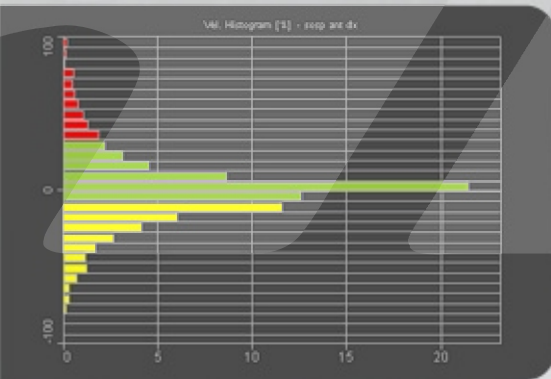
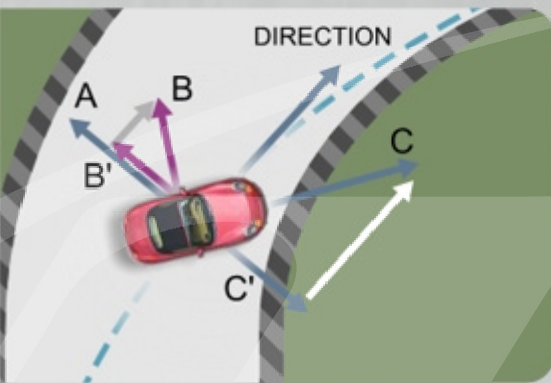




Racing Data Power

MXL Pro

OVERSTEERING AND UNDERSTEERING ANALYSIS ON-TRACK SESSIONS



System: MXL Pro + GPS

Track: Adria (RO, Italy)

Vehicle: Car from
IPS Championship

Date: 05/20/2007



ENGINE ANALYSIS

Introduction

To hold this test, we have been using the following sensors: GPS, 4 shock potentiometers, steering angle potentiometer, front and rear brake pressure potentiometer, longitudinal accelerometer, lateral accelerometer, gyro, 4 speed sensors and all channels acquired from MBE 992 ECU connected in CAN line.

Analysis

One of the troubles reported in on-track data analysis is to understand with a good approximation, the behaviour of the vehicle when the driver pulls it to the limit, especially in understeering and oversteering situations.

We remind you that oversteering is caused by loss of grip of the rear axle (opposite steering is needed), while understeering is caused by loss of heading of the steering axle (the car's trend is to "go straight").

A valuable instrument for analysing the vehicle reaction, is comparing GPS values and on-board dedicated sensor values.

But a brief explanation is required:

let's take, for example, the lateral acceleration value as shown in the diagram below.

Let's identify with "A" the GPS_LatAcc vector module, calculated through GPS antenna trajectory. We'll call "B" the Lateral Acceleration vector module, obtained by on-board lateral accelerometer values.

With a neutral car (not affected by understeering or oversteering condition) and with constant speed and cornering radius, A and B vectors are equal.

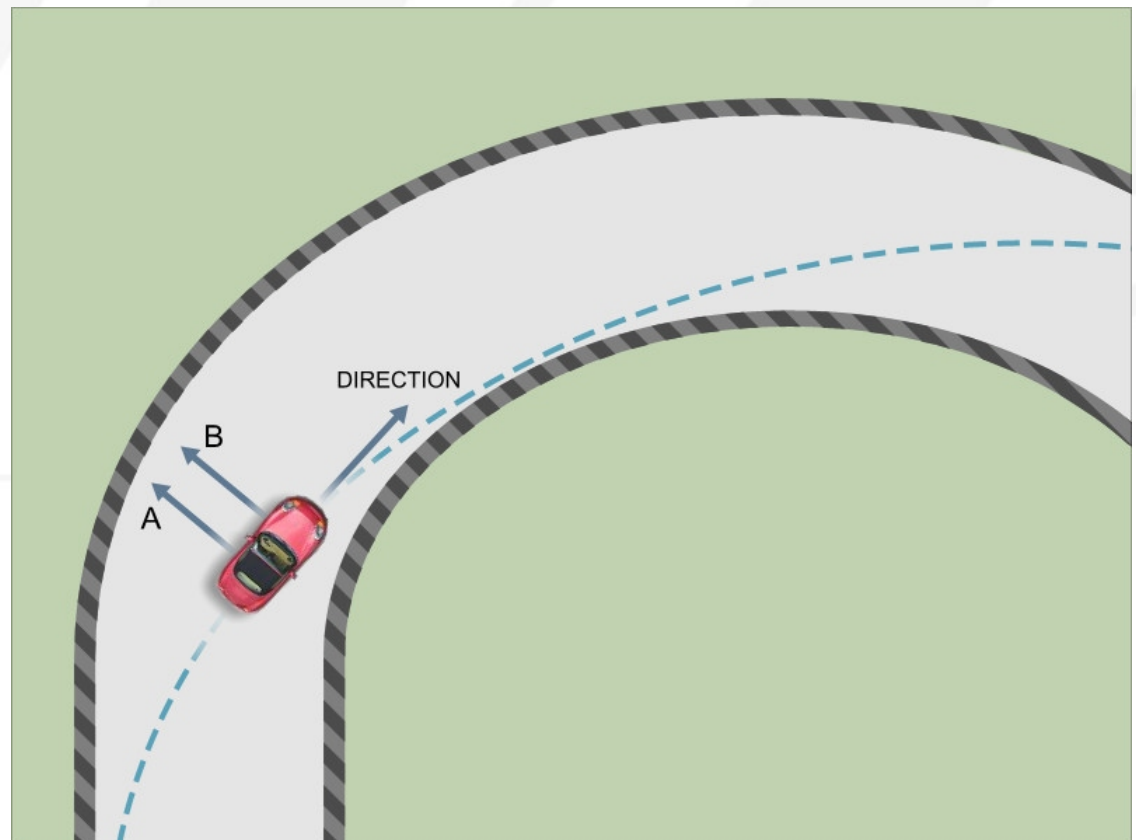


Figure 1

On the other side, on oversteering vehicle, the value of the projection on the normal Lateral acceleration vector trajectory calculated through the on board lateral accelerometer (identified as "B"), is lower than the GPS-calculated one.

B' is also affected by the Longitudinal acceleration vector projection "C" on the normal trajectory as shown in the picture below.

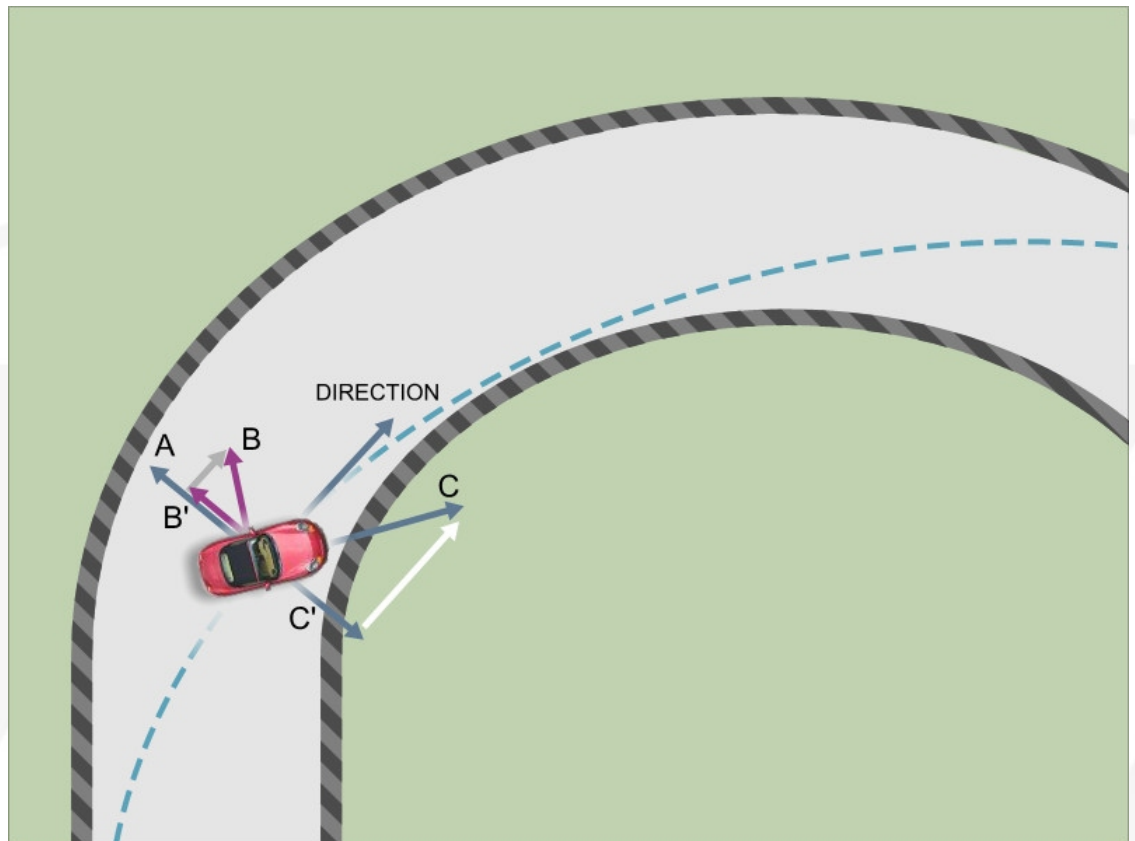


Figure 2

With vehicle completely deviated compared to normal trajectory, the result value would be a "B" Lateral Acceleration equal to zero.

Similarly, in case of understeering (figure 3), we obtain a C related longitudinal acceleration component called C', due to its projection on the normal trajectory, that adds itself vectorially to the normal lateral acceleration related to B' trajectory.

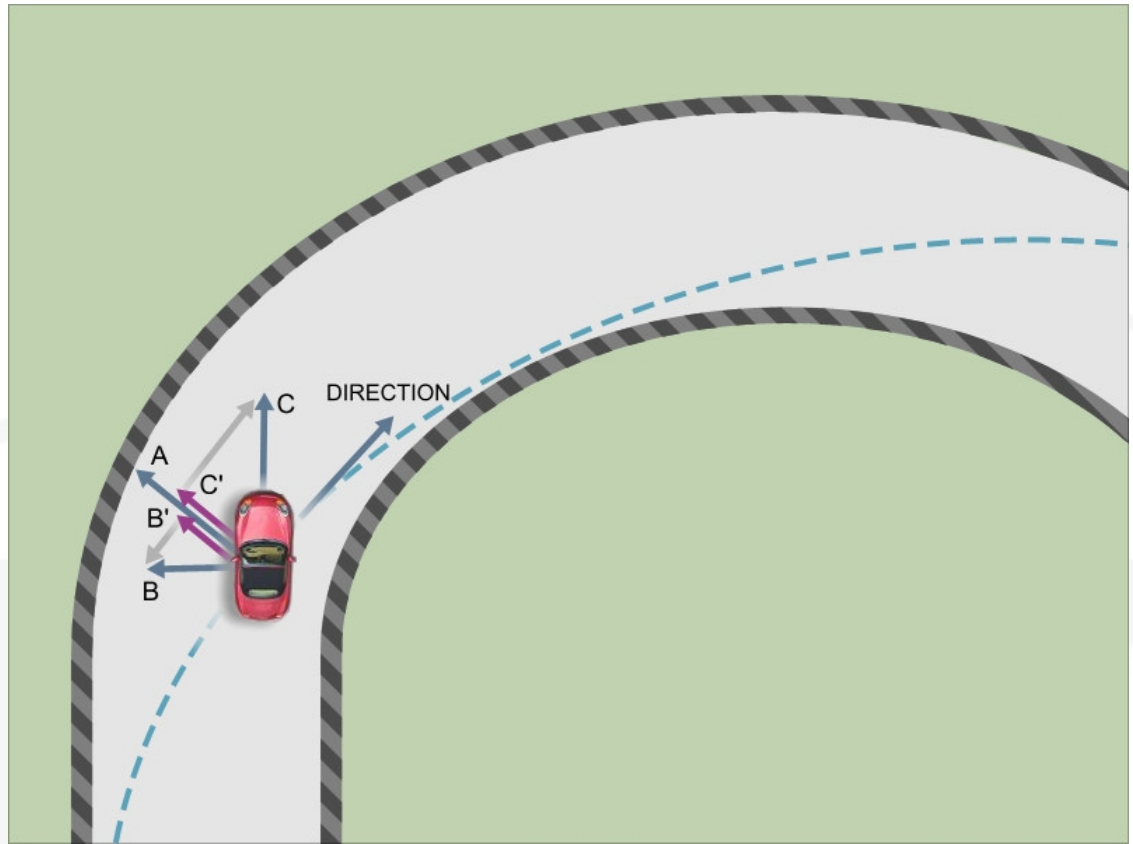


Figure 3

Now, let's identify a simple match channel called Diff_LatAcc by using the formula:

$$\text{Diff_LatAcc} = \text{GPS_LatAcc} - \text{LatAcc}$$

We can extend this reasoning also to the gyro.

This is because the GPS_gyro channel indicates the vehicle's yawrate as tangent of covered trajectory, while the gyroscope sensor measures vehicle's cornering.

Let's create a second math channel called Diff_gyro, defined by the formula:

$$\text{Diff_gyro} = \text{GPS_gyro} - \text{Gyro}$$

At this point, we can say that:

- 1) $\text{Diff_gyro} > 0$ understeer condition;
- 2) $\text{Diff_gyro} < 0$ oversteer condition;
- 3) $\text{Diff_LatAcc} > 0$ oversteer condition;
- 4) $\text{Diff_LatAcc} < 0$ understeer condition;

But further explanation is needed.

Let's take for example gyro e GPS_gyro channels values.

If the vehicle is in a oversteering condition, inertial sensor value will be more than gps_gyro because the vehicle would had a wider yaw angle than trajectory related one.

Let's mark right curves as positive and left corners are as negative.

For all right corners in oversteering condition we obtain:

$$\text{gyro} > \text{GPS_gyro}$$

In case of left corners, with parity between cornering range and yaw angle with oversteering vehicle, we'll obtain:

$$\text{GPS_gyro} > \text{gyro}$$

So the channel:

$$\text{Diff_gyro} = \text{GPS_gyro} - \text{gyro}$$

To obtain the same oversteering indication, the parameters have to be inverted and defined as:

$$\text{Diff_gyro} = \text{gyro} - \text{GPS_gyro}$$

To define these conditions, it is necessary to use absolute values:

$$\text{Diff_Gyro Abs} = \text{abs}(\text{GPS_Gyro}) - \text{abs}(\text{gyro})$$

This way, the absolute value will be considered, no matter what their sign is. The difference channel obtained through absolut gyroscope values will be named as Diff_Gyro Abs.

In the meanwhile, we have to create the Diff_LatAcc Abs channel.

The correct syntactic string to be inserted as math channel in Race Studio 2 software is:

$$\text{Diff_LatAcc Abs} = \text{abs}(\text{GPS_LatAcc}) - \text{abs}(\text{Acc}_1)$$

Once the channels have been defined, the behaviour of the vehicle can be summarized in this way:

Diff_gyro cond > 0 understeer condition;

Diff_gyro cond < 0 oversteer condition;

Diff_LatAcc > 0 understeer condition;

Diff_LatAcc < 0 oversteer condition;

Now, let's analyze these two math channels values (figure 4).

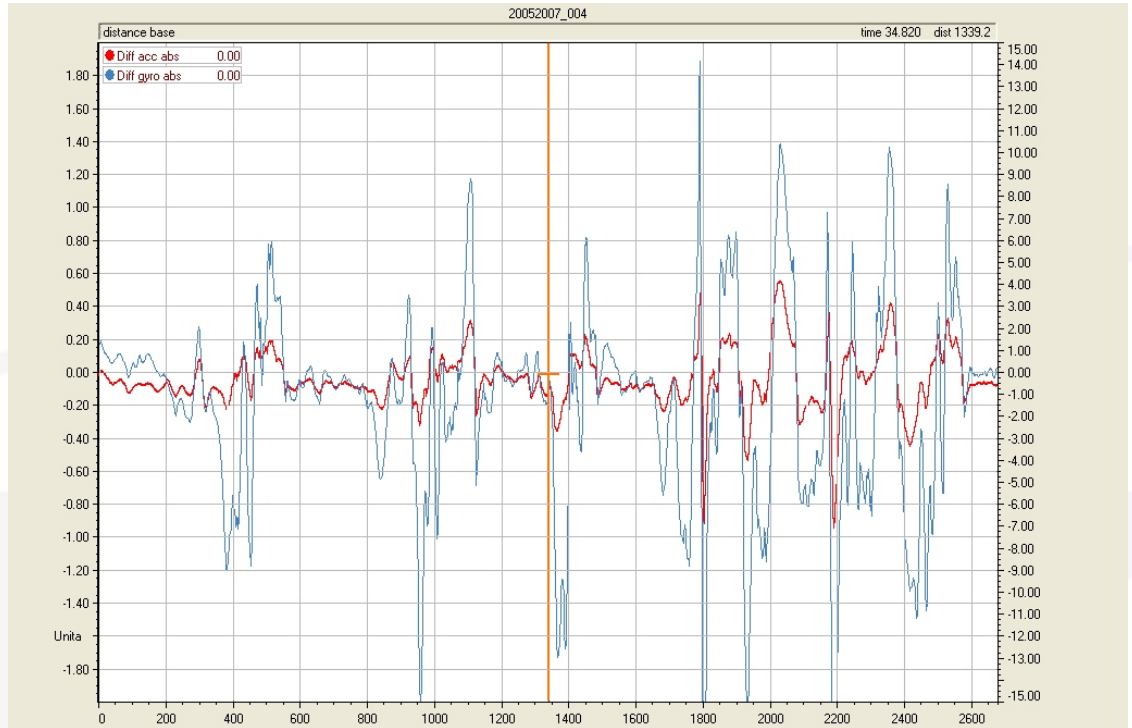


Figure 4

We can immediately observe that both channels (BLUE Diff_gyro Abs, RED Diff_LatAcc Abs) are in phase, giving us a double check of what said before.

Thanks to GPS trajectories software viewer (figure 5), it is possible to obtain a chromatic scale of Diff_gyro Abs and Diff_LatAcc Abs values with related variation on the track map.

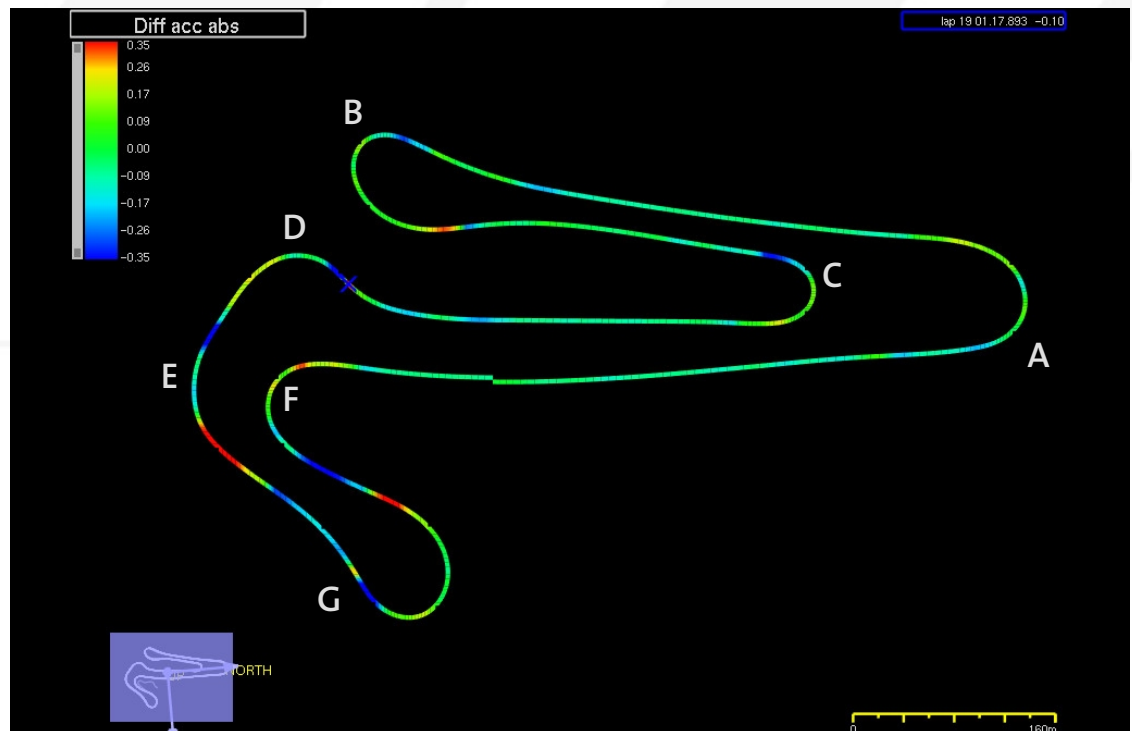


Figure 5

As said before, blue zones indicate oversteer while red ones are understeer.

It's easy to verify how the vehicle oversteered while entering some corners (marked as C, D, E, F, G blue points). This behaviour is less noticeable in corners A and B.

Please note the change between oversteering and understeering in corners B, E and G. This is evidenced through the analysis of Diff_Gyro Abs channel also (figure 6).

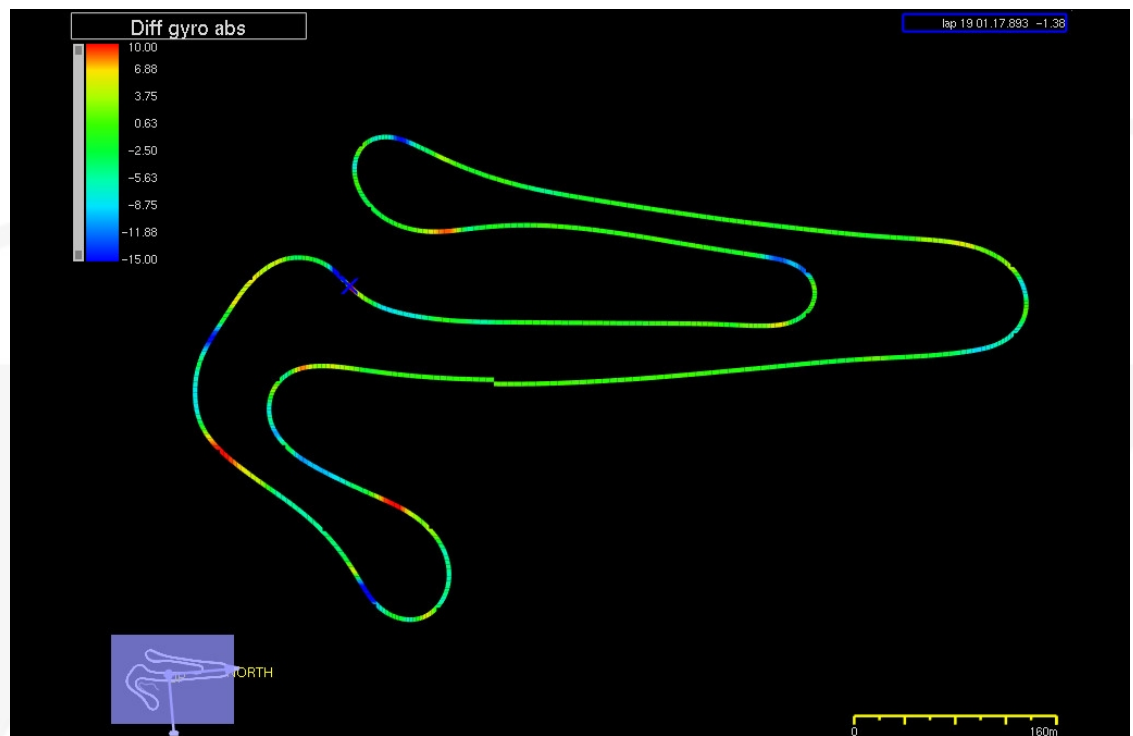


Figure 6

Also in this case, oversteering condition is evidenced in blue, while the understeering condition is evidenced in red. Now, let's analyze a specific part of the track (figure 7).

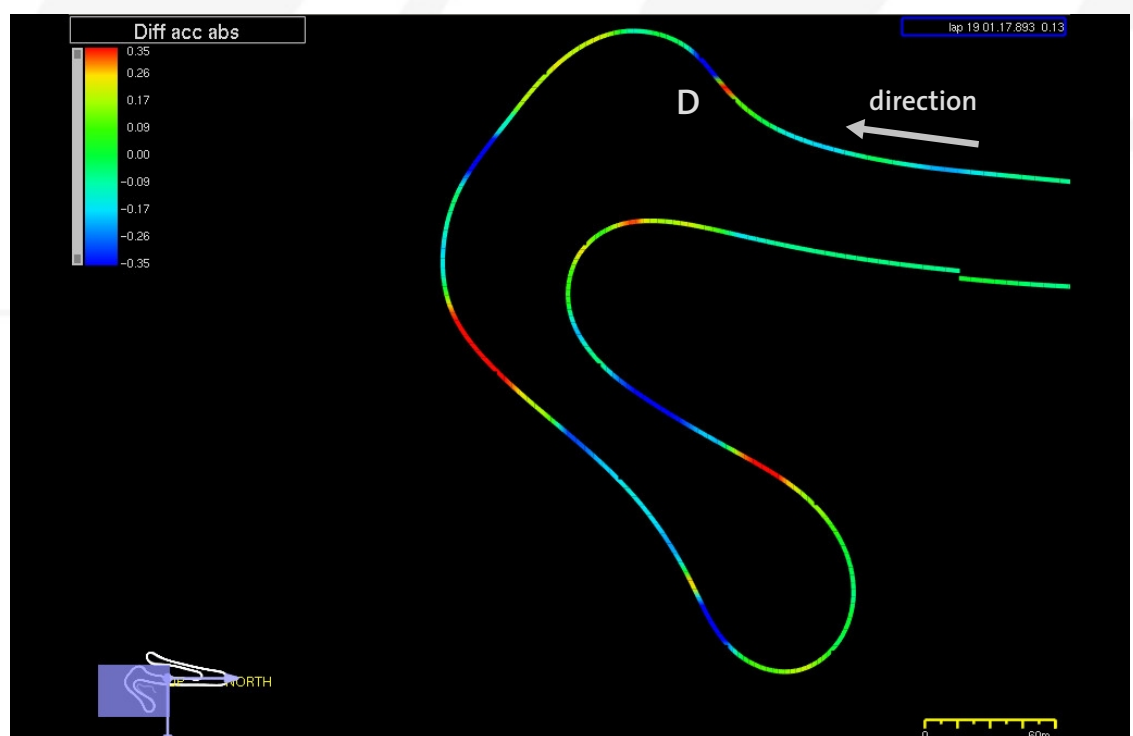


Figure 7

It's clearly evidenced how the vehicle reaches point D while braking after the straight line and understeer before entering the left corner in oversteering condition.

This is also evidenced by Diff_Gyro Abs channel (figure 8).

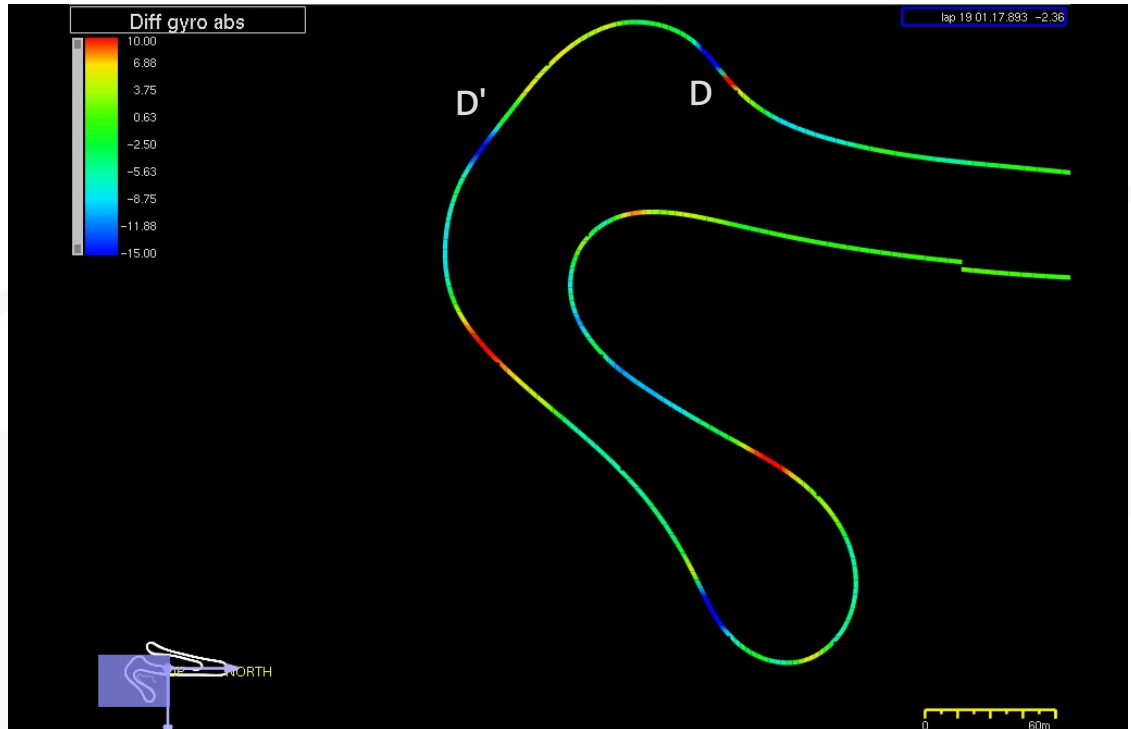


Figure 8

By analyzing driver's behaviour in this corner, we can notice that the car is neutral because of driver applying brake and throttle at the same time (figure 9).

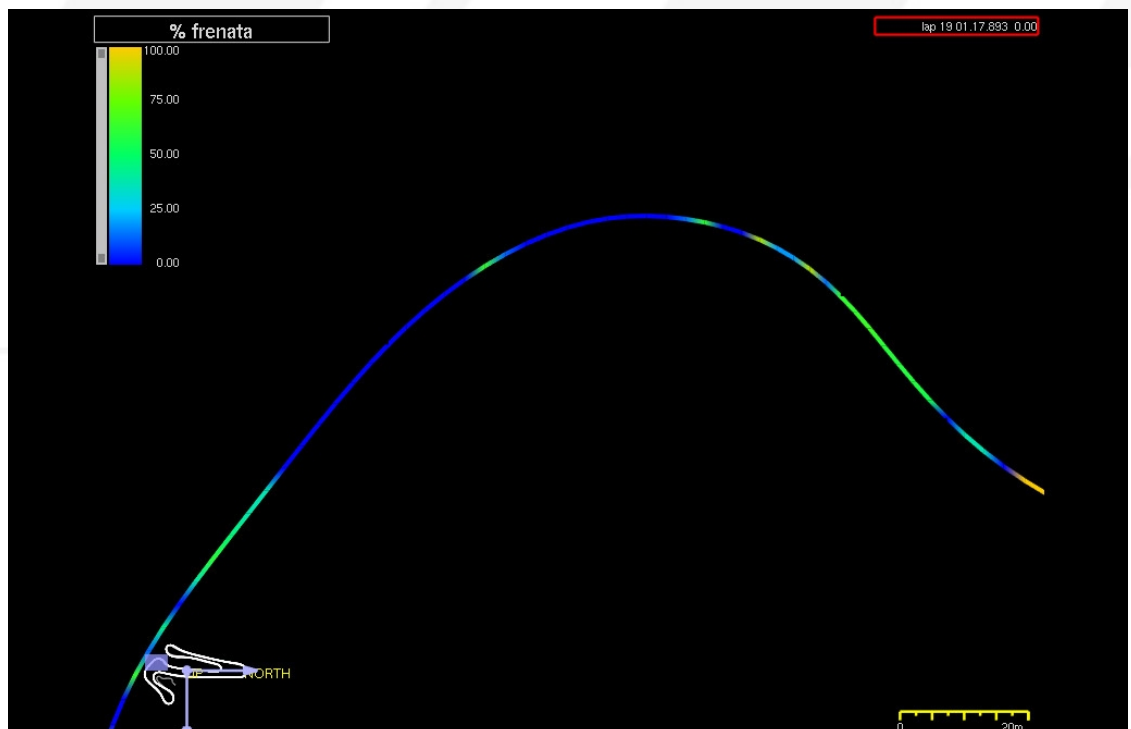


Figure 9

But it becomes undesteering in throttle-opening phase as evidenced below.

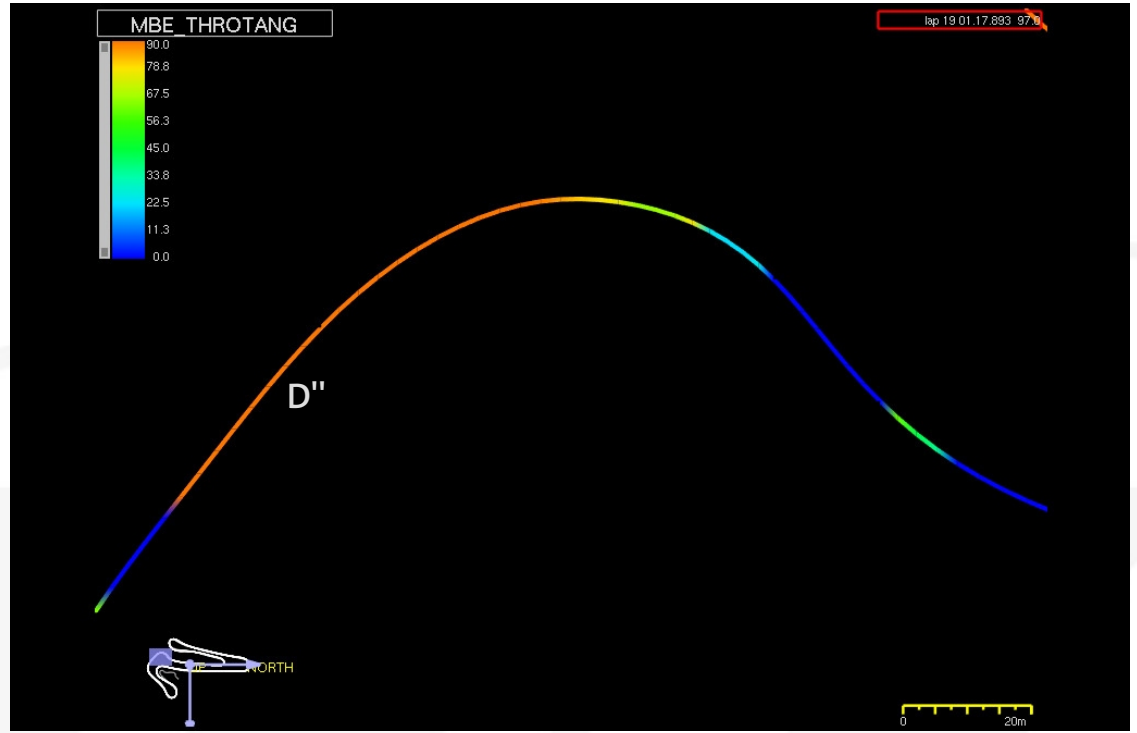


Figure 10

The steer channel viewed at D'' point, shows that the driver had to strongly deal with the steering wheel to keep the vehicle in the best trajectory (figure 11).

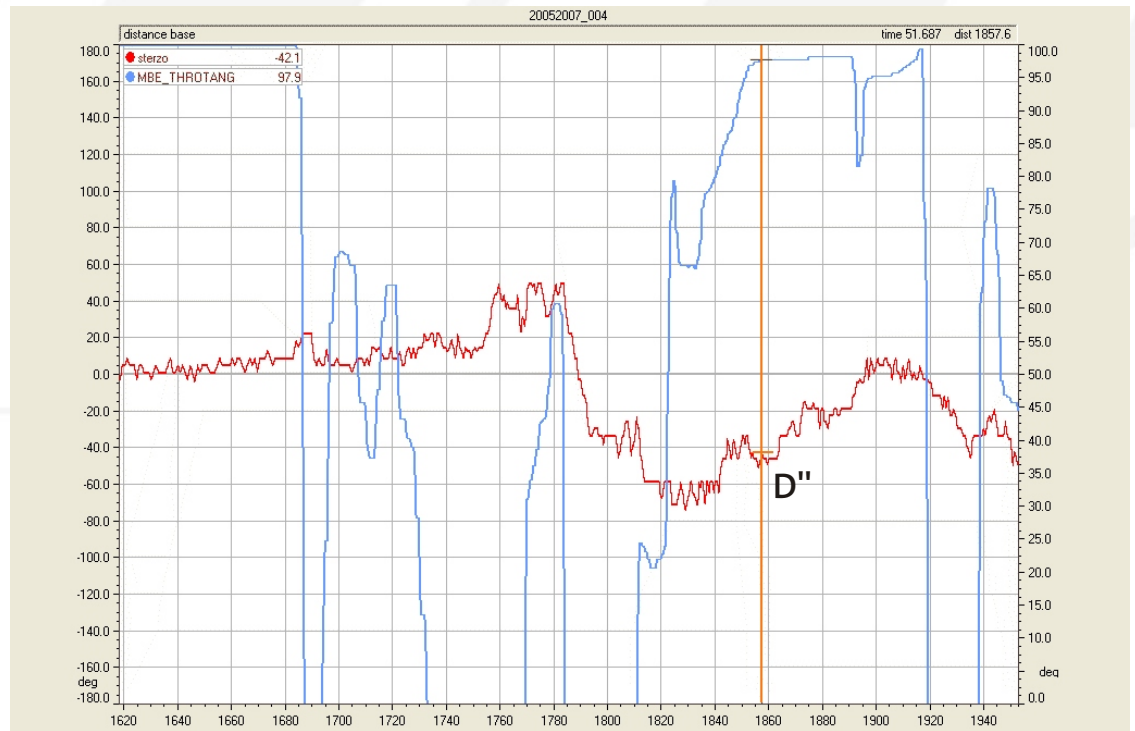


Figure 11

The strong oversteering behaviour at the entrance of the corner and the understeer while exiting, was caused by the wreck of front left shock absorber.

As clearly shown in shock speed histogram (figure 12), the “A” shock loss completely efficiency, causing the shock itself to work without any absorbtion.

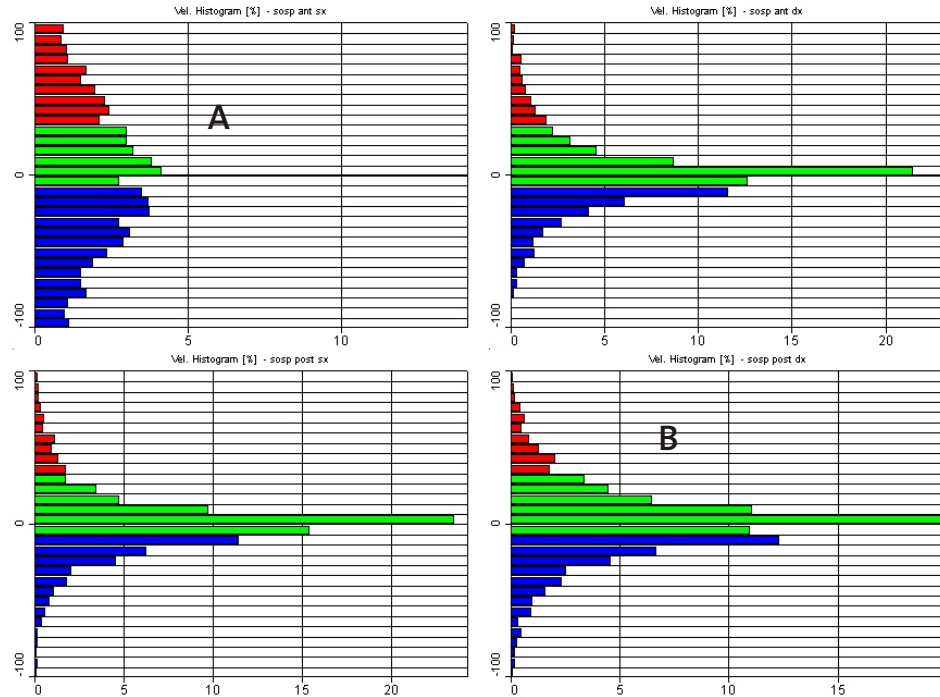


Figure 12

This shock failure caused the vehicle to loose grip.

Note how the rear right shock B suffers mainly this condition.

With parity of compression and extension settings at high and low speeds compared to rear left, the rear right can't absorb the tyre shaking, While reading shock speed histograms, don't forget that "X Axis" is automatically software-scaled.

The diagram low scale for the rear left shock is 25%, while is 20% for the rear right.

With scale parity, the rear right diagram should be compressed.



Racing Data Power

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© 2007 AIM Srl - Via Cavalcanti, 8 20063 Cernusco sul Naviglio (MI) - Italy
Tel. +39.02.9290571 - info@aim-sportline.com

www.aim-sportline.com