

TruckSim 8.1 New Features

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TruckSim 8.1 provides major new features in the math models and introduces major improvements in visualization.

Introducing the VehicleSim Visualizer: VsV

Animation in TruckSim has been provided for over a decade by the program SurfAnim. In support of advanced driving simulators, Mechanical Simulation is pleased to introduce a new program called VehicleSim Visualizer (VsV). VsV makes use of modern graphical processing units (GPU) and shape file formats. It provides advanced lighting (true shadows, multiple light sources, reflected highlights), highly efficient rendering, rear-view mirrors, and advanced techniques developed by the video game industry.

VsV includes plotting that is synchronized with animation. It supports commands similar to VS commands for defining new variables with algebraic equations that can be plotted or used to

control motions of animated shapes. The user interface supports many interactive features to support artists working with new 3D shapes.

Future development of VsV will include more work in automating plots and spectral analysis, with the intent of replacing the TruckSim plotter WinEP and the spectrum analyzer tool. In this initial release, the priority in VsV development has been to support driving simulators. Although the default animator is still SurfAnim, VsV is provided as an optional animation tool that can be used for evaluation.

To try VsV, go to the **Preferences** screen (use the **Tools** menu and select **Preferences**), select the dataset named **Defaults Settings VsV**, then return to the Home **Run Control** screen. To go back to SurfAnim, go to the **Preferences** screen and select the dataset named **Defaults Settings**. (Your current preferences are those that were most recently selected.)

VsV is backward compatible with file formats and datasets used in TruckSim. Some of the shapes provided in past versions of TruckSim do not display well in VsV; they have been replaced with updated shapes that work well in both VsV and SurfAnim.

The first thing to know when using VsV interactively is that you use the right mouse button to control the camera. Hit the F1 key to bring up a summary of the keyboard and mouse commands used to control the view in VsV. The left mouse button does not adjust the camera.

Improvements in the Math Models

Several major new options have been added to the math models in addition to many minor improvements in the architecture.

Continuously Variable Transmission (CVT)

The TruckSim powertrain now includes an option for a CVT, with corresponding improvements in the GUI (two new screens) and updated powertrain documentation.

Driver Model Improvements

Several new options have been added to the closed-loop controllers for speed and direction.

- A path preview speed control option is available where the controller looks ahead at the driver reference line and defines a target speed as a function of curvature, 3D geometry (banking angle, grade angle, vertical curvature), aggressiveness (lateral and longitudinal acceleration limits), and skill level. A new screen was added to support this option.
- The closed-loop speed controller was extended to include nonlinear cubic feedback and to take engine braking into account when setting low throttle levels.
- There is a tight connection between the driver model, the road geometry (road reference line), and the vehicle initialization. The initialization options have been extended and clarified to handle ambiguities that could occur with looped paths and roads.

Reference Paths for Road Geometry and Controllers

TruckSim has supported two reference paths that are used to initialize the vehicle position and orientation, provide a target for the closed-loop steering, and provide motion information for moving objects such as traffic vehicles. One of these paths—the road reference line—is also used to link geometric and friction properties together to define a 3D road surface. TruckSim 8.1 extends these capabilities in several ways:

- Some ambiguities have been clarified involving the two potential paths. One path is always defined as the road reference line and the other is always defined as a driver reference line. Both have the same conventions for defining longitudinal position (station), setting the initial vehicle position and orientation, and handling of looped paths (test tracks and racetracks).
- Both reference paths can now be used at the same time. In this case, the road reference line is used to specify the 3D road surface properties, and the driver reference line is used by the controllers and to optionally initialize the vehicle position and orientation.
- More information is available for looped paths. The starting station for each path is set with a parameter. When looped, the maximum station for each type of path is available from a parameter whose value is automatically calculated internally. A state variable, `SV_N_START_CROSS`, is updated every time the vehicle crosses the start of the loop (corresponding to the start of the table of X-Y coordinates used to define the path). This can be used to count the number of laps made.
- In past versions of TruckSim, the initial vehicle direction along a path was determined by comparing two parameters `SSTART` and `SSTOP`. This method had limits on looped paths (where `SSTOP` could be reached traveling in either direction), and in complicated procedures where the vehicle changes direction during the run. A new parameter `OPT_DIRECTION` is now available that makes control more obvious and simplifies the creation of scenarios in which the vehicle might change direction in the middle of a run.

Import and Output Variables

Many minor changes were made to import and output variables involving name consistencies. Also, the following major changes were made:

- A road axis system was added to support road-based vehicle variables such as accelerations, roll angle, and pitch angle. These are more convenient in some applications involving roads with hills and/or banked turns. The documentation for roads was expanded to include more discussion in the concepts underlying the model. It also describes details of the road axis system.
- Older versions of TruckSim included auxiliary import and output variables that were not part of the vehicle physics model, but were included to support user-defined model extensions. With the capabilities now provided in VS commands and the VS API for adding new variables, these old “built in” auxiliary variables are not needed and have been removed. The variables that were removed are listed in Table 1 on

page 8. An example dataset is included in the TruckSim database that will restore these variables if needed (page 8).

Configurable Table Functions

TruckSim math models make extensive use of configurable functions that can be set at runtime to represent nonlinear relationships using various table-lookup methods, linear coefficients, or constants. New options are available in TruckSim 8.1 to make it easier to extend the models.

- All of the configurable functions used to specify open-loop driver controls (steering, braking, etc.) allow scaling and offset of both the output variable and time. This simplifies the description of complicated tests that use variations of a waveform such as sine-with-dwell steering—the same waveform is simply rescaled for repeated tests with different amplitudes.
- Some of the configurable functions that calculate a dependent variable from two independent variables now include parameters to scale and offset both independent variables. For example, tire force tables now allow scaling of output force (dependent variable), vertical load (independent variable), and the other independent variable (lateral slip, longitudinal slip, or inclination angle). This provides support for advanced users to apply normalized datasets.
- A new option for the function type is `_EQUATION`. With this option, you provide an equation that is used in place of the function. The equation can be based on the built-in independent variable(s) and can make use of other variables in the model. This allows functions to be extended to provide sensitivity to other variables beyond the original model. Support for this option is provided in the relevant GUI screens and is covered in the documentation.
- The VS API was extended to include functions that define new configurable table functions and apply them in external custom programs.

Tire Model Improvement

TruckSim has two built-in tire models that take data in tabular form and apply combined slip theory to generate forces and moments. The original equations for combined slip were taken from a technical paper published in 1991 by Pacejka and Sharp, which summarized some work published in 1989 by Bakker, Pacejka, and Lidner that had additional detail to handle a transition between two types of combined slip (“normalized” and “theoretical”). With some sets of tire data, the transition option provides more realistic behavior for some extreme conditions.

The TruckSim models now include additional tire parameters for advanced users who can evaluate friction ellipses using the TruckSim tire testers and make adjustments.

The tire table-lookup functions have been extended to include scale factors for the two independent variables (instant vertical load and lateral slip, longitudinal slip, or inclination), allowing advanced users to work with normalized tables that can be transformed to define tires with different load ratings and stiffness properties.

New Parameter in Frame Torsional Flexibility Option

A parameter `H_NODE` was added to specify the height of the torsional node used in the math models with torsional flexibility. This height determines the contribution of lateral inertial loading on frame twist.

In the original version, the node height was set at the average wheel height of the unit.

Miscellaneous Architecture Improvements

Improvements were made in the simulation process that are not specific to vehicle features.

1. Processing of Parsfiles during events has been improved for RT systems.
2. Support has been added for 64-bit versions of TNO and COSIN tire models, allowing them to be used with TruckSim when running with other 64-bit software (e.g., 64-bit Simulink).
3. New parameters were added—`ID_Run` and `ID_Event`—to identify the database parsfile ID associated with run and event conditions. These are also available as output variables for plotting or exporting to external software such as Simulink.
4. Symbolic equations provided to set values or equations in VS commands can reference a constant with the symbol `G` (9.80655), along with existing constants `PI` (3.14159265...) and `DR` (57.2957795...).
5. Multiple instances of the VS commands `DEFINE_IMPORT`, `DEFINE_PARAMETER`, and `DEFINE_VARIABLE` applied with a variable that has already been defined can now be used to update the value assigned to the variable.
6. More information is provided in the log text file generated with each run.
7. Reading of parsfiles is more forgiving of the use of spaces (including lack of spaces) in expressions.
8. The VS API has functions for defining moving objects and sensors under full control of external software.

Improvements in the Database

In past versions of TruckSim, the database has served to provide examples for using the software. Most users would then create new datasets for specific vehicles, subsystems, procedures, etc. This is still the case for experienced users working for OEMs and suppliers.

As usage of TruckSim has extended to many new applications, some users rely on TruckSim not only for the software tools, but also for representative datasets for tires, engines, entire vehicles, and advanced procedures. The database in TruckSim 8.1 covers the same sorts of examples and previous versions. However, the example vehicles and procedures have been reviewed and tested to ensure that when used in simulations, they produce reasonable behavior for conventional tests covering full ranges of acceleration, braking, steering, handling, and stability.

Organization of Example Datasets

Existing users of TruckSim can continue to work with existing databases with vehicles and procedures of interest. However, the examples in TruckSim 8.1 have been reworked to provide more immediate help to new users. The example runs are organized into categories for three general purposes:

1. Examples that show how to apply common test procedures. The categories have names such as **Brake Tests**, **Handling and Stability Tests**, etc. Most of the runs show how a test procedure provided in TruckSim is applied to some vehicle. Changing to a different vehicle is so easy that usually there is only one example.
2. Examples that show alternative modeling or data options in TruckSim. These categories have names such as **Alternate Vehicle Data Measurement**, **Roads**, **Tire Models**, etc. Example runs make use of some vehicle dataset using an alternate option that might be more convenient, depending on available sources of data.
3. Examples that show software features of TruckSim. New features have TS 8.1 in the title (e.g., * **TS 8.1 CVT Powertrain**). Others have titles related to the features of interest, such as **Aero Effects**, **Extended Models**, **External Control of Runs**, etc.

Features that require an extra license option (frame twist, PBS procedures and vehicles, Swift tire model, etc.) are demonstrated with one run per option in the category **More Examples (Extra License Options)**. More examples for each option are available, but are not part of the standard TruckSim database that is intended as a foundation for basic usage. These have been pre-run and the results may be viewed.

Procedures

The general method for making a new run is to select a vehicle, select a procedure, click the **Run Math Model** button, and view results with the **Animate** and **Plot** buttons. With this in mind, procedures are included that are fairly independent of the vehicle being run.

One test procedure included in TruckSim 8.1 applies the scripting capabilities of VS Commands to provide a complete test sequence with one click. This is the constant-radius understeer test series (ISO 4138 and ISO 14792), in which multiple tests are on a constant-radius path long enough for the vehicle to stabilize to characterize how steer, roll, and other variables vary as functions of lateral acceleration. This procedure is described in detail in a new technical memo, "Making Advanced Procedures with VS Commands."

Animation Data

TruckSim driving simulators are now being developed using the VehicleSim Visualizer (VsV) that is also provided in TruckSim 8.1. VsV has many visualization capabilities that do not exist in the older SurfAnim program in TruckSim. It is also more stringent about descriptions of 3D shapes in OBJ and STL files; datasets that violate some conventions display OK in SurfAnim, but not in VsV (and other advanced rendering programs).

All of the existing OBJ and STL files in TruckSim were reviewed and modified to ensure that they display properly in both SurfAnim and VsV. Further, many of the files were modified to

provide improved appearance, especially in VsV where more lighting and texture options are supported. VsV can also support more file types such as .osg for greater animation flexibility.

Hitch Data

The example dataset used for representing fifth-wheel hitches was improved to take into account observed effects of frame compliance. The new dataset provides a more realistic behavior when the trailer relative roll angle passes through the lash. Details are provided in the hitch documentation.

Improvements in the GUI

This update mainly introduces new model features and the new Visualizer. The GUI was updated to provide support for these new features, along with some other notable improvements.

1. New screens were added to support the CVT option and path preview option in the speed controller.
2. New screens were added for 5-axle lead units, 4-axle trailers, and tire groups covering up to nine axles. A new powertrain screen was added to support 10x10 systems. These screens are not used in existing examples, but are provided to support possible custom vehicle models. Please contact Mechanical Simulation for information on custom vehicle configurations.
3. New Windows COM functions were added to access the VS browser remotely: `GetBlueLink` (get information about a blue link on the current screen) and `ExportParsfile` (export a parsfile from the current screen plus all linked data screens).
4. The **Libraries** menu was reorganized to simplify navigation to the main screens in systems such as **Powertrain** where there are many data screens.
5. The **Libraries** menu was also modified to merge the libraries for 3D ground and road properties into a single library **Ground and Roads**. (The old **Roads** library no longer exists.)
6. When making a simulation run using a built-in model, the progress status includes the current simulation time along with the status bar. The status bar is not shown if neither a stop time nor a stop station is specified.
7. Screens for configurable functions were modified to support the new `_EQUATION` option when possible. (Not all configurable functions support the new option, as described in the documentation.)
8. Screens for configurable functions include more information about scaling options for independent variables.
9. Screens for tire tables always show plots that go down to zero slip or inclination. (The values at zero slip or inclination are added by the tire model and are not part of the normal tabular data.)

10. The Calculator Tool, available from most screens with configurable functions, has settings for the number of significant digits in X and Y values that are calculated.
11. The **Preferences** screen was extended to include a miscellaneous field for setting global preferences for advanced system-level parameters in the math models.
12. Minor revisions were made to the **Run Control** screen, the **Procedures** screen, the **Road: 3D Surface (All Properties)** screen, the **Hitch** screens, and the **Vehicle: Lead Unit Sprung Mass** screen to provide more options for advanced users, while maintaining the same appearance for basic use.

Compatibility with Older TruckSim Versions

Most of the new features in the math models involve adding new parameters and output variables. Old datasets do not use these features, so the lack of parameter settings is not a problem. However, a few variables used in old models were removed or renamed. These changes will not affect most users, because the affected variables were either hidden or only used for advanced applications.

Auxiliary Parameters and Variables Removed

Older versions of TruckSim included auxiliary variables that were not part of the vehicle physics model, but were included to support user-defined model extensions. With the introduction of VS commands such as `define_variable`, `define_output`, and `define_parameter`, the old built-in variables are no longer necessary.

Table 1 lists variables in earlier versions of TruckSim that were removed from TruckSim 8.1. If they are referenced in existing datasets, they can be restored using VS commands. In fact, the database installed with TruckSim 8.1 includes a VS command dataset in the library **Generic VS Commands** named **Install Obsolete TruckSim 8.01 Generic Variables** that restores the variables from Table 1, along with the 12 generic tables mentioned in the next subsection.

Table 1. Discontinued auxiliary parameters and variables.

Name	Indexing	Description
<code>FLAG_i</code>	$i=1 - 1$	Auxiliary flag variables (parameters and outputs)
<code>IMP_AUX_i</code>	$i=1 - 20$	Auxiliary import variables
<code>IMP_DXEXT_i</code>	$i=1 - 10$	Derivatives of auxiliary state variables (defined externally)
<code>SV_XEXT_i</code>	$i=1 - 10$	Auxiliary state variables (defined externally)

Generic Tables Removed

Recent versions of TruckSim included twelve generic tables (keyword = `GENERIC`) for use in VS commands. The VS command `DEFINE_TABLE` makes these built-in functions unnecessary. If you have existing datasets that use the `GENERIC` function, it can be restored with the `DEFINE_TABLE` command. These tables can be restored using the VS commands dataset in the library **Generic VS Commands** named **Install Obsolete TruckSim 8.01 Generic Variables**.

Import Variable IMP_PWR_EXT_ENGINING_AV Renamed

The variable IMP_PWR_EXT_ENGINING_AV (power available from external engine model, needed by built-in speed controller) was misspelled. It has been renamed IMP_PWR_ENGINE_AV, and is consistent with a configurable function used to connect with external models from AVL Cruise (PWR_ENGINE_AV).

Y vs. Axle Roll Solid-Axle Kinematics (Keyword and Definition)

The sign convention for axle roll in the configurable function used to define lateral movement of the wheel centers used the opposite sign convention for roll that is used in all other screens. This was inconvenient and could lead to error if the documentation was not checked for this particular screen. The sign convention was changed to match the other screens: positive roll of the suspensions and axles occur when the sprung mass has positive roll (i.e., the sprung mass rolls to the right).

To avoid ambiguity about the sign convention in new and old datasets, the old function keyword SUSP_LAT_AXLE_ROLL has been replaced with SUSP_Y_AXLE_ROLL. When datasets from previous versions of TruckSim are loaded into TruckSim 8.1, the roll values are multiplied by -1 and the table is flipped (to provide ascending values of roll). Therefore, when you look at the data in TruckSim 8.1, the plots will appear flipped horizontally from their appearance in earlier versions.

For data handled through the browser (trucksim.exe), conversion is completely automatic. However, if you are using advanced simulation methods where suspension data are provided from external files, it will be necessary to change the data files to use the new keyword and sign convention.

Reference Paths for Road Geometry and Controllers

TruckSim 8.1 extends the use of the road reference line and the driver reference path to provide new capabilities and fix some ambiguities that existed in past versions. The VS browser has been updated such that datasets for basic runs that ran in past versions should provide the same results with no modifications required of the user. However, old datasets that pushed the limits or used tricks to accomplish complicated maneuvers might require modifications.

YIN_TABLE Used for Both a Target Path and the Road Reference Line

TruckSim has supported two models for defining the 3D ground surface, selected using the parameter OPT_ROAD. When OPT_ROAD is zero, the ground geometry is defined with a 3D table that calculates elevation Z based on values of X and Y. When OPT_ROAD is not zero, the ground geometry is defined using the VS road model that uses coordinates of S (station) and L (lateral position). The road model is built with a road reference line, defined with a table of X-Y coordinates identified by the keyword YIN_TABLE.

If the closed-loop steering controller is enabled, a target path is defined with S and L coordinates along a reference path. With past versions, if the road model and closed-loop steering were both enabled, then the driver model always used the road reference line. However, if the road model was not enabled, then a target path was used that was represented with a table of X-Y coordinates, also identified by the keyword YIN_TABLE.

In TruckSim 8.1, both paths can be used at the same time. The table of X-Y values used to define a road reference line is now identified with the keyword `ROAD_REF_XY_TABLE` and the table used for a driver path has the keyword `DRIVER_REF_XY_TABLE`. The keyword `YIN_TABLE` is still recognized internally by the VS solvers as being equivalent to `ROAD_REF_XY_TABLE`, allowing old datasets to work if used to describe road reference lines. However, old datasets that had the combination of no road and the closed-loop steering controller must be modified to use the new keyword `DRIVER_REF_XY_TABLE`. (Revisions are needed only if the data parsfiles are provided under the control of external software such as MATLAB. If the TruckSim GUI and database are used, then everything is automatic.)

Station in Looped Paths

The TruckSim VS solvers have always included a state variable `SV_STATION` and associated output variable `Station` for the distance along the reference path used by the driver controllers and the 3D road model. The VS road model has supported loops to represent test tracks and racecourses. With a looped path, the station is forced into the range covered by the loop in order for the road model to calculate the ground geometry (elevation and slope). Although the station was usually forced to the range of the looped path internally, the state variable and associated output variable were not always modified.

In TruckSim 8.1, there are two potential station variable pairs: one for the driver reference path (state variable `SV_STATION` and output variable `Station`) variables, one for the road reference line (state variable `SV_STA_ROAD` and output variable `Sta_Road`). In both cases, if the path is looped the station is forced to be within the range of the loop. The new behavior is documented and more consistent.

For most scenarios, differences in how station is calculated do not affect results. However, old datasets that define complicated scenarios in which station is monitored with VS Commands might fail on looped roads now that station is forced to stay within the range of the loop. If this is the case, the datasets will have to be modified.

Setting Direction of Travel

In past versions of TruckSim, the direction of travel along a target path was determined by comparing values of the parameters `SSTART` and `SSTOP`. The parameter `SSTOP` had two roles: it was used as a condition for stopping the run if another parameter `OPT_SSTOP` was greater than zero. If `OPT_SSTOP` was not greater than zero, it was still used to define the direction of the vehicle for initialization and controller settings.

When working with looped paths, the old method could be confusing and sometimes required elaborate sequences of events.

TruckSim 8.1 simplifies the setting of direction with a new parameter `OPT_DIRECTION`. During initialization, `OPT_DIRECTION` is set to one of two values: +1 or -1. For backward compatibility with old datasets, it will be set based on a comparison of `SSTART` and `SSTOP` during initialization if it has not been assigned a nonzero value in a parsfile.

The TruckSim GUI sets up the initial direction automatically, providing backward compatibility for most simulations. However, in some complicated scenarios, events are used to change the direction during a run. Old datasets required tricks where `SSTOP` is given a new value based on

the current position of the vehicle. Some of the tricks probably won't work anymore unless OPT_DIRECTION is reset. (It is usually much simpler using OPT_DIRECTION directly.)

Position of Yellow Field Changed in Procedures Screen

The **Procedures** screen has two sections with titles **Additional Data**, with nine potential data links and two miscellaneous scrollable yellow fields (Figure 1a). In the figure, the blue arrow zigzag line shows the sequence in which data from these controls are written into the parsfile associated with the display. One of the miscellaneous fields appears before any of the links (①), such that advanced users can use it to define parameters or variables that are referenced in linked datasets that follow. Another miscellaneous yellow field (⑨) appears after most of the links, but before the last two. It can be used to set values to override settings made in the linked datasets.

Past versions of TruckSim 8 have the same two miscellaneous fields and eight data links with a different layout (Figure 1b). In this case, the first miscellaneous field (①) has only two potential links that follow (⑧ and ⑩). When data from TruckSim 8.0x is loaded into TruckSim 8.1, all of the linked datasets and contents of the yellow fields are retained. However, the sequence that they are written into the parsfile is changed, as indicated by comparing Figure 1a and Figure 1b. In most cases, this is OK.

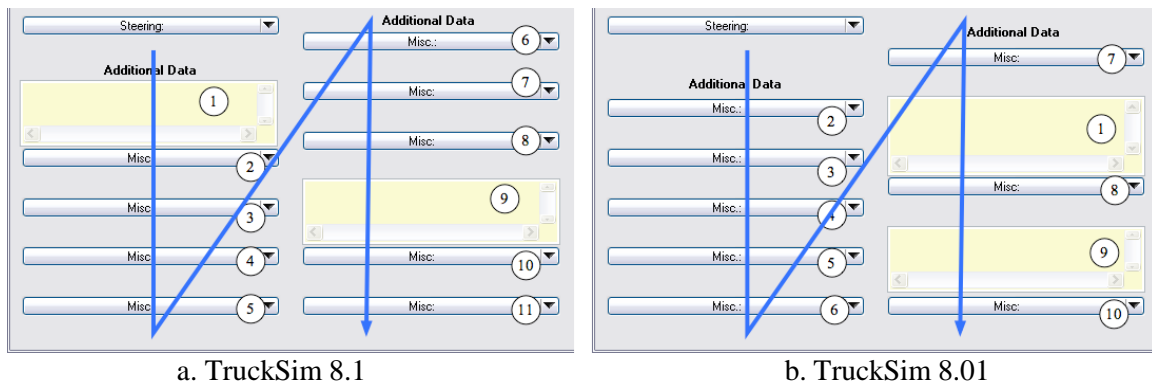


Figure 1. Layouts of bottom-left part of **Procedures** screen.

On the other hand, some advanced users might have made datasets in which settings in the first yellow field (①) are not valid when read by the VS solver unless data from one or more of the links (②) - (⑦) have already been read by the VS solver. If this is the case, the contents from the first field must be moved manually.

Road-Based Variables Removed

The TruckSim solvers had built-in output variables for the station and lateral coordinate of the axle centers (Sta_A1, Lat_A1, Sta_A2, Lat_A2). These were removed because the calculation can sometimes cause numerical problems when using the option to set the driver path with X-Y coordinates that describe a tight turn. They can be defined easily using VS commands if needed. (Use the functions ROAD_S and ROAD_L, using X and Y coordinates for the axle centers as arguments.)

Hidden Parameter IROAD renamed as IDZ_ROAD

The 3D road model in TruckSim has off-center elevation changes defined with a configurable function ROAD_DZ that supports two datasets. The first dataset is intended for design features such as cross-slopes, ditches, and curbs. Starting with the TruckSim 8.1 release, it is also used to define a road reference axis system to support road-based vehicle variables such as roll and pitch. The second dataset can be used for other features such as roughness or special events. In past versions, the two datasets have an associated hidden parameter named IROAD. This parameter has been renamed IDZ_ROAD for consistency, allowing IROAD to be used for future improvements supporting multiple roads. This change is made in both the VS solvers and the TruckSim GUI. It will only affect users who are using automation methods involving Parsfiles made with older versions that involve the second DZ component and have lines that read "IROAD 1" and "IROAD 2". If you have any such files, the lines should be changed to use the keyword IDZ_ROAD.

Camber Output Variables

Camber output variables for independent and solid axle suspensions did not include compliance effects. The internal variables used in the multibody equations were correct; the output variables provided for plotting and export were inconsistent. The camber output variables now match the internal variables.

New Parameter in Frame Torsional Flexibility Option

A parameter H_NODE was added to specify the height of the torsional node used in the math models with torsional flexibility. In the original version, the node height was set at the average wheel height of the unit. In the new version, the default value (used in old datasets where the parameter is not set) is 500 mm.

Bug Fixes and Errata

The following bugs were identified and corrected.

1. The open-loop steering configurable function was always listed in the echo file, even if disabled. It is now hidden if not active.
2. The spring design deflection was added to the suspension deflection before considering mechanical advantage. This has been corrected so the design deflection is now added to the spring deflection as calculated using the mechanical advantage configurable function. The design deflection option is not used in any examples supplied with TruckSim; they all use the reference jounce parameter option (OPT_JNC_DESIGN).
3. Past versions allowed import of camber angle for each wheel. This ignored an associated jacking effect that occurs on the road. The import variables related to camber of the road wheel were removed. Camber (and other suspension kinematical variables) can instead be imported by using configurable functions and VS commands, which can be set up to handling jacking effects correctly.

4. The aligning moment calculated by the built-in extended tire model (OPT_TIRE_MODEL = 6) sometimes missed the contribution due to F_x and the Y displacement of the contact patch center implied by the overturning moment.
5. The closed-loop speed controller would get confused if the vehicle rolled backward (e.g., sitting in neutral on a hill).
6. A limited simulation program is used to separate auxiliary roll moment from total roll moment measured at the ground when using the **Suspension: Measured Roll Stiffness** screen. The simulation program did not recognize some of the enhancements made for configurable functions in recent versions of TruckSim. It has been replaced with a new VS solver that supports the newer options.
7. The closed-loop speed controller didn't consider negative engine torques when interpolating to calculate throttle.
8. Range and tracking sensors behaved incorrectly when passing through cylinder target objects (an error occurred when one edge of the target was in front of the sensor and another edge was behind it).
9. In the optional extended dynamics models (frame twist and cab suspension), the calculated trailer frame twist due to the trailer hitch moment at the front of a trailer had incorrect sign. This has been corrected.