Joseph F. Ware, Jr.
Advanced Engineering Lab

Ware Lab Sponsorships, Competitions Results and Tour Outreach for 2022-23

From L to R: *Steel Bridge Team* at STEAM Day 2023 in Roanoke, VA. *HEVT's* new Cadillac Lyriq project car. *Human Power Sub* at STEAM Day.

This report summarizes sponsorship, competition results, and Ware Lab tour outreach for all competition teams housed in the *Joseph F. Ware Jr. Advanced Engineering Lab* facility for Virginia Tech's College of Engineering. Ware Lab is home to ten undergraduate teams that design, test, build and compete top-notch vehicles, submarines, structures, lunar robots, and autonomous surface water craft! Majors from all engineering departments are represented along with students in business, science, and communications. Team budgets, sponsorship and lab tour outreach summaries, along with a gallery of team posters, is included in this report. Ware Lab statistics and demographics are available on the *Ware Lab Stats* link at:

https://eng.vt.edu/academics/warelab.html.

Please direct questions concerning the content of this summary and Ware Lab operation to Dewey Spangler, PE (spangler@vt.edu), Ware Lab Manager.

Contents:

Section 1- Ware Lab Team Budgets and Sponsorships

Table 1 is a summary of corporate, private, and university level contributions for the 2022-23 academic year. Corporate support totaled $499,200 demonstrating strong support from companies such as *Boeing, GM, Blue Origin, Lockheed Martin, Gillig*, and *Nucor,* to name a few. See Table 2 for a detailed list of our top corporate sponsors.

Virginia Tech's *Student Engineers' Council* (SEC), a consistently strong supporter of Ware Lab for many years, gave over $52,000 in funding to all teams in the facility in 2022-23. Private sponsorship totaled $53,000 and additional support from Virginia Tech totaled $43,700, including a yearly Ware Lab stipend. Stipends are awarded based on teams completing multiple tasks during the academic year such as participation in *STEAM Day* and *Kid's Tech University*. Teams must also pass all bay and common-use lab inspections in order to receive a stipend. Support is used to pay for team expenditures, including *supplies, parts, equipment, third party contacting*, and *travel* which all totaled $221,000 in 2022-23.

Of special note for this year was a sizable private contribution made by Virginia Tech alum Mary Prim Jones to support teams at the *Advanced Engineering Design Lab* (AEDL). Prim is a 1962 graduate of mechanical engineering and is a member of *Engineering Insiders,* who consist of the college's most generous contributors. Thanks to Mary's contribution and a matching gift from the College of Engineering, Ware Lab and the AEDL were able to purchase a new industrial grade water jet router valued at $110,000. The device has a 4 ft by 4 ft table and can accommodate any metal up to 6 inches in thickness! The FLOW water jet will be a shared resource between the Ware Lab and the AEDL and will revolutionize manufacturing processes for teams in both facilities.

Ware Lab teams simply could not complete project deliverables and travel to many North American destinations to participate in world class competitions without these sources of corporate, university and private support! Please see *Appendix A* for specific team budget and sponsorship information.

Table 1 – Team Budget Summary

	Astrobotics	Baja SAE	BOLT	CCT	DBF	FSAE	HEVT	HPS	SailBOT	SBT	Totals
Top Corporate Sponsor	$5,000	$10,000	$7,000	$250	$5,000	$15,000	$396,320	$5,000	$400	$27,500	$471,470
Next Top Corporate Sponsor	$3,000	$5,000	$4,000	$0	$1,000	$10,000	$0	$1,500	$178	$5,000	$29,678
Private Sponsorship	$0	$28,538	$0	$1,000	$5,000	$18,000	$450	$0	$0	$0	$52,988
Ware Lab Stipend	$550	$550	$550	$550	$550	$550	$300	$550	$550	$550	$5,250
Student Engineers' Council (SEC)	$1,500	$4,710	$4,500	$3,194	$9,167	$5,000	$0	$9,250	$6,750	$9,250	$53,321
Other Virginia Tech Sponorship	$4,000	$0	$0	$0	$8,000	$14,000	$4,708	$4,707	$1,800	$6,525	$43,740
Team Expenditures	-$10,148	-$42,394	-$43,600	-$3,388	-$13,263	-$59,500	-$6,082	-$20,886	-$5,113	-$17,025	-$221,399
Net Balance	**$3,902**	**$6,404**	**-$27,550**	**$1,606**	**$15,454**	**$3,050**	**$395,696**	**$121**	**$4,565**	**$31,800**	**$435,048**

Table 2 – Team Corporate Sponsorship Summary

Team	Top Corporate Sponsor	Amount	Next Top Corporate Sponsor	Amount	Grand Total
Astrobotics	Blue Origin	$5,000	VA Space Grant Consortium	$3,000	
Baja SAE	General Motors	$10,000	Lockheed Martin	$5,000	
BOLT	CSM	$7,000	Boeing and Vector	$2,000	
CCT	Chandler Concrete Company	$250	-	$0	
DBF	Lockheed Martin	$5,000	Boeing	$1,000	
FSAE	Gillig	$15,000	General Motors	$10,000	
HEVT	Not Reported	$396,320	Not Reported	$0	
HPS	Aquateck Adventures	$5,000	Northrop Grumman	$1,500	
SailBOT	Collision Plus	$400	Total Boat	$178	
SBT	CSI America*	$27,500	Nucor	$5,000	
Totals		**$471,470**		**$27,678**	**$499,148**

Section 2 - Competition Results

Ware Lab teams traveled to 13 events throughout North America last year to compete in top-tier regional and international events. Teams traveled to destinations including **California, Michigan, Wahsington State, Massachusetts, Florida** and **Arizona** to compete with other peer university and colleges (see Table 3). Table 4 is a summary of competition results with *Baja SAE, Design Build Fly, Formula SAE*, and *Steel Bridge* ranking in the top 10 percentile at their respective events (shown in red). Participation in such events provide teams with real world experience in meeting hard deadlines and in networking with other college students that share common interests. A detailed list of competition events is included in *Appendix B*.

Table 3 – Ware Lab Team Competition Locations for 2022-23

Team	1st Competition Event	Location	2nd Competition Event (if applicable)	Location
Astrobotics	NASA Lunabotics Competition	Online	Caterpillar Robotics Mining Competition	University of Alabama, Tuscaloosa, Alabama
Baja SAE	Oregon Baja	Washougal, **Washington**	Ohio Baja	Nashport, **Ohio**
BOLT	Did not compete	NA	NA	
CCT	ASCE Virginias Student Symposium	Marshall University, Huntingdon, **West Virginia**	NA	
DBF	AIAA Design, Build, Fly	Tucson, **Arizona**	NA	
FSAE	Michigan Formula EV	Michigan International Speedway, Brooklyn, **Michigan**	2023 Michelin FSAE Shootout	Laurens County, **South Carolina**
HEVT	EcoCAR EV Challenge - Year 1	Orlando, **Florida**	NA	
HPS	17th International Submarine Races	Bethesda, **Maryland**	NA	
SailBOT	International Robotic Sailing Regatta	Amesbury, **Massachusetts**	NA	
SBT	ASCE Virginias Student Symposium	Marshall University, Huntingdon, **West Virginia**	National Student Steel Bridge Competition	University of California, **San Diego**

Table 4 – Ware Lab Team Competition Results for 2022-23

Team	1st Competition Event	Results	2nd Competition Event (if applicable)	Results
Astrobotics	NASA Lunabotics Competition	35 out of 49	Catepillar Robotics Mining Competition	7 out of 22
Baja SAE	Oregon Baja	13 out of 86	Ohio Baja	**3 out of 90**
BOLT	Did not compete	-	NA	-
CCT	ASCE Virginias Student Symposium	4 out of 6	NA	-
DBF	AIAA Design, Build, Fly	**4 out of 99**	NA	-
FSAE	Michigan Formula EV	8 out of 67	2023 Michelin FSAE Shootout	**2 out of 20**
HEVT	EcoCAR EV Challenge - Year 1	8 out of 13	NA	-
HPS	17th International Submarine Races	5 out of 19	NA	-
SailBOT	International Robotic Sailing Regatta	2 out of 6	NA	-
SBT	ASCE Virginias Student Symposium	**1 out of 6**	National Student Steel Bridge Competition	**4 out of 43**

Section 3 - Ware Lab Tours

Ware Lab teams, in addition to preparing for competition, perform outreach by speaking to multiple visitors to the lab each year. Tables 5, 6, and 7 detail groups touring the lab from K12 schools, universities, private industry, and visiting families. Ware Lab teams provide representatives for these events to meet groups in their bays to discuss project specifics. Over 1400 people visited the lab in 2022-23 to learn about the great things that teams are doing.

Table 5 - Ware Lab Tours for Fall 2022

Group	Number
VT Alumni	15
AOE Deoartment	45
AOE Department Tour for Wytheville High School Students	20
Blue Origin Representatives	5
Carroll County High School Students	15
CEED	20
Civil Engineering Board Member	2
COE Board Memeber	2
Crystal Spring School	35
Current ME Students	5
ECE Department	4
Elementary School Students - Mountgomery Country Public Schools	147
EMHS Class	34
EMHS Robotics Class	10
German Fulbright Group	12
High School AP Class	15
KNUST Delegration from Ghana	2
Mechanical Senior Design Tour with Representative from General Dynamics	6
Middle School Trip ('Be a Hokie for a Day' Program)	22
Mountgomery County Public Schools	91
Pratt Miller Representatives	3
Prospective Student from Atlanta, GA	4
Prospective Student from D.C.	4
Prospective Student from Harrisonburg, VA	2
Prospective Student from North Carolina	3
Prospective Students from Ohio	5
Prospective Student from Oralndo, FL	4
Prospective Student from PA	3
Prospective Student from Pittsburg, PA	3
Prospective Student from Virginia	1
Prospective Student Tour from Washington D.C.	2
Prospective Student Tour from Maryland	4
Prospective Student Tour from Virginia	2
Prospective Students from VA and TX	9
Radford Elementary School	30
Semester Total	**586**

Table 6 - Ware Lab Tours for Spring 2023

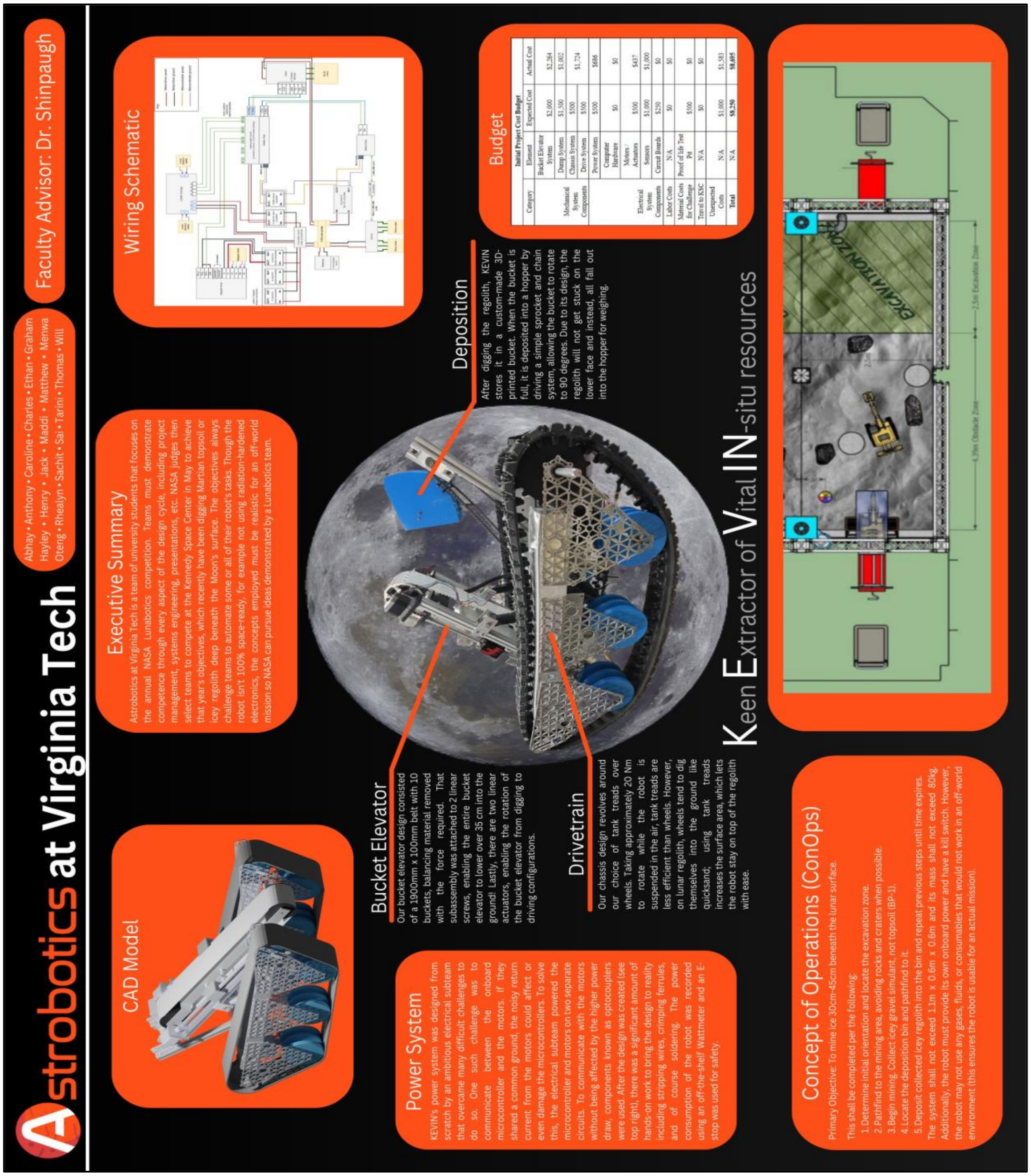
Group	Number
Legacy International Professional Fellows Group	20
7th & 8th Graders from Pittsylvania County Public Schools	75
Alumni and Prospective Student	2
Alumni from Texas	3
Alumni	5
AOE Department	6
Blacksburg Major	3
Blacksburg Middle School	100
CEED Event	20
CEO and President for Textron Aviation	2
Christiansburg High School Class	15
COE Open House	55
Group from Boeing	12
Halliburton Representative	1
Henrico High School	40
Hokie Focus for Admitted Students	20
Incoming Freshman from Pennsylvania	2
Incoming Freshman	6
Prospective Grad Students from Morgan State University	7
Prospective Student from California	4
Prospective Student from Washington D.C.	4
Prospective Student from Florida	5
Prospective Student from Indiana	3
Prospective Student from New York	2
Prospective Student from North Carolina	2
Prospective Student from Pennsylvania	2
Prospective Student from South Carolina	2
Prospective Student from Virginia	2
Prospective Student tour from North Carolina	2
Prospective Students	14
Pulaski County 5th Grade Class	15
Representatives from Misumi	3
Transfer Student from Maryland	1
University Open House	300
Women's Preview Weekend	30
Semester Total	**785**

Table 7 - Ware Lab Tours for Summer 2022

Group	Number
BEE VT - Gobblers	14
Matthew and Family	4
Representatives from ONE	5
STEAM Group	45
BLAST - Summer Camp	60
Semester Total	**128**
Grand Total for 2022-23	**1499**

Section 4 – Gallery of Team Posters

One requirement for receiving a Ware Lab stipend is the submission of a team poster. Posters demonstrate the level of complexity of design and workmanship needed for success at competition events. In this section Ware Lab team posters illustrating details about design, construction, sponsorship, and competition results are shown.



Baja SAE at Virginia Tech

About the Team:

- Undergraduate engineering design team
- 50+ students from 12 majors in engineering and beyond
- Engineering outreach for students across Virginia
- All students welcome, regardless of prior experience with cars
- Mechanical engineering capstone opportunity
- Fleet of 3 vehicles maintained for hands on driving and maintenance training
- Team running continuously since 1986

2023 Competition Results:

- Oregon
  - 13th place overall
  - 2nd place Hill Climb
  - 4th place Overall Dynamics
  - 4th place Acceleration
- Winter
  - 1st place overall
  - 1nd place Hill Climb
  - 1th Slome
  - 2nd place Endurance

About the Car:

- Competing around the USA against 90+ other universities at each event
- Competition mandated 10 hp motor
- Top speed of 43 mph off road
- 15 inches of suspension travel per corner
- Full roll cage and 5 point harness system
- Designed and manufactured fully in the Ware Lab at Virginia Tech in Blacksburg, VA
- Custom designed all time 4WD system
- Driven by students in competition
- Can hit an 12 inch log at 15 mph

Faculty Advisors: Dr. R.L. Clark Jr. and Dr. Arthur Ball

Key Sponsors: Altium Designer, Collision Plus Inc., CSM, General Motors, Lockheed Martin, Trova Commercial Vehicles, Yamaha Motor Ventures

BOLT Electric Motorcycle Design Team

Senior Design Members:
Erin Cox, Caleb Esatto, Josh Dalton, Dalton Reck, Erin Freck, Mason Gautschi, Colton Gehr, Collin Gray, Matt Mayger, Mason McCray, Ben Ryan, Marissa Sluss, Weesam Semaan, and Kensey Wishon

VIRGINIA TECH. BOLT

Introduction

BOLT designs, builds, and races electric motorcycles. The goal of this year's project is to develop the next-generation BOLT bike that will compete in the AHRMA Formula Lightning Division. This project builds on the previous year's senior design projects with a new powertrain, an updated cooling system, and new modular battery packs.

Customer Needs

The team held discussions with our faculty advisors and potential customers to develop customer needs and target specification values

High voltage systems are safe
Capacity is sufficient to complete a race
Maintain safe battery temperature
Maintain safe motor and motor controller temperature
Maintain reasonable weight (~460lbs)
Appropriate center of gravity
Durability on the track
High lean angle
Ensure ease of assembly
Minimize cost
Power comparable to similarly sized superbikes

Modular Pack Design

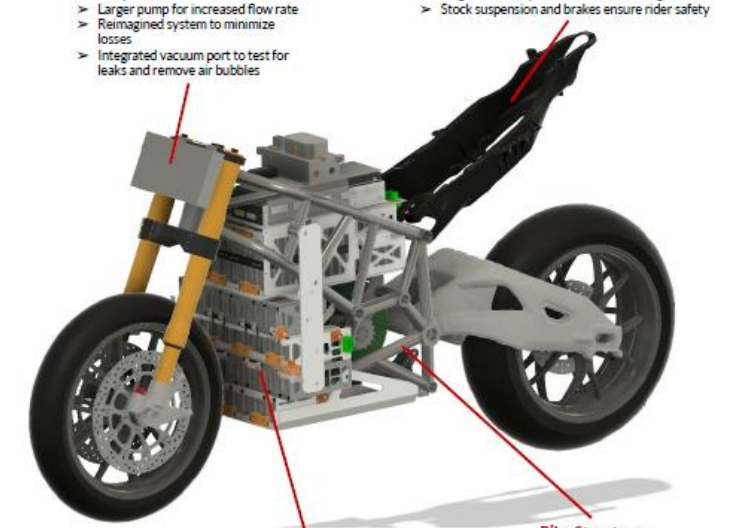
- Includes milled and 3D printed ABS alongside laser cut aircraft grade 1100 aluminum
- Multi-layered design ensures easy manufacturability
- State-of-the-art wire bonding decreases contact resistance
- Modular and easily serviceable in the event of a cell failure

Upgraded Cooling System

- Increased radiator size for more heat dissipation
- Larger pump for increased flow rate
- Reimagined system to minimize losses
- Integrated vacuum port to test for leaks and remove air bubbles

Stock Components

- Utilized stock frame components made of magnesium alloys to decrease bike weight
- Stock suspension and brakes ensure rider safety



Battery Pack Structure

- Lightweight sheet metal construction
- Modular design increases serviceability
- Structure decreases load on individual cells
- Easily removed from the bike with plugged connections and quick disconnect fittings

Bike Structure

- Tube trellis design maximizes weight and strength
- Welded 4130 steel
- Custom designed, built, and manufactured by students
- Welds tested under 3 ton loads
- Aluminum internal structure for efficient mounting
- Optimized for internal volume and quick assembly

Increased Sensor Data Collection

Thermistors

- Monitors temperatures of individual battery modules
- Increased from 8 thermistors (BOLT IV) to 47 thermistors (BOLT V)

Strain Gauges

- Monitors the forces on the custom frame
- Logs data to CAN for future analysis

Telemetry

- Real time CAN data transmission from the bike when it is on the track
- Data displayed using a custom GUI

Powertrain Components

Total pack: 600V at 300A **Peak power:** 180kW

Motor - Emrax 268 MV
- 210kW at 4500RPM
- 500Nm peak torque
- 22.3kg

Motor Controller - PM150DZR
- 225A continuous current
- 170kW peak output
- 10kg

BMS - Orion BMS 2
- 144 cell capacity
- 2.2kg

Battery Cells - Molicel P45B
- Delivers rated power for up to 5 minutes
- Tested at up to 60A per cell continuous

Winglets

- First step towards a full aero package in the team's history
- Designed for 30lbs of downforce total at race pace
- Manufactured out of carbon fiber reinforced nylon

Validation Results

Validation consisted of a variety of electrical and mechanical tests, alongside running the bike on a dynomometer to test power

	Target	Validated
Pack Voltage differential	Less than +/- 1 V	+/- 0.4 V
Isolation Faults	0	0
Battery Pack Capacity	21Ah	22.4Ah
Bike Weight	450	460 lb
Lean Angle	55°	58° (current)
Weld Test Maximum Load	Above 10 kN	13.86 kN
Cooling Power Dissipation	18kW	44.94kW
Battery Pack Temperature	25°C - 70°C	25°C - 70°C

Future Considerations

- Design and validation of aeronomic fairings
- Race data collection and dataset creation
- Testing to determine optimal gear ratio; race preparation
- Power delivery tuning and optimization

Virginia Tech

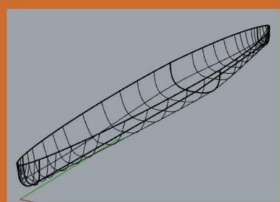
Concrete Canoe 2023-2024

CONCRETE CANOE

COLLEGE OF ENGINEERING
THE CHARLES E. VIA JR. DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
VIRGINIA TECH

Planning:
Each year, ASCE releases a Request for Proposals (RFP) with stringent guidelines tasking teams to create the best concrete canoe. It is up to each team to determine the optimal design for a high quality and resilient canoe, including how to best allocate resources through proper scheduling and budgeting.

The Basics:
The ASCE Concrete Canoe Competition gives students hands-on and practical experience consisting of designing and constructing a canoe made of concrete with stringent guidelines culminating in a competition against other civil engineering students.



Hull Design:
After preliminary scheduling, the hull design must be completed. This involves optimizing the shape of the canoe to balance factors such as straight-line speed, ability to turn quickly, stability, and constructability.

APEX PREDATOR
CONCRETE CANOE AT VIRGINIA TECH

Form Construction:
After the hull design is complete, form construction can begin. The form consists of precision-cut MDF cross sections spaced at 6" with foam glued in between. After the foam and MDF are combined, layers of drywall compound are applied and sanded smooth to create a smooth surface.

Structural Analysis:
After hull design is completed, a structural analysis is performed on the canoe to determine the design stresses used to set the strength requirements for the concrete mixture and reinforcement.

Canoe Construction:
After form construction, mix design, and reinforcement design is completed, canoe construction can begin. Construction consists of hand placing 3 layers of concrete sandwiching 2 layers of mesh reinforcement. In addition, prestressing will be employed in the gunwale. After concrete placement and curing, the canoe will be sanded smooth. Graphics will be created with inlaid concrete and stain. Finally, sealer will be applied to the canoe to prevent water ingress.

Competition:
This year, Virginia Tech is hosting the regional competition. At the competition, teams will be judged on final product/aesthetics, a technical proposal (that is submitted in February), a technical presentation, and 5 races. The winning team will have the opportunity to advance to the national competition hosted by which school?

Mix and Reinforcement Design:
After the design stresses are determined, an iterative mix design process can begin. The team carefully blends cements, pozzolans, lightweight aggregates, and chemical admixtures to achieve a strong, lightweight concrete. In addition, various reinforcements are tested in different orientations to determine the optimal reinforcing scheme.

AERODYNAMICS

Designs the aircraft and wing configuration. Analyzes and determines the aircraft parameters.
Tools: XFLR5, AVL, CFD

STABILITY AND CONTROL

Designs the aircraft tail and control systems. Determines the aircraft flight characteristics.
Tools: AVL, XFLR5

STRUCTURES

Designs the internal structures of the aircraft. Analyzes structural components using FEA software to ensure structural integrity.
Tools: SOLIDWORKS, Ansys

CAD

Designs 3D model of the aircraft, systems, and payload.
Tools: SOLIDWORKS

SYSTEMS

Designs, integrates, and tests system components based on the mission rules.
Tools: SOLIDWORKS. MATLAB, Arduino

PROPULSION/ELECTRONIC

Designs, integrates, and tests propulsion and electronics systems to optimize aircraft performance.
Tools: eCalc, MotoCalc, Static Propulsion Testing Rig, Open Jet Wind Tunnel

MANUFACTURING

Makes design changes ensuring manufacturability and fabricates the aircraft.
Tools: Laser cutter, CNC, 3D Printer, Shop Tools, Composite Manufacturing

DESIGN, BUILD, FLY! AT VIRGINIA TECH®

Welcome to DBF! We are an interdisciplinary design team open to all undergraduate students. Each year, the team competes in the international Design/Build/Fly competition hosted by AIAA, Raytheon Technologies, and Textron Aviation. The team works together to design, build, and test remote controlled aircraft in preparation for the April 2024 competition in Wichita, Kansas.

PROJECT SCHEDULE

SPONSORS

Lockheed Martin, SNC Sierra Nevada Corporation, Boeing, AOE Aerospace & Ocean Engineering, AUVSI Ridge and Valley, Virginia Tech College of Engineering Ware Lab, SEC Student Engineers' Council

2023 Project

The 2022-23 rules required a UAV electronic warfare system designed to accomplish several mission requirements. The key points include:

- Must disassemble and fit within a suitcase alongside spare wings
- Withstand high static g-loading
- Fly with a heavy weight electronics package
- Fly with an antenna affixed to the wingtip
- Fly surveillance mission as quickly as possible

The team placed 4th overall out of 99 teams!

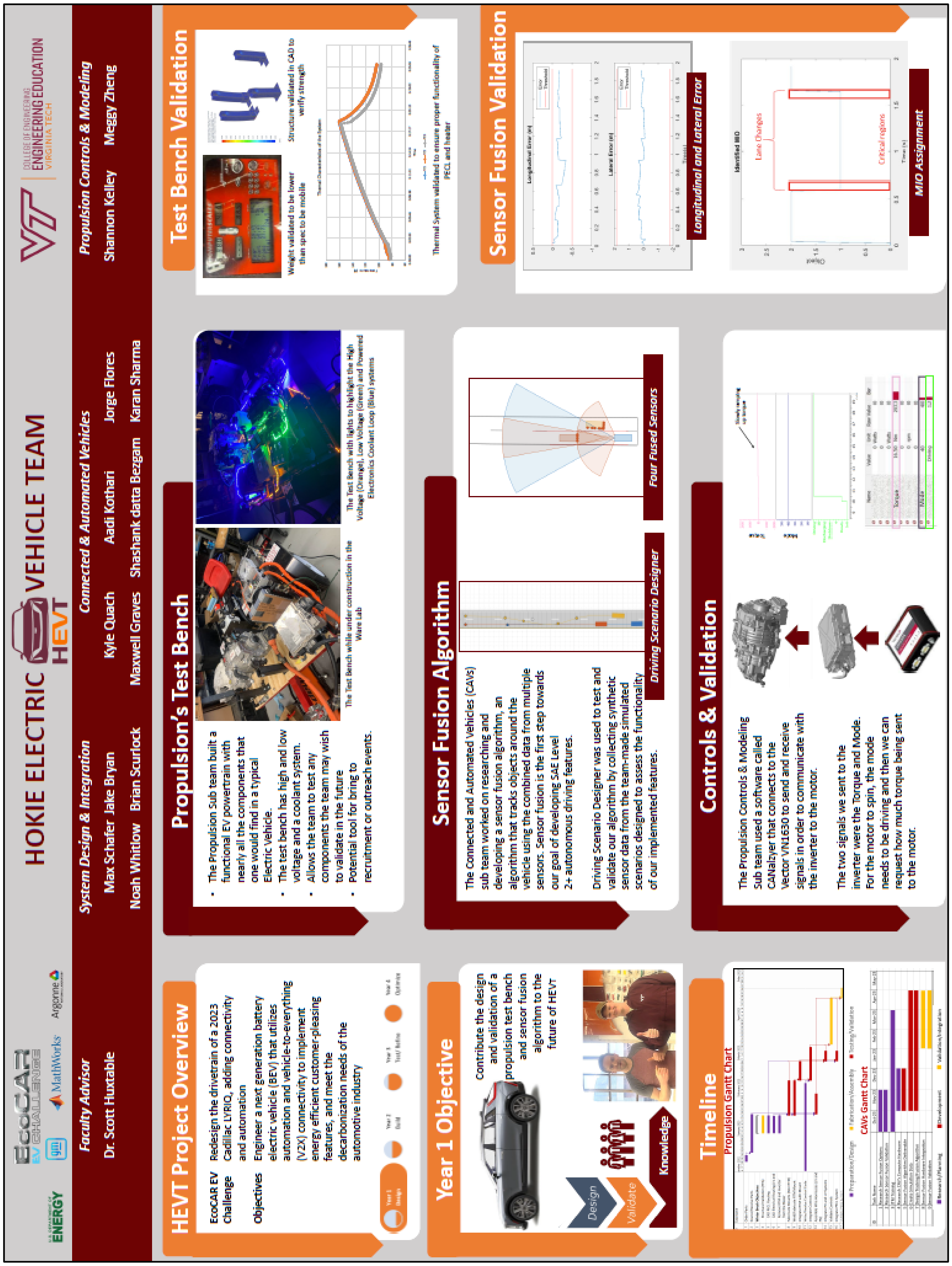
2023 TEAM

PREVIOUS SUCCESS

2nd Place 2018

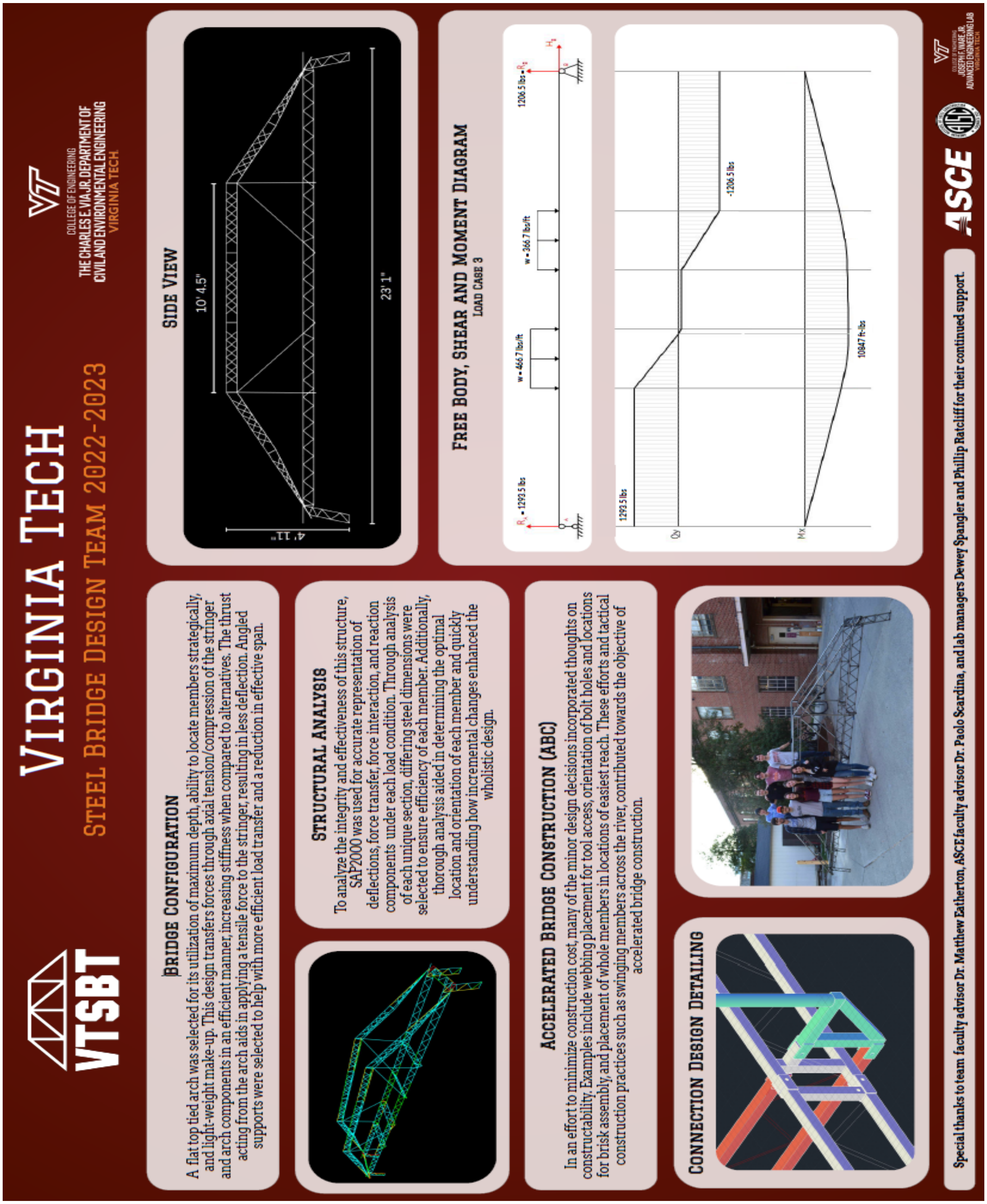
5th Place 2022


About the team:
Undergraduate student design team with about 70+ students from over 5 difference College of Engineering majors.
Outreach across Blacksburg and surrounding areas
Student designed, manufactured and tested
Team has been a part of VT Engineering since 1988
Capstone for ME, EE, CPE majors
FORMULA SAE
2023 EV 8th Place Overall
THANK YOU TO OUR SPONSORS
About the team:
Competition at Michigan International Speedway
EV competition against ~75 teams, IC Competition against ~120 teams
Both competitions attract the top universities in the world to attend
Car can pull over 2g's when cornering
Single cylinder turbocharged engine
Carbon composite chassis, and aero components


U.S. DEPARTMENT OF ENERGY
EcoCAR EV CHALLENGE
gm
MathWorks
Argonne
HOKIE ELECTRIC VEHICLE TEAM
HEVT
COLLEGE OF ENGINEERING
ENGINEERING EDUCATION
VIRGINIA TECH
Faculty Advisor
Dr. Scott Huxtable
System Design & Integration
Max Schafer Jake Bryan
Noah Whitlow Brian Scurlock
Connected & Automated Vehicles
Kyle Quach Aadi Kothari Jorge Flores
Maxwell Graves Shashank datta Bezgam Karan Sharma
Propulsion Controls & Modeling
Shannon Kelley Meggy Zheng
HEVT Project Overview
EcoCAR EV Challenge
Redesign the drivetrain of a 2023 Cadillac LYRIQ, adding connectivity and automation
Objectives
Engineer a next generation battery electric vehicle (BEV) that utilizes automation and vehicle-to-everything (V2X) connectivity to implement energy efficient customer-pleasing features, and meet the decarbonization needs of the automotive industry
Year 1 Design
Year 2 Build
Year 3 Test/ Refine
Year 4 Optimize
Propulsion's Test Bench
The Propulsion Sub team built a functional EV powertrain with nearly all the components that one would find in a typical Electric Vehicle.
The test bench has high and low voltage and a coolant system.
Allows the team to test any components the team may wish to validate in the future
Potential tool for bring to recruitment or outreach events.
The Test Bench while under construction in the Ware Lab
The Test Bench with lights to highlight the High Voltage (Orange), Low Voltage (Green) and Powered Electronics Coolant Loop (Blue) systems
Test Bench Validation
Weight validated to be lower than spec to be mobile
Structure validated in CAD to verify strength
Thermal System validated to ensure proper functionality of PECL and heater
Year 1 Objective
Contribute the design and validation of a propulsion test bench and sensor fusion algorithm to the future of HEVT
Design
Validate
Knowledge
Sensor Fusion Algorithm
The Connected and Automated Vehicles (CAVs) sub team worked on researching and developing a sensor fusion algorithm, an algorithm that tracks objects around the vehicle using the combined data from multiple sensors. Sensor fusion is the first step towards our goal of developing SAE Level 2+ autonomous driving features.
Driving Scenario Designer was used to test and validate our algorithm by collecting synthetic sensor data from the team-made simulated scenarios designed to assess the functionality of our implemented features.
Driving Scenario Designer
Four Fused Sensors
Sensor Fusion Validation
Longitudinal Error (m)
Lateral Error (m)
Longitudinal and Lateral Error
Identified MIO
Lane Changes
Critical regions
Time (s)
MIO Assignment
Timeline
Propulsion Gantt Chart
Preparation/Design
Fabrication/Assembly
Testing/Validation
CAVs Gantt Chart
Research/Planning
Development
Validation/Integration
Controls & Validation
The Propulsion Controls & Modeling Sub team used a software called CANalyzer that connects to the Vector VN1630 to send and receive signals in order to communicate with the inverter to the motor.
The two signals we sent to the inverter were the Torque and Mode. For the motor to spin, the mode needs to be driving and then we can request how much torque being sent to the motor.
Slowly ramping up torque
Torque
Mode
Driving


DESIGN PHILOSOPHY
THE GOAL WAS TO CREATE THE FASTEST DESIGN IN THE SINGLE-PERSON PROPELLER-DRIVEN SUBMERSIBLE CATEGORY, LEVERAGING THE TEAM'S 30 YEARS OF EXPERIENCE.
MARINE PROPULSION DESIGN
PROPELLER DESIGN
SIMULATE HYDRODYNAMIC INTERACTIONS BETWEEN A VEHICLE AND ITS PROPULSOR BY MODELING THE PROPELLER AS AN ACTUATOR DISK TO CALCULATE KEY COEFFICIENTS.
UTILIZE THE COEFFICIENTS AND OPENPROP SOFTWARE TO CONDUCT A PARAMETRIC DESIGN STUDY, OPTIMIZING THE PROPELLER GEOMETRY AND OPERATING CONDITIONS FOR IDEAL PERFORMANCE.
FABRICATE THE PROPELLER USING A 3D PRINTER, COVER THE PROPELLOR WITH A 2" CARBON FIBER SLEEVE AND COMPLETELY COAT WITH EPOXY.
FINISHED PROPELLER
HULL FORM DESIGN
MYRING MODEL & GENERAL ARRANGEMENTS
GENERATE THE OPTIMAL HULL FORM USING MYRING EQUATIONS AND STRATEGICALLY PLACE BALLAST FOAM TO ENSURE IT DOESN'T OBSTRUCT THE PILOT WHILE MAINTAINING THE SUBMARINE'S MID-WATER BUOYANCY.
MANUFACTURING
1. MODELING IN SOLIDWORKS: CREATE A DIGITAL MODEL OF THE SUBMARINE'S HULL.
2. MOLD CREATION:
A. USE RENSHAPE TO FORM A POSITIVE MOLD OF THE HULL'S HALF.
B. COAT THE MOLD WITH DURATEC AND SAND IT DOWN FOR SMOOTHNESS.
3. NEGATIVE MOLD CONSTRUCTION:
A. APPLY FIBERGLASS LAYERS ON THE POSITIVE MOLD, USING RESIN AND VACUUM FORMING.
B. STRENGTHEN THE MOLD WITH FOAM STRIPS.
C. CREATE A WOODEN CRADLE TO HOLD THE NEGATIVE MOLD.
4. HULL LAYUP PROCESS:
A. SPRAY DURATEC ON THE NEGATIVE MOLD AND CRADLE.
B. CONDUCT A TWO-PART LAYUP: FIRST WITH FIBERGLASS LAYERS, THEN ADD FOAM FOR BUOYANCY AND ANOTHER SET OF FIBERGLASS LAYERS.
C. REPEAT THE PROCESS FOR BOTH HALVES OF THE HULL, ENSURING THE TOP HALF HAS MORE FOAM FOR BUOYANCY.
5. ASSEMBLY OF THE HULL:
A. CUT THE TOP HALF INTO THREE SECTIONS (BOW, HATCH, STERN).
B. JOIN THE HALVES USING EPOXY AND HARDENER.
HUMAN POWERED SUBMARINE AT VIRGINIA TECH
17TH INTERNATIONAL SUBMARINE RACES
JUNE 2023
GOBBLERFEST 2023
SAFETY & ERGONOMICS
PILOT SCUBA TANK MOUNT
PILOT CHEST PLATE
BOUY HOLDER
BOUY DEAD-MAN RELEASE
TO MAKE SURE KRAKEN IS RELIABLY SAFE, STRATEGICALLY POSITION SAFETY LIGHTS FOR VISIBILITY AND A CAREFULLY CONSTRUCTED HATCH RELEASE MECHANISM FOR PILOT ACCESS.
TESTING
KRAKEN UNDERWENT RIGOROUS TESTING IN CONTROLLED ENVIRONMENTS, INCLUDING THE ROANOKE YMCA POOL FOR BUOYANCY AND OPERATIONAL CHECKS, AND IN THE BLACKSBURG QUARRY TO ASSESS SYSTEM FUNCTIONALITY AND SIMULATE COMPETITION SCENARIOS.
2023 KRAKEN QUARRY TEST
HULL FEATURES
HATCHES
INSTALL A MAIN HATCH FOR PILOT ENTRY AND A MAINTENANCE HATCH FOR ENGINE ACCESS.
HYDROSCOOP
CUT 6X2 INCH HOLE WAS CUT ABOVE THE PILOT IN KRAKEN'S HATCH TO MANAGE BUOYANCY AFFECTED BY RELEASED AIR.
WINDOWS
FIT THE PILOT'S AREA WITH PETG THERMOPLASTIC WINDOWS FOR VISIBILITY.
PROPULSION SYSTEM
DRIVETRAIN
DRIVETRAIN: PORT VIEW
DRIVETRAIN: STARBOARD VIEW
PEDAL MOUNTS
STERN PLATE
INSTALL A DRIVETRAIN WITH A CENTRAL GEARBOX CONNECTED TO PEDALS AND A STERN PLATE TO SUPPORT THE PROPELLER SHAFT.
CONTROL SYSTEM & ELECTRONICS
DUAL MANUAL AND ELECTRONIC CONTROLS
CONTROL ROD, GEARBOX, AND HORSESHOE PIECE SETUP
JOYSTICK
TO CONSTRUCT THE KRAKEN'S CONTROL SYSTEM, INSTALL ELECTRONIC CONTROL UNITS CONNECTED TO JOYSTICKS WITH BUTTONS THAT OPERATE STERN MOTORS FOR CONTROL SURFACE MANIPULATION. FOR MANUAL OPERATION, SET UP A MECHANISM WHERE THE JOYSTICK'S PHYSICAL MOTION DIRECTLY ACTUATES THE CONTROL SURFACES. INCLUDE A SMALL KEY FOR SWITCHING MODES: INSERT IT INTO THE MOTOR FOR ELECTRONIC CONTROL OR REMOVE IT FOR MANUAL STEERING CAPABILITIES.
HORIZONTAL CONTROL SURFACE
NAVIGATION SYSTEM & SENSOR ARRAY
TO CREATE KRAKEN'S NAVIGATION SYSTEM, INSTALL TWO PRESSURE TRANSMITTERS AND A GYROSCOPE TO FEED DEPTH, SPEED, PITCH, AND YAW DATA TO THE PILOT'S DISPLAY. PLACE HALL EFFECT PROXIMITY SENSORS BY THE PROPELLER SHAFT WITH A MAGNET TO TRACK AND RELAY RPM INFORMATION FOR MONITORING PROPELLER EFFICIENCY.
SPONSORS
ULINE
NORTHROP GRUMMAN
Signarama
LOCKHEED MARTIN
NAVSEA
ADVANCED CIRCUITS
cfc


SAILBOT AT VIRGINIA TECH
What is SailBot?
SailBot is an engineering-based design team open to all academic years and skill levels where the goal is to design, build, and compete an up to 2-meter remote control and autonomous sailboat.
At Virginia Tech all majors and skill levels are welcome to help in every part of the process. All team members are volunteers, participating for the experience and fun of it!
SailBot allows for real-world application of classroom learning along with the development of inter-personal skills, time and finance management, and public speaking.
Subteams
Electrical: responsible for boat and shore hardware and communication and sensor implementation
Mechanical: responsible for the design and manufacturing of the moving systems and appendages
Naval Architecture: responsible for the overall design of the boat and construction of the structural elements
Propulsion/Sail: responsible for sail design and construction
Public Relations: responsible for sponsorships, social media, and outreach
Software: responsible for boat autonomy through sensor utilization and machine learning
History
2012: Initial Founding of SailBot at Virginia Tech
2018: Revival of team
2019: Placed 2nd at International Robotic Sailing Regatta
2020-2021: Competitions canceled (COVID-19)
2022: Placed 2nd at International Robotic Sailing Regatta
2023: Placed 2nd at International Robotic Sailing Regatta
Reach Out
@sailbotvt
www.sailbot.aoe.vt.edu
SailBot at Virginia Tech is committed to creating an inclusive and welcoming space for all regardless of gender, race, sexuality, national origin, religion, or ability level.
SAILBOT International Robotic Sailing Competition


VTSBT
VIRGINIA TECH
STEEL BRIDGE DESIGN TEAM 2022-2023
COLLEGE OF ENGINEERING
THE CHARLES E. VIA JR. DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
VIRGINIA TECH
BRIDGE CONFIGURATION
A flat top tied arch was selected for its utilization of maximum depth, ability to locate members strategically, and light-weight make-up. This design transfers forces through axial tension/compression of the stringer and arch components in an efficient manner, increasing stiffness when compared to alternatives. The thrust acting from the arch aids in applying a tensile force to the stringer, resulting in less deflection. Angled supports were selected to help with more efficient load transfer and a reduction in effective span.
STRUCTURAL ANALYSIS
To analyze the integrity and effectiveness of this structure, SAP2000 was used for accurate representation of deflections, force transfer, force interaction, and reaction components under each load condition. Through analysis of each unique section, differing steel dimensions were selected to ensure efficiency of each member. Additionally, thorough analysis aided in determining the optimal location and orientation of each member and quickly understanding how incremental changes enhanced the wholistic design.
ACCELERATED BRIDGE CONSTRUCTION (ABC)
In an effort to minimize construction cost, many of the minor design decisions incorporated thoughts on constructability. Examples include webbing placement for tool access, orientation of bolt holes and locations for brisk assembly, and placement of whole members in locations of easiest reach. These efforts and tactical construction practices such as swinging members across the river, contributed towards the objective of accelerated bridge construction.
CONNECTION DESIGN DETAILING
SIDE VIEW
10' 4.5"
4' 11"
23' 1"
FREE BODY, SHEAR AND MOMENT DIAGRAM
LOAD CASE 3
R_A = 1293.5 lbs
w = 466.7 lbs/ft
w = 366.7 lbs/ft
1206.5 lbs = R_B
H_B
1293.5 lbs
Qy
-1206.5 lbs
Mx
10847 ft-lbs
Special thanks to team faculty advisor Dr. Matthew Eatherton, ASCE faculty advisor Dr. Paolo Scardina, and lab managers Dewey Spangler and Phillip Ratcliff for their continued support.
ASCE

Appendix A: Team Budget Specifics

In this appendix details about corporate, private and university sponsorships are shown along with team expenditures such as *supplies, parts, lab equipment* and *travel costs*. Net balances (in yellow) account for all team contributions and expenditures at the time of reporting.

Astrobotics:

Team Sponsorship	Dollar Value	
Top corporate sponsor:	Blue Origin	
Monetary contribution	$	5,000.00
Total:	$	5,000.00
Next top corporate sponsor:	VA Space Grant Consortium	
Monetary contribution	$	3,000.00
Total:	$	3,000.00
Ware Lab Stipend	$	550.00
Student Engineers' Council (SEC)	$	1,500.00
Other	$	4,000.00
Grand Total:	$	14,050.00
Team Expenditures		
Supplies/Parts	$	6,018.00
Lab Equipment	$	1,982.83
Travel Cost	$	2,148.00
Total:		$10,148.83
Net Balance:	$	3,901.17

Baja SAE:

Team Sponsorship	Dollar Value	
Top corporate sponsor:	General Motors	
Monetary contribution	$	10,000.00
Next top corporate sponsor:	Lockheed Martin	
Monetary contribution	$	5,000.00
In-kind contribution	$	3,899.00
Software contribution	$	4,950.00
Monetary contribution	$	19,689.00
Total:	$	28,538.00
Ware Lab Stipend	$	550.00
Student Engineers' Council (SEC)	$	4,710.00
Grand Total:	$	48,798.00
Team Expenditures		
Supplies/Parts	$	32,782.00
Travel Cost	$	5,812.00
Competition Registration Fees	$	3,800.00
Total:		$42,394.00
Net Balance:	$	6,404.00

BOLT:

Team Sponsorship	Dollar Value
Top corporate sponsor:	CSM
In-kind contribution	$ 7,000.00
Next top corporate sponsor:	Boeing & Vector
In-kind contribution	$ 2,000.00
Monetary contribution	$ 2,000.00
Total:	$ 4,000.00
Ware Lab Stipend	$ 550.00
Student Engineers' Council (SEC)	$ 4,500.00
Total:	$ 5,050.00
Grand Total:	$ 16,050.00
Team Expenditures	
Supplies/Parts	$ 40,000.00
Lab Equipment	$ 2,000.00
Travel Cost	$ 600.00
Competition Registration Fees	$ 1,000.00
Total Expenditures:	$43,600.00
Net Balance:	$ (27,550.00)

Concrete Canoe Team (CCT):

Team Sponsorship	Dollar Value
Top corporate sponsor:	Chandler Concrete Company
In-kind contribution	$ 250.00
Top private sponsor:	Morgan Family
Monetary contribution	$ 1,000.00
Ware Lab Stipend	$ 550.00
Student Engineers' Council (SEC)	$ 3,194.00
Grand Total:	$ 4,994.00
Team Expenditures	
Supplies/Parts	$ 1,194.00
Travel Cost	$ 594.00
Other - (Shipping, Social and Outreach)	$ 1,600.00
Total:	$3,388.00
Net Budget:	$ 1,606.00

Design Build Fly (DBF):

Corporate Sponsorship	Dollar Value
Top corporate sponsor:	Lockheed Martin
Monetary contribution	$ 5,000.00
Next top corporate sponsor:	Boeing
Monetary contribution	$ 1,000.00
Private Sponsorship	
Monetary contribution	$ 5,000.00
Virginia Tech Sponsorship	
Ware Lab Stipend	$ 550.00
Student Engineers' Council (SEC)	$ 9,166.19
AOE Department	$ 8,000.00
Grand Total:	$ 28,716.19
Team Expenditures	
Supplies/Parts	$ 9,000.00
Lab Equipment	$ 4,147.78
Other - Outreach Supplies	$ 115.00
Total Expenditures:	$13,262.78
Net Balance:	$ 15,453.41

Formula SAE (FSAE):

Team Sponsorship	Dollar Value
Top corporate sponsor:	Gillig
Monetary contribution	$ 15,000.00
Next top corporate sponsor:	General Motors
Monetary contribution	$ 10,000.00
Private Sponsorship	
In-kind contribution	$ 10,000.00
Software contribution	$ 5,000.00
Monetary contribution	$ 3,000.00
Total:	$ 18,000.00
Virginia Tech Sponsorship	
Ware Lab Stipend	$ 550.00
Student Engineers' Council (SEC)	$ 5,000.00
ME and EE Grants	$ 14,000.00
Total:	$ 19,550.00
Grand Total:	$ 62,550.00
Team Expenditures	
Supplies/Parts	$ 45,000.00
Lab Equipment	$ 7,000.00
Travel Cost	$ 5,000.00
Competition Registration Fees	$ 2,500.00
Total:	$59,500.00
Net Balance:	$ 3,050.00

Hokie Electric Vehicle Team (HEVT):

Team Sponsorship	Dollar Value
In-kind contribution	$ 53,876.00
Software contribution	$ 202,922.00
Monetary contribution	$ 139,522.00
Total:	$ 396,320.00
Private Sponsorship	
Monetary contribution	$ 450.00
Ware Lab Stipend	$ 300.00
Other VT sporsorship:	$ 4,707.59
Grand Total:	$ 401,777.59
Team Expenditures	
Supplies/Parts	$ 6,081.98
Net Budget:	$ 395,695.61

Human Powered Sub (HPS):

Team Sponsorship	Dollar Value
Top corporate sponsor:	Aquatrek Adventures
Monetary contribution	$ 5,000.00
Next top corporat sponsor:	Northrop Grumman
Monetary contribution	$ 1,500.00
Ware Lab Stipend	$ 550.00
Student Engineers' Council (SEC)	$ 9,250.00
Other	$ 4,707.40
Total:	$ 14,507.40
Grand Total:	$ 21,007.40
Team Expenditures	
Supplies/Parts	$ 14,845.11
Lab Equipment	$ 1,332.96
Travel Cost	$ 2,707.40
Competition Registration Fees	$ 2,000.00
Total:	$20,885.47
Net Balance:	$ 121.93

Steel Bridge Team (SBT):

Team Sponsorship	Dollar Value
Top corporate sponsor:	CSI America
Sorfware contribution	$ 27,500.00
Next top corporate sponsor:	Nucor
Moneteary contribution	$ 5,000.00
Ware Lab Stipend	$ 550.00
Student Engineers' Council (SEC)	$ 9,250.00
Other VT sponsorship	$ 6,525.00
Total:	$ 16,325.00
Grand Total:	$ 48,825.00
Team Expenditures	
Supplies/Parts	$ 8,000.00
Lab Equipment	$ 3,000.00
Travel Cost	$ 1,800.00
Competition Registration Fees	$ 2,625.00
Other - (Shipping, Social and Outreach)	$ 1,600.00
Total:	$17,025.00
Net Budget:	$ 31,800.00

SailBOT:

Team Sponsorship	Dollar Value
Top corporate sponsor:	Collision Plus
In-kind contribution	$ 400.00
Next top corporate sponsor:	Total Boat
In-kind contribution	$ 178.00
Ware Lab Stipend	$ 550.00
Student Engineers' Council (SEC)	$ 6,750.00
Other VT sponsorship	$ 1,800.00
Total:	$ 9,100.00
Grand Total:	$ 9,678.00
Team Expenditures	
Supplies/Parts	$ 3,078.78
Lab Equipment	$ 89.96
Travel Cost	$ 1,943.90
Total:	$5,112.64
Net Budget:	$ 4,565.36

Appendix B: Team Competition Specifics

Specifics about team competition dates and locations are shown in this appendix. Also details about final competition results are provided for teams who provided these items at the time of reporting.

Astrobotics:

Competition	NASA Lunabotics Competition	Catepillar Robotics Mining Competition
Dates	3/29/2023	5/21/2023 - 5/26/2023
Location	Online	University of Alabama (Tuscaloosa, AL)
Number Of Schools	49	22
Results	**35th - overall**	**7th - overall**

Baja SAE:

Competition	Oregon Baja	Ohio Baja
Dates	May 31st - June 3rd	September 6th - 10th
Location	Washougal Washington	Nashport Ohio
Number Of Schools	86	90
Results	4th - all dynamic events **13th - overall**	1st - all dynamic events **3rd - overall**

BOLT:

Competition	*Not indicated.*
Dates	*Not indicated.*
Location	*Not indicated.*
Number Of Schools	*Not indicated.*
Results	BOLT did not attend competition in 2022-23. The team is on a 2-year design cycle, and last year was year 1 of this cycle. The team plans to complete in 2023-24 with BOLT V.

Concrete Canoe (CCT):

Name	ASCE Virginias Student Symposium
Dates	April 13-15, 2023
Location	Marshall University - Huntingdon, WV
Number Of Schools	6
Results	6th - racing events 2nd - proposal 3rd - technical presentation 3rd - product prototype **4th - overall**

Design Build Fly (DBF):

Competition	AIAA Design, Build, Fly
Dates	13th - 16th April 2023
Location	Tucson, AZ
Number Of Schools	99
Results	**4th - overall**

Formula SAE (FSAE):

Competition	Michigan Formula EV	2023 Michelin FSAE Shootout
Dates	June 12th - June 18th	October 6th - October 8th
Location	Michigan International Speedway, Brooklyn, Michigan	Laurens County, South Carolina
Number Of Schools	67	20
Results	**8th - overall**	**6th - overall IC engine** **2nd - overall EV motor**

Hokie Electric Vehicle Team (HEVT):

Competition	EcoCAR EV Challenge - Year 1
Dates	21st May to 25th May 2023
Location	Orlando, Florida
Number Of Schools	13
Results	1st - Mobility Equity Advocate Award 3rd - project management **8th - overall**

Human Powered Sub (HPS):

Competition	17th International Submarine Races
Dates	06/26/23-06/30/23
Location	Bethesda, Maryland
Number Of Schools	19
Results	3rd place - speed **5th - overall**

SailBOT:

Competition	International Robotic Sailing Regatta
Dates	June 5-9 2023
Location	Amesbury, MA
Number Of Schools	6
Results	3rd - presentation 1st - endurance 1st - payload 2nd - station keeping 3rd - fleet race **2nd - overall**

Steel Bridge Team:

Competition	Virginias Regional Symposium	National Student Steel Bridge Competition
Dates	April 14-15, 2023	June 2-3, 2023
Location	Marshall University, Huntington WV	University of California San Diego
Number Of Schools	6	43
	1st - construction speed	8th - construction speed
	1st - lightness	2nd - lightness
	1st - aesthetics	2nd - aesthetics
	1st - stiffness	12th - stiffness
	1st - cost estimate	17th - cost estimate
	1st - economy	5th- economy
	1st - efficiency	6th - efficiency
Results	**1st - overall**	**4th - overall**