

Race Car Body Design

Fall 2011, Mike Ornstein

What's the point?

A race car is more than just a vehicle. It is an expression of speed. It has to go fast, and look good.

In addition to being an engineering exercise, the Formula SAE competition is about making an exhilarating formula style race car that would entice a consumer to purchase the ride.

The first thing a potential customer sees is the **body**.

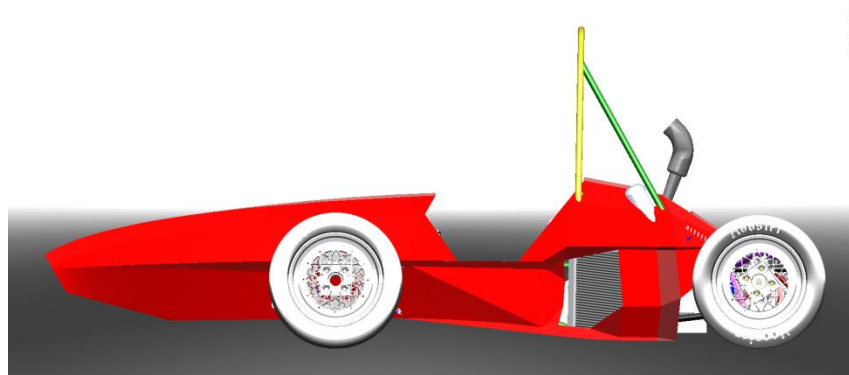
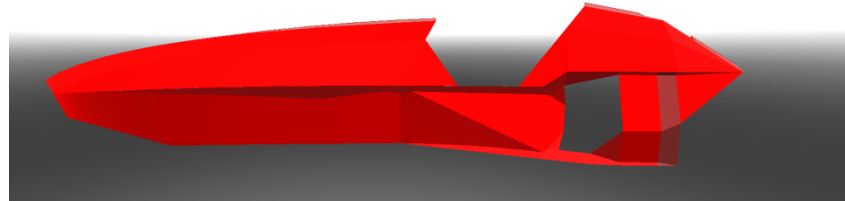
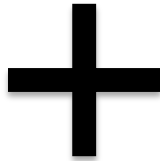
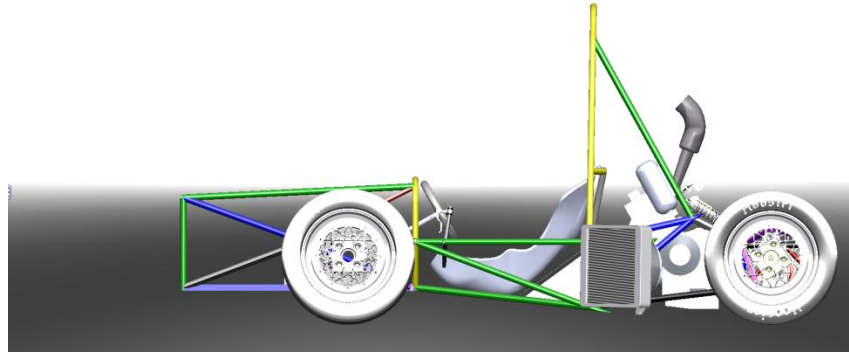
Outline

- What goes into a race car body?
- How can you go about making a body?
- This year's approach to design of the body
- Implementation of the approach
- Analysis and conclusions of the design
- Suggestions for future improvement

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The Body



Purpose

- The body is the external surface for the chassis of the race car
- Functions as a streamlining element to reduce drag at high speed
- Acts as a closeout to prevent foreign objects from coming into driver compartment during normal operation
- **Ensure the car looks fast standing still**

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The Possibilities

From consumer automotive industry

Metallic panels *pressed, stamped, machined, welded*
Fiberglass, polymer panels



From automotive racing industry

Carbon fiber monocoques,
Carbon fiber panels



From aerospace industry

Aluminum/fabric stressed skins



The Decision

From automotive racing industry

Carbon fiber monocoques,
Carbon fiber panels

Considering the team's past experience in fabricating carbon fiber body panels, the popularity of the approach amongst other Formula SAE teams, and the continued implementation of carbon fiber body elements in the racing industry, making a molded carbon fiber body is appropriate for Carnegie Mellon Racing.



Carnegie Mellon Racing's Past



Race Car 39

- Hand formed XPS Foam plug (*time consuming*)
- Poor Surface Finish
- Vinyl covering (*not paint*)



Race Car 79

- Honda sponsored CNC male plug, single layup
- Acceptable Surface Finish
- PPG sponsored paint

The Ideal Process



Design

Aesthetics are determined based on the input of the team and designers



Model

A digital model is made to further visualize design and to provide a means from which to create the plug



Plug

Using the model, a male plug is created out of foam. This step can be performed by hand or via CNC machine



Mold

A fiberglass mold is laid up around the male plug, transferring the outer surface of the plug to the inner surface of the mold



Panels

Carbon fiber panels are laid up in the fiberglass mold, picking up the smooth surface on the outside of the final panels



Fit

The panels are fit to the car and a mounting solution is established



Finish

The panels are finished and painted, ready for competition

Semester 1 (3 units)

Semester 2 (6 units)

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Lessons From the Past

- Hand finishing is extremely time consuming
 - *Do whatever helps to minimize hand finishing*
- It is very difficult to take advantage of a digitally modeled body when constructing a mold by hand
 - *The process involves dozens of templates and is very difficult to verify*
- Surface finish suffers when time runs low on a hand worked body

Building on Lessons Learned

Priority 1 Design:

Arrive at competition with a car that looks awesome (*last year was embarrassing*)

Priority 2 Model:

Have a CNC machined foam plug to ensure an achievable timeline for the aforementioned awesome looking car

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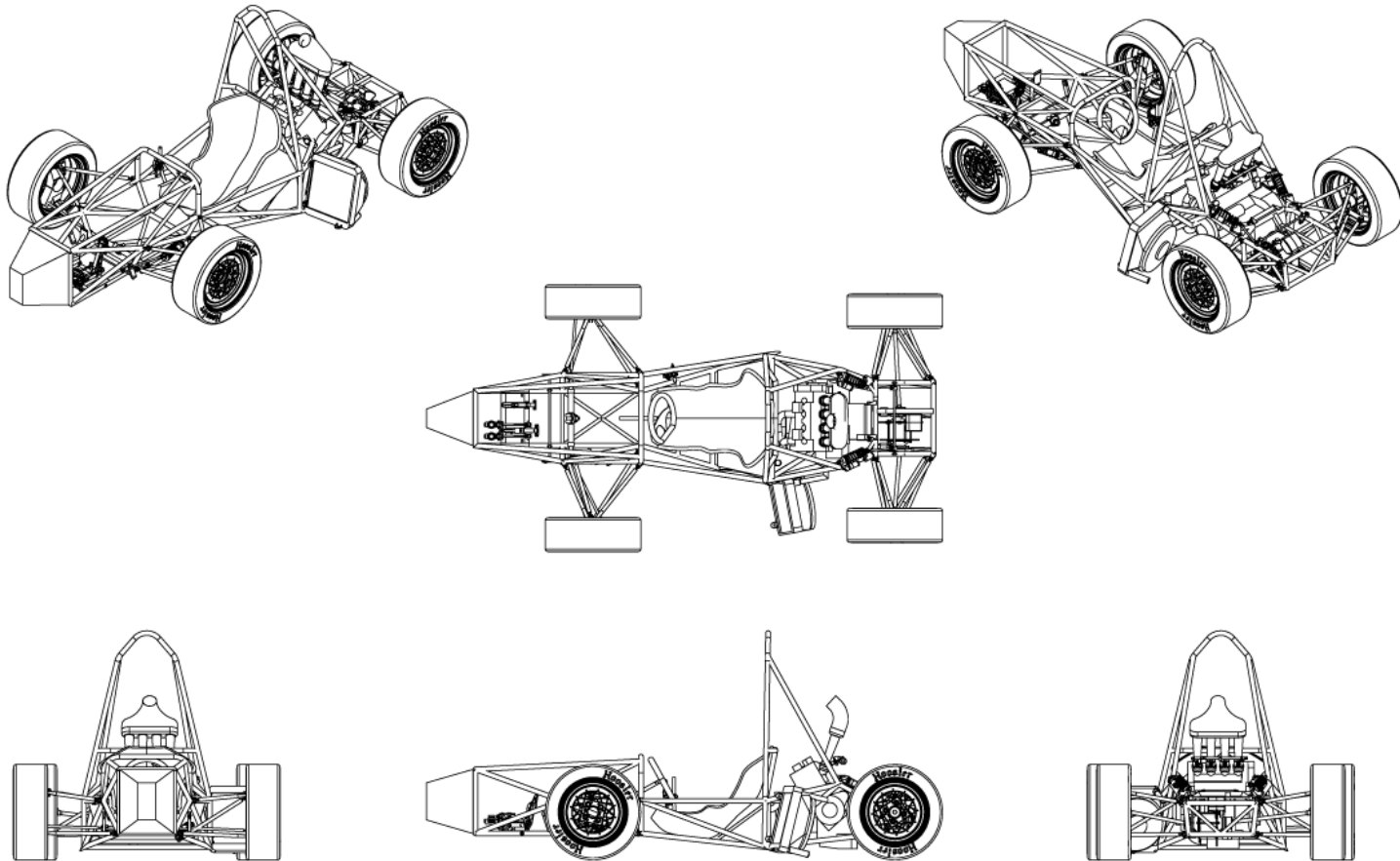
Achieving Priority 1

Priority 1 Design:

Arrive at competition with a car that looks awesome (*last year was embarrassing*)

The body team consists of not only gearheads who like painted flames and raw metal, but also aesthetically aware Industrial Designers. This composition will yield an attractive car.

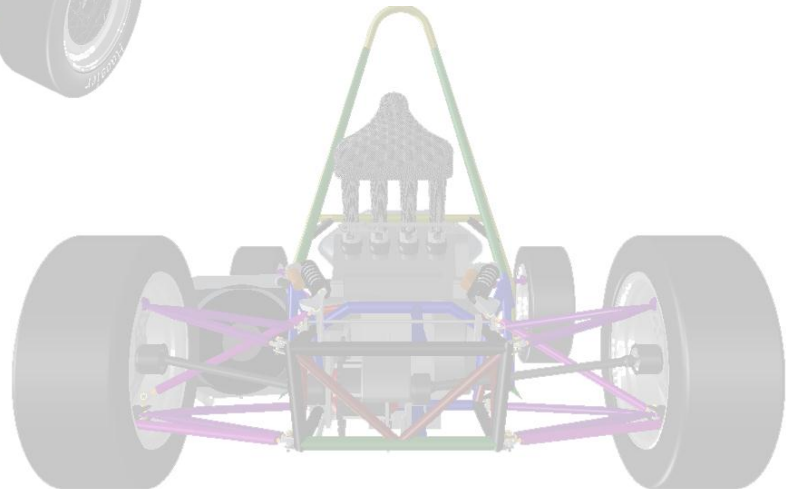
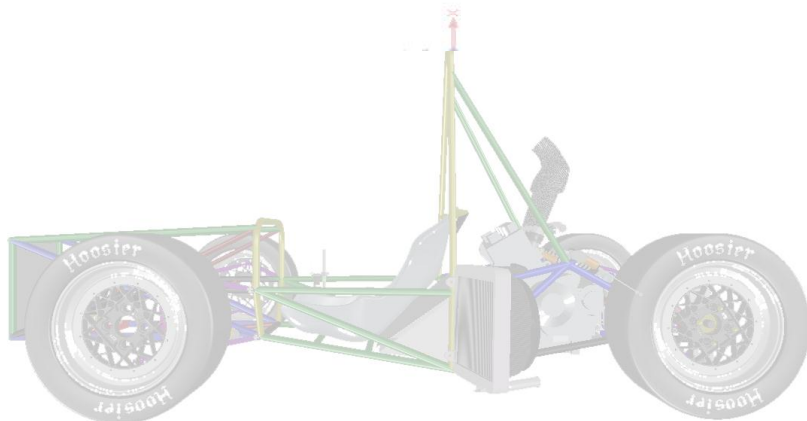
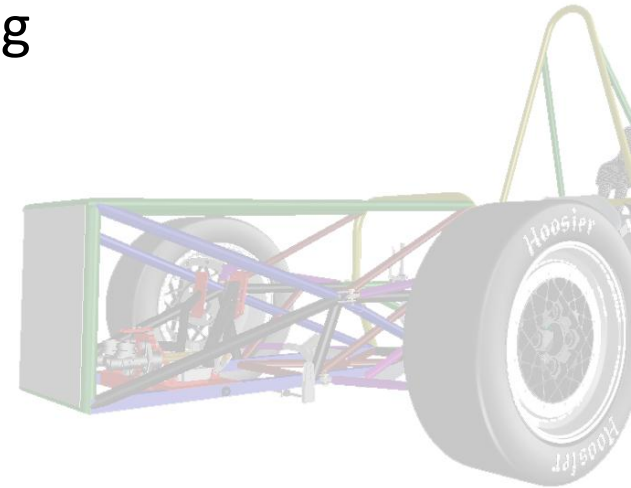
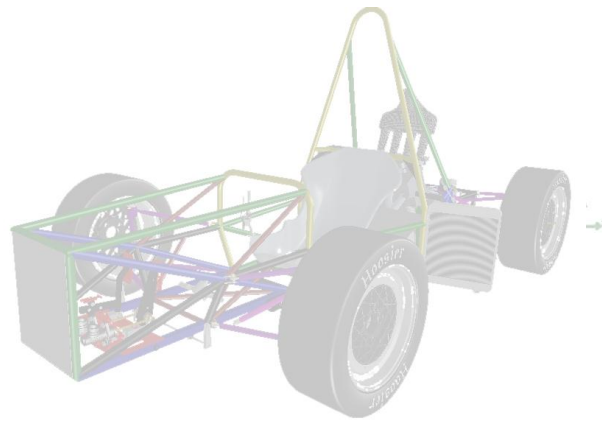
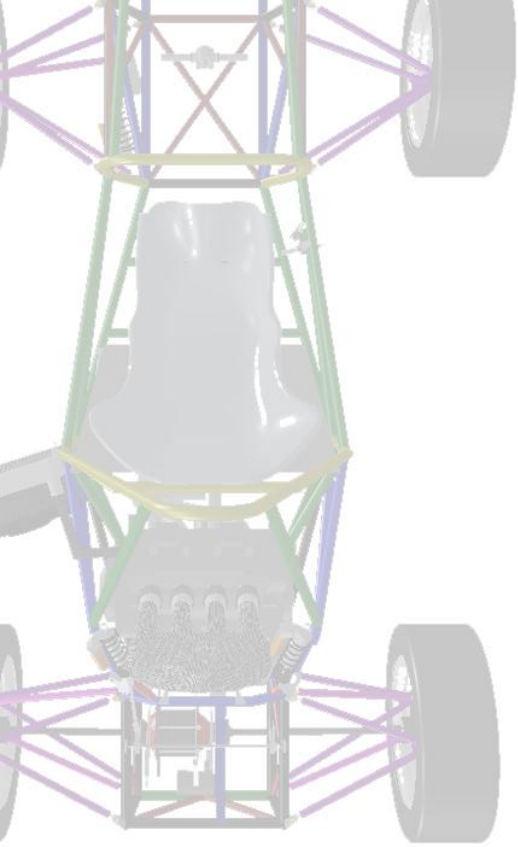
Preliminary Sketches



Preliminary sketches focused on these basic views of the car. About 15 hours of sketching was performed until a final design materialized.

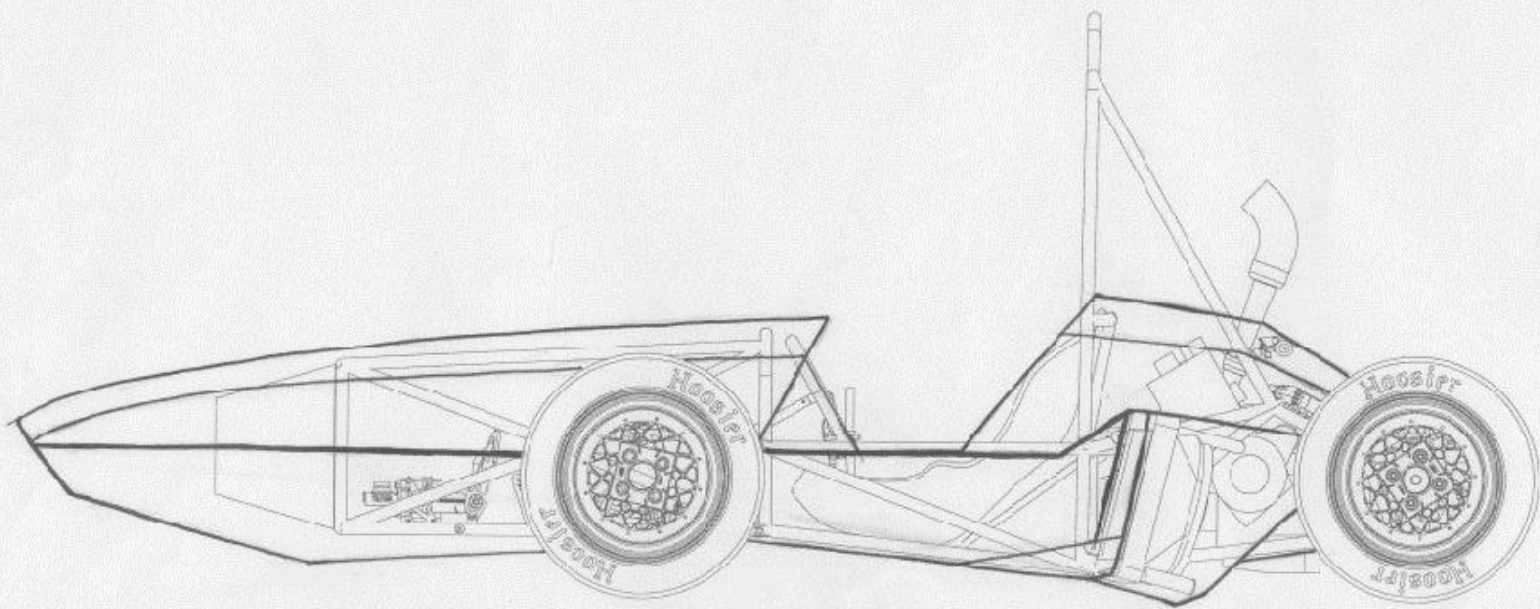
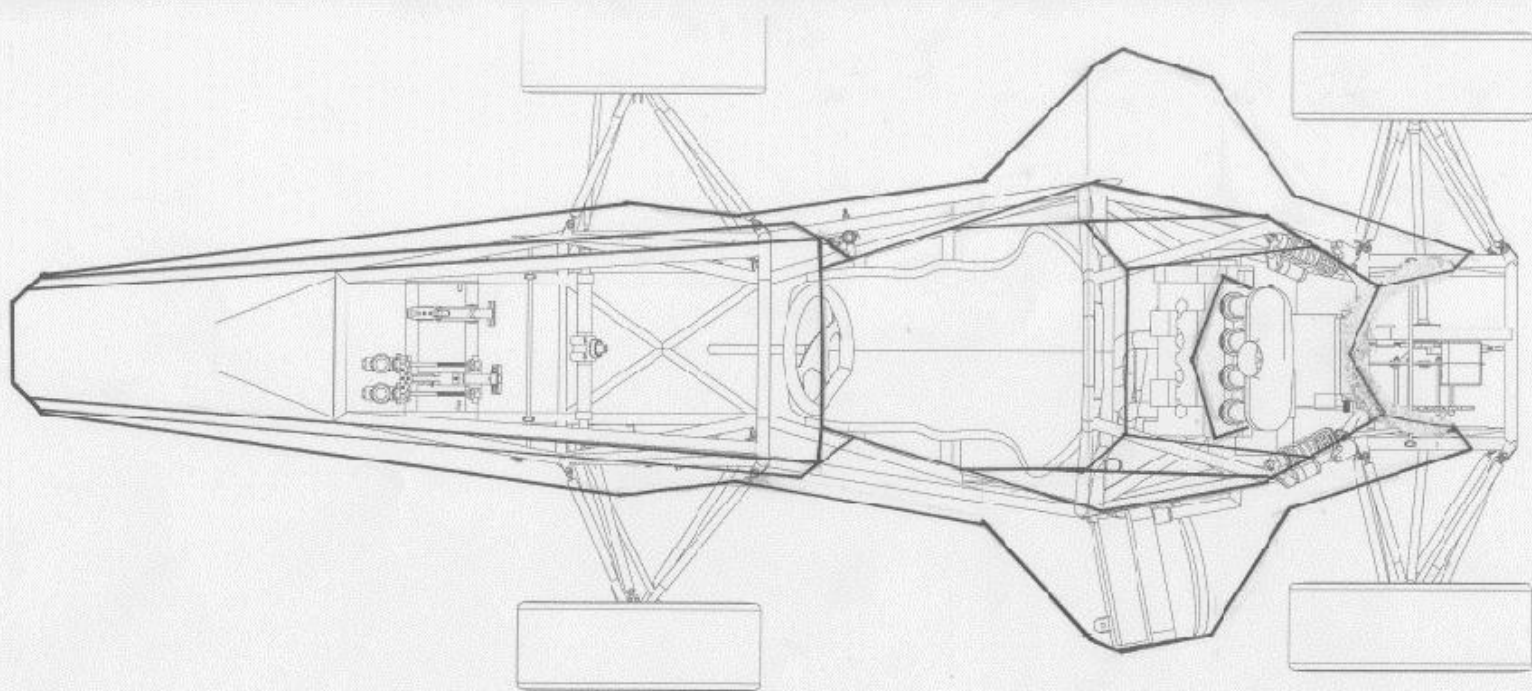
Perspective Overlays

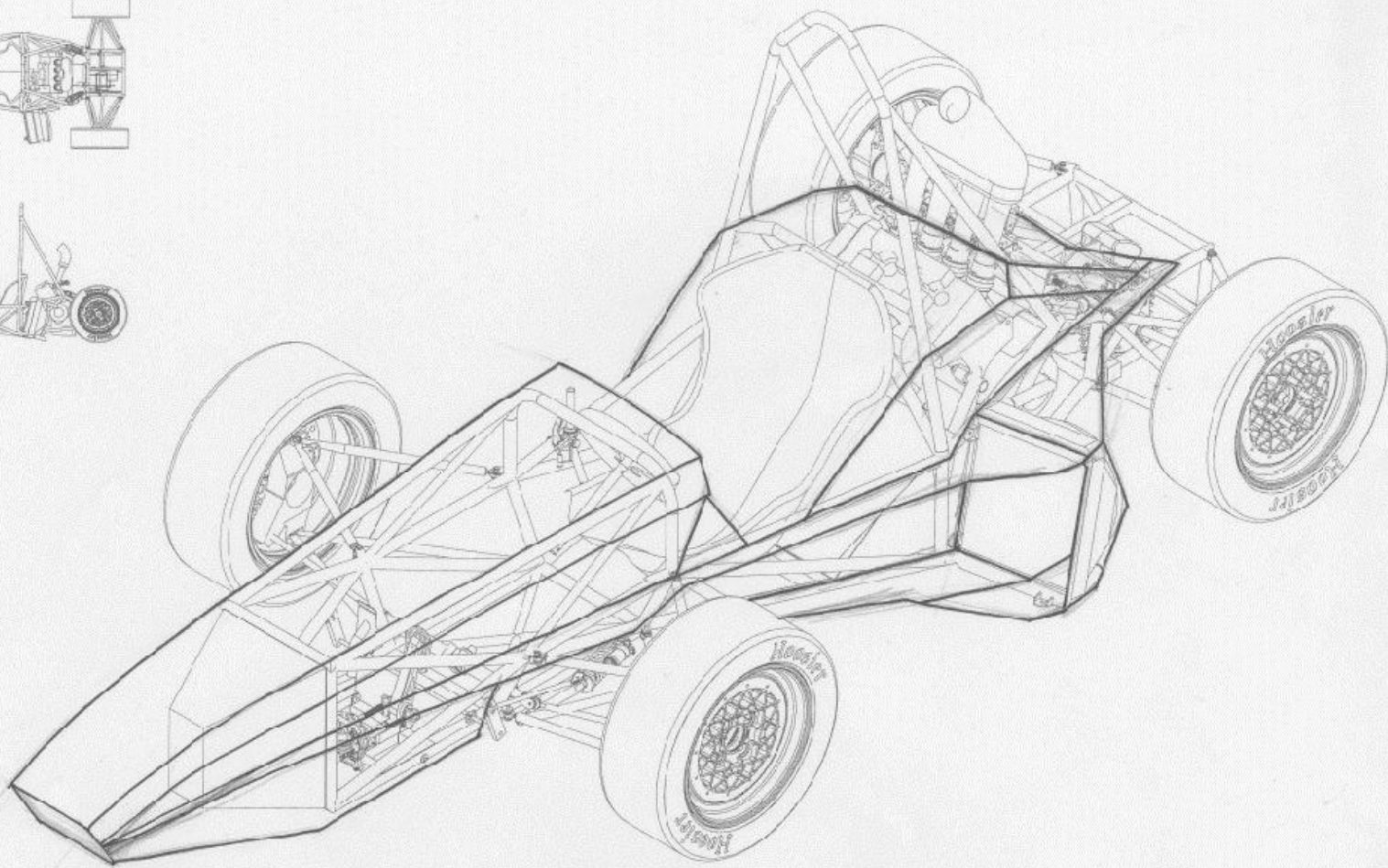
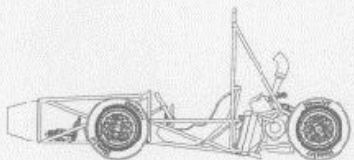
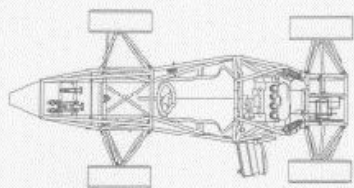
Views with perspective were used as a starting point to get some ideas down in 3D



Control Drawings

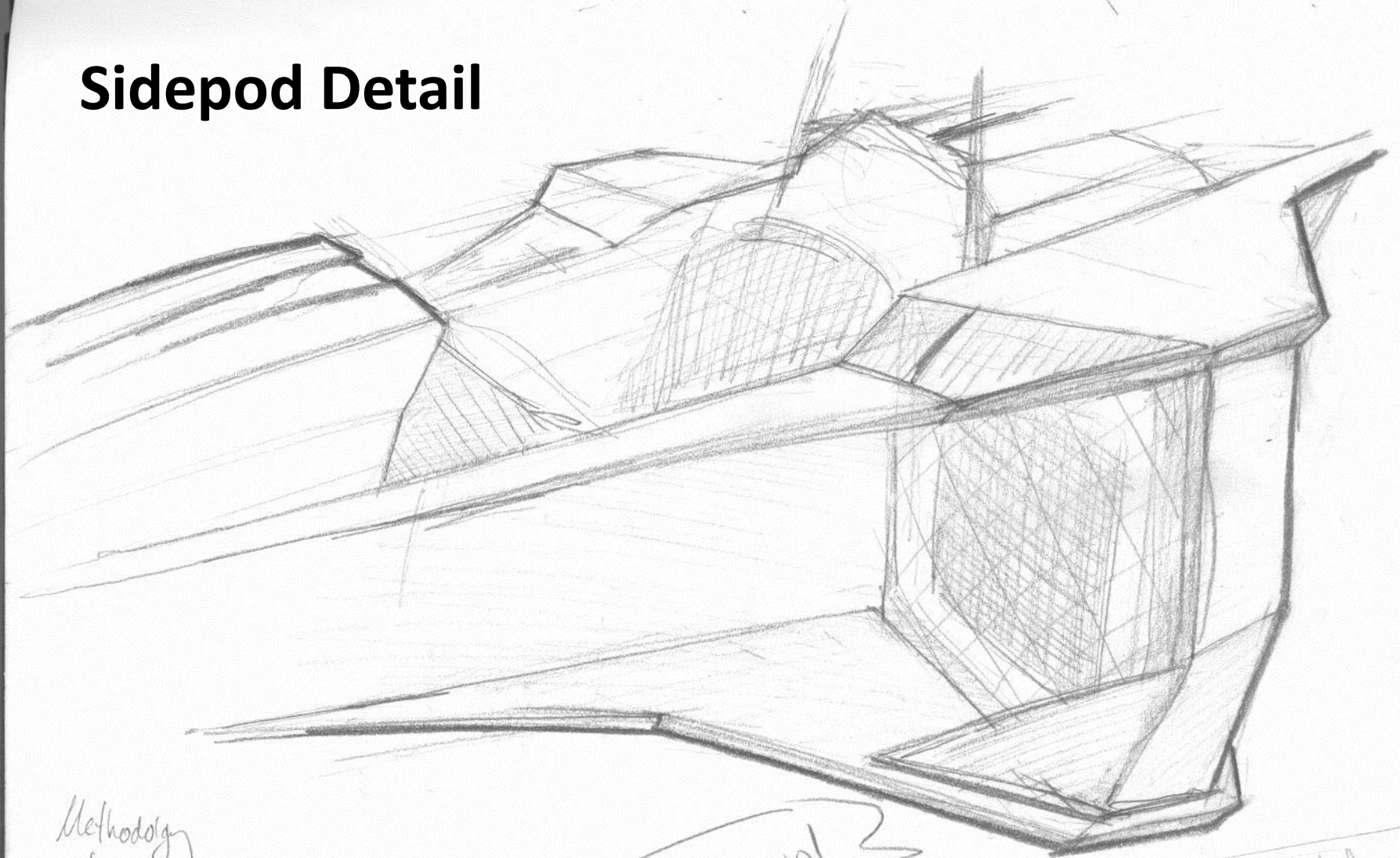
- Three designers submitted control drawings of their final works to be used as a blueprint in the 3D CAD model
- The submissions not selected are included in the support material at the end of the presentation
- The chosen design is included on the following two slides, with details and iterations after





final iteration

Sidepod Detail



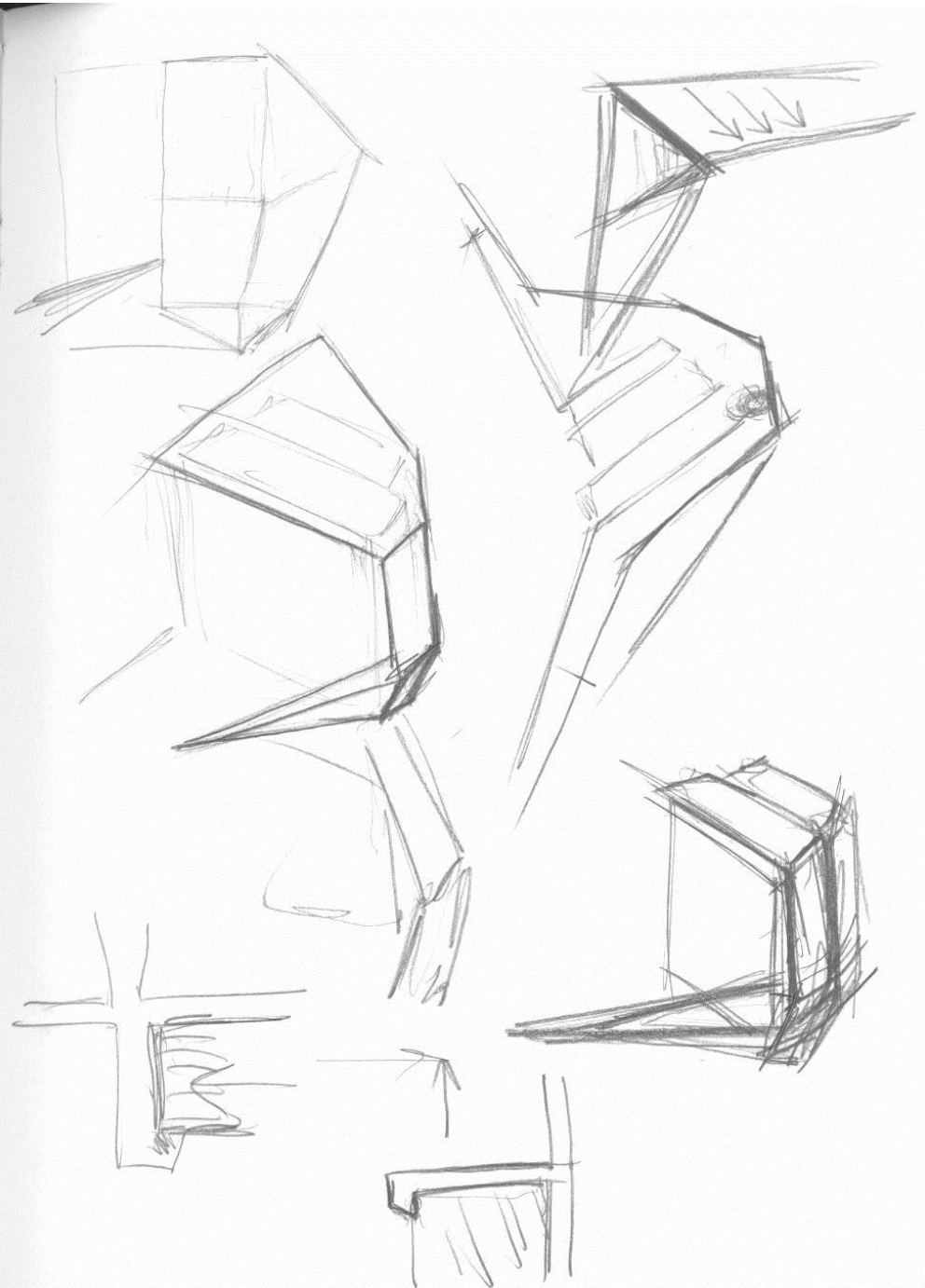
Methodology
of
Visualization

Mat Zawicki

☺ BUENO!

11/11/11

In moving from paper to digital media, some ambiguities arose. It was imperative to work closely with the designer to maintain a model consistent with her vision.



Achieving Priority 2

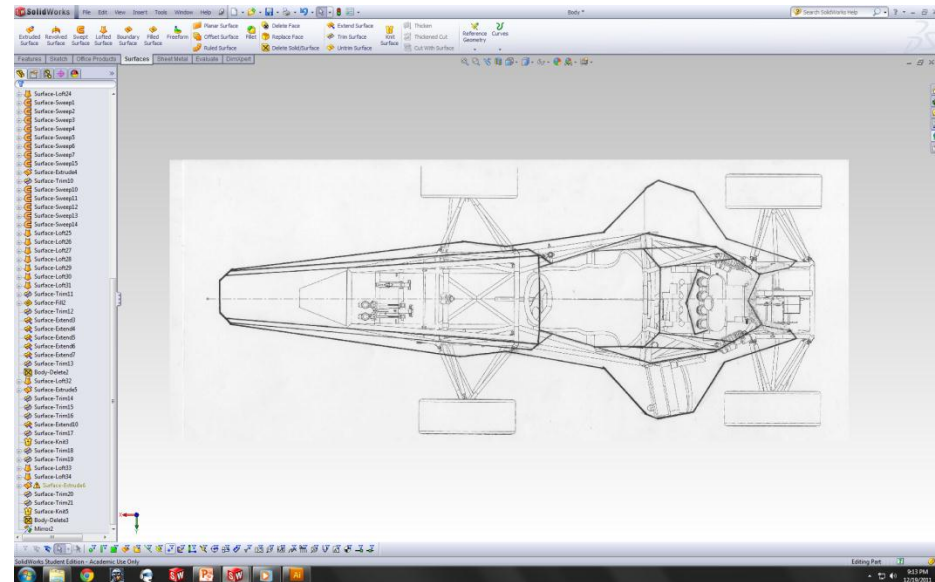
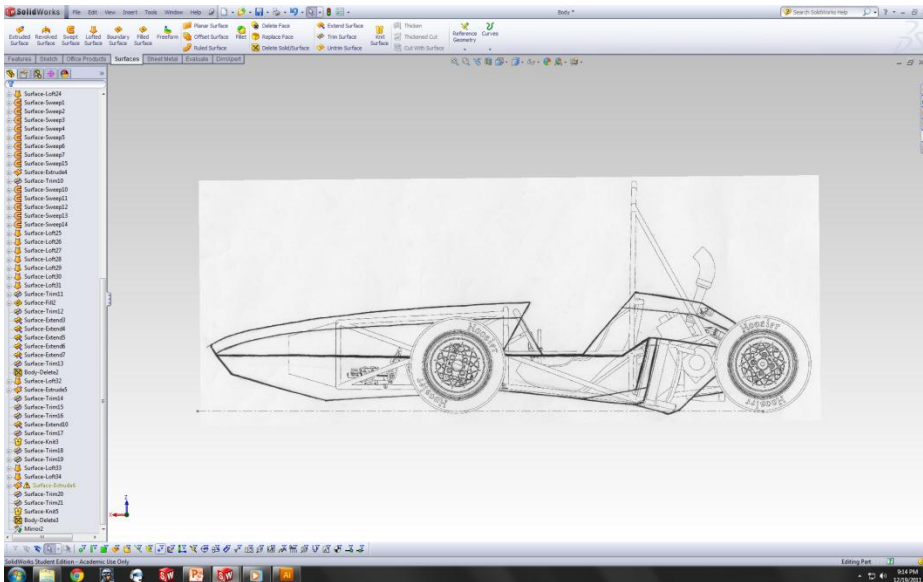
Priority 2 Model:

Have a CNC machined foam plug to ensure an achievable timeline for the aforementioned awesome looking car

In order to achieve the goal of machining a foam plug for the body, it is imperative that the digital model of the body be of very high fidelity.

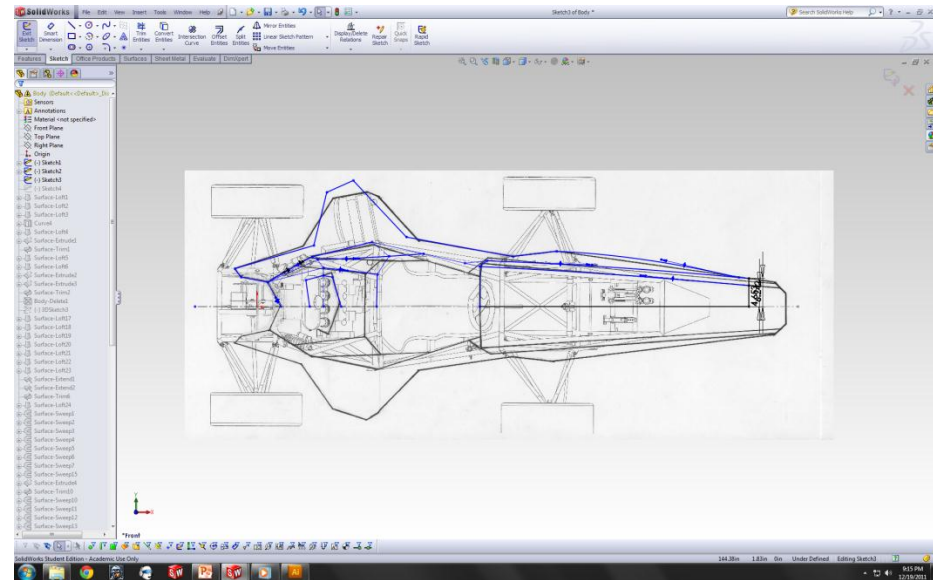
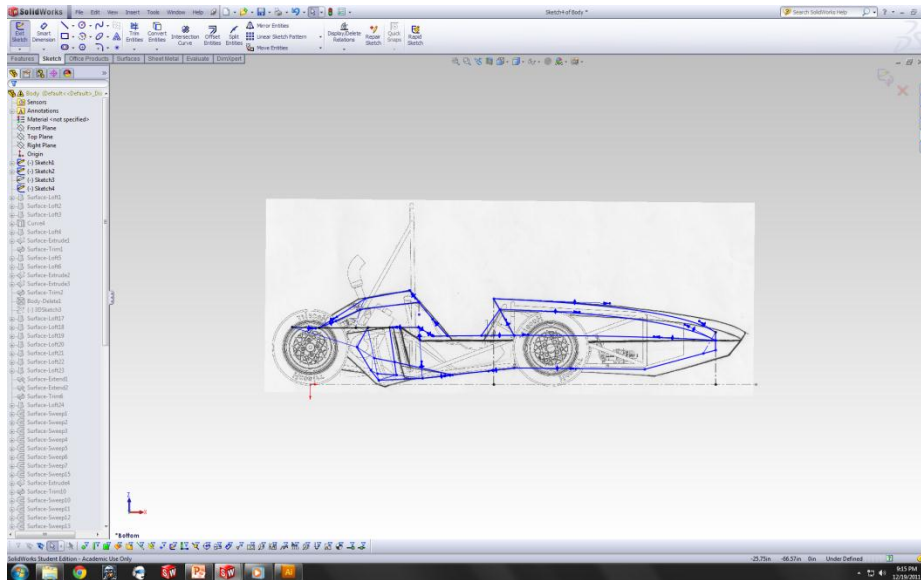
Preliminary Modeling

- The first step is to bring the control drawings into SolidWorks *our CAD package of choice*



Primary Features Sketch

- Sketches were created that initially follow the control drawings precisely, but as the model progressed the sketch was updated



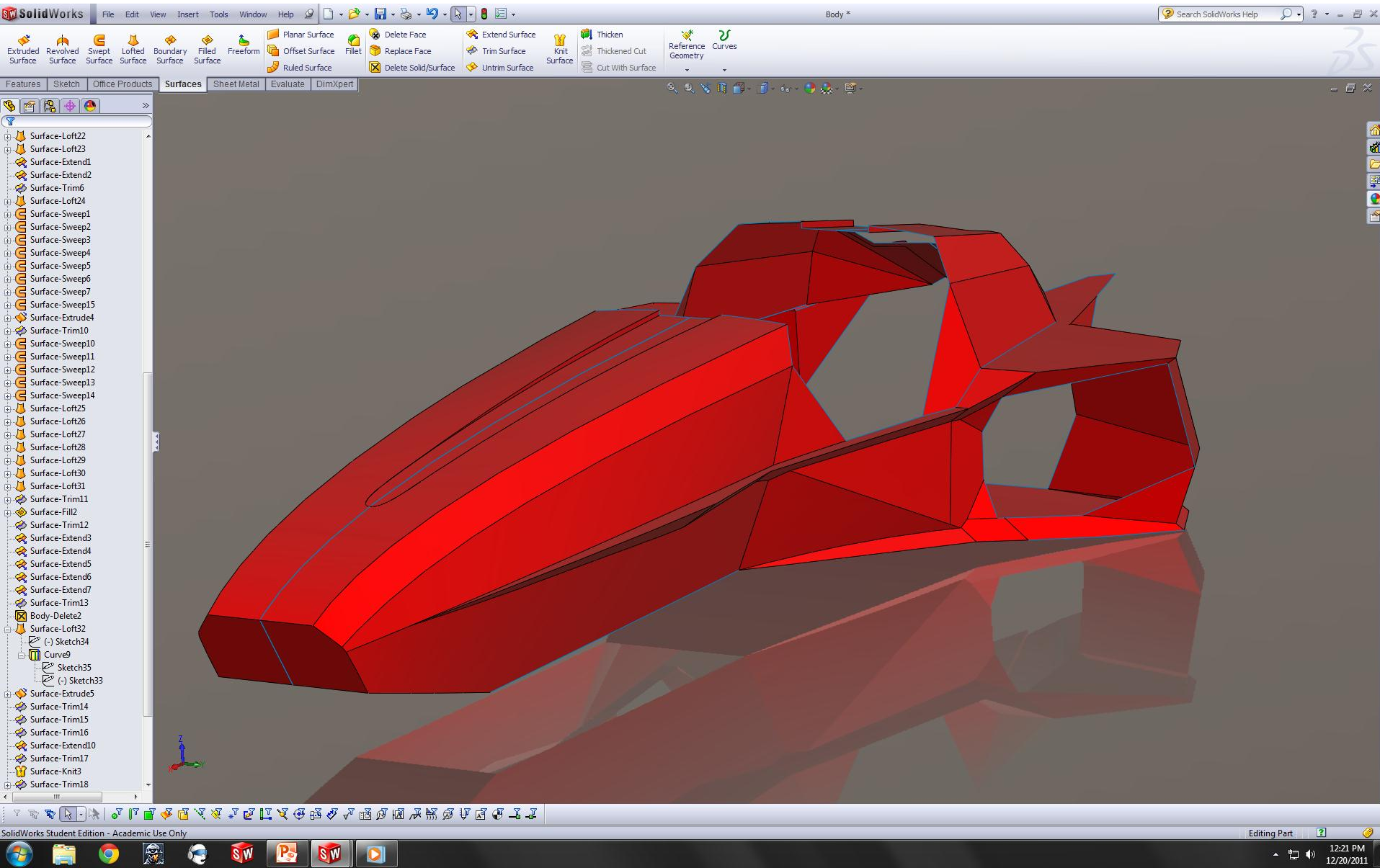
Creating Curves and Surfaces

- The 2D sketches based on the control drawings are projected into 3D curves. These curves are the basis for all other features.
- Using the projected curves, surface lofts and sweeps were used to create the surfaces that create the form of the body
 - **Surface Lofts** join two disjoint curves with a smooth surface
 - **Surface Sweeps** use a profile curve and a path to create a surface

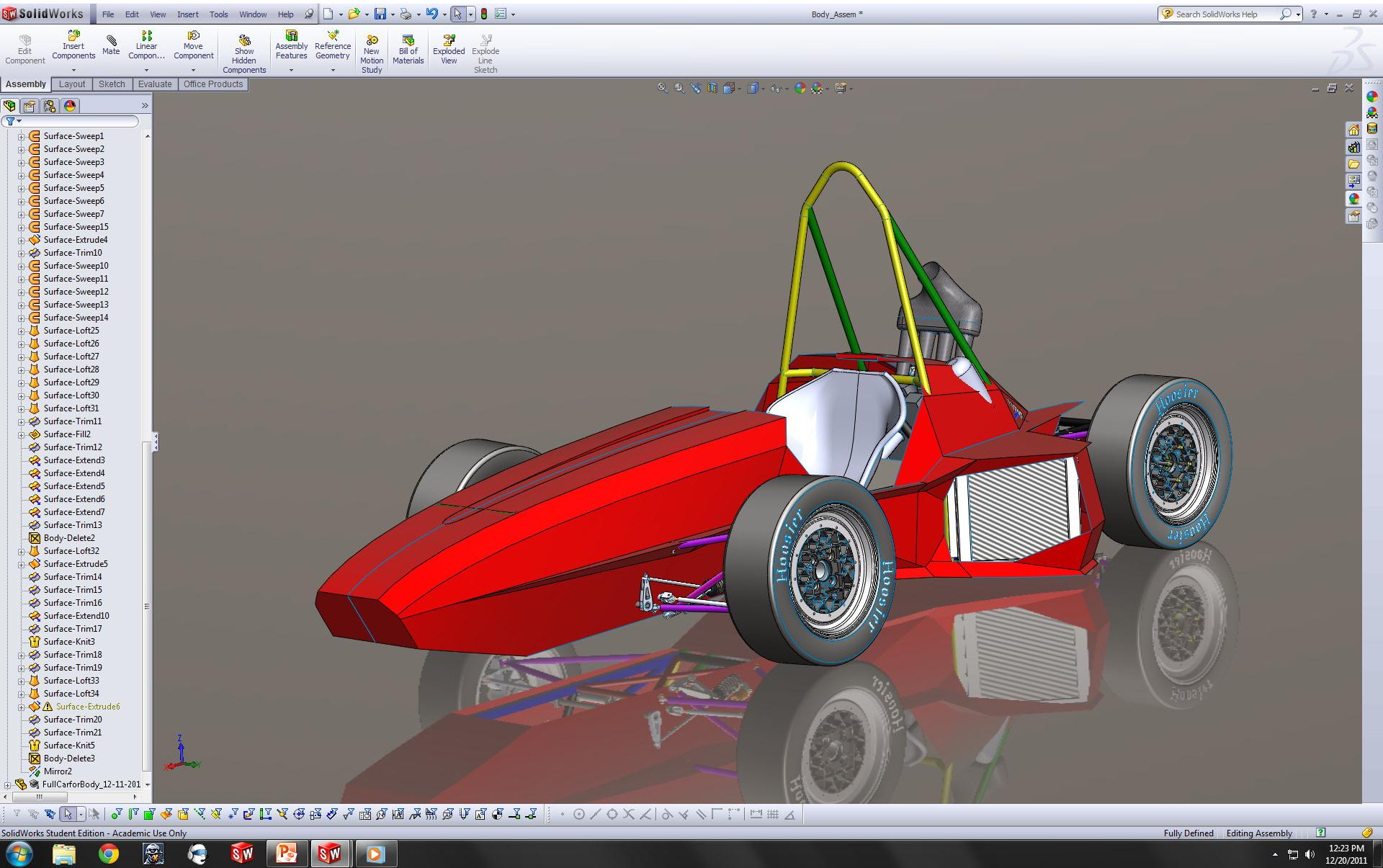
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Near Complete Body Model



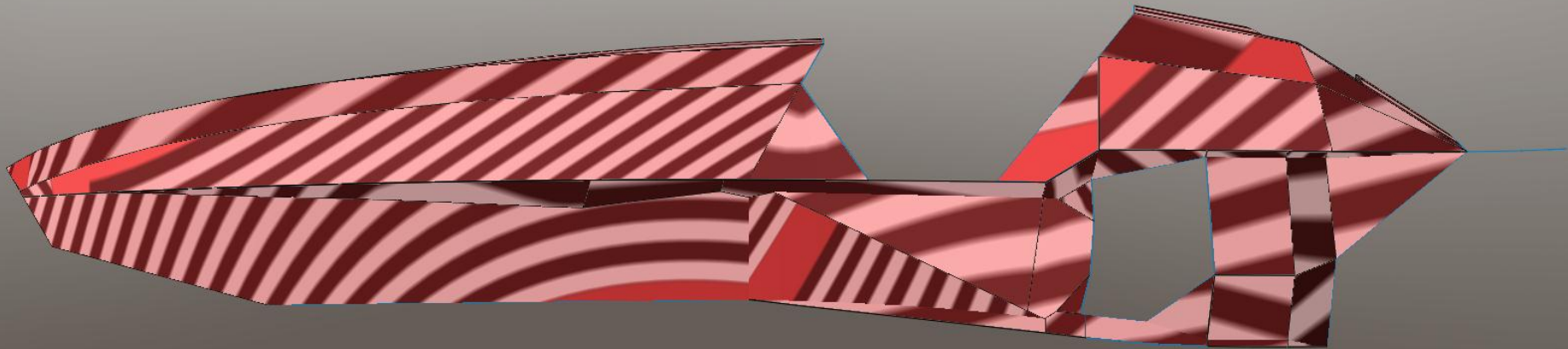
Full Model Integration



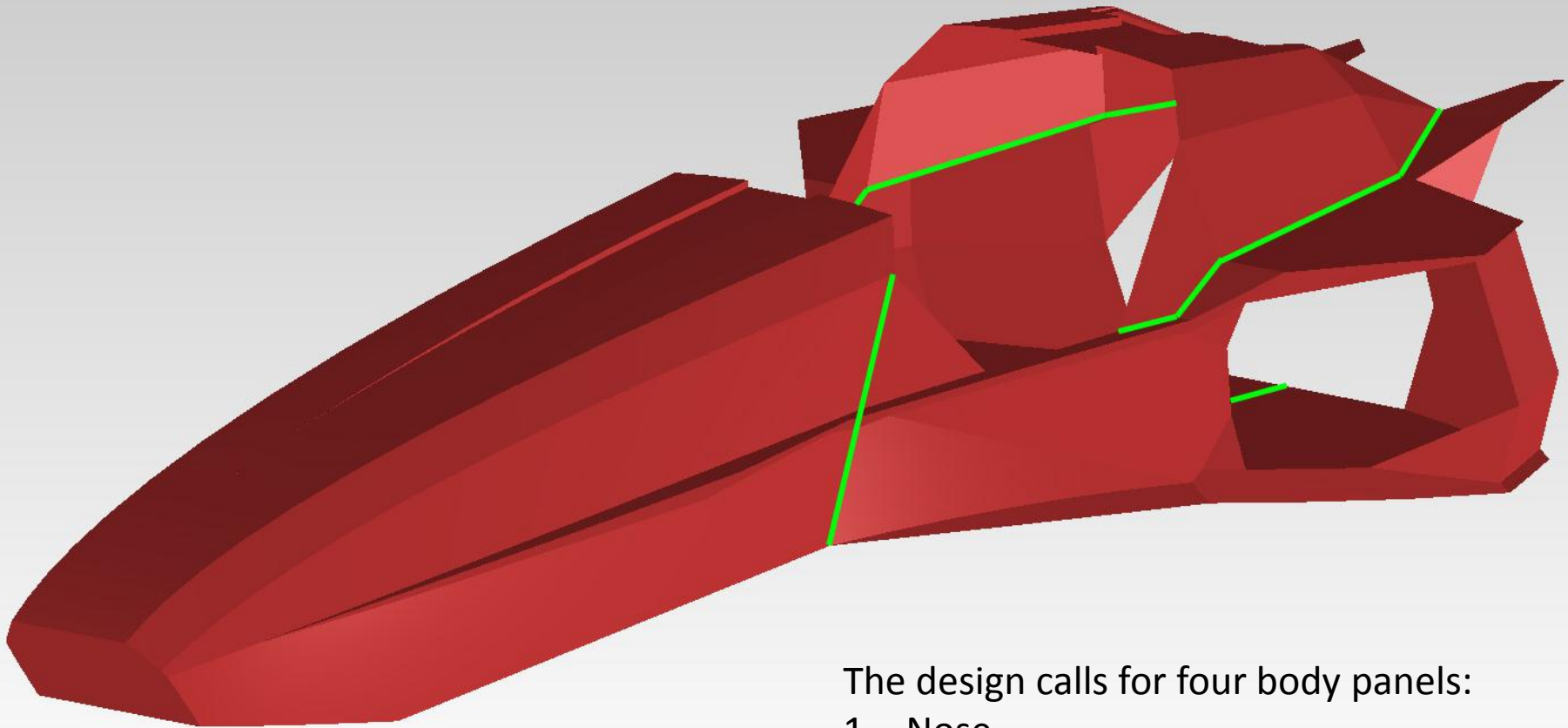
Model Quality

Zebra stripes help to verify surface quality and surface transition continuity

- Note that in this image, no fillets have been added which are of high concern in this sort of quality verification



Parting Lines for Molding

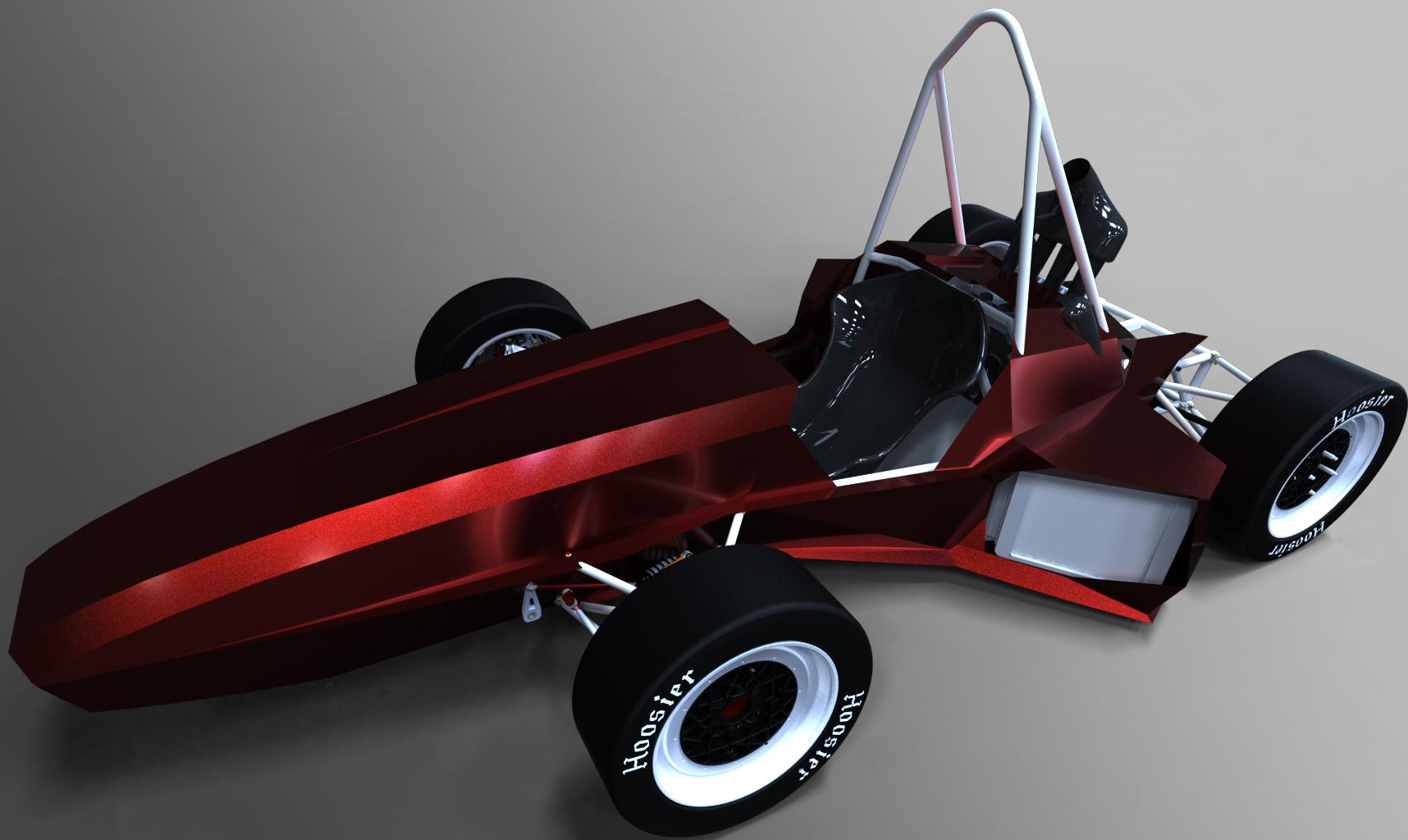


The design calls for four body panels:

1. Nose
2. Left Sidepod
3. Right Sidepod
4. Cowl







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Collaboration

This project is very complex. It is worthwhile to seek outside insight and expertise when it comes to the design and modeling of the body.

In the future, additional consideration should be given to aerodynamic loads as well as refinement of design for ease of manufacture with a CNC machine and molding.

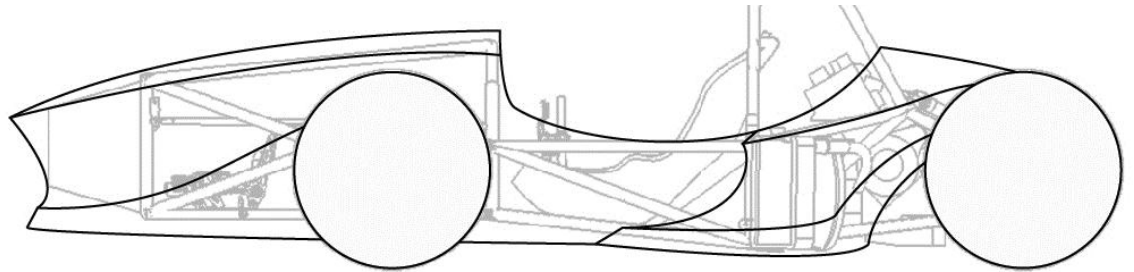
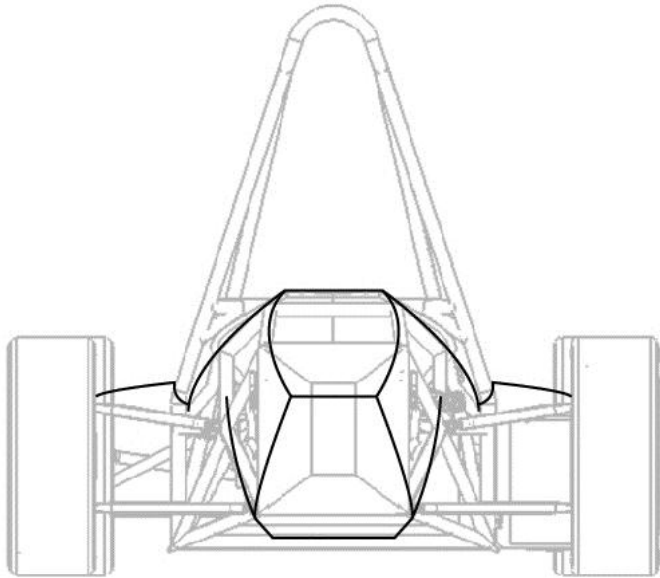
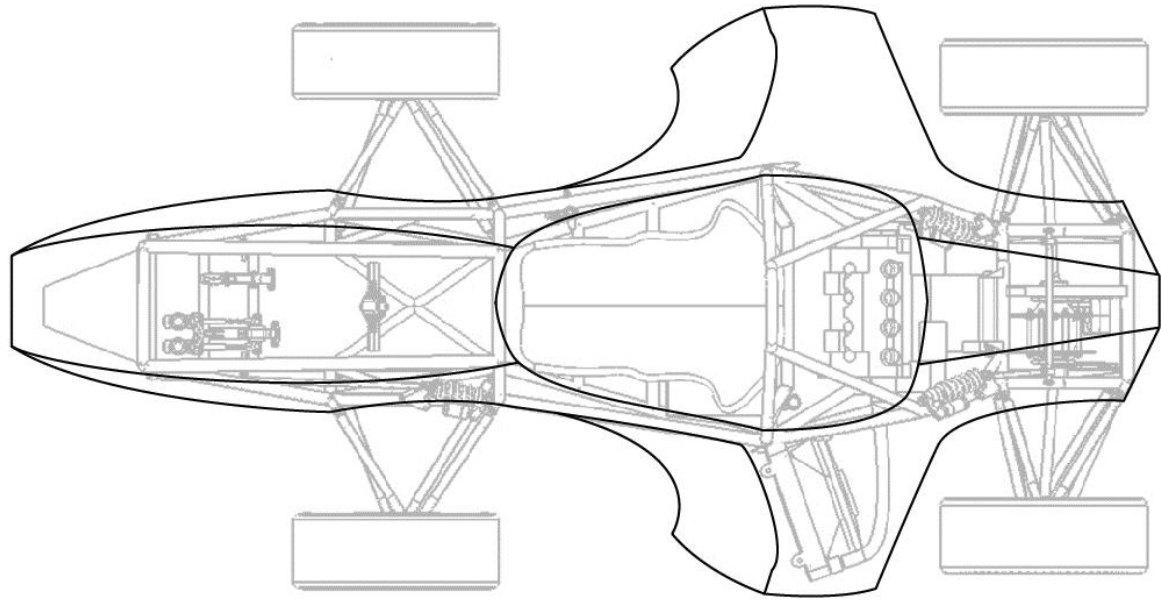
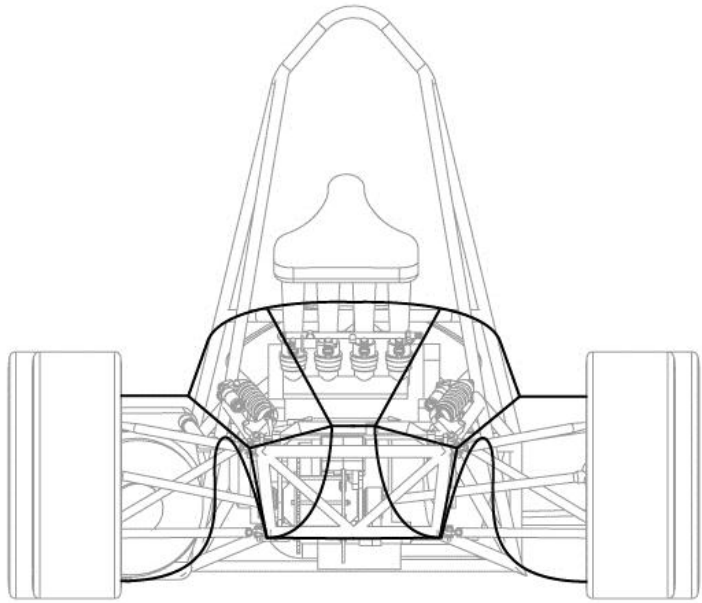
Top Down Modeling

Having a very clear end goal is important for modeling effectively.

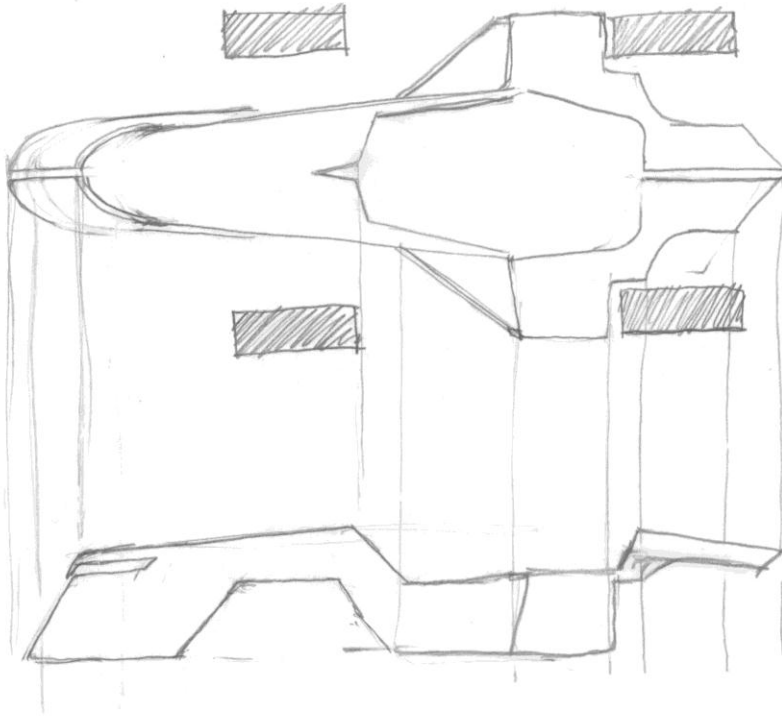
As features are continuously added to the model, it is easy for edges and vertices to become discontinuous, resulting in difficulties with the final steps of modeling (*filleting, knitting, meshing etc.*).

Support Material

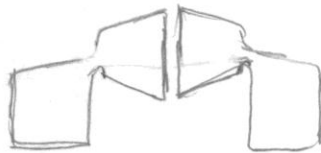
Additional Control Drawings



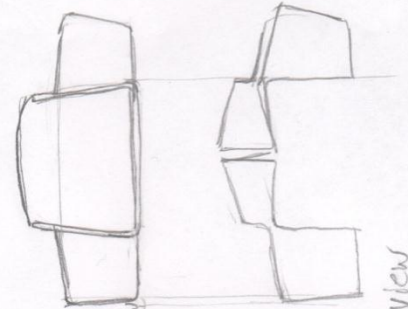
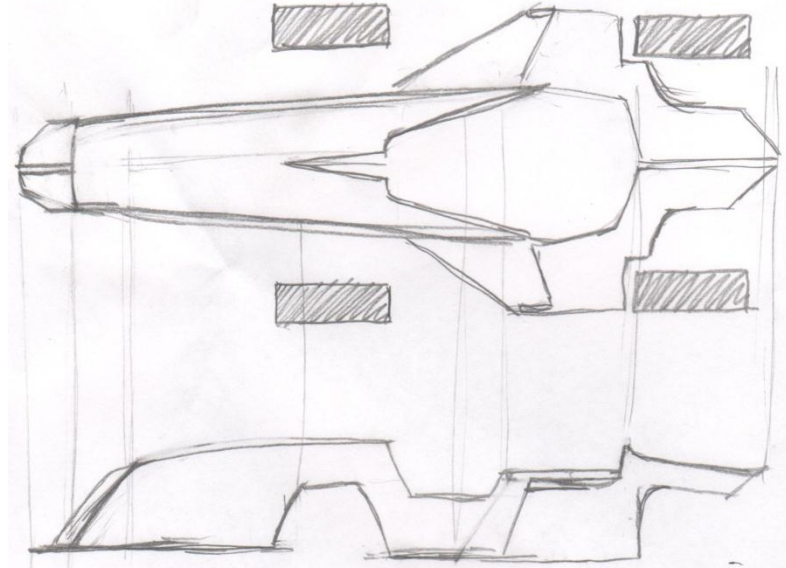
Additional Control Drawings



front



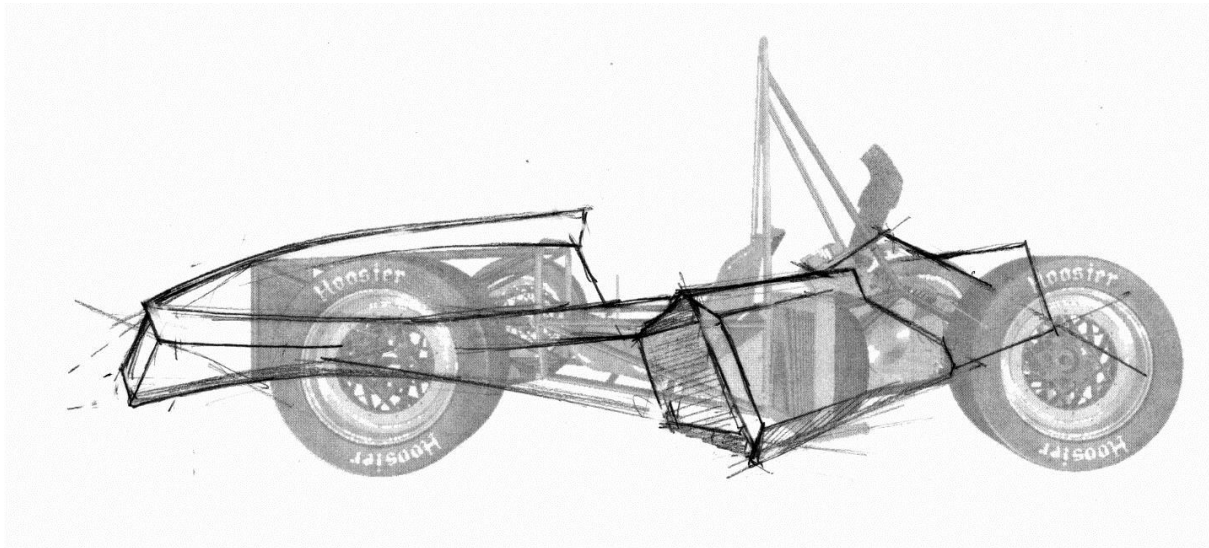
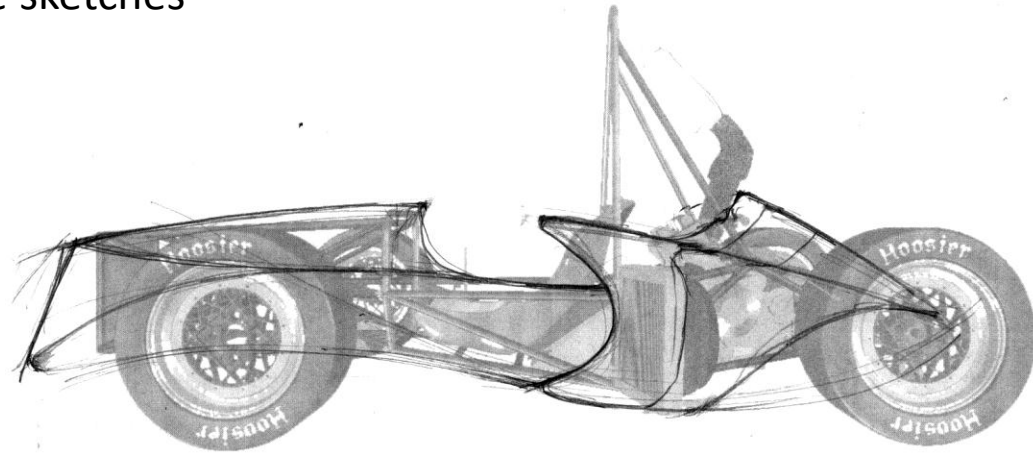
rear



front view

rear view

Perspective sketches



SAE GD MEETING

- FORWARD LETTER
OF SUPPORT
FROM SINGH

DUST ++

Daklo
plugs @ andrew
style @ andrew

Random Doodles

Lambda

Lambda

