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Advanced Vehicle Technology Competitions

ECOCAR MOBILITY CHALLENGE

The 12th DOE Advanced Vehicle Technology Competition Series

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U.S. Department of Energy laboratory
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OVERVIEW

TIMELINE

DEC 2016

Headline Sponsor RFP released

JAN 2018

Headline Sponsors confirmed

MAY 2018

University teams selected

AUG 2018 – JUNE 2019

Year 1

AUG 2019 – JUNE 2020

Year 2*

AUG 2020 – JUNE 2021

Year 3*

AUG 2021 – JUNE 2022

Year 4

** Time period for this presentation*

PARTNERS

- **Headline Sponsors:**
DOE, General Motors, MathWorks
- **23 other industry & government sponsors**
- **Managed by**
Argonne National Laboratory

BARRIERS

- **Lack of engineers and business leaders trained to meet future energy and transportation challenges**
- **Lack of advanced vehicle technology curricula in academia**

BUDGET

COMPETITION				TOTAL
FY	YEAR	DOE	SPONSORS	BUDGET
2021	Y3	\$2,026,473 <i>to date</i>	\$1,027,729 <i>to date</i>	\$17.9M* (over four years)
2020	Y2	\$3,000,000	1,606,353	
2019	Y1	\$2,758,866	2,269,613	

**Does not include in-kind/cash support provided to universities*

PROJECT OBJECTIVES

OBJECTIVE

Pairs the greatest minds in academia with the resources of Government & Industry to solve mobility challenges

IMPACT TO PROJECT BARRIERS

Provide a real-world training ground for students to gain hands-on experience

- EMC to date: ~2000 students, ~700 grads
- >200 companies hired an EMC student in FY21 alone
- EcoCAR graduates command higher starting salaries (~\$7k on average)

OBJECTIVE

Accelerate the development and demonstration of key technologies

IMPACT TO PROJECT BARRIERS

Teams design, build, and refine hybrid-electric powertrains capable of SAE level-2 automation

FY20: teams design powertrain architecture and complete initial vehicle build
FY21: teams integrate radar and vision-based perception systems to achieve SAE level 2 automation



**VTO TECHNOLOGY
INTEGRATION GOAL
ADDRESSED:
Economic Growth**

Seed the North American auto industry with top-notch talent to provide a strategic business advantage to drive energy-efficient products into the marketplace

APPROACH TO MEETING PROJECT OBJECTIVES

EcoCAR Technical Goals

1

Integrate Advanced Propulsion systems to enable improvements in energy efficiency

- Electrify a 2019 Chevy Blazer

2

Develop CAV technologies to meet energy efficiency goals and market needs

- Target SAE level 2 automation using radar and vision-based perception systems
- Implement vehicle-to-vehicle and vehicle-to-infrastructure communication

3

Balance energy efficiency needs with the consumer acceptability, safety and cost considerations unique to the target market

- EcoCAR is a complex design problem demanding simultaneous optimization

APPROACH TO MEETING PROJECT OBJECTIVES

Multidisciplinary Approach

40% of competition
activities focused on
CAV technologies

Project Management
ties together complex
multi-year project

Contributions from
each “swimlane” are
critical to success

Engineering Disciplines

Propulsion System
Integration

Propulsion Modeling
and Controls

Connected and Automated
Vehicle Systems

Project
Management

EcoCAR Vehicle
Development

MILESTONES

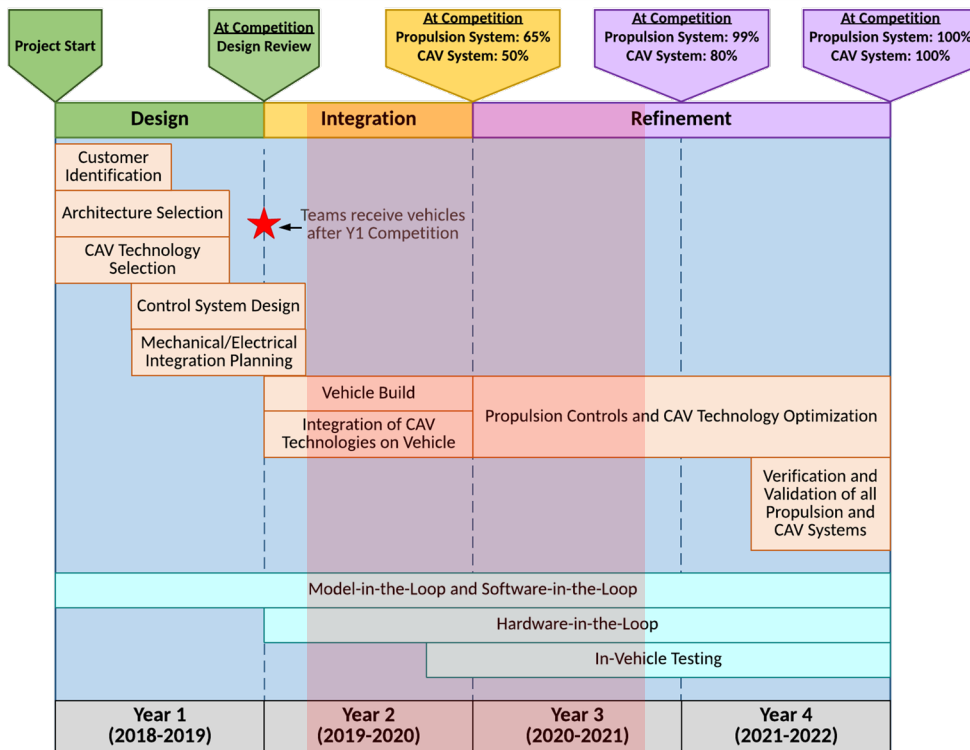
Year 2 Vehicle Goals

Propulsion system 65%

- Complete integration
- Baseline propulsion system functionality (vehicle can drive)

CAV systems 50%

- Complete integration
- Sensor fusion and tracking functional for single target lead vehicle
- Basic CAV control and safety interfaces operable



Period covered by this presentation (FY2020)

ACCOMPLISHMENTS / PROGRESS

Y2 Vehicle Development

Teams received donated hardware from competition sponsors

- 2019 Chevy Blazer
- GM 4-cylinder engine (of varying sizes) and 9-spd transmission
- GM HEV battery pack (7 teams)
- Bosch radar sensors
- Intel MobilEye 6 vision sensor
- dSPACE MicroAutoBox II
- Cohda V2X DSRC Radio kits

Energy storage systems

- Custom pack co-designed by 4 teams (OSU, VT, MSU, Waterloo) and Hybrid Design Services
- Ground-up design to achieve higher power and capacity
- Pack design and fabrication completed by HDS in late Fall 2019
- Remaining 7 teams utilized GM HEV4 pack

Vehicle Integration & Functionality

- Integration ~80% complete (on the aggregate across all teams)
- 4 teams with functional HV systems
- 10 teams able to repeatedly start their engine
- 5 teams able to spin wheels (on lift)
- ***Note: COVID shutdowns substantially hindered vehicle development progress for university teams***

ACCOMPLISHMENTS/PROGRESS

FY2021 – Career Connected Learning

CAREER CONNECTED LEARNING INITIATIVE

A concentrated, multi-faceted effort to enable team success in hybrid environment, resulting from the pandemic

- Novel effort launched in Fall 2020
- Goal: Virtually deliver EcoCAR training and mentorship usually accomplished during in-person workshops and events

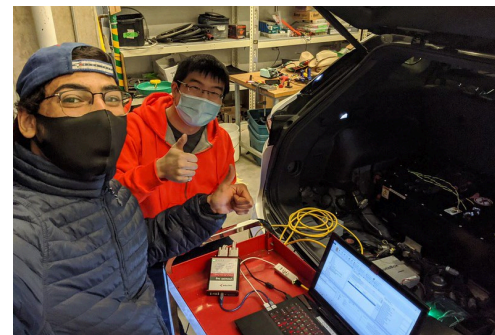


ACCOMPLISHMENTS / PROGRESS

Y3 Vehicle Development

Virtual Vehicle Technical Inspections

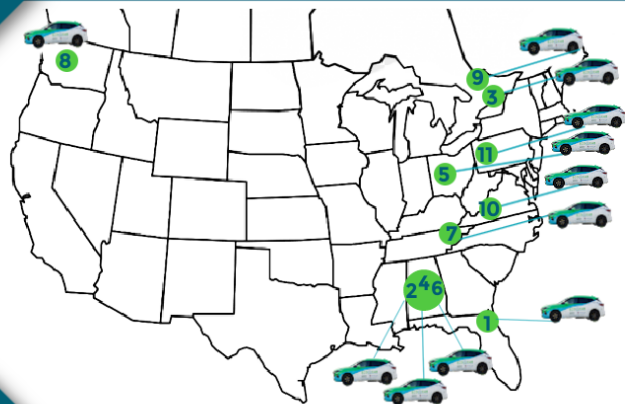
- In-person vehicle inspections by industry experts not feasible due to COVID travel restrictions
- Vehicle inspection process adapted to virtual environment to overcome travel restrictions
- Series of 16 educational videos developed to train teams to self-inspect vehicles
- All teams passed Vehicle Technical Inspection



ACCOMPLISHMENTS / PROGRESS

Y3 Vehicle Development

EcoCAR SPRING VEHICLE EVALUATION



TESTING LOCATIONS:

1. Embry-Riddle..... Cecil Field Spaceport
2. Georgia Tech Barber Motorsports
3. McMaster University..... McMaster Automotive Resource Centre
4. Mississippi State University Barber Motorsports
5. Ohio State University Transportation Research Center
6. University of Alabama Barber Motorsports
7. University of Tennessee..... Knoxville Dragstrip & Cumberland Sports Complex
8. University of Washington Evergreen Speedway
9. University of Waterloo Waterloo Test Track
10. Virginia Tech..... Motor Mile Speedway & Virginia Tech Transportation Institute
11. West Virginia University.. Pittsburgh International Race Complex

Vehicle Testing at Local & Regional Sites

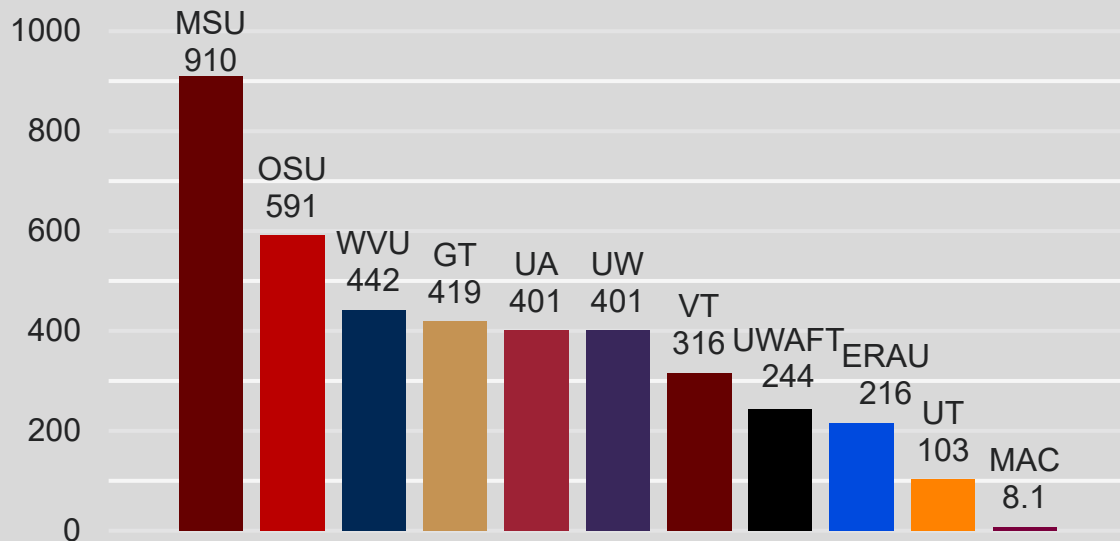
- Conducted by teams at sites across North America
- Spring Vehicle Evaluation and Final Validation Testing Events included:
 - ✓ 0–60 MPH acceleration
 - ✓ 60–0 MPH braking
 - ✓ Drive Quality evaluation
 - ✓ CAV perception system and longitudinal control evaluation
 - ✓ Energy Consumption

ACCOMPLISHMENTS/PROGRESS

Year 3 Testing and Mileage Accumulation

YEAR 3 MILEAGE ACCUMULATION (August 2020 – April 2021)

- Goal: 400 miles accumulated during Year 3
- 4,051 total miles accumulated during Year 3 despite COVID hindrances
- 7/11 teams accumulated at least 400 test miles



ACCOMPLISHMENTS / PROGRESS

Y3 Vehicle Development

Vehicle Integration & Functionality

- While COVID continued to have a major impact, with new initiatives implemented, teams were able to achieve 100% vehicle integration
- All vehicles capable of driving engine-only
- 9 teams capable of driving in hybrid mode with basic control strategy



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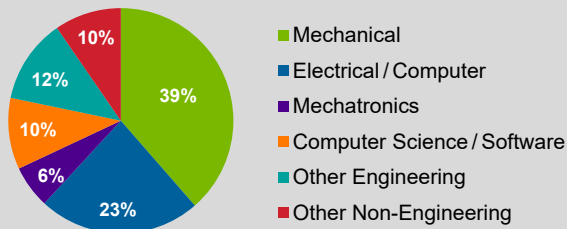
ACCOMPLISHMENTS / PROGRESS

Student Participation & Employment Impacts

STUDENT PARTICIPATION

- ~2000 student participants to date
~1100 during Year 2
- 700 student graduates to date
~400 during Year 2
- Students from 29 majors total

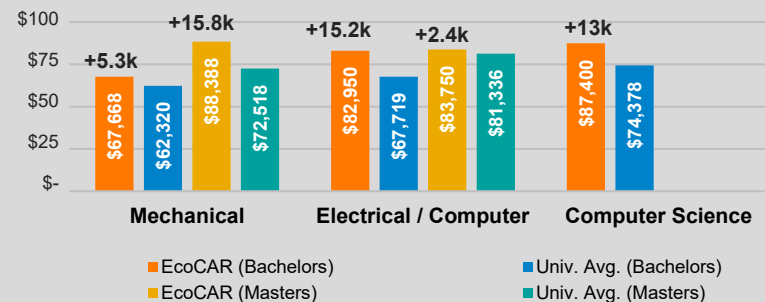
EcoCAR Students By Major



EMPLOYMENT IMPACTS

- EcoCAR grads command higher salaries
- >200 companies hired an EcoCAR student

Salary Comparison EcoCAR Grad Vs. University Avg *in thousands of dollars*



ACCOMPLISHMENTS / PROGRESS

Communications Program

The Communications Program is a fully integrated multi-disciplinary aspect of AVTCs and has been successful since its inception 10 years ago

Continued support of this aspect of the competition from stakeholders including: faculty, administration, sponsors and students

Each EcoCAR team has a funded Communications Manager (CM) that acts as an ambassador to promote the team in the university's local community

Professional development training is provided to the CMs to execute deliverables in areas of:

Media relations & interviewing; strategic social media, website development, recruitment tools, youth STEM education and influencer campaigns, blog writing, outreach events, sponsor collaboration



ACCOMPLISHMENTS / PROGRESS

STEM Outreach & Campus Involvement

Diversity in Engineering Award to encourage DE&I among EcoCAR teams and youth outreach

Women in STEM Award to continue to encourage female engineers participation

Middle and High School STEM events

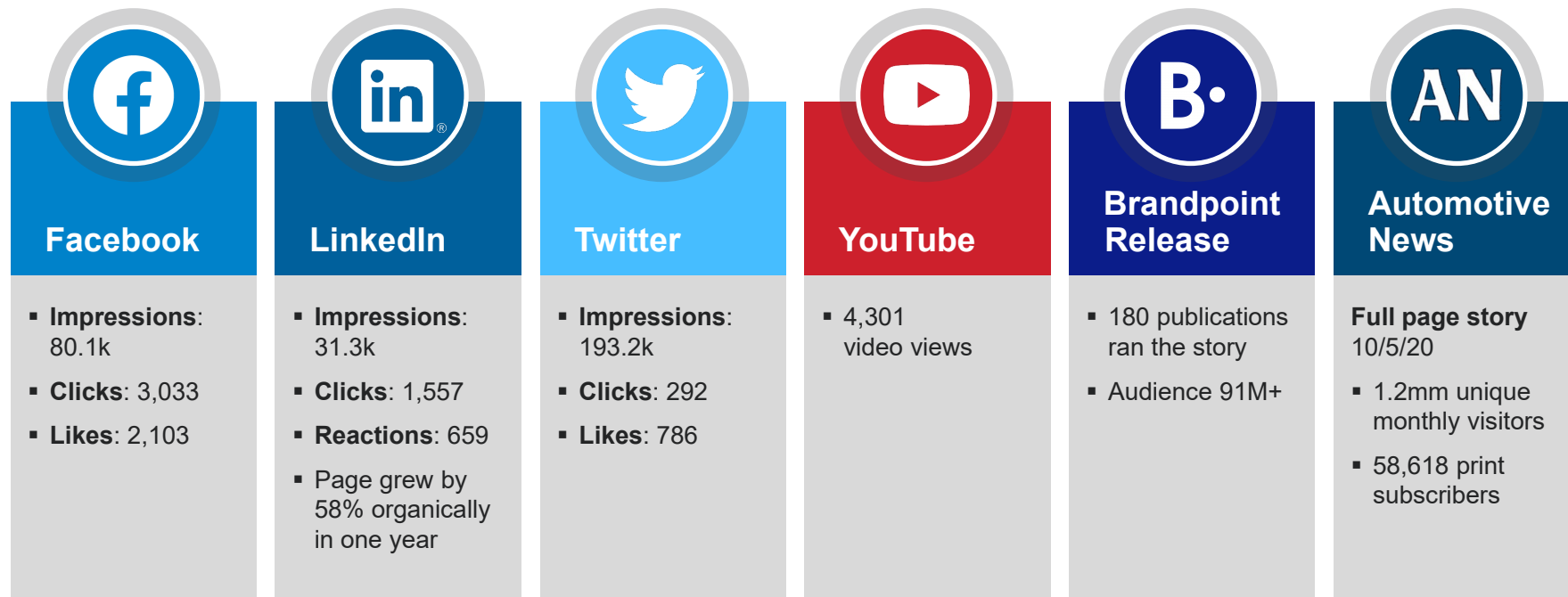
Reached more than 14,000 students through in-person and virtual engagements (Y2 & Y3)

More than 46 university campus outreach events in Year 2



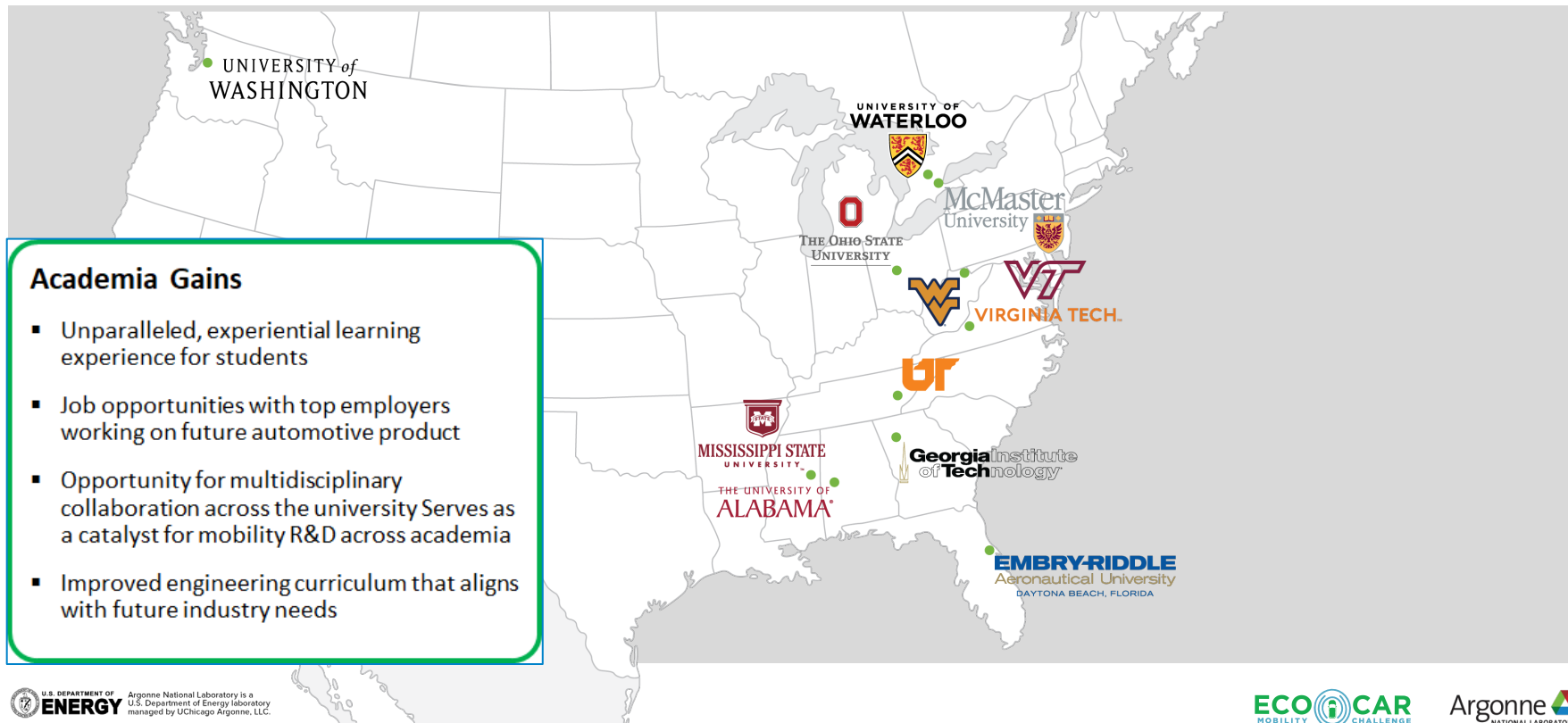
ACCOMPLISHMENTS / PROGRESS

Earned & Social Media – 1 year snapshot



COLLABORATION

11 North American Universities



COLLABORATION

Strong Consortium of Industry Support

HEADLINE



general motors



VISIONARY



LEADERSHIP



dSPACE

intel.

PACCAR

SUSTAINING



DENSO

HORIBA

SIEMENS



CONTRIBUTOR



J.D. POWER



Industry Support

- More than \$12M in financial support
- Industry-leading software tools
- Batteries, powertrain components, hardware
- State-of-the art testing facilities and equipment
- Top industry SMEs for mentoring, training and professional development
- Introduction to key industry standards, processes and best practices

MARKET IMPACT AND SUSTAINABILITY

Looking Ahead to FY2022

FY2022 coincides with final year of EcoCAR Mobility Challenge (Year 4)

In-person events resume

Training workshops	Vehicle Testing Events	Year 4 Competition & Series Finale
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University COVID-19 restrictions expected to be lifted or loosened

- Full access to all lab space and workspace restored

Year 4 vehicle expectations

- Refined and reliable propulsion system functionality with optimized hybrid mode
- Refined consumer features and driver interfaces
- Reliable CAV perception systems and longitudinal control
- V2X features deployed to vehicles



Advanced Vehicle Technology Competitions

SUMMARY

BARRIERS

Lack of engineers and business leaders trained to meet future energy and transportation challenges

Lack of advanced vehicle technology curricula in academia

OBJECTIVES

Train the next generation of engineers to address future energy and transportation challenges

Accelerate the development and demonstration of key technologies

APPROACH

Provide real-world, hands-on automotive industry experience in an academic setting

Utilize industry-grade tools, methods and processes

Deliver comprehensive training/mentoring from industry SMEs

IMPACTS

2k+ EMC students to date

700+ EMC grads In Y2

EcoCAR graduates out-earn their peers by avg. ~\$7k/yr.

Outreach activities reached 13k+ middle school students

Robust social media presence

Overcame substantial COVID-related challenges



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TECHNICAL BACKUP SLIDES



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33-YEAR HISTORY OF COLLABORATION WITH DOE & INDUSTRY



- Established in 1988 for DOE
 - Managed by Argonne in close partnership with auto industry
- Series of multi-year automotive competitions
 - Initially a demonstration of alternative fueled vehicles
 - Well established as the preeminent training ground for North America's future automotive engineers and business leaders
 - At the forefront of automotive technology for over three decade
- 25K Alumni from 93 Educational Institutions
 - Seeded virtually all areas of the industry
 - Shaping mobility solutions that have revolutionized the auto market



ECOCAR MOBILITY CHALLENGE

TECHNICAL SWIMLANES

Propulsion System Integration PSI

Responsible for all hardware packaging and mounting, electrical system design and integration, thermal systems, and vehicle ride & handling characteristics

Propulsion Controls & Modeling PCM

Responsible for design and implementation of a safe, robust and functional propulsion system supervisory control system and developing models used to simulate the vehicle and subsystems

Connected and Automated Vehicle Systems CAV

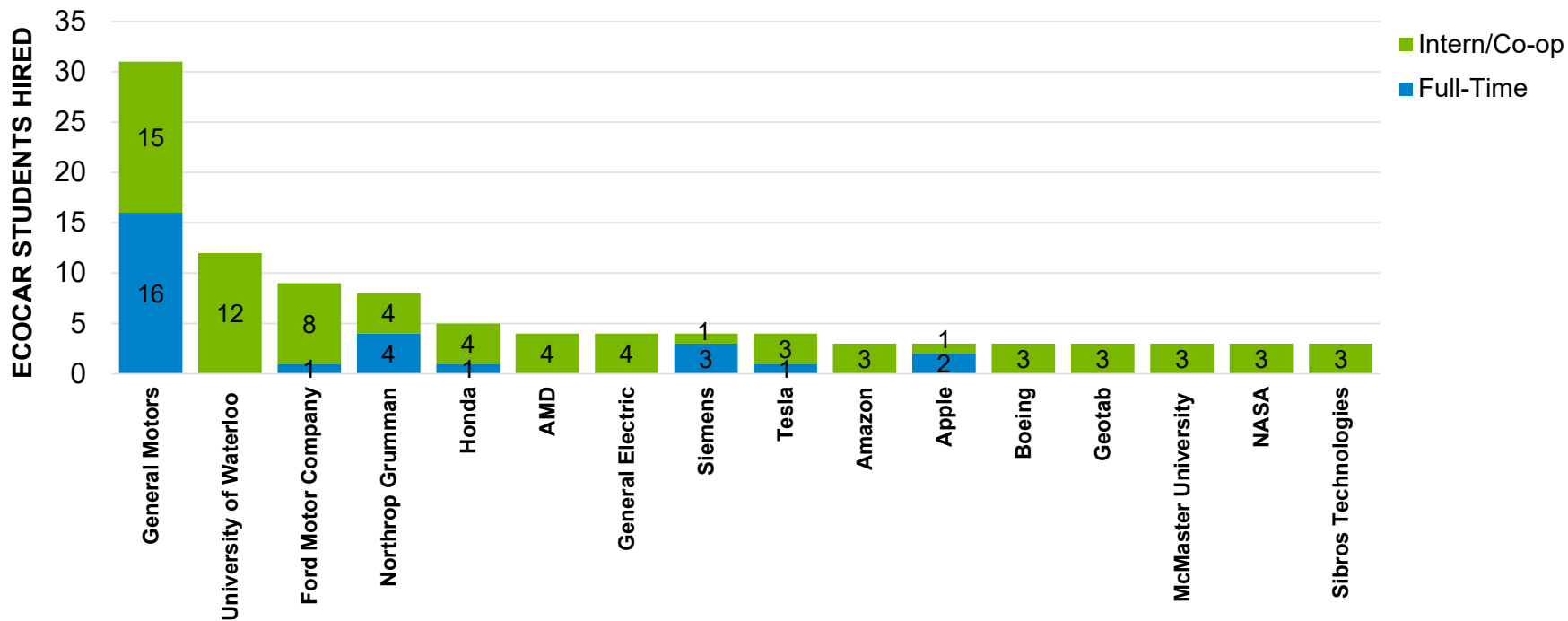
Responsible for developing reliable and accurate multi-sensor vehicle perception systems, V2X communication systems, and autonomous control systems

Project Management PM

Responsible for defining organizational processes, creating project plans, providing project oversight, and asserting authority to monitor & control the execution of project tasks

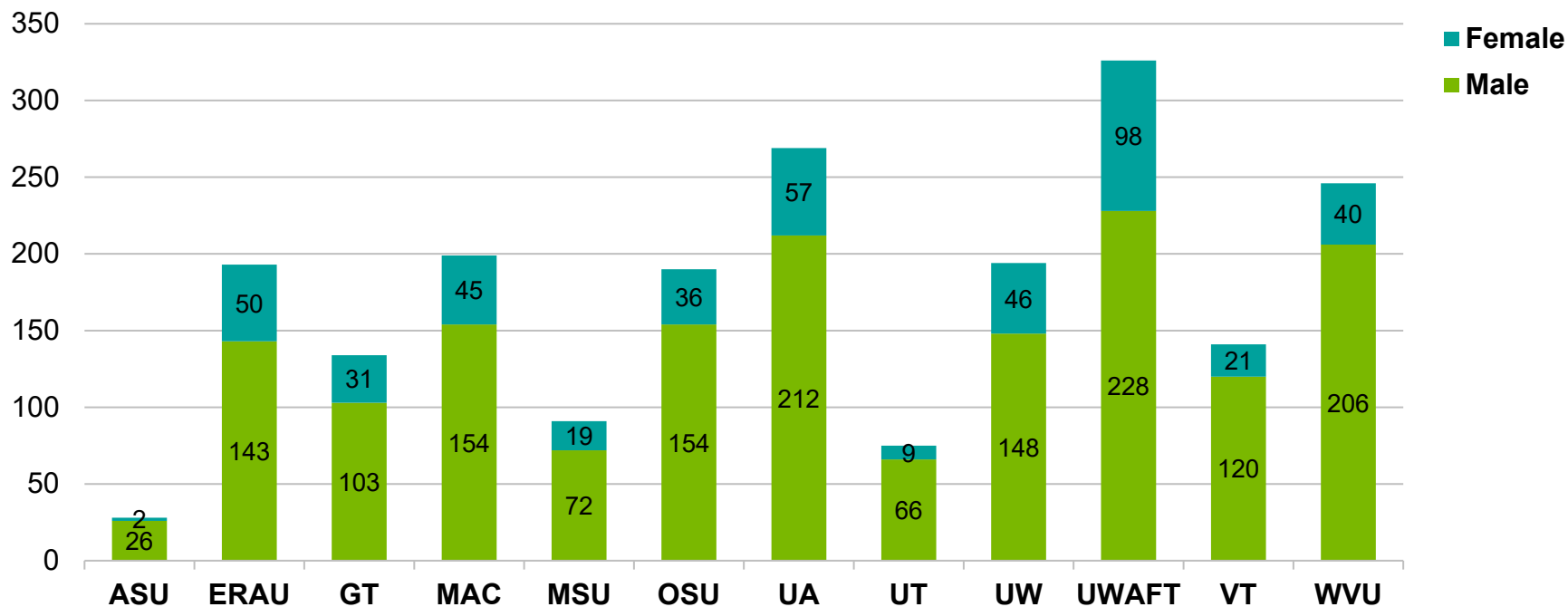
ECOCAR STUDENTS

Employers Hiring EcoCAR Students



ECOCAR STUDENTS

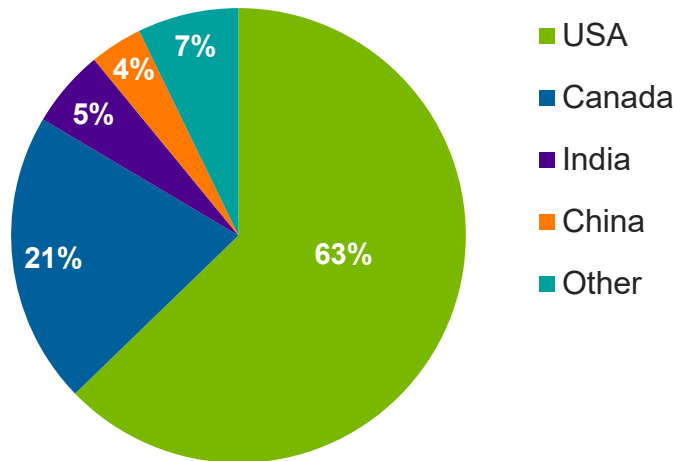
By Gender



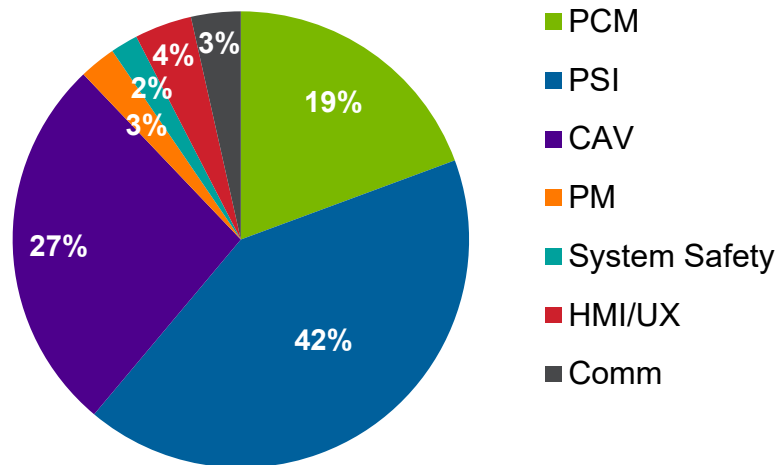
ECOCAR STUDENTS

Demographics

NATIONALITY



ECOCAR SWIMLANE



An aerial photograph of the Argonne National Laboratory campus, featuring a large circular building complex, parking lots, and surrounding greenery. The image is overlaid with a semi-transparent green filter.

Argonne

NATIONAL LABORATORY

