Intelligent Testing to Advance Vehicle Performance

a series of reports by OptimumG, June 2010

Introduction

In February 2010 OptimumG in collaboration with Oreste Berta S.A. performed a comprehensive vehicle dynamics test in Argentina. The primary goals of this test were to characterize vehicle performance and demonstrate what is possible with advanced data acquisition. This test was made possible by the collaboration of many sensor and data acquisition companies, specifically Kistler, Corrsys-Datron, GeneSys, Texys, and Motec.

Before the results of this test are presented, the vehicle, sensors, and facilities used for this test will be described. Reports created by OptimumG from this test will then follow. These reports will cover different aspects of the vehicles kinematics, aerodynamics, brakes, differential, and tires.

Vehicle and Sensor Description

The tests were performed using a race car designed to compete in the Argentinean TC2000 racing series. This is a front engine and front wheel drive vehicle that has a front weight distribution of 58%. The body is based on the Ford Focus, thus, unlike purpose built racecars, it does not rely significantly on aerodynamics. Although it does employ a rear wing and adjustable front splitter to generate some downforce.

The location and mass of the sensors will obviously have an effect on the handling and performance of the vehicle. Therefore the weight, yaw inertia, and center of gravity location for this vehicle was measured with all of the sensors installed to achieve the most accurate results. The primary sensors used for this test are described here.

Figure 1: The vehicle and sensors used for the testing. This car was built for the Argentinean TC2000 racing series.

Corrsys Datron S350 Slip Angle Sensor

Quantity used 2

Location
Front and rear bumper

Measurements
Longitudinal and transversal velocity
Vehicle slip angle

Corrsys Datron SHR Slip Angle Sensor

Quantity used 1

Location
Front bumper

Measurements
Longitudinal and transversal velocity
Vehicle slip angle at high resolution

Corrsys Datron SFII Slip Angle Sensor

Quantity used 4

Location
Each wheel

Measurements
Longitudinal and transversal velocity
Wheel slip angle

Corrsys Datron RV4 Wheel Position Measurement System

Quantity used 2

Location
Each front wheel

Measurements
Wheel position (x, y, and z) and orientation (steer and camber) relative to the vehicle chassis

Corrsys Datron HF500C Ride Height Sensor

Quantity used 3

Location
Rear center, front right and left

Measurements
Vehicle Orientation (roll, pitch, and heave) relative to the ground

Corrsys Datron Measurement Steering Wheel (MSW)

Quantity used 1

Location
Steering wheel

Measurements
Steering wheel angle and torque

Corrsys Datron Dynamic Camber Angle (DCA) Sensor

Quantity used 2

Location
Each front wheel

Measurements
Wheel camber angle relative to the ground

Texys Pitot Tube

Quantity used 2

Location
In front of car
and above hood

Measurements
Dynamic pressure relative to the local airspeed

Texys IRN8 Tire Temperature Measurement Sensors

Quantity used 4

Location Each tire

Measurements Tire tread temperature at eight locations across the width of the tire

GeneSys ADMA-G Inertial Measurement Unit

Quantity used 1

Location
Near vehicle CG

Measurements
Vehicle position and orientation
Acceleration in x, y, and z
Roll, Pitch, and Yaw Rate

Texys 3-way Accelerometer and Gyro

Quantity used
1 Accelerometer & 1 Gyro

Location
Near vehicle CG

Measurements
Acceleration in x, y, and z
Roll, Pitch, and Yaw Rate

Kistler RoaDyn S625 Wheel Force Transducer

Quantity used 4

Location
Each wheel

Measurements
Tire forces (Fx, Fy, and Fz) and moments (Mx, My, and Mz) at the hub
Wheel rotational speed

Kistler 8305B50 Single Axis Accelerometers

Quantity used 8

Location
One at each corner of the car and on each uprights

Measurements
Vertical acceleration and transmissibility between the sprung and unsprung mass

Motec ADL2 / ADL3 Datalogger

Quantity used
1 ADL2 and 2 ADL3

Location
Inside the vehicle

Function
Log all the data channels being collected on the car

MTS Temposonics Linear Position Sensors

Quantity used 4

Location
Attached to each damper

Function
Measure the displacement and velocity of the spring and damper

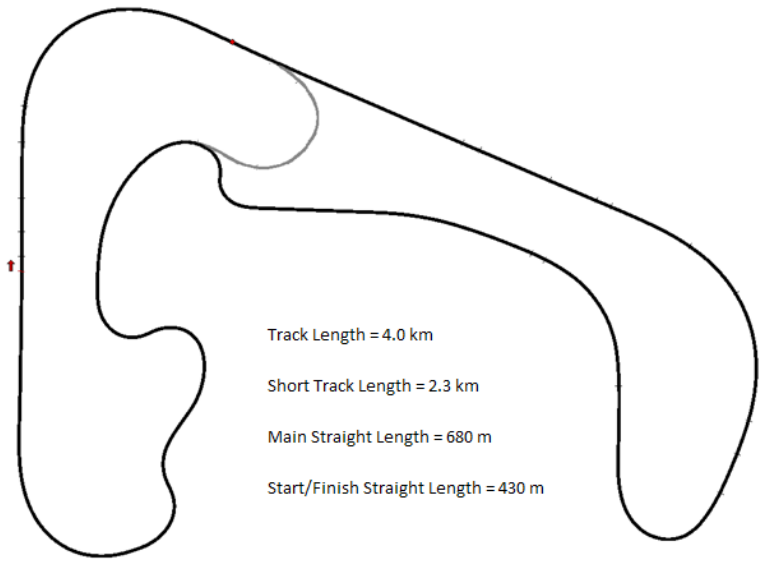
Additional Sensors

- 4 x Coil Over Spring Perch Load Cell
- 4 x Tire Pressure Sensors
- Brake Pressure (front and rear)
- Brake Rotor Temperature
- Steering Rack Force
- Throttle Position
- Single Channel IR Tire temperature (3 per tire)
- Engine Parameters (RPM, Oil Temperature, Oil Pressure, etc.)

Test Summary
The primary goals of the testing were to collect data on the steady state, transient, and aerodynamic performance of the car. Additional tests were also performed to evaluate the engine and braking performance, the tire temperature and pressure buildup, and the sprung and unsprung mass interaction. The following table describes the tests performed and the specific goals for each test.

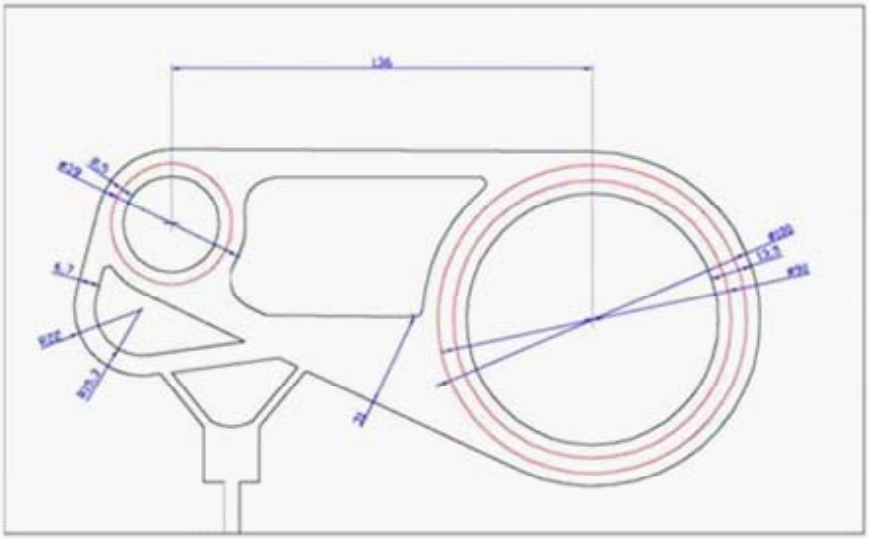
The layouts of the two tracks that were used are shown. For the slalom and double lane change tests, the front straight of the Cabalen Road Course was used.

Cabalen Road Course



Test	Location	Primary Goals
Constant Velocity Skidpad	Oreste Berta Test Track	Evaluate steady state behavior at various speeds and setups (i.e. camber and inflation pressures)
Increasing Velocity Skidpad	Oreste Berta Test Track	Generate data to create tire models
Slalom	Cabalén Road Course	Evaluate transient vehicle behavior at different cone spacings and different speeds
Double Lane Change	Cabalen Road Course	Compare vehicle performance to ISO 3888-1 compliance standards
Hot Laps	Cabalén Road Course	Evaluate the effect of tire temperature and pressure build up on the cars handling overa period of sustained running
Straight Line Constant Velocity	Cabalén Road Course	Determine downforce produced by the vehicle at different speeds
Straight Line Coastdown	Cabalén Road Course	Determine rolling resistance and aerodynamic drag of the vehicle at different speeds
Chassis Dynamometer	Oreste Berta Test Laboratory	Compare chassis dynamometer and wheel force transducer data
Driving / Braking	Cabalén Road Course	Compare on track engine and brake performance to dynamometer results
Run over Rumble Strips	Oreste Berta Test Track	Analyze the transmissibility between the sprung and unsprung mass
Tire Warm-up	Cabalén Road Course	Evaluate the effects of different tire warm up procedures

Berta Test Track



Track Length = 700 m

Straight Length = 135 m
Large Skidpad Outer Diameter = 110 m

Small Skidpad Outer Diameter = 50 m