2023-24 VD Living doc

Wednesday, July 12, 2023 11:26 PM

Small living doc to make documentation for future teams easier for VD. Will consist of all the projects done, justification. A "internal design document". Important so we can easily go back and verify work done for certain aspects of the car and facilitate future team growth. Boogity boogity boogity

Team Goal:
IC- top 10
EV- top 5

VD goals (for design): *to be clear these are our goals, but we don't share some of the internal goals listed to design judges*

- Reduce time in autocross (insert some x amount of time lost for points gain)
    - We do this through more testing, we think testing time will give valuable driver experience and stress the car
    - We also believe that data acquisition will give us an invaluable understanding on the vehicle characterstics during these dynamic events which will help us test characteristics more relevant to the car
- Reduce steering torque:
    - Calculated estimate for current steering torque, measured steering torque
    - X amount decrease bc bad for driver times
- *Design and Manufacture an upright*

Shit I think would be cool

- Front and rear anti roll bar
    - Validation with dacq now on car would be fuckin gang buster
    - Id be willing to let someone fuck this up
- Rear packaging changes to ecar
    - Put a fuckin drexler on it
        - In seriousness, we can try and estimate how much we are losing wihtout a drexler
    - YEET THE YOKE PLATE
        - Big slab of metal
        - Maybe packaging for drexler can become rear impact structure???? Lore
- Downsize on tire sidewalll would be nice
    - Temperature profile investigation
    - Optimal temperature investigation (ttc)
    - Changes in forces now that tire isn't as forgiving
        - Tire camber will become a lot more sensitive to wheel camber (chassis camber)
- Control arm investigation
    - How are the slopes of our camber gain in bump and roll determined???/

Sim shit

- Dynamic roll center investigation, effects on camber gain
    - Is this optimized for our tire?
    - Source of jacking issues on ic car?
        - This might be a caster thing, will have to consider more
- Downforce distribution model
    - Downforce on each tire, easily connect to normal load experienced on tire would be fuckin sick
    - Can deifne downforce demands at different cases, can actually give parameters for aero to grow

VD Learn Outline

Monday, August 7, 2023 8:48 PM

Noobie Classes:

Class 1: VD Basic, Competition Overview, Tires and Grip, Handling
- This class is foundational
- Intent is to start with tires and directly tie to how it will better car performance
- To talk about, comp events, tires, lateral force, tire data, oversteer understeer
- Tire topics
  - Slip angle
  - Camber
  - Tire Load Sensitivity
  - Tire data outline and basic interpretation
- Handling topics
  - Tire lateral force relationship
  - Oversteer understeer
  - Vehicle cornering dynamics

Class 2: Suspension Geometry and Wheel Loads
- Will briefly touch up on suspension kinematic basics (a arms, roll center, roll pitch yaw motions)
- Very important part of VD is understanding load paths and how forces interact with system
- Suspension geometry topics
  - Outboard Geometry
    - Caster
    - Kingpin Inclination
  - Camber
    - Camber Gain in Roll and Bump
    - Camber Gain in Steering
  - Basic Motion Outlines
    - Roll, Pitch, Bump
    - Typical Load Cases
  - Free Body Diagram showing suspension components in different motions
    - Put everything in context of forces acting on the suspension during different maneuvers

Class 3: Brakes and Steering, Questions?
- Steering
  - Ackermann, Anti Ackermann, Parallel Geometry
- Brakes
  - Main system construction and outline
  - Pedal to Line to Rotor to Disc etc.
- Questions

Review:
- I should try a lot harder in trying to rope newbies into just seeing the shit I do and explaining as I go
- Classes started from level 2 and shoudlve started at a level 0
  - Start with the goal of our competition, rope in how tire is the biggest limiter to the goal of competition and how we can maximize the tire
- No classes on fridays bc attendance will be low
- Should shoot for all classes being on the same day
- Classes are good but generally should dial in one 2 newbies or 3 and focus all newbie energy on them
- Create newbie tasks over the summer or something, it'll be difficult

Debrief notes:
- Start earlier L O L
- Pitt can be a good event to just grab newbies and have them shadow
- Really should lean into shadowing more if it works for a sub group
- We could think about doing classes again before comp
  - HV did one ahead of EV comp which was nice (couldn't attend) but we should try and do a sub group run down of design
- Fatty rip on not outlining labor day on calendar lol
- All need to be on the same page of how rules test are done and what is a "passing" rules test

2023/24 Design Stage

Monday, June 26, 2023 8:26 PM

VD Provisional List:

- Upright
- Alignment
- Lap sim
- Kinematic re evaluation
- Anti Roll Bar
    - Put on before august?
        - Aj that one (lol)
- Dampening tuning and characterization
    - Roll stiffness
    - Dampening compensation and setup potential?
    - Dampening Ratio Characterization and influence into lotus model
- Direct mount shocks
    - No arb
- Steering
    - Spherical bearing on toe and tie rods
        - Better rod end
        - Smaller sphericals
    - Steering effort investigation
    - Calculation for slope in steering bearing
- New wheel inserts
    - Fea thing, rope in
- Tire investigartion
    - Smaller sidewall lc0
        - Temperature?

Design notes:

- Broad goal: define kinematic targets for camber, normal load, from tire
- Trickle down to project goals

4 Wheel Model eval

Caster
- range
- ensure optimal camber across sweep through turn
- correct slip angle

4 wheel model
- optimal camber
- optimal slip angle

all ttc shit

- dictated by llt
    - normal force change
- at this load need this slip angle
- changes load, chanes slip angle
- targets; slip angle and camber

autocross
- 3 radius turns

optimal camber- 0 degree

Steering things

Wednesday, July 12, 2023 11:28 PM

Stearing:

Forces

Tie rod in bending or column

Loading on upright

Is it in load path of another load

Cockpit template
Gets tighter furthes as you go in

U joint angles

Compliance:

- Identifying compliant parts of our system, wear vs fatigue
- How can we design

Identifying steering effort

- What contributes? Alignment of rack to joint, angle of u joint, steering pickup location on upright (far from center)(from center pivot)(and movement in left to right direction), steering wheel diameter, rack ratio, not fuck up bump steer, rack travel, steering wheel travel(how much rack you use, rack ratio)
- Put items into excel and look into component sensitivity to identifying steering effort
- Steering pickup location dependent mostly on compliance
- Idea of tie rod location, Higher loaded tie rod will be in tension (put it where we put it for passing template)
- Compliance was also introduced by having multiple points on your toe pickup location
- Bray Problems: rakc location, perpendicular steering pickup location
- John notes: pass percy, the more perpendicular the more ackermann you lose,
- To find Ackermann, change upright point angles relative to center line, move rack location relative to the points as well
- Create map of steering effort to Fy, based off Mz
- Could tilt rack, would not find much (put in sw)
- Weld torque wrench onto steering for measurement
- Statically, change of normal load during steering

Actionable items:

- Calculate and measure steering effort for steering effort for target value
- Calculate sensitivity in system for each component and its steering effort

Wheel insert project

Thursday, July 27, 2023 8:11 PM

Wheel Insert

Loads

- cornering
  - 600lbs see upright matlab and VD spreadsheet
- static
  - 600lbs/4 150static
  - Forward weight transfer 400lbs
- bump
  - https://www.real-world-physics-problems.com/impulse-and-momentum.html
- twisting
  - no as significant as cornering, will be left out
- Fatigue

Centering feature

From <https://kennesawedu.sharepoint.com/sites/Team-KS6-C/Shared%20Documents/Vehicle%20Dynamics/Big%20list.docx>

Where to Start

- Ansys has wheel insert FEA
- FEA Log https://kennesawedu.sharepoint.com/:w:/r/sites/Team-KS6-C/_layouts/15/Doc.aspx?sourcedoc=%7B11A151BE-C45E-4A4F-835A-595A8C1FDD06%7D&file=FEA%20log%20Wheel%20Insert.docx&action=default&mobileredirect=true&cid=1765999b-c0d3-4be5-aa1b-4d32fc48969f
- https://www.ijraset.com/research-paper/dynamic-design-and-analysis-of-car-wheel-rim (DYNAMIC FEA)

Deliverables

- Look Nicer
- Process documentation
  - What are the constraints?
  - FEA Comparison
  - Verification (On-Car Testing)
- Maybe Aerodynamic advantage
  - Run investigation
- Maybe lightweighting
- FOS Increase? Min FOS of 2

Questions

1. Do I need specific numbers for % increase/decrease in weight, accel, efficiency, etc.

Planning

Phase 1 Milestones

1. Proposal 1 Complete
2. Gantt Chart 1st Draft Complete

To Do

Proposal/Planning

- [ ] Pre-liminary wheel designs
  - [ ] Weight projections
  - [ ] FOS/Strength Projections

Engineering

- [ ] Engineering
  - [ ] CAD
    - [ ] Design Review
    - [ ] Revisions
  - [ ] FEA Research
  - [ ] FEA Run
  - [ ] Design Comparison
    - [ ] Run FEA on new and Old
  - [ ] Drawing
  - [ ] Final Design Review

Manufacturing

- [ ]

Questions

- What is the current wheel weight?
- What is the current FOS?
  - How do you calculate FOS
  - What are the FEAs that we need?
- What wheel designs will be lighter
  - What material should we use?
    - Cost matters most, so long as it hits weight
- What is the load casing that we want to have the 1.5 FOS?

Current Wheel

Weight - .620 pounds in CAD

FOS - 1.623

Calculate through FEA

- Need to design more rigorous/thought out tests to accommodate wheel dynamics

Alignment

Thursday, June 29, 2023 5:27 PM

- Our shit is constantly misaligned
  - Shit comes from driving the car
  - Need to make a way to realign accurately even if we aren't on level ground
    - Put some feet on that shit or something
  - Shit that you need to add to it
    - Toe balance points
    - Camber balance points
    - Ride height measurement
      - Chassis or front wing kinda depends
    - Corner balance
      - We could do ramps for that shit and have the car roll onto it
  - Methods
    - Ramps roll onto the balance
    - Lasers
    - Wheel pieces
  - We could also look into "dummy shocks"
    - Straight up stick that goes in place for shocks but don't do anything
      - Measures some sort of displacement
      - Honestly should look into it for overall shock characterization

Emil to do:

Toe

- Find point on wheel assembly to measure from
- Check for clearance on body
- Insert 2 slots for tape measures

Corner Balance

- Feet to balance and level
- Pad to put on top

- Go back and calculate deflection under point load for plate thickness
- Square tube cheaper than round tube
- Square tube bolted together = slop between pads, go back to original idea of brackets with C-Channels (bolted connection) and have separate C channels for each car instead of trying to implement cancer adjustment that creates extra slop
- Investigate cost of having separate C-Channels for the two cars
- Figure out better way to measure toe, standoff idea sounded good in my head but in practice I would have to make the plate on the sidewalls of the pad holders incredibly thick to do this
- Grab Ecar cornerbalance weights to do point load calcs on plate to determine what thickness plate needs to be used

Deflection at center

$$y_m = k_1 \frac{Pa^2}{Et^3}$$

- Only need ecar cornerbalance w driver numbers to do hand-calcs and then I can move forward with the design (note to not make assembly cad cancer this time)
- Will assume 200lbs as worst load case (somewhat overkill considering an unbalanced car corner + scale weight is <175 lbs
- 0.07373in of deflection at center with 1/8th in A1008 Carbon Steel
  - I will put this on hold until cooling is completed.

10/25/23

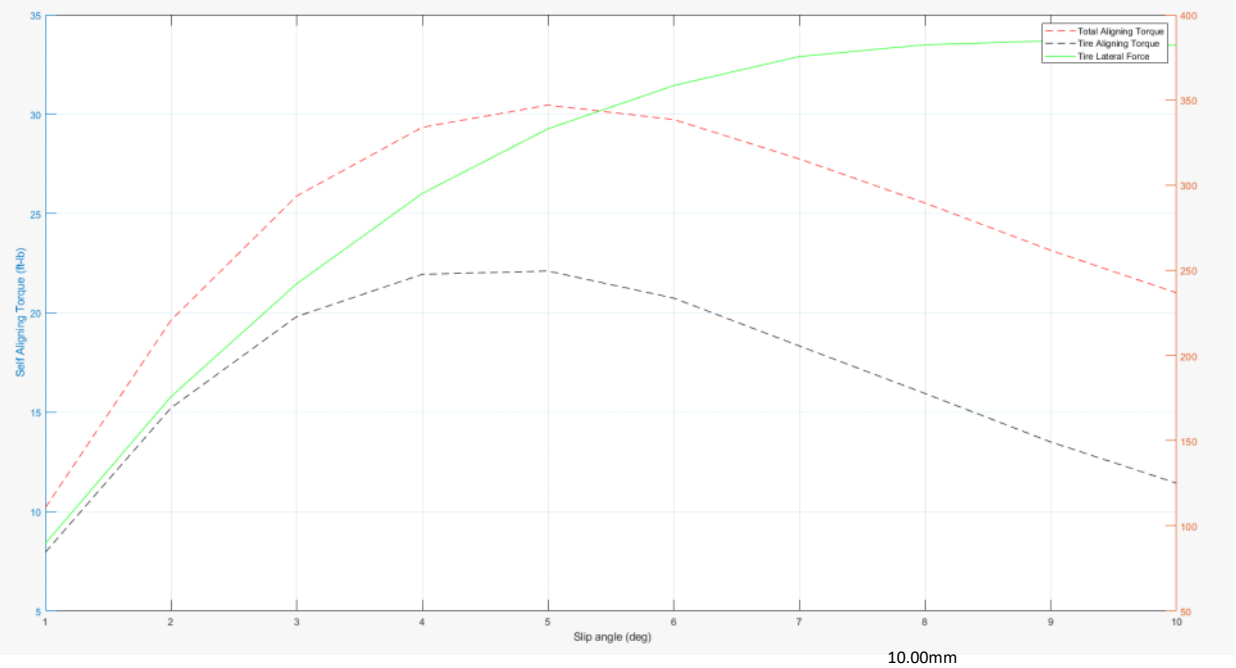
- Debating removing sheet from center of angle irons, will save separate cad of one without sheet and one with.

Upright Design Process

Monday, September 11, 2023 1:23 PM

Front Outboard Geometry Outline:
Caster- [2-4] degree
Mechanical Trail - 0.0456 in
KPI - 3 degree
Scrub Radius - .549 in

Rear Outboard Geometry Outline
Caster - 1 degree
Mechanical Trail - 0.1504 in
KPI - 1 degree
Scrub Radius - .0589 in



10.00mm

Upright check list
- [ ] Bearing bore size correct
- [ ] Bearing bore spacing accommodate hub and tension cap
- [ ] Bearing bore does not contact past race

- [ ] Top and bottom spherical pockts rigth height
- [ ] Clearnace for stearing sweep in to and pot
- [ ] Clearnce in jounce and rebound
- [ ] Bolt head and washer have clearnace
- [ ] Nut has clearance
- [ ] Wrench can acces

- [ ] Brake caliper fits along disk ais
- [ ] Bolt sizing corect for type of connect (front and rear are different)
- [ ] Fists radialy

- [ ] Check bolt hole sizes
- [ ] No sharp inside corners

Upright drawing notes

Thursday, November 30, 2023 7:57 PM

- Half tenth tolerance incremental change
- About tenth of thou loss between upright and hub during manufacturing

Kinematic validation

Sunday, September 17, 2023 3:35 AM

Shit for test:

- Measurable damper (3d printed)

Shit to measure:

- Motion ratio
- Toe sensitivity with shims
- Camber change in steer
- Normal load change in steer
- Ackermann %

Purpose:

- We can easily measure and validate calculated value into real world and see where we could be incorrect

Newbie Tasks

Friday, August 18, 2023 10:12 AM

- [x] Tire Log - Zane
  - Record the tires we currently have
- [ ] Fix leaky wheels
  - [ ] Identify leaky wheels
  - [ ] Put some sort of sealant

Notes

Monday, September 11, 2023 2:05 AM

Notes for shit later

Steering forces

Monday, September 11, 2023 2:05 AM

- All resistance to steer input is aligning moment.
- Tire Mz is the aligning moment from the tire based on it construction and is a function of slip angle at the contact patch
- Another is a tire pneumatic trail, when a tire is creating lateral force under slip angle, the force is unequally distributed along the contact patch. Lateral force increases rearwards until tire can no longer sustain the slip angle
- The sum of this lateral force creates a moment arm called the pneumatic trail. The resultant aligning moment is the multiple of the tire lateral force and pneumatic trail
- The aligning torque in the suspension kinematics (mechanical trail), Tire forces act on the moment arm adding the aligning moment like the pneumatic trail.
- When a steering lock is applied, any inclination in the steering axis will result in some vertical tire motion which will raise or lower that corner of the suspension. The vertical moetion creates an equal and opposite jacking force reaction to raise or lower the chassis creating extra steering effort for the driver

Design notes

Saturday, November 4, 2023 5:13 PM

- Track width validation
    - Frontal area
    - Lateral load transfer

Vd teaching notes

Wednesday, November 29, 2023 6:32 PM

- End goal for people who are learning
    - To do projects? To become lead?
- Starting point?
    - Going for quickest laptime > going for largest acceleration
    - Lateral force Fy
        - Important bc

Relevant starting point:

- Relevance to component specific for project
    - Real life example and visualization
- Less broadening and more centralized
- More interactive
    - Example: aero CFD, demonstrations
    - Example classes – FEA, Matlab
-

Differential vs. Spool

Wednesday, December 27, 2023 9:28 PM

Spool = engine/motor sends equal torque to both wheels of rear axle
Differential = depending on an amount of lock, torque across both wheels may vary depending on level of resistance on that wheel

notes:

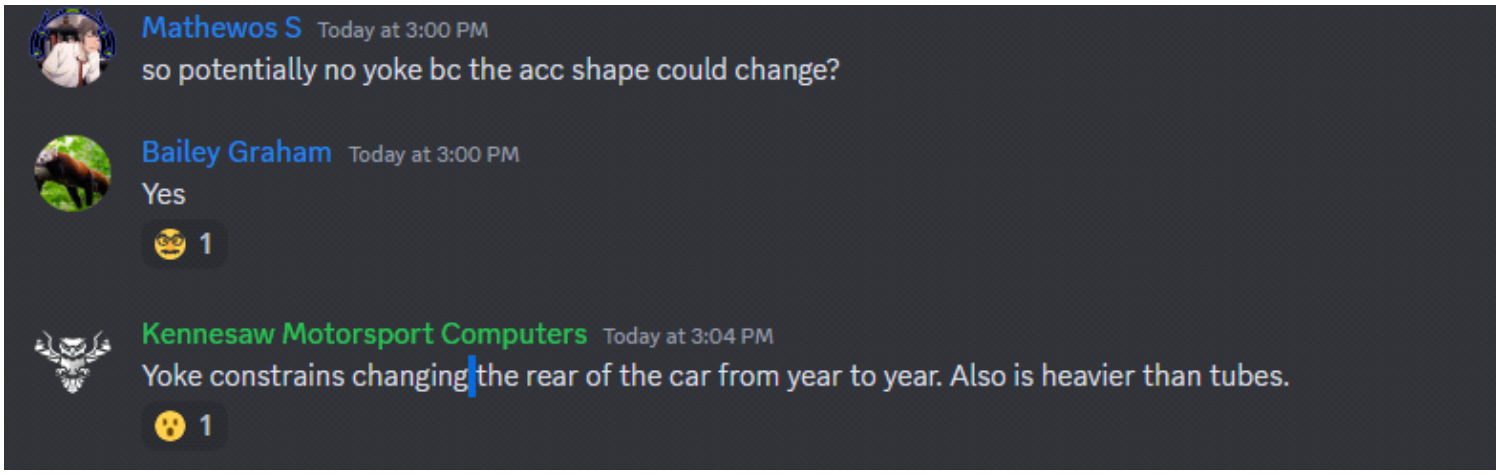
- spools can contribute a lot of yaw inertia in cornering just because the rates at which both wheels spin is different but because it is a fixed amount on both wheels, you automatically have to take the lowest torque which means less power in corners or your break traction and your only way of going through a corner is using pure motor torque on that wheel.
- Differentials can negotiate torque very quickly and effectively making it a lot easier to split the torque and corner smoothly
- Breaking down a hair pin, spools will always be worse on corner entry compared to diffs just because you are dealing with the tightest cornering radius of that hairpin, which makes both options of driving with a spool pretty bad
- The one silver lining of spools is it's good on corner exit, where your driver likely wants the most power out of that corner they'll find the most from a rear axle with max amount of torque on both wheels but it really depends on the type of corner exit it is
- In formula sae the main advantage of spools come from it being cheap, simple, and most teams (including us) don't have the time, knowledge, or man power to do the simulation and tuning of the differential. So from a design aspect if you have no way to maximize or get reliable comparative data from either why go with the one that's $3500

Notes on differential and diff tuning:

- just to get it out the way you can play with different types of differentials but make it simple and buy the $3500 clutch pack drexler with the tuning knob. They'll leak a lot but it does all the hard work for you and wont break
- The key to mastering a differential is mainly understanding how quickly your diff is locking and finding whats optimal
- From the past notes on a classic hair pin, on corner entry youre wanting to reduce yaw inertia and corner exit maximize torque output. In terms of the diff you want as much free roll as possible on entry while getting as much lock on exit
- Luckily in FSAE comp gives you a cut and dry method of applying this in slaloms where you're constantly loading and unloading tires side to side and you'll quickly have to optimize for what distance slaloms you want to optimize for
- On one hand small length slaloms are very low power while larger length slaloms are higher power, not to mention depending on how your driver wants to take the slalom
- Another note to take in any practical tuning of the diff is a measure of your lateral load transfer during slaloms, how much? How is that effecting the rate of change of wheel speed?

Yoke plate

Saturday, December 23, 2023 3:07 PM



The yoke was made detachable with the intent to swap plates and trial rear end changes. Could use some more on how the plate is not able to be changed.

As to weight the plate takes a few parts in combo, would be interested to se simple cad to see how much weight can be removed.

Arb:
Bc was not designed to accept
Design is too open ended to say you're supports or does not.
Shock config may have to change, some one should properly stick some lines in cad to see
Iregard to style arb path needs to be in static kenematics

Testing

Sunday, September 17, 2023 2:54 AM

Dump for notes about testing

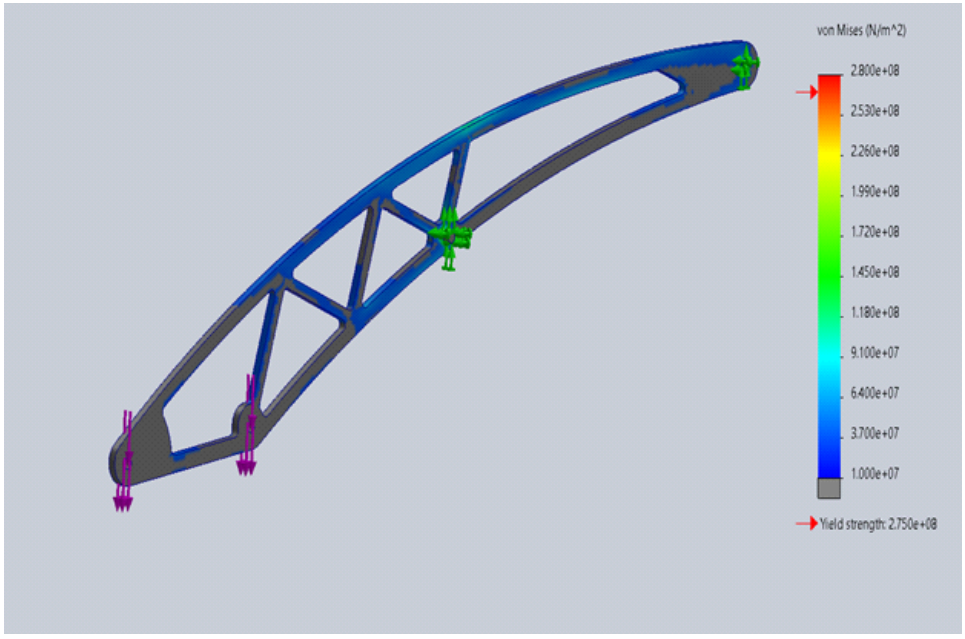
SAE lecture Testing notes

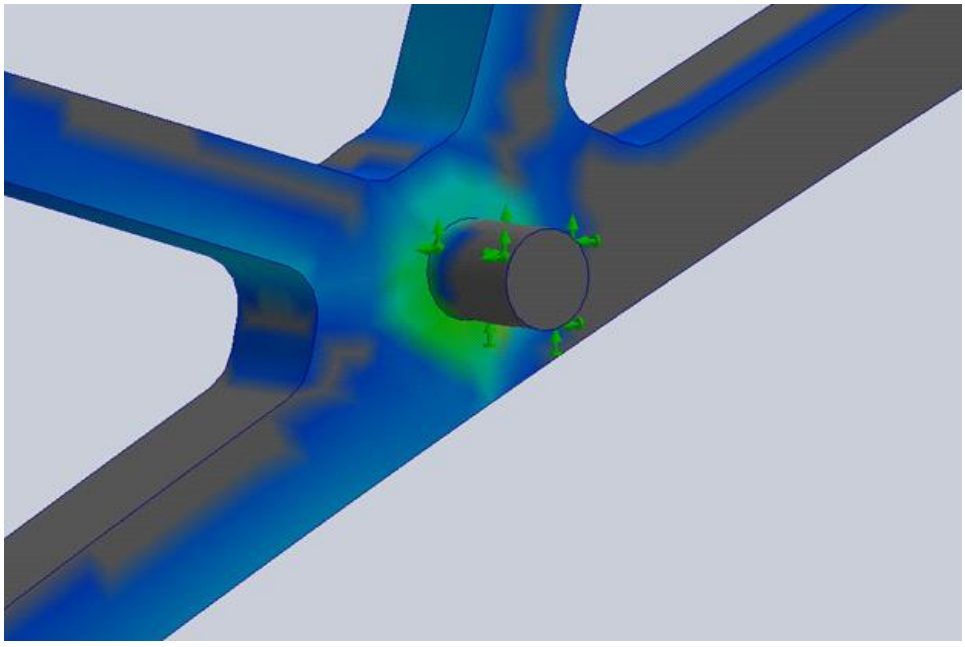
Sunday, September 17, 2023 2:54 AM

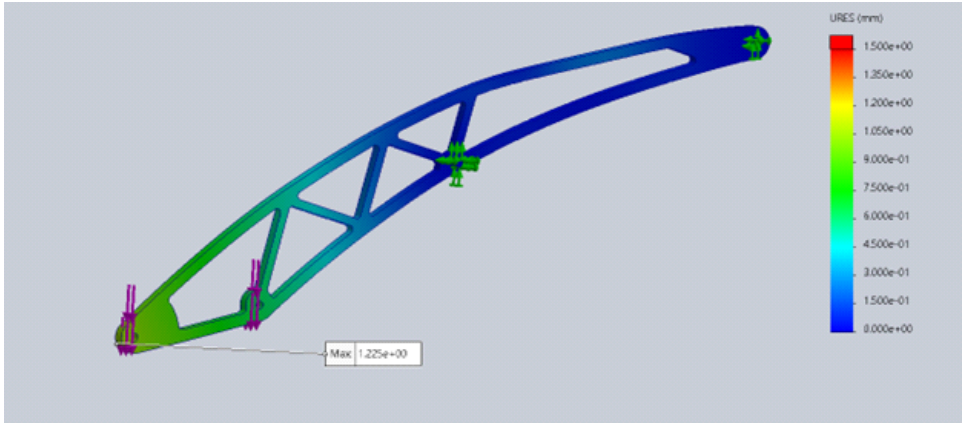
- Mid corner
  - No input/ minimal input
  - Peak steer angle
  - Ability to quantify grip levels
- Corner exit
  - Reduce steer angle
  - Power application
- Corner entry
  - Ability to change direction
  - Brake balance
  - Increasing steering
- Various radii
  - Vehicle balance with speed
  - Steering geometry effects

https://www.youtube.com/watch?v=mIexjpiqQnA&t=1025s

- Create a readme file with whatever data file we use when creating logs, should contain
  - Date
  - Test purpose
  - Run #
  - Driver
  - Etc.
- make that shit two ways, in the excel where we are recording times, temps, etc., create a column to hold whatever data files associated with that run to dummy proof if we fuck up
- Scoring sheet to relate subjective notes?
  - -5 understeer, +5 over steer scale?
- **RETURN TO BASELINE AT THE END OF TEST DAY**


von Mises (N/m^2)
2.800e+08
2.530e+08
2.260e+08
1.990e+08
1.720e+08
1.450e+08
1.180e+08
9.100e+07
6.400e+07
3.700e+07
1.000e+07
Yield strength: 2.750e+08




URES (mm)
1.500e+00
1.350e+00
1.200e+00
1.050e+00
9.000e-01
7.500e-01
6.000e-01
4.500e-01
3.000e-01
1.500e-01
0.000e+00
Max 1.225e+00

Suspension Bolts Check

Thursday, September 21, 2023 11:43 PM

Ffs please check this shit before we take the car out, it's a fucking bolt

SUSPENSION BOLTS CHECK

FRONT LEFT

- [x] Bellcrank chassis
- [ ] Control arm
- [ ] Steering Tie rod
- [ ] Toe rod
- [ ] Toe rod shims
- [ ] Upright bolts
- [ ] **TORQUE WHEEL (40 ft/lb)**

FRONT RIGHT

- [x] Bellcrank chassis
- [x] Upper control arm
- [x] lowerControl arm
- [x] Steering Tie rod
- [x] Toe rod
- [x] Toe rod shims
- [x] Upright bolts
- [ ] **TORQUE WHEEL (40 ft/lb)**

RIGHT REAR

- [x] Bellcrank chassis
  Should not be tight, just visiably have no gapping between bolt and bellcrank (this is bc bellcrank will deform to clamping force) THIS IS FOR ALL 3 BELLCRANK BOLTS
- [x] Control arm
- [x] Toe rod
- [x] Toe rod shims
- [x] Upright bolts
- [ ] **TORQUE WHEEL (40 ft/lb)**

LEFT REAR

- [x] Bellcrank chassis
- [x] Control arm
- [x] Toe rod
- [x] Toe rod shims
- [x] Upright bolts
- [ ] **TORQUE WHEEL (40 ft/lb)**

Toe Alignment:
If you do this please record who did it

- [x] With tape measure, measure the tie rod (not the toe rod, rods coming out of steering rack) length and make it equal left right and paint marker a line where the tie rod and steering rack meet
- [x] Ensure shims are correctly at zero amount (5 shims on the front, 3 shims in the rear) everything should b in the green suspension box and tire pressures are at 12 (sidewall deflection with pressure is real)
- [x] Undo jam nuts on toe rod and using toe plates (ensure they are centered with each other) tape measure

front and rear of each tire)

- [x] Ensure the length front to rear of the tire is the same

Rinse and repeat for rear

Corner Balance:

Record names of who did it and make sure to save this as the very last thing to do on the cars

- [ ] Fill tires to 12 psi, get a person in the car
- [ ] Loosen jam nuts on the push rods
- [ ] Put scales next to each side, turn on, ZERO BEFORE PUTTING CAR ON, put the car on
- [ ] I would take a pic here before doing anything to see the difference of before zeroing and after zeroing
- [ ] When corner balancing think about it as legs on a table, they work diagonally so try to corner balance across the car (guessing and checking is also fine as well). You do need to make sure to avoid bottoming out the push rod (you are pre loading it when adjusting which can be bad for the push rod under load)
- [ ] I try to get it to within 5 lbs of each corner but when you're done take a picture and put it in car-testing channel or in here (in here is preferred)
- [ ] Lock jam nuts and pack it up **(NEEDS TO BE REDONE AT BARBER)**

Measurements before taking car out:

Corner Balance

LF Weight:
RF Weight:
LR Weight:
RR Weight:

Camber

LF:
RF:
LR:
RR:

Dacq

Monday, September 18, 2023 12:51 PM

- Gyro
    - Yaw, pitch, roll
        - Yaw control (stability) in a hairpin
- Accelerometer
    - Driver comparison
    - Diagnose trends of time loss
- Shockpots
    - Damper tuning
- Steering
    - Gg circle
        - Understeer gradient

- Parsing consideration

Thursday, September 21, 2023 5:19 PM

Does the mail glv conector clear as acc drops out, it's this an unnecessary risk

Do you have the airs in hand?
Is there space to revert?

How is the box attached to the lid?

Tire Model

Friday, September 29, 2023 1:13 PM

Combined model from both bill cobb and Morrison tire model

Main goals:

- Be able to evaluate and parse other tire .dat files
- Capable of parsing longitudinal tire data (drive and brake)
- Capable of integrating into lap time simulation
    - 4D cubic spline?
    - Magic Formula?
- Evaluate variables
    - Slip angle
    - Lateral force
    - Longitudinal force
    - Normal load
    - Slip ratio
    - Camber Angle
    - Pressure

Method:

- Start with bill cobb method to start plotting basic variables
- Then integrate with Morrisons previous model
- Document entire process so script can be remade and iterated on

Steady state model

Friday, January 5, 2024 10:10 PM

All notes from RCVD chapter 5

Bicycle model notes:
- No lateral or lon load transfer
- No rolling or pitch motion
- Linear tire model
- Constant forward velocity
- No aero effects
- Position control
    - People who operate cars from racers to normal people operate steering to certain extents of position and force based. Due to lower steering ratios In passengers, passengers operate in a more positional control system. With racecars with much more faster ratios, they operate more on a force control basis
- No chassis or suspension compliance effects

Some examples of the investigations you can run:
- effects of front and rear tire cornering stiffnesses
- Center of gravity location along the wheelbase
- Geometric steering angle in yaw and sideslipping motion
- Basic vehicle control and attitudes

The bicycle model two degrees of freedom are the motion variables, v (lateral velocity) and r (the yawing velocity). The input variables is the front wheel steer angle which is a driver control

Bicycle model can start to develop the basic definitions of under, over, and neutral steer.
When applying a constant radius test for a neutral steer test, the biggest indication is when measuring front and rear slip angle over lateral acceleration, the rate of change is the same for Ay.

Understeer car:
Most weight for this car is not shifted to where the CG is closer to the front axle than the rear axle. Everything remains the same though, total wheelbase, cornering stiffness, Ackermann steering angle for a given path. In RCVD, the CG is now 1/3 the wheelbase behind the front track.

In this analysis, the vehicle acts as a horizontal lever. The side force must be reacted at the individual tracks in inverse proportion to the CG to track distances. Meaning the front now has to work a lot harder than the rear tires. In this analysis this takes the form of a higher slip angle on the front tires compared to the rear.

Compared to the previous constant radius test, the vehicle slip angles is less by the reduction in rear slip angle so that creates a lower front slip angle. Compared to the Neutral steer car we need to make the loss in rotation up by providing more steering angle to the front tire, so increase front slip angle. Not to mention how much greater slip angle is still needed to bring back the balance of total lateral acceleration.

In the context of the rate of change of slip angle to Ay, the front rate of change is larger than the rear.

Oversteer car:
The rate of change of the rear slip angle Ay is greater than the front slip angle Ay.

Throughout this analysis it becomes clear the importance of the grip balances both front and rear. It also becomes clear that the front and rear are fundamentally coupled because of the chassis that it needs to be on.

Equations of motion

Friday, January 5, 2024 11:15 PM

The equations of motion are developed from the bicycle model in the previous analysis. This is a linear model with two degrees of freedom which enables the calculation of the motion variables as a function of the forces and moments acting on the vehicle. The motion variables of interest are forward velocity (u) lateral velocity (v) and yaw rate (r). Yaw rate is the angular velocity of the vehicle around a vertical axis passing through the CG.

The vector sum of u and v is the path velocity V which is perpendicular to the turn radius R. the x axis of the car is at the body slip angle with V. for straight ahead motion body slip angle is 0 and R is infinite.

The total side force is Y and the yawing moment about the CG is N. in VG we typically assign V as an independent variable to calculate how the other variables turn out. Also since V = u, the two remaining dependent variables are r and v which is why it is considered two DOF.

Comp

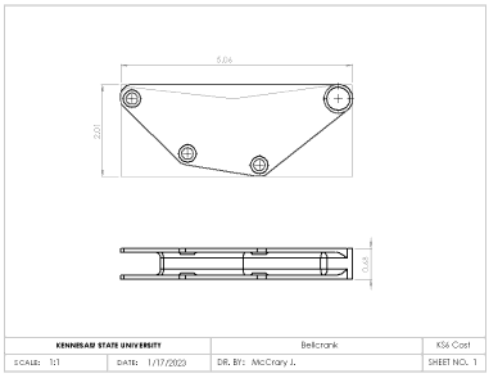
Tuesday, January 9, 2024 3:27 PM

Pages about static and dynamic events at comp 2024 comp IC + EV

Cost Event List

Tuesday, January 9, 2024 3:28 PM

Checklist moved to other locations



Example drawing for cost:

- This shouldn't be the quality of drawing actually used for anything outside of showing non engineers and cost
- Should dimension
    - Holes
    - Overall dimensions

Example Render:

- Go to Solidworks > solidworks add ins > photo view 360

Design Event

Tuesday, January 9, 2024 3:28 PM

Slides breakdown (subject to change):

Slide 1: tire data processing and tire selection
- Tire data processing and synthesis
- Using primarily Matlab, evaluate different tires using ttc data
- Hopefully have a decision matrix to show how the tire was ultimately selected for our team and application in mind
- From the goal set out by chief engineer for accel and Skidpad, best tire was chosen

Slide 2: geometry target definition given tire data
- From tire data developed, normal load targets, camber targets
    - For the concern of time prob should only do skidpad, if we can get into bigger gg circles and maybe slaloms that'd be cool

Slide 3:

Brakes Ergo Steer- Design Event

Wednesday, January 10, 2024 7:50 PM

Jan. 17 Meeting
Catch Emil up meeting

What to expect?
- How is the pace of brake + ergo design?
- How in depth do they go in each section?

Brakes and ergo is more open ended. Can start from wherever start with a big picture, want to have a ease of access goal. Go into goals of that year, start with cockpit and controls because they sit in the car. Walk through the controls because it is right in front of them. Went into steering system, overview of entire system. Safety, floor pan and calculations for steering column. Then dash and other control schemes. Something to mention that wasn't mentioned in power point, go into decision matrix for impact attenuator. Go into bonding of impact attenuator and decision matrix justifying the decision.

How to prepare?
- What was used to prepare for design?

Go through old design binders and presentation.

Mock Design Date?
- What's a good day we can run a mock design to gauge Emil's knowledge

March 22nd Mock Design

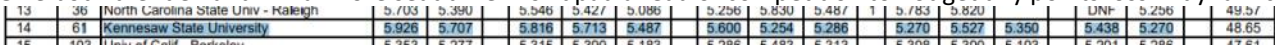
Design event strategy?
- Do we want all three? Do we have Emil observe at IC comp and run through it EV comp?

Design questions:
- Justification for brake rotors?
    - Size shape weight
- Theoretical brake questions of the system as a whole, temperatures on wheels
-

Skidpad

Tuesday, January 9, 2024 3:36 PM

Prepare before comp:

- Do not need to resweep toe but when testing definitely need to run 3-4 values in the parking lot to have a final comp setup
- Give both brenden and mihai more seat time in skidpad ahead of competition to not get any points loss in dynamic events
- 

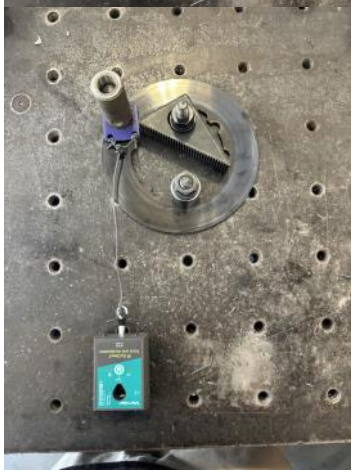
13	36	North Carolina State Univ - Raleigh	5.703	5.390		5.546	5.427	5.086		5.256	5.830	5.487	1	5.783	5.820			DNF	5.256		49.57
14	61	Kennesaw State University	5.926	5.707		5.816	5.713	5.487		5.600	5.254	5.286		5.270	5.527	5.350		5.438	5.270		48.65
15	103	Univ of Calif - Berkeley	5.353	5.277		5.315	5.200	5.182		5.286	5.483	5.313		5.209	5.200	5.103		5.201	5.286		47.61

- Last year skidpad time at competition IC was 5.27 and 5.66 at EV <- diff difference

Brake Mu Empirical Testing 3/21/2024

Thursday, March 21, 2024 5:12 PM

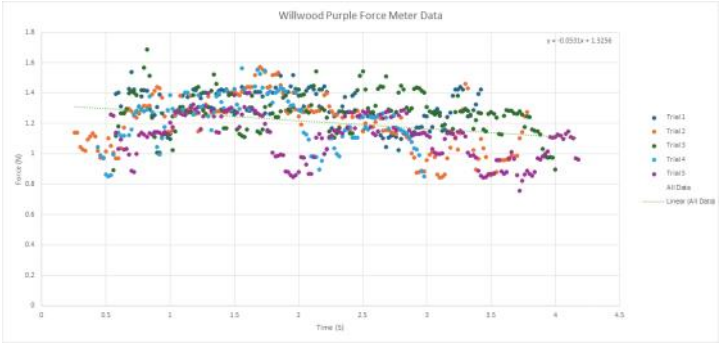
- Removed rotor from hub to empirically test coefficient of friction value of the Willwood Purple pads
- Dragged the weighed down pads across the rotor (which was fixtured on the welding table) using a force meter



Willwood Purple Mu = 0.6
345g of weight added

Normal Force:

- F=m*g
  - F = 395g * 9.81 (m/s^2)
    - = 0.395kg * 9.81 (m/s^2)
    - F = 3.87495 N



Average Frictional Force	Normal Force	Calculated Mu
1.202741199 N	3.87495 N	0.310388831

Mass Of Pad W/ Weight
0.395 kg

Gravitational Acceleration
9.81 m/s^2

KS8

Monday, February 12, 2024 6:08 PM

Tire Evaluation

Monday, February 12, 2024 6:09 PM

1. Sorting tires preliminary through what's readily available in the United States and what has TTC data coverage. 10" rims preselected from the available wheels the teams have.

   Tire selected for Evaluation:

Brand	**Size**	**Compound**
Hoosier	16.0 x 7.5 - 10	R20
Hoosier	16.0 x 6.0 - 10	R20
Hoosier	18.0 x 6.0 - 10	R20
Hoosier	16.0 x 6.0 - 10	LCO
Hoosier	16.0 x 7.5 - 10	LCO
Hoosier	18.0 x 6.0 - 10	LCO

2. Design Matrix Elements:

- Cornering stiffness
- Load sensitivity

Launch Control Dump

Tuesday, March 19, 2024 10:00 PM

DUMP Purely for Launch Control (NOT TRACTION) (although can easily be adapted to)

- Semi-closed loop controller:
  - NEEDS: Wheel speed sensors to observe slip, *Load cells to observe normal force?*
  - For accelerating off a line, run some tq amount for some time (open loop)
    - Torque value based on grip estimate with 0 load transfer (static)
  - After that given time, given load, given some observed slip, respond with some tq command to induce more slip
    - Window of optimal slip: if above, torqueDOWN, if below, torque UP?
    - PID controller
  - Run every partition to check for load and slip and supply some tq to a grip ceiling value or some 3d plot of both slip and load

- Open-loop time based (Jonathan Proposal):
  - Curve based off real data, good accel runs

- Open-loop time based (Simulation result based):
  - Start launch at torque calculated from static weight distribution
  - Ramp up torque based on predicted load transfer (and downforce?) at X timestep
    - At time t, predict Fz, torque = Fz * grip calculator
  - Run time adjustable (like before you enter launch mode) "coefficient of friction" which changes torque - part of the "grip calculator"
- Closed-loop, acceleration feedback:
  - NEEDS: longitudinal acceleration sensor
    - This could be calculated based on velocity delta over time. Wheel speed can be used for this
  - Estimate rear axle Fz based on longitudinal acceleration.
  - Apply torque based on esimate Fz and grip calculator
- Closed-loop, force feedback:
  - Load cells. Just have fucking load cells in the suspension so we can get a close measurement of real Fz
  - Calc torque same way, have adjustable Mu and go ham
- Closed-loop, speed command:
  - Use pm100dx speed command mode and just try to ramp up speed

How to properly bleed brakes

Friday, March 29, 2024 11:11 PM

Our car uses a dual master cylinder setup, with dual bleed screws on each caliper. Thus, both circuits need to be bleed simultaneously, as well as following the correct order for the inner and outer bleed screws. See video and typed out procedure below:

Bleeding Brakes With Dual Master Cylinders

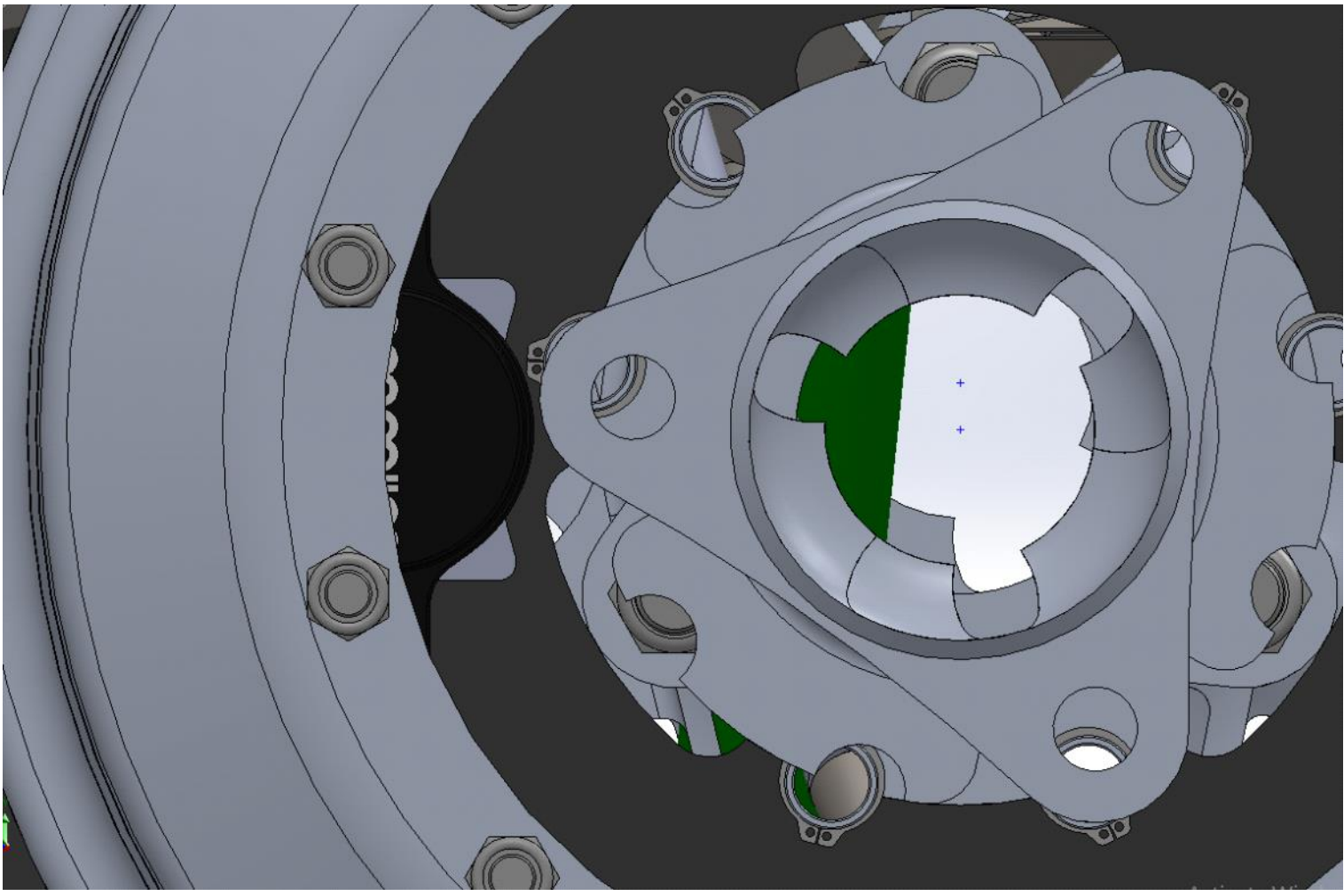
1. Bleed/prime the master cylinders- they are full of air and need to be primed before just attempting to get a regular bleed. Ideally we'd do a bench bleed, but in the car is fine too.
    a. Fill up each reservoir with fluid
    b. Crack the outlet fitting on both masters
    c. Lightly depress brake pedal until fluid begins to leak/drip from the outlet fittings
    d. Tighten the outlet fittings

2. Bleed the front & rear caliper pair which is furthest from the master cylinders (ecar would be left side)
    a. Inboard bleed screws first
        i. Depress pedal
        ii. Crack both front and rear bleed screws simultaneously
        iii. Close screw
        iv. Release pedal & press again
        v. Repeat until no air escapes out of bleed screw
    b. Repeat above with outboard bleed screws

3. Repeat above with other side of car (ecar would be right side)

Upright skitzo

Saturday, April 6, 2024 4:29 PM



Confadant this this is not gonna clide with the hub

Flange for barke was offset inboard via .13in

Next iteration moving mount to the top of the upright to fit tool and be able to remove shims for camber without doing weird control arm stuff

Pickup was really long across the top, could move the toe pickup to the bottom, reason for collision on the top with control arm. For now add chamfer

3/4inch squish at the end of the control arm

Clearnce holes need to have l;arge radi than .125
An endmill shuld not fully engaged

The control arms need to be stretched to fit the pickup points on the chassis
Need to reevaluate how we jig our control arms

KS7C Car Testing

Wednesday, April 17, 2024 6:29 PM

Possible Tests to do:

- Skidpad toe characterization and setup
  - Running through the top 5 setups from the box and whisker plots
  - Characterize setup with drivers, main KPIs are consistency (standard deviation) and overall performance (lap time)
- Acceleration baseline and tire pressure characterization
  - Baseline before competition to understand what performance window we are currently sitting in compared to last year
  - Pressure main form of change because compared to toe and camber, very quickly adjustable
  - Should run with 12 psi squared, 10psi squared, then a higher front pressure bias compared to rear (20psi front- 10psi Rear)
    - Hypothesis is rear grip will catch up quicker and reducing front grip reduces tire drag and resistance
- Autocross setup characterization - toe.
  - In terms of shit to change toe goes before camber just because tires are far more sensitive to slip than they are to camber
  - Should start with skidpad setup and track should have 3 distinct sections min radius hairpin or a hair pin, 5 cone slalom, and a constant radius corner
  - Main things to look at is comparative yaw rate and lateral Gs between different setups
  - Comparing driver steering responses and correlating to lap times also next step
  - Comparative tire temperatures front-rear very important to identify car balance and what correlates to not only faster lap times but to comfort in the car (driver feedback)
- Autocross setup characterization - camber
  - Main thing to note here is tire temperature across
    - Correlating car balance (yaw rate) to tire temperature and lap time
    - My suspicion is for some drivers higher negative camber (where excessive inside heat) will lead to faster lap times bc lost front grip will increase tire response
- Testing in the Rain
- Benchmark and tune Skidpad:
  - big tuning tool for skidpad is our static toe and driver comfort in the car
  - For toe we can look at how our base from last year based off of the comp setup we developed through our toe sweep (with the variance in the plot would not hurt generally re running adding/dropping shims generally and measure the effects
  - History wise we know toe out front and toe in rear
  - For driver comfort in the car we can start using some of the logged data we got specifically tps and steering, comparing across runs.
  - (could) call andrew to do a skidpad run and see what time we are aiming for and what he is getting from logged data and getting drivers to recreate that in the skidpad
  - [from plot, get top quickest setups and see correlation between current drivers]
- Benchmark and tune for acceleration
  - Chassis/ suspension changes are not very obvious here, if we had the time and tires understanding what pressure effects across different axles could help
  - Beforehand need to atleast get time on dyno to adjust our tune for new headers and meet/surpass our power numbers from last year

- Testing Wise
- GG Circle
  - A lot of front kinematic changes in terms of caster will change our camber change in steer which pushed our envelop for lateral force, would be interesting to see the direct effects of it on gg circles and compare to last years times
  - I would use same diameter and follow a lot of the methods we did last year in pushing towards a standard deviation
- Autocross
  - We still really don't have an autox setup made yet, I think a very easy way of doing that is changing our toe and static camber on isolated slaloms. This allows things to be easily repeatable and be able to quickly revisit
- Endurance
  - There will be a big change to the steering feel of the car and small car preparation stuff and fatigue failures have plagued the IC car in events, being able to directly hit those with mock endurances like we did last year would help the team a lot in knowing we can finish endurance in the IC car

First order:

- Benchmark Skidpad: given time, priority is running our toe setups from previous sweeps to benchmark and have an understanding of where the cars condition sits
- Quickly do this by running the top 5 setups from previous sweeps and then have the drivers work towards a standard deviation of .2 for 3 series of 5.
- Could be done with 2 drivers
  - Setups:
  - 1F/3R
  - 3F/2R
  - 5F/2R
  - 5F/1R
  - 6F/2R
- Benchmark Accel: currently power limited- could increase camber on the front of the tire by incrementally adding shims to the front uprights, as well like last year increasing pressures could be a worthwhile option for getting proper accel times.

- *GG Circle: to compare to last years gg circle times, across multiple drivers and diameters of 12, 22, 27, 32m left and right. Preference is it is done with bray and brenden bc we have the most amount of data for them on last years gg circle*
- *Like the skidpad, benchmark make series in 5 laps and a conclusive point would be getting the drivers to a standard deviation of .2 for 3 series*
- 4/26/2024 Skid Testing
  - Finalize skidpad setups and get drivers as much seat time for it
  - Run through the sweeps of setups for Skidpad
  - Brenden and Mihai
- 4/27/2024 Accel Benchmarking
  - Run at 12psi squared
  - Run with front higher and rear lower (20psi/10psi respectively)
  - Mihai preferred, maybe Brenden
- 4/27/2024 Endurance for IC car
  - Would want Emil and Mihai if available
  - Purely to get car to

4/19 DAQ playground

Sunday, April 21, 2024 5:08 PM

We ran just 10 round of skidpad. This data is not yet usefull for compairison as the drivers were improveing at more than .1 sec pr a run.

What we did learn,
Load transfer was with in 15% or projected.

Lap time, shock pot (displacement), and accelerometer data match up.
All correlating to a 1.2g run (please put in updated weight)

Tire temp data supports lack of slip in the front tires, as well as close correlation to lap time.

Wheel speeds sensors are off by a clean factor of 2 for the front and 10? For the rear. (def could be me miss scaling)

Throttle sizing (with other tune parm) is in a great range for skidpad, with driver in 30 to 55% at all times.

KPI in front needs some work to calc more, its wrecking the shockpot with minor steering adjustments. Daq furthers conjecture that is too much.

I don't have camber vs slip chats atm but we can correlate this with tire temps and steering to ensure we have setting correct. (being LC0 not too big a concern)

Stearing Check