

Safety Award Report
Prometheus Team
Shell ECO Marathon

Team ID: 622



TABLE OF CONTENTS

MOTIVATION

INSIDE VEHICLE ACTIVE PROTECTION

- Intro

- Active Vital Function Monitor and Prediction

 - Concentration Monitor through EEG

 - Biomedical Wiring and Monitor

 - Face Reaction Pattern Recognition

- Summary

INSIDE VEHICLE PASSIVE PROTECTION

- Chassis Design

 - Crash Simulation

 - Thermal Analysis

- Driver's Suite Reinforcement

OUTSIDE VEHICLE PROTECTION PLAN

- Intro

- Prometheus Safety Team

- First Aid Skills

- Assisting and Warning Other Competitors

- Accounting

 - Assembly points

 - Safe buddies



Motivation

In our two years of participation in the London's contest, we observed safety risks and possible threats that can be occurred at any time, something that led us to take at serious consideration the need of safety strategy in each section of the contest. So, we decided to design a, vital importance, protective veil around the driver which aims to actively protect and monitor her during the race. Furthermore, we established a safety plan that will initiate and become the routine of all the team members while being off-track for the smooth and safe conduction of the competition.

Inside Vehicle Active Protection

Intro

Based on our experience, we know that racing to shell eco marathon needs the maximum concentration and the best psychological and physical driver's condition. So, we designed a monitoring and assistance system for the driver, which will take into consideration its biometric features, will monitor its concentration and, through a camera, will analyze the expressions of her to, not only to keep our driver alert but also, warn other drivers in the road using a horn pattern.

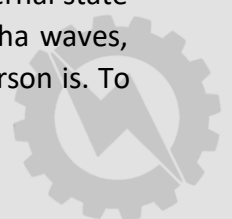
Active Vital Function Monitoring and Prediction

More specifically, our system consists of 3 parts:

- An electroencephalography (EGG) circuit for the detection of brain signals for concentration and readiness
- an integrated data acquisition system from biometric sensors
- use of vision algorithms to detect the eyes and head orientation of the driver to be aware of her vital state at any time.

Concentration Monitor through EEG

EEGs are a noninvasive way to "look into" a brain and are used to monitor the internal state of a person. There is a variety of brain waves, but we are only interested on alpha waves, observed at around 8-12Hz, that provide an estimation of how concentrated a person is. To



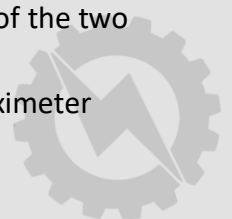
obtain those signals, we use 3 electrodes: 2 to measure a voltage difference across the scalp, and one as a neutral point. Brain signals are measured at $10\ \mu\text{V}$ to $100\ \mu\text{V}$, so we designed and built a hand-made circuit that acquires these signals, amplifies and filters them in order to, finally, be analyzed by a microprocessor. Based on a specialized research in brain neural networks, our analysis consists of a sequence of peak detections, which have been responsible to indicate an upcoming driver's distraction.



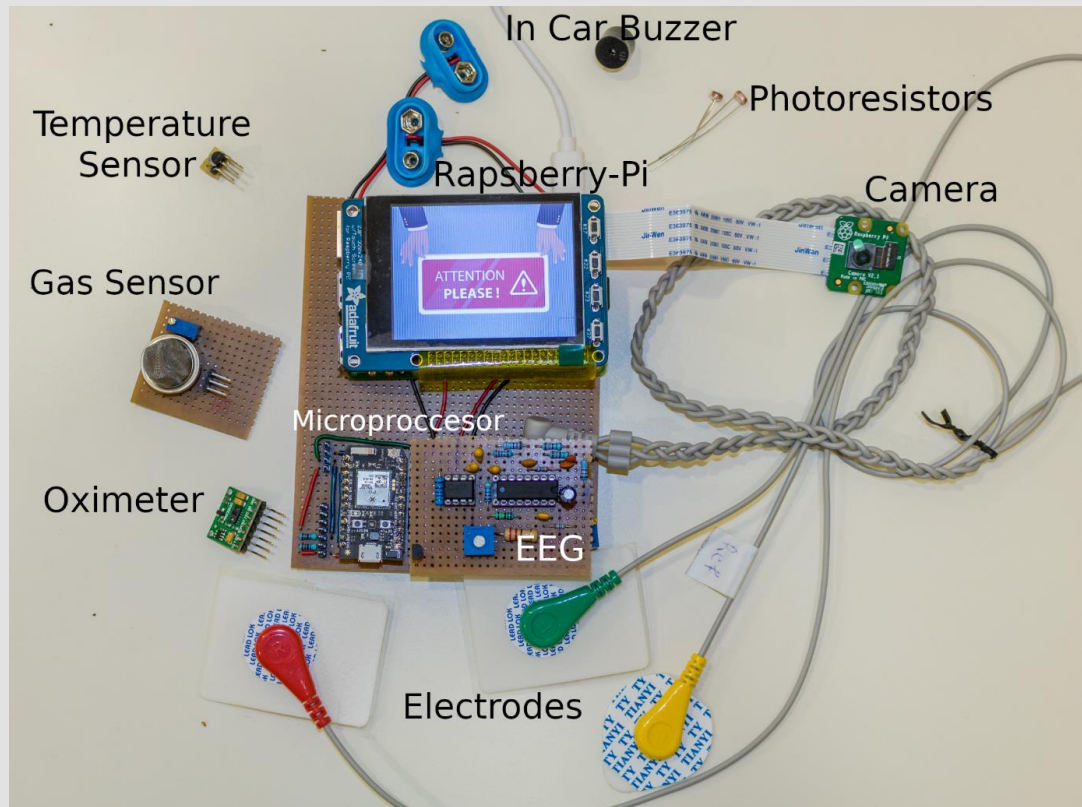
Biomedical Wiring and Monitor

We built another circuit board in which all biometric sensors are located, while also includes the central microprocessor that will analyze all the signals and extract the result of the driver's status. The microprocessor takes as inputs:

- Internal and external data temperature of the driver's suit for comparison of the two environments
- Heartbeat and saturation of oxygen in the driver's blood measured by an oximeter

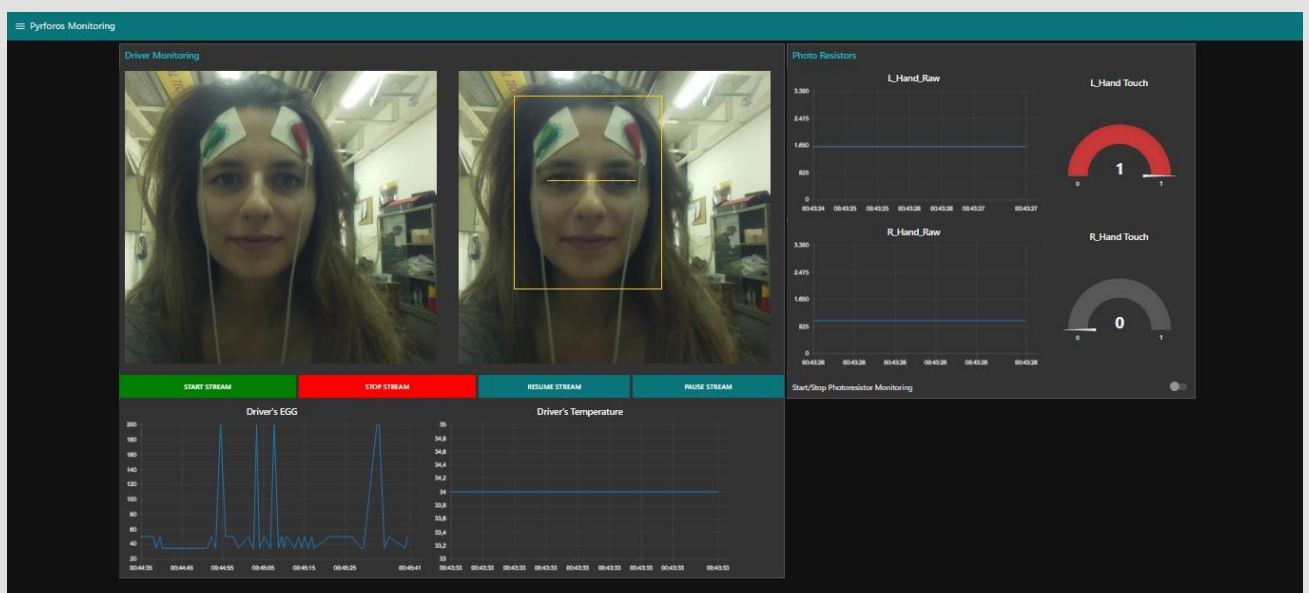


- The position, or not, of the driver's both hands on the steering wheel using two photoresistors
- And finally, the possible concentrations of gases such as LPG, propane, hydrogen, smoke and others, monitored by a gas detector.



Face Reaction Pattern Recognition

Using the Raspberry-Pi and the appropriate camera, we record live footage from the driver's face. We aim to detect the eyes and the rim of the driver's helmet and, in real time, detect if her eyes are opened and pointing to the right direction and whether her head is in a reasonable inclination to make sure nothing undesirable has happened (i.e. faint or blackout).



Summary

Based on all the above distinct systems and all the measurements we acquire, we have trained a "machine learning model", which, prioritizing them by their importance and considering past measurements and results, returns a percentage of how likely it is an unwanted situation to happen. At the same time, it automatically notifies the driver for the result which then tells the system (using a touchscreen) whether it was a correct or false alarm, training the model on the go. From our part and relying on the system's result, we also notify our driver and at the same time we warn the rest of the vehicles on the road through a specific horn pattern.

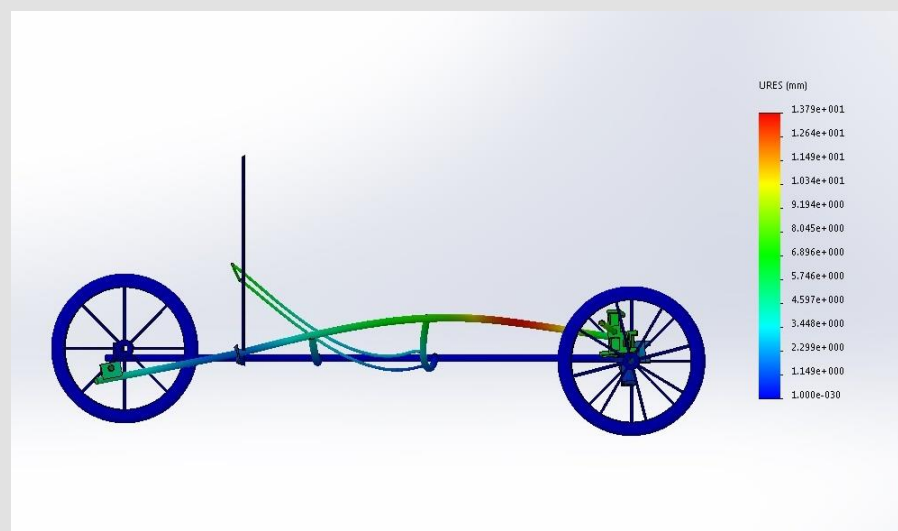
Inside Vehicle Passive Protection

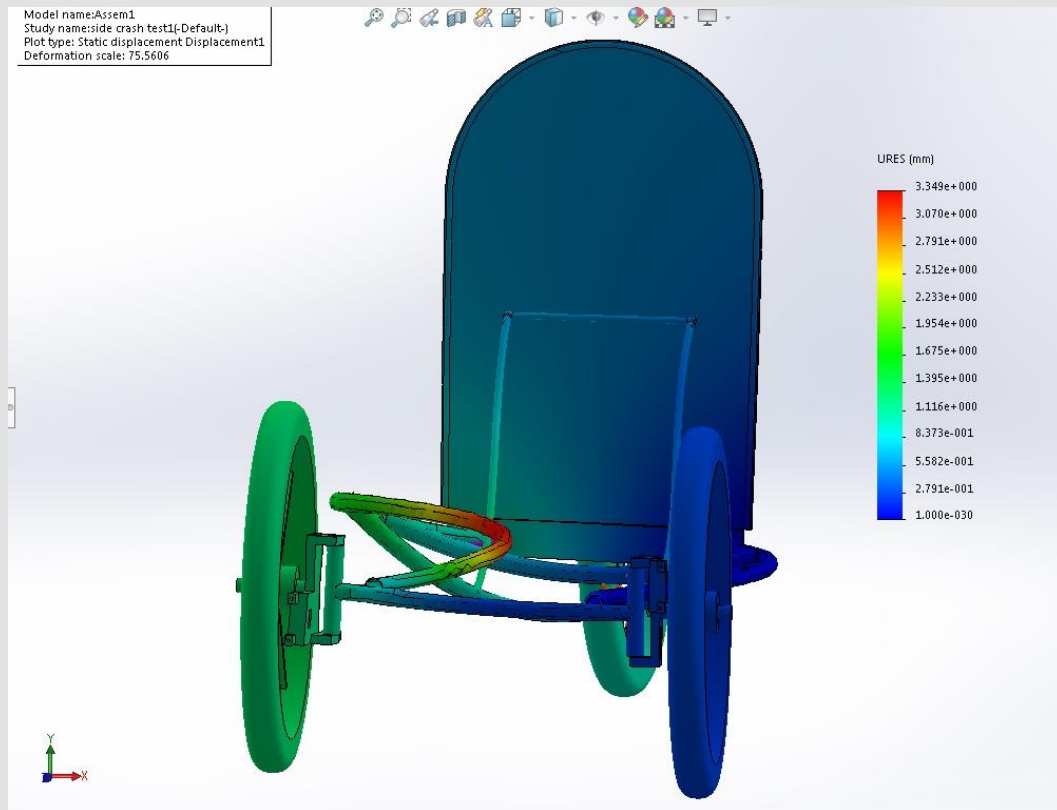
Chassis Design

Our vehicle consists of an aluminum frame and a fiberglass shell that, although independent, are easily connected. Based on our last year brand new chassis, we tried to improve the safety features. After its lightweight construction – weighing just 4 kg – and design with the aim of embracing the driver and protecting her against a possible collision, we added an additional crumble zone that acts like a safety veil around the driver. This, of course, is our new seat with the unique feature of having the exact shape of the driver's body and being made of aluminum tubes and suspended fiber that hugs the driver and protects her in the event of a collision.

Crash Simulation

While we were designing our new chassis, we wanted to prevent any driver injuries in the event of a collision. Below you can observe our crash simulation that lead us to the final design that minimizes any unwanted situations.

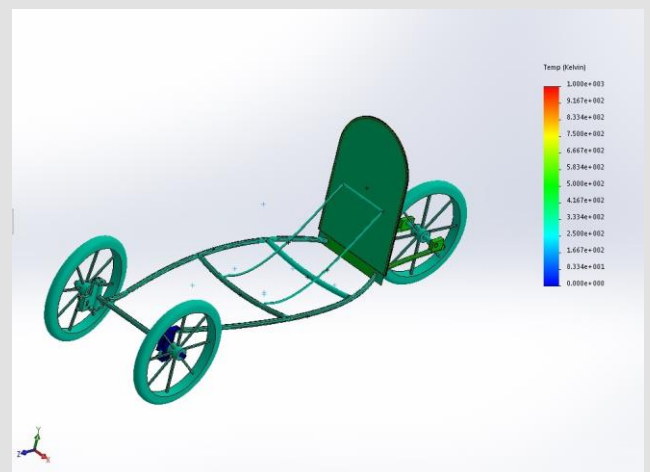
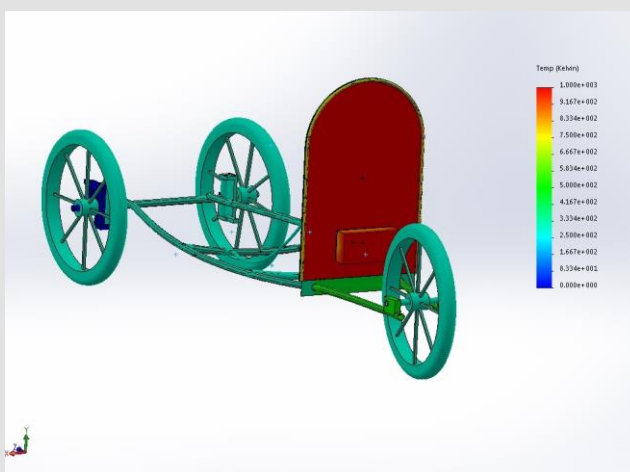




It is obvious that the chassis is facing upwards and not towards the inside of the vehicle in purpose of embracing and protecting the driver.

Thermal Analysis

In case of battery fire or fire in the electronic circuit boards, the frame is designed to conduct heat in such a way that it will not approach the driver fast, giving her time to evacuate the vehicle. Below is a presentation of the thermal simulations that were conducted using Solidworks to find the best battery position and the most suitable materials.



Driver's Suite Reinforcement

In our effort to reassure the driver's physical safety in the occasion of an incident, we tried to take advantage of the excess weight and space in the driver's suit. After a major research we made on a variety of materials, we ended up on a specific category called "Non-Newtonian fluids", which we embed in the driver's suit. Its unique feature, appealing to our situation, is that when force is applied to them they instantly harden and become near solid, sealing the driver.



Outside Vehicle Safety Plan

Intro

This part of our safety and protection plan aims to implement certain daily habits and activities, to all team members, that promote safety and create a safe environment for everyday manufacture process, while also cultivate the knowledge, skills and awareness to deal with undesirable situations.

Prometheus Safety Team

As everyone knows, when being under pressure or in a rush and we have to deliver your best, we often neglect the safety rules based on which we should work. Thus, to achieve the continuous observance of the safety rules, both in the paddock and the camping, we created a subgroup, called "Prometheus Safety Team", which will be responsible for overseeing the work within the paddock, giving advice on the correct operation of the tools, knowing the needs of each team member and also being in readiness of giving immediate help to anyone who needs it.





First Aid Skills

Having participated in the competition for almost a decade, our team has come to the realization that, each member, should be in position of providing the necessary help in the occasion of an accident, either on the track field, or – more often – in the paddocks or the camping. So, we worked on obtaining the necessary knowledge and certificates to be able to provide that kind of help and now each of our team's member is a qualified RTI First Person on Scene 1 (FPOS-1) which is an advanced first aid skills certification provided by Rescue Training International.



Assisting and Warning Other Competitors

However, being a FPOS 1 or having a warning horn pattern has little value if none of the participants is aware of them. So, we will spread a leaflet containing a QR Code that will lead to a special webpage with the necessary information about our help aiding skills and our horn pattern in case of a driver's emergency, so that other drivers and track marshals are more focused in the track to avoid unwanted collision.



Accounting

Assembly points

In case of emergency, the team is prepared to meet at one of the two predefined assembly points, one near the Emergency Exit of the paddock and the other at the ArcelorMittal Orbit sculpture.

Safe buddies

Since accounting for all team members after an emergency is essential, we have predefined 7 pairs of people, the “safe buddies” based on their body structure. Everyone is expected to, always, know where their buddie is, so that, in case of emergency, accounting will be done fast and efficiently.

