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Improving Your On-Track Driving

Using a G-Analyst can be bad the ego but good for the lap times

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When it comes to flinging Porsches around race tracks on the very edge of control, PCA members are expert, capable and talented. Just ask us! But admit it: haven't there been times that each of us hero drivers has suspected that significant improvement was still possible, and perhaps even needed?

For example, have you ever been convinced that you have lapped a given track absolutely as well as it can be done, only to find someone else with an equal car turning better lap times? Frequently, we address such problems by charging off to buy the latest trick tires, strut stabilizers, cross-drilled rotors, or any number of other go-fasters. And then the guy with the stock 944 is *still* faster. What's a hard charger to do?

There are many possibilities, of course, including racing schools, seminars, private instructors, videotapes, etc. But one of the most effective I've found is the g.Analyst by Valentine Research, Inc. It costs less than a set of tires for most Porsches, and installation/calibration is easy. With proper use, it can tell you more about your driving than you would believe possible.

The purpose of this article is to describe how a typical PCA member can utilize a g.Analyst in improving his driving skills at track events, using specific examples drawn from my own experience running an SCCA Sports Renault in club racing events. The lessons are fully applicable to high-performance street cars on race tracks or at hillclimbs. While a g.Analyst has relatively little direct benefit for street use, there is no question but that the car-control skills learned at track events can make you a safer driver on the street.

Attributes and basic use

The g.Analyst is an instrument for measuring the g forces acting on an automobile. It has two key features: objective precision and unfailing memory. As noted in a number of reviews, the instrument is quite precise and accurate. For example, consider a basic gear shift from third to fourth. The g.Analyst reveals that a "good" shift in a Sports Renault will take 0.6 second, split about evenly between the "lift-clutch-shift" phase and the "unclutch-stand on it-engine response" phase. During this time, acceleration force will drop from 0.11 g to a negative 0.05 g, and then return. A "bad" gearshift takes another 0.2 seconds and the acceleration force will drop to a negative 0.07 g before recovering.

The g.Analyst's precision is matched by complete objectivity. No more, "Well, I did that pretty well!" when your maximum sustained cornering force was only 0.75 g and your car is capable of 0.90! As a friend remarked, on viewing the data on his understeering, unsteady charge through turn 7 at Watkins Glen, "Hmmmm. This sucker just doesn't lie, does it?"

Recording data is straightforward. Set the device on "Loop Record" before entering the course, and punch the big black button to get it started. Once on the track, punch the button again each time you pass start/finish and it will record a marker in the data, which will simplify your review later on. After a series of several good laps, or at the end of the session, press the Stop button. The unit will record eight minutes of data, sampled every tenth of a second. That's enough for three to five complete laps at most race tracks (and represents something like 14,000 individual pieces of data)—more than enough to keep you busy! Once recorded, your data will stay intact until you next record over it, regardless of whether the g.Analyst is turned on or off or the cables are disconnected in the interim.

Assuming you don't have a personal computer at the track, you or a helper should carefully play back the data, with the g.Analyst set to "average" the readings, and write down the following for each of the critical turns: the maximum reading for braking force before the turn, the maximum reading for cornering force during the turn, and any special feature of the data, such as a mid-corner dip in cornering force and/or acceleration.

By using the "average" setting, and writing down the highest figure shown for each section of the track, you will be recording the maximum g force you sustained over any one-second period. This procedure doesn't take long and allows you to compare, on a reasonably consistent basis, readings from one lap or session to another.

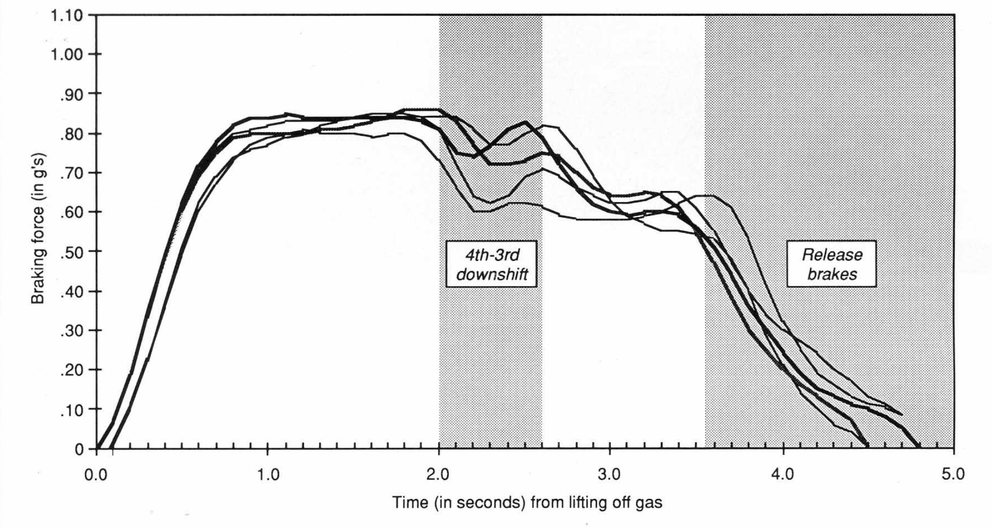

FIGURE 1. Analysis of turn 1 braking force, sample of 5 laps at MARRS 2

If you have any IBM-compatible personal computer, or an Apple Macintosh, you can easily dump the data from the g.Analyst into it, using a PC interface adaptor available from Valentine Research. It includes the software needed to view the data on the computer monitor in either numerical or graphical form. The IBM version has an outstanding display of cornering, braking and net total force data (simultaneously), as well as excellent friction circle diagrams. Two different sets of data can be compared side by side, and the data can be printed out in the form of a strip chart. The software also allows you to convert the data into a file readable by most spreadsheet and/or graphics programs, such as Lotus 1-2-3 or Microsoft Excel, so that you can perform any sort of analysis on the data that you might wish.

Regardless of how you record the data, you should also view it directly from the g.Analyst once or twice between sessions at the track, looking for strengths and weaknesses. Before long, you will recognize the patterns of data and will quickly spot any unusual aspects, favorable or otherwise. Once you recognize your own pattern, it's surprising how different another driver's data may appear, even if he is in an identical car. Sneaking a look at another driver's data, even if you have to lend him your g.Analyst to obtain it, can be very instructive! By the same token, the readings from George's 935 may not have much to do with your 912 effort. Okay, enough generalities. Let's get down to specifics.

I know there's something wrong with my braking

At the start of the 1987 racing season, I was rusty and my mind wasn't altogether in gear. At the first couple of races, I thought I was right on the edge with my "threshold" braking (i.e., sustained braking from high speed for a slow corner), but I was still being outbraked by key competitors. What's more, I had wheel locking but I wasn't sure if it represented a problem or just the normal limit. I decided to do a little sleuthing.

Figure 1 shows five laps of g.Analyst data, braking for turn 1 at Summit Point race track in West Virginia, recorded at the second event of the Mid-Atlantic Road Racing Series (MARRS). While the laps are reasonably consistent, they are also reasonably bad! Note the relatively low maximum braking force (about 0.85 g), the big dip in brake force beginning at the two-second mark, the wimpy brake force thereafter, and the protracted release of pedal pressure as I entered the turn.

Reviewing this data back home after the event, I was fairly confident that the low 0.85 g force was attributable to a brake balance problem. My Sports Renault would typically corner at about 1.1 g, and I figured that it should be able to brake at 1.0 g or so. I made a note to work on the brake balance at the next event. Viewing the data at the track, I hadn't paid much attention to the temporary dip in brake force, nor had it dawned on me why it was happening. Once I combined the five laps of data together, however, it stood out like a sore thumb (or toe, in this case) and I quickly realized it was caused by poor heel/toe technique while downshifting from fourth to third. I added this to my list of things to work on.

Why was my brake force following the downshift so poor? The data jogged my memory of something I had noticed on the track but had promptly forgotten: in my state of rustiness, I was braking too early; as I slowed,

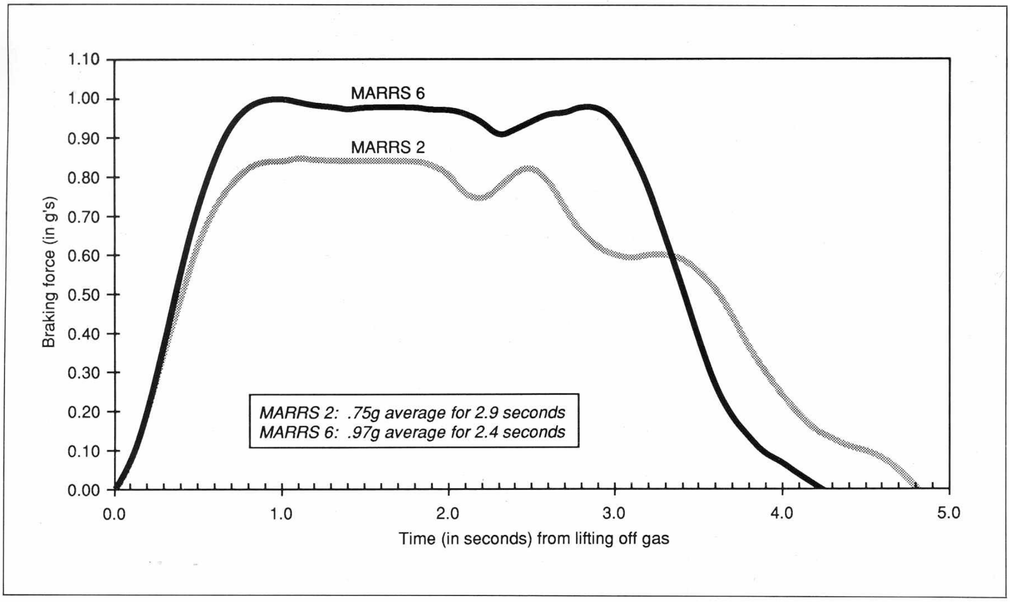

FIGURE 2. Comparison of turn 1 braking force, MARRS 2 vs. MARRS 6

I would realize that I'd started too soon and would let off the brakes a little to avoid slowing down too much. Each time it happened, I'd resolve to push that braking point further on the next lap, and each time I would either forget or chicken out. Stupid, right? Yes, but without the g-data I'm not sure when I would have realized it. Another entry for my list.

Figure 2 takes the best of the laps from Figure 1 and compares it to a typical good lap at MARRS 6 later in the season. Note the major improvement in maximum force (from 0.85 to 1.0 g) due to a balance adjustment, minor improvement in braking while downshifting, improved maintenance of high level brake force throughout (due to braking later), and a faster rate of release. Measuring over the period of sustained full braking, I was now averaging 0.97 g for 2.4 seconds as compared to 0.75 g for 2.9 seconds previously. This improvement in braking for turn 1 alone translates into an estimated lap time reduction of 0.24 second. Areas for further improvement? Well, is it necessary to take as much as 0.8 seconds from the time of lifting off the gas to reaching maximum brake force? And that residual fourth-to-third dip can be erased altogether with a little more practice.

Why do the instructors keep harping on smooth cornering?

The g.Analyst excels at providing detailed data on

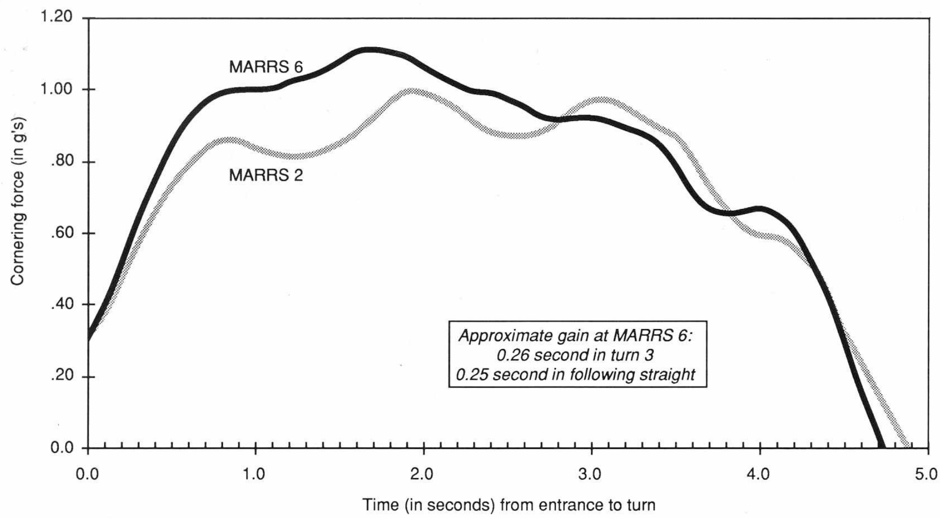

FIGURE 3. Comparison of turn 3 cornering forces, MARRS 2 vs. MARRS 6

cornering. Did you turn in too soon? Did you lift in the middle of the turn? Is your cornering force in turn 7 as high as it is in turn 2? It's all there, just waiting for the humble viewer.

Figure 3 is a case in point. Early in the season, my rustiness led to an unsmooth entry to turn 3 at Summit Point (a medium-fast, somewhat uphill left-hander). My shaky start soon caused a series of excessive applications of lock, followed immediately by slight corrections (see gray curve). I effectively made it into three shorter, tighter turns. And although I hadn't lifted, my exit speed was not good at all.

With more practice and confidence, I smoothed out and improved significantly, as indicated by the black curve. Average cornering force increased from 0.87 to 0.99 g, and resulted in an estimated lap time reduction of 0.51 second—0.26 second in the turn itself and 0.25 second on the following short straight. It was still not ideal, as it is probably possible to reach a higher cornering force two or three tenths of a second sooner, and the peak force of 1.1 g could be sustained over a significantly longer period. But then, the g.Analyst merely tells you what's wrong; somebody still has to go out there and do it better—and we all know how easy that is.

Sharp-eyed readers may note the overall pattern of the MARRS 6 curve in Figure 3. Cornering force starts high and gradually tapers off. This brings up an important issue. At Summit Point, the first half of turn 3 is uphill. A higher g force is possible on this section of the turn than on the second half, where the track levels off. Thus, the declining pattern in this case is somewhat attributable to the elevation change.

When reading the g.Analyst, it's important to take into account any sections of the track with elevation changes, banking or negative camber. They can affect the available cornering force, as illustrated above. The g.Analyst will properly measure your cornering force regardless of the corner's characteristics. In other words, if your car can corner at 1.0 g normally and at 1.2 g on a particular banked turn, then the g.Analyst will show 1.2 g on the banking. The unit compensates for the tilt of the car, and continues to measure the forces acting on the tires. Similarly, in an off-camber turn the car may only be able to pull 0.9 g—and that's what the g.Analyst will read. Please keep all that in mind before you try to equalize your g readings throughout the bridge turn at Road Atlanta.

Figure 4 shows an interesting progression of passes through Summit Point's turn 10. The first curve is from MARRS 2 and shows a mediocre level of cornering force with a substantial dip in the middle of the turn. The low level of g force stood out when compared to the forces generated elsewhere on the track, and convinced me of the need to try harder. The mid-turn dip was due to a slippery spot on the track surface, right at the apex, where the track grip was a little deficient (for reasons unknown, since there was no oil or water).

The second panel compares performance at MARRS 6 with the earlier curve from MARRS 2. By trying harder (yes, sometimes that's all it takes!) and modifying my line to avoid the slippery patch, I was able to improve on the cornering forces substantially. Note, however, that cornering force builds slightly in the second half of the turn—a sign that either I turned in a little too

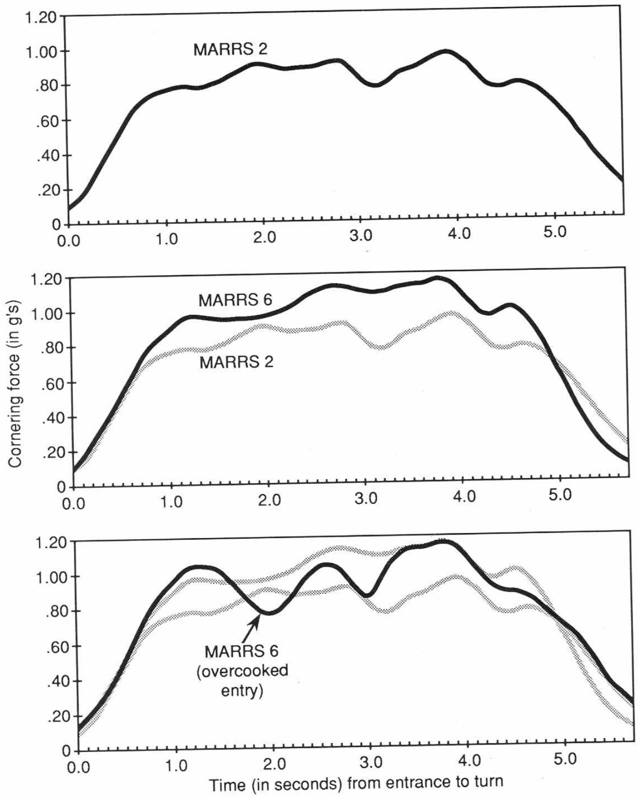

FIGURE 4. Comparison of turn 10 cornering forces, MARRS 2 vs. MARRS 6

early, the track surface provided somewhat less grip initially, or I could try harder still by entering the turn more aggressively. I was pretty sure that my line was okay since I wasn't running out of room at the exit or having to tighten up to stay on course. I wasn't sure about the track surface; it felt all right.

So I tried harder. The result is shown in the third panel of figure 4. The black curve illustrates graphically what we have all felt through the seat of our pants—the moment you "step over the line" but manage to gather it back together without going off course. My cornering force built up more quickly and to a higher level, but the car quickly overstepped its capabilities and I had to apply opposite lock, with a resulting sharp drop in cornering force. Once recovered and back fully on the gas, cornering forces built back up just in time for me to hit the slippery spot and go through the whole process again! Once the drama was over, the last third of the turn was about normal. I concluded that traction was not quite as good in the first half of the turn and that the g forces shown in the middle panel were about as good as I was able to do.

The more subtle aspects of a good lap—trailbraking

The subject of trailbraking has had a long and honorable history of dispute. As most drivers' school participants recognize, trailbraking is the technique of gradually releasing brake force while simultaneously building up cornering force. Some claim that it is unnecessary, provokes instability, and leads to spinouts more often than it reduces lap times. Others insist that it's absolutely essential for a quick lap. I'm no expert, but many hours of reading g.Analyst data has convinced me that without trailbraking, you are just not getting the maximum use of your tires as often as you could. And without using your tires to their maximum as often as possible, you're likely to be slower. Without debating the issue further, let me just state that the g.Analyst will show you very graphically how well you are doing if you choose to try trailbraking.

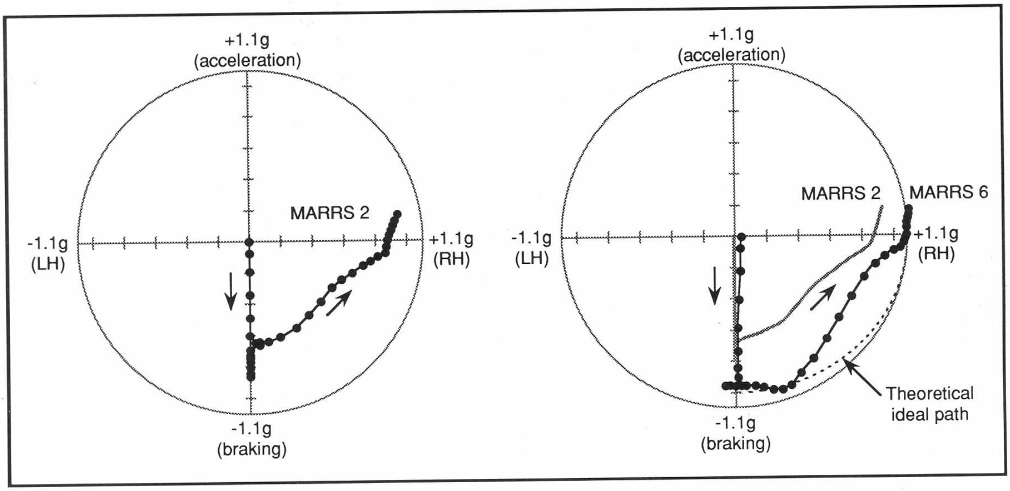

FIGURE 5. Comparison of trail-braking for turn 1, MARRS 2 vs. MARRS 6

The simultaneously display of both braking and cornering forces gets a little more complicated than showing either force separately, as I've done so far. The "friction circle" concept, or "g-g diagram" as it's sometimes called, was invented for this purpose. Two of the four display options on the g.Analyst utilize this method (the other two show either braking or cornering force alone, corresponding roughly to the views shown in Figures 2 and 3 respectively).

Figure 5 shows two friction circle diagrams, the first from MARRS 2 and the second comparing MARRS 2 and MARRS 6. A point at the very top of the circle would represent an acceleration force of 1.1 g (which is not possible for any road-going cars, not even your tweaked 930 Turbo)! A point at the very bottom would be a 1.1 g braking force. Pure cornering forces are similarly shown to the right and left, depending (naturally) on the direction of the corner. Any point within the circle, taking into account the limited acceleration force available, is possible. (Remember, too, that the specific outer limits will vary from one type of car to another.) If you are simultaneously cornering at 0.3 g and accelerating at 0.2 g, then your data will show up at the point corresponding to (0.3,0.2) on the graph—in other words, about where the "M" in MARRS 2 is on the first graph. But that's not where you want to be. Your friendly tires are quite willing to go play at the outer edges of the circle, if you're willing to take them there.

In the first diagram in Figure 5, we're back to turn 1 at Summit Point for MARRS 2. At the end of a 3000-foot straight, I began to brake for the turn. The first dot represents the moment I lifted. At the second dot, 0.1 second later, my foot is still in the air, headed for the brake pedal. A few tenths later, I've built up to my 0.85 g limit and I'm still braking in a straight line. When I begin to turn, I'm braking at only 0.65 g and the dots have just begun to move rightward, representing the initial development of cornering force. During the brief tran-

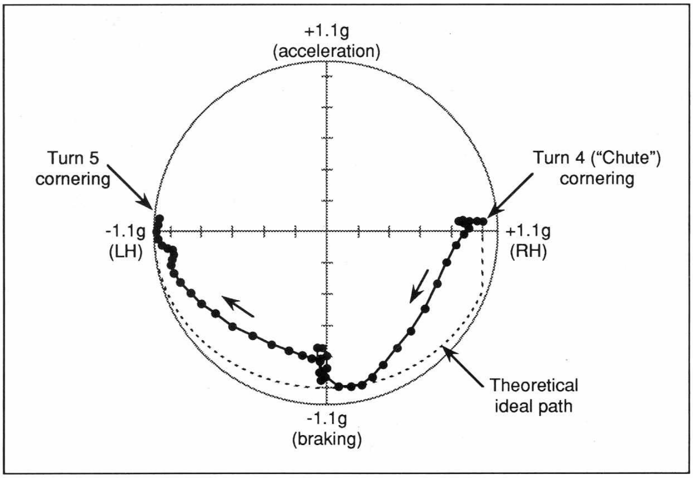

FIGURE 6. Trail-braking out of turn 4 into turn 5, at MARRS 6

sition to full cornering, I screw around with a *combined* cornering and braking force of only 0.60 g for awhile, with brake force diminishing and cornering force building. This represents only about 60 percent of the car's capability. Eventually, my foot's off the brake and moving toward the gas, and I end up cornering at 0.9 g with about 0.2 g acceleration. On a good day, you could nearly match that with Bob Gutjahr's old VW!

Quickly turning to the second part of Figure 5, we see a somewhat better example from MARRS 6 later in the season. We've already seen the steps needed to improve braking performance and, as before, the diagram shows a more rapid build-up to a peak reading of about 1.0 g. Note, however, that the friction circle diagram now reveals something new: at peak straight-line braking, the car is wandering slightly left and right, where before it was dead steady—the result, as you would expect, of a more rearward brake balance. Note also that at MARRS 6 I've begun to corner while still braking at nearly 1.0 g. For half a second, I'm right on the edge of the tires' maximum potential (assuming limits of 1.0 g for braking-only and 1.1 g for cornering-only for a Sports Renault). As my speed comes down, however, I apparently fail to take full advantage of it by using as much steering lock as I could. (Or maybe I just scared myself and eased up on the steering. The g.Analyst's memory won't tell you everything!) Eventually, I'm back on the gas and cornering at 1.1 g where I should be, but I've given up roughly 15-20 percent of the tires' capability for nearly a second. Still, it's a significant improvement over MARRS 2.

Another, and somewhat more unusual, example of trailbraking is shown in Figure 6. The fourth turn at Summit Point is a very fast, downhill right-hander called the "Chute." In a Renault, it's flat out in fourth at nearly 100 mph. It leads almost immediately into the slow, left-hand turn 5. With most cars, taking the Chute flat out requires using all the road, but then doing so results in inadequate braking distance for turn 5. Unless you modify your line (resulting in slower times), you must begin to brake at the tail end of the Chute and carry that braking into turn 5. Fortunately, turn 5 is a classic "type 2" turn, coming at the end of a fast section and not leading onto another straight, so you don't give up anything here using trailbraking and an early apex. But notice that in this instance, taking the Chute properly *requires* trailbraking whether you want to or not—and not only when entering turn 5, but earlier, *leaving* the Chute. (One might call this "backwards trailbraking," that is, converting cornering force to braking force at the *exit* of a turn. In fact, more than one driver has ended up backwards as a result of trying it here.) Figure 6 shows what all this looks like on the g.Analyst.

In a Sports Renault, taking the Chute without lifting requires about a 1.0 g cornering force and the car is capable of slightly more at that speed. So, beginning at the *exit* of the Chute, Figure 5 shows a cornering force of roughly 1.0 g with a small acceleration force of 0.06 g (at nearly 100 mph, that's all there is, folks). Straightening up slightly at the exit, on go the brakes. This time, I've used about 75 percent of the available total cornering and braking force (I know, I know, but you try putting the brakes on while cornering at 100 mph!), but at least I managed to build it up to about 100 percent at the very end of cornering for the Chute. A brief spell of straightline braking at around 0.9 g finds me still going way too fast to take turn 5 normally. So into turn 5 early, still on the brakes for additional trailbraking, this time to the left, and again using about 80 percent of the tires' combined potential. Eventually, the speed is right, the power comes on, and we're cornering at 1.1 g to the left. Not bad, overall—but the g.Analyst still shows the room for improvement.

Gee, what else can I do with it?

The examples above should give you some idea of how to put a g.Analyst to use to improve your track driving skills. If you don't smash it in a fit of rage at its dispassionate display of your mistakes and limitations, it can become an invaluable instrument in your quest to be Regional Hot Shoe. But there are also a number of other useful roles for a g.Analyst to play. Some examples follow.

One of the two friction circle displays shows the accumulation of all data points, not just the most recent 3.5 seconds as with the other displays. Play back a lap on fast forward using this display and study the results. You will see a "filled-in" friction circle, but is it filled in symmetrically? Is your maximum cornering force to the right as great as to the left? Is your trailbraking as good in one direction as in the other? If not, maybe your car's alignment needs attention.

On a clear section of track, get a rolling start in, say, third gear, with your rpms at the bottom end of your usable range. At a convenient landmark, floor the gas. Then punch the g.Analyst's marker button at every 1000 rpm interval until redline. Back in the pits, graph out the acceleration g force versus your rpm and you've got an instant "torque curve" of sorts. Then, when you change power chips, exhaust systems, or make other modifications, go back out and do it again. The effect of the change will be obvious in the data, even if not to the seat of the pants. And the next time you think you're down on power, run this test and compare the results to your baseline from before. My friend and Solo I expert, Terry Donohue, has even developed a fairly reliable method of converting this data into estimated torque and horsepower figures if you're so inclined.

Nobody available to time you during practice? If you're careful to hit the marker button at start/finish each lap, the g.Analyst will gladly tell you your lap times when you get back to the pits. (Under *no* circumstances should you try to read any of this data while out on the track—you'll end up bent and dusty before you can even figure out the scale on the display!)

Other straightforward uses include determining optimal shift points for maximum acceleration, measuring "interval times" (lap times over track subsections), and evaluating alternative cornering lines in the rain (but don't let your g.Analyst get wet). Ultimately, its usefulness is limited only by your creativity.

I think Stirling Moss once said, "People never think of themselves as being anything less than ideal lovers and expert drivers." With respect to the latter, a g.Analyst may tell you otherwise. But it will also tell you where you need to improve and subsequently, with luck, that you have improved. And perhaps someday Valentine Research will invent a device for measuring your performance with the respect to the former. ☺