XPD TOOLS LAPSIM SOFTWARE - QUICK START GUIDE V1.0

Introduction

'X-PD LapSIM' is a vehicle simulation toolbox comprising a suite of software components which can be used for the detailed analysis of vehicle performance over a defined vehicle path. Utilising a comprehensive, non-linear multi-mass vehicle model described by over 200 parameters & characteristic arrays it can be used to simulate and subsequently characterize a road or competition vehicles performance over a defined path in the virtual test environment.

1.0 Installation Instructions

1. Run the XPDTools setup.exe install program.
2. Choose the 'No Questions Asked Installation' option to install in default locations.
3. Run the MCRInstaller.exe program and follow onscreen instructions*.
4. Place your license file in the program root folder (default "C:/Program Files (x86)/XPD/XPD Tools").
5. Insert the dongle into a USB port and wait for windows to automatically install the correct drivers.
6. Run the XPD Tools program from the desktop Icon.

Notes:

A valid dongle for XPD tools is required for the application to launch successfully; the dongle must remain connected to a USB port on your computer while the application is running for continued functionality. The license file and dongle are linked such that only the appropriate license file and dongle pair will allow full use of the software as licensed, it is not possible to mix and match license files/dongles.

**The MCR installer program is located in the c:/Program files (x86)/XPD/XPD Tools/Support Files or can be downloaded from www.x-pd.com*

2.0 License Centre

The License Centre is the main container application from which all other main software components and tools can be accessed; the License Centre GUI will open when the application is launched.

The License Centre GUI is shown in Fig.1 – For full LapSIM functionality (including Motec I2 Pro data output**) the first 4 components must be enabled as shown in the figure, when the appropriate license file and dongle are in place the licensed components and details are displayed, each component can be launched by clicking the start button for the appropriate component (not applicable for the data conversion component).

Notes:

*All software components that are open will close when the License Centre is closed, a warning will be given to confirm this and the intended application exit. **Motec I2 Pro API license is required for this functionality.*

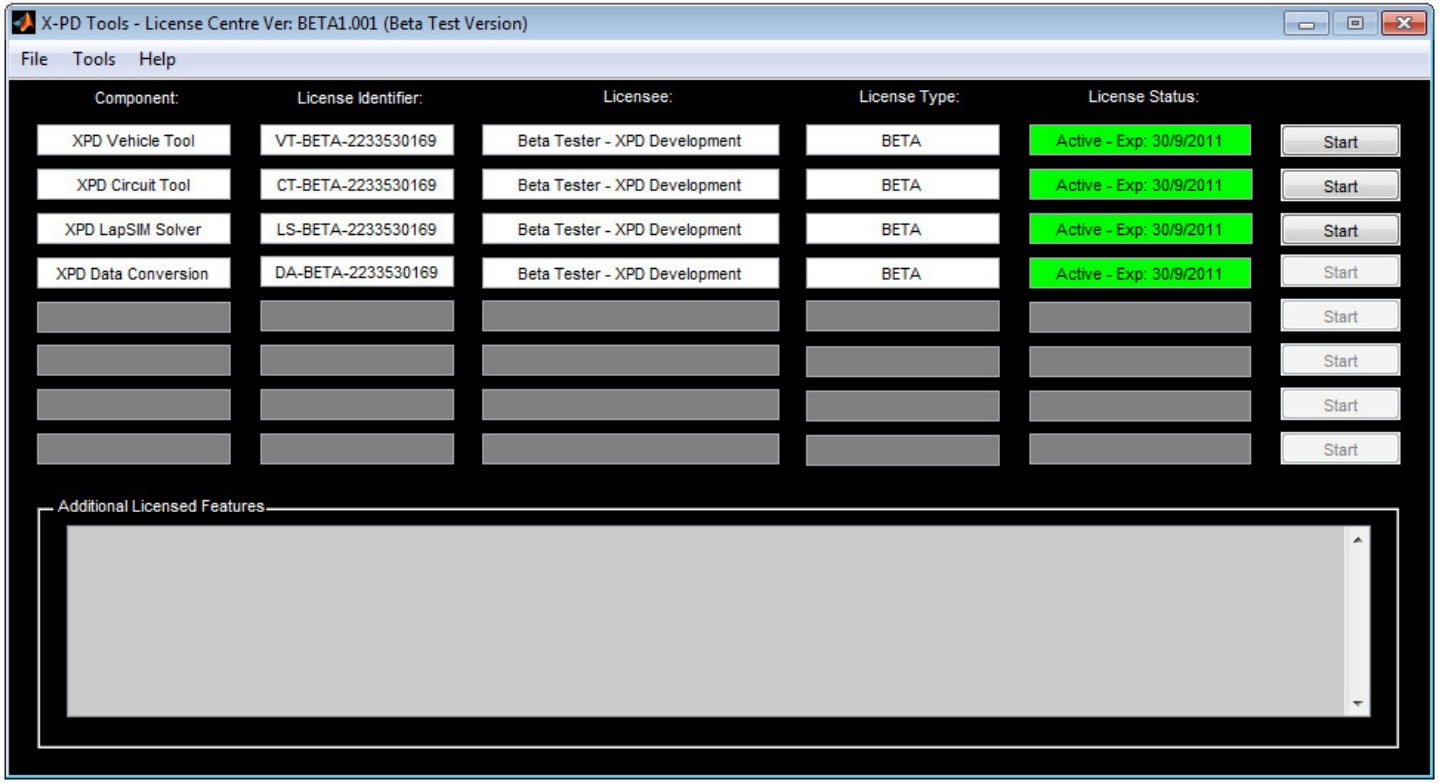

Fig.1

Notes:

The 'File' menu item allows access to the license file details dialog (shows details or indicates the absence/status of the file).

The 'Tools' menu item allows for the refreshing of license status (required when new license file or dongle is installed while the software is running) and also allows for default file paths to be set – when the software is installed a directory structure is placed in the main users documents folder (named 'XPD Tools'), there are sample application files contained in this directory structure so it is recommended that you select these directories as the default paths in the first instance.

Notes:

Fig. 2 shows the modal dialog box for setting the default file paths, the path must be selected using the 'Set' button on the right hand side, and cannot be typed or pasted into the edit fields directly. Once the paths are selected the dialog can be closed by the red 'X' in the top right hand corner (this is typical of any modal dialog box in the software). The nature of the 'modal' dialog box means it must be closed before continued use of the software is possible; this is applicable throughout the software. An audible tone will indicate a modal dialog is open and must be closed if another application dialog/window is clicked on.

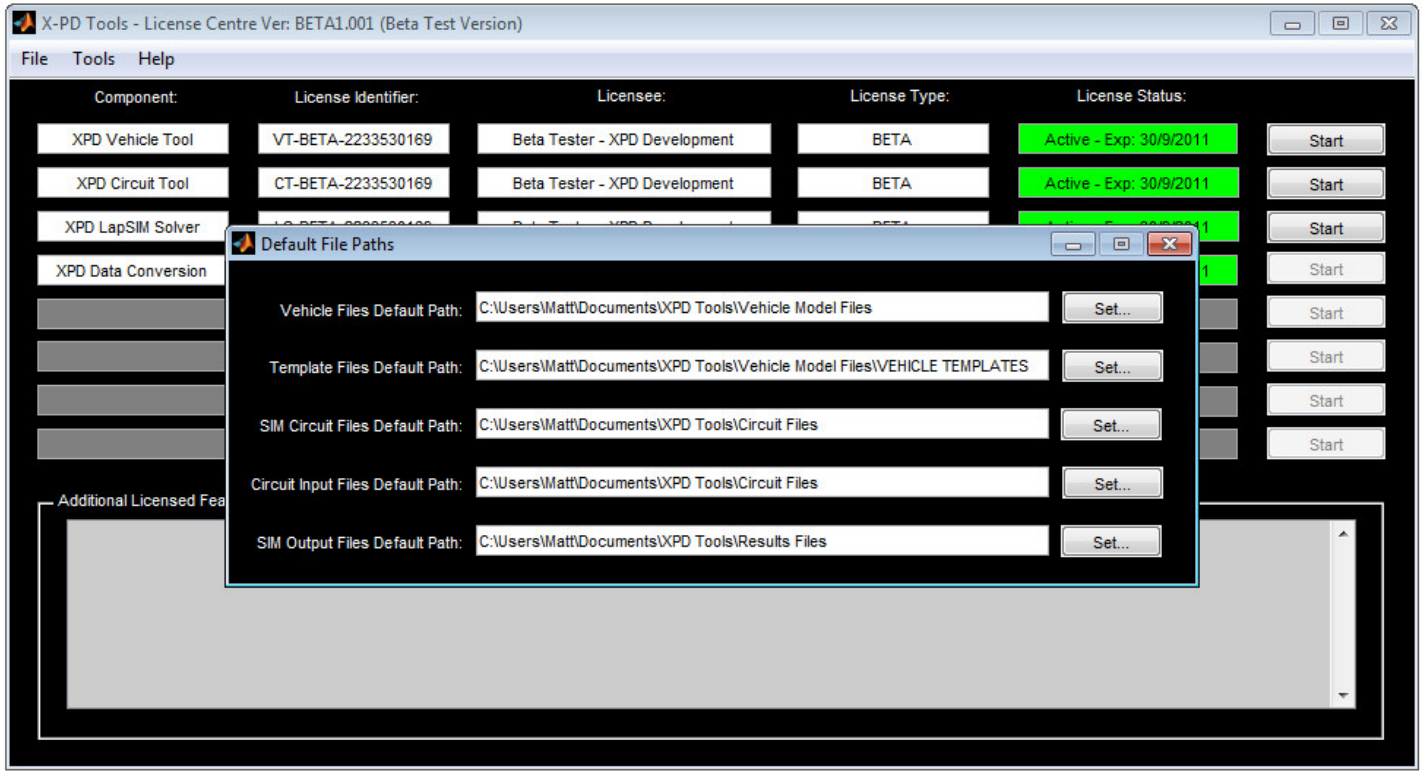

Fig. 2

3.0 Vehicle Tool

The Vehicle Tool is used for construction of the vehicle description and for detailed parameter setting. Split into separate vehicle 'modules' (chassis, tyres, suspension, engine, aerodynamics etc) every aspect of the vehicle which influences performance in the simulation is captured and can be individually defined, saved and re-loaded to build the complete vehicle.

The Vehicle Tool GUI is shown in Fig. 3 – This GUI provides full control for building the vehicle definition and creating vehicle & vehicle module files. When initially loaded the software will warn that a vehicle file or a template file must be loaded, the toolbar shortcuts for creating a new vehicle file (by initially loading a template) or loading an existing vehicle file are enabled (while the other tools are disabled until a vehicle file or template is loaded).

The vehicle templates provide a base structure consisting of a set of default parameters for a generic vehicle type; this provides a basis for constructing a new vehicle definition. A previously saved vehicle file can also be loaded initially.

Notes:

The 'File' menu item also provides the ability for vehicle and template files to be loaded into the Vehicle Tool.

The 'Tools' menu item provides access to other functionality relating to the vehicle definition, for example for creating & editing gear ratio lists.

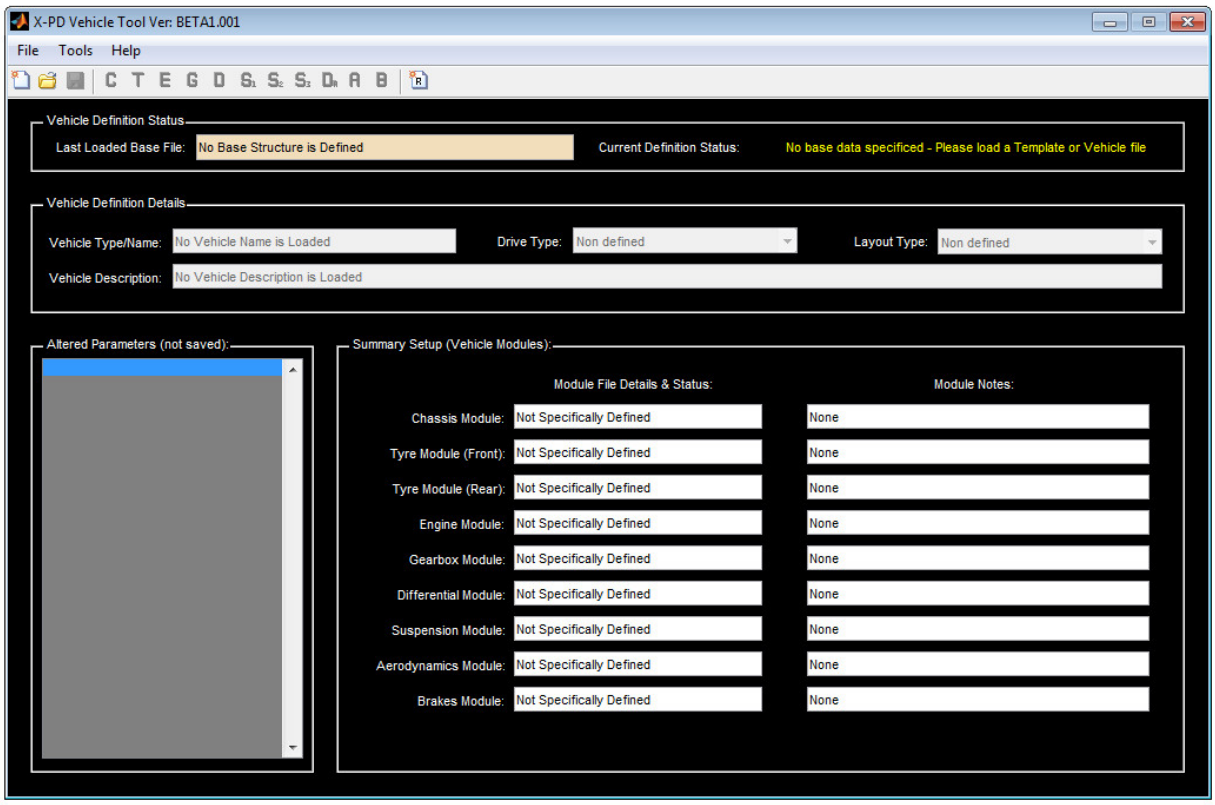

Fig. 3

The following table shows the files extensions associated with the different file types used in the Vehicle Tool application.

File Type:	File Extension:
Template	*.xvtem
Vehicle	*.xveh
Chassis Module	*.xchs
Tyre Module	*.xtyr
Engine Module	*.xeng
Gearbox Module	*.xgbx
Diff Module	*.xdif
Suspension Module	*.xsus
Aerodynamics Module	*.xaro
Brakes Module	*.xbrk
Gear Ratio List	*.xrat

Fig. 4 shows the Vehicle Tool GUI once a template file has been loaded, the shortcut toolbar is now available and the individual vehicle modules can be accessed through their respective shortcut buttons. In addition the gear ratio list shortcut can be used to bring up the gear ratio list management tool.

The main GUI shows the vehicle description, drive type, layout and a summary of modules that compose the vehicle file. On the left side the 'Altered Parameters' list updates as changes are made to the vehicle parameters, providing a parameter change history, this is cleared once the vehicle model is saved.

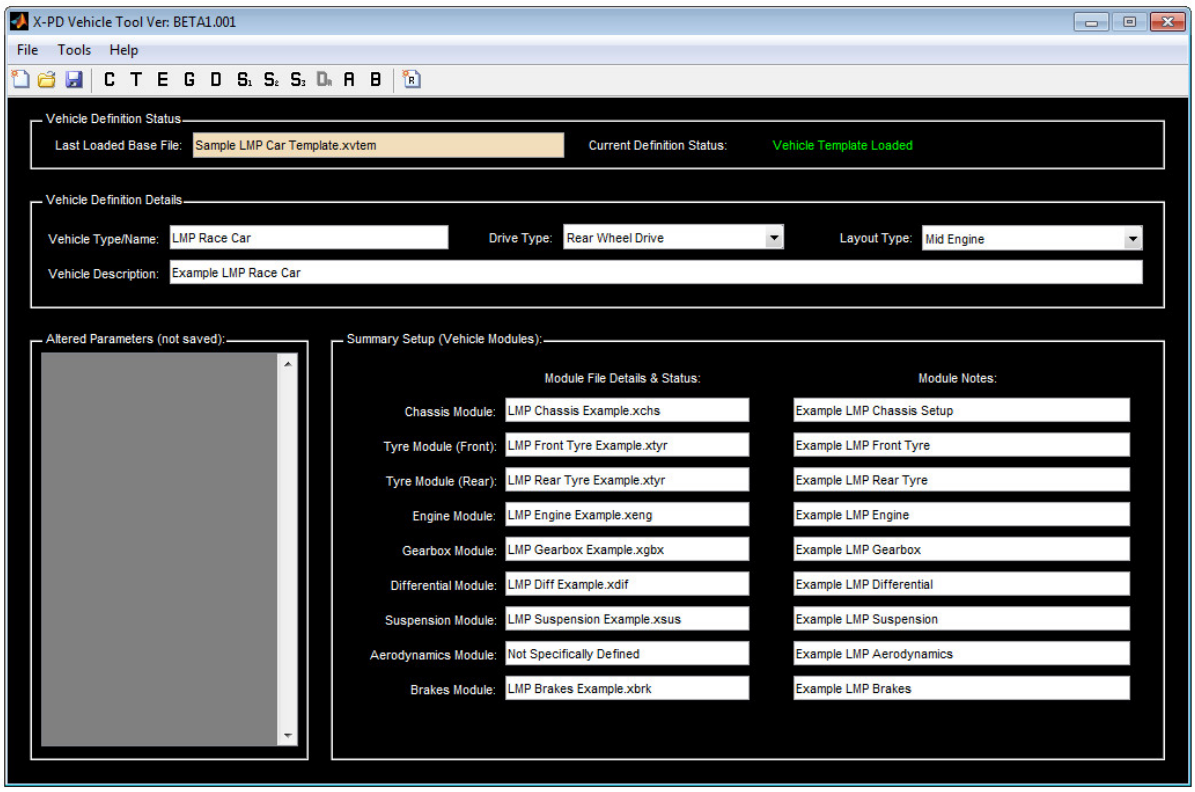

Fig. 4

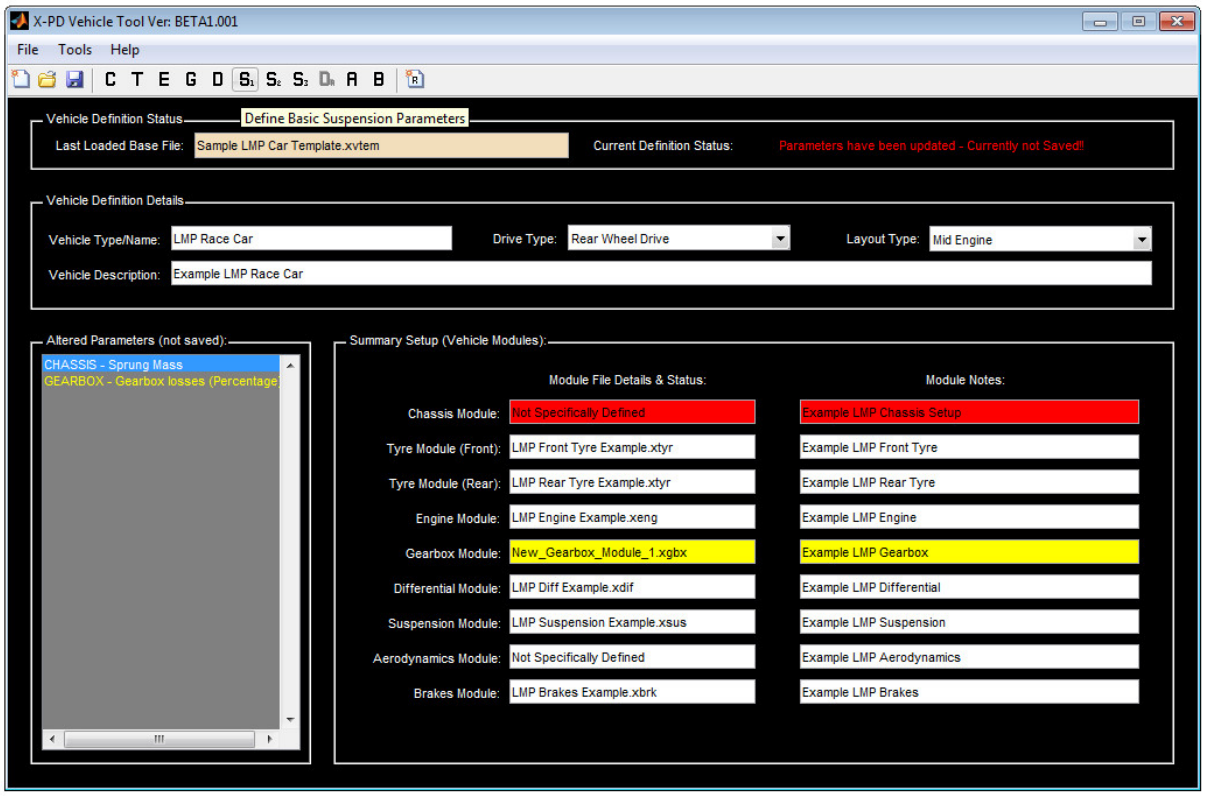

Fig. 5

Fig. 5 shows the Vehicle Tool GUI after changes have been made to the vehicle, the parameters that have changed appear in the 'Altered Parameters' list on the left side and the module field backgrounds change colour according to their status, to indicate if they are saved as individual files and/or into the vehicle file.

Notes:

When the mouse is placed over the shortcuts on the toolbar a tooltip is shown to indicate the vehicle module or function to which the shortcut relates (as shown in Fig. 5)

When parameters are changed the background of the relevant module in the summary pane changes colour to red and the details/status changes accordingly, this is to indicate that changes have been made and are not saved.

When the individual module is saved (through the file menu of the individual module GUI's) the background changes to yellow to indicate the module has been saved as a module file BUT NOT into the vehicle file.

When the vehicle file is saved all the field backgrounds in the summary pane will change to white, as they also do when a new vehicle file or template is loaded.

When the module files are saved the status field changes to show the filename of the module file, this allows you to maintain a record of the components used in the construction of a vehicle file.

It is recommended that previously created module files are not changed as a matter of course if this feature is to be used since this can cause confusion due to the fact that the individual vehicle files are independent and do not reference the module files themselves.

4.0 Circuit Tool

This software tool is for the construction of the circuit path and geometry to be used in the lap simulation, the circuit profile is constructed and split into sections from existing track data (usually measured on car), this process is highly automated but the software also allows you to manually define local gradient, camber and grip variations to more accurately recreate the circuit.

The Circuit Tool GUI is shown in Fig. 6 – The tool allows for the creation of a circuit from raw data or for a previously created circuit to be loaded for the purpose of running the simulation.

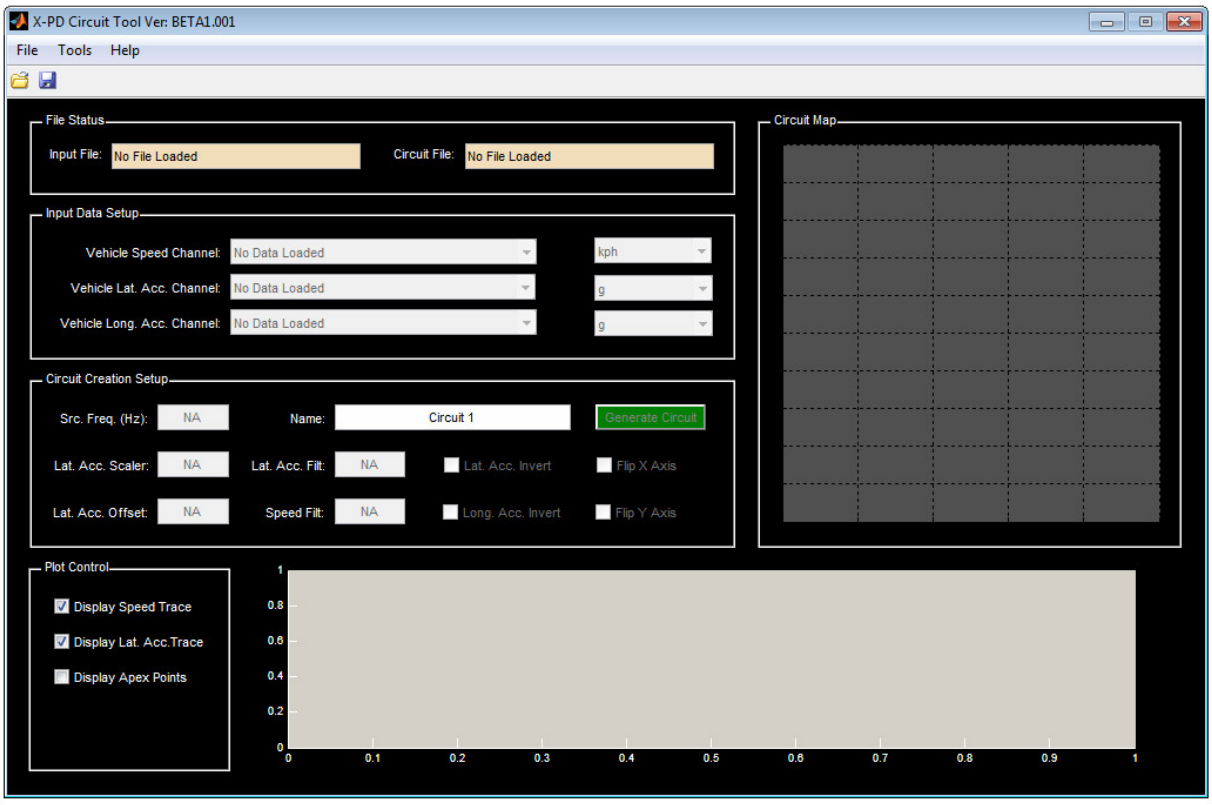

Fig. 6

Notes:

Circuit or input files can be loaded via the 'File' menu item or the open file shortcut on the toolbar, for raw data a Matlab file or a CSV file can be used, the Matlab export from all major data analysis packages (i2 Pro, Toolbox, ATLAS for example) can be used, and is recommended.

To generate a new circuit from raw data the channels of lateral acceleration, speed and longitudinal acceleration are required to initially create the 2D path profile.

Once a raw data file has been successfully loaded the channels within that raw data set will be available to select in the drop down lists of the 'Input Data Setup' pane, the correct channels (and respective units) should be selected here (See Fig. 7) in order that a circuit can be generated.

A circuit name can be entered into the 'Name' field in the 'Circuit Creation Setup' pane and the correct source file frequency should also be specified here (as per the export from the original data set for example), it is then possible to generate the circuit profile by clicking the 'Generate Circuit' button, the circuit map will appear in the map window.

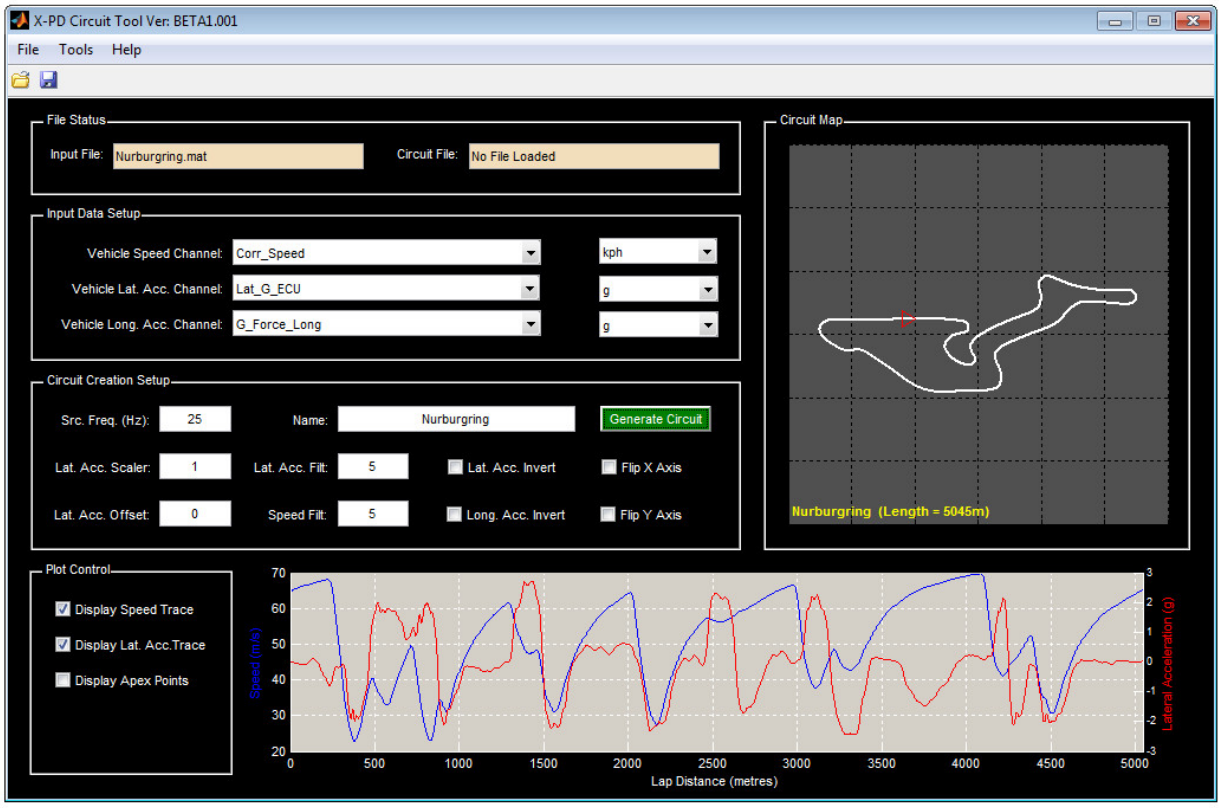

Fig. 7

Notes:

The speed and lateral acceleration from the raw data used to create the circuit profile will appear on the bottom axes; this allows you to check the data used is of an acceptable quality.

In the 'Circuit Creation Setup' pane there are settings to apply offsets, scalars and filters etc to manipulate the mapping and account for imperfections in the raw data, the 'Generate Circuit' button must be clicked to apply any changes made

Circuit path curvature (point radius) is used by the simulation as a predefined vehicle path, this is derived from the speed and acceleration values, hence a 'noisy' input will result in a 'noisy' output, smoothing the raw data used to create the path profile within the Circuit Tool will provide a more refined output.

When the circuit profile is generated/re-generated any previously defined apex points will be deleted and will need to be re-defined.

*Once the circuit has apexes defined (see next section) it can be saved to file, the file extension denoting a circuit file created by the Circuit Tool is *.xcir.*

Once the circuit profile has been generated the circuit must be prepared for use with the simulation, this involves breaking the circuit into sections defined based on the corner apex points, thus the apex points need to be specified, this can be done by selecting the 'Circuit Apex Points…' item in the Tools menu.

The Circuit Apex Definition window is shown in Fig. 8, (this is a modal dialog window) it allows the creation and editing of circuit apex points on the 2D circuit profile.

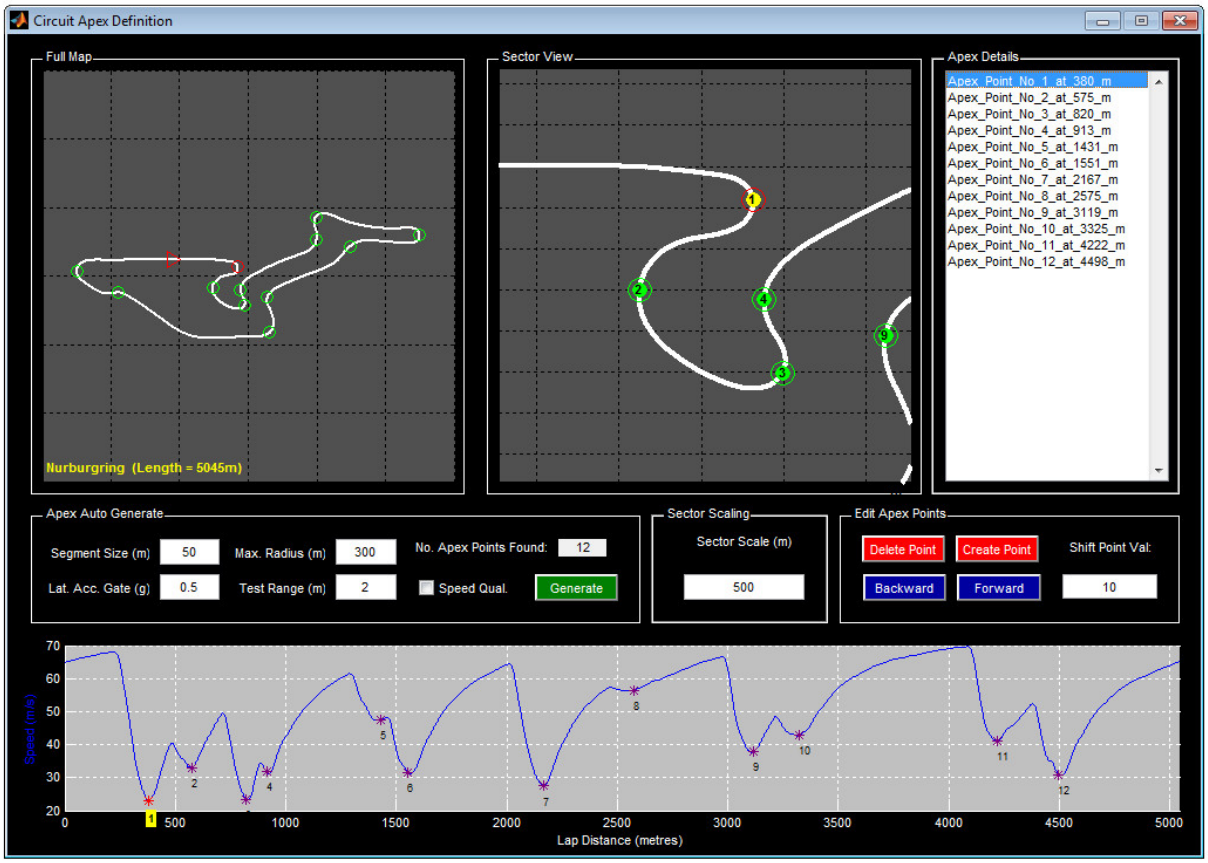

Fig. 8

The Apex Auto Generate pane provides control for creating the apex points automatically; this is generally the best method to use. Default values in this pane are typically acceptable. Clicking the 'Generate' button will create the apex points, display them on the circuit plots as shown and list them in the right hand list box as well as on the raw data speed trace on the bottom axes.

Notes:

Apex points are generated based on path curvature, it is recommended to delete any apex points which are clearly not 'true' apex points based on the speed data trace displayed on the bottom axes.

Noisy input data (particularly lateral acceleration) may give rise to additional apex points being generated erroneously; while these can be deleted it is recommended that applying a filter to the input data when generating the circuit profile will also help to yield better overall results.

Apex points can be added and deleted as required although adding points which have not been auto generated is not advised as you may be placing them at points which are not minimum radius apexes.

The 'Sector View' plot allows a more detailed view of circuit sections for editing apex points, the scale is specified in the 'Sector Scaling' pane, clicking on the full map will move the focus of the sector view.

When the apex definition window is closed the main window plots are updated with the defined apex points, it is now possible to save the circuit file and/or use it for the lap simulation.

The 'Tools' menu item in the main GUI provides access to the tools for editing localised circuit grip, camber and the elevation profile.

5.0 LapSIM Solver

The LapSIM Solver is the tool used for implementing the solution algorithm based on a specified circuit and vehicle definition. A vehicle file created in the 'Vehicle Tool' application and a circuit file created in the 'Circuit Tool' application can be loaded into the solver to run the simulations, or the solver can be set up to use the existing (currently open) circuit and vehicle definitions. The solver also allows ambient conditions to be specified and has options for solution resolution & convergence.

The LapSIM Solver GUI is shown in Fig. 9 - The circuit and vehicle files to use can either be loaded into the solver application directly or the Solver can be configured to use the circuit and vehicle definitions that are currently open in the respective software components.

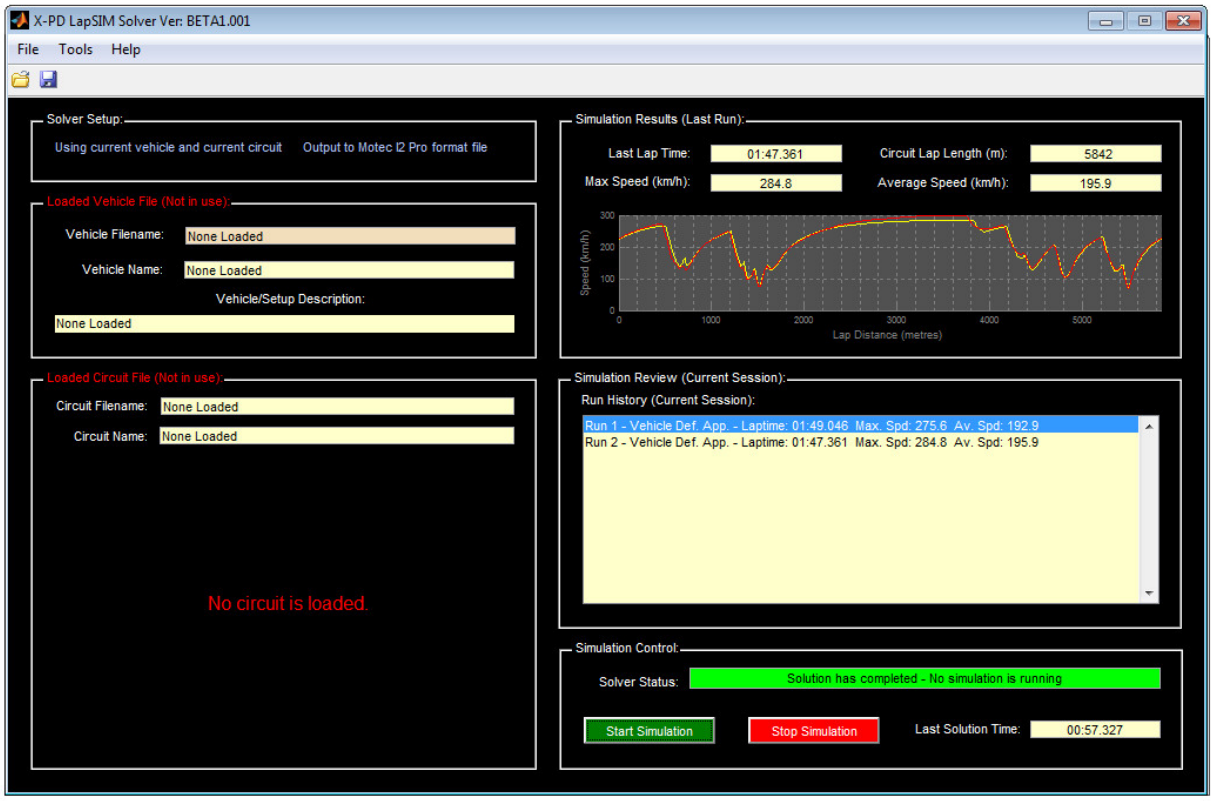

Fig. 9

To run the simulation simply click the 'Start Simulation' button, a progress dialog will appear while the simulation runs displaying relevant information and once complete the results are shown as in the figure and added to the run history list, lap time, V_{max}, and $V_{average}$ are displayed. The speed trace produced is shown in the axes below the results (in yellow), overlayed with the speed trace of the raw data used to generate the circuit path profile (in red) to allow a quick check of output quality or correlation.

The 'Stop Simulation' button can be used to stop the simulation before it has completed, the solver status field in the 'Simulation Control' pane indicates the status of the solver and the duration of the last simulation run (time of calculation) is also displayed.

Dependant on settings the software will ask if you want to save the results to file and for notes to add to the output data file once the simulation has completed.

Fig. 10 shows the 'Solution Setup' dialog, this can be accessed through the 'Tools' menu item in the main Solver GUI. Parameters affecting the simulation and Solver functionality can be set here.

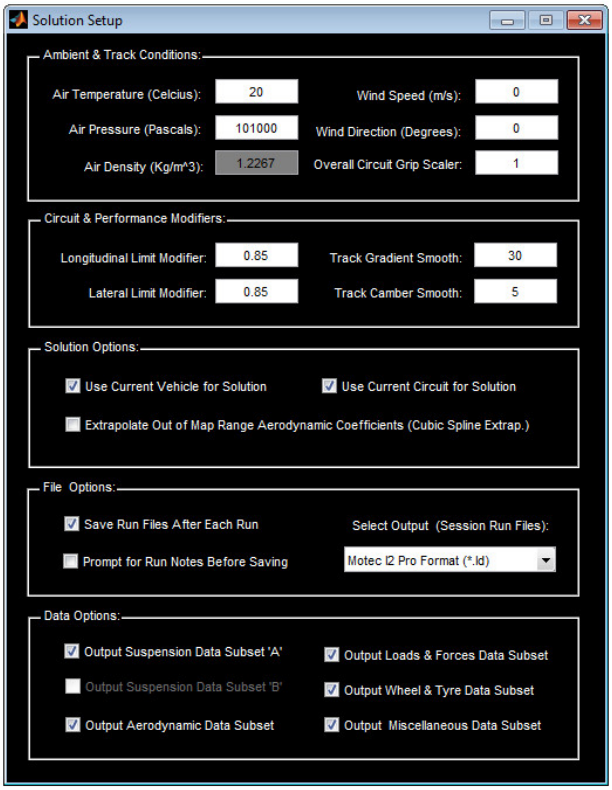

Fig. 10

Notes:

'Solution Setup' allows you to set the ambient conditions for the simulation, circuit & performance modifiers, solution & file options, the output type and the channels to output to file.

Wind direction is specified in degrees from the straight ahead at the start-finish line (tail wind on the start-finish straight) its angle is defined from this axis in a clockwise direction.

The overall circuit grip scalar is applied in addition to any local grip variations that have been specified in the circuit definition.

In the 'Solution Options' pane it is possible to select whether the currently open vehicle and circuit definitions are used for the solution, if these checkboxes are not selected the software will use the files loaded in the main Solver GUI.

Access to the Solver Options dialog is also provided within the 'Tools' menu item of the Solver GUI, typically it should not be necessary to adjust these settings from the default values, as they effect solution resolution and can affect the results and/or cause the solution to generate different results.

The facility to adjust them is provided in order to allow advanced users maximum scope to adjust the simulation control to suit the type of analysis being undertaken (for trade off of data resolution/convergence accuracy).

It is possible to save the simulation session through the toolbar shortcut or the 'File' menu item, this session can be reviewed later and data files exported to the format of choice. The number of runs per session is limited to 20, after which the session must be saved or cleared to continue.

6.0 Analysis Export

The data analysis export facility allows the advanced user to evaluate the results of a simulation in numerous ways. With multiple output formats it is possible to analyse simulation data as you would data recorded on a real race-car on-board system. Using for example time, distance or XY plots of the generated data (e.g. speed, 'g' forces, suspension displacements, contact loads, ride heights, etc) detailed post-processing of data and complete analysis of simulation results is possible alongside real car data within the users preferred analysis environment.

The solver can output the Motec *.ld file format for the i2 Pro analysis software which provides extensive analysis capabilities. This facility requires the software installation has the appropriate license to integrate with the i2 Pro software (Motec API License).

Other output formats include Pi Toolbox (Matlab dataset format) and MES ATLAS (Matlab session format) in addition to the XPD proprietary and standard CSV formats.

Fig. 11 shows the sample output data displayed in Motec i2 Pro, data can be displayed and manipulated as with data recorded on a cars data logging system, including creating math channels and exporting to other formats.

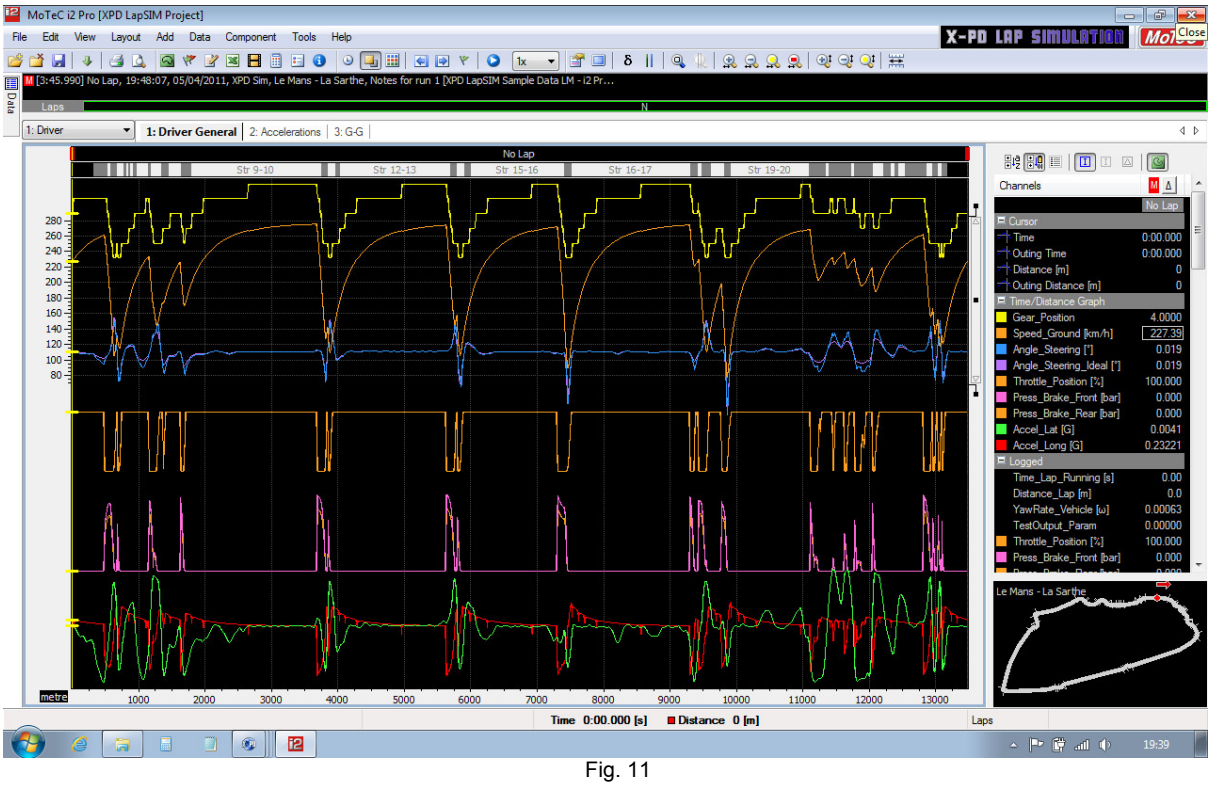

Fig. 11

In the program root directory (normally "C:/Program Files/XPD/XPD Tools/Support" project/workbook templates are available for i2 Pro, Pi Toolbox and MES ATLAS, also within the 'My Documents/XPD Tools' file structure that was created on installation there are sample results files in these formats.

Notes:

Appropriate licenses are required in order to open the output files in the respective analysis software tools; these are not typically supplied with the LapSIM software and should be sourced separately.

APPENDIX A – Simulation Data Output Channels

Standard Output Channels:	Std Unit:
TIME/GENERAL PERFORMANCE/OTHER	
Time_Lap_Running	Sec
Distance_Lap	m
YawRate_Vehicle	Deg/Sec
TestOutput_Param	NA
DRIVER & CONTROLS	
Throttle_Position	%
Press_Brake_Front	Bar
Press_Brake_Rear	Bar
Angle_Steering	Deg
Angle_Steering_Ideal	Deg
BASE DATA	
Accel_Lat_Base	g
Accel_Long_Base	g
Speed_Ground_Base	Km/h
YawRate_Base	Deg/Sec
CIRCUIT	
Circuit_Radius	m
Circuit_Camber	Deg
Circuit_Grip	Scaler
Circuit_Gradient	Ratio
Circuit_X	m
Circuit_Y	m
Circuit_Z	m
SPEED/VELOCITY	
Speed_Ground	Km/h
DISPLACEMENTS	
Disp_Wheel_FL	mm
Disp_Wheel_FR	mm
Disp_Wheel_RL	mm
Disp_Wheel_RR	mm
Disp_RideHeight_Front	mm
Disp_RideHeight_Rear	mm
ACCELERATIONS	
Accel_Lat	g
Accel_Long	g
Accel_Vert	g
LOADS	
Load_Contact_FL	Kg
Load_Contact_FR	Kg
Load_Contact_RL	Kg
Load_Contact_RR	Kg
ENGINE & TRANSMISSION	
Gear_Position	Absolute
Engine_RPM	rpm
Engine_Power	Bhp
Engine_Torque	Nm
Gear_Torque	Nm
Diff_Lock_Percent	%
WHEELS/TYRES/GRIP	

Tyre_Slip_Front	Deg
Tyre_Slip_Rear	Deg
Optional Output Channel Subsets:	
WHEELS & TYRES - SUBSET	
Tyre_SlipLat_FL	Deg
Tyre_SlipLat_FR	Deg
Tyre_SlipLat_RL	Deg
Tyre_SlipLat_RR	Deg
Tyre_SlipLong_FL	%
Tyre_SlipLong_FR	%
Tyre_SlipLong_RL	%
Tyre_SlipLong_RR	%
Tyre_Sat_FL	%
Tyre_Sat_FR	%
Tyre_Sat_RL	%
Tyre_Sat_RR	%
Tyre_SatLong_FL	%
Tyre_SatLong_FR	%
Tyre_SatLong_RL	%
Tyre_SatLong_RR	%
Tyre_SatLat_FL	%
Tyre_SatLat_FR	%
Tyre_SatLat_RL	%
Tyre_SatLat_RR	%
SUSPENSION - SUBSET A (Springs/BR's & Roll Bars)	
Disp_Spring_FL	mm
Disp_Spring_FR	mm
Disp_Spring_RL	mm
Disp_Spring_RR	mm
Disp_BR_FL	mm
Disp_BR_FR	mm
Disp_BR_RL	mm
Disp_BR_RR	mm
Disp_Spring_Fr3rd	mm
Disp_BR_Fr3rd	mm
Disp_Spring_Rr3rd	mm
Disp_BR_Rr3rd	mm
AERO - SUBSET	
Load_Aero_Front	Kg
Load_Aero_Rear	Kg
Load_Aero_Drag	Kg
Coef_Aero_Front	NA
Coef_Aero_Rear	NA
Coef_Aero_Drag	NA
Speed_Air	Km/h
LOADS & FORCES - SUBSET	
Load_LatTrans_Front	Kg
Load_LatTrans_Rear	Kg
MISC - SUBSET	
XPDDevParam_TS1	NA
XPDDevParam_TS2	NA
XPDDevParam_TS3	NA