SMP Tool Beta v3.5 Quickstart Guide

April 26, 2023

SMP Tool (Semi-Markov Process Tool) is a MATLAB application, currently in a beta version, for analyzing Semi-Markov Processes. This quickstart guide covers installation and analysis of a SSF (Stochastic StateFlow) model using SMP Tool. There is also a manual for SMP Tool SMP_Tool_Beta_v3.5_Manual.pdf which mainly focuses on the older but still supported SMP and HSMP models. For questions and clarification, the reader is encouraged to send an email to kaalen@kth.se.

1 Installation

A prerequisite for installing SMP Tool is a working installation of MATLAB 2021b with Simulink/Stateflow, Symbolic Math Toolbox, and Statistics and Machine Learning Toolbox. Note that SMP Tool has only been tested on Windows 10 64-Bit and MATLAB 2021b but may work on other platforms and other MATLAB versions. To install SMP Tool after it has been downloaded, extract SMP_Tool_Beta_v3.5.zip and run the MATLAB application installation file *SMP Tool Beta v3.5.mlappinstall* and click *Install* in the dialog that appears. After installation SMP Tool can be launched from the *APPS* tab in MATLAB by finding it in the drop-down menu and clicking on it. When launched, the graphical user interface shown in figure 1 appears.

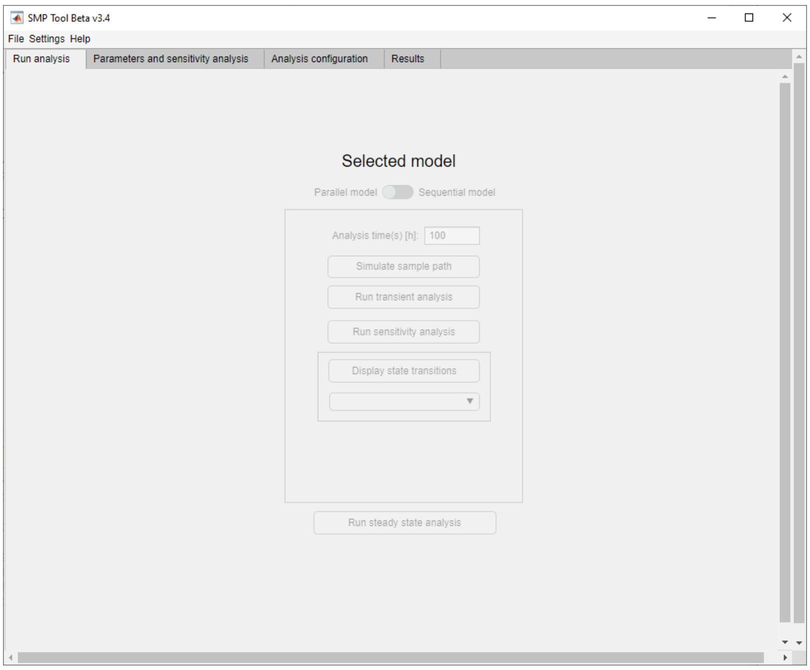

Figure 1: Graphical user interface for SMP Tool.

1.1 Open a Model

To load a model into SMP Tool, click the *File* button in the top left corner and hover over the button *Open* in the drop-down menu that appears, see figure 2. To open the existing model *Gearbox_wheel_lock* found in *example_models* click *Existing model*, and select the model in the dialog that appears. The model is an SSF model which is an extension of a subset of Stateflow described in [1]. Most of the SSF syntax is exemplified by the *Gearbox_wheel_lock* model. The graphical user interface is updated as seen in figure 3 and a Stateflow window showing the model is opened.

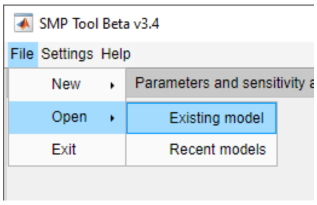

Figure 2: *File* menu from SMP Tool.

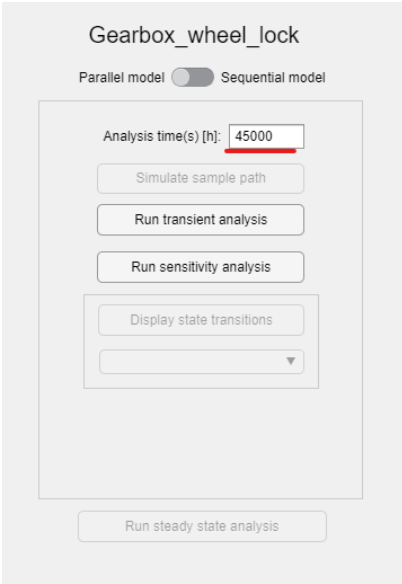

Figure 3: *Run analysis* tab from SMP Tool.

1.2 Analyze a Model

Analyses are started under the *Run analysis* tab seen in figure 3. For the opened model *Gearbox_wheel_lock* transient analysis and sensitivity analysis are available. The analysis time is also specified here, which is the time of interest in hours for the analyses. Change the analysis time to *45000* hours, see figure 3.

Currently these analyses are done analytically or using Monte Carlo simulations. The solvers can be changed under the *Analysis configuration* tab and *Solver method* panel. Select both solvers.

The analytical solver has mainly one parameter that affects accuracy, which can be changed under the *Analysis configuration* tab in the field titled *GSMS path absolute error*, see figure 4. Change *GSMS path absolute error* to *1e-08*.

The Monte Carlo simulation solver has one parameter that affects accuracy, the number of simulations, which can be changed under the *Analysis configuration* tab in the field titled *No. simulations*, see figure 4. Change *No. simulations* to *1e+08*.

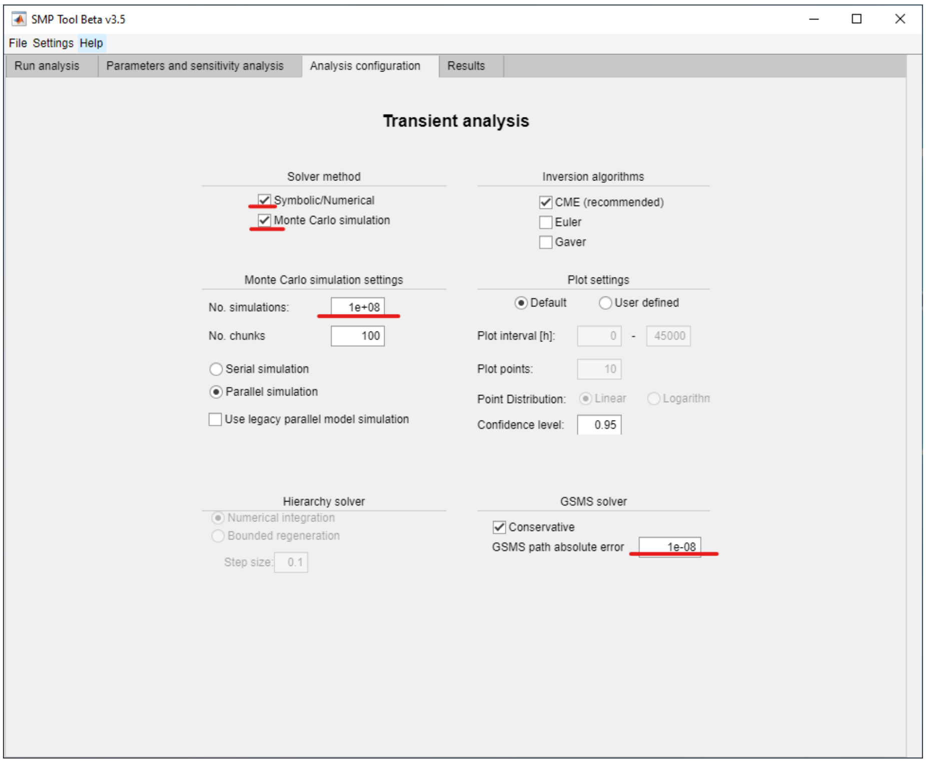

Figure 4: *Analysis configuration* tab from SMP Tool.

1.2.1 Transient analysis

Transient analysis calculates the reliability, availability and failure probability for the model. To find this for the opened model *Gearbox_wheel_lock* click *Run transient analysis* and wait for the analysis to complete. When completed, tabs showing the analysis results using both solver methods are opened under the *Results* tab, see figures 5 and 6. As seen in the figure the probability of failure during the analysis time is found to be *4.98e-7* using the analytical solver and around *4.7e-7* with a certain confidence interval using the Monte Carlo simulation solver.

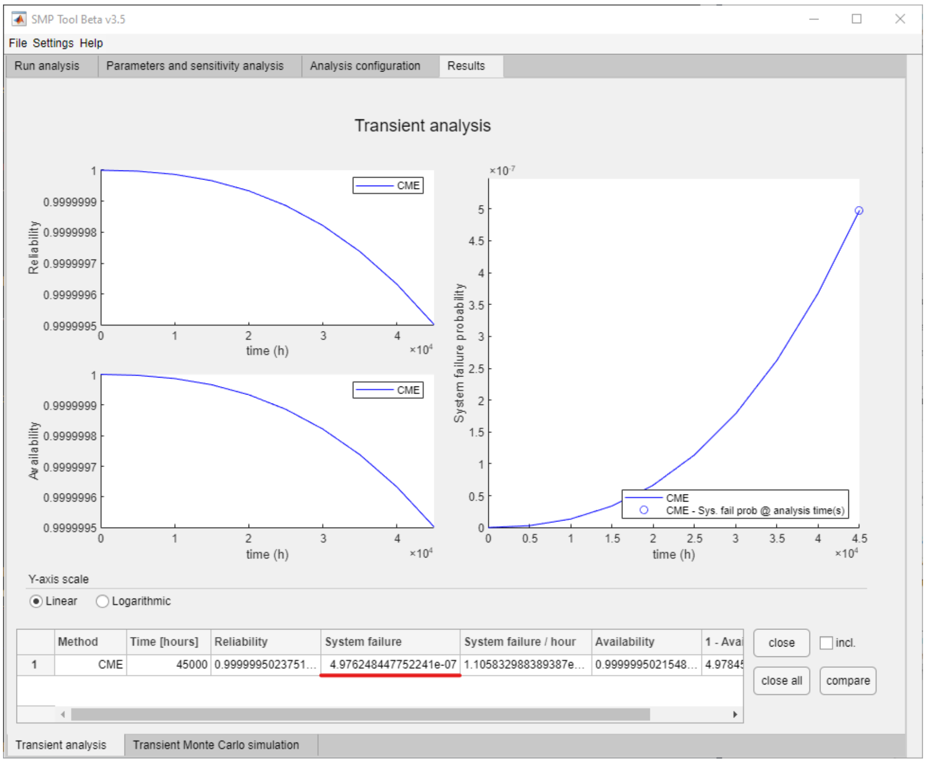

Figure 5: Result from a transient analysis of the *Gearbox_wheel_lock* model using analytical solver. The *GSMS path absolute error* was *1e-8* and the analysis time was *45000* hours.

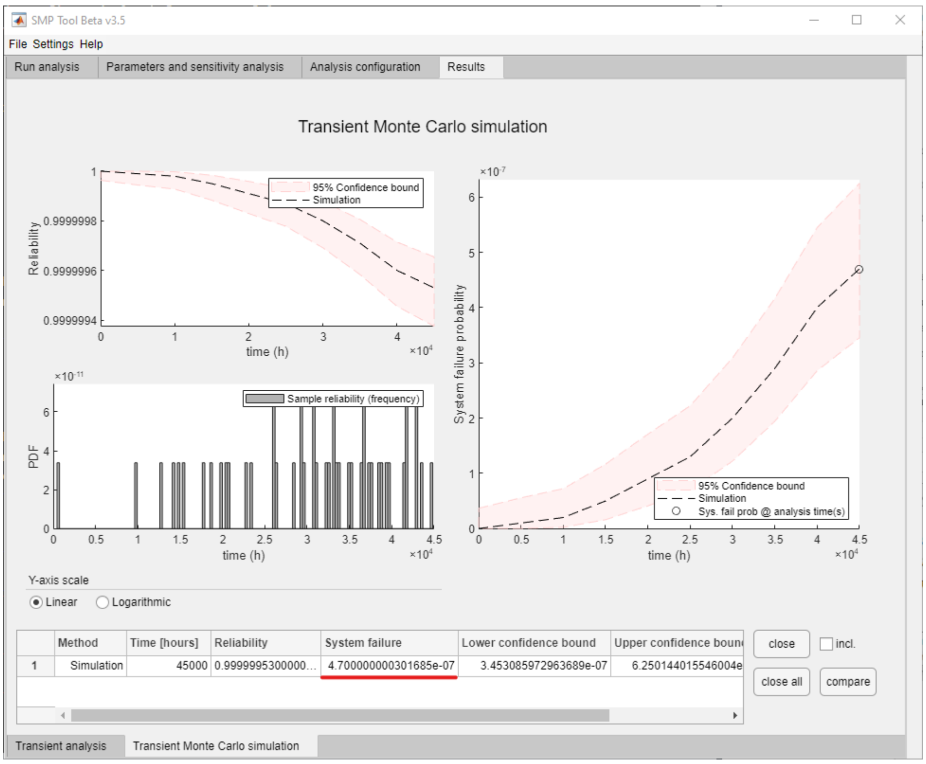

Figure 6: Result from a transient analysis of the *Gearbox_wheel_lock* model using Monte Carlo simulation solver. The number of simulations was *1e8* and the analysis time was *45000* hours.

1.2.2 Sensitivity Analysis

Sensitivity analysis calculates failure probability for the model where each specified parameter is varied one at a time. A sensitivity analysis gives a clear view over which parameters affect the failure probability the most and the least.

The specific parameters and their ranges can be changed under the *Parameters and sensitivity analysis* tab, see figure 7. Select the parameters *restart_time* and *FR_SCG* and change their respective ranges to *[1.6 16 160]* and *[1e-07 1e-06 1e-05]*.

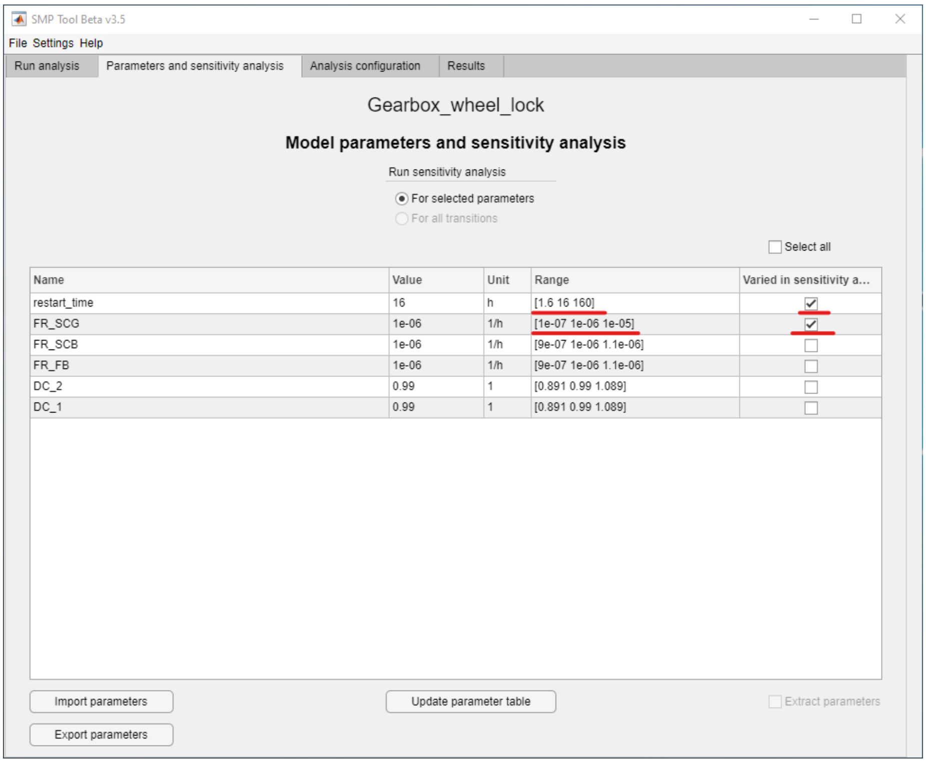

Figure 7: *Parameters and sensitivity analysis* tab from SMP Tool.

To perform a sensitivity analysis for the parameters *restart_time* and *FR_SCG* for the opened model *Gearbox_wheel_lock* click *Run sensitivity analysis* under the *Run analysis* tab and wait for the analysis to complete. When completed, tabs showing the analysis results using both solver methods are opened under the *Results* tab, see figures 8 and 9. Note that the results are split into sub-tabs, one for each parameter. As seen in the figure the parameter *restart_time* doesn't affect the overall failure probability much when it is varied between the specified values while *FR_SCG* does.

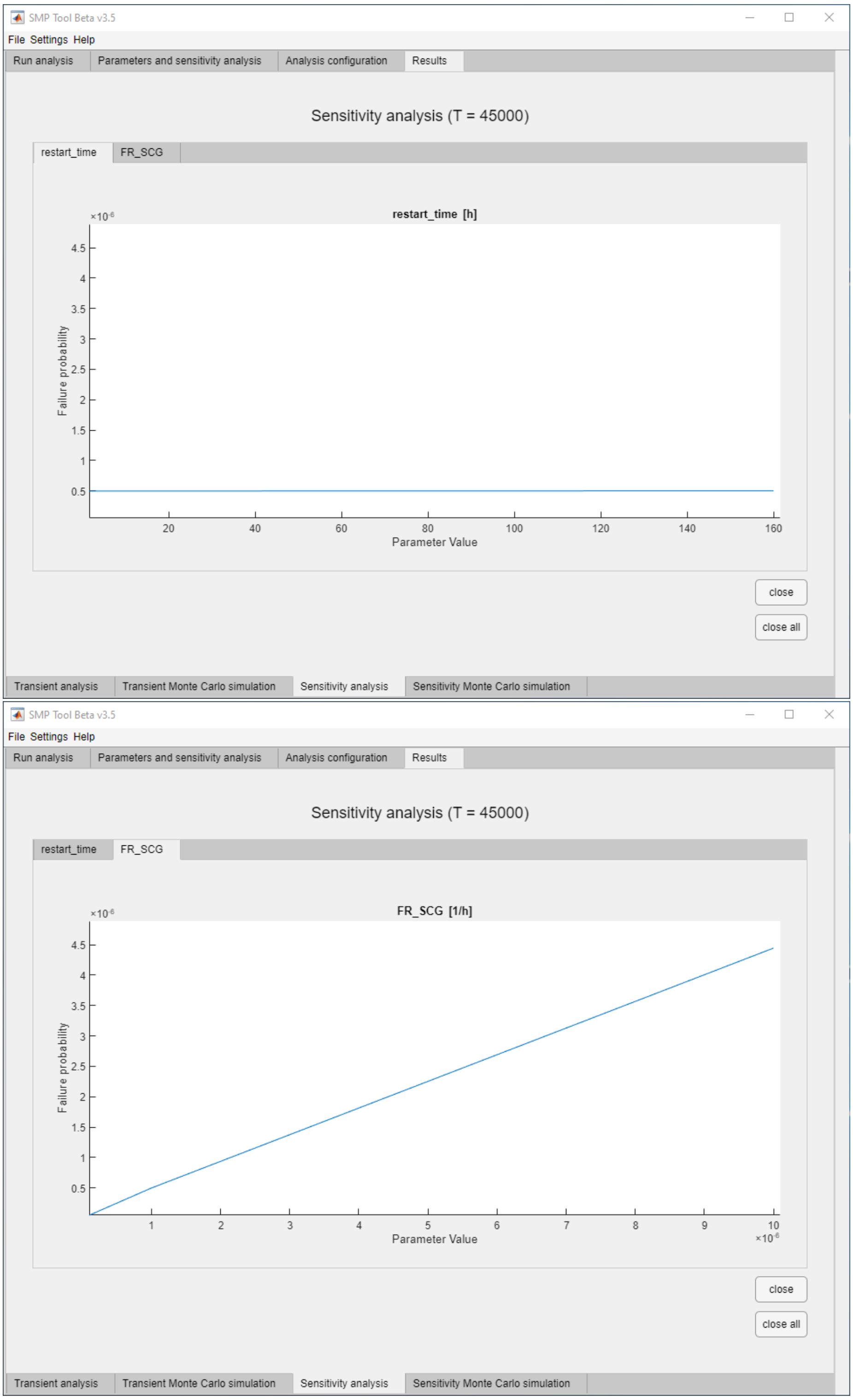

Figure 8: Result from a sensitivity analysis of the *Gearbox_wheel_lock* model using analytical solver. The *GSMS path absolute error* was *1e-8*, the analysis time was *45000* hours and the parameters *restart_time* and *FR_SCG* were varied ±900%.

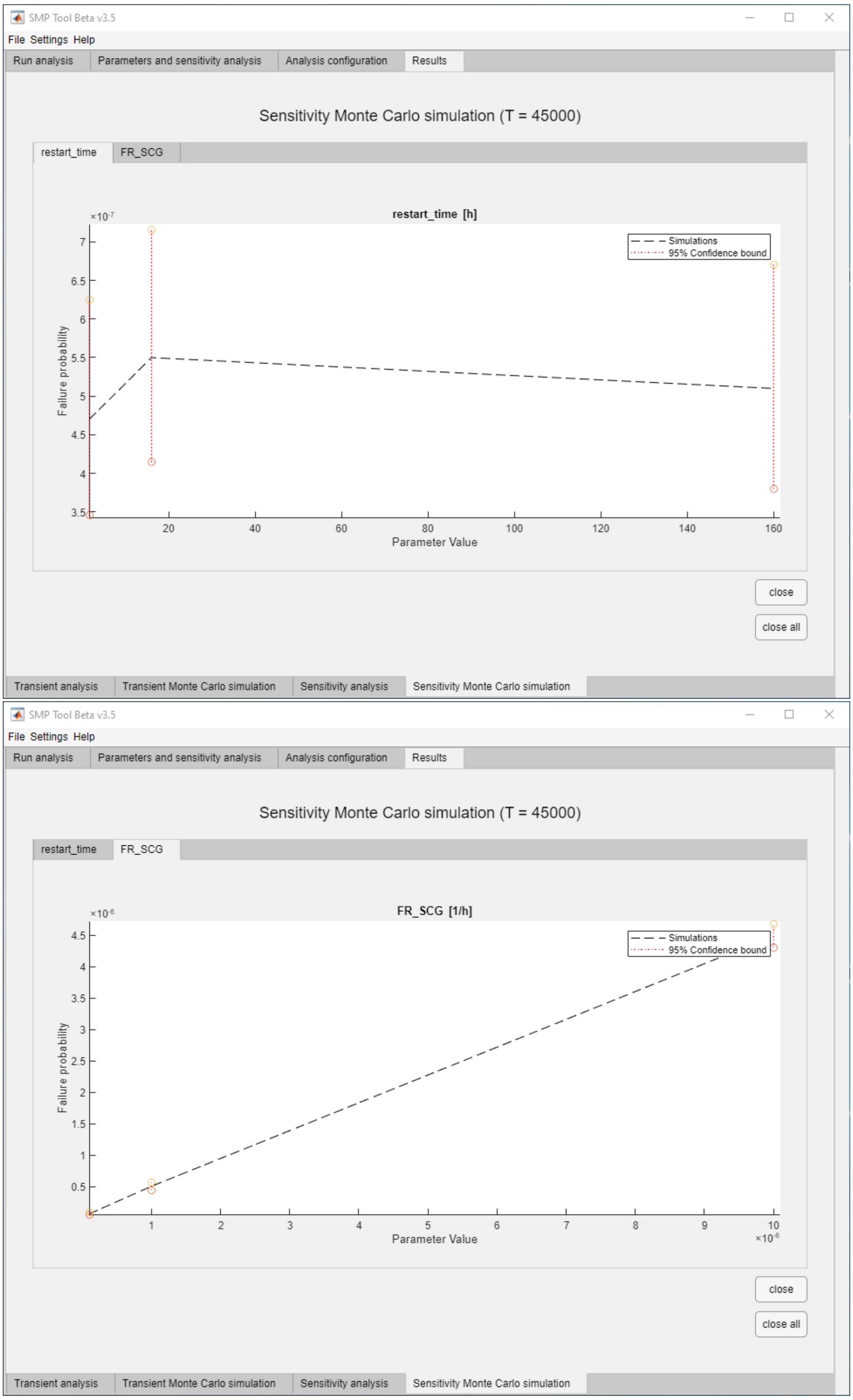

Figure 9: Result from a sensitivity analysis of the *Gearbox_wheel_lock* model using Monte Carlo simulation solver. The number of simulations was *1e8*, the analysis time was *45000* hours and the parameters *restart_time* and *FR_SCG* were varied ±900%.

References

[1] Stefan Kaalen et al. “A Stochastic Extension of Stateflow”. In: *Proceedings of the 2022 ACM/SPEC on International Conference on Performance Engineering*. 2022, pp. 211–222.