

Parallel VS Math Models

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The VS Math Models constructed in CarSim, TruckSim, and BikeSim can run under many external software workspaces, such as Simulink, LabVIEW, and environments that use the Functional Mockup Interface (FMI). When used this way, multiple VS Math Models may be run simultaneously, in parallel.

The capability for running multiple VS Math Models in parallel has been available for many years. The operation was simplified in version 2020.0 with the introduction of the **Parallel VS Math Models** tool (named “Multiple Vehicles” tool in the 2020.0 release, renamed in 2020.1 and 2021.0).

Note

Version 2020.1 introduced the capability to construct VS Math Models in CarSim and TruckSim to represent multiple vehicles that operate in the same environment, with the same ground terrain, and possibly moving objects used in ADAS scenarios. The option to construct a VS Math Model with multiple vehicles is described in the technical memo *Simulations with Multiple Vehicles*.

Running a VS Math Model in an External Workspace

When running a VS Math Model in an external workspace such as Simulink, a VS Wrapper serves as the interface between the simulation environment and a VS Solver library. For example, when working with Simulink, the wrapper is an S-Function named `vs_sf` that appears as a block in a Simulink model, and which handles the exchange of import and export variables between the Simulink model and a VS Math Model that is automatically constructed using modules in a VS Solver library (e.g., `carsim_64.dll` in Figure 1).

The VS **Run Control** dataset has a link to a vehicle dataset, plus links for a procedure and other aspects of the simulated scenario. It also has a link to a **Models** dataset that identifies a Simulink model file (with extension `.mdl` or `.slx`), and lists of variables that are activated for import and export. When a simulation is started from Simulink, the VS Solver library is loaded by the S-Function wrapper and provided the name of a text simulation control file, called a *Simfile*. The Simfile specifies top-level information about the simulation, such as the name of a text input *All Parsfile*, and details about the variables that are imported and exported. The All Parsfile defines the vehicle configuration (number and types of axles, and all properties in the vehicle model).

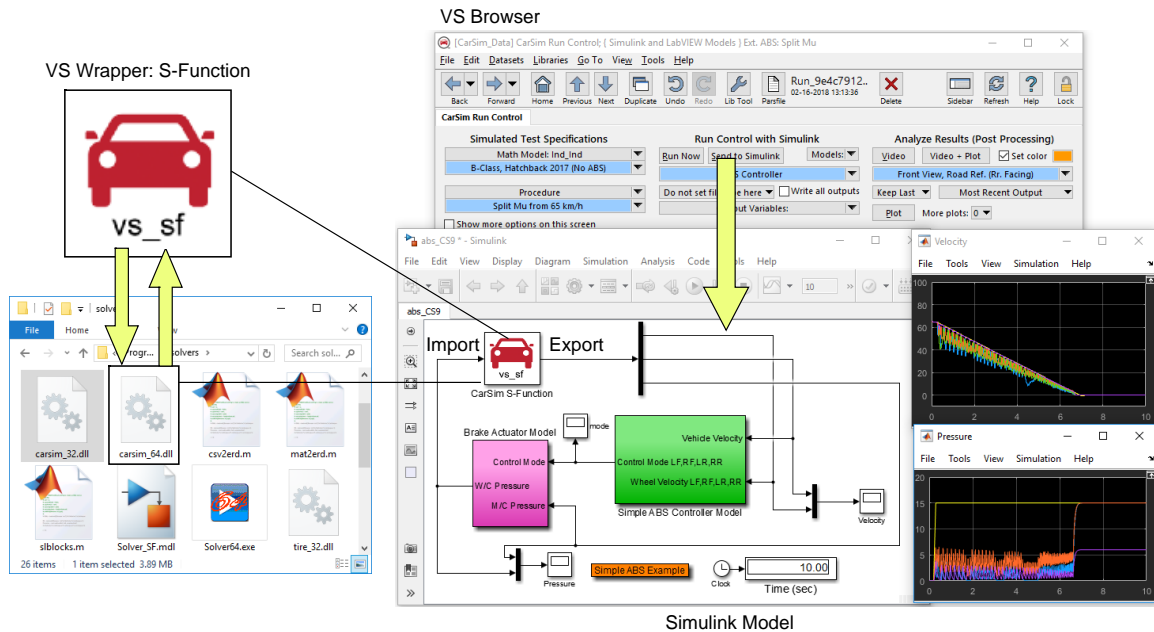


Figure 1. Running a single VS Math Model in Simulink.

In order for two or more VS Math Models to be used in the same Simulink model, it is necessary that each use a separate VS Solver library file with an associated Simfile that identifies an input All Parsfile name associated with the **Run Control** dataset.

The **Parallel VS Math Models** tool helps synchronize multiple **Run Control** datasets to support an external model with multiple VS Math Models. The rest of this document describes how to set up simulations in Simulink with multiple vehicles when using this tool.

Notes Details of how the VS Math Model works are provided in the *VS Math Model Reference Manual*. Details of how the Solver is connected to external models are provided in the Help document *External Models and RT Systems*, associated with for the various model screens.

Run Control Datasets for Parallel VS Math Models

Each VS Math Model used in a simulation with multiple solvers is represented with a separate **Run Control** dataset. For example, Figure 2 show the dataset for one of the vehicles used in an example with adaptive cruise control that involves two vehicles.

As with most simulations in a VS product, the vehicle properties are obtained from a link to a vehicle dataset (1), and the controls are obtained with a link to a **Procedure** dataset (2). This **Run Control** dataset specifies the option to use Simulink, with a **Models** dataset (3) identifying the Simulink model file and other information. In order to view results for both vehicles, the Overlay box is checked, and a link is made to the **Run Control** dataset for the other vehicle (4).

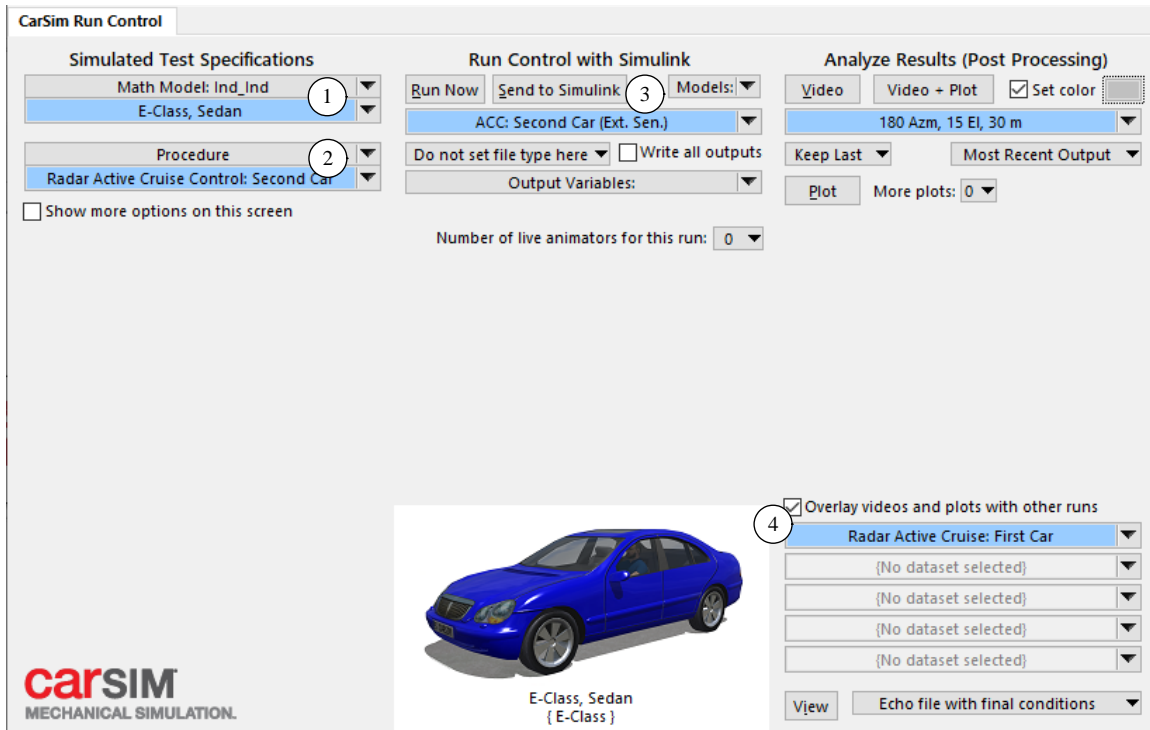


Figure 2. Run Control dataset for a vehicle used in a simulation with two vehicles.

Each of the **Run Control** datasets used for the Simulink simulation should have a link to a **Models: Simulink** dataset similar to the one shown in Figure 3. Some of the settings should be the same for each Models dataset:

1. The box should be checked for setting the working directory (2), and the dataset used for each vehicle should specify the same directory (1).
2. Each dataset should have the same settings for the numerical integration and time step (3, 4, and 5).
3. Each should have the checkbox **Run parallel VS Math Models** checked (6).
4. Each should specify the same Simulink MDL or SLX file (9).

On the other hand, the different **Models: Simulink** datasets may specify different sets of Import (7) and Export (8) channels.

The Simulink S-Function for Multiple Solver Libraries

Starting with version 2020.0, CarSim, TruckSim, and BikeSim include an S-Function for Simulink models involving parallel VS Math Models, which requires multiple VS Solver libraries. Figure 4 shows two windows in Simulink: the one on the left is a model that includes two CarSim S-Functions; the window on the right shows a library of S-Functions provided with CarSim. The one with the name “Multiple Solvers” was dragged twice from the library into the model window. With each copy, the number shown in the block is increased automatically.

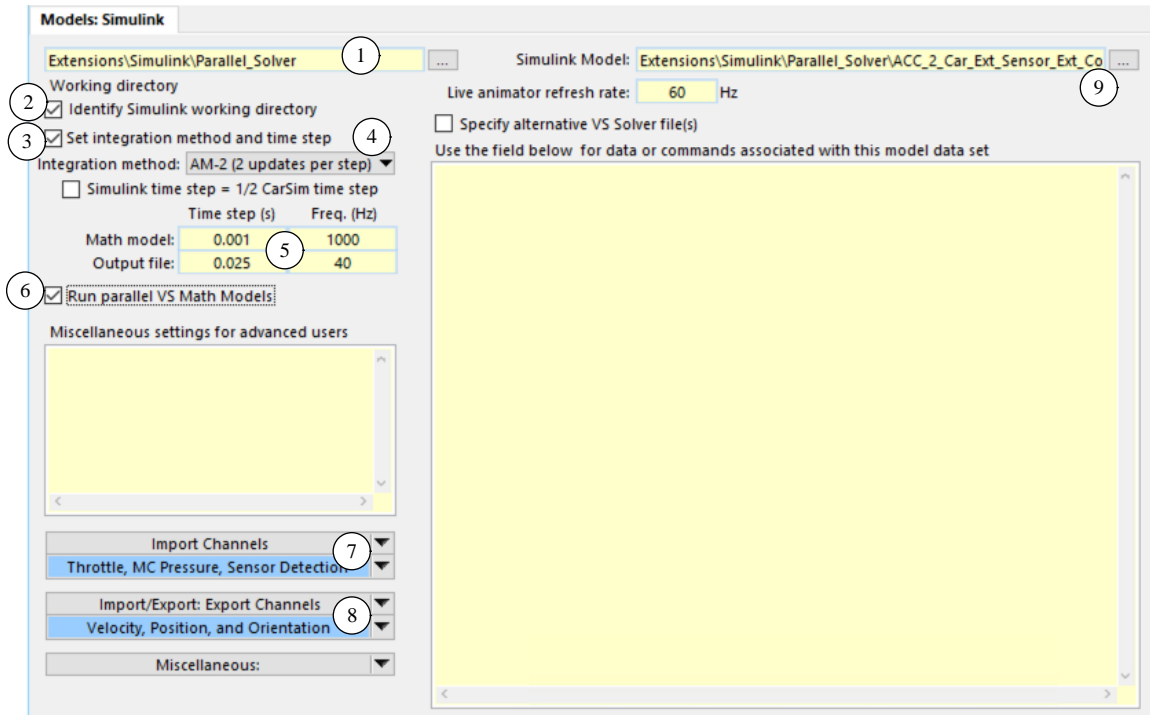


Figure 3. Models: Simulink setup for multiple vehicles.

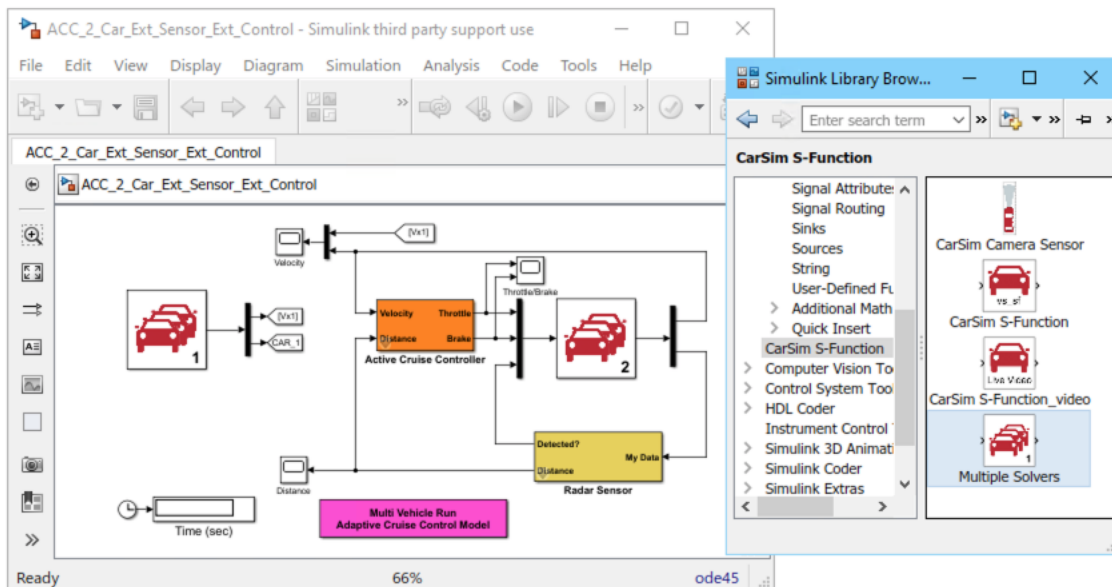


Figure 4. S-Functions for multiple vehicles in CarSim.

The Multiple Solver S-Function is used in the same manner as the regular S-Function. It is connected to Simulink signals that correspond to CarSim Import and Export variables that were specified in for use in each of the **Run Control** datasets.

When the Simulink Run button is clicked, the Multiple Solver S-Functions check the working directory to ensure that an independent VS Solver library DLL file exists. For example, if this is 64-bit Simulink running CarSim models, the S-Functions in the example will look for the files

carsim_64_1.dll and carsim_64_2.dll. If they do not exist, the S-Function will copy the installed DLL (carsim_64.dll from the CarSim_Prog\Programs\Solvers folder) and rename each copy appropriately. Each S-Function then constructs a VS Math Model using a copy of the original VS Solver DLL.

The Parallel VS Math Models Tool

The **Parallel VS Math Models** library can be accessed using the **Tool** menu (Figure 5) or the **Libraries** submenu **Batch**.

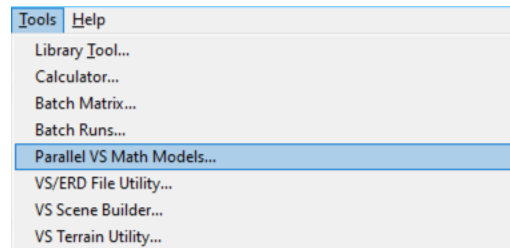


Figure 5. Use the Tools menu to locate the Parallel VS Math Models screen.

The **Parallel VS Math Models** screen (Figure 6) provides a quick way to update all of the Simfiles and associated All Parsfiles used for simulations involving multiple vehicles. The screen supports Simulink models running on Windows, and FMI models running with several RT operating systems.

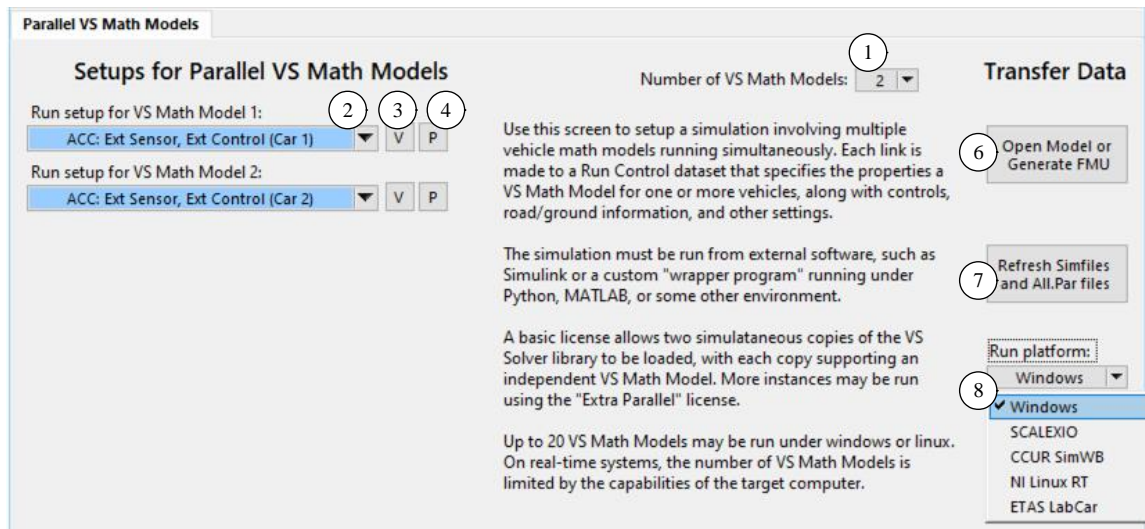


Figure 6. The Parallel Solvers screen.

- ① Drop-down control to specify the number of vehicles that will be simulated in the external workspace. The screen supports up to 20 linked **Run Control** datasets. As explained later (page 6), extra licenses are needed if the simulation has three or more links to **Run Control** datasets.

- ② Link to a **Run Control** dataset that specifies a vehicle and associated controls that should be included in the simulation.
- ③ Button to view a video in VS Visualizer as setup in the linked **Run Control** dataset. This is intended for use after the simulation has been run. If different **Run Control** datasets show different points of view, this provides a convenient place to quickly bring them into view.
- ④ Button to view plots in VS Visualizer as setup in the linked **Run Control** dataset. If different **Run Control** datasets are set to show different plots, this provides a convenient place to quickly bring them into view.
- ⑤ Button to view live video in VS Visualizer when running on an RT system (Figure 7).

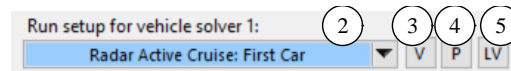


Figure 7. Viewing options when running on an RT platform.

- ⑥ Button to write a new Simfile and All Parsfile for each linked **Run Control** dataset, and then open the Simulink model from the first linked **Run Control** dataset. Once the links have been set and the platform has been selected (⑧), a new run can be made at any time with this button.

To actually make a new run, you need to view the external model (e.g., in Simulink) and make the run from there.

- ⑦ Button to write a new Simfile and All Parsfile for each linked **Run Control** dataset. This is not needed if you have clicked the above button to open the model (⑥). However, it is handy if the Simulink model is already open and changes have been made to any of the datasets affecting the **Run Control** setups.

After refreshing the files, make a new run from the external software (e.g., Simulink).

- ⑧ Drop down control to choose the operating system (Figure 8). If an RT system is chosen, a **Send** button is also shown.

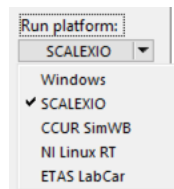


Figure 8. Operating systems supported for Parallel Solvers.

Running with More than Two VS Math Models

Be aware that a normal Windows license supports two solvers running in parallel; in order to run more, “Extra Parallel Solver” ① licenses are needed (Figure 9).

<input checked="" type="checkbox"/>	CarSim Engine Mount	carsimengmtus	BIA001C422606EB		2020	Yes (1)	1	401
<input checked="" type="checkbox"/>	CarSim Frame Twist	carsimfus	BIA001C422606EB		2020	Yes (1)	1	401
<input checked="" type="checkbox"/>	CarSim Sensors	carsimsmous	BIA001C422606EB		2020	Yes (1)	1	401
<input checked="" type="checkbox"/>	CarSim Extra Live Animator	carsimanius	BIA001C422606EB		2020	Yes (1)	1	401
<input checked="" type="checkbox"/>	CarSim Extra Parallel Solver	carsimparallelsolveru	BIA001C422606EB		2020	Yes (4)	4	401

Double-click Take column to edit

☒ Don't show this window when starting

Select Cancel

Figure 9. License screen showing Extra Parallel Solver licenses.

When it comes to viewing videos of results, be aware that the **Run Control** screen supports the overlay of results from five additional **Run Control** setups, for a total of six. If the simulation has more than six **Run Control** setups, the existing GUI can only be used to view six at time.