Electric Formula SAE 2020-21

Easton, Pennsylvania 18042-1775

LAFAYETTE COLLEGE

Lafayette College 2020-2021 FSAE Formula One Hybrid Team

Project Management Plan

Table of Contents

Scope 3

Operations 3

Risk Management 4

Expected Results 5

Change Management 5

Appendix A - Organization 6

Appendix B - Work Breakdown Structure 7

Appendix C - Gantt Chart 12

Appendix D - Budget 13

1. Scope

A reasonable goal set from the beginning of the semester was to have a 'on-paper' electric car by the end of the semester. This term implies that all designs, test plans, and most documentation would be complete by the end of the Fall Semester (12/3/20). This will leave the project in a state where we can piece it together and test it when the students are back for the Spring Semester (now 2/8/21). Given the current pandemic situation this was a reasonable goal as not all students were on campus, thus not allowing them to work on the physical car. These documents, when finalized, are then reviewed by the team to make sure there is nothing missing from them. By the end of the Fall Semester we want to make sure that there is nothing missing for when we start back work in the Spring.

Software was also something that could be completed in this situation, thus we tasked our SCADA (Supervisory Control and Data Acquisition) team to be complete before the end of the semester. This large part of the project monitors all important features of the car such that it can transmit the information through our CarMan (Car Manager) and to the driver through the dashboard. In order for the car to be safe and notify the driver of any mishaps the SCADA system needs to be fully operational. The CarMan, mentioned before, handles the safety loop that is present throughout the car. When one part of the safety loop malfunctions it can send fault signals to the driver and stop the car by not allowing high voltage to reach the motor.

These are just two of the subsystems that are present within the car. Our Chassis, Suspension, Steering, Brakes, Cooling, Interconnect, EPAL (External Panels & Lights) are also hard at work completing designs and fleshing out what makes the Lafayette Motorsports car operate. Each of these subteams operate in a cooperative manner, allowing them to work well together and achieve our Fall Semester goal of creating an 'on-paper' electric car. Our goal for teamwork within the project is to provide the students an environment that mimics that of an industry environment that allows students to work together and produce their own designs. The environment that the project creates should help students become more familiar with such a setting and help them in the long run. By completing the 'on-paper' car, this will then help achieve our second semester goal of building and operating our rules compliant electric car so that we can end our senior year with this great achievement.

2. Operations

In order for any team to operate properly there must be teams dedicated to different aspects of the car including top level roles. Outlined in Appendix A, the first thing that the team needed for the project to take shape were Project Management. In Lafayette Motorsports this consists of 4 members that work on the course and competition deliverables, scheduling and work breakdown, organizing weekly meetings and heading them, as well as just acting as the lead for knowing everything that is going on within the team.

A second group of students that provide structure to the project are the three System Engineers. The System Engineers are responsible for the technical top level view, working more in depth with the subteams about making a cohesive plan of action that works well with other subteams. They act as one of the main sources of information when somebody wants to know what is going on in one part of the team. The top level view is needed such that there is nothing missing from the subteams development progress that was overlooked, or even just streamlining the purchasing process by making sure subteams are using similar parts where possible.

At the top of every substeam there is the Team Lead that is the main contact for anything deeply subsystem related. They know everything about what is happening within their group and are able to share that with the team during weekly meetings organized by management. It is during these meetings that the team is able to see what progress has been made and what stopgaps are occurring to hinder progress. The team leads are able to act as the main voice for their group and can talk with the system engineers directly to inform them of things that are going on.

The Work Breakdown Structure (WBS) outlines every part of the project that is needed in order to create a working rules compliant electric car. The document is extremely detailed so the top level breakdown is available in Appendix B for examination. Within the formal document, each level 1 goal has its own tab that the subteams can flesh out with their own goals in mind to help their organization and planning. In regards to the top level, the car is broken down into two main goals, Rolling Chassis and Dyno Integration. The Rolling Chassis includes all parts that are needed to have a moving car frame which includes the subteams of chassis, drivetrain, steering, suspension, and brakes. This is the head goal for most of the mechanical subteams such that if they can piece together the mechanical parts the chassis will be movable. The second top level goal is Dyno Integration, the top level goal for the electrical subteams. Once all of the electronic subsystems are hooked up into our Dyno room with a motor they can be tested and analysed to make sure they function properly. This document is used as the main source of information during weekly meetings to determine what is behind and what is on time. Within these weekly meetings we can then identify what is stopping progression and address the issue. To follow up on the scheduling, Appendix C includes our Gantt chart which relies on illustration progress and dependencies.

Addressing the budget, we have made sure that all purchasing be reviewed before any ordering takes place. This is handled by management through purchase requests and can be granted once their designs are signed off on. The budget was determined through analysis of what the previous year teams actually used of what they put into their budget. Extra funds were added to account for any design modifications that would need to be made throughout the design process. Thus the current budget is an estimate rather than a concretely set value. These funds come directly from Lafayette College and need to be approved through our budget. Refer to Appendix D for more budget information.

3. Risk Management

Risk is inherent when working within a project setting such as this. One large risk factor specifically relating to this year is the presence of COVID-19. Lafayette College is allowing us to come back to the school with notable safety procedures that we will follow. However, it is unpredictable whether or not somebody will get the virus and thus not be able to work on the car or even worse infect more people. Extreme caution will be taking place in order to mitigate the risks of the virus spreading including the wearing of face masks at all times as well as limiting the amount of people working in one room at a time. If this becomes an issue we will reevaluate the situation and possibly need to move people around to work on other aspects of the car when others are incapable of doing so. This however, could only happen after virus testing of team members is complete and sanitization of the work spaces is conducted. We are very eager to work on the car, however will take all the necessary precautions to not allow the virus to affect our work.

Other safety risks are inherent when working on a high voltage electric car. This is why we have enacted a safety plan for everybody involved that will be understood by all members of the team and posted in all workplaces. This way the team understands what is involved when performing any high risk

action. When working on high voltage we enacted a lockout tagout procedure: All work on the car must take place after a lock and tag have been placed on both of the Segment Maintenance Disconnect Switches (SMDs) found on the two accumulator packs, as well on the GLV Master Switch, located on the right side panel of the car. Only after all three of these switches are locked and tagged by a student should work of any kind be completed on the car after it has been assembled.

4. Expected Results

When determining the expected results for the FSAE electric car project one can look at the goals we placed within the scope of the project. As the semester is winding down we are currently on track to complete our first semester goal of an 'on-paper' rules compliant electric car within the first few weeks of winter break. Some of the tasks are behind schedule due to the learning curve at the beginning of the semester; this contributed to the tasks being completed in a slower time than expected. This is not an issue however, as we see that much of the design phase is being completed within these last few weeks and ordering will be starting soon. If we have all of the designs finished and parts ordered within the first few weeks of break that would be considered a success and allow us to hit the ground running in the Spring.

In order to complete the car, measures of success include the full Dyno Integration and Rolling Chassis completed towards the end of February and early March. All of the parts can be put together and tested separately so that progress can continue with the development of the entire car. Although there is no official physical race day, we intend the car to be complete before much of the design due dates outlined within the rules.

5. Change Management

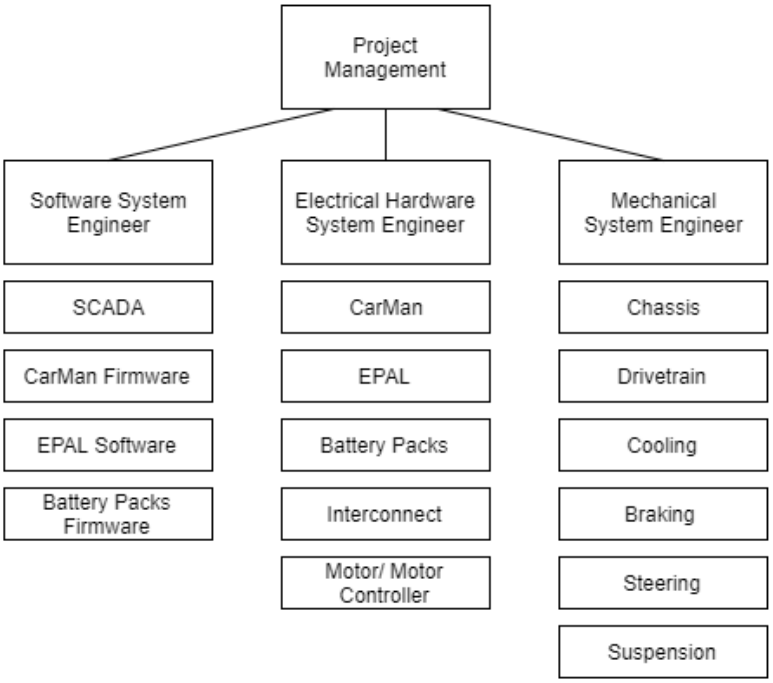
Addressing the issue of change management, we must consider that change is not bad and make sure the team sees it that way as well. When due dates are missed it is not a thing to look down upon, rather something that needs to be worked out with the team to adjust the schedule and make sure they have everything they need to succeed. The schedule will not be adjusted, however the expectations once discussed can be changed to fit the current situation. These are always discussed with the entire team during weekly meetings.

Changes to design or subsystems that affect other team members are required to be discussed with them before implemented. The team has a group Slack that allows them to communicate whenever about whatever change that is being made. This makes it easy for them to contact each other on the fly, or if more formally they are suggested to create a group call or talk about it within a design review. Design reviews are intended for subsystem feedback purposes, and can be a bringer of change to the overall car design.These are open to anybody on the team and allow for critical thought about the piece of the car and open up discussion about change.

One example of change of project focus came with our Battery Pack subteam when it was brought to management attention that there were not enough people working on that subsystem. This prompted us to encourage those who can to help support the team and work on the Battery Packs, a subsystem that is instrumental to car operation. These spots were filled and the progress within that team is slightly behind due to the oversight, but is working to be on track with the rest of the project. This example demonstrates why it is important to cultivate a 'team environment' rather than a subdivision one. The entire team should feel responsible if a part of the car does not meet expectations and we want them to step up and contribute to help the project succeed.

6. Appendix A - Organization

Organization Chart outlining the hierarchy of Lafayette Motorsports.



*Each subteam contains their own team lead that reports to the System Engineers and Management about anything being worked on.

7. Appendix B - Work Breakdown Structure

Work Breakdown Structure (WBS) Top-Level as of 11/24/20

					Total Percent Complete
					33%
Task #	**Task**	**Owner**	**Start Date**	**End Date**	**Percent Complete**
0	**Car Integration**				39%
1	**Dyno Integration (DI)**			**3/1/21**	36%
1.1	Wiring Diagram Completed	Interconnect	8/17/20	11/12/20	80.00%
1.2	Parts Manufactured and Tested	DI Subteams	10/19/20	2/19/21	36.83%
1.3	Wiring Completed	Interconnect	2/22/21	2/26/21	0.00%
1.4	Test Plan Created	DI Subteams	11/2/20	11/20/20	0.00%
1.5	Test Plan Conducted	DI Subteams	2/26/21	3/1/21	0%
2	**Rolling Chassis (RC)**			**2/26/21**	10%
2.1	Inventor Model	Chassis	8/17/20	10/30/20	0%
2.2	Parts Manufactured and Tested	RC Subteams	10/19/20	2/8/21	52%
2.3	Parts Mounted To Chassis	Chassis	1/25/21	2/12/21	0%
2.4	Test Plan Created	RC Subteams	10/19/20	11/20/20	0%
2.5	Test Plan Completed	RC Subteams	2/12/21	2/26/21	0%
3	**Interconnect**				35.00%
3.1	Inventor Models		10/24/20	11/1/20	95.00%
3.2	Wiring Diagrams		8/17/20	10/19/20	95%
3.3	Parts Ordered		11/8/20	11/12/20	30.00%
3.4	Drawings Done & Sent to Manufacturing		11/1/20	11/8/20	0.00%
3.5	Parts Received		1/20/21	1/25/21	0.00%
3.6	Parts Assembled		1/25/21	2/19/21	0.00%
3.7	Interconnect Assembled		2/19/21	2/26/21	0.00%
3.8	Test Plan Created		11/1/20	11/10/20	100.00%
3.9	Test Plan Conducted		1/20/21	1/25/21	0.00%
3.10	BOM		8/17/20		45.00%
3.11	Website Documentation Updated		8/17/20	Throughout	25.00%
4	**CarMan**				32%
4.1	Inventor Models		8/17/20	11/6/20	74%
4.2	Wiring Diagrams		8/17/20	10/20/20	100%
4.3	Board Layouts		8/17/20	11/3/20	71%

4.4	Parts Ordered		11/5/20	11/6/20	0%
4.5	Drawings Done & Sent to Manufacturing		11/6/20	11/10/20	0%
4.6	Parts Received		11/10/20	11/17/20	0%
4.7	Parts Assembled		11/17/20	12/1/20	0%
4.8	Firmware		8/17/20	12/1/20	40%
4.9	CarMan Assembled		11/17/20	1/15/21	0%
4.10	Test Plan Created		11/6/20	11/20/20	0%
4.11	Test Plan Conducted		12/1/20	2/1/21	0%
4.12	BOM		8/17/20	10/23/20	61%
4.13	Website Documentation Updated		8/17/20	Throughout	38%
5	**Battery Packs**				11%
5.1	Mechanical Test Assembly				11%
5.2	Electrical Function Demonstration				32%
5.3	Integrated Prototype				0%
5.4	Battery Pack Production				0%
6	**External Panels & Lights**				34%
6.1	Inventor Models		8/17/20	10/26/20	70%
6.2	Wiring Diagrams		8/17/20	10/19/20	100%
6.3	Software Diagrams		8/17/20	10/23/20	100%
6.4	Board Layouts		8/17/20	10/30/20	99%
6.5	Software Written		10/31/20	11/20/20	68%
6.6	Parts Ordered		11/10/20	11/13/20	0%
6.7	Drawings Done & Sent to Manufacturing		10/27/20	11/13/20	17%
6.8	Parts Received		1/25/21	1/25/21	0%
6.9	Parts Assembled		1/26/21	2/5/21	0%
6.10	Panels & Lights Assembled		2/6/21	2/8/21	0%
6.11	Test Plan Created		11/1/20	11/20/20	0%
6.12	Test Plan Conducted		2/9/21	2/12/21	0%
6.13	BOM		8/17/20	10/19/20	99%
6.14	Website Documentation Updated		8/17/20	Throughout	15%
7	**SCADA**				69%
7.1	Documentation		8/17/20	4/30/21	75%
7.2	Display Configurable Simulated Data in dyno room		10/16/20	10/30/20	90%
7.3	Carman Display with live CAN Data		10/5/20	11/16/20	78%
7.4	Carman Display with Live I2C Data		9/21/20	11/16/20	72%
7.5	Display Non-Numeric Data Types		8/17/20	10/30/20	85%
7.6	Configurable Active System Control Simulated		10/26/20	11/16/20	67%
7.7	I2C Actions		10/16/20	11/16/20	80%

7.8	CAN Actions		10/18/20	11/16/20	78%
7.9	JSON update for Driver display		8/17/20	2/1/21	75%
7.10	Post Processing Browser with Analysis		10/11/20	SPRING 2021	0%
7.11	Maintainability/Installation Files		10/12/20	4/30/21	58%
8	**Cooling**				40%
8.1	Inventor Models		8/17/20	10/19/20	98%
8.2	Wiring Diagrams		8/17/20	10/5/20	100%
8.3	Parts Ordered		10/19/20	10/26/20	95%
8.4	Drawings Done & Sent to Manufacturing		10/19/20	11/16/20	95%
8.5	Parts Received		10/26/20	1/29/21	0%
8.6	Parts Assembled		1/29/21	2/8/21	0%
8.7	Cooling Assembled		2/1/21	2/19/21	0%
8.8	Test Plan Created		10/19/20	11/2/20	20%
8.9	Test Plan Conducted		1/29/20	2/19/21	0%
8.10	BOM		8/17/20	10/19/20	100%
8.11	Website Documentation Updated		8/17/20	Throughout	20%
9	**Chassis**				40%
9.1	Inventor Models		8/17/20	10/28/20	96%
9.2	Parts Ordered		10/15/20	11/30/20	50%
9.3	Drawings Done & Sent to Manufacturing		10/15/20	12/4/20	18%
9.4	Parts Received		12/4/20	1/27/21	15%
9.5	Parts Assembled		1/27/20	2/7/21	0%
9.6	Chassis Assembled		1/27/20	2/7/21	0%
9.7	Test Plan Created		11/11/20	12/3/20	0%
9.8	Test Plan Conducted		2/12/20	2/19/21	0%
9.9	BOM		10/11/20	10/30/20	44%
9.10	Website Documentation Updated		8/17/20	Throughout	60%
9.11	VR3 Quote		10/16/20	10/30/20	100%
10	**Brakes**				47.00%
10.1	Inventor Models		8/17/20	10/28/20	90%
10.2	Parts Ordered		10/28/20	10/30/20	70%
10.3	Drawings Done & Sent to Manufacturing		10/30/20	11/4/20	70%
10.4	Parts Received		10/30/20	11/6/20	80%
10.5	Parts Assembled		1/29/21	2/5/21	0%
10.6	Brakes Assembled		2/5/20	2/12/21	0%
10.7	Test Plan Created		11/6/20	11/8/20	80%
10.8	Test Plan Conducted		2/12/21	2/15/21	0%
10.9	BOM		8/17/20	11/13/20	80%
10.10	Website Documentation Updated		8/17/20	Throughout	0%

11	**Steering**				50.00%
11.1	Inventor Models		8/17/20	10/30/20	90%
11.2	Parts Ordered		10/30/20	11/2/20	70%
11.3	Drawings Done & Sent to Manufacturing		11/2/20	11/6/20	70%
11.4	Parts Received		11/9/20	11/13/20	80%
11.5	Parts Assembled		2/5/21	2/12/21	0%
11.6	Steering Assembled		2/5/21	2/12/21	0%
11.7	Test Plan Created		11/9/20	11/13/20	90%
11.8	Test Plan Conducted		2/12/21	2/15/21	0%
11.9	BOM		8/17/20	11/20/20	50%
11.10	Website Documentation Updated		8/17/20	Throughout	50%
12	**Drivetrain**				58%
12.1	Inventor Models		8/17/20	10/19/20	99%
12.2	Parts Ordered		10/5/20	10/21/20	88%
12.3	Drawings Done & Sent to Manufacturing		10/21/20	10/26/20	75%
12.4	Parts Received		10/7/20	10/28/20	95%
12.5	Parts Assembled		10/28/20	11/4/20	0%
12.6	Drivetrain Assembled		11/4/20	11/18/20	0%
12.7	Test Plan Created		11/4/20	11/16/20	30%
12.8	Test Plan Conducted		11/23/20	11/25/20	0%
12.9	BOM		8/17/20	11/25/20	80%
12.10	Website Documentation Updated		8/17/20	Throughout	40%
13	**Suspension**				64%
13.1	Inventor Models		8/17/20	10/19/20	100%
13.2	Optimum Kinematics		9/21/20	10/26/20	88%
13.3	Parts Ordered		10/23/20	11/2/20	100%
13.4	Drawings Done & Sent to Manufacturing		11/2/20	11/9/20	90%
13.5	Parts Received		11/9/20	11/13/20	100%
13.6	Parts Assembled		1/29/20	2/5/21	0%
13.7	Suspension Assembled		2/5/20	2/8/21	0%
13.8	Test Plan Created		11/13/20	11/20/20	90%
13.9	Test Plan Conducted		2/8/20	2/12/21	0%
13.10	BOM		8/17/20	10/23/20	90%
13.11	Website Documentation Updated		8/17/20	Throughout	50%
14	Full Car Inventor Model Complete	Chassis			0%
15	On Car Wiring Completed	Interconnect		3/5/21	0%
16	Electrical Systems Installed On Car	DI Subteams	3/2/21	3/5/21	0%
17	On-Vehicle Electrical Test Plan Created	DI Subteams		11/20/20	0%
18	On-Vehicle Electrical Test Plan Conducted	DI Subteams	3/6/21	3/12/21	0%

19	Full Car Test Plan Created	Full Team		11/20/20	0%
20	Full Car Test Plan Conducted	Full Team		4/30/21	0%
21	**Competition Deliverables**				25%
21.1	Structural Equivalency Spreadsheet (SES)	Chassis Team	8/17/20	10/14/20	100%
21.2	Project Management Plan	Management	8/17/20	11/30/20	0%
21.3	Electrical System Form 1 (ESF-1)	Full Team	8/17/20	10/21/20	100%
21.4	Program Information Sheet	Management		12/7/20	0%
21.5	Team Photo	Management		12/7/20	100%
21.6	Interim Project Report	Management		2/15/21	0%
21.7	Impact Attenuator Data	RC Subteams		2/8/21	0%
21.8	Site Pre-Registration	Management		2/15/21	0%
21.9	Electrical System Form 2 (ESF-2)	DI Subteams		2/7/21	0%
21.10	Design Report	Management		3/22/21	0%
21.11	Sustainability Report	Management		3/22/21	0%
21.12	Design Specifications Sheet	Management		3/22/21	0%
22	**Course Deliverables**				34%
22.1	TD001 Conceptual and Preliminary Design Study	Management	8/17/20	9/21/20	100%
22.2	TD002 Design Proposal	Management	9/28/20	10/19/20	100%
22.3	TD003 Safety Plan	Management	8/17/20	12/3/20	39%
22.4	TD004 Weekly Team Status Report and Presentations	Management	8/17/20	5/10/21	50%
22.5	TD005 5 Minute Status Presentation	Management	8/17/20	9/21, 10/19, 11/16	100%
22.6	TD006 Design Reviews	Full Team	8/17/20	5/10/21	80%
22.7	TD007 Mid-Year Progress Report	Management		12/3/20	0%
22.8	TD008 Mid-Year Presentation	Management		12/3/20	0%
22.9	TD009 Spring Update Report	Management		Mid Spring	0%
22.10	TD010 Final Design Report	Management		5/10/21	0%
22.11	TD011 Final Presentation	Management		5/10/21	0%
22.12	TD012 Project Video	Management		5/10/21	0%
22.13	TD013 Posters and Poster Sessions	Management		11/30/20, 5/10/21	0%
22.14	TD017 Project Website	Full Team		5/10/21	20%
22.15	TD018 Final Purchasing Report	Management		5/10/21	0%
22.16	TD019 Users Manuals and Training Videos	Full Team		5/10/21	0%
22.17	TD020 Maintenance Manual	Full Team		5/10/21	0%
22.18	TD021 Final Delivery Checklist	Management		5/10/21	0%
22.19	ID001 Statement of Individual Goals	Full Team		10/19/20	100%

8. Appendix C - Gantt Chart

This is a snip of the layout of our Gantt Chart, using the plus buttons on the left hand side it can expand to show more detail into things like “Inventor Models” for each subsystem.

FSAE EV 2020/21

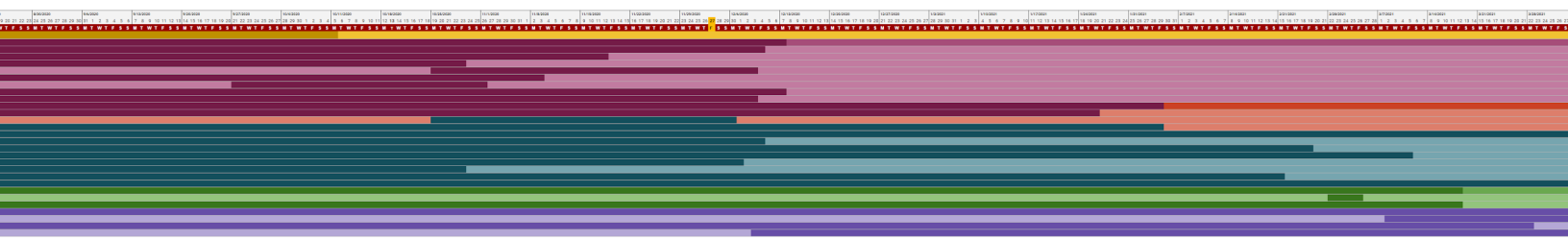
Lafayette College

Project Management
Devin Murphy
Thomas Stranick
Andrew Bachman
Zach Pitner

Project Start:	8/17/20
Display Week:	1

TASK	ASSIGNED TO	PROGRESS	START	DAYS	END
Phase 1 : Infrastructure		100.00%	8/17/20	49	10/5/20
Phase 2 : Built to Print		79.64%	8/17/20	112	12/7/20
Inventor Models		89.20%	8/17/20	109	12/4/20
Wiring Diagrams		96.43%	8/17/20	87	11/12/20
Software Diagrams		100.00%	8/17/20	67	10/23/20
Test Plans Creation		41.00%	10/19/20	45	12/3/20
Board Layouts		84.86%	8/17/20	78	11/3/20
Optimum Kinematics		87.86%	9/21/20	35	10/26/20
Competition Deliverables		60.00%	8/17/20	112	12/7/20
Course Deliverables		77.75%	8/17/20	108	12/3/20
Phase 3 : Ordering & Inventory		45.63%	8/17/20	165	1/29/21
BOMs		64.90%	8/17/20	156	1/20/21
Parts Ordered		25.00%	10/19/20	42	11/30/20
Parts Recieved		47.00%	8/17/20	165	1/29/21
Phase 3 : Fabrication & Assembly		36.41%	12/30/99	44326	5/10/21
Drawings Done & Sent to Manufacturing		22.33%	8/17/20	109	12/4/20
Parts Assembed		7.42%	1/27/20	389	2/19/21
Systems Assembed		4.00%	1/27/20	403	3/5/21
Firmware		57.50%	8/17/20	106	12/1/20
Software		84.45%	8/17/20	67	10/23/20
Competition Deliverables		0.00%	12/30/99	44242	2/15/21
Course Deliverables		80.00%	8/17/20	266	5/10/21
Phase 4 : System Testing		0.00%	1/29/20	408	3/12/21
Dyno Completed		0.00%	2/22/21	4	2/26/21
System Test Plans Conducted		0.00%	1/29/20	408	3/12/21
Phase 5 : Finalization		0.74%	8/17/20	266	5/10/21
Car Completion		0.00%	3/2/21	59	4/30/21
Competition Deliverables		0.00%	8/17/20	217	3/22/21
Course Deliverables		2.22%	12/3/20	158	5/10/21

Continuation of Gantt Chart:



9. Appendix D - Budget

Preliminary Budget was based on last year's spending & asking amount. The current Bill of Materials are also displayed showing how much is planned on being used.

Current Budget				
Subsystem	**Asking Amount**	**Additional**	**Total**	**Current BOMs**
Drivetrain & Cooling	$100	$1,900	$2,000	$320.99
SCADA	$500	$500	$1,000	$350
Steering Suspension Brakes	NA	$2,000	$2,000	NA
CarMan	$2,700	$0	$2,700	NA
Shipping/tax	NA	$2,500	$2,500	$2,500
Interconnect	NA	$2,000	$2,000	NA
Registration	$0	$0	$0	0$
EPAL	$300	$700	$1,000	$96.34
Battery Packs	NA	$5,000	$5,000	NA
Frame	$7,310.00	$700	$8,000	$1,057.47
Overall	$10,910	$15,300	$26,200	$3,267.33