

# SUSPENSION RESEARCH IN THE PURSUIT OF GRIP

### INTRODUCTION

The goal of the suspension is to support the weight of the chassis with a driver and prevent any undesired body motion while maintaining a proper contact patch of the tires at all time. It should also maintain the wheels in proper steer and camber attitudes to the road. The characteristic behavior should resist chassis roll during steady state cornering. Fulfillment of these fundamental goals would result in an exceedingly quick and maneuverable racecar. The kinematic behavior of the system is designed using Lotus Suspension Analysis – SHARK, to optimize the motion of the tires during vertical and lateral movement. Components for the front and rear suspension are designed to withstand the expected forces present during various driving situations. Structural finite element analysis is conducted to validate a safe design of all components.

### REQUIREMENTS

- Allow for wheel travel of 2 inches (1 inch in both vertical directions)
- Visible mounting points to the frame
- Allow for 2 G lateral load
- Adjustable: camber and toe
- Minimum ground clearance of 5 inches
- Shall meet the standards to pass "Tilt Test"

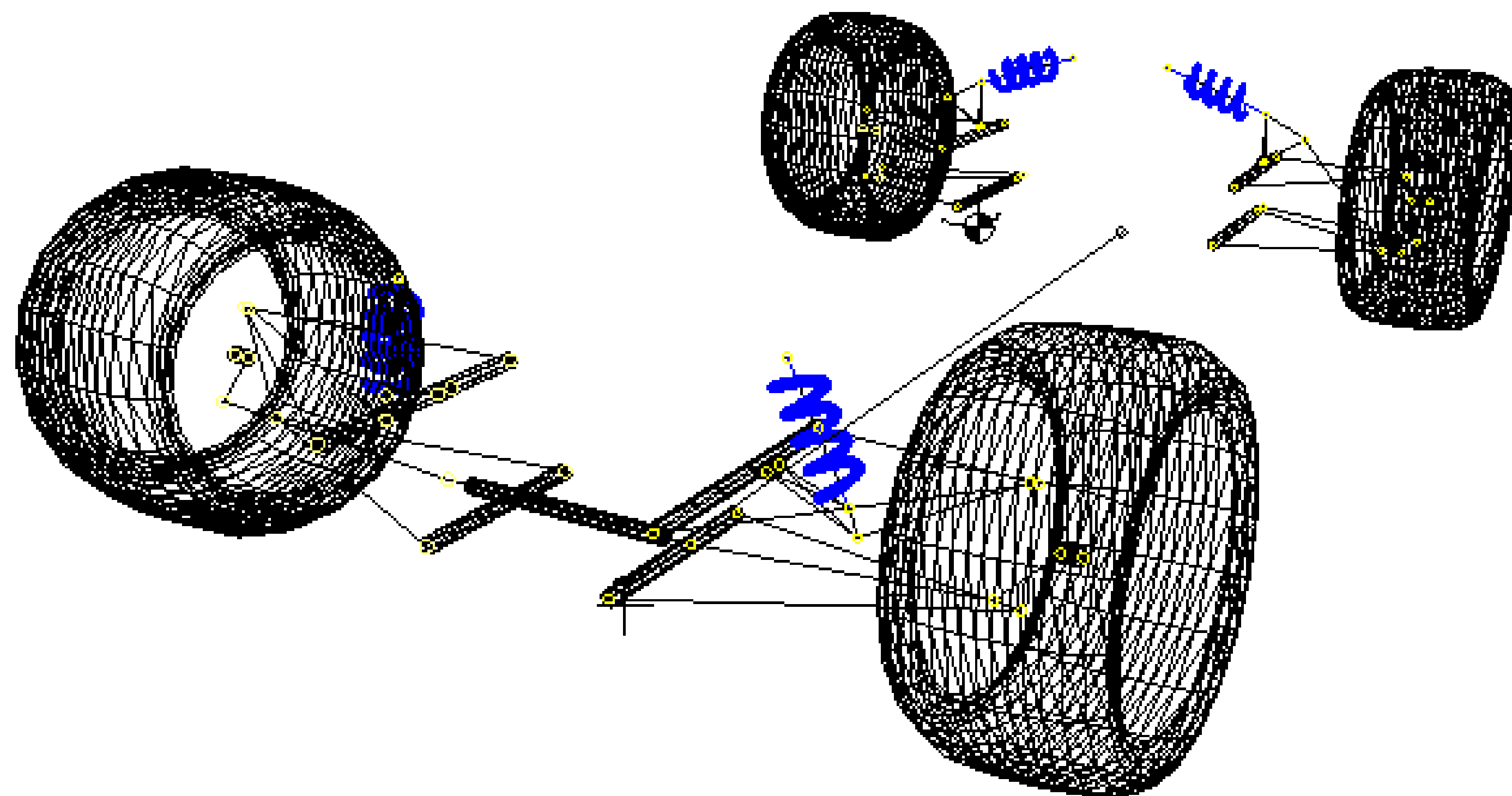


Figure 1: Suspension Kinematic Model Designed in LOTUS SUSPENSION ANALYSIS - SHARK.

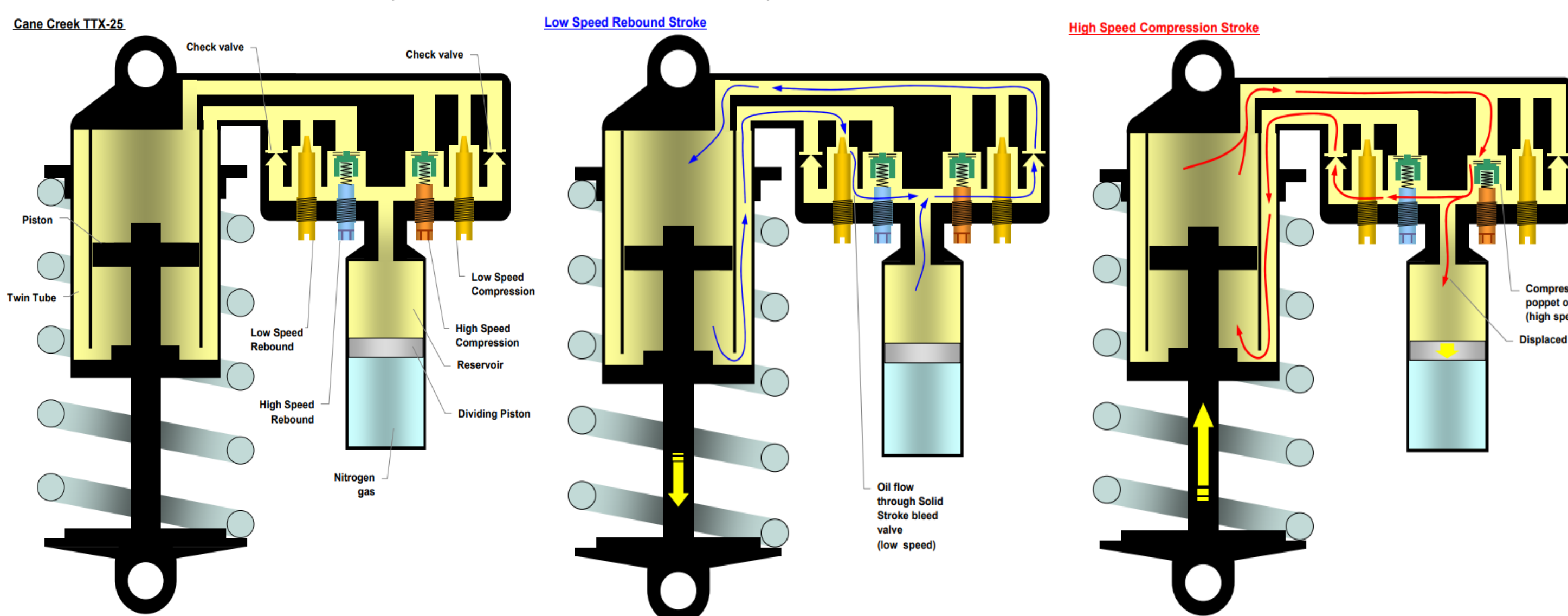


Figure 2: OHLINS TTX25 MkII Damper Designed for FORMULA SAE Internal Schematic

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### ABSTRACT

The ERAU Motorsports team in Daytona Beach designs and builds a high caliber FSAE car for the Michigan competition each year. As part of the engineering curriculum at ERAU the team is mainly comprised of juniors and seniors who are mechanical engineering students studying high performance vehicles. In a way to strengthen the teams understanding of the dynamics of the vehicle, a group of students traveled to the OHLINS facility to utilize their advance 4-post shaker rig. A test plan was developed in order to achieve a wide range of usable data in the limited time allotted for testing. With assistance from the engineers at OHLINS the team was able to run 27 test with a range of input variables of the shaker rig while the team made adjustments to the dampers and spring settings on the car. Throughout the day the team found success in terms of mechanical tire grip with a 2% increase on the front and an impressive improvement of more than 20% on the rear. Perhaps the greatest take away from the day was the discovery of the effect of friction in the moving components of the suspension. This understanding helped the team redesign the main pivot point of the suspension on the front and rear. The team is making plans to return to OHLINS with the new car with hopes of obtaining valuable data for design judging at competition.



Figure 3: ER-03 on the OHLINS 4-Post Shaker Rig in Hendersonville, North Carolina

### PURPOSE

The main objective of the test was to gather information and data to develop a deeper understanding of the vehicles dynamics. Specifically, the damper's various valve settings were explored to optimize their performance. The different spring and damper variables were explored in a controlled environment to develop a relationship between the adjustments and the vehicle's forced and natural responses.

### ANALYSIS

The data from the 4-Post shaker rig testing of ER-03 shows that there is a dominate presence of friction within the suspension system. Mostly contributed from the bell crank pivot location mounted to the frame. Throughout the series of tests, a 21.71% rear grip improvement was found. Redesign of components to reduce friction for ER-04 and years to come.

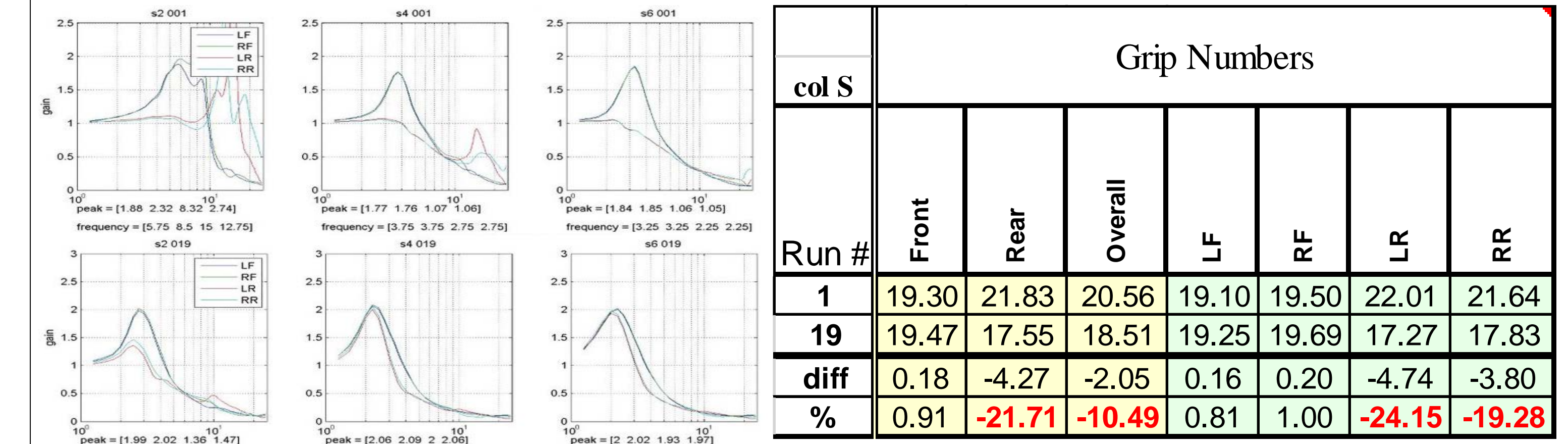


Figure 4: Data from 4-Post Shaker Rig Testing at OHLINS USA Shows Improvements Between Test by Reducing Friction of Major Rotating Components in Rear Suspension Area

The values associated with grip correlate with contact patch load variation (CPL Variation). It is the normalized RMS value. Lower number is less tire force variation, hence better the grip.

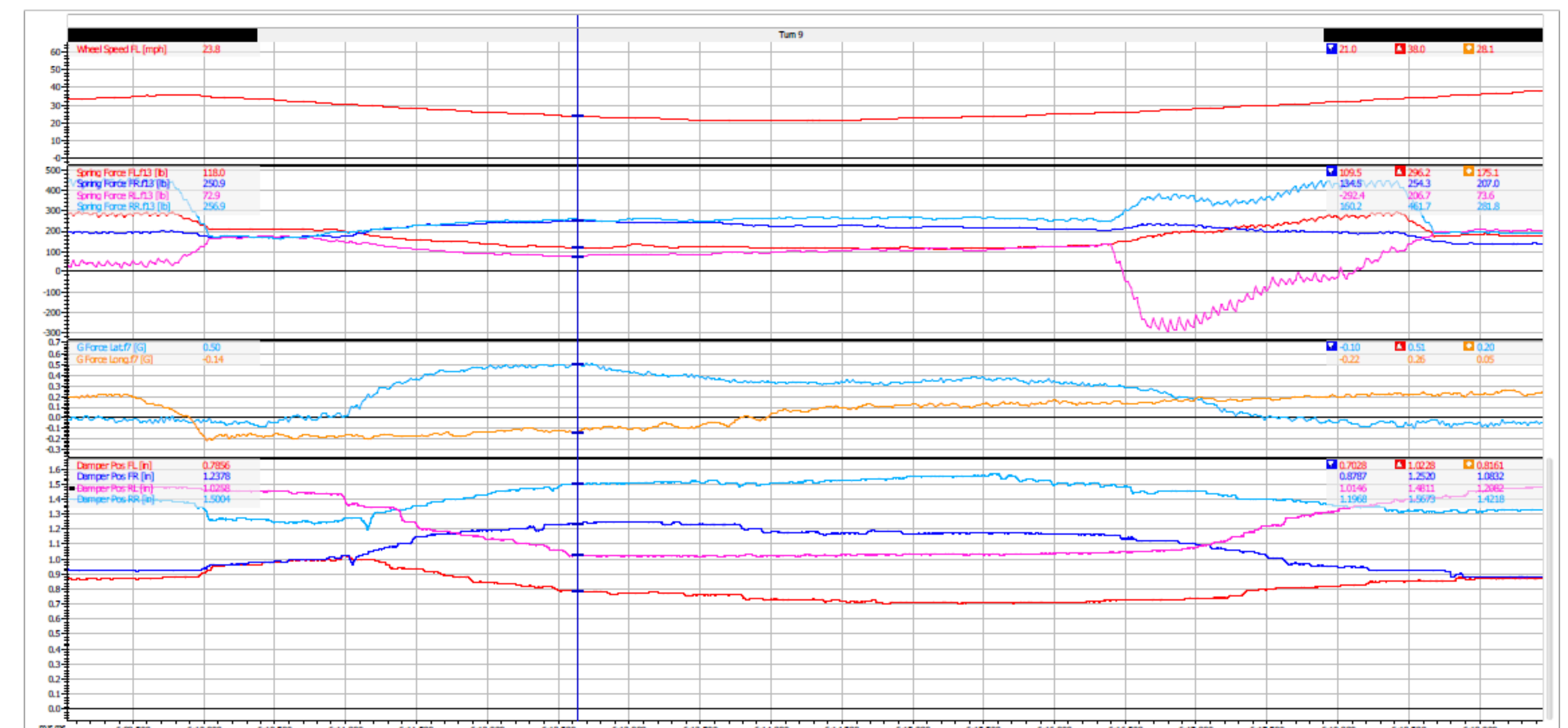


Figure 5: Data Acquisition From Onboard Sensors During Physical Testing

The graphs above show where this research is leading. Above is data we gathered using the vehicle's load cells in conjunction with other sensors. With this data, we are working on writing a program to separate the tire normal forces to generate the results from Ohlin's without using a dedicated shaker rig. This technology could be applied to improve grip of performance vehicles by increasing the amount of data and information generated during normal vehicle testing.

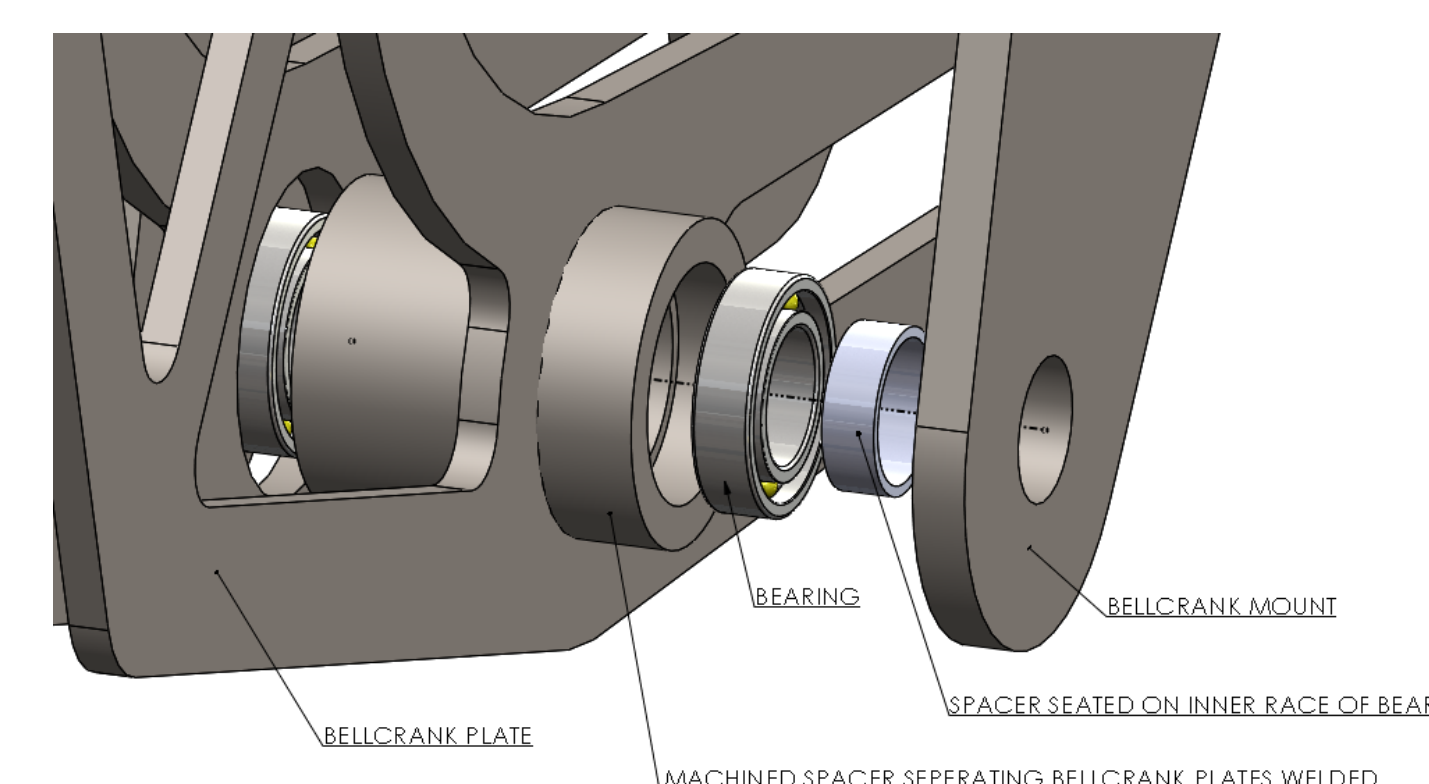


Figure 6: Design for Front and Rear Bellcrank Pivot Location Mounted to the Frame

Currently, the new bell crank design utilizes the inner race of the as the pivot point. Two individual ball bearings are pressed into a separating spacer inside the bell crank. A turned spacer sits between the welded tabs and ball bearings.