Proving ground optimization

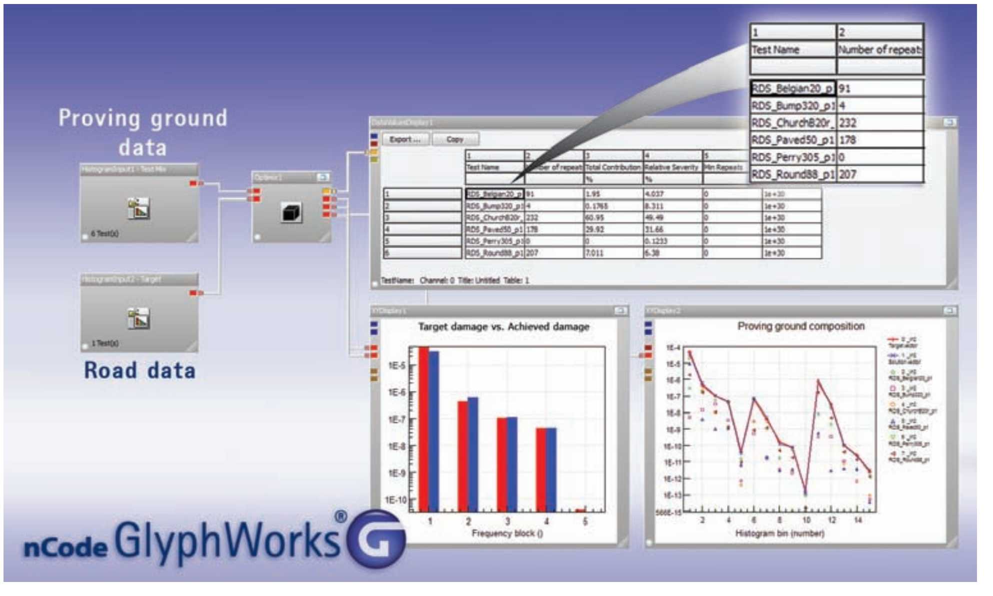
New technology for proving ground-schedule development enables durability engineers to get best value and minimize test time

HBM-nCode
Email: ncode@hbm.com
Web: www.ncode.com

Proving grounds can provide an extremely efficient means of solving the durability engineer's perpetual paradox: to ensure very quickly that the vehicle will last a very long time in real usage. But how is it possible to get the best value from proving-ground usage? HBM-nCode has addressed these current challenges through new technology for proving ground-schedule development.

The use of proving-ground surfaces is being reviewed and reinvented at many OEMs. Consolidation and changed ownership have meant that certain proving grounds are no longer available for use. For example, Ford's proving ground at Wittman, Arizona, was originally the Volvo Arizona proving ground, while in 2008, what had been the Ford desert facility at Yucca was acquired by Chrysler. Determining 'equivalence' between proving grounds has gained importance: what mix of which road surfaces or events at proving ground A is required to match what was used at proving ground B?

Increasingly, vehicle programs are used in many countries by global counterpart divisions. Questions arise regarding which test schedule is appropriate for different versions, and how to quantify the effect of the varying durability schedules that are used globally.



ABOVE: nCode GlyphWorks can provide users with a rich framework for signal processing large amounts of data

The actual usage differences in these markets are also being considered. Many manufacturers conduct customer-usage programs to help understand real-world usage. Some OEMs use detailed customer surveys to determine percentage driving patterns and actual representative highway or rough-road surfaces. Specially instrumented vehicles are used on these surfaces to capture strains, accelerations, and loads to quantify real-world conditions.

A larger fleet of vehicles can alternatively be used to capture data from the vehicle network, capturing and storing CANbus information on engine usage, speed, gear position, and so on. As new vehicle types, using hybrid and electric drivetrains, are developed, questions need to be answered regarding the engineering requirements for meeting customer needs, and how these new platforms will affect driving styles and usage.

There is also ongoing pressure for quicker, more cost-effective development programs. The cost of prototype vehicles and the many weeks of effort required for physical testing at several global locations will continue to be the target of streamlining measures. How can we remove a prototype from the schedule? Can we run the test more quickly with fewer events? Can we rely on CAE simulation for certain aspects? What tests can be run on simulators in the lab? Can we eliminate complete tests?

Because proving ground tests have typically been developed over many years, there is often reluctance to change the test process, even though it has long been accepted that proving-ground testing is far from perfect and will tend to under-test certain components and over-test others. This knowledge has been gained by long and sometimes costly experience, making the challenge of optimizing a well-established durability schedule even more daunting.

Until recently, solutions to this optimization problem have had varying success. Numerical results would often be sensitive to the sequence in which the surfaces were considered, or provide non-physical results such as negative numbers of repeats.

Also, the data analyzed are often simplified rainflow-cycle counts that tend to emphasize matching, non-damaging small cycles of load – which are more numerous – at the expense of the fewer larger cycles that cause most of the damage. Rainflow-cycle counts also do not contain any frequency information, and therefore omit the effect of fatigue damage, due to vibration on subsystems, such as steering columns or other non-structural components.

New software by nCode, an HBM brand that focuses on providing durability solutions, will soon be available to help address many of these issues. The challenge is to determine the optimum, most efficient mix of proving-ground surfaces required to match an overall target. This target, for example, could be another proving ground or a customer-usage profile from another region of the world. The need to consider measurements and responses from not only one location on the vehicle but from many parts can make these challenges particularly difficult. Optimization algorithms are required to determine the best mix that minimizes the difference across all channel locations.

This 'TestMatch' solution is integrated within nCode GlyphWorks, which provides a rich framework for signal processing large amounts of data. The approach comprises two parts. First, a relative damage-spectrum technique is provided to calculate fatigue damage for each channel for multiple frequency bands, to produce a damage-weighted frequency spectrum.

Defaults shown to be best for ground-vehicle road data are provided, but users can also define their own ranges. Accelerations can be automatically converted into approximate displacements, which tend to correlate more directly to the strain that drives fatigue damage.

Second, both linear and non-linear least squares-optimization techniques are provided to find the best mix of surfaces. The optimization methods can aim to give either the closest match of data, or to minimize the number of repeats required, and thereby save time required for testing. Constraints can also be defined to ensure realizable results by setting limits on every surface. This means that no single surface can, for example, be allowed to account for than 20% of an overall schedule. The interface enables what-if trade-offs to explore the application of different constraints or the removal of complete events. The input for the optimization is very flexible and, despite the advantages of the relative-damage spectrum, can also optimize the summation of many types of data, including rainflow-cycle counts, or even overall fatigue-damage values.

Results from these new techniques are shown to be robust. This is a powerful tool to help meet the durability engineer's challenge of determining which mixture of proving-ground surfaces offers the best representation, while minimizing total test time. ❮

"The challenge is to determine the optimum, most efficient mix of proving ground surfaces required to match an overall target"