Finite Element Analysis

Solid models are a vital design tool.

The solid model is created by using a planar extrusion that gets revolved around the axis of the hub and we effectively then apply more detail to it in the CAD although for our modelling purposes we remove some of that to try and save ourselves some elements. So for example on the thread, which you can see here is obviously quite a sharp detail which records a lot of elements, we remove that on the model here to try and save ourselves some computing time, because it's irrelevant to our results really. And also any small radii that aren't associated with the structure of the component we will also remove.

So the load case we are considering is cornering which means there are loads associated with that exclusively to this case on the bearings which we apply in a distinct fashion using pressure distribution. The constraint applied on this flange is actually our primary constraint for the model and this restricts axial and radial movement. There's also a force applied to the nut to represent the pre-load, that is obviously on there when the nut is tight, and the wheel load is applied at a distance away from the centre of the axle to represent the moment that's applied, and this may actually cause parting of this joint with the wheel which means there are higher stresses here than would otherwise be the case.

In short this is a linear static analysis in this case, which represents the load case using just a single load, which is obviously not the case in reality, so to actually try and work out the life of this component based on all the load cases we apply to it, we actually use the materials data against a fatigue life to try and come up with some approximations of its effective life.
Lewis made a lot of interesting points there. First he confirmed that the analysis will be a linear static analysis even though in reality the situation is highly dynamic. Nothing wrong with that - as long as we keep in mind this and all the other assumptions we are making.
For the linear, elastic, isotropic and homogenous material (steel) we only need the modulus of elasticity (Young's modulus) and the Poisson's ratio of strains for the material behaviour to be modelled.

And he explained how the model for analysis can be adapted from the computer aided design model but with a lot of information stripped out. One of the more difficult things to model correctly is contact between mating faces, particularly where restraints are concerned. In this exercise one of these would be where the bearings' outer surfaces fitted and contacted the upright.

Red Bull get around this by trying another approach. Instead of modelling the bearing outer surfaces as some form of contact restraints they actually load them with a pressure. After all in reality they would experience a pressure in reaction to the loading of the wheel. In this case Lewis put the pressure loads on first, having worked out beforehand what they'd be to balance the applied wheel load. He specifies the pressure loads on the outer surfaces of both bearings, each as a sinusoidal distributed force.

This means though that the model is not restrained yet and we need to do something to it to stop it flying off into space, theoretically anyway, when the loads are applied. Lewis had restrained the degree of freedom in the axial direction representing the thrust face behind the wheel flange and then specified a zero displacement for one bit of the flange, here at the top.

This is a neat way of representing the real situation in computational terms. It does mean though that in this region of the restraint there may well be some localised high stresses computed. We know that they are not there in reality and can be ignored, but that the rest of the model results are valid.

The same goes for the application of the load. Remember that this is offset down at ground level. This means that there will be an end force on the hub and a moment. Lewis applied the load at its notional real position, including the offset. He connected it to the hub model using a special rigid body element and chose the amount of offset to give the maximum possible moment effect - when the wheel and flange part company.