Package Design Specifications

Friday, May 2, 2025 9:03 PM

8C: Simulated

Cl	

Need direct Cl and Cd for straight line with and without aero.

Do not know planform area so cannot calculate

8E (Simulated)

Cl	
Cd	
CoP (40 mph straight)	

Important Dates

Friday, February 7, 2025 7:31 PM

Design Presentation:

Complete Aero Packages:

- March 14th

EV Rolling

- March 21st

KS9

Tuesday, December 3, 2024 4:41 PM

Pre-liminary Questions

- What is important when changing architecture?
- How do you define what you want your aero package to do?
  - Maximize grip in specific speed range
  - 50% (On CoG) balance with CoP Movement
    - Have a range based on Sammy' bike model
  - Drag budget based on energy consumption
  - Weigh a specific amount while maintaining rigidity
  - Cooling capabilities
- How do you design concurrently with vehicle dynamics?
  - What is our yaw angle?
  - What pitch do we see?
  - What roll do we see?
  - What ride heights can we achieve?
  - How much does aero effect suspension?
- Should we do sensor integration?
  - Yaw sensor?
  - Pressure sensor?

Meeting Notes

- Decisions between wings should account for manufacturing
- Narrow down to a couple concepts with half-car, then do yaw, pitch, roll, etc.
  - Aero starts their design, is happy with a few, then checks for integration with VD
    - Now VD can design off this.
- Keep in mind nose design and other things
- Aero Development Goals:
  - Fully Reasoned Drag Budget
  - Suspension Integration
  - Cooling Integration (Brakes, Powertrain)
    - Cool Integration
  - Transferrable Package?

Post Comp:

- Sim validation
- Achievable endurance pace with aero, drag limit

Test Downforce/Drag Numbers -> Improve Simulation Accuracy (10% Difference) -> Define Package Goals -> Design & Simulate -> Integrate -> Manufacture -> Test -> Recap

For simulation accuracy: Accuracy should be to unsteady simulation, with a correction factor between steady & unsteady.

Workflow

Wednesday, July 9, 2025 11:41 AM

What does aero want to achieve?

- ★ Full aero package, better integrated into system
  (Assuming full aero is optimal concept)
- ★ Simple and solid. Easily improved each year.
- ★ Outline design process and documentation for future generations.

- Therefore: FW, RW, UT

What is the optimal workflow for each component and the system?

1. Study component concepts, combine different concepts, select best combination, refine.
   a. Easily divisible between FW, RW, and UT.
   b. Concepts can be narrowed initially by subgroup goals.
      i. CD or CL Targets/Maximums
      ii. Roll, pitch, heave envelopes
      iii. CoP Static, Pitch, roll, yaw sensitivity.

Component Wise Delegation Workflow

1. Generate Concepts based on research
   a. Determine analysis method
2. Combine concepts in whole car
   a. Determine analysis metrics
3. Iteration: Compare, refine good concepts, re-sim whole car
4. Select optimal concept
   a. Based on sub-system goals
5. Refine and finalize concept

Parking Lot

- Each member gets to FAFO on each component (in a structured way)
- Lead gets to put them all together and see how they interact, then improvement areas can be identified and pushed back to individual components
- Specify all combinations possible, divide up work and have each member sim a couple combos and report their findings.

Pre-Liminary Design Requirements

1. Sub-system goals/targets
2. Standardized Simulation Processing/Post-processing
3. Standardized Analysis methods
   a. Free stream analysis
   b. On-car analysis

PDR1

RW

1. Airfoil selection
   a. Benzing
   b. MSHD (Motor Sport High Downforce)
2. # of Elements
3. Chord Length
4. Slot Gap (After Airfoil Selection)

- Can simulate 2D or 3D
- Simulate with KS8 FW and UT

UT

1. Flat bottom without undertray
2. Simple Bernoulli tunnel
3. Ground Clearance

-

Design Principles

Thursday, July 3, 2025 9:00 PM

Inputs to Downforce

RW
- Airfoil shape
- Camber (Large = better)
- AoI control
- Surface Area

FW
- Airfoil shape
- Ground effect
- Camber
- Surface Area
- Flow Control

UT
- Ground effect
- Camber
- Inlet/Outlet Control
- Vortex columns

Discussion

RW

The idea is circulation while keeping flow attached. Achieving this is through a multi-element wing. The airfoil profiles for this may depend on the dimensions of the wing. Increasing the angle of incidence may allow for more camber and more circulation, but how to get that to happen and then keep flow attached could be difficult.

I think the RW airfoil selection could be investigated again. Choose airfoil, number of elements, AoA, and slot gaps. This could be with respect to the overall goals of the aero pack.

Definitely need to look into how to clean up the air when it meets the RW. Perhaps flow control from up front, something to stop recirculation from the headrest, or a slat to energize the air.

FW

The FW mainplane should probably remain the same with adjustment to the airfoil to reduce flow separation into the undertray. Not sure if we should change the loft. I want to get rid of it because there wasn't really a data driven decision behind the front or rear wing.

The upper element style may deserve a change because of low camber middle elements and ineffective outer elements. They should be pulled away from the tires by a good margin. This could be investigated on where.

The vortex generators need to re-done cause they don't do their job correctly. There needs to be more vortex generation by the FW to control flow to the tires, UT, and RW.

UT

Inlet angle needs to change. Too steep and too much pressure. Outlet angle may need to change but the tires really mess up the flow back there. Quang showed that

Pre-Lim Requirements

Wednesday, June 25, 2025 6:08 PM

Things to Iterate on:

- FW Flow Control
- RW Flow Separation
- UT Flow Structures & Integration
- Body (Nose & Side Panels)

Visible Problems

- FW elements low energy
- No airflow to UT Side Wings
- Rear Tire wake in UT
- Poor UT pressure recovery
- UT inlet has high pressure (geometry or FW RC)
- RW dirty air from Roll Hoop
- RW low energy and flow separation on elements

High Level Goals:

1. Reduce drag (Target)
   a. Efficiency points in endurance
   b. Faster pace allowed in endurance
      i. Need to characterize how much we need to slow in endurance, find CD that will allow for full pace.
2. Maximum Downforce within Drag Target

Side Goals:

1. Reduce complexity for ease of manufacturing
2. Improve manufacturing quality
3. Cooling flow control
   a. Placement and flow control
4. Pressure Tap System
   a. Easy to integrate to structure

Pathways: High Level Goals

1. New FW and UT Design
   a. Control and Avoid Tire Flow Disturbance
   b. UT: Acc Removal Friendly
   c. FW: Front Tube access available
2. New RW Design
   a. Further away from MH/MHB
   b. More aero box clearance

NEED TO DO:

1. **Sim accuracy (Review mesh and geometry)**
2. **Use Star CCM Design iteration program**

Standard Targets

- **CL**
- **CD**
- **CoP**
- **CoP Migration (Sensitivity)**

Can be based on car accel targets.
Can use previous year for reference.

Car Targets

- **Acceleration**
  - **Long**
  - **Lat**
  - **Yaw**
- **Weight & Distribution**

Problems on KSB:

FW

1. Inner element 2
   i. higher than expected pressure
2. Outer Elements
   i. 0/Positive Pressure Coefficient
3. Vortex generator
   i. does not fully extract air away from front tire
4. Mainplane
   i. Pressure coefficient has un-even distribution, outsides have less pressure than insides.
   ii. Flow separation
5. Tire Blocker
   i. Just has negligible effects
6. Acc serviceability
   i. Must remove to lift car.
      1) Could be UT fic
      2) Could be wheel jacks
   ii. Possible: Remove UT w/o lifting car

UT

1. Tire Wake
   i. Front tire wake enters around side wings
   ii. Rear tire wake enters immediately
      1) Lots of stagnation during pressure recovery
2. Side Wings
   i. Front tire wake completely staggers air to side wings, no downforce is generated.
3. Diffuser
   i. Poor Pressure recovery, middle section is the only one that is slowed to free stream
      1) Not sure about this, need to understand pressure recovery more and what is ideal for FSAE
4. Ride Height
   i. Too low, would scrape in roll with drivers above 200lbs. Could not adjust height much further.

RW

1. Element 4
   i. Flow separation along top edge
2. Mainplane & Element 2
   i. Small negative pressure coefficient
3. Suspension & Front Wheels
   i. Creates stagnant wake towards RW

Other

1. DRS
   i. Return spring or default for DRS. Failsafe closed

Points Analysis:

- Drag reduction can increase points through efficiency
  - DRS
  - Lower Drag Budget
    - How do points scale with CD in efficiency?
    - Passive Drag Reduction:
      - Tire flow management
      - Diffuser Pressure Recovery
      - Closed Drag
      - Open Drag
  - *Find what's possible now with DRS. Should calculate what it is with DRS given expected closed areas, then how much CD you can have in the closed areas to set a limit to making downforce.
    - DRS Open and high CD will possibly maintain efficiency score but will improve endurance score if higher CL. Make sure you identify how much CL you must make to have a net benefit.
- Improving downforce to a certain CL will increase points in lap time
  - Depends on tire load

Conclusion:

- Just need to know target drag for efficiency points and target downforce for lap time points.

Goals:

1. Hit Points Target
2. Improve Flow Control (Devices and Separation)
3. Improve Serviceability & Scraping

How will PDR workflow work?

Work Distribution

1. By part
2. Do some design first (FW) then do by part. N/C can start with RW
3. Give them Mounting Task

What changes can happen deep into design that

Setting the CD Target:

- What is the relationship between Energy vs. CL vs CD in endurance?
  - Can I also plot time and then calculate points, maybe plot all in one graph?
- Are we able to use full energy w/o aero in endurance?
  - Yes: How much aero until we cant? (Drag Budget)
  - No: How much aero can you add until the endurance points loss (from lap time and efficiency) outweighs the performance gain in other dynamic events?
- Possibilities
  1. CD target is based on maximum energy consumption
     - Con: Does not consider optimum balance between CL/Lap Time and CD/Efficiency
       - I.e. Is the max drag CL the best for points? Or is a lower drag, and lower CL more points? This will have to include all other dynamic events.
     - Pro: Setting this is very easy, ensures you don't limit the car dynamically, and goes along with more downforce more better.
       - More importantly: There are much more effective ways to improve efficiency that do not alter the lap time performance of the car.
         - E.g. Regen braking, cooling systems.
  2. CD Target is based on ideal efficiency score
  3. CL/CD Target based on set CL or CD.
     - I.e. As you change CL, your lap time changes across all events (minus accel) and your points change. But your points also change in efficiency, so what is the best balance between CL and CD for each set CL?

Subsystem Target Yap

Placement Goal -> Points Goal -> Acceleration Goal -> Sub-system goal

Before targeting what aero *should* do, the concept of the car needs to be defined. Is it going to be a powerhouse, is it going to be a super light car, is it going to be maximum grip, or is it going to be super cost effective (to name a few) in order to meet the desired placement goal?

The overall concept of the car will determine what each sub -system needs to provide in order to reach that concept.

Aero can decide targets individually, but the result would be that you automatically narrow what the overall concept of the car is going to be.

Since we are a low budget team, changes to powertrain architecture and other major systems is limited from year to you. You inherently have to carry over most components to reduce cost.

This means that I can maybe reason to what is optimal based on the platform that we have to carry over....

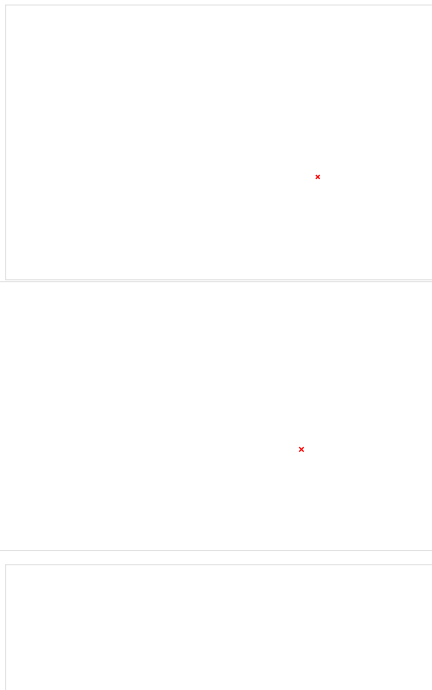
Other thoug

- If we ar
  aero ar
  depth ir
  architec
  metrics
  discusse

Carry over platform

The car will most likel

- Powertrain and d



nts on system design:

e trying to change
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should probably be
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carry over....

riveline

Notes from Dr. Jones's Article

Lap Time Simulation
- Limit inputs to make optimal concept easier to identify
- Use more than just lap time simulation (OptimumLap), e.g. skidpad hand analysis or MATLAB acceleration.
- "A good design engineer always approaches simulation tools with some skepticism and honest questioning, striving to understand the insights and limitations intrinsic to any evaluation tool."
  - Understand tool limitations and how to correct with other tools

Mass Model
- "A well-maintained and calibrated mass model grants an FSAE team the ability to design for truth, as opposed to designing for hope"
- Each change will have mass consequences across the car (e.g. heavier acc means heavier chassis), and you can set mass budget for changes with the model.

Cost/Labor Extension of Mass Model
-

So now I can say....

Given our powertrain architecture will stay the same, what concepts can I develop that will achieve the placement goals.

Then I can derive what aero will look like for each of those concepts.

We can choose a concept that will be most optimal for us to design, and aero can then design to whatever that need may be.

This will then come pre-defined with the targets that aero needs to hit to make the concept work and then all the design for the aero kit can start efficiently

Milestones

Saturday, June 28, 2025 10:47 AM

Milestone To-Do List

SRR
- [ ] **Points Analysis & Design Targets**
- [ ] **Design Workflow Outline**
  - [ ] **Star CCM Iteration Tool**
  - [ ] **Revision Tracking w/o PDM**
  - [ ] **Success Metrics**
- [ ] **Work Distribution**

SRR --> PDR1
- [ ] **Individual Component Concepts Simulated**
- [ ] **Define set of components to combine into configurations**

PDR1 --> PDR2
- [ ] **Component configurations simulated**
- [ ] **Decide final component concepts based on configuration**

PDR2 --> FDR
- [ ] **Daily iterations made to system**

Idea PL:
- Structures designed in parallel
  - Need to design adjustability (In case what we actually produce is out of range)
- Set base targets for simulation (e.g. must have no flow separation, drag budget, CoP location)

Workflow
SRR --> PDR1
- **Investigate concepts for each component**
- **Determine**

PDR1 --> PDR2
- **Investigate selected concepts in whole system**

PDR2 --> FDR
- **Select final concept**
- **Refine**

Dependencies:
- Rib design
- Swept wing decision

Milestones: Aero

1. Set goals (SRR)
   a. Aero validation and RCA
   b. Lap sim modeling (Time, efficiency, aero balance)
      i. Define aero stall speed
   c. Theory research and general studies
      i. Geometry selections
2. Conceptual designs
   a. Iterate through FW, RW, and UT Designs
   b. Track performance, manufacturability, mount-ability, & serviceability
   c. PDR1: Initial review of concepts, narrow range
      i. Light simulation, quick iteration
   d. PDR2: Final review of concepts, select best concept to integrate
      i. Pitch and ride height sensitivities
3. Final design
   a. Structures integration
   b. Mounting integration

Milestone Deliverables

SRR
1. **Sub-system goals**

PDR1
1. **Multiple component level concepts (FW/RW/UT)**
   a. **CAD models, simple free-stream/full-car analysis**
2. **Concepts selected for system configuration analysis**
   a. **3 FW, 3-5 UT, 2-3 RW**

PDR2
1. **~30 Configuration Concepts**
   a. **Straight line simulation only**
2. **Optimal configuration selected**
   a. **Performance, manufacturability, & cost**
   b. **Achieves large sub-system targets (CL, CD, CoP)**

FDR
1. **Final, refined design**
   a. **Achieve pitch and heave CL, CD, and CoP sensitivity**
   b. **Transient Simulations used to refine design**

Milestones: Aero Structures

1. Set goals (SRR)
   a. Design Debrief and RCA
   b. Theory research and general studies
   c. SRR: Review requirements
2. Conceptual designs
   a. Iterate through FW, RW, and UT Structure Designs
   b. Track performance, manufacturability, mount-ability, & serviceability
   c. PDR1: Initial review of concepts, narrow range
      i. Light hand calculations and assembly/manufacturing plans
   d. PDR2: Final review of concepts, select best concept to integrate
      i. FEA/CAE Analysis with hand analysis to verify
      ii. Detailed manufacturing/assembly plans
3. Final design
   a. Structures integration
   b. Mounting integration

CFD Dumps

Tuesday, July 1, 2025 9:30 AM

1. Purpose
2. Scope
3. References (If req.)
    - If you reference any documents in text, put them in here.,
4. Definitions (If req.)
5. Background
6. Materials/Equipment/Procedure (If req.)
7. Results (If req.)
8. Discussion
9. Conclusion
    - Give me a summary of what I just read,
10. Attachments (If req.)

- Link results data and references here.

Full Car Analysis

Tuesday, July 1, 2025 9:30 AM

Simulated our Aero (8E), found a couple interesting things, and looking for feedback from the uncs on post processing.

- UT side wings dont get fresh air. Evident from velocity cut, streamlines, pressure coefficient, and wall shear stress. In the cut video you can see what the side wings top and bottom look like vs what the should look like based on the RW.,
- There is tire wash that disturbs the underbody towards the diffuser section. You can see it in all the plots as well. Poor pressure Recovery.

Looking to maybe automate this post-process for each sim so we can standardize the comparison. I am going to look at the mesh later today and run another sim tonight to see if there is any change in results. Residuals look fine but all im looking for is straight line.

RW Isolated Flow

Tuesday, July 1, 2025 9:33 AM

1. Purpose

   Compare RW flow with car removed. Determine impact of flow structures generated by full car (FW, Body, UT)

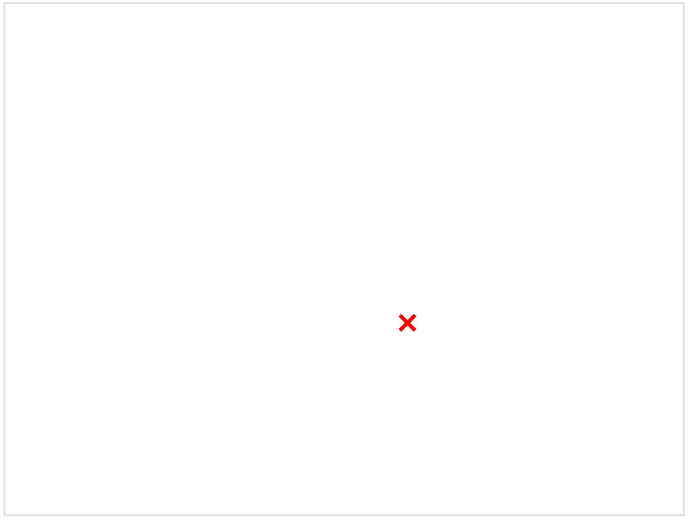
2. Definitions (If req.)
3. Background

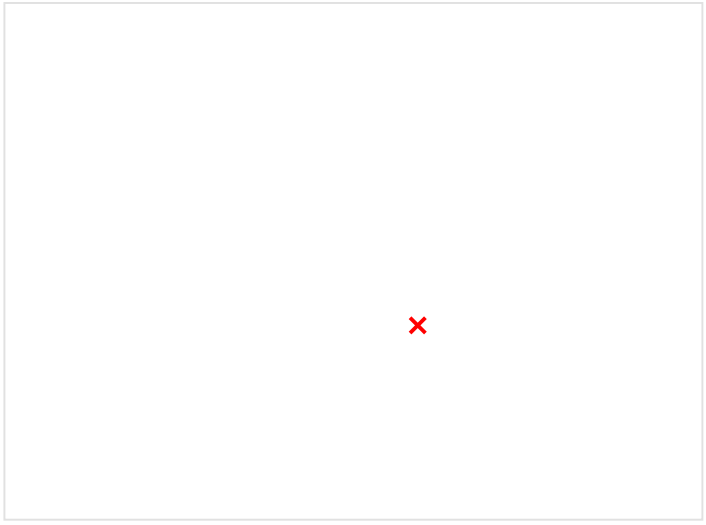
   RW has flow separation and turbulent structures on the mainplane and element 4. It is most likely a combination of forward structure disturbance (MH/MHB/Head, Front Tires, FW). This reduces downforce capability of the RW and should be investigated.

4. Procedure

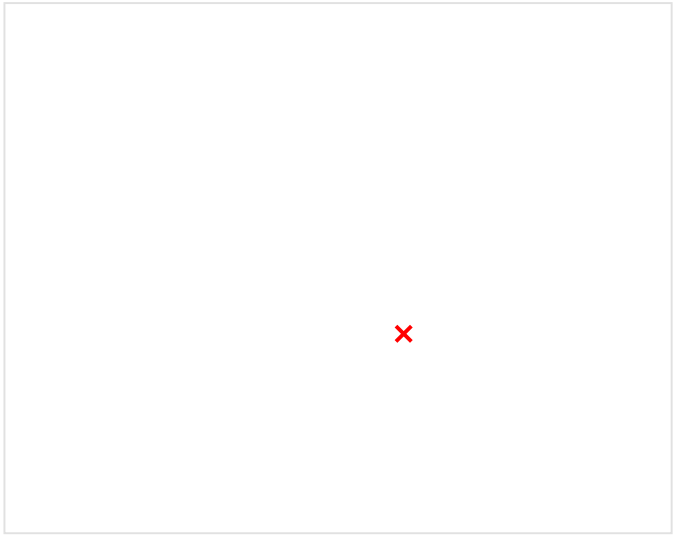
   Simulate RW in free stream and compare to RW on car.

5. Results (If req.)
   - MH/MHB reduces dynamic pressure at inlet of RW. Low dynamic pressure translates to low velocity and low pressure.





   - Velocity Magnitude plot is very similar.



6. Discussion
    - Low dynamic pressure translates to low velocity and low pressure. Low downforce.
    - This outcome is obvious, and with any wing this will happen. However, it defines exactly what needs to be improved to enhance the RW when on the car.
        - There is most likely some balance between clean air, wing position, and wing size (dependent on position).

7. Conclusion
    - Give me a summary of what I just read,
8. Attachments (If req.)

- Link results data and references here.

KS8 Goals - 2024-2025

Sunday, April 21, 2024 11:21 AM

Aerodynamic Subgroup Goals

1. Resolve Major Shortcomings/Failures of KS7C/E
2. Whole Car System Integration (Energy Consumption, Suspension Platforming, Driver Feedback)
3. Increase Flow Structure Complexity

Deliverables

- Kickass, reliable, and tunable aero packages.
- Deeper understanding of system and connection between CFD/Reality through high quality and high quantity testing. Use understanding as reasoning for a new package for the KS9, as well as a base for knowledge transfer to new members.

Prime Aerodynamic Goals

- Increase grip (Outweigh weight and drag gain)

Execution Goals

- Validate all changes
- Tunable
- Stiff & enduring
- Work concurrently with suspension

BE ABLE TO JUSTIFY THE AERODYNAMIC PACKAGE AS A SYSTEM DOWN TO THE INDIVIDUAL COMPONENTS AND VALIDATE THAT.

Design Philosophy

1. Fix IC & EV, Quickly Produce, Validate, Close Loop
2. Design new packages starting October.

Overall Car Goals

IC

- Quick production, lots of testing, minimal change

EV

- Energy Architecture Change, focus on energy management

Both

- Reliable, serviceable, hit weight target
- 200 miles of testing time

Budget

~$15,000 design budget split across both platforms. ~$10,000 used for 600v architecture.

Analysis

Due to budget constraints, making new molds for new designs is not feasible. Furthermore, it is not as beneficial to "start from scratch" with a new package. Rather, it is better to tune, test, and validate the current designs to broaden our understanding of each package. By doing so, we will refine CFD simulations with on-car test data, uncover structure failure points that are unknown as of now, and get driver/performance feedback which will inform decision making for the KS9.

CAD and sim the *ideal* version of the KS8, where budget and feasibility are small factors. Do a lot: Nose, Body, UT, side tunnels, louvers, whiskers, DRS, vortex generators.

With the sim data and budget/buildability constraints, select and re -design package that maximizes performance with constraints.

Deliverables

Designing an ideal package (within reason w/r to time) will convey to the judges that the team understands the direction aero development *should* go even though it may not be possible to produce. It will also demonstrate a thorough decision -making process that resulted in the final product based on max wholistic performance and budget constraints. Finally, the aero team will get much more quality experience with deep aero concepts and design processes that will *hopefully* afford them impactful internship experiences.

Thought Parking Lot

- Deadline for "last call" on what is being made
- What are the cl/cd goals of each car? What is optimal?
- Deadline for ideal version
- Deadline for final version
  - Rolling deadline for new parts, which can be designed during manufacturing of old
- Can the EV mainplane fit on the IC and produce better downforce?
- Write down what sims you want to have and why before finalizing.
- Throughout semester, refine previous packages reasoning and design. Make it bullet proof/improve on areas that are lacking.

Both or One: What needs to be known to decide?

Timeline

Guiding Constraints:

- IC Complete by January
- EV Complete by March
- Optimal manufacturing window: Sept - Dec, begin end of August.

Deadlines:

- **August 31st**
  - CAD & CFD for "Ideal" Aero Package - Both cars
  - Identify components that can be manufactured effective immediately
- **September 31st**
  - CAD & CFD for "Optimal" Aero Package - Both cars
  - Ensure manufacturing timeline is acceptable by both composites and aero
- **January (31st?)**
  - IC Aero Package Manufactured and Assembled
- **March (31st?)**
  - EV Aero Package Manufactured and Assembled

*Note: These are tentative deadlines subject to change with team timeline and feasibility.

Projects:

Fix Failures

- EV FW Mounting
- EV Undertray Mount
- Height adjustment for FW

System Integration

- EV DRS
- CoP/Max Cl Adjustment

Flow Complexity

- Undertray Strakes
- Whiskers
- Louvers
- Take Data from Comp to use in CFD after comp
- Vortex Generators

Other

- Swan Neck

Burning Questions:

1. What energy/lap loss from drag is achievable with DRS?
2. What are the drag and downforce coefficients from the testing data?
3. What is our maximum cornering speed? (Relating to DRS, maybe make it TPS and speed based)

G-G V Circles: Use for Comparison

THE PERFORMANCE ENVELOPE OR G-G-V DIAGRAM | Subsystems to optimise racecar performance

KS7E Evaluation

Sunday, September 29, 2024 11:47 AM

Prime Aerodynamic Goals
- Increase grip (Outweigh weight and drag gain)

Execution Goals
- Validate all changes
- Tunable
- Stiff & enduring
- Work concurrently with suspension

Goal	Reached?	Notes
Increase Grip	Unknown	- No shockpot/loadcell data - Have flow vis data - Lap time comparison (Not good because suspension is set for aero)
Stiff & Enduring	Unknown	- FW has validation - RW no validation
Validate All Changes	No	- Not all validation has been completed
Stiff & Enduring	No	- Bonding manufacturing techniques

To-Do
- [ ] Shockpot/LoadCell Data, update simulation
- [ ] RW Stiffness Testing
- [ ] UT Stiffness Testing
- [ ] Learn, Design. And Layout Manufacturing Plan
- [ ]

List of Validation Techniques
- Flow Vis
- Dial Gauge (Deflection)
- Load Cell

What does Seth need to figure out/understand fully?
- Composite structure manufacturing steps
- Simulation setup/results/shortcomings/verification

General Knowledge/Training

Saturday, May 11, 2024 10:55 AM

Section Contents:

1. Resources
2. Training Information
3. Standardized Documentation

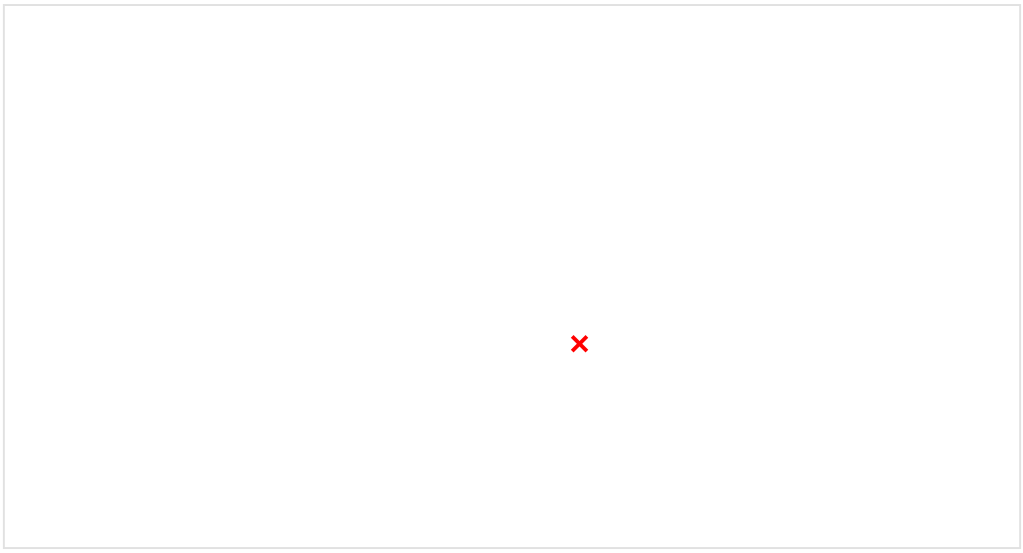
Suspension & Aero

Friday, July 12, 2024 12:28 PM

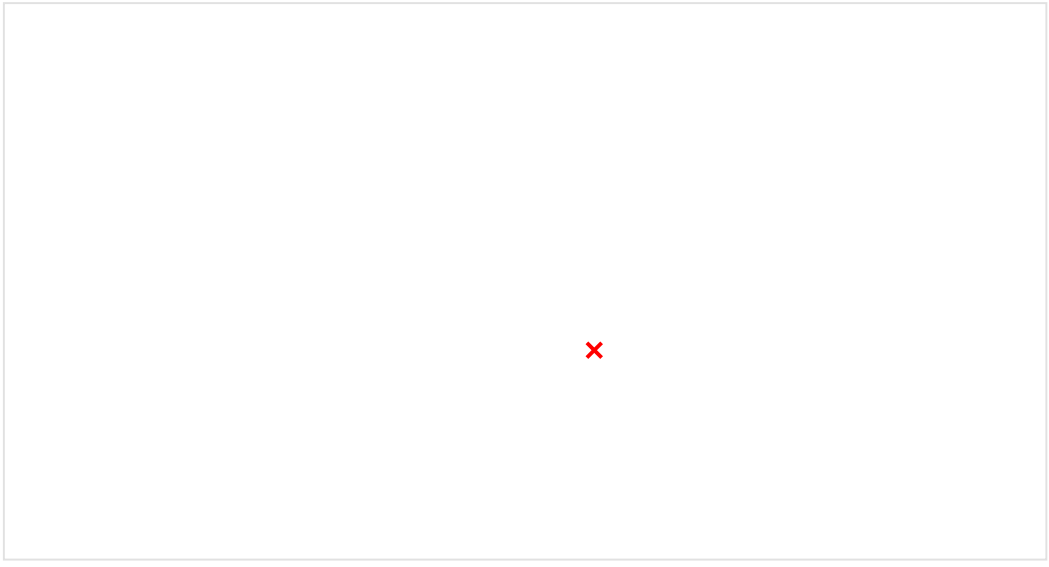
JFK Aero Notes

Suspension and Aero Interactions

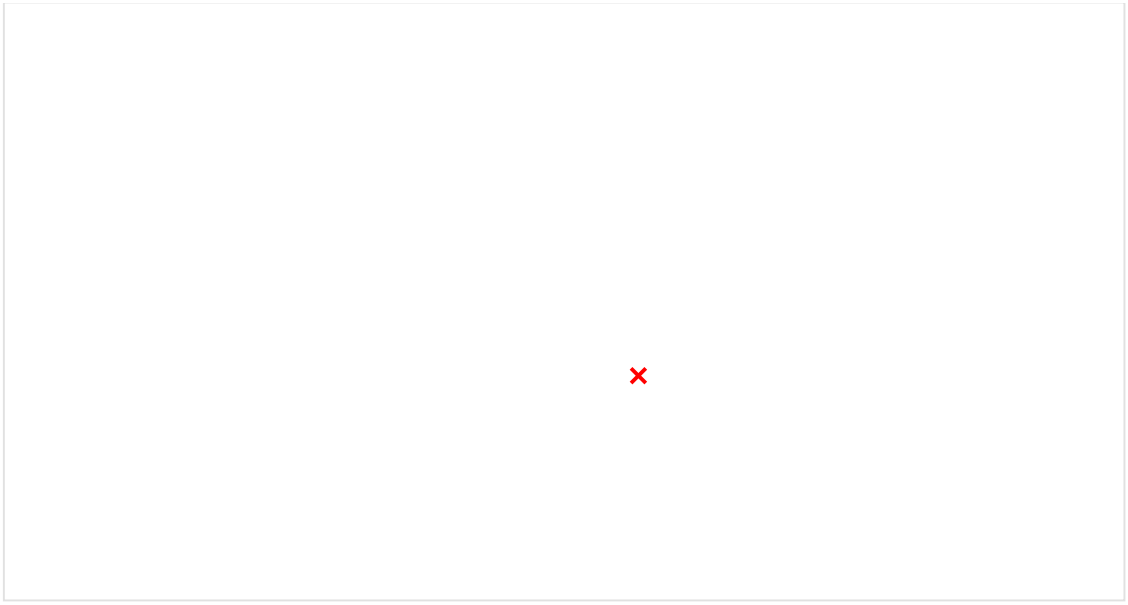
The Aero Map



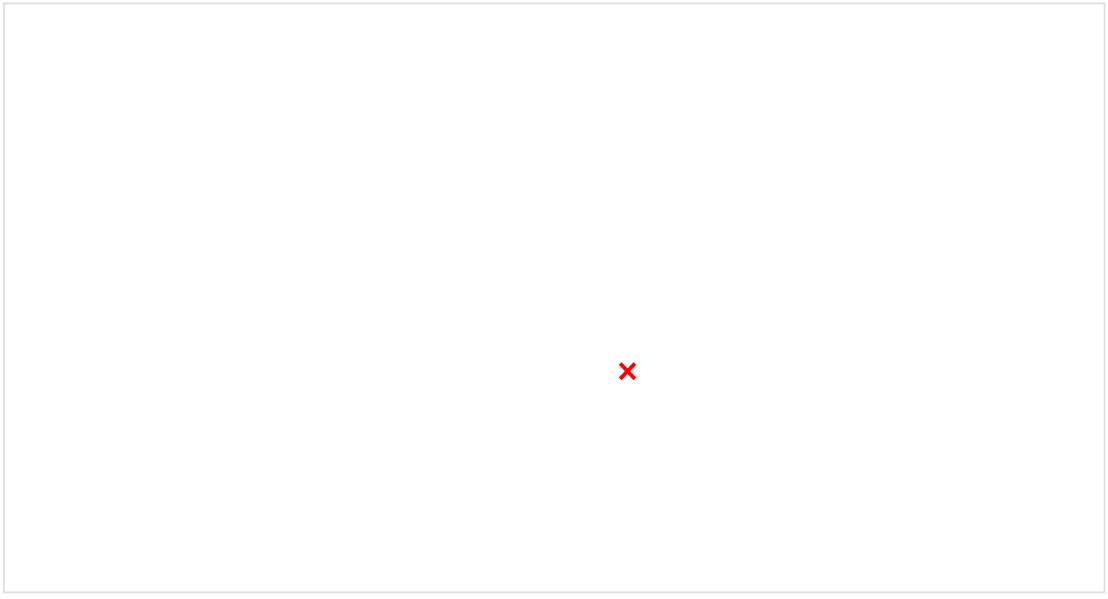
- ^ Rear Ride Height (RRH) and FRH plot vs SCZF (Frontal Area * Lift Coefficient) (ACl)



- ^ Same for SCZR (Rear Downforce Coefficient * Frontal Area)



- ^ Percent Aero balance



- ^ Axle Limited Aero Map. Based on front and rear ride height and their respective downforce, you can plot the most optimal combination with the logic that if you have a lot of Cl on your front axle and none on your rear, then you are limited by the rear and that is your peak Cl.
  - Are the colors total Cl?

The Drag Map

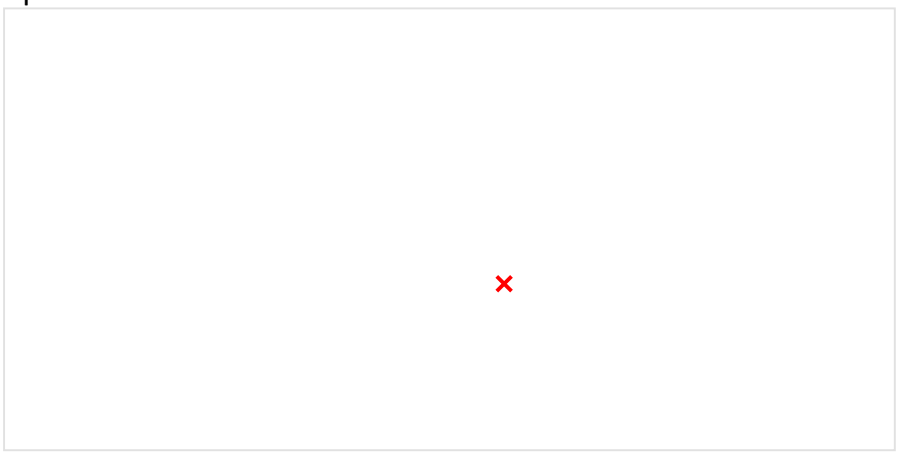
What is a drag map?

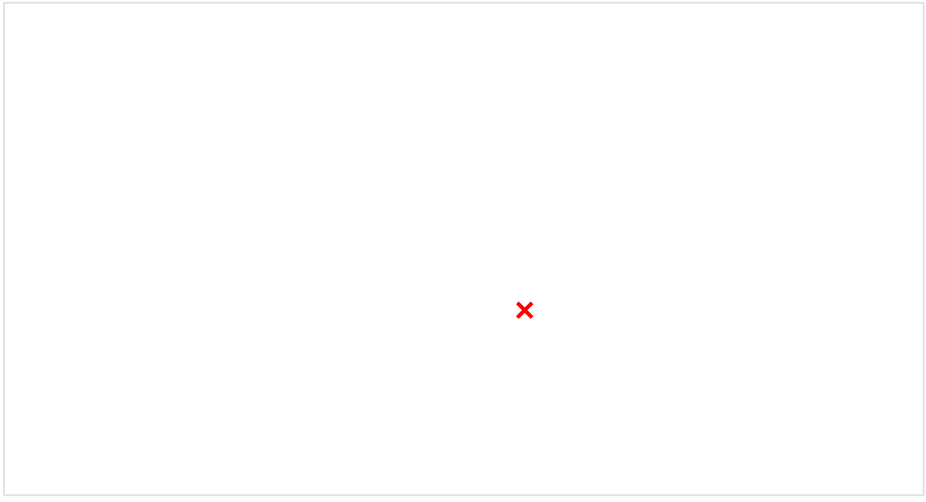
How to Estimate Drag Level and Targets

- Only reasonable method: Lap time simulation with

OptimumLap

- Ask these questions: What track are we running? What are the power characteristics?
  - With a drag, downforce vs lap time map, we can determine what combinations our car makes is most optimal for that track.

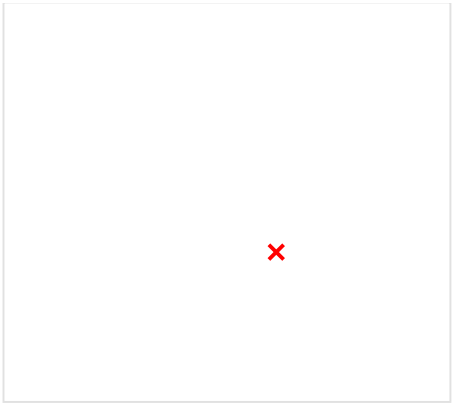




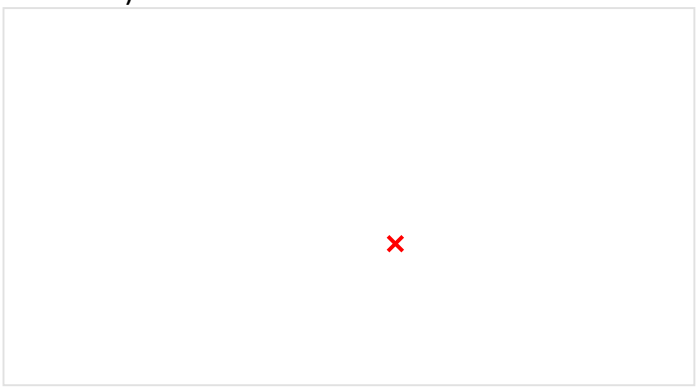
- Lap time is a function of downforce and drag. Unfortunately when df goes up so does drag.

Aero v. Mech Grip

- Front or rear axle usually slips first, product of balance.
- There is a limit to tire grip, so more force may not be better. Find the max grip of the tire.



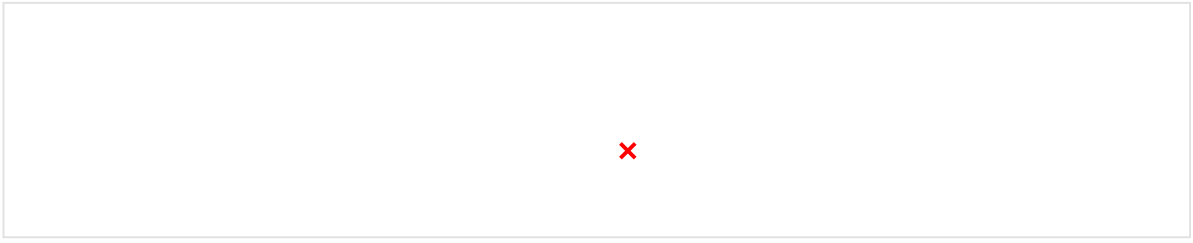
- If you have load variation (bumps that are not damped well from mech grip) then you will have overall less grip (if in bad part of the curve above^)



  - This comes from stiff springs (like with Aero cars)
- More stiffness on front, front has less grip and vice versa

Aero Balance

- Generally, you want to match CoP with CoM.



Suspension Design & Integration w/ Aero

- You want your suspension to "stiffen" as you increase aero load
  - This is done by changing geometry of pushrod, bell crank, and spring/dampers
  - Aka motion ratio
- You can also have different motion ratios front and rear to produce different roll stiffnesses to account for Aero imbalance
  - For example, if you wish to have more understeer at high

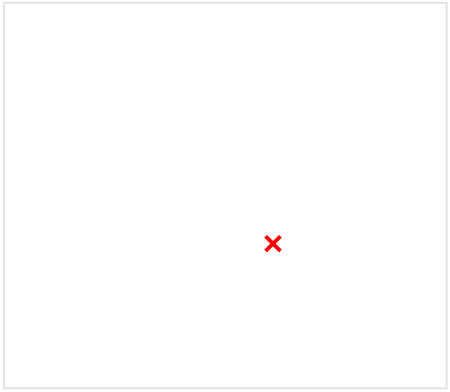
speeds, the motion ratio of the bellcranks can favor more stiffness up front at a certain speed to introduce loss of front end grip.

Ride Control & Aero Effects (Suspension design & tuning)

- Role stiffness vs. heave stiffness compromise:
  -

Cornering Phases & Aerodynamic Effects

- 3 Phases: Entry, Mid, & Exit
  - Entry: Negative crosswind (in to out), front ride height lower, rear ride height higher.
    - Driver does not want loose end, so *some* rear df is needed
  - Mid: Negative or positive crosswind depending on corner radius (tighter is more negative),
    - KEY: want to have even distribution of Aero to maximize grip.
    - Yaw angle should be a heavy consideration
  - Exit: Weight transfer shifts rearwards, front rises, loss in total grip of rear due to multiple tire load directions (lateral and accel)
    - You can design to have your peak rear df to be under exit accel.



    - DO NOT have your rear df acting BEHIND the rear axle since it will cause front axle to lose load (Like a cantilever)
      - Must be on or ahead of rear axle

Key Learning

- Aero and mechanical grip is constant compromise (mech grip at low speed and aero grip at high speed)
- Drag targets are important, and they should be simulated. Figure out where you want to sit for drag and downforce
- Aero development is a constant feedback loop from sensors and adjusting suspension

CFD

Wednesday, July 10, 2024 6:21 PM

Chris Penny Stuff

Question Detail (siemens.com)

Student competition team content (siemens.com)

Star CCM+ Stuff

POD License: Simcenter STAR-CCM+ - Licensing options and setup, installation, and troubleshooting (siemens.com)

Quantity	What It Represents	Example Location in Flow	Interpretation / What It Tells You
Velocity (v)	Flow speed and direction	Flow approaching the front wing	Shows how fast and in which direction air moves; helps identify flow acceleration or separation regions
Pressure (Static)	Fluid force per area at a point	Pressure on car's nose or diffuser surface	High pressure = stagnation or compression; low pressure = suction; relates to lift/downforce or drag
Total Pressure	Sum of static + dynamic pressure	Just upstream of the front wing	Shows total energy in the flow; used to identify losses or recovery zones
Dynamic Pressure (q)	Kinetic energy density of the flow	Free-stream region ahead of the car	Relates directly to aerodynamic forces; higher q → higher potential downforce or drag
Vorticity (ω)	Local rotation rate of fluid parcels	Wake behind rotating wheels	Shows where flow spins strongly; can indicate turbulent shear layers or tip vortices
Q-Criterion	Balance of rotation vs strain, indicating vortices	Vortex core behind rear wing or diffuser edges	Highlights coherent vortices; helps identify vortex tubes causing downforce or drag
Turbulent Kinetic Energy (TKE, kk)	Energy in turbulent velocity fluctuations	Turbulent wake behind tires or diffuser	Shows intensity of turbulence; high TKE means chaotic, mixing flow affecting drag and noise
Turbulent Dissipation Rate (ε)	Rate turbulence energy converts to heat	Near boundary layer on the car body	Indicates scale of turbulence decay; helps model energy loss at small scales
Pressure Coefficient (Cp or C_p)	Pressure normalized by freestream dynamic pressure	Pressure distribution on the front wing surface	Shows relative pressure changes driving lift/downforce; negative CpC_p = suction
Reynolds Stress Components	Momentum transport due to turbulence fluctuations	Inside separated flow region behind the car	Measures turbulent momentum transfer, influencing drag and flow stability
Strain Rate Tensor (SS)	Rate of deformation of fluid elements	Near sharp edges or diffuser walls	Shows how flow stretches or compresses, important for viscous effects and turbulence generation
Helicity	Alignment of velocity and vorticity	Twisting vortex shed from wingtip	Identifies helical (twisted) vortices; related to vortex stability and persistence

Post Processing

https://www.racetechmag.com/2019/02/willem-toet-explains-cfd-post-processing/

https://www.racetechmag.com/2019/02/willem-toet-explains-cfd-post-processing-part-2/

https://www.racetechmag.com/2019/02/willem-toet-explains-cfd-post-processing-part-3/

Pizza tracker lookin ass
Seth cookin

Simulation Setups

The y-plus (y+) value and its importance for mesh generation (cfd.university)

Resources

Sunday, April 14, 2024 11:39 AM

General

1. *Low Speed Aerodynamics: From Wing Theory to Panel Methods.* Katz J. & Plotkin. A.
2. https://www.designjudges.com/articles/adding-aero-justifying-aero
   a. Basics considerations of designing an aero package. Incremental steps is key. Predicting, Testing and iterating is very important.
3. https://www.designjudges.com/articles/aero-placement-and-mounting
   a. Mounting basics
4. Adding Aero, Justifying Aero — DesignJudges.com
5. If I judge you one day | OptimumG

Dr. Sucosky
Advanced CFD and Heat Transfer

Diffusers

1. Ehirim, O. & Knowles, Kevin & Saddington, Alistair. (2018). A Review of Ground-Effect Diffuser Aerodynamics. Journal of Fluids Engineering. 141. 020801. 10.1115/1.4040501. Ground-effectDiffuserReview_r2.pdf
2. Sovran, G. and Klomp, E. D., 1967, "Experimentally Determined Optimum Geometries for Rectilinear Diffusers with Rectangular Conical or Annular Cross-section", Fluid Mechanics of Internal Flow, ed. by G. Sovran, Elsevier, Amsterdam, pp. 270–319.
3. Ruhrmann A. and Zhang X., 2003, "Influence of Diffuser Angle on a Bluff Body in Ground Effect", ASME Journal of Fluids Engineering, 125(2), pp. 332–338 experimentally-determined-optimum-geometries-for-rectilinear-diffussers-with-rectangular-conical-or-annular-cross-section.pdf

Testing

1. https://www.mathworks.com/help/sldo/ug/estimate-vehicle-drag-coefficients-by-coast-down-testing.html

CFD

1. STAR-CCM+ 2d wing build, mesh, run, validation, and automation
2. Star CCM+ 2D airfoil Simulation Tutorial
3. Y+ Value : https://resources.system-analysis.cadence.com/blog/msa2023-y-boundary-layer-thickness

High Nose

1. Enhancing formula student car performance: Nose shape optimization via adjoint method - ScienceDirect

Getting Daq Data - MCAP/Foxglove

Tuesday, July 9, 2024 4:31 PM

MCAP: Has data and decoding stuff all in one place

Git Hub: [GitHub - KSU-MS/KS5e-Data-Logging: Loggin for the ks5e. Based on logging code by Hytech Racing]

Aero Box Contents

Wednesday, September 11, 2024 00:54

4mm Allen Key
2 x 3/8 Wrench

Hardware

FW

Pitch/Dia.	Qty.	Length	Drive	Notes
10-32	8	3/4"	4mm Allen, 7/16" Nut	DT

RW

Pitch/Dia.	Qty.	Length	Drive	Notes
1/4-20	16	3/4"	4mm	
Washer	16			ID - 1/4" OD - 1"
10-32	6	3/4"	3/8"	DT

Testing Days

Monday, March 24, 2025 8:07 PM

Clutch cable broke, no running tonight
Note on what happened will be in IC car log

03/26/2024 - Shakedown/Aero First Run

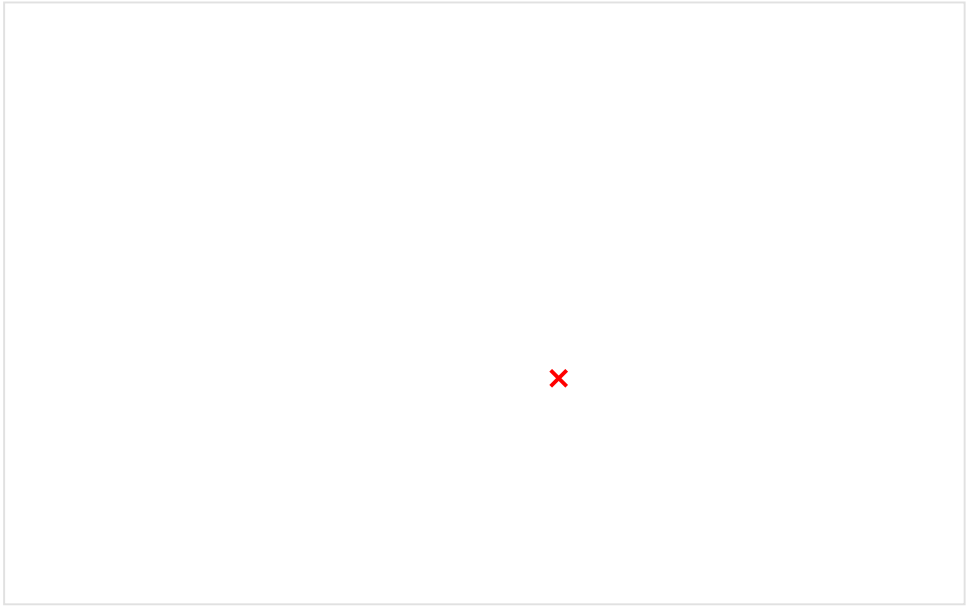
Monday, March 24, 2025 8:08 PM

Temp Testing

- Idea is to track temperature rise in intervals so we can plot and see a maximum.
    - Since we wont be going hard, we may not get to max temp, so we will note that in our "report"
- Talk to Sam, Carter, and the Driver to find out the intervals in when you can take temps with the temp gun
- Use the temp sticker as well to corroborate

Temp Chart

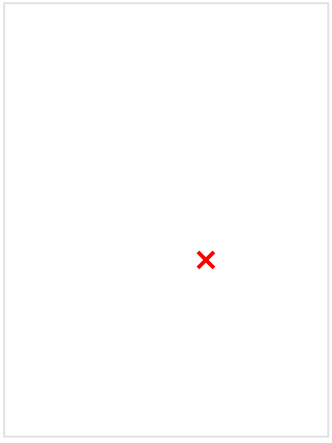
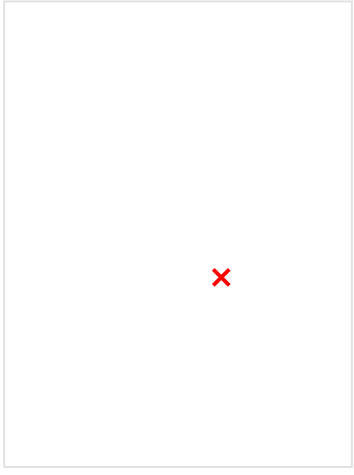
Due to other issues we didn't get as many laps in as we wanted.

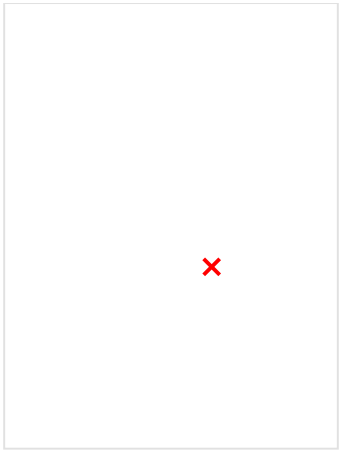


First record was initial heat after driving to the lot. Second temp was taken after 3 laps. Third temp was taken after another 6 laps. Last temp was taken after another 6 laps. The sticker on the side panel closest to the driver only activated at the very end but this validated the results we saw from the temp gun.

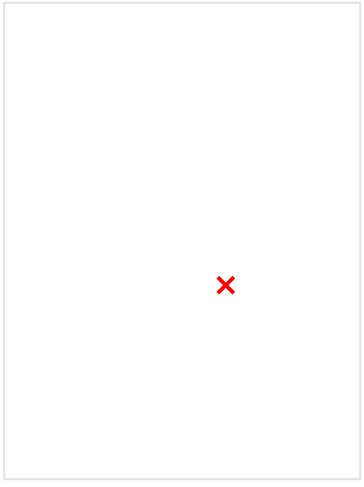
Other than the temps, the aero package seemed solid. Rear wing was incredibly stiff although slightly slanted due to inconsistent strut lengths (personal error in setting it up). Front wing experienced a lot of deflection during turns but not enough to scrape, just needs the tension cables on.

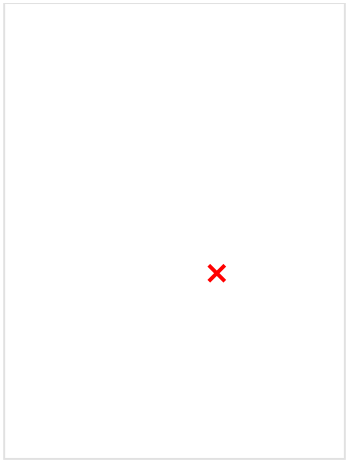
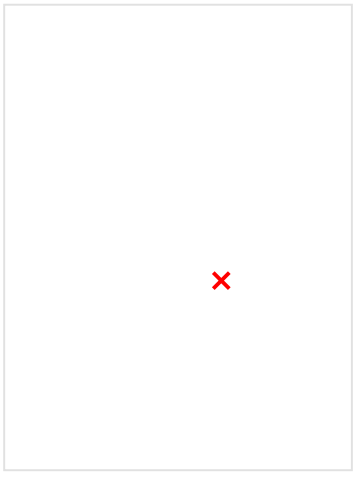
Pictures of the position of temp stickers before running the car relative with the exhaust

- 
- 
- 

- 
- 
- These pictures represents the 5 spots we monitored the temperature/ any change to sticker during test

After testing, these are pictures of temperature stickers

- 

- 
- 
- There were no changes to any of the temperature stickers, highest temperature recorded during entirety of testing was 140° F

Validation

Saturday, November 2, 2024 12:30 PM

Validation Priorities

1. Cl, Cd, & CoP Steady State
    a. Shock Pot Steady State
    b. Pressure Tap Steady State
    c. Energy consumption
2. Lateral G
    a. Radii Sweep GG Circle (Get projections)
3. Lap Time
    a. All events on/off
    b. Flow visualization over endurance
    c. Endurance energy consumption
4. Flap Position Sweep
    a. Steady State & GG for Cl, Cd, & CoP values
    b. Dynamic for energy consumption/temperature effect & driver feel

Shows CFD accuracy

Shows performance change

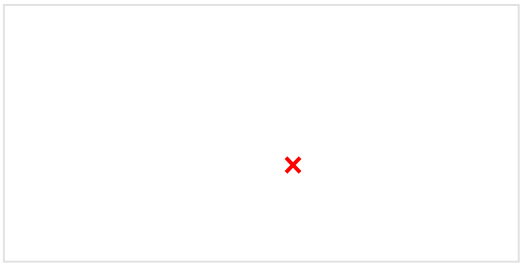
Shows efficiency points loss, temperature effect

Are there any other parameters that I want to test?

With the listed parameters, we validate the accuracy of our CFD through comparing Cl, Cd, CoP, and Flow Visualization, validate the performance envelope change between aero on and off through a GG circle and pure lap time comparison, and validate the energy consumption projections through steady state and dynamic tests. These tests will tell us if the aero we designed is accurate and if it provides a net benefit to the car. Results of the tests will provide sufficient data to make informed alterations to the car's setup, e.g. changing spring stiffness and flap angles.

Weight

Sunday, May 4, 2025 9:24 AM



These weights are with all mounting and hardware attached.

7E Flow Visualization

Saturday, November 2, 2024 12:30 PM

Barnesville. Nov. 2024

Overview

- Compared Flap 3 AoA Flow Separation
- Investigated Yaw Effects on FW & RW

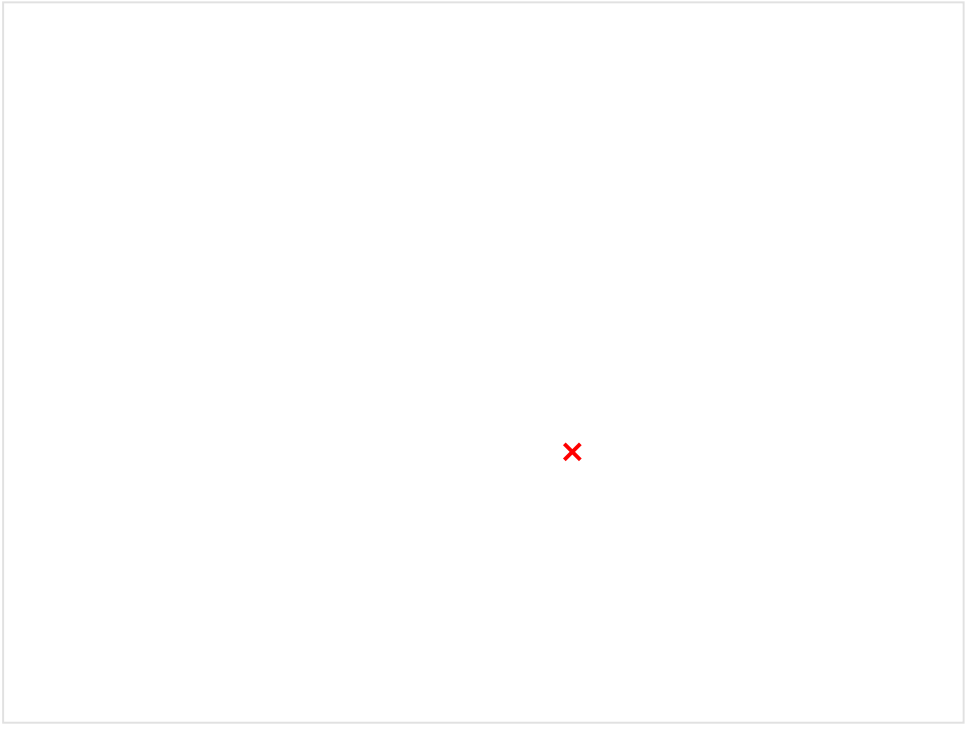
Flap 3 Separation

- One run with flap in one position above bottom
- One run with flap in bottom position

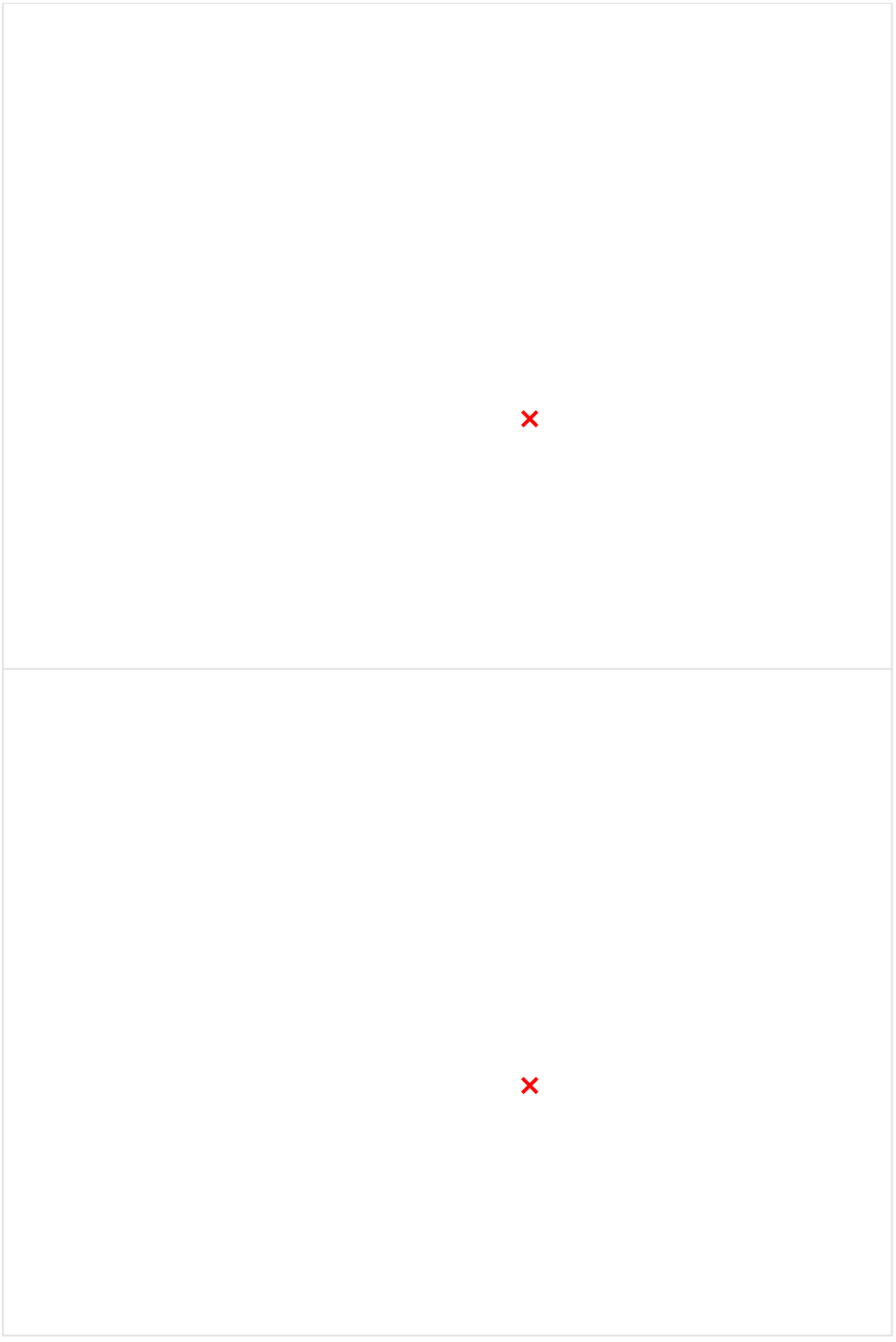
Findings

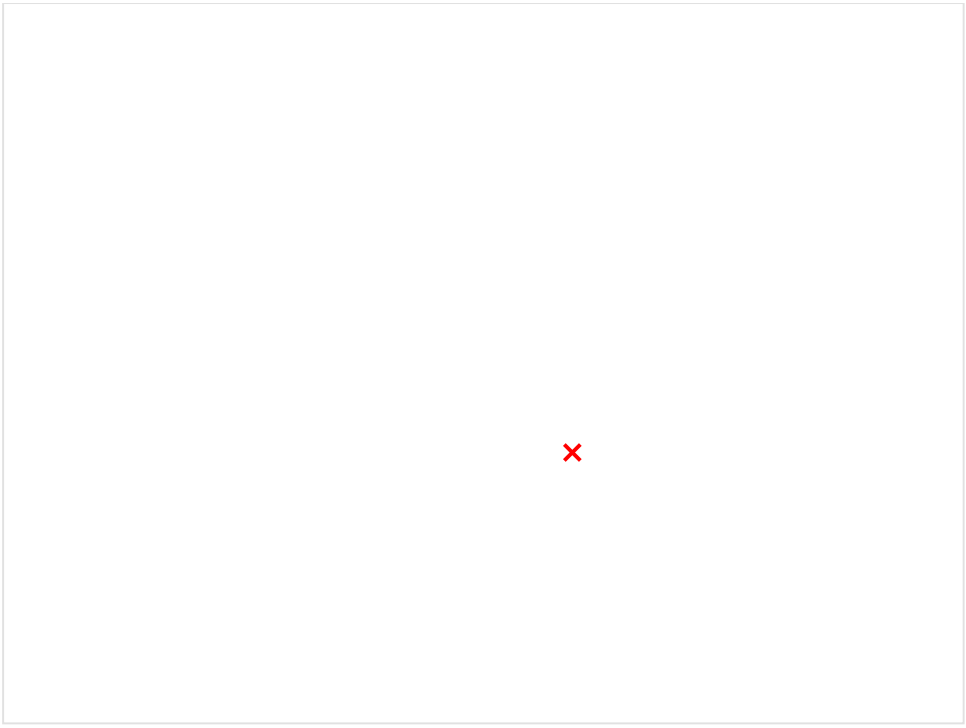
- Flow separated less in the lower AoA position (Position 2)
  - Still had some flow separation
- Flow separation significantly greater.

Flap 1 in 2nd Position



Flap 1 in 1st Position (High DF)



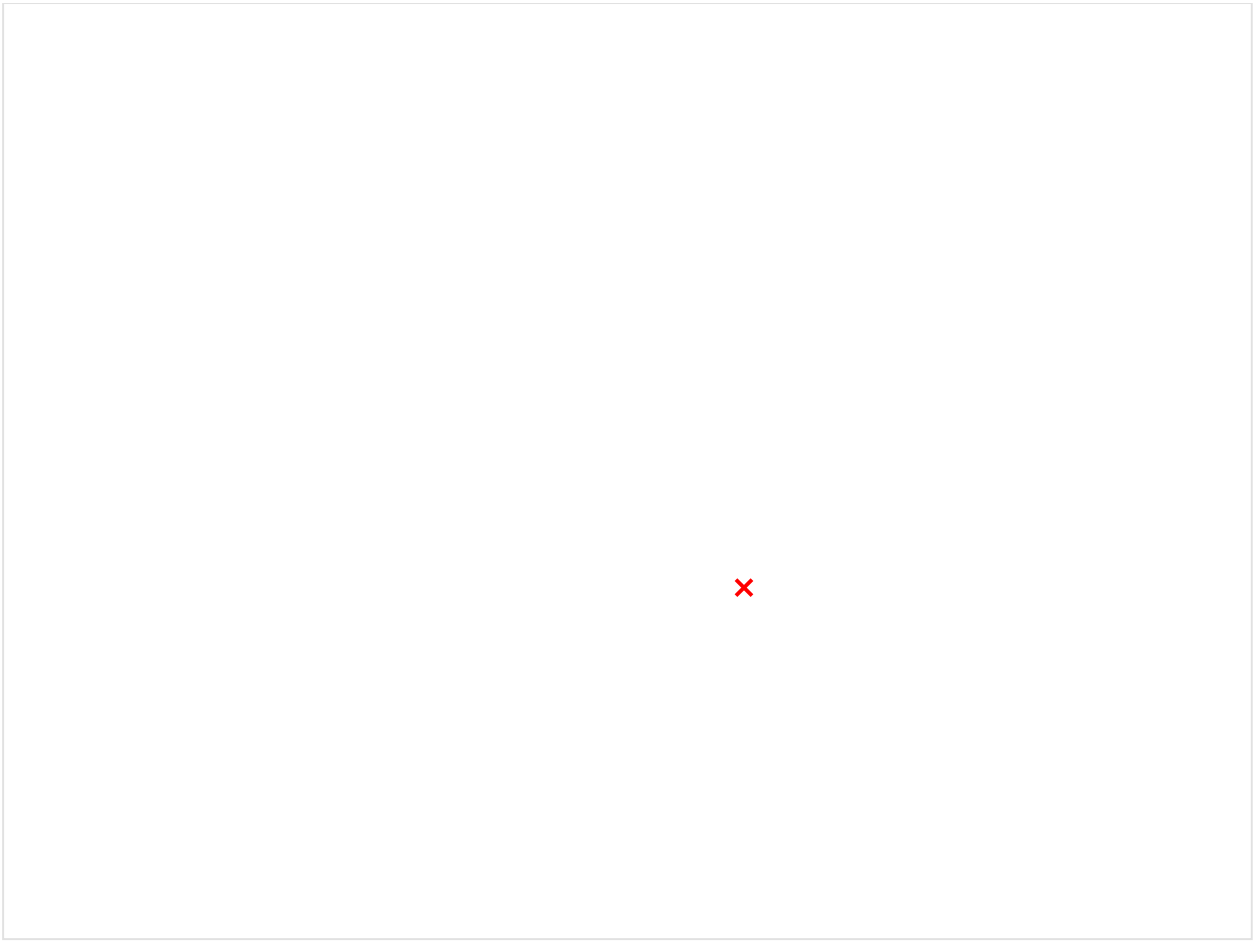


Yaw Effects

- Multiple runs with Flow Vis on FW & RW
  - Track is left turn heavy

Findings

- Uniform direction across wing
  - Could be due mostly to inertial forces
  - Inner side had less sideways flow than outer side



Steady State CFD

Thursday, May 22, 2025 11:15 AM

Teams: Steady State Sim Validation

Results:

- Speed:
- Average Downforce:
- Average Drag:
- CoP Location:
- Average Cl:
- Average Cd:
- Frontal Area:

IC Comp

Thursday, April 24, 2025 8:29 PM

Competition Goals

- First timers present findings on other cars

Debrief - IC

Saturday, May 17, 2025 08:01

Problems

- Left FW inner EP de-bond
- UT mounts de-bond
- FW INNER EP too close to tire!! Damage to FW and contact with body on right side
- UT front scraped, cut about 3/4” to raise clearance
- RW struts added a two nuts to two rod ends to make
- FW Bottom, holes in Kevlar center piece

Design Feedback

- "Maximize" and "Improve" is not good enough
  - Need to know end goal, then can find many pathways to meet it
- Validation (Downforce/Drag/CoP numbers) are king
- Car designer, not subsystem designer
- Must pass high level 1 questions to be able to get to nitty gritty
- Speak on overall car design instead of subsystem
- Any decision is okay as long as its justified and other decisions are evaluated
- **It is okay to not have enough time, as long as it's evaluated/planned beforehand**

Design Open-House

Skitter

- Can you confirm there is no traction limitation in accel?
- EFI Histogram: Shows we are using max TPS in our peak power range, this does not show that we are grip limited, there needs to be another way.
- Do individual points sweeps of drag, downforce, mass, energy consumed, mu, and power. Add them together to see the net change with aero on. (**This can decide your aero target ranges from a point mass)**
  - **Make a summary table**
- Show cost of performance and make a summary table.
- **TARGET RANGES ARE A MUST.**
  - Example: "We need to reach a Cl between 2-2.5 to put us in the performance window for a points gain of x and a placement of y, meeting this year's car goal.

Design Finalist Presentation

- Highest Score: Completed the circle on all of their components
- SHOW YOUR WORK
- High system synthesis results in good score.

KEY TAKEAWAYS:

1. **Honest, thorough design wins**
2. **Have specific goals that tie in well to car goals**
3. **Complete the loop on every component**

Have reasoning for re-using the package, and not building a new one.

- New acc tradeoff, available resources, history with manufacturing timeline

Packing List

Tuesday, May 6, 2025 8:48 PM

Aero

- Safety wire
- Safety wire pliers
- 3/8 & ¼ Ratchet/Wrench (RW Mount)
- 3/8 Ratchet & 4
- 4.0 mm L shaped allen (Panhead Fasteners)
- 4.5 mm L shaped allen (FW mount to chassis and carbon)
- Extra nylon countersunk 10-32 fasteners (FW endplates)
- Extra ¼-28 panhead fasteners (RW endplates)
- Extra Nylon ¼-20 fasteners (FW mounts to chassis)
- Flat Head Screwdriver (FW countersunk screws)
- Extra pushbuttons
- Dremel with dremel things
- 5 minute epoxy
- Rubber endplate trim
- E-60 HP adhesive and adhesive applicator
- Tension Cable
- Turnbuckle Set
- Thimbles

Tools

- Power Ratchet
- 7/16" Socket or Wrench
- 3/8" Socket or Wrench
- 5/16" Socket or Wrench
- 1/4" Socket or Wrench
- 4mm L-Shape Allen
- 1/8" Allen (L-Shape or Socket or T)

Fasteners

- 10-32,

Design Event Prep

Thursday, April 24, 2025 5:17 PM

Rules Conformity

Monday, April 14, 2025 11:00 AM

- FW Mount *barely* in forwards aero box
  - **When chassis powder coated, route more of the mount holes out**
  - **Tape 3mm radius to forward facing edge**
- RW Fits with old mount, bad AoA, and questionable in Accel mode
  - **New mount was not sized correctly in CAD**
  - **youtResize IRL/CAD and re-cut on wednesday**
- UT Needs more copper tape up front
  - **Finish copper tape on the UT**

Problems

Front Wing
- Wing Tab (Rear right) cannot be fastened to anymore
- Wing is outside forward aero box
- Leading edge radius questionable

Rear Wing
- Swan neck mount is too long, rear aero box not met

Undertray
- Copper tape does not cover complete area around accumulator

Root Cause Analysis

Front Wing
- Large hole in chassis side mount (fangs) paired with small diameter nut and high torque deformed the tab
- Elasticity of FW mount jig allowed enough movement forward to put FW out of aero box when aligning jig

Rear Wing
- CAD/IRL Discrepancy

- Swan neck was made correctly *according to CAD*

Solutions

Front Wing
1. Drill holes below current location on rear tabs of wing
2. Aluminum sleeve around broken tab and re-drill

1. Route chassis side holes out by 1cm more

Rear Wing
- Re-evaluate IRL wing position using chassis nodes and compare to CAD

Re-Evaluation
- Root cause most likely from chassis accuracy and **REAR TIRE PLANE CAD LOCATION**
  - **I suggest we re-evaluate aero box location references in CAD**

Solution
- Move RW forward 4.5 to meet ~0.5" margin as specified by shortening swan neck
- Rotate swan neck 2.5 deg. Downwards to meet angle of attack specification
- Struts set a bit higher than half of its adjustability (~3/4") to account for forward movement. Expect to have to shorten strut length with new swan neck
- Current height is about 118 w/o full acc weight and w/o corner balance. Have just over half an inch to play with, but will have adjustability with strut.

FW Solution #1 Pro/Con

Pro	Con
Fast Solution, no need for manufacturing time or material	Drilling may be difficult
	Holes across wing may not line up
	Possible not enough material
	Permanent change

FW Solution #2 Pro/Con

Pro	Con
Non-destructive, but permanent	Bond quality is unknown, but will be same procedure as all bonds this year
Good second option if first solution does not work	

EV Comp

Thursday, April 24, 2025 8:29 PM

Aero Ready Condition:

- [ ] Cross Brace Welded
- [x] UT Fully Taped
- [x] Strut Ring Terminals
  - [x] (Maybe) UT Ring Terminals
- [ ] Check Aero Box

Design Brief

- [ ] Aero Points Analysis Sweep
- [ ] Aero Cl/Cd/CoP Design Targets
  - [ ] Summary of CFD Projections
- [ ] Lap sim of AutoX &/or Endurance Track w/ Lateral G, Longitudinal G, Velocity
  - [ ] Energy Consumption Projection
- [ ] Bike Sim Lateral G projections
- [ ]

Prep

Tuesday, May 20, 2025 10:45 AM

Aero Readiness

FW

- [x] Re-bond Inner Endplates
- [ ] Position & Drill FW Mounts
  - Car needs to be on ground and level

RW

- [x] Inspect Rib bonding and structure integrity
- [ ] Install RW Mounts, Check Aero Box
- [ ] Weld cross brace

UT

- [ ] Install UT & Check Clearances
- [ ] Cut for jacking bar
- [ ] Trim stud length

HV Stuff

- [ ] Ring terminals for Strut
- [ ] Finish UT Tape

- Get good at UT removal

Preventing Testing:

- [ ] Car on ground with tires and weight
- [ ] Welding RW Mount Cross Brace
- [ ]

EV Design Brief

Wednesday, April 23, 2025 2:21 PM

What do I need to communicate?

1. Preview of team/sub-team goals, designs, and processes
2. Provide discussion points

Let's Re-design our Aero Pack for Design

Wednesday, April 23, 2025 2:21 PM

Basically, I want to congregate all of our knowledge and **add** new knowledge in the gaps that are present.

Goals:

1. Consolidate Data
2. Fill in Data Gaps

How have we justified the FIRST Aero package?

- We are grip limited
    - What data do we have on this?
    - In what conditions?
- Model Drag Budget based on power
- Model Effects of Energy
- Create Hypothetical Traction Envelope
- Possible Target Downforce with 400lb Springs

What are our targets with the FIRST aero package?

- Our increase in grip (minus increase in weight) needs to place us in Top 10 Dynamically
    - What amount of downforce with a prescribed amount of drag will produce this result?

I will start here, and then I would like to do the same for the development jump from 6 to 7.

Drag Budget

Friday, April 25, 2025 8:12 PM

Developing a drag budget:

Limitations:
1. Top Speed
2. Acceleration
3. Energy

Questions to answer:
1. When does drag force overcome powertrain power? (Top Speed)
2. Where is the inflection point for drag for a given downforce?
3. How does drag effect energy over a range?
4. What is our efficiency goal? Is there a minimum?
5. What is the inflection point of lap time points vs. efficiency points?
6. What maximum Cd will achieve our efficiency goal given the last endurance track?

^^These questions will answer whether or not our package was designed with a drag number within budget and if our IRL testing falls within the drag limitations

1. When does drag force overcome powertrain power? (Top Speed)

What do I need for this?

Speed vs. Power*drivetrain loss factor
Drag force curve converted to power

IC Design Brief

Friday, January 10, 2025 12:50 PM

Notes on the design presentation for the BC & BE

Needed:
- Cd, Cl, FA, and other aerodynamic metrics
- Justification of Aerodynamic package
- Proper attachment analysis
- Drag-reduction strategies

Looks like I need to:
- Explain what our package is, basic coefficients and metrics
- Explain what airfoils and why
- Explain why we chose to use all three elements

Notes from Design Meeting
- Get how much the car can roll/pitch before it's bad for aero
- Pretend that we developed the package this season
- Prepare re-directs away from topics that you haven't covered in the design.

Questions for Tonight's Meeting:
- We haven't analyzed airflow to coolers and brakes, is this an issue? It is a metric they judge.

CORE: Design, Build, Validation/Refinement, & Understanding

Show...

What you designed. 1st principles to CAD/Drawings

How you built it.

How you validated, how did you refine the package

Do you understand basic principles? Advanced principles? How does the vehicles design and the validation/refinement show this?

Design Presentation Should Have:
- Cl, Cd, CoP Targets
- Selection of airfoils
- Downforce vs. drag vs. mass validation
- Show components
  - Adjustability
- Flow lines to show FW/RW interaction, as well as UT/RW interaction
- CoP adjustment simulations
  - CoP Sensitivity to Yaw/Pitch/Roll
- Overall design philosophy

CFD
- Overview of Simulation tools, methods, models, accuracy, and design cases

Testing
- Track testing
  - Procedures
  - Equipment/Methodology
  - Flow-vis/Tufts

Mechanical
- Composite Manufacturing Techniques (Materials, finish, fasteners)
- Mounting methods, chassis loads, mounting design

Overview
- Either go with macro design selection or wit detailed design work

Important Info
- Don't completely lie, they will know.
- Know why everything was made
- Do not speak on what's wrong right off the bat, lead them through the process
- Be ready from random theoretical questions
- Negotiate why old drag justification was not good and how we changed that
- Need to know basic aero specs
- Energy Limit
  - Show new effect of EV Powertrain

Must Include
- Start with why you need aero
- Selection of targets to hit based on performance
- Air foil selections

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s Slides
erview
nits (Drag)
eady State Graphs, Stall Speed Graphs
sting/Validation

lers (Reference Nathan's Slides)
rview
Aero
Aero (Airfoil Selection)
simulation
ctures (Design & Testing)
or Energy Negotiation (Display the strongest)

Car Data

Sunday, March 23, 2025 9:43 AM

Tension Cable Weight

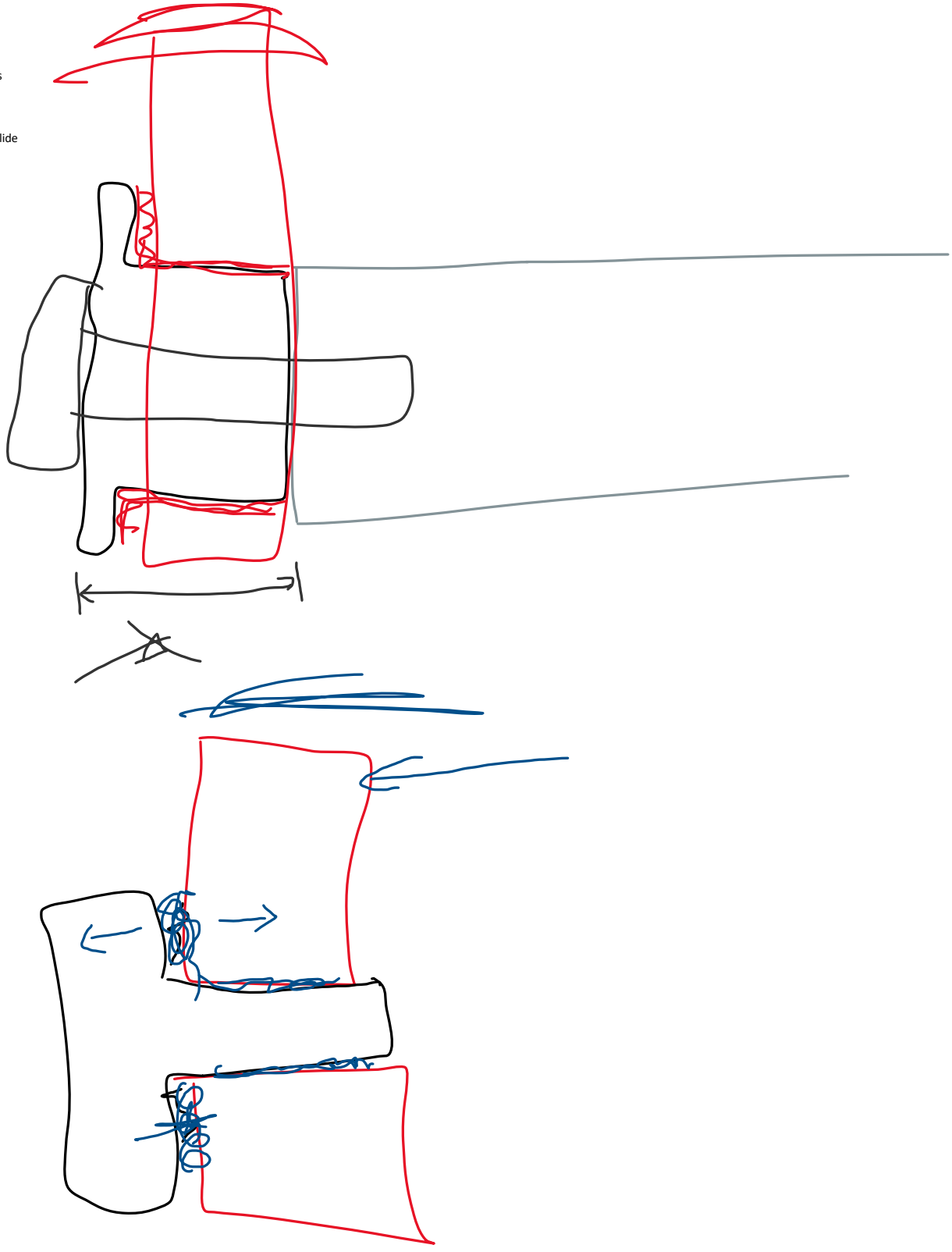
Name	Weight	QTY
Turnbuckle	0.11	2
Thimble	N/A	8
Compression Sleeve	N/A	8
Tension Cable	0.04	2
FW Tabs	0.01	2
Chassis Tabs	0.05	2
TOTAL		

Final Touches

Tuesday, March 18, 2025 8:00 PM

What do I need to add now?

- Fix any comments left by yourself and others
- New render of IC aero
- Put in ClA, CdA, & Planform area
- Add more photos to CFD simulation slide
- Add more photos to aero package decision slide



Meeting with Sammy

Monday, March 17, 2025 9:29 PM

- Show simulation philosophy
- Sims
    - What sims do we run, why
    - What are our capabilities
- Testing
    - What test will we do, and what conclusions will we draw from these?
- Add in overall justification &

Second Draft

Sunday, February 23, 2025 10:42 AM

Main Feedback:
- Tie to overall car goals
- Show cascading goal/project selection
- Show decision making process to current aero architecture

Brief Goal
1. Address all areas highlighted in template
    a. Design
    b. Build
    c. Testing/Validation/Refinement
    d. Understanding

    The brief should show how the aero package was designed (Points/Performance Analysis), how it is constructed (Hollow core method), how the package was tested and refined, and how much you understand about your goals and area.

Slide Outline
1. Overview
    a. Subgroup Goals
    b. Specifications
2. Design Methodology & Process
3. FW Rigidity & Flow Separation Reduction
4. Internal Wing Structures & Manufacturing Method
5. Testing
    a. Goals of testing
    b. Relevant Data
    c. CoP/AoA Refinement
6. CFD Refinement

Design Brief: What story am I telling?

The judges will look over this document and evaluate the level of the car based on its contents.

The judges want to see how overall goals were chosen, then how each subgroup has made that goal.

This year, we wanted to bang out the car quickly, and really get a lot of testing time to refine the platform we have. Aero did this by configuring an already made package to the new one, and making some changes that solved issues seen on the previous package. The goal of this year is to get plenty of data on the aero package to build a better understanding of how it may be tweaked for more performance in the following year.

Testing: What do we want out of it?

1. Cornering limit On/Off comparison, sweep circle radii to get different speeds
    a. Average speed comparison will verify performance of aero
    b. Shock pot data tells us downforce & subsequently tire force, used for CFD verification
        i. If yaw/roll sims available, can correlate and improve simulation accuracy
2. On/Off vs. Lap-time, Autocross
3. Autocross CoP Sweep, lap time & driver feedback comparison

Overview

Friday, January 10, 2025 12:52 PM

Slide Order

A. Overview
    a. Cl, Cd, Frontal Area, CoP
    b. Airfoil Type
    c. Weight
    d. Structure Type
    e. CoP Adjustability
B. Points Justification
    a. Lap time sweeps

C. Airfoil Selection
D. Simulation
    a. Iterations based on
        i. Velocity Sweeps
    b. Final Analysis
        i. Pitch
        ii. Roll
        iii. Yaw
E. Manufacturing
F. Testing & Validation
    a. Steady State Shock Pot Data
    b. GG Circle A/B Testing
    c. AutoX Flow Visualization

From John:

- Start from the beginning, why aero, and make your way down the line into what you have
- Look at overall car goals, and your goals, and see how they line up.

From Emil:

- Set goals, justify
- Make sure the numbers look good
- Close the loop
- Tangible values for your goals
- Biggest thing: Confidence, know what you're talking about, come up with clever answer

Bailey

- How we came up with this stuff

Nate (Joe) Meeting

Thursday, January 23, 2025 9:21 PM

Questions for Joe:

- What were the high level design goals and targets of the EV package?

John Meeting

Thursday, February 27, 2025 7:16 PM

- Post analysis of what aero would be optimal for the new pack
- Look at points wise where aero is going to contribute the most
- Is aero worth the weight, how much do we want, how much is useful, how much do we want from powertrains perspective

1. New pack capacity: Analysis of how aero could benefit the car with this pack
2. With new pack: Define where aero will contribute the most to points
3. How much downforce do we want & is useful?
    a. Point mass simulation sweep and tire characteristics
4. How much drag is acceptable?
    a. Acceleration, top speed
    b. Energy
5. Is aero worth the weight?

Post-design Analysis

Thursday, February 27, 2025 7:20 PM

1. How much downforce do we want & is useful?
   a. Point mass simulation sweep and tire characteristics
2. How much drag is acceptable?
   a. Acceleration, top speed
   b. Energy
3. Is aero worth the weight?
4. New pack capacity: Analysis of how aero could benefit the car with this pack
5. With new pack: Define where aero will contribute the most to points

Topic 1: Useful Downforce

- [ ] What is no aero lateral accel based on slip angle?
- [ ] What is max lateral acceleration available with tire?
- [ ] What force does aero need to produce to maximize tire grip?

How much downforce do we want?

- What does downforce do?
  - Increase Fz on tires to increase lateral acceleration and therefore cornering speed and decreased lap time
  - Tires will have a maximum slip angle, therefore maximum lateral acceleration. What is this?
- Based on theoretical max lateral acceleration, how much downforce should we add?
  - How does CoP and weight shift effect this? What percentage of force is placed onto one wheel? Is this at a critical time?
- Disregarding downforce, how much drag is too much drag?
  - Acceleration and top speed based
  - Efficiency based in endurance for EV

May be going too deep with this, perhaps start a bit higher level with just downforce lap sims.

IC Design Binder

Tuesday, April 29, 2025 3:34 PM

Summary of Previous Binders:

1. Aero Justification
    a. Accel Cd vs. time
    b. Skid pad Cl vs. time
    c. Accel mass vs. time
    d. Skid pad mass vs. time
    e. AutoX points vs. time
    f. Endurance points vs. time
    g. Drag Budget
        i. RPM vs. TPS Endurance
2. Aero Design Parameters
    a. CoP Hand Calculation based on sim data
    b. Spring Rate Calculation & Selection Process
    c. Ride height selection based on CoP straight line target
3. Design Development
    a. RW Airfoil Selection
    b. Speed sweep
    c. FW Ride Height Selection
    d. RW Ride Height Selection

4. Validation/Refinement

Nate Yap:

- Use Nate's aero justification as we never encountered an issue with original aeor justification
- Add a couple of preliminary analysis things to support Nate's aero desing targets
- Get the schpeal from nate about how he dsesigned the aero pack, know the ins and outs
    - This will be a lot
- Do as much testing as possible and make roadmaps to how you will test in the future
- Make plans for how you would re-design things if they are bad (UT mounts)

Quick Yap:

The thing I am struggling with most is the presentation of the aero package as it stands. I fail to answer the question "So tell me about your aero package" succinctly with sufficient data

- Lacking story & data

So, my primary task now should be to develop the story of our aero development and to tie it into what we did this iteration.

- **Need to be ready for all types of questions**
    - **Sim is a weakness**
- **Need to be ready to show how the goals have been progressed on the design brief.**

Session 1 Summary

- It is best to justify why taking aero off the car would be a bad idea
    - You need to know that from a points perspective, theoretically you should run aero.
- If possible, test the lap simulations with the car to see if you get the expected performance increase
- You need to develop a drag budget for the aero package. Maybe you can adjust the element location in order to hit this. Its all about making the car actually faster not bullshitting.
- You'll need to try to back up some of the original design justifications with some more car data, e.g. the TPS vs. RPM graph with something
- After you justify why, you need to understand the whole design process of this aero package
- You need to know how the simulation was set up and why it was done the way it was. What are some of the trade offs you have made? How have you updated the simulation with real data? Why have you not done wind tunnel testing and what are you missing out with that?

    High level:
        Begin with why -> move to how (design/manufacture) -> move to testing/validation

Conversation Tree Diagrams

Tuesday, May 6, 2025 2:45 PM

Need to have:

1. Main conversation pathway
2. Side conversation/knowledge checks
3. Data/work/plans on improvement

Nathan's Conversation

- Don't seem like the poor team that didn't do anything
- Don't straight up give them that you re-used a package
- Best way to start: List out your goals
  - 7E Goals:
- Mass Goal: 1.5 lb df/lb mass is break even point

EFI Histogram

1. Possibility of data is wrong
   i. Is the throttle actually lined up with the power/torque band
2. There are a couple points where you are full throttle
   i. Downforce is king, and optimizing two parameters will begin to give diminishing gains. It is an improvement, but its so small, and could be something in the future.

Stuff I did for flow separation

- Great opportunity to show that we COMPLETED THE LOOP

Added

General Conversation:

1. Aero Justification
   - Team & Aero Goals
     - Points Gain: Lap Sim
       - Cl v Time and Cl v Cd v Time Sweep
         - Show greater impact of downforce over drag
         - General 1/3 ratio of added drag with added downforce
       - Mass v Time
         - Downforce vs weight time impact
       - Cd v Time
     - Drag Tangent: Power limited, not grip limited
       - EFI Histogram
       - TPS vs. Torque Curve
         - Prove EFI thought pattern
2. Package Design
   - Rear Wing
     - Airfoil Selection
       - Trade Study
         - What we studied
         - General Findings
         - Why we chose and other options
   - Front Wing
     - Airfoil # And Geometry: Sim Sweep
       - Max downforce, RW Compatibility, CoP Target, Undertray Feed, & Roll Envelope
     - Pitch Sweep
       - Steady state ride height selection
   - Undertray
     - Inlet & Outlet Geometry
       - Swept areas until optimal
     - Ride Height
       - Swept but had to settle with 1.5" due to scraping
3. Build
   - Composites Selection
     - Weight Comparison
     - Stiffness Comparison
     - Ply Schedule Selection
       - Orientation
       - Number
   - Mold Style Selection
     - Foam Core Comparison
     - MDF Female Molds
       - Make & Layup Technique
     - 3D Printed Molds
   - Internal Structures
     - Hat-channel
       - Bending Calculation: Thickness & Geometry Selection
   - Mounting
     - Swan Neck
       - Reasoning: Serviceability, not for flow
       - Free Body Diagram
       - Hand Analysis, FEA Support
     - FW Mount
       - Designed for body removal
       - Testing/Validation: Problem Found
         - Tension Cable selection
4. Validation
   - Flow Visualization
     - Rear Wing Separation
       - Design Change
       - Change Validation
     - Simulation Comparison
       - Vortices
   - Skid-Pad Lateral G & Time
   - Manometer Readings & Sim Comparison

Items in Design Brief
What we want to do but couldn't before comp

Brief Questions

- "Why did you re-use the aero pack?"

Nate Mock Design

- Force into their mouths servicability and manufacturing time
- Need GG Circle prediciotn vs actual
- Validation/loop closing testing questions….

BS Questions

- What is your cell count
- Turbulence model

Lap sims -> package goals (high downforce) -> gives you rough archtiecture (Drag question will be here) -> how you actually designed it

Design Schpeal

- RW
  - Design this way because of this
  - Not efficient, but makes hella downforce
- FW
- UT

Build

- Composites
  - Weights
  - Ply schedules
  - Angle of plys
- Structures
  - Bending calcs
- Mounting
  - Talk about swan neck
    - Not for flow, its for serviceability
    - May also get flamed about flow
  - Talk about FW and cables
    - Why we did it
    - Loop back into design

Validation

- Flow vis
  - Rear wing flow separation

Fri. May 9. 2025 - Design Run-through

"Tell me about your aero package"

Our aero aimed to reduce autocross/endurance lap time to maximize downforce within the manufacturing constraints, as well as improve upon the previous design with better sensitivity to pitch, roll, and yaw.

We conducted lap simulations to analyze the effects of downforce, drag, and mass on lap time across all four dynamic events. We found there is a major sensitivity to downforce in lap time for autocross and endurance, and was greater than the effect of drag and mass.

Points analysis showed we would increase our autocross and endurance points by 8 and 7 respectively, placing us within the 80th percentile for the two events.

It was decided to ignore drag optimization for this aero package because it has a weaker effect than drag, and because our car has the power headroom to exceed drag effects during cornering.

An RPM vs. TPS % Histogram of a previous autocross run shows that we utilize a low throttle percentage for a majority of the run, only maxing it for about 5% of the run. This hints that we 1. Have headroom to overcome drag and 2. the we are grip limited in the corners. More grip means more throttle.

Questions about drag

Tue. May 13, 2025 - Design Run-through

Quang Presentation:

- [ ] FW: Show camber differences w/r to ground effect
- [ ] FW: Numbers for pitch movements
- [ ] Graph showing Cl & Cd constant across speed range 20-50
- [ ] FW: Loft front view
- [ ] What airfoil do we use for FW and for RW?

References Needed

- Lift equation
- Reynolds Number
- Simulation Types

Andrew/Morrison Mock Design Session:

- What were your manufacturing constraints?
  - Tools to timeline: We have tools only for a wet layup style mold. In order to reduce weig and improve surface finish, we opted to use a majority MDF female mold design. Ideally, would use a resin infusion or pre-preg style, but we don't have an autoclave or propper mold material for a pre-preg layup, and resin infusion has been unreliable with compress stability and bagging. These would be ideal for maintaining weight across all parts becau of better resin volume control.
- Why did we see diminishing returns after 4-5 elements?
  - Delta between added gaps: As you add more elements, each subsequent element gap g smaller, and so the air pressure follows the same path. Air pressure scales inversely proportional to inlet area in Bernoulli's equation, so as the area delta becomes smaller a smaller, the pressure gradient gains will follow linearly.
- How did you design or design around the pitch and roll of the car?
  - We started with establishing the pitch and roll envelopes, considering a buffer for uneve track conditions.
    - What were these envelopes
  - The FW height was initially set to a steady height that would most likely be pitch insensi It was swept here to meet the 45/55 CoP target.
  - A pitch sweep was conducted to the maximum pitch envelope and the CoP was verified be within acceptable movement tolerance
    - What was this CoP tolerance and why?
  - In considering this, the mainplane was designed to have 0 AoA and low camber to maxi the ground effect since there is less of a delta from LE to TE

After we had our RW selected we needed to balance out the CoP of the car, and to maxi we needed and UT and FW within manufacturing capabilities.

The FW and UT were designed and iterated in tandem to match the CoP target of 45/55 the FW there are a couple key points. The mainplane was designed first and optimized t ground effect on the FW. A low camber benzing airfoil was selected for this.

Final Push:

- Aero on car analysis
- Radiator airflow considerations
- Yaw simulation of 8C, maybe 6C

1. Aero justification
2. Design of RW, UT & FW
3. Validation that we saw and made improvements on
4. Structures design
5. Mounting design
6. Validation we wish to do in the future

What I said we would do in design brief:

- We used the BE aero molds to make the IC aero
- Increase the FW rigidity
  - I think this is pretty goooooood
- Increase RW flow attachment
  - I think this is pretty good too
- Develop full car yaw/roll sims
  - We lost full car simulation from the membership change, so we had to re make it
  - When we re-made it, we found that the design changes they made were in the correct direction and this is the percentage change with respect to yaw
- Refine simulation to be within 10%
  - From our pressure tap areas that we were able to achieve, we validated the simulation
  - The plan is to use shock pots
- The FW/RW transfer decision needs to be put into ppt
  - Need

a

The Story of Aero

Wednesday, April 30, 2025 10:48 AM

Request: "Tell me about your aero."

1. Explain what is exactly in front of them
    a. FW, RW, UT, Lofts in mainplane, side wings
    b. Hollow core structure with a custom c-channel spar
    c. Drag, downforce, CoP at specific condition
    d. Effect it has had on time for autox/endurance/skidpad

"Why did you decide to put aero on the car?"

- Theoretically, adding downforce was the greatest contributor to improving performance for our platform.
    - Back this up with data
    - Back the data up with testing
- The best avenue to achieve this goal was ____

"What are the parameters for the current aero's architecture?"

- Points analysis showed that we could improve the most in autox and endurance, so the parameters were set with this in mind, not skidpad and accel.
    - Show points analysis
- Because downforce directly correlated with points increase, the primary goal was to make as much downforce as possible
- Since downforce is accompanied by drag, we needed to understand how much drag was allowed before it became a limiting factor to performance. In other words, when did drag begin to turn the performance curve around?
    - Given set downforce values, show maximum drag before reverse points effect
    - In parallel, TPS vs. RPM endurance data shows that in most cases, we are not power limited, meaning we have headroom before we cannot overcome drag effects
        - Get other data to corroborate findings
    - Show data that compares engine power and drag power
- So, with this architecture we wanted to add as much downforce as possible without exceeding ___ amount of drag.

Justification: Points Analysis

- Why is AutoX and Endurance the most important?
    - I need to show the points gain per percentage time decrease with respect to the competition

Would it be good to say we didn't have justification for aero in the first place but comaprison this year shows that if we remove aero then we would be out of our performance target window?

The high level path that you will take the judge.

This year:

1. Explain primary goals to judge and why they are the primary goals
2. Explain the things that you did this year to meet those primary goals
3. Explain how each of those things were done and the choices behind them
4. Explain the validation of those goals

Past Years:

1. Aero justification: "Why do y'all have an Aero Package on the car?"
2. Architecture: What were the goals of the aero package
3. Design: What were the design decisions you went with and why did you go with them?
4. Testing: Did the designs actually do what you expected? How did they differ?

Nate Yap

Tuesday, April 29, 2025 6:58 PM

- 2% of time we are full throttle
- Not worth chasing the gains when we can max out the downforce and get very similar results
- **We are trading drag for downforce**
- We are 90% there to autoX
- How to get better drag: Tweak airfoil elements
- Maybe identify inflection point of drag
- Show why your car is the best with what you got
- Have understanding of why your car was built the way it was
- Some judges will have prejudices as to how you should be presenting
- Rando judge -> this is what we brought -> explain why this is the fastest car you can build
- They are evaluating your knowledge overall

Mock Design Pt. 1

Tuesday, April 29, 2025 7:57 PM

- Where are we actually grip limited
- Show multiple RPM vs. TPS graphs
- **Better justification for grip limitation**
- TPS graph does not show grip limitaiton, it shows that we are not power limited
- Don’t go over something that they explain
- "Stop me at any time to ask questions"
- Better analysis of why we are using EV aero on IC. Points and cost analysis
- Dissimilar materials in wing can cause different thermal expansion which is a risk.
- **Think of questions they will ask, make a flow chart of the conversations of each**

John Yap

Wednesday, April 30, 2025 20:00

- Can’t say we just want to
- What is our simulation tree?

EV Design Binder

Tuesday, May 6, 2025 2:46 PM

Refinement

1. What did we do this year and why?
2. What was the original design intent of the aero package?
    a. Think Cl, Cd, CoP because of Lat Accel because or time because of points. Analysis for each step
3. Re-evaluate what we can add or change after these two have been addressed

6/10/2025

Tuesday, June 10, 2025 3:57 PM

To finish up your design presentation, start with the data and work that you already have, then go back and try to get in order of priority design parameters that are important. If you cannot get the parameter, evaluate the reason why you can and understand the tradeoff. You should spend more energy in the present, for example devising how to collect data with the little testing time you have before competition.

List of Things I Worked on:

1. DRS
2. Flow Attachment
3. FW Mounting
4. RW Mounting

List of Test Data:

1. GG Circle On/Off Validation
2. AutoX Traction Circle Validation
3. Coast Down Data (Collect from last year)

Make meaningful conclusions from this data and how you may work around any problems

Efficiency

Tuesday, May 6, 2025 2:46 PM

Given:

- Total energy available to use
- Efficiency score target

Given the energy limit, what configuration gives more points given open configuration and closed configuration from time and efficiency score.

Calculate energy used for open and for closed, simulate lap time difference between open and closed, use percentage difference to calcualte

Problem: We slowed down because we did not have enough energy, thermal control, and the wing was scraping. The main limitation was the wing scraping. I cannot use past data because it has been influenced by this. I don't know if I can calculate the efficiency score using 2024 result data because the theoretical lap time is inaccurate to the score we placed.

I could set our target scores and see how much energy we can use based on the 2024 results and if that is possible given each aero configuration.

Based on the 2024 EV Results:

- To get an endurance score of 220 and an efficiency score of 30, we need to use 5.31 kWh (241 Wh/lap) and have an average time of 75.3 sec (or 1656.6 sec total)
- If we use the 266 Wh/km limit, we need to set an average lap time of 70.26 (1545.6 total) adjusted time, which is faster than the top position by 1.62 sec per lap (35.66 sec total).

8E_Aero_Analysis_2024CompPointsAnalysis.xlsx

Plot the curve of energy used vs lap time for 250 points

Identifying Traction Limitation

Tuesday, May 20, 2025 10:26 AM

I need to look at accelerometer data when the aero was off the car and see if it can be improved theoretically with aero. This should be easy for the KS6E data.

Points Analysis

Thursday, May 22, 2025 1:40 PM

Sweeps:

- Drag vs. time -> points
- Downforce vs. time -> points
- Mass vs. time -> points
- Energy Consumed vs. time -> points
- Mu vs. time -> points
- Power vs. time -> points

- [ ] Summarize point sweeps in a table
- [ ] Compare different net changes
- [ ] Identify limitations of analysis

^Find correlation between time and points over each sweep and convert^

- [ ] Accel
  - [ ] Cl
    - [x] Time
    - [ ] Long Accel
    - [ ] Speed
  - [ ] Cd
    - [x] Time
    - [ ] Long Accel
    - [ ] Speed
  - [ ] Mass
    - [x] Time
    - [ ] Long Accel
    - [ ] Speed
  - [ ] Power
    - [ ] Time
    - [ ] Long Accel
    - [ ] Speed
- [ ] Skid Pad
  - [ ] Cl
    - [ ] Time
    - [ ] Lat Accel
    - [ ] Speed
  - [ ] Cd
    - [ ] Time
    - [ ] Lat Accel
    - [ ] Speed
  - [ ] Mass
    - [ ] Time
    - [ ] Lat Accel
    - [ ] Speed
  - [ ] Power
    - [ ] Time
    - [ ] Lat Accel
    - [ ] Speed
- [ ] Auto
  - [ ] Cl
    - [ ] Time
    - [ ] Lat Accel
    - [ ] Long Accel
    - [ ] Speed
  - [ ] Cd
    - [ ] Time
    - [ ] Lat Accel
    - [ ] Long Accel
    - [ ] Speed
  - [ ] Mass
    - [ ] Time
    - [ ] Lat Accel
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    - [ ] Speed
  - [ ] Power
    - [ ] Time
    - [ ] Lat Accel
    - [ ] Long Accel
    - [ ] Speed
- [ ] Endurance
  - [ ] Cl
    - [ ] Time
    - [ ] Lat Accel
    - [ ] Long Accel
    - [ ] Speed
    - [ ] Energy Consumption
  - [ ] Cd
    - [ ] Time
    - [ ] Lat Accel
    - [ ] Long Accel
    - [ ] Speed
    - [ ] Energy Consumption
  - [ ] Mass
    - [ ] Time
    - [ ] Lat Accel
    - [ ] Long Accel
    - [ ] Speed
    - [ ] Energy Consumption
  - [ ] Power
    - [ ] Time
    - [ ] Lat Accel
    - [ ] Long Accel
    - [ ] Speed
    - [ ] Energy Consumption

Endurance 2024 Analysis

- 2.74 seconds/point

AutoX 2024 Analysis

- 0.166 seconds/point

Skid Pad Analysis

- 0.017 seconds/point

Acceleration 2024 Analysis

- 0.020 seconds/point

Efficiency:

I have the time difference and energy consumption difference between aero and no aero from optimum lap. I can use the same percent difference with the 2024's efficiency results and see what the efficiency points difference would be.

The assumptions here: The points difference has the same effect no matter where you placed in the field, so we can use the slower than expected time set in the 2024 EV Endurance.

What to look at next:

- Cost to the car, how many points lost in cost?
- Time aero takes to get put on
  - If we have project proposals, could compare time
- Check EV points difference
- Was difficult to get every subgroup to do a similar points analysis

The Schpeal

Thursday, June 5, 2025 6:50 PM

The primary goal this year is to place within the Top 10 overall, with additional goals of run time and reliability/serviceability.

In order to get a top 10 placement, it is necessary to at least maintain aero on the car, and improve it if possible. This was determined through points analysis with 2024 EV results and optimum lap point mass simulation. 25 Points is attributed to the current aero package.

A trade study for whole car changes that could increase probability of hitting the points targets revealed that a powertrain change would provide the most bang for the buck, and a new aero package was found to have a much higher ratio of investment to points.

Within aero, the option to add DRS was a prime choice to increase points with out detracting from manufacturing time or cost, contributing to the goal of overall testing time.

Regarding Design:

- Analysis on how aero improves lap time
  - Optimum lap KPI sweeps (Lat Accel, Avg Speed)
- What is max pitch, yaw, and roll
- How sensitive is the aero pack to this (CoP Change long, lat)
  - How does this effect tire load distribution and slip angle/lat accel
- What is our theoretical grip envelope between aero on and aero off?
  - Bike sim front and rear load based on CoP and Downforce?
- Points analysis to hit 10 points goal, starting with CL and cascading to CD then mass. These are the minimum targets, but goal is maximum downforce.

*Somehow argue that this package's parameters will allow us to achieve the performance goals set this year of top 10 with the new accumulator

The latest schpeal:

First id like to show you the analysis that we have done of aero effects on the car with respect to competition events and points, which will reveal the design targets for the aero package and the theoretical points increase for the 2025 competition. This analysis was a combination of OptimumLap sweeps, 2024 EV points analysis, and a bicycle sim cornering model.

The three variables that we swept were CL, CD, and Mass in point-mass analysis of 2024 EV AutoX. In almost every event, CL had the greatest effects compared to CD and Mass. For example, looking at lap time in AutoX (and indirectly points), CL had on average 2 times the effect of CD on lap time. On average, a CL of 2.5 would improve lateral accel by 10% across all corners using a bicycle simulation with ttc data.

This lead to the conclusion that CL is the primary target for designing the aero package, so having the largest CL possible is our goal. If this is done while maintaining an efficiency of _____ and a mass increase/CL ratio of _____, then we would score about 10 points over no aero, which would make the resource and time endeavor worthwhile.

Random Questions

What is Y+?

- Y+ is a dimensionless parameter to characterize near wall flow. It is a function of distance from the wall, free stream velocity, and dynamic viscosity. We target a Y+ value of one with our mesh since we use SST K-w RANS model, which does not use wall functions to model near wall flow. The wall functions take longer to simulate than the SST K-w model, but delivers similar

Andrew/Morrison Rough Draft Feedback

Friday, June 6, 2025 7:25 PM

Add in:

- Overall points analysis that contributes to top 10
  - What you will score in what
- Points sensitivity to cl and cd over each event
- Better explanation of why you decided to use the previous aero package, perhaps in terms of risk management.
- Mention its from 2024 EV, points analysis
  - Mention that the competition was normal
- Don’t make a blanket statement without the why and how

Andrew:

- Change item names in table
- Set my minimums

Lessons Learned

Monday, April 21, 2025 5:38 PM

Seth's Dump

- Aero Box CAD may not be accurate.
    - Problems with 7E Neck rear locating
    - Problems with 8E rear locating

Design

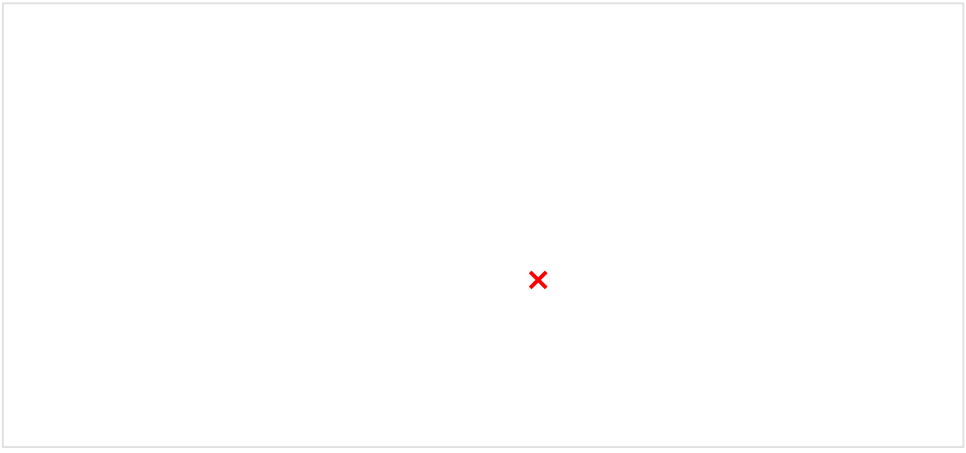
Monday, October 21, 2024 01:39

1. Don’t over analyze.
2. Pre-lim investigation -> Targets -> Designs
3. 1 project per person (Person must be experienced)
4. Newbie projects must be made
5. Get design and budget in EARLY

Logistics

1. Itemize EVERYTHING
2. For sheet metal: Plan out area needed

- Less parts, better analysis
    - Endplate inserts: Bond and stress analysis was not conducted but only assumed.



Undertray

Saturday, May 10, 2025 23:01

IC

- Low to ground, scrapes
  - Impacts chassis
  - Mounts don’t allow much movement

EV

- Sides scrape on UT, mostly middle section
  - Scrape is consistent on almost all corners

Front Wing

Wednesday, May 21, 2025 8:51 PM

Problems:

- Removability is a problem when taking out of trailer. Damage happened cause we didn't take the FW off
- Getting a jack on the front with the front wing still on
- Mounting hardware not accessible easily due to wing and pedal box

Rear Wing

Friday, June 6, 2025 2:48 PM

Mount

- EV: Mount immediately buckled on first drive. The event was not observed but buckling was noticed after 2 or 3 skid pad runs.
    - Swan neck is twisted w/r to its face plane.
    - Wing is shifted about 1/2” to right side of car, noticeable against wheels and struts, struts are not even
    - When pushed down on from the top rear of the end plate, there is a sideways motion, and the crossbrace is compressed, most likely due to the torsions of the swan neck
- It is unknown if the torsion is due to the manufacturing of the mounting, but should be identified.

Alignment Meetings

Wednesday, July 3, 2024 4:27 PM

Meeting Format:

1. Announcements (5-10 min.)
2. Team Review (30-60 min.)
3. Task Q/A (10-30 min.)
4. Aero Learning Session (30-60 min.)

What do I want to do this week? (High Level)

- I want to be ready to put EV UT and RW on
- I want to fix IC RW
- I want to be ready to run tests
- IC Endplate Adhered,

07/10/2025

Thursday, July 10, 2025 11:54 AM

Agenda
- Design Workflow
- Subsystem Pre-Lim Goals
- What is gating you from designing?
  - Using the sim?
  - CAD?

Deliverables
- We all start CAD and Sim NOW
  - Next Week we view findings and start whole system combinations

To-Do

1. Next Thursday
   a. 1-2 Concepts in CAD and Simmed
2. Every day checkup
3. GET STARTED

Notes

Gating Design

- Star install

RW Design Direction

1. Figure out how large it can be
2. Fits in aero box
3. Pick a couple airfoils
   a. MSHD or Benzing, higher camber
4. Put it all together with noted slot gaps and AoAs of each
   a. Excel sheet with this info
   b. Output scenes*, CL, CD

*Scenes will be specified
*Specific metrics to hit (CD, CL)

07/03/2025 - KS9 Start

Thursday, July 3, 2025 5:32 PM

Deliverables

To-Do

Idea PL

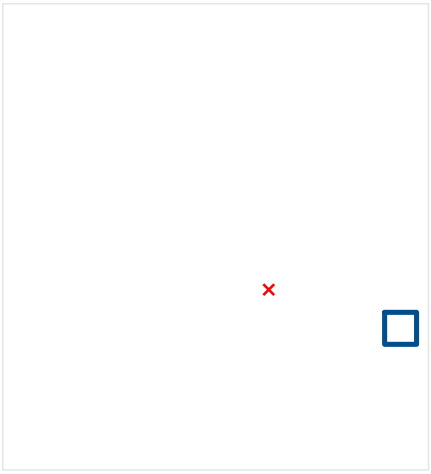
- [x] Design Schedule
- [x] Design Goals
- [ ] Design Workflow Brainstorm & Decision

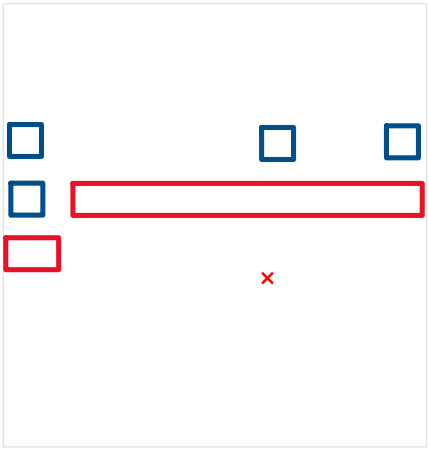
Meeting Notes

- Map input and output relationships of changes to FW and RW, then choose combinations that work.

04/24/2025

Thursday, April 24, 2025 7:21 PM





Agenda

1. ~~Update on Aero~~
2. Timeline Review
3. Discussion of Aero Justification Methods

Timeline

1. April 26-27: Initial Aero Testing
    a. Most likely yarn-tufts or pressure taps
2. May 1st: New RW Mounts
3. May 3-4: More shakedown, perhaps testing Aero
4. May 5-11: IC Comp Preparation (Mostly Statics)

Please be available for testing days, I would like to hand-off responsibility for you to gain experience.

To-Do

- List of parallel testing

John, Emil, Sam Yap

- Model braking, acceleration, and lateral
- Accumulator weight and energy linear relationship, to compare with drag

03/13/2025

Thursday, March 13, 2025 10:34

Topics
- Personal Update
- Car status update
- Design Judges Assignment
- Metals, isotropic/anisotropic

Agenda:

Announcements:
- Seth leaves BMW for Formula (FSAE FOR LIFE)
- Please come in on Friday

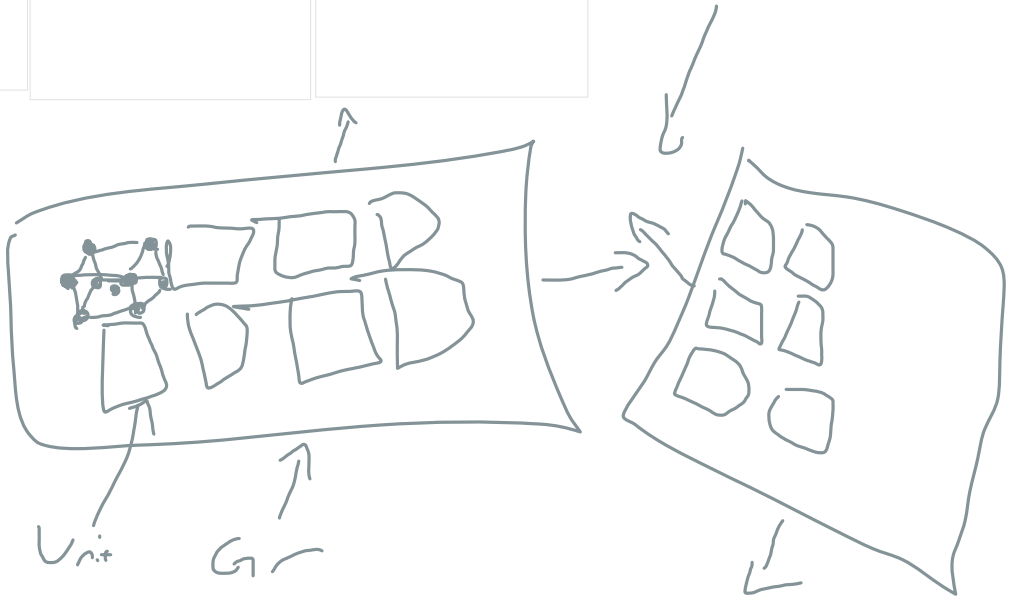
Topics:
- Design Judge Reading
  - Read some articles, take some notes, write down questions, and come prepared to talk about it next Thursday.

Q/A:

Learning Session:
- Metals, isotropic/anisotropic

How is a metal constructed?
- Sea of electrons

Timeline Update



Al +

18-8 SS ← Alloyed w/ Cr

"Chrome"

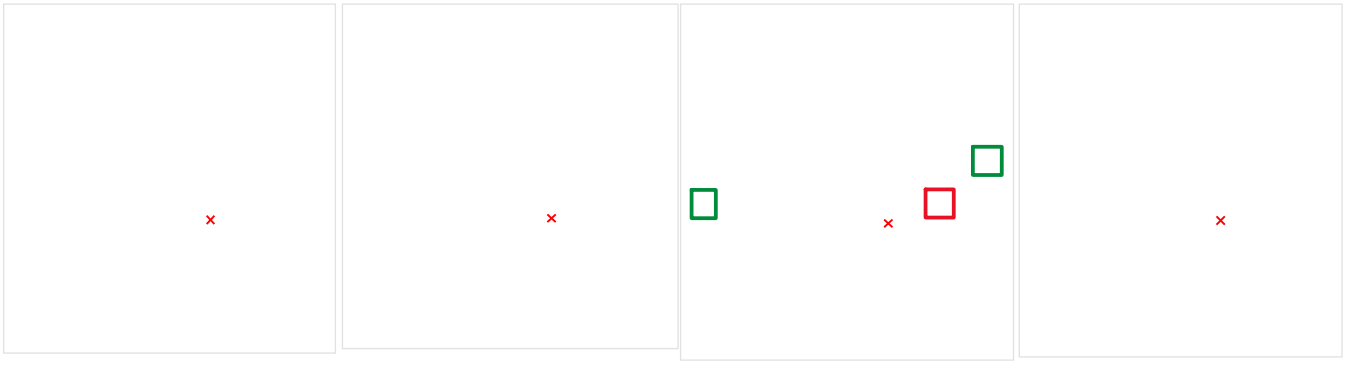
Steels

Al 6061-T6

Alloy

03/06/2025

Thursday, March 6, 2025 8:07 PM



Agenda:

Announcements:

Topics:
- ☑ Cost Documentation
- ☑ Review of Timeline & Building

Q/A:

Learning Session:
- Aero Data Stuff: Drag/Downforce vs Time

Timeline Update

- **March 8th, Assembly:** 12-2:30
  - FW On
  - RW On
    - Struts may or may not be ready
  - UT On*
- **March 9th, Second Assembly:** Afternoon sometime

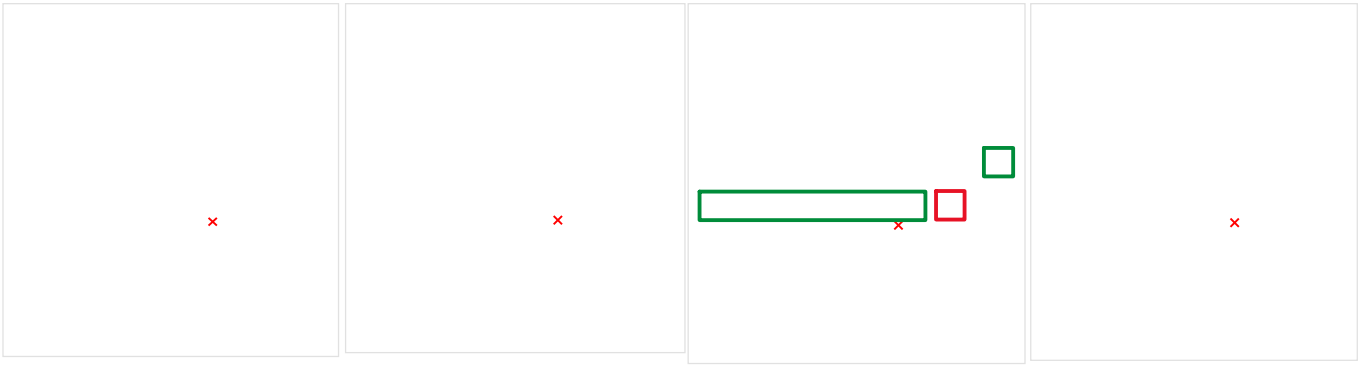
Seth Task List
- Set up Cooper & David for Strut Adhesion

FSAE Comp
Wanna win
Build fast car
We have no aero car
How to make car faster?
Maybe aero?
Analysis to prove aero is faster

Point Mass - Low Effort, Low Data
Bicycle - Med Effort, Med Data
4 Wheel - High Effort, High Data

02/25/2025

Tuesday, February 25, 2025 8:14 PM



Agenda:

Announcements:
- [x] Update to Timeline!

Meeting Topics
- [x] Initial Testing Plan w/ Sam
- [x] KS8C Sim

Q/A:

Learning Session:
- Recap for MONEY!!
  - How is a vortex generated over a wing? (David)
    - Draw it? (Grayson)
  - What are applications of vortices?
    1. Energizing the boundary layer (David)
    2. Increase downforce by reducing UT pressure (Noah)
    3. Sealing off low pressure from high pressure (Krish)
  - What causes flow separation? (Krish)
    - Adverse Pressure Gradient
  - Why is flow separation not favorable? (David)
  - How do you remedy flow separation?
    - AoA (David)
    - Energize the BL (David)
    - Less Camber (Krish)
  - Why don't we use just one big wing and why do we use a stacked wing? (Krish)

Timeline Update

- **March 15-16:** IC Aero Scrape Test
- **March 2nd:** Aero on IC Day
- **Testing:** 8th-13

Action Items
- Sam will get template from Mihai
- Members divide and conquer making test plan templates

David - $5
Noah - $1
Grayson - $1
Krish - $4

Initial Testing Plan
- [x] When can we run to check IC?
  - [x] Can we check A/B Lap Time Testing
- [x] What is needed for planning each test session? Any documentation? Standardization?
  - Getting with Mihai, maybe slimmed down test proposals
- [ ] How do you want to coordinate? What do you need from aero?

Sam's Plan
- Skid-pad in East Lot (Or big lot)(A/B)
  - Generally open in spring break
- General Track Testing (A/B)
  - Subjective Feedback from Driver
  - Time Comparison
  - Tire Temp
  - Flow Vis*
- Coast Down Testing

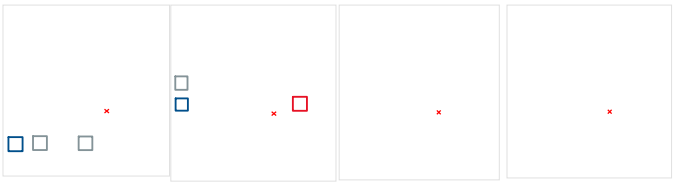
*Throughout: Measure effectiveness of this package vs. previous package

Down the Line:
- Budget pressure tabs on various elements
- Standardized data collection for iteration comparison

Testing Involvement
- Test is prepped and documented
  - Pre-test measurements
- **Seth will put together task list after aero is on IC**

02/20/2025

Monday, February 17, 2025 8:20 PM



Agenda:

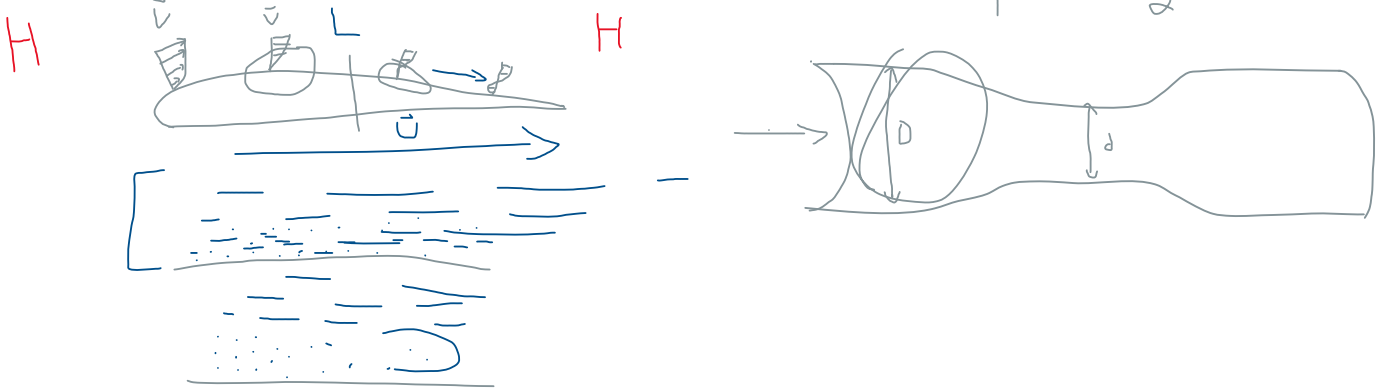
Announcements:
- [x] More manufacturing tasks assigned
- [x] Install Star and let me know when you're ready to sim

Meeting Topics
- [ ] Review important deadlines

Q/A:

Learning Session:
- Flow Separation & Adverse Pressure Gradients!

Schedule
- March 14: DROP DEAD IC
  - Goal: Have IC & EV Aero packages on car
- Feb. 23 (Sunday): All components manufactured/assembled
  - Ready to put aero on
- TBD (Before March 14): Endplates Complete
  - Aero can go onto IC & EV
- TBD (Before March 14): RW Trim Complete
- March 9th: Test Plans Complete & Sequenced



$= \quad 1\rho$

$\rho_1 v_2 A_2$

$A_1 > A_2$

$v_1 < v_2$

02/13/2025

Thursday, February 6, 2025 8:23 PM

Agenda:

Announcements:

- [ ] Design Brief First Draft
- [ ]

Team Review:

Q/A:

Learning Session:

- Vortices!

Weekly Accomplishments

- X

(photo)

02/02/2025 - Aero Coefficients

Sunday, February 2, 2025 11:18 AM

Agenda:

Announcements:
- Feedback
- Weekly Accomplishments

Team Review
- ~~Simulations~~
- UT Mount

Q/A

Learning Session:
- Coefficients!
  - Cl
  - Cd
  - CoP
  - Re
- FA

Weekly Accomplishments
★ X
(photo)

Meeting Notes

Simulation & CoP
- Want to know:
  - Corner CoP
  - Exit CoP
  - Entrance CoP
  - High-Speed CoP
- Maybe CoP relation with velocity
  - Or map on track teehee

Drag & Lift Coefficient Factors
- Shape of the airfoil
- Angle of attack
- Importance: Can describe aero package characteristics

CoP
- Center of Pressure
- You can substitute distributed load to this point
- Ideal: 50/50 - 40/60 Front/Rear
- Migrates with speed and with pitch

01/30/2025

Thursday, January 23, 2025 7:29 PM

Topics:

- Form Results & Applications

01/23/2025

Thursday, January 16, 2025 9:52 PM

Topics:

- CFD Review w/ Quang
- Composite Opportunities
- Q/A

01/16/2025 - Task Updates

Tuesday, January 14, 2025 8:34 PM

Topics:

- Getting CAD Help
    - CAD Info chat in Discord
    - Open Door on weeknights for 30 mins (~8:30-9:30)
- Project Sitreps
    - Simulation
        - Ride height sweeps
        - 0.5 Pitch sweeps full car
        - Yaw sweeps :)
- NMP Check-in
    - Delay NMP Deadlines and Classes
    - Short crash courses for Aero related topics

01/09/2025 - KS9 & NMP Review

Sunday, December 29, 2024 10:36 AM

Topics:

- Members present notes on conceptualization
- Opportunities to watch/participate in manufacturing
- Opportunities to create Aero test plans
    - Test plans will evolve into test execution
- Project Lists
- New Weekend Meeting Time Suggestions
    - Thursday @ 8 Virtual, Weekends in person when necessary
- Update on what I have done

Deliverables

- [ ] Members understand what's been done so far
- [ ] Members know what the next steps are (CAD & Analysis)

To Do: CAD Tutorial, Hand Analysis, message quang about working with kiernan, make new projects

12/12/2024 - Step 1 Review, Structural Analysis

Wednesday, December 11, 2024 11:36 AM

Agenda

- [ ] Weekly Re-cap, HL Overview, Next Week's goals
- [ ] Review Step 1 OneNotes, Feedback
- [ ] Structural Analysis Crash Course
- [ ] Assignment: CAD, Revise Step 1

12/5/2024 - New Member Project & Testing

Tuesday, December 3, 2024 5:21 PM

Agenda

- [x] Discuss New Member Project
- [ ] Review Testing Brainstorm
- [ ] Review Development Brainstorm

11/13/2024 - Post Budget Update

Wednesday, November 13, 2024 8:19 PM

What's happened?:
- -Design deadline passed, projects approved
  - -Board meeting to discuss IC aero
- -Budget way less than initially expected/projected
  - -Lots of projects axed
  - -Aero levels based on available budget
    - -MVP: Keep FW and rework RW for use on both cars

Aero decisions after budget:
- -Rework RW
  - -Separate RW endplates for E & C
- -Side panels
- -Cut DRS, FW COP adjustment, 8E RW mount, FW mount (but tension cables are happening)

Projects moving forward:
- -RW mount
  - -SN (Luke)
  - -Struts (Cooper)
- -Manufacturing
  - -EP layups
  - -SP layups
  - -RW rework

Newbie project:
- -Will have a problem, constraints, criteria to hit/adhere to

STAR:
- -Santana Roberts (our faculty advisor) and Marco Blanco (Siemens support engineer) are now in contact
- -We need Santana to make an account and to distribute licenses

Testing schedule
- -On 11/14, Seth and Sammy will sit down and discuss the path forward and list everything we want validated/what we want tested
  - -Talk of renting out the Rome Airstrip

Seth, you need to have a meeting for aero design debrief and what can be done better

CW16

Tuesday, October 15, 2024 8:43 PM

Topics:

- CoP FW Inner EP CAD
- Side Panel CAD & Sealant Choice
- RW Mount State of Affairs
- FW Mount State of Affairs

(CAD Spins: Making sure all our ducks are in a row^)

CW15

Wednesday, October 9, 2024 6:46 PM

Topics

- [x] Current Projects
  - [x] What we got
  - [x] Expectations
  - [x] Questions?
- [x] Migrating to PDM
  - [x] How to access PDM
  - [x] Rules
  - [x] People Allowed

List of Current Projects

- FW Mount
- RW Mount
- SIS Panel
- SC Panel
- DRS
- CoP Movement
  - RW needs to shift forward. 1 inch

PDM Rules

1. DON'T FUCK WITH ANYONE ELSES SHIT
2. Only work within the Aero assembly, if you want to move into main static, LET ME KNOW
3. Name Scheme (Temporary) - Car_Subgroup_Subassembly_Part_Revision
   a. E.g. 8E_Aero_FW_Mount_Rev-1
      i. "A" is first signed off part
      ii. "1" is the actual revision
   b. This is subject to change when I figure out a better revision control system

CW13

Wednesday, September 25, 2024 7:48 PM

Objectives

- [ ] What is happening with:
  - [x] FW Mount
  - [x] DRS
  - [x] RW Mount
  - [x] CoP Migration
  - [x] IC Aero
- [x] What's happening next?
- [x] Any questions for me?

CW11

Wednesday, September 11, 2024 7:54 PM

Agenda

- [x] DRS Review
- [x] CoP Update
- [x] FW Update
- [x] RW Update
- [x] MSHD Sim Update
- [ ] General Stuff

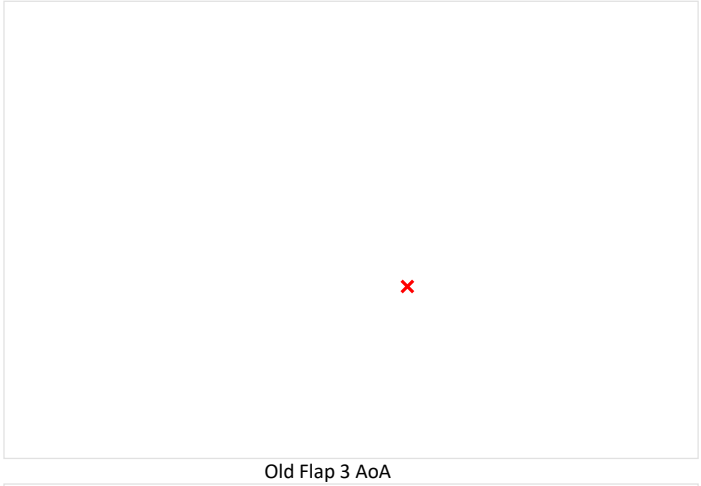
General Stuff

- Check Pitt Readiness
  - Tech Inspection
  - Aero Tool/Hardware Box
  - CAD/Print Endplate 1/4-20 Sleeve
- FW & RW due next week
- Once complete, begin KS9 work

CoP Update:

- CFD simulation of 4 preset setups are finish, result can be check on Teams under: Aerodynamics -> Design -> Projects -> Undertray -> Quang UT -> aero sim logbook.xlsx
- New AoA on RW helps reduce drag and minor increase in downforce
- Created a standardize CFD logbook template for the aero team to use from now on. Will update where this template location will be upload

-



Old Flap 3 AoA

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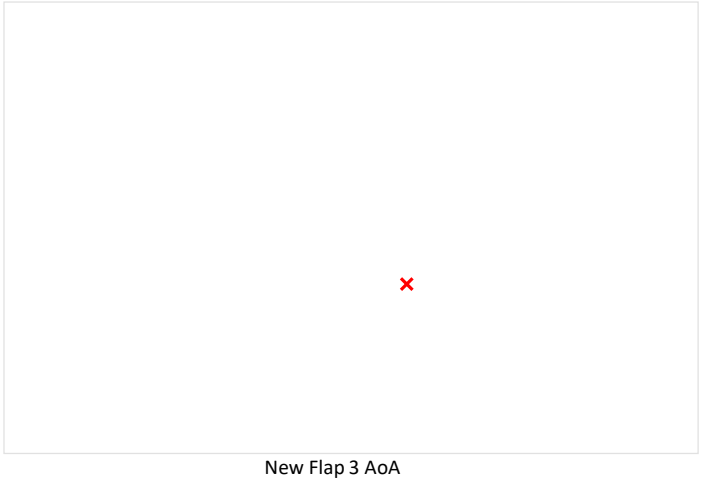


New Flap 3 AoA

CW1

Wednesday, July 3, 2024 4:31 PM

Aero Updates

- Investigating DRS, Mounting Methods, and Whiskers
  - DRS will require re-manufacturing
    - Mainplane with new ribs
    - Endplates with better mounting (for lateral stiffness)
    - Plan: Unless we have the materials and time, or structures are ready, we should wait until we are ready to make the KS8. Agree?
  - Mounting methods have not been handed off yet
  - Whiskers: Waiting for simulation. Should be ready next week.
- Understanding KS7C/E Aero Packages this week
  - Subgroup HL goals and ranked priority list will follow

Composites Update

- Beginning wing structures.
  - Proposal for structure (documentation only, no approval). CAD of idea. Sample part.

Meeting Summary

- Discuss mounting responsibilities with David.
- DRS Summer Testing will take too much effort for the data it outputs.
  - Instead will focus on force data. Shock pot data.
- DRS Automatic actuation based on TPS, BPS, GPS. Basically testing code
  - If your DRS is open in a corner, then you can revise it before it gets on the car.
- Drag/Downforce Measurements via Shockpots
  - First: One night to verify that we can pull data.
  - Mathew can get force values.

Next Steps

- Hand off FW mounting
- Project: DRS Code actuation verification
- Testing: Shockpot data verification and Drag/Downforce values

CW2

Wednesday, July 10, 2024 2:40 PM

Meeting skipped, not enough progress to align

CW4

Monday, July 22, 2024 10:57 AM

Aero Only Points:

- "Ideal Package" design done by end of August
  - All *Aero* CAD
  - Sim data: Cl, Cd, CoP, pitch sweep, roll sweep, yaw sweep, vorticity analysis
- "Optimal Package" design done by end of Sept.
  - All *Aero & Structures* CAD
  - Same sim data: Sim data: Cl, Cd, CoP, pitch sweep, roll sweep, yaw sweep, vorticity analysis
    - AoA/Spacing Adjustment sims from main sims
- "Roles" idea
  - CFD and CAD: Luke does CFD *mainly.* Quang and Cooper CAD *mainly.*
    - Dabbling in CFD or CAD but not having it be your main purpose is okay. The goal is to narrow scope to increase understanding and hit more difficult CAD and CFD targets.
  - Switch between seasons for well-rounded engineers
  - CFD role will still have deliverables: Write ups/presentations that describe all sim settings, difficulties, results, interpretations, and recommendations.

Aero/Composite Points

- What projects are people working on?
  - Britton: Dissolvable molds
  - David: Logistics
- Manufacturing Capability
  - Can we produce two packages?
- Molds to be made:
  - 6C Mainplane
  - 6C/7E E3 (Flap 2)
  - 6C FW Mainplane
  - 7E FW Mainplane
  - 7E RW Mainplane
- Manufacturing rough timeline
  - Half of last year budget, plan for
  - Re-visit fully manufactured deadline at Sept. 31st.
  - **August 31st**
    - CAD & CFD for "Ideal" Aero Package - Both cars or One Car, undecided
    - Identify components that can be manufactured effective immediately
  - **September 31st**
    - CAD & CFD for "Optimal" Aero Package - Both cars or One Car, undecided
    - Ensure manufacturing timeline is acceptable by both composites and aero
  - **January (31st?)**
    - IC Aero Package Manufactured and Assembled
  - **March (31st?)**
    - EV Aero Package Manufactured and Assembled

*Note: These are tentative deadlines subject to change with team timeline and feasibility.

Meeting Outcomes:

- EV gets package, IC gets no package or same
- Loose member roles
  - Quang & Cooper: CAD
  - Luke: CFD

New Member Project - Structure

Tuesday, November 19, 2024 1:27 PM

What is it?

This project will have new members (mostly freshmen) develop core engineering skills related to aerodynamic structures by designing a wing spar by designing and manufacturing a "fake" component of an aerodynamic device.

What will you learn?

- Problem identification, goal setting
- Basic CAD in SolidWorks
- Stress Analysis (Hand Calculations)
- Design for Manufacturing
- Manufacturing Techniques (Lathe, Mill, Waterjet, Composites)
- Validation techniques (Closing the engineering loop)

These are the core concepts involved with designing a new component or system, which will streamline the design process for components going on the car.

What is the goal?

At the end of the project, you will have two things:

1. The knowledge and capability to design a component on the car with greater autonomy and quality
2. A project that demonstrates *preferred* (not just required) skills for a mechanical engineering internship
    a. For example you will be able to say:
        i. Developed design criteria using 1st principles
        ii. Experience designing with SolidWorks
        iii. Verified structural targets using hand analysis techniques
            1) Verified FEA accuracy with hand analysis techniques
        iv. Used DFM philosophy to simplify manufacturing and avoid error
        v. Validated hand analysis and FEA with prototype testing

What is the project?

Overview

You will design a spar for a wing element. The spar of a wing is an component that provides rigidity to the wing *span wise.* Without a spar, a long element (think the size of the rear wing) will deflect, or bend, given enough pressure is applied.

What you'll do

The project will have a few milestones that you will hit. Each of these milestones marks a new section of the design process, and they include:

1. Problem Analysis, Goal Setting
2. CAD
3. Structural Analysis (Hand Analysis)
4. Component optimization/CAD finalization
5. Bill of Materials, Part Drawing, Assembly Drawing
6. Manufacturing
7. Testing & Verification

Before you complete each section, I will teach you the skills and expectations of each, and we will review weekly before moving onto the next milestone.

Your Mission

During competition last year, we realized that the whisker on the nose cone deflected upwards at speed over 20 mph. The deflection caused the rear wing to produce less downforce and subsequently made the rear end of the car unstable. This was noticed during slalom sections of the track, where the car would spin out.

It is clear that the whisker does not have enough stiffness to resist the aerodynamic loads it creates. Therefore, you are to design a spar that connects between the root and tip of the whisker. Your design must meet the following criteria:

- Deflection < 0.125" from 10 lb located at the CoP.a
- Weight: As light as possible to hit the displacement goal
- Budget: $50

You will be provided with the whisker's CAD, and your design will need to fit within the whisker's bounds. Furthermore, the spar will be the structure of the whisker that attaches to the body, so the tab CAD will be provided to you as well.

Weekly Deliverables

Step 1: Problem Analysis & Goal Definition

In a OneNote Page*:

- [ ] Clarify Component Function
- [ ] Define General Load Cases (Draw FBDs)
  - Things to consider:
    - What are the intended load cases?
    - What are possible unintended load cases?
      - Should these be designed for?
- [ ] Define Analysis Deliverables (Criteria I Listed)
  - Things to consider:
    - What is my maximum Deflection?
    - What is the Factor of Safety?
    - Will my part fatigue?
  - These will determine what equations you will use^
- [ ] Install SolidWorks

*Do some digging into each of the suggestions and ideas that you may have. Maybe search up what you should do for this using ChatGPT. I also recommend looking at the "Machine Design" textbook in the aero books section in teams.

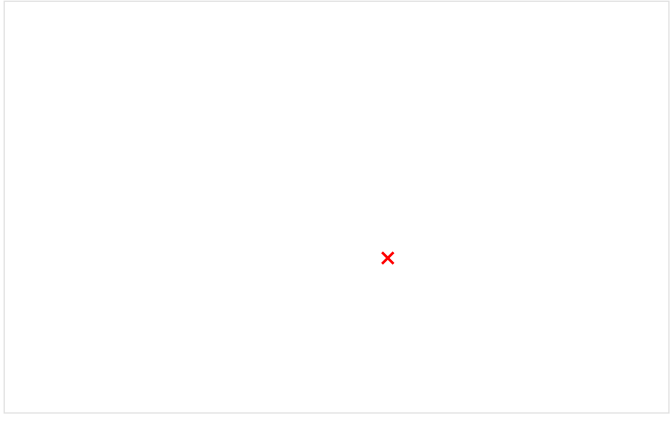
In this step, you will be doing a lot of thinking and abstract conceptualization. There won't be many hard numbers (like FoS, max stress, and dimensions), but you will define how the system operates.

The goal of this step is to draw out a rough "map" of how to get to your end product. Without this "map", the journey will almost always take more time than you have, because you will most likely go in circles.

When in CAD and Analysis, you will refer to this "map" to avoid over-designing and over-analyzing. Without it, you will have no idea what an acceptable first product looks like.

Presently, the whisker is **adhered to the body.** This is what causes the excessive movement. You are to design a structure that **connects to a pre-designed chassis** tab and goes through the whisker **to the outer rib**. The structure must produce the criteria outlined above.

The rough dimensions for the whisker's forces and where it will mount are given. You can see that the tab is offset from the whisker by about 2 inches. Mounting design will be given in a later step, for now just determine the general load cases and what analyses you will conduct .



Step 2: 3D Model Development (CAD)

Lesson Coverage

1. CAD

    1. Like you haven't touched
    2. Make a mock part
2. Structural Analysis (Hand Analysis)
    1. Statics Crash Course
    2. Strength of Materials Crash Course
3. Component optimization/CAD finalization
4. Bill of Materials, Part Drawing, Assembly Drawing
5. Manufacturing
6. Testing & Verification

PPT Flow

- Intro
- Explain all constituents
- Give example using all constituents (not the same as the project)

Lesson 1 - Problem Analysis & Goal Setting

Thursday, December 5, 2024 7:00 PM

Problem Analysis

Here you better define the system which you are working with. You try to boil down the problem to its components and begin to define solutions off them. This is also known as a **1st principles approach**, a term you will hear a lot from employers in your internship search.

The idea is that the problem is understood at its roots, i.e. there is no more simplification that you can do.

For example: I had a problem of the front wing oscillating. My thought process (and analysis process) went like this: What is actually moving? (analysis) > What contributes to this movement? (Load path, material choice, geometry) > What are the things that change these contributors? (Moment arms, elastic modulus, second area moment of inertia) <---- These are my 1st principles, it does not get more simple than this.

I can now say that my problem is a function of the moment arm, elastic modulus, and/or the second area moment of inertia. In adjusting these parameters, I can easily guide what my design will be and reach my solution.

Engineers (and by extension employers) like to use 1st principles because it typically results in a more effective and simple design rather than being overcomplicated. By boiling it down to the base inputs, you then only solve for those inputs instead of other unnecessary clutter.

Lesson 2 - Conceptualization & CAD

Thursday, December 5, 2024 7:03 PM

Core goals of this step:

1. Rough draft/draw your ideal solution(s)
2. Bring your ideas into CAD

At the end of this stage, you will have enough information to begin your analysis. For each design, you will be able to cross reference the underlying principles you developed in the first stage and actually build your analyses.

For example, if you chose to use a tube geometry, you will realize from the previous stage (and structural analysis basics) that changing the inner diameter, outer diameter, and material will be the major contributors to your deflection, FoS, and Fatigue analyses.

If you chose an I-Beam, the height, thickness, width, and material will influence your studies.

By now you should see how each stage augments one-another. This will ultimately lead to a part that you have "full" knowledge over, meaning you can speak in depth about important decisions you have made for its success. Primarily, this ensures that you have made a safe and reliable part, but it also shows that you can make intelligent engineering decisions and have been through struggles with the design process, a chief trait that highly-competitive companies are looking for.

Importance (Why should you do this?):

- Ideas are "reality checked" on paper
- Multiple ideas can be catalogued and "saved" before being forgotten
- CAD further reality checks by providing a 3D model to view
    - Manufacturability and assembly integration is better understood here as well

Project Deliverables: - DUE Jan. 2, 2025

- [ ] Draw and Note your designs, as many as you want (should be no less than 2 or 3)
    - You can draw in 3D (Isometric) and designate side, top, front, or bottom views
- [ ] CAD your drawings with arbitrary (but guesstimated) dimensions.
    - For example, we know that the length needs to be about 10 inches

CAD Lesson

Practice - **DUE Dec. 26th, 2024**

- [ ] Make the second part
    - We will hop on a call and go over your work and answer outstanding questions

Lesson 3 - Structural Analysis

Tuesday, December 10, 2024 3:50 PM

Knowledge Assumptions

- Pre-statics experience

What to teach

- Fundamentals of Static Analysis
- Fundamentals of Strength Analysis
- Important Material Properties
- Cantilever Beam Fundamentals
- Incorporating Excel w/ Goal Seeking

Goal

- Members have the ability to analyze multiple geometries & materials and provide an effectiveness ranking based on a trade study

Assignment

- Study the following geometries of 6061-T6
  - Vertical Flat plate
  - Horizontal flat plate
  - Cylinder
  - Hollow Cylinder (specified radius, various thicknesses)
- Study different materials for the hollow cylinder
  - 6061-T6 Aluminum
  - 5052-H32 Aluminum
  - 18-8 Stainless Steel
  - Carbon Fiber (Look up specifications, they may give you an elastic modulus to assume)

Lesson Plan

1. Fundamentals of Statics
   a. What is statics?
   b. Why is it important?
   c. Force types
      i. Applied Forces
      ii. Reactionary Forces
      iii. Internal Forces
   d. Resolving Vectors into Components
2. Free Body Diagram
   a. What is it?
   b. Why is it important?
   c. Types of Supports
   d. How do you draw one?
      i. Simple & Complicated
3. Static Analysis
   a. Equations of Equilibrium
   b. Static Determinacy
4. Example Problem: Static Analysis
5. Internal Forces
   a. What are they?
   b. Why is it important?
   c. Sign Convention
6. Shear/Bending Diagrams
   a. What are they?
   b. Why are they important?
   c. Relationships (Integrals)
7. Example Problem: Simply supported beam with point load.
8. Stress
   a. What is it?
   b. Why is it important?
   c. Von mises stress
9. Material Properties
   a. Area moment of inertia
   b. Elastic Modulus
   c. Stress/Strain Curve
      i. What is stress, strain
      ii. Yield Strength
   d. Factor of Safety
   e. Fatigue (Introduction)
10. Structural Analysis
    a. Von mises stress
    b. Factor of Safety
    c. Deflection

New Member Projects

Thursday, December 5, 2024 7:25 PM

Krish P

Saturday, December 21, 2024 3:00 PM

Step 1

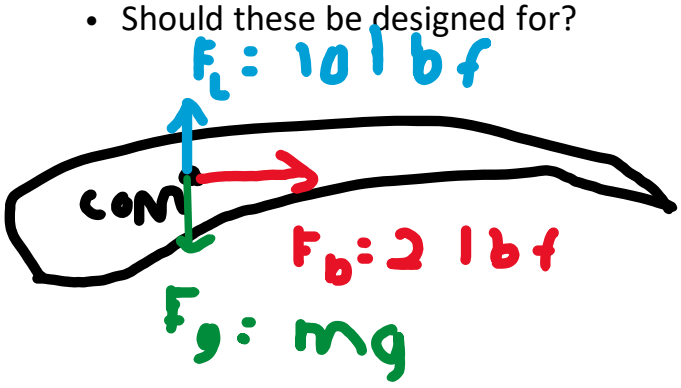
Saturday, December 21, 2024 3:02 PM

Clarify Component Function

The component's function is to stabilize the whisker for 10 pounds of lift with a maximum deflection of 1/8 of an inch.

Define General Load Cases (Draw FBDs)

- Things to consider:
  - What are the intended load cases?
  - What are possible unintended load cases?
    - Should these be designed for?



*-This is the lift to account for at 20 mph. Exxceeding 20 mph would result in much greater lift that should be accounted and designed for.

*-This is the drag at 20 mph. It can exceed this drag at higher speed which should be accounted and designed for.

Force of gravity is helpful to account for as it assists in reducing the displacement from lift.

Define Analysis Deliverables (Criteria I Listed)

- Things to consider:
  - What is my maximum Deflection?

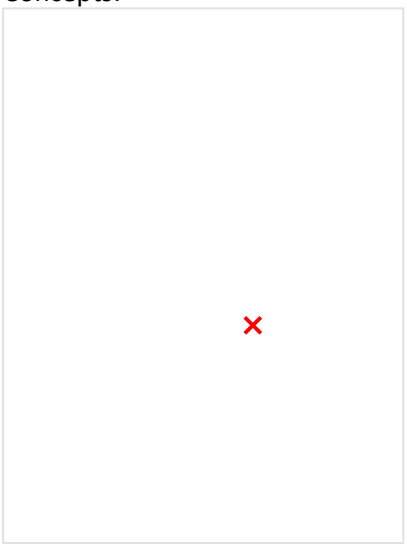
    - What is the Factor of Safety?
    - Will my part fatigue?
- These will determine what equations you will use^

Installed SolidWorks

Step 2

Thursday, January 09, 2025 5:38 PM

Concepts:



Step 3

Thursday, January 16, 2025 2:02 PM

6061-T6 aluminum

- Elastic Modulus - 68.9 Gigapascals or approx. 10,000 ksi
- Density - 2.7 g/cc, 0.0975 lb/in³

5052-H32

- Elastic Modulus – 70.3 Gigapascals or approx. 10,200 ksi
- Density - 2.68 g/cc, 0.0968 lb/in³

18-8 Stainless Steel

- Elastic Modulus - 193 GPa or approx. 27,992.3 ksi
- Density - **7.93 g/cm3** (0.286 lb/in3)

Grayson

Friday, December 20, 2024 8:41 AM

Step 1:

Friday, December 20, 2024 8:42 AM

Clarify Component Functions:

Whiskers on an aerodynamic race car, such as dive planes or canards, are used to manage airflow and enhance performance.

They guide air around the car, reducing turbulence and drag while improving stability and efficiency.

Whiskers can generate downforce at the front to aid cornering, create vortices to energize airflow for better attachment to surfaces, and redirect air to key areas like the underbody or cooling systems.

They also help control airflow from the front wheels, improving the performance of rear components like the diffuser and wing.

Overall, they fine-tune the car's aerodynamics for maximum speed and handling.

Define General Load Cases:

Intended Loads:

Aerodynamic Loads:

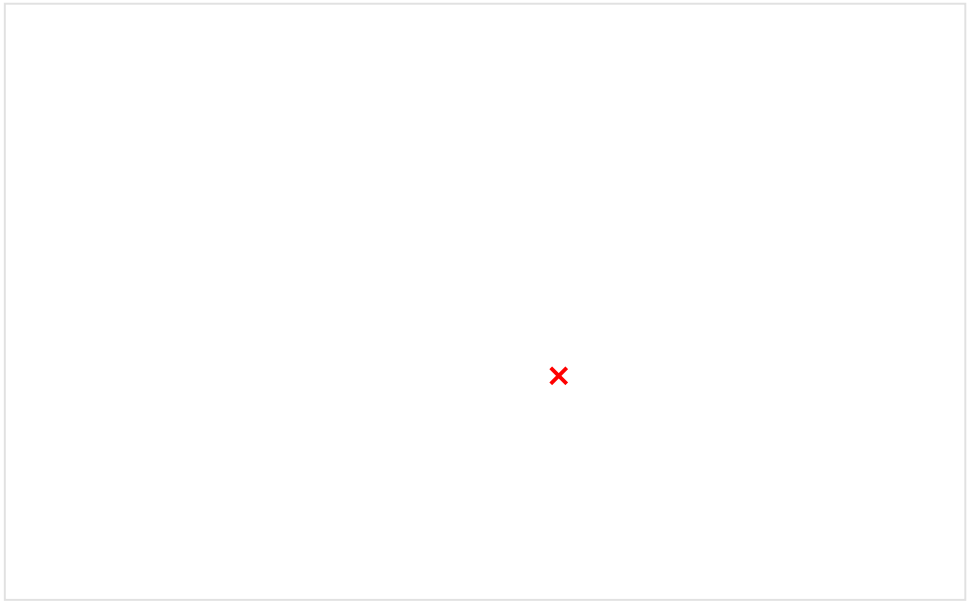
- **Lift:** A vertical aerodynamic force that acts upward, perpendicular to the surface of a vehicle, caused by pressure differences between the top and bottom surfaces. In cars, excessive lift can reduce traction and stability.
- **Downforce:** A vertical aerodynamic force that acts downward, pressing the vehicle toward the ground. It is generated by shaping components like wings, splitters, and diffusers to create higher pressure above and lower pressure below, improving grip and handling.
- **Fatigued Loads:** Fatigued aerodynamic loads happen when air pushes on an aerodynamic body over and over, like when it's flying or moving through the air. These forces change as the vehicle turns, speeds up, slows down, or hits bumpy air.

Unintended Loads:

- **Impact Loads**: Unintended impact loads are sudden, unexpected forces that hit a car due to something on the track or in its environment. This could be from debris flying up, hitting a curb too hard, or sudden changes in airflow, like getting caught in the wake of another car or a strong crosswind.
- **Collision Loads:** Collision loads refer to the forces acting on a race car during direct or indirect impacts with other objects. These loads are sudden, extreme, and often occur in unpredictable directions, making them particularly challenging for engineers to account for in design.

- **Kerb Strikes:** When a race car hits or rides over a kerb (the raised edge of a race track) harder than intended. While kerbs are designed to guide cars and discourage cutting corners, hitting them too aggressively or at the wrong angle can cause **unintended loads** on the car's suspension, chassis, and aerodynamics.
- **Crosswind Loads:** A strong crosswind pushes against the side of the car, creating a sideways force. This can cause the car to slide or push wide off the racing line, especially at high speeds. The aerodynamic surfaces, like the sidepods, rear wing, and even the body shape of the car, experience this force and must be designed to resist or react to it.
- **Thermal Loads:** As a race car heats up during a race, parts of the vehicle, especially the body, wings, and other aerodynamic components expand due to the heat. Different materials expand at different rates, and this can slightly change the shape or position of aerodynamic surfaces. A small change in the angle of attack of the rear wing or front splitter, for example, could affect the car's downforce or drag.

  Implementing features and systems to prevent these or work around these unintended loads can and will be very crucial to the development of a durable and effective aero package. While racing on the race track, it can have many unintended variables, and if not fully accounted for, these loads could fracture or break the aero package which will then create an ineffective package.



Defining Analysis Deliverables:

- Deflection < 0.125" from 10 lb located at the CoP.
- Weight: As light as possible to hit the displacement goal

    - Different materials can be used to determine the least amount of weight while maintaining proper durability
- Budget: $50
    - Different materials can be used to best fit the budget but also not fall short of safety and durability requirements
- ***CoP:*** Center of Pressure is where most of the air pressure resides and being acted on.

Cooper

Thursday, December 5, 2024 7:25 PM

Step 1: Problem Analysis

Thursday, December 12, 2024 7:12 PM

Deliverables:

- [ ] Clarify Component Function
- [ ] Define General Load Cases (Draw FBDs)
  - Things to consider:
    - What are the intended load cases?
    - What are possible unintended load cases?
      - Should these be designed for?
- [ ] Define Analysis Deliverables (Criteria I Listed)
  - Things to consider:
    - What is my maximum Deflection?
    - What is the Factor of Safety?
    - Will my part fatigue?
  - These will determine what equations you will use^
- [ ] Install SolidWorks

Clarify Component Function

"The spar of a wing is an component that provides rigidity to the wing *span wise.* Without a spar, a long element (think the size of the rear wing) will deflect, or bend, given enough pressure is applied." -Seth Cornman

The last whisker we used experienced deflection during competition, leading to lowered aerodynamic forces. The function of the new internal structure is to prevent vertical deflection of the whisker while a load is applied to it, leading to better aerodynamic forces during competition. The load will be the aerodynamic forces experienced while driving the car along with any other external forces we design for, like somebody leaning on it for example.

Define General Load Cases

The main load case comes from the aerodynamic forces applied to the whisker while the car is in motion. Seth Cornman has defined our load case to be 10 lbs of lift and 2 lbs of drag. Other forces to consider may include somebody setting an object on the whisker or putting their weight on the whisker. I do not believe these forces should be designed for as they may add significant weight to the project that can easily be avoided by clearly communicating to the team that the whiskers should not be used to support any external weight.

Diagrams from Seth Cornman

Define Analysis Deliverables

Deliverables for the analysis include deflection, factor of safety (FOS), and fatigue. The deflection deliverable was given by Seth Cornman to be,
"Deflection < 0.125" from 10 lb located at the CoP.a
Weight: As light as possible to hit the displacement goal
Budget: $50 "
An FOS of 2 (*ask Seth if he gave us a FOS*) will be appropriate for this part, this number comes from the FOS used for the swan neck due to the swan neck and whiskers having similar aerodynamic load cases.
This part will experience fatigue over time, the car goal of reaching 500 (don't remember if it was 500) miles of testing along with about 50 miles of competition use means that we need to design for that amount of fatigue. We will say that every turn is one cycle of use of the whiskers and assuming the endurance track is roughly 1 mile long and it contains about 32 turns (see picture on right), we can design for 17600 cycles. This number comes from the 32 turns per mile multiplied by 550 miles from testing and competition.

Final deliverables:

Deflection < 0.125" from 10 lb located at the CoP.a
FOS of 2
17600 cycle lifetime
$50 budget
Minimal weight

Feedback

> "I do not believe these forces should be designed for as they may add significant weight to the project that can easily be avoided by clearly communicating to the team that the whiskers should not be used to support any external weight"

You can't prove that it adds significant weight. You have not defined what a significant weight increase would be, nor have you defined what the load case you would be designing for in the event of misuse.

Delicate parts DO NOT last on FSAE cars. Whether intentional or unintentional, thought through or not, people have stepped on the wings, placed heavy objects on the wings, kicked the wings, hit cones, accidentally used them for support when falling, the list goes on.

It is almost a certainty that there will be misuse of this part. Being next to all of the suspension, its very possible someone might hit it with a component or a tool, or use it for support subconsciously when bending down to inspect something.

This is very good reason to add this load case to your design. You have NO IDEA what will happen in actuality, because you have never made it. If this was a component that we have tested and used for many many years, and no one ever leaned on it, then we can say it's an unnecessary load case.

The bottom line, the part should not fail. If you have a lighter version that ends up failing, that is infinitely worse than a heavier version that makes it through competition.

So, quantify what you think would be a sufficient misuse case(s). How much force would someone leaning or grabbing produce? What if someone put a drill on top of it? I'm suspecting around 20-40 pounds of force, but you could verify with a scale and maybe pretending you're the one leaning on it. Could this force go backwards? Or upwards? What is the trade study? Maybe your geometry already is sufficient for these other directions.

> "An FOS of 2 (*ask Seth if he gave us a FOS*) will be appropriate for this part, this number comes from the FOS used for the swan neck due to the swan neck and whiskers having similar aerodynamic load cases."

With the misuse load case, which will be your maximum load case, a factor of safety of 1.5 is sufficient. If this breaks under this load case, safety is not much of a concern. If it could cause harm or be life-threatening, you'd want to look at an FOS of 4-5.

> "We will say that every turn is one cycle of use of the whiskers"

The whiskers will also cycle with bumps and speed. You could look into how many bumps we see per run with data aq but that would be pretty deep. With this part, since it is non-critical and not life-threatening if failed, I would hit the FOS criteria first, then see how large of a cycle number it is. A general rule of thumb is 500K cycles for our parts.

This also depends on your material. If you use steel, you may be below the threshold for fatigue failure, with aluminum, you may just have a very high cycle life.

Furthermore, you don't want to design your part to fatigue exactly at the end of the year, because it probably will then or before that, especially if you have unaccounted loads.

Step 2: 3D Model Development

Thursday, December 12, 2024 8:05 PM

Noah Parayil

Sunday, December 08, 2024 9:05 PM

Clarifying of Component Function:

- Whiskers are used to help optimize the car's aerodynamics and help manage the airflow around certain areas
- Additionally, this helps with the overall performance of the car while on the track
- Whiskers can have 3 main goals:
  - Flow conditioning: Helping to direct or manage airflow around a particular area of the car
  - Minimizing drag: By the control of the airflow, this component can reduce the drag or lift that could negatively impact the car performance under high speeds
  - Stability and balance: Whiskers can help to balance the forces on the car to ensure the car is stable in high speeds

Defining of General Load Cases:

- **Intended:**
  - Aerodynamic Loads
    - Lift: The upward force created sometimes by the pressure difference , counteraction with gravity
    - Downforces: Pushes the car down, force coming down onto the car
    - Drag Force: The resistance that is faced when the car is moving the air, caused by friction and pressure difference, acts opposite to direction of the motion and this will slow the car down
    - Shear Forces: Force that is parallel to the ground, caused by the fluid's viscosity
  - Vibrational Loads
    - Vibrations from the airflow: As the car is moving at a high speed, varying factors such as pressure and different aspects of the air can cause vibrations of the component to occur
  - Fatigue loads
    - Fatigue in the component as it continues to undergo repeated tests with aerodynamic forces, this causes fatigue in the material for less strength and more flexibility
- **Unintended:**
  - Impact Loads
    - Contact with the surface of track: The whisker can be exposed to different impacts of debris from tracks which can cause bending, breaking, or displacement of the component
    - Other parts of the car: Other components of the car can come in contact with the whisker which can lead to damage or displacement
  - Thermal Loads
    - Heat from engine or exhaust: If component is placed close to hot components elsewhere in the car, it can cause warping, melting, or material degradation
  - Structural Loads
    - Overloading: Improper mounting or misalignment with airflow can cause bending and twisting which will lead to failure of component
  - Environmental Loads
    - Water or other weather condition impact: Heavy rain conditions or mud can add more forces and load, or it can create a build-up of drag with a build-up of debris on the component

    - Wind Loads
        - When the component goes through an unexpected wind gust, it could experience a resonance effect, which can lead to excessive oscillation that can cause for failure due to stress or fatigue
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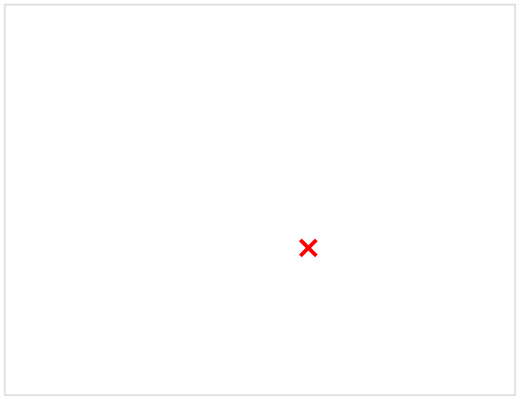
- 

Defining Analysis Deliverables:

- Maximum deflection <0.125"
- Minimum weight
    - Look into the properties of different materials
- Budget of $50
    - Look into different types of materials, being cost effective yet best material possible for a successful outcome
- Stress distribution on the component: The stress based on the external loads
- Strain distribution on the component: The amount the component deforms under different types of forces
- Factor of Safety (FoS): It is a check to ensure that the component will not fail under certain condition, there is a formula for it: Yield Strength/ Maximum Applied Stress
- Center of Pressure (CoP): The point where the majority of the pressure force is acting on
- Also check for cycle life: The number of times it can be used over and over until it can no more
    - Fatigue analysis

Problem Analysis & Goal Setting

Thursday, December 5, 2024 7:26 PM

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- Wind Loads
  - When the component goes through an unexpected wind gust, it could experience a resonance effect, which can lead to excessive oscillation that can cause for failure due to stress or fatigue

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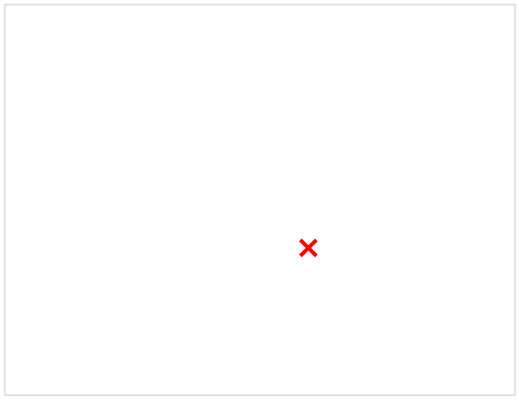
- 

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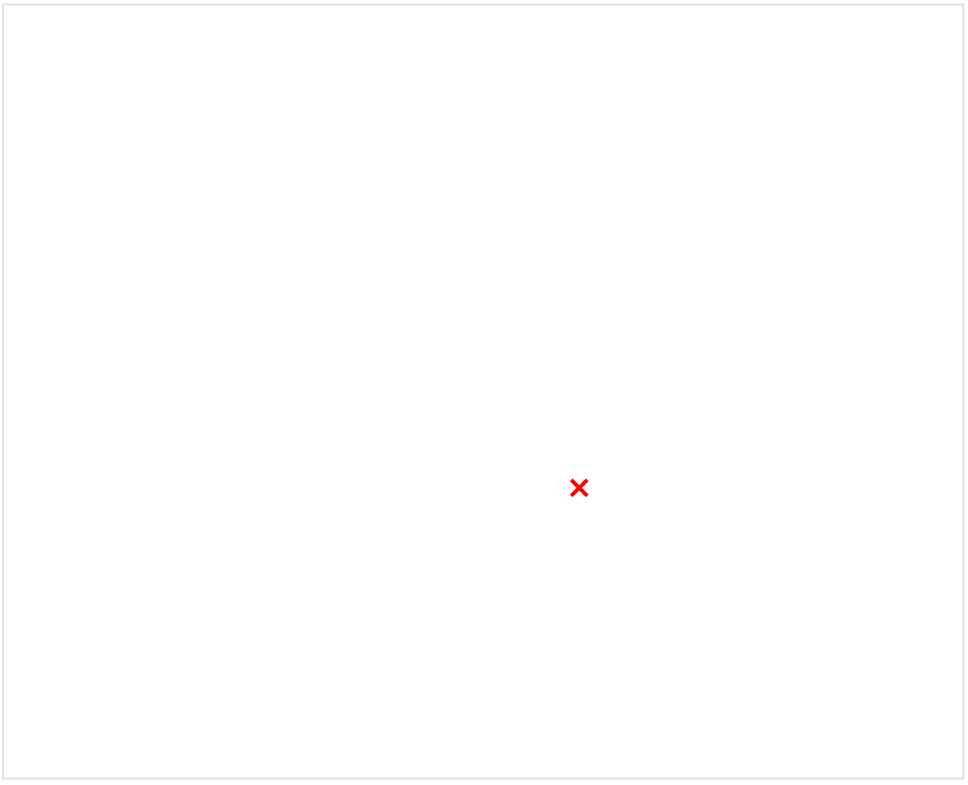
- Center of Pressure (CoP): The point where the majority of the pressure force is acting on
- Also check for cycle life: The number of times it can be used over and over until it can no more
  - Fatigue analysis

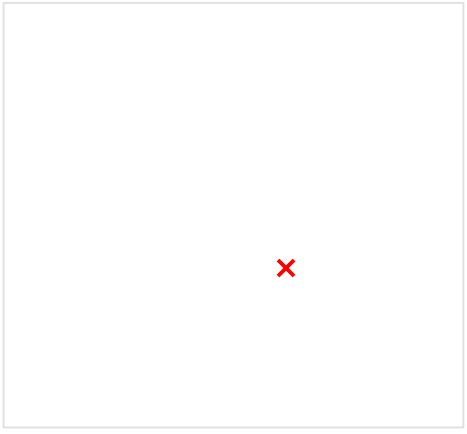
3D Model Design

Thursday, January 09, 2025 12:43 AM

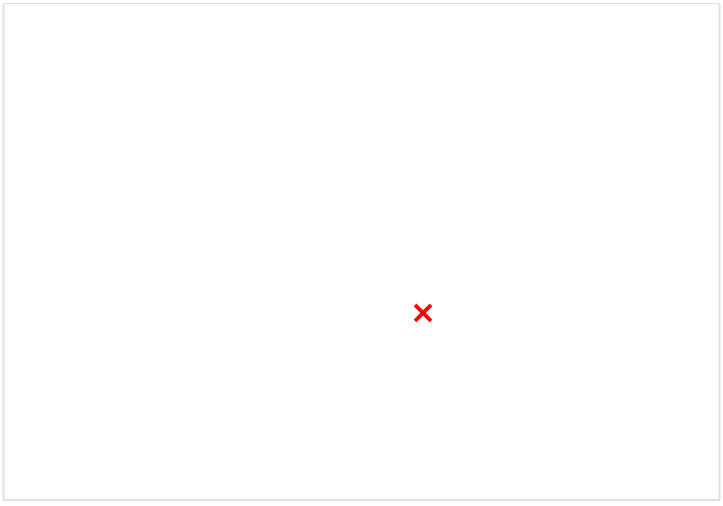


Practice 2

Idea #1- I-Beam

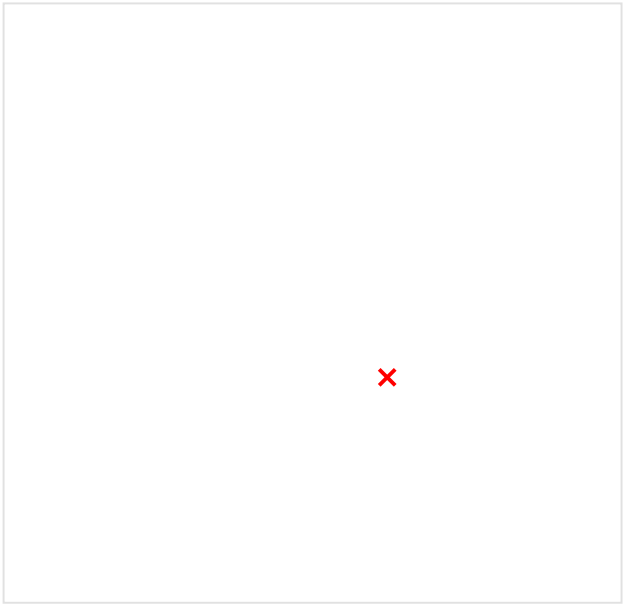


Idea #2- Box Beam/C-Channel



Reseearch more into 2 and 3

Idea #3- Tube



Ian

Friday, December 13, 2024 9:44 PM

Week 1: Analysis

Friday, December 13, 2024 9:44 PM

Component Function: The whisker for the car increases aerodynamic performance by deflecting wind upward, which creates a downforce on the car by directing air flow to the rear wing. Due to the air moving upward, it deflects the car upward, which causes some lift on the wing and whisker specifically.

https://www.researchgate.net/figure/Design-for-controlling-the-side-air-flow-using-a-whisker_fig1_361619881

Design for whisker air flow control

Fake ahh FBD:

IMG_3243

Lily

Thursday, December 19, 2024 12:19 PM

Week 1

Thursday, December 19, 2024 12:21 PM

Problem:

Whisker deflection

- Upwards?? Is from the air off the front wing?
- Only at speeds above 20 mph
- Causes less downforce on rear wing>> causes turbulent airflow.

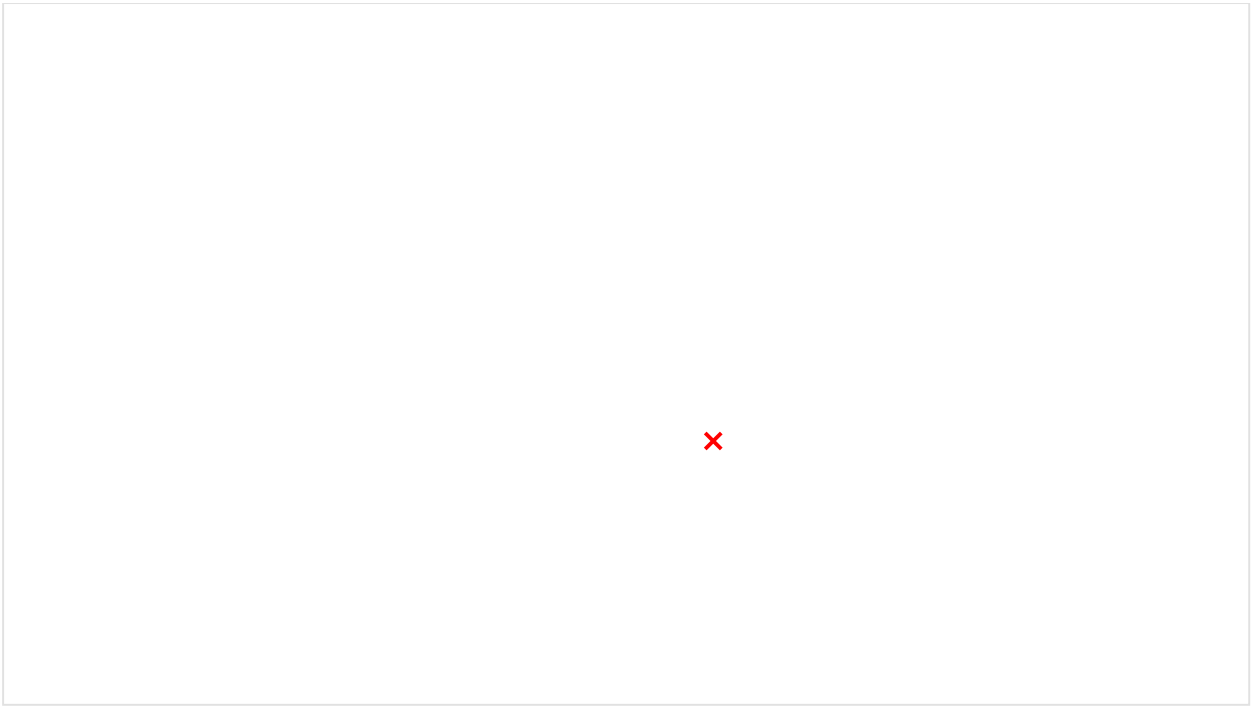
Whisker set up for lift??

Goal:

- Decrease deflection to <0.124” (at tip??) caused by 10lb at CoP.a (.a?)
- No max weight, less weight = better (duh)
- Budget =$50

The function of the spar is to decrease the deflection of the whiskers such that the disturbed air currents do not become redirected over the rear wing causing less downforce.

FBD:



What is max deflectoion:

0.124”

What is F.O.S. :

FOS=x

Will part fatigue:

depends heavily on materials and loadcase

Formulas needed:

FOS

Deflection

Flexure formula

Strain

Stress/strain relationships

DeltaMAX = F L^3 / 48 E I

I = pi/64 (D)^4

deltaMAX = f(E, I) = f(E, D)

Goal Seek function (in excel)

Week 2

Thursday, December 19, 2024 12:35 PM

https://www.onlinemetals.com/en/buy/aluminum/1-x-1-x-0-125-aluminum-t-bar-6063-t52-extruded/pid/21873

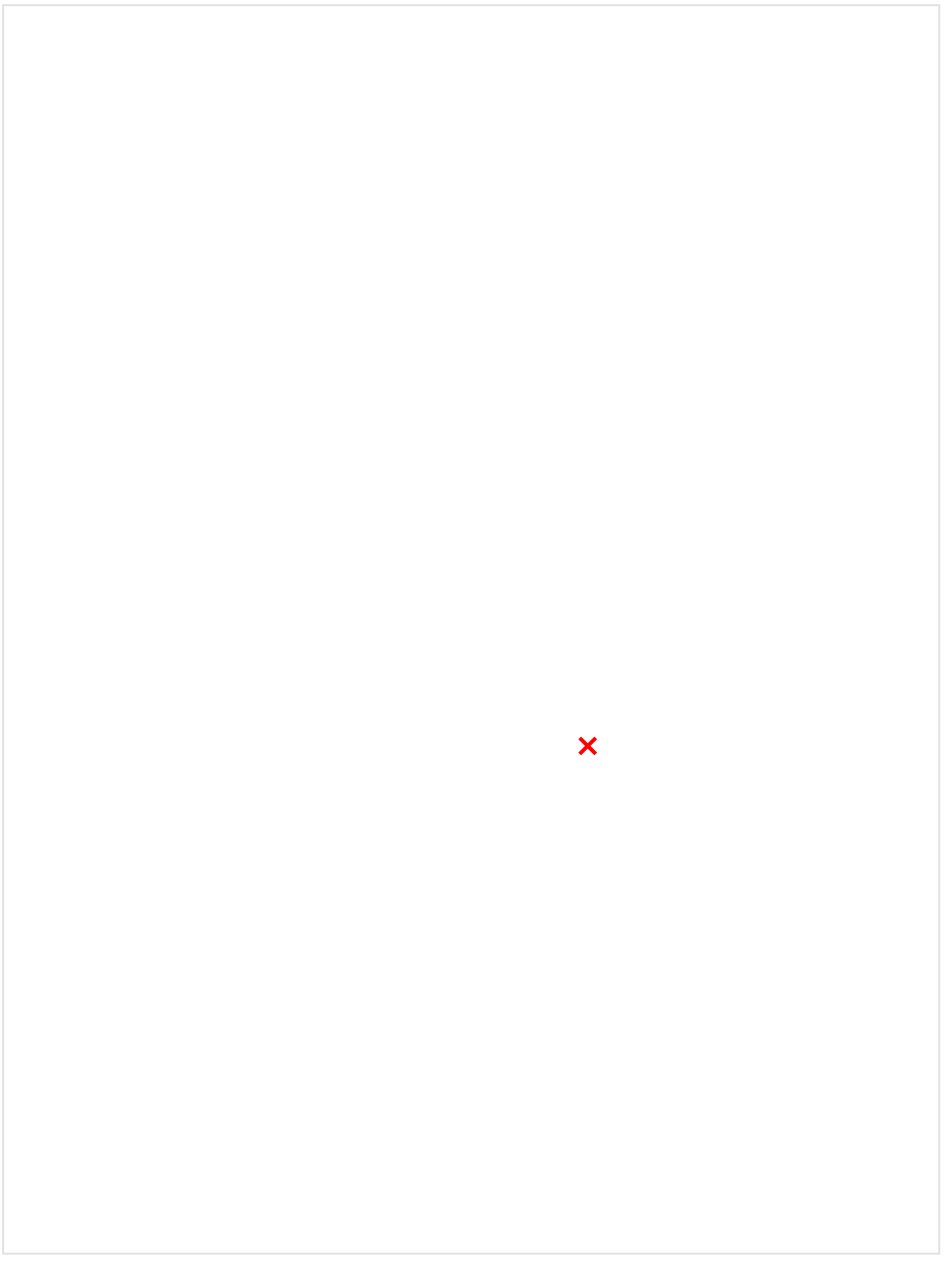
Confirm with FEA

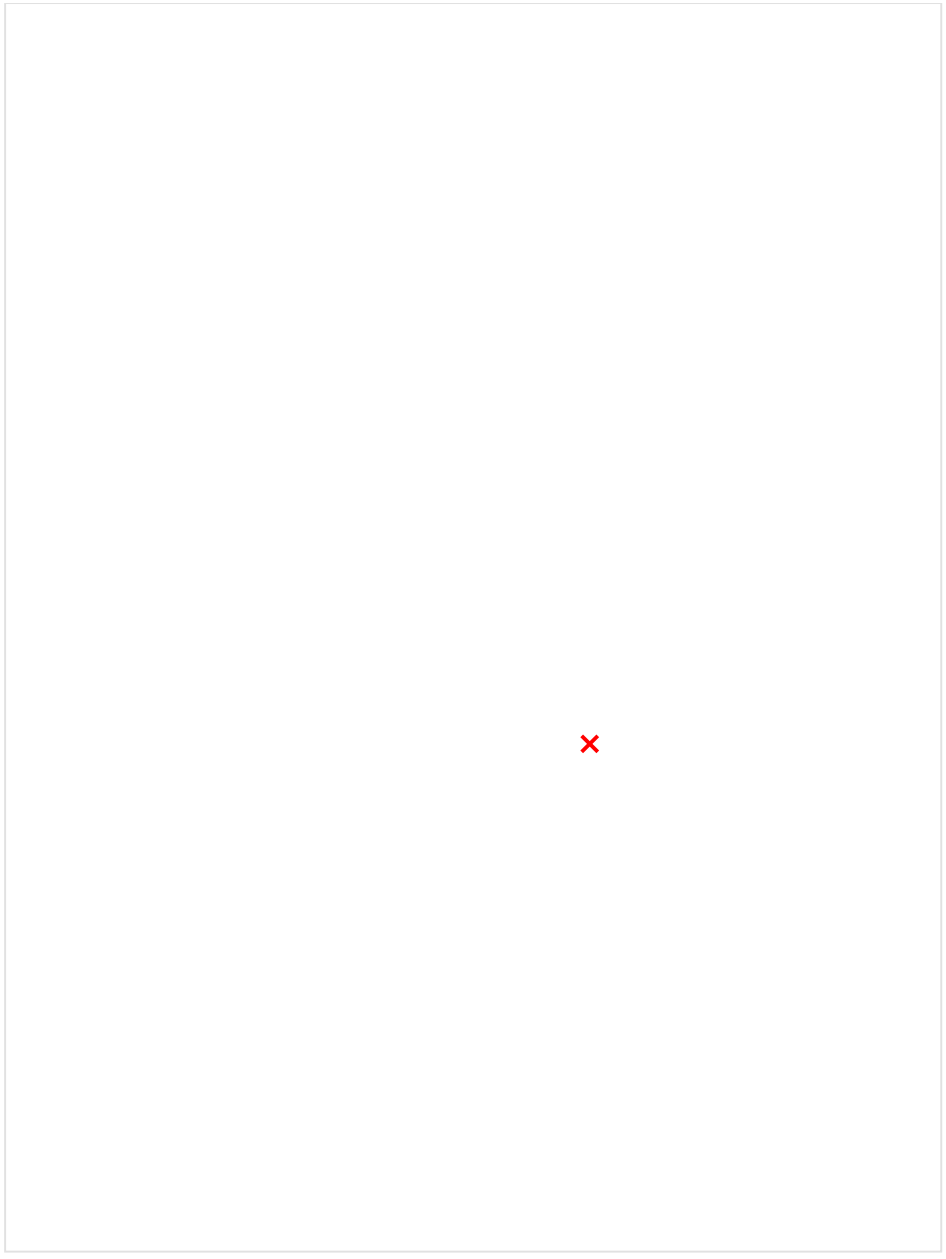
Manufacturing

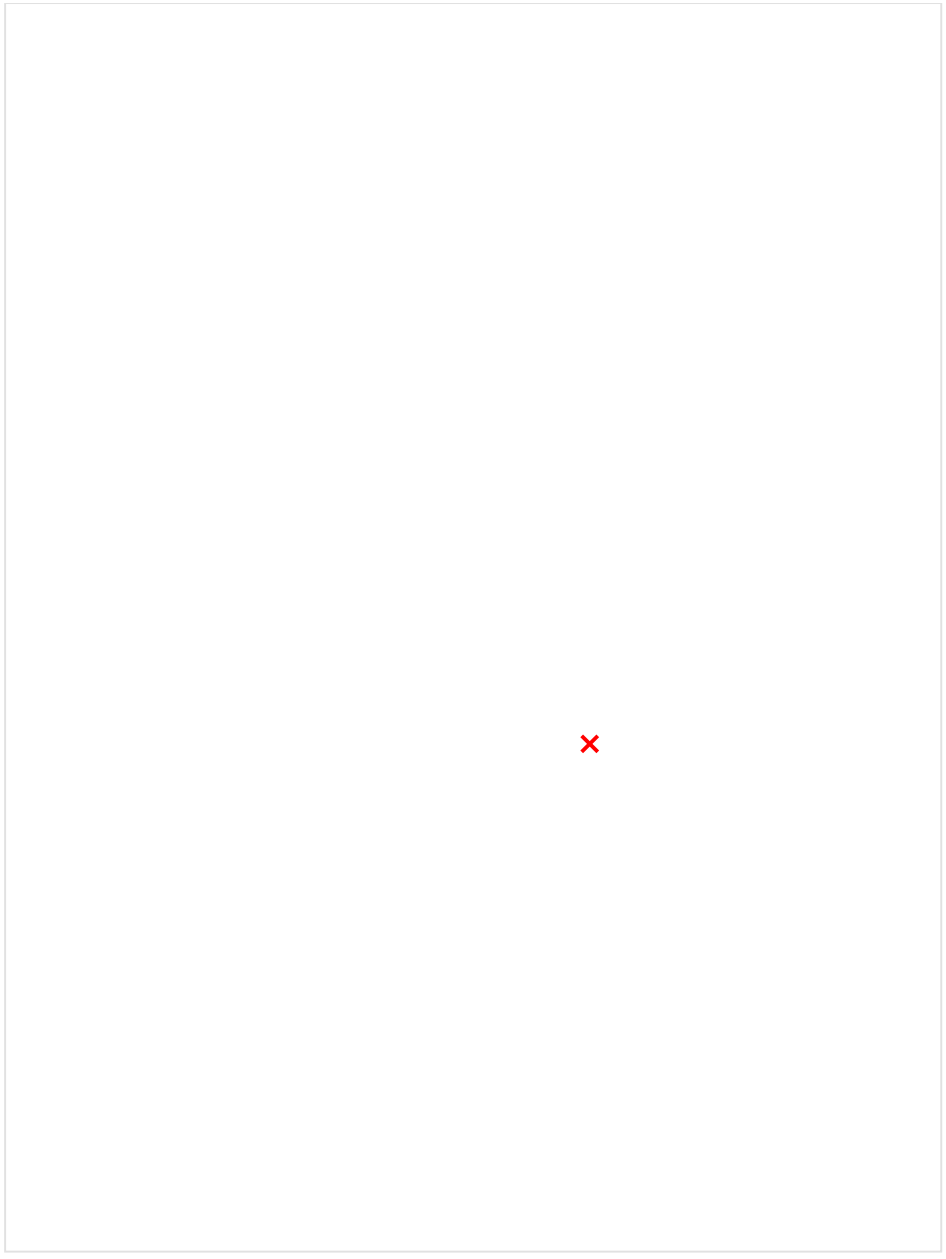
Monday, January 6, 2025 4:08 PM

Endplate Routing

Monday, March 31, 2025 8:43 PM







Post-workday

Monday, March 3, 2025 6:37 PM

Front Wing
- Updated FW TC Tab triangle piece, ~~designed~~, cut, and welded
- TC's cut to length, looped through tabs, and crimped on both ends
- FW TC Tab adhered to wing, Chassis TC Tab welded to car
- FW Mount or mount tab re-drilled to fit wing (Check aero box fitment)
- Final FW Mount tab welded on
- FW checked for aero-box clearance

Rear Wing

Conditional: Car on ground AND level
- Rear wing assembled (Composites)
- Strut inserts manufactured (Manufacturing)
- Strut inserts adhered together, rod ends installed with lock nuts
- Mount onto rear wing with tabs fastened to mount
- Rear wing held up to car, height and levelness checked, tack on tabs, remove mount/wing from tabs
- Finish welding tabs with mount as jig
- Add rear wing with struts to expected length, have tabs on struts, hold wing at level with ground, make tabs contact with chassis, tack in place, remove wing and finish weld
- RW checked for aero-box clearance

Undertray

Conditional: Car on ground and jacking bar in place
- Make sure tabs are on UT
- Slide UT under IC
- Fasten rear tabs to jacking bar
- Measure various distances from chassis to ensure location placement is correct
- Fasten tabs to front tab holders
- Tilt up to make contact to the chassis, tack in place and remove UT
- Finish welds
- UT checked for aero-box clearance

Questions:
- Can bray and Marco do the TCs?
- Will RW be available by Saturday?
- Do we have all the fasteners we need?
  - Make a list

Task List for Week

FW
- [ ] Cut FW TC Tab - Marco
- [ ] Weld FW TC Tab - Marco (or welder)
- [ ] Cut TC's to length, make loops through tabs - Bray or Marco
- [ ] Adhere FW TC Tab to wing (Un-bend the tab that is over-bent) -
- [ ] Weld Chassis TC Tab to wing (AFTER TC IS LOOPED THROUGH)
- [ ] FW Mount re-drilled or mount tab broken off and moved to fit wing (Check aero box fitment with wing first before deciding what to drill)
- [ ] Weld on final FW Mount Tab

RW
- [ ] Rear wing assembled (Composites)
- [ ] Struts manufactured (Manufacturing)
- [ ] Struts assembled
- [ ] Mount added to RW

UT
- [x] Check UT for tabs

Bolt & Nut List

Thread	Length	Head Type	Nut Type	QTY	For
1/4-28	3/4"	Hex or Allen	Locking	4	UT
10-32	>.375"	Allen	Locking	4	FW Mount
10-32	>1.5"	Hex or Allen	Locking	4	FW Tabs
10-32	>.5"	Hex or Allen	Locking	6	RW

IC Aero On

Tuesday, February 25, 2025 9:07 PM

Need:

- [x] Fasteners accounted for
- [ ] Tension cable tabs welded and adhered (by sat)
- [ ] Tension Cables assembled (lengths should be defined)
- [ ] IC FW Tabs welded by friday

Fasteners

Bolts

Thread	Shaft Length	Overall Length	Head	Quantity
10-32	N/A	1-1/2	Socket	8
10-32	N/A	1/2	Socket	12
10-32		5/8	Round Socket	50

Nuts

Thread	Type	Quantity
10-32	Distorted	25
1/4-20	Distorted or Nylock	10
This	Mil. Spec. Distorted-Thread Flange Locknut, Low-Strength Steel, with Lubricant, 1/4"-28 Size, MS21042L-4 | McMaster-Carr	10
And this	Cadmium-Plated Steel Hex Head Screw, Medium-Strength, 1/4"-28 Thread Size, 17/32" Long | McMaster-Carr	10

Washers

- Can be any 10-32, but these guys work (QTY 25)
  - 18-8 Stainless Steel Washer, for Number 10 Screw Size, 0.203" ID, 0.438" OD | McMaster-Carr

To-Do List

Wednesday, January 29, 2025 10:53 AM

FW

- [ ] FW Mount Jig Reviewed and made
- [ ] Tabs bent
- [ ] Tabs welded

RW

- [ ] RW Mount Jig
- [ ] Tabs welded
- [ ] Strut Inserts Manufactured
- [ ] (IC) Tubes Cut to length
- [ ] Strut inserts assembled

UT

- [ ] Tabs manufactured
- [ ] Tabs Bent
- [ ] Tabs Welded
- [ ] Positioning checked

Miscellaneous

Before putting everything together:

- [ ] Make sure we have all of the hardware required
- [ ]

Manufacturing/Ordering Checklist

Monday, January 6, 2025 4:08 PM

All components (Structures)
- ~~Endplate Inserts DRS~~
- ~~Endplate Inserts non-DRS~~
- Strut Inserts
- Outer Ribs
- 8C Swan Neck
- 8C/E FW Mount
- 8C/E Swan Neck Tabs
- 8C/E Strut Tabs
- 8C/E FW Mount Tabs
- 8C/E Undertray Tabs

Ordered Components
- iGus bushings
- e-rigging order
- McMaster Order

Tabs: Manufactured

EV:
- [x] RW Mount
- [x] RW Strut
- [ ] UT Rear Tab
- [ ] UT Front Tab
- [x] FW Tab

IC:
- [x] RW Mount
- [x] RW Strut
- [x] UT Rear Tab
- [x] UT Front Tab
- [x] FW Tab

Inserts: Manufactured

EV:
- [ ] Strut
- [ ] Endplate
- [ ] Endplate Mainplane

IC:
- [ ] Strut
- [ ] Endplate

Mount: Manufactured

EV:
- [ ] RW
- [ ] Strut CF

IC:
- [ ] RW
- [ ] Strut CF

Tension Cables
- [ ] Bond calculations/Mount Design
- [ ] Upper Tab Design finalized
- [ ]

Tabs: Welded

EV:
- [ ] RW Mount
- [ ] RW Strut
- [ ] UT Rear Tab
- [ ] UT Front Tab
- [ ] FW Tab

IC:
- [ ] RW Mount
- [ ] RW Strut
- [ ] UT Rear Tab
- [ ] UT Front Tab
- [ ] FW Tab

Inserts: Assembled

EV:
- [ ] Strut
- [ ] Endplate
- [ ] Endplate Mainplane

IC:
- [ ] Strut
- [ ] Endplate

Mount: Assembled

EV:
- [ ] RW
- [ ] Strut CF

IC:
- [ ] RW
- [ ] Strut CF

Assembly Checklist

Friday, January 10, 2025 7:55 PM

- [ ] Tension Cables

Side Panel

Monday, October 14, 2024 8:09 PM

Side panels

Geometry
- Not interfering with chassis tubes
- Offset by thickness of gap fillers

CAD
- Put final CAD in PDM, main assembly
- Need mold CAD

Manufacturability
- No complex or unnecessary curvature

Panel Gap fillers

Weight
- Compare weight to current tape
- Identify what panels should be changed

attachment
- Adhesion, clamp on, etc

Side panel CAD

Monday, October 14, 2024 8:25 PM

Requirements:

- Manufacturability
- Does not interfere with chassis
- Manufacture tolerances

Started with this surface but the curvature here is Unnecessary and suboptimal for manufacturing

David made a design but it had uneven spacing from the chassis tubes, could be improved

New method of surface modeling led me to make this current model. For future reference I drew a new 3D sketch on top of the chassis tubes and used that sketch to create a lofted surface. Need to finalize some point and line placements. Also still need to place the cad in assembly

Cad done. There is a 0.315 inch offset from chassis. This can be adjusted to thickness of whatever gap sealant we use. There is no interference with chassis tubes. Mihai said I need to fillet the edges but I don't know how.):

Gap filler Analysis

Monday, October 14, 2024 8:09 PM

Panel Gap fillers

Weight
Compare weight to current tape
Weight of 1 foot of tape:
29 oz./in.

Weight of 1 foot of gap filler:
0.86 g/cm3

Check current gaps on car to find width/length of gap filler needed

Thickness of gap filler 0.315" and 0.591" wide

Style E,

0.591"	0.315"	Acrylic	-100° to 175°	-5° to 130°	Yes	Black	10	93085K775	3.37	2.85

https://www.mcmaster.com/93085K775

~20 inches of contact space on both sides of the nose cone = ~3.33 ft * $3.37 per foot = $11.23

These types of fillers are prone to falling off the panels and the surface area connecting to the chassis would be small, leading to not much of a seal.

There are plenty of options with channels but we would have to design with these channels in mind beforehand. The gap we have doesn't really fit for this kind of seal though so its not worth investigating.

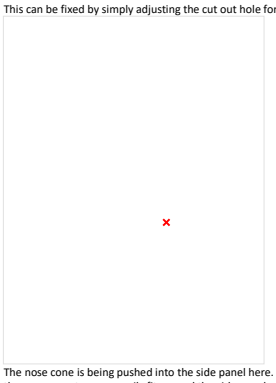
This is what I think is the best, it has adhesive so it will stick to where we want, the simple shape allows it to fit perfectly in the gaps. Also its cheap. There are different options for thicknesses in case we decide to increase or decrease its thickness. I believe the 0.315" by 0.591" would be good because it offers 1/2" contact area which should be plenty, it also is thin enough to not cause any issues with interference and can easily form around the panels due to it's rubbery material.

For the side panels we should just keep using tape, there is no real reason to change

Reason for deformation of current side panel

This is caused by the nose cone pushing into the side panel. It is only on the IC and not the EV. Here is the EV

This can be fixed by simply adjusting the cut out hole for the suspension



The nose cone is being pushed into the side panel here. By cutting a slightly larger hole, we can allow the nose cone to more easily fit around the side panels, stopping the deformation.

RW Stiffness

Sunday, September 29, 2024 12:32 PM

Analysis

Sunday, September 29, 2024 12:33 PM

RW Mount

Friday, September 27, 2024 3:48 PM

8C Analysis

Friday, December 13, 2024 8:39 PM

Simulation 1: 8E fit to 8C

Max Stress: 27ksi

FoS: 1.4

Displacement:

Simulation 2: Rear Truss moved near vertical.

FoS: 1.6

Simulation 3: Increased Thickness all around

Displacement: 0.17"

FoS: 1.9

Simulation 4: Length of rearward member increased (height raised)

Displacement: 0.121"

FoS: 2.2

Reverse Load Case

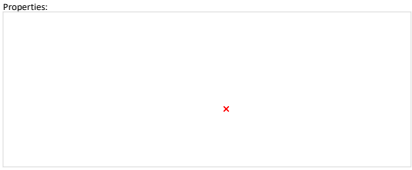
50 lbf upwards, 50 lbf car front, derived from Quang's simulations

Same load & fixtures as main load case

Results:

Carbon Rod Calculation

Properties:



Unnatural stress from contact

Simulation 5: Fillets Adjusted. Space for Cross Brace Weld Added.

Displacement: 0.122"

FoS: 2.1

DRS

Thursday, September 26, 2024 7:56 PM

High Priority Items

Tuesday, November 5, 2024 8:27 PM

- [ ] Make hard stops for open and closed.

General Notes

Friday, August 9, 2024 2:42 PM

DO THIS
- Shoulder of shoulder bolt must contact spacer, adjust play with endplate insert

Things to Fix
1. Flap 1 leading edge match CAD
2. Indexing feature for ribs during layup
3. Linkage redesign between flap 2 spacer and link 8
4. Linkage and bolt wear. Use shoulder bolts
5. New bonded rib, rotation point near COP
6. Endplate lateral stiffness increase

Design Considerations

Cornering Speed Analysis
- Compare cornering speed delta between open aero and closed aero
  - Do all in optimum lap to get a consistent delta
  - Use time delta to calculate points gain.
  - Find weight increase to offset points gain, including every event.
  - Compare top speed increase (by using no aero config in optimum lap) of autocross

1. **Endurance Cornering Speed: Open vs. Closed w/ DRS Weight**
   - **a.** Lap time delta
   - **b.** Include energy limit through power consumption
2. **Autocross Straight Speed: Open w/ DRS weight vs. Closed**
   - **a.** Lap time Delta
3. **Skid Pad: Weight difference**
   - a. Lap Time Delta
4. **Accel: Weight Difference**
   - a. Time Delta

To-Do
- [ ] Create endurance, autocross, skid pad, and accel tracks in OL
- [ ] Define max power usage in straights of endurance that equates to 260 kwh/lap (Use max accel speed data from 2024 EV Comp? Increase by some factor to equate?)
- [ ] Define frontal areas and coefficients
- [ ] Do the work

Assumptions
- 260 kWh/lap accounts for pack within thermal load limit
- Downforce changes due to pitch, yaw, and roll are accounted for with 10% decrease in aero performance in corner.
- Loss of lap time dependent on speed difference out of corner between configurations
- DRS weighs _____ lbs from Joey's CAD, add 10% for wiring, boards, and misc additions
- CG shift is negligible.

DRS Weight: .34774 (kg)
Car Weight No DRS: 287.578 (kg)
Car Weight w/ DRS: (kg)
Cl Open: 0.92
Cd Open: 0.68167
Cl Closed: 2.079
Cd Closed: 1.815
Frontal Area Open: 9.606706e-01 (m^2)
Frontal Area Closed: 1.146118e+00 (m^2)
Top Area Closed: 0.8087835705 (m^2)
Top Area Open: 0.832982205 (m^2)

Question Hit List
- [ ] How will it rotate? What options are available?
- [ ] How will the rotational component connect to the endplate?
- [ ] What makes the endplate not rigid and what is that solution?
- [ ] Can we change the point of rotation? How does this affect linkages?

What needs to be done?
- [ ] Verification of acceleration/cornering speed
- [ ] When does it activate?
- [ ] Linkage update
  - [ ] Re-design flap 2 and link 8
- [ ] Point of rotation selection
- [ ] Rotation method
- [ ] Servo location (Will being on the end cause instability?)
- [ ] Low friction surface between endplate and rib
- [ ] Use justification (Energy Usage) (Aero On/Off Testing) (Whole Comp Points Difference On/Off)

Testing
- [ ] Aluminum Spacers and Linkages
- [ ] Code for servos
- [ ] Method for measuring LV draw

1st to 2nd Iteration To-Do
- Flap 3 Spacer CAD change to make space for articulation
  - Thicken middle hole wall thickness
- Re-make endplate attachment posts
- Make hole in bottom of spacer 1

Preliminary BOM

Water Jet Parts

Item	Cut Area (in^2)	$/in^2	Thickness	Total
Linkages	47	0.15	0.125	$8
Mainplane Spacer	120	0.26	.25	$31

Milled Parts

BOM

Thursday, September 26, 2024 7:56 PM

Preliminary BOM

Water Jet Parts (Aluminum 6061-T6: Subject to change)

Item	Cut Area (in^2)	$/in^2	Thickness	Total
Linkages	100	0.15	0.125	$16
Mainplane Spacer	240	0.26	.25	$60

3D Print Parts (PLA: Subject to Change)

Item	Volume (in^3)	$/in^3	Total
F1 Spacer	2.6	0.0244	<$1
F2 Spacer	<F1	0.0244	<$1
F3 Spacer	<F1	0.0244	<$1

Fasteners (From Joey's SDII Report)

Item	Qty	Cost
Counter Sink	10	$3.21
3/8" 10-32 Button Head	50	$8.74
Low Profile DT Nut	10	$3.47
5/8" 10-32 Button Head	25	$9.79

Total: $105

Notes:

- Servo and various fasteners/links have already been purchased/made, significantly reducing cost
- Materials and design are subject to change for engineering purposes
- A more comprehensive BOM will be made when more design decisions are completed

CAD Change List

Monday, October 21, 2024 6:51 PM

Oct. 21, 2024

- Endplates increased to .3"
- Configuration added "DRS"
- Rotation holes increased to 0.5"
- Endplate extended RW 0.25"

270.92762848mm
6.350000mm

Project Proposal 2 Info

Wednesday, October 23, 2024 12:06 AM

-

FW Mount

Wednesday, September 25, 2024 9:47 AM

General Notes - FW Mount

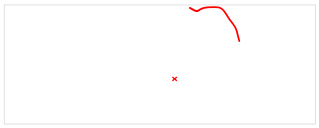
Thursday, September 12, 2024 6:32 PM

Problem:
- Oscillation
- Reposition limited by chassis and swept wing

Solution:
1. Spar cut to bottom
2. Lightweight mount forks (remove bend at mounting point)
    a. Increase Area Moment of Inertia
3. Tension cables through old body holes

Hit List
1. Select and add tension cables
2. Remake Ribs for bottom spar cut
3. Re-design mount forks

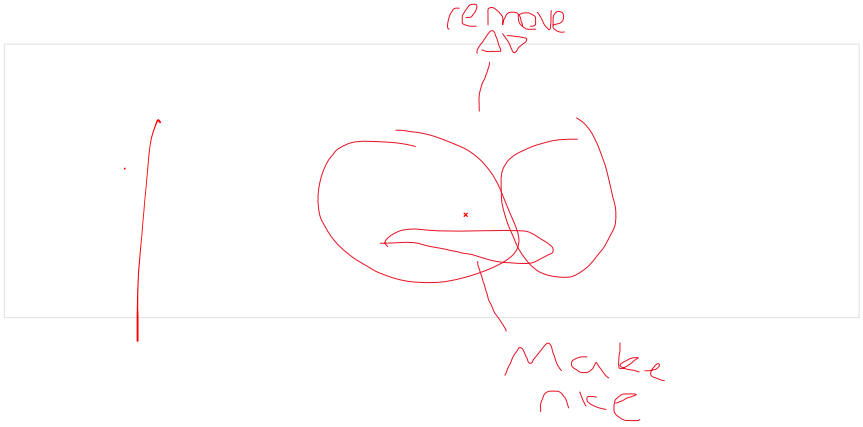
Things I need to come back to:
- [ ] Front eye over CoP
- [ ] Lightweighting
- [ ] Hand Calc Tab Welds
- [ ] Hand Calc Rivnut to Carbon Connection



Max Disp under 50 lbs - 5mm

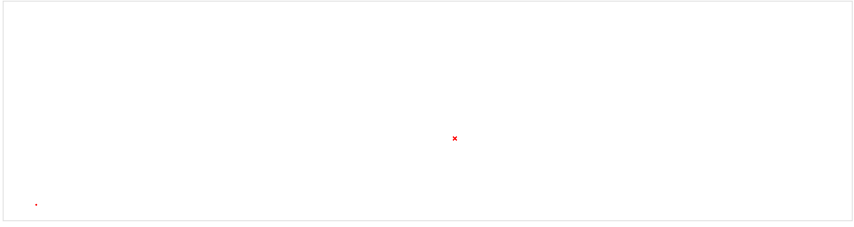
Tension Cable Hardware

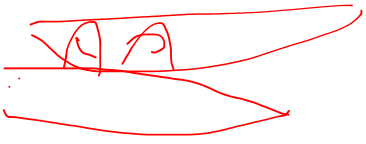
Part	Cost (Total)	Link	Notes
Loop to Loop Cable	$30	https://www.mcmaster.com/30645T342	8 in 4 Total 400 lbs
Turnbuckle	$55	https://www.mcmaster.com/30315T611	Order matching Jam Nuts 300 lbs 5 1/4" Retracted Length 2 total
Routing Eyebolts	$20	https://www.mcmaster.com/9490T4	Need 2 Jam Nuts 2 Total 1/4-20
Custom Spar Insert	N/A		Aluminum 1" Adhesion Surface ~3/4" Thread Depth 1/4-20 Thread

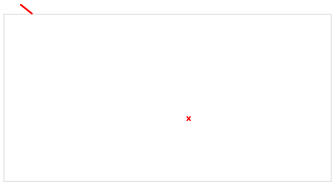


To Do
- [x] Design 2 different height mounts
- [x] Design TC spar connection plate
- [ ] PP Doc

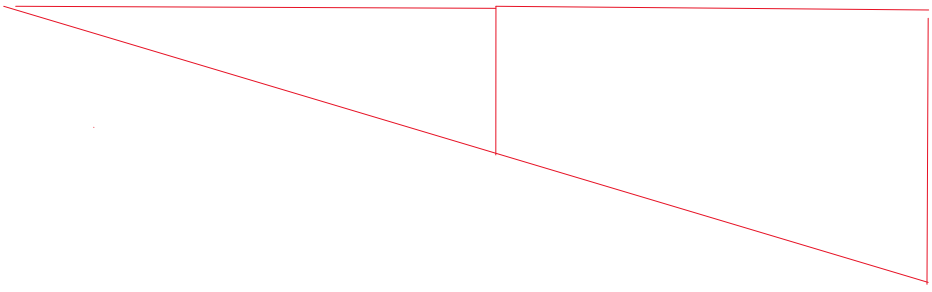
Quantification
- Deflection at wing tip under multiple loads
- Deflection of mount with same load (Compare mount and wing deflection)
- Deflection when driving (Can compare to interpolated data to find rough load measurement)

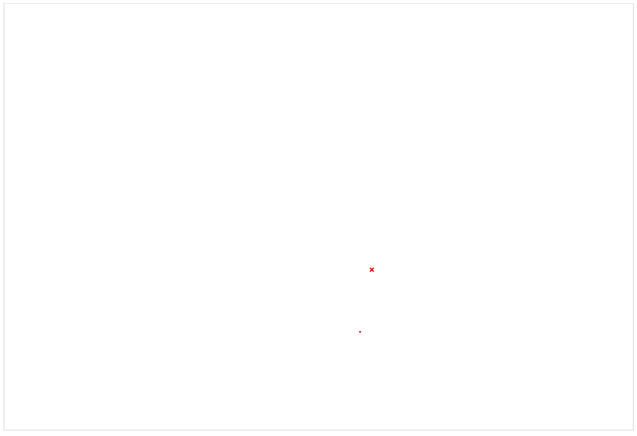


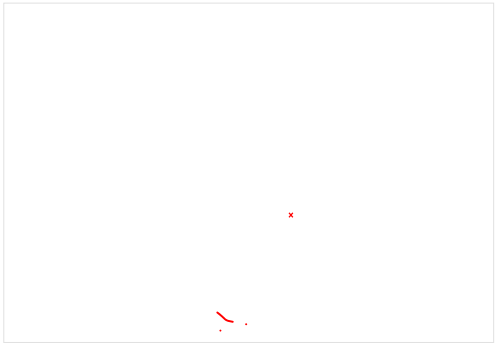


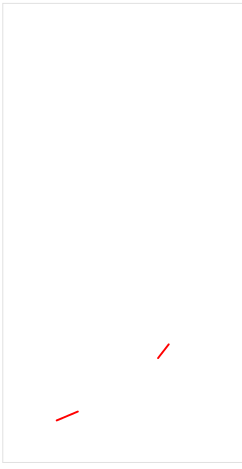


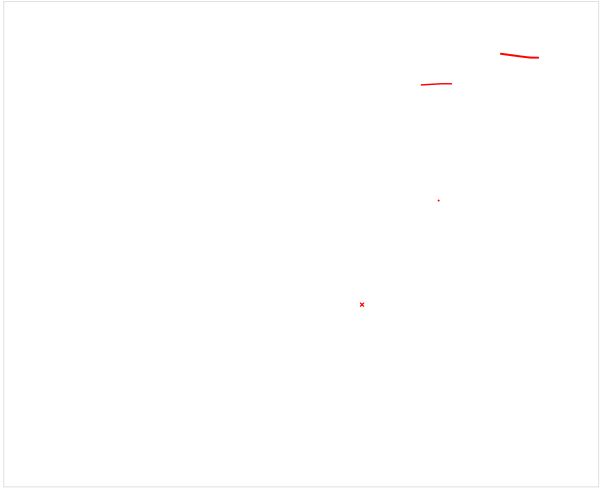
1 in dia

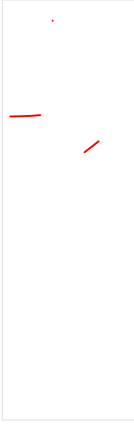


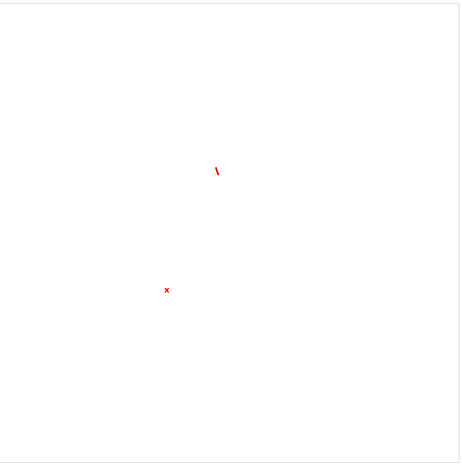












Rev 1 Assembly

Wednesday, October 16, 2024 12:12 PM

TC BOM:

Wire (150lb - 10ft): https://www.mcmaster.com/3461T45

TB (Qty: 2) : https://www.mcmaster.com/30315T57

Clamp (Qty: 24): https://www.mcmaster.com/30325T14
or
Crimp (Qty: 8): https://www.mcmaster.com/3897T23

Carabiner (Qty: 2): https://www.mcmaster.com/3933T12

Rivet Nuts (10-24)(Qty: 10 pk): https://www.mcmaster.com/97217A361

Eyebolts (10-24)(Qty: 4): https://www.mcmaster.com/9489T514

Design Document

Wednesday, October 16, 2024 11:55 AM

Topics

- Reasoning for Tension Cables
  - Show Difficulties/downsides of other mounting methods
- FEAs with & w/o tension cables
  - Max load, kick, misuse, cone impact
  - Rivnut connection hand calcs
  - Welded area calcs
  - Explain TC tensioning philosophy
- New BOM
- Fishing line test

GET BOM TO MIHAI AND ASK FOR EXTENSION ON OTHER PARTS

Deflection Quantification - FW Mount

Wednesday, September 25, 2024 9:47 AM

Purpose

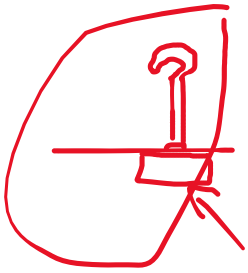
Measure the deflection caused by a specified moment about the center of the wing rotating along the x-axis (or length) of the car. Quantify how much deflection is contributed by mount deformation and how much is contributed by wing deformation.

Test 1

Method

1. Weight the wing with a load that produces a set moment about the center. Measure the deflection at the endplate
2. Weight the mount with a load that produces the same moment about the center. Measure the deflection at the endplate.
3. Compare Results

Procedure & Data



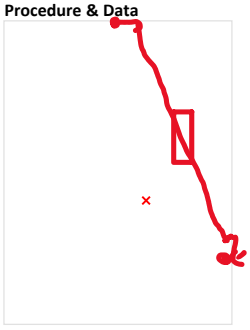
The first picture shows weight on the wing and a dial indicator on the endplate. The second picture shows the method of measuring weight on the mount, with a dial indicator in the same position as the first step. The car was secured on the chassis to limit deflection from the suspension or other compliant components.

Test 2

Method

1. Weight the wing with a load that produces a set moment about the center. Measure the deflection at the endplate
2. Move dial gauge and measure defection at the mount.
3. Calculate theoretical endplate deflection assuming rigid wing using similar triangles.

Procedure & Data



The dial indicator is now measuring the deflection from the weighted wing but purely at the mount. This isolates any bending in the wing.

The data shows that a majority of the wing deflection occurs from the mount rather than the wing itself, however about 0.5" is produced by the wing at the maximum moment.

Conclusion

Discussion

This data shows that there is an equal displacement between each measurement, which would conclude that the mount is the prime contributor to the deflection seen during operation.

However, it may be complete coincidence that these two points exhibit a similar stress-strain relationship under these conditions. It is entirely possible that there is no mount deflection during the first measurement, and this test did not highlight that.

Another test will be done to isolate this possibility. The dial gauge will be set on the mount and the weight will be placed on the wing. Using trigonometry we can identify the endplate position from mount deflection and see if it matches the previously measured point.

The data shows that a majority of the wing deflection occurs from the mount rather than the wing itself, however about 0.5" is produced by the wing at the maximum moment.

Conclusion

Increasing mount stiffness is the primary way to reduce torsional wing deflection.

Tension Cable Equipped Mount

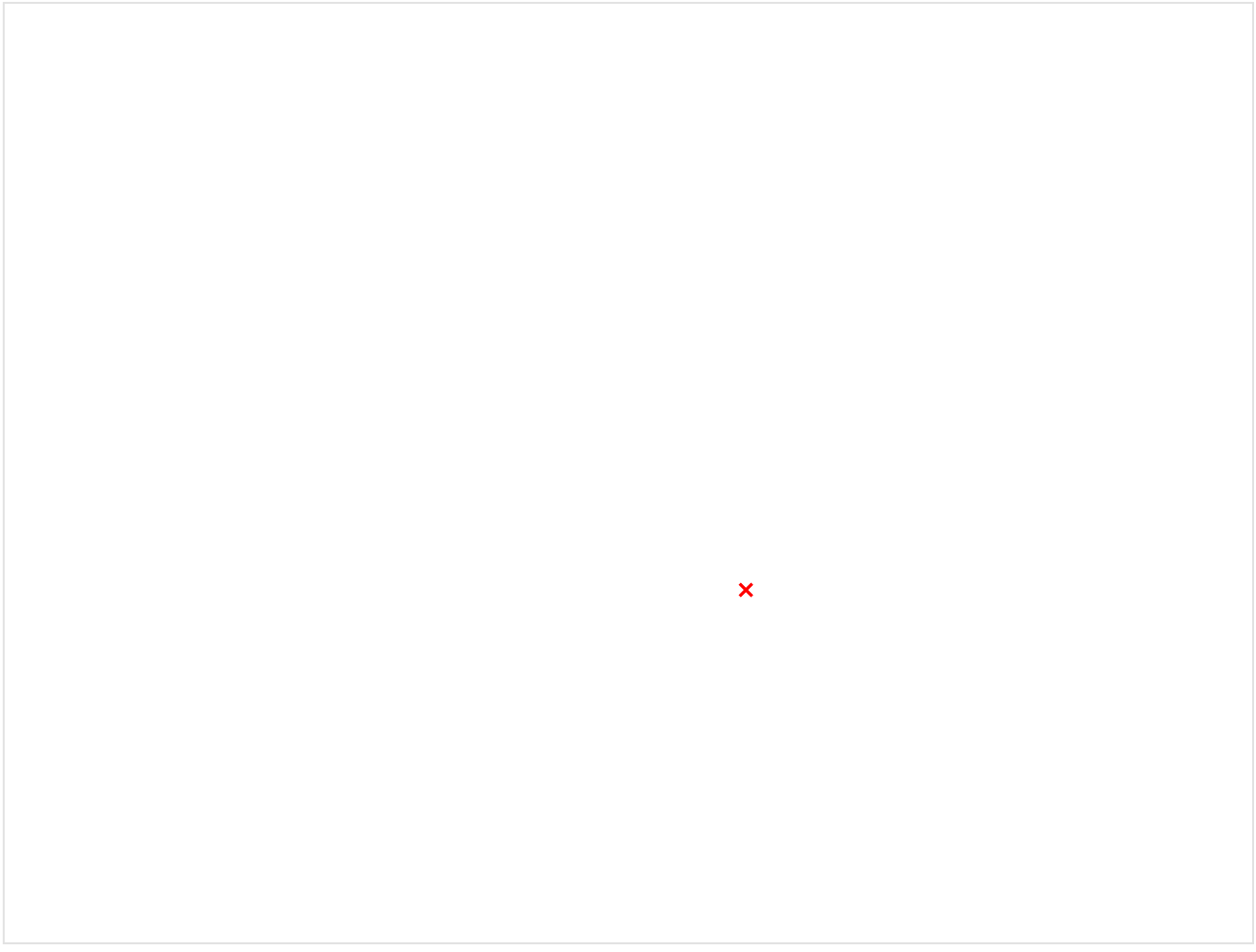
Tuesday, October 8, 2024 3:46 PM

Goals:

1. Improve Wing adjustment/tool accessibility
    a. Change lateral stiffness strategy/flat instead of L bracket
2. Reduce weight
    a. Stiffness target may possibly be smaller because of tension cables

Mount Change List

1. Front tab hole moved 1 in forward to reduce a value

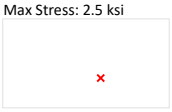


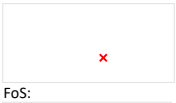
TC Mount FEA Notes

Thursday, October 10, 2024 8:20 PM

Max Lift + Bump

Max Stress: 2.5 ksi



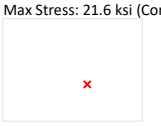


FoS:

Max Displacement: 0.6mm (Leading Edge)
TC Load: 109 lbs (Both)

40 lbf Side Force

Max Stress: 21.6 ksi (Corner in Rib). 6 ksi (Cross Brace)



Chamfer ^

FoS: 1.8

Max Displacement: 1.5mm

TC Load: 10 lbs (Opposite Side)

Cone Impact (40 mph)

Deflection Test

May want TCs to have no pre load to give more weight to mounts

Max Force: 110lbs

BOM:

Wire (150lb - 10ft): https://www.mcmaster.com/3461T45

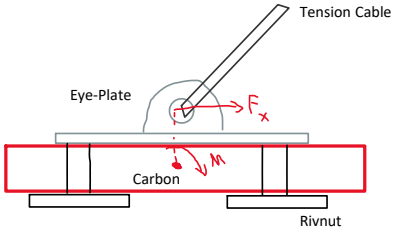
TB (Qty: 2) : https://www.mcmaster.com/30315T57

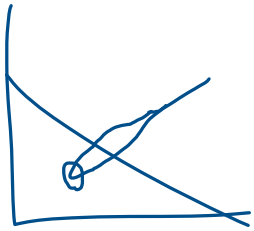
Clamp (Qty: 24): https://www.mcmaster.com/30325T14
or
Crimp (Qty: 8): https://www.mcmaster.com/3897T23

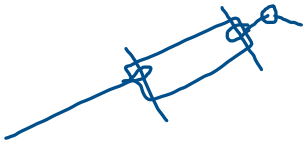
Carabiner (Qty: 2): https://www.mcmaster.com/3933T12

Rivet Nuts (10-24)(Qty: 10 pk): https://www.mcmaster.com/97217A361

Eyebolts (10-24)(Qty: 4): https://www.mcmaster.com/9489T514







FW TC Tab

- Max 68 Mpa (well within elastic region)
  - Sim not the greatest, but worst worst worst case scenario with lots of breathing room

Calcs (Short for….)

Tuesday, October 15, 2024 5:12 PM

Mount

Cross Brace

Buckling FoS: 2.4

Tension Cables

FoS (S_e) = 3.6

Tabs

Spar
Chassis

TC Connections

Thursday, February 13, 2025 6:46 PM

Chassis Connection

- Tab in corner
- Eye bolt in tab in rivnut
- Tab in corner with loop welded

Component Notes

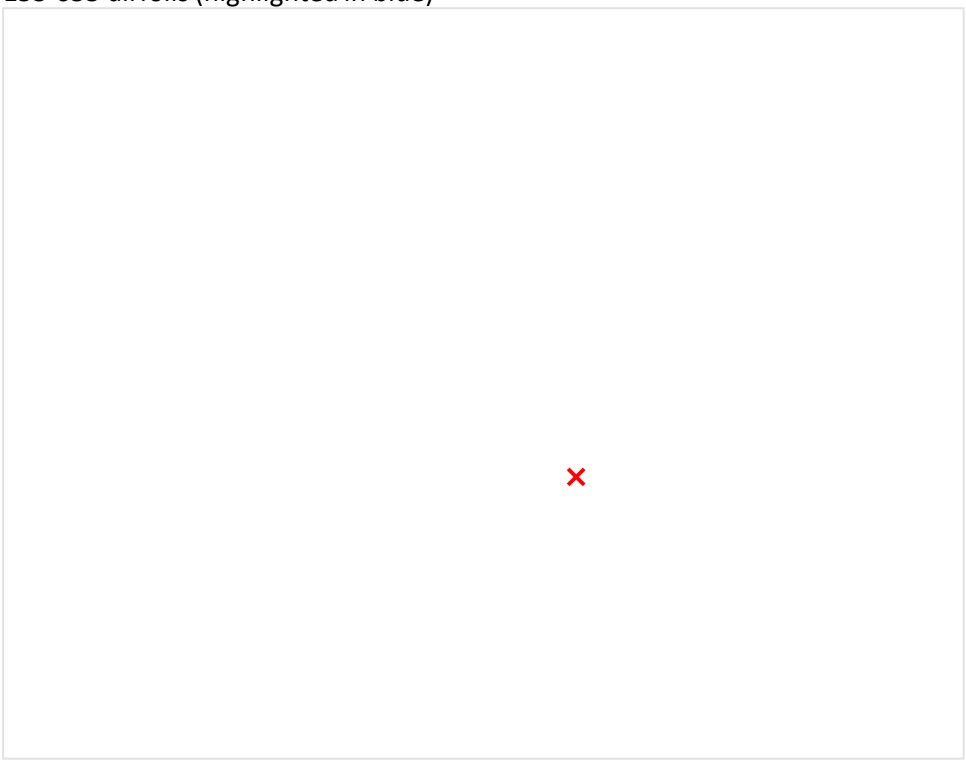
Tuesday, May 28, 2024 16:48

This section houses all of the main aero package components and subpages dedicated to lessons learned (problems we find or good things to continue) and resources related to the component.

FW

Monday, March 24, 2025 10:36 PM

The elements of the front wing are a mix of benzing 122-155 airfoils (highlighted in red) and benzing 153-055 airfoils (highlighted in blue)



Note that the label on the drawing above is wrong but it has been corrected in the current 3 view

For more information about these airfoils visit
http://www.benzing.it/enrico.profili.htm
Front wing designed by Nathan Farlie

Undertray

Sunday, July 7, 2024 2:33 PM

Failures/Shortcomings

Sunday, July 7, 2024 2:50 PM

Mounting

Problems	Causes
- Front UT must be bent to meet mounts, rear mounts had to be bent down to meet UT	- Mounts were not fabricated correctly and iterations were made. Currently, they aren't meant to touch the UT.
- Rear deflects significantly when pushed on. Possibly causes scraping from oscillation.	- Rear mounts are too far from the rear of the UT, so it is left unsupported

DRS

Wednesday, June 26, 2024 8:19 PM

Things to Fix

1. Flap 1 leading edge match CAD
2. Indexing feature for ribs during layup
3. Linkage redesign between flap 2 spacer and link 8
4. Linkage and bolt wear. Use shoulder bolts
5. New bonded rib, rotation point near COP
6. Endplate lateral stiffness increase

Design Considerations

KS8 Iteration Ideas

- R

Summer Testing

- [ ] Code for servos
- [ ] Method for measuring LV draw

1st to 2nd Iteration To-Do

- Flap 3 Spacer CAD change to make space for articulation
  - Thicken middle hole wall thickness
- Re-make endplate attachment posts
- Make hole in bottom of spacer 1

Current Status

- Manufacturing issues cause DRS not to run properly. Identify what needs to be remanufactured, check feasibility, and make a decision on what to do.

Testing

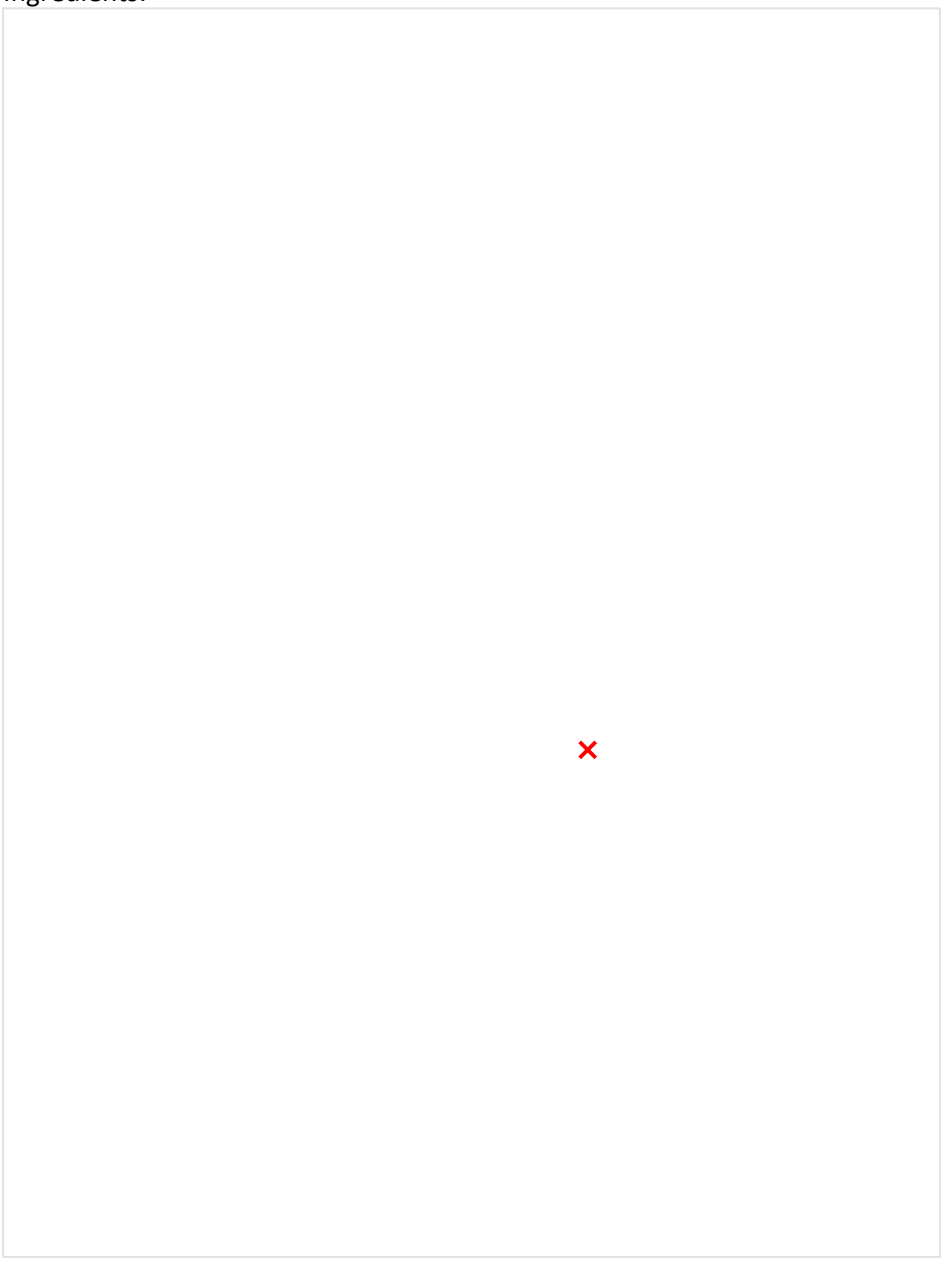
Saturday, May 11, 2024 11:00 AM

Section Contents:

Flow Vis

Wednesday, September 11, 2024 00:53

Ingredients:



Mixtures:

Mid-Corner On/Off Testing

Monday, August 12, 2024 6:57 PM

Methods

- Circle with different radii

Aero/Suspension Tuning

Monday, August 12, 2024 6:12 PM

What's wrong?

- "Oversaturated" feeling (Too much grip)

Plan of Action:

- Make incremental adjustments and note driver feel changes
  - Change toe, tire pressure, high and low speed damping
- With best set up, compare before and after
- Try before and after with other drivers
- Run autocross to "feel" it out, can use skid pad or to compare best to original

Sammy's Plan

- Run 3 different "set-ups"
- Get 10 laps per set-up
  - Account for cooling
- Run Saturday. Come in at 8 and run by 10.

Data Acquisition

- [ ] Driver Feedback
- [ ] Initial Setup/New Setup
  - [ ] Brake bias shift to rear
  - [ ] Toe Shim # (Rear first, then front)
  - [ ] Tire Pressure
  - [ ] High Speed Damping
  - [ ] Low Speed Damping
- [ ] Lap Time
- [ ] Yaw Rate

On/Off Testing

Monday, July 8, 2024 8:47 PM

Deliverables:

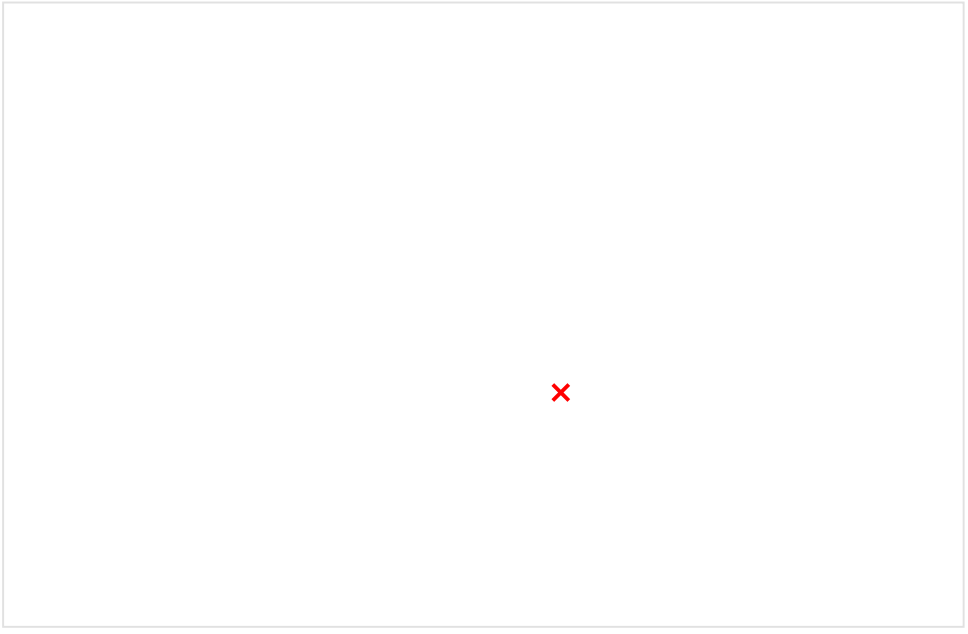
- Driver feedback. This means there should be space to take qualitative notes.
- Daq to driver feedback correlation
    - Where the car understeers and oversteers
- Comparative lap times. Are they faster with Aero on? What are the limitations to comparing these?
- SOC vs. Top Speed on straights.

Data Usage

- Performance validation
- Change requests based on driving feel (Does the FW get choked?)

Procedure

1. Set up autocross track with adequate corners that provide a variety of aero conditions
2. Have the driver run this until they feel comfortable and fast, 10 laps
    a. Record times
    b. Take shock pot, vector nav, steering angle (part of vectornav?) data to see oversteer, understeer, and COP shift
3. Take aero off fast and have the driver re-run to see the difference.
    a. Record times
    b. Record driver feedback



Summer Test Plan

Monday, June 24, 2024 8:17 PM

Priority

1. Force data for lift and drag
2. Deflection identification between FW and FW Mount

AERO ON/OFF DECISION BY

IC: MARCH 19TH
EV: (Not known)

Drag and Downforce

- On/off acc draw (Drag)
- On/off shock pot values (Downforce)
    - Possible to get COP, but may not be accurate from Drag moment.

Testing Talks w/ Joey

Tuesday, June 25, 2024 12:52 PM

- Test Proposal for Star CCM Validation
- How much deflection is from FW and how much is from mount
    - Hard mount FW and do basic deflection and torsional testing

KS9 Design Projects

Tuesday, May 28, 2024 16:48

Pages covering design projects.

New Member Projects

Wednesday, July 31, 2024 6:30 PM

1. Adjustable Front Wing Mount
2. Under Tray Mounting Revision

New Nose EV/IC

Tuesday, July 16, 2024 5:26 PM

Subgroup and Team Goals:

Assists effectiveness of subgroup goal 1 by allowing more freedom in the FW mounting system and the whisker mounting.

Overview:

Our noses are getting old, opening an opportunity to have more freedom for FW mounting whisker mounting, and side panels. We would run sims to see what is optimal on the car wholistically, considering the impact of drag and lift forces, as well as airflow to other devices such as undertrays, whiskers, and the RW.

Priority Rank Reasoning:

Time (1) - A new body is a significant labor undertaking. It takes a lot of time to sand and bondo the body to perfection.

Cost (2) - The cost of manufacturing material (molds, cf, resin, bagging) is also significant, but not worse than say an undertray, but still up there.

Benefit (2) - This does not directly affect team goals other than giving CFD analysis experience and supporting other projects that directly affect team and subgroup goals.

Ease (1) - Similar to time, it is very difficult to make this part, requiring bondo and sanding skill with little room for error. The investigation will be somewhat labor intensive, but that is dependent on how many CFD sims are run and how many comparisons are made.

Risk (4) - There is little risk to this DQ'ing the car at comp so long as it passes static rules evaluation, which tolerances will be set in place for.

Analysis Steps:

Whiskers EV/IC

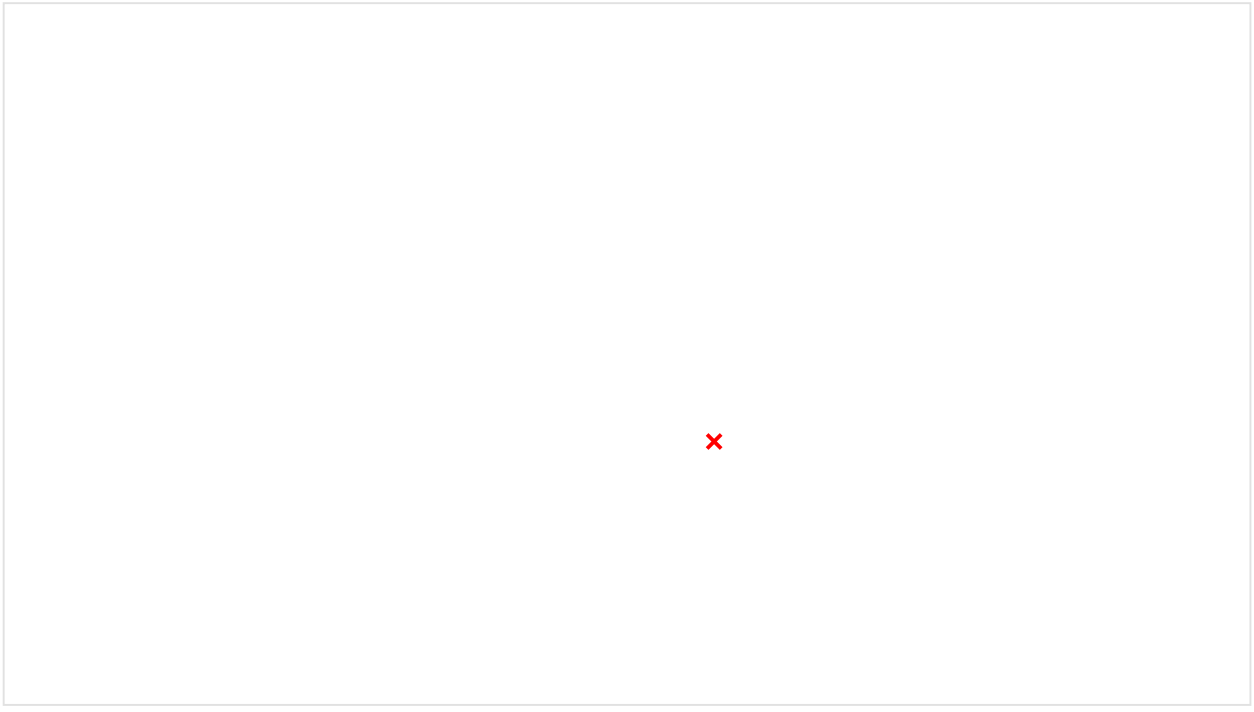
Tuesday, July 16, 2024 4:58 PM

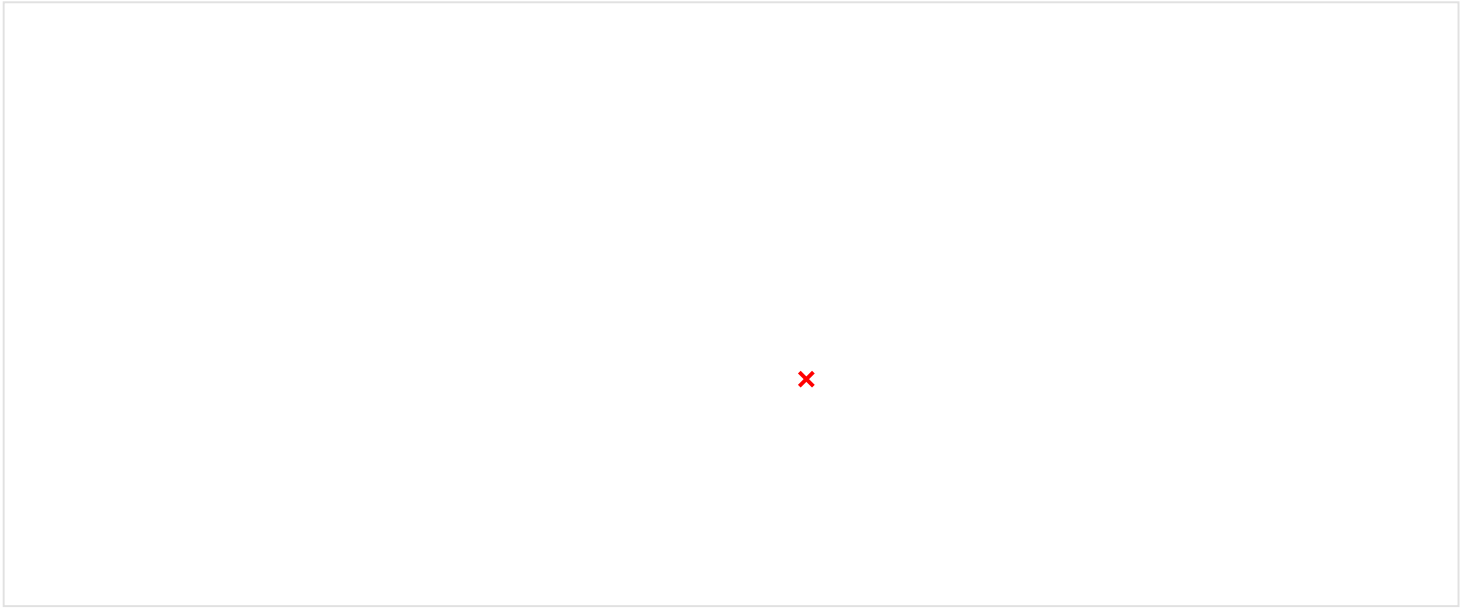
Subgroup and Team Goals:

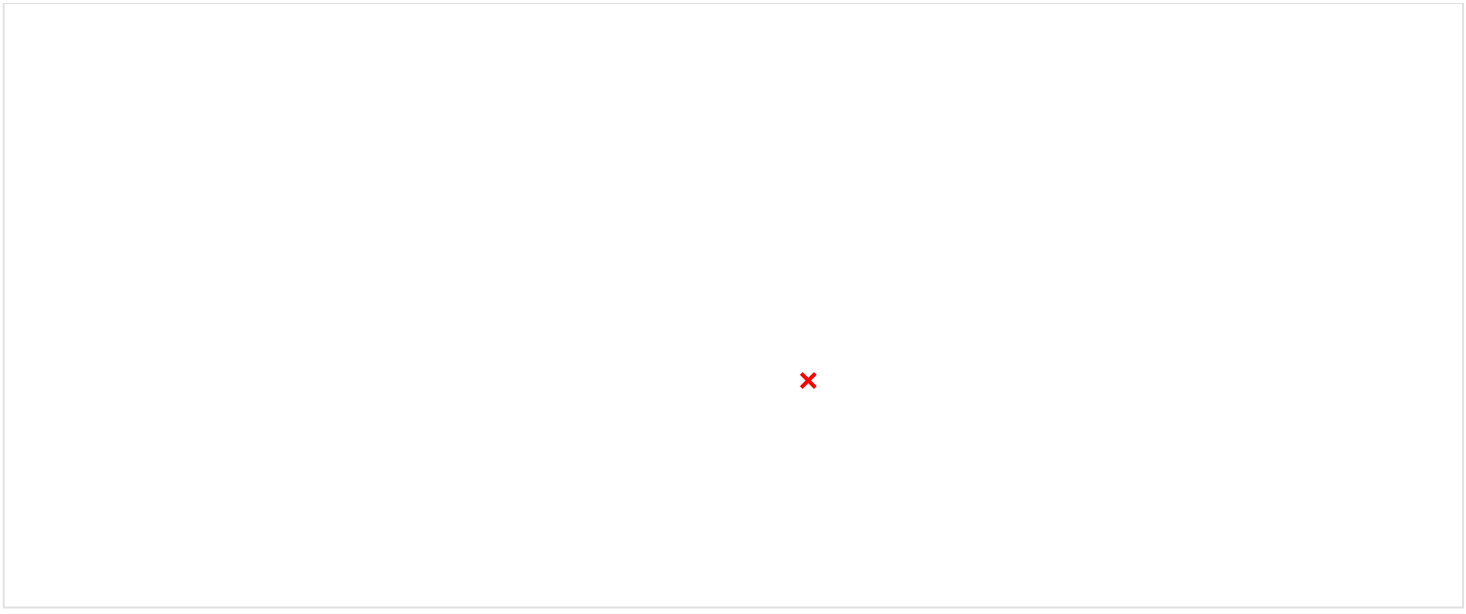
Whiskers increase complexity of the aero package as well as the downforce and drag characteristics, therefore accomplishing subgroup goal 3 and the primary and secondary team goals.

Overview:

"Whiskers" are aerodynamic down wash elements that divert upwash from the front wing away from the free stream bound for the rear wing. Up wash interrupts the free stream headed towards the RW with lower velocity airflow, therefore decreasing the effectiveness of the rear wing. Initial CFD studies show that adding a non-optimized airfoil as a whisker within the aero box per rules increases downforce by about 10 pounds and drag by about 2 pounds.







Priority Rank Reasoning:

Time (3) - Very nominal time. There is no glaring difficulty in making 4 elements nor the bracket. The mounting system is the most uncertain, but from a conceptual standpoint there are no prominent issues.

Cost (4) - This is dependent upon how many molds are made, but the element is comparable to a singular FW middle flap, so it is not expensive relative to other components. Worst case: Two molds and 4 FW elements worth of materials.

Benefit (3) - This increases the complexity & performance of the aero package. Although it is not a drastic increase, it is significant.

Ease (3) - Worst case scenario, we make a new mold for each car, so two molds total with mounting reversed for each side. Best case scenario, we use a part of molds already made in an effort to decrease cost and manufacturing time. The best case will happen unless there is a significant performance increase with an optimized airfoil.

Risk (4) - This is still TBD, however if mounted to the chassis there is little reason that this element would fall off. A tolerance can be decided on by the engineer and chief engineer to ensure it is within rules when manufactured.

Analysis Steps:

1. CFD of best fit airfoil that already has a mold compared to CFD of best airfoil for this application
2. CFD analysis of roll, pitch, and yaw sensitivity of device.
3. Mounting: Define mounting method, CAD, integrate with current body or new side panel and new body. FEA.

Whisker Integration

Tuesday, November 05, 2024 9:38 AM

Front Wing Mounting EV/IC

Sunday, July 7, 2024 3:03 PM

Subgroup and Team Goals:

Contributes to subgroup goal 1.

Overview:

The 7E FW (Front Wing) mount is one of the contributors to oscillation of the FW during dynamic events. The oscillation causes the FW to scrape the endplates, which can cause us to DQ (De-que) during dynamic events and lose significant points.

Furthermore, FW oscillation detracts from the aerodynamic performance of the car. Theoretically/conceptually, when the wing oscillates and changes its height from the ground, it also changes the amount of downforce the wing provides since the area, therefore velocity therefore pressure (Bernoulli), changes. In a similar manner, when the endplates touch the ground and oscillate, the vortex generators' vortices are altered and/or destroyed.

Another problem not related directly to performance is the serviceability (install and removal) of the FW Mount.

Finally, the mount is not flush with the bottom of the underbody and is deflected by the chassis.

This project will look into re-forming the current mount to allow for adjustable AoA and FW height so the aero can be dialed in during car testing.

Priority Rank Reasoning:

Time (3) - Only conceptualization of adjustment methods, CAD, and FEA of part. Very standard.

Cost (4) - Compared to other projects, this is significantly cheaper. Only a small amount of aluminum needed. Slightly more may come from further design.

Benefit (4) - This increases the complexity and design quality of the front wing by allowing us to fine tune to data and driver feedback, hitting on subgroup goals.

Ease (1) -.

Risk (4) -

Analysis Steps:

Concepts

- "hook" aligning feature
  - Requires body to change
  - Accessible adjustment up and down
- Adjustment for manufacturing inconsistencies

Problem

The 7E FW (Front Wing) mount is one of the contributors to oscillation of the FW during dynamic events. The oscillation causes the FW to scrape the endplates, which can cause us to DQ (De-que) during dynamic events and lose significant points.

Furthermore, FW oscillation detracts from the aerodynamic performance of the car. Theoretically/conceptually, when the wing oscillates and changes its height from the ground, it also changes the amount of downforce the wing provides since the area, therefore velocity therefore pressure (Bernoulli), changes. In a similar manner, when the endplates touch the ground and oscillate, the vortex generators' vortices are altered and/or destroyed.

Another problem not related directly to performance is the serviceability (install and removal) of the FW Mount.

Finally, the mount is not flush with the bottom of the underbody and is deflected by the chassis.

Cause

For the oscillation and scraping, among other contributors, the distance between the mount and the end of the FW is large, and the internal structure deflects (bends) significantly. Statically, we know that the bending moment increases linearly with distance from the point of rotation, in this case the FW mount.

The serviceability is poor since the mount curves over where you could otherwise visually line up the mount and the wing. The curve also reduces the workspace for setting the screws between the mounting holes.

Solution

The amount of bending can be reduced by reducing the distance between the point of bending (FW Mount) and the end of the FW. Another way to think of this is increasing the distance between the mount.

For serviceability, it may be easier to revert to the previous style of mounting, where the mount and wing stay attached and the mount gets bolted on and off the chassis via a locating bracket on the chassis.

Undertray Strakes

Sunday, July 7, 2024 3:44 PM

Validation:

This project satisfies the subgroup goal of adding to aerodynamic performance and package complexity.

Workflow:

Undertray Tension Cables

Monday, July 8, 2024 12:31 PM

Goal:

Implement an optimal tension cable design to support the Undertray outlet.

Tasks

1. Research tension cable mounting methods. Create a quick PowerPoint that reviews known methods and selects the best option for our application.
    a. This step will require you to review some literature and see how we can connect tension cables in CAD. Also, for the selected mounting points, make a Free Body Diagram that shows all of the known forces acting on the system.
        - [x] Literature Review
        - [ ] CAD Compatibility (Feel free to make *quick* a mockup)
        - [ ] Free Body Diagrams

Resources

[Aero Placement And Mounting — DesignJudges.com]

UT Mounting Iteration

Tuesday, July 16, 2024 8:40 PM

Concepts

- "L Bracket" that mounts in Y rather than Z

FW/RW Redesign

Tuesday, July 16, 2024 8:57 PM

Dependent on budget and time

We will review re-designing IC package after determining how much we want to invest into each car.

KS8 Design Projects

Friday, August 9, 2024 2:28 PM

Current List:

- [ ] Side Panels for IC
- [ ] CoP Tuning
- [ ] RW Mount
- [ ] FW Mount
  - [ ] Tension Cables
- [ ] DRS EV
  - [ ] Endplate Mounting
- [ ] Undertray
  - [ ] Mounting Locations
  - [ ] Grounding Method
  - [ ] Install/Uninstall Method

RW Mount

Tuesday, August 13, 2024 6:16 PM

Goal:

- Reduce RW SN Weight
- Investigate and move struts onto endplates, compare aerodynamic effects

Deliverables:

- [ ] CAD of SN and Struts
  - [ ] Directly address previous shortcomings of endplate mounting
    - [ ] Contact Nathan, Joey, and/or Andrew Thomas about endplate mounting endeavors
- [ ] CFD: Velocity sweep 10, 20, 30, & 40 at steady state between old and new SN and Struts. (Unsteady if possible)
- [ ] FEA: Normal loading for SN and Struts, Reverse loading at 50 mph (Compression and Tension for SN and Struts repsectively)
- [ ] Manufacturing plan of SN and Struts
- [ ] Assembly plan for both (Including hardware, tabs, etc)
  - [ ] Struts must have ergonomic access for tools, either chassis or wing side

Context:

- Swan neck supplemented by struts connected to bottom of mainplane
- Struts interrupt boundary layer, therefore decrease velocity, increase pressure, and decrease downforce
- Ideal solution: pure swan neck. Cannot due to mainplane proximity to main hoop brace (MHB)
- Proposed solution: Retain struts to accommodate package constraints, but move them into a more aerodynamic position.
- Endplate mounting has been done in the past, but has failed for various reasons, these will need to be addressed directly.

Rules (Know them)

Internal Wing Structure & Endplate Mounting/Rigidity

Friday, August 9, 2024 2:28 PM

Problem:

Skin Deflection

Endplate Mounting

- Carbon/Honeycomb is crushed by screws
- Rotational deflection along chord axis of endplate rib

Goal

Skin Deflection

- [ ] Find the maximum pressure experienced by FW & RW
- [ ] Measure pressure on different surfaces. (Possibly through force gauge)
  - [ ] Does it deflect?
    - [ ] Yes? We need to add more ribs
    - [ ] No? Our internal structure is solid

Endplate Mounting

- [ ] Increase compression strength of endplate. Does not deform under X torque w/ X mm washer.
  - [ ] Torque defined by pre-tensioning required by fastener. (Seth will determine)
  - [ ] Size washer (Seth will determine)
- [ ] Reduce chord rotational deflection to <1mm at top of endplate under X force
  - [ ] Force defined by inertial forces, expected handling forces, or aero forces. Whichever is largest.

Potential Solutions

Skin Deflection

- Depends on if skin deflection occurs.

Endplate Mounting

- Higher strength material (aluminum, carbon fiber, 3D print) inside of endplate at mounting locations.
  - If using 3D print material: Test compression strength by converting torque to tension applied by screw, a force gauge, or an MTS machine.
- Add fastener location off chord axis to counteract moment about axis

AoA/CoP Tuning

Friday, August 9, 2024 3:24 PM

Goal

Tunability of Aero devices to test effects of different configurations' performance.

- Induce understeer/oversteer characteristics. Grip characteristics on corner entry/exit.

Deliverables

1. FW & RW AoA Positions w/ CFD Analysis showing CoP, Downforce, and Drag. (Depending on time, velocity sweep to identify consistency of CoP location, ride height for the same reason)
2. "Test Plates" for IC that allow us to determine which AoA configs we want to use without creating permanent endplate locations
3. Tuning plans: One to identify driver feedback and favored CoPs, One to identify lap time difference between high downforce and preferred CoP.

Simulation

- Run w/ UT and itemize FW, RW, and UT CoP to back calculate CoP if we remove UT.

Design Notes

Tuesday, July 23, 2024 4:05 PM

Includes:

- Notes for design (e.g. projected project budget)

Cost Analysis

Tuesday, July 23, 2024 4:07 PM

How much will each package cost to remake based on current material stock?

- Surface area/ply schedule for carbon, resin used per unit area
- How many molds expected to be made and how many to be remade worst case
    - Volume of MDF for each mold

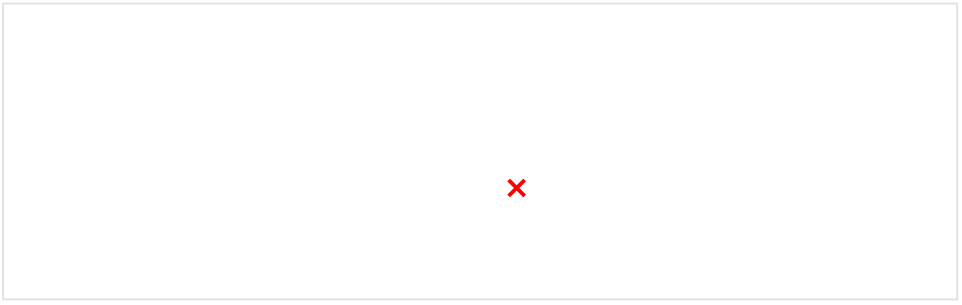
Goal

- Spreadsheet of all items, document of how all quantities were arrived at

Drag Reduction

Wednesday, July 24, 2024 6:37 PM

I need to understand the points increase if we were to reduce energy consumption by the amount that DRS would provide. I then have to see the delta between that and fully open aero, and then include the amount of points gained from downforce in the corners w/ DRS. Then, I can see how "worth it" DRS is. Perhaps there is a happy medium with a different angle of attack.



https://github.com/KSU-MS/python-endurance-drag-energy-calculator

Frontal Area, No Aero: 0.6776
Frontal Area, Open Aero: 9.606706e-01 (m^2)
Frontal Area, Closed Aero: 1.146118e+00 (m^2)

At a point, we begin to be thermally limited rather than energy limited. So chasing there is a max e/L that's based on thermal capacity. So, are we faster with the aero on or off with the e/L that reaches our thermal limit.

Design Meetings

Sunday, July 7, 2024 3:00 PM

March 4th - Second Draft

Tuesday, February 25, 2025 4:14 PM

August 15th - Design Meeting

Thursday, August 15, 2024 5:31 PM

Goals:

1. Review comments and provide information for newly uncovered areas lacking information.
2. Answer questions about design specifics and wholistic impacts

Design Meeting - June 24 - Shortcomings/HL Goals

Tuesday, June 18, 2024 10:54 AM

Meeting Purpose/Scope: Decide on high level design goals for KS8 package. Focus on design goals only.

Meeting Deliverables:

1. KS8 Package Design Goals (High Level: Stiffer, more reliable, less drag, etc)
2. Ranked Design Matrix Template
3. Unanswered Questions

Agenda:

1. Align on failures of KS7 E Package
   a. 20 min.
2. Align on team goal constraints
   a. 20 min.
3. Decide KS8 package goals
   a. 60 min.
4. Introduce/Discuss/Finalize design matrix pillars
   a. 10 min.
5. Decide on Design matrix
   a. 10 min.

Meeting Summary:

After we started, it was quickly realized that the meeting surrounded problems with manufacturing and composite's area of responsibility, and not Aero design. The only action Aero is to take is to maintain clear CAD iterations and consistently communicate with composites regarding the current iteration and confirm if all iterations match each other.

We decided that composites would have full autonomy to make decisions and take measures they see fit to nullify these problems, both design related and admin related.

Composites will identify, design, and test solutions for structures over the 2024 summer design season. Furthermore, Aero and Composites will have weekly meetings to align on project statuses. This will open up opportunities for identifying errors in manufacturing early and maintain a healthy/communicative relationship between composites and aero.

Shortcomings/Failures:

These are **mechanical/performance/manufacturing** shortcomings/failures that occurred. Only list the problem, solutions will be discussed in the next meeting with design matrix rankings.

Seth

- FW Deflection/Oscillation
- Trailing/leading edge quality inconsistency

Grayson

- IC FW spar collapse
- IC RW adhesion Failures
- Wing skin deflection
- Ease of mounting
- Ease of assembly
- Impact with road
  - Self-clearancing
  - delaminations
  - Holes in bottom skin
- Ease of fabrication
- Cost
  - Is this something that could be brought down and how
- Rigidity of mounting

Team Goals that Directly Affect Aero

Please leave team goals that will directly affect Aero

Seth

- Efficiency/Drag Reduction
- Acc/Chassis Changes
- Pitch/Roll/Ride Height Changes & Aero Sensitivity
- Radiator airflow requirements

Grayson

- Decreased cost
- Decreased weight
- Decreased drag
- Increased downforce
- Increased cooling
- Increased rigidity
- Decreased Skin Deflection
- Increased Ease of Fabrication
- Decreased Time for fabrication
-

Failure/Shortcoming	Cause	Notes
EV FW Oscillation	- Debonding & crack propagation - Large clearance between skin and rib - EV FW Mount deflection - CAD/Manufacturing discrepancy • Ply schedule not in CAD	
EV RW Trailing Edge Inconsistency	- No template to trim around • No drawing	- "Wavy" pattern from rear view
EV FW Trailing Edge Inconsistency	- CAD discrepancy: Iterations were not tracked	- Gap between top and bottom of wing
IC RW Bond Failure	- Fatigue failure - Cracks were not addressed - No regular inspections - Fabrication mishaps	
IC FW Rib Collapse	- Cone impact	 - Design needs iteration for robustness, but inherently good
Wing Skin Deflection	- Internal structure placement not thorough	- Describe?
Assembly Difficulty	Admin topic	- What was difficult? - Was the difficulty unnecessary? - Does this affect serviceability?
EV RW Pushrod Tab Displacement	- Could be bent, or whole rib is not "upright" • Possible: Rib not adhered/jigged correctly	- Monitor this on KS7E during Testing
EV FW Mount Movement	- Possible: Bolt not tightened on left side - No jig for placement of tabs	
CF Pushrod Bond Failure	- CAD not sized correctly - Inserts not etched, CF not scored	- Test new ones by just running car - Current tubes in CAD are different size than IRL

KS8 Package Goals

Goal	Description
Reduce Overall Deflection or Increase Rigidity	Aero package deflection does not contribute to ground scraping
Robust package adhesion.	
Production accuracy to CAD	Reduce manufacturing inconsistencies that decrease wing performance.

Unanswered Questions

Question	Answer
How many packages will we be making? Remake E Car? New IC Package, or re-use?	

One-Off Meetings

Sunday, July 7, 2024 3:00 PM

John Design Brief Talk

Thursday, February 27, 2025 5:49 PM

- Why are we running it
- What did I do to maximize its effectiveness
- Post analysis of what I should have been doing
- Post analysis of what aero would be optimal for the new pack
- Look at points wise where aero is going to contribute the most
- Is aero worth the weight, how much do we want, how much is useful, how much do we want from powertrains perspective

- RCVD Milliken & Milliken, second half of the book, chapter of car architecture

Andrew Coffee Chat

Sunday, February 23, 2025 10:37 AM

- Show relative bond area change, and design into RW ribs
- Show your best side
- CoP: Select what CoP is the best and adjutability if for variance between sim and IRL
- Whatever you hit, say you designed for it. (If you get best CoP in mid corner, say you designed for that
- **Have a debrief to have the same structure of slides**

What do I show in this design presentation?

- 3 projects that progressed car goals
- Show yaw and roll sims and why we did them for this year
- Show Architecture:
    - Hollow core
    - Maybe: Lofted rear wing & front wing
    - Maximize aero box
        - Why

Design Brief Alumni Review

Tuesday, February 18, 2025 8:14 PM

Overall

- Include red/green of when team raced or didn't each year, shows trend and why we have simple/passing car
- Treat the existing design as your own design

Aero

- Have CoP distribution as it pitches and as it rolls
- Connect your goals to team goals
- What are my CoP goals? (Range, expected forces during various corners, how does this relate to the slip angle and grip maxxing?)

Direct Feedback

- List the intent, and how we tried to hit that intent

-

John's Common Talking Points

- Start from the very beginning, top down. Why are you racing to designing a tab
- Top to bottom, top to bottom, top to bottom
- Cascading goals

Nate Design

Thursday, February 6, 2025 6:46 PM

Beast Engineering
- Multi element, introduce high energy air, delay flow separation, higher effective camber = more downforce
  - Something something diminishing returns on element quantity, not worth manufacturing
- Don't say full range of CoP

To-Do
- Find actual airfoil selection

Idea Parking Lot
- Force engineering discussion over judge asking "Why?" with negative implication.
  - Avoid negative implications
- Simulation workflow

Overview

Justification
- Points analysis
  - Relationship between drag, downforce, weight, and points
  - Trade study of weight and downforce gain
  - Net gain in points with Aero

Airfoils
- Maybe include yaw stuff
  - Sweep reasoning

Simulation
- Goals

- Setup
- Outcome

Structures
- Only capable of male mold, bad surface finish
- MDF Female mold has better surface finish
- More manufacturing effort but better quality and repeatability
  - Did not scrap parts anymore
  - Better achievable tolerances
- Lighter
- Use of Hat-channel

Testing
- STIFFNESS!

The schpeal….

What makes our car the best car??

- High downforce package

KS9 Design

Saturday, January 25, 2025 12:15 PM

Overall:

- Get as much data out of the car now that will help with design of the next car.

Discussion with Sam:

- Choose CoP range based on stability index found from testing and simulation by VD
- Get real data of energy consumption from competition and from before comp
    - Compare lot data to comp data
    - To choose drag budget and efficiency
- Pitch/Role Sensitivity to decide suspension targets next year
- For general design consideration: Incorporate cooling into aerodynamic study/design

Questions

- What other things can we do to help us choose what we want for design?

EP Insert Review/Composites Update

Thursday, January 23, 2025 6:09 PM

Topics:

- Review EP Inserts
- Update on manufacturing timeline
    - 2 weeks to one side panel

Feedback from Sam

Saturday, January 25, 2025 9:39 AM

Good
- Easy to approach, friendly
- Care for team doesn't come out as a tweaker
- Do good work (FW Mount stuff, logbook for sims)

Bad (New Lead)
- Finding the cut off of a design or decision
- Modulate design for aero based on team necessities
- Show more face

Bad (General)
- Suck up the work when it needs to be done
- Aero is helpful, but a PITA
    - Be very transparent about all design
    - Work with the team on a higher expectation than normal
    - Be extra particular about design so that you minimize concessions to aero.
    - Don't make Aero the priority
        - This is why people of combative
- Don't entertain conflicting ideas for too long (i.e. PETG vs. Aluminum)
    - I need to give more information before handing it off

Application
- **Show more progress** of things getting made, or things toward it.
    - Maybe get reports from members about what has been done
    - Post notes of work progress
    - Pictures
    - People only care about effort
- Be more precise about what is done (or more understanding)
- Frequent meetings with David
    - Show face to enhance quality
- Be more selfish in knowledge gain
    - Budget a day to do something for yourself, so you can have knowledge gain

- Don't make aero in a box
- Pissing people off makes them not want to let you do it

Parking Lot
- Seeing what newbies want to do
- 1-1 meetings
- For PETG ribs
    - Support investigation more with clear guidelines
    - Don't give something that you don't do

Question
- How do you maintain credibility?

Rib Manufacturing w/ Abri

Monday, January 6, 2025 7:15 PM

- What is needed to laser cut the ribs?
  - Kennedy Drawing
    - Manufacturing in Discord > Pinned Message
      - Callout radii, thicknesses, etc. No need to do large radius if airfoil
  - @ Abri in discord about drawing being ready.
    - Have drawing in message.
    - Have Date in message
- What is in the way of doing inserts?
  - Lathe inoperable.
  - Abri will look into solutions
- Do I need to specifically "order" tabs for the aero package, or were they automatically remade?
  - Check send-cut-send order for my tabs
  - If not, laser or scs them
- CNC of Side Panel Mold
  - Can do
    - Abri would like to see final mold
  - Abri will announce when we can go train
- Tool for routing Endplates
  - Seeing options for compression tools

Action Item List

- Follow up with Abri tomorrow if not heard from

After Break w/ David

Monday, January 6, 2025 6:03 PM

- What is the manufacturing plan?
  - Our Deadline: Feb. 10th
  - Endplates
    - Scale run of split honeycomb
    - 4 Days to do it, waiting for John and Delta
      - Re-visit when he gets back
    - Could route, but need the tool,
  - Side Panels
    - Send what's in CAD
    - 2 weeks
  - Rear Wing
    - Need ribs done before we cut
- What is in our way?
  - Nope
- How will you do the rear wing?
  - Ribs
    - PETG Stabilizer w/ Dowel Pins
  - How to cut the wing straight
    - Solutions by next Monday (Call)
- What do you need from me?
  - Ribs made

Action Item Parking Lot

- Get info from John
- Ask Abri about:
  - CNC of Side Panel Mold
  - Tool for routing Endplates
- Make Gantt Chart
- Ribs cut before RW
- PETG Rib Stabilizer. Get Newbie to CAD
- Scale run of the split endplate this week
- Strut Inserts for 8C

Side Note Parking Lot

- Need more honeycomb
- Side panels will start with one then do the rest to test

Project Solidification

Thursday, August 8, 2024 3:57 PM

Purpose:

Present and list projects that align with subgroup and car goals for subgroup review.
Decide, as a subgroup, projects to pursue over the KS8 deign period based on car and subgroup goals.
Assign projects to group members and present project workflow and expectations.

Agenda:

1. Luke's Presentation
2. ~~Cooper's Presentation~~
3. Quang's Presentation
4. Discussion and Decision
5. Project Assignment, workflow and expectations discussion.

Outcomes:

- [x] Members fully equipped to begin their assigned projects
- [x] Submission timeline is clear and acceptable
- [x] Yippee we do aero things!

To-Do

- [ ] Write out criteria/expectations for each project
- [ ] Set meetings for Monday/Tuesday next week (After 7)

Idea Parking Lot

- Is the UT worth its weight?
- Individual meetings to discuss project deliverables.

Projects

- ~~DRS~~
- ~~AoA/CoP Tuning~~
- ~~Internal Structure Layout (Ribs/Spars)~~
- ~~Element Mounting (Endplate Rigidity)~~
- ~~FW Mount~~
- ~~RW Mount (CF SN, Endplate mounting pushrods)~~
- ~~UT Strakes~~
- ~~Whiskers~~

Project Assignment (Move to main page)

Cooper
FW Mount (IC & EV)
RW Mount (IC & EV)

Luke
Internal Structure (IC & EV)
Element Mounting (IC & EV)

Quang
AoA/CoP Tuning (IC & EV)
UT Strakes (IC & EV)

Seth
DRS (EV)
UT Performance Analysis (IC & EV)

Workflow

1. Project Proposal
   a. Understand and articulate Context, Goals, Constraints
      i. Fills out first 3 of doc
   b. Begin conceptualization, analysis, and/or CAD (Hand sketches, FBDs, CFD/Lap simulations, numerical models)
      i. Fills out the rest of the first section
   c. Fill out document (unless done already), create brief (PPT)
2. Project Report
   a. Design matrix
      i. Consider at least two design options to accomplish your goal and rank them. You should have already done this during your conceptualization.
   b. Hardcore CAD and Sims
      i. Deep dive into your selected method, document along the way. This may take two or more weeks to finish.
   c. BOM
      i. Itemize your project, how much is everything and how much will we really spend?
3. Manufacturing
   a. Use diagrams, CAD screenshots, and other methods to show manufacturing AND assembly steps.

Key Takeaways

1. **DOCUMENT DOCUMENT DOCUMENT!**
   a. Mostly through personal notes, but make them legible for later recall. People will actually read these things.
2. Be **thorough.**
3. Treat each step as if it is to your **employer.** (Because it actually will be)

Expectations

- Design complete by Sept. 23rd
- Attend every design meeting, always bring something new
- Thoughtful on every step, and every step is high quality
- Slow and steady is faster than burning out
- Few, high quality projects >>>>> many, low quality projects

Design Milestones

Sept 2nd - All Proposals Approved. Carryover elements begin manufacturing.
- Last submission: Aug 23rd
- Carryover relevant structures solidified

Sept. 30th - All Reports and Mfg. Plans Approved. Full Mfg. begins.
- Last Submission: Sept. 20th

Project Doc. Kickoff

Wednesday, July 31, 2024 4:35 PM

Topics:

- Start documentation for each project
- Select new batch of projects based on cost & performance analysis
- Decide whether to do weekly wrapups during our alignment meeting.

Once I have overall goals, I can tell people to start attacking things that make that better, starting with things we expect to do with our resources and what would make the greatest impact to things we can do with more resources.

Resource Limitations

1. Molds staying the same except:
   - 6C FW Mainplane Top - Remade
   - 6C RW Mainplane -Remade
   - 6C/7E Flap 2 - Possible Rework
   - 7E FW Bottom - Rework
   - 7E RW Flap 1 - Remade

General Design Goal

1. Drag Reduction on EV
2. Down Force improvement on IC

We can start with this today, but I need to have a quantified and good reasoned goal for both EV and IC.

I want each member to consider the goals for each car and investigate/resaerch two methods to reach that goal. We will reconvene next Thursday during our review meeting and review each project through a project brief PPT. This will give each member time to dive deep into aerodynamic pronciples and race car applications, and split the brain drain among the group. This is in light of not having quanitifed goals just yet, which I will provide by that time. Each member will keep in mind the mold limitations, investigating methods around that first and then adding molds as a last resort. I will be investigating DRS for EV and AoA adjustment for the IC.

Design Review Schedule:

Important Dates:

- Design Review (Team Signoff)
  - Submission Deadline
    - Chief Review Prior
- Subgroup Signoff (Aero Review)
  - Submission Deadline (1-Day in Advance)

Ranked Priority List

Tuesday, July 16, 2024 6:35 PM

Deliverables:

- List of projects that will be pursued immediately
- Ranked priority list agreed upon by subgroup

Agenda

- [x] Review and agree on subgroup goals
- [x] Review current priority list projects and their ranks, finalize ranks
- [x] Add projects to list, any project
- [x] Define highest impact projects, assign for preliminary research (like with whiskers)
- [x] Vibe check the list of priority projects to feasibility of doing it this year

Next Steps

- Assign project due dates and expectations/meetings to present
- Re-evaluate "vibe check" for feasibility after prelim goal discussion w/ team
- Argue to focus on one aero package and remove from the other to save money and time

Solutions meeting

Tuesday, June 25, 2024 9:44 PM

Undertray

- Multi-Piece?
  - No Gaps = better for Aero
- Strakes
- Flat bottom car
-

Ground Clearance

- Don't make the belly lower than the bottom of the endplates

- Make Components height adjustable
- Prevent wing oscillations
- Mount stiffness
- Wing structure stiffness
-

Admin Meeting - June 24 - Problem Identification

Monday, June 24, 2024 4:51 PM

Meeting Purpose/Scope: Identify and align on issues with administration for Aero and Composite responsibilities

Deliverables:

1. Condensed Problem List
2. List of methods, systems, and solutions to condensed problems that will be used for KS8
3. Determine if there are steps to be taken from this meeting

Condensed Problem List/Solutions

CAD is Bad: What would help?

- Consistent Trailing Edge "Blocks"
- PDM Iteration Control
- Ply Schedule Included: Skin thickness, internal structure dependent on skin thickness
- Molds required in PDM and Project Proposals (Composites will put together, but in Aero Proposal)
- Actual drawings for all manufactured components
  - Tolerances, Abri will advise

Communication

- Weekly alignment meetings between aero and composites
  - Simple PowerPoints or show and tells
- Weekly Aero Design Meetings
  - Invested parties roped in at project discretion
- Monday Meeting: Update on past week's progress and this week's goals

Aero and Composite Responsibilities

- Revisit after role definition meeting

Manufacturing

- Checklist for mold prep

Action Items

- Create mold checklist
- Document that lists everything needed for a design (trailing edge consistency, tolerancing, drawings, etc.)
- Wednesday Aero/Composite Alignment Meeting
- High-level workflow/process steps (Like best practices during design)

Idea Parking Lot

- Change in mold material

Whiteboard

CAD is Bad: What would help?

- Consistent Trailing Edge "Blocks"
- PDM Iteration Control
- Ply Schedule Included: Skin thickness, internal structure dependent on skin thickness
- Molds required in PDM and Project Proposals (Composites will put together, but in Aero Proposal)
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Aero and Composite Responsibilities

- Revisit after role definition meeting

Manufacturing

- Checklist for mold prep

Meeting Summary:

This meeting was a follow-up from the previous design meeting that this is a sub-page to. It discussed similar themes surrounding administration and CAD iteration control.

Moving forward, Aero will maintain a more transparent iteration control of it's development. This may be through PDM Iteration control or by just updating PDM regularly. Aero and composites will maintain regular communication through weekly meetings and standalone design meetings for project specifics. Composites will act as a standalone subgroup that provides structure solutions to Aer designs.

List of Problems

Grayson

- Positioning relative to CAD
- Shape tolerance
- Design CAD to Mold CAD
- Design iteration naming
- Communication between groups
- Ply schedule decisions not including composites group
- Composites manufacturing decisions made without the composites group
- Lack of planning in the fabrication of the parts

Abri

- Mold & Part CAD naming/revision scheme
  - In PDM
- Molds & blank dimensioning done for PPT
  - Stud finder to all molds
  - I would like to make a mold prep and making checklist (w/ grayson)
- Drawings need to be specific and accurate to tolerances
- Tolerance test
- Oct 23(started making mold) -Dec 22(Arch Closed, all molds were done)
- Undertray finished Nov 7th
- Feb 27 (started last two mold) - Mar 5 (finished last two molds)

David

Problems

1. Manufacturing happened too late. (I will beat this dead horse)
   a. Mold Prep finished too late (night of layup sometimes), volume of layups per night started to stack up, crammed months' worth of layups into weeks. Everything Snowballed
      i. 3D Printed Mandurels/ Wing Elements could have been done much earlier and as a "Hands on Lab" to teach newbies
2. Issues with facilities
   a. Had to Frankenstein the old compressors, facilities comes and turns off air while parts were curing, someone had cut off air that one time.
3. Sub group overstepping
   a. Aero does not curate ply schedules or structure. Composites does not change the design, goals, and intent of the aero package at a design level. (These are general examples, role definitions should hopefully help clear this up)
      i. **THIS DOES NOT MEAN ONE CAN NOT HELP THE OTHER.** Both groups should be encouraged to learn/help each other. (ie. Aero guys helping with a layup and getting a better understanding of what the manufacturing process is like and gain a greater knowledge of the capabilities of ***properly*** made composite parts. Composites guys learning/running CFD, aero theory and principles, the decision making process into the components they are making.)

Solutions

1. Bulk of Aero devices/ Composite components mostly finalized by mid-October (Absolute Latest)
   a. Gives enough time for materials to be ordered slightly beforehand and the opportunity to review what we are refurbishing/redoing, allowing time to fix mistakes and other issues.
   b. Ample time for mold manufacturing and prep to happen.
   c. Ability to do layups as we go instead of one big sweep.
2. No inherent solution besides leaving signs bc we're not their boss.
3. Understand where the line/ boundary is of overstepping

Composites need's to sign off on aero manufacturability (fabrication and assembly)

David's take on listed problems (Move if Needed)

- Positioning relative to CAD, Shape Tolerance
  - Unsure of what this means
- Design CAD to Mold CAD
  - Aero designs the part
  - Composites Designs the mold with Manufacturing Group "consultation"
- Design Iteration Naming
  - Use a ***system***, we are not the only people in the engineering space to encounter this issue
- Communication, Ply sched, composites manu decisions, lack of plan
  - Already touched on
- Molds & Blank dimensioning for PPT
  - For Proposals?
  - Easy fix, just need to implement
- Stud Finder
  - I take blame for that Inner Endplate fiasco, desperate attempt to fix mistakes, under a lot of pressure at that time.
  - Also an easy fix
- Mold Prep checklist
  - Mold Prep Tracker?
  - Already have a system in place for it, just requires actually using it which proved to be difficult given the time crunch and timeline the last go around.
- Drawing Tolerance
  - Thumbs Up
- Tolerance Test
  - ???

Financial Meeting Notes

Monday, July 22, 2024 8:28 PM

- July 1st to June 30th is fiscal year
- Accounts: Foundations, Alumni, SABAC
- External Accounts: First Horizon Bank & PayPal

Foundations Account

- Standard savings account
- Restrictions: Need receipts, cant buy from private sellers, cant pay tax
- Fund availability varies on donations, case-by case basis

Alumni Account

- 75K funding pot
- Present to Alumni board to get money and money is allocated
- Funds use requested by team to student affairs, we track

SABAC Account

- Like alumni for acquiring funds
- Cannot use for materials for the car, only for events
- Lead time for getting funds from this is 2-3 months

First Horizon Bank

- External to the uni
- Very easy to use

PayPal

- Collection for students
- Stopover to the Horizon bank

Projected Budget

- $67,904
- How much we can use for design: $13,536
- All design money is last done by October.

To-Do

- Accurate way to document required materials for project completion.
  - Show how much we request after the initial request
- Standardized docs for orders placed, personal spending, and requesting budgeting.

Questions

Foundations v. First Horizon, why would we ever use the first?	
When will we get access to our funds? Based on previous years.	
How much do we lose percentage wise from our design only budget?	

Archive

Saturday, May 11, 2024 10:54 AM

This includes all pages before May 11, 2024

STAR-CCM+ intro

Monday, December 13, 2021 5:28 PM

Getting Help:
If you don't know what something is press F1 to pull up the guide for the program which allows you to search up features ad explain them.
Prepping models:
To prepare for importing to solidworks ensure that the model does not has a lot of interference as this can cause problems with the mesh. Also check to make sure that parts are not disconnected as this will also cause problem when meshing. For tubes and parts with small internal volumes that we do not care about the flow around like the chassis tubes simply make them a solid body and merge them together. This will reduce the amount of cells required ad reduce the mesh complexity.
Importing models:
There are a few methods to import models. There are three different import options. Import in to 3d-CAD model, import mesh, and import CAE Model. Because we are using STAR CCM+ built in mesher and the CAE model import option is a Siemens exclusive file type the import that is being used is import CAD model into 3D-CAD. This setting can be found under File->Import->Import CAD Model into 3D-CAD. This import option can be found in the toolbar as well and is the isometric cube with a curved arrow coming out of the middle.
Importable files:
While STAR-CCM+ claims you can import Solidworks files whenever you try to use a solidworks part file or assembly it gives an error of no imported bodies. To get around this you should use a parasolid file. You can do this by saving the solidworks part or assembly as a parasolid file .x_t or .x_b.
Getting parts:
Under 3d cad models right click and select new parts to convert the cad model to a geometry part. Also the 3D CAD space should be when you add parameters any dimensions or mates(will be added when understood). A part that will need to be made is the box that will define the fluid domain. Under Geometry right click on parts and select New Shape Part>Block. If you are going to do a half car sim make one of the boxes sides cut the car model in half . Ensure that the front/inlet of the block is 2-4 times the length of the car from the front of the car while the rear/outlet is 5-10 times the car length behind it. If a reversed flow error occurs increase the distance between the outlet and the back of the car. The sides and top of the block should be 1-3 times their respective dimensions away from the car to ensure that any turbulance the car produces goes back to free stream before it encounters the outlet boundary.

Regions:
Prior to meshing every part that you are going want a volume mesh for will have to be assigned to a region and then a boundary within in order for the automated mesher to work. Within the Regions create a boundary for each part of the simulation that will need different boundary conditions. So make boundary conditions for the inlet, outlet, symmetry plane, ground, and, car geometry with different boundaries for different parts.

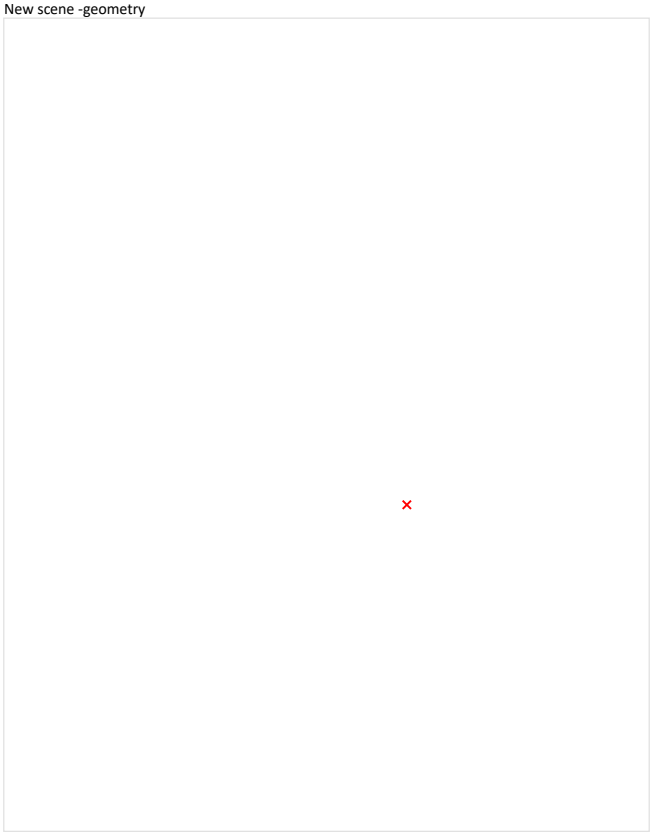
Inlet: for the inlet of the

Meshing:
To mesh create a new operation under Geometry>Operations>Mesh>Automated Mesh. If not prompted to enter the meshing models select Surface remesher, Automatic Surface Repair, Polyhedral Mesher, and Prism Layer Mesher. After selecting the parts that the automated mesh will be applied to an exclamation point in a yellow triangle will be displayed on the symbol. This is not an error and simply means that the mesher has not been executed yet
Before adjusting anything to get a finer mesh run the automated mesh to check for any errors. If the Chassis tubes are not merged together or made to be one solid part then you may encounter an error regarding manifold vertices and faces or other errots due to the way in which the chassis tubes are modeled with surfaces.
Physics Continua:
The physics continua is what determine the physics and solver for the simulation. For our situation. For the simulations you should elect the following physic models.

For regular runs Steady time is chosen due to the effects of unsteady flow characteristics such as vortex shedding being negligible. This small effect will be seen in minor oscillations of force and residuals graphs. If the oscillations is to great i.e. more than a few percent of variation then you should select unsteady time to better model those flow characteristics. The K omega Turbulence model is chosen

because it work best at modeling the turbulence that matter to us. Constant density is also chosen because at the speeds we run air is assumed to be a constant density due to the low mach number.

Operations-surface wrapper
New scene -geometry



Block - split
by patch

Add block to surface wrapper in operations

Add proxmity reinfment
Mesher execution - serial

Base size = .05m
Disable cad projection

Tagert surface size .005m

Min surface size .001m

Surface curvature
72 points/circle

Surfaxe priximity 8

Custom controls-surface control

Assign surface wrapper bodies

Operation-new-mech-automated mesh
Surface remseher
Automated surfacerepair
Trimmed cell mesher
Prism layer meseher

Input parts-surface wrapper

Continua-new-physicmodels-select moidels-3d-gas-segregarted flow-constant density-steady-turbulent-komega

Regions-new region-new boundary- make a ton of them

Adding surface wrapper to region 1

Outlet-pressure outlet

GENERATURE VOLUME MESH ONCE ALL BODIES ARE ASSIGNED TO A REGION

Goals 2023-2024

Thursday, June 29, 2023 7:02 PM

EV-Only focus (but fix any fundamental risky issues on IC)

Use KS6-C as benchmark for improvement

Collect DF data on car – DAQ does front end work
Improve downforce 10% (placeholder value)
Reduce drag 5% in accel config (placeholder value)
Weight increase of < 3 lbs
Explore attitude sensitivity
Match df transfer to within 10% of weight transfer? (arbitrary goal but lets go for it)
Stiffer skins
Less FW scrape
More stable RW mounting
FW not hitting ground and mount not breaking as it did last year
Remove body without removing FW
UT can be mounted in under 5 mins repeatably

Crack head moment

Friday, August 11, 2023 2:59 AM

FW Mount Concerns

Wednesday, October 4, 2023 11:10 PM

Bend radius of .029 is way too small for .1875 thick sheet
Will probably crack at bends

This is Just for the SolidWorks Model which for bend radius has never paid attention to. Bc we only have the one sheet metal brake and can't change the radius. Iv bent 5000 series .125 in aluminum very well. But your concern is valid. But we have no way to actually use the correct bend radius.

I'm confused by this. We can adjust the bend radius on the brake

We can not adjust the Bend on the brake. The adjustment you are thinking of adjusts for sheet metal thickness. The radius of the teeth that hold down the material is what make the radius. And we cannot change this.

Entire mount is basically in bending

- Front view approx. 2 in unsupported
- Top view approx. 7.5 in unsupported

All valid and already contemplated points. Now that I have a final front wing rib from nathan with attachment point locations. I can FEA to see that adjustments are needed. To the shape and area in question.

Why not bolts? Or at least 1 pin and 1 bolt that way there is clamping force to help keep wing from moving

First off there is not a spring in the cad to lock the locking hook.
I have contemplated bolting, at least one. However the simplest method that does not include separate pieces that could be lost does not have enough for threads on the stud. Between the Aluminum mount and the frame. This is because moving the mount further from the frame cuts into vertical adjustment as the front of the mount start to interfere with wing. I can explain in person how the wing is captive in all axis.

DRS Pseudo Code

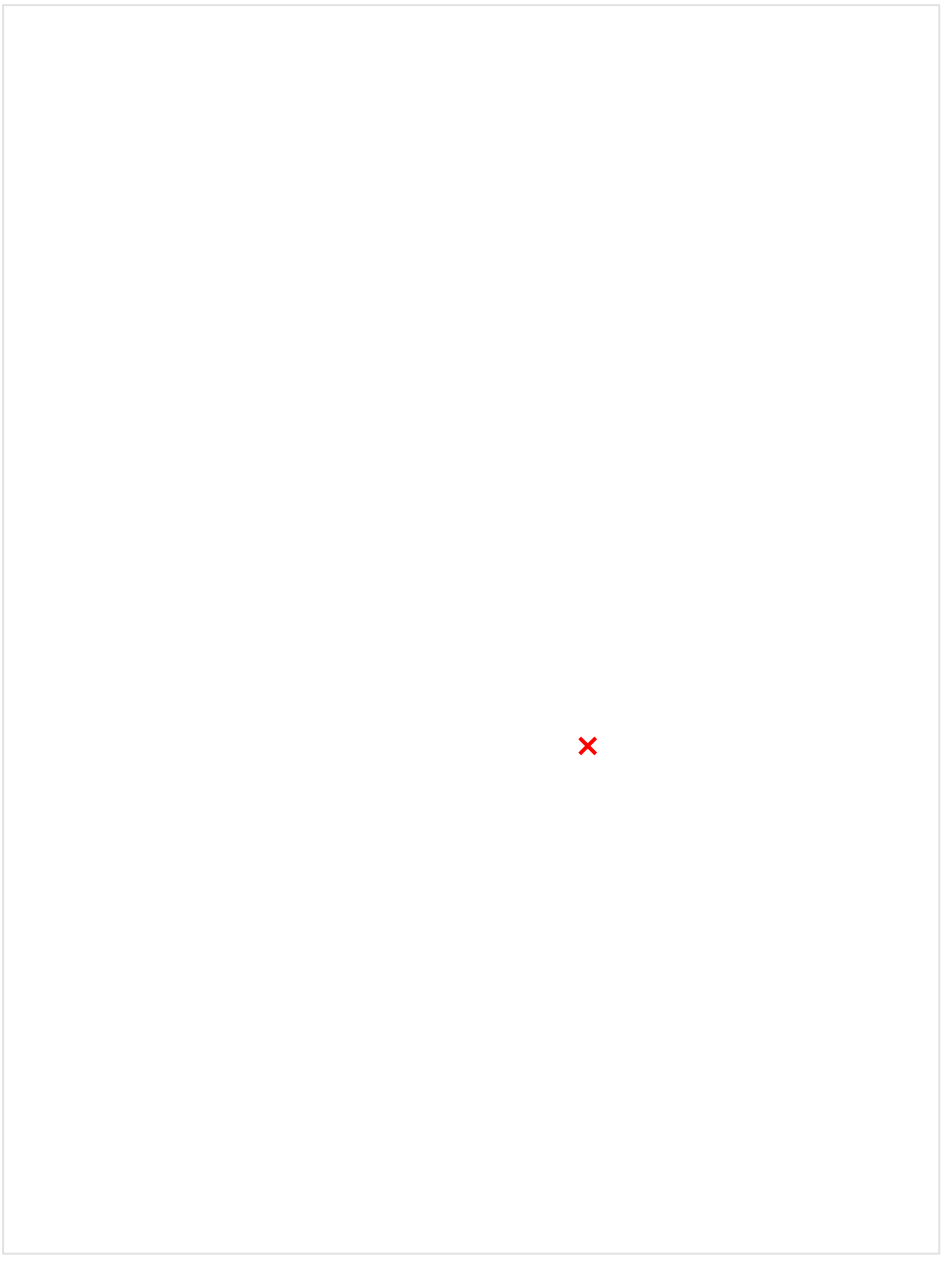
Wednesday, January 17, 2024 10:08 PM

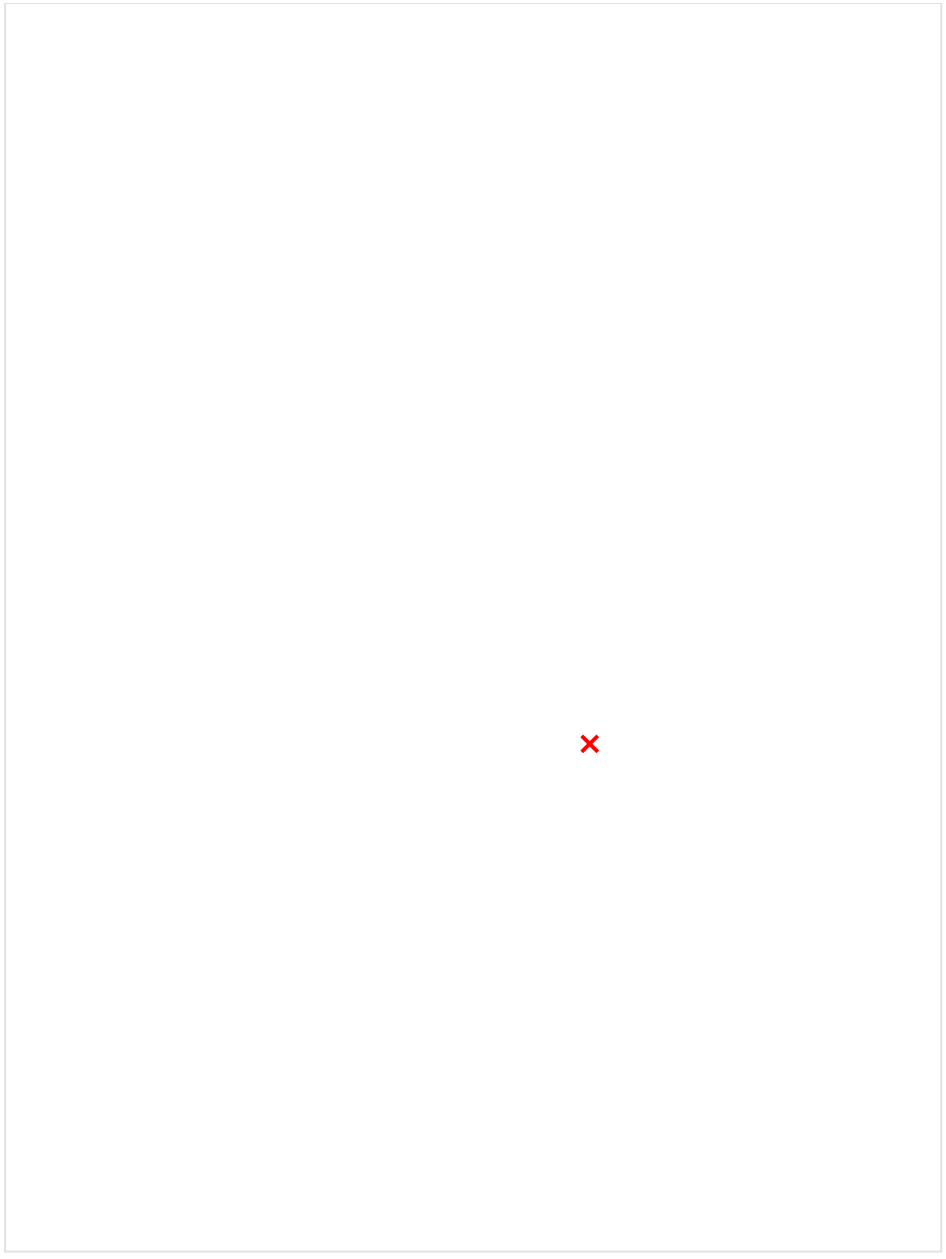
DRS servos have an encoder so we can choose the position
This means that there is a range of motion
For now lets assume 100% is open and 0% is closed

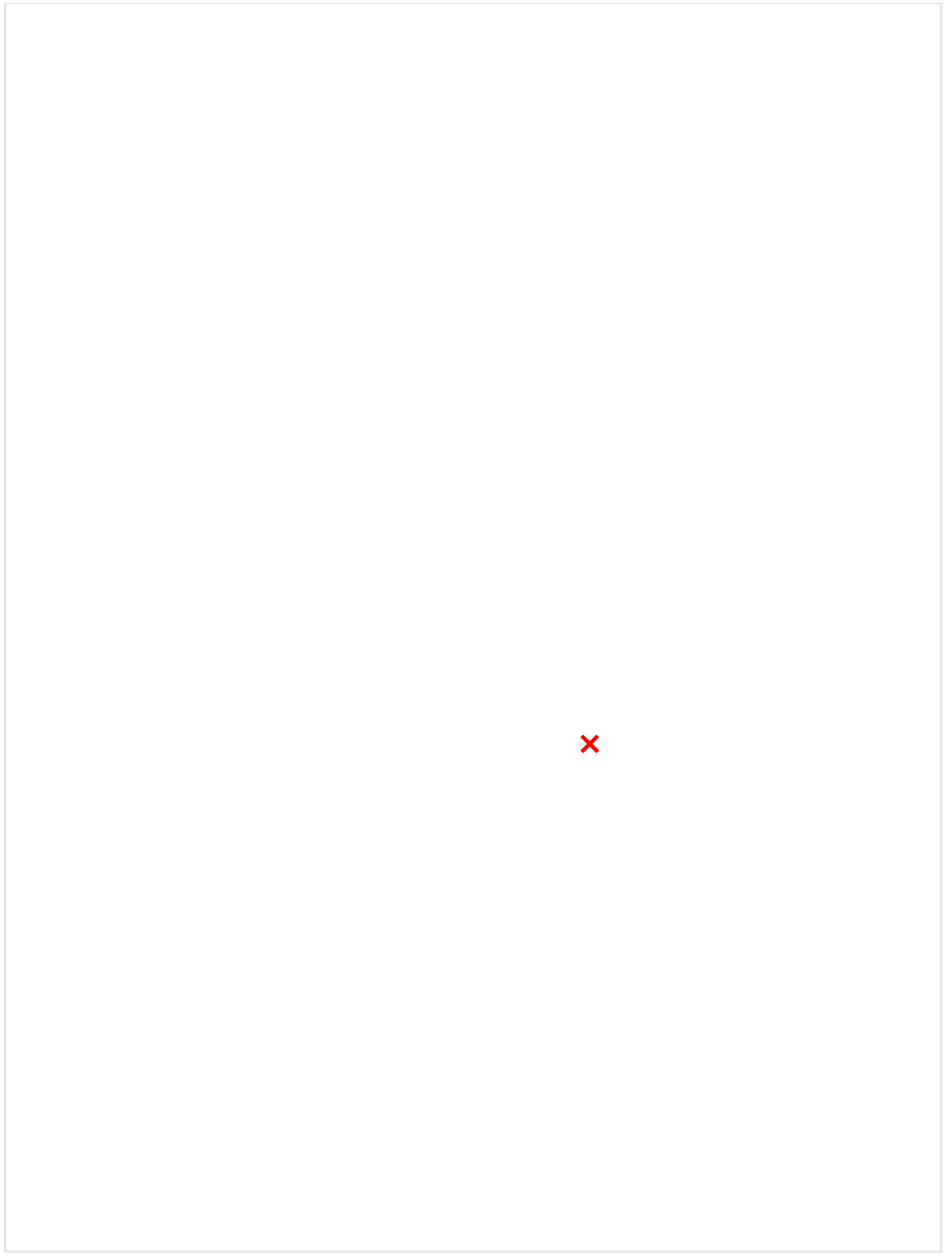
```
Function Car_startup()
        DRS_pos = 100
        DRS_pos = 0


Function drs(steering_angle, gas_pot, brake_pot)
        If(steering_angle <= 15 deg AND brake_pot <= 5% AND gas_pot => 5%){

        DRS_pos = 100

        }Else{

        DRS_pos = 0

        }
```

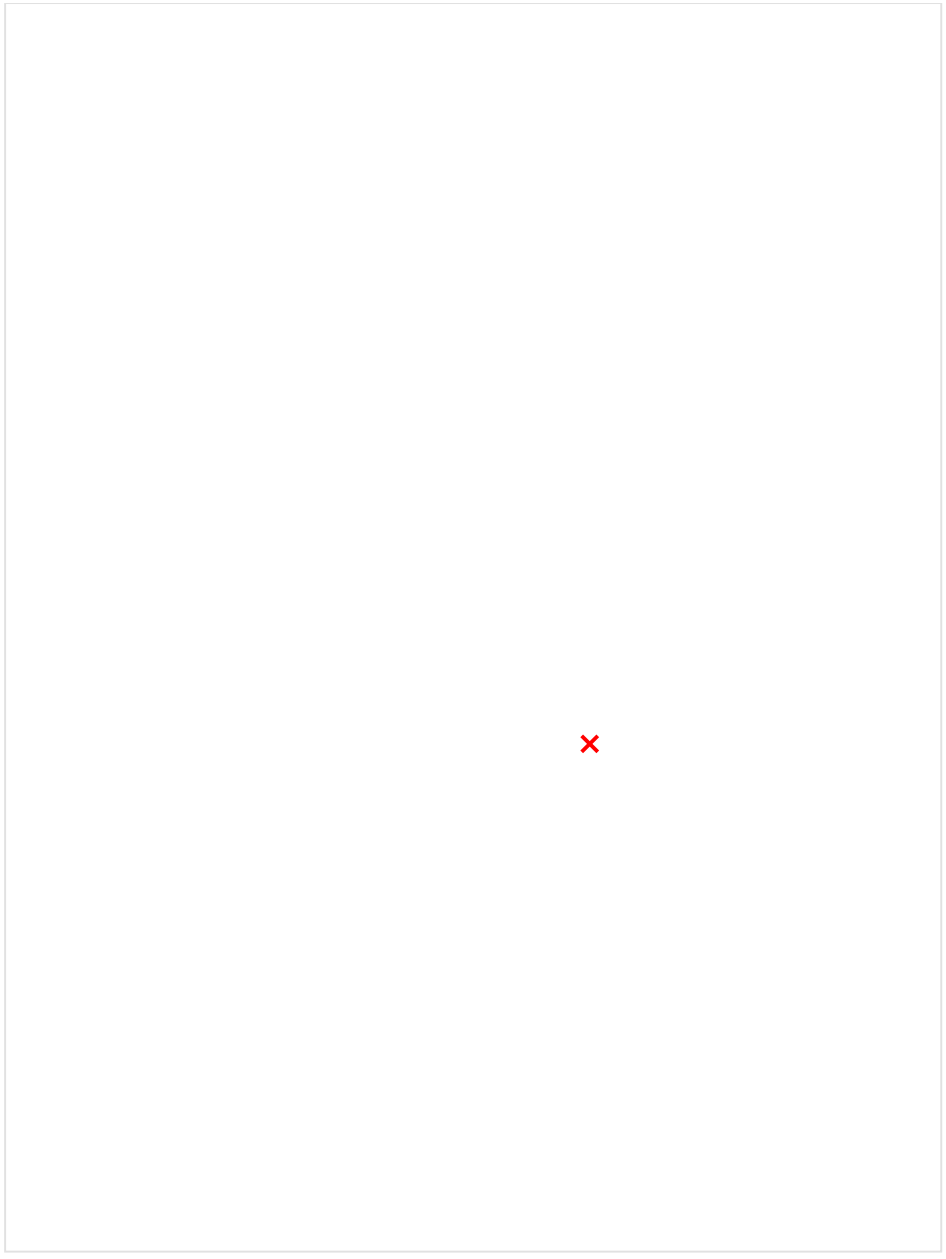
Initial flow vis mix test

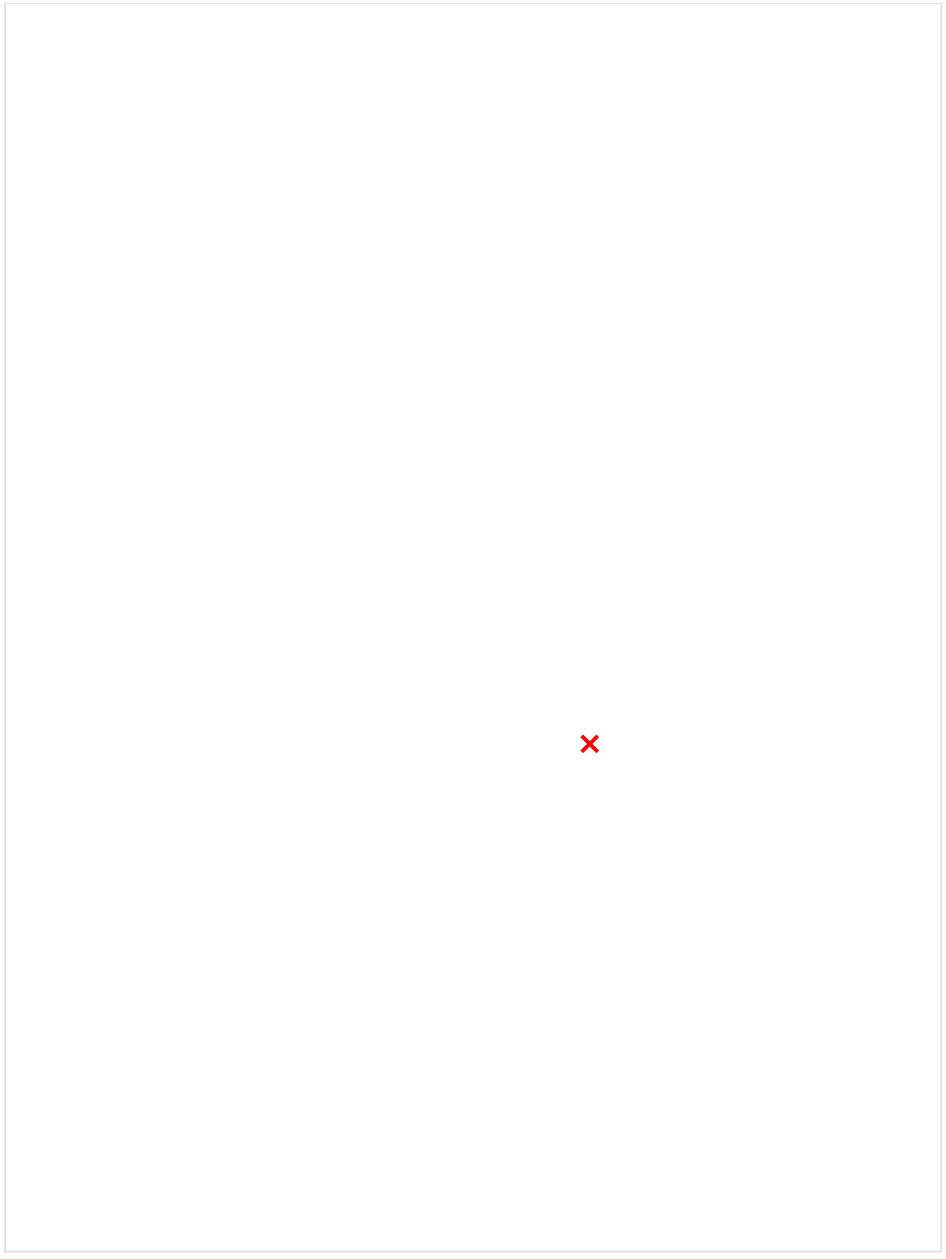
Monday, October 30, 2023 12:40 PM

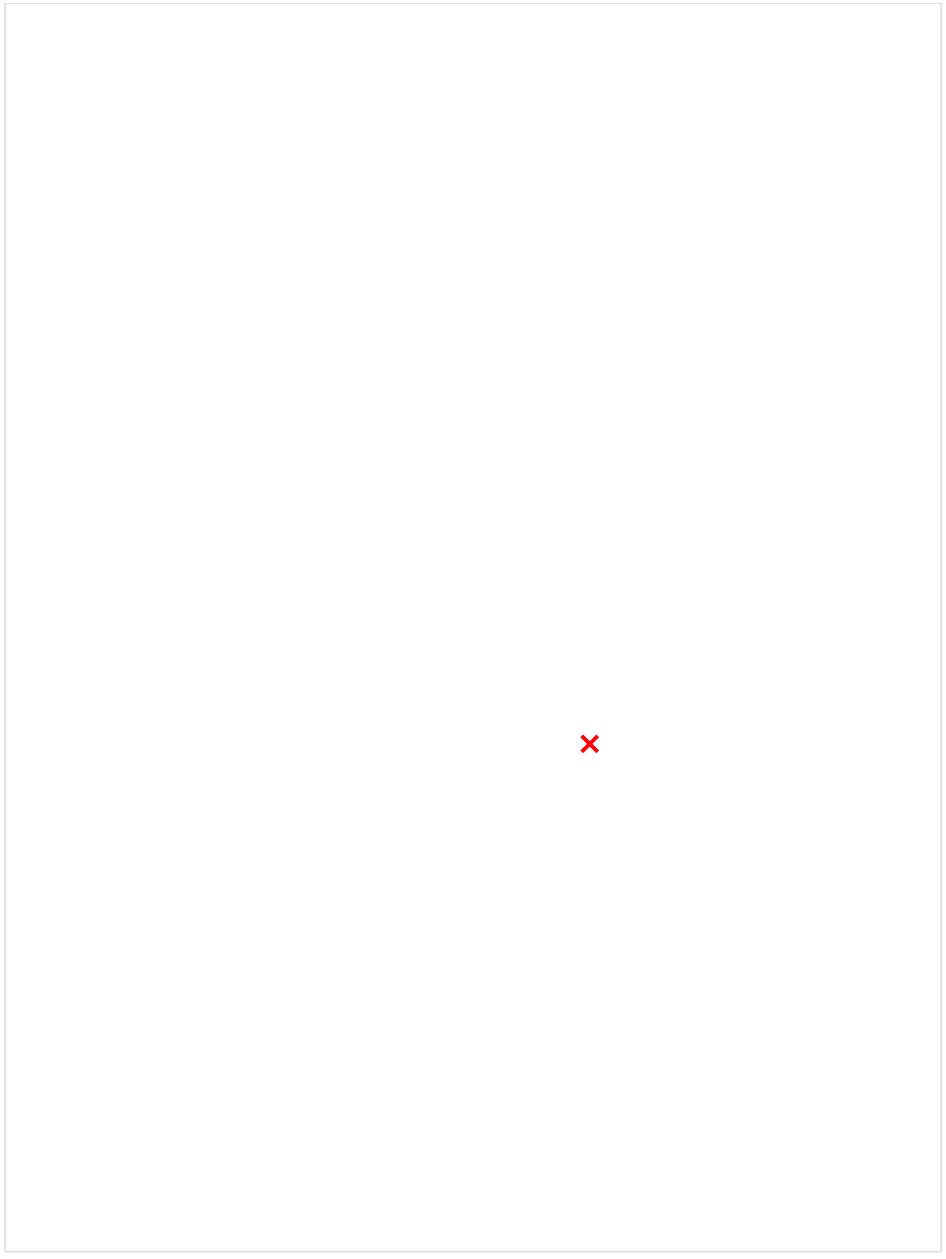


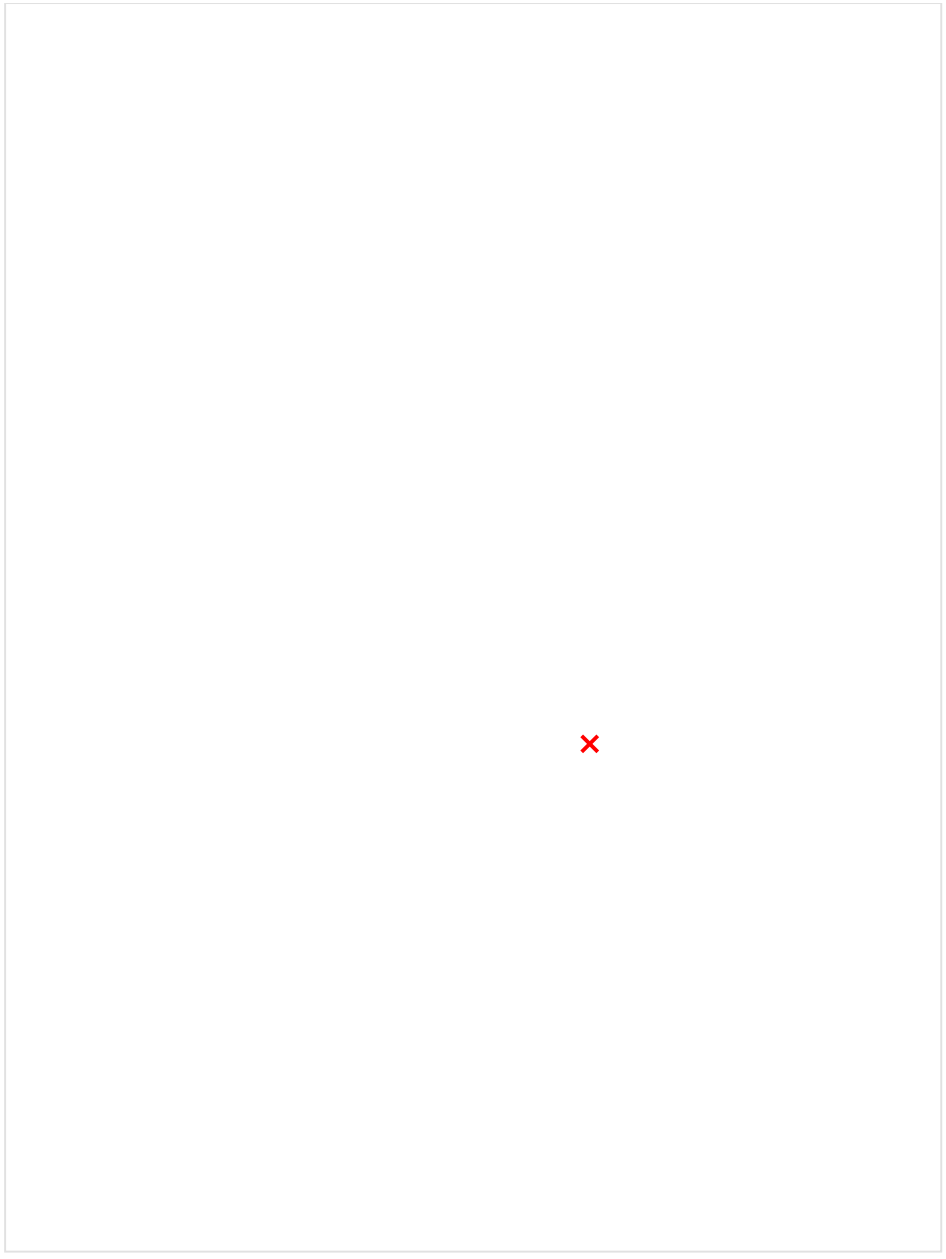


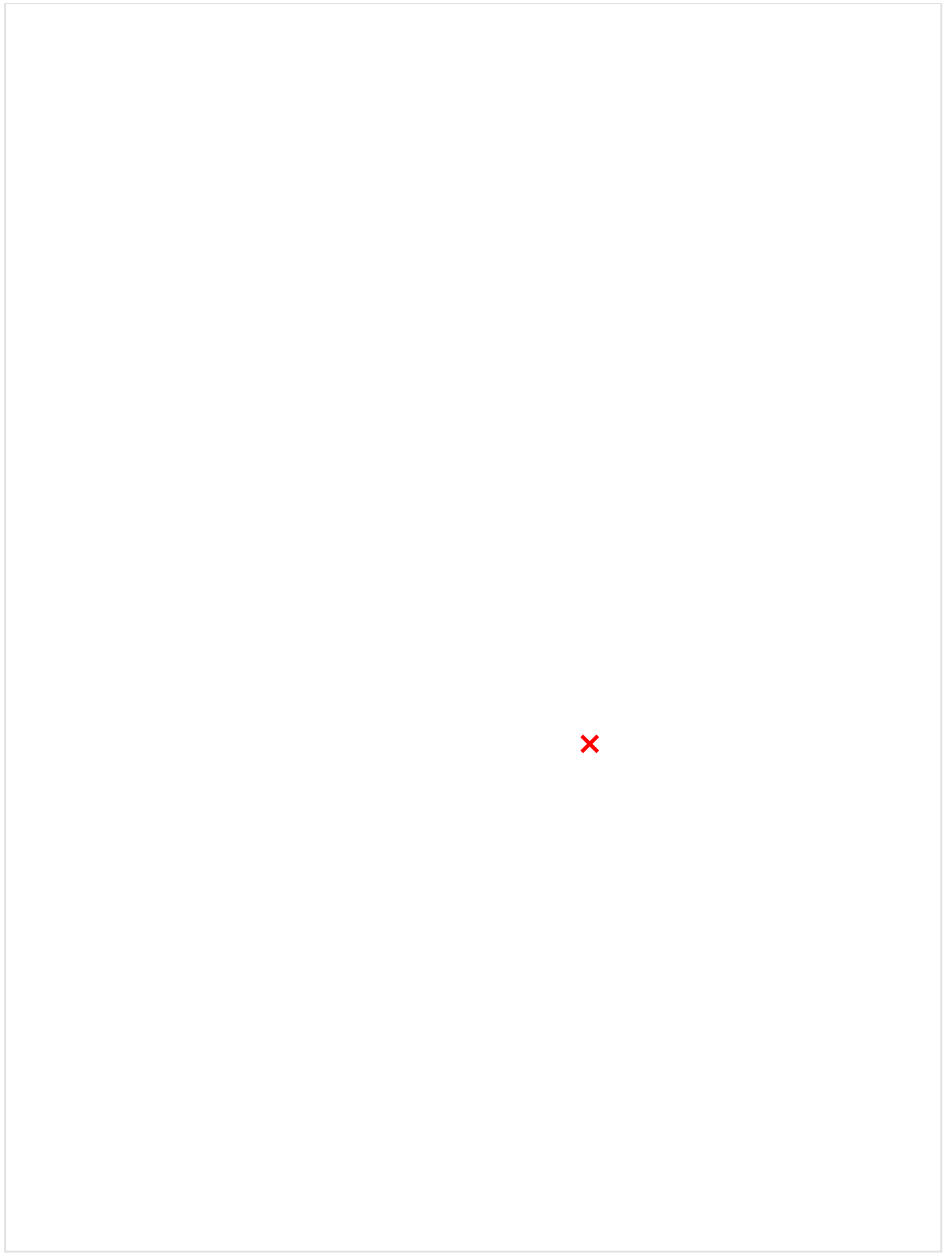


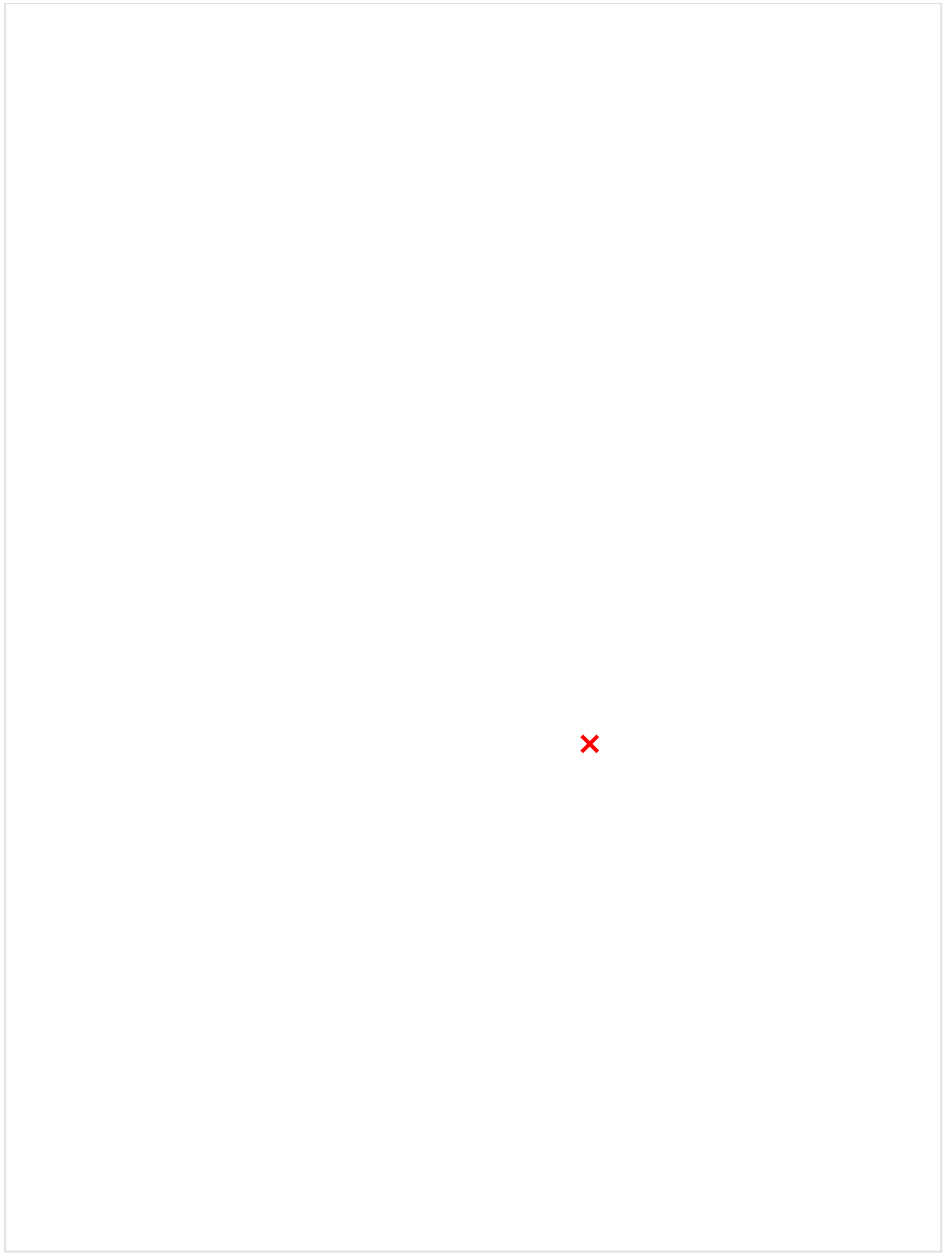


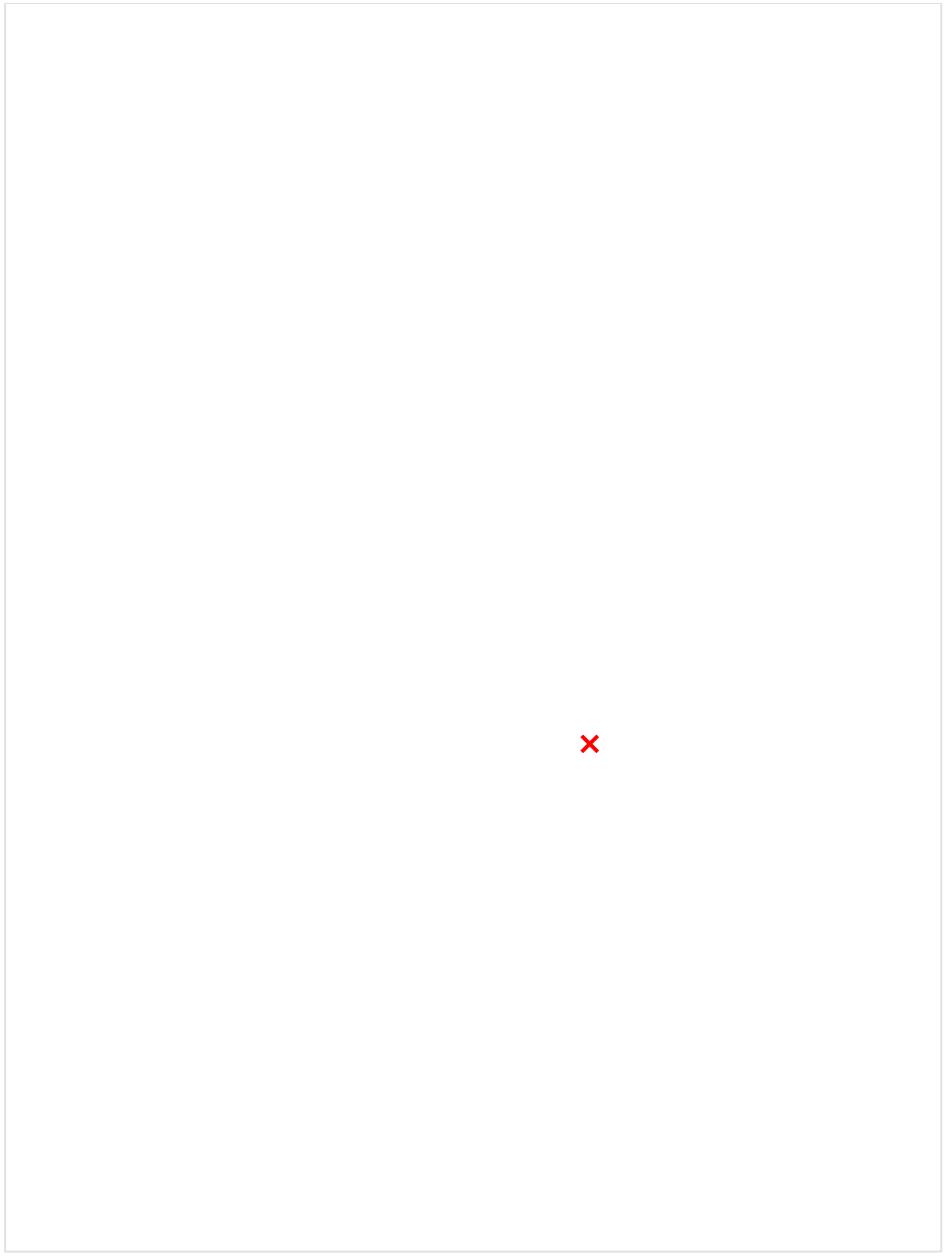


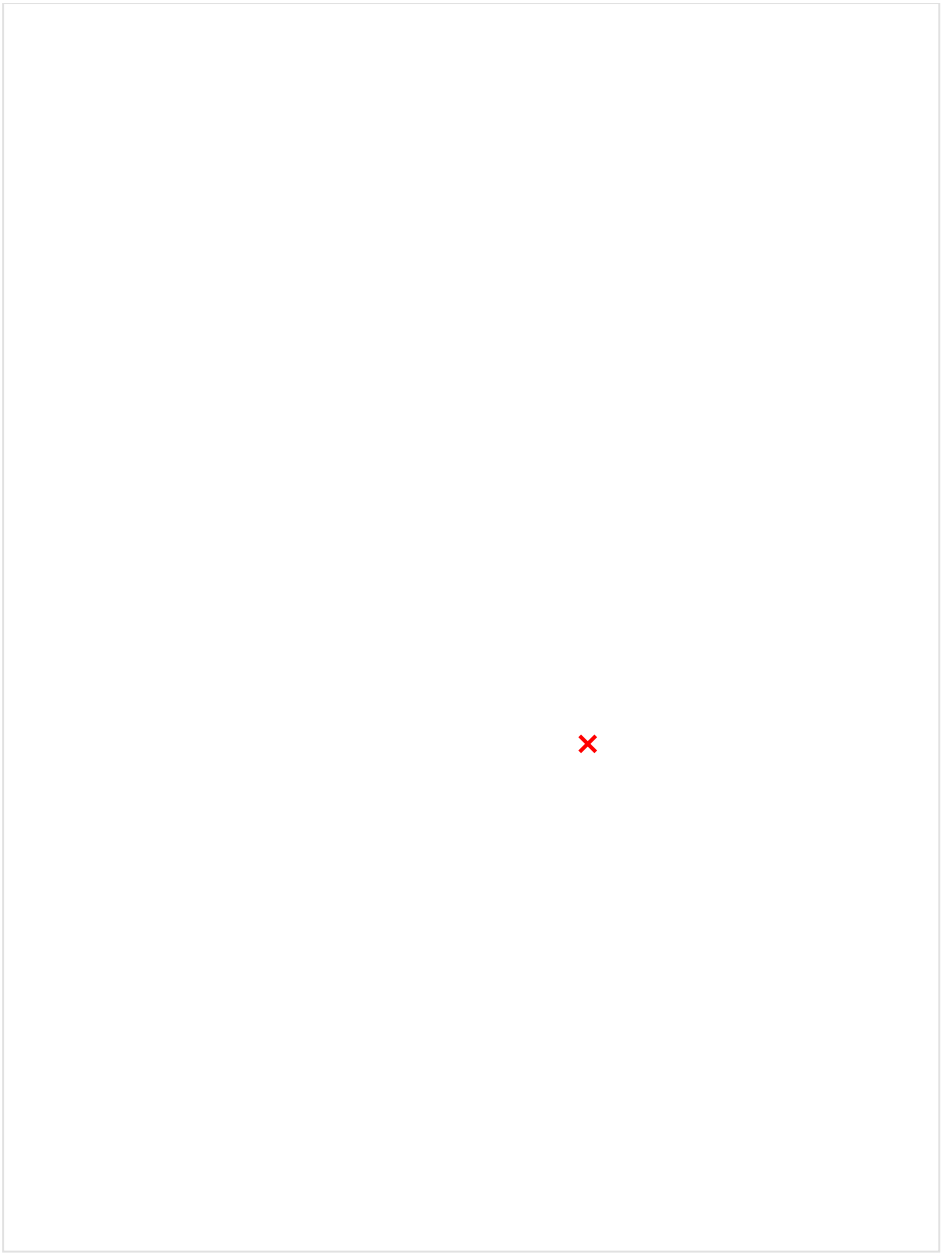


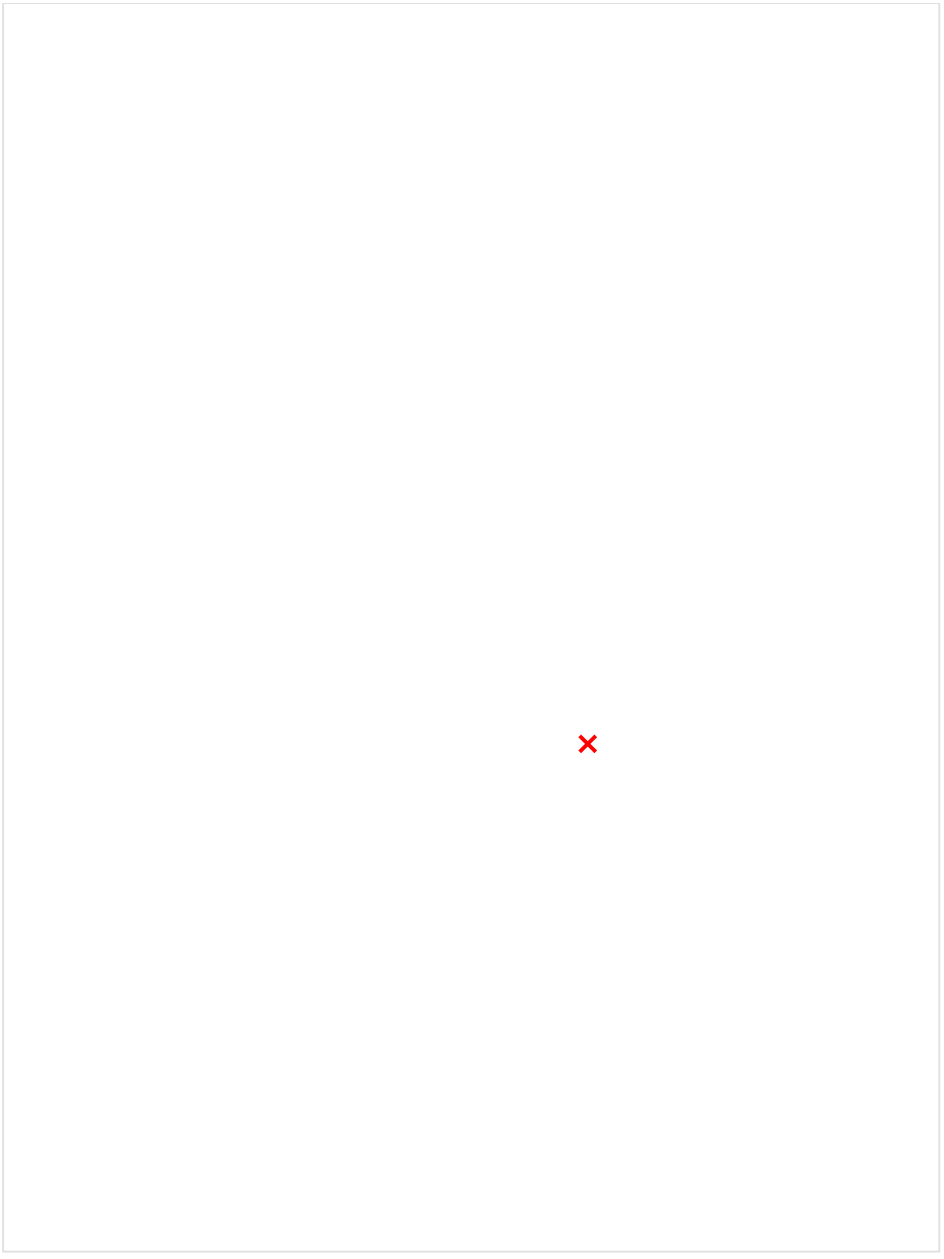


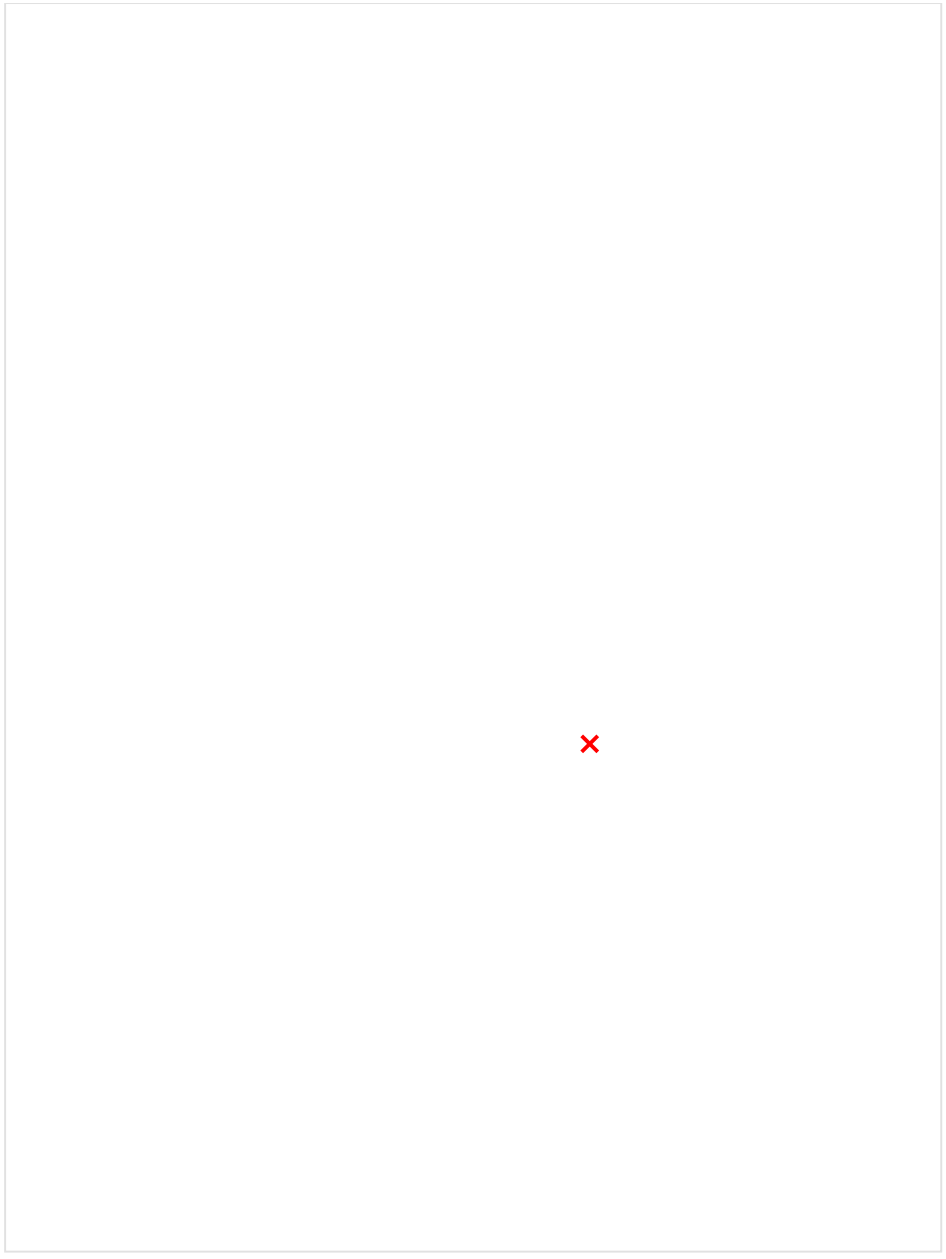


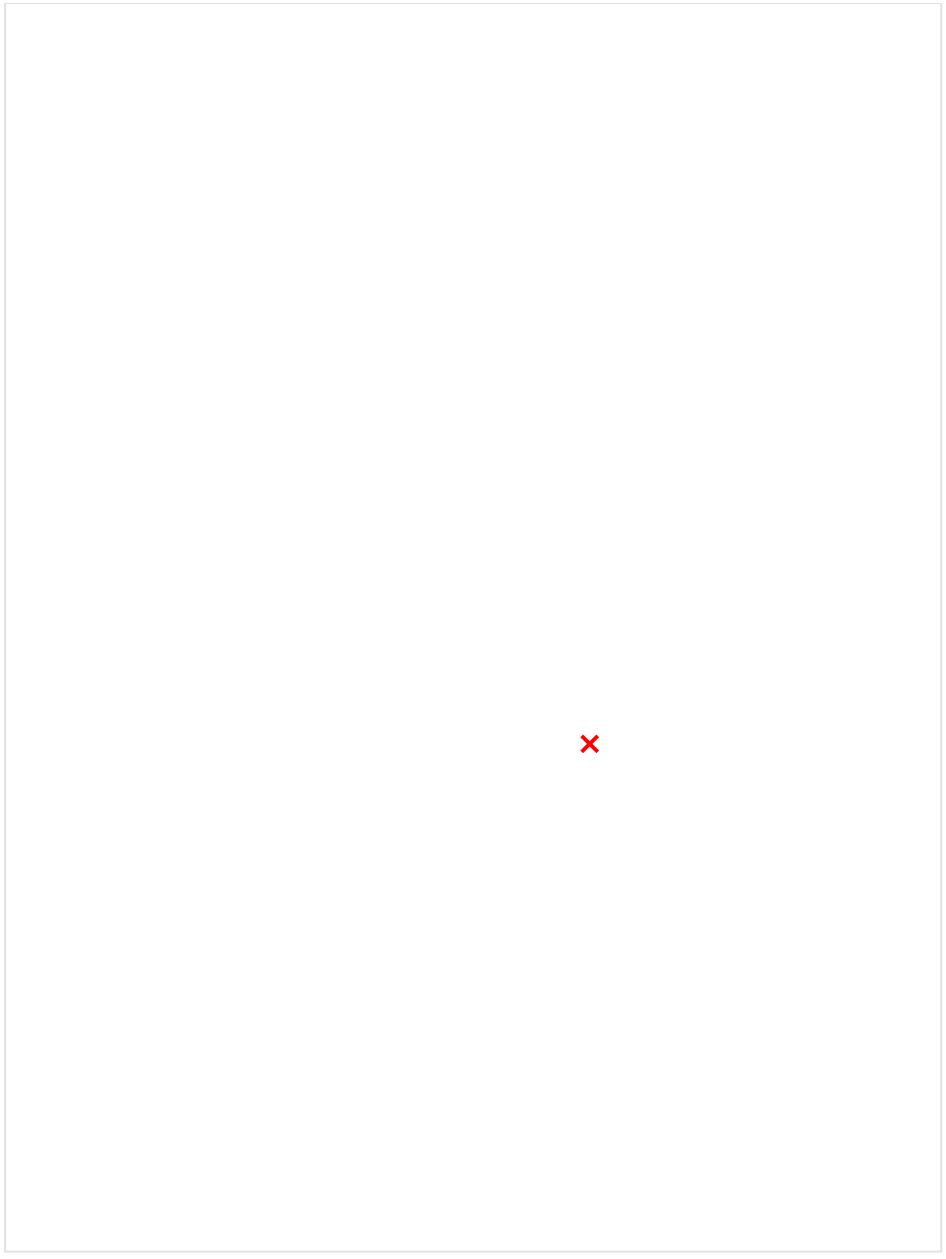


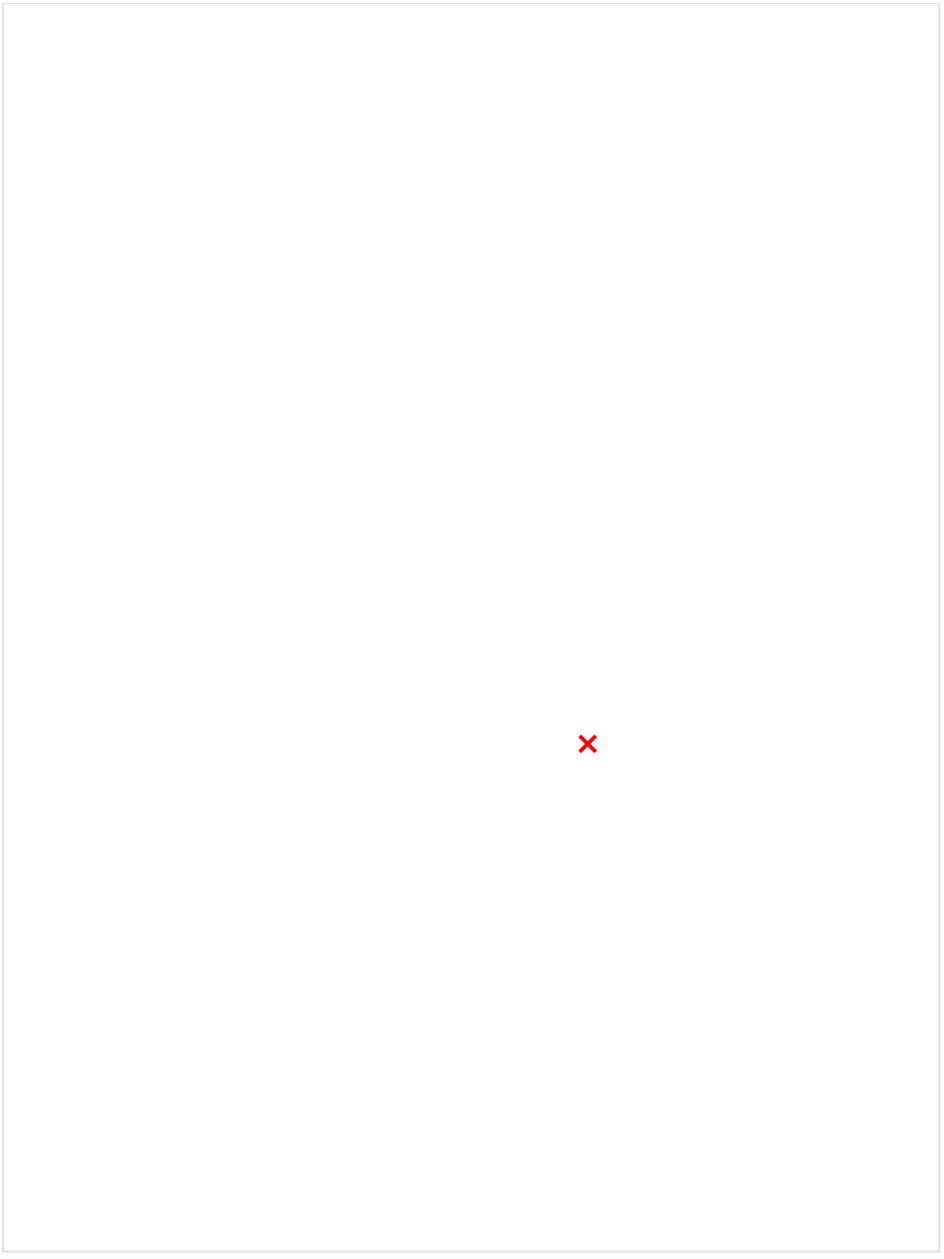


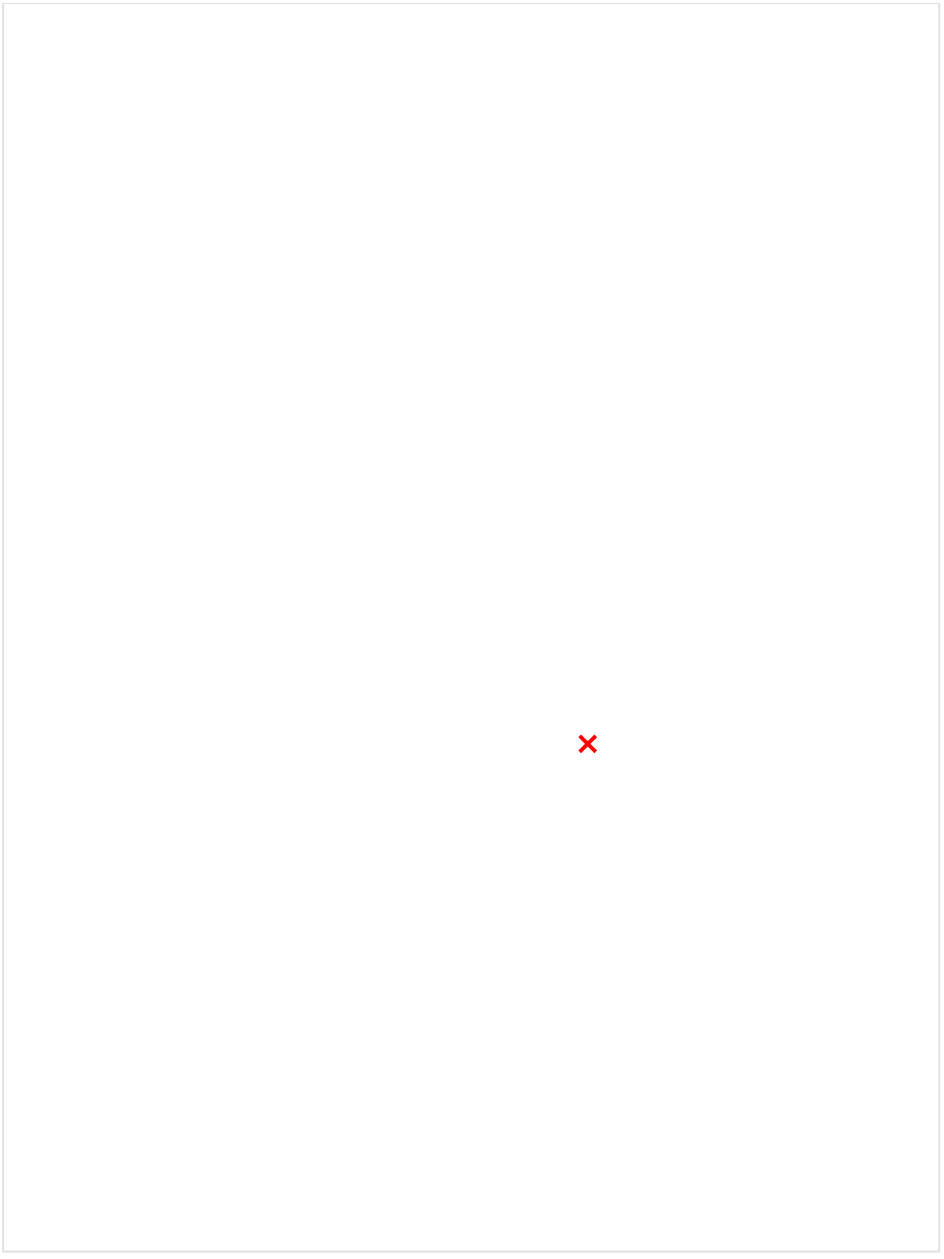


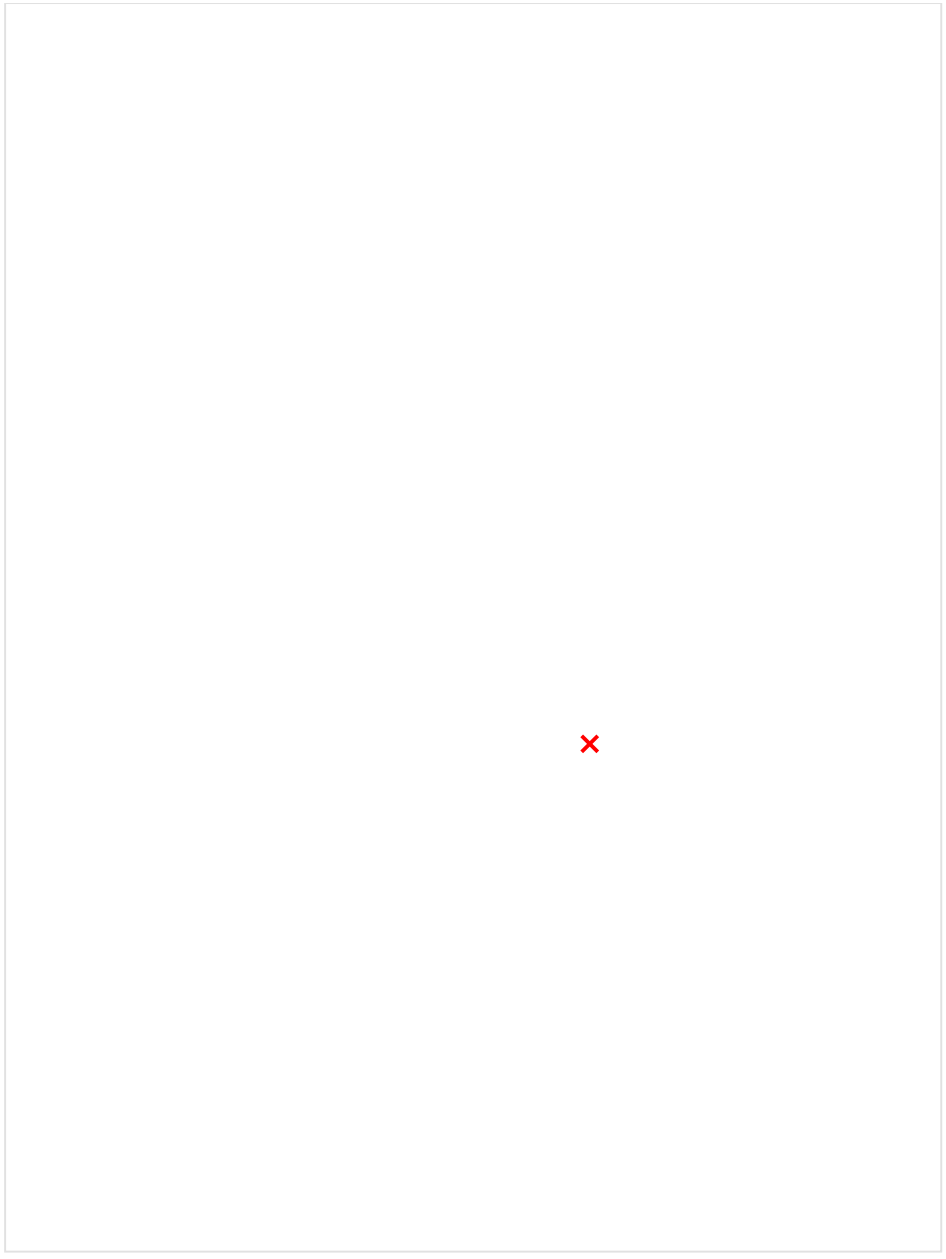


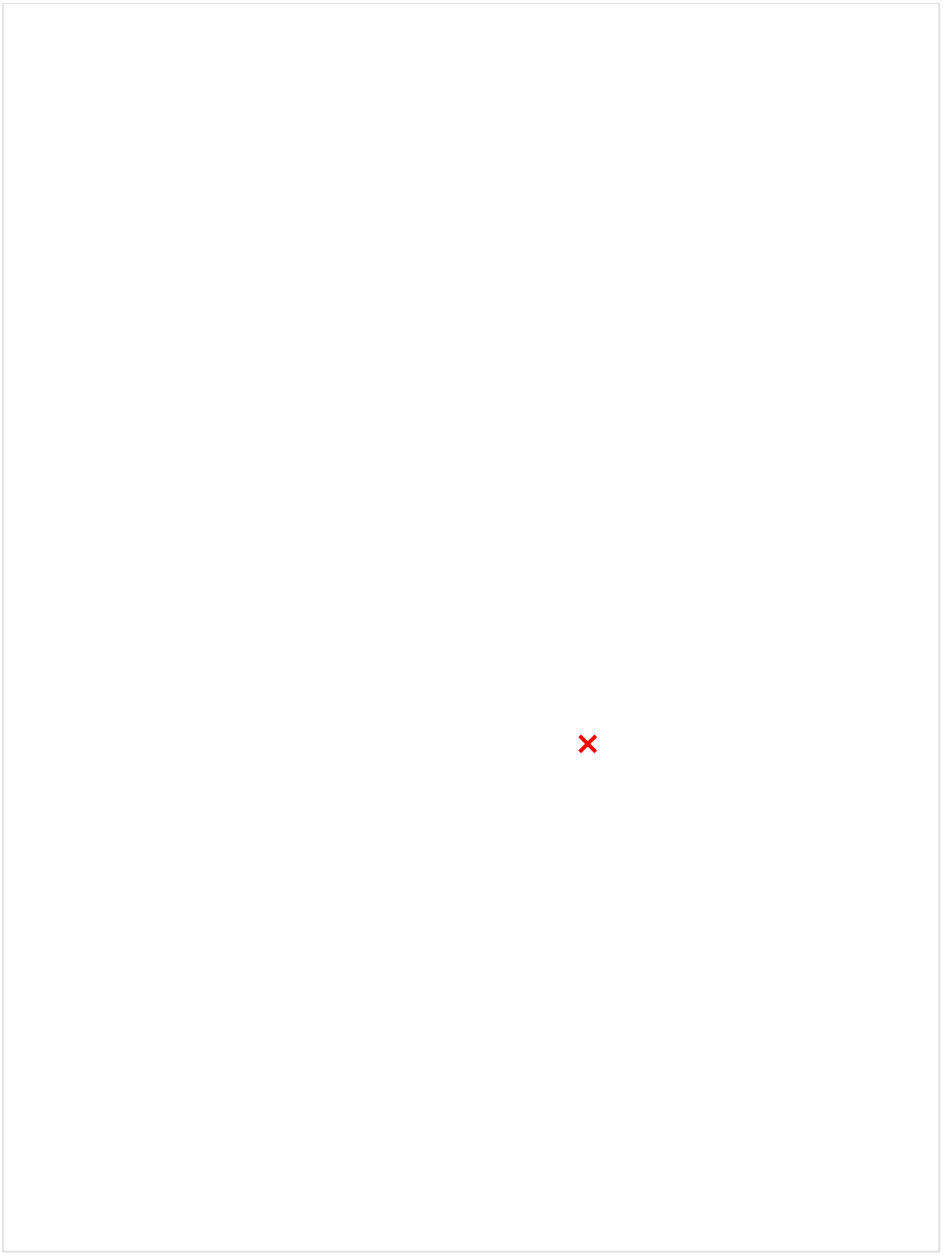


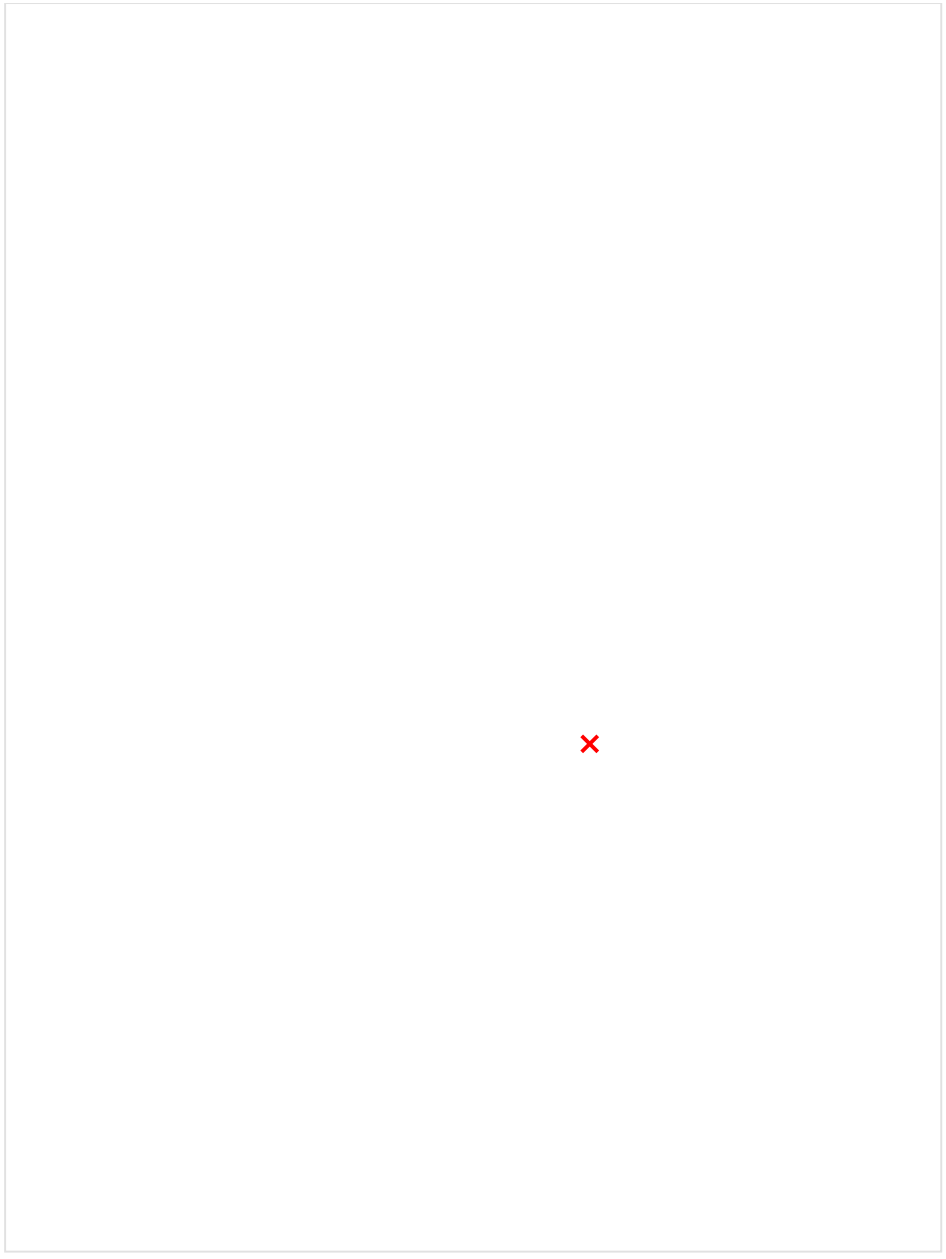












KS8 Undertray Diffuser Schizo Ramblings

Friday, January 26, 2024 4:35 PM

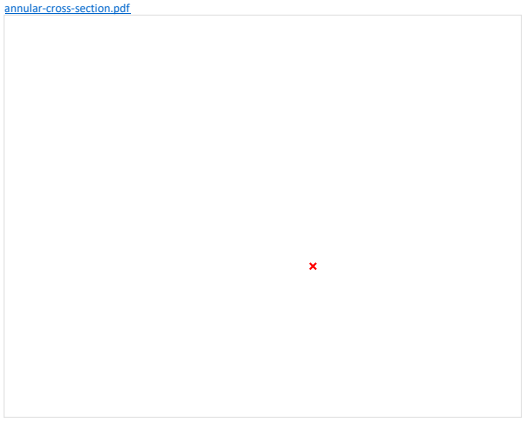
Ehirim, O. & Knowles, Kevin & Saddington, Alistair. (2018). A Review of Ground-Effect Diffuser Aerodynamics. Journal of Fluids Engineering. 141. 020801. 10.1115/1.4040501.
Ground-effectDiffuserReview_r2.pdf

- Plane-wall diffuser area ratio: $\frac{h_2}{h_1}$
  - h_2 is 2 times the height between the top of the diffuser and the ground
  - h_1 is 2 times the height between the top of the inlet and the ground
- Plane-wall diffuser aspect ratio: $\frac{W}{h_1}$
  - W is the length of the inlet
- "optimum diffuser length reduces as area ratio decreases and optimum area ratio increases as ride height reduces" (page 22)

Based on some schizo math using the above tables and formulas, it looks like about 14 degrees is usually the optimal outlet angle, which is the same conclusion that was made in this article:
Design and Analysis of Undertray Diffuser for a Formula Style Race Car.pdf

Obviously this angle should only be used as a starting point, as the optimal angle changes varies based on inlet height and length, throat height and length, and outlet length.

Sovran, G. and Klomp, E. D., 1967, "Experimentally Determined Optimum Geometries for Rectilinear Diffusers with Rectangular Conical or Annular Cross-section", Fluid Mechanics of Internal Flow, ed. by G. Sovran, Elsevier, Amsterdam, pp. 270–319.
experimentally-determined-optimum-geometries-for-rectilinear-diffussers-with-rectangular-conical-or-annular-cross-section.pdf



Ruhrmann A. and Zhang X., 2003, "Influence of Diffuser Angle on a Bluff Body in Ground Effect", ASME Journal of Fluids Engineering, 125(2), pp. 332–338

Conductive Epoxy for UT GNDing

Tuesday, March 26, 2024 10:47 PM

https://phys.libretexts.org/Bookshelves/College_Physics/College_Physics_1e_(OpenStax)/20%3A_Electric_Current_Resistance_and_Ohm's_Law/20.03%3A_Resistance_and_Resistivity

Assuming:
4g volume epoxy usage per stud
~1cm length to conductive mesh
Target impact on resistance <0.1 ohms

Given:
Length to conductive mesh (cm)
Volume (cm)
Target impact (ohm)

Find:
Equivalent rectangular area of epoxy (cm^2)
4g = 64cm^3
64cm^3/1cm = 125cm^2 equivalent area

Resistivity threshold p (ohm-cm)
R = p(L/A)
p = (R*A)/L
p = (0.1*(64))/1 = 6.4 (ohm-cm)

Thus the epoxy must be rated for <6.4 ohm-cm

Here is a list of suitable epoxies ($ per 10g things)
https://atomadhesives.com/aa-duct-903-electrically-conductive-nickel-filled-epoxy-adhesives-room-temp-cure/
19.99

https://atomadhesives.com/aa-duct-gs1-silver-glass-sphere-coated-electrically-conductive-epoxy-adhesive/
38.99

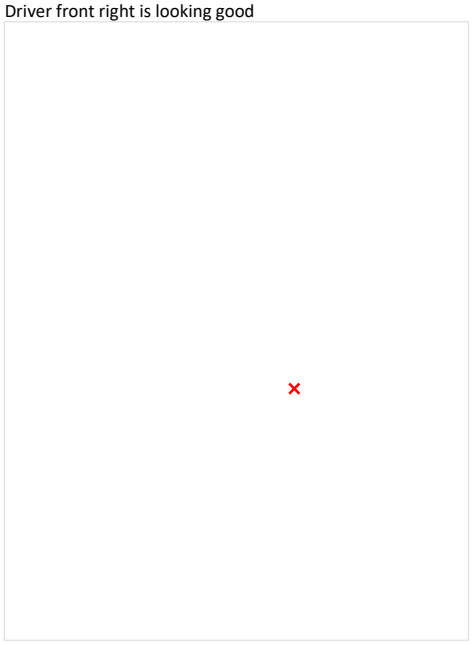
https://atomadhesives.com/aa-duct-2924-2-part-electrically-conductive-heat-resistent-silver-epoxy-adhesive/
35.99

This guy probably best
https://atomadhesives.com/aa-duct-906-low-cost-low-volume-resist-electrically-conductive-silver-epoxy-adhesive/
18.99

Undertray

Tuesday, May 28, 2024 11:46 PM

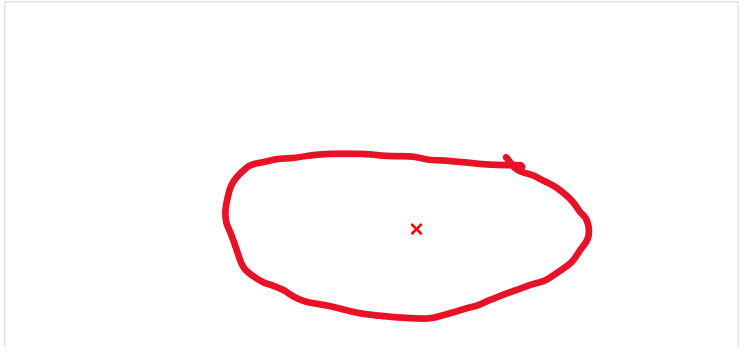
Driver front right is looking good



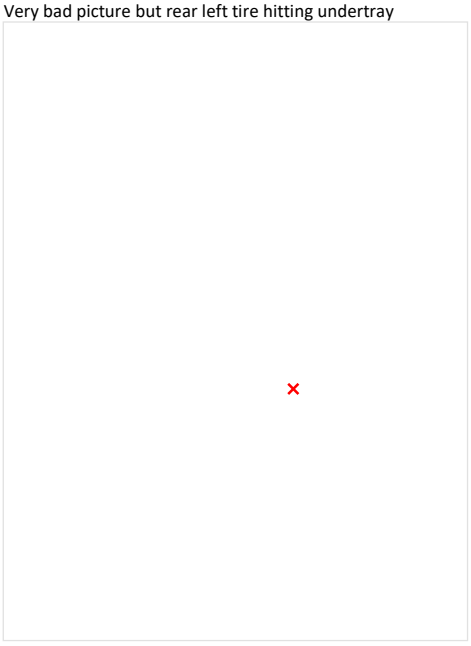
Undertray hitting roll hoop chassie bars hitting on both side

Driver front left

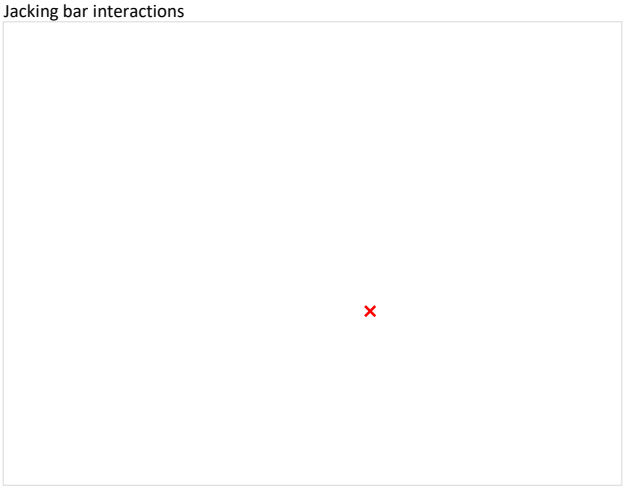
Rear right



Very bad picture but rear left tire hitting undertray



Jacking bar interactions



Quick Thoughts

Wednesday, May 29, 2024 11:34

Problems:
- Firefighting: Poor communication when firefighting errors
  - How do we ensure proper communication/channels so mistakes aren't made?

How to make design decisions that result in a good design score:
- Reasoning/Team Goal Alignment (e.g. reduce drag to reduce energy consumption)
- Simulation/Data Confirmation (Confirm if change will make an impact. E.g. how much energy expected to be saved by DRS?)
- Thorough Design Considerations (Wholistic Car Impact, load cases, manufacturing restraints, serviceability)
- Thorough Manufacturing Instructions and Tools
- Comparison to prior iteration
- Verification

Sponsors
- Reach out to 3M for PPE
- Reach out to aerospace companies
- Search for student sponsorship areas
-

Lead Transfer

- Select someone for lead role training, have them oversee KS9C development.

New Member PowerPoint Topics
- Name, Position
- What does aerodynamics do?
  - Design and HELP build all aerodynamic elements of FSAE car.
    - RW, FW, UT. Radiator placement for optimal airflow, exhaust header/intake flow simulation.
- What is important about aero?
  - Increase grip tremendously w/o adding weight. Cornering increases.
  - Deep connection with suspension to provide ultimate dynamic control.
  - Sponsor space and looks fuckin sick.
- What do you need to know?
  - Rules, Rules, Rules
  - Aerodynamic principles (Bernoulli's, Lift, Boundary Layer, Flow Separation, Components, Workflow)
- How do you join?
  - Pass subgroup rules test (Currently WiP, eta is two weeks)

-

Jacking Bar Notes:
- Integration: Tool clearance

- UT Trimming Idea
  - Measure out cut points and mark
  - Line up with jacking bar to make sure it lines up
  - Cut away
  - Cook up some loss mitigation devices

- Would like to see hand calcs with internal stresses and deflection
- Buckling FOS

I am tasked with making an aero package better for the KS8. It needs to be more complex and fit the drag and downforce goals that are set. To do this, I need to change what we have, however I am limited by time, resources, and knowledge. In order to make upgrade the aero, I need to know what it currently does. I can find pitfalls and design them out, and I can identify areas of opportunity.

How do I learn what our aero package currently does?

- Note down all of the devices we use and where they go. How effective are they? How do you determine effectiveness of that device?
- Driver feedback from comparing with and without. Are there any hidden anomalies affecting performance?
- Lap time delta. Do we reach a faster time with the aero package?

What to do:

- Get all major stats of the aero package
- Conduct standard whole car CFD sims
- Get accurate driver feedback and lap time deltas.

What's New?
- FW Mount: Quantification of Deflection/Stiffness, Investigate material change w/o mainplane cut.
- RW Mount: Final revision, review with knowledgeable ppl
- CoP Tuning: Waiting to hear back from Quang.
- DRS: BOM -> PPT -> Re-evaluate steps/make hitlist (Finishing up FW Mount first)
- Going to revisit overall goals and timeline for things. Want to think the shit out of how the rest of the year is going to go and try to predict what needs to happen and when.

Post IC Stuff
- Get started on testing IC Aero
- Assemble EV Aero
  - Assemble RW
  - Chassis TC's Routed & Welded
  - FW: Check aero box
- Finish IC/EV Aero
  - Wing TC Tabs Cut, Bent, Routed, & Adhered

z

Designs for review

- UT Mount Change
- IC/EV FW TC Tab (Upper & Lower)

Introduce: Subgroup goals, heavy hitter projects, design philosophy, and team goals.

"Prove why we *need* to do two, not accept it as the default"

Why we NEED to do:

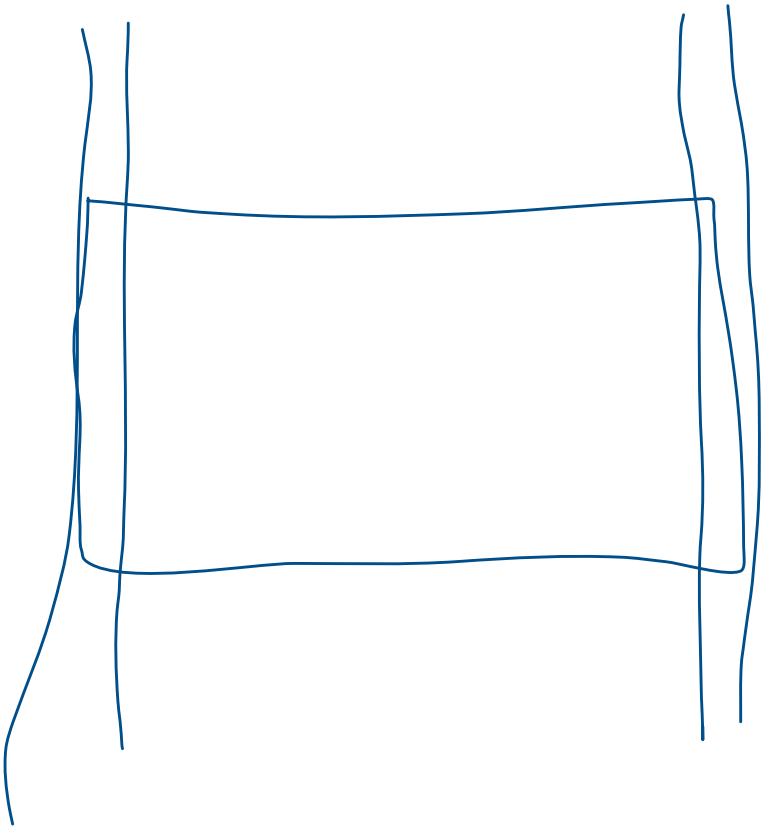
One Car
-

Two Cars
- School relations
- RSO/More sponsors
- Comp twice

What is the great benefit for all of the downsides for two cars?

- Comp twice

- UT Mount Change
- IC/EV FW TC Tab (Upper & Lower)



What is important for Aero

Monday, April 14, 2025 6:26 PM

In terms of the competition, what are KPIs for aerodynamics?

- Meet tech rules
- Safe/sturdy/well put together
- Understanding why it is used, what/why the targets are
- Understanding of realized effects

KPIs

1. Design parameters and goals deeply understood and used
2. Realized product tested and correlated
3. Passes tech inspection
4. Securely mounted

Formula Isms

Saturday, May 3, 2025 2:47 PM

- "Hello my name is…."
- "Oh dude dab me up bro dab me up"
- "Aaaaaaahahallhalahhalahlahlhhhhllllh"
- "Dih to yo crack" (Dick to your crack)
- "Crazy style"
- “Techniques”

Other teams

Thursday, June 19, 2025 17:42

Laval

- 1.9 and .9
- PA60 Ribs
- Efficiency and drag were better targets cause of torque limit

Hytech

- 1.4 and 4.8

TE Connectivity for pressure transducers

Design Debrief

Thursday, November 14, 2024 4:26 PM

Seth:

Stuff I want to do:

- Make more informed decisions earlier, stick to them
- Less analysis. Decide analysis in planning stage and don't go too deep
    - Think RW Mount analysis
- More eyes on each project, especially cross-system integration
    - Think DRS-Low Voltage woes
- Be more involved in steering team member projects
- Complete design milestones (PP1, PP2, PP3) earlier

Team Stuff:

- Promote/maintain an environment of positive affirmation

Budget Debrief

Thursday, November 14, 2024 4:16 PM

Seth:

- List of common stock & hardware ordered
- Method to track everyone's stock needs

- Budget "Check in"
    - Mid design season, check if projects need to find more cost effective solutions
- Time for sponsor reach out before final design decisions are made
    - Designs completed earlier to use for sponsor requests

Monday, July 14, 2025 8:14 PM

Chief Engineer	PM
1. Support and review for all major subsystem design decisions 2. Document review and submission for general engineering tasks - CR, SES, FMEA, ETNOI, DB, etc etc, basically everything but biz	1. Lead bi-weekly project status check-ins 2. Track milestone and paperwork deadlines (SES, Design Reviews, etc.)
Should Do - Document key decisions and keep team informed (cause they are reviewing these decisions) - Action trackers?	Questions about PM? - Action trackers?

Work distribution:

Garrett
-
Cooper
-