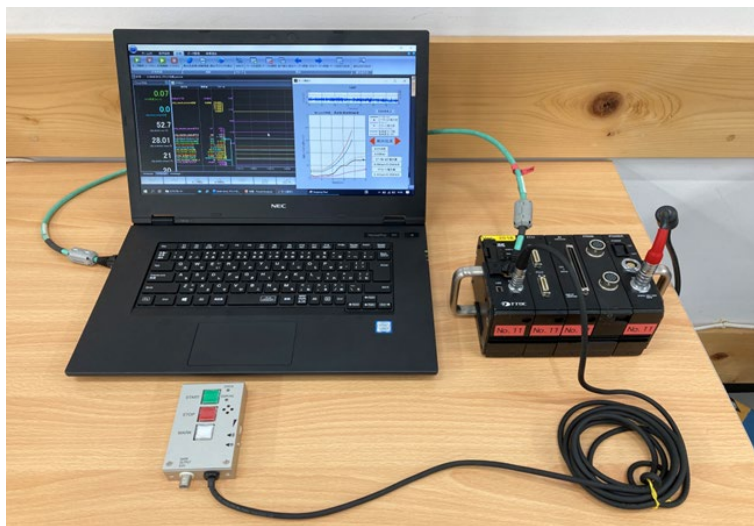


Contributing to drivability evaluation testing through real-time analysis technology!



Evaluation equipment, including Panel4 Source: TMC

Toyota Motor Corporation
Vehicle Development Center,
Chassis & Vehicle Technology
Development Division



Vehicle Technology Development Department
Dynamic Performance Development Department 1
Mr. Nagata, Shunin



Vehicle Technology Development Department
Brake and Dynamic Drivability Testing Section
Mr. Ouchi, Team Leader

◆What kind of work do you do?

Mr. Nagata: I am primarily responsible for the development of dynamic performance, particularly drivability. Drivability is the indicator of how well a vehicle responds to the driver's intentions. For example, it refers to the quality of the vehicle's response when the driver steps on or releases the accelerator. Rather than developing production vehicles, we are involved in developing drivability performance development processes and technologies for more efficient development tools. In addition, we are involved in designing the hardware and control methods needed to achieve the target performance. Our work extends beyond evaluation, and we are deeply involved in the design phase as well.

Mr. Ouchi: I'm responsible for evaluating the vehicle's dynamic performance in actual vehicle tests, particularly its driving performance. We drive the vehicle on a proving ground to evaluate its powertrain performance, such as launch acceleration, passing acceleration, and top speed. We also evaluate drivability to determine whether the vehicle feels comfortable to the driver, is smooth to drive, and responds appropriately to accelerator operation.

◆What were the key requirements for solving these issues?

With the conventional evaluation process, it took a considerable amount of time to go from collecting data on the test track to analyzing it, reviewing the results, and preparing reports, making the overall workflow inefficient. More specifically, once the collection of time-based data (such as acceleration and vibration) from the proving ground was finished, we then had to return to our desks and process it before we could calculate quantitative KPIs, such as shock levels, vibration levels, and response times. That entire process took a significant amount of time. Since it took so much time just waiting for the results, it was difficult to correlate the driver's subjective impressions during the test drive with the analyzed data. Preparing reports to document the analyzed data was also a time-consuming part of the process.

◆What were the key requirements for solving these issues?

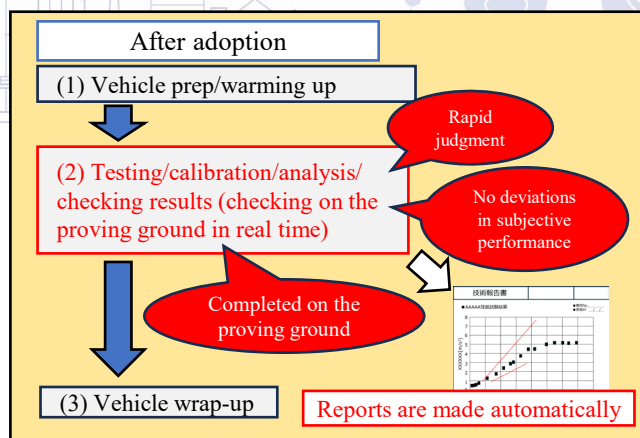
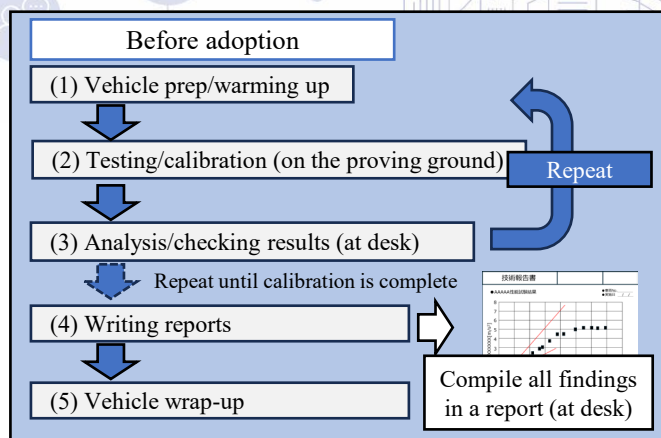
When evaluating a vehicle's dynamic performance, it's important to accurately assess response characteristics and shock levels. The following requirements had to be met to solve these issues.

- 1) Detailed data, such as accelerator position and vehicle speed, is displayed on a monitor during testing, allowing evaluators to view it in real time. This enables them to accurately keep track of the test conditions while carrying out the evaluation.
- 2) If we can calculate quantitative KPIs directly in the evaluation vehicle, without having to return to our desks, we can significantly reduce the time required to make pass/fail judgments and determine whether a retest is needed.
- 3) If a technical report can be generated automatically once the analysis is complete, it can significantly reduce the amount of work required after returning to our desks.



Working environment of
evaluations and tests
Source: TMC

Dramatically reducing evaluation time through real-time analysis and data visualization!



Comparison of the evaluation workflow before and after adoption

◆Could you tell us why you choose TTDC?

In the past, data collection, analysis, and report preparation were all done manually. As part of our workflow improvement efforts, TTDC developed a tool that allows us to perform post-processing and analyze drivability test data. This dramatically improved the efficiency of evaluations. We wanted to build on the tool's success and improve the process even further. Because of TTDC's technical expertise and proven track record, we asked them to develop a next-generation real-time analysis tool for drivability evaluation.



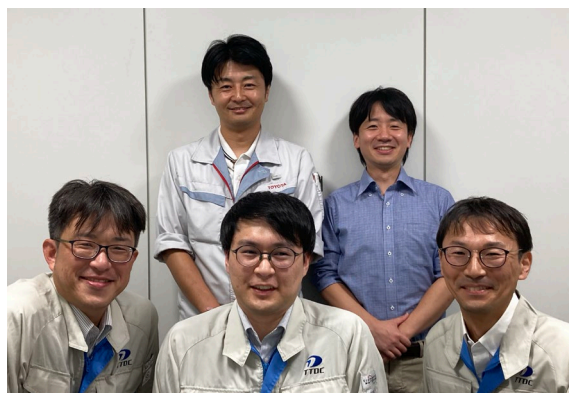
Post-processing and analysis Source: TMC

◆What were the benefits of adoption?

Previously, it wasn't possible to confirm in real time whether quantitative KPIs, such as shock and vibration levels in response to accelerator inputs, met their targets while driving the test vehicle. Instead, we analyzed the collected data afterward using an offline drivability analysis tool. However, thanks to TTDC's technology, we can now analyze data and display the results in real time, significantly improving the evaluation process. With the real-time analysis tool, we can now instantly verify KPIs related to accelerator operation while driving on the proving ground. As a result, we can make decisions much more quickly on site, improving the accuracy of our evaluations. In addition, because the collected data is quantified on the spot, if a KPI is not met, evaluators can immediately rerun the test and investigate the cause while they are still on the proving ground. It also makes it much easier to correlate the quantitative data with the evaluator's subjective impressions, improving the reliability of the evaluation results. Previously, there was always some uncertainty until the data had been analyzed and the results could be reviewed. Now, however, we can obtain reliable results immediately on the spot.

◆Could you tell us about your plans for the future?

The analysis tool is now being rolled out to other departments. In particular, for drivability evaluation, the tool can now be accessed and used by other departments via our shared internal site. For example, the engine development team has adapted the existing analysis logic to evaluate the responsiveness of the control system when the accelerator is released. Going forward, we plan to continue working with TTDC to expand the tool's capabilities and application based on requests from the powertrain, chassis, and other development teams. We're also planning to use the analysis tool that's currently used for vehicle testing during the simulation phase, allowing us to verify that the vehicle specifications and design meet our expectations before physical testing. In whole vehicle simulations, the vehicle is driven in a virtual environment, and acceleration data is collected as time-series data in the same way as during physical vehicle testing. The simulation data is then post-processed using the same analysis tool we use for physical vehicle testing, allowing us to verify whether the target KPIs have been achieved in the virtual environment. Finally, the same analysis tool is also being used on the powertrain HILS* bench. On the HILS bench, the powertrain is actual hardware and the vehicle is represented by a simulation model. Virtual vehicle acceleration data is collected and used to calculate quantitative metrics. Going forward, we'd like to establish a consistent evaluation process that uses the same analysis tool from the simulation phase through to physical vehicle testing, allowing us to verify quantitative metrics and evaluate KPI achievement throughout the entire development process. ※ Hardware-in-the-loop simulation



Back row, from the left: Mr. Ouchi, Mr. Nagata
Front row (from the left): Mr. Ito (TTDC), Mr. Miwa (TTDC), and Mr. Niwa (TTDC)