Chassis Set Up Manual

SSC Racing

3101 East Alejo Road
Palm Springs, CA 92262

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Techniques and Theory

General Theory

To enable us to properly set up a kart chassis, we must first understand the most basic principals of the racing kart, which is a unit made up of tubes and front steering geometry, propelled through a live axle (one without a differential). Making adjustments to enable the race kart to turn without oversteer or understeer is difficult and challenging. Achieving a well-balanced chassis set up is part art and part science.

Kart racing chassis are designed in a manner to allow it to turn the only way it can without having a differential – with the inside rear tire lifting off the track on corner entry. The outer rear tire drives "around" the outer front tire allowing the chassis to efficiently turn into the corner because the inner rear tire is off the track surface.

If the inner wheel does not lift, no matter how much you turn the steering wheel, the front of the chassis wants to keep going straight, creating an understeer or "push" condition.

When a chassis lifts up the rear wheel properly, the chassis can pivot and drive through the corner. The kart must be set up with sufficient side grip to force the inner rear tire to lift on corner entry – this is by far the fastest most efficient way through a corner.

Generally, when the chassis elements are on soft settings, the kart has less grip. As the chassis elements are made more rigid, grip will be increased, however there are points of diminishing return where the chassis will get too firm to perform properly.

A kart will typically perform best when the rear width is set as wide as possible and the front width is as narrow as possible, *while providing a fast, well-balanced and stable package*. You cannot simply set the chassis on these maximum and minimum settings and hit the track, but this concept will help create a target for your efforts to tune a "happy" chassis.

It is best to work on the end of the kart that is not handling well. If, for example, the problem is understeer, try to solve the problem first by adding more front

grip. If that is not successful, try taking grip away from the rear to balance the chassis.

When the kart is properly set up, steering effort will be reduced and it will seem to "float" through the corners. Remember, the front and the rear of the kart must be in balance, with neither end too tight or too loose. If you turn the steering wheel and the motor load increases, the chassis is "bound," and wasting horsepower. Freeing up the chassis will gain performance!

Engine power is be wasted in several ways, including:

- Brake pad drag
- Friction in the wheel bearings
- Incorrect wheel alignment.
- Misaligned engine/sprockets

Such problems cause increased rolling resistance, which means more power is required to achieve the same acceleration and speed. Since the engine doesn't magically gain power to overcome rolling resistance, The kart just goes slower. If the increased rolling resistance is due to bad alignment, the kart will probably also handle poorly. Small improvements all add up to faster lap times and race wins on the track.

Often, the most stable set up is one where the kart tends to understeer just a bit into corners while braking, and then turns to neutral steering when the power is applied and the kart is driven out of the corner. Not massive understeer, but just enough to hint that understeer is present. Kart chassis' set up this way are stable in the corners and easier to drive. Remember, oversteer may be tons of fun, but unfortunately much slower on the track.

When setting-up your kart chassis, it's a good idea to find the longest corner on the track and set the kart up to bounce a bit (just this side of hopping) in this corner. This bounce should not be enough to put you off line. It should be kept within easily controllable limits. If the kart is set up this way, then it will be giving maximum grip through the longest corner and this is where the greatest gain in lap times is achieved.

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General Set Up Conditions

Chassis Attitude

The chassis attitude (frame in relation to ground) should slope from front to rear – the front being slightly lower than the rear. Adjusting the ride height with axle carriers in the rear and or kingpin shims up front, attains this.

Engine Types

Generally, 100cc karts will be set up to control understeer, as they do not have the power to require maximum rear grip. Excessive grip will slow the kart down, overall. Shifter karts require a higher amount of weight on the rear wheels and more chassis tuning to create increased rear grip.

Tall Drivers

Tall drivers in 100 cc karts will want to make adjustments to reduce grip in order to overcome the additional leverage their higher center of gravity can produce. This may be done with more flexible seats, a softer axle, maximum rear tread width, medium to short wheel hubs, no seat struts, and a general softening of the chassis.

ADJUSTABLE ELEMENTS

Front End Adjustments

Some of the most important handling adjustments are made at the front of a kart. Problems that occur when entering a corner are frequently due to an improperly adjusted front end. Front-end bite and steering response can be corrected by simple adjustments, and toe setting is a good place to start.

Toe in/out settings

Toe settings affect weight distribution, top speed, and cornering response. The more toe in or toe out, the slower the top speed becomes due to excessive drag by the tires. Despite this negative effect, increasing the toe out can have some benefits. For example, increasing toe-out will increase initial cornering response, thus giving the driver a better turn into the corner and reduced understeer. However, if the kart is overly sensitive to steering wheel movement at the point of turn in and begins to oversteer, the toe-out settings may be too high. With toe-out, the inside front wheel moves down in relation to the chassis more than it will with zero toe or toe-in. On a dry surface, a toe setting of 0 to 3 mm out is recommended. For a very high-speed track, setting toe at close to zero may help top speed. Toe-in is not normally used on race karts.

Generally, the goal is to have zero toe when the chassis is fully loaded with the weight of fuel and driver, sitting on the track. Therefore, a heavier driver will need more unloaded toe-in than a lighter driver to achieve a zero toe status when fully loaded.

Remember, kart chassis' deflect under the driver's weight and this deflection affects toe, caster and camber settings.

On road racing tracks (as opposed to sprint tracks), karts will handle and accelerate better with toe set to absolute zero.

For sprint tracks, slight toe-out (rarely more than two millimeters) helps turn-in to corners (except in wet conditions, when larger toe-out settings may be needed to achieve grip).

When setting the amount of toe, make sure the toe settings and adjustments are equal on each side.

If you reset caster and camber, you will have to reset toe as well.

Ackerman

Ackerman steering geometry, which is standard on all race karts, makes the front wheels turn at different rates – with the inside front wheel turning quicker than the outside when turning into a corner. By turning more, the inside wheel lifts the chassis on the inside - causing the front end to shift weight to the outside front wheel – in turn causing the inside rear wheel to lift. Adding Ackerman makes the kart steer much more positively - the driver will notice a decreased amount of steering input needed to turn the kart - reducing fatigue. As a result, the kart becomes more sensitive to the driver's input. In contrast, decreasing Ackerman makes the kart steer more slowly, and more steering effort needed to turn.

Spindles usually have 2 tie rod hole locations; the inside hole increases Ackerman, while the outside hole decreases Ackerman. The tie rods can be lengthened or shortened to fit either hole position.

Caster/Camber Adjusters

For CRG chassis, the adjusters (caster pills) at the front spindles should start at II/II (top/bottom) setting. Refer to the Caster/Camber chart at the end of the manual for the effect of various settings. Generally, karts are quite sensitive to caster adjustments and are not as sensitive to camber changes.

Caster has the greatest effect at corner entry and during the first third of the corner.

Camber has the greatest effect in the middle third of the corner.

The final third of the corner is controlled largely by rear axle setup.

When caster and camber are <u>both</u> set correctly, there will be indication of even wear across the tire face.

Caster

Caster affects the grip of both the front and rear of a kart. It does this by transferring weight to the opposite rear wheel during cornering. Although it may seem complicated, there are a few simple rules to follow concerning caster.

If the caster is decreased, the kart will be easier to steer. Some drivers have noted that it adds feel to the kart and increases bite on the front end. It may be advisable to decrease the caster setting if the track conditions are providing too much grip. The kart will free up and be more drivable if caster is removed.

The driver may want to add caster if the conditions are cold, or if the class requires hard compound tires. This will offer more front grip, less rear grip and help eliminate understeer. For most applications, use the II/II, top/bottom settings on the front end adjusters. Smaller drivers should decrease caster while larger drivers should increase it.

Many teams take caster out of the chassis for qualifying when tires are fresh and have good grip. Caster also causes change of camber when the steering is turned, resulting in more negative camber on the outside front wheel and more positive camber on the inside front wheel.

Importantly, increased caster also increases the jacking effect on the front wheels, which helps unload the rear axle (inside wheel) more on corner entry. If a soft rear axle is being used, it is possible that increasing caster will alleviate an understeering condition by unloading the rear axle more and help balance the chassis. Since the rear tire is lifting sooner in the corner, there is, in effect less rear grip at this point.

Karts are sensitive to caster changes, so adjusting it can be very effective as a primary tuning tool.

Camber

Camber is measured by how far the front tires are leaning in or out as viewed from the front of the kart. If the tire is "leaning in" the kart has negative camber. If the tire is leaning out, the kart has positive camber. Camber is usually adjusted when the track surface is wet. In these conditions, the driver can negatively adjust the camber to find more grip. Camber is the setting most responsible for maintaining the maximum outside front tire rubber contact patch in corners, particularly mid-corner. Setting camber to zero will usually be the best starting point, and camber can be fine tuned by using either tire wear pattern or tire temperatures, measured across the tread, as a guide.

Karts are not as sensitive to camber changes as they are to caster. However, camber can still be used as a valuable tool for chassis tuning, particularly for mid-corner performance.

Front Track(Width)

The most common handling adjustment to a kart is changing its front track or front-end width. Widening the front track creates more jacking effect when turning. This results in more front-end grip and quicker turn in. Narrowing the front track will have the opposite effect. This will result in slower turn in and less front-end bite.

The lack of jacking effect prevents the kart from rotating into the corner due to the inside rear wheel not raising, thereby creating a "push" condition due to the excess traction provided by both rear wheels remaining on the track.

If the kart pushes or understeers entering a corner, widen the front track. If the front track is at maximum width and the kart still pushes, move the front wheels back to the starting position and increase caster/camber. If the kart is over gripping or "binds" on the front when the wheels are turned, reverse the procedure.

A rule of thumb is; the less available grip, the more scrub radius (increase of front width), caster and starting tire pressure should be used. (For more detail on the relationship of starting (cold) tire pressures and racing (hot) tire pressures, read the section on Tires.

Rear End Adjustments

Rear end adjustments include wheel hub length, track, rear ride height, axle stiffness, bearing locations and seat struts. Changes to these settings are usually made when handling problems occur on the exit of corners.

Wheel Hub Length

There are usually three different wheel hub lengths. It's highly recommended that a karter own all three sizes, as they are the most common adjustment on the rear end - changes that have significant impact on chassis balance. Longer hubs provide more rear grip – shorter ones less. If the kart oversteers as it exits a corner, a longer hub may be desirable.

Short hubs are used when the kart understeers at the exit of corners. If the driver runs out of track surface as the kart exits the corner, he is probably experiencing understeer, sometimes described as a "push". Switching to shorter hubs reduces grip at the rear and may be a desirable adjustment to correct the problem.

Hub length selection can be determined by how the rear tires are wearing. If the kart is running little caster, a soft axle and generally feels good, but the rear tires are "coning" (the inside of the tire is wearing faster than the flat or outside), decrease the rear track. If the problem persists, increase the hub length or turn the bearing carriers facing out to support the axle end more – effectively stiffening the axle.

Rear Track

The idea is to run the rear of the kart as wide as feasible, assuming the chassis is performing well. For sprint racing in the US, most rules dictate a maximum rear track of 52 or 55 inches.

Most chassis are designed for rules allowing a 55-inch rear track. Therefore, it is important to set the kart's rear track to the maximum that the rules allow. A wider rear tread will provide a smoother ride.

There is a relationship between rising/falling grip and stability in the 52" to 55" range - with maximum grip in the 54" range. Narrower *track widths provide more grip, at the expense of stability*. Wider rear track set up provides more stability, but less outside tire grip and requires more energy to lift the inside rear wheel in turns. Usually, rear track adjustment is made as a last resort. The driver

should always change to short wheel hubs before decreasing rear track. If necessary, narrow the rear track in 1/8-inch increments, as most chassis are very responsive to minor changes.

It's best to start at the 55" dimension, as this gives the ability to narrow the rear slightly if more grip is needed to balance the chassis. This is also a very stable setting. It becomes necessary to narrow the track when the rear of the kart has too little grip. Keep the operating range of movement on the rear width in a fairly small range. Generally, don't adjust in from the legal maximum more than 1.5 to 2".

Narrower:	more grip, but less stable.
Wider:	more stable, but less grip.

Axle Stiffness

There are a wide variety of axle hardness's for chassis. *Axle hardness significantly influences rear grip*. In most cases you will want to use a mid-range axle. The hard (stiff) axle is used when the weather is cold, in slippery track conditions, or when rules mandate the use of harder compound tires. The softer axle is used if conditions are extremely "grippy", or where there is excess rubber build up on the track surface.

In general, high horsepower karts need stiffer axles for more traction. Lower horsepower karts have a greater need to free up the chassis and will run softer axles.

Tall drivers generally need softer axles to help reduce grip.

Rear Ride Height

Most chassis have two settings for the rear ride height. The chassis should be run with the higher ride height for better grip. The higher ride height creates more leverage and more weight transfer to the outside tires increasing grip for the driver. Lowering the ride height will have the opposite effect and cause the kart to oversteer. Only in cases where there are very tacky track conditions should the ride height be decreased.

Remember, ride height is literally how high the kart is above the track. To raise the rear ride height requires placing the bearing carrier bolts in the *lower* bolt holes.

Wheels

Wheel stiffness effects grip – either front or rear. Softer wheels such as spun aluminum will usually provide less grip than cast or forged magnesium wheels.

Softer wheels can promote uneven tire wear. A soft wheel will tend to wear the inner portion of the tire. It is usually best to run stiffer wheels.

Rear wheels with less offset effectively stiffen the rear axle as it will be necessary to move the hubs inward in order to maintain the same overall rear width. Therefore, an offset that allows the hubs to be moved outward will effectively soften the rear axle. The further the hub mounts from the axle bearing, the softer the set up.

Seat Struts

Most conditions will call for two seat struts on each side of the seat for a total of four. These struts should run from the very top of the seat to the two outer bearing cassettes. On the motor side, it may only be possible to use one strut. Seat struts allow a higher leverage point for the driver to transfer load to the rear tires – creating more tire bite. Removing seat struts reduce rear tire grip and weight transfer to outer wheel.

Usually, one would want to remove or loosen seat struts if trying to reduce rear grip. Tall drivers, for example, will have less need for seat struts.

Rear Torsion Bar

The rear torsion bar is a flat blade and stiffness can be adjusted by rotation of the blade. The rear torsion bar can be left out when you want to reduce rear grip. However, if you want to increase rear grip, place the torsion bar in the flat position.

Even more rear grip can be achieved if the torsion bar is placed vertically. In a low grip situation, (parking lot or other temporary circuits or perhaps a street track) the installation of the torsion bar in any capacity will net the rear end more grip by allowing the chassis to more directly transfer weight to the outside wheel by leveraging up the inside wheel allowing the kart to "drive" through the corner.

Front Bumper

The front bumper should remain tight at all times. There is a school of thought that loosening the front bumper will provide less front grip. The current generation of CRG manufactured karts, however, are designed to perform most consistently with the front bumper tight.

Rear Bumper

The rear bumper should be kept tight at all times. 100 inch pounds is considered a normal tightness. As above, there is an opinion that loosening the rear bumper will provide less rear grip, but again, the current generation of CRG manufactured karts perform best with the rear bumper tight.

Tire Pressures

Tire pressures range from 6-30psi (pounds per square inch), depending on the tire compound used, ambient temperature, track surface, and overall chassis set-up. For most applications you should stay between 10-14psi. Harder compound tires require higher pressures – up to 30psi for the Bridgestone YBN, for example. All tires have a range in which they work best – set up experience will dictate which is best for you.

In general, the higher the tire pressure, the faster the tires will come up to temperature and the more grip will be available. However, too much air pressure reduces the contact patch, reduces grip and increases wear.

See the section on Tires for more detail.

Side Pod Bars

Mostly, side pods are run loose. Tightening the side pod bars will give the kart more side bite and generally tighten (bind) the chassis. Let the bars fit loosely in the chassis, but be sure the bolts themselves are tight (use Nylock nuts).

Bearing Carriers

Axle bearing carriers influence axle stiffness, since the portion of the axle between the bearing and the hub is the part that flexes – as can the axle between bearings. If you widen the rear track, you lose a bit of traction because the distance from the bearing carrier to the hub mount point increases – softening the set up. The normal bearing installation is with the long side of the carrier pointed inward.

To soften the rear axle, the third (inside) bearing can be loosened in the frame housing. The normal mounting bolts are replaced with bolts of a smaller cross section and the bearing is not secured with locking screws to the axle.

Turning the long portion of the bearings outward will stiffen the axle ends, gaining grip. Bolting the third bearing securely in place and tightening the set screws to the axle stiffens the axle and increases grip. Remember, the bearings all function like fulcrums with the axle working like a lever, so the flexing on both sides of the bearings affect the overall stiffness of the rear assembly.

If the bearing is not moving smoothly in the hanger, it can absorb and release energy in an uncontrolled manner, which could cause corner hopping.

Rear Axle Assembly Run out

The package of wheels, axle, bearings, hubs, tires, etc. will all inevitably have a certain amount of run out and/or deviation from being perfectly round. Sometimes small individual irregularities add up to cause a significant "out of round" condition. This, in effect, often feels like an out of balance tire that will tend to upset the kart in middle and exit of the turn when dynamic loading is greatest.

The kart may feel loose and hopping, but the effect can be subtler to the driver causing the tuner to keep adjusting/tightening the kart to the point of binding, when the real problem is run out.

Careful assembly of components will help minimize run out by using the irregularities of each individual element to balance each other and not provide a cumulative problem.

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Chassis Set Up Procedure

Measuring the Chassis

To effectively determine if the chassis is straight, it is necessary to remove the seat and mount the kart on a stand.

First, measure the parallel relationship between the front spindle bolts and the rear axle. Measure each side of the kart from the back of the rear axle to both the bottom and the top of the king pin bolt. They should be equal.

If not, it will be necessary to "stretch" the short side of the chassis. This is done by jacking between the rear bearing hanger and the king pin post. Chromoly steel is springy, so it will be necessary to jack the chassis a little further than needed, as it will tend to spring back. Be cautious and jack in small steps to avoid over stretching. It is vital the chassis be equal length on both sides, before attempting other adjustments.

Check to see if axle is centered in chassis by measuring from axle ends to chassis tubes. Then, measure diagonally from axle ends to top of opposite kingpin. This diagonal check is important and will tell you if the chassis runs out of line of center. If the diagonal check shows variance, it is best to leave the chassis alone and simply offset the axle slightly to overcome the problem. Once this is completed, the axle ends can be reliably used to accurately position the rear hubs.

Once the chassis is the same length on both sides, and the axle is centered, it is time to center the steering to ensure that the front spindles are parallel to the rear axle. This is necessary in order for the kart to steer evenly in both directions and track straight. Unmounted rims are installed for this procedure.

First, lock the steering wheel into a dead, straight ahead, position by using either Vice Grips on the nylon steering bearing or tie downs from the steering wheel to the seat back. Then, by placing a metal carpenter's level (or a fluorescent light tube) against the rear wheel face, adjust the corresponding front wheel to be exactly parallel to the guide. In effect, the front and rear edge of the front rim will be equal distance from the measuring device – square to it.

Once the first wheel is set (with the steering straight ahead), set the opposite wheel to zero toe. This establishes your central reference point. If, for example, you want a total of 2mm toe out, without a driver, move the front of each wheel out 1mm (for a total of 2mm). Now, your steering is perfectly straight and your toe out is set, as well.

Progression of Chassis Tuning in a Shop

- Measure chassis front to rear and side-to-side.
- Center steering and set front wheels straight.
- Set caster and camber to the recommended settings.
- Set toe out.
- Weigh the kart to be sure the chassis corner weights are correct.
- Set front and rear track, ride heights, etc.

Progression of Chassis Tuning at the Track

When testing at the track, drive a corner as fast as you can and then ask yourself what is keeping you from going through the corner faster. Careful thought will normally help you determine if the kart is sliding in the front (understeer), sliding in the rear (oversteer), hopping, etc. Once you know what the problem is, you can begin to solve it.

In general, start with an axle that you feel will work, use medium hubs and set the rear width in the middle of the proper range. Then change track width to adjust for oversteer or understeer. As you reach the limit of the track adjustment, switch hubs and go back to the center of the track width range for more testing.

Never change more than one item at a time or you won't know what is helping or hurting your setup! And, record each adjustment.

The following are the most common adjustments at the track:

- Tire pressure variations
- Repositioning weight
- Adjusting frame stiffness (add/remove struts, etc.)
- Adjusting front and/or rear track
- Adjusting ride height
- Changing rear hubs
- Using softer or stiffer wheels

Proper record keeping is critical. Write down every change, so that you can go back to your base settings if your changes are not working.

Maintenance

First, pull every bearing and moving part off the chassis. Then, thoroughly clean and oil where necessary. Make sure each moving part is in good condition and if doubtful replace it. Aerosol white lithium grease is excellent for rear bearings. It may be desirable to remove the debris guards on the bearing to ease maintenance.

Check that kingpin bearings are fitted properly and not worn. The same applies to steering shaft bearings, tie rod ends, wheel and axle bearings. Check the chassis for any cracks and repair. Reassemble using new Nyloc nuts throughout.

Finally, you must make certain that the rear axle; brake disc and the front wheels all run free. Wheel balance is important, with the fronts a bit more critical than rears.

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Kart Scaling and Weight Distribution

Weight distribution is a huge factor in chassis handling. The weight/mass of the driver is often greater than the kart, so this mass must be positioned properly. Scaling the kart will help determine what adjustments are to be made to properly balance the chassis.

Proper scaling leads to ideal weight distribution and chassis balance – without it; you will increase the difficulty of properly making other chassis adjustments at the track. You will not be able to achieve optimum performance.

Some problems of an improperly scaled kart include understeer, excessive or insufficient load on any one tire, chassis binding, and lack of side bite in cornering. Improper weight distribution can also lead to incorrect diagnosis of handling problems leading to wasted effort. For most karts, the following weight distribution is a good starting point:

43% Front 57% Rear

50%/50% Left/Right

Lead weights should be added low as possible, initially. For drivers near minimum weight, it may be advantageous to be overweight and have a properly balanced chassis. The stopwatch will tell.

Scaling the Kart: The following steps are very important to the scaling accuracy of your kart.

- Use digital scales for the highest degree of accuracy and repeatability
- Be certain the floor is level. If necessary, place shims under the appropriate corner scales. This is critical for accurate scaling.
- Set caster and camber evenly on both sides of the kart.
- Set spindle heights evenly on both sides of the kart.
- Set toe (always set toe after setting caster and camber) and center the steering wheel. Uncentered steering will cause one wheel to load more than the other causing false scale readings. Set steering dead ahead and keep wheel movement suppressed by using Vice Grips on the nylon steering block to lock the column.

- Set tire pressures at race settings (hot pressures).

- Fill the fuel tank to the front break. Remember that fuel weights will change during the race.

- Have driver (wearing full race gear including helmet) sit in normal driving position (hands on the wheel) before reading scales and avoid unnecessary movements of the head or arms - they will result in false readings.

- Zero all scales and write down the readings.

Adjusting Kart Weight

Adding weight, if necessary, will aid in perfecting weight distribution. For many drivers, weight usually has to be added anyway. A good general rule for the location of added ballast is to center the weight somewhere on the seat, given that the mass of the kart needs to be centered as best as possible. Adding weight to the seat aids in this. The area under the front edge of the seat is excellent for 4-5 pounds of ballast. Generally the weight should be added as low as possible. Lead shot in the frame should not be used.

Drivers are usually reluctant to add weight to improve weight distribution if already at class minimum. However, there is evidence that adding weight to "perfect" weight distribution is more beneficial than leaving if off and running an out-of-balance kart. It is ultimately up to the driver to test both methods, and then choose the quickest alternative.

After correct distribution is achieved, the driver should make one more observation. The front wheels should scale within five pounds of each other. The same situation applies to the rear wheels. If this is not the case, re-check the factors affecting weight distribution given above and re-scale the kart. If the problem persists, you may have to adjust the seat again and start the process all over. Only then will the proper distribution be achieved.

Tweaking the Chassis

If the side to side weights are outside an allowable range and all basic settings of steering, tire pressure, etc are correct, then you may need to "tweak" the frame to achieve proper weight distribution. There are several means of

adjusting the chassis. The following is one method for adjusting out of weight front ends.

First, place the kart on a flat surface (ground or shop floor) floor. Put a spare wheel, block or jack under the front wheel that weighed heaviest. Then, with someone standing on the rear wheels push down on the opposite side of the front end. Repeat until both front wheels scale the same weight. Once the front is even the back will also be even.

Seat Placement/Adjustment

The seat placement is the single most important weight adjustment on the kart and is done before the scaling process. Proper seat placement may result in almost perfect weight distribution before the weight is added to the kart. You may find that after running the kart a bit, you will have a number of mounting holes drilled in your seat to allow you to shift the seat for changing track conditions. For example, you could move the seat forward to fight an understeer by shifting drivers weight toward the front end.

A good seat mount starting point for an average weight driver is:

Rear edge of upper seat back direct to axle:	23cm
Front edge of seat to front frame rail:	58cm
Seat bottom below frame:	2cm

The location of the seat is an effective tuning tool. Over time your seat may look like Swiss cheese, but it will still work.

For most chassis, the seat bottom should be about 2 cm (3/4") below the bottom of the frame. A tall driver can go too as little as 3/4" ground clearance from the seat bottom.

The four seat bolts should be very tight allowing no movement. If seat struts are fitted, four is the best number to use - mounted from the top of the bearing carriers to as high a point on the seat as possible.

A tall driver may consider using a more flexible seat to reduce chassis stiffness. He may also omit seat struts to reduce grip.

These are merely recommended starting points. Weight can be moved around at the track to fine-tune the handling characteristics. Moving weight to the front of the kart will provide more front-end grip. If weight is moved to the rear of the kart, the effect will be more rear-end grip. Weights can also be moved vertically

up or down. Moving the weight upwards will provide more grip to the tires most close to the weight. For example, if weight is placed high on the seat, we could expect more grip in the rear of the kart. If weight is placed lower on the seat, we would expect the kart to lose rear-end grip.

Tires (Care and Feeding)

Tire Pressures

Correct tire pressure is the most important factor to insure the best performance from any kart tire. That is easily said, but the real problem is the word "correct," because it's meaning varies with conditions such as driving style, chassis design, course layout, road surface, weather and temperature, to name only a few. The manufacturer's approved pressure is usually about 11 to 18 psi and the proper inflation pressure should initially be in that range.

Lowering tire pressure improves grip because the effective contact area is increased and there is a better tire cushioning effect. However, if tire pressure is lowered too far contact becomes uneven and driving more difficult.

Increasing tire pressure generates heat faster and causes increased grip from quicker heat buildup. However, too much pressure distorts the tire cross section, lifting the tread and loss of grip. Try for pressures that won't increase more than 2-3 psi in a race session.

Finding the correct balance between heat/grip/wear is the key to success.

10 psi can be considered a good starting point for both front and rear tires for medium compound tires. Drive for a while with the tires inflated to this pressure, and then change inflation pressure by 1-3psi until you find the pressure you think is best.

- Hard compound tires (cold) 12-13 psi
- Medium compound tires (cold) 9-10 psi
- Soft compound tires (cold) 8-9 psi

Generally, when a tire is inflated correctly, pressure will rise approximately 2psi when hot.

Pyrometers

An even better means of evaluating tire pressure performance is the use of a pyrometer to measure tire temperatures across the tread face.

These tread temperature measurements should be taken immediately upon re-entry to the pits. Laser type pyrometers are easiest to use, but the probe types are more accurate as they are not measuring a rapidly cooling surface, but rather a bit into the interior of the tread where heat doesn't dissipate as quickly. It is best to take three temperature readings across the tread width.

- Too much heat in the center of the tread usually indicates too much pressure,
- A cooler center indicates too low tire pressure.
- Hottest on both interior edges can mean too much negative camber.
- Hottest on both interior edges can also mean too much caster.
- Too cool on the interior edge may suggest a need for more camber.
- Try for equal tire temperatures across each tire face.
- Temperatures may vary somewhat from one tire to another.

Pyrometers - Not!

An alternative comes with experience by simply examining the tire surface. A properly inflated tire on a properly aligned chassis will have a slightly grained surface similar to sandpaper. A tire that is running cool may be a hard compound or just not being used aggressively enough to build up heat – it will appear smooth with no graining. A tire with smooth graining, but the interior edge shows small strips of rubber or aggressive rubber deposits that look like overheated rubber indicate you are probably running too much castor, camber, or some other condition is overheating that edge. The point is; the edge looks different than the rest of the tire because it is running too hot – indicating need for adjustments.

Varying Conditions

Understeering / Oversteering:

Raise rear tire pressure about 0.5-1psi to correct understeering or lower pressure by a similar amount to counteract oversteering. It is the opposite for front tires.

Do not make extreme pressure changes, however, because correct front tire sidewall stiffness is critical and is effected by tire pressure. The effect may vary with different tire designs and manufacturers.

Generally, if using soft compound tires, rear pressures less than 10 psi should not be used to correct oversteer. Look elsewhere (hubs, rear tread width, etc.) for a better solution.

Change in atmospheric temperature

The general rule is to raise inflation pressures slightly as the temperature falls and lower it as temperatures rise. If there is a significant difference between morning and afternoon temperatures, raise the inflation pressure a little in the morning for a better grip by increasing the load to generate more tire heat. Lower it in the afternoon to reduce heat generation.

Compounds:

Tire pressures can be raised when using hard compound tires. With high grip compounds, pressures are usually lower.

Variations in road surface:

Lots of rubber residue on the track surface causes increased roll resistance and on such a surface it is good to lower air pressure to reduce heat generation of the tires. This factor is more prevalent in summer months.

Rain Tires and Abrasion:

For rain tires, use the same inflation pressure as for dry conditions or increase by 1-6psi. When the track dries out, however, a heavy load is imposed on the pattern blocks of rain tires in the corners causing heavy abrasion. The best remedy is to change to slicks if possible, but it's also possible to use wet tires, with reduced inflation pressure and achieve good grip.

Extreme wet conditions:	25-30 psi
Moderate wet conditions:	20-25 psi
Drying conditions:	15-20 psi

Course abrasion also affects slick tires if the friction coefficient of the track surface is very high, when drifting, or when putting a heavy load on the tires. Use the same remedies for this condition as explained above for wet tires.

Rim Width:

Overall rim stiffness changes as inflation pressure is varied, but by changing the rim width, lateral and vertical stiffness, especially lateral stiffness, can change dramatically. Furthermore, since the contact area does not change appreciably as it does with an alteration in inflation pressure, grip remains the same, but finer changes can be made in maneuverability (steering response, slide characteristics, true tracking of the rear tires). For example, if the rear slide is not smooth, a wider rim than standard is called for. However, the range in which rim width can be varied is within ± 0.5 inches (approx. 13mm).

Maneuverability:

Maneuverability can be changed by varying the tire size (tread width). On racing circuits with many braking points or on karts with powerful engines, larger rear tires will improve braking and traction force. On circuits and chassis' that cause understeering, large front tires can be used or smaller rim size. Oversteering is corrected by doing the opposite. To "free up" a kart, a smaller size wheel with less grip is indicated or when more grip is needed a larger size is called for.

Please note that tire sizes are often dictated by the class in which the kart is competing, so this option is usually limited.

Tire Diameters

The outside diameter (circumference) of a tire varies in response to different conditions. This must be taken into consideration when selecting sprocket ratios. It is generally accepted that the gearing must be changed for each 12-15mm change in rear tire circumference. The amount of change in diameter occurs quite easily with variations in inflation pressure and other conditions.

Another matter is mismatched tire diameters. This can have a very negative effect on handling and chassis set up. Therefore, efforts should be made to run tires with matching diameters. Under some conditions, setting the kart up with

equal tire diameters may be more effective than trying to use identical tire pressures.

The rear tire circumference should not vary by more than 10mm.

A small tire can be "stretched" to closer match a larger one by inflating it to approximately 40psi for overnight or similar time period. It is also effective if the tire can be left in the hot sun for a shorter period. Recheck the circumference after the tire is reset to proper race pressure.

High air pressure	Diameter increases
Low air pressure	Diameter decreases
Immediately after mounting new tire on rim	Diameter small
Some time after mounting new tire on rim (Stabilizes after about 6 hours)	Diameter increases
Tire temperature rises (after running)	Diameter increases
Worn tire	Diameter decreases
High speed running	Diameter Increases

The Moving Target of Proper Pressures

Ultimately, one of the difficulties in setting correct tire pressures lies in the condition of lower pressures producing more grip once the tire is up to operating temperature. However, higher pressures will bring the tire up to operating temperature sooner, but ultimately at the expense of grip later in the race compared to a lower pressure at that same tread temperature.

Therefore, proper tire pressures are often based on how soon and how long optimum grip is needed. This principal is more relevant in lighter direct drive or clutch karts. Heavier shifter karts tend to generate higher tire temperatures more rapidly due to their increased power and weight.

Setting Up for SL Tires

The first basic to realize about SL tires is that they have less grip – they are a "hard compound". As a result the wide rear stance of a kart that runs on open tires will not necessarily work with SL's. To start setting up for SL tires initially, set the kart up fairly wide and then after several laps bring the rear track in 1.0cm (0.5cm per side). Repeat this procedure until the back of the kart stops sliding and starts to lift when cornering. Each time on the track it is necessary to travel about four laps before testing for grip as the SL tires require considerable time to reach optimum temperature.

Once you have the kart handling consistently in both directions and find you have the rear end of the kart handling well, but the front is pushing or understeering, the first step is to widen the front track – usually by adding spacers.

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Basic Chassis Set-up (Normal track Conditions)

The following settings are recommended as a starting point for a dry track with normal levels of grip:

- Weight Distribution should be 43.0% front, 57.0% rear, and 50/50% side/side.
- Front bumper should *always* be tight.
- Toe should be set out 1/16" to 1/8" (1-3mm) - for harder compound tires, set toe out 1/8" – 1'4" (3-6mm).
- Caster/Camber adjusters set at II top, II bottom.
- Front "track" width should be 45 1/2" to 46".
- Side pod bars kept loose, but with bolts tight.
- Seat should be attached at the standard mounting points.
- Seat struts installed.
- Rear wheel hubs should be medium length.
- Rear ride height set low as possible.
- Rear track set just below the legal limit of the rules (55" for most classes, 50" for Juniors) (CRG: 139 cm or 54.75").
- Axle - medium stiffness.
- Torsion bar adjusted to horizontal position and tightened.
- Rear bumper mounting bolts tightened to +/- 100 inch pounds.

Tire Pressures

• Hard compound tires	(cold)	12-13 psi
• Medium compound tires	(cold)	9 -10 psi
• Soft compound tires	(cold)	8 - 9 psi

Maximum Grip Setup (Low Grip Track)

The following settings are recommended as a "starting point" for a dry track with low grip. These types of tracks are often referred to as "green," given the inherent lack of established grip. The goal here is to gain more grip from the kart. The following recommendations should aid in this:

- Weight Distribution - 43.0% front, 57.0% rear, 50/50% side/side.
- Front bumper – always set tight.
- Toe - set "out" 1/16"-1/8" (CRG: 0 - 4mm toe out).
- Caster – set to maximum (CRG: set adjusters at III top, III bottom for maximum front grip).
- Front track - 45" to 46" (CRG: 117 cm, 46" for maximum front grip).
- Front ride height - start in middle position. Use both shims under front spindle to raise ride height for increased grip.
- Side pod bars - bolts loose, use nylocks.
- Seat - set to factory recommendations.
- Seat struts – two per side mounted to bearing carriers.
- Rear wheel hubs – use medium or long (for maximum rear grip).
- Rear ride height - set high as possible (axle in lowest position).
- Rear track - set just below the legal limit for maximum rear grip.
- Axle - medium to stiff (CRG: stiff axle for maximum rear grip).
- Rear torsion bar - position in either the flat or vertical location.
- Rear bumper – tightened to 100psi.

Dry Setup (High Grip Track)

The following settings are recommended as a "starting point" for a dry track with high grip - seasoned with lots of rubber from previous karting actiivity.

- Weight Distribution - 43.0% front, 57.0% rear, and 50/50% side/side.
- Front bumper - always tight.
- Toe - set "out" 1/16" to 1/8" (1-3mm). (Zero with driver in place).
- Camber - set at 1/2 to 0 degree (CRG: set adjusters at II top, II bottom).
- Caster - Add positive to past neutral. More caster may be needed over the weekend to fight tire wear and loss of grip.
- Front track – set at 44" to 44 1/2".
- Side pod bars – run loose, use nylocks on bolts.
- Seat – set low as possible (can be as low as 3/4" above the track).
- Seat struts - remove or run loose.
- Rear wheel hubs - shortest length.
- Rear ride height - low as possible.
- Rear track - set just below the legal limit - 55" for many classes. (CRG: 139 cm or 54.75").
- Axle - soft.
- Rear torsion bar - removed.
- Rear bumper – tighten to 100psi.

Rain Set-Up

Install rain tires! Racing a wet track is challenging, more so if you have a dry chassis set-up and unexpected rain comes. The adjustments below will help soften the chassis and improve drivability for a wet track.

- Front track - move wheels "out" as far as possible.
- Front Wheels - use "rain hubs" to widen track, if available.
- Rear track - moved "in" as far as possible - until the rear tire tread centerline aligns with the inside edge of the front tires.
- Front ride height – maximum height.
- Rear ride height - high as possible.
- Caster – maximum setting (CRG: top-III, bottom –III).
- Camber - Increase (Alternate setting: top –III, bottom –II).
- Toe - set from 1/4" to 1/2" out.
- Front and rear bumpers - tight.
- Tire pressure - increase: front tires should be at least 15 pounds, rear tires around 20 - this makes tires heat up quicker. Low tire temperatures can be significant problem in the wet. See the section on tires for more detailed information.
- Wheels – In rain magnesium will corrode if not painted or coated.
- Torsion bars – remove.
- Seat – raise to about 1" to 1 1/4" above normal recommendation.
- Rear brake rotor - shield from water, possibly by taping up the seat struts.
- Side pods - tape over ends to keep water out.
- Ignition – spray with WD-40 or similar repellent.
- Seat - drill two holes in bottom for water drains.

Basic Chassis Tuning*

Front end not gripping in corners (understeering)

- Move front wheel out one spacer on both spindles.
- If front of kart becomes too wide, move wheels back to original spacing and change Caster/Camber adjusters from II/II to II/III or III/III.
- Change to shorter hubs on rear wheels.
- Raise hot rear tire pressures 0.5 to 1 psi.
- Remove seat struts, if fitted.
- Use softer rear axle.

Back end loose at the entrance of the corner or too much Front end bite.

- Move front wheels in one spacer on both spindles.
- Lower 0.5 to 1 psi in the rear tires.
- Move weights (if used) away from the front of the kart.
- Lower the front of the chassis using spindle shims.
- Reduce caster (adjusters at I/II or I/I top/bottom).
- Check tightness of front bumper – tighten if loose.
- Check that toe is at neutral.
- Install stiffer rear axle.
- Install longer rear wheel hubs.
- Properly install seat struts (maximum of four).
- Tighten rear bumper to specs (always run rear bumper tight).
- Raise rear ride height.

Kart is hopping at the rear in corners.

- Install shorter wheel hubs on the axle.
- Set the rear track to/close to maximum allowed width.
- Raise rear tire air pressures 0.5 to 1 psi.
- Mount rear ballast lower, vertically if possible.
- Lower the rear ride height to the maximum.
- Change to a softer axle.
- Remove seat struts

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* Make only one adjustment at a time and record changes.

Trouble Shooting Guide

Recommended adjustments for various handling problems. NOTE: Always make only one adjustment at a time and keep written log of each adjustment.

Back end is loose at the entrance of the corner, or there is too much front end bite.

- Move in front wheel 1 spacer on both spindles
- Lower rear tires 1 psi
- Move weights toward rear of kart.
- Lower front of the chassis using king pin shims
- Reduce caster. (adjusters at I/II or I/I top/bottom)
- Toe set at neutral w/driver in kart
- Fit stiffer rear axle
- Fit longer hubs on rear wheels
- Fit seat struts (four total)
- Raise rear ride height

Front end of the kart is "pushing out", there is understeer, or the back end is tight at the entrance of the corner.

- Move out front wheels 1 spacer on each spindle.
- Increase 1 psi in the rear tires
- Add or move weights forward
- Add more caster. (adjusters to III/II or III/III top/bottom, if starting @ II/II))
- Raise front end using king pin shims.
- If toe at neutral, add more toe out

Kart is sliding on all four wheels too much or there is to little side bite.

- Tighten the torsion bars.
- Lower the hot tire pressures in all 4 tires by 1 psi.

Kart is not sliding enough on all four wheels or there is too much side bite.

- Loosen or remove the torsion bars.
- Raise the hot tire pressures in all 4 tires by 1 psi.

Kart is loose at the exit of the corner.

- Install longer wheel hubs.
- Set rear track to around 54" or 137mm.
- Raise pressure in rear tires by 1 psi.

- Raise weights to a higher vertical position on the rear of the kart.
- Raise rear ride height to the maximum if not already done.
- Change to a stiffer axle.
- Add seat struts (maximum of four)

Kart is tight at the exit of the corner or the front end is understeering at the exit of the corner.

- Install shorter wheel hubs.
- Shorten rear track by up to 1/2 inch.
- Raise pressure in the rear tires by 1 psi.
- Change to softer axle.
- Lower weights to a lower vertical position at the rear of the kart.
- Remove one pair of seat struts.
- Lower the rear ride height.

Kart understeers or oversteers, but only in one direction

- Scale kart and check if corner weights are equal side-to-side.
- Check for twisted or bent chassis.
- Check that all settings on one side of chassis are same as opposite
- Check equal side to side tire pressures

The kart "darty" on the straights and dives rapidly into the corners.

- Too much toe out. Try around 1/8" (3mm) for normal conditions (zero with driver in place).
- Front track too narrow, widen by one spacer each side

The kart is hopping at the rear in corners.

- Change to shorter wheel hubs
- Widen rear track to maximum allowed
- Raise the pressure in the rear tires by 1 psi.
- Lower weights to lowest vertical position on the rear of the kart.
- Lower the rear ride height to the maximum
- Change to a softer axle
- Remove seat struts

Push/kick.

- Move seat forward
- Decrease rear tread width
- Increase front tread width
- Increase rear tire pressure

Terminology

- *Oversteer*: the tendency of the rear of the kart to slide outward at corner entry or mid corner. It's important to understand that this tendency must be occurring as you enter the corner, not on corner exit, when application of power can bring about *power induced oversteer*.

- *Power induced oversteer*: tendency of the rear of the kart to slide outward at corner exit under hard power application. Steady state throttle should not upset the chassis balance.

- *Understeer*: the kart will not turn into the corner due to lack of front-end grip. This is sometimes called "push," which is more correctly lack of turn-in capability due to the front tires being overpowered by excessive rear traction. Although these terms are often used interchangeably, understanding the difference will help you to set up your chassis more correctly.

- *Push/kick*: Occurs at the apex of the turn as the kart transitions from brakes to application of throttle. The kart rear kicks out suddenly at the apex.

- *Hopping*: The kart bounces as throttle is applied near the apex of the turn.

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