# ==== General Pages ====

Wednesday, August 20, 2025 11:48 AM

Ranked priority list for each component that incorporates points improvements

Are side wings worth the time penalties for putting acc in

Points improvements per part, per change in the part

Have a flow chart of how the CAD is structured

Skid Pad Specific Sim (Curved domain, full car)

Accel Specific sim (with the pitch)

Non-uniform thickness endplates

# Subsystem Targets

Tuesday, July 29, 2025 11:39 AM

Quantified Targets:

CLA -
CDA -

Speed: 15 m/s (33.5 mph)

Downforce @ 15 m/s - 118* lbs. (*Re-define with shock-pots)
Drag @ 15 m/s - 43 lbs.

Qualitative Targets:

1. Drag Reduction System
2. DFMA
3. Clear of vehicle jack points

*Temporary: Determined from optimumlap and points analysis delta required, waiting for VD Lap Sim goal.

**Temporary: Car can complete endurance full-out without running out of energy

Reasoning:

CDA

CDA is the driving factor for all other goals. The budget was determined based on testing of the KS8. During an endurance style test, the KS8 achieved 268 Wh/km energy consumption with the Aero on. This is the upper limit of endurance energy usage with a 15% buffer. So long as the aero package does not exceed this target, the car will have enough energy to complete endurance without needing to conserve energy through throttle discipline.

CLA

Downforce was derived from OptimumLap using a conversion factor between the KS7E's AutoX lap time and the OptimumLap AutoX lap time. Using the 2024 EV results, a 10% increase in points is required to reach 70th percentile goal of 111 points, which is a 3% decrease in lap time. In order to hit a 3% decrease in lap time in OptimumLap by adjusting aero, the range of CLA = [3.48, 3.83] and CDA = [0.58, 1.41] was found to make the 3% lap time decrease possible.

Therefore, a CLA = 3.83 with maximum CDA = 1.41 with meet the energy and lap time requirements for our placement goals this year.

Design Philosophy

We will begin with targeting the CLA of 3.83 then optimizing to hit the CDA target if need be. Then, development will shift towards drag reduction while maintaining the CLA of 3.83 as close as possible.

# KS7/8 Lessons Learned

Monday, August 18, 2025 11:40 PM

Disclaimer: These are only the issues with the package, there were many good things about the package as well.

Aerodynamic Specifics

FW

- Center portion too closed to ground (test and sim correlate)
  - Would scrape like hell
  - Less downforce than outer regions
- Outer endplates would scrape under heavy brake and turn in, perhaps too soft of springs or too low to the ground.
- Inner flap 1 not has low pressure, can be cambered more
- Outer element flow has high disturbance from tire was
- Vortex generator too small. Does not fully protect underside or reduce tire wake
- Tire blocker is too small

UT

- Rear tire wake largely increased pressure on bottom surface and hurt pressure recovery for the diffuser
- Front ramp angle and/or FW caused stagnant region caused high pressure at inlet
- Tire wash from front tires almost completely nullified side wing flow
- Would scrape in turns

RW

- Driver, headrest, and MH/MHB severely limits flow to RW, very small negative pressure in the center of the RW (Half of outer areas)
- Shocks create stagnant region that propagates to outer RW, about a 10lb reduction in downforce at 40mph
- Still some flow separation on flap 3 (Element 4) after changing AoA and spacing

General Vehicle Integration

FW

- Inner endplates way too close to front wheel
- Wing is generally riding the edge of front space because it cant move rearwards without the inner endplate being shaved by the front tire
- Middle wing blocked chassis tube, but it would be better to just access the next chassis tube to jack the car rather than reducing FW performance.

UT

- Cant drop the acc w/o dropping the UT
  - Realistically, unless a hatch is used, will have to drop UT before Acc
- UT was considerably hard to drop because side wings would collide with tire jacks, force the person lifting the car to move their feet (dangerous), and would block almost every jacking point
- Collided with a lot of chassis points and was very close to the ground

RW

- Very close to chassis since the rear was close to being out of aero box, especially with the wing in accel mode

Mounting

FW

- Fang mount was a PAIN IN THE ASS to fasten. Very little room between the wing and the L bracket to slide a fastener in while holding the wing up, and the tool clearance was rough.
- Having adjustability for FW AoA under the pedal box is slightly annoying, but we never needed to mess with the AoA enough to where it became too annoying, however this limited the ability to test AoA changes.
- Tension cables were probably too thick, as well as turn buckles. They were definitely oversized
- Tension cables were really a band-aid for the Fang width. If the fang mount width was greater the problem would have been less, among other internal structure issues.

UT

- Damn, that shit just sucked
- Difficult to line up every hole
- UT would

RW

- Strut placement (dictated by un - changeable internal structure) was in the middle of a tube and somewhat blocked access to the acc (although the RW in general does that)
- Cross brace was not strong enough because of strut mis-alignment, had to use second cross brace. A larger diameter tube would help.
- Welding the small aluminum cross brace to the small aluminum swan neck is very difficult
- Otherwise, swan neck and strut combo was fantastic, more clearance from the chassis could enable a strutless design

Structures

FW

- Incorrect skin revisions that were made resulted in the FW spar not contacting the bottom skin. Lead to flexible FW and the addition of Tension Cables.

RW

- 1/8" Ribs were not very enjoyable to install
  - Addition of rib stabilizers greatly helped

Manufacturing Problems:

**KS7**

- Poor Timeline
  - Orders not put in until febuary
  - Mold prep inconsistent throughout the year
  - Layups start 3 weeks before drop dead
  - Not enough focus on productive work
- Lack of experience among group
  - 1 returning lead with 4-5 new members
- Composites lead not in control of ply schedule
- Lack of Aero-Composite communication
- Mounting ribs cutting were eyeballed, no way to make square
- Part trimming done late and rushed, resulted in crooked parts, RW geometry affected
- Lack of revision control of FW CAD resulted in different skin geometries, loft and trailing edge affected
- Threaded aluminum ribs were prone to strip
- Endplates would experience core crush
- Dramatic Adhesive failure in IC RW
- 1/8" ribs not fun to bond with

**KS8**

- Virtual admin not good
- No budget projection resulted in projects going to far under an assumption of budget, had to switch to minimum viable product with new budget constraints
- Unclear of what parts were under what groups purview
- Management/experience issue lead to prolonged lead time of parts
- Deeper analysis of FW mounting showed issues at the part/ fab level
- Overall pretty OK year (Thumbs up)

UT
- No reasoning for increased ply schedule, resulted in being extremely overweight.

SideWings
- Foam section in between the skins were very helpful for skin stiffness

Simulation

Testing
- Bottlenecked by troubleshooting powertrain
- Pressure device inconsistent with simulation (not flush with skin, may have taken on dynamic pressure
- Drag data needed more runs to get lower standard deviation
- Not knowing wind speed has impact on verifying forces
- More on/off testing

Goal Setting Philosophy
- Proven difficult to directly simulate required downforce to hit specific times for AutoX and Endurance, however Sam is working diligently on a number from lap simulations
- However, we know that the KS7E's configuration was capable of obtaining the target AutoX time (which can translate to endurance time) as well as Accel and Skid
- We also can assume from some endurance testing that full drag does not impact the car's ability to complete endurance, but verification is required.
- So: Pre-liminary drag and downforce max and mins respectively can be set to give the aero group direction while lap sim data can be completed and aero targets can narrow down.

Drag Target
- The endurance run from Emil which was not power limited resulted (roughly) to be within range of our pack's energy limits with aero fully closed. Michelin testing was supposed to verify this, but we did not get to run endurance.
- As a pre-liminary target, we will shoot for a CDA of 1.40 (43 lbs of force @ 33.5mph)
- After downforce is generated, we will try to adjust geometry to reduce this further as a safety margin
- Note on DRS:
  - DRS will be pursued starting next week, needs to overcome understanding battery draw and a re-design congruent with the new RW, which is aiming to do 2-3 elements instead of 4. Aero analysis of correct position will be done. CLA will not be increased this year to account for CDA reduction from DRS in case DRS fails.

Downforce Target
- Achieved 1.33 G target for skidpad, and likewise this configuration has hit points goals for autoX (most aero sensitive)
- CLA target of 1.87 (60 lbf @ 33.5mph)
  - Tentative on shock pot data analysis, assume number will change

CoP/Height/Pitch Sensitivity
- Preliminary goal for CoP is 50/50 to 45/50 Front/Rear range
- Height and Pitch Sensitivity goal needs more time to be discussed with VD, will be set in about 2-3 weeks

# CL Target Derivation

Thursday, July 31, 2025 12:29 PM

## Target Development

- Most effective at X speed in X Radius
- Stall speed is greater than max speed radius
- Design for autoX, most points benefit

## Skid Pad

- Time goal: 5.231s
- Lat. Accel. Goal: 1.342g
- To hit 1.342g given tire data, downforce is:
- ^ how does this match TTC data for max?

## AutoX

- Using 2025 Results, 2024 Results, and OptimumLap I derived the time increase that would need to happen in order to get the desired points. I then batch swept CL and CD and pulled the coefficients that matched with that lap time. They are:

| Lap Time | CL | CD | CL/CD |
|---|---|---|---|
| 68.4395158 | 5.000 | 1.919 | 2.605263 |
| 68.4395124 | 4.899 | 1.768 | 2.771429 |
| 68.4435283 | 4.798 | 1.616 | 2.96875 |
| 68.4371407 | 4.646 | 1.364 | 3.407407 |
| 68.443983 | 4.495 | 1.111 | 4.045455 |
| 68.4364176 | 4.444 | 1.010 | 4.4 |
| 68.4311628 | 4.394 | 0.909 | 4.833333 |
| 68.4319822 | 4.192 | 0.505 | 8.3 |

- We are most likely to hit somewhere in the range of CL = [4.444, 4.646] which means we need a CD = [1.01, 1,364]

- Using the 2024 results was a lot more reasonable in terms of numbers that we can hit.

| CL | CD | Time |
|---|---|---|
| 3.030303 | 0.505051 | 70.11832 |
| 3.030303 | 0.555556 | 70.14864 |
| 3.030303 | 0.606061 | 70.17896 |
| 3.080808 | 0.606061 | 70.1041 |
| 3.080808 | 0.656566 | 70.1345 |
| 3.080808 | 0.707071 | 70.16513 |
| 3.131313 | 0.707071 | 70.09037 |
| 3.131313 | 0.757576 | 70.12218 |
| 3.131313 | 0.808081 | 70.1549 |
| 3.181818 | 0.808081 | 70.08058 |
| 3.181818 | 0.858586 | 70.11348 |
| 3.181818 | 0.909091 | 70.14628 |
| 3.181818 | 0.959596 | 70.17961 |
| 3.232323 | 0.959596 | 70.10674 |
| 3.232323 | 1.010101 | 70.14209 |
| 3.232323 | 1.060606 | 70.17759 |
| 3.282828 | 1.060606 | 70.10557 |
| 3.282828 | 1.111111 | 70.14125 |
| 3.282828 | 1.161616 | 70.17716 |
| 3.333333 | 1.161616 | 70.10559 |
| 3.333333 | 1.212121 | 70.14271 |
| 3.383838 | 1.262626 | 70.10926 |
| 3.383838 | 1.313131 | 70.14726 |
| 3.434343 | 1.363636 | 70.11429 |
| 3.434343 | 1.414141 | 70.15286 |
| 3.484848 | 1.414141 | 70.08249 |

- Drag wise, we are around 1.4, so assuming we don't go below that, we should range our CL = [3.03, 3.33] (CLA = [3.48, 3.83] assuming FA = 1.15m^2). Our drag budget in endurance will then set the minimum CL required to hit the AutoX target.
- A few questions arise: Does this configuration get us the required points in skid pad? How does this CL relate to max lat. accel across different radii turns with respect to tire data?

# CD Target Derivation

Thursday, July 31, 2025 12:30 PM

Reasoning

- We are most likely energy limited in endurance. We don't know if no-aero would be able to make it through an endurance, so in the meantime we should assume that there is exactly enough energy to complete an endurance without aero.
- Asking the right questions:
  - CD directly increases energy consumption
  - CL also increases energy consumption by increasing average speed (Drag = v^2)
  - Using 2025 results and 2024 results, what would be the required energy and lap time to hit the points goal of 131.3 and 71.4 for endurance and efficiency respectively?
    - I have to derive the points goal
    - Assuming we don't change our efficiency, the energy consumption will remain the same.
    - Then I can use the pace of the 7 at the beginning to get a good idea of placement
    - Then I can see how much we need to improve in lap time in order to meet the goal, or how much CD we need to knock down to do it. (Its already low as it is)

Questions:

- [ ] What is our efficiency score if Emil kept pace the whole endurance in 2024, assuming same energy consumption? What is endurance score?
- [ ] What is the delta we need to achieve to meet top 10 placement?
- [ ] If we hold energy constant, how much faster do we need to go?
- [ ] How much do you need to adjust CL in order to do that?
- [ ] What is the CL and what is the efficiency? What is the lowest CL and Lowest efficiency to achieve that? Do these meet the goals of AutoX and SkidPad?

Getting Drag

- Can I take average speed over the endurance based on lap time and track length and use that to calculate drag energy loss?

Energy Consumption w/ Aero from mock endurance KS8:

- Energy Per lap average: 2*305 + 2*105 = 820 ft = .25km
- Approximate lap distance: 67Wh
- Energy per km: 268Wh
- Energy per 22km: 5,896 Wh/Endurance

# Notes

Tuesday, July 29, 2025 11:40 AM

Developing CD Target:

- Efficiency limitation is a good start but not the only consideration (lap time still affected)
- Energy calculator by Matthew gives us a good idea of the energy *difference* between closed, DRS, open, and no aero (Does not account for speed difference)
- Questions to answer:
    - Are we energy limited without aero? (Assume not thermally limited)
        - Yes: What aero configuration theoretically outweighs the decreased speed in endurance due to energy management with points in autoX and skid pad?
            - No configuration works: No aero run
            - Some configuration works: Use that configuration as it is the most optimal combination for points scoring assuming no other energy management methods are used (e.g. regen braking)
        - No: How much CL and CD can be added before we are energy limited in endurance? (Remember more CL is proportional to energy consumption because of higher average speed)

Summary

If we are limited in endurance already w/o aero, then adding aero will force the driver to limit energy consumption further. Adding aero will improve points in AutoX and Skid Pad, so the question becomes: Do the points gained in AutoX and Skid Pad outweigh the loss in points in Accel, Endurance, and efficiency?

If there is no combination of Aero that satisfies that question with a yes, then aero should not be utilized. If there is a combination, then that is the most optimal configuration for points given no other energy management solution is used (e.g. regen braking).

Other remarks

DRS

DRS will always improve lap time since it effectively increases wing efficiency by lowering overall drag consumption. In other words, a DRS wing has a lower CD than a non-DRS wing, so A more aggressive wing (Higher CL & CD while closed) can be used for the same CD as a non-DRS wing. DRS should be pursued regardless if Aero is a net benefit.

Other Energy Management Strategies

From a very high level thought chain, if the car does not have spare energy after an endurance event without aero, it could probably benefit more from regen braking or other efficiency improving methods before aero. That is not to say if there is a configuration that theoretically scores more net points with aero than without that we should not pursue it. Instead I am stating that principally the powertrain architecture is not suited for aero if the condition of energy limitation w/o aero is true.

Planned Actions

1. Drag Budget (CD) requires empirical data. Must wait for car testing.
2. Point-mass analysis assuming no aero energy budget and limiting power with different aero combinations can reveal relationship and potential CL & CD budget optimal for all events.

# Point Mass Analysis

Tuesday, July 29, 2025 12:42 PM

Goal:

- Compare different CL & CD Combinations with an energy limit set by no-aero (so assuming accumulator energy is optimized for no aero) to find if there is an optimal configuration of aero that nets more points than no aero.

Quick Notes

- It will be good to set up the calculation pipeline that way you can quickly see the points change based on the lap times and energy consumption.

# Task List

Monday, August 25, 2025 12:37 PM

CFD Refinement

- Sweeps
  - Finish KS8 pitch
  - Pitch on new FW
  - Velocity on latest package
    - Iterate

  People: Seth, Cooper, Quang

- FW
  - GFs on E4 & E3
  - Slot Gap
  - AoA
  - EP Curve
  - EP Airfoil
  - Strake gap & Number

  People: Anastasia, Neeshu

- RW
  - EP Profile
  - EP Cut outs for drag reduction (TE or Louvers)
  - Slot Gap
  - AoA

  People: Anastasia, Neeshu

- Whisker
  - Reduced to one element
  - EP on/off effect
  - AoA
  - Span
  - Location

  People: Anastasia, Neeshu

CAD

- FW
  - MP
    - Ribs
    - Spar
    - Adhering and structure calcs
  - Elements
    - Ribs
    - Fastening method
    - Adhering and calcs
- RW
  - EP insert update with plastic pucks
  - MP
    - Ribs
    - Spar
    - Adhering and structure calcs
  - Elements
    - Ribs
    - Fastening method
    - Adhering and calcs
- Whiskers
  - Mounting method
  - Rib and (maybe) spar
  - Adhering and structure calcs

I want to get a good picture of the FW CAD workflow before I sick the aero team on it. In the meantime I can distribute simulation tasks.

Sim Pre-reqs

1. Set up
2. Post process data gathering
3. Data consolidation and reporting

Available Members

- Neeshu
- Anastasia
- Cooper
- Quang*
- Noah
- Kiernan*

Action Items

- Pack and go the aero assem
- Send to yall
- Make your new part and reference the mainplane
- Ask all the questions

CFD (Need Video)

- Corey (Time)
- Alex (Time*)
  - Whiskers
- Aneesh (Time)
- Anastasia

CAD (Need video) (Due Friday)

- Aariz
- Tucker
- Noah*
- Samit

Seth needs to:

- Make parameters for CFD, or show pipeline from CAD to CFD

# General Aero Design

Tuesday, September 9, 2025 5:06 PM

## Function[SC1]

### Why

Aerodynamics of a race car are used solely to improve vehicle dynamics, more specifically the grip characteristics of the tire, while producing as little aerodynamic drag as possible. Tire tractive force can be broken down to the following basic friction equation:

$$F_y = \mu F_N$$

That is, the lateral force is equal to the product of the tires friction coefficient and the normal force acting on the tire. It is clear that by increasing the normal force on the tire you will linearly increase lateral acceleration potential, which is related to velocity by:

$$v = \sqrt{F_y R}$$

Therefore, using substitution, velocity is proportional to the square root of normal force acting on the tire. In reality, the system is more complex than this relationship, including effects of tire slip angle, balance of pressure, however this summarizes the general trends.

### How[SC2]

### What's good design?

"Good" design of an aero package, however, is not solely reliant on how much downforce it can produce. With the addition of downforce comes the addition of drag, which has a net negative effect on the car's performance. There are two primary detractors from added drag: lap time and energy consumption.

Drag acts directly against accelerating force, so a vehicle with a large aero package (and lots of drag) will accelerate slower than a vehicle without (this is what defined early race car design philosophy). The nuance here comes from incorporating downforce. Faster cornering speeds means corner exit speed is higher than a non-aero car, and the aero car generally covers the straight distance quicker than a non-aero car, that is if the downforce benefits outweigh the drag. We'll come back to this point.

Since drag is a force that is applied over time, it can be defined as work the car is producing and therefore requires energy to sustain. Over an endurance in 2023 FSAE Electric, drag force was calculated to account for about 1/3 of energy consumed. This has a *huge* impact on efficiency points, and is more impactful on points than the time loss from isolated drag effects.

Coming back to that point about drag outweighing downforce, it is important to identify how much drag you are willing to accept for the amount of downforce you are generating, or the other way around. In this consideration, it is more important to consider the energy effects of drag than the lap time effects because of the nature of FSAE Electrics low energy density powertrains and efficiency scoring.

[SC1]Add in graphs like performance envelope

[SC2]Will return to this, bigger fish to fry

From <https://kennesawedu.sharepoint.com/sites/Team-test_ksu/Shared%20Documents/General/04_Project%20Proposals/Proposals/Aerodynamics/KS9%20Aero%20Package.docx>

# Aero Help Desk

Thursday, July 31, 2025 10:27 AM

# Star CCM+

Thursday, July 31, 2025 10:27 AM

[Simcenter STAR-CCM+ - User Guide (html)]

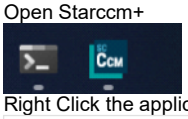
# STAR CCM+ Batch

Thursday, October 30, 2025 9:52 PM

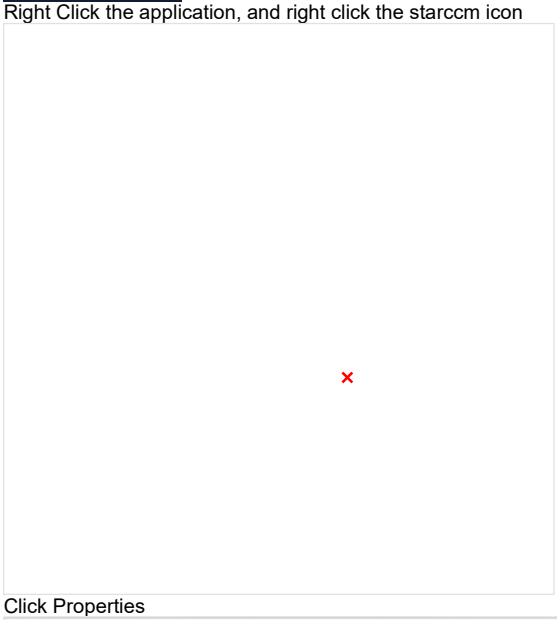
**"C:\Program Files\Siemens\20.04.008\STAR-CCM+20.04.008\star\lib\win64\clang17.0vc14.2\lib\starccm+.exe"** -power -podkey MYPODKEY -licpath 1999@flex.cd-adapco.com -np PROCESSES -batch run SIM.sim
The bolded value should be the file location of your STARCCM+.

To find follow the steps below:

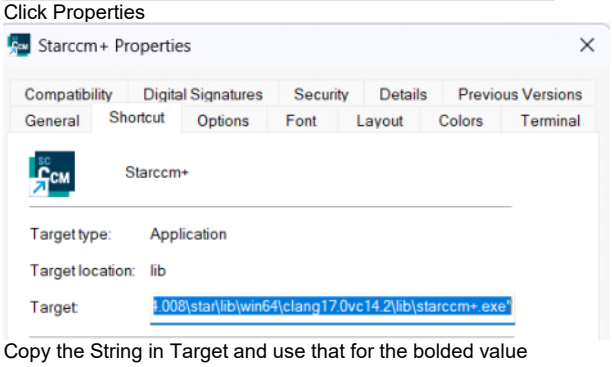
1. Open Starccm+



2. Right Click the application, and right click the starccm icon

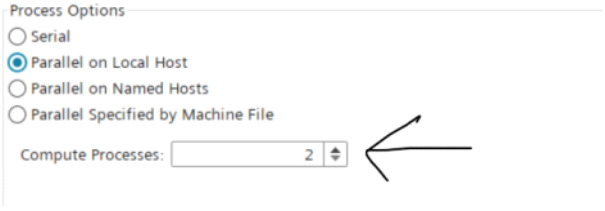


3. Click Properties

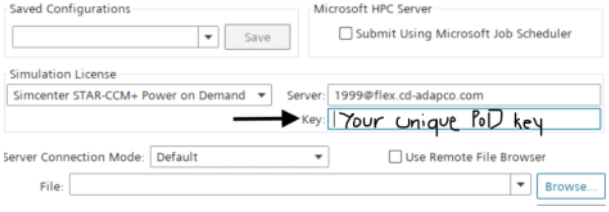



4. Copy the String in Target and use that for the bolded value

MYPODKEY – Your Power On Demand key that you use to run a sim.




PROCESSES – The number of cores you want to utilize




SIM.sim - The name of the sim, make sure it contains no spaces. Eg. 9_Aero_CFD_HalfCar_A1021_30,55.sim

For each sim you want to run use the write up from the beginning.

```
"C:\Program Files\Siemens\20.04.008\STAR-CCM+20.04.008\star\lib\win64\clang17.0vc14.2\lib\starccm+.exe" -power -podkey MYPODKEY -np PROCESS -batch run Star1.sim
"C:\Program Files\Siemens\20.04.008\STAR-CCM+20.04.008\star\lib\win64\clang17.0vc14.2\lib\starccm+.exe" -power -podkey MYPODKEY -np PROCESS -batch run Star2.sim
"C:\Program Files\Siemens\20.04.008\STAR-CCM+20.04.008\star\lib\win64\clang17.0vc14.2\lib\starccm+.exe" -power -podkey MYPODKEY -np PROCESS -batch run Star3.sim
"C:\Program Files\Siemens\20.04.008\STAR-CCM+20.04.008\star\lib\win64\clang17.0vc14.2\lib\starccm+.exe" -power -podkey MYPODKEY -np PROCESS -batch run Star4.sim
```

Type everything into a .txt file and rename it to SCCMBatch. Once you have saved the file change the extension to a .bat file


Double click to run when you have completed the above steps, and you will be running STARCCM+ in batch mode. Make sure to use the **SCCM_Template** in teams.

# LLNL Info Dump

Monday, September 29, 2025 10:50 PM

- Use NASA or MILSPEC data sheets for calculation references
    - Bolt calcs (NASA 5020B)
    - (Maybe) Adhesive/weld calcs
- Can calculate friction force (joint slip margin of safety)
- Use margin of safety instead of FoS
- Use MathCAD if possible to help show calcs
- Vibrational analysis is good but may only be applicable to launch load case, nothing on the car
- Emphasis on showing presentable work

# ==== Misc Investigations ====

Wednesday, August 20, 2025 11:48 AM

# RW 3rd Element Custom Airfoil

Saturday, September 6, 2025 10:30 PM

# KS8 Airfoils

Sunday, September 21, 2025 1:24 PM

FW

UT

RW

- Benzing 153-055: 6in
- Custom NACA (?): 5in

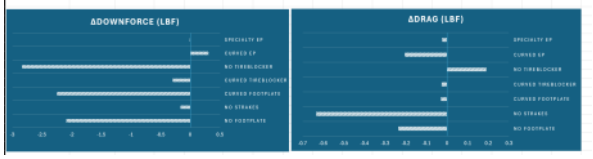
For manufacturing:

- We have no useable molds *right now,* but we do have *repairable* molds.
- Q: How much time would it take to repair the molds? How much time would it take to make new molds?
- Q: What are the downsides to repair? (e.g. dimensional accuracy)
- Q: What are the points benefits of making new molds?

# End Plate Designs

Tuesday, November 04, 2025 5:30 PM

| Title | Downforce (lbf) | ΔDownforce (lbf) | Drag (lbf) | ΔDrag (lbf) | CoP Front |
|---|---|---|---|---|---|
| Control | 27.614 | 0 | 18.126 | 0 | 52.31482 |
| No FootPlate | 25.525 | -2.089 | 17.898 | -8.237 | 44.93591 |
| No Strakes | 27.449 | -0.165 | 17.501 | -8.634 | 46.94639 |
| Curved FootPlate | 25.366 | -2.248 | 18.105 | -0.03 | 42.07894 |
| Curved TireBlocker | 27.335 | -0.279 | 18.105 | -0.026 | 48.04909 |
| No TireBlocker | 24.777 | -2.837 | 18.325 | 0.19 | 43.2753 |
| Curved EP | 27.916 | 0.302 | 17.929 | -0.206 | 48.49463 |
| Specialty EP | 27.604 | -8.81 | 18.111 | -8.024 | 48.35395 |



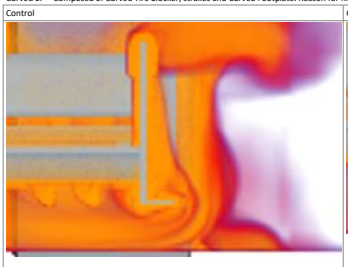
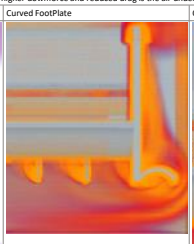
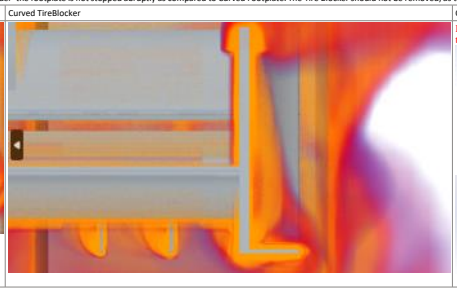

Strakes should be removed. Unnecessary Drag induced by strakes, which is shown in the Front Vorticity when compared to contro l

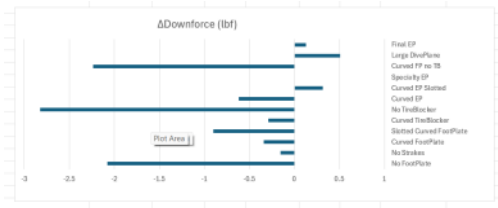
| No Strakes | Control |
|---|---|
|  |  |
| Here drag it is seen that with the removal of strakes the magnitude of the vortices are reduced, which reduces the flow of air into the tire | Due to the air being pushed into the tire the magnitude of the vortices are greater and the magnitude is further increased by the tires. |

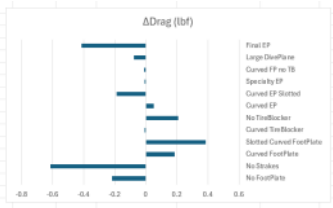
It is essential to either remove the strakes or have them move air away from the tires, this could be achieved by moving the strakes closer to the end plate and shaping away, or by removing the strakes overall. For the former idea, simulations are re quired to understand the advantage of strakes.

## More Sims required due to incorrect CAD used

Curved EP – Composed of Curved Tire blocker, strakes and Curved Footplate. Reason for higher downforce and reduced drag is the air under the footplate is not stopped abruptly as compared to Curved Footplate. The Tire Blocker should not be removed, as the drag an d lift created from the tire is much higher when compared to control.

| Control | Curved FootPlate | Curved TireBlocker | Curved EP |
|---|---|---|---|
|  |  |  | I don't have pictures, as they were simmed using AWS, and I did not run the macro. I do have the sim files, so the data can be collected tomorrow.   |

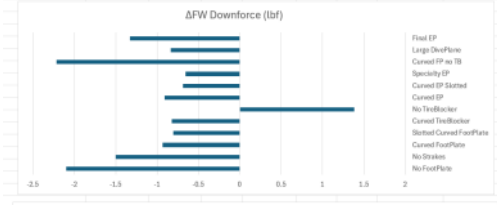


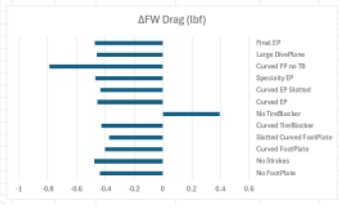




ΔFW Downforce (lbf)

| Title | Downforce (lbf) | ΔDownforce (lbf) | Drag (lbf) | ΔDrag (lbf) | CoP Front | FW DF Rank | FW Drag Rank | Rank Sum | |
|---|---|---|---|---|---|---|---|---|---|
| Control | 27.603 | 0 | 18.117 | 0 | 52.25681 | | | | |
| No FootPlate | 25.525 | -2.078 | 17.898 | -0.219 | 44.93591 | 11 | 6 | 17 | 9 |
| No Strakes | 27.449 | -0.154 | 17.501 | -0.616 | 46.94639 | 10 | 11 | 21 | 11 |
| Curved FootPlate | 27.265 | -0.338 | 18.304 | 0.187 | 48.15041 | 8 | 3 | 11 | 5 |
| Slotted Curved FootPlat | 26.702 | -0.901 | 18.502 | 0.385 | 49.06135 | 4 | 2 | 6 | 2 |
| Curved TireBlocker | 27.316 | -0.287 | 18.109 | -0.008 | 48.04909 | 5 | 4 | 9 | 4 |
| No TireBlocker | 24.777 | -2.826 | 18.325 | 0.208 | 43.2753 | 1 | 1 | 2 | 1 |
| Curved EP | 26.985 | -0.618 | 18.167 | 0.05 | 48.6575 | 7 | 7 | 14 | 7 |
| Curved EP Slotted | 27.916 | 0.313 | 17.929 | -0.188 | 48.49463 | 3 | 5 | 8 | 3 |
| Specialty EP | 27.604 | 0.001 | 18.111 | -0.006 | 48.35395 | 2 | 9 | 11 | 5 |
| Curved FP no TB | 25.368 | -2.235 | 18.105 | -0.012 | 42.07894 | 12 | 12 | 24 | 12 |
| Large DivePlane | 28.112 | 0.509 | 18.042 | -0.075 | 47.8851 | 6 | 8 | 14 | 7 |
| Final EP | 27.733 | 0.13 | 17.703 | -0.414 | 46.66662 | 9 | 10 | 19 | 10 |

| | A | C | D | E | F |
|---|---|---|---|---|---|
| | Title | STD | | | |
| CDA | | 0.00742 | | | |
| Frontal Area | | | | | |
| CLA | | 0.01654 | | AVG STD | 0.10688 |
| FX | | 0.21437 | | | |
| FX FW | | 0.04002 | | | |
| FX RW | | 0.11524 | | | |
| FX UT | | | | | |
| FX Wheel Front | | 0.05945 | | | |
| FX Wheel Rear | | 0.07745 | | | |
| FZ | | 0.47772 | | | |
| FZ FW | | 0.2899 | | | |
| FZ RW | | 0.2779 | | | |
| FZ UT | | | | | |
| FZ Wheel Front | | 0.06386 | | | |
| FZ Wheel Rear | | 0.06554 | | | |
| FZ Body_Chassis_&_Driver | | 0.05387 | | | |
| FX Body_Chassis_&_Driver | | 0.09957 | | | |
| Planform Area | | | | | |
| FZ Whisker | | 0.03547 | | | |
| CoP Z | | 0.00691 | | | |
| CoP X | | 0.00691 | | | |
| FX Whisker | | 0.0157 | | | |




# Final EP:

- No Strakes
- Curved FootPlate
- Curved TireBlocker

Reasoning -

- In the second image above it can be seen that each design was ranked in accordance to how they performed on the front wing, with an emphasis on higher downforce and lower drag. A secondary group of simulations were run to find the standard deviation between sims in order to understand if the data was within reasonable differences of simulations, and could be neglected as a result.
- No TireBlocker came in first in the rankings but when looked at on an overall scale the data showed it had the most negative effect on downforce and drag due to conventional understanding of aerodynamics. When a tire is hit by wind it accelerates the air underneath it creating lift, which reduces drag. The tire also acts as a wall creating immense drag due to it blocking air and creating dirty air behind the wheel due to the air being spun up by the wheel.

- In second, was slotted curved footplate which was used in the final design. On its own it still created many issues and could not be used as it was, but it was promising.
- In third was a preliminary design of the Final EP, which included strakes. This by far had one of the best results in both the overall and the FW only. This mad e it a frontrunner for being the design we go with.
- Ultimately, strakes were removed. This can be understood in the first write up about why strakes are bad. The final design reduced drag significantly while either maintaining a similar level of downforce or a higher value. Even though it had bad results for FW only, its results in overall showed it was promising. The sim was ran a total of 3 times due to computing limitations, but the upper bound values for both drag and downforce reflected positive results and why this should be the endplate for the KS9.
- For understanding why other values were not chosen the table reflects either negative standing relative to chosen results, or negligible differences as seen by the standard deviation table. The only other overall positive downforce is an endplate that is not practical to manufacture for the KS9, but should be looked into for the KS10.

# ==== Components ====

Wednesday, August 20, 2025 11:48 AM

# RW

Wednesday, July 16, 2025 6:06 PM

# 3D wing study

Sunday, August 03, 2025 6:07 PM

Continuing from the 2D study, I will now turn the 2D profiles into wings.

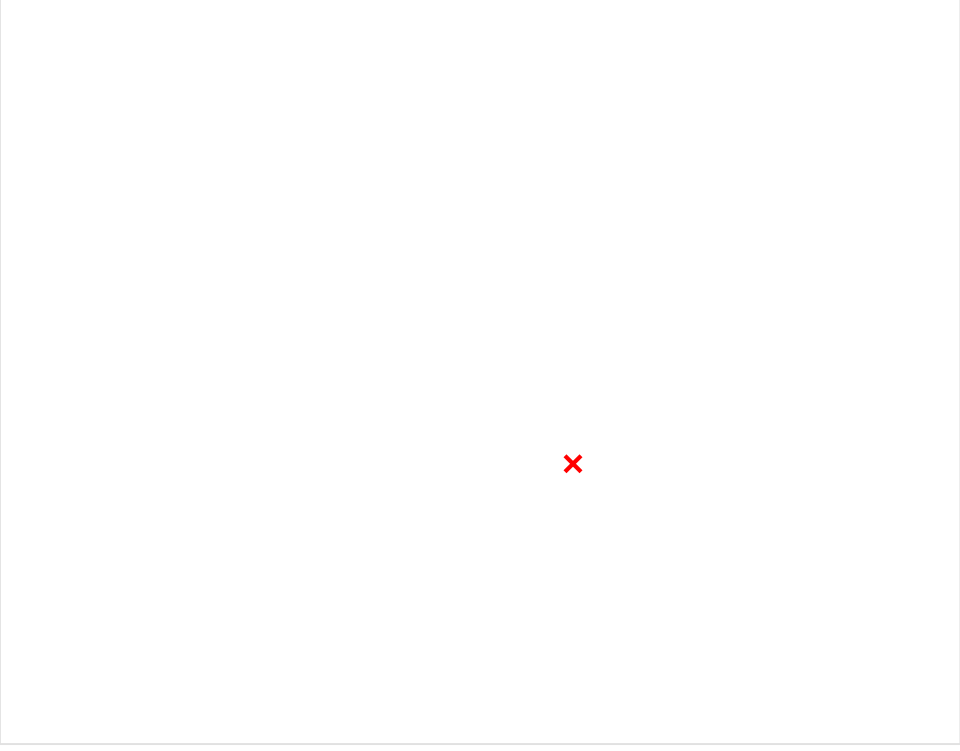
# 3D Wing study Noah

Saturday, August 09, 2025 2:15 PM

Cooper did some studies on different airfoils and ran in through simulation

Trial #4

Based on different trials, I took trial #4 and have started making a 3D model of the wing and will now be running simulations on it



# 3D wing study Cooper

Saturday, August 09, 2025 2:15 PM

# Goals and Results of 2D study

Wednesday, July 30, 2025 5:17 PM

**Goals set by Seth:**

Overall Objective: 2D & 3D Conceptual Design to position aero for easiest integration of car goals.

RW

a. 2-D Design Study
    i. Overall Camber Constant (High Downforce)
        1) Find 2-3 airfoils per configuration (# of Elements)
            a) Find the best AoA, Slot Gap, and Slot Overlap by eyeball.
            b) Keep a logbook of each iteration
            c) Velocity Plot, CD, CL, Slot Gap, Slot Overlap for each, then highlight best.
        2) Stick to benzing and MSHD

What I did to meet these goals:

1:

Read research papers and watch videos to gain a better overall understanding of concepts that will be utilized for RW design.
https://ir.library.oregonstate.edu/downloads/bv73c2553
https://repository.lib.ncsu.edu/server/api/core/bitstreams/56e62390-f800-4126-af2a-f06873e998d9/content
https://occamsracers.com/2023/08/08/car-wings-examined/
http://www.benzing.it/enrico.profili.htm
http://airfoiltools.com/airfoil/naca4digit

2:

Simulate a variety of different 2D wing designs with different # of elements, airfoil profiles, slot gap, etc. A dump of this progression can be found in the following one note pages, they go over general ideas and why I made changes that I did or chose profiles that I did. (Ignore the Solidworks page, the meshing had issues that were not found until after all the data was found so the sims are kind of trash)

3:

Document quantitative data and airflow from each sim. I plotted all the results into an excel sheet with CL, CD, CL/CD, and information about geometry like airfoil configurations, chord length, AoA, etc. The Excel sheet will be put on the new teams on the aero channel and it is labeled

"Aero_RW_2D_logbook"

Results:

Before going over results it should be know that as of the time I did this study and as I write this (July 30, 2025), we have not set our car goals. This means that I did not have target CL or CD values, those will be calculated soon. What that means for this study is that none of these results are going to be the "best" because we might find that we need significant Cl with no regards for CD or we might find that we need extremely limited CD. These results are just general concepts that can be referenced later to help with aero development when we have our goals.

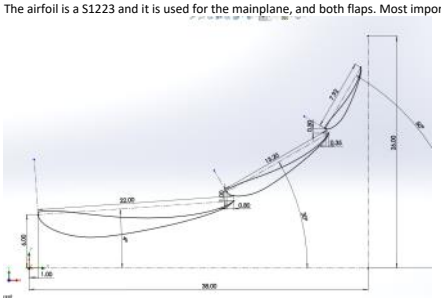
# 2D airfoil study (Star CCM)

Saturday, July 26, 2025 2:13 PM

After moving to StarCCM I have started to work with 3 element designs and will post data found here
I will not go voer too much info on how to set up star just know that I am running at 40 mph.

I will also start an excel sheet with more quantitative data to find trends.

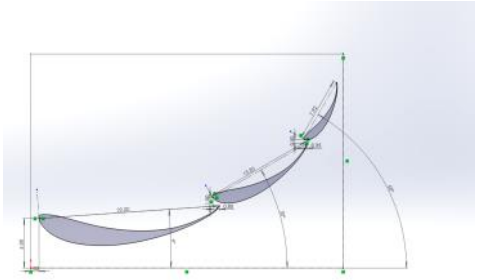
Now I am using 3 element designs starting with a configuration found in a research paper. Here Is link to the paper: file:///C:/Users/Kennesaw%20Motorsports/Downloads/content%20(1).pdf
The airfoil is a S1223 and it is used for the mainplane, and both flaps. Most important take away from this research paper is the sizing of flaps com



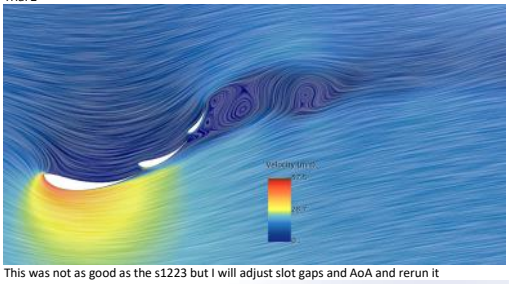
Trial 1

This is actually pretty good but I want to compare to the MSHD

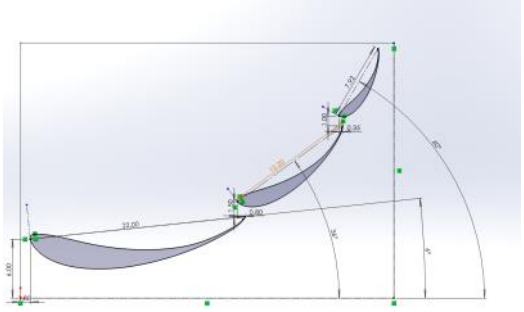
After some more research I want to investigate the MSHD airfoils and will try that airfoil with the same chord lengths, AoAs and slot gaps as shown above.
Here is research on MSHD airfoils https://repository.lib.ncsu.edu/server/api/core/bitstreams/56e62390-f800-4126-af2a-f06873e998d9/content



Trial 2

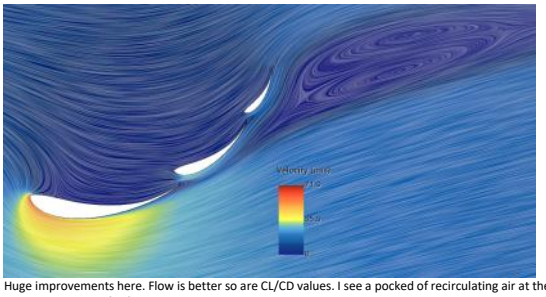


This was not as good as the s1223 but I will adjust slot gaps and AoA and rerun it

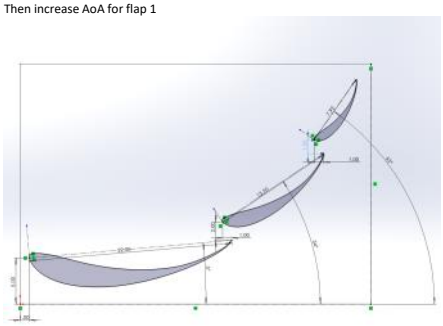


Trial 3

Results
I have some varying results that seem decently promising. I will start some 3D Sims and iterations of some profiles now. I will continue Trial 19, 17, and 4. these Configurations have some traits that could be useful.
Trial 4 and 19 both show improvements to CL with room to optimize CD
Trial 17 shows good CL/CD with overall lower numbers, could be good for lower CD targets.

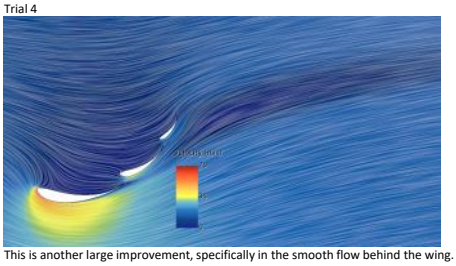


Huge improvements here. Flow is better so are CL/CD values. I see a pocked of recirculating air at the end of the MP. I will lower the AOA of MP by 1-2 degrees
Then increase AoA for flap 1



Should say that chord length is 40.3"

Trial 4



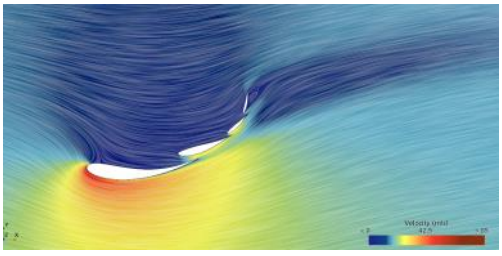
This is another large improvement, specifically in the smooth flow behind the wing.
I am going to keep AoA, chord lengths, and overlaps the same and just chane slot gap a few times to find whats best
I will put that data in the excel sheet and not here until I find whats best

Ok the best numbers I got were

| | | |
|---|---|---|
| -4.486 | 0.365 | -12.29041096 |

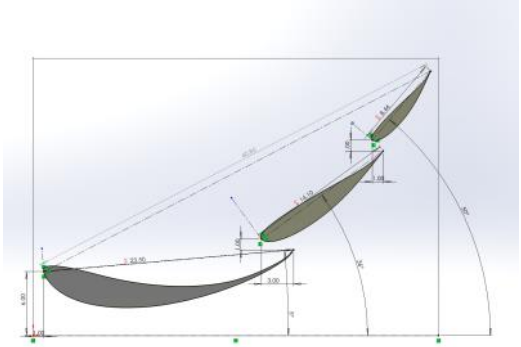
For CL, CD, and CL/CD respectavly. I also ran a sim of our current wing as a comparison and got these numbers
CL -4.043 CD 0.311 CL/CD -13

Keep in mind that the color ploits for all of these are different so do not compare then directly, I need to standardize it b ut have not found a
Good set up. From now on I will keep the set up I used below.
Chord length for this wing is 39.59"

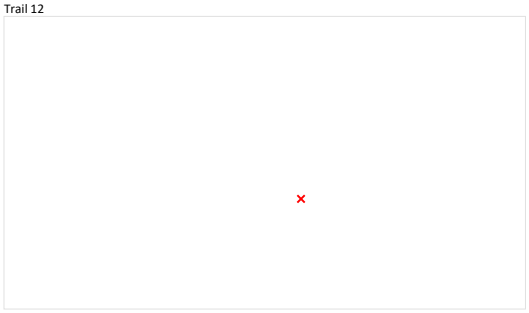


Doing some research before next design, here are resources I am using
https://ir.library.oregonstate.edu/downloads/bv73c2553
https://repository.lib.ncsu.edu/server/api/core/bitstreams/56e62390-f800-4126-af2a-f06873e998d9/content
https://occamsracers.com/2023/08/08/car-wings-examined/

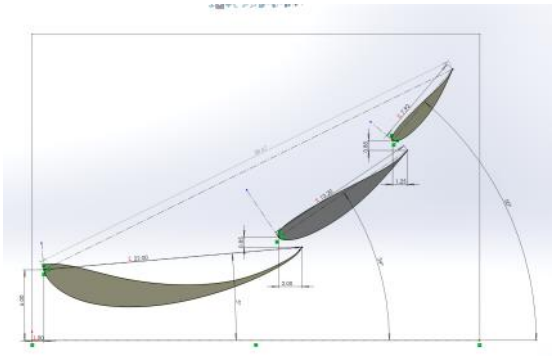
Ok here is a new concept I will try. I think the MSHD is really good but the high camber is not optimal for flaps.
So I switched to benzing 153-055 flap geometries while keeping the MSHD MP



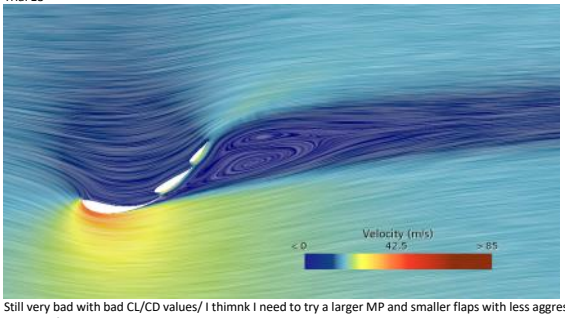
Trail 12



Yeah this is really bad. Will make the MP smaller and adjust positions of flaps to help with that recirculation



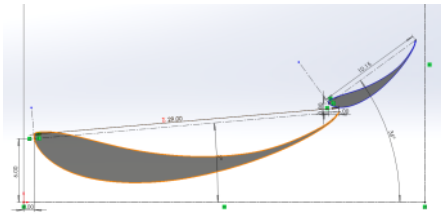
Trial 13




Still very bad with bad CL/CD values/ I thimnk I need to try a larger MP and smaller flaps with less aggressive MP and Adjusted flaps.

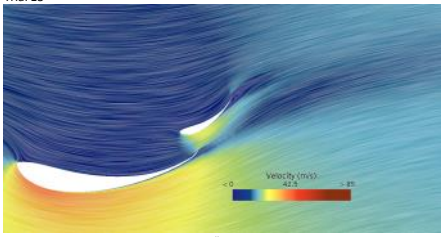
I am starting now to look at some 2 element wings for reference. This is the MSHD profile with geometry taken from The research paper. I forgot to get the screenshot of flow visualization so I apologize

Trial 14



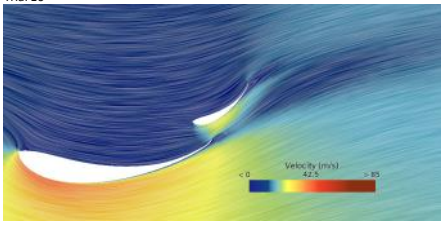
The flow was fine but the flap was way too close and not helping so I made a much larger gap for the next iteration
I do not have the solidworks Screenshot for the next one but the geometry is described in the excel sheet. I just made overla p
And slot gap 2" bigger each

Trial 15

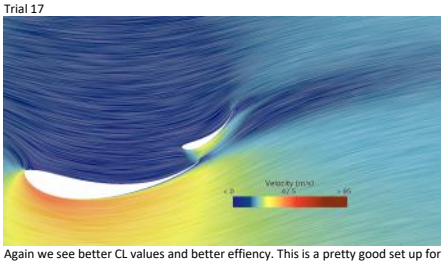


I am now going to lower the gap by 0.5" and try again.

Trial 16

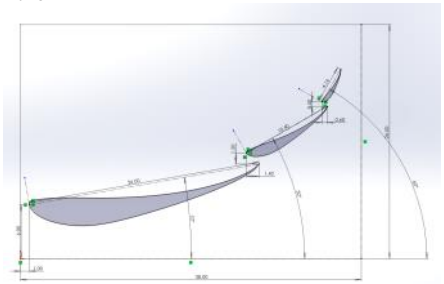


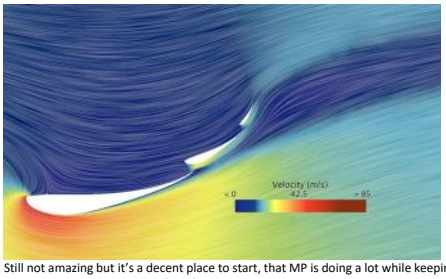
It is hard to tell from the picture but this is better. We actually achieve very similar effiency to our
Current wing but with lower CL/CD values. This is a good start if we decide we need less downforce.
I will reduce slot gap by another 0.5" and try again because I have gotten lower CL values every time i decrease the gap
Trial 17



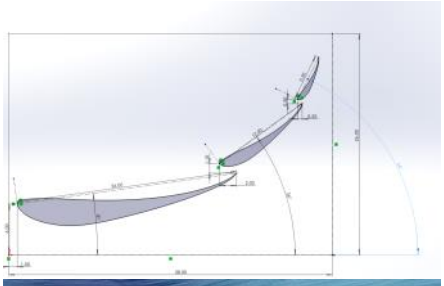

Again we see better CL values and better effiency. This is a pretty good set up for a 2 element wing
I am pretty satisfied with that data and won't spend too much time tweaking it for small gains. I will go back to some
3 element designs starting with the S1223 airfropil with larger MP and smaller flaps, along with adjusted AoA and gaps.

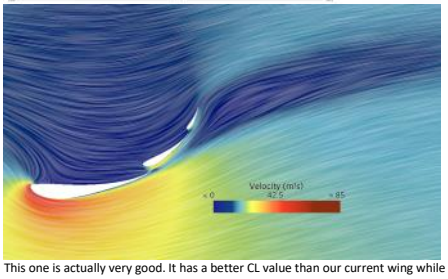
Trial 18






Still not amazing but it's a decent place to start, that MP is doing a lot while keeping flow attatchment well
I will look at changing some of the flaps now
Trial 19

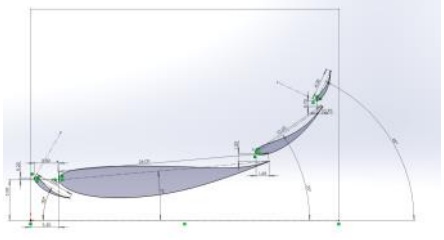


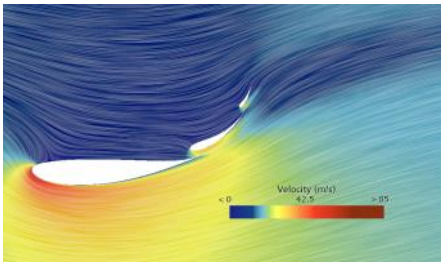



This one is actually very good. It has a better CL value than our current wing while being less efficient
With a good bit more drag. I think with some optimization thios wing could be very good.\

The last concept I want to try is a 4 element idea with a front slat. Here Is wing with the slat.
For a control I will run the sim with no slat then with it. The airfoils are be 122-125 and be 153-055

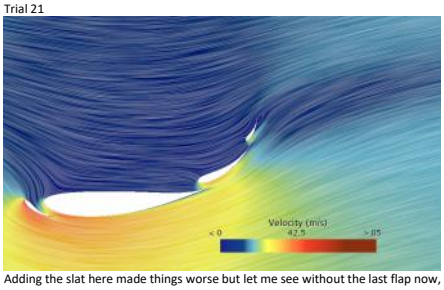
Trial 20






This alone is actually not too bad, generally decent numbers but needs optimization for sure. Needs better CL numbers but has good CD. Now I will add the slat in the front.

Trial 21




Adding the slat here made things worse but let me see without the last flap now, it doesn't seem to be doing much

Trial 22

This was the slat without flap 2 but I forgot the picture

Trial 23

In this case, it was better without the slat

# 2D airfoil study (SolidWorks)

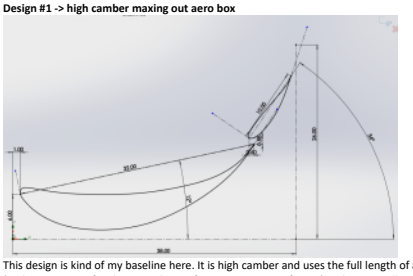
Wednesday, July 16, 2025 6:07 PM

**Ignore all this data lowkey. Meshing was bad and I switched to StarCCM 2D sims after learning how to use them

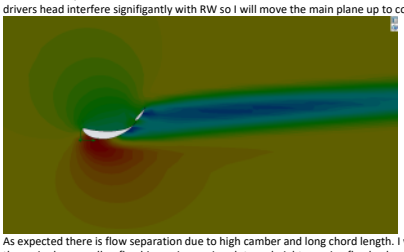
The purpose of this study is to get a better understanding of airfoil geometry and how multiple airfoils interact with each other in multi element wings. As of now (July 16th, 2025) car goals have not been made and therefore we are choosing geometries to be on the car just yet, this is purely research that we can use later depending on what car goals are made.
Quantifiable end goals: downforce and drag data about different styles of rear wings. Flow structure will be looked at as well but is harder to quantify.

I will start by investigating different 2 element designs with different camber, cord lengths, slot gaps, and thickness. I will use SolidWorks 2D slow simulation with 2000 iterations for each of these. I will keep designs within current aero box as per the 2025 FSAE rulebook.

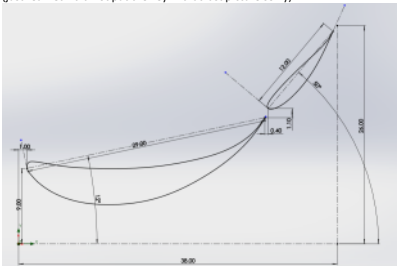
**Design #1 -> high camber maxing out aero box**

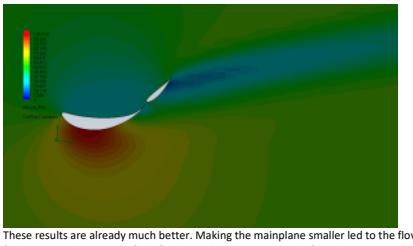


This design is kind of my baseline here. It is high camber and uses the full length of aero box (with some space for theoretical manufacturing margins of error) and is very tall. I made this into a full RW and put it into StarCCM to compare star and solidworks sims and found that they seem to mostly be the same. Here are solidworks results. I also realized that the roll hoop and drivers head interfere signifigantly with RW so I will move the main plane up to compensate.

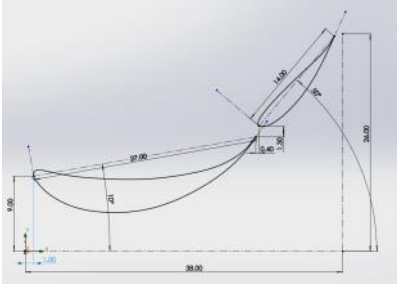


As expected there is flow separation due to high camber and long chord length. I will try making the mainplane smaller, flap bigger, increasing slot gap height, moving flap backwards, lowering AoA of flap, and move everything higher in aero box to account for driver head and roll hoop. (just realized I did not put the key in that last picture sorry)

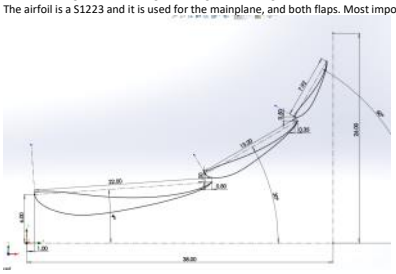


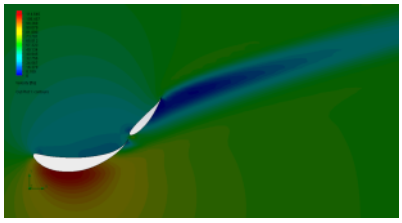


These results are already much better. Making the mainplane smaller led to the flow attaching for longer. reducing AoA of the flap led to less drag. It is kind of hard to interpret how the changes of the slot gap effected things though. I am going to try lowering the AoA of the main plane a little, making the mainplane a tiny bit shorter, and making the flap a tiny bit bigger. Also slot gap a little bigger.

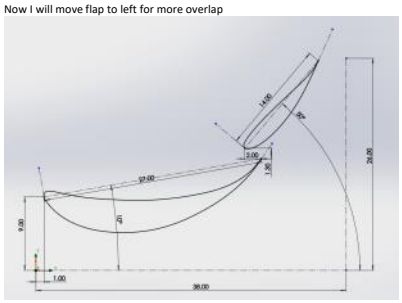


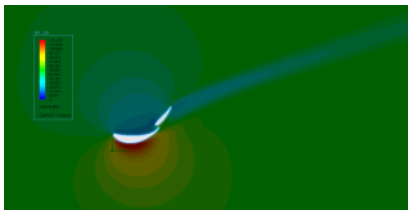
Now I am using 3 element designs starting with a configuration found in a research paper. Here Is link to the paper: file:///C:/Users/Kennesaw%20Motorsports/Downloads/content%20(1).pdf
The airfoil is a S1223 and it is used for the mainplane, and both flaps. Most important take away from this research paper is the sizing of flaps com





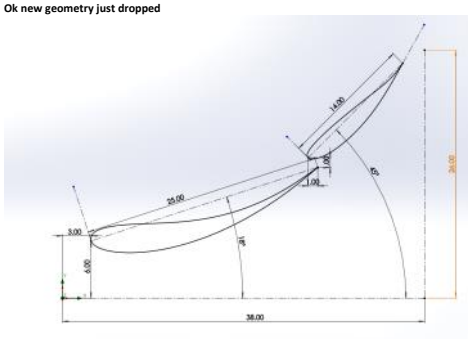
Now I will move flap to left for more overlap

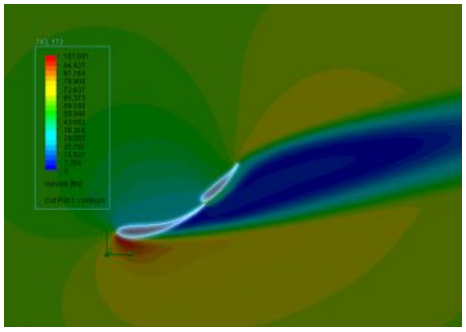


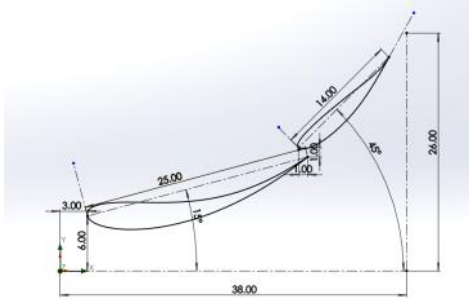
**Ok I am sill not seeing the flow attachment I wanted so I am going to switch airfoil geometry so a slightly less cambered mainplane. Switching now to a Be 122-125 for the mainplane**

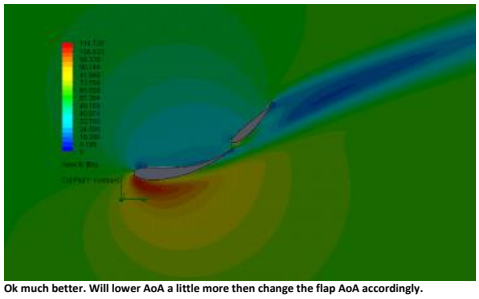
**Ok new geometry just dropped**



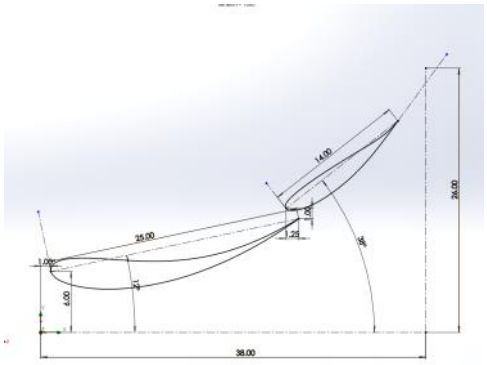



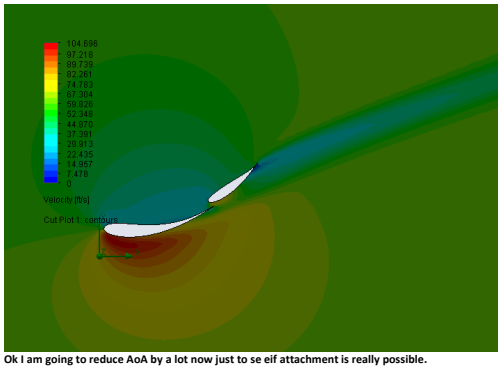
**Erm ok lowering AoA now**



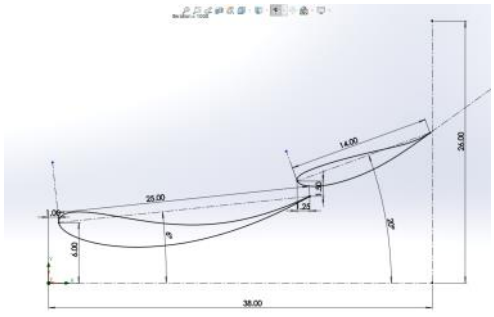


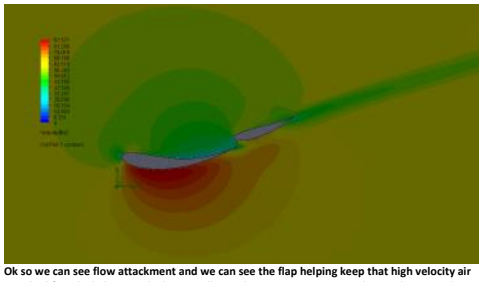
**Ok much better. Will lower AoA a little more then change the flap AoA accordingly.**



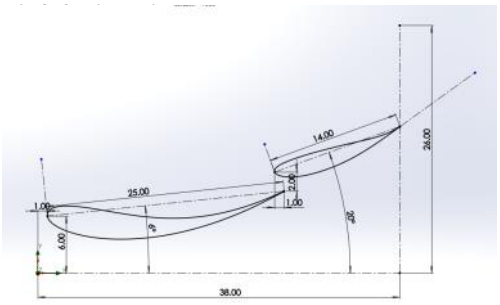



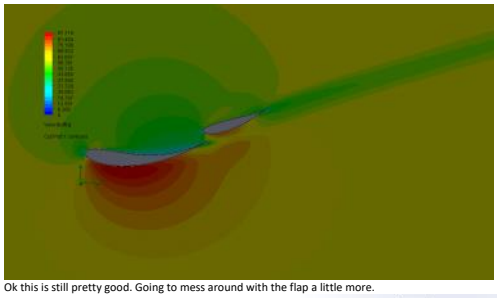

**Ok I am going to reduce AoA by a lot now just to se eif attachment is really possible.**



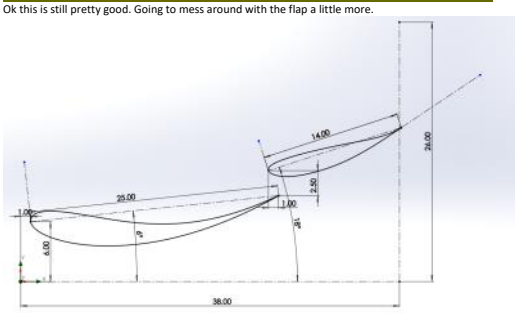



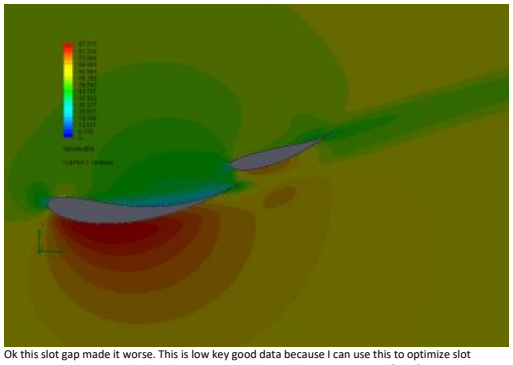
**Ok so we can see flow attackment and we can see the flap helping keep that high velocity air attached for a little longer which is a really good sign. I a mnot ging to change the Main plane I am just going to adjust the flap**



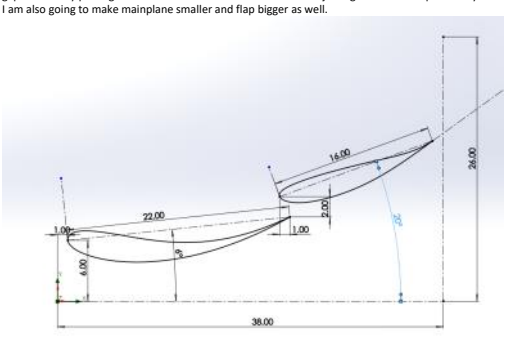



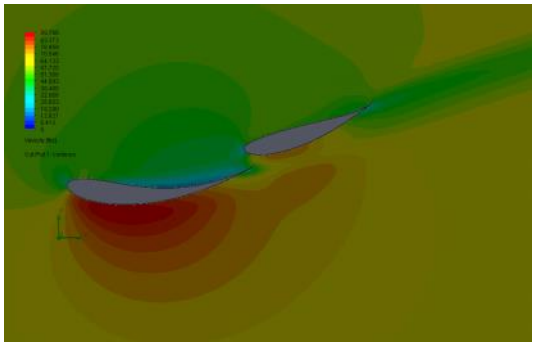
Ok this is still pretty good. Going to mess around with the flap a little more.



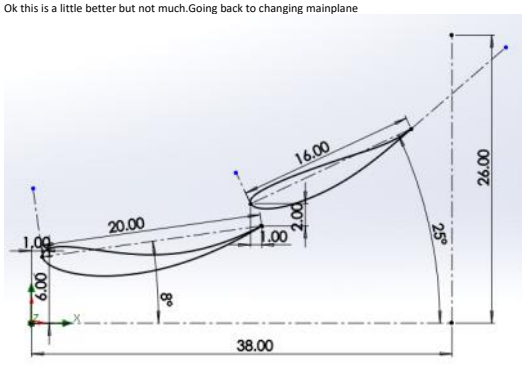



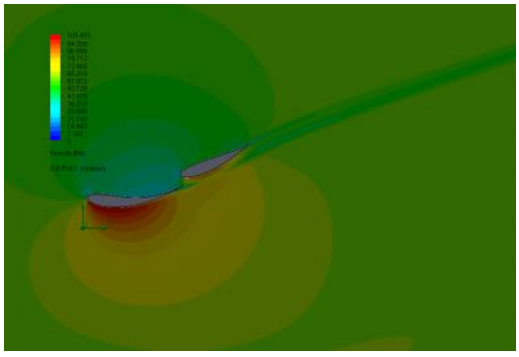
Ok this slot gap made it worse. This is low key good data because I can use this to optimize slot gap. Let me try putting it back to how it was in the last sim but asjusting AoA of the flap. Actually I am also going to make mainplane smaller and flap bigger as well.





Ok this is a little better but not much.Going back to changing mainplane



Switching to 3 element airfoil now

# FW

Sunday, June 29, 2025 7:13 PM

Overall Objective

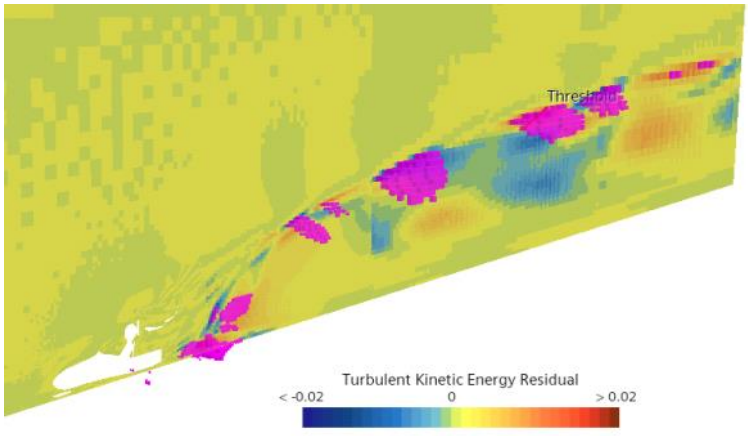
- Understand ground effect sensitivity to airfoil profile
- Understand effect of body on FW airflow
- Understand methods to generating vortices and how to control size and strength

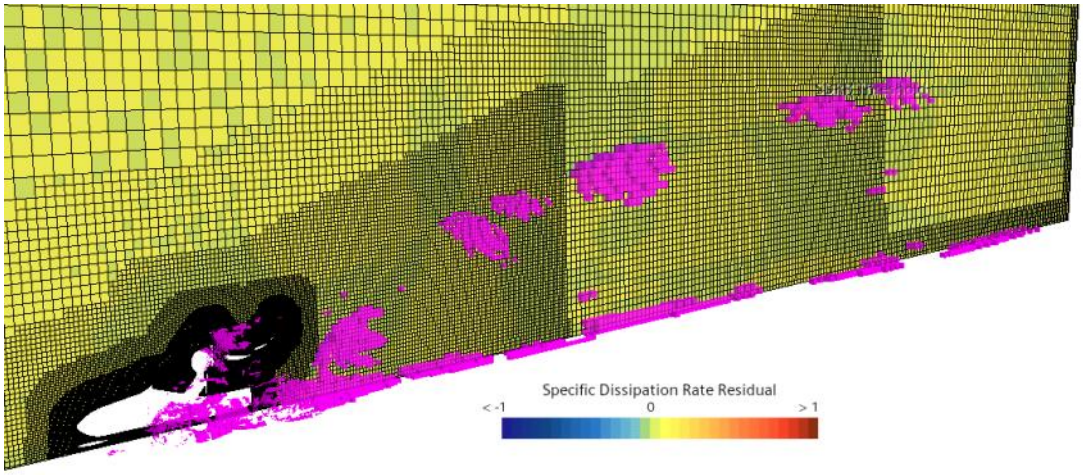
# Meshing

Monday, August 11, 2025 4:49 PM

I'm running through different mesh methods and learning what's good and bad. This is documentation of my process.

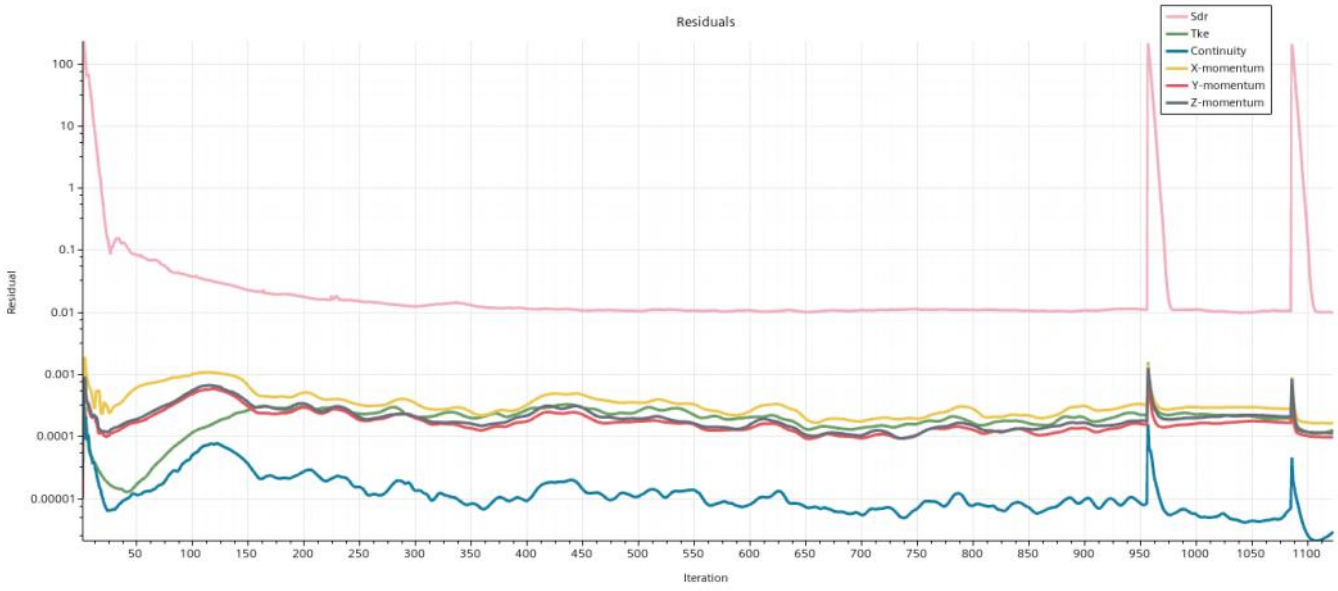
This was with a triangle surface mesh and default trimmed cell mesher. Does not look that great.

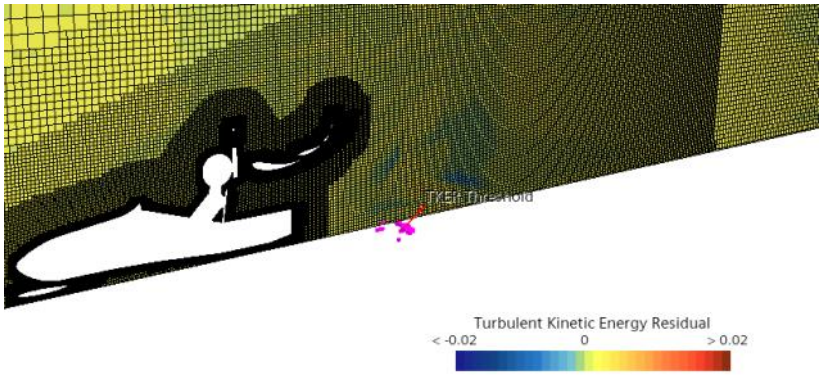


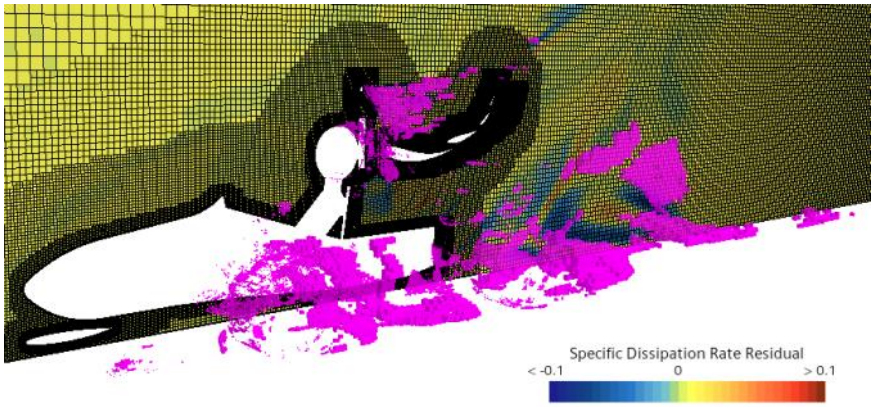



Based on this changing:

- All wake zones reduced by about half (1/2 size)
- Tire wake added, 15% base size
- Tire surface target is 10 and min 5 of base size
- Previous cell count was 22 mil






- Tire wake was not introduced
- Cell count was 24 mil

- Tire wake introduced
- 47 mil cells, way too much, no TKE residuals tho
- Removed target and minimum surface size and increased wake from 15 to 25% on tire control

# Pre-Liminary Research

Monday, July 28, 2025 11:29 AM

## "Aerodynamic Development of a Formula Student Front Wing"

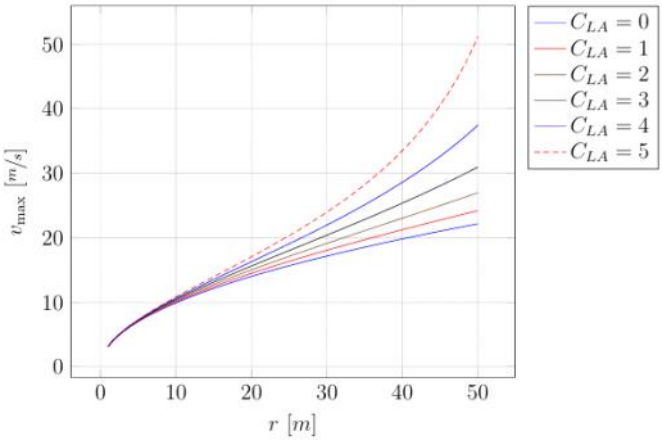



Figure 1: Maximum cornering speed as a function of corner radius plotted for $C_{LA}$-values of zero to five.

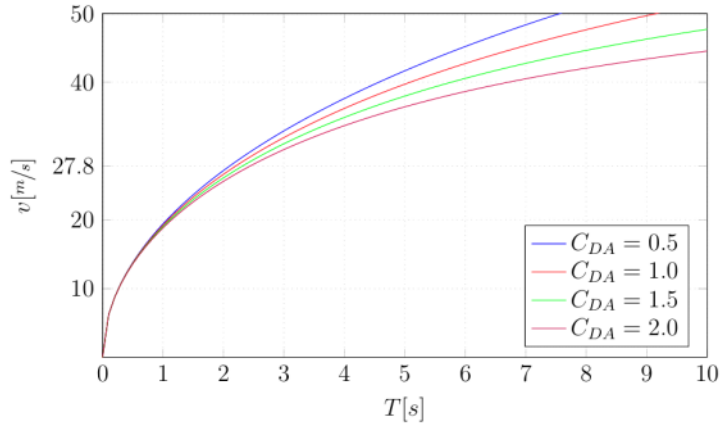



Figure 2: Velocity when accelerating from a standstill as a function of time plotted for $C_{DA}$-values of 0.5 to two.

# 2D Airfoil Profiles Study

Wednesday, July 23, 2025 5:10 PM

Deliverables:

1. How does camber (downforce from circulation) and ground effect relate to each other?
2. What is the sensitivity to ground clearance?

Method:

1. Compare different airfoil cambers and thicknesses at constant height (2in)
   a. Select best airfoils based on CL, CD, and Flow Attachment
2. Sweep ground clearance on each airfoil and compare affects.

- Length in X should stay constant (Chord length may vary
- AoA starts at 0 and changes to find optimal for profile

Control Variables
1. Profile
   1) AoA
2. Thickness
   1) AoA
3. Ground Clearance

Results
1. CL
2. CD
3. Flow Attachment

Theory:

- High camber will be bad for flow attachment
- Thickness has some effect on flow attachment as well, cannot think of what will be better (Thin or thick)

Results

- Increased camber = higher CL & CD --> Lower efficiency
- Increased thickness = Lower CL, higher CD --> Lower Efficiency

Discussion

- As you increase the thickness of the airfoil there are no positive effects in this case. The CL decreases, the CD increases, and the efficiency drops.
- As you increase camber, CL jumps dramatically but so does CD
- The amount of variation between the different cambers and thicknesses makes it difficult to see how they all relate. For now I am going to choose the 1000 radius airfoil and vary thickness to see the effect, then I will select a good thickness and see how different radii affect the outputs.
  ○

So...

Start with airfoil profiles, change their AoA, and change thickness at each AoA

Choose best combination

Compare ground clearance of best combionations

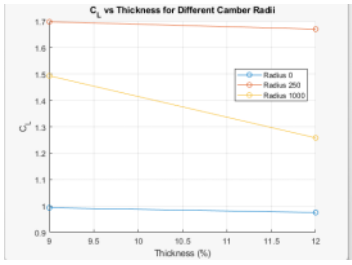
Record CL, CD, & flow attachment (photos)

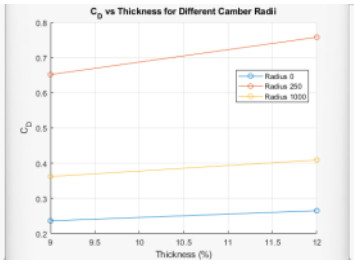
Question:

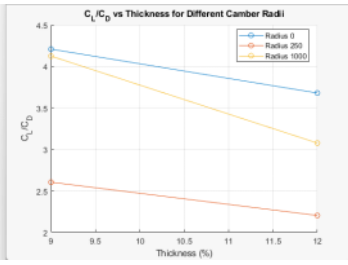
I know that I can use Star CCM Design Manager to change AoA & ground clearance, but can I have it change out different geometries too?

Usually, the process of design optimization combines Optimization, DOE, and Robustness and Reliability studies:

1. An **Optimization** study evaluates designs over a broad range of input parameters and parameter values. This study gives you the best design.
2. A **DOE** study evaluates the input parameters in a small range of parameter values about the best design. This approach gives you the parameters that have the greatest impact on the performance of the design.
3. A **Robustness and Reliability** study uses the sensitive parameters identified in the DOE study to determine the robustness of the best design.



# 2D AoA & Height Study

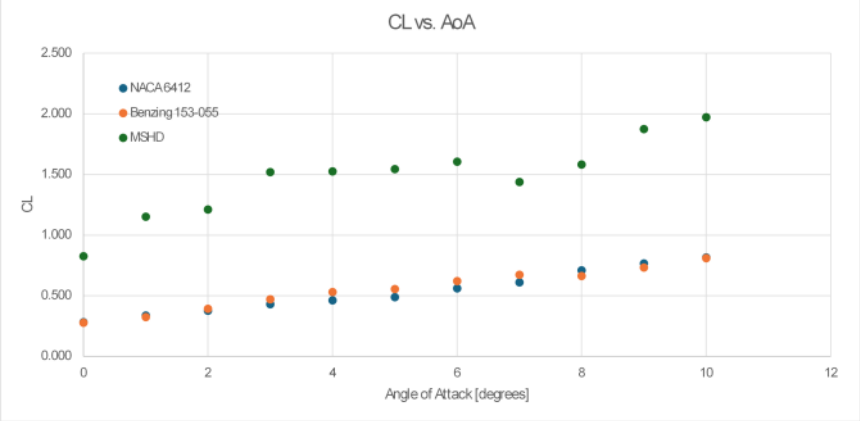
Wednesday, July 30, 2025 4:03 PM

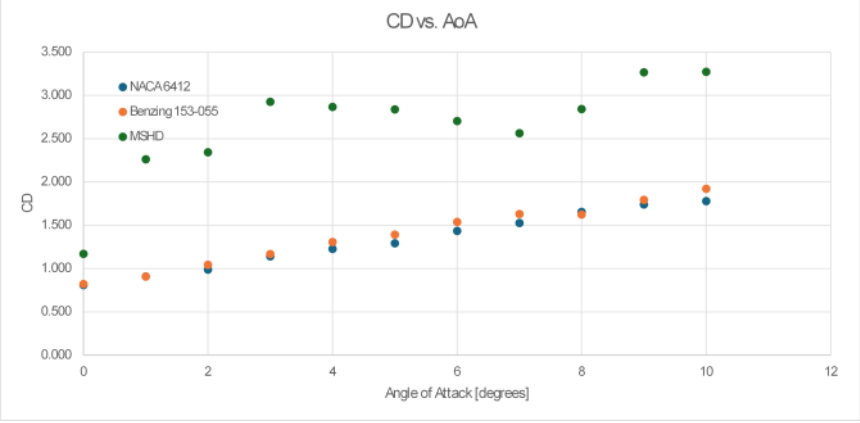
Objective:

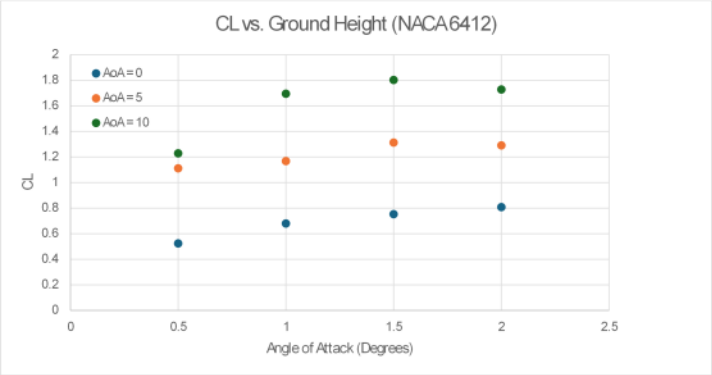
1. See effect on CL and CD of AoA change with ground proximity
2. See effect on CL and CD of height change

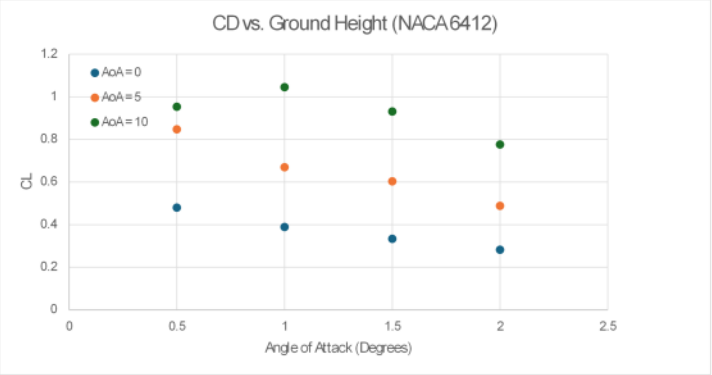
Method:

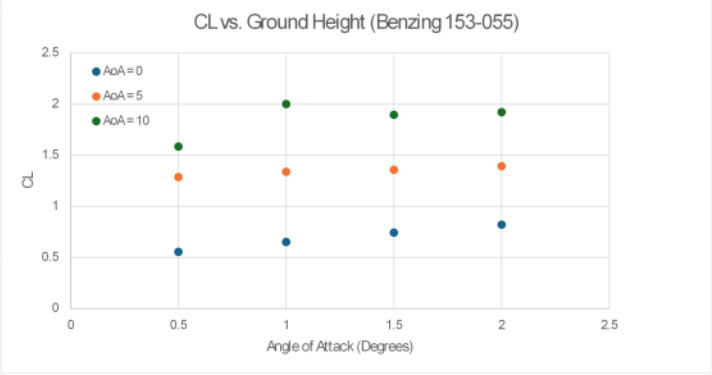
- Sweep 10 degrees of AoA through 3 different camber airfoils (NACA 6412, Benzing 153-055, and MSHD)
- Sweep .25" decrements at 0 and 10 degrees of each airfoil.

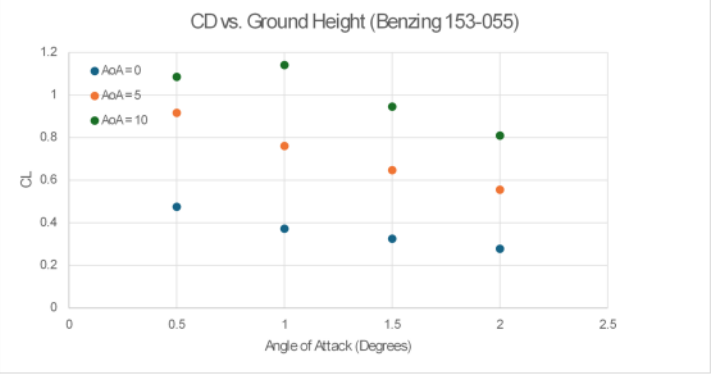


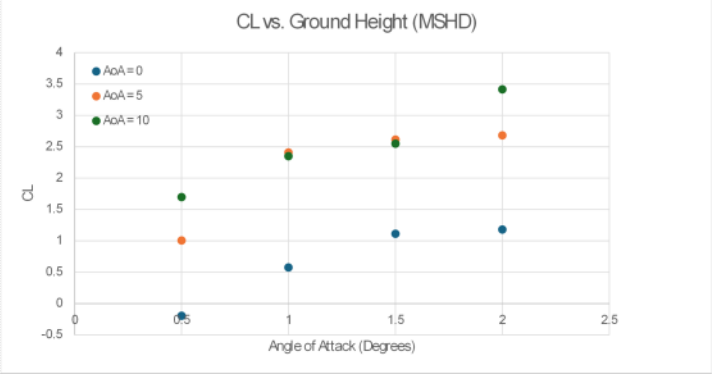



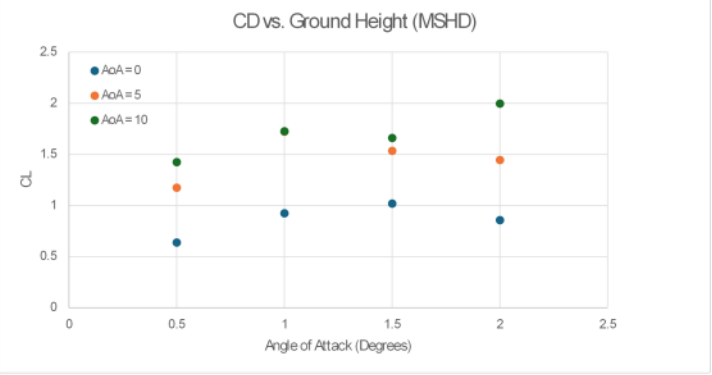

CL vs. Ground Height (NACA6412)
AoA = 0
AoA = 5
AoA = 10
CL
Angle of Attack (Degrees)


CD vs. Ground Height (NACA6412)
AoA = 0
AoA = 5
AoA = 10
CL
Angle of Attack (Degrees)


CL vs. Ground Height (Benzing 153-055)
AoA = 0
AoA = 5
AoA = 10
CL
Angle of Attack (Degrees)


CD vs. Ground Height (Benzing 153-055)
AoA = 0
AoA = 5
AoA = 10
CL
Angle of Attack (Degrees)


CL vs. Ground Height (MSHD)
AoA = 0
AoA = 5
AoA = 10
CL
Angle of Attack (Degrees)


CD vs. Ground Height (MSHD)
AoA = 0
AoA = 5
AoA = 10
CL
Angle of Attack (Degrees)

# 3D FW Pre-Lim Analysis

Tuesday, July 29, 2025 6:44 PM

Overview:

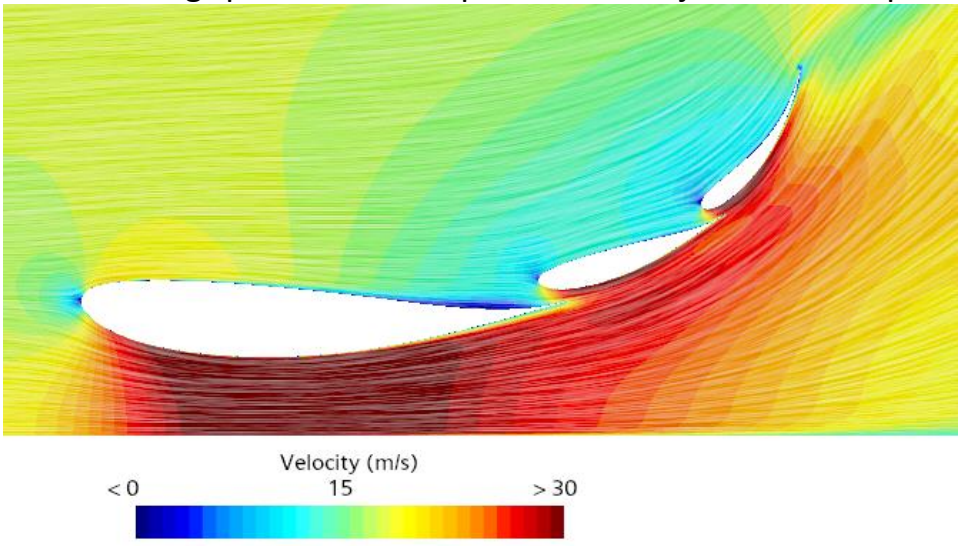
- Investigated relationship between FW and Body, aiming to see if body contributed to downforce, drag or flow separation.

Methods

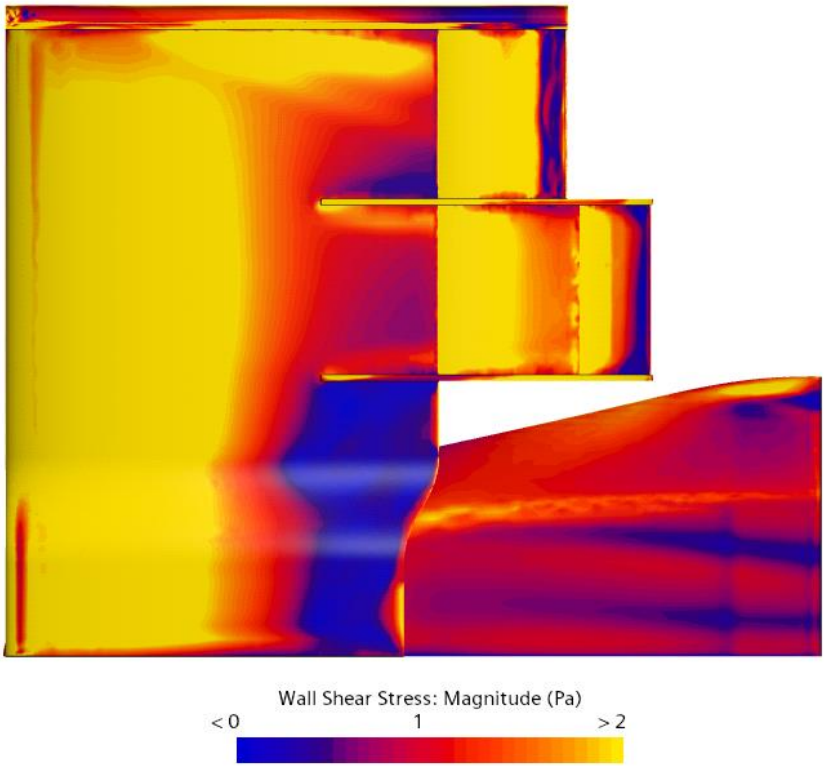
1. KS8 FW w/ Body Half Car
2. KS8 FW w/o Body Half Car

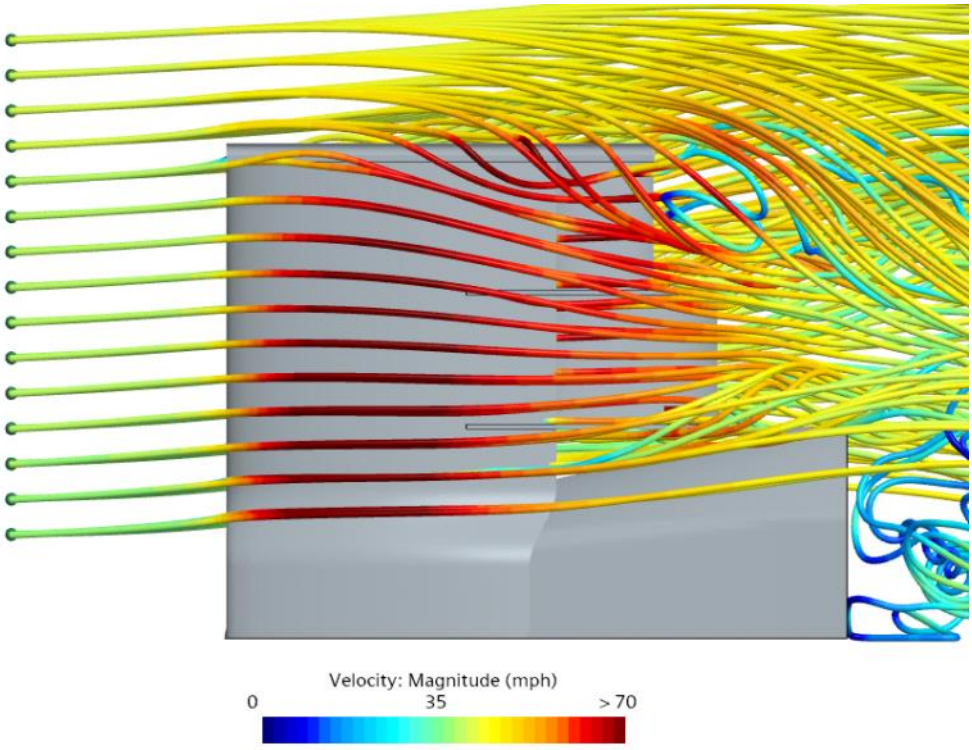
Results

- Stacked wings prevent flow separation from just one mainplane airfoil



- Recirculation from endplate on back side of wing causes some flow separation on outer/upper elements






- The no body generates 9% less drag on the FW but 18% less downforce on the FW

# Vortex Generator Study

Wednesday, July 16, 2025 12:09 AM

Deliverables:

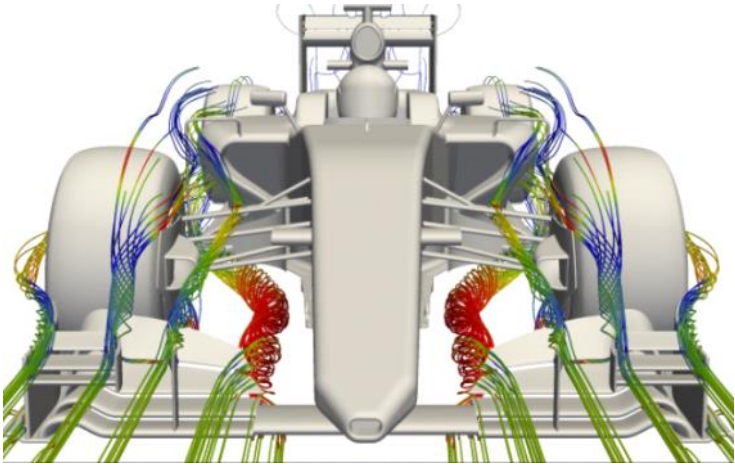
- Quantify different vortex generation methods seen in formula student and in motorsport.

Methods:

1. Compare the effect of stacking an MSHD or similar high camber airfoil, starting with one airfoil up to 3.
2. Compare just one MSHD or similar airfoil with varying AoA

Questions to answer:

1. How do stacked elements affect the vortex?
2. How does flow separation from high AoA change the vortex

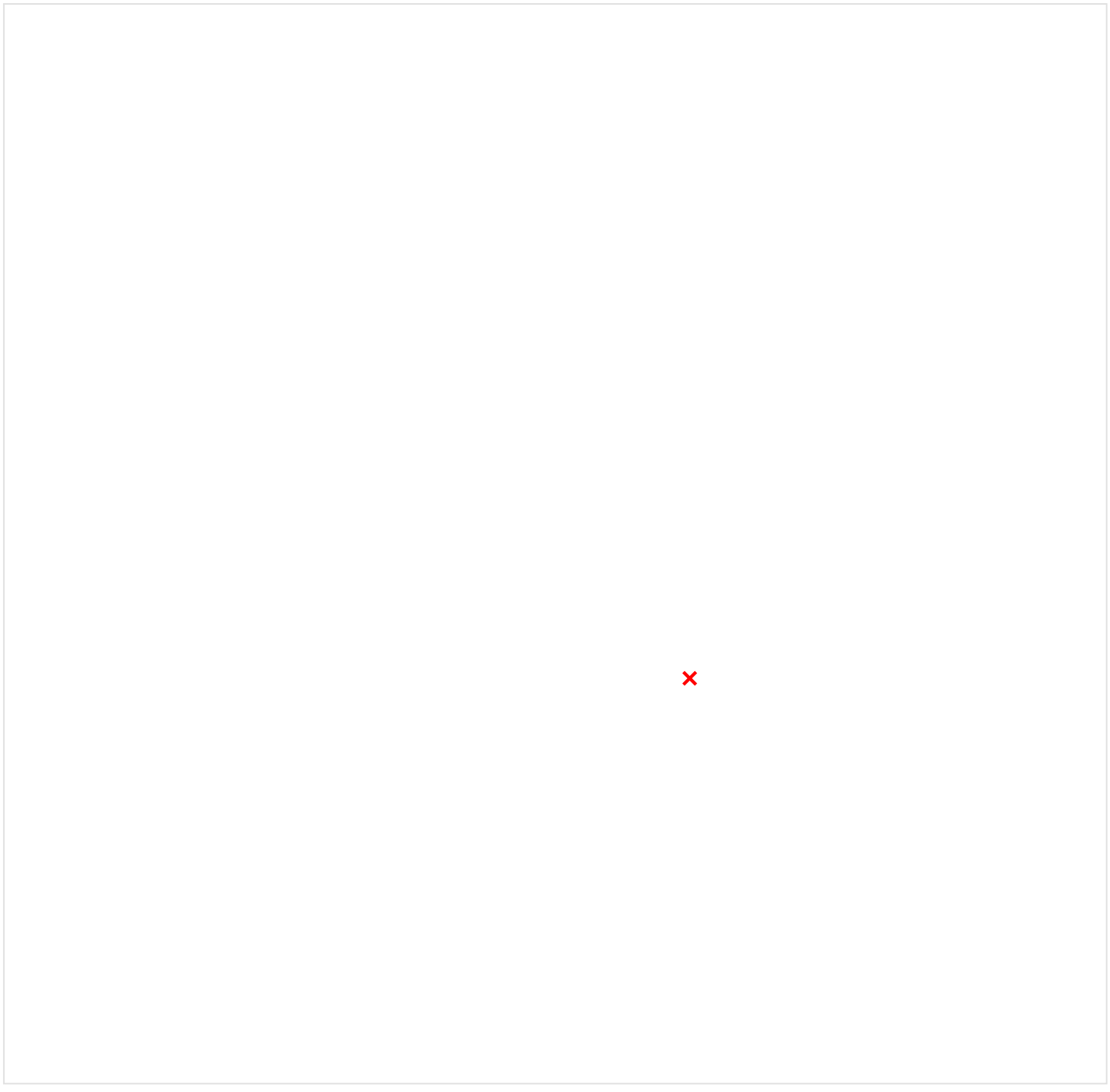


What do I want to have set up before I run sims?

- Results storage
  - What results?
    - Vorticity
    - Core Radius
    - Length (Duration)

# UT

Tuesday, July 29, 2025 3:37 PM



Taking cones

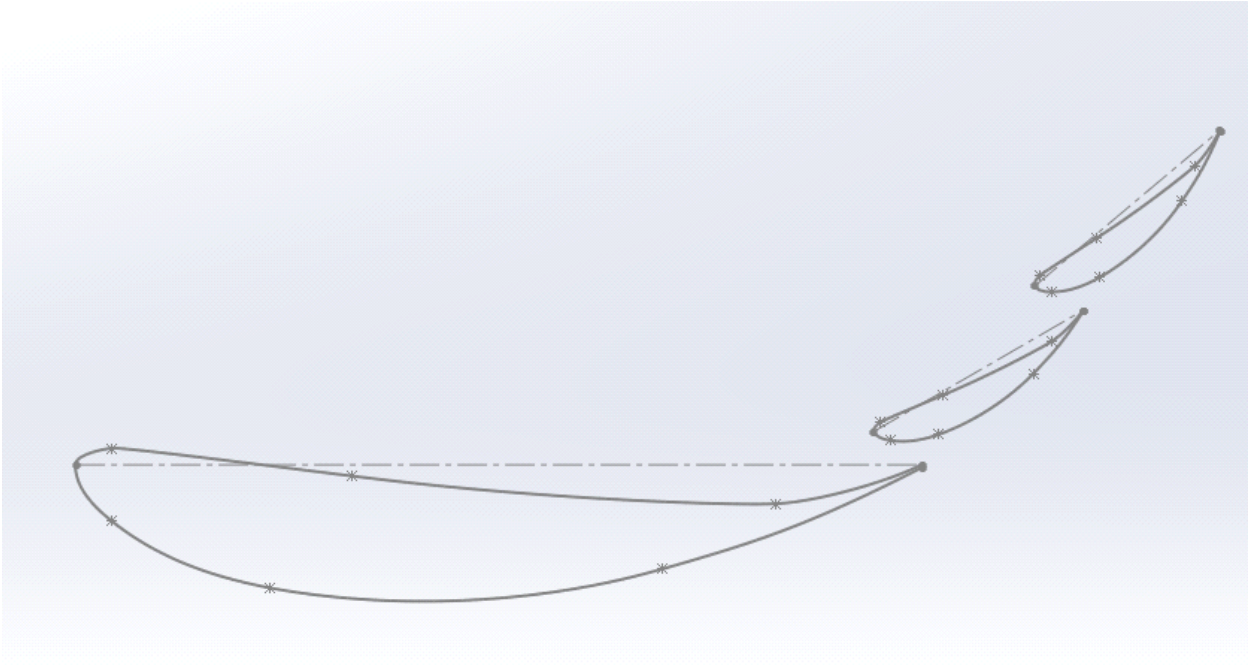
# 2D Tunnel profile study

Tuesday, July 29, 2025 3:38 PM

2D simulations allows me to quickly test out different tunnel roof profile without needing to do complete 3D concept. This let me quickly choose out which concept is best to start with and not wasting time with the other design.

Although the downside of this is that it doesn't account for complex vortex interaction with ground effect that can provide a huge performance boost to the side tunnel without the extra drag penalty

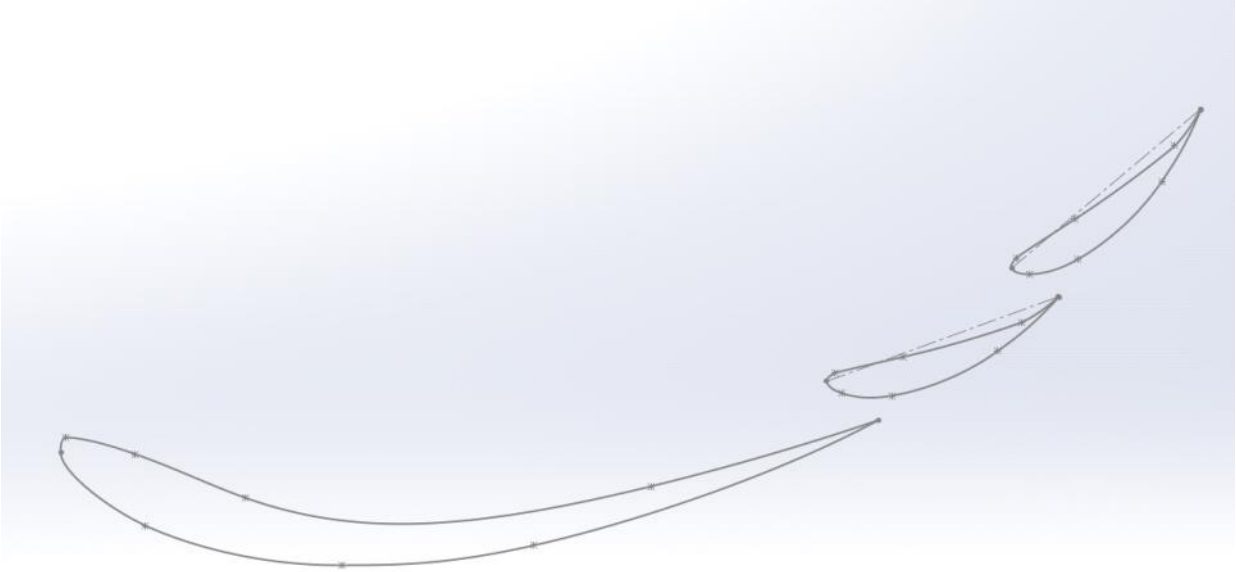
2D concept 1:



The airfoils used here are Be 153-105, The main plane have chord length of 70 cm, the 2nd and 3rd flaps chord length are both 20 cm and have respective AoA of 20o and 40o.

(Insert CFD image here, I forgot to save the image and result)

2D concept 2:
Next I want to see if the top side of the airfoil profile affect the performance of the tunnel so I created a custom airfoil based on the underside of the Be 153-105 and a thinner upper side

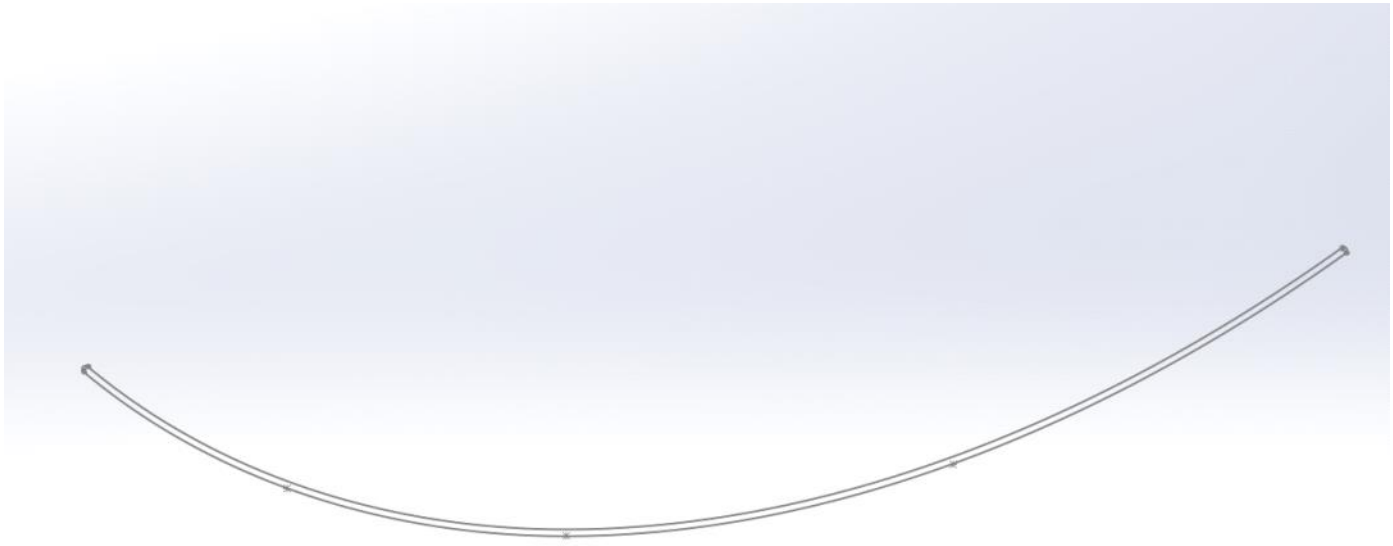


Only the Main plane got this treatment because for the 2nd and 3rd flaps to work, its upper side need to remain the same as the original airfoil

(Insert CFD image here, I forgot to save the image and result)

Spoiler alert, it did increases a lot of drag due to air separation on the top side of the airfoil. Thus decreasing the effectiveness of the 2nd and 3rd flaps

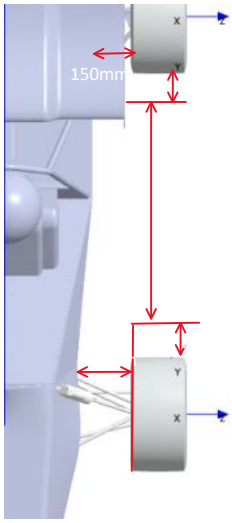
2D concept 3:
Simple concept of a concave tunnel roof profile

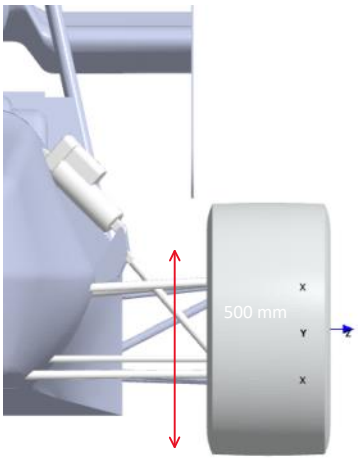


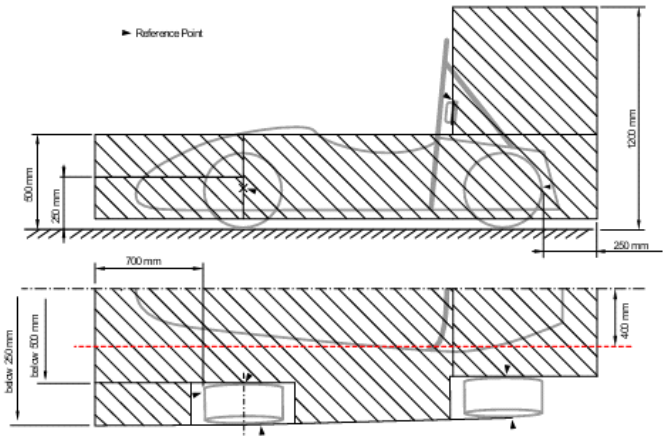
Encountered the same issue with concept 2 where increase drag caused by air separation on top side of the tunnel roof

# Tunnel Expansion Analysis

Thursday, July 31, 2025 10:05 AM




Objective:

- Given defined inlet and outlet dimensions of a tunnel, identify important tunnel parameters that affect CL, CD, and Flow Structures and conduct an analysis to provide insight on those affects.

Goals:

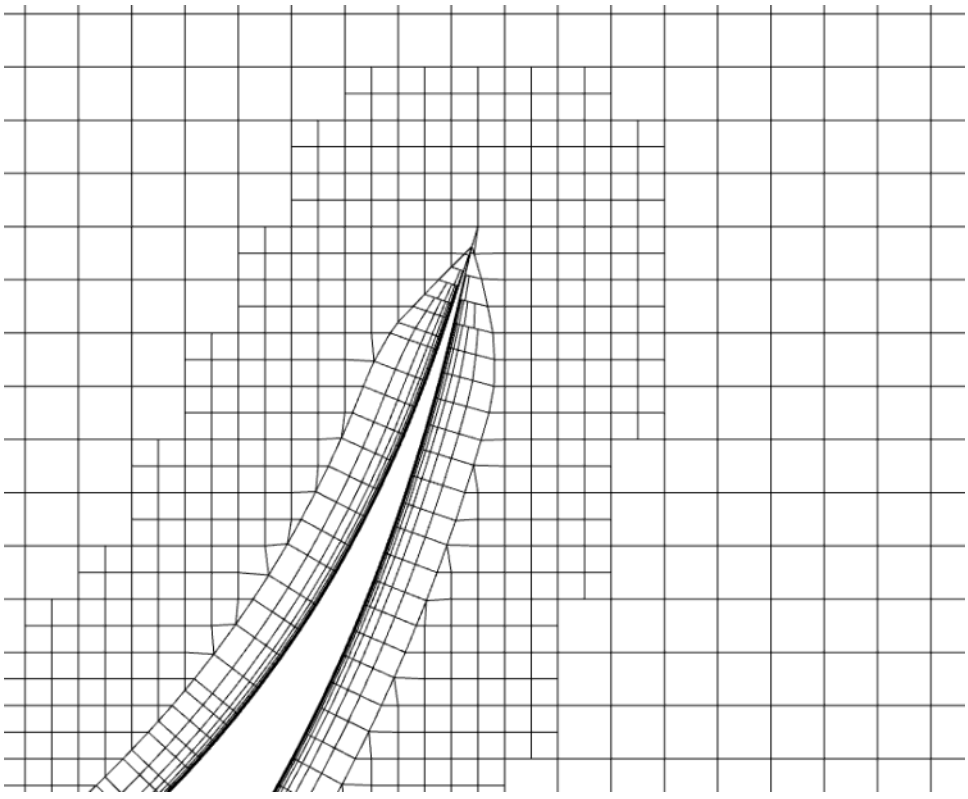
1. Identify tunnel parameters that are typically changed to tweak performance
2. Sweep parameters and consolidate findings, make a recommendation to use 1 or more concepts for further development.

# Meshing note

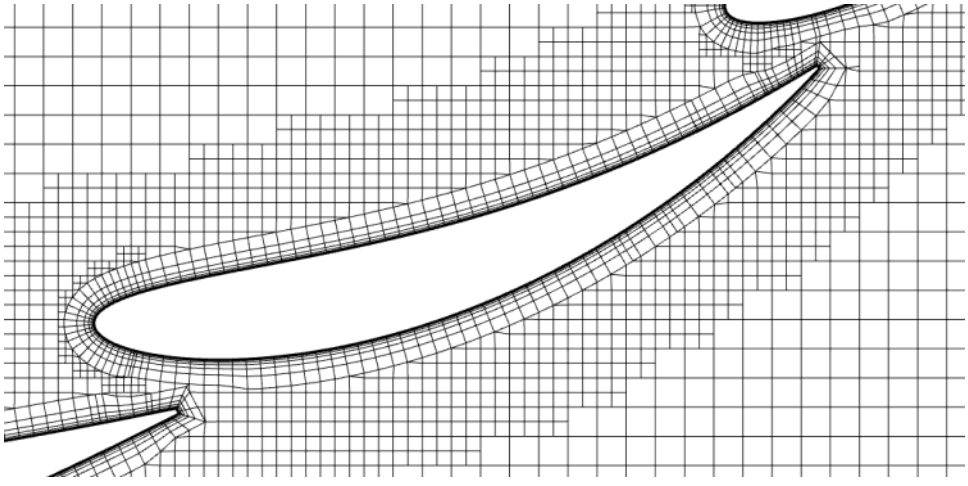
Wednesday, August 06, 2025 2:43 AM

Ran into some issue in Star CCM+ that causes a floating point error and prevent the CFD sim from running. A potential cause for this was determined to be bad meshing of the model. Some locations that required attentions are: Suspension tube, Airfoils trailing edge, and small gaps

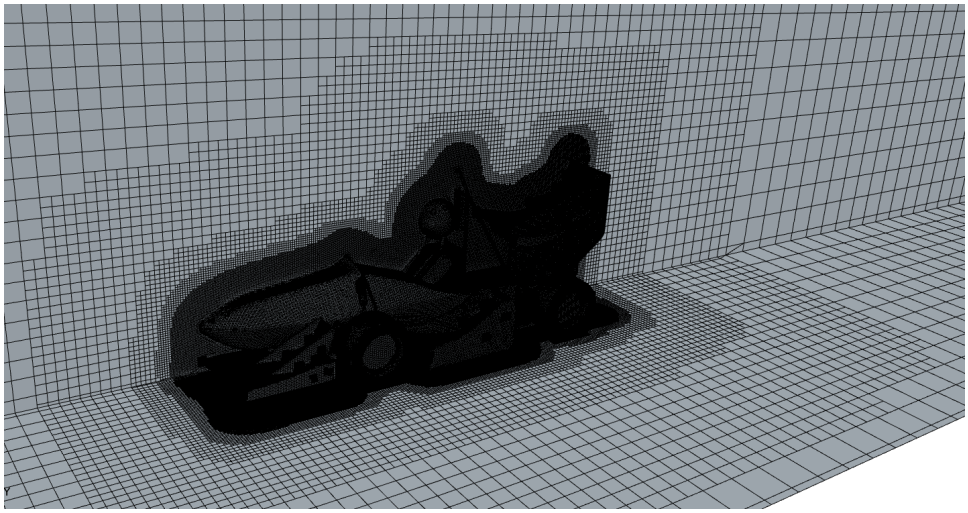
Example of bad trailing edge mesh:



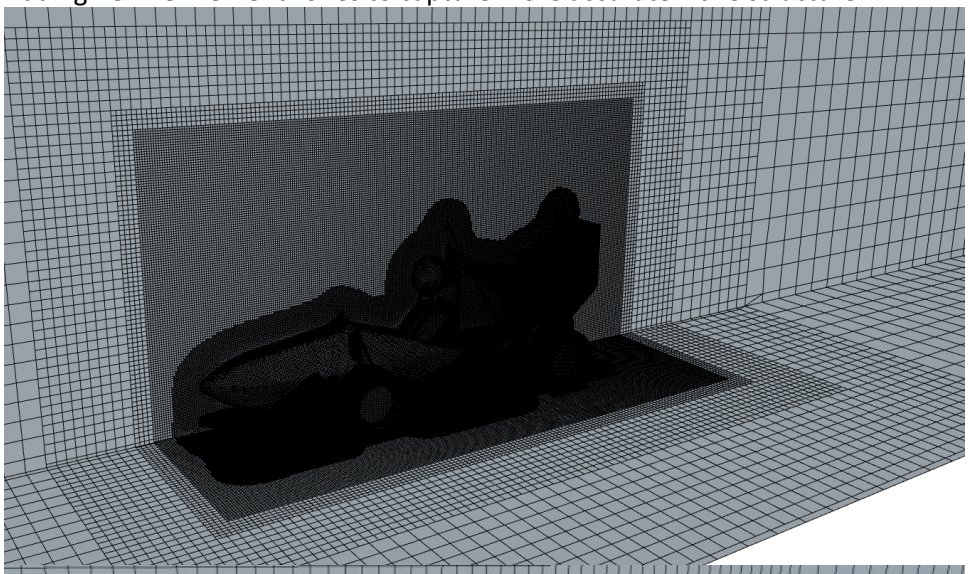
In the picture above, the TE have a sharp ending causing the mesher to have no idea on how to form prism layers around it. A way to solve it is to squared off the TE, which also representative of the manufactured airfoils. This creates better mesh around the TE

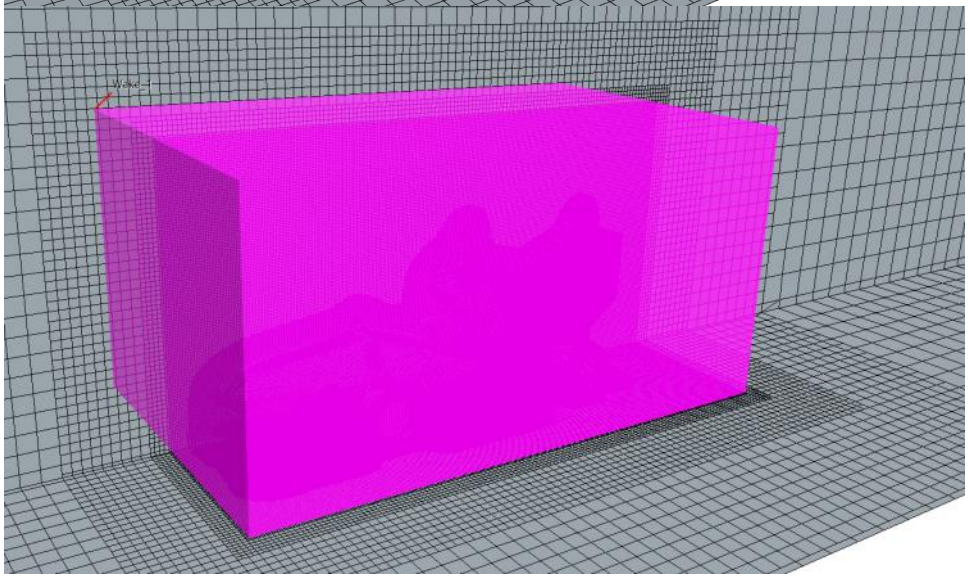


Old Mesh

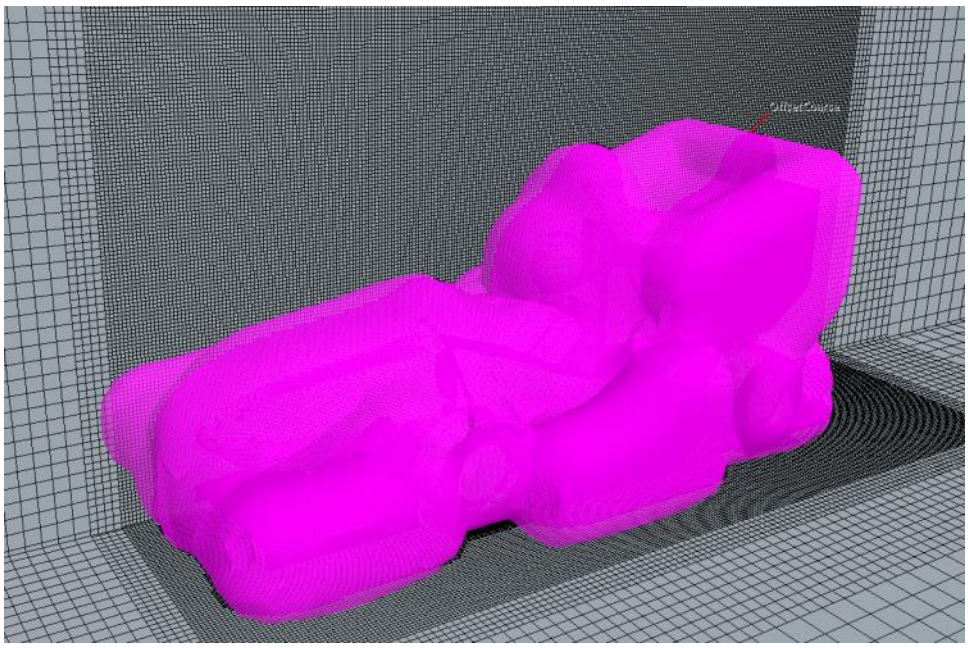


New Mesh:
Adding new refinement zones to capture more accurate wake structure

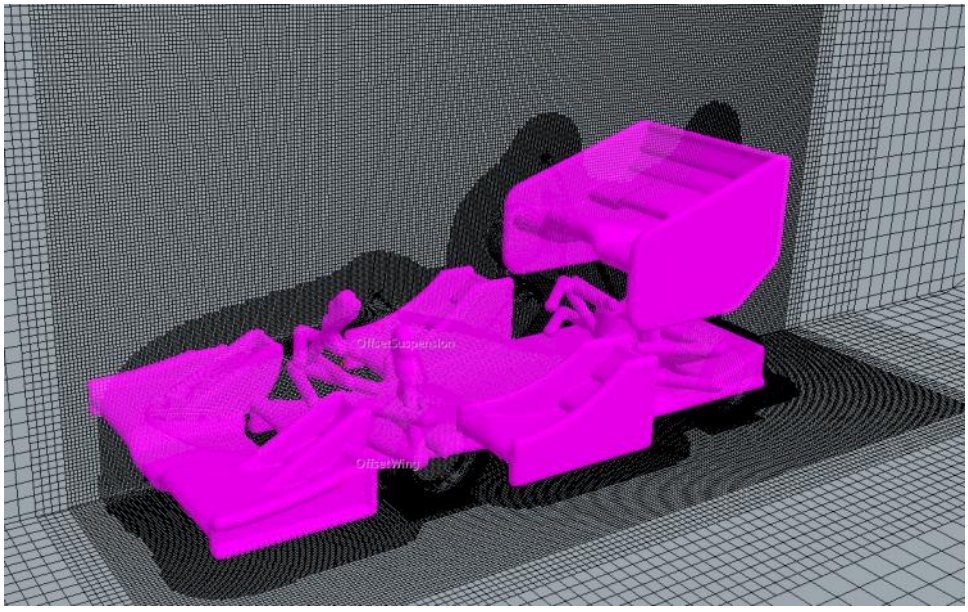




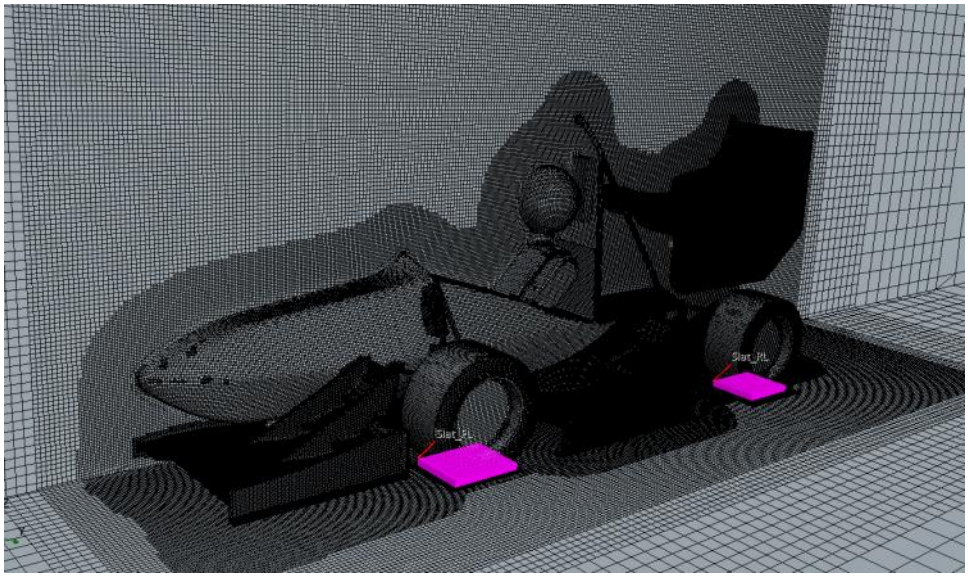
Near wake capture zone with 50% base size



Car offset with 25% base size



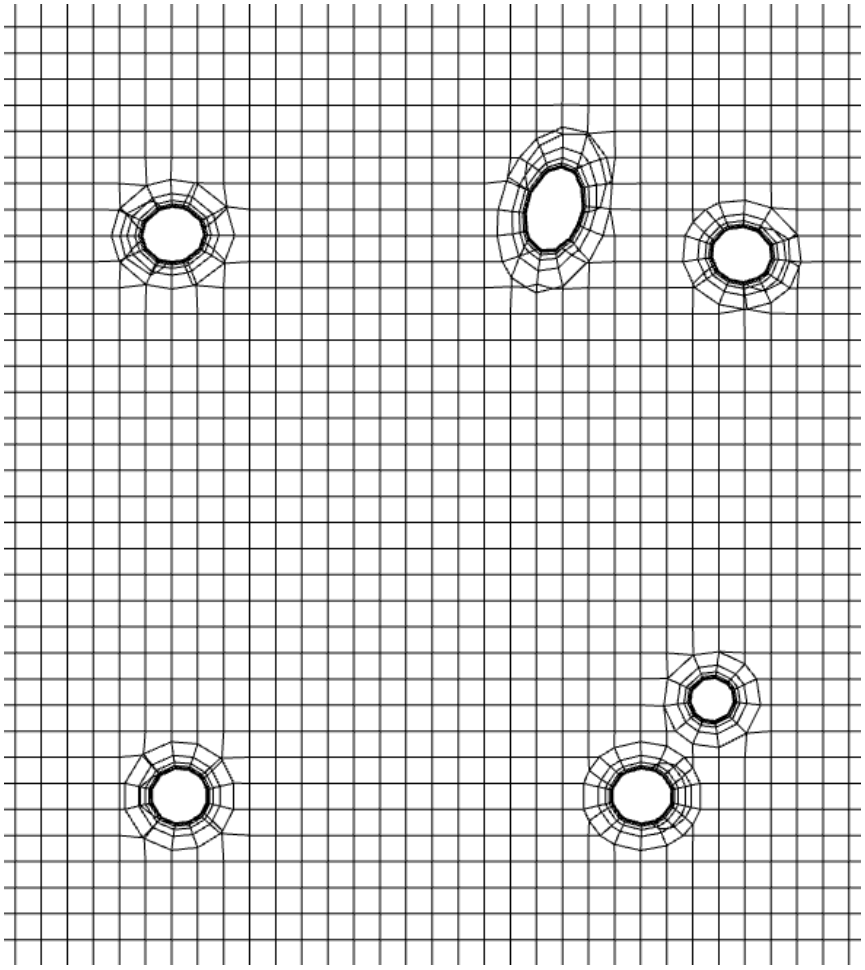
Suspensions and Wings components offset with 12.5% base size



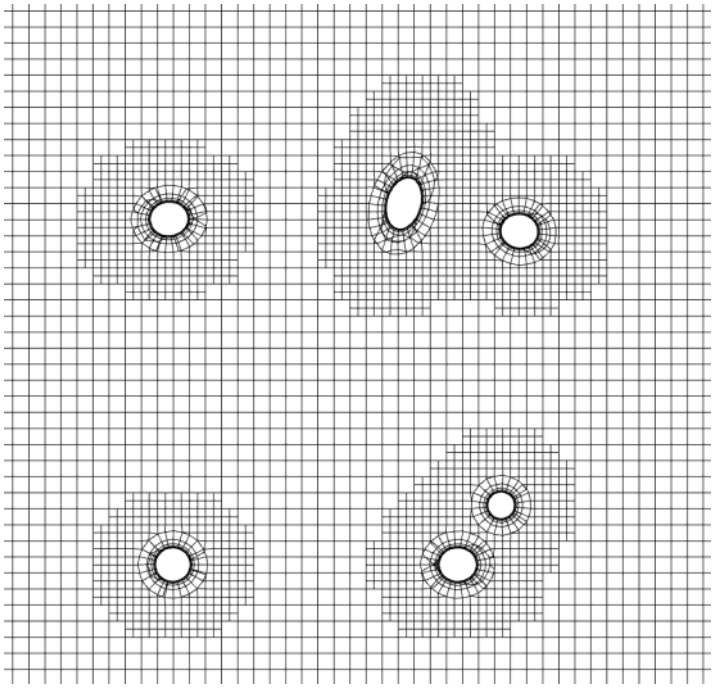
Wheel slats to capture tire wakes with 3.125% base size

Cell counts increase from 12,618,364 to 22,859,657

Suspension tube refinement before:



After:



Although refinement was made to the meshing, the error still occurs leading me to believe the problem lies in the UT geometry. Changes has been made to the UT to find potential causes but I couldn't figure out what causes this.
SUGGESTION FIX: make new UT 3D geometry

# Whiskers

Tuesday, August 19, 2025 6:43 PM

Carbon tube in airfoil

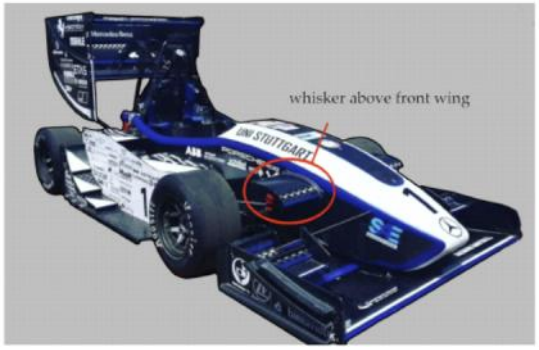
Insert in the tube on the chassis side, female end to reduce forces on the bolt connection

# Whisker Prelim Study

Friday, August 15, 2025 6:37 PM

Objective:
Whiskers have historically been utilized to harness air coming off the front wing and suck in nearby wake to help isolate rearward aero features and free flowing streams. The goal of this study is to compare different airfoil shapes, particularly in directing and generating high velocity vortices.

Background/related works:
https://www.researchgate.net/publication/361619881_Efficiency_Enhancement_Design_Approach_in_the_Side_Wing_of_a_FSAE_Car_Utilizing_a_Shutter-Like_Fairing_Structure




First set of whiskers in FSAE from Rennteam Uni Stuttgart

# Body

Wednesday, August 20, 2025 5:45 PM

# Pre-Lim Research

Wednesday, August 20, 2025 5:45 PM

Rules from FSAE Rules regarding the body of the car:

**T.7.2 Bodywork**

T.7.2.1 Conventionally designed Bodywork or a nose cone is not considered an Aerodynamic Device

T.7.2.2 Bodywork, a nose cone, or another component mounted to the vehicle is an Aerodynamic Device if is designed to, or may possibly, produce force due to aerodynamic effects

T.7.2.3 Bodywork must not contain openings into the cockpit from the front of the vehicle back to the Main Hoop or Firewall. The cockpit opening and minimal openings around the front suspension components are permitted.

T.7.2.4 All forward facing edges on the Bodywork that could contact people, including the nose, must have forward facing radii minimum 38 mm. This minimum radius must extend 45° or more relative to the forward direction, along the top, sides and bottom of all affected edges.

Criteria's that are being kept in mind when designing:

- Easy layup
- Able to relatively access parts of the car easily that would be covered by the body of the car
- Space for removable and putting on of the FW and UT
- Low drag

Characteristics teams look for when designing body/ Research papers that I found to help with designing:
https://www.ijert.org/research/design-material-selection-and-fabrication-of-a-race-car-body-panel-IJERTV5IS040719.pdf

https://ijret.org/volumes/2015v04/i10/IJRET20150410025.pdf

Body panel ideas of different teams:

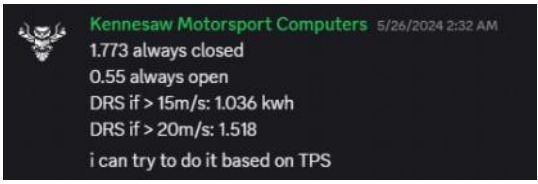

Deloitte.

# DRS

Friday, August 29, 2025 1:07 AM

Responsibilities:

1. Linkage design (Reliant on wing geometry)
2. Selection of optimal point of rotation and AoA
3. Endplate mounting (Think how will it rotate and connect to endplate)
4. Coordinate control scheme development with DAQ
5. Design packaging for motor, board, and other electronics for in-wing system




Resources:

1. Joey's SDII files and reports

# Control Scheme

Friday, August 29, 2025 1:07 AM

Pre-liminary investigation:

1. Old logs with different control schemes, use python to visualize in Foxglove, or just foxglove user script

# ==== Iteration Notes ====

Wednesday, August 20, 2025 11:48 AM

# Merged

Sunday, September 7, 2025 11:11 AM

# Low Drag 3

Saturday, September 27, 2025 1:23 AM

FW

- 4th inner element
- Slot gaps reduced to make room for upwards movement
- Moved up 1 in

# Low Drag Concept 1

Sunday, September 7, 2025 11:11 AM

Changes

FW
- Longer strakes
- Only 3 elements
- Larger EP

RW
- E3 removed
- EP style change
- GF of 0.5in

Whisker
- EP added
- Slight AoA change

General Results

FZ - 37
FZ - 17
CoP - 42/57 F/R

- Strakes did have a noticeable decrease in inner tire squirt
- The IEP extension did help a bit, but the culprit of the FW flow sep is AoA on E3
- The whisker EP pushed the vortex WAY out, which I think is a good thing but cant directly compare due to the RW change

# Low Drag Concept 2

Sunday, September 7, 2025 11:11 AM

Changes

FW

- AoA changed to

# Low Drag no UT

Wednesday, September 10, 2025 12:10 AM

Goal:

See low drag CoP and force numbers with no UT to see if this meets the downforce target within the drag budget

Goals to hit as per the SRR:
At 15 m/s (33mph)
CDA 1.4
Drag 43 lb
CLA 1.87
Down Force 60lb
COP target 45/55 (verify that while pitching forward we do not interfere with breaks)

No undertray results
Downforce 59.8
Drag 35.82
COP 54.14 front and 45.85 rear

Elements used
FW

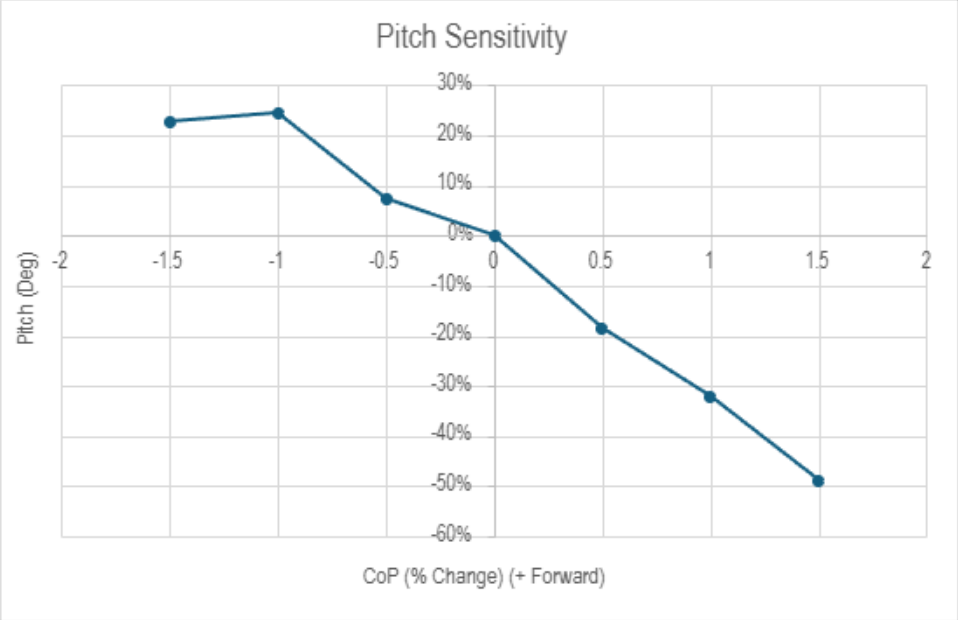
| | |
|---|---|
| -E1 modified NASA 6412 | 10" |
| -E2 modified NASA 6412 | 6" |
| -E3 benzing 153-055 (need to verify) | 5" |
| -E4 benzing 153-055 (need to verify) | 5" |

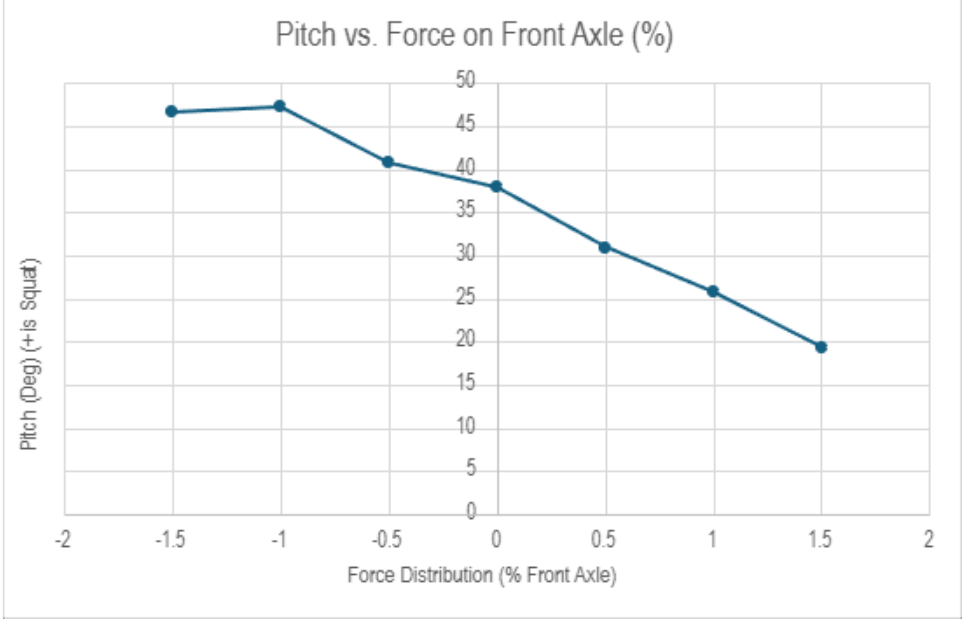
RW

| | |
|---|---|
| -MP is custom and will need its own mold no matter what | ~22.5" |
| -E1 Benzing 125-105 | 10" |

Whisker

Pitch sensitivity



# PP2 Re-Sim

Tuesday, November 11, 2025 2:07 AM

Goal:

- Simulate KS8 (No UT), UT low downforce & high downforce concepts, No UT low downforce and high downforce concepts, and finalized concept.
  - KS8 (No UT)
  - A1019LD-A2009-A3007LD
  - A1021-A2007-A3010
  - A1019LD-A3007LD
  - A1021-A3007
  - A1022-A3007LD
- All using NACA6412-6IN Whisker @ 7 degrees AoA

# FW

Friday, August 29, 2025 1:22 PM

# A1014

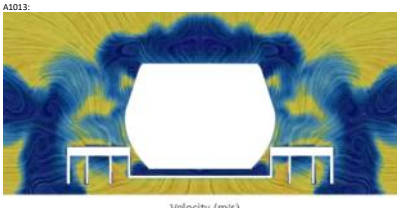
Friday, August 29, 2025 1:22 PM

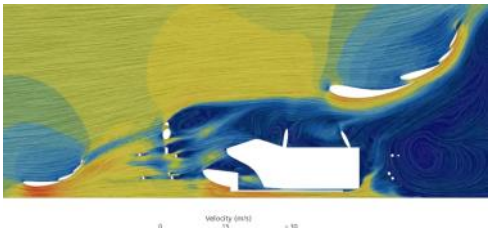
Objective:

1. Study VG on bottom of wing for tire wash control
2. Study higher concavity EP VG

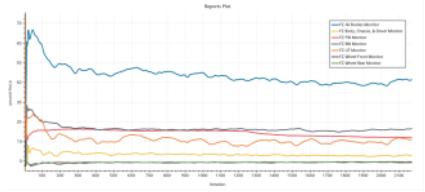
Results:

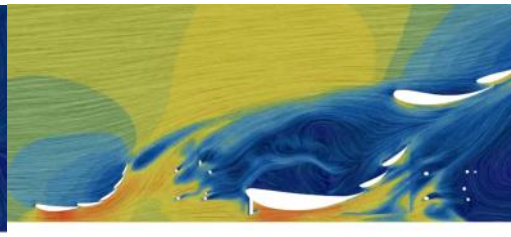
A1013:



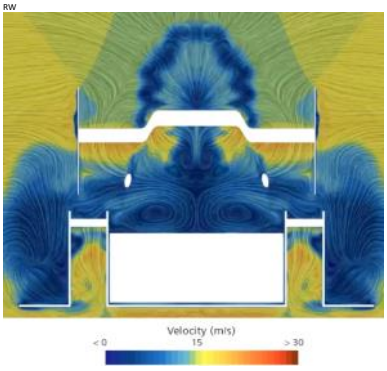


UT Df:





RW

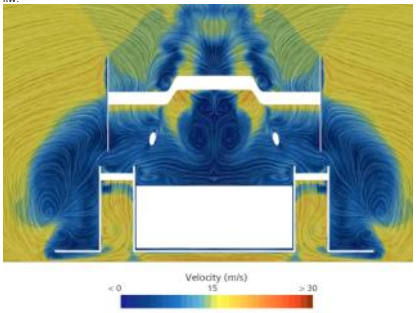



A1014:

UT Df:



RW:




Highlights

- 1014 had heavy upwash that affected the RW by 2 pounds
- 1012 might not have converged all the way which could reduce drag and increase downforce
- 1013 is more efficient than 1014
- 1014's VG kind of sucked a lot, I bet there would be more downforce from 1014 if VG wasn't there
- E2 on 1014 (Lower and less AoA) makes ~.25 pounds more Fz
- E1 on 1014 makes ~1.5 pounds less (AoA is pointing up a couple degrees
  - Could definitely be from the VGs on the bottom of the mainplane

| A1012 | A1013 | A1014 |
|---|---|---|
| 14.65 | 12.14 | 13.27 |
| 1.89 | 2.47 | 3.72 |
| | | |

# A1016

Tuesday, September 2, 2025 11:20 AM

Objectives:

- Study CA Covers
- Study more aggressive inboard whisker
- Study less aggressive outboard whisker
- Study curved VG on endplate
- Study

Results:

1. Overall car drag dropped by 4 pounds, cannot tell if this was from CA covers
    a. CA covers had flow separation, need to be tuned
2. Stacked element is much better on outboard whisker with aggressive front wing
    a. Saw about a 14 pound difference on the RW (full car)
3. The CA covers, the double inboard whisker, and the VG on the FW all contributed to a 3 pound half car downforce decrease across the UT
    a. I have no idea why this was, but it looks like the tire was kills airflow to the outer most part of the UT Tunnel
4. The VG on E5 of the FW didn't really do that much

Discussion:

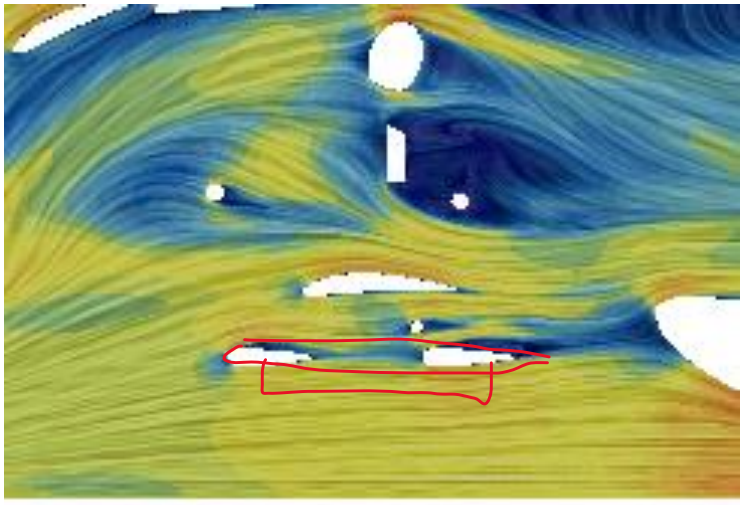
- An outwash element that pushed the tire wake outwards may assist the UT more than the CA covers.
- Double outboard whiskers are necessary for an aggressive FW
    - It may be good to try a less aggressive FW and see overall effects, if they are numerically the same why do a huge FW?
- It would probably be best to try and get that tire wash situated first, then look at changing the FW. That is killing downforce on the UT.
- If im going to protect the UT in all conditions, I need to shoot air into it, not control the tire wake downstream.
    - The tires will turn and change where the wash is, if I shoot something towards that area then I will always hit the wash, instead of having something fixed in space near the tire

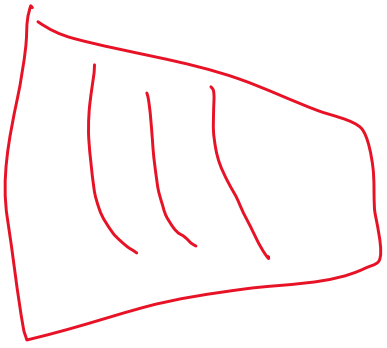
# A1017

Tuesday, September 2, 2025 1:34 PM

Changes:

- Outboard whisker flap added back
- Delta shape VG added to inside of FW
- Reverted to A1015 element spacing and no gurney
- Changed AoA of inboard whiskers





# A1017 - A1018 (E4/E5 Study)

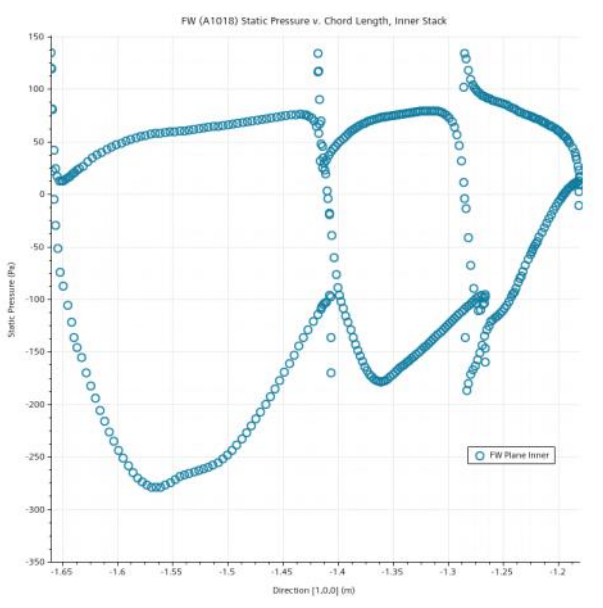
Thursday, September 4, 2025 12:30 PM

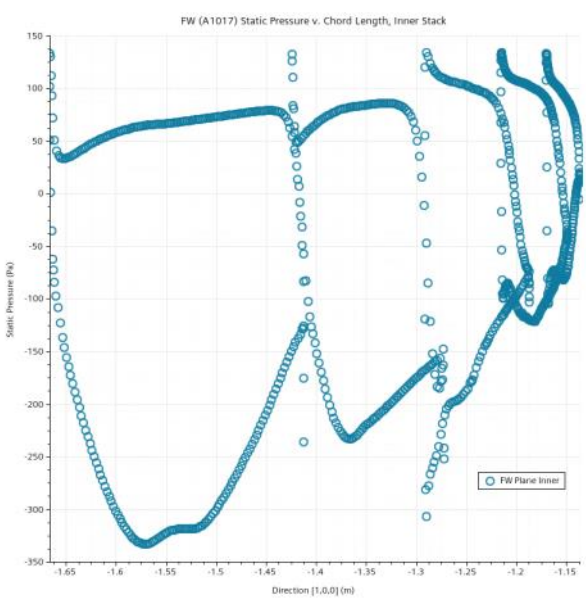
Scope:

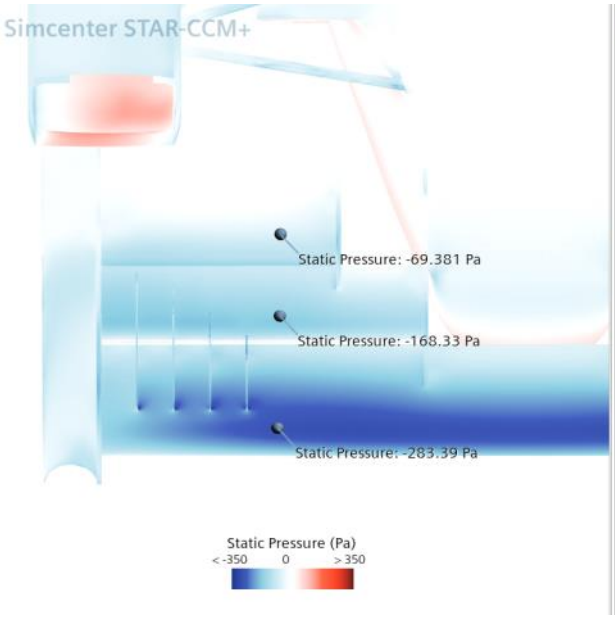
- Measure effects of E4 and E5 on FW downforce and flow to UT

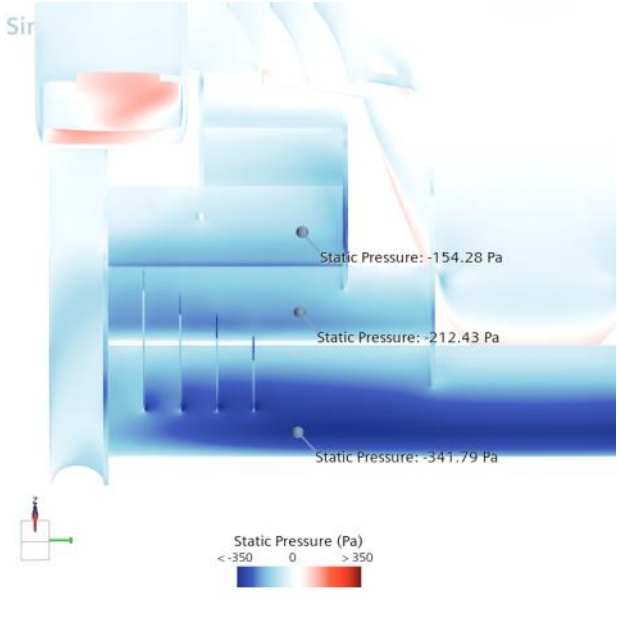
Results

FW Pressure




FW Forces

Half Car Downforce

| Part | E1 | E2 | E3 | Total |
|---|---|---|---|---|
| A1017 | 10.27 | 3.23 | 1.81 | 17.4 |

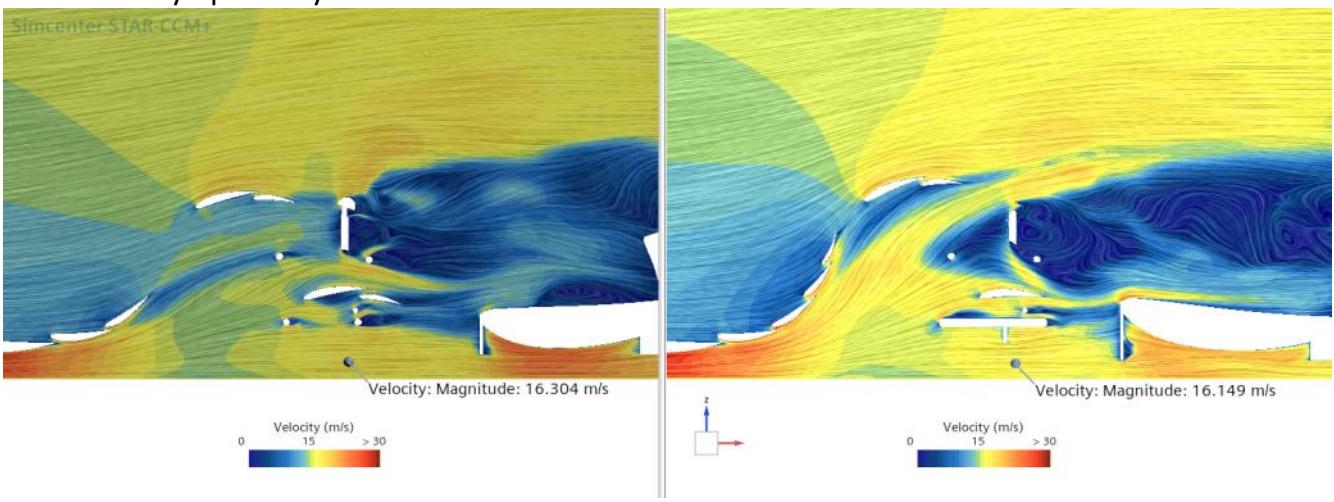
| | | | | |
|---|---|---|---|---|
| A1018 | 8.62 | 2.55 | 1.24 | 13.5 |

Half Car Drag

| Part | Total |
|---|---|
| A1017 | 3.19 |
| A1018 | 1.62 |

UT Flow (Different UT) (No strakes on A1018)

Flow Velocity up to tray



# UT

Friday, August 29, 2025 1:22 PM

# RW

Friday, August 29, 2025 1:22 PM

# A3005

Thursday, September 4, 2025 10:27 PM

# A3006

Thursday, September 4, 2025 10:26 PM

# A3007

Thursday, September 4, 2025 10:27 PM

# Concept Phase Summary

Saturday, August 30, 2025 8:56 PM

## Executive Summary

This phase of design explored large design changes including different airfoils, angles of attack (AoA), number of elements, vortex generators, and out/down wash elements. The goal was to see how these changes affected overall downforce at the component level. Each component went through iterations using the neighboring KS8 components (Undertray, or UT, would use KS8 Rear Wing, or RW, and Front Wing, or FW, throughout its iterations) to isolate component change effects on itself and the system. This was done to avoid complexity of adding in the other component iterations at each step and quicken the iterative process. To re-iterate, we were looking at large changes and avoiding small interactions.

The most important conceptual decisions that will begin the feasibility & fine tuning phase are as follows:

Starting from the front of the car moving rearwards, the front wing will focus on a shorter "split" mainplane that has a better pressure to surface area ratio. It will avoid implementing complex geometry for tire wash/UT flow control due to the added complexity outweighing the observed effects, and will instead rely on whole wing camber tuning and "whisker" elements to condition downstream air to the UT and RW.

The UT will focus on a mid-car placement between the wheels with airfoil shaped, stacked element side tunnels. A flat bottom will bridge the two side tunnels that provides clean air to the bottom of the car.

The RW will focus on a 3 element profile that has a lofted feature in the middle. The 3 elements allow for easier DRS implementation as it reduces the movable flaps to 2 instead of 3. The central loft increases the camber and reduces angle of incidence with the air, allowing the RW to access free stream flow coming from above the drivers head. Louvers and other drag reduction methods will be investigated during the fine tuning stage.

This process has clarified which concepts are most effective that fit within the targets set by the SRR. The next phase uses the best concept of each component and combines them to focus on intricate fine tuning with hard constraints from manufacturability, assembly, mounting, and whole car integration (radiator, jacking bar, chassis changes, etc.)

Weight Reduction from KS8

| Component | FW | RW | UT |
|---|---|---|---|
| KS8 | 5.6 | 7.9 | 17.4 |
| KS9 | 4.77 | 6.5 | 8.7 |

Weight Change w/ UT: 11 lbs

Weight Change w/o UT: 2.3 lbs

## FW

### Executive Summary

The goal of FW development is to improve from KS8. The KS8 front wing suffered from flow separation on upper elements, low camber airfoils, ineffective EP vortex generators, and integration issues regarding jacking point access.

2D airfoil simulations identified that higher camber increased downforce over flat airfoils at the most optimal ground height for ground effect (about 2 inches at a chord of 18 in, or 1/9 the length of the chord), showing this as a dominant trait. It was also discovered that single elements (mainplanes) would separate flow on the bottom side towards the trailing edge unless a stacked element was placed behind. Furthermore, the mainplane could be "split" into two airfoils to increase the surface area in which there was low pressure and reduce the area that was ambient, making it more efficient at producing downforce for its surface area and therefore weight.

Overall, the FW during this phase improved downforce by about 20% relative to itself (not whole car) while also reducing in size length wise by about 2 inches and at a height of 3.5 inches off the ground plane. If we need to make more downforce to move CoP forwards, we can.

### A1009

### A1010

### A1011

### A1012

A1013
A1014
A1014-2
A1015

UT

Executive Summary

A2002

Second side tunnel concept, stacked element, curved tire blocker, strakes

A2003

Two stacked elements, outlet throat length change, strake length reduced, VG on footplate

A2005

No footplate VG, diffuser with current chassis & strakes

A2006

Footplate VG back, reduced inlet strakes to one, barge board at inlet

RW

Executive Summary

A2001

S1223 3 Element

A2002

S1223 3 Element, Loft, Shortened rearwards

A2003

S1223 4 Element, Loft, Shortened rearwards

A2004

A2003 with gurney flap

# PP2/PP3 Notes

Saturday, November 15, 2025 4:57 PM

Topics:

PP2

- Concept Comparison
- Final Concept Deep Dive
  - CFD
    - Vel Sweep
    - Pitch Sweep
    - RW AoA Sweep
  - CAD
    - Aero Box Margins
    - Mounting
  - Goal Evaluation
    - Downforce
    - Drag
    - CoP
    - Weight
- BOM

PP3

- Manufacturing Procedure*
  - David is on it!
- Assembly Procedure
  - Exploded Views
- Drawings
  - Ribs
  - Endplates
  - Mounts
  - Wing Span
- BOM
  - Carbon/Resin

To Do:

- [ ] Sim setups for sweeps
  - [x] Update A1019 with new EP (Curved and shortened 2/3in)
  - [x] Update A3007 w/ new EP
  - [ ] Set sweeps
- [ ] CAD
  - [ ] RW Mount
  - [x] RW EP and FW EP
  - [x] Remove Middle EP
  - [x] Remove Whisker
  - [x] Remove E4
  - [x] Change EP bottom
  - [ ] RW Internals
  - [ ] (After CAD done) Full Weight
  - [x] VISIBILITY TO RTDL
  - [ ] FW Bolt Holes
  - [ ] 1/4 mainplane RW Rib
  - [ ] 3D print RW Flap rib
- [ ] BOM
  - [ ] David: All composite pieces
  - [ ] Seth: All non composite pieces and mount
- [ ] Assembly
  - [ ] David: Putting into writing then will do photos later

To Do Pt 2

CAD

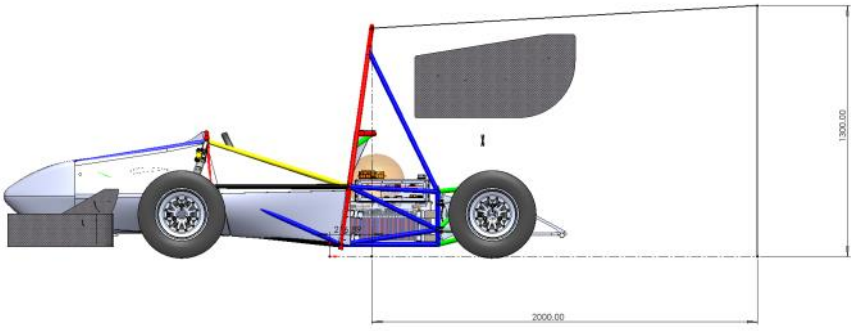
- [x] RW Strut
- [x] RW Strut Tabs
- [ ] RW Rib Cutouts
- [ ] FW Rib Cutouts
- [ ] RW re-build
- [ ] FW E1 and E2 fastener holes
- [ ] All fasteners
- [ ] Material selections

To Do Pt. 3

- [ ] CoP and Velocity Results
- [ ] CAD Projected Weight
- [ ] Adjustments for Aero Box
- [ ] Best pass of CAD for images
- [ ] BOM
- [ ] Assembly Images
- [ ] Talk to David about manufacturing

Questions for Soup

- What is the plan for internals on FW and RW
- Do you have a manufacturing plan we can lay out for PP3?
- I will do an assembly plan for PP3 and drawings
- Do you have a BOM?



# ==== Meetings ====

Wednesday, August 20, 2025 11:48 AM

# Daily Standups

Wednesday, August 20, 2025 11:48 AM

Meeting at 6 Every Day, come prepared (Sim reviewed) (Tues, Thurs, Fri)

- If cannot make it, notify early

Daily sim progress

Send ZIP sims in morning

Biggest Factor is sim

Fixes:

- Sim meshes within 30 minutes
- Sims sent in morning

# Sep. 05, 2025

Monday, August 25, 2025 5:01 PM

Simulation review

Review

RW
UT
Body
FW
- Separation, change last element AoA
- Change length of strakes

To do

Cooper
- Aggressive whisker
- Use A1019

Quang
- Use A1019
- Increase A2009 to AoA of 10

Seth
- Increase A2009 height by .5in

Shared Elements

Benzing 153-105
- 10
  - FW E1
  - RW E2
- 6
  - FW E2
  - UT E2
  - UT E3
- 5
  - FW E3
  - FW E4
  - RW E3
- Modified
  - UT E1

Custom
- RW E1

Game Plan:

I need to set the FW's concept (how many elements) so that the UT and RW can do their adjustments to compensate. I should set what chord lengths it will use so that the other components can use those, that will be a strict constraint.

Once I set that, we should look at RW LE distance, RW AoI and Element stack, UT ground clearance, AoA, Element Stack, and radiator placement. We should also define mounting areas for the UT (maybe blocks) that we have to design for.

By this point, we can evaluate if the whole package meets force goals and rough CoP goals, if it doesn't we tweak components to meet it.

We can then sweep velocity, pitch, and height to see CoP and force change, and then tweak to be in the range we want (which we need to define)

What individual Studies need to happen:

General
- AoA
- Slot Gap
- Chord Lengths

FW
- Strake # and length (and the effect directly)
- VG & tire blocker size, effect if not curved EP

Day 1 (Thurs Night)
1. No Whisker, Low Camber FW
   a. Decides FW Concept for UT and RW design support
2. Optimal RW AoA, Shared Airfoils, and LE Distance, loft width
   a. Set baseline of RW for comparison to different airfoils
   b. Use aggressive FW
3. Optimal UT AoA, Shared Airfoils
   a. Sets baseline
   b. Use aggressive FW, no CA Cover or IB Whisker

Freeze FW, RW, & UT Chords & Airfoils

Day 2 (Fri Night) (Combine Best RW and UT)
- These will need to be independent of other changes

1. RW LE Moved Back
   a. Cooper
   b. Determines: How small can RW be?
2. UT Ground Clearance Increase
   a. Quang and Seth
   b. Determines optimal height of UT

Freeze RW Sized

Freeze UT Height/Mounting

Day 3 (Mon Night)
1. Radiator Placement UT & Whisker Position
   a. Quang
   b. Dependent on radiator list from James
2. Outboard whisker big single & CA Covers & Airfoil FW EP
   a. Seth
   b. Use shared airfoils
   c. Determines stack or no stack
3. RW Endplate Concept & Small FW EP Footplate
   a. Cooper

Freeze Whisker Size & Position

Know affect of radiator UT (Might not have radiator set up)

Sitrep:

Frozen
- FW size frozen
- RW & UT airfoils frozen
- RW LE Position frozen
- UT Ground clearance frozen
- Radiator UT change determined
- Whisker Element Chosen

Undetermined
- Rad effect on RW if center placement
- Rad effect on side placement
- CA Covers Worthwhile?

The big question: Is everything ready to be frozen at this point?
- Need to have aero targets met, and not want to do any low hanging fruit for drag reduction, this will be your final form.
- Need integration with mounting, chassis, and other components okayed by decision makers

After freeze: Sweep velocity, pitch, and height. Make adjustments as necessary.

Once all aero parameters are met:
- Finalize mounting
- Design internal structures and connections
- Design DRS

Studies to do
- Louvers on RW
- FW Strake effectiveness
- FW EP Curved Effects
- Covered SN
- Other stuff?

Day 4 (Tue Night)
1. Rad Effects on RW
    a. Cooper
2. CA Covers effect
    a. Seth
3. Louvers (Or something else)
    a. Quang

Day 5-7 (Wed-Fri)
- Mounting Design

Day 8-10 (Mon)
- Sweeps

Biggest Next 2 Week Deliverables:
- Team confirmation on integration
    - Mounting
    - Radiator
    - Collisions
- Aero meeting force/CoP targets
    - Steady
    - Sweep

# Sep. 04, 2025

Monday, August 25, 2025 5:01 PM

Simulation review

Question: Are our sims hitting our goals right now?

YES: Our most aggressive package makes 40 pounds of drag and 92 pounds of downforce, with CoP being 55% rear bias (ish)

Agenda:
- [ ] Review Sim
- [ ] Next Sim Steps
- [ ] UT Mounting

Review

RW
- Moved back about 2in from KS8

RW

Things I want to know on their own:
- What does KS8 report with the updated body?
- How far back can the LE on the mainplane go before it loses downforce?
- (Maybe after the previous note) should we split the mainplane?
- What elements can be shared and how do they impact what we think is optimal?
  - Find optimal elements first? Or just do what meets goals then see if there is a drag reduction option?
- After all that then

UT
- Rad placement design compared to best UT iteration
  - Need rad from James
-

Body

FW

Things I want to study on their own:
- What are the effects of no whiskers on the low camber FW?
  - Decide which one to pursue, then can optimize flap angle and gap
- What is the effect of whisker in the inboard?
  - Then, how many elements do we need? Stacked?
  - Then, what is the optimal gap and AoA?
- What is the effect of CA covers?

To do

FW

RW

UT

Body

Shared Elements

Benzing 153-105

10
- FW E1
- RW E2

6
- FW E2
- UT E2
- UT E3

5
- FW E3
- FW E4
- RW E3

Modified
- UT E1

Custom
- RW E1

Game Plan:

I need to set the FW's concept (how many elements) so that the UT and RW can do their adjustments to compensate. I should set what chord lengths it will use so that the other components can use those, that will be a strict constraint.

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Freeze FW, RW, & UT Chords & Airfoils

Day 2 (Fri Night) (Combine Best RW and UT)
- These will need to be independent of other changes

1. RW LE Moved Back
   a. Cooper
   b. Determines: How small can RW be?
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   a. Quang and Seth
   b. Determines optimal height of UT

Freeze RW Sized

Freeze UT Height/Mounting

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1. Radiator Placement UT & Whisker Position
   a. Quang
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   a. Seth
   b. Use shared airfoils
   c. Determines stack or no stack
3. RW Endplate Concept & Small FW EP Footplate
   a. Cooper

Freeze Whisker Size & Position

Know affect of radiator UT (Might not have radiator set up)

Sitrep:

Frozen
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- RW LE Position frozen
- UT Ground clearance frozen
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- Whisker Element Chosen

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- Rad effect on side placement
- CA Covers Worthwhile?

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After freeze: Sweep velocity, pitch, and height. Make adjustments as necessary.

Once all aero parameters are met:
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Studies to do
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- FW Strake effectiveness
- FW EP Curved Effects
- Covered SN
- Other stuff?

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1. Rad Effects on RW
    a. Cooper
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    a. Seth
3. Louvers (Or something else)
    a. Quang

Day 5-7 (Wed-Fri)
- Mounting Design

Day 8-10 (Mon)
- Sweeps

Biggest Next 2 Week Deliverables:
- Team confirmation on integration
    - Mounting
    - Radiator
    - Collisions
- Aero meeting force/CoP targets
    - Steady
    - Sweep

# Sep. 03, 2025

Monday, August 25, 2025 5:01 PM

Simulation review

RW
UT
Body
FW
Whisker

To do

FW

RW

UT

Body

Game Plan:

What do we want to design?

Cooper:

Quang
- e

Seth

Up Next:

# Aug. 30, 2025

Monday, August 25, 2025 5:01 PM

Simulation review

Damn this shit rocked a lot

RW

UT

-

Body

FW

- Flow separation on E5, gurney flap could benefit
- No large vortex on top of curved endplate

Whisker

- Need CA airfoils to see how much flow is reduced
- Inboard whisker needs an AoA change
- Upper whisker can be op

To do

FW

RW

UT

Body

## Game Plan:

## What do we want to design?

1. UT with AoA change
2. UT with airfoil change
3. UT with radiator on inside
4. FW with gurney flaps and cone VG on EP
5. RW 3 Element
6. Gurney flap on 4 element
7. Whisker AoA and placement changes
8. Control arm airfoils

## Cooper:

- RW 3 Element moved back
- UT Airfoil Change

## Quang

- UT with AoA change

## Seth

- ~~Whisker changes~~
- ~~CA Airfoils (No UT Change)~~
- ~~Gurney on FW and RW~~

- ~~VG on FW EP~~
- ~~FW Slot Gap~~

Up Next:

- UT with radiator
- UT with swoop on bottom*
- RW Slot gap

# Aug. 29, 2025

Monday, August 25, 2025 5:01 PM

Simulation review

RW

UT

- Experiencing turbulence on top of mainplane, need to sdjust AoA/airfoil profile to reduce

Body

FW

- FW slot gaps should be bigger to reduce sensitivity to manufacturing defects
- Lots of un-utilized space between the inner EP and the body
- VGs reduced FW downforce by 2 lbs and created a lot of turbulence, no real effect on UT flow

To do

FW

- [ ]

RW

UT

- [ ] CAD file with custom airfoil profile
- [ ] CAD file with AoA changed 3-5 deg. "down"

Body

Overall Design Notes

- Need to consolidate design so far, decide what else should be investigated and if we are hitting our goals
- Complete the rest of those investigations, summarize, and freeze the concepts
- Add in mounting, structures, and other components into design considerations and make changes necessary, simulate, confirm, then do sweeps

# Aug. 28, 2025

Monday, August 25, 2025 5:01 PM

Simulation review

RW
UT
Body
FW

To do

FW
- [x] No loft
- [x] Remove inside footplate and expand VG concavity
- [ ] Diveplanes
- [x] VG on bottom of wing for tire wash control
- [x] Measure each element downforce to compare to KS8

RW
- [ ] Mainplane up well into that free stream
- [ ] Add in the RTD Light
- [ ] Move RW mainplane back a bit too

UT
- [ ] Diffuser study with rear of main hoop angled up for ideal flow

Body

Edit surface model by adding front geometry and supporting curve lines

# Aug. 25, 2025

Monday, August 25, 2025 5:01 PM

Simulation review

RW
- Sim ran well
- Comparable DF numbers to current wing
- Added data to excel sheet

UT
- Run old UT with new FW to test new Star templates
- Residue is much lower, result is similar to full car
- There are still tire squirt entering SW outer part
- Big vortex under SW is the key to make BIG Downforce

Body
- First iteration of a revolved body is done
- Got a working rough surface model done
- Working on surface model of nosecone, top panel, and side panel

FW
New iteration got rid of tall boy
Added elements
Upper elements are mitered at an angle

To do

RW
- Will add lofted middle section to mainplane that allows higher camber and AoI to airflow behind driver's head
- Outer edges of RW seem to be fine and geometry will not change much
- After one sim with lofted wing, will add gurney flap

UT

Body
- Edit surface model by adding front geometry and supporting curve lines

# Aug. 22, 2025

Wednesday, August 20, 2025 11:49 AM

## Simulation Review

FW
- Huge outside pressure bleed from endplate without a vortex generator
- The tall boi wasn't great at generating a meaningful vortex
- The inner elements did create somewhat of a meaningul vortex but wasn't positioned correctly.
- There was no vortex that aided RW, UT, or flow in general.
- The mainplane had low pressure on back half of chord, maybe split the mainplane
- The step down on the mainplane made a pretty good vortex
- Need to find a way to protect the UT from tire wash using FW

UT
-

RW
- A3002 didn't run, sim crash
- Noticed AoI in center section is bad on KS7, camber of AoA change could improve flow
- Looking at a moved rearward mainplane could be beneficial, realistically we need to keep the total length in x the same

Body
- Pre-lim research done
- Beginning CAD

Whisker

Misc
- New tags in the simulation template to make it easier
- Identified why the other sims were failing (Region issues and tooooo many cells)
- Cooper didn't crash!!!!!

## Items to Incorporate or Change

FW
- [ ] Vortex generator or some sealant on the endplate bottom
- [ ] Split the mainplane on the outer portions, follow the angle guy with the stacked elements
- [ ] Make a CoP calculator in excel template
- [ ] Next run, incorporate "tunnel" for tunnel

UT
- [ ] Re-simulate with new template

RW
- [ ] Just loft center section and change camber to optimize AoI
- [ ] Have separate iteration to look at KS7 RW moved rearwards
- [ ] Slat geometry on A3002

Body
- [ ] Surface modelling tangible part

Whisker

Misc
- [ ] Tomorrow I want to do new geometry

# Aug. 21, 2025

Wednesday, August 20, 2025 11:49 AM

## Simulation Review

FW
- Sim fail

UT
- Sim fail

RW
- Sim fail

Body
- Pre-lim research done
- Beginning CAD

Whisker

Misc
- New tags in the simulation template to make it easier
- Identified why the other sims were failing (Region issues and tooooo many cells)
- Cooper didn’t crash!!!!!

## Items to Incorporate or Change

FW
- [ ] Re-simulate from previous night

UT
- [ ] Re-simulate with new template

RW
- [ ] Re-simulate with new template

Body
- [ ] Surface modelling tangible part

Whisker

Misc
- [ ] Tomorrow I want to do new geometry

# Aug. 20, 2025

Wednesday, August 20, 2025 11:49 AM

## Simulation Review

FW

UT

RW

Body

Whisker

Misc

## Items to Incorporate or Change

FW

- [ ] Remove bottom VGs
- [x] More elements with inner EP gone, VG to shoot into UT
- [x] Shorten center chord to avoid collision
- [x] Change airfoil type for outer regions
- [x] VG to suck in tire and shock wake

UT

- [ ] Diffuser concept study with current chassis
- [ ] Shorten initial lateral transition*

RW

- [ ] 2 inch margin of all aero box locations
- [ ] ~3-4 inches rearward LE compared to KS8

Body

- [ ] List out rules for body
- [ ] Criteria
  - [ ] Low Drag
  - [ ] Easy layup
  - [ ] Give space to FW/UT
  - [ ] Use FSG cars for reference
  - [ ] Pre-lim research into typical characteristics that ppl design for

Whisker

Misc

# Weekly Alignments

Wednesday, July 16, 2025 6:30 PM

# 09/23/2025

Monday, September 22, 2025 8:25 PM

Agenda:

PP Review
- [ ] FW Skin Deflection

PP Review Notes

FW Skin Deflection

# 09/09/2025

Tuesday, September 2, 2025 9:09 PM

Goals this week:

- [ ] Aero concept broken down to points gain from previous pack
  - [ ] Per component points gain from no aero and from KS8 aero
- [ ] Numerical/points improvement from building new aero pack (Why is it needing to be re-built?)
- [ ] Decide if Side Wings are worth the acc/radiator trade off
- [ ] Decide if design freeze for airfoils now outweighs more development later.

# 09/02/2025

Tuesday, September 2, 2025 9:09 PM

Written by Cooper

Composites integration
Proposed: endplate mounting for FW
- Want to do testing to see how to bond mount to mainplane of FW - David
- Mounting solution to the chassis seems possible though - David
- If we can find a solution that connects MP to FW then the design should be continued seems to be the idea - consensus
- Can the rib just be extened to become the mount - Alex
  - Some versions of this idea are being drawn, discussing If composites can make this
- Current "fang" plus spar is the baseline, we need at least that - david
- Can we do foam core wing -Cam
  - Discussing if we have the materials, and if the weight is worth it.
- Brought up nathans sinosoidal wave structure
  - People think it could be good
  - Want to test deflection of it, don't trust it with no data - david
  - Could be good with no lofted wing design
  - Sam thinks it could be better than current spar due to some deflection nerd shit, something about the vertical elements
- Sam thinks we should pass on this idea because we need FW mount locked in soon for SES deadline.
  - We are going to agree with sam here, nathans design for FW structure will not be used because we do not have time to test the idea due to limits with current materials in composites. If in the future we get to test the idea and have the time/materials to test, then we could do it because in theory it could be a better mounting structure.
  - We will most likely continue with a normal spar/rib structure because we have experience with it and can get the project done by SES deadline
- Counter argument by seth, we just need to figure out the mounting, not the internal structure. So if we lock in the mount and connections then we can still change the internal structures.
  - We need to figure out how its mounting to the chassis then to the FW, that is what we need for SES. So we will just work on mounting and not worry about internal structure

**Outcome: we have not ruled out Nathan's internal wing structure, we just need to find how the FW mount will connect to the chassis by the SES deadline. We will most likely do the inner endplate mount.**

**It is Feasible to do silly strakes on FW**

Feasability of whiskers/ control arm covers:
Yeah seems easy, could just use fiberglass or something -alex
Looked at whisker mounting from another team and it looks pretty easy
- Idea is that it could poke through body and mount to chassis tabs (we can look into this later)

Will whisker be a part of SES? -david
- We are finding out

Whicker can be same airfoil as FW to make manufacturing super easy, don't need more molds

We could use some easy clip to put on control arm covers, seems like not a bad project in terms of manufacturing

Do we need to sim at different angles of suspension -alex
- It will prob be neglible and not worth our time - seth
- Is it really worth its weight-sam
- We have not done a weight study but it will be worth it, it helps with DF. Also we are just seeing if it is possible to make and add to car -seth
- We should make it replaceable because they can break easy-alex

We should test to see if this is even worth pursuing -sam
We can test with KS8 to get test date, use 3D printed parts -Seth
**Outcome: part is feasible but we should test to see if it is even worth it first**

FW endplates
Are endplate sizes a problem, these ones are smaller than normal -Seth
Its fine- david

Undertray
We should add mounting points to specific locations along the side of the car for multiple locating points -Sam
Inner UT endplate could be flat to help manufacturing a lot-Seth
JK, make it two flat panels that combine at a corner-Seth
Outside kinda has to be curved so that wont change-seth
Issue is attaching all the pieces together -alex
The actual elements are not bad indivually -david

Try to reusese as many airfoils as we can for manufacturing-everyone tbh
We can try to consolodate all elements to see what we can reuse-sam
See what neccesitates a new mold and try to bring down # of total new molds

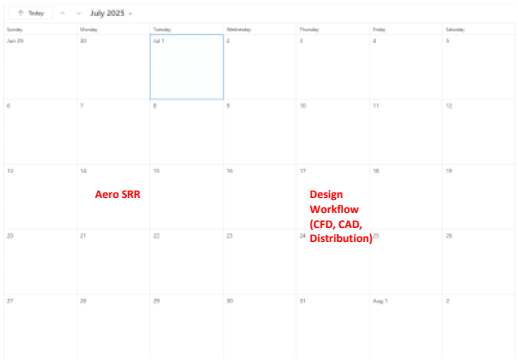
Top and bottom of sidepods can be flat so we only have to use 1 mold for each side -seth

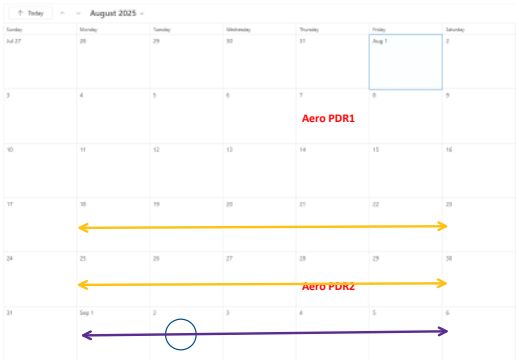
If the limiting factor is manufactoring, can we streamline getting the composites materials so we can streamline manfucatruing the molds so that manfucaturing is not as much of a limiting factor -seth
Depends on money given from school and if rules change -sam

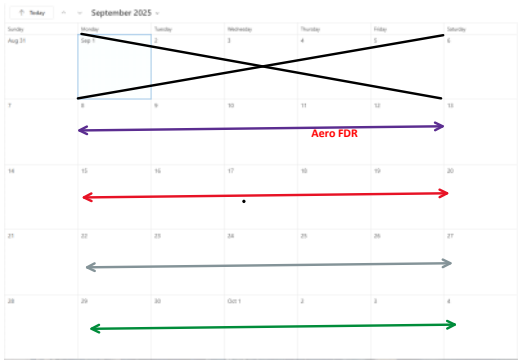
We will get list of airfoils for David ASAP

09/02/2025

Wednesday, July 16, 2025 6:30 PM




Disclaimer: Not final designs

Questions/Things to Cover

- Composites:
  - FW
    - Curved EP
    - Strakes on bottom
    - IB Whiskers and CA Covers
    - OB Whisker
    - "Small" IB Eps
    - "EP" Mounting
  - UT
    - Side tunnel airfoil construction
    - Connected to middle section? Channel?
    - No diffuser, No center inlet
  - RW
    - Lofted, possibly curved, center geometry
    - Possibly using louvers
    - Sandwich panel swan neck that connects to bottom
  - Misc
    - ??
- EV Powertrain
  - Where can radiator be placed?

Meeting Deliverables:

- EV Powertrain
  - [x] Placement of Radiator
- Composites:
  - [ ] Aligned on geometry/ideas
- Aero
  - [ ] Where is Aero with Design?
- PM
  - [ ] Access to PDM for Cooper & Quang

Meeting Notes:

Radiator

- What flow rate for the radiator?
- Requirement List

Timeline

Independent Study

- Daily sim updates through OneNote documentation
- Independent components refined enough to move to combined studies
- Evaluate progress at end of 1st week

Merged Study

- Daily CAD updates and simulations
  - Morning: Review and distribute geometry tweaks
  - Mid-day: CAD and Mesh
  - EoD: Run overnight
- 2nd week: Run height, pitch, and velocity sweeps

Detailed Final Tweaks

- Evaluate deliverables closer to zone

Document, Report, & Present

Re-evaluate position, continue structure integrations

Final conceptual studies --> Mounting/Radiator/Misc Integration Re-design --> Sweep Sims/Yaw Sims --> Team Integration Review

Michelin Testing

Sat

- Energy consumption and telemetry over endurance
- Aero integrity before and after (Structure)
- (Optional) Yarn Tufts

Sun

- Straight Line on/off Drag & Downforce Data Collection
  - Loads through pots
  - Pressures at 3 areas on mainplanes
  - Torque telemetry (Drag)
- Skid-pad/GG On/Off Data collection
  - Lap times
  - Shock Pots for load distribution

Checklist

- [ ] Tape
- [ ] Yarn
- [ ] Cameras?
- [ ] Manometer
- [ ] Tube (Lost of it)
- [ ] Tools for aero removal (Composites Box)

Post-meeting Tasks

RW

- RTD Light in template correctly
- Optimize Slot Gaps, Chord Lengths, and AoA (3 Element)
  - Measure downforce and drag on each element, also get point pressures

FW

- Strakes for EP VG
- Strakes for CA outwash to UT
- Trading overall AoA for RW/UT flow (Trading FW downforce for RW downforce)

UT

- Less AoA and slit mainplane
- Radiator Integration

^^^^^

Finish these sims then start DFMA and Mounting (Somewhere do DRS)

^^^^

After review and acceptance of team for mounting and DFMA, complete Sweep sims, fine tuning, yaw sims, and final team integration review

Adjacent Tasks

- PDM access for mounting iteration

Simming Tasks

Seth

- New template with tags set up, better controls, and RTD integrated (Tonight)

Cooper

- RW iteration, slot gap, AoA, Chord lengths

Quang

Radiator Tasks

James

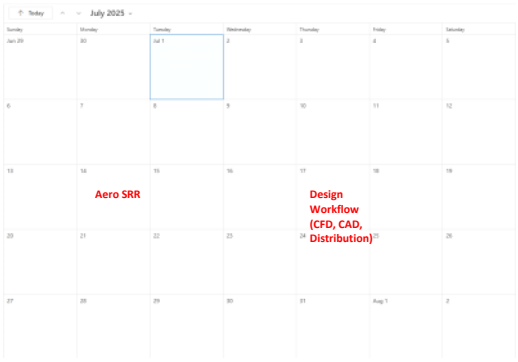
- [ ] List of radiators with CFM specs that are good candidates

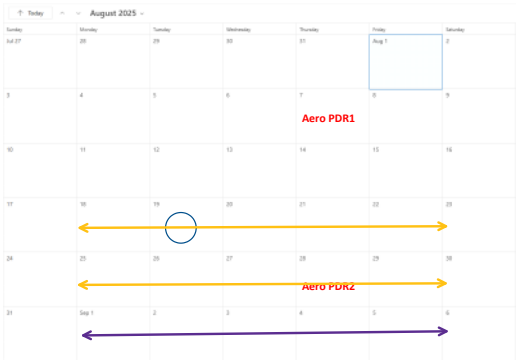
Aero

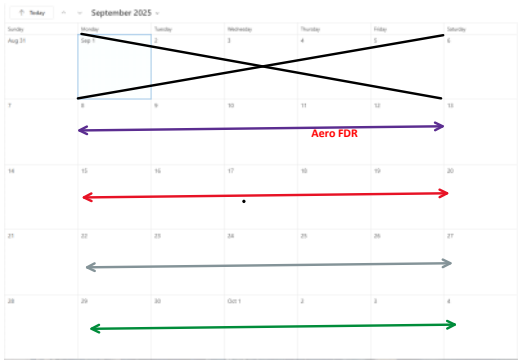
- [ ] Find candidate areas that fit CFM requirements or are near it for fan power
- [ ] After more fine tuning, UT with and without center section downforce difference
- [ ] Curved vs. flat endplate study (Curved is hard to manufacture)

08/19/2025

Wednesday, July 16, 2025 6:30 PM




Agenda:
- [ ] Simulation Tutorial
- [ ] Daily Stand Up availability
- [ ] Review Work Expectations
- [ ]

Meeting Deliverables:
- [ ] Know how to use SIM
- [ ] Daily Stand-Up Scheduled
- [ ] Work Time Agreed To

Current Objective: Independent 3D Half-Car study

Deliverables:
- Daily simulated progress (Daily documentation, starting Tue. Aug 19)

Timeline

Independent Study
- Daily sim updates through OneNote documentation
- Independent components refined enough to move to combined studies
- Evaluate progress at end of 1st week

Merged Study
- Daily CAD updates and simulations
  - Morning: Review and distribute geometry tweaks
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Detailed Final Tweaks
- Evaluate deliverables closer to zone

Document, Report, & Present

Re-evaluate position, continue structure integrations

Idea Dump

Seth
- RW will eventually need to do DRS study, perhaps 1-2 weeks out from Sep. 18

Post-meeting Tasks (Due Tuesday Aug. 19):

Seth
- [ ] Use tags
- [ ] Introduce UT
- [ ] Figure out PDM workflow
- [ ] Change Body

Post-meeting (Tue.) Tasks (Due Thur Aug. 21)

Goal
- Independent CAD models and sims of each component with half-car template.
- Determine which components need more time to be independent and which can be used for the next round of independent sims. (1 more week to complete)

Seth
- [ ] Specific deliverables for each design iteration
- [ ] Independent FW design (VGs included)

Quang
- [ ] Independent UT iteration

Cooper & Noah
- [ ] Independent RW iteration

Arron
- [ ] Independent Body Study

Alex
- [ ] Independent whisker study

Solid Works
Star CCM
- Importing
- Surface Wrap
- Subtract & Offset
- Volume Mesh
- Run
- Post Process

Michelin Testing

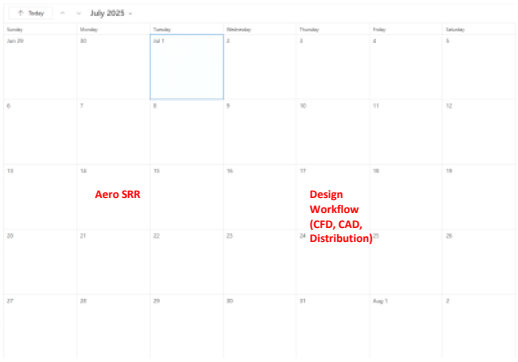
Sat
- Energy consumption and telemetry over endurance
- Aero integrity before and after (Structure)
- (Optional) Yarn Tufts

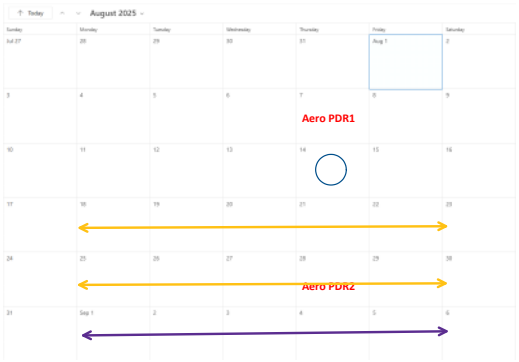
Sun
- Straight Line on/off Drag & Downforce Data Collection
  - Loads through pots
  - Pressures at 3 areas on mainplanes
  - Torque telemetry (Drag)
- Skid-pad/GG On/Off Data collection
  - Lap times
  - Shock Pots for load distribution

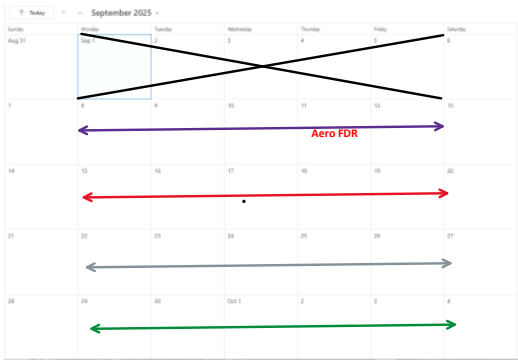
Checklist
- [ ] Tape
- [ ] Yarn
- [ ] Cameras?
- [ ] Manometer
- [ ] Tube (Lost of it)
- [ ] Tools for aero removal (Composites Box)

# 08/14/2025

Wednesday, July 16, 2025 6:30 PM




Agenda:
- [x] Simulation Update
- [x] Timeline Update
- [x] Work Expectations during each phase
- [x] Michelin Testing Deliverables & Prep
- [x] Post Meeting Tasks
- [ ] Ask questions/make suggestions

Meeting Deliverables:
- [ ] Timeline is good
- [ ] Everyone has work to do
- [ ]

Current Objective: Independent 3D Half-Car study

Deliverables:
- Daily simulated progress (Daily documentation, starting Tue. Aug 19)

Timeline

Independent Study
- Daily sim updates through OneNote documentation
- Independent components refined enough to move to combined studies
- Evaluate progress at end of 1st week

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Detailed Final Tweaks
- Evaluate deliverables closer to zone

Document, Report, & Present

Re-evaluate position, continue structure integrations

Idea Dump

Seth
- RW will eventually need to do DRS study, perhaps 1-2 weeks out from Sep. 18

Post-meeting Tasks (Due Tuesday Aug. 19):

Seth
- [ ] Complete star sim template
- [ ] Teach how to use simulation (Adding new parts from SW assembly, setting localized mesh regions)
- [ ] Template for sim outputs
- [ ] Misc PM/Lead documentation (SRR, Current Progress, material projections, etc.)
- [ ] Availability tracker link

Quang
- [ ] Document UT findings so far
- [ ] UT Iteration

Cooper & Noah
- [ ] Document RW findings so far
- [ ] RW Iteration

Arron
- [ ] Parts based mesh tutorial (In star documentation: Home > Tutorials > Mesh > Parts-Based Meshing External Aerodynamics)
- [ ] Optional: Request KS8E CAD from Seth and try to set up your own simulation
- [ ] Pre-lim analysis on Body Design (Document in OneNote)

Alex
- [ ] Parts based mesh tutorial (In star documentation: Home > Tutorials > Mesh > Parts-Based Meshing External Aerodynamics)
- [ ] Optional: Request KS8E CAD from Seth and try to set up your own simulation
- [ ] Pre-lim analysis on Whisker Design (Document in OneNote)

66.69
Up 1.25

Post-meeting (Tue.) Tasks (Due Thur Aug. 21)

Goal
- Independent CAD models and sims of each component with half-car template.
- [ ] Determine which components need more time to be independent and which can be used for the next round of independent sims. (1 more week to complete)

Seth
- [ ] Specific deliverables for each design iteration
- [ ] Independent FW design (VGs included)

Quang
- [ ] Independent UT iteration

Cooper & Noah
- [ ] Independent RW iteration

Arron
- [ ] Independent Body Study

Alex
- [ ] Independent whisker study

Michelin Testing

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  - Shock Pots for load distribution

Checklist
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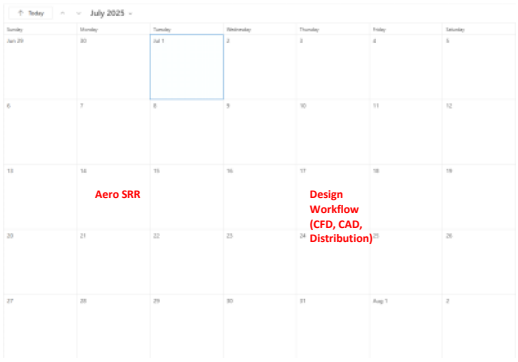
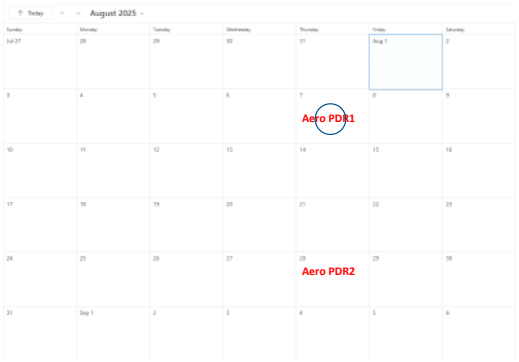
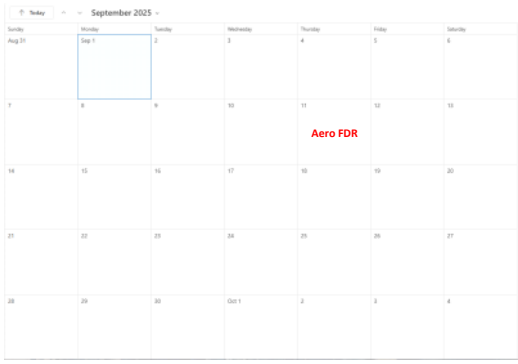
- [ ] Cameras?
- [ ] Manometer
- [ ] Tube (Lost of it)
- [ ] Tools for aero removal (Composites Box)

08/07/2025

Wednesday, July 16, 2025 6:30 PM




Agenda:
- [x] Target Review
  - [x] CDA and CLA
  - [x] Component Level Targets
- [ ] Review & Progress Conceptual Design
- [ ] Review weekly ideas
- [x] Project Objective Update

Meeting Deliverables:
- [x] Refresh overall objective
- [x] Aero Targets Set

Overall Objective: 2D & 3D Conceptual Design to position aero for easiest integration of car goals.

--> FW/RW: Develop 2-3 Individual 3D concepts that meet component downforce goal: At least one done by Aug. 14th.

--> UT: Make as much downforce as possible, consider 2-3 concepts (Center, Full body, diffuser): Update on Aug. 14th with new downforce number

Pre-meeting Tasks:

Seth
- [ ] Component Drag Targets (Force & Speed)
- [ ] Component constraints (Height, chassis clearance)
- [ ] Present goal setting analysis

Post-meeting Tasks:

Seth
- [ ] Aero targets in place
- [ ] Specific requirements for each component set
  - [ ] Downforce
  - [ ] Ground Clearance
- [ ] Sim requirements for later design (Sweeps)

Quang

Cooper

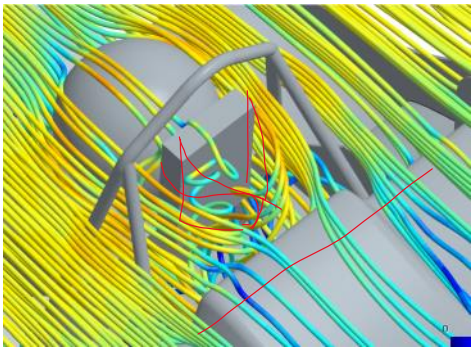
Idea Dump

Seth
- Custom tool (Excel or MATLAB) to calculate load to tire based on downforce and drag moments instead of relying on just Star pressure/shear measurements

Cooper

Quang

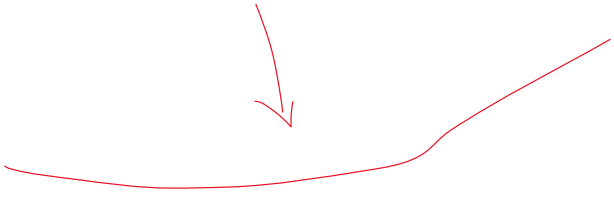
Arron
- Slope as aggressively as possible then kamnback (blunt it off) when no more room, unless you can make it to the TE.

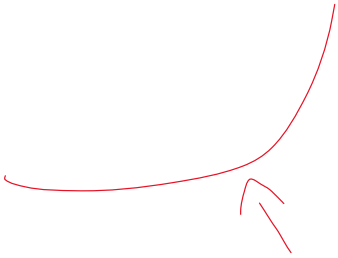


Quick thought dump:

Rear Wing Development
- This will be the gating component for FW and UT, so make as much downforce as possible within the component level drag budget
- Start with making a bunch of downforce, then tune out the drag as much as you can and see where that lands. Make 2-3 concepts that achieve this.
  - Once we put full car together, we will be able to tune out more drag with flow control devices up-stream.
- Check your "RW" OneNote tab for details on constraints
- Review relevant Aero rules including RTD light visibility.

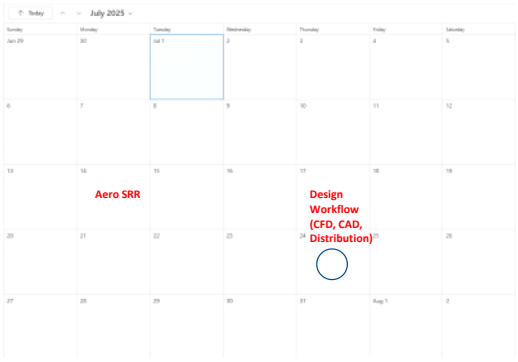
Front Wing Development
- Begin with developing 2-3 concepts with different downforce potentials

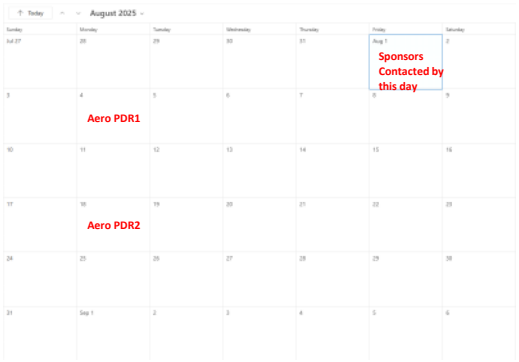


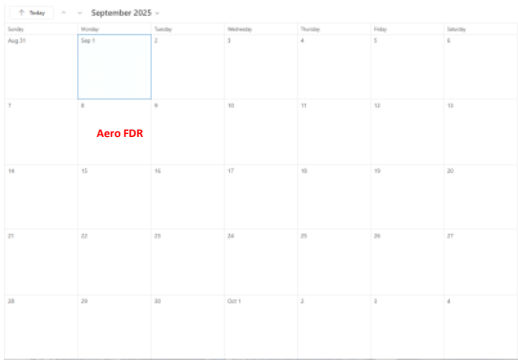


07/24/2025

Wednesday, July 16, 2025 6:30 PM



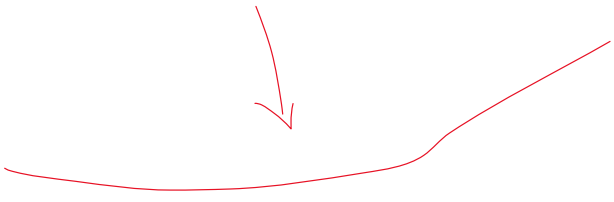



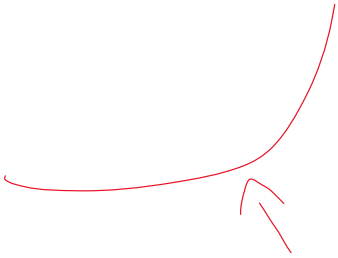




To-Do

Tuesday - FW/RW/UT Airfoil & Configuration Analysis Review
- Re-consider moving to 3D Conceptual Design

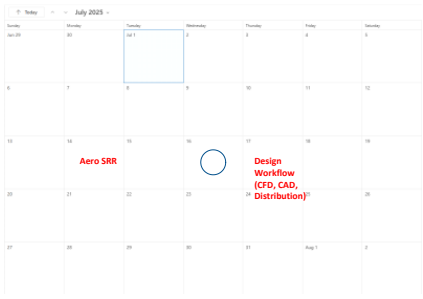
Overall Objective: 2D & 3D Conceptual Design to position aero for easiest integration of car goals.

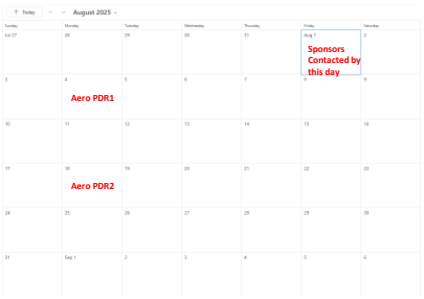


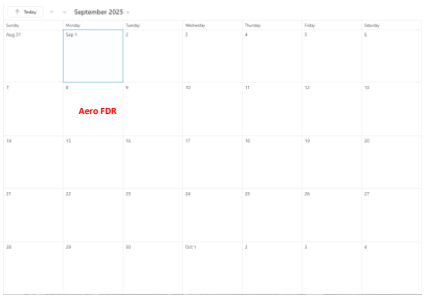


# 07/16/2025 - First Star Concept

Wednesday, July 16, 2025 6:30 PM

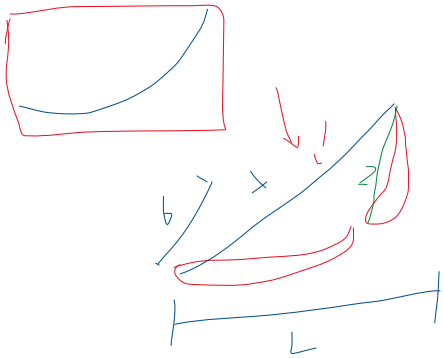


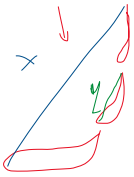

Agenda

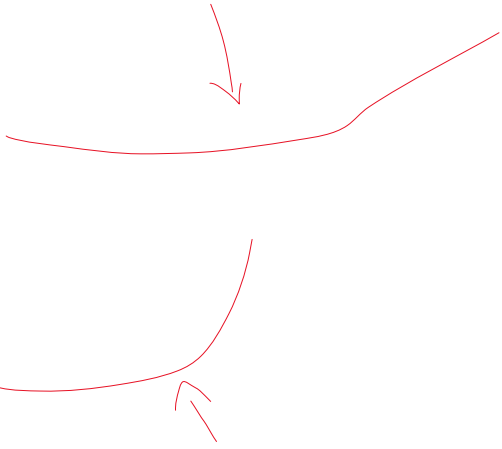
1. Review Concepts, Identify Iteration Improvements
2. Brainstorm & select standard star views for excel template
3. Brainstorm & select next week goals



2. Standard View Brainstorm

1. Set Slot Gap, Overlap, & AoA
   a. For each # of Element





3. Next Week Targets (Friday Next Week)
   a. General
      i. CFD Tutorial
   b. RW
      i. 2-D Design Study
         1) Overall Camber Constant (High Downforce)
            a) Find 2-3 airfoils per configuration (# of Elements)
               i) Find the best AoA, Slot Gap, and Slot Overlap by eyeball.
               ii) Keep a logbook of each iteration
               iii) Velocity Plot, CD, CL, Slot Gap, Slot Overlap for each, then highlight best.
            b) Stick to benzing and MSHD
      c. UT
         i. 3-D Tunnel Study
            1) Inlet/outlet angles
            2) Adjusting throat width
      d. FW
         i. Low camber profile study with ground effect
            1) Compare the with and without body
         ii. Vortex generation studies

RW Study Deliverables

- What is possible with each configuration to hit camber goal
- Some comparison between Benzing and MSHD airfoils target higer CL lower CD) (stall rates)
- Understanding of rough slot gap and overlaps

FW Deliverable

- What is the relationship between camber and ground effect
- How to develop and control voriticies

To-Do

- Set Lengths and spans (Aero boz) - Seth

# One-off Meetings

Wednesday, July 30, 2025 5:59 PM

# FW/RW 2D Analysis

Wednesday, July 30, 2025 5:59 PM

## Agenda

- [x] RW Analysis Findings
- [x] FW Analysis Findings
- [x] UT Findings
- [ ] Refresh Working Objective to PDR1
  - [ ] Include summarization of Analysis, which also includes anything else the analysis needs to be "complete"

## Meeting Notes

### Quang's Takeaways

- Multi element has most downforce
- Bottom is the only thing that matters
- Just tunnel has stagnant region on top, which reduces suction

### Cooper's Takeaways

- MSHD as mainplane is most effective
- High camber E2-E4 is difficult to maintain flow attachment
- There are some combinations of that resulted in higher CL with marginal CD increase than current wing
- 3 Element MSHD is a great starting point for 3D design

### Seth's Takeaways

- Middle section should be flat and no flow separation (Unless no issues with stagnant air behind wing)
- Outer sections should be high camber for max downforce
- 1.5 inches is roughly where CL begins to decrease with decreasing ground clearance

## Planned Deliverables

### Quang

- [ ] 2D CFD of each concept w/ CD, CL, and flow scenes
- [ ] Research and analysis of Inlet/Outlet and vertical/horizontal expansion

### Cooper

- [ ] 2 Element Wing studies
  Data Collection
  - [ ] Overall AoA
  - [ ] Show relationship between CL and CD change (% change from current)

Seth

- [ ] Increase height sweep to clearance of 4in
- [ ] Vortex Generator simulation setup
- [ ] Look into tunnel downforce theory and research
- [x] Get Arron access to Star CCM, set goals on tunnel geometry

Arron

- [ ] Analysis of tunnel parameters given max inlet and max outlet geometry