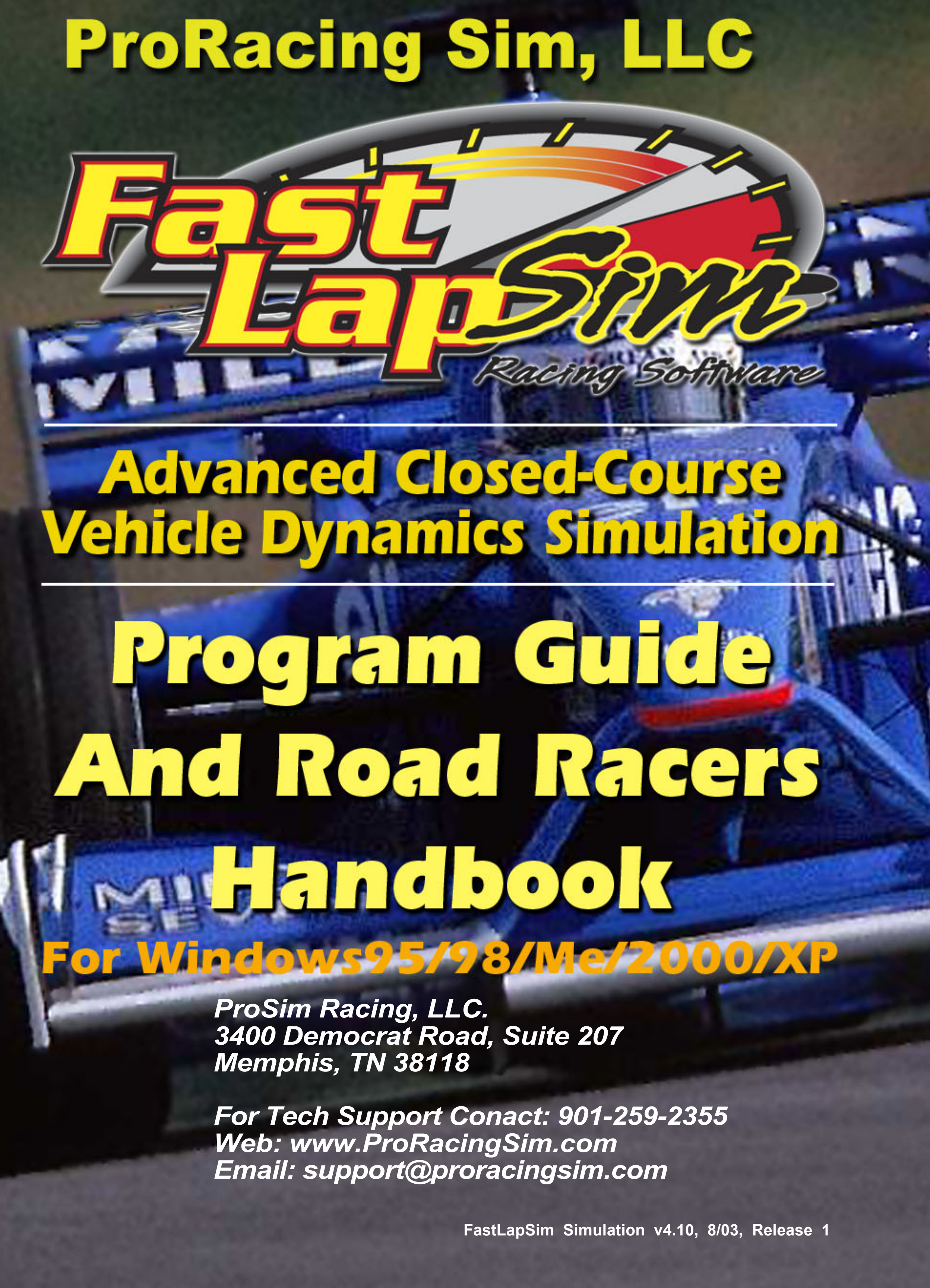

ProRacing Sim, LLC

FastLapSim
Racing Software

Advanced Closed-Course Vehicle Dynamics Simulation

Program Guide And Road Racers Handbook

For Windows95/98/Me/2000/XP

ProSim Racing, LLC.
3400 Democrat Road, Suite 207
Memphis, TN 38118

For Tech Support Conact: 901-259-2355
Web: www.ProRacingSim.com
Email: support@proracingsim.com

FastLapSim Simulation v4.10, 8/03, Release 1

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Memphis, TN 38118

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And thanks to the many other individuals who have contributed to the successful development and marketing of this software.

Larry Atherton, Pres., CEO
Motion Software, Inc.

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CONTENTS

INTRODUCTION

Note: *If you can't wait to start FastLapSim™, feel free to jump ahead to* **INSTALLATION** on page 14, *but don't forget to read the rest of this manual when you have time. Also, make sure you fill out and submit the registration form that appears when you start your software—this entitles you to receive FREE upgrades and other information and support.*

Thank you for purchasing *FastLapSim*™ for IBM®-compatible computers. This software is the result of several years of development and testing. We hope it helps you further your understanding and enjoyment of road racing and performance technology.

HOW IT WORKS

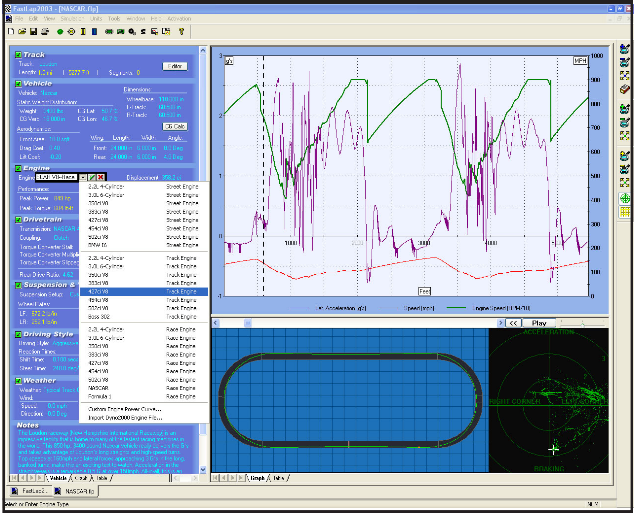
FastLapSim is a Windows95/98/2000/Me/XP, 32-bit, vehicle-dynamics simulation. FastLapSim simulates the complex physics of road racing with virtually any vehicle on any asphalt track. You can simulate rear- and front-wheel-drive passenger cars, professional race vehicles (including open-wheel Indy-type vehicles), autocross racers, and just about any 4-wheel vehicle you can dream up. You can select and change any vehicle component, and modify driver input from "perfect" to amateur, and see the results in seconds on a comprehensive data display.

Note: This program functions similarly to the *DynoSim*, and users of our engine simu-

Fast*LapSim*™ is the most advanced vehicle dynamics road-racing simulation ever offered to the performance enthusiast. It combines ease-of-use, powerful data-analysis, and detailed graphics.

Introduction To FastLapSim

FastLapSim Main Component Screen



☑ Track
Track: Loudon
Length: 1.0 mi (5277.7 ft) Segments: 0

☑ Vehicle
Vehicle: Nascar
Static Weight Distribution:
Weight: 3400 lbs CG Lat: 50.7 %
CG Vert: 18.000 in CG Lon: 46.7 %
Dimensions:
Wheelbase: 110.000 in
F-Track: 60.500 in
R-Track: 60.500 in
Aerodynamics:
Front Area: 18.0 sqft
Drag Coef: 0.40
Lift Coef: -0.20

Wing:	Length:	Width:	Angle:
Front:	24.000 in	6.000 in	0.0 Deg
Rear:	24.000 in	6.000 in	4.0 Deg

☑ Engine
Engine: SCAR V8-Race
Displacement: 358.2 ci
Performance:
Peak Power: 849 hp
Peak Torque: 604 lb-ft

☑ Drivetrain
Transmission: NASCAR 4
Coupling: Clutch
Torque Converter Stall:
Torque Converter Multipli
Torque Converter Slippag
Rear-Drive Ratio: 4.62

☑ Suspension &
Suspension Setup: Cu
Wheel Rates:
LF: 672.2 lb/in
LR: 252.1 lb/in

☑ Driving Style
Driving Style: Aggressive
Reaction Times:
Shift Time: 0.100 secs
Steer Time: 240.0 deg/

☑ Weather
Weather: Typical Track C
Wind:
Speed: 0.0 mph
Direction: 0.0 Deg

Notes
The Loudon raceway (New Hampshire International Raceway) is an impressive facility that is home to many of the fastest racing machines in the world. This 850-hp, 3400-pound Nascar vehicle really delivers the G's and takes advantage of Loudon's long straights and high-speed turns. Top speeds at 160mph and lateral forces approaching 3 G's in the long, banked turns, make this an exciting test to watch. Acceleration in the straightaways is a remarkable 0.5 G at over 150mph. All-in-all, this is an

elect or Enter Engine Type

FastLapSim incorporates a clean, intuitive user interface. If you wish to change a component, simply click on the component name and select a new component from a pop-up *DirectClick*™ menu. The comprehensive data displays are fully customizable. Multiple vehicle and/or data comparisons are possible. All components and graphics displays can be printed in full color.

lation software should find the menus and interface incorporated in this product a familiar sight.

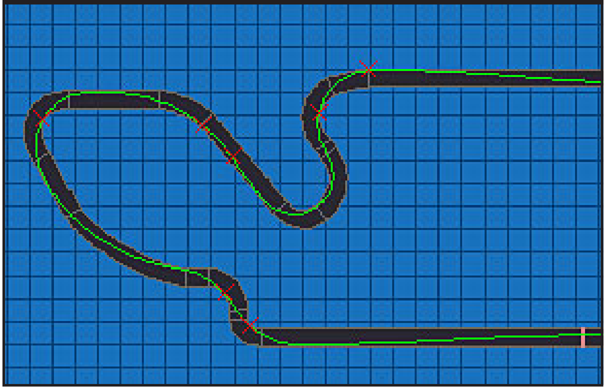
In a nutshell, FastLapSim lets you test vehicles on any one of dozens of supplied race tracks, or you can build just about any closed-course track you can imagine (a closed-course track forms a closed loop, where the end of the course meets the starting point). Then select from a wide variety of vehicle components, driver inputs, and weather conditions using ***DirectClick***™ pop-up menus to easily "assemble" a test vehicle. After the vehicle is complete, a comprehensive simulation of vehicle dynamics is performed as the vehicle moves throughout the entire course. The simulation results resemble a typical data-acquisition display, and can include a wide variety of "recorded" variables, including *Vehicle Speed, Lateral and Longitudinal Acceleration, Engine Rpm, Braking Forces, Suspension Movement,* and much more. In addition, a comprehensive table lists various *Elapsed Times, Engine Rpms, Vehicle Speeds, etc.,* at critical points and/or track segments throughout the course.

FastLapSim begins the simulation process by determining an optimum race line. This is one of the most difficult tasks in the simulation. An ideal race line allows the vehicle to accelerate as soon and as long as possible, brake as late as possible, and traverse a corner at the largest possible radius. FastLapSim uses several techniques to perform this complex calculation. First, the race line is approximated as a series of points. At each point the curvature or corner radius is calculated and a default lane (a lane is a possible vehicle path across the width of the track) is assigned. The next step iterates through the paths, modifying lane assignments, and recalculating the curvatures until optimum path through the track has been found.

Once this initial path is computed, the next step applies a theoretical speed through each point by assuming that corner speed is limited only by peak tire grip. The speed

Introduction To FastLapSim

Finding The Optimum Race Line



FastLapSim begins the simulation process by determining an optimum race line (green line). This complex task locates the path that will allow the vehicle to accelerate as soon and as long as possible, brake as late as possible, and traverse a corner at the largest possible radius (and the greatest speed).

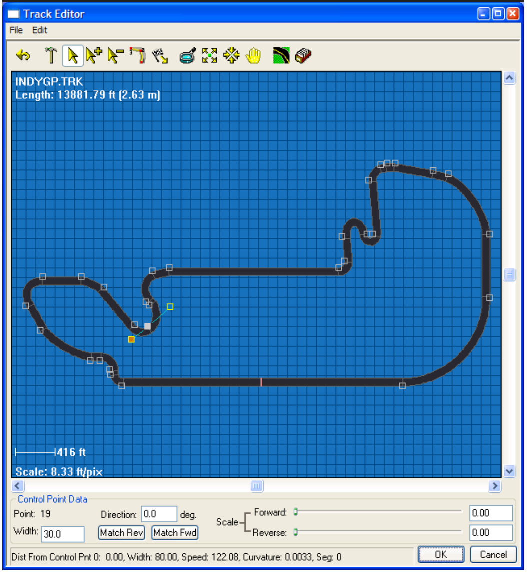
and radius are calculated to determine braking points (the positions on the track where the brakes are applied).

A final calculation uses a repeating process called *Gradient Descent* to further improve the race line and estimate lap time. If the new path offers a performance improvement, the specifications are maintained; if no improvement is noted, the path is modified again, and the process is repeated until there is convergence on an optimal path.

Despite the complexity of the underlying simulation, FastLapSim has been de-

One of the most powerful features of FastLapSim is the *TrackEditor*™. Here, you can design any track you can imagine, from simple ovals to complex road courses. Even simulate a parking-lot autocross. The *TrackEditor*™ is a full-featured graphics editor, allowing a what-you-see-is-what-you-get construction and editing of turns, straights, and track widths.

FastLapSim *TrackEditor*™



INDYGP.TRK
Length: 13881.79 ft (2.63 m)

416 ft
Scale: 8.33 ft/pix

Control Point Data
Point: 19
Direction: 0.0 deg.
Width: 30.0
Scale
Forward: 0.00
Reverse: 0.00

Dist From Control Pnt 0: 0.00, Width: 80.00, Speed: 122.08, Curvature: 0.0033, Seg: 0

signed to be easy to use. In addition to an intuitive, point-and-click interface with *DirectClick*™ menus, this software contains a built-in analysis system that scrutinizes selected components and combinations. An alert is triggered when component combinations may produce unreliable results. You are then presented with information that will help you correct the problem and maintain the highest predictive accuracy and data reliability.

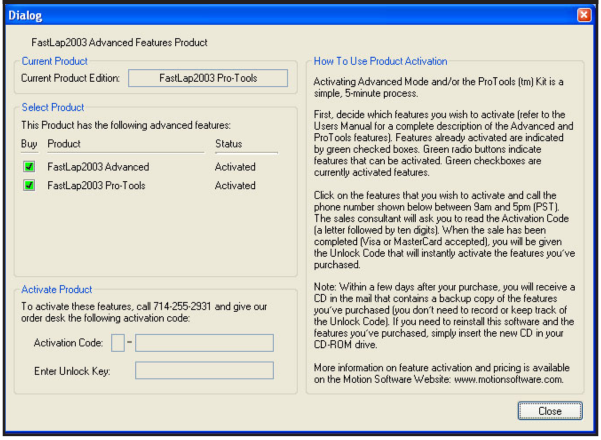
Product Activation Modes

FastLapSim can run in three distinct modes: 1) ***Demo***, 2) ***Advanced***, and 3) ***ProTools™ Activated*** (for more information on the Demo Mode and Product Activation, see page 100). The ***Advanced*** Mode includes a powerful set of features that allows enthusiasts and professionals to test components and determine optimum combinations for just about any application. All essential simulation features are included in the *Advanced Mode*, The ***ProTools™*** mode extends existing features to allow a more technical and/or detail analysis of vehicle performance. For example, in *Advanced Mode*, the user can measure and monitor numerous vehicle data sets, including Accelerations and Speeds. The ***ProTools™ Kit*** (activated in the ***ProTools™*** mode) adds additional dynamics and force measurements, including individual wheel movements and forces, etc.

The ***ProTool Kit™*** can be activated by opening the ***Product Activation*** menu in FastLapSim and following the simple steps described on the activation screen. The ***ProTool Kit™*** contains the following features:

- A ***Real-Time Simulation Screen:*** View the simulation process realtime, review an extensive data display, watch the simulation zero-in on the best braking points and corner speeds, see suspension movement, G-forces, and more!

***ProTools™* Activation**



FastLap2003 Advanced Features Product

Current Product

Current Product Edition: FastLap2003 Pro-Tools

Select Product

This Product has the following advanced features:

Buy	Product	Status
☑	FastLap2003 Advanced	Activated
☑	FastLap2003 Pro-Tools	Activated

Activate Product

To activate these features, call 714-255-2931 and give our order desk the following activation code:

Activation Code: ☐ - ☐

Enter Unlock Key: ☐

How To Use Product Activation

Activating Advanced Mode and/or the ProTools (tm) Kit is a simple, 5-minute process.

First, decide which features you wish to activate (refer to the Users Manual for a complete description of the Advanced and ProTools features). Features already activated are indicated by green checked boxes. Green radio buttons indicate features that can be activated. Green checkboxes are currently activated features.

Click on the features that you wish to activate and call the phone number shown below between 9am and 5pm (PST). The sales consultant will ask you to read the Activation Code (a letter followed by ten digits). When the sale has been completed (Visa or MasterCard accepted), you will be given the Unlock Code that will instantly activate the features you've purchased.

Note: Within a few days after your purchase, you will receive a CD in the mail that contains a backup copy of the features you've purchased (you don't need to record or keep track of the Unlock Code). If you need to reinstall this software and the features you've purchased, simply insert the new CD in your CD-ROM drive.

More information on feature activation and pricing is available on the Motion Software Website: www.motionsoftware.com.

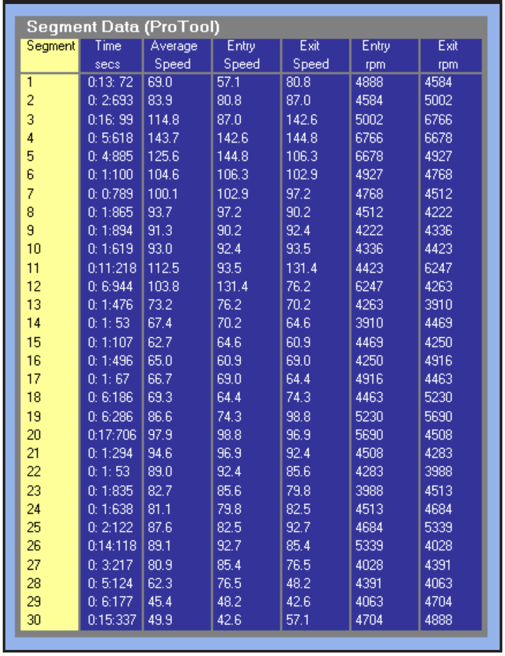
If you are a serious enthusiast, racer, or part of a professional team, you will find the additional tools and features supplied in the *ProTools™ Kit* a valuable addition to FastLapSim. Many features in the standard program have been enhanced with extended functionality. In addition, there are new features aimed directly at the professional, like the *DataZones™*, Extended Graphing, and *Pro-Printing™* that generates a "presentation-quality" test report including the name and logo of your company.

- ***Simulation Optimization:*** This ***ProTools***™ feature includes optimization routines that perform a more in-depth analysis of every corner, braking points, all suspension movement and forces applied to the test vehicle. This calculation-intensive analysis, when activated by the user, predicts lap times and vehicle performance data with the highest possible accuracy. If you need the most accurate analysis possible, the ***ProTools™ Optimization*** will help you achieve your goals.

- The ***Spring/Damper QuickCalculator™:*** A powerful ***ProTool*** for serious performance seekers. This tool will help pick the most appropriate shock absorber for any spring rate. The Calculator tests dampers with the current spring, performing a spring/shock dyno simulation and selecting a combination that effectively dampens the spring (without overdamping). The ***Spring/Damper QuickCalculator™*** is an indispensable tool for zeroing-in on the best shock combinations for virtually any vehicle or track.

- The ***Optimum Gear Iterator™:*** This ***ProTool*** performs a quick iteration using the current vehicle setup and simulation test data to find the best transmission and rear-axle ratios for the test vehicle. The ***Optimum Gear Iterator™*** is another tool

ProData Table *(ProTools™)*



Segment Data (ProTool)

Segment	Time secs	Average Speed	Entry Speed	Exit Speed	Entry rpm	Exit rpm
1	0:13: 72	69.0	57.1	80.8	4888	4584
2	0: 2:693	83.9	80.8	87.0	4584	5002
3	0:16: 99	114.8	87.0	142.6	5002	6766
4	0: 5:618	143.7	142.6	144.8	6766	6678
5	0: 4:885	125.6	144.8	106.3	6678	4927
6	0: 1:100	104.6	106.3	102.9	4927	4768
7	0: 0:789	100.1	102.9	97.2	4768	4512
8	0: 1:865	93.7	97.2	90.2	4512	4222
9	0: 1:894	91.3	90.2	92.4	4222	4336
10	0: 1:619	93.0	92.4	93.5	4336	4423
11	0:11:218	112.5	93.5	131.4	4423	6247
12	0: 6:944	103.8	131.4	76.2	6247	4263
13	0: 1:476	73.2	76.2	70.2	4263	3910
14	0: 1: 53	67.4	70.2	64.6	3910	4469
15	0: 1:107	62.7	64.6	60.9	4469	4250
16	0: 1:496	65.0	60.9	69.0	4250	4916
17	0: 1: 67	66.7	69.0	64.4	4916	4463
18	0: 6:186	69.3	64.4	74.3	4463	5230
19	0: 6:286	86.6	74.3	98.8	5230	5690
20	0:17:706	97.9	98.8	96.9	5690	4508
21	0: 1:294	94.6	96.9	92.4	4508	4283
22	0: 1: 53	89.0	92.4	85.6	4283	3988
23	0: 1:835	82.7	85.6	79.8	3988	4513
24	0: 1:638	81.1	79.8	82.5	4513	4684
25	0: 2:122	87.6	82.5	92.7	4684	5339
26	0:14:118	89.1	92.7	85.4	5339	4028
27	0: 3:217	80.9	85.4	76.5	4028	4391
28	0: 5:124	62.3	76.5	48.2	4391	4063
29	0: 6:177	45.4	48.2	42.6	4063	4704
30	0:15:337	49.9	42.6	57.1	4704	4888

With *ProTools™* activated, FastLapSim displays an additional *ProData™* table of segment times, helpful in professional track tuning efforts. Up to 30 segments can be defined for any track.

that will give any serious racer a winning edge.

- ***Track Segments*** defines portions of the track as “segments.” Segments begin and end at Corner Points, and once defined, segments can be used to analyze vehicle entrance and exit speeds, average speeds, and other vehicle data. Optionally, choose unique colors for each segment, making visual identification a snap. Up to 30 segments can be defined for each track.

- Graph ***DataZones™:*** Set colored ranges on any simulation results graph to mark target times, distances, accelerations, speeds, or any other race variables. ***DataZones*** also can be used to graphically indicate gear ratios overlaid on speed, acceleration, and other distance-based data-sets. ***DataZones*** produce professional-looking graphs, isolate vehicle characteristics, help detect excess speeds or loads, and add color to graphic displays.

- ***ProTools*** also includes track-segment ***ProData™*** that is calculated and displayed in an additional table of test results (available by selecting the ***ProData*** tab at the bottom of the graph screen). Up to 30 segments can be defined and uniquely colored. Each segment of the track can be used to record and analyze vehicle entrance and exit speeds, average times, and more.

- ***Pro-Printing™:*** Allows you to printout a comprehensive, presentation test report of any simulated vehicle on any track. This professional report includes a custom cover page with the name of your business and/or vehicle designer, vehicle data, all performance data tables, graphic performance data, and all extended data available with ***ProTools*** (as described above). Even include an optional Table of Contents and/or Glossary of Terms with your test reports. Use this eye-popping report to make the best presentation possible of your latest vehicle simulation designs.

FastLapSIM REQUIREMENTS

Here are the basic hardware and software requirements to properly run FastLapSim:

- An IBM® compatible PC with a CD-ROM drive.
- At least 32MB of RAM (random access memory) for Windows95/98/Me; 64MB for WindowsNT; 128MB for Windows2000/XP (for best performance, use 512MB or more)
- Windows95/98/Me or Windows NT/2000/XP (NT version 4.0 with SP6 or later)
- A video system capable of at least SVGA (800 x 600 resolution). Recommend 1024 x 768, 1280 x 1024, or higher to optimize display of engine components and performance analysis graphics.
- A fast system processor (1GHz or faster) will improve processing speeds. How-

ever, FastLapSim will operate on any Windows95/98/Me/NT/2000/XP system, regardless of processor (see page 12 for processor-speed vs. simulation time comparisons).

- A mouse or pointing device.
- Any Windows compatible printer (to obtain vehicle-test printouts).

REQUIREMENTS—ADDITIONAL CONSIDERATIONS

Windows95/98/Me/NT/2000/XP: FastLapSim is a full 32-bit program designed for Windows95 through WindowsXP (all versions). If you use an early version (especially the first release) of Windows95, make sure to install the latest service packs for both Windows and for Internet Explorer (use the Windows Update feature available in the Start Menu or visit www.microsoft.com to locate updates and service packs for your operating system).

Video Graphics Card And Monitor: Virtually any Windows compatible monitor and video display card that is capable of 800 x 600 resolution will work with FastLapSim. Systems with SVGA or better graphics (1024 x 768, 1280 x 1024 resolution or higher) provide more screen "real estate." This additional display space speeds component selections and power-curve analysis.
Note1: See FAQ on page 154 for help in changing the screen resolution of your system and monitor.

System Processor: FastLapSim is extremely calculation-intensive. Billions of mathematical operations are required to complete a race simulation. While the program has been designed to optimize speed, a faster processor will improve data-analysis capabilities. To reduce calculation times and extend the modeling capabilities of the program, use the fastest system processor possible.

The following table gives an approximation of the time required to complete a full simulation on the Indy GP track with a typical high-performance vehicle on both modern and legacy computers.
Note: The times shown here are for FastLapSim ***version 4.10***.

Computer	Math Coprocessor	Calculation Time To Complete Simulation
Pentium 3.0Ghz	Built-In	2.25 Minutes
Athlon 2800	Built-In	2.75 Minutes
Pentium 1.8Ghz	Built-In	5.5 Minutes
Pentium 400Mhz	Built-In	24.75 Minutes
Pentium 200Mhz	Built-In	49 Minutes
Pentium 133Mhz	Built-In	74 Minutes
Pentium 60Mhz	Built-In	1.8 Hours
80486DX 33Mhz	Built-In	5.65 Hours
80386DX 25Mhz	Yes (added)	20.7 Hours
80486SX 25Mhz	No	10 Days

80286 at 10Mhz	No	25 Days
8088 at 8Mhz	Yes (added)	2 Days

Mouse: A mouse (trackball, or other pointer control) is required to use FastLapSim. While many component selections and other program functions can be performed with the keyboard, several operations within FastLapSim require the use of a mouse.

Printer: FastLapSim can print a comprehensive “Track-Test Report” on any Windows-compatible printer. If you use a color printer, the data curves and component information will print in color (see page 96 for more information about FastLapSim printing).

INSTALLATION

Installation Tips

FastLapSim installation is a quick and easy process. Review these points and follow the installation steps below:

- The FastLapSim requires Windows 95/98/Me® or Windows NT/2000/XP® and at least 64MB of installed memory (see page 12 in the Users Manual for more information about system requirements).
- The software SETUP program will install FastLapSim onto the **C:** drive in the **FastLapSim** directory. Placing program files within this directory will ensure that future upgrades and enhancements will install correctly. Please accept the default installation path for trouble-free operation.

Read and perform each of the following steps carefully:

1) Start Windows, if necessary.

2) Insert the FastLapSim CD-ROM into your CD drive.

3) An installation Welcome screen will appear on your desktop within 5 to 30 seconds (depending on the speed of your CD drive). Proceed to **step 5**.

4) If the FastLapSim installation Welcome screen does not automatically display on your desktop within 30 to 60 seconds, run the **Setup** program included on the DynoSim CD-ROM. (Choose ***Settings*** from the ***Start*** menu, select ***Control Panels***, then double click ***Add/Remove Programs***, finally click on ***Install***.)

5) Click ***Next*** to view the ProRacing Sim License Agreement. Read the Agreement and if you agree with the terms, click ***I Accept...***, then click ***Next*** to continue with the installation.

6) A *Readme* file includes the latest changes made to this software and information not available at the time this *Install & QuickStart Guide* was published. After you have reviewed the *Readme*, click ***Next*** to proceed with the installation.

Installing & Starting FastLapSim

7) The **Setup Type** window will present three installation options:
Typical—Installs FastLapSim, sample files, Users Manual, demo software/updates, and tutorials and videos.
Minimal—Installs FastLapSim, sample files, and Users Manual only.
Custom—Allows you to select the installed elements.
We recommend you select ***Typical***, and press ***Next*** to continue the installation.

8) The **Ready To Install** screen gives you a chance to review installation choices. Press ***Back*** to make any changes; press ***Install*** to begin copying files to your system.

9) When main installation is complete, the **Setup Complete** screen will be displayed. Click ***Finish*** to close this window and a final dialog box will ask for permission to install a Camtasia™ Codec on your system (needed to display tutorial and help files). Choose ***Install*** to complete FastLapSim installation.

Starting FastLapSim

10) To start FastLapSim, open the Windows **Start** menu, select **Programs**, then choose ***ProRacing Sim Software***, ***FastLapSim Vehicle Simulation***, and finally click on ***FastLapSim Vehicle Simulation*** icon displayed in that folder.

11) When you first start the program, a Registration dialog will be displayed. Please fill in the requested information, including the serial number found on page 4 of this QuickStart Guide. Then press the ***Proceed*** button. If you have an Internet connection, your registration will be submitted to ProRacingSim automatically. If you do not have an Internet connection, you will be presented with other registration options. If you do not register this simulation, you will not qualify for tech support nor will you be able to participate in any of the exciting contests that will be conducted in the weeks and months ahead.

Note: Demos of the new *DynoSim* and *DragSim* have been included with FastLapSim. Start the demos by opening the ***Start*** menu, select ***Programs***, ***ProRacing Sim Software,*** then choose the ***DynoSim Engine Simulation*** or ***DragSim Vehicle Simulation***. These demo programs can be *Activated* to the **Advanced** or **ProTools™** versions by using the *Product Activation* menu within each program (see page 15).

12) You can also access additional information about our simulation software and obtain technical support by visiting (www.ProRacingSim.com) or by opening the ***Start*** menu, select ***Programs***, ***ProRacing Sim Software,*** then click on ***Tech Support Website***.

13) Please review the remainder of this QuickStart guide for more information on menu

selections, program functions, and simulation tips.

14) If you experience installation problems, please review program requirements on pages 11-13 in the Users Manual, and take a few minutes to look over the following sources of information before you contact technical support:

- The FAQs on page154 provide additional installation and operational questions-and-answers.
- Visit the Tech Support section of the ProRacing Sim Software website for additional tips and FAQs.

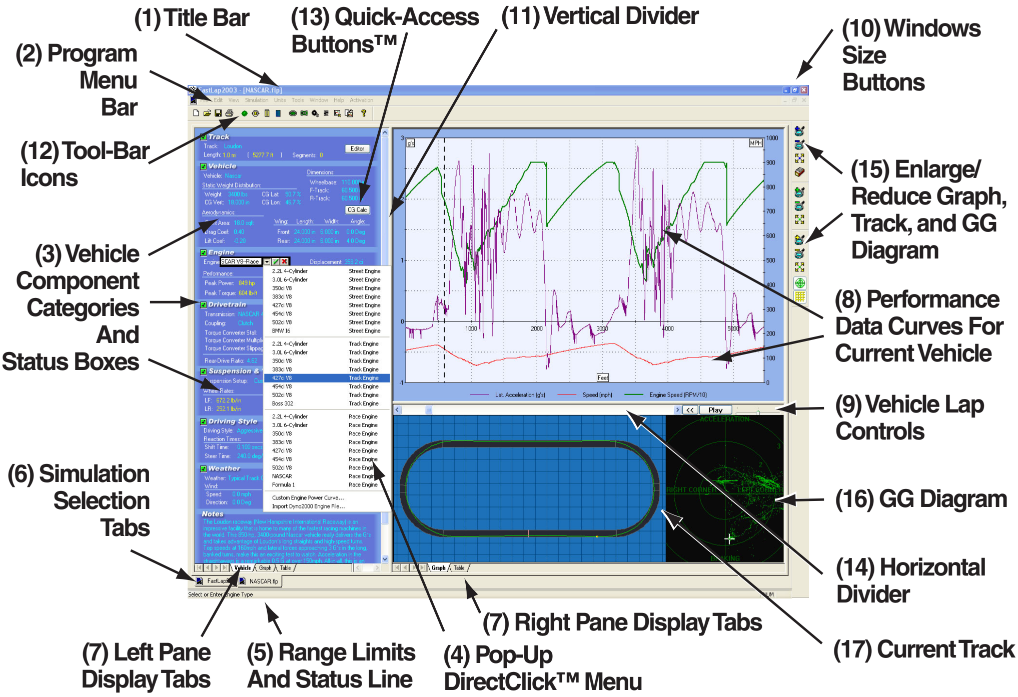
If you cannot find a solution to your problem, use the mail-in form on page 161. Mail the completed form to:

ProRacing Sim Software, LLC.
3400 Democrat Road, Suite 207
Memphis, TN 38118
Tech: 901-259-2355, or visit our
Web: www.proracingsim.com
Email: support@proracingsim.com

Note: Tech support will only be provided to registered users. Please fill in the *Registration Form* that appears when you first start your software to qualify for technical support from the ProRacing Sim Software staff.

Advanced Road-Race Simulation

OVERVIEW



THE MAIN PROGRAM SCREEN

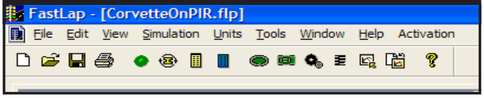
The **Main Program Screen** allows you to select vehicle components, dimensions, and specifications. In addition, track data, vehicle performance data curves and/or simulation numeric data are displayed in graphical and chart form. The Main Program Screen is composed of the following elements:

1) The **Title Bar** displays the program name followed by the name of the currently-selected simulation file.

2) The **Program Menu Bar** contains nine pull-down menus that control overall program function. Here is an overview of these control menus, from left to right

Program Overview

Program Menu Bar



Program Menu Bar contains nine pull-down menus that control overall program function.

(additional information on menu functions is provided elsewhere in this guide):

File—Opens and Saves FastLapSim test files, prints engine components and power curves, allows the quick selection of the most recently used FastLapSim files, and contains a quit-program selection.

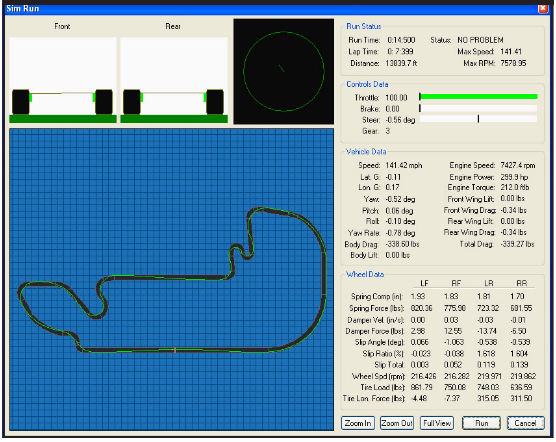
Edit—Clears all component choices from the currently-selected simulation. (The *Simulation Selection Tab* indicates the currently-selected simulation; see ***Simulation Selection Tabs***, below).

View—Allows you to turn various ***Toolbars***, the ***Status Bar*** and ***Workbook*** layout on or off. In addition, you can select the overall color scheme for FastLapSim from this menu.

Simulation—***Run*** performs a simulation using the current component selections. ***Run With Real-Time Data*** *(a ProTools™ feature; see Product Activation, below)* performs a simulation while displaying a detail analysis of simulation progress and realtime data "acquisition" (takes longer). ***Simulation Results Setup*** opens a dialog that allows you to select several program options, including the *Data Save Interval* (for telemetry), an *Optimize Simulation* function (ProTools™ option that improves accuracy but takes additional time), whether to *Save Simulation Results* (save telemetry) data, several other options that limit vehicle body roll, yaw, etc., and a checkbox for *Fast Graph*

The *Run With Real-Time Data* screen *(a ProTools™ feature; see Product Activation, on page 100)* performs a simulation while displaying a full analysis of simulation progress and realtime data acquisition.

Run With Real-Time Data



Run Status

Run Time: 0:14:500
Status: NO PROBLEM
Lap Time: 0: 7:399
Max Speed: 141.41
Distance: 13839.7 ft
Max RPM: 7578.95

Controls Data

Throttle: 100.00
Brake: 0.00
Steer: -0.56 deg
Gear: 3

Vehicle Data

Speed: 141.42 mph
Engine Speed: 7427.4 rpm
Lat. G: -0.11
Engine Power: 299.9 hp
Lon. G: 0.17
Engine Torque: 212.0 ftlb
Yaw: -0.52 deg
Front Wing Lift: 0.00 lbs
Pitch: 0.06 deg
Front Wing Drag: -0.34 lbs
Roll: -0.10 deg
Rear Wing Lift: 0.00 lbs
Yaw Rate: -0.78 deg
Rear Wing Drag: -0.34 lbs
Body Drag: -338.60 lbs
Total Drag: -339.27 lbs
Body Lift: 0.00 lbs

Wheel Data

	LF	RF	LR	RR
Spring Comp (in):	1.93	1.83	1.81	1.70
Spring Force (lbs):	820.36	775.98	723.32	681.55
Damper Vel. (in/s):	0.00	0.03	-0.03	-0.01
Damper Force (lbs):	2.98	12.55	-13.74	-6.50
Slip Angle (deg):	0.066	-1.063	-0.538	-0.539
Slip Ratio (%):	-0.023	-0.038	1.618	1.604
Slip Total:	0.003	0.052	0.119	0.139
Wheel Spd (rpm):	216.426	216.282	219.971	219.862
Tire Load (lbs):	861.79	750.08	748.03	636.59
Tire Lon. Force (lbs):	-4.48	-7.37	315.05	311.50

Update, a feature that can improve the speed at which the track is displayed on your computer system (effectiveness depends on the video system installed in your computer).

Units—Selects between the ***US*** and ***Metric*** measurement systems.

Tools—Contains several tools and calculators that can be used to find optimum component combinations. The first selection opens the ***Gear Iterator™*** and ***Spring-Damper Calculator™*** *(ProTools™ features).* The ***Lap-Time Slip*** selection opens a quick-reference "time slip" that can be positioned anywhere on the FastLapSim window. The ***SimData™*** window provides a detailed display of performance data for the currently-selected reticle position (click on the results graph to show the data reticle). The final selections open the ***Custom Engine Power Curve...*** and ***Import DynoSim Engine File...*** dialog boxes.

Window—A standard Windows menu for arranging and selecting simulation display screens.

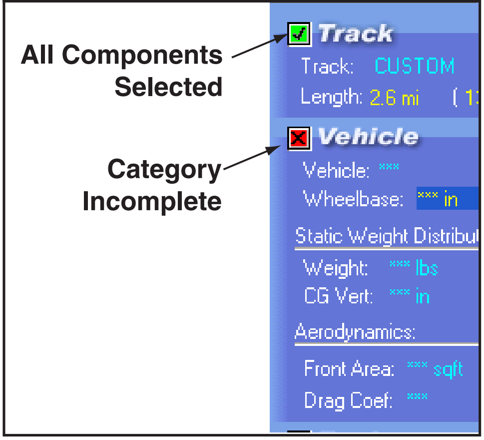
Help—Gives access to this Users Guide and other program help features.

Product Activation—Activates optional ***ProTools™*** features of FastLapSim, including *Spring-Damper Calculator™*, *DataZones™* and other optional features (see page 100 for additional information on optional program features).

3) The **Vehicle Component Categories** are made up of the following groups:

TRACK—Selects the track on which to perform the vehicle-dynamics simulation. Select the ***Editor*** button to open the **Track Editor** (see page 69 for more information on the Track Editor) to modify any track or design and build any

Component Status Boxes



☑ Track
Track: CUSTOM
Length: 2.6 mi (1

☒ Vehicle
Vehicle: ***
Wheelbase: *** in

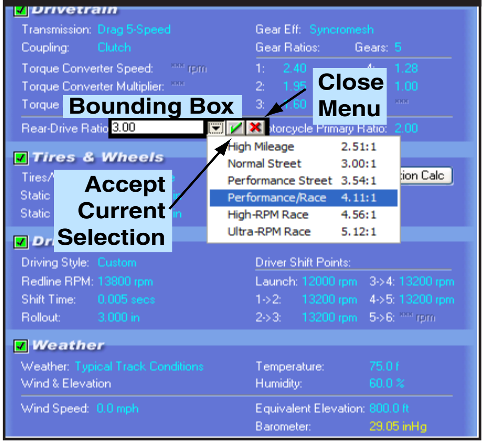
Static Weight Distribu
Weight: *** lbs
CG Vert: *** in

Aerodynamics:
Front Area: *** sqft
Drag Coef: ***

The *Component Status Check Boxes* are located in the upper left corner of each Vehicle Component Category. These boxes either contain a red boxed X, indicating that the category is not complete (inhibiting a simulation run), or a green-boxed checkmark ✔, indicating that all components in that category have been selected.

The PopUp, DirectClick™ Component Menus list components and specifications for each of the Component Categories. Click on any component specification to open its menu. The menu will close when a selection is complete (or accept the current selection by clicking on the green ✓). If you wish to close the menu before making a new selection, click the red X repeatedly or press the Escape key until the menu closes.

PopUp Component Menu



☑ Drivetrain
Transmission: Drag 5-Speed
Coupling: Clutch
Torque Converter Speed: *** rpm
Torque Converter Multiplier: ***
Torque
Rear-Drive Ratio 3.00
Gear Eff: Syncromesh
Gear Ratios: Gears: 5
1: 2.40
2: 1.95
3: 1.60
4: 1.28
5: 1.00
***
torcycle Primary Ratio: 2.00

High Mileage 2.51:1
Normal Street 3.00:1
Performance Street 3.54:1
Performance/Race 4.11:1
High-RPM Race 4.56:1
Ultra-RPM Race 5.12:1

Driving Style: Custom
Redline RPM: 13800 rpm
Shift Time: 0.005 secs
Rollout: 3.000 in
Driver Shift Points:
Launch: 12000 rpm
1->2: 13200 rpm
2->3: 13200 rpm
3->4: 13200 rpm
4->5: 13200 rpm
5->6: *** rpm

☑ Weather
Weather: Typical Track Conditions
Wind & Elevation
Wind Speed: 0.0 mph
Temperature: 75.0 f
Humidity: 60.0 %
Equivalent Elevation: 800.0 ft
Barometer: 29.05 inHg

closed-course track.

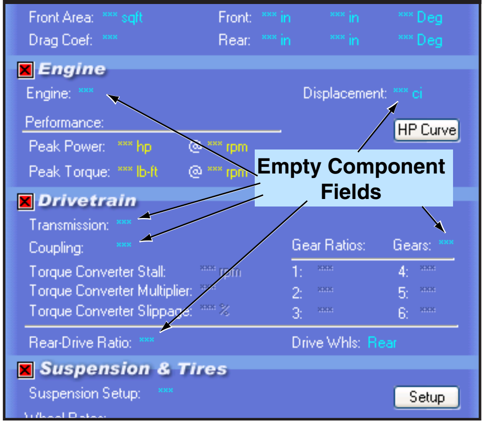
VEHICLE—Selects the vehicle type, weight, and other vehicle specifications. Press the ***CG Calc*** button to open the ***Center-Of-Gravity Calculator***, a tool that determines CG location from corner weights.

ENGINE—Selects an engine from a pop-up list of various powerplants, imports DynoSim engine files, or allows the direct entry of any engine power curve (either in the form of a “dyno-test” curve or by entering peak power and torque values). This category also includes a ***Redline RPM*** field (the maximum engine speed used in the simulation).

DRIVETRAIN—Selects the transmission type, gear ratios, coupling (clutch or

Component fields that do not yet contain valid entries are marked with a series of asterisks. This indicates that the fields are empty and (most) require data input. Numeric fields accept direct keyboard entry or selections from provided drop-down menus. Text selection fields (like the *Vehicle* or *Transmission* choice menus) only accept selections from the associated drop-down menus. When a valid selection has been made, it will replace the asterisks next to the field names.

Incomplete Component Fields



Front Area: *** sqft
Drag Coef: ***
Front: *** in *** in *** Deg
Rear: *** in *** in *** Deg

☒ Engine
Engine: ***
Displacement: *** ci
Performance:
Peak Power: *** hp @ *** rpm
Peak Torque: *** lb-ft @ *** rpm

☒ Drivetrain
Transmission: ***
Coupling: ***
Torque Converter Stall: *** rpm
Torque Converter Multiplier: ***
Torque Converter Slippage: *** %
Rear-Drive Ratio: ***
Gear Ratios: Gears: ***
1: ***
2: ***
3: ***
4: ***
5: ***
6: ***
Drive Whls: Rear

☒ Suspension & Tires
Suspension Setup: ***

torque converter), rear-axle ratio, and other drivetrain specifications.

SUSPENSION & TIRES—Selects the type of suspension and tires that will be modeled in the simulation. This comprehensive data-entry category allows simple pop-up menu selections or you can enter custom specs for virtually every suspension component. Click the ***Setup*** button to open the detail suspension data-entry screen.

DRIVING STYLE—Selects the level of proficiency of the driver on the selected course. *Shift Time, Shift Accuracy, Shift Error Rpm,* and *Steer Time* can be individually modified.

WEATHER—Selects the temperature, barometric pressure, humidity, wind speed, wind direction, and equivalent elevation.

NOTES—Enter any comments about the current simulation. Notes are saved with the vehicle *.FLP* file.

Note: Each component category (except *NOTES*) contains a **Status Box** located in the upper left corner. These boxes either contain a **red boxed X**, indicating that the category is not complete (inhibiting a simulation run), or a **green-boxed** checkmark ✓, indicating that all components in that category have been selected. When all component categories have green checks, a simulation can be performed using the current data values and the results will be displayed in the graph on the right of the Main Program Screen (the simulation and data plot will be performed automatically if ***Autorun*** is checked in the **Simulation** drop-down menu, see **Simulation Menu** description, on page 17).

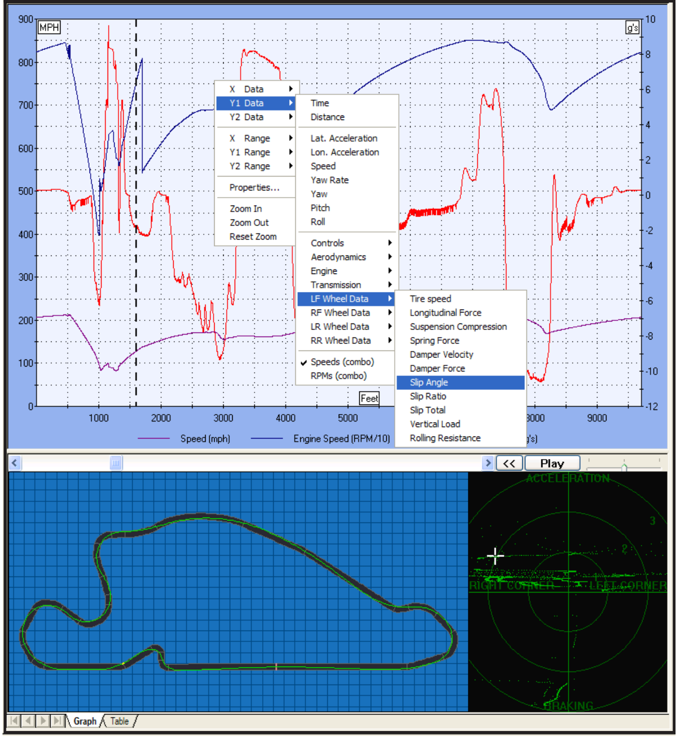
4) The **PopUp *DirectClick*™ Component Menus** contain components and specifications for each of the Component Category choices. Click on any component specification to open its menu. The menu will close when a selection is complete. If you wish to close the menu before making a new selection, click the red **X** next to the drop-down box repeatedly or press the **Escape** key until the menu closes.

5) Several Component Category menus allow direct numeric entry. During this data entry, the range of acceptable values will be displayed in the **Range Limit And Status Line** at the bottom of the screen.

6) FastLapSim can simulate several vehicles at once. Switch between “active” vehicles by selecting one of the Tabs in the **Simulation Selection Tabs** located just above the **Range Limit Line**. The currently-selected simulation (filename) is indicated on the foreground Tab. The filename of the currently-selected FastLapSim file is also displayed in the **Title Bar**.

Program Overview

Upper And Lower Graph Options Boxes



The graphic data display can be modified by right-clicking on the upper graph and reassigning each curve in the *Graph Options Menu*. In addition, you can use the *Properties...* choice available at the bottom of the Menu to setup comparisons between "active" vehicles. Right-clicking on either the lower track or GG diagram opens an option menu that can be used to customize these displays.

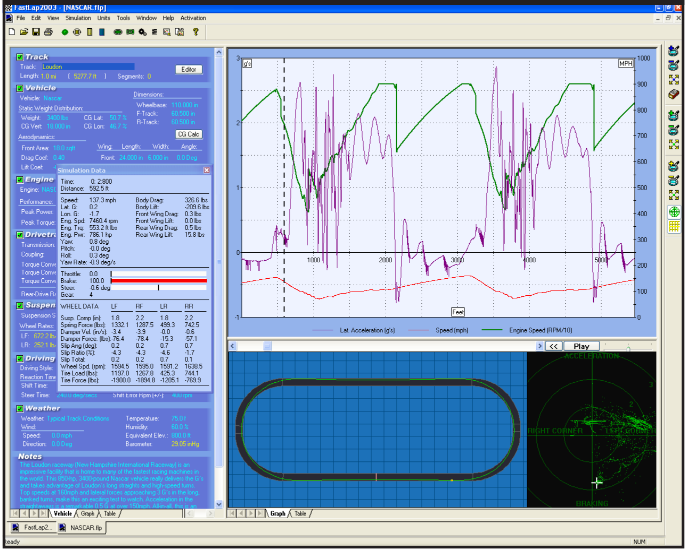
7) The Main Program Screen is divided into three panes (the width and height of these panes are adjustable; drag the vertical and/or horizontal screen dividers to resize, see **11** and **14**, below). Both the right and left panes contain **Screen Display Tabs**. Use these Tabs to switch the displays to component lists, graphs, or other data displays.

8) The **Performance Data Display Curves** indicate the acceleration, speed, engine rpm, suspension movement, and much more about the simulated vehicle. The curves shown on page 17 are the default display, however, the data can be customized by right-clicking the graph and reassigning any curve using the **Graph Options Box**. When simulation curves are visible on the graph (after a simulation has been completed), a single click on the graph will display a reticle line that points to a specific set of data points obtained from realtime data. Open the *SimData™ Slip*, see 12, below, and page 68 for a direct display of data under the reticle.

9) Using the **Vehicle Lap Controls**, you can replay the "action" as the vehicle moves over the track, brakes for the turns, and accelerates down the straightaways. The slider adjusts the replay speed from slow-motion, through real time,

Program Overview

Simulation Results Graph With Data Reticle



Track
Track: Loudon
Length: 1.0 mi (5277.7 ft) Segments: 0

Vehicle
Vehicle: Nascar
Static Weight Distribution:
Weight: 3400 lbs CG Lat: 50.7 %
CG Vert: 18.000 in CG Lon: 46.7 %
Dimensions:
Wheelbase: 110.000 in
F-Track: 60.500 in
R-Track: 60.500 in
Aerodynamics:
Front Area: 18.0 sqft
Drag Coef: 0.40
Lift Coef:
Wing: Length: Width: Angle:
Front: 24.000 in 6.000 in 0.0 Deg

Simulation Data
Time: 0: 2:800
Distance: 592.5 ft

Speed: 137.3 mph
Lat. G: 0.2
Lon. G: -1.7
Eng. Spd: 7460.4 rpm
Eng. Trq: 553.2 ft lbs
Eng. Pwr: 786.1 hp
Yaw: 0.8 deg
Pitch: -0.0 deg
Roll: 0.3 deg
Yaw Rate: -0.9 deg/s

Body Drag: 326.6 lbs
Body Lift: -209.6 lbs
Front Wing Drag: 0.3 lbs
Front Wing Lift: 0.0 lbs
Rear Wing Drag: 0.5 lbs
Rear Wing Lift: 15.8 lbs

Throttle: 0.0
Brake: 100.0
Steer: -0.6 deg
Gear: 4

WHEEL DATA	LF	RF	LR	RR
Susp. Comp (in):	1.8	2.2	1.8	2.2
Spring Force (lbs):	1332.1	1287.5	499.3	742.5
Damper Vel. (in/s):	-3.4	-3.9	-0.0	-0.6
Damper Force. (lbs):	-76.4	-78.4	-15.3	-57.1
Slip Ang (deg):	0.2	0.2	0.7	0.7
Slip Ratio (%):	-4.3	-4.3	-4.6	-1.7
Slip Total:	0.2	0.2	0.7	0.1
Wheel Spd. (rpm):	1594.5	1595.0	1591.2	1638.5
Tire Load (lbs):	1197.0	1267.8	425.3	744.1
Tire Force (lbs):	-1900.0	-1894.8	-1205.1	-769.9

Engine
Engine: NASC
Performance:
Peak Power:
Peak Torque:

Drivetra
Transmission:
Coupling:
Torque Conve
Torque Conve
Torque Conve
Rear-Drive Ra

Suspen
Suspension S
Wheel Rates:
LF: 672.2 lb
LR: 252.1 lb

Driving
Driving Style:
Reaction Time
Shift Time:
Steer Time: 240.0 deg/secs Shift Error Rpm (+/-): 400 rpm

Weather
Weather: Typical Track Conditions
Wind:
Speed: 0.0 mph
Direction: 0.0 Deg
Temperature: 75.0 f
Humidity: 60.0 %
Equivalent Elev.: 800.0 ft
Barometer: 29.05 inHg

Notes
The Loudon raceway (New Hampshire International Raceway) is an impressive facility that is home to many of the fastest racing machines in the world. This 850-hp, 3400-pound Nascar vehicle really delivers the G's and takes advantage of Loudon's long straights and high-speed turns. Top speeds at 160mph and lateral forces approaching 3 G's in the long, banked turns, make this an exciting test to watch. Acceleration in the straightaways is a remarkable 0.5 G at over 150mph. All-in-all, this is an

When simulation curves are visible on the graph (after a simulation has been completed), a single click on the graph will display a reticle line that points to a specific location on the test lap. Open the *Simulation Data Window* for a display of exact data under the reticle.

and to ten-times speeds. Open the *SimData™ window* (see **12**, below) to review data-acquisition info as the vehicle runs the course.

10) The Main Program Screen also incorporates **Windows Size Buttons**. These buttons provide standard maximizing, minimizing, and closing functions that are common to all windows applications. Refer to your Windows documentation for more information on the use of these buttons.

11) The widths of program panes are adjustable. Simply drag the **Vertical Screen Divider** to resize the Component-Selection and Graphics-Display panes. By dragging the **Vertical Screen Divider** to the left screen edge, vehicle-performance graphs can be enlarged to full screen for maximum resolution. Also see **14**, below.

12) The **Tool Bar** contains a series of icons that speed up the selection of commonly used program functions and features. The **Tool Bar** in FastLapSim contains the following icons: *Create A New Simulation Setup*, *Open Saved Simulation*, *Save Current Simulation*, *Print Current Vehicle/Simulation Data*, *Run Simulation*, *Open Gear & Damper Calculators™*, *Open Lap-TimeSlip™*, *Open SimData™ Window*, *Open Track Editor*, *Open the CG Calculator*, *Open Gear Chart*, *Open Suspension Setup dialog* box, *Open Power-Curve Dialog*, *Open DynoSim-File Importer*, and display program *"About Box."*

13) Several component categories contain ***QuickAccess Buttons***™ that give "one-click" access to important data-entry functions and calculators: 1) The **TRACK** category contains an ***Editor*** button that opens the *Track Editor*, 2) the **VEHICLE**

category contains a ***CG Calc*** button that opens the *Center-Of-Gravity Calculator*, 3) the **ENGINE** category contains an ***HP Curve*** button that opens the *Power-Curve Entry* dialog box, and 4) the **SUSPENSION & TIRES** category contains a ***Setup*** button that opens a comprehensive *Suspension Dialog*, used to change virtually every element of the front and rear suspension.

14) The heights of the right-hand, graphics-display panes are adjustable. Simply drag the **Horizontal Screen Divider** to resize the Graphics Displays. By dragging the **Horizontal Screen Divider** to the top or bottom of the screen, the upper or lower vehicle-performance data displays can be enlarged for optimum resolution.

15) This additional **Toolbar**, positioned along the right side of the Main Program Screen, lets you quickly zoom-in and -out on the Data Display (top group of icons), the Track Display (center group of icons), and the GG Display (lower group of icons).

16) The **GG Diagram** shows the range of forces generated by the vehicle throughout the test lap. Each dot represents the total of all forces acting on the vehicle at each one-hundreth of second (default). Acceleration dots are displayed above the horizontal centerline, deceleration is below the line. Left lateral acceleration is shown to the left of the vertical centerline, and right lateral acceleration is shown to the right of the vertical line. The circles indicate increasing forces in 1-G steps.

17) The **Track Display** provides a representation of the current track and shows the vehicle position as a small rectangle. As you move the reticle through the data set (as described on page 68), exact data points can be viewed for every position on the track in the *DataSim*™ window, available from the main *Toolbar* (see **12** on page 21).

HOW TO SETUP AND RUN A SIMULATION

Begin using FastLapSim by selecting a track, then “assemble” a test vehicle from component parts:

1) Start FastLapSim and load an existing vehicle simulation with **Open** from the **File** menu (or select **New** to begin a new vehicle buildup from “scratch”). For new vehicles, all component categories start off empty, indicated by strings of asterisks (****) next to each incomplete component label.

2) Move the mouse cursor into the **TRACK** category and double click the left mouse button on the asterisks in the Track field.

3) When the component-menu bounding box appears, click on the ▼ symbol to open the **American**, **European**, or **Custom** submenus.

Program Overview

4) Move the mouse pointer through the menu choices.

5) When the Track submenus open, move the mouse cursor over the choices in one of the submenus.

6) Click the left mouse button on your selection. This loads the track specifications in the **TRACK** category. Note that the red boxed **X** (Status Box) on the left of the **TRACK** category changed to a green-boxed checkmark ✔, indicating that the selection(s) in this category have been completed.

7) To close the menu without making a selection, click the red **X** on the right of the bounding box or press the **Escape** key until the menu closes.

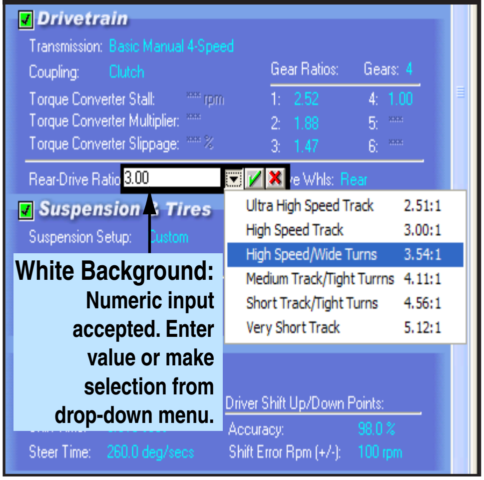
8) Continue making component selections until all the category Status Boxes have changed to green. At this point a vehicle simulation can be performed by choosing **Run** from the **Simulation** drop-down menu. When the simulation is complete (this may take several minutes, see page 12 and 13) the results will be displayed on the graphs and tables in the right pane of the Main Program Screen.

DIRECT-ENTRY™ MENU CHOICES

When a component field supports direct data entry, the bounding box will have a white interior (see left photo, below). On the other hand, if the only selection possible is a choice from the drop-down menu, the bounding box will have a gray interior. Component-field menu selections are detailed in the tables on the next two pages.

If you directly enter or select a new value from a pop-up menu, the new value will

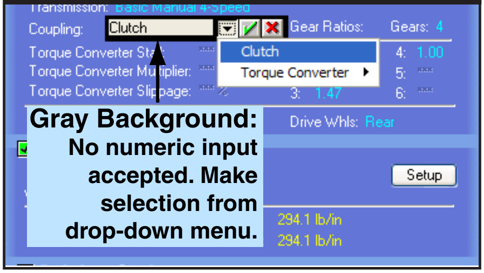
Fields Accepting Direct Input



Transmission: Basic Manual 4-Speed
Coupling: Clutch
Torque Converter Stall: *** rpm
Torque Converter Multiplier: ***
Torque Converter Slippage: *** %
Gear Ratios: Gears: 4
1: 2.52 4: 1.00
2: 1.88 5: ***
3: 1.47 6: ***
Rear-Drive Ratio 3.00
e Whls: Rear
Suspension Setup: Custom
Driver Shift Up/Down Points:
Accuracy: 98.0 %
Steer Time: 260.0 deg/secs
Shift Error Rpm (+/-): 100 rpm

White Background: Numeric input accepted. Enter value or make selection from drop-down menu.

Fields Not Accepting Direct Input



Transmission: Basic Manual 4-Speed
Coupling: Clutch
Gear Ratios: Gears: 4
Torque Converter St ***
Torque Converter Mu tiplier: ***
Torque Converter Slippage: *** %
3: 1.47 4: 1.00
5: ***
6: ***
Drive Whls: Rear
294.1 lb/in
294.1 lb/in

Gray Background: No numeric input accepted. Make selection from drop-down menu.

Component fields that support direct data entry have white bounding boxes (left, and the table on page 26). When the only selection possible is a choice from the menu, the bounding box will have a gray interior (above, and the table on page 27).

replace the currently displayed value. When you press **Enter** the new value will be tested for acceptability, and if it passes, it will be used in the next simulation run. If you press **Enter** without making a new entry, the currently displayed data remains unchanged.

Numeric Data entry into any field in the component-selection screen is limited to values over which FastLapSim can accurately predict vehicle performance. The range limits for each field are displayed in the **Range Limit And Status Line** located at the bottom-left corner of the Main Program Screen. If you enter an invalid number, FastLapSim will sound the Windows error tone and wait for new input.

For example, to make direct numeric entry for **Frontal Area**, click on the current Area value (or asterisks, if no data is present). The range limits for **Frontal Area** will

FastLap Direct Data-Entry Fields (white bounding box)		
Track Category		
Track Description		
Vehicle Component Category		
Vehicle Description	Front-Track	Rear-Track
Vehicle Weight	Vehicle Wheelbase	CG Lateral
CG Longitudinal	Frontal Area	Drag Coefficient
Front Wing Length, Width, Angle	Rear Wing Length, Width, Angle	
Engine Component Category		
Engine Description	Displacement	Redline RPM
Drivetrain Component Category		
Transmission Description	Trans Gear Ratios	Number of Gears
Torque Converter Stall	Converter Multiplier	Converter Slippage
Rear Drive Ratio		
Suspension & Tires Category		
Suspension Description		
Driving Style Category		
Shift Accuracy Percent	Shift Error Rpm Range	
Shift Time	Steer Time	
Weather Category		
Weather Description	Temperature	Humidity
Equivalent Elevation	Wind Speed	Wind Direction

FastLap Menu-Only Selection Fields (gray bounding box)
Suspension Component Category
Suspensioni Setup
Drivetrain Component Category
Transmission Coupling
Drivnig Wheels
Driving Style Category
Driving Style Description

be displayed in the **Range Limit And Status Line** (square feet). Make an entry within the acceptable range followed by **Enter**. If you select an invalid number, FastLapSim will sound an error tone and wait for new entry.

THE MEANING OF SCREEN COLORS

The colors used on the component-selection screen provide information about various vehicle components and specifications. Here is a quick reference to screen color functionality:

White Field Labels: All vehicle component fields and specifications in each component category are displayed in white. These fields can be followed by either Yellow (calculated only) or Light Blue (changeable) values, as described below.

Yellow Numeric Values: Yellow specifications, such as Barometer, indicate that they are automatically calculated by program and cannot be directly altered.

Light Blue (cyan): All specifications that can be changed by the user through pull-down menus or direct data entry are displayed in light blue.

COMPONENT MENUS

THE TRACK CATEGORY

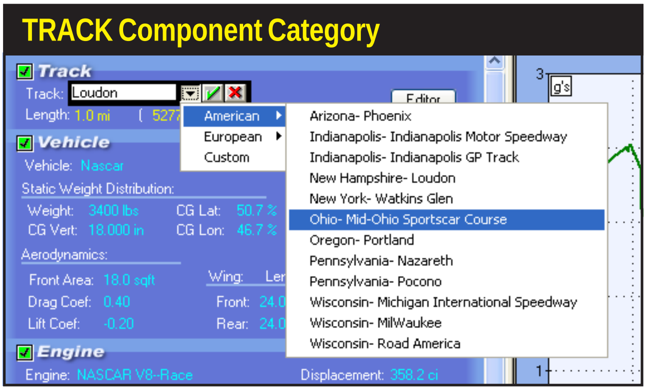
The **TRACK** category is located at the top of the left pane on the Main Program Screen. Use this category to select the track on which the simulated vehicle will be evaluated. FastLapSim is supplied with over 40 tracks located within the US and throughout the World, plus you can build any track you wish using the Track Editor (see page 69 for complete details on using the Track Editor). Select a course for the simulation using the ***Track*** drop down-menu. Submenus include several American and International tracks. When a track is loaded its name and length are displayed in the TRACK category, in addition, an overhead view of track layout is shown in the ***Track Display*** on the lower, right side of the Main Program Screen (see #17, on page 17).

The **TRACK** category also contains a **QuickAccess Button**™ that gives "one-click" access to the FastLapSim ***Track Editor***. Use this tool (described on page 69) to build or modify any track, to specify track segments for timing or data analysis (a ***ProTools***™ feature), to establish track scaling, to position the Start/Finish line, and determine the direction of vehicle movement.

THE VEHICLE CATEGORY MENUS

The **VEHICLE** component category establishes the type of vehicle and the basic chassis and aerodynamics configuration. This category has sixteen data-entry fields.

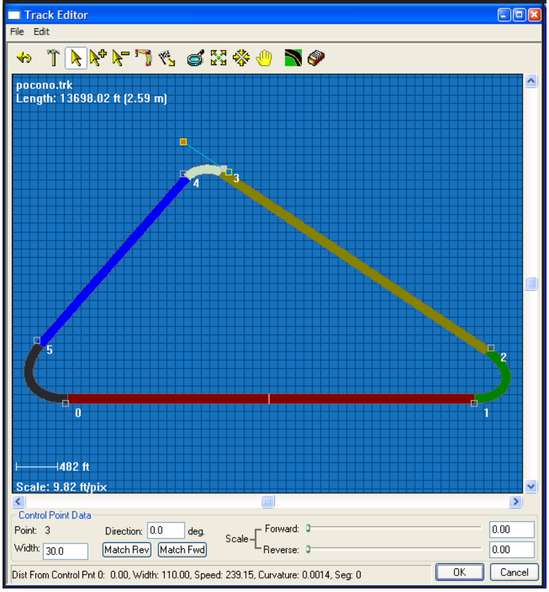
Use the TRACK Category to establish the course on which the simulated vehicle will be evaluated. FastLapSim is supplied with approximately 40 tracks located within the US and throughout the World. The *Editor* button within the category provides "one-click" access to the *Track Editor*, a powerful tool used to build or modify any track.


TRACK Component Category

☑ Track
Track: Loudon
Length: 1.0 mi (5277
☑ Vehicle
Vehicle: Nascar
Static Weight Distribution:
Weight: 3400 lbs
CG Lat: 50.7 %
CG Vert: 18.000 in
CG Lon: 46.7 %
Aerodynamics:
Front Area: 18.0 sqft
Drag Coef: 0.40
Lift Coef: -0.20
Wing: Ler
Front: 24.0
Rear: 24.0
☑ Engine
Engine: NASCAR V8-Race
Displacement: 358.2 ci

VEHICLE Category Menus

The *Track Editor*



pocono.trk
Length: 13698.02 ft (2.59 m)

482 ft
Scale: 9.82 ft/pix

Point: 3
Direction: 0.0 deg.
Width: 30.0
Forward: 0.00
Reverse: 0.00

Dist From Control Pnt 0: 0.00, Width: 110.00, Speed: 239.15, Curvature: 0.0014, Seg: 0

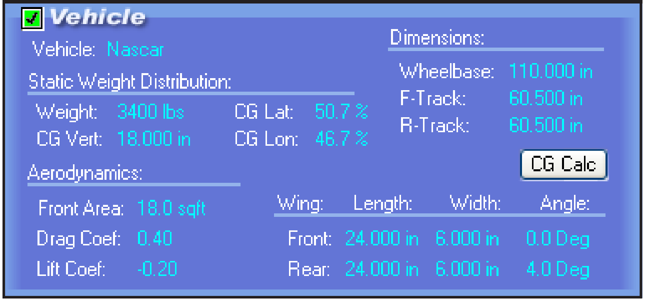
FastLapSim includes a powerful *Track Editor* "*construction set.*" Use this tool (described in detail on page 69) to build or modify any track, to specify track segments for timing or data analysis, to establish track scaling, to position the Start/Finish line, and to determine the direction of vehicle movement. The *Track Editor* can be used to build any closed-course track with any number of turns. Turns and straights are constructed with "control points" using a technique similar to that used in the *Adobe Illustrator*™ drawing program.

The ***Vehicle*** menu is located on the upper-left of the **VEHICLE** category. By opening this menu, you are presented with a variety of domestic, import, and race-only predefined vehicle configurations. If any one of these choices is selected, the appropriate vehicle name, weight, wheelbase, front- and rear-track widths, location of driving wheels, center-of-gravity locations, frontal area, aero drag coefficient, and wing specifications are loaded into the **VEHICLE** category. In addition to, or instead of, selecting an existing vehicle configuration, you can directly enter individual vehicle specifications (within the acceptable range limits, displayed at the bottom of the screen in the **Range Limit And Status Line**).

The ***Vehicle*** menu, and the **VEHICLE** category in general, can be considered a "handy list" of common specifications. The selection of any predefined vehicle from the ***Vehicle*** menu does not assume the use of any specific engine, trans, gear ratios,

Opening the *Vehicle* menu presents a variety of predefined domestic, sport-compact, and race vehicle configurations. Each of these selections loads the appropriate vehicle name, weight, wheelbase, CG locations, frontal area, drag coefficient, and wing specifications into the VEHICLE category.

VEHICLE Component Category



Vehicle: Nascar

Static Weight Distribution:
Weight: 3400 lbs
CG Lat: 50.7 %
CG Vert: 18.000 in
CG Lon: 46.7 %

Dimensions:
Wheelbase: 110.000 in
F-Track: 60.500 in
R-Track: 60.500 in

Aerodynamics:
Front Area: 18.0 sqft
Drag Coef: 0.40
Lift Coef: -0.20

Wing:	Length:	Width:	Angle:
Front:	24.000 in	6.000 in	0.0 Deg
Rear:	24.000 in	6.000 in	4.0 Deg

VEHICLE Category Menus

The domestic, import, and race *Vehicle* component menus contain predefined vehicle specifications that you can instantly select and use in a simulation. In addition, you can modify any of these built-in vehicle combinations with custom wheelbases, weights, frontal areas, and other component specifications.

Vehicle Menus

FastLap - [ChampCarOnPIR.flp]

!! DB VERSION !!

☑ **Track**

Track: CUSTOM

Length: 1.9 mi (9897.2 ft) Segments: 0

☑ **Vehicle**

Vehicle: Champ Car

Wheelbase: 124.000 in

F-Track: 70.500 in

Static Weight Distribution:

Weight: 1550 lbs

CG Vert: 12.000 in

CG Lon: 47.0

Aerodynamics:

Front Area: 23.0 sqft

Drag Coef: 0.96

Wing:

Front: 24.0

Rear: 24.0

☑ **Engine**

Engine: 502ci V8--Race

Performance:

Peak Power: 1178 hp @ 8000 rpm

Peak Torque: 795 lb-ft @ 7500 rpm

☑ **Drivetrain**

Transmission: Basic Manual 4-Speed

Coupling: Clutch

Torque Converter Stall: *** rpm

Torque Converter Multiplier: ***

Torque Converter Slippage: *** %

Rear-Drive Ratio: 3.00

☑ **Suspension & Tires**

Suspension Setup: Custom

Wheel Rates:

LF: 294.1 lb/in

LR: 294.1 lb/in

RF:

RR:

☑ **Driving Style**

Driving Style: Professional

etc., even if a specific vehicle was equipped with only one type of engine. The ***Vehicle*** menu loads only the specifications included in the **VEHICLE** category into the simulation database.

Each of the fields in this category is used by the simulation to determine acceleration, braking, and cornering performance. Here is a description of the data displayed in each **VEHICLE** component field:

Vehicle: This is short description of the vehicle that is loaded from the ***Vehicle*** menu selection. In addition, you may change, modify, or enter your own custom vehicle description in this field. The ***Vehicle*** name is an information-only field that has no effect on the simulation.

Wheelbase: The ***Wheelbase*** field indicates the distance between the front- and rear-axle centerlines, measured in inches (or millimeters). This value is used by the simulation, in part, to determine weight transfer during acceleration, braking, and cornering.

Front- and Rear-Track Widths: The front and rear track widths are the distances between the centerlines of the front-tire treads (front track) and the centerlines of the rear-tire treads (rear track). Track widths are a critical element in the simulation of the performance of the suspension and vehicle dynamics, particularly in corners.

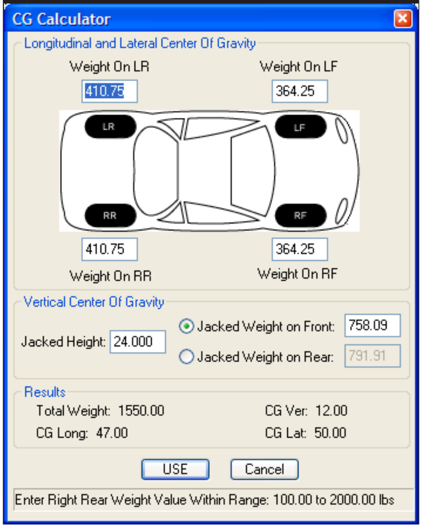
Vehicle Weight: This is the total, static weight of the vehicle (the sum of the weights on each of the wheels). This field is used to determine the total mass of the vehicle, and in combination with the ***CG Location***, ***Wheelbase***, ***Track Widths***, and the dynamic forces applied to the vehicle as it moves along the track, FastLapSim will determine the instantaneous center of mass of the vehicle and the forces transferred through each tire at every 0.001-second throughout the race.

CG Locations (Vertical, Lateral, and Longitudinal): The ***CG Location*** fields indicate where, within the three-dimensional space of the vehicle, the center of mass is located (assuming the vehicle is static on a level surface). The ***Vertical CG*** location is the height of the center of mass as measured from of the road surface. The ***Lateral*** and ***Longitudinal*** fields indicate the left/right and front/rear distribution of vehicle weights and are shown as percentages; for example, ***Lateral CG*** indicates the percentage of total vehicle weight that rests on the left tires. In other words, if the weight on both right tires is 1200 pounds and the weight on the left tires is 1000 pounds, the ***Lateral CG*** distribution of weight is approximately 45% (left weight divided by total vehicle weight, or 1000 / 2200 = 45.5%). The ***Longitudinal CG*** indicates the percentage of total vehicle weight that rests on the front tires. For example, if the weight on the front tires is 900 pounds and the weight on the rear tires is 1300 pounds, the ***Longitudinal CG*** distribution of weight is 41% (front weight divided by total vehicle weight, or 900 / 2200 = 41%). All three CG values can be quickly calculated using the ***CG QuickCalculator™***, available by clicking the ***CG Calc*** button in the **VEHICLE** category.

Using The CG QuickCalculator™: Finding the CG height and the longitudinal and lateral CG weight distribution for any vehicle is quicker and less error-prone using this calculator. If you are modeling a real-world vehicle, first measure (using individual wheel scales) the weight at each wheel, and the total weight on the front or rear axle when the opposite end of the vehicle is raised 18 to 24 inches. In addition to this data, the ***CG QuickCalculator™*** will apply the wheelbase entered in the VEHICLE category

The *CG QuickCalculator™* will help you find the CG height and the longitudinal and lateral CG weight distribution for any vehicle. Press the *USE* button to apply newly calculated values to the simulation database (updating the values in the VEHICLE category).

CG QuickCalculator™



Longitudinal and Lateral Center Of Gravity

Weight On LR: 410.75
Weight On LF: 364.25
Weight On RR: 410.75
Weight On RF: 364.25

Vertical Center Of Gravity

Jacked Height: 24.000
● Jacked Weight on Front: 758.09
○ Jacked Weight on Rear: 791.91

Results

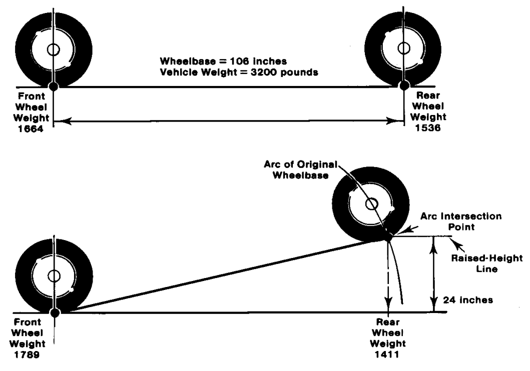
Total Weight: 1550.00
CG Ver: 12.00
CG Long: 47.00
CG Lat: 50.00

Enter Right Rear Weight Value Within Range: 100.00 to 2000.00 lbs

VEHICLE Category Menus

If you are modeling a real-world vehicle, first measure (using individual wheel scales) the weight at each wheel. Then measure the total weight on the front or rear axle when the opposite end of the vehicle is raised 18 to 24 inches. Enter these values in the appropriate fields in the CG Calculator. Total vehicle weight and the CG values will be calculated.

Measuring CG Weights



to determine the required CG values. Simply enter the values in the appropriate fields (boxes), and the total vehicle weight and the CG values will be calculated. Press the ***USE*** button to apply the new values to the simulation database (updating the values in the VEHICLE category).

Frontal Area: This field displays the square-foot area displaced as the vehicle moves forward through the air. Combined with the ***Aero Drag Coefficient*** (discussed next) FastLapSim can determine the aerodynamic drag resisting the forward movement of the vehicle throughout the race.
Note: If you do not know the ***Frontal Area*** of the vehicle that you would like to model, you can select a vehicle with a similar front-body design from the ***Vehicle*** menu. You can also calculate the ***Frontal Area*** by drawing representations of the main components of the front of the vehicle as rectangles on graph paper. For example, to determine the displaced area of the windshield, measure the true height of the windshield (the height of the top of windshield to the ground minus the height of the bottom of the windshield to the ground) and its width in inches and draw a rectangle of the same (scaled; perhaps 1 foot equals 1 inch) dimensions. Then multiply the height by the width and divide by 144 to obtain the square-foot frontal area of the windshield. Continue this process for the hood, grill, bumper, tires, and all surfaces that you can view from the front of the vehicle; the surfaces that deflect air as the vehicle moves forward. When you add up the area of all of the measured surfaces, you will have determined the ***Frontal Area*** of the vehicle.

Aero Drag And Lift Coefficient: Aero Drag is the ratio of the actual aerodynamic forces on the vehicle (usually measured in a wind tunnel) compared to the calculated drag of a flat-front object (like a box, generating the highest possible wind resistance) with the same Frontal Area. Smaller numbers indicate that the vehicle can move more efficiently move through the air (than a flat surface). The ***Aero Drag Coefficient*** is always less than 1.0.
Note: If you do not know the ***Aero Drag Coefficient*** of the vehicle you would like to

VEHICLE Category Menus

Wing Configuration

The wing models used in FastLapSim include end plates and Gurney flaps. In addition, the simulation includes chord-angle modeling. This is a measurement of the shape of wing surfaces and provides an indicator of the ability to produce lift with a zero attack angle. In FastLapSim the chord angle is set to zero degrees; lift is produced only when the angle of attack is greater than zero.

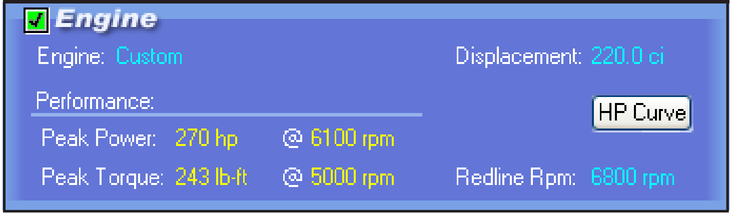
model, you can select a vehicle with a similar front-body design from the ***Vehicle*** menu and, based on the aero coefficients displayed, make an “educated guess” of a coefficient that would approximate the vehicle you would like to model.

You can also select the ***Lift Coefficient*** for the test vehicle. Lift aerodynamics simulate the lift (or downforce) applied to the vehicle by the shape of the body and/or cowling and other airfoils that are incorporated into the body structure. A positive number indicates lift (from +0.01 to +0.99; a value of +1.0 would lift the vehicle off of the track) and a negative number will apply a downforce (from -0.01 to - 4.00; -4.00 applies four times the vehicle weight to the track). Lift or downforce is applied to the body at the CG point.

Front- And Rear-Wing Dimensions: The simulation calculates the downforces and drag from an airfoil-type front wing and rear wing. The basic dimensions of ***Length***, ***Width***, and ***Angle*** (angle of attack—the angle produced by the centerline of the wing relative to the moving airstream). These three fields can be modified for each wing and establish the operational characteristics of downforce and drag (drag increases as downforce increases). A wing, as modeled in FastLapSim, is defined by its surface area (length x width) and its angle of attack. The forces produced by the wings are applied at the CG height over the front and rear axles, respectively. If you wish to disable either or both wings, set the attack angle to zero.

The ENGINE component category establishes the basic type of engine used in the simulated vehicle and its power curve.

ENGINE Component Category



☑ Engine

Engine: Custom

Displacement: 220.0 ci

Performance:

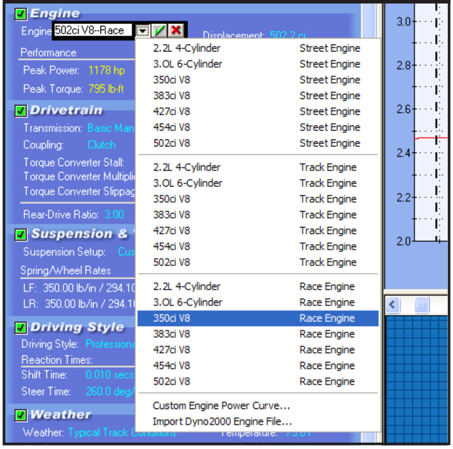
Peak Power: 270 hp @ 6100 rpm

Peak Torque: 243 lb-ft @ 5000 rpm

Redline Rpm: 6800 rpm

ENGINE Category Menus

Built-In Engine Selections



The engine menu includes a basic list of several Street, Track, and Race engines (in addition, you can load any engine power curve, see pages 35 and 36). Use these choices to quickly load an engine power curve and displacement into the simulation database. The power curves from these choices can be easily modified by clicking the *HP Curve* button to open the *Custom Power Curve* dialog screen.

Note On Wing Simulation: The wing models used in FastLapSim also include end plates and Gurney flaps, however, the dimensions for these components is fixed within the simulation. In addition, the simulation also includes chord-angle modeling. This is a measurement of the shape of wing surfaces and provides an indicator of the ability to produce lift with a zero attack angle. In FastLapSim the chord angle is set to zero degrees, indicating that both wings will develop no lift on their own; lift is produced only when the angle of attack is greater than zero.

THE ENGINE CATEGORY MENUS

The **ENGINE** component category establishes the type of engine used in the simulated vehicle and its basic power curve. This category has three data-entry fields (and four additional display-only fields). The menu selections in the **ENGINE** category are:

Engine: This menu is located in the upper-left corner of the **ENGINE** component category. This menu allows the selection of several built-in test engines, or you can load any DynoSim engine file, and you also can specify any engine power curve using the *Custom Engine Power Curve* dialog:

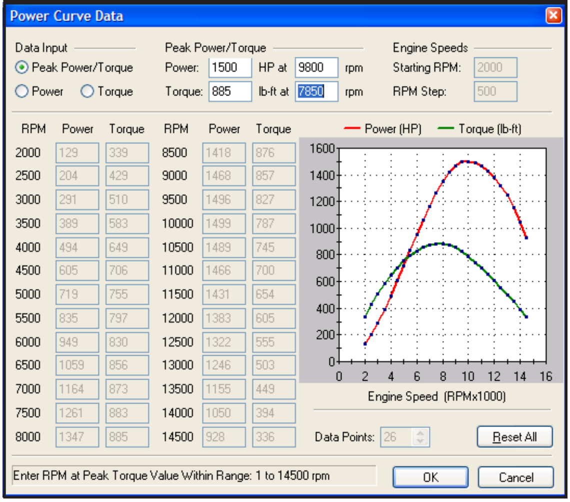
Built-In Engine Selections: The engine menu includes a list of several Street, Track, and Race engines. Use these choices to quickly load an engine power curve and displacement into the simulation database. The power curves from these choices can be easily modified after making an engine selection by clicking the ***HP Curve*** button in the ENGINE category.

Custom Engine Power Curve: This selection opens the ***Custom Engine Power Curve*** dialog screen that allows direct entry of power/torque values or, by entering the peak torque and horsepower values, FastLapSim can calculate the horsepower and torque curves.

Note: The *Custom Engine Power Curve* dialog box may be opened at any time by

ENGINE Category Menus

Using The *Peak Power/Torque* Method



Power Curve Data

Data Input

● Peak Power/Torque

○ Power ○ Torque

Peak Power/Torque

Power: 1500 HP at 9800 rpm

Torque: 885 lb-ft at 7850 rpm

Engine Speeds

Starting RPM: 2000

RPM Step: 500

RPM	Power	Torque	RPM	Power	Torque
2000	129	339	8500	1418	876
2500	204	429	9000	1468	857
3000	291	510	9500	1496	827
3500	389	583	10000	1499	787
4000	494	649	10500	1489	745
4500	605	706	11000	1466	700
5000	719	755	11500	1431	654
5500	835	797	12000	1383	605
6000	949	830	12500	1322	555
6500	1059	856	13000	1246	503
7000	1164	873	13500	1155	449
7500	1261	883	14000	1050	394
8000	1347	885	14500	928	336

Data Points: 26

Enter RPM at Peak Torque Value Within Range: 1 to 14500 rpm

The *Peak Power/Torque* data entry method lets FastLapSim calculate the entire power curve from the peak-horsepower and peak-torque values (often published in "road tests" in magazines or books). To activate this method, click on the *Peak Power/Torque* radio button. When peak horsepower and torque values have been entered, FastLapSim will extrapolate a complete horsepower and torque curve and replace any existing power values with the new, calculated values.

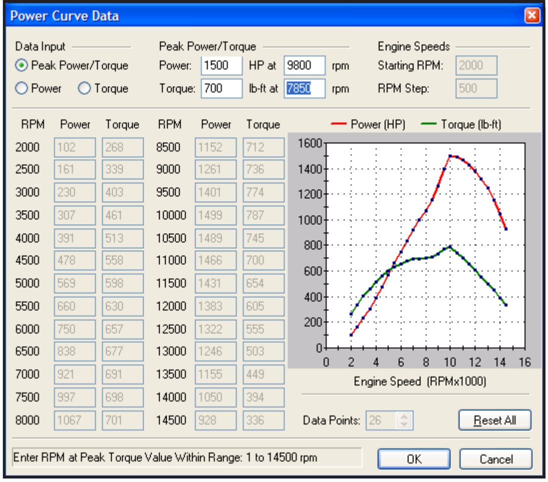
either clicking the *Custom Power Curve* icon in the Toolbar, by selecting *Custom Engine Power Curve* from the **Tools** menu (located in the Menu Bar), or by clicking on the ***HP Curve*** button in the **ENGINE** component category.

Some tips in using this dialog box follows:

How To Enter Peak Power/Torque: The Peak Power/Torque data entry is the quick method to load an engine power curve into FastLapSim. By simply entering the peak torque and power values (sometimes published in road-test magazines), and the rpm points at which these peaks occur, FastLapSim will calculate the power and torque curves, display them on the graph, and list the

If the horsepower and torque curve extrapolated from Peak values has an unusual "bump" or "dip," it is probably caused by using incorrect Peak Power/Torque Rpm points. FastLapSim will always draw power and torque curves that pass through the entered peak power and torque points. If these values don't correspond with the appropriate rpm values, a nonuniform curve will be generated (as shown on the right). Try changing the power/torque or rpm values to obtain smooth curves.

Irregular Power Curve



Power Curve Data

Data Input

● Peak Power/Torque

○ Power ○ Torque

Peak Power/Torque

Power: 1500 HP at 9800 rpm

Torque: 700 lb-ft at 7850 rpm

Engine Speeds

Starting RPM: 2000

RPM Step: 500

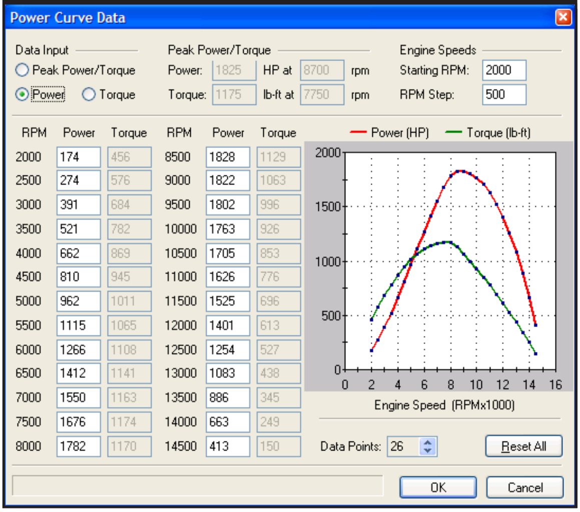
RPM	Power	Torque	RPM	Power	Torque
2000	102	268	8500	1152	712
2500	161	339	9000	1261	736
3000	230	403	9500	1401	774
3500	307	461	10000	1499	787
4000	391	513	10500	1489	745
4500	478	558	11000	1466	700
5000	569	598	11500	1431	654
5500	660	630	12000	1383	605
6000	750	657	12500	1322	555
6500	838	677	13000	1246	503
7000	921	691	13500	1155	449
7500	997	698	14000	1050	394
8000	1067	701	14500	928	336

Data Points: 26

Enter RPM at Peak Torque Value Within Range: 1 to 14500 rpm

ENGINE Category Menus

Using The *Direct Data Entry* Method



Power Curve Data

Data Input
○ Peak Power/Torque
● Power ○ Torque

Peak Power/Torque
Power: 1825 HP at 8700 rpm
Torque: 1175 lb-ft at 7750 rpm

Engine Speeds
Starting RPM: 2000
RPM Step: 500

RPM	Power	Torque	RPM	Power	Torque
2000	174	456	8500	1828	1129
2500	274	576	9000	1822	1063
3000	391	684	9500	1802	996
3500	521	782	10000	1763	926
4000	662	869	10500	1705	853
4500	810	945	11000	1626	776
5000	962	1011	11500	1525	696
5500	1115	1065	12000	1401	613
6000	1266	1108	12500	1254	527
6500	1412	1141	13000	1083	438
7000	1550	1163	13500	886	345
7500	1676	1174	14000	663	249
8000	1782	1170	14500	413	150

Data Points: 26

You can directly enter engine power curve data by clicking on either the *Power* or *Torque* radio buttons. If you select *Power*, the program will accept horsepower values; if you select *Torque*, the program allows the direct entry of torque values. The *Start* and *Step Rpm* values (located in the top-right corner of the dialog box) determine the start-and step-rpm values for each power point, up to 26 data-entries.

individual power points in the table. To activate this method of data entry, activate the ***Peak Power/Torque*** radio button located at the top-left of the dialog. When activated, individual *Torque* and *Power* fields for all rpm points are dimmed. When peak horsepower, torque, and rpm values have been entered in the fields to the right of the radio buttons, FastLapSim will extrapolate complete curves and replace any existing power values with the new, calculated values. Click ***OK*** to transfer these values to the simulation; click ***Cancel*** to discard any changes and revert to previous power values (if any).

Note: If the horsepower and torque curve extrapolated from Peak values has an unusual “bump” or “dip” (see photo on previous page), it is probably caused by using a Peak Horsepower or Peak Torque value that does not correspond to the Peak Power/Torque Rpm points. FastLapSim will always attempt to draw power and torque curves that pass through the entered peak power and torque points. If these values don’t correspond with the appropriate rpm values, a nonuniform curve will be generated. Try changing the power/torque or rpm values to obtain smooth curves.

How To Directly Enter A Power/Torque Curve: To activate this method of data entry, click on either the ***Power*** or ***Torque*** radio button (not *Peak Power/Torque*) located at the top-left of the dialog box. If you select ***Power***, the program will accept horsepower values; if you select ***Torque***, the program allows the direct entry of torque values. The ***Start Rpm*** and ***Step Rpm*** values located in the top-right corner of the dialog box (default 2000 and 500rpm, respectively), indicate at what rpm the power curve begins and the speed increase for each power point, for up to 26 data-entry points or 14,500 rpm maximum. If you wish to extend the power curve beyond 14,500 rpm, simply increase the ***Start*** or ***Step Rpm***.

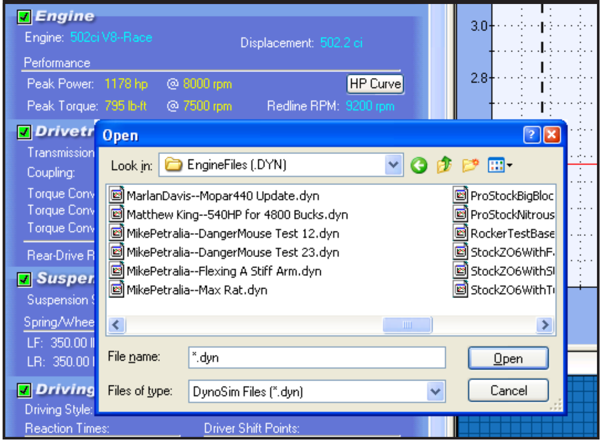
Important Note: **Specify the *Start* and *Step* values *BEFORE* you enter the power curve, or you may not obtain the power curve you desire.** *If you change either the **Step** or **Start Rpm** values after a power curve has been entered, the program will attempt to change only the rpm points; the horsepower and torque values will remain unchanged. In addition, if you select an rpm range that invalidates some of the power-point values used by the program (like shift rpm or redline rpm), some of the horsepower and torque values may be altered by the program to "fill-in" the discrepancy. As a result, we recommend that you establish the **Start** and **Step** values **BEFORE** you enter any power curve data and only change **Start** and **Step** values with caution.*

Now enter the first horsepower or torque value, press the ***TAB*** key, and the *related torque or horsepower value* will be calculated and placed in the adjacent field. When you have entered the final power-curve value, press ***Enter*** or click ***OK*** to close the dialog box and load the power curve into the simulation.

Data Entry Tip: If you need to expand the power curve to higher rpm values, click the ***up-scroll-arrow*** next to the ***Data Points*** field (just above the ***OK*** button); or reduce the number of power values by clicking on the ***down-scroll-arrow***. When you expand the number of power points, the horsepower value in the last entry field is duplicated in the added fields, however the torque value is recalculated for the higher rpm values.

Import DynoSim Engine Files: FastLapSim will directly import DynoSim engine files. This is, by far, the fastest way to store engine performance data in the simulation database. To load a DynoSim test engine into the simulated vehicle, select ***Import DynoSim Engine File*** from the **Engine** menu (or click on the ***Import DynoSim*** icon in the Toolbar). A file-open dialog box allows you select any DynoSim file on your system. The default location for DynoSim files is ***C:\DynoSim\EngineFiles (.DYN)***.

Import DynoSim Engine Files



Engine: 502ci V8-Race

Displacement: 502.2 ci

Peak Power: 1178 hp @ 8000 rpm

Peak Torque: 795 lb-ft @ 7500 rpm

Redline RPM: 9200 rpm

Look in: EngineFiles (.DYN)

MarlanDavis--Mopar440 Update.dyn
Matthew King--540HP for 4800 Bucks.dyn
MikePetralia--DangerMouse Test 12.dyn
MikePetralia--DangerMouse Test 23.dyn
MikePetralia--Flexing A Stiff Arm.dyn
MikePetralia--Max Rat.dyn
ProStockBigBloc
ProStockNitrous
RockerTestBase
StockZO6WithF
StockZO6WithSl
StockZO6WithT

File name: *.dyn

Files of type: DynoSim Files (*.dyn)

FastLapSim will directly import DynoSim engine files. To load a DynoSim test engine, select *Import DynoSim Engine File* from the Engine menu. A file-open dialog box allows you select any DynoSim file on your system. The default location for DynoSim engine files is C:\DynoSim\EngineFiles (.DYN)

ENGINE Category Menus

DRIVETRAIN Component Category

☑ Drivetrain

Transmission: Porsche Carrera 6-Speed

Coupling: Clutch

Torque Converter Stall: *** rpm

Torque Converter Multiplier: ***

Torque Converter Slippage: *** %

Gear Ratios: Gears: 6

1: 3.15 4: 1.27

2: 2.00 5: 1.03

3: 1.56 6: 0.86

Rear-Drive Ratio: 4.00

Drive Whls: Rear

The DRIVETRAIN component category establishes the method of engine coupling and other basic transmission and driveline specifications.

> **Note:** If the Redline Rpm value designated in the ENGINE category maps to a zero horsepower value in the imported DynoSim engine file, the program will warn you that some rpm points reference zero horsepower values. To correct this problem, FastLapSim will null the redline rpm, allowing you to enter a new value or you can open the ***Custom Power Curve Dialog*** box and extend the rpm range of the imported power curve. (If you don’t know the power values for higher rpms, simply extend the curve using the final power value; this technique often produces acceptable results).

Displacement: Enter the displacement of the engine in this field. This value is not used to determine engine power, rather it is used to calculate the “rotational inertia” of the engine. This is a property of the engine (and all matter) that resists changes in speed. Rotational inertial hinders performance because the engine must not only accelerate the vehicle (and the driveline), it must also accelerate its own internal components (and repeat this process as the vehicle accelerates through each transmission gear). The larger the engine, the greater the weight of these components, and the larger the losses from rotational inertia.

THE DRIVETRAIN CATEGORY MENUS

The **DRIVETRAIN** component category establishes a method of engine coupling to the remainder of the drivetrain (transmission, etc.) and other basic driveline specifications. This category has thirteen data-entry fields. The menu selections in the **DRIVETRAIN** category are detailed below:

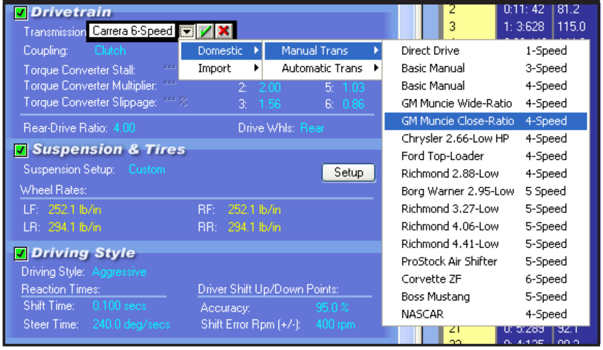
Transmission: Located on the upper-left of the DRIVETRAIN category, this menu offers an extensive list of Manual and Automatic transmissions for both domestic and sport-compact applications, plus there are several race-only gear boxes available. When you select any of the transmission types, the ***Number Of Gears*** and the ***Gear Ratios*** are loaded into DRIVELINE component fields. It is also possible to DirectClick™ on any DRIVETRAIN data field and enter custom transmission specs.

Note: The **Coupling Method** (either a ***Clutch*** or a ***Torque Converter***) is selected separately from the transmission type and is NOT determined from a Transmission menu selection (***Coupling*** is described later).

Number Of Gears: The ***Gears*** menu establishes the number of forward gear ratios for the transmission. You can choose ***1*** (for direct drive) to ***6*** forward gears.

DRIVETRAIN Category Menus

Transmission Selections



Drivetrain
Transmission: Carrera 6-Speed
Coupling: Clutch
Torque Converter Stall: ***
Torque Converter Multiplier: ***
Torque Converter Slippage: *** %
2: 2.00 5: 1.03
3: 1.56 6: 0.86
Rear-Drive Ratio: 4.00
Drive Whls: Rear

Suspension & Tires
Suspension Setup: Custom
Wheel Rates:
LF: 252.1 lb/in RF: 252.1 lb/in
LR: 294.1 lb/in RR: 294.1 lb/in

Driving Style
Driving Style: Aggressive
Reaction Times:
Shift Time: 0.100 secs
Steer Time: 240.0 deg/secs
Driver Shift Up/Down Points:
Accuracy: 95.0 %
Shift Error Rpm (+/-): 400 rpm

FastLapSim offers an extensive list of Manual and Automatic transmissions for both domestic and sport-compact applications. It is also possible to DirectClick™ on any DRIVETRAIN data field and enter custom transmission specs. When a transmission selection is made, the *Number Of Gears* and the *Gear Ratios* are loaded into DRIVELINE component fields.

Transmission Gear Ratios: FastLapSim will impose several rules upon the entry of each transmission ***Gear Ratio***. Each higher gear (2nd, 3rd, etc.) must be numerically lower than the previous gear, and all ratios must fall between 9.99:1 and 0.50:1.

Coupling: This menu allows the selection of either ***Clutch*** or ***Torque Converter*** coupling (connection) between the engine and the transmission. As mentioned earlier, this choice is completely independent of the ***Transmission*** selection. In fact it is possible to "assemble" and test both of these driveline combinations:

- **Manual Transmission With A Clutch**
- **Automatic Transmission With A Torque Converter**

and the following two combinations are also possible:

- **Manual Transmission With A Torque Converter**
- **Automatic Transmission With A Clutch**

While it may be rare (or impossible) to build either of the last two combinations in the real world, FastLapSim makes it possible to try virtually any combination. Keep in mind that the ***Transmission*** (**Manual** or **Automatic**) and ***Coupling*** (**Clutch** or **Torque Converter**) are separately selected and independently evaluated by the simulation.

Clutch: This ***Power Coupling*** selection activates a sophisticated clutch model. The clutch will automatically adjust itself to the power, weight, and driving characteristics of the vehicle. It will offer sufficient slippage to absorb high shock loads to the drivetrain. It will provide a near-slip-free shifts and hook up solidly at speed. As horsepower increases, the clutch model will change to accommodate the needs of high horsepower applications. You can consider FastLapSim clutch model to be near-optimum, and the Lap Times predicted with this model to be in-line with competitive vehicles.

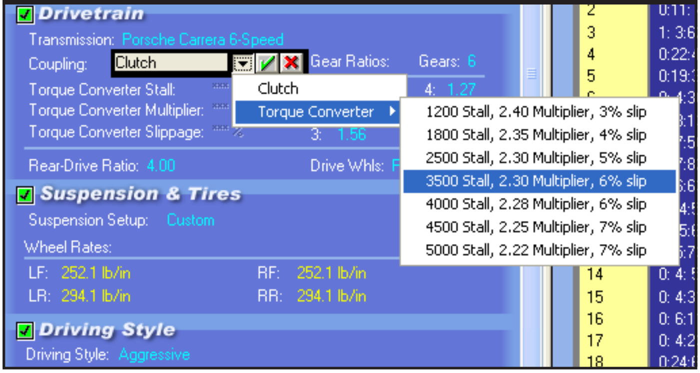
Torque Converter: This menu choice opens the ***Torque Converter*** submenu that offers several torque-converter combinations. When any of these choices is selected, the appropriate ***Stall Rpm***, ***Torque Multiplier***, and ***Slip*** percentage will be loaded into the DRIVETRAIN category. It is also possible to DirectClick™ any of these DRIVETRAIN data fields and enter custom values.

The torque converter is typically composed of an impeller, turbine, and a stator fitted with blades that direct fluid and power flow. The engine drives the impeller

DRIVETRAIN Category Menus

The *Coupling* menu allows the selection of either a Clutch or a Torque Converter. Keep in mind that the *Transmission* (Manual or Automatic) and *Coupling* (Clutch or Torque Converter) are separately selected and independently evaluated by the simulation.

Power Coupling Menu



☑ Drivetrain

Transmission: Porsche Carrera 6-Speed

Coupling: Clutch

Gear Ratios: Gears: 6

Torque Converter Stall:

Torque Converter Multiplier:

Torque Converter Slippage:

4: 1.27

3: 1.56

Rear-Drive Ratio: 4.00

☑ Suspension & Tires

Suspension Setup: Custom

Wheel Rates:

LF: 252.1 lb/in RF: 252.1 lb/in

LR: 294.1 lb/in RR: 294.1 lb/in

☑ Driving Style

Driving Style: Aggressive

that imparts energy to the internal fluid. The turbine is attached to the input shaft of the transmission and is driven by the fluid flow generated by the turbine. The stator is locked to a fixed shaft and does not rotate. This stationary stator redirects fluid flow against the impeller and raises the torque forces on the turbine higher than the load imparted by the impeller alone. This ***Torque Multiplication*** dramatically increases efficiency and performance in standing starts. Typical torque multipliers range from 1.9 to 2.5 for most automotive applications. In other words, the torque (lb-ft) measured at the turbine (input to the transmission before the vehicle begins to move) is 1.9- to 2.5-times greater than the torque generated by the engine.

Since the torque converter is a “fluid coupling,” it can never be as efficient as a clutch (some passenger-car torque converters incorporate a clutch that “locks up” the converter at higher road speeds and improves cruising efficiency; this is not modeled in FastLapSim). The built-in inefficiency in all torque converters is measured (in part) as a ***Slip Percentage***. The higher the slip, the greater the rpm difference between the input and output rpm above the stall speed (discussed

Torque Converter Specifications

☑ Drivetrain

Transmission: GM Turbo 400 3-Speed

Coupling: Torque Converter

Torque Converter Stall: 3500 rpm

Torque Converter Multiplier: 2.30

Torque Converter Slippage: 6.0 %

Rear-Drive Ratio: 3.00

When any torque converter is selected, the *Stall Rpm*, *Torque Multiplier*, and *Slip* percentage fields become active in the DRIVETRAIN category. Use FastLapSim built-in selections or DirectClick™ any data field and enter custom values.

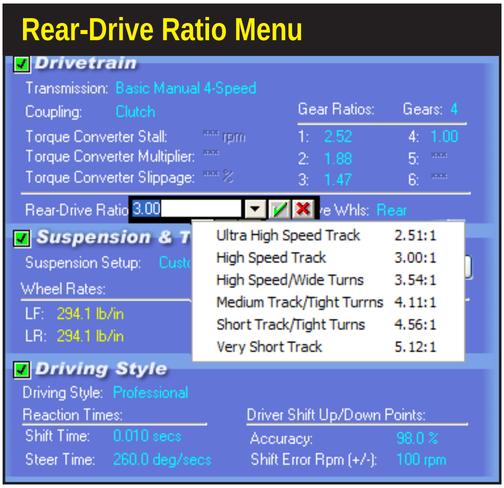
next). Typical automotive torque converters slip between 6 and 15%.

Finally, every torque converter has a rated ***Stall Speed*** that indicates the maximum engine speed that can be achieved at wide-open throttle with the vehicle standing still (i.e., before the transmission input shaft begins to rotate). For street applications and some racing applications, a low stall speed (1000 to 1500rpm) optimizes the efficiency of the converter and takes advantage of the low-speed torque capability of some engines. On the other hand, high-speed engines, especially used in standing-start competition, produce peak torque at much higher engine speeds. To accommodate these applications, a torque converter can be modified to stall at higher rpm (3000 to 5000 or more). At these speeds, racing engines transfer near-peak torque loads to the rear wheels at the starting line, assuring maximum acceleration. However, high stall speeds also reduce efficiency and can dramatically increase transmissions fluid temperatures.

For road racing applications a stock (non-lock-up—lockup converters will not withstand racing use), large diameter, low-stall-speed converter is often the best choice, since it is likely to have the highest efficiency, the lowest slippage, and impart the least amount of heat to the transmission fluid.

Rear-Drive Ratio: The ***Rear-Drive Ratio*** is the numerical gear ratio of the rear-driving axle or—in the case of front-wheel drive vehicles—the front-driving axle. This ratio indicates the number of turns the driveshaft (or pinion gear) rotates for each revolution of the rear wheels. The ***Rear-Drive Ratio*** submenu in FastLapSim includes several common (automotive) rear-axle ratios. It is also possible to DirectClick™ on ***Rear-Drive Ratio*** and enter any custom ratio between 9.99:1 to 0.50:1.

Driving Wheels: The ***Drive Wheels*** field accepts either **Front** or **Rear** entries. This field establishes the simulation model that applies engine torque to the front or rear wheels.



Rear-Drive Ratio Menu

☑ Drivetrain

Transmission: Basic Manual 4-Speed

Coupling: Clutch

Torque Converter Stall: *** rpm

Torque Converter Multiplier: ***

Torque Converter Slippage: *** %

Gear Ratios:		Gears: 4	
1:	2.52	4:	1.00
2:	1.88	5:	***
3:	1.47	6:	***

Rear-Drive Ratio 3.00

e Whls: Rear

Ultra High Speed Track	2.51:1
High Speed Track	3.00:1
High Speed/Wide Turns	3.54:1
Medium Track/Tight Turrns	4.11:1
Short Track/Tight Turns	4.56:1
Very Short Track	5.12:1

☑ Suspension & T

Suspension Setup: Custo

Wheel Rates:

LF: 294.1 lb/in

LR: 294.1 lb/in

☑ Driving Style

Driving Style: Professional

Reaction Times:

Shift Time: 0.010 secs

Steer Time: 260.0 deg/secs

Driver Shift Up/Down Points:

Accuracy: 98.0 %

Shift Error Rpm (+/-): 100 rpm

The *Rear-Drive Ratio* is the numerical gear ratio of the front or rear driving axle, depending on whether the vehicle is front- or rear-wheel drive. This ratio indicates the number of turns the driveshaft (or pinion gear) rotates for each revolution of the rear wheels.

SUSPENSION & TIRES Category Menus

SUSPENSION & TIRES Component Category

Suspension Setup: Custom

LF: 252.1 lb/in
RF: 252.1 lb/in
LR: 294.1 lb/in
RR: 294.1 lb/in

Despite its “simple” appearance, the *Suspension & Tires* component category is probably the most complex and comprehensive in FastLapSim. Click the *Setup* button to modify individual component specs.

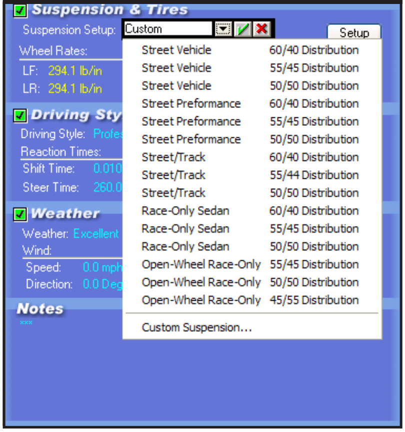
THE SUSPENSION & TIRES CATEGORY MENUS

The **SUSPENSION & TIRES** component category, despite its “simple” appearance, is probably the most complex and comprehensive category in FastLapSim. The menu selections in this category (really, in all component categories) have been designed to be easy to use, with the vast array of technical choices “hidden” below the surface, but fully available by “drilling down” into more detailed data-entry screens. This allows fast and powerful selections from the topmost menus, while still allowing minute adjustments to individual components. Details of the these selctions follow:

Suspension Setup: This menu presents several “prepackaged” choices of entire suspension setups, including selections for suspension design, spring rates, sway bars, shocks, tires, and brakes. Using these upper-level choices you can quickly evaluate “stable” system packages on a variety of vehicles and tracks. And if you wish to modify component groups to test their effect on vehicle handling and performance, simply click on the ***Setup*** button to open the Suspension Setup dialog box.

The Suspension Setup dialog introduces another “level” of menus. Rather than selecting entire suspension packages, these menus offer a range of components in each of the Spring, Damper, Geometry, Tire/Brake, and Front/Rear Sway Bar categories. These component selections offer components and specifications from lists of common values or off-the-shelf products. If you would like to “dig deeper” and try

Suspension “Packages”

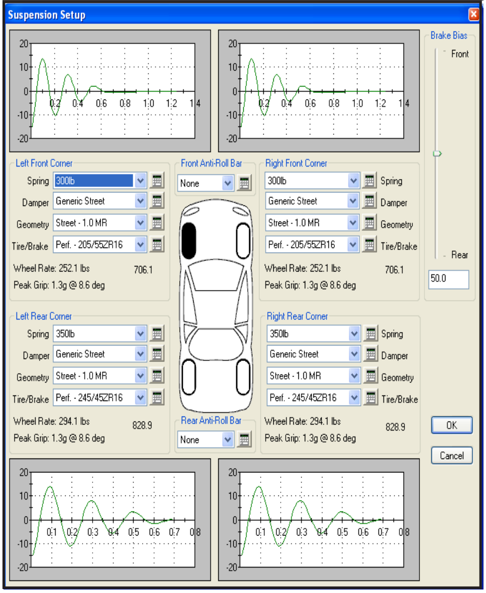


Several “prepackaged” choices of entire suspension setups, including selections for suspension design, spring rates, sway bars, shocks, tires, and brakes are available from the *Suspension Setup* menu. Using these choices you can quickly evaluate “stable” system packages on a variety of vehicles and tracks. And if you wish to modify component groups to test their effect on vehicle handling and performance, simply click on the *Setup* button to open the *Suspension Setup* dialog box or select “Custom Suspension” from the Suspension Setup menu.

SUSPENSION & TIRES Category Menus

Use the *Suspension Setup Dialog Box* to modify individual components for each wheel and test their effect on vehicle handling and performance. Rather than selecting entire suspension packages as you can from the Main Component Screen, these menus offer a range of components in each of the Spring, Damper, Geometry, Tire/Brake, and Front/Rear Sway Bar categories. Here you'll find component selections and specifications of common, off-the-shelf products. If you would like to "dig deeper" still and try custom components and specifications, click on any one of the four calculator buttons next to the component categories. The 18 calculator screens available in this dialog box let you test a virtually unlimited number of possible combinations. The four graphs indicate how the spring on each wheel is damped by the shock absorber. For details on using these graphs, see pages 46-47).

Suspension Setup Dialog



Left Front Corner
Spring 300lb
Damper Generic Street
Geometry Street - 1.0 MR
Tire/Brake Perf. - 205/55ZR16
Wheel Rate: 252.1 lbs 706.1
Peak Grip: 1.3g @ 8.6 deg

Front Anti-Roll Bar None

Right Front Corner
Spring 300lb
Damper Generic Street
Geometry Street - 1.0 MR
Tire/Brake Perf. - 205/55ZR16
Wheel Rate: 252.1 lbs 706.1
Peak Grip: 1.3g @ 8.6 deg

Brake Bias 50.0

Left Rear Corner
Spring 350lb
Damper Generic Street
Geometry Street - 1.0 MR
Tire/Brake Perf. - 245/45ZR16
Wheel Rate: 294.1 lbs 828.9
Peak Grip: 1.3g @ 8.6 deg

Rear Anti-Roll Bar None

Right Rear Corner
Spring 350lb
Damper Generic Street
Geometry Street - 1.0 MR
Tire/Brake Perf. - 245/45ZR16
Wheel Rate: 294.1 lbs 828.9
Peak Grip: 1.3g @ 8.6 deg

custom components and specifications, click on any one of the four calculator buttons next to the component categories grouped together for each wheel. (Note: The four graphs indicate how spring motion at each wheel is damped by the shock absorber; for details on interpreting these graphs, see page 46). The total of 18 calculator screens let you select suspension designs and component specifications. With, literally, billions of possible suspension component combinations, this is the heart of FastLapSim—these selections allow you to test, modify, and fine-tune your suspension to optimize lap times.

The following information offers an overview of the individual component selections

There are seven major categories of component specifications available in the suspension Setup Dialog box. With, literally, billions of possible suspension component combinations, you can test, modify, and fine-tune your vehicle to optimize lap times.

Spring	Damper	Geometry	Tire	Brake	Front Roll Bar	Rear Roll Bar
Coil Spring	Bump Force	Spring D1Arm	Lat. Peak	Diameter	Bar Length	Bar Length
Number of Coils	BF Velocity	Spring D2 Connector	Lon. Peak	Thickness	Inner Bar Dia.	Inner Bar Dia.
Coil Diameter	Rebound Force	Spring Bellcrank Ratio	Lat. Slope	Pad Area	Outer Bar Dia.	Outer Bar Dia.
Wire Width	RF Velocity	Damper D1 Arm	Lon. Slope	Friction Coef.	Arm Length	Arm Length
Torsion Bar	Bump Slope	Damper D2 Connector	Shape	Rear Bias		
Bar Length	Rebound Slope	Damper Bellcrank Ratio	Stiffness	Front Bias		
Inner Bar Dia.		Maximum Travel	Curvature			
Arm Length		Static Toe	Camber Slope			
Leaf Spring		Static Camber	Spring Rate			
Number of Leaves			Diameter			
Length			Width			
Width			Pressure			
Thickness						
Manual						
Spring Rate						

provided in the **SUSPENSION & TIRES** component categories (for additional help in tuning suspension components, see ***The Handling Clinic*** on page 106):

Spring Calculator Tab: Clicking on the calculator buttons next to the ***Spring*** drop-down menus will open a ***Spring Calculator***. Here you can select three types of spring systems for that particular wheel: **Coil Springs**, **Torsion Bars**, or **Leaf Springs** (the suspension arm/linkage designs are chosen in the *Geometry Tab,* discussed later).

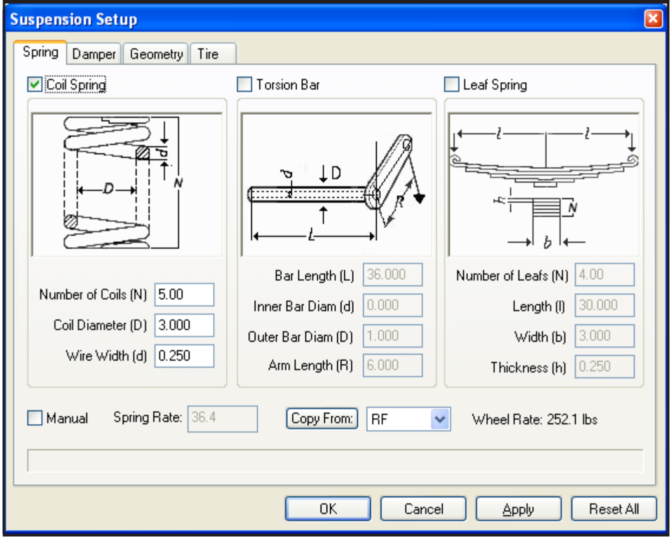
When you select one of the three spring types, the related fields for that spring are activated. Enter the required specifications, and the spring rate will be calculated and displayed in the ***Spring Rate*** field. Refer to the spring illustration for "keys" to the required data. The range limits for each variable are displayed in the ***Range Limit Line*** at the bottom of the dialog box.

Note: Instead, you can directly enter a spring rate by clicking the ***Manual*** box and entering a spring rate value in the ***Spring Rate*** field.

If you would like to copy the spring specifications from another wheel, select the desired wheel from the drop-down menu and click ***Copy From***. The spring specs from that wheel will be copied into the current ***Spring Calculator Tab***.

When you have entered the values necessary to calculate the ***Spring Rate*** and ***Motion Ratio*** (determined in the *Geometry Calculator Tab*, discussed below), the ***Wheel Rate*** will be displayed. This variable is a "basic" characteristic of suspension systems and reflects the relationship between the motion of the wheel and the motion of the spring, plus the spring rate. In other words, ***Wheel Rate*** measures the *effective spring rate*. For example, if a vehicle has a 300-lb/in spring, that does not mean 300-pounds of force are required to push the fender down 1 inch. In fact, considerably less force often will produce a 1-inch deflection.

Spring Calculator Tab



☑ Coil Spring ☐ Torsion Bar ☐ Leaf Spring

Number of Coils (N) 5.00
Coil Diameter (D) 3.000
Wire Width (d) 0.250

Bar Length (L) 36.000
Inner Bar Diam (d) 0.000
Outer Bar Diam (D) 1.000
Arm Length (R) 6.000

Number of Leafs (N) 4.00
Length (l) 30.000
Width (b) 3.000
Thickness (h) 0.250

☐ Manual Spring Rate: 36.4 Copy From: RF Wheel Rate: 252.1 lbs

***The Spring Calculator Tab* lets you select three types of spring systems for each wheel: Coil Springs, Torsion Bars, or Leaf Springs.When you select one of the three spring types, the related fields for that spring are activated. Enter the required specifications, and the spring rate will be calculated and displayed in the *Spring Rate* field. (Alternatively, you can directly enter a spring rate by clicking the *Manual* box.)**

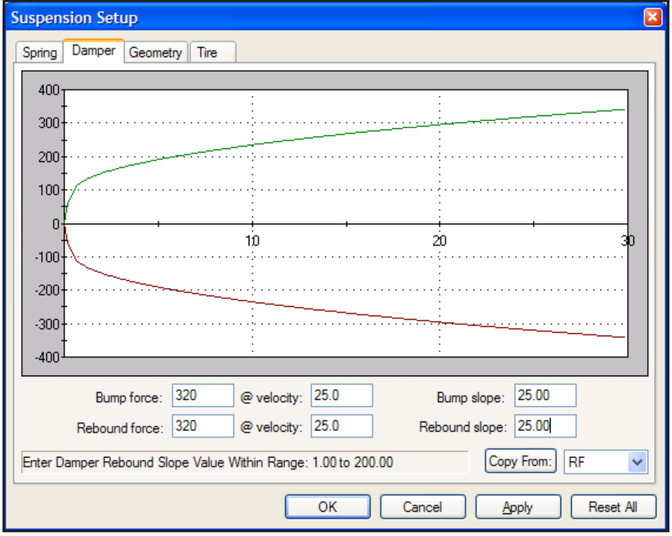
This (motion ratio) comes about, primarily, from the spring mounting location, which is positioned at an angle or offset from the tire. This reduces the amount of spring compression relative to wheel travel (and, therefore, the force returned by the spring). The ***Wheel Rate*** measures this relationship and is always equal to, or less than, the ***Spring Rate***.

When you have completed data entry, click ***OK*** or ***Apply*** to use the spring rate determined in the dialog; press ***Reset All*** to return all specifications to the values displayed when the dialog was opened. Press ***Cancel*** to close the dialog, discard any changes (unless ***Apply*** had been pressed), and return to the ***Suspension Setup Dialog*** box.

Spring Selection Tips: In many cases, an effective *Wheel Rate* should be no less than one-half of the corner weight of the vehicle. For example, if the weight over one tire is 500-pounds, the effective *Wheel Rate* should be at least 250-pounds-per-inch. There are many ways to achieve this; for example, a 400-lb/in spring could be mounted inward and/or at an angle from vertical, or a 300-lb/in spring could be mounted vertically and as close to the wheel as possible.

Damper Calculator Tab: Clicking on any of the four calculator buttons next to the ***Damper*** drop-down menus will open a ***Damper Calculator Tab***. Here you can view "shock-dyno" curves for the damper used on that particular wheel. The curves indicate how the damper resists movement in both the bump (compression; as shown on the top of the graph) and rebound (extension shown on the lower portion of the graph). You can modify the bump and rebound curves by entering custom specifications in the ***Force***, ***Velocity***, and ***Slope*** fields. The ***Force*** and ***Velocity*** are directly linked together: The ***Force*** indicates the pounds of force required to move the piston with the indicated ***Velocity*** (in inches per second). The ***Slope***

Damper Calculator Tab



Bump force: 320 @ velocity: 25.0 Bump slope: 25.00

Rebound force: 320 @ velocity: 25.0 Rebound slope: 25.00

Enter Damper Rebound Slope Value Within Range: 1.00 to 200.00

Copy From: RF

***The Damper Calculator Tab* displays the results of "shock-dyno" test curves. The curves indicate how the damper resists movement in both bump and rebound. Modify the bump and rebound curves by entering custom specifications in the *Force*, *Velocity*, and *Slope* fields.**

adjusts the shape of the curve. The higher the ***Slope***, the greater resistance is offered to slow movements, the lower the ***Slope***, the more slowly the resistance builds as ***Velocity*** increases.

If you would like to copy the damper specs from another wheel, select the desired wheel from the drop-down menu and click ***Copy From:***. The damper specs from that wheel will be copied into the current ***Damper Calculator Tab***.

When you have completed data entry, click ***OK*** or ***Apply*** to use the damper specifications shown in the dialog; press ***Reset All*** to return all specifications to the values displayed when the dialog was opened. Press ***Cancel*** to close the dialog and discard any changes (providing the ***Apply*** button had not been pressed), and return to the ***Suspension Setup Dialog*** box.

Damper Selection Tips: When designing a spring/damper setup, optimum dampening of suspension movement is the goal. Dampening is dependant on several factors including *Spring Rate*, *Geometry Design*, *Unsprung Weight*, and of course the characteristics of the Damper (shock absorber). There are three possible outcomes when installing components: the suspension can be over-damped, under-damped, or critically-damped.

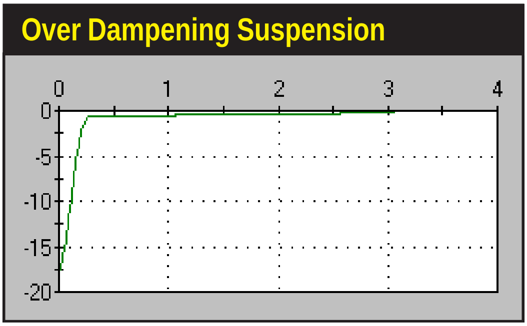
Over-dampening occurs when the shock absorber is too stiff and non-compliant in bump (compression), preventing the spring from doing its job, i.e., returning the tire to the road surface as quickly as possible. Over-dampening acts as if springs with excessive rates had been installed, resisting movement and forcing the tires to loose contact with the road surface longer than necessary.

An **under-damped** suspension allows the spring to oscillate (compress and relax) more times than necessary; letting the tire leave the road surface several times after encountering a bump. Under-dampening is often the result of the damper contributing insufficient force in bump, allowing the spring to store excessive energy which is returned to the wheel on rebound.

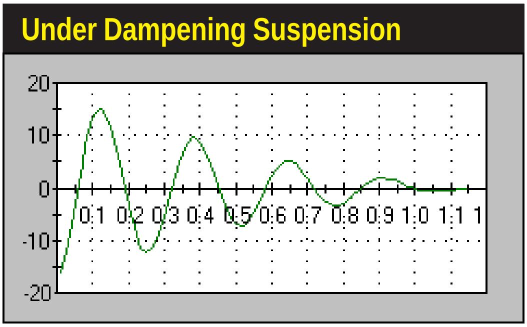
Critical-dampening is the goal. This allows the suspension to move and react but not oscillate. The suspension returns the tire to the road surface as quickly as possible, optimizing traction and handling.

The three nearby graphs show how each of these suspension setups respond to an input (bump). The curves show suspension movement (vertical axis) over time (horizontal axis). Notice how the critical-dampened system absorbs energy in

Over-dampening occurs when the shock absorber is too stiff and non-compliant in bump (compression), preventing the spring from doing its job, i.e., returning the tire to the road surface as quickly as possible. Over-dampening acts as if springs with too high a rate have been installed, resisting movement and forcing the tires to loose contact with the road surface longer than necessary.

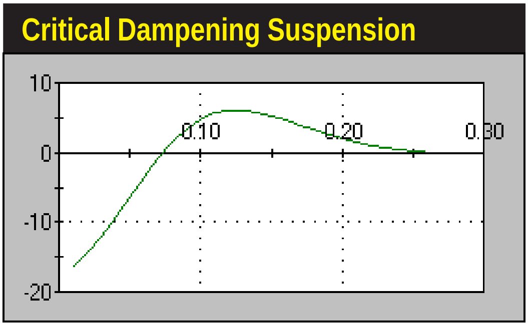

Over Dampening Suspension

SUSPENSION & TIRES Category Menus



Under Dampening Suspension

An under-damped suspension allows the spring to oscillate (compress and relax) more than necessary; letting the tire leave the road surface multiple times after encountering a bump. Under-dampening is often the result of the damper contributing insufficient force in bump, allowing the spring to store excessive energy which is returned to the wheel on rebound.



Critical Dampening Suspension

Critical-dampening is the goal. This allows the suspension to move and react but not oscillate. The suspension returns to the tire to the road surface as quickly as possible, optimizing traction and handling.

compression and extension, but does not continue to bounce. It returns the wheel to a stable position in less than 0.30-seconds.

Geometry Calculator Tab: Clicking on any of the four calculator buttons next to the ***Geometry*** drop-down menus will open a ***Geometry Calculator Tab***. Here you can specify the length of critical suspension arms, their mounting points, overall suspension travel, and basic pre-race alignment geometry. The ***Geometry Calculator*** supports three types of suspension systems: *Coil Over Shock Independent*, *MacPherson Strut Independent*, and *Coil- or Leaf-Sprung Straight Axle*. Refer to the suspension illustrations for “keys” to the required data. The range limits for each variable are displayed in the ***Range Limit Line*** at the bottom of the dialog box. When you have entered data in each of the fields in the **Spring Geometry** group, the ***Motion Ratio*** for the suspension will be calculated. Similarly, when the fields in the **Damper Geometry** group have been completed, the ***Motion Ratio*** of the damper will be calculated.

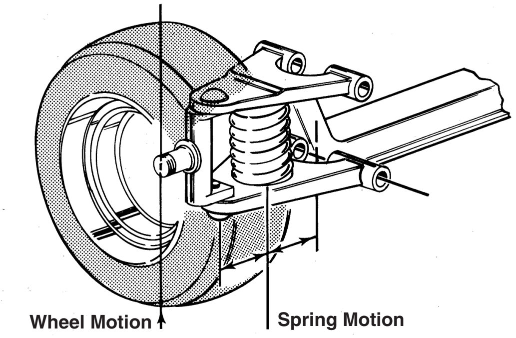
If the suspension design on the vehicle you wish to model is not included in the *Geometry Calculator*, or you do not know all the dimensions required by the calculator, you can manually enter any effective ***Motion Ratio*** by clicking one of the Manual radio buttons.

Note 1: The ***Motion Ratio*** is the relationship between vertical wheel movement and the spring or damper movement. For example, if the ***Motion Ratio*** was 0.5 (50%), a 2-inch vertical wheel movement would result in a spring/damper motion of 1-inch (50%).

Note 2: A ***Bellcrank*** is a device, shaped similarly to a 30-, 60-, 90-degree

The *Motion Ratio* is the relationship between vertical wheel movement and the actual spring or damper movement (Spring Motion divided by Wheel Motion). For example, if the *Motion Ratio* was 0.5 (50%), a 2-inch vertical wheel movement would result in a spring/damper motion of 1-inch (50%).

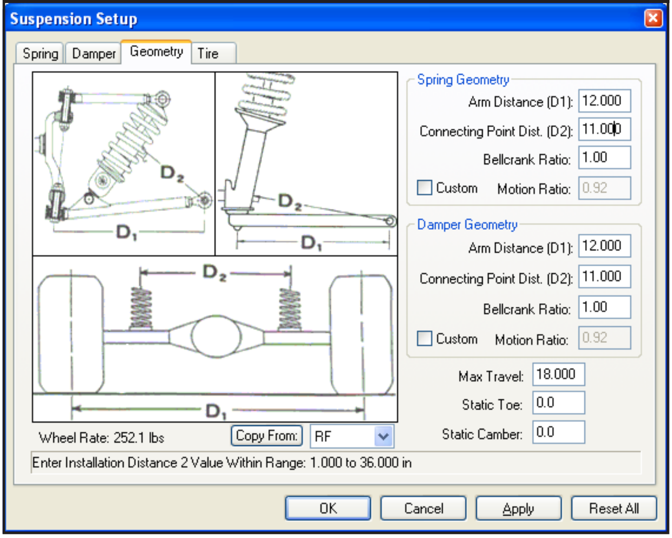
Motion Ratio



triangle, that either increases or decreases the amount of motion applied to one end of the triangle. The bellcrank pivots around one point (usually through a mounting hole). The other two points connect to the suspension and/or the spring/damper (one end is often connected to a push rod and the other end is directly connected to the spring/damper). When the pushrod moves, it causes the bellcrank to pivot and compress the spring. If a bellcrank has a ratio of 0.5, this means that the end imparting motion (usually the pushrod end or the side connected to the wheel) will move twice as much as the side connected to the spring. In this case, the pushrod link would be connected to the longer side of the triangle and the spring to the shorter end. In most bellcrank systems, the spring and damper act through the same bellcrank, but there are some suspension designs

***The Geometry Calculator Tab* sets the lengths of critical suspension arms, their mounting points, overall suspension travel, plus basic pre-race alignment geometry. *Coil Over Shock Independent*, *MacPherson Strut Independent*, and *Coil- or Leaf-Sprung Straight Axles* are supported. When data has been entered in each of the fields, the *Motion Ratio* for the suspension will be calculated. In addition, any motion ratio can be entered by clicking the Custom box.**

Geometry Calculator Tab



Spring Geometry

Arm Distance (D1): 12.000

Connecting Point Dist. (D2): 11.000

Bellcrank Ratio: 1.00

☐ Custom Motion Ratio: 0.92

Damper Geometry

Arm Distance (D1): 12.000

Connecting Point Dist. (D2): 11.000

Bellcrank Ratio: 1.00

☐ Custom Motion Ratio: 0.92

Max Travel: 18.000

Static Toe: 0.0

Static Camber: 0.0

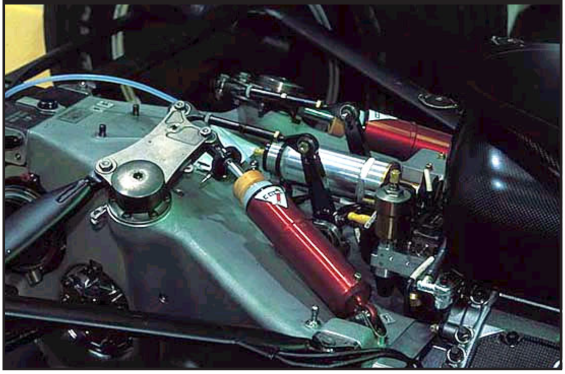
Wheel Rate: 252.1 lbs

RF

Enter Installation Distance 2 Value Within Range: 1.000 to 36.000 in

A *Bellcrank* is a device shaped similarly to a 30-, 60-, 90-degree triangle. It either increases or decreases the amount of motion applied to one end of the triangle. The bellcrank pivots around one point, the other points connect the suspension to the spring/dampers. This Koni equipped Formula-1 suspension system transfers motion to the dampers and other suspension-tuning elements through a meticulously designed pushrod/bellcrank system.

Bellcrank In Suspension Design



that use separate bellcranks for the spring and damper. FastLapSim supports none, single-, and dual-bellcrank designs.

Note 3: If your suspension system does not use a bellcrank mechanism, set the bellcrank ratio(s) to 1.00.

With the Spring and Damper *Motion Ratios* defined, enter the ***Total Suspension Travel***, the ***Static Toe*** and ***Static Camber*** settings for the selected wheel.

If you would like to copy all the suspension geometry specifications from another wheel, select the desired wheel from the drop-down menu and click the ***Copy From:*** button. The geometry specs from that wheel will be copied into the current ***Geometry Calculator Tab***.

When you have completed data entry, click ***OK*** or ***Apply*** to use the *Motion Ratios*, *Travel*, and *Alignment* specs in the current simulation; press ***Reset All*** to return all specifications to the values displayed when the dialog was opened. Press ***Cancel*** to close the dialog, discard any changes (providing the ***Apply*** button had not been pressed), and return to the ***Suspension Setup Dialog*** box.

Tire/Brake Calculator Tab: Clicking on any of the four calculator buttons next to the ***Tire/Brake*** drop-down menus will open a ***Tire/Brake Calculator (Tab)***. Here you can specify critical tire and brake specifications for each specific corner of the vehicle.

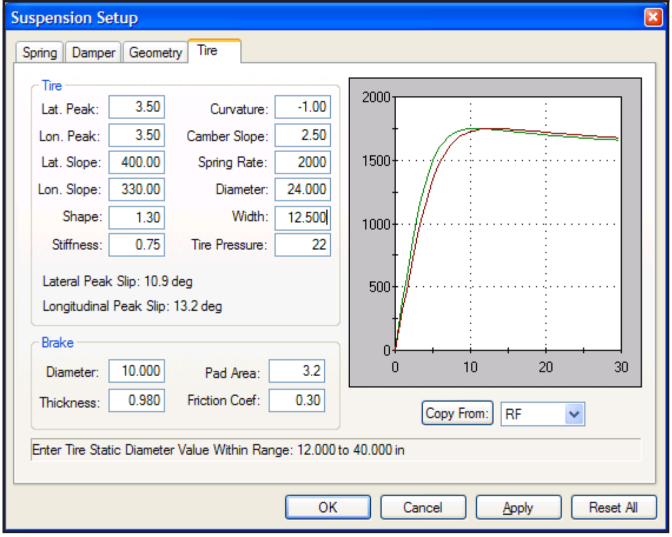
The tire graph will help you analyze tire performance and show how changing any of the tire variables will affect performance. The vertical axis indicates the force (in pounds) being generated by the tire/ground interaction (traction) with a 500-pound vertical test load on the tire. The horizontal axis is the angle of “slippage”; commonly called the ***Slip Angle*** for lateral loads (green line) and the ***Slip Ratio*** for longitudinal loads (red line). In effect, the ***Slip Angle*** and ***Slip Ratio*** measure how much the tire is sliding or slipping on the pavement (either laterally, on turns, or longitudinally, on acceleration or braking). The graph shows how much force can be generated by the tire throughout the slip-angle range. The peaks in the traces are the maximum forces that can be produced by the tire.

For racing applications, a tire that produces a quick falloff from peak forces as

SUSPENSION & TIRES Category Menus

Tire/Brake Calculator Tab

***The Tire Calculator Tab* will help you analyze tire performance and how tire variables affect the test vehicle. The graph indicates how much force can be generated by the tire throughout its slip-angle range. The peaks are the maximum forces that can be produced by the tire. For racing applications, look for a tire that produces a quick falloff from peak forces, since this provides significant feedback and allows the driver to immediately respond to loosing grip.**



Tire

Lat. Peak: 3.50

Lon. Peak: 3.50

Lat. Slope: 400.00

Lon. Slope: 330.00

Shape: 1.30

Stiffness: 0.75

Curvature: -1.00

Camber Slope: 2.50

Spring Rate: 2000

Diameter: 24.000

Width: 12.500

Tire Pressure: 22

Lateral Peak Slip: 10.9 deg

Longitudinal Peak Slip: 13.2 deg

Brake

Diameter: 10.000

Thickness: 0.980

Pad Area: 3.2

Friction Coef: 0.30

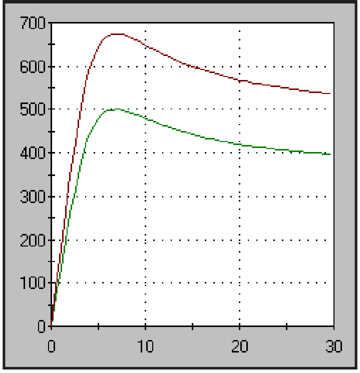
Enter Tire Static Diameter Value Within Range: 12.000 to 40.000 in

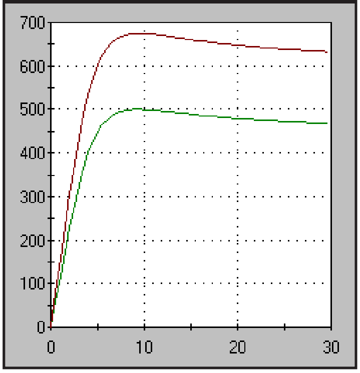
the slip angle increases will transfer an obvious change to the driver (the steering wheel response quickly shifts from stiff to light as the tire transitions from sticking to sliding across the road surface). This is commonly used in racing applications since it allows the driver to immediately respond to changes in grip. If the tire performance curves are flatter and tire forces remain high as the slip angle increases, it can lead the driver past the point of no return; by the time the driver realized the tires are sliding it could be too late to effectively recover.

Optimum tire selection is entirely dependent on type of vehicle and race track you wish to model. While the Tire group contains twelve tunable elements (as defined by tire manufacturers), the two factors that determine the major handling characteristics of the tire are *Peak Grip* and *Peak Slip*.

Rapid Falloff In Grip

A tire that generates a quick falloff in tractive forces as the slip angle increases will transfer an obvious change to the driver (the steering wheel response quickly shifts from stiff to light as the tire transitions from sticking to sliding across the road surface). This is ideal for a racing since it allows the driver to immediately respond to changing grip.





Slow Falloff In Grip

If the tire performance curves are flatter and tire forces remain high as the slip angle increases, it can lead the driver past the point of no return in a high-speed turn; by the time the driver realized the tires are sliding, it could be too late to effectively recover.

Peak Grip—This defines the maximum (peak) force that the tire can generate with the road surface. For a fixed vertical load, no matter how much horsepower is applied or how well the chassis is tuned, the forces produced by the tires will never increase beyond this value. Since ***Peak Grip*** is dependant on vertical load, adding downforce is the only way to increase traction forces. In general, the following values represent common ***Peak Grip*** values for various classes of tires:

Street Tire	0.7 to 1.0
Autocross	1.0 to 1.5
Race	1.2 to 1.8
Sticky Qualifying Tire	1.5 to 2.5
Drag-Racing “Slick”	3.0 to 6.0

Peak Slip—This value indicates the *Slip Angle* at which the tire reaches its maximum limit of *Peak Grip*. The lower the ***Peak Slip***, the more quickly the tire will reach *Peak Grip*. Tires with this characteristic tend to feel stiff and abruptly change traction characteristics. The higher the ***Peak Slip*** angle, the more the tire will tend to slip before starting to slide. This makes the tires feel mushy and can contribute to oversteer. Most street tires have peaks in the range of 8- to 11-degrees. Race tires are generally lower, falling between 7- to 9-degrees.

Note 1: The *Slip Angle* and *Slip Ratio* are a measure of the difference in the direction of the vehicle relative to the “direction” of the tire. For example, if a vehicle is moving in a straight line but the front wheels are turned at 5 degrees, a 5-degree slip angle is generated that, in turn, creates a force that causes the car to yaw. Similarly, in the longitudinal direction, the ***Slip Ratio*** measures the difference between road speed and wheel speed. So, when you hit the gas, the angular velocity of the tire increases and it moves faster than road speed. This generates a ***Slip Ratio*** that produces a force (shown on the graph) that propels the car forward.

Note 2: Tire width does not affect the forces shown on the graph. What does change tire forces is the weight of the tire which directly affects wheel damping and the simulation. It's built into the other values. Also, while it's generally true that a wider tire will have more grip, tire composition is much more important than width.

Brake Component Specs And Front/Rear-Brake-Bias Slider: The *Brake Group* is located at the bottom of the ***Tire/Brake Calculator (Tab)***. Here you can specify critical brake specifications for each wheel.

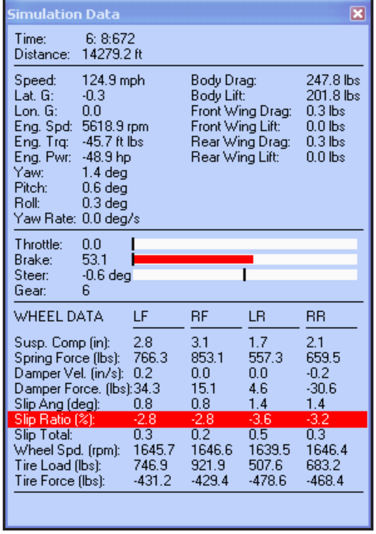
Optimal lap-times can only be achieved when the vehicle has been equipped with as much braking power as possible, and the large braking forces generated are properly proportioned to each wheel. Maximum braking for any vehicle is directly related to the physical size of the disk rotors and pads that can installed at each wheel. In FastLapSim, however, there are no limitations imposed by this real-world constraint, but keep sizing practical if you are trying to evaluate a realistic vehicle.

Forward/Rear brake bias can be easily adjusted, in both FastLapSim and the real-world. The goal is to achieve heavy braking without tire lockup. If the rear brakes lockup first, move the bias toward the front brakes. Examine the ***Slip Ratios*** (displayed in the ***SimData™ Window*** available in the **Tools** menu) for the front and rear tires when entering a braking zone: A higher negative peak indicates that wheel lockup is imminent. When the front and rear tires reach a peak simultaneously, the bias has been properly established. For most vehicles, optimum bias should around 60% to 70% front bias.

Brake Note 1: FastLapSim models brake pedal and master cylinder pressures. Because of this, virtually all braking systems can be simulated accurately using the variables available in the ***Tire/Brake Calculator Tab***.

Forward/Rear brake bias can be easily adjusted. The goal is to achieve optimum braking without tire lockup. If the rear brakes lockup first, move the bias slider in the *Tire/Brake Calculator* toward the front brakes. Examine the *Slip Ratios* (displayed here in the *SimData™ Window* available in the Tools menu) for the front and rear tires when entering a braking zone: A higher negative peak indicates that wheel lockup is imminent. When the front and rear tires reach a peak simultaneously, the bias has been properly established. For most vehicles, optimum bias should around 60% to 70% toward the front.

Analyze *Slip Ratios*



Time: 6: 8:672
Distance: 14279.2 ft

Speed: 124.9 mph
Lat. G: -0.3
Lon. G: 0.0
Eng. Spd: 5618.9 rpm
Eng. Trq: -45.7 ft lbs
Eng. Pwr: -48.9 hp
Yaw: 1.4 deg
Pitch: 0.6 deg
Roll: 0.3 deg
Yaw Rate: 0.0 deg/s

Body Drag: 247.8 lbs
Body Lift: 201.8 lbs
Front Wing Drag: 0.3 lbs
Front Wing Lift: 0.0 lbs
Rear Wing Drag: 0.3 lbs
Rear Wing Lift: 0.0 lbs

Throttle: 0.0
Brake: 53.1
Steer: -0.6 deg
Gear: 6

WHEEL DATA	LF	RF	LR	RR
Susp. Comp (in):	2.8	3.1	1.7	2.1
Spring Force (lbs):	766.3	853.1	557.3	659.5
Damper Vel. (in/s):	0.2	0.0	0.0	-0.2
Damper Force. (lbs):	34.3	15.1	4.6	-30.6
Slip Ang (deg):	0.8	0.8	1.4	1.4
Slip Ratio (%):	-2.8	-2.8	-3.6	-3.2
Slip Total:	0.3	0.2	0.5	0.3
Wheel Spd. (rpm):	1645.7	1646.6	1639.5	1646.4
Tire Load (lbs):	746.9	921.9	507.6	683.2
Tire Force (lbs):	-431.2	-429.4	-478.6	-468.4

Brake Note 2: The frictional coefficient of the brake pad is dependent on its construction and composition: common materials are *Organic*, *Metallic*, and *Semi-Metallic*. Organic materials are commonly used in street applications. They contain asbestos, glass, and other synthetic materials. These compounds have frictional coefficients that range from 0.25 to 0.30. Fully-metallic pads were developed for high-performance applications. They offer excellent braking and resistance to high temperatures. Although some early metallic pads were so abrasive they would wear through brake drums, modern metallic pads are more practical and offer frictional coefficients between 0.30 to 0.45. Semi-metallic pads were developed to provide a compromise in performance between the limited braking potential of organic compounds and the harshness of metallic. Modern semi-metallic pads are usually asbestos-free, and offer some high-performance characteristics, however, they often fade at higher temperatures. Semi-metallics frictional coefficients range from 0.25 to 0.35. All-out competition (often carbon-fiber) brake components can generate frictional coefficients as high as 0.60.

Brake Note 3: FastLapSim does not directly model drum brakes. While most road race vehicles use disk brakes, you can "modify" the disk parameters to simulate drum brakes:

Diameter = Use this as the inner diameter of the drum.
Thickness = This is the depth of the drum.
Pad area = This is the area of the shoe.
Friction Coef. = The coefficient of friction of the shoe material.

This cross-reference will allow FastLapSim to reasonably approximate drum-brake performance.

Front And Rear Anti-Roll Bar Calculators: Clicking on either calculator button next to the ***Anti-Roll Bar*** drop-down menus will open an ***Anti-Roll Bar Calculator***. Enter the dimensions of the bar and the lever-arm length, and the calculator will determine the anti-roll rate (in pounds per inch of deflection) for a front or rear bar. The deflection force is generated by the difference in travel between the two sides of the vehicle. The compressed side will transmit a force through the bar that reduces the load on the opposite tire, producing a counter-roll force on the body at the bar attachment point. This causes the body to roll in the opposite direction (anti-roll).

Anti-Roll Bar Setup: Choosing the most effective Anti-Roll-Bar rate for any specific application is often relegated to a trial-and-error process. It is easy to calculate the bar rate when the required anti-roll rate is known. Unfortunately, finding the needed roll rate is pure guesswork in most situations.

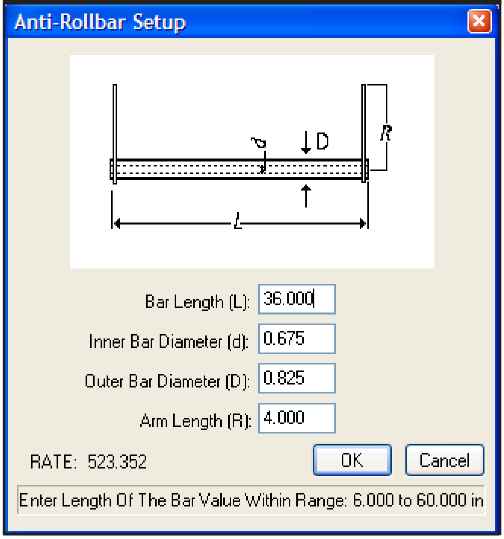
THE DRIVING CATEGORY MENUS

The **DRIVING** component category determines the Shift-Up and Down-Shift points, Shift Time, Steering Reaction Time, and other basic driving/driver characteristics. The menu selections and component fields are detailed below:

Driving Style: This menu offers a simple and easy way to establish ***Shift Rpms***,

DRIVING Category Menus

Anti-Rollbar Calculator Tabs



Bar Length (L): 36.000

Inner Bar Diameter (d): 0.675

Outer Bar Diameter (D): 0.825

Arm Length (R): 4.000

RATE: 523.352

Enter Length Of The Bar Value Within Range: 6.000 to 60.000 in

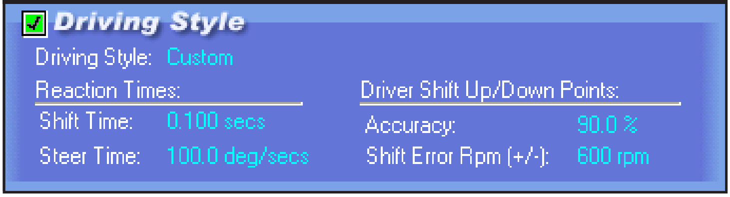
Use the *Anti-Roll Bar Calculator* to determine the anti-roll rate (in pounds per inch of deflection) for the front or rear bar. This is the force generated by the difference in travel between the two sides of the vehicle. The compressed side will transmit a force through the bar that reduces the load on the opposite tire, producing a counter-roll force on the body at the bar attachment point, resulting in a roll force of the opposite direction (anti-roll). Unfortunately, choosing the most effective Anti-Roll-Bar rate for any specific application is often relegated to a trial-and-error process. Fortunately, that's where FastLapSim shines.

Shift Time, and ***Steering Reaction Time***. Each of the choices in this menu apply unique model to these and other variables. The models are illustrated in the ***Driving Style Defaults*** table on the page 55.

The three basic ***Driving Style*** choices offer a quick way to select the variables needed to simulate most racing scenarios. Each selection directs FastLapSim to determine a specific ***Up/Down Shift Rpm*** (by analyzing the current engine power curve, vehicle position on the track, and other variables), the ***Shift Time***, and the ***Steering Reaction Time***. It is also possible to DirectClick™ on these calculated data fields and enter custom values.

Shift Time: This value only applies to vehicles that use **Clutch Engagement** (**Torque Converter** transmission shift times are set to zero, since power flow to the driving wheels is not interrupted during a shift) and specifies the amount of time the driver takes to complete an up-shfit or down-shift. During the **Up-Shift Time** the driveline is effectively in "neutral," sending the engine to the redline and the acceleration to zero. When the shift time has elapsed, the next gear is engaged and the vehicle continues to accelerate. During a ***Down-Shift Time***, the driveline offers no engine braking for the length of time specified in the ***Shift Time***

DRIVING Component Category



Driving Style: Custom

Reaction Times:

Shift Time: 0.100 secs

Steer Time: 100.0 deg/secs

Driver Shift Up/Down Points:

Accuracy: 90.0 %

Shift Error Rpm (+/-): 600 rpm

The DRIVING component category determines the shift points, the steering reaction time, and other basic driving/driver characteristics.

DRIVING Category Menus

The *Driving Style* menu offers a simple and easy way to establish *Shift Rpms*, *Shift Time*, and *Steering Reaction Time*. Each of the three choices in this menu (Conservative, Aggressive, and Professional) apply unique models to these variables and emulate a specific driving style.

Built-In *Driving Style* Defaults

Shift Rpm Accuracy	Shift Rpm Error	Shift Time	Steering Reaction Time
Conservative Driving Style			
90%	600rpm	0.250-seconds	120.0 degrees/sec
Aggressive Driving Style			
95%	400rpm	0.100-seconds	240.0 degrees/sec
Professional Driving Style			
98%	100rpm	0.010-seconds	260.0 degrees/sec

field. When shift time has elapsed, the previous gear is engaged and the engine continues to offer driveline braking (or acceleration if the throttle is depressed).

Shift Up/Down Accuracy and Shift Error Rpm: FastLapSim determines the engine speeds at which the transmission shifts into the next higher or lower gear. The simulation performs a detailed analysis that takes into consideration the position of the vehicle on the track (proximity to the next turn, etc.), whether the vehicle is braking or accelerating, the current transmission gear and ratio, the up/down shift gear ratio and resulting engine speed and vehicle braking or acceleration that would result from changing gears. This analysis is performed at each 0.001-second throughout the race. The simulation places a high priority on finding the best point on the track to down/up shift to maintain engine rpms as close to peak engine torque as possible.

Because of the complexity in determining shift points, specifying the exact shift rpms are not appropriate for FastLapSim. Instead, the simulation uses the values entered in the ***Shift Accuracy*** and ***Shift Error Rpm*** fields to modify the shift points from optimum to produce less-than-perfect shifting performance. ***Shift Accuracy*** indicates a percentage of the time the driver initiates a shift at precisely the correct point on the track. A value of 90% would indicate that the driver shifts precisely 9 out of 10 times. The ***Shift Error Rpm*** field specifies an rpm range within which the driver would shift, centered around the ideal shift point engine speed. Using the previous example, a 90% accurate driver would shift at precisely at the correct shift rpm 90% of the time, and the remaining 10% of the time the driver would shift early or late at an value randomly selected by the simulation within the ***Shift Error Rpm*** range.

Steer Time: This field determines how quickly the driver provides the required steering input. A value of 100 degrees-per-second indicates that the driver is able to turn the steering wheel at a rate of 100 degrees of rotation (a little more than 3/4 of a full turn) within one second. The values can range from 100- to 359.9-degrees/second (from a rate of about 3/4- to 2-turns per second). FastLapSim assumes that lock-to-lock steering is ±45° (90-degrees total). For example, with a Steer Time of 100-degrees/second, the driver can move the wheel from straight-ahead to full-right or full-left lock in 0.45 seconds.

WEATHER Category Menus

THE WEATHER CATEGORY MENUS

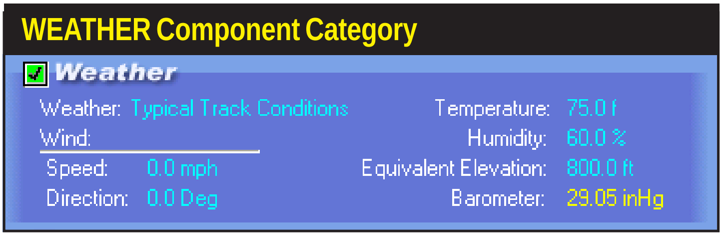
The **WEATHER** component category determines the ambient temperature, humidity and other basic weather conditions that exist during the simulated race. The menu selections and component fields in this category are detailed below:

Weather: This field allows you to select several common weather scenarios that can exist during vehicle testing. Each menu selection loads default values for ***Temperature***, ***Wind***, ***Humidity***, and ***Equivalent Elevation***, simplifying and standardizing vehicle test conditions. In most cases, the selection of ***Typical Race Track Conditions*** from the ***Weather*** menu will produce the most accurate lap-time predictions during daytime conditions at “near-sea-level” race tracks. Optimum, or “track-record” runs can usually be modeled with the ***Excellent Track Conditions*** choice. It is also possible to DirectClick™ on any of the data fields in the **WEATHER** category and enter custom values.

Humidity: Indicates the moisture (water) content of the air. The higher the water content, the less oxygen will be available for combustion. As oxygen content is reduced, engine power output will be factored. In addition, water vapor tends to quench combustion, so it further acts to reduce horsepower. Optimum power is produced at 0% humidity.

Equivalent Elevation: This field accepts the altitude above sea level for the race simulation, assuming the barometric pressure at sea level is 29.92-inches of mercury (see note, below). As altitude is increased, the atmospheric pressure (called barometric pressure) decreases, reducing the oxygen available for combustion. As oxygen content is reduced, engine power output will be factored. Elevation values from -2000 feet (below sea level) to 30,000 feet (above sea level) can be used for testing.

Note: The **Barometric Pressure** displayed in the **WEATHER** category is calculated from ***Equivalent Elevation***. The calculated barometric pressure and the actual barometric pressure at the race track my be quite different. This is due, primarily, to the barometric pressure at sea level varying from the assumed standard of 29.92-inches of mercury. For example, if the actual elevation of a track is 1000ft, an ***Equivalent Elevation*** of 1800ft may be required to reproduce the barometric pressure reading taken at the track at the time of the race. *If the barometric pressure is known, enter an* **Equivalent Elevation** *that reproduces that same barometric pressure to obtain the most accurate simulation results.*



WEATHER Component Category

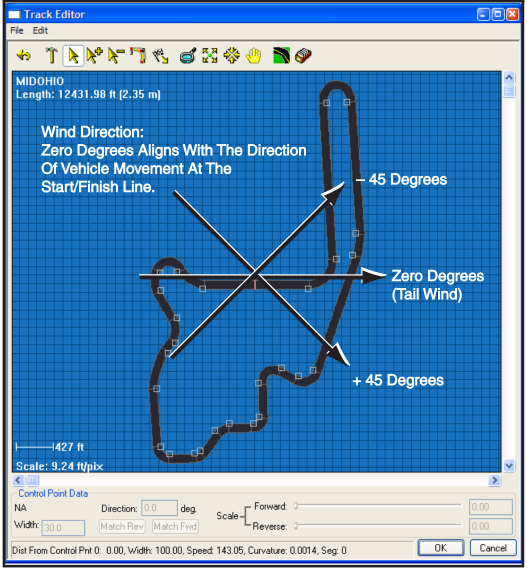
☑ Weather

Weather: Typical Track Conditions
Temperature: 75.0 f
Wind:
Humidity: 60.0 %
Speed: 0.0 mph
Equivalent Elevation: 800.0 ft
Direction: 0.0 Deg
Barometer: 29.05 inHg

The WEATHER component category determines the ambient temperature, humidity and other basic weather conditions that exist during the race.

WEATHER Category Menus

Wind Direction Measurement



Length: 12431.98 ft (2.35 m)

Wind Direction:
Zero Degrees Aligns With The Direction Of Vehicle Movement At The Start/Finish Line.

Scale: 9.24 ft/pix

Direction: 0.0 deg.

Width: 30.0

Forward: 0.00

Reverse: 0.00

Dist From Control Pnt 0: 0.00, Width: 100.00, Speed: 143.05, Curvature: 0.0014, Seg: 0

The *Wind Direction* within FastLapSim is always measured in the direction of the starting line. A zero-degree *Wind Direction* would indicate a direct tail wind on the test vehicle (at the starting line). A +45-degree wind would blow from the upper-left and behind. A ±180-degree wind is a head wind.

Wind Direction and Speed: This data field establishes the ambient wind conditions during the race. ***Wind*** conditions are used to determine overall vehicle drag and side loading. ***Wind Direction*** is relative to the starting line, regardless of the orientation the track. A zero-degree wind direction would indicate a direct tail wind at the starting line. A 45-degree wind would blow from the left and behind. A 180-degree wind is a head wind.

Wind Speed indicates the speed of the prevailing wind. Values from -200 to 200mph are permitted. ***Wind Speed*** is always assumed to be measured directly in line with wind direction.

Temperature: This field accepts the ambient air temperature. In combination with the ***Humidity*** and ***Elevation***, FastLapSim is able to calculate the oxygen content of inducted air. As oxygen content is reduced, engine power output will be factored. The ***Temperature*** field will accept -50°F to +180°F.

THE SIMULATION RESUTS SETUP SELECTIONS

The next section discusses simulation results. Options are provided in the ***Results Setup Dialog*** (select ***Results Setup*** from the **Simulation** pull-down menu; see photo on next page) that allow you to influence how the simulation will perform an analysis of the current vehicle components and track. Here is a short description of these options:

Data Save Interval: The items in this area modify how often results data telemetry is saved during a simulation run.

Fixed Interval: Will save vehicle acquisition data at a fixed time interval. The box sets the amount of time that will pass between each data "snapshot."

Fixed Distance: Will save data at fixed distances. The box specifies the distances for each data "snapshot."

Simulation Optimization: When selected, ***Simulation Optimization*** performs additional calculation to optimize accuracy. Calculation times will increase when this feature is enabled. Note: This is a ***ProTools™*** option only.

Save Simulation Run Data: Enables saving telemetry data displayed in the main data-acquisition graph (in an .FLD file) along with the vehicle/track setup data (in an .FLP file). If the option is unchecked, only the vehicle/track setup data will be saved.

Advanced Options box: These options adjust how the simulation will react to oversteer, understeer, wheelspin, etc. If these maximum values are exceeded during testing, the simulation will make driving adjustments so that the vehicle does not exceed these values, usually by slowing the vehicle.

Max Roll: This is the maximum amount of allowed body roll.

Max Off Line: This value specifies the maximum distance that the vehicle will be allowed to deviate from the "ideal" race line. Limiting this value often limits understeer and oversteer.

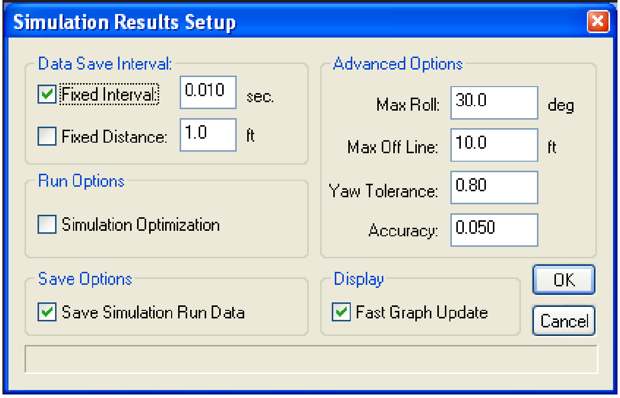
Yaw Tolerance: Yaw measures the difference between the direction in which the vehicle is pointing and the direction in which it is moving. ***Yaw Tolerance*** establishes how much Yaw is permitted in the simulation. A 0.0 tolerance will maintain body yaw very close to the slip-angle limits of the rear tires. A value of 1.0 (maximum value) will allow much greater yaw. In many cases, a ***Yaw Tolerance*** of 0.0 will slow lap times, while larger values may improve performance.

Accuracy: This value determines the precision used to locate braking/steering/acceleration points on the track. The smaller the value, the more accurate the results, but the longer the simulation will take to complete calculations.

Fast Graph Update: If the graph display "flashes" during data playback (as the reticle moves), try changing this option. Video cards respond differently, so turning ***Fast Update*** on or off may provide the cleanest display on your system.

The *Results Setup Dialog* box (select *Results Setup* from the Simulation pull-down menu) allows you to influence how the simulation performs an analysis of the selected vehicle components and track. The default values are often a good compromise between accuracy and calculation time, however, you can change driving characteristics by customizing these choices to suit your requirements.

Results Setup Options



Simulation Results Setup

Data Save Interval:

☑ Fixed Interval: 0.010 sec.

☐ Fixed Distance: 1.0 ft

Run Options

☐ Simulation Optimization

Save Options

☑ Save Simulation Run Data

Advanced Options

Max Roll: 30.0 deg

Max Off Line: 10.0 ft

Yaw Tolerance: 0.80

Accuracy: 0.050

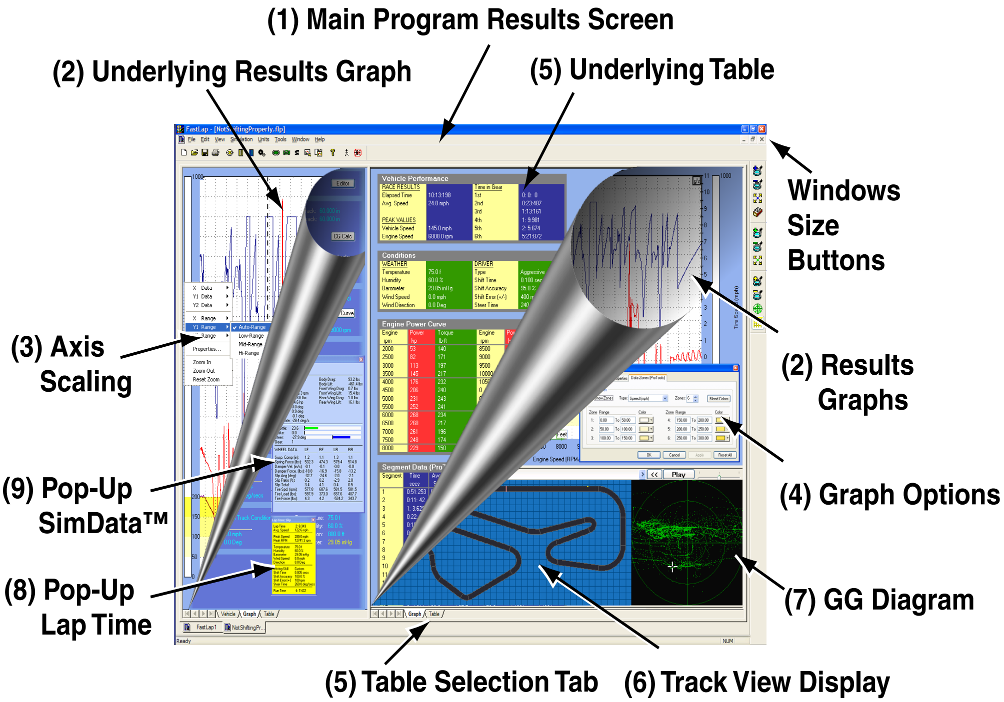
Display

☑ Fast Graph Update

Fast LapSim Racing Software

Advanced Road-Race Simulation

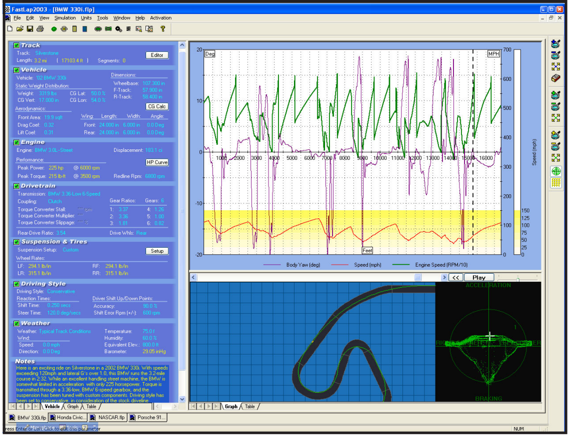
SIMULATION RESULTS



When all the component categories have been completed (all categories have green Status Boxes) you can begin a simulation by selecting ***Run*** from the **Simulation Drop-Down Menu**. Simulation results will be displayed on fully-scalable precision graphs. The default display begins at the start/finish line, marked by the left vertical axis, and continues throughout the course to conclude, once again, at the start/finish line, designated by the right vertical axis. The curves plotted on these graphs are the result of a comprehensive mathematical analysis of the forces acting on the vehicle, at each one-thousandth of a second, as it negotiates the turns and straights of the track. The data graphs are fully customizable and can display virtually any performance variable on any axis. Auto-scaling or manual-axis scaling are easily setup by right-clicking within any graph. And you'll find a comprehensive "table" display of elapsed times and speeds, rpm data, times in each gear, horsepower, torque and

Simulation Results Displays

Upper And Lower Results Screens



Race results are displayed in top-and-bottom screen windows (called panes). The main graph is a *Speed Combo Plot* along with *Lateral Acceleration*. Note the *DataZones*™ within the main graph displaying vehicle speed bands (a *ProTools*™ feature).

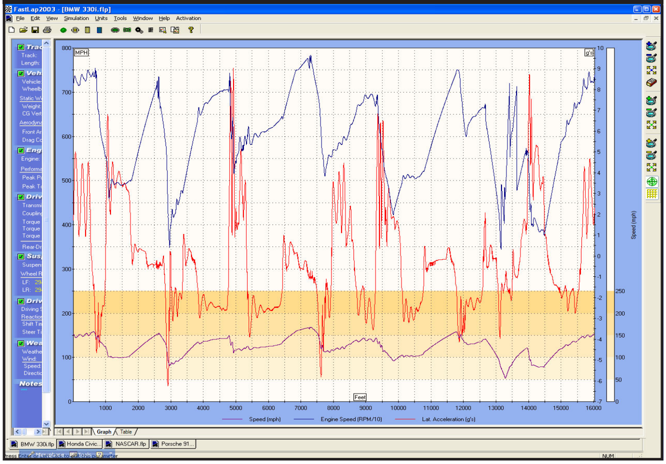
more.

The **Simulation Results** displays, shown on these pages, are composed of several elements that help retrieve the most information from any simulation test. An overview of each of these elements follows:

1) The **Main Program Screen** is divided into three sections (called panes), with the component selection categories on the left and the result displays on the right (by default). The vertical and horizontal dividers between each pane can be moved (click-hold and drag) to increase the size of any results display to suit your requirements. The graphs will redraw and rescale to compensate for changes in display area.

The horizontal and vertical screen dividers can be moved to allow the graph more display area. This screen shows the dividers moved down and to the left to display graph data nearly "full screen."

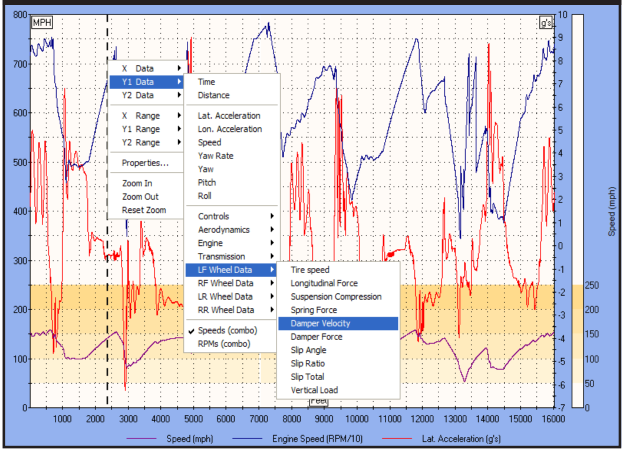
Move Pane Dividers To Increase Graph Detail



Simulation Results Displays

The results graph consists of three axis; a left, right, and bottom (horizontal) axis. Each of these axis can be assigned one or more engine, vehicle, or track data variables. Right click on the graph to display the *Graph Options Submenu* to assign variables to any graph axis (or display one of the *Speed* or *Rpm Combo Plots*). If *ProTools*™ are activated, individual wheel data, such as *Spring Force*, *Slip*, etc., can also be graphed and analyzed.

Graphs Can Be Fully Customized



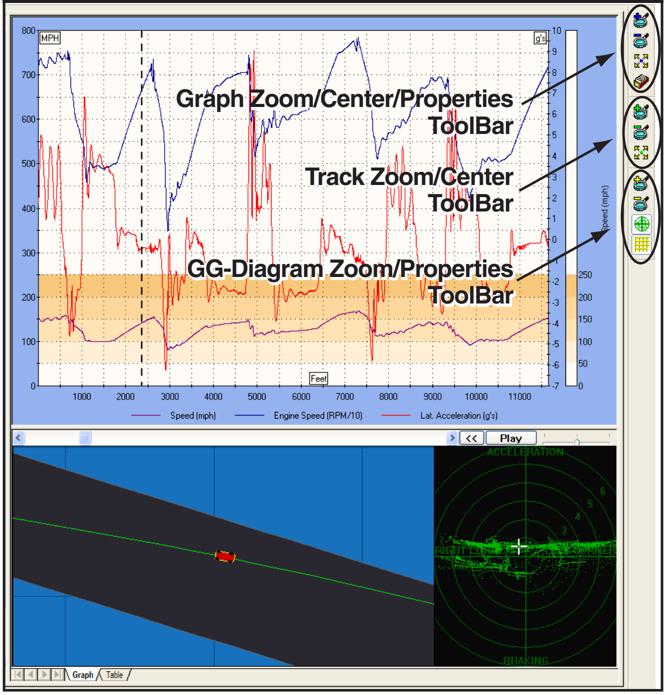
2) The main **Results Graph** consists of three axis, a left and right (vertical), and bottom (horizontal) axis. The upper graph displays (by default) ***Engine Speed*** (rpm), ***Vehicle Speed***, and ***Lateral Acceleration***. The ***Speed Combo Plot*** selected for the Y1 variable includes both vehicle speed and engine speed displayed on the left vertical axis (the curves use the same scale). The ***Lateral Acceleration*** line shows the side-force "Gs" as the vehicle travels throughout the course on the right vertical axis. A reticule line (dotted vertical indicator line) can be used to locate exact positions on the course and analyze performance data at that point. Activate the reticule by left-clicking anywhere on the graph. Click-hold and drag the reticule to any position. As you move the reticule, the Track and GG-Diagram windows remain synchronized to the reticule position. To view the exact data "under" a particular point, open the ***SimData™ Window*** (open the **Tools** drop-down menu and select ***SimData™ Window***).
Note: Each graph axis can be reassigned to at least one other variable. *Right-Click* any graph to display the **Graph Options Submenu** and assign performance data to any graph axis. ***Y1-Data*** is displayed on the left vertical axis; ***Y2-Data*** is displayed on the right vertical axis, and ***X-Data*** is displayed on the horizontal axis.

3) The results graphs support several methods of **Axis Scaling**. Each axis will scale to ***Low***, ***Medium***, ***High***, and ***Auto-Scale*** ranges. When *Auto-Scaling* is turned off, the axis values remain constant, establishing a fixed baseline for direct curve comparison. Small values will display near the bottom of the graph; large values will position curves near the top of the graph or even disappear beyond the top margin. On the other hand, *Auto-Scaling* ensures that the data curves are always visible and display at 80 to 90% of full graph height for maximum resolution. When the same units are displayed on the left and right vertical axis,

Simulation Results Displays

Located to the right of the Results Graph, three Toolbar button groups allow quick and easy adjustments to each of the three Results Displays. The top group controls the *Zoom*, *Centering*, and *Properties* for the main data Graph Display. The central group performs *Zoom* and *Center* functions for the Track Display (lower, left), and the bottom Toolbar group adjusts the *Zoom* and *Properties* of the GG-Diagram. Like all Windows Toolbars, you can drag each of these tool pallets to any location on the Main Program Screen. They can even be "docked" with the main Toolbars above the Component Selection categories.

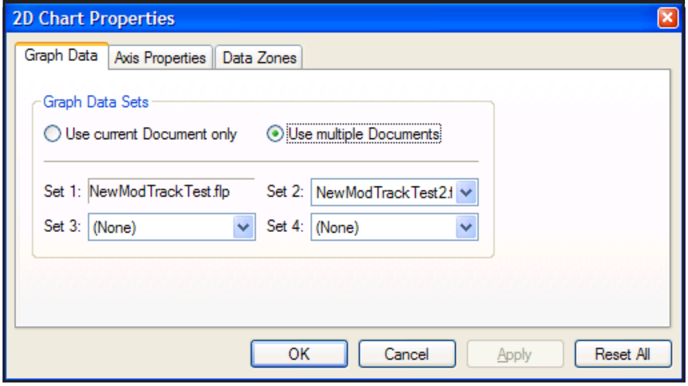
The Results Screen ToolBar Buttons



FastLapSim will use "Intelligent Auto-Scaling" that maintains the same scaling for both axis (scaling values are determined by the minimum and maximum values derived from BOTH curves), making comparisons between data curves easier and more accurate.

4) Right click on the graph to open the **Graph Options Submenu**, then select

Graph Properties—*Graph Data*



Graph Data Sets

○ Use current Document only ● Use multiple Documents

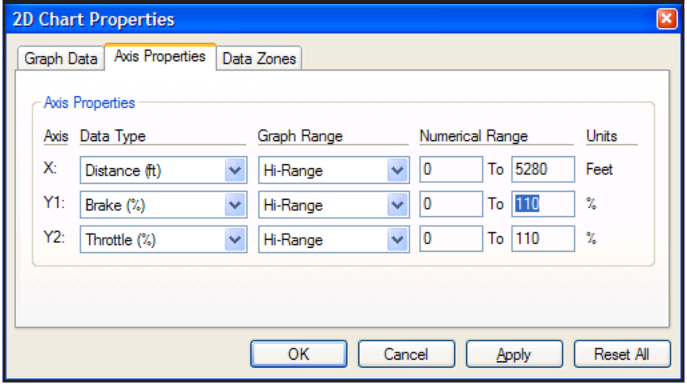
Set 1: NewModTrackTest.flp Set 2: NewModTrackTest2.f

Set 3: (None) Set 4: (None)

Use the *Graph Data Properties* dialog box to establish on-graph comparisons of up to four track/vehicle simulations. Activate the Multiple Document radio button, then select the comparison data from the *Graph Data Sets* drop-down menus.

Simulation Results Displays

Graph Properties—*Axis Properties*



Axis Properties

Axis	Data Type	Graph Range	Numerical Range			Units
X:	Distance (ft)	Hi-Range	0	To	5280	Feet
Y1:	Brake (%)	Hi-Range	0	To	110	%
Y2:	Throttle (%)	Hi-Range	0	To	110	%

The *Axis Properties* dialog box displays the current *Data Type*, *Graph Range*, and *Numerical Range* for the current graph. Change the characteristics of the display by modifying these properties. *(Numerical Range* modification is a *ProTool*-only feature)

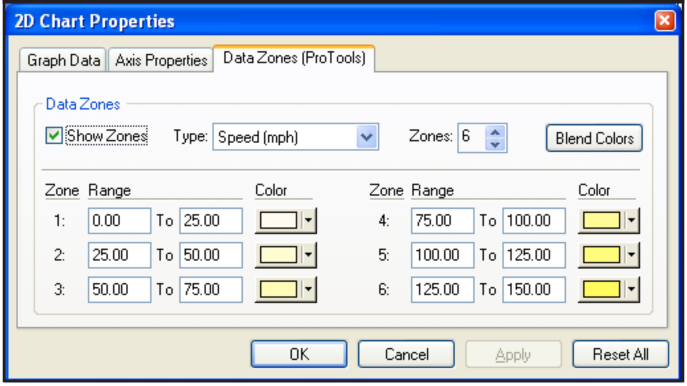
Properties. This will open a dialog box that has allows three tabbed data pages:

Graph Data—Use the **Graph Data Sets** page to establish on-graph comparison of up to four vehicles at once. The vehicles you wish to include in the comparison must be "open," have active tabs in the ***Vehicle Selection Tabs*** at the bottom of the Main Program Screen, and the simulations for all vehicles must be completed. Activate the ***Multiple Document*** mode, then use the ***Graph Data Sets*** drop-down menus to select from currently-open simulations. When you click ***Apply*** or ***OK***, the graph will redraw with the desired data comparisons. A legend at the bottom of the graph provides a key to all graph curves.

Axis Properties—This page indicates the *Data Type* and *Graph Range* for the current display. Change the characteristics of the display by modifying the graph properties drop-down menu selections.

Data Zones™—This ***ProTools™*** feature displays additional data and data-ranges on the graphs (see page 100 for more information on activating optional program features). ***DataZones™*** extend the graphic-display and data-analysis capabilities of FastLapSim. Using this feature, you can display additional vehicle

Graph Properties—*Data Zones (ProTools™)*



Data Zones

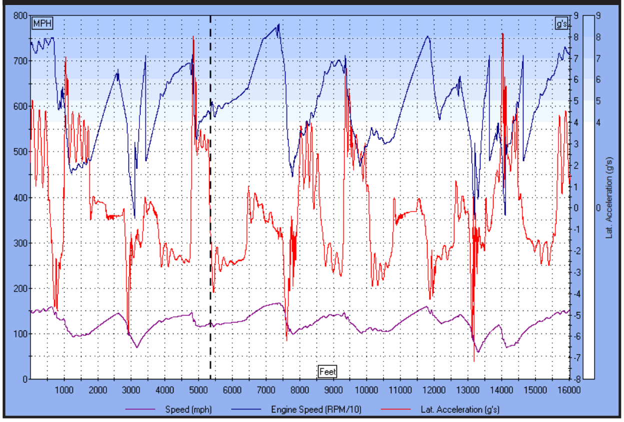
☑ Show Zones   Type: Speed (mph)   Zones: 6

Zone	Range			Color
1:	0.00	To	25.00	🟨
2:	25.00	To	50.00	🟨
3:	50.00	To	75.00	🟨
4:	75.00	To	100.00	🟨
5:	100.00	To	125.00	🟨
6:	125.00	To	150.00	🟨

***DataZones* (*ProTools™*) extend the graphic-display and data-analysis capabilities of FastLapSim. Using this feature, you can display additional data, show ranges, or clearly label excess speeds, acceleration values, and more.**

Simulation Results Displays

DataZones™ Display



This *DataZone* display *(a ProTools™ feature)* shows *Lateral Acceleration* bands drawn on the standard Speed Combo Plot graph. The *DataZone* range values are indicated on the right of the graph, and the banded blue area shows increasing force levels from 4- through 9-G's.

data and/or show ranges for target values or clearly label dangerously high engine speeds, vehicle speeds, excessive aero drag, and more. To setup a *DataZone* display, first select the data that you would like to display from the ***Type*** drop-down menu.

Note: *DataZone* display variables must be the <u>same as</u>, or <u>directly derived from</u>, one of the variables currently displayed on the graph (so that it can share axis scaling). For example, you can display *Speed DataZones* on standard **Speed Combo Plot** graph since *Vehicle Speed* is a variable displayed on one of the axis of the graph, but *Spring Force* cannot be included on the Speed graph since there is no axis for pounds (**Speed Combo Plots** two vertical axis consist of ***G's***, ***Speed***, and ***Engine Speed*** [Rpm] drawn on the speed axis).

Next, select the number of *DataZones* you would like to display by clicking on the "up" or "down" arrows next to the ***Zones*** field. You can modify the ***Range*** values and ***Colors*** for each zone (if you set a starting and ending color, press ***Blend Colors*** to have FastLapSim build a uniform transition between these colors for intermediate zones). Click on ***Apply*** or ***OK*** to draw the specified zones on the main graphic display.

5) In addition to 2D graphing capability described above, a chart (table) display is available by clicking on the ***Table*** tabs located at the bottom of both the Component Selection Category and the Results Display panes. The chart lists a variety of elapsed times, speeds, rpms, driving styles, and weather conditions recorded during the test run. In addition, the power and torque values for the current engine are displayed in 500rpm increments from 2000 to 14,500rpm.

The topmost part of the table shows the full-course race results: ***LapTime*** and ***Average Speed***. The next data points are the **Peak Vehicle Speed** and ***Peak Engine Speed*** (rpm) reached during the lap. ***Elapsed Time In Gear Per Lap*** data can also be found at the top of the table. This indicates the duration of time the transmission was engaged in each gear during the lap (a combination of the

Simulation Results Displays

Table Shows Exact Results

Vehicle Performance

RACE RESULTS		Time in Gear	
Elapsed Time	0:30:305	1st	0: 0: 0
Avg. Speed	123.0 mph	2nd	0: 0: 0
		3rd	0:13:926
PEAK VALUES		4th	0:16:389
Vehicle Speed	160.2 mph	5th	0: 0: 0
Engine Speed	9003.1 rpm	6th	0: 0: 0

Conditions

WEATHER		DRIVER	
Temperature	75.0 f	Type	Aggressive
Humidity	60.0 %	Shift Time	0.100 secs
Barometer	29.05 inHg	Shift Accuracy	95.0 %
Wind Speed	0.0 mph	Shift Error (+/-)	400 rpm
Wind Direction	0.0 Deg	Steer Time	240.0 deg/secs

Engine Power Curve

Engine rpm	Power hp	Torque lb-ft	Engine rpm	Power hp	Torque lb-ft
2000	93	244	8500	841	520
2500	179	376	9000	810	473
3000	233	408	9500	750	415
3500	262	393	10000	625	328
4000	345	453	0	0	0
4500	443	517	0	0	0
5000	538	565	0	0	0
5500	622	594	0	0	0
6000	690	604	0	0	0
6500	748	604	0	0	0
7000	785	589	0	0	0
7500	833	583	0	0	0
8000	849	557	0	0	0

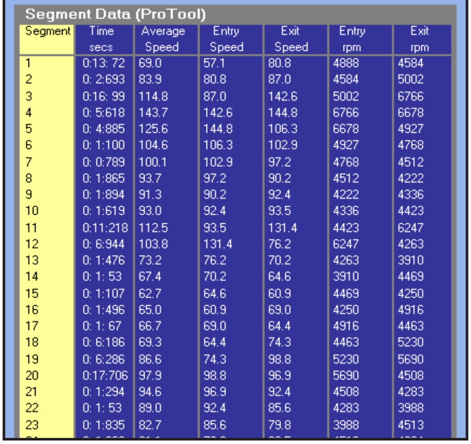
In addition to 2D graphing, FastLapSim offers a table display, available by clicking the "Table" tabs located at the bottom of the *Component Screen* and the *Results Displays*. The chart lists a variety of elapsed times, speeds, rpms, driving styles, and weather conditions recorded during the test run. In addition, the exact power and torque values for the current engine are displayed in 500rpm increments from 2000 to 14,500rpm.

acceleration and deceleration times). The two groups of data just above the ***Engine Power*** table display the ***Weather Conditions*** and the ***Driving Skills*** that were used during the lap test.

Note: If you have activated the ***ProTools***™ features of FastLapSim (see page 100 for more information on optional program features), you can display a table of performance data recorded for each track segment that you define. For information on using track-segments, refer to the ***Track Editor***, on page 69).

6) The **Track View Display** provides an overhead view of the track and the test

***ProTools*™ Segment Data Analysis**



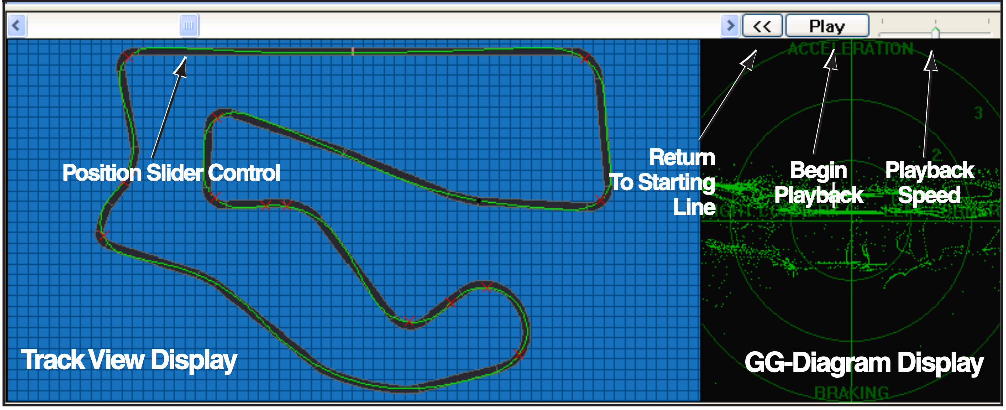
Segment Data (ProTool)

Segment	Time secs	Average Speed	Entry Speed	Exit Speed	Entry rpm	Exit rpm
1	0:13: 72	69.0	57.1	80.8	4888	4584
2	0: 2:693	83.9	80.8	87.0	4584	5002
3	0:16: 99	114.8	87.0	142.6	5002	6766
4	0: 5:618	143.7	142.6	144.8	6766	6678
5	0: 4:885	125.6	144.8	106.3	6678	4927
6	0: 1:100	104.6	106.3	102.9	4927	4768
7	0: 0:789	100.1	102.9	97.2	4768	4512
8	0: 1:865	93.7	97.2	90.2	4512	4222
9	0: 1:894	91.3	90.2	92.4	4222	4336
10	0: 1:619	93.0	92.4	93.5	4336	4423
11	0:11:218	112.5	93.5	131.4	4423	6247
12	0: 6:944	103.8	131.4	76.2	6247	4263
13	0: 1:476	73.2	76.2	70.2	4263	3910
14	0: 1: 53	67.4	70.2	64.6	3910	4469
15	0: 1:107	62.7	64.6	60.9	4469	4250
16	0: 1:496	65.0	60.9	69.0	4250	4916
17	0: 1: 67	66.7	69.0	64.4	4916	4463
18	0: 6:186	69.3	64.4	74.3	4463	5230
19	0: 6:286	86.6	74.3	98.8	5230	5690
20	0:17:706	97.9	98.8	96.9	5690	4508
21	0: 1:294	94.6	96.9	92.4	4508	4283
22	0: 1: 53	89.0	92.4	85.6	4283	3988
23	0: 1:835	82.7	85.6	79.8	3988	4513

The *ProTools*™ option also activates a comprehensive table of track segment data. For information on how to use track segments, refer to the Track Editor Chapter, page 69).

Simulation Results Displays

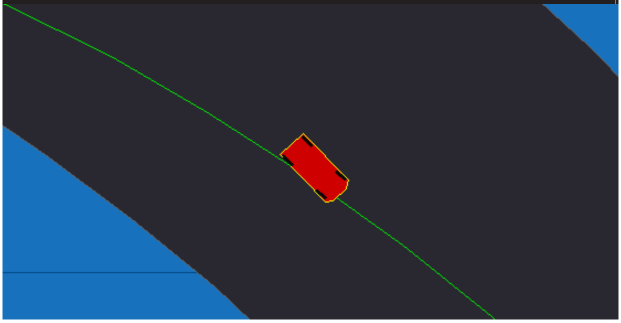
Track View Display And Controls



The Track View Display provides an overhead view of the track and the test vehicle. The position of the vehicle on the track is synchronized with the reticule on the main data display. Move through the course by dragging the graph reticule, moving the Position Slider, or by pressing the *Play* button just above the *GG-Diagram Display*.

vehicle. The track and vehicle are drawn to scale, and the vehicle reflects the current wheelbase and wheel-track widths. Use the track View Toolbar on the right of the Main Program Screen (see page 62) to zoom in and out and center the Track. The position of the vehicle on the track is synchronized with the reticule position on the main data display (display the reticule on the data graph by left-clicking anywhere on the graph). You can move through the course in three ways: 1) Move (left-click-hold, then drag) the reticule on the data graph to any position, 2) Move the ***Slider Control*** located just above the Track View, or 3) Press the ***Play*** button just above the *GG-Diagram Display* (discussed next). If you use the ***Play*** feature, you can adjust playback speeds using the small slider control to the right of the ***Play*** button. The center position (default) will playback at realtime speeds; move the slider to the left to slow playback or to the right to speedup vehicle movement faster than realtime. The small button located to

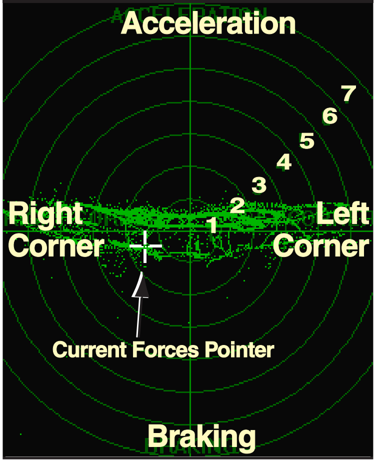
Track Vehicle Representation



Not only is the position of the test vehicle synchronized with the data-graph reticule, it is drawn true-to-scale, with accurate wheelbase and track widths. Press the *Play* button and "go for a ride" around the track in realtime. The cornering and braking points and speeds have been optimized by FastLapSim, based on the current component selections.

Simulation Results Displays

GG-Diagram Display



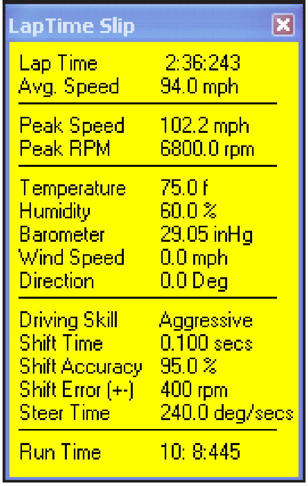
The GG-Diagram is comprised of single dots, each representing the total force applied to the test vehicle at on instant in time. Braking forces are shown as dots below the horizontal centerline. Cornering forces map dots to the left or right of the vertical centerline, and acceleration forces fall above the horizontal centerline. The crosshair indicator locates the dot that represents the total force and its direction applied to the test vehicle at the current instant in time. In this example, the crosshair is located below the horizontal centerline, to the left of the vertical centerline. This indicates that the vehicle is experiencing braking and right-cornering forces with a magnitude of about 1.5-G.

the left of ***Play*** will reset the playback to the beginning of the test lap (to the ***Start/Finish Line***). Open the ***SimData™ Window*** (discussed below) to view exact telemetry data for the current vehicle position.

7) The **GG Diagram Display** displays the instantaneous sum of all forces acting on the test vehicle recorded at every 0.001-second as the vehicle moves through the course. The sum of the forces (added using vector math) produces a total resulting force and a direction in which that force is acting. The image in the GG-Diagram is made up of dots, each positioned at the tip of one of these force/direction arrows. For example, if a vehicle experiences a 2-G braking force on a straight section of track, this force acts directly in line with vehicle movement (along the vertical centerline of the GG-Diagram), but it acts to reduce forward movement (the head of the arrow points down). The braking force for this example would be displayed as a dot below the horizontal centerline, directly on the vertical centerline, positioned at the 2-G-ring location. The GG-Diagram displays cornering forces as dots positioned to the left or right of the vertical centerline. Acceleration is mapped as dots above the horizontal centerline. The crosshair indicator locates the single dot that represents the total force applied to the test vehicle at that instant in time. The GG-Diagram shows all of the thousands of recorded force vectors measured throughout the test lap as a scatter-diagram. **Note:** The GG-Diagram is a powerful way to obtain an at-a-glance overview of vehicle performance. For a chassis that is set up well, combined with an experienced and consistent driver, the dot pattern will congregate around the “circle” of maximum tire traction. In most cases, however, the dot pattern will spread out around the diagram, but it still should show the “average” level of performance for both the vehicle and driver.

Simulation Results Displays

PopUp LapTime™

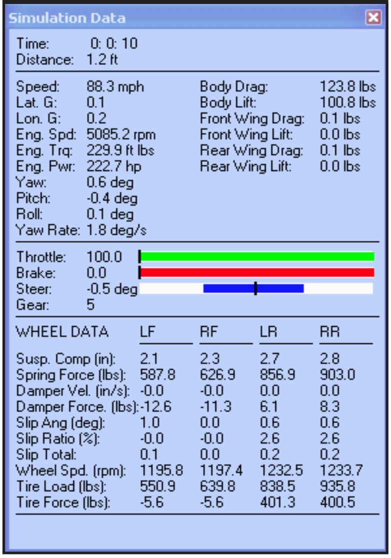


LapTime Slip

Lap Time	2:36:243
Avg. Speed	94.0 mph
Peak Speed	102.2 mph
Peak RPM	6800.0 rpm
Temperature	75.0 f
Humidity	60.0 %
Barometer	29.05 inHg
Wind Speed	0.0 mph
Direction	0.0 Deg
Driving Skill	Aggressive
Shift Time	0.100 secs
Shift Accuracy	95.0 %
Shift Error (+-)	400 rpm
Steer Time	240.0 deg/secs
Run Time	10: 8:445

A *PopUp LapTime™ Window* can be displayed by clicking on the *LapTime™ Icon* in the toolbar or by selecting *LapTime™ Window* from the Tools menu. The *LapTime™* display provides a quick overview of vehicle performance and testing conditions. It can be moved to any convenient position on the Main Program screen.

PopUp SimData™



Simulation Data

Time: 0: 0: 10
Distance: 1.2 ft

Speed:	88.3 mph	Body Drag:	123.8 lbs
Lat. G:	0.1	Body Lift:	100.8 lbs
Lon. G:	0.2	Front Wing Drag:	0.1 lbs
Eng. Spd:	5085.2 rpm	Front Wing Lift:	0.0 lbs
Eng. Trq:	229.9 ft lbs	Rear Wing Drag:	0.1 lbs
Eng. Pwr:	222.7 hp	Rear Wing Lift:	0.0 lbs
Yaw:	0.6 deg		
Pitch:	-0.4 deg		
Roll:	0.1 deg		
Yaw Rate:	1.8 deg/s		

Throttle: 100.0
Brake: 0.0
Steer: -0.5 deg
Gear: 5

WHEEL DATA	LF	RF	LR	RR
Susp. Comp (in):	2.1	2.3	2.7	2.8
Spring Force (lbs):	587.8	626.9	856.9	903.0
Damper Vel. (in/s):	-0.0	-0.0	0.0	0.0
Damper Force. (lbs):	-12.6	-11.3	6.1	8.3
Slip Ang (deg):	1.0	0.0	0.6	0.6
Slip Ratio (%):	-0.0	-0.0	2.6	2.6
Slip Total:	0.1	0.0	0.2	0.2
Wheel Spd. (rpm):	1195.8	1197.4	1232.5	1233.7
Tire Load (lbs):	550.9	639.8	838.5	935.8
Tire Force (lbs):	-5.6	-5.6	401.3	400.5

The *PopUp SimData™ Window* displays the exact data values for the current reticule position (note that the *Track View* and the *GG-Diagram* windows are also synchronized to the reticule position). The values displayed in this window are updated in realtime when you replay telemetry data (by pressing the *PLAY* button located above the GG-Diagram). Like the *LapTime™ Window*, it can be positioned anywhere on the Main Program screen.

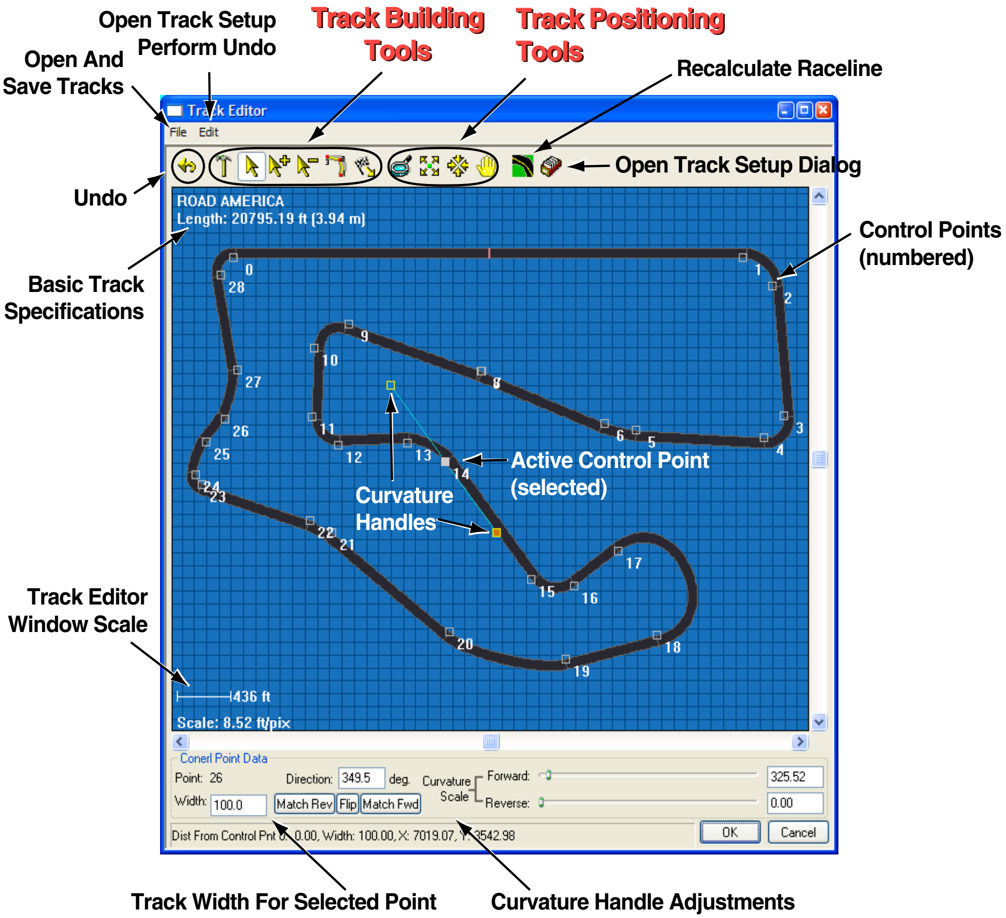
8) A ***PopUp LapTime™ Window*** is available by clicking on the ***LapTime™* Icon** in the **Toolbar** or by selecting ***LapTime™ Window*** from the **Tools** menu. The pop-up ***LapTime™ Slip*** provides a quick overview of vehicle performance; it can be moved to any convenient position on the Main Program screen. The ***LapTime™ Window*** displays performance data for the currently-selected vehicle (as indicated by the **Vehicle Selection Tab** currently highlighted at bottom of program screen).

9) A ***PopUp SimData™ Window*** is available by clicking on the ***SimData™* Icon** in the **Toolbar** or by selecting ***SimData™ Window*** from the **Tools** menu. The ***SimData™ Window*** displays the exact data values for the current reticule position on the data graph (note that the Track view and the GG-Diagram windows are also synchronized to the reticule position). The ***SimData™ Window*** displays performance data for the currently-selected vehicle (as indicated on the **Vehicle Selection Tab** currently highlighted at bottom of program screen).

Fast LapSim Racing Software

Advanced
Road-Race
Simulation

THE TRACK EDITOR



ROAD AMERICA
Length: 20795.19 ft (3.94 m)

Scale: 8.52 ft/pix

Conerl Point Data

Point: 26

Direction: 349.5 deg.

Curvature Scale Forward: 325.52

Reverse: 0.00

Width: 100.0

Dist From Control Pnt 0: 0.00, Width: 100.00, X: 7019.07, Y: 3542.98

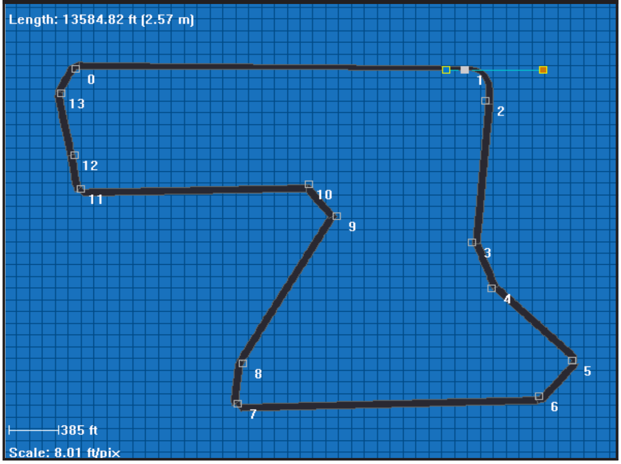
THE TRACK EDITOR—AN OVERVIEW

While FastLapSim is a powerful simulation, the usefulness of this technology would be limited if it could only model a few dozen of the most popular tracks and courses. The ***Track Editor*** built into FastLapSim addresses this issue and makes it possible

The *Track Editor*

The *Track Editor* built in to FastLapSim allows you to build any track you can dream up, from super speedway to parking-lot autocross using a *what-you-see-is-what-you-get* interface. The *Track Editor* will draw the track for you, turn by turn. After building the basic framework, use the built-in editing tools to fine tune each element of the track (note the corner radius adjustment being made on Corner Point #1). When complete, you're ready to test any vehicle on the newly-built track.

Building A Track By Placing Corner Points



Length: 13584.82 ft (2.57 m)

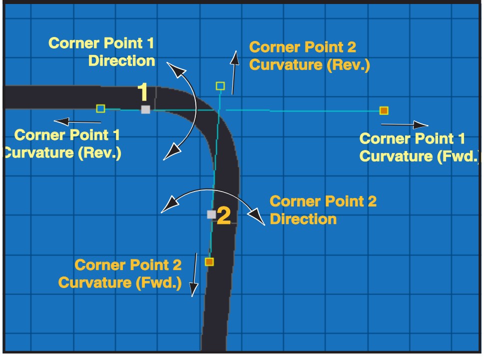
Scale: 8.01 ft/pix

to build any track you can imagine using a *what-you-see-is-what-you-get* interface. Determine the radii of the turns and the length of the straightaways, then simply click the location for each *Control Point* on a precision background grid. The *Track Editor* will draw the track for you, turn by turn. After building the basic framework, use the built-in editing tools to fine tune each element of the track. When this process is complete, you're ready to test any vehicle on the newly-built track. The *Track Editor* lets you create any track you can dream up, from super speedway to parking-lot autocross.

HOW IT WORKS

The *Track Editor* uses a drawing technique called vector graphics. Vector drawings define the transitions between turns and straightaways with ***Corner Points***. Each Corner Point not only marks a transition in the track, but also it determines the initial radius (curvature) and direction of the turn. These dimensions are indicated with

***Vector Graphic* Drawing Elements**



The *Track Editor* uses vector graphics to define the transitions between turns and straightaways. *Corner Points* mark a transition in the track and determines the initial radius (curvature) and direction of the turn. These dimensions are indicated with curvature handles; the longer the handles, the greater the radius; and the direction of the handles dictate the direction of the turn. While this technique may seem complex, after you have constructed a few tracks, you will soon feel comfortable placing corner points and curvature handles.

curvature handles; the longer the handles, the greater the radius; and the direction of the handles dictate the direction of the turn. While this technique may seem complex, after you have constructed a few tracks, you will soon feel comfortable placing corner points and curvature handles. In fact, this technique offers both high precision and easy adjustment, and building even complex tracks in the *Track Editor* can be accomplished quickly.

You may find it helpful to read through this entire chapter before using the *Track Editor*. On the other hand, if you would like to “play” with the drawing tools and functions as you learn, you can either build a track from scratch or open one of the tracks supplied with FastLapSim and modify it by moving or adding corner points and adjusting curvature handles.

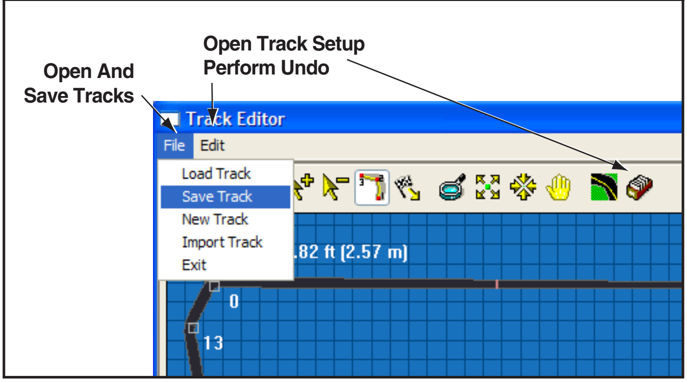
FIRST THINGS FIRST—SAVING & OPENING TRACK FILES AND THE TRACK-SETUP WINDOW

Before exploring Track Editor construction tools, two important topics need to be covered. The first is the use of ***File Open*** and ***Save*** functions available from the ***File*** drop-down menu (note: saved track files are automatically given a ***.TK*** extension and stored in the ***Track Files (.TK)*** directory). Use ***File Save*** to regularly back up your work as you build and modify tracks. Saving ensures that a backup is available if unwanted track modifications cannot be undone. While the Track Editor includes a powerful ***Undo*** function, play it safe and regularly save your work. The ***File*** drop-down menu also provides an ***Open File*** command that loads track files included with FastLapSim and tracks that you have created and saved. The Track Editor searches the ***Track files (.TK)*** directory (by default) for valid track files.

In addition to the *File Open* and *Save* functions, there are several important Track Editor defaults that should be reviewed before you build a track. Open the ***Track Setup*** window from the ***Edit*** drop-down menu or click the ***Track Setup*** icon in the Toolbar. The following groups are available within the *Track Setup* dialog:

The ***Description Group,*** located at the top of the *Track Setup* dialog, includes

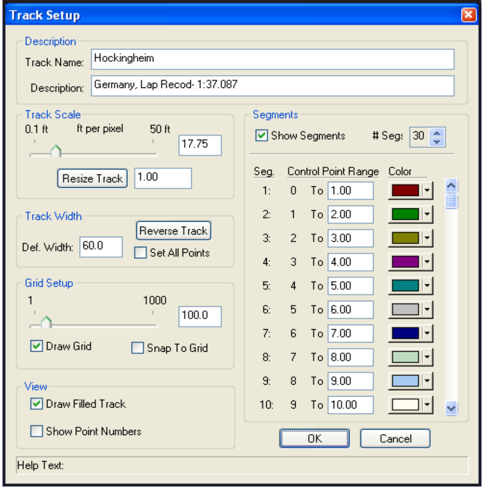
Opening And Saving Track Files (.TK)



Use *File Save Track* to regularly back up your work. Saving ensures that a backup is available if unwanted track modifications cannot be undone. The *File* drop-down menu also provides an *Open File* command that loads track files included with FastLapSim and tracks that you have created and saved.

The *Track Editor*

The Track Editor Setup Dialog



Track Setup

Description

Track Name: Hockingheim

Description: Germany, Lap Recod- 1:37.087

Track Scale (0.1 ft – 50 ft, ft per pixel): 17.75

Resize Track: 1.00

Track Width

Def. Width: 60.0

☐ Set All Points

Grid Setup (1 – 1000): 100.0

☑ Draw Grid

☐ Snap To Grid

View

☑ Draw Filled Track

☐ Show Point Numbers

Segments

☑ Show Segments

Segs: 30

Seg.	Control Point Range			Color
1:	0	To	1.00	🟥
2:	1	To	2.00	🟩
3:	2	To	3.00	🟨
4:	3	To	4.00	🟪
5:	4	To	5.00	🟦
6:	5	To	6.00	⬜
7:	6	To	7.00	🟦
8:	7	To	8.00	🟩
9:	8	To	9.00	🟦
10:	9	To	10.00	⬜

Help Text:

Important Track Editor defaults can be found in the *Track Setup* window. Open the *Track Setup* from the *Edit* drop-down menu or click the *Track Setup* icon in the Toolbar (on the right end of the icon group). The track Segments is a ProTool™ allows you to analyze vehicle entrance and exit speeds, average speeds through segments (up to 30 segments can be defined), and other performance data.

two fields: 1) Text entered in the ***Track Name*** field will be displayed on the Track Editor construction screen and in the **TRACK** Component Category, and 2) The ***Description*** field accepts any further descriptive text (entry here is optional).

The ***Track Scale Group*** provides a slider that establishes the scale of track display from 0.1- to 50.0-feet-per-pixel (this scale can also be set easily from within the Track Editor construction window).

The ***Track Width Group*** sets the ***Default Width*** for each Corner Point added to a track, also changes the ***Width*** of any selected Corner Point. By selecting ***Set All Points***, you can force the Track Editor to set all Corner Points on the current track to the ***Default Width***. The ***Reverse Track*** button will reverse the order of all Corner Points and Directions, reversing the direction of vehicle movement on the track. After using this feature, you may have to fine-tune some Corner Points to reestablish correct/optimum Directions and Curvatures.
Note: The ***Undo Tool*** does not undo a ***Reverse Track*** operation, however, you can apply a second ***Reverse Track*** operation to Undo the first track reversal.

The ***Grid Setup Group*** includes a slider that determines spacing between background grid lines. Set any scale from 1- to 1,000-feet per grid line. This group also includes two check boxes: 1) Click the ***Draw Grid*** box to display the background grid, and 2) Click the ***Snap To Grid*** box to force Corner Points to align with background gridlines (helpful during track construction).

The ***View Group*** includes two check boxes: 1) The ***Draw Filled Track*** box (checked by default) displays the Track as a filled-in "road," rather than two thin guard rails, and 2) The ***Show Point Numbers*** box allows you to choose whether to display sequential numbers for the Corner Points.

Finally, the ***Segments Group*** (a ***ProTools***™ feature, see *Product Activation* on page 100) defines portions of the track as segments. Segments always begin and end at Corner Points. Once defined, a segment can be used to analyze vehicle entrance and exit speeds, average speeds, and other performance data. To activate segments, click the ***Show Segments*** box and select the number of segments with the arrows in the ***# Segs*** field. Optionally, choose a color for each segment, making it easy to visually identify segments. Up to 30 segments can be defined for each track.

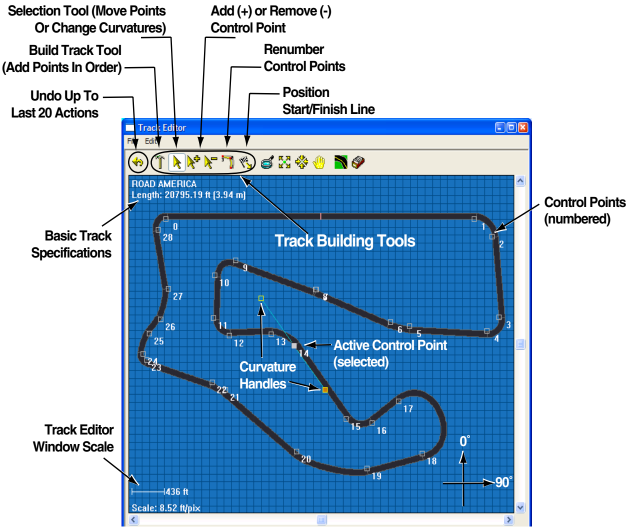
TRACK EDITOR TOOLS

To quickly and accurately build and modify tracks, a thorough understanding of each Track Editor tool is essential. Each tool is selected by clicking an icon in the Toolbar located at the top of the Track Editor window. As each tool is selected the appropriate icon is highlighted. Tools are organized in two main groups. The *Track Building Group* contains six icons, and each performs a unique track building and/or modifying function:

The ***Build Track Tool*** is the first icon in the *Track Building Group*. Use this tool to build a track, Corner Point by Corner Point, in order, from scratch. Click on the construction window to place the first point. It will automatically be numbered zero. Note that when you click to locate the second point, the Track Editor will establish the direction (from the zero to the one point) that

An understanding of each Track Editor tool is essential to working accurately and efficiently in the Track Editor environment. Each tool is selected by clicking an icon in the Toolbar. As each tool is selected the appropriate icon is highlighted. Tools are organized in two main groups. The *Track Building Group* (shown here) and the *Track Positioning Group* (described later).

Tools For Building A Track



vehicles will race on the track. As soon as you click the location of the third point (all tracks must have at least three points), the Track Editor will draw the track between all points using the default width specified in the *Track Setup* dialog. If you insert a Corner Point at the wrong location, either click the ***Undo Tool*** or use the ***Selection Tool*** to reposition the Point (the *Undo* and *Selection Tools* are discussed below).

The ***Selection Tool*** is used to adjust the location of Corner Points and the length and direction of their curvature handles. Click on any Corner Point to highlight the point. Click on the forward or reverse curvature handles to drag them to a new length or direction. Position the ***Selection Tool*** directly over a Corner Point to activate the move function (indicated by a four-headed cursor arrow). Left-click and drag the Corner Point to a new location. Click anywhere on the background grid to deselect all points.

The ***Add Point Tool*** will add a new Corner Point at any location. The Track Editor will insert the new Corner Point within the closest track segment. After the point has been inserted, the ***Add Point Tool*** will automatically deselect and the cursor will revert to the ***Selection Tool***. If you insert a new Corner Point at the wrong location, click the ***Undo Tool*** to remove the Point and return the track to its previous condition (the *Undo Tool* is discussed below). Use the ***Selection Tool*** (described above) to fine-tune the position of the new Corner Point.

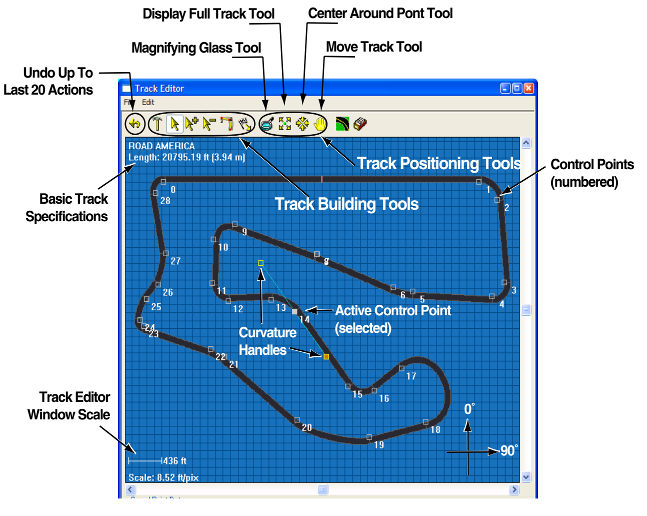
The ***Remove Point Tool*** deletes an existing Corner Point on the track. Like the ***Add Point Tool***, the *Remove Tool* will automatically deselect and the cursor will revert to the ***Selection Tool*** after a Corner Point has been deleted. If you delete the wrong Corner Point, click the ***Undo Tool*** to restore the Corner Point and return the track to its previous condition.

The ***Reorder Points Tool*** is used to reorganize how the track is drawn from Corner Point to Corner Point. If the Points are in the correct location, but the track has been drawn incorrectly, the ***Reorder Point Tool*** can be used to renumber the drawing sequence. When this tool is selected, the *Show Point Numbers* option (available in the Track Setup dialog) is activated. Use the *Reorder Tool* by clicking on the last correctly ordered Corner Point; this begins a new counting sequence from that point number. Next, click on each subsequent point in the new desired order. The track will automatically redraw to the new Point numbering system. If you click on the wrong Corner Point, used the ***Undo Tool*** to restore the previous Point number, then continue reordering Corner Points. The ***Reorder Point Tool*** remains selected until you select another tool in the Track Editor.

The location of the Start/Finish Line is set using the ***Start/Finish***

The *Track Editor*

Tools For Positioning/Zooming The Track



The *Track Positioning Group* provides a set of four tools (the *Magnifying Glass*, *Display Full Track*, *Center Around Point*, and the *Move Track Tool*), each performing a unique track positioning/zooming function.

Tool. Select this tool from the Toolbar and click anywhere on the track to position the Start/Finish Line. Like the *Add Point Tool*, the ***Start/Finish Tool*** will revert to the ***Selection Tool*** after the Start/Finish Line has been located. If you click on the wrong location, either use the *Undo Tool* or, simply, use this tool again to reposition the Start/Finish line.

The next set of tools in the Track Editor Toolbar is the *Track Positioning Group.* This toolset contains four icons, each performing a unique track positioning/zooming function:

The ***Magnifying Glass Tool*** will zoom in or out on any portion of the track display. This tool remains selected until another tool is used. The ***Magnifying Glass Tool*** zooms-in by default and switches to a zoom-out function when the *Control Key* is depressed. In addition, you can click and drag a selection in the Track Construction Window and the ***Magnifying Glass Tool*** will display the selected area as large as possible. To return to a standard full-track display, use the ***Display Full Track Tool*** (discussed next).

The ***Display Full Track Tool*** re-sizes the display to the horizontal or vertical margins of the track, centering the track within the window. This tool can be used with any other tool in the Track Editor Toolbar, since it does not remain selected. Using the ***Display Full Track Tool*** centers the full-track within the window and immediately returns selection to the previously active tool. To center the track around a particular Corner Point, use the ***Center Around Point Tool*** (discussed next).

The *Track Editor*

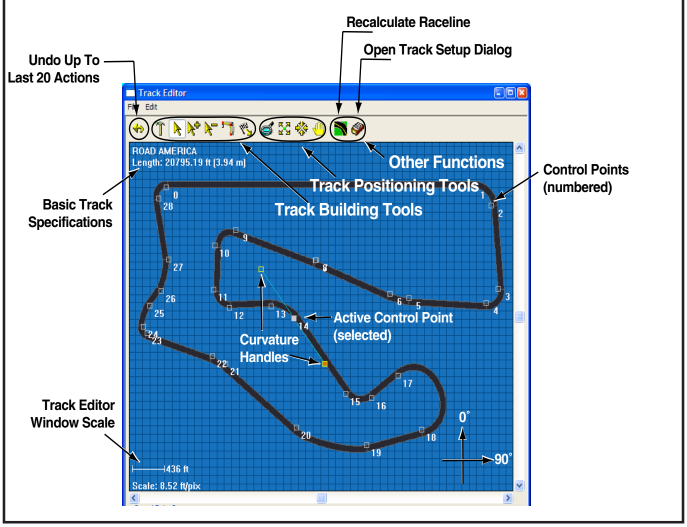
The ***Center Around Point Tool*** provides an easy way to position any *selected* Corner Point in the middle of the construction window. This allows easier *Curvature-Handle* and *Corner-Point* adjustments. To use this tool, first select any Corner Point on the track (using the *Selection Tool*), then click on the ***Center Around Point Tool***, and the track will be repositioned so that the selected Point appears in the center of the construction window (at current magnification). Like the *Display Full Track Tool*, this tool can be used with any other tool in the Track Editor Toolbar, since it does not remain selected. Using the ***Center Around Point Tool*** centers the track around the selected Corner Point and immediately returns selection to the previously active tool.
Note: If no Corner Point is selected when this tool is activated, the track will be *centered* in the display window at the current magnification.

The ***Move Track Tool*** (represented by a hand) "grabs" the track and lets you to position it anywhere within the Track Editor construction window. The tool is activated by clicking the ***Move Track Tool*** icon, then holding the left mouse button depressed while you drag the track to a new location. The ***Move Track Tool*** remains at selected until another tool is chosen.

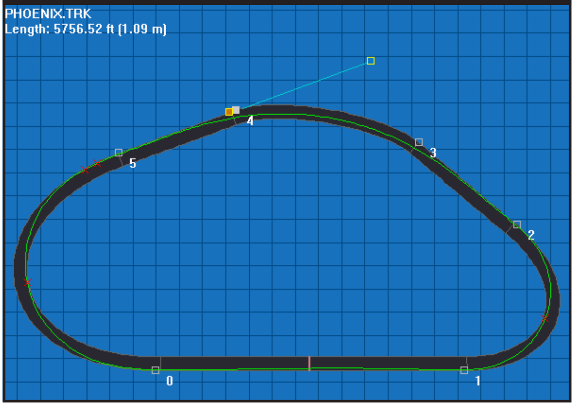
One of the most important tools in the Track Editor Toolbar is the ***Undo Tool***. This tool will undo any operation performed by any of the above tools. Clicking the ***Undo Tool*** multiple times *will undo up to the last 20 changes* made in the track display. Using this tool, along with regular ***File Save*** operations (see page 71), will minimize the likelihood of loosing any work that you've invested in building and modi-

A third set of tools is performs "other" functions. These two tools include *Calculate Raceline* that displays the optimum driving path that vehicles try to maintain on the track, and the *Track Setup Dialog* that provides a convenient shortcut to the *Track Setup Dialog* window (where you can set several track-building default values).

Tools For Performing Other Functions



Calculate Raceline



PHOENIX.TRK
Length: 5756.52 ft (1.09 m)

The *Calculate Raceline* tool performs one of the most complex functions within FastLapSim. An ideal raceline allows the vehicle to accelerate as soon and as long as possible, brake as late as possible, and traverse a corner at the largest possible radius. The raceline is displayed as a green path on the track.

fying track files.

The final set of tools in the Track Editor Toolbar are located in the *Other Functions Group.* The two icons include ***Calculate Raceline*** that determines the optimum driving path that vehicles try to maintain on the track, and the ***Open Track Setup Dialog*** that provides a convenient shortcut to the *Track Setup Dialog* window (see page 71):

Calculate Raceline performs one of the most complex functions within FastLapSim. An ideal raceline will allow the car to accelerate as soon and as long as possible, brake as late as possible, and traverse a corner at the largest possible radius. FastLapSim uses two techniques to derive this solution. First, a raceline is approximated by a series of points, at which the curvatures or corner radii are calculated and default lanes (several possible paths across the track) are assigned. The next step iterates lane assignments (performs multiple tests) modifying paths and recalculating the curvatures until the most linear (shortest) path through the track has been found. Once this path is computed, the theoretical maximum speed through each point is determined, assuming speed is limited by peak tire grip. When this step is complete, a new series of calculations analyze the computed speeds and radii to determine where braking should begin. The last computation cycle uses a Gradient Descent technique to optimize the calculated path. As this is performed, the path is modified slightly, and the lap times are estimated. If the new path proves to be an improvement, its specifications are retained, if it is not the quickest path through the track, the entire process is repeated until there is a convergence upon an optimal path. Raceline calculation requires millions of mathematical operations, however, it only requires about two seconds of calculation time on 1GHz or faster processors.

Track Setup opens the *Track Setup Window* used to establish several important Track Editor defaults. See page 71 for a complete description of the Track Editor Setup window.

BUILDING YOUR FIRST TRACK

The next section in this chapter provides an in-depth look at the complete process of building a complex track using the Track Editor. However, if you have never used the Track Editor, we recommend that you review the following step-by-step procedures for building a simple track. This tutorial will help you become familiar with basic track-editing tools, and the experience you gain here will help you tackle more complex track construction projects (like the Portland International Raceway Track constructed in the next section).

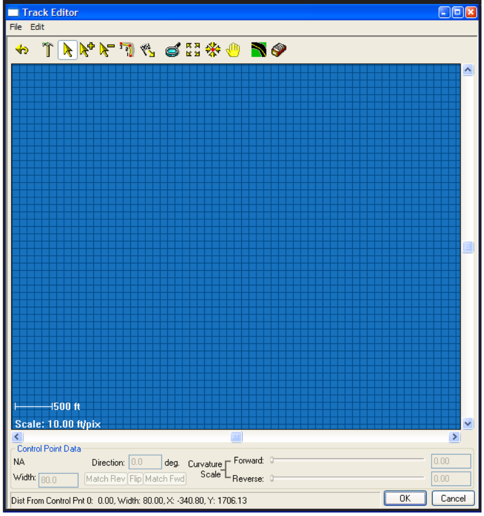
The following steps will detail process of constructing a simple Tri-Oval track. For the purposes of this tutorial, the dimensions of any real-world track are not duplicated, rather the intention is to focus on the construction process and using specific tools in the Track Editor. It is not important that the track you build look exactly like the one illustrated on these pages. However, despite any differences that might exist, your Tri-Oval track should be fully usable within FastLapSim to test any vehicle.

Note: This section assumes that you have read the previous information in this chapter on the basic tools provided in the Track Editor. If you are not familiar with this material, we encourage you to refer to this information if you are uncertain about the function of any tool used in this tutorial.

Step 1: If necessary, start FastLapSim and open the Track Editor by either selecting ***Track Editor*** from the **Tools** drop down menu or by clicking the ***Editor*** button in the *Track Component Category*. If a track is visible in the Track Editor construction window, select ***New Track*** from the **File** drop down menu. At this

Open the Track Editor by either selecting *Track Editor* from the Tools drop-down menu or by clicking the *Editor* button in the *Track Component Category*. At this point you should see an empty Track Editor window on your screen.

Building Your First Track: Step 1



Scale: 10.00 ft/pix

NA

Direction: 0.0 deg.

Width: 80.0

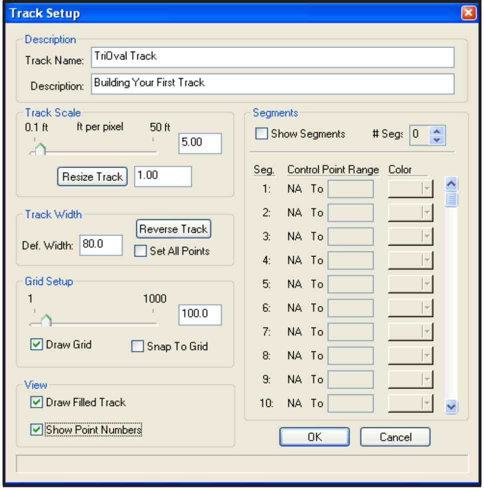
Forward: 0.00

Reverse: 0.00

Dist From Control Pnt 0: 0.00, Width: 80.00, X: -340.80, Y: 1706.13

The *Track Editor*

Building Your First Track: Step 2



Track Setup

Description

Track Name: TriOval Track

Description: Building Your First Track

Track Scale

0.1 ft ft per pixel 50 ft

5.00

Resize Track 1.00

Track Width

Def. Width: 80.0

Reverse Track

☐ Set All Points

Grid Setup

1 1000

100.0

☑ Draw Grid ☐ Snap To Grid

View

☑ Draw Filled Track

☑ Show Point Numbers

Segments

☐ Show Segments # Segs 0

Seg.	Control Point Range			Color
1:	NA	To		
2:	NA	To		
3:	NA	To		
4:	NA	To		
5:	NA	To		
6:	NA	To		
7:	NA	To		
8:	NA	To		
9:	NA	To		
10:	NA	To		

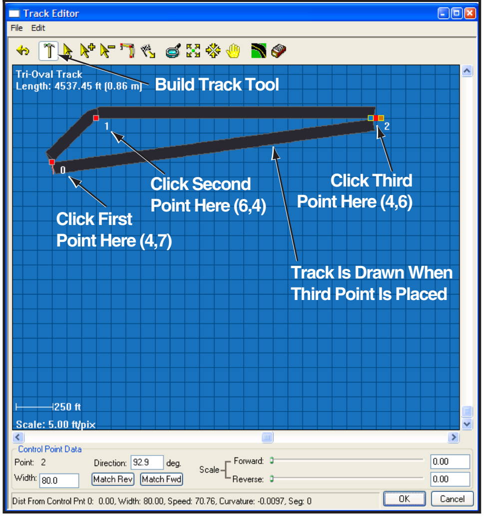
Open the *Track Setup* window by selecting the *Track Setup* icon in the Toolbar or by choosing *Track Setup* from the Edit drop-down menu. The defaults displayed in this window establish the basic setup for the Tri-Oval track we are about to build. Set your dialog box to match these values, including a *Track Width* of 80 feet.

point, you should have an empty Track Editor window displayed on your screen.

Step 2: Open the *Track Setup* window by selecting the ***Track Setup*** icon in the Toolbar or by choosing ***Track Setup*** from the **Edit** menu. Set the values for the Tri-Oval track we are about to build to match those in the **Step-2** photo, including a ***Track Width*** of 80 feet.

Step 3: Activate the ***Build Track Tool*** by clicking on the small hammer located

Building Your First Track: Step 3



Point: 2

Direction: 92.9 deg.

Width: 80.0

Scale Forward: 0.00

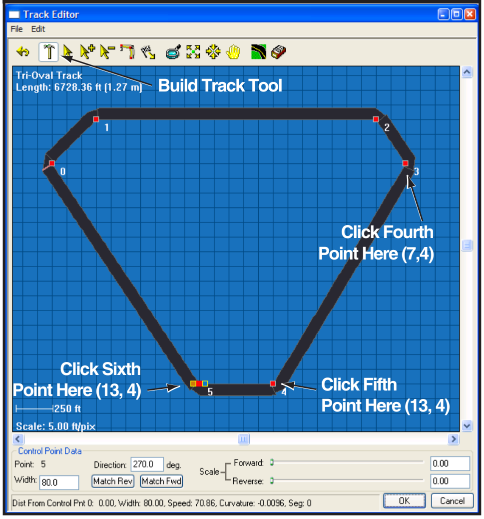
Scale Reverse: 0.00

Dist From Control Pnt 0: 0.00, Width: 80.00, Speed: 70.76, Curvature: -0.0097, Seg: 0

Activate the *Build Track Tool* by clicking on the small hammer located in the Toolbar. Place (by clicking) three Corner Points, in order, as described in the text. When you place the third Corner Point, the track editor will draw a track connecting these points. If the track doesn't look similar to this photo, click on the *Undo Tool* (multiple times if necessary) and reposition the three points.

The *Track Editor*

Building Your First Track: Step 4



Tri-Oval Track
Length: 6728.36 ft [1.27 m]

Scale: 5.00 ft/pix

Point: 5 Direction: 270.0 deg. Scale Forward: 0.00 Reverse: 0.00
Width: 80.0

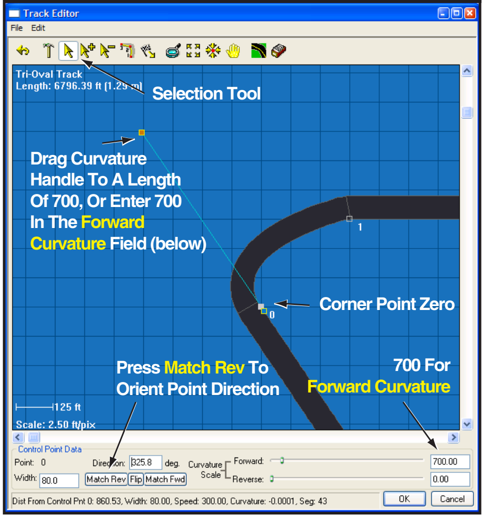
Dist From Control Pnt 0: 0.00, Width: 80.00, Speed: 70.86, Curvature: -0.0096, Seg: 0

Use the *Build Track Tool* to continue adding points to the track. When all points have been placed, the track should look similar to this photo.

in the Toolbar. Place (by clicking) three Corner Points, in order, as described below. Start with Point 0 and locate it about 4 grid lines from the left and about 7 grid lines from the top. Place the second Point (Point Numbered 1) about 6 grid lines from the left and 4 grid lines from the top. Next, place the third Point (Point Numbered 2) 4 grid lines from the top and about 6 grid lines from the right. When you place the third Corner Point, the track editor will draw a track connecting these points. The track should look similar to the photo at the bottom of the previous page. If it doesn't, click on the ***Undo Tool*** (multiple times if necessary)

Adjusting the Corner Points will smooth transitions from the straightaways into the turns. Zoom in to the Corner Point #0, and activate the *Selection Tool*. Highlight the Corner Point by clicking on the small square next to the Point number. Next, drag the forward curvature handle (with the red square) to a length of 700, or enter 700 directly in the *Forward Curvature Scale* box, also located in the Control Point Data area. This will increase the curve radius. Now, click on the *Match Rev* button to align the Corner Point direction with the previous Corner Point (Point 5). At this point, your track should look similar to this photo. If it doesn't, click on the *Undo Tool* (multiple times if necessary) and repeat the procedures in Step 5.

Building Your First Track: Step 5



Tri-Oval Track
Length: 6796.39 ft [1.29 mi]

Scale: 2.50 ft/pix

Point: 0 Direction: 325.8 deg. Curvature Scale Forward: 700.00 Reverse: 0.00
Width: 80.0

Dist From Control Pnt 0: 860.53, Width: 80.00, Speed: 300.00, Curvature: -0.0001, Seg: 43

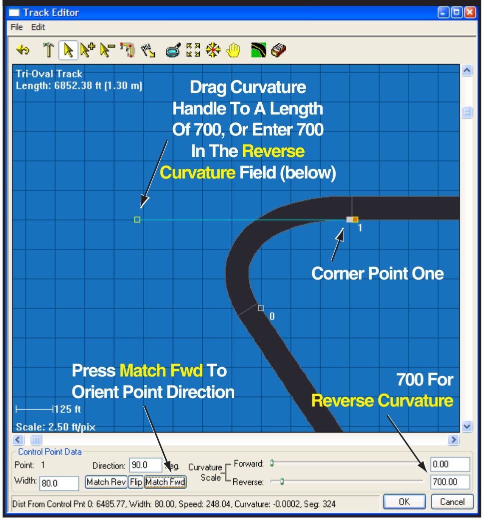
and reposition the three points.

Step 4: If necessary, reactivate the ***Build Track Tool*** and continue adding points to the track. Add the fourth Point (Point Numbered 3) by clicking at about 4 grid lines from the right and 7 grid lines from the top. Place the fifth Point (Point Numbered 4) at about 13 grid lines from the right and 4 grid lines from the bottom. Place the final Point (Point Numbered 5) at about 13 grid lines from the left and 4 grid lines from the bottom of Track Construction Window. The track should now look similar to the Step-4 photo.

Step 5: Now that the basic outline of the track has been constructed, we'll adjust the Corner Points to provide smoother transitions from the straightaways into the turns. Start with Point Zero. First, zoom in closer to the Corner Point (use the ***Magnifying Glass Tool*** and the ***Move Track Tool***, if necessary). Then activate the ***Selection Tool***, and highlight the Corner Point by clicking on the small square next to the Point number. Next, either drag the forward curvature handle (with the red square) to a length of 700, or enter 700 directly in the ***Forward Curvature Scale*** box, also located in the Control Point Data area. This will increase the curve radius just after Point Zero. Finally, click on the ***Match Rev*** button located in the *Corner Point Data* area. This will align the Corner Point direction with the previous Corner Point (Point 5). At this point, your track should look similar to the Step-5 photo. If it doesn't, click on the ***Undo Tool*** (multiple times if necessary) and repeat the procedures in this step.

Step 6: In this step, we will repeat procedures performed in Step 5 on Corner Point One. With the ***Selection Tool*** activated, highlight Corner Point One by

Building Your First Track: Step 6



Tri-Oval Track
Length: 6852.38 ft (1.30 m)

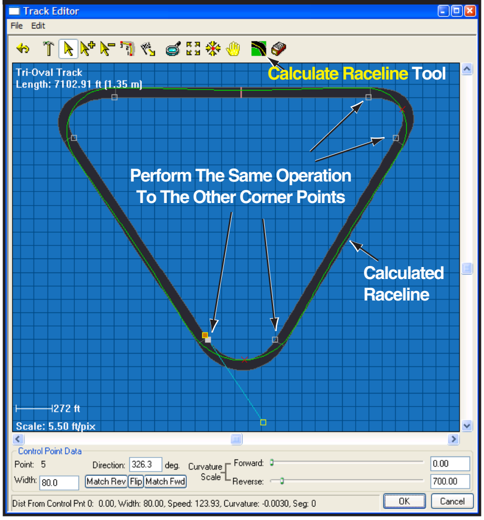
Scale: 2.50 ft/pix

Point: 1
Direction: 90.0 deg.
Width: 80.0
Curvature Scale Forward: 0.00
Curvature Scale Reverse: 700.00

Dist From Control Pnt 0: 6485.77, Width: 80.00, Speed: 248.04, Curvature: -0.0002, Seg: 324

Now repeat the procedures performed in Step 5 on Corner Point #1. With the *Selection Tool* activated, highlight the Corner Point and extend the <u>reverse</u> curvature handle (with the blue square) to a length of 700, or enter 700 directly in the *Reverse Curvature Scale* box. Click on the *Match Fwd* button to align the Corner Point direction with the next Corner Point (Point #2). Your track should look similar to this photo.

Building Your First Track: Step 7



Tri-Oval Track
Length: 7102.91 ft (1.35 m)
272 ft
Scale: 5.50 ft/pix

Control Point Data
Point: 5
Direction: 326.3 deg.
Width: 80.0
Curvature Scale Forward: 0.00
Curvature Scale Reverse: 700.00

Dist From Control Pnt 0: 0.00, Width: 80.00, Speed: 123.93, Curvature: -0.0030, Seg: 0

Use the same procedures described in the last two steps to adjust the curvature scales for points 2, 3, 4 and 5 to 700-feet. Remember to apply curvature to the handles that face into the turn, and align and Corner Point directions with their adjacent straightaways. After adjusting all the Corner Points, click the *Calculate Raceline Tool.* A smooth green raceline should be displayed within the track. If there are any "strange" wiggles or bumps, one or more of the Corner Point handles are pointing in the wrong direction. When you have finished, your track should look like this.

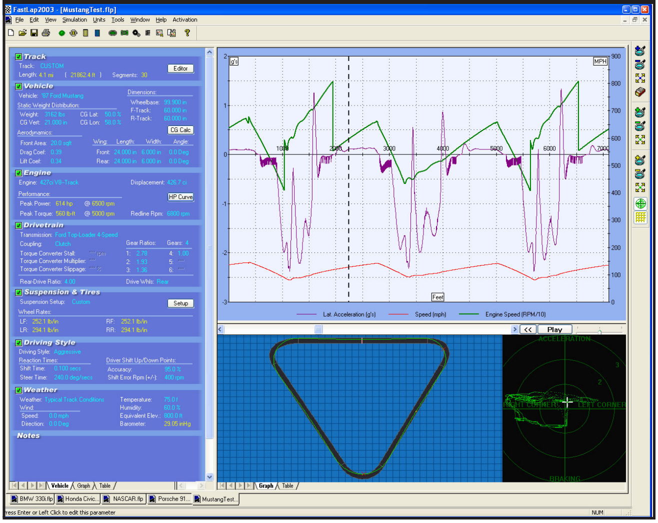
clicking on the small square next to the number. Next, extend the reverse curvature handle (with the blue square) to a length of 700, or enter 700 directly in the ***Reverse Curvature Scale*** box. Now, click on the ***Match Fwd*** button to align the Corner Point direction with the next Corner Point (Point 2). Your track should look similar to the Step-6 photo, and the turn should offer a much smoother transition from and to the adjacent straightaways.

Step 7: The track is taking shape. This step applies similar curvature adjustments to the remaining Corner Points. Use the same procedures described in the last two steps to adjust the curvature scales for points 2, 3, 4 and 5 to 700. Remember to apply the curvature to the handles that face into the turn, and align and Corner Point directions with their adjacent straightaways. After adjusting all the remaining Corner Points, click on the ***Calculate Raceline Tool***. A smooth green raceline should be displayed within the track. If there are any "strange" wiggles or bumps in the raceline, it is probably due to one or more of the Corner Point handles pointing in the wrong direction. When you have finished, your track should look similar to the Step-7 photo.

Step 8: All that remains is saving the track (use the ***File*** drop-down menu), closing the Track Editor by clicking the ***OK*** button, and using your new track in the next simulation run. The photo in Step-8 shows the results of running a simulation on the Tri-Oval track. The vehicle is a hot Mustang.

Step 9: Now that we've covered the basics of building a track, try modifying the simple Tri-Oval by adding S-turns, changing the curvature of one or more Corner Points, or changing track width and determining their effects on raceline calcula-

Building Your First Track: Step 8



FastLap2003 - [MustangTest.flp]

Track
Track: CUSTOM
Length: 4.1 mi [21862.4 ft] Segments: 30

Vehicle
Vehicle: '87 Ford Mustang
Static Weight Distribution:
Weight: 3162 lbs CG Lat: 50.0 %
CG Vert: 21.000 in CG Lon: 58.0 %
Dimensions:
Wheelbase: 99.900 in
F-Track: 60.000 in
R-Track: 60.000 in
Aerodynamics:
Front Area: 20.0 sqft
Drag Coef: 0.39
Lift Coef: 0.34

Wing:	Length:	Width:	Angle:
Front:	24.000 in	6.000 in	0.0 Deg
Rear:	24.000 in	6.000 in	0.0 Deg

Engine
Engine: 427ci V8--Track
Displacement: 426.7 ci
Performance:
Peak Power: 614 hp @ 6500 rpm
Peak Torque: 560 lb-ft @ 5000 rpm
Redline Rpm: 6800 rpm

Drivetrain
Transmission: Ford Top-Loader 4-Speed
Coupling: Clutch
Torque Converter Stall: *** rpm
Torque Converter Multiplier: ***
Torque Converter Slippage: *** %
Gear Ratios: Gears: 4
1: 2.78 4: 1.00
2: 1.93 5: ***
3: 1.36 6: ***
Rear-Drive Ratio: 4.00
Drive Whls: Rear

Suspension & Tires
Suspension Setup: Custom
Wheel Rates:
LF: 252.1 lb/in RF: 252.1 lb/in
LR: 294.1 lb/in RR: 294.1 lb/in

Driving Style
Driving Style: Aggressive
Reaction Times:
Shift Time: 0.100 secs
Steer Time: 240.0 deg/secs
Driver Shift Up/Down Points:
Accuracy: 95.0 %
Shift Error Rpm (+/-): 400 rpm

Weather
Weather: Typical Track Conditions
Wind:
Speed: 0.0 mph
Direction: 0.0 Deg
Temperature: 75.0 f
Humidity: 60.0 %
Equivalent Elev.: 800.0 ft
Barometer: 29.05 inHg

Notes

ress Enter or Left Click to edit this parameter

All that remains is saving the track file (.TK) and closing the Track Editor. Use your new track in the next simulation run. Here are the results of running a simulation on the newly-constructed Tri-Oval track. The test vehicle is a hot Mustang.

tion and simulation results. Review the Track Editor tools described on pages 73 to 77, and experiment with each one. After you build a couple of additional "simple" tracks, you'll be ready to model an real-world track in the Track Editor (the subject of the next section).

BUILDING A REAL-WORLD RACETRACK IN THE TRACK EDITOR

A track can be completely free-form, representing no real-world track, such as the Tri-Oval used in the previous example. Or you can choose to model a track based on actual racetrack. Duplicating a real-world track in the Track Editor can, at first, seem a daunting challenge. However, taken one step at a time, the job can be reduced to a series of relatively simple steps.

Regardless of the track, the building process consists of these ten basic steps:

1) Locate or draw an "overhead view" map of the track.
2) Pick an arbitrary origin point for all measurements (a convenient origin point is often the center of the area bounded by the track).
3) Place *Corner Points* on a track map.
4) Measure X,Y coordinates of all Corner Points relative to origin.
5) Scale X,Y coordinates from the map measurements to full-scale (real-world) dimensions.
6) Set a *Default Width* for the track in the *Track Setup* window.
7) Build the track by placing the full-scale Corner Points in the Track Editor window; add Points in the direction of vehicle movement.
8) *Zoom In* and adjust Corner Point locations and *Curvature Handles*.
9) Adjust track widths, if necessary, and fine tune all points.

10) Set the *Start/Finish* line location.

Step 1: Locate Or Draw A Track Map

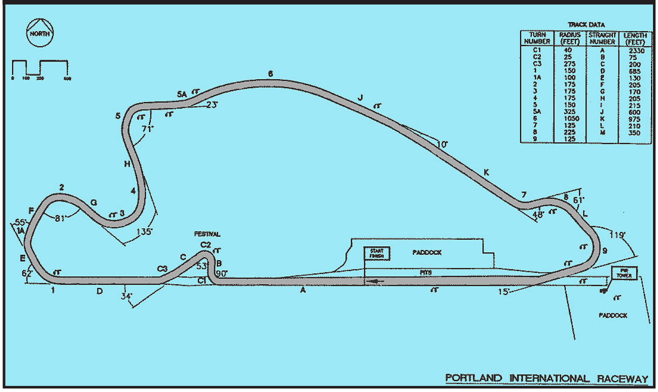
In this section, we will detail the process of building a replica of an existing track: Portland International Raceway (PIR). To make this process substantially easier we are using a detailed drawing of the Raceway. This drawing was compiled from published sketches and track data. Since this drawing was made to scale (300-feet = 1-inch), it will further simplify duplicating this layout. A table is included with corner radii and straightaway lengths, although this data is not needed to build a track in FastLapSim. Unfortunately, most published maps will not provide this level of detail. However, always try to obtain an overhead track map, aerial photo, or any other descriptive data of the track before you attempt modeling in the Track Editor. Having this information handy will save you considerable frustration.

Step 2: Preparing The Map

In order to extract the Control Point locations from the drawing, some preparation is necessary. First an origin from which all points are measures must be chosen. The origin point always has the X,Y coordinates of 0,0, meeting that all points are measured relative to this point in both horizontal and vertical directions. You can place the origin anywhere on the map you like; it really doesn't matter. What does matter is that all the Corner Points on the track are measured from this point. The following assumptions always apply to measurements made from the origin-point:

Any point to the left of the origin will have a negative X coordinate.
Any point to the right of the origin will have a positive X coordinate.
Any point above the origin will have a positive Y coordinate,
Any point below the origin will have a negative Y coordinate.

A Basic Track Map



TRACK DATA

TURN NUMBER	RADIUS (FEET)	STRAIGHT NUMBER	LENGTH (FEET)
C1	40	A	2330
C2	25	B	75
C3	275	C	200
1	150	D	585
1A	100	E	130
2	175	F	205
3	175	G	170
4	175	H	205
5	150	I	215
5A	325	J	600
6	1050	K	975
7	125	L	210
8	225	M	350
9	125		

The first step in building a real-world racetrack in the Track Editor is to base your "construction work" on a detailed drawing of the Raceway. This drawing was compiled from published sketches and track data (scale is 300-feet = 1-inch). Always try to obtain an overhead track map, aerial photo, or any other descriptive data of the track before you attempt modeling in the Track Editor.

The *Track Editor*

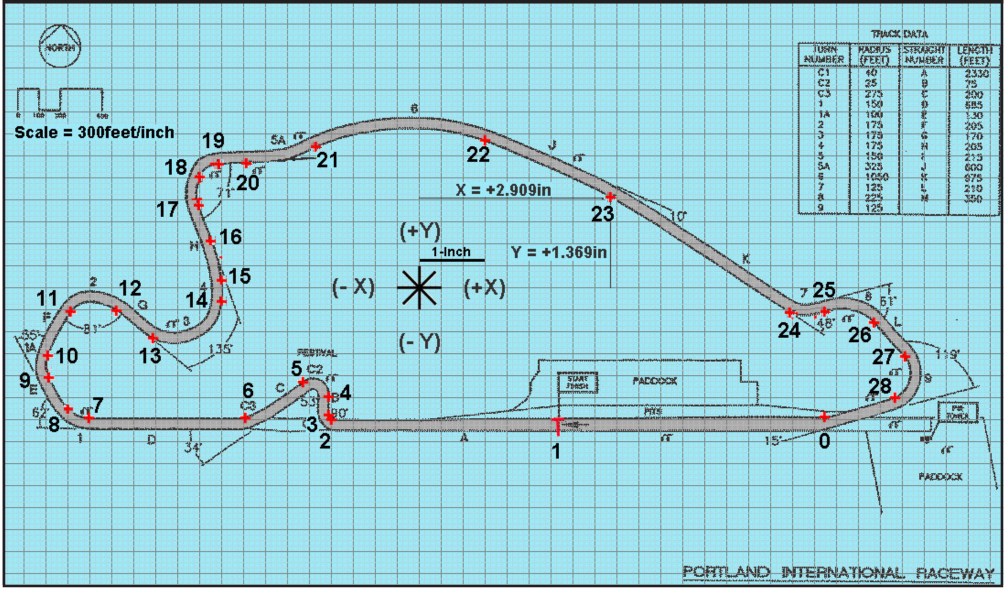
These assumptions establish a uniform way to enter Control Point measurement data into the Track Editor. Since the origin within the Track Editor Construction Window is positioned in the center of the screen, an origin point location that matches the Track Editor makes Control Point data entry a bit more straightforward. However, an origin point located elsewhere (e.g., in the upper-left corner of the track map, the default location when using *Windows Paint*® to help you perform map measurements, as described below) really won't complicate data-point entry in the Track Editor and will produce the same results. The entire measurement and data-entry process will become clear as you follow along with this tutorial.

Step 3: How To Position Corner Points

With an origin selected (we've chosen the approximate center of the area bounded by the track, as shown in the drawing, below), we'll begin to locate Corner Points on the track. Corner Points are places where track curvature changes, in other words, where turns begin, end, or where there is a significant change in turn radius.

In the case of the PIR Raceway, we'll arbitrarily place the first Corner Point (point #0) at the start of the main straightaway. This is the location where the last, shallow turn ends and the straightaway begins. We'll place the second Corner Point (point #1) at the ***Start/Finish*** line. While there is no curvature change at this point, it simply acts

Preparing The Track Map & Locating Corner Points



TRACK DATA

TURN NUMBER	RADIUS (FEET)	STRAIGHT NUMBER	LENGTH (FEET)
C1	40	A	2330
C2	25	B	75
C3	275	C	200
1	150	D	585
1A	100	E	130
2	175	F	205
3	175	G	170
4	175	H	205
5	150	I	213
5A	325	J	600
6	1050	K	975
7	125	L	210
8	225	M	350
9	125		

We have selected an origin (the double-X in the center of the track) from which to measure all points on the track. Corner Points are located where track curvature changes: where turns begin, end, or where there is a significant change in turn radius. The exception is Corner Point #1; it marks the *Start/Finish* line (it is not required).

When all of the Corner Points have been placed on the track map, measure the distances from the Corner Points to the origin point. Here are all of the Corner Point location measurements for PIR Raceway. We scanned the drawing into a graphics editing program (*Photoshop*®), set the "zero point" for the ruler on the track origin point, and simply read the distances to all Corner Points from the Info Box in the program (see photo on page 88).

as a marker and is entirely optional.

Note: In almost all cases, curvature transitions in the track _must_ have Corner Points positioned at the beginning and end of transitions, however, Corner Points can also be used as "markers," placed anywhere on the track. But use marker points sparingly, since they can produce unwanted changes in track shape, and extraneous Corner Points will slow down simulation calculations.

The third Corner Point (point #2) is positioned at the end of the straightaway, where the track begins a sharp 90-degree turn (called C1). The next Corner Point (point #3) is located exactly where this 90-degree corner ends, beginning a very short straight (called B). The next Corner Point (point #4) is positioned just at the start of the 100-degree corner (called C2). The next point (point #5) marks the end of this same corner as it terminates into a straightaway (called C). Using this same technique, continue placing Corner Points throughout the remainder of the track as shown in the illustration on page 85).

There are a few Corner-Point positions (Points #14, #18, and #21) that require some additional explanation. At first it may look like Point #14 is accidentally placed within the turn marked by Points #13 and #15. However, at Point #14, the track transitions from a corner radius to a very short, nearly-straight section, then bends to the left at Point #15. While it is not absolutely necessary to place a point here, the track will be most accurately modeled if this slight change in curvature and short "straight" section is properly modeled. A similar situation exits at Point #18. Here the right turn has two distinct radii, a shallow entrance, then a tighter (smaller radius) section between Points #18 and #19. A Corner Point is required at Point #18 to model this changing radius. A different situation exists at Point #21. This point act as BOTH the termination of turn 5A and the beginning of the large, sweeping, right-hand turn 6. Since there is no straight section of track between these turns, and one turns blends smoothly into the other (like the transition between turns 7 and 8), only a single Corner Point is needed to "identify" the change in curvature.

Step 4: Measuring Corner Point X,Y Locations

When all of the Corner Points have been placed on the track map, the next step is to measure the distances from the Corner Points to the origin point (the location of the origin point was discussed earlier, see page 84). Remember, regardless of the Corner Point locations, the following assumptions always apply to origin-point measurements: 1) Corner Points to the left of the origin have ***-X*** values, 2) Points to the right of the origin have ***+X*** values, 3) Corner Points above the origin have ***+Y*** values,

Corner-Point Data For Portland International Raceway								
Corner Description	Corner Point Number	X, Y Track Map Position (inches from origin)	Map Scale (feet per inch)	X, Y Scaled Coordinates (feet from origin)	Placed In Track Editor	Control Point Direction	Curvature Handles (Fwd/Rev)	Corner Point Adjusted
Start of Straightaway	0	+6.158, -1.979	300	+1847, -594	✔	270	0 / 106	✔
Start/Finish Line	1	+2.125, -1.987	300	+638, -596	✔	270	0 / 0	✔
C1 (begin)	2	-1.239, -2.006	300	-372, 602	✔	270	76 / 0	✔
C1 (end)	3	-1.374, -1.935	300	-412, -581	✔	0	0 / 53	✔
C2 (begin)	4	-1.373, -1.644	300	-412, -493	✔	0	145 / 0	✔
C2 (end)	5	-1.756, -1.428	300	-527, -428	✔	239	0 / 151	✔
C3 (single)	6	-2.638, -1.978	300	-791, -593	✔	239	47 / 0	✔
1 (begin)	7	-5.012, -1.979	300	-1504, -594	✔	270	24 / 0	✔
1 (end)	8	-5.327, -1.840	300	-1598, -552	✔	330	0 / 18	✔
1A (begin)	9	-5.621, -1.368	300	-1868, -410	✔	330	28 / 6	✔
1A (end)	10	-5.635, -1.036	300	-1691, -311	✔	28	0 / 12	✔
2 (begin)	11	-5.282, -0.373	300	-1585, -112	✔	28	330 / 0	✔
2 (end)	12	-4.588, -0.352	300	-1376, -106	✔	127	0 / 47	✔
3 (begin)	13	-4.041, -0.766	300	-1212, -230	✔	127	485 / 0	✔
3 (end)	14	-2.986, -0.201	300	-896, -60	✔	0	87 / 436	✔
4 (begin)	15	-2.994, +0.108	300	-898, +32	✔	345	0 / 12	✔
4 (end)	16	-3.158, +0.707	300	-947, +212	✔	345	0 / 0	✔
5 (begin)	17	-3.345, +1.245	300	-1004, +374	✔	340	83 / 0	✔
5 (middle, opt.)	18	-3.322, +1.667	300	-997, +500	✔	6	108 / 0	✔
5 (end)	19	-3.031, +1.876	300	-909, +563	✔	89	0 / 47	✔
5A (begin)	20	-2.618, +1.888	300	-785, +566	✔	89	638 / 0	✔
5A (end)	21	-1.564, +2.130	300	-469, +639	✔	57.5	781 / 0	✔
6 (end)	22	+1.005, +2.223	300	+302, +667	✔	114	0 / 520	✔
6A (single)	23	+2.909, +1.369	300	+873, +411	✔	123	60 / 60	✔
7 (begin)	24	+5.630, -0.379	300	+1689, -114	✔	123	130 / 0	✔
7 (end)	25	+6.163, -0.368	300	+1849, -110	✔	71	402 / 85	✔
8 (end)	26	+6.905, -0.530	300	+2072, -159	✔	137	0 / 24	✔
9 (begin)	27	+7.378, -1.042	300	+2216, -313	✔	137	248 / 0	✔
9 (end)	28	+7.218, -1.671	300	+2165, -501	✔	254	0 / 200	✔
Start of Straightaway	0	+6.158, -1.979	300	+1847, -594	✔	270	0 / 106	✔

and 4) Points below the origin have ***-Y*** values.

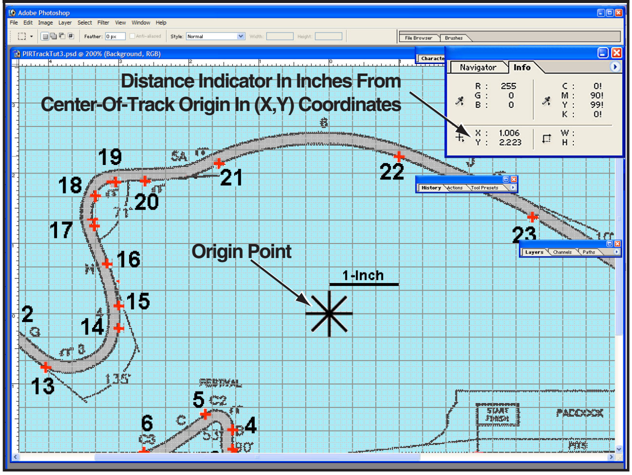
The nearby table lists all of the Corner Point location measurements for PIR Raceway measured relative to the origin point shown on the track drawing. For example, **Corner Point #23** is located above and to the right of the origin point, meaning that its **X** and **Y** values will both be positive (refer to the photo on page 85). **Corner Point #23** lies 2.909-inches to the right and 1.369-inches above the origin. So the X,Y coordinate for Point #23 is ***(+2.909, +1.369)***, note this value has been recorded in the table for Point #23.

Note: You may ask how this distance can be measured so accurately. There are precision measuring instruments, like digital calipers, that can perform this function, however, if you have access to a scanner and computer, you can let the computer do the "hard work" for you. Scan the drawing and display it in a graphics editing program (*Photoshop*® is an awesome tool for measuring distances, but the free *Windows Paint*® program also works fine—find *Paint* in the ***Start/Accessories*** submenu). These programs, and others like them, often have a way to measure how many units (inches, pixels, etc.; the units don't matter) one point is located from another. Simply set your origin point, or use the default origin point in the program, and measure the distances, in (X,Y) coordinates from the origin to each Corner Point and record it in a table. If you cannot scan the track map into a computer or use a graphics program to help measure Corner Point distances, draw gridlines on the track map to aid measuring X and Y coordinates of any point on the track.

Step 5: Scale Map Measurements

When all of the Corner Points and their X- and Y-distances from an origin have been recorded, the final step is to convert these measurements into real-world lengths by

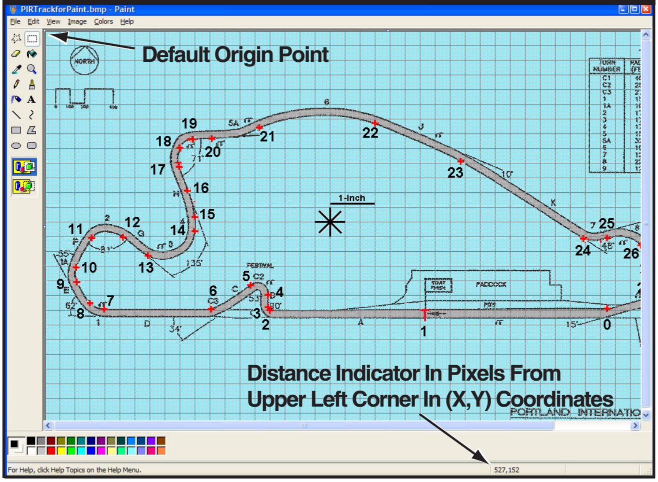
Measuring The Track Map In Photoshop®



R : 255
G : 0
B : 0
C : 0!
M : 90!
Y : 99!
K : 0!
X : 1.006
Y : 2.223
W :
H :

While you can use precision measuring instruments, like digital calipers, if you have access to a scanner and computer, you can let the computer do the "hard work" of precisely measuring track map distances. Scan the drawing and display it in a graphics editing program (like Paint™ or Photoshop™). Set your origin point and measure the distances, in (X,Y) coordinates, from the origin to each Corner Point.

Measuring The Track Map In Windows Paint®



Set the origin point to the upper left corner, or use the default origin point in the program, and measure the distances, in (X,Y) coordinates from the origin to each Corner Point. Here the distances are shown in *Paint*™, a simple graphics program supplied with Windows™. Record each measurement in the data table (see page 87).

multiplying them by the scale of the map. For the PIR Racetrack, a distance of 300-feet of “real-world” length is converted to one-inch on the track map, and each inch is divided into 3 major gridlines, with each line representing 100-feet. This scale matches the scale of the track drawing, i.e., 300feet/inch. If a track map does not indicate a precise scale, you will have to determine the scale by comparing a known distance (often the length of the main straightaway) with the length of the same section of track on the map (in inches). For example, if a straightaway measures 8-inches and the real-world length is 1000-feet, the scale for the map would be 125-feet-per-inch. If you drew a grid of 1-inch squares over the map, each square would represent 125 feet. To make it easier to extract Corner Point locations, draw *at least* five subdivisions within each 1-inch square.

When you have converted the map measurements into actual track distances (for the PIR Raceway, we simply multiply each map measurement—in inches—by 300 to obtain real-world distances in feet), you can begin building a model of the track by entering these measurements in the Track Editor.

Remaining Five Steps For Track Modeling

With all the preparation work completed, here are the remaining steps required construct a track model in the FastLapSim Track Editor:

Step 6: Every track has a general (or average) width. Track width can vary around the course, but for now, we’ll use an average value for this dimension. We’ll leave adjusting widths for the “fine-tuning” steps to come. The drawing on page 85 shows that the average width of PIR Raceway is about 60 feet. Enter 60-feet into the default ***Width Field*** in the **Track Setup Window** (see page 71 for more information on the *Track Setup* screen). Choose ***OK*** to return to the Track Editor construction window.

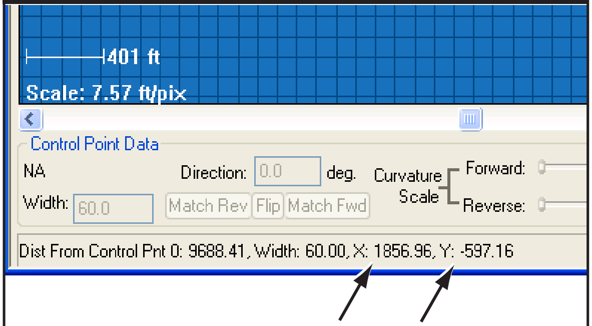
The *Track Editor*

Step 7: Now we can start creating the track in the Track Editor (remember to ***Save*** your work periodically). Start off by centering the work area in the Track Editor construction window by clicking on the ***Center Track Tool***, then select the ***Build Track Tool*** from the Toolbar (the hammer icon). This tool will place Corner Points consecutively, and it is this sequential order that determines the direction of vehicle movement on the track. Make sure that each point you place follows consecutively along the track.

Note: You may find it helpful to place Corner Points that locate the main straightaway first, as we did on the Track Map. Since the straightaway is often one of the largest objects in the track, it forms an visual reference from which to place the remaining Corner Point locations (although this technique is not required; you can start with any Corner Point in the Track Editor).

The first Corner Point we'll place for PIR Raceway will fix the start of the main straightaway. Lookup the real-world coordinates for that point in the data table. The point location is: ***(+1847, -594)***. This means that the point is located 1847-feet to the right and 594-feet down from the origin point (the center of the construction window). Move the ***Build Track Tool*** within the Track Editor window and review the location of the tool, relative to the Track Editor origin point, by the numbers displayed in the **Status Line**. The **X** and **Y** values are displayed in feet from the origin. Move the ***Build Tool*** until approximately ***X: 1847, Y: 594*** is displayed (it doesn't have to be exact, we'll adjust the points when we zoom in later). If these points are not located within the construction window, click on the ***Up*** and ***Down*** or ***Left*** and ***Right*** arrows at the ends of the scroll bars to move the "ground" in the Track Window until the coordinates are visible (click on the ***Windows Maximize*** button to display the Track Editor full screen and present the largest displayable construction area). When you are reasonably close to the coordinates, click the left mouse button once. A single point will be

Track Editor X and Y Position In Status Line



NA

Direction: 0.0 deg.

Width: 60.0

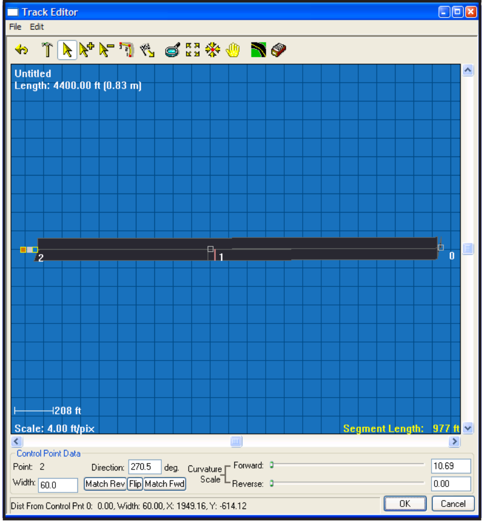
Dist From Control Pnt 0: 9688.41, Width: 60.00, X: 1856.96, Y: -597.16

X and Y Distances From The Origin Point

Use the *Build Track Tool* within the Track Editor window and review the location of the tool, relative to the Track Editor origin point, by the numbers displayed in the *Status Line.* The X and Y values are displayed in feet from the origin. Move the *Build Tool* until approximately *X: 1847, Y: -594* is displayed (it doesn't have to be exact, we'll adjust the points when we zoom in later).

The *Track Editor*

Placing Three Corner Points



Point: 2

Direction: 270.5 deg.

Width: 60.0

Forward: 10.69

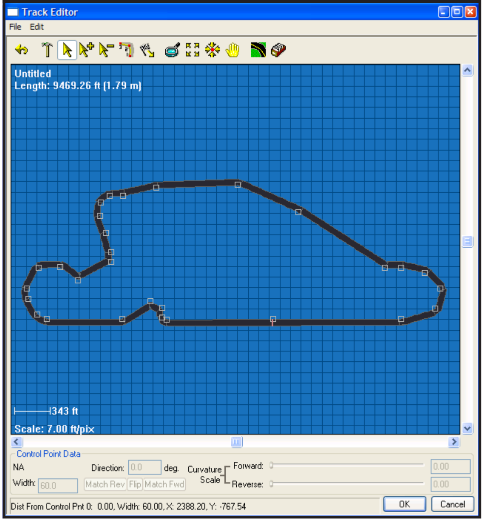
Reverse: 0.00

Dist From Control Pnt 0: 0.00, Width: 60.00, X: 1949.16, Y: -614.12

After you have placed the first Corner Point, continue placing points in order. When you place the third point, the Track Editor will draw a connecting track between each point (three points, at minimum, are required to define any track).

placed. Continue placing points in order. When you place the third point, the Track Editor will draw a connecting track between each point (three points, at minimum, are required to define any track). Continue placing Points, in order, until you have created Corner Points at all measured locations on the track. The track should look similar to the Track Map, except that the corners will be too "square." If you place a Corner Point in the wrong location, simply click the ***Undo Tool*** and re-place that point. When you have placed all Corner Points, deselect the ***Build Track Tool*** by clicking on the ***Selection Tool***.

All Corner Points Placed



NA

Direction: 0.0 deg.

Width: 60.0

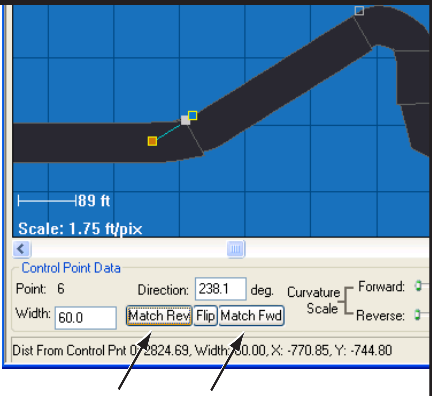
Forward: 0.00

Reverse: 0.00

Dist From Control Pnt 0: 0.00, Width: 60.00, X: 2388.20, Y: -767.54

Continue placing Points, in order, until you have created Corner Points at all measured locations on the track. The track should look similar to the Track Map, except that the corners will be too "square." If, while you are placing points, you click in the wrong location, simply click the *Undo Tool* and re-place that point. When you have placed all Corner Points, deselect the *Build Track Tool* by clicking on the *Selection Tool*. Your Track Editor screen should look like this.

Curvature Match Buttons



Point: 6

Direction: 238.1 deg.

Width: 60.0

Dist From Control Pnt 0: 2824.69, Width: 60.00, X: -770.85, Y: -744.80

Match Corner Point Direction Forward And Reverse

With all the Corner Points placed, there are three adjustments needed: *Location*, *Direction*, and *Forward*-and-*Reverse Curvature*. First, use the *Zoom Tool* and examine the position of each Point. Make any adjustments by clicking on the point and dragging it to the correct location (Point position data is displayed in the *Status Line*). Repeat this process for all Corner Points. When the Corner Points are properly positioned, the next adjustment "aims" Corner Points (and the track) in the correct directions. If a Corner Point is located at a transition from a straightaway into a turn, the *Corner Point Direction* is aligned with the straightaway. To help set Point directions, use the *Match Fwd* and *Match Rev* buttons to align Points with the next or previous Corner Point.

Step 8: With all the Corner Points placed, there are three adjustments needed for each point: ***Location***, ***Direction***, and ***Forward***-and-***Reverse Curvature***. First, use the ***Zoom Tool*** and examine the position of each Point. Make any adjustments by clicking on the point and dragging it to the correct location (Point position data is displayed in the **Status Line** when dragging the Corner Point). Repeat this process for all Corner Points.

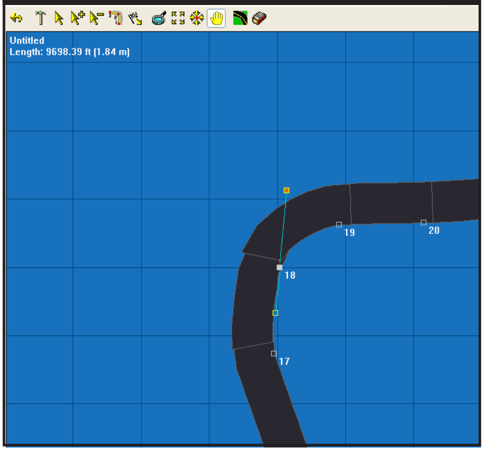
When the Corner Points are properly positioned, the next adjustment "aims" Corner Points (and the track) in the correct directions. Establishing the correct *Corner Point Direction* is relatively straightforward. If a Corner Point is located at a transition from a straightaway into a turn, the *Corner Point Direction* is aligned with the straightaway (as shown in the previous tutorial, *Building Your First Track*, on page 78). To help set Point directions, use the ***Match Fwd*** and ***Match Rev*** buttons to align Points with the next or previous Corner Point. The ***Match Fwd*** button will orient the *Corner Point Direction* in-line with (point directly at) the next Corner Point. The ***Match Rev*** button will orient the *Corner Point Direction* toward the previous Corner Point.

If a Corner Point falls in between turns, for example, in the middle of a series of turns, such as "S-Curves," or in the middle of a singe turn that may have a changing radius, the *Corner Point Direction* may need to be positioned at a tangent to the track or somewhere in between. A good example of this can be found on Point #18 on the PIR track. This point redirects the turn toward a sharper (smaller) radius. The Corner Point direction is 6-degrees, or slightly tilted to the right from vertical, more-or-less at a tangent to track direction.

The last Corner Point adjustments set the *Forward* and *Reverse Curvatures*. These attributes apply the correct "shape" to the corners. The ***Forward Curvature***, indicated by the length of the ***Red Curvature Handle***, defines the radius of the track as it moves away from a Corner Point (moving in the direction of vehicle movement). The ***Reverse***

The *Track Editor*

Corner Point Within A Turn



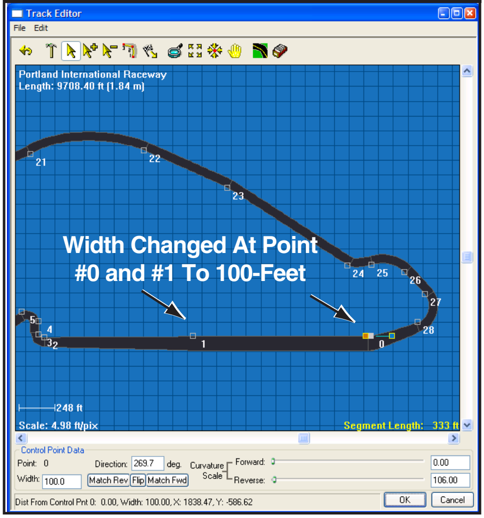
If a Corner Point falls in between turns, for example, in the middle of a series of turns, such as "S-Curves," the *Corner Point Direction* may need to be positioned at a tangent to the track or somewhere in between. A good example of this can be found on Point #18 on the PIR track. This point redirects the turn toward a sharper (smaller) radius. The Corner Point direction is 6-degrees, or slightly tilted to the right from vertical, more-or-less at a tangent to track direction.

Curvature, indicated by the length of the ***Blue Curvature Handle***, defines the radius of the track as it approaches the Corner Point. In most cases where a straightaway meet a turn, it will only be necessary to adjust one of the Curvature handles (usually the Forward Curvature), but for more complex adjustments, both the *Forward* and *Reverse Curvatures* may need to be extended to achieve the desired corner shape.

Step 9: The track is nearly complete, however, some tracks vary significantly in width from corner to corner. FastLapSim allows each Corner Point to have a width setting. The width of the track between Points is an interpolation of the widths of the two

FastLapSim allows each Corner Point to have a width setting. The width of the track between Points is an interpolation of the widths of the two adjacent Corner Points. If you set a control point width to 100-feet and one to 60-feet, the track will gradually taper from 100-feet to 60-feet. For example, the main strait at PIR is slightly wider than the remainder of the track. To set this width change, select Point #0 and change the *Width* field to 80-feet in the lower part of the Track Editor window. Also change the *Width* of Corner Point #1 (located at the Start/Finish line) to 80-feet wide. Now the straightaway measures 80-feet across and tapers down to 60-feet by Corner Point #2.

Changing Corner Point Width



Width Changed At Point #0 and #1 To 100-Feet

Control Point Data

Point: 0

Direction: 269.7 deg.

Width: 100.0

Curvature Scale Forward: 0.00

Curvature Scale Reverse: 106.00

Dist From Control Pnt 0: 0.00, Width: 100.00, X: 1838.47, Y: -586.62

adjacent Corner Points. If you set a control point width to 100-feet and one to 60-feet, the track will gradually taper from 100-feet at the first Corner Point to 60-feet at the next Corner Point. For example, the main strait at PIR is slightly wider than the remainder of the track. To set this width change, select Point #0 and change the ***Width*** field to 80-feet in the lower part of the Track Editor window. Also change the ***Width*** of Corner Point #1 (located at the Start/Finish line) to 80-feet wide. Now the straightaway measures 80-feet across and tapers down to 60-feet by Corner Point #2. **Note:** If you would like to set all Corner Points to the same ***Width***, the Track Setup window includes a ***Set All Points*** check box. Place a checkmark in this box and set the ***Default Track Width*** to the desired value. When you close the Track Setup window, all the Corner Points on the track will be reset to the default value.

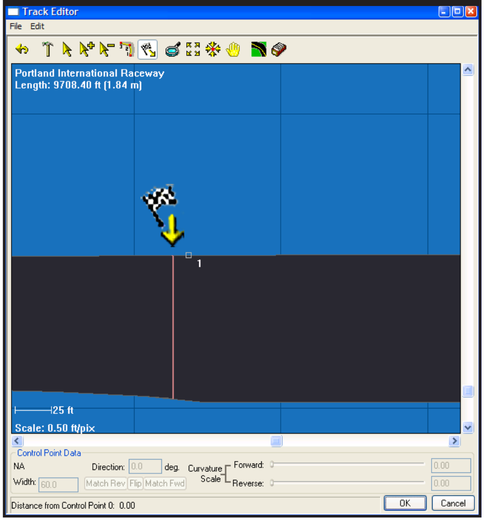
Before you move on to the final step in building a real-world track, click on the ***Calculate Raceline Tool*** in the Toolbar and verify that a smooth raceline passes though each corner and straightaway. If you see any loops or strange bumps in the raceline it means that a control point is not pointing in the proper direction or that two control points are overlapping. ***Zoom In*** to discover the problem.

Finally, give each Corner Point one final review. If any of the curves in the track need fine-tuning, moving Corner Point positions and slightly adjusting Directions and Curvatures should fix any issues. If, despite your best efforts, you cannot obtain the desired track shape, you may need to add an additional Corner Point to increase your tuning flexibility at that location.

Step 10: The final step in completing your track model is to position the *Start/Finish Line*. This is done with the ***Start/Finish Tool*** located in the Toolbar. Activate this tool then click on the track where you want to position the *Start/Finish Line*. The *Start/Finish Line* on the PIR track is located at Point #1, so ***Zoom In*** on that point and

The final step is to position the *Start/Finish Line*. This is done with the *Start/Finish Tool* located in the Toolbar. Activate this tool then click on the track where you want to position the *Start/Finish Line*. The *Start/Finish Line* on the PIR track is located at Point #1, so *Zoom In* on that point and click directly *on the track* at the Point #1 position. A small red line will appear at exactly the Start/Finish point. If you would like to reposition the *Start/Finish Line*, simply use the *Start/Finish Tool* again.

Place The Start/Finish Line



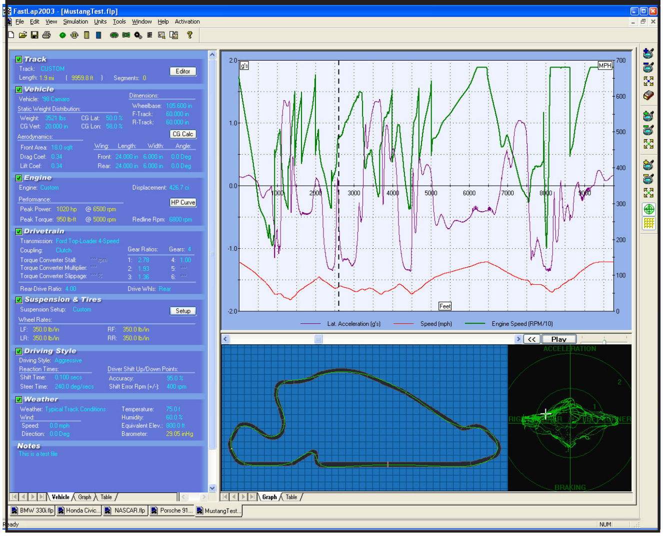
Portland International Raceway
Length: 9708.40 ft (1.84 m)

Scale: 0.50 ft/pix

Control Point Data
NA
Direction: 0.0 deg.
Width: 60.0
Curvature Scale Forward: 0.00
Curvature Scale Reverse: 0.00

Distance from Control Point 0: 0.00

Changing Corner Point Width



FastLap2003 - [MustangTest.flp]

Track
Track: CUSTOM
Length: 1.9 mi [9959.8 ft] Segments: 0

Vehicle
Vehicle: '98 Camaro
Static Weight Distribution:
Weight: 3521 lbs CG Lat: 50.0 %
CG Vert: 20.000 in CG Lon: 58.0 %
Dimensions:
Wheelbase: 105.600 in
F-Track: 60.000 in
R-Track: 60.000 in
Aerodynamics:
Front Area: 18.0 sqft
Drag Coef: 0.34
Lift Coef: 0.34

Wing:	Length:	Width:	Angle:
Front:	24.000 in	6.000 in	0.0 Deg
Rear:	24.000 in	6.000 in	0.0 Deg

Engine
Engine: Custom
Displacement: 426.7 ci
Performance:
Peak Power: 1020 hp @ 6500 rpm
Peak Torque: 950 lb-ft @ 5000 rpm
Redline Rpm: 6800 rpm

Drivetrain
Transmission: Ford Top-Loader 4-Speed
Coupling: Clutch
Torque Converter Stall: **** rpm
Torque Converter Multiplier: ****
Torque Converter Slippage: **** %
Gear Ratios: Gears: 4
1: 2.78
2: 1.93
3: 1.36
4: 1.00
5: ****
6: ****
Rear-Drive Ratio: 4.00
Drive Whls: Rear

Suspension & Tires
Suspension Setup: Custom
Wheel Rates:
LF: 350.0 lb/in RF: 350.0 lb/in
LR: 350.0 lb/in RR: 350.0 lb/in

Driving Style
Driving Style: Aggressive
Reaction Times:
Shift Time: 0.100 secs
Steer Time: 240.0 deg/secs
Driver Shift Up/Down Points:
Accuracy: 95.0 %
Shift Error Rpm (+/-): 400 rpm

Weather
Weather: Typical Track Conditions
Wind:
Speed: 0.0 mph
Direction: 0.0 Deg
Temperature: 75.0 f
Humidity: 60.0 %
Equivalent Elev.: 800.0 ft
Barometer: 29.05 inHg

Notes
This is a test file

Ready

After placing the Start/ Finish line, close the Track Editor and run a test vehicle on your "brand new" track. This 1000hp Camaro really delivers the action!

click directly *on the track* at the Point #1 position. A small red line will appear on the track at exactly the Start/Finish point. If you would like to reposition the *Start/ Finish Line*, simply use the ***Start/Finish Tool*** again.

Now that your track is complete, open the Track Editor Setup window again and enter a ***Track Name*** and ***Description*** in the fields at the top of the window. Then save the track file (.TK) one final time in the default track directory—***TrackFiles (.TK)***. Then close the Track Editor and run a test vehicle on your "brand new" track.

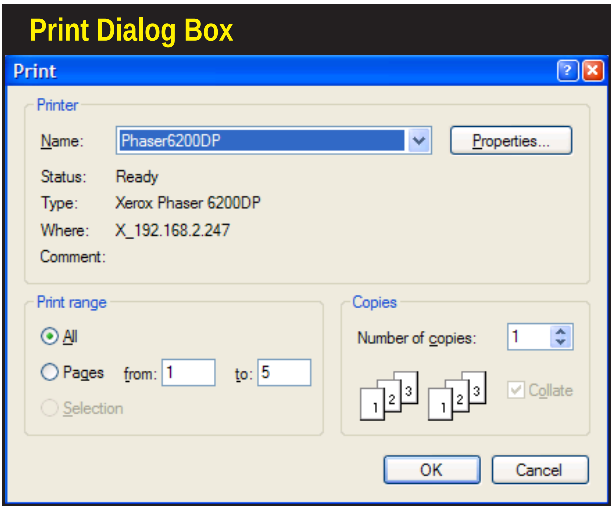
PRINTING

PRINTING VEHICLE DATA AND TRACK-PERFORMANCE CURVES

FastLapSim is capable of printing a complete list of vehicle components, exact test result values, and 2D graphic curves of speed, rpm, acceleration, and several other vehicle-test variables. Each of these data sets print on separate pages that comprise a complete multi-page, drag-test document of the currently-selected vehicle. You can determine which pages you would like to print, preview the pages before you print, and direct the output to any installed Windows printer.
Note: If you have activated ***ProTools™*** in FastLapSim (see page 100 for more information on optional-feature activation), ***ProPrinting™*** options are available that produce comprehensive "presentation" reports of lap test results. ***ProPrinting™*** features include special page graphics, a cover page with the name of your business (or you personal name), additional engine-data values, pressures, forces, and more.

There are three choices in the ***File*** menu (located on the *Main Program Screen*) that will help you setup your printer and print vehicle test data. The choices are:

Print—Opens a dialog box that allows the selection of a printer, access to printer *Properties*, and the *Print Range* of drag-test pages. Printing can be started from this


Print Dialog Box

Print

Printer
Name: Phaser6200DP
Status: Ready
Type: Xerox Phaser 6200DP
Where: X_192.168.2.247
Comment:

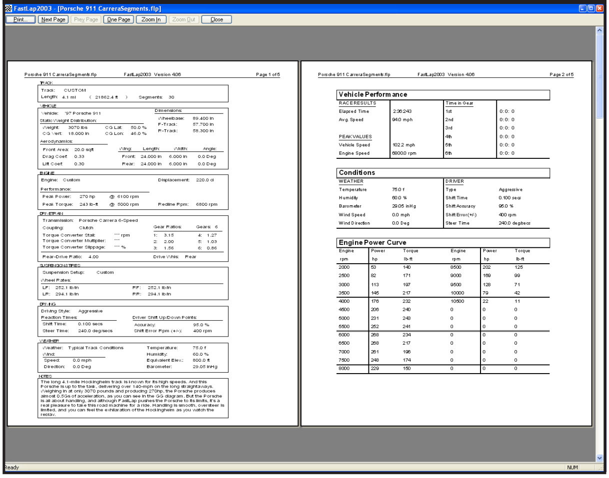
Print range
● All
○ Pages from: 1 to: 5
○ Selection

Copies
Number of copies: 1
☑ Collate

The print dialog box, accessible from the *File* menu, allows the selection of a printer, access to printer Properties, and you can enter the range of lap-test report pages. Printing can be started from this dialog box.

Printing FastLapSim Test Reports

Print Preview Dialog Box



Print Preview, accessible from the *File* menu, provides an on-screen rendering of what each page in the basic lap-test printout will look like when printed on the selected Windows printer. Use this feature to determine which pages you would like to include in the printout.

dialog box.

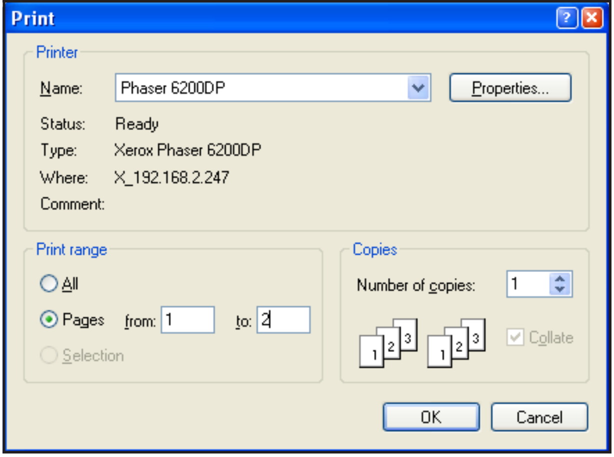
Print Preview—Opens the Print Preview Screen that provides an on-screen rendering of what each page in the drag-test report will look like when printed on the selected Windows printer.

Printer Setup—Similar to the Print dialog box (allows printer selection), except printing cannot be started from this box.

The lap-test report generated by FastLapSim consists of 5 pages. Here is description of each page:

Page 1—This page prints all the components selected for the current simulated vehicle. The appearance of this page is similar in layout to the *Component Selection*

Printing Specific Pages



Name: Phaser 6200DP

Status: Ready

Type: Xerox Phaser 6200DP

Where: X_192.168.2.247

Comment:

○ All

● Pages from: 1 to: 2

○ Selection

Number of copies: 1

☑ Collate

The print dialog box allows you to specify a range of pages to print. Here only pages 1 and 2 will print, as shown in the above photo.

Categories of the *Main Program Screen*.

Page 2—Displays all calculated performance data in chart form. The chart is virtually identical to the *Results Table* shown on the top of page 65.

Page 3—The vehicle-performance data graph is reproduced on this page (this is the graph located on the top, right side of the *Main Program Screen*. Full color printing is supported.

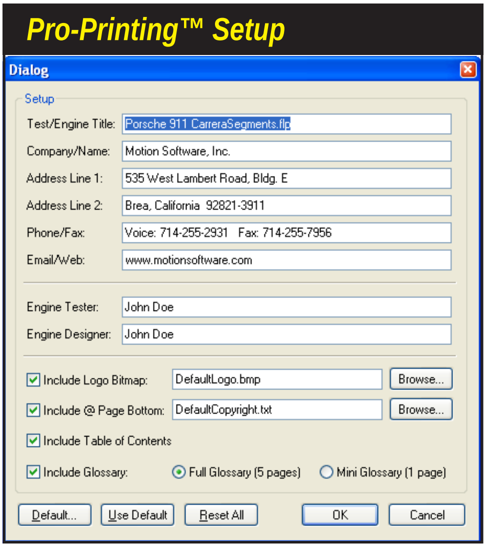
Page 4—This page provides a rendering of the current Track and related data.

Page 5—(***ProTools™*** only) This page includes a data graph of all segments defined fort the current track, see photo on bottom of page 65.

ProTools™ ProPrint Features

When ***ProTools™*** have been activated (see page 100 for more information on optional-feature activation), ***ProPrinting™*** is available that will generate a comprehensive "presentation" report of vehicle test data. ***ProPrinting™*** features include special page graphics, a cover page with the name and address of your business (or your personal name and address) and logo, a table of contents, optional text printed at the bottom of each page (can be a disclaimer, copyright notice or any other text you wish), optional comprehensive or "mini" glossaries, and a complete listing of all test data and results. This full-color report is built within FastLapSim and delivered to your default Internet browser (e.g., Microsoft *Internet Explorer™*) for on-screen display and printing. To view a multiple-page print preview of this report, select *ProPrint Preview* from within FastLapSim, the select *Print Preview* from within your browser.

Note: Some browsers, like recent versions of *Internet Explorer*) do not print "background graphics" by default. This will prevent the printing of background colors in many of the data tables in the ***ProPrinting™*** report. To enable full-function printing, open the

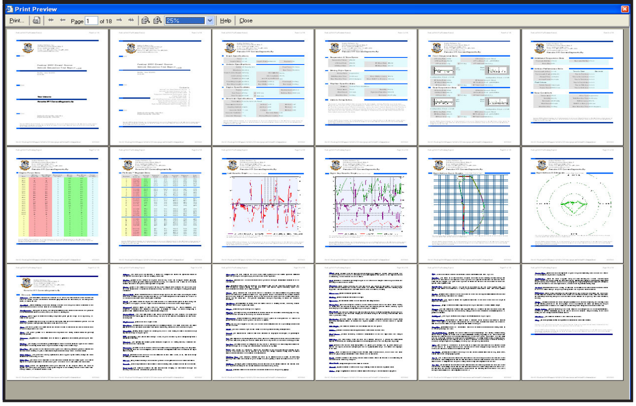


Test/Engine Title: Porsche 911 CarreraSegments.flp
Company/Name: Motion Software, Inc.
Address Line 1: 535 West Lambert Road, Bldg. E
Address Line 2: Brea, California 92821-3911
Phone/Fax: Voice: 714-255-2931 Fax: 714-255-7956
Email/Web: www.motionsoftware.com
Engine Tester: John Doe
Engine Designer: John Doe
☑ Include Logo Bitmap: DefaultLogo.bmp
☑ Include @ Page Bottom: DefaultCopyright.txt
☑ Include Table of Contents
☑ Include Glossary: ● Full Glossary (5 pages) ○ Mini Glossary (1 page)

***ProPrinting™*, a *ProTools™* feature, turns the results of any vehicle simulation into a professional test report. Use the *Pro-Printing™ Setup* dialog box, available from the *File* menu, to enable and customize *Pro-Printing™* features. You can add your name, address, your company logo, specialized (copyright) text, a table of contents, and even a short or long glossary to your *ProPrint* report. Use the *Default...* button to save your preferences that will be applied by default to new vehicle simulations. The files for the Default Logo.bmp and the DefaultCopyright.txt are located in the *FastLapSim/Manuals & Videos/proprint* subdirectoy. You can modify these files to suit your requirements.**

ProTools™ Printing Features

Pro-Printing™ FastLapSim Test Report



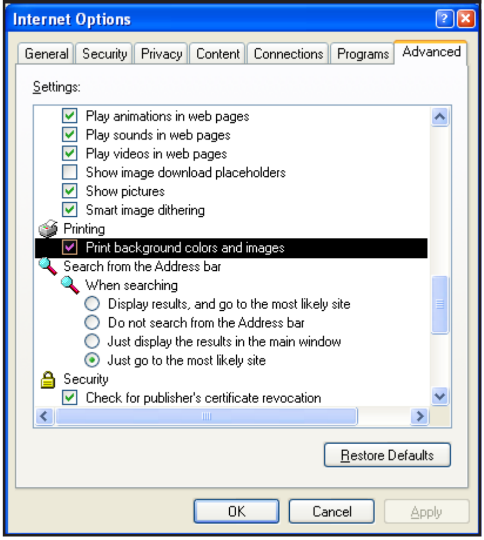
A *ProPrinting*™ report includes "presentation" graphics, a cover page with the name and address of your business (or your personal name and address) and logo, a table of contents, optional text printed at the bottom of each page, optional "full" or "mini" glossaries, and a complete listing of all test data and results. The report is delivered to your default web browser for printing (or *print previewing* as shown here).

Internet Options menu (often located at the bottom of the *Tools* menu within Internet Explorer), choose the *Advanced* tab, and click the box (to enable) *Print background colors and images*.

Use ***ProPrinting*™ *Setup***, available from the **File** menu in FastLapSim, to enable and configure ***ProPrinting*™** features. If you activate ***Include Logo***, the logo file must be a .BMP file (should be square with the size near 100 by 100 pixels). If you activate ***Include @ Bottom Of Page***, the included text file must be non-formatted text only (for example, created in *Notepad*) and no longer than about 50 words. You will find these files located in the *FastLapSim/Manuals & Videos/proprint* directory.

Some browsers, like recent versions of *Internet Explorer)* do not print "background graphics" by default. This will prevent the printing of data table background colors in *ProPrinting*™ reports. To enable full-function printing, open the Internet Explorer *Options* menu (typically located at the bottom of the Tools menu within Internet Explorer), choose the *Advanced* tab, and click the box (to enable) *Print background colors and images*.

Pro-Printing™ IE Configuration



Settings:

☑ Play animations in web pages
☑ Play sounds in web pages
☑ Play videos in web pages
☐ Show image download placeholders
☑ Show pictures
☑ Smart image dithering
Printing
☑ Print background colors and images
Search from the Address bar
When searching
○ Display results, and go to the most likely site
○ Do not search from the Address bar
○ Just display the results in the main window
● Just go to the most likely site
Security
☑ Check for publisher's certificate revocation

Fast Lap Sim
Racing Software

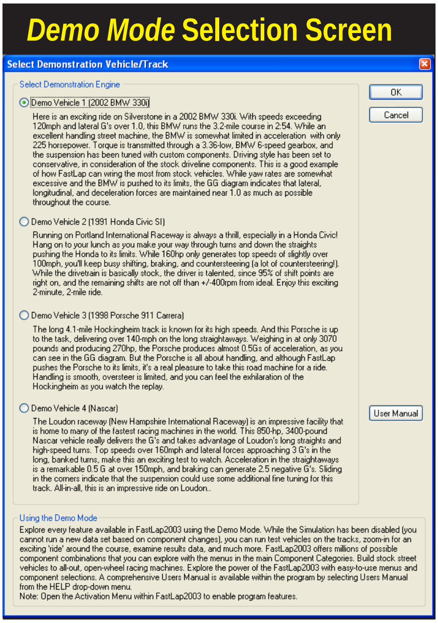
Advanced
Road-Race
Simulation

OTHER FEATURES

FEATURE ACTIVATION

FastLapSim can start-up and run in three distinct modes: 1) ***Demo***, 2) ***Advanced***, and 3) ***ProTools™ Activated***.

Demo Mode—If you have downloaded FastLapSim from an Internet site or installed FastLapSim Demo on your system along with other, purchased Motion Software simulations, FastLapSim will start in the *Demo Mode*. The Demo presents a dialog box from which you can select any of several test vehicles. All the features of FastLapSim are available, and you can fully explore the capabilities of the program, except that the *Demo Mode* does not allow changes to the weight and type of vehicle, and you cannot load or save files. For additional information about the *Demo Mode*, refer to the ***Help*** button on the *Demo Vehicle-Selection Screen* (shown below).



Demo Mode Selection Screen

● Demo Vehicle 1 (2002 BMW 330i)

Here is an exciting ride on Silverstone in a 2002 BMW 330i. With speeds exceeding 120mph and lateral G's over 1.0, this BMW runs the 3.2-mile course in 2:54. While an excellent handling street machine, the BMW is somewhat limited in acceleration with only 225 horsepower. Torque is transmitted through a 3.36-low, BMW 6-speed gearbox, and the suspension has been tuned with custom components. Driving style has been set to conservative, in consideration of the stock driveline components. This is a good example of how FastLap can wring the most from stock vehicles. While yaw rates are somewhat excessive and the BMW is pushed to its limits, the GG diagram indicates that lateral, longitudinal, and deceleration forces are maintained near 1.0 as much as possible throughout the course.

○ Demo Vehicle 2 (1991 Honda Civic SI)

Running on Portland International Raceway is always a thrill, especially in a Honda Civic! Hang on to your lunch as you make your way through turns and down the straights pushing the Honda to its limits. While 160hp only generates top speeds of slightly over 100mph, you'll keep busy shifting, braking, and countersteering (a lot of countersteering!). While the drivetrain is basically stock, the driver is talented, since 95% of shift points are right on, and the remaining shifts are not off than +/-400rpm from ideal. Enjoy this exciting 2-minute, 2-mile ride.

○ Demo Vehicle 3 (1998 Porsche 911 Carrera)

The long 4.1-mile Hockingheim track is known for its high speeds. And this Porsche is up to the task, delivering over 140-mph on the long straightaways. Weighing in at only 3070 pounds and producing 270hp, the Porsche produces almost 0.5Gs of acceleration, as you can see in the GG diagram. But the Porsche is all about handling, and although FastLap pushes the Porsche to its limits, it's a real pleasure to take this road machine for a ride. Handling is smooth, oversteer is limited, and you can feel the exhilaration of the Hockingheim as you watch the replay.

○ Demo Vehicle 4 (Nascar)

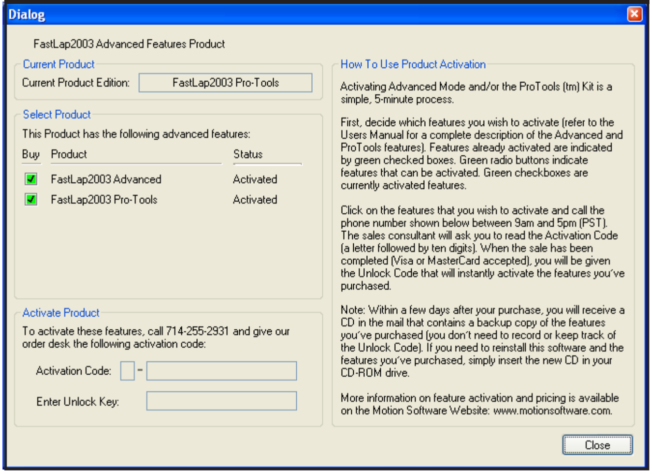
The Loudon raceway (New Hampshire International Raceway) is an impressive facility that is home to many of the fastest racing machines in the world. This 850-hp, 3400-pound Nascar vehicle really delivers the G's and takes advantage of Loudon's long straights and high-speed turns. Top speeds over 160mph and lateral forces approaching 3 G's in the long, banked turns, make this an exciting test to watch. Acceleration in the straightaways is a remarkable 0.5 G at over 150mph, and braking can generate 2.5 negative G's. Sliding in the corners indicate that the suspension could use some additional fine tuning for this track. All-in-all, this is an impressive ride on Loudon..

Explore every feature available in FastLap2003 using the Demo Mode. While the Simulation has been disabled (you cannot run a new data set based on component changes), you can run test vehicles on the tracks, zoom-in for an exciting 'ride' around the course, examine results data, and much more. FastLap2003 offers millions of possible component combinations that you can explore with the menus in the main Component Categories. Build stock street vehicles to all-out, open-wheel racing machines. Explore the power of the FastLap2003 with easy-to-use menus and component selections. A comprehensive Users Manual is available within the program by selecting Users Manual from the HELP drop-down menu.
Note: Open the Activation Menu within FastLap2003 to enable program features.

If you've downloaded FastLapSim from an Internet site or installed FastLapSim Demo on your system, the program will start-up in the *Demo Mode*. The Demo presents a dialog box from which you can select any of several test vehicles. All the features of FastLapSim are available, except that the *Demo Mode* prevents any changes to the vehicle type and weight, and you cannot load or save files. For additional information about the *Demo Mode*, refer to the *Help* button on the *Demo Vehicle-Selection Screen* (shown here).

Other Program Features

Activating Features



FastLap2003 Advanced Features Product

Current Product

Current Product Edition: FastLap2003 Pro-Tools

Select Product

This Product has the following advanced features:

Buy	Product	Status
☑	FastLap2003 Advanced	Activated
☑	FastLap2003 Pro-Tools	Activated

Activate Product

To activate these features, call 714-255-2931 and give our order desk the following activation code:

Activation Code: -

Enter Unlock Key:

How To Use Product Activation

Activating Advanced Mode and/or the ProTools (tm) Kit is a simple, 5-minute process.

First, decide which features you wish to activate (refer to the Users Manual for a complete description of the Advanced and ProTools features). Features already activated are indicated by green checked boxes. Green radio buttons indicate features that can be activated. Green checkboxes are currently activated features.

Click on the features that you wish to activate and call the phone number shown below between 9am and 5pm (PST). The sales consultant will ask you to read the Activation Code (a letter followed by ten digits). When the sale has been completed (Visa or MasterCard accepted), you will be given the Unlock Code that will instantly activate the features you've purchased.

Note: Within a few days after your purchase, you will receive a CD in the mail that contains a backup copy of the features you've purchased (you don't need to record or keep track of the Unlock Code). If you need to reinstall this software and the features you've purchased, simply insert the new CD in your CD-ROM drive.

More information on feature activation and pricing is available on the Motion Software Website: www.motionsoftware.com.

Activating *Advanced Mode* from the *Demo* version or activating *ProTools*™ from the *Advanced* version is a simple 5-minute process. Call the phone number shown between 9am to 5pm (PST). A sales consultant will ask you to read the *Activation Code*, and when the sale has been completed, you will be given the *Unlock Code*. Note: Within a few days you will receive a new CD in the mail.

Advanced Mode—(Base Version Of FastLapSim) FastLapSim contains a rich and powerful set of features that most enthusiasts will find more than sufficient to allow them to test components and determine optimum combinations for just about any application. All essential simulation features are included in the *Advanced Mode*, The ***ProTools***™ mode extends existing features to allow a more technical and/or detail analysis of vehicle performance.

For Example: In *Advanced Mode*, the user can measure and monitor various vehicle data sets, including Acceleration and Aero Drag, and Speeds. The ***ProTools™ Kit*** includes additional dynamics and force measurements, including Tire Growth, Tire Slippage, Corrected Horsepower Values, Rotational Inertias, etc.

ProTools™ Kit Activated—(Professional Version Of FastLapSim) If you are a serious enthusiast or professional racer, you will find the additional tools and features supplied in the ***ProTools™ Kit*** a valuable addition to FastLapSim *Advanced Mode*. Many features in the Advanced Mode have been enhanced with extended functionality.

Here is a list of FastLapSim ***ProTools™ Kit*** contents:

- A ***Real-Time Simulation Screen:*** View the simulation process realtime, review an extensive data display, watch the simulation zero-in on the best braking points and corner speeds, see suspension movement, G-forces, and more!

- ***Simulation Optimization:*** This ***ProTools***™ feature includes optimization routines that perform a more in-depth analysis of every corner, braking points, all suspension movement and forces applied to the test vehicle. This calculation-intensive analysis, when activated by the user, predicts lap times and vehicle performance data with the highest possible accuracy. If you need the most accu-

Other Program Features

FastLapSim Feature Activation

FastLapSIm Program Features	Program Activation Modes		
	Demo	Advanced	*ProTools™*
Tracks Available	Fixed	Unlimited	Unlimited
Vehicle Specifications	Fixed	User Selectable	User Selectable
Color FastLap Test Printouts	✔	✔	✔
Fast Units Switching	×	✔	✔
Track Editor™	×	✔	✔
Comprehensive Suspension Mods	×	✔	✔
Extended Color Interface	×	✔	✔
Real-Time Simulation Screen	×	×	✔
High Resolution Testing	×	×	✔
ProPrinting™ FastLap Reports	×	×	✔
Graph ***DataZones™***	×	×	✔
Extended Simulation Graph Data	×	×	✔
ProData™ Tables	×	×	✔
Iterative Testing (***Spring/Damper***)	×	×	✔
Track Segment Data Analysis	×	×	✔

If you are a serious enthusiast, racer, or professional engine builder, you will find the additional tools and features supplied in the *ProTools™ Kit* a valuable addition to the DynoSim. Many features in the Advanced Mode have been enhanced with extended functionality. In addition, there are new features aimed directly at the professional, like the *ProIterator™* and *Pro-Printing™* that generates a "presentation-quality" dyno test report including the name and logo of your company.

rate analysis possible, the ***ProTools™ Optimization*** will help you achieve your goals.

- The ***Spring/Damper QuickCalculator™:*** A powerful ***ProTool*** for serious performance seekers. This tool will help pick the most appropriate shock absorber for any spring rate. The Calculator tests dampers with the current spring, performing a spring/shock dyno simulation and selecting a combination that effectively dampens the spring (without overdamping). The ***Spring/Damper QuickCalculator™*** is an indispensable tool for zeroing-in on the best shock combinations for virtually any vehicle or track.

- The ***Optimum Gear Iterator™:*** This ***ProTool*** performs a quick iteration using the current vehicle setup and simulation test data to find the best transmission and rear-axle ratios for the test vehicle. The ***Optimum Gear Iterator™*** is another tool that will give any serious racer a winning edge.

- ***Track Segments*** defines portions of the track as "segments." Segments begin and end at Corner Points, and once defined, segments can be used to analyze vehicle entrance and exit speeds, average speeds, and other vehicle "acquisition" data. Optionally, choose unique colors for each segment, making visual identification a snap. Up to 30 segments can be defined for each track.

- Graph ***DataZones™:*** Set colored ranges on any simulation results graph to mark target times, distances, accelerations, speeds, or any other race variables.

DataZones also can be used to graphically indicate gear ratios overlaid on speed, acceleration, and other distance-based data-sets. ***DataZones*** produce professional-looking graphs, isolate vehicle characteristics, help detect excess speeds or loads, and add color to graphic displays.

- ***ProTools*** also includes track-segment ***ProData™*** that is calculated and displayed in an additional table of test results (available by selecting the ***ProData*** tab at the bottom of the graph screen). Up to 30 segments can be defined and uniquely colored. Each segment of the track can be used to record and analyze vehicle entrance and exit speeds, average times, and more.

- ***Pro-Printing™:*** Allows you to printout a comprehensive, presentation test report of any simulated vehicle on any track. This professional report includes a custom cover page with the name of your business and/or vehicle designer, vehicle data, all performance data tables, graphic performance data, and all extended data available with ***ProTools*** (as described above). Even include an optional Table of Contents and/or Glossary of Terms with your test reports. Use this eye-popping report to make the best presentation possible of your latest vehicle simulation designs.

Activating *Advanced* Or *ProTools™* Modes

Activating *Advanced Mode* from the *Demo Mode* or activating the ***ProTools™*** Kit from *Advanced Mode* is a simple, 5-minute process. Open the **Product Activation** dialog box (the **Activation** menu is located just to the right of the **Help** menu) and decide which features you wish to activate. Features already activated are indicated by green checked boxes. Green radio buttons indicate additional features that can be activated. Select the feature you wish to activate and call the phone number shown in the Activation box between 9am to 5pm (PST). The sales consultant will ask you to read the **Activation Code** (a letter followed by ten digits). When the sale has been completed (Visa or MasterCard), you will be given the **Unlock Code** that will instantly activate the features you've requested.

Note: Within a few days after your purchase, you will receive a new CD in the mail that contains a backup copy of the features you've purchased (you don't need to record or keep track of the *Unlock Code*). If you need to reinstall FastLapSim, including any or all of the optional features you have activated, simply insert the new CD in your CD-ROM drive.

GENERAL SIMULATION ASSUMPTIONS

FastLapSim closely simulates the conditions that exist during an actual road race. The goal is to reliably predict the torque to the driving wheels, the weight transfer that occurs during acceleration, cornering, torque losses through the driveline, and a myriad of other factors to accurately predict vehicle performance throughout the course.

General Simulation Assumptions

Here are some of the assumptions within FastLapSim that establish a modeling baseline:

Engine:

1) The engine power curve is assumed to be corrected to Standard Temperature And Pressure, and the power delivered to the powertrain is corrected for the weather conditions established in the Weather Category.
2) Engine speed will never exceed the Redline Limit established in the Engine Category.
3) Full throttle engine power will be applied to the powertrain as much as possible throughout the duration of the race.

Environment:

1) As engine inlet air gets colder and denser air, the higher horsepower the engine will produce. For induction air at the standard temperature and pressure (STP) of 68-degrees(F), dry (0% humidity), with a barometric pressure of 29.92-in/Hg, engine power will not be corrected and will be used as entered in the *Power Curve* dialog box (power values entered in the Power Curve dialog or imported from a DynoSim engine (.DYN) file are assumed to be corrected to STP).
2) The engine, oil, and coolant have been warmed to operating temperature.

RaceLine:

The calculation of the raceline is the most complex function within FastLapSim. An ideal raceline will allow the car to accelerate as soon and as long as possible, brake as late as possible, and traverse a corner at the largest possible radius. FastLapSim uses two techniques to derive this solution. First, a raceline is approximated by a series of points, at which the curvatures or corner radii are calculated and default lanes (several possible paths across the track) are assigned. The next step iterates lane assignments (performs multiple tests) modifying paths and recalculating the curvatures until the most linear (shortest) path through the track has been found. Once this path is computed, the theoretical maximum speed through each point is determined, assuming speed is limited by peak tire grip. When this step is complete, a new series of calculations analyze the computed speeds and radii to determine where braking should begin. The last computation cycle uses a Gradient Descent technique to optimize the calculated path. As this is performed, the path is modified slightly, and the lap times are estimated. If the new path proves to be an improvement, its specifications are retained, if it is not the quickest path through the track, the entire process is repeated until there is a convergence upon an optimal path. Raceline calculation requires millions of mathematical operations, however, it only requires about two seconds of calculation time on 1GHz or faster processors.

Transmission and Differentials:

General Simulation Assumptions

The simulation uses a unique system to simulate the gearbox-and-differential system. It is defined as a system of connections that have both outputs and inputs and can feedback or pass-through forces and speeds to various components. For example, on a rear-wheel drive car, the engine transfers power into the gearbox which feeds the rear differential which feeds the wheels and tires. During engine braking, the tires feed back into the differential which feeds back to the gearbox which feeds back to the engine. At each point the system is modeled and outputs are calculated.

Aerodynamics:

There are two types of aerodynamics modeled in FastLapSim: Body and Wings. Body aerodynamics are simulated by analyzing the coefficient of drag (Cd), and frontal area. Cd ranges from 0.20 (very aerodynamic car) to 0.70 (a brick). The frontal area is the area covered by a “shadow” of the car as projected down the length of the vehicle. With these parameters a calculation is performed to estimate vehicle drag. Wing aerodynamics simulate the downforce and drag produced by an airfoil wing. A wing is defined by surface area (length x width), chord angle (the curve of the wing), and the angle of attack (the angle that the wing is mounted onto the car). You can specify a front and rear wing. The force produced by the wing is applied at the front or rear axle, respectively.

Advanced
Road-Race
Simulation

HANDLING CLINIC

Finding The CG Height Of A Real Car

Start by weighing the vehicle at all four wheels. Record the total weight and the weight over the front and rear wheels. Now raise one end of the vehicle up about 24 inches if possible. Use a heavy-duty hydraulic jack or an overhead hoist to do this. Keep the wheels at the other end on the scales. Record how much weight is now indicated on the scales.

You will now need to know the wheelbase with the car raised as well as the wheelbase with all four wheels on the ground. To measure the "static" wheelbase, drop a plumb from the center of each wheel and make a mark on the ground. Use a tape to measure the distance. To measure the wheelbase when one end is raised, drop a plumb from the raised end and make a mark on the ground. Measure from the mark to the wheel center mark from before. We now have enough information to calculate the CG height (this height is from the ground).

Note: You can also use the *CG QuickCalculator* (described on page 31) to perform this calculation.

$$\text{CGV} = \frac{(\text{Level Wheelbase} \times \text{Raised Wheelbase} \times \text{Added Weight})}{(\text{Distance Raised} \times \text{Overall Weight})}$$

There are a few things that can affect an accurate determination, like suspension droop (and compression at the end on the scales), fuel slosh, etc. The suspension can be locked in place by replacing the damper (shock) with a rigid bar and the fuel tank can be emptied to improve accuracy.

Chassis Setup—Introduction

Here are specific problems that can arise when tuning a car for a given racetrack. The list of problems discussed and the possible solutions are based on experience and research, however, they are by no means a complete list of all the possibilities. The suggested remedies are believed to be accurate, but there are always exceptions. The following material should be treated as solution guidelines, not fixed rules.

It is necessary to make the distinction between changes that will always improve the performance of the car (make all of these first) and changes that tune or balance the car (these have trade-offs). The first category includes things like more power and stickier tires; the second group includes small changes like spring rates or adjusting anti-roll bars. It takes good initial design and careful tuning to produce a successful car.

One major cause of handling problems is suspension/component/chassis compliance (or flexibility). All materials are flexible to some degree. Loads on various parts of a vehicle can be surprisingly large, leading to unexpected distortions. With unknown and/or excessive compliance, it can be very difficult to predict any aspect of racecar performance. Cars that have large compliance (often unknown by the race team) are usually unresponsive to typical changes to which most race cars respond. FastLapSim does not model structural compliance and assumes a 100% rigid frame.

Table 1 lists principal chassis adjustments that can be made on modern racecars. You can consult ***Table 2*** if you have an existing problem, and it should point to changes that will have a significant influence. The most challenging part of determining an optimum race setup is that any change affects virtually everything else. A change made to improve one aspect of performance can easily degrade overall lap times. The best lap times are achieved with a setup that is the best compromise for the circuit as a whole. ***Table 3*** puts this into perspective by illustrating some of the effects that can occur when a particular modification is made to improve one problem area.

Given the differences between cars, the set of tables in this chapter should only be considered a starting point in the setup process. Ideally, enough testing can be done to put numbers on the results of any given change. This test data will be invaluable at the track when time is short.

Setup

Racing is all about driving the vehicle at its limits, near the “g-limit” boundaries of tire traction. Finding a vehicle setup to accomplish this is referred to as the optimum setup or chassis tune. The task involves many compromises for each vehicle on each circuit. FastLapSim allows you to test many setups before taking them to the track. However, even the best simulation results may not suite a particular driver or track conditions, so final on-track evaluation is always necessary.

Here are the principal objectives in setting up a car:

1 Cornering balance (neutral steer) under maximum lateral conditions.
2 Compromise between cornering performance and drag on high-speed tracks.
3 Eliminating specific control and stability problems at any point on the circuit.
4 Maximize acceleration out of corners and down the straits.

The traditional setup procedure involves making changes in vehicle adjustments based on subjective driver comments and lap/segment times. This feedback might be supplemented with remarks from observers stationed at various points around the track and tire temperature measurements taken in the pits.

Table 1—Principal Chassis Tuning Items

Tires	a. Different designs, sizes and front/rear combinations b. Tire pressures/tire temperatures c. Stagger (different tire circumference) frequently used across an axle d. Rim widths and offsets (possible track change) e. Static alignment (toe, camber, caster)
Static Wheel Loads	a. Longitudinal CG location (shifting ballast b. Lateral CG location (shifting ballast) c. Wedge, diagonal weight jerking, or warp (changes in spring preload)
Lateral Load Transfer Distribution(LLTD)	a. Roll couple distribution front to rear b. Roll center heights (front and/or rear) c. Ride spring rates d. Anti-roll bars or Z-bars e. Progressive rate springs, linkages and bump stops (Notes: Coupling occurs with ride height changes when progressive rate linkages are used. Cockpit adjustment of LLTD may be provided.)
Ride Height and Body Attitude (Roll and Pitch	a. Wheel orientation changes via suspension geometry Camber curves Ride (bump)/roll steer Anti-dive/squat Steering geometry Wheel travel b. Aerodynamics (function of ride height and body attitude)
Aerodynamic Forces and Moments	a. Lift/downforce b. Drag c. Pitching and yawing moments (Note: As affected by size, shape, angle of wings, car shape/underbody, internal air flow, etc.)
Brakes	a. Distribution, front to rear b. Cooling
Driveline	a. Gearing b. Differential, type and functional behavior c. Spool d. Engine performance characteristics
Dampers	a. Type and curve shape.
Driver-Vehicle Interface	a. Steering ratio b. Pedal forces and movements c. Force feedbacks (kickback, oscillations)
Compliances	a. Chassis and suspension stiffness maximized by design b. Suspension compliances are not adjustable for tuning (as in road cars)

Tables 1 covers the principal chassis tuning items. The first four items are directly concerned with the tires, desirable wheel orientations, and tire loads. The aerodynamic lift/downforce is an important component when aero devices are allowed. Brake distribution affects control and balance through modifications in tire loads. Driveline characteristics acting through longitudinal and lateral tire slip and can significantly affect the available lateral tire forces. Finally, dampers have some direct control on tire loads under rough road and transient conditions.

The Handling Clinic

The professional racing approach to setup has become much more sophisticated in recent years. In the first place, the cars have become more adjustable. Second, electronic on-board and trackside instrumentation is being used by most well financed teams. With the advent of simulation like this it is now possible to experiment with various modifications before using valuable track time.

Chassis Adjustment

Table 1 covers the most important items that can be modified to optimize chassis tuning and handling. Since competition experience and ingenuity are continually producing new ideas, this table should not be viewed as complete. Rather use it as a guideline for your modifications.

An examination of ***Table 1*** indicates that a major part of chassis tuning is maximizing the lateral tire forces while achieving proper balance. The first four items are directly connected with the tires, desirable wheel orientations, and tire loads. Aerodynamic lift/downforce is an important component of vertical tire loads when aero devices are allowed. Brake distribution also affects control and balance through modification on tire loads throughout the friction circle. Driveline characteristics act through the interaction of longitudinal and lateral tire slip and can significantly affect the lateral tire forces. Finally, dampers have some direct control on tire loads under rough-road and other transient conditions.

Although it is desirable to make one configuration change at a time, there are major and subtle interactions between modifications that we'll cover in the upcoming sections.

Using Table 2—Primary Setup Guide

Table 2 is a first cut at the major problem areas for high-performance / racing cars. Down the left side of the table is a list of different operating conditions and across the top is a list of items that can be changed. The numbers in the chart correspond to the numbered paragraphs in this section on Primary Setup. The choice of which relationships to discuss was made on the basis of "most likely to affect performance." As an aid to understanding, we recommend that the reader stop and create a mental picture for each situation.

The changes along the top of the table are ordered from left to right in approximate mechanical difficulty. Changes on the left side of the table require a fair amount of effort and may need to be designed into the car; those on the right are items that can be changed relatively easily in tuning the car.

1. The Effect of CG Location on Straight Line Braking

When the brakes are applied, load is transferred from the rear tires to the front tires. The higher the CG, the more is transferred for any given deceleration. Tires are load sensitive, thus theoretical best braking occurs with the tires evenly loaded (if the tires are the same on both ends of the car). For the typical

Table 2□Primary Setup	CG Location	Roll Center	Anti-pitch	Steering Geometry	Camber	Ride/Roll Steer	Aero-dynamics	Differential	Tire & Rim Size	Ride Spring Rates	Ride Height	Brake Balance	Roll Stiffness Distribution	Dampers
Low-Speed Steady-State:														
Straight Line Braking	1								2			3		
Braking & Cornering	4	5										6	7	
Cornering	8	9			10				11				12	
Acceleration & Cornering								13					14	
Straight Line Acceleration	15		16					17						
High-Speed Steady-State:														
Straight Line Braking							18					19		
Braking & Cornering							20					21		
Cornering							22							
Straight Line Acceleration							23							
Transient Behavior:														
Dropped Throttle in a Turn	24					25		26						27
Braking in a Turn	28											29		
Poor Road				30		31				32	33			34
Control Characteristics:														
Steering Force & Ratio				35					36					
Steering Kickback				37				38	39					

RWD or FWD road car (with initial forward load bias) this says that to improve the absolute level of braking, the CG should be as low as possible and moved toward the rear of the car. Clearly this is not always feasible for FWD race cars but it should be taken into account when a car is being designed.

2. The Effect of Tires and Rim Sizes on Straight Line Braking

To the extent that changing the tires/rims changes tire/road friction properties, the braking performance will be affected. The end with the stickiest tires can generate relatively more braking force for a given load.

3. The Effect of Brake Balance on Straight Line Braking

Brake balance is the name given to the proportioning of brake force (or brake torque) to the front and rear tires. The brake balance to give “correct” proportions of braking to the front and rear (relative to their potential) varies with deceleration rate. The harder the stop, the more heavily loaded will be the front wheels and the more braking effort they can support. Likewise, the rear tires are unloaded as the deceleration increases and they must have less braking force. This is accomplished in several ways: Either the brake balance is fixed and is biased heavily toward the front, which means the rears don’t do their share on relatively gentle stops, or various types of proportioning valves are used to limit hydraulic pressure to the rear brakes to prevent premature locking. Finally, an antilock system may be fitted. When the brakes are not correctly set up (for racing) one end will lock up before the other. If the rears lock first, the car will tend to spin, based on the destabilizing side force that the still-rolling front tires provide. If the fronts lock up first, steering control will be lost and the car will go straight or slide down the camber of the road. Because the desirable brake balance varies with the deceleration, different brake balances are required on different coefficient of friction surfaces. For example, snow gives little absolute braking capability and the best brake balance will be very close to the fore-aft static weight distribution. Where possible, it is desirable to fit some sort of brake balance adjustment to racecars to allow tuning of the brakes to different surfaces and conditions.

4. The Effect of CG Location when Braking and Cornering

The result of combined braking and cornering on turn entry is to load the outside front wheel very heavily (perhaps as much as one half the weight of the car). At the same time, the inside rear wheel is lightly loaded. The higher the CG, the more load will be transferred. This situation will be exaggerated if the CG is forward to begin with. The heavily loaded outside front tire will be operating at a relatively low coefficient because of load sensitivity. Assuming the car has been otherwise set up, a low and rearward CG position is going to keep the tires most evenly loaded on turn entry, and this will give the best performance.

5. The Effect of Roll Center Location when Braking and Cornering

Roll center heights front and rear partially determine the way the roll moment on the car from lateral force is distributed. Lowering the roll center on one end will lower the roll moment resisted by that end; the wheels on that end will be more evenly loaded in cornering compared to the other end of the car. For example, assume that the car is loose on turn entry; the idea is to sacrifice grip on the front to increase grip on the rear. The outside front is taking the largest share of the load and increasing the front roll resistance by raising the front roll center will further degrade it to help the rear stick proportionately better. Additional help can be obtained by lowering the rear roll center height as well. It should be noted that “too high” a roll center leads to jerking.

6. The Effect of Brake Balance on Combined Braking and Cornering

The correct brake balance for straight line stopping may not be appropriate on turn entry. The outside front tire is very heavily loaded and generates relatively more lateral force than the rear leading to spin. This is true even though the front is operating at a lower coefficient (due to load sensitivity). Thus, too much rear brake bias may be described as “loose coming into the turn.” Some production cars have almost no rear brake bias (to prevent accidental spins) and the sometimes-used practice of trail braking (braking while on the throttle in a front-wheel drive) has a compensating effect. The engine power reduces the braking on the front wheels while the rears are still receiving a normal amount of braking force. The result is that the rear tires are saturated and the car begins to spin;

carefully controlled, this can be used to get the tail out on entry to tight comers.

7. The Effect of Roll Stiffness Distribution when Braking and Cornering

The roll stiffness distribution is the other way of changing the loads on the wheels under lateral force. Roll stiffness can be raised by increasing anti-roll bar stiffness or increasing spring stiffness. Again, assuming the car is loose on turn entry, it is appropriate to resist more of the body roll moment on the front. Higher front roll stiffness will do this. If the car has a “rising rate” spring installation, the front roll stiffness increases when the vehicle pitches forward. For front-wheel drive the problem may be reversed, if the CG of the car is so high and/or forward that the inside rear wheel is off the ground, the rear of the car is already offering all the roll stiffness it can and further changes in rear roll stiffness will have no effect.

8. The Effect of CG Location on Steady-State Cornering

A neutral car is best for steady-state cornering. By tuning, cars with a range of CG positions near the center of the car (and same tires front and rear) can be made to be neutral. If the CG is forward, the lightly loaded rear end will stick better than the front (because of tire load sensitivity) and the rear end must be degraded to bring the car back to neutral (this ignores the friction circle effect which can degrade the drive tires a great deal, even at road load power). The best use of equal-sized tires in steady-state cornering is made with the CG near the center of the car.

9. The Effect of Roll Center Location on Steady-State Cornering

If the car is forward weight biased, a rear roll center higher than the front will tend to make it neutral. If both roll centers are so low (i.e., on the ground) that the car has a large amount of body roll, absolute cornering performance may be affected through adverse tire camber. It is necessary to strike a compromise here because too high a roll center leads to jerking (and lateral tire scrub on bumps), an undesirable characteristic.

10. The Effect of Camber on Steady-State Cornering

It is desirable to have a small amount of negative camber (top of the tire leaning toward the center of the car) on the outside wheels. This produces the maximum lateral force from the two outside tires. Tire temperature taken across the tread width is commonly used to set static camber; the camber is changed until the temperature is roughly the same across the tread width. For race courses where the direction of turn is always (or mostly) the same, positive camber on the inside wheels will also help. Camber can also be used to balance the car.

11. The Effect of Tire and Rim Sizes in Cornering

Cornering stiffness is often a function of tire/rim size, aspect ratio, and width. As has been mentioned earlier, higher cornering stiffness tires require lower slip angles to produce a given amount of lateral force. Lower slip angles means lower “induced drag” or scrub and less speed loss in cornering. The optimum rim width may also play a part in maximizing the total grip available from a given tire.

12. The Effect of Roll Stiffness Distribution on Steady-State Cornering

For a symmetrical car (50% weight on the front wheels, 4WD, etc.), the roll stiffness would ideally be the same on front and rear, if steady cornering were to be optimized. In 2WD cars, the drive degrades the lateral force capability at that end and the roll stiffness is biased toward the non-driven end. Many suspensions (especially rear) have an anti-roll bar “built-in” (twist axles). These double-duty suspensions require care in calculating the roll stiffness.

13. The Effect of Differential Type on Acceleration Out of a Corner

With an open differential the lightly loaded inside wheel is free to spin up under power if enough torque is available. This limits the available acceleration. Limited slip differentials have been used with varying success. It is unlikely that the simple addition of such a differential will be successful. As with any major change, a period of development must be gone through to make the new setup work. The type of limited slip differential chosen will be very important. Undesirable jerkiness occurs with many types and experience has shown this to be undesirable for combined acceleration and fuming.

The locked rear end or spool is another common solution to the problem of wheel spin. Because the locked axle has high resistance to yaw, more front cornering power may be required to keep the car neutral. If all the turns are the same direction, stagger (differential tire circumference) may be used to “split the difference” between low drag when straight running and when fuming.

14. The Effect of Roll Stiffness Distribution on Acceleration Out of a Corner

Roll stiffness is the easy way to change lateral load transfer distribution. For rear-wheel drive the tendency is to spin the inside rear; more roll stiffness on the front (less on the rear) will help this. On the other hand, acceleration from low speed can reduce the front tire load so much that the car plows. For front-wheel drive, if the inside front wheel is spinning on acceleration out of a low-speed comer, more rear roll stiffness will help if the inside rear wheel isn’t in the air.

15. The Effect of CG Location on Straight Line Acceleration

The CG location determines the point of wheel spin. As the CG is moved further rearward in a rear-drive car, the fraction available increases. CG further forward in a front drive car increases fraction available. Traction is a problem at low speeds (low gearing = high torque) with high-powered cars and on slippery surfaces. The need to move the CG to get fraction with a FWD is exaggerated when compared to a RWD because load is shifted off of the front tires on acceleration. The CG should be as low as possible to minimize this undesirable weight transfer. All of the other requirements for a good handling car suggest that the CG should be toward the center of the car; the fraction requirement of front-wheel drive forces a compromise in CG position. That is, put the CG as far back as you can and still get enough fraction.

16. The Effect of Anti-Pitch Characteristics on Straight Line Acceleration

Rear-drive cars, especially those for drag racing, may profit from rear lift (anti-squat). This raises the CG and increases weight transfer to the rear wheels on acceleration. The lift effect is created by choosing the rear suspension attachment points to give a high pitch center; the torque reaction from the driving wheels lifts the car. On a FWD, such lift is detrimental to acceleration. Although anti-lift geometry is possible for the front suspension (namely, the wheel moves forward on bump) it leads to harshness and is generally avoided. Some FWD front suspensions have lift built in (as an aid to good ride); this may be removed for high-performance use. On acceleration, the rear of a FWD will squat; there is no torque reaction available to counteract this.

17. The Effect of Differential Type on Straight Line Acceleration

If both tires are on similar coefficient pavement at similar vertical load, the differential type should not affect straight line acceleration capability (wheel spin limited). This is true of most independent suspensions and some torque tube solid axles. With solid rear axles this is not true because the wheel loads differ on acceleration. With the differential partially locked, small differences in tire size may cause the car to pull on acceleration (especially true on some front drives). This can be diagnosed by swapping the tires; if it pulls the other way, the wheels are being locked to the same rpm by the differential and the tires differ in circumference.

18. The Effect of Aerodynamics on High-Speed Braking

Aerodynamic drag helps the brakes at high speed. As an extreme example the Formula One cars of a few years ago had enough aero drag to decelerate at two-thirds of a “g” at 170 mph with no brakes at all! The same ground-effects cars could brake at over five g’s because of aero down load. The aero down load distribution front to rear will partially determine the best brake balance and this may change with speed.

19. The Effect of Brake Balance on High-Speed Braking

Best brake balance at high speeds will be different than at low speeds because of aerodynamic forces. If the brake balance is biased toward the rear (relative to the balance required for four-wheel simultaneous lockup), the rear wheels may lock and the car will tend to swap ends (hard to control at high speed). Brakes heat up when slowing the car, especially if the stop is from high speed. If different brakes are used front and rear, the brake balance may change as the car slows down and the brakes heat up, if the brake linings change coefficient of friction.

20. The Effect of Aerodynamics on Combined Braking and Cornering at High Speed

Aerodynamic down load (or lift) affects the stability of the car at high speed. If down load is available at the rear, it will help keep the rear wheels stuck down and make the car stable. If down load is available at the front, it will tend to destabilize the car and aid turn-in. An appropriate balance between aero down (or lift) loads must be reached.

21. The Effect of Brake Balance on Combined Braking and Cornering at High Speed

Best brake balance for high-speed turn entry is different than for straight braking. Too much braking on the lightly loaded rear degrades already marginal amounts of lateral force; this may lead to spin. For front-heavy cars ideal brake balance puts more braking on the front as the car comers harder. At high speed it is unlikely that the driver will want to get the tail out very much; it is generally better to go into high-speed bends with the front tires limiting slightly.

22. The Effect of Aerodynamics on High-Speed Steady-State Cornering

If there is down load available it will improve corner speeds. High-speed comers are often power limited: at full throttle the car slows down due to tire induced drag (scrub). Aero down load will reduce tire slip angles (tire induced drag), but aero down load often adds aero drag. The question is: When is the reduction in tire drag more than the increase in aero drag?

At high speed the road load power (the power required to maintain constant speed) is much greater due to aerodynamic drag. Friction ellipse effects may limit the drive axle tire side force.

Direct side force from vertical surfaces may also be used. This adds the aero induced drag to the tire induced drag and it is likely that the aero induced drag will be higher. In other words, direct aero side force may not be very useful on low powered cars.

23. The Effect of Aerodynamics on High-Speed Straight Line Acceleration

Aerodynamic drag (and to a much lesser extent other losses) limits the top speed of cars. Lowering the drag will allow a higher terminal velocity. What is not so commonly realized is that at high speeds the available forward acceleration is a function of the air drag as well as the power. At high speed the air drag has a large effect on the available acceleration.

24. The Effect of CG Location on Dropped Throttle in a Turn

When the throttle is lifted in a turn, several things happen at once. Load is shifted onto the front wheels and off the rear wheels by engine braking. The CG height, wheelbase, and the motoring torque determine the amount of load shifted. The immediate effect of this load shift is to increase the front tire lateral force and decrease the rear lateral force. The key here is “immediate” because the load shift happens quickly enough that the tire slip angles stay the same. A careful look at tire data will show what is happening. The result is that the front end “tucks in” and/or the rear end comes out. In extreme cases the car will spin if the driver does not take corrective action. Lowering the CG reduces this effect.

25. The Effect of Ride and Roll Steer on Dropped Throttle in a Turn

When the throttle is dropped, the car pitches forward. It is possible to arrange the ride steer to change the wheel steer angles on pitch to reduce the effect of dropped throttle. Toe-out with bump travel on the front end will reduce the steer angle on the outside front wheel. This will reduce the front side force and lower the amount of tuck in. In moderate turns, some toe-in on rebound at the rear will reduce the effects of dropped throttle as well.

At high lateral accelerations it is not so easy to correct dropped throttle effect with ride steer. The rear tire slip angles need to be increased to give more lateral force to make up for the decrease in load. The problem is that the tire is almost at its peak already and increasing the slip angle may not increase the side force available. The problem with ride/roll steer is that it is undesirable for much of the rest of operation. In general, geometric and compliance steer effects are ineffective at high lateral accelerations.

26. The Effect of Differential Type on Dropped Throttle in a Turn

The differential type affects dropped throttle behavior. An open differential that distributes the torque evenly from side to side will probably have the least effect on dropped throttle behavior. A differential that remains locked (possibly due to some preload) when throttle is dropped produces a stabilizing yawing moment or “yaw damping” moment. Some limited slip differentials may put shock loads into the drivetrain when they lock and unlock. This can have effects that are hard to predict.

27. The Effect of Dampers on Dropped Throttle Behavior

When the throttle is dropped in a turn the body of the car pitches forward and the loads on the front and rear track change over a short period of time. Soft dampers will stretch out this transient and the dropped throttle response will not be so sudden. Overall, however, soft dampers can have an adverse effect on control.

28. The Effect of CG Location While Braking in a Turn

When the brakes are first applied, a large amount of load shifts from the rear to the front axle. This changes the tire operating loads and side forces and the car tucks in. Lowering the CG reduces the load change on braking.

29. The Effect of Brake Balance While Braking in a Turn

The large transient effect of brake application is to transfer load forward and change the loads on the tires. Brake balance also can affect this transient through the friction ellipse effect. If the rear of the car is “coming around” too much on brake application, shifting the brake balance forward will reduce the side force available from the front tires and effectively increase the side force at the rear. Lockout or proportioning valves can change this behavior but require adjustment for different track friction coefficients.

30. The Effect of Steering Axis Geometry on Poor Road Behavior

Kingpin inclination and kingpin lateral position determine the scrub radius measured at the ground. It has become popular to design FWDs (in particular) with “negative scrub radius.” This tends to stabilize the car in straight running when the two wheels are on different coefficient surfaces under braking or fraction. For poor road straight running this is probably a good thing.

Non-driven front axles ideally have a small scrub radius. This reduces steering mosques due to one-wheel bumps. Unfortunately, large brakes and suspension links often conflict with centering the tire print on the kingpin. In this case the steering system must be designed to accept these shock loads.

The caster angle and longitudinal kingpin location determine the trail. The trail is commonly measured on smooth surfaces but on rough roads the tire contact patch can effectively move forward and the trail disappear or reverse. To avoid this, extra trail may be an appropriate modification for cars that have little to start with.

31. The Effect of Ride or Roll Steer on Poor Road Behavior

Ride steer is a geometric effect which results in the wheels steering with ride motion. Ride/roll steer is often built into production cars to influence low lateral acceleration handling. Small changes in the wheel steer angles will have little effect on the limit handling because the tires are nearly saturated. What ride steer will do is steer the car with bump travel when traveling straight; this is why most racing cars have been bump steered, the name given to the process of adjusting the steering linkage to minimize bump steer. This is especially important if the ride height has been changed from stock or the suspension geometry modified.

Ride steer and roll steer are closely related but they load the steering system (and box/rack mounts) in different directions depending on the detailed geometry. If there were no compliance in the steering system or suspension, ride steer and roll steer would be just a function of the wheel ride position to the chassis. In reality this is not often true.

32. The Effect of Ride Rates on Poor Road Behavior

The spring rates or ride rates must be chosen to match the terrain and the wheel travel must be chosen at the same time. A reasonable ride rate will keep the suspension off of the bump stops most of the time but not be so stiff that the bump stops are never reached (except on very smooth tracks). In fact, progressive bump stops may be considered part of the spring rate a highly nonlinear part. Contact with a solid bump step is upsetting to the ear in any circumstance.

If nonlinear ride springing is used (often through “rising rate” geometry) it has the effect of a smoothly progressive bump stop.

33. The Effect of Ride Height on Poor Road Behavior

If the car is lowered it is likely that there will be less suspension travel. To keep from bottoming on rough roads, the spring rate must be raised or the dampers stiffened. This in turn will change the ride and handling. Changing the ride height (up or down) will often change the ride steer or ride camber characteristics.

34. The Effect of Dampers on Poor Road Behavior

The best damper settings (adjustable dampers) for rough road will control the body motion to keep the car fairly level but allow the suspension to follow the surface. Dampers adjustable in bump and rebound separately are best for this. It can be difficult to sort out the difference between dampers that are too stiff and springs that are too stiff.

35. The Effect of Steering Axis Geometry on Steering Wheel Force and Ratio

Steering forces (with manual steering) at the steering wheel come from the tire self-aligning torque, from the mechanical trail, and from steering gear friction. The forces at the wheels are divided by the steering ratio before they reach the driver; the forces can be very large at the front wheels in a turn. If any aspects of the steering geometry are changed it is likely to affect the steering force characteristics.

Some examples: If caster angle is increased the self-centering torque will increase. If kingpin inclination is changed the rise and fall of the front end with steering will change this may affect steering forces at low lateral accelerations. The rise and fall of the wheels changes the diagonal wheel loading similar to “wedge.” If the scrub radius is changed the parking-lot-speed force levels will change. Simple changes like tire diameter, wheel offset, and ride height will affect the front-end geometry. If the steering ratio is not satisfactory, the steering arm(s) length can be changed. Bump steer may be changed by steering arm changes; in particular, changing outer ball joint height is a standard method of changing ride steer.

36. The Effect of Tire and Rim Sizes on Steering Wheel Force and Ratio

Changes in tire cornering stiffness change the effective steering ratio. A tire that has a steep cornering force curve needs less slip angle for a given lateral force than a softer tire. The steer angle required for a given comer is the sum of the Ackermann angle (depending on radius-of-turn and wheelbase) and the slip angle; reducing the slip angle required “speeds up” the steering. Simply changing the rim width can change the cornering stiffness; changing to larger size or wider tires will likely raise cornering stiffness. Steering wheel force will be affected if tires are fitted that have different aligning torque characteristics.

37. The Effect of Steering Axis Geometry on Steering Kickback

In general, race cars with little scrub radius will track well over rough roads. On smooth tracks, larger scrub radius (perhaps due to interference between wheel/ knuckle/ brakes) can be tolerated.

For the special case of FWDs, a slight amount of negative scrub radius gives the steering a self-correcting feature in straight line operation. If one wheel has more fraction than the other while accelerating or braking, it would tend to yaw the car, but the difference in tractive force turns the front wheels slightly to compensate. This may result in small steering wheel motions on rough or slippery surfaces but the car will tend to keep tracking straight. For a front-drive race car with high power, negative scrub radius may not be so desirable because of combined cornering and braking/accelerating. The heavily loaded outside wheel will dominate the steering force and the driver may be fighting the wheel with power changes. Moving toward centerpoint steering will improve this.

38. The Effect of Differentials on Steering Kickback

For FWD race cars. If any limited slip differential is fitted that locks-up or unlocks suddenly, it will be reflected to the steering. If there is any scrub radius, the change in drive torque will produce a torque about the kingpin which will be noticed at the steering wheel. Even with centerpoint steering a change in engine torque will change the tire self-aligning torque and this will change the steering force in a turn.

39. The Effect of Tire and Rim Sizes on Steering Kickback

The early wide street tires had a tendency to “nibble”; that is, follow longitudinal ridges in the road. While this has been improved, the current use of very wide tires has brought it back. If this is a problem, little can be done but play with tire pressures or change to narrower tires.

Using Table 3—Secondary Setup Guide

Table 3 refers to the numbered and lettered paragraphs that follow. This table shows some side effects that can occur from a change in setup. To use the table, enter on the left side with the proposed change and then refer to the lettered items to see the effect of this change on the various aspects of performance listed across the top of the chart. If nothing else, the wide variety of effects and consequences should highlight the fact that setup is all about compromise.

1. Moving the CG Position

Table 3 Secondary Setup Guide Key	Steady-State Characteristics						Transient Characteristics			Control Characteristics			
	Strait Line Braking	Braking & Cornering	Cornering	Acceleration & Cornering	Strait Line Acceleration	High-speed Stability	Turn-In	Dropped Throttle in a Turn	Braking in a Turn	Rough Road Tracking	Rough Road Cornering	Steering Force and Ratio	Steering Kickback
1. CG Position	A	B	C	D	E	F	G	H	I	J	K	L	M
2. Roll Center Location		A	B	C			D	E	F	G			
3. Anti-Pitch Geometry	A	B		C	D				E			F	
4. Steering Axis Germ		A	B	C		D	E			F		G	H
5. Camber Effects		A	B	C		D	E			F			G
6. Ride/Roll Steer	A	B	C	D	E	F	G	H	I	J	K		
7. Differential				A	B			C	D	E	F		G
8. Track Width		A	B	C					D	E	F		
9. Tire & Rim Sizes	A	B	C	D	E	F		G	H			I	J
10. Ride Spring Rates		A	B	C			D			E	F		
11. Roll Stiffness and Roll Stiffness Distribution		A	B	C		D	E	F	G	H	I		

A Straight line braking will be best when the tires are evenly loaded. This means an aft CG is best for equal-sized tires. For a forward CG, larger front tires are needed for best braking. A lower CG will reduce weight transfer.

B Lowering the CG will reduce weight transfer (and improve performance) on turn entry (combined cornering and braking). The outside front tire will be the most heavily loaded. The best CG position is again aft for equal-sized tires, and moves forward as the front tire size is increased.

C The highest lateral acceleration (best steady-state cornering) will be had with a neutral car. For equal-sized tires this is easiest with a CG near center.

D For best acceleration out of a corner, wheel spin must be avoided. This implies a rearward CG position for RWD and a forward CG position for FWD. The FWD has a conflict with A-C above; higher-powered FWDs will need more weight forward; the acceptable range seems to be 60% to 70% (or possibly more) load on the front wheels as the power-to-weight ratio goes up. The upper end is appropriate for cars with 10 lb./hp or less.

E Again, the CG must be toward the drive wheels for fraction.

F High-speed straight line stability implies understeer in the low lateral acceleration range. A CG forward of the neutral steer point is understeer and stable.

G Turn-in (transient response to step steer) will be improved as the CG is moved forward and the front tires do more of the cornering.

H Dropped throttle tuck-in will be reduced by lowering the CG.

I Braking in a turn will result in tuck-in if the brakes are balanced aft. Lowering the CG will reduce the load shift when the brakes are applied, and reduce the size of the transient.

J Rough road tracking calls for an understeering configuration forward CG location.

K Rough road cornering setup will depend on driver style. For those who are content to plow around comers, a forward CG is appropriate. If a tail-out attitude is desired a more central CG location is called for.

L Moving the CG forward will increase the steering force at low speeds (parking) and also in corners as there is more lateral force at the tire and thus more moment about the kingpin.

M If a front-drive car is lowered to lower the CG, the driveshaft angles will change. This means that different amounts of torque reaction (likely more) will be present at the hub and thus in the steering. If the driving torque varies from one side to the other, kickback in the steering will be present.

2. Moving the Roll Center Positions

A Lowering the front roll center or raising the rear will make the rear take more roll couple and the rear will saturate sooner. Balancing the brakes to give more on the rear may have the same effect.

B As 2A but not confused with brake balance. The roll center locations will probably not be easy to change once the car is built; they need to be considered at design stage.

C For best acceleration for a FWD car out of a comer the front wheels need to be evenly loaded. This will happen if the rear is taking as much roll couple as possible, when the inside rear wheel is off the ground. A rear roll center higher than the fort will help achieve this. The situation far the rear drive is just opposite.

D During turn-in, the roll center heights determine the proportion of lateral load transfer that is passed through the suspension linkage. The rest of the load transfer is passed through the springs and anti-roll bars as the vehicle rolls. Raising the roll centers gives an anti-roll effect and reduces body roll. High roll centers lead to jerking (the whole car rises when lateral force is applied) and lateral wheel travel on bump; these are undesirable.

E Dropped throttle tuck-in will be improved if the rear roll resistance is reduced or the front increased. This can be done by lowering the rear roll center or raising the front roll center. This will make the car more understeer; more of the total roll moment will be resisted on the front.

F Tuck-in under braking la a turn is similar to dropped throttle. The problem is always present in cars that are balanced near neutral steer at zero longitudinal force. In FWDs there are conflicting requirements for fraction out of the corner which call for even front wheel loads (low roll center height).

G Rough road tracking will be best when the suspension contributes the minimum disturbance to the vehicle. Roll centers near the ground give low lateral wheel motion with ride travel and minimize lateral “shake” on rough roads.

3. Changing the Anti-Pitch Geometry

A Adding some anti-dive to the front will reduce the pitch down on braking; likewise anti-lift will stop the rear from rising on braking. Anti-pitch is roughly analogous to the anti-roll effect that comes from raising the roll centers. The body attitude (pitch) will have little effect on the amount of braking available unless the car pitches so much that the suspension travel is used up and the wheels are against the bump stops; tire fraction decreases when the load is fluctuating. Some dive is desirable as a cue to braking level, according to competition drivers.

B Anti-dive geometry puts braking loads through the suspension and tends to add stiction to the suspension. This is usually not desirable.

C Anti-squat (RWD) and Anti-lift (FWD) geometry is similar; engine torque reaction changes the ride height. Some FWD sedans come with the opposite the suspension pickup points are such that the front wheels move back on bump travel. This is done to improve ride but has the side-effect that the front end rises on acceleration. Excessive pitch on turn exit is probably undesirable.

D Anti-pitch geometry affects the absolute amount of fraction available on a rear drive in two ways. By increasing the transient loading on the drive wheels it may help prevent wheel spin, and by raising the CG height it promotes rearward weight transfer. Tractive force “antics” work on engine torque reaction. On RWDs, the front end will rise on acceleration since no anti-effect can be incorporated. On FWDs, the rear end will lower on acceleration for the same reason.

E The transient when braking in a turn will be more sudden if anti-dive is added. With more anti-dive, more of the load shifted to the front wheels (from the rear wheels) will be carried in the suspension members and less in compression of the springs.

F When anti-dive/lift is added to the front suspension, it may have the side-effect of changing the trail and/or caster angle with bump travel. This will change the steering force with ride height not desirable.

4. Changing the Steering Axis Geometry

A In combined braking and cornering the outside front wheel is heavily loaded and it will dominate the steering torque. In conventional FWDs, negative scrub radius (kingpin axis intersects the road outside of the center of the tire patch) will tend to give steering in the oversteer direction. The opposite is true of positive steering offset, as used in most rear-wheel-drive cars.

B In steady cornering the trail and the pneumatic trail (aligning torque) determine the steering force. More trail equals higher force level and more spin back. Too much trail will mask the aligning torque. The self-aligning torque is a valuable signal of front tire breakaway; it first increases with lateral force and then decreases or reverses as the tire reaches its limit. With a modest amount of trail the driver can sense this as a reduction in steering force.

Reverse-Ackermann geometry (usually obtained with the steering linkage in front of the front axle) will give more steer angle to the outside front wheel than the inside. This is appropriate for high-performance use because the outside wheel has more load on it and reaches its peak at a higher slip angle than the inside, lightly loaded wheel. With conventional Ackermann steering geometry the inside front tire is dragged around comers at a slip angle over its peak. Parallel steering may be a reasonable compromise for cars that will be street driven. Reverse-Ackermann results in high rolling resistance at low lateral accelerations.

C For FWDs, as in the braking case, negative scrub radius is not useful when accelerating out of a turn. In this case the outside wheel dominates and steers in the understeer direction the FWD is almost certainly understeering enough at this point already.

D For high-speed stability in the presence of road disturbances, zero or slight negative scrub radius is desirable.

E In tight turns, turn-in will be helped if the kingpin inclination (front view) and the caster angle (side view) are large. This gives negative camber with steer on the outside wheel which helps front adhesion. It is important to put this in perspective by finding out just how much steer the driver uses on the track; the effect is very small at small steer angles.

F Rough road tracking is good with negative scrub radius. A random longitudinal bump load on a front wheel will tend to yaw the car and at the same time the wheel will steer to counteract the yaw moment.

G Steering force goes up as trail is increased. Steering force at parking speeds goes up as scrub radius decreases highest at centerpoint steering. If the steering arm is changed in length, the steering ratio is changed and it is likely that the amount of Ackermann (or reverse Ackermann) is changed.

H As the scrub radius moves away from centerpoint steering the amount of steering kickback will increase.

5. Changing the Camber—Note: Camber effects are much less with radial tires than with bias tires.

A The camber on turn entry is affected by the roll camber, ride camber, lateral force compliance camber, steer-camber (on the front), and the static camber. It is unlikely that the camber will be correct over the range of combined operation, from hard braking/light-cornering to hard cornering / light braking. It is common to use temperature across the tread as an indicator of a good camber setting but this is only an average of a range of conditions.

B Camber has been found to affect tire performance over the whole slip angle range. The correct negative camber will optimize the tire lateral force. For oval tracks or other circuits where the car turns one way, both wheels can be “leaned into the turn.”

C On turn exit, plow is often the problem. The actual camber is a function of those items mentioned in A. above. Ideally the camber would change from best camber for cornering at the apex to zero for acceleration once the turn is finished. In reality the tire is not often at “best camber.”

D Camber thrust increases with load. Consider a pair of negatively cambered front wheels: when a disturbance transfers some load to, say, the left wheel, the left tire camber thrust to the right increases and the car starts to turn right. This in turn increases the load transfer to the left and so on. To counter this tendency to wander, a little toe-out is often necessary (depending on the tire construction this might be on the order of 10% of the camber angle).

E For best turn-in the front tires probably want to be at best camber before the turn starts. This implies that static camber be set fairly high. If the turn is initiated under braking the ride camber from pitch down will add.

F If the suspension design gives much camber change with ride travel the camber thrust that results will give poor rough road tracking.

G If the suspension design gives camber change on bump travel the steering will kick back (or possibly tramp/shimmy) over bumps. This is because the wheels act as gyroscopes and the reaction torque to a camber change is around the kingpin. This is a problem with suspension designs that have rapid camber change with one wheel bump, like solid axles and swing axles; it is also possible to get short swing arm lengths with independent designs in the search for “camber compensation” to correct for camber `lost” due to body roll angle.

6. Changing the Ride/Roll Steer Characteristics

A Under hard braking, ride steer will only disturb the car. If the wheels steer (toe) with dive (on the front due to braking) they will be using up some of the friction circle fighting against each other.

B Roll and ride steer will change the attitude of the car in racing-turn entry but the tire slip angles (except for effects that steer one side more than the other) will stay the same. This is not the case for maneuvering below the limit where the under/oversteer can be greatly modified by ride and roll steer.

C In limit cornering, steering the wheels with tell steer (front or rear wheels) will simply cause the car to corner at a different attitude angle to the path. In sublimed maneuvers, it is this reorientation of the car that drivers sense as roll understeer or roll oversteer.

D In turn exit (at the limit), the front tires will be saturated due to light load (unless fraction is broken with excess power on the rear). Changing the angles of front or rear wheels will not change the fact that the rear tires still have margin left while the front tires are limiting.

E As in braking, it is important that the tires are pointing straight ahead for best traction. Any ride steer with pitch (due to longitudinal acceleration) will only hurt performance.

F If the front wheels steer on one wheel bump (ride steer) the car will not track well, especially if high cornering stiffness tires are fitted. With racing tires, small steer angles can give surprisingly large side forces.

G Roll steer can modify the amount of steering required for turn-in. To give an example, as a car with roll understeer is turned-in it begins to roll, the body-roll steers the wheels out of the turn, and the driver must add more steering to compensate.

H At lower lateral accelerations, ride/roll steer can influence dropped throttle behavior. When the throttle is dropped in a turn, the car pitches forward and roll understeer (front end) will correct for the tuck-in. At high lateral accelerations, steering on the rear will have little effect the rear tires are unloaded and will be at or near their limits. Roll understeer on the front may tend to alleviate tuck-in.

I Ride/roll steer can affect the car while braking in a turn if the tires are not saturated (low braking and lateral forces). The situation is similar to dropped throttle. In maneuvers near the friction circle limit, roll understeer will have some effect if used on the front of the car. Load and camber are the variables that affect the size of the friction ellipse, not steer angle.

J Ride or bump steer is very distracting when trying to negotiate a rough road, especially with tires that have high cornering stiffness.

K For rough road cornering some roll understeer may be desirable. As an outside tire hits a bump the load on it (and the side force it is producing) increases. If the front wheel steers out as it moves up it will tend to compensate and the car will tend to hold a smooth path. On the rear, toe-in with bump has a similar effect.

7. Different Types of Differential

A When accelerating out of a comer the drive wheels are unevenly loaded and traction on the inside wheel is limited to a lower value than the outside wheel. Different types of differentials are available which may help in this situation. Ideally, both drive wheels would be fitted with an anti-spin device that would apply the maximum driving torque to each tire, given the load and slip angle of operation. The inside wheel wants to be at a lower rpm (less load and smaller radius of travel) than the outer but this seems to be beyond the computation ability of mechanical devices. The best that limited slip differentials will do in this situation is lock the two axles to the same speed. The worst type of differential for this situation is the standard “open” type; it will allow the inside wheel to spin up and limit the driving torque on each wheel to that of the spinning wheel.

B For independent suspensions the differential is less critical for straight line acceleration. Loads on the tires are even (independent suspension) and the same torque is applied to each axle. If the two wheels are locked together, small differences in tire size may steer the car. This acceleration-torque-steer is found primarily on FWDs due to compliance and asymmetry in the steering and suspension.

For solid axle suspension, the wheel loads are uneven on acceleration unless some torque reaction device is used. A limited slip differential or spool certainly helps in this case.

C When the throttle is dropped in a turn, the front tires are loaded up and they produce more side force (destabilizing) than they did when the power was on. An open differential probably has the least effect in this situation; the driving torque (present before the throttle is dropped) and the motoring torque are split evenly between the drive wheels. If the drive wheels are locked (or partially locked) under power (by a limited slip differential, and they unlock when the power is removed (a characteristic of certain differentials), relatively more side force will suddenly be available. A differential that remains locked with the throttle dropped will add “yaw damping”

D While braking in a turn it is most desirable to have antilock. Barring that, a differential that keeps both wheels fuming at the same speed (regardless of braking) will help prevent lockup. This would be one of the fixed preload types of limited slip.

E For best rough road fraction (and probably directional control) some sort of antilock differential will keep an unloaded wheel from spinning up and then disturbing the car when it lands.

F For FWDs, a limited slip differential may be some help in rough cornering. On the minus side a differential that is locking and unlocking the front axle will make steering difficult. Ideally the limited slip differential would be smooth in operation.

G For FWDs, any type of differential that dynamically changes the torque on the two wheels will give a steering reaction. This reaction will add to any torque reaction caused by regularity of the driveshafts due to steer angle or other misalignment such as that caused by ride travel.

8. Changing the Track Width

A Increasing the track width reduces the load transfer on turn entry. With the tire loads more evenly distributed the tires can produce more force (load sensitivity).

B In steady-state cornering the track width and the CG height determine the total lateral load transfer. Increasing the track reduces the load transfer. This will improve lateral acceleration capability.

C If the track is increased the load transfer is decreased and this may allow more of the total roll resistance to be taken on the non-driving end of the car before wheel lift. This will give more equal loads on the drive wheels for acceleration on turn exit.

D Increasing the track will improve the braking in a turn performance by increasing the maximum lateral force available.

E Bumpy road tracking may not be improved by a track width increase. The yawing and rolling moment from hitting a one-wheel bump is increased and the car may tend to be re-aimed more severely than with a narrower track.

F Track width increase will help rough road cornering. More even wheel loads improve tire performance. Less lateral load transfer gives less body roll and this means there is more suspension travel available before hitting the bump stops.

9. Tires and Rims

A-H Tires dominate racecar chassis setup. Small changes in tire performance through tire (or rim) width, compound, pressure, camber, load, ambient and track temperature, stagger, etc., are always happening, even when not desired. In general, the end of the car that is limiting performance is the one that needs improved grip, and occasionally this can be found. If the car cannot be balanced by improving one end, it may be balanced by degrading the other end; this is commonly done by increasing roll stiffness, etc.

Improving the tire performance on the non-limiting end is less likely to improve overall performance, except on power-limited high-speed turns where any reduction in slip angles reduces the tire-induced drag.

I Steering torque at the kingpin (ignoring steering system losses) is a function of front end geometry and tire self-aligning torque. If the trail is not so large that it swamps out the self-aligning torque, changing tire size or construction will likely change the steering force characteristics. The effective steering ratio (at the steering wheel) includes the tire cornering stiffness. For example, radial tires usually have higher cornering stiffness than bias tires and they require less steering wheel motion for a given maneuver (at speed).

J Steering kickback can occur with very wide tires. This nibbling over ridges in the road was severe in the past but has been much improved by changes in tire design. Very wide (50 or wider series) tires may still nibble in certain situations.

Often, wide rims have different offset than stock rims and do not preserve the original scrub radius. If the center of the print is not near the kingpin intersection with the ground, steering kickback can be expected on rough roads.

10. Changing the Ride Spring Rates

A-C Ride spring rates affect the lateral load transfer distribution. Lowering the ride rates on one end will even out the loads on that end (assuming that both wheels are on the ground) and this will raise the lateral force available from that end of the car. Stiffer springs than fitted to production cars generally limit the amount of body motion in pitch and roll and this is desirable for racing. Race cars often wind up with the non-driven end very stiffly sprung relative to the driven end; this keeps drive wheels more evenly loaded for fraction.

D Stiffer springs will speed up the response in turn-in. With stiffer springs the car does not take as long to get to steady-state roll angle and this aspect of the transient is improved. For cars that have poor suspension geometry (excessive ride steer and ride camber), stiffening up the springs effectively removes some of the “disturbance” from these effects.

E For rough road operation spring rates are very important. It is necessary to take advantage of all of the suspension travel to keep the wheels on the ground as much as possible. If a flat ride (that is, the car lands flat after crossing a bump) is desired the spring rates must be adjusted to give slightly higher undamped natural frequency on the rear than on the front, i.e., approximately 10% stiffer on the rear. This often is not possible because of the high front spring rates required for front roll stiffness.

F Rough road cornering is influenced by the smooth surface behavior (under/oversteer). However, if one end of the car is more stiffly sprung or has higher unsprung weight, the wheels on that end will spend less time on the ground and that end will limit performance. If the springs are not stiff enough the car may hit the bump stops with a combination of roll in a turn and one wheel bump.

11. Adjusting the Roll Stiffness and Roll Stiffness Distribution

A If the car is loose on turn entry (and the driver cannot make use of this effect), more front roll stiffness (or less rear) will make the rear tire loads more equal and help the problem, if all four wheels are still on the ground.

B Adjusting the anti-roll bars is a common way to change the stability of a car in a steady turn. This works through the load sensitivity of the tires a pair of unevenly loaded tires has degraded lateral force performance compared to the same tires with the same total load split evenly between them. Thus, to degrade lateral force capability of the front end of a car the anti-roll bar is stiffened on that end. This works until the inside front wheel is off the ground and the front track can provide no additional roll moment.

C For best fraction on acceleration out of a comer the drive wheels need to be evenly loaded. Taking as little roll moment on the driven wheels as possible gives the desired affect- low roll stiffness on the drive axle. However, if the roll resistance of the suspension is reduced too much, excessive body roll will become a problem.

D Anti-roll bars do not have much effect at low lateral accelerations (low amounts of lateral load shift to distribute between the front and rear tracks). If straight running is a problem, it is unlikely that changing the roll couple distribution will help.

E Stiffening the car in roll will improve turn-in by reducing the roll angle of the car (and the time to get the car set to a new roll angle).

F If the car has a large dropped throttle response, increasing its basic stability will give a greater margin before spin (by increasing the rear grip available). Higher front roll stiffness (or lower rear roll stiffness) will accomplish this. Higher total roll stiffness reduces transient response time by increasing the rate that load changes occur at the tires.

G Braking in a turn adds a large forward load shift to the lateral load shift due to cornering. This degradation of rear grip is sometimes used by drivers to get vehicle slip angle on turn entry. Roll stiffness tuning is effective in changing the stability because it changes tire operating conditions, for example, increasing the roll stiffness will reduce the body roll angle and this in turn may give more favorable tire camber (and more grip).

H For best rough road tracking, little additional roll stiffness (beyond that from the ride springs) is desirable. Anti-roll bars attempt to force the wheels on an axle to move together; this reduces the independence of the suspension action and increases the one-wheel bump rate.

I The above is true for rough road cornering as well. Best grip is with the four wheels following the road. If the car rolls so much that suspension travel is used up on the outside wheels then the roll stiffness must be increased.

The Handling Clinic

A CHECKLIST OF CAUSES AND EFFECTS

INSTABILITY

Straight line instability— general

- Rear wheel toe-out - either static due to incorrect (or backwards) setting or dynamic due to bump steer and/or deflecting steer.
- Vast lack of rear downforce or overwhelming amount of front downforce.
- Wild amount of front toe-in or toe-out.
- Loose or broken chassis, suspension member or suspension link mounting point.

Straight line instability under hard acceleration

- Malfunctioning limited slip differential.
- Insufficient rear toe-in.
- Deflecting steer from rear chassis/ suspension member or mounting point.

Straight line instability—car darts over bumps (especially single wheel bumps)

- Excessive Ackermann steering geometry.
- Excessive front toe-in or toe-out.
- Uneven front castor/trail setting.
- Uneven front shock forces, incorrectly adjusted bump rubbers/ packers.
- Front anti-roll bar miles too stiff.
- Insufficient rear wheel droop travel.

Instability under the brakes—front end wanders

- Too much front brake bias.
- Excessive front damper rebound force.

Instability under the brakes—car wants to spin

- Excessive rear brake bias. Unbalanced ride/ roll resistance - too much at the rear.
- Insufficient rear droop travel.
- Excessive rear damper rebound force.
- Insufficient rear negative camber (usually in combination with one or more of the above).

RESPONSE

Car feels generally heavy and unresponsive

- Tire pressures too low.
- Excessive aerodynamic download (Note: If the car feels sluggish on acceleration at high speed, the culprit is often a rear wing Gurney lip that is too high).

Car feels sloppy; slow to take a set in corners; rolls a lot; resists changing direction

- Insufficient damper forces.
- Car too soft in ride and/ or roll.

- Insufficient tire pressure.

Car responds too quickly—has little feel—slides at slightest provocation

- Car too stiff for inexperienced driver.
- Excessive ride or roll resistance.
- Excessive tire pressure.
- Excessive rear toe-in.
- Excessive damper forces.
- Insufficient downforce.

UNDERSTEER

Corner entry understeer—car won't point in and gets progressively worse

- Excessive front tire pressure.
- Insufficient front track width (compared to rear).
- Excessive front roll stiffness. Front roll center too high or too low.
- Insufficient front damper bump force.
- Insufficient front downforce. Excessive dynamic positive camber on laden (outside) front tire.
- Braking too hard and too late.
- Insufficient front roll resistance — car may be falling over onto outside front tire due to insufficient front track width or diagonal load transfer under trail braking. Understeer can often be cured by increasing front roll resistance even though doing so will increase the amount of lateral load transfer.

Corner entry understeer—car initially points in then washes out

- Excessive front toe-in or toe-out.
- Insufficient front wheel travel in droop (non droop limited cars only).
- Insufficient front damper bump resistance.
- Incorrectly adjusted packers (car rolls onto the packers). Nonlinear load transfer due to the spring/ bar geometry, to roll center migration or to incorrect roll axis inclination.

Corner entry understeer—car points in and then darts

- Incorrectly adjusted packers (see above).
- Insufficient front wheel travel.
- Nose being sucked down due to ground effect.
- Excessive Ackermann steering geometry.

Corner exit understeer—slow corners

- Big trouble! Often a function of excessive corner entry and mid-phase understeer followed by throttle application while maintaining the understeer steering lock. This causes the driving thrust on the inside rear tire to accentuate the understeer. The first step must be to cure the corner entry understeer.
- Can also be caused by unloading the front tires due to rearward load transfer

on acceleration. Increasing the rear ride rate or anti-squat and/ or reducing the front damper low piston speed rebound force usually helps

OVERSTEER

Corner entry oversteer

- Severe rearward ride rate/ roll resistance imbalance.
- Diabolical lack of rear downforce.
- Severely limited rear wheel droop travel.
- Broken or non-functioning outside rear damper or front anti-roll bar.
- **Note:** A slight feeling of rear tippy-toe type hunting on corner entry can be due to excessive rear toe-in or to excessive rear damper rebound force.

Corner exit oversteer—gets progressively worse from the time that power is applied

- Worn out limited slip differential.
- Insufficient rear spring, bar or shock (low piston speed bump control) allowing car to “fall over” onto outside rear tire.
- Excessive rear roll stiffness.
- Excessive rear negative camber.
- Too little rear toe-in.
- Insufficient rear download.
- **Note:** If car feels as if it is sliding through the corner rather than rolling freely, reduce the rear toe-in and see what happens.

Corner exit oversteer—sudden—car takes its normal corner exit then breaks loose

- Insufficient rear suspension travel (lifting the inside tire due to droop limitation or bottoming the outside wheel due to bump limitation.)
- Dead rear damper.
- Incorrectly adjusted packers.
- Sudden change in outside rear tire camber.
- Too much throttle applied after driver’s confidence level has been boosted by car taking a set.

Does not put power down on the exit of smooth surface corners

- Excessive low piston speed bump force on rear damper.
- Excessive rear tire pressure.
- Excessive rear roll resistance (probably from bar rather than springs).
- Tires gone.
- Excessive rear dynamic negative camber – either from download or from camber change on squat.

Does not put the power down on the exit of bumpy corners

- Any or all of the above.
- Excessive rear low piston speed damper force.
- Excessive rear rebound force jerking the car down and losing compliance.

- Insufficient rear droop travel.

Understeer in, snap to oversteer on power application—the most important complaint of all!

- Too little front roll resistance — falls over on turning then snaps.
- Front anti roll bar plus front spring or (quick indication) front bump setting. Stiffening front anti roll bar will transfer load back onto inside rear tire on corner exit.
- If above cures understeer but the car still snaps, it is almost certainly falling over at the rear on longitudinal/ diagonal transfer. Can add rear anti roll bar or rear spring. Rear anti roll bar will transfer load away from inside rear tire. Spring will not. Spring will decrease fraction over exit bumps, bar will not.
- Check for proper inflated shape of front tires.
- Loose anti roll bar linkage/ blade sockets can have same effect.

ROAD-RACE GLOSSARY

2

2-cycle—The most common type of engine used in karting. 2-cycle engines need special fuel which contains oil in order to lube the internal components and bearings, since it does not have its own separate engine oil system like a 4-cycle engine.

200 Mph Tape—Also known as "racer's tape." Duct tape so strong it will hold a banged-up race car together long enough to finish a race.

4

4-cycle—A type of engine used in most racing classes.

A

Ackerman—The Ackerman effect is the increase of toe-out on the front wheels as the wheels are turned in a curve. The toe-out increase is reverse-proportional to the turn radius, i.e. the steeper the curve, the more toe-out. Just optically the effect seems to be that the inside front wheels appears to turn 'more' than the outside front wheel, which is in line with the observation that the inside front wheel actually needs to traverse a tighter curve than the outside wheel. It depends on the track if you really need Ackerman steering or not.

Adhesion—See stickiness.

Aero Push—When following another car closely, a vehicle does not get as much downforce on the front of the car and thus it doesn't turn in the corners well.

Aerodynamic Drag—This indicates how well a car travels through the air and the resistance it offers.

Aerodynamics—As applied to racing, the study of airflow and the forces of resistance and pressure that result from the flow of air over, under, and around a moving car.

A-Frame—Either upper or lower connecting suspension piece (in the shape of an A) locking the frame to the spindle.

Air Box—Housing for the air cleaner that connects the air intake at the base of the windshield to the carburetor.

Air Cooled—An engine that radiates off excess heat to the surrounding air. These engines typically have fins to accomplish this. Air cooled engines are simpler than water cooled engines, but are typically louder as well and are overheating more easily.

Air Filter—A device to filter the air before it enters the carburetor. There are foam filters, wire-mesh filters, and some people just have a sock over the carburetor. There are advantages and disadvantages to all of these means. The wire-mesh filters appear to be most common these days. Paper gauze, or synthetic fiber element used to prevent dirt particles from entering the engine. Located in the air box.

Air Dam**—**A metal strip that hangs beneath the front grill, often just inches from the ground. The air dam helps provide aerodynamic downforce at the front of the car.

Alignment**—**The positioning of the front wheels relative to each other. There may either be toe-in or toe-out.

Altered**—**A class of drag racer that starts with an automobile body and can then be modified.

Alternator**—**A belt-driven device mounted on the front of the engine that recharges the battery while the engine is running.

Apex**—**The inside portion of a curve where the vehicle should be closest to the curb in order to take the fastest way around the track. This is often, but not always, the geometric center of the turn. Hitting the apex just right will be an important art to learn for every new driver. Driving a late apex, i.e. hitting the inside curb after the geometric center of the turn, will often result in higher lap-times, while hitting the apex early will often result in disaster. Certain track characteristics might warrant a late apex or early apex, though. Strictly speaking, the apex is actually always the geometric center of the bend. But drivers tend to use this term to describe the clipping point, i.e. the point where the car is closest to the curb and travels the slowest.

A-Post**—**The post extending from the roof line to the base of the windshield on either side of the car.

Apron**—**The paved portion of a racetrack that separates the racing surface from the (usually unpaved) infield.

Asphalt oval**—**As the name implies, racing on an oval track, made from asphalt. See speedway.

Asphalt racing**—**Racing on a hard, smooth surface (asphalt, concrete) as compared to dirt racing. Slick tires are used.

Autocross**—**A gymkhana: sometimes used to mean a gymkhana that allows greater speed than usual.

Axle**—**Rotating shafts connecting the rear differential gears to the rear wheels. Can also refer to the front or rear mounting points of the wheels.

B

Back Marker**—**A slower car that is running near the rear of the field.

Back Off**—**To slow down; often said of a driver who is attempting to pass and realizes he can’t make it, so he “backs off” to try again later.

Ballast**—**See weight.

Banking**—**The sloping of a racetrack, particularly at a curve or corner, from the apron to the outside wall. Degree of banking refers to the height of a track’s slope at its outside edge.

Banked turn**—**A turn that’s inclined so the outside area is higher than the inside area.

Battery**—**Part that supplies electrical power to the engine.

Road-Racers Glossary

Bead breaker—A tool for dismounting tires from wheel rims.
Bend—A shallow turn.
To damage a car slightly.
Bear grease—Slang term used to describe any patching material used to fill cracks and holes or smooth bumps on a track's surface. Can also be used as a sealer on the track.
"Be" housing—A cover, shaped like a bell, that surrounds the flywheel/ clutch that connects the engine to the transmission.
Behind The Wall—When a car is behind the pit wall because of significant damage that can't be fixed on pit road.
Bias-ply—Layers of fabric within a tire that are woven in angles. Also used as a term to describe tires made in this manner.
Big banger—A powerful engine; one with a large volume of displacement, usually more than 350 cubic inches.
Big bore—See Big Banger.
Binders—The brakes.
Bite—This term has two different meanings, first, "Round Of Bite" describes the turning or adjusting of a car's jacking screws found at each wheel. "Weight jacking" distributes the car's weight at each wheel. Second, it can be the adhesion of a tire to the track surface.
Black flagging—A black flag is show to a driver by race officials when he/she is disqualified, i.e. needs to end the race instantly. This typically happens as a result of a rules violation. See also flag man.
Blades—Another term for torsion bars.
Bleeder valve—A valve in the wheel used to reduce air pressure in tires.
Blend—A racing fuel combining methanol and nitromethane.
Blend line—Line painted on the track near the apron and extending from the pit road exit into the first turn. When leaving the pits, a driver must stay below it to safely "blend" back into traffic.
Blip—To race an engine intermittently with repeated short bursts on the accelerator.
Block—An engine's cylinder block.
To impede the progress of another racer.
Blower—A supercharger.
Blown motor—Major-league engine failure, for instance, when a connecting rod goes through the engine block, producing a lot of smoke and steam. Also refers to a turbo or supercharged engine.
Blueprinting—What the engine builder does to a new, stock engine to make it competitive. It is a costly procedure (several hundred to more than a thousand dollars) in which the new engine is taken completely apart, and all parts are machined to the (hopefully allowable) limit, in order to get as much performance out of the engine as possible. Non-blue printed engines are often not competitive.
Body work—Various pieces and panels attached to the vehicle. The amount and measurements of the body work may be regulated. The fabricated sheet metal that encloses the chassis.
Bore—Pistons travel up and down within each cylinder, or bore, in the engine block. The diameter of the cylinder bore.

Road-Racers Glossary

Box—The transmission.

B-Post—Post extending from the roofline to the base of window behind the driver's head.

Brake—The system to slow down a moving vehicle.

Brake Caliper—The part of the braking system that, when applied by the driver, clamps the brake disk/rotor to slow or stop the car.

Brake Disc—The brake disc is mounted on the wheel and rotates with the same speed. The disc is aligned to sit precisely between the two brake pads. The brake disc is also called the brake rotor.

Brake Fade—Loss of braking effectiveness, usually caused by overheating.

Brake Pads—There are typically two brake pads mounted to the calipers. When the brake is applied, the brake pads are pressed down by the calipers on the rotating surface of the brake disc. Through friction, the vehicle is slowed down.

Brake Rotor—A different name for brake disc.

Bubble—The last position on the starting while qualifying is going on; the driver in that position is said to be "on the bubble."

Bull ring—An oval track of a half-mile or less.

Bump Drafting—The act of bumping the car in front of you while drafting. This gives the car in front extra speed that pulls along the entire draft.

Buy the farm—To die in an accident.

C

Calipers—The brake pads are mounted to them. The calipers are moved via hydraulics which in turn presses the brake pads onto the rotating brake disc.

Cam shaft—The opening and closing of the intake and exhaust valves is controlled by the cam shaft. The cam shaft rotates over the end of the valves, periodically pressing them close via eccentric lobes.

Camber—Camber is the number of degrees that the top of the tire is tipped inward (negative camber) or outward (positive camber). It affects handling. The amount a tire is tilted in or out from vertical. Described in degrees, either positive or negative.

Camshaft—A rotating shaft within the engine that opens and closes the intake and exhaust valves in the engine.

Carb—Short for carburetor.

Carburetor—A device connected directly to the gas pedal and mounted on top of the intake manifold that mixes the fuel with oxygen before it enters the cylinder in which it will eventually detonate. This mixing is necessary, since without oxygen there would be no explosion, or burning.

Caster—Caster is the amount of degrees the top of the kingpin leans towards the rear of the kart. On some frames this is adjustable. It affects handling. Check out the description of kingpin for more information.

CC—Cubic centimeters, the standard measure of displacement in Europe. A liter, 1000 cubic centimeters, is approximately 61 cubic inches.

Chassis—See frame.

Chassis Roll—As the car travels around corners at high speeds, the side of the car facing the inside of the turn becomes lighter, causing it to rise up. The extra weight that shifts toward the outside of the car causes that side of the car to pitch downward.

Checking Up—When a driver reacts quickly because of changing track conditions ahead such as a wreck.

Checkered Flag—The flag of black and white squares that signals the end of a race.

Chicane—A man-made corner set up to reduce speed at a certain point on a road track.

CHT—The Cylinder Head Temperature.

Chute—A racetrack straightaway.

Cleaners —Various more or less poisonous substances which are used to remove dirt buildup, oil, grease and other stuff from parts and engine.

Clutch—The clutch allows the engine and drive wheels to be disconnected (such as when idling at a stop) when disengaged, and the engine and rear wheels to be connected when fully engaged.

Compound—Various types of tires will use different compounds, i.e. rubber mixtures. The compound determines the stickiness of the tire. A formula or "recipe" of rubber composing a particular tire. Different tracks require different tire compounds.

Compression Gauge—A tool to measure the pressure in the cylinder at the top end of travel of the piston. Comparing this pressure to the baseline that was established for this kind of engine can give indications of the internal conditions of the engine. Low compression usually means poor performance. The tool is inserted in the slot for the spark plug after the plug was removed.

Compression Ratio—Amount that the air-fuel mixture is compressed as the piston reaches the top of the bore. The higher the compression, the more the horsepower.

Computer—These days more and more kart racers use computers to analyze their lap times and other data, just like the professional racing teams. Of course, the right software is needed. Computers are heavy equipment, so it is advantageous if the software runs on small and portable computers as well.

Connecting Rod—A metal rod inside of the engine that connects the crankshaft to the piston. The purpose of the connecting rod is to translate the up-and-down motion of the piston into the rotational motion of the crankshaft.

Contact Patch—The area with which a tire makes contact with the road surface. The larger the contact patch, the more grip the tire will develop. The load on the tire also determines the size of the contact patch.

Cotter Pin—A pin made from a thick wire, folded such that one end of the pin will have two wire ends. The pin can then be used for the same purpose as safety wire, by bending the two wire ends apart, after the pin has been inserted into the hole, such that the pin can not slip out anymore.

Cowl—A removable metal scoop at the base of the windshield and rear of the hood that directs air into the air box.

C-Post—The post extending from the roofline of a racecar to the base of the rear window to the top of the deck lid.

Crankcase—The part of the engine that houses the rotating crankshaft. On 2-cycle engines which use the reed valve or rotary valve principle, it also contains the intake for the air-fuel mixture. The crankcase is located inside of the sump. The area of the engine block that houses the crankshaft.

Crankshaft —The rotating shaft within the engine that delivers the power from the pistons to the flywheel, and from there to the transmission.

Cross weight —In oval racing the weight is not evenly distributed across the frame since some wheels have to carry much more load than others. The percentage of weight on the right front vs. the left rear wheel is called the cross weight.

Cubic-inch displacement—The size of the engine measured in cubic inches. The maximum size for a Nascar Busch Series, Grand National Divisions engine is 358.000 cubic inches.

Cubes—Slang for Cubic inches of displacement, as in, “That car has 350 cubes.”

Cylinder—Part of the engine in which the piston is moving up and down. The detonation of the air-fuel mixture takes place in the cylinder.

Cylinder head—Made of aluminum, it is bolted to the top of each side of the engine block. Cylinder heads hold the valves and spark plugs. Passages through the heads make up the intake and exhaust ports.

D

Deck lid—Slang for the trunk lid of a racecar.

Dialed In—When a car is achieving optimum performance at a certain track.

Dicing—Close, dangerous driving; from the notion that the driver is gambling with lives.

Differential—The final link in the drive train, which transmits power to the wheels.

Direct drive—When the crankshaft is directly connected to the rear axle.

Dirt tires —Contrary to slicks, dirt tires have a profile which is useful when racing on mud, sand or dirt. See dirt oval.

Dirt oval—As the name implies, dirt racing on an oval track, made from dirt or clay. See speedway.

Dirt racing —Racing on dirt (sand, clay, mud) as compared to asphalt racing. Special dirt tires are used.

Dirty air—Aerodynamic term for turbulent air currents caused by fast-moving cars that can cause a particular car to lose control.

Displacement—A measure of an engine’s size. It’s the difference between the volume contained in the cylinders when the pistons are at the bottom of the stroke and the volume that remains when the pistons are at the top of the stroke. It can be calculated by multiplying bore times stroke times 0.785 times the number of cylinders.

Display—Another name for the gauges which are typically attached to the steering wheel.

Donuts—Slang term for black, circular, dent-line marks on the side panels of stock cars, usually caused after rubbing against other cars at high speed.

Downforce—A combination of aerodynamic and centrifugal forces. The more downforce, the more grip your car has. But more downforce also means more drag, which can rob a racecar of speed.

Downshift—Shifting from a higher to a lower gear, used in road racing to slow a car without any significant change in engine speed.

Draft—Slang term for the aerodynamic effect that allows two or more cars traveling nose-to-tail to run faster than a single car. When one car follows another closely, the one in front cuts through the air, providing a cleaner path through the air; that is, less resistance, for the car in back.

Drafting—When a vehicle takes advantage of another vehicle's draft and thereby manages to either keep up with or even gain ground on the leading vehicle that is producing the draft. The second vehicle is said to be drafting. It is interesting that a drafting vehicle even increases the speed of the leading vehicle somewhat. The trailing vehicle's presence in the relative vacuum produced by the first vehicle will straighten out the air turbulences behind the leading vehicle. These turbulences would otherwise have slowed down the leader.

***Drag*—**The resistance a car experiences when passing through air at high speeds. A resisting force exerted on a car parallel to its airstream and opposite in direction to its motion.

***Drift*—**A controlled, four-wheel slide through a turn, to get a car line up for a straightaway with a minimum of steering.

***Driveshaft*—**A steel tube that connects the transmission of a race car to the rear end housing.

***Drive train*—**The system that carries power from the engine to the driving wheels; it includes the crankshaft and the differential.

Drivers meeting —The drivers' meeting is where the participants on a race day are briefed about club rules and regulations. It is very important to attend this meeting since one might also receive information about schedule or rule changes.

Duct tape —A commonly used type of sticky-tape which holds racing vehicles together in pretty much all forms of racing.

Durometer—A device I used to test the stickiness of tires. It is usually applied during tech inspection right after the race has been completed, to see whether a competitor's tire does not exceed the legal amount of grip.

***Dyno*—**Shortened term for "dynamometer," a machine used to measure an engine's horsepower.

Dynamometer—Also called 'Dyno'. A machine that allows the engine builder to measure the torque and horsepower of an engine.

E

EGT—The Exhaust Gas Temperature. As the burned fuel-air mixture exits the engine, the temperature of the spent gases can be measured. The higher the temperature, the more efficiently the fuel-air is burning.

Engine —The power plant that produces the energy necessary to accelerate the vehicle.

***Engine Block*—**An iron or aluminum casting from the manufacturer that envelops the crankshaft, connecting rods and pistons.

Engine braking—The effect of slowing down a vehicle by keeping the clutch engaged while in high gear without opening the throttle enough to maintain speed. The engine will want to drop to lower Rpms since not enough fuel is supplied to maintain the current RPM. But the vehicle is still going so fast that the engine would be forced to higher Rpms. Since the engine is difficult to turn over without supplying fuel, the energy of the moving vehicle will be transformed into the up-down motion of the moving piston inside of the engine. Essentially the opposite of what happens when fuel is supplied to the engine.

Engine builder—An individual or company which specializes on engine blue printing and rebuilding.

Engine mount —Heavy duty pieces or piece of metal with which the engine is mounted to the frame.

Esses—Slang term for a series of acute left- and right-hand turns on a road course, one turn immediately following another.

Exhaust —The system which allows the exhaust gases to escape from the cylinder. Sometimes the word ‘exhaust’ just refers to the exhaust gases.

F

Fabricator—A person who specializes in creating the sheet metal body of a car.

Factory—A term designating the “Big Three” auto manufacturers: General Motors (GM), Ford, and Chrysler. The “factory days” refer to periods in the 1950s and ’60s when the manufacturers actively and openly provided sponsorship money and technical support to some race teams.

Fairing—The body work in front of the car.

Fan—An electrically or mechanically driven device that is used to pull air through a radiator or oil cooler. Heat is transferred from the hot oil or water in the radiator to the moving air.

Fins—Air cooled engines are typically covered with cooling fins. These fins are increasing the surface of the cylinder and cylinder head, which increases the heat-transfer from the engine to the surrounding air.

Fire Suit—Protective clothing the driver wears to shield against fire in the vehicle.

Firewall—A solid metal plate that separates the engine compartment from the driver’s compartment of a race car.

Fishtail—Movement of the rear end of a car from side to side. Also a verb, as in, “His car is really fishtailing as it comes out of the turn.”

Flag man—The race official who is displaying the flags and who has the power to start and stop a race, thus controlling the race.

Flags—The race officials will communicate with the drivers via flags. Every driver should be familiar with the flags and their meaning used at their track. Flags will be shown by the flag man.

Flat-out—Slang term for racing a car as fast as possible under given weather and track conditions.

Flywheel—A heavy metal rotating wheel that is part of the race car’s clutch system, used to keep elements such as the crankshaft turning steadily.

Formula—A set of specifications that defines a class of racing cars; Formula One is the best known.

Four-barrel—The type of carburetor used in NASCAR Busch Series, Grand National Division racing.

Frame—The metal “skeleton” or structure of a racecar, on which the sheet metal of the car’s body is formed. Also referred to as a “chassis.”

Front clip—Beginning at the firewall, the frontmost section of a racecar. Holds the engine and its associated electrical, lubricating, and cooling apparatus; and the braking, steering, and suspension mechanisms.

Front steer—A race car in which the steering components are located ahead of the front axle.

Front track—The distance between the two front wheels. Varying the front track changes the handling of the vehicle. Front track is part of the setup.

Fuel—See gas. Also known as “gasoline.”

Fuel Cell—A holding tank for a racecar’s supply of gasoline. Consists of a metal box that contains a flexible, tear-resistant bladder and foam baffling. A product of aerospace technology, it’s designed to eliminate or minimize fuel spillage.

Fuel filter—The fuel filter is part of the fuel line. It is a clear piece of plastic, which contains a filtering material. The purpose is of course to prevent any impurities to enter the carburetor.

Fuel line—The fuel line connects the tank to the engine.

Fuel Pump—A device that pumps fuel from the fuel cell through the fuel line into the carburetor.

G

Gapping tool—A small tool that makes it very easy to measure the gap at the bottom of a spark plug.

Gas—Fuel burned in a vehicle’s engine. It is possible to run ‘pump’ gas, but most people will use race gas, which has a higher octane level than pump gas.

Gasket—A thin material, made of paper, metal, silicone, or other synthetic materials, used as a seal between two similar machined metal surfaces such as cylinder heads and the engine block.

Gasser—A drag race vehicle that runs on gasoline.

Gauge—An instrument, usually mounted on the dashboard, used to monitor engine conditions such as fuel pressure, oil pressure and temperature, water pressure and temperature, and RPM (revolutions per minute). These measurements are essential to proper driving and tuning of the car. Gauges are also referred to as displays.

Gear—Circular, wheel-shaped parts with teeth along the edges. The interlocking of two of these mechanisms enables one to turn the other. Depending on the context, it may means the gear ratio or a specific driven sprocket.

Gear ratio —The ratio between the sizes of the drive sprocket and the driven sprocket. Different ratios can quickly be set by changing the size of the driven sprocket.

Gearbox—Refers to the “box” that contains all the gears and linkages. Sometimes referred to as the transmission.

Go into the country—To mistakenly leave the racetrack.

Grand Prix—A race that counts toward a World Drivers’ Championship.

Greenhouse—The upper area of a race car that extends from the base of the windshield in the front, the tops of the doors on the sides, and the base of the rear window in the back. Includes all of the A, B and C pillars, the entire glass area, and the car’s roof.

Grid—Short for starting grid. The order in which the drivers line up for the race start. This order is usually determined through qualifying. The driver who managed to end up in the first position is in pole position.

Grip—How much force a tire can produce. The stickier a tire, and the larger the contact patch, the more resistance against sliding the tire will have. This means higher cornering speed and acceleration/deceleration. Also called traction.

Groove—Slang term for the best route around a racetrack. The most efficient or quickest way around the track for a particular driver. The "high groove" takes a car closer to the outside wall for most of a lap, while the "low groove" takes a car closer to the apron than the outside wall. Road racers use the term "line." The groove sometimes changes depending on track and weather conditions.

GT—Grand Touring; originally from the Italian Gran Turismo, meaning a sedan built in limited quantities and designed to provide fast, comfortable transportation over fairly long distances.

Gymkhana—A competition in which cars are driven around a twisting course, executing certain specified maneuvers, against the clock.

H

Handling —The overall driving characteristics of a vehicle. Different handling characteristics may be favored by different drivers or may be necessary for different tracks or conditions. Handling is influenced by many, many factors; some of which are: frame, engine, clutch, tires, driver, weight distribution, front track, rear track, etc.

Happy Hour—Slang term for the last official practice session held before a race. Usually takes place the day before the race and after all qualifying sessions and support races have been staged.

Hairpin—A turn that goes through 180 degrees.

Hairy—Frightening; originally short for "hair-raising."

Harmonic balancer—An element used to reduce vibration in the crankshaft.

Head wrench—Slang term for a race team's crew chief.

Heel-and-toe—A driving technique in which the accelerator is operated with the right heel and the brake pedal with the toes of the right foot.

Heating The Tires—During cautions the cars swerve back and forth to get heat in the tires and to clean debris off of them.

Hopping—A nasty handling characteristic in corners where the rear tires alternately grip and slip. This causes the chassis to bounce up and down in the turns.

Horsepower—A measurement of mechanical or engine power. A horsepower is the amount of power it takes to move 33,000 pounds one foot in a minute.

Hub—The hub sits snugly on the axle, and has the wheel rim mounted to it. Essentially, it connects wheels and axle.

I

Idle setting—The idle setting determines the RPM the engine will hold on its own, without depressing the throttle.

Ignition—An electrical system used to ignite the air-fuel mixture in an internal combustion engine.

Independent—Slang term for a driver or team owner who does not have financial backing from a major sponsor and must make do with secondhand equipment such as parts and tires.

Infield—The area enclosed by a course. Often used for spectator seating at major races.

Intake Manifold—A housing that directs the air-fuel mixture through the port openings in the cylinder heads.

Intake port—The opening in the engine casing through which the air-fuel mixture is drawn into the cylinder.

Interval—The time/distance between two cars. Referred to roughly in car lengths, or precisely in seconds.

J

Jackman—Person who raises the car during the pit stops.

Jet—When air is sent at a high velocity through the carburetor, jets direct the fuel into the airstream. Jets are made slightly larger to make a richer mixture or slightly smaller to make a more lean mixture, depending on track and weather conditions.

Juice—Slang for a racing fuel blend.

Jump—To start before the signal is given; usually in drag racing.

K

Kingpin—The joint that connects the spindle to the frame. The positioning of the kingpin in the frame affects caster and camber.

Kingpin inclination—The amount of degrees the top of the kingpin leans towards the center of the vehicle.

L

Lap—One trip around the racing track. As a verb, when one driver gets so far in front of another that he passes him, thus putting the second driver more than a lap behind, he is said to have lapped him.

Lap Down—When one vehicle has been lapped by the race leader.

Lapped traffic—Cars that have completed at least one full lap less than the race leader.

Lap time—The time it takes to complete one lap around a racetrack. The most important measure whether changes to the setup are successful is a decrease in lap time.

Leadfoot—An aggressive driver who always goes for the lead.

Lead lap—The lap that the race leader is currently on.

Lean—When the air-fuel mixture is too rich, the driver may adjust the needles to lean out the mixture, i.e. increase the air to fuel ratio. If the engine runs too lean, it may get too hot which can severely damage the engine.

Le Mans start—A type of start in which the drivers, at the starting signal, run to their cars, start the engines, and begin racing.

Line—See groove.

Liter—Used to measure displacement; a liter is 1000 cubic centimeters, about 61 cubic inches, a little more than a quart.

Load—The tire load is a term for the weight placed on a tire. The larger the load, the more the increase the grip of the tire. It is important to understand that the load shifts and changes during a drive. In every corner the load is shifted to the side, during acceleration it is shifted to the back, under braking to the front.

Loose—Also known as “oversteer.” When the rear tires of the car have trouble sticking in the corners. This causes the car to “fishtail” as the rear end swings outward during turns. A minor amount of this effect can be desirable on certain tracks.

Loose stuff—Debris such as sand, pebbles, or small pieces of rubber that tend to collect on a track's apron or near the outside wall during a race.

Loud Pedal—The accelerator.

Lug nuts—Large nuts applied with a high-pressure air wrench to wheels during a pit stop to secure the tires in place. All NASCAR Busch Series, Grand National Division cars use five lug nuts on each wheel, and penalties are assessed if a team fails to put all five on during a pit stop.

M

Male Joint—A ball inside a socket that can turn and pivot in any direction. Used to allow the suspension to travel while the driver steers the car.

Marbles—Excess rubber buildup above the upper groove on the racetrack. Also see Loose stuff.

Master cylinder—The master cylinder converts the mechanical pressure applied by the driver on the brake pedal into hydraulic pressure, which is converted back by the slave cylinder into mechanical pressure, slowing down the vehicle.

Matching Tires—Tires from the factory are broke up in different sets or series. A crew may exchange tires with other crews to get a certain set, thus getting a more consistent handle on the car.

Mixture—A term for the air-fuel ratio that is adjusted via the needles on the carburetor.

N

Nascar—The National Association For Stock Car Auto Racing.

Needles—Screw adjusters to alter the air-fuel ratio in the carburetor. Typically there as a low speed needle and a high speed needle.

Nerf—To bump lightly against another car, usually from behind and often on purpose as a warning.

Nerf bars—A simple piece of metal tubing that is mounted to the frame between the wheels. It is used to prevent damage to the vehicle from casual contact during racing.

Neutral—A term a driver uses to refer to a car that is neither loose nor pushing (tight).

Nitro—Nitromethane, commonly in racing-fuel blends.

Nomex—Nomex is a fire resistant material used for racing suits.

Normally aspirated—An engine that isn't supercharged. See supercharger.

Nose cone—Another term for front nose.

O

Offset—Some vehicles have the right rear wheel larger and might be located further outside than the left rear wheel. The reason is that there is consistently more load placed on the right rear wheel in oval racing. These cars are said to be offset.

Off Track Time—Time it takes for a driver to pit. This includes the time it takes to enter and leave the pit as well as the pit stop itself.

Road-Racers Glossary

Oil Pump—This device pumps oil to lubricate all moving engine parts.

Oval—Describes a racetrack generally shaped as an oval. These may be dirt or asphalt ovals. An oval may be either banked or flat.

Oversteer—When during cornering the rear tires loose grip before the front tires. The rear of the vehicle will slide towards the outside of the curve. The vehicle over-rotates what the steering input suggested. Another term for this condition is loose. See understeer, handling.

P

P & G—A procedure for checking the cubic-inch displacement of an engine. The term comes from the manufacturer of the particular gauge used.

Pace Car—Vehicle that leads the race cars around the track during cautions or before the start.

Pacer—A driver who travels at close to the same speed throughout the race, conserving the car in the hope that those traveling faster will be forced to drop out with mechanical problems.

Pace Lap(s)—Lap(s) before the start of the race taken to warm up the vehicles.

Panhard Bar—A lateral bar that keeps the rear tires centered within the body of the car. It connects to the frame on one side and the rear axle on the other. Also called a track bar.

Piston—A round metal cylinder that is attached to the top end of the connecting rod, inside of the cylinder. The piston compresses the air-fuel mixture on the upward motion, and is pushed downward when the mixture explodes. This downward motion then drives the crankshaft.

Piston ring—One or more rings around the circumference of the piston, used as a seal between the piston and the inside cylinder wall.

Pit Crew—The crew that services the vehicle on pit stops.

Pit Road—The area where the pit crew service the vehicle. Generally located along the front straightaway, but because of space limitations, some racetracks sport pit roads on both the front and back straights.

Pit Stall—The area along pit road that is designated for a particular team's use during pit stops. Each car stops in the team's stall before being serviced.

Pit steward—Race official that helps line up the races and keeps the show moving.

Pitman arm—Another term for spindle arm.

Pits—The staging area in which racing teams are setting up shop on race day.

Pit Stop—Point during the race in which a car pulls into its pit stall and the crew services the car. This includes tires, fuel, window and grill cleaning, and damage repair.

Pole position—The driver who starts from the top of the grid is said to be on pole position. This preferred position is usually earned through qualifying.

Polish Victory Lap—When the winner of a race takes a backwards slowdown or victory lap.

Pop—Slang to any exotic fuel blend.

Pre tech—Some clubs and organizations require a tech inspection even before the race starts. This usually is mostly concerned with safety of driver and vehicle.

Production—A production engine or car is one that is made in quantity, usually on an assembly line.

Prototype—A sports car that is not in production; either an experimental model or a car made in very limited quantities, solely for racing.

Provisional—Starting positions at the rear of the field that are reserved for special use.

Pulling A Number—When a team is disqualified, their number is “pulled” from scoring, which means that they are not earning any points for the remainder of the race.

Pushing—Another term for Understeer or Tight.

Pyrometer—An electronic device used to measure tire temperatures.

Q

Qualifying—The positions on the starting grid are determined through qualifying. The format may differ from series to series or even club to club. It usually involves either timed runs around the track or heat races. Some clubs may use the pea pick. See pole position.

Quarter Panel—The sheet metal on both sides of the car from the C-post to the rear bumper below the deck lid and above the wheel well.

R

Race director—The person with overall responsibility for conducting a safe race. The final word in rules violations.

Racing line—Not necessarily the shortest, but the fastest course around the track. When driving the racing line, the vehicle is taking the curves with the largest possible radius, allowing higher cornering speed that will also carry more speed along the straights.

Radiator—A device necessary for water-cooled engines to cool down the water.

Rear Clip—The section of a race car that begins at the base of the rear windshield and extends to the rear bumper. Contains the car’s fuel cell and rear-suspension components.

Rear-Steer—A car in which the steering components are located behind the front axle.

Rear track—The distance between the two rear wheels. It can be varied by moving the wheel hubs inward or outward on the rear axle. Varying the rear track changes the handling of the vehicle. Rear track is part of the setup.

Reduction ratio—Other term for gear ratio.

Restart—The waving of the green flag following a caution period.

Restrictor Plate—A thin metal plate with four holes that restrict airflow from the carburetor into the engine. Used to reduce horsepower and keep speeds down. The restrictor plates are currently used at Daytona International Speedway and Talladega Superspeedway, the two biggest and fastest tracks raced on by NASCAR Busch Series, Grand National Division teams.

Rev—To gun an engine. As a noun, “revs” is short for “revolutions per minute.”

Rev Limiter—A device which is wired into the cars ignition system to prevent the engine from exceeding maximum RPMs. It controls the engines ignition so that it cannot exceed a specific setting.

Rich—When the air-fuel mixture is too lean, the driver may adjust the needles to richen the mixture, i.e. decrease the air to fuel ratio. If the engine runs too rich, you may notice a loss in power. The engine doesn't pull as good anymore, since there is not enough oxygen in the cylinder for an effective combustion.

Ride Height—The distance between the car's frame rails and the ground.

Riding the rails—Taking the outside line around a turn.

Roll bar—A frame of tubular steel that protects the driver if the car rolls over.

Rims—What the tires are mounted on. Generally, there are one-piece rims and two-piece rims. Two-piece rims consist of two cup-like halves, which are screwed together, while one-piece rims look like a spindle and consist of only one part.

Road Course—A track containing numerous combinations of left and right turns and straight sections.

Roll Cage—The steel tubing inside the race car's interior. Designed to protect the driver from impacts or rollovers, the roll cage must meet strict safety guidelines and are inspected regularly.

Roof Flaps—Flaps put on the roof of the car that keep the car from becoming airborne. They disrupt airflow around the car to try to keep it on the ground.

Rookie—A new racer.

Round—Slang term for a way of making chassis adjustments utilizing the racecar's springs. A wrench is inserted in a jack bolt attached to the springs, and is used to tighten or loosen the amount of play in the spring. This in turn can loosen or tighten up the handling of a racecar.

RPM—Rotations Per Minute. How many times the piston goes through one up-down motion per minute. The higher, the faster. Every engine has an optimum RPM range. The RPMs are displayed on the tach.

R***ubber (aka Spring Rubber)***—A single rubber disc inserted between the coils of the four springs. They can be put in or taken out to adjust the vehicle's spring rate.

Rubbin'—Also know as trading sheet metal or trading paint. It is the act of hitting another car during race conditions. This can leave a donut on the car that was hit.

S

Safety wire—A stiff wire that is used to secure screws and pins on the kart, so that they will not fall off during the race. Typically, a screw would have a thin hole drilled through it at the end, which extends past the nut. The safety wire would be threaded through this hole, so that the nut could not come off anymore. An alternative to the safety wire can be a cotter pin.

Sandbag—To hold back on a car's performance, during trial runs and qualifying, to mislead other drivers as to its potential.

Save—When a driver saves his car from wrecking after he lost control.

Sawing On The Wheel—When a driver turns the wheel violently to keep control of the car.

Scales—Used to measure the weight of the vehicle. With several scales, or one scale and more effort, the proper weight distribution of the vehicle can be measured.

Scrub—Term to describe a tire sliding over the track surface. When the vehicle is understeering the front wheels are 'scrubbing off speed'.

Scuffs—Used tires. During practice, teams put new tires on the car and run a few laps on them. After a few laps, the tires are removed and placed aside for use during qualifying or the race. Some race setups may favor used tires, that is, the car's performance improves as the tires are "broken in." Scuffs are typically used during the final pit stop of a race, to give the driver a slight advantage.

Seat Time—This term describes the amount of time or experience a driver has behind the wheel.

Self-Cleaning Track—A self-cleaning track has a high degree of banking in the turns and because of this, fluids, wrecked cars, and debris slides to the bottom of the track.

Setup—A vehicle's setup is the set of all variables of the system, i.e. the setting of all those things that can be modified on the vehicle. A different setup may induce different handling characteristics, or may be suitable for different track conditions. The setup may also be different for different drivers. Some of the things which make up a specific setup are: rear- and front track, weight distribution, spring/dampers, tires, etc.

Shoes—Slag for Tires.

Short Track—A Speedway under one mile in distance.

Shunt—A British term for a collision.

Shut the gate—To block a competitor who's attempting to pass.

Shut-off—A point at which a driver has to begin slowing down in order to negotiate a turn.

Silly Season—Slang for the period that begins during the latter part of the current season, wherein some teams announce driver, crew, and/or sponsor changes for the following year.

Slalom—A type of gymkhana in which drivers maneuver through a course marked by pylons.

Slave cylinder—The slave cylinder is mounted 'around' the brake disc and contains the calipers with the brake pads mounted to them. The slave cylinder is connected to the master cylinder via the brake hoses. It converts the hydraulic pressure transmitted through the hoses by the brake fluid into mechanical pressure, by forcing the brake pads down onto the rotating surface of the brake disc.

Slick—A track condition where, for a number of reasons, it's hard for a car's tires to adhere to the surface or get a good "bite." A slick racetrack is not necessarily wet or slippery because of oil, water, etc. A racing tire with no tread pattern.

Slingshot—A maneuver in which a car following the leader in a draft suddenly steers around it, breaking the vacuum; this provides an extra burst of speed that allows the second car to take the lead.

A type of drag racing car in which the driver sits behind the rear wheels.

Slipping —When the clutch in a clutch kart is disengaged because the RPM are below the stall speed, the clutch is said to be 'slipping'.

Smoking The Tires—Occurs when the tires are sliding across the road surface and because of the heat generated, the tires will smoke. The term is usually associated to tires under hard acceleration.

Spark plug—A little device sitting in the middle of the cylinder head, which generates an electric spark when the piston has reached the top point, and the air-fuel mixture is compressed. The spark will ignite the mixture that will rapidly burn. This in turn will drive the piston down again.

Speed trap—An area at the end of a drag strip where electric eyes are used to measure a vehicle's speed at the end of its run.

Speedy Dry—Similar to car litter, is used to soak up fluids from the racetrack.

Speedway—A high-speed racetrack. This term is usually associated with an oval track.

Spin—To lose control so that the car revolves around its vertical axis. Also "spin out."

Spindles—The 'axles' of the front wheels. They are connected to the steering column through the tie rods. The front wheels are mounted on the spindles. The spindles themselves are mounted to the frame via the kingpin. The part of the spindles to which the tie rods are connected is called the spindle arm or pitman arm.

Spindle arm—Part of the spindle. The tie rod is connected to the end of the spindle arm. The spindle arm sticks out backwards in a steep angle from the actual front 'axle'. Also called pitman arm.

Splash 'n Go—A quick pit stop that involves nothing more than refueling the racecar with the amount of fuel necessary to finish the race.

Spoiler—A metal blade attached to the rear deck lid of the car. It helps restrict airflow over the rear of the car, providing downforce and traction.

Spoiler Angle—The angle at which the spoiler is mounted on the rear of the car. The angle is expressed in degrees.

Sponsor—An individual or business that financially supports a race driver, team, race, or series of races in return for advertising and marketing benefits. Usually, the sponsor's name, colors, and corporate or product logo are adorned on the racecar for high visibility and product identification.

Spotter—Member of the crew that sees the action from high above and tells drivers about other cars relative to the driver and wrecks.

Sports car—Generally, any car that handles better, brakes better, and is more maneuverable than an ordinary passenger car.

Sportsman—A type of stock car with a light body and engine modified in certain limited ways.

Stagger— The size difference between two opposite tires, i.e. between the two rear tires or the two front tires. Stagger is only used for oval racing. Stagger causes the vehicle to automatically turn in a particular direction.

Stall speed—The engine RPM where a torque converter matches engine speed.

Starter—Person in the flag-stand who controls the race with flags. An electrical motor used to turn an engine over until it can run by itself.

Starting grid—See grid.

Stick—Slang term for tire traction, as in "the car's sticking to the track."

Stickers—Slang term for new tires. The name is derived from the manufacturer's stickers that are affixed to each new tire's contact surface.

Stickiness—The stickiness of a tire is determined by its compound. See tires.

Stock—An unmodified car, almost exactly as produced by the manufacturer.

Stock block—An unmodified engine.

Stop 'n Go—A penalty, usually assessed for speeding on pit road or for unsafe driving. The car must be brought onto pit road at the appropriate speed and stopped for one full second in the team's pit stall before returning to the track.

Stroke—The distance the piston travels within the cylinder.

Stroking—Said of a driver who allegedly "lays back" in a race so as not to punish or wear out equipment before the end of an event.

Superspeedway—A racetrack of a mile or more in distance. Road courses are included. Racers refer to three types of oval tracks. Short tracks are under a mile, intermediate tracks are at least a mile but under two miles, and speedways are two miles and longer.

Sump—The bottom portion of the engine that houses the crankcase. Towards the top, the cylinder extends from it. Recessed area in the bottom of the fuel tank to improve consistency of fuel flow when the fuel level is low.

Supercharger—A high-powered fan that forces air into the engine, increasing power.

Sway Bar—Sometimes called an "anti rollbar." Bar used to resist or counteract the rolling force of the car body through the turns.

Switchback—A hairpin turn.

T

Tach—The tachometer. One of the gauges which displays the current RPM. A sensor is attached to the spark plug cable, close to the plug. It detects the electric pulses to the spark plug.

Tachometer—See Tach.

T-bone—To hit another vehicle broadside.

Tear offs—Thin layers of transparent plastic that are layered over the face shield of the helmet or windshield. Once the top layer gets dirty, the driver or crewmember can tear it off (hence the name), exposing a new, still clean layer underneath.

Teeth—The size of the driven gear is measured in the teeth around the circumference of this sprocket. Changing gears therefore requires to 'run more/less teeth', i.e. use a driven gear of different size.

Ten-tenths—Driving at the car's absolute limit.

Temperature gauge—One of the gauges that displays the current engine temperature.

Template—A device used to check the body shape and size, to ensure compliance with the rules. The template closely resembles the shape of the factory version of the car.

Testing—When cars visit a track before that race to make the car better for when the race comes.

Threshold braking—Applying the brakes without any safety margin left. During normal racing, brakes will be applied to some 98% of their maximum braking capacity, or so. Under threshold braking, the driver reaches and occasionally exceeds 100% of the brakes' capabilities. The tires may lock up. Threshold braking is obviously not recommended for every curve during normal racing, since it is very risky and the driver is bound to make a mistake, sooner or later. Threshold braking is therefore usually only used in qualifying or during high-risk passing maneuvers.

Throttle—The pedal that is typically located on the right side of the kart. Press it down and hopefully the kart will accelerate. It is connected to the carburetor via the throttle cable.

Road-Racers Glossary

Tie rods—Two tie rods are typically connecting the steering column to the spindle arms of the spindles. The tie rods are adjustable in length. Also see brake tie rod.

Tight—Also known as "understeer." A car is said to be tight if the front wheels lose traction before the rear wheels do. A tight racecar doesn't seem able to steer sharply enough through the turns. Instead, the front end continues out toward the wall.

Tire Profile—A term that describes the shape of a tire. Under-inflated tires tend to sag, while over-inflated tires have a very upright profile.

Tires—Many different types of tires are used, depending on the class or the area in which you are running. Manufacturer and tire *stickiness* are typically mandated by the governing body of your race. Harder tires do not provide as much grip as stickier tires, but they will last longer (several races), compared to a really soft tire (one race). Harder tires are typically used in the novice classes. A tire is mounted on the wheel rim.

Tire Wear Indicator—A small indentation in a tire used to indicate how much a tire is worn in a specific spot. Indicators are placed in rows across the tread of the tire.

Toe-in—Toe-in means that the front of the front wheels are closer together than the rear-end of the front wheels. Essentially, it looks like the two front wheels want to drive towards each other. A small amount of toe-in improves the response during corner entry. See alignment and toe-out.

Toe-out—Toe-out means that the front of the front wheels are further apart than the rear-end of the front wheels. Essentially, it looks like the two front wheels want to drive away from each other. Toe-out will make the vehicle dart rapidly into a corner when the steering wheel is turned. Toe-out is usually not recommended. See alignment and toe-in.

Torsion bars—Steel bars that usually have a spline or square mounting area at each end. When the bar is twisted, it produces a spring rate.

Traction—A different name for grip.

Track Bar—See "Panhard Bar"

Trading Paint—Slang term used to describe aggressive driving involving a lot of bumping and rubbing.

Trailing Arm—A rear suspension piece holding the rear axle firmly fore and aft yet allowing it to travel up and down.

Trail braking—When the brake is applied during and after steering into a curve. Traditionally in racing, brakes are applied while the front wheels are still steering straight. Trail braking may allow deeper braking into a corner, but if not done properly can very quickly result in massive oversteer, since the rear wheels are not only unloaded, but also have to perform braking duty.

Transponder—An electronic device mounted to the vehicle, which triggers an external (track side) mechanism each time you cross a certain point on the racetrack. Some organizations use transponders to automate their timing and scoring systems, enabling them to accurately determine the starting grid in qualifying. Personal systems are also available.

Tri-Oval—A racetrack that has a "hump" or "fifth turn" in addition to the standard four corners. Not to be confused with a triangle-shaped speedway, which has only three distinct corners.

Turbocharger—A supercharger driven by a turbine that, in turn, is driven by the car's exhaust gases.

Tweak—To fine-tune an engine or make any minor modification that will result in a slight power increase.

U

Understeer—When during cornering the front tires loose grip before the rear tires, the front of the vehicle will slide towards the outside of the curve. The vehicle is slowed down, since the front tires are effectively scrubbing off speed. This condition is also referred to as pushing. See also oversteer, handling.

V

Valance—Also known as the front air dam. It is below the front bumper of the car.

Valves—Typically the devices on the top of the cylinder of a 4-cycle engine that allow the air-fuel mixture to enter the cylinder above the piston and the exhaust gases to exit the cylinder after the combustion. On a 4-cycle engine the valves are operated by the cam shaft. 2-cycle engines do not require valves, but may have similar devices to reduce backflow of the fuel - air mix into the carburetor on the down stroke of the piston.

Valve Stem—The point on a tire where it is filled with air.

Vented—Describes the fact that the brake disc was designed in such a way that heat and gases produced when applying the brake are more easily dissipated. This helps to obtain a steady and predictable braking performance.

Victory lane—Sometimes called the "Winner's Circle." The spot on each racetrack's infield where the race winner parks for the celebration.

W

Waiver—A form that you sign when entering the track, waiving the right to sue the race operators for liability, as you acknowledge that racing is a dangerous activity and are doing it anyway.

War Wagon—Also known as a pit wagon. Teams keep tools in there as well as electronic equipment.

Water cooled —Describes an engine that relies on water circulating around the engine as a means to dispose of excess heat. The water is then cooled in a radiator which adds to the complexity of these engines, as compared to the air cooled ones. Water cooled engines are typically quitter and do not overheat as easily.

Wedge—Term that refers to the cross weight adjustment on a racecar. Adjusting the handling of the car by altering pressure on the rear springs. These adjustments are made by turning the weight jacking screws with a ratchet. This alters the relationship of the weight of each corner of the car.

Weight Jacking—All cars must weigh the same amount. That weight can be unevenly distributed, however, to provide maximum grip at the wheels that need it most. "Weight Jacking" is the art of shifting the car's weight to favor certain wheels.

Wheel—Typically the combination of rim and tire. The wheel is mounted to the axle via the wheel hub.

Wheelbase—The distance between a car's front and rear axles.

Windmill—Slang for a supercharger.

Road-Racers Glossary

Window Net—A woven mesh that hangs across the driver's side window, to prevent the driver's head and limbs from being exposed during an accident.

Wind Tunnel—A place that race teams go to test the aerodynamic qualities of their cars.

Wing—An aerodynamic device that provides downforce to aid in tire traction.

Wires—Wire wheels.

Wrench—Slang for racing mechanic.

X

X-car—An experimental car.

Y

Yellowtail—A rookie NASCAR driver, so called because cars driven by rookies have yellow rear bumpers.

Yellow flag—A flag used to signal caution because of dangerous conditions. A driver is not allowed to improve his position under the yellow.

FastLapSim Racing Software

Advanced
Road-Race
Simulation

COMMON QUESTIONS

COMMONLY ASKED QUESTIONS

The following information may help answer questions and solve problems that you encounter when installing and using FastLapSim. If you don't find an answer to your problem here, send in the **Mail/Fax Tech Support Form** on page 161 *(Motion Software provides Mail/Fax technical service to registered users only—register your software today).* We will review your problem and return an answer to you as soon as possible.

INSTALLATION/BASIC-OPERATION QUESTIONS

Question: Received an "Error Reading Drive D" (or another drive) message when attempting to run or install FastLapSim. What does this mean?

Answer: This indicates that your computer cannot read FastLapSim CD-ROM installation disk. The disk may not be properly seated in your drive, the drive may be defective, or the disk may be damaged. If you can properly read other CD-ROM disks, but FastLapSim distribution disk produces error messages, try requesting a directory of a known-good disk by entering **DIR X:** or **CHKDSK X:** (where **X** is the drive letter of your CD-ROM drive) and then perform those same operations with FastLapSim disk. If you receive an error message only when using FastLapSim disk, the disk is defective. Return the disk to Motion Software, Inc., for a free replacement (address at bottom of Tech Support Form).

Question: Encountered "Could not locate FastLapSim CD-ROM disk" error message when trying to run the program. Why?

Answer: Please insert FastLapSim disk in your CD-ROM drive. FastLapSim may need to periodically access the CD. Please keep FastLapSim disk handy.

Question: FastLapSim produced an *Assertion Failure* error. What should I do?

Answer: Please note down all of the information presented in the message box, provide a quick synopsis of what lead up to the error, then send this information to Motion Software (support@motionsoftware.com). Thank you for your assistance in helping us improve FastLapSim.

Common Questions

QUESTIONS ABOUT RUNNING A SIMULATION

Question: When I run a simulation, part of the graphic curves don't appear on my screen. What can I do to correct the display?

Answer: Open the **Graph Options** menu (right-click on the graph) and select Auto Range for the **Y1** or **Y2** variable. See pages 61 to 63 for more information about graph scaling and plotting variables.

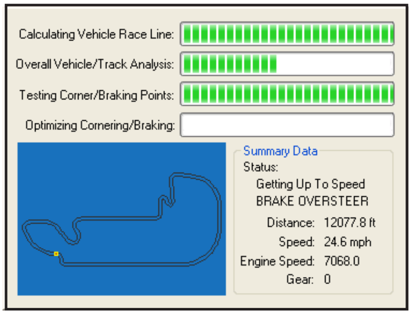
Question: What are the ***Frontal Area*** and ***Aero Drag***?

Answer: As a vehicle moves forward, it displaces the air around it. The larger the vehicle, the more air it must push aside. At its most basic, a vehicle can be thought of as a "brick wall," equivalent in size to the height and width of the vehicle. When the square-foot area of the brick wall is equal to the "head-on" area of the vehicle, they both displace the same amount of air as they move forward and, therefore, have the same frontal area. But a brick wall has much more *wind resistance* than most vehicles. The difference is a measure of the efficiency an object posses as it moves through the air (i.e., how much energy is consumed at a specific speed relative to a moving flat "brick-wall" surface); this ratio is called the aerodynamic drag. The brick wall has an ***Aero Drag*** equal to 1.0. However, a well designed vehicle of the same frontal area may consume only one-half of the energy required as it "slices" its way through the air. In this case, the Aero drag would be equal to 0.5, or 50% of the flat surface. Review the list of vehicles in the **Vehicle Menu** to determine how the aerodynamic drag changes with vehicle design. Aero Drag can be reduced anywhere from 0.01 to as much as 0.1 by lowering the front of the vehicle to provide a better "angle of attack" and through the addition of aerodynamic "dams" that redirect air around the vehicle rather than allowing it pass underneath. FastLapSim uses both Frontal Area and Aero Drag to calculate the energy required to move the vehicle through the air at any speed.

Question: Why do the progress bars occasionally move backwards during a simulation run?

Answer: The calculation of an ideal raceline, corner speeds, and braking points (plus

The calculation of an ideal raceline, corner speeds, and braking points and much more is an iterative process. The simulation attempts to push the vehicle through turns at high speeds. When it encounters handling problems, it slows down and tries the turn again. You can watch this process on the Progress Bar display.



Status:
Getting Up To Speed
BRAKE OVERSTEER
Distance: 12077.8 ft
Speed: 24.6 mph
Engine Speed: 7068.0
Gear: 0

brake loads, brake balance, engine speeds, gears, throttle, and much more) is an iterative process. In other words, the simulation attempts to push the vehicle through turns at high speeds. When it encounters handling problems, it slows down and tries the turn again. At times the simulation must back up a considerable distance to establish the optimum turn entrance speeds, brake loads, etc. You can watch this process on the Progress Bar display.

FastLapSim Testing Notes

FastLapSim Testing Notes

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Tech Support Request

Please use this form (or a copy) to obtain technical support for FastLapSim from ProRacing Sim, LLC. Fill out all applicable information about your system configuration and describe your problem thoroughly. We will attempt to duplicate the problem and respond to your questions as soon as possible. Mail this form and any vehicle-test printouts to the address below. *Note: We will only respond to problems from registered users—if you haven't already, please take a moment and fill out and send in the registration form that appears when you start FastLapSim.*

Your Phone (   ) _______-__________ Your Fax (   ) _______-___________

Your Name ____

Address ____________________________ Apt. or Building __________

City ________________________ State _____ ZipCode ___________

Brand of computer ____________________ CPU _______ Speed _______

Size of hard drive _______ Amt of RAM ______ Video Card _____________

Running Windows95 ☐ Windows98 ☐ WindowsXP ☐ (What Version _________)

Version of FastLapSim (see front of CD-ROM) _________________________

Please describe the problem you encountered with **FastLapSim** and, if necessary, include any menu choices or other conditions that created the problem.

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Can you duplicate the problem? ___________________________________

Mail this form to:

ProSim Racing, LLC., 3400 Democrat Road, Suite 207
Memphis, TN 38118

Version FastLapSim v4.10, 8/03, Release 1

Fast Lap Sim
Racing Software

ProSim Racing, LLC.
3400 Democrat Road, Suite 207
Memphis, TN 38118

For Tech Support Conact: 901-259-2355
Web: www.ProRacingSim.com
Email: support@proracingsim.com