SUSPENSION DESIGN PRESENTATION

University of Connecticut

Formula SAE

Natalie Paliulis
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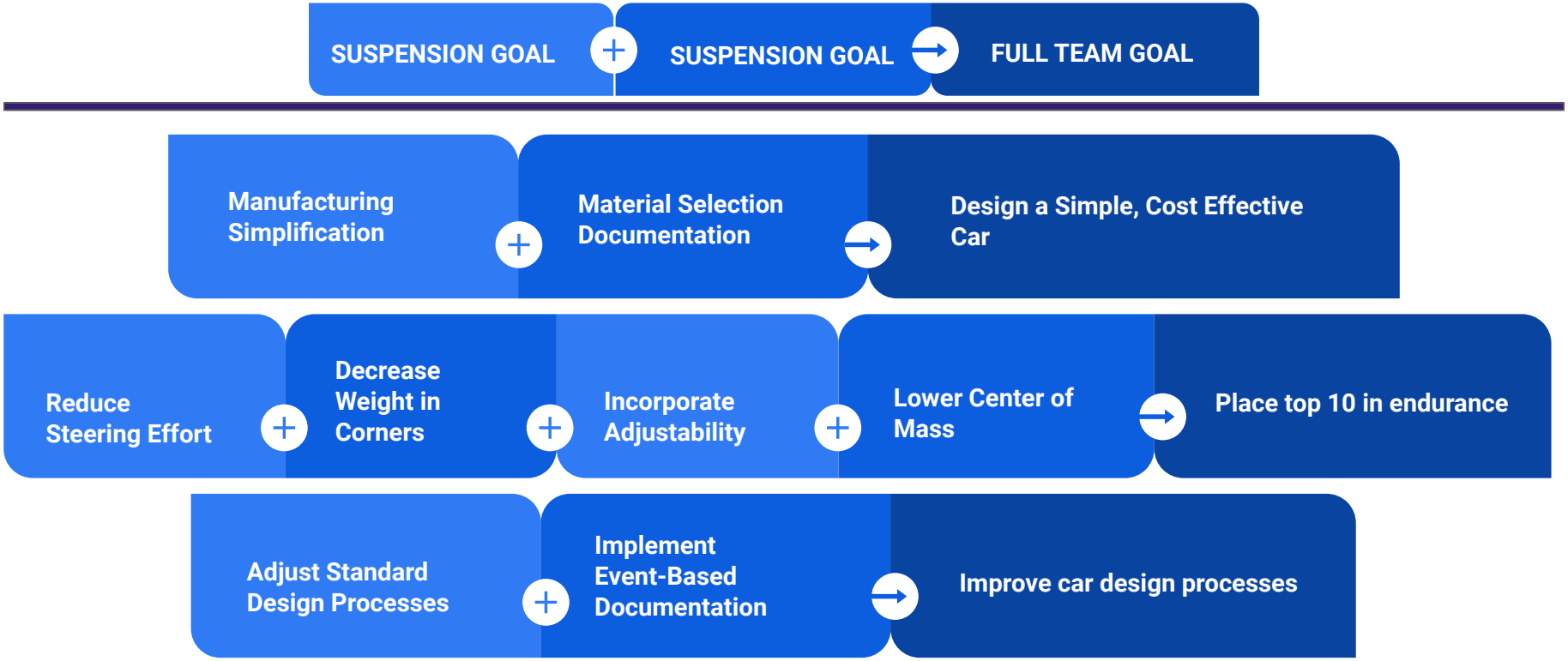
UCONN FORMULA SAE

DESIGN GOALS



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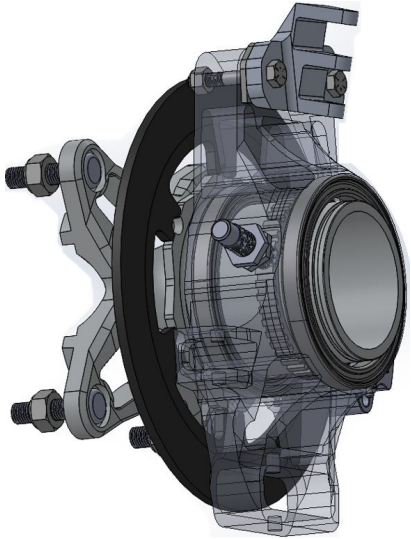
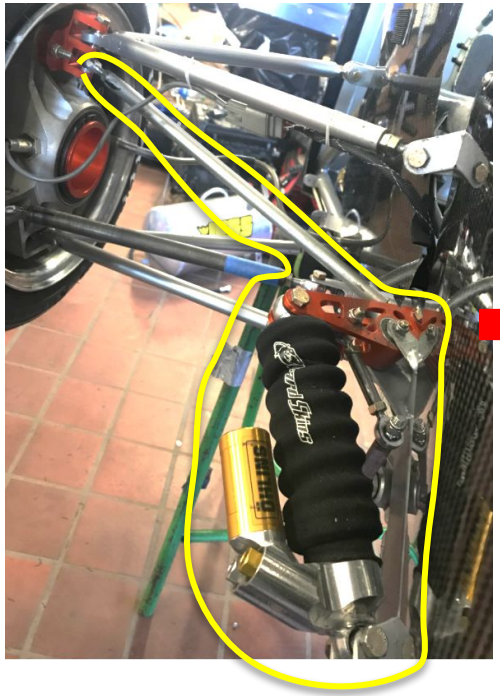
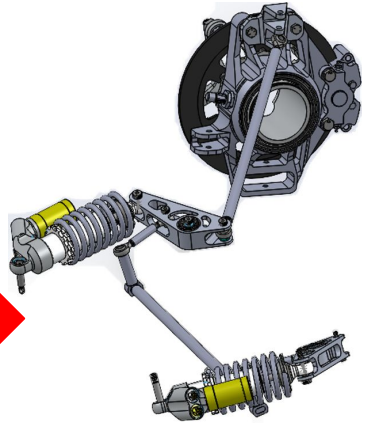
SYSTEM OVERVIEW



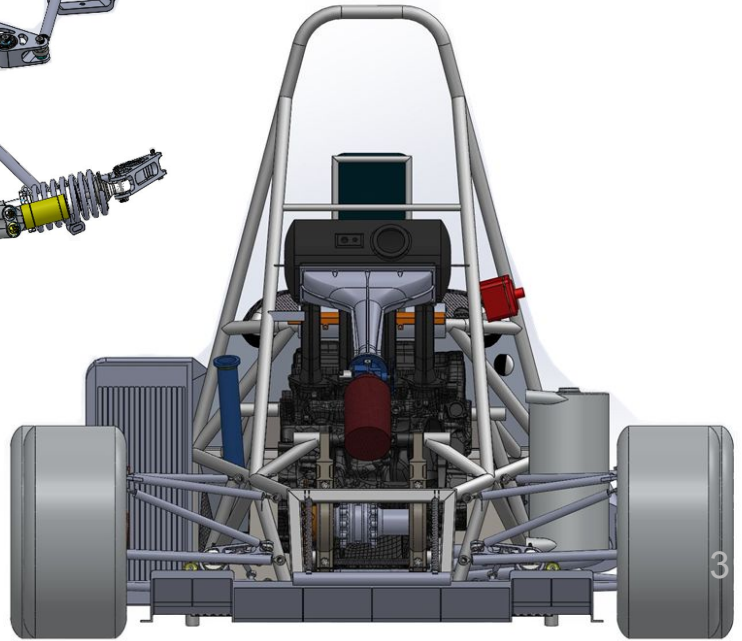
Hub-Spindle-Wheel Center Combination

Front Pull Rod Assembly

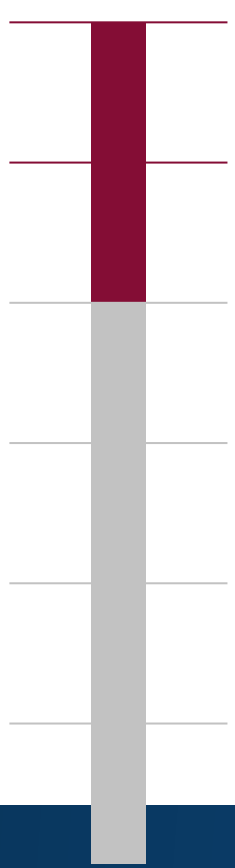




Full Car Assembly



DESIGN PROCESS



Tire Selection

System Design- Suspension & Steering Point Design

Frame Design Completion

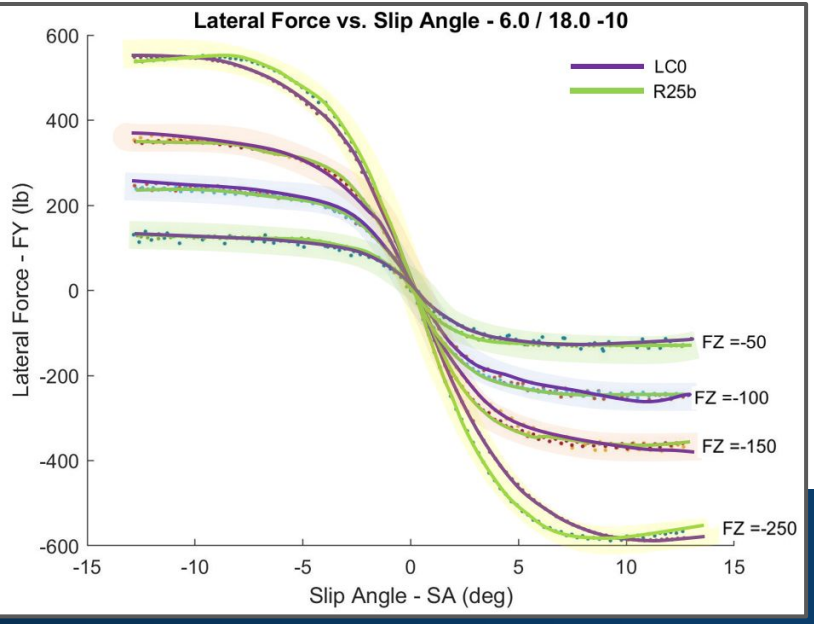
System Design - Pull Rod-Damper Assembly Design

Component Design

Manufacturing Jig Design

TIRE SELECTION

- Hoosier Supplier
  - Compound
    - ~~R25B~~
    - LC0
  - Sizing
    - Diameter
      - Smaller OD
        - Less rotational inertia
        - Smaller contact patch
        - Smaller/stiffer sidewall
        - Less force on car components
    - Width
      - Smaller Width
        - Less rotational mass
        - Better acceleration
      - ~~Larger Width~~
        - Higher interia
        - More tractive & lateral grip



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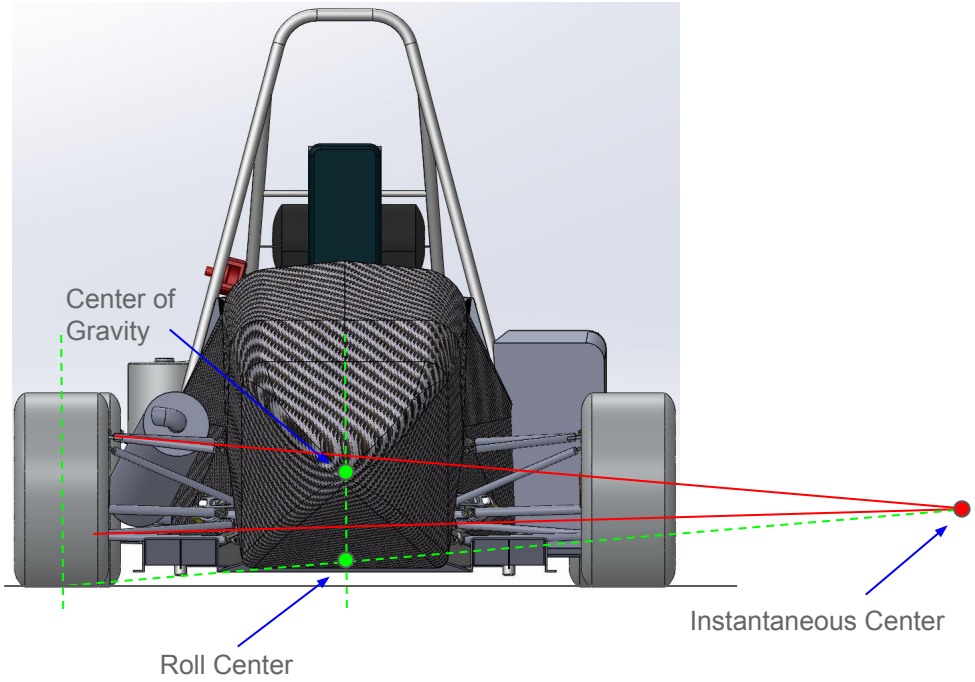
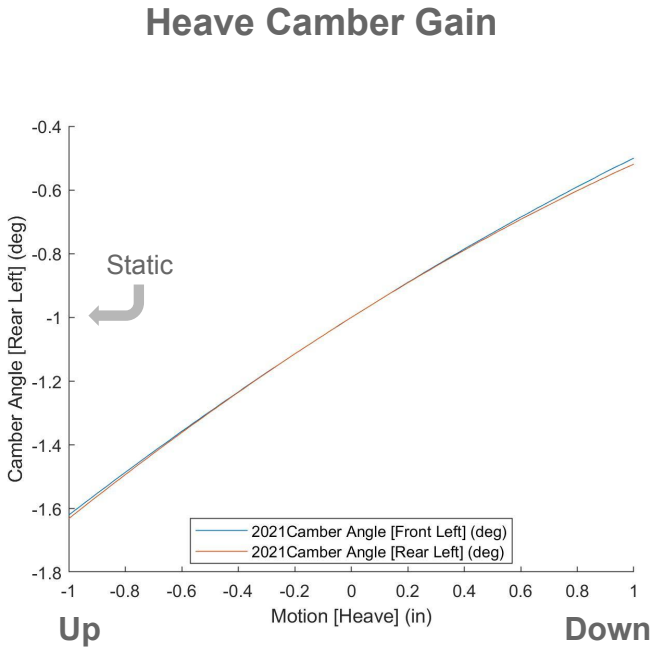
SYSTEM DESIGN - SUSPENSION & STEERING POINTS

ROLL & PITCH





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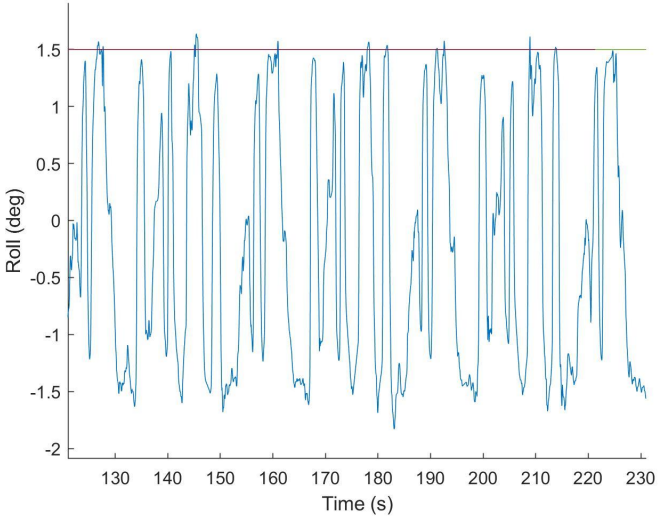
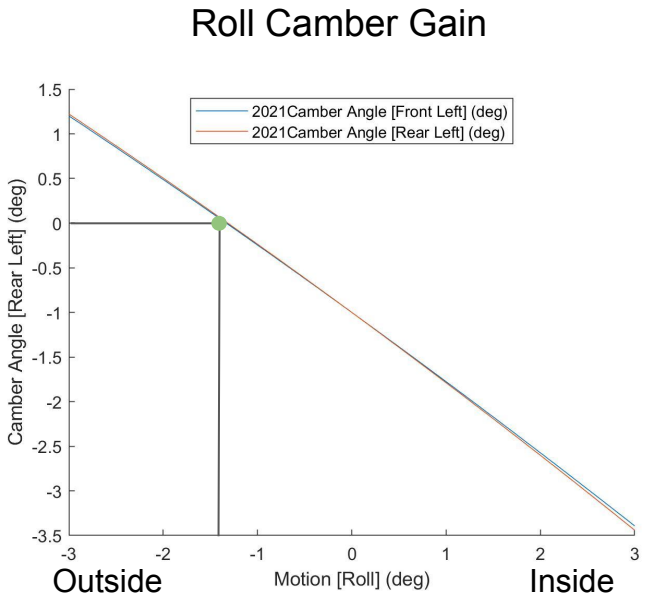
SYSTEM DESIGN - SUSPENSION & STEERING POINTS

CORNER CHARACTERISTICS





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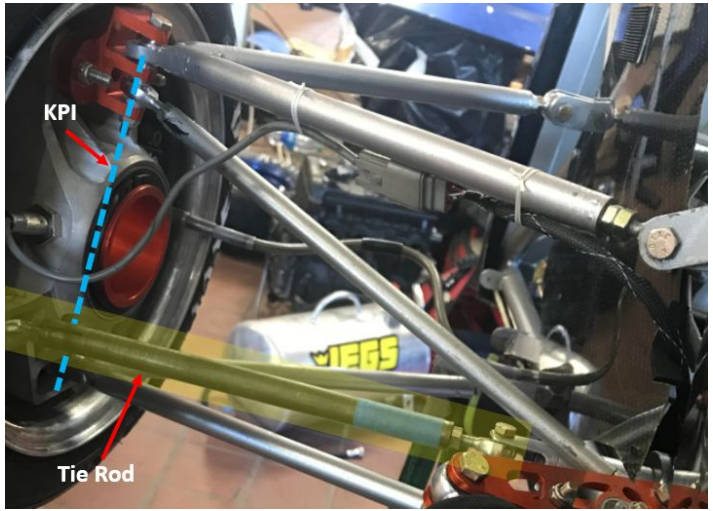
SYSTEM DESIGN - SUSPENSION & STEERING POINTS

Steering

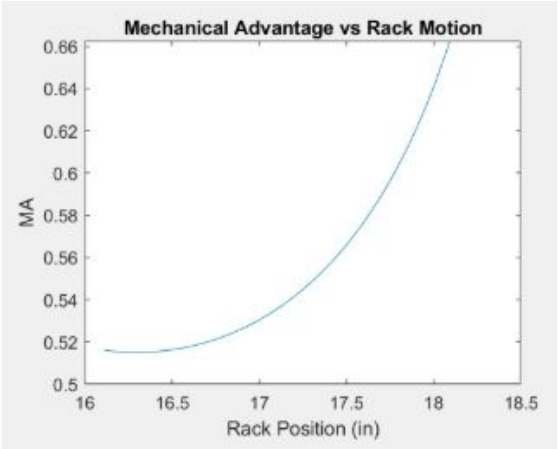


Reduce Driver Effort

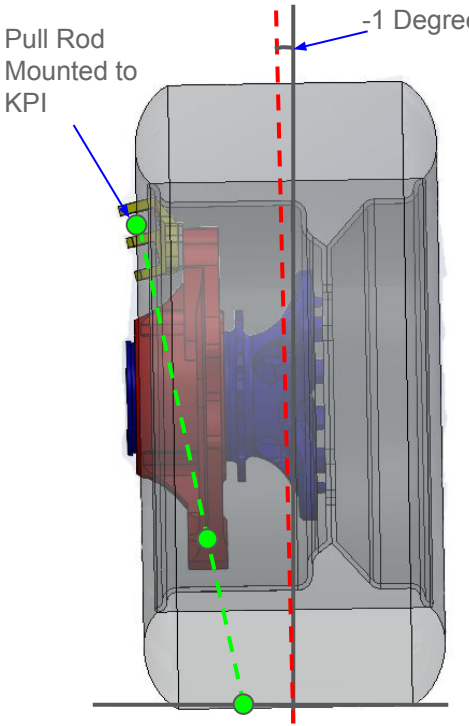
- Consider steering system mechanical advantage
- Manage scrub radius
- Reduce jacking forces, small KPI

Systems Integration

- Position of inboard steering components
- Symmetrical corner, outboard tie rod mount
- Pullrod and frame clearance for full range of motion

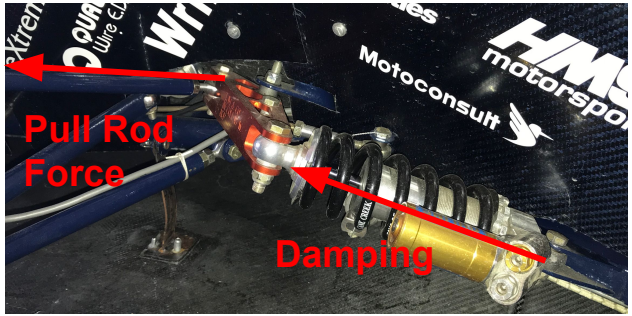


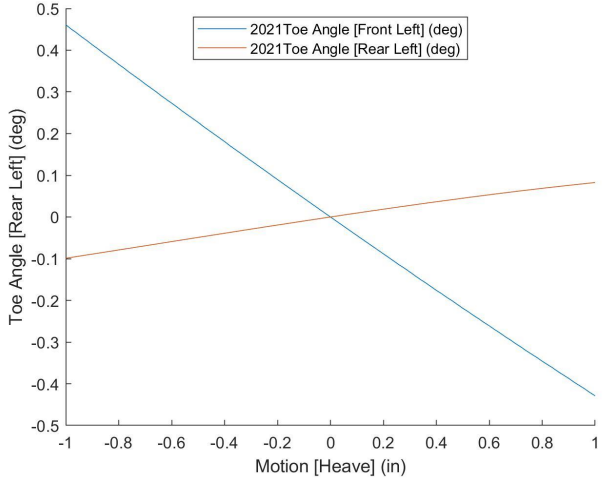
SYSTEM DESIGN - PULL ROD-DAMPER ASSEMBLY



Pull Rod Actuation:

- Avoid buckling
- Low mounted damper and rocker
- Pull Rod mounted to suspension bracket
  - Reduce **bump steer**

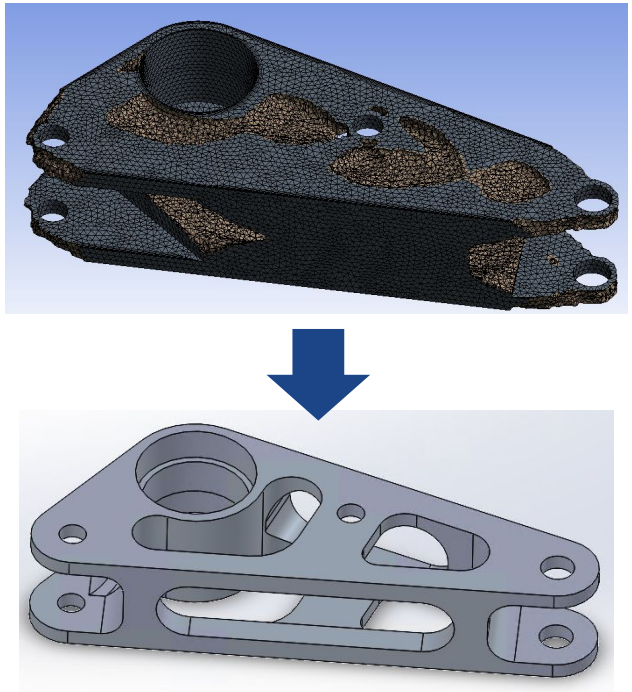


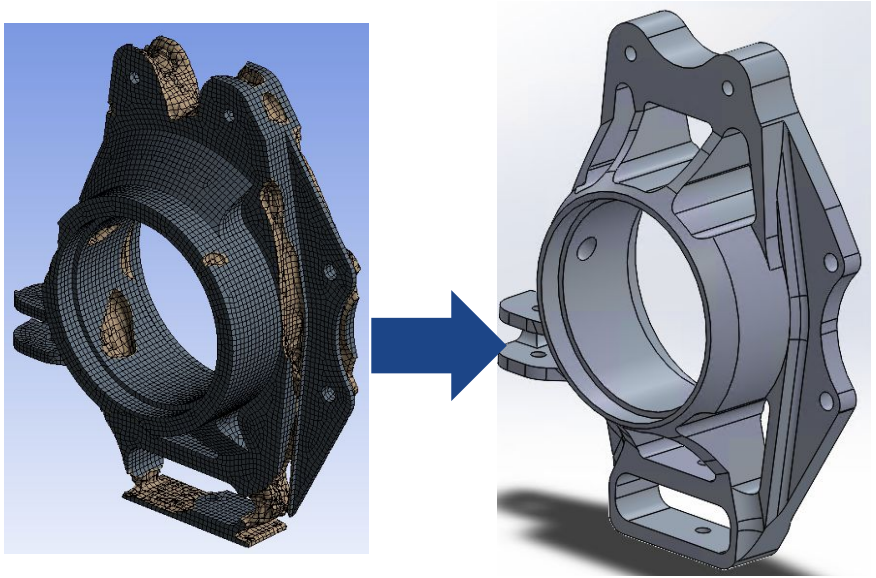


Bump Steer

COMPONENT DESIGN

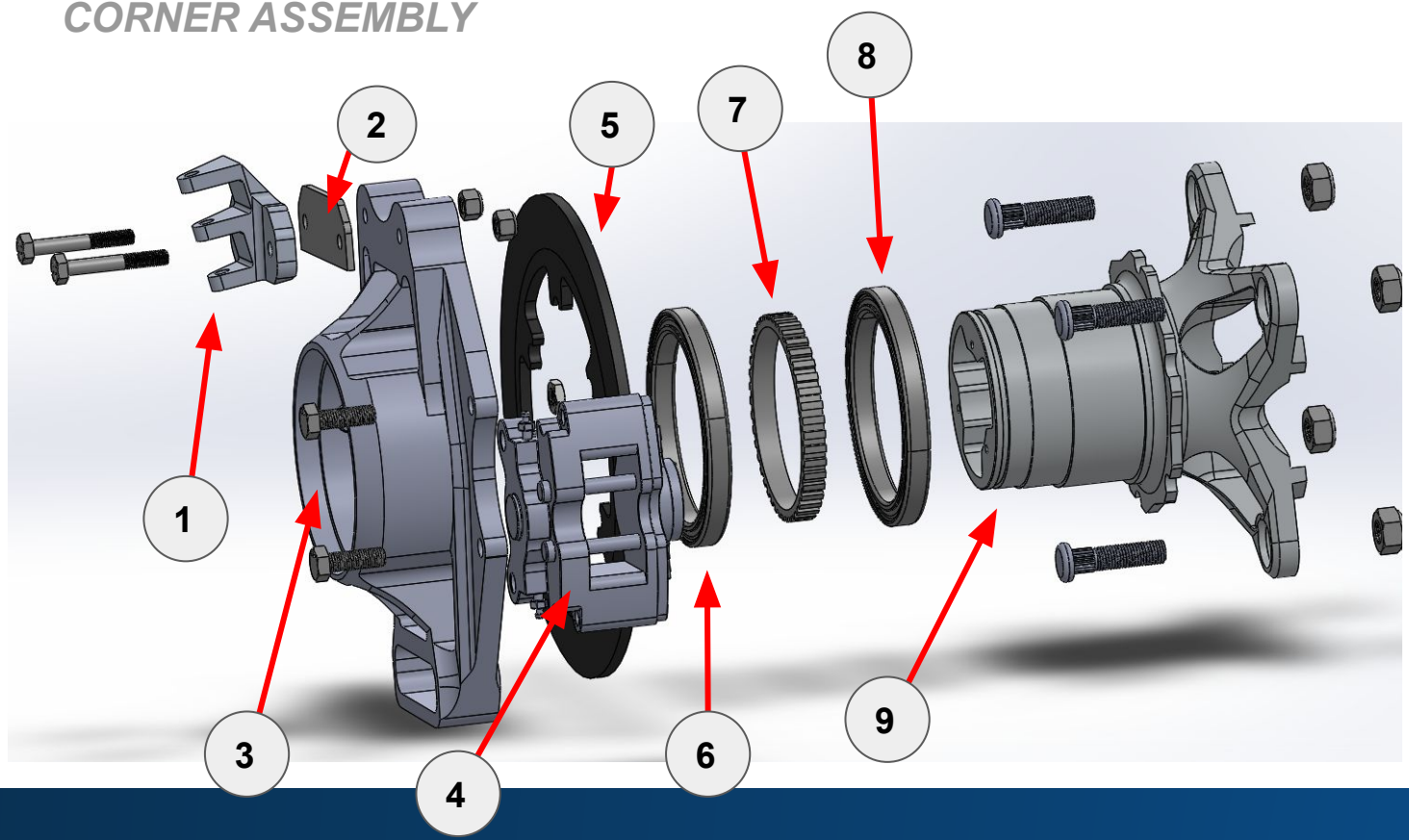
TOPOLOGY OPTIMIZATION





COMPONENT DESIGN

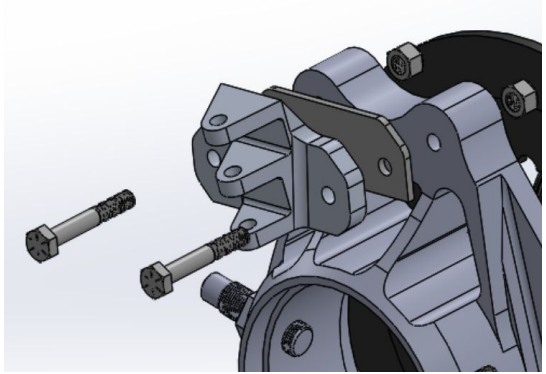
CORNER ASSEMBLY



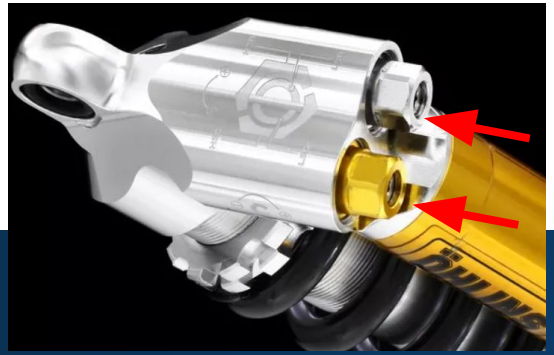
1. Suspension Bracket
2. Camber Plate
3. Upright
4. Brake Caliper
5. Brake Rotor
6. Inboard Bearing
7. Tone Ring
8. Outboard Bearing
9. Hub-Spindle-Wheel Center Combination

SUSPENSION TUNING - ADJUSTABILITY

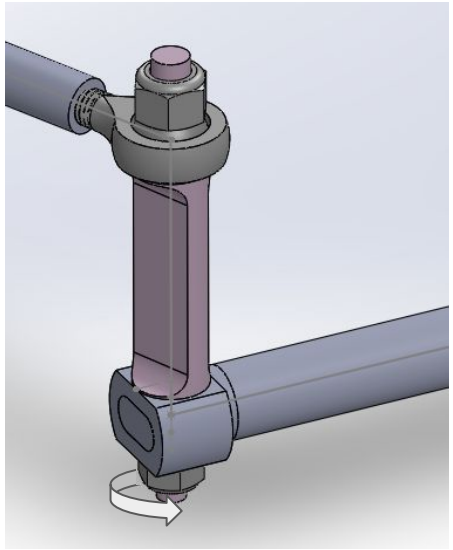
Removable Camber Plates



4-Way Adjustable Dampers



Variable Rate Roll Bar Blade



Interchangeable Blades

Roll Gradient Range: 0.1 deg/g

Roll Gradient Change: +/- 5%

Adjust Over / Under Steer

SUSPENSION TUNING - EVENT-BASED VEHICLE SET-UP

- Toe
- Camber
- Damping
- ARB
- Tire pressure
- Ride height

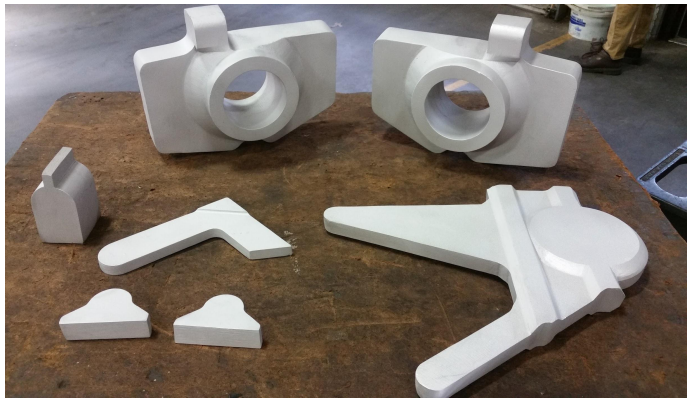
Event	Acceleration		Skid Pad	
Location	Front	Rear	Front	Rear
Toe	0 deg	Out	Out	
Tire Pressure	Increase	Decrease	Even	Even
Compression Damping	Increase	Decrease	Even	Even
Rebound Damping	Decrease	Increase	Even	Even

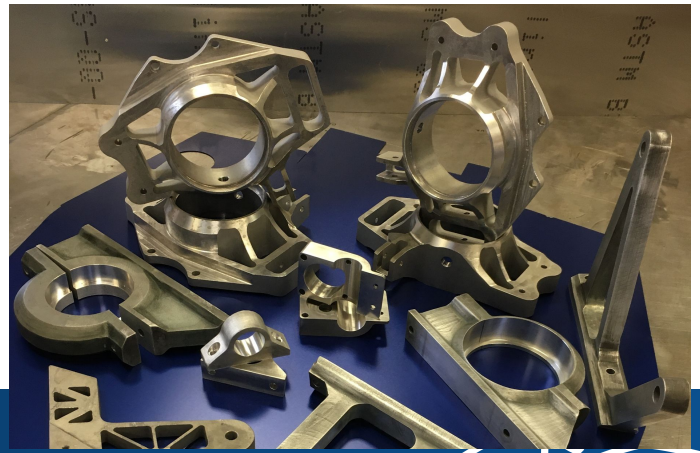
MANUFACTURING

Jig Assembly

Corner Assembly

Mag Casting





Open Discussion & Questions

Thank you!

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Extras

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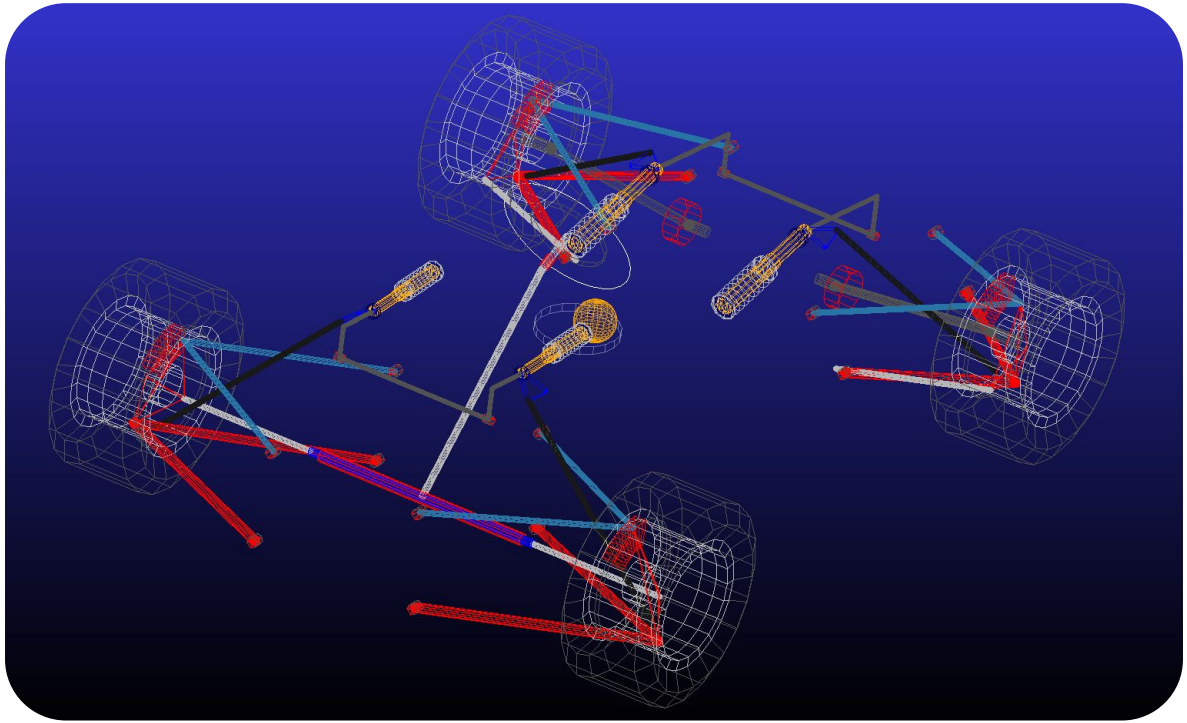
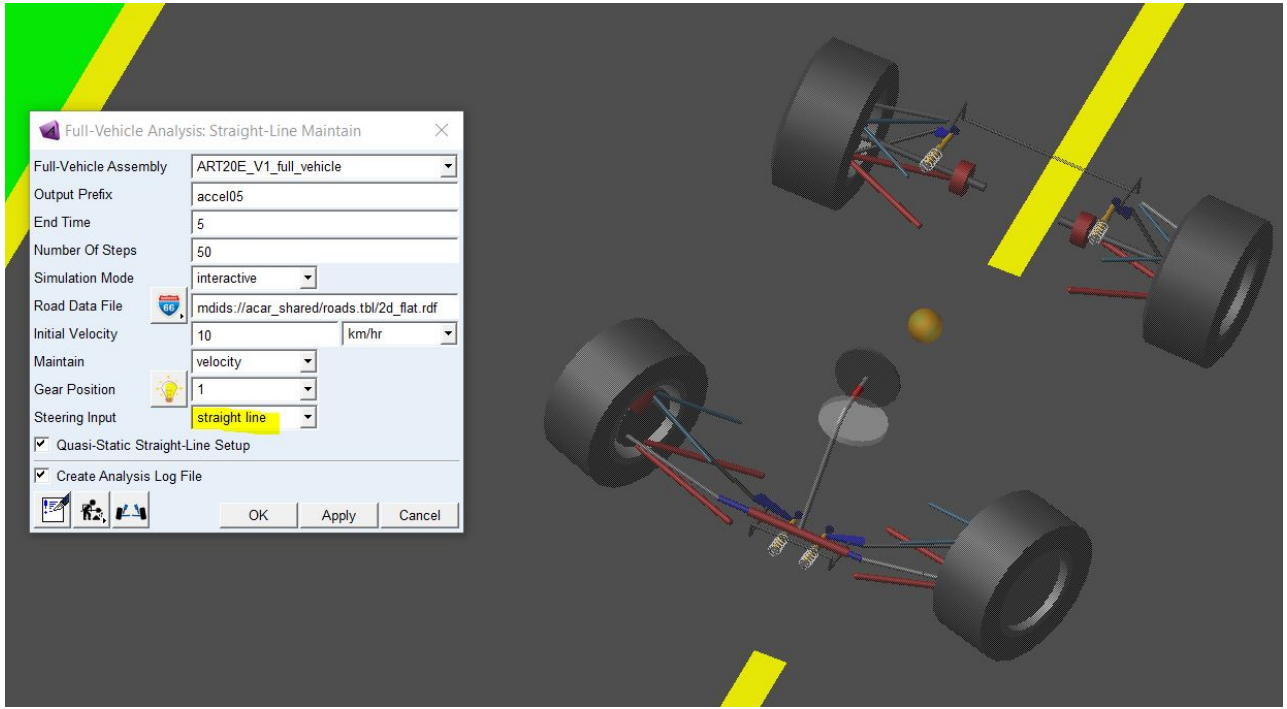
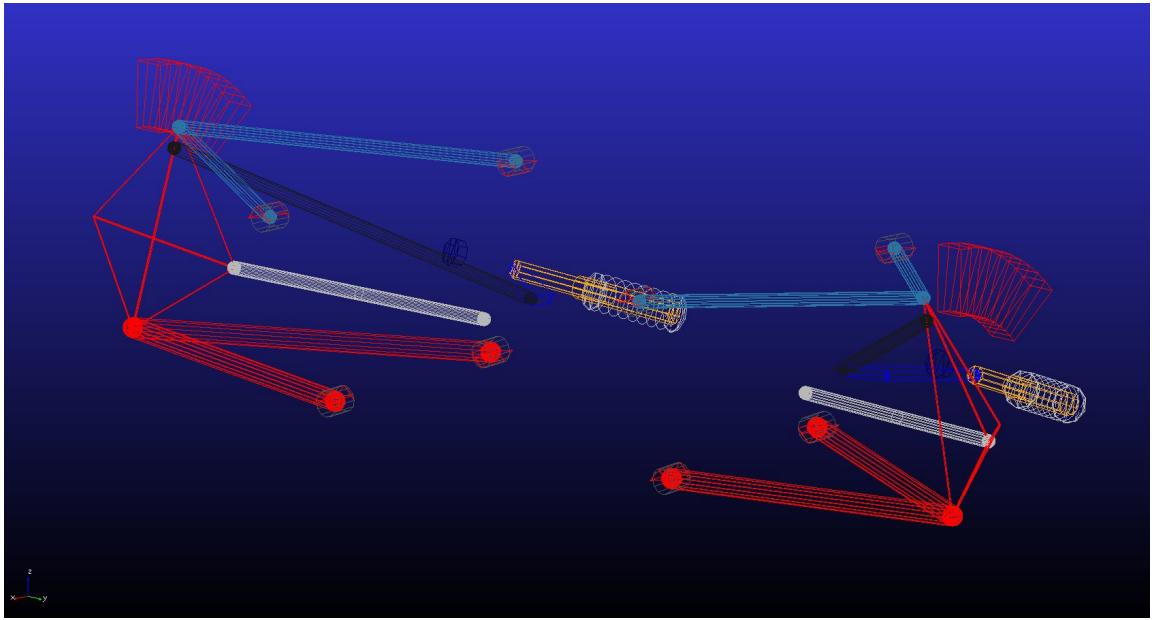
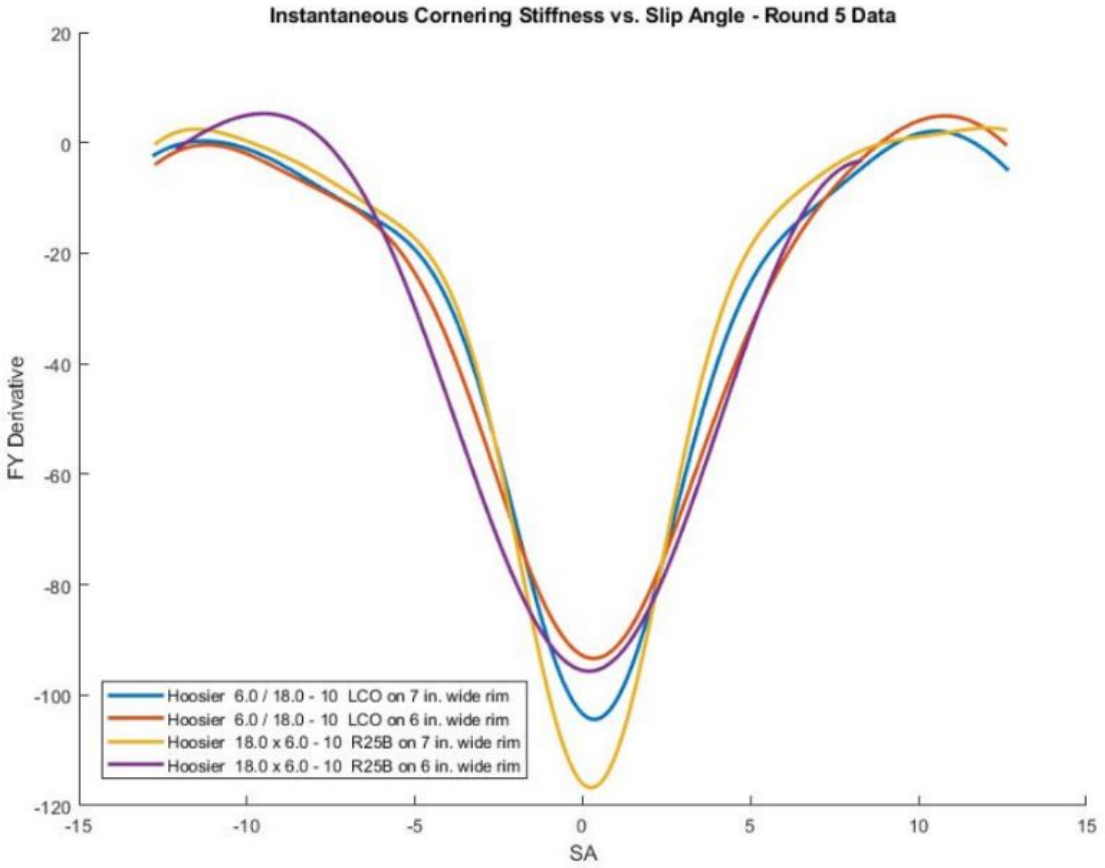


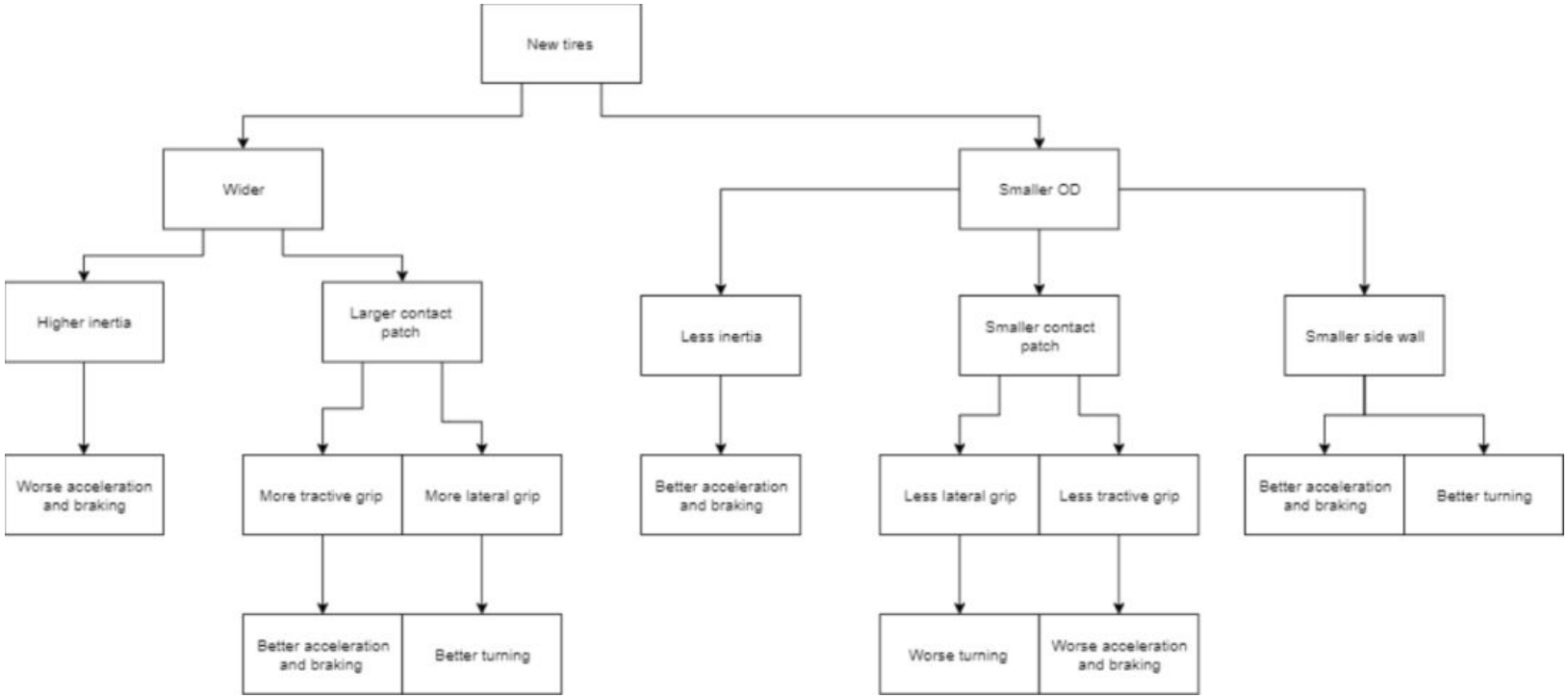

Full-Vehicle Analysis: Straight-Line Maintain
Full-Vehicle Assembly
ART20E_V1_full_vehicle
Output Prefix
accel05
End Time
5
Number Of Steps
50
Simulation Mode
interactive
Road Data File
mdids://acar_shared/roads.tbl/2d_flat.rdf
Initial Velocity
10
km/hr
Maintain
velocity
Gear Position
1
Steering Input
straight line
Quasi-Static Straight-Line Setup
Create Analysis Log File
OK
Apply
Cancel

2019 front suspension modeled in adams



Derivative of Lateral Force vs. Slip Angle




New tires
Wider
Smaller OD
Higher inertia
Larger contact patch
Less inertia
Smaller contact patch
Smaller side wall
Worse acceleration and braking
More tractive grip
More lateral grip
Better acceleration and braking
Less lateral grip
Less tractive grip
Better acceleration and braking
Better turning
Better acceleration and braking
Better turning
Worse turning
Worse acceleration and braking

Steering Considerations