

JOSEPH F. WARE ENGINEERING LAB

Newsletter 2023-24



ENGINEERING
VIRGINIA TECH.

Welcome to our 2022-23 Newsletter!

This edition of Virginia Tech's *Ware Lab Newsletter* has details on team activities for the 2022-23 academic year. As manager of the Ware Lab, I am excited to tell you about our great teams and their participation in world class competitions and exciting outreach opportunities. Ware Lab student groups excelled at international competition events in the areas of off road vehicles, steel truss structures, high speed street racers, and military remote controlled aircraft, to name a few.

If you have any question about Ware Lab please contact me at spangler@vt.edu. Tours of the facility can be arranged for families, school groups, and industry partners. More information about Ware Lab can be found in the 2022-23 Ware Lab Summary Report and the Ware Lab 2022-23 Stats Report, both available upon request.

Dewey Spangler, PE

Ware Lab Manager- Virginia Tech College of Engineering



Battery Operated Land Transport (BOLT) at the Roanoke Higher Ed Center for STEAM Day



Hokie Electric Vehicle Team's Cadillac Lyriq.



Design Build Fly at the Taubman Museum of Art for STEAM Day.

On the Front Cover: Two high performance Formula SAE vehicles are shown using internal combustion (left) and EV (right) power-trains. The EV vehicle earned 8th place at the 2023 Michigan Formula event, out pacing many peer engineering schools! The vehicles are shown on display at the STEAM Day 2023 event in Roanoke, Virginia. All 10 Ware Lab teams were in attendance which provided a day long outreach opportunity for over 1300 K-12 students, home-schoolers, and the general public.

STEAM Day 2023

Ware Lab teams spent the morning and afternoon of October 20 with many folks from the surrounding K-12 service area at STEAM Day 2023 in Roanoke, Virginia. Event venues included the Roanoke Higher Ed Center, the Science Museum of Western Virginia, and the Taubman Museum of Art. STEAM Day (STEM + arts) is an annual event organized by Virginia Tech's Higher Ed Center for the purpose of bringing the good news about VT engineering to many under-represented students in the Roanoke area. Hands-on learning is in full force as visitors have the chance to speak with student teams in a relaxed atmosphere. Over **1300** visitors participated with all Ware Lab and AEDL (Aerospace Engineering Design Lab) teams in attendance, a new record!

<https://www.vtrc.vt.edu/STEAM/steam-day.html>



CW from top left at the event: Formula SAE, A future motorsport racer, Human Powered Sub, Baja SAE, HEVT, SailBOT, Concrete Canoe, Steel Bridge, Center: STEAM Day K-12 participants.

Back2School Free Haircut Program

Remember the old jingle “Shave and a hair cut, 2 bits!” Well, those days are long gone with an average hair cut today being out of reach financially for many families with kids starting school in the fall. On August 6th Baja SAE and Hokie Electric Vehicle Team participated in the *Back2School Free Haircut Program* in Christiansburg, Virginia.

Sponsored by the Alpha Kappa Lambda Chapter of Alpha Phi Alpha Fraternity, this program provides K-12 students with a free haircut from participating businesses so they can look their best on the first day of school. Baja brought their competition vehicle 007 and HEVT provided a working demo of the team’s EV power train system. This demo showed participants how integration of lithium batteries, a control system (BMS), water cooling, and an EV motor will occur in the team’s new GM Cadillac Lyriq competition vehicle.

Over 130 students attended the event this year and in spite of rain many learned about the great things going on at Ware Lab and about engineering and college opportunities, in general.

<https://www.wdbj7.com/2023/08/06/alpha-kappa-lambda-chapter-hosts-an-event-give-free-back-school-haircuts/>



L to R: Baja SAE at the summer event with VT Engineering Education faculty member Dr. Tremayne Waller. A future off road enthusiast. Looking great for the first day of school! HEVT with their EV proof-of-concept demo.

Ware Lab Team Updates:

Astrobotics

Astrobotics at VT designs, manufactures, and programs an autonomous robot for the NASA Lunar Robotics Mining Competition. The team placed 35th nationally in 2023. The team also competed at the Caterpillar Robotics Mining Completion at the University of Alabama, tying for 7th.

Both competition events required robots to navigate, mine, and deposit moon soil in a simulated lunar environment while minimizing mass, power consumption, and operator input (via system autonomy). Surface craft must navigate rough terrain and locate icy gravel in order to extract water for future manned lunar and Mars missions. Water can be used for drinking or for rocket fuel after hydrogen and oxygen atoms are separated. In addition to performance, teams are ranked on project management, systems engineering, outreach, and final presentation.

<https://eng.vt.edu/academics/student-teams/astrobotics.html>

Astrobotics team members with AOE advisor Dr. Kevin Shinpaugh



Astrobotics team members participate at the NASA competition.

Baja SAE

What a great year for VT Baja SAE! In May of 2023, Virginia Tech attended the *Oregon Baja* event in Washougal, Washington, traveling over 2500 miles. At this event the team's car Phoenix earned 2nd in hill climb and 4th in acceleration. VT's vehicle consistently ran the fastest lap during the 4-hour endurance but due to excessive repairs the team placed 13th out of 86 overall.



L to R: Virginia Tech at Ohio Baja. Baja car with signed Honda hood and tail fin for 1st place finish in all dynamic events (blue hood) and outstanding sportsmanship (black tail fin). Phoenix: light but mighty!

In September VT Baja traveled to Nashport, Ohio for their final competition for 2023 – *Ohio Baja*. Going in the team knew that they had a fast and reliable car. The competition started with design presentations where fifteen judges grilled the team on many aspects of design. The team earned 11th place out of 90 in judging. After technical inspection, the car's brakes were tested by locking all four tires within the allotted travel distance, marking an improved performance compared to that at Oregon, where brake problems plagued the team.

The next day involved participation in acceleration where the team's vehicle ran the full 100 ft straight distance in under 4.6 seconds, an 8th place finish. In the Pilot Pull event, a constant force is applied by requiring the Baja vehicle to pull a Honda Pilot (which weighs about 4000 lbs). The team nervously entered this event because other vehicles traveled only a few feet or were flipped backwards because of poor vehicle weight balance. VT'S Phoenix did not experience either issue, accelerating the Honda Pilot most of the way down the course! VT Baja earned a solid 3rd place in this event.

Baja SAE - con't

In maneuverability, the vehicle's improved steering allowed Phoenix to maneuver through the Ohio course without touching a single cone or incurring any penalties, resulting in a 3rd place finish. The next event, suspension and traction, involved 52-inch tires, two-foot-deep mud pits, concrete blocks, and junk cars which vehicles were required to maneuver over. VT's Phoenix placed 2nd in this event.

Now for the most demanding challenge, endurance. Going in, the team noticed some vehicle damage that was readily repaired before the start. Two hours into the course VT's driver had to pit due to a loose bolt on a brake caliper. After a quick repair the car returned to the course, losing only two positions, allowing VT to regain 1st place. Unfortunately, the car had to pit once more when a front wheel hub broke. Five minutes later Phoenix returned with a new driver and still finished in 4th place.

Due to the great performance for all events the Virginia Tech team earned 1st in all dynamic events and 3rd overall, beating top tier schools Rochester Institute of Technology (4th place) and Cornell University (6th place)!

<https://eng.vt.edu/academics/student-teams/baja-sae.html>



VT Baja's Phoenix.



Air time at Ohio Baja.

BOLT

VT BOLT (Battery Operated Land Transport) has completed development and manufacturing of the team's fifth-generation motorcycle and has continued performance testing at a dynamometer facility in Roanoke, Virginia. During dyno testing, BOLT V rated a power output of 119 amps using a throttle setting of 58% of maximum. BOLT V has successfully passed battery, cooling, control systems, and power output validation. During the output test, motor temperatures reached a nominal 32 C and motor controller temperatures reached 28 C. This is a marked improvement over BOLT IV which had prolonged heating issues.

BOLT V also marks another milestone by having a custom built battery chassis, allowing for a better fit with the onboard battery array. In the past the team used a stock chassis having a more circular geometry making placement of the square array difficult.

The team started a new program this year involving the conversion of an off-road motorcycle (dirt bike) from combustion to full electric power. This program is restricted to incoming underclassmen and will allow new recruits to be oriented to EV systems integration to the existing bike's frame and suspension.

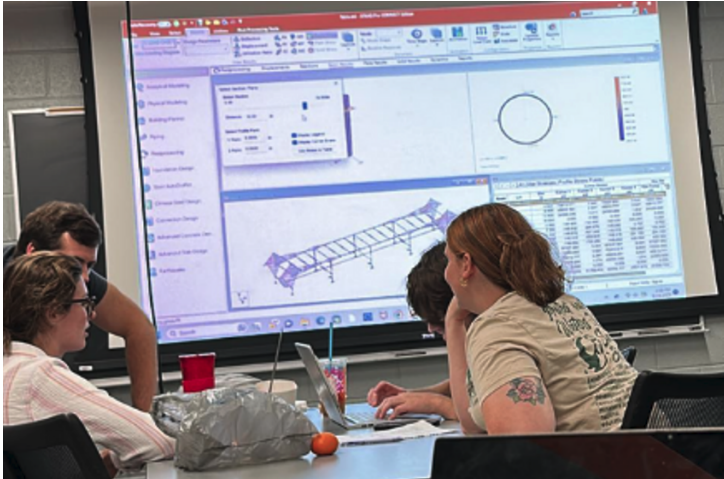
BOLT did not attend a competition in 2023 since they were in year 1 of a 2 year design cycle. The team plans to compete in 2024 with the completed BOLT V vehicle.

<https://www.vtbolt.com/>



Virginia Tech's EV *BOLT V* with custom battery array and frame, brush-less EV motor, and student built battery management system.

Concrete Canoe



VT CCT during preliminary design of *Apex Predator*.



Mold construction at the Thomas M. Murray Structures Lab.

Virginia Tech Concrete Canoe Team produces a lighter-than-water concrete craft using a custom mix design. In typical building and highway construction concrete three times heavier than water is used, having a compressive strength of about 3000 psi. The Concrete Canoe team uses a concrete which weights slightly less than water (1/3 that of normal concrete) so it actually floats like ice! No steel rebar is used in the craft due to difficulty in placing so plastic beads are used in the mix instead. The final compressive strength of the team's concrete is about 1000 psi, sufficient to result in a craft that can carry four adults at competition.

In 2023 VT Concrete Canoe continued working on their latest iteration *Apex Predator*. In addition to mold construction and concrete placement the team focused on enhancing racing skills which is crucial for success at the annual regional ASCE (American Society of Civil Engineers) competition.

The team had a disappointing performance at the 2023 event due to a material failure at the during the first race. Undeterred, the VT Concrete Canoe team hopes to come back strong in 2024 to place well at the regional event and hopefully qualify for participation in the national competition in June.

<https://asce.cee.vt.edu/concrete-canoe-team/>

Design Build Fly

In April, Design- Build- Fly participated in the 2023 AIAA Design/Build/Fly competition hosted by Raytheon Technologies in Tucson, Arizona. VT DBF's aircraft, the *Spirit of Blacksburg*, completed three flight and one ground mission to achieve a top 5 final position. Spirit of Blacksburg flew with a 3-foot section of PVC tubing attached to the end of one wingtip and carried a 4-pound electronic payload to simulate an electronic-warfare flight mission. The aircraft, with an empty weight of only 5 lbs, sustained 140 lbs of static loading during the ground mission, meaning that it is capable of withstanding over 70 g's of aerodynamic loading during flight.

Of 99 teams (representing 14 countries), Virginia Tech placed 4th internationally and 2nd nationally beating top institutions such as Embry-Riddle Aeronautical University: Prescott, Massachusetts Institute of Technology, Stanford University, and Georgia Tech! This year's competition marks VT DBF's best performance in the last 5 years and they are now rank 6th in top 5 finishes. Virginia Tech is the 4th best performing team in the history of the AIAA Design/Build/Fly competition!

<https://gobblerconnect.vt.edu/organization/dbf>



The Spirit of Blacksburg in flight. Notice the off-center PVC pipe simulating warfare conditions.



Design Build Fly in Tucson, Arizona with AOE advisor Dr. Rakesh Kapania

Formula SAE

In 2023 VT Formula SAE focused on design and construction of their second fully electric (EV) performance racer. Vehicle construction started in early March with testing completed in April. The team labored continuously to troubleshoot recurring technical issues.

Formula SAE's goal for 2023 was to complete all static and dynamic events including endurance (a timed 22 km autocross) and rank in the final top 10. Out of 67 teams in attendance only 21 passed tech inspection and only 11 were able to finish endurance, illustrating the intense scrutiny that all teams face. In dynamic events, Virginia Tech placed 10th in acceleration, 17th in skid-pad, 14th in autocross and 6th in endurance. The team's final rank was a strong 8th place, competing against programs such as Ecole de Technologie Superieure (ETS), Carnegie Mellon, and RIT. These programs have much larger budgets and compete in multiple SAE international events each year.

The 2023 vehicle is Virginia Tech's first EV car entry to complete all events and rank in the top 10 and the team's second EV vehicle to pass the rigorous tech inspection (the last was in 2017)!

<https://eng.vt.edu/academics/student-teams/formula-sae.html>



VT FSAE driver and EV car at the Michigan International Speedway in 2023.



Virginia Tech's Formula's team at Michigan Formula.

Hokie Electric Vehicle Team participated in the EcoCAR EV Challenge - Year 1 in Orlando, Florida in May, 2023. This General Motors sponsored event is limited to only 13 universities across North America and has a design cycle of four years due to its level of complexity. Virginia Tech, like all participating schools, must apply to GM every design cycle in a rigorous process which insures a team's readiness. Since the 1990s Virginia Tech has secured a position, typically earning in the top five at competition (with a 1st place win in 2012). This year Virginia Tech was accepted to be a part of EcoCAR and earned a hard won 8th place out of the competitive 13 teams.



HEVT team members receive awards at EcoCAR Year 2.



Virginia Tech's team at the GM event in Orlando, Florida with GM advisor and mentor Keith Van Houten.

At the EcoCAR event, VT HEVT delivered six impactful presentations on propulsion controls, connected and automated vehicles, systems design and integration, project management, communications, and diversity, equity, and inclusion. Their work earned them the Mobility Equity Advocate Award and a third-place finish in the project management category.

HEVT is moving forward in Year 2 with the integration of Level 2+ driving autonomy and an improved EV power train for a GM *Cadillac Lyriq*. GM donates a new stock vehicle every four years to qualifying teams who have full access to vehicle cad files allowing effective integration of new EV, mechanical, structural and software components.

<https://eng.vt.edu/academics/student-teams/hevt.html>

Human Powered Sub

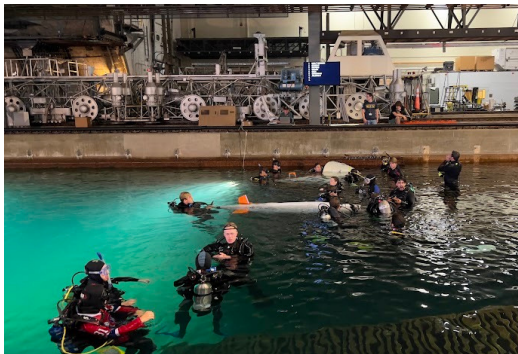
At the 17th International Submarine Races in Bethesda, Maryland VT Human Powered Sub's newest creation, *Kraken*, reached speeds resulting in a 5th place finish out of 19 teams. This event takes place in July at the US Navel testing center in Carderock, Maryland. The team's submarine Nautilus (constructed during the Covid-19 pandemic) competed as well with *Kraken* reaching 1.7 knots and Nautilus reaching 0.5 knots during the 100 meter drag race. The race takes place at a depth of 20 feet at pressures over 1.7 atmospheres.

In *Kraken's* construction, the team used a fiberglass hull and a carbon fiber propeller. The team attempted to use electronic steering controls but due to waterproofing issues this had to be abandoned. Once electronic controls are more secure in future submarines the team will start using steering autonomy. With this innovation the sub's human occupant will be able to concentrate less on steering and more on powering the craft to obtain even higher underwater speeds.

Currently, electronic sensors are used to measure propeller speed, vehicle depth, speed, pitch, and yaw with output displayed on a screen that the pilot sees during operation. VT's team uses a waterproof Blue Robotics canister to isolate electronic components from moisture. The canister has had problems maintaining a proper seal around wiring connections, allowing water to damage electronic components.

HPS will continue testing this year to determine the effects of water pressure at higher submarine depths, hoping to solve the recurring waterproofing problem. Implementing electronic controls and sensors underwater is a real challenge but Virginia Tech's team is determined to continue to make progress and eventually have a full autonomous steering craft.

<https://www.hps.aoe.vt.edu/>



HPS at the Carderock, MD navel testing facility.



2023 HPS VT Team.



Kraken sub and SCUBA spotters under water at Carderock.

SailBOT



VT's sail boat with two competitors.



Two views of the VT craft and its solid sail.

VT SailBOT takes on the seemingly impossible task of designing a sail boat that can autonomously operate on open water exposed to unpredictable lake currents and wind. Virginia Tech's SailBOT meets this challenge by participation in the 2023 International Robotic Sailing Regatta in Amesbury, Massachusetts. At last year's event the team placed 2nd overall out of 9 schools, including 1st place in endurance and payload, 2nd in station-keeping (keeping the craft on course) and 3rd in fleet races.

The event's rules allow for some use of remote control in addition to autonomy with higher points going to teams with the most autonomous performance. Even with the use of a more steerable solid sail (as opposed to a flexible cloth sail), VT SailBOT's craft had some issues with autonomy but is hoping to improve on this in 2024. Upgrades are underway to streamline electrical/mechanical integration and vehicle telemetry (the ability for the craft to know its location and relay that to steering control). The team looks forward to the upcoming 2024 regatta in June where it hopes to earn first place.

<https://eng.vt.edu/academics/student-teams/sailbot.html>

Steel Bridge

Last year Virginia Tech's Steel Bridge Team welcomed new leadership and ushered in a renewed sense of spirit and optimism. In 2021, coming out of the Covid 19 pandemic, the team had only four members and had a disappointing disqualification at the ASCE (American Society of Civil Engineers) regional event. In 2022 the team was a top regional winner but scored in the lower 50 percentile at the national event. Undeterred in 2023, VT SBT overhauled their bridge design process by using an new computer analysis program and dedicating themselves to optimizing bridge geometry, connection design and ease-of-fabrication, and construct-ability.

Perseverance paid off with a sweeping 1st place finish in all six categories at the *ASCE Virginias' Regional Conference* in Huntington, West Virginia, in April, 2023. After the big win, the team took what they had learned and redesigned several structural members and connections. The team also dedicated themselves to more bridge load testing (to 2500 lbs!) and construction practice, resulting in a final construction time of under 15 minutes. SBT looked forward to the upcoming national event in San Diego, California.

At the nationals, an event sponsored by ASCE and AISC (American Institute of Steel Construction), VT's Steel Bridge team won 4th place overall out of over 170 North American universities and colleges! This includes 2nd place for Aesthetics and 2nd in Bridge Weight. This marks the first time since 2009 that the Virginia Tech bridge team has earned a top 5 ranking at the national event!

<https://asce.cee.vt.edu/steel-bridge-team/>



VT SBT with CEE advisor Dr. Matt Eatherton.



SBT member during the timed construction event in San Diego, California.

New Equipment!

This year saw the arrival of a new heavy duty open trailer to allow for the transport of HEVT's full sized vehicles. The trailer has dual axles and has a total length of 18 feet. Funds for this equipment came from the Bare Family Competitive Fund and the John and Elizabeth Donehower Fund.

Steel Bridge Team received a donation of a new horizontal band saw located in their project bay. The team cuts hundreds of web and chord bridge members each year during bridge construction and having a dedicated saw will allow SBT to have uninterrupted access reducing fabrication time.

Thanks to a sizable contribution from Virginia Tech alum Mary Prim Jones along with a matching give from the College of Engineering, Ware Lab was able to purchase a new FLOW water jet valued at \$110,000. Prim Jones is a 1962 graduate of mechanical engineering and is a member of *Engineering Insiders*, who consist of the college's most generous contributors. Prim was one of only three women in her graduating class!

The industrial grade water jet has a 4 ft by 4 ft cutting table and can accommodate any metal up to 6 inches in thickness! The FLOW water jet will be a shared resource between Ware Lab and the AEDL (Aerospace Engineering Design Lab) and will revolutionize manufacturing for teams in both facilities.

Without private, corporate and university support the Ware lab and AEDL could not prepare teams to participate in world class competitions throughout North America. Thanks again to the Bare, Jones and Donehower families and Virginia Tech's College of Engineering for their continued support!



18 foot open trailer.



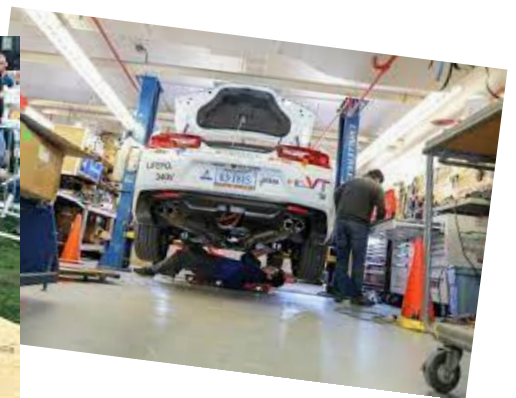
Steel Bridge team's new horizontal band saw.



FLOW water jet to be installed in February of 2024.

Did you know...

- Last year out of 13 competition events in North America four Ware Lab teams (Baja SAE, Design Build Fly, Formula SAE, and Steel Bridge) finished in the top 10% among other peer universities and colleges.
- In 2022-23 Ware Lab teams traveled to competitions in Alabama, Arizona, California, Florida, Maryland, Massachusetts, Ohio, San Diego, South Carolina, and West Virginia raising their own money for travel and lodging.
- Ware Lab hosted over **1300** visitors last year for lab tours from K-12, universities, colleges, student groups, industries, and families.
- The SEC (Student Engineers' Council) contributed over **\$53,000** to all Ware Lab teams in 2022-23.
- Corporate sponsorship included GM, Blue Origin, Lockheed Martin, Gillig, Northrop Grumman, Boeing, Aquateck Adventures and CSI American and totaled over **\$500,000** in-kind and monetary contributions! Private contributions totaled **\$53,000** in 2022-23.
- Ware Lab teams recruit students from all academic majors and levels across all colleges of Virginia Tech.



CW from top left: AOE advisory board visits HPS. Baja SAE presenting to tour visitors. Formula SAE IC vehicle. HEVT's Chevy Camaro. Steel bridge load test. Four generations of Baja off road vehicles.

Ware Lab Administration

- ***Keith Thompson*** – Ware Lab Director and Associate Dean of Student Affairs



- ***Dewey Spangler*** – Ware Lab Manager



- ***Philip Ratcliff*** – Ware Lab Assistant Manager



- ***Margaret Leary*** – Ware Lab Tour Coordinator



- ***John Bobbitt*** – Ware Lab Shop Assistant



Ware Lab Faculty Advisors

- ***Kevin Shinpaugh (AOE)*** – Astrobotics



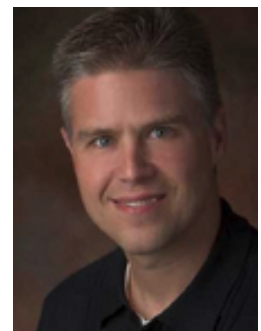
- ***Jared Bryson (VTTI)*** - Baja SAE



- ***Arthur Ball (ECE)*** - BOLT



- ***Richard Clark (ME)*** - BOLT and Formula SAE

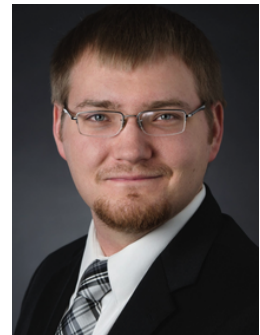


Ware Lab Faculty Advisors - con't

Bill Baumann (ECE) - Formula SAE - EV



Alex Brand (CEE) - Concrete Canoe



Rakesh Kapania (AOE) - Design Build Fly



Scott Huxtable (ME) - Hokie Electric Vehicle Team



Ware Lab Faculty Advisors - con't

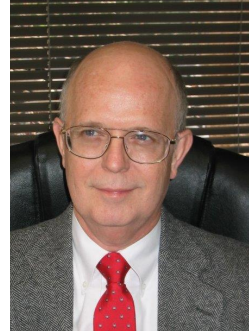
Stefano Brizzolara (AOE) - SailBOT



Matt Eatherton (CEE) - Steel Bridge



Robert Stone (BEAM) - Human Powered Sub



Contact Us

Joseph F. Ware, Jr. Advanced Engineering Lab
320 Stanger Street
Blacksburg, VA 24061
spangler@vt.edu
enge.vt.edu/warelab