SMP Tool Beta 3.6.0 Quickstart Guide

July 6, 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_3.6.0_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 2022b 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 2022b but may work on other platforms and other MATLAB versions. To install SMP Tool after it has been downloaded, extract SMP_Tool_Beta_3.6.0.zip and run the MATLAB application installation file *SMP Tool Beta 3.6.0.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.
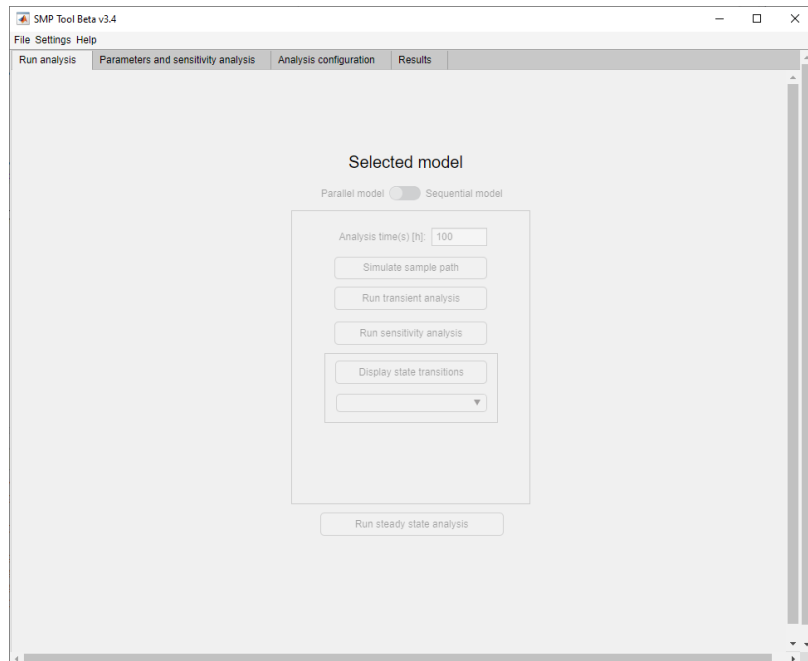

Figure 1: Graphical user interface for SMP Tool.

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.
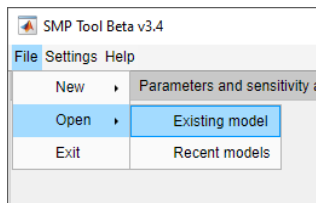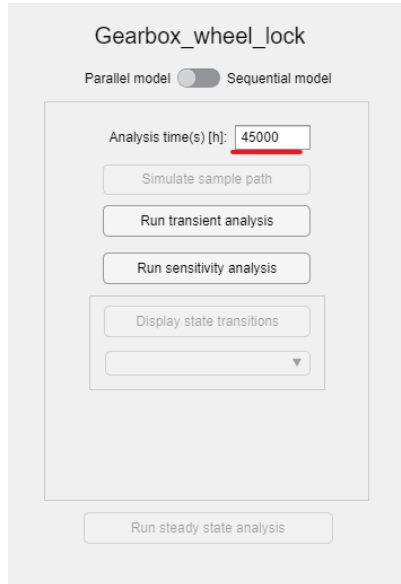

Figure 2: *File* menu from SMP Tool.

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*, two analyses, 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*.
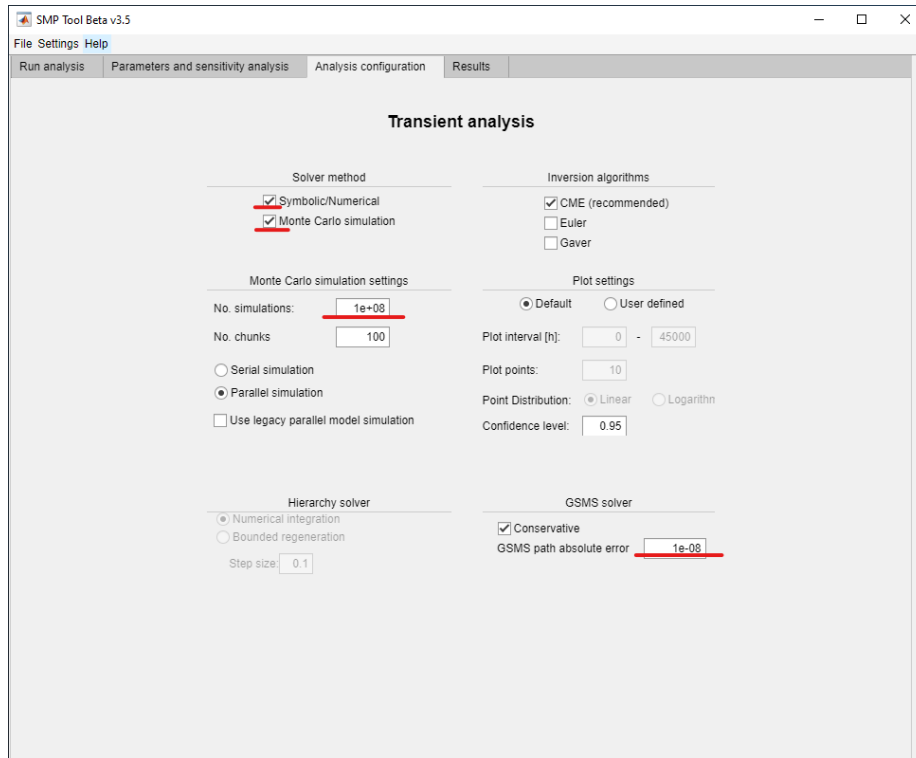
Figure 4: *Analysis configuration* tab from SMP Tool.

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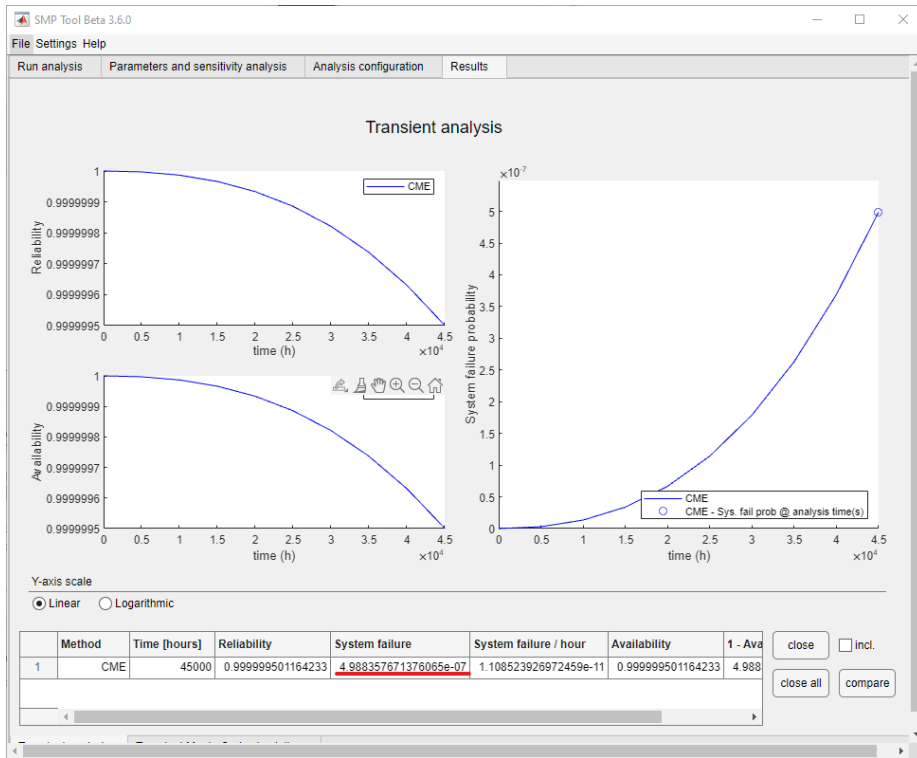
Figure 5: Result from a transient analysis of the *Gearbox_wheel_lock* model using analytical solver. The *GSMS path absolute error* was *1e-8* and the analysis time was *45000* hours.
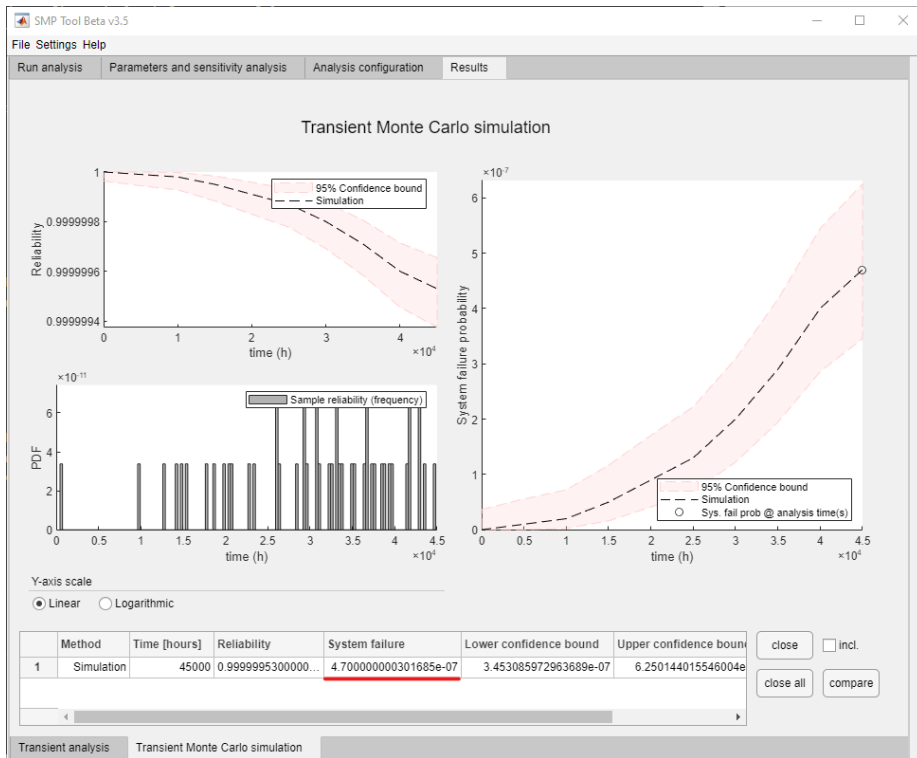

Figure 6: Result from a transient analysis of the *Gearbox_wheel_lock* model using Monte Carlo simulation solver. The number of simulations was *1e8* and the analysis time was *45000* hours.

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]*.
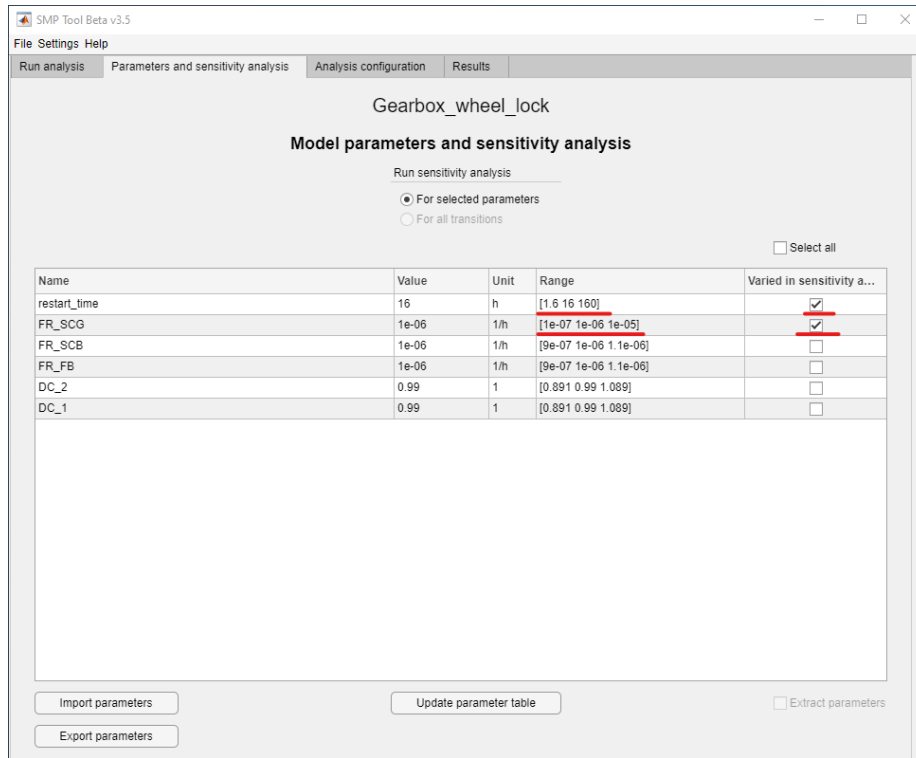

Figure 7: *Parameters and sensitivity analysis* tab from SMP Tool.

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.
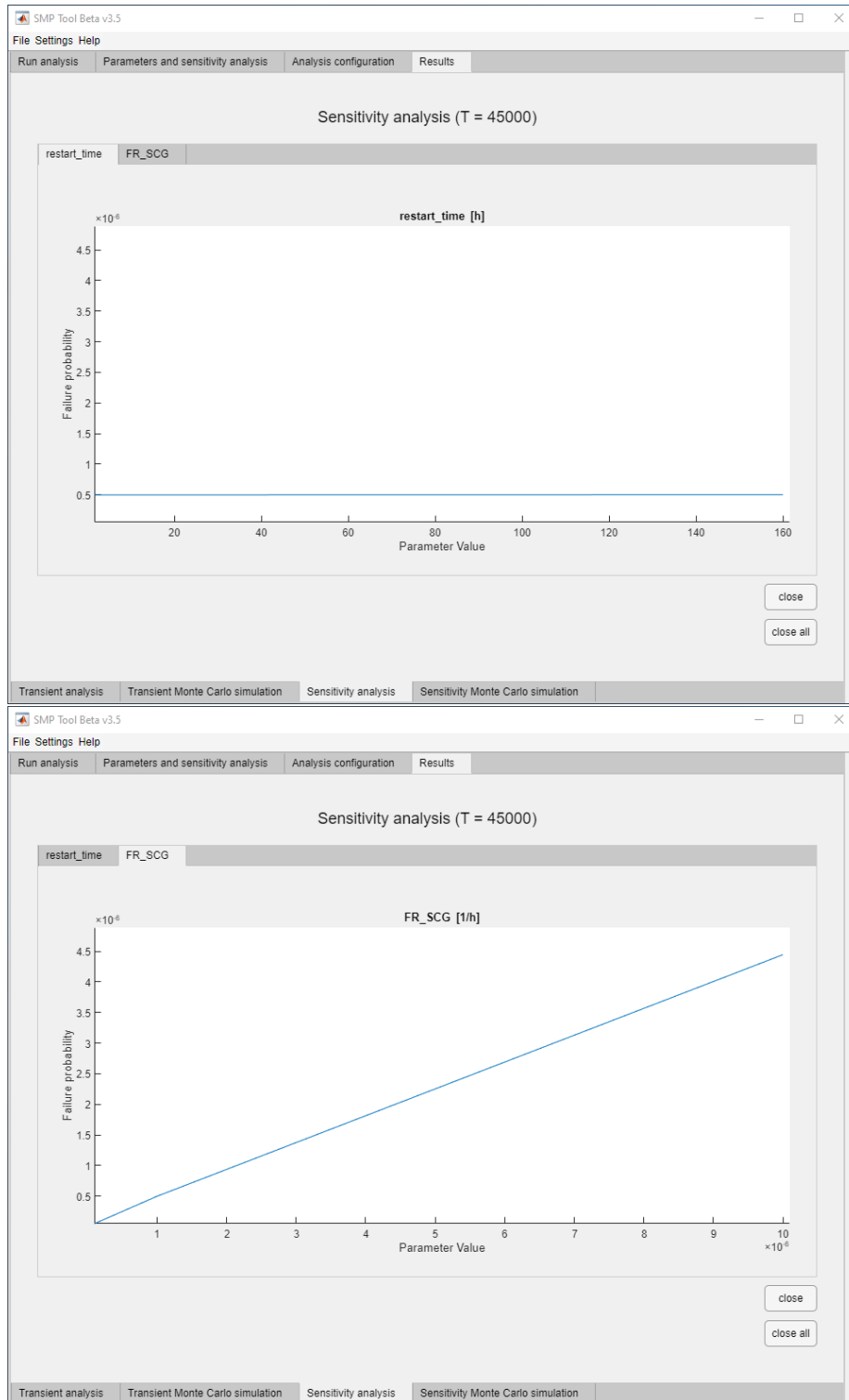
Figure 8: Result from a sensitivity analysis of the *Gearbox_wheel_lock* model using analytical solver. The *GSMS path absolute error* was *1e-8*, the analysis time was *45000* hours and the parameters *restart_time* and *FR_SCG* were varied ±900%.
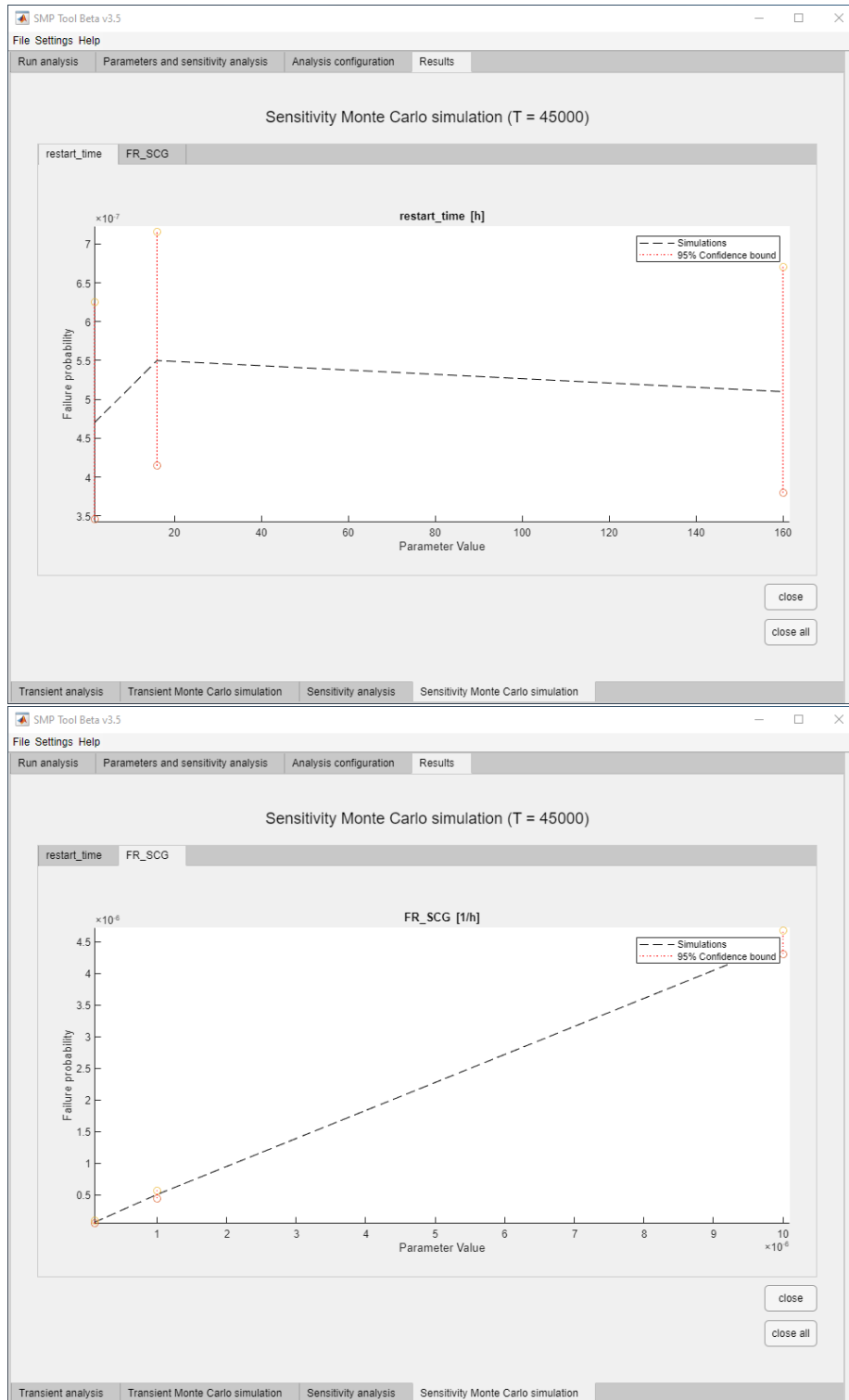
Figure 9: Result from a sensitivity analysis of the *Gearbox_wheel_lock* model using Monte Carlo simulation solver. The number of simulations was *1e8*, the analysis time was *45000* hours and the parameters *restart_time* and *FR_SCG* were varied ±900%.

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.