# THE PROFESSIONALS!

**The big boys have more time and more toys than the weekend warriors to help them understand what makes a car tick. But the basic principles of data logging remain the same. By Graham Templeman**

SO FAR in this series, we have been looking at how to make the most of an entry-level data logging system which might cost not much more than a couple of sets of tyres. But what happens when the system costs the same as a small motor home and has a full-time expert to look after it?

To find out how different things can be, we spent some time with two professional teams. As you might expect, things are both very similar and very different.

First, Lee Penn of LNT Motorsport and Albert Lau and Jean-Patrice Loof of West Surrey Racing deserve a huge thank-you for being so helpful in providing the material for this feature. Lee let me watch and ask innumerable questions during a test session at Silverstone and Albert and J-P gave me a really thorough run through the data engineering of an A1GP car at the WSR headquarters.

Starting with the similarities, amateurs and professionals are all trying to minimise lap times by understanding and reacting to what the car is doing. The difference comes in the resources available to them. A well-funded professional team will log as many parameters as it is interested in and will have the manpower to install and maintain the system and to manage the resultant data.

The number of channels is not an issue – if you need more, you use an expansion box – and what seem like astronomical prices for sensors to the clubman become rational choices for a professional team. Laser ride height sensors fitted each corner would cost about £600 per corner range and the choice is made on the basis of whether the extra information will help make the car go faster.

In this case, knowing the actual dynamic ride height and the damper movement allows the engineer to calculate how much the tyre deflects under load. This can be measured as either a distance or a frequency. If there are strain gauges fitted to dampers, this data can be combined with the tyre deflection to calculate the actual tyre spring rate. If the car is being run in a category where the choice of rubber is free, then the team can talk with some confidence to the tyre engineers about the appropriate tyre specification for this car.

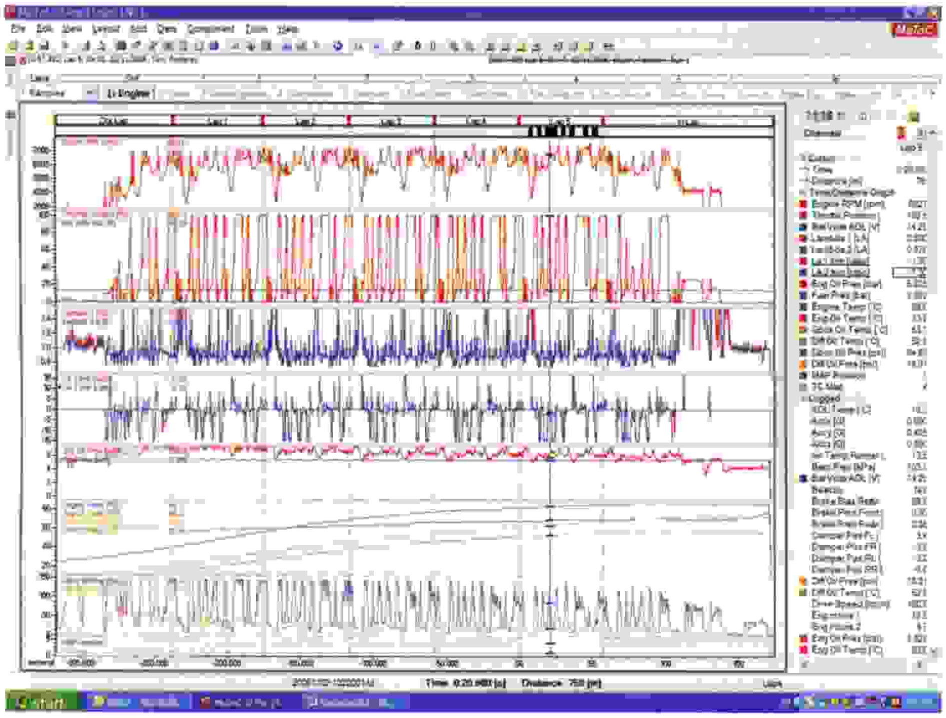
Apart from the inevitable budgetary constraints, professional teams also have to work within the rules imposed by the series organisers. British GTs, for instance, are not allowed to use telemetry (the transmission of data back to the pits while the car is running) and A1GP only allows telemetry at 1 Hz. Other series specify the type of logger to be used and impose further constraints by limiting the available memory.

> “Joe Clubman tries hard but just how careful the teams are to manage the data properly was a revelation”

In the eyes of a club racer, the range of sensors in regular use is enormous. In addition to the usual

**RIGHT** West Surrey Racing's meticulous approach to gathering and storing information is legendary on the pit lane. It means that when data is compared from its A1GP cars, for instance, one car can be superimposed upon another with minimum fuss and in the knowledge that the figures are valid

**FIGURE 1** VITAL SIGNS



**LEFT** The first step is for the data to be dumped onto a couple of screens in order for the vital signs to be checked. This screen includes engine and gearbox pressures and temperatures and lambda measurements from each bank of cylinders

suspects, the speeds of all four wheels, brake line pressures, damper travel and pushrod or damper load sensing all seem pretty much routine and four-corner laser ride height sensing, infra red brake temperature monitoring and three axis accelerometers are also used. There did not seem to be much interest in the direct measurement of yaw.

WSR's A1GP uses a pitot tube to measure airspeed since this can vary significantly from road speed and can help to explain anomalies in the data. Sepang has two long straights that run at almost 180 degrees to each other and airspeed and downforce can vary significantly between the two. The effects of a tow from another car can be seen very clearly because the pitot tube data fluctuates wildly.

Logging rates are what you might expect with most parameters being logged at 20 to 50 samples per second. The less important data, like battery voltage, is logged at much lower rates. Data relating to suspension movement is logged at about 200 Hz. Although faster sampling rates are possible, 200 Hz works and avoids the need to filter the noisier data that faster rates would provide.

Having access to information about damper travel means that the professionals are less interested in the actual value of lateral g generated by the car. The assumption is that a professional driver is capable of getting the best from the car and there is very little soul-searching about just how fast the car is cornering. Lateral g might merit a quick check to see that values are within the expected range, but very little more.

Of more interest is the attitude of the car as indicated by damper movement. This gives insights into the extent to which the car pitches, heaves and rolls and the effects that this is having on handling.

Downloading the data and having at least a quick look at it after every run is seen as imperative. A starting point is to dump all of the data on to one or two screens just to check that all the sensors are operational and giving reasonable data. Then follows a quick look at the drive train's vital signs – revs, temperatures and pressures – just to give a swift overview of trends over the run.

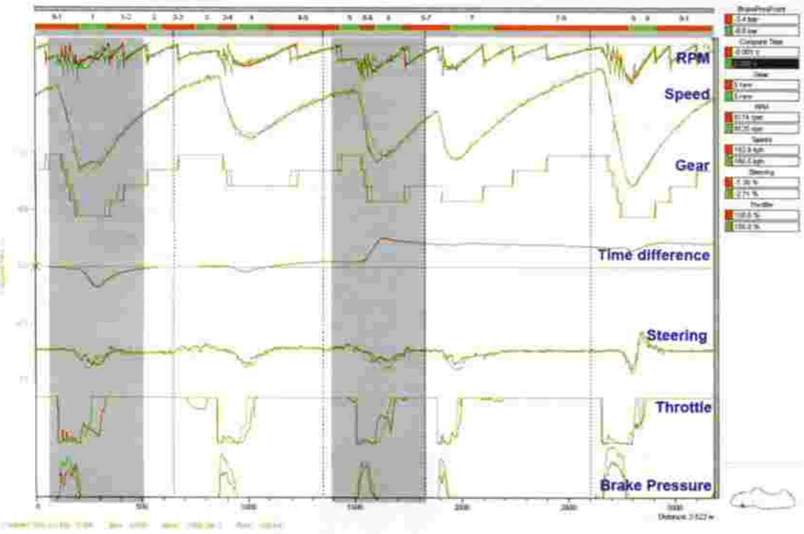
Pressures may be expected to fall slightly as temperatures increase and an eye is kept on fuel pressure because drops in pressure can be indicative of fuel surge. Figure 1 shows one such screen that includes engine and gearbox pressures and temperatures and lambda measurements from each bank of cylinders.

The needs of the driver come next. Both teams used a driver activity screen showing the usual things; the only difference at this level is that there is a routine monitoring of brake line pressure. This gives an indication of the level of braking asked for by the driver and if front and rear circuits are both measured, even more information can be extracted.

A maths channel showing the relationship between front and rear pressures is an immediate and unarguable record of brake balance. The brake balance should show a consistent percentage but occasionally the trace deviates from a straight line when the pedal is pressed or released. This is strong evidence of some sort of stiction in the balance bar linkage.

Figure 2 shows a typical driver comparison screen and the shaded area on the left shows the loss of time through turn 1 due to an over-ambitious entry ▶

**FIGURE 2** DRIVER COMPARISON SCREEN




**LEFT** The shaded area on the left shows the loss of time through turn 1 due to an over-ambitious entry speed. The right hand shading indicates time gained by firm braking and an orderly progress through turn 6

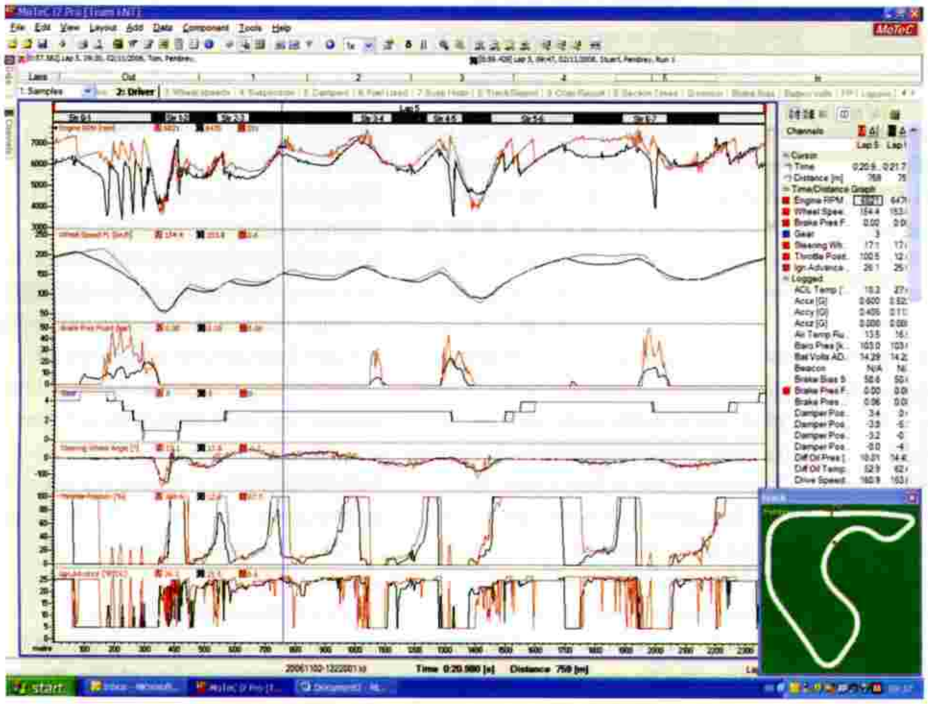
speed. The right hand shading indicates time gained by firm braking and an orderly progress through turn 6.

There is a presumption that the driver will be getting the best out of the car and that all that is required is to identify which technique yields the best results as shown on the time comparison trace.

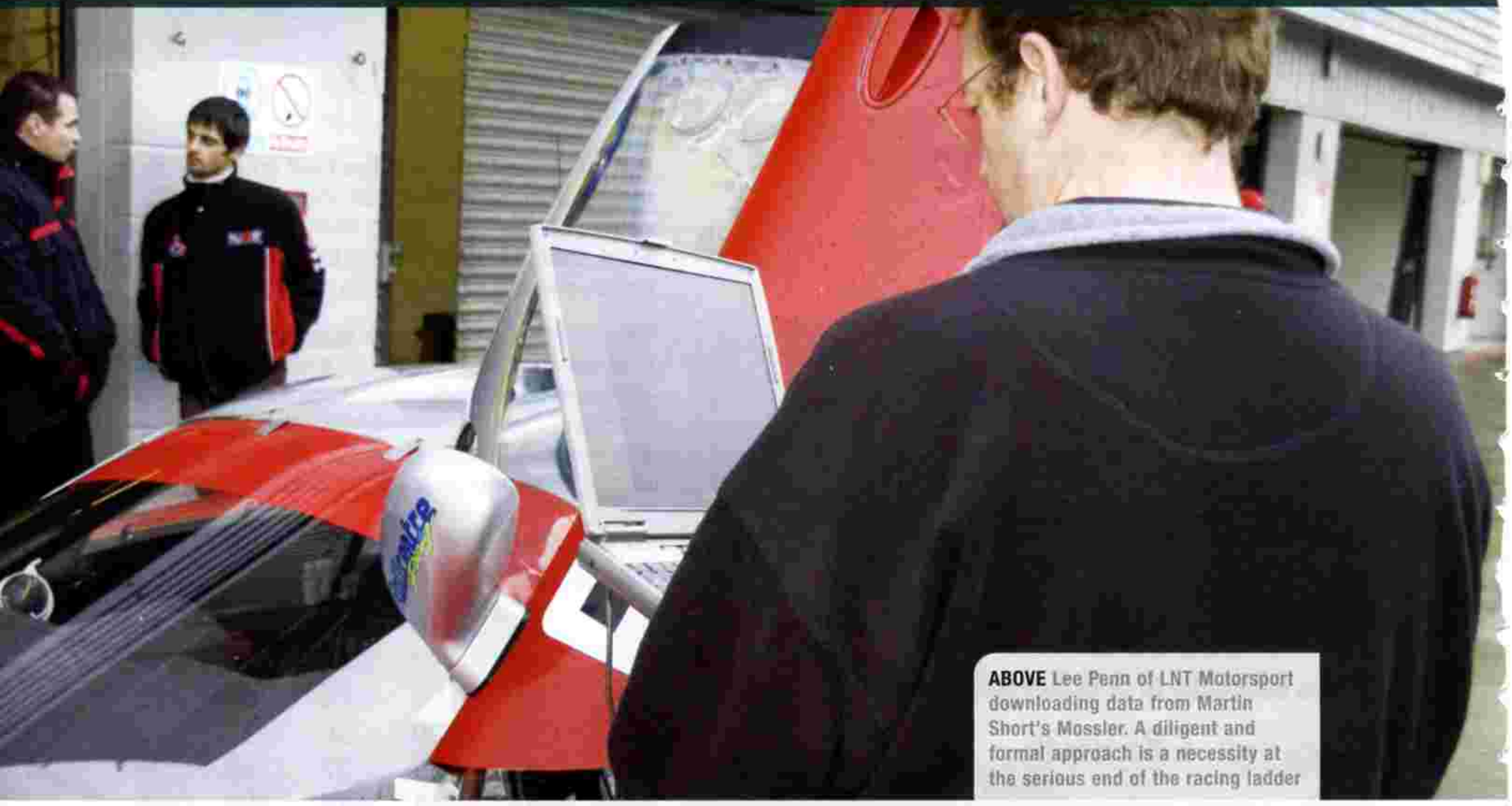
Figure 3 shows a fragment of a brake pressure trace where the red line is the professional driver and the blue line belongs to a club championship winner having his prize drive with a first taste of carbon brakes and high downforce. The lack of belief in the system's power is obvious both in terms of braking early and gently. By the end of the day, the traces were much more comparable.

One aspect at the pro level that came as a surprise was the inter-relationship between the dash logger and the engine ECU. Dash loggers are designed to take advantage of the ECU's sensor data but communication is very much two-way. For example, when ▶

**FIGURE 3** BRAKE PRESSURE TRACE




**LEFT** The red line is the professional driver, the blue a club championship winner having his prize drive. The latter's first experience of carbon brakes and high downforce is reflected in his braking early and gently



**ABOVE** Lee Penn of LNT Motorsport downloading data from Martin Short's Mossler. A diligent and formal approach is a necessity at the serious end of the racing ladder

four wheel speeds are logged, the percentage speed difference front to rear can be calculated as a logger maths channel and the dash can then send signals to the ECU to use some strategy for traction control. To do this, the ECU can cut sparks or fuel or can retard the ignition slightly to reduce torque.

Working with a client of LNT Motorsport, one of the items on Penn's agenda in the morning's test was to refine a strategy for traction control. When an engine is mapped on the dyno, it is possible to collect data about the extent to which retarding the ignition reduces the torque output. The data for various engine speeds and degrees of retardation provides the raw material for the traction control mapping.

While there is moderate wheelspin, the ignition is retarded and torque can be reduced by a known percentage. If the wheelspin gets severe, the power is cut completely. The challenge was to create a strategy that assisted the driver through the turns and rescued him in the event of severe changes in grip. A traction control map that worked fine in the dry had proved far too sudden in the wet.

Another revelation was just how careful the teams are to manage the data properly. Whereas Joe Clubman tries hard to be sensible and rational, teams absolutely need to have a formal and properly-documented approach. They have to use well-designed and well-understood protocols for collecting and storing data.

At WSR, with two-car teams in both BTCC and A1GP, there are carefully laid down data conventions for things like how the driver is identified (first name only) the car (by the chassis number) and the file structure (year, circuit name, date, driver).

Channels are given standardised names (Load FL, Load FR) and measurement conventions are set (downforce is positive, load is measured in kgF). These standards then apply to both the cars. The team can then not only superimpose one lap upon another, it can superimpose one car upon another with minimum fuss and know that the data is valid.

The set up of the data logger sensors becomes part of the formal operational processes. The mechanics set up the car before each run with a given amount of fuel and driver ballast. While the car is in this state all accelerometers, damper pots and strain gauges are also zeroed, as is the steering with the steering wheel pointing straight ahead. It is by this sort of attention to detail that championships are won.

The logger is even used to provide the data for the management of the components. Engine run time is recorded as a matter of course and the gear histogram (that shows the percentage of time spent in each gear) can be used to life individual ratios.

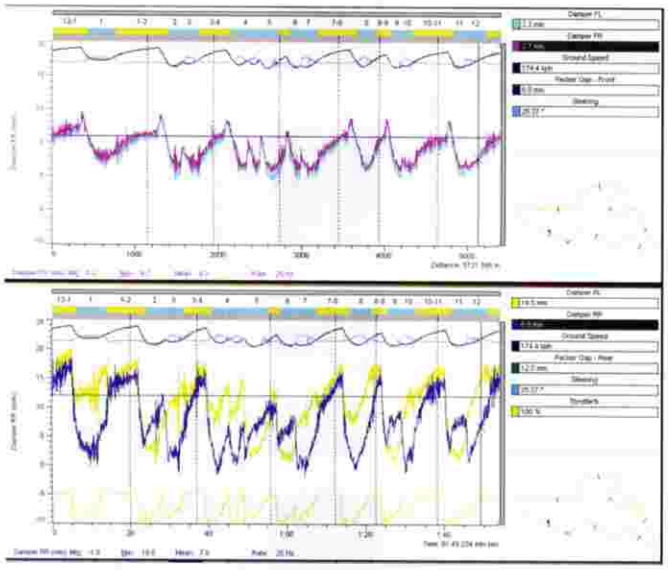
Many club racers will be familiar with the routine of draining the fuel tank before an event, putting in a known quantity prior to qualification, draining again and calculating fuel consumption from the amount consumed. This is then used for deciding on the race fuel load with fudge factors to allow for lower consumption on warm up laps and the possible intervention of the safety car.

The professionals use logged fuel injection data to calculate fuel consumption. They create a maths channel that combines engine activity, the flow rate of the injectors and the injection duty cycle to calculate the actual amount of fuel consumed. The dash can display another maths channel calculation, this time fuel load at start minus fuel consumed, to indicate the amount of fuel remaining in the tank.

The canny engineer can also relate data showing fluctuating fuel pressure to amount of fuel left in the tank and be able to cope with, or take steps to cure, any fuel surge problems that present themselves.

Having data for all four wheel speeds gives an insight into braking and traction problems. Club racers tend to rely on a single sensor on the outside front wheel and any lock up can affect the distance calculations and hence the presentation

**FIGURE 4** DAMPER TRAVEL ON AN A1GP CAR



**LEFT** The straight line at 6 mm on the top trace shows the stage at which the car goes on to the bump stops; above that line, the bump stops are being compressed. As the road speed increases, the dampers are being compressed by the aero load and as the driver steers through the long right-hand Turn 1 the speed and the downforce decrease. There is a small amount of roll, but only to the extent that the outer wheel compresses the damper 1 mm more than the inner. The lower set of traces shows that there is much more movement at the rear but still limited to less than 10 mm

of the data. Logging two front wheels allows the speed calculation to be done on the maximum of these two, i.e. automatically compensating for locked wheels.

With four wheel speed sensors, locking up under braking can relate either to an incorrect balance (one end locking before the other) or driver technique (braking while turning in). Poor gearchange technique is visible with rear wheels locking in downshifts or spinning in upshifts.

A professional team is also likely to try to find the time for creating an aero map for the car. This process involves driving the car in a straight line at steady speeds and with differing aero settings. This is yet another opportunity to spend money because piezo-electric pressure sensors are available that measure the relatively low numbers associated with airflow over surfaces. By measuring the load on the dampers or pushrods, the downforce and the centre of pressure can be calculated and by measuring pressures the interactions between front and rear wings and tunnels can be explored.

> “Engine run time is recorded as a matter of course and the gear histogram can be used to life individual ratios”

The effect of high levels of downforce is obvious from the damper trace. Figure 4 shows front and rear damper travel on the A1GP car and the aero load is almost enough to wipe out body roll completely.

Looking at the top trace, the straight line at 6 mm shows the stage at which the car goes on to the bump stops; above that line, the bump stops are being compressed. As the road speed increases, the dampers are being compressed by the aero load and as the driver steers through the long right-hand Turn 1 the speed and the downforce decrease.

What does not happen, though, is that the left front compresses and the right front extends. Without downforce, you would expect to see the traces heading in different directions as the body rolled. There is a small amount of roll, but only to the extent that the outer wheel compresses the damper 1 mm more than the inner. Only on three occasions during the lap does the inside wheel manage to extend the damper, and then only by very small amounts.

The lower set of traces shows that there is much more movement at the rear but still limited to less than 10 mm. No wonder the top teams own damper dynamometers. Knowing the damper travel means that it is possible to calculate damper speed and to prepare histograms of the percentage of time spent at each speed. This then gives an idea of the relative importance of high speed and low speed damper setting and the extent to which a reasonable balance has been achieved.

Again, you have to envy the professional teams with all the extra toys that they have to play with and their ability to measure what is happening.

Overall, that sums up the pro/am difference. More time, more toys and more chance to understand what makes a car tick. The principles – an emphasis on accuracy and a methodical approach – remain the same.

One sound bit of advice sticks in the memory: people try to read too much into the data and not realise that it is just one part of a complicated bigger picture. The driver, the team and many other sources of information need to be consulted before thinking that you know all the answers. ■