

SUSPENSION DESIGN

Every difficulty slurred over will be a ghost to disturb your repose later on.

Frederic Chopin



Over 1500 hours were spent designing the chassis.

Larry didn't want any modifications to the shape of our car—which presented some challenging constraints on the design of the vehicle. Handling was our top priority, so we started with suspension design. We digitized one of our cars and placed the body and wheel data into a computer to establish a baseline to work from. Then, we put in the CAD data for the engine, transmission, and differential. Next, we designed the best suspension kinematics we could possibly fit in the area we had to work with between the wheels and around the engine and other parts. When we finally had the suspension exactly how we wanted it, we designed the chassis to the suspension pick-up points.

Obviously, suspension design is critical to the handling of the car. My brother Thomas has spent his life studying race cars. His expertise was invaluable to

create the proper kinematics of the suspension. The suspension was designed as a short-arm, long arm (SLA) suspension patterned after almost all modern, purpose-built race cars. We worked very hard to come up with the best “street” suspension that could possibly be made to fit in the package we had to deal with. Many “Hot Rodders” mistakenly think they want a “race car” suspension when, in fact, it would be totally unacceptable for street use. A race car suspension would be much too stiff and harsh for street use. Also, an F1 suspension typically has very little travel because the less a suspension travels, the easier it is for the engineers to control the camber and toe change of the wheel. However, bouncing off curbs and potholes on the street with F1 suspension rates will quickly make the driver's eyes blur.

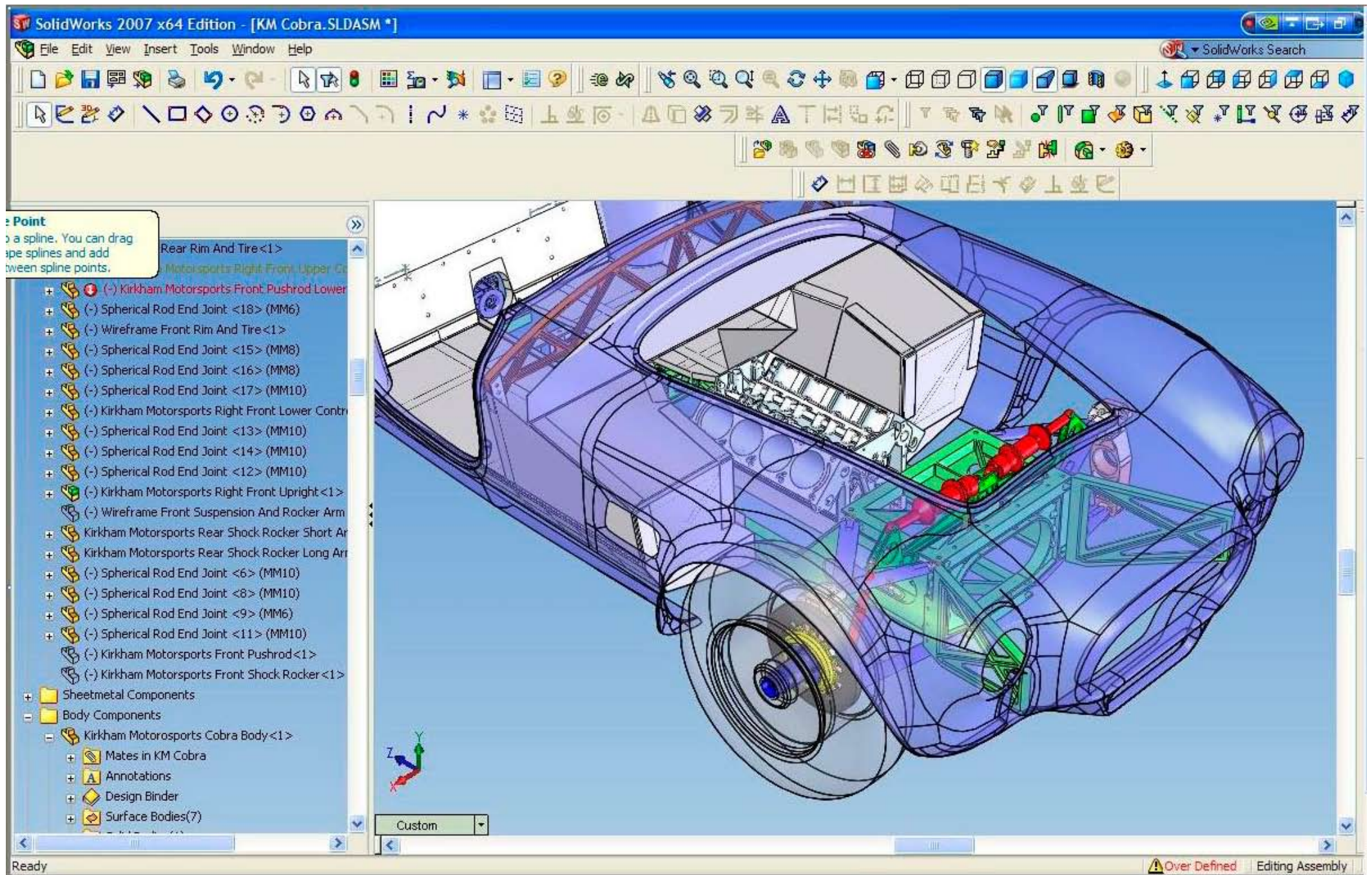


Digitizing the body shape.

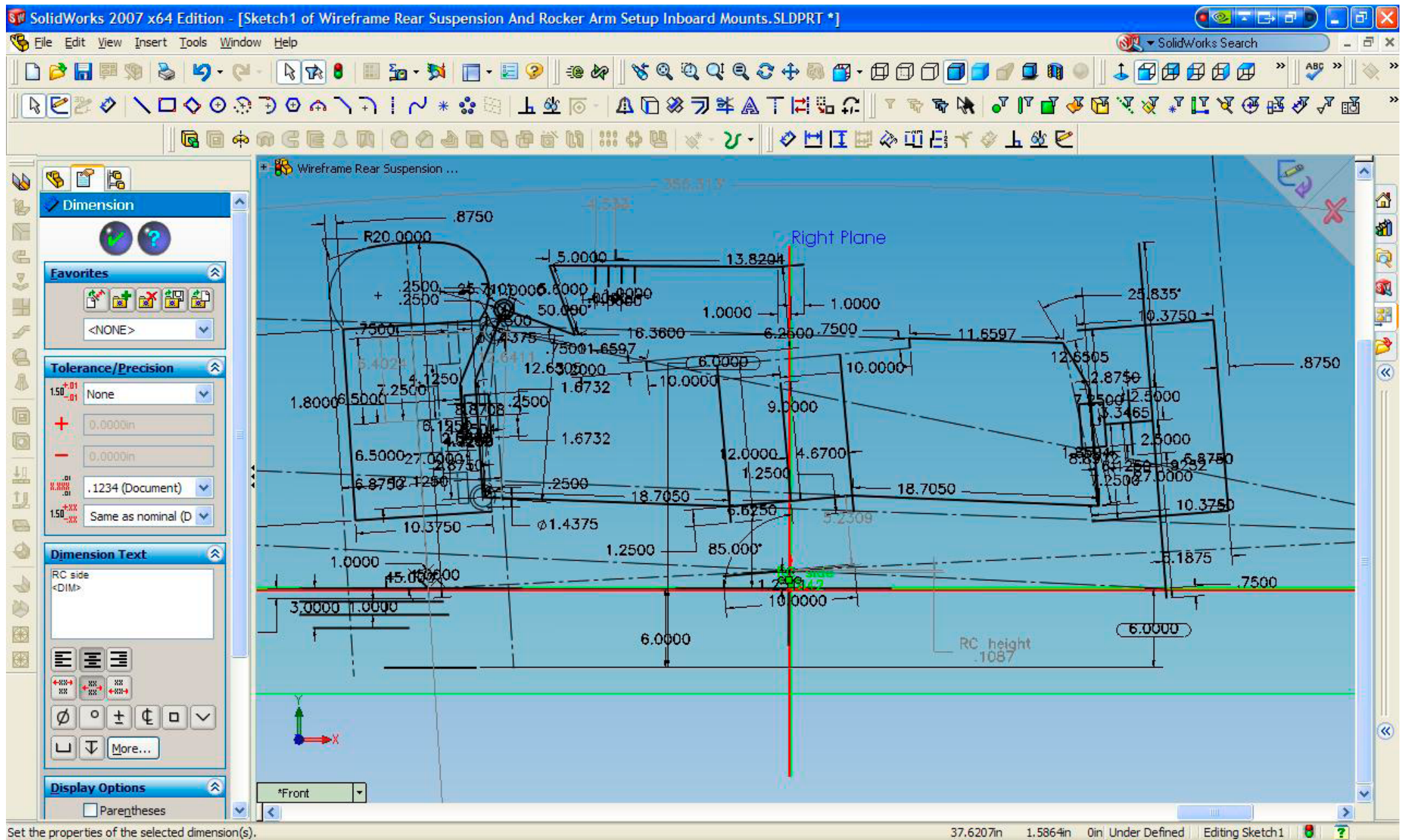
We needed the entire body—with all the substructure tubes, engine, transmission, seats, interior panels, wheels, and differential—in a CAD model to define the boundaries of the car, as we were not going to change the shape of the car. The CAD model provided an accurate datum so everything could be packaged correctly. In the above picture, everywhere the tape lines cross on the body, a point is taken by the digitizing arm and recorded in an X, Y, and Z dimension. The points are then “stitched” together into a surface by the computer.

We used the CAD data when designing the suspension and chassis to fit all the parts correctly in

relation to each other. With Solidworks (a CAD modeling program), we were able to virtually move the suspension model up and down and evaluate the kinematics of the suspension throughout its travel. “Bump steer” (the change in toe as the suspension moves up and down) is a vexing problem in any suspension design. If the toe changes too much under travel (or in an undesirable direction), the driver will describe the car as nervous, vague, unpredictable, or even scary. The original Cobra has “puckering” bump steer characteristics. As all drivers of an original car can tell you, sometimes they don’t know which end of the car is doing the steering.

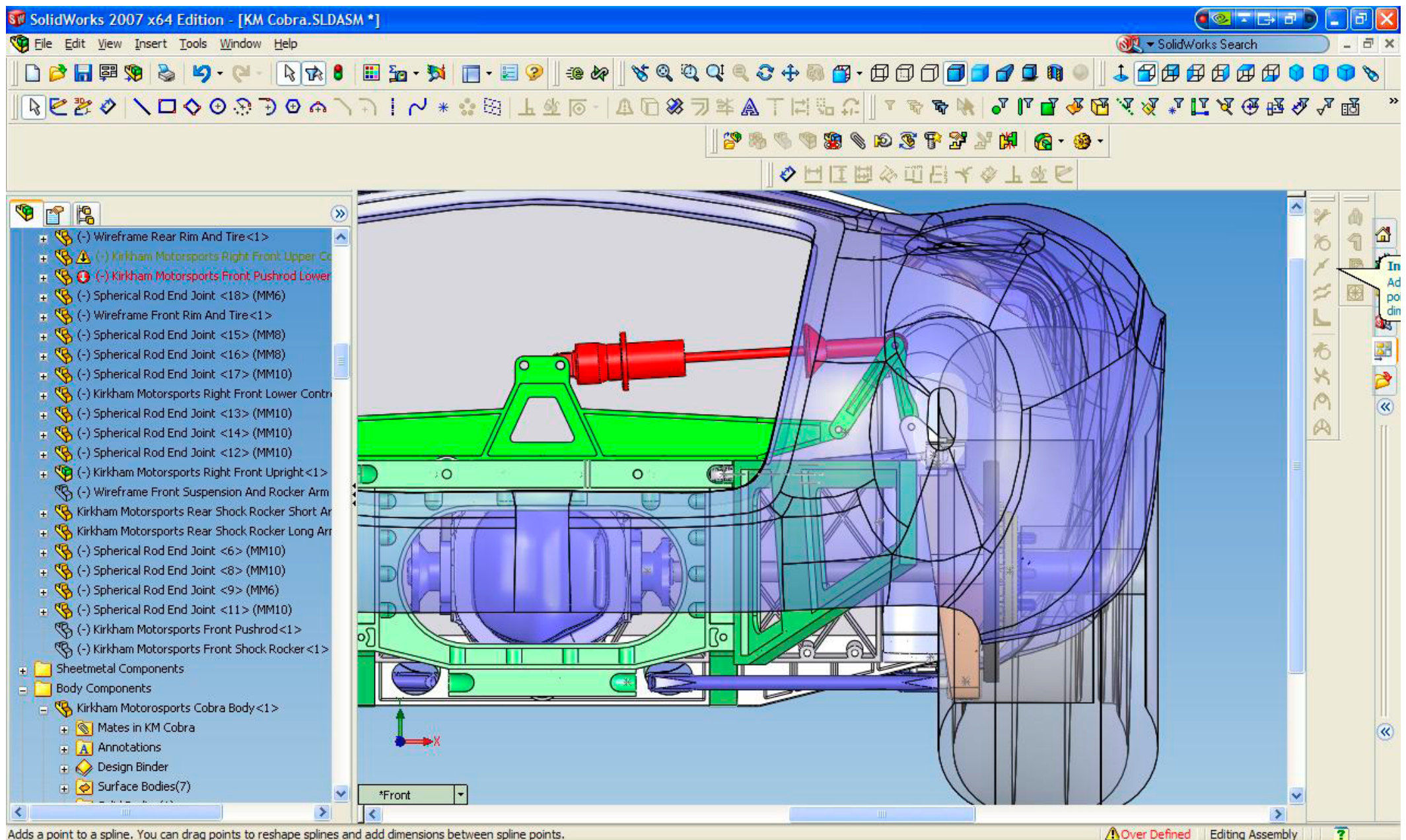


The first thing we did on the computer was to place the body over the wheels to see how much space we had to work with to design the suspension.



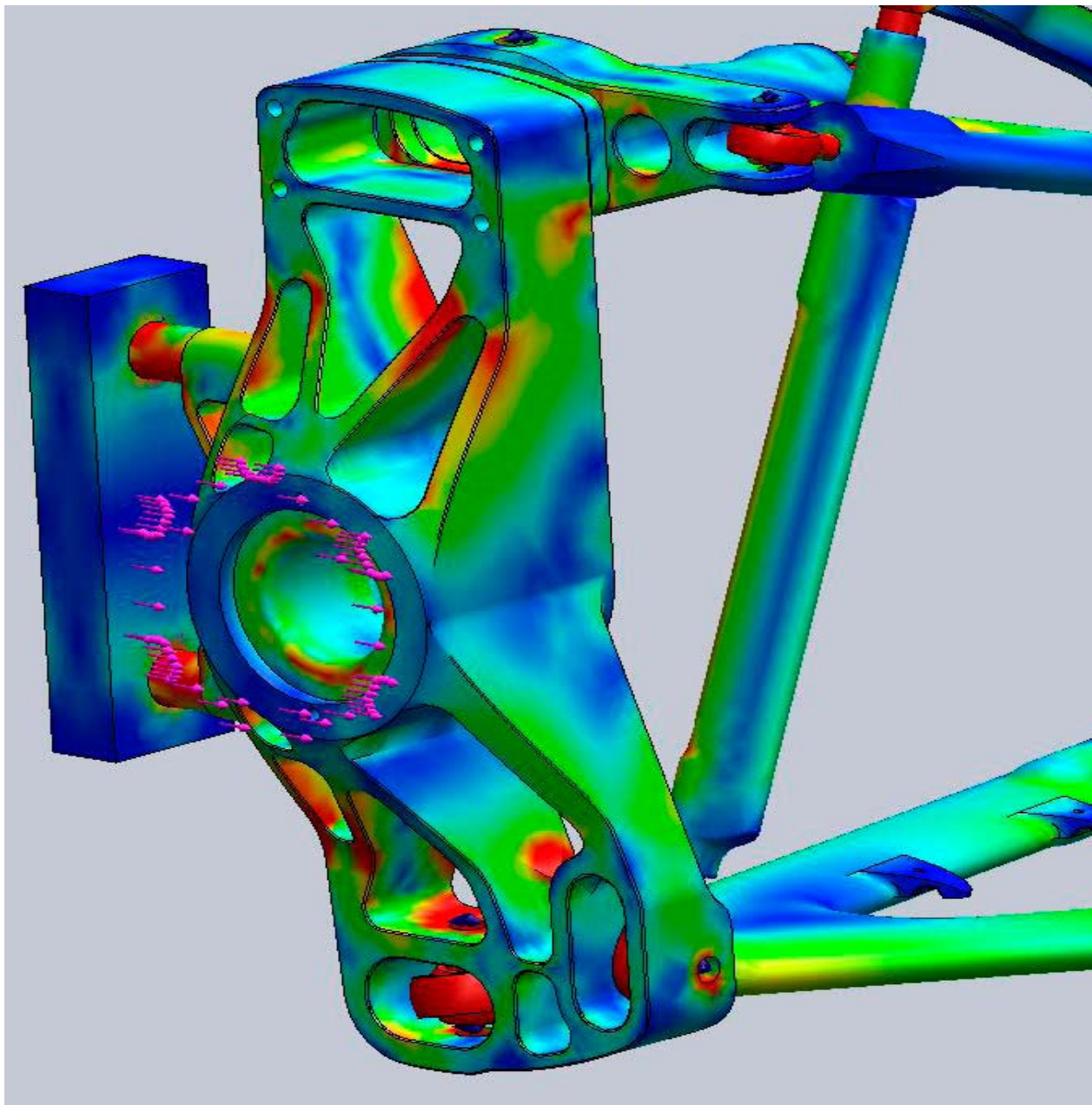
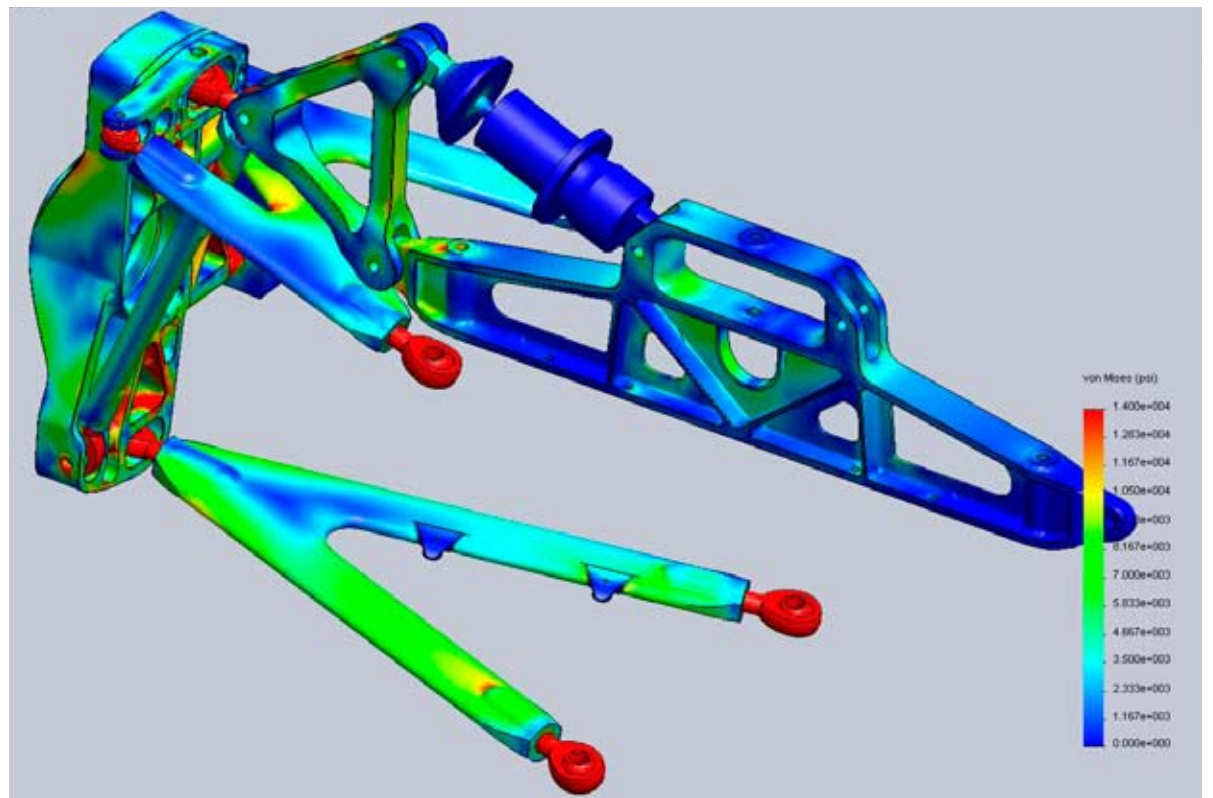
In this screen capture, the car is leaning into a corner as if the car were turning to the right and the weight were shifting to the left. The “center” about which the car “rolls” is called its “roll center.” The roll center of the front and the rear need to be close to each other so the car does not become unstable in a corner.

Opposite: Solidworks allowed us to design the suspension to the best possible kinematic compromise for the given package.



This is the first version of the suspension we designed; we later updated it with lighter parts. The rear lower control arm is placed horizontal at ride height so the tire scrub is minimized for the first up and down movements of the chassis. The body is translucent to check for any interferences.

The different colors in FEA (Finite Element Analysis) represent different stress levels in the suspension. Blue represents the least amount of stress and red the most. The rod ends are red because we told the computer they were made out of the same 6061 aluminum alloy as everything else (to simplify the number crunching). The rod ends are actually made of high strength, 4340 chromoly steel, nickel plated to prevent corrosion. The entire suspension was modeled in FEA—maximum braking, maximum acceleration, maximum compression, and maximum rebound.



In these pictures, you can see why we call FEA “Looking for rainbows.” Red areas in the upright signal areas that need attention. Most interestingly, sometimes you can actually remove material in the red areas and make the part stronger and lighter at the same time.