2002-21-0041

# Performance Driver Information Systems, Enhancing the Fun-to-Drive Equation

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## ABSTRACT

Most driver information systems offered in automobiles today display vehicle speed, fluid levels, fluid temperatures, and some basic diagnostic information (warnings, panel lamps). Optional driver information systems add to this list by offering fuel economy information, compass heading, outside temperature and other comfort and convenience related items. Very few provide information in regards to the real performance of the vehicle, its motion in 3-dimensional space, or the driver's skill and performance. Making this information available to the driver can enhance the "fun-to-drive" aspects of driving.

## INTRODUCTION

Drivers use their automobiles for a variety of reasons. Of course, using an automobile as a form of basic transportation to get from point "a" to point "b" is at the top of that list. To aid in that task, driver information systems do not need to be very complex. Essentially, all that is required is a speedometer and a fuel gauge. The speedometer helps you obey local speed restrictions along the route, and the fuel gauge lets you know your range. Any other instrument is extra, to ward off potential trouble or to give you peace of mind. Warning lamps are used to indicate conditions that may cause damage to any of the on-board mechanical parts. Trip computers help you gauge your fuel economy or make sure you are going in the correct basic direction. A daily commute to and from work rarely requires any more information than that. Making a daily commute to work "fun-to-drive" will take a great deal of imagination and may not be possible whatever information can be made available to the driver.

But luckily we have weekends and vacation days where we hopefully do not have to fight construction delays and congested traffic. People just don't use their cars for work; they can also use them for play. There are many ways that people use automobiles for play. Some keep extra cars that are only used on the weekend. They may have an old classic vehicle they just enjoy driving or tinkering on, or it could be a performance vehicle that is not appropriate for that bumper-to-bumber commute to work. Whatever the case, one thing is for sure, people have fun with their cars in their own personal way.

**Figure 1. - Having "Fun" in the Cone-zone**

Most major automotive manufacturers have discovered this customer pull and offer products to fill this "fun-to-drive" niche. Probably one of the first American "sports cars" to take this market seriously was the Chevrolet

Corvette of the 1950's. Hot on the heels of the first California street rods, it combined the right blend of style and performance to attract a loyal following. However, a vehicle segment that really capitalized on the "fun-to-drive" equation were the muscle cars of the 1960's and 1970's. Even today, many enthusiast clubs exist that still take their 1970's Cudas and Roadrunners out on "Cruise Nights" and open track events around the country. But you will also find people driving Vipers now that are only a few years old enjoying them just as much. In fact, now that the majority of OEM's build products that fit this fun-to-drive mold, you can often find a club for any specialty vehicle. Besides basic auto shows and cruise nights, these clubs will often organize competitive events for their vehicles. Sometimes it's a brute show of horsepower in the form of drag racing at the local strip. But at other times it's a show of driver skill in harmony with the vehicle chassis in the form of autocross racing. Whatever the form, people like to drive their cars to the limit on occasion.

**Figure 2. - Blazing your own trail**

But not all automobile enthusiasts are interested in looking good and going fast. Function sometimes outweighs style. Some like to take to the trails to visit nature and to get away from the asphalt jungle. For over 50 years now, Jeep vehicles and other vehicles designed for use off paved roads have been catering this group of fun-to-drive individuals. Off-road events are just as organized as on-track events and have dedicated trails and just like racetracks. Granted, the scenery goes by a lot slower when you travel off-road, but the trail can be just as demanding as the track for the driver (figure 2.).

Since the formation of these enthusiast organizations over 50 years ago, vehicle technology has changed a great deal. The sport and process of having fun is very similar, but the equipment is better and much more complex. Sports cars now contain plenty of technology to assist in their behavior. Fuel injected engines are not bothered by excessive g-forces sloshing fuel in the carburetor. Anti-lock brakes and electronic stability control computers smooth out the job of stopping the car. Traction control algorithms can allow the automobile to accelerate at its absolute maximum rate. But all of these systems take the driver out of the control equation. The computers just make everything happen "automatically", with the driver having very little to do with the most optimized method. How can we give the driver back some fun without destroying the benefits these systems offer? The answer is to provide driver information systems that show vehicle performance. Let the driver see the results. Let the driver know where they are going. Giving the driver this information will put more fun back into the driving experience.

## PLAYFUL CUSTOMERS

There are many ways that owners can have fun with their cars on weekends. For vehicles built for performance and handling, the answer is racing. There are many forms of racing, and are even a few types that allow the customer to use their vehicle in a relatively stock form and is very low cost to participate in. It is possible to use your car for a daily commute during the week and then race it on the weekend. Brought to public attention recently by movies like the "The Fast and Furious", there is a tendency of people today to race on city streets. This is a very dangerous activity and should not take place, but it does highlight what many people think is fun to do with their cars. Add as many performance modifications to your car that you can afford then go and race it against others. This has been a favorite pastime in America for over 50 years now. But there are safer forms of racing to test your skill and machine than street racing. On virtually every weekend of the year, you can find a club sponsored form of racing called autocross or Solo racing.

### SOLO Racing

Solo racing is a name given to autocross competition by the Sports Car Club or America (SCCA) [1]. Autocross racing usually takes place on a flat track, parking lot surface, or inactive airstrip. It is a relatively simple course fashioned with orange caution cones in a predetermined shape (Figure 1.). The objective is to drive inside the cones and not to hit any. Racing on a autocross course allows drivers to test their car and their skill against the clock. The car must be able to accelerate quickly, brake well, and handle even better. The only measure of your performance is the stopwatch at the end of the course. How fast can you get through the course? What is the best technique? Although the vehicle rarely exceeds legal highway speeds, the combination of concentration and car feedback creates an adrenaline rush. It is like being in a movie chase scene, only the police aren't after you and there is no big crash in the end.

There are also two variations of Solo racing. Solo 1 is strictly a timed elimination event. Multiple heats (usually four or five) are run and your finishing time for each heat added for a total time. Lowest time (in your class) wins. Solo II racing is a little more real-time competitive. Two identical but separate tracks are laid out. Two cars then start on the separate tracks at the same time and race simultaneously. The winner finishes first and advances. Solo racing also has very simple rules. Bring the car you want to race (even drive it to the event), a driver's license, and a helmet. Events are scheduled on a regional basis around the country [2].

But because Solo racers usually use production or slightly modified vehicles to race, current on-board driver information systems do not help much with the improvement of your race time. Do you really need to know the average fuel economy you are getting driving around safety cones? How can you tell what performance improvements actually work, and which do not? What suspension system set-up is best suited for the track and environmental conditions that day? What driving technique works best? How do you verify your results? How can the technology that is available today be used improve my driving performance? Weekend racers can use better driver and vehicle information systems to improve their results.

**G.Meter Performance Display**

**Figure 3. - Chrysler Crossfire Concept Vehicle**

Professional racing teams answer these questions with sophisticated on-board data acquisition systems. Every on-board vehicle sensor and parameter is logged and studied after each practice or real time during a race. Unfortunately, the cost of a sophisticated data acquisition system is prohibitive, preventing applications from appearing in standard automotive products. But in a recently built concept car called the Crossfire (Figure 3.), a lower-cost data acquisition system called the G.Meter display was installed and demonstrated. The G.Meter was used to relate chassis movements in a graphical/numerical way to the driver. Driving by the "seat of the pants" can be deceiving, as racers know. Even against a stopwatch, it is difficult to objectively judge your performance, to know where you went slowly or fast on the track. Using real engineering units to back up your subjective evaluation can improve your knowledge of performance, both the vehicle's and your own.

By measuring the acceleration values present in the vehicle, the device is able to display information relative to driver and vehicle performance. It is a new form of driver information system. It does not provide miles-per-gallon information. It links the driver to the chassis and the dynamic nature of the vehicle. Measured results can help the driver improve the way they handle the vehicle. You can try one driving style against the next and evaluate the results. Overlay one lap against another, what works and what doesn't.

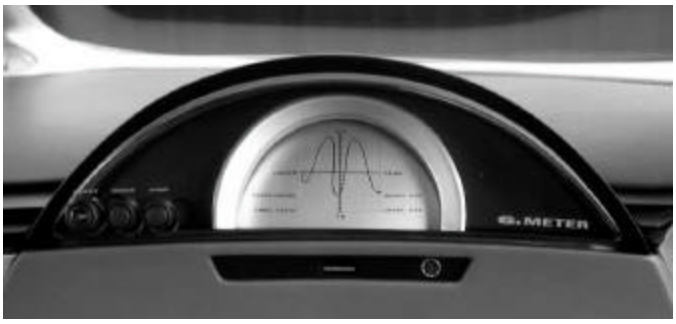


**Figure 4. – Chrysler Crossfire G.Meter Display**

The G.Meter system uses a 3-axis accelerometer system mounted to the vehicle floor to measure performance. A computer mounted in the rear cargo area of the vehicle samples and accumulates the accelerometer values and displays them on the instrument panel mounted Liquid Crystal Display (LCD) (Figure 4.). This display is used for real time viewing of the measured results. There is a mode switch that allows the user to change the way the information is shown. A simple vehicle movement display can be selected to minimize the attention draw while driving. But other more detailed display options are possible. A second mode shows vehicle movement in four quadrants, simultaneous displaying both lateral and longitudinal values. This mode can be also used to display a scatter diagram, showing the most extreme values over a period of time. A final mode shows the information in oscilloscope form, providing a time reference for the data. But in all cases, the information is stored on-board for later download to more tools for analysis.

**Low Cost Effort** - Knowing that weekend warriors are reluctant to spend a great deal of money for extra tools, the G.Meter is designed to be low cost. The accelerometer system, which originated from the M.I.T. Media Lab in Cambridge, MA., is a low cost unit designed to track human movement in computer gesture experiments [3]. It could also be used to measure vehicle gestures (movements) in this application. The system uses low-cost accelerometers and a simple microcontroller, both manufactured by Analog Devices. It has a footprint of a cubic inch and costs less than $50 in small quantities. The low-cost computer in the trunk

acquires the accelerometer data and formats it for display. In a production car, this function could easily be integrated with a controller that is already on-board for other functions (i.e. powertrain, chassis, body controllers). In fact, with some vehicles that already contain Electronic Stability Protection (ESP) systems, the accelerometer data is already present in the vehicle. So, for a production car system, the information display is the most costly device. As LCD prices continue to decrease and more vehicles contain multi-function displays, the G.Meter function can simply be added as another screen in the system options. The G.Meter system also allows the driver to download information off the vehicle. Post analyzing your race session will assist the owner the following weekend. The acceleration data is conveniently stored on a Secure Digital (SD) flash memory card mounted just below the LCD display. This flash memory card can then be removed and the data transferred to a handheld or laptop computer (Figure 5.). This allows the user to overlay one weekend over the next to evaluate changes you made on race weekends. The information could also be posted on the Internet to share with enthusiasts across the country what performance modifications are best, or maybe brag about the best driver. Most likely though, those with the best times will keep their secrets to themselves. By replaying the data stream, much like you would replay a saved game on a video game console, you can also relive your best weekend performance.

**Good on your commute also** - However, performance driver information systems are not just designed to entertain the driver for fun or to improve performance. Once certain parameters are obtained about the vehicle's motion, the information can also be used for other driver benefits. Having already mentioned that the accelerometer was originally used by MIT to recognize human movements or gestures [4], the same theory can be applied to the vehicle. Vehicle gestures - such as lane charges, accelerations, and swerves - could be used to identify driver attention or fatigue, road hazards, or other unsafe conditions. In the end, it's possible to enjoy the product and remain safe at the same time.

**Figure 5. - Flash Card Data Transfer**

**Other functional uses --** When integrated with existing systems in the vehicle, the G.Meter system can have many other practical applications as well. For example, since it is capable of measuring tilt angles in addition to movement in all three directions, the G.Meter can supplement the vehicle's anti-theft system by detecting if the car is being lifted or towed away. The G.Meter could be used to enhance an automotive compass. Since a magnetic compass is very sensitive to tilt, the G.Meter's output can be fed into the car's compass to compensate for tilt, making the compass much more accurate. With some small modifications, The G.Meter could use the driver's cell phone to make a call to an emergency number if a high-G impact or rollover should occur. Worried parents can use the system to monitor their teenager's driving habits. The possibilities are endless.

**Enthusiastic Response** – The G.Meter system is not a Telematics System. There are still plenty of vehicle purists out there who have no need for "excess" information. Not everyone wants the Internet in his or her vehicle. And when you drive a spirited sports car for fun, you most certainly want to remain as far apart as possible from your e-mail. The type of customer who buys a sports car, and drives it like one, loves the mechanical nature of the car and thrives on the physical feedback that only it can provide. Their car is not an appliance to them. Many owners also attempt to improve the performance and style of their vehicles. They do this by installing new tires and wheels, different chassis components, or even add under-hood components. The specialty equipment and accessories market for automobiles still thrives, even in this age of computer controlled systems. The G.Meter can help sort out the changes. Improvements or changes made to the chassis or engine system to personalize the vehicle can be measured to gauge their effectiveness. Owners can get direct feedback on their after-market investments.

## HAVING FUN OFF ROAD

Not everyone likes smooth surfaces to race on. Many people find paved roads too crowded to have much fun driving on. Weekend warriors who take their vehicles off-road also represent a large number of enthusiasts that have fun experiencing nature. To blaze your own trail or to follow a path established by Native American Indians can also be plenty of fun.

### The Rubicon Trail

Although hundreds of established vehicle trails exist in America, not one is as famous to off-roaders as the Rubicon trail [5]. The Rubicon trail is a very primitive trail established by native Americans over 200 years ago. The trail is over 20 miles long traversing some of the roughest terrain in the nation. Most trails established for off-road use are rated from one to 10 for difficulty, 10 being the most difficult. The Rubicon trail is rated a solid 10. It takes a very special vehicle to traverse this territory with a skillful driver that has plenty of patience. This is not a trip you make in a day. What is interesting

about the Rubicon is that enthusiasts have been driving on it for over 50 years. Not everyone takes the highway; some people like to take the hard way. Don't count on road construction on the trail, the requirements to make-it-the-distance have not changed in 50 years. It should also be no surprise that OEM's use the Rubicon trail as a testing ground, to establish what equipment is necessary to make the grade.

But once again, the on-board driver information systems found in off-road vehicles do very little to help you on the Rubicon. The electronic compass on-board shows course heading information, with 45-degree resolution. The resolution is fine for finding your way on roads built after the Homestead Act of 1862, but not good enough to find your way in the wilderness. A marine compass found in a boat uses a full rosette to navigate, accurate to a single degree or less. Off-roaders should use an instrument with the same resolution in uncharted territory.

**Extended Capabilities**

**Figure 6. - Jeep Compass Concept Vehicle**

The Jeep Compass (Figure 6.) is a vehicle designed for off-road use. It is designed for a commute during the week and your trek off-road on the weekends. Recognizing the intent of the owner, the design includes a full rotating compass as part of the standard instrument cluster. This instrument is designed specifically to assist the owner in their process of having fun. Now you can leave the road surface and navigate your way through the backcountry more accurately.

Instead of using traditional flux gate-based circuitry normally found in a standard automotive compass, this compass uses a highly sensitive magneto-resistive sensor to improve resolution. The instrument is displayed prominently just to the left of the speedometer (Figure 7.). Ironically, the speedometer itself becomes a secondary instrument to the compass when traveling off-road. The analog method of displaying the heading information provides not only much better resolution, but also a more intuitive method of determining direction than its digital counterpart. Instead of having to determine heading using a text-based value (“the compass says SE; now which way do I turn to go west?), the driver needs only to glance at the rosette dial, which provides the traditional compass look and feel.

**Figure 7. - Compass Instrumentation**

However, the compass is just a starting point. It helps with basic navigation but does not fill the entire need. Many hard-core off-roaders now navigate with GPS. They navigate with "way points" not headings. The Rubicon trail can be followed by entering a set of "way points" into your GPS unit. More capable off-road vehicles of the future will make best use of digital topographical relief maps as part of their standard GPS navigation systems. The topographical maps can be used to help enthusiasts navigate in all three dimensions, showing elevation changes as well.

**Figure 8. - Topographical Map Application**

One such application of a 3-D topographical navigation system can be found in the Jeep Willys Concept Vehicle. This system combined a laptop computer (customer provided) with a built-in LCD display mounted high in the instrument panel (Figure 8.). A GPS receiver attached

to the laptop provided the signal to locate the Willys on the planet. The display showed the terrain ahead to the driver. An "off-the-shelf" 3-D topographical mapping software [6] package provided the computer output. This off-the-shelf software can show 3-D terrain information to the driver in many different ways, including satellite views! Having knowledge of the terrain ahead will give adventurous off-roaders a chance to pick the best route, which may not be the simplest route.

## CONCLUSION

It has been discussed that vehicles are not just used by their owners for the commute to work or to shop, they are used for "fun" as well. Fun has many forms, but it is best when it occurs off the highway under controlled conditions. Advanced electronic systems can help fill this customer niche. Re-configurable displays can be used to display information that is relevant to the vehicle control task. Recording chassis information can be used to fine-tune a race set-up or to check a new set of tires. An electronic compass can help an off-roaders find their way more accurately in an area with no street signs. Electrical/electronic systems are preferred because they can be quickly reconfigured to personalize or these interfaces. Once installed, these same systems may also be used to give the car a different personality for a different driver and their demands. Finally, electronics can complement the advanced mechanical systems that provide the enthusiast with the fun to drive experience.

## ACKNOWLEDGMENTS

The authors would also like to acknowledge the contributions made by the DaimlerChrysler Product Design Office.

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