, undo, load, save and share their work in a responsive and robust environment.

Our system facilitates simple building and testing of GRACE programs, enabling non-technical users to develop software quickly without prior training, saving time and cutting costs.

The front end of our software is built in Java, utilizing the Picocli command line interface framework and Maven project management software. The back end uses Delta Dental's existing core libraries containing fundamental calculation algorithms and data structures.





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Evolutio
ERP Reserve Preservation Platform

Evolutio is a group of technology professionals convinced that business problems have simpler solutions than the market is led to believe. Evolutio works with the non-profit, Elephants, Rhinos and People (ERP), to preserve and protect wild elephants and rhinos in Southern Africa through a distinctive strategy based on rural poverty alleviation. The desired result is that community members have access to income through non-lethal alternatives to poaching.

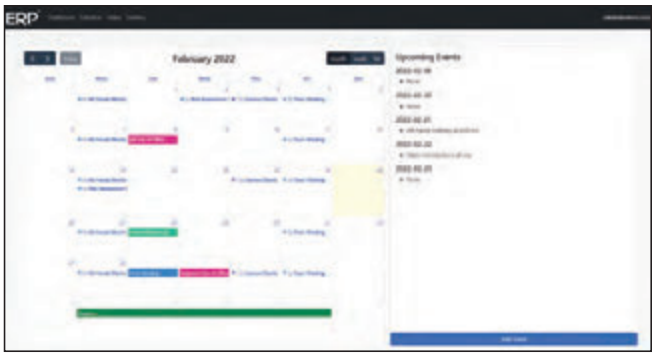
ERP is constantly taking steps forward to ensure that the poaching problem is being mitigated in the short term, while working towards alleviating poverty in the long term. These steps include elephant relocation, veterinary emergency response units, drought relief programs, threat detection, drone air force, and an extensive reserve ranger program.

Our ERP Reserve Preservation Platform is an intuitive web and mobile application makes the lives of those working on the reserve easier by aiding in the success of these short-term goals.

The platform includes a community member and ranger work scheduling system with notifications built in, a system to view live-stream footage of the reserve for security purposes, a place to view footage from the drone air force, and GPS tracking of elephant migration. The platform contains a quizzing system to evaluate the skills and knowledge of those seeking to be a community member or ranger as well.

The community members and rangers benefit from a single platform to view all reserve security tools and management systems in one single place. This platform makes the quality of life better and daily tasks go smoother for those on the reserve, while dealing with very busy, yet engaging, lives.

The ERP platform is developed with the React Native and Flask framework, alongside Python and JavaScript, and deployed onto Heroku.



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General Motors
High Frequency Data Ingestion

General Motors, headquartered in Detroit, Michigan, is the largest vehicle manufacturer based in the United States. OnStar, a subsidiary of General Motors, provides in-vehicle communications, security, navigation, and remote diagnostics.

Within a week of COVID-19 being declared a national emergency, General Motors and OnStar shifted approximately 12,000 OnStar service agents from extremely predictable call center environments to largely variable home offices.

OnStar agents conduct phone calls to vehicles via an internet connection requiring fast and reliable speeds for phone calls to be clear. General Motors IT must know when internet speeds drop, as poor call quality can result in customer dissatisfaction.

Currently, connection speed records are automatically gathered on OnStar agents' computers into files, which are then regularly transferred to a centralized server for processing. When thousands of OnStar agents are online and making calls, the server processing often becomes backlogged, and data is sometimes lost.

Our High Frequency Data Ingestion application resolves the bottlenecks induced by influxes of data by providing efficient file reading, processing, and writing operations. Furthermore, existing backlogs of files are resolved by limiting the number of data points for any given OnStar agent.

In addition to data ingestion, our software features interactive web dashboards. Data from the ingestion application can be analyzed on multiple webpages. This data includes the OnStar network metrics, OnStar agent comparison tables, and ingestion application processing statistics.

The ingestion application is written in C# and is optimized to work with Microsoft network-attached storage drives and a Microsoft SQL Server. The web application is written in Python Flask and uses Socket-IO and Plotly for plotting.

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Kellogg's
Global Business Services Customer Satisfaction

Kellogg's, headquartered in Battle Creek, Michigan, is the world's leading producer of cereal and a leading producer of snack and convenience foods with commonly known brands like Pringles, Cheez-Its, and Frosted Flakes.

With products manufactured in 18 countries and marketed in over 180 countries worldwide, Kellogg's works to provide quality products and services to all its customers and clients. To this end, Kellogg's Global Business Services (GBS) team distributes a quarterly customer satisfaction survey to stakeholders.

The GBS survey contains a series of standardized questions related to the quality and ease of the stakeholders' use of GBS services as well as open-ended questions where stakeholders can provide suggestions and feedback for improvement. In the past, the survey has not reached the target response rate, which makes it harder for Kellogg's to provide the customer service that meets their high standards.

Our Global Business Services Customer Satisfaction system includes a redesign of the user interface of the survey and a web dashboard used to visualize analytics.

Our new Global Business Services customer satisfaction survey has built-in user behavior collection, automated data visualization, automatic survey translation and easier survey question updating mechanisms.

The analytics provided by our web dashboard regarding user behavior and responses has led to an increase in the response rate of the survey from 7% to 15%. This increase in response rate enables Kellogg's to develop a more detailed and strategic plan to provide customers with better products and a more fulfilling experience.

Users access the survey on a web application built in R with R-Shiny for the user interface. The data is stored in Amazon S3, and the data visualization is done through Tableau.

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Kohl's
Athenaeum

Headquartered in Menomonee Falls, Wisconsin, Kohl's operates as one of the largest department store chains in the world. The company's business line features apparel, footwear, accessories, beauty and home products through its stores and website.

At Kohl's, technology teams are constantly exploring, designing, and developing new ways to make the customer's shopping experience more effortless and unique to them. In order to accomplish this, developers need to be able to share their questions and technical issues with each other.

Previously, the Kohl's development teams shared a massive group chat of over 500 developers, where their questions were not only difficult to track, but were also redundant, creating a very disorganized and confusing forum.

Our Athenaeum web application provides an effective solution to this disorder by acting as a centralized platform for the Kohl's development teams to better coordinate collaboration.

Athenaeum is an organized platform that brings order and clarity to the Kohl's development teams; with Athenaeum, Kohl's developers can find solutions to their technical issues with ease. Athenaeum's web interface provides an easy place for developers to ask questions, receive feedback from other developers, search for related questions, and collaborate with their colleagues.

The platform's simple and intuitive user interface gives developers the visual clarity for their collaboration, so that they can easily navigate their way to a solution for each technical issue that arises. Moreover, Athenaeum makes collaboration fun, utilizing a point system to gamify the experience of sharing solutions and resolving each other's issues.

With a ReactJS front end, Flask back end and MySQL database, Athenaeum is deployed on Google Cloud Platform, making the web app fully cloud native.

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Lockheed Martin Space
SmartSat™ Satellite App Store

Lockheed Martin Space, headquartered in Denver, Colorado, is one of the largest space defense contractors in the world, employing over sixteen thousand people, with the goal of developing an impressive range of products from satellites and space probes to missile defense systems.

Storage space, processor utilization, and memory utilization are important factors to consider when deploying software to satellite assets. Applications may also require additional dependencies that must be present on an asset before an application can run.

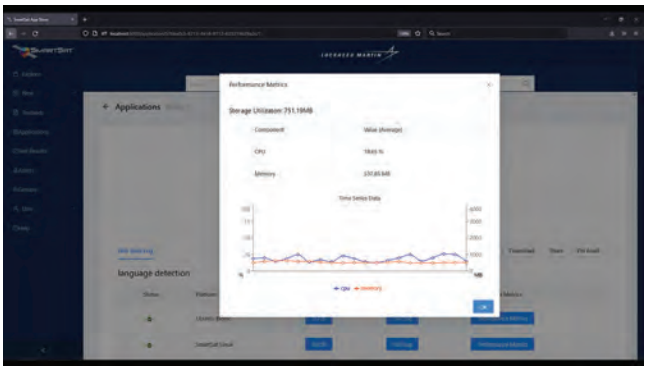
Our SmartSat Satellite App Store is a web-based marketplace for uploading and installing applications to live satellites with rigorous software testing capabilities to guarantee the software runs successfully on these satellites.

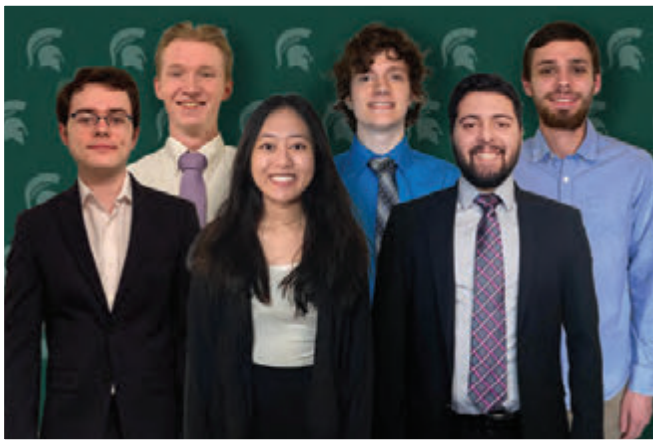
During the testing process, the app store monitors the system resource utilization of the application. When an application is uploaded or deployed, the system ensures the correct dependencies are installed on an asset.

During the testing process, an application manager monitors the resource utilization of the target application. These metrics are sent back to the app store and displayed for operators to view.

The app store automatically keeps a record of an application's dependencies to ensure the required packages necessary for an application to run are installed on the asset. Our SmartSat App Store provides satellite software with assurances that the software is reliable and functional when uploaded to a satellite.

The app store uses a Jenkins pipeline for testing. Data is stored in a Nexus repository, as well as a PostgreSQL database, which is managed by pgAdmin. The web back end is built with Flask, while the front end is built with React. All components of the SmartSat Satellite App Store are built in Docker containers to ensure system portability.





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Malleable Minds
Advancing PreK-12 Educational Opportunities

Malleable Minds is an emerging startup building the world's most extensive collection of PreK-12 programs, from the arts to the sciences, so students can further develop academic, interpersonal, and communication skills. The Malleable Minds web app connects students to programs that interest them and contributes to their academic success.

However, it can be difficult for users to navigate the vast collection of programs and plan their customized education path. Displaying such a large collection of information can also lead to slowed site loading speeds.

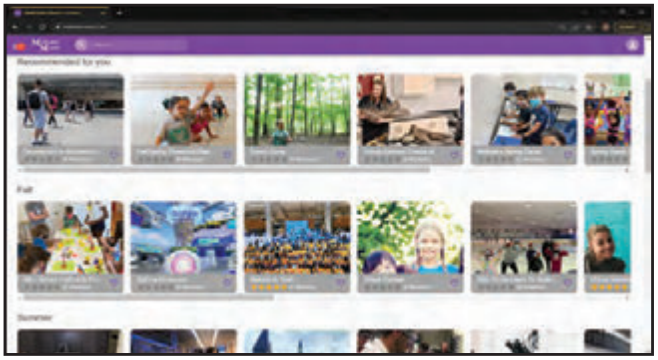
Our Web App for Advancing PreK-12 Educational Opportunities helps users find the programs best suited for them, track their progress in-site, and improves website performance.

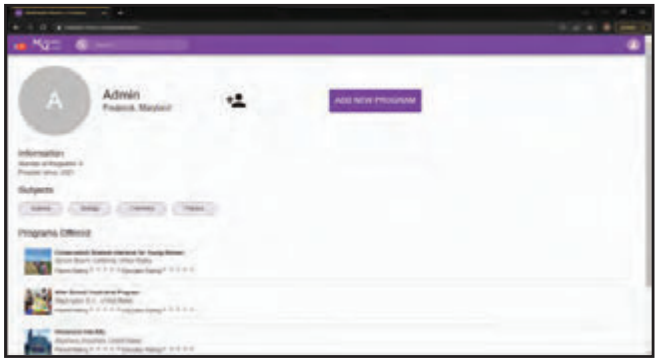
Better navigational features include website subject pages, such as art or science, enabling users to see all of the programs offered in categories of interest. Clicking on a program redirects users to the program page, which holds information such as the provider, location, and cost. This page also includes the program's ratings and reviews left by users after experiencing the program.

The skill tree feature enables users to plot out how to achieve their future goals. Users can track their progress and explore future opportunities in a given subject area. Any progress made on skill development is tracked and the next steps for skill growth are clearly displayed.

Our system improves the existing application by better guiding users to find the programs that are right for them, increasing engagement and customer satisfaction.

The front end is written in React JS, and the back end is in Python. Our site also makes extensive use of Amazon Web Services. By using AWS Lambdas, the back end is serverless to improve site-wide performance.





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MaxCogito
Blockchain Based Vaccine Passport System

MaxCogito, founded by Steve Akers, is a young company that provides high value cloud services to their clients. They focus on providing their clients with strategies for protecting and appropriately managing sensitive documents and communications.

With the onset of the COVID-19 pandemic, humanity has faced new challenges, and different types of vaccinations have been provided as a response to the virus. However, the paper-based immunization status cards currently provided by clinics and hospitals can be stolen, lost, or falsified.

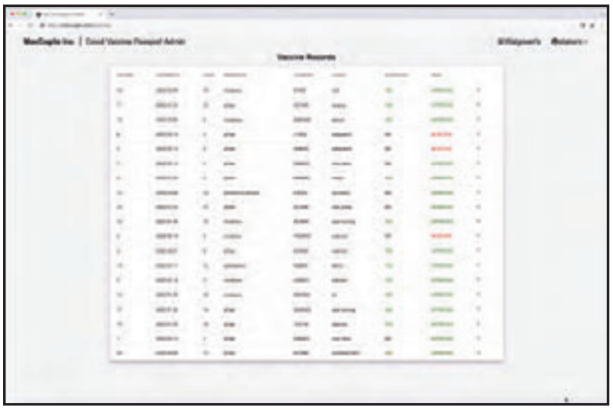
Our Blockchain Based Vaccine Passport System provides reliable and secure vaccination status of users, which cannot be falsified and are secured on the internet.

Our system is accessed by patients and vaccine administrators through an easy-to-use web interface. After receiving a vaccine, users upload a copy of their vaccine record as well as some supplementary data. Vaccine clinics and hospitals then use our web application to validate any vaccine records uploaded by their patients. Once a patient's vaccine record is verified as authentic, the patient can request a vaccine passport from our system that can be used to verify their vaccination status whenever needed.

The vaccine verification is built on Blockchain technology that provides a safe and secure way to apply for vaccination status, which cannot be changed or deleted following verification by the client's health care provider.

Our system provides ease of use for individuals wanting absolute proof of their vaccination status and peace of mind for anyone needing to verify vaccination status beyond any doubt.

The front end of our system is developed using HTML, CSS, Angular and TypeScript. Our back end uses Spring Boot, Web3j, and a PostgreSQL database hosted on AWS. Our Blockchain is built on Ethereum, utilizing Solidity for our Smart Contracts..



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Meijer
Meijer Smart Shopper

Meijer is a family-owned business founded in 1934 that has pioneered the one-stop shopping experience. With over 240 shopping centers operating in the Midwest, Meijer provides a wide array of products from household items to pharmaceuticals.

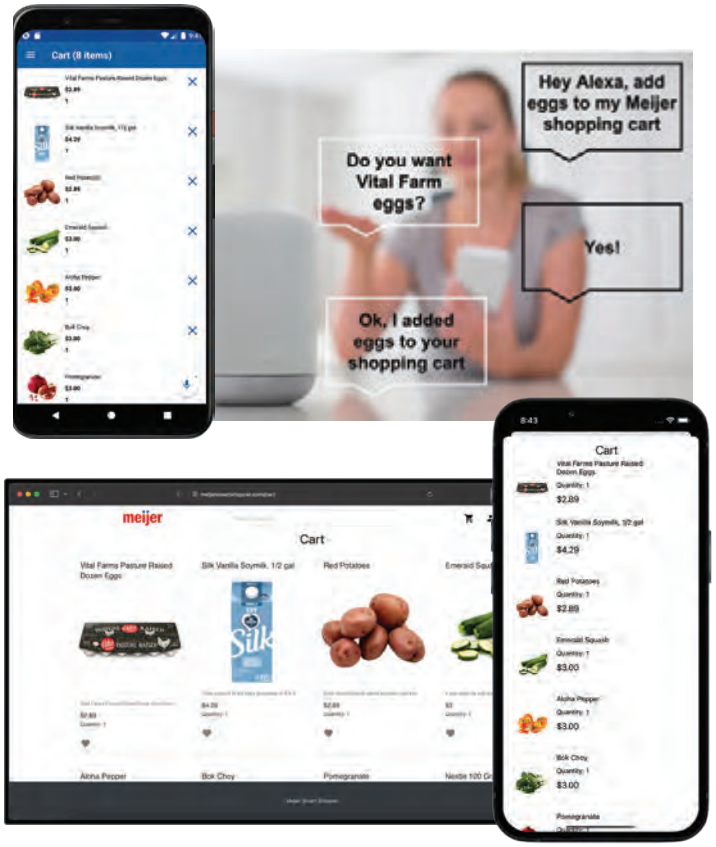
Grocery shopping is a task that takes organization and planning. Adding an item to a shopping list requires resources like time, memory and a list itself. Often, shoppers think of an item they need but don't have those resources readily available. Moreover, shoppers can be unsure of what Meijer coupons, called mPerks, apply to the items on their list, or if that item is available at their local Meijer.

Our Meijer Smart Shopper enables customers to use Alexa to interact with the Meijer application, simplifying the shopping experience. A shopper can interact with our application using their phone's microphone or an Alexa-enabled device.

In a verbal interaction with Alexa, a shopper can add or remove items from their Meijer shopping cart and list. Our application recognizes shopper patterns to improve Alexa's accuracy when determining what brand of item a shopper wants. Alexa uses these preferences to alert the shopper when their favorite items are on sale. Additionally, Alexa informs the shopper when an added item is unavailable at their local Meijer and suggests an alternative.

Meijer Smart Shopper modernizes Meijer's pioneered one-stop shopping experience. Shoppers can now be confident they are utilizing every available mPerk and that their shopping list is complete.

Meijer Smart Shopper is a website, iOS and Android application. The website uses React and is written using HTML, CSS and JavaScript. The iOS application is written in Swift and the Android application in Kotlin. Our back end is hosted using Microsoft Azure and is written using Python.



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Michigan State University Computer Science
Data-Driven Mechanic: Applications and Infrastructure

The DeepTech Lab at Michigan State University conducts research into the use of machine learning algorithms and vibroacoustic (sound and acceleration) signals to improve the maintenance of diverse physical systems.

An estimated 290 million vehicles operate below optimal efficiency due to delayed service or unaddressed faults. The DeepTech Lab has developed algorithms that can identify the make, model, and certain fault types for vehicles using audio captured by mobile devices.

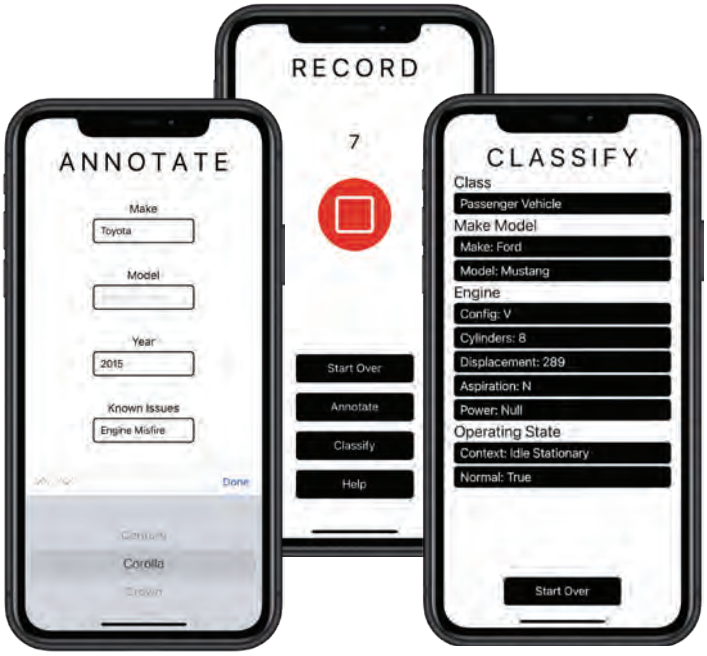
Developed under the supervision of Dr. Josh Siegel, the Data-Driven Mechanic application helps everyday people benefit from the DeepTech Lab's algorithms to improve the maintenance and care of their vehicles.

Users record audio and vibration data from their vehicle in our software with the native microphone and accelerometer on their mobile device.

When the user selects the classify option, the data are processed by the DeepTech Lab's algorithms, and the results are displayed to the user, outlining details and detected faults of their vehicle.

When the user chooses the annotate option, they are shown a series of form pages populated with dynamic fields to fill in with information about the vehicle. After annotation, the labeled data are stored in a server for later use by the DeepTech Lab. The annotate function enables users to participate and contribute to the improvement of the DeepTech Lab's algorithms for diagnosing vehicles and other physical systems.

Our software runs on both Android and iOS mobile devices that have a built-in microphone and accelerometer. The front end is written in JavaScript using the React Native Expo framework. The back-end server is written in Python Flask and the underlying database is MySQL.



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Michigan State University Linguistics
On-Premises Automatic Speech Recognition Pipeline

The Sociolinguistics Lab within Michigan State University's Department of Linguistics, Language, and Cultures hosts Michigan Diaries, which chronicles the changes in the lives and languages of people throughout and after the Covid-19 pandemic, as well as provides insight into language change over time.

Michigan Diaries collects long form audio recordings from volunteers and then uses Google's Automatic Speech Recognition (ASR) commercial software to create time-aligned transcripts needed for researchers to conduct linguistic analysis. Currently, there is no robust open-source ASR software package for researchers to circumvent Google's platform. This leads to unnecessary costs and privacy concerns as private data is getting sent to a third party.

Our On-Premises Automatic Speech Recognition Pipeline is an open-source all-in-one speech-to-text software package that creates time-aligned transcripts from audio files.

After users upload their audio files, the system automatically constructs a time-aligned transcript. This transcript is separated into sentences, along with metadata including timestamps of when the sentence begins and ends, speaker identification, and confidence values for the predicted text.

The training feature is used to improve performance. Users upload their own datasets to fine-tune various models used for inference including, speaker diarization, ASR, punctuation restoration, language modeling and entity extraction.

Our system avoids the need to use Google's speech recognition technologies, reducing operational costs and protecting user privacy.

Our ASR pipeline is containerized through Docker and implemented using state-of-the-art machine learning libraries Hugging Face, NVIDIA NeMo and Pyannote.

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Mozilla Corporation
Improve Firefox's Reader View

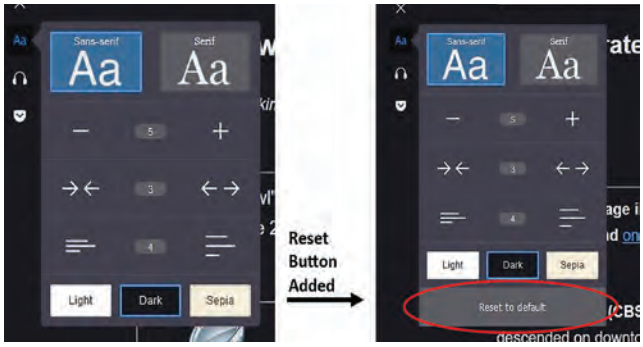
The Mozilla Corporation is behind Firefox, one of the world's largest web browsers. Mozilla boasts the only browser made by a non-profit, mission-driven organization. Firefox's open-source development allows users from all over the world to contribute to its improvement and advancement.

Browsing websites can be frustrating due to clutter from ads and images. Firefox's Reader View feature solves this problem by reducing a page down to the essentials, which is perfect for those accessing websites with a screen reader or requiring better accessibility. Reader View must remove distracting ads, background images and other noisy elements on the page, along with allowing users to customize their web browsing experience.

Our version of Firefox's Reader View builds on many of the requested additional features, fixes, and improvements to make the website's raw information even simpler to read and the Reader View experience more enjoyable.

The improved Firefox's Reader View expands Reader View to cover more heavily used sites, such as Wikipedia. Mozilla's mission is to make the internet open and accessible to all, and our improvements to Reader View are created with this goal in mind. Fixing previously identified bugs and implementing enhancements expands Reader View's ability to facilitate uncomplicated online reading for users. By addressing these problems, the user experience and the functionality of Reader View are substantially improved.

Reader View is a feature that lives within the Firefox codebase: a vast piece of software spanning multiple languages, including HTML, CSS, JavaScript, and C++. The enhancements to Reader View are developed within the Visual Studio Code IDE and released to users in stages via the Firefox Nightly, Beta and Full Release browser applications.



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MSU Federal Credit Union
Ever Green 3C: Financial Education Content Library

Founded in 1937, Michigan State Federal Credit Union has been working towards financial freedom and security for over 320,000 members. With $6.6 billion in assets, over 900 employees, and 21 branches, MSUFCU provides services to help members achieve big dreams.

MSUFCU's goal to help members achieve big dreams spreads beyond the company. Other credit unions seek support from MSUFCU's vast financial education content library and have requested to purchase a detailed organization of the content library.

MSUFCU created Ever Green 3C to spearhead the organization and management of the content library. Ever Green 3C has to manually label its library of content, which is a time-consuming process. They need an accurate and efficient way to organize thousands of articles into detailed categories.

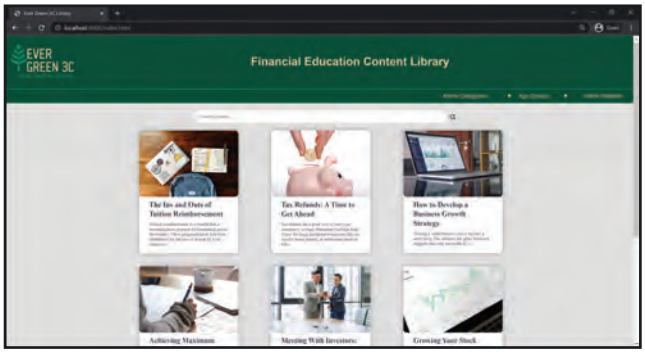
Our Ever Green 3C: Financial Education Content Library is a sorting tool used to remove the burden from the Ever Green 3C team manually sorting thousands of documents.

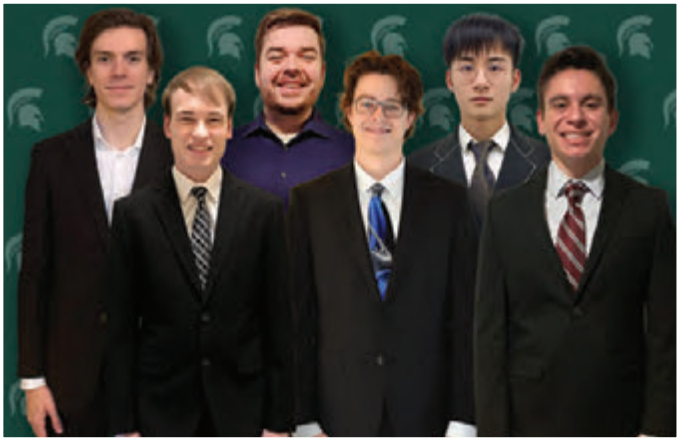
The software enables the Ever Green 3C development team to efficiently identify thousands of articles, their content, their financial categories and their targeted demographics.

Our software stores the financial articles and the respective labels for each article in a database for quick, accurate searching rather than classifying each article on a search-by-search basis. This provides improved speed and efficiency when searching.

The development of this application saves weeks of time for the Ever Green 3C team and turns an otherwise tedious process into a simple push of a button.

Our back-end software is primarily a Python application utilizing ASP.NET to handle the transfer of data to and from a MongoDB database including articles and user searches from the front-end UI developed with a mix of HTML, PHP and JavaScript.





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Rocket Companies
Team Member Mapping Application

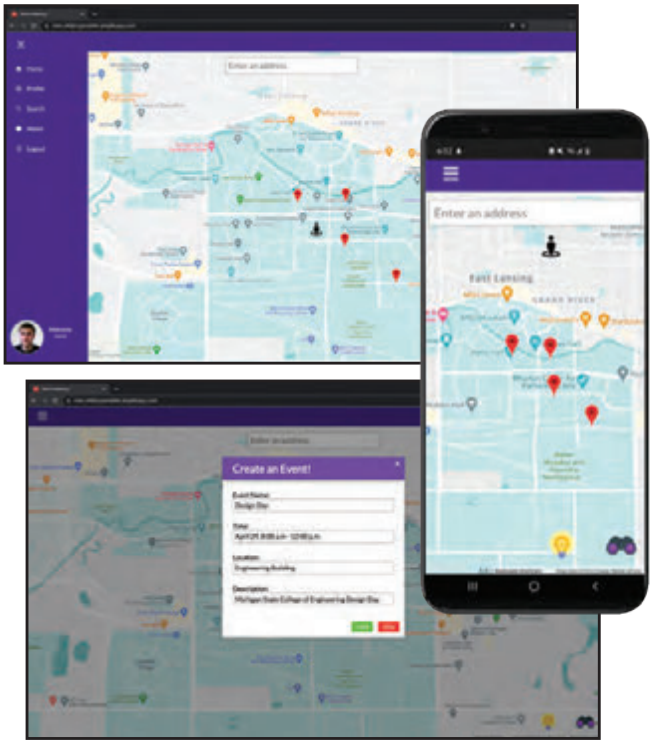
Headquartered in Detroit, Rocket Companies is an expansive family of financial service enterprises, ranging from Rocket Mortgage, the nation's largest mortgage lender, to Amrock, a leading title insurance provider. Always striving for improvement, Rocket Companies succeeds in helping their clients achieve homeownership and financial freedom.

With the shift to remote work schedules during the pandemic, two major aspects of the work environment important to Rocket Companies have been stifled: natural collaboration and community building. Working from private residences, connections beneficial to productivity and essential to a meaningful work experience are partially lost.

Our Team Member Mapping Application helps to alleviate the issues present with remote workplace communication through a location-based application, enabling Rocket Companies' employees to find nearby team members for any host of reasons.

The Team Member Mapping Application displays the location of employees in a general area on a map, as well as contains the ability to filter team members that share similar interests or are within certain companies. The user also has the ability to opt out of having their precise location shown, instead having their associated zip code displayed. The user can create events that other users can see and join on the map, whether it is for a work conference or a book club. Through our Team Member Mapping Application, connectivity between employees at Rocket Companies is greatly simplified and enhanced, most notably in a remote setting.

Our front end of the web application is generated using the REACT framework and hosted on Amazon's AWS Amplify service. The back end is implemented with Node Js within a serverless AWS Lambda. It is used for storing and updating user locations and event data within our MongoDB NoSQL database.



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Scout
Smart Little Hunter of Fakes

Scout provides agile software solutions that enable organizations to make calculated decisions derived from data collection and analysis. With specialized solutions for financial fraud, counterfeit detection, and brand protection, Scout makes its clients' lives easier by bridging the gap between information and action.

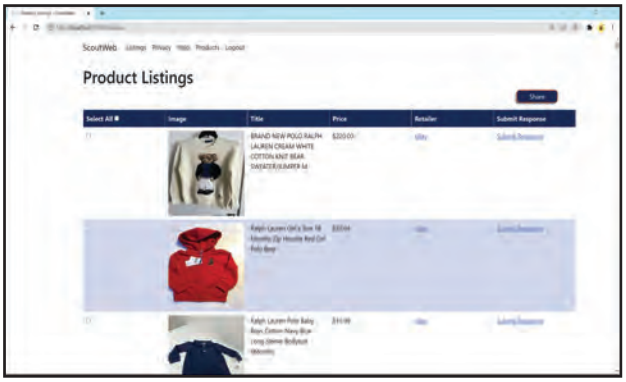
Online shopping has become a massive industry. As a consequence, it has led to the rise of fake product listings. Companies employ brand protection specialists to combat the issue, but they are limited in what they can do. Fake product listings are far too common for specialists to identify and remove them all.

Our Smart Little Hunter of Fakes application provides users with a simple and interactive way of locating, identifying, and removing fake product listings.

This application uses brand specific information and hunts through online marketplaces, such as Amazon and eBay, searching for matching product listings. The massive number of returned product listings are sorted and cleaned to ensure that only the reliable listings are presented to the user.

Users review the presented data and provide their expert responses for each product listing, labeling each as "Real," "Fake," or "Unknown." Our system analyzes user responses and returns its own prediction. Over time, this system learns from its users in order to provide more accurate predictions. Our Smart Little Hunter of Fakes application lowers the risk of receiving knockoff products to create a safer shopping experience.

The front end is implemented in C# using the ASP.NET framework. The back end stores information in a SQL database in the Microsoft Azure cloud and implements the prediction model using ML.NET Model Builder. Our system is available for all Windows devices.



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TechSmith
ViSUI : Video Simplified User Interface

TechSmith is the global leader in screen recording and screen capture software and solutions. The company's goal is to make content creating for trainings, tutorials, lessons, and everyday communication an easier and more effective process. TechSmith's flagship products, Snagit and Camtasia, have more than 34 million users worldwide.

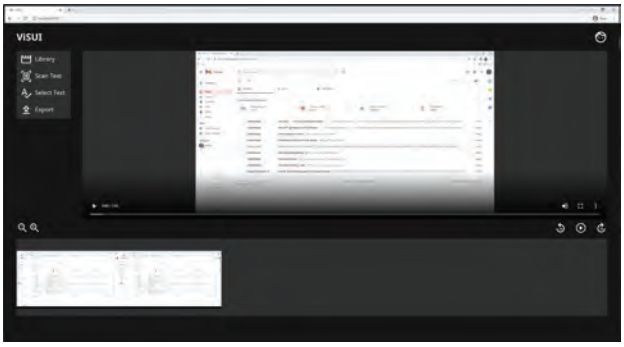
The ability to create content that does not require translation is a challenge that many TechSmith customers face as they work to generate material for speakers of varying languages. Screen captured images or videos that contain text in another language or that is irrelevant to the goal of the video is confusing and distracting to the audience. There is a need for a system that helps customers create more language agnostic content for their audience to consume.

Our ViSUI: Video Simplified User Interface web application enables customers to effortlessly remove distracting text from a video by replacing it with simple shapes, such as rectangles. This makes videos simple and understandable to all audiences.

When the user uploads a video, they can press a button that prompts our software to scan the entire video for text. Once the scanning is complete, the user is presented with suggestions for simplifying the text on each frame of the video. The user can then edit the Simplified User Interface rectangles as desired.

Users also have the option to remove the audio track from the video they upload. Once editing is complete, users can save their project to a video library and export it to another application for sharing.

Our web application is made using JavaScript and React. The text detection is accomplished with Microsoft's Optical Character Recognition API and the frame-by-frame video manipulation is handled with the FFmpeg framework. Our web application, video storage, and database are hosted on Microsoft Azure.



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Union Pacific
Railroad Data Visualization

Union Pacific, founded in 1862, is now the leading railroad transportation company in North America. With over 32,200 miles of track, 8,300 locomotives, and 43,000 employees, Union Pacific plays a major role in the transit of goods throughout the nation.

Derailments cost transportation companies millions every year due to missed deliveries, additional employee time, and equipment repairs. Union Pacific uses simulations to analyze such incidents and diagnose causes. These simulations record data, such as speed and buff/draft forces, and this information is output as a raw data file.

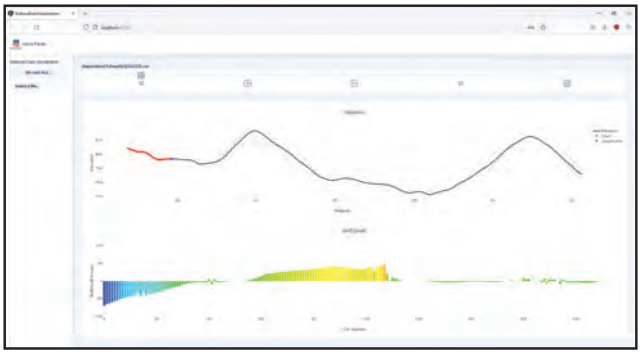
Our Railroad Data Visualization tool provides a web-based user interface that converts a simulation's raw data file into clean, readable, and intuitive visualizations. These interactive graphs aid in the analysis of derailment simulations.

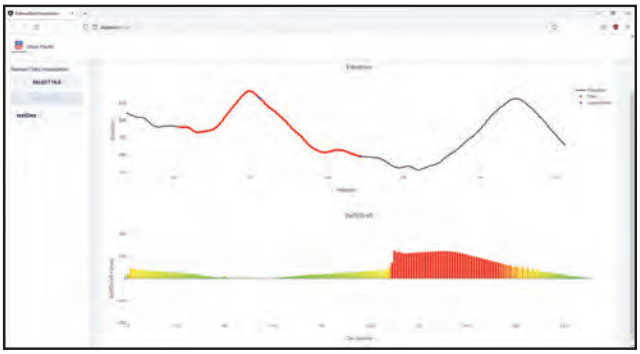
After a simulation is completed, the raw data file is uploaded to our system via a menu on our web page. A user can also select to view a historical data visualization set instead.

Our platform produces animated graphs that visualize train elevation, as well as buff/draft forces between cars over time. Users can control the animation through buttons on the page's toolbar.

Using our system, Union Pacific employees can more quickly and accurately determine the cause of derailments and accidents, in addition to predicting future incidents, saving Union Pacific valuable time and money.

Our Railroad Data Visualization software system has a front-end web user interface that uses the Angular framework, along with the Plotly visualization library. Our web application is also written in TypeScript and HTML. Our back end is written in Java, built around a Spring framework, and stores data in an Oracle MySQL database. The front end and back end communicate with each other via a REST API.





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United Airlines
Performance Scorecard Automation

United Airlines is a Fortune 500 airline company that flies over 850 aircraft and has flights to hundreds of destinations. In 2019, over 160 million passengers flew on United Airlines flights, an all-time-high for the company.

When it comes to air travel, safety is of the utmost importance. That is why at United Airlines, various safety and compliance metrics are used to keep track of safety at each of their seven hubs in the continental United States. These metrics, however, are currently created and managed manually, which takes a significant amount of time for United Airlines employees.

Our Performance Scorecard Automation quickly generates attractive safety metric scorecards, which eliminate human error and the tedium of manually selecting and entering data.

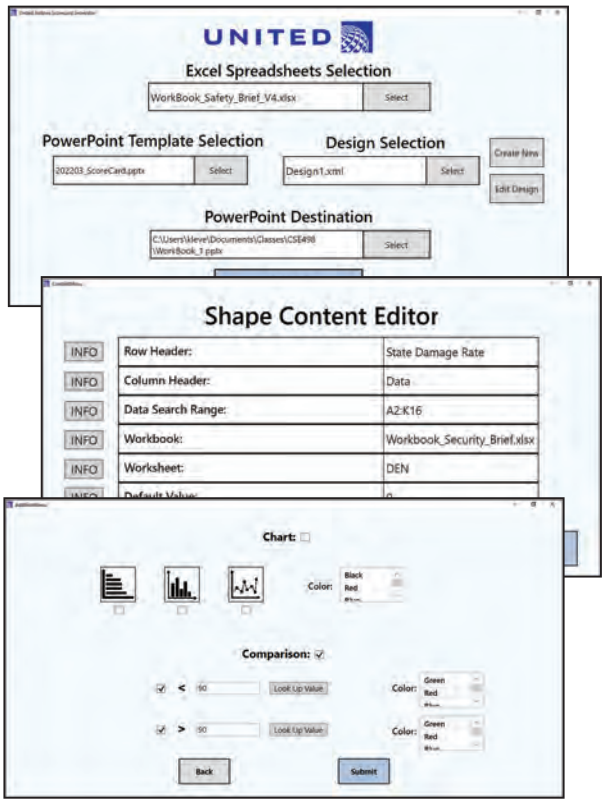
The Performance Scorecard Automation tool automatically reads data from several Excel files that contain the raw safety and compliance data for various airports. The tool then automatically generates a PowerPoint containing pertinent data based on a specified PowerPoint template.

Users can specify any combination of raw Excel data, template PowerPoints, and our own proprietary design files. These design files easily generate associations between raw Excel data and the finalized PowerPoint presentations and maintain the desired look and feel of a manually created PowerPoint.

Our tool enables users to easily create future scorecards without manual adjustment, while also making the program customizable in case the data needs to be changed.

The Performance Scorecard Automation saves time for United Airlines' employees and improves the safety of United Airlines.

The Performance Scorecard Automation is written using C# with the .NET Framework. It uses Microsoft's Office Interop Libraries for interfacing with Excel and PowerPoint.



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United Airlines
Audit Management System

United Airlines, Inc. is a leading American airline headquartered in Chicago, Illinois. In 2019, United Airlines operated 4,900 flights a day from 362 airports. Running an airline requires diligence in all logistical and technical aspects to ensure the best flight experience for "Every customer. Every flight. Every day."

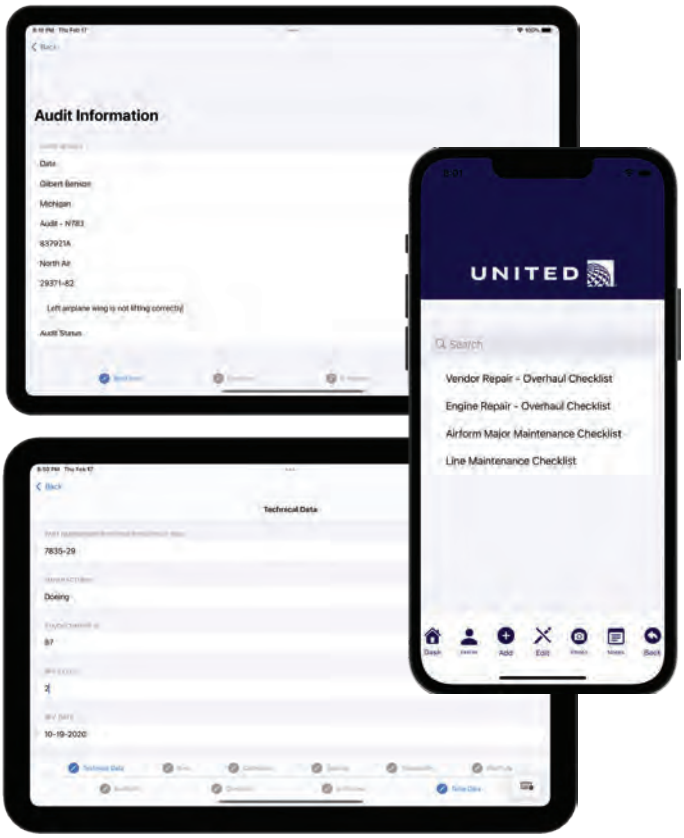
Within United Airlines, the Technical Operations Quality Assurance division plays a vital role in meeting United Airlines' shared goals of efficiency, reliability, and safety.

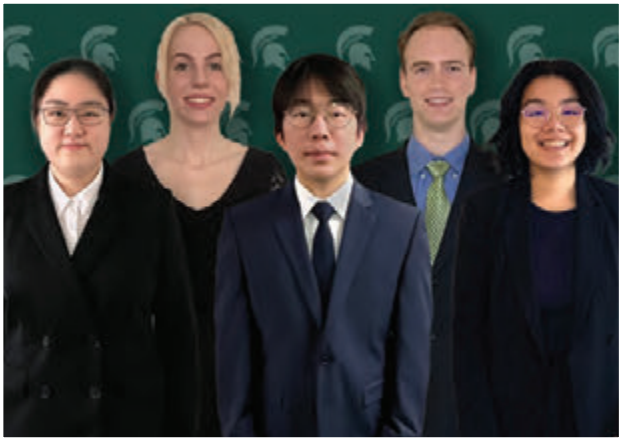
To accomplish this, the United Airlines Quality Assurance team conducts live audits to ensure all equipment and services are maintained according to Federal Aviation Administration (FAA) standards. However, current audits require handwritten documents that are hard to keep track of and difficult to share.

Our Audit Management System enables quality assurance administrators to create new audits and assign them to their respective auditors more easily. Our system also provides auditors with a solution to have electronic access to audit documentation on their mobile devices.

Our system recreates digital versions of forms used by auditors, which facilitates easier editing, saving, and submission of audit documentation. Additionally, our mobile application facilitates real-time access to the device's camera to easily photograph and attach evidence, such as photos and notes to audit forms. Web scraping of the FAA website is included as well, to relay even more information to users of our system. The time of auditors is valuable, and our system enables them to perform their duties in an efficient manner in order to reduce errors and simplify the auditing process.

The front end of our application is written in Swift for iOS integration. The back end is hosted on Amazon Web Services (AWS). Python performs FAA website scraping and stores updated data on a MySQL database hosted through AWS.





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United Airlines
Training Forecast Model

United Airlines is a leading American airline headquartered in Chicago, Illinois. United Airlines connects people and unites the world with over 330 destinations served and over 3,000 departures daily in 2021 across its comprehensive network. With a workforce of over 70,000 employees throughout the world, United Airlines is positioned strongly to provide outstanding service to its customers.

To uphold its rigorous standards for safety and reliability, United Airlines requires routine inspection and maintenance for the hundreds of aircrafts in its fleet, which in turn requires properly trained technicians stationed in the right places at the right times across all of the airports it serves. Training resources must be allocated carefully to keep the skills of technicians in line with the demands of evolving flight schedules and fleet composition.

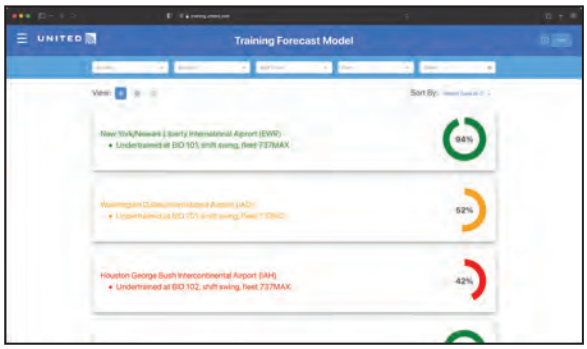
However, determining what training must be provided to keep United Airlines' network operating smoothly is a complex task due to the large numbers of flights and airports involved.

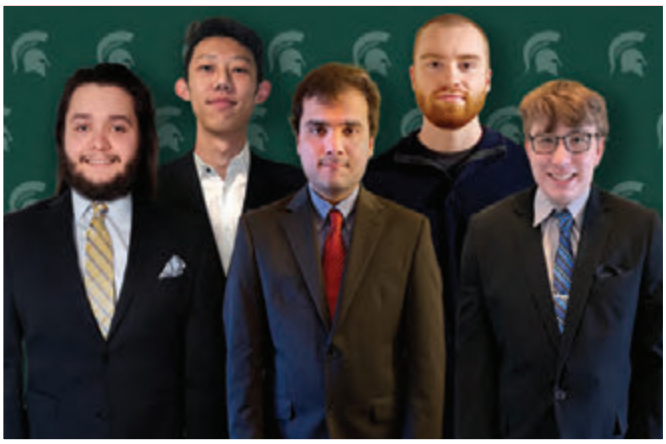
Our Training Forecast Model predicts when and where unmet needs for technicians arise and guides decisionmakers toward where to provide additional training to bridge those gaps.

When United Airlines training staff opens our dashboard, displayed is an overview of understaffing risks at various airports, relaying key insights to staff. They are provided the ability to dig deeper into flight schedules and training data to analyze the most pressing needs on a finer scale. Predictive forecasting is included as well, to help determine what future risks may appear.

The information from our Training Forecast Model application enables United Airlines to reliably catch training risks in advance, reducing threats due to shortages of trained staff.

Our front-end interface is written as an SPA in TypeScript using the React framework. Back-end APIs written in Python are deployed on Azure Functions, backed by an Azure SQL database.





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Urban Science
Customer Insights Dashboard

Urban Science is a global automotive consulting firm that works with major automakers. Headquartered in Detroit and founded in 1977, Urban Science transforms market information into success, utilizing data and business science to improve profitability for their automotive partners.

Urban Science constantly receives massive amounts of market information from various sources. With so much information, it is vital for dealers to spend their limited time chasing the most attractive opportunities.

Our Customer Insights Dashboard identifies the most promising opportunities for dealers to pursue. The dashboard provides dealers with customer contact information and the factors that contribute to a good sales opportunity.

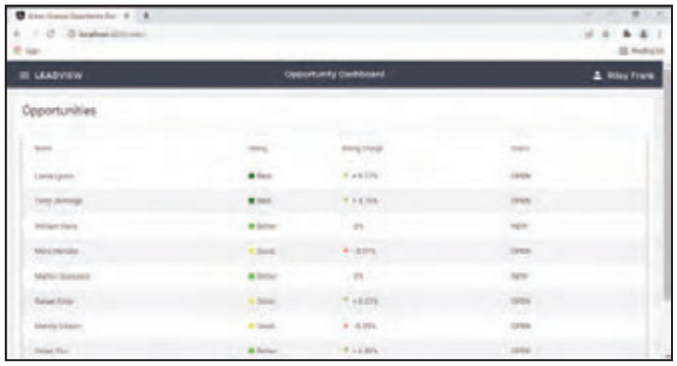
Our Customer Insights Dashboard can be opened in any web browser. When a dealer accesses the dashboard, they are taken to a main page that displays opportunities in a table format. Opportunities are rated by their potential. The default sort on the dashboard is by rating. Dealers are also able to sort opportunities by name, rating change and status.

Dealers can click on a table row to navigate to the row's respective opportunity page, which contains the opportunity's customer contact information, vehicle model information, and the main factors that contribute to the opportunity's rating.

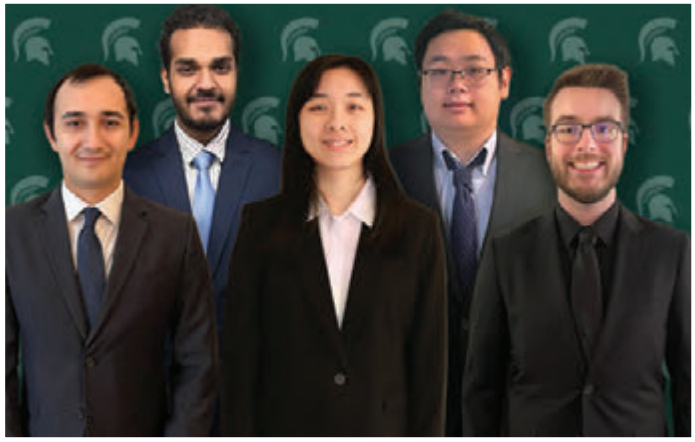
The main opportunities page displays only open or new opportunities. Closed opportunities are found in a different page of the web application and are accessible in the menu.

Our system identifies the most promising leads for dealers to pursue, cutting wasted time and increasing sales.

The front end of our Customer Insights Dashboard application is built using Angular. The back end is written in Python and uses a MySQL database with a .NET Core API.



URBAN SCIENCE



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Vectorform
Employee Recognition on Blockchain

Founded in 1999, Vectorform is headquartered in Detroit. Vectorform helps organizations move from an idea to an invention with digital products and hardware solutions. They combine a variety of technologies such as Internet of Things, augmented or virtual reality, and other emergent systems to develop solutions for their clients.

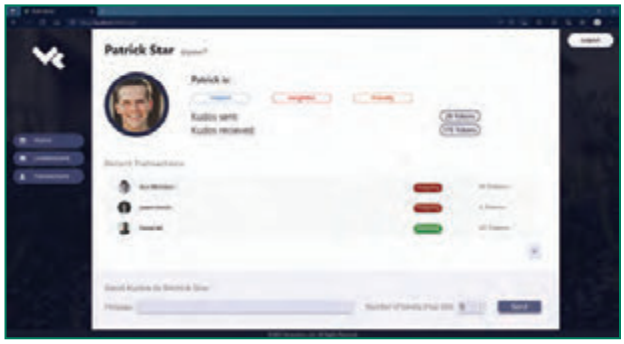
Recognition is an important aspect of Vectorform's culture. Employees at Vectorform frequently congratulate each other in many informal ways on Microsoft Teams or in meetings. This recognition happens in real time and is not always visible to other employees.

Our Employee Recognition on Blockchain software solves this issue by making recognition publicly accessible to everyone in the workplace. Recognition is viewed through a web application and as messages in the Vectorform Microsoft Teams channel. Our software is integrated in Microsoft Teams as a new tab that mirrors the web application.

When a user sends recognition to a coworker, the system logs it as a transaction in a public ledger. The sender writes a message and specifies the number of tokens they wish to send. These tokens are used to measure appreciation and calculate rankings for a workplace leaderboard. Descriptions and keywords are generated from received messages for each user.

Our system ensures employees are recognized for their performance, improving company morale and culture.

The front end of our software is built using ReactJS, while the back end is implemented using Node.js. Microsoft Azure is used to host our SQL database and web application. Our application utilizes the Harmony blockchain, an Ethereum Virtual Machine compatible blockchain. OpenAI is used to create the user descriptions and keywords.



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Whirlpool Corporation
Recipe Progression Tracking

Whirlpool Corporation, based out of Benton Harbor, Michigan, is one of the world's best-known appliance manufacturers with over $22 billion in annual sales, 69,000 employees, and 54 manufacturing and technology research centers across the globe. Whirlpool's current focus is improving the home-cooking process.

With the global pandemic leaving its mark everywhere, many are left lacking guidance on how to properly prepare meals themselves. Typical recipes include step-by-step instructions on how to cook the recipe, but they have no real-time feedback on if the steps are being completed correctly.

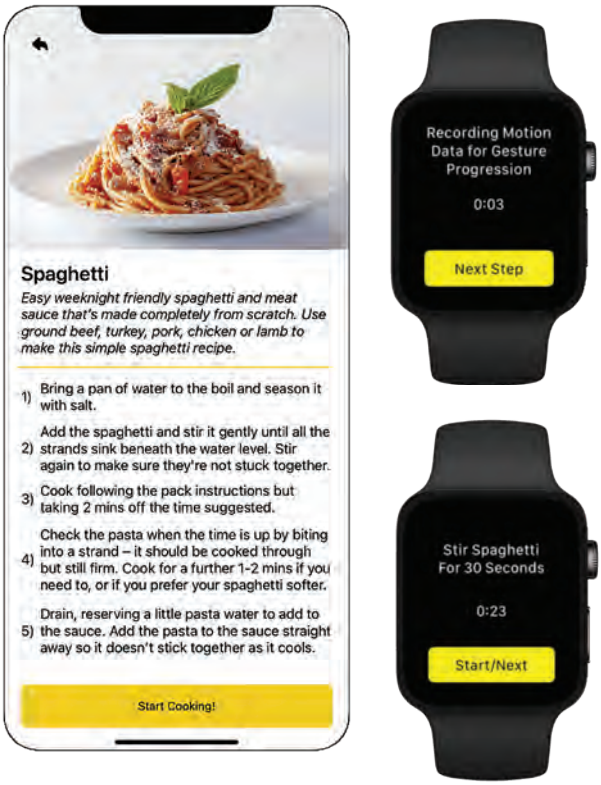
Our Recipe Progression Tracking application provides users with step-by-step instructions on how to prepare dishes, along with motion-based feedback on if the directions are being followed properly.

This application runs on both an Apple Watch and iPhone. While cooking, the user is guided through each instruction, which is displayed on both devices.

An Apple Watch records motion data gathered from a user's arm. Using neural networks and machine learning algorithms, the cooking data recorded from the sensors within the watch is analyzed to provide feedback in real time on how well the user is completing a step.

The Recipe Progression Tracking application helps advance the future of cooking by combining traditional cooking methods with machine learning to produce an innovative style of preparing dishes. Our application helps Whirlpool achieve their vision of making cooking easy and accessible to everyone.

Our back end utilizes an Ubuntu server, MySQL, and TensorFlow to store and transmit the recipes and sensor data, while our front end is built using Swift and XCode. Both components communicate using a Rest API.



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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 fall of 2021.

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 Anthropocene Institute 1
Air Pollution Health Outcomes Forecasting Tool

Back Row: Tate Bond, Hannah Francisco
Front Row: Lukas Richters, Lindsey Boivin, Zhendong Liu
Presented by Tony Dean, Ross Hacker and Scott Lake

MSU Federal Credit Union Praxis Award

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

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

Team TechSmith
Snagit Template Creator

Back Row: Yash Anandakumar, Dalton Lauerman
Front Row: Miaoyu Yang, Heather Noonan, Akansha Dey
Presented by April Clobes and Ben Maxim

While each of the awards has a principal focus, every winning team is required to design, develop, document, and deliver a successful comprehensive software system, and to demonstrate outstanding communication skills by presenting, demonstrating, and defending their 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 Evolutio
ERP Kids: Wildlife Conservation

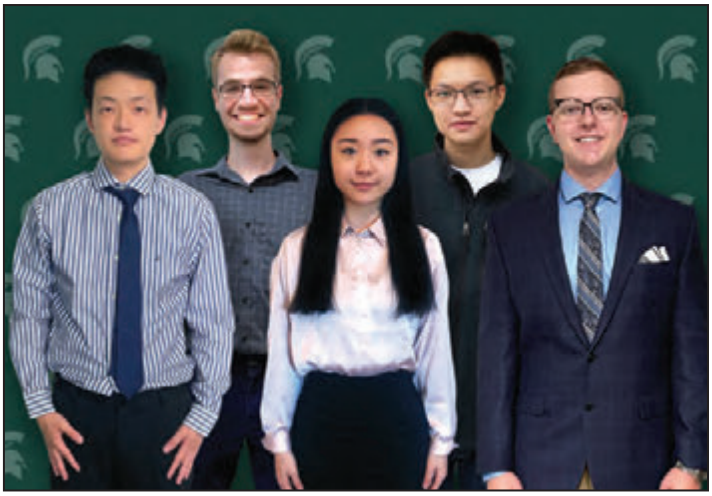
Back Row: Jonathan Skidmore, Gabe Sanborn
Front Row: Lindsey Murrell, Joe Daprai, Jennifer Sageman
Presented by Wendy Hamilton, Tony Lambert and David Norris

Amazon 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 Amazon Sigma Award, which is sponsored by Amazon of Seattle, Washington and Detroit, Michigan.

Team Amazon
Amazon Web Services: AWSome Availability Zones



Back Row: Jamison Heiner, Jung Chak
Front Row: Wynton Huang, Iris Kim, Jake Hood
Presented by Garret Gaw

ENGINEERING AT

TechSmith®

{DEVELOP} with us

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

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

Benefits {DEVELOP}ed to support you

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

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

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

Tuition & Loan Assistance
TechSmith supports a portion of loan repayment and pays ⅔ of any tuition and books for qualified classes taken by full-time employees to improve their job skills, up to $5,250 per year.

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

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

Explore open positions and submit your application at techsmith.com/careers.

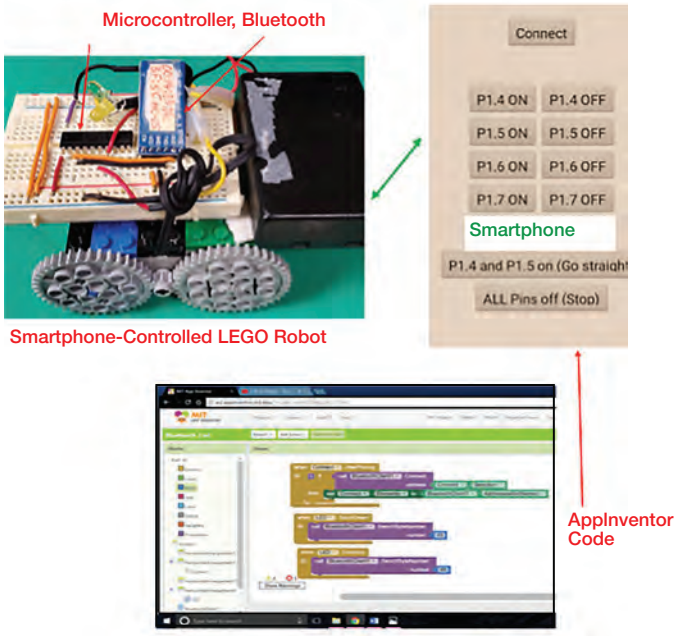
ECE 101 Introduction to Electrical and Computer Engineering

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

Problem Statement

ECE 101 is an elective course introducing freshman students to Electrical and Computer Engineering through a series of unique/innovative **hands-on flipped laboratory experiments** linked to Smartphones, App development and creative research/teaching approaches. The experiments include (a) MATLAB Mobile, (b) App Inventor, (c) Ohm's Law Simulation and Testing, (d) Smart Bracelets for Health Monitoring, (e) Smartphone Digital Microscope, (f) Smartphone Controlled LED/Motor using Bluetooth Module and Microcontroller, and (g) Microcontroller Programming using a Smartphone-based IDE (Integrated Development Environment).

Student Assistant: Joel Martinez



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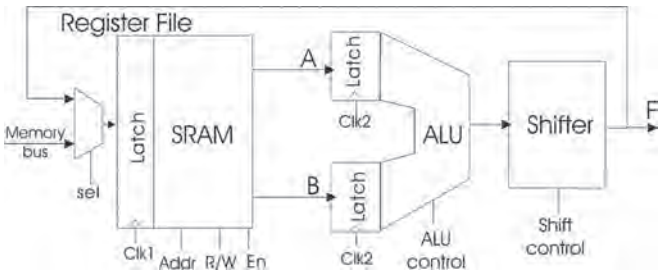
Chase Graham Noah Petrovski Camdyn Reiss	Group 2: Arduino Project
Matthew Hein Ethan Helmer Evan Smith Henry Vergowven	Group 3: Blink Morse Code
Jaclyn Bommarito Pranshu Dixit Hanbyul Lee	Group 4: Blink LED
Salomon Beyloune Brody Keeley Raymond Smith Brody Zurvalec	Group 5: Arduino Project
Akash Bedi Roman Kizyma Jon Toomey Satwik Vejandla	Group 6: Arduino Project
Scott Andrews Tea Comai Owen Gray Griffin Schoener	Group 7: Audio Modifer
Zach Johansen Alex Kraus Colin McNeal	Group 8: Arduino Project

Design and Characterization of a CMOS 8-bit Microprocessor Data Path

Instructor: Professor Shannon Nicley
TA Staff: Toshi Vijaywargia, Haojun Wang

Problem Statement

Students in ECE 410 were challenged to design the schematic and physical layout of an 8-bit microprocessor data path, including an Arithmetic Logic Unit (ALU), a barrel shifter, and a register file, using CMOS circuitry and Cadence VLSI design tools. The resulting microprocessor datapath projects will be judged on their ability to satisfy several competing goals, including speed, minimization of area, number of operations and difficulty of the operation set.



Smartphone-Controlled LEGO Robot

Intel Outstanding Project Award

The Intel Outstanding Project Award ($600) will be awarded to the team that produces the best overall project, as judged by a panel of experts from industry and academia. The faculty and students of Electrical and Computer Engineering are very grateful to Intel for the generous sponsorship of this award.

Competition Schedule

Team 1
Arpitha Gowda
Pratik Joshi
Adithya Rao

Team 2
Hyunmin Choi
Connor Schanenburger
Nicklaus Fites

Team 3
Mason Rice
Nick DeLisle
Brooke Osterkamp

Team 4
Joseph Divito
Michael Mackay
Rebecca Wang

Team 5
Dylan Chaben
Matt Maser
Evan Miller

Team 6
Timothy Cholewa
Samuel Lefurgey
Nick Zurlo

Team 7
Daniel Hawkins
Bruno Hinojosa
Alyssa Hook

Team 8
Ethan Hopp
Anchen Xue
Bohan Zhou

Team 9
Joshua Jennings
Sydney Johnson
Alihel Sanchez
Elioenai Vasquez

Team 10
John Murdoch
Elijah Savoie
Jack Vezmar

Team 11
Umar Hassan
Sam Polus
Heyi Qu
Gungeet Singh

Team 12
Ayesha Khan
Nilay Patel
Ghazi Rizvi

Team 13
Josiah Bostic
Sepehr Rahgozar
Adam Slavin

Team 14
Daniel Karczmarczyk
Michael Scepka
Josh Springsteen

Team 15
Ryan Daniel
Conner Graham
Jack Wegh

Team16
Timothy Boyd
Hunter Gendregske
Brandon Kushion

Team 17
Spencer Barrer
Ryan Doyle
Alex Jones

Team 18
Ethan Galdikas
Shashank Gowda
Spenser Lafferty

Team 19
Kent Bazman
Dominick Campbell
Ryan Zboril

The Capstone Projects

Dr. Lalita Udpa
Professor of Electrical
And Computer Engineering

Dr. Satish Udpa
Professor of Electrical
And Computer Engineering

Faculty Advisors: Sergey Baryshev, Shaunak Bopardikar, Tim Hogan, Woongkul Lee, Tongtong Li, Nihar Mahapatra, John Papapolymerou, Jian Ren, Nelson Sepulveda, Mi Zhang

Baryshev

Bopardikar

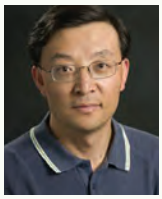
Hogan

Lee

Li

Mahapatra

Papapolymerou



Ren

Sepulveda

Zhang

Presentation Schedule – Engineering Building, Room 2245

Time	Team Sponsor	Project Title
8:30 a.m.	MSU Solar Racing Team	Development of Electric Motor Vehicle Controller
8:50 a.m.	MSU Solar Racing Team	Solar Car Vehicle Dashboard System
9:10 a.m.	MSU Solar Racing Team	Solar Car Battery Pack
9:30 a.m.	Texas Instruments	Video and mmWave Radar Data Capture System
9:50 a.m.	NASA	Solar System Communication Network Project
10:10 a.m.	BREAK	
10:20 a.m.	General Motors	Autonomous Vehicle Fluid Level Sensor
10:40 a.m.	General Motors	Repurpose Fuel Injector Boost Supply to Stabilize ECU
11:00 a.m.	General Motors	Machine Learning Technique for Automatic Thermal Seat Control
11:20 a.m.	General Motors	Autonomous Virtual Hardware In-the-Loop Project
11:40 a.m.	GE Aviation	Large-Scale Testing of a Flight Management System using a Cloud-Based Simulation Environment

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, resumes, evaluations, posters, web pages, and oral presentations; and
- Requiring each student to complete four individual hardware/software laboratory assignments.

MSU Solar Racing Team
Development of Electric Motor Vehicle Controller

The MSU Solar Racing Team is developing an electric vehicle using a new battery pack. This vehicle will require a new customized motor controller that enables the operator to control the motor speed and receive essential motor data. The goal of the project is to design and implement a functional motor controller for the MSU Solar Racing Team's new electric vehicle. The controller will be able to control two motors through a control loop implemented using instructions on a microcontroller, and receive data from the motors, such as mechanical motor speed, position, temperature, and motor current. The controller will also have Controller Area Network capabilities to relay motor data to the vehicle. The motor circuit can be designed, or alternatively a pre-built design can be implemented.

Michigan State University
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Saad Hasan
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Alyssa Hook
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Dan Beaudrie
Cody, Wyoming

Bruno Alejandro
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Jonathan Schleusener
Dimondale, Michigan

Danny Nowicki
Lansing, Michigan

MSU Solar Racing Team
Project Sponsor

Woongkul Lee
East Lansing, Michigan

Project Facilitator

Dr. Nelson Sepulveda

MSU Formula Racing Team
Solar Car Vehicle Dashboard System

The Michigan State University Solar Racing Team (MSU SRT) is a student-led engineering organization that designs, manufactures, and competes with full-sized solar electric vehicles against other colleges. The next car, Cynisca, will compete in the 2024 American Solar Challenge in the challenger class as a single-occupant vehicle.

The goal of this project is to develop an effective dashboard infotainment system (DIS) prototype for the new single-occupant vehicle. The data present on the DIS may include the car's speed, battery level, battery temperature, solar array current, solar array voltage, and motor characteristics such as speed and torque.

These characteristics were chosen because they give the driver the best idea of the car's status without flooding them with irrelevant information. With this data, the driver can communicate with the pit crew and determine the best course of action at any point in the race without needing to stop and run diagnostics. This can save time during the race and give the team a competitive edge. This project will help team members gain an advantage over their competitors within the district as they can focus more on other essential electrical components on the vehicle that need development.

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Michigan State University
Team Members (left to right)

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Josiah Bostic
Farmington, Michigan

Matt Jelcin
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MSU Solar Racing Team
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East Lansing, Michigan

Woongkul Lee
East Lansing, Michigan

Julia O'Mara
East Lansing, Michigan

Project Facilitator

Dr. Tim Hogan

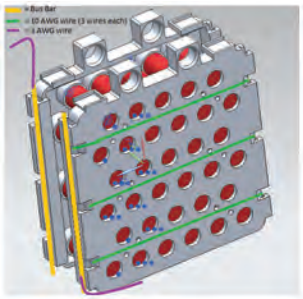
MSU Solar Racing Team
Solar Car Battery Pack

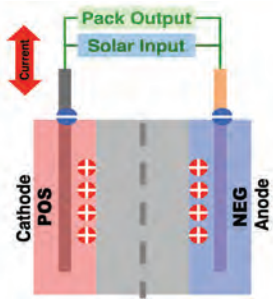
Founded in 2000, the MSU Solar Racing Team is a student-run organization that competitively designs, and races solar-powered electric vehicles. The MSU SRT is planning to design a cruiser class car for participating in the Formula Sun Grand Prix (FSGP) of 2023 and the American Solar Challenge (ASC) of 2024. Our team's task is to research and build two battery modules for the next challenger class racing car. The Solar Racing Team will build the entire battery pack to be utilized by the car based on the guidelines and data provided by the team.

To evaluate the most viable options for the battery pack, a multitude of battery cells and module materials were researched. Among the many battery cell materials currently available on the market, Lithium-Ion cells were chosen for their high power-to-weight ratio, high energy efficiency, quality high-temperature performance, and low self-discharge rate. The battery cell parameters that are most crucial towards vehicle performance are voltage, current and energy density, which were all considered during battery cell choice.

The battery module frame is crucial for the battery design. Three main problems need to be solved: covering exposed wiring, securing cells more efficiently, and improving air circulation. Previous models used glue to secure cells in the module frame that made it inconvenient to access the batteries. Inclusion of a latch to hold the two ends of the frame provides the ease of accessing the cells within a battery module. Using a lattice design for the frame itself allows for more airflow both in horizontal and vertical direction, as well as using rubber lining for cell holes to allow for more security and to absorb any vibrations.

Ultimately, the module's design and specifications will facilitate a battery pack with more range, safety, and weight distribution.





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Dr Nihar Mahapatra

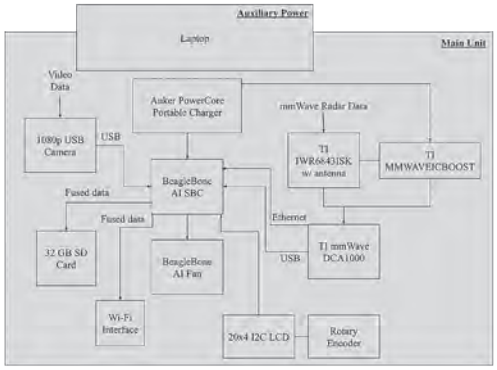
Texas Instruments
Video and mmWave Radar Data Capture System

Texas Instruments is a global semiconductor company that, for decades, has made it their mission to foster continuous development and growth by creating affordable products that are smaller, more reliable, and more efficient. With approximately 80,000 products covering a wide range of key markets including industrial, automotive, and personal electronics, TI proves itself year after year to be a trustworthy innovator in all its endeavors.

Notably, Texas Instruments is an industry leader in integrated radio-frequency (RF) complementary metal-oxide semiconductor (CMOS) radar technology with its mmWave radar sensors. These sensors are capable of precisely and accurately measuring an object's velocity, range, and angle even in complicated environments. This makes industrial sensors, like the IWR6843, ideal for use in multi-leveled data collection systems.

Utilizing this potential, our Video and mmWave Radar Data Capture System was designed to act as a stand-alone mobile system capable of simultaneously capturing video, UART, and mmWave Radar data, fusing them together into a single, intuitive file, and storing large collections of data on an SD card. The next objective of the project was to duplicate the design and create a networking interface for multiple capture systems. Through this interface, multiple systems could exchange software configurations, communicate data, and thereby, accurately classify moving objects within a dynamic environment using machine learning.

By combining the capabilities of the TI hardware boards, their software source development kit, as well as the OpenCV python library, we believe that we were able to develop a meaningful and reproducible design that can act as a framework for future data handling applications.



TEXAS INSTRUMENTS

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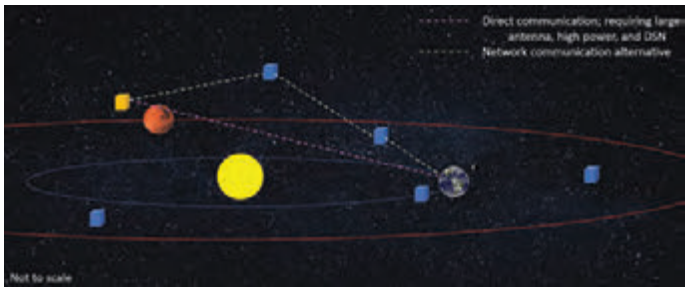
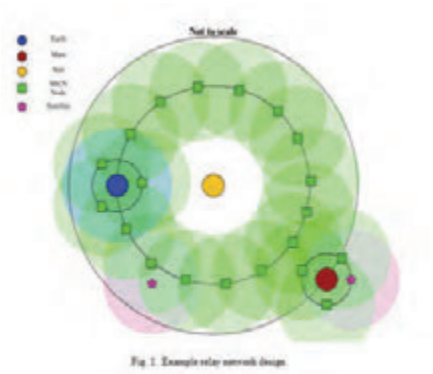
NASA
Solar System Communication Network Project

Exploration satellites designed for deep space currently require costly, powerful, and heavy communications equipment. This is due to the nature of the communications problem presented and the current technology available. Presently, deep space communication is based on a direct link between earth and the exploration satellite through NASA's Deep Space Network (DSN). The DSN is a global array of giant radio antennas designed to communicate with spacecraft exploring the far reaches of the solar system and beyond. The DSN is critical to deep space exploration, and many satellites utilize the DSN. As a result, scheduling time on the DSN is often costly and the network is frequently overwhelmed with requests.

The Solar System Communication Network (SSCN) project, sponsored by NASA, plans to alleviate the load borne by the DSN. The SSCN will consist of many 12U CubeSats designed to relay data in deep space dispersed throughout the inner solar system. The 12U CubeSat would act similar to a cell tower, where satellites would only have to relay information to the closest SSCN satellite instead of creating a direct-to-earth link. This would reduce mass, cost, and power consumption in communication systems of future exploration spacecraft.





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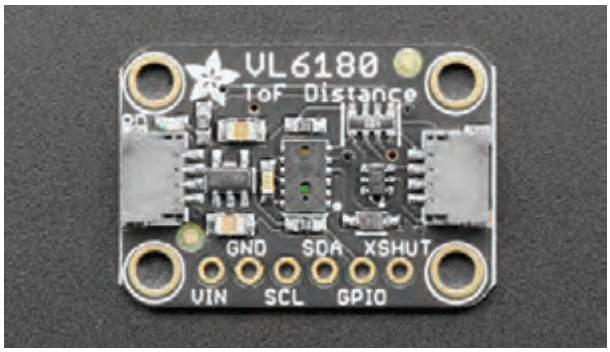
General Motors
Autonomous Vehicle Fluid Level Sensor

General Motors, founded in 1908, is one of the largest automobile manufacturers based in the United States and among the largest internationally. With the age of self-driving autonomous vehicles on the horizon, General Motors has been advancing into the next generation of self-driving vehicles.

Our team was tasked with designing an apparatus for continuous and accurate measurement of the washer fluid level in the reservoir. For autonomous vehicle applications, knowing the current fluid level without manually checking a fleet of them is critical. Windshield washer fluid is not only used for cleaning the windshield, but keeping camera and sensor arrays clean from dirt, salt, road and other organic debris. It is crucial that the autonomous vehicle must understand and plan for washer fluid usage to better predict future outcomes.

The end goal is to be able to report the remaining percentage of fluid level within 1% (99, 98, 97...%). The sensor must be low cost and available off the shelf. It needs to be durable, accurate, and able to survive the vibrations from the road. It should be able to work while the vehicle is moving, and not wear down or corrode over time. The sensor we will integrate will use a time-of-flight LiDAR sensor to measure the fluid capacity.



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General Motors
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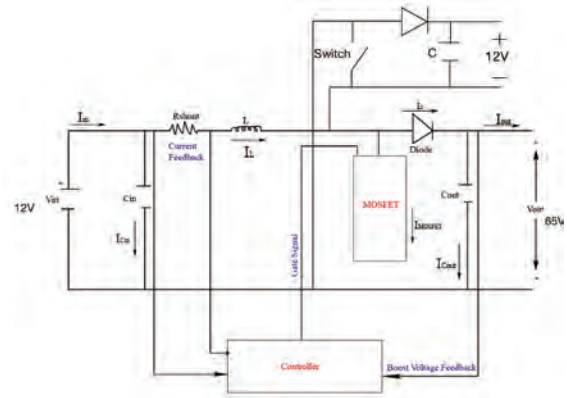
General Motors
Repurpose Fuel Injector Boost Supply To Stabilize ECU

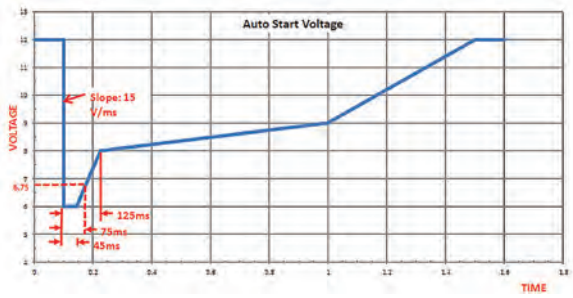
Since 1908 General Motors has worked to design and manufacture exemplary automobiles for millions of customers around the world. With 155,000+ employees across 22 time zones, General Motors plans to create a world with no crashes, no emissions, and no traffic, one step at a time. A major step in that plan is vehicle efficiency and the optimization of fuel use.

General Motors has tasked our team with finding a smaller, more cost-effective solution to the voltage drop applied to the Electronic Control Units (ECU) during the auto-start feature on automobiles developed by General Motors. This will reduce the cost of producing the electronics in these vehicles. The energy from these boost converters will be repurposed to supply the fuel injectors of the ECU during the auto-start feature.

Auto-Start is a feature of newer automobiles that increases fuel economy and reduces emissions. It is achieved by shutting down portions of the engine, which causes fuel consumption to be reduced significantly. In General Motors automobiles, this is achieved by using multiple external DC/DC converters to ensure that the battery voltage stays above 9.5 Volts (V) during auto-start.

The auto-start feature is designed to turn off the engine while the vehicle is at a complete stop. Currently, once auto-start is triggered, the battery voltage drops to 6V and will stay below 8V for 200 msec. The voltage will not return to the ideal voltage of 12V for 1.5 seconds. The issue with this is that each ECU requires at least 9V for stable operation. The goal of this project is to eliminate these external DC/DC converters to reduce the overall cost of the vehicle and to increase the lifespan of the ECUs that will be affected.





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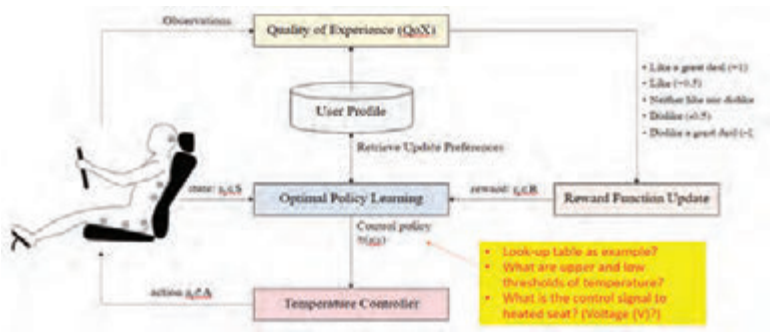
General Motors
Machine Learning Technique for Automatic Thermal Seat Control

Thermal seats with heat and ventilation are becoming more common in today's vehicles. These are typically controlled automatically by an onboard electronic controller based on thermal conditions outside the vehicle and inside the passenger cabin. General Motors' current thermal automatic seat control does not meet their customer satisfaction criteria. In order to reach this standard, a machine learning protocol must be implemented within the closed loop feedback control system to adjust user setting changes under a set of conditions. When the learning for a given condition is complete, the baseline calibration value will be adjusted such that the automatic control will start to move away from the baseline to more personalized controls. Given occasional variations such as high metabolism, emotional behavior changes, etc. are unavoidable, learning can be continuous, but the maturation of learning will be robust enough to filter out occasional variations. The direct heat addition and extraction by the thermal seat will also improve efficiency at the occupant's thermal conditioning more than the indirect climate control system. As a result, adapting the automatic control of thermal seats to user preferences will boost customer satisfaction and overall battery health.



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Oxford, Michigan

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Warren, Michigan

Project Facilitator

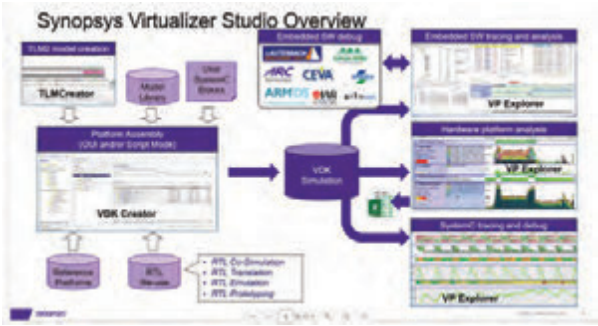
Dr. Mi Zhang

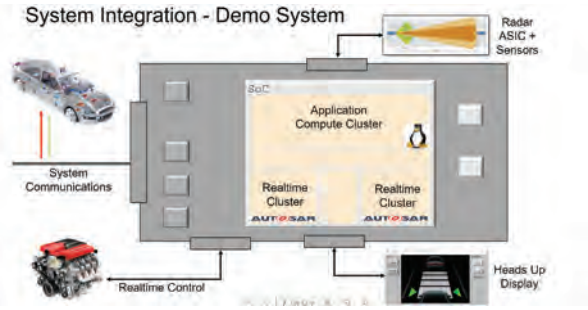
General Motors
Autonomous Virtual Hardware In-the-Loop Project

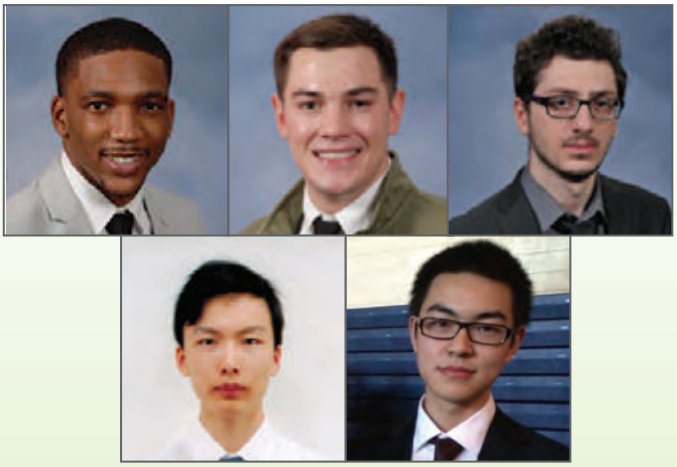
General Motors' (GM) autonomous driving division has been advancing the next generation of self-driving vehicles through fast-to-market simulation and machine learning approaches. The project will aim at creating a virtual hardware in-the-loop (VHiL) simulator to enable the VHiL team to code, run, and test software without using their hardware rack. The project lead should be familiar with software coding, distributed system testing, and hardware compute architectures. This project will reduce the development time needed to improve GM's autonomous driving features. It will also enable the software team to test their code faster and reduce the hardware dependency required for automated driving distributed architecture.

In the past couple of years, there has been a huge growth in the market for autonomous driving. GM's newly created VHiL team will work closely with the MSU team to develop and test a virtual Electronic Control Unit (ECU) for their autonomous vehicles. The MSU team will be training together with their new hires on using their development kits and test platforms. Furthermore, the virtual ECU will be tested for correct behavior and the data collected will be used to visualize the output.

Additionally, the project team is tasked with building an interface that could simulate camera and LiDAR traffic input that is applicable for ACP 3 & 4. The Virtualizer Development Kits (VDK) from Synopsys will be used to achieve this objective. The VDK provides a fully functional model of system executing target code. The Synopsys Virtual Prototyping converts the raw data into richer, more descriptive information, which can be visualized in real time. Consequently, the developer could then directly use those higher-level perceptual outputs which include object classification, velocity measurement, semantic scene segmentation, and obstacle detection.







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Project Facilitator

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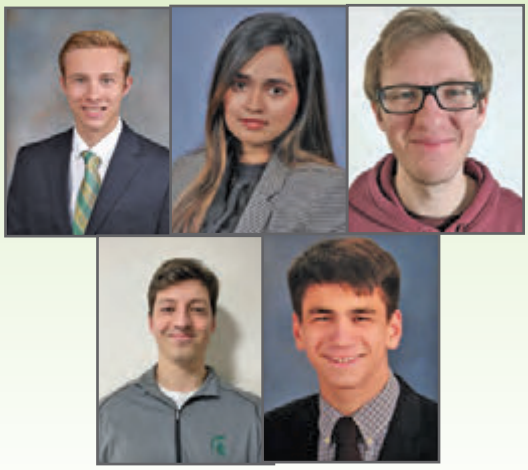
GE Aviation

Large-Scale Testing of a Flight Management System Using a Cloud-Based Simulation Environment

General Electric (GE) Aviation is the world leader in providing aircraft engines systems and avionics (aviation electronics). For the past two decades GE has made significant strides in advancing avionics beyond jet propulsion. In 2007 GE acquired Smiths Aerospace, this allowed GE to broaden its offerings by adding innovative flight management systems, electrical power management, mechanical actuation systems and airborne platform computing systems. Then in 2012 GE acquired Austin Digital, which revealed new ways for GE to use flight data analysis to optimize flight operations. This enabled GE to consolidate it, growing digital services into the single business GE Aviation in 2016.

The Flight Management System (FMS) is the onboard avionics computer that flies the aircraft after the flight crew has entered the route, along with additional parameters. Essentially the FMS is a crucial part in one's flight from when the plane takes off to when the plane lands. To avoid any in-service problems the FMS is constantly updated and extensively tested.

The main objective of this project is to create an environment that can execute flights on the FMS at a large scale in order to evaluate its constant updates. The data used to conduct these tests will be extracted from an online flight simulator "FlightAware." FlightAware is an online flight simulation that tracks and collects data from flights; this data includes departure location, arrival location, route taken, speed, altitude, and distance. For this project the team goal is to be able to extract multiple flights' data from FlightAware, then use a scripting language to create inputs for the FMS. The FMS will simulate a large number of flights, while being monitored for any exceptions or errors that might arise.



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Dr. Satish Udpa
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Faculty Advisors: John Albrecht, Bei Fan, Nihar Mahapatra, Robert McGough, Daniel Morris, Jeffrey Nanzer, Hayder Radha, Jian Ren, Peng Zhang

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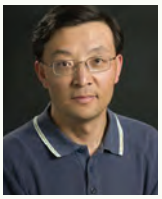
Mahapatra

McGough

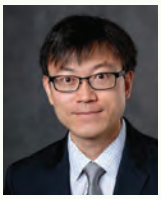
Morris

Nanzer

Radha



Ren



Zhang

Presentation Schedule – Engineering Building, Room 2250

Time	Team Sponsor	Project Title
8:30 a.m	Great Lakes Crystal Technologie	Thermal Imaging During Diamond Growth
8:50 a.m.	MSU ECE Department	Detection of Buried Lead Water Pipes
9:10 a.m.	MSU ECE Department	Miniature Self-Driving Car
9:30 a.m.	MSU ECE Department	Wearable Temperature Monitoring Device
9:50 a.m.	MSU ECE Department	Diaper Monitoring System
10:10 a.m.	BREAK	
10:20 a.m.	Fraunhofer Institute	Electrochemical Instrument for Sensor Miniaturization
10:40 a.m.	MSU ECE Department	Vocal Enhancement Device
11:00 a.m.	MSU ECE Department	Aerial Drone for NDE Applications
11:20 a.m.	AMP Robotics/MSU Surplus Store & Recycling Center	Maximizing Use & Efficiency of Robotic Sorting

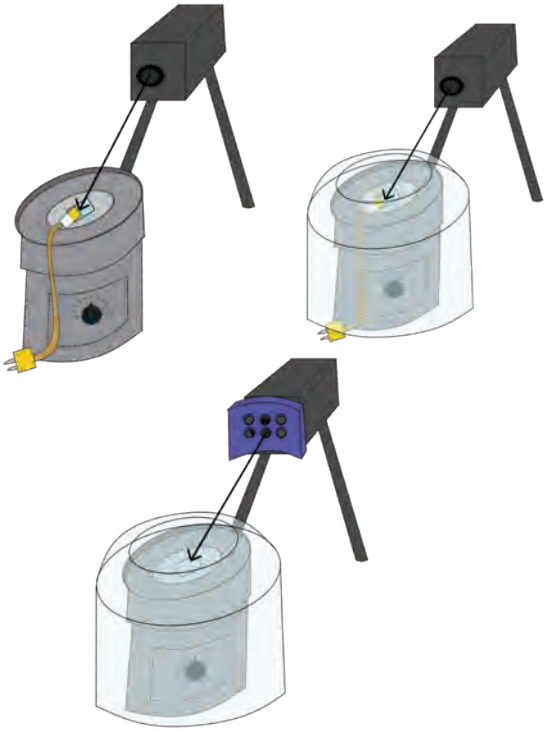
ECE 480 Senior Design

We gratefully acknowledge the support of this semester's project sponsors: AMP Robotics, Fraunhofer Institute, GE Aviation, General Motors, Great Lakes Crystal Technologies, MSU Electrical & Computer Engineering Department, MSU Solar Racing Team, MSU Surplus Store & Recycling Center, NASA, and Texas Instruments.

The ECE Project Facilitators who supervised ECE 480 teams this semester are: John Albrecht, Shaunak Bopardikar, Bei Fan,Tim Hogan, Woongkul Lee, Tongtong Li, Nihar Mahapatra, Robert McGough, Daniel Morris, Jeffrey Nanzer, John Papapolymerou, Hayder Radha, Jian Ren, Nelson Sepulveda, Mi Zhang, and Peng Zhang.

Great Lakes Crystal Technologies
Thermal Imaging During Diamond Growth

The main objective of this project is to create an environment that can simulate diamond growth. This environment is meant to be like the one located at Great Lakes Crystal Technologies (GLCT). There are numerous components to this environment design, such as an IR camera, quartz bell jar, thermocouple, diamond plate, hot plate, and custom-designed 3D printed pieces. The 3D printed pieces will be curved rectangular shapes with evenly spaced holes. On each piece, the diameters of the circular holes will be different. The first piece will have holes with a diameter of 6 mm, and each subsequent piece's holes will decrease in diameter by 1 mm down to 3 mm, resulting in a total of four 3D printed pieces. These components will be set up in the configurations shown in the diagrams to the right. Once the simulated environment is set up, it will undergo three experimental tests to provide accurate temperature data of diamond growth. Each experiment's environment will be set up slightly differently. In the first test, the diamonds' temperature will be measured with both the IR camera and the thermocouple, and the quartz bell jar will not be used. The second test is nearly identical to the first but with the addition of the quartz bell jar. Finally, the third testing setup will consist of similar aspects of the second testing environment but the thermocouple will be removed. Additionally, the 3D printed pieces will be placed directly in front of the IR camera to study how the IR imaging will be affected by the varying hole diameters of the 3D printed pieces. Moreover, the gathered data from the IR camera's thermal imaging, light sensitivity readings, and temperature measurements will be processed and analyzed. This project will provide valuable heat distribution data for GLCT to optimize their diamond growth conditions.



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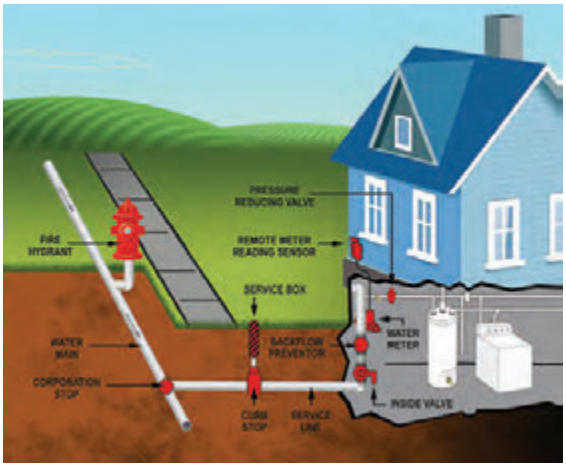
MSU Department of Electrical & Computer Engineering
Detection of Buried Lead Water Pipes

There are many communities, including those based in Michigan, that are facing challenges surrounding the delivery of clean, potable water from legacy infrastructure. Some older lead pipes have experienced leaching into the water system and have caused people to experience health issues. One of the most prominent examples is Flint, Michigan. Lead poisoning has a significant effect on children and can cause weight loss, loss of appetite, and intellectual disabilities. With the Safe Drinking Water setting the standard for water distribution and mandating the phase-out of lead pipes, one might think that it would be a simple matter of digging up and replacing the existing pipes. However, there are many variants of pipes with lead being just one. Many municipalities did not keep extensive records of legacy pipe materials underground. Since the process to replace pipes is very expensive and time-consuming, post-installation mapping is critical. This in itself is an expensive and laborious process.

To that end, the goal of this project is to design and demonstrate an effective method to detect lead water pipes without the need to explicitly excavate them. The design will be robust, safe, and intuitive to non-engineers for easy use. This specific endeavor will pursue the measurement of pipe resistivity to determine its pipe material. Water pipes come in different materials and the resistivity of lead, steel, and copper is substantially different such that it should be possible to distinguish the pipe material from this measurement alone. The four-wire method will be used in tandem with an AC current to measure the voltage drop across the pipe. By using coherent detection techniques, the pipe can be classified without being excavated.



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MSU Department of Electrical & Computer Engineering
Miniature Self-Driving Car

Self-driving cars appear to be the future of ground travel. However, many are skeptical about the costs of the sensing technology and control designs of such cars. With good implementation, such cars could avoid many problems that come with human drivers and could reduce collisions making it safer to drive on the road. However, with bad implementation, perception and control of such a vehicle may fail, or even be infeasible due to the cost of supporting and optimizing these platforms.

We are building a 1:10 scale miniature self-driving car in a cost-effective way. We will be using a 1:10 scale miniature car, along with a Raspberry Pi, Lidar, cameras, and a flight controller, as well as other interfacing/sensor devices, to build the final product. For navigation purposes we will be using our cameras to read AprilTags across the indoor environment. We will then fuse our data from the AprilTags with IMU data to provide an accurate localization of our car's 3D position and orientation. Typically, a GPS would be used in this case, however a GPS system does not work in an indoor environment.

In order for the components of our car to communicate effectively with one another, we have been provided with Python and C++ code which will seamlessly allow our components to operate together.

Successful development of this project will result in an autonomous miniature car that is able to navigate through an indoor environment.

April Tag Example

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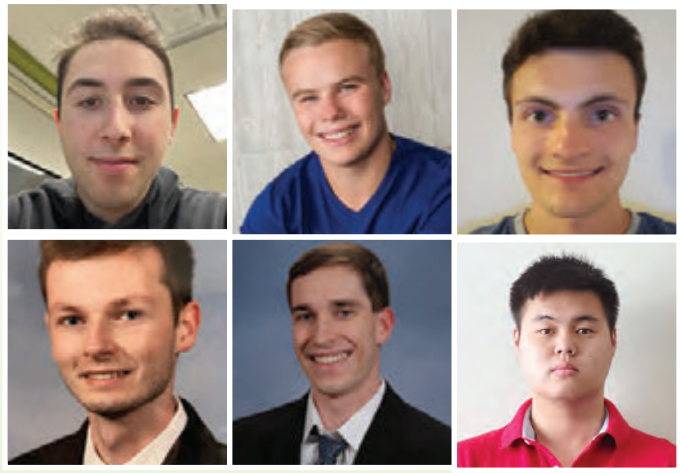

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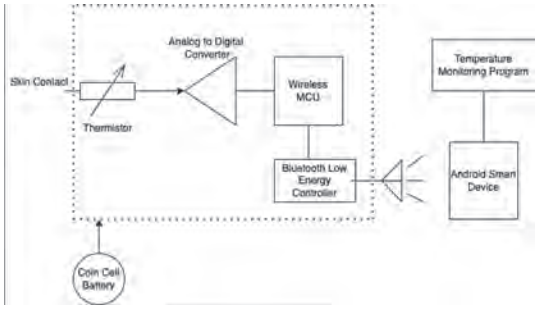
MSU Department of Electrical & Computer Engineering
Wearable Temperature Monitoring Device

Considering the recent COVID-19 pandemic, monitoring health symptoms in an effective way to reduce the spread of the virus has become a popular topic of discussion. Under current practices, a temperature measurement is required to be taken by a healthcare worker at a relatively close range and, if necessary, periodically rechecked. With current practices, there is the possibility for a healthcare worker to transmit the virus and vice versa. In an ideal world, healthcare workers and patients alike would be able to monitor temperatures while maintaining proper distance. In an attempt to solve this problem, a patient-worn Bluetooth temperature sensing device that can be monitored by a central smart device has been proposed.

The Bluetooth device will generate an accurate temperature reading at five-minute intervals to observe patient temperatures. Comfort and obscurity are paramount in the design of the sensing device, as patient satisfaction is an important goal for healthcare workers. Another important characteristic of the device is cost efficiency as, if implemented, a network of Bluetooth monitors would likely be utilized in order to measure a broad range of patient temperatures.

The wearable device will utilize a high tolerance thermistor to obtain temperature measurements which will communicate with the on-chip analog to digital converter of the selected TI CC2652RB microcontroller. This temperature measurement will be transmitted via Bluetooth Low Energy module on the microcontroller to an Android device. The partnering Android application will display a user-friendly graphical interface that will report patient information, as well as the corresponding temperature measurements.



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MSU Department of Electrical & Computer Engineering
Diaper Monitoring System

Single-use absorbent diapers are commonly used by parents to help keep their babies and young children clean. However, the only way to determine if a diaper has been soiled and needs to be replaced is by manually checking. This can lead to situations where a baby wears a soiled diaper for an extended period of time, such as overnight or when its guardians are away. This is unhygienic for the baby and can lead to rashes or other conditions.

The Diaper Monitoring System uses a smartphone app to notify parents when a diaper needs to be replaced. This increases the effectiveness of diapers by ensuring they do not remain soiled for an extended period. Eliminating this situation reduces occurrences of rashes and increases overall hygiene.

This system utilizes a pair of Ultra-High-Frequency radio-frequency identification (RFID) tags that communicate with an RFID reading device placed in the same room as the baby. One tag acts as a "control" and the other is used to determine if the diaper needs to be changed. When the diaper is clean, both tags are read consistently. However, if the diaper is soiled, one RFID tag does not communicate effectively with the reading device. When this tag is not being read and the "control" tag is present, the system notifies the smartphone application that the diaper needs to be changed. The RFID reading device communicates this information with a Raspberry Pi, which then alerts the phone application over local Wi-Fi.

Consumers of this product will only spend a few cents more per unit compared to traditional diapers because RFID tags are mass-produced for low cost. The Diaper Monitoring System requires users to make a one-time purchase of the RFID reading device and download the smartphone application.

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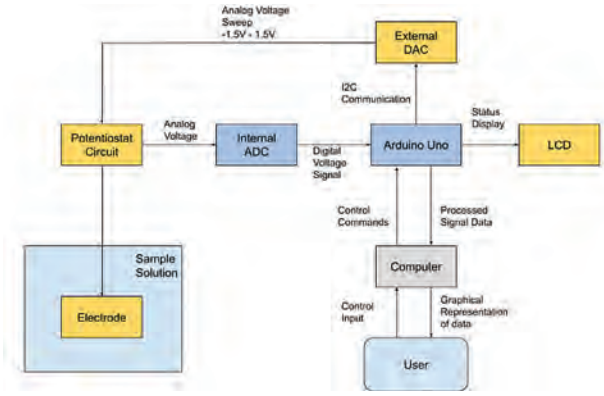
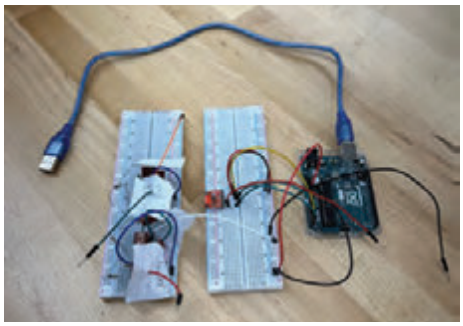
Fraunhofer Institute
Electrochemical Instrument for Sensor Miniaturization

Fraunhofer USA Center Midwest is a research organization in East Lansing, Michigan that focuses on the development of coatings and diamond technologies. The headquarters of Fraunhofer USA are located in Plymouth, Michigan. The development of these technologies is useful for the electrodes in a variety of different applications involving electrochemistry. Electrochemical instrumentation is greatly useful for the analysis of particles such as heavy metals and viral particles in saliva. The analysis of these particles allows for better detection statistics using chemical measurements. Our aim for this design project is to create an affordable and integratable electrochemical instrument to detect lead in water.

Our design is based on using a potentiostat circuit that is connected to an electrode to monitor and measure samples of water for lead based on its signature response in cyclic voltammetry. Our design aims to be cheaper than current tests at our price range that are often one-time use and cannot be easily hooked up to software.

This design is aimed at a person or company who will be frequently testing their water, which is a different user than most miniaturized lead testing products that cater to testing drinking water. Most lead testing kits sold in stores are lead testing strips that are cheap but only one-time use. Other kits that people buy online get sent to a remote lab for testing and are also one-time use since you can only collect and send one sample. Our design will be a reusable device that will be aimed towards people or companies that need to test water for lead on a continuing basis. Removing the need to buy a new lead testing kit each time will be more practical and add up to savings over time for the consumer. Also, the cost of all the materials and components that make up this device is low, leading it to have a much lower life-cycle cost over existing products when used for ongoing testing.





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MSU Department of Electrical & Computer Engineering
Vocal Enhancement Device

Musical audio engineers use a variety of software modules capable of manipulating sound signals in various ways. These effects are used to improve clarity and quality of vocals. Previously, studios used bulky equipment made from electrical hardware to achieve the same effects.

The proposed project challenges the team to design a compact box with multiple filters to implement these effects. The most important of these filters are a volume gain, an equalizer, a compressor, and a reverb.

The box will be connected between a microphone and speaker and manipulate the input signal before sending the output to the speaker. This project would eliminate the need to pre-record audio before applying the effects. In other words, the proposed device will provide the effects in real time.

Physical constraints include weight, size and cost. The user accessibility of this device would be hindered if the finished design is too heavy to carry or the price is too high. Our objective is to constrain our design to a weight below 15 lbs, a volume less than one cubic foot, and a price under $350.

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Aerial Drone for NDE Applications

Non-destructive evaluation (NDE) has been used to evaluate the structural integrity of critical structures across many industries. With the help of sensor technology that is selected based on the material and geometry of the structure, NDE techniques detect damage precursors so the appropriate maintenance can be performed to ensure safe and continual operation. Larger structures such as wind turbines, power plants, and building infrastructure can be difficult to scan. That is why we are working on utilizing a drone to capture 2D video which can then be reconstructed into a 3D model using photogrammetry. Photogrammetry is the science of obtaining reliable information about a structure through the process of recording and interpreting 2D photos and videos.

In addition to the stock camera, an RGBD camera will be mounted on the drone to provide two streams of data: RGB video, and depth data. The two data sources are utilized separately to provide a 3D reconstruction of the scanned object. To generate 3D information from RGB video, a photogrammetry approach is being used with the AliceVision framework. To acquire this data from the camera we will be utilizing a Raspberry Pi that will be mounted to the drone. Once the data is obtained, the AliceVision framework will be utilized to reconstruct a 3D image of the structure that was scanned.

In order to mount the new camera and the Raspberry Pi we designed a mount using 3D modeling software, then 3D printed the mount using material that is light and sturdy. This is to ensure that the drone will still be able to fly with the added weight.

` Overall, the objective of this project was to obtain an aerial drone and modify it so it can be utilized for NDE applications, such as scanning large structures, to detect any damage precursors that might be presenting themselves.

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AMP Robotics / MSU Surplus Store & Recycling Center

Maximizing Use & Efficiency of Robotic Sorting

As consumption of plastic packaged products grows, so does the importance of finding sustainable and effective ways to dispose of them. In 2006, MSU launched the "Be Spartan Green Environmental Stewardship Initiative" to help reduce the impact of waste on the environment. MSU is home to the Surplus Store & Recycling Center (SSRC) that processes between 20 to 25 million pounds of material annually, including between 8 and 9 million pounds of recycling material from MSU's campus.

Recycling centers rely on the speed and accuracy of sorters to bale recyclables. Traditionally, the sorting was done by humans who would load and hand sort the line. More recently, with the rise of artificial intelligence cyber-physical systems, robotic sorters have been developed to surpass the speed in picks per minute of human sorters. Robotic sorting systems can nearly double the speeds achieved by human sorters. This increased speed directly correlates to an increase in profits for the facility and a decrease in risk to employees encountering sharp and toxic materials, such as broken glass, needles, and medications often found in recyclables.

The goal of this project can be broken down into three main objectives, each rooted in the prospect of reducing the number of employees interacting with the recyclable materials and increasing their effectiveness. First, this project aims to identify processes to optimize the use of the AMP robotic sorting system at the MSU Surplus Store & Recycling Center through increasing the number of picks per minute performed by the robot. Second, this project investigates the addition of a sensor to the Cortex system to identify the depth of the recyclables on the conveyor belt. Third, this work constructs additions to the chutes in which recyclable materials are sorted to reduce instances of spillover.

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ME 412 Heat Transfer Laboratory

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Academic Specialist
Department of Mechanical Engineering

Experimenting with Thermal Energy Storage

Thermal energy storage (TES) is found in various applications, as a large-scale system or as a simple "battery" device. It is essential in renewable energy production systems such as a solar thermal power plant or a wind farm, providing flexible energy supply and improving the overall system efficiency. When used in a building heating system or heat recovery units, TES also leads to better economics. In this project, students in ME412 are expected to understand the thermal energy storage process and technology through two parts of work. For the major part, each team will design, build, analyze, and test a simple thermal battery. The objective is to provide sufficient heating to an airflow or a space after the battery is "charged" (heated) and stored for a certain time. For the secondary part, each team will chose a specific type of thermal energy storage system and conduct a review on its application, technology, operation, and performance analysis. A testing station with instrumentations for flow and temperature measurements is available for teams to test their device. On the presentation day, each team will prepare a power-point slide show or a video clip to explain the design decisions, fabrication, thermal analysis, and testing results of their devices.

Competition Schedule

Team 1
Emma Clawson
Tanner Nurnberger
Mitchell Ruczynski
Chris Sadler
Coleson White

Team 2
Connor Bragg
Tyler Lim
Daniel Mondrusov
Henrique Pio
Robert Walston

Team 3
Britney Bush
Sean Colling
Natalie Kinsley
Matt Stucky
Garrett Watson

Team 4
Devyansh Agrawal
Ian Beshears
Jessica Gothro
Matt Simental
Jeremiah Waterman

Team 5
Ryan Lokar
Smitkumar Patel
Martin Stokes
Cooper Strebeck
Connor West

Team 6
Douglas Heine
Chloe Ho
Tommy Pang
Youngbin Song
Emma Todd

Team 7
Sarh Al Bawardi
Hernan Brarda
Stacy Fakhoury
Blake Mallamo
Quentin Wade

Team 8
Garrett Colasinski
Christopher Douglas
Kace Krauss
Nick Occhiuto
Austin Pollock

Team 9
Ben Gaynier
Hanna Gehrke
Kendall Lusk
Zachary VanderStel
Max Wiedemann

Team 10
Brendan MacDonald
Claire McMillen
Liam Ranik
Harrison Schaub
Zach Stroud

Team 11
Nick Demeester
Samir Hussain
Rhett Pimentel
Jax Prusakiewicz
Stephen Stormzand

Team 12
Abigail Bowman
Allison Fox
Livia Noble
Eric Parsons
Eli Rodriguez

Team 13
Ninh Dang
Garrett Gould
Nicole Kowalski
Mckyle Stanfield
Justine Stewart

Team 14
Nathan Ansbro
Michael Bachleda
Eli Pickard
Jack Rutkowski
Jacob Wescott

Team 15
Valerie Aten
Jacob Grimmer
Jacob Hoffman
Kirk Maibach
Kengo Takenouchi

Team 16
Ian Burress
Will Erskine
Andrew Flight
Zack Friess
Julia O'Mara

Team 17
Drew Boudreau
Ethan Neitzke
Alex Toth
Jack Voigt
Griffin Yakey

Team 18
Renad Alhassani
Taku Benson
Jacob Campion
Spencer Labuda
James McDonald

Team 19
Adam Bresson
Noah Crusoe
Jacob Pawloske
Sam Pellinen

Team 20
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John Dela Cruz
Cody Hayse
Jack Lambrix
Madeline Stump

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Ty Ebling
John Gregor
Anthony Kasiyan
Robert Pedder
Abhyuday Rastogi

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Caleb Holtschlag
Oliver Larroquette
Hailey Minton
Garrett Ruhala

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Justin Kinville
Landon Luyckx
Bradley Matte
Michael Trajkovski

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Paige Brechtelsbauer
Bobby DiPanni
Ailohi Izirein
Mark McCloskey
Kearri Myrick

Team 25
Elco Blanco
Braden Heiler
Tucker Hendrie
Alyssa Lafeir
Sarvesh Subramanian

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Cam Depauli
Joe Fantin
Kanglin Ma
Logan Malak
Xichen Zhu

Team 27
Kobie Davis
Hunter Hansen
Tom Ott Jr.
Michael Vangel
Kainnon Vilminot

Team 28
Bryce Hitchcock
Luke Janecke
Ash Mckesson
Alex Oreilly
Val Vargas

Team 29
Anna Citko
Drake Deming
Alex Kriese
Vanessa Pariso
Sophia Swiecki

Team 30
Emma Carduner
Mason Chorpenning
Karli Deutscher
Raj Lamport
Ryan Zerona

Team 31
Veronica Giordano
Parang Khanal
Katlyn Knudsen
Julie Pham
Drew Tyrrell

Team 32
Michael Batina
Ryan Koschay
Sean Martella
Akhilesh Swaminathan

ME 456
Mechatronic System Design

Dr. Guoming Zhu, Professor
Department of Mechanical Engineering

Learning Objective:

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

Mechatronic System Used for the Lab Sessions:

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

ME 470 Mechanical Design & Manufacturing II

Michael Lavagnino
Academic Specialist
Department of Mechanical Engineering

Water Displacement Mechanism

The goal in this project is to design and manufacture a mechanism that can move as much water as possible in one minute from a 5 gallon bucket on the floor to a bucket 5 feet in the air. The teams will utilize 4-bar linkages and human power to compete in displacing the most water possible in one minute. Students will utilize materials and manufacturing capabilities from the Manufacturing Teaching Laboratory (MTL) as well as premade components.

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Connor Laubach
Anjali Patel

Team 1B
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Alex Feige
Richard Lin
Suven Sinha

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Sarvesh Subramanian
Stephen Tamboer
Ryleigh Turner

Team 2B
Seth Gower
Alexandra Iorga
Hailey Kelley
Zach White

Team 3A
Ben Finkbeiner
Sean Lickfold
Alex Oreilly
Tommy Wierzbicki

Team 3B
Evan Backer
Caleb Holtschlag
Kainnon Vilminot

Team 4A
Atticus Crimmins
Jake Cuffaro
Jack Girling
Kendall Lusk

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Katie Mcmillan
Emily Peterson
Andrew Reddy

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Scott Fingeroth
Kearri Myrick
Luke Willemsen

Team 5B
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Qixian Chen
Michael Gertley
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Miguel Jarquin-Lopez
Saeha Lederle
Andrew Pieper

Team 6B
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Jaclyn Duff
Abdulhamid Salem

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Eric Ernvall
Aaron McDowell
Daniel Vance

Team 7B
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Ryan Bartlett
Parang Khanal
Noah Moyer

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Jennifer Blowers
Evan Lamb
Max Wiedemann

Team 8B
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Bryce Hitchcock
Nicholas Michaels

Team 9A
Conner Cadieux
Dino Iovtchev
Nathan Kowalski
Mark Zum Mallen

Team 9B
Elco Blanco
Bradley Matte
Mark McCloskey
Jackey Tran

Team 10A
Nathaniel Clarke
Jacob Cristofori
Bryn Dittmar
Julia Fox

Team 10B
Zaid Almodhi
Kyle Pawlowski
Donnie Schuster
Cole Treece

Team 11A
Spencer Labuda
Cole Lutkenhoff
Peter Phan
Thomas Supal

Team 11B
Frederick Bruner
Tyler Marshall
Austin Pollock
Shamit Topiwala

Team 12A
Erin Chynoweth
Maddy McKown
Rob Paquette
Olivia Reyes

Team 12B
Alejandro Castillo
Jeffrey Li
Tommy McGowan
Michael Strong

Team 13A
Bill Altier IV
Amber Bliven
Hyun Kim
Ash McKesson

Team 14B
Mason Chorpenning
Eric Douglas
Van Duong
Mitchell Essenmacher

Team 15A
Olivia Lage
Ryan Peters
Spencer Stefani
Grace Veenstra
Kyle Zerafa

ME 478
Product Development

Haseung Chung
Assistant Professor of Mechanical Engineering

Autonomous Mixing and Depositing System for 3D Printing

The objective is to develop an automated mixing and depositing system of an olive oil – sand mixture which can be adopted by 3D printing machines based on resin-powder (metal, ceramic) mixture.

The requirements of system are the following:

1. The system should be capable of combining and homogeneously mixing a solution of 1:4 weight ratio of olive oil and sand (i.e. 5 grams of oil and 20 grams of sand).
2. The olive oil mixed with sand should be deposited on a 10 x 10 cm platform in a weight controlled manner.

Presumably, the system might consist of:

1. A material supplying module. This module is capable of adding sand and extruding oil into the mixer with a specific weight ratio. This is very similar to what the binder jet 3D printer does.
2. A mixing module. Blend the oil and sand together until the solution is homogeneous.
3. A deposition module. Deposit a certain amount of the mixed solution (10 grams).

Evaluation criteria:

1. The homogeneity of the solution will be inspected visually.
2. The quantity of the deposition will be based on the weight of each deposition.

If necessary, the electric motors must be controlled by MyRio, which will be provided. Starting from an individual project and progressing into a team project, each team must produce the machine through a series of design and manufacturing tasks. Each student needs to contribute individually as well as collaboratively to accomplish a series of tasks. CAD/CAM packages, CNC machining, rapid prototyping, testing, etc. will be used to produce the machine.

Teams and Team Members

Team 1:
Sean Colling
Nathan Fleming
Zach Friess
Zach White

Team 2:
Emma Clawson
Liam Ranik
Daniel Vance
Robert Walston

Team 3:
Qixian Chen
Miguel Jarquin-Lopez
Evan Lamb
Willis Wuebben

Team 4:
Olivia Dario
Vanessa Pariso
Jessica Thomas

Team 5:
Cam Depauli
Michael Gertley
Connor Laubach
James McDonald

Team 6:
Michael Bachleda
Jack Hasselbring
Samatha Lawlis
Youngbin Song

Team 7:
Drew Boudreau
Alex Feige
Seth Gower
Bradley Matte

Team 8:
Arianna Finn
Natalie Knisley
Trent Treppa

Team 9:
Delano Dalfonsi
Brendan MacDonald
Katie Mcmillan
Tommy Pang

Team 10:
Jahzeel Alcantar Gallegos
Landon Luyckx
Ailohi Lzirein
Abdulhamid Salem

ME 497
Biomechanical Design

Dr. Tamara Reid Bush
Associate Professor of Mechanical Engineering

MKT 420
New-Product Development

Dr. Hang Nguyen
Assistant Professor of Marketing
Business College

Biomechanical Design and New-Product Development

The Biomechanical Design and New-Product Development course (ME 497/MKT 420) provides students with a unique opportunity to develop and market a real, new product that incorporates biomechanical function. Students work in inter-disciplinary teams of engineers and marketers and experience the entire process of new product development, from need identification, concept generation and testing, to product development, design analysis and launch. This course further strengthens students' knowledge and real-world exposure by working with Spartan Innovations. This year General Motors provided $100 per team for prototyping costs, and the Mechanical Engineering Department Endowment sponsored an in-class competition providing awards to the top three product ideas.

#	Team Members	Team Slogan
01	Ben Gaynier, Parks Gissinger, Cade Rathbone, Maggie Ritchie, Sophia Swiecki	**The Shoe-In:** A hands-free shoe assist device (Putting on your shoes has never been easier)
02	Emma Clawson, Jon Cruz, Garrett Ruhala, Chris Sadler, Michael Yamin	**Crutch-Claw:** "Reach No Further"
03	Wyatt Cool, Jack Falardeau, Steven Souphis, Grace Veenstra, Max Wiedemann	**Chair-Roids**: "The ultimate way to juice up your chair, a convenient and versatile way to exercise the upper body right from the wheelchair"
04	Allison Keller, David Lawless, Amanda Miner, Lila Ninotti, Olivia Simone, Jerica Tallman	**Straight-Up:** Simple chair attachment to correct posture while sitting
05	Will Brendlinger, Bryn Dittmar, Maddy McKown, Rob Paquette, Trevor Stephenson	**Pocket Crutch:** "The crutch that comes in clutch"
06	Heather Kulkis, Nicholas Michaels, Vigneshwer Ramamoorthi, Olivia Reyes, Kainnon Vilminot	**GrowKart:** A garden cart that helps you up.
07	Katie Bieszke, Kaitlyn Blazo, Brittany Bush, Alex Grotjohn, Nicole Kowalski, Lucas St John	**Thumb360:** An inovation in brace technology that helps strengthen, heal, and to live life painlessly
08	Jennifer Blowers, Paige Cordts, Chloe Gunther, Rhett Pimentel, Katharine Walters, Claire Weller	**Throne Alone:** Increase bathroom independence with the use of the toilet assist
09	Kobie Davis, Anna McClellan, Anthony Pero, Bridgeen Shapton, Tommy Wierzbicki	**The Anchor Arm:** A device designed for individuals who struggle with muscular weakness and need assistance with lifting and moving the arm in any environment
10	Joe Fantin, Erica Igwe, Logan Malak, Adam Van Gieson, Tamia Wilson	**EVA (Ergonomic Vest Arm):** Clasp it and grasp it
11	Michael Bachleda, Sean Brady, Ginger Haller, Jack Lambrix, Matt Stucky	**ErgoNomics:** Ergonomic advancement to the I.V. pole in order to assist in smoothly raising and lowering the pole with one hand.
12	Grace Biebly, Kylie Decker, Grace Kruger, Claire McMillen, Hailey Minton, Hailey Swamy	**Safe-Rail:** A collapsible, portable support railing to assist disabled and elderly users to propel themselves to a standing position
13	Miel Edwards, Leah Kiura, Kace Krauss, Olivia Lage, Ash McKesson, Jax Prusakiewicz	**EZ Grip:** A device created for people who suffer from rheumatoid arthritis and need to pick up items without using hand-finger grip strength

The Capstone Projects

Dr. William Resh
Professor of Mechanical Engineering

Faculty Advisors: Manoochehr Koochesfahani, Ranjan Mukherjee, Norbert Mueller, Prasad Nadimpalli, Joerg Petrasch, Sara Roccabianca


Koochesfahani


Mukherjee


Mueller


Nadimpalli


Petrasch


Roccabianca

Presentation Schedule – Engineering Building, Room 1202

Time	Team Sponsor	Project Title
7:30 a.m.	MSU Solar Car Team	Solar Car Body and Chassis Design Prototype
8:00 a.m.	Ingham ISD	In-School or In-Home Lift Assist Device
8:30 a.m.	Ingham ISD	Portable Posture Assist
9:00 a.m.	Ingham ISD	Step Therapy Device for Motor Skills Development
9:30 a.m.	Ingham ISD	Device to Facilitate Self-Installing Foot-Ankle Brace
10:00 a.m.	Heartwood School/Ingham ISD	Adult Ride-on Mobility Car Development
10:30 a.m.	Ingham ISD	Portable Ramp for Regular School Bus Use
11:00 a.m.	MSU Department of Theatre	Counterweight Elevator

Mechanical Engineering Design Projects

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

- Use the technical expertise, communication skills, and teaming methodologies they have learned throughout their mechanical engineering curriculum, together with their creativity, to solve real world problems
- Collaborate with practicing engineers to address problems sponsored by industry
- Develop new products or redesign existing products to reduce costs or enhance reliability and functionality
- Interact with large, medium, and small companies in the automotive, defense, aerospace, consumer products, and agricultural industries, and with US government agencies.

We gratefully acknowledge the participation support of this semester's project sponsors: Adventures in Training with a Purpose, Asahi Kasei Plastics North America, Battleship New Jersey Museum & Memorial, Cleveland-Cliffs Inc., Consumers Energy, EarthSense Inc, Flash Steelworks Inc, Heartwood School, Ingham ISD, Lacks Enterprises, McLaren Engineering, Michigan AgrAbility, Michigan Department of Natural Resources (DNR), MSU Adaptive Sports and Recreation Club, MSU Department of Mechanical Engineering, MSU Department of Theatre, MSU Formula SAE Racing Team, MSU Recycling Center, and MSU Solar Car Team.

MSU Solar Car Team
Solar Car Body and Chassis Design Prototype

Michigan State's Solar racing team is a student run group focused on competitively designing and racing solar powered vehicles. The team competes in two solar "rayces" —The Formula Sun Grand Prix (FSGP) and the American Solar Challenge (ASC). FSGP is a track event that is held on grand prix or road style closed courses. ASC is a cross-country time/distance rally event where teams compete over a 2,000 mile course between multiple cities across the country. With 10 years of racing experience, the solar car team remains competitive by making continuous improvements to their vehicles. They have produced five complete vehicles - four Single Occupant (SOV) and one Multi Occupant (MOV). In the design of their upcoming vehicle, the team hopes to upgrade crucial aspects of the car's aeroshell and chassis. These two aspects play a large role in the weight and aerodynamics of the vehicle, which are essential for producing a competitive vehicle. The team plans to begin manufacturing this vehicle by the end of summer 2022 and compete in FSGP and ASC 2024.

Using the information provided to our team by Michigan State's solar racing team, we were able to assess the chassis and aeroshell design of the solar team's previous SOVs. Additionally, we researched the designs of competitive vehicles, pulling the most from those that performed well in competition worldwide. The chassis and aeroshell created were modeled in Siemens NX. The chassis then went through extensive force analysis in the ANSYS Structure. The aerodynamics of the aeroshell were evaluated with the program Fluent. The design went through many iterations. Ultimately, we ended with a successful design that utilizes a safe frame design and an aeroshell that is aerodynamic to make the car as efficient as possible. A 3D printed scale model displays the final design that was chosen.

Michigan State University
Team Members (left to right)

Alyssa LaFeir
Sterling Heights, Michigan

Ryan Zerona
Canton, Michigan

Julia O'Mara (Sponsor)
Okemos, Michigan

Will Erskine
Ionia, Michigan

Ian Burress
Poquoson, Virginia

Zack Friess
Canton, Michigan

MSU Solar Car Team
Project Sponsor

Julia O'Mara
Okemos, Michigan

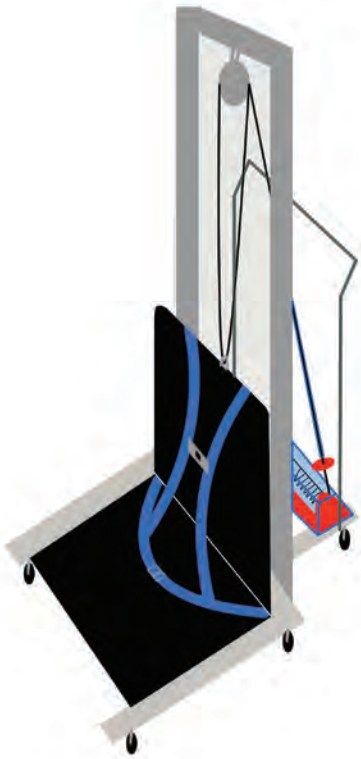
ME Faculty Advisor

Dr. Joerg Petrasch

Ingham ISD
In-School or In-Home Lift Assist Device

The Ingham Intermediate School District (Ingham ISD) is a shared community of schools in the surrounding Lansing area that strives to fill learning gaps and enhance education for all students. Ingham ISD has worked with the Mechanical Engineering Department at Michigan State University for a number of semesters to design an assistive lifting device for students with disabilities.

The goal of this project was to add safety advancements to a partially completed assistive lift so that it may be used with students from Ingham ISD to improve their quality of life. The lift was originally designed for a specific student, but all safety advancements modified the lift to be able to be used for students with a variety of disabilities. The device safely lifts students weighing up to 150 pounds from floor level to a standard seated level of 30 inches off the ground with the ability to stop at any height in between. The lift is operated by a remote control used by a single caregiver, instead of manually lifting the student using multiple caregivers. With added safety improvements the lift will be able to be used by a variety of students to meet their needs. Added to the device was a seatbelt covering both the student's waist and upper body, which can be adjusted to the student's specific needs, as well as technology to prevent the lift from exceeding 30 inches, thus preventing failure and reducing the risk of injury for students in the lift. The addition of collapsible handles allows the device to easily relocate students around a school or home and store the device in minimal space when not in use. Finally, the device was complete with extra stability to prevent tipping when the lift is operating and covers for the cables and machinery to prevent student and operator injury. The lifting device is compact enough to travel or be stored around a school or home. Overall, the ability to be easily lifted to a variety of heights improves students' quality of lives allowing them to better interact inside the classroom and in their home.



Ingham Intermediate School District
A Regional Educational Service Agency

Michigan State University
Team Members (left to right)

Emma Todd
Grand Ledge, Michigan

Jack Lambrix
Monroe, Michigan

Madeline Stump
Lansing, Michigan

Nathaniel Clinger
Grand Rapids, Michigan

Karli Deutscher
Huntsville, Alabama

Ingham ISD
Project Sponsor

Joanne Janicki
Mason, Michigan

ME Faculty Advisor

Dr. Siva Nadimpalli

Ingham ISD
Portable Posture Assist

Ingham Intermediate School District is a regional education service agency serving more than 44,000 students, including special needs children. Many special needs children require extra support for proper posture due to weakness, impaired balance, and gross motor delays; but they also want a chair that looks like those of their peers and not like a piece of medical equipment. When kids are not supported correctly, they use a lot of their focus and energy to remain upright. These students learn best when they are supported properly, and their brains can focus on what is being presented.

Our task was to adapt an existing chair to fit these needs. Our team created a portable support system to aid the students in maintaining this proper posture. This system includes armrests, a lower arch support and a foot support to perpetuate the ideal 90, 90, 90 angles of their hips, knees, and arms while maintaining a neutral head position. The new arm rests and foot support are adjustable to account for different size children. The system is applicable to a variety of chair shapes and sizes, depending on the school or child where the system is implemented.

Ingham Intermediate School District
A Regional Educational Service Agency

Michigan State University
Team Members (left to right)

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Nicole Kowalski
Reese, Michigan

Paige Cordts
Ann Arbor, Michigan

Chloe Ho
St. Johns, Michigan

Ingham ISD
Project Sponsor

Joanne Janicki
Mason, Michigan

ME Faculty Advisor

Dr. Siva Nadimpalli

Ingham ISD
Step Therapy Device for Motor Skills Development

Ingham Intermediate School District is a regional education service agency and has been in operation since 1962. Many of the 350 staff members work directly in local schools and in community settings. Ingham Intermediate School District serves as a shared community resource that creates networks of support and enhanced educational opportunities for all learners in the service area.

This project is a collaboration with an Ingham ISD physical therapist and an Okemos Public Schools Autism Spectrum Disorder teacher to address an accessibility issue for students with Autism Spectrum Disorders and provide them an opportunity to practice motor skills, specifically with regard to negotiating bus stairs.

This task can be challenging due to attentional, motoric (physical), and behavioral issues. Many repetitions of a motor skill are necessary to master the skill. While practicing the task in the environment in which it occurs is ideal, this is not always practical for a variety of reasons such as scheduling, staffing, and weather. As the students master these skills, they are enabled to more fully participate in school activities. The device is a portable structure with steps on both sides. One side mimics a school bus with regards to height, depth, width, and handrails. The other side was designed with shallower steps to increase confidence, as well as adjustable handrails to accommodate the range of targeted students. Additional design aspects are the contrasting color at the edge of the steps, non-slip treads, and visual/auditory cues that indicate correct foot placement. The cues are removable as the student's confidence and ability increase.

Ingham Intermediate School District
A Regional Educational Service Agency

Michigan State University
Team Members (left to right)

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Suttons Bay, Michigan

Liam Ranik
Northville, Michigan

Hunter Hansen
Lansing, Michigan

Julie Pham
Lansing, Michigan

Raj Lamport
South Lyon, Michigan

Ingham ISD
Project Sponsor

Christina Wolfe
Mason, Michigan

ME Faculty Advisor

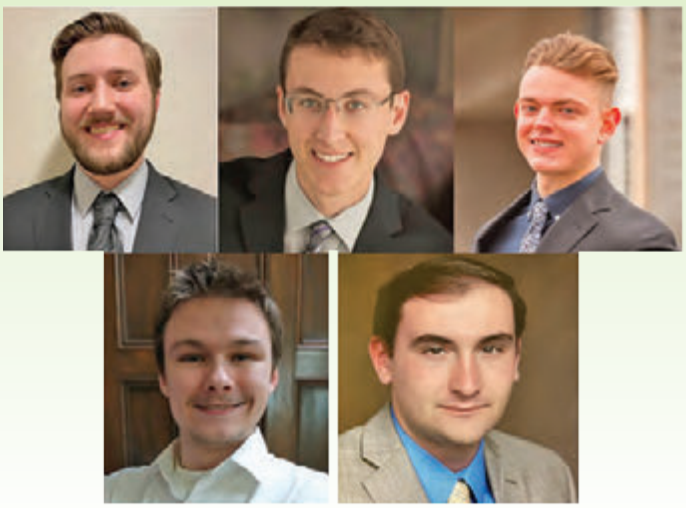
Dr. Abraham Engeda

Ingham ISD
Device to Facilitate Self-Installing Foot-Ankle Brace

Ingham Intermediate School District is a regional educational service agency that works with 12 schools within seven counties, providing support for preschoolers, students with special needs, their families, and educators. It collaborates with these schools through hundreds of programs and services to give every student a chance to succeed as a learner. One group of students they work with are students who require physical therapy due to physical limitation. Ingham ISD therapists work with students in the local districts to help them achieve independence with functional tasks

One such case can be seen from the project Ingham ISD had tasked our team. They had asked us to develop and create a device that would hold an ankle foot orthosis (AFO) steady while users are attaching the brace to themselves. The project was assigned to help one particular student who had developed Rapid Onset Dystonia Parkinsonism. This device allows him to safely insert his foot into his brace and use the other side of his body to secure the brace himself. At the request of Ingham ISD, the device has been designed such that it can be used universally by many users with a multitude of conditions that would require them to use an AFO. This required the device to have an adjustable/adaptable mechanism capable of comfortably and efficiently securing the AFO of the subject. This was accomplished through the scissor jack base, adjustable Brannock-like device, and 3-dimensional scanned back for comfort.

Ingham Intermediate School District
A Regional Educational Service Agency



Michigan State University
Team Members (left to right)

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Rochester, Michigan

Joe Fantin
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Martin Stokes
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Adam Van Gieson
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Michael Trajkovski
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Ingham ISD
Project Sponsor

Heather Vogt-Frechette
Mason, Michigan

ME Faculty Advisor

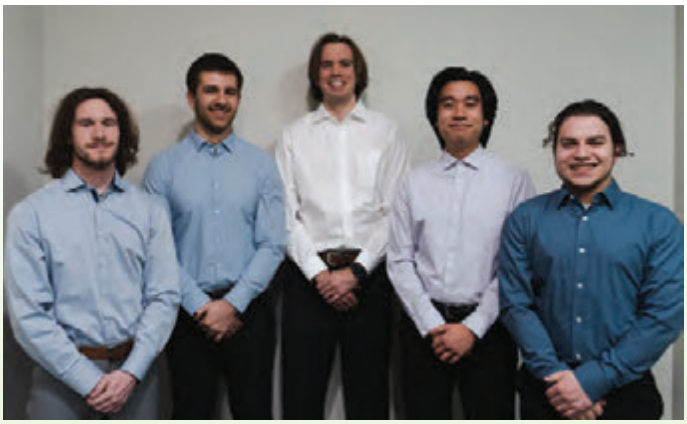
Dr. Norbert Mueller

Heartwood School/Ingham ISD
Adult Ride-on Mobility Car Development

The Adult Ride-on Mobility Car was developed by our team for Heartwood School. Heartwood serves students with moderate to severe cognitive impairments and disorders. These students can range between ages 3 to 26. Programs at Heartwood help these students to achieve their greatest potential via a safe, educational, and supportive program.

The Adult Ride-on Mobility Car developed by our team for Heartwood School was designed to be a vehicle that both young and old students could use to develop better motor skills, coordination, and muscle strength. Our team needed to design and create a vehicle that could be moved by the users' feet or an assistant's hands via a handle. The key elements addressed in this project were a strong body framework, seatbelt, handle system, and interactive elements for the students. In addition, these components needed to be safe and capable of withstanding significant weight and bumps/impacts. We kept in mind that students of vastly varying size and capability should be able to use the Mobility Car. A caregiver, if needed, would be able to push the vehicle with the student secured. Alternatively, a student with more physical capability could use their feet to maneuver it. Research, design, CAD modeling, fabrication, and testing was done to produce the best possible result, a mobility car that the user enjoys using.

Ingham Intermediate School District
Heartwood School



Michigan State University
Team Members (left to right)

Lucas St. John
Northville, Michigan

Steven Souphis
Northville, Michigan

Stephen Stormzand
Northville, Michigan

Kengo Takenouchi
Rochester Hills, Michigan

Jacob Hoffman
Northville, Michigan

Heartwood School/ Ingham ISD
Project Sponsor

Heather Vogt-Frechette
Mason, Michigan

ME Faculty Advisor

Dr. Norbert Mueller

Ingham ISD
Portable Ramp for Regular School Bus Use

Ingham Intermediate School District is in south mid-Michigan. Ingham ISD serves twelve public school districts, ten public school academies, and extends into seven different counties. Ingham ISD is a shared community resource for the school districts that it serves. Among the many districts that it supports is Mason Public Schools, which is the district that we worked with during this project. Our project sponsor is a physical therapist that works for Ingham ISD, and her role is to assist kids that have physical disabilities.

Our team was tasked with designing a bus ramp that could be easily installed on a regular international style bus. There is a student that attends Mason Public Schools that was unable to access regular school bus stairs due to a lack of mobility in her hips and knees. This made it impossible for her to ride the bus with her friends. Therefore, the goal of this project was to design something that would allow her to navigate the bus stairs without any issues. The design was created because of her need but is intended to be accessible for all students that have similar difficulties.

Ingham Intermediate School District
A Regional Educational Service Agency

Michigan State University
Team Members (left to right)

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Brighton, Michigan

Allison Keller
Clarkston, Michigan

Rahmi Khalil
Macomb, Michigan

Jerica Tallman
Grand Haven, Michigan

Matthew Stucky
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Ingham ISD
Project Sponsor

Kristi Weber
Mason, Michigan

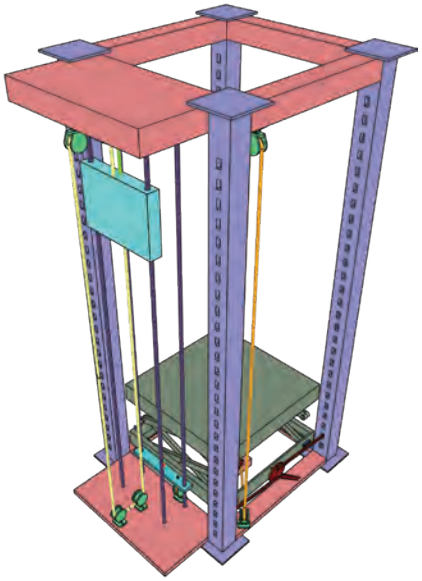
ME Faculty Advisor

Dr. Manoochehr Koochesfahani

MSU Department of Theatre
Counterweight Elevator

Beginning in 1968, Michigan State University's Department of Theatre has been pushing the boundaries of musicals and plays for over fifty years. Known for its groundbreaking theatrical stage designs and extravagant performances, the Department of Theatre uses the performing arts to better express current events. It allows students to express themselves more fully and choose their own path, which helps them grow into more gifted individuals. This department is ever changing as theatrical styles and forms change to reflect current societal issues. Although the Department of Theatre is currently only putting on smaller performances due to Covid-19, it usually has many different large-scale musicals or plays being performed throughout the year. This means that stage design and implementation must be quick and effective, so any premade intricate parts that are adjustable are invaluable concerning time management.

The objective of this project was to build a counterweight elevator that would be built into a stage platform. The elevator would have a person stand on it as it lowers them down slowly, creating a sinking feeling. The elevator has a complex pulley system design which meets the desired factor of safety of 8. The system is operated by two people. The platform is portable and can adjust to the stage height, which can vary from 6 to 10 feet. The system has a built-in safety system that will stop the elevator from free falling if the rope breaks.



Department of Theatre
MICHIGAN STATE UNIVERSITY

Michigan State University
Team Members (left to right)

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East Lansing, Michigan

Elias Mackoul
East Lansing, Michigan

Atharva Wadhokar
Pune, India

Smitkumar Patel
Canton, Michigan

Nathan Vigneau
Lambertville, Michigan

MSU Department of Theatre
Project Sponsor

Mark Willoughby
East Lansing, Michigan

ME Faculty Advisor

Dr. Sara Roccabianca

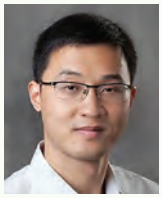
The Capstone Projects

Dr. William Resh
Professor of Mechanical Engineering

Faculty Advisors: Andre Benard, Abraham Engeda, Tong Gao, Farhad Jaberi, Lik Chuan Lee, Himanshu Sahasrabudhe, Neil Wright


Benard


Engeda


Gao


Jaberi


Lee


Sahasrabudhe


Wright

Presentation Schedule – Engineering Building, Room 1220

Time	Team Sponsor	Project Title
7:30 a.m.	MSU Recycling Center	Improved Cart Tipper Design
8:00 a.m.	MSU Recycling Center	Recycling, Debagging and Film Removal
8:30 a.m.	McLaren Engineering	Design Factors Affecting Radiated Noise of an e-Axle Housing
9:00 a.m.	McLaren Engineering	Gear Design for Noise Reduction
9:30 a.m.	Consumers Energy	Advanced Methane Detection Cooling System
10:00 a.m.	Consumers Energy	Gas Leak Detection System Control Panel
10:30 a.m.	Cleveland-Cliffs, Inc.	OCR Camera Mount for Mill Conveyor System
11:00 a.m.	Cleveland-Cliffs, Inc.	OCR Character Recognition Camera Mount

Mechanical Engineering Design Program

Mechanical engineers make the world move and provide the energy for it to do so. One goal of the MSU Mechanical Engineering Program is to educate engineers who are prepared to lead, create, and innovate as their professional or graduate careers evolve. The Mechanical Engineering Design Program is the key element of the curriculum that supports this goal. There are five required design courses in the program which provide our students with eight hands-on team-based, 'design, test and build' 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.

The ME faculty who supervised ME 481 design teams this semester are: Rebecca Anthony, Ron Averill, Seungik Baek, Andre Benard, Giles Brereton, Abraham Engeda, Tong Gao, Farhad Jaberi, Manoochehr Koochesfahani, Lik-Chuan Lee, Ranjan Mukherjee, Norbert Mueller, Siva Nadimpalli, Thomas Pence, Joerg Petrasch, Sara Roccabianca, Himanshu Sahasrabudhe, Harold Schock, Indrek Wichman, Neil Wright, Sharon Xiao, and Moshen Zayernouri.

MSU Recycling Center
Improved Cart Tipper Design

The MSU Recycling Center manages MSU waste through an integrated system of reuse, recycle, and educate. Each year it processes between 20 to 25 million pounds of material that is discarded on MSU's campus. The discarded material comes in the form of recyclables, pre-consumer food waste, and surplus goods donated by departments and the community. Our project focused on the food waste system employed by the MSU Recycling Center, which prevents an average 10 to 20 carts per day of food waste produced from on-campus dining halls from going to the landfill. There are two different carts that separate compostable food waste from other food waste. The compostable food is fed to onsite worms that convert the food into compost. Food that isn't sent to the onsite worms is either sent to a digester for energy or is sent off site for composting. The other food waste is sent to be processed and used for energy on the MSU Farms. Both carts utilize a cart tipper that was the focus for our project.

The original cart tipper design had some structural flaws that made using it cumbersome and slowed down the efficiency of cleaning the carts. The cart tipper needed to be stationary when in use, but also portable for cleaning. Our task for this project was to improve the design of the cart tipper to make it faster and easier to use.

Surplus Store and Recycling
managing waste as a resource

Michigan State University
Team Members (left to right)

Youngbin Song
Seoul, Korea

Veronica Giordano
Lake Bluff, Illinois

Valerie Aten
Lake City, Michigan

Jiachen Qu
Beijing, China

Zhemeng Fan
Shenzhen, China

MSU Recycling Center
Project Sponsor

Sean Barton
East Lansing, Michigan

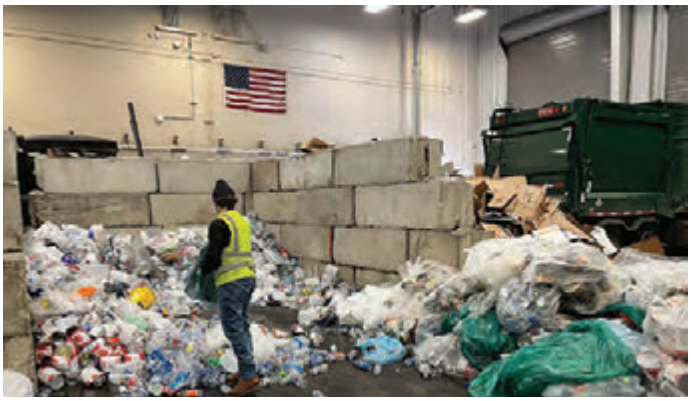
ME Faculty Advisor

Dr. André Bénard

MSU Recycling Center
Recycling, Debagging and Film Removal

The MSU Recycling Center, located in East Lansing, Michigan, handles the University's recycling needs. Each year, the center processes over 25 million pounds of discarded material from the University's various academic buildings and residence halls. Currently, recycled materials arrive at the center inside of plastic film trash bags. The bags are then cut open by hand before being loaded onto a conveyor belt for sorting and eventual compaction. These bags, while great for keeping recyclables contained during transport, require workers to open them by hand once they reach the recycling center. This creates a less than ideal situation in which workers put themselves at risk while bottlenecking the recycling process. Recently, the recycling center installed robotic sorting technology capable of detecting missed recyclables while allowing for non-recyclable items to be discarded in a receptacle below. While this is great for the end of line processing, it does not eliminate the slow and potentially dangerous process of opening the film bags.

There are various methods used in the industry to help with this problem, but many require extensive funding or policy changes. Our team was tasked with researching these existing methods and coming up with our own solution that meets the university's needs. We evaluated three possible solutions: a bladed conveyor belt-mounted device to cut through bags, a floor-mounted device to lift bags and streamline the cutting process, and a device fixed to the pile bunker to facilitate opening multiple bags simultaneously. The chosen solution will save money and help the university achieve its sustainability goals, making MSU a deeper shade of Spartan Green.



Surplus Store and Recycling
managing waste as a resource

Michigan State University
Team Members (left to right)

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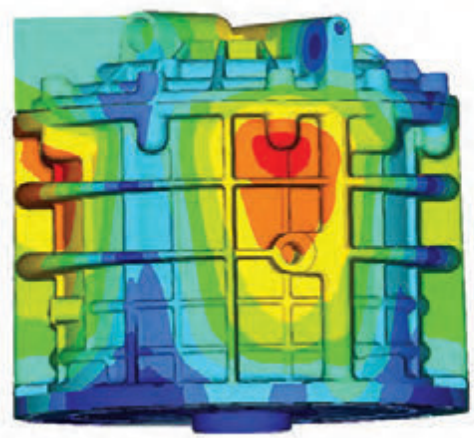
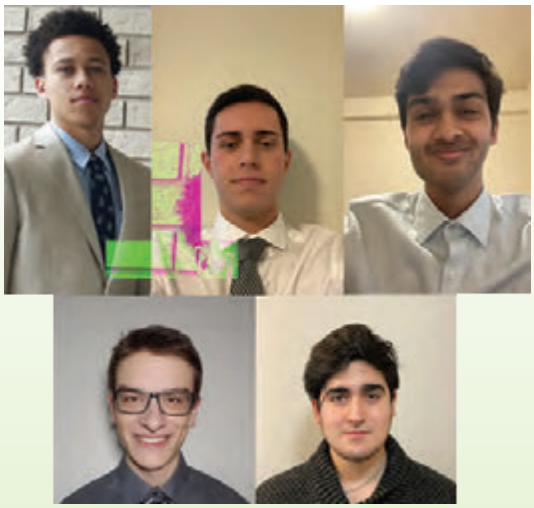
McLaren Engineering
Design Factors Affecting Radiated Noise of an e-Axle Housing

McLaren Engineering, located in Livonia, Michigan has additional technical centers located in North America, Europe, and China. McLaren Engineering has made a name for itself throughout the years with their expertise in engine and transmission/driveline design and engineering. With the recent demand for electrically powered vehicles the company has shifted some of its focus and resources to this expanding market.

McLaren Engineering focuses on the design, development, and testing of several components and systems in traditional internal combustion, hybrid, and electrically powered propulsion systems. Their testing capabilities include rapid prototyping, Noise, Vibration, and Harshness (NVH)/acoustic evaluation, performance/development durability, mechanical testing, metallurgical inspection, and cold fluid testing. This wide range of testing capabilities has allowed them to address some of the elevated NVH problems that have been found in the gearboxes and drivelines of hybrid and electric vehicles. McLaren Engineering's focus is to find a cost-effective solution to these challenges that allows the consumer to enjoy the quietest ride possible.

Our team was tasked with developing an understanding of the factors influencing radiated noise from propulsion system structures. There were several variables that our team had to consider when attempting to improve the NVH values that the components of the e-axle housing were experiencing, including wall thickness, ribbing, and material. Axle housing units contain many complex parts, so our group had to test the effects of these variables on multiple components, a flat plate, and a cylinder. This research has provided McLaren Engineering with further insight on the impact of material, component geometry, and ribbing techniques that they can incorporate into their products and provide consumers with a smoother sounding vehicle.





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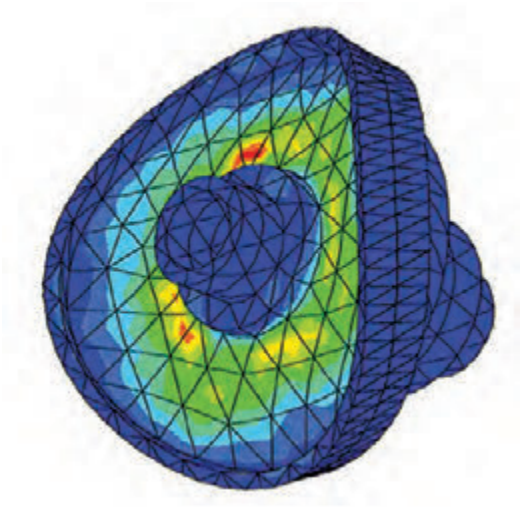
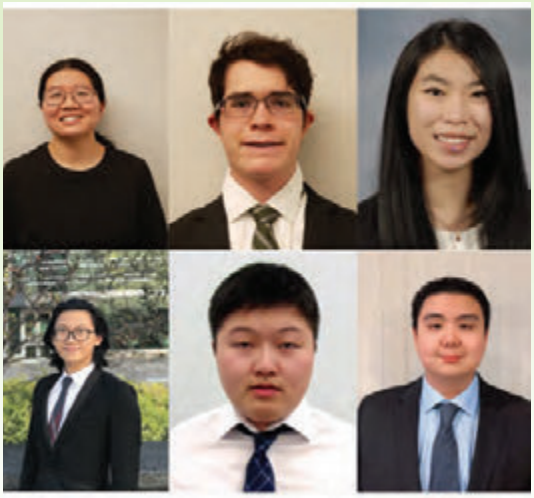
McLaren Engineering
Gear Design for Noise Reduction

McLaren Engineering is Linamar's leading-edge technology and product development team for its mobility segment. The foundation for Linamar's technical advancements is rooted in the expertise of McLaren Engineering. Purchased by Linamar in 2003, McLaren provides design, development, integration, manufacturing, and testing capabilities that provide its customers a world-class, full-service supplier partner that develops complete vehicle powertrain and driveline systems for both the global electrified and traditionally powered vehicles.

Our team has been tasked with developing an automated Computer Aided Engineering (CAE) analysis process for the EV propulsion system Noise, Vibration and Harshness (NVH) issues – or, more specifically, gear whine. This issue is significant because EVs lack the masking noise produced by classic Internal Combustion Engines (ICEs), resulting in more prominent tonal noise that annoys car passengers. Additionally, the electric motors that power EV e-axles operate at high speeds, causing high-frequency tonal noise in the passenger compartment. This noise may be mitigated by adjusting the dynamic compliance of the gear mesh, or "tuning" the gear, in order to reduce the gear meshing force, and thereby reduce the tonal noise. Dynamic compliance analyses can be run by CAD/CAE applications, so the focus of our project is to develop a tool to automate the tuning and frequency response analysis of gears for design space exploration purposes.





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Consumers Energy
Advanced Methane Detection Cooling System

Consumers Energy is one of Michigan's largest providers of natural gas and electricity. Its robust natural gas infrastructure includes 30,000 miles of natural gas pipeline, through which it delivers more than 350 billion cubic feet of natural gas to customers every year. In addition, the company maintains pressure-regulating stations and underground storage facilities to ensure that gas can be delivered safely and efficiently to people across the state. Consumers Energy is committed to reducing greenhouse gas emissions and plans to reduce methane emissions by 80% by 2030. To this end, Consumers Energy has begun using Picarro's methane detection technology to identify and correct emissions.

The main goal of this project is to develop a cooling device for the advanced methane detection system that Picarro has produced. Consumers Energy has teamed up with it in detecting methane emissions and pinpointing areas of interest for methane investigations. The main issue is overheating of the system causing premature battery drainage during the summer months when the car's smart idle system shuts down and the internal cooling fans are left to run on reduced battery capacity. This leads to an irregular shutdown process and a complicated reboot process. To account for this error, our team has developed a product that will take in real time temperature of the system and begin cooling once the area of interest has surpassed the battery efficiency threshold.

Consumers Energy
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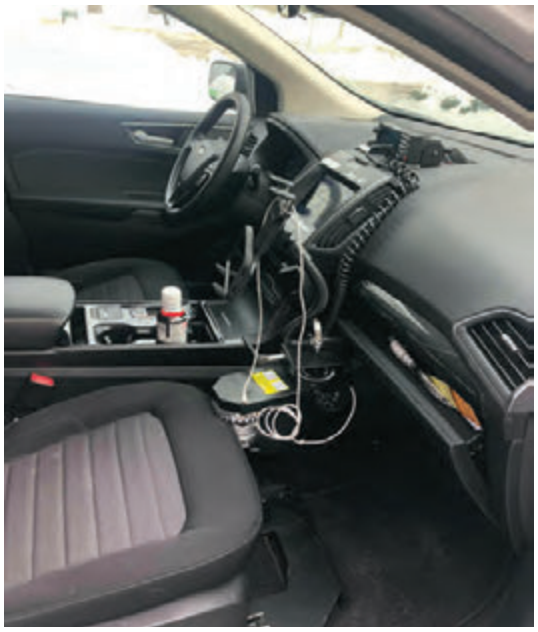
Consumers Energy
Gas Leak Detection System Control Panel

Consumers Energy was founded in 1886 in Jackson, Michigan. It is one of the leaders in providing electricity and natural gas to over 6 million Michigan residents. The main goal of the company is to provide reliable and safe energy to the people of Michigan while putting an emphasis on increasing the use of clean, renewable energy to minimize Michigan's carbon footprint leading to a cleaner world. Consumers Energy generates 5,885 Megawatts of generating capacity to over 87,097 miles of electrical lines. On top of this, it provides 27,958 miles of pipeline for natural gas distribution.

To make sure Consumers Energy's pipelines are not experiencing defects, it must continually perform routine checks. One of the ways it checked for faults was to introduce an air analyzer into two of its instrumented cars. The air analyzer was used to determine if there was a methane leak by comparing controlled samples of air concentrations to the air the system was intaking when it drove by the pipelines. The analyzer was connected to a tablet or phone to allow the driver to view the air quality in real time.

The goal of this project was to create a more stable tablet/phone mount that the driver can position to easily view to receive updates about the air quality. In addition to creating a more stable mount, LEDs were added to inform the driver if there is internet connection. This improvement allows the driver to know if the data are being processed and uploaded to Consumers Energy's database in real time. With the newly implemented mount, the overall work quality for the driver has improved.



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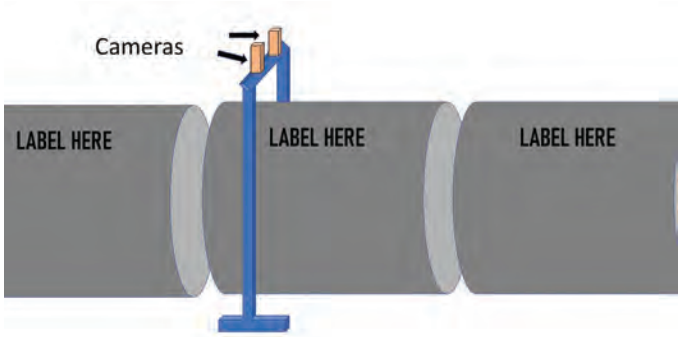
Cleveland-Cliffs, Inc.
OCR Camera Mount for Mill Conveyor System

Since its founding in 1887, Cleveland-Cliffs now has 68 operating facilities and is the largest flat-rolled steel company in North America. The company is vertically integrated and therefore is responsible for the entire steel production process. This includes the mining of raw materials and the refinement of high-end steel products for markets, including but not limited to, automotive, appliance, aviation, industrial, and construction. Cleveland-Cliffs is considered an advanced manufacturing and engineering service company and provides high quality tool building capabilities such as hot and cold stamping and has continually proven to be a leader in die design.

A majority of their sales, however, are steel coils, which can weigh anywhere between 50,000 to 80,000 pounds. In order to remove any impurities on the outside of the steel, the steel coils go through a pickle line in which they are loaded onto a conveyor belt in a very specific order and then run through a bathtub of hydraulic acid. In order to avoid missing a coil or loading the wrong coil onto the conveyor belt, two IV3-500CA Optimal Character Recognition (OCR) cameras are used to read the labels. The goal of this project was to construct a robust mount capable of holding these cameras so that the labels of the steel rolls could be processed. Ease of fabrication, how much space would be taken up, and the ability to readjust the camera were all factors taken into consideration during the design.



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Cleveland-Cliffs, Inc.
Optimal Character Recognition Camera Mount

Cleveland-Cliffs has been traditionally recognized as the largest and oldest independent iron ore mining company in the United States. In 2020 with the acquisition of two prominent steel companies, Cleveland-Cliffs conducted a transformation that will keep the company thriving for the next century. Today, they are now the largest flat-rolled steel company and the largest iron ore pellet producer in North America. The Company is vertically integrated from mined raw materials, direct reduced iron, and ferrous scrap to primary steelmaking and downstream finishing, stamping, tooling, and tubing and downstream with hot and cold stamping of steel parts and components. They have the unique advantage of being self-sufficient with production of the raw materials for their steelmaking operations.

Due to the extreme volume of flat-rolled steel, it is important for Cleveland-Cliffs to create increasingly efficient production methods to save money and time. Our group was assigned to aid in efficient production by creating a stationary OCR (optical character recognition) system. The flat-rolled steel (right) has identification codes that are crucial for identifying the placing order. Each coil has a different treatment process. They also have different metallic properties and misplacement of the coils can cost no less than $50,000. These coils are placed by hand, which can lead to error. Our mission was to design a camera mounting station that can identify if there is a misorder. The system is a gantry with two camera mounts hanging over the conveyor (right), which will send the coil number images to personnel managing the plant. This will allow the plant to save time and money by ensuring the order of the coils is correct every single time.

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Presentation Schedule – Engineering Building, Room 1300

Time	Team Sponsor	Project Title
7:30 a.m.	Battleship New Jersey Museum & Memorial	Smoke Simulation from the Stacks
8:00 a.m.	Michigan Department of Natural Resources	Efficiency of Ice Suppression Systems
8:30 a.m.	MSU Adaptive Sports & Recreation Club	Sled Hockey Transfer Platform: Phase V
9:00 a.m.	MSU Adaptive Sports & Recreation Club	Inclusive Sports Wheelchair
9:30 a.m.	MSU Adaptive Sports & Recreation Club	Increasing Hockey Sled Mobility
10:00 a.m.	Michigan AgrAbility	Self-Propelled Beehive Lifting Mechanism
10:30 a.m.	Flash Steelworks, Inc.	Utility Vehicle Trailer
11:00 a.m.	Flash Steelworks, Inc.	Flash Tubing Lightweight Steel Bike Trailer Design

Mechanical Engineering Design Program Awards

The Mechanical Engineering Design Program makes two project awards on Design Day. The most significant award is the Thomas Alva Edison Design Award–a medal–given to each member of the ME 481 Capstone design team that produces the most outstanding technical design project. This award considers the team's performance over the duration of the project, their presentations, the project solution, and prototype quality.

A second ME 481 Capstone award is given to the team that gives the best technical project presentation. The importance of communication of scientific and engineering ideas cannot be understated, and it is for this reason that we make the ME 481 Project Presentation Award. Award winners typically will have built an impressive prototype which forms the basis for a very clear and effective presentation of the project background and its solution, often incorporating live or video demonstrations of its functionality.

The ME Design Program also presents the Leonardo da Vinci Machine Design Award to the winners of its ME 470 Machine Design competition. The specific design problem and criteria for this competition change from semester to semester.

Battleship New Jersey Museum & Memorial
Smoke Simulation from the Stacks

The Battleship New Jersey is the longest, fastest, most decorated battleship in history, serving in WWII, the Korean War, the Vietnam War, and the Persian Gulf. In 2001, she became a museum in Camden, New Jersey. The Battleship New Jersey Museum & Memorial have worked to preserve and restore the USS New Jersey to keep the memories of those who came before us alive. Repairing the ship's horn and search radar antenna were among the projects completed to bring the ship to its former glory.

Moving forward, the Battleship New Jersey Museum & Memorial is working to simulate smoke from one of the ship's smokestacks. Initial experimentation with a commercial fog machine was used to generate a theatrical smoke effect. It was found to be a demanding system that required a lot of upkeep and can be costly with the constant purchase of fog machine fluid. A more permanent system, dependent on water and electricity, was designed to lower the cost and provide visible simulated smoke efficiently without any structural changes to the ship. This mechanism has the ability to handle New Jersey winters and can be shut on and off when desired. If successful, this would be the first naval museum ship to simulate smoke and appear active.

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Battleship New Jersey Museum & Memorial
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Michigan Department of Natural Resources
Efficiency of Ice Suppression Systems

The Michigan Department of Natural Resources (DNR) is the agency appointed by the state of Michigan which is charged with maintaining Michigan's natural resources such as state parks, state forests, state harbors, and other recreational areas. The state of Michigan boasts unique and challenging seasons with varying temperatures year-round. During the winter months, Northern Michigan sees temperatures continuously below freezing. As Northern Michigan is a hub for industry and tourism at the state and national level, especially in the summer months, it is necessary to keep these resources accessible, and in good condition throughout the year. Access to harbors, which provide access to the Great Lakes, is essential in keeping this area available to tourists and natives of Michigan alike. Straits State Harbor in Mackinaw City serves as a prime example of a place that is vital to industry, tourism, and recreation year-round.

To ensure that the harbors are safe and ready for use during the difficult months of winter, systems have been implemented to reduce and eliminate the amount of ice that forms in the harbors. The two types of systems commonly used are ice eater systems and bubbler systems. The ice eater system incorporates a propeller that agitates the water below the surface and forces warmer water below the ice upwards to melt the ice on the surface and keep the area clear of ice. The bubbler system applies the same principle of moving warmer water upwards but through the use of air bubbles that are generated by a pump and pipe system below the surface. Currently, Straits State Harbor operates a bubbler system. In order to ensure operability at all times of the year, effects of motor wear on the current system's performance, efficiency of system types compared to one another, and efficiency improvements due to zoning changes were explored to maximize energy efficiency, minimize costs, and improve ice suppression capabilities at Straits State Harbor.

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MSU Adaptive Sports & Recreation Club
Sled Hockey Transfer Platform: Phase V

The MSU Adaptive Sports and Recreation Club is an organization that includes athletes and individuals with physical disabilities as well as volunteers and members of a greater community. Within the adaptive sports community promoting a physical and socially accessible space is a continually evolving task. The club has established an integrated community through a variety of sports including sled hockey. While constantly promoting physical health, social behavior, and psychological wellness through adaptive sports, the community strives to provide a self-determination approach focusing on athlete autonomy, competence, and relatability. By doing this the club has provided members with increased independence and enhanced quality of life, leading to success both in sports and in other domains.

Our team focused on the locking mechanism of the sled and the handles of the transfer platform to help improve the overall independence and durability of the device. These changes included modifications of the handrails and the locking mechanism from the previous design. These changes provided better functionality and safety, accommodating users with varying levels of mobility.

Michigan State University
Adaptive Sports & Recreation Club
Est. 2014

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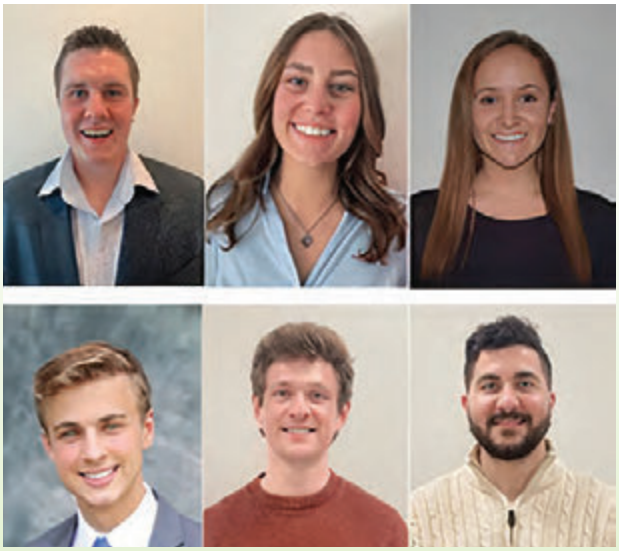
MSU Adaptive Sports & Recreation Club
Inclusive Sports Wheelchair

The MSU Adaptive Sports & Recreation Club's purpose is to promote the benefits of physical activities to individuals with physical disabilities. The club establishes a space where athletes with physical disabilities and able-bodied volunteers can come together to create an integrated community of peers that serves to eradicate negative stereotypes about disability by highlighting the abilities of individuals with physical disabilities. There are multiple sports that are played through the MSU Adaptive Sports & Recreation Club, which include wheelchair hockey, wheelchair tennis, wheelchair basketball, wheelchair rugby, rowing, boccia ball, discus throw, handcycling, and many more. These sports are extremely important for the individuals in the inclusive sports. It gives the individuals the ability to become stronger, complete goals, and interact with peers.

Over the past few years, an existing wheelchair has been modified to fit the needs of a club member, David. Traditional designs for these wheelchairs focus on individuals who have limited mobility in the lower half of their body, whereas this wheelchair was designed for limited mobility in the left half of the body. To modify and improve the existing design of David's adaptive sports wheelchair, a previous team implemented a steering system allowing the chair to brake on one side or the other. This semester the function of the chair was improved by implementing an efficient way to brake both wheels, allowing the chair to come to a complete stop, while keeping David comfortable and not be physically demanding. This was achieved using David as a resource to know what movements are comfortable for him. The system that was developed was efficient, and David was able to use the wheelchair with ease.

Michigan State University
Adaptive Sports & Recreation Club
Est. 2014



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MSU Adaptive Sports & Recreation Club
Increasing Hockey Sled Mobility

The MSU Adaptive Sports & Recreation Club is an inclusive club that promotes health, wellness, and teamwork through sports for individuals with physical disabilities. The club wanted to implement a new sport into their program called Sled Roller Hockey. This game would be played on a hockey rink at Demonstration Hall. However, the hockey rink is not made of ice, it is made of a rubber material. Roller Hockey Sleds will be used on this surface. A previous group developed a prototype of the Roller Hockey Sled, and our task is to improve its functionality to make it more inclusive.

The club provided our team with the previous design of the sled called the Phase 1 Design. Our focus is on improving the speed, acceleration, and turning ability of that sled. We plan on doing this by redesigning the bottom of the sled. Specifically, we will redesign the wheel layout, material of the wheel, and how the wheels spin. We will also add camber wheels to improve turning capabilities and study the surface of Demonstration Hall to reduce the amount of friction caused by the wheels. The current design of the sled requires a lot of upper body strength to move it, so someone with physical disabilities might not be able to use the sled at all. Our goal is to make the sled more inclusive and easier to use. Designing a sled with higher performance will make the game more competitive and fun!

Michigan State University
Adaptive Sports & Recreation Club
Est. 2014

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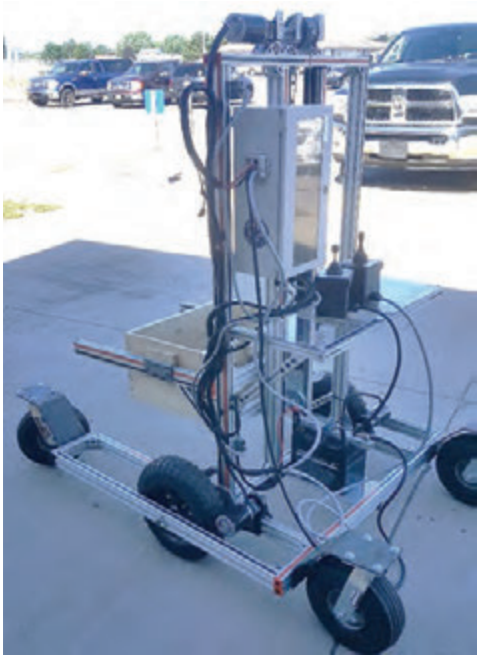
Michigan AgrAbility
Self-Propelled Beehive Lifting Mechanism

Michigan AgrAbility offers no-cost solutions to aid people with injuries, illnesses, or disabilities in the agricultural industry through the partnerships between Michigan State University and Easterseals Michigan. Michigan AgrAbility, along with Heros to Hives, has set out to assist Michigan veterans to start and continue to keep bees. For this specific task, the beekeepers with back and leg injuries cannot always lift the hives for inspection. With the reducing bee population due to diseases, constant inspection is critical to maintaining healthy hives throughout the year. These hives can weigh anywhere between 90 to 300 pounds and with constant inspections needed, this task may be difficult or not possible for some beekeepers. Michigan AgrAbility wants to make sure these issues do not continue to impede beekeepers by providing the necessary tools and resources to aid them in their work.

Our team was tasked with designing a self-propelled beehive lifting mechanism that aids beekeepers by lifting and transporting the hives during inspections. A previous design team completed the base for the lifter. Thus, the goal of this semester was to construct the lifting mechanism and drive component. The lifter is designed to carry 300 pounds over rough and difficult terrain. The lifter is a two-frame system made from carbon steel. The smaller frame is connected to a track and carriage system in the large frame. Fork arms are connected to the smaller frame and made manually adjustable to account for different size boxes. There are folding flaps on the forks to grab and release the box handles. With the help of Michigan AgrAbility and their controls expert, all controls will be powered by a 24V battery system. Additionally, the lifter is operated by two easy-to-use joysticks. The team's lifting mechanism will help ensure beekeepers with illnesses, injuries, and disabilities are able to continue their work with ease.



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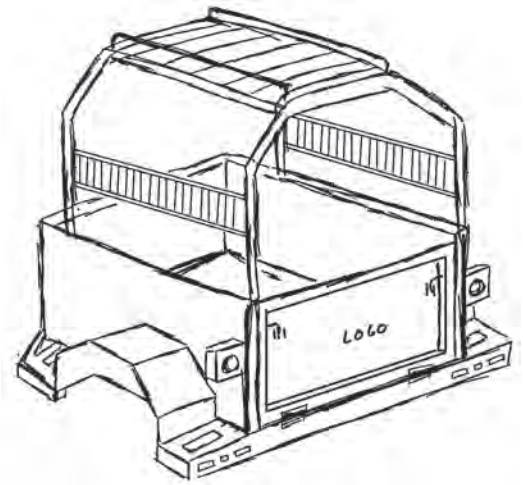
Flash Steelworks, Inc.
Utility Vehicle Trailer

Flash Steelworks, Inc. developed a revolutionary thermal processing cycle that is capable of strengthening steel to an exceptional level. This process allows the steel to have a high level of strength, formability, and weldability for a lower cost than existing ultra-high strength steels. Flash Ultra 600 Armor plate is made using this process This allows it to be lighter than other armor plate options while also being one of the only weldable ultra-hard armor plate options on the market.

Our team used high strength steel tubing, made using Flash Steelworks' revolutionary thermal processing cycle, to design and build a high strength and lightweight off-road utility trailer. It is able to be pulled behind a truck or a side by side. The trailer has a tube chassis and is able to carry anything from off-road gear and a rooftop tent to a lawn tractor. The suspension we designed is an axle-less, independent suspension. It also has aluminum diamond plating to help keep mud and water off of the cargo. We designed it with ease of manufacture in mind. This helped the build process to be smoother and quicker.



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Flash Steelworks, Inc.
Flash Tubing Lightweight Steel Bike Trailer Design

Flash Steelworks Inc, headquartered in Washington, Michigan, is a research and development firm specializing in the development of advanced high-strength steel. The U.S. Department of Energy has called Flash Steelworks, Inc. "the world's leading performing material for lighter and stronger vehicles." The technique used is a patented, novel heat-treating methodology in which steel is heated from room temperature to 1000 degrees Celsius in seconds and immediately quenched upon reaching peak temperature. Using this high-strength steel, Flash Steelworks, Inc. has been able to fill the strength requirements of existing systems while reducing the weight significantly. The ability to reduce the weight of products while maintaining the structural integrity has many applications.

Our team was asked to create a new hitch-mounted bike rack design using Flash Steelworks, Inc. steel. Existing bike racks are heavy, expensive, and difficult to use. Some bike racks can even cause damage to the frame of the mounted bike and have parts that tend to wear quickly with use. These issues are required to be addressed in a new design. Due to the strength of the steel, the wall thickness used to construct the rack was lower than on existing products, driving the weight down. By using a simple design, thus limiting the number of parts, the team attempted to reduce the price in relation to current market standards. A successful design will produce a bike rack that is lightweight, easy to use, and available at a lower cost.

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Flash Steelworks, Inc.
Project Sponsor

Gary Cola
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ME Faculty Advisor

Dr. Xiran Xiao

The Capstone Projects

Dr. William Resh
Professor of Mechanical Engineering

Faculty Advisors: Ronald Averill, Seungik Baek, Giles Brereton, Himanshu Sahasrabudhe, Harold Schock


Averil


Baek


Brereton


Sahasrabudhe


Schock

Presentation Schedule – Engineering Building, Room 2205

Time	Team Sponsor	Project Title
8:00 a.m.	MSU Department of Mechanical Engineering	Piston Friction Reduction to Improve Engine Efficienty
8:30 a.m.	Adventures in Training with a Purpose	Ambulation Aid – Foot Design
9:00 a.m.	Adventures in Training with a Purpose	Quick-Release Handle Design
9:30 a.m.	EarthSense, Inc.	Chestnut Harvester
10:00 a.m.	EarthSense, Inc.	Chestnut Harvester
10:30 a.m.	Asahi Kasei Plastics North America	Ergonomic Lifting Solution for Packaged Materials
11:00 a.m.	Lacks Enterprises/MSU Formula SAE Racing Team	Formula SAE Composite Wheels

Mechanical Engineering Design Project Sponsorship

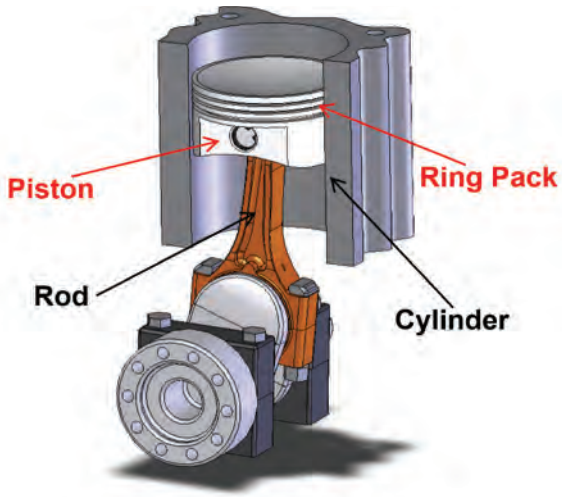
Interesting design projects that challenge the seniors in ME 481 and showcase the range of activities where mechanical engineers can work helps to make the Design Day experience special. The Design Program at MSU invites you to provide a challenging project for members of our senior class of mechanical engineers. As a sponsoring company, you introduce students to opportunities for ME students at your company; have the opportunity to create, build, and maintain relationships with students; benefit from the students' innovative design work; and bring the academic and working world together for them. Contact Jim Lang at langjame@msu.edu or 810.224.0055 to learn more about the opportunities to sponsor a design project.

MSU Department of Mechanical Engineering
Piston Friction Reduction to Improve Engine Efficiency

The Michigan State University Department of Mechanical Engineering is the second largest department in the College of Engineering, making up over 26% of students in the college. Professors within the Department of Mechanical Engineering conduct leading edge research with funding and sponsorships from numerous US organizations and industries, which give undergraduate students the opportunity to volunteer or work.

Nearly two hundred million piston engines are put into service each year. Engineers globally are working to design and optimize pistons to reduce contact friction between the piston and liner, while concurrently limiting wear due to the lateral motion of the piston within the cylinder. Using a software tool called CASE, our team conducted numerous optimizations on a typical piston skirt profile below the ring pack region to minimize the frictional forces experienced by the piston and to determine the magnitude of these forces. Research has revealed that minor changes to the piston geometry could have significant effects on piston-to-liner friction, which accounts for nearly 20% of the losses that occur within an internal combustion engine. Minimizing these frictional forces was critical to improving the efficiency of these internal combustion engines.

Our team was tasked with developing an initial design of a testing fixture that will be used to validate the findings from the software optimizations. In the future, our initial testing fixture design will be improved and manufactured to aid the Michigan State University Department of Mechanical Engineering and Energy and Automotive Research Lab in the experimental validation of computational models.



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MICHIGAN STATE UNIVERSITY

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Adventures in Training with a Purpose
Ambulation Aid – Foot Design

Directed Steps is a project centered in confronting mobility issues as part of the Adventures in Training with a Purpose (ATP) program. This program provides support for those who no longer have the benefit of paid rehabilitation. In addition, few facilities are equipped with the level of trained staff and devoted time necessary to develop programs for those in need. ATP tackles these challenges head on, restoring quality of life and improving movement in each individual. Through Adventure, participants are motivated to take a journey that promises challenges, but also brings deep meaning along the way. In Training, the program takes participants through mobility work, strength exercises, and aerobic conditioning to develop the individual's physical armor. Altogether, participants embark on an adventure of purposeful physical training, creating a fulfilling Purpose for every person who takes on the journey.

The goal of this project was to design and prototype an ambulation aid for a patient undergoing physical rehabilitation for a spinal cord injury. This device compensates for range of motion and strength insufficiencies in the upper and lower extremities to improve their function and the patient's quality of life. Common injury aids, such as braces and underarm crutches, lack the amount of support necessary for those with chronic conditions and do not provide the opportunity to increase physical ability. To combat these problems, our team designed a spring-loaded forearm crutch with a larger crutch base than employed in traditional crutches. These features help propel forward motion by increasing the kinetic energy utilized during the swing phase in order to improve the patient's mobility.

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ME Faculty Advisor

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Adventures in Training with a Purpose
Quick-Release Handle Design

Adventures in Training with a Purpose (ATP), located in Pittsburgh, PA, is a nonprofit organization that helps people suffering with chronic pain and disease regain mobility. The organization prioritizes restoring quality of life, improving functional movement, and ultimately regaining independence. Its mission is especially noble considering clients' serious degrees of injury, need for dedicated one-on-one training, and ATP's commitment despite insurance coverage rarely supporting long-term rehabilitation.

A quick-release mechanism was designed for use with forearm crutch cuffs. The mechanism allows users to release the cuff from the crutch body in an instant. This is especially important in situations when the user is falling. The quick-release mechanism allows them to free their hands from the crutches, break their fall, and prevent further injury from being tangled within the crutch. ATP clients will finally be able to safely regain independence with crutches that prioritize their safety.

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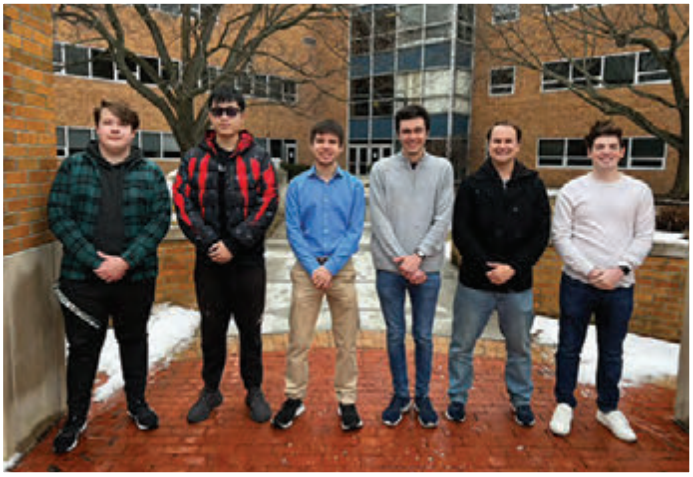
EarthSense
Chestnut Harvester

EarthSense is a top developer of autonomous robots that specializes in biosystems and agriculture. Its ultracompact robots are easy to use on tablet apps with advanced data-collection technology. These technologies include high-definition cameras, accurate positioning systems, fast perception, and long-distance control. The navigation system on these robots has been tested on over 200,000 corn plots. These autonomous vehicles typically drive on fields in swarms. This allows their 3-hour battery life to be met as large fields are swept by multiple vehicles. EarthSense's innovative designs of autonomous vehicles have created new opportunities and better observation and control of the agriculture industry.

In collaboration with EarthSense, the Michigan State Biosystems and Agricultural Engineering department tasked our team to create a system that collects variable sized chestnuts off the ground of a biologically diverse and cluttered orchard floor using autonomous ground vehicles as a base platform. An assumption for this project was that the vehicle already had a chestnut detection system, and the vehicle would drive to that location to collect the chestnuts. The vehicle used in this project was the TerraMax, which is being designed to fertilize fields. This autonomous vehicle, at roughly 4x4x3 feet, was created to have multiple ways to interface agricultural technology to the hull of the machine. The machine is capable of holding up to 2000 lbs, which gave significant design freedom for both the collector and collector bin. Our project was designed to attach to the hull of the vehicle and was programmed to pick up a chestnut and deliver it into a collection system. The TerraMax was still in testing and early development, so we were not able to interface with the actual vehicle. We simulated the structure of the vehicle by building a mule out of wood to interface our project for reference.

EARTHSENSE
AGRICULTURAL INTELLIGENCE



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EarthSense
Chestnut Harvester

Earth Sense is a company that specializes in the production of unmanned ground vehicles (UGVs), mainly for the purpose of farming and agricultural needs. Their UGVs have the capability to collect data about a field of crops simply by navigating through it and scanning plants. Using the data it collects, it is able to analyze and give feedback on the state of the crops, allowing for more in-depth management of a field. Its innovative design allows the UGV to traverse many different terrains, making it useful in many types of fields. The company is hoping to soon release a new vehicle that can not only scan plants but also collect ripe crops, store them onboard the vehicle, and bring these crops to a collection location.

The chestnut harvester was a project that aimed to create a subsystem for this new EarthSense UGV that allows it to harvest chestnuts. Often chestnut orchards are too large for handpicking, but too small for large machinery to harvest the nuts. With the chestnut harvester, many UGVs will be able to traverse and pick up the nuts much faster than it would take humans to handpick them. The subsystem was designed with the idea that it has already detected chestnuts on the ground and that there may be environmental variations such as twigs and burrs that make them difficult to pick up. It has a robotic arm attachment, equipped with an end effector for picking up nuts. The articulating arm allows it to place the nut in the UGV's onboard storage. Although this project focused on chestnuts, this concept has immense scope in the agricultural industry and can have varied applications in other types of fields.

EARTHSENSE
AGRICULTURAL INTELLIGENCE

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Asahi Kasei Plastics North America
Ergonomic Lifting Solution for Packaged Materials

Asahi Kasei Plastics is a leader in plastics technology and innovation. As a major supplier for the automotive industry, on average 11 pounds of Asahi Kasei plastics can be found in cars today. Other segments also contain Asahi Kasei plastics, including pool and spa, industrial, furniture, housing, construction, and more. Workplace safety is a high priority, and Asahi Kasei is constantly looking for ways to improve manufacturing operations and increase safety. Currently, in the Fowlerville manufacturing facility an operator must manually lift 25kg paper sacks of raw material from a pallet to the blender where the material is processed. The repetitive stress of manually moving these heavy bags of raw material poses a potential safety issue for back injuries.

The objective of this project was to design and implement an ergonomic solution to eliminate the task of manually lifting paper sacks of raw materials from the pallet to the blender. The targeted workspace had height and space constraints, and the solution needed to accommodate multiple pallet locations and variable bag sizes and weights. Our solution consists of a powered mechanism to lift the paper sacks of raw material, allowing an operator to direct the bags from the pallet to the blender with little effort. The solution is expected to improve the efficiency and throughput of production by successfully transporting the packaged materials undamaged while decreasing the instance of ergonomic injuries.

AsahiKASEI
ASAHI KASEI PLASTICS NORTH AMERICA

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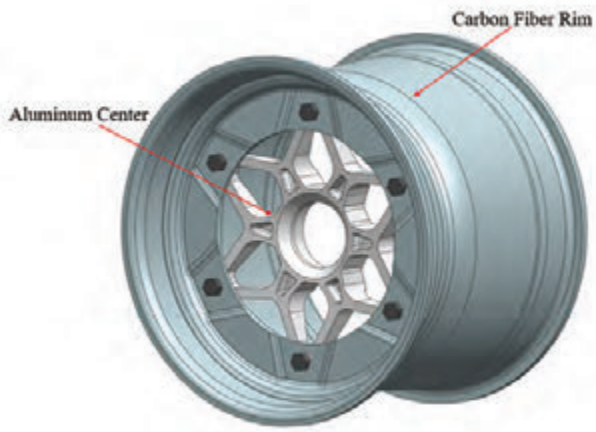
Lacks Enterprises/MSU Formula SAE Racing Team
Formula SAE Composite Wheels

Lacks Enterprises is a plastic molding and finishing organization comprised of three business units: Lacks Trim Systems, Plastic Plate, and Lacks Wheel Trim Systems. Lacks has been continuously developing their hybrid carbon fiber wheels since 2018, producing wheels that have the longevity, beauty, and strength of the aluminum wheel that it replaces. Formula SAE is a collegiate competition that challenges students to design, build, test, and race small, open wheel cars against universities from all around the world. Teams spend 8-12 months designing, building, and preparing their vehicles for competition. These cars are judged in a series of static and dynamic events, technical inspection, cost, presentation, engineering design and high-performance endurance. Michigan State competes in the main competition at Michigan International Speedway every year.

The team designed and manufactured a hybrid wheel, consisting of a carbon fiber reinforced plastic rim with an aluminum center to be used by Michigan State's Formula SAE team to reduce the overall weight of the car and reduce lap times. The carbon fiber wheels lowered rotational inertia in the outboard assemblies and maintained better contact with the ground due to decreased weight. They also increased stiffness, which reduced compliance and increased the tire's lateral capability under loading. The team created a replicable process to produce multiple sets of wheels using the same molds and developed testing procedures to analyze failure modes, both through simulation and on track testing.



LACKS CARBON FIBER
A DIVISION OF LACKS ENTERPRISES

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Lacks Enterprises/ MSU Formula SAE Team
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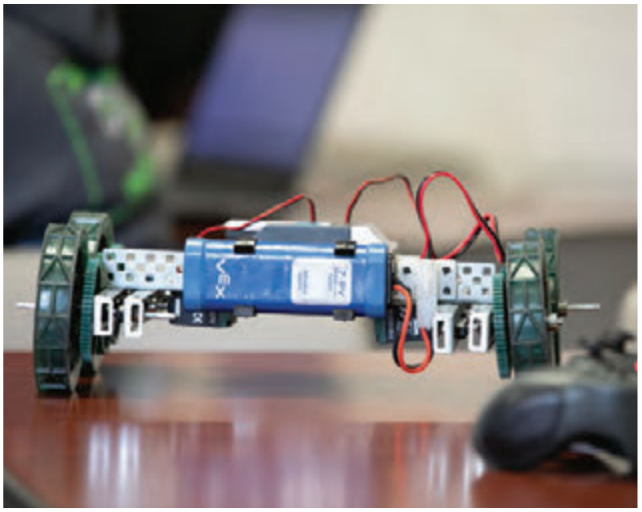


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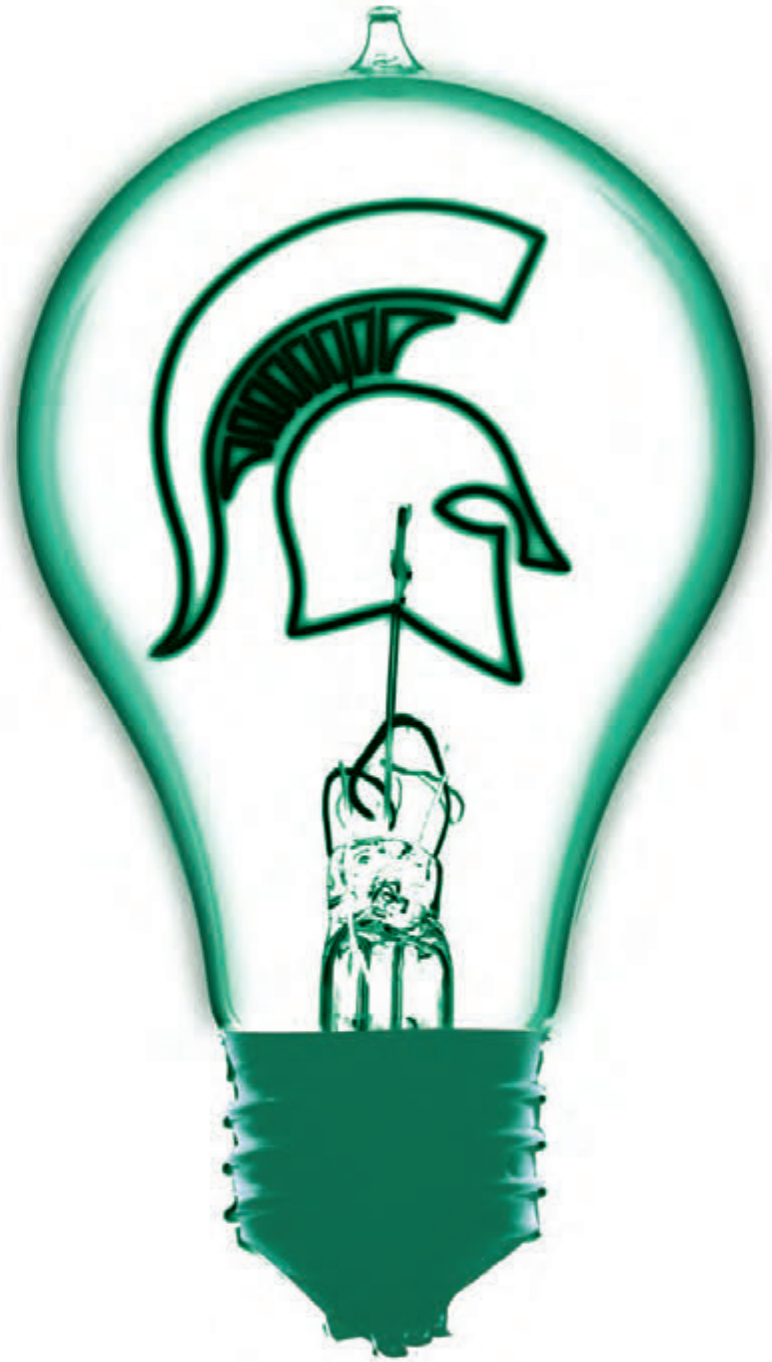

For information on sponsoring Design Day and design projects, contact

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