I think it is possible to draw a distinction between two types of shock adjustments you might make. The change is either for:
(a) Response, control of the chassis platform, and/or "wheel control"
(b) Balance.
And we should probably add another.....
(c) Genius at work.
We should be aware that some changes we make under (a) can change balance.

There is general agreement amongst racing people about the aims of shock tuning for response, control of the chassis platform and tyre compliance. We want quick response, but not too quick for the driver to handle, good control of the chassis platform, and good tyre compliance. We could consider adjustments to rebound particularly, but also bump, to improve response in initial turn in, improve power down, and control the car in roll, dive and squat. These are the most important shock adjustments. A general procedure for baselining shock settings, as recommended by most racing shock manufacturers, is shown at the bottom of this page.

But shock tuning for balance is a different story. Many of the popular Authors on race car set up and handling have got errors in their descriptions of what is happening, or wrong suggestions for changing shock settings. The same applies, amazingly, to some shock absorber company manuals, and tuning advice issued by them. Also many people setting up and/or driving race cars must get confused, if they make a change going in the wrong direction.

## Smithees Shock Tuning for Balance Procedure:

With shock tuning for balance, you are choosing a particular transient (corner phase), a movement of the car, where you can wedge or de-wedge the car, sometimes to increase overall grip and at other times, to make the car more progressive for the driver. For example, you may want to improve turn in, or reduce the onset of oversteer on corner exit. Note that improving one corner phase may influence another corner phase for the better, or worse. (See Neil Roberts article.)

1. Draw a diagram of your corner phase showing where the weight is going - an arrow from the shock(s) in rebound to the shock(s) in bump.

2. Consider the affect of weight transfer for the front wheel pair first, and then the rear wheel pair <u>seperately</u>. Is the weight (as indicated by the arrow on your diagram) moving towards the inside wheel, or the outside wheel? This will tell you if you are adding to inside percentage, or decreasing inside percentage, for each of front and rear wheel pairs.

3. Consider whether the increasing or decreasing inside percentages at front and rear are adding to your aim of wedging or de-wedging the car, or subtracting from it.

4. If the weight movement is helpfull, stiffen that shock (or shocks). This will speed up the weight transfer. If the weight movement is in the wrong direction, soften that shock (or shocks). This will delay the weight transfer. For road racing, we change both front and/or both rear shocks so that the car behaves the same for RH & LH corners.

We know it is inside weight percentage, front vs rear, that affects balance. So for the diagonal weight transfers, as described by Neil Roberts, if we soften one corner, we always stiffen the opposing corner, and vice versa. There are any number movements of the race car which you could influence using our tuning procedure. As with all suspension tuning, the chassis must be stiff enough to allow the loads to build, and the shocks need to be in a tuneable range.

## Shock Tuning Concepts

As far as I know, nobody disputes the basic model of weight transfer. There may be extra layers of complexity added to it (see Claude Roulle article). More often than not, there will be other factors at work, quite apart from weight transfer theory, which will wreck what we are trying to do with shock adjustments for balance. This happens all the time with race car set up, so we can live with that. It is probably the reason why so many erroneous shock suggestions have got into print in the first place. In fact, there may be a case for not trying to use shock adjustments for balance at all. We could do the best we can with response etc as per (a) above, and balance the car by any or all of the other means at our disposal.

But, as Neil Roberts says, it is worth giving it a try. Fortunately, the weight transfer effects on tyre loadings from shock adjustments are always clear, always applicable, for all types of race vehicles, or tuneable road cars. There is no room for ideas such as "if the shocks were way stiff (or way soft) it might go the other way".

1. With shock tuning for balance, we are wedging and de-weding the car (or leaving wedge unchanged), just as we do for with springs and antiroll bars, except that shocks are only applying loads while they are moving in bump or re-bound (transients).

2. The stiffer shock always transfers weight faster than the softer shock, in both bump and rebound. Everyone knows stiffer shocks give you faster response, but many stumble when it comes to applying it to shock tuning for balance. If we increase shock stiffness in bump and/ or rebound weight transfer happens quicker, quicker response. We happily use this fact tuning for driver feel or for "hitting" the tyres harder or softer etc - as per (a) above. The weight transfer will always follow this rule, from super stiff shocks right through to very soft shocks.

If a shock is bound up ie shock stiffness goes to infinity, weight transfer is almost instantaneous, like hitting a hard bump stop. If the shocks have failed completely ie shock stiffness is zero, weight transfer is slow and spongy (and of course the chassis hunts around in an uncontrolled manner). Why not let the same rule we use for response transients apply to shock tuning for balance as well?

The effect of a shock hitting full droop is interesting. Any weight left to go must instantly be transferred to the other side. At the rear this could cause snap oversteer, and lack of tyre compliance on the inside rear wheel for acceleration. All bad. So why would we do it on the front - the so called "zero droop" front suspension? A negative effect could be understeer as the final amount of weight is transferred. At least understeer is more stable. There are a couple of positive effects I can think of. The car would stay jacked down at the front, helping aerodynamics (less air under the car), and negative camber in droop would be reduced, helping grip on the inside tyre. Maybe the slightly lower CG at the front is enough to reduce weight transfer somewhat.

3. The stiffer shocked wheel pair will always transfer more weight than the softer shocked wheel pair (just as for wheel pair stiffness from springs, bars and suspension geometry). Each shock adds to wheel pair stiffness, whether in bump or rebound. Shock forces add to roll and pitch resistance. In bump, it's easy to see the shock resistance adding to spring resistance. In rebound, it is very important to visualise how the rebound shock force is adding to wheel pair stiffness as well. The spring is letting the weight go, but the shock is being extended by the chassis movement. The force it generates is resisting chassis roll and pitch. You can see there are quite powerfull forces at work here that we should use to our benefit. Shock rebound force and shock bump force are working together to resist roll and pitch.

4. A stiffer shock transfers the same amount of weight as a softer shock. Think of it like this. As weight is transferred in the car, and the chassis rolls or pitches, the loads build up in the springs and bars. In the initial phase of roll or pitch the shock is doing most of the work - the springs/bars have not moved enough to build much load yet. As the loads build in the springs and bars with more chassis movement, shock shaft speed reduces, and shock load reduces. As the the shock stops moving the spring/bar is taking all the load. Therefore load transfer is the same for stiff or soft shock.

5. In the last phase of roll or pitch, the stiff shock in rebound is still be moving, while a softer shock would have already stopped. The chassis is still moving. Won't the stiff shock still be transferring weight? No, it will not. The weight has already been fully transfered. The wheel loading is constant. All that is happening is the stiff shock overpowering the springs and bars, and the chassis is jacked down a bit, until the springs/bars take all the load away from the shock.

6. The Most Common Mistake: "Less front rebound allows for a greater amount of weight transfer to the rear under acceleration." We know this is wrong. The same amount of weight will transfer for stiff or soft rebound in the front. So why would drag cars go for very soft rebound in the front? I guess it would be to hit the rear tyres not so hard and to pitch the car high in the front, so as to overshoot the front springs in extension. This, along with some pro-lift in the rear suspension, might lift the centre of

gravity, and this will transfer more weight. The exagerated chassis movement might also create some inertia to help rear tyre loadings. I think they call all this "wrapping the tyres". None of it applies, except at the drag strip.

7. Let's very quickly revise weight transfer in pitch. Most racing people understand weight transfer in roll well enough. Pitch is the same as roll turned around 90 degrees. So, instead of front and rear wheel pair stiffness, the amount of weight transfer will be in proportion to RH and LH wheel pair stiffness. For road racing, RH and LH wheel pair stiffness will be the same. So weight transfer in pitch is 50-50 each side. The car is not wedged. For asymetrical speedway set ups, if the car is RH stiff, the RHS side transfers a greater percentage of the weight transfer. The car is wedged in forward pitch, and de-wedged in rearward pitch (in relation to LH turns). If the car is LH stiff, the car is de-wedged in forward pitch and wedged in rearward pitch.

8. We need to work with the shocks showing the greatest movement, otherwise the effect we are after will be cancelled out. This might be determined by driver description, track side observation, or from data acquisition.

Neil Roberts is a CART Crew Chief. His excellent article on suspension tuning with shock absorbers is here....go to the Neil Roberts article.

Neil describes some corner phases and then gives you a chart showing shock changes you could make to influence car balance - either more understeer, or more oversteer.

You can actually derive his chart by applying our shock tuning procedure..

Here's one easy tuning adjustment that always works. Where the whole car unloads over a rise in the track, all 4 corners go into rebound. For instance, as you come off the dogleg at Oran Park, the car goes light and you are still turning left. (Too many Konica V8 Lite Supercars have looses here.) Set your front low speed rebound stiffer at the front than the rear. The stiffer front end will unload the most. So our car will be momentarily wedged (tighter). If shock settings were stiffer at the rear, the car would momentarily de-wedge (or be loose).

If it were possible to work out which end of the car was moving the most, either by observation or on-board data, you could change one end only.

Go to next page for the Neil Roberts article......

## More on Shock Tuning:

The shocks must be in sync with your springs. If you increase your spring rate you probably decrease shock bump, and increase shock rebound, and vice versa. You need shock dyno graphs to show that your shock adjusters are working as expected, and matched between shock pairs. You will probably want a fair bit of "nose" on your graphs, irrespective of whether you have low speed adjustment or not. This is to give you good low speed control over the chassis platform. As a result, you may be able to run softer springs to increase tyre compliance with the road.

Your bump curve on the dyno graph will probably be digressive ie flatten out with increasing shaft velocity, so the car is not too harsh. Your rebound curve should show increasing force pretty much in proportion to shaft velocity, and only digress at higher shaft velocities. You will want as much rebound as you can, short of jacking the car down excessively, lifting wheels clear of the road, or where too much rebound affects power down.

Hopefully, your car will work over a reasonable range of shock settings. Only then could you consider using shock adjustments for balance, as per (b).

Adjustments as per (c), "genius at work". There must be something in it, if shock technicians spend so much time poring over data and shock dynoing, looking for an edge.

**PLEASE READ THIS.....**

**There is a huge caveat on all of this as it relates to shock tuning for balance - you must work on the shocks with sufficiently greater movement for it to work.** Also the driver must be consistent with the way he balances the car as he drives, otherwise the movements of the car may be different. The worst situation would be if the other side of the car was moving more than you thought. Then your knowledge of wedge tells you, you could get the exact opposite effect from what you are looking for.

Speedway teams are at less risk of getting it wrong. They only need to change one side at either front and/or rear.

Consider the following table from the Carrerra Shocks website:-

**Tech Tips**

**If you only run at one track, you've probably got your set-up down pat. However, if you travel to different tracks getting your car handling well, quickly, is a must if you want to win.**
**Here are a few tips to help you get close.**

**from the pros!**

| ASPHALT HANDLING TIPS | |
|---|---|
| • Short Tracks: | Softer all the way around. |
| • Flat or Tight Turn Tracks: | Softer rears. |
| • High Bank Tracks: | One step stiffer on RF & RR. |
| • Push Going In: | Softer compression on RF or stiffer rebound on LR. |
| • Loose Coming Out: | Softer RR or stiffer rebound on LF. |
| • Loose Going In: | Softer rebound on LR or stiffer RF. |

The first three are suggestions are for wedge or de-wedge in roll, which would could only be considered in context with the overall set up.

Look at the "going in" examples. They are assuming no trail braking. Roll only, no pitch. So there suggestions should work OK.

The interesting one is "loose coming out". At first sight it might look the complete opposite of what we've been talking about. Look again. Their suggested weight movement is going on the opposite diagonal to a Phase 4 corner exit. They must be sliding the car a lot, with opposite lock under accleration. Would seem to be a good change for a big power dirt car. Interesting, eh. But they should explain what movement of the car they've got in mind, like Neil Roberts does.

The beauty of it is that because we only have to change one side at front and/or rear for the left turns, the worst we can get is probably no effect. For road racing, where we have to change both sides, we could be way wrong, and make our problem worse.