ECEN403

Electrical Design Laboratory I - Fall 2016

Submission Date: December 05, 2016

Senior Design Project - Progress Report

Shell Eco Marathon

Team Members:

Mohammed Hallawa (ECEN)

Ahmad Mokahal (MEEN)

Mohab Hanbal (MEEN)

Tariq Atiyah (MEEN)

Jayson El Turk (MEEN)

Doaa Awad (MEEN)

Mohamed Mohamed (MEEN)

Jawad Yammine (MEEN)

Mentor:

Dr. Michael Schuller

Supervisor:

Dr. Ziyad Shafik

Mr. Muhammad Bin Yousaf

"On my honor, as an Aggie, I have neither given nor received

Unauthorized aid on this academic work"

Table of Content:

Abstract:

The effects of energy fuels used daily by machines which are driven by humans is a huge issue that environmentalists are stressing about. Therefore energy companies are trying very hard to try and create a solution for this problem. Each year around the world the Shell Eco marathon competition takes place, which this year is taking place in Singapore. The aim of this competition is to encourage students to create and design cars that are energy efficient. The main purpose of this project is to create a vehicle that would compete and cope with the changes happening in the world right now. This means that car manufacturers and students in this case should start and focus on how to build a car that would use the least amount of fuel for the longest distance possible. In this project the group will concentrate on creating a vehicle that could adapt to a small amount of energy (fuel), by creating a car that is light weight, also has great body dimensions to be optimum when it comes to aerodynamics. The electrical part of this project is to design and implement all the electrical circuits the car needs, including all the auxiliary systems. In addition to that, to design and create a “Vehicle Monitoring System”, that will act as the first aid and the main safety for the driver during the competition.

Chapter 1 - Customer Needs:

In this project there are two main customers, one being Shell including all their rules and regulations and the other is the MEEN department in Texas A&M. The first customer needs are found in the rules and regulations handbook given by the committee of the Shell Eco Marathon. The second customer needs is based internally coming from the MEEN department which include the needs to build the optimal car for this year's competition.

Rules and Regulations:

For safety reasons, the maximum voltage on board of any vehicle at any point must not exceed 48 Volts nominal and 60 Volts max (this includes on-board batteries, external batteries, Super Capacitors, fuel cell stack, etc.).	Two Batteries were chosen: 24 Volts, 12 Ampere 12 Volts, 10 Ampere
For all vehicles only one on-board battery is allowed	Which is what is implemented in the design
Both propulsion and accessory batteries must be installed outside of the Driver's compartment behind the bulkhead.	A special compartment in the front of the car is being implemented.
The vehicle horn is required to be powered by a built-in battery.	A DC motor is directly connected to both the wipers and horn.
Electrical wiring should be in good condition, neat, clearly labelled, secured and not close to any moving parts	Implemented as shown in the schematic design shown in the appendences.

The table above shows that the needs from the competition committee is met and is all shown in the schematic and the car's electrical wiring layout shown in the appendices. All wiring will be also labeled and avoid "spaghetti wiring" as mentions in the requirements. All wiring will follow a specific path in a conduit throughout the car. The battery that was picked will be shown in chapter 2 and the reasoning behind it. Due to only one battery being used, most of the lighting that will be ordered would be LED due to its low usage to power.

MEEN Department Needs:

All Wires preferably should be done on the right side of the car to avoid area of driver.	This was implemented as shown in the wiring layout in the appendences.
The engine started should be electric.	Also as shown in the appendices, a wire connecting the battery to the engine would be used. Specification to this wire were chosen already, with bigger cross section area.
The engine should include a solenoid valve that cuts off the fuel from reaching the engine and it should be functioned electrically.	Already implemented and ordered from the electrical team, with a switch close to the driver.
Reasoning behind why the electrical team needs the battery on the front side of the car.	Reasoning was given which will be included under the table.
All electrical equipment in the car should be light weight and consume power as small as possible from the battery.	LED lights, Raspberry PI and all systems use very little power to work and function.

The main concern in the case of our project whether it is from the rules and regulations by Shell eco marathon and necessities by the MEEN department is safety. Safety of both the car in general and the driver in specific during the competition and race. The battery needs to be low voltage to avoid big incidents if the battery had a defect. The solenoid switch is needed to cut off the fuel to the engine in the case of a hazard. All the electrical wiring system is on the right side of the car to avoid any contact with the driver, coming in and out of the car. Battery was chosen to be in the front side for various reasons including:

1- Avoid the excessive heat produced by the engine
2- Avoid bumping into the mechanical team during the competition.
3- Closer to the fuse box and all the switches that will be implemented.
4- Mechanical team had the concern of power dissipation in the wire running from the engine to the battery for the starter, but due to the picking of a bigger cross sectional area of the wire, power dissipation or voltage drops is minimal or close to zero.

Chapter 2 – Benchmarking:

In this part of the report the main concern is to view different type of products that would be used to achieve the overall final project. Different materials and equipment for both the electrical and mechanical aspects of the car will be shown, mentioned and discussed. Most of the equipment that was chosen had two main advantages, first it met with the calculations done and had the weight desired to keep the car light. The team's main aim is to keep the car with the minimum weight as possible to have an advantage during the race in March.

Car Battery:

	LFX 24L3 – BS12	LFX 36L3 – BS12
Volts	12 V	12 V
Amps	24 A	36 A
Weight	1.80 Kg	2.19 Kg
Length, Width, Height	6.55 3.39 6.10 (inches)	6.55 3.39 6.10 (inches)

Looking at the table above, one could see that both batteries have the same voltage, same dimensions too, but the Ampere is different. The second battery has a higher ampere and after research one could notice that the higher ampere is much better when starting the engine. Higher cranking which improves the starting, and minimizes power dissipation.

Sensors:

All Sensors being bought are shown in the appendences section which include:

1- Tire Pressure sensors.
2- Oil Temperature sensor.
3- Engine Bay Temperature sensor
4- Battery Compartment temperature sensor
5- Fuel flow Meter.
6- Speed Sensor.

All sensors bought can handle very high temperatures, to ensure none get damaged when used.

Vehicle's Engine:

	Engine	Weight	L48N	L70N	L100N
A	Mass	0.22	42.23	32.96	25.26
B	Cost	0.11	38.58	34.72	26.71
C	Power Output	0.33	18.87	34.91	44.81
D	Size	0.11	44.05	31.90	24.05
E	Reliability	0.22	33.33	33.33	33.33
		Total	32.26	33.77	33.60

Looking at the table above, the engine in the middle came out to be the most suitable one due to its weight and power output. It is the engine that would produce the amount of torque needed by the calculations done (65 N.m), and at the same time the lightest in its category.

Vehicle's Transmission:

Criteria	Weight				
		Continuously Variable transmission	1 speed transmission	5 speed manual transmission	3 gear transmission (neutral/reverse/forward)
Mass	0.286	20	50	10	20
Cost	0.190	30	35	15	20
Operation difficulty	0.048	40	40	5	15
Installation difficulty	0.048	25	30	20	25
Reliability	0.143	25	30	25	20
Durability	0.048	25	25	25	25
Fuel efficiency	0.238	35	20	35	10
Total weight	1	27.645	34.56	20	17.86

From the above table one can see that due to efficiency in weight and being able to move the car too, the one wheel transmission is the safest option to go with.

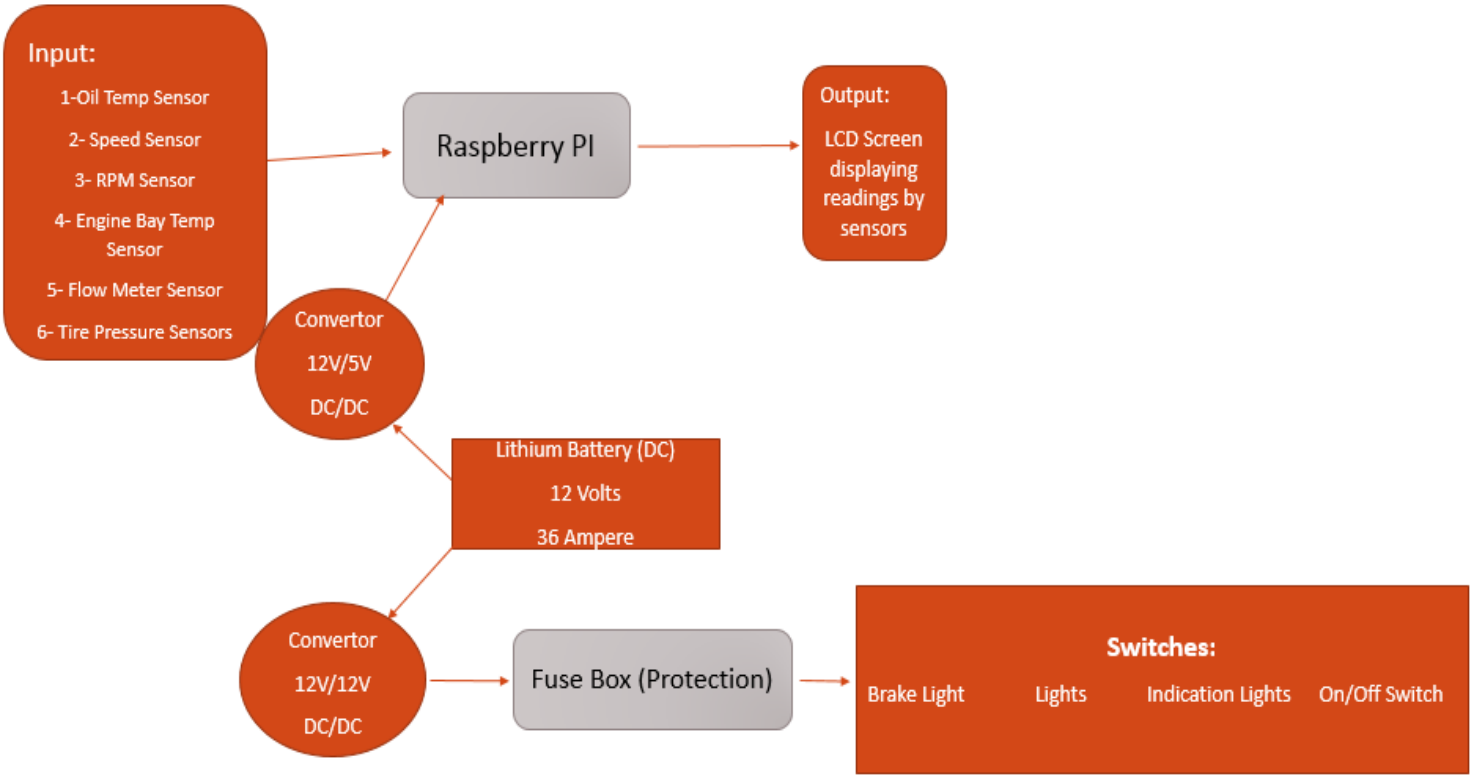
		Weight	**Carbon Fiber**	**Aluminum (6061)**	**Balsa Wood**	**Steel (1018)**
A	Mass	0.33	40	20	30	10
B	Cost	0.13	10	30	35	25
C	Ease of Manufacturing	0.07	28	22	20	30
D	Reliability	0.20	30	30	25	15
E	Safety	0.27	25	25	20	30
			29.2	24.8	26.3	19.7

Also from the above table, one could see that carbon fiber scored the lowest when it comes to cost but scored the highest in the other categories. This was not a problem though and carbon fiber came out to rank # 1 against other materials.

Body Design Material:

	Body Concepts	**A**	**B**	**C**	**D**	**E**	**F**	**Total**	**Weight**
A	**Safety**	/	1	1	1	1	1	5	0.53
B	**Mass**	0	/	1	1	1	1	4	0.27
C	**Cost**	1	1	/	1	1		3	0.20
D	**Reliability**	0	0	0	/	1	1	2	0.13
E	**Ease of manufacturing**	0	1	1	0	/	1	1	0.07
F	**Factor**	0	0	0	0	0	/	0	0
						Total		15	1

Chapter 3 – Function Modeling:



The main power supply is stationed in the middle which is a lithium battery as discussed above which generates 12 volts and 36 Amps. This supply is used for two main functions, one being the auxiliary system of the car which is shown in the switches section. It is used to power the engine, indication lights, lights, brake lights, horn and wiper. The engine will have a thicker wire to make sure no voltage drop or power dissipation occurs. Before the switches there will be a fuse box to protect the wiring from external affects.

The second function is to power the vehicle monitoring system, which has to go through a DC to DC convertor first, this is implemented to drop down the power from 12 volts to 5 volts. The vehicle monitoring system is operated using raspberry pi 3. This is written using C-coding and will operate by receiving data from the inputs (sensors) shown above which will be later on displayed on an LCD (7 inch) screen as the outputs on the dashboard for the driver to view.

Chapter 4 – Concept generation and selection:

Subsystem	Chosen Concept
Engine	Yanmar L70N
Fuel	GTL Diesel
Transmission	One Speed Transmission
Differential	No Differential (One Wheel Drive)
Body Shell Design	Hybrid
Body Shell Material	Carbon Fiber
Frame	Replace Aluminum Sheets with Balsa Wood
Suspension	No Suspension
Brake	Hydraulic Brake System
Steering	Mechanical Go Kart Steering
Battery	LFX36L3-BS12 (12 V, 36 A)
EMS Programmer	Raspberry PI 3
Sensors	(As shown in the Appendices)

Criteria	Complexity of design	Failure probability	Modification /innovation	Torque to weight	Experience/ competitiveness	Sponsor	Cost	Part availability	Total
Weight	**0.139**	**0.222**	**0.056**	**0.056**	**0.056**	**0.19**	**0.17**	**0.111**	1
GTL Diesel	40	40	33.33	40	37.5	33.33	35	50	**38.47918**
Gasoline	30	30	33.33	30	37.5	33.33	35	30	32.08918
Electric	30	30	33.33	30	25	33.33	30	20	29.42918

GTL diesel is a synthetic diesel substitute that is derived from natural gas. The state of Qatar is one of the leading countries that are rich with the amount of natural gas found. This type of fuel contains zero sulfur content and very low emissions, which makes this diesel both clean and friendly to the environment. The demand of energy is universally expanding and other alternatives are being developed to help keep up with the demand, therefore, the rise in use of GTL diesel all around the world.

Looking at the table above it explains why GTL diesel is the better option between its competitors. This is due to the reasons that it is the easiest to design, costs the lowest and has the best torque to weight conversion. This information can show that it is beneficial because of low cost, and the best fuel that converts power onto the wheels, and most efficient one.

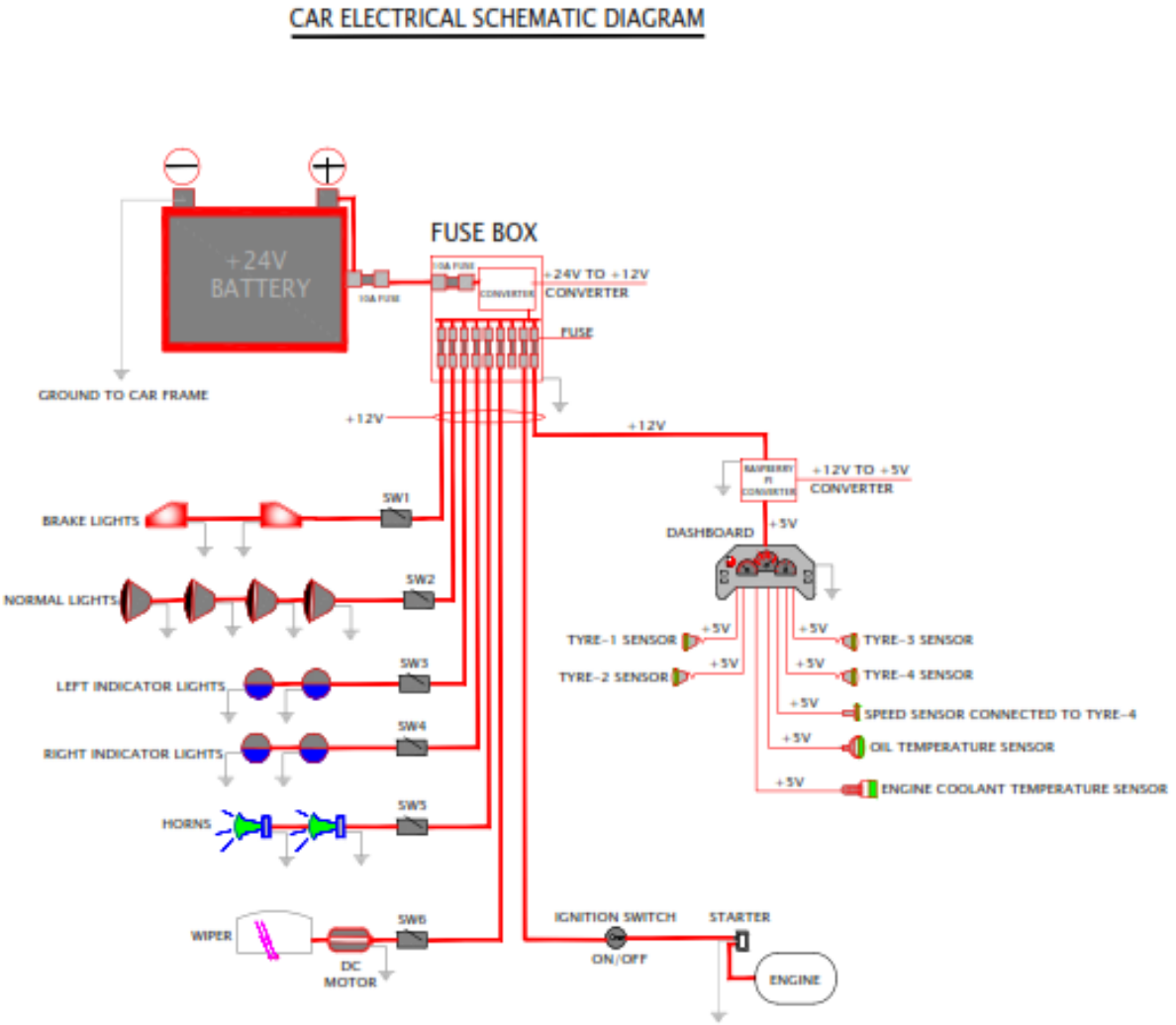
When it comes to develop the interactive monitoring system, the system shall use Raspberry PI 3, as the processing unit to display the measured parameters on a 7 inch screen.

Arduino	Raspberry PI 3
Has limited libraries and difficult to implement in future upgrades	It is Linux based and offers various libraries, for future comp and upgrades
Big processing Power (1.2 GHZ)	Limited Processing Power (16 MHZ)
Storage (512 KB)	Storage (32KB)
HDMI cable for output	N/A

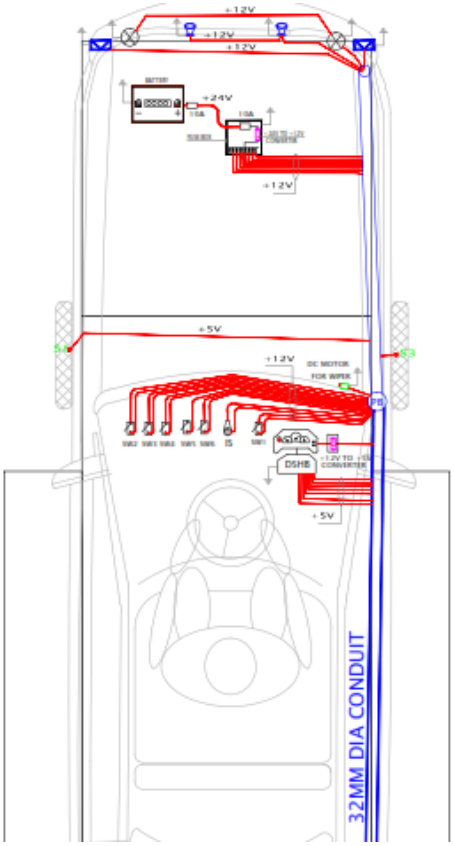
It was easy to choose between the two options above, the raspberry PI gives the user many more opportunities. This includes having larger space, operating at a much faster rate and also allows one to operate freely with no complications. This means that one can use the Raspberry PI to receive data from inputs and provide it on an output. In this case the Raspberry Pi would be reading the sensors and displaying the results on the 7 inch LCD screen that would be displayed in front of the driver during the race.

Chapter 5 – Detailed system Design:

Schematic Design:



Car wiring Layout:



SW1=BRAKE LIMITING SWITCH FOR BRAKE LIGHTS
SW2=LIGHTING SWITCH FOR NORMAL LIGHTS
SW3=LIGHTING SWITCH FOR LEFT INDICATOR LIGHTS
SW4=LIGHTING SWITCH FOR RIGHT INDICATOR LIGHTS
SW5= SWITCH FOR HORNS
SW6= SWITCH FOR WIPER

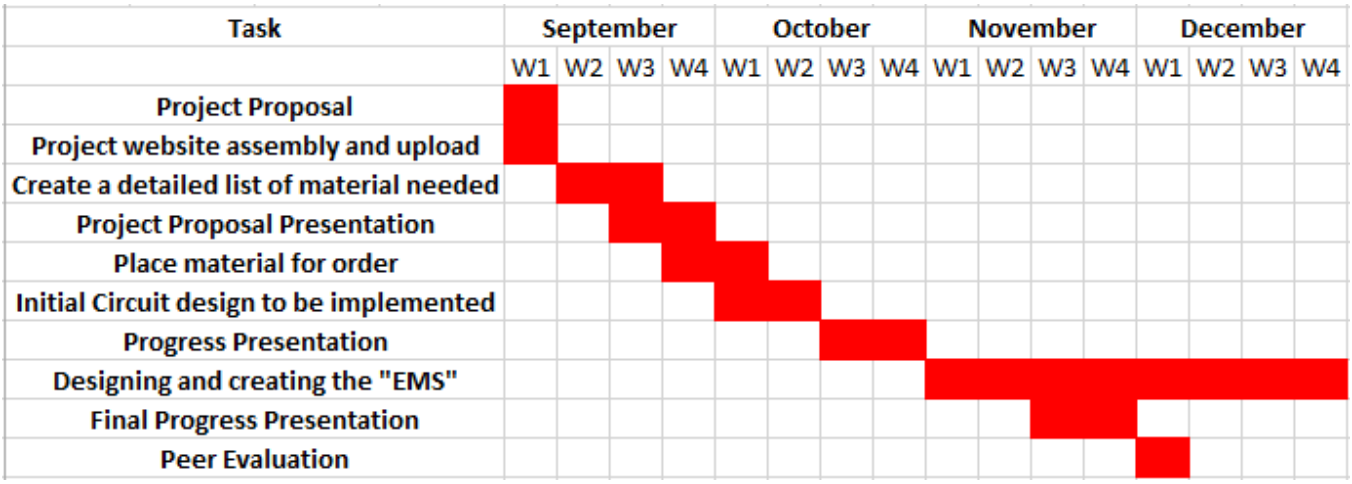
S1=TIRE PRESSURE SENSOR FOR TIRE-1
S2=TIRE PRESSURE SENSOR FOR TIRE-2
S3=TIRE PRESSURE SENSOR FOR TIRE-3
S4=TIRE PRESSURE SENSOR FOR TIRE-4
S5=SPEED/DISTANCE SENSOR
S6=OIL TEMPERATURE SENSOR
S7=ENGINE COOLANT TEMPERATURE SENSOR

=INDICATOR LIGHTS
=NORMAL LIGHTS
=BRAKE LIGHTS
=HORN
=FUSE
DSHB =DASHBOARD INSTRUMENTAL PANEL
IS =IGNITION SWITCH
S =STARTER
= +24V TO +12V DC CONVERTER
= RASPBERRY PI +12V TO +5V DC CONVERTER
=+24V LITHIUM ION BATTERY
= SWITCH
= GROUND WIRE TO CAR FRAME
10A = 10A MAIN FUSE/BREAKER
= DC MOTOR FOR WIPER
P8 = PULL BOX
= 32MM DIA FLEXIBLE CONDUIT

Component List:

Material	Quantity	Price
Speed/Distance Sensor	2	$5
Oil Temperature Sensor	2	$30
Fuel Flow Meter/ Solenoid Valve	2	$70
Engine Chamber Temperature sensor	3	$35
Battery Compartment temperature sensor	2	
Tire Pressure Sensor	8	N/A
Raspberry PI 3 + GPS	2	$40
LCD Screen + Case	2	$200
LED Lights		$100
Total		$500

Timeline:



Looking at the timeline above, one could see that tasks were kept up with and done on time, design was implemented and designed early in the semester. Two things were held back due to circumstances that weren't in the hands of the group. Ordering the material took a very long time due to delays for getting the funds, and finding the correct sensors that would suit the job. This also held back in designing the EMS, which would be delayed until mid-December to start working and coding. Other than that, the timeline was very realistic and tasks were done up to date.

Conclusions and Progress:

During the period from the 23rd – 5th of December, all the tasks on the timeline have been met and finished. The only two delays that was faced are ordering the part and due to that, the design of the VMS. This will be done during the winter break, in collaboration with Dr. Ziyad (advisor). All wiring layouts have been viewed to the mechanical department and approved with a few feedbacks and concerns. Which were later on corrected and addressed. The order list was also approved by the department and will be ordered in the very near future. Next semester will start with coding the Raspberry pi and calibrating the sensors, in addition to using the interface to display the reading on the LCD. This will be followed with working on wiring the auxiliary system, and implementing it on the car as shown in the initial design attached in this report. This needs to be done in the first two months, for the car needs to be shipped in mid-February to reach Singapore in time for the competition.

References:

1- "FROM DESIGN TO PRODUCT - Solar Team Eindhoven". *Solar Team Eindhoven*. N.p., 2015. Web. 20 Oct. 2016..

2- "SAMAGAGA". *Samagaga.com. N* .p., 2016. Web. 20 Oct. 2016.

3- "Shell Eco-Marathon, Rules 2017". *shell.com. N* ..p., 2016. Web. 20 Oct. 2016.

4- "Home - Yanmar Marine". *Yanmarmarine.com*. N.p., 2016. Web. 20 Oct. 2016.

5- http://www.shell.com/energy-and-innovation/shell-ecomarathon/asia/news-and-highlights/_jcr_content/pagePromo/image.img.1000.jpeg/1456915443294/shell-eco-marathon-2015-track.jpeg

6- http://photos.prnewswire.com/prnvar/20120917/MM76045LOGO?max=1600

7- http://img.cdn2.vietnamnet.vn/Images/english/2015/02/13/16/20150213164336-eco-marathon.jpg

8- http://shellecomarathon.newsweaver.co.uk/files/1/31964/56654/5550191/83924f8fcc9b533967d2e880/sem_newsweaver_header_asia_banner2_v1_0.jpg

9- http://www.eventindustrynews.co.uk/wp-content/uploads/2015/06/SEM-Asia-2014-Track-Photo-2.jpg

10- http://www.shell.com/energy-and-innovation/shell-ecomarathon/about.html

11- http://www.zinc.uk.com/wp-content/uploads/2012/05/shell-eco-marathon-day-4-2012-5-19-8-20-38.jpg

12- https://www.google.com/search?q=raspberry+pi+screen+with+gauges&espv=2&biw=1366&bih=667&source=lnms&tbm=isch&sa=X&ved=0ahUKEwi-4JPcgpbPAhWD6RQKHVd8Cw4Q_AUIBygC#imgrc=2LGikGzqZvVxPM%3A

13- http://www.shell.com/promos/download-the-shell-eco-marathon-global-rules/_jcr_content.stream/1472744744388/7b204129356de26d47c9f21e2c8f58e07f3e2e4f266ae7714c8e6b17bb7051e1/sem-2017-rules-chapter-1.pdf

Appendices:

Appendix A (Team Photo):

Appendix B (Sensors Chosen + other material):

Magnet Sensor for Speed. Not photo diode because it might not work correctly in sunlight conditions.

http://www.ebay.com/itm/Hall-Switch-Sensor-Module-For-Arduino-Smart-Car-Motor-Speed-Test-New-/121672320988?hash=item1c543c47dc:g:fx8AAMXQydtTPNGS

Engine Chamber Temperature Sensor.

http://www.ebay.com/itm/Digital-Thermal-Sensor-Module-Temperature-Sensor-Module-LM393-for-Arduino-/122192478826?hash=item1c733d426a:g:QasAAOSwnbZYCc6b

http://www.ebay.com/itm/Digital-Infrared-Temperature-Sensor-for-Arduino-MLX90615-GY-90615-Module-/400973656570?hash=item5d5be471fa:g:9SAAAOSw3ydVxIQP

Fuel Flow meter with solenoid Valve

http://www.ebay.com/itm/1-2-Water-Diesel-Fuel-Oil-Flow-Meter-LCD-Display-Flow-Sensor-Solenoid-Valve-/322115021364?hash=item4aff8d2a34:g:t10AAOSwuR5XPtyb

Extra temp sensor different type. Thermocouple type.

http://www.ebay.com/itm/MAX6675-Module-K-Type-Thermocouple-Thermocouple-Sensor-for-Arduino/311724738160?_trksid=p2047675.c100005.m1851&_trkparms=aid%3D222007%26algo%3DSIC.MBE%26ao%3D2%26asc%3D38530%26meid%3D2b7556fa5dbf415389cff2522ccb322c%26pid%3D100005%26rk%3D3%26rkt%3D6%26sd%3D282272766034

oil temp sensor (resistance based):

http://www.ebay.com/itm/Aftermarket-Gauge-Universal-Water-Temperature-Sensor-Oil-Temp-Sender-NPT1-8-S161-/261974520834?hash=item3cfee5f402:g:maYAAOSwjVVVxL8P

http://www.tanskyshop.com/tansky-water-temperature-oil-temperature-sender-sensor-temperature-sendertemp-sensor-by-high-quality-ntp-18-tkcgq06-p-216.html

Tire pressure:

http://forum.arduino.cc/index.php?topic=169919.msg1266163#msg1266163

raspberry pi + gps:

https://www.amazon.com/Gowoops-Ceramic-Passive-Antenna-Raspberry/dp/B01AW5QYES/ref=sr_1_3?ie=UTF8&qid=1480591538&sr=8-3&keywords=raspberry+pi+3+gps

Rear view camera:

https://www.amazon.com/ELP-Raspberry-microphone-security-camera/dp/B01E8OX212/ref=sr_1_12?ie=UTF8&qid=1480591738&sr=8-12&keywords=raspberry+pi+3+usb+camera

LCD + case:

https://www.amazon.com/Raspberry-Pi-7-Touchscreen-Display/dp/B0153R2A9I/ref=pd_bxgy_147_img_2?_encoding=UTF8&pd_rd_i=B0153R2A9I&pd_rd_r=9WVCH60D0DX62QVZ4W2K&pd_rd_w=gaEMu&pd_rd_wg=jmBjD&psc=1&refRID=9WVCH60D0DX62QVZ4W2K

https://www.amazon.com/Premium-Touchscreen-Raspberry-Display-7-Inch/dp/B01GQFUWIC/ref=sr_1_5?ie=UTF8&qid=1480591817&sr=8-5&keywords=raspberry+pi+3+lcd

https://www.amazon.com/dp/B01J52TWD4?psc=1

LEDs:

https://www.amazon.com/Gikfun-900-1000LM-White-Arduino-EK2014x2/dp/B00XJF4TNC/ref=pd_day0_147_3?_encoding=UTF8&pd_rd_i=B00XJF4TNC&pd_rd_r=BWDY1JW3BWH6X8VQFAW2&pd_rd_w=ZDOOQ&pd_rd_wg=XK1pV&psc=1&refRID=BWDY1JW3BWH6X8VQFAW2

https://www.amazon.com/Gikfun-White-Power-Arduino-EK2012/dp/B00XJF4QDK/ref=sr_1_1?ie=UTF8&qid=1480592131&sr=8-1&keywords=high+power+led+arduino

https://www.amazon.com/Brightness-Piranha-Energy-Saving-Luminance/dp/B016IC4A4U/ref=pd_day0_147_1?_encoding=UTF8&pd_rd_i=B016IC4A4U&pd_rd_r=BWDY1JW3BWH6X8VQFAW2&pd_rd_w=ZDOOQ&pd_rd_wg=XK1pV&psc=1&refRID=BWDY1JW3BWH6X8VQFAW2

Appendix C:

(Car Chassis):