

Why does composites exist

Thursday, May 22, 2025 8:33 PM

The Good

- Strength:Weight over typical engineering materials such as steel and aluminum
 - Imagine the aero replaced with aluminiun
- Shave weight where not needed such as boxes and low stress items
- Flexibility with material choice
- Carbon = Stiff, FG = Strong

The Bad

- Cannot reasonably predict when it will fail sometimes
 - Bad for high stress components like A-Arms or Pushrods \
 - Shit just failssometimes when nopt done coirrectly
- Math is AIDS
- It's dirity
- Its expensive

How does this help the team achieve its car related goals

- Reduce weight while keeping things strong (Hopefully)

How to Clearcoat

Tuesday, May 27, 2025 8:02 PM

Instructions

- Prep your part
 - Sand from 220 to 400 Dry
 - This is your time to eliminate high spots
 - **Wet sand 800-3000**
 - These are you smoothing/polishing stages
 - Realistically you should not be

Mono Mansplain Manifesto - Nathan Fairlie 14 March 2024

Monday, January 08, 2024 4:41 PM

This document will serve the purpose of providing my opinion on guidance for if the team ever builds as monocoque as well as some pros can cons of different routes that can be taken.

Some of the original documentation (from my freshman year) is not great but it can be found in Teams under chassis > files > mono.

Some of the original data files for the testing can be found in Teams under Data Acquisition

Rule 1 for designing a monocoque: Don't be arrogant or in over your head. Being humble is the best way to avoid failure.

Coupon Testing/Jigs

When we first embarked on the project in 2020, the first thing we did was make A. the perimeter shear testing jig and B. the 3 point bend testing jig (we already had one so now we have two). I conceptualized but never built a seat-belt pullout testing jig. The design was to be adjustable as to change the angle that the bolt was pulled out as the geometry of this was uncertain. However, seatbelt pullout testing is not necessarily required as per rules if you connect the main hoop and front hoop with tubes on either side and weld the seatbelt mounting tabs to those. I might suggest purchasing a jig from another team if one is available.

The original perimeter shear testing seemed promising but we only tested 1 side (not a sandwich panel). After this, I made two 3-point bend samples and tested them. They were both comprised of .5" honeycomb, and varying skin thicknesses, layed up in one shot with adhesive sheet. All these original samples were pre-preg fabric. I am unsure on the exact fiber but I believe T300 3K PW or similar. In testing, one of these samples had a thinner delaminated and the other had a thicker skin and crushed the core. The thicker skinned-sample barely did not pass the required strength in the SES so the solution was to go to 1" honeycomb with the thicker skin. I am very confident that this one would pass. This sample was made but never tested due to constraints on being able to use the MTS lab.

Design Considerations

We originally set out to make a half-monocoque chassis for the IC car. The goal being that it would be cheap and simple to become a reality. The plan was to use expired fabric we had. We originally had no certainty on autoclave/oven time so one idea we had was to lay it up, freeze it under vacuum in the walk-in freezer we had acquired for \$100, then wait for autoclave/oven time. The idea was to do a uniform layup meaning one continuous ply schedule that would pass the strict rule for side-impact everywhere on the car. Based on my predictions, this conservative design would be within 4 lbs of one of our full-tube frames. (~ 60 lbs +-4). This value was based off of the actual weight of a side impact 3-point bend sample that I thought would pass and the surface area of a working design. This design would likely be considerably stiffer than a tube frame though we never planned to do any simulation since we would be well-overbuilding it. One thing to note is that other teams have

published estimated for the point of torsional stiffness diminishing returns to be 2000 Nm/Deg (which a tube frame can achieve) but this does not account for local stiffness requirements. One of the main goals that this would achieve would be freedom of mounting items to anywhere on the car.

Pros

Mounting freedom

- Allows iteration from year to year
- Can drill a hole anywhere to mount
- Side wing mounting interface is easier

Reusability

- Mold Reusability
- In a half-monocoque design, the monocoque could be carried over while the rear tube-frame is reused

Weight loss after years of development

Stiffness

Safety

- Do not have to manufacture a body, side-body, or floor
- Should create less turbulence and drag having more of the car sealed off by a continuous smooth structure

Accu installation on hub motor full-monocoques

Cons

Initial Investment

Each additional monocoque from the same mold would still cost more than a tube frame

Design likely locked-in based on molds

Risk

- Mechanical failures
- Manufacturing failures

Time sink

Design and simulation difficulty

Yearly sample tests

No initial weight loss

Harder to service (working on brakes etc.)

Hard to repair (in event of failure, you cannot weld it back together)

Full vs Half

The original goal in 2020 (Pre-KS5-E (also called KS2-E)) was to develop a half monocoque for IC. It would be easier to design and build for the first iteration. (We would have also had enough expired carbon for this). In 2024, the IC is phasing out and the EV is phasing in. My opinion is that an EV would perhaps be easier to design for a monocoque since an accumulator would provide simpler geometry and more freedom for mounting than a combustion motor. This makes the idea of a full monocoque less daunting in my opinion.

One thing I like about some of the full monocoques I have seen from other teams is how the teams with hub motors are able to dismount the accumulator out the back of the car as if it is rack-mounted on drawer slides. But this does not make sense for an inboard motor car.

Regardless, the team should not bite off more than it can chew. The choice between full and half goes back to Rule 1.

Autoclave/Oven

In my opinion, an autoclave is not necessary and an oven will do just fine, given a good vacuum. One nuance to this might be if there is problems with adhesion to core material. Another difference between autoclave and oven might be the electrical resistance which would be required to be less than 5 Ohms to GLV for an EV as per the rules.

Some possible ovens are:

Delta Flight Products

Nor Ral

GTRI-ATAS

Some possible autoclaves are:

Delta Tech Ops

Nor Ral

Atomic 6 (promising)

1 Piece vs Multi-Piece

Many teams make the monocoque in one piece while others make it in multi-parts and bond it together. The ones where the monocoque is one piece will require multiple molds that mate together with a very small seam before being layed up on. This will usually create a 'flash line' where resin will fill. This can usually be easily knocked off. For a half-coque, this will usually mean 2 molds and for a full monocoque, it may be 3-5 molds (sometimes still 2). Another question that arises from this is "Where do I put the split?". My original answer was left and right because that is what I was recommended by my superior. My educated opinion is to split the monocoque top and bottom. This would allow the CNC router to make the bottom mold/part in one shot and maintain higher symmetry for the suspension. The top half of the monocoque would be less critical but still has to mate well with the bottom. For a pre-preg process, I would make the monocoque in one piece if the geometry is possible. This way you do not have to rely on a bond. However, for a resin infused process, 2 parts would be required to be bonded together.

Resin Infused vs Pre-Preg vs Cut-and-Fold

With wet-layup not being possible, these are the three options. We initially set out to do pre-preg because that was the fabric we had, but that isn't necessarily the gospel. These are the existing processes because they are not very time constrained manufacturing wise like a 2-hour wet-layup is. Resin infusion was not considered since the team did not have experience in it however, resin infusion may be cheaper than pre-preg because pre-preg would require high-temp mold materials. The cut-and-fold process is the idea of using a pre-fabricated sandwich panel, routing contours in the flat sheet, folding it to the desired shape, and bonding it together. This could be reinforced with carbon fiber angle brackets bonded to the chassis. The limitations of this are many however: pre-fabricated flat panels of the required size are not something we could make in house, it would be hard-pressed to find a panel of the required dimensions and ply schedules, it would also heavily constrain geometry. I am also not sure if our required thicknesses would be too high for this process. Apart from this, I would say it is a tossup between infused and pre-preg. The team would have to do a cost analysis and have completed successful resin infusions first.

Mold Materials (Pre-Preg)

The pre-preg process will require a male 'plug' and then a female composite mold to be created off of that. This could be either fiberglass or carbon fiber but carbon is recommended because it will have a similar CTE to the final carbon part. These will require

expensive high-temp resins. Conversely, you could technically get away with committing to a multi-piece-bonded-together monocoque and use high-temp tooling block, but that is also crazy expensive. Another take is to do an aluminum sheet metal mold. This will require minimal surface prep (really nice) but will heavily constrain the design based on how sheet metal can be bent. You may be able to weld multiple pieces together. You will save time on the mold and might save money. It however be hard to hit the correct bending tolerances. For the 'plug', cheap foam or MDF may be used but MDF will likely have way more dimensional accuracy despite costing more. It will also be less fragile and have less mold-prep involved.

Core Materials

We went with Aramid-Nomex honeycomb because it was cheap and we also had it, I see no need to change this. The primary goal is to get thickness to the part without adding weight. If a higher adhesion between core and skin is required, a better adhesive sheet, or higher cell density may be useful. Foam cores will likely be expensive but will be stiffer and have a better bond. If resin infusion is the chosen route, a foam compatible with it will be required.

Shape

A more square XY profile (Cut section parallel with front plane) may be easier to layup however, a more round (octagonal, filleted, or circular) profile will be torsionally and locally stiffer. In general, keep the geometry simple to save manufacturing headache. Also, flatter regions are easier to mate to.

Consider constraints such as cockpit and foot templates, Percy, driver fit, steering wheel placement, steering rack, ergo, seat, firewall, hatches, AI plate, pedal box, suspension mounting, ARBs, aerodynamics and aerodynamic interfaces (ex: side wings, FW), roll bars, headrest bar, MHB, or almost any part of the car. The rules will be constraint #1, packaging #2. Work with the chassis, suspension, powertrain, and aero leads especially.

Inserts/Bolted Connections

I am no expert on this but a couple different options are hard aluminum or plastic inserts placed in the layup, thru hole with sized washers/nut plates, and potted inserts (such as a NAS-1834-4-1000). On non-torqued parts, it may be recommended to fill the surrounding honeycomb with epoxy or use a hard insert in case the bolt moves and damages the surrounding core.

Core Crushing

This is an issue I have read up on that teams experience where the edge of the honeycomb (rather than the face) is exposed to the wrath of the vacuum and the core crushes from the side. You should generally not be concerned about an autoclave crushing the face of the honeycomb.

Cost

Yet to input the breakdown in a clean way but expect \$6-8k for a first iteration.

Maintenance

Tuesday, November 14, 2023 2:10 PM

Circuit breaker, 3rd panel, circuit 16 goes to O-101 outlets

End Plate Schizo Tacks

4 PLYS

- How many Plys do they actually need to be? (2 PLYS?)
- VI.1 used carbon sheet, ~~200g/m²~~

~~Weldments~~
- Prevent crushing endplates by bolting to metal



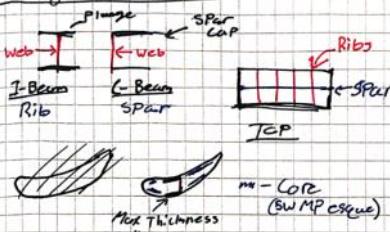
~~Weldments~~
- glued in honeycomb
Integrates

- How w/ wet layup?
 - Sandwich inside & drill out holes?
 - Sheet (like vicks)
 - Machine holes in sheet

ET600?

- Black, Sandable adhesive to get good surface finish
- Round endplates ~~top~~ McMaster Weatherstripping

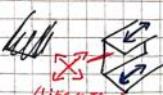
Wing Structures



Ideas

"Grid" Design

etc.



Building a PW - Easy Composites (VI.1)

- ET600 Adhesive
 - Shown for glue onto foam
 - Proprietary Adhesive for Mylar on element
 - Gloss finish
 - No breather/peel ply ???
- Spray Tackling PLYS
 - Fusion fix
 - Heat about 40°C
 - Effects Resin & Fiber Adhesion?
 - Squeezes Enclosed Parts
 - Something flat covered w/ breather
 - Ply orientations?
 - How Cut/Trim Carbon Parts on CNC?
 - Endplate Schizo Notes ~~PP4~~ (Pg 4)

Cornell Composite Notes

Motor Mounts

- Team Picay (www.picay.com)
 - Dovots to locate holes
 - To prevent core crush, hollow/no core (bottom heavy) in these spars
- Trapezoid to mount to endplate
- Endplate mounting for FW?
- Endplates
 - No inserts
 - Clean hand tight $\frac{1}{4}$ 20 or 28
 - Magnetic hatch w/ button & Magnets (O)
 - Aluminum Trim w/ Nuts
 - "Sine Wave" Structure; like a bunch of spars

Comp Sheet

PFT

Everything bonded using ~~ET600~~ E-100

- Carbon suspension
- Bond Cuts
 - Determining where?
 - Acid Etching & Sand blasting
 - Prop's interference
 - $\frac{3}{4}$ " - 1" Deep (Insert)
 - Smaller Beginning Diameter, then goes to true ID
 - Locating Jig?
 - Endplate inserts
 - Like a Rivet
 - Circular inside then outside like a fender washer
- Riv Mounting
 - Flat Panel w/ Bowtie insert
 - Appears to be Machined Post Manufacturing, one side will appear bent core crush no more
 - "Double shear", EP sandwiched between

Designs Amer, Wisconsin

Quarter Turns

- Cool

- Bitch to locate

Mono Cowl

- Prop Thrust w/ Carbon fiber mold

- PVBBS - Heat resistant?

- QSR - Dissolvable

Split lines & Finish

- Sants to 5000

- Epoxy Split lines & Sants

- Intentional lip for mold to overlap skins

- Rivets ~~as~~ as bonding



Nose (1.0)

Profile Nose

- Spread toe ???

- Relief Cuts ??

- Looks whole

- EP tape not rounded & ~~flat~~ Tech (Bad)

Tenn Tech

- Acrylic Panels, ~~flat~~ like

- ~~flat~~ Using Steel Wire/Tube for Fil Mounting 1.0

- Big fan of Lawrence Tech Body

- 1955 esque (Bad)

- Univ. of Victoria Livery = Balling

Dodge RW

- EP Bent (Bad)

- Gaps in foil & EP

- DRS issue?

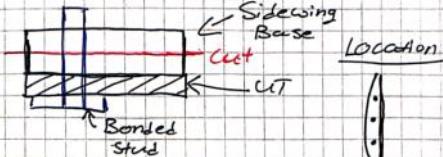
- Bad implementation

- Roof Air Compressor is Badass

- Person dedicated to Clicking for business

Other Glass Cut YCP

Bolted Sidewings



- Pre-drill holes prior to cutting

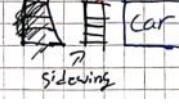
- 10-32 Studs, $\frac{1}{4}$ " Long, 29/32 Base (McMaster)

- Bolt & Washer

- Allows for ~~side~~ Siding under car

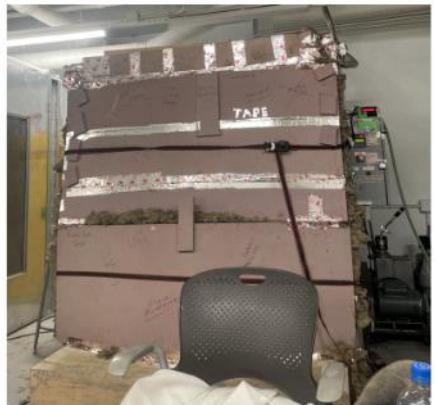
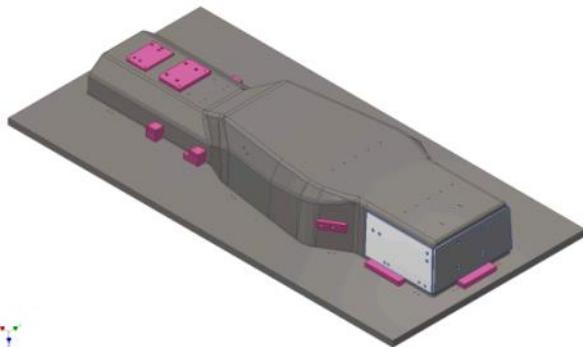
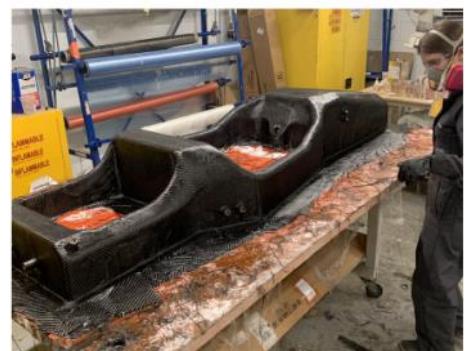
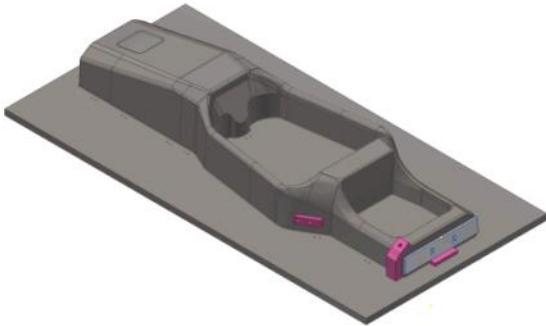
- Lift 8" in compared to $2\frac{1}{4}$ "

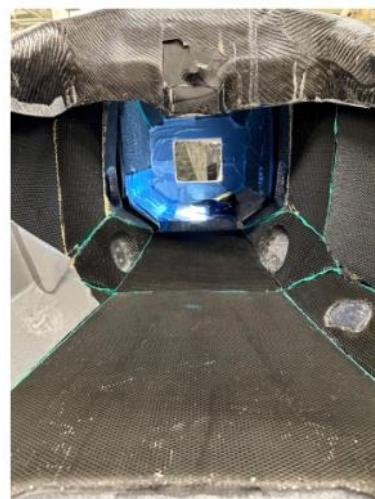
- Tension Rod to chassis



Cornell Coque

Tuesday, June 25, 2024 1:36 PM







Freezer Woes

Thursday, May 22, 2025 8:28 PM

- If it don't be freezing, blow out the fan and radiation on top of the guy
- Freezer leaks constantly, get with scarpinato about a drain on it, at worst you can plumb some Copper pipe from inside to out, the walls are just foam and the drain is a nipple on the left side of the condenser (I think that's what its called)
- Use the fiberglass dude

Subgroup Meetings

Tuesday, June 25, 2024 6:27 PM

Projects 24-25

Tuesday, June 25, 2024 6:28 PM

Topics:

- Projects
 - What projects do you want to do?
 - Summer testing/research
 - What testing and research do you want to do?
- Final Project
 - What projects do you want to do?
- TODO
 - How can we do better going forward?
 - What changes are going to happen this year?

Dump:

James

- Improving the shop for next season (permanent/quick setups for PVA and such)
- More consistent worktimes/meetings
- Maybe a shop camera 24/7 for timelapses and security

Matt

- how to better keep the space clean during layups.
- if there will be other teams using the space we need to find a way to keep our stuff separate/organized. (perhaps sign in sheet for other teams)
- Not killing members through their circadian rhythms
- Make EHS leave us alone
- new member friendly

Grayson:

Testing:

- Pushrod MTS testing
 - Compression
 - Tensile
 - 3 point bend
 - Torsion
- Carbon Sample
 - Compression
 - Tensile
 - 3 point bend
 - Torsion
- Carbon Electrical Testing
 - Grounding
- Intake Deflection Data
 - Apparently we already have this

Research:

- Dissolvable Molds
- Heat Resistant Molds
- Multi-Point Molds
- Compression Mold
- Grounding
- Carbon Structural Testing
- Adhesives Properties
- Material Properties
- Fabrication Processes

Projects:

- Body
 - Raked Dash
 - Carbon Steering Wheel
 - Raked Floorboards
 - Wing structures
 - Carbon Suspension
 - Seat integration with firewall
 - Engine cover/Engine cooling solutions
 - Intake
 - Gas & Brake Pedals
 - Cockpit internal covers
 - Carbon FW/RW Mounting
 - Carbon Grounding
 - MATLAB Composites Structure Analysis
 - Detachable Side Wings
 - Quick Assembly Wings
 - Closed Edge Endplates
 - Carbon Edge Cut Resistance
 - Low-Slung Carbon Scraping Solutions
 - Shop Layout

How can we do better?

- Organization of the shop
 - Biweekly/Weekly Cleaning
 - Clean/Dirty room
- Scheduling
 - Consistent
 - Plan a day ahead
 - All-nighters NO
 - minimized
- Safety???
 - Inventories
 - Binder
 - Online Excel?
 - Ply schedules?
 - Easier with organization
 - SDS Sheets
- Communication
 - Keep main up to date
 - O to Q
 - 2 slides at main...lol
 - Pictures
 - Details
 - Plans
 - Testing
 - Set meeting dates
 - Have everyone input that
 - Aero and composites meeting
- Progress Log
 - Notebook/Binder
 - in one spot
 - Shared
 - OneNote?
 - Put note on door that says to update it
 - Put together before fabrication season
- Computer in composites
- Maybe use the TV for something like a countdown, schedule, etc...

Research/Processes:

- Resin Infusion
- Prepreg
- Compression Molds
 - In-laid Aluminum/3d print
 - Complex cores
- 3D print materials
- Mold materials
- Core materials
- Filament Winder
- Adhesive Research
- Physical Testing
- Metric Research
- Grounding
- MATLAB Carbon Analysis
- Fibersim
- Sample Testing
- Machining Tolerance
- Prefer
- Quality of part

Maintenance:

- Maintenance Schedule
- Air compressor
- Vacuum Pumps
- Extension Cords
- Air hoses
- Vacuum Press
- Sealable tables

Projects:

- Body
 - Aero Based
 - Collab
 - Whiskers
 - Side bodies = Composites maybe
 - Raked Dash
 - Seth?? Sad he said no
 - Carbon Steering Wheel
 - Britton, Grayson & Grayson
 - Learn Scary MATH
 - Raked Floorboards
 - Newbie
 - Wing structures
 - Oven
 - Carbon Suspension
 - Matt
 - Talk to Sammy on doing some correlation to shock pot data
 - Seat integration with firewall
 - Bray, Emil, Grayson, Anelia, Matt
 - Engine cover/Engine cooling solutions
 - Britton
 - Research
 - Aero-Based
 - Intake
 - Any log has pressure
 - Might find one with an explosion
 - Gas & Brake Pedals
 - Britton and Grayson or David
 - Cockpit internal covers
 - Newbie
 - Carbon FW/RW Mounting
 - Matt
 - Carbon Grounding
 - TJ PLATE!!!
 - MATLAB Composites Structure Analysis
 - Grayson, Britton, Anelia
 - Detachable Side Wings
 - David
 - Quick Assembly Wings
 - Britton
 - Closed Edge Endplates
 - Grayson
 - Carbon Edge Cut Resistance
 - Newbie
 - Low Slung Carbon Scraping Solutions
 - Matt
 - Shop Layout
 - Anelia
 - Multi Piece Undertray
 - Aero Based
 - Flat Bottom Car???
 - Strakes???

David

Research/Design

- Resin Infusion
- New Body design
 - Panels w/ hatch deal
 - Both detachable
 - Endplate Inserts
 - Someone make a material rack for the love of god

Projects

- Taking on much as I can tbh, want to have fun
 - Phone Call with atomic 6 head of business tomorrow at noon

Thoughts

- Start Excel Sheet for inventory
- Personal Accountability of progress tracking
 - We already have two systems

24-25

Friday, August 2, 2024 7:11 PM

Projects:

	Body Status
-Body	
-Aero Based	
-Collab	
-Whiskers	
-Side bodies = Composites maybe	
-Raised Dash	
-Seth??? Sad he said no	
-Carbon Steering Wheel	
-Britton & Grayson	
-Learn Scary MATH	
-Raised Floorpans	
-Newbie	
-Wing structures	
-Grayson	
-Carbon Suspension	
-Matt	
-Talk to Sammy on doing some correlation to shock pot data	
-Seat integration with firewall	
-Bray, Emil, Grayson, Anelia, Matt	
-Engine cover/Engine cooling solutions	
-Britton	
-Research	
-Aero-Based	
-Intake	
-Any log has pressure	
-Might find one with explosion	
-Gas & Brake Pedals	
-Bray and Grayson or David	
-Cockpit internal covers	
-Newbie	
-Carbon FW/RW Mounting	
-Matt	
-Carbon Grounding	
-TJ PLEASE!!!	
-MATLAB Composites Structure Analysis	
-Grayson, Britton, Anelia	
-Detachable Side Wings	
-David	
-Quick Assembly Wings	
-Britton	
-Closed Edge Endplates	
-Grayson	
-Carbon Edge Cut Resistance	
-Newbie	
-Low Sitting Carbon Scraping Solutions	
-Matt	
-Shop Layout	

- Anelia
- Multi Piece Undertray?
- Aero Based
- Flat Bottom Car???
- Strakes???

Atomic six call notes

Wednesday, June 26, 2024 12:06 PM

Speaking with Dakota Ward Head of Business Relations

Where does Atomic-6 lie within team goals/What do we do

What is the Composites Process Look Like

Proprietary Mold Technology

Through mold reduce cure cycle

Where do we want to improve and what can Atomic-6 help with

Relationship with Material Provider