Senior Design Clinic

2022 - 2023

School of Engineering

UNIVERSITY OF St.Thomas

2023 SCHOOL OF ENGINEERING
SENIOR DESIGN CLINIC

Welcome to the University of St. Thomas School of Engineering 2023 Senior Design Clinic.

This book is just one part of celebrating the incredible accomplishments of our seniors. Through their hard work, they have developed into truly remarkable engineers. They hold the powerful combination of technical skills and character that will, without question, make the world a better place as they go forward from St. Thomas.

These pages reveal 29 projects that started as just ideas several months ago. The ideas transformed from primitive sketches to reality, from an industry problem to a working solution. The resulting projects are the culmination of two semesters of the dedication and persistence of St. Thomas School of Engineering seniors. Each year, nearly 40 companies and non-profit organizations engage our students with real-world engineering challenges. With the past several years of adversity faced, the challenges our students have overcome have been amplified. On reflection, each student can take stock in the character traits of resiliency, perseverance, courage, patience, tolerance, and wisdom gained by facing both the adversities inherent in project design and the external adversities brought on by so many of the current events in our lives.

The work in this booklet captures the essence of the St. Thomas Senior Design Clinic. Students gained new skills outside of the classroom in planning, in budgeting, and in working on a real-world problem without an obvious or pre-determined solution. The students learned to adjust to unforeseen circumstances.

In short, what you see here is engineering!

We are grateful for the support of the local and global sponsoring companies and organizations that have committed their funds, equipment, and time, to make this a truly great experience for our students. We are especially grateful for the support of the family, friends, and mentors on whom each of our seniors has relied, to reach this point in their incredible life journey.

Again, thank you and enjoy!

Dr. Don Weinkauf

Dean of the School of Engineering

School of Engineering

UNIVERSITY OF St.Thomas

SENIOR DESIGN CLINIC GUIDEBOOK 2023

NAME	TEAM	PAGE
Abdimuhsin, Mohamud	Team 2	7
Abusharar, Ahmed	Team E	5
Achenbach, Kate	Team 1	6
Almich, Maija	Team 10	15
Althoff, Mason	Team 19	24
Audi, Michael	Team 5	10
Bailey, Alexander	Team 8	13
Balfany, Jeffrey	Team 18	23
Becker, Will	Team 7	12
Benusa, Michael	Team 21	26
Bollinger-Brown, Paige	Team 12	17
Bourdage, Alexander	Team 16	21
Brietzke, Adrian	Team 8	13
Broberg, Seth	Team E	5
Catton, Brooke	Team 12	17
Cunningham, Connor	Team 12	17
Danner, Eric	Team 7	12
Davis, Michelle	Team 22	27
Delgadillo Bonequi, Ian	Team 20	25
DeSimone, Nick	Team 24	29
Deutsch, Ethan	Team 4	9
Dolezal, Joshua	Team 3	8
Doriott, Carter	Team 22	27
Eagan, Will	Team B	2
Eckman, Treycen	Team 16	21
Eid, Drew	Team A	1
Elbrawi, Sherif	Team D	4
Eldredge, Charlie	Team 7	12
Eldridge, Lauren	Team 12	17
Emmerich, Ava	Team 14	19
Endris, John	Team 23	28
Ennis, Michael	Team 17	22
Faacks, Sophia	Team 1	6
Fjellman, Erik	Team 6	11
Fritz, Morgan	Team 2	7
Gahnz, Karlyn	Team 3	8
Gerber, Gracie	Team 11	16
Gilbert, Ben	Team 16	21
Gustafson, Ben	Team 8	13
Halla, Cole	Team 8	13
Hammond, Seth Sawyer	Team 22	27
Hansen, Jared	Team E	5
Heimerman, Matthew	Team C	3
Heitkamp, Paige	Team 9	14
Heun, Jack	Team C	3
Hintermeister, Renna	Team 23	28
Holmes, Michael	Team 11	16
Howard, Julia	Team B	2
Huntington, Colin	Team 10	15
Ireland, Jacob	Team 2	7
Jacobs, Alex	Team B	2
Ja'ffer, Suleyman	Team E	5
Johnson, Josh	Team 21	26
Kaeding, Will	Team C	3
Kavie, Owen	Team 18	23
Kiefer, Charles	Team 10	15
Knox, Mason	Team 21	26
Kratzke, Alison	Team 16	21
Larson, Kyle	Team 17	22
Le, Duy	Team 3	8
Lee, Kathy	Team 15	20
Lemesh, Mikita	Team 13	18

SENIOR DESIGN CLINIC GUIDEBOOK 2023

NAME	TEAM	PAGE
Lewis, Terence	Team 21	26
Lindell, Julia	Team A	1
Lockwood, Skyler	Team 14	19
Long, McKendra	Team 20	25
Lovdahl, Zachary	Team 5	10
Lu, Jimmy	Team 20	25
Marks, Sean	Team 19	24
Masese, Faith	Team 1	6
Mesler, Jolee	Team 4	9
Michelizzi, Jacob	Team 6	11
Mink, Elizabeth	Team 4	9
Monfil Jr., Jorge	Team A	1
Montes de oca Correa, Vanesa	Team 23	28
Mugaas, Jacob	Team 17	22
Nelson, Calin	Team 1	6
Norpel, Dallas	Team D	4
Padden, Maria	Team 3	8
Paterson, Allie	Team 18	23
Patton, Caleb	Team D	4
Pechman, Jacob	Team 14	19
Pedevila, Valentina	Team 9	14
Perkins, Kevyn	Team B	2
Pfister, Alex	Team 15	20
Phan, Tri	Team 9	14
Pillai, Srajan	Team 5	10
Porter, Jake	Team D	4
Porter, Scott	Team E	5
Rasmussen, Raymond	Team 10	15
Roberts, Emma Rae	Team 2	7
Roche, Sean	Team C	3
Rodriguez, Anthony	Team 5	10
Schik, Peter	Team 24	29
Schupanitz, Marie	Team 6	11
Schwarz, Evan	Team 4	9
Scott, John	Team 13	18
Selin, Evan	Team 1	6
Sevenich, Regan	Team 19	24
Simon, Jackson	Team 20	25
Singleton, Logan	Team 19	24
Smith, Wyatt	Team 13	18
Spellman, Colin	Team 11	16
Spurgat, Nate	Team 9	14
Strantz, Cory	Team 22	27
Sucher, Thomas	Team 17	22
Tester, Genevieve	Team 2	7
Tharalson, Steven	Team C	3
Thatcher, Hannah	Team 11	16
Theisen, Andrew	Team A	1
Thelen, Ryan	Team 24	29
Thibault, Jack	Team A	1
Thuma, Tom	Team 15	20
Truong, Evelyn	Team 14	19
Tuchtenhagen, Emily	Team 6	11
Valipour, Niloofar	Team D	4
Vogel, John	Team 18	23
Vue, Jonathan	Team 13	18
Warren, CJ	Team 24	29
Woessner, Sophie	Team 15	20
Yang, Christina	Team 11	16
Ziglinski, Isaac	Team 7	12
Zimmerman, Max	Team 23	28

CHANGEMAKING

The University of St. Thomas, designated as an Ashoka U Changemaker Campus, is part of a global network of 150 colleges and universities re-envisioning the role of higher education and the university in society as major drivers of social impact. What is changemaking? Taking the freedom, confidence, grit and societal support to address social problems and drive change, all for the common good.

Engineering develops entrepreneurial and solutions-oriented skills that can be used to promote innovations for society. Several of our Senior Design projects have been officially designated as changemaking projects. Look for these logos throughout this guide:

SENIOR DESIGN CLINIC PROJECT SPONSORS

PROJECT SPONSOR	TEAM#	PAGE#
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The Andean Alliance for Sustainable Development	Teams A & 11	1 & 16
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Auris AI	Team 15	20
Boston Scientific	Team 4	9
Burns & McDonnell	Team 1	6
Carestream	Team 5	10
City of Bloomington, Minnesota	Team C	3
Emerson Electric Co., Rosemount Inc.	Team 16	21
Forever Ware	Team 18	23
Mayo Clinic	Team E	5
Medtronic	Team 21	26
Minnesota Children's Museum	Team 12	17
Northrop Grumman	Team 17	22
nVent-HOFFMAN	Team 9	14
Partners in Food Solutions	Team B	2
Pre-start up Mayo Clinic Spin-Off Company	Team 14	19
Process Logic	Team 10	15
Ramsey County	Team 2	7
Safran Test Cells	Teams 8 & 22	13 & 27
Sensata Technologies	Team 23	28
SOTA Systems	Team 7	12
Teleflex Medical OEM	Team 19	24
Toro	Team D	4

SOLAR POWERED WATER PUMP

From left to right: Andrew Theisen, Jorge Monfil Jr., Julia Lindell, Jack Thibault, Drew Eid

THE ANDEAN ALLIANCE FOR SUSTAINABLE DEVELOPMENT

TEAM A

INDUSTRY REPRESENTATIVE
Aaron Ebner

FACULTY ADVISOR
Andy Tubesing

PROJECT SUMMARY

Farmers in the Andes face increasing water shortages which dramatically affect their crop yields and ability to earn a living. A solar water pump can be used in a variery of scenarios to help move water from natural sources to where it is needed for agricultural use. The use of solar power is particularly advantageous for those farming communities that do not have access to stable electricity.

A river valley in the Andes Mountains near Cusco, Peru. The team engineered an irrigation system to help farmers in this area, and a software tool to assist in the design of future projects powered by utility and solar energy systems

DESIGN GOAL

This project aims to develop a culturally appropriate, low cost solution to pump water using solar energy, from natural and manmade sources to points of need in the Andes in Peru. Additionally, a software will be developed to assist in site specific analysis and planning.

DESIGN CONSTRAINTS

- Culturally appropriate to local farmers
- Low cost
- Safe and simple construction, set-up, and use by Andean Farmers
- Easy to Transport
- Off-grid energy capture and storage sufficient to power water pump
- Theft prevention
- Made of durable materials for the climate conditions
- Able to be completely constructed and repaired in the Sacred Valley

GLOBAL CHANGEMAKING

GRAIN SANITIZING EQUIPMENT

From left to right: Will Eagan, Julia Howard, Alex Jacobs, Kevyn Perkins

PARTNERS IN FOOD SOLUTIONS

TEAM B

INDUSTRY REPRESENTATIVE
Amanda Traaseth

FACULTY ADVISOR
Robert Bach

PROJECT SUMMARY

A small and growing company in Uganda intends to process finger millet into finger millet flour and sell the flour to a large buyer that processes the flour into a nonalcoholic drinking beverage. The local millet buyer is expected to purchase substantial quantities of finger millet flour, but the quality of finger millet supplied by the company has consistently failed quality tests by the buyer on grounds of microbial loads.

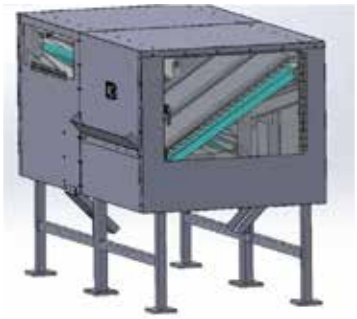
DESIGN GOAL

The project shall be to design prototype equipment that can subject millet to UVC lights to reduce microbial load so that the millet can pass supplier standards when the grain is tested. Designing this technology will not only create business opportunities for industries dealing in grain but also enable grain processors to have a clean and safe input of grain.

DESIGN CONSTRAINTS

- The prototype shall fit grain 1.0 mm to 2.0 mm
- The prototype shall reduce the microbial load of E.coli, salmonella, staphylococcus aureus, yeast, and mold in accordance with the East African Standards
- The working prototype shall have a capacity of 25 kg per hour, scaled to 500 kg per hour
- The final prototype shall be fabricated with parts that can be easily sourced in Africa
- The final design shall be food safe.
- Operators will not be exposed to harmful UVC rays

The team has chosen two possible designs to explore in an engineering design and consulting role. To the left is a freefall method and to the right is a conveyor system. Each design will utilize UVC bulbs to fully sanitize the finger millet grain



GLOBAL CHANGEMAKING

I-35W BICYCLE ROUTE

From left to right: Will Kaeding, Matt Heimerman, Sean Roche, Steven Tharalson, Jack Heun

CITY OF BLOOMINGTON MINNESOTA

TEAM C

INDUSTRY REPRESENTATIVES

Julie Long
Amy Marohn
Bryan Gruidl

FACULTY ADVISOR

Travis Welt

PROJECT SUMMARY

The city of Bloomington has tasked this University of St. Thomas Senior Design team to look into possible bicycle routes. The Team has proposed three different routes for consideration. After comparing the different routes based on specific criteria proposed by the team, the city route was determined to the best of the three. From there the team was tasked to create a design proposal using the software AutoCAD and generating a preliminary cost estimate for the city of Bloomington.

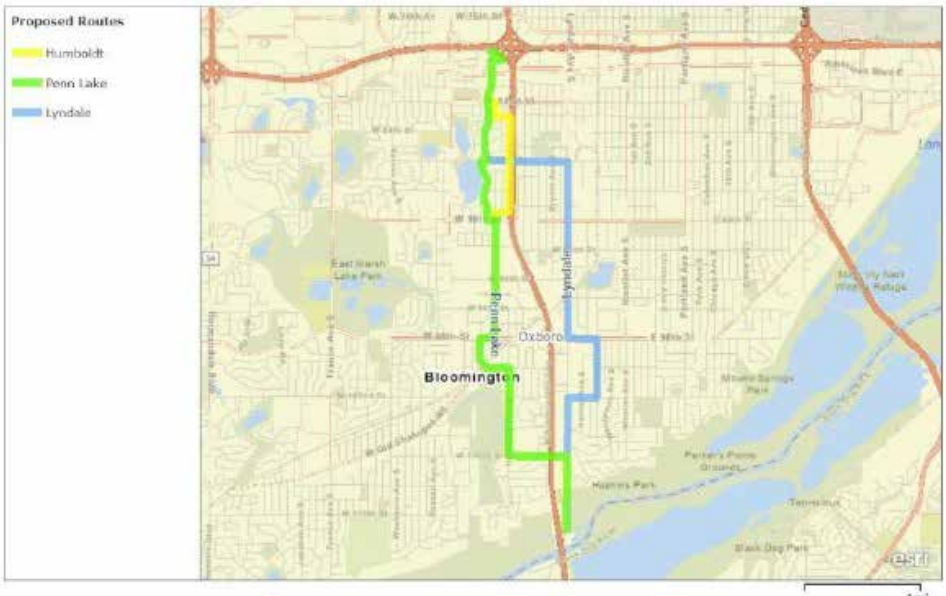
DESIGN GOAL

Create a bike path at the Orange Line Stations at 98th Street and Knox Ave/American Blvd.

DESIGN CONSTRAINTS

- All MnDOT requirements must be met
- All potential facilities on State Aid roadways shall meet State Aid Standards
- All potential off-road facilities shall be ADA compliant
- All water resources components shall follow The Bloomington Surface water Management Plan and Nine Mile Creek Watershed District regulations

Potential bicycle routes considered during design phase



LOCAL CHANGEMAKING

TORO AUTOMATED TRIMMER

From left to right: Dallas Norpel, Jake Porter, Caleb Patton, Sherif Elbarawi, Niloofar Valipour

TEAM D

INDUSTRY REPRESENTATIVE
Dana Lonn

FACULTY ADVISOR
Chong Xu

PROJECT SUMMARY

Golf courses use many hours of labor a year to manually trim around infrastructures on the course. This project's goal is to create a device that will automatically trim around a piece of infrastructure, such as a sprinkler, to reduce the hours of labor needed to maintain these infrastructures.

DESIGN GOAL

To design an automated trimmer that is able to identify an infrastructure and trim around precisely without causing damage to the infrastructure.

DESIGN CONSTRAINTS

- Device must trim within 0.2 inches of target infrastructure
- Device cannot damage infrastructure
- Device must be able to trim around circular and rectangular infrastructures
- Trimming must be done in a timely manner
- System is independent

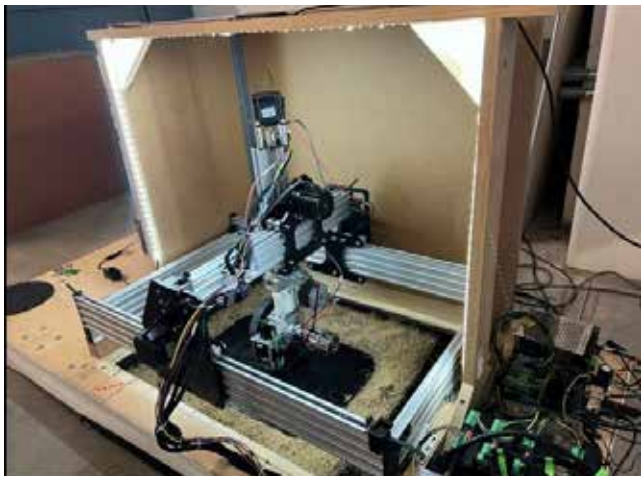


Image of current device

Cutting blade getting ready to trim around infrastructure

IMPROVED SPINAL ROD TEMPLATE

From left to right: Seth Broberg, Suleyman Ja'ffer, Ahmed Abusharar, Jared Hansen, Scott Porter

MAYO CLINIC

TEAM E

INDUSTRY REPRESENTATIVES
Stephen Kuehn
Timothy Rossman

FACULTY ADVISOR
Chris Haas

PROJECT SUMMARY

Mayo Clinic currently uses an aluminum intubation stylet as a template during spinal fusion surgery. The template is shaped to the pedicle screws attached to the spine. Once desired shape is achieved the template is removed from the pedicle screws and used as a guide to bend a titanium or cobalt chrome rod. During removal and template transfer operations, the aluminum rod can mistakenly deform. These deformations can be hard to see and cause the titanium or cobalt chrome rod to not fit correctly.

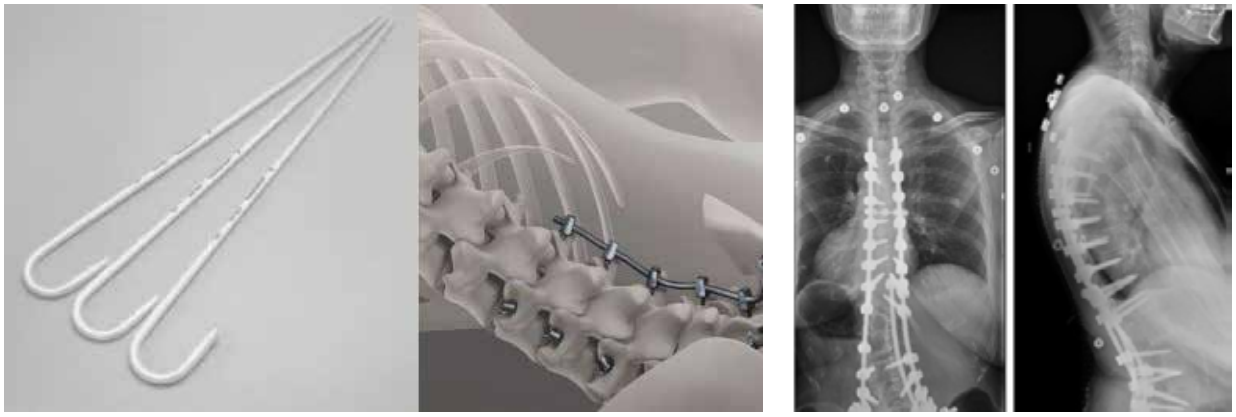
This fitment issue leads to increased surgery time, increased stress risers in the rod, increased surface nicks, and postoperative pedicle screw loosening or pullout. The St. Thomas Senior Design Team is tasked with developing a new template rod that maintains its shape once the desired shape is set.

DESIGN GOAL

Design a template that conforms for easy installation into pedicle screws. Once the desired shape is achieved, the template maintains the shape through the rod bending process.

DESIGN CONSTRAINTS

- Support lengths up to 80cm
- Diameter between 5-5.5mm
- Conforms to any pedicle screw location
- Maintains unique shape once removed to assist the rod bending procedure
- Cost less than $100



left to right: Spinal rods; CGI of rod and pedicle screws; X-rays of installed rod and pedicle screws

LANDFILL GAS COLLECTION AND CONTROL SYSTEM

From left to right: Sophia Faacks, Calin Nelson, Evan Selin, Kate Achenbach, Faith Masese

BURNS McDONNELL

TEAM 1

INDUSTRY REPRESENTATIVES
Matt Evans
Marcus Ault

FACULTY ADVISOR
Rita Lederle

PROJECT SUMMARY

As material within a landfill decomposes, methane gas is created. Methane is a harmful greenhouse gas that contributes to climate change. The purpose of this project is to create a gas collection and control system for a landfill in Hall County, Georgia. A geomembrane prevents gas from escaping into the environment, but the gas must be managed to prevent the gas from finding another route. As Hall County experiences rapid population growth, the landfill is reaching its capacity to where gas management is mandated. This team was tasked with designing a system that is able to collect and control the gas produced and burn off the methane while following state and federal regulations.

DESIGN GOAL

The purpose of this project is to create a landfill gas collection and control system that adequately collects and burns the methane produced from the landfill as the waste decomposes. The finalized design contains four major components of a landfill gas collection and control system: wells, piping, sumps, and flare(s).

DESIGN CONSTRAINTS

- Meet criteria from the Federal Environmental Protection Agency
- Meet criteria from the Georgia Environmental Protection Division
- Gas must be collected and burned at a sufficient rate to destroy 98% of collected methane
- Landfill gas collection and control system must integrate with the current facility
- Design must consider future maintenance of the system

Aerial image of Hall County Landfill

EUSTIS STREET IMPROVEMENT DESIGN

From left to right: Genevieve Tester, Jacob Ireland, Emma Rae Roberts, Mohamud Abdimuhsin, Morgan Fritz

RAMSEY COUNTY
Public Works

TEAM 2

INDUSTRY REPRESENTATIVES
John Mazzitello
Alan Maxwell

FACULTY ADVISORS
Mohsen Tahmasebi Nasab
Matt Metzger

PROJECT SUMMARY

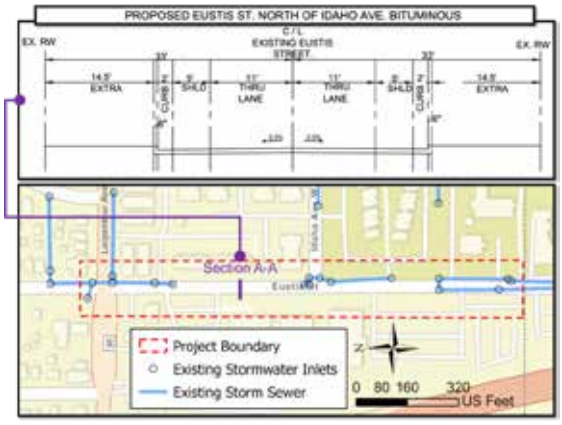
Eustis Street is located within Ramsey County in the city of Lauderdale, MN, adjacent to Highway 280. The existing road suffers from pavement deterioration, sidewalk inaccessibility, and flooding due to inadequate drainage systems. The project corridor contains eight commercial and residential properties. We considered various alternatives to remediate the current challenges of the site. Existing stormwater was evaluated to propose an improved stormwater collection system. In addition, new pavement design was evaluated for a 20-year design life that considers the site's projected traffic loading. Finally, a continuous sidewalk design was selected based on a cost analysis of alternatives to provide access across the project limits.

DESIGN GOAL

Ramsey County is reconstructing a 0.27-mile stretch of Eustis Street from the southern city limits of Lauderdale to Larpenteur Avenue West to provide adequate drainage capacity, construct a continuous and accessible sidewalk, and correct existing pavement deterioration. The improvements will minimize the impact on surrounding residences while improving the overall quality of life for those using and living in this corridor.

DESIGN CONSTRAINTS

- Design within the current right-of-way and easement limits
- Design for a speed limit of 30 mph
- Reduce or match the current impervious surface area
- Design an improved stormwater system
- Comply with local and national standards



The project corridor is outlined in red with the proposed cross section shown at section A-A

BENCHTOP MITRAL VALVE REPLACEMENT TRAINING MODEL

From left to right: Duy Le, Karlyn Gahnz, Joshua Dolezal, Maria Padden

Abbott

TEAM 3

INDUSTRY REPRESENTATIVES

Preston Huddleston
Kelly Fitzgerald
Alyssa Nelson
William Peckels

FACULTY ADVISOR

Farida Kasumzade

PROJECT SUMMARY

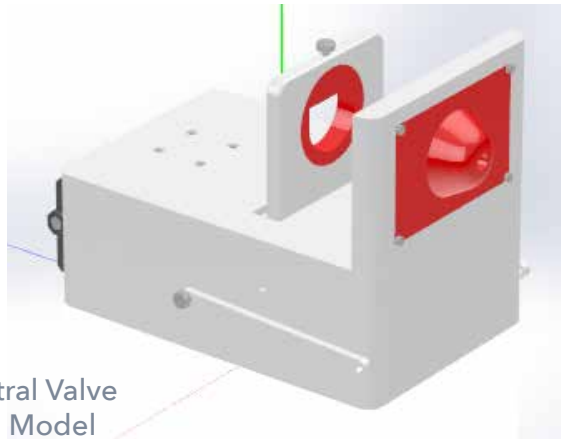
The mitral valve is an atrioventricular valve in the heart that stops blood from flowing the wrong way through the heart. The Tendyne mitral valve replacement procedure is an innovative technology that allows patients who need a mitral valve replacement but cannot be surgically operated on, to receive the treatment they need. Abbott's benchtop training model is used in the training procedure to teach physicians and doctors how to insert the Tendyne mitral valve into a patient. The purpose for improving the current training model is to ensure that the physicians and doctors have a clinically relevant model to practice on. It is critical that the physicians and doctors have a model that resembles the real-life scenario of a beating heart to best simulate replacing the mitral valve in open heart surgery.

DESIGN GOAL

Our goal was to create a more realistic model to improve the training experience for physicians who will be implanting the Tendyne mitral valve. We aimed to do this by creating elements of the heart anatomy out of a rubber silicone called Dragon Skin 30, implementing a motor that mimics a heartbeat, and incorporating cameras to mimic ultrasound images.

DESIGN CONSTRAINTS

- Smooth and quiet heartbeat simulation
- Adjustable heartbeat rate
- Realistic heart & tissue feeling
- Different heart angles
- Easy to manufacture and assemble
- High durability
- Long battery life
- Low cost
- Portable and easy to transport
- Easy to operate



CAD Model of the Mitral Valve Replacement Training Model

WAFER SCALE FUNCTIONALIZATION SYSTEM

From left to right: Jolee Mesler, Evan Schwarz, Ethan Deutsch, Elizabeth Mink

Boston Scientific
Advancing science for life™

TEAM 4

INDUSTRY REPRESENTATIVES
Raia Finc
Greg Sherwood

FACULTY ADVISOR
Francis Porbeni

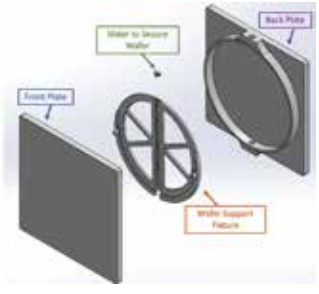
PROJECT SUMMARY

In the United States, lung cancer is one of the leading causes of cancer death. To increase the rate of early lung cancer detection, Boston Scientific's breath sensor team has developed a non-invasive lung cancer screening device. This device uses sensors to measure volatile organic compounds (VOCs) in exhaled breath. The 120 sensors on the device map out a breath print, unique to the individual. The patterns in the VOCs from the breath print are then used to determine whether the individual has lung cancer. The sensors on the lung cancer screening device must go through a functionalization process where they are soaked in a solvent-receptor solution, rinsed, and then dried. Boston Scientific is looking to improve this process by creating a system that functionalizes full or partial wafers, opposed to their current process of functionalizing single sensors.

DESIGN GOAL

The goal of this project is to design a system that functionalizes the sensors on the surface of full or partial silicon wafers.

(Left to right) Wafer of sensors, sensor chip, and card with sensors

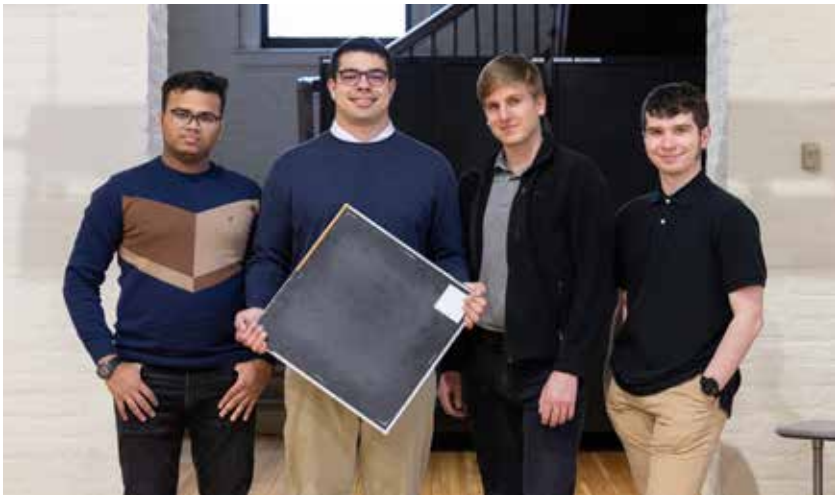


SolidWorks model of the functionalization system

DESIGN CONSTRAINTS

- The system shall suspend a full and partial 6-inch or 8-inch silicon wafer in the solvent receptor solution
- The container used during functionalization shall not react with required solvents
- The system shall allow for processing of silicon wafers in 38 different solvent receptor solutions
- The system shall not allow evaporation of the solvent receptor solutions
- The system shall restrict all UV light exposure on the designated wafers that require it during the soaking process
- The system shall be contained without the possibility of spilling solvent throughout the soaking process
- The system shall track the wafers throughout the build process for traceability, while also tracking the time spent soaking, rinsing, and drying
- HMIS labels shall be attached to and visible on the containers used during the functionalization process

X-RAY DETECTOR INSERTION AID



From left to right: Srajan Pillai, Anthony Rodriguez, Michael Audi, Zachary Lovdahl

Carestream

TEAM 5

INDUSTRY REPRESENTATIVE
Curt Wiens

FACULTY ADVISOR
Robert Monson

PROJECT SUMMARY

In order for an X-ray to be taken of a patient's torso using a mobile X-ray machine, an X-ray detection plate must be put under the patient's torso. This is most commonly done by having one or two technicians lift the patient into a sitting position while another technician places the detector under the patient. This can be very difficult and potentially dangerous to both the patient and the technician depending on the patient's weight. The wedge design makes it possible for a single technician to get the X-ray detection plate quickly and safely under the patient with ease.

DESIGN GOAL

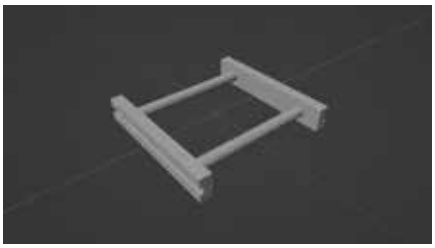
To design a solution or device that allows a single technician, using minimal effort, to place an X-ray detector plate underneath the torso of an immobile patient quickly, safely, and efficiently.

DESIGN CONSTRAINTS

- Production Cost: Target <$0.50 per use preferred (can be re-usable or single use)
- Apparatus Weight: <5 lbs.
- Power Requirements: Optional - 120V power is available (not required)
- Time to insert detector < 1 minute
- Requires only 1 person to complete the action
- Force required to insert Detector is <20 lbs.
- Works with patients up to 300 lbs. who are immobile
- Focus is Chest X-Rays – must work when patient is lying flat or inclined up to 20 degrees

▲ Wedge

◄ X-ray detection plate



Push-Bar Aid ►

SPECIALTY WINDOW SNAKE TOOL PULLING IMPROVEMENT

From left to right: Erik Fjellman, Emily Tuchtenhagen, Jacob Michelizzi, Marie Schupanitz

RENEWAL by ANDERSEN
FULL-SERVICE WINDOW & DOOR REPLACEMENT

TEAM 6

INDUSTRY REPRESENTATIVES
Tom Hansen
Eli Weinmann

FACULTY ADVISOR
Paul Chevalier

PROJECT SUMMARY

Renewal by Andersen custom-bends their unique composite material to create curved window frames; the bending process can cause kinks or defects that ruin the appearance. To prevent this, reusable plastic support tools are inserted into the hollow frame. Unfortunately, tool removal by hand after bending can be difficult for the employees, increasing cycle time and risk of injury. The design team's solution is to refine the support tool shape for easier removal with testing and design a ball screw-driven actuator that eliminates the need for manual tool removal. To evaluate the effectiveness of the tool reshapes, the design team developed a fixture that allows for repeatable and consistent testing and results.

DESIGN GOAL

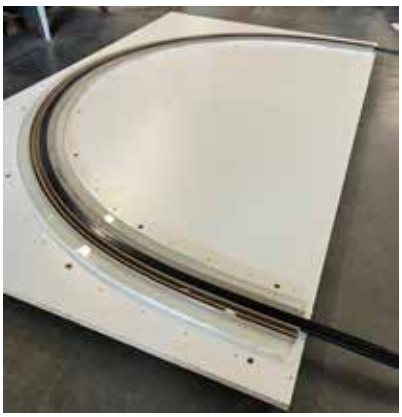
Improve the ergonomics and cycle time of Renewal's custom window frame bending process.

DESIGN CONSTRAINTS

- Material of support tools shall be manufacturable into multiple different shapes
- Solution shall not result in any visual defects on window frames
- Support tools shall be able to bend to different radii, from 12" to 58"
- Support tools shall not melt at temperatures of 130 °C or less
- Solution shall meet a cycle time of 30 seconds or less
- Solution shall not exceed a unit cost of $15

◄ Cross section of straight window frame

Fixture for testing tool reshapes and materials ►



UNDERWATER GAME CAMERA

From left to right: Eric Danner, Isaac Ziglinski, Will Becker, Charlie Eldredge

SOTA SYSTEMS

TEAM 7

INDUSTRY REPRESENTATIVE
Preston Huddleston

FACULTY ADVISOR
Greg Mowry

PROJECT SUMMARY

Current technologies such as trail cameras exist for capturing still images of game animals, while underwater cameras typically only produce live feeds. SOTA Systems aims to combine the two technologies, creating an underwater game camera that utilizes image recognition AI to save pictures of underwater species. This camera system is designed to be compatible with docks for use in the summertime, as well as ice fishing applications. The full system consists of a processor housing, a submersible camera housing, 100 feet of cable between the housings, and a weighted bottom referencing system that allows users to set the camera at a desired height off the lake bottom.

DESIGN GOAL

Develop an underwater camera system that can capture and store images of aquatic wildlife without human interaction for up to a week at a time.

DESIGN CONSTRAINTS

- Project budget of $1500
- System must be rated for 0˚F–100˚F
- Power systems in both AC and DC configurations that must run autonomously for 7 days
- Camera housing must be waterproof and impermeable up to 30 feet below the water's surface
- Battery & processor housing must be weatherproof and located onshore 100 feet away from camera housing

◄ Organizational design of our processor housing to include different power options and a monitor for the sponsor to test and debug in real time

◄ Submersible camera housing in action as it takes a photograph of a live fish underwater

TURNING VANE IMPROVEMENTS

From left to right: Ben Gustafson, Adrian Brietzke, Cole Halla, Alexander Bailey

SAFRAN

TEAM 8

INDUSTRY REPRESENTATIVE
Steve Margl

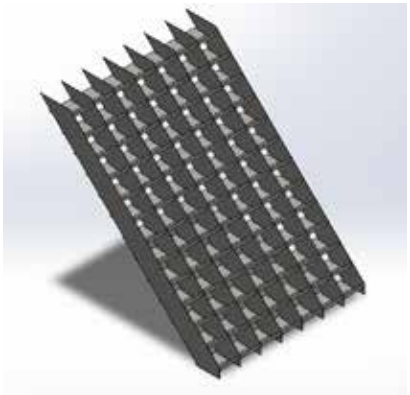
FACULTY ADVISOR
David Forliti

PROJECT SUMMARY

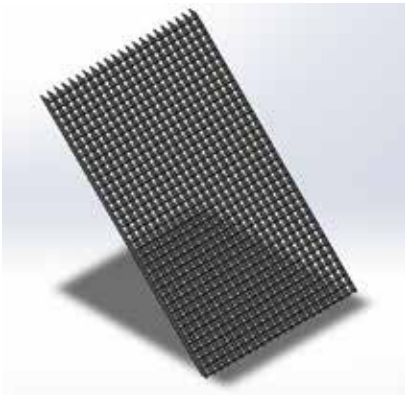
The currently used turning vane designs are from over 40 years ago and are outdated. Our team is looking for a less expensive turning vane design by reducing the amount of material needed to manufacture the turning vane. Designs were tested in ANSYS using CFD to make sure the airflow after the vanes meets the requirements set by our sponsor. Structural analysis is also required to validate that the structure can withstand the forces exerted on the newly designed turning vanes.

DESIGN GOAL

The design goal was to re-design turning vanes to be smaller and less expensive than the current design used by Safran.



Old Design



New Design

DESIGN CONSTRAINTS

- Turning vane chord length shall be scaled from 1 meter to a length between ¼ and ⅓ of a meter
- The simulation and experimental Reynolds number shall be approximately the same as the simulation data that is provided
- Mass flow of 2150 kg/sec shall result in a cell flow of 4300 kg/sec
- Design test cell shall be scalable to a 7-meter by 7-meter cross-sectional area
- Velocity distortion index (VDI) shall be 0.35 or less
- The original cost of the turning vanes ($400,000) shall be reduced by 25% through manufacturing, installation, and material usage
- The splice plates shall be able to withstand a mass flow of 1822 kg/sec at 130319 pounds thrust

STAINLESS STEEL DOOR CORNER FORM

From left to right: Tri Phan, Nate Spurgat, Valentina Pedevila, Paige Heitkamp

TEAM 9

INDUSTRY REPRESENTATIVE
Scott Schramske

FACULTY ADVISOR
Brian Plourde

PROJECT SUMMARY

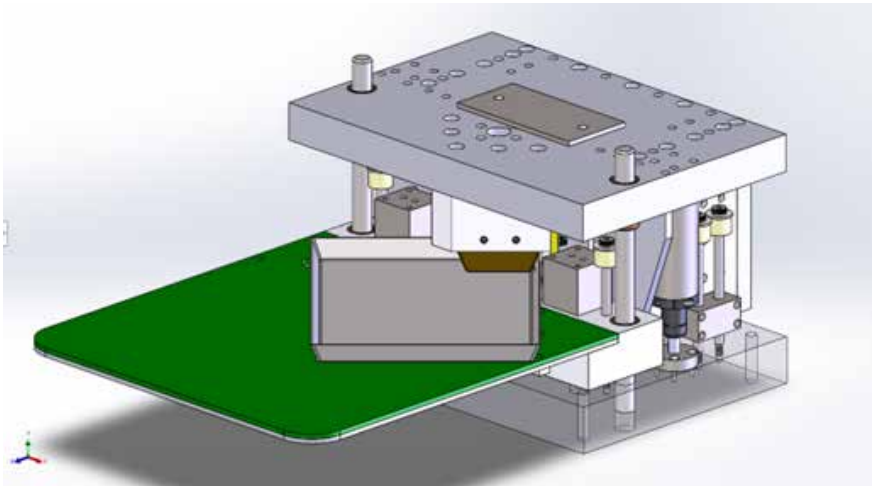
nVent HOFFMAN specializes in enclosures for electrical systems in various sizes, environments, and purposes. They are seeking a method to manufacture a new line of enclosures they are developing, which have 75° slanted corners and sides. Within the manufacturing process, they want the corner forming process to not require welding and grinding, and they succeeded in designing a tool for that task for the regular 90° door by using a hydraulic press and various mechanisms. The main goal of this project is to adapt that tool to create the corners needed in the new door design.

DESIGN GOAL

nVent HOFFMAN has a tool that currently bends sheet metal to form a 90° corner. The design goal of this project is to adapt that tooling to be able to form a 75° corner.

DESIGN CONSTRAINTS

- The design needs to be able to be used in the same hydraulic press and in turn be roughly the same size as its predecessor
- Ergonomics and ease of use should be similar to the old design
- Must allow for quick swapping of tool (no permanent installation)
- It can bend 14-gauge steel with reliable results
- Follows every safety and hazard consideration that the workspace demands



CAD model of new tooling to bend metal to a 75° corner

REMOTE-CONTROLLED COMMERCIAL DOWNSPOUT LIFT AND POSITIONER

From left to right: Maija Almich, Raymond Rasmussen, Charles Kiefer, Colin Huntington

PROCESS LOGIC
INTELLIGENTLY INNOVATIVE SOLUTIONS

TEAM 10

INDUSTRY REPRESENTATIVE
Kurt Scepaniak

FACULTY ADVISOR
Bob Bach

PROJECT SUMMARY

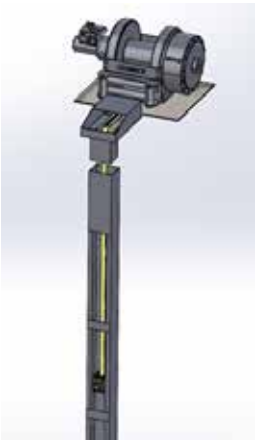
Current downspout installation practices include methods that require workers to operate using unsafe practices and positions which can cause injury or death. The current process limits the points of contact the worker would have with the ladder because they have to simultaneously hold the downspout in place while working power tools to fasten it to the building's wall. Overall, the current process allows for a higher accident potential. This project aims to design a safer way to lift and install a downspout using a winch or similar lifting mechanism. This product would allow for the worker to maintain safer positions atop the ladder, only having to focus on fastening the downspout to the building.

DESIGN GOAL

Develop a mechanism that will assist in the installation of commercial downspouts so that the installation process is safer for the Process Logic employee.

DESIGN CONSTRAINTS

- Prototype shall work with 10ft – 60ft long and 15 – 90 lb downspouts
- Mechanism shall adapt to different cross-sections of downspouts
- Mechanism shall remain compatible with various weather conditions
- Design shall be compatible with power sources utilized on a typical job site
- Design shall maintain or decrease current installation cycle time



◄ Solidworks Assembly of Prototype

Wedge Mechanism ►

COFFEE DE-PULPER

From left to right: Christina Yang, Michael Holmes, Colin Spellman, Hannah Thatcher, Gracie Gerber

THE ANDEAN ALLIANCE FOR SUSTAINABLE DEVELOPMENT

TEAM 11

INDUSTRY REPRESENTATIVE
Aaron Ebner

FACULTY ADVISOR
Brittany Nelson-Cheeseman

PROJECT SUMMARY

Coffee farmers in the Sacred Valley of Peru work in rural locations of the Andes Mountains where maintenance and transportation of the final product and equipment are both time-consuming and an economic burden. The coffee harvesting process involves removing the flesh of the coffee cherry by operating a manual and labor-intensive de-pulping machine. This creates an acidic environment causing corrosion of critical components, including the camiseta. Replacing this component, along with upkeep maintenance, is conducted by a skilled machinist and requires a great amount of transportation effort as well as monetary investment.

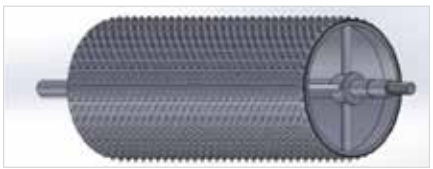
DESIGN GOAL

Modify the coffee depulper to decrease maintenance, allow access to interior components for cleaning, and eliminate rusting of the camiseta. The design should result in a longer lifespan for the coffee depulper and maintain a high quality of coffee beans.

DESIGN CONSTRAINTS

- The prototype shall be culturally appropriate for local farmers
- The prototype shall be powered manually
- The prototype shall be able to be completely constructed in Peru. The materials and tools required shall be available locally
- The prototype shall weigh less than 45 kg
- The camiseta, the main component, shall be made of a material that does not exceed the current thickness of the material used and does not puncture during the punching process
- The prototype shall withstand the acidic environment of the coffee cherries (pH 4.5) and be corrosion resistant
- The prototype should be able to remove the pulp from the coffee cherries with limited damage to the final product

A de-pulper machine used by the team in Peru. Coffee cherries enter the machine through an opening on the top, the pulp of the cherry is then removed from the bean by rotating a drum through use of a manual crank. The coffee beans and pulp are then separated, and the beans are output through channels on the front and the pulp is pulled to the back.



A SolidWorks model of the camiseta.

GLOBAL CHANGEMAKING

BACKYARD EXHIBIT COMPONENT: MUD LAUNCHER

From left to right: Lauren Eldridge, Paige Bollinger-Brown, Connor Cunningham, Brooke Catton

Minnesota Children's Museum

TEAM 12

INDUSTRY REPRESENTATIVE
Jess Turgeon

FACULTY ADVISOR
Tom Shepard

PROJECT SUMMARY

Minnesota Children's Museum is creating a new backyard exhibit for the summer of 2023. This interactive exhibit will promote creativity and experimentation through mud. Children and adults will make their own mud, experimenting with how it moves and behaves. This project will focus on developing two fully functional prototypes with different methods and testing the capabilities of each to launch mud of different consistencies. In the prototyping and testing processes, recommendations for the most effective mechanisms as well as dirt types will be communicated. Manufacturing drawings and a maintenance manual will be drafted to accompany the prototypes.

DESIGN GOAL

This project seeks to develop two fully functional prototypes with different methods for launching mud. Not only do the launchers need to be capable of launching mud, but they also need to be safe and intuitive for children to operate.

◀ Indoor mud-testing space

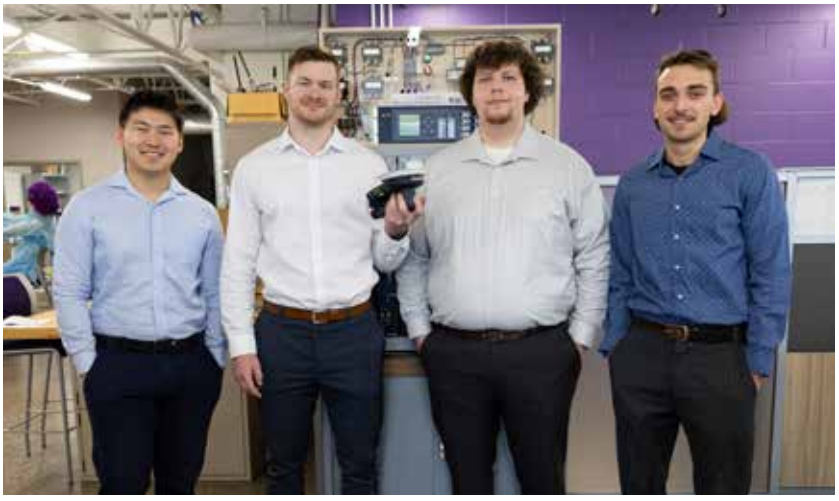
▲ Draft mock-up of launcher set-up

DESIGN CONSTRAINTS

- Each launching mechanism shall launch mud in the range of 9 to 12 feet
- The force needed to launch shall not exceed 20 lbf
- The temperature of the launcher material surfaces shall not exceed 109°F
- Removal of dirt from the launchers shall take one person no more than 15 minutes
- The launchers shall be able to withstand normal repetitive uses by children as intended
- The launchers shall be able to function after exposure to weather conditions
- The launchers shall abide by the American Disabilities Act and be accessible

LOCAL CHANGEMAKING

HOOK & LOOP ATTACHMENT OF COATED ABRASIVE DISCS TO SANDING TOOLS



From left to right: Jonathan Vue, John Scott, Mikita Lemesh, Wyatt Smith

TEAM 13

INDUSTRY REPRESENTATIVE
Sally Lewis

FACULTY ADVISOR
Stacha Reed

PROJECT SUMMARY

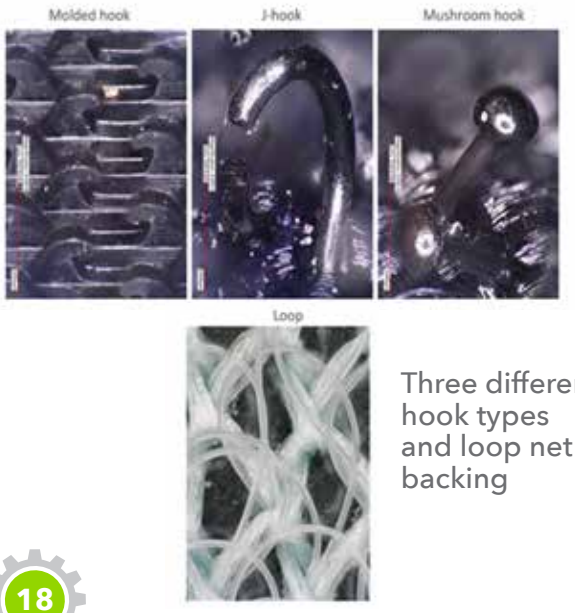
For optimum performance, an abrasive disc needs to firmly attach to its BUP and not move during use. Our goal is to investigate how to best measure attachment during use. In a basic hook and loop system, a DA backing pad with rigid plastic hooks attaches to a sanding disc with soft nylon loops. There are three different hook types that can be used: J-hook, mushroom, and molded. For the data, the team conducted multiple tests to arrive at conclusions on the strength, effectiveness, and durability across all three hook types. For the test method, the team designed a mounting fixture that would hold the sander in place along with an adjustable circular portion to accurately measure shift. This, coupled with the centering fixtures designed by the team, ensures accurate test results.

DESIGN GOAL

The team was tasked with creating a reproducible test to accurately measure shifting of the abrasive sanding disc on a dual-action sander (DA). In addition, testing was to be done to collect data on the different hook and loop combinations to understand the interaction between them and their respective properties.

DESIGN CONSTRAINTS

- Test shall be reproducible at all 3M facilities
- Design shall have improved gage R&R for measuring shift
- Design shall be testable across different hook and loop families



Three different hook types and loop net backing

SolidWorks assembly of test fixture

SOUND SOURCE LOCATION DEVICE

From left to right: Skyler Lockwood, Evelyn Truong, Jacob Pechman, Ava Emmerich

MAYO CLINIC

TEAM 14

INDUSTRY REPRESENTATIVES
Steve Kuehn
Erik Clemens
Supriya Pakala

FACULTY ADVISOR
Bob Mahmoodi

PROJECT SUMMARY

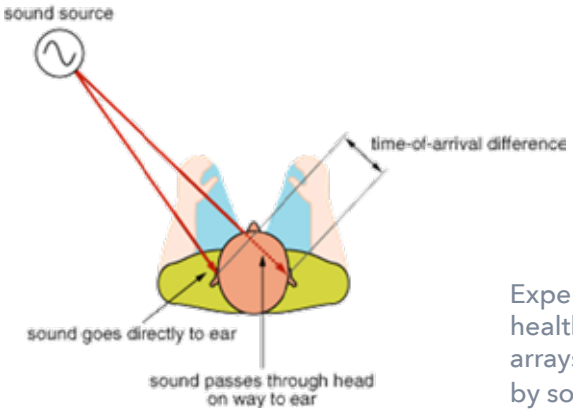
Auditory impairment conditions, including bilateral or unilateral hearing loss, inhibit the ability to identify surrounding sounds due to a lack of directional awareness and an excess of background noise in an environment. Current technologies, such as hearing aids, are unable to provide enhancement for specific noises due to a lack of sound location functionality. The team will investigate the technical means to identify the direction of a sound of interest, and, when pointed in that direction, enhance the sound while attenuating background noise. The long-term goal of this project is to implement this system into a wearable device in a way that is comfortable for the user.

DESIGN GOAL

The project goal is to create a proof-of-principle device to aid users with varying degrees of hearing loss in social settings. The device seeks to identify the direction of arrival (DOA) of incoming speech, provide a directional indicator to the user, and amplify the sound signal while attenuating background noise.

DESIGN CONSTRAINTS

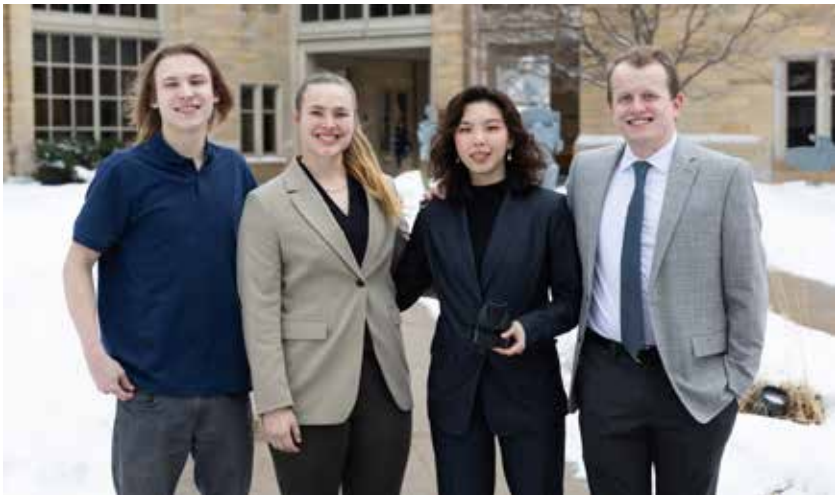
- The device shall incorporate multiple MEMs microphone into an array
- Spacing and angle between microphones shall vary to determine the effect on DOA accuracy and source sound enhancement
- The device shall output an indicator that displays DOA
- The device shall target to enhance sounds located in front of the user by 3 decibels
- The device shall target to attenuate sounds coming from other angles by 6 decibels
- The device shall primarily function for frequencies associated with human speech



◄ In healthy individuals, the direction of sound arrival is determined by minute differences in arrival time between ears

Experimental testing setup to simulate healthy hearing with 2 microphone arrays in a 3D-printed fixture separated by sound absorbing foam ►

ENHANCED DIGITAL STETHOSCOPE



From left to right: Alex Pfister, Sophie Woessner, Kathy Lee, Tom Thuma

AURIS AI
MEDICAL TECHNOLOGIES

TEAM 15

INDUSTRY REPRESENTATIVES
John Wallace
Ebenezer Dadson

FACULTY ADVISOR
Brian Zuelke

PROJECT SUMMARY

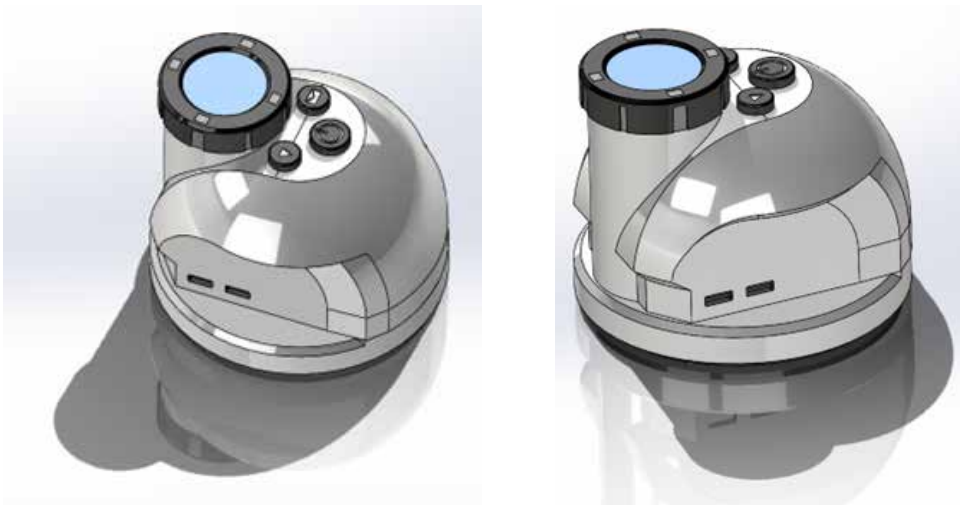
The digitally enhanced stethoscope is multifaceted and capable of capturing a heartbeat signal. It will be able to capture an accurate signal to later be used to diagnose patients with potential heart problems such as cardiac arrest, arrhythmia and atrial fibrillation. This is a continuation project from last year. Last year's team was able to make a design that captured a signal at a precise placement on a patient's chest. This year's team has modified the design to be lighter, easier to handle, use more sophisticated signal processing and have a more complete form with a PCB.

DESIGN GOAL

To design a working prototype that is ergonomic to hold and capable of capturing and filtering an EKG signal by placing it on a patient's chest with feedback to the clinician.

DESIGN CONSTRAINTS

- Shall have a circular form factor
- Cost lower than $250
- Display live feedback on positioning
- Contain a PCB for the purpose of filtering and amplifying the signal
- Able to save the information onto a SD card
- The prototype shall be 25% (9.75 oz) lighter than the previous design (13 oz)
- The prototype shall be 25% (11.81 in3) smaller than the previous design (15.74 in3) in size



Auris AI enhanced digital stethoscope design views

SMART CONDUIT PLUG

From left to right: Ben Gilbert, Alison Kratzke, Alexander Bourdage, Treycen Eckman

EMERSON

TEAM 16

INDUSTRY REPRESENTATIVE
Jacob Holm

FACULTY ADVISOR
Jason Petaja

PROJECT SUMMARY

Emerson transmitters are used in industrial control systems to measure manufacturing processes. Currently, when the control system indicates that a transmitter is reporting an out-of-range or error value, technicians must examine each transmitter on a panel to identify the source of the fault. The Smart Conduit Plug will be an add-on feature to Emerson temperature and pressure transmitters that allows technicians to visually identify in-range, out-of-range, and error states from a distance. This functionality decreases the time required for fault identification and the number of labor hours spent examining transmitters during routine maintenance.

DESIGN GOAL

The Smart Conduit Plug would offer a convenient way to upgrade device capabilities without complete replacement. The device will also offer insights for instrument health that will reduce maintenance and downtime caused by instrument failure.

Smart Conduit Plug assembly with transmitter

DESIGN CONSTRAINTS

The product shall...

- Cost less than $30 per unit at scale of 10,000 units
- Be within the size specifications 2 inch X 2 inch x 2 inch external to the conduit entry
- Operate in ambient temperature ranges from –40°C to 85°C (-40°F to 185°F)
- Operate on power derived from the 4-20mA analog signal without disrupting the loop current
- Not exceed a weight of 500 grams (1.1 pounds)
- Provide visual indication from 1.5-3 meters (5-10 feet) distance in daylight conditions
- Not inhibit the transmitter's ability to withstand internal pressure up to 6895 kPa (1000 psi)
- Be able to be fully submersible in water to a depth of 2 meters (6.56 feet) for 1 hour
- Comply with the following standards:
  - International Electrotechnical Commission - IEC 60079
  - International Electromechanical Commission – IEC 60529
  - Canadian Standards Associations - CSA C22.2
  - Factory Mutual Approvals - FM3615
  - National Pipe Thread - 1/2NPT
  - Highway Addressable Remote Transducer (HART) Protocol

MATERIAL PROCESSING MACHINE

From left to right: Thomas Sucher, Kyle Larson, Michael Ennis, Jacob Mugaas

NORTHROP GRUMMAN

TEAM 17

INDUSTRY REPRESENTATIVES
Noah Kopen, Noah Tews
Robert Monson, Derek Olson
Johnathan Feigum

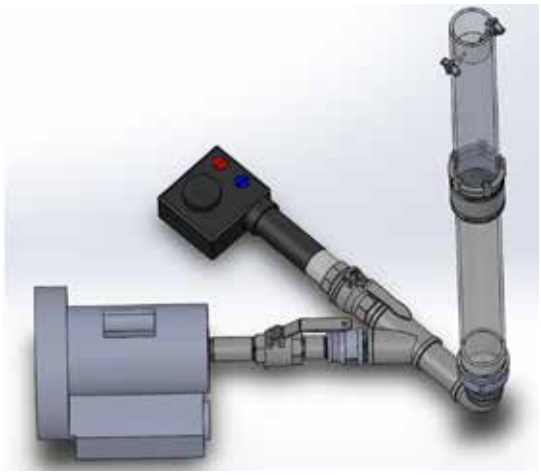
FACULTY ADVISOR
Chris Haas

PROJECT SUMMARY

Northrop Grumman and the St. Thomas design team partnered together to design and build a material processing machine for use at Northrop Grumman's facility. This material processing machine will allow Northrop Grumman to produce the material at specific density ranges, without having to order it from an outside source. The machine will provide consistent and customized results for a wide variety of uses at the Northrop Grumman facility. The material processing machine will be accompanied by a density measuring device and support materials, such as operating manuals and troubleshooting guides. This material processing machine will incorporate some system of controls for an operator to easily use this machine for manufacturing specifications. This Graphical User Interface (GUI) uses a program called LabVIEW to create and run all the code necessary for the heater and airflow operations.

DESIGN GOAL

The goal of this material processing machine is to alter the physical characteristics of the material by using controlled heat transfer to allow NGC a more efficient and sustainable manufacturing process for Northrop Grumman's facilities.



Full prototype with heater, compressor, and processing chamber

DESIGN CONSTRAINTS

- The density measuring device shall operate with the use of a 15-amp 240-V AC standard outlet power
- The material processing machine shall process 2 kg of the material at a specified density per 8 hours
- The assembled machine shall fit within a 5-foot by 5-foot floor space with a 5-foot height restriction
- The material processing machine shall be fully serviceable with no critical areas being inaccessible
- The user manual and troubleshooting guide for the material processing machine shall be clear and concise
- Any exposed machine surface shall not exceed 120°F
- The heat and flow settings shall be controllable through a GUI

SMART RETURN BIN

From left to right: Allie Paterson, Jeffrey Balfany, John Vogel, Owen Kavie

forever ware™

TEAM 18

INDUSTRY REPRESENTATIVES
Natasha Gaffer
Nolan Singroy

FACULTY ADVISOR
Lucas Koerner

PROJECT SUMMARY

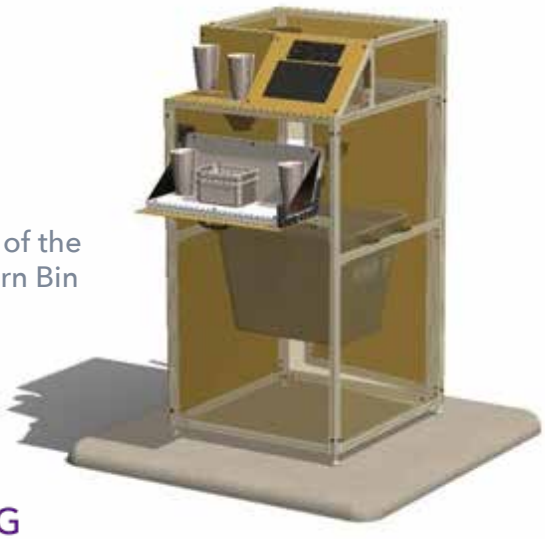
Twenty billion disposable containers cause tons of waste and major environmental issues. To reduce this, Forever Ware provides asset tracking technology for reusable takeout container programs at food service establishments across the US. Reusable containers are tracked and returned using wireless scanning technology. Their current return device has a high tolerance for misuse, which leads to interruptions at busy venues. The design of a smart return bin would reduce this interruption, assist with returns, and provide refunds, while also facilitating information collection for future product decisions. This user-friendly experience will encourage more customers to use reusable containers when buying takeout.

DESIGN GOAL

Design a smart return bin that allows the Forever Ware's reusable takeout containers to be returned easily and accurately.

DESIGN CONSTRAINTS

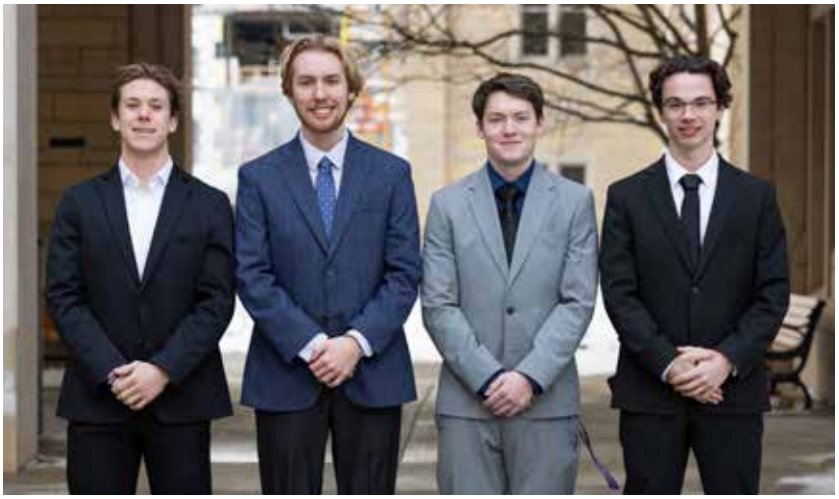
- Be within the approximate dimensions of a commercial garbage can
- Read asset tags on containers with wireless scanning technology
- Mechanically prevent theft.
- Keep the bin clean with a liner or another mechanism with a low-waste strategy
- Be a durable and long-lasting structure for commercial use.
- Battery powered and charged via wall outlet
- Process container returns via wi-fi



Full Model of the Smart Return Bin

LOCAL CHANGEMAKING

AUTOMATED MANDREL LOADER



From left to right: Regan Sevenich, Mason Althoff, Sean Marks, Logan Singleton

Teleflex® MEDICAL OEM

TEAM 19

INDUSTRY REPRESENTATIVES

Josh Conway
Dannyelle Donahue
Nate Rhodes

FACULTY ADVISOR

Jeong Ho You

PROJECT SUMMARY

Teleflex manufactures braided catheters using a horizontal braiding machine. This can be done by feeding a mandrel, which acts as a core to braid over, into a port at the rear of the machine. The mandrel is then fed into the machine and stainless steel wire is braided over the mandrel. Feeding a mandrel and the processes of cutting and collecting mandrels after braiding is currently done manually by a machine operator, which removes them from their regular tasks. Sensors, Programmable Logic Controllers (PLC), and a Human Machine Interface (HMI) will control motors and pneumatics that proceed mandrels through the machine, automating the process.

DESIGN GOAL

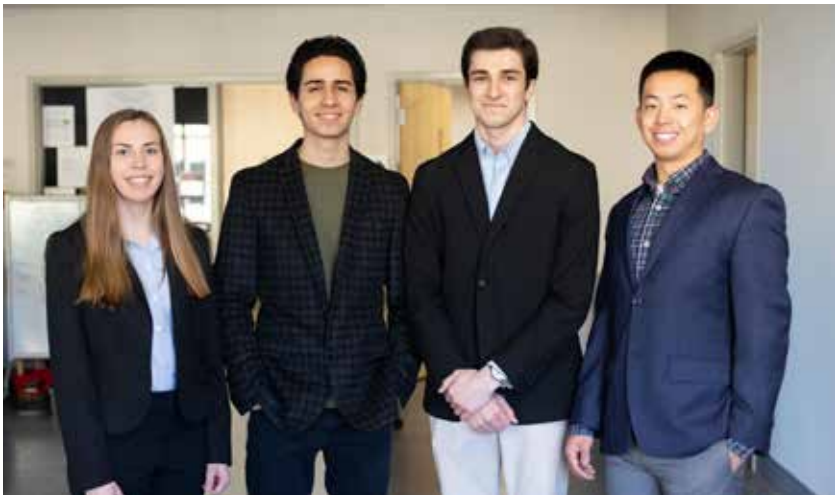
Design, prototype, and integrate sections of an automated system that loads, separates, and unloads mandrels without the need for an operator.

DESIGN CONSTRAINTS

- Must work with the horizontal braiding machines at Teleflex facilities
- Must hold a minimum of 10 mandrels
- Adjustable design for varied sizes of mandrels
- Emergency stop (E-stop) included and connected to the Braiding machine E-stop
- 10 mandrels can be run in succession without operator intervention

Isometric View of Full Assembly and Steeger Braiding Machine

OFF-AXIS HAZE TESTER FOR OPTIC FILMS



From left to right: McKendra Long, Ian Delgadillo Bonequi, Jackson Simon, Jimmy Lu

TEAM 20

INDUSTRY REPRESENTATIVES
Adam Readinger
Greg King

FACULTY ADVISOR
Steve Albers

PROJECT SUMMARY

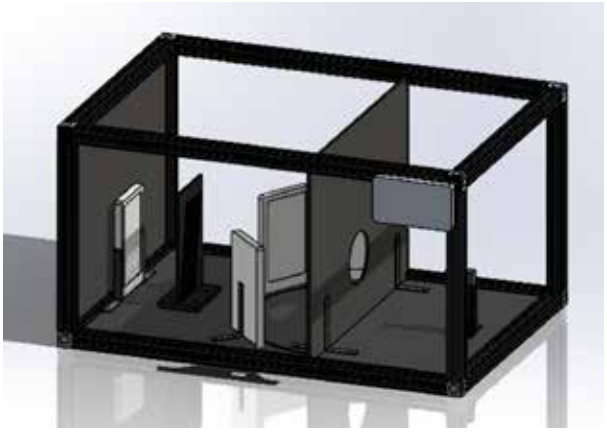
Selected 3M window films contain nano-pigment dispersions that block solar radiation, but can cause scattering of light. A level of haze or "milkiness" in automotive and commercial window films has been observed by customers when light strikes pigmented films at certain angles; current measurement methods with on-axis haze meters are unable to quantify the milkiness in a way that can be correlated to customer feedback. This project aims to create a new device that, through the use of image processing methods, is capable of accurately measuring "milkiness" in film samples with incident light directed at varying angles, to aid in the development of future pigments and products.

DESIGN GOAL

The purpose of the project is to develop a new device that will quantify milkiness within film samples, at varying lighting angles, and provide data that can be compared to customer feedback and used for the development of future products.

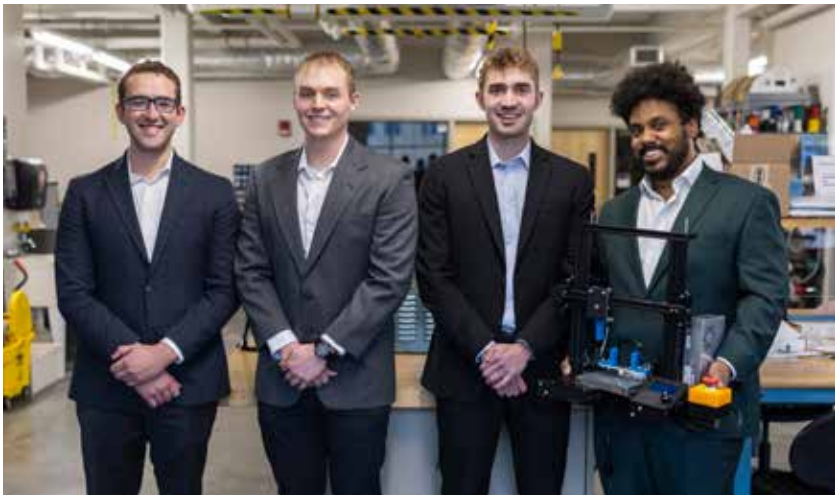
DESIGN CONSTRAINTS

- The device shall be capable of differentiating between film samples with varying levels of milkiness
- The device shall quantify milkiness as a simple haze percentage metric with varying off-axis lighting angles
- The device shall be easily operable by a single person
- The device shall have a maximum of 5 input parameters for the operator to select or enter as an input into the device's user interface before performing a milkiness measurement
- The device shall take less than 10 minutes total to set up and run an individual haze measurement



Solidworks model of the Haze measurement system

X-RAY DISPLACEMENT APPLICATION MACHINE



From left to right: Michael Benusa, Mason Knox, Josh Johnson, Terence Lewis

Medtronic
Engineering the extraordinary

TEAM 21

INDUSTRY REPRESENTATIVES

Vince Whelan
Charles Wilson
Nick Nagel

FACULTY ADVISOR

Keith Berrier

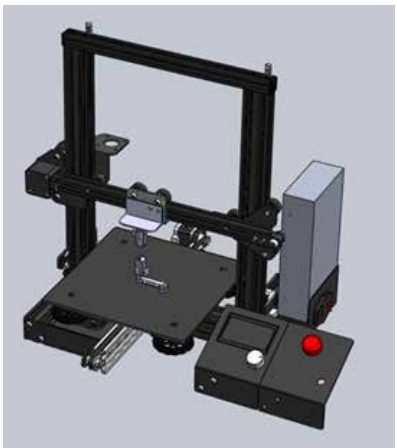
PROJECT SUMMARY

Medical devices undergo many forces during implantation and use. It is important to be able to characterize a device's behavior under various bending, compression, and tension forces. We will create a machine that can subject medical devices to deformation on multiple axis (X, Z, rotational), executes commands on its own, and is able to display and sync force measurements with a camera or X-Ray system. The system should also be optionally operable with no desktop computer necessary.

This product is not used in testing actual medical devices but is used to characterize materials and in early development for medical devices.

DESIGN GOAL

This project aims to build upon another team's design of a desktop tensile tester to be used in testing medical device packaging and parts. The deliverables include a fully functioning desktop CNC machine along with software to sync force and image measurements which can be used as a stand-alone system and operated from a distance, outside of X-Ray housing systems.



FRAIM II device for tensile testing

DESIGN CONSTRAINTS

- The device shall work in unison with Digital Image Correlation (DIC) tracker software
- The device shall be able to rotate one of the fixtures 180 degrees to apply a torque of at least 32-inch ounces
- The device shall be able to execute the deformation process remotely to allow an operator to adjust forces applied externally to an X-Ray machine
- The device shall fit within the 12x15x10 inch X-Ray area
- The top moving apparatus shall be able to move 6 inches in the horizontal and vertical directions from the origin location
- The device shall be built with parts with an obsolescence timeframe of more than 1 year
- The device shall produce a linear force greater than 20 lbf
- Digital Image Correlation system's view of the test sample must be unobstructed
- Machine shall be able to operate in accordance with user interface to send g-code scripts for repetitive motion

SPIDER CART TRANSPORTER

From left to right: Cory Strantz, Michelle Davis, Carter Doriott, Seth Sawyer Hammond

SAFRAN

TEAM 22

INDUSTRY REPRESENTATIVES
Will Lustig
Steve Margl

FACULTY ADVISOR
Andrew Tubesing

PROJECT SUMMARY

Safran currently uses and sells a large transportation cart to move jet engines around preparation areas and into the test cell of an engine center. The current transportation cart was designed in the 1980s and still functions properly today, but a modernization is desired. The new cart design needs to have an electric drive system, it needs to be more maneuverable, it needs to be created with easy to access off the shelf components, and it needs to have the same engine to cart interface as the original design. Finally, this cart will be globally distributed and used outside which means the cart must be designed to withstand a variety of harsh weather conditions.

DESIGN CONSTRAINTS

- Hold engine and adapter that weigh a maximum of 24,000 kilograms
- Travel up slopes with a 5% grade
- Be able to rotate in a circle
- Travel at walking speed
- Travel 16 kilometers when loaded before needing to recharge
- Withstand rough terrains
- Withstand rain, snow, and temperatures from -35 to 55 degrees Celsius

DESIGN GOAL

Our goal for this design is to redesign the SPIDER transporter cart to be more modern. The cart needs to be self-propelled, electronically controlled, more maneuverable, and have safety features to protect operators and the surrounding environment. Our phase of the project focused on the design of the cart frame, drive motor system, control system, and battery system.

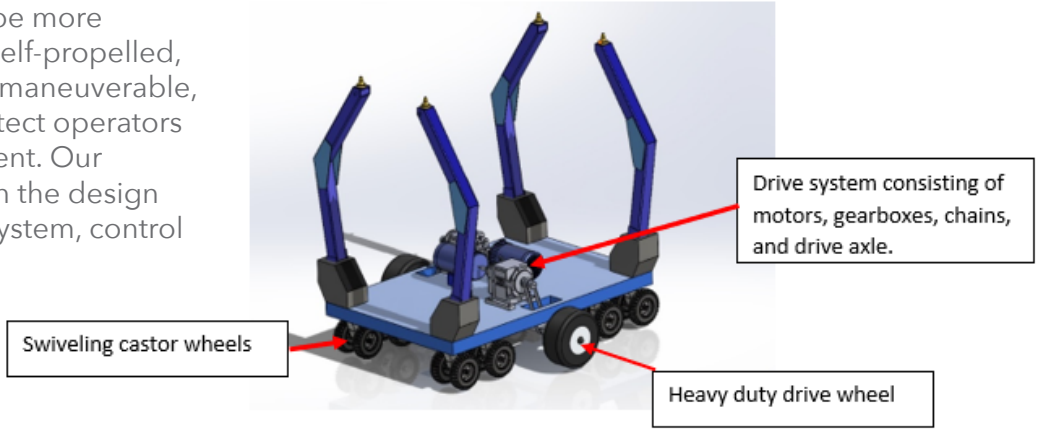
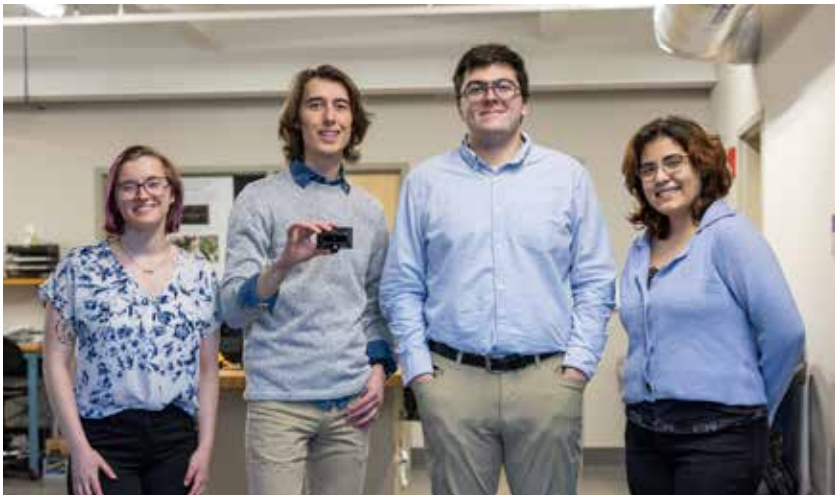


Figure 1: CAD model of the Safran Spider Cart prototype

DRIVING SIMULATOR TO TEST ADAS FUNCTIONALITIES OF AI DASHCAMS



From left to right: Renna Hintermeister, John Endris, Max Zimmerman, Vanesa Montes de oca Correa

Sensata IN

TEAM 23

INDUSTRY REPRESENTATIVES

Justin Klassen
Nate Williams
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FACULTY ADVISOR

Surya Iyer

PROJECT SUMMARY

Sensata's automotive dash-cameras automatically sense vibrations, harsh accelerations, and other common car conditions. This information is sent to the user by the dash camera for generating crash reports, receiving real time alerts, and other safety applications. Current camera testing involves human testers who can't intentionally cause dangerous incidents that can produce high force data needed for camera validation. This makes testing not only unreliable but also inefficient and time-consuming. A new solution must be created to accurately and precisely test camera conditions to ensure product quality and testers' safety.

DESIGN GOAL

Our design goal is to create a test rig that will consistently and safely test Sensata Technologies Owlcam Dash Camera.

DESIGN CONSTRAINTS

- Must fit on a standard desktop and have secure attachment points
- A minimum of 4gs of translational force produced
- Camera must be securely and rigidly connected to the test fixture
- Create REST APIs for control of Raspberry PI, data acquisition, and Motor Control
- Onboard accelerometer with data acquisition and logging capabilities
- There must be a safety enclosure around the entire system

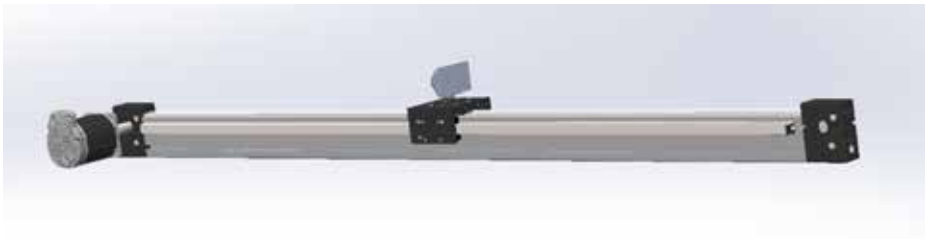

Figure 1. Shows dash cam mounted to a belt driven linear actuator and powered by an electric motor. The camera accelerates along the track and then is quickly brought to a halt to simulate 4+gs of force

Figure 2. Shows a model of the Owlcam Dash camera

IN LINE PROFILE MEASUREMENT SYSTEM

From left to right: Peter Schik, Ryan Thelen, CJ Warren, Nick DeSimone

ANDERSEN™ WINDOWS & DOORS

TEAM 24

INDUSTRY REPRESENTATIVE
Matthew Carlson

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Michael Hennessey

PROJECT SUMMARY

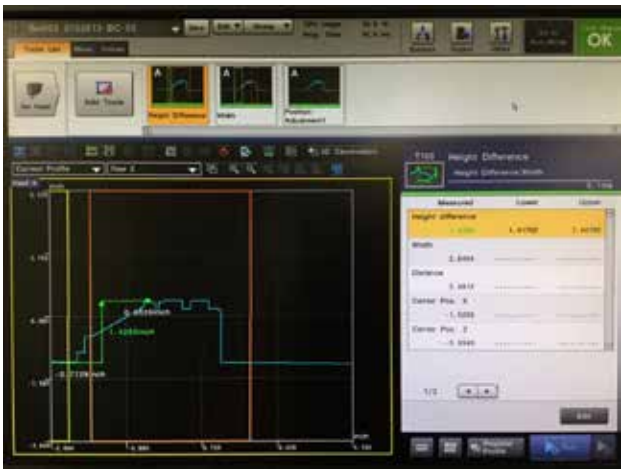
Currently on the Andersen Window moulder line there is no way to determine if a part is within specification without frequent stops to the line for the operator to manually measure the dimensions of the wood profiles. If out-of-spec parts are not caught in time, they can make it all the way to the warehouse before they are eventually found to be out-of-spec. This adds up to a lot of wasted time and wasted product. With the laser measurement system, real time data will be provided to the operator to alert them as soon as the product goes out-of-spec.

DESIGN GOAL

Design a system to measure wood profiles and provide a real time alert for when the parts go out-of-spec.

DESIGN CONSTRAINTS

- Laser should measure and record the height and width of 7 different part profiles
- The system should alert the operator when one of the height or width is greater than 0.015" outside of the nominal dimension
- The operator should be able to see and hear an alarm when the part is out-of-spec
- The operator should be able to select the specific program for the part running through the moulder
- Data collected by the laser should be stored in a hard drive
- Live capture of the profile should be displayed for the operator



Software display of profile measurement

Support electronics layout for profile measurement system

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