LAFAYETTE COLLEGE

Electric Formula SAE 2020-21

Easton, Pennsylvania 18042-1775

FSAE Electric Formula Car TD001 - Conceptual and Preliminary Design Study

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Introduction

This document outlines the preliminary design and plan for the 2020-2021 Lafayette College FSAE Formula One Hybrid Team. This is the 2021 Senior Design Project for 17 Electrical and Computer Engineers and 14 Mechanical Engineers that encompasses 2 semesters of work both on campus and off. The project is in beginning stages and this is reflected by the Conceptual and Preliminary Design Study.

The main goal for the 2020-2021 Lafayette Formula Electric Vehicle team is to deliver a completed "on-paper car" by the end of the Fall semester and a fully functional, rules compliant electric car by the end of the Spring semester. Our definition of an "on-paper car" will include completed mechanical designs, software, firmware, thorough testing and analysis, and all required documentation needed for a rules compliant vehicle. With all of these criteria met, only the fabrication and installation of the completed designs will be necessary to provide a rules-compliant vehicle in the spring semester.

1. Motivation for Project

The motivation for participating in the Formula Electric Vehicle project is to compete in the 2021 Formula SAE Electric vehicle competition in the spring of 2021. The 2020 team did not have the chance to compete in the competition and left designs, documentation, and physical systems and structures so that we could build upon it and finish the car this year. For the fall semester, the motivation is to complete an on-paper design of any subsystems that need to be manufactured in the spring. This includes anything that can be completed while remote including; software, rules compliant designs, inventor models, and in depth subsystem manuals. This will allow the team to complete the physical aspects of the car in the spring and have a completed car for the competition.

Through the process of completing the car, the students will have learned and participated in a team oriented environment with a common goal. This is instrumental in helping students build teamwork and communication skills needed in the workforce. It will also help them build personal or professional interests in different parts of engineering.

Success can be measured depending on whether Lafayette College allows an on-campus experience in the spring 2021 semester. A successful first semester will be determined if the required on-paper documents and code are finished by the end of the semester. This will allow for car completion in the spring as well as allow any future teams to be able to take the designs and implement them if we do not go back in the spring. If we do go back in the spring, a success will be making it onto the track on competition day. Either of these situations will reflect well on the students and professors who worked 2 long semesters completing and designing a rules complaint car.

2. State of the Art

2.1 Current State of the Art

To create an understanding of the current state of the art Formula Hybrid designs it was necessary to the competition's outstanding performers. By looking at previous designs and documentation through other high achieving team's websites. Numerous websites and designs were assessed however, RPI and IIT were laboriously documented and provided a window into both the competition's work structure and helped to quantify competitive performance guidelines for Lafayette's Formula Hybrid project. Most importantly, however, is to understand the performance and innovation being made within this competition. Previous results are published and available, and will be used to form a benchmark for the performance of the Lafayette Motorsports FSAE EV.

Perhaps the most important point of comparison to state of the art is the team's ability to pass the rigorous technical inspection. The vehicle cannot compete if it does not pass tech. Therefore, the rules document provided is vital to shaping the design of the 2020-2021 vehicle. Many teams do not pass this technical inspection, and simply doing so is the first step towards a competitive effort at the track. The team will use the rules document and input from competition officials as the primary benchmark when making design decisions.

Next, comparing our projected performance to previous successful vehicles will be valuable when making decisions. Based upon results from years past, some of the data points readily available are cost, performance statistics, vehicle weight, and track times. Through this analysis, it is found that vehicles who score highest for the FSAE EV competition have a price under $20,000, 0-60mph times of less than 4.5 seconds, perform well in curved tracks, weigh approximately 400-500 lbs, and are constructed soundly to be able to complete endurance and efficiency events.

After comparing last year's team's pre-existing mechanical designs with those of the competition, we saw minor technical differences, the majority of which were based on following updated rules. However, the structure of the other cars varied greatly. Both the RPI and IIT cars attempted to optimize for air resistance by adding wings to both the top and bottom of the car. In conjugation with changing the location of the batteries to a more central area, again focusing on the aerodynamics of the car. In order to reach competitive track times both the RPI and IIT have multiple Ermax motors to improve speed performance, instead of the single Emrax currently in use. RPI and IIT use Lithium Ion batteries in large quantities to store more energy to compensate the motor.

Continuing to compare the designs, the electrical systems RPI uses a custom system named RFHB, which is used to monitor the electrical "monitors several performance characteristics such as wheel speed, suspension position, driver input encoders and hardware in the pedalbox and on the dashboard, a six degree of freedom Inertial Measuring Unit, and a GPS receiver." IIT also demonstrates on their website a working phone dashboard that displays information from the car to the driver and for testing and debugging.

References:

https://www.sae.org/binaries/content/assets/cm/content/attend/2019/student-events/formula-sae/north/fsae_on_2019_ev_result.pdf

https://sites.google.com/iit.edu/iit-motorsports/the-car?authuser=0

https://rpiformulahybrid.com/VMR-X.html

2.2 Contributions to State of the Art

Our team's designs for various subsystems attempt to closely mirror that which has been accomplished by other competitive teams. The team will build heavily upon the previous designs set forth by Lafayette Motorsports, and will seek to improve these designs wherever possible or necessary.

The phone dashboard and audio integration will be something new to the Lafayette team and should be well integrated with the data from the CarMan and SCADA. These systems integrate the electrical side of the car fully and allow the car to move safely.

Lafayette Motorsport's primary goal for this project is to provide a car that comes as close to approaching the current state of the art of the competition, while also still maintaining feasibility and cost effectiveness. Throughout the course of the project, the team anticipates making developments that perhaps could even advance the state of the art of the competition even further. If nothing else, this year's team will greatly advance the state of the art of Lafayette Motorsports.

3. Planned Approach

3.1 Battery Packs (TSV - Tractive System Voltages)

The objective of the TSV team is to deliver a rules-compliant and logically developed accumulator. The previous year's iteration of an accumulator was not completed and so it is the duty of this year's team to deliver the final functioning packs.

There are two main objectives of design for this year's team. First is a system that completely separates all high and low voltage systems. Second is an accumulator that is able to withstand 40G of acceleration horizontally and 20G of acceleration vertically without breakage of any component or mount.

To make a logically developed accumulator, the team intends to follow the design principle of working from the outside to the inside. Ergonomics and mindfulness of physical spaces are accounted for at the beginning of the design process. Through these restrictions due to pre-placed objects on the exterior, the team can simplify the interior.

To meet the isolation requirement for high and low voltage systems, the team has chosen one insulating material: garolite. In choosing garolite, its rigidity will allow the TSV unit to withstand the acceleration tests, while still insulating the differing voltage systems.

The accumulator unit should have a footprint that is not excessively large. As to try to keep a mindfulness of keeping the weight of the car as low a value as possible. TSV must also remember that the thick orange double-aught cables will be occupying the rear three-quarters, or between the seat's firewall and the motor and motor housing. Consciousness of space will always be valued.

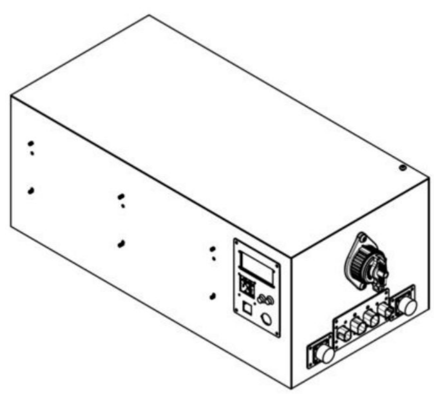

Figure 1: 2019-2020 Prototype Accumulator

The TSV team from 2019-2020 completed initial design concepts and now it is the responsibility of this year's team to deliver two rules-compliant, functional battery packs. The accumulator prototype from 2019-2020 will be analyzed for rules compliance and intended functionality. The team will fully assemble the prototype pack from last year by November 6th, 2020. And then conduct functional testing throughout the week before the beginning of Winter Break.

Once assembled, the prototype will be evaluated for performance, functionality, and rules compliance. Any needed revisions will be implemented into Inventor parts and assemblies. A design review will be hosted in the first week of school for the 2021 Spring semester. The date of the first day of class is not yet known, due to complications with COVID-19.

The design review will serve to update the entire team on the state of the packs, with any improvements to the design or critical issues noted and worked upon. fabricated by January 24, 2020.

From that meeting, work will begin to ensure that all materials needed to construct the two final enclosures are present, all part drawings are up to date, and the most recent assembly exists documenting all of these changes. These two battery packs are expected to be the final battery packs used for competition and will be modified as needed throughout later testing.

Engineering metrics and specifications for TSV design largely come from the FSAE-EV 2021 competition rules. The majority of these rules relate to safely insulating high voltage circuitry, isolating high voltage and low voltage battery pack components, having the battery packs be weather resistant, and withstanding 40 and 20 Gs of force in the vertical and horizontal directions, respectively.

Other design metrics relate to ease of use when it comes to activities relating to opening the battery packs, such as replacing parts and troubleshooting. Outside of normally scheduled class time, the TSV team meets up to 3 times per week to discuss these design metrics, ensure they are being met, and communicate with other teams to ensure rules outside of the TSV team's scope, but still related to its responsibilities, are being met, such as coordinating the mounting of the packs with Chassis.

The first order of approach for the electrical side of the battery packs is to create a unified wiring diagram to represent the TSV electrical system and all of its components. While Cellman and Packman boards have been fabricated, there remain issues with the firmware that are documented in the Errata pages left by the 2019/2020 team. In addition, the charger for the batteries has issues detecting full charge, and must either be updated or replaced.

3.2 Grounded Low Voltage (GLV)

The objective of the Grounded Low Voltage Team is to provide a rules compliant and safety-oriented GLV system in which all low voltage systems of the car depend upon. In order to achieve this goal, the team must first evaluate the current 5.1 BOB design, and make note of any designs they do not agree with or any designs that are incorrect. A main objective when redesigning 5.1 BOB is to address the identified shortcoming with the current design, including the lack of AMS fault logic. The team will then design and order a new board that fixes these errors while incorporating new designs that improve the current state of the art of the system. These designs will also be guided through the development of a test plan that will ensure functionality and rules compliance. While working on these designs, new documentation will be written that describes all parts of the GLV design and how they function. Safety will be of the utmost importance when considering and designing all aspects of the GLV system. Collaboration with SCADA, TSI, and TSV teams will also be vital to the success of the redesigned GLV system.

Work has been subdivided within the team as follows: Zachary Martin and Troy Coleman will be working primarily with the hardware design for the GLV system. Zhanfan Yu will primarily work on design, and collaboration between the GLV team and other subsystems. Zachary will primarily handle documentation, and all members will contribute to the testing if the system.

A review of the newly redesigned BOB will be held on or around October 30th, 2020, and subsequently, the testing of CAN and I2C lines will be conducted with the help of a completed SCADA system. Testing and troubleshooting of the BOB should be completed on or around November 20th. Documents and manuals will be provided on or around December 3rd, 2020.

3.3 Tractive System Interface (TSI)

The approach of the Tractive System Interface is based largely on the progress made by last year's TSI team. The previous year's team produced firmware and a TSI board that had begun testing before the forced conclusion of their semester.

Functionality that is missing from the current system includes register based configuration of firmware, MISRA-C compliant firmware design, drive state display output, proper IMD fault light latching, bus current sensing, and cooling system control.

The immediate approach of the TSI team is to finish the testing of their board, and identify problems that must be addressed. We predict most of these relate to the sensor calibration and throttle plausibility sections of the board. Once problems have been identified, a new revision of the board will be produced and tested to correct them. As current documentation is lacking in several areas, new documentation has been and will continue to be produced.

The TSI team has divided their work accordingly to help facilitate development based upon our team members' strengths. Ethan Miller is writing TSI board firmware and documentation while John

Burk and Nate Beal test the TSI board and its functionality. John and Nate have access to the ECE department's equipment and have been using such to further development.

A new throttle test rig is expected to be completed on or around September 27th, 2020. Troubleshooting of the current sensors and associated fixes are scheduled to be completed on October 11, 2020. Errata should be compiled by the 18th of October, and a fifth revision of the TSI system will be designed by November 1. A design review of the new system will be conducted the same week, and a final rules compliance assessment will be performed by November 16th.

3.4 Dashboard

The dashboard team's objective is to deliver a user-friendly and rules compliant dashboard that can inform the driver of the car's running status while driving. Due to the rudimentary progress made by last year's team, the Dashboard team is working on developing a new design, with a main goal to include both audio and visual notifications for the driver. This is in service of our second main goal, streamlining the process of driving the car and reducing the amount of driver overstimulation present in the driving process.

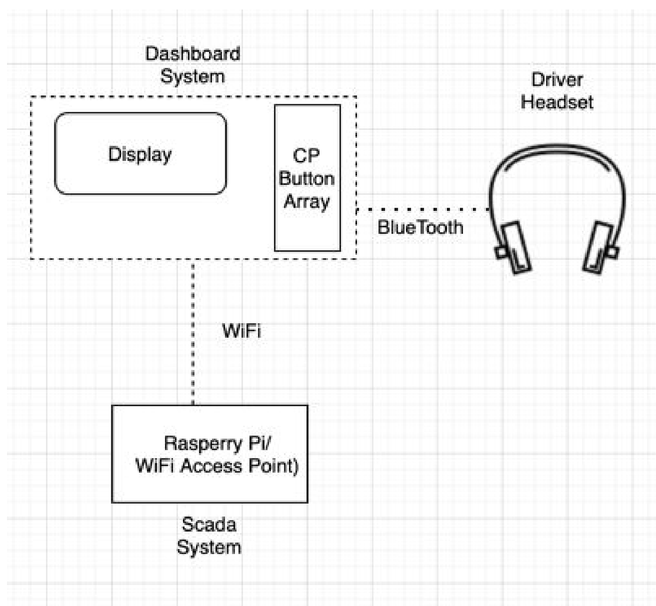

Figure 2: Proposed Dashboard Block Diagram

In order to achieve this task, we plan to use a smartphone display and status LEDs to visually indicate the state of the car, as well as the wireless capabilities of the smartphone to communicate with the driver through bluetooth audio signalling.The use of a smartphone also allows us to communicate wirelessly with the SCADA System easily through Ad-Hoc wireless methods. Adding only this functionality to the design from last year would invalidate much of the previous design, so we also plan on redesigning the cockpit panel required by the rules to streamline its operation during driving. By combining some of the status LEDs with the required cockpit buttons, we hope to reduce the number of things the driver has to look at while operating the vehicle.

While using a smartphone display is helpful for many things, we are also conscious of the rules that require certain lights and buttons to be included in the cockpit, or be otherwise visible to the driver. In service of this goal we are also planning to include a redesign of the LED layout on the Car's dashboard to make the display understandable at a glance, rather than requiring concentration to understand the dashboard information. This goes hand in hand with generating concise, helpful audio feedback for the driver to aid the driver in understanding the car's status without introducing yet another visual indicator to confuse anyone driving the car. Through including multiple methods of information communication, each of which has been simplified for ease of understanding, we aim to develop an information delivery system that aids the driver while requiring as little effort as possible on the driver's part.

3.5 Frame/Chassis

The objectives of the Chassis team are to bring last year's frame into rules compliance and to fix the ergonomic and mounting issues that multiple subsystems are facing in the rear third of the frame. The chassis has been reviewed and checked for compliant rule issues, and it is now clear what necessary alterations must be made to ensure a rules compliant chassis.

As the 2021 team received the frame, the side impact members are not 350 mm from the ground and must be cut and re-welded into compliance. Last year's team implemented a temporary fix to solve issues with the ride height being too low, which was to elevate the rear a-arm pick up points by two inches. This year's team seeks a permanent solution.

The Chassis team must also provide mounting solutions for each subsystem. The frame in its current guise does not efficiently maximize the physical space within the footprint of the car. This year's team is redesigning the rear third of the chassis in order to give more space to subsystems, and thus increase the flexibility in mounting components such as the CarMan enclosure, Motor Controller, GLV Battery, Radiator and Fan, and more. The team understands that by increasing the space available to other teams will allow other subsystems to find logical and ergonomic mounting solutions.

When designing the rear of the car, the team aims to take special care of the rear suspension. The suspension is an integral subsystem that determines many aspects of chassis design, with the suspension mounts being the most crucial. The 8 rear mounting points for the A-arms comprise the majority of the team's concern. Through many meetings with Professor Helm and the Suspension team, Chassis team understood that the 2019-2020 team delivered a well thought out system, and it was in the interest of the

2020-2021 team not to compromise the existing suspension geometry. As to change the geometry would mean the suspension team would need to spend time redesigning the rear of the car, costing the team valuable time.

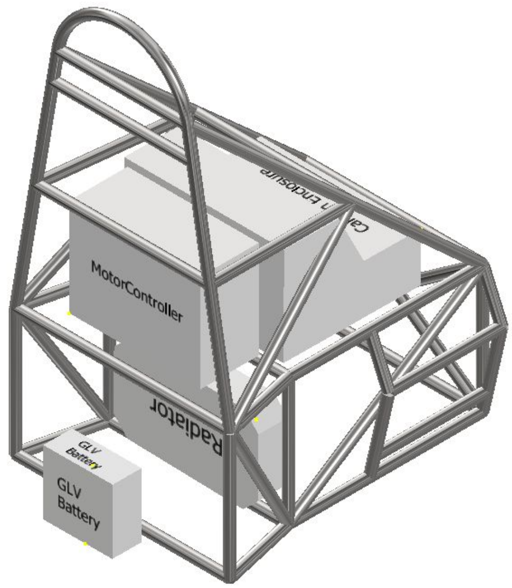

Figure 3: Isometric view of proposed rear third with fitment of components.

The firewalls are a major component for safety and rules compliance for the chassis. These protect the driver from potentially high temperature components, most notably the batteries. With the 2020-2021 rules change, the Chassis team was excited to learn that the accumulators in their current design would serve as their own firewalls, as the container is completely encased in aluminum siding that fulfills the rules.

Our main goal is to have a chassis optimized for each subsystem's needs and requirements to allow full functionality of those systems. Specifically, these goals target the needs of systems and drivers with logical, easy to access mounting locations that will allow the team to compete on the track come race day.

3.6 Interconnect

The primary design objectives of the Interconnect team are to design, manufacture and install an electrical enclosure for the Tractive System Interface (TSI), Grounded LowVoltage (GLV), Supervisory Control and Data Acquisition (SCADA), and Relay board as well as the Motor Controller and Side Panels. The team will also create a Cable Test Bench to facilitate cable manufacturing and testing across the entire FSAE project. The secondary goals of the interconnect team will be to assist in the design and implementation of other low voltage electronics. Particularly, buttons, light fixtures, key dashboards and interfaces in addition to the fabrication and strain relief of cables interconnecting the subsystems of the car. Below is a list of short term Interconnect subsystem goals:

Cable Workbench

- Block Diagram
- Determine frequently used connector types
- Bill of Materials
- Electrical Design
- Physical Design
- Pass Critical Design Review and Manufacture

Side panels

- Bill of Materials
- Determine new Master reset button and Emergency Stop Buttons.
- Update Panel Design
- Pass Critical Design Review and Manufacture

Carman enclosure

- Enclosure lid
  - Update design for the display panel
  - Update panel integration

Standardization of Connectors

- Determination of connector types for the car..
- Bill of materials

Models, Diagrams, Rules & Other

- Keep Sparky Diagram updated to reflect finalized design changes
- Keep Interconnectivity Diagram updated to reflect finalized design changes
- Comprehend and verify pre-existing designs
- Comprehend applicable rules
  - Verify Rules compliance

In order to complete these goals in a timely, efficient and effective manner the team is engaged in a rigorous brainstorming, design and revision process. Interconnect must continually collaborate with the TSI, GLV, and SCADA subsystems to create effective solutions.

By early October Inetconnect's goal is to have the cable test bench built, tested, and operational for use by the FSAE team. As well as manufactured Carman lid and side panels.

By late November Interconnect's goal is to have the enclosure built to print in conjunction with explicit documentation of the car's interconnections to facilitate fabrication in the new year .

Figure 4: Proposed Carman Enclosure Design

The team has identified several engineering metrics and goals for the design of the enclosure. Primarily, this is rules compliance. The enclosure contains both low voltage and high voltage zones and thus they must be separated appropriately. In addition, the design will focus on accessibility and ease of access to as much of the internals as possible, whilst protecting the internals during the raintest.

3.7 SCADA

The overarching goal for SCADA is to have a maintainable and configurable data acquisition system that is able to interface with devices & sensors on the car using several different protocols. The goal for maintainability is to develop a configuration tool that will allow the user to easily add and edit sensors using a GUI. In terms of functionality the SCADA system must be capable of sorting and parsing data from the following protocols: CANOPEN, Parallel IO, I2C and USB protocols. It must also display real time data from every connected sensor and present post-processed data for later review. In addition to passive data acquisition, the SCADA system must be able to set sensor values based on both user input and detection of critical sensor values.

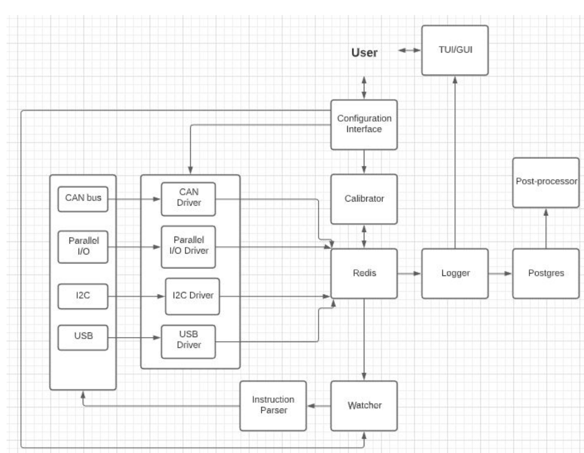

Figure 5: High-Level Software Architecture Diagram

Through having clear software architectural diagrams (see Figure 3) and specific class descriptions that the entire SCADA team is on board with, we plan to interface the backend and front end of the SCADA system to ensure a well defined and reliable system. We have also been in communication with other subteams for configuration of the various sensors, data, and messages that we will be interacting with to ensure SCADA is integrated well with the entire car project. Figure 4, the text user interface prototype, demonstrates a proof of concept for our initial designs. Figure 3 above demonstrates the various SCADA classes, and how they connect with each other. The arrows in the class diagram represent the flow of data between classes. In the file containing our class diagram we have also provided a description of each class and their functionality. This file can also be found in the scada subsection on Slack.

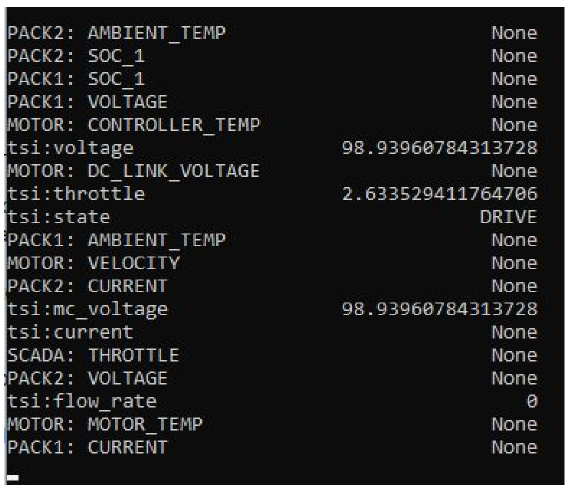

Figure 6: Text User Interface Prototype for Displaying Real-Time Data

By creating visual output we are able to confirm our progress in the backend and connectivity of our code. We can evaluate the maintainability by having engineers with no experience in our software configure the system themselves through our configuration interface.

3.8 Cooling and Drivetrain

Cooling has decided on most of the components of the cooling system using a combination of heat transfer calculations and previous teams' knowledge. We have added a reservoir to the system to increase heat capacity for the acceleration test. We have also elected to use a larger radiator in the interest of achieving absolute certainty that the car will not overheat under any combination of usage or environmental factors. The Drivetrain & Cooling team is working closely with the Frame team to ensure adequate mounting space and clearances between all subsystems. Our goal is to implement an integrated drivetrain and cooling solution that fulfills all design requirements and is managed automatically, with or without driver input.

The drivetrain team has decided that the current drivetrain needs revision. Most of the components for this redesign have been chosen using feedback from group members, Professor Helm, and the applicable stress and flexural calculations. We have decided to shift the motor to be directly mounted to the housing in order to create a support "train" that will flex the housing significantly less than the previous design. With the addition of a flex coupling and bearing support the torque applied to the housing via the front sprocket will be significantly decreased. This will require the current housing to be reworked or possibly remanufactured, but the goal of the drivetrain is to make the necessary improvements without changing the footprint of the drivetrain and through slight modification of current components. By shifting the motor, the cooling lines, thermocouple, and speed sensor wires are more exposed, lending to easier connecting points as well as easier addition of a waterproof housing. The overall goal is to improve the drivetrain design while fulfilling all of the design requirements while providing ample power for the car to be successful.

4. Roles and Responsibilities

4.1 Management: Andrew Bachman, Devin Murphy, Zach Pitner, Thomas Stranick

Management is required to hold meetings weekly that bring together the team to discuss the current status of the project. These meetings all require agendas that will be made and distributed before the meetings. Here the managers can gauge if the project is moving forward and help determine what is missing or going wrong and where and how it can be fixed. Project deliverables from the competition as well as Lafayette will be completed by management. The managers will request any information that they need from the team and compile it as well as elaborate on anything to complete documents that are needed. Deliverables and presentations will require team involvement to fill in information, however the management team will finalize the document and submit them.

4.2 System Engineers: Adam Tunnell, Lucas Foulk, Ben Surman

The System Engineers are broken down into more specific roles; Adam Tunnell is in charge of Software and Firmware, Ben Surman is in charge of CarMan and Interconnect, and Lucas Foulk is in charge of the Mechanical Engineering side of the car. The main responsibilities of the System Engineer relate to the high level technical side of the car project. They will make sure no part of the car is overlooked and talk to the subteams to remedy anything that comes up. The SEs should know about each of the subsystems that are under their area of expertise at a high level. Software and Firmware is mainly in charge of Dashboard, SCADA, Battery Systems, Motor Control and Carman. CarMan and Interconnect

SE is in charge of the electrical components of CarMan, TSI, TSV, Interconnect, and the Dashboard. The Mechanical Engineering SE is in charge of cooling, drivetrain, suspension, brakes, frame, and cockpit. These are the main subsystems the SEs will be in charge of however they can help out in others if needed. The focus is on high level of the whole car, thus integrating mechanical parts and electrical parts will be essential to the SE's job.

4.3 Team Leads:

The Team Leads are the main connection between the Managers and System Engineers and their respective subsystems. They are responsible for knowing what work is happening, what work needs to be done, as well as connecting and communicating with the team. The Team Lead should make sure that the subsystem gets management specific deliverables done in the time frame required. The Team Leads are listed below next to their subsystem.

Battery Packs: Tony Xiao

Dashboard: Han Xu

CarMan/Interconnect: Ben Surman

GLV: Zack Martin

TSI: Ethan Miller

Drivetrain & Cooling: Matt Eckhart

Frame: Jack Mueller

SCADA: Irwin Frimpong

Steering, Suspension, Braking: Mike Anderson

5. Team Schedule

The team's external deliverables that are to be submitted to the Formula Hybrid website or the Lafayette professors. The deadlines presented must be completed in order for the project to be considered a success. Internally, management has collaborated with the subsystems to create a flushed out work breakdown for internal deadlines.

Team Deliverables		
Task Name	**Accountablility**	**End Date**
Structural Equivalency Spreadsheet (SES)	Frame	10/14/2020

Project Management Plan	Managers	11/30/20
Electrical System Form 1 (ESF-1)	Electrical Team	10/21/20
Program Information Sheet	Managers	12/07/20
Team Photo	Managers	12/7/20
Interim Project Report	Managers	2/15/21
Impact Attenuator Data	Frame	2/8/21
Site Pre-Registration	Managers	2/15/21
Electrical System Form 2 (ESF-2)	Electrical Team	02/07/21
Design Report	All	3/22/21
Sustainability Report	All	3/22/21
Design Specifications Sheet	All	3/22/21
TD001 Conceptual and Preliminary Design Study	Managers	9/21/20
TD002 Design Proposal	Managers	10/19/20
TD003 Safety Plan	All	12/3/20
TD005 a 5 Minute Status Presentation	Zach Pitner	9/21/20
TD005 b 5 Minute Status Presentation	Zach Pitner	10/19/20
TD005 c 5 Minute Status Presentation	Zach Pitner	11/16/20
TD007 Mid-Year Progress Report	Managers	12/3/20
TD008 Mid-Year Presentation	Managers	12/3/20
TD009 Spring Update Report	Managers	Mid Spring
TD010 Final Design Report	Managers	5/7/20
TD011 Final Presentation	Managers	5/7/20
TD012 Project Video	Managers	5/7/20
TD015 Top Level Laboratory Test Plan & Report	All	Plan by 12/3/20, by ECD: 3/12/20
TD016 On-Road Test Plan and Report	All	Plan by 12/3/20, by FDD: 5/7/20
TD017 Project Website	Managers	Updated Weekly, FDD: 5/7/20
TD018 Final Purchasing Report	Managers	FDD: 5/7/20
TD019 Users Manuals and Training Videos	All	FDD: 5/7/20
TD020 Maintenance Manual	All	FDD: 5/7/20
TD021 Final Delivery Checklist	Managers	FDD: 5/7/20

6. Required Resources

Below is the current preliminary budget. The initial asking amount is what the subteam has asked for in their current state. Additional budgeting has been allocated for anything else that the team might not have thought of yet and this was based on the total budget from last semester. Much of what they allocated for they did not fully finish spending however this is a good estimate for where the team should be at the start of the year.

Current Prelim Budget			
Subsystem	**Asking Amount**	**Additional**	**Total**
Drivetrain & Cooling	$100	$1,900	$2,000
SCADA	$500	$500	$1,000
Steering Suspension Brakes	NA	$2,000	$2,000
TSI	$2,700	$0	$2,700
GLV	NA	$2,000	$2,000
Shipping/tax	NA	$2,500	$2,500
Interconnect	NA	$2,000	$2,000
Registration	$0	$0	$0
Dashboard	$300	$700	$1,000
Battery Packs	NA	$5,000	$5,000
Frame	$7,310.00	$700	$8,000
Overall	$10,910	$17,300	$28,200

The second budgeting table encompasses any competition expenses that we would need including the three main items; transportation, hotels, and safety equipment. The transportation is based on the enterprise car rental estimates given from the school for either a van rental for 3 Days or 2 large SUVs. Depending on the amount of people coming this number might increase. Hotels around the area average at $150 a night per room, this number will add up depending on the number of people attending the competition.

Budget for Competition	Amount
Transportation	$500
Hotel	$150/night/room
Safety Equipment	$1000

7. Stakeholders or External Partnerships

Throughout the design process, students will need to consult with those who have had previous experience building the Lafayette electric car in order to gain a better understanding of what they are working on and for feedback on how to make the project better. The two main resources for this information are Professor Nadovich and Helm as well as Lafayette FSAE Electric Car alumni.

In the beginning and throughout the process of building and designing the car, sub-teams will need to contact alumni to better understand the components that were left by the previous year. Since the 2019-2020 team did not get the chance to complete the car they left documentation and parts of subsystems behind for this year to pick up and finish. Many sub-teams will contact the authors of the documentation and builders of components in order to fully understand their thought process and see what else needs to be done.

The best resource to consult throughout the project will be Professor Nadovich and Helm who have worked on the electric car project for many years. This experience allows them to be able to see and compare to previous years designs and comment on new additions and improvements that subsystems are completing. This will be in the form of design reviews and meetings where they can comment on what the team plans to do moving forward in the project.

Conclusion

The Lafayette College 2020-2021 FSAE Formula Hybrid Team is currently working on the design of a built to print Formula Electric Vehicle. The measures of success for this task is whether or not the team will be able to assemble and test a complete, rules compliant car during the spring semester of 2021. Throughout these two semesters, the larger project team will be working in smaller sub-teams to complete and test each of the subsystems outlined above using the approach they specified for their work on this project. In the process of completing their sub-team's goals, as well as their personally stated goals for the project, students should gain work experience as part of an engineering team, as well as individual experience working on areas of the project that interest them.

While Lafayette Motorsports has never won the FSAE competition, our goal to pass all rule inspections and make it onto the track has been accomplished previously in 2018. We aim to repeat this effort and result. However, our program's structure leaves less room for innovation than other teams with larger budgets and larger workforces who continue work for more than one academic year. That being said, our sub-teams have already proposed some ideas that are new to the Lafayette Motorsports program, and they are already being worked on to implement into the 2020-2021 vehicle. The vehicle's performance compared to the state of the art can be quantified once we have a functioning vehicle, and the features included can be compared to previous iterations of the electric vehicle program at Lafayette College.

Each Sub-team has laid out their approach above, and the uniting feature of these plans seems to be the use of previously designed material as a starting point for the efforts of each sub-team. In this regard, each subteam has already or will soon become familiar with the documentation left by previous teams. From there, each sub-team decided whether or not to test and improve the previous design or start over with new contributions to the project's design for their subsystem. This decision then decides what the rest of each sub-team's approach will look like. For those teams redesigning a previous subsystem, they will likely begin with testing and functionality verification like TSI has already begun. Other teams, like the cooling team, will decide to reuse certain parts and develop new parts in other areas of their subsystem. This decision then pushes them towards beginning with functionality calculations and parts selection as detailed above. In summary, the project's overall approach is to study what has been left for us and determine whether or not new functionality is necessary before working to develop and build a rules compliant electric vehicle.

The management and structural organization of the project is broken down in detail above, however, the guiding principles we used to make these divisions are to share knowledge and responsibility in an consolidating fashion, so that the managers of the project know which system engineer to ask when a problem arises, that system engineer knows which team lead to talk to, and that team lead can point to the team member specializing in that element of the car to help troubleshoot. Alongside this process of knowledge division, we also hope that the schedule and budget detailed above can additionally guide the project towards the goals and objectives set by each individual, the team as a whole, and the statement of work. The schedule is particularly malleable at the moment due to the uncertainty surrounding the spring semester at the moment. With that in mind, the team's goals and work breakdown are both subject to change with more information regarding the college's plans for the spring semester.