ACCESS ALL AREAS

PART 2

Data logger now chosen, the world – or at least the racetrack – lies at our feet. But what do we do with those pretty pictures once we have them on screen? Graham Templeman gives us a few clues

IF YOU are not careful, data will tell you the blindingly obvious.

The throttle histogram almost invariably shows that lap times are minimised when the driver spends more time on the throttle. You can also learn that the fastest laps come by carrying speed through the corners and on to the following straight. Did we really need to spend a week and the price of three sets of tyres to be told that?

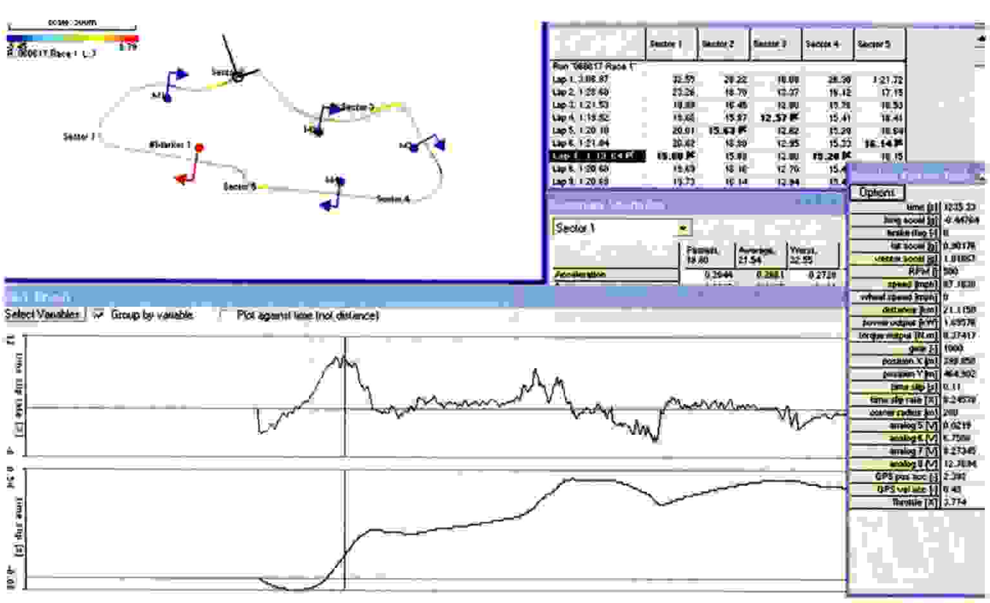
We have to look for more subtle signals and it is best to have some sort of organised method for finding them. And a step before that, we will look at some sort of organised approach to collecting, analysing and managing the data.

Even the smallest teams need a strategy for managing the data. It sounds obvious, but the logger needs switching on every time it goes on track. It also needs downloading whenever it comes back again and the data needs looking at. The driver is a good person to be given the responsibility of switching it on (it makes him or her feel important and avoids the 'I thought you switched it on and now we will never know how I broke the lap record!' sort of a tantrum).

Downloading is best done by someone else in the team because drivers are always adrenaline-fuelled when they get back and would probably break something anyway. Interpretation is a multi-stage process involving everyone at some point.

Data should be examined immediately at the end of each run. It should also be looked at again without the inevitable time pressures. The first attempt gets a general impression of how

FIGURE 1 TIME SLIP



LEFT The upper black trace shows the rate of time slip, the lower one the gradual build up of time lost through the lap. The RT software shows nothing for the first part of this lap (Lap 7) because Sector 1 was the fastest sector time of all. It is difficult to interpret from a static trace like this, but on a computer the cursor could be moved to the point of interest and the location on the circuit could be identified from the map. In the trace shown here, time was saved (0.1 sec) under brakes for the fast left hander (the Craner Curve) but more than that (0.25 sec) was lost under braking for the fast right hander (the Old Hairpin). The map has been specified to show rate of time loss from blue (good) to red (bad) things were going, the second, third and fourth attempts can be more leisurely, often just browsing to see what you see, but also equally often with a specific goal in mind – such as evaluating the performance of the brakes or whatever.

There is always a big temptation not to look at the data after the last run of the day. Everyone just wants to pack up and start the journey home. This is a pity, because it is always best to look at things while everyone is still together and while events are still fresh in people's minds.

Sadly, the excitement when the first data comes out of the system soon fades when it simply looks like a bunch of uninterpretable squiggles. The traces hold a huge amount of information but it has to be decoded and this can be pretty daunting. But if it is approached methodically, you will extract an awful of useful stuff.

"The traces hold a huge amount of information but it has to be decoded and this can be pretty daunting"

The logger gives you the *data* (individual facts, like the fact that the engine was pulling 7,200 rpm at the apex of a bend) and it puts lots of bits of data together in the form of charts and histograms from which it is our job to extract *information*, but what we are really after is *knowledge*. The logger won't tell you that there is understeer at turn-in which could be easily fixed by adjusting the dampers. Not in so many words, but with a bit of experience it becomes possible to identify the shape of the lateral g curve that gives you the clue.

So assuming that the driver is away doing the 'Did you see me drive round the outside of you at the Hairpin' routine, where can we start? We should look at the basics, just to reassure ourselves that there are no problems waiting to catch us out later.

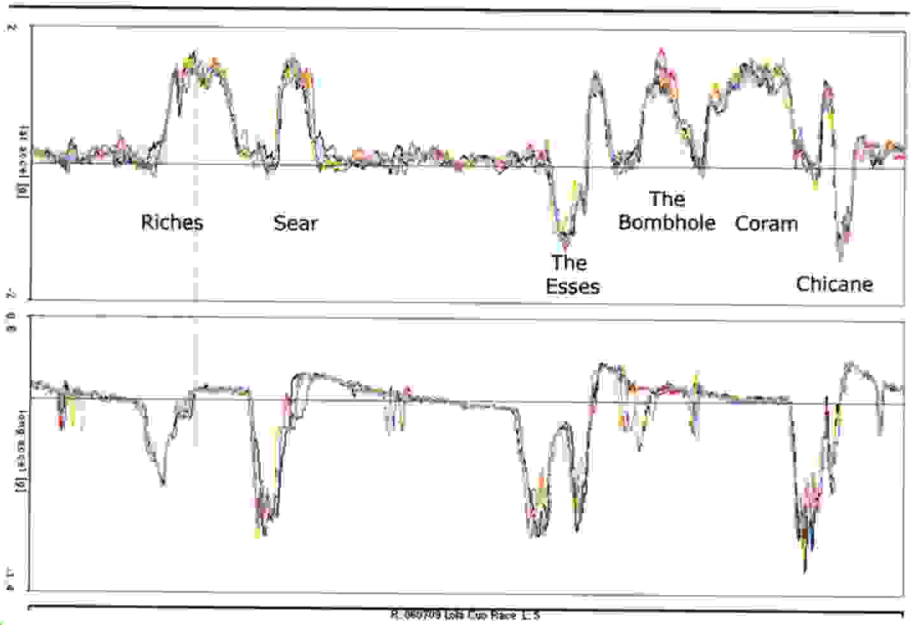
If we are logging temperatures and pressures, a quick scan of the whole session can be made to ensure that they have been within limits. Revs come next. Has the engine been buzzed and if so how seriously? This leads on to gear ratios – is the engine reaching peak revs at the end of the fastest straight? Is every corner being taken at engine revs that are within the power band? If not, what changes need to be made to the ratios?

Then look at performance level in general. You pretty soon get a feel for the sort of performance to expect from the car on a good day. Much of the data on show here and in future issues is taken from Sports 2000 where cornering of 1.6g is about right and braking of 1.3g. A small amount of aero downforce is hoped for and not always achieved. Acceleration in the lower gears can be .4 to .5 g, tailing off to .2 at higher speeds. But these figures represent the ballpark that we need to be in and if not, questions need to be asked and solutions found.

This is where it is useful to have someone in the same class with whom you share data – it might just be a slow day and you might be chasing your tail. When you have built up a bank of data, you can look at your data for this circuit on previous outings.

By now, the driver is back and we can look at things in more detail. Drivers inevitably, and quite rightly, want to focus on the ▶

FIGURE 2 INCONSISTENCIES



LEFT Overlaying a number of laps shows up where there are inconsistencies that would bear further investigation. The lateral g trace (top) shows that Sear, the second part of the Esses and the Chicane seem to be fairly well under control. These are the three slowest corners so we need to discuss with the driver where the problem lies with the faster corners. The long g trace shows inconsistencies in braking for the Esses and the Chicane, so again we need to establish whether it is a matter of brake set-up or driving technique

DL1 LOGGER

MOST of the data and analysis charts shown in this series have been compiled using Race-Technology's DL1 logger and the RT Analysis package. It was chosen because of the ease of set up, the large number of available channels and the fact that it is the lowest cost logger available. There can be no accusations that this was a high budget operation where any problems were solved with the application of copious amounts of money.

Unlike the others at this level, the DL1 uses GPS technology not only to draw very high quality maps but also to measure speed. The GPS measures its position on the ground 10 times per second and combines this data with that from its on-board two axis accelerometers to provide accurate data.

The two immediate practical advantages are that it does not need a lap beacon to trigger it and it is not necessary to install and calibrate wheel speed sensors. Lap beacons are easily forgotten and left on the pit wall and speed sensors tend to be expensive and are easily damaged in an accident. Calibrating them can be a pain because the rate of tyre growth at speed is not easily measured, so the rolling circumference is always a best guess.

Sadly although the maps are accurate enough to show what side of the road the car crossed the startline, without definitive maps of the boundaries of the track, they are not much use in evaluating racing lines. A race circuit is no place to do two slow laps surveying the inside and outside kerbs!

Because of the basic difference in concept, the software works somewhat differently to conventional packages, but still provides all of the functions needed for proper analysis. It also has a few bells and whistles not easily available to conventional systems, but that will be dealt with in a later article.

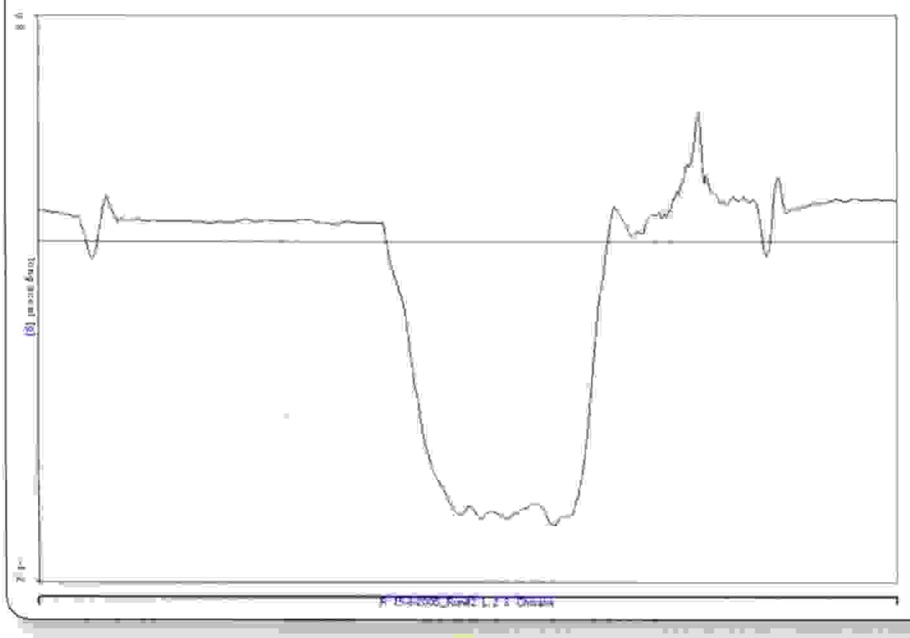
fastest lap and whether any further time could be found. The tool for this is a graph showing time slip. This enables you to compare where one lap is faster than another. The name used and the form of the display varies from one software package to another but FIGURE 1 is taken from the R-T Analysis package which shows time slip (the cumulative time lost through a lap) and the rate of time slip (how much faster or slower this part of the lap is, measured as a percentage). These charts show precisely where time is made or lost and can then prompt further investigation as to why that has happened.

> "Overlay as many laps as the software allows. What you are looking for is inconsistency"

Useful as the time slip analysis is, there are other methods. One is to overlay as many laps as the software allows on top of each other. Almost any combination of speed, revs, steering and g forces will do, because what you are looking for is inconsistency.

Some corners will have nice consistent traces where one lap sits on top of another lap with hardly any difference. Some corners will have traces which are all over the place. The consistent corners are the ones where there is no immediate problem. The driver is in a routine that gets through them without any drama. Whether they should be taken faster or on a different line is a question for later in the analysis process. FIGURE 2 shows this approach. ▶

FIGURE 3 BRAKING



LEFT This trace shows a production-based car under heavy braking. The blip at the beginning of the trace is the last gearchange along the straight, the small positive long g figure shows that the car is running out of steam and when the brakes are hit, the downward slope shows the build up of braking effort. The flat portion is the time spent at peak braking and the steep climb shows the driver getting out of the brakes before turning in

The inconsistent corners are giving you a strong message that there is a problem there. For some reason it has not been possible for the driver to get through those corners consistently. It could be a driver problem, being unable to get to grips with some aspect of the corner, but it could be that the car is not allowing this to happen. Don't forget that one of the inconsistent approaches must be quicker than the rest and this is where the time slip trace can be useful.

Use the traces and some common sense. Look at the whole corner and try to sort out where the inconsistencies come from. Does it start under braking – does the car arrive at the corner in a nicely composed manner with an orderly transition from braking into cornering? Use the lateral, longitudinal and combined g charts to decide.

With the braking, what you are looking for is a long g trace which plunges sharply downwards, flattens off and then climbs upwards as the lateral g trace builds into the corner. This represents rapid application of the brakes (the sharp downward plunge), sustained heavy braking (the flat portion), and then a climb up to and over the zero line.

"Usually, what a driver calls opposite lock is a reduction in the amount of lock applied"

The climbing long g trace does not indicate that the car is speeding up, only that the rate at which it is slowing down is reducing. Actual acceleration starts when the trace crosses the zero line. FIGURE 3 shows a typical braking trace – this time of a production-based car achieving almost 1g of braking effort.

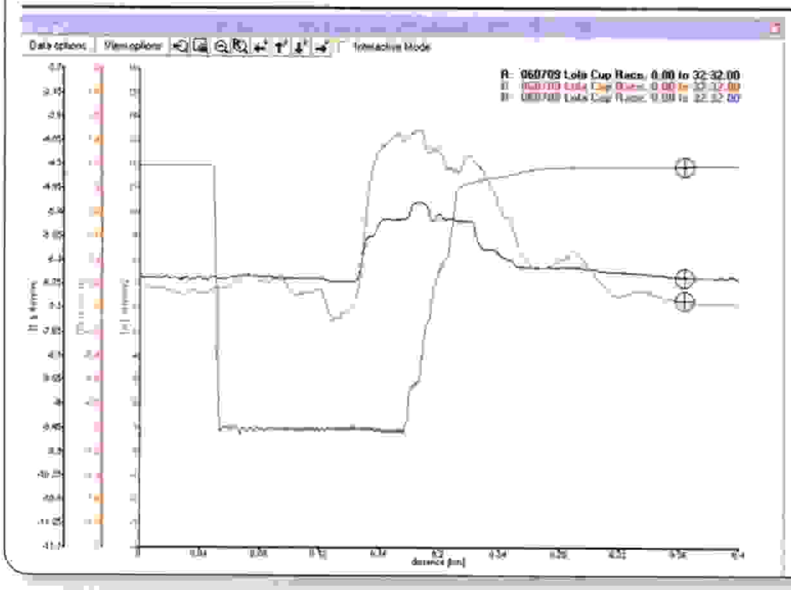
The downward slope shows that the build up took about 1.3 seconds and 2.3 were spent at or near peak braking. The steep return slope indicates that this is not a car that encourages the driver to turn in while braking.

Once the car gets to the bend you need to consider what happens next. Don't abandon the traditional methods that you used before data logging. Split the corner into phases and consider each one. We've already considered the braking phase but what can we now learn about the turn-in, the mid-phase and the exit?

The lateral g curve is full of information but it contains two separate strands. Its general shape indicates the line that the car takes through the corner. A symmetrical trace shows the classic racing line through the bend – the one that starts wide, moves towards a central apex and then drifts out wide again. A trace that peaks early and then flattens out indicates a late apex. This is a bit counter-intuitive but it makes sense. To take a late apex, the driver has to turn in fairly sharply and then straighten the line and aim at an apex towards the end of the bend. The opposite – a gentle lead-in with a sharper curve towards the end of the corner – indicates an early apex: the driver has committed to an early clipping point that will eventually force a sharper curve towards the end of the bend.

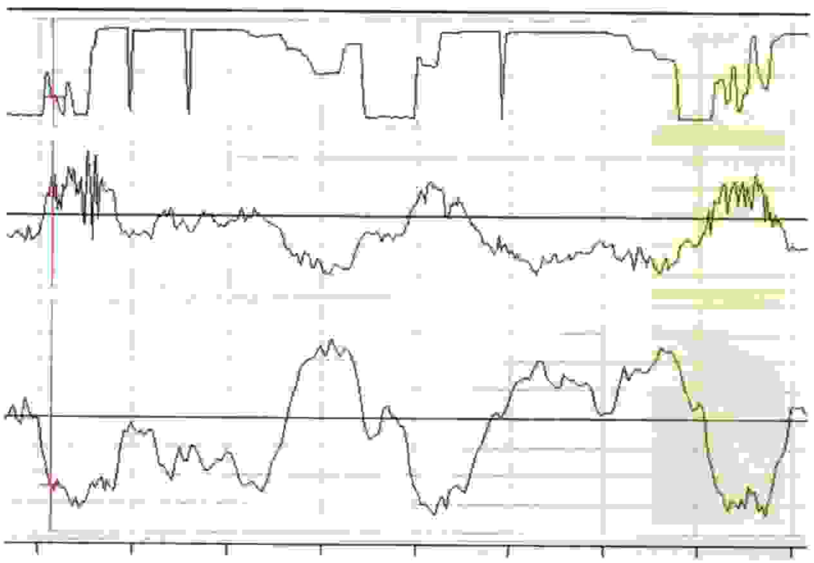
The car's handling will disguise these shapes. Oversteer will generally make the trace ragged as the car grips, loses grip with opposite lock correction and then grips again. The effects of oversteer on the lateral g curve is to put rounded spikes into the curve at a rate that reflects how quickly the car reacts. A purpose-built race car will react more quickly than a modified production car and the frequency of the spikes will be shorter. If a steering trace has been logged, the symptoms are unmistakable and a throttle trace can often tie the oversteer in to the driver's right foot.

FIGURE 4 CORNERING TRACE



LEFT Here lateral g is in red, steering input in black and throttle position in purple. The general shape of the lateral g curve indicates a late apex (the highest g forces are seen at the entry to the corner so that most of the turning is done early and the driver can get on the throttle as soon as possible). The car's handling confuses the issue slightly because there is a trace of mid-corner understeer – the driver felt the need to use more steering after the throttle was applied and the lateral g forces decreased slightly. The front end then got some bite and built up cornering force again

FIGURE 5 OVERSTEER



LEFT In this screenshot the top trace is throttle, the middle is steering and the bottom is lateral g. Looking at the green shaded area, the driver is very anxious to get into the throttle (top trace) but doing so necessitates lots of steering correction (middle trace) and the need to back out of the throttle again. This gives the lateral g (bottom trace) the characteristic jagged appearance associated with oversteer

Opposite lock, in the sense that the driver is steering to the right in a left-hand bend, rarely occurs. Usually, what a driver calls opposite lock is a reduction in the amount of lock applied. What normally happens is that the trace indicates the steering correction to be pretty rapid and limited to about 20% of the applied lock. Once the correction is made, the original steering angle is almost always put back on immediately.

ALL IS REVEALED

The sequencing of the traces is interesting. You can expect to see a steering correction *followed* by a reduction in lateral g. So what the driver feels is the car beginning to break away through a reduction in self-aligning torque of the steered wheels *before* the cornering force diminishes. The back steps out and reduces the slip angle of the front tyres, which are still gripping at this point, but this reduces the torque felt at the steering wheel and prompts our hero to wind back the steering and probably get out of the throttle as well.

Then when the crisis goes away, it's back on with the lock and the power. You can tell a lot about the driver and the car by working out what goes on when the front has more grip than the rear. All of this excitement serves to hide the overall shape of the curve from which we originally hoped to understand the line that the car took.

Understeer can be more subtle. You might see the lateral g forces fall away as the driver applies the throttle and this could also be tied in with an increase in steering angle. On the other hand, understeer is often shown up as a flat area on the g trace – often towards the end of the corner – or diminishing g levels through the corner.

But there are other variants. To confuse the issue, you might find that the steering trace reflects the driver's desperate attempt to kill understeer by rapidly putting on lots of lock at the entry to the corner and winding it off again in reaction to the slide that this has created. The trace climbs rapidly, heads momentarily in the opposite direction and then resumes a more normal pattern. Engineers of front wheel drive cars might recognise this, but it is not something that presents itself in Sports 2000 too often.

FIGURE 4 shows understeer and the challenge is to understand why. Clearly the driver influences the situation by the application of throttle but could the car be improved? Peak lateral g is just a touch down on what would be expected from a car of this type. The turn-in was clean enough (so the dampers were doing their job) and the throttle was applied early so the driver felt confident. Some change to the relative roll rates front and rear might kill the understeer but before embarking on this change a whole range of factors need to be considered.

The decision would be easier on a test day than race day, and cannot be made on the basis of just one corner. It would need to be a repeated pattern to justify any changes and in any case mild understeer might be part of a set up strategy that makes the driver feel comfortable in a long race.

FIGURE 5 shows oversteer created by a greedy driver who is very impatient to get on the throttle. The early throttle application brings with it steering corrections and maybe a little more patience would benefit the lap time.

Reading the data adds considerably to the workload on race day but, done methodically, should improve the quality of decision making. It is very easy for egos to get in the way, with people adopting their own interpretation and defending them rather than admitting that there are other possible explanations.

It is very important that the data be re-examined as soon as possible after returning to base when heads are cooler and there is time to take a more leisurely and opportunistic look through the data. In the next instalment we will consider the range of other information offered by the various analysis packages. ■