

# Simcenter Testlab fatigue and load-data analysis

Solution brief

Siemens PLM Software

## Delivering lighter, stronger and more durable vehicles

### Meeting customer expectations

Market trends in the transportation industry significantly impact durability testing processes. Vehicle manufacturers market an exponential number of vehicle variants in response to the global trend of mass customization. These variants have to be based on lightweight designs in order to minimize fuel consumption. They also need to meet consumers' expectations for quality, reliability and minimizing maintenance costs while considering long-term use and high mileage.

On a global scale, emerging markets boost the economy and are essential to the growth of the industry. Consumers in those markets change the rules of the game for the durability engineers: They have different driving habits, potentially driving on rougher roads or in extreme-loading conditions. These trends burden durability testing teams,

which struggle with the increased workload and shorter timelines to successfully fulfill test-based engineering campaigns.

To tackle the challenges of durability testing and validation, durability teams need to streamline their processes, accelerating the delivery of critical insights with every step of the test campaign, from road-load data collection to insightful analysis.

With Simcenter Testlab™ software, Siemens provides an integrated end-to-end solution for load-data collection and analytics. It encompasses every step of a typical durability test campaign, from channel setup and measurements to validation, consolidation, analysis and reporting. The latest software release sets higher standards for analytics, accelerating the delivery of critical durability insights.

### Innovative durability-load analysis

With Simcenter Testlab, engineers extract durability-specific content from large

## Challenges

- Set accurate durability targets
- Get more insights from load measurements
- Optimize durability engineering processes

## Solutions

- Rely on a wealth of analysis methods using Simcenter Testlab load and fatigue analysis
- Use the Simcenter portfolio for data collection, analytics and modeling
- Save analysis and calculation time by using accurate, appropriate methods
- Better understand the fatigue content of load data, providing more insights into the behavior of the component being tested
- Streamline the test and analysis process to gain confidence in the data

# Solution focus

data sets and rely on efficient interpretation methods to qualify and quantify the load-data durability potential.

Performing the load-data analysis of a time signal delivers valuable information. However, in a durability test campaign, engineers usually handle huge data sets. Understanding the durability potential of time signals can be a tedious task. Using Simcenter Testlab supports creating rainflow histograms to classify the applied loads by amplitude, number of repetitions, general characteristics of the load (compression or tension) and more. Alternatively, engineers may create range pair versus damage histograms based on rainflow matrixes.

### Relying on a wealth of analysis methods to get more insights

Durability engineers who are using counting methods to represent the data can better understand the fatigue

content of load data as these methods represent the time signal with an easy-to-interpret histogram view. Counting methods also permit fatigue-related data manipulation (editing, extrapolation, superposition, etc.); for example, in order to optimize the target damage.

Imagine a scenario in which the durability engineer collects six measurements. Each measurement is done on the same road and under the same weather conditions, but by a different driver. Will the engineer collect exactly the same fatigue damage content from these six measurements? This question is difficult to answer just by looking into the time signals.

At this point, counting methods are useful to tackle the complex problem. The durability engineer will simply apply the rainflow counting method over these six measurements and calculate the range pair versus damage histogram over the rainflow histogram. For that, he or she refers to the Palmgren-Miner rule, which is based on cumulative characteristics of fatigue. This method helps to calculate damage for each load level (amplitude) identified by the rainflow matrix, and shows the repetition of the load. The engineer can also expose each amplitude (with its repetition factor) to a damage calculation by using either a specific or a default S-N curve.

Simcenter Testlab also allows you to overlay all the range pair curves of these different measurements on a single diagram. The wealth of calculation methods available in Simcenter Testlab reduces the effort and amount of data required to compare the fatigue content of various measurements. On top of damage comparison methods, Simcenter Testlab also offers full fatigue life prediction capabilities. Fatigue life prediction combines loading, geometry, and material properties information to estimate the expected lifetime of a component, using the stress-life and the strain-life methods. Results are displayed as values in a table format or as graphics showing range pair, S-N or damage parameter curve and life curve.

### Defining accurate targets

The target definition is another important step in the durability analysis. The durability target is used to describe the expected damage to the product or component being tested in defined use cases. It is usually expressed in the rainflow domain, sometimes accompanied by spectral information given as power spectral densities (PSDs). The durability target is expressed using rainflow matrices or PSDs for a list of key channels.

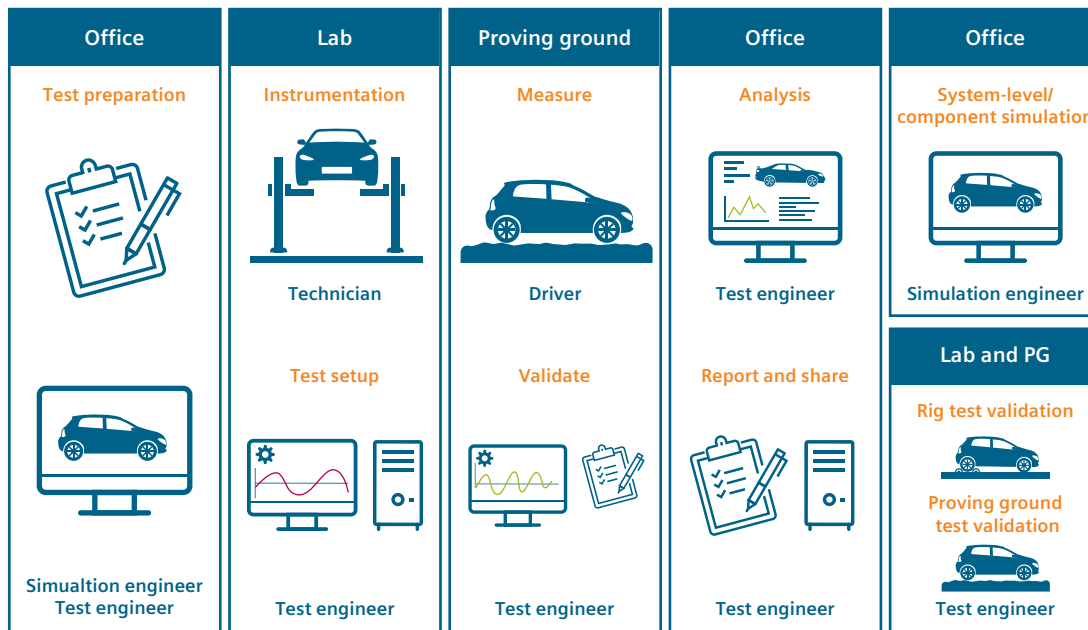


Figure 1: Typical steps in a test-based durability engineering campaign.

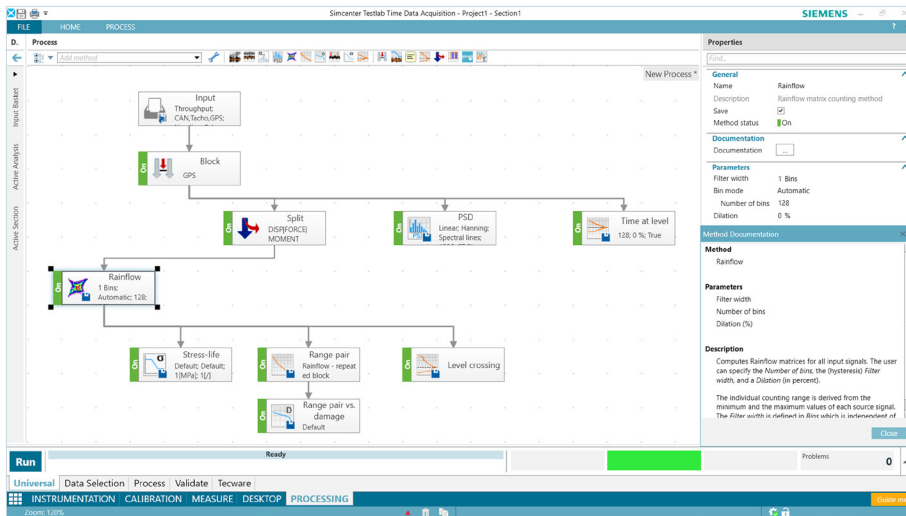


Figure 2: Create automated repetitive tasks by using innovative and industry validated load analysis.

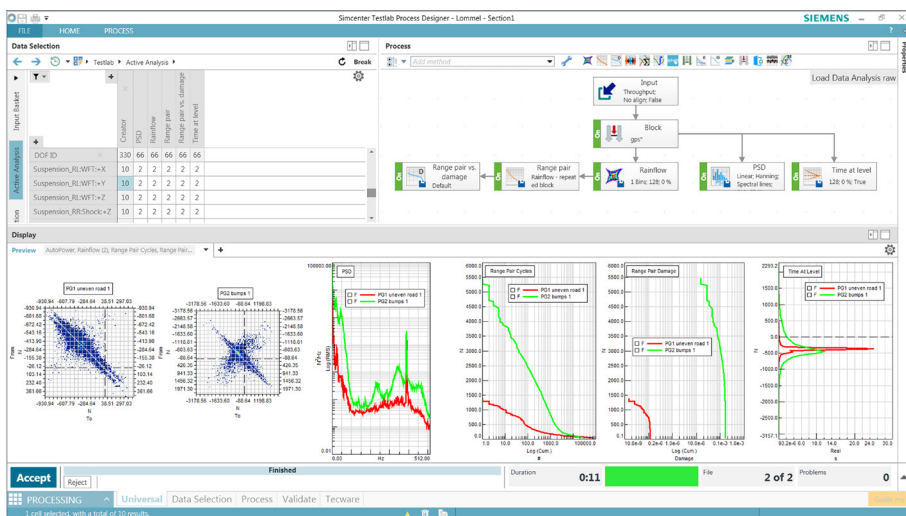


Figure 3: Comparing two time signals with embedded load analysis in Simcenter Testlab.

Short test sequences might be repeated by a factor that represents their expected occurrence in the defined target.

The superposition method in Simcenter Testlab uses multiple runs as input and combines the corresponding channels with repetition factors to calculate the total result. The method investigates events in the rainflow and PSD domain when measurements are repeated in sequence. The corresponding method in time domain would be the time series append method.

Since a durability target usually corresponds to a long time period (or a distance of over 500,000 kilometers), the append method in time domain is just not efficient enough to do the job. Instead of repeating and appending the time signals and doing the rainflow and

PSD calculation of the time data result, the superposition method takes the rainflow and PSD results in the test sequences and calculates the corresponding total result without going to the time domain.

These innovative load-analysis methods can be used to compare test and simulation results as well. This helps simulation engineers to correlate their models with real-life loads and, ultimately, to deploy a digital twin of the vehicle optimized for durability performance.

As manufacturers shorten their vehicle development cycles and go to market more rapidly, shorter laboratory tests are required. This also has a positive impact on costs, as laboratory test time is expensive. Simcenter Testlab offers a

solution for accelerated life testing that helps design shorter and damage-equivalent test schedules for vehicle validation on single and multi-axis durability test rigs. The industry validated method is preprogrammed in Simcenter Testlab, with the flexibility to adjust parameters to application-specific requirements.

### Maximize the testing productivity

Simcenter Testlab includes common analysis features, such as anomaly cleanup, filtering, new channel derivation based on mathematical operations, load-counting analysis (rainflow, range pair, time at level, level crossing), frequency based analysis, etc. It enhances these features with fast calculation times and an intuitive user interface (UI).

Simcenter Testlab presents a task-based software environment suitable for both novice users and experts. Novice users rely on industry validated predefined durability processes, and only modify and save new parameters and process flows when required. Experts can access the full breadth of functionalities to customize and automate their processes.

A major task for the durability engineering team is consolidating acquired data. Simcenter Testlab offers reliable methods for data consolidation, but also allows engineers to simply view time signals on which they can interactively apply required actions, such as filtering, offset or drift correction, mean removal, etc. They can further save this editing step in their designed process for future use.

Using Simcenter Testlab enables instant visualization of the measured data. Different data types can be selected and allowed to easily compare processing runs or an original time signal with the processed signal. Users obtain displayed results with a simple click on the data pivot table.

Effective reporting puts the last touches on successfully completing a durability test campaign. Using Simcenter Testlab makes it easy to create and share active reports with a mouse click. The measured data is fully embedded in the report charts, yielding interactive graphs in place of static bitmaps. Other



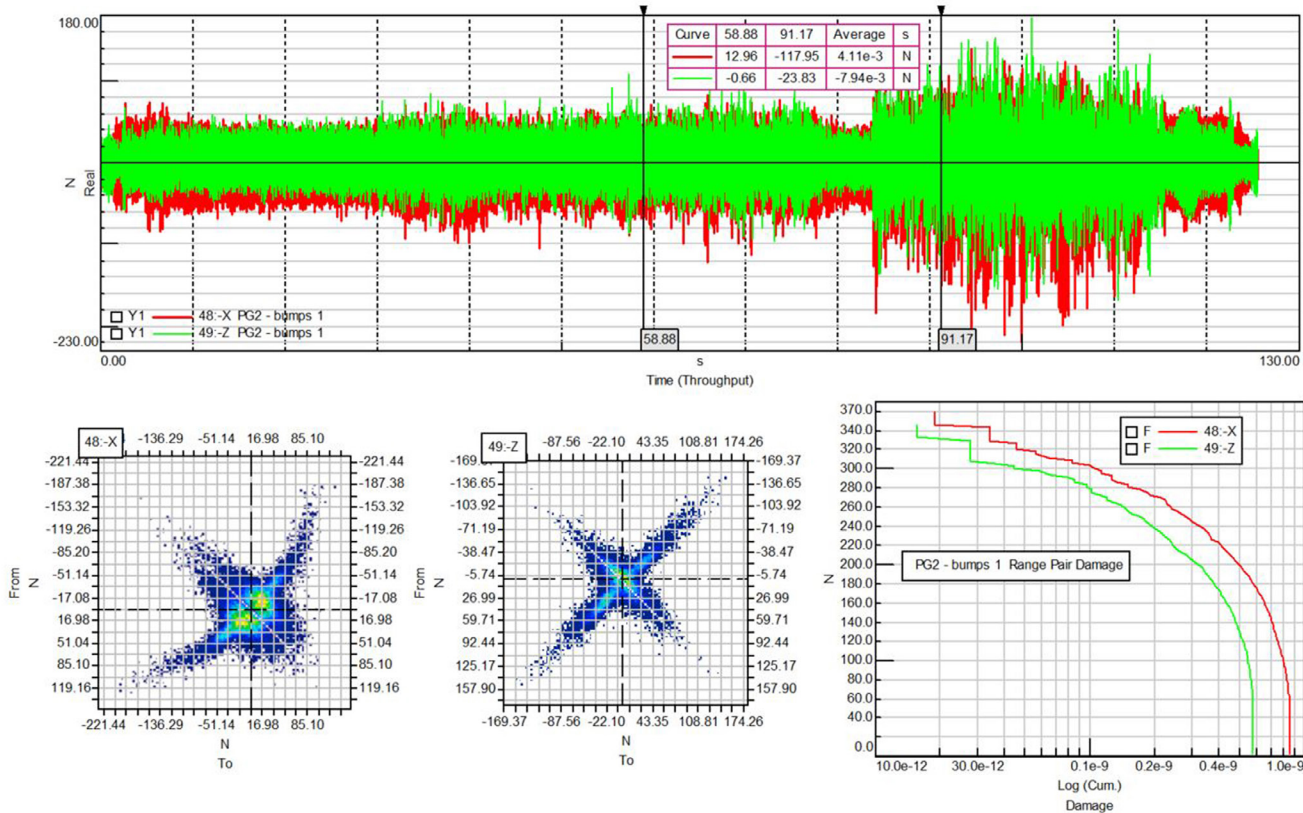


Figure 4: Quicker delivery by embedding complete test data in actionable reports.

team members or staff management can further assess the results and format or edit graphs as they see fit.

**End-to-end durability engineering**

Simcenter™ solutions streamline road-load data acquisition and analysis in order to set realistic durability targets for simulation and test-based validations. They accelerate time-to-market, and enable you to meticulously balance weight, strength and durability to avoid vehicle recalls and meet customers’ expectations.

“Simcenter Testlab offers an integrated, end-to-end solution for load-data acquisition and processing,” comments Guillermo Gonzalez, function and durability manager at Nissan Technical Center Europe, Spain. “The solution accelerates the delivery of critical durability insights when preparing for test rig campaigns or reliable simulations. It is faster, easier to use and robust.”

**Siemens PLM Software**  
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