Vehicle Screens and Outputs

The vehicle being simulated in TruckSim is typically a light or heavy truck or bus with two or more axles with wheels that have single or dual tires. The overall vehicle might also include one or more trailers with one or more axles.

This document describes the vehicle screens that provide size and weight information about the sprung masses as well as datasets used to assemble datasets for the other parts of the vehicle. Output variables that described the motions of the overall vehicle units are also listed, along with variables tied to the motions of the associated sprung masses.

Overview of Vehicle Screens

When specifying a vehicle from the **Run Control** screen, you typically link to a dataset from one of two types of vehicle screens.

1. **Vehicle: Lead Unit** screens (with 2 to 5 axles) — the vehicle is an assembly of datasets that define the major systems and components. The vehicle as defined by any of these

screens is in a design load condition. If a test doesn't involve payloads or trailers, you can link to this library directly from the **Run Control** screen.

2. **Vehicle: Loaded Combination** — a motor vehicle (from a **Vehicle: Lead Unit** library) may also include additional masses (i.e., payloads), virtual sensors (ADAS and Motion Sensors), and trailers. Changes in loading conditions or sensor locations can be made by changing a few links, without making any changes in the basic vehicle description. In TruckSim, this is the most used screen to link to vehicle datasets since most truck tests involve payloads or trailers.

The following screens are also described in this document.

1. **Trailers** (with 1 to 4 axles) — use screens like a **Vehicle: Lead Unit** screen to assemble trailers.
2. **Dollies** (with 1 to 3 axles) — use screens like the **Vehicle: Trailer** screens to assemble dollies used to connect multiple trailers.
3. **Vehicle: Lead Unit Sprung Mass** — set size and weight information about the sprung mass of the lead unit. Optionally set parameters describing torsional flexibility and connect to **Vehicle: Suspended Cab** screens (requires optional license).
4. **Vehicle: Trailer Sprung Mass** — set size and weight information about the sprung mass of a trailer.
5. **Vehicle: Suspended Cab** — Use of this feature requires optional license. Set properties of a cab mounted on springs, including mass, inertia, and stiffness and location of mounts.

Vehicle Unit screens

A TruckSim vehicle unit is made of a sprung mass, supporting axles, and in the case of a trailer, the location for the front hitch.

Vehicle Lead Unit Screens

A TruckSim lead unit has a sprung mass, 2 to 5 axles, a powertrain, and steering for the front and possibly other axles.

Figure 1 shows the **Vehicle: Lead Unit with 3 Axles** screen on which the components and systems of a 3-axle truck or tractor are assembled. Similar screens are provided for lead units with 2, 4, and 5 axles.

The vehicle as defined by this screen is in the design load condition (sometimes called curb condition, in which the vehicle is unladen and not hitched to a trailer). Additional masses and inertias can be added or subtracted on the **Vehicle: Loaded Combination** screen, along with trailers and sensors.

System Level Vehicle Properties

① Link to a **Vehicle: Lead Unit Sprung Mass** dataset.

2 Link to an **Aerodynamics: Main Screen** dataset.

3 Link to an animator dataset to define the appearance of the sprung mass when viewed by the animator.

4 **3x1 image scale** checkbox. If the image of the vehicle looks distorted, try checking or unchecking this box to improve the appearance.

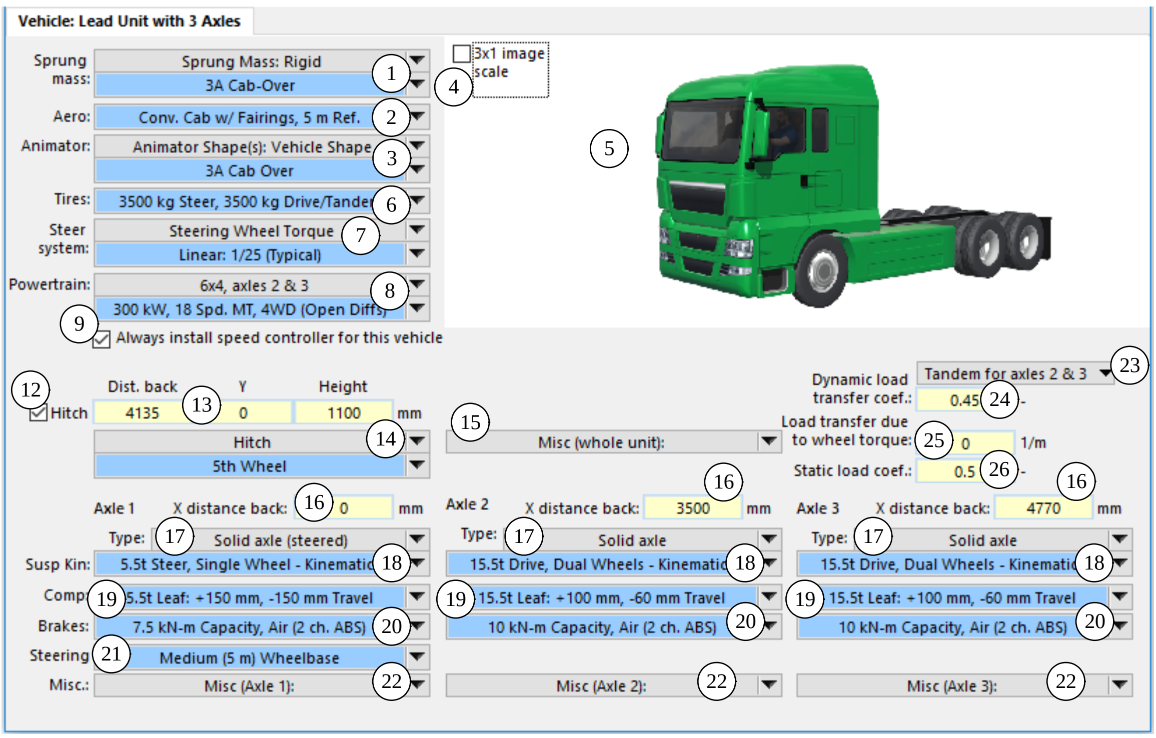

Figure 1: Vehicle: Lead Unit with 3 Axles screen.

5 Image of vehicle. When you change the link to the animator dataset 3, the associate image from that dataset is shown here. You can also specify an alternate image by clicking on the image to display a drop-down list of options (Figure 2). See the *VS Browser Reference Manual* for details about these options.

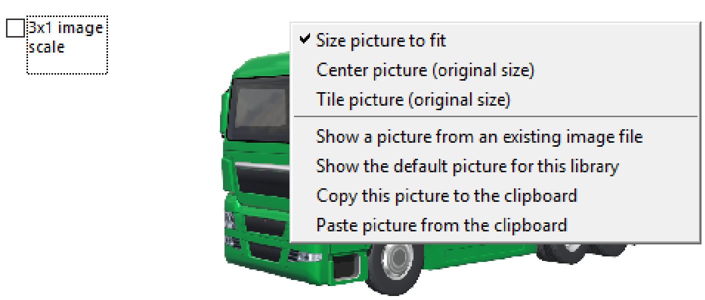

Figure 2. Options for setting and adjusting the image for a vehicle dataset.

⑥ Link to a **Tires: Vehicle Unit with 3 Axles** dataset. (Similar links exist for other lead unit screens matched to the number of axles.)

⑦ Link to a **Steering Wheel Torque** dataset. This determines how the total moment about the kingpin axes for the front axle are scaled to apply at the steering wheel.

Powertrain

⑧ Pull-down control for specifying the type of powertrain.

Figure 3 shows the options for the **Vehicle: Lead Unit with 2 Axles** screen.

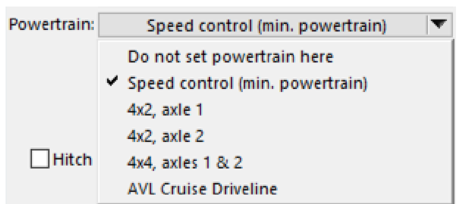

Figure 3. Powertrain options for 2-axle lead unit.

Figure 4 shows the options for the **Vehicle: Lead Unit with 3 Axles** screen.

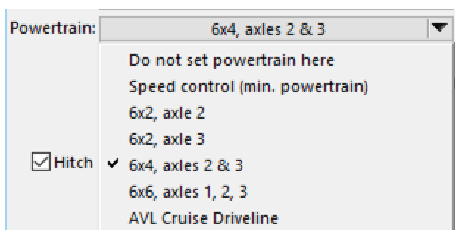

Figure 4. Powertrain options for 3-axle lead unit.

Figure 5 shows the options for the **Vehicle: Lead Unit with 4 Axles** screen.

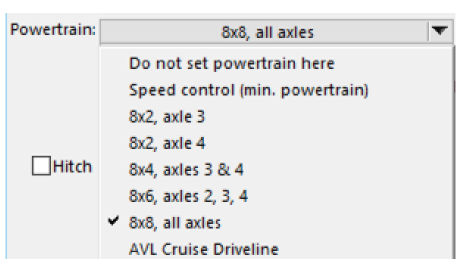

Figure 5. Powertrain options for 4-axle lead unit.

Figure 6 shows the options for the **Vehicle: Lead Unit with 5 Axles** screen.

The first item on each list (**Do not set powertrain here**) is used in case the powertrain is applied to a trailing unit, rather than the lead unit.

The second option (**Speed control (min. powertrain)**) shows yellow fields for the speed controller, as described below.

All other settings show a blue link to a driveline dataset and a checkbox involving the speed controller (9).

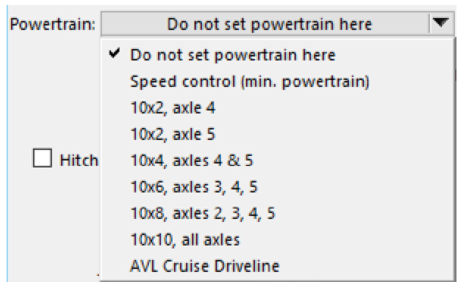

Figure 6. Powertrain options for 5-axle lead unit.

(9) Link to a driveline dataset and checkbox **Always install speed controller for this vehicle**. These appear for any type of powertrain other than **Speed control (min powertrain)**, based on the selection made with the pull-down control (8).

The options for types of links displayed different for 2-5 axle trucks. Each available powertrain option displays a link to a dataset in one of several powertrain libraries. In addition to linking to a powertrain dataset,

The “Front-wheel drive”, “6x2, axle 2”, and “8x2, axle 3” selections display a link to the **Powertrain: Front Wheel Drive** library.

The “Rear-wheel drive”, “6x2, axle 3”, and “8x2, axle 4” selections display a link to the **Powertrain: Rear Wheel Drive** library.

The “4-wheel drive”, “6x2, axle 2 & 3”, and “8x4, axle 3 & 4” selections display a link to the **Powertrain: 4-Wheel Drive** library.

The “6x6” and “8x6, axles 2 & 3 & 4” selections display a link to the **Powertrain: 6-Wheel Drive** library.

The “8x8” and “10x8” selections display a link to the **Powertrain: 8-Wheel Drive** library.

The “10x10” selection displays a link to the **Powertrain: 10-Wheel Drive** library.

TruckSim includes a closed-loop speed controller that may be used to control throttle and braking based on a target speed and other settings. The controller is not used for driving simulators or tests involving open-loop throttle and braking. Checking the checkbox **Always install speed controller for this vehicle** causes the command `INSTALL_SPEED_CONTROLLER` to be written into the Parsfile for the vehicle dataset.

In most cases, this is not necessary. The speed controller is automatically installed by linking to a **Speed Controller** dataset or specifying a target speed on the **Run Control** or **Procedure** screens. However, in some scenarios, the simulation will start with the vehicle throttle set in open-loop mode, and later switch to using speed control by triggering a VS Event. The speed controller cannot be installed after the simulation starts (it installs differential equations), so this checkbox may be used to ensure the speed controller will always be available when simulating this vehicle.

If the **Speed Control (min powertrain)** option is selected, yellow fields are shown (10 and 11), Figure 7) and the powertrain link 9 and speed controller checkbox are hidden. (The checkbox is not shown, because the command `INSTALL_SPEED_CONTROLLER` is automatically written for this option.)

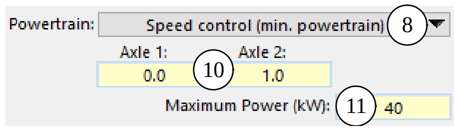

Figure 7. Parameters for the minimal powertrain option (2-axle example).

10 When the powertrain option selected is **Speed control (min. powertrain**), yellow fields are displayed that define the fraction of drive torque (from the speed controller) that goes to the wheels on each axle of the lead unit.

The minimal powertrain option is intended to simplify the creation of a vehicle dataset when detailed powertrain behavior is not involved in the simulated tests. The closed-loop speed controller determines the drive torque needed to follow the target speed and applies the torque to the axles based on the specified fractions of the overall torque.

This simple powertrain option is only used with the speed controller. Direct throttle and shift control have no effect without the more detailed powertrain options.

Alert	The minimal powertrain mimics a free differential at each drive axle. If a drive wheel lifts off due to extreme cornering, the power goes to the wheel in the air, which will spin to a high rate. Power to the wheel on the ground is diminished, possibly limiting the overall vehicle speed. If the vehicle cannot reach a target speed due to wheel lift-off, then a full powertrain model is probably needed.

11 If the powertrain option 8 is **Speed control (min. powertrain**), a yellow field is shown that limits the power used by the speed controller (keyword = `PMAX_SC`). The speed controller uses proportional-integral control to try to match a target speed. The power being transferred to the wheels is monitored and not allowed to exceed this limit.

Hitch

12 Hitch checkbox. When not checked, the hitch-related parameters and link are hidden.

The control of the appearance is done to provide quick visual feedback about the main intended use of the lead vehicle. If this dataset is used for a single unit vehicle (truck, bus, etc.) and the hitch box is checked, the hitch information is ignored by the math model solver program. On the other hand, if the dataset is used for a combination vehicle and no hitch is specified, then default hitch properties are used.

13 Yellow fields with coordinates that locate hitch point. The first is the distance the hitch point lies behind the origin of the sprung mass coordinate system (keyword = `LX_H`). (The X coordinate is nearly always a negative number, so a definition is used such that the value is typically a positive number.) Y is lateral coordinate of the hitch point (keyword = `Y_H`). The height (keyword = `H_H`) is relative to the origin of the sprung mass coordinate system.

These fields are visible only when the **Hitch** box 12 is checked.

14 Link to a **Hitch: Joint Assembly** dataset for the hitch. This is visible only when the **Hitch** box 12 is checked.

Miscellaneous (Whole Unit)

15 Miscellaneous link. This has no predefined purpose, but can be linked to datasets that specify parameters for extensions to the model or information for the animator. Data from this link applies to the lead unit.

Axles

Parameters for each axle are associated with the system index parameter `IAXLE`.

16 Distance the axle center lies behind the origin of the sprung mass coordinate system (keyword = `LX_AXLE`). The convention is usually to set the front axle at position 0, thereby defining the origin of the sprung-mass coordinate system as being aligned with the front axle. However, if you define the origin of the sprung mass elsewhere, then use a non-zero value for the front axle.

17 Drop-down control for selecting a type of suspension data. There are two choices for the first axle (Figure 8) and four for the other suspensions (Figure 9). The first axle is always steered; the others have separate options for steered or unsteered.

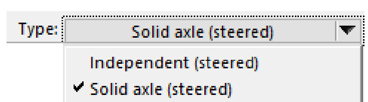

Figure 8. Options for the first suspension.

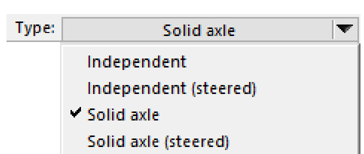

Figure 9. Options for suspensions other than the first.

Two links are shown underneath: one for kinematical data 18 and one for compliance, springs, and dampers 19. If the suspension is steered, then a link is shown to steering information for the axle 21. If the axle is not steered (i.e., either **Independent** or **Solid axle**), then the axle parameter OPT_STEER_EXT is set to 1 (not steered) and the link to a steering dataset is hidden.

18 Link to either a **Suspension: Independent System Kinematics** dataset or a **Suspension: Solid Axle System Kinematics** dataset, depending on the selection of the ring control 17.

19 Link to either a **Suspension: Independent Compliance, Springs, and Dampers** dataset or a **Suspension: Solid Axle Compliance, Springs, and Dampers** dataset, depending on the selection of the ring control 17.

20 Link to a **Brakes: Two-Wheel System** dataset.

21 Link to a **Steering System** dataset. This is always visible for axle 1. For other axles, it is visible only if the selected suspension type 17 supports steering.

22 Miscellaneous link. This has no predefined purpose, but can be linked to datasets that specify parameters for extensions to the model or information for the animator. Data from each miscellaneous link apply to the axle as indicated on the screen.

Tandem and Tridem Suspensions

If the vehicle has three axles, the model supports a tandem suspension connecting two of the axles. If it has four axles, the model supports two tandems that may overlap to make a tridem. If it has five axles, the model supports three tandems (axles 1 and 2, and a tridem with axle 3, 4, and 5). The options for setting load-sharing properties are summarized below; a more detailed discussion is presented in a separate section **Tandem and Tridem Load Sharing** (page 22).

23 Pull-down control to specify location of a tandem suspension. The static load sharing of axles in a tandem are connected, and there is a load transfer between the axles when braking torques are applied to the wheels.

24 Coefficient that defines the fraction of spring load shared with the other axle of the tandem: 0 - 0.5 (keyword = R_TANDEM). 0 means no dynamic load transfer, as with a fully independent axle. 0.5 means perfect load sharing, as with a walking-beam suspension.

25 Coefficient to determine tandem suspension load transfer due to applied wheel spin torque M_y (keyword = CFZ_MY_TAND). This is the load transferred to the lead axle of the tandem, divided by the total spin torque of all four wheels of the tandem. A positive sign implies that the front axle load decreases during braking (brake torque is a negative moment).

26 Fraction of tandem static load carried by the springs of the rear axle of the tandem in the nominal load condition, unloaded and without a trailer (keyword = R_TAND_TRAIL_STATIC). This is typically close to 0.5. This parameter is not available if the tandem overlaps with another tandem to make a tridem; in that case, the static load condition is always 1/3 per axle in the tridem. This parameter is used only during initialization, to determine static spring reference values.

Vehicle Trailer screens

There are four screens to assemble the major system and components of a semitrailer or full trailer with dolly, in support of trailers with 1 – 4 axles. The trailers as defined by those screens are in the unladen condition, often called curb condition. Additional masses and inertias can be added or subtracted on the **Vehicle: Loaded Condition** screen using payloads.

Figure 10 shows the **Vehicle: Trailer with 2 Axles** screen. The other trailer screens are similar.

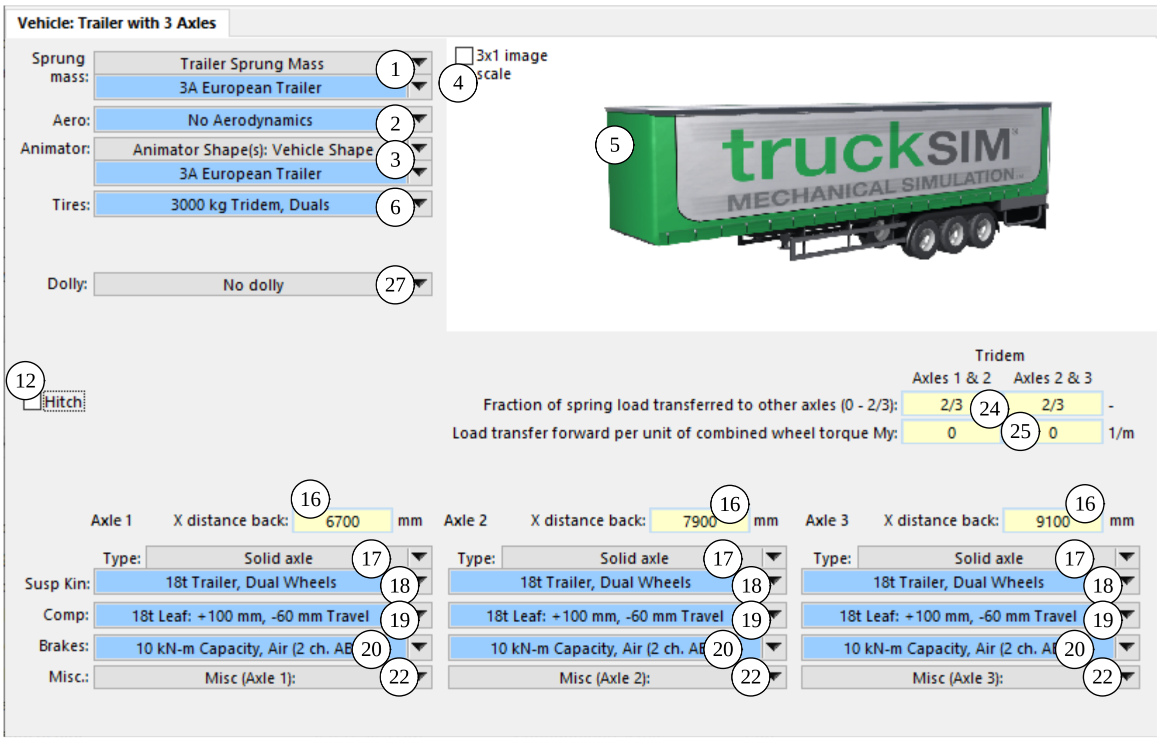

Figure 10: Vehicle: Trailer with 3 Axles screen.

Most of the controls for a trailer vehicle unit screen also exist on a lead unit screen and were described in the previous section. The trailer screen does not have any steering information nor any powertrain options. On the other hand, it has a link for a dolly dataset 27 in case this is a semitrailer normally associated with a dolly. If the trailer has a dolly, there are choices for 1, 2, and 3-axle dollies as specified with a dataset from one of the dolly libraries.

Vehicle Dolly Screens

There are three screens, the **Vehicle: Dolly with 1 Axle** screen, the **Vehicle: Dolly with 2 Axles** screen, and the **Vehicle: Dolly with 3 Axles** screen, to assemble the major systems and components of a dolly.

Use this screen to specify the properties of a dolly used in multiple trailer combination vehicles. It has a subset of the elements in the **Vehicle: Trailer** screens. The main difference is that the dolly screen does not have links for a dolly or aerodynamic dataset and does not include parameters for torsional flexibility. Dollies are assumed to be torsionally rigid in all models. In addition, the hitch information is always visible because a dolly always has a trailing hitch.

The standard set of TruckSim models uses only the **Vehicle: Dolly with 1 Axle** screen. The others may be used if you have purchased custom models for other vehicle configurations.

Vehicle: Loaded Combination

Figure 11 and Figure 12 show the **Vehicle: Loaded Condition** screen used to combine a lead unit with a trailer or trailers, and/or add payloads, sensors, and custom model extensions.

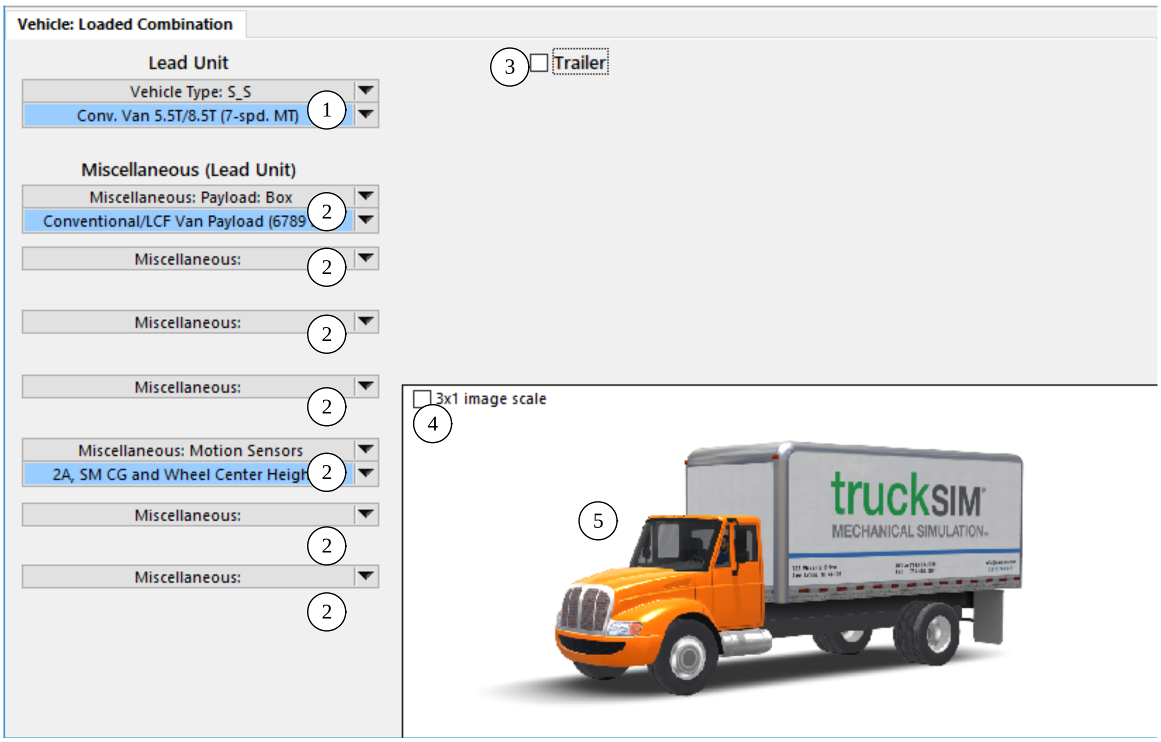

Figure 11: Vehicle: Loaded Combination screen with no trailers.

(1) The vehicle type shown here is used to determine which of many VS Solver programs should be used to make the simulation run. (In Figure 11 it is `S_S` and in Figure 12 it is `S_SS`.) When the linked dataset has an associated image, that image will be shown (5) when the link is made.

(2) Links to miscellaneous datasets that add optional parts to the lead unit, such as payloads, motion sensors, target objects, user-defined forces and moments, and sets of VS Commands.

(3) Trailer checkbox. If not checked, then the vehicle has no trailer, and all visible settings apply for the lead unit (Figure 11). When checked, additional links appear for specifying a trailer (4), its loads, sensors, and other items (6) (Figure 12).

(4) **3x1 image scale** checkbox. If the image of the vehicle looks distorted, try checking or unchecking this box to improve the appearance.

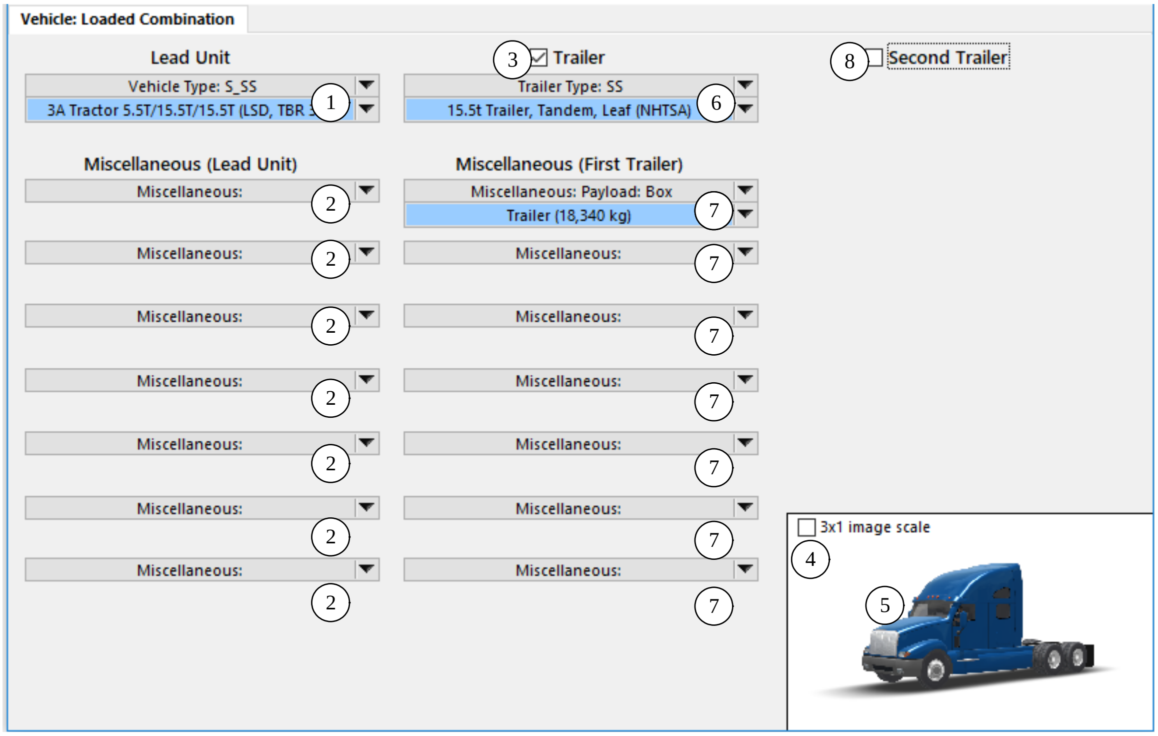

Figure 12. Vehicle: Loaded Condition screen when there is one trailer.

> **Note** When working with datasets from older versions of the software (before 2009), images associated with datasets might have been included that are scaled for a 3x1 aspect ratio (the image is three times wider than it is high). Images that are created automatically from within the VS browser have a 2x1 aspect ratio.

5. Image of vehicle. When you change the link to the lead vehicle dataset (1), the associated image from that dataset is shown here. You can also specify an alternate image by clicking on the image to display a drop-down list of options. See the *VS Browser Reference Manual* for details about these options.

6. Link to a trailer dataset, such as **Vehicle: Trailer with 2 Axles**.

7. Links to miscellaneous datasets that add optional parts to the trailer, such as payloads, motion sensors, user-defined forces and moments, and sets of VS Commands.

8. Checkbox to include a second trailer. The control is not visible unless the checkbox for the first trailer is checked (3). If the box for a second trailer is checked, then the image is hidden, and the right side of the screen has links to datasets for the third trailer (Figure 13).

9. Link to a second trailer dataset, such as **Vehicle: Dolly and Trailer with 1 Axle**. If no dataset is selected, then all links under this one are hidden. Note that the link may be made to a semitrailer or a full trailer with a dolly.

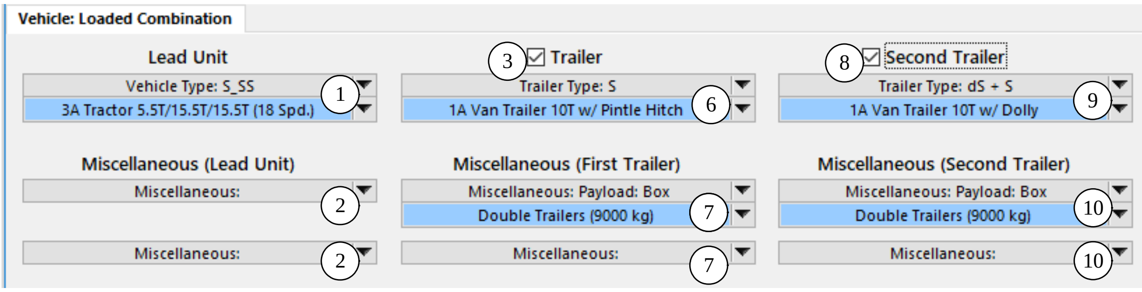

Figure 13. Vehicle: Loaded Condition screen when there are two trailers.

10 Links to miscellaneous datasets that add optional parts to the trailer, such as payloads, motion sensors, user-defined forces and moments, and sets of VS Commands.

> **Note** Datasets from the **Single Moving Object (Custom)** library may be specified with the miscellaneous links (2, 7, and 10) to attach target objects to sprung masses, as described in the **Help** menu document *ADAS Sensors and Moving Objects*. If links are made to both **Moving Object** datasets and **Payload** datasets, place the links such that the **Payload** links appear before the **Moving Object** links. Otherwise, the animation of **Payload** shapes might not work as intended.

Sprung Mass Features

A sprung mass is the part of a vehicle unit that is supported by the suspensions. It accounts for the main size and weight properties of a vehicle in its unladen configuration, called the design condition in TruckSim. It is sometimes called the curb condition.

In addition to defining the design load condition, the sprung mass defines the locations of points in the vehicle model with its coordinate system.

The math models are provided in two forms: the core TruckSim models in which the sprung mass is a single rigid body, and a second set of models with extended dynamics, including frame torsional flexibility and a suspended cab. The license for the extended dynamics models is an available option. The sprung mass screens each have a Checkbox for enabling the extended features. When the box is checked, the screen is also used to set values for the parameters associated with the frame torsional twist and to link to properties of a suspended cab.

Vehicle Coordinate System

Loads, sensors, and various reference points are specified using X, Y, and Z coordinates in a coordinate system fixed in the sprung mass. The axis directions and the location of the origin of the coordinate system are defined specifically for the vehicle with the mass properties defined on this screen when the pitch and roll angles are zero. In this condition, the Z axis points up parallel to gravity, the X axis points forward, and the Y axis points to the left. Normally, the origin of the coordinate system is on the longitudinal centerline of the sprung mass. However, this is not a requirement.

The state of the sprung mass represented by this screen defines the *design load* condition in TruckSim. For more information about the design load, please see the Technical Memo: *The Design Load Condition in TruckSim and TruckSim*.

Changes in load due to payloads or aerodynamic effects can tilt the axes and move the origin up or down relative to the ground plane. In addition, the effects of different tire sizes front and rear or tire compression can also tilt the sprung mass and its axes. In general, a vehicle at rest on a flat and level surface will not have zero pitch. If the vehicle is asymmetric, it is also unlikely to have zero roll.

Aerodynamics

In TruckSim, three forces and three moments define the aerodynamic effects on the sprung mass. The forces act on a point on the sprung mass called the aerodynamic reference point, defined by X, Y, and Z coordinates in the sprung mass coordinate system (see **Aerodynamics: Main Screen**). If changes are made to the data on a sprung mass screen, the location of the aerodynamic reference point might need revision.

Suspension and Steering Kinematics

The steering system model for an axle includes a jounce vs. steer coefficient. When this coefficient is non-zero, the definition of jounce has a direct effect on the steer of the wheels on the axle. Independent suspensions include another interaction involving jounce: wheel toe and camber angles have a nonlinear relationship to jounce. See the **Steering System** screen, and various suspension screens.

Due to these kinematical relationships, the definition of jounce can affect the wheel steering and inclination. TruckSim supports two definitions of jounce in the design load condition. One is based on the load carried by the suspension, so when a change is made to this sprung mass screen, the definition of jounce is affected and therefore the toe and camber behavior are also affected.

Frame Twist

This feature is part of the TruckSim extended dynamics model “TruckSim with Frame Flex,” and requires an optional license. If you don’t have this license and you need the torsional flexibility “frame twist” feature, please contact Mechanical Simulation.

Heavy trucks typically have low chassis torsional stiffness as compared to suspension roll stiffness. Truck chassis are designed to flex to reduce local stress in chassis and frame components, increasing component life. Chassis twist influences relative roll at each axle and the distribution of load transfer between axles. The chassis twists in response to suspension forces, powertrain torque, and the roll moment at the hitch.

Seven parameters are used in the description of chassis twist: the measured stiffness and damping about a longitudinal axis, the vertical and longitudinal position of a node point which describes the distribution of torsional stiffness along the length of the frame, two dimensions for the locations of points at which measurements were made, and a coordinate for the location at which the powertrain torque is reacted at the chassis.

The points used to measure chassis stiffness must be laterally equidistant front and rear, and longitudinally equidistant left and right to describe a rectangle as shown in Figure 14. If it is not possible to attach equipment to the chassis in this configuration, fixtures may be attached to provide the proper spacing. The reported stiffness in the dataset should be based on the angles of deflection and moments as applied at these points. A damping value is required for numerical stability, but its actual value has little effect on most handling maneuvers.

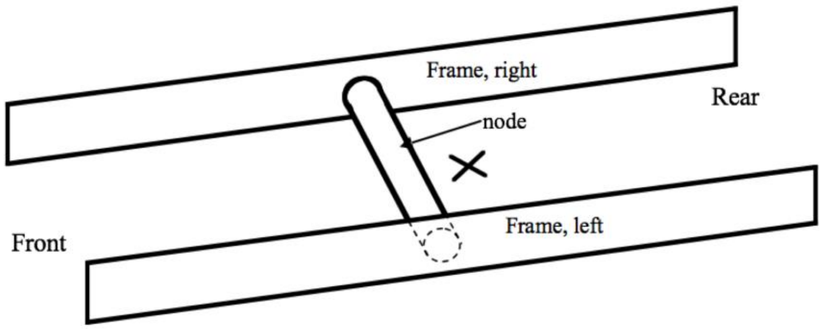

Figure 14: Rectangular geometry associated with frame twist.

The X coordinate of the node point can be determined from the vertical loads measured at four measurement points for the tilted chassis. For example, when the chassis is tilted to the left (it causes the load transfer from right to left) as shown in Figure 15, the load transfer measured on the two front measurement points is ΔF_f, and the load transfer measured on the two rear measurement points is ΔF_r. The X coordinate of the node is:

$$X_{node} = L \cdot \Delta F_r / (\Delta F_f + \Delta F_r)$$

where L is the distance between the front and rear measurement points.

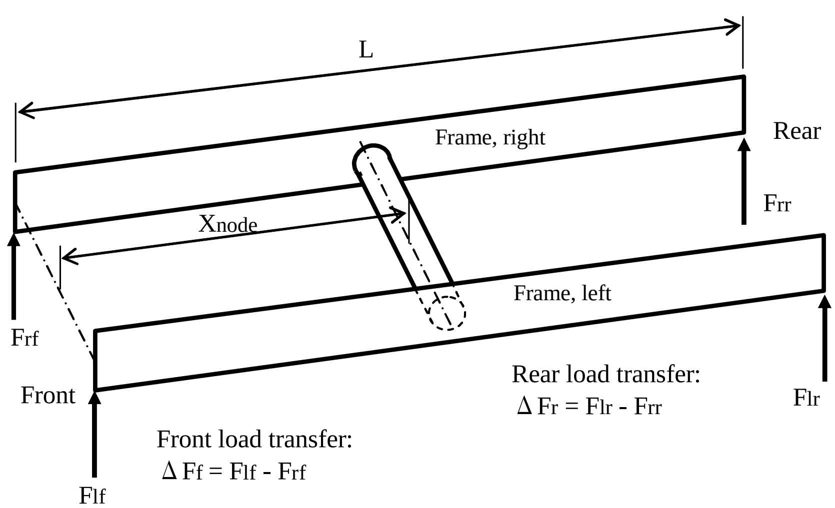

Figure 15: Front and rear load transfer due to frame twist.

The height of the node can be determined for a vehicle with a known CG height and mass on the same test. Tilting the vehicle produces a moment that is apparent in the total load transfer. The difference in loads at the two ends yields the torsional moment resulting from roll. The ratio of the torsional moment to the total load transfer moment, multiplied by the height of the CG above the measurement points yields the height of the CG above the node. Subtract this from the CG height to find the height of the node. The node height determines how much of the inertial lateral force develops chassis torsion.

The effective mounting location of the engine can similarly be determined by locking the drive shaft to the transmission, as putting an automatic transmission in “park,” and applying a moment. Then, you can measure the load transfer and apply the above equation.

Table 1 lists the output variables associated with frame twist.

Table 1. Output variables involving frame twist.

Short Name	**Units**	**Long Name**	**Type**
`AA_Tor`	deg/s2	Chassis twist acceleration about X axis	Angular accel.
`AV_Tor`	deg/s	Chassis twist rate about X axis	Angular rate
`A_Tor`	deg	Chassis twist angle about X axis	Angle
`A_Warp`	deg	Chassis twist angle about Y axis	Angle
`RolT_A1`	deg	Axle 1 roll relative to twisted chassis	Angle
`RolT_A2`	deg	Axle 1 roll relative to twisted chassis	Angle
`XFrL_1`	m	Global X Coord. Of left “frame rail” at node	Global X coord.
`XFrR_1`	m	Global X Coord. Of right “frame rail” at node	Global X coord.
`YFrL_1`	m	Global Y Coord. Of left “frame rail” at node	Global Y coord.
`YFrR_1`	m	Global Y Coord. Of right “frame rail” at node	Global Y coord.
`ZFrL_1`	m	Global Z Coord. Of left “frame rail” at node	Global Z coord.
`ZFrR_1`	m	Global Z Coord. Of right “frame rail” at node	Global Z coord.
`PchFrL_1`	deg	Euler pitch of left “frame rail”	Angle
`PchFrR_1`	deg	Euler pitch of right “frame rail”	Angle
`RolFrL_1`	deg	Euler roll of left “frame rail”	Angle
`RolFrR_1`	deg	Euler roll of right “frame rail”	Angle
`YawFrL_1`	deg	Euler yaw of left “frame rail”	Angle
`YawFrR_1`	deg	Euler yaw of right “frame rail”	Angle

Hitch Moments with Frame twist

Trailer hitch properties include the combined effects of components on the leading and trailing vehicle units. The moments at the hitch are typically measured by rolling the trailer. Deflection due to frame twist occurs at both sides of the hitch (both units), so a convention must be chosen to define the hitch angle. In TruckSim, with or without frame twist, the hitch angle is defined as the difference in rigid body angles for the two units on either side of the hitch. For hitch roll in the frame twist model, this is the difference between the roll angles at the longitudinal locations of the respective torsional node points for the two units.

Vehicle Lead Unit Sprung Mass Screen

TruckSim includes libraries for the sprung masses of lead units and trailers.

Figure 16 shows the **Vehicle: Lead Unit Sprung Mass** screen.

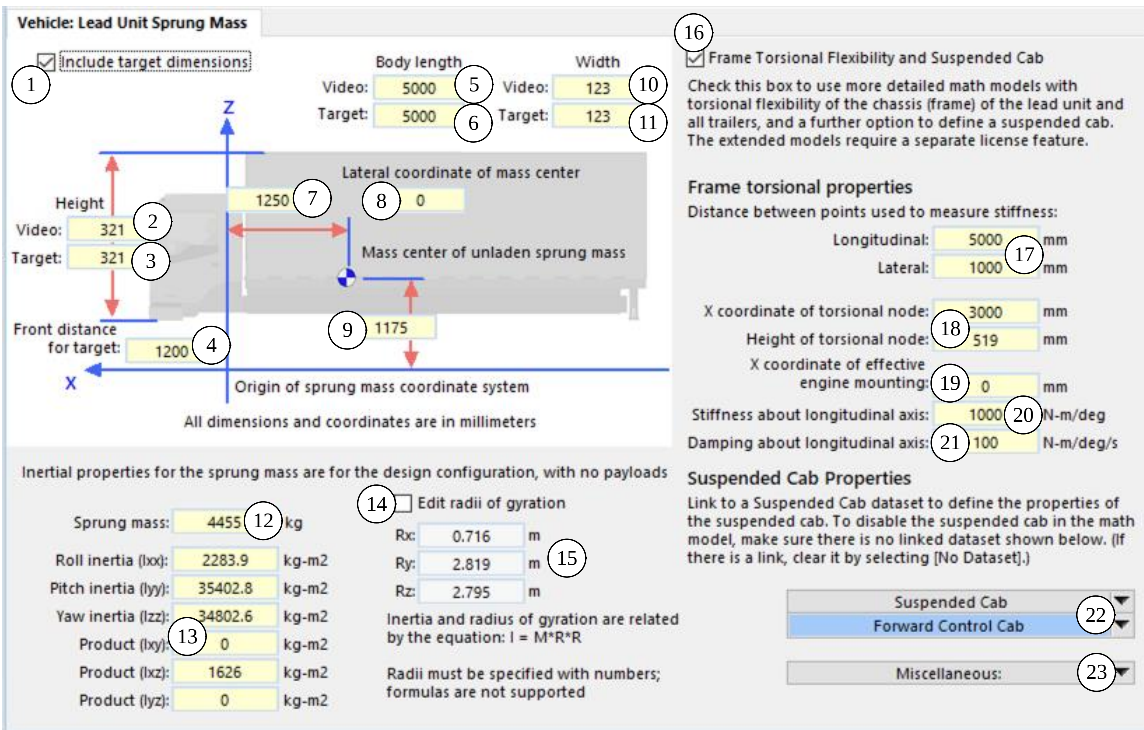

Figure 16: Vehicle: Lead Unit Sprung Mass screen.

(23) Miscellaneous link. This has no defined purpose, but can be linked to datasets that specify parameters for extensions to the model or

The other numbered settings are described in the following sections, covering three applications:

1. Three are used to scale the 3D animator shape used by VS Visualizer to show the vehicle body in videos.
2. Four are provided as references for possible use in custom VS Commands, or to automatically size a Moving Object target that might be attached to the sprung mass.
3. Most are used to describe the sprung mass coordinate system and the physical properties of the sprung mass in the TruckSim math model. The internal equations of the math model make use of these parameters.

Parameters for VS Visualizer (Scaling)

2 Reference height for the 3D shape used by VS Visualizer to show the vehicle body. This dimension is used to stretch or shrink the vertical scale of the shape used for the vehicle sprung mass. The keyword for VS Visualizer is `Z_LENGTH`. As described in the next subsection, this value is also assigned to a VS Solver parameter.

5 Reference length for the 3D shape used by VS Visualizer to show the vehicle body. This dimension is used to stretch or shrink the lateral scale of the shape used for the vehicle sprung mass. The keyword for VS Visualizer is `X_LENGTH`. As described in the next subsection, this value is also assigned to a VS Solver parameter.

10 Reference width for the 3D shape used by VS Visualizer to show the vehicle body. This dimension is used to stretch or shrink the lateral scale of the shape used for the vehicle sprung mass. The keyword for VS Visualizer is `Y_LENGTH`. As described in the next subsection, this value is also assigned to a VS Solver parameter.

Parameters for Sizing Moving Object Targets

One of the options for locating a Moving Object is to attach it to a vehicle sprung mass. If this option is selected, and the shape for moving object is rectangular, then the dimensions of the object can be specified using with four parameters, as described in the Help document *ADAS Sensors and Target Objects*.

Although the TruckSim Solver recognizes the following parameters, they are not used directly in the built-in equations of the math model; they are used to conveniently size a target object. They may also be used in custom equations added with VS Commands.

1 Checkbox to show the four dimensions used to scale moving objects. If the box is not checked, the four yellow fields described below are not visible.

3 Reference height available in the TruckSim Solver in support of VS Commands and possibly scaling a moving object rectangular target. The keyword for the TruckSim Solver is `HT_SM`. The corresponding parameter for a rectangular moving object is `H_OBJ`.

4 Distance from the front of the sprung mass shape to the origin of the coordinate system. The keyword for the VS Solver is `LX_F_SM`. The corresponding parameter for a rectangular moving object is `LX_FRONT_OBJ`.

6 Reference length available in the TruckSim Solver in support of VS Commands and possibly scaling a moving object rectangular target. The keyword for the VS Solver is `LEN_SM`. The corresponding parameter for a rectangular moving object is `LENGTH_OBJ`.

11 Reference width available in the TruckSim Solver in support of VS Commands and possibly scaling a moving object rectangular target. The keyword for the VS Solver is `WID_SM`. The corresponding parameter for a rectangular moving object is `WIDTH_OBJ`.

Inertia Properties

7 Distance that the (unladen) mass center lies behind the origin of the coordinate system (keyword = LX_CG_SU). This parameter, together with the axle locations, determines how much of the mass is supported by axles in the design condition.

8 Lateral coordinate of mass center (keyword = Y_CG_SU). Normally zero, this can be given a non-zero value if the vehicle is not laterally symmetric. A positive value means the mass center is located on the left side of the vehicle.

9 Height of (unladen) mass center above the origin (keyword = H_CG_SU).

12 Sprung mass (keyword = M_SU). This is the mass of the vehicle in the design load configuration minus the unsprung masses associated with the wheels, axles, and moving suspension parts. If the suspended cab option is used, the mass entered here should include the cab mass, that is, for the total sprung mass. The math models adjust the mass and inertia of the sprung mass to compensate for cab mass and inertia entered on the **Vehicle: Suspended Cab** screen. This avoids the need for you to make separate measurements of the vehicle with and without the cab installed.

13 Moments and products of inertia of the unladen sprung mass. The moments and product are all taken about the mass center of the sprung mass with a coordinate system parallel to the sprung mass coordinate system.

The moments of inertia in roll (IXX_SU), pitch (IYY_SU), and yaw (IZZ_SU) can be entered directly in these fields. Alternatively, they can be calculated using radii of gyration 9.

The X-Z product of inertia, also about the mass center of the sprung mass, is defined as the negative of the volume integral:

$$I_{XZ} = -\int^{V} \rho \; x \; z \; dv$$

The product is positive when the principal X axis of the sprung mass tilts down (looking forward). This value must be entered directly—there are no built-in tools to calculate it.

If the suspended cab option is used, the inertia data entered here should include the cab inertia, that is, they are inertias for the total sprung mass. The math models adjust the mass and inertia of the sprung mass to compensate for cab mass and inertia entered on the **Vehicle: Suspended Cab** screen. This avoids the need for you to make separate measurements of the vehicle with and without the cab installed.

14 Checkbox **Edit radii of gyration**. Three fields are shown with X, Y, and Z radii of gyration 15. When this box is checked the moments of inertia fields are locked, and the values displayed in them will be updated based on changes made to the radii of gyration and mass. When it is unchecked, the moments of inertia fields are enabled for editing and the radii of gyration fields are locked, displaying values calculated from the mass and inertias.

15 Radii of gyration. Sometimes measured values for I_{XX}, I_{YY}, and I_{ZZ} are not available but R_X, R_Y, and R_Z can be estimated. When you click the button, the corresponding moment of inertia is calculated with the equation:

$$I = M \cdot R^2$$

where M is the sprung mass (12) and R is the specified radius of gyration.

Use any of these three radii if the corresponding moment of inertia is not available but the corresponding radius can be estimated. If used:

- a guess for R_X might be a third of the vehicle width,
- a guess for R_Y might be half the wheelbase, and
- a guess for R_Z might be half the wheelbase.

Frame Torsional Properties and Suspended Cab

Chassis torsional flexibility and cab suspension are part of the extended dynamics models "TruckSim with Frame Flex", and require an optional license. If you don't have this license and you need the suspended cab feature, contact Mechanical Simulation.

(16) Checkbox to reveal the list of flexibility and suspended cab parameters (11) through (16).

(17) Distances between points on the chassis where the stiffness is measured. (keywords = `L_FRAME` and `W_FRAME`).

(18) Distance that the torsional node point lies behind the origin of the coordinate system (keyword = `X_NODE`), and the height of the node point above the sprung mass origin (keyword = `H_NODE`).

(19) Distance that the effective engine mounting point lies behind the origin of the coordinate system (keyword = `X_ENG`).

(20) Torsional stiffness of the chassis about the longitudinal axis (keyword = `K_FRAME`).

(21) Torsional damping of the chassis about the longitudinal axis (keyword = `C_FRAME`).

(22) Link to a **Vehicle: Suspended Cab** dataset. If no dataset is linked here, the cab is rigidly mounted to the chassis.

Vehicle: Trailer Sprung Mass

Use this screen to define the size and weight properties of a trailer sprung mass. It has the same elements as the **Vehicle: Lead Unit Sprung Mass** screen described above, with a few differences.

First, the trailer screen includes an extra parameter (24) to specify the height of the leading hitch point relative to the origin of this sprung mass (Figure 17), with keyword = `H_H_FRONT`.

Second, the trailer screen includes an extra drop-down control (25) to support connection systems with a separate moving part. These are the hinged tow bar and the articulation system. For details, please see the **Help** document *Trailer Hitches*.

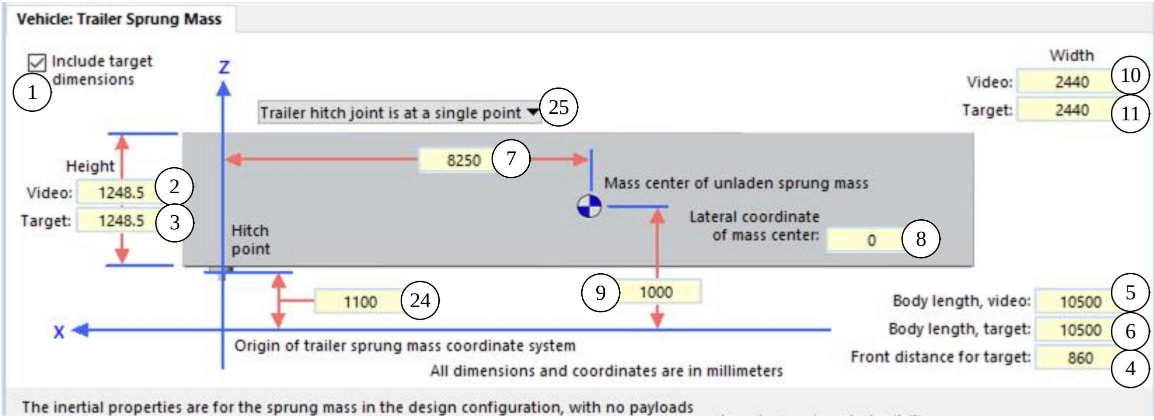

Figure 17. Part of Trailer Sprung Mass screen showing hitch height.

Third, there is no checkbox for showing frame torsional flexibility parameters. The fields for the parameters are always visible, even if they are not used. The checkbox on the **Vehicle: Lead Unit Sprung Mass** determines whether the torsionally flexible models are used. When it is checked, the lead unit and any trailer(s) in the run are torsionally flexible. Torsional flexibility is a feature included in the TruckSim extended dynamics models "TruckSim with Frame Flex" and require an optional license. If you don't have this license and you need the torsional flexibility, contact Mechanical Simulation.

Fourth, there is no link for a suspended cab dataset, because the suspended cab is only available for the lead unit.

Note that when the field for the length used for the animator is left blank 2, the distance from the hitch to the rear axle is used by VS Visualizer to scale the body.

Vehicle: Suspended Cab Screen

Use this screen to define the properties of a suspended cab and its suspension system (Figure 18). This feature is part of the TruckSim extended dynamics models "TruckSim with Frame Flex," and requires an optional license. If you don't have this license and you need the suspended cab feature, please contact Mechanical Simulation.

The suspended cab is defined by its mass and inertia properties, the stiffness and damping of 4 mounts, and simple kinematics described by a pitch axis and a roll axis. The cab can pitch, roll, and translate vertically. The mounting springs and dampers react on the frame rails in the torsionally flexible chassis, so chassis twist influences cab motion.

The pitch and roll axes are both assumed to be horizontal. The roll axis is in the plane of the sprung mass coordinate origin. Each pair of mounts (front, rear) has identical properties and are symmetrically arranged about the vehicle centerline.

The primary uses anticipated for this feature include study of the effects of cab motion on the environment of the driver, including low frequency ride and effects like roll amplification (the increased roll angle experienced by the driver in cornering, due to the combined vehicle roll and cab roll).

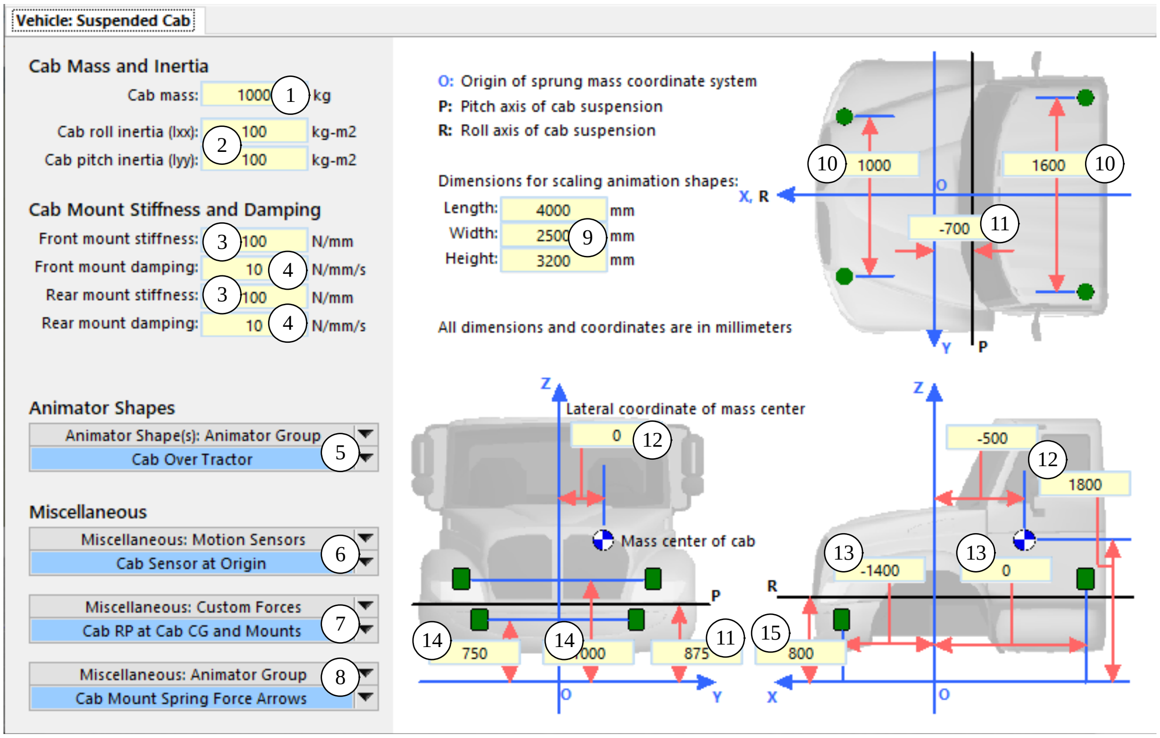

Figure 18: Vehicle: Suspended Cab screen.

> **Note** Staring with version 2020.1, TruckSim supports multiple vehicles running from the TruckSim solver. At this time, only one of the vehicles may use a suspended cab.

① Mass of the suspended cab (keyword = `M_CAB`).

② Roll inertia (keyword = `IXX_CAB`) and pitch inertia (keyword = `IYY_CAB`) of the suspended cab.

③ Vertical stiffness of each of the front mounts (keyword = `FS_CAB_MT_COEFFICIENT(1)`) and rear mounts (keyword = `FS_CAB_MT_COEFFICIENT(2)`).

④ Vertical damping coefficient of each of the front mounts (keyword = `FD_CAB_MT_COEFFICIENT(1)`) and rear mounts (keyword = `FD_CAB_MT_COEFFICIENT(2)`).

⑤ Link to an animator dataset to define the appearance of the suspended cab when displayed by the animator.

⑥ Link to an **Output: Sensors** dataset that defines up to five acceleration sensors on the suspended cab, plus an angular velocity sensor and velocity sensor.

⑦ Link to an **Output: Reference Points** dataset that defines up to ten reference points on the suspended cab. Their global X, Y, and Z coordinates are tracked.

8. Miscellaneous link. This has no defined purpose, but can be linked to datasets that specify parameters for extensions to the model or information for the animator.
9. Animator reference length (keyword = X_LENGTH), width (keyword = Y_LENGTH), and height (keyword = Z_LENGTH). The animator uses these values to stretch or shrink the dimensions of the shape used for the suspended cab.
10. Lateral distance in mm between the front mounts (keyword = LY_MOUNTS_F) and rear mounts (keyword = LY_MOUNTS_R). They are symmetrically arranged about the vehicle centerline.
11. Location of the pitch axis of the suspended cab behind and above the vehicle coordinate origin (keywords = LX_PITCH_CAB, and H_PITCH_CAB, respectively).
12. Location of the CG of the suspended cab behind, to the left, and above the vehicle coordinate origin (keywords = LX_CG_CAB, LY_CG_CAB, and H_CG_CAB, respectively). Dimensions are in mm.
13. Distance of the front mounts (keyword = LX_MOUNTS_F) and rear mounts (keyword = LX_MOUNTS_R) behind the vehicle coordinate origin. Mounts located ahead of the vehicle coordinate origin should be given negative values.
14. Height in mm of the front mounts (keyword = H_MOUNTS_F) and rear mounts (keyword = H_MOUNTS_R) above the vehicle coordinate origin.
15. Height in mm of the roll axis of the suspended cab above the vehicle coordinate origin (keyword = H_CAB_ROLL).

Tandem and Tridem Load Sharing

Any vehicle lead unit with more than two axles or any trailer or dolly with more than one axle may be specified to share part of the axle dynamic load with an adjacent axle or axles. Mechanisms to share load between axles reduce the total dynamic load on each axle, allowing the structural specifications of each axle to be lower than if it were separately sprung, and reducing peak dynamic loads on highways and bridges. When a pair of adjacent axles share load, they are called a *tandem* suspension; three axles that share load are commonly called a *tridem*.

Load sharing can be accomplished by many different mechanisms, but typically takes the form of a lever between loaded ends of leaf springs of a pair of adjacent axles, or by plumbing of air springs so that they share a common air volume and hence pressure.

Note To determine if a pair of axles has load sharing capabilities, examine the vehicle code for the vehicle configuration being used. If the letters indicating suspension type (S for solid axles, I for independents) are separated by an underscore character (“_”) they cannot share load (e.g., S_S). If they are written without separation (S_SS for a 3-axle lead unit, SS for a trailer or dolly), they can share load.

For vehicle units that might have load sharing tandems or tridems, User Settings for load sharing appear on each vehicle unit screen. Descriptions of pull-down controls and data fields can be found in the sections of this document discussing each type of vehicle unit.

The "dynamic load transfer coefficient" describes the faction of load at an axle that is transferred *away* from that axle to one or two other axles. That is, one load transfer coefficient is used to describe load sharing from each axle to the next. When the axle is displaced under load, its spring is compressed by the portion of load not transferred away, plus the portion of load transferred to it by the other axle.

For perfect load sharing in a tandem, a coefficient of one-half (0.5) is used. This means half the dynamic load at the lead axle is distributed to the trailing axle and half the dynamic load at the trailing axle is distributed to the leading axle, resulting in equal distribution of dynamic loads. A load transfer coefficient of zero means there is no load sharing mechanism for the pair of axles.

For tridems, the situation is slightly more complicated. Obviously, for perfect load sharing each axle must transfer away two-thirds of its dynamic load to the other axles. But the symmetry of load sharing between two axles (leading and middle, or middle and trailing) would seem to imply that the middle axle should transfer away two-thirds to the lead axle plus two-thirds to the trailing axle, or more than 100% of its load. Clearly this cannot be the case.

The middle axle of a tridem transfers load away to each of the other axles in proportion to the load sharing parameters for both load sharing tandems. The fraction of load transferred to the lead axle from the middle axle F_L is:

$$F_L = \frac{R_L^2}{R_L + R_T}$$

where R_L is the load-sharing parameter for first tandem (with the leading and middle axles), and R_T is the load-sharing parameter for second tandem (with the middle and trailing axles). The fraction of load transferred to the trailing axle from the middle axle F_T is:

$$F_T = \frac{R_T^2}{R_L + R_T}$$

When the load-sharing parameters are both 2/3, the fractions transferred are:

$$F_L = F_T = \frac{(2/3)^2}{2/3 + 2/3} = 1/3$$

Vehicle Motions

Motions of the vehicle are provided as output variables involving each vehicle unit, sprung mass, and user-defined (custom) motion sensors. Outputs from custom motion sensors are described in a separate document (*Custom Forces and Motion Sensors*). This section describes the points of interest that are built into the TruckSim models, and the outputs based on their motions.

The Center of Gravity (CG) of a Vehicle Unit

TruckSim includes several output variables that apply to the motion of the center of gravity (CG) of the total laden vehicle unit (Table 2). The variables listed in the table are all calculated from the total CG point and are fundamental to characterizing the total vehicle response. If the vehicle includes a trailer, the word "vehicle" in the descriptions apply for the lead unit.

Table 2. Output variables involving the instant system CG for a vehicle unit.

Short Name	Units	Long Name	Type
`Ax`	g	Long. acceleration, vehicle	Longitudinal acceleration
`Ax_Rd`	g	Vehicle long. accel, road ref	Longitudinal acceleration
`Ay`	g	Lateral acceleration, vehicle	Lateral acceleration
`Ay_Rd`	g	Vehicle lat. accel, road ref	Lateral acceleration
`Ay_SM`	g	Lateral accel., vehicle SM CG	Lateral acceleration
`Az`	g	Vertical acceleration, vehicle	Vertical acceleration
`Az_Rd`	g	Vehicle vert. accel, road ref	Vertical acceleration
`Beta`	deg	Vehicle slip angle	Angle
`BetaR`	deg/s	Vehicle slip angle rate	Angular rate
`BetaRd`	deg	Vehicle slip rel. to road ref	Angle
`BetaRdR`	deg/s	Vehicle slip rate rel. to road	Angular rate
`Hcg_TM`	mm	Height, inst. CG, unit 1	Height (local Z coordinate)
`LxcgTM`	mm	Lx distance to inst. CG, unit 1	Lx distance (local -X coord.)
`Vx`	km/h	Longitudinal speed, vehicle	Longitudinal speed
`Vxz_Fwd`	km/h	Longitudinal speed in XZ plane	Longitudinal speed
`Vx_Rd`	km/h	Vehicle long. speed, road ref	Longitudinal speed
`Vy`	km/h	Lateral speed, vehicle	Lateral speed
`Vy_Rd`	km/h	Vehicle lat. speed, road ref	Lateral speed
`Vz`	km/h	Vertical speed, vehicle	Vertical speed
`Vz_Rd`	km/h	Vehicle vert. speed, road ref	Vertical speed
`Xcg_TM`	m	X coordinate, inst. CG, unit 1	Global X coordinate
`Ycg_TM`	m	Y coordinate, inst. CG, unit 1	Global Y coordinate
`YlcgTM`	mm	Local Y, inst. CG, unit 1	Local Y coordinate
`Zcg_TM`	m	Z coordinate, inst. CG, unit 1	Global Z coordinate

The location of the CG of the total unit is written for each unit the Echo file, along with the total mass and moments of inertia (Figure 19).

The total laden mass is the sum of the masses of all parts of the vehicle unit and is constant during a simulation. However, the three local coordinates of the system mass center are dynamic and can change during the simulation through suspension motions. The dynamic values are available as output variables with the names: `Hcg_TM`, `Lxcg_TM`, and `YlcgTM`.

Because this point moves relative to the sprung mass coordinate system, these variables are typically not measurable in physical testing. When simulation results need to be compared to physical test results, motion variables based on points that are fixed in vehicle parts should be used.

If the vehicle includes one or more trailers, then additional outputs are provided for each trailer. They have similar names but with a suffix to indicate the unit number (e.g., `Ay_3` is the lateral acceleration of the CG for unit 3).

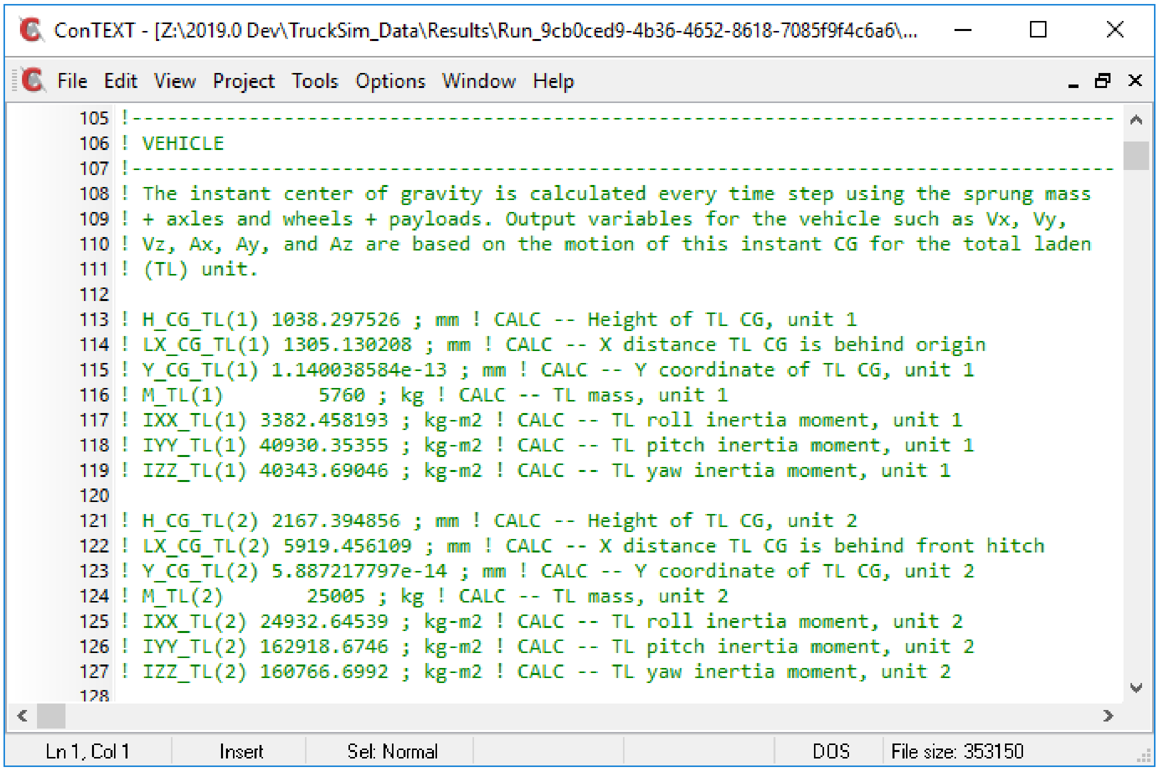

Figure 19. Location of vehicle unit total mass CGs, mass, and moments of inertia.

Note A spreadsheet with all output variables for a TruckSim vehicle can be generated from the **Run Control** screen using the **View** button in the lower-right corner. The contents of Table 2 were obtained by generating a spreadsheet, sorting for variables with the category "Chassis motion," and copying the rows of interest from the spreadsheet into the Microsoft Word document used to create this PDF file.

Motions of Sprung Masses

TruckSim includes several output variables based on the motions of the sprung mass. If there is a trailer, variables are also provided for motions for the trailer sprung mass. There are two points of interest that are tracked for each sprung mass: the origin of the coordinate system, and the CG. TruckSim supports static payloads that can be added to each sprung mass. The CG whose motion is defined with output variables is for the total sprung mass, including any attached payloads. The sprung mass properties are listed in the Echo file immediately after the Vehicle section (Figure 20).

The Echo file lists the parameters provided in the sprung mass screens (lines 114 – 138) related to the sprung mass inertia and CG location. These parameter keywords all have the suffix _SU for "sprung mass, unladen." If payloads were specified using the **Vehicle Loaded Condition** library, the equivalent parameters are calculated and shown with the suffix _SL ("sprung mass, laden," see lines 141-151).

ConTEXT - [Z:\Current\TruckSim 2017 Beta\TruckSim_Data\Results\Run_d2a55239-1f56-400e-aa13...

File Edit View Project Tools Options Window Help

LastRun_ECHO.PAR #

```
108 !------------------------------------------------------------------------------------
109 ! SPRUNG MASSES
110 !------------------------------------------------------------------------------------
111 ! The following parameters apply for the sprung mass without payloads, designated
112 ! SU (sprung mass unladen)
113
114 H_CG_SU(1)        1020 ; mm ! Height of CG of sprung mass, unladen (SU), unit 1 [I]
115 LX_CG_SU(1)       1385 ; mm ! X distance SU CG is behind sprung mass origin [I]
116 Y_CG_SU(1)           0 ; mm ! Y coordinate of SU CG, unit 1 [I]
117 M_SU(1)           6310 ; kg ! Mass of unladen sprung mass (SU), unit 1 [I]
118 IXX_SU(1)         6879 ; kg-m2 ! Roll inertia for unladen sprung mass, unit 1 [I]
119 IYY_SU(1)        21711 ; kg-m2 ! Pitch inertia for SU, unit 1 [I]
120 IZZ_SU(1)        19665 ; kg-m2 ! Yaw inertia for SU, unit 1 [I]
121 IXY_SU(1)            0 ; kg-m2 ! XY product of inertia for SU, unit 1 [I]
122 IXZ_SU(1)          130 ; kg-m2 ! XZ product of inertia for SU, unit 1 [I]
123 IYZ_SU(1)            0 ; kg-m2 ! YZ product of inertia for SU, unit 1 [I]
124
125 ! N_PAYLOADS(1)      0 ! CALC -- No. of payloads attached to this sprung mass
126
127 H_H_FRONT         1100 ; mm ! Height (Z) of front hitch point in trailer sprung-mass
128                        ! coordinate system [I]
129 H_CG_SU(2)        1661 ; mm ! Height of CG of sprung mass, unladen (SU), unit 2 [I]
130 LX_CG_SU(2)       7303 ; mm ! X distance SU CG is behind front hitch point [I]
131 Y_CG_SU(2)           0 ; mm ! Y coordinate of SU CG, unit 2 [I]
132 M_SU(2)           5925 ; kg ! Mass of unladen sprung mass (SU), unit 2 [I]
133 IXX_SU(2)       9959.7 ; kg-m2 ! Roll inertia for unladen sprung mass, unit 2 [I]
134 IYY_SU(2)       171336 ; kg-m2 ! Pitch inertia for SU, unit 2 [I]
135 IZZ_SU(2)       179992 ; kg-m2 ! Yaw inertia for SU, unit 2 [I]
136 IXY_SU(2)            0 ; kg-m2 ! XY product of inertia for SU, unit 2 [I]
137 IXZ_SU(2)            0 ; kg-m2 ! XZ product of inertia for SU, unit 2 [I]
138 IYZ_SU(2)            0 ; kg-m2 ! YZ product of inertia for SU, unit 2 [I]
139
140 ! N_PAYLOADS(2)      1 ! CALC -- No. of payloads attached to this sprung mass
141 ! H_CG_SL(2) 2157.17107 ; mm ! CALC -- Height of CG of sprung mass, laden (SL):
142                          ! sprung mass + payloads, unit 2
143 ! LX_CG_SL(2) 6291.245846 ; mm ! CALC -- X distance SL CG is behind front hitch
144 ! Y_CG_SL(2)          0 ; mm ! CALC -- Y coord. of laden sprung mass CG, unit 2
145 ! M_SL(2)      26507.76 ; kg ! CALC -- Mass of laden sprung mass (SL), unit 2
146 ! IXX_SL(2) 25560.08088 ; kg-m2 ! CALC -- Roll inertia for SL, unit 2
147 ! IYY_SL(2) 284368.1712 ; kg-m2 ! CALC -- Pitch inertia for SL, unit 2
148 ! IZZ_SL(2) 291145.6303 ; kg-m2 ! CALC -- Yaw inertia for SL, unit 2
149 ! IXY_SL(2)           0 ; kg-m2 ! CALC -- XY product of inertia for SL, unit 2
150 ! IXZ_SL(2) -3830.577107 ; kg-m2 ! CALC -- XZ product of inertia for SL, unit 2
151 ! IYZ_SL(2)           0 ; kg-m2 ! CALC -- YZ product of inertia for SL, unit 2
152
```

Ln 1, Col 1 | Insert | Sel: Normal | DOS | File size: 474331

Figure 20. Inertial properties of the sprung mass loaded and unloaded.

The motions of the sprung mass include coordinates, velocities, and accelerations for two points of interest: the CG for the laden sprung mass, and the origin of the sprung mass coordinate system (Table 3).

Table 3. Output variables for motion of the sprung mass origin and CG points.

Short Name	Units	Long Name	Type
Ax_SM	g	Long. accel., vehicle SM CG	Longitudinal acceleration
Ay_SM	g	Lateral accel., vehicle SM CG	Lateral acceleration
Az_SM	g	Vertical accel., vehicle SM CG	Vertical acceleration
GPSlongA	deg	GPS absolute longitude	GPS longitude
GPS_Lat	deg	GPS relative latitude	GPS latitude
GPS_LatA	deg	GPS absolute latitude	GPS latitude
GPS_Long	deg	GPS relative longitude	GPS longitude
VxNf_SM	km/h	Global X speed, vehicle SM CG	Speed
Vxz_Fwd	km/h	Longitudinal speed in XZ plane	Longitudinal speed
Vx_SM	km/h	Long. speed, vehicle SM CG	Longitudinal speed
VyNf_SM	km/h	Global Y speed, vehicle SM CG	Speed
Vy_SM	km/h	Lateral speed, vehicle SM CG	Lateral speed
Vz_SM	km/h	Vertical speed, vehicle SM CG	Vertical speed
Xcg_SM	m	X coordinate, CG, sprung mass	Global X coordinate
Xo	m	X coordinate, vehicle origin	Global X coordinate
Ycg_SM	m	Y coordinate, CG, sprung mass	Global Y coordinate
Yo	m	Y coordinate, vehicle origin	Global Y coordinate
Zcg_SM	m	Z coordinate, CG, sprung mass	Global Z coordinate
Zo	m	Z coordinate, vehicle origin	Global Z coordinate

Orientation angles, angular velocities, and angular accelerations are also written for the sprung mass bodies (Table 4). In the table, the angles refer to the "vehicle." More specifically, they refer to the sprung mass of the vehicle.

Parameter Indices

All the parameters used to describe vehicle properties are indexed because there might be more than one part of the vehicle being described.

A TruckSim lead units has up to five suspensions with two wheels each. A trailer may have up to four suspensions with two wheels each. The context for where a part is in the simulation is determined by index parameters (Table 5).

Table 4. Output variables for angular motions of the sprung mass body.

Short Name	Units	Long Name	Type
AAx	rad/s2	Roll acc. (body-fixed), vehicle	Angular acceleration
AAy	rad/s2	Pitch acc. (body-fixed), vehicle	
AAz	rad/s2	Yaw acc. (body-fixed), vehicle	
AA_P	rad/s2	Pitch accel. (Euler), vehicle	
AA_R	rad/s2	Roll accel. (Euler), vehicle	
AA_Y	rad/s2	Yaw accel. (Euler), vehicle	
AVx	deg/s	Roll rate (body-fixed), vehicle	Angular velocity
AVy	deg/s	Pitch rate (body-fixed), vehicle	
AVz	deg/s	Yaw rate (body-fixed), vehicle	
AV_P	deg/s	Pitch rate (Euler), vehicle	
AV_R	deg/s	Roll rate (Euler), vehicle	
AV_Y	deg/s	Yaw rate (Euler), vehicle	
Pitch	deg	Pitch, vehicle	Angle
PitchRd	deg	Vehicle pitch rel. to road ref	
Roll	deg	Roll, vehicle	
Roll_E	deg	Roll (Euler), vehicle	
Roll_Rd	deg	Vehicle roll rel. to road ref	
Yaw	deg	Yaw, vehicle	

Table 5. Index parameters that determine which part of a vehicle is current.

Index Parameter	Definition
IVEHICLE	Current vehicle (motor vehicle and possibly a trailer)
IUNIT	Current vehicle unit (a sprung mass plus supporting suspensions)
IAXLE	Current suspensions in current unit
ISIDE	Current side on current suspensions
ITIRE	Current tire on current wheel

For example, consider a line from an Echo file for a TruckSim run:

```
LX_AXLE(1,2)  4000 ; mm ! X dist. axle 2 is behind the sprung-mass origin
```

The indices (1,2) indicate that the parameter applies for unit 1 (the lead unit), axle 2 on that unit. However, the Parsfile for the sprung mass screen (Figure 21) does not show indices: only the root keyword LX_AXLE (line 49). (This Parsfile is for a 2-axle lead unit.) In this Parsfile, the current axle number IAXLE is set to 2 on line 47.

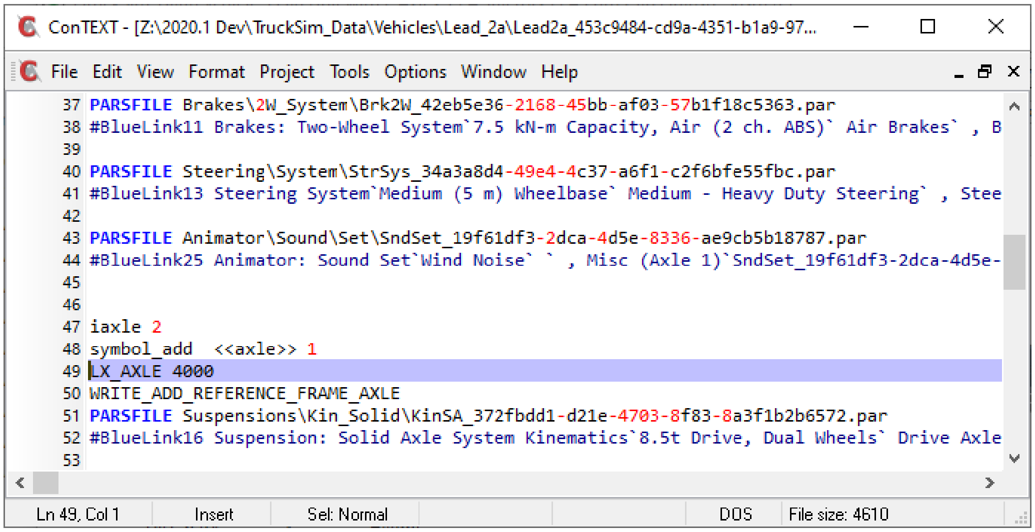

Figure 21. Parsfile for a 2-axle Lead Unit where LX_AXLE is set.

The top of the same Parsfile (Figure 22) shows that the `IUNIT` index is incremented with a database command `IUNIT_INCREMENT`, and the `IVEHICLE` index is also incremented with a simple assignment statement. These settings cause the TruckSim Solver to the value for `LX_AXLE` on unit 1, axle 2.

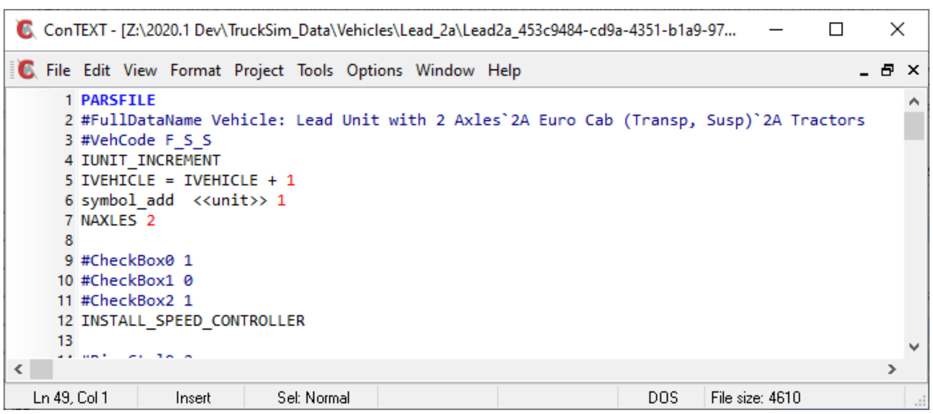

Figure 22. Parsfile for a 2-axle Lead Unit where IUNIT is set.

The `IUNIT` and `IVEHICLE` index parameters are only given numerical values in one place in the database: the top of each Parsfile from the **Run Control** screen sets a few index parameters to zero: `IOBJECT`, `IUNIT`, and `IVEHICLE` (Figure 23).

As shown in Figure 22, the Parsfiles for lead units increment both `IUNIT` and `IVEHICLE`. Parsfiles for trailers increment `IUNIT`, but do not alter `IVEHICLE`.

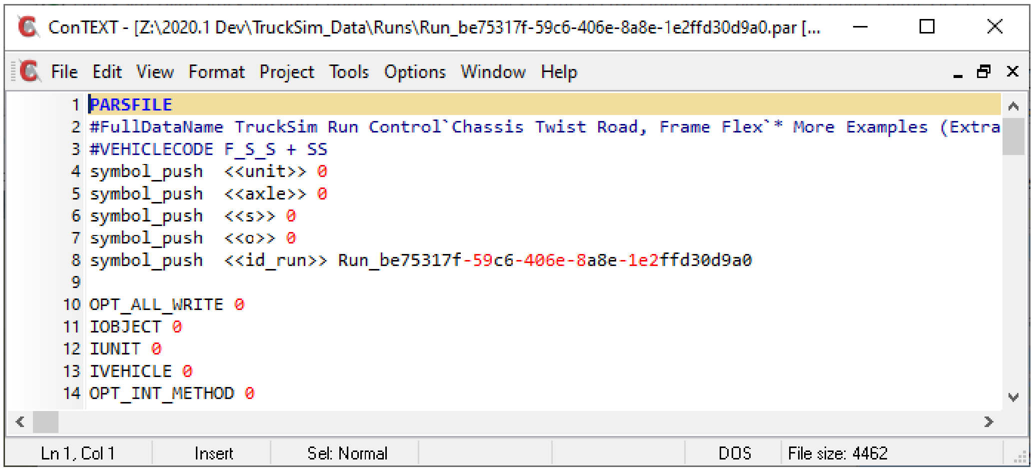

Figure 23. Each Run Control Parsfile sets some of the index parameters to zero.

In a simulation with one vehicle, the lead unit (motor vehicle) is always unit 1. If there is a trailer, it is unit 2. However, if there are multiple vehicles, units for the extra vehicle are always incremented. For example, if vehicle #1 has a trailer (unit 2), then the lead unit for vehicle #2 is unit 3, and if there is a trailer, it is unit 4.