Race Car Body Design

Midterm Report

Spring 2012, Mike Ornstein

Outline

- Finalizing the CAD Model *First half of semester*
- Choosing and sourcing foam
- Cutting the plug
- Experimenting with the molding process
- Prepare plug for molding *Second half of semester*
- Construct and finish fiberglass molds
- Layup carbon fiber panels
- Fit, Finish and Paint
- Suggestions for future improvement

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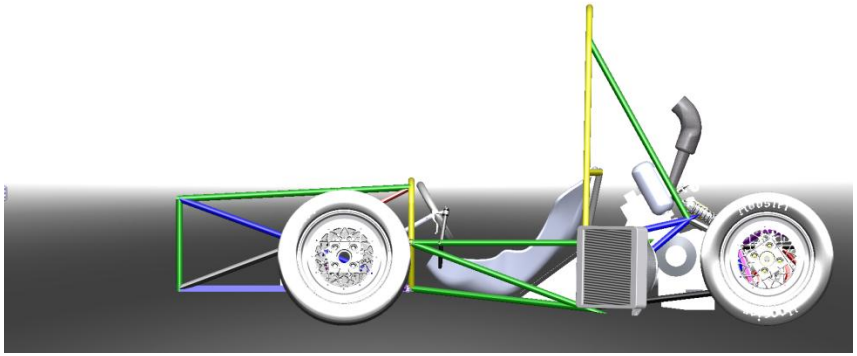
The Body, From Last Semester



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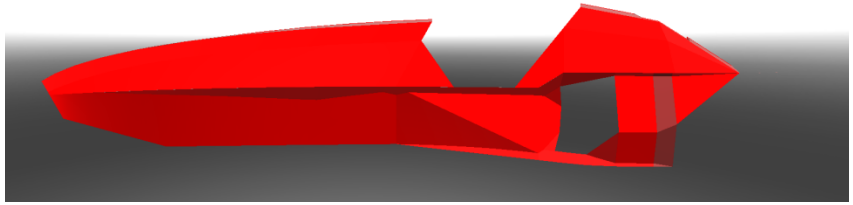
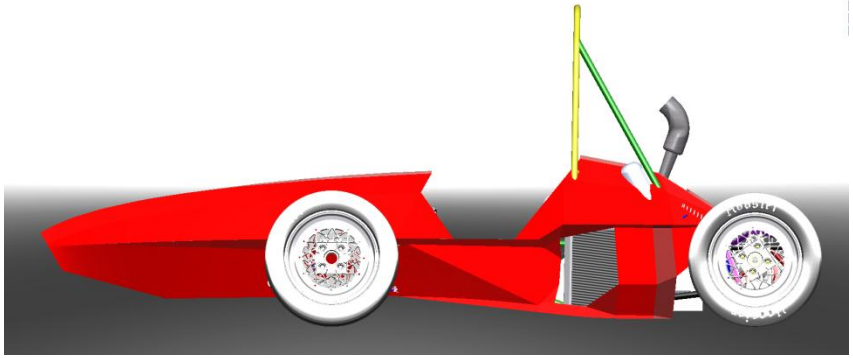




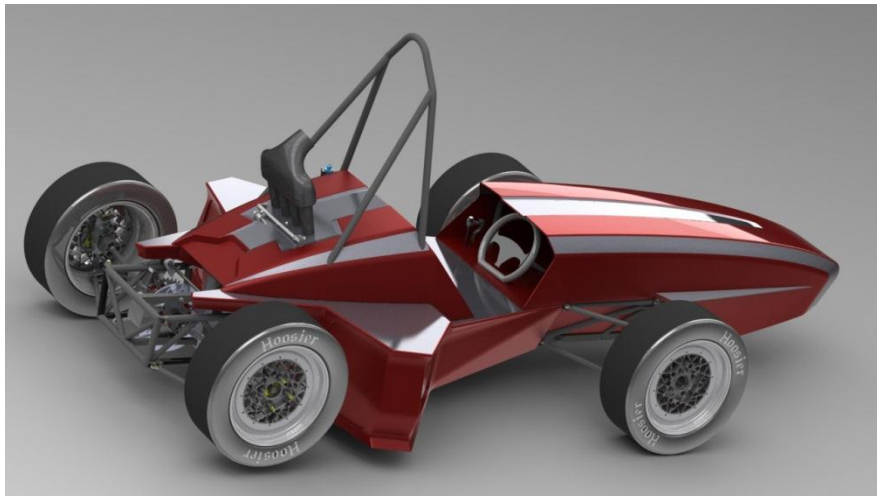

Hoosier
Hoosier
Hoosier
Hoosier


57

After Winter Break

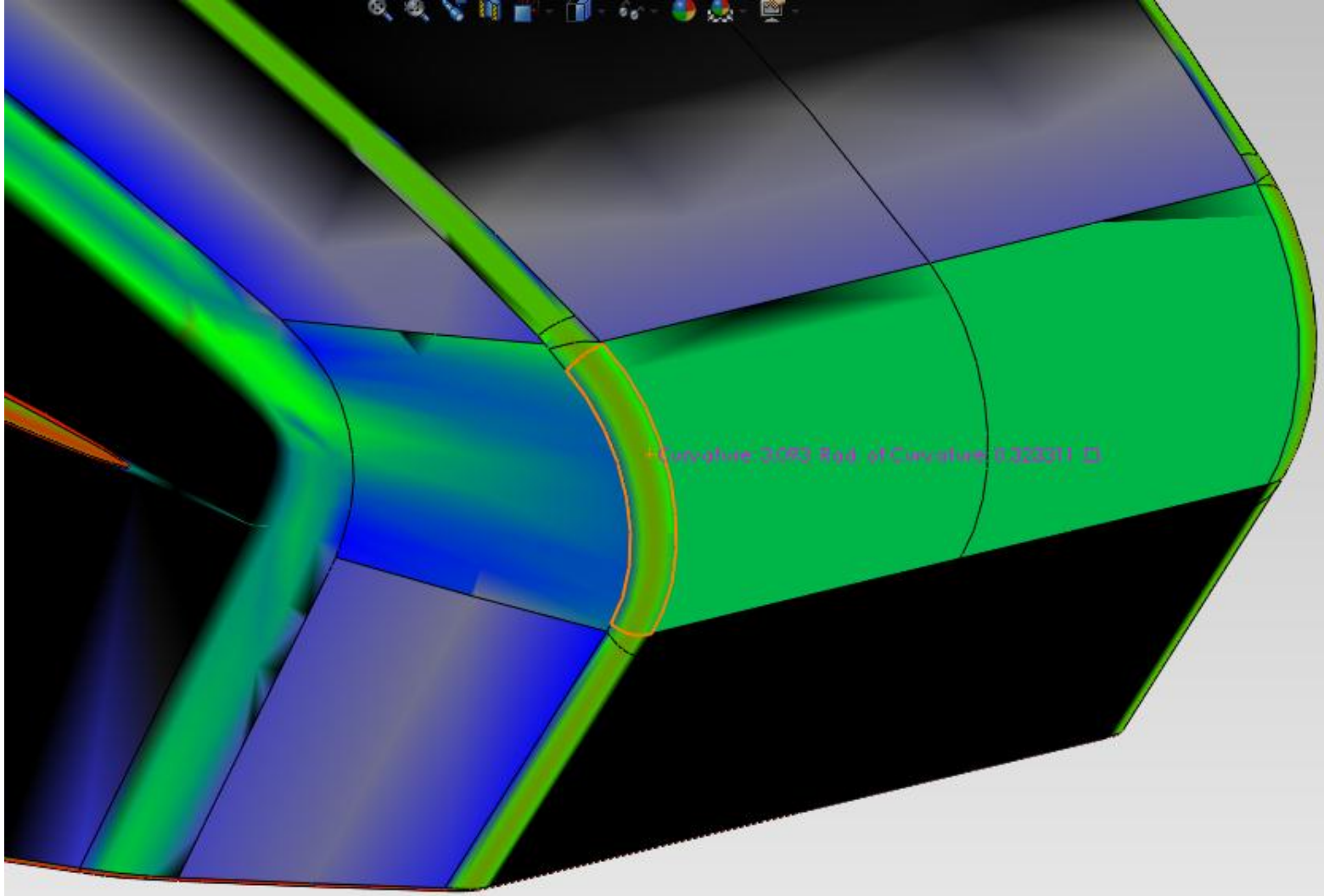

57

Color Scheme Options



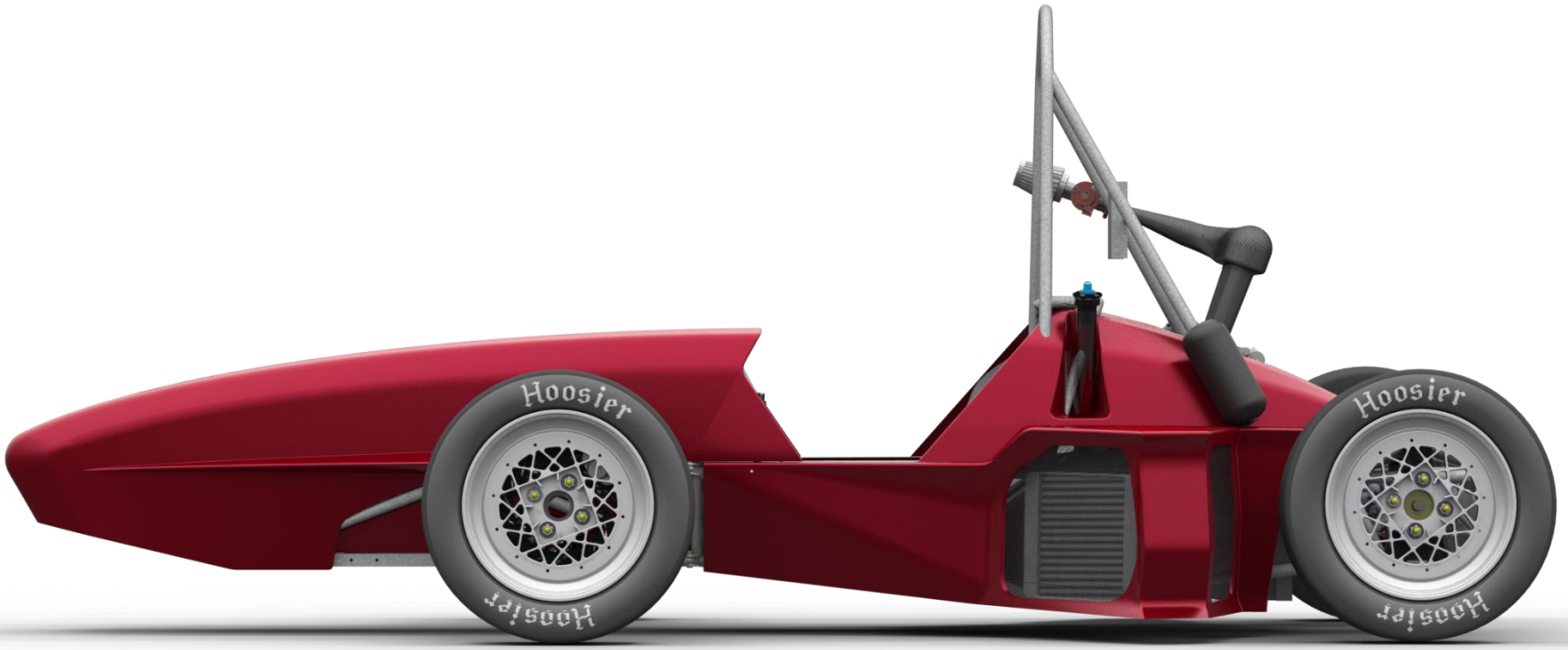
Rule Abidance Issue

“All forward facing edges on the bodywork that could impact people, e.g. the nose, must have forward facing radii of at least 38 mm (1.5 inches). This minimum radius must extend to at least forty-five degrees (45°) relative to the forward direction, along the top, sides and bottom of all affected edges.”



Problem Solved, Partially

Due to the late realization of this problem, our CNC sponsor (Advanced Pattern Works) was unable to update their code to meet our new specification. We will be hand finishing the sharp radius to meet the rules. The following renderings demonstrate the final appearance of the body, with an increased radius on the side of the nose.


Hoosier
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Hoosier

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Ideal Foam Properties

- Good machined finish
  - Closed cell
  - High density
- Available in large thickness and (6”+)
- Good chemical compatibility
  - Non reactive to polyester based resins
- Economical

Foam Comparison

Vendor	Density (lb/ft^3)	Max Thickness	Foam Type	Cost
Last-a-foam	20	4”	Urethane	$$$$
Elliot Foam	6	18”	Polyiso	$$
Elliot Foam	4	24”	Polyiso	$

Elliot Foam: P400

- Due to cost constraints, the least expensive option was chosen.
- Density is low, and we expect a lower surface quality than other options
- Large thicknesses are available to minimize necessity for glue-ups to create large blocks

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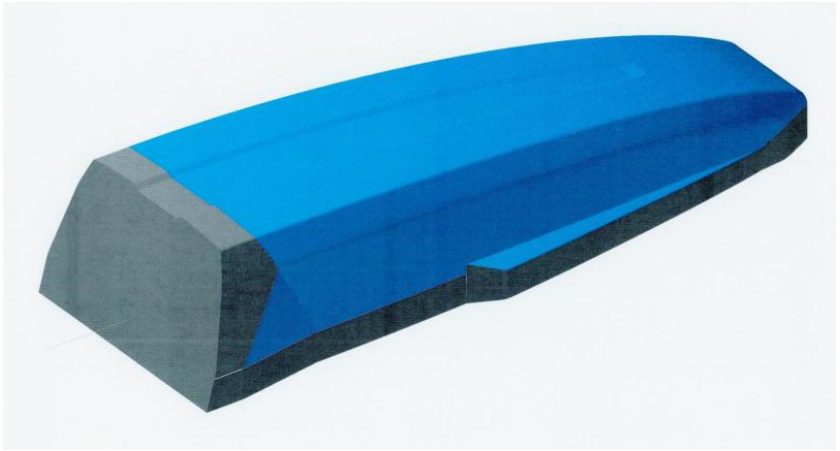
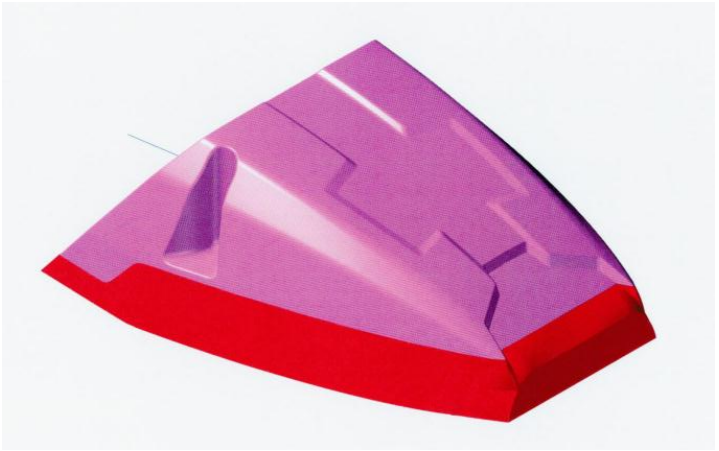
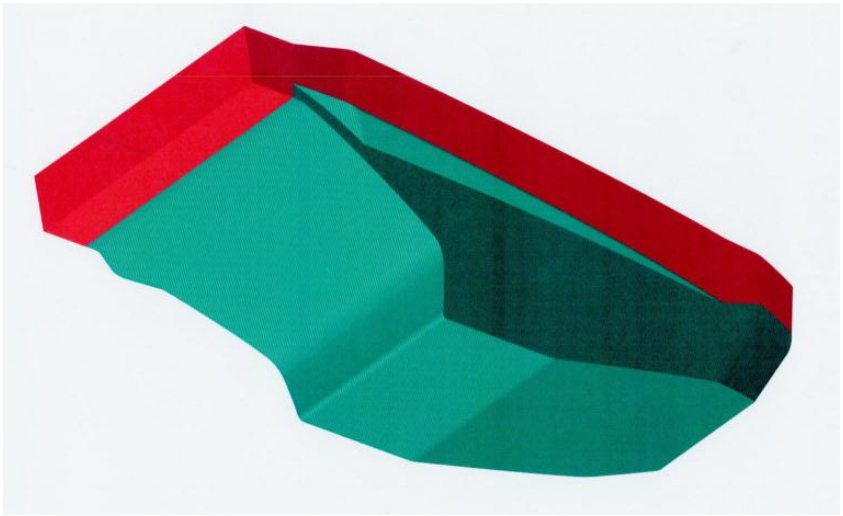
Advanced Pattern Works

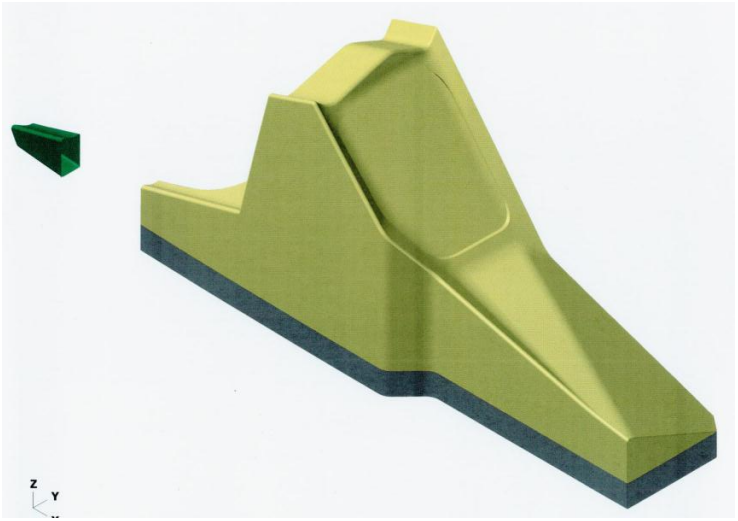
- The plug is being cut in 5 sections.
  - 2 parts for the nose
  - 1 part for each of the two side pods
  - 1 part for the cowl
- Due for delivery Tuesday, March 13 and Friday, March 16.

CNC images









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Sealing and Releasing from the Plug

- Sealers- close pores and creates smooth surface
  - Duratec EZ Sanding Primer
  - Zyvax Quickskin
- Releases
  - Wax and PVA
  - Zyvax Watershield
- Test Layups!

Testing Scheme

Test Number	Foam Density	Sealer	Release
1	4	QuickSkin	Wax/PVA
2	4	QuickSkin	Watershield
3	4	Primer	Wax/PVA
4	4	Primer	Watershield
5	6*	QuickSkin	Wax/PVA
6	6*	QuickSkin	Watershield
7	6*	Primer	Wax/PVA
8	6*	Primer	Watershield

Conclusion: Use Duratec Primer on our 4lb foam combined with wax and PVA for release.

*tested for future knowledge.

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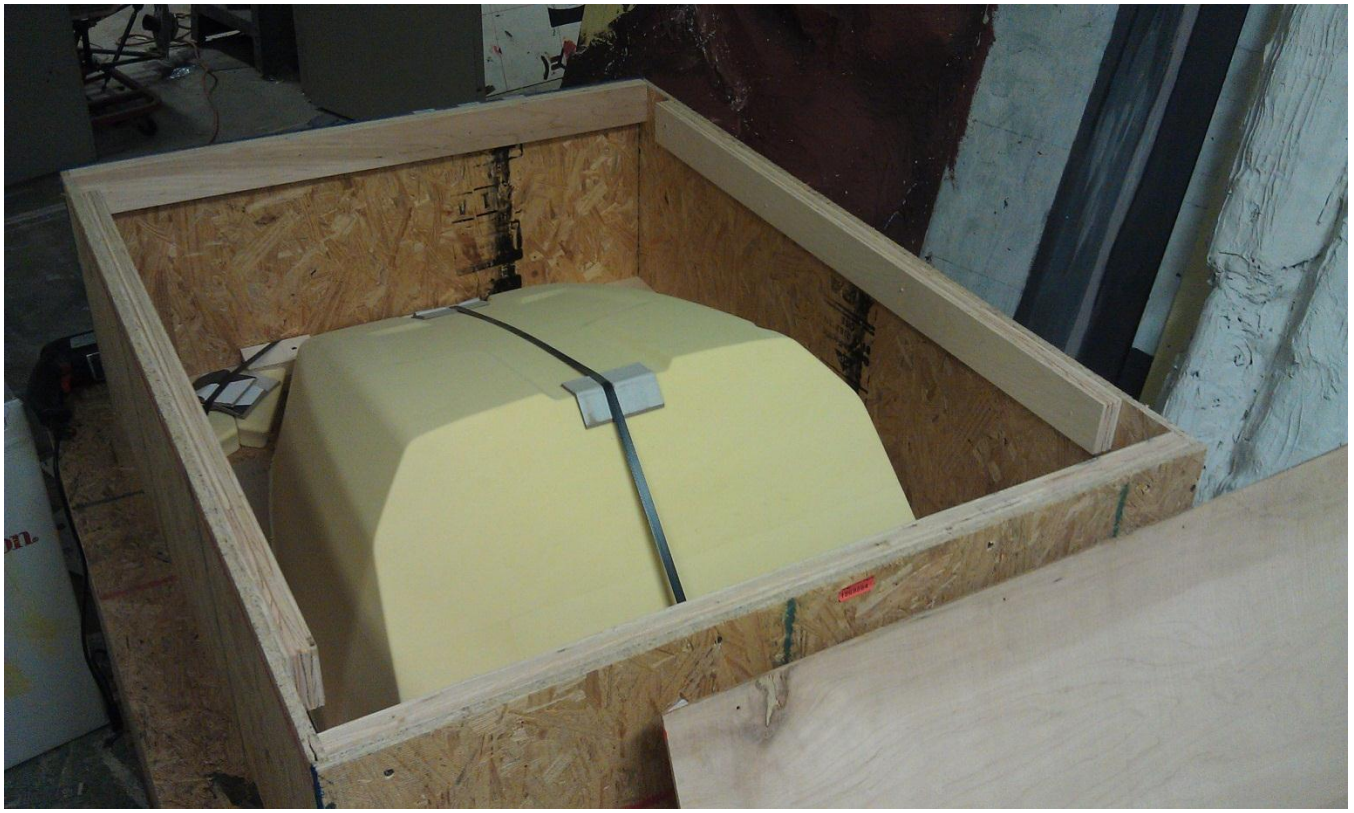
Plug Preparation Process

- Plugs arrive in wooden shipping containers in raw foam
- Join parts as necessary
  - Nose arrives in two halves and must be trimmed using reciprocating saw and razor, bonded with body filler
  - Small tails on sidepods joined with body filler
- Repair damaged sections with body filler

Reception Condition of Cowl



Fuel-filler neck repair

Porosity detail

Reception Condition of Side Pods

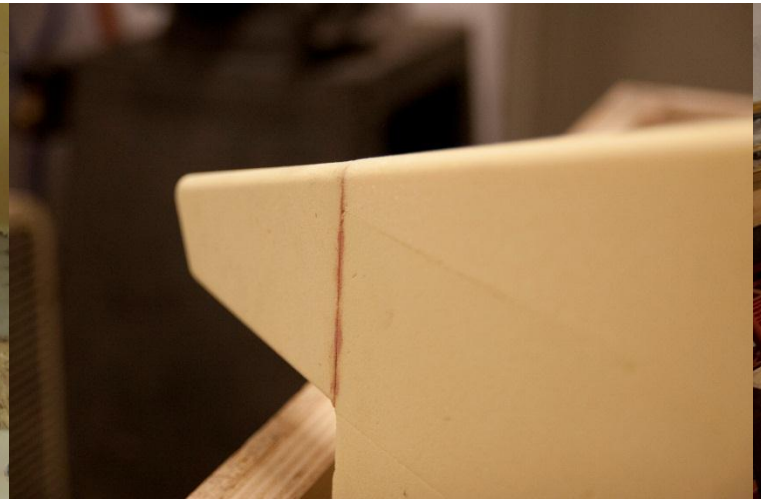
Damage due to slipped edge-guard

Crumbling foam joint made preCNC

Surface porosity and finish detail

End of Part line scribed in foam

Bonding Tails on Side Pods


A thin layer of body filler and welding wire pins attach the tails to the rear of the side pods

Joining and Repairing the Nose

Coating and Finishing Plugs

- Foam coated with Duratec EZ-Sand Primer
  - Applied using gravity gun
  - Best results achieved by sanding to 220girit in between coats until 3 coats applied
  - Depressions repaired with body filler
- Sand to 400 grit
- Wash
- Wax (5 layers)
- PVA (2 coats)

Spraying Primer and Sanding Plugs

Nose

Side Pods

Cowl

Finishing, Waxing, PVA'ing Plugs

Final Spray on Side Pods

Waxed Nose

PVA Coated Cowl

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Molding Process

After applying release (wax, PVA) to the finished plug surface, another two coats of primer are applied to then act as the surface of the mold. The two coats of primer are bonded to the fiberglass and come away with the mold. Bonding the resin and primer is time sensitive – either a full cure and rough sand of the primer forms a mechanical bond with the resin, or a 'tack-free' primer forms a chemical bond with the resin. Both are effective, but one problem to be aware of is a false cure, resulting in 'alligatoring.' Fiberglass layups using isophthalic tooling resin and chop-strand mat are made in stages until molds are ¼" to ensure rigidity, but in stages thin enough to avoid distortion due to heat during curing.

Nose Mold Overview

- Due to part geometry, a two part mold was necessary
  - Flange constructed to enable two-half registration
  - Flange constructed of cardboard, plastic dropcloth, paintsticks, hot glue, aluminum tape, and clay
- The top half of the nose was laid up first
  - Included air-injection ports for ease of release
- Flange was removed, second half laid up
  - Release applied to top-side flange to ensure full release
- Matched drilled holes for bolts to align and secure halves
- MDF buck constructed to rigidize mold

Two Part Nose Mold

Flange Construction

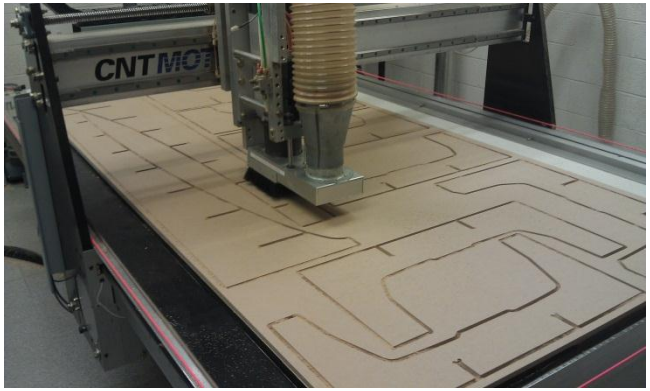
Fiberglass Layup on Nose

Top side fiberglass mold

Bottom side after flange removal

Bottom side fiberglass mold

Nose Buck Construction



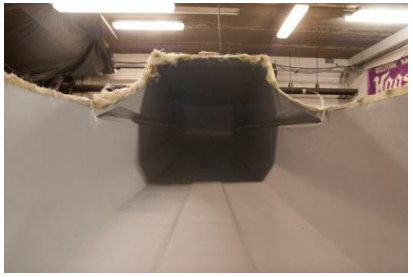
CNC routed buck, made of ½” MDF

Attachment of buck to top half of nose mold

Detail of mold finish

Top mold with clay

Bottom mold



Joined mold halves

Bolt detail

Side Pod Mold Layups

Skim coat of fiberglass

Continuous strand mat, yuck

Chopped strand mat

Side Pod Mold Release

Cowl Mold

Commentary on Mold Making

- Wax + PVA make for an excellent release from the plug
- It's possible to fudge drafts, but parts release most easily with careful high draft angles
  - The side pods should have been impossible to release, but due to flexing in the mold and destruction of the plug, it was possible to save the mold.

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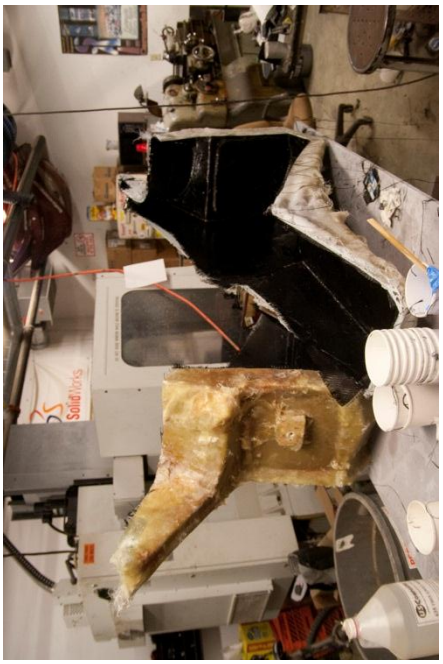
Carbon Part Layups

- Wet layups on waxed/PVA'ed molds
- Primarily 1 layer of carbon fiber – 5.7oz twill
  - Reinforced to 3 layers at areas around fasteners
  - Core material added for increased rigidity
- Use US Composites Slow Cure Epoxy Resin and West System 105 Epoxy-206 Hardener

Cowl Layup and Partially Trimmed Part

Side Pod Layup and Trimmed Part



Nose Layup

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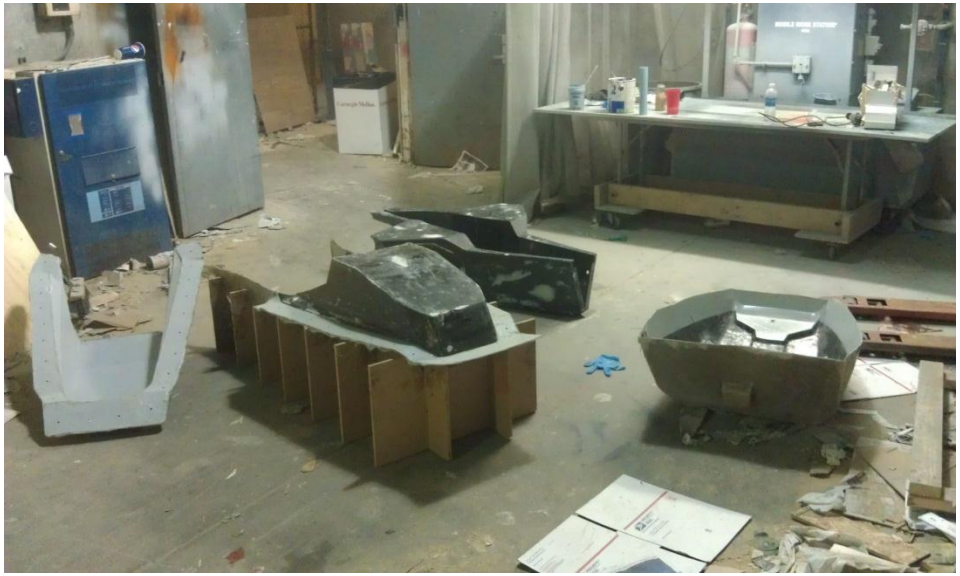
Part Trimming and Painting

- Parts trimmed and attached to car using Dzus fasteners
- Rigidity assed, addressed
  - Additional foam support material added around edge of nose
  - Carbon reinforcement in large flat areas and fastener locations
- Body handed off to PPG for final body work and paint

Trimmed Carbon Parts



Bare Paint


FEV
FORMULA SAE
Carnegie Mellon
SKF
SPACEX
Goodyear
VAC
ATOMATIC
Advanced Pattern Works, LLC
PPG
EAGLE
GOODYEAR


Carnegie Mellon
SKF
SPACEX
Goodyear
URO
ACalspan
MAC
ATOMATIC
Advanced Pattern Works, LLC
ALCOA
PPG
NATIONAL INSTRUMENTS
57
GM
ExOne
EAGLE
GOODYEAR


SPACEX
GOODYEAR
SKF
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NATIONAL INSTRUMENTS
SolidWorks

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Cost Savings

- The body ended up coming in significantly over budget.

Too big

Cost	Vendor	Descriptio
$ 47.50	Signs By Tomorrow	4 number
$ 1,454.45	USComposites	Gelcoat (1
$ 1,332.39	Elliot Foam	3 Foam 4'x
$ -	Elliot Foam	Sample pa
$ -	Zyvax	Sample pa
$ 71.96	Pegasus Racing	30 dzus re
$ 82.83	USComposites	100 Dump
$ 383.36	Composites One	4 gallons c
$ (19.92)	Composites One	Tax credit
$ 205.50	Echo Global Logistics	Freight ch
$ 49.95	Pepboys	120, 220, 4
$ 733.73	USComposites	5 gallon to
$ 219.40	Composites One	2 Gallons c
$ 347.35	FiberGlast	10 yards 1.
$ 276.45	Composites One	3 gallons c
$ 99.73	Home Depot	Latex glov
$ 87.35	Advance Auto Parts	Fiber glass
$ 119.61	Home Depot	Fiber glass
$ 53.97	Pepboys	Fiber glass
$ 5.00	FibreGlast	Paint chip
$ 5,550.61	Total	

Cost Reduction Techniques

- Big ticket items were foam and carbon
  - Get sponsors for each; only 20% discount on foam this year, full price on carbon
  - Use a smaller volume of foam to get surface of body machined

Rigidize Carbon Parts

- 1 Carbon layer is fine for small parts – too flimsy for body, even after reinforcement
- Use 2 -3 layers all around
- Be more careful in layups around sharp corners
- Use a pattern to pre-cut carbon to make layup process quicker and more efficent