Road America:

The Analyst's Perspective

David M. Redszus, Ph.D, of Precision AutoResearch, provides data acquisition and race engineering services for the Porsche Cayman Interseries. As engineer and coach to pro and amateur teams in a wide range of motorsports, he has guided clients to over 350 championships over the past 30 years.

More than 40 years ago, a famous Porsche 917 driver referred to Road America as an "Autocross Course", as the corners were so slow compared to the straights. To a driver having some difficulty with corners 7, the Kink, and 13, this may seem hard to imagine. But put into perspective: Mark Donohue's car had 5+ times the power-weight ratio of a modern Cayman, yet only 10-20% more grip! He had to "point and shoot". Try this with a Cayman, and prepare to run at the back of the pack.

How you drive a track depends upon the characteristics of your car. Each must be driven differently. So, advice from a driver of one vehicle type might not be universally applicable to another. We have fitted most of the Interseries cars with very capable data monitoring systems, which is used to evaluate the driver and car. G-forces, steering corrections, corner radii, trajectories, and dozens more variables can be used to optimize cornering force, brake techniques, car balance, and many other analyses. Used properly, this device can help you reduce lap times and save you a lot of money. Use it poorly, and it's just a fancy stopwatch...

It may come to a surprise to some that only ***two*** factors determine cornering speed: ***G-force*** and ***Corner radius***. Why is this? Well, it's fairly simple physics, which applies to any object in rotation.

$$MPH = \sqrt{15 \cdot g \cdot R}$$

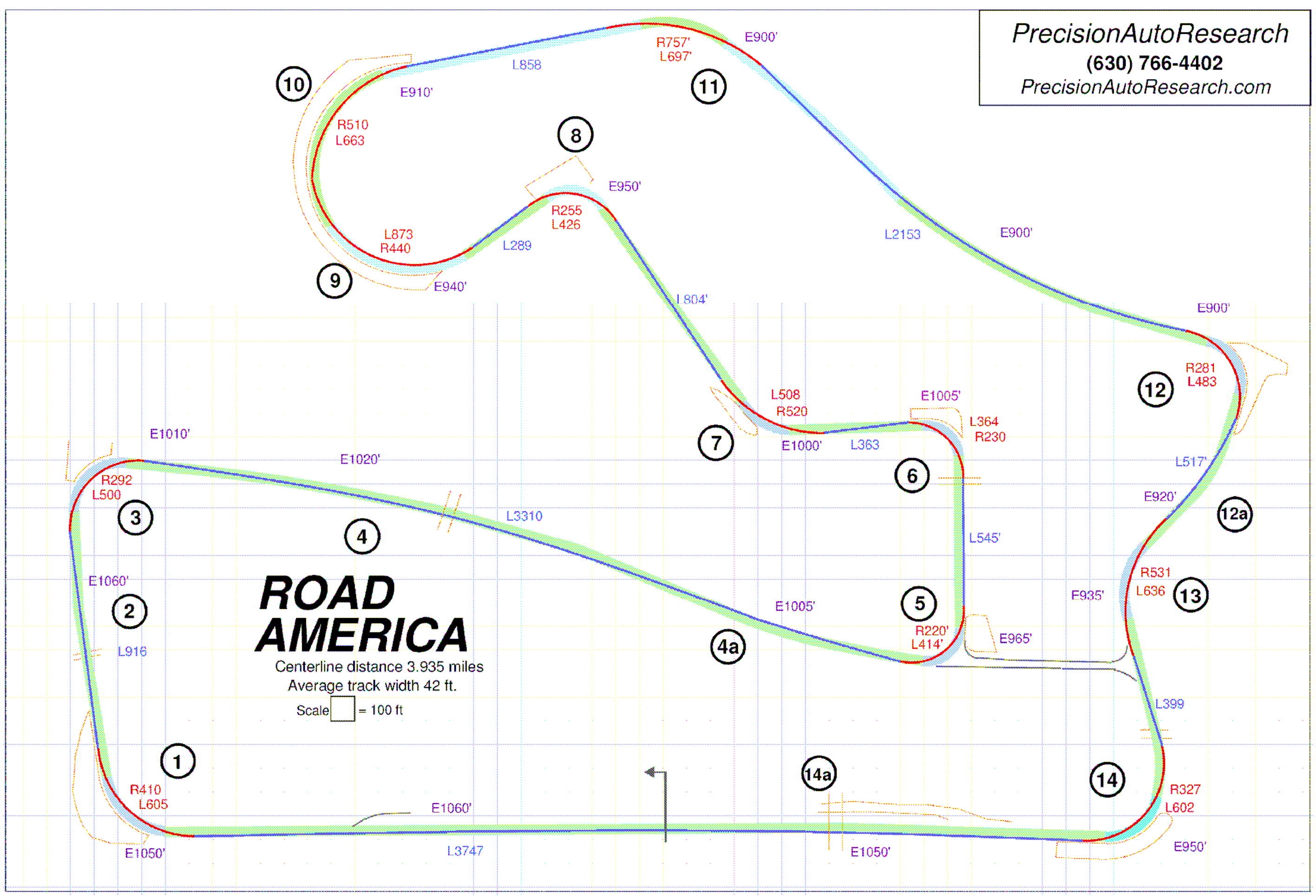
g is the cornering G-force
R is the corner radius (ft)

So, if you want to go faster, all you need to do is pull more G's, drive a larger radius…or both!

An Interseries Cayman on a dry Road America track may pull up to 1.35g, if you are brave (or foolish enough) to attempt! If your car is not set-up right, or the tires are old, or there is debris on the track, then the G limit will be lower. Typically, the driver has little control over the g-force limit. He may only choose to not explore this limit.

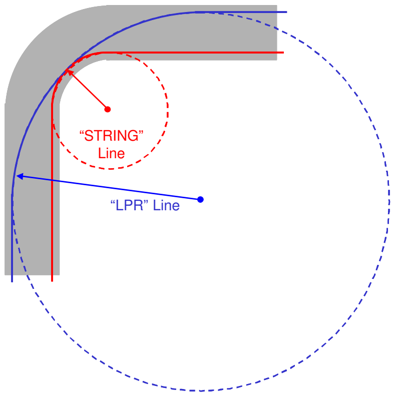
The car has little influence over the corner radius. This is up to the driver and the track geometry. Simply put, you cannot maintain a larger arc than the track width permits. The largest arc is the so called ***Largest Possible Radius*** (LPR) line. Many drivers drive tighter arcs than they should, which results in peaky G's and slower minimum speed in a corner. I see this all the time, and it often separates pros from the other contenders. In fact, there is a minimum radius that you should ever drive around a corner. More on that in a minute.

The graphic below shows Road America from an engineer's perspective, showing the maximum corner radius available for each turn. Any "line" you drive will, at some point in the corner, be tighter (smaller) than this radius. If maximum corner speed is your goal, then the objective is to prevent this from happening.



Now, things get real interesting. We have also surveyed the track and established inside arc dimensions of each turn. When we developed this concept for a factory training program 20 years ago, we coined it the ***StringLine***, as a representation of the arc that a string would take if pulled taut around the track. It is naturally the shortest path around the track, as you might take if you wanted to walk the course in minimum time.

Here's is a graphic example of a ***StringLine*** (vs. an LPR (***Largest Possible Radius)*** line) for a simple corner:



The dashed circles represent effective diameters of the corner using these two very different lines. As you might imagine, the blue arc can be driven at a much faster speed. However, it also means you will be on the curve for a longer distance as well. Ultimately, we would like to ***minimize time***, not merely ***maximize speed***.

The relationship between time and g's and radius is pretty straightforward:

$$t = \sqrt{\frac{1.22 \cdot R}{g}}$$

(for simplicity, this is time to drive around a full circle of said radius)

In essence, if you drive a larger radius, the time goes up. If you increase g's, the time goes down.

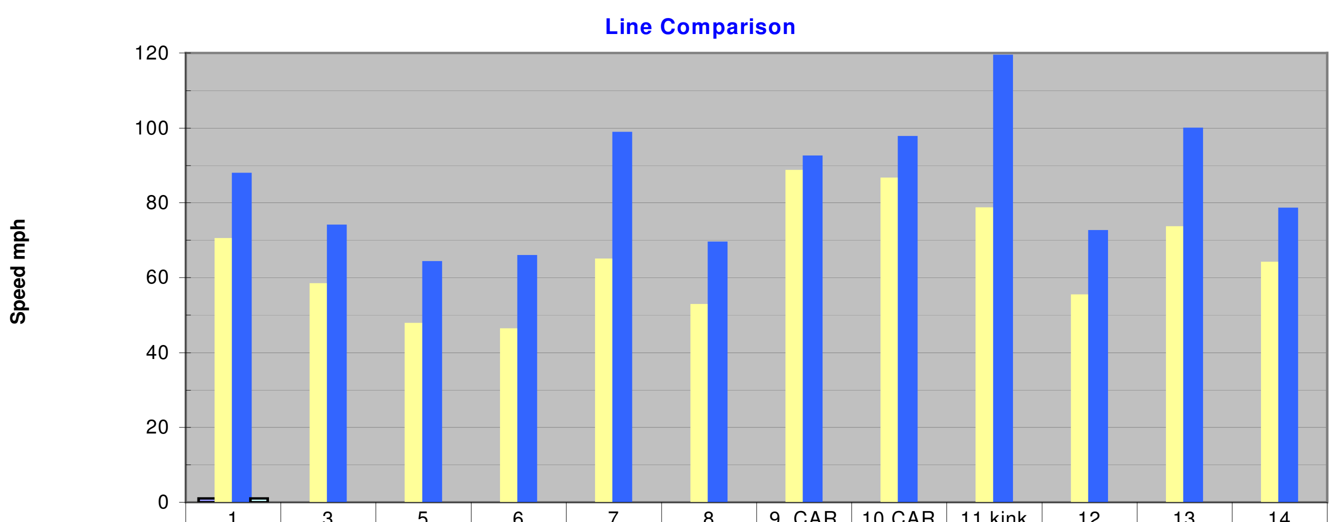
But wait, we were taught to run large arcs, right? Well, it turns out you should ***run a larger arc as long as the g's don't drop***. Once the g's fall, a larger arc just takes more time!

So, what does this mean as a driver? Simply, if you cannot reach the g-force potential of your car in a corner (Example: a large radius corner, where your entry speed is already well below the corner speed potential), then drive an arc tighter than the LPR. In some cases, this may even necessitate driving the *StringLine*. In cases where you can maintain max g's through the entire corner, then make the corner as big as you can!

With the data systems we provide for race cars, we log instantaneous corner radius (and foot-by-foot profiles of radius) for each corner. It is interesting to note drivers often are cornering even tighter than the *StringLine*, even though they insist they are using all the road. How is this possible? Simply, these drivers are "squaring off the corner," usually by running an excessively late apex. This slows their cornering speed, and they lose time which is never recoverable on the ensuing straightaway.

A unique motorsport engineering tool called ***RaceDataPower***, can be used to visualize corner speed potential for any track. The graph below provides speed targets for Road America, using a more conservative 1.25g as the cornering limit. The Blue bars are the upper speed limit, which you are unlikely to attain -- if you did, you would be using every inch of the road at max g's, with no room for error!

The Yellow bars are the speed target if you were to drive the *StringLine*. If you can get your minimum speeds through each corner above the *StringLine* speed, you are then in the appropriate zone. A nice bonus is that you will find your average speed throughout the straightaways will typically increase as well.



	1	3	5	6	7	8	9 CAR	10 CAR	11 kink	12	13	14
Road America	1											
StringLine	70.2	58.3	47.6	46.2	64.8	52.7	88.4	86.4	78.4	55.3	73.5	63.9
Raceline	87.8	73.9	64.1	65.7	98.6	69.3	92.3	97.5	119.3	72.4	99.8	78.3
1.25	1											

Corner number