Deciphering Data

Now That You Have a Data System, How Do You Use It?

story by peter krause • photos as credited

Data acquisition systems have come a long way since the 1970s, when they started showing up in the pro ranks. Today's GPS-based technology is more powerful, more reliable and more attainable. The tricky part is understanding all of those wavy lines.

But even interpreting the data has become easier. Speed and g-load information displayed on color-coded track maps allows for quick comparisons. Sensors and wiring looms are no longer necessary because everything is self-contained. Pre-loaded templates allow observant drivers to coach themselves.

Driver inputs are recorded accurately enough to reveal plenty of areas for improvement—if you know where to look. Don't forget, the most powerful tool is worthless if you don't know how to use it.

Frustrated users refer to these devices as expensive lap timers. Others post raw video to the Web before their brakes get cold, rarely overlaying speed, friction circle or lap times. Video is great entertainment, but learning how to decipher data can help you find the speed you're looking for—and with less risk.

Using a few simple features every time out makes it easy to identify weaknesses in your driving. Understanding these simple X-Y graphs and looking at a properly driven friction circle can yield a lot of insight. (For further reading on the subject, be sure to check out "Making Sense of Squiggly Lines," now available from Motec USA West guru Chris Brown.)

My method for optimizing drivers begins with reviewing their data, jettisoning the 80 percent of it that demonstrates their good skills, and identifying the 20 percent that shows what's keeping them from making a big leap forward in performance. I like to harvest the low-hanging fruit first.

I use velocity (speed) and distance (position) along with longitudinal g-loads (braking and acceleration forces) and lateral g-loads (cornering forces) to gauge a driver's fundamental skills. After that, we move on to perfecting that crucial transition between braking and selecting the proper corner entry speed. Finally, we explore how soon to apply the throttle when exiting a corner and how long to keep it planted before the next braking zone.

Speed vs. Distance

To begin, let's use a simple speed vs. distance graph. The speed trace indicates both minimum and maximum speeds, which helps determine gearing. It also provides the rate at which speed rises and falls.

When setting up this kind of graph, plot distance instead of time on the x-axis. Distance is much more consistent when comparing relative performance between cars and drivers, regardless of their lap times. Distance shows where events occur, while time shows how long they last.

Reading the graph is easy: As speed increases, the trace rises. Lower gears will produce a steeper climb. The speed trace flattens out when the car approaches terminal velocity, climbs hills, or maintains a steady-state throttle. Then there's braking: The harder the braking, the more sharply the trace falls. Coasting? The trace lowers gently.

Ideally, the trace should be strongly rising or falling at all times. Anything else means time was wasted—or that the course had a very long corner.
Clean Up Acceleration-to-Brake Transitions: If read left to right, every point in the average graph can represent a distance of car lengths. When transitioning from full acceleration to standing on the brakes, the goal is to do it in the shortest distance possible. If you use up too much real estate going from the gas to the brake, you’re giving up valuable ticks of the clock.

Countless drivers are convinced they’re on the gas right up to the brake point, but lazy, flattened or gently curved “peaks” tell the real story. Speed should rise to a sharp point and then drop like a stone, indicating the braking zone. Here is a proper approach to Turn 1 at VIR (black trace) and one that needs more commitment in the transition (red trace).

Don’t Overslow the Turns: Thanks to the effects of aerodynamics, fast corners and slow corners will yield different speed vs. distance “valleys.” Aero doesn’t come into play in slower corners, and the quick transition back to power produces a V-shaped curve.

Turn 1 at VIR (shown in Graph 3) produces a V-shaped trace. Like Jackie Stewart says, the goal is to apply the throttle only when you’re sure you can keep your foot in it until the next braking zone.

Faster corners—one you can take at 70 mph or more—produce U-shaped transitions in the trace. These corners feature larger radii that allow a car to cover more ground in less time. Brakes are released gently and throttle is squeezed progressively on these turns. Both factors produce gentle slopes on the graph. Turn 10 at VIR yields a nice U-shaped trace.

If your transitions back to power in fast corners produce V-shaped traces, you’re probably overslowing and staying on the brakes too long. Pay attention to brake release rather than application. Easy does it.

Improve Braking Technique: When applying brakes, make sure you’re “drawing” a downward trace that’s linear and nearly vertical. This is especially important if you need to lose a lot of speed—say, more than 30 mph. If your downward trace isn’t linear, it means that your brake pedal pressure was inconsistent. Remember, you won’t save any time by asking the car to brake. Tell it what to do.

Proper release of the brake is important, too. Be careful that you don’t lift your foot prematurely when entering a slower corner—one you’d take at less than 60 mph. This will result in a “lazy coast” (see the red trace in Graph 2) or a “double dip” (like the blue trace in Graph 2) through corner entry.

Acceleration and Braking vs. Distance

Next, select the trace that shows acceleration/braking or longitudinal g-load vs. distance. According to standard engineering practice, these graphs depict acceleration forces rising above the horizontal zero-axis and braking forces dipping below. The greater the deceleration rate, the farther the trace falls under that line.

Traqview and TraqStudio graphs, on the other hand, display the vertical measures in the opposite direction. Braking forces rise above the horizontal axis, while acceleration forces dip below.

No road racing car can accelerate as quickly as it can slow, so focus on using your vehicle to its maximum potential in all respects. The most common area for improvement—and one that yields huge benefits when done properly—is slowing the car. Let’s continue with our tips.

Stop Short: To slow your car efficiently, apply the brakes to the point of maximum deceleration over the shortest distance possible. The trace should reach peak values steeply.

Longer braking zones should produce a trace that stays at a high level and then trails off at the end on a flat and level track—like the black
trace in Graph 4. With most drivers, as their eyes get bigger, they press harder on the pedal. (See the red trace in Graph 4.) Some drivers are not consistent with their pedal pressure when they heel and toe, and this is shown by the blue trace in Graph 4.

**Shift Quickly:** Without trashing the gearbox, save time by shifting more quickly. The standard synchro box shift should take no more than 0.35 second, as shown by the black trace in Graph 6.

Most drivers take longer than that—some as long as 0.8 second (red trace in Graph 6). With a dog-ring, non-synchro gearbox, the shift may be hardly noticeable, as shown by the blue trace in Graph 5.

**Don’t Lift:** Identify lifts or breaths off the throttle by looking at a longitudinal vs. distance graph. Overlaying graphs can help you target areas for improvement.

When studying this trace, be sure to consider how steering scrub can slow a lower-powered car as it goes up a hill. The black trace in Graph 6 shows a driver who is flat through the Uphill Esses at VIR (Turns 7-9). A more conservative driver starts with longer lifts (red trace in Graph 6) and finishes with shorter ones (blue trace in Graph 6).

**Lateral g-Load vs. Distance**

A lateral g-load vs. distance graph can reveal the true measure of your cornering technique. Let’s hit the books for a minute. A 1987 data acquisition device called the gAnalyst came with a great booklet written by journalist and Indy 500 racer Pat Bedard.

In it, Bedard explained optimal cornering technique and showed how early turn-in, late turn-in and ragged turns could be detected in the g-load data. Those lessons still hold true today.

The black trace in Graph 7 shows what happens when a driver turns in too early at VIR’s Turn 4. We can see a gentle rise in lateral loading, then a big increase, then an ebb. This results from the driver “crabbing in”—that is, leaving the outside of the road too early, taking a shallow entry angle, and then having to turn the wheel substantially to negotiate the corner.

The blue trace in Graph 7 shows a driver who has good discipline but still needs some work. The late turn-in is properly executed, but perhaps too much track is available at the exit. The data shows an absence of lateral loading, then a quick building of forces early in the corner, and finally a long ebb.

Want to see the turn taken correctly? The red trace in Graph 7 shows a driver who preserves corner entry speed and allows for the longest, most productive duration of cornering g-loads.

**Friction Circle**

The friction circle illustrates the forces acting on the car as well as its transitions between braking and cornering. When it comes to grip, keep this in mind: You can use 100 percent of your tires’ grip while braking, accelerating or cornering. Asking the car to change its state in multiple ways at once—for example, braking while turning into a corner—requires you to divide that 100 percent of available grip between inputs. Your goal is to come as close as possible to maximum grip while performing any combination of these tasks on track.

Every data review program can display these forces on an X-Y graph. Each dot in Graph 8 is a sample of g-load measurements collected over time. The red circles indicate the 1.25g (inner) and 2.5g (outer) points. The peak value for grip obviously depends on the tire, but in this case anything over 1.25g is very good.

When a driver doesn’t use all of the available grip in a transition, the dots will form a condensed convex shape between maximum braking and cornering. This is shown in the left half of Graph 8.

When the tire’s traction limit is used more efficiently—remember, we’re trying to use 100 percent of the tires’ grip—the sample dots start to extend towards our circular ideal. This is shown in the right half of Graph 8.

**Side by Side**

Now that we can read and interpret the data, how can we use it? One way is to focus on the delta-T measurements, also called time slip or time gap measurements.
Let's say we want to compare two different drivers, and they happen to drive similar cars—Spec Miata, Spec E30, Spec Racer Fords or whatever. We're after the differences in technique. In our example, Driver B (shown by the red trace in Graph 9) is losing time at VIR to Driver A (shown by the black trace in Graph 9).

We'll use the speed vs. distance feature and overlay the two laps. Then we'll select the delta-T feature.

The two lines tell the whole story. Ignoring the small, temporary peaks and valleys around braking zones, the difference between the two lines shows where time is gained or lost. We can even zoom in on their specific data to find out who's maximizing throttle and using all of the track.

**Putting Your Best Lap Forward**

Now we can use this data for one more thing: putting together the best lap possible and measuring driver consistency. Most data acquisition software makes this easy thanks to a feature typically called ideal lap, theoretical best lap or best rolling lap.

This feature combines the best segments from a session to form a lap of the driver's greatest hits. That best-of lap is then compared to the driver's actual best lap. A few data system software packages will even allow the users to graph the difference between the two, but most will at least show the best theoretical time and the best actual time.

A quick warning, though: Physics often prevents a driver from achieving the best theoretical lap, as going faster through one segment may compromise the next. However, the spread between the theoretical best lap and the actual best lap should be relatively narrow.

The best pro drivers are generally within 0.3 to 0.7 second of their theoretical best times. The best amateur drivers come within 0.5 to 0.9 second, while most accomplished drivers are off by 0.7 to 1.1 seconds. If your gap is any wider than that during a session, it may be time to get back to the fundamentals—and don't forget to use your data system to chart your progress.

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**Most GPS data acquisition systems include an extremely effective delta-T feature. It shows exactly where time was lost in a comparison between two laps. In the case of two drivers sharing the same car, the slower driver can take cues from the faster one to get up to speed more quickly.**