REQUEST FOR PROPOSAL

THE 12TH U.S. DEPARTMENT OF ENERGY AVTC SERIES

NORTH AMERICA'S PREMIER COLLEGIATE AUTOMOTIVE ENGINEERING COMPETITION

THE ADVANCED VEHICLE TECHNOLOGY COMPETITION PROGRAM
IS MANAGED BY ARGONNE NATIONAL LABORATORY
FOR THE U.S. DEPARTMENT OF ENERGY
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AVTCSERIES.ORG

Executive Summary

Item	Description
Request for Proposals Issue Date	March 7, 2018
Submission Deadline for Proposals	April 12, 2018, at 4 p.m. Eastern Standard Time
Required Documents	1. Administrative Proposal (requirements listed in Section E-2) with the following naming convention: UniversityName_AVTC12AdminProposal.pdf 2. Letter signed by the Dean of Engineering confirming the university support requirements (listed in the "Dean of Engineering Letter Content" Section E-3) with the following naming convention: UniversityName_AVTC12DeanLetter.pdf 3. Modeling Exercise report (requirements listed in Section E-4) with the following naming convention: UniversityName_AVTC12ModelingExercise.pdf
Means of Submission	An electronic PDF version of the Administrative Proposal, Dean's letter, and Modeling Exercise Report must be ***emailed*** **as three single files** to ***avtc@anl.gov*****.**
Anticipated Teams Accepted	Up to 16 teams
Eligibility	Schools located in the continental United States and are accredited by the Accreditation Board for Engineering Technology (ABET). Schools located in Canada and are accredited by the Canadian Engineering Accreditation Board (CEAB).
Multiple Submissions	Universities are permitted to partner with another university or college, as long as the partnership is clearly articulated in the proposal. Only one joint proposal will be considered. The proposal must designate a Lead University, who will receive the financial and in-kind support from the competition sponsors and will serve as the primary contact with competition organizers and mentors (unless approved in advance).
Non-Disclosure/IP Agreement	All participating universities will be required to agree to and adhere to the terms defined in non-disclosure and Intellectual Property (IP) agreements from competition-level sponsors. Under the IP agreement from GM, the student participants and graduate participants will retain ownership of any intellectual property they create while working on the project and will grant GM a license to practice any inventions created.

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A Overview

The U.S. Department of Energy (DOE), in partnership with Argonne National Laboratory (Argonne) and the automotive industry, established the Advanced Vehicle Technology Competition (AVTC) program in 1988. For thirty years, the AVTC program has embodied the heart of American automotive ingenuity and provided the ultimate training ground for future automotive engineers and innovators. More than 25,000 students from 93 unique educational institutions have participated, seeding the industry with engineers who have helped redefine the automobile over the last three decades. Today, the AVTC program is North America's premier collegiate automotive engineering competition, providing an unparalleled, hands-on educational experience that has transformed the traditional classroom environment into a hub for automotive innovation. By engaging university students in advanced technology research, the competitions also support national efforts to encourage students to pursue careers in science, technology, engineering, and math (STEM) and enable the U.S. to develop the workforce needed to be competitive in the global marketplace.

DOE is pleased to partner with General Motors (GM) and MathWorks (MW) to sponsor the next AVTC series to explore emerging, innovative technologies that may hold the promise to increased energy efficiency. Managed by Argonne, the 12th AVTC series (AVTC12) will explore developing connected and automated vehicle (CAV) technologies and implement advanced electric and combustion vehicle technologies to increase vehicle efficiency. As the administrator of this four-year competition series, Argonne is releasing this Request for Proposal (RFP) to select up to 16 North American universities with accredited engineering programs to participate in AVTC12.

Like its predecessors, the goal of AVTC12 is to provide a hands-on, real-world experience for the next generation of engineers and business leaders, with emphasis on practical expertise in electrification and autonomous controls, automotive mechatronics, connected and automated vehicle technologies, and other critical engineering disciplines.

University teams will be challenged to explore innovative CAV technologies and implement advanced propulsion systems to maximize vehicle efficiency for the emerging Mobility as a Service (MaaS), shared-mobility vehicle market. Using a 2018 production, mid-size SUV as a platform, each team will design and engineer a MaaS vehicle that will meet their own customer market specifications and then go head-to-head against other teams at an end-of-year competition, vying for more than $100,000 in cash prizes.

As in previous AVTC programs, AVTC12 will continue to place a strong emphasis on the hands-on experience students gain by selecting their own advanced propulsion system components, integrating them into their vehicle, and then testing the vehicle to ensure it meets requirements. From these integration activities, students gain in-depth experience on how engines, transmissions, electric machines, energy storage systems and other hybrid technologies work. This propulsion system knowledge is critical to students designing a well-rounded, reliable vehicle that supports the objectives of AVTC12. AVTC12 will expand the use of CAVs technologies in AVTC competitions by challenging students to incorporate vehicle to vehicle (V2V) communication, on-board sensors, and other connectivity technologies (V2X) into their vehicle. The overall goal of these efforts is to use the CAVs technologies to improve the energy consumption and safety of the stock vehicle in various simulation and on-road demonstrations. Teams will also be challenged to take on additional automotive related innovation topics to encourage more advanced research and exploration throughout the competition.

The competition series will be divided into four academic years. In Year 1, teams will define their unique customer market and utilize Model-Based Design tools to design and simulate advanced propulsion system configurations to select a vehicle architecture. Teams will also perform low-level component packaging and integration design as well as simulation of longitudinal driving scenarios to select their propulsion system components and CAV's-related sensors. At the conclusion of Year 1, teams will receive their donated production vehicle, which will serve as the platform for their propulsion system and CAVs technologies throughout the remainder of the series.

In Year 2, teams will integrate their advanced propulsion system and sensors into their competition vehicle, demonstrating hybrid functionality at the year-end competition. In Year 3, teams will be expected to demonstrate reliable hybrid propulsion system operation along with fully functional longitudinal CAV and V2X systems. In the fourth and final year, teams will be expected to demonstrate fully-refined hybrid propulsion and CAV systems that meet both their customer market expectations and the competition Society of Automotive Engineers (SAE) Level 1-2 Autonomy target. AVTC12 will culminate with an over the road event that demonstrates the robustness and energy efficiency of the competition vehicles.

Selected universities will design and engineer energy-efficient vehicles for the MaaS shared-mobility vehicle market that:

- Integrate hybrid propulsion systems that enable significant improvements in energy efficiency for the MaaS market
- Deploy CAV technologies to meet energy efficiency goals and MaaS market needs
- Balance energy efficiency needs with the consumer acceptability, safety and cost considerations unique to the MaaS market

Participation in AVTC12 will be determined through this RFP process; all teams who continue to operate in good faith will participate throughout the four-year competition series. No other teams will be selected to participate in subsequent years. The organizers anticipate selecting up to 16 university teams.

Universities wishing to be considered for participation in the competition must complete both a modeling exercise to demonstrate technical competency, and an administrative proposal that demonstrates high levels of administrative support from their schools. Teams will be selected for AVTC12 based on multiple factors, including the quality of the proposal, technical expertise, related experience, and administrative support committed by the university and other local partners. Additional updates will be posted on www.avtcseries.org until the competition name has been announced and a website and other social media have been developed.

B AVTC12: Vision and Goals

The overall vision of AVTC12 is to provide an opportunity for university students to participate in hands-on automotive R&D at the leading edge of technology by using contemporary industry standards and practices. Our detailed vision and technical goals for the competition are listed below.

B-1 Vision

- Provide a hands-on, real-world experience in STEM that:
    - Fosters practical learning in a safe environment
    - Incorporates the use of math-based tools to improve engineering education
    - Enables participants to develop and refine complex vehicle control and safety systems by using industry testing/validation processes and methodologies;
    - Prepares students to work in the automotive, mobility and energy industries
- Develop highly-skilled engineering leaders and innovators with a strong understanding of:
    - Advanced propulsion systems
    - Propulsion system controls
    - Connected and automated vehicle technologies
    - Automotive mechatronics
    - Model-Based Design (MBD) techniques
    - Structural design and analysis
    - Other critical engineering disciplines
- Support university teams in the recruitment of students in the following disciplines:
    - Mechanical Engineering
    - Electrical and Computer Engineering
    - Computer Science and Software Engineering
    - Industrial Engineering, Systems Engineering and other engineering disciplines
    - Communications and Business
- Recruit and retain students that represent the diversity of automotive customers and promote an environment of inclusion and diversity within the program and among the participating teams
- Implement youth outreach and recruiting initiatives that promote careers in STEM
- Demonstrate the potential of advanced propulsion systems, CAV technologies, and other innovative technologies to improve energy efficiency, leading to greater transportation energy affordability, reliability, and security

- Challenge students to weigh all the benefits of their design, such as energy efficiency and consumer features, against the constraints of cost and risk of implementation
- Provide a platform to facilitate systems-level engineering curriculum and instruction in engineering departments at an elevated level
- Educate students in key aspects of project management, enabling them to develop exceptional leadership, teamwork, and professional skills that will better prepare them for their future careers

B-2 Technical Goals

The technical goals of AVTC12 are to design and engineer energy-efficient vehicles for the MaaS shared-vehicle market that:

- Integrate advanced propulsion systems to enable significant improvements in energy efficiency
- Deploy CAV technologies to meet energy efficiency goals and MaaS market needs
- Balance energy efficiency needs with the consumer acceptability, safety and cost considerations unique to the MaaS market

AVTC12 will include significant advanced propulsion system engineering activities, including High Voltage (HV) system integration and electrification vehicle controls. As a complement, the competition will also include a significant element of CAV technologies. Teams can expect roughly 40% of the overall competition engineering activities to be focused on CAV technologies.

C About the Competition

C-1 Team Structure and Interdisciplinary Emphasis

In order to be successful in AVTC12, universities must employ a strong interdisciplinary initiative both internal and external to the College of Engineering. Teams should recruit students in the areas of Mechanical Engineering, Electrical and Computer Engineering, Software Engineering and/or Computer Science, in order to meet competition objectives and requirements. In addition to the various areas of engineering, the AVTC12 competition has a heavy focus on Communications and Project Management. University teams will likely find students from other disciplines to be valuable and necessary assets to the planning and execution of their AVTC12 programs. The emphasis on these areas imitates a real-world automotive industry environment and gives AVTC12 graduates the skills to enter the field fully prepared for a successful career immediately upon graduation.

In order to ensure success in AVTC12, teams should establish the following minimum team leadership roles:

Project Manager (PM)
Engineering Manager (EM)
Vehicle Systems Lead (VSL)
Connected and Automated Vehicle Technology Lead (CAVs Lead)
Propulsion Controls and Systems Modeling & Simulation Lead (CSMS Lead)
Communications Manager (CM)
Faculty Advisor

We do not require that the students for these roles be identified by the time of your proposal submission. However, the roles are explained in the following subsections to convey the depth of the program, to detail the resources required for successful execution, and to reiterate how they are aligned with general industry practices.

C-1.1 Project Manager (PM)

The Project Manager is a competition-funded graduate engineering student who serves in a key management role for the overall team. The PM should be a graduate student from any discipline, up to the discretion of the Lead Faculty Advisor, but they must have an engineering undergraduate degree or currently be enrolled in an engineering graduate program. Additionally, the PM must have strong technical and leadership skills and be capable of providing continuity to the team

over multiple years. The PM works very closely with the Lead Faculty Advisor to plan, execute and manage all competition deliverables and requirements and to ensure the team can operate efficiently and align with business and automotive industry practices. The PM will not only develop the overall project timeline and work plan but is responsible for tracking and executing all project-level activities, knowledge transfer, and recruiting and retention activities. The PM will also work with the Lead Faculty Advisor, College of Engineering staff and the rest of their student team to manage all local sponsorship and fundraising activities.

C-1.2 Engineering Manager (EM)

The Engineering Manager is a competition-funded, graduate engineering student who serves as a chief engineer for the team, providing strong technical expertise and continuity throughout multiple years of the four-year program. The EM will oversee key technology development within each of the technical sub-teams, exploring complex engineering challenges, such as hardware integration, energy storage system (ESS) integration, controls, and simulation. The EM must also provide technical team leadership and maintain continuity within the team over an extended portion of the four-year program. The EM may be a graduate student from any engineering discipline, based on the discretion of the lead faculty advisor. However, as the lead engineer on the team, the EM should be very familiar with the team's overall vehicle and its individual subsystems and will oversee the technical swimlanes (see Section C-1.8 for swimlane descriptions).

C-1.3 Vehicle Systems Lead (VSL)

The Vehicle Systems Lead should be a mechanical engineering graduate research assistant who serves as team lead for or advisor to the Hardware and Integration (H/I) swimlane. Funding for this GRA should be provided by the university as matching support for the competition-funded Engineering Manager. The Vehicle Systems Lead will provide technical expertise to the H/I swimlane to support integration activities. In particular, this GRA is intended to provide expertise for any advanced engineering that is required, such as finite-element analysis (FEA) or computational fluid dynamics (CFD). Additionally, this GRA is intended to provide some level of management, organization, and knowledge transfer for vehicle hardware systems over the course of the four-year competition.

C-1.4 Connected and Automated Vehicle Technology Lead (CAVs Lead)

The CAVs Lead is a competition-funded, graduate research assistant who serves as the Sub Team Lead for the CAVs swimlane. The CAVs Lead is preferably a graduate student in Electrical Engineering, Computer Engineering, Software Engineering or Computer Science. However, graduate students in Mechanical Engineering with the appropriate prior experience will be permitted. The CAVs Lead will provide management, organization, and leadership for the CAVs swimlane, as well as technical knowledge transfer over the four-year competition. Additionally, the CAVs Lead should provide technical expertise for the CAV technologies and systems deployed on the team vehicle.

C-1.5 CSMS Lead

Universities are required to fund a graduate student to serve as the Sub Team Lead for the Controls and Systems Modeling & Simulation swimlane, through matching funding from the university. The CSMS Lead should be a graduate student in engineering, preferably with experience in embedded controls and MATLAB/Simulink. The CSMS Lead will be responsible for coordinating the propulsion control system development and simulation activities for the team.

C-1.6 Communications Manager (CM)

The Communications Manager is a competition-funded position that oversees all Communications and Outreach activities for the team. The CM may be an undergraduate or graduate student and will be funded on an hourly basis. The CM will work the team to plan STEM outreach events, campus and community events and work with university staff to secure local media coverage and government relations outreach. Your university's Communications departments should provide leadership and mentoring to enable the CM's success throughout the four-year program. If a proposing university is unable to fill this role with one of its own students due to the lack of an appropriate Communications degree program, it may collaborate with a neighboring university to obtain a candidate for this role.

C-1.7 Faculty Advisors

Each team is required to have no fewer than two faculty advisors supporting their team: one faculty from the Mechanical Engineer department and a second faculty from the Electrical Engineering, Computer Engineering, or Computer Science departments. These two primary faculty advisors should collectively have experience in advanced propulsion systems, vehicle design and integration and CAV's technologies. An ME advisor may oversee the CAVs development, assuming that they have the appropriate expertise. However, one faculty advisor must be appointed the lead of the propulsion system development activities while the other faculty advisor must be appointed lead of the CAVs activities.

Additionally, one faculty advisor must be appointed as the Lead Faculty Advisor for the team, who will be the organizers main contact and will have responsibility and authority for the program and participating students. Faculty release time and other requirements are defined in a later section. Additional faculty are strongly recommended to provide additional technical support and/or mentoring, but are not a competition requirement.

C-1.8 Competition Swimlanes and Suggested Team Organization

AVTC12 will define five distinct swimlanes that will be used to organize activities over the course of the competition. These swimlanes are defined below:

- Technical Swimlanes:
    - Hardware and Integration (H/I): responsible for physical integration and mounting of all vehicle hardware in addition to thermal systems, vehicle ride and handling characteristics, and aerodynamics
    - Propulsion Controls and Systems Modeling & Simulation (CSMS): responsible for all controls, modeling and simulation related to propulsion systems
    - Connected and Automated Vehicle Systems (CAVs): responsible for all controls, modeling, and simulation related to propulsion systems
- Project Management: responsible for providing management and planning for the overall project so that the team can operate more efficiently and better align with business and automotive industry practices
- Communications: responsible for managing various communications activities, such as outreach campaigns, social media, planning and executing local events, plan writing, and more

Although each university may structure its team to best fit its individual circumstances, Figure 1 provides an example of an organizational structure that includes the swimlanes and management roles defined previously. It should be noted that training and competition events will be modeled after this structure.

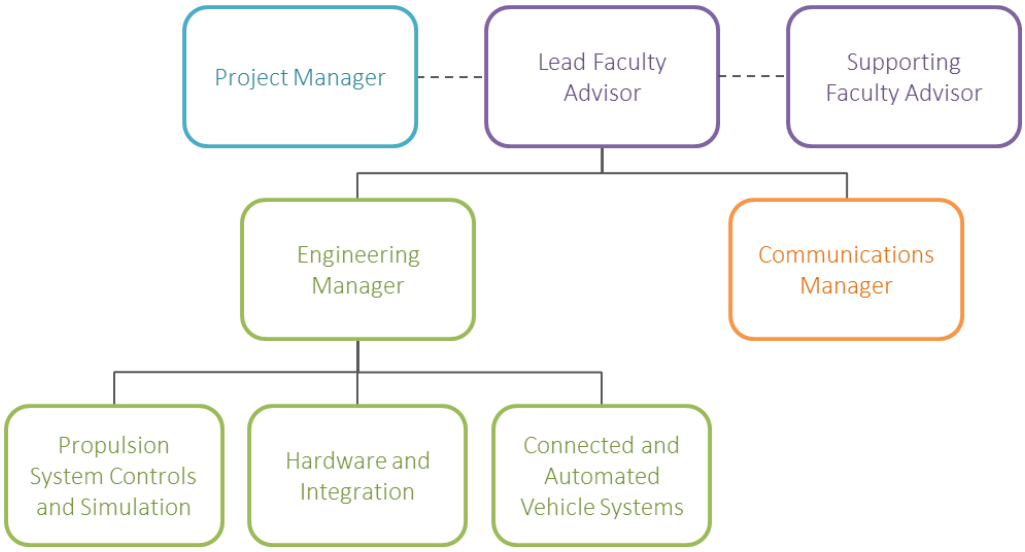

FIGURE 1: EXAMPLE TEAM ORGANIZATIONAL STRUCTURE

C-2 Competition Format, Structure, and Timing

C-2.1 GM Global Vehicle Development Process (GVDP)

GM uses a global vehicle development process for vehicle development. The process begins with the determination of market opportunities and development of requirements. After significant research and planning have occurred, the program initiation milestone will be reached, and design, development, and testing using mathematical models and simulations, decoupled subsystem development, and physical hardware testing will begin. The GVDP has further milestones that dictate feature functionality, calibration, and manufacturing process validation of prototype and integration vehicles until a product that can be sold to a customer results. The GVDP provides GM with a competitive global process that integrates best practices from all regions and is based on several fundamentals of vehicle development, including the following:

- Verified and correlated mathematical models are used as the basis for the vehicle development program.
- Specific subsystem "decoupled development" is employed to reduce risk and remove uncertainty from program timing.
- Virtual and analytical simulations of the product and the process precede any physical property evaluations.
- The use of physical prototypes as the primary method of validation is minimized. There is strict adherence to the timing and prototype use requirements outlined in the learning analysis, development, and validation plan.
- Product and process development and validation are based on only three physical prototypes:
  - Underbody and subsystem mules,
  - Integration vehicle, and
  - Manufacturing validation vehicle.

C-2.2 AVTC12 Vehicle Development Process (VDP)

The GVDP serves as a model for the AVTC12 Vehicle Development Process that establishes a plan for the analysis, development and validation of the AVTC12 vehicle design. The VDP is a template that illustrates the development of various vehicle systems throughout the many stages of the competition. The goal of the VDP is to establish a long-term, high-level plan for the four-year competition to guide teams through the development of their vehicle to meet competition goals. It also emphasizes the Model-Based Design philosophy and uses simulation and analysis tools to complement the hardware phases, not just to gain initial design approval. The VDP approach is setup to encourage teams to spend time on designing their vehicles to be robust early on in the competition in order to prevent them from making premature hardware

modifications. The VDP will not be a strictly detailed plan for development; rather, it will be a high-level guide focused on meeting year-end goals and milestones. Figure 2 shows an example VDP for AVTC12.

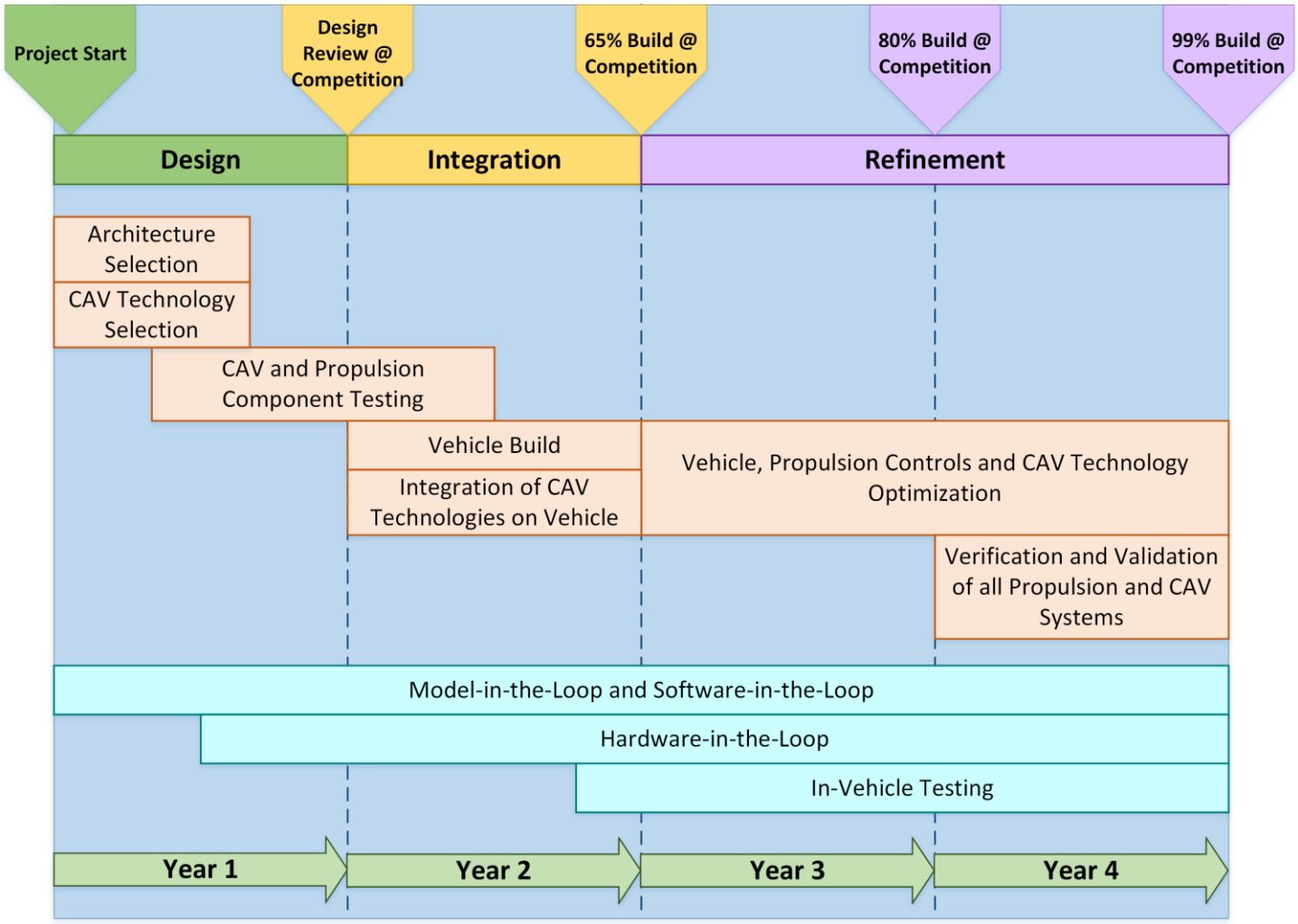

FIGURE 2: EXAMPLE AVTC12 VEHICLE DEVELOPMENT PROCESS

The AVTC12 VDP will incorporate key goals for simulation, propulsion system integration, and CAV technology demonstrations. While it is modeled after the GVDP described above, it is modified to account for academic years, team structures, and overall competition objectives. Detailed goals, milestone expectations, and deliverable requirements will be released to teams yearly.

C-2.3 Four-Year Overview of AVTC12

As emphasized by the VDP, AVTC12 will follow a four-year plan with distinct milestones established for each competition year. These annual milestones provide year-over-year goals to lead teams toward the end-goal: a fully functional, refined, and reliable vehicle that meets consumer expectations and demonstrates the targeted level of automation. Table 1 summarizes these milestones for each competition year; additional details are provided later in this section. As a supplement to the year-end milestones, intermediate milestones will be established for each year of the competition. The resulting glidepath will serve as a month-by-month guide to help teams stay on track over the course of the academic year so that they can achieve the stated milestones and objectives for that year's competition.

TABLE 1: FOUR-YEAR OVERVIEW OF AVTC12 COMPETITION ACTIVITIES AND MILESTONES

Year	Propulsion System Activities	CAV Activities
Year 1	• Customer definition • Architecture and component selection • Low-level component packaging and integration design finalized • Donated vehicle delivery (Expected summer 2019)	• Customer definition • Definition of intended CAV technologies to be developed • Sensor selection and low-level packaging and integration design finalized • Simulation of longitudinal driving scenarios
Year 2 65% vehicle GOAL	• Complete vehicle integration • Vehicle propulsion system capable of completing selected dynamic driving events	• Sensor integration (longitudinal sensors) • Longitudinal CAV system baseline functional • V2X system baseline functional
Year 3 80% vehicle GOAL	• Reliable coordinated propulsion system operation • Calibration not yet refined to customer's satisfaction	• All CAV hardware integrated • Fully functional longitudinal CAV system • V2X system fully functional
Year 4 99% vehicle	• Refined and reliable propulsion system • Refined calibration – close to consumer acceptable level (99%) • All consumer features in place	• All CAV systems fully functional and meet consumer expectations • Vehicle demonstrates target autonomy level in closed course environment

C-2.3.1 Year 1

The first year of the VDP is an essential foundation for establishing a successful design. Year 1 of the competition series will emphasize vehicle design through the following activities:

- Defining the target customer and establishing vehicle technical specifications (VTS) to meet customer needs
- Using energy consumption modeling and simulation tools to select propulsion system components and propose viable architectures
- Using modeling and simulation tools to select CAV technology features and sensors to be integrated on-vehicle
- Using computer-aided design (CAD) and computer-aided engineering (CAE) tools to package components
- Developing the foundation for vehicle control and safety systems via industry testing/validation processes and methodologies, such as: model-in-the-loop (MIL), software-in-the-loop (SIL), hardware-in-the-loop (HIL), design for failure modes and effects analysis (DFMEA), and fault tree analysis (FTA)
- Using MBD techniques to demonstrate, via simulation, vehicle propulsion system and CAV system capability

These first-year activities will prepare schools for the vehicle development and refinement tasks in subsequent years of the competition. A competition event at the end of Year 1 will bring all student teams together to assess each team's design process, customer definition, propulsion system component selection and configuration, CAV sensor selection and CAV feature definition. Approximately $100,000 in industry-funded awards will be presented at each annual competition.

Teams will also receive their donated competition vehicle after the Year 1 competition to allow for the finalization of vehicle donation, licensing, and registration paperwork to be done in summer 2019. Hence, the goal is to prevent these necessary administrative steps from delaying engineering activities during the academic year.

C-2.3.2 Year 2

During Year 2, the focus will be on propulsion system and CAV sensor integration and baseline functionality. The key goal of Year 2 is to achieve a running vehicle that can operate up to highway speeds and sustain driving functionality for 50+ miles. While a running vehicle is the expectation, it is not required that all propulsion system modes of operation are functioning. The goal of delivering a running vehicle by Year 2 competition is critical because it will be an enabling factor for the advanced CAV system development activities in Years 3 and 4, as well as propulsion system refinement and reliability testing.

Year 2 may include the following activities:

- Developing simulation environments (MIL, SIL, and/or HIL) for the development and evaluation of control methods
- Developing control systems for propulsion systems and CAV systems
- Bench testing to establish baseline functionality of individual components and subsystems
- Deploying control system designs to on-vehicle controller hardware using rapid prototyping and MBD
- Integrating propulsion system components and CAV sensors to realize Year 1 designs
- Vehicle testing to achieve functionality of all vehicle systems

Year 2 will culminate in a year-end competition held in the May-June timeframe. This competition will bring together all vehicles and teams to compete in a series of rigorous events that evaluate safety, integration quality, performance, energy efficiency, and consumer appeal. Table 2 provides a list of example events that may be run during Year 2 (either at competition or throughout the academic year). Teams will garner points in each of the competition events; the team that scores the most points will win that year's competition. Vehicles will also undergo a strict static safety inspection and dynamic safety evaluation to ensure AVTC12 vehicle safety requirements are met.

TABLE 2: SAMPLE COMPETITION EVENTS

Events	Description (Measurements)
Vehicle Performance	Acceleration, handling, braking, ride quality, drive quality
Tank-to-Wheels Energy Efficiency	On-road evaluation of propulsion system efficiency
CAV System Evaluation	Longitudinal CAV system and V2X system demonstration
Written Reports	20-page technical report
Oral Presentations	30-minute formal oral design presentations
Vehicle Design Review	Vehicle inspection and design review
Consumer Appeal	Consumer acceptability review and static vehicle utility
Outreach	Outreach activities review, website, and presentation
Inspections	Mid-year deliverables, inspections, progress reports

C-2.3.3 Year 3

In Year 3, teams will build on the foundation established in Year 2 and work to achieve a reliably functioning vehicle. Team activities in Year 3 will include:

- Using previously established simulation environments for virtual development and validation of vehicle controls
- Refining propulsion system integration and packaging designs where necessary using CAD and CAD tools and MBD
- Closed-course vehicle testing to verify propulsion system and CAV system functionality

By Year 3 competition, vehicle propulsion systems should be capable of reliably executing all intended modes of operation, control system design and diagnostics should be complete, though system calibration, efficiency, and drive quality may still need refinement. CAV systems should also be fully integrated with full functionality from any longitudinal system or V2X system. Like Year 2, all vehicles and teams will be assembled in the May-June timeframe for a competition that will include vehicle inspections and evaluations, as well as formal oral design presentations.

C-2.3.4 Year 4

The end goal for Year 4 is the cumulative goal for AVTC12 as a whole: deliver a fully functional, refined, and reliable vehicle that meets consumer expectations and demonstrates the targeted levels of efficiency and automation. To achieve these goals, teams must plan and execute extensive vehicle testing in concert with virtual development and validation of vehicle control systems. Hence, consistent access to a closed-course testing environments will be critical to success.

Like Year 2 and Year 3, all vehicles and teams will be assembled in the May-June timeframe for a competition that will include vehicle inspections and evaluations, as well as formal oral design presentations. Additional events may be included in Year 4 to evaluate full vehicle functionality and the integration of CAV systems with propulsion systems to achieve the goals of energy efficiency and safety.

C-2.4 Vehicle Technical Specifications

During the first year of competition, teams will identify their targeted customer within the MaaS market identified by the competition and derive vehicle technical specifications to meet the needs of the customer. Teams should then select propulsion system components and a vehicle architecture to meet that set of VTS. In addition, the competition will establish VTS minimum requirements for metrics such as energy efficiency and vehicle performance. These requirements are the lowest desired level of performance; to produce well-rounded vehicles, teams should design beyond the minimum requirements to meet the needs of their target market.

C-3 Vehicle Technologies Supported

AVTC12 is a unique competition employing advanced propulsion system and CAV technologies. Teams may propose any propulsion system architectures during the formal propulsion system selection process in Year 1. Architectures are subject to approval by organizers pending feasibility of design, availability of components, and other factors. After an architecture is approved, it is very costly and time-intensive to change course and alter the architecture design. Hence, the architecture approval process is put in place as an approval gate to ensure teams can execute their conceptual design and to guard against poor decisions that may have significant negative impacts on subsequent years of the competition.

C-4 Fuels

AVTC12 vehicles are limited to using liquid fuels and grid electricity; for logistical reasons no gaseous fuels will be supported. All energy consumption or energy efficiency evaluation will be conducted on a tank-to-wheel basis. Additionally, the following restrictions apply to AVTC12:

- The use of any fuel additives that change the chemistry or energy content of the fuels will not be allowed
- The use of a consumable liquid without utilizing its energy content for propulsion (such as urea for exhaust emissions control) will be allowed *only* with prior notification of and approval from the organizers
- The use of nonstandard or exotic energy storage devices or energy converters must be pre-approved by the organizers

C-5 Emphasis on Innovation and Cost

AVTC12 teams will be required to address elements of cost in their vehicle designs, which may include up-front costs, operating costs, or both. The impact of cost will be evaluated in one or more events over the course of the competition. In addition to cost, AVTC12 will also emphasize automotive innovation throughout all four years of the competition. Teams will be expected and encouraged to pursue innovative technologies and designs that will impact the vehicle and enhance the consumer experience in a meaningful way. Innovation will also be a key focus of the CAVs swimlane, challenging students to explore and develop emerging technologies that hold promise to improve the energy efficiency of vehicles.

C-6 Safety

Building and operating a safe vehicle is of paramount importance when competing in AVTC12. Vehicles that do not pass periodic rigorous safety inspections or are deemed unsafe will not be allowed to participate in the competition. Teams will not be permitted to make any modifications to their vehicles that would compromise safety or crashworthiness. Teams wishing to make modifications to the vehicle that could affect the safety or crashworthiness of the vehicle will be required to submit an analysis that proves the modification meets competition requirements to designated subject matter experts (SMEs). All participants must adhere to stringent requirements to ensure the safety of added subsystems (such as high-voltage traction batteries). Additionally, with the introduction of significant CAV related activities to AVTC12, teams will be expected to incorporate safety related algorithms into their propulsion control systems to ensure the vehicle is able to operate safely in all operating modes. When teams are actively operating their vehicle, the driver of the vehicle is expected to be attentive at all times, regardless of what CAVs related technology the vehicle may have.

Participating schools must develop and submit safety plans for their AVTC12 efforts, and the plans must include processes and procedures for safe operations in their facilities. These plans must have defined training and certification procedures (approved by the administration) for all equipment that will be used or worked on during the course of the project, including

but not limited to subjects such as high-voltage electrical safety, machine shop, welding, and vehicle hoist operations. Participants must have a working knowledge of the proper use of appropriate personal protective equipment whenever they perform work on AVTC12 vehicles at the schools and at all AVTC12 events.

D Support for Teams Accepted Into AVTC12

D-1 Support Provided By the Competition

Participating universities will receive extensive support from competition-level sponsors to enable their success throughout AVTC12. At the time of the drafting of this RFP, these contributions are still in development, although commitments from AVTC12 Headline Sponsors are described below. In the previous series, however, EcoCAR 3 sponsors provided more than $920M of hardware, software, and cash support to the 16 participating universities (an average of $57.5M per team). More details on historical levels of support are provided in Section D-1.3.

D-1.1 Cash Contributions

Teams will receive up to $70,000 USD/annually to fund three graduate students (Engineering Manager, Project Manager and CAVs Lead) and one Part Time Communications Manager~~.~~. These funded positions are critical to enabling the continuity of leadership and expertise required for the team to be successful over the multi-year competition. Universities are required to match this funding with two additional graduate students (Vehicle Systems Lead and CSMS Lead). See Section C-1 for description of funded positions and Section D-2.4 for further description of matching funding requirements.

Each team also will receive seed money of no less than $20,000 USD for program initiation support in the first year of the program. GM will also donate a production, mid-size crossover SUV to each team, delivered after the Year 1 competition (Expected summer 2019). A significant amount of information about the vehicle will be donated to each school on a confidential basis, thereby enabling the teams to perform detailed component location packaging, structural analyses of vehicle modifications, and electrical interfacing. Teams will be required to sign a nondisclosure agreement (NDA) with GM, and the donated competition vehicles will be supplied with a State of Michigan salvage title. The organizers will establish a review and approval process for vehicle modifications to ensure safe operation during vehicle operation.

Teams will also receive significant travel allotments each year (an avg. of $22K USD/team was distributed annually to EcoCAR 3 teams for travel support) and vehicle shipping support from GM and other sponsors to participate in the annual end-of-the-year competition as well as two to three annual workshops. Universities will likely have to supplement travel support with some additional support (see Section D-2.1).

D-1.2 In-Kind Contributions

To maximize the success and learning opportunity for AVTC12 teams, the competition will offer various in-kind donations including software, hardware, and engineering/mentoring support. This will include in-kind support from GM, MathWorks, and various other competition sponsors. This may also include paid faculty support, although a funding commitment is in process at the time of this RFP release date.

D-1.2.1 GM Donated Components

GM will donate powercubes (engine and transmission combination) and other production parts and will provide extensive technical support and mentoring to support teams with their propulsion system modifications. Teams may expect GM to offer the following components for donation:

- A limited range of GM production gasoline engines
- GM-developed automatic transmissions
- Other select components from GM vehicles currently in production in North America

D-1.2.2 GM Blue Dollars

In addition to these specialized components, AVTC12 plans to offer each school GM “Blue Dollars” that can be used to obtain GM production North American service parts required in support of its designs. In EcoCAR 3, each school received

$5,000/year. In the past, many other AVTC sponsors also offered no-cost or low-cost parts, controllers, and components to participating schools, greatly leveraging the ability of those schools to develop and implement the complex systems and subsystems required for the competition. We intend to enable that heritage of sponsorship for AVTC12.

D-1.2.3 GM Mentor Program

Teams will also be assigned a GM engineer as a team mentor. Each GM mentor will be a knowledgeable automotive engineer with years of industry experience and will function as a resource to help guide the team through the vehicle design and integration process. The GM mentor will also serve as a team liaison to GM throughout the competition. In addition, SMEs will provide technical training and be available to participating teams through for additional support.

D-1.2.4 MathWorks Modeling, Simulation, and Mentor Support

Model-Based Design is commonly used for the development of propulsion and CAV systems naturally leading to a strong emphasis on modeling and simulation in the AVTC12 competition. The competition organizers have partnered with MathWorks to provide engineering tools commonly used in industry and guidance for implementing Model-Based Design processes. MathWorks will provide their MATLAB and Simulink environment to participating teams and assign technical mentors to support teams with Model-Based Design implementation.

D-1.2.5 Other Donated Components and In-Kind Support

The organizers also expect to offer AVTC12 teams other in-kind donations from various competition sponsors, which may include some or all of the following:

- A limited range of ESS solutions
- CAV components such as radar sensors or V2X modules
- Auxiliary components such as HV A/C compressors or HV DC/DC converters
- Supervisory controller hardware
- Hardware-in-the-loop simulators
- Vehicle CAN diagnostic hardware and software
- Tools and toolbox
- Various modeling, simulation, or analysis software suites to support engineering activities

Teams must note that the competition will be unable to supply every team with all of the components required to implement their desired propulsion system design. Thus, teams must plan to purchase or solicit donations for propulsion system components and/or parts that cannot be obtained via donation from a competition sponsor. Teams are also not required to use any components offered (other than the production GM-donated vehicle). More information on AVTC12 components will be available at the start of the competition.

D-1.3 Historical Competition-Level Sponsor Contributions (from EcoCAR 3)

As referenced earlier, sponsors for the previous competition series, EcoCAR 3, provided more than $920M of hardware, software, and cash support to the 16 participating universities (an average of $57.5M per team). We will target similar support for AVTC12 teams, although the extent of support that will be provided is still in development at this time.

Table 3 provides a summary of the average support received by teams in EcoCAR 3.

TABLE 3: DONATIONS DISTRIBUTED TO TEAMS DURING ECOCAR 3 (AVERAGE PER TEAM)

Cash	Software	Hardware	Total
$368,000	$57,000,000	$134,000	$57,502,000

The cash support received by teams included seed money, GRA funding, travel support, and competition prize money, among other things. Teams also received extensive in-kind support including hardware and software donations from various competition sponsors, as enumerated in Table 4. Additionally, EcoCAR 3 teams were typically successful in leveraging this support into additional state and local support for their programs.

TABLE 4: IN-KIND SUPPORT PROVIDED BY ECOCAR 3 COMPETITION SPONSORS TO ECOCAR 3 TEAMS

Area	Sponsor	Item and Description	Approximate Total Value
Vehicle	GM	2016 Chevy Camaro (for every team)	$546k
Engine	GM	LEA 4-cylinder engine kit	$66k
Transmission	GM	8-speed longitudinal transmission	Included in Camaro cost
ESS		A123 PHEV battery kits (4 available configurations)	$500k total
		A123 black-box HEV battery	
	Bosch	Black box PHEV battery pack	$10k total
HV Traction Motor	Bosch	SMG motor	$14k total
	Bosch	Discounted IMG motor	$30k in total discounts
	Denso	BAS motor	$4k total
Supervisory Controller Hardware	ETAS	Supervisory controller	$136k total
	New Eagle	Supervisory controller	$20k total
	Woodward	Supervisory controller	$12k total
	dSPACE	Supervisory controller	$113k in total discounts
HIL Simulator	dSPACE	HIL simulator (for every team)	$225k total
Other Hardware	Denso	HV A/C compressor	$9k total
	Denso	DC/DC converter	$4k total
	NXP	ADAS board and camera (every team)	$40k total
	Vector	CANcase and other hardware	$5k total
Tools & Supplies	Snap-on	toolbox and comprehensive set of tools (every team)	$450k total
	Snap-on	Electronic parts catalog	$30k total
	Tesa Tape	Various adhesive products	$5k total
	Champlain	HV and LV wire	$13k total
Software	MathWorks	MATLAB, Simulink, etc. (every team)	n/a
	ANL	Autonomie (every team)	n/a
	Siemens	NX CAD suite (every team)	n/a
	MentorGraphics	Vesys, VolCANo, FlowMaster, etc. (every team)	n/a
	AVL	DRIVE (every team)	n/a
	Synopsys	Virtual development kit for NXP board (every team)	n/a
	Vector	CANoe, CANape	n/a
	ETAS	Controller software	n/a
	Woodward	Motohawk software suite for controllers	n/a
	New Eagle	Raptor software suite for controllers	n/a

D-2 Support Provided By Universities

To be successful in AVTC12, teams will have to supplement the support provided by the sponsors with additional local resources. Signed letters of support from the Dean of Engineering or a senior University Administrator are required with each proposal (see Section E-3). If accepted into AVTC12, each team will be required to sign an annual "Good Faith Agreement" (GFA) by September 15 of each academic year, which will reaffirm the university's full support of the team and explicitly state its willingness to participate in all AVTC12 activities.

D-2.1 Matching – Travel and Participation

AVTC12 teams will be required to travel to workshops and competitions during each academic year. In Year 1, this typically requires student and faculty participation at 2-3 workshops (3-4 days including travel) and one end-of-the-academic-year competition (6-8 days including travel). In subsequent years, there are typically two workshops (3-4 days including travel) and one end-of-the-academic-year competition (12-14 days including travel). Online tools will be used to replace or supplement in-person training and events to minimize the time students and faculty are away from campus. At least one faculty member must accompany student team members to all workshops and annual competitions to provide technical advising and leadership, and serve as the official university representative.

GM and other sponsors provide travel allotments to the participating teams but often teams find they need to supplement this funding with ~15-20% additional funding from the university or external sponsors.

The Lead Faculty Advisor is required to work with the university administration and faculty to make arrangements to ensure that students who travel to competition events are not penalized for their absence from campus/class.

D-2.2 Matching – Administrative Support

AVTC12 teams will require the support and guidance of university administration and support staff to plan and execute their activities throughout the four-year program. Universities must specify in their proposal the administrative services that will be provided at no cost to the team throughout all four years of the program. Some examples may include:

- Supporting the team with accounting, invoice processing and travel coordination;
- The College of Engineering's development office may support the team's local fundraising and sponsorship efforts
- The University or College of Engineering's Communications office may support local media relations and team news coverage.

If overhead or other fees must be assessed by the university, a description of the fees and what services they apply to must be included in the proposal and will be a factor for acceptance into AVTC12.

D-2.3 Matching Seed Money

Universities are required to match the seed money, no less than $20,000, with an equal amount of university cash contributions. Seed money will be provided at the beginning of the first year, and the university must match this with cash to the team by the beginning of Year 2 of the four-year program. In-kind support from the university administration is not considered an adequate substitute for the matching cash funding requirement.

D-2.4 Matching Engineering GRA Funding

As explained previously, each university is also expected to match the GRA funding. AVTC12 sponsors expect to provide approximately $70,000 USD annually for three Full Time GRAs and one Part Time Communications Manager. Universities are required to match this funding with two additional full time graduate students (Vehicle Systems Lead and CSMS GRA). See Section C-1 for descriptions of the funded positions.

Canadian universities may require supplemental funding from outside sources due to funding restrictions or other limitations from U.S. sponsors, but will be addressed after team selection.

We also understand GRA rates at different universities may vary. In some cases, the $20,000 USD annual funding may not cover a university's costs associated with one full-time GRA. We expect that any additional costs to ensure that the competition-funded GRAs are full time will be supplemented by the university (see GRA matching requirements below). In other cases, the provided funding may cover most of the expenses for two GRAs, with the university providing tuition and other fee waivers. As long as the combined support enables the five full time GRAs and one Part Time Communications Manager (as described in Section C-1), the program's minimum requirements will be met.

The university will be expected to explain how it met the GRA requirements in the proposal it submits and in annual Good Faith Agreements. Additional details about GRA funding will be provided after the teams are selected.

D-2.5 Course Credit

Universities will be **required** to integrate AVTC12 content into the curriculum of a minimum of **two** courses per year, to enable course credit for students for their involvement in AVTC12. Special consideration will be given on a case-by-case basis for teams unable to set up these courses in Year 1. Operating AVTC12 solely as a club activity has not previously resulted in long-term success for AVTCs and will not be permitted as the only mechanism for student involvement.

Best practices in previous AVTCs have enabled AVTC content in a senior design course, supplemented by an independent study or technical elective that enables students to learn more advanced technical concepts and get additional course credit for those involved in multiple years of the program. Given the increased emphasis in CAVs, we recommend that the two courses include one focused on propulsion systems topics and one on CAVs.

Universities will be required to document the proposed course(s) that will include AVTC12 content and how they will enable a mechanism for course credit for student involved in AVTC12. Once admitted, teams will be expected to show verification that some participating students are receiving course credit each semester, through the submission of an annual Good Faith Agreement.

D-2.6 Faculty Support

As described in Section C-1.7, each university will be required to identify two faculty advisors for AVTC12: one faculty from the Mechanical Engineering department and a second faculty from the Electrical Engineering, Computer Engineering, or Computer Science departments. These two primary faculty advisors should collectively have experience in advanced propulsion systems, vehicle design and integration and CAV's technologies. An ME advisor may oversee the CAVs development, assuming that they have the appropriate expertise. However, one faculty advisor must be appointed the lead of the propulsion system development activities while the other faculty advisor must be appointed lead of the CAVs activities.

Additionally, one faculty advisor must be appointed as the Lead Faculty Advisor for the team, who will be the organizers main contact and will have responsibility and authority for the program and participating students. Faculty release time and other requirements are defined in a later section. Advisors from other areas of the university will be helpful to support the project management and communications swimlanes. Additional faculty are strongly recommended to provide additional technical support and/or mentoring, but are not a competition requirement.

Given the commitment required for faculty to support AVTC12, both faculty advisors must have at least TWO of the following accommodations from the university:

- Teach one AVTC12-specific course for course credit annually as part of their normal annual teaching load
- Receive Faculty release time for one course from their teaching load annually
- Receive one month of paid summer salary support

Special consideration for course credit will be given on a case-by-case basis for new teams unable to set up this support in Year 1.

Universities will be required to document their faculty support commitment in the proposal. Additional faculty support is an enabler for team success and will be considered as part of the team selection process. Once accepted, a university will be required to show documentation of faculty support in their annual Good Faith Agreement.

D-2.7 Facilities

Universities are required to provide a number of facilities on campus at no cost to their AVTC12 team to ensure their success in the program. At a minimum, these facilities must include the following:

- Dedicated garage space with a vehicle lift
- Secure high-voltage work area to enable high voltage subsystem testing in a secure and safe environment
- Abundant access to a machine shop with fabrication capabilities
- Dedicated team offices and work area for use by the AVTC12 team
    - Must include a mechanism for secure storage and access of digital information provided by GM and other sponsors, as required by competition Non-Disclosure Agreement(s)
- Abundant access to a computer lab with simulation and CAD capabilities
- Abundant access to a closed-course facility for vehicle testing and a method to transport the vehicle to this facility
    - This test area does not need to be an actual vehicle test facility, but can be a typical facility re-purposed for vehicle testing (a closed parking lot, runway, etc.). Proposals should detail the facility itself, limits to the testing teams can conduct, availability of the facility (cost, scheduling requirements, etc.), and availability of trailering or towing equipment to transport the vehicle to this facility. Note, GM will cover the cost to ship team vehicles to competition events where the vehicle is needed. However, the team does need a method to safely transport their vehicle to local events and closed-course vehicle testing.

    - It is strongly encouraged Universities have closed courses available to them where they can do both propulsion system and CAVs vehicle testing. The propulsion system and CAVs testing facilities do not need to be the same, but proposals should detail what facilities are available and what types of testing can be done at each.
- Universities also benefit from an electronics lab, vehicle and engine dynamometer and test facilities, etc.

All facilities must have appropriate safety equipment for the work performed in each area. Throughout the competition, teams will be required to demonstrate that safety requirements for their work sites are met. Teams will also be required to keep safety documentation up to date throughout the four-year program. While many teams will not necessarily have all of these capabilities before they are accepted into the competition, they will be required to have secured computer and simulation facilities, as well as student offices, by September 1, 2018. Teams must also have the appropriate garage space and vehicle lift to safely and adequately integrate, test, and refine their advanced technology vehicles by January 1, 2019. Universities will be expected to explain in the proposal how they will be able to secure these facilities within the required timeframe.

E AVTC12 Proposals

Each school wishing to be considered for acceptance into AVTC12 must prepare and submit a proposal that conforms to the outline that follows. AVTC12 proposals are to be written primarily by the students, with faculty advisor guidance. Each proposal must be signed by all student authors and indicate their expected graduation dates and faculty advisor(s). Important considerations in the selection process include the extent of administrative support provided, the interdisciplinary focus of the team's organizational structure, the commitment and backgrounds of the faculty advisors, the type of facilities available to the proposing team, and the documented experience and expertise of the team in areas applicable to the program.

Participants in this competition become collaborators with the organizers and other teams in a multi-million-dollar, four-year program to design and build the vehicles of tomorrow and train the engineers of the future. A significant factor in the success of schools in prior competitions has been the team's desire to take advantage of all the opportunities offered in the competition. Knowledge, capability, facilities, and experience are necessary but, on their own, are insufficient for success in AVTC12. The commitment of the university administration, faculty, and students and the focus on interdisciplinary collaboration are essential to success. The following description outlines the required components for the AVTC12 proposal.

E-1 Proposal Process Overview

The AVTC12 proposal process is broken down into three documents: the Administrative Proposal, the Dean of Engineering's letter, and the Modeling Exercise Report. The required elements of each part of the proposal are detailed within this section and its subsections. Proposals will be reviewed by a team of organizers and sponsors who have the appropriate technical background and experience.

E-2 Administrative Proposal

E-2.1 Administrative Proposal Content

Universities are to use this outline for writing their AVTC12 Administrative Proposal. Each Administrative Proposal must include responses to all of the topics noted in the subsequent subsections. Note that this is the university's chance to demonstrate that it has the knowledge, experience, facilities, and desire and that it will provide the support necessary to compete successfully in AVTC12. If you cannot meet any portion of the minimum requirements stated below, please describe in detail what you can do instead to still be successful in the program or how you will work to meet these requirements (and an expected time when you intend to satisfy these requirements).

E-2.1.1 Abstract

In 500 words or less, describe why your team should receive an invitation to participate in AVTC12. Include the overall rationale for your school's participation, including the goals and objectives of the College of Engineering and how these goals and objectives will be met.

E-2.1.2 Interdisciplinary Focus

In this section, teams should summarize how their university will specifically enable interdisciplinary collaboration within the College of Engineering and throughout the appropriate areas within the university.

I) Engineering

- Provide the expected interdisciplinary engineering plan for your team. Include how the faculty and students from these departments will communicate, collaborate, and provide resources to support systems-level engineering.
- Address how the team will support an increased emphasis on CAV technology (estimated at ~40% of the team's workload, competition deliverables, etc.).
- Highlight any existing key partnerships within the College of Engineering that will improve your team's chances of successful interdisciplinary collaboration.

II) Project Management

- Describe how you will ensure the Project Manager has the technical and leadership skills to collaborate appropriately with all areas of the team and with the appropriate faculty, administration and support staff as needed.
- Describe what resources will be available to support the students' activities (faculty advisors, administrative and staff support, etc.) such as fundraising/sponsorship, accounting, travel arrangements, etc.
- Describe your plan for sponsorship development and how you would accomplish the goal of identifying, confirming, and maintaining these sponsors throughout the four-year program.
- Highlight any existing external sponsorship commitments or key collaborations with local, regional, and/or state organizations that may enhance your team's local support.

III) Communications

- Describe the department, club, or organization from which the Communications Manager will be recruited (Public Relations, Journalism, Communications, etc.).
- Describe how you will ensure the technical and communications team members work together to plan and execute team deliverables.
- Detail what resources will be available to support the Communications Manager with local media relations and government relations outreach efforts. Include a description of the support provided by the university (College of Engineering's Communications office or other area of the university) to support the Communications Manager with local media relations and team news coverage.

E-2.1.3 Team Personnel Plan

In this section, teams should describe their plan to establish a team leadership structure, support graduate students, recruit and retain students, and support the faculty members needed to be successful in the competition.

I) Team Management

Please see Section C-1 for a description of the funded student positions referenced below.

- Engineering: Describe how you expect your team will fulfill the key engineering management roles throughout the four-year program: Engineering Manager, Vehicle Systems Lead, CAVs Lead, CSMS Lead, etc.
- Project Management: Describe how you expect your team will fulfill the Project Manager role throughout the four-year program.

- Communications: Describe how you expect your team will fulfill the Part Time Communications Manager role for the four-year program.

II) Leadership Succession

As team members and student leaders move on throughout the AVTC12 series, planning and executing a successful knowledge transfer plan will be very important. Therefore, teams must have a progression and succession plan for team leadership (in engineering, project management, and communications) and include it in this section. For example, will there be any overlap between current and future leadership roles? How is the team planning to train its current students to assume leadership roles in the future? The proposal should address how your team will ensure continuity over the four-year competition.

III) Team Structure & Recruiting & Retention

Discuss how your school will recruit and retain the necessary team members from the engineering and communications disciplines.

IV) Faculty Support

To be successful in the competition, AVTC12 teams will require the support and guidance of dedicated faculty throughout the four-year competition. This section should detail the faculty supported afforded to the AVTC12 team.

- Identify the two specific faculty advisors who will support the AVTC12 team and describe their qualifications and the specific roles they will serve over the four-year program. Describe any relevant experience or backgrounds of the advisors that will enable them to provide information on and share knowledge of automotive systems and to mentor to the team.
- Explain each advisor's course load and explain planned funded research commitments during the duration of AVTC12.
- Describe how the university will meet the requirements for faculty release time, as listed in Section D-2.6.
- Provide a detailed description of any additional faculty who will serve in a mentoring or advisory capacity to the team and how their support will be managed by the Lead Faculty Advisor.

E-2.1.4 Additional University Support

Describe the support that will be provided by the university. If you cannot meet any portion of the minimum requirements stated in this section, please describe in detail what you can do to still be successful in the program.

I) Graduate Student and Assistantship Support

This subsection covers the use of competition-provided GRA funding, as described in Section C-1 and D-2.4.

- Describe how your university will utilize the funding for the three competition-funded GRAs (Project Manager, Engineering Manager, and CAVs Lead). Will the university need to supplement this funding to ensure the graduate students are full time?
- Describe how your University will provide matching funding to ensure the two additional full time GRAs (Vehicle Systems Lead and CSMS Lead).
- Describe any anticipated additional matching support from the university or outside sponsor for GRAs.
- Describe how your university will utilize the funding to support a Part Time Communications Manager and any matching funding provided by the university or outside sponsor.

II) Curriculum

- Integration into Existing Curriculum: Explain how AVTC12 will be integrated into TWO existing and/or planned courses, as described in Section D-2.5.
- Systems-Level Automotive Engineering Curriculum: Include a summary table of any classes available to students that include automotive-engineering-related content in addition to the required classes referenced above. Include advanced vehicle propulsion systems and vehicle technology, as well as control and mechatronics classes, at a minimum.

- Areas of Note: If your school has special institutes or relevant areas of excellence, describe how they will specifically be used to support AVTC12.

III) Academic Credit:

Describe the mechanism that your university will provide for students to meet the minimum requirements for earning academic credit for working on the program.

IV) Administration and Support Staff

AVTC12 teams will require the support and guidance of university administration and support staff to plan and execute their activities throughout the four-year competition.

- Describe the administrative services that will be provided at no cost to the team throughout all four years of the program. As described previously, some examples may include, supporting the team with accounting, invoice processing and travel coordination; the College of Engineering's development office may support the team's local fundraising and sponsorship efforts; and the university or College of Engineering's Communications office may support local media relations and team news coverage.
- If overhead or other fees must be assessed by the university, a description of the fees and what services they apply to, must be included in the proposal and will be a factor for acceptance into AVTC12.

V) Travel Support:

Describe how faculty advisors will participate in annual workshops and competitions. Also state how faculty advisors will ensure students who travel to competition events will not be penalized for their absence from campus/class. List any financial support provided by the university to supplement the competition-funded travel stipends.

E-2.1.5 Prior Student Competition Experience

Provide a table describing your school's experience in conducting other major vehicle or engineering research or project; include team or faculty members who participated in any previous DOE AVTCs, the SAE collegiate design competition series, or other vehicle competitions. If your University does compete in additional vehicle competitions, explain how resources will be allocated to properly support AVTC12. Special attention will be focused on teams who are already heavily engaged in other large-scale student competitions that may compete for resources within the university.

E-2.1.6 Facilities

In this section, teams should describe the facilities support provided by the university.

I) Required Facilities

Include a table showing the facilities available at the college or university that could be used to accomplish the goals of AVTC12. Teams must use the template shown in Table 5 (or something similar). Teams should provide pictures of any facilities they plan to use during AVTC12. Teams may place these photos in the appendix if desired.

Table 5: Template for Required Facilities

Facility	Summary Description	Date Available	On Campus?	Hours of Student Access	Shared or Dedicated
Secured simulation and computing laboratory					
Secured garage with hoist					
Secured office space or work area					
Machine shop and fabrication facilities					
Secured high-voltage work area					
Closed-course facility for vehicle testing (include types of testing, cost, scheduling and other relevant details in the description column)					
Transportation method for your vehicle to local events/testing					

II) Additional Facilities

Include a table of any special features or facilities at your university that would enable the team to work more effectively, such as vehicle lifts, dynamometers, CAD lab, etc. Teams must use the template shown in Table 6 (facilities listed here are examples). Teams should provide pictures of any facilities they plan to use during AVTC12. Teams may place these photos in the appendix if desired.

Table 6: Template for Additional Facilities

Facility	Summary Description	Date Available	On Campus?	Hours of Student Access	Shared or Dedicated
Engine dynamometer					
Chassis dynamometer					
Other					

E-2.1.7 Safety Processes

In this section, teams should outline the safety process that are currently in place or that will be implemented upon acceptance into AVTC12.

I) Team Operations

Describe how safety will be built into the school's plans and procedures throughout the competition. Provide an overview of how the university plans to develop the required safety plan(s) for on- and off-campus AVTC12 activities. Be sure to include a summary of current machine shop, welding, vehicle hoist, and high-voltage electrical safety training and certification procedures if they exist.

II) Vehicle Design

Include an explanation of the current infrastructure setup for students to learn and implement advanced analytical techniques to justify their designs. This can include structural designs or modifications requiring finite element analysis (FEA) and nonstructural designs requiring CFD, high-/low-voltage circuit analysis, software and controls design and processes and/or thermal analysis for mechanical and electrical systems.

III) Facilities and Protocol

Identify who is responsible for defining and enforcing laboratory safety practices relative to the testing of mechanical systems, high-voltage electrical systems, and liquid hydrocarbon fuels per applicable local fire standards and college or university procedures. Identify who is responsible for defining and enforcing safety practices relative to vehicle systems testing outside of the laboratory environment.

E-2.1.8 Fundraising and Outside Relationships

In this section, teams should provide a general project budget and a brief fundraising plan that describes any university support and existing local partnerships as well as how the team would engage new partners if accepted.

I) Budget Planning

Provide a high-level, four-year budget outline needed to support successful participation in AVTC12. Elements to consider include funding for vehicle parts, subsystems, and components; tools and safety equipment fabrication and finishing; possible testing fees; team travel not provided by the organizers (to workshops, competition events); trade show and sponsorship materials; and community outreach.

II) Fundraising Plan

Document any existing university or local sponsorship commitments from external partners or and highlight any successful examples of partnerships from a previous program. Provide a plan for acquiring additional contributions (product donations, cash, technical support, etc.). Include letters of support from potential or confirmed sponsors in the appendix, if possible.

E-2.1.9 Summary and Discretionary Factors

In this section, teams may include any other considerations that would demonstrate that your school is capable and committed to success in AVTC12. Include any additional information that may indicate your university has what it takes to be a successful competitor in AVTC12.

E-2.1.10 Appendix

The appendix is exempt from the page limit, however, teams are restricted in what information can be included. Teams may not use the appendix to circumvent the page limit for the proposal. Therefore, only the following documents may be included in the appendix:

- Photos of facilities secured for use by the team in AVTC12 (see Section E-2.1.6)
- Summary of safety procedures for team facilities (see Section E-2.1.7)
- Letters of support from local sponsors (see Section E-2.1.8)

Teams may include support letters from local sponsors or supporting documentation for facilities, curriculum, etc. Note that the required support letter from the Dean of Engineering is a *separate* document.

E-2.2 Administrative Proposal Formatting Requirements

The Administrative Proposal is limited to 17 pages total, excluding the cover page, table of contents, and the appendix (which includes letters of support). Proposals must be written in English and submitted as a PDF document. Teams must a font size at least as big as 11 point Calibri and may not use margins smaller than 1 inch. Proposals should be written by students and must be signed by all authors and the faculty advisor(s).

Team reports must follow the outline provided in Table 9. This table also illustrates the page limit requirements and provides insight on how the report will be evaluated. Each submission must include responses to all of the topics and must follow the format and structure provided, including the table templates where indicated. The finished report must be signed by the students that participated in authoring the report, as well as any faculty advisor that contributed to the report.

TABLE 7: ADMIN PROPOSAL SUBMISSION OUTLINE AND SCORING

Scoring	Section	Page Limit
0%	Cover Page	No limit
0%	Table of Contents	No limit
3%	Abstract	17 pages
15%	Interdisciplinary Focus	
	Team Personnel Plan	
45%	Additional University Support	
30%	Prior Student Competition Experience	
	Required Facilities	
	Safety Processes	
5%	Fundraising and Outside Relationships	
7%	Summary and Discretionary Factors	
	Appendix (including letters of support)	No Limit

E-3 Dean of Engineering Letter

Each university must also include a letter signed by its Dean of Engineering or another senior university administrator, agreeing to meet the following minimum requirements as described Section D-2:

- Travel and Participation
- Administrative Support
- Matching GRA Funding
- Matching Seed Money
- Curriculum Integration and Course credit
- Faculty Support
- Required Facilities
- Commitment to Interdisciplinary collaboration

E-4 Modeling Exercise

The 12th AVTC series will require students to demonstrate technical competency in various areas including electrification and autonomous vehicle controls, automotive mechatronics, and CAV technologies. The modeling exercise described in the following sections includes elements of propulsion system modeling and CAV system modeling, both of which will be foundational activities performed over the four years of AVTC12. As part of the team selection process, teams are required to complete this modeling exercise as a demonstration of the technical competency required from any university selected for participation in AVT12. Hence, the reports submitted by applicants will be evaluated by industry experts to gauge the technical competency of applicant universities, which will be one of several factors considered during the team selection process.

This modeling exercise is intended to be completed by either graduate or undergraduate students, with guidance from a faculty advisor. Applicants should note that the work required for this modeling exercise likely cannot be completed by a single person in a matter of days. Rather, universities are encouraged to recruit a group of students to complete the modeling exercise and write the required report as a team.

E-4.1 Modeling Exercise Report Content

The modeling exercise includes two main portions: propulsion system modeling and CAV system modeling. Both portions of the modeling exercise revolve around an example model described in Section E-4.3. Teams are intended to use this example model to complete the exercise outlined in the following sections.

When writing the report for this modeling exercise, teams are free to use figures, charts, and tables as needed to most effectively and efficiently convey the required information. Teams should carefully consider what information is placed in

the body of the report and what is delegated to the appendix. Information that is critical to supporting the team discussion or conclusions should be presented in the body of the report. Data that is supplementary or auxiliary and is not critical to underpinning discussions or conclusions is appropriate for the appendix.

E-4.1.1 Connected and Automated Vehicle System Modeling

For this portion of the modeling exercise, teams should begin with the stock parameters for the propulsion system and run the model over HWFET, UDDS, and US06 drive cycles. Teams should first run the model over these drive cycles using the conventional driver model and then re-run the model using the adaptive cruise control (ACC) model. Teams should collect the results of both sets of runs and report on the following items:

- Report the energy consumption (Wh/mi) of the vehicle over the specified cycles for each driver model
- Which driver model yielded better energy consumption results *and why*?
- Which drive cycle yielded the biggest difference between the two driver models *and why*?
- How could the ACC driver model be modified to improve energy consumption results?
- Compared to an actual ACC-equipped vehicle, what simplifications and assumptions does the ACC controller make?

E-4.1.2 Propulsion System Modeling

For this portion of the modeling exercise, teams should begin with the stock parameters for the propulsion system and use the conventional driver model (not the adaptive cruise control model). First, teams will examine the effects of regen braking in the example model. Teams should begin by running the model (using stock parameters) over the HWFET and UDDS cycles. After collecting results from the simulations, teams should comment on the following items in the body of their report:

- Report the energy consumption (Wh/mi) of the vehicle over the HWFET and UDDS cycles
- During which cycle is the vehicle most impacted by the effects of regen braking *and why*?
- How much *useable* energy (Wh) is recovered via regenerative braking and stored in the battery over the HWFET and UDDS cycles? Briefly discuss how this was determined.

Next, teams should adjust the parameters of the model to achieve a 200-mile driving range based on the US06 drive cycle while also meeting the power requirements of the US06 cycle. In the motor plant model, teams should only modify the maximum torque and maximum power parameters and should not adjust the other parameters. In the battery plant model, teams should only modify the number of cells in series (Ns) and the number of cells in parallel (Np). After completing this exercise, the team must report any model parameters that were modified using Table 8 as a template.

TABLE 8: TEMPLATE FOR REPORTING MODEL PARAMETERS

Plant Model	Parameter Name	Units	Value
Battery	Cells in series	---	
Battery	Cells in parallel	---	
Motor	Maximum torque	Nm	
Motor	Maximum power	W	
BMS	Discharge limit	W	
BMS	Charge limit	W	
Vehicle	Vehicle mass	Kg	
…	…	…	
…	…	…	

Teams should also comment on the following items in the body of their report:

- Briefly describe the process used to calculate the range of the vehicle and state any assumptions for the minimum SOC of the battery
- Briefly describe the process used to verify the vehicle could meet the power requirements of the US06 drive cycle
- Report the maximum voltage (V), energy capacity (kWh), and expected total system weight of the battery. Briefly discuss how these battery characteristics were determined.

- What impacts, if any, does battery sizing have on motor sizing? What impacts do battery and motor sizing have on the regen braking capabilities of the vehicle?

E-4.2 Modeling Exercise Report Formatting Requirements

Teams must submit a brief report capturing their work on the AVTC12 RFP modeling exercise. Note that this is a ***separate*** report from the administrative proposal. This report must be submitted in PDF format and must be no longer than six pages, not including a cover page, table of contents, or appendices. Teams may include an appendix, which may not exceed four pages. Teams must a font size at least as big as 11 point Calibri and may not use margins smaller than 0.5 inches.

Team reports must follow the outline provided in Table 9. This table also illustrates the page limit requirements and provides insight on how the report will be evaluated. Each submission must include responses to all of the topics and must follow the format and structure provided, including the tables and figures where indicated. The finished report must be signed by the students that participated in authoring the report, as well as any faculty advisor that contributed to the report.

TABLE 9: MODELING EXERCISE SUBMISSION OUTLINE

Scoring	Section	Page Limit
0%	Cover Page	No limit
0%	Table of Contents	No limit
50%	CAV System Modeling	6 pages
50%	Propulsion System Modeling	
0%	Appendices (including references, if desired)	4 pages

E-4.3 Example Model Overview

As previously stated, the modeling exercise revolves around an example Simulink model that has been made available to all applicants. This example model is a modified version of the Electric Vehicle Reference Application from the Simulink Powertrain Blockset. The main modification is the addition of a classical adaptive cruise controller. This ACC controller used in the example model is inspired by the ACC controller from the "Adaptive Cruise Control with Sensor Fusion" example from the Automated Driving Systems Toolbox. However, teams should note that there are significant differences between ACC controller in the RFP example and the MATLAB example noted above.

Figure 3 provides an overview of the example model. All of the propulsione system plant models are contained within the Passenger Car block. Teams should use this block to complete the battery and motor sizing activities described in Section E-4.1.2. The two driver models (conventional and ACC) are contained within the Longitudinal Driver block. More details on running the model are provided in Section E-4.3.2.

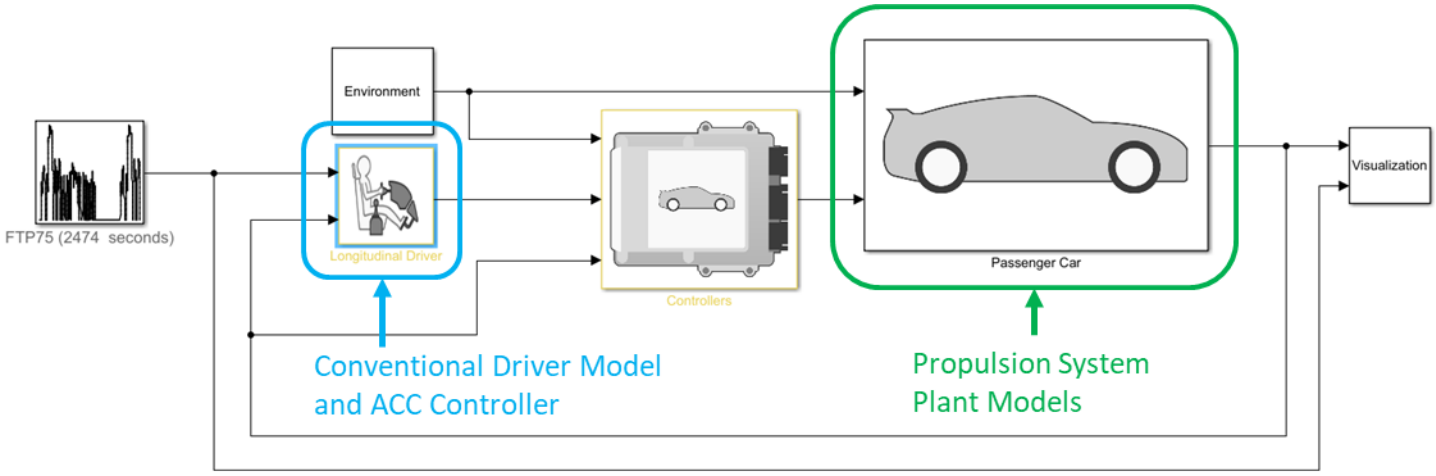

FIGURE 3: OVERVIEW OF EXAMPLE MODEL USED FOR MODELING EXERCISE

Teams should take care to thoroughly explore and understand the model before completing their proposal. Comments and annotations have been left throughout the example model to assist with this purpose. A robust understanding of the model will be essential to successfully complete this modeling exercise.

E-4.3.1 Instructions for Downloading the Example Model

The example model used for this modeling exercise can be accessed for download via Box.com at the following link: https://anl.box.com/v/AVTC12RFP. This folder contains all materials for the RFP including the example model, which is titled "EvRefApp6.zip". This link is open to anyone and a Box.com account is *not* required to access and download the materials.

E-4.3.2 Guidance for Running the Example Model

After downloading the model, the files should be unzipped and placed in a directory on the computer's hard drive. To open the model, use the MATLAB folder explorer pane to locate the directory containing the model, as illustrated in Figure 4, and follow the directions below:

1. Double click the file titled "EV.prj" to initialize the directories for the example model within MATLAB
2. Double click the file titled "EvReferenceApplication.slx" to launch the example model

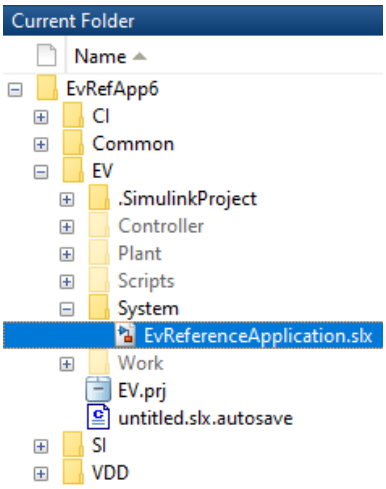

FIGURE 4: EXAMPLE MODEL FILE STRUCTURE

To run the example model, select a drive cycle in the Drive Cycle Source block and press play. Depending on the installation of MATLAB, the user may be required to download and install the drive cycles required for this exercise. This can be accomplished via the Drive Cycle Source block, as illustrated in Figure 5.

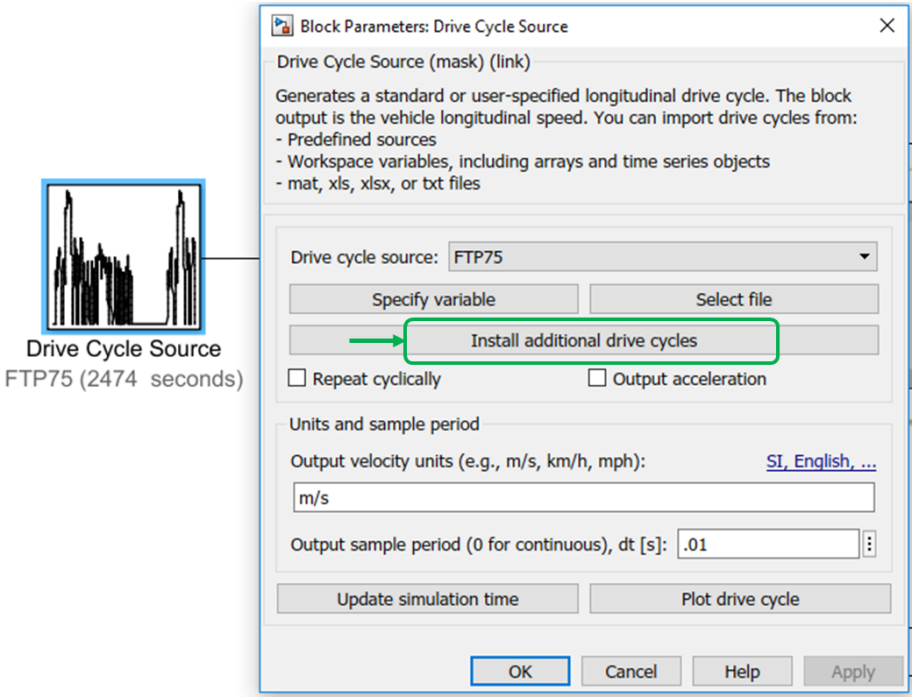

FIGURE 5: DRIVE CYCLE SOURCE BLOCK – HOW TO DOWNLOAD ADDITIONAL DRIVE CYCLES

To toggle between the conventional driver model and the ACC controller, a switch was added to the Longitudinal Driver block. To change which vehicle controller is used, teams can simply change the UseAdaptiveCruiseControl parameter as shown in Figure 6.

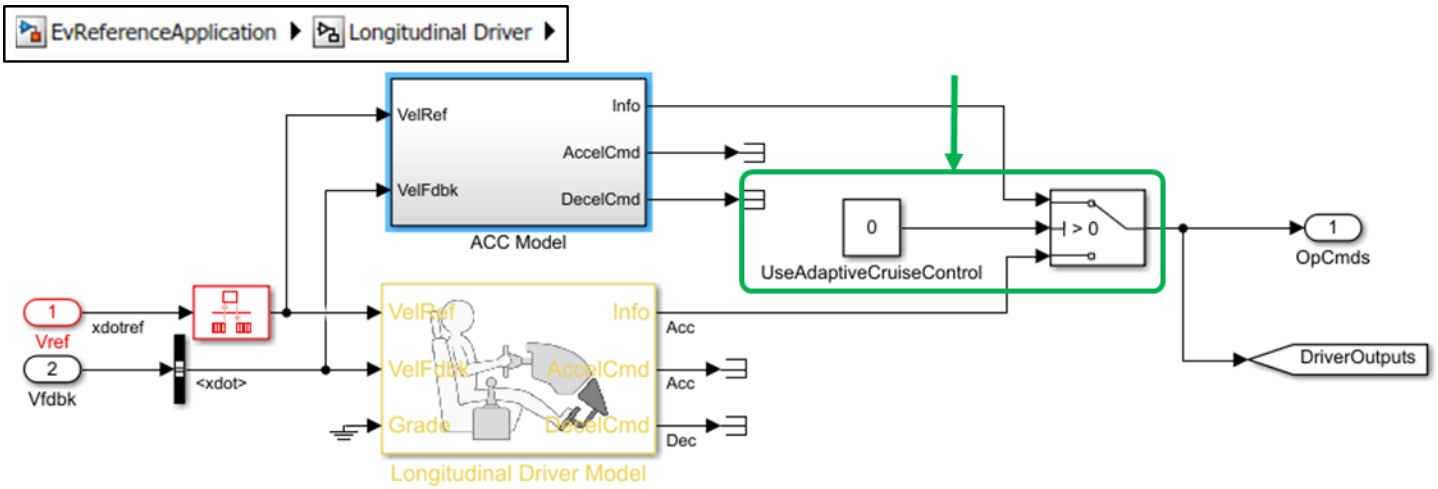

FIGURE 6: LONGITUDINAL DRIVER BLOCK – ACC CONTROLLER SWITCH

As previously stated, teams must develop a robust understanding of the example model to understand the interactions and dependencies of the various model blocks and parameters. One such example is the Battery Management System block, which is under the Controllers block on the top level of the model. The contents of this block are illustrated in Figure 7.

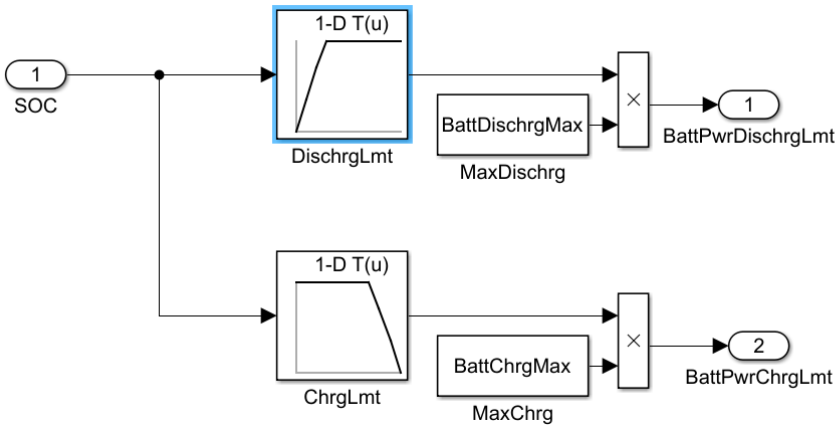

FIGURE 7: BATTERY MANAGEMENT SYSTEM BLOCK

The Battery Management System block enforces charge and discharge limits consistent with the behavior of a typical battery system. These power limits are based on battery SOC and can be adjusted if the battery pack is scaled up or down. Note that this block is in a completely separate branch of the model compared to the plant model of the battery. Thus, this is an excellent example of an interaction between various parts of the model that affect overall performance. Teams should be advised that this specific example will directly impact teams during the battery and motor sizing exercise.

E-4.3.3 Software Requirements to Run the Example Model

To run the example model, MATLAB version R2017b must be installed, along with the following MathWorks products (at a minimum):

- MATLAB 9.3
- Simulink 9.0
- Powertrain Blockset 1.2

Teams must also download and install the latest update for version R2017b, which will fix some minor bugs in the model. The MATLAB update installer can be accessed at the link below:

https://www.mathworks.com/downloads/web_downloads/download_update?release=R2017b&s_tid=ebrg_R2017b_1_1640479

Universities that do not have access to these products may contact studentcompetitions@mathworks.com to arrange for a short-term trial license. Requests *must* use the subject line "AVTC12 RFP License" to be valid. Requests will be fulfilled within 72 business hours.

E-5 Submission Criteria

Only one proposal per university will be considered. As stated previously, universities are permitted to partner with another university or college, as long as the partnership is clearly articulated in the proposal. Only one joint proposal will be considered.

An electronic PDF version of the Administrative Proposal, the Dean of Engineering's letter, and the Vehicle Powertrain Modeling and Design Problem Proposal submission must be ***emailed*** **as three single files** to ***avtc@anl.gov*** *no later than* 4:00 p.m. Eastern Standard Time (U.S.) on April 12, 2018. Teams are to attach the three documents to the email using the following naming convention:

- Administrative Proposal: UniversityName_AVTC12AdminProposal.pdf
- Dean of Engineering letter: UniversityName_AVTC12DeanLetter.pdf
- Modeling Exercise Report: UniversityName_AVTC12ModelingExercise.pdf

Teams are also required to include their university's name as the subject line and to include the name of the person who is submitting the proposal, along with his or her, title, email address, and phone number, in the body of the email. The PDF version of the proposal must be able to be viewed and printed correctly; the organizers take no responsibility for, and will make no efforts to correct errors in the proposal or its PDF form. If any uploaded proposal contains PDF errors that will not allow it to be viewed and/or printed properly, it will be returned to the school and not be reviewed.

IMPORTANT: Submissions not conforming to all the requirements of this solicitation may result in rejection of the proposal. Argonne National Laboratory is not responsible for any costs associated with the preparation or submission of a proposal. Argonne National Laboratory assumes no liability for disclosure or use of any proposals for any purpose. Argonne National Laboratory reserves the right to select or reject any or all proposals. Argonne National Laboratory reserves the right to amend the RFP as it may consider appropriate to meet the goals of AVTC12. Any potential funding associated with selection for AVTC12 is subject to availability of funding from the Government and/or potential Sponsors.

E-6 Evaluation Criteria

Each proposal will be evaluated on the basis of the submitted materials by a panel of government and industry experts. The evaluation criteria for the Administrative Proposal and Modeling Exercise Report are outline in Sections E-2.2 and E-4.2, respectively. The organizers will use the following weighting to combine the evaluations for both documents to achieve a final score:

- Administrative Proposal (70%)
- Modeling Exercise Report (30%)

E-7 Notification of Acceptance or Rejection

Schools submitting a proposal will be notified whether they will be accepted into AVTC12 in early May 2018. Every attempt will be made to notify the university before the end of your Spring Semester. The Dean of Engineering and Lead Faculty Advisor(s) of accepted schools will receive an official acceptance letter. Organizers will also contact the Lead Faculty Advisor of each accepted school to review the program timeline and other details. Selected schools will also receive an invitation to the mid-September Kickoff Workshop and public announcement of the participating teams and the new competition series (the official name is forthcoming). Public discussion (including media coverage) about the selected schools or about the

competition will be strictly embargoed until specific details are provided by organizers. Teams selected must adhere to the restrictions outlined in the Embargo Document that will be provided to chosen schools.

F AVTC12 Schedule

Table 10 lists the dates for AVTC12 competition milestones.

TABLE 10: AVTC12 COMPETITION MILESTONES

Date*	Milestone
March 7, 2018	RFP released
April 12, 2018	Proposals DUE
May 2018	Teams notified of selection (embargoed until September 2018)
September 2018	Team selection announcement/Kick Off Workshop
January 2019	Pending Year 1 Winter Workshop
May 2019	Year 1 Competition

*The competition organizers reserve the right to make changes to these dates.

Questions Concerning the RFP and AVTC12: General questions should be sent to avtc@anl.gov .