

# Toyota Racing Development Makes Faster and More Efficient Engineering Decisions with MATLAB®

For different race track surfaces, should the car's suspension be changed for better responsiveness, or the shocks adjusted for better road feel? To answer questions like these, which can mean the difference between first and second place on the race track, engineers must quickly interpret vast amounts of test data.

Toyota Racing Development's (TRD) Race Vehicle Engineering group uses MATLAB® to analyze and process test data for all of Toyota's racing initiatives, including the NASCAR Craftsman Truck series.

"Everything that I want in an engineering package is there in MATLAB, and it's very accessible," says Skip Essma, senior race vehicle engineer, at Toyota Racing Development. "MATLAB gives the best combination of ease of programming and access to powerful routines, techniques, and visualization tools."



Shaker lab testing.

The challenge, says Essma, is to make the vast quantities of data produced by these tests meaningful: "These days, you can gather more data than you can store on a hard drive, but you need to make that data useful by correlating individual metrics with on-track performance and driver feedback."

## THE SOLUTION

TRD used MATLAB and the Statistics Toolbox to process, analyze, visualize, and share data generated from laboratory testing and simulations and apply the results to improve performance.

"MATLAB often helps us correct a deficiency on the vehicle, respond to driver feedback, or address the conditions of the track with five changes as opposed to twenty," Essma says.

Using MATLAB, TRD performs detailed tire analysis for each race track. Essma and his team import data from a commercial lap simulation program into a tire analysis routine written with MATLAB, where they process and present data to help understand how the tires will perform in the upcoming race.

## THE CHALLENGE

To access and analyze vast quantities of test data and make intelligent engineering decisions quickly

## THE SOLUTION

Use MathWorks tools to import the data, perform the analysis, visualize the data, and process the results

## THE RESULTS

- Reduction in analysis time
- Reusable analysis results
- Successful performance on the track

## THE CHALLENGE

Before arriving at the track on race day, TRD evaluates a race vehicle's chassis by performing wind tunnel, shaker, kinematics, compliance, and hundreds of other tests in the laboratory. These evaluations help TRD consider the millions of possible combinations of vehicle components and recommend ways to improve vehicle performance and drivability.

“There isn’t a piece of data that goes into a simulation program that is not processed with MATLAB,” explains Essma. “From fitting the aerodynamic maps to analyzing tire models, MATLAB handles all our preprocessing and postprocessing tasks.”

TRD used the Statistics Toolbox to develop the Experimental Design Tool (EDT), which uses Design of Experiments to help define the most significant test points to acquire during on-track or laboratory test runs. They also used the EDT with simulation programs to batch process thousands of simulation runs for different attributes of performance, and then automatically aggregate and analyze the data. Response surfaces are then fit to results to evaluate which setup changes had the most effect on performance.

The TRD team created graphical user interfaces (GUIs) to make engineering tools accessible to end users and plans to distribute the GUIs to other groups using the MATLAB Compiler. They also plan to use the Optimization Toolbox to balance multiple design tradeoffs.

“ We get more data than we can possibly sift through. MATLAB is our workhorse for viewing, sharing, and processing that data. ”

Skip Essma, Toyota Racing Development

## THE RESULTS

### ■ Reduction in analysis time.

“Originally, we used Excel for the tire analysis, which took a couple of days,” says Essma. “With MATLAB and the Statistics Toolbox, it now takes only a couple of hours.”

■ **Reusable analysis results.** “Once we figure out a good way to analyze the data to prepare for a race, we code it in MATLAB, and reuse it again and again,” comments Essma. “Everyone in the group shares this code to be more efficient.”

■ **Successful performance on the track.** In only their first year in the NASCAR Craftsman Truck series, TRD has already helped Toyota capture four wins and place three drivers in the top fifteen in championship points.

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### APPLICATION AREAS

- Automotive
- Data analysis

### PRODUCTS USED

- MATLAB
- Statistics Toolbox
- Optimization Toolbox
- MATLAB Compiler

[www.mathworks.com](http://www.mathworks.com)