TruckSim 2021.0 New Features

This document lists notable new features in TruckSim version 2021.0.

VS Solver: Architecture

Improvements were made in the handling of VS Commands.

1. Parsing of VS Commands has been extended and reworked to provide more informative error messages, and to provide a foundation for more for more user-defined features.

2. The expression evaluator and calculator for the VS Commands has been re-written to improve performance.

3. The `DEFINE_VARIABLE` command has been extended to support the creation of new single-index arrays, e.g.,

```
DEFINE_VARIABLE MY_ARRAY(10)
```

VS Solver: Models

Improvements were made in the TruckSim Math Model.

Kingpin Rotation Angle Calculation

For suspensions which use a fixed kingpin axis and have steer angles defined in vehicle coordinates, the VS Math Model converts the steer kinematics from the suspension/steering tables into an equivalent rotation about the inclined kingpin axis. This kingpin rotation angle is then used as a constraint in the multibody suspension model.

This calculation was replaced beginning in version 2021.0 with a more efficient version that does not rely on iteration. Consequently, the model will no longer fail during the run with the error message, *"…there was a problem in kp_constraint: could not calculate the kingpin steer angle…"*. Error handling for the new calculation method occurs at initialization, by checking the total inclination of the kingpin axis with respect to vertical and making sure it does not exceed 45 degrees.

The new calculation method produces slight differences in simulation results, but these are attributable to the accuracy of the new calculation compared to the previous iterative calculation, which would produce results only as accurate as its solution tolerance allowed.

Steering System Inertia Improvements

Beginning in version 2021.0, the VS Math Model can automatically calculate a suspension contribution term to the steering rotational inertia and add it to the user-provided steering system inertia value. This feature is enabled based on the setting of the parameter `OPT_I_GEAR_IN`:

- `OPT_I_GEAR_IN = 0`. The suspension contribution to steering system inertia is not calculated automatically. The user-provided value of `I_GEAR_IN` is used as-is. The user must calculate the suspension contribution themselves and include it in the specified `I_GEAR_IN`; alternatively, the user may decide to neglect the suspension contribution.
- `OPT_I_GEAR_IN = 1`. The kingpin geometry, steered unsprung mass and inertias, linkage kinematics, and steering gear kinematics are used to calculate an inertia term which represents the rotation of the steered unsprung masses around the left and right kingpin axes. This term is referenced to the steering gear input rotation and is added to the user-provided `I_GEAR_IN` value. In other words, the user-provided value is the steering system inertia not including the effect of the unsprung masses rotating about the kingpins. The total steering system inertia, consisting of the user-provided value plus the calculated value from the suspension, is output with the output variable `IstrGear`. It is, in general, not constant, due to the nonlinear kinematics; the Echo file value corresponds to the value at the time the Echo file was written.

Versions of the VS Math Model prior to 2021.0 are equivalent to setting `OPT_I_GEAR_IN` to 0 and neglecting the suspension contribution to the system inertia. Consequently, turning the suspension contribution on will cause differences in simulation results. This may require re-assessing and suitably adjusting steering system data such as damping and assist-force time constant.

The `OPT_I_GEAR_IN` option is supported in the GUI with a new checkbox on the **Steering Column** screen.

Battery-Electric and Hybrid-Electric Powertrain Enhancement

The battery-electric and hybrid-electric powertrain model now supports multiple electric motors to allow one motor for every driving wheel. Two options are added to specify either one or two electric motors on each drive axle. An electric motor locates at the center of a conventional mechanical differential for one-motor case, while an electric motor is directly connected on each side of wheel for two-motor case. For example, a four-wheel (2-axle) vehicle can have one motor on the front axle and two motors on the rear axle, and a 5-axle truck is able to have up to ten electric motors.

The drive torque reaction for two-motor case can be selected to either wheel or sprung mass. For in-wheel motor, the drive torque reaction can be set to the wheel. The torque distribution between the front and rear, and between left and right electric motors can be set by a user parameter or external command through Simulink, VS Commands, etc.

All electric motors are involved in the battery state-of-charge calculation. Also, the electric motor(s) on the drive axle and differential clutch (LSD) can be used simultaneously.

Miscellaneous

1. Steering stops that were previously available only in torque-steer mode are now functional in angle control. Added output variables for steering stop torque (analogous to jounce and rebound stops)

2. A new import variable, `IMP_AT_CLUTCH`, has been added to control the automatic transmission lock up clutch. Previously, the clutch could only be controlled by table (`LOCK_AT_TABLE`) or by manipulating the clutch capacity on the fly (`IMP_M_LOCKUP_CLUTCH_CAP`).

3. The built-in electronic stability control has been extended to support multiple vehicles running within a single simulation. (This feature was mentioned in error in the 2020.1 release notes, as described in the 2021.0 backwards compatibility document.)

4. The built-in hybrid and electric vehicle powertrain model has been extended to support multiple vehicles running within a single simulation.

5. The VS Math Model will write a warning in the log file if it detects potential issues with the straight-line distance approximation of station that is used for X-Y spline segments.

VS Browser: Graphic User Interface (GUI)

Procedures Screen

The Procedures screen was simplified slightly by replacing a set of four initialization-related checkboxes with a single one. As a result of changes in the past few years in the architecture of VS Math Models, the options to start the vehicle in approximate equilibrium (with the parameter `OPT_INIT_CONFIG = 1`) and with the wheel and powertrain spin rates synchronized to the vehicle speed (`OPT_INIT_SPEED = 1`) are always recommended when staring a simulation. Checkboxes to turn off these options were removed.

The remaining option, to locate the vehicle using Path station (`OPT_INIT_PATH`) is still an option that can be disabled if the user wishes to locate the vehicle by setting X, Y, and Yaw values directly.

Powertrain: Front and Rear Differential Screens

On the Powertrain: Front and Rear Differential screens, a new drop-down menu is added to select one of three cases: **Not electric**, **One electric motor on center**, and **Two electric motors one on each side**. The new screen layout enables to set the electric motor(s) and differential clutch (LSD) simultaneously. The detail of setting is described in the separate Powertrain System document.

Powertrain: Transfer Case Screen

On the Powertrain: Transfer Case screen, a new drop-down menu is added to select one of three cases: **Mechanical**, **Electro-mechanical (hybrid)**, and **Full electrical**. The new screen layout enables to set mechanical and/or electrical torque distribution to rear axle. The detail of setting is described in the separate Powertrain System document.

Other Tools: Stacks

RT Platforms

From version 2021.0 TruckSim supports new Real-Time system: Linux-RT (from dSPACE release 2020B) on dSPACE SCALEXIO including DS6001.

On the NI Linux RT now you can run parallel solvers with LibVIEW and VeriStand.

FMU for Linux System

From version 2021.0 TruckSim can generate the FMU running on Windows, Linux or on both systems.

VS Scene Builder Proving Ground Tile

A new proving ground tile has been created for the VS Scene Builder. This tile provides a complete environment with nine testing areas, including: a five mile circle track, a hill grade surface, an on-grade split-mu surface, a split-mu surface, a rough road section, a 1000m straight, a 500m skid pad, a handling course, and an urban multi-lane environment. Use the over 600 built-in paths or create your own in the VS Scene Builder.

VS SDK

The VS SDK was created in conjunction with the 2019.1 release with the goal of supporting end-users who are building tools around a VehicleSim product using the VS API.

For the 2021.0 release, the VS SDK has been simplified for the benefit of software developers who do not routinely work with a VehicleSim product.

Licensing

An improvement has been made to the way the license feature selections can be configured with the `ts-lm-cli` utility. This change will allow users to specify a source preference for each individual feature being checked out. For example, in the `license_source.cfg` file, given the following data:

This will allow the `requested_licenses.cfg` file to be configured as such:

With this configuration, `carsimlinuxsolverxx` and `carsimtxx` features will be selected from the `@primary.corp.com` license source, while the `carsimfxx` and `carsimparallelsolverxx` features will be selected from the `@secondary.corp.com` license source.

Documentation

The following documents have been added to the **Help** menu:

1. Database Upgrade Guidelines (Release Notes sub-menu)

2. Initialize a Vehicle Using Imported Variables (Technical Memos sub-menu)

3. Modular Vehicle Models (Technical Memos sub-menu)

4. VS Table Tool Introduction (Reference Manuals sub-menu)

5. VS Table Tool Usage (Technical Memos sub-menu)

The following Guides and Tutorials have been updated:

6. Introduction to CarSim (and TruckSim)

The following Reference Manuals have been updated:

7. System Parameters in VS Math Models (former title: System Parameters in VS Solvers)

8. VS Browser (GUI and Database)

9. VS COM Interface

10. VS Commands

11. VS Commands Summary

12. VS Math Models (former title: VS Solver Programs)

13. VS SDK

14. VS Visualizer

The following Screen documents have been updated:

15. Aerodynamics

16. Animator: Camera Setup

17. Atlas GPS Tool (in Paths, Road Surfaces, and Scenes sub-menu)

18. Electronic Stability Control (ESC) (in Controls sub-menu)

19. Driver Controls (in Controls sub-menu)

20. Data Groups (in Generic Data Screens sub-menu)

21. External Models and RT Systems (in Model Extensions and RT Systems sub-menu)

22. Home: The Run Screen

23. Import and Export Variables (in Model Extensions and RT Systems sub-menu)

24. Parallel VS Math Models (in Tools sub-menu)

25. Paths and Road Surfaces (in Paths, Road Surfaces, and Scenes sub-menu)

26. Powertrain

27. Powertrain for Electric and Hybrid Electric Vehicles

28. Preferences (in Tools sub-menu)

29. Procedures and Events

30. Run Control Screen

31. Steering Systems

32. Suspension Systems

33. Tire Models

34. VS Scene Builder (in Paths, Road Surfaces, and Scenes sub-menu)

35. VS Terrain (in Paths, Road Surfaces, and Scenes sub-menu)

The following Technical Memos have been updated:

36. Example: Camera Sensors

37. HPC Licensing

38. Initialization in CarSim and TruckSim

39. Modular Vehicle Models

40. Numerical Integration in VS Math Models (former title: Numerical Integration in VS Solvers)

41. Simulations with Multiple Vehicles

The following Real-Time and DS System documents have been updated:

42. DS6001 Network Settings

43. NI RT Target Systems

Database

New and Updated Examples

The following subsection titles correspond to categories for new examples that all share the prefix "*** TS 2021.0**," e.g., *** TS 2021.0 – Electrically Driven Wheels**

Electrically Driven Wheels

The TruckSim vehicle models support electrical motors at each drive axle, including one motor per wheel (i.e., two per axle).

LCF Van with 8x8 Powertrain and an Acceleration-based Shift Schedule

A new 4-axle LCF Van is included in TruckSim 2021.0 that uses two front steer axles, an 8x8 powertrain, and a 16-speed manual transmission. The road wheel steer kinematics of the two front steer axles have been calculated to provide Ackerman geometry based on the wheelbase and front track width of the vehicle, considering a handwheel angle range of +/- 720 degrees. Axle 1 serves as the reference steer angle for both Axles 1 and 2 in the Ackerman calculations; this was used to determine the Gearbox Input / Output Ratios (one each for Axles 1 and 2) and the handwheel reaction torque that represents the torque feedback to the driver.

The transmission shift schedule data was calculated based on the acceleration performance of the vehicle with the intent of maintaining constant power when shifting from one gear to the next. Although the engine's governed rpm is 2100 rpm, the shift schedule is biased towards the 90% - 95% governed rpm range, taking advantage of the engine's higher torque output in this region. This works well for both coastdown and acceleration maneuvers, and has been tested on road grades up to 15%.

This vehicle is demonstrated using four new Run Control examples: Acceleration (20% and 100% throttle); Coastdown in gear; and a Low Speed Turning Test on a Figure 8-shaped path with a radius of 12 meters.

Updated Road Wheel Steer Kinematics for SS_SS Vehicles

Based on the work done for the new 8x8 LCF Van with the 16-speed manual transmission, all 4-axle SS_SS vehicle examples in TruckSim use the same axle positions and road wheel steer kinematics data for Axles 1 and 2. During the development of the new vehicle, it was found that the previously used road wheel steer kinematics data was acceptable for small steering wheel angles (i.e., a high speed double lane change) but performed poorly with large inputs, such as what might be encountered during low speed maneuvers (i.e., negotiating an intersection or a slowly increasing steer test). Since the data wasn't matched well to the wheelbase of the truck, it was found that Axle 2 steered more than Axle 1; this resulted in counteracting tire lateral forces that diminished the vehicle's ability to negotiate small radius turns and led to unreasonable steering torque feedback. The new road wheel steer kinematics data works to address these deficiencies.

3-Axle Dump Trucks with No Brakes Linked to Axle 2

TruckSim has included several examples of a 3-Axle Dump Truck for many years, with variations including a payload, locked Transfer Case, and towing a dolly / trailer combination. Two of the dump trucks inadvertently had the brake system for Axle 2 set to "No brakes." Although this had no effect on the Run Control examples in which they were used, the lack of a brake system on Axle 2 would produce longer stopping distances than an equivalent vehicle with brakes linked. For TruckSim version 2021.0, these trucks were replaced with vehicles that include a brake system linked to Axle 2. As part of this effort, several duplicate datasets were removed while others were renamed.

Data Changes related to Steering System Inertia

To demonstrate the new suspension contribution to steering system inertia (see page 2), the following vehicles have received updates to their steering system data:

- Compact pickup truck
- Hybrid compact pickup truck
- Electric compact pickup truck
- Electric 4WD compact pickup truck
- Dual rear wheel (DRW) pickup truck which has rack and pinion steering.

Using the new version of these vehicles with existing procedures produces different simulation results due to the updated data.

New Datasets to Highlight New Animator Assets

Two new datasets have been added to highlight new or updated animator assets for TruckSim. The assets are:

- Improved Cab shape for 3A Sleeper Cab lead unit
- New flatbed trailer
  - New trailer body

- o   New landing gear
- o   New axle and air suspension components
- o   New mudflaps
- o   New 41k lbf Coiled Steel payload
- New shipping container trailer
  - o   Front, Mid, and Rear components for different length containers
  - o   Containers can be added as part of the object (for traffic) or as custom payloads (Ego vehicle)

The TruckSim Run Control datasets associated with these new assets are:

- { *TS 2021.0 – New Vehicle Shapes } 3A Sleeper Cab with Flatbed Trailer
  - o   This example shows the new 3A Sleeper Cab hauling the 41k lbf Coiled Steel payload on the new Flatbed Trailer down a section of 5-Lane Highway
- { *TS 2021.0 – New Vehicle Shapes } 2A Container Trailer + 2 20' Containers
  - o   This example shows a 3A Cab-Over lead unit pulling the new Container Trailer down a section of 5-Lane Highway. The payload consists of two 20' Dry Cargo Containers.
- { *TS 2021.0 – New Vehicle Shapes } 2A Container Trailer + 40' Container
  - o   This example shows the 3A Cab-Over lead unit pulling the new Container Trailer down a section of 5-Lane Highway. The payload consists of a single 40' Dry Cargo Container.

New Datasets to Show the New Proving Ground Tile

The new proving ground scene is demonstrated with the following examples:

- TS 2021.0 - New Proving Ground > Hill Start Assist (Manual Trans)
- TS 2021.0 - New Proving Ground > Sine Bumps - Out of Phase
- TS 2021.0 - New Proving Ground > Split Mu Hill Climb w/ Driver Only
- TS 2021.0 - New Proving Ground > Top Speed Test
- TS 2021.0 - New Proving Ground > Trailer Oscillation Test

These examples don't show all available sections of the new proving ground, which has nine testing areas including a five mile circle track, a hill grade surface, an on-grade split-mu surface, a split-mu surface, a rough road section, a 1000m straight, a 500m skid pad, a handling course, and an urban multi-lane environment. Additional reference paths, for other test sections, are set up in the Scene: External Import dataset for the proving ground, which you can view there. You can also open the VS Scene Builder to view the new proving ground's tile, where over 600 paths are available for export.