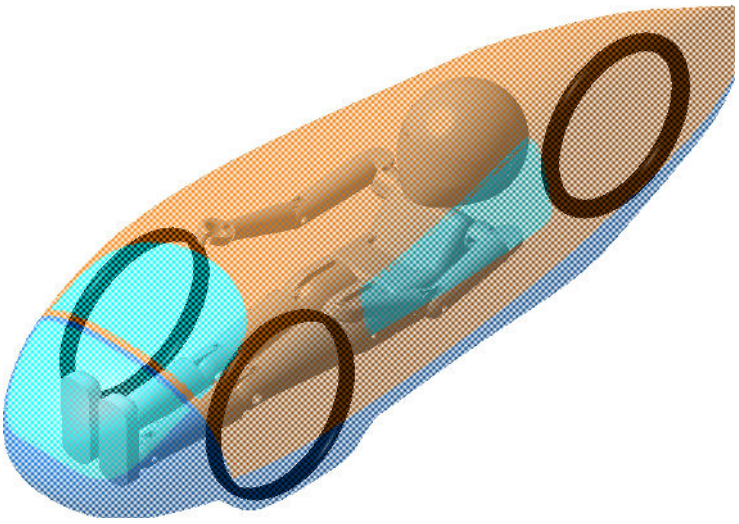
MMF325 Automotive Engineering Project

Project work report

Chalmers Eco-marathon 2007
Shell stiffness



Chalmers University of Technology
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Introduction

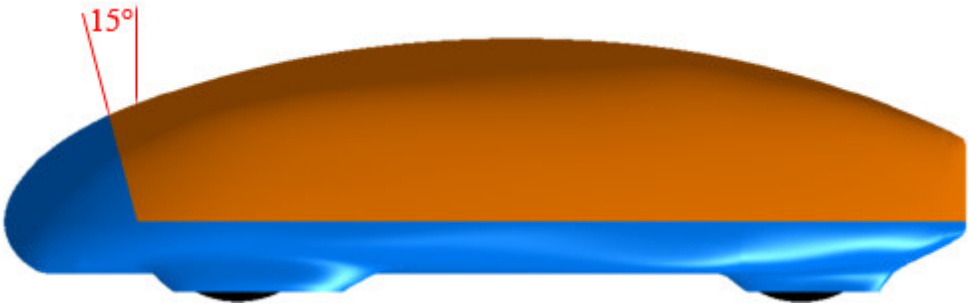
The aim of Chalmers Eco-marathon project is to build a vehicle which will be able to run a maximum distance consuming the smallest amount of fuel as possible. To reach this goal, each part of the vehicle must be optimized for high efficiency from a mechanical and aerodynamic point of view.
This report is a short summary of a specific part of this project: the shell stiffness.

In order to make a vehicle stiff and light, every piece fixed on the shell will provide stiffness in addition to its normal function:

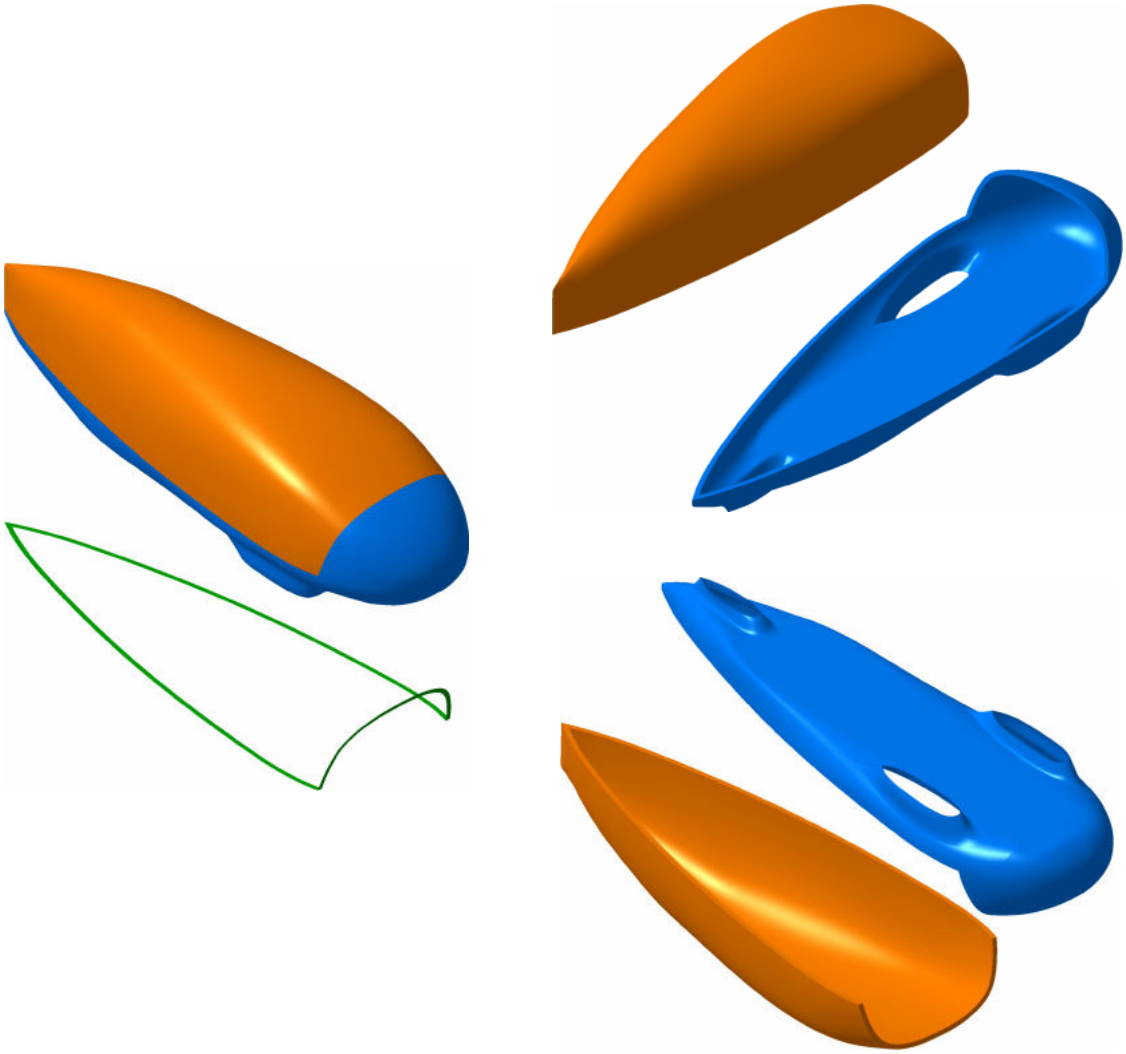
- Opening/closing systems must be placed in judicious positions where the shell is under high strains (aerodynamic forces) and where it is more bendable (mechanical strength);
- If the frame and the shell are glued together on the overall length of the vehicle, it can keep us away from adding some reinforcements and consequently circumvent the problem of extra weight on the lower shell;
- If the firewall has an adapted shape, it can be a crucial support in the middle of the upper shell and can also avoid useless extra weight on the upper shell;
- Windows (frontal and lateral) could also provide high stiffness in addition to very aerodynamic junctions between the window and the shell if the technique of “polymer sandwich” is used;
- Rear mirrors will be placed on each side on the inner surface of the shell to get the best visibility depending on the lateral windows location and may provide some easy and efficient grip points to help the driver to open and close him/herself the shell.

Shell cutting with reinforcement on the edges

In order to make the vehicle as aerodynamic as possible by controlling the stagnation point on the nose of the vehicle, the shell will be not be cut along an horizontal plane for the very front end. We will keep this part in one piece as following:



In order to keep an easy access to the wheels, the cutting will be done before the front wheels axle (on the previous picture, it is even before the very front of the tyre)
The first reinforcement will be done on the edge of both parts of the shell. A width of 2 cm would be enough to harden the border (without touching the wheels!) and to help for a fine adjustment of the two parts when closing.

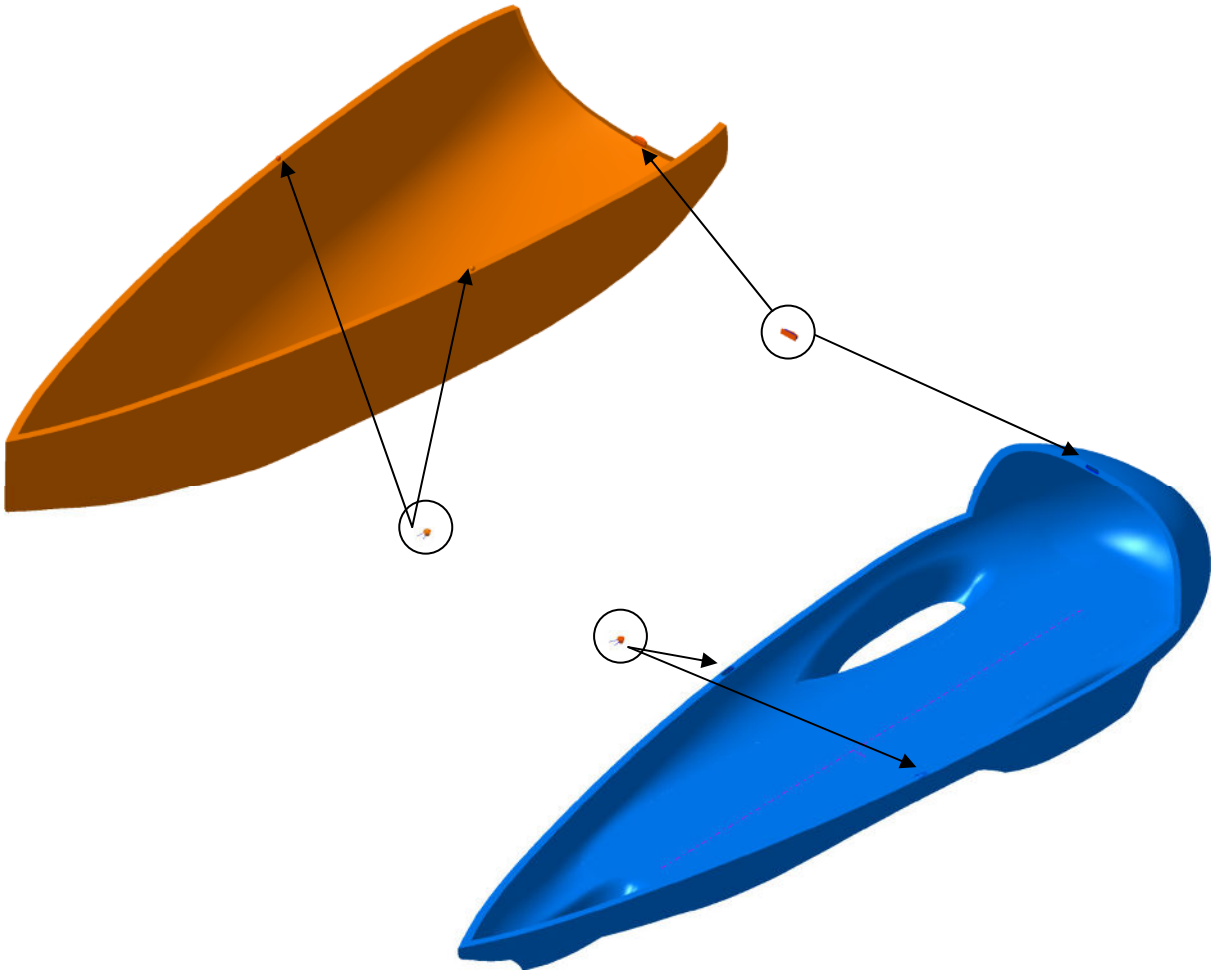


Opening and closing systems

Many solutions can be found for this function, so we should choose the simplest, lightest and most reliable systems as we can.
Existing systems which have already made their proof in daily life can be adjusted to our purpose.

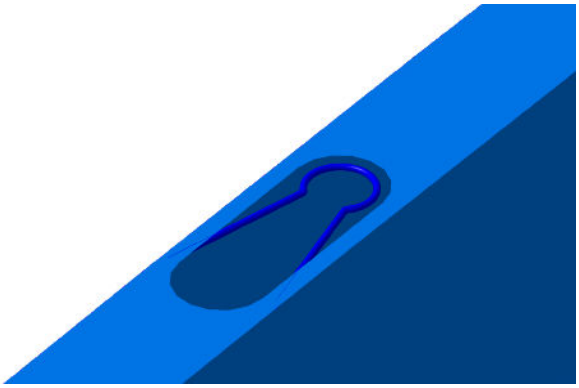
A “clips” system using elasticity of the materials may be a good technique to keep the shell closed during the competition and to make an easy and efficient manipulation from the interior and exterior of the vehicle.
The main idea is to close the shell by putting down the upper shell slightly (a few centimetres) on the rear and then push it towards the front to block it (need of a voluntary pressure to open it) and to maintain it in position (to keep the edges of both part of the shell aligned).

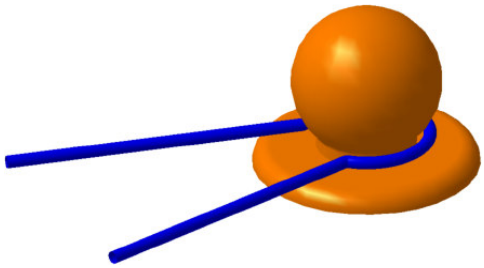
The minimum required should be 3 attachment points:



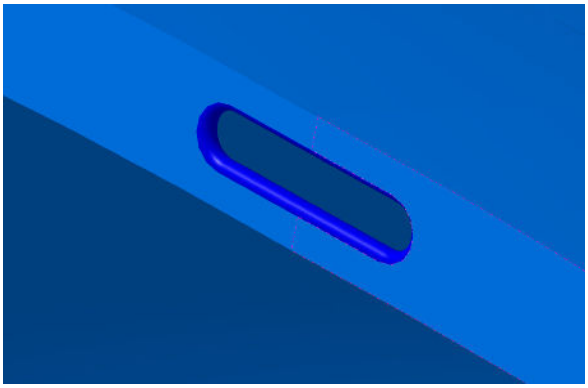
More numerous are the fixation, better will be the strength of the system but heavier… We have to find the good compromise.
6 attachment points may be enough to fix the upper part of the shell:
- 4 on the side (2 on each);
- 3 in the middle (2 on the front and 1 on the rear of the centre line of the vehicle).
In this case, there won't be any obstacle in the front view of the driver and the rear fixation could be a simple self centring guide.

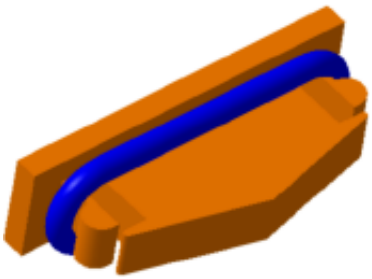
Lateral fixation





Central front fixation



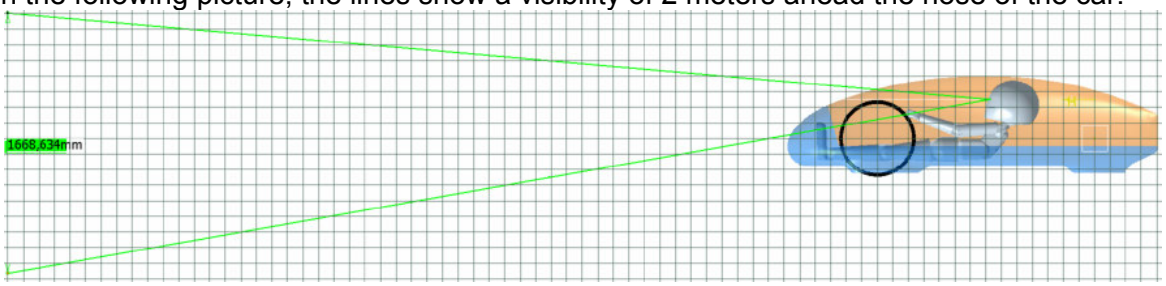


Other shape with the same principle can be used (see appendix at the end of the report).

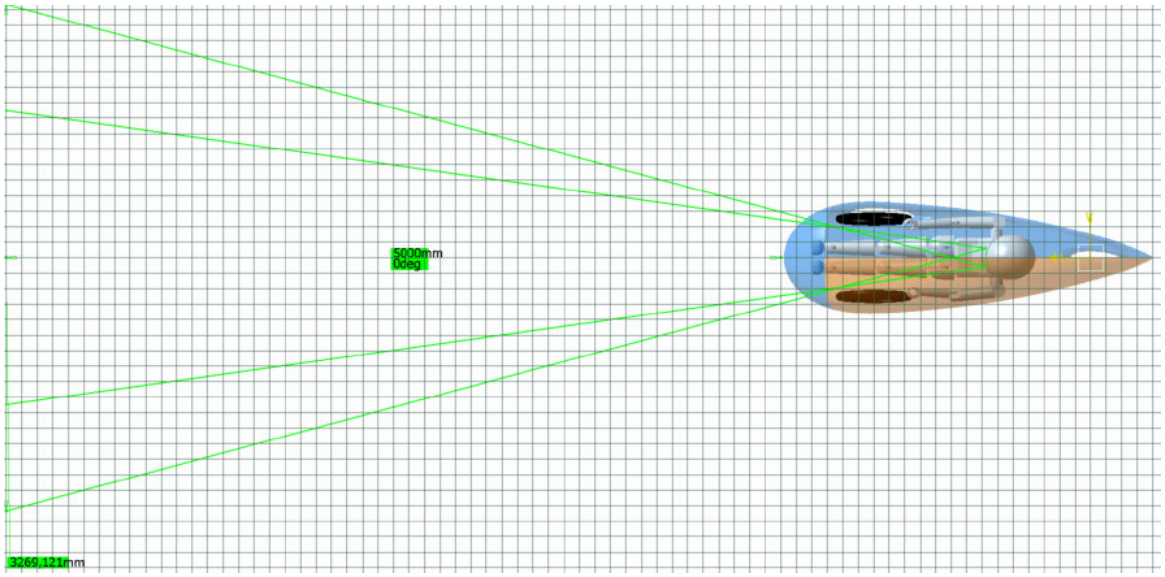
Visibility

Visibility is a major need for security and for a suitable driving comfort (consequently for a good strategy during the competition).
The main problem we have to solve before thinking about visibility stuffs is the driver environment inside the car: the windows and side mirrors will be placed depending on the driver position, frame shape, steering wheel, wheel cover, information board…
Everything in the vehicle has to be optimized and undersized for low weight but also to leave space for comfort and visibility.
It is important that the driver has a direct vision on 180° at a minimum distance of 5 meters. The side mirrors must be adjustable and big enough to guarantee the minimum visibility required.
If these conditions are not fulfilled, the vehicle won't be able to pass the security test (for more details, see the legislations in the appendix)

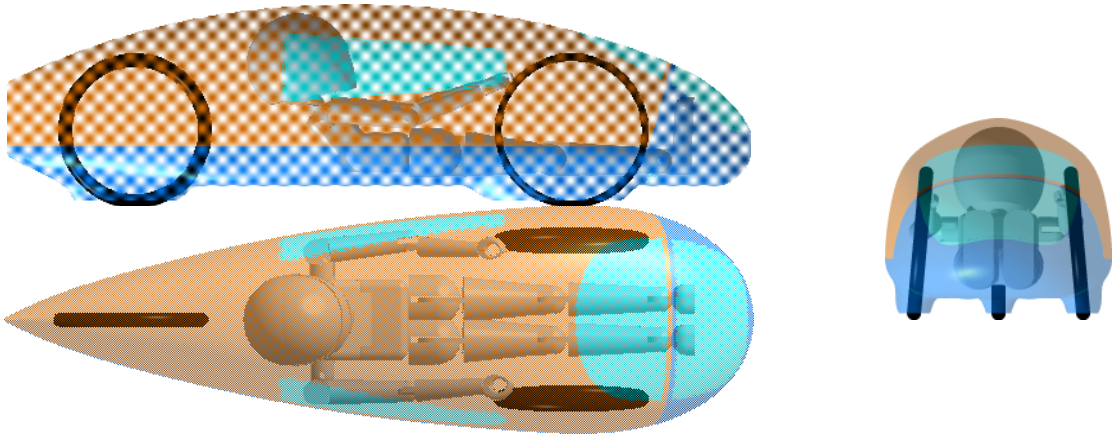
On the following picture, the lines show a visibility of 2 meters ahead the nose of the car:



From the top view, we can see that the visibility will be more than 3m width at a distance of 5m:



The final sketch of the windows is the following:



In this case, the frontal window will be in two parts: one on the lower shell and one on the upper one. This can bring many advantages since they will provide stiffness and make easier the manufacture (for the “polymer sandwich” technique sketch, see the appendix).

The side mirrors will be fixed next to the wheel, just before the lateral windows.

Appendix

Shell Eco-marathon Rules 2007

Article 21: Visibility

The driver must have adequate direct visibility in front and on each side of the vehicle and be able to turn his or her head **90°** on each side of the longitudinal axis of the vehicle. This field of vision shall be achieved without aid of any optical devices such as mirrors, prisms, periscopes, etc. Moreover, the vehicle shall be equipped with a side-view mirror on each side of the vehicle, each with a minimum surface area of **25cm^2**. The visibility provided by these mirrors, and their proper attachment, shall be subject to inspection.

Visibility in each of the vehicles shall be checked by an Inspector sitting in the driver's seat in order to assess on-track safety. This Inspector shall check good visibility with seven **60cm** high blocks spread out every **30°** in a half-circle, with a 5m radius in front of the vehicle. Note that the driver must be able to move his/her head in order to see any "blind spots".

All the windows should be covered with a safety film on the inside of the windows to prevent sharp splinters hurting the driver.

Article 30: Vehicle Access

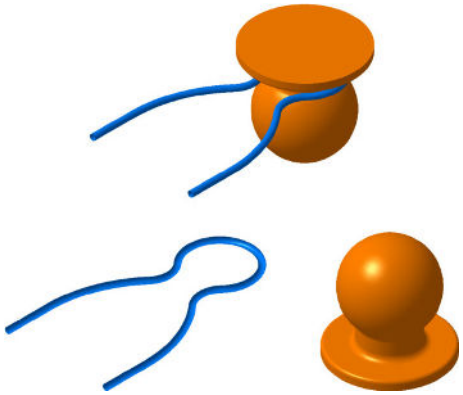
It is imperative for drivers to be able to vacate their vehicles at any time without assistance. Vehicles with closed bodywork shall be equipped with a sufficiently large opening for the cockpit. The driving position shall be designed so that emergency services can easily extract the driver from his/her vehicle, if necessary.

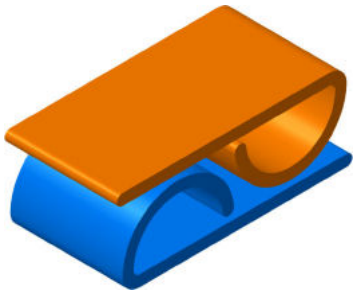
Said opening may be enclosed wholly or partly by means of hinged, detachable and/or folding doors, provided that a release mechanism is easily operable from inside and that the method of opening from the outside is clearly marked by a red arrow and does not require any tools.

It is forbidden to attach or to reinforce the bodywork or cockpit with adhesive tape.

The Race Marshals reserve the right to extract the driver from the vehicle by opening and/or closing that vehicle, whenever they deem this to be necessary. Any intervention by the Race Marshals shall not be subject to protest and shall not lead to any penalties for the team in question.

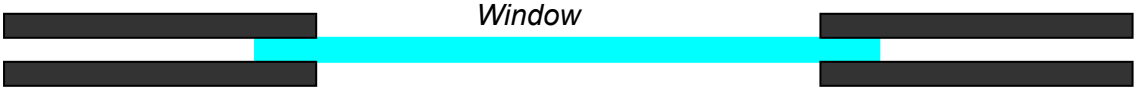
Alternative shapes for fixation parts:





"Polymer sandwich" technique:

Outer carbon fibre layer



Inner carbon fibre layer