The use of Simulation in Race Car setup analysis – F3 Case Study.

Introduction

Simulation is an ideal tool to explore the setup parameters for any given circuit. The reasons for this are,

- Excessive Testing is either not allowed, and/or is too costly and labour intensive.
- With simulation the engineer can investigate as many setups as possible. This will allow the engineer to know what combinations will or will not work before arriving at the race track.

This presentation details the results of the application of the simulation package,

ChassisSim™ - will be used to a setup problem experienced by a F-3 car in a wet/damp qualifying session. The nature of the problem will be discussed and

ChassisSim™ - shall be applied to solve it. The results will then be discussed and analysed.

Nature of the problem to be simulated.

The data shown in Fig-1 is taken from an actual qualifying session in wet and dry conditions. The problem encountered is illustrated in Fig-1.

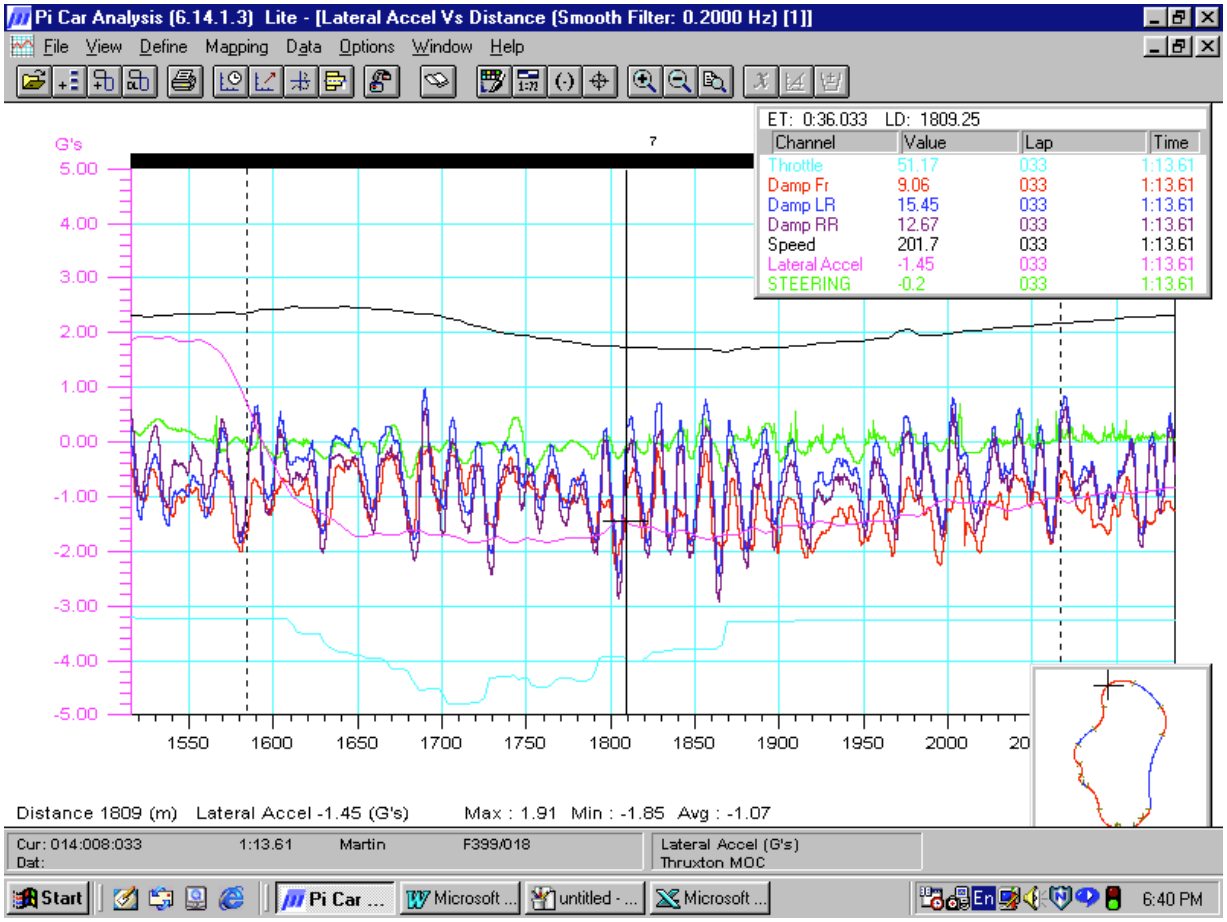

Fig-1: Resonance induced understeer in a high speed corner.

Correlating the steering trace to the damper trace it is very apparent that the oversteer is resonance related. This is due to the fact that the frequency response of the steering is directly related to the movement of the suspension. It is clear that the dampers are oscillating at a resonant frequency. A resonant frequency refers to a frequency where the damper response to a frequency input is at a maximum value. To further illustrate this consider Table 1,

Table-1: Variation of frequency and amplitude of steering and damper movement in Goodwood corner for each session.

Session	Front Damper		Rear Damper		Steering	Amp
	F (Hz)	Range(mm)	F (Hz)	Range(mm)	F (Hz)	Rear/Front
1:14.50s	3-5	2-8	3-5	5-14	3-5	2
1:13.73	3-5	3-8	3-5	7-13	3-5	2
1:14.34s	3-5	3-6	3-5	5-14	3-5	2
1:13.61s	3-5	2-7	3-5	8-13	3-5	2
1:13.21s	3-5	2-8	3-5	4-14	3-5	2

Not only was it apparent for this session, Table 1 shows that the oversteer mode manifested itself throughout the running for that day. In simple terms the car is being

subjected to a frequency input which causes the tyre force to become inconsistent. In dry conditions this is undesirable and in wet conditions it is disastrous because of the impact it has on driver confidence. The driver debrief confirmed this was the primary problem.

From the data it is clear the oscillation of the car, particular at the rear was strongly related to the oversteer and the lack of grip in this corner. Consequently to solve this problem the following steps were needed.

- The damping should have been increased.
- A spring change was required.

Simulation Analysis

A simulation was conducted of the car traversing this circuit in wet and damp conditions. It should be highlighted that where the weather is wet and damp conditions (grip etc) vary considerably. Consequently when formulating the simulation the attention was focused on where the oversteer was most apparent.

The simulation of the base setup is shown overleaf in Figures 2 and 3. The simulation is shown in red and the data is shown in black. While the simulation is not an exact match it is obvious from Fig-2 that the trends of the lap, in particular the throttle lift in Goodwood corner have been replicated. Fig-3 also illustrates that the simulation has replicated the resonant modes in the dampers and the steering trace shows resonant related oversteer.

The modelling parameters within the simulation could have been manipulated to provide a closer fit. However, this is a comparative analysis. The nature of the problem at Goodwood corner was so profound it was deduced that further refinement of the simulation was unnecessary. The analysis shown is an example of a preliminary analysis that could be conducted between sessions.

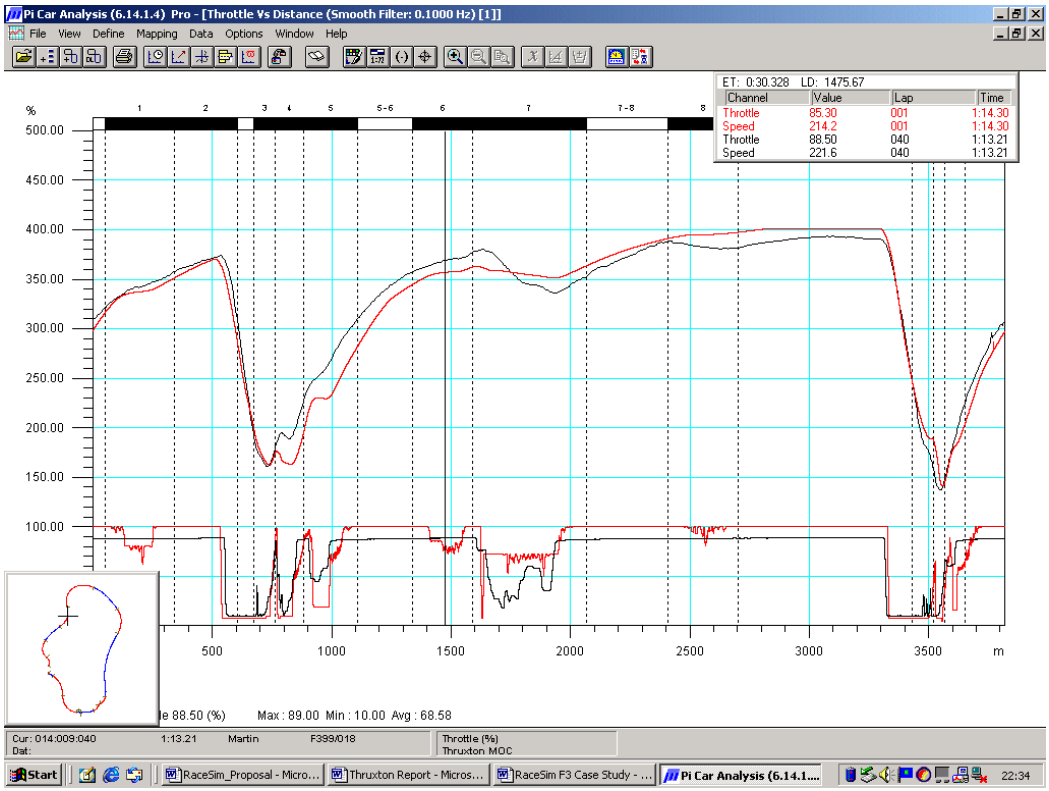

Fig-2: Comparison of overall speed and throttle for Simulation and Data.

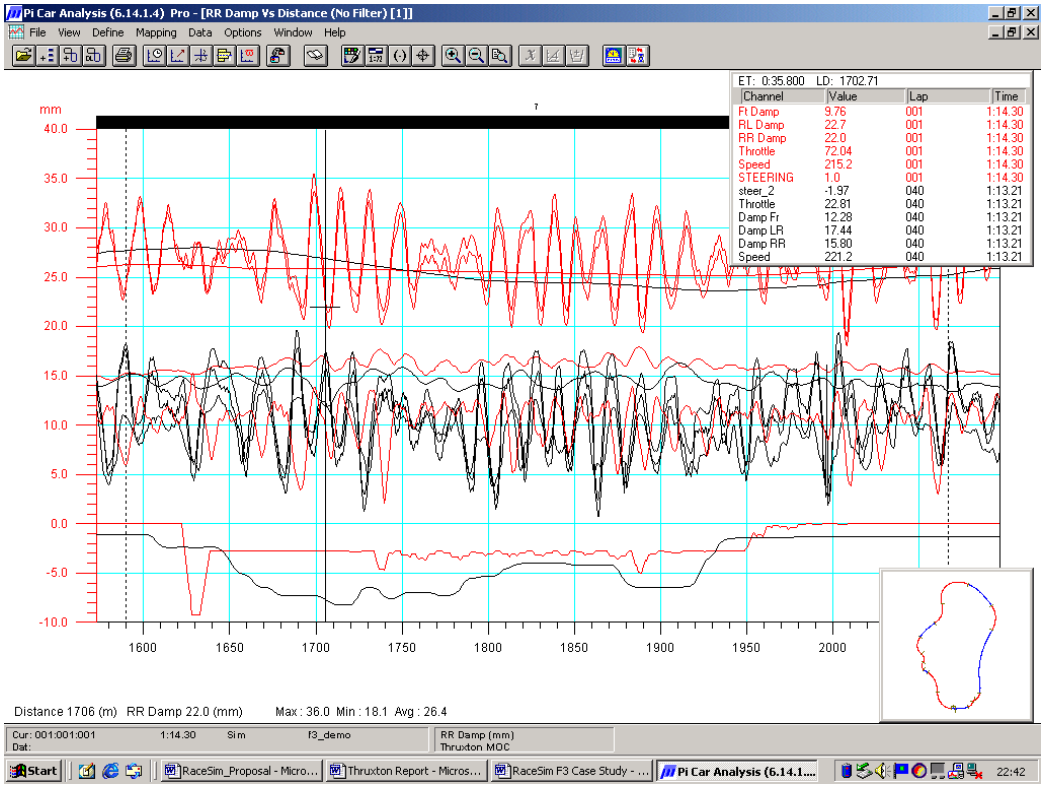

Fig-3: Comparison of driver and chassis parameters in Goodwood Corner.

From the data it was clear the resonant response of the vehicle needed to be reduced. Consequently the rear damping on the simulation was doubled. The results at Goodwood corner are illustrated below,

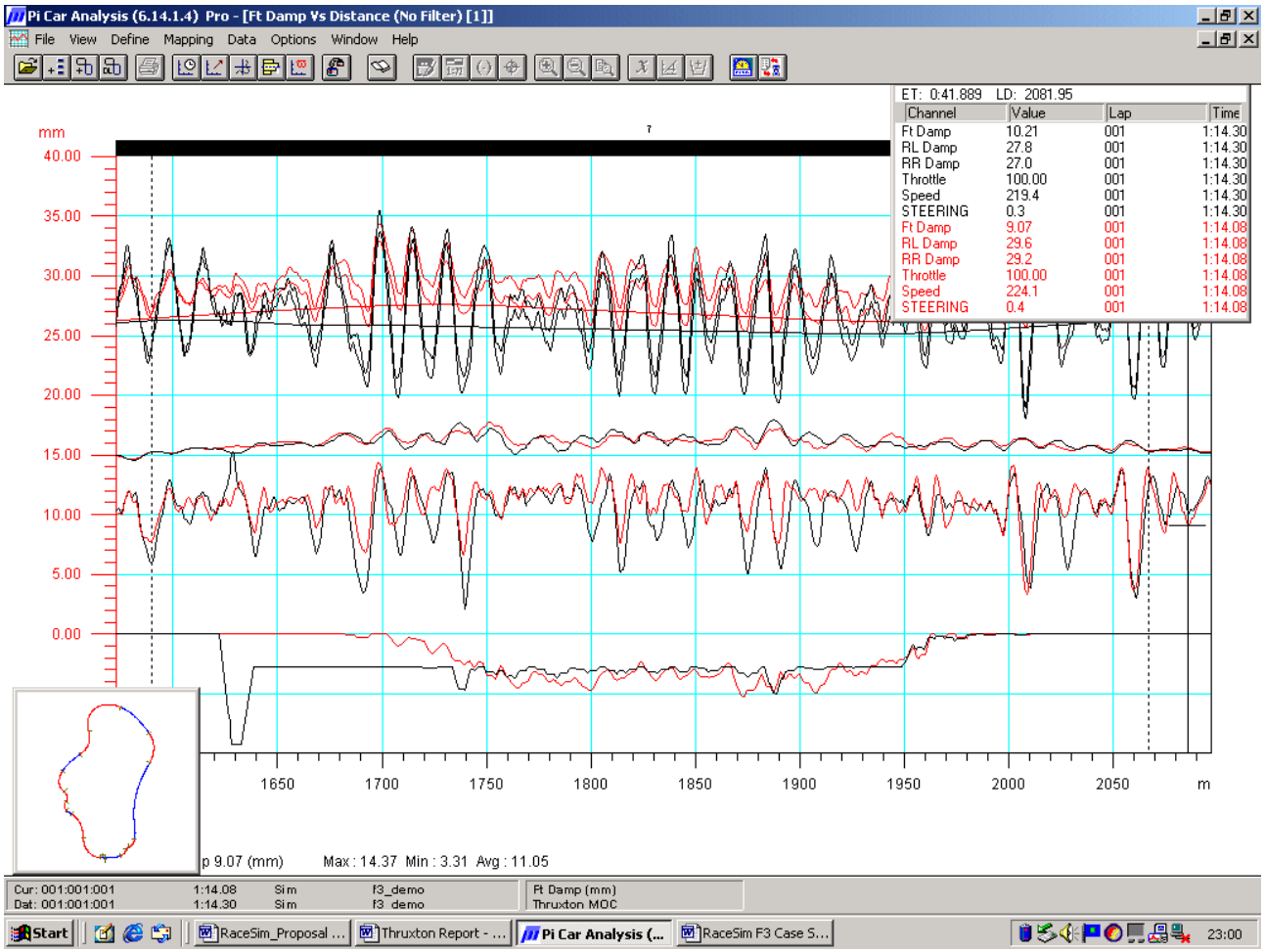

Fig-4: Comparison of Std setup (Black) to increased rear damping setup (Red) through Goodwood corner.

Fig-4 demonstrates that the increase in rear damping has settled both the front and rear damper oscillations. The corner speed has increased from 210 km/h to 219km/h and from the steering trace it is clear that the oversteer has been reduced. This confirms what was deduced from the race data. Unfortunately, it was not possible to confirm this on the day because the simulation package was still in development.

The overall improvement in simulated lap time was 0.22s. A comparative time analysis shows that in this corner the gain was 0.5s. This type of change could be expected to have a profound influence on the driver's confidence through Goodwood corner. It would be obvious to test this setup change and further gains might reasonably be expected.

Conclusion

Simulation provides an ideal tool for analysing changes to a race car's setup before a test or practice/qualifying session. It does not involve the expense or possible rule violations involved in testing, and it allows the engineer to understand what works and why.

A setup problem encountered during a qualifying session for a F-3 car was presented. This was due to a resonant mode of the car being excited as the car traversed a high speed corner. From the data it was clear the resonant response had to be changed. However at the time there was no way of confirming this.

The simulation analysis confirmed the data analysis. The standard setup was simulated, and while not an exact match, it showed the same trends as the real vehicle, in particular through the high speed corner in question. Increasing the rear damping by a factor of 2 showed that significant gains through this corner were possible. The simulation analysis correlated strongly with the data analysis and testing should confirm both the data and simulation analysis.

It should also be highlighted these results where obtained by a preliminary analysis. Consequently this is the sort of analysis that could be conducted between sessions at the race track.