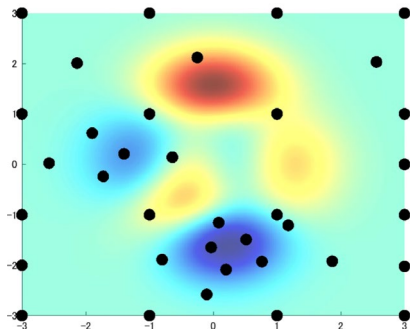
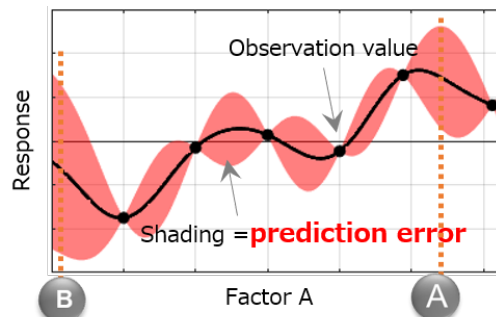


Integrating AI in our workflow and shortening development time!



Visualization of AI-based search



◆ What type of work do you do?

Our work involves connecting simulation models and data across vehicles, powertrains, and control domains to evaluate from a mobility perspective. We immerse ourselves in the workplaces of vehicle performance evaluation, testing, and simulation-based evaluations respectively to promote digital development. Our team integrated AI in the V-shaped (development) process for mobility development and made evaluations more efficient. Raising evaluation efficiency requires domain, engineering, and AI knowledge. We selected a suitable AI from the limitless number of available options, and are now creating new value by reducing the number of logically useless evaluations and measurements, and by shortening development time.

Toyota Motor Corporation

Drive Digital Integration Dept. Vehicle Digital Development Div.



Mr. Minoru Tsuchiyama,
department manager



Mr. Kohei Shintani,
group manager

◆ What challenges do you face in digital development?

We rely on the V-shaped process model-based development approach for the digital development of mobility. The V-shaped process makes it possible to separate work into two categories: the design process (left side), and the evaluation process (right side). The left side mainly involves fixing the design and specifications related to mobility. The right side involves digging deeper into the evaluation of the selected model. We tailor the vehicle's driving characteristics for each market by optimizing control parameters and vehicle specifications. With model-based development, it is possible to conduct digital evaluations through simulations instead of using hardware. This also makes development possible at various locations, with software alone. As models become capable of representing a wide variety of hardware, different models can be combined in diverse ways, resulting in an enormous number of possible configurations. Selecting a model compatible with the constraints and conditions from all those variations and refining it increases the number of parameters. The exponential rise in computation volume makes it difficult to obtain an answer within a realistic timeframe. Problem solving through collaboration with companies like TTDC that have divisions with a vast range of specialized knowledge, and the education of new personnel that have a wide set of skills is proving to be challenging.

◆ What are the requirements for solving issues?

Technology that efficiently searches for the optimal combinations for on-site needs (optimization technology) is necessary. We need to identify the models, tools, equipment, and test conditions of all regions that use V-shaped development. We also need to create performance-based model sets, tool sets for different applications, equipment for each stage of the process, and complex test conditions. There are two requirements for solving these challenges.

- (1) Being able to connect optimization technology with simple tools and equipment.
- (2) The ability to integrate domain expertise with AI expertise.

We are looking into AIs that meet those requirements and prove usable and practical in CAE and test evaluations. AI is an umbrella term that encompasses a wide range of technologies, including image recognition, anomaly detection, and natural language processing. One of our challenges is recruiting and developing engineers with the expertise needed to meet our department's specific requirements. Engineering skills cover a very broad range, and deeper specialization is needed to remain competitive. To address this, we are also establishing in-house systems and frameworks for personnel development, but we still do not have enough engineers. For this reason, we believe that working closely with TTDC and collaborating with engineers who have specialized expertise is essential to solving these challenges.

Significantly reduce development time and costs by integrating AI with existing LA, XILS, and simulation models!

◆ Tell us why you chose TTDC

Based on our previous experience working with TTDC, we had seen firsthand its strength in development environment construction, which is why we asked for its support. Optimization technology alone cannot transform the development process. The AI technologies we develop are applied across a wide range of areas, including XILS (particularly SILS and HILS) and VRS test facilities. Their full potential can only be realized by achieving integration and automation. We believed that collaborating with TTDC, which is engaged in the development of XILS environments and the implementation of LA systems, would be the quickest way forward. Furthermore, we wanted to work together as part of the Toyota group.

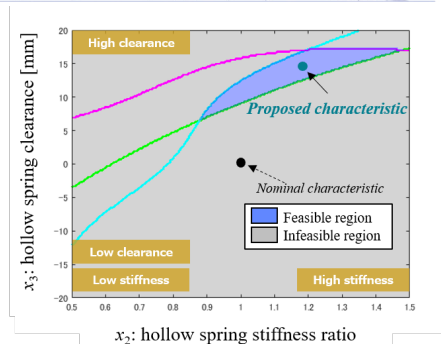


PT-VRS bench

◆ What were the benefits of adoption?

Here are two clear examples of how we benefitted.

The first (right-hand part of the V-shaped development process) is the application of AI technology (Bayes Dock) to automating screening evaluations for driveability. This example illustrates how we automated a series of steps by employing Bayes Dock to search through the ratings in the results after using an actual PT-VRS device for the driver model and evaluation. Replacing actual vehicle screening evaluations with a combination of bench testing and automation enabled us to reduce work hours as well as the number of tests. With the conventional method, an exhaustive search had to be performed, requiring the evaluation of five million combinations. Given the limited development schedule, this was not a realistic number of evaluations. Thanks to the continuous suggestions of the appropriate location to search provided by Bayes Dock, we have been able to reduce the number of searches from five million to 750. Evaluating 750 cases is a much more realistic target within the development schedule. At the same time, we also evaluated the differences between AI and humans, and obtained screening results comparable to those achieved by professional drivers relying on their experience and intuition.



Region where achieving both strength and ride comfort is feasible

The second (left-hand part of the V-shaped development process) is the use of Bayes Dock for the rigid axle suspension characteristic design. Characteristic design involves searching for the intersecting area of the strength and ride comfort feasibility regions. Finding the whole intersecting area (the blue area in the figure above is the intersecting region of feasibility) is extremely important in determining robustness and deciding on suspension characteristics that account for variation. Similarly, narrowing down the intersecting area as development progresses and new requirements arise makes it possible to avoid rework. Using the feasibility search, another Bayes Dock feature, to make all-encompassing searches has (without giving specific figures) helped reduce development time and reduce costs by several hundred billion yen.

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

We have built up a strong track record in drivability screening and, going forward, we plan to expand its application to ADAS, as well as to incorporate simulation into vehicle testing that has traditionally been conducted using actual vehicles. As we must address these challenges with a limited number of people, we will set priorities moving forward. Specifically, we plan to apply it to XILS-related applications and powertrain calibration, while expanding its range of applications by improving its portability. This will physically expand its range of application. To improve maintainability, we are also considering using it in the cloud. In addition, we are also considering further technical enhancements so that it can support a wider range of categorical variables, and have plans to expand its scope.



Back row (from the left): Mr. Yamaguchi (TTDC), Mr. Iwata, Mr. Murai (TTDC)

Front row (from the left): Mr. Tsuchiyama, Mr. Shintani