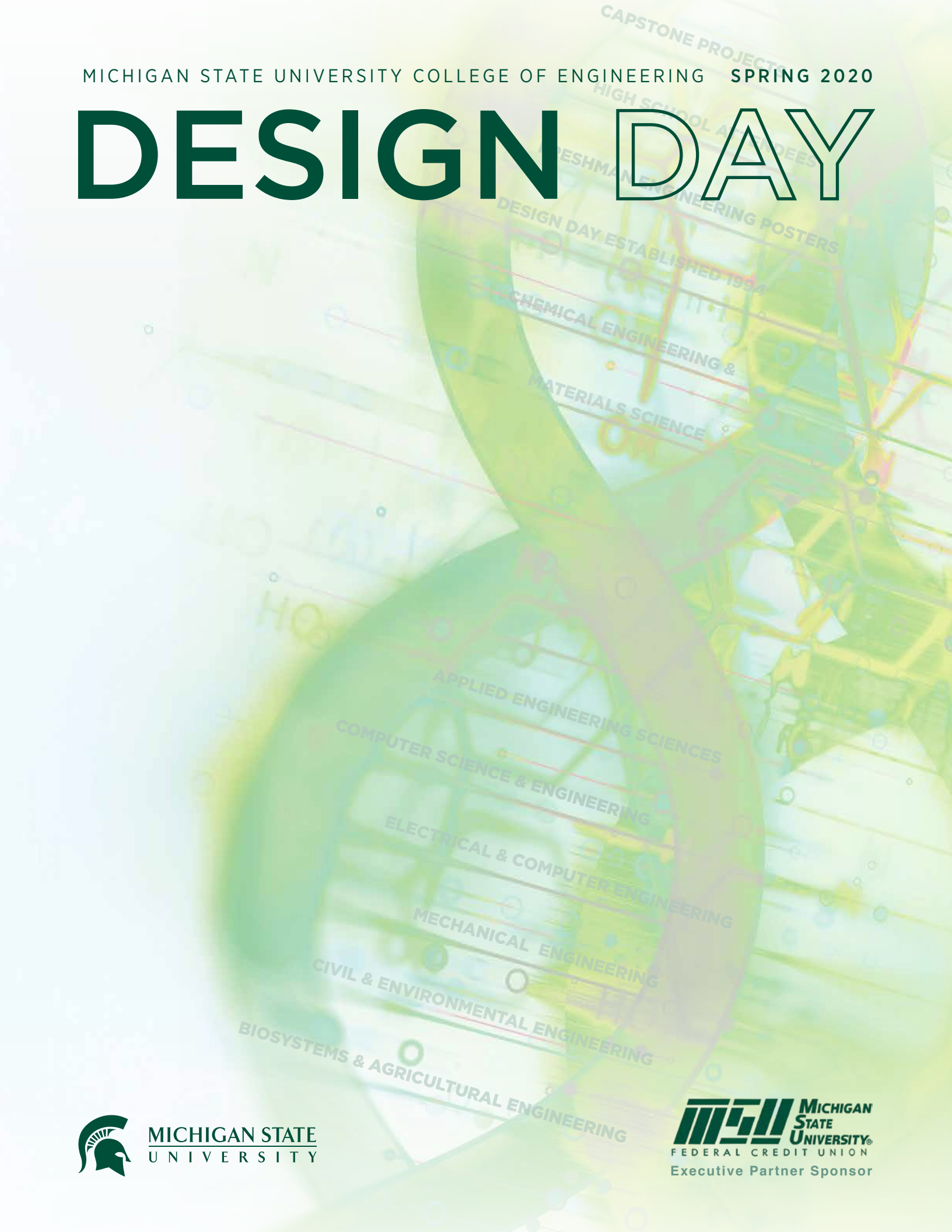
MICHIGAN STATE UNIVERSITY COLLEGE OF ENGINEERING **SPRING 2020**

DESIGN DAY



MICHIGAN STATE UNIVERSITY

MICHIGAN STATE UNIVERSITY FEDERAL CREDIT UNION

Executive Partner Sponsor

Welcome to the MSU College of Engineering Design Day Booklet!

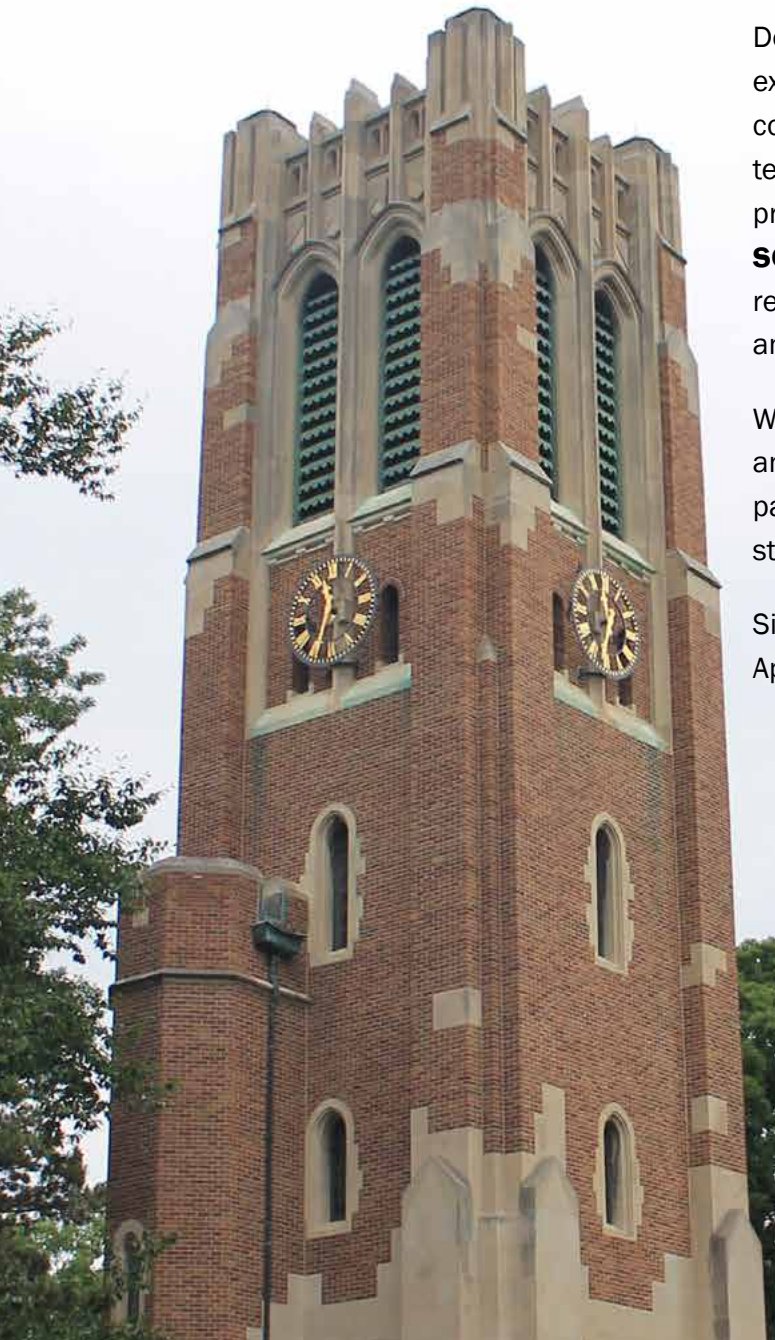
On behalf of Michigan State University Federal Credit Union (MSUFCU) in partnership with the College of Engineering, and Michigan State University, we **welcome** you to explore this booklet to see the **extraordinary** work of MSU students.

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

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

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

Sincerely,
April M. Clobes, President/CEO, MSUFCU



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Welcome from the Dean

Design Day has become one of our premier undergraduate academic events of the semester. Now in our 26th year, we have been planning for yet another record Design Day on April 24, with participation by all ten of our academic programs, involving over 1,200 students.

Unfortunately, due to the current health situation in our country and our community, we have decided that it would be most prudent to cancel the Design Day activities that were scheduled to be held in the Engineering Building. This is consistent with our people-first, student-centered philosophy as we weather this pandemic together.

While in-person class meetings were cancelled at MSU, courses were not. Our committed and resourceful faculty, staff and students pivoted to bring the College of Engineering online within twenty-four hours.

We are putting our mantra into practice, "Spartans Will!"

We are pleased to acknowledge Michigan State University Federal Credit Union as our Design Day Executive Partner Sponsor and Amazon as our Design Day Directing Partner Sponsor. Our Design Day Supporting Partner Sponsors include Auto-Owners Insurance, Blackstone Technology Group, Ford Motor Company, MaxCogito, Meijer and TechSmith. We thank our sponsors for their generosity and their ongoing commitment to Design Day.

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.

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

Our graduating seniors are the headliners of our Design Day program. Their projects represent the capstone of their educational career. As you read about their projects in this booklet, you will see that our MSU engineers are ready to lead, create and innovate.

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

We are confident that our Design Day tradition will continue once again in December.

Dr. Leo Kempel

Dean of the College of Engineering

Professor of Electrical and Computer Engineering

Michigan State University

Events Schedule Friday, April 24, 2020

EVENTS	7 a.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	Noon	1 p.m.
Audio Enthusiasts and Engineers		2nd Floor Rm 2228 8:00 a.m. – Noon					
Engineering Students Organizations		1st Floor West Wing Lobby 8:00 a.m. – Noon					
ECE 101 Demonstrations			2nd Floor 2300 Hallway 9:00 a.m. – Noon				
EGR 100 Demonstrations			2nd Floor 2300 Hallway 9:00 a.m.-11:30 a.m.				
ME 412 Competition		1st Floor Rooms 1252 8:00 a.m.-11:45 a.m.					
ME 456 Competition		1st Floor Dow Wing 8:00 a.m. - Noon					
ME 470 Competition		1st Floor Room 1345 8:00 a.m.-11:45 a.m.					
ME 478 Competition		2nd Floor Room 2320 8:00 a.m.- Noon					
ME 497/MKT 420 Demonstrations			1st Floor 1200 Hallway 9:00 a.m.-11:30 a.m.				

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 most. BE and ECE on 2nd Floor 2200 Hallway ChE on 2nd Floor 2400 Hallway					
AESC 410/SCM 472 Project Presentations		Anthony Hall, Rooms 1235, 1255, 1257 & 1260 8:00 a.m. – 11:30 a.m.					
CE 495 Project Presentations		1st & 3rd Floors – Rooms 1225, 1230, 1234 & 3105 8:00 a.m. - Noon					
CSE 498 Project Presentations		1st Floor, 1300 Hallway 8:00 a.m. - Noon					
ECE 480 Project Presentations		2nd Floor Rooms 2243 and 2245 8:00 a.m. - 11:00 a.m.					
ME 481 Project Presentations		1st & 2nd Floor Rooms 1202, 1220, 1300, 2205 & 2435 7:30 a.m. - Noon					

OPENING AND AWARDS							
Middle School Opening			1st Floor Anthony Hall, Room 1279 8:00 a.m. - 8:30 a.m.				
Middle School Awards			1st Floor Engineering, Room 1345 12:15 p.m. - 12:30 p.m.				
MSU Awards			1st Floor Anthony, Room 1281 1:15 p.m. - 2:00 p.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

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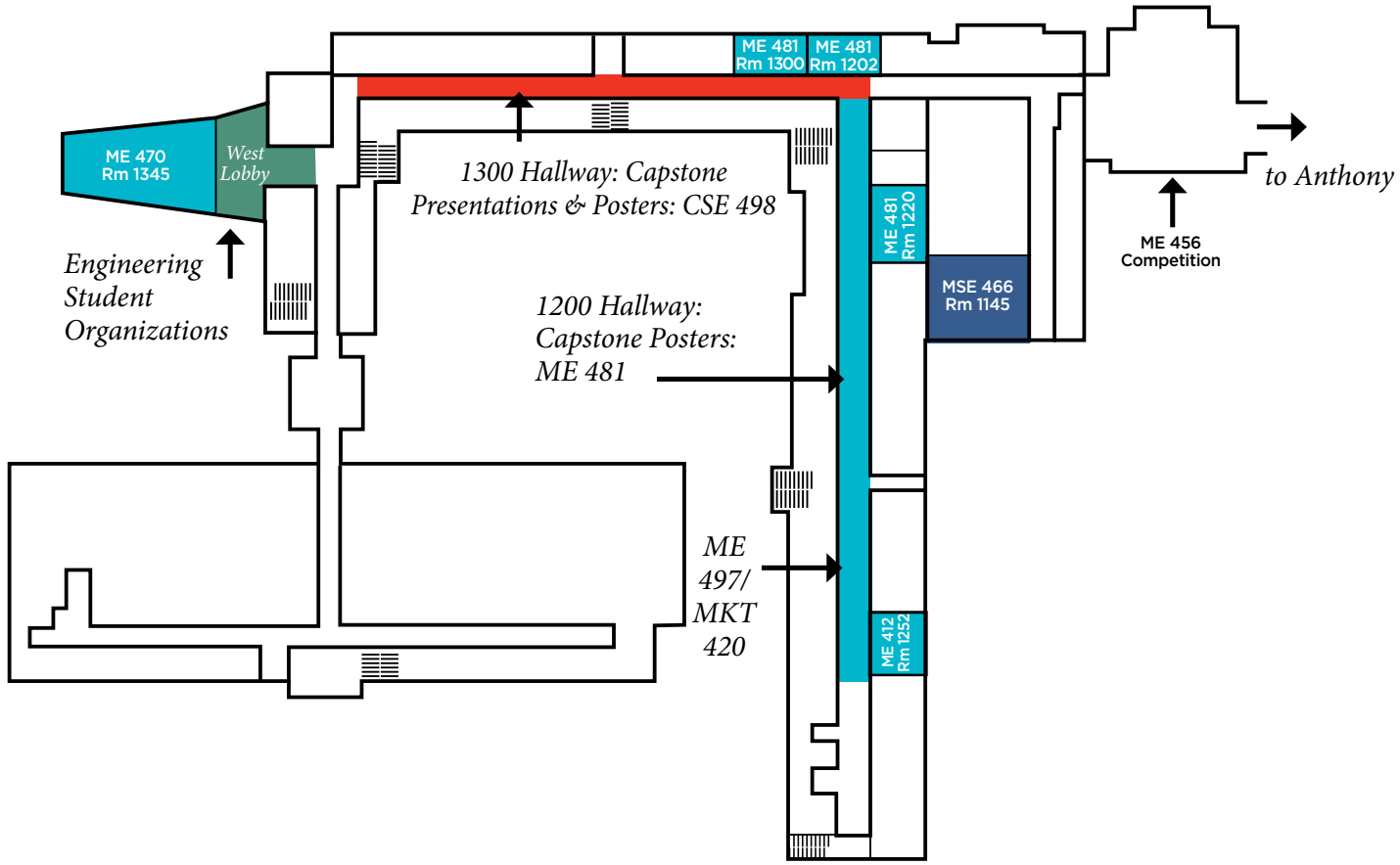
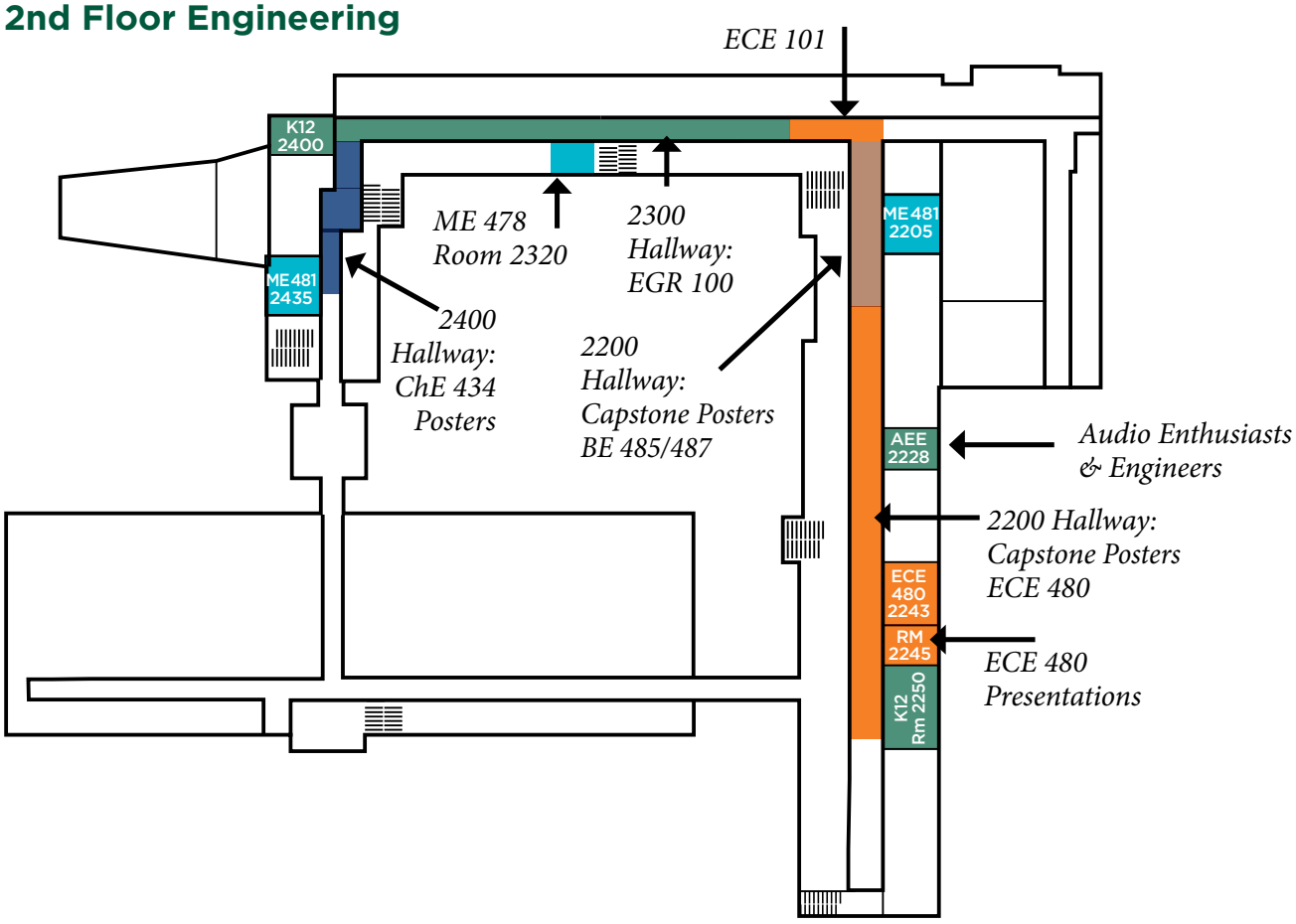
1st Floor Engineering

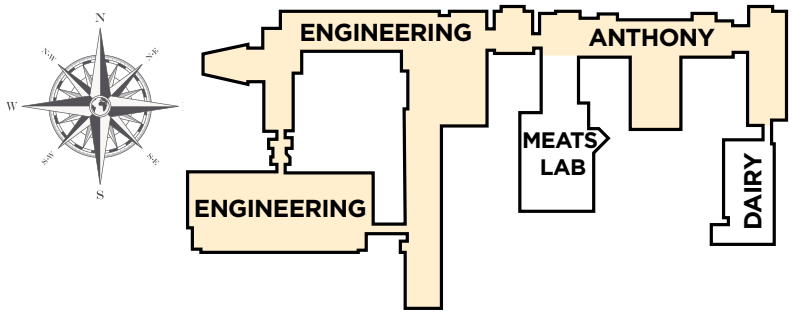


2nd Floor Engineering

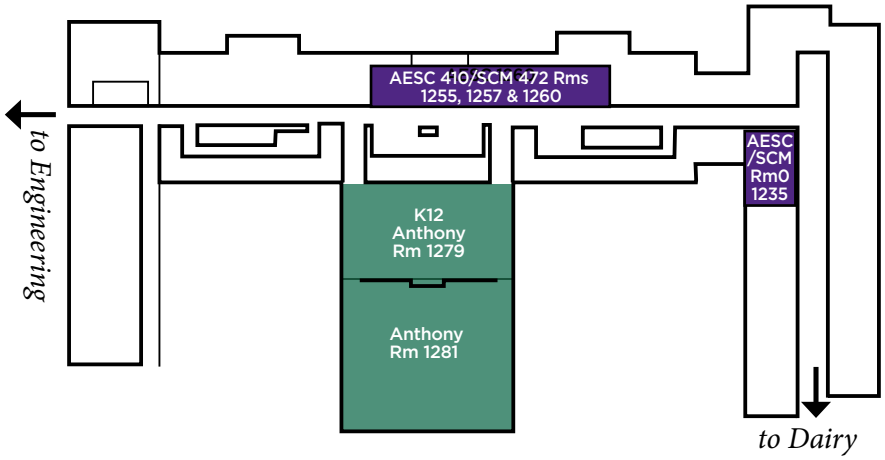


Design Day Floor Plans of the MSU Engineering Building

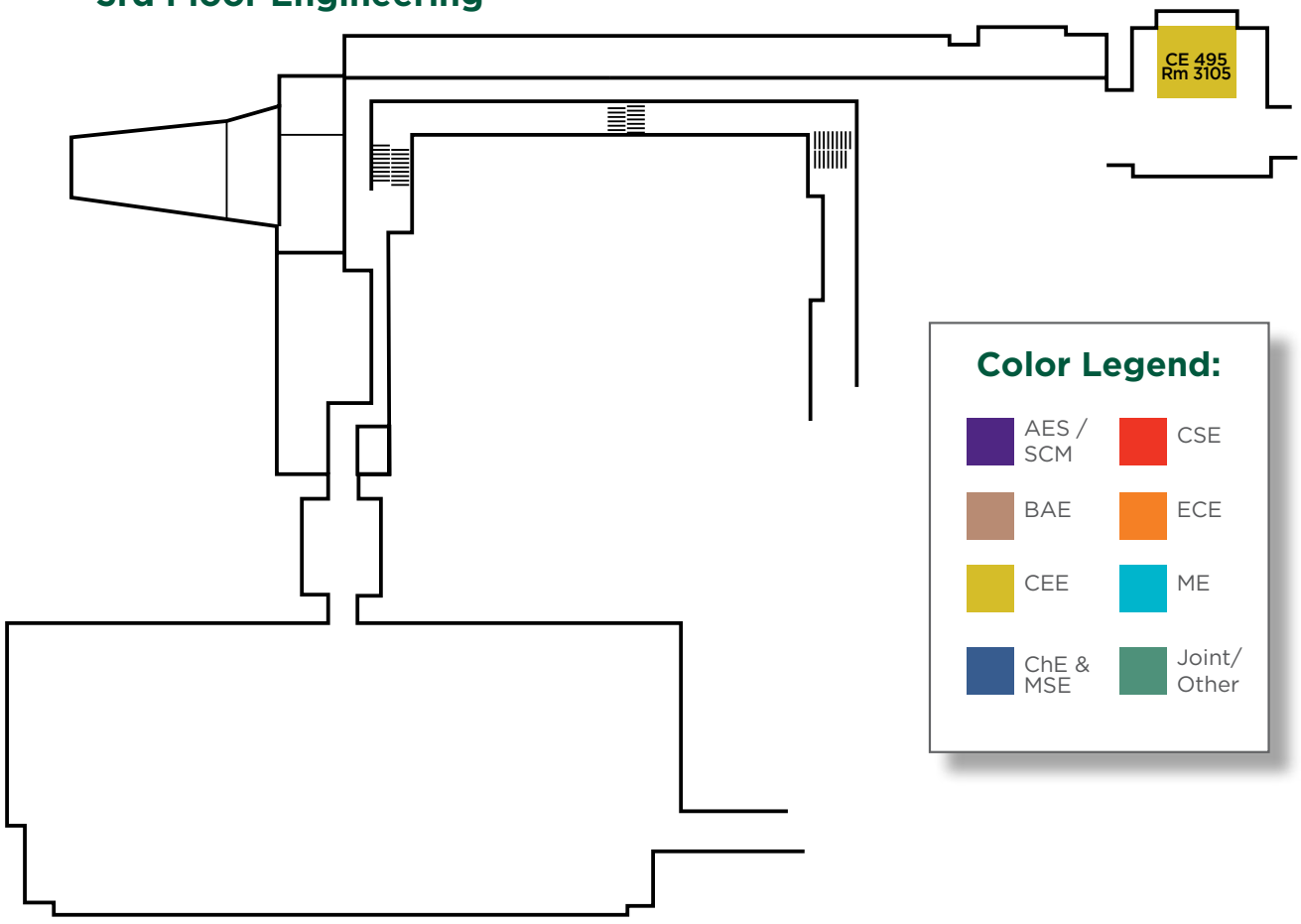
Overview



1st Floor Anthony



3rd Floor Engineering



Color Legend:

- AES / SCM
- CSE
- BAE
- ECE
- CEE
- ME
- ChE & MSE
- Joint/ Other

Middle School Innovation & Creativity Day

Precollege Student Voting: During the morning on Design Day all visiting precollege students will be viewing Engineering Projects and voting.

During this time college students will have a chance to interact with "non-engineering" students and demonstrate the underlying principles from their projects. This interaction allows the college students an opportunity to practice explaining engineering concepts to non-engineers. As the precollege students work their way through the wide variety of presentations, they will get an overview of the many different branches of engineering. Additionally, as the precollege students see both entry-level and advanced engineering applications, it allows them to see the natural progression of engineering. Lastly, this session also provides a chance for the precollege students to interact with student organizations within the College of Engineering.

The following schools and groups will be participating in this Spring's Design Day events: Innovation Central 9th Grade, Scranton Middle School, Stockbridge Middle School, and Women in Engineering.

	1279 Anthony Hall Auditorium: Check-in for all schools	K'NEX Bridge Team Build Room 2250	VEX Robotics Room 2400	1st & 2nd Floor Voting/project viewing	Trebuchet Launch Competition 1279 Anthony Hall
8:00–8:15	Check in for all schools				
8:15–8:30	Welcome & voting procedures – Drew Kim, Assistant to Dean, and Luis Donado, Assistant Director				
8:40–9:30		Scranton Middle School	Innovation Central HS 9th	Stockbridge Middle School	WIE
9:35–10:20		Innovation Central HS 9th	Stockbridge Middle School	WIE	Scranton Middle School
10:25-11:10		Stockbridge Middle School	WIE	Scranton Middle School	Innovation Central HS 9th
11:15-12:00		WIE	Scranton Middle School	Innovation Central HS 9th	Stockbridge Middle School
12:15–12:30	Awards Ceremony (Everyone) 1345 Engineering Building, lunch at Brody immediately after the awards ceremony				

http://www.egr.msu.edu/future-engineer/ LIKE US: https://www.facebook.com/futurespartanengineers

MEMBERS OF THE ORGANIZING COMMITTEE FOR MIDDLE SCHOOL INNOVATION & CREATVITY DAY: SPRING 2020

Drew Kim
MSU Engineering
Assistant to the Dean
Recruitment, Scholarships,
and K-12 Outreach

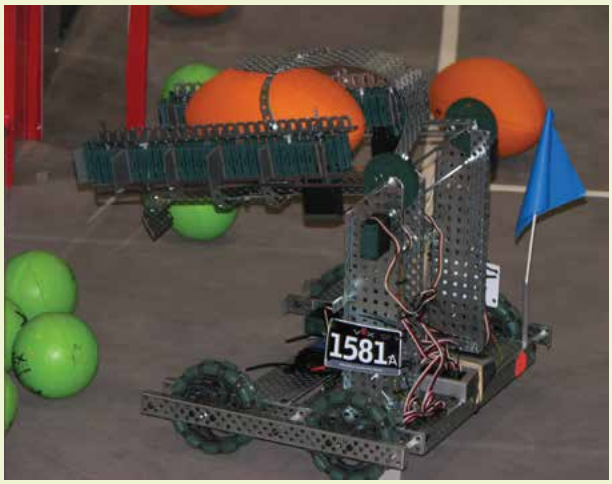
Dean Buggia
Instructor and
Technology Teacher,
Okemos High School

Luis Donado
Assistant Director of MSU
Engineering Recruitment
and K-12 Outreach

Bob Watson
MSU Engineering
K-12 Outreach LEGO and
VEX Robotics Coordinator

VEX ROBOTICS

Our team of experts has designed a lab experience to give precollege students an introduction to robots. Students will work in small groups and have a hands-on approach learning to control the VEX robot. They will write programs using Robot C language, and they will program the robot to be controlled by a remote control. Application and discovery of how programming works will be similar to lessons presented in science and math classes. Each team will discover how to adjust their programs based upon the program inputs and actual output (robot performance). During each phase, new challenges will be introduced to engage the students. This will reinforce new ideas and concepts while exposing students to the newly emerging capabilities of student-controlled robotics programs.



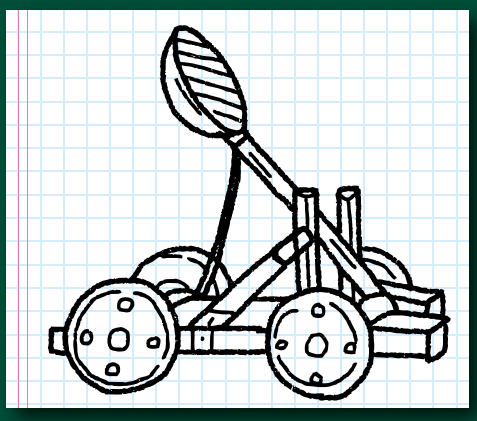
INTERDISCIPLINARY ENGINEERING BUILD

In this build you and your team will be integrating practices from multiple fields of engineering to build and evaluate a support system. Support systems can range from simple beams to intricate bridges composed of gussets, trusses, cables, etc. These types of systems are used throughout Civil, Mechanical and Structural Engineering works. This session will start with a brief introduction to the forces and stresses that act on support systems. Additionally, you will see how digital sensors can read and convey data about these stresses to a computer. We will also look at the computer code that takes this raw data and converts it into a format that can easily be interpreted.

During the build portion of this session you and your team will be given the design constraints for the structure. Utilizing the information learned at the start of the session and the limited materials provided, your team will need to design and then construct a model to be tested. Your finished structure will be placed on one of our test beds for evaluation. With the help of MSU Engineering students, the results will be collected by a sonic ranging sensor. These data points will be interpreted by the computer program and your team will be evaluated on percent deflection of your support. Throughout this session you will need to listen, learn and utilize your team to be successful. Good Luck.

TREBUCHET LAUNCH COMPETITION

The trebuchet activity at Design Day provides students with an opportunity to manipulate some of the parameters associated with launching a small projectile at a specific target. Using basic conservation of mechanical energy concepts from physics, student groups load a small, pre-made trebuchet with potential energy and release the device, transforming the stored energy into kinetic energy to throw the projectile. Students have control over the length of the throwing cord, the placement of the counterweights, and the pivot point on the throwing arm. The event is scored based on proximity to the target point.



High School Innovation and Creativity Day

K12 Awards Fall 2019

EGR 100 First Place Winners "Finna Eat"
Team Members Noah Darcy, Henry Gruber and Anthony Miller with Tim Hinds and Jenahvive Morgan

EGR 100 Second Place Winners "Heat Exchanger"
Members Kenneth Gordon, Brooke Osterkamp, Hannah Yantus and Laina Young with Tim Hinds and Jenahvive Morgan

ECE 480 Winners "Robotic Crop Weeder"
Members Anthony Doan, Greggory Adams, Jaime Mortensen, Devon Thompson, Jacob Reinaur and Kristopher Canty with Mi Zhang

VEX Robotics Winners Women in Engineering
Members Aine, Mackenzie and Julia with Teresa VanderSloot and Geralynn Phelps of the WIE Recruitment Office, and Instructor Bob Watson

Catapult Design Winners
Brighton High School with Mr. Jourden and Connor and Sanders, PhD candidates in MSU Mechanical Engineering

K'Nex Bridge Build Winners
Innovation Central High School Members Aaron Zimmerman, Zach Buell and Thomas Mish with Instructor Dean Buggia and Elisabeth Geim, ICHS STEM teacher

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 863 students enrolled in EGR 100 this semester.

For the final course project, the student teams selected from seven project types: **(i) Solar Car Competition, (ii) Cell Phone App Inventor, (iii) Design of a Heat Exchanger, (iv) 3D Printing, (v) Arduino Programming, (vi) Costa Rica Environmental Educational Model Design, and (vii) CoRe Industry-Sponsored Projects.** CoRe Industry-Sponsored Projects involved collaborations with ArcelorMittal on an optimal basic oxygen furnace steelmaking scrap mix design. Teams from each of the project types will display their prototypes at Design Day along with posters detailing their design concepts. Pre-college students will recognize the most outstanding projects with awards.

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

Fall 2019 EGR 100 Project Poster Award Winners:

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

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

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Applied Engineering Sciences

Capstone Course Sponsors

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

American Axle & Manufacturing, Inc

Asahi Kasei Plastics North America

Aspen Surgical Products

BP PLC

Dow

Freight Waves

GM

Guardian Industries

Harman International Corp

Ingersoll Rand

John Deere

KLA Corporation

MSU Infrastructure Planning & Facilities

MSU Office of Sustainability

MSU RCPD

NASA/ASU

Quality Dairy

Ranir

Truck-Lite

ZF Friedrichshafen AG

Applied Engineering Sciences

Dr. Laura J. Genik
Director
Applied Engineering Sciences

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

Graduate Teaching Assistants

Salik Aziz
MBA (2020)

Corinne E. Brunckhurst
JD/MBA (2020)

Charles Fobbs
MBA (2020)

Elliot Lourie
MBA (2020)

Sugandhi Sawhney-Cox
JD/MBA (2021)

Presentation Schedule – Room 1235 , Anthony Hall

Time	Team Sponsor	Project Title
8:00 a.m.	Aspen Surgical	Automated Pen-Plug Placement Station Redesign
8:25 a.m.	ASU/NASA Psyche Mission	Capstone Design Scalability
8:50 a.m.	Caterpillar	Customer Order Pattern Analysis
9:15 a.m.	Caterpillar	Improving the Supply Chain Through Data Visibility
9:40 a.m.	Break	
9:50 a.m.	MSU IPF: Maintenance Services	Mobilize the Maintenance Stockroom
10:15 a.m.	MSU IPF: Sustainability	Carbon Sequestration & Carrying Capacity of MSU Trees
10:40 a.m.	GM	Sequencing Strategy– Best Practice and Future Trends
11:05 a.m.	Guardian Industries	Float Glass Rack Optimization

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.

Aspen Surgical
Automated Pen-Plug Placement Station Redesign

Established in 1999, Aspen Surgical has quickly become a leader in the market of surgical disposable products. Between their two facilities in Michigan and Puerto Rico, Aspen Surgical operates with over 500 dedicated employees and 250,000 square feet of manufacturing and office space.

Aspen Surgical manufactures and sells a wide range of products including scalpels, surgical needles, instrument cleaning equipment, and several safety accessories. One of their top product categories is the patient identification and surgical marking pens. Over 120 million pens were manufactured and sold during 2019 alone.

Several different types of patient identification and surgical marking pens are made and sold through Aspen Surgical. Unfortunately, persistent manufacturing errors can occur due to the design of the pen-plug feeding station.

Occasionally, during assembly, the design of the pen-plug feeding station can cause machinery jams, misfeeding of the plugs, or damaged components. These issues can lead to having to temporarily halt the assembly process from anywhere between seconds to hours of valuable manufacturing time depending on the issue.

Our team has worked to develop a machinery solution that provides a potential solution to be implemented within the already present assembly machinery for the marking pens. This solution could be used by Aspen Surgical to decrease the downtime of their machinery.

This potential solution could allow Aspen Surgical to grow even further within their market through the creation of more patient identification and surgical marking pens while furthering their reputation as a reputable, reliable company.

Michigan State University
Team Members (left to right)

Jack Iden
Hartland, Michigan

Emily Doss
Ellicott City, Maryland

Luis Diaz
Grand Rapids, Michigan

Isaac Cislo
Brighton, Michigan

Mitchell Williams
Holland, Michigan

Aspen Surgical
Project Sponsor

Creighton Bradley
Caledonia, Michigan

ASU/NASA Psyche Mission
Capstone Design Scalability

NASA's Psyche Mission is a journey to a faraway asteroid with the hope that it will be able to teach us something about our home. Psyche is an asteroid, made of metal, orbiting the Sun between Mars and Jupiter. What makes Psyche important is that it is believed to be the exposed nickel-iron core of an early planet. The goal of the mission is to launch an unmanned spacecraft to study the asteroid to find out if it is the core of an early planet and what it can tell us about the core of our own planet.

The mission is being led by Arizona State University's School of Earth and Space Exploration but includes over 40 capstone teams from universities all over the United States. Each capstone team has its own unique place in the mission. Our team's goal is to locate inefficiencies in the internal processes of the team at ASU and give recommendations as to how to improve on them to ensure a more efficiently moving mission and scale the mission by adding new capstone teams from more universities across the country.

To improve the internal processes of the mission, the team had to take an in-depth look at the current processes the team at ASU had been performing. The team then had to research project management processes, tools, and software to find those that would improve the lives of the team at ASU.

The mission has a launch date in 2022. With it quickly approaching, the team is looking to scale the amount of capstone teams to include more diverse teams that come from a wide range of technical backgrounds. The team is making that possible by providing the necessary information and tools on how to reshape their internal mission processes to make this a reality.

Michigan State University
Team Members (left to right)

Gabriel Zeidner
West Bloomfield, Michigan

William Richmond
Bloomfield Hills, Michigan

Micala Tafelski
Plymouth, Michigan

James Money
Bridgeport, Connecticut

ASU/NASA Psyche Mission
Project Sponsors

Cassie Bowman
Tempe, Arizona

Audrey Talamante
Tempe, Arizona

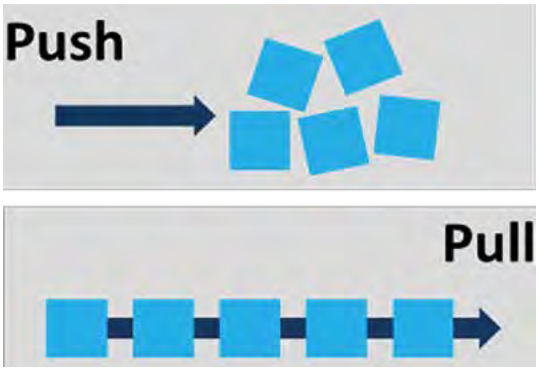
Caterpillar
Customer Order Pattern Analysis

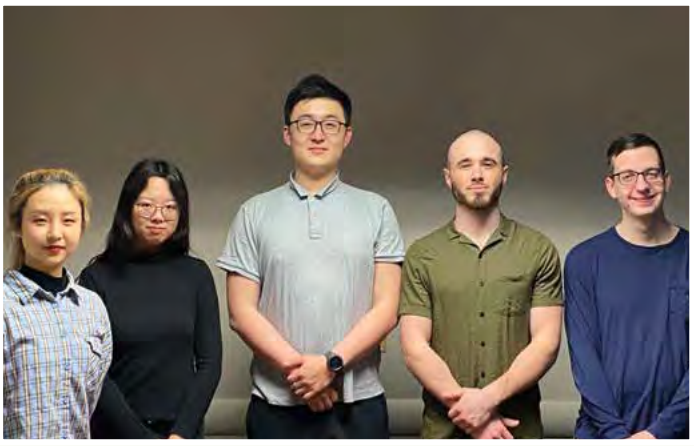
For the past several decades, Caterpillar has used a standard ordering and delivery system for parts such as seals, nuts and bolts. These parts are delivered to Caterpillar's manufacturing facilities through its internal distribution network, the Caterpillar Manufacturing Parts Nodes (MPN) Network. There are three "nodes," also called logistic centers, in North America that will be the focus of this project. These three nodes service over 300 customers and 30,000 unique parts.

Due to current system limitations, each manufacturing facility can order parts from these nodes using only one of the two following methods: a 24-hour Kanban pull trigger, or a forecasted MRP push method with defined lead times and due dates. With pending system upgrades, these ordering system limitations could be removed because Caterpillar suspects there is value in allowing each customer to use both a push and pull method, depending on the part.

Our project is to determine which parts should use a push method and which parts should use a pull method; doing so has the potential to increase the velocity of the supply chain and reduce inventory-related costs for the network and its customers.

The main goal is to develop a classification model to help Caterpillar determine which parts should use the 24-hour Kanban pull trigger or use the forecasted MRP push system. The classification model will determine and quantify which ordering method(s) will be most optimal for each customer's associated parts.





Michigan State University
Team Members (left to right)

Hongtong Ou
East Lansing, Michigan

Jiani Li
East Lansing, Michigan

Desheng Lu
East Lansing, Michigan

Griffen Rourke
Lake Orion, Michigan

Alex Burger
Chicago, Illinois

Caterpillar
Project Sponsor

Laura Cronkleton
Chicago, Illinois

Caterpillar
Improving the Supply Chain through Data Visibility

Caterpillar (CAT) began in 1925 after the merger of two tractor companies. Its humble beginnings transitioned into a multi-billion-dollar construction company, continuing their tractor business and expanding into engines, construction equipment, financial services, and insurance services. The bulk of CAT's revenue is generated from the engines and the equipment it powers, which leads to the need for inventorying and distributing a massive amount of parts.

Currently, CAT has twelve manufacturing parts nodes (MPN) located in countries all around the world. The two key metrics that help define node performance are On Time in Lines (OTIL) and Inventory Turnover. These metrics are organized and analyzed by management using Microsoft Excel. The most advanced analysis that this allows is color-sorting of cells and the creation of graphs. This makes it difficult to notice common trends, such as a yearly dip in performance, or an extremely slight trend.

Our team was tasked with discovering a better method of displaying CAT's key metrics. With the power of Tableau, our team created a dashboard that displays metrics in a way that will allow for far better performance analysis. The dashboard will enable CAT to analyze OTIL at a part level, which will allow for a deeper analysis as to why various logistic centers are underperforming, as well as give insight regarding the trend between logistic centers' business days and inventory turns. This dashboard will give CAT's management team a dynamic tool to analyze and communicate its key metrics, which will help drive decision-making and innovation.

Michigan State University
Team Members (left to right)

Evan Haase
Midland, Michigan

Paul Marvin
Troy, Michigan

Daniel Wheeler
Leslie, Michigan

Andrew Walker
Battle Creek, Michigan

JC Pritchett
Midland, Michigan

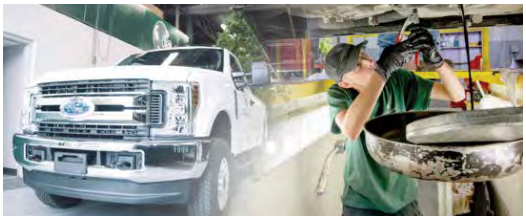
Caterpillar
Project Sponsor

Christopher Fink
Peoria, Illinois

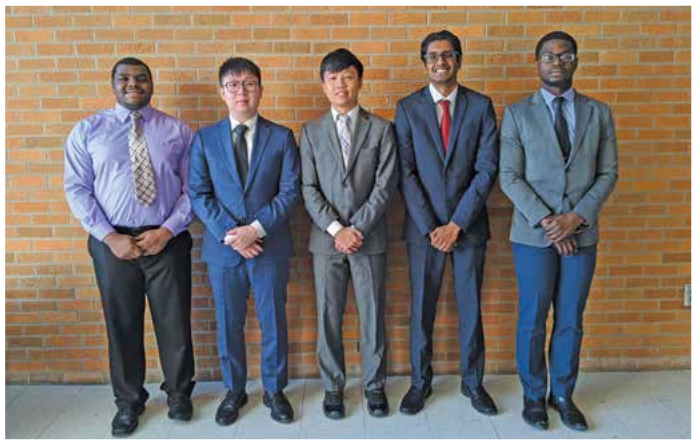
MSU IPF: Maintenance Services
Mobilize the Maintenance Stockroom

The MSU Infrastructure and Planning Facilities (IPF) Maintenance Services department is responsible for the maintenance and operations of all buildings on campus. IPF handles issues ranging from servicing dormitories to any general maintenance requests. Currently, tradesmen drive service vans around campus, carrying a limited supply of materials and tools. When a tradesman requires a certain part that is not in their vehicle, they drive to the IPF stockroom for additional materials. This can occur numerous times per day, leading to decreased productivity and increased vehicle usage by tradesmen.

For this project, the plumbing tradesmen were the only team within the scope of analysis. IPF utilizes Verizon Networkfleet, a vehicle tracking software that generates reports for vehicle metrics such as: miles per gallon, vehicle emissions, length of trips, etc. Monthly reports were generated for 2019 and 2020 to analyze the following: average trip time, average miles driven, and mpg. Included in the multi-factor analysis were the labor rates of the plumbing tradesmen and other vehicle costs provided by IPF. The recommendation is to implement a student delivery model, where a student will deliver materials to multiple tradesmen when they request additional materials. IPF already has a mobile application with the capacity to implement the recommendation. The application has the capability for tradesmen to place orders from their mobile phone, and workers in the warehouse will receive a notification to pick, package, and deliver the requested materials to the tradesmen. The biggest success of this project will be eliminating the need for tradesmen to travel from their work site to the IPF stockroom to collect additional materials. In turn, there will be an increase in tradesmen productivity and a decrease in vehicle usage by the entire fleet of tradesmen vehicles, leading to less non-value add trips, fuel consumption, and emissions.



Infrastructure Planning and Facilities
MICHIGAN STATE UNIVERSITY



Michigan State University
Team Members (left to right)

Percy Bean III
Kalamazoo, Michigan

Jiahui He
Yiwu, Zhejiang China

Haoyu Yang
Harbin, China

Hemanth Musunur
Troy, Michigan

Olatolu Afolabi
Westland, Michigan

MSU IPF: Maintenance Services
Project Sponsors

Jeff Groll
East Lansing, Michigan

Stacy Nurenberg
East Lansing, Michigan

MSU IPF: Sustainability: Carbon Sequestration & Carrying Capacity of MSU Trees

Michigan State University Infrastructure Planning and Facilities Sustainability department is responsible for analyzing how MSU contributes to global climate and carbon systems. As a land grant institution, MSU has a longstanding commitment to the environment. This is evident in the many green spaces and wooded areas on campus. Currently, MSU has over 20,000 trees on campus and cuts down, on average, 300 trees per year. MSU would like to collect data and design a system that will allow them to not only understand but also manage the carbon sequestration capacity of campus.

This project is focused on calculating the carbon sequestration value of Michigan State's campus in order to have a better understanding of how MSU is contributing to the local and global environment. This includes a method for calculating carbon sequestration that allows IPF to easily calculate an updated value on a yearly basis. The team is also responsible for identifying the canopy coverage of campus and mapping areas of campus where trees can be planted. This will aid IPF in the future with their plans for tree planting on campus. The project also includes creating a process to score trees based on age, canopy cover, carbon sequestration, and DBH. This score helps IPF determine which trees are most valuable to them and helps them maintain the diversity of trees on campus. Upon completion of this project, IPF will have a method of calculating the carbon sequestration value of campus, a better understanding of where to plant trees in the future, and which trees are most important to them. All of these will aid IPF in maintaining the beauty of Michigan State's campus for years to come.

Infrastructure Planning and Facilities
MICHIGAN STATE UNIVERSITY

Michigan State University
Team Members (left to right)

Shiliang Lai
Shandong, China

Xiaohan Jai
Shandong, China

Alexa Johnson
West Bloomfield, Michigan

Nicholas Habib
Sterling Heights, Michigan

Ethan Wolf
Midland, Michigan

MSU IPF: Sustainability
Project Sponsor

Ann Erhardt
East Lansing, Michigan

General Motors
Sequencing Strategy – Best Practice & Future Trends

General Motors (GM), founded in 1908, has been pushing the limits of transportation and technology for over 100 years. Headquartered in Detroit, Michigan this multinational corporation designs, manufactures, markets, and distributes vehicles and vehicle parts. General Motors has transformed how the world moved throughout the last century and are determined to do it again as they redefine mobility to serve their customers.

Our team was tasked to develop an analytical template that can be used by General Motors Supply Chain to determine the optimal build vehicle sequence strategy. Our team will work to determine the longest time that a vehicle sequence can be transmitted such that a supplier can be located and still supply the assembly plant parts in build order sequence. Within the automotive OEM industry, there is a general alignment in transmitting material requirement forecast and daily ship schedules, but there are a variety of strategies in the broadcasting of the individual vehicle build sequence.

Our team is working with General Motors to investigate whether a longer broadcast window is the optimal solution and, if so, how GM can communicate further upstream trigger points. The team is responsible for identifying potential benefits and cost savings, as well calculating the total lead time of the in-line sequencing strategy. Such findings will potentially enable a more effective supply chain strategy for each individual assembly plant and its associated vehicle launches.

GM General Motors

Michigan State University
Team Members (left to right)

Victoria Davis
Williamston, Michigan

Meghan Zula
Grosse Ile, Michigan

Megan Klimkowski
Highland, Michigan

Gabriele Manley
St. Joseph, Michigan

Alyssa Sekulovski
Rochester, Michigan

General Motors
Project Sponsors

Robert Harris
Detroit, Michigan

Bradley Karas
Detroit, Michigan

Gino Ottaviano
Detroit, Michigan

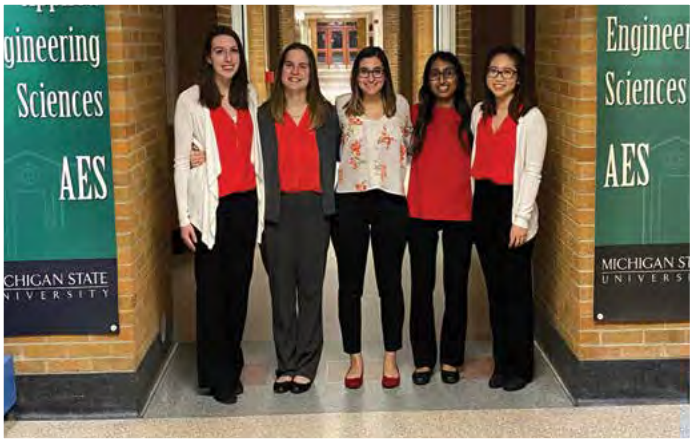
Guardian Industries
Float Glass Rack Optimization

Guardian Industries is a privately held industrial manufacturer of glass primarily for building applications. The company is one of the world's largest glass manufacturers, serving about 160 countries and five continents with headquarters based in Auburn Hills, Michigan. The focus of this project revolves around float glass and the racks used at six of their U.S. manufacturing sites.

Guardian Industries wished to reduce the amount of rack types that their six float glass plants were using. The objective was to analyze data on the 50 different racks in order to standardize them with a goal of keeping 10-15 racks. To do so, we analyzed the data provided, including usage in shipments since 2017, and cost data associated with each rack.

Upon initial usage analysis, it was clear that the plants had already been using approximately eight different rack types for about 97.5% of all shipments since 2017. With further discussion, we were able to refine the scope down to identifying three primary racks for Guardian to continue using. We were then encouraged to expand the scope further into more creative concepts for optimization. This included developing modifications to the design of the three existing racks to improve efficiency and allow for more glass dimension adaptability. We also expanded the project to consider the materials used for rack preparation and reduce the process time to package a rack for shipment.

Ultimately, our team was able to reduce the amount of rack types used from fifty down to three, as well as provide recommendations for future rack modifications and process improvements.



Michigan State University
Team Members (left to right)

Alyssa McCulloch
Walled Lake, Michigan

Cierra Grimes
Lansing, Michigan

Ashley Cotey
Fraser, Michigan

Pavitra Gangapur
Northville, Michigan

Nhu Quynh Do
Wyoming, Michigan

Guardian Industries
Project Sponsors

Nathan Harrison
Auburn Hills, Michigan

Patrick Nicholl
Auburn Hills, Michigan

Jeff Rende
Auburn Hills, Michigan

Curtis Weiermiller
Auburn Hills, Michigan

Kyle Wiesemann
Auburn Hills, Michigan

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Applied Engineering Sciences

Dr. Laura J. Genik
Director
Applied Engineering Sciences

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

Graduate Teaching Assistants

Salik Aziz
MBA (2020)

Corinne E. Brunckhurst
JD/MBA (2020)

Charles Fobbs
MBA (2020)

Elliot Lourie
MBA (2020)

Sugandhi Sawhney-Cox
JD/MBA (2021)

Presentation Schedule – Anthony Hall, Room 1255

Time	Team Sponsor	Project Title
8:00 a.m.	Harman	Global Supply Chain – Global Procure-to-Pay Process
8:25 a.m.	ASU/NASA Psyche Mission	Visualizing Contributions to a Successful Space Mission
8:50 a.m.	MSU RCPD	Gotcha - Electric Scooter Revolution
9:15 a.m.	MSU IPF: Custodial Services	Robotics Workforce Analysis
9:40 a.m.	Break	
9:50 a.m.	John Deere	Engine Overhaul Kit Packaging Study
10:15 a.m.	John Deere	Part Consolidation and Proliferation Avoidance
10:40 a.m.	John Deere	Strategy Refresh - Wireform
11:05 a.m.	Truck-Lite	Supplier Performance Scorecard

AESC Engineering Program

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

Harman
Global Supply Chain - Global Procure-to-Pay Process

Harman is a global company that touches over 30+ countries with technologies that create a connected world. Harman is involved in various technologies: connected car, lifestyle audio, professional solutions, and connect services. Harman is the industry standard in studios and on the stage for various artists. They have worked in venues around the world and maintain long-term customers like Audi, BMW, and Volkswagen.

With multiple, diverse products comes a lot of movement and shipping of their products.

Harman currently does not have a unified procure-to-pay freight audit process among the different regions of the company. Harman is striving to understand all processes: North America, Europe and Asia. Harman is motivated to understand what needs to change within their current regional processes.

The focus of the project will be to develop a process map of Harman's current process in each region, specifically targeting freight audit information. This process map will act as an internal guide for Harman.

Harman has asked our team to highlight gaps in the process. Therefore, our team will be performing an analysis of each region's process, which will allow us to identify inconsistencies between processes across different regions of the world.

The findings will be presented in an online packet for Harman. This resource will enable Harman to demonstrate inconsistencies between processes and implement a unified solution. These findings will provide Harman with crucial feedback on how to improve their freight audit process for different regions within North America and the globe.

Michigan State University
Team Members (left to right)

Callie Shelton
Clio, Michigan

Kayla Burmis
Jerome, Michigan

Nick Koester
Novi, Michigan

Allie Cayo
Allen Park, Michigan

Brooke Gazdick
Fair Haven, Michigan

Harman
Project Sponsors

Laurel Becker
Novi, Michigan

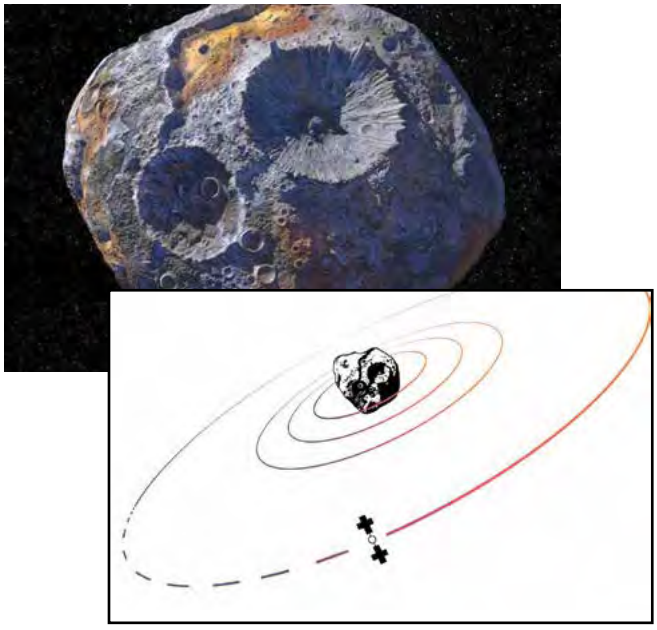
Edward Donnellon
Novi, Michigan

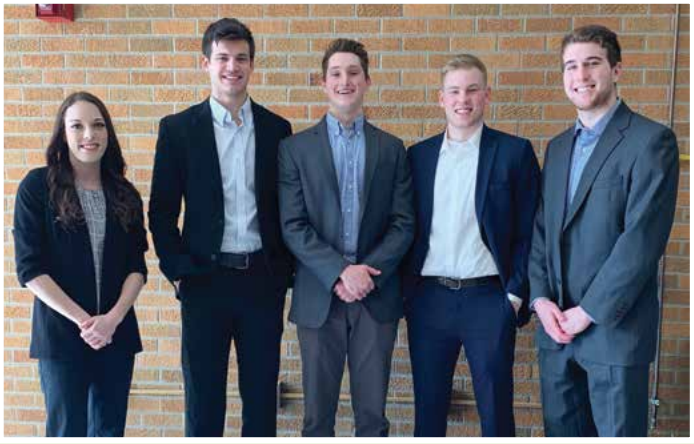
ASU / NASA Psyche Mission
Visualizing Contributions to Successful Space Mission

NASA has made the journey and exploration outside of Earth possible. Whether it is a trip to the moon, other planets in our solar system, or an asteroid made of metal, NASA is working to explore it all. The NASA Psyche Mission is an exploration, led by Arizona State University, to an asteroid not made of rock or ice, but almost entirely of metal. The belief is that this nickel-iron asteroid is the remnant of an early planet that lost its outer shell over the course of many violent collisions. Earth's planet core is too hot and deep to realistically explore. Psyche provides the opportunity to explore a planet core and lead to discoveries about how Earth and other planets came to form.

Our team was tasked to create an interactive visualization that showcases the complexity of the Psyche Mission. The Psyche team is not just a team of engineers but requires the involvement of many people that each bring a different expertise to the table. In the project, each team member became an expert on specific categories that make the mission possible. The key components our team decided to focus on include the background and timeline of the mission, the Psyche asteroid itself, partnered institutions and team members, and key spacecraft components and suppliers. The visualization brings together each category and the complexity of launching a mission like this one.

Our team has worked diligently for the past few months to ensure the best design of said visualization in order to make information regarding the Psyche Mission accessible and understandable to the public. The four main categories we focused on are vital to pushing Psyche to the front of the race in terms of being a well-known mission. It is important that public awareness and involvement in the mission is high, so the public is aware of how their tax dollars being used.





Michigan State University
Team Members (left to right)

Melissa Finneran
South Lyon, Michigan

Noah Van Reesema
Chelsea, Michigan

Jon Urich
Grand Rapids, Michigan

Tyler Nette
Paw Paw, Michigan

Richie Gentile
Riverside, Illinois

ASU/ NASA Psyche Mission
Project Sponsor

Cassie Bowman
Tempe, Arizona

MSU Resource Center for Persons with Disabilities
Gotcha - Electric Scooter Revolution

MSU Resource Center for Persons with Disabilities (RCPD) delivers equal access to university education for all students. The Center provides services to students and employees who are blind/visually impaired, deaf/hard of hearing, have barriers with mobility, learning disabilities, brain injuries, psychiatric, and various chronic health conditions.

Michigan State University is committed to providing equal opportunity for full participation in all programs, services and activities. The exponential use of electric scooters on MSU's campus and nationally has led to challenges upholding this commitment. When parked in the middle of sidewalks and walkways, scooters create significant physical risks, particularly for persons with visual impairments This project identified and pursued solutions to reduce safety concerns for these individuals. Michigan State University has established a cooperative partnership with Gotcha who are interested in developing solutions for national implementation. Our team collaborated with Gotcha throughout the project to ensure the solution's effectiveness.

The project involved the sponsor, MSU RCPD, and MSU's contractual relationship with Gotcha. The goal was to create a mobile application on the iOS platform to aid those with visual impairments in detecting incorrectly parked Gotcha scooters. This app uses Bluetooth scanning to pinpoint the locations of nearby Gotcha scooters and alert the user once within a given proximity. This feature can be toggled on and off to preserve confidentiality and when not required. When the feature is toggled on, Gotcha scooters will emit an auditory alert once close enough to the device. This alerts the user of the upcoming obstruction as well as its location to reduce the risk of potential bodily injury. This application also provided Gotcha with a proof-of-concept for implementing a similar functionality within their existing app.

RCPD
Maximizing Ability & Opportunity

Michigan State University
Team Members (left to right)

Nate Olsen
Grandville, Michigan

Bailee Droste
DeWitt, Michigan

Mike Hudson (Sponsor)

Mamduh Muridi
Lansing, Michigan

Sophia Venticinque
New Baltimore, Michigan

AJ Shaw
Troy, Michigan

MSU Resource Center for Persons with Disabilities
Project Sponsor

Mike Hudson
East Lansing, Michigan

MSU IPF: Custodial Services
Robotics Workforce Analysis

MSU IPF Custodial Services hires over 330 employees to clean over 13.5 million gross square feet of campus facilities. High turnover rate is a current challenge, such as the 200% rate of temporary positions in 2018. In order to combat this challenge, semi-autonomous floor cleaning robots have been purchased and deployed so that employees can be allocated to other cleaning tasks. This project will work towards creating an understanding for how the fleet of robots can be employed to improve efficiency from a man hours and financial perspective. By continuing to pursue an interest in robotics, this provides an opportunity to enhance the custodial workforce through increased performance and provide new ways for custodial employees to align with strategic planning initiatives.

The goal of the project is to deliver the requested current state analysis with documentation and information gathered throughout the investigative process specifically looking into finances, operations, and efficiency reports. A PowerPoint presentation of the project will be used in future conferences to share MSU Custodial Services' pioneering research in the application of robotics to custodial services. The current state analysis will provide the framework to assist with the current and future integration of robotics into the custodial workforce at MSU and will show MSU's commitment to maintaining its cutting-edge status with technology integration into custodial work.

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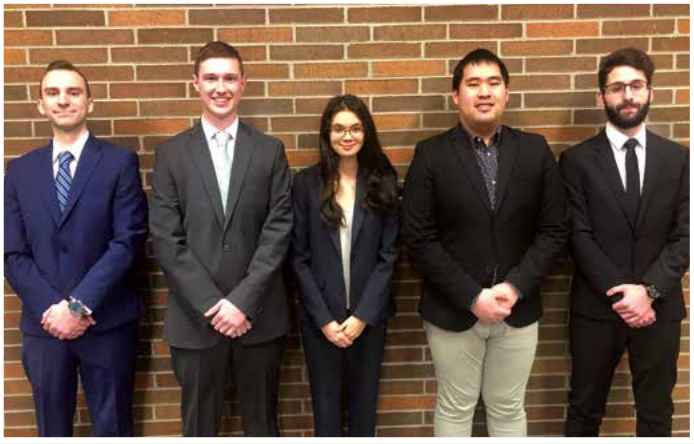
Infrastructure Planning and Facilities
MICHIGAN STATE UNIVERSITY



Michigan State University
Team Members (left to right)

Eric Bernhardt
Bingham Farms, Michigan

Kyle Grill
Saline, Michigan

Elizabeth Slifkin
Troy, Michigan

Ely Hsu
Allendale, New Jersey

Feras Abulborghol
Damascus, Syria

MSU IPF: Custodial Services
Project Sponsor

Brandon Baswell
East Lansing, Michigan

John Deere
Engine Overhaul Kit Packaging Study

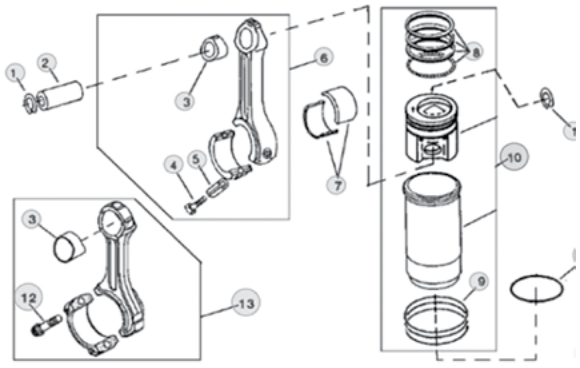
The objective of this project is to create a business case and to evaluate the feasibility of removing Piston Liner Kits (PLK), as seen in the schematic to the right, from the larger Engine Overhaul Kits (EOK). This is done to reduce the cost of shipping the EOKs, as well as to reduce the amount of damage claims upon arrival, which lead to increased costs due to expedited shipping. Removing the PLKs will generate expected cost savings due to a reduced risk of damage to all EOK components and due to a weight reduction of the EOK. This will be done by analyzing logistics costs, cost of expedited shipping using the current system, estimated cost of expedited shipping with new packaging, and cost of standard shipping, as well as estimated shipping with reduced weight.

To create a business case for John Deere, competitors were benchmarked in order to understand the industry standard and how these kits are normally packaged. This illuminates areas where John Deere can possibly improve on their processes.

Coordinating with John Deere's packaging supplier to develop new dimensions for packaging the EOKs and PLKs to be shipped separately has also been done.

Our team performed this analysis to find profit potential with the new shipping arrangement as well as to help reduce potential damage from occurring during shipping.

In the end, the team will have shown if there is a business case to remove the Piston Liner Kit from the Engine Overhaul Kit, which John Deere can use in the future.



Michigan State University
Team Members (left to right)

Ryan Havens
Novi, Michigan

Jon Firehammer
Saline, Michigan

Hannah Boomer
Howell, Michigan

CJ Manquen
Shelby Township, Michigan

Anthony Elenbass
South Lyon, Michigan

John Deere
Project Sponsors

Cody Kresser
Waterloo, Iowa

Josh Nunez
Waterloo, Iowa

John Deere
Part Consolidation and Proliferation Avoidance

John Deere is a world leader providing advanced products and services and is committed to those linked to the land. Since it was founded in 1873, John Deere has been delivering innovative products built with the utmost quality and rooted in the tradition of integrity. The company, headquartered in Moline, Illinois, currently sells machines and engines for a variety of applications such as agricultural equipment, construction, marine, and forestry. Our team is specifically working with a division of John Deere called John Deere Power Systems, which manufactures agricultural, industrial, marine, and genset diesel engines.

John Deere Power Systems has tasked our team with tackling its historic part proliferation within its turbocharger platform. Turbochargers extract energy from the exhaust of an engine and use the energy to compress air entering the engine. John Deere would like to reduce the amount of turbocharger complexity that exists across its engine product lines. Reducing the proliferation of turbochargers will allow the company to have a better understanding of overall part-carrying cost and an easier path in product serviceability. This will lead to significant reductions in part procurement cost and complexity while improving quality.

Our team's effort is divided into three components: research, part analysis, and economic analysis. Our first task is to help build the business case for Deere to work towards reducing turbocharger part proliferation. This includes research into how reducing proliferation in industry has been successful. Once the best approach has been established, we will categorize and group turbocharger designs from their attributes to identify part numbers that are duplicates or could be substituted. Lastly, an economic analysis will reveal the opportunistic reduction in cost, quality issues, and complexity from implementation of this grouping and duplicate reduction scheme.

JOHN DEERE

Michigan State University
Team Members (left to right)

Jad Al-Farah
Northville, Michigan

Matthew Rightor
Midland, Michigan

Lindsay Knuth
Manistique, Michigan

Peiyu Zhang
Changchun, China

Nicklaus Steiner
Midland, Michigan

John Deere
Project Sponsors

Bradley Nordmeyer
Waterloo, Iowa

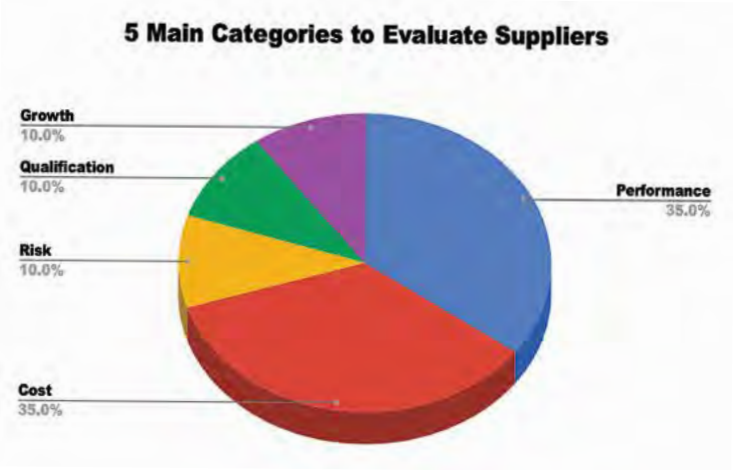
Jenna Scheider
Waterloo, Iowa

John Deere
Strategy Refresh – Wireform

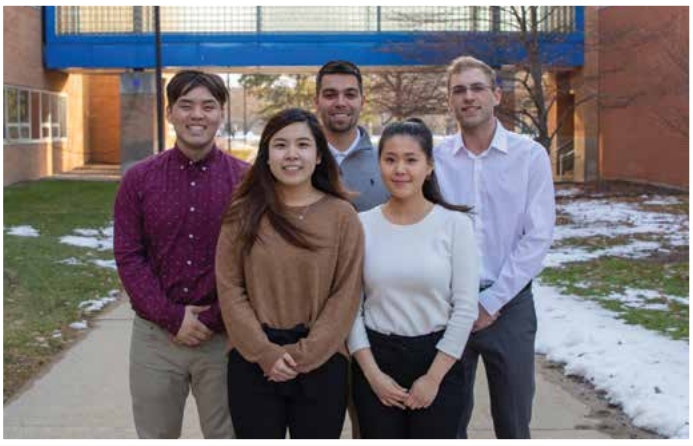
John Deere, a manufacturing company headquartered in Moline, Illinois, is known for agricultural, construction, forestry machinery, diesel engines, drivetrains used in equipment, and lawn care equipment.

Our team developed a supplier evaluation tool for John Deere to quantitatively assess suppliers that can be beta-tested on the company's current suppliers within their wireform commodity. The tool calculates average supplier scores based on five evaluation categories (performance, cost, risk, growth, and qualifications) that are weighted according to John Deere's supplier priorities. The categories are made up of various sub-criteria that include examples of quality, delivery, supplier certifications, financial stability, and capacity.

Documenting the key supplier metrics creates an up-to-date supplier scoreboard and gives a high-level overview of the suppliers and commodity base as a resource for strategic decision- making. Additionally, the tool provides an opportunity for John Deere to understand the current state and standing of suppliers among other suppliers. Our objective is to form a quantifiable feedback tool for supply base managers and prioritize supplier evaluation categories for varying metrics within the tool. The long-term objective is to establish an integratable and functioning supplier evaluation tool that can be implemented across all John Deere commodities.



JOHN DEERE



Michigan State University
Team Members (left to right)

Paul Lee
Rochester Hills, Michigan

Jennifer Yoo
Macomb, Michigan

Nick Gazall
Lansing, Michigan

Bella Jin
Rochester Hills, Michigan

Jacob Hoffman
Saginaw, Michigan

John Deere
Project Sponsors

Breanna Rath
Moline, Illinois

Elmar Schlechter
Mannheim, Germany

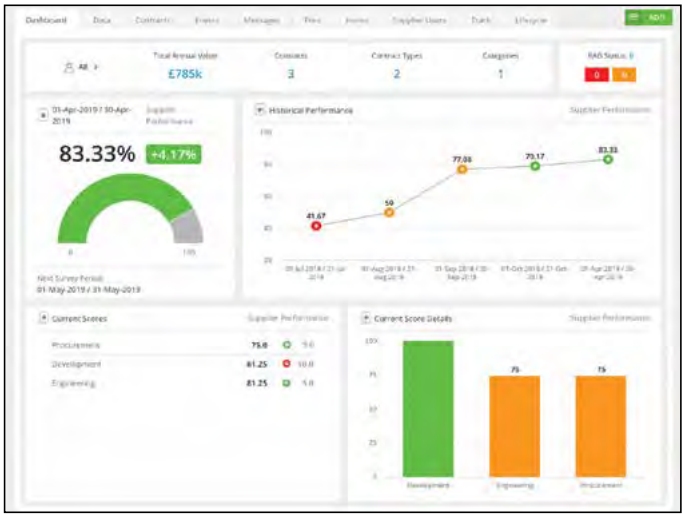
Truck-Lite Co, LLC
Supplier Performance Scorecard

Founded in 1955, Truck-Lite is a premier vehicle electronics company with an international presence that provides lighting, safety, engine filtration and telematic products into the commercial vehicle, military, recreational and marine industries.

Our project is to develop a Supplier Performance Scorecard that will be common across Truck-Lite's five divisions: Truck-Lite, Rigid, Lumitec, Davco, and RoadReady. This scorecard will incorporate consistent performance data across the previously mentioned divisions. With approximately 1,000 suppliers, it is critical to set clear performance expectations and measure key performance indicators (KPIs).

The scorecard will include, but will not be limited to, measuring performance as it relates to cost, quality, delivery, and innovation. We will benchmark industry scorecards by utilizing academic knowledge and previous professional experiences, while gaining an understanding of what is important to Truck-Lite's functional leaders and internal stakeholders.

Implementation of the team's recommendation aims to have a significantly positive impact for supplier performance, which will become the basis for choosing the suppliers that remain in Truck-Lite's supply base.



Michigan State University
Team Members (left to right)

Sam Wilson
Brookfield, Illinois

Danielle Linska
Macomb, Michigan

Alyssa Zimmerman
Shelby Township, Michigan

Mariam Ahmad
Novi, Michigan

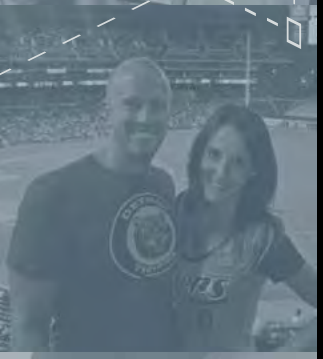
Alex Christiansen
Grand Haven, Michigan

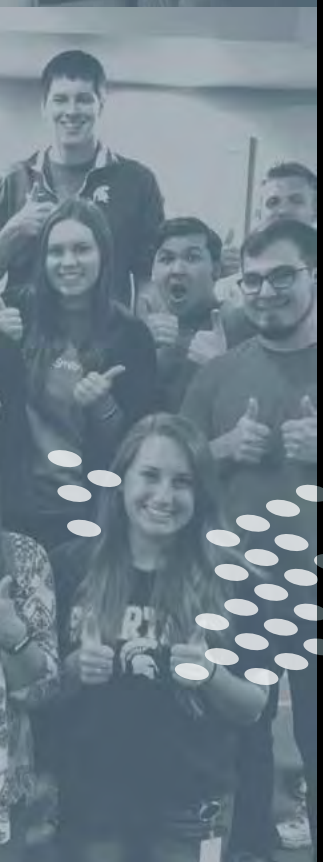
Truck-Lite Co, LLC
Project Sponsors

Brad Everingham
Auburn Hills, Michigan

Kevin Krause
Auburn Hills, Michigan

David McKean
Auburn Hills, Michigan





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Applied Engineering Sciences

Dr. Laura J. Genik
Director
Applied Engineering Sciences

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

Graduate Teaching Assistants

Salik Aziz
MBA (2020)

Corinne E. Brunckhurst
JD/MBA (2020)

Charles Fobbs
MBA (2020)

Elliot Lourie
MBA (2020)

Sugandhi Sawhney-Cox
JD/MBA (2021)

Presentation Schedule – Anthony Hall, Room 1257

Time	Team Sponsor	Project Title
8:00 a.m.	KLA	Manufacturing Cost Modeling by Product Type & Region
8:25 a.m.	KLA	IP Risk Analysis by Product Type & Region
8:50 a.m.	Quality Dairy	Data Driven Customer Attraction and Retention
9:15 a.m.	Ranir	Go Green Packaging
9:40 a.m.	Break	
9:50 a.m.	Ingersoll Rand	Long Term Strategy for Sustainability in Logistics
10:15 a.m.	Ingersoll Rand	Carrier Rationalization and Benchmark
10:40 a.m.	Ingersoll Rand	Fusing Transportation Costs into Material Planning
11:05 a.m.	ZF	Automated Material Pricing for Contractual Updates

Applied Engineering Sciences Awards

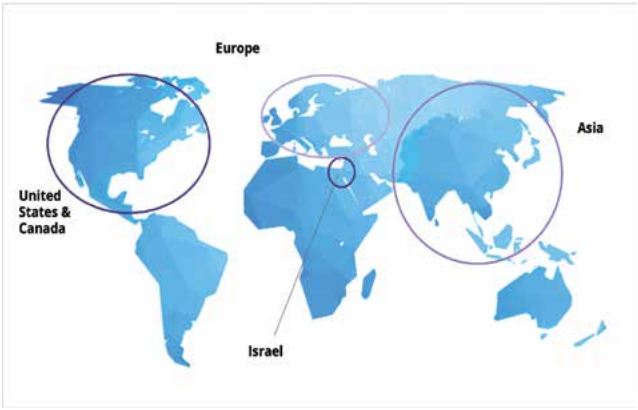
Applied Engineering Sciences Design Program presents three awards on Design Day. The Most Impactful Award is given to the team whose project will potentially have the most immediate impact on their sponsor. The team whose project will produce the most sustainable results for their sponsor receives The 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.

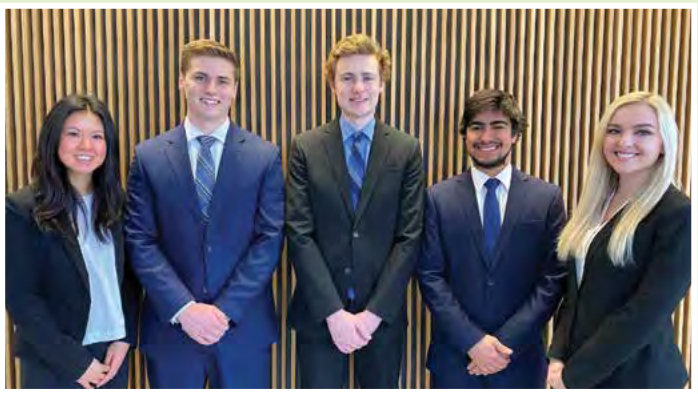
KLA
Manufacturing Cost Modeling by Product Type & Region

Keep Looking Ahead Corporation (commonly known as KLA) was founded in 1997 with the merger of two large semiconductor equipment companies, KLA Instruments and Tencor Instruments. Based in Milpitas, California, KLA is a worldwide leader in creating technological solutions for the next generation. They specialize in electric and photon optics, sensor technology, and artificial intelligence.

As KLA is looking ahead to expand the company worldwide, it is important to determine where the best locations to expand would be. To accomplish this, KLA asked our team to create a visual representation of manufacturing cost by region. These regions would include North America, Europe, Asia, and any other countries we find significant while conducting research. The costs associated with manufacturing include land and property cost, labor cost, as well as the cost of specialization in these industries. Specialization consists of finding individuals who are highly qualified in optics, optical engineering, and physics from reputable educational institutes around the world.

Our team, consisting of Supply Chain Management and Applied Engineering Sciences students, chose Tableau as the software to create a heat map of the associated costs and the regions of specialization data. The purpose of the heat map is to calculate and show KLA the cost and availability of land and labor, as well as the countries that specialize in the field. By building the database in Excel and utilizing functions within the program, KLA can determine and change how much each cost factor should weigh when calculating manufacturing cost. This heat map acts as a cost tool and will give KLA the information they need to determine where the next location to expand should be.





Michigan State University
Team Members (left to right)

Natalie Liou
Kalamazoo, Michigan

Samuel Johnson
Mason, Michigan

Ryan Mayer
Rochester Hills, Michigan

Anthony Cantu
Lake Orion, Michigan

Kelsey Blatchford
Big Rapids, Michigan

KLA
Project Sponsor

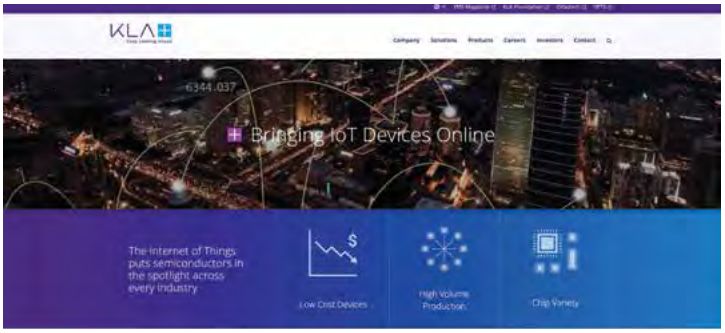
Shirley Wu
Milpitas, California

KLA
IP Risk Analysis by Product Type & Region

KLA is a leading global equipment company that supplies process control equipment to the semiconductor industry. Due to KLA's massive investments in R&D that increase year after year, intellectual property protection is of the utmost importance to them.

Our project is to deliver a unique heat map to KLA, mapping the intellectual property risk of different regions throughout the world. KLA will be able to confidently see which countries are best at protecting intellectual property. The regions being looked at are Asia, Europe, and North America and others. In Asia, the individual countries being examined are China, Japan, Taiwan, South Korea, Vietnam, Thailand, and Malaysia. In Europe, Germany, Czech Republic and Romania are being studied. Lastly, in North America and others, the United States and Israel are analyzed.

To accurately evaluate intellectual property risk, our team utilizes MSU resources such as past studies, alumni research, and formal definitions. The main basis of concern in each region is the intellectual property protection laws, agencies, regulations, and enforcement. Additionally, the frequency of intellectual property is also important. To ensure that this heat map is unique to KLA, an emphasis on each KLA product (Optics, Lasers, and Image Computers) is weighed into each regions' rankings. KLA's investment history and product revenue are the key characteristics that define the difference and uniqueness of our heat map.



Michigan State University
Team Members (left to right)

Brendan Crites
Rochester, Michigan

Nathan Garlick
Rochester, Michigan

Timothy Chao
Pleasanton, California

Jacob Gottlieb
Hoboken, New Jersey

Steven DeSantis
Sterling Heights, Michigan

KLA
Project Sponsor

Shirley Wu
Milpitas, California

Quality Dairy Company
Data Driven Customer Attraction & Retention

Established in 1936, Quality Dairy Company (QD) began as a local milk store, breaking away from at-home milk delivery. Over the past 84 years, QD has grown into a family-owned convenience store chain in the Greater Lansing Area. Aside from providing retail convenience, a variety of the 29 store locations are equipped with gas stations, laundromats, and quick service restaurants.

QD's customer base has shrunk over the years due to changing customer trends, increased competition, and traditional business practices. Because of this, QD is seeking help to increase customer attraction and retention, reduce marketing and promotional costs, and increase company revenues, all while leveraging the technological abilities of the company.

Although located in a centralized region, QD stores can be broken down into several store location types: Lansing City, suburban, rural, and university. A focus of our project is to establish a criteria of influences on consumer buying behavior and determine a process to define customer demographics by each store type.

Another focus of the project is to construct an approach to attract and increase a more diverse customer base. QD has the opportunity to expand and adjust current customer attraction and retention techniques to best serve all potential consumers.

The last focus of the project is to recommend how to best utilize location-specific promotions and geo-fencing. The world of technology is constantly changing and, in order to stay relevant and competitive, QD must come up to date with these advancements.

In order to tackle the deliverables of the project, ample data regarding customer demographics, industry trends, and convenience store best practices must be gathered and analyzed.

Upon completion, Quality Dairy will be left with an improved understanding of the communities in which they operate along with a criteria, process, and recommendations as to how to best attract and serve the members of these communities.

Michigan State University
Team Members (left to right)

Kyle Isaacson
Novi, Michigan

Kailey Steele
Grand Blanc, Michigan

Zoé Crowe
Rochester, Michigan

Emily Taubitz
Northville, Michigan

Candace Waite
Rochester, Michigan

Quality Dairy
Project Sponsor

Kenneth Martin
Lansing, Michigan

Ranir
Go Green Packaging

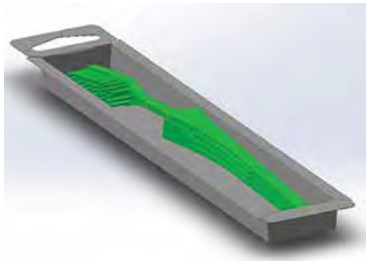
Ranir is a leading global manufacturer of store brand consumer oral care products. They are headquartered in Grand Rapids, Michigan. Ranir's mission is to serve retail customers globally, and they are committed to delivering affordable, healthy smiles to millions of households every day.

The idea of the Go Green Packaging project from Ranir is to redevelop manual toothbrush packaging to be fully recyclable and potentially compostable. Current toothbrush packaging involves a backer made from paperboard and a plastic blister that can fit all of the different manual toothbrush designs manufactured at Ranir. This redesign would eliminate all plastic involved in the package and use a cellulose screen on the backer for visibility of the product.

In addition to the redesign, a cost analysis was performed to compare the current package design costs to the new package design costs. The cost analysis specifically looked into the individual package parts, including the paperboard backer, label and plastic blister, together with machine and labor costs. Cost savings are not required for this project, but they may be achievable through reduced labor as this new process would be more automated. The cost analysis will help determine feasibility and cost efficiency of the new package.

Overall, this project is a great opportunity to assist Ranir in reaching their sustainability goals while our team learns about driving a large project from start to finish.

The team is an interdisciplinary team that is comprised of Applied Engineering Sciences students and Supply Chain Management students. We were able to apply packaging and supply chain knowledge from coursework and internships.



Michigan State University
Team Members (left to right)

Joe Tang
Guangzhou, China

Sarah Ly
Holland, Michigan

Kathryn Leon
Plymouth, Michigan

Benji Liu
Okemos, Michigan

Jordan Moffit
DeWitt, Michigan

Ranir
Project Sponsors

Jerry Bailey
Grand Rapids, Michigan

Jason Robb
Grand Rapids, Michigan

Brad Walbridge
Grand Rapids, Michigan

Ingersoll Rand
Long-Term Strategy for Sustainability in Logistics

With a history dating back to 1871, Ingersoll Rand is a global industrial manufacturing company that includes market-leading brands, such as Club Car, Trane and Thermo King, that serve customers in commercial, industrial and residential markets. Ingersoll Rand strives to advance the quality of life by helping customers achieve real progress and create a positive impact in their world, while making environments comfortable, sustainable, and efficient.

As part of the company's 2030 Sustainability Commitment, Ingersoll Rand is striving to reduce their carbon footprint by 1 billion metric tons of CO_2e. This Sustainable Logistics Strategy project aims to contribute to this goal, working to reduce other harmful pollutants by providing a long-term strategy for sustainability in logistics. Currently, Ingersoll Rand's freight vendors participate in the EPA's SmartWay program, a system for tracking and documenting information about fuel use and freight emissions across supply chains. This project focuses on using reported SmartWay data to assess past emissions for U.S. transportation carriers and evaluate vendor performance.

Additionally, this Sustainable Logistics Strategy project creates tools to help Ingersoll Rand identify and select more efficient transport modes, equipment, and operational strategies. The project provides the opportunity for Ingersoll Rand to reduce emissions and engage in more sustainable logistics practices to better the environment for its customers and the world.

SmartWay℠ Transport Partnership
Getting There With Cleaner Air

Ingersoll Rand

Michigan State University
Team Members (left to right)

Adam Rowlands
Farmington Hills, Michigan

Phillip Conrad
Canton, Michigan

Erin Bahm
Farmington Hills, Michigan

Winter Romeyn
Ellsworth, Michigan

Joshua Gonzalez
Trenton, Michigan

Ingersoll Rand
Project Sponsors

Ramya Josyula
Davidson, North Carolina

Mark Slezak
Davidson, North Carolina

Ingersoll Rand
Carrier Rationalization and Benchmark

Ingersoll-Rand was founded in 1871 and is a leading diverse industrial conglomerate with over twenty brands in their portfolio. They are well known for reliability, with their best-known brands being Club Car golf carts, Trane air-conditioning systems, Thermo King transport temperature control equipment, and Ingersoll-Rand industrial equipment.

Within North America, Ingersoll-Rand currently spends approximately $275 million a year in transportation costs associated with Truckload, Less-Than-Truckload, and third-party shipping transportation modes. They currently utilize hundreds of carriers within their carrier portfolio with a mix of asset-based, broker, and dedicated carriers.

Our team has developed a Carrier Portfolio Breakdown Dashboard that provides a user-friendly interface that visualizes and rationalizes the current carrier portfolio within Ingersoll-Rand. It allows the user to visualize what transportation type is taking place and by which carriers within each custom defined region in North America. Additionally, this dashboard allows users to easily see cost, weight, and mileage data.

The transportation types that can be filtered are inbound vs outbound, truckload vs less-than-truckload vs third-party shipping, and asset-based vs broker vs dedicated.

This dashboard also offers predictive analytics and allows users to see what would happen nationally and within each region if a carrier or carrier type were changed.

In addition to predictive analytics, this dashboard performs internal benchmarking of the current carrier mix, grading each carrier based on performance data, while also recommending which carriers should be used less or eliminated and which carriers should be utilized more.

Michigan State University
Team Members (left to right)

Alex Cavellier
Lake Orion, Michigan

Brad Merola
Sterling Heights, Michigan

Brandon Imirowicz
Clarkston, Michigan

Saaketh Sirani
Northville, Michigan

Wenxuan Zhang
Beijing, China

Ingersoll Rand
Project Sponsor

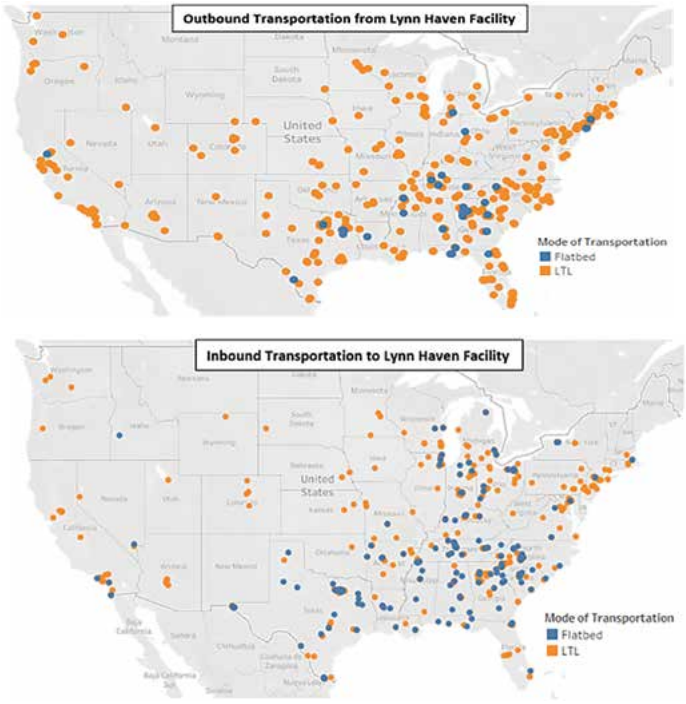
Matthew Clayton
Charlotte, North Carolina

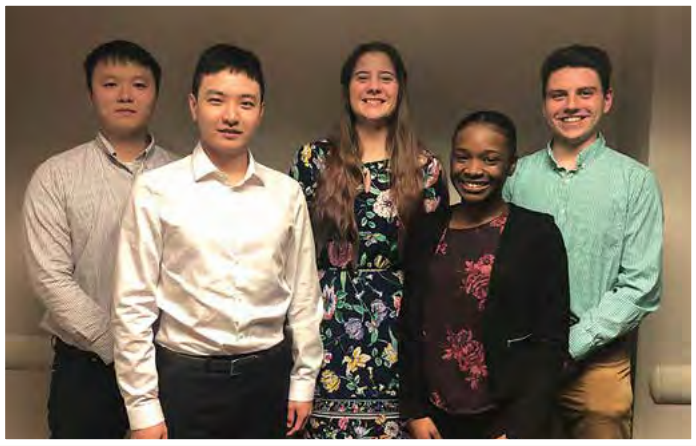
Ingersoll Rand
Fusing Transportation Costs into Material Planning

Ingersoll Rand is a diversified industrial manufacturing company committed to its mission of inspiring progress. With headquarters in Dublin, Ireland, Ingersoll Rand currently has more than 99 manufacturing facilities worldwide. Ingersoll Rand works to improve productivity through innovative equipment, products and services that extend through global commercial, industrial and residential markets.

The focus of the project is on a facility located in Lynn Haven, Florida that produces commercial grade Heating, Ventilation and Air Conditioning (HVAC) units to customers throughout the United States. Currently, there are issues with shipments being received and sent out that are not being used for their fullest potential loads, causing high and unnecessary transportation costs. The Lynn Haven Facility exclusively uses third-party companies which primarily include Flatbed shipments having direct point-to-point routes and Less-Than-Truckloads (LTLs) shipments that require multiple stops and additional points of contact before reaching the desired destination. It is within these two shipment types that there is room to reduce the mileage of both inbound and outbound shipments in addition to reducing emissions.

Our team project is to look at one of Ingersoll Rand facility's inbound and outbound transportation shipments to see if there is room for route optimization in addition to total cost minimization. Through consolidating shipments going to/coming from nearby locations, total mileage across the shipments will be reduced, decreasing the overall emission levels of the shipments, thus optimizing the current transportation network. Simulations were used to look at various route options, such as milk runs, cross-docks, and a hybrid of the two, to give Ingersoll Rand numerous options to best minimize their transportation costs and emissions.





Michigan State University
Team Members (left to right)

Yifan Yao
Shanghai, China

Qinming Zhang
Changsha, China

Amanda Beachnau
Portland, Michigan

Carrington King
Detroit, Michigan

Andrew Hixson
Novi, Michigan

Ingersoll Rand
Project Sponsor

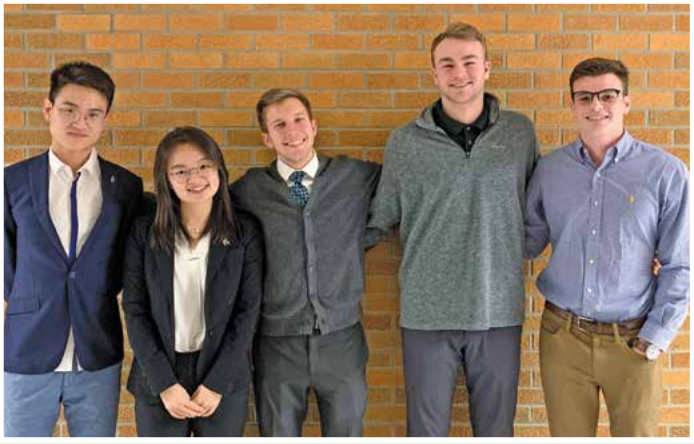
Erin Nuccitelli
Davidson, North Carolina

ZF Friedrichshafen AG
Automated Material Pricing for Contractual Updates

ZF Group is a global technology company headquartered in Friedrichshafen, Germany. The company has around 149,000 employees with 230 locations in 40 countries. ZF supplies systems for passenger cars, commercial vehicles and industrial technology, enabling the next generation of mobility. The company brought in €36.9 billion in sales revenue for the year 2018. The purchasing department is a vital part of the company, particularly the raw materials division.

For this project, the raw material purchasing department at ZF is concerned with automating their contractual update process from raw material inputs. The completion of the project will positively impact the contractual management of nearly €17 billion in spending annually. Our team will create a tool that automatically collects several raw material price inputs from suppliers as well as published indices such as Scrap Price Bulletin and American Metal Market. These prices will be updated according to their respective contracts with various OEMs to calculate the final surcharge rate that ZF will use to purchase their raw materials.

We created an automated pricing tool that is composed of a Python script to gather the raw material pricing information from different indices. We also recreated an Excel spreadsheet to perform the calculations for each OEM contract and eventually export the final surcharge price. This tool will help to greatly reduce the large amounts of time spent by employees manually entering each raw material input. The automated pricing tool will also eliminate the potential for human error to be made in the surcharge calculations. Lastly, the tool is user-friendly and will streamline the onboarding process for new employees and quickly teach associates who currently perform the contract updates. All pricing information will be exported to the appropriate buying contract files to be analyzed for cost savings opportunities.



Michigan State University
Team Members (left to right)

Zhuoyan Bai
Shanxi, China

Xinyi Sun
Anhui, China

Adam Brigmann
Rochester, Michigan

Cody Church
South Lyon, Michigan

Kyle Veich
Marshall, Michigan

ZF Friedrichshafen AG
Project Sponsor

Robin Adams
Northville, Michigan

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Applied Engineering Sciences

Dr. Laura J. Genik
Director
Applied Engineering Sciences

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

Graduate Teaching Assistants

Salik Aziz
MBA (2020)

Corinne E. Brunckhurst
JD/MBA (2020)

Charles Fobbs
MBA (2020)

Elliot Lourie
MBA (2020)

Sugandhi Sawhney-Cox
JD/MBA (2021)

Presentation Schedule – Anthony Hall, Room 1260

Time	Team Sponsor	Project Title
8:00 a.m.	ASU/NASA Psyche Mission	Art and STEM Vision for Future Interns
8:25 a.m.	BP PLC	Effective Usage of Producer Price Indexation Analysis
8:50 a.m.	BP PLC	Subsea Hardware Inventory Management Optimization
9:15 a.m.	BP PLC	Contract Management in Procurement and Supply Chain
9:40 a.m.	Break	
9:50 a.m.	American Axle Manufacturing	Shim Project – A Required Parts Forecast Model
10:15 a.m.	Asahi Kasei Plastics North America	Identify Cost Savings through Spend Data Analysis
10:40 a.m.	Dow	Integrated Supply Chain Intelligent Personal Assistant
11:05 a.m.	FreightWaves	Analytics Competition

AESC Awards Support

Dr. Philip L. Fioravante is the longstanding sponsor of the Applied Engineering Sciences Capstone Awards for Most Sustainable and Most Impactful projects. Dr. Fioravante is an alumnus (BS '84) of our program, winner of the 2004 AES Distinguished Alumni Award, winner of the 2013 College of Engineering Claud R. Erickson Distinguished Alumni Award and former Chair of the College of Engineering Alumni Board. Design Day award winners are selected based on both final written project reports and on oral presentations at Design Day. We thank Dr. Fioravante for his generous and continuing support of the AESC Design Day Awards.

ASU/NASA Psyche Mission
Art and STEM Vision for Future Interns

It all started with one woman, one team, and one vision. Lindy Elkins-Tanton is the principal investigator of NASA's mission to a metal asteroid named 16 Psyche. The mission seeks to determine whether this asteroid, located between Jupiter and Mars, is the metallic core of an early protoplanet. Launching in 2022, the findings of this mission will provide insight into not only the asteroid, but also our Earth. Psyche Inspired is an internship program that brings undergraduate students from any university, discipline, or major together. The program's goal is to share the excitement, innovation, scientific, and engineering content of NASA's Psyche mission with the public in new ways through artistic and creative works.

Our project is to better understand how to administer the program to provide maximum impact for the interns, their universities and communities, and the public. Meetings were held with our NASA sponsor to determine the direction we should take when establishing the scope of our project. Surveys were created and sent to past and current interns to gain insight into what changes need to be made to improve their experience while taking into consideration the requirements held by Psyche Inspired.

The resulting project encompasses the intern experience and the administration of the program, separating the interns into two directions: one focusing on outreach and the other on STEM concept illustration. Themes were designated to each group that help emphasize and inspire Psyche interns. To help intern outreach, themes including some of NASA's core values, will be used to inspire viewers about the mission. Students working under the STEM concept illustration are given resources to develop creative works centered around the science, technology, engineering, and mathematics that go into the space mission. Our systemic and process improvements to the National Art and STEM Program will help future Psyche interns and administrations thrive.

Michigan State University
Team Members (left to right)

Fadzai Joy Mazhangara
Chiredzi, Zimbabwe

Kelly Littmann
Romeo, Michigan

Jackson Reetz
Mount Pleasant, Michigan

Julia Gabrysh
Greenville, Michigan

Miya Vantol
Essexville, Michigan

ASU/NASA Psyche Mission
Project Sponsor

Cassie Bowman
Tempe, Arizona

BP PLC
Effective Usage of Producer Price Indexation Analysis

BP PLC has a strategy of best operator in the Gulf of Mexico. A key element is cost competitiveness. Effective use of Producer Price Index (PPI) values would support BP in business forecasting, deciding when to approach markets for price negotiations, use strategic levers to mitigate anticipated cost increases or take advantage of decreases, and understanding underlying factors in the oil field service market.

Using internal indexation and commodity weight distributions, a model can be created for two of BP's offshore rig components: drilling and completions. The PPI data points are public values provided by the U.S. Bureau of Labor Statistics measuring the average change over time in the selling prices received by domestic producers for their output.

The overarching goals and opportunities of this project align with the project deliverables. First, having a clear understanding about the oil and gas industry/services will provide insight into market trends and clarify empirical relations within the field based on well services and pricing. Second, using computational data and updated PPI values over the past five years, opportunities for BP to improve their existing negotiation strategy from conviction to data driven decision-making will present itself. Last, in relation to the first two goals and opportunities, they will ensure that BP has a reconditioned negotiation model that allows for cost competitiveness using strategic levers to reallocate spend according to the updated and validated commodity weightings.

In accordance with the above deliverables BP will be equipped with a tool to improve their negotiation process allowing them to directly correlate the PPI values with their commodity weightings.

Michigan State University
Team Members (left to right)

Michael Geiger
Eaton Rapids, Michigan

Nicholas Hughes
Grand Rapids, Michigan

Julia Rios
DeWitt, Michigan

Louis Wyre
Detroit, Michigan

Tre Lee
Detroit, Michigan

BP PLC
Project Sponsors

Abhijit Malegaonkar
Houston, Texas

Sandeep Syal
Houston, Texas

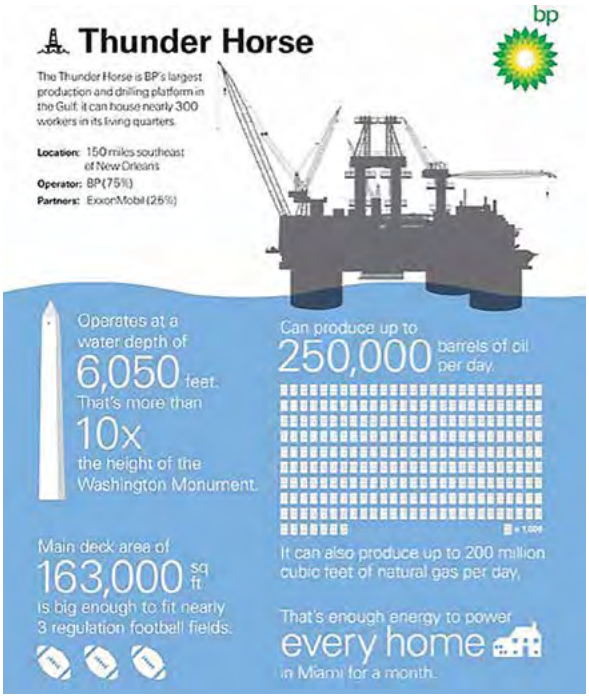
BP PLC
Subsea Hardware Inventory Management Optimization

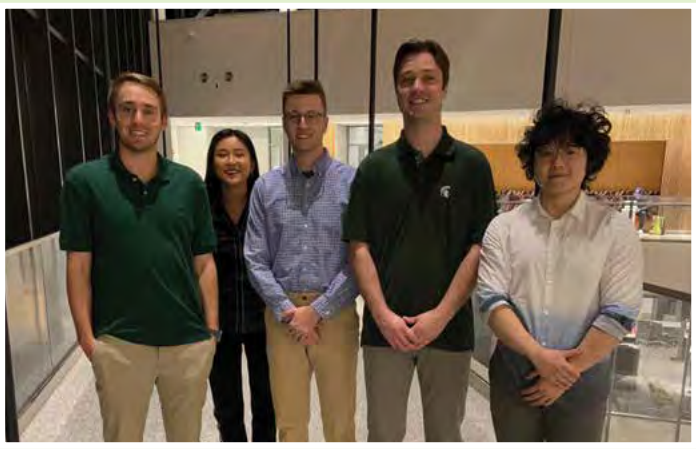
For over a century, BP PLC has been one of the leading oil and gas companies in the industry. BP has assets all over the world ranging from the desert to the ocean. The focus location for this project is concentrated in the Gulf of Mexico.

The Gulf of Mexico holds some of the largest oil reserves in the world, making it a very profitable region for the oil industry. With that, it can be difficult to forecast how much inventory a company actually needs to effectively operate an oil rig. This is an issue BP is currently grappling with in the Gulf of Mexico.

Specifically, BP is experiencing a surplus of subsea hardware to run the four oil rigs they operate with multiple partners in the Gulf. This specific hardware is used to run and maintain the everyday operation on each of these oil rigs. The size of equipment ranges from small pieces, which can be purchased with a short lead time, to large pieces that take over a year to receive and utilize. These variable lead times make forecasting extremely difficult when it comes to ordering such hardware.

Our team has been developing different tools and recommendations that BP can use to monitor, analyze, and forecast equipment inventory levels. The main objective is to recommend what BP should do with their excess inventory holding cost, as well as to recommend a way to prevent this issue from occurring in the future.





Michigan State University
Team Members (left to right)

Jeff Ingell
Highlands Ranch, Colorado

Xinchen Hu
Zhengzhou, Henan

Justin Spindler
Lansing, Michigan

Glen Kastelic
Muskegon, Michigan

Jiawei Wang
Qingdao, Shandong

BP PLC
Project Sponsor

Brian Sexton
Houston, Texas

BP PLC
Contract Management in Procurement and Supply Chain

Headquartered in London, England, BP PLC is a multinational oil and gas company. The firm operates in 78 countries worldwide and has approximately 73,000 employees.

This global reach has allowed BP to maintain a diverse portfolio of businesses including upstream, downstream and alternative energy businesses, as well as many other things. Specifically, within BP's Upstream Business, there are multiple core/strategic suppliers who have multiple contracts in place to cover the work being executed globally. BP uses Global Frame Agreements (GFAs) that outline specific terms and conditions that BP and their suppliers have agreed to, reference and follow for work orders.

Subsea is the target market for this project. The subsea market recently has undergone significant changes and there is a push to find another way to manage these contracts currently operated in silos between procurement and engineering. This Contract Management project provides the opportunity to help BP reduce contractual cycle time, reduce risk, and costs through a Total Expenditure Model of developing offshore projects and consolidating projects. This provides the key to enable BP to achieve highest efficiency when working with their suppliers of the subsea market. There are four main questions from BP that our team needs to answer. What are the cost savings for BP and suppliers? What is the total cost of implementation? What challenges will BP face when implementing the recommendation? How will BP mitigate the potential risks associated with the recommendation?

All of these questions will be answered using a TOTEX model to show the data.

Michigan State University
Team Members (left to right)

Aaron Ciarkowski
Ann Arbor, Michigan

Yafa Samaha
Ann Arbor, Michigan

Kyle Cornetet
Grand Rapids, Michigan

Tyler Wynn
Grand Rapids, Michigan

Roman Milot
Ann Arbor, Michigan

BP PLC
Project Sponsor

Brian Sexton
Houston, Texas

American Axle and Manufacturing
Shim Project - A Required Parts Forecast Model

American Axle and Manufacturing is a manufacturer of automobile driveline and drivetrain components and systems. AAM is headquartered in Detroit, Michigan and has locations all over the world.

Shims are a small, but important part in AAM's manufacturing process. A shim is a washer or small piece of material that is used to align parts, make them fit, or reduce wear. Each of AAM's products has a shim chart that may consist of twenty to thirty different shim sizes. Currently, there is not a process in place that is able to make accurate shim forecasts by part numbers. This has resulted in excess shim inventory in plants, stock-outs, and labor hours wasted on a misaligned shim supply.

Our team was tasked to analyze future customer predicted demand data and historical plant floor usage consumption data to create a forecasting tool that predicts shim forecasts by part number. This tool will be able to notify the supply scheduler at American Axle when there is a significant change in shim demand. This will be accomplished by utilizing Microsoft Excel to create a forecasting tool to accurately predict shim demand. This tool will also be integrated with AAM's current Enterprise Resource Planning system.

Michigan State University
Team Members (left to right)

Bosong Wang
Weihai, China

Allison Beshears
Canton, Michigan

Chloe Miller
East Lansing, Michigan

Michael Bucholtz
Washington Township, Michigan

Junyi Fu
Zhuhai, China

Brianna Zajac
Macomb Township, Michigan

American Axle and Manufacturing
Project Sponsor

Eddie Hobson
Detroit, Michigan

Asahi Kasei Plastics North America
Identify Cost Savings through Spend Data Analysis

Asahi Kasei Plastics North America (APNA) is a subsidiary of Asahi Kasei Corporation (AKC), a $20 billion Japanese Conglomerate. APNA is known for manufacturing high performance grade polymers for OEMs and tier suppliers around the globe. The materials produced in APNA's Fowlerville, Michigan and Athens, Alabama manufacturing locations can be found in a variety of areas such as automotive, furniture, industrial, and heavy trucking segments.

The focus in North America is to utilize process improvements and efficiencies throughout the various locations. With this in mind, APNA partnered with Michigan State University with a project focused on supplier consolidation and data centralization. This project included working with four other Asahi Kasei subsidiaries located in North America: Sage Automotive Interiors, Celgard, Daramic, and Asahi Kasei Bioprocess.

Our team put together a data analysis and data visibility recommendation after researching the data provided by the five Asahi Kasei subsidiaries. The Python analysis successfully provided detailed recommendations for vendor consolidation within packaging materials at each of the organizations. Additionally, this provided insights to vendor spend across all five subsidiaries allowing Asahi Kasei to take strategic actions to reduce tail spend while eliminating maverick spend.

Another top priority for the five Asahi Kasei subsidiaries was centralized data visibility. The centralized data hub allows North America spend data to be accessible across all five subsidiaries in one location. Consolidating data helps spread best practices and make decisions based on accurate data analysis.

AsahiKASEI
ASAHI KASEI PLASTICS NORTH AMERICA

Michigan State University
Team Members (left to right)

Will Neidhart
Rochester, Michigan

Zachary Jones
Chicago, Illinois

Luke Shermetaro
Lake Orion, Michigan

Moeka Yamamoto
Irvine, California

James Bradley
Rochester, Michigan

Asahi Kasei Plastics North America
Project Sponsor

Abishek, Jindal
Fowlerville, Michigan

Dow Chemical Company
Integrated Supply Chain Personal Assistant

Dow is a multinational company that has a large integrated supply chain and enormous inventory flow among cities and countries. Dow is using Diamond Systems Reporting to facilitate their inventory management. However, Dow's supply chain analysts are depending on massive Excel sheets to display and extract data manually, which is not efficient for analysts.

The current Excel sheets depict cost, volume and price of products offered by Dow in their respective regions. Due to the data being displayed poorly, analysts often cannot accurately predict the data for next quarter. Also, all of the real-time quarterly data need to be entered manually by analysts to make comparisons.

The integrated personal assistant will provide better data visibility by using Power BI to display data on a dashboard. This Power BI dashboard will showcase simple graphs, comparisons to previous quarters, and contain automatic input from the SAP system. An additional function that we will be researching will be a personal assistant. The personal assistant is built on Microsoft Azure and is a QnA bot that would be able to answer questions pertaining to the dashboard. This bot would be able to pull data and perform variable manipulation.

Azure and Power BI have built-in connectivity. This allows the dashboard to pull data effectively from the Dow SAP. The overall goal is to create an adaptive and useful dashboard for the Supply Chain group within Dow that can hopefully be an example for future automated processes.

Michigan State University
Team Members (left to right)

Griffin Keough
Dexter, Michigan

Luke Easton
Grand Rapids, Michigan

Fred Smith
Westland, Michigan

Ian Springfield
Sterling Heights, Michigan

Borong Liu
Guangzhou, China

Dow Chemical
Project Sponsors

Jeremy Archbold
Midland, Michigan

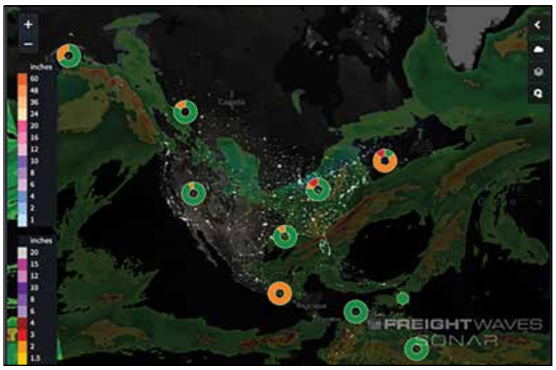
Mohamed Radwan
Midland, Michigan

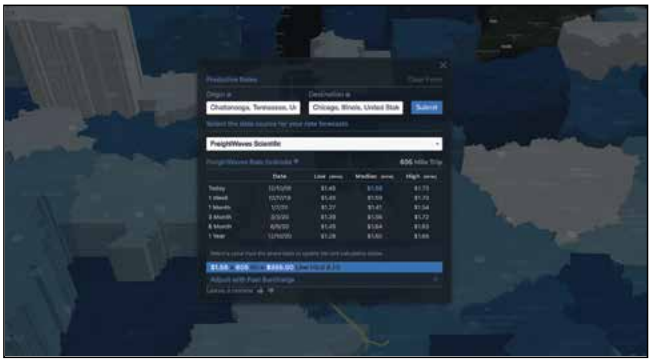
FreightWaves
Analytics Competition

FreightWaves takes pride in being the largest publisher of freight, logistics, cargo and transportation news and data in the world. FreightWaves allows supply chain companies to revolutionize how they make decisions by providing information gathered through their software tool, SONAR. SONAR is an up-to-the-minute information platform that uses the non-stop change in capacity, demand, regulations, weather and more, so that FreightWaves' customers can successfully respond to market conditions and forecast the future.

Our project considers seven transportation lanes: LA to Dallas, Dallas to LA, LA to Seattle, Seattle to LA, Philadelphia to Chicago, Chicago to Atlanta, and Atlanta to Philadelphia. The goal is to deliver insights that outline the most appropriate actions to take in response to market shifts, and present data that support predicting these shifts to assist logistics companies with planning. This will be done by using SONAR to construct visual data (graphs, charts, etc.) representing historical data on multiple influences in the logistics market.

With this data and independent research, our team will deliver insights for forecasting and allow customers and carriers to better plan moving forward, thus making experiences more seamless.





FREIGHTWAVES SONAR

Michigan State University
Team Members (left to right)

Cam Stevenson
Wixom, Michigan

Kathryn Dow
Western Springs, Illinois

Helena Zhang
Guangzhou, China

Clare Sjogren
Novi, Michigan

Luke Pap
Marquette, Michigan

FreightWaves
Project Sponsor

Will Sehestedt
Chattanooga, Tennessee

AESC Awards 2019

The AESC 2019 Most Impactful Award:

Team Ingersoll Rand
"Predict Regional Peak Seasons with Online Weather Forecast Data"

Left to right: Hailey Atkins (SCM), 0Erika Hanses, Patrick Grady (SCM), Brett Thelen, Lilly Couch

The AESC 2019 Most Sustainable Award:

Team MSU IPF
"Improvement of Recycling Processes"

Left to right: Kiersten Anderson, Kristen Dante, Madison Ameel, Taylor Renner

AESC Awards 2019

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 2019 Mike Sadler Competitive Edge Award:

Team Gerdau: "Long Lead Time Product Optimization"

Back row left to right: Laura Genik (AESC Director), Abhinav Anand, Will Martyka

Front row left to right: Donnie Haye (Chair, College of Engineering Alumni Board), Karen Sadler, Nina Marchione, Veronica Sanchez, Madison Farrell, Coach Mike Tressel (Assistant Head Coach/Defensive Coordinator/ Linebackers Coach)

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

Dr. Luke Reese
Assoc. Professor
Biosystems &
Agricultural Engineering

About the Program

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

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

BE 485 / BE 487 Courses

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

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

2019/20 Projects

Ice Cream Inclusion Analysis and Process Optimization

Team Name – Team Tillamook
Sponsor – Tillamook Creamery (project under Non-Disclosure Agreement)
Faculty Advisor – Dr. Yan "Susie" Liu

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

(L to R) Esha Jain, Alicia Ziegler & Stephanie Gardner

Biosystems BE 485/487 / 8:00 a.m. - Noon

Engineering Building, 2200 Hallway | Second Floor

Development of Manufacturing Model for Popped Snacks

Team Name – Baby Snack Pack
Sponsor – Nestlé Nutrition (project under Non-Disclosure Agreement)
Faculty Advisor – Dr. Kirk Dolan

Nestlé is looking to expand Gerber Organic Popped Crisps globally. Currently, this product is manufactured in the US by a co-manufacturer. The project scope centered on developing a regional finishing site, where the puffed product is in-house produced, bagged, and sent to a distribution facility. For the preliminary design recommendation, a region was chosen, and equipment was selected based on the needs of the line and the region. The client was provided with a functional piping and instrumentation diagram and an operational description. The design met the client's payback period constraint, and in-house production reduced supply chain and distribution costs.

(L to R) Nama Naseem, Allyson Gower, Ricci Lopez & Emma McDonald

HVAC Energy Efficiency at Pharmaceutical Manufacturing Plant

Team Name – Sensible Energy Solutions
Sponsor – Perrigo (project under Non-Disclosure Agreement)
Faculty Advisor – Dr. Chris Saffron

Perrigo is interested in HVAC energy efficiency solutions to reduce energy costs and meet plantwide sustainability goals. SE Solutions researched dew point control and supplemental cooling coils as a customized approach to Perrigo's current system where the whole plant is controlled to setpoints required in only two suites. The team performed an HVAC energy balance to assess the theoretical impact of these designs and provided complete cost models to Perrigo. Dew point control met the required payback period and the design implementation is completed. SE Solutions analyzed HVAC data to quantify the actual savings realized with this new system.

(L to R) Matthew Wholihan, Aryn Thomas, Emily Peruski & Mario Aliaj

Potato Storage Ventilation Analysis

Team Name – Team Techmark
Sponsor – Techmark, Inc.
Faculty Advisor – Dr. Wei Liao, PE

Techmark Inc. is an international agricultural company that specializes in stored crop ventilation systems. Techmark designed and implemented an air cup ventilation system in a Greenville, Michigan potato storage facility. The 10,570 ft^2 facility has experienced product losses in previous years from improper storage conditions. Important system characteristics hypothesized to be involved in product loss were the following air properties: temperature, humidity, and overall airflow distribution in the storage room. CFD analysis and data collected served as tools to determine condensation possibility within the air cup. A data collection plan was created for further analysis with potatoes present.

(L to R) Sean Pelfery, Amanda George, Caroline Schuetz & Christopher Wells

Operational Analysis of Trident Biometrics' Drug Testing Process

Team Name – Team Trident
Sponsor – Trident Biometrics (project under Non-Disclosure Agreement)
Faculty Advisor – Dr. Jade Mitchell

Trident Biometrics, a drug testing laboratory in Holland, Michigan, specializes in urine testing. Trident needed to optimize their process to handle an expected sample volume doubling while maintaining their promised 48-hour results turnaround time. Based on time study data collected by the team, a Work Breakdown Structure and Gantt Chart were created in Microsoft Project to identify the critical pathway. The critical path determined five tasks that directly affected testing time and was used to identify resource limitations. To increase sample throughput, the team recommended labor and equipment solutions and rearranged methods on machines, which optimized testing time and reduced risk of bottlenecks.

(L to R) Natalie Coaster, Scott Lyon & Courteney Roberts

Simulation of Thermal Energy Transfer through Neurological Tissue during Electrosurgery

Team Name – Phantom
Sponsor – Stryker (project under Non-Disclosure Agreement)
Faculty Advisor – Dr. Ilce Medina Meza

(L to R) Rosemary Laurito, Peter Jansen, Leah Allen & Scott Piper

Electrosurgery has many medical applications, one of which involves the use of radiofrequency technology to resect tumorous brain tissue. Stryker is interested in simulating the transfer of thermal energy from an electrosurgical instrument in a synthetic tissue model to characterize the propagation of heat through actual brain tissue. Team Phantom evaluated two materials that mimic the thermal and physical properties of the human brain to accurately quantify heat dissipation during electrosurgery. The team evaluated a polyacrylamide gel containing bovine serum albumin (BSA) protein and an evaporated milk agar, and then compared these to pig brain tissue results to make a final model recommendation.

Blake's Hard Cider Apple Pomace Utilization and Optimization

Team Name – Blake's By-product Bash
Sponsor – Blake's Hard Cider Co.
Faculty Advisor – Dr. Brad Marks, PE

(L to R) Taylor Quillan, Jacob Wright, Meghan Donovan & Anna Raschke

Blake's Hard Cider Company located in Armada, Michigan, was looking for an opportunity to reduce apple pomace by-product, which they now land apply as a soil amendment. Through research and experimentation, the team determined that an enzymatic pretreatment of the apple mash before pressing is the best method to reduce apple pomace. Enzymatic pretreatment breaks down long-chained sugar molecules before pressing, increasing juice yield up to 30%. With a simple one-step addition to their production process, Blake's has the potential to reduce apple pomace by 72% and increase profits.

Determining Equipment and Utility Recommendations for a Food Business Accelerator

Team Name – Food ACCELS
Sponsor – Food, Agriculture, Research, and Manufacturing Business Incubator
Faculty Advisor – Dr. Darrell Donahue, CQE

(L to R) Erin Keller, Meredith Freeby, Alexandrea Peake & Rachelle Crow

The Food, Agriculture, Research, and Manufacturing Business Incubator is being built in Muskegon, Michigan, to provide a facility for food businesses to test and produce products, establish brands, and grow their businesses. To accomplish this goal, Team Food ACCELS designed six processing lines accommodating fruit, vegetable, and beverage products. The team recommended equipment and utility requirements necessary to produce the selected products at a rate of up to 40 gpm. These deliverables assisted in purchasing ancillary equipment within the $200,000 budget, applying for grants, determining rental rates, and configuring the facility with necessary utilities including electricity, water, air, and steam.

Wastewater Optimization for Cost Efficiency

Team Name – WasteWatchers
Sponsor – Large Food Manufacturer (project under Non-Disclosure Agreement)
Faculty Advisor – Dr. Steve Safferman, PE

Our client, a large food manufacturer, pretreats their wastewater before sending it away for further treatment. Wastewater must be pretreated properly before discharge to abide by permit regulations and not negatively impact the environment. This company was looking for an opportunity to minimize the overall cost but still properly treat the wastewater. WasteWatchers discussed nine design alternatives to address the opportunity. After research and an economic analysis, managing the residual product was deemed the best solution. Areas of focus for this solution were how to properly treat and handle the residual product and possible post-treatment utilization options.

(L to R) Devin Martin, Keegan Mackin, Sydney Shellhouse & Jillian Meade

Pawpaw Fruit Skin Removal Improvement

Team Name – Team Pawpaw
Sponsor – Treeborn
Faculty Advisor – Dr. Dan Guyer

Pawpaws are a relatively unknown North American fruit native to lower Michigan. Their taste is often described as a tropical mango-banana blend. Pawpaws must tree ripen, have a very thin skin, and damage easily in transport thus making them difficult to market fresh. Treeborn creates a puree with the pawpaw pulp which requires complete skin removal prior to processing. Skin removal must be efficient as skin remnants in the pulp and the resulting oxidation after peeling can cause puree off-flavor and color. Treeborn uses a labor and time intensive manual skin removal process. The selected design provides an appropriate-scale solution that improves skin removal efficiency, reduces processing time and labor, and increases pulp yield.

(L to R) Rachel Paulson, Taylor Pelland, Jessica Mehall & Brandon Wilsdon

Tuberculosis Diagnosis using Artificial Intelligence

Team Name – Team AIM
Sponsor – Dr. Nirajan Bhusal
Faculty Advisor – Dr. Evangelyn Alocilja

In Nepal, Tuberculosis (TB) affects nearly 32,000 individuals annually, resulting in around 7,000 deaths. Team AIM was challenged with creating a cost-effective and accurate TB diagnostic tool. The new diagnostic method removes human error and improves detection accuracy using an Android smartphone application. The application utilizes Artificial Intelligence (AI) in combination with the Nanoparticle-based Colorimetric Biosensing Assay (NCBA) test method to rapidly diagnose TB. The team anticipates that this new method's accuracy will exceed 83% and result in an efficient and affordable diagnosis for Nepalis. The implementation of AI to TB detection will create rapid diagnosis for individuals to begin treatment, overall decreasing the spread of TB in affected areas.

(L to R) Daniel Millar, Alysa Gonzalez, Anna Carmody & Tyler VanBuren

Industry Advisory Board & Project Evaluators

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

Board

Ms. Janelle Boosi - Kellogg
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Ms. Jessica Bruin - Nestlé Nutrition
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Mr. Matthew (Matt) Burtt - AbbVie
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Ms. Laura Doud, PE - MDARD
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Mr. Eric Van Middendorp, MSE - Spectrum Health Innovations, LLC
Mr. Nate Wood - Perrigo
Mr. Rob Yoder - BDI, Inc.

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

Project Evaluators

Mr. Mitch Baldwin - Stryker
Dr. Nirajan Bhusal - Kathmandu University, Nepal
Mr. Keith DeBates - Perrigo
Mr. Sam Effa - Techmark, Inc.
Ms. Sarah Flowers - Trident Biometrics
Mr. Todd Forbush - Techmark, Inc.
Ms. Megan James - Stryker
Ms. Rebecca Jones - Trident Biometrics
Mr. Matt McAlpine - Blake's Hard Cider Co.
Mr. Jim Molchan - Nestlé Nutrition
Mr. Bill Nash - Treeborn
Mr. Matthew Rycenga - Trident Biometrics
Mr. Luke Stahle - Tillamook Creamery
Mr. Chris Walker - Cargill

BE Showcase Public Presentations

BAE 2018/19 Industry Advisory Board

If you are interested in sponsoring a BE 485/487 capstone project for the 2020_21 Senior Design teams, please contact Dr. Dana Kirk at kirkdana@msu.edu or Dr. Luke Reese at reesel@msu.edu.

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The Capstone Projects

Mr. Anthony Ingle
Teaching Specialist

Faculty Advisors: Professors Alcantar, Carlson, Chatti, Hashsham, Ingle


Alcantar


Carlson


Chatti


Hashsham


Ingle

Presentation Schedule – Room 1225

Time	Team	Room
9:20 a.m.	Team 1 – Between the Lakes Engineering	First Floor Room 1225 EB
10:40 a.m.	Team 3 – Mitten Dynamic Engineering	First Floor Room 1225 EB

Presentation Schedule – Room 1230

Time	Team	Room
8:00 a.m.	Team 5 – Michigan Liquid Solutions	First Floor Room 1230 EB
9:20 a.m.	Team 6 – Spartan Engineering, Inc.	First Floor Room 1230 EB
10:40 a.m.	Team 7 – Spark Engineering	First Floor Room 1230 EB

Presentation Schedule – Room 1234

Time	Team	Room
8:00 a.m.	Team 8 – Superior Engineering	First Floor Room 1234 EB
9:20 a.m.	Team 9 – Advanced Engineering Group	First Floor Room 1234 EB
10:40 a.m.	Team 10 – MiSt Engineering	First Floor Room 1234 EB

Presentation Schedule – Room 3105

Time	Team	Room
9:20 a.m.	Team 2 – Fluid Design	Third Floor Room 3105 EB
10:40 a.m.	Team 4 – GNEISS Engineering	Third Floor Room 3105 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, geotechnical, hydrological, pavement, transportation, and structural issues for the project. A student project manager coordinates each team. Design reports are judged by the faculty; progress reports and the oral presentations are judged by a board of practicing professionals.

CE 495 SENIOR DESIGN IN CIVIL & ENVIRONMENTAL ENGINEERING

Michigan State University Water Treatment & Storage

Michigan State University has proposed a massive improvement to the campus water distribution system, with the construction of a new water treatment plant and elevated storage tank on campus. The University is currently constructing a 2 million gallon water tower to replace the function of the water reservoir on campus. The water tower must be connected to a proposed water treatment plant located immediately south of Service Drive, west of Farm Lane. The students in CE 495 provided a preliminary design for the infrastructure improvements necessary to procure this project for construction.

This design project includes an 11,500 gross square foot water treatment plant which will include water treatment processes such as chlorination and fluoridation (in addition to iron removal), which are currently done at the reservoir. The old reservoir will be taken out of service when the new water treatment plant becomes operational. Total construction costs are estimated to be $18 million, with operational opening date in Spring 2020. This project will improve water quality and reliability throughout the campus and is designed to meet future needs projected in the next 40 years.

https://ipf.msu.edu/construction/current-projects/campus-water-system-filtration-plant-and-storage-tower

Fig. 1: Exisiting Aerial Photo

Fig. 2: Proposed Treatment and Storage Site Plan

Fig. 3: Rendering of Treatment Plant

Fig. 3: Tank Logo Detail

Team 1: Between the Lakes Engineering

Back Row (l-r): Julian Quiroga (H), Zhongda Lu (P), Matthew Mandryk (PM) **Front Row (l-r):** Jared Heinze (S), Amber Brannick (E), Emily Mulrenin (T), Lukas Pulice (G)

Team 2: Fluid Design

Left to right: George Apwisch (P), Kendal Mcburrows (S), Paul Grisdela (E), Marisa Grassi (T), Justin Buck (G), Xian Li (H), Luke Keener (PM)

Team 3: Mitten Dynamic Engineering

Left to Right: Jordan Buck (G), Kayla VanPorfliet (T), Myriam Sarment (S), Logan Maser (E), John Conklin (H), Ashlynn Caviness (PM), Ryan Canna (P)

Team 4: GNEISS Engineering

Back Row (l-r): Faisal Shahin (WR), Patrick Hoedeman (S), Ethan Nordstrom (E), Scott Merk (T) **Front Row (l-r):** Weiying Chen (P), Mckenzie Kolp (G), Summer Haught (PM)

Team 5: Michigan Liquid Solutions

Left to Right: Carlie delePaz (P), Taylor Warstler (H), Victoria Wellings (S), Shane Pauw (G), Erin DiNunzio (PM), Donnie Blackman (T), Dana Schultz (E)

Team 6: Spartan Engineering, Inc.

Left to Right: Nate Whitting (G), Iane Perry (P), Keaton LeFevre (E), Ryan Cope (H), Cameron Brantz (S), Nick Garver (PM), Travis Holpuch (T)

Team 7: Spark Engineering

Left to Right: Phillip Meffert (S), Joey LaVoie (T), Jack Domeier (E), Evan Hanes (G), Dylan Smith (PM), Matthew Bergeron (P), Jianfeng Wang (H)

Team 8: Superior Engineering

Left to Right: Tyler Pozan (E), Hao Ye (G), Milo Taylor (PM), Brendan Bresser (P), Molly Everly (H), Al Michels (S), Tyler Rogers (T)

Team 9: Advanced Engineering Group

Left to Right: Andrew Voyd (S), Jacob Henning (E), Michael Licata (PM), Georgia Brattin (G), Gabrijel Baric (H), Alex Schultz (P), Drew Thelen (T)

Team 10: MiSt Engineering

Left to Right: Brianna Adams (H), Divya Iyer (PM), Nick Lamberjack (P), Oonagh McKenna (S), Matthew Mastromatteo (G), Megan Connelly (E), Jordan Hankin (T)

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

CE 495 SENIOR DESIGN IN CIVIL & ENVIRONMENTAL ENGINEERING

PROFESSIONAL SEMINAR SPEAKERS

Michele Buckler, P.E.
Detroit Diesel

Mark Dubay, P.E.
Michigan Department of Transportation

Brad Ewart, P.E.
Soil & Materials Engineers, Inc.

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

Leanne Panduren, P.E.
Rowe Professional Services

Robert Rayl, P.E.
RS Engineering LLC

Charles Rolfe, P.E.
OHM Advisors

Jon Stratz, P.E.
Michigan Department of Transportation

Scott Stowitts, P.E.
Barton Mallow

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.

Heather Bowers
Fishbeck

Ryan Butler
Consumers Energy

Rick Chelotti
Bergmann Associates

Heather Cheslek
Black & Veatch

Dan Christian
Terra Tech MPS

Jim Corsiglia
HED Development

Brian Davies
Hubbell, Roth & Clark

Tyler Dawson
NTH Consultants

Max Drenth
HED Development

Joel Ingle
RS Engineering LLC

Cindy Irving
Lansing Board of Water & Light

Matt Junak
HNTB

Al Kaltenthaler
C2AE

Yogesh Kumbargeri
Soil & Materials Engineers

Mike Labadie
Rowe Professional Services

Justin Logsdon
Michigan Department of Transportation

Peter Margules
NTH Consultants

Jon O'Brock
Materials Testing Consultants

Mario Quagliata
Bergmann Associates

Brian Richey
Fleis and Vandenbrink

Emily Schlanderer
Fishbeck

Tim Sullivan
Hubbell, Roth & Clark

Anthony Thomas
Soil & Materials Engineers

Peter Vogelsang
AECOM

Stephan Wang
WPS

Jon Ward
Rowe Professional Services

Emily Warners
Consumers Energy

Thomas Wolff
Michigan State University

Design Day Awards Fall 2019

Rolla C. Carpenter Senior Design Award

The Rolla C. Carpenter Senior Design Award ($700 and medals) is presented to the best team as judged by the faculty and a panel of practicing engineers.

Rolla C. Carpenter, Renaissance Engineer, was a graduate of The State Agricultural College in 1873 with a Bachelor of Science degree. After earning a Master of Science Civil Engineering, he was appointed professor of the Department of Mathematics and Civil Engineering at the State Agricultural College, which would later become MSU. He designed bridges, built ice houses, taught students French, astronomy, mathematics, mechanical drawing, hydrostatics, hydraulics, survey, and civil engineering. He prepared the design and working drawings for the Farm Lane Bridge, laid a water supply pipe to Williams and Wells Halls, and designed a pile driver for a dam built across the Red Cedar River. He later designed several buildings on campus, including the Mechanical Building, which was constructed in 1885. Throughout all of his work on campus, he involved students throughout the analysis, design and construction, forming what was essentially the first senior capstone design class.

The faculty and students of the Department of Civil and Environmental Engineering gratefully acknowledge the generous contributions from Barr Engineering Co. and Fishbeck.

Rolla C. Carpenter Senior Design Award Winners, Fall 2019

Team 3: SBA Engineering

Left to right: Steven Andooparambil, Paige McClintock, Natasha Sonck, Jeffrey Lorencen, Rece Shankleton, Kristina Crimmins

ChE Process Design and Optimization

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

Ziwei Wang
Graduate Student & Teaching Assistant of Chemical Engineering

Course Description

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

For over 50 successive years, MSU's ChE 434 students have spent about 30 days working intensively on the annual American Institute of Chemical Engineering (AIChE) Student Design Competition problem. The Chemical Engineering and Materials Science Department uses these industry-based problems to enhance chemical engineering students' capstone design experience for three reasons: 1) they provide real-world, open-ended design experiences typical of those students are likely to face after graduation; 2) they require self-directed active learning, including project-specific research to obtain information needed to solve the problem; and 3) they serve as a national benchmark for MSU chemical engineering students to demonstrate excellence in their professional skills.

As the Chemical Engineering program's contribution to Design Day, several ChE 434 students will 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 2019 Design Competition

Since 1968, MSU has had the best record nationally for awards in the AIChE Student Design Competition. In 2019, for the first time, all four solutions MSU sent to AIChE for judging won a national award. In the individual category, **Mason Sitar** won the A. McLaren White Award for Best Overall Design, and **Hailee Perrett** won the A.E. Marshall Award for Second Best Overall Design. In the team category, **Aleksandra Salic** and **Grace Jansen** won the William Cunningham Award for Best Overall Design. **Mark Elinski** and **Kip Mitchell** won the Ted Ventrone, Ephraim Scheier & Walt Silowska Awards for Best Applications of Inherently Safer Design.

Mason Sitar

Hailee Perrett

AIChE®

Manufacturing Facility for Ammonia

In 2020, the AIChE Student Design Competition problem was to design a next-generation process for ammonia (NH3) production that has a lower environmental impact than the traditionally used Haber-Bosch process. For decades, this process produced NH3 that has enabled dramatic increases in agricultural productivity worldwide. However, the Haber-Bosch process has also been responsible for 1–3% of the world's total energy consumption, 5% of natural gas consumption, and a significant portion of greenhouse gas emissions. For these reasons, this year's AIChE Design Competition problem asked engineers to design an innovative process that would have a lower environmental impact and use raw materials and an energy source that were renewable.

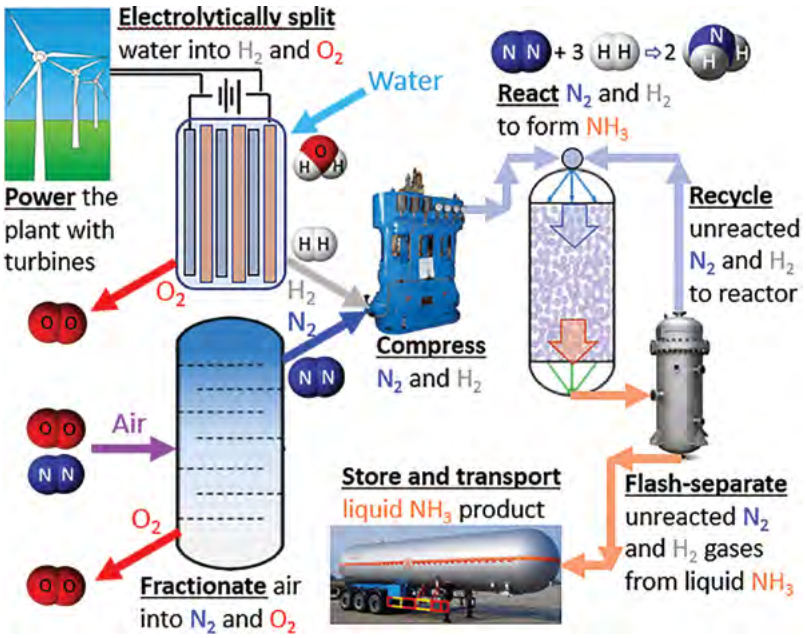
The process flowsheet below shows a next-generation, environmentally friendly process whose raw materials are simply air and water. The air is fractionated to obtain streams of nitrogen (N2) and oxygen (O2) gas, and the water is split electrolytically to obtain streams of hydrogen (H2) and O2 gas. The N2 and H2 gases are compressed and pumped into a catalytic reactor, where they react to form NH3. Because this reaction does not go to completion, the reactor's product stream is passed through a flash separator. There, liquefied NH3 is separated by gravity from unreacted N2 and H2 gases, which are recycled to the reactor. Oxygen gas produced as a byproduct of the air fractionation and water splitting can either be returned to the atmosphere or sold. To limit the environmental impact, the new plant should be sited near its point-of-use in the US Corn Belt and in an area where wind levels and local regulations are well suited for renewable electricity generation via wind turbines.

Students submit their solutions as reports up to 225 pages long. The reports include details of the manufacturing plant's equipment and 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.

Aleksandra Salic (left) and Grace Jansen

Mark Elinski (left) and Kip Mitchell

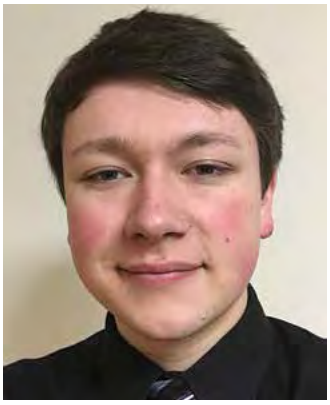
Process Flowsheet for Ammonia Production



Individual-Solution Poster Presenters

Montgomery Smith

Andy Millar



Benjamin Farris

Team-Solution Poster Presenters

David Errer and Vincent Milano

McKenna Coskie and Ryan Brown

Husain Al Naji and Shatha Alabbad

The Capstone Projects

Dr. Martin Crimp
Professor of Chemical Engineering and Materials Science

Songyang Han
Graduate Teaching Assistant

Course Description

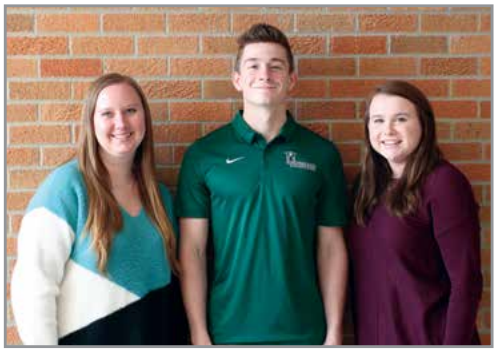
MSE 466 is a senior level course for Materials Science & Engineering majors that provides students with a team-based capstone design experience. A major aspect of this course is to have students apply their course-learned background knowledge and skills in materials science and other disciplines to real-life problems. A failure analysis investigation (FAI) fits this context. Failures are a major motivating factor for promoting more innovative designs or design changes. The MSE 466 failure analysis investigations provide a unique platform for designing investigations and solving real-world engineering problems via systematic engineering approaches. By focusing on specific design failures, the student teams learn how to confront open-ended problems that require them to develop strategic investigation design plans and to execute the methodology for assessing how and why the failures occurred. The analyses are conducted using established failure analysis investigative procedures and constraints. This semester there are nine teams working on nine real engineering failures.

Presentation Schedule – First Floor Room 1145

Time	Team	Project
8:00 a.m.	The Spring Breakers	Failure Analysis of a Garage Door Torsion Spring
8:25 a.m.	Brazen about Brazing	Failure Analysis of a Brazed Aluminum Oil Cooler
8:50 a.m.	AnchorPan: The Legend of Cast Iron	Investigating Cracking in a Cast Iron Skillet
9:15 a.m.	Exploring Turbos	Investigating the Failure of a 2015 Ford Explorer Turbo Shaft
9:40 a.m.	The Bootleggers	Failure Analysis of a Beer Growler
10:05 a.m.	Sway Boys	Failure Analysis of a Sway Bar Link
10:30 a.m.	Barred from Failing	Failure Analysis of the Socket Head of a Torque Bar
10:55 a.m.	Pirates of the Carabiners	Fracture Analysis of a Fusion Climb D-Shaped Carabiner
11:20 a.m.	Corrode Rage	Corrosion of an Automotive Heat Shield in the Midwest Environment

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-five minute presentations. For 2020, the nine teams are conducting the following failure analysis investigations:



Left to Right: Kim Boyne, Tom Mittelbrun, Renee Owen

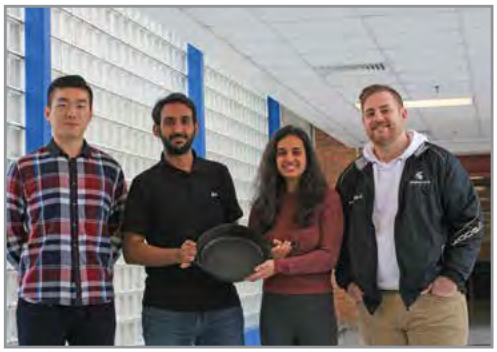
Time: 8:00 a.m. | Team Name: The Spring Breakers
Project Name: Failure Analysis of a Garage Door Torsion Spring

After approximately one year of use, a garage door torsion spring fractured catastrophically from an unknown cause. The prematurely failed spring was an oil tempered steel wire that had an expected lifespan of around nine years. The fracture occurred in the middle of the 25-inch spring when an approximately 130- to 150-pound garage door was in use. To establish a testing plan, the fracture surface of the spring was examined and documented. For comparative analysis, non-destructive and destructive testing was then completed on the fractured component as well as on an exemplar spring to identify failure cause.

Left to Right: Ryan Ellis, Sara Abate, Ryan Griere

Time: 8:25 a.m. | Team Name: Brazen about Brazing
Project Name: Failure Analysis of a Brazed Aluminum Oil Cooler

Quality control in the production of high-volume parts is crucial in sustaining an automotive supply business. A layered coil oil cooler produced by a heat exchanger company based in Wisconsin failed quality check at its manufacturing location in Shanghai, China. The oil cooler failed leak testing and was observed to be leaking through both welds of the coolant pipes. The cause of this manufacturing failure was determined through a series of tests and experiments, both destructive and non-destructive.



Left to Right: Zequn He, Mohamad Aljah-dali, Aradhya Agnihotri, Jack Payne

Time: 8:50 a.m. | Team Name: AnchorPan: The Legend of Cast Iron
Project Name: Investigating Cracking in a Cast Iron Skillet

Cast iron has been used as cookware for centuries, dating back to the Han Dynasty (220 AD) in China, and has continued to be a mainstay in kitchens ever since. Because of their durability, consumers are able to keep the same cast iron skillet for decades without any decrease in quality or performance. With this in mind, it was quite confusing for a local home cook when his cast iron skillet formed a large crack during routine stovetop use. Using stereo and electron microscopy, and performing mechanical properties tests on both the sample and similar exemplars, the root cause of the failure was determined.

Left to Right: Yuheng Nie, Parth Patel, Erik Van Laeke, Tianyu Wang

Time: 9:15 a.m. | Team Name: Exploring Turbos
Project Name: Investigating the Failure of a 2015 Ford Explorer Turbo Shaft

A turbocharger consists of a centrifugal compressor driven by an exhaust gas turbine. It is employed in engines to improve the overall performance and fuel efficiency. A turbocharger from a 2015 Ford Explorer failed, and the causes of failure were examined. In particular, the turbo's forged steel shaft was investigated to determine the mechanisms behind the failure. A series of non-destructive tests were carried out prior to cleaning. Fracture surfaces were examined using scanning electron microscopy. Metallographic examination of the microstructure was carried out following sectioning of the steel shaft. Additionally, uniaxial tensile testing and chemical analysis were performed.

Left to Right: Derek VanderWeg, Miles Cabean, Abdullah Alahmad, Paul Michael Giuffrida

Time: 9:40 a.m. | Team Name: The Bootleggers
Project Name: Failure Analysis of a Beer Growler

The beer growler lost its life before the first use. When filled with beer, the neck of the growler broke upon the first pull of the closed metal clasp. A normal beer growler should sustain multiple uses before failing under similar circumstances. The topographic features of the fracture surface were analyzed under a stereo microscope and scanning electron microscope in order to determine the true nature of the failure. The strength of the growler was tested for its actual strength, in comparison to the theoretical strength, to provide an explanation for the fracture.

Left to Right: Zach Redoute, Varun Ramadhyani, Garrit Hotchkiss, Kevin McGregor

Time: 10:05 a.m. | Team Name: Sway Boys
Project Name: Failure Analysis of Sway Bar Link

A sway bar link of unknown origin, possessing characteristics of both ductile and brittle fracture, was acquired. Typically used to help stabilize the steering and suspension of an automobile, a sway bar is incorporated into both the front and back end of an automobile. Accordingly, a sway bar link is used to attach the sway bar to the control arm, allowing it to support and help pivot the sway bar. This enables the vehicle to make smoother turns. A failure analysis was conducted using a variety of techniques including: non-destructive testing (NDT), microscopy techniques, material characterization techniques, stress analysis, dimensional analysis, and chemical analysis.

MSE 466 / 8:00 a.m. - 11:45 a.m Engineering Building, Room 1145 | First Floor

Left to right: Jordan Thorpe, Quintin Ruddell, Emma Schuele

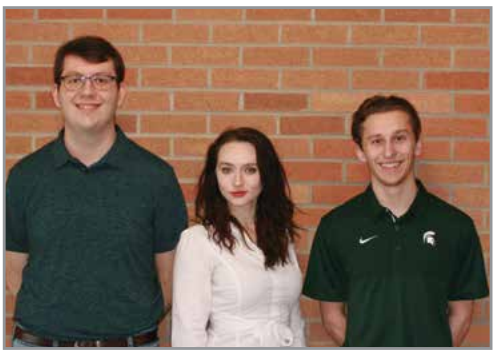
Time: 10:30 a.m. | Team Name: Barred From Failing
Project Name: Failure Analysis of the Socket Head of a Torque Bar

A torque bar is a specialized wrench that utilizes a long handle to exert increased torque to loosen bolts. Harbor Freight Tools is known for marketing low cost torque bars. Consequently, the materials used are more cost-effective rather than mechanically effective. A sample Harbor Freight torque bar failed on the opposing side of a repetitive applied force while being used to remove the shock absorber lower bolt on a 2010 Ford F150. This project sought to analyze the fracture surface, material makeup, and mode of failure of the torque bar in question in order to determine the technical cause of failure.

Left to Right: Ryan O'Shea, Bettie Schelske, Caelen Malmstrom, Erik Mitra

Time: 10:55 a.m. | Team Name: Pirates of the Carabiners
Project Name: Fracture Analysis of a Fusion Climb D-Shaped Carabiner

The Fusion D-Shaped Carabiner inspected was an exemplar of a subject carabiner which malfunctioned in an accident during a Ringling Brothers Circus performance. The part was analyzed and a failure mechanism was determined. The surface of the fracture was initially examined through multiple non-destructive tests, such as 3-dimensional replication system and scanning electron microscopy (SEM). Additionally, the carabiner also experienced various destructive testing methods. These tests were performed in order to compare the chemical, mechanical, and physical properties to an intact exemplar, as well as accessible manufacturer information to gain insight on the failure.



Left to Right: Brad Luzenski, Mack Marshall, Nate Graff

Time: 11:20 a.m. | Team Name: Corrode Rage
Project Name: Corrosion of an Automotive Heat Shield in the Midwest Environment

Failure analysis was performed on an exhaust heat shield from a 2011 Toyota Highlander. The part was located on the underside of the car near the front of the vehicle. A corrosive and high temperature service environment led to the premature failure of the part. Multiple non-destructive and destructive tests were performed on the component to determine the root cause of the failure, including chemical analysis and scanning electron microscopy (SEM).

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Sunnyvale, California

Chicago, Illinois

Okemos, Michigan

Chicago, Illinois

Detroit, Michigan

Royal Oak, Michigan

The Capstone Projects

8:00 a.m. — Noon | Engineering Building | 1300 Hallway | First Floor

Dr. Wayne Dyksen
Professor of Computer Science and Engineering

Ryan Johnson

James Mariani

Teaching Assistants

CSE 498 Collaborative Design

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

During the capstone experience, students

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

Our clients are local, regional, and national including Accenture, Amazon, AppDynamics, Auto-Owners Insurance, Bosch, Dow, Evolutio, Ford, General Motors, Google, Harvard Law School, Herman Miller, Learning A-Z, Lockheed Martin Space, MaxCogito, Meijer, Michael Sadler Foundation, Michigan State University, Microsoft, Mozilla, MSU Federal Credit Union, Place Technology, Principal Financial Group, Proofpoint, Quicken Loans, Technology Services Group, TechSmith, Union Pacific, United Airlines, Urban Science, Vectorform, and Volkswagen.

Amazon

Amazon Data Hub

Headquartered in Seattle, Amazon is the world's largest online retailer and is also the world's largest cloud services provider with their Amazon Web Services (AWS) products.

As a leader in the technology sector, Amazon has access to massive amounts of data. They employ teams of data scientists to analyze this data to improve Amazon's various offerings, including their product recommendations.

The task of finding the best dataset for a problem is time- consuming and requires significant manual work, including looking through thousands of individual files that are stored in many different locations. This process takes up a substantial amount of time that could be better used for development.

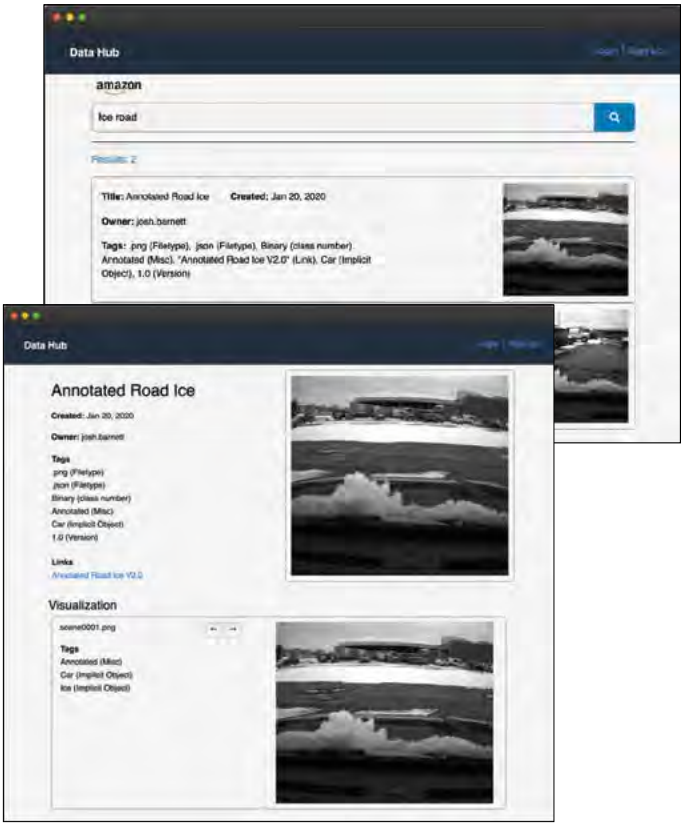
Our Amazon Data Hub software streamlines dataset acquisition with an easy-to-use website that allows data scientists to automatically search through Amazon's collection of data.

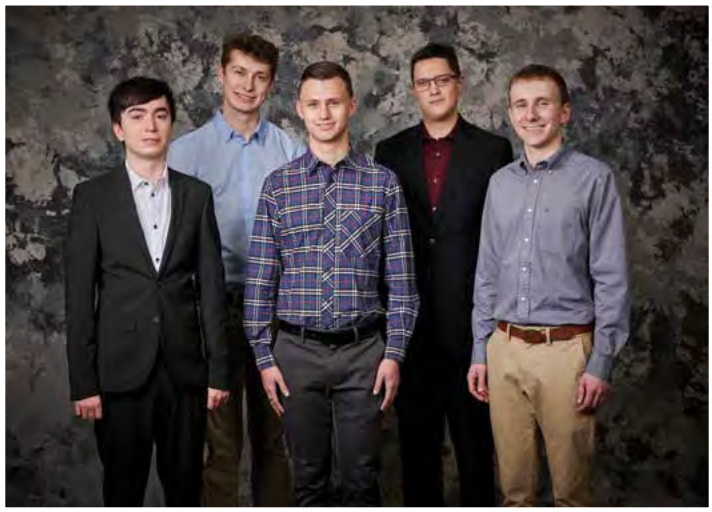
When an Amazon data scientist uploads a dataset to our Amazon Data Hub repository, it undergoes automated analysis. This includes object detection and speech recognition for images, videos and audio, as well as statistical analysis of numerical data.

Data scientists use the web application to search through our catalog of datasets. Search results include information provided when the dataset was uploaded, as well as information from our automated analysis. Intuitive visualizations of each dataset allow users to quickly evaluate the relevance of each dataset.

The Amazon Data Hub decreases the time it takes to find suitable datasets from hours to minutes, allowing data scientists to spend their time on more important work.

Our system uses AWS's scalable products, including S3, DynamoDB, Rekognition, Transcribe, Lambda, Elastic MapReduce, and Elasticsearch, to store, process and search the datasets. Python Flask is used to connect our back end with our ReactJS front end.





Michigan State University
Team Members (left to right)

Robert Ramirez
Hemlock, Michigan

Cameron Nejman
Algonquin, Illinois

Josh Barnett
Shanghai, Shanghai, China

Austin Cozzo
Delaware, Ohio

Dan Farat
West Bloomfield, Michigan

Amazon
Project Sponsors

Asif Aziz
Detroit, Michigan

Christin Burek
Seattle, Washington

Garret Gaw
Detroit, Michigan

Derek Gebhard
Detroit, Michigan

Jeff Zyla
Detroit, Michigan

AppDynamics
Segmented Data Anomaly Detection

AppDynamics, headquartered in San Francisco, provides a leading application performance management (APM) platform, which is used by corporations around the world to monitor the performance of their software systems.

Application owners and developers use the BizIQ feature of the APM to quickly correlate business consequences with application performance.

For example, imagine that users with Acme credit cards and hyphenated surnames are experiencing lengthy response times while making purchases on an e-commerce store. Lower customer satisfaction rates ensue, leading to quantifiable revenue risk.

BizIQ monitors this software issue, investigates the root causes of the performance bottlenecks, and delivers actionable insights. However, BizIQ is currently unable to automatically recognize unique combinations of factors, such as Acme users with hyphenated surnames that are causing issues.

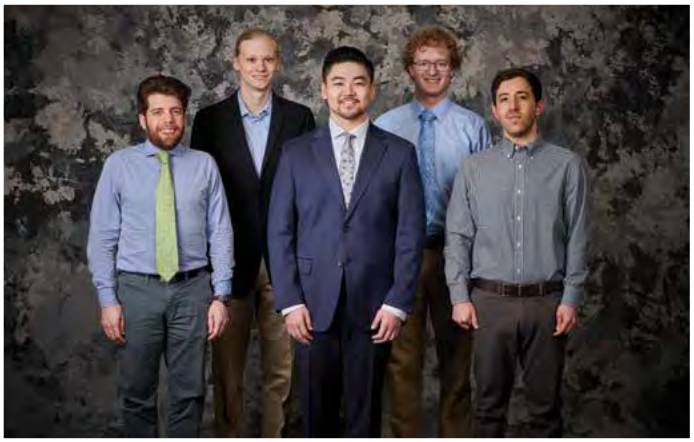
Segmented Data Anomaly Detection utilizes the copious amounts of customer data collected by the APM to improve the diagnostic aspect of BizIQ with machine learning.

Leveraging cluster analysis and unsupervised machine learning, anomalies are explored across hundreds of performance metrics. This leads to the discovery of specific combinations of factors that cause performance issues.

Automating this diagnosis in parallel with data collection saves time and determines the root cause of an issue more accurately.

Segmented Data Anomaly Detection uses Node.js to pull data from the APM, and scikit-learn running on Python to perform data analysis. The results of the analysis are rendered on a web app, which will be developed using JavaScript and includes cluster visualizations powered by D3.js.

APPDYNAMICS



Michigan State University
Team Members (left to right)

Titus Merriam
Charlotte, Michigan

John Wagenmaker
Chicago, Illinois

Aojia Rui
Shanghai, China

Caleb Jenkins
Clarkston, Michigan

Eduardo Columna
Ann Arbor, Michigan

AppDynamics
Project Sponsors

Chirag Desai
Southfield, Michigan

David Hope
Buffalo, New York

Shawn Penrice
Southfield, Michigan

Michael Sickles
Southfield, Michigan

Scott Young
Columbus, Ohio

Auto-Owners Insurance
Phish Phinder

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

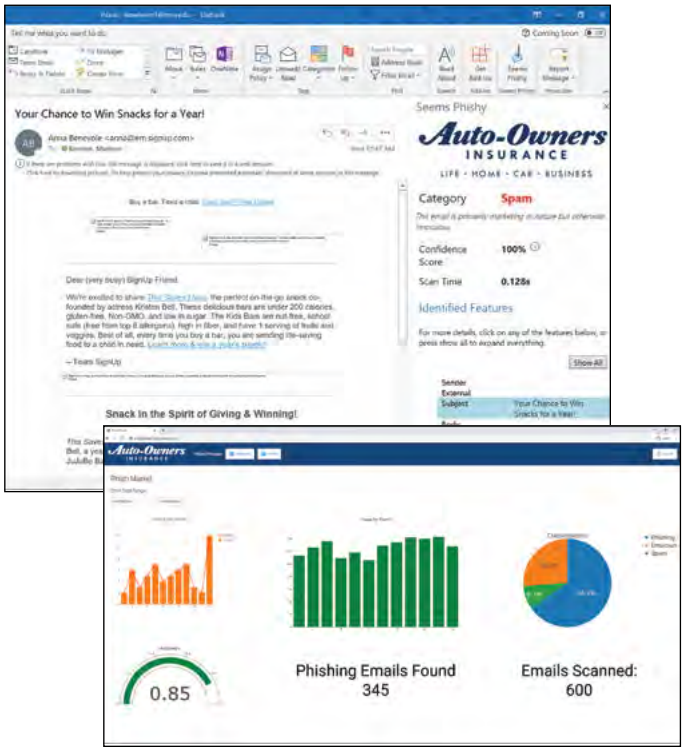
Every day, associates at companies like Auto-Owners receive phishing emails that attempt to obtain sensitive personal and company information. Educational awareness programs, while common, do not protect a company against all phishing attempts and lead to extremely cautious employees. As a result, cyber security departments are flooded with emails forwarded to them by concerned associates.

Our Phish Phinder is an Outlook add-in which automates the phishing detection process for wary professionals. When a user sees a suspicious email and clicks the add-in button, our software scans the email and returns a categorization and confidence score. In an Outlook sidebar, the email is categorized as a confirmed phishing attempt, a suspected phishing attempt, spam or harmless.

The user is also given an educational tutorial detailing and explaining the suspicious parts of the email. This gives associates a method to better understand the characteristics of spam and phishing attempts.

The email data gathered by Phish Phinder is visible to executives and administrators in an analytics dashboard, and the emails themselves are available for review within a webpage. This allows companies to keep track of phishing targets in a streamlined manner.

The technologies involved in the Phish Phinder back end include Azure SQL, Python Flask API and Azure Web Services. The front end incorporates an Angular framework for the webpages and CSS, HTML and JavaScript for the Outlook add-in.



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Michigan State University
Team Members (left to right)

Madison Bowden
Canton, Michigan

Jacob Loukota
Bentonville, Arkansas

Hunter Hysni
West Bloomfield, Michigan

Alex Larson
Rochester Hills, Michigan

Gabi Singher
Brighton, Michigan

Auto-Owners
Project Sponsors

Tony Dean
Lansing, Michigan

Ross Hacker
Lansing, Michigan

Scott Lake
Lansing, Michigan

Bosch
Classifying Target Vehicles for Adaptive Cruise Control

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

Bosch's adaptive cruise control is an advanced driver assistance system that allows a vehicle to automatically change its speed based on traffic conditions. Using software that processes radar data and video footage from the vehicle, the behavior of surrounding vehicles is labeled.

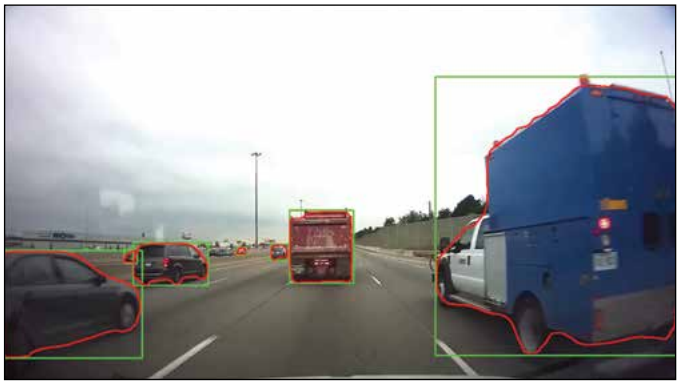
For example, if the system determines that a car is cutting into the lane directly in front of the host vehicle, it will identify and label the new vehicle, and intelligently adjust its pace in real time.

Currently, Bosch employees determine the accuracy of the adaptive cruise control software by manually labeling video files and comparing them to the behavior of the vehicle. While necessary, this labeling process is costly and difficult because Bosch collects thousands of hours of video footage.

Classifying Target Vehicles for Adaptive Cruise Control is a tool that automates the label generation process. Using machine learning, video is analyzed to detect lane lines and surrounding vehicles. Then, a combination of statistical logic and machine learning labels the environment in a time-series fashion. Each label is assigned a confidence rating, allowing Bosch employees to easily identify and fix incorrect labels.

This tool significantly reduces the time and effort required to manually label testing videos.

Our software is deployed to both Windows and Linux. The user interface is built with PyQt. The YOLOv3 algorithm is used to recognize vehicles, and ERFNet for lane line detection. A combination of machine learning and logic is used to compute the labels.



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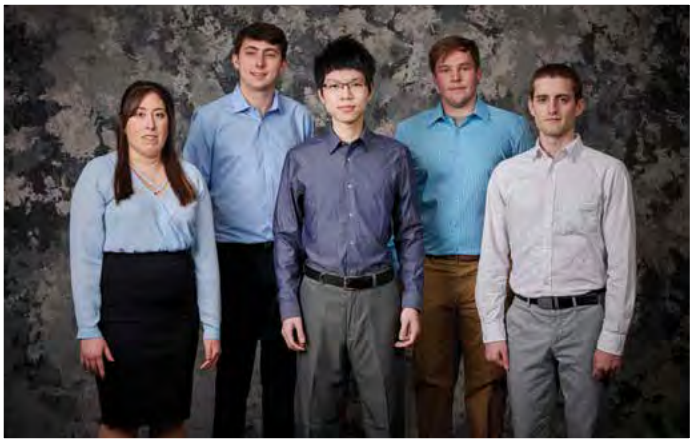


Michigan State University
Team Members (left to right)

Sabrina Garcia
Sturgis, Michigan

Adam Schroth
Wixom, Michigan

Tianlun Chen
Tai Zhou, China

James Gengelbach
Grand Rapids, Michigan

Bradley Bauer
Marlette, Michigan

Bosch
Project Sponsors

Kevin Buckner
Plymouth, Michigan

Nate Kesto
Plymouth, Michigan

Steve Koski
Plymouth, Michigan

Troy McCormick
Plymouth, Michigan

Ryan Rummer
Plymouth, Michigan

The Dow Chemical Company
Manufacturing Avatar Plant Twin (MAPT)

Headquartered in Midland, Michigan, Dow is a global leader in specialty chemicals, advanced materials, and plastics. Dow provides a world-class portfolio of advanced, sustainable, and leading-edge products.

Working with chemical products requires extreme precision to ensure the safety of all involved. This necessitates the need for precise equipment location and tracking records. Currently, Dow's technical experts manually complete these monotonous, non-uniform reports. With plants in 160 countries, it is increasingly difficult to coordinate this information.

Our Manufacturing Avatar Plant Twin (MAPT) system provides Dow's experts with the simple and precise tools needed to report accurate equipment locations and build a centralized database with up-to-date information.

Our system streamlines the sensor assignment process for different pieces of equipment at Dow plants. Using our web application, a user analyzes assets such as pumps, compressors and furnaces, then reports the locations of sensors attached to these pieces of equipment.

Once the user is finished reporting sensor locations, the information is propagated to the database, where it is compared with other reports assigned to the same asset. Discrepancies and errors are flagged in the background.

To aid in the reporting process, machine learning is used to suggest potential layouts to the user for new assets, based on trends in previously submitted data.

Our web application is built using the Microsoft Azure Cloud Computing Platform. The user interface runs on CSS, HTML, and JavaScript. All the records are stored in an SQL database that is managed and implemented with C#. The Manufacturing Avatar Plant Twin supports desktop and mobile browsers.

Michigan State University
Team Members (left to right)

Larry Zahner
Pentwater, Michigan

Chenyu Hu
Beijing, China

Colin Heinemann
Rochester Hills, Michigan

Jack Brooks
Livonia, Michigan

Francisco Santos
Holt, Michigan

Dow
Project Sponsors

Chris Anderson
Chicago, Illinois

Mike Dessauer
Houston, Texas

Marc Habermann
Houston, Texas

Kaytlin Henderson
Houston, Texas

Fareed Mohammed
Midland, Michigan

Evolutio
ERP Air Force: Conservation Threat Detection

Evolutio is a group of technology professionals convinced that business problems have significantly simpler solutions than the market is led to believe. These solutions span across the globe, including the non-profit Elephants, Rhinos, and People (ERP), a group founded to preserve and protect Southern Africa's wild elephants and rhinos.

As part of their initiative to preserve and protect wildlife, ERP uses drones, or unmanned aerial vehicles (UAVs), to monitor elephants at the Rietvlei Reserve in South Africa.

Wildlife is threatened every day by not only poachers, but also by the destruction of food sources, the disruption of habitat by tourists and natural threats such as floods, wildfires, and drought. In a 400,000-acre park, it is impossible to detect and monitor threats without an automated system.

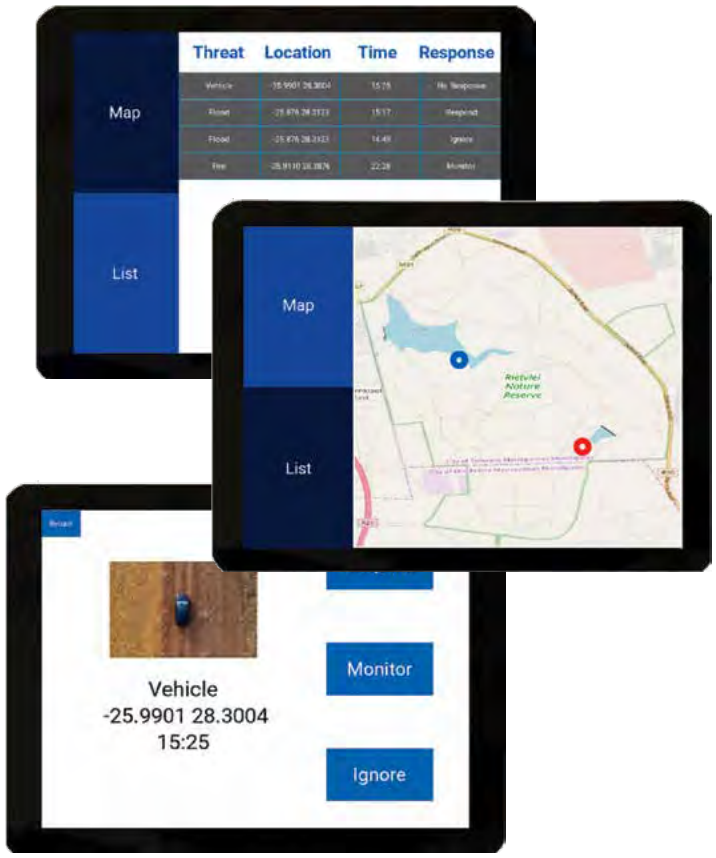
Our Conservation Threat Detection system serves two primary functions: auto-identify threats in drone footage and inform rangers of these identified threats in real time.

ERP pilots fly drones equipped with cameras throughout the reserve and our system automatically detects any threats, including cars, humans, fires, and floods, from the camera feed in real time.

If a threat is detected, nearby rangers are informed of the threat and its location through a graphical user interface (shown on the right), together with silent notifications conveyed through vibration motors mounted in our custom-designed ranger vest.

Our system allows ERP to monitor large areas of land in real time without the need for ERP personnel to manually analyze hundreds of hours of drone video footage. This allows ERP to more quickly respond to imminent threats.

Our threat detection is done using neural networks built with TensorFlow. All components of the system communicate through Ethernet protocol and the main system runs on a Jetson Nano.



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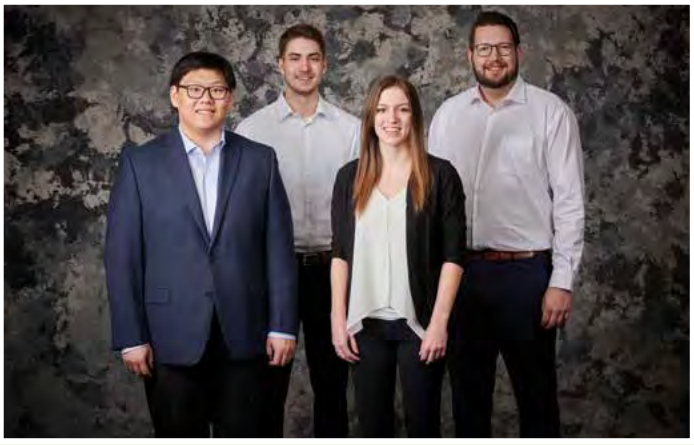


Michigan State University
Team Members (left to right)

Qingyang Li
Ningbo, Zhejiang, China

Drew Schineller
Scarborough, Maine

Maddie Jones
Fort Mohave, Arizona

Logan McDonald
Bloomfield Hills, Michigan

Evolutio
Project Sponsors

David Allen
Johannesburg Area, South Africa

Jordan Cobe
Lansing, Michigan

Bob Dyksen
St. Louis, Missouri

Francois Maass
Johannesburg Area, South Africa

Adam Ties
Indianapolis, Indiana

Laura Vetter
Indianapolis, Indiana

Christian Wheeler
Johannesburg Area, South Africa

Ford Motor Company
Ford Augmented Reality Owner's Manual

Ford Motor Company is a multinational automotive manufacturer headquartered in Dearborn, Michigan, employing 199,000 employees and producing a total of 5.9 million vehicles in the last recorded year. Ford designs and manufactures a full line of cars, trucks, SUVs and electric vehicles under both the Ford and Lincoln brands.

Every Ford vehicle comes with a printed owner's manual containing more than 300 pages of basic information pertaining to the operation and maintenance of the vehicle. This manual is cumbersome, difficult to navigate, and has not evolved with the technology inside the vehicles.

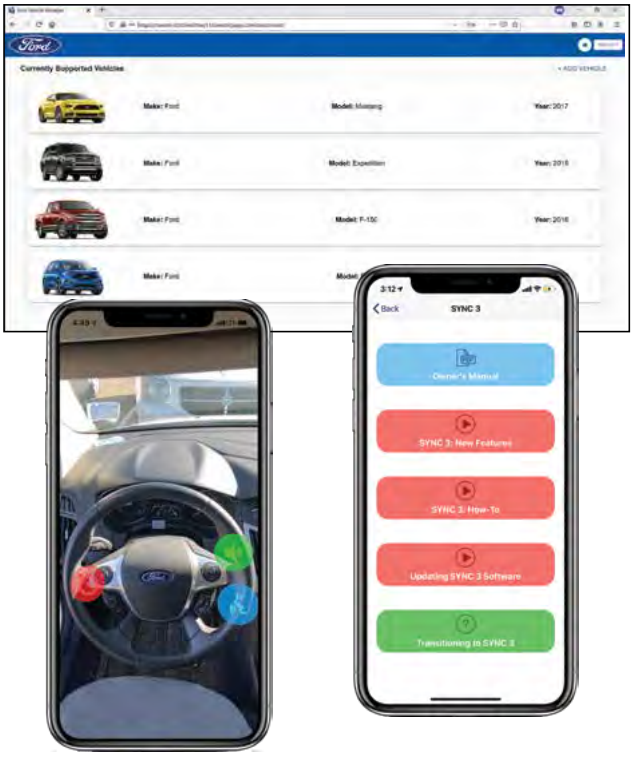
Our Augmented Reality Owner's Manual application provides an intuitive and accessible digital version of the owner's manual with augmented reality (AR) capabilities.

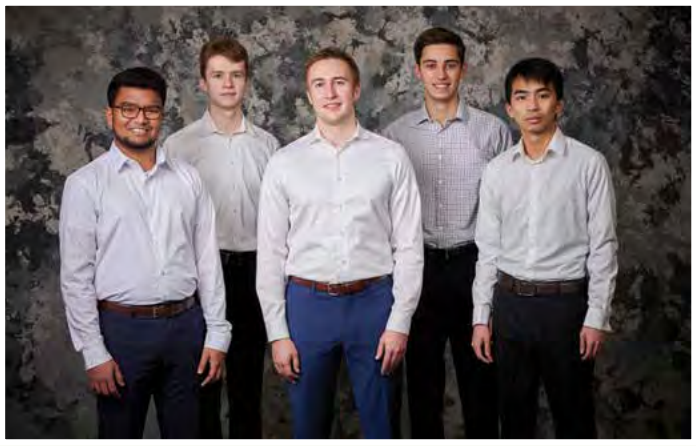
The interior of the vehicle is displayed from the driver's perspective using the phone's camera. From this screen, interactive digital content is overlaid using AR, enabling users to quickly access resources.

When a user clicks on an interactive component of the augmented reality display, a list of relevant content is displayed. This content includes a digital version of the corresponding owner's manual section, tutorial videos and answers to frequently asked questions. Alternatively, the same content is accessible through the search bar from the app's homepage.

Authorized Ford employees create, edit and delete vehicles and manage any associated content through the web application. This content is accessed via the iOS app for the respective vehicle.

Our iOS application leverages Swift and ARKit to provide an AR experience. The web application is built using the ReactJS framework. The web application and iOS application are linked through an API and database hosted by Amazon Web Services.





Michigan State University
Team Members (left to right)

Shadman Rahman
Grandville, Michigan

Shawn Peerenboom
Rockford, Michigan

Torrin Bates
Dexter, Michigan

Ryan LaHaie
Grand Blanc, Michigan

Jiahao Wang
Chongqing, China

Ford
Project Sponsors

Adam Haas
Dearborn, Michigan

Marcus Harold
Detroit, Michigan

Waseem Hijazi
Detroit, Michigan

Jake Prickett
Dearborn, Michigan

Matt Tarnowsky
Detroit, Michigan

Michael Volk
Dearborn, Michigan

General Motors
Open Source Intel

General Motors (GM) is a multinational automotive manufacturer headquartered in Detroit, Michigan. GM is ranked #13 on the Fortune 500 for total revenue and is the largest auto manufacturer headquartered in the United States.

Maintaining strong information security is a priority for GM to protect sensitive information that could compromise asset security and communication privacy. Publicly visible credentials grant unauthorized parties the opportunity to infiltrate GM assets and view private communication networks.

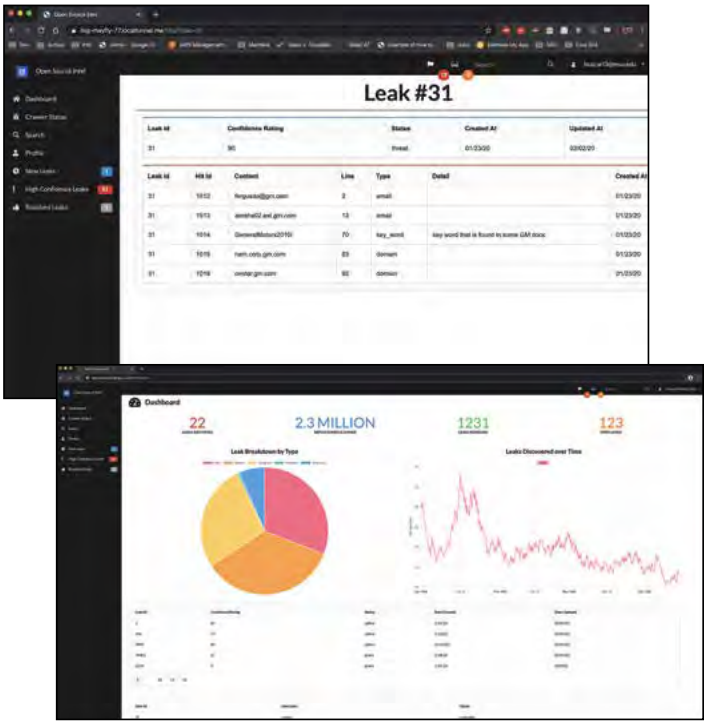
Our Open Source Intel system automates the discovery of security threats by collecting and analyzing information from various public code repositories on the internet such as GitHub, GitLab and Bitbucket.

Confidential intellectual property (IP) such as GM usernames, API keys and code snippets are displayed on a user-friendly web application. When a threat is discovered, relevant information about the IP leak is displayed so that GM employees can quickly act to mitigate the threat.

A machine learning service gives each discovered leak a confidence score. If a threat is assigned a high enough confidence score, employees are notified via text message and/or email.

Open Source Intel automates the currently manual process of discovering the warning signs of a leak and drastically increases employee effectiveness by letting them focus on threat mitigation instead of threat discovery.

The Python data collection pipeline is orchestrated using Celery, pipeline data is stored temporarily in Redis, and code is processed using PyDriller. A trained scikit-learn machine learning model quantifies each hit discovered by the pipeline. Open Source Intel stores data in a PostgreSQL database. This database then feeds the Python Django web application for display.



Michigan State University
Team Members (left to right)

Taylor Zachar
Morrice, Michigan

Ben Buscarino
Saginaw, Michigan

Will Crecelius
Plymouth, Michigan

Qiming Ren
Nanjing, Jiangsu, China

Igli Ndoj
Clinton Township, Michigan

GM
Project Sponsors

Clayton Davis
Warren, Michigan

Vinny Hoxha
Warren, Michigan

Fred Killeen
Warren, Michigan

Wade Kirschner
St. Petersburg, Florida

Johnny Medina
Austin, Texas

Chris Walter
Warren, Michigan

Harvard Law School
StackLife 2.0: Library Search and Display Tool

Located in Cambridge, Massachusetts, Harvard Law School is arguably the most prestigious law school in the world and is home to the world's largest academic law library. The school's faculty consists of more than 100 full-time professors and more than 150 visiting professors, educating students and delivering research on traditional and emerging legal fields.

The Harvard Library has consolidated approximately 15 million records describing documents from multiple sources surrounding Islamic policy, law and history. Access to this data is very limited with no user-friendly way of viewing it, depriving researchers of valuable information that could be beneficial to their research efforts.

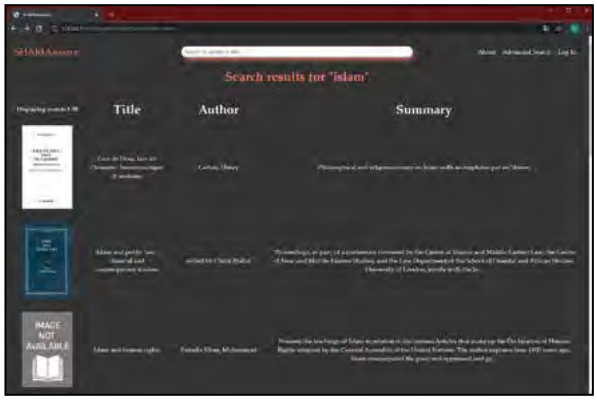
Harvard Law School wants to facilitate universal access to this data in order to preserve a significant part of our shared world heritage, as well as promote new and data-centric research.

Our StackLife 2.0: Library Search and Display Tool consolidates the data for these resources and allows researchers to access it in an easy-to-use web application.

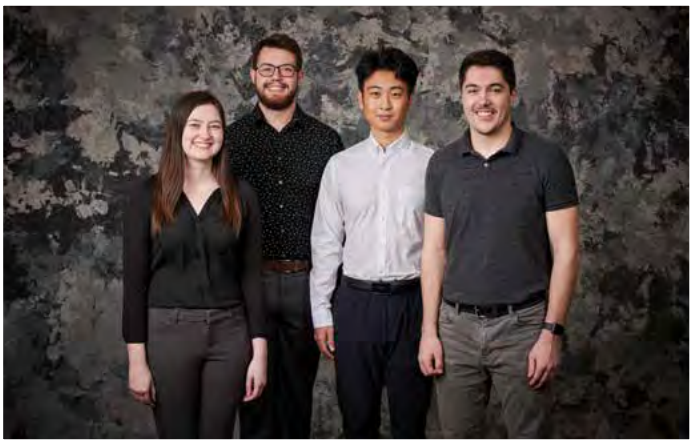
Our system allows researchers to filter records based on multiple search parameters in order to find the resources that are most relevant to them. It also enables users that are registered with the system to save search parameters to their profile and then build their own custom collection of resources.

Once a user finds a desired resource, our application provides the relevant data about that resource, including where the user can retrieve it. Our system also provides data visualization capabilities to enable researchers to plot data.

Our application is built using the Flask web microframework for Python with HTML, CSS, JavaScript, and Bootstrap. The data is stored inside of a relational database system using MySQL 8.0 that is hosted using Amazon Web Services.



HARVARD LAW SCHOOL



Michigan State University
Team Members (left to right)

Allison Mutka
Okemos, Michigan

Brandon Field
Caledonia, Michigan

Zian Gong
Shaoxin, Zhejiang, China

Jake DeNell
Crystal Falls, Michigan

Harvard Law School
Project Sponsors

Mohammad Ghassemi
East Lansing, Michigan

Intisar Rabb
Cambridge, Massachusetts

Sharon Tai
Cambridge, Massachusetts

Herman Miller
Measuring Workspace Impact on Employee Experience

Herman Miller, a 100+-year-old company from Zeeland, Michigan, is an industry leader in home and office furniture. Known for its history of design innovation, Herman Miller dedicates research to office space quality in an effort to quantify the effectiveness of different workspace layouts. Currently, sensors are employed to measure utilization of workspace areas.

Sensor solutions, however, do not provide information regarding employee satisfaction, or sentiment, towards a specific workspace.

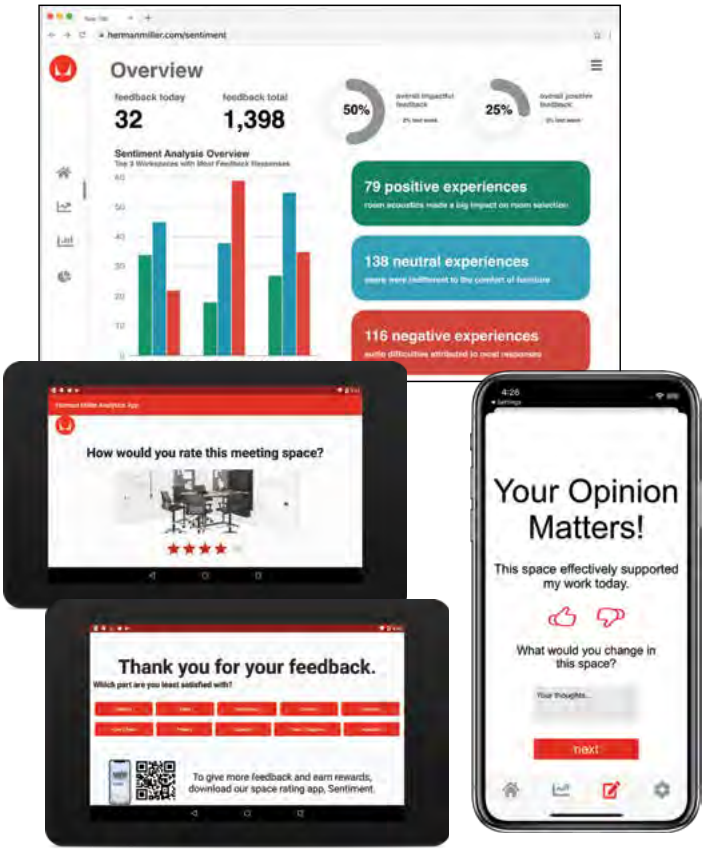
Our Measuring Workspace Impact on Employee Experience application allows employees to use kiosk stations and their mobile devices to input sentiment about specific workspaces. Additionally, our sentiment analysis web platform derives quick data insights from the survey results.

Users have the option to log in to the mobile application using their company code and either their user identification or continue as a guest. Registered users can view their rewards and statistics pages.

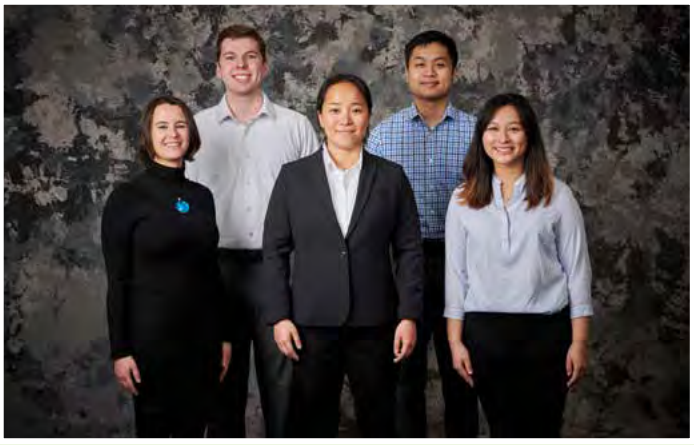
When a user with the mobile application leaves a workspace, a proximity beacon sends a notification prompting sentiment questions about the workspace. Kiosk stations are available in key workspace locations across a floor plan.

Collected data is displayed through the analytics web platform, accessible only by Herman Miller administrators. The platform allows users to better understand how to alter workspaces to increase employee satisfaction.

Our software uses Amazon Web Services including their relational database service, natural language processing, and API gateways for our back end to collect and analyze data. Estimote Proximity Beacons detect participating user locations on their Android or iOS devices. The web analytics platform is built using ReactJS and displays data using the Google Analytics API.



HermanMiller



Michigan State University
Team Members (left to right)

Sophia Frankel
Grand Rapids, Michigan

Jake Baum
Grand Rapids, Michigan

Lynn Dai
Nanjing, China

John Nguyen-Tran
Holt, Michigan

Marla Mae Defensor
Manila, Philippines

Herman Miller
Project Sponsors

Ryan Anderson
Zeeland, Michigan

Mark Buikema
Zeeland, Michigan

Missy Groothuis
Zeeland, Michigan

Tom Holcomb
Zeeland, Michigan

Learning A-Z
Sandwich Builder Parts of Speech Guessing Game

Learning A-Z is an education technology company that expands students' literacy through thoughtfully designed tools and resources, equipping students with the skills they need to succeed in the classroom.

Elementary school students use Learning A-Z's software for multiple subjects and are familiar with the content and style. When a new resource is added, students spend less time learning the software and more time learning the material.

Our Sandwich Builder Parts of Speech Guessing Game provides a fun and interactive learning experience for students. The game is designed with Learning A-Z's style and content, allowing the students to focus on learning the parts of speech of different words.

When a game is started, an empty outline of a sandwich with a part of speech in each layer is displayed in addition to a list of randomly chosen words.

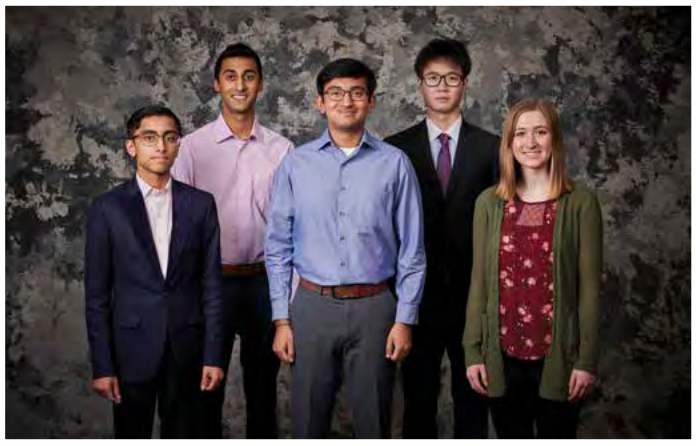
If the student drags a word to the correct part of speech, the corresponding layer of the sandwich fills with a pleasant, correct color. If the student is incorrect, the layer of the sandwich fills with a mold-like color.

Once all parts of the sandwich are displayed, the student submits their work. If correct, the student is awarded 50 stars, the common currency for Learning A-Z software.

After correct completion of the sandwich, the user enters a bonus round, where they must correctly select a single word that matches two parts of speech. This round is worth an additional 10 stars.

Our Sandwich Builder Parts of Speech Guessing Game is developed using Angular for the front end of the web application and Swift for the iOS platform. It communicates with the MySQL database using PHP.

Learning A-Z



Michigan State University
Team Members (left to right)

Harry Mathon
Lansing, Michigan

Aarish Medhora
Novi, Michigan

Raunak Shivkumar
Lansing, Michigan

Yibei Huang
Beijing, Beijing, China

Samantha Zielinski
Brighton, Michigan

Learning A-Z
Project Sponsors

Paul Fonte
Ann Arbor, Michigan

Kent Kanipe
Ann Arbor, Michigan

John Lucas
Ann Arbor, Michigan

Kirsten Monson
Ann Arbor, Michigan

Rick Sansburn
Ann Arbor, Michigan

Jeff Weakland
Ann Arbor, Michigan

Lockheed Martin Space
SmartSat™ Satellite App Store

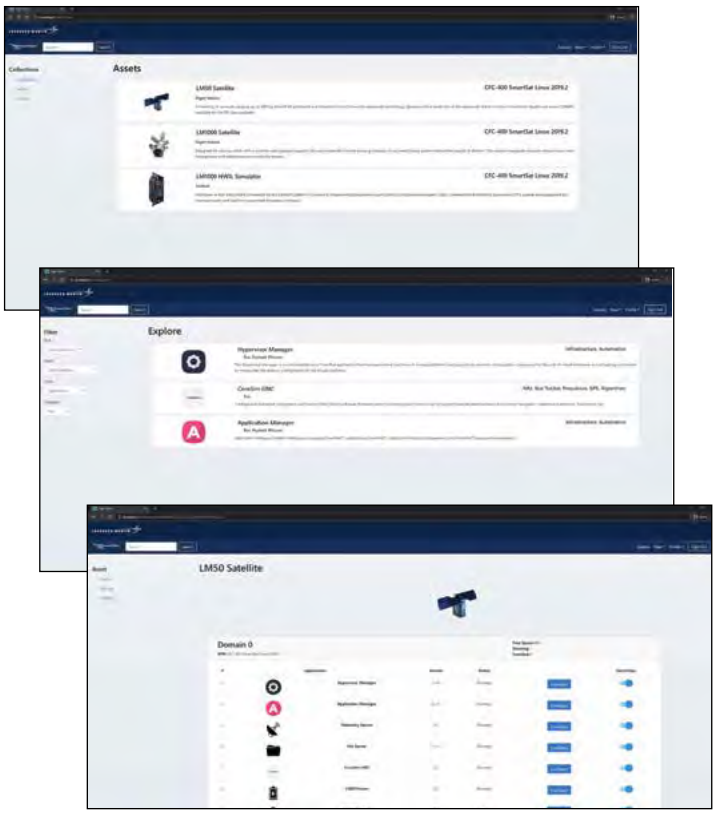
Headquartered in Littleton, Colorado, Lockheed Martin Space is one of four business areas comprising Lockheed Martin, an American global aerospace, defense, security and technologies development company that employs 110,000 people worldwide. From the Orion spacecraft to satellites that can be reconfigured while in orbit, Lockheed Martin Space is a global leader of the space sector.

The Lockheed Martin Space SmartSat™ system introduces a universal software format that secures and standardizes satellite applications, allowing for frictionless collaboration on projects and compatibility across many different Lockheed Martin satellite models.

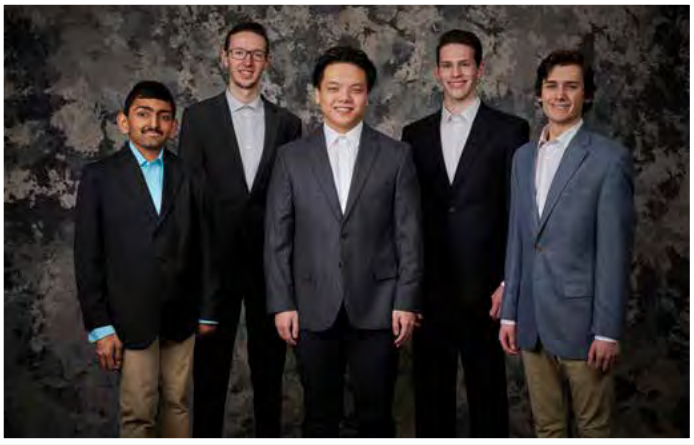
Our SmartSat™ App Store provides a web-based marketplace for browsing, uploading, and installing mission-ready applications directly to live satellites. Operators manage their entire fleet directly through our web page, enabling and disabling applications installed on satellites with the press of a button. Lockheed Martin Space and third-party satellite application developers alike are granted tools to collaborate efficiently on our platform, with shared access to projects and satellites.

Every new application uploaded to our app store is put through our automated compatibility testing to assess on which Lockheed Martin satellites the software can be deployed. This can save hundreds of hours of development by allowing a single piece of software to be deployed on multiple different satellite models.

Our web application stack consists of ReactJS UI components, Flask for back end, and a PostgreSQL database. The storage and distribution of SmartSat™ applications is done through Nexus, and compatibility testing is automated using a continuous integration server.



LOCKHEED MARTIN



Michigan State University
Team Members (left to right)

Sailesh Gundepudi
Grand Rapids, Michigan

Brian Fuessel
Mokena, Illinois

Peng Sun
Chongqing, China

Daniel Webb
Troy, Michigan

Tony Miller
Northville, Michigan

Lockheed Martin Space
Project Sponsors

Kristin Barrackman
Littleton, Colorado

Josh Davidson
Littleton, Colorado

Adam Johnson
Littleton, Colorado

MaxCogito
Identity Based Communication and Content Services

Founded in 2019, MaxCogito provides software tools for customers to understand and work with their data.

Most companies are blind to the content of the messages passing through their servers. However, recent regulations such as the European Union's General Data Protection Regulation (GDPR) and the California Consumer Privacy Act (CCPA) require enterprises to understand the data they store.

Our Identity Based Communication and Content Services platform automatically categorizes and analyzes every message that passes through a company's servers to help them remain compliant with any regulations, and also to identify any valuable information that might otherwise have been missed.

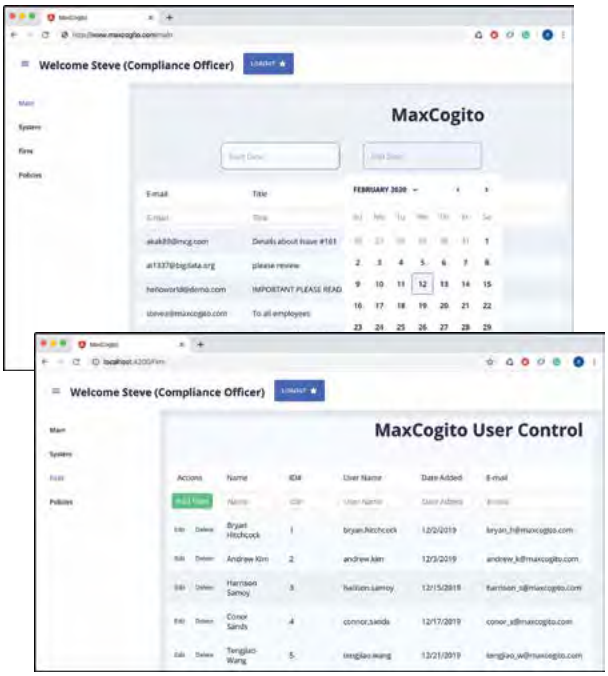
Businesses using our product select the types of information to monitor, which can include data that could result in regulatory violations, contain trade secrets, or personally identify an individual.

As internal and external messages are sent to and from the employees of an enterprise, our platform automatically searches for content based on each company's indicated needs. Any messages containing sensitive information are automatically tagged before being forwarded to the final recipient.

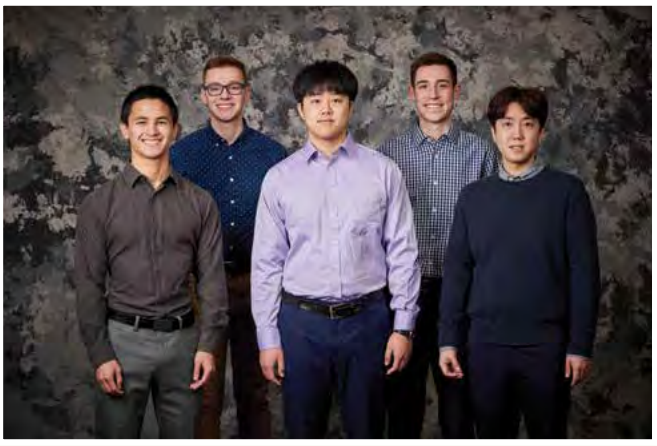
Our service generates intuitive reports on the content of the messages that come through their servers so that administrators and compliance officers can easily find and assess the quantity and type of sensitive data they currently have on their servers.

Our platform greatly simplifies the data analysis process, saving companies hundreds of man-hours while also avoiding fines for policy violations.

The Identity Based Communication and Content Services platform uses an SMTP server to collect messages, Apache Tika to extract text from each message, and Elasticsearch to index the data. Connecting the back-end services are RESTful APIs written in Java.



MaxCogito
The company with big ideas



Michigan State University
Team Members (left to right)

Harrison Samoy
Plymouth, Michigan

Bryan Hitchcock
Commerce Township, Michigan

Tengjiao Wang
Chengdu, Sichuan, China

Conor Sands
DeWitt, Michigan

Andrew Kim
East Lansing, Michigan

MaxCogito
Project Sponsor

Steve Akers
Mashpee, Massachusetts

Meijer
Reducing Shoplifting Using Machine Learning

Founded in 1934, Meijer is the pioneer of the modern supercenter with 242 stores across the Midwest.

Every year, an estimated $10-30 million in assets are lost due to organized shoplifting. Meijer has identified behavior strongly associated with shoplifting, including short or long dwell times in high risk areas, leaving the store without passing through a point of sale, as well as leaving the store using employee or emergency exits.

However, Meijer stores do not have the manpower to watch and monitor every shopper who comes through their doors.

Our Reducing Shoplifting Using Machine Learning project automatically tracks Meijer shoppers throughout the store to identify suspicious behavior to prevent shoplifting.

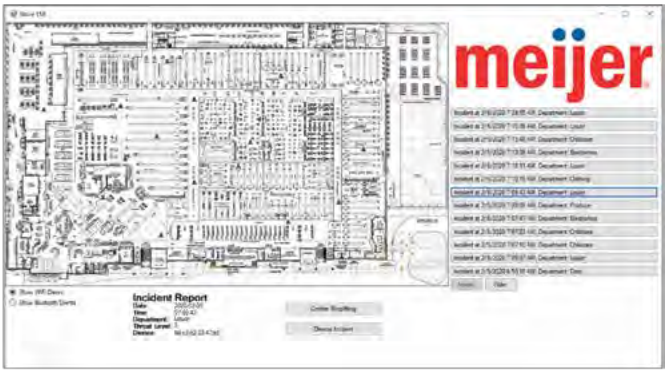
Meijer has installed Mist wireless access points throughout their stores, which gives them the ability to track the general location of shoppers during their time in the store.

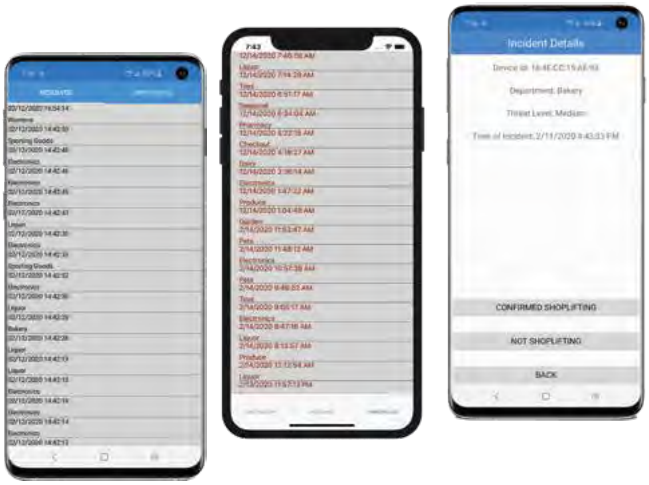
Our system tracks, in real time, the paths various shoppers take. It then uses machine learning to determine the probability that a given shopper is engaged in illegal shoplifting behavior.

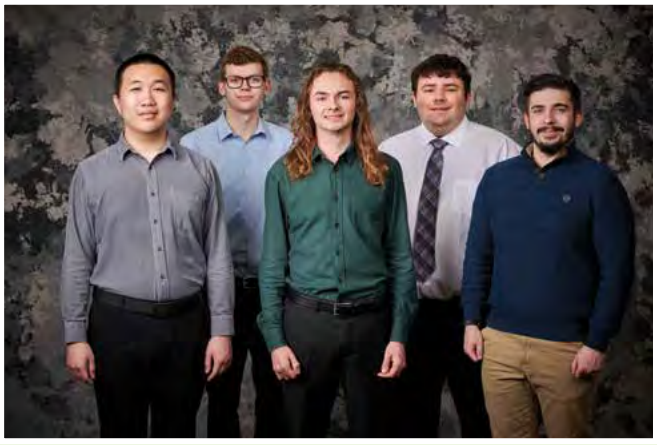
If any suspicious activity is identified, the Meijer Asset Protection team receives an alert on their smartphone regarding the incident. The employee then uses that information to review the incident using the store surveillance system integrated into our desktop app. If an incident is confirmed to be shoplifting, the device number associated with the shoplifter is stored for future alerts.

Whenever a device that has previously engaged in shoplifting reenters a Meijer store, employees are notified and action can be taken to prevent further acts of shoplifting.

Our desktop app and mobile apps are written in C#. Our database is on Azure SQL. Our machine learning algorithm is written in Python and devices are tracked via Wi-Fi and Bluetooth using Mist access points.







Michigan State University
Team Members (left to right)

Xiaojun Wang
Shenzhen, Guangdong, China

Billy Ochab
Chicago, Illinois

Justin Marinelli
Livonia, Michigan

Matt Schafer
Midland, Michigan

Jesse Stricklin
Oxford, Michigan

Meijer
Project Sponsors

Bill Baer
Grand Rapids, Michigan

Chirag Ghimire
Grand Rapids, Michigan

Phil Kane
Grand Rapids, Michigan

Sameer Kona
Grand Rapids, Michigan

Chris Laske
Grand Rapids, Michigan

Terry Ledbetter
Grand Rapids, Michigan

Murali Rajagopalan
Grand Rapids, Michigan

Michael Sadler Foundation
Gamifying GameChang3rs

The mission of the Michael Sadler Foundation is to inspire and empower students in building their personal legacies. The foundation uses their Six Pillars of character as stepping-stones for this growth and does so with the GameChang3rs Program.

GameChang3rs is a program that provides K-8 students with tools to help them develop strong character, make good choices, and mature both socially and emotionally. GameChang3rs ambassadors are volunteer high school students who teach and mentor elementary school students.

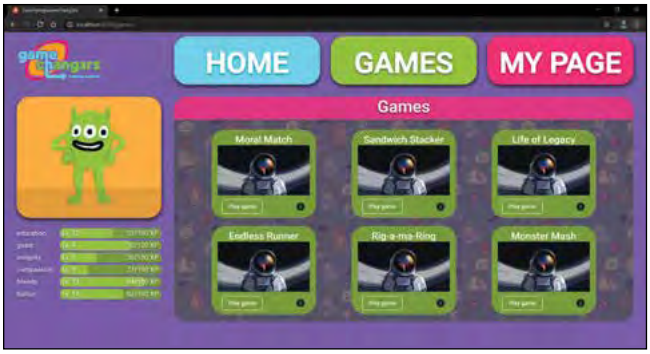
Students and ambassadors meet once a month during the school year. However, between these meetings, the Michael Sadler Foundation is concerned that their students do not retain the important information from the GameChang3rs lessons.

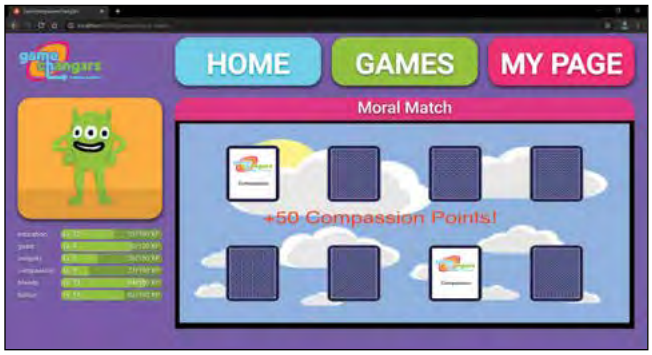
Our Gamifying GameChang3rs project is a web-based platform designed to keep students continually engaged with the Six Pillars material throughout the time between meetings.

Gamifying GameChang3rs contains a variety of educational games designed to teach K-8 students lessons about the Six Pillars of character. Students have fun and earn points all while interacting with material in a fun and educational manner.

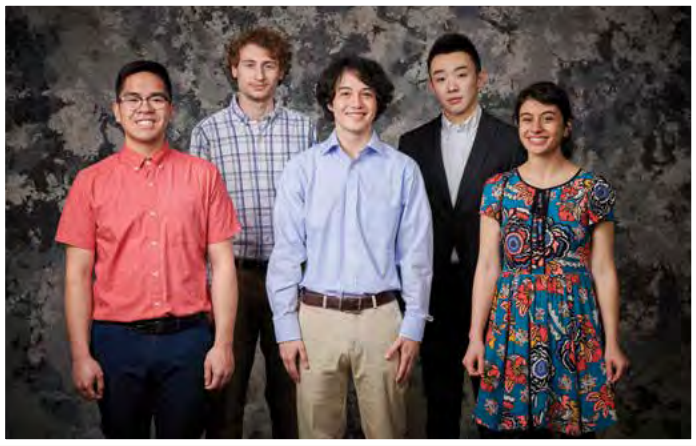
GameChang3rs administrators can view statistics about which games are the most popular, how many games are being played a day, and how many students are logging in to the system. To adhere to privacy regulations, no information that can identify students is stored. Instead, this information is used to identify which games are effective to guide the development of future games.

The front end of our system is built using Angular 8, while the back end is implemented using Express. In addition, the Unity game engine, along with WebGL provides a simple solution to develop native web games. Game and user information is stored in a MongoDB database.





MICHAEL SADLER FOUNDATION™
Empowering Today's Game Changers to Become Tomorrow's Leaders™



Michigan State University
Team Members (left to right)

Matthew Vedua
Shelby Township, Michigan

Daniel Marinetti
West Bloomfield, Michigan

Tristan Özkan
Midland, Michigan

Dima Zhang
Beijing, China

Lina Jebara
Dearborn Heights, Michigan

Michael Sadler Foundation
Project Sponsors

Kim Evans
Grand Rapids, Michigan

Dean Rehberger
East Lansing, Michigan

Karen Sadler
Grand Rapids, Michigan

Michigan State University CSE
Using Sensors to Study Human Behavior

The nation's pioneer land-grant university, Michigan State University (MSU) is home to nationally ranked and recognized academic, residential college, and service-learning programs.

Among the fastest-growing academic programs at MSU, the Department of Computer Science and Engineering (CSE) hosts nine research laboratories and equips students with practical skills that enable them to adapt to changing technology.

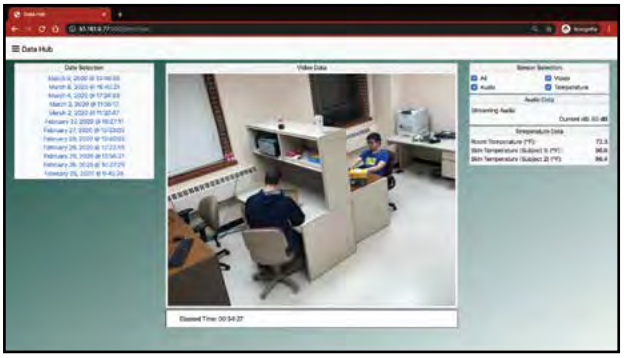
Dr. Mohammad Ghassemi is an associate professor in the computer science department at MSU. Dr. Ghassemi researches human health and behavior using machine learning, and is the director of a study at MSU in which the behavior and interactions between small groups of individuals are examined.

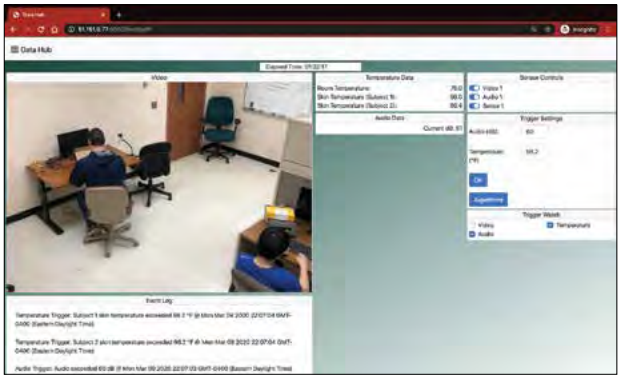
Our Using Sensors to Study Human Behavior system transforms the laboratory dedicated to this study into a "smart" meeting space. Human movement is captured using cameras, dialogue is collected using microphones, and an electroencephalogram (EEG) is used to study brain activity.

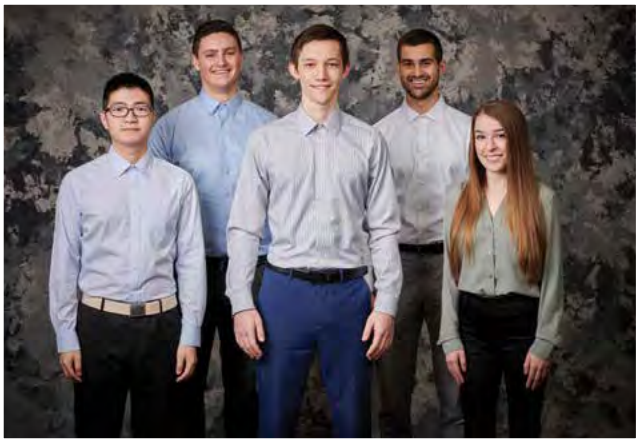
The collected data is used to train machine learning algorithms, detect anomalies in human conversation, and track eye movements using strategically mounted cameras.

The data is streamed to our website (called The Data Hub) where it is viewed and analyzed by researchers and stored for later research and analysis. Additionally, The Data Hub allows researchers to set event triggers in response to data. Triggers can be as simple as a text notification or as complex as a change in the environment of the lab.

The lab contains an EEG as well as multiple cameras and a microphone connected to Raspberry Pis that stream data to our remote server running MySQL. The Data Hub is written in Python using the Flask web framework.







Michigan State University
Team Members (left to right)

Lianghao Shu
Chongqing, Chongqing, China

Ben Seeger
DeWitt, Michigan

Rainier Devolder
Gent, Belgium

Taylor Whitacre
Grand Ledge, Michigan

Merryn Marderosian
Birmingham, Michigan

Michigan State University CSE
Project Sponsor

Mohammad Ghassemi
East Lansing, Michigan

Michigan State University ITS
Degree Navigator

Michigan State University is a public research institution founded in 1855. The Information Technology Services (ITS) unit delivers and maintains effective technology resources for students, faculty and staff.

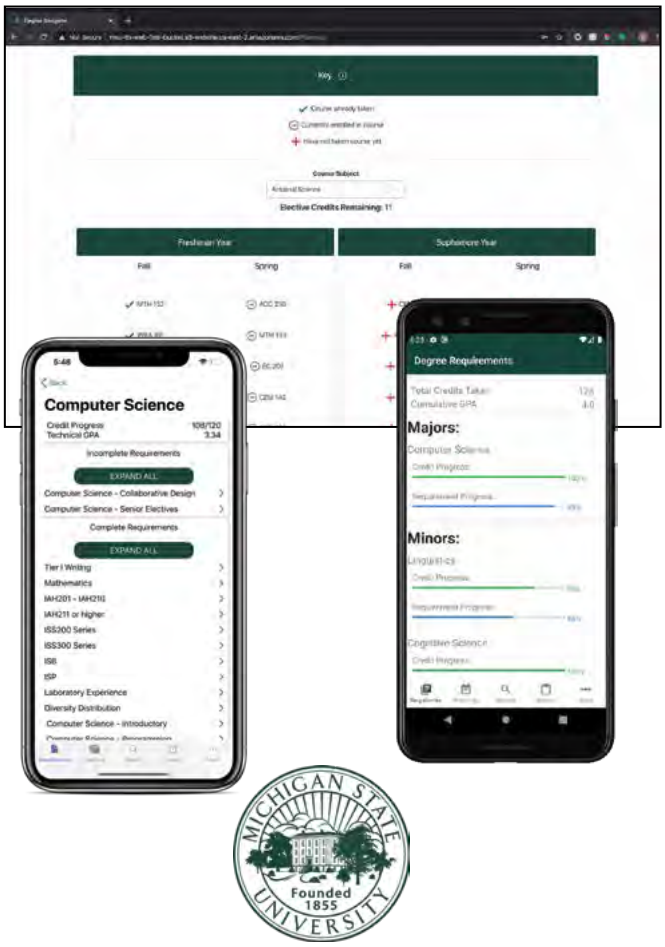
There are 97 majors of study and more than 100 minors available to students. While only required to complete one major, students can complete any combination of majors and minors as well as participate in the Honors College. Each of these programs has a unique set of graduation requirements, causing students to struggle to keep track of which have been met and which still need to be completed.

Our Degree Navigator application provides an easy-to-use interface for students to check their progress in each of their chosen programs. The landing page displays a summary of each program in which the student is participating – a major, a minor, or the Honors College.

Clicking on any of these programs navigates the user to a list of program requirements in the form of either a specific course or a list of courses. Incomplete requirements are listed at the top. The user can expand a requirement and get more detailed information about which classes can fulfill that requirement or can expand all requirements to view a detailed description of the program.

In addition, students can view recommended four-year course schedules for each major provided by Michigan State. Each course is accompanied by a symbol that represents whether the course was already taken, currently being taken, or not yet taken by the student.

Degree Navigator is developed with Swift for iOS, Kotlin for Android, and ReactJS for web. It uses an AWS API to access information stored in a DynamoDB database via Lambda functions written in Python.



Michigan State University
Team Members (left to right)

Tony Fedewa
St. Johns, Michigan

Chad Capuzzi
Pittsburgh, Pennsylvania

Christian Velkovich
Novi, Michigan

Sarah Johanknecht
Cranberry Township, Pennsylvania

Michigan State University ITS
Project Sponsors

Spencer Ottarson
East Lansing, Michigan

Nick Summers
East Lansing, Michigan

Mozilla Corporation
No More Yellow Screen of Death in Firefox

Founded in March 1998, Mozilla Corporation is a free software community whose mission is to keep the internet open and accessible for all. They are best known for the popular internet browser, Firefox.

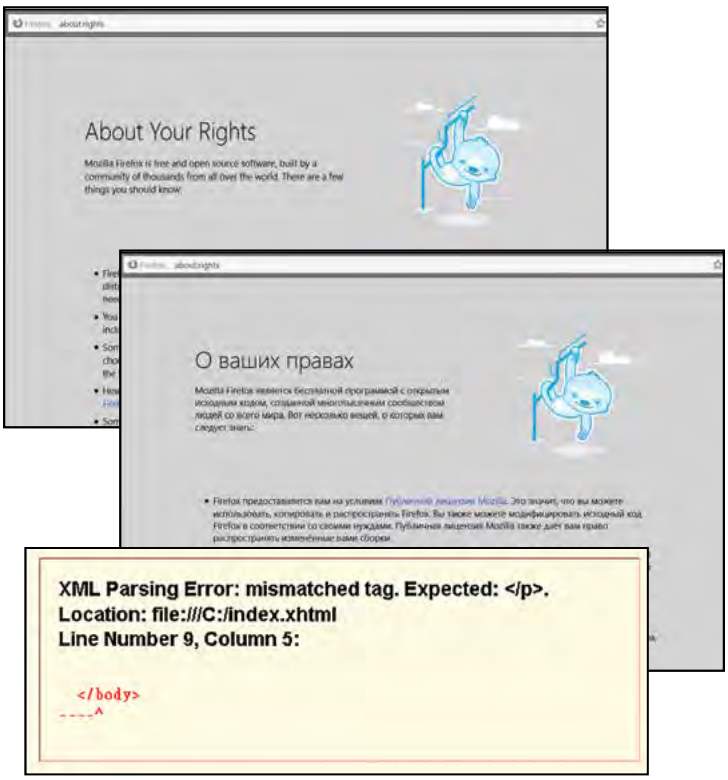
Over 250 million people use Firefox every month. To accommodate the 60% of users whose preferred language is not English, Firefox is available in over 100 languages. Localization is the term for supporting languages other than the default, which in Firefox's case is American English. Localizing Firefox requires translating menus, buttons and many other parts of the browser.

Previously, to change from the default language, the user had to either download a separate version of Firefox or go through a labyrinth of configuration steps. Worse, even if the user managed to change their language, sometimes tiny translation mistakes would render Firefox unusable. This led to the Yellow Screen of Death (shown on the right). The only solution for the Yellow Screen of Death would be to uninstall and then reinstall Firefox.

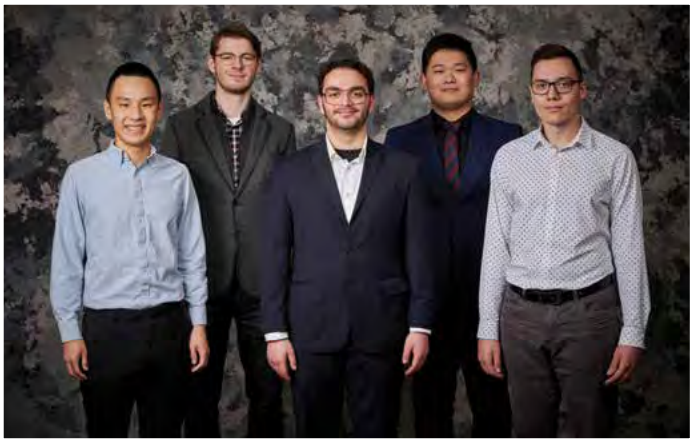
Our No More Yellow Screen of Death in Firefox software eliminates the Yellow Screen of Death by integrating Fluent, a technology Mozilla specifically developed to help with localization, throughout Firefox.

Integrating Fluent throughout Firefox also simplifies the process of changing languages, allowing the user to quickly change languages with the click of a button.

Additionally, our system uses Python scripts to automatically update certain old files to Fluent. Specifically, programmers only need to integrate Fluent in one language, by convention American English, after which our software automatically updates the other 99+ with no additional work from the programmer.



Firefox Browser



Michigan State University
Team Members (left to right)

Lifan Zeng
Troy, Michigan

Riley Byrd
Bloomfield Hills, Michigan

Julian Shomali
Corunna, Michigan

Bingjing Yan
Jinan, China

Artem Salniker
Oak Park, Michigan

Mozilla
Project Sponsors

Mike Conley
Toronto, Ontario, Canada

Gijs Kruitbosch
Hinckley, Leicestershire, United Kingdom

Jared Wein
Burton, Michigan

MSU Federal Credit Union
MSUFCU Achieve It

Founded in 1937, Michigan State University Federal Credit Union offers financial services to students, faculty, and staff of Michigan State University and Oakland University. With over $4.1 billion in assets and 280,000 members, MSUFCU is the largest university-based credit union in the world.

MSUFCU offers superior service while also helping their members and employees achieve financial security, their goals, and ultimately, their dreams. A cornerstone of their customer-focused offerings is educational content to inform and guide members.

Our MSUFCU Achieve It platform is a family-oriented educational tool to help children develop a healthy relationship with money and banking at an early age.

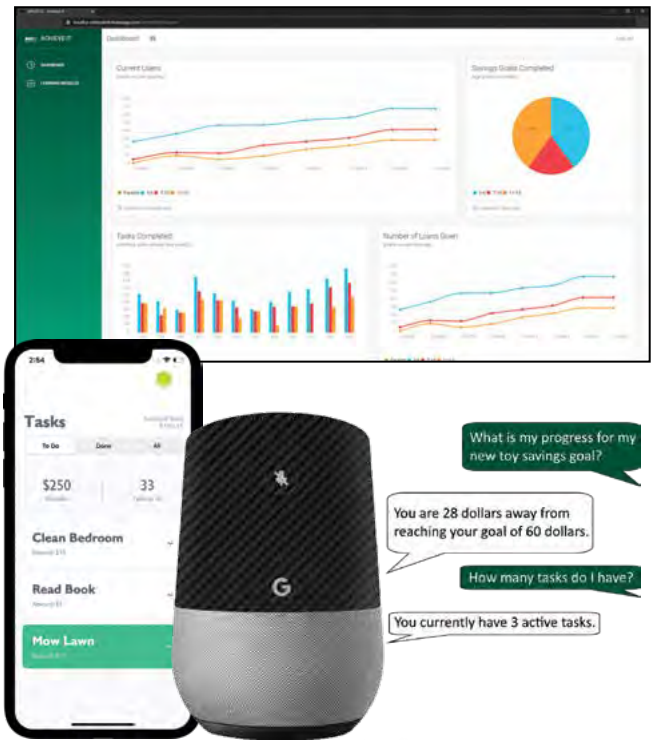
The customer applications of Achieve It are available on Android, iOS, web and Google Home, and enable children to learn about finances in an environment controlled by their parent.

Our applications allow parents to set tasks, goals, and lessons for their children to complete in order to earn real money. These tasks can include anything from household chores to watching videos on financial education.

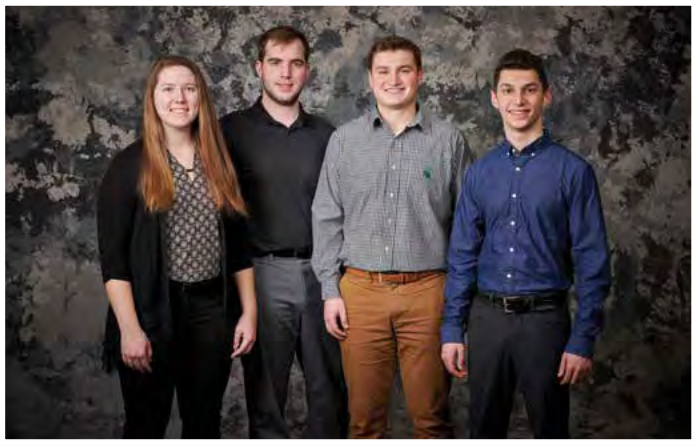
Children learn the value of money while completing tasks or lessons on our child Achieve It application and earn a monetary reward provided by the parent. Achieve It teaches children about the fundamentals of saving money, and also allows them to obtain loans administered by their parent to learn the difference between borrowing and saving.

Additionally, MSUFCU administrators can view statistics about Achieve It utilization through our web-dashboard to enable them to develop new and engaging content more easily.

Our software is developed in Kotlin and Swift for Android and iOS, ReactJS for web, and Google's DialogFlow for Google Home. The back end is built on the Google Firebase suite of products.



MICHIGAN STATE UNIVERSITY FEDERAL CREDIT UNION
Building Dreams Together



Michigan State University
Team Members (left to right)

Rachel Hamilton
Haslett, Michigan

Ben Carroll
West Bloomfield, Michigan

Ben St. John
Grand Rapids, Michigan

Michael Bachuri
West Bloomfield, Michigan

MSUFCU
Project Sponsors

Samantha Amburgey
East Lansing, Michigan

April Clobes
East Lansing, Michigan

Austin Drouare
East Lansing, Michigan

Collin Lochinski
East Lansing, Michigan

Ben Maxim
East Lansing, Michigan

Liam Petraska
East Lansing, Michigan

Val Torrey
East Lansing, Michigan

Place Technology
Predictive Support Module

Place Technology is a Salesforce Independent Software Vendor partner based in Austin, Texas. Salesforce is a cloud-based software company that provides companies with customer relationship management services and solutions.

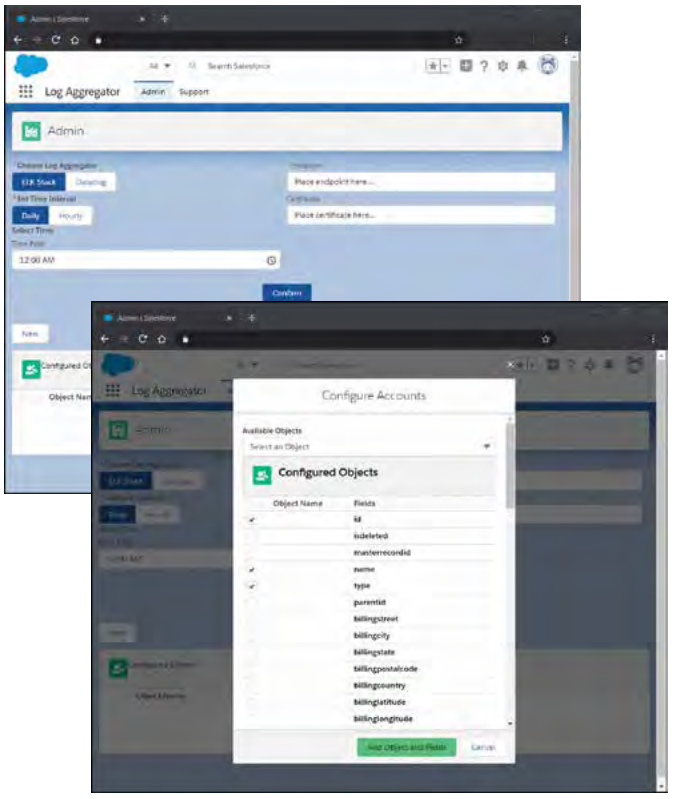
Place Technology has developed a Salesforce product, PlaceCPM, which enables customers to create future forecasts based on historical accounting transactions imported into their Salesforce environments. Place Technology is expanding this product with our Predictive Support Module, enabling customer support teams and other clients to easily extract and store data.

Each customer has their own personalized version of Salesforce installed in a cloud environment called a Salesforce Organization. It is necessary for independent software vendor partners to provide customer support for the products they sell using the Salesforce customer base.

Our Predictive Support Module makes it easier for customer support to retrieve log data and analyze it so that they can resolve issues the customer may have. This is achieved through a Salesforce Managed Package that sends data to a log aggregator for further analysis by customer support.

The Predictive Support Module is available on the Salesforce AppExchange for installation onto a customer's Salesforce Organization, similar to downloading an application onto an iPhone from the App Store. After being installed and configured, the module sends data from Salesforce objects to a log aggregator either on demand or at a predetermined interval specified by an organization's administrator.

The customer can create a support issue, add additional information to the issue (including log data), and forward it to customer support. The two log aggregators the customer can choose between are Datadog and the ELK Stack.



place.CPM
simplify financial forecasting

Michigan State University
Team Members (left to right)

Mithuun Srinivasan
South Lyon, Michigan

Kingston Tran
Caledonia, Michigan

Lin Cheng
Qingdao, Shandong, China

Brian Dokas
Ann Arbor, Michigan

Angela Satullo
Beverly Hills, Michigan

Place Technology
Project Sponsor

Kabe VanderBaan
Austin, Texas

Principal Financial Group
ARIN Application Launcher

Principal Financial Group of Des Moines, Iowa is a leading global investment manager. Their financial services include retirement planning, insurance, and investment. They are a Fortune 500 company and manage over $735.3 billion in assets.

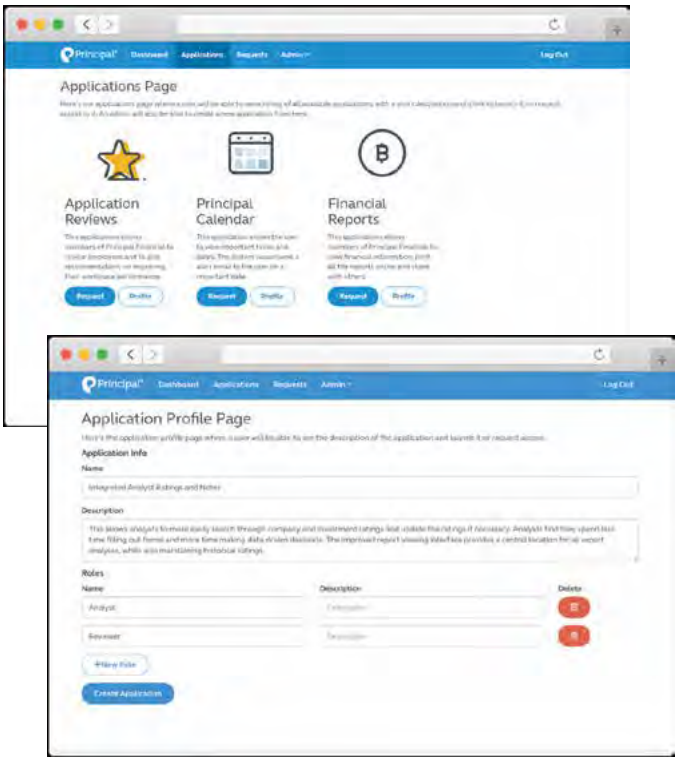
The Data Science team at Principal Global Investors (PGI) is responsible for building systems, models, and frameworks to analyze large data sets and produce forward-looking insights. To this end, the Data Science team builds and deploys many web applications.

As these applications are built, user management and authentication adds a significant amount of overhead to the development process. Our Analytics Research Intelligence Network (ARIN) Application Launcher eliminates this overhead by providing a single point of access for employees to manage, request access to, and launch applications.

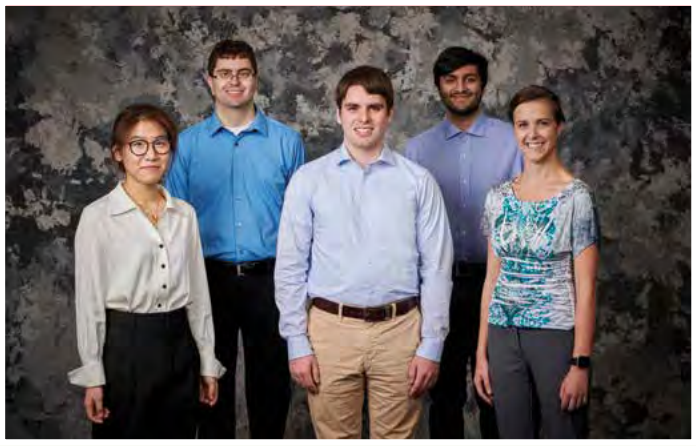
After logging in, users see a dashboard showing all of the applications to which they have access. They can either launch an application or browse through a list of applications. A user can click on an application to view a description, image, and list of all approved roles. They can request access to the application, which is either approved or denied by an administrator based on the role of the requestor.

When a user launches an application, they are redirected and receive context-sensitive information provided by our ARIN Application Launcher.

The ARIN Application Launcher is built with a serverless architecture, using the React JavaScript framework and a suite of Amazon Web Services for storage (S3, DynamoDB), routing (CloudFront), authentication (Cognito), and the hosting of our functions (Lambda).



Principal



Michigan State University
Team Members (left to right)

Shiyi Zhao
Hangzhou, Zhejiang, China

Matt Adomshick
Wheaton, Illinois

Seth Killian
Jackson, Michigan

Raaed Khan
Freeland, Michigan

Maegan Johnson
Holland, Michigan

Principal AAL
Project Sponsors

Joe Byrum
Des Moines, Iowa

Harris Federman
Des Moines, Iowa

Alexana Frahm
Des Moines, Iowa

Farshad Niayeshpour
Des Moines, Iowa

Principal Financial Group
Investment Portfolio Construction

Founded in 1879, the Principal Financial Group is a financial services company headquartered in Des Moines, Iowa. They are a member of the Fortune 500 and a global investment management leader, managing $735.3 billion in assets as of December 2019.

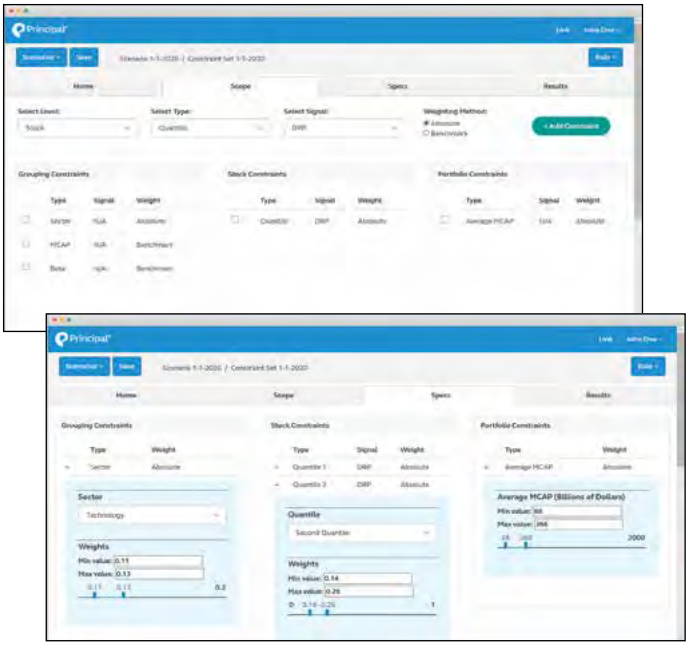
The company's success as an asset manager is contingent on their ability to construct a variety of investment portfolios that are optimized to provide returns for their individual and institutional investors. Thus, investment analysts at Principal need an efficient way to generate and tweak portfolio constructions based on different constraints and quantitative signals.

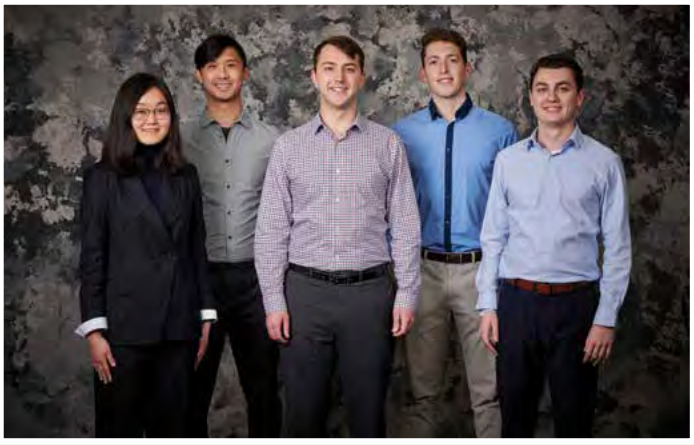
Our Investment Portfolio Construction system is a web application that provides a user interface for investment analysts to communicate with Principal's existing optimization engine and generate portfolio constructions.

The application allows users to specify a set of constraints and an objective around which to construct a desired portfolio. Once the user specifies all desired parameters, the application sends this information to Principal's optimization engine, which uses the data to construct an optimized portfolio. Our application retrieves this portfolio construction and displays it to the user.

Additionally, the Investment Portfolio Construction system provides users with the ability to save constraint sets and portfolio results as scenarios within the application. The scenarios can either be saved so that only the saving user can access them, or the scenarios can be saved to be accessed by a user's entire group within the company. This allows analysts to collaborate and iterate on portfolio constructions based on changing factors and signals.

Our application is built according to the serverless architecture model using Amazon Web Services (AWS). The technologies utilized include the Angular framework, AWS S3, AWS API Gateway, AWS Lambda, and AWS DynamoDB.





Michigan State University
Team Members (left to right)

Yue Wang
Beijing, China

Don Nakashima
Novi, Michigan

Andrew Watson
Dexter, Michigan

John Parke
Sterling Heights, Michigan

Sean Kennedy
Pittsburgh, Pennsylvania

Principal IPC
Project Sponsors

Joe Byrum
Des Moines, Iowa

Harris Federman
Des Moines, Iowa

Alexana Frahm
Des Moines, Iowa

Farshad Niayeshpour
Des Moines, Iowa

Proofpoint
Predictive Engine for Long-Term Malware Detonation

Headquartered in Sunnyvale, California, Proofpoint is a cybersecurity firm focusing on enterprise-level threat tracking, mitigation, and elimination. While Proofpoint is known for client endpoint protection, they also employ an extensive R&D infrastructure for handling and analyzing new malware.

Analyzing malware is challenging. Viruses, spyware, ransomware and other malicious programs come in many forms. To protect its customers, Proofpoint analyzes malware using tools called sandboxes, which are isolated computing environments where malware can be tested safely. The industry standard is a short-term analysis on malware samples for 2 to 15 minutes each.

However, malware developers know of sandboxes and often design their malware to change its behavior weeks or months after infecting a system. Because of this, short-term malware analysis is not always effective in determining the effects of certain malware.

Our Predictive Engine for Long-Term Malware Detonation platform offers an intuitive web dashboard to efficiently manage malware samples and analysis, as well as a service to quickly identify unique and duplicated malware samples.

Our website allows Proofpoint analysts to upload malware samples, view the results of previously analyzed samples, monitor currently running malware, and view overall system statistics.

When a malware sample is uploaded from our dashboard, it is automatically analyzed in a few minutes to determine if it is unique or similar to previously run samples. Because running the sandbox for long periods of time is expensive, our system will prioritize unique malware samples for long-term analysis and discard duplicated samples to save on processing time and money.

Our predictive engine is implemented in Python, using Cuckoo, YARA, and OPNsense. Our web app uses Angular 8 for the front end, and Python Flask and MongoDB for the back end.

proofpoint™

Michigan State University
Team Members (left to right)

Izzy Dove
Iron Mountain, Michigan

Joshua Wilson
Allendale, Michigan

Alex Kendall
Hartland, Michigan

Geoffrey Witherington-Perkins
Arlington Heights, Illinois

Samuel Gendelman
West Bloomfield, Michigan

Proofpoint
Project Sponsors

Leilani Alejo
Sunnyvale, California

Mercedes Sanchez
Sunnyvale, California

Brad Woodberg
Plymouth, Michigan

Technology Services Group
Volunteer Onboarding and Patient Visit Management

Founded in 1996 in Chicago, Technology Services Group (TSG) is an expert in data and document management. TSG has many clients across a wide range of industries and is a leading provider of content management solutions.

TSG also works with nonprofit companies in the medical industry who are often burdened with large volumes of documents and forms. Two of the most common include employee onboarding documentation and patient forms. Human resource representatives spend much of their valuable time tracking and collecting these documents.

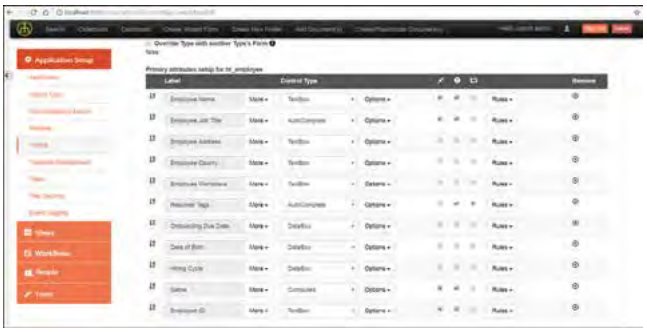
Our Volunteer Onboarding and Patient Visit Management system integrates the power of the Microsoft Azure cloud with TSG's existing software, OpenContent Management Suite (OCMS) to create new OCMS dashboards to streamline the creation, upload, and management of employee onboarding documentation and patient forms.

Our newly designed web dashboards simplify the employee onboarding process by aggregating the completed and outstanding necessary documentation to one central location. Employees can use our visualization tools to quickly track the progress of a new employee's onboarding and monthly patient visits.

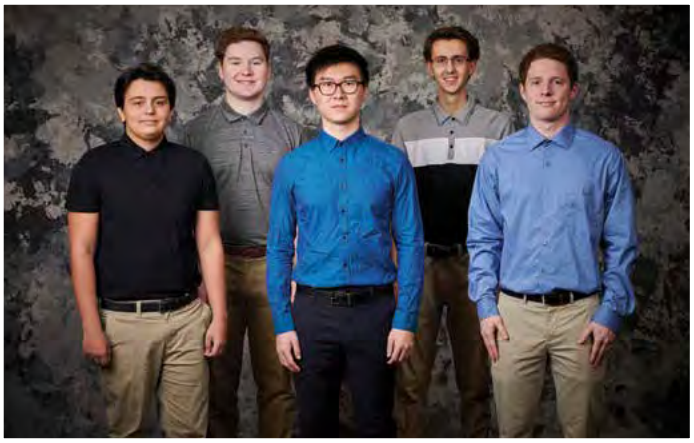
Additionally, employees can automatically record, save, and track patient visits without the need for paper forms. Employees can search, add, and update any required patient documents quickly and easily.

Our system saves employees significant time and energy. Patient tracking is now automatically handled in one convenient location that can be accessed by anyone at any location.

Our Volunteer Onboarding and Patient Visit Management system utilizes Apache Tomcat, HTML, Java, JavaScript, and the Microsoft Azure cloud service HDInsight.



technology services group



Michigan State University
Team Members (left to right)

Lazaro Cruz
Wyoming, Michigan

Will Giger
Naperville, Illinois

Xiaokuan Zhang
Beijing, Beijing, China

Genya Dobrev
Walled Lake, Michigan

Jacob Harris
Plainwell, Michigan

Technology Services Group
Project Sponsors

Marc Brouillette
Chicago, Illinois

Brad Doherty
Chicago, Illinois

Dave Giordano
Chicago, Illinois

Nick Quillin
Chicago, Illinois

Graham Singer
Chicago, Illinois

TechSmith
Smart Camera

To help its customers communicate more effectively, TechSmith assists in the creation of images and videos. Its flagship products, Snagit and Camtasia, are used by more than 30 million customers, worldwide.

Many customers of TechSmith do not have a background in video production. This lack of experience can often lead to less than professional content.

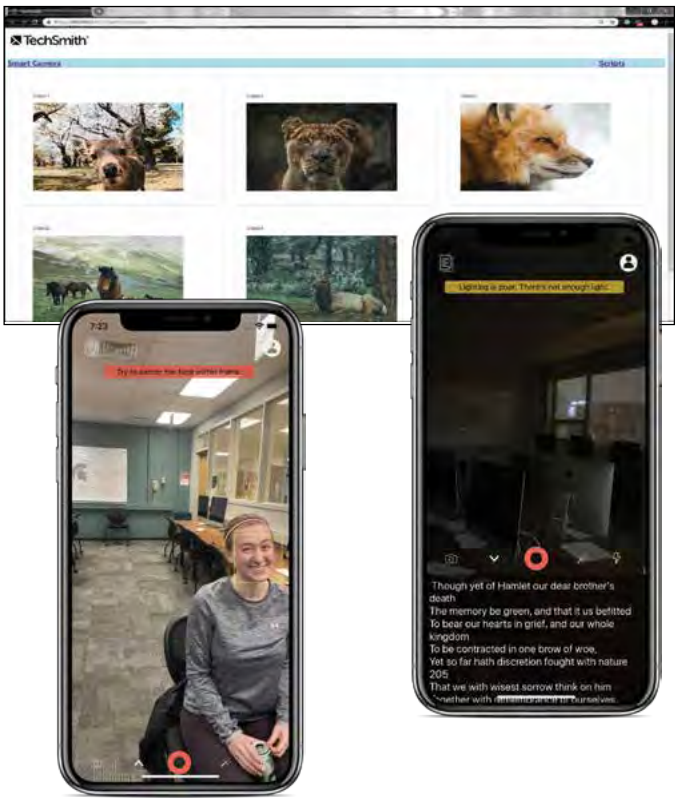
Our Smart Camera software assists TechSmith users in creating better video content through intuitive, easy-to-use mobile and web applications. The content created using our system can be easily used with TechSmith's video editing software, Camtasia.

The Smart Camera iOS application offers a suite of tools to give video creators feedback and advice on filming in real time. As the user films a video, our software automatically analyzes video frames continuously to provide feedback on the lighting quality, as well as the framing of their video scenes. Example feedback can be seen in our screenshots on the right.

Smart Camera also supports a live teleprompter feature on mobile devices to display prepared scripts during filming. The teleprompter non-obtrusively overlays the user's script on the camera view (shown on the right).

The Smart Camera web dashboard allows users to create and manage their scripts, which can be exported to the Smart Camera mobile application for filming. Additionally, the web dashboard aggregates all completed video assets, including scripts and raw video files. These assets can be exported automatically from the Smart Camera mobile application.

Our web application is made using JavaScript, C# and the ASP.NET core framework. Our web application, video storage, and database are hosted on Microsoft Azure. The mobile application is written in Swift.



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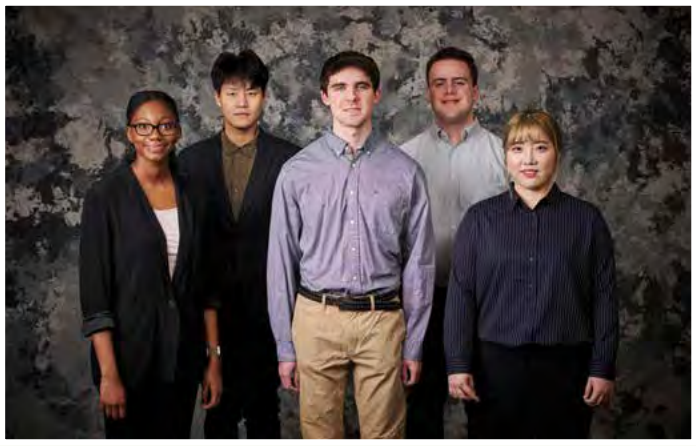


Michigan State University
Team Members (left to right)

Omo Irumundomon
Chicago, Illinois

Zhaolin Liu
Chongqin, China

Nathan Anthony
Grand Rapids, Michigan

Drew Bensinger
Canton, Michigan

Amy Kim
Incheon, South Korea

TechSmith
Project Sponsors

Rob Allie
Okemos, Michigan

Ryan Eash
Okemos, Michigan

Wendy Hamilton
Okemos, Michigan

Tony Lambert
Okemos, Michigan

Dave Norris
Okemos, Michigan

Jill Rinckey
Okemos, Michigan

Paul Stanos
Okemos, Michigan

United Airlines
Safety Reporting and QC Audit Center Mobile App

United Airlines is the world's second largest airline, operating approximately 4,900 flights a day and transporting over 150 million passengers a year out of 362 airports around the globe. To maintain its fleet of 1,300 aircraft and ensure successful flights, it is crucial to identify and resolve safety concerns and hazards.

Over 88,000 employees work for United Airlines, yet less than 10% of the airport operations employees fill out safety reports, called GSAP forms. This is because GSAP form submission can only be done on a desktop computer, meaning that employees in the field must go inside and find an available computer in order to fill out a form.

Similarly, the Quality Control (QC) Audit forms are currently filled out with pen and paper while the employee is in the field, and then require additional time for the employee to input that information onto a computer.

Using our Safety Reporting and QC Audit Center Mobile App, employees can efficiently and effectively fill out GSAP and QC Audit forms in the field.

Within the application, users can create, save and submit forms. Saved forms can be accessed at a later time via desktop or mobile app, and are available until the employee submits the form or the form expires. The application caters to an employee's position and only shows the types of forms that are applicable to their specific role.

This application helps employees save time and effort by enabling the completion of GSAP and QC Audit forms in the field. The ease of use incentivizes more employees to fill out safety reports, increasing participation in the GSAP program.

Our Safety Reporting and QC Audit Center Mobile App is built with Swift and Texture for iOS, Kotlin for Android, Python and Django for the API, and a Microsoft SQL Server database.

Michigan State University
Team Members (left to right)

Camille Emig
Grand Rapids, Michigan

Ivan Zhang
Chongqing, Chongqing, China

Allison Lollo
Novi, Michigan

Josh Jarvis
Novi, Michigan

Tudor Robaciu
Farmington Hills, Michigan

United Airlines Airport Operations
Project Sponsors

Melissa Baker
Houston, Texas

Mario Bufo
Chicago, Illinois

Adriana Carmona
Chicago, Illinois

Christine Clarida
Chicago, Illinois

John Kleberg
Chicago, Illinois

Kaitlyn Shanahan
Chicago, Illinois

Rachel Shultz
Chicago, Illinois

Scott Turner
Chicago, Illinois

United Airlines
Virtual Reality Aircraft Walkaround

United Airlines is one of the world's largest airline companies. Headquartered in Chicago, they operate 4,900 flights a day from 362 airports worldwide.

Prior to each of these flights, technicians perform an aircraft walkaround to identify potential defects and issues with the aircraft. Training for this task is mainly done on the job, with little control over the types of defects or issues that can be demonstrated.

Our Virtual Reality Aircraft Walkaround software mitigates this problem by allowing technicians to be trained through virtual reality simulations on iPads and Oculus Quest headsets.

Virtual Reality Aircraft Walkaround features both user training and testing modes. In training mode, the technician performs a guided walkaround in virtual reality. Defects appear on the aircraft with popup boxes that display information about what the technician should look for in that location.

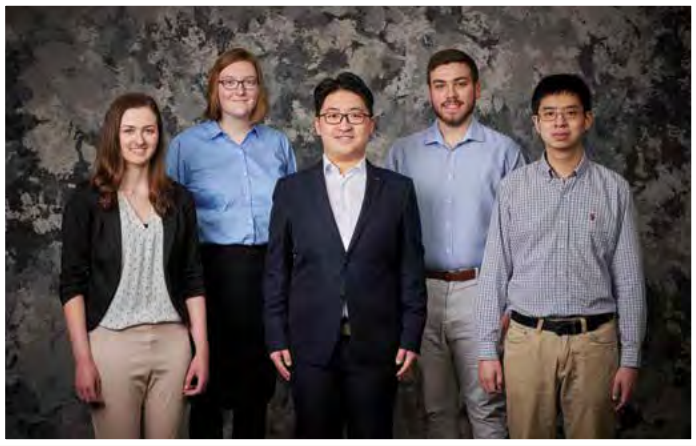
In testing mode, the technician spots and marks defects in an unassisted walkaround. After the technician completes the walkaround, a report that provides a summary of the technician's performance is generated. The report is saved for instructors to assess a user's progress. The technician is given the opportunity to return to the aircraft and review any mistakes.

A variety of aircraft models are available for both training mode and testing mode walkarounds. Each aircraft has a number of preset scenarios with predetermined defects. In testing mode, the technician may also choose a randomized scenario that spawns different defects on the aircraft each time.

Our software allows United Airlines to train technicians quickly, effectively, and cheaply.

Our software is developed with the Unity game engine. Scripts are written in C#, and the reports are saved using Unity Analytics. The software is available on both the iPad and the Oculus Quest.

UNITED



Michigan State University
Team Members (left to right)

Caitlin Brown
Albany, New York

Ellie Locatis
Byron Center, Michigan

Jiachen Lin
Wusu, China

Jacob Turcano
Lake Orion, Michigan

Cheney Wang
Grand Rapids, Michigan

United Airlines Safety
Project Sponsors

Amadou Anne
Chicago, Illinois

Craig Bennett
Chicago, Illinois

Rick Brown
Chicago, Illinois

Shiju Samuel
Chicago, Illinois

Mike Wisniewski
Chicago, Illinois

United Airlines
Training Scheduling and Optimization System III

United Airlines is a major international air-carrier operating 4,900 flights per day from 362 airports. Operating an airline requires diligence in all logistical and technical aspects to ensure the proper flight experience for "Every customer. Every flight. Every day."

Within United Airlines, the TechOps training division is responsible for the operations of aircraft and their important maintenance. The TechOps team leverages a sub-team of 45 instructors to teach a catalog of 100+ courses for around 700 classes per year to their skilled team of 7,000 technical staff members. Currently, the orchestration of scheduling these courses is the responsibility of a single individual.

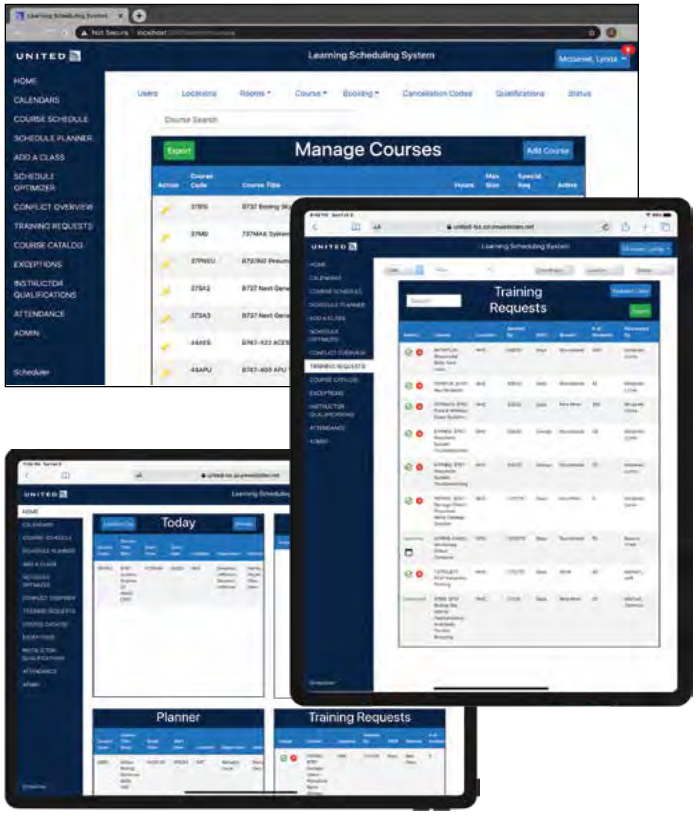
Our Training Scheduling and Optimization System III provides a production-ready web app to facilitate United's maintenance training schedulers to schedule instructors, students, classrooms and courses across the country.

A scheduler uses our mobile compatible website to add classes to the schedule manually or make use of the schedule optimizer. The schedule optimizer automates the scheduling of multiple classes at a time. Our optimizer can schedule months of classes in a few minutes, compared to the many hours it currently takes to schedule these courses.

An automatic email system alerts the scheduler of important changes, including when new training requests or employee availability changes arrive.

Our platform streamlines the scheduling process for United Airlines' TechOps division, allowing their employees to spend their time on more important tasks.

Our software is built using ASP.NET Core 3.1, Angular 8, Node.js, an Entity Framework, and an Azure SQL Database. The web app is hosted on Azure Cloud Platform.



Michigan State University
Team Members (left to right)

Sam Vitu
Saginaw, Michigan

Weiyu Huang
Quanzhou, Fujian, China

George Poliakov
Farmington Hills, Michigan

Sean Wisely
Clarkston, Michigan

Amanda Hackbardt
South Lyon, Michigan

United Airlines Training
Project Sponsors

Amadou Anne
Chicago, Illinois

Craig Bennett
Chicago, Illinois

Rick Brown
Chicago, Illinois

Lynda McDaniel
Houston, Texas

Tom Wilson
Chicago, Illinois

Urban Science
AutoHook Mobile Redemption Tool

Headquartered in Detroit, Urban Science is internationally renowned for providing data-driven, science-based solutions to problems in the automotive, health, and retail industries. AutoHook is a subsidiary of Urban Science and assists automotive dealers and OEMs in increasing walk-in customer traffic.

AutoHook currently provides a voucher redemption service used by auto dealerships. This service allows dealers to redeem customer's vouchers at the dealership for rewards, such as gift cards. Currently, the redemption service is solely available as a desktop website, meaning that all redemptions must be performed using a computer.

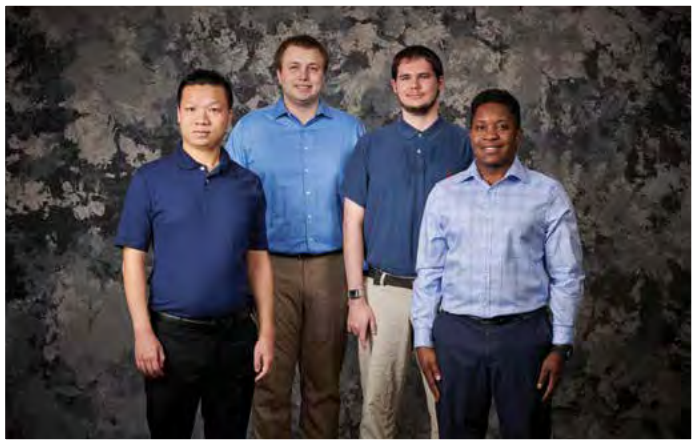
Our AutoHook Mobile Redemption Tool enables auto dealers to utilize any mobile device with a web browser to redeem vouchers for their customers.

Dealers have access to our redemption tool from anywhere, including the vehicle lot or during customer test drives. Additionally, our redemption tool utilizes the camera found in most mobile devices as a barcode scanner. This allows dealers to scan the barcode located on a customer's voucher instead of being required to manually enter the relevant information.

Additionally, our AutoHook Mobile Redemption Tool offers intuitive visualizations and graphs of helpful statistics and calculated metrics to enable dealers to understand the effectiveness of their voucher campaigns. Also included in our platform is a dedicated question and answer section, which includes useful documentation and training videos.

AutoHook Mobile Redemption Tool is an online web application designed to work on all modern mobile browsers. The front end, created with Angular 8, is easy to extend and modify. The tool makes use of a supporting ASP.NET back end on 4.8 .NET Framework.

URBAN SCIENCE



Michigan State University
Team Members (left to right)

Heng Yan
Hua Yuan, Hubei, China

Devin Hook
Delton, Michigan

Justin Perry
Birch Run, Michigan

Torel Welsh
Southfield, Michigan

Urban Science
Project Sponsors

Robert Buttery
Detroit, Michigan

Mike DeRiso
Detroit, Michigan

Anthony Graziosi
Detroit, Michigan

Elizabeth Klee
Detroit, Michigan

Matthew Menzies
Detroit, Michigan

Adam Serruys
Detroit, Michigan

Vectorform
Rumble Test Suite

Vectorform, headquartered in Royal Oak, Michigan, invents digital products and experiences both for their own products and for the world's leading brands.

Our Rumble Test Suite includes a Rumble device, an iOS application, and a web application. The Rumble Test Suite upgrades washing machines by recognizing, in real time, when a washing machine has finished running.

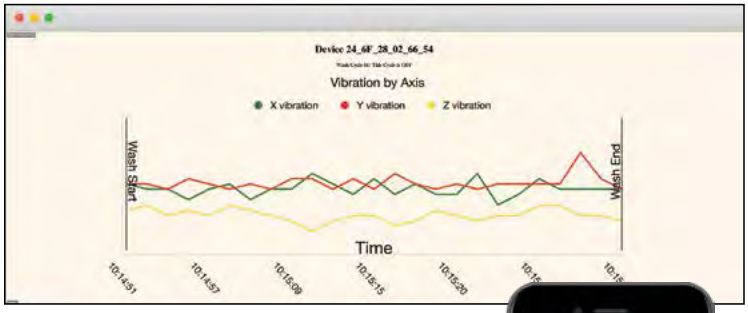
The Rumble device contains a sensor that detects the vibrations coming from a washing machine. Additionally, the Rumble device contains communication technology to wirelessly transmit the information from its sensors across the internet.

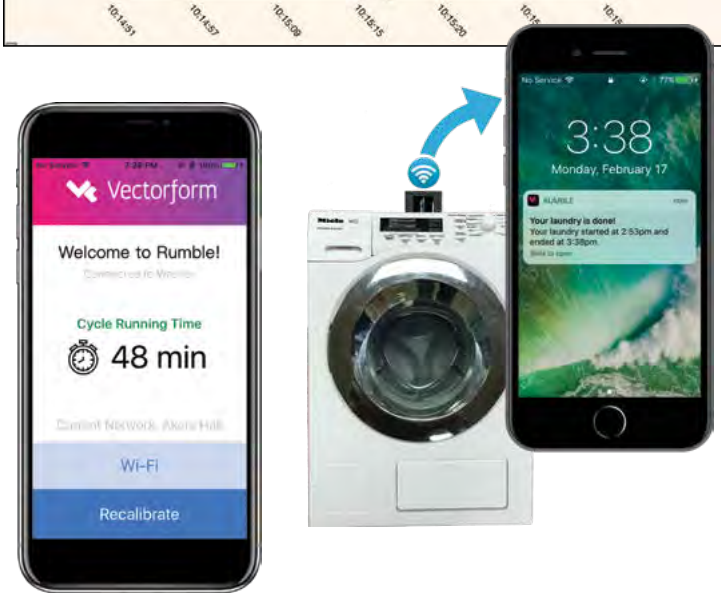
Using the data collected from the Rumble device, our Rumble Test Suite distinguishes when a washing machine is operating, and when it has finished. Our solution uses deep learning to make predictions on the state of the washing machine. Additionally, our solution is generalizable to any type of washing machine and wash cycle. This allows our platform to be widely deployed without any additional development overhead.

The iOS application alerts users when their laundry finishes, affording people more freedom to do other activities without worry of forgetting their laundry.

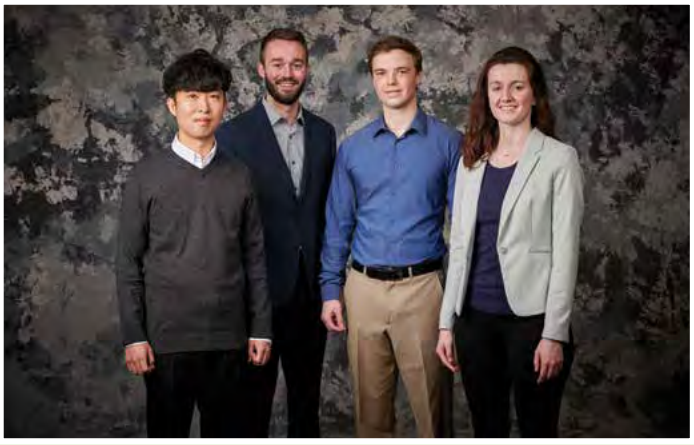
The iOS app configures the Rumble device while it is deployed, allowing developers to quickly diagnose and fix any problems. Our web app displays all wash cycle data from the Rumble device for analysis by Vectorform employees.

The Rumble Device contains an ESP32 and an accelerometer. The ESP32 is connected to an iOS device using Bluetooth Low Energy. The accelerometer reads vibration data that is pushed to our MySQL database over MQTT. The web application is implemented using HTML, CSS and the ReactJS extension Victory React for data visualization.





Vectorform



Michigan State University
Team Members (left to right)

Hyeungsuk Kim
Seoul, South Korea

Andreas Frame
Clarkston, Michigan

Reis Wiedemann
Clarkston, Michigan

Anna Quenon
Novi, Michigan

Vectorform
Project Sponsors

Chris Cornish
Royal Oak, Michigan

Anthony Laurain
Royal Oak, Michigan

Jeff Meador
Royal Oak, Michigan

Josh Parmenter
Seattle, Washington

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. The winners are selected on Design Day by a panel of distinguished judges.

Auto-Owners Insurance Exposition Award

Auto-Owners INSURANCE
LIFE • HOME • CAR • BUSINESS

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 TechSmith
Smart Automatic Video Creation

Jiaqi Zuo, Patrick Renner, Scott James, Mingzhu Wei, James Davison
Presented by Scott Lake and Tony Dean

MSU Federal Credit Union Praxis Award

MSU Michigan State University FEDERAL CREDIT UNION
Building Dreams Together

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 Mozilla
Splitting the Atom. Again

Alex Vamvounis, Teja Bayya, Carson Greene, Tyler Staats, James Jahns
Presented by Ben Maxim

Design Day Judges

Steve Akers
MaxCogito

E.J. Dyksen
Michigan State University

Ben Maxim
MSU Federal Credit Union

Michael Taylor
Google

Ryan Anderson
Herman Miller

Rich Enbody
Michigan State University

Rob McCurdy
PwC

Frank Weith
Volkswagen

Amadou Anne
United Airlines

Garrett Gaw
Amazon

Asif Naseem
Paragon Development Systems

Melissa Woo
Michigan State University

Mike DeRiso
Urban Science

Dave Giordano
Technology Services Group

David Norris
TechSmith

Karen Wrobel
Fiat Chrysler

Bob Dyksen
Evolutio

Keith Landau
ATX

Karen Sadler
Michael Sadler Foundation

TechSmith Screencast Award

TechSmith®

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 Meijer
Creating Picking and Fulfillment Efficiency

Mitchell Setsma, Dylan Iseler, Yingbao Wang, Aslan Tashtanov, Sarah Mostofizadeh
Presented by Wendy Hamilton and David Norris

Urban Science Sigma Award

URBAN SCIENCE

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

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

Team Evolutio
ERP Air Force: Drone Elephant Recognition and Tracking

Rei Doko, Jeremy Arsenault, Tyler Lawson, Nic Wiggins, Kunyu Chen
Presented by Mike DeRiso and Bill Bye

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: Anna Citko

Team Members	Project Title
Group #1: Maryann Kukla, Jarred Mcpherson	Smartphone App Using MIT App Inventor
Group #2: Kurt LaBlanc, Brian Liu, Gabe Phibbs	Simulating Different Circuits with Smartphone Apps
Group #3: Ethan Dowd, Jose Garciajimenez, Niko Koris	Making Educational Videos Based Off of In-Class Labs
Group #4: Heding Huang, Hanlin Ouyang, Jiafeng Yu	Smartphone App Using MIT App Inventor
Group #5: Lucas Cletterbaugh, DaQuan McClean, Jack Pawlicki	How to Use MATLAB Mobile
Group #6: Deaven Kirn, Erin McAliden, Logan Teitsma	MIT App Inventor Flashcard App
Group #7: Devyansh Agrawal, Ethan Crawford, Jack Lister	Programming a Game in C++
Group #8: Zhonggi Jiang, Sibo Peng, Auditya Shasty	Creating an App Using Programming in C

The Capstone Projects

Dr. Lalita Udpa
Professor of Electrical and Computer Engineering

Dr. Mi Zhang
Assistant Professor of Electrical and Computer Engineering

Faculty Advisors: Baryshev, Deng, Li, Morris, Sepulveda, Udpa, Wang


Baryshev


Deng


Li


Morris


Sepulveda


Udpa


Wang

Presentation Schedule – Room 2243 Engineering Building, Second Floor

Time	Team Sponsor	Project Title
8:00 a.m.	MSU Solar Racing Team	J1772 Charging Control Board
8:25 a.m.	Hillsdale Hospital	Lighting System for Horse & Buggy Injury Reduction
8:50 a.m.	Texas Instruments	Radar Sensor & Camera Fusion for Autonomous Vehicles
9:15 a.m.	City of St. Johns	Characterization of Buried Water Service Line Materials
9:40 a.m.	MSU Office of the VP for Auxiliary Enterprises	Robotics in a Residence Hall Dish Room 2.0
10:05 a.m.	MSU ECE Department	Aerial Aggregate Analyzer
10:30 a.m.	Niowave	Improved Phase-locked Loop for Electron Accelerators

ECE 480 Senior Design

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

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

MSU Solar Racing Team
J1772 Charging Control Board

The Michigan State University Solar Racing Team has been designing and racing cars competitively since their founding in 2000. Their first solar powered vehicle was built in 2010; subsequently they have produced five different models.

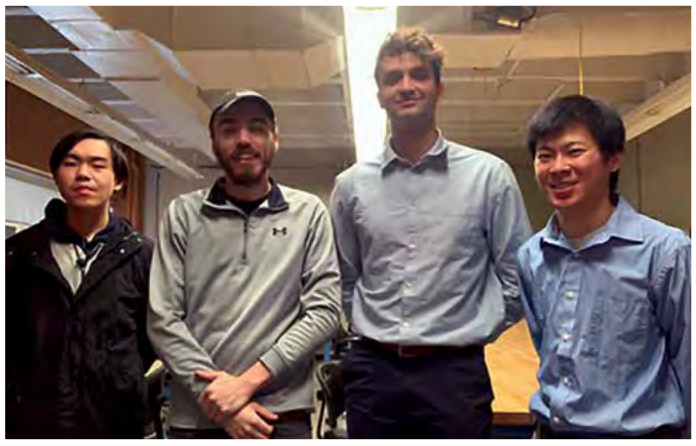
The team is working on their current vehicle, Aurora, and they hope to compete in the Formula Sun Grand Prix later this year. This model is built for two people and uses an onboard charging module, which enables it to be charged at standard level two charging stations.

Our project is a continuation of the work of the Fall 2019 capstone team. It involves designing an interfacing circuit to monitor and control the charging device. Data are communicated among the Electric Vehicle Supply Equipment, the charger, the battery management system, and a power distribution board. A CAN, which is interfaced via a DB-9 Connector, is used to communicate between the charging station and the vehicle. The board to be created will be programmed on an Arduino Due with feedback from the CAN data.

The final product will enable a user to monitor the charging systems and allow them to adjust current output using potentiometers. To observe and control the charging module, diagnostic LED lights will be used to monitor the states and the monitored states will be displayed on an LED screen. A 12V external power supply will be included together with an emergency shut-off switch in the event of a malfunction.

SAE J1772-2009 Electric Vehicle Connector

MSU SOLAR RACING TEAM



Michigan State University
Team Members (left to right)

Xuan Zhao
Guangdong, China

Devin Palmer
Owosso, Michigan

Nick Sly
Macomb, Michigan

Itsuki Okamoto
Monroe, Michigan

MSU Solar Racing Team
Project Sponsors

Jacob Randall
East Lansing, Michigan

Shubham Shedge
East Lansing, Michigan

Project Facilitator

Dr. Bingsen Wang

Hillsdale Hospital: Lighting System for Horse and Buggy Injury Reduction

Founded in 1915, Hillsdale Hospital is a community-based hospital, providing quality healthcare in the community.

Since then, Hillsdale Hospital has been committed to providing high-quality health care services, such as acute inpatient services, skilled nursing rehabilitation, state-of-the-art joint replacement and bariatric surgery, all with a personal, caring touch.

They have noticed that there is a significant need for improvement in lighting systems that are currently in place within the Amish community. With the interest of reducing injuries and properly integrating this lighting technology into the culture, the hospital chose to address this issue.

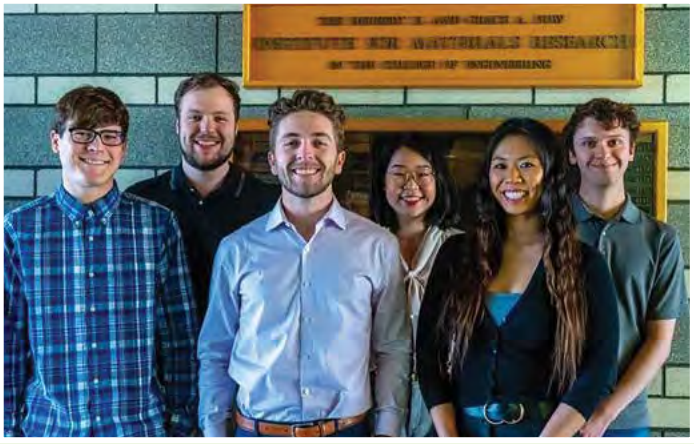
Our LED-Based Lighting System reduces the risk for injury by providing a horse and buggy system with proper lighting mechanisms. The system is a magnitude brighter than the current system in place. In addition, it allows a user to signal turns, signal braking, and employ headlights.

The headlights are powered by multi-D cell batteries. These batteries are recharged by a solar panel located on the buggy.

To ensure durability, the lights are encased and firmly installed on padded material. This allows for doubling of waterproofing and vibration proofing.

Modern engineering assessment, marketing analysis, and electrical engineering design have been used to provide safety augmentation to centuries old horse and buggy transportation.

HILLSDALE HOSPITAL
Caring. Commitment. Community.



Michigan State University
Team Members (left to right)

Nick Freda
Canton, Michigan

Chris Nastoski
New Baltimore, Michigan

Michael Woodham
Macomb, Michigan

Xinxin Xiao
Hunan, China

Elaine Nguyen
Holland, Michigan

Jason Sargent
Northville, Michigan

Hillsdale Hospital
Project Sponsor

John Cargill
Hillsdale, Michigan

Project Facilitator

Dr. Tongtong Li

Texas Instruments: Radar Sensor & Camera Fusion for Autonomous Vehicles

Autonomous vehicles depend on multiple sensors including cameras, lidars, radars and ultrasound for driving safely and optimally in a variety of weather and road conditions. Sensors have differing resolutions, accuracies, ranges, and behaviors, particularly under adverse weather conditions. As a result, sensor fusion will be of paramount importance for achieving level-4 autonomous all-weather driving.

In this project, a system that combines the TI 77 GHz radar module (currently used in the automotive industry) with a camera for object recognition and identification was developed. While cameras are very accurate when detecting objects in clear conditions, radar can provide additional support in less optimal conditions.

Our project involves sensor synchronization, calibration, data-logging and detection-level fusion using radar and camera sensors to be used for autonomous driving. The system performance was evaluated under a variety of conditions and distances.

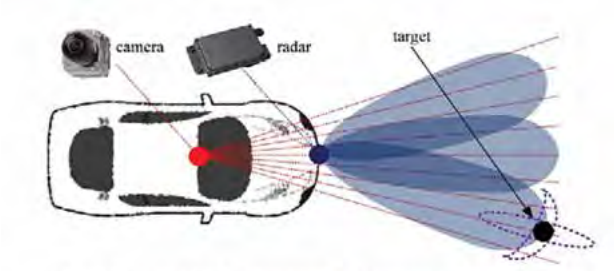


Figure 1. Expected fusion results of camera and radar sensors.

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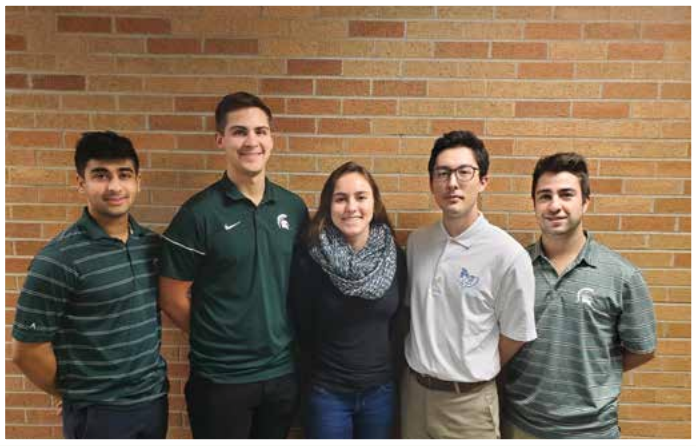


Michigan State University
Team Members (left to right)

Neeraj Pagel
Troy, Michigan

Thomas Pavey
Grand Rapids, Michigan

Whitley Huelskamp
Grand Blanc, Michigan

Dakota Kuhn
Dearborn, Michigan

Lucas Pucheta
Northville, Michigan

Texas Instruments
Project Sponsor

John Papapolymerou

Project Facilitator

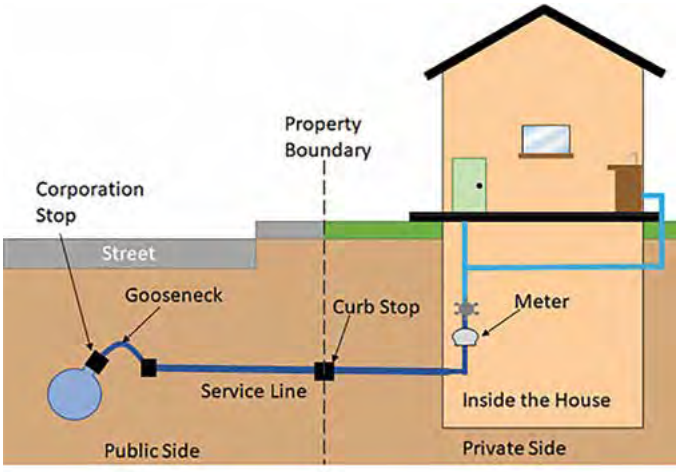
Dr. Daniel Morris

City of St. Johns: Characterization of Buried Water Service Line Materials

Lead is a durable and malleable metal that was commonly used for water service lines in Michigan until the 1950's. While lead's properties have made it an optimal pipe material, it is not safe for human consumption or handling due to its toxicity. There is poor documentation regarding the usage and extent to which lead service lines were installed in homes. This makes it difficult to determine if a home has a lead service line in need of replacement without excavating. Presently, the only way of identifying pipe material is invasive and costly. The development of a non-invasive method to identify pipe material would allow a more efficient transition of infrastructure to safer materials.

Our project is to develop a non-invasive method of identifying different service line materials by building a self-contained, easy-to-use system capable of identifying the nature of the service line material. We will leverage the unique resistivity values of the service line materials in designing this device.

The principle on which the device would work involves applying a high current power source through the pipes and measuring the voltage across the pipe. Using Ohm's law, we will then be able to calculate the resistance of the pipe and further determine the resistivity. The calculated resistivity will then help us determine the material that likely makes up the service line.



Michigan State University
Team Members (left to right)

Ashtyn Carvalho
Lake Orion, Michigan

Noor Ali
Dadaab, Kenya

Terran Williams-Bowens
Farmington Hills, Michigan

Marie-Irene Yayishimiye
Kigali, Rwanda

Ewurama Owusu-Hammond
Accra, Ghana

Emily Kulkis
Lake Orion, Michigan

Allyssa Sanderson
Macomb, Michigan

Claire Marquardt
Lake Orion, Michigan

City of St. Johns
Project Sponsor

Jon Stoppels
St. Johns, Michigan

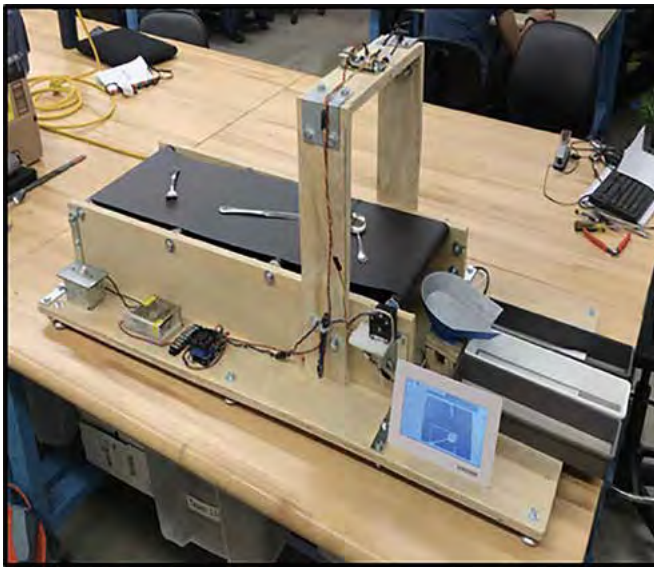
Project Facilitator

Dr. Satish Udpa

MSU Office of the VP for Auxiliary Enterprises
Robotics in a Residence Hall Dish Room 2.0

The Michigan State University Brody dining hall provides 1.6 million meals a year. The dining hall staff has made it their mission to provide a clean environment for students in order to reduce the risk of cross-contamination. The most important task of the dish room is to ensure that all the dining utensils are cleaned extensively to prevent illnesses caused by harmful bacteria.

Our project is to improve the existing robot design of a system that processes and sorts dining hall utensils into their assigned bins. For this redesign we plan to implement a process that has the capability of capturing higher resolution images for the object recognition feature to detect silverware on the conveyer belt. With this redesign we are focused on decreasing the processing time for the recognition software and improving the productivity within the dish room.



Michigan State University
Team Members (left to right)

Nolan Carter
Kalamazoo, Michigan

Arielle Tolbert
Southfield, Michigan

Jordan Claxton
Detroit, Michigan

Tia Smith
Detroit, Michigan

Isaiah Carter
Kalamazoo, Michigan

MSU Office of the VP for Auxiliary Enterprises
Project Sponsors

Stacey Dawson
East Lansing, Michigan

Donald Donagrandi
East Lansing, Michigan

Project Facilitator

Dr. Yiming Deng

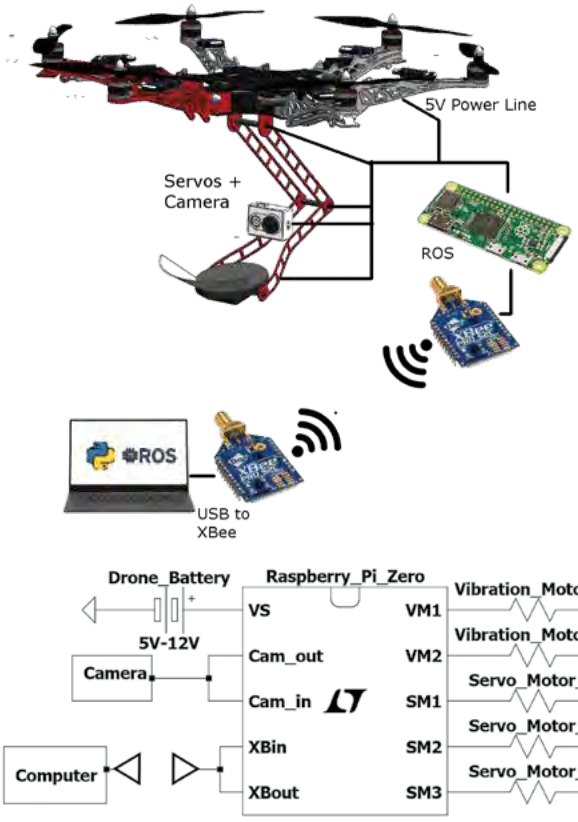
MSU Department of Electrical & Computer Engineering: Aerial Aggregate Analyzer

The long-term objective of the aerial aggregate analyzer project is to develop a system that will remotely inspect the quality and size of aggregate before it is used in road construction. To achieve this, our team will develop an arm and scoop that will attach to a drone capable of flying to aggregate sites in large quarries. This will help save time and resources, as well as ensure the safety of personnel working around large quarry machinery.

The robotic arm will have three main functions: (1) scoop, settle, and rotate aggregate, (2) capture high resolution images from multiple angles, and (3) send images to a laptop to construct a 3D model of the aggregate. It will be a two-link arm with a rotating scoop attached to the bottom as a third link. The total weight will be under 600g, which is within the payload capacity of a mid-sized quad/hex rotor.

The arm will be controlled via a laptop with graphical interface from a safe distance away (up to 1 mile). An onboard Raspberry Pi will control the servo motors, vibrational motors, and camera and will remotely communicate with the laptop using long-range XBee transceivers.

The final demonstration of the project will showcase the analysis of aggregate by using the designed arm attached to a table, images collected by the camera and transmitted to the remote laptop using the Raspberry Pi and XBee transceivers, and the reconstruction of aggregates using 3D Zephyr software.



College of Engineering
MICHIGAN STATE UNIVERSITY

Michigan State University
Team Members (left to right)

Anna De Biasi
Plymouth, Michigan

Anna Schierlinger
Rochester Hills, Michigan

Cory Hilton
Chesterfield, Michigan

Audrey Guest
Rochester Hills, Michigan

Jacob Swaneck
Hartland, Michigan

Megan Henderson
Rochester Hills, Michigan

MSU Department of Electrical & Computer Engineering
Project Sponsor

Vaibhav Srivastava
East Lansing, Michigan

Project Facilitator

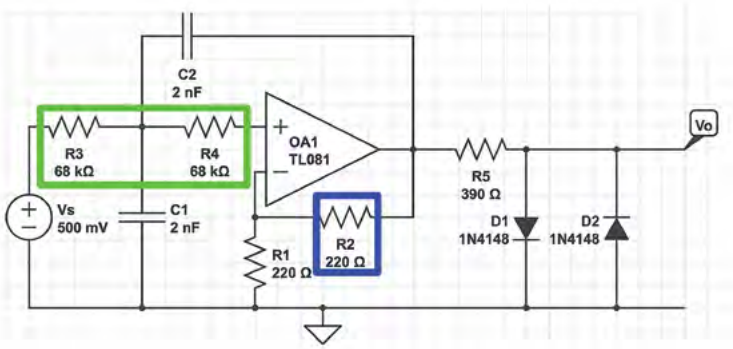
Dr. Sergey Baryshev

Niowave Inc.: Improved Phase-locked Loop for Electron Accelerators

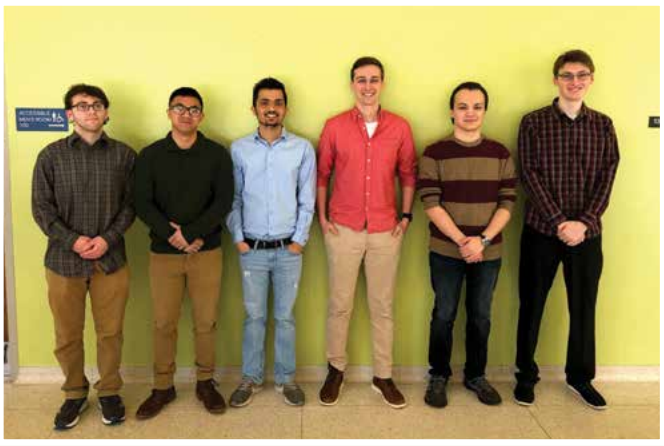
Niowave, Inc. located in Lansing, Michigan is a spinoff of Michigan State University dedicated to the production of radioisotopes through the use of high-power superconducting electron accelerators. Complementary to the exotic isotopes being studied at MSU's Facility for Rare Isotope Beams, the medical isotopes being produced at Niowave include molybdenum-99, a precursor for a majority of the radioisotope studies being done in hospitals today, and new cancer-killing agents like the alpha-emitting actinium-225 (dubbed the "rarest drug in the world").

Electron beams are used to make x-rays which then split atoms in fuel rods or transmute targets by knocking out protons and neutrons. These high-power beams must be well controlled to prevent damage to the targets or to the accelerator, itself. One key system is the phase-locked loop (PLL), which aligns the frequency of all of the RF structures in the system to the superconducting niobium cavity. The intrinsic quality factor of the cavity is 109, and even when loaded down by the high-power beam, it remains 106.

Our project was to build a gain and filter block (loop filter) for the error signal in the PLL. This gain and filter block should be configurable for the different conditions under which the cavity is operated, and eventually should be capable of communicating via a digital channel to the programmable logic controller system. Specifications are that the block deliver an adjustable gain of 1 to 100 with a low-pass filter that has an adjustable cutoff frequency between 0.1 to 20 KHz.



NIOWAVE
Accelerating Your Particles



Michigan State University
Team Members (left to right)

Sean Castle
Shelby Township, Michigan

TJ Nguyen
Warren, Michigan

Indra Adhikari
Lansing, Michigan

Tim Drangines
Lake Villa, Illinois

Cobian Gleason
Berkley, Michigan

Jason Troppens
Shelby Township, Michigan

Niowave Inc.
Project Sponsors

Sam Baurac
Lansing, Michigan

Chase Boulware
Lansing, Michigan

Project Facilitator

Dr. Nelson Sepulveda

The Capstone Projects

Dr. Lalita Udpa
Professor of Electrical and Computer Engineering

Dr. Mi Zhang
Assistant Professor of Electrical and Computer Engineering

Faculty Advisors: Davila-Montero, McGough, Mitra, Morris, Radha, Salem, Srivastava


Davila-Montero


McGough


Mitra


Morris


Radha


Salem


Srivastava

Presentation Schedule – Room 2245 Engineering Building, Second Floor

Time	Team Sponsor	Project Title
8:00 a.m.	Bordrin	Sensor Calibration for an Automated Vehicle
8:25 a.m.	Consumers Energy	Real-Time Power System Analysis
8:50 a.m.	MSU RCPD/MSU Bikes	Intelligent Defense System (IDS)
9:15 a.m.	OIH/MSU RCPD	Energy Harvesting Active Battery Balance System
9:40 a.m.	MSU ECE Smart Microsystems Lab	Underwater Sensor Hub (Joint Project with ME 481)
10:05 a.m.	General Motors	Sound Emission for Hybrid/Electric Vehicles (Joint Project with ME 481)
10:30 a.m.	MSU Human Augmentation Technologies Lab	Wearable Interpersonal Monitor for Enhanced Teamwork
11:00 a.m	MSU/ME Department (Note: This presentation takes place in Room 2205 EB)	E-Bike Dynamometer (Joint Project with ME. See page 168 of this booklet).
11:30 a.m	Microsoft (Note: This presentation takes place in Room 1220 EB)	TeleTech Datacenter Telepresence Robot (Joint Project with ME. See page 149 of this booklet).

ECE 480 Senior Design

We gratefully acknowledge the support of this semester's project sponsors: Bourdrin, Inc., City of St. Johns, Consumers Energy, General Motors, Hillsdale Hospital, Microsoft, MSU Bikes, MSU ECE Smart MicroSystems Lab, MSU Electrical Engineering Department, MSU Human Augmentation Technologies Lab, MSU Mechanical Engineering Department, MSU Office of the Vice President for Auxiliary Enterprises, MSU Resource Center for Persons with Disabilities, MSU Solar Racing Team, Niowave, Inc., Orphans International Helpline, and Texas Instruments.

The ECE Project facilitators who supervised ECE 480 teams this semester are: Sergey Baryshev, Sylmarie Davila-Montero, Yiming Deng, Tongtong Li, Robert McGough, Joydeep Mitra, Daniel Morris, Hayder Radha, Fathi Salem, Nelson Sepulveda, Vaibhav Srivastava, Satish Udpa, and Bingsen Wang.

Bordrin
Sensor Calibration for an Automated Vehicle

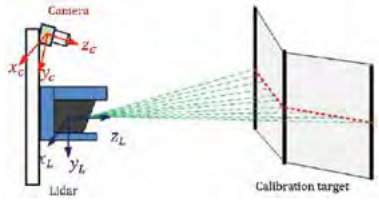
Bordrin is a smart electric vehicle company that has been working on advanced driver-assistance system (ADAS) and autonomous driving feature development. Their prototype vehicle is equipped with a smart front camera and a 360° lidar.

Our project is to develop a calibration method for the sensors in its perception system. Calibrating the lidar with the camera is important because both devices need to take precise data readings within a shared time period. When calibrated, these two devices will enable the ADAS to accurately identify the surroundings, regardless of certain factors, such as camera lens distortion. An uncalibrated system can create discrepancies, potentially leading to confusion in the ADAS.

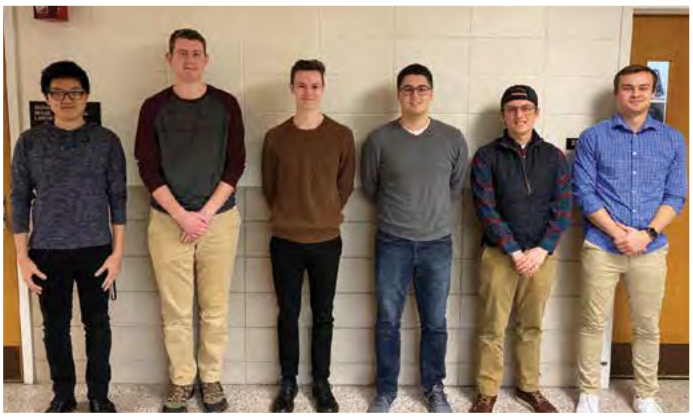
An ADAS sensing system and corresponding software will be designed to meet the customer's required specifications. This project consists of two parts. The first part is building a low-cost sensing and data collection system. This system will consist of an in-vehicle PC for data collection, a lidar sensor, and camera. An adjustable lidar/camera mount will be designed so that the two devices can read data from a similar perspective and can be moved around with ease.

The second part is developing an automated calibration method for the lidar and camera. Calibrating the lidar using stationary objects is the first step to developing a solution. After the lidar is calibrated, the camera can be calibrated by matching objects detected by the lidar, using OpenCV and other ROS software.

The two devices will be calibrated by comparing the angles of the lidar and camera, as well as the point where their perspectives intersect.



BORDRIN



Michigan State University
Team Members (left to right)

Walter Lee
East Point, Michigan

Kevin McMahon
Algonquin, Illinois

Tom Cansfield
Dexter, Michigan

Troy Anderson
Grand Ledge, MIchigan

Andrew Kilponen
Novi, Michigan

Drew Kapnick
Tecumseh, Michigan

Bordrin
Project Sponsor

Hiro Kawakubo
Oak Park, Michigan

Project Facilitator

Dr. Daniel Morris

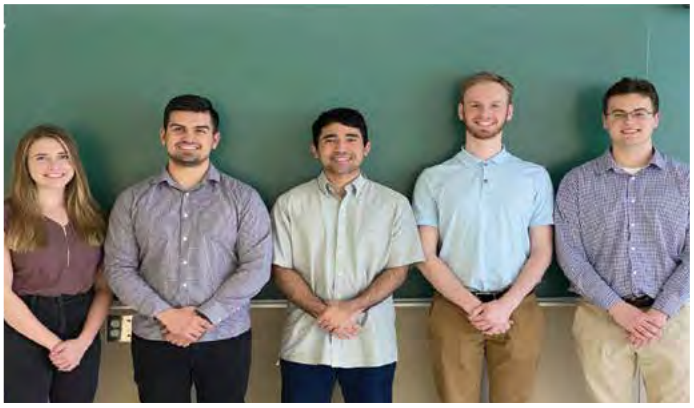
Consumers Energy
Real-Time Power System Analysis

To begin replacing coal power generation, Consumers Energy is preparing for an increase in Distributed Energy Resources (DER) penetration on its Low Voltage Distribution system. DER includes small scale energy technologies, such as solar gardens, that may connect to the transmission grid. Due to this transformation in the energy system, the best control methodology for the integration of new DER is unknown. To address this challenge, Consumers Energy is seeking a solar garden system analysis and a comparison between real-time digital power system simulators.

The solar garden system chosen for analysis is the Kalamazoo solar garden. The Kalamazoo solar garden includes, but is not limited to, a PV panel array, a battery storage unit, and an inverter. Through software simulations of the Kalamazoo solar garden circuit, case studies, such as various weather conditions, load values, and fault types, are investigated under both transient and steady-state conditions. These studies provide Consumers Energy insight on how to manage and design DER.

The three leading manufacturers of real-time digital power system simulators—RTDS technologies, OPAL-RT technologies, and Typhoon HIL—are compared based on criteria that Consumers Energy will consider when deciding which simulator to purchase. For example, two factors of the criteria are the number of buses per rack and the simulator's ability to communicate with Consumers Energy's existing control system. This comparison provides Consumers Energy real-time digital power system simulator information to reference as needed.

Consumers Energy
Count on Us®



Michigan State University
Team Members (left to right)

Emily Fluent
Lake Orion, Michigan

Ryan Champagne
Riverview, Michigan

Majeed Fardin
Inkster, Michigan

Shaun Fillwock
Mason, Michigan

Quentin Hinshaw
Glencoe, Illinois

Consumers Energy
Project Sponsors

Matthew Henry
Jackson, Michigan

Rosanna Kallio
Jackson, Michigan

Leo Martinez
Jackson, Michigan

Project Facilitator

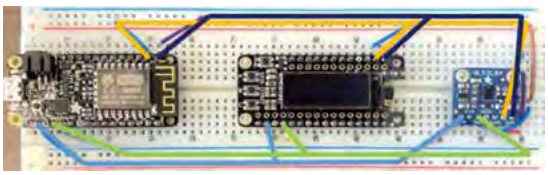
Dr. Joydeep Mitra

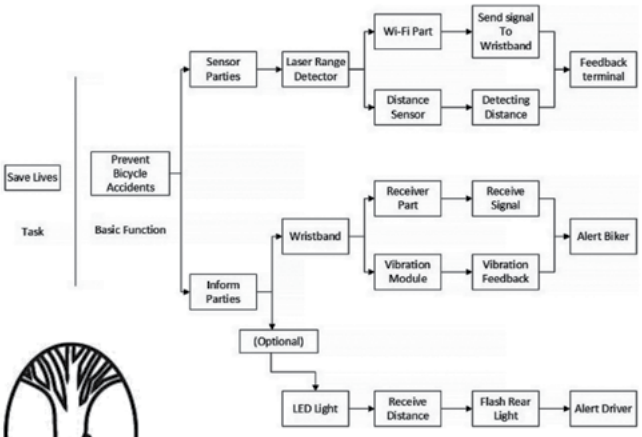
MSU RCPD/MSU Bikes
Intelligent Defense System (IDS)

Due to the increasing number of people distracted by their cellphone use while walking or driving, the safety of cyclists is severely threatened. Our project is to develop a lightweight, portable and simple system that can alert cyclists to impending danger.

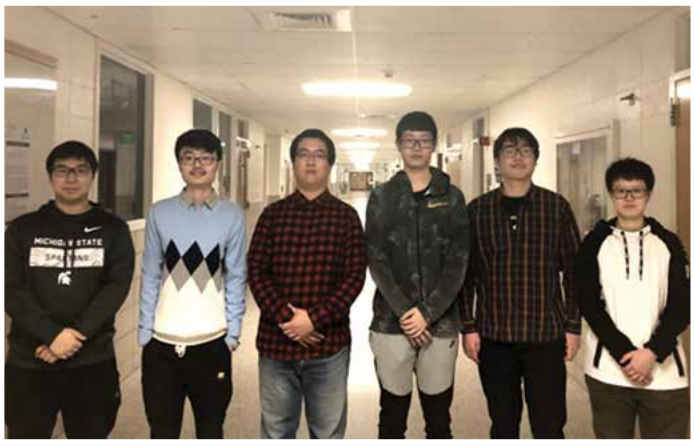
There are several systems that have been implemented, including radar and camera detection. Neither of these systems is optimal. Radar detection is expensive, and the reaction time using camera detection is slow.

We plan to create a distance sensor, which uses light that reflects the area around a bike. The system is lightweight, portable and inexpensive, making it a better alternative. A WiFi module will be used to transmit the signal. It will have a microcontroller for processing data and sending a signal to a band mounted on the bike. The band then vibrates, warning the cyclist of potential danger. The use of WiFi allows the system to be hands-free as well.





RCPD
Maximizing Ability & Opportunity



Michigan State University
Team Members (left to right)

Yuanhui Zeng
Beijing, Beijing, China

Boshi Feng
Hami, Xinjiang, China

Yue Gu
Beijing, Beijing, China

Ruhao Chen
Shanghai, Shanghai, China

Taozhan Zhang
Hangzhou, Zhejiang, China

Yongqian Gao
Shanghai, Shanghai, China

MSU RCPD / MSU Bikes
Project Sponsors

Steven Blosser
MSU RCPD

Tim Potter
MSU Bikes Service Center

Project Facilitator

Dr. Hayder Radha

Orphans International Helpline/MSU RCPD
Energy Harvesting Active Battery Balance System

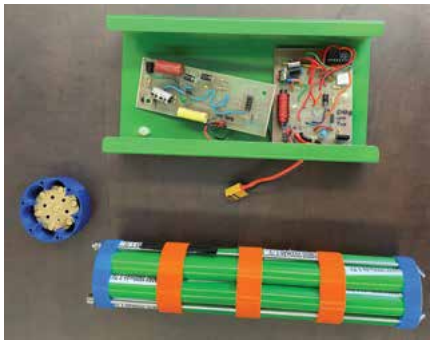
Founded in 2003, Orphans International Helpline (OIH) is a non-profit company created to help orphans in Haiti. They provide shelter, medical care, clothing, food, and Christian education for many children. Due to many natural disasters in the region and lack of domestic and foreign investment, it is very difficult to maintain and control the basic needs such as electricity and water.

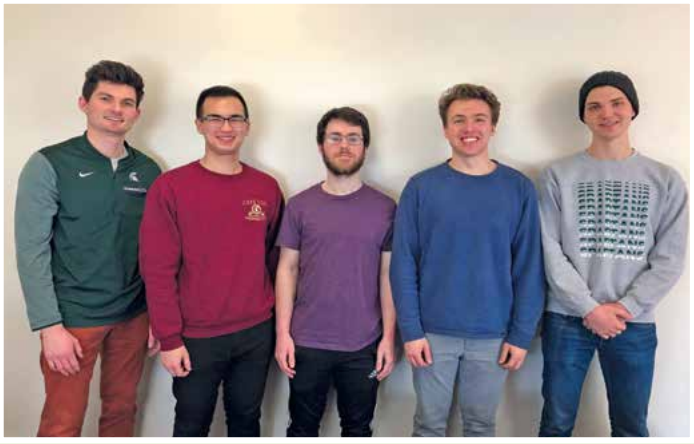
Currently a hospital is being built in Haiti, which is entirely funded by donations and will be self-sufficient in terms of its energy consumption. It will be powered by solar panels, wind turbines, and generators, and will use lithium batteries to store energy.

Our project is to design and build an active battery management system that can collect and store the power from each source. Also, the system needs to be able to detect and manage the voltage of each cell individually to ensure that no cell is strained more than any other during charge and discharge.

The system needs to be designed such that the people in Haiti can build the system themselves by following given instructions.

In order to meet the functional requirements of the project, the active battery management system will monitor the voltage of each cell and control power flow based on the relative strength of each cell during charge and discharge to increase battery health and efficiency.





Michigan State University
Team Members (left to right)

Jack O'Boyle
Hartland, Michigan

Alexis Haselwanter
Clarkston, Michigan

Kyle Jones
Rochester Hills, Michigan

Alexander Koenig
South Lyon, Michigan

Mark Lapinski
Beverly Hills, Michigan

Orphans International Helpline/MSU Resource Center for Persons with Disabilities
Project Sponsor

Steven Blosser
East Lansing, Michigan

Project Facilitator

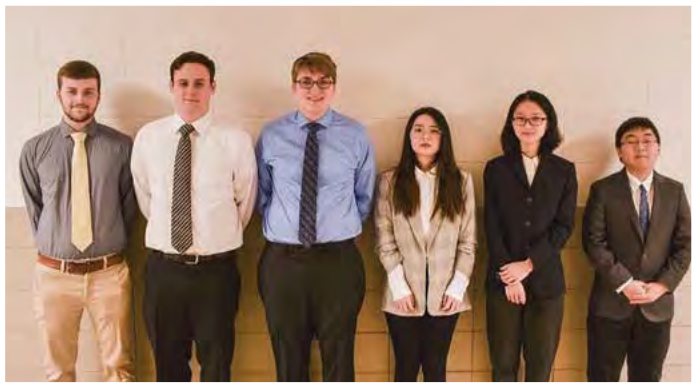
Dr. Fathi Salem

MSU ECE Smart Microsystems Lab
Underwater Sensor Hub

Exploration of the bottom of lakes, oceans, and other bodies of water is a growing research field. The Smart Microsystems Lab at Michigan State University has taken great interdisciplinary strides toward understanding their surroundings. Accordingly, many sensory modalities are employed to collect various types of data on the body of water, such as depth, temperature, and current velocity.

Our project is to create and update previous components of an underwater sensor hub capable of collecting data on depth, pressure, and from preexisting fish acoustic tags. The hub is designed to be compact, waterproof, and able to withstand water pressure at a depth of 30m. The hub data collection and power level inside should be able to communicate with an onboard receiver via a protected ethernet cable and a Raspberry Pi. The entire sensor hub is able to come apart to allow access into the sensor hub for periodic inspection and servicing. An automated winch system has also been updated to better deploy and store the underwater sensor hub. The purpose is to design an effective and easy-to-use sensor hub that can accurately collect the desired data for the Smart Microsystems Lab research.

College of Engineering
MICHIGAN STATE UNIVERSITY



Michigan State University
Team Members (left to right)

Justin Carbary (ME)
South Lyon, Michigan

Ethan Schrader (ME)
Williamston, Michigan

Jacob Ortmann
Saline, Michigan

Xinyang Yu
Chengdu, China

Jingyi Shen
Changsha, China

Eric Song
Birmingham, Michigan

MSU ECE Smart Microsystems Lab
Project Sponsor

Dr. Xiaobo Tan
East Lansing, Michigan

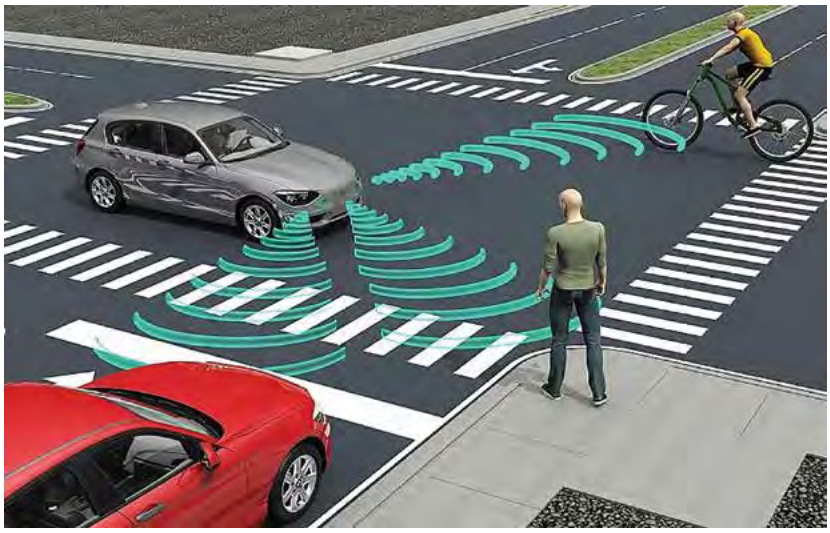
Project Facilitator

Dr. Vaibhav Srivistava

General Motors
Sound Emission for Hybrid/Electric Vehicles

Hybrid/Electric Vehicles are extremely quiet due to the lack of an internal combustion engine. This can cause a safety hazard for pedestrians because the vehicle is too quiet to alert them. This hazard has prompted the government to enact safety regulations for these vehicles. This regulation has required Electric Vehicles to emit an artificial sound to alert pedestrians of the vehicle's presence.

Our project is to create the sound generating system and the integration of the system into the vehicle. The safety requirements of this system mandate that there must be a certain sound intensity at various distances around the vehicle. We approached this problem by creating a transducer to push the desired sound through waveguides to the outside of the vehicle to alert pedestrians.



Michigan State University
Team Members (left to right)

Jason Smith
Owosso, Michigan

Zijing Wu (ME)
GuangDong, China

Scott Anthony (ME)
Grand Rapids, Michigan

Tianyu Han (ME)
Qingdao, China

Anthony Bassett
Eaton Rapids, Michigan

Nicholas Wilson
Livonia, Michigan

James Haven
Clarkston, Michigan

General Motors
Project Sponsor

Douglas Moore
Milford, Michigan

Project Facilitator

Dr. Robert McGough

MSU Human Augmentation Technologies Lab: Wearable Interpersonal Monitor for Enhanced Teamwork

Have you ever had to work in a team that left you frustrated? Ever struggled to cooperate and had no idea how to improve? Imagine a world where there was a device that improved teamwork. Effective team interactions could be enhanced by making team members aware of their emotions, intentions, and methods of communicating.

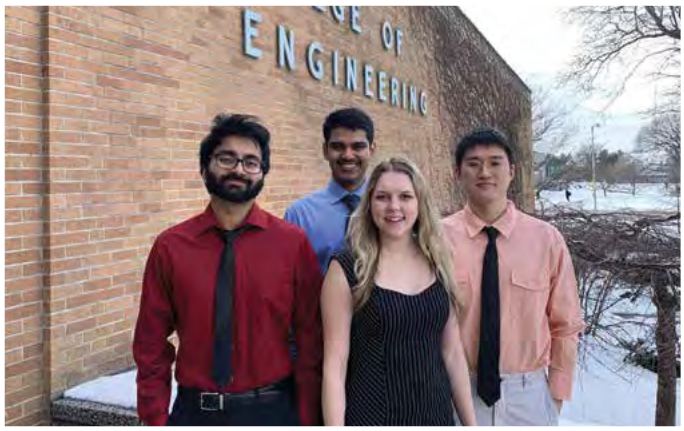
Much of today's technology is focused on individualized products that have a side-effect of isolating their users from the real world. With Teamwork Enhancing Accessory, Modernizing Communication and Accelerating Productivity (TEAM CAP), we are hoping to change this reality and create a gadget that can enhance our interpersonal relationships.

We will achieve this by monitoring non-verbal channels of communication between team members and analyzing their patterns of behavior. In the workplace, people interact with each other throughout the day using both verbal and non-verbal communication. Non-verbal communication refers to all aspects of communication that do not make use of words. This includes gestures, body language, the distance between individuals, and voice intonation.

Most of our communication is non-verbal and people engage in behavioral communication whether consciously or unconsciously. In essence, the way individuals deliver non-verbal messages is just as important as verbal dialogue. Extraction and analysis of these non-verbal cues can help enhance team cohesiveness and interpersonal relationships by drawing awareness to their behaviors.

Our goal is to produce a wearable device that is capable of monitoring dialogue functions of position, attention and speech factors from multiple person interactions in real time.

HAT lab
Human Augmentation Technologies



Michigan State University
Team Members (left to right)

Sriram Motheram
Ann Arbor, Michigan

Varun Venkatrao
Hyderabad, India

Sidney Schrand
Farmington Hills, Michigan

Toby Wang
Chengdu, Sichuan, China

MSU Human Augmentation Technologies Lab
Project Sponsor

Andrew Mason
East Lansing, Michigan

Project Facilitator

Dr. Sylmarie Davila-Montero

Design Day Awards Fall 2019

Electrical & Computer Engineering Winners, Fall 2019

Prizes are awarded each semester to the most outstanding teams in the Electrical and Computer Engineering Senior Capstone Design Course, as judged by a panel of engineers from industry. A team with members from both ECE and another engineering major (mechanical engineering, for example) is also eligible, if the team's project is administered through ECE 480.

First Place:
Team MSU Offices of the Executive VP for Administration: "Smart Hotel Cart System"

Left to right: Natalie McQuade, David Osinski, Shelby Webber, Mitchell Loe, Jon Spight, Ryan Mulka

Second Place:
Team MSU Solar Racing Team: "BEV Level 2 On-Board Charging Module"

Left to right: Stephen Pietras, Jacob Randall, Evan Charles, Shubham Shedge, Gabriel Romzek

Third Place:
Team MSU ECE Robotics Lab: "Robotic Crop Weeder"

Left to right: Anthony Doan, Greggory Adams, Jacob Reinauer, Kristopher Canty, Devon Thompson, Jamie Mortensen

8:00 a.m. - 11:45 a.m. Engineering Building, Room 1252 | First Floor

ME 412 Heat Transfer Laboratory

Yuping Wang
Academic Specialist
Department of Mechanical Engineering

Cooling With A Vortex Tube

Heating and cooling processes can be found everywhere, and, thus, a variety of systems are designed to meet the needs for thermal management. For this project, students are asked to focus their attention on the various ways to enhance cooling. Each team will conduct a review on different types of cooling systems, then on a specific cooling application of their interest. Each team will also design, build, analyze, and test a vortex tube, which is commonly used in industrial spot cooling. A Ranque-Hilsch vortex tube is a simple, compact, light mechanical device that separates a single inflow of compressed air into two outflows: one hot and one cold. The design objective is to maximize the temperature difference between the hot and cold streams. There are no restrictions on the dimensions of the tube, but the compressed air will operate at a fixed setting. On the testing day, compressed air will be provided. Temperatures of the hot and cold outflows will be measured. Each team will have 15 minutes to set up, demonstrate, and dissemble their vortex tube. In addition, they will also prepare a power-point slide show or video clip for the audience to explain their design decisions, analysis, and operations of their device.

Competition Schedule

Time	Station	Team members
8:00	A	Mike Falter, Stephen Oberheim, Matt Rice, Thomas Smither, Lucas Walsh
	B	Cameron Barghahn, Liam Kelly, Dylan Lott, Diego Prakash, Megan Weiss
8:15	A	Brandon Chan, Devon Davenport, Ben Washington, Elias Zepeda-Barragan, Lucas Zheng
	B	Torre Crown, Justin Gilgallon, Zach Hoffman, Nehemiah Mork, Justin Stasevich
8:30	A	Rachel Arnold, Ajay Mehta, Andrew Mizer, Joey Pinakidis, Taylor Ruelle
	B	Vincent Richard, Kyle Woods, Xiaoyu Xiong, Haoran Zhang, Haoyang Zhang
8:45	A	Matthew Arenz, Austin Aselage, Nick Borellis, Paul Han, Ryan Kalis
	B	Sam Addy, Scott Anthony, Evan Drew, Yash Gupta, Nick Pak
9:00	A	Sadab Bahar, Jordan Bommarito, Ryan Fantin, Pankti Tank, Joe Troy
	B	Jenna Dalrymple, Radhika Murgai, Alyssa Salciccioli, Jayme Stiglich, Nadine Twal
9:15	A	Adam Bolyard, Steven Dubey, Rhylan Huss, Mausam Patel, Stephen Wernette
	B	Humphrey Han, Ross Kelly, Jack Rees, Joe Russell, James Schradle
9:30	A	David Abatan, Latif Bouda, Chris McGinnis, Sam Rinke, Jin Zhang
	B	Abbey Bugenske, Danielle Keusch, Emily Oswald, Noah Rimatzki, Ben Vitek
9:45	A	Alex Kraski, Garrison Osborne, Brendan Rybicki, Jeremy StPierre, Connor Wilson
	B	Zak Kubiak, Sean Labadie, Matthew Rightor, Claire Trygstad, Yen-Cheng Wang
10:00	A	Andrew Albright, Naif Alzahrani, Ryan Ball, Zahji Billingslea, Kayla Gibbs
	B	Ghali Alwajih, Zac Brei, Rob Hernandez, Jacob Morrison, Tariq Salim
10:15	A	Wyatt Beachy, Nathan Engler, Owen Jarl, Erin Mettler, Benj Shapiro
	B	Adam Goodes, Minir Jakupi, Melissa Karas, Mitchell Morin, Caden Swindell
10:30	A	Devan Dejong, Mikayla Nitoski, Dominic Rende, Moe Tabateh, Volkan Vildirim
	B	Rourke Brummette, Helen Miller, Tim Ohtake, Alyse Richards, Brent Weakland
10:45	A	Matt Bergdolt, Jacob Broman, Victoria Farrell, Karl Havens, Daniel Quinn
	B	Michael Faber, Bradley Harris, Mike Johnson, Todd Myers, Kyle Raymo
11:00	A	Paul Beiter, Mira Crain, Mia Gilreath, Alex Kintner, Niranjan Kulkarni
	B	Devin Cao, Jillian Jukubiec, Leah Williams, Gabbie Wink, Zijing Wu
11:15	A	Christian Abbate, Timur Aminov, Brian Chan, Hongxiang Chang, Scott Maxey
	B	Trevor Dame, Brett Howe, Yeeun Lee, Nick Thiel, Tommy Tsuchiya
11:30	A	Ali Alhajji, Devon Killebrew, Zachary Kupa, Gi Lee, David Marshall, Kent Peterson
	B	Marcell Benkes-Toth, Joe Hegger, Taylor Jacobs, Paul Sytsma, Hannah Wyatt

ME 456
Mechatronic System Design

Dr. Guoming Zhu
Professor of Mechanical Engineering

Learning Objective:

The learning objective of ME456 is for students to understand the entire process of developing a mechatronic system. This includes: a) system modeling, b) PID control, c) control implementation to the Arduino platform using Simulink, and d) experimental validation. The class will also help students 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:

TheAn Arduino-based Mini Segway robotics (see figure) will be provided to each student who may use his/her own laptop (with installed Matlab/Simulink and Arduino library developed by MSU) to interface with the Mini Segway through the 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.

8:00 a.m. - 11:45 a.m. Engineering Building, Room 1345 | First Floor

ME 470 Mechanical Design & Manufacturing II

Michael Lavagnino
Academic Specialist
Department of
Mechanical Engineering

Palletizing Robot

The goal in this project is to design a small scale three degree of freedom palletizing robot that collects and stacks items of cylindrical shape within a 2-minute time period. The teams will utilize mechanisms such as 4-bar linkages, gear sets, and cam-follower systems. Each team manufactured or utilized 3D printing to create the majority of their components. Performance will be measured by the total weight stacked divided by the total weight of the robot.

Time	Team	Station	Team members
8:00	1	A	Garrett Armock, Nick Holda, Aaron Pekrul, Brandon Phan
	1	B	Samantha Halaby, Brendan Jones, Ajay Mehta, Joey Pinakidis
8:15	2	A	Evan Chechack, Parker Dukus, Nattida Jubju, Scott Kelley, Alison Reinhold
	2	B	Alec Bailey, Tyler Davis, Ethan Mekjian, Andrew Scott
8:30	3	A	Adam Lyons, Greta Myran, Alaura VanNest, Jacob Wallace, A.R. Zebdi
	3	B	Jillian Jukubiec, Ryan Stawara, Mark VanBuskirk, Yen-Cheng Wang, Nathan Ward
8:45	4	A	Kevin Carlson, Mathias Cornet, David DeMeo, Austin Smith
	4	B	Kyle Evans, Justin Roelant, Josh Saluk, Jack Schlegel
9:00	5	A	Brandon Barker, Jenna Dalrymple, Patrick Korte, Sarah Tumavitch
	5	B	Paul Chen, Trevor Hofman, Andrew Schultz, Alex Vu
9:15	6	A	Nathan Cascarelli, David Harris, Matthew Koenig, Neil Stump
	6	B	Nathan Buchweitz, Jacob Jyawook, Jake Nevin, Connor Quigg
9:30	7	A	Michael Faber, Dominick Ferro, Boyuan Li, Xuyuan Zhao
	7	B	Ryan Babiarz, Abner Barbosa, Cam Lewis, Michael Townsend
9:45	8	A	Marissa DePolo, Sydney Rehr, Benj Shapiro, Victor Wang
	8	B	Ahmed Alhosani, Jonathan Borgiel, Nick Moscone, Brandon Twiehaus
10:00	9	A	Will Book, Taylor Burris, Bradley Davis, Jacob Turner
	9	B	Yuxin Chen, Brett Hahne, Cameron Papson, Megan Phanrisvong
10:15	10	A	Noah Dudley, Alexis French, Rhylan Huss, Zachary Myers
	10	B	Andrew Dolenga, Mathew Flegel, Ethan Lau, Owen Ruster
10:30	11	A	Matt Archambo, Joseph Auty, Antonino Destasi, Dillon Shimel
	11	B	Artea Azizi, Houduo He, Derek Raymond, Gregory Vitous
10:45	12	A	Alena Chapdelaine, Max Herzog, Emma Malik, Travis Wesley
	12	B	Matthew Covert, Matthew Donahue, David Lawless, Anthony Su
11:00	13	A	Evan Alvanas, Robert Miller, Chase Weber, Kris Zoto
	14	B	Ryan Garman, Anna Graffeo, Robert Gustke, Shalvi Save
11:15-11:45			The top teams compete in a tournament style competition.

ME 478
Product Development

Haseung Chung
Assistant Professor of Mechanical Engineering

3D Printing Machine

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

The requirements of the system are: 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); and 2) The olive oil mixed with sand should be deposited on a 10 x 10 cm platform in a weight controlled manner.

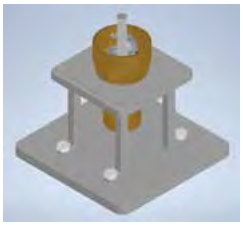
Presumably, the system might consist of: 1) A material supplying module. This module is capable of adding sand and extruding oil into the mixer with a specific weight ratio (this is very similar to what the binder jet 3D printer does); 2) A mixing module. Blending the oil and sand together until the solution is homogeneous; and 3) A deposition module. Depositing a certain amount of the mixed solution (20 grams) onto a platform. Evaluation criteria: 1) The homogeneity of the solution will be inspected visually; and 2) The quality 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. Finally, a few teams will demonstrate their machines on Design Day. The details of the designed machine will be presented before Design Day.

Teams and Team Members

GROUP 1:

Albert Asta
Parker Dukus
Dave Kumiega
Vicent Pernicano
Audrey Schroeder



GROUP 2:

Devin Cao
Mathew Flegel
Boyuan Li
Kyle Raymo
Andrew Scott

GROUP 3:

Brandon Chan
Trevor Hofman
Hunter Moore
Joe Russell
Victor Wang

GROUP 4:

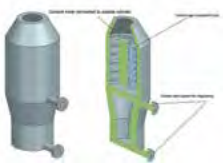
Thomas Cook
Caleb Karthabortles
Aaron Pekrul
Brendan Rybicki
Megan Weiss

GROUP 5:

Kim Boyne
Noah Dudley
Joe Hegger
Erik Mitra
Natalie Schlesinger

GROUP 6:

Thomas Burke
Mike Falter
Alex Kraski
Mitchell Morin
Brandon Twiehaus



GROUP 7:

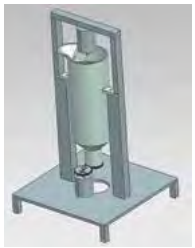
Cam Cabana
Tianyu Han
Cam Lewis
Todd Myers

GROUP 8:

Ryan Babiarz
Ryan Ellis
Tyler Gleason
Chris Mcginnis
Zach Redoute

GROUP 9:

Trevor Dame
Nick Gerich
Chris Heilman
Alex Overholser
Ben Vitek



GROUP 10:

Kyle Evans
Ryan Giere
Dennis Volostnykh
Jin Zhang

9:00 a.m. - 11:30 a.m. Engineering Building, 1200 Hallway | First Floor

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 and the National Science Foundation (NSF) provided funds for device prototyping while Spartan Innovations provided our competition awards. (CBET-1603892)

#	Team Members	Team Slogan
01	Ana Castillero, Lindsey Eisenshtadt, John Gartland, Mikayla Nitoski, Grace Warmann, Hannah Wyatt	**Swing Straps:** A wheelchair attachment to give users more independence and ease when leaving their seats.
02	Shankho Bhattacharjee, Peter Cullen, Paige Hartman, James Schradle, Madeline Warner	**Chordinator:** A solution to playing guitar for those with limited hand mobility.
03	Sam Holley, Danielle Keusch, Julia Lutz, Emily Oswald, Keaghan Rickard	**Orthios:** Happiness walks on stable feet.
04	Maddie Arnold, Brett Hahne, Houduo He, Sean Rudy, Jacob Turner	**Lifesytle Walker:** A walker can transform into a cane for patients in need of walking assistance.
05	Tyler Davis, Aaron Kaplan, Matthew Koenig, Jackson White, Olivia Statler	**Sharp Shooter:** Who says that competition has an age limit?
06	Alexis French, Zachary Myers, Connor Porrell, Alison Reinhold, Cooper Zajac	**Helping Hamper:** An in-home laundry hamper that features an easy, comfortable way for elderly people or people with mobility issues to slide a heavy laundry basket up or down stairs with retractable wheels to transition from stairs to floor seamlessly.
07	Alexa Avendt, Mausam Patel, Zahra Sheikh, Leah Williams, Gabbie Wink	**Curbie:** An attachment for standard wheelchairs that allows users to safely descend curbs.
08	Nathan Buchweitz, Elysse Knapp, William Luke, Jake Nevin, Brandon Twiehaus	**Steady Step:** The lightweight apparatus for healthy foot-drop correction.
09	Claire Brouwer, Devin Cao, Torre Crown, Mia Gilreath, Anjaleca Sokana	**X-Tendo Bin:** Never Bend Again!
10	Amanda Dooley, Carlton Jones, Jacob Keller, Emilee Leroux, Lucas Serraiocco, Jake Stuifbergen	**Walking Buddy:** An oxygen caddy with walker connection.
11	Madison Fleischer, Vincent Pernicano, Claudia Shaw, Conner Stevenson, Bryce Sutton	**Sock Monkey:** An innovative in-home device primarily for the elderly and disabled who need assistance doing everyday tasks such as putting on their socks.
12	Blake Banas, Madison Begin, Abbey Bugenske, Rachel Emerick, Jessica Ryan	**Crutch n' Climb:** An adaptable addition to crutches that increases support when going up or down stairs.
13	Allison Bell, Kamera Black-Holliday, Haram Gil, Sydney Rehr	**Active Basket:** A cargo unload tool for the elderly or disabled in wheelchairs who have limited arm strength.
14	Babz Afolabi, Connor Crawley, Paul Han, Ben Merrill, Brendan Rybicki	**The Clutch:** A crutch device designed to help pick and scoop up various objects from below, an alternative to the normal crutch.

The Capstone Projects

Dr. William Resh
Professor of Mechanical Engineering

Faculty Advisors: Reid Bush, Engeda, Jaberi, Koochesfahani, Xiao


Reid Bush


Engeda


Jaberi


Koochesfahani


Xiao

Presentation Schedule – Engineering Building, Room 1202

Time	Team Sponsor	Project Title
8:00 a.m.	MSU Recycling Center	Reduction in Consumption of Plastic Bags
8:30 a.m.	MSU Recycling Center	Pallet Recycling Initiative
9:00 a.m.	MSU Recycling Center	Food Waste Collection Cart Redesign
9:30 a.m.	McLaren Greater Lansing	Rehab Gym Adjustable Car
10:00 a.m.	MSU Biomechanical Design Research Lab	Scooter Impact Test and Fixture Design
10:30 a.m.	MSU Adaptive Sports & Recreation Club	Sled Hockey Transfer Platform
11:00 a.m.	MSU Adaptive Sports & Recreation Club	Inclusive Sports Wheelchair – Phase 3
11:30 a.m.	Meritor	Crush Spacer Design

ME 481 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.

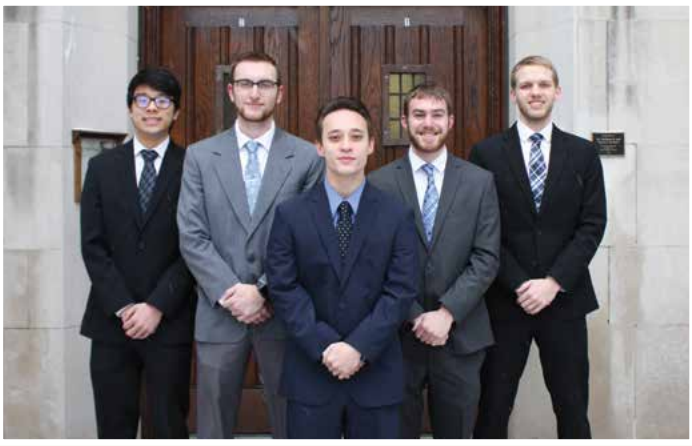
We gratefully acknowledge the participation support of this semester's project sponsors: ArcelorMittal, Department of Natural Resources (DNR), Flash Steelworks Inc, General Motors, Heartwood School/Ingham ISD, Holt Public Schools /Ingham ISD, Marshall NASA Space Center, McLaren Greater Lansing, Meritor, , Michigan AgrAbility, Microsoft, MSU Adaptive Sports and Recreation Club, MSU Biomechanical Design Research Lab, MSU Department of Mechanical Engineering, MSU Department of Theatre, MSU Recycling Center, Okemos Public Schools/Ingham ISD, Salt Yoga, Swagelok, and Terphane .

MSU Recycling Center
Reduction in Consumption of Plastic Bags

MSU Recycling strives to keep the community clean and green by reusing and recycling materials, collaborating with the community, and educating the public on best practices of recycling. This results in nine million pounds of materials being recycled each year at their Materials Recycling Facility (MRF). The MRF is a plant that receives, sorts, and bales materials received from the many recycling bins located across the MSU campus. In addition to recycling materials, the MSU Surplus Store provides community members with the opportunity to purchase used items, as well as to prevent their own unwanted goods from ending up in a landfill.

Despite the plethora of recycling occurring on campus, many of the collection bins for recycled material and trash use plastic bags to collect the material. The bags used often become contaminated with food waste and can result in inefficiencies in the collection and sorting process. In this project, we worked towards a goal of standardizing a new system to reduce the waste of plastic bags and increase the efficiency of the material collection process throughout the Michigan State University campus.

Surplus Store and Recycling
managing waste as a resource



Michigan State University
Team Members (left to right)

Tommy Tsuchiya
Novi, Michigan

Nick Thiel
Lansing, Michigan

Robert Hernandez
Lansing, Michigan

Spencer Goosen
East Lansing, Michigan

Brett Howe
Lansing, Michigan

MSU Recycling Center
Project Sponsor

Dave Smith
East Lansing, Michigan

ME Faculty Advisor

Dr. Manoochehr Koochesfahani

MSU Recycling Center
Pallet Recycling Initiative

The MSU Recycling center manages the university's waste with the goal of reducing, reusing, and recycling as much of it as possible. Established in 1988, the Recycling Center is a self-reliant entity within Michigan State University. In 2019, they were able to divert 15 million pounds of waste from reaching local landfills. Their goal is to eventually keep 90% of the received waste from being diverted to landfills. As part of achieving this goal, the recycling center needs to mitigate the quantity of pallets that are disposed of in landfills.

The MSU Surplus Store and Recycling Center collects and processes about 7,500 pallets annually for recycling, resale or waste. Pallets that are in good condition are sold to pallet remanufacturing companies. Pallets that are in poor condition are given away or sent to the landfill. This project identified safe, cost-effective, and efficient ways to disassemble and repurpose pallets. There are multiple ways to effectively recycle pallets, including creating woodchips, disassembling the pallet and selling the wood, or redistributing them directly to specialized recycling centers.

Surplus Store and Recycling
managing waste as a resource

Michigan State University
Team Members (left to right)

Nathan Engler
Oxford, Michigan

Erin Mettler
Ann Arbor, Michigan

Emily Money
Commerce Twp., Michigan

Benj Shapiro
Ann Arbor, Michigan

MSU Recycling Center
Project Sponsor

Sean Barton
East Lansing, Michigan

ME Faculty Advisor

Dr. Manoochehr Koochesfahani

MSU Recycling Center
Food Waste Collection Cart Redesign

The MSU Surplus Store and Recycling Center, located on Michigan State's campus in East Lansing, oversees the processing of many different materials. All recycling and food waste from on campus plus recycling from their 24/7 public drop-off center gets taken care of at this facility. All the food collected on campus is either used to power the anerobic digestor or turned into compost. At the center, once the food waste is collected in bins, they are dumped and rinsed with a power washer into a larger dumpster. About 1 million pounds of food waste are processed annually.

Our project focused on clean, efficient removal of food waste from the bins located around campus. The process of emptying and cleaning the bins is time-consuming and uses a lot of water and energy. As a continuation from a prior capstone project, the cart needed to be redesigned. It was suggested by the previous group to switch from HDPE plastic to ABS with an LPS coating. We tested different food safe coatings applied to existing bins in order to prevent food from sticking to the sides. This allowed for the removal of many steps, such as heated power washing and transporting the bins back and forth from the recycling center. We tested many different applications to ensure that even the worst food materials, such as peanut butter and pizza, would come off cleanly.

Surplus Store and Recycling
managing waste as a resource

Michigan State University
Team Members (left to right)

Dillon McClintock
Flushing, Michigan

Zahji Billingslea
Detroit, Michigan

Ben Washington
Detroit, Michigan

Devin Cao
West Bloomfield, Michigan

MSU Recycling Center
Project Sponsor

Kris Jolley
East Lansing, Michigan

ME Faculty Advisor

Dr. Farhad Jaberi

McLaren Greater Lansing
Rehab Gym Adjustable Car

McLaren Greater Lansing is an acute care hospital with two campuses located in the Lansing area. They are also currently in the process of constructing a new hospital located just south of Michigan State University, which is slated to open in the fall of 2021. The new hospital will include a rehabilitation gym for patients who require Occupational Therapy as a part of their recovery process. Occupational Therapy is a service profession that helps patients learn how to perform everyday tasks with the highest level of independence possible with their current condition. This rehabilitation gym will utilize the adjustable truck cab that we have designed and constructed to practice getting in and out of a car independently once they are discharged from the hospital.

Our team researched and purchased a hydraulic lift that was able to support the weight of a patient and a truck cab. The cab had been donated to McLaren for this project. We then attached the lift to the bottom of the truck cab and marked guidelines for different heights to adjust the lift in order to simulate a sedan, crossover, or truck. Our team also designed and manufactured a retractable running board that is attached to the truck cab and can be used if the patient's vehicle has a running board on it.

McLaren
GREATER LANSING

Michigan State University
Team Members (left to right)

Matthew Arenz
Lake Orion, Michigan

Stephen Oberheim
Lake Orion, Michigan

Matthew Rice
Holt, Michigan

Tyler Gleason
Kalamazoo, Michigan

Mike Falter
Lake Orion, Michigan

McLaren Greater Lansing
Project Sponsor

Debbie Slezak
Lansing, Michigan

ME Faculty Advisor

Dr. Farhad Jaberi

Special Acknowledgement:

Peter and Daniel Renzulli
Spartan Engineering Endowment Fund

MSU Biomechanical Design Research Lab
Scooter Impact Test and Fixture Design

The recent increase in popularity of electric scooters has led to increased concern over the head injuries experienced by users. Currently, there are no well-enforced regulations regarding helmets while riding. This is particularly relevant among young adults on college campuses. In response to this surge in head injuries, Dr. Tamara Reid Bush of the Biomechanical Design Research Laboratory (BDRL) at MSU recognizes the need to research the impact experienced by electric scooter users in the case of a collision. In the BDRL, Dr. Bush and her students develop models, methods, devices, and experiments to apply engineering principles to the human body. This allows them to analyze and better understand how people interact with devices and their surroundings.

In order to analyze how a body moves and experiences impact during an electric scooter collision with a stationary object like a curb or parked car, the BDRL required a method of mimicking such a collision with a human surrogate. Our team was tasked with designing and creating a test apparatus and acquiring a mannequin with proper weighting and joint articulation to simulate the collision and analyze the subsequent body motion. The resulting scooter platform with supported mannequin rider can be propelled into the simulated curb, releasing the surrogate upon impact. This allows the BDRL to employ the necessary measurement techniques to analyze the mannequin's head movement and extent of impact when propelled off the scooter, providing a means for researching the head injuries experienced by electric scooter users.

BUSH LAB
MICHIGAN STATE UNIVERSITY

Michigan State University
Team Members (left to right)

Hannah Wyatt
Lake Orion, Michigan

Megan Weiss
Arlington Heights, Illinois

Thomas Burke
Grand Rapids, Michigan

Leah Williams
Pinckney, Michigan

Gabrielle Wink
Brighton, Michigan

MSU Biomechanical Design Research Lab
Project Sponsor

Tamara Reid Bush
East Lansing, Michigan

ME Faculty Advisor

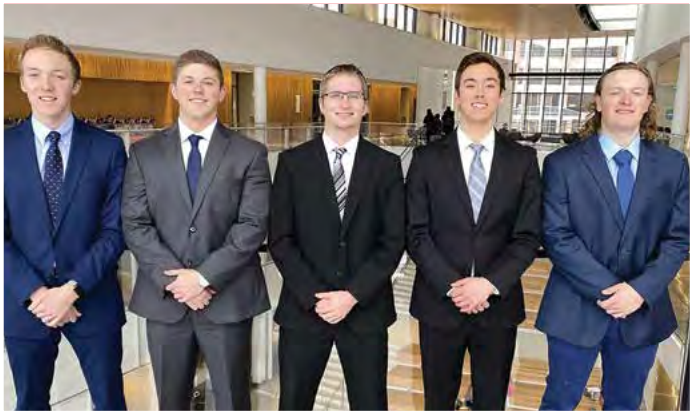
Dr. Tamara Reid Bush

MSU Adaptive Sports & Recreation Club
Sled Hockey Transfer Platform

The MSU Adaptive Sports & Recreation Club is a Registered Student Organization that was established in 2014 as a free program open to athletes with physical disabilities, able-bodied volunteers, and academic projects personnel, who are MSU students, employees, alumni, and members of the Greater Lansing community. The program seeks to create and cultivate a physically and socially acceptable space where athletes with physical disabilities and able-bodied volunteers come together to establish an integrated community of peers. The program uses sports to validate the disability experience by eradicating inaccurate societal stereotypes and invalid self-perceptions about disability, while promoting physical and personal health goals. The program adopts a self-determination approach that focuses on athlete autonomy, competence, and relatedness as key facilitators in the process of acquiring self-efficacy in the area of sports and physical activity; skills that can be transferred to other life domains.

Our team focused on modifying the existing design to increase the user's safety and independence. The key design changes included modifying the handrails, the sled hockey docking mechanism, and converting the lift to be electrically controlled. The changes needed to be compact, robust, and universal to accommodate a wide range of users presenting various levels of physical function.

Michigan State University
Adaptive Sports & Recreation Club
Est. 2014



Michigan State University
Team Members (left to right)

Joseph Hegger
Rochester Hills, Michigan

Kyle Woods
Mattawan, Michigan

Adam Bolyard
Otsego, Michigan

Jacob Keller
Ferndale, Michigan

Devon Davenport
Oxford, Michigan

MSU Adaptive Sports & Recreation Club
Project Sponsors

Stephen Blosser
East Lasing, Michigan

Piotr Pasik
East Lansing, Michigan

ME Faculty Advisor

Dr. Tamara Reid Bush

MSU Adaptive Sports & Recreation Club
Inclusive Sports Wheelchair- Phase 3

MSU Adaptive Sports and Recreation Club is an inclusive club at MSU that promotes health, wellness, and teamwork through sports for individuals with physical disabilities. Athletes have the opportunity to play a variety of sports in this club including boccia ball, wheelchair hockey, wheelchair rugby, hand-cycling, table tennis, and wheelchair tennis. Through the use of sports, the club strives to improve the physical health of its athletes as well as eliminate the societal stereotypes about disabilities. Though inclusion is the goal of the Adaptive Sports and Recreation Club, individuals can still be excluded from sports based on the capacity of available adaptive sports equipment.

This project is the third phase of a custom-made inclusive sports wheelchair that will be specialized for an ambulatory individual. This project focuses on designing an inclusive sports chair with a durable propulsion method and an effective steering mechanism while keeping the athlete's dominant arm free for sports play. An example of an intended user of this wheelchair is someone who has experienced a stroke and now has dominant strength on one side of their body. Past phases of this project lacked mobility, reliability, and foot protection during sports. These issues will be addressed in this phase of the project.

Michigan State University
Adaptive Sports & Recreation Club
Est. 2014

Michigan State University
Team Members (left to right)

Joseph Brenton
Northville, Michigan

Emma Curd
Clarkston, Michigan

Julia Lutz
Livonia, Michigan

Alex Pomaville
Grand Ledge, Michigan

Thomas Smither
Northville, Michigan

MSU Adaptive Sports & Recreation Club
Project Sponsor

Piotr Pasik
East Lansing, Michigan

ME Faculty Advisor

Dr. Abraham Engeda

Meritor
Crush Spacer Design

Headquartered in Troy, Michigan, Meritor is a leading global supplier of drivetrain, mobility, braking, and aftermarket solutions for commercial vehicles and industrial products. It has a strong team with years of experience engineering innovative products that offer superior performance, efficiency and reliability. Meritor provides a leading array of differentiated services supporting customers' products throughout their lifecycle. It provides solutions for fire and rescue, defense, agriculture, heavy haul, and many other groups.

Our team has been tasked with designing a low-cost crush spacer that demonstrates constant load versus displacement characteristics suitable for heavy vehicle operation. Current heavy vehicle designs utilize hardened selectable spacers in axle assembly. Due to tolerance stackups and the limitations of the assembly gauging process, an incorrect length spacer may be selected leading to assembly rebuilds. Through the utilization of CAD and ANSYS, we have designed a crush spacer that adjusts to the tolerance stack-up. Our crush spacer design allows for ease of manufacturing.

MERITOR
RUN WITH THE BULL

Michigan State University
Team Members (left to right)

Jimmy Almacddissi
Macomb, Michigan

Vincent Richard
Batavia, Illinois

Sean Labadie
Brighton, Michigan

Alex Counseller
DeWitt, Michigan

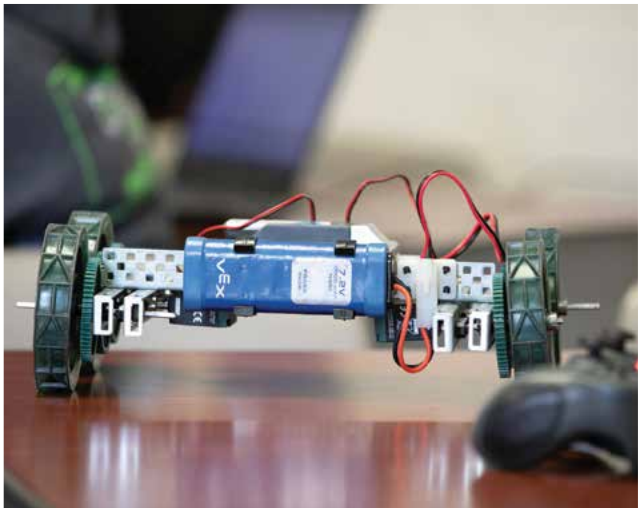
Meritor
Project Sponsors

Nick Bofferding
Troy, Michigan

Supreeth ChandraShekar
Troy, Michigan

ME Faculty Advisor

Dr. Xinran Xiao


VEX


SPARTANS WILL.
the future.
SPARTANS WILL.
MICHIGAN STATE UNIVERSITY


AUTHORIZED AS A STORAGE AREA ONLY

The Capstone Projects

Dr. William Resh
Professor of Mechanical Engineering

Faculty Advisors: Averill, Baek, Benard, Grimm, Kwon, Xiao, Zhu


Averill


Baek


Benard


Grimm


Kwon


Xiao


Zhu

Presentation Schedule – Engineering Building, Room 1220

Time	Team Sponsor	Project Title
8:00 a.m.	Okemos Public Schools/Ingham ISD	Improving Access in the Cafeteria
8:30 a.m.	Heartwood School /Ingham ISD	Therapeutic Pool Track System
9:00 a.m.	Heartwood School /Ingham ISD	Revision of Adapt-a-Step Project
9:30 a.m.	Heartwood School /Ingham ISD	Revision of Mechanical Pony
9:40 a.m.	MSU ECE Smart Microsystems Lab (Note: This presentation takes place in Room 2245)	Underwater Sensor Hub (Joint Project with ECE. See page 122 of this booklet)
10:00 a.m.	General Motors	Electric Car Sound Design
10:30 a.m.	Holt Public Schools/Ingham ISD	Lift for Zeke
11:00 a.m.	Flash Steelworks, Inc	Flash Process Tubing Handling Apparatus
11:30 a.m.	Microsoft	TeleTech Datacenter Telepresence Robot (Joint Project with ECE 480)

ME 481 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: Ron Averill, Seungik Baek, Andre Benard, Giles Brereton, Tamera Reid Bush, Gary Cloud, Abraham Engeda, Brian Feeny, Michele Grimm, Farhad Jaberi, Manoochehr Koochesfahani, Patrick Kwon, Norbert Mueller, Ahmed Naguib, Thomas Pence, Joerg Petrasch, Harold Schock, Vaibhav Srivastava, Elisa Toulson, Indrek Wichman, Neil Wright, Sharon Xiao, Junghoon Yeom, Moshen Zayernouri, and Guoming Zhu.

Okemos Public Schools/Ingham ISD
Improving Access in the Cafeteria

Bennett Woods Elementary School (located in Okemos, Michigan) is in need of efficient cafeteria access for students with physical impairments. One kindergarten student in particular, Gabe, was born with achondroplasia, meaning he is short in stature and his limbs are shorter in relation to the rest of his body. Gabe has recently expressed the desire for more independence and would like to purchase lunch with his peers. Due to his specific needs, Gabe struggles to see any food options as well as to move his food tray along the serving counter. Gabe has had to leave for lunch and receive help from an adult assistant prior to other students going to lunch.

Our team was tasked to adapt the environment of the cafeteria to better suit Gabe in the lunch line. The design allows Gabe to look over the kitchen counter, reach the food, and walk across the lunch line in an efficient manner. The device is also storable, easy to set up, and will not hinder the lunch line process for other students. Since this school has grades K-4, Gabe, as well as other students with certain physical impairments or who are shorter in stature, will be able to use this device for years to come.

Michigan State University
Team Members (left to right)

Ryan Fantin
Rochester, Michigan

Mausam Patel
Ann Arbor, Michigan

Radhika Murgai
Canton, Michigan

Lindsay Goodrich
Dimondale, Michigan

Sadab Bahar
Northville, Michigan

Okemos Public Schools/ Ingham ISD
Project Sponsor

Christina Wolfe
Okemos, Michigan

ME Faculty Advisor

Dr. Michele Grimm

Heartwood School/Ingham ISD
Therapeutic Pool Track System

Heartwood School is a center-based program located in Mason, Michigan and is a part of the Ingham Intermediate School District. Heartwood serves students from 2.5 to 26 years old with moderate to severe cognitive impairments, severe multiple impairments, autism spectrum disorders, and physical impairments. Several of the students are not independent ambulators (walkers) and require some form of adaptive equipment or significant hands-on support to walk. The warm, therapeutic pool provides a great opportunity to work on gait training, strengthening, and motor control.

Our team focused on creating a device that allows non-independent ambulator students the ability to walk in the therapeutic pool without hands-on help from the therapists. This device is designed to be portable inside the room and have the ability to reach all areas of the pool, as well as the ability to reach all depths of the pool. The design can be attached to multiple harnesses to provide use for different sizes and disabilities of students. Our team focused on safety and durability of the device, allowing the weight of any student to be carried, as well as durable against the pool chemicals and room humidity.

Ingham Intermediate School District
Heartwood School

Michigan State University
Team Members (left to right)

Christopher McGinnis
Washington, Michigan

Melissa Karas
Shelby, Michigan

Gabby Zapolnik
Saline, Michigan

Mikayla Nitoski
Troy, Michigan

Alex Kraski
Shelby, Michigan

Heartwood School/ Ingham ISD
Project Sponsors

Paul Frank
Mason, Michigan

Rebecca Love
Mason, Michigan

Heather Vogt-Frechette
Mason, Michigan

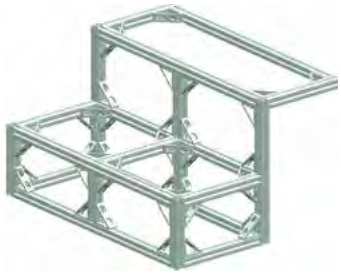
ME Faculty Advisor

Dr. Michele Grimm

Heartwood School/Ingham ISD
Revision of Adapt-a-Step Project

Heartwood School is a center-based program located in Mason, Michigan and is part of the Ingham Intermediate School District. Heartwood serves students from 2.5 to 26 years of age with moderate to severe cognitive impairments, severe multiple impairments, autism spectrum disorders, and physical impairments. Some of the students have yet to develop the ability to reach the first step when entering and exiting the bus for school. To aid the students while they work towards independence, a stepping system, together with an adjustable rail system, were created. These devices reduced the size of the initial step and added upper body support so the students are able to board the bus self-sufficiently.

Our team was asked to revise the current system in order to increase the mobility, ease of use, and to make it functional across various size bus steps. The new steps were adjusted to allow for transportation on the bus while meeting school bus safety standards, increasing the mobility of the system. The new design is easier to maneuver between the buses and the school, increasing the ease of use for both the school and the students. The step system was made adaptable to accommodate multiple bus sizes so that the students could board a variety of bus models. Finally, a new way of attaching the railing system was implemented to make it more user-friendly.



Ingham Intermediate School District
Heartwood School

Michigan State University
Team Members (left to right)

Rachel Emerick
Rockford, Michigan

Zach Hoffman
Midland, Michigan

Claire Trygstad
Rochester Hills, Michigan

Nehemiah Mork
Midland, Michigan

Madison Begin
Northville, Michigan

Heartwood School/ Ingham ISD
Project Sponsors

Rebecca Love
Mason, Michigan

Heather Vogt-Frechette
Mason, Michigan

ME Faculty Advisor

Dr. Seungik Baek

Heartwood School/Ingham ISD
Revision of Mechanical Pony

Heartwood School is a local school for children ages 2.5 to 26 with cognitive and physical impairments and autism spectrum disorders. Heartwood School places an emphasis on its specialized curriculum by incorporating the MOVE program in order to improve the quality of life of physically disabled individuals with an emphasis on increasing independence through incorporating opportunities for students to develop and refine their motor skills. One such opportunity to develop motors skills in a fun and engaging way, is through therapeutic horseback riding using a mechanical pony. This pony was designed and built in the spring of 2017 by a mechanical engineering capstone team. First round revisions and enhancements were completed in the spring of 2019. Therapeutic horseback riding helps develop core and lower back strength, which are critical for stability and body motion. Having a realistic design and an attachable TV showing scenery makes the activity feel like a real horseback ride.

Our team was asked to develop a regimen to test the capabilities of the mechanical pony as well as determine preliminary signs of failure. A testing regimen can prevent future injuries to the children who use the pony daily and can allow the pony to be maintained and repaired when the risk of injury is lower. We have identified many points for improvement as well as developed a series of tests that would address the concerns presented, increase reliability, and assist in future improvements.

Ingham Intermediate School District
Heartwood School

Michigan State University
Team Members (left to right)

Andrew Quang
South Lyon, Michigan

Nuno Marriott
Guayaquil, Ecuador

Michael Powers
Linwood, Michigan

Diego Prakash
Saginaw, Michigan

Brian Chan
Holland, Michigan

Heartwood School/ Ingham ISD
Project Sponsor

Melissa Walraven
Mason, Michigan

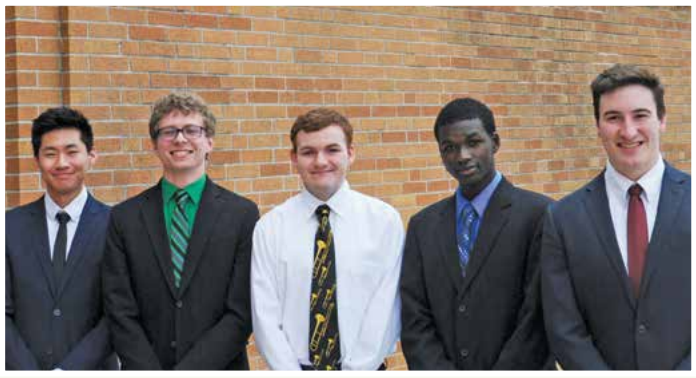
ME Faculty Advisor

Dr. Xinran Xiao

General Motors
Electric Car Sound Design

One of the significant developments in the automobile industry over the last decade has been the rise of hybrid and electric vehicles. These vehicles have many advantages over traditional internal combustion engine (ICE) automobiles, but there are different challenges in their development. One such challenge is brought by the lower volumes of electric vehicles when compared to traditional ICE cars. While this may seem to be an advantage, the low sound of an electric vehicle can be a hazard to pedestrians and other vulnerable road users. To address this issue, the US government has issued regulations that all electric vehicles produce minimum safe sound levels and pitches. General Motors (GM) is an original equipment manufacturer that has been in operation since 1908. GM owns popular and successful automobile brands, including Chevrolet, Cadillac, GMC, and Buick. GM has been a major contributor to the electric vehicle market with such designs as the new Chevrolet Bolt and is therefore on the cutting edge of electric car sound design.

Our team was assigned the task of developing three sounds. Our desire was to produce sounds that meet the specific government regulations, effectively communicate the presence of the vehicle to pedestrians, and yield an emotional response from the listener. The aural experience is a major factor of what makes a particular automobile attractive to the customer, just like paint color or trim. The three sounds we created fulfill the given criteria and our aesthetic desires.



Michigan State University
Team Members (left to right)

Hexin (Humphrey) Han
Xi'an, China

Ross Kelly
Perry, Michigan

Paul Sytsma
Macomb, Michigan

Latif Bouda
Ypsilanti, Michigan

Matt Bergdolt
Dexter, Michigan

General Motors
Project Sponsor

Doug Moore
Milford, Michigan

ME Faculty Advisor

Dr. Guoming Zhu

Holt Public Schools/Ingham ISD
Lift for Zeke

The sponsor for this project is the Holt Public Schools/Ingham Intermediate School District. This organization is a shared community resource that provides a network of support for students with special needs, their families, and educators. This project revolves around Zeke, a freshman student at Holt High School. Zeke is a motivated, intelligent, and outgoing student, who was born without arms or legs, a condition called Quadramelia. He needs assistance for most activities but has independent mobility in his power wheelchair and this independence brings him great joy.

The goal of this project was not just to build a lift, but to have a meaningful impact on Zeke and increase his quality of life. The lift incorporates work from a previous project. Our team revised this lifting device to specifically aid in moving Zeke in and out of his chair safely and comfortably. The previous lifting process required two adults. This new lift enables Zeke to transfer with minimal assistance and thus gives him greater independence. The lift incorporates ergonomic folding arms to facilitate safe transfers and give Zeke adequate support without a harness. The motorized seat allows easy transfer from his wheelchair to a level that he desires for everyday use. The design also allows him to reposition himself to be more comfortable and help regulate his body temperature. Zeke can now be eye level with his peers, lowered to the floor, and his to his favorite height – to see what is in the refrigerator.

HOLT PUBLIC SCHOOLS
District Pride • Community Wide

Ingham Intermediate School District
A Regional Educational Service Agency

Michigan State University
Team Members (left to right)

Ben Vitek
Wixom, Michigan

Emily Oswald
Grand Rapids, Michigan

Harrison Haynor
Zurich, Switzerland

Danielle Keusch
Portland, Michigan

Noah Rimatzki
Livonia, Michigan

Holt Public Schools/ Ingham ISD
Project Sponsor

Joanne Janicki
Mason, Michigan

ME Faculty Advisor

Dr. Ronald Averill

Flash Steelworks, Inc.
Flash Process Tubing Handling Apparatus

Flash Steelworks, Inc. is an R&D firm that specializes in the development of advanced high-strength steels (AHSS) using their patented heat treating process. The process involves the use of rapid thermal cycling to transform commercial off-the-shelf steel sheets, plates, and tubing into AHSS. Induction technology is used to heat commercial steel to a temperature of about 1070-1200°C. Once the steel has reached this temperature, it is immediately quenched using water. The Flash process is different from conventional heat treating processes because it leverages the natural chemical and morphological heterogeneity of steel to limit carbon migration and carbide dissolution. By limiting the heating time, Flash is able to control carbon migration and carbide dissolution within the steel thereby preserving material heterogeneity to generate a complex, multi-phase steel. This process gives Flash the ability to produce the strongest, most ductile, and most readily weldable steel in the world.

Our team's focus was to help Flash optimize their heat treating process for steel tubing by redesigning a material handling fixture that is capable of feeding a piece of tubing along a path of motion while simultaneously rotating it. The fixture enables 48" of steel tubing to be processed per minute and also allows the tubing to fully rotate every 1/8" of linear motion using rollers and a motor. These design features ensured that Flash could continue manufacturing high-quality AHSS while also increasing their throughput. Legs were designed for the fixture to provide structural support as well.

Michigan State University
Team Members (left to right)

Wyatt Beachy
Barrington, Illinois

Caden Swindell
Greenville, Michigan

Jin Zhang
Fuzhou, China

Gary Cola (Sponsor)

David Abatan
Ann Arbor, Michigan

David Kumiega
Macomb, Michigan

Flash Steelworks, Inc.
Project Sponsor

Gary Cola
Washington, Michigan

ME Faculty Advisor

Dr. André Bénard

Microsoft
TeleTech Datacenter Telepresence Robot

Microsoft is an American-based multinational company that manufactures, develops, licenses, supports, and sells software, electronics, computers, and more. To support its push into cloud computing, Microsoft has an array of datacenters. Datacenter technicians are tasked with maintaining the smooth operation of Microsoft's datacenter fleet. The datacenter environment is hot, loud, and humid, creating a difficult working environment. To make the technicians' jobs safer and easier, Microsoft plans to develop datacenter-centric telepresence robots. These robots would save technicians time by performing simple tasks. It is estimated that one-third of their time is spent traveling between server rooms to check on the status of repairs, to find a tool, or to perform a simple task. A telepresence robot could alleviate the burden of these tasks. Furthermore, telepresence robots would enable remote inspection and diagnostics from experts at other sites and provide a platform for security patrols.

Our team was tasked with integrating both a 6-axis collaborative robot arm and a vision system into an autonomous mobile platform. The vision system consists of a 360-degree 3D camera as well as another camera mounted to help control and navigate the arm. The vision system is paired with a VR headset to allow a technician to control and navigate the robot and arm remotely using an Xbox controller. All system components were mounted onto the robot and the final system was modeled in CAD. This project was a collaborative effort with an ECE senior capstone team.

Microsoft

Michigan State University
Team Members (left to right)

Front Row:

Xhongyi Jiang (ECE)
Jiangsu, Changzhou, China

Asha Shekar (ECE)
Farmington Hills, Michigan

Kevin Le (ECE)
Holt, Michigan

Titapa Thaivattanaporn (ECE)
Bangkok, Thailand

John Miller
Saline, Michigan

Back Row:

Nik Buchholz
Haslett, Michigan

Brian Hofer (ECE)
Clinton Twp., Michigan

Robert Mothersell
Okemos, Michigan

Kevin Hancock (ECE)
New Hudson, Michigan

Taylor Fuhrman
Perry, Michigan

Fanghan Lu
Yuyao, China

Microsoft
Project Sponsor

Nicholas Keehn
Redmond, Washington

ME Faculty Advisor

Dr. Patrick Kwon

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The Capstone Projects

Dr. William Resh
Professor of Mechanical Engineering

Faculty Advisors: Naguib, Toulson, Wichman, Wright


Naguib


Toulson


Wichman


Wright

Presentation Schedule – Engineering Building, Room 1300

Time	Team Sponsor	Project Title
8:00 a.m.	MSU Department of Theatre	Adjustable Height Cutting Table
8:30 a.m.	MSU Department of Theatre	Automated Metal Cleaner
9:00 a.m.	NASA Marshall Space Flight Center	High Performance Nuclear Thermal Propulsion
9:30 a.m.	NASA Marshall Space Flight Center	Tensile Tester for Thermal Protection Systems
10:00 a.m.	MSU Department of Mechanical Engineering	Modular Work Station for SAE Racing Teams
10:30 a.m.	MSU Solar Racing Team	Electric Motor Dynamometer
10:30 a.m.	General Motors (Note: This presentation takes place in Room 2245)	Sound Emission for Hybrid/Electric Vehicles (Joint Project with ECE. See page 123 of this booklet)
11:00 a.m.	Salt Yoga	Core Roller
11:30 a.m.	Terphane	Food Take-Out & Delivery Container System

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.

MSU Department of Theatre
Adjustable Height Cutting Table

The MSU Department of Theatre is challenging the traditional approach in order to create something new, unique and fresh. Every day the Theatre Department spends multiple hours on costume design ideas. The department is in need of an adjustable height cutting table. When the costume is designed and cutting patterns are made for it, the Theatre Department uses a large table to do the layout and design work with the fabric. In order to compensate for students and Theatre Department personnel of varying heights, the Theatre Department currently utilizes stepstools which still leave the users at an awkward height. Also, for students who are taller than average, it is uncomfortable to work on the table at its current fixed height. Furthermore, there is a need for storage space under the table for all of the completed and upcoming work.

Our Team has been tasked with creating a 4'x 12' adjustable height table. The table needs to adjust from a height of 32" to 44". The adjustment should be powered by a mechanism that can be controlled using a motor. Controls of such a mechanism can be any type of directional switches. The table should be able to support 500 pounds or more. Due to the storage space restriction, the mechanism cannot be bulky or take up too much space under the table. The table design should also have a cork top for pinning fabric. Our team will be fulfilling all these design constraints and delivering a product that will serve the Theatre Department and the community for years to come.

DEPARTMENT OF THEATRE
www.theatre.msu.edu

Michigan State University
Team Members (left to right)

Yeeun Lee
Troy, Michigan

Niranjan Kulkarni
Mumbai, India

Naif Alzahrani
Al Baha, Al Baha

Hongxiang Chang
Wuhan, China

Vincent Pernicano
Ann Arbor, Michigan

MSU Department of Theatre
Project Sponsors

Angela Wendelberger
East Lansing, Michigan

Mark Willoughby
East Lansing, Michigan

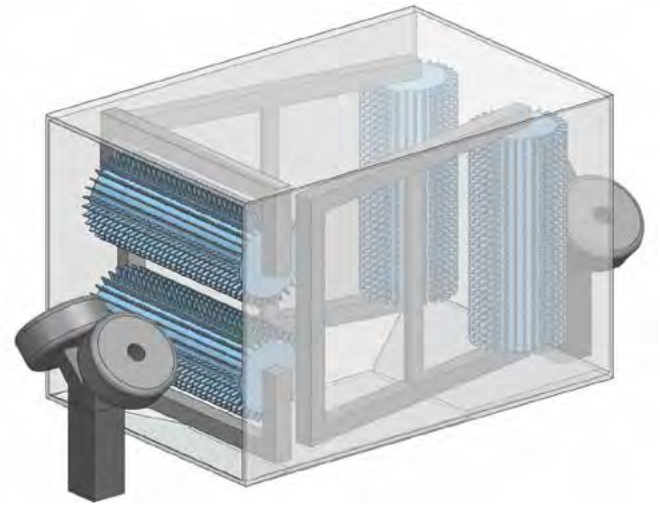
ME Faculty Advisor

Dr. Indrek Wichman

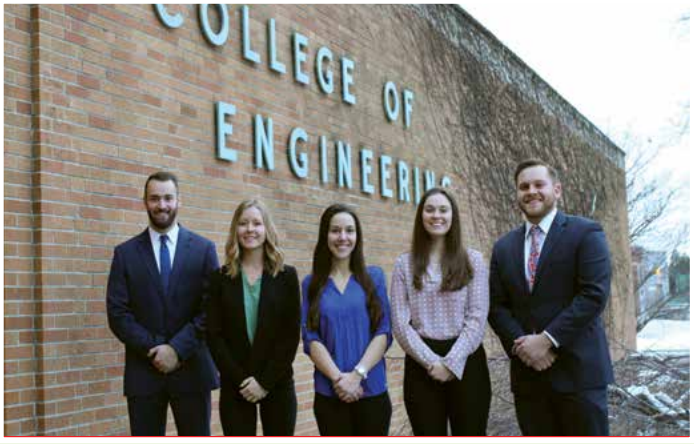
MSU Department of Theatre
Automated Metal Cleaner

The MSU Department of Theatre (DoT) offers not only a one-of-a-kind self-selected undergraduate education but also new and inspiring plays. In the 2019-2020 season, the DoT has presented 12 different, thought-provoking and trailblazing productions. MSU has the unique opportunity to create its very own sets for theatre productions and the College of Music Opera program within the 9,370-square-foot scene shop. Within the shop, the equipment, tools, and technology range from a complete welding area to a full-size paint studio.

Our team was tasked with designing a device capable of cleaning metal beams by removing oil and residue buildup. When creating the scenery for productions, the DoT uses metals of varying geometries for aesthetic and structural purposes. Prior to building this device, the process to clean the metals was inefficient and tedious. With this revolutionizing method of cleaning, the designers at the scene shop will be able to clean and build scenery in a fraction of the time it used to take. The device functions like a car wash, in which a piece of metal is fed into one end, goes through a full cleansing and drying process, then emerges fresh and clean from the other end.



DEPARTMENT OF THEATRE
www.theatre.msu.edu



Michigan State University
Team Members (left to right)

Albert Asta
West Bloomfield, Michigan

Kayla Gibbs
Minneapolis, Minnesota

Mira Crain
Wyckoff, New Jersey

Abbey Bugenske
Shaker Heights, Ohio

Andrew Albright
Comstock Park, Michigan

MSU Department of Theatre
Project Sponsor

Levi Galloway
East Lansing, Michigan

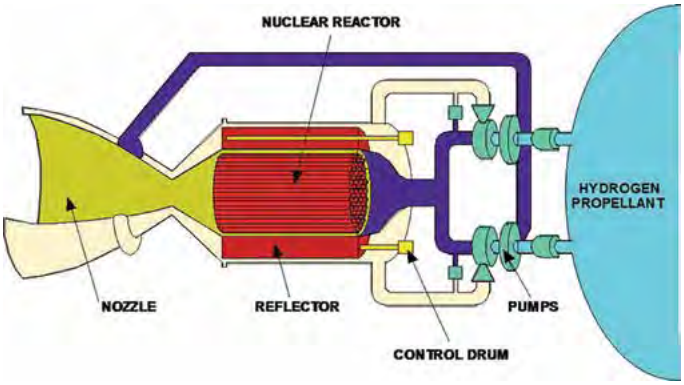
ME Faculty Advisor

Dr. Indrek Wichman

NASA Marshall Space Flight Center
High Performance Nuclear Thermal Propulsion

NASA Marshall Space Flight Center (MSFC) is located in Huntsville, Alabama. NASA MSFC is a United States government research center for spacecraft propulsion, founded on July 1, 1960. Its first mission was developing the Saturn launch vehicles for the Apollo program. NASA seeks more research on the solar system and the next goal is to make it to Mars. In that process a Nuclear Thermal Propulsion rocket (a fission reactor heating hydrogen or other substances that accelerate through a nozzle) is one approach to making the trip to Mars safe, affordable, and viable.

Our team worked on a research project for a second generation Nuclear Thermal Propulsion (NTP) unit. The NTP system would be used for a rocket that would journey to Mars and back. The research included one-dimensional analysis calculations, regarding heating hydrogen propellant through the use of fissioning liquid uranium in a rotating cylinder. With the remainder of the given time, an investigation of the pressure of the H2 from the propellant tank to the H2 pump, and the pressure requirement from the H2 pump to the blades for fuel cylinder rotation was in progress We began an investigation of the pressure of the H2 from the propellant tank to the H2 pump, and the pressure requirement from the H2 pump to the blades for fuel cylinder rotation. Due to the lack of time, calculations, such as the viscosity and heat transfer coefficient of liquid uranium at 5000k, were not completed. We left them in variable form so that it will be easy to insert the values when they are known.



Marshall Space Flight Center

Michigan State University
Team Members (left to right)

Garrison Osborne
Holland, Michigan

Volkan Yildirim
Haslett, Michigan

Daniel Quinn
Garden City, Michigan

Austin Coha
Marysville, Michigan

Joseph Abbawi
East Lansing, Michigan

NASA Marshall Space Flight Center
Project Sponsor

Mike Houts
Huntsville, Alabama

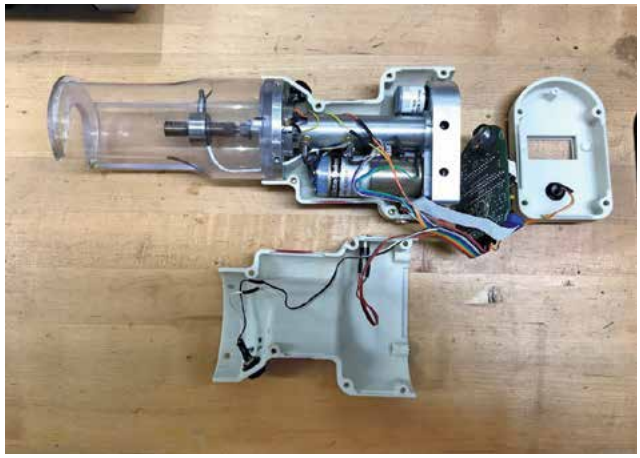
ME Faculty Advisor

Dr. Indrek Wichman

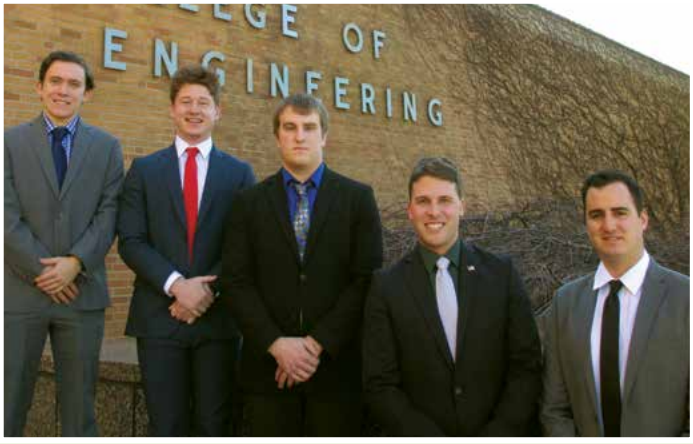
NASA Marshall Space Flight Center
Tensile Tester for Thermal Protection Systems

The NASA Marshall Space Flight Center has been in operation since 1960 and is at the forefront of space exploration in the United States. As one of NASA's largest field centers, this facility specializes in the propulsion systems for space exploration; its focus is on traditional solid and liquid propulsion systems. Utilizing the best propulsion technologies, Marshall has been developing NASA's heavy-lift Space Launch System (SLS). This system is the backbone of NASA's exploration plans and is the only rocket capable of carrying people to the Moon and eventually Mars. NASA's Marshall Space Flight Center's expansive capabilities and state-of-the-art facilities are critical for every aspect of NASA's mission for future space endeavors.

Our team was tasked with the implementation of a redesigned portable tensile testing machine for the Thermal Protection System (TPS) on the SLS. This device is utilized for testing the adhesion of the insulating foam after it has been applied to the exterior of the Launch Vehicle Stage Adaptor and Core Stage components of the rocket. This foam is responsible for maintaining a stable fuel temperature when exiting the atmosphere and entering into cold space. The current device used is outdated and no longer produced, so we created a new machine adapted to the current test procedure. In order to verify the adhesion of the TPS, the tensile tester pulls on test tabs that are installed in the foam. Surpassing a force threshold ensures the integrity of foam application and allows for the next stages of assembly.



Marshall Space Flight Center



Michigan State University
Team Members (left to right)

Brent Weakland
South Lyon, Michigan

Owen Jarl
South Lyon, Michigan

Todd Myers
Scotts, Michigan

Lucas Walsh
Canton, Michigan

Josh Theis
St. Johns, Michigan

NASA Marshall Space Flight Center
Project Sponsor

Amy Buck
Huntsville, Alabama

ME Faculty Advisor

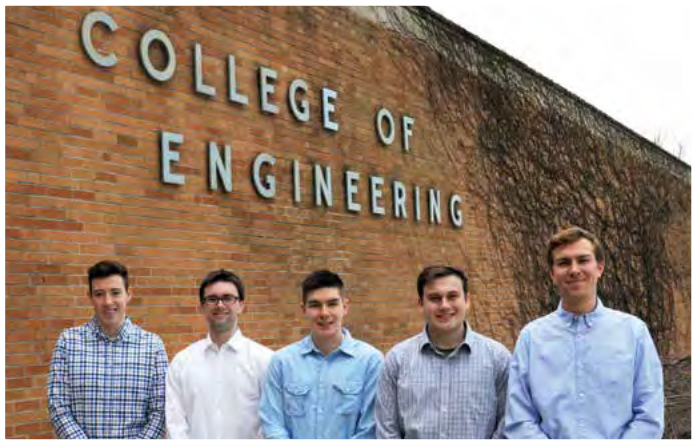
Dr. Ahmed Naguib

MSU Department of Mechanical Engineering
Modular Work Station for SAE Racing Teams

The College of Engineering Baja and Formula Racing Teams are student organizations that participate in the nationwide Society of Automotive Engineers (SAE) design competitions. Last-minute repairs and adjustments to the vehicles are common in this fast-paced environment. Previously, the teams had to load and fasten the required equipment to the trailer that was hauled to the competitions.

Our team focused on designing a modular work station that could serve as a welding and machining area. This movable device can mount tooling and machines, such as a welder, mill, drill press, and other accessories as requested by the teams. We also worked to ensure that the system would be secure in rough driving conditions. The station was designed using NX 11, and analyzed using Altair Inspire. The team successfully created a design that was safe, modular, and of use for years to come.

Department of Mechanical Engineering
MICHIGAN STATE UNIVERSITY



Michigan State University
Team Members (left to right)

Steven Dubey
Macomb, Michigan

Paul Beiter
Flushing, Michigan

Alex Kintner
Flint, Michigan

Cameron Cabana
Holland, Michigan

James Schradle
Romeo, Michigan

MSU Department of Mechanical Engineering
Project Sponsor

Mike Koschmider
East Lansing, Michigan

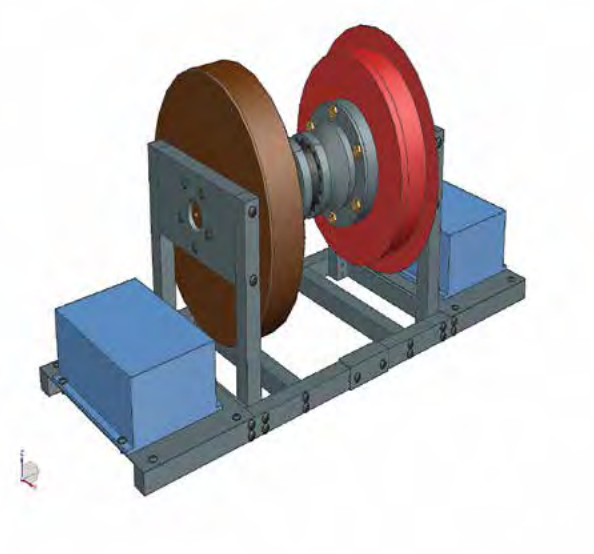
ME Faculty Advisor

Dr. Elisa Toulson

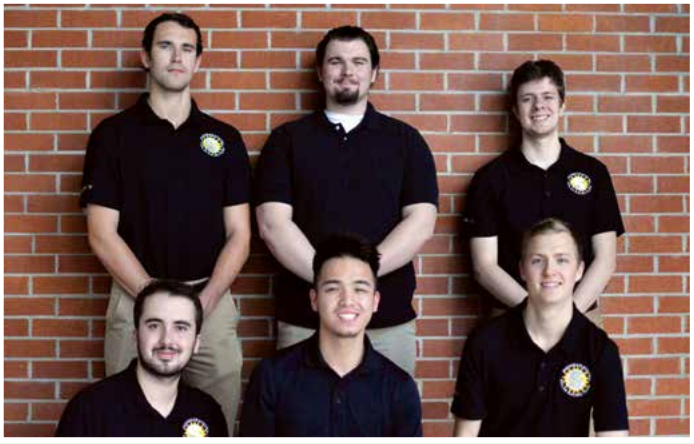
MSU Solar Racing Team
Electric Motor Dynamometer

The MSU Solar Racing Team (MSU SRT) was founded in 2000 with a grant from the College of Engineering at Michigan State University. After several generations of team members and through research/support from other teams, MSU SRT built its first car, named Brasidius, in 2010. Between 2010 and 2012 two improved versions of Brasidius were made. In 2014 the team completed a new vehicle called Leonidas, and improved that vehicle in the subsequent years. In 2018, the team began designing the first multi-occupant, coupe-style vehicle called Aurora, which was completed in July 2019. The team has continued making improvements on the car for upcoming competitions to be held in the summer of 2020.

A major factor that has prevented MSU SRT from success in past years' competitions has been a lack of testing. The goal of this project was to build an electric motor dynamometer that will aid in analyzing MSU SRT's propulsion system. In order to accomplish this, the team had to build a custom motor stand, create a method of applying loads to the motor, configure the motor controller to record desired inputs/outputs, and analyze the recorded results from tests. Team members for this project had to be skilled in control systems, electric motor functionality, motor controller operations, electrical wiring, Arduino coding, and manufacturing processes.



MSU SOLAR RACING TEAM



Michigan State University
Team Members (left to right)

Front Row:
Kevin Kinsey
South Lyon, Michigan

Brandon Chan
Zeeland, Michigan

Zachary Kubiak
Grosse Ile, Michigan

Back Row:
Trystan Melnyk
Royal Oak, Michigan

Connor Wilson
Ferndale, Michigan

Zach Kupa
Brighton, Michigan

MSU Solar Racing Team
Project Sponsor

Shubham Shedge
East Lansing, Michigan

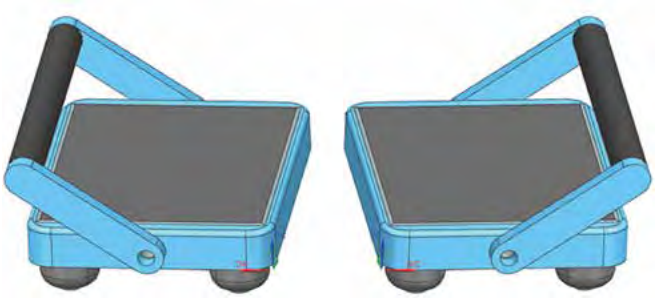
ME Faculty Advisor

Dr. Elisa Toulson

Salt Yoga
Core Roller

Salt Yoga, located in East Lansing, Michigan, is a yoga studio that offers a variety of different classes for people of any athletic ability and strength. The studio is pursuing a simple and innovative product to create a new take on a rigorous core workout. This product allows for more engaging abdominal workouts. The goal is to help bring to life a simple idea for a novel device. The mission is to make the customers' workout experience more challenging and beneficial. The unique design engages muscles that are not normally used in other abdominal exercises.

Our team was tasked with transforming a concept for a portable core roller using rigorous design, build, and test methods. The device will help strengthen the core muscles through a vigorous workout for users with any level of athletic ability and strength. The core roller enables versatile workout motion by using one's hands or feet. In addition, the core roller can be used on a wide array of surfaces. The product's functionality allows the individual to perform many different workouts. The core roller makes it possible to have a powerful core workout anywhere you go.



Michigan State University
Team Members (left to right)

Alyse Richards
Waterford, Michigan

Mike Bowen
White Lake, Michigan

Chris Heilman
Waterford, Michigan

Brenden Carter
White Lake, Michigan

Nadine Twal
Sterling Heights, Michigan

Salt Yoga
Project Sponsor

David Thomas
East Lansing, Michigan

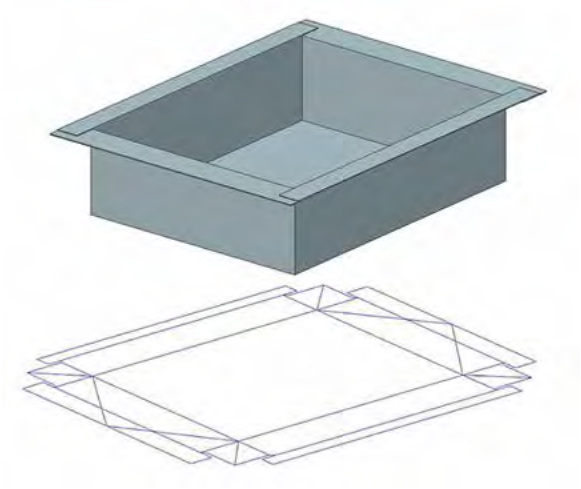
ME Faculty Advisor

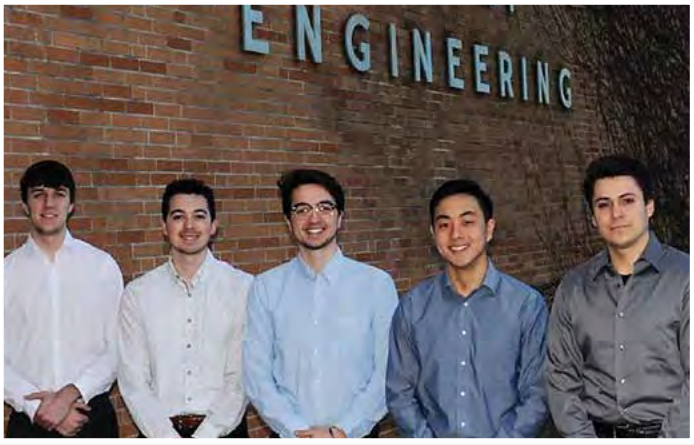
Dr. Neil Wright

Terphane
Food Take-Out & Delivery Container System

Terphane is a packaging materials company that manufactures specialty polyester films in the US and Brazil. Terphanes's films are thin (12 micron) and have special coatings that allow them to heat seal to themselves and to other polyesters. These films are also capable of high temperatures, such as those in an oven or microwave. In order to grow their business, Terphane is using these films as liners for takeout food containers. By integrating its film with paperboard and developing mechanisms that can be used in a food retail environment to assemble the take-out container, they can significantly reduce the cost and environmental impact of take-out packaging.

Our team was tasked with developing a low-cost, easy-to-use system utilizing paperboard, film, and a sealant lamination to create a food delivery container for use in the retail shop environment. A simple machine was designed to use heat in order to construct the container from a flat sheet of laminated paperboard. The machine was low cost at less than $100, operator friendly, and able to be plugged into an outlet. The driving force behind this project was to reduce the environmental impact of take-out and delivery containers which are currently on an upward growth trajectory. Effectively converting a flat sheet into a container onsite saves on cost and energy of shipping.





Michigan State University
Team Members (left to right)

Grant Hoffman
Macomb Twp., Michigan

Jordan Bommarito
Macomb Twp., Michigan

Dominic Rende
Washington Twp., Michigan

Paul Han
Okemos, Michigan

Brendan Rybicki
Shelby Twp., Michigan

Terphane
Project Sponsor

Marcos Vieira
Bloomfield, New York

ME Faculty Advisor

Dr. Neil Wright

The Capstone Projects

Dr. William Resh
Professor of Mechanical Engineering

Faculty Advisors: Engeda, Feeny, Mueller, Naguib, Pence, Petrasch, Yeom


Engeda

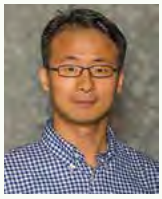

Feeny


Mueller


Naguib


Pence


Petrasch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Presentation Schedule – Engineering Building, Room 2205

Time	Team Sponsor	Project Title
7:30 a.m.	MSU Department of Mechanical Engineering	HPVC Frame Design
8:00 a.m.	MSU Department of Mechanical Engineering	HPVC Truss Bike Frame
8:30 a.m.	MSU Department of Mechanical Engineering	Human Powered Vehicle Frame Design
9:00 a.m.	MSU Department of Mechanical Engineering	ASME HPVC Energy Storage Device Concept
9:30 a.m.	MSU Department of Mechanical Engineering	HPVC Energy Storage Device Concept Design
10:00 a.m.	MSU Department of Mechanical Engineering	Bicycle Kinetic Energy Storage Device
10:30 a.m.	MSU Department of Mechanical Engineering	HPVC Energy Storage Device
11:00 a.m.	MSU Department of Mechanical Engineering	E-Bike Dynamometer (Joint Project with ECE 480)
11:30 a.m.	MSU Department of Mechanical Engineering	Bicycle Frame Manufacturing

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
HPVC Frame Design

Michigan State University's Human Powered Vehicle Challenge (HPVC) Team participates annually in a competition held at ASME's E-Fests. The competition brings together teams from many locations to compete in an endurance race and drag race using a two- or three-wheeled human powered vehicle. MSU has hosted the event in this region in 2019 and 2020, and doing well in the event can be a huge source of pride for the MSU College of Engineering. The HPVC Team is composed of a group of MSU engineering students, each dedicating their time to the project and balancing their roles on the team with coursework and other commitments. As the team is relatively new, designing and manufacturing a custom frame has not been feasible yet. Instead, the current frame is a purchased part, not optimized for this type of competition.

Our team has been tasked with designing a new frame that will strengthen the performance of the vehicle. One aspect of the competition is the soundness of design, so the team designed a frame from scratch while documenting their justification for design decisions. The new design will help maximize the performance of the vehicle, so turning radius, weight, comfort, possibility for attachments, etc. were all considered as part of the design process.

Department of Mechanical Engineering
MICHIGAN STATE UNIVERSITY

Michigan State University
Team Members (left to right)

Tim Ohtake
Livonia, Michigan

Joe Russell
Grand Blanc, Michigan

Kent Peterson
Livonia, Michigan

Derek Wittenberg
Dexter, Michigan

Rishi Gupta
Yamunanagar, Haryana, India

MSU Department of Mechanical Engineering
Project Sponsor

Geoffrey Recktenwald
East Lansing, Michigan

ME Faculty Advisor

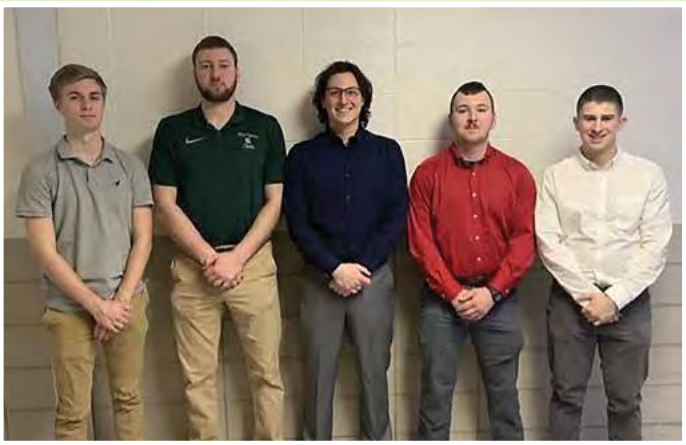
Dr. Thomas Pence

MSU Department of Mechanical Engineering
HPVC Truss Bike Frame

Each year, ASME holds several Human Powered Vehicle Challenge (HPVC) competitions. This year, HPVC-North will be held in East Lansing. In each competition, there are men's and women's drag races and an endurance race. The drag race focuses on speed, whereas the endurance race focuses on maneuvering through different terrain and transporting a small package which simulates groceries. Furthermore, each team must submit a written report that contains information about the design choices. The vehicle must be designed with safety in mind, and a roll cage must be built to protect the driver in the event of an accident.

Our team has focused on designing a new frame for next year's competition. The frame is redesigned from scratch using a truss system. Different materials were researched for their weight and cost. We created a CAD model of the frame while also performing calculations, including finite element analysis, dynamic calculations, center of gravity calculations, and weight distribution. The design created is something that could be implemented into next year's competition.

Department of Mechanical Engineering
MICHIGAN STATE UNIVERSITY



Michigan State University
Team Members (left to right)

Devan deJong
Oxford, Michigan

Jeremy St. Pierre
Mason, Michigan

Jack Rees
Amherst, Massachusetts

Foster Whipple
Mason, Michigan

Samuel Rinke
Gaylord, Michigan

MSU Department of Mechanical Engineering
Project Sponsor

Geoffrey Recktenwald
East Lansing, Michigan

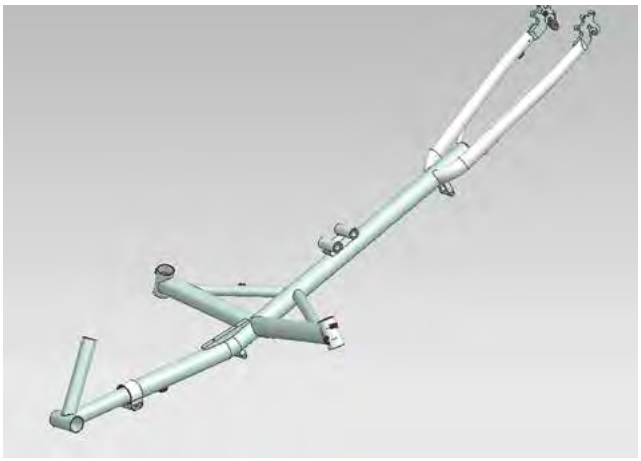
ME Faculty Advisor

Dr. Thomas Pence

MSU Department of Mechanical Engineering
Human Powered Vehicle Frame Design

The Human Powered Vehicle Challenge (HPVC) provides students a chance to develop a sustainable, practical, and alternative solution to transportation for underdeveloped or inaccessible regions of the world where human powered transportation might be the only option. The goal of the challenge is to work in teams to design and build engineered vehicles for everyday use which requires humans to provide the force necessary for motion. This Challenge occurs yearly and universities from across the nation participate. The designs consist of a two- or three-wheeled bicycle with roll cage, gears, and aerodynamic attachments.

The focus of this project was to redesign the main frame for the bicycle. To do so, we were tasked with developing an entirely new concept for it. This consisted of having a safe, lightweight, manufacturable tadpole bike frame for the competition, performing research to back up any of our design decisions to improve speed, power, balance, and comfort. Lastly, the final design had to incorporate attachments for possible aerodynamic parts and an RPS.



Department of Mechanical Engineering
MICHIGAN STATE UNIVERSITY

Michigan State University
Team Members (left to right)

Jake Fosmoen
Brighton. Michigan

Gregorio Gaio
Ribeirão Preto, Brazil

Cameron Barghahn
Waterford, Michigan

Amarildo Alijaj
Rochester, Michigan

Rourke Brummette
Grand Ledge, Michigan

MSU Department of Mechanical Engineering
Project Sponsor

Geoffrey Recktenwald
East Lansing, Michigan

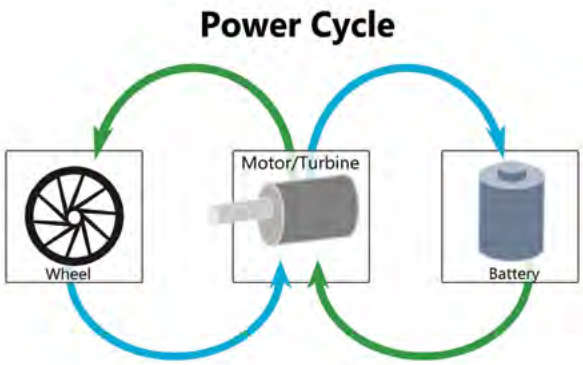
ME Faculty Advisor

Dr. Abraham Engeda

MSU Department of Mechanical Engineering
ASME HPVC Energy Storage Device Concept

The MSU Department of Mechanical Engineering focuses on teaching and research about devices and systems that utilize motion and energy to accomplish a wide range of objectives. MSU ME faculty, students, and graduates work to develop technologies in fields such as vehicle design, plumbing systems, robotics, biomechanics, manufacturing methodologies, and more. Undergraduate studies in the department's classes often focus on the process of applying engineering knowledge to design projects, many of which are featured at Design Day.

One ongoing research area for the MSU Department of Mechanical Engineering is participation in the American Society of Mechanical Engineers' Human Powered Vehicle Challenge. Our team was tasked with designing an electric energy reclamation system to be used during an endurance race to allow energy generated by the rider to be carried over between riders. Our approach was to emulate the regenerative braking systems used in Formula 1 racing. Energy that would be dissipated during active slowdown of the vehicle is instead diverted into a device that generates electricity, stored in a battery, that can later be sent back through the device, which then acts as a motor driving the vehicle forward. In accordance with ASME HPVC rules, the energy storage device's battery can be drained, so that all the energy in the vehicle is produced by a human rider over the course of the event.



Department of Mechanical Engineering
MICHIGAN STATE UNIVERSITY

Michigan State University
Team Members (left to right)

Yongyi Yang
Yanji, Jilin Province, China

Bradley Harris
Farmington Hills, Michigan

Mia Gilreath
Southfield, Michigan

Sterling White
Detroit, Michigan

Derek Edwards
Lansing, Michigan

MSU Department of Mechanical Engineering
Project Sponsor

William Resh
East Lansing, Michigan

ME Faculty Advisor

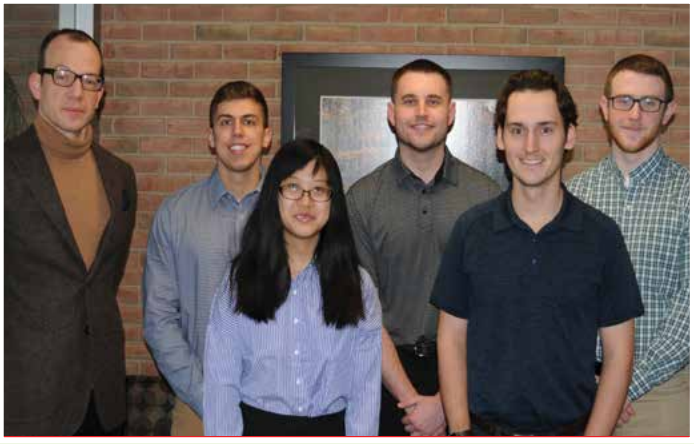
Dr. Joerg Petrasch

MSU Department of Mechanical Engineering
HPVC Energy Storage Device Concept Design

This year, Michigan State University's Mechanical Engineering Department will host the Human Powered Vehicle Competition (HPVC) for the north region teams of North America. This competition provides an opportunity for teams to design and develop operable human powered vehicles capable of transportation. Recently, the idea of an energy storage device was considered for use during the competition. With the implementation of this rule, competitors will need to assess new design tasks associated with the energy storage device, thus enhancing the engineering development process.

Our team was asked to evaluate prospective potential energy storage concepts for the Human Powered Vehicles. We have developed a potential energy storage device that is capable of storing energy, which could then be used to propel the vehicle from rest to 3 km/hr. We also considered the feasibility of this function when the device begins with zero stored energy and all input energy originates from the human operator. With the use of this device, a novel energy storage method will be introduced to HPVC that is capable of providing energy to the vehicle without any additional energy from the operator. The success of this concept will enable cyclists to speed up even when the cyclist input is minimal.

Department of Mechanical Engineering
MICHIGAN STATE UNIVERSITY



Michigan State University
Team Members (left to right)

Joerg Petrasch
(Faculty Advisor)

Scott Maxey
Grosse Pointe Woods, Michigan

Michelle Huang
Ann Arbor, Michigan

Cameron Ploss
Clarkston, Michigan

Adam Goodes
Troy, Michigan

Justin Gilgallon
Tecumseh, Michigan

MSU Department of Mechanical Engineering
Project Sponsor

William Resh
East Lansing, Michigan

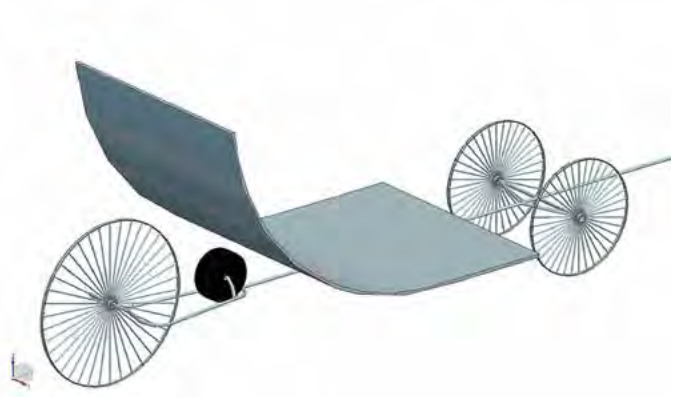
ME Faculty Advisor

Dr. Joerg Petrasch

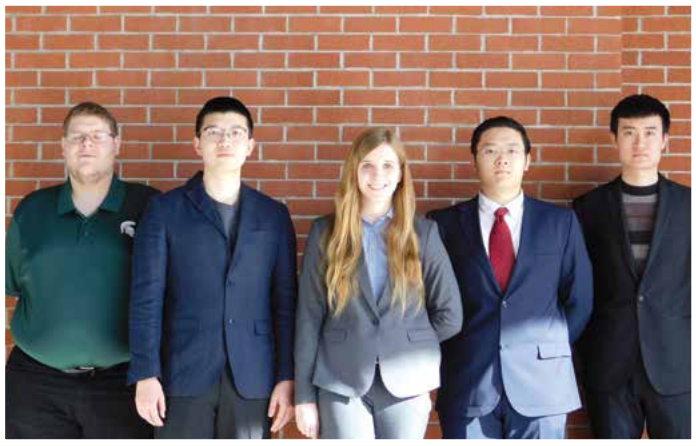
MSU Department of Mechanical Engineering
Bicycle Kinetic Energy Storage Device

This project was sponsored on behalf of the ASME's Human Powered Vehicle Challenge (HPVC). Many underdeveloped and inaccessible parts of the world experience difficulties with transportation, where vehicles that operate using a chemical or electrical fuel simply aren't viable. The overarching goal of the HPVC is to allow young engineers opportunities to prove themselves in the application of engineering practices by designing human powered vehicles and competing against each other. In turn, they would develop designs that could allow for a transformation in local transportation in regions that need it the most.

Our team was asked to assist in the design of an energy storage system for the human powered vehicle, with an emphasis on storing excess energy in a kinetic form for later use. It was decided that the best form of kinetic storage to explore and design was a flywheel system; this was due to a combination of factors. A history of industrial research and use, many existing designs from which to draw inspiration, and the relative simplicity of the device all led us to pursue this as our design solution. Some of the primary goals decided on by the team were to ensure a satisfactory level of safety with the device, together with reliability and ease-of-use.



Department of Mechanical Engineering
MICHIGAN STATE UNIVERSITY



Michigan State University
Team Members (left to right)

Michael Schultz
Perry, Michigan

Fangao Shi
Nanjing, Jiangsu

Taylor Ruelle
Fond du Lac, Wisconsin

Weiyu Li
Beijing,Beijing

Xiaoyu Xiong
NanChang, JiangXi

MSU Department of Mechanical Engineering
Project Sponsor

William Resh
East Lansing, Michigan

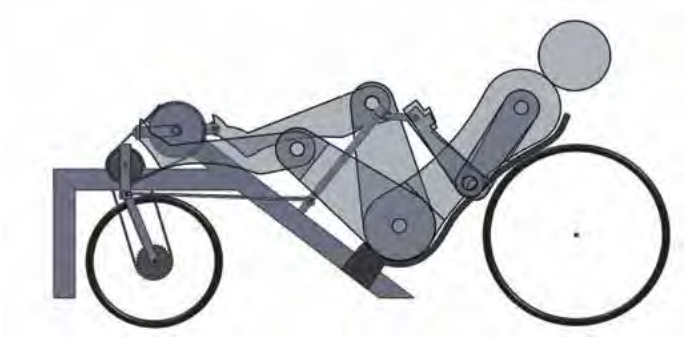
ME Faculty Advisor

Dr. Junghoon Yeom

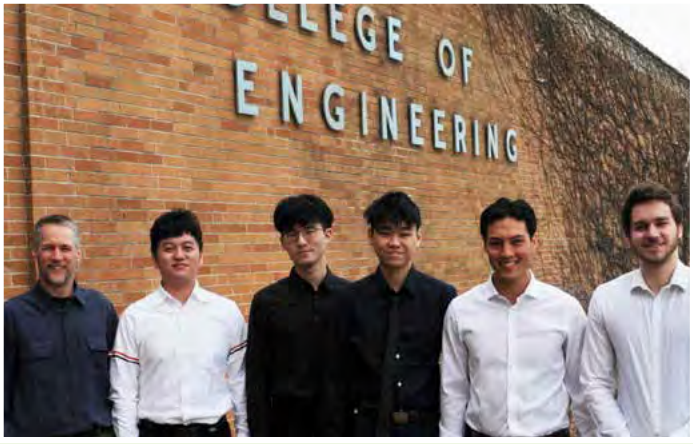
MSU Department of Mechanical Engineering
HPVC Energy Storage Device

Founded in 1880, the American Society of Mechanical Engineers (ASME) is a professional, non-profit engineering society that helps develop solutions to real-world challenges by allowing collaboration and consistency across all engineering disciplines. With its nearly 600 codes and standards implemented in more than 100 countries, ASME's 100,000+ members are able to utilize widely accepted industry practices in order to develop new technology while also creating a safer world. The Human Powered Vehicle Competition (HPVC) allows ASME to apply these codes and standards to the development of efficient, sustainable, and safe transportation methods.

The rules of the competition require the vehicle to store energy provided by the rider for reuse when desired. Other rules require that the vehicle come to a complete stop for three seconds every lap and to start the event with zero stored energy. The main goal for the energy transmitting device was to be able to accelerate the vehicle from rest to 3 km per hour twice per lap. Another requirement was to make sure the energy is released at the correct time in order maximize the safety of the rider, as well as the efficiency and reliability of the vehicle. Our group designed and analyzed an energy transmitting device that can transfer kinetic, potential, and chemical energy from the rider to the storage device and from the storage device back into the vehicle. This device will assist riders with a burst of energy when they need it most.



Department of Mechanical Engineering
MICHIGAN STATE UNIVERSITY



Michigan State University
Team Members (left to right)

Brian Feeny (Faculty Advisor)

Haoran Zhang
Nantong, China

Haoyang Zhang
Nanjing, China

Lucas Zheng
Guangzhou, China

Justin Stasevich
Clarkston, Michigan

Stephen Sutherland
Bloomfield Hills, Michigan

MSU Department of Mechanical Engineering
Project Sponsor

William Resh
East Lansing, Michigan

ME Faculty Advisor

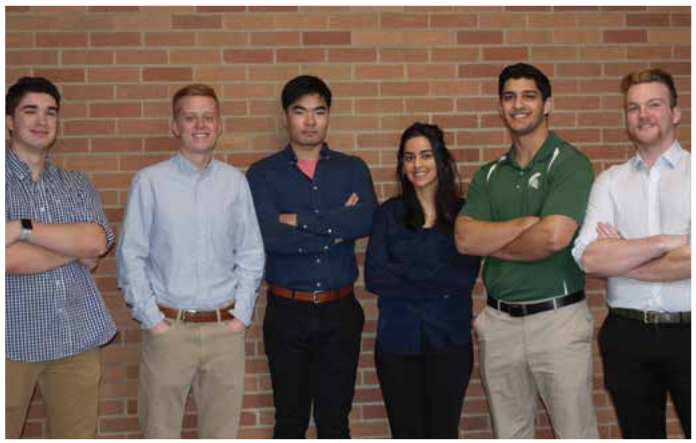
Dr. Brian Feeny

MSU Department of Mechanical Engineering
E-Bike Dynamometer

The Michigan State University Mechanical and Electrical Engineering departments focused on a project involving an electric bike dynamometer. This project is a continuation of a previous capstone project from the fall of 2019. The electric bike has two sources of power: the mechanical power from the rider and the electric power from the motor. The dynamometer had to be able to sense a range of loads and speeds that a rider would experience in real life.

The dynamometer measures the power output of the rear wheel of the bike for different load conditions. The goals of this project involved fixing and improving the previous design to provide accurate and realistic results. The first issue that was fixed was properly mounting the load cell to the motor. The second issue was constructing a more stable dynamometer structure. Fixing these two issues allowed for easier use and implementation of the original control strategy. The original control strategy was to account for different grades of roads along with different masses of bikes and riders. The varying resistance from the dynamometer can recreate these parameters for different simulated conditions.

Department of Mechanical Engineering
MICHIGAN STATE UNIVERSITY



Michigan State University
Team Members (left to right)

Ian Shelby (ECE)
Commerce Twp., Michigan

Adam Steslicki (ECE)
Northville, Michigan

Nicholas Pak
Rochester Hills, Michigan

Komal Dixit (ECE)
Troy, Michigan

Samuel Addy
Rochester Hills, Michigan

Evan Drew
Rochester Hills, Michigan

MSU Department of Mechanical Engineering
Project Sponsor

William Resh
East Lansing, Michigan

ME Faculty Advisor

Dr. Norbert Mueller

MSU Department of Mechanical Engineering
Bicycle Frame Manufacturing

In order for low volume bicycle manufacturers to meet production demands and remain profitable, they must have an efficient system for manufacturing bicycle frames. It is important that a manufacturer is able to repeatedly produce bicycle frames, with slight adjustments. These adjustments include differences in sizing and frame geometry. If a manufacturer is able to use the same tools, fixtures, and process from frame to frame, its profits will increase greatly.

Our team was provided CAD models for a bicycle frame and was tasked with bringing the design to life. This included verifying CAD models and creating fixtures that streamlined the assembly process. The purpose of these fixtures is to help consistently replicate a specific bicycle frame but be adjustable to other frame plans in the future. We developed a manufacturing plan to allow for low volume production at a rate of one frame per day.

Department of Mechanical Engineering
MICHIGAN STATE UNIVERSITY

Michigan State University
Team Members (left to right)

Kyle Raymos
Marysville, Michigan

Hunter Moore
New York, New York

Thomas Cook
Haslett, Michigan

Lucas Serraiocco
Warren, Michigan

Nicholas Gerich
Woodhaven, Michigan

MSU Department of Mechanical Engineering
Project Sponsor

William Resh
East Lansing, Michigan

ME Faculty Advisor

Dr. Ahmed Naguib

The Capstone Projects

Dr. William Resh
Professor of Mechanical Engineering

Faculty Advisors: Brereton, Cloud, Mueller, Schock, Zayernouri, Zhu


Brereton


Cloud


Mueller


Schock


Zayernouri


Zhu

Presentation Schedule – Engineering Building, Room 2435

Time	Team Sponsor	Project Title
7:30 a.m.	Pratt Miller Engineering	Formula SAE Drag Reduction System (DRS)
8:00 a.m.	MSU Baja Racing Team	On-Vehicle Transmission Testing System
8:30 a.m.	MSU Baja Racing Team	Shock Dynamometer
9:00 a.m.	MI Department of Natural Resources	Straits State Harbor Renewable Energy Generation
9:30 a.m.	Michigan AgrAbility	Log Trough
10:00 a.m.	Swagelok	Alignment Fixture for Tube Bending
10:30 a.m.	Swagelok	Indexable Tool for Deburring Large Diameter Pipes
11:00 a.m.	ArcelorMittal	Crane RFID Antenna Mount
11:30 a.m.	ArcelorMittal	Floor Plate Inversion Table

Supporting ME Design Projects

Each semester, ME 481 has a wide range of design projects for the students to select from. Many of these are from industrial sponsors. But many of these engineering projects come from groups not typically associated with engineering, such as, the Theatre Department, social service or humanitarian groups, and MSU student groups or clubs (i.e., MSU Adaptive Sports & Recreation Club and the Sailing Club). Some of you reading this may have done your capstone project on an experience of this type.

These projects need funding and will benefit from your support through a contribution or endowment. Your gift enables the ME Design Program to continue to complete projects that help these worthwhile causes. Contact Jim Lang at langjame@msu.edu or 810.224.0055 to learn more.

Pratt Miller Engineering
Formula SAE Drag Reduction System (DRS)

Formula SAE is a collegiate design competition that challenges students to design, manufacture, and race an open-wheeled racecar against universities from around the world. Cars from universities such as Michigan State compete in dynamic events to evaluate their performance within areas of design, control, and, most notably, in aerodynamic performance.

The objective of the Drag Reduction System is to improve the performance of Michigan State University's 2020 Formula SAE racecar - the SR-20. The Drag Reduction System improved lap times by reducing the overall vehicle drag when activated within its open state. The aerodynamic airfoils on the vehicle's rear wing were made to be adjustable, powered by a control module that triggers a linear pneumatic actuator over the vehicle's CAN-Bus Controller Area Network – Bus. The stroke of the actuator acts through a linkage system to optimize the angle of attack of each airfoil when the DRS system is adjusted between open or closed states. With DRS, the time saved, owing to decreased time spent on track straightaways, reduces the time penalty induced by weight and drag in a well-designed vehicle.

Technical support was provided by Pratt Miller Engineering - a product development company specializing in complex applications within motorsports, defense, and specialized software solutions. PME provides engineering and design, prototyping, low-rate production, and digital solutions.

PRATT MILLER

Michigan State University
Team Members (left to right)

Minir Jakupi
Troy, Michigan

Christian Abbate
Hanover, Massachusetts

Brendan Frenczli
DeWitt, Michigan

Victoria Farrell
Grand Rapids, Michigan

Timur Aminov
Troy, Michigan

Pratt Miller Engineering
Project Sponsor

John Lankes
New Hudson, Michigan

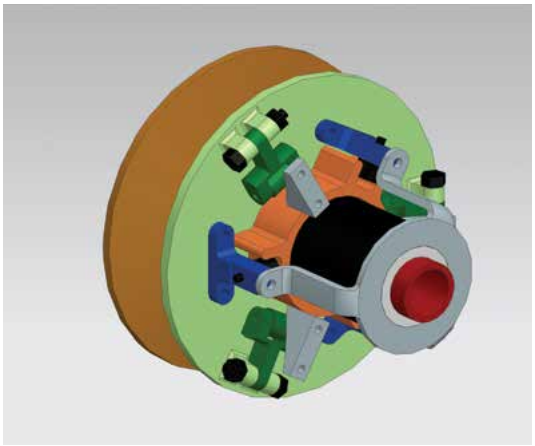
ME Faculty Advisor

Dr. Gary Cloud

MSU Baja Racing Team
On-Vehicle Transmission Testing System

The MSU Baja Racing Team is a Society of Automotive Engineers collegiate design team that designs, builds, and races an off-road buggy in competitions around the country. The team has competed in off-road vehicle racing since the 1980s. The focus of the team is to develop engineering students and provide them with a chance to apply their classroom knowledge to a complicated real-world problem.

Previously, Michigan State Baja has used Continuously Variable Transmissions (CVT) designed for snowmobiles and junior dragsters but has made the move to using a custom CVT on their car this year. With the increased tuning capabilities offered by the custom CVT, our team designed and programmed an on-vehicle transmission testing system for the team to use. The system accurately measures the rotational speed of both portions of the CVT while also measuring the linear distance the CVT changes during ratio shifts. The system is also set up to measure belt speed and temperature in future testing. All sensors were designed to fit into a housing that mounts directly to the vehicle and enables the system to be transferred to future team vehicles. The completed project will allow the MSU Baja Race team to improve their CVT tuning, allowing for a faster and more efficient vehicle.



MICHIGAN STATE BAJA

Michigan State University
Team Members (left to right)

Tariq Salim
Tripoli, Libya

Brian Fedewa
DeWitt, Michigan

Ali Alhajji
Al-Ahsa, Saudi Arabia

Jacob Morrison
Charlotte, Michigan

Ghali Alwajih
Ibb, Yemen

MSU Baja Racing Team
Project Sponsor

Phil Hill
East Lansing, Michigan

ME Faculty Advisor

Dr. Guoming Zhu

MSU Baja Racing Team
Shock Dynamometer

The MSU Baja Racing Team is a Society of Automotive Engineers collegiate design team that designs, builds, and races an off-road buggy in competitions around the country. The team has competed in off-road vehicle racing since the 1980s. The focus of the team is to develop engineering students and provide them with a chance to apply their classroom knowledge to a complicated real-world problem.

A shock dynamometer was designed to help the team accurately measure the damping rate of shocks, which are a key suspension component. This tool relates the velocity of the shock plunger to a resistive force. Using this dynamometer, the team was able to quantitatively design a better suspension system and help future team members develop a deeper understanding of vehicle dynamics.

MICHIGAN STATE BAJA

Michigan State University
Team Members (left to right)

Zhiyao Wang
Hefei, Anhui

Devon Killebrew
Mason, Michigan

Jake Stuifbergen
Essexville, Michigan

Charlie Tappan
Grand Rapids, Michigan

Zac Brei
Milford, Michigan

MSU Baja Racing Team
Project Sponsor

Phil Hill
East Lansing, Michigan

ME Faculty Advisor

Dr. Mohsen Zayernouri

MI Department of Natural Resources (DNR)
Straits State Harbor Renewable Energy Generation

Michigan Department of Natural Resources Parks and Recreation Division (DNR) is charged with the care of 19 state harbors, 103 state parks, and over 100 state forest campgrounds. The Straits State Harbor is one of the locations and is the focus of this project. Operating costs for a typical DNR managed harbor can reach up to $6,000 a month when the ice-suppression bubblers are running. As part of the development of the harbor, in 2007 the DNR invested in eight windmill turbines to supplement the harbor's energy requirements. The windmills led the harbor to become one of the most eco-friendly in the State of Michigan. However, currently only two of the eight windmills are functioning. The wind turbine manufacturer is no longer in business, so it has been difficult finding a company to repair them, meanwhile maintenance costs continue to increase.

Our group was tasked with analyzing all available data on the windmills and geography of the region. At which point, we would provide a recommendation for the DNR to either effect repairs on the current windmills, or to replace them with an entirely new alternative energy system.

Michigan State University
Team Members (left to right)

Elias Zepeda-Barragan
Imlay City, Michigan

Moe Tabateh
Ann Arbor, Michigan

Yash Gupta
New Delhi, India

Aaron Warstler
Grand Ledge, Michigan

Gi Hwan Lee
Seoul, South Korea

MI Department of Natural Resources
Project Sponsor

Keith Cheli
Cheboygan, Michigan

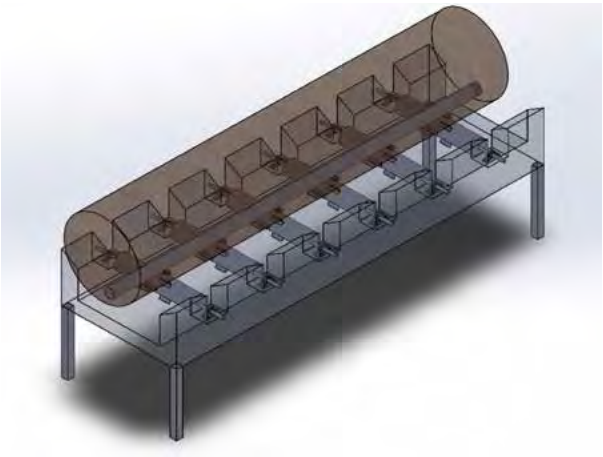
ME Faculty Advisor

Dr. Harold Shock

Michigan AgrAbility
Log Trough

Michigan AgrAbility assists workers in the agricultural industry with disabilities, both physical and mental, to allow them to continue pursuing the occupation they enjoy. These disabilities create daily challenges for Michigan farmers and can burden them with financial challenges, lifestyle changes, and an uncertain future. AgrAbility works closely with Michigan Rehabilitation Services to eliminate such barriers through the development and design of specialized farming equipment and tools. This allows farmers with disabilities to continue to work independently and experience an improved quality of life.

Our team was tasked with designing a log trough for a family that relies on a wood furnace to heat their home during the winter months. The trough had to accommodate logs ranging from three to twenty-eight inches in diameter, and ten to twelve feet in length. Manually moving a log of this size is no easy task, making it necessary to design a mechanism that moves the log forward and backward. In addition, it enables the log to be clamped and cut as desired. By hydraulically assisting the movement of the log, the amount of physical labor required to perform this important task was significantly reduced. The implementation of this project has considerably improved the log splitting capacity of the family.



Michigan State University
Team Members (left to right)

Ned Stoller (Industry Advisor)
Grand Rapids, Michigan

Marcell Benkes-Toth
Ann Arbor, Michigan

Taylor Jacobs
Howell, Michigan

Kurtis Potier
Lake Orion, Michigan

Helen Miller
Ann Arbor, Michigan

Jacob Sickelsteel
Newaygo, Michigan

Michigan AgrAbility
Project Sponsor

Ned Stoller
Grand Rapids, Michigan

ME Faculty Advisor

Dr. Giles Brereton

Swagelok
Alignment Fixture for Tube Bending

Swagelok is a $2 billion dollar company that develops innovative solutions for fluids systems operating on a local and global level. Our group worked with the Farmington Hills location. This location is an innovation center specializing in fabricating high-pressure products, tubing and tools, and welding systems. The wide range of projects encountered by this facility requires tools that promote accurate and rapid prototyping.

The goal of the project was to design and manufacture a universal alignment and measurement fixture used for different sizes of stainless-steel tube bending. The process heavily relied on human visuals for phase alignment. When multiple bends were required, this process often became a trial and error process resulting in material and time wasted. The created fixture eliminates the possibility for human error in the tube-bending process. The fixture allows the user to accurately bend tubing with intuitive and easy-to-use alignment features. Moreover, the size and weight of the fixture promote easy transportation. The device is expected to increase internal efficiency at Swagelok.

Swagelok Michigan | Toledo

Michigan State University
Team Members (left to right)

Christopher Kiesling (Sponsor)

Karl Havens
Monroe, Michigan

Rachel Arnold
Sterling Heights, Michigan

Pankti Tank
Shelby Township, Michigan

Jeremy Coleman
Canton, Michigan

Christopher Fadanelli
Novi, Michigan

Swagelok
Project Sponsor

Christopher Kiesling
Farmington Hills, Michigan

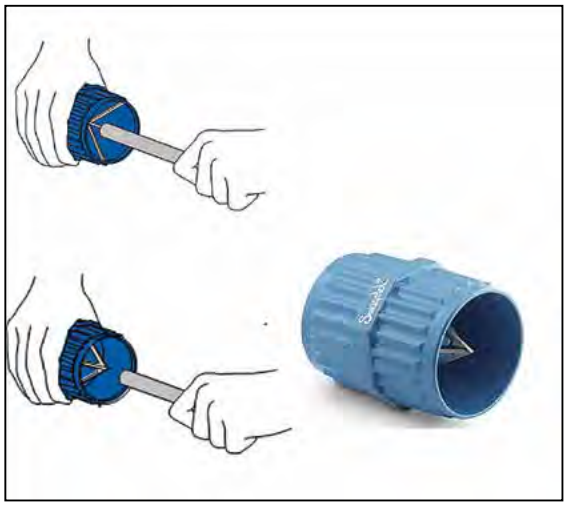
ME Faculty Advisor

Dr. Giles Brereton

Swagelok
Indexable Tool for Deburring Large Diameter Pipes

Swagelok Michigan/Toledo is an authorized sales and service center for the Swagelok Company. Founded in the 1940s, Swagelok is known for tube fittings, exotic alloys, and high-quality products for fluid systems. With 8,000 employees working in over 80 distribution centers, Swagelok is the leading supplier of fluid system components globally. Swagelok strives to find a better way. Through new products, system designs, training, and services Swagelok is focused on improving the customers' experience.

Swagelok offers high quality tubing in sizes up to two inches in diameter, which is cut to specified lengths for customers. When cutting, burrs are left on the interior and exterior diameters of the tubing, preventing proper use by customers. Before shipping, they must be removed. On smaller diameter tubing (up to 1 ¼ inches) there is currently a tool to remove the burrs. On larger diameters, it must be done by hand. The project goal was to develop a tool that can quickly and efficiently remove harsh burrs from the inside and outside diameters of stainless steel tubing for a variety of sizes. Universal milling inserts were utilized throughout the project in order to achieve cutting. Additionally, a power unit was included to create the deburring action. This way, the task is safer and easier for the operator. The tool is a rigid setup that can be used over a large size range, including the large and small diameter tubing. Therefore, the new tool allows Swagelok's operations to be more efficient.



Swagelok Michigan | Toledo

Michigan State University
Team Members (left to right)

Jayme Stiglich
South Lyon, Michigan

Conner Stevenson
Wixom, Michigan

Ryan Kalis
Walled Lake, Michigan

Christopher Kiesling (Sponsor)

Austin Aselage
White Lake, Michigan

Alyssa Salciccioli
Commerce, Michigan

Swagelok
Project Sponsor

Christopher Kiesling
Farmington Hills, Michigan

ME Faculty Advisor

Dr. Norbert Mueller

ArcelorMittal
Crane RFID Antenna Mount

ArcelorMittal is the world's leading integrated steel and mining company – present in 60 countries with an industrial footprint in 18 countries. Melted down iron ore pellets are cast into sheets and rolled into coils (pictured to the right) that can weigh between 50,000 and 80,000 pounds each. Many of the steel rolls look very similar but have had different treatments leading to different material properties. Accurately tracking each coil is therefore critical to ensure the customer receives the correct product. This location has integrated the use of RFID chips into several steps of the manufacturing process.

Our group is responsible for determining an optimal design for an RFID mount that allows crane operators to identify each steel coil after it is placed in the warehouse. The mill would like to expand the use of RFID technology to assist in crane pickup to generate a map of these identified coils using the mount designed by our team. The mount needs to be durable and easily attachable to the crane. The successful completion and implementation of our team's design solution has a yearly cost-saving potential of more than $1M and will save the crane operators hours of work each month searching for the correct coil.

ArcelorMittal

Michigan State University
Team Members (left to right)

Dylan Lott
Gettysburg, Pennsylvania

Tyler DuBois
Linden, Michigan

Allison Bell
Lincolnshire, Illinois

Neil Haakenson
Novi, Michigan

Joe Troy
St. Charles, Illinois

ArcelorMittal
Project Sponsor

Lauren Hart
Burns Harbor, Indiana

ME Faculty Advisor

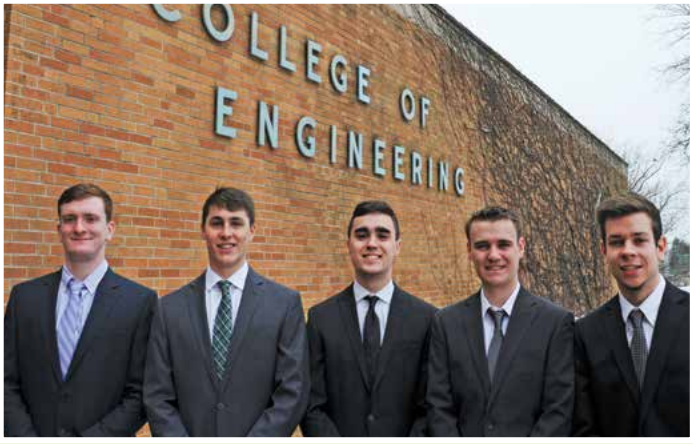
Dr. Giles Brereton

ArcelorMittal
Floor Plate Inversion Table

ArcelorMittal is the world's largest integrated steel mining and manufacturing corporation in the world. Headquartered in Luxembourg City, Luxembourg, ArcelorMittal annually produces 118 million tons of crude steel as of 2018. The corporation is a leading supplier in major North American and European markets providing steel solutions to the automotive, construction, consumer appliance and machinery industries. ArcelorMittal employs more than 200,000 people across 60 countries with significant operations in France, Germany, Belgium, Luxembourg, and Poland. In the United States alone, ArcelorMittal employs 18,000 people across 25 operations. Operations such as mining, steelmaking and finishing are fully integrated to meet a wide range of customer demands across diverse industries.

In Burns Harbor, Indiana ArcelorMittal's plant is 60 years old. Due to the age of the plant, many of the plant's steel floor plates require maintenance. These floor plates weigh nearly 3 tons and require mechanical advantage to safely rotate them upside down for re-attachment of the support beams. The team designed an inversion table to assist in the repair of these steel floor plates. The table utilizes pressurized, piston-driven cylinders to control the motion of the floor plates as they rotate. The shear weight of the floor plates made the design more challenging as it required very robust designs. The repair of these steel floor plates greatly improves the logistic efficiency of steel transportation within the plant.

ArcelorMittal



Michigan State University
Team Members (left to right)

Andrew Mizer
Cadiz, Ohio

Ryan Ball
Brighton, Michigan

Liam Kelly
East Lansing, Michigan

Jacob Broman
White Lake, Michigan

Stephen Wernette
Brighton, Michigan

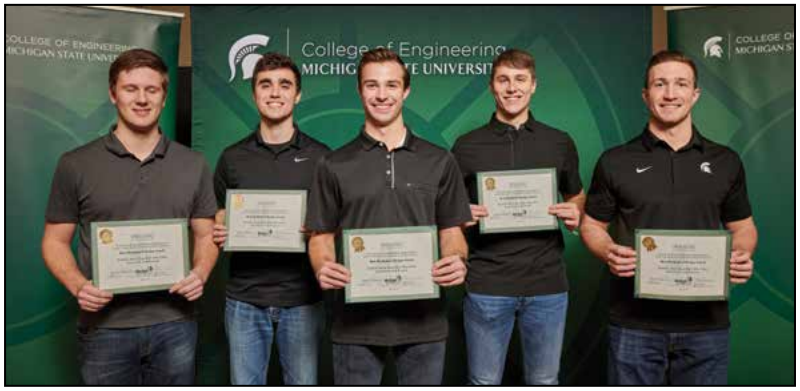
ArcelorMittal
Project Sponsor

Lauren Hart
Burns Harbor, Indiana

ME Faculty Advisor

Dr. Giles Brereton

Design Day Awards Fall 2019



FALL 2019
ME 470 DA VINCI AWARD

Left to right:Josh Peckens, Liam Kelly, Matthew Arenz, Ryan Ball, Mike Falter

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FALL 2019
ME 481 PROJECT PRESENTATION AWARD

Team Heartwood School/Ingham ISD
"Bus Safe Climbing System"

Left to right: Garrett Weidig, Ryan Heinze, Chelsey Jenkins, Elizabeth Schester, Laura Hohnstadt

FALL 2019
ME 481 EDISON AWARD

Team Michigan AgrAbility
"Automatic Gate Opener"

Left to right: L. Joe Gusumano, Bradford Chapman, Ryan Qamar, Jeffrey Masten-Davies, Maria Daniela, Martin Pereira

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Dr. Wayne Dyksen
Executive Director, Design Day
(517) 353-5573 dyksen@msu.edu

Jill Bielawski
Director, Design Day
(517) 353-8133 bielawsk@egr.msu.edu

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