Welcome to the 14th Annual Formula Hybrid+Electric International Competition!

We never dreamed that this year's competition would be so different from ever before, with a complete restructuring made necessary by the coronavirus pandemic. But the innovative spirit of Formula Hybrid has never been stronger. Our steadfast volunteers and sponsors, and most importantly, our inspirational teams have risen to this unprecedented challenge, competing virtually in static events and being willing to forego being on track until safer times. We salute your adaptiveness and socially distanced but unwavering camaraderie.

This year's 18 teams include 17 previous competitors and one new team. Also, several new companies have joined the ranks of our dedicated sponsors who make Formula Hybrid+Electric possible.

In addition, our logo now emphasizes both of the classes—hybrid and electric—we’ve had at competition for several years. Our new logo reflects the fact that there’s more than one road to the future—and that each track requires the cross-disciplinary teamwork, ingenuity, commitment, and perseverance that have been the hallmarks of our competition from the start.

As always, Formula Hybrid+Electric greatly appreciates the contributions of the hundreds of individuals—from our sponsors and volunteers to our team members and advisors—to the success of the competition and its mission of challenging students to work together to do great things.

Mike Chapman, Director
Michael.C.Chapman@dartmouth.edu

Doug Fraser, Co-founder and Director Emeritus
Coordinating Manager
jessica.d.kinzie@dartmouth.edu

Formula Hybrid Competition Organizers

Thayer School of Engineering at Dartmouth • 14 Engineering Drive • Hanover, NH 03755 • 603-646-6580 • formula-hybrid.org

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**Schedule**

### Sun April 26

- **8:00 AM**: Registration
- **9:00 AM**: Electric Tech. Inspection (Electrical only) North Garage Bay 1
- **10:00 AM**: Lunch Break
- **11:00 AM**: Electric Tech. Inspection Mechanical North Garage Bay 1
  - **12:00 PM**: Electrical* Electrical Tech. Building

### Mon April 27

- **8:00 AM**: Mechanical North Garage Bay 1
  - **9:00 AM**: Electrical* Electrical Tech. Building
- **10:00 AM**: Design Event* Center Garages
- **11:00 AM**: Presentation Event* Jack Ratta Media Center

### Tue April 28

- **8:00 AM**: Design Event* Center Garages
- **9:00 AM**: Presentation Event* Jack Ratta Media Center
- **10:00 AM**: Lunch Break
- **11:00 AM**: Acceleration Event NASCAR Main Straight

### Wed April 29

- **8:00 AM**: Presentation Event* Jack Ratta Media Center
- **9:00 AM**: Mechanic Inspectors Mtg. North Garage Bay 1
- **10:00 AM**: Electrical* Electrical Tech. Building

### Thu April 30

- **8:00 AM**: Mandatory Elect. Safety Class Electrical Tech. Building
- **9:00 AM**: Autocross Guided Walk Turn 4, Oval
- **10:00 AM**: Endurance Event NASCAR Main Straight
- **11:00 AM**: Lunch Break

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**Note:** Garages closed from 12:00 midnight until 8:00 AM the following morning.

**Registration Main Gate**

**Optional**

- **Electrical Tech. Inspection**
- **Mechanical North Garage Bay 1**
- **Electrical* Electrical Tech. Building**

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**Endurance Event NASCAR Main Straight**

**Note:** A half-hour lunch break will be scheduled based on track activity.

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**Endurance Course Guided Walk**

**Note:** Garages closed from 12:00 midnight until 8:00 AM the following morning.

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**Received For Advisors, Officials, and VIPs**

- **Brotton's Suite Overlooking the Speedway**
- **North East Motorsports Museum**
  - **Shuttle Transport**

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**Group Photo**

**NASCAR Oval—Main Straight**

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**Autocross Drivers Meeting**

**Center Garages**

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**Design Finals**

- **Top 2–4 Teams**
- **Center Garages**

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**Reception**

**For Advisors, Officials, and VIPs**

**Autocross Drivers Meeting**

**Center Garages**

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**Endurance Event NASCAR Main Straight**

**Note:** A half-hour lunch break will be scheduled based on track activity.

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**School Visit Day**

**Note:** Garages closed from 12:00 midnight until 8:00 AM the following morning.

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**Awards Ceremony**

**Victory Lane**

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**Schedule subject to change—watch for postings.**
Q: What made you interested in cars and racing?
A: For as long as I can remember, I’ve been interested in cars, motorcycles, sailboats—really anything mechanical. I’ve always had an interest in engineering. And, as with a lot of engineers, I’ve taken apart a lot more things than I’ve put together.

My first car was a ‘69 Austin Healey Sprite that I bought while still in high school. Well, Dad bought it and I spent many years paying him back for it. It was a lovely machine: small, light, quick but not too quick. You could throw it into corners, and it had excellent manners—it always let you know when you were pushing things too far before things got too exciting. I never raced it, but it was a blast to drive.

Q: When and why did you get involved with Formula Hybrid?
A: I was invited to get involved with Formula Hybrid by founding director Doug Fraser right from the start in 2006. I’ve been involved in the Thayer School Annual Fund since 1982 and would run into Doug when I came up to Dartmouth for meetings. He was THE car guy and I always enjoyed talking with him. When he started Formula Hybrid, he asked if I would like to participate. I couldn’t say yes fast enough.

In a weird cosmic way, I could say that my involvement with Formula Hybrid was due to a car that I’ve never owned or driven. I grew up in a rural area outside of Philadelphia where they didn’t do a great job of plowing snow. A neighbor couple in a Porsche 356 got bogged down in a snowbank and ended up spending the night at our house. It so happened that the woman’s mother lived in Beverly, Mass, and when my family moved to the Boston area, we looked at houses near Beverly, ending up in Manchester, Mass. My high school principal there was a Dartmouth grad, and that was how I ended up at Dartmouth and Thayer School. Fast forward many years: I moved back to Massachusetts from Illinois and met with a recruiter. We spent most of the time talking about the Porsche 356 model on his desk and how he had one in his garage. He invited me to go with the Porsche 356 club on a tour to Paul Russell & Co, a local very high-end restoration shop. The next time at I was at Thayer, I mentioned it to Doug Fraser and found out that he had worked with all of the Paul Russell folks in the past. Maybe that’s why he asked me to come on as a Formula Hybrid volunteer.

Q: What’s your favorite aspect of Formula Hybrid?
A: For me, Formula Hybrid checks all the boxes: engineering, cars, education, and Thayer’s approach of readying the next generation of engineers to solve the problems we can’t even conceive of. Formula Hybrid mirrors my own educational style. I struggled mightily with some of the more theoretical courses, but when I got into solving project problems, something really clicked. When I got into upper-level mechanical design courses, things really took off.

Q: What would you like students to get out of Formula Hybrid?
A: A few things: An appreciation for working in multi-disciplinary teams and the fact that you can get so much more done in a much shorter time if you work at it. The knowledge that real engineering is more than a problem set. Sometimes there is no “right” answer but by taking into account all the myriad factors, there is a “best” answer. An understanding that hard work, failure, and ultimate success can be fun when shared with the right team of people. The chance to rub elbows with practicing engineers and racers and to make those connections that will help them chart their careers.

Q: What is the most satisfying part of Formula Hybrid for you?
A: Seeing the faces at Thursday’s awards ceremony, knowing that these students have just worked an unbelievable number of hours just to get to the track, let alone get the car on track. Maybe things didn’t go perfectly, but seeing the sense of accomplishment on their faces makes it all worthwhile.

Q: Is there anything you’d like more people to know about Formula Hybrid?
A: Formula Hybrid is the only college/university competition to offer both electric and hybrid categories. You’ll commonly hear that hybrid is “old technology” and that battery electric vehicles are the way of the future. But if that’s true, why is Formula 1, the technological pinnacle of racing, based on hybrid vehicles? We hear from some of our sponsors that a few more top-level racing series are going to go hybrid within the next year or so. Originally founded to immerse students in the very complex and challenging world of hybrid vehicles, Formula Hybrid is proudly already at the starting line.
<table>
<thead>
<tr>
<th>Team Name</th>
<th>Car Name</th>
<th>Advisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Victoria</td>
<td>UVI920</td>
<td>Dr. Zuomin Dong</td>
</tr>
<tr>
<td>R.V. College of Engineering</td>
<td>RZXXH</td>
<td>Dr. Nandakumar S. Kulkarni</td>
</tr>
<tr>
<td>Milwaukee School of Engineering</td>
<td>MPS</td>
<td>Dr. Matt Schaefer</td>
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<tr>
<td>UVic Hybrid</td>
<td></td>
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<tr>
<td>Battery</td>
<td></td>
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<tr>
<td>Saieetta 119R</td>
<td>25.2 kW @ 3,751 RPM</td>
<td></td>
</tr>
<tr>
<td>KTM 250 SX-F</td>
<td>31 kW @ 13,000 RPM</td>
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<tr>
<td>Gasoline</td>
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<tr>
<td>None</td>
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<tr>
<td>345 kg* (including driver)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wyoming Motorsports</td>
<td>7220 Honey</td>
<td>Dr. Lawrence Willey</td>
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<tr>
<td>Hybrid</td>
<td>Capacitor</td>
<td></td>
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<tr>
<td>Saietta 119R</td>
<td>20 kW @ 5,500 RPM</td>
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<td>Energuin 142</td>
<td>3,110.04 W-h</td>
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<tr>
<td>Parker GVM-142</td>
<td>43.9 kW @ 12,000 RPM</td>
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<tr>
<td>Helvenco Swissauto 250 EFI</td>
<td>28.3 kW @ 9,500 RPM</td>
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<tr>
<td>Gasoline</td>
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<tr>
<td>Rear</td>
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<tr>
<td>365 kg</td>
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<tr>
<td>Single-speed, parallel drivetrain for an effortless driving experience. Octagonal frame for increased torsional rigidity. Adjustable Hybrid Control Strategy to maximize energy use.</td>
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<tr>
<td>SRM Engineering College, Chennai</td>
<td>MP5</td>
<td>Dr. P. Nandakumar</td>
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<tr>
<td>Hybrid</td>
<td>Capacitor</td>
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<tr>
<td>Saietta 119R</td>
<td>25.2 kW @ 3,751 RPM</td>
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<tr>
<td>Honda CBR 250R</td>
<td>28.3 kW @ 9,500 RPM</td>
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<td>Gasoline</td>
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<td>Rear</td>
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<tr>
<td>300 kg*</td>
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<tr>
<td>Series Hybrid, Electronic Throttle Control, Modular Accumulator Container, DAQ System (Data Acquisitions System), PMDC Motor (high efficiency).</td>
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<tr>
<td>UVic Hybrid</td>
<td>Capacitor</td>
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<tr>
<td>Saietta 119R</td>
<td>22.5 kW @ 3,751 RPM</td>
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<tr>
<td>KTM Duke 200</td>
<td>18.97 kW @ 10,000 RPM</td>
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<td>Gasoline</td>
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<td>Rear</td>
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<td>345 kg* (including driver)</td>
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<tr>
<td>Hybrid</td>
<td>Battery</td>
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<td>Winston Battery Ltd.</td>
<td>1,917 W</td>
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<tr>
<td>Saieetta Agni 119R</td>
<td>25.2 kW @ 3,751 RPM</td>
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<tr>
<td>KTM 250 SX-F</td>
<td>31 kW @ 13,000 RPM</td>
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<tr>
<td>Rear</td>
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</tr>
<tr>
<td>365 kg</td>
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<tr>
<td>This car features a very compact pushrod suspension design that fits almost completely outside of the monocoque frame. It allows for additional room inside of the vehicle for other components.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Vehicle Specifications

#### University of Vermont

**Team Name:** Alternative Energy Racing Organization  
**Car Name:** ClearSpeed AS  
**Advisor:** Dustin Rand

**Drive Type:** Electric  
**Accumulator:** Battery  
**Drive Motor:** Enrg Austria (2)  
**Engine:** N/A  
**Fuel Type:** N/A  
**Generator:** N/A  
**Regen Braking:** Rear  
**Weight:** 287 kg  
**Unique Features:** Team Designed Data Acquisition system.

#### Rensselaer Polytechnic Institute

**Team Name:** Rensselaer Formula Hybrid  
**Car Name:** VMR-xe  
**Advisor:** George Gala

**Drive Type:** Electric  
**Accumulator:** Battery  
**Drive Motor:** (4) Neumann 50kW  
**Engine:** N/A  
**Fuel Type:** N/A  
**Generator:** N/A  
**Regen Braking:** Front, Rear  
**Weight:** 348 kg  
**Unique Features:** Active rear wing. Custom carbon fiber body kit and diffuser. 4-wheel drive with electronic differential. 440 cell Li-ion battery.

#### Tufts University

**Team Name:** Tufts Electric Racing  
**Car Name:** TER11  
**Advisor:** Dr. Mahesh Krishnamurthy

**Drive Type:** Electric  
**Accumulator:** Battery  
**Drive Motor:** Enstroj Enras 228  
**Engine:** N/A  
**Fuel Type:** N/A  
**Generator:** N/A  
**Regen Braking:** Rear  
**Weight:** 340 kg  
**Unique Features:** TER 11 will feature a fully integrated data acquisition system, completely redesigned accumulators, a custom steering wheel with a built-in display, and for the first time in team history, an aero package featuring a front and rear wing.

#### Boston University

**Team Name:** BU Racing  
**Car Name:** Stella  
**Advisor:** Enrique Gutierrez-Wing

**Drive Type:** Electric  
**Accumulator:** Battery  
**Drive Motor:** (2) Zero Motorcycles FX  75.5 kW @ 4,000 RPM  
**Engine:** N/A  
**Fuel Type:** N/A  
**Generator:** N/A  
**Regen Braking:** Rear  
**Weight:** 348 kg  
**Unique Features:** Custom accumulators with LifePO4 pouch cells.

#### Lawrence Technological University

**Team Name:** Blue Devil Motorsports  
**Car Name:** BDE 20  
**Advisor:** Hamid Vojdani and Gary Lowe

**Drive Type:** Electric  
**Accumulator:** Battery  
**Drive Motor:** (4) Custom  
**Engine:** N/A  
**Fuel Type:** N/A  
**Generator:** N/A  
**Regen Braking:** Front, Rear  
**Weight:** 204 kg  
**Unique Features:** 4 in-wheel Direct Drive Hub Motors, Student Designed Custom Motor Controllers, Student Designed Custom Internally Mounted Brake Calipers.

#### Illinois Institute of Technology

**Team Name:** Illinois Tech Motorsports  
**Car Name:** Hawkrod  
**Advisor:** Dr. Mahesh Krishnamurthy

**Drive Type:** Electric  
**Accumulator:** Battery  
**Drive Motor:** LG HG2 cells in AllCell packs  
**Engine:** N/A  
**Fuel Type:** N/A  
**Generator:** N/A  
**Regen Braking:** None  
**Weight:** 360 kg  
**Unique Features:** Torque vectoring differential action. Brake-actuated active aerodynamics. Carbon fiber skin.

#### Rensselaer Polytechnic Institute

**Team Name:** Rensselaer Polytechnic Institute  
**Car Name:** VMR-xe  
**Advisor:** George Gala

**Drive Type:** Electric  
**Accumulator:** Battery  
**Drive Motor:** (4) Neumann 50kW  
**Engine:** N/A  
**Fuel Type:** N/A  
**Generator:** N/A  
**Regen Braking:** Front, Rear  
**Weight:** 348 kg  
**Unique Features:** Custom accumulators with LifePO4 pouch cells.
<table>
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<tbody>
<tr>
<td><strong>Indiana University</strong></td>
<td><strong>Jaguars</strong></td>
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<tr>
<td><strong>Purdue University</strong></td>
<td><strong>Da JAG</strong></td>
<td>Dr. Jing Zhang</td>
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<tr>
<td><strong>Northeastern University</strong></td>
<td><strong>MEG20</strong></td>
<td>Andrew Gouldstone</td>
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<tr>
<td><strong>Yale University</strong></td>
<td><strong>Bulldogs Racing</strong></td>
<td>Corey O’Hearn</td>
</tr>
<tr>
<td><strong>University of Waterloo</strong></td>
<td><strong>BB16</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Lafayette College</strong></td>
<td><strong>Lafayette Motorsports</strong></td>
<td>Christopher Nadovich, Jeffrey Helm, Sally Sadidian</td>
</tr>
</tbody>
</table>

### Vehicle Specifications

#### Drive Type
- Electric

#### Accumulator
- Battery
- Enredel 4,300 W/h

#### Drive Motor
- Hi Performance EV Systems AC-9-03.27-1

#### Engine
- N/A

#### Fuel Type
- N/A

#### Generator
- N/A

#### Regen Braking
- None

#### Weight
- 230.6 kg*

#### Unique Features
- Custom PCB Electronics.
- FreeRTOS based custom firmware.
- 2 Independently driven motors.

---

**Vehicle Specifications**

| Drive Type | Electric
|------------|-----------|
| Accumulator | Battery
| Power        | 3,563 W-h |
| Drive Motor  | Emrax 228
| Power        | 100 kW @ 5,500 RPM |
| Engine       | N/A
| Fuel Type    | N/A
| Generator    | N/A
| Regen Braking| None
| Weight       | 300 kg

#### Unique Features
- Torque Vectoring
- Vintage Body Aesthetics

---

**Vehicle Specifications**

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| Drive Motor  | Emrax 228
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| Engine       | N/A
| Fuel Type    | N/A
| Generator    | N/A
| Regen Braking| None
| Weight       | 300 kg

#### Unique Features
- CAN Bus communication between CP Display, Accumulators and TS interface.
- In house designed Accumulator Management System.
- Data Acquisition System with On-Car viewing and Offline viewing.

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**Vehicle Specifications**

| Drive Type | Electric
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| Accumulator | Battery
| Power        | 3,563 W-h |
| Drive Motor  | Emrax 228
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| Engine       | N/A
| Fuel Type    | N/A
| Generator    | N/A
| Regen Braking| None
| Weight       | 300 kg

#### Unique Features
- Custom Central Vehicle Controller.
- In-house Designed Gearbox.
- Rear Torque Vectoring Capabilities.

---

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#### Unique Features
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- FreeRTOS based custom firmware.
- 2 Independently driven motors.

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#### Unique Features
- Custom PCB Electronics.
- FreeRTOS based custom firmware.
- 2 Independently driven motors.
With more than 12,000 electric hybrid propulsion systems and nearly 300 zero emission systems operating around the globe, BAE Systems is providing electric propulsion and power solutions for transit buses and motor coaches. Contact us to learn about the many ways we’re helping buses be more efficient and getting transit emissions to zero.

Good Luck Formula Hybrid 2020!

We hope we helped you with:
- Resins
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- Fiberglass
- Vacuum Bagging Materials
- Scissors and Cutters
- Composite Finishing Tools
- ChromaGlast® Paint
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- Sandwich Cores
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HARD WORK PAYS OFF

Toyota commends the 2020 SAE Formula Hybrid student competitors

Prius
best-selling hybrid of all time

Prius Prime
best MPGe of any plug-in hybrid

RAV4 HV
best-selling hybrid 2019

RAV4 Prime
new plug-in hybrid for 2021

Mirai
best-selling fuel cell electric vehicle with new model for 2021

TS050 Hybrid
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MEng for depth and specialization in biomedical engineering

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Let’s form new paths together.
We would like to thank all of the volunteers for their time and generous support. Their hard work and dedication make the event possible.

Acknowledgements

DOCUMENT REVIEWERS
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Phil Gott, New England Region, SCCA
David Hyman, Omvis, LLC
Ahmed Nasser Korka, R&D Engineer, AEG Egypt
Susanne Royce, Principal, Albion Associates LLC

TECHNICAL INSPECTORS / ELECTRICAL
Rob Wells, P.E., Integral, LLC
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Paul Messier, Senior Principal Electrical Engineer, BAE Systems
Ricky Williams, Electrical Engineer and Product Designer, Harley-Wad & Deck
Chris Chapman, Principal Engineer, General Electric Aviation
Gary Grise, BSEE (ret.), IEEE
Jon Goelnick, Jon Goelnick Consulting
Jenna Pollock, EV Systems Engineer, Harley Davidson
Charlie Sullivan, Professor, Thayer School of Engineering
Trenton Miao, Product Line Director, Product Marketing Director, Analog Devices (Ret.)
Wahed Ahmad, Project Computer Engineer, Lutron Electronics
Eric Carlson, Electromechanical Engineer

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