Repeatable dynamic testing

Sophisticated use of testing methods and data gathering are integral to gathering dynamic tire footprint measurements in an accurate – and repeatable – manner

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Figure 1: This single map collects and organizes data for various slip angles (SA) and camber angles (CA) to show the effect of wheel alignment on the tire contact state

Figure 2: A&D's Dynamic Contact Force Rig (DCFR) uses a drum-type tire tester and ultra-compact force sensors that measure the three-component contact force distribution embedded in the drum road surface to solve the problem of repeatability and test conditions in tire contact measurement

When people test drive cars, they expect a quiet, comfortable, fuel-efficient, reliable and safe ride. These desirable qualities are all related to tire performance, which is meticulously tested by engineers throughout the development and manufacturing process. Tire ground-contact testing is crucial for providing valuable insights into tire performance, quality and safety. It uses specialized equipment designed to replicate real-world driving conditions and parameters relevant to tire behavior to evaluate the interaction between a tire and the road surface. This type of test analyzes the tire's traction, grip, brake performance, cornering stability, steering response, hydroplaning resistance, rolling resistance, wear and durability.

Dynamic footprint measurement is important because it measures how well a tire performs under specific conditions, which enables tire manufacturers to optimize the design for specific environments or driving styles. Handling and maneuverability responses to driver input are measured during testing, enabling engineers to assess the tire's performance in terms of cornering, braking and overall stability, thus ensuring a more predictable and controlled driving experience.

Tire wear patterns seen during ground contact testing provide valuable information about the tire's construction, alignment and maintenance. By identifying irregular wear patterns, engineers can alter the design to increase the tire's lifespan. Test information can also help develop tires with lower rolling resistance, which means improved fuel economy and reduced greenhouse gas emissions.

The detailed force distribution of the dynamic footprint influences the dynamic characteristics of the vehicle, which change depending on the tire posture, based on the wheel

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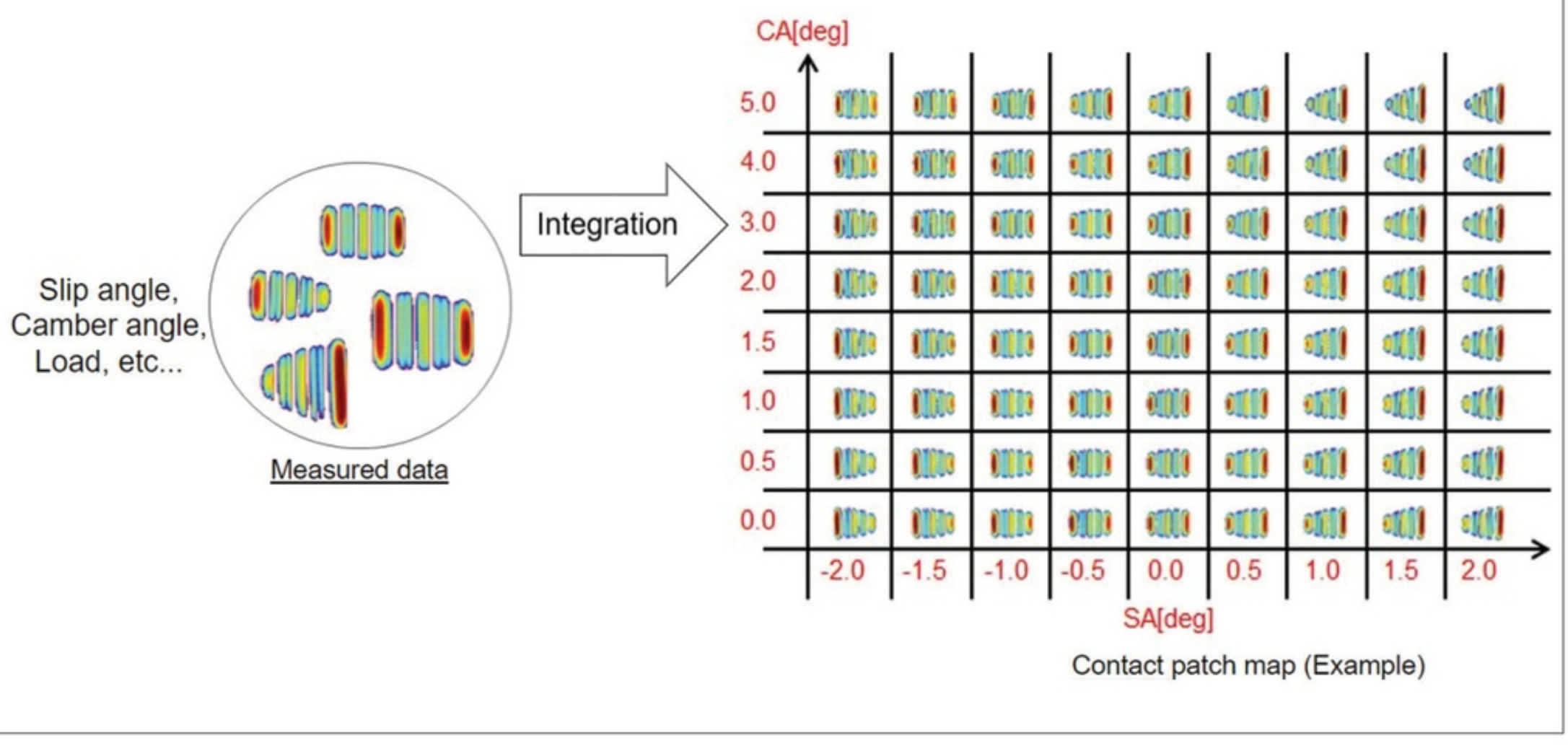
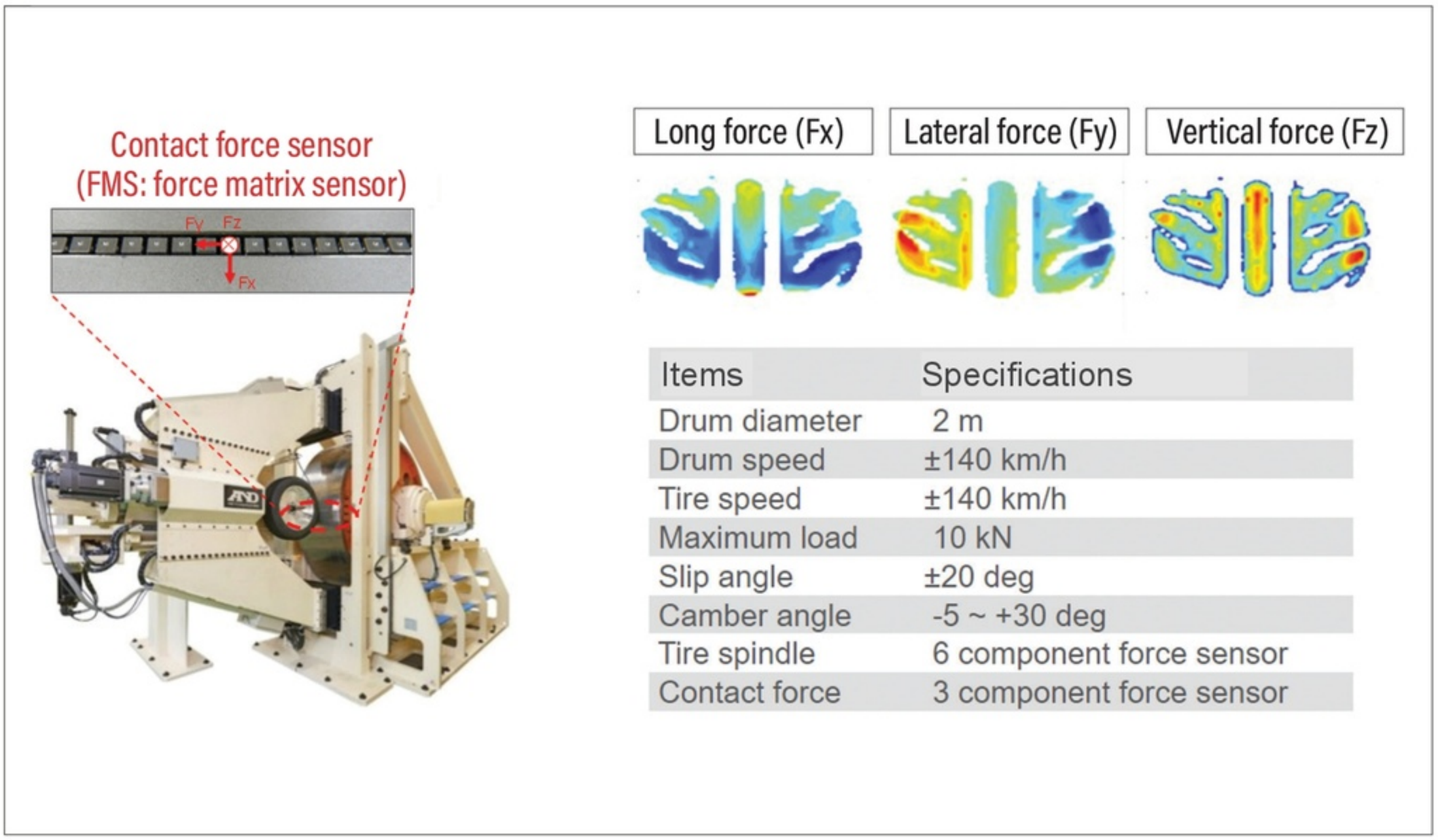




Items	Specifications
Drum diameter	2 m
Drum speed	±140 km/h
Tire speed	±140 km/h
Maximum load	10 kN
Slip angle	±20 deg
Camber angle	-5 ~ +30 deg
Tire spindle	6 component force sensor
Contact force	3 component force sensor

Figure 3: The conventional methods used to measure the ground contact state are to statically press the tire onto pressure-sensitive paper or install a sensor on the road and have the vehicle pass over it

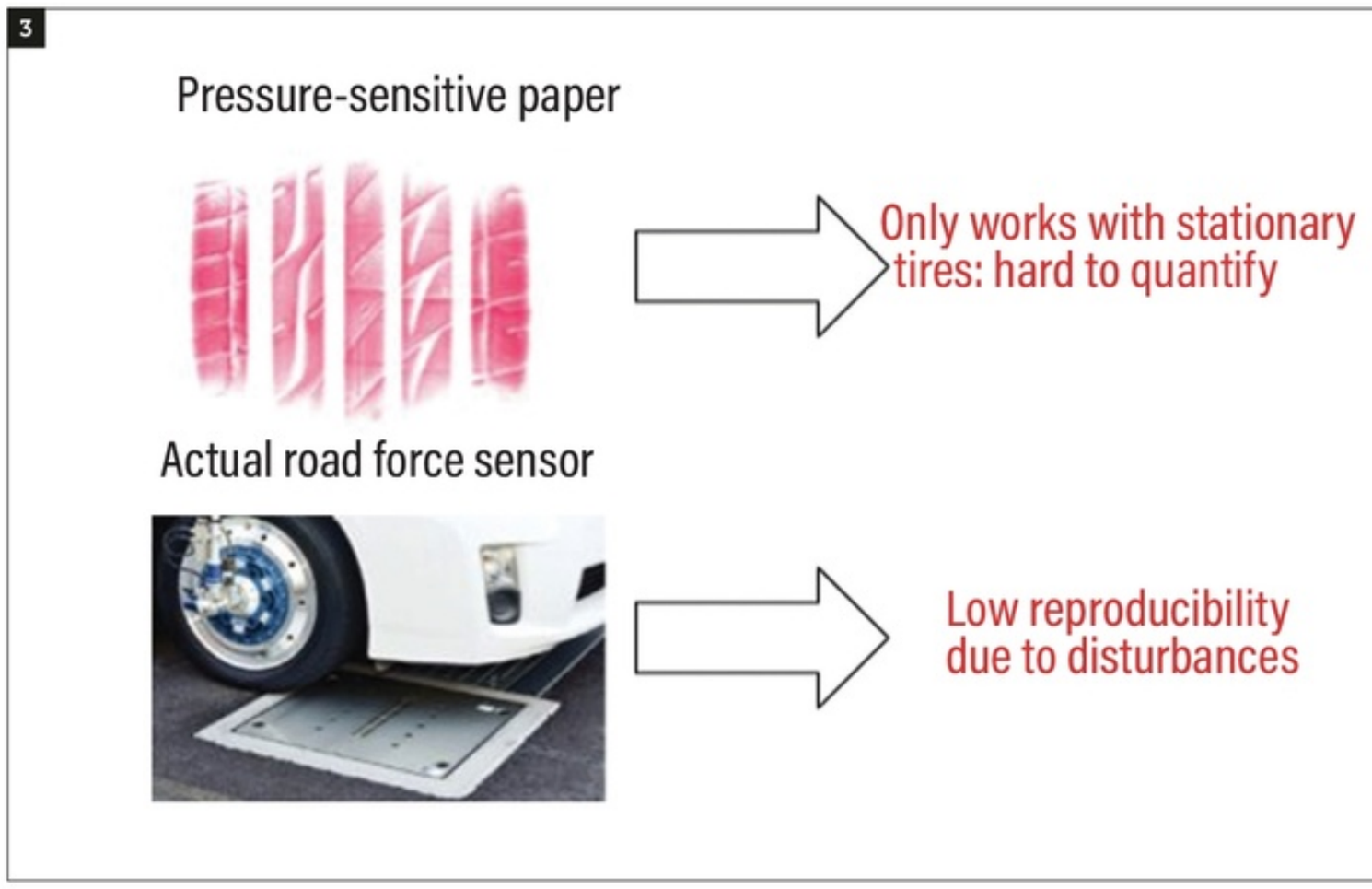
alignment settings. To optimize alignment settings it is important to understand the impact of tire posture changes on the dynamic tire footprint.

The conventional methods used to measure the tire footprint under various vehicle motion conditions are either to statically press the tire onto pressure-sensitive paper, or install a sensor on the road and drive the vehicle over it. In terms of measuring dynamic footprints, these methods are understandably impractical, due to the lack of test repeatability in reproducing disturbances and the inability to take measurements while the tires are rotating.

Providing repeatability

A&D's Dynamic Contact Force Rig (DCFR) addresses this problem of test condition repeatability in tire contact measurement by seeking to understand how tire alignment settings impact the behavior of tires when their ground contact changes. The DCFR uses a drum-type tire tester and ultra-compact force sensors embedded in the drum road surface, which measure the three-component contact force distribution.

The DCFR typically consists of a programmable moving platform for road simulation, actuators to apply simulated acceleration, braking and cornering forces, a load cell sensor in the spindle to measure the tire forces and moments, a control system, and a data acquisition system.



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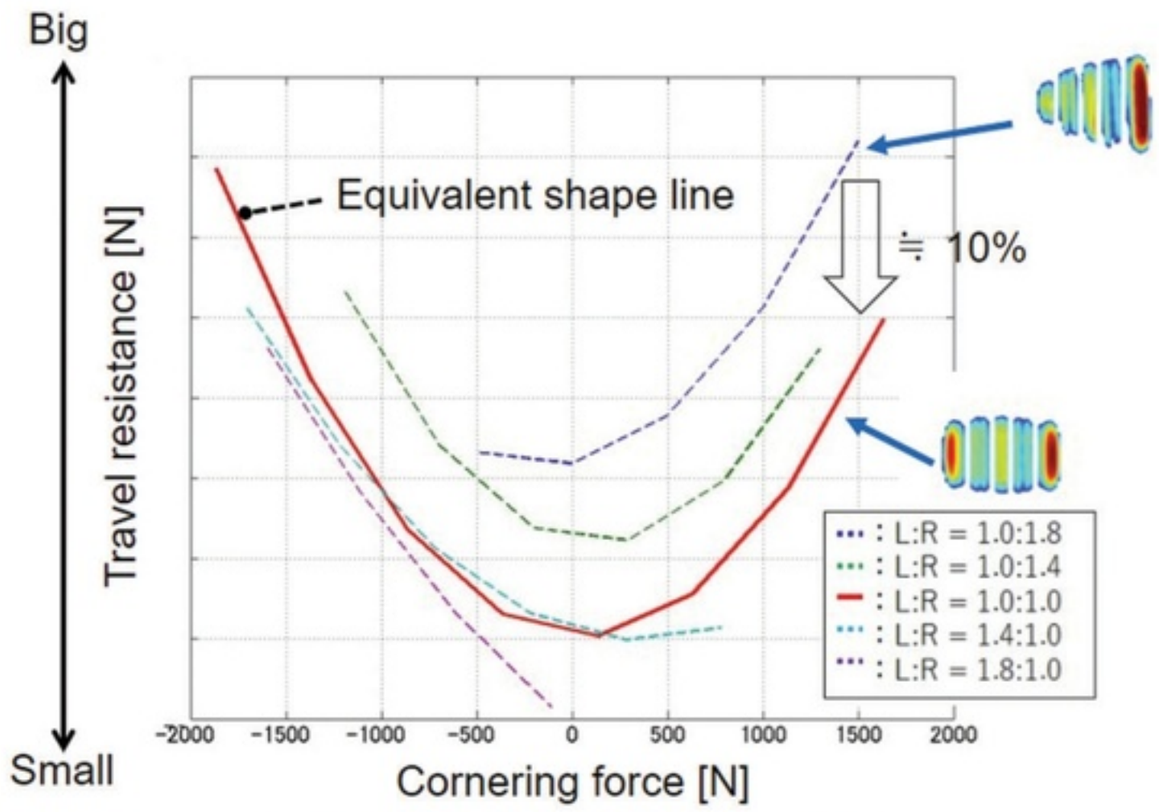
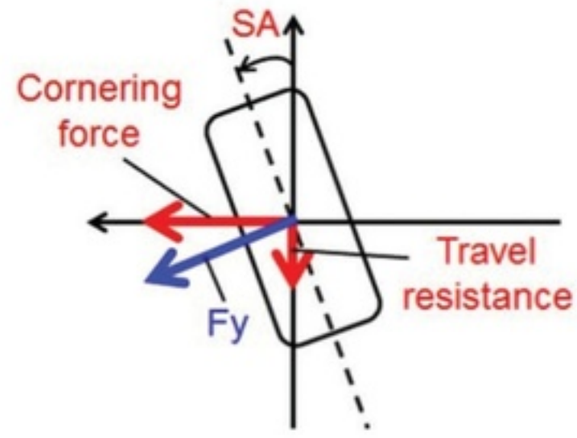


Travel resistance vs. Cornering force (approximated)



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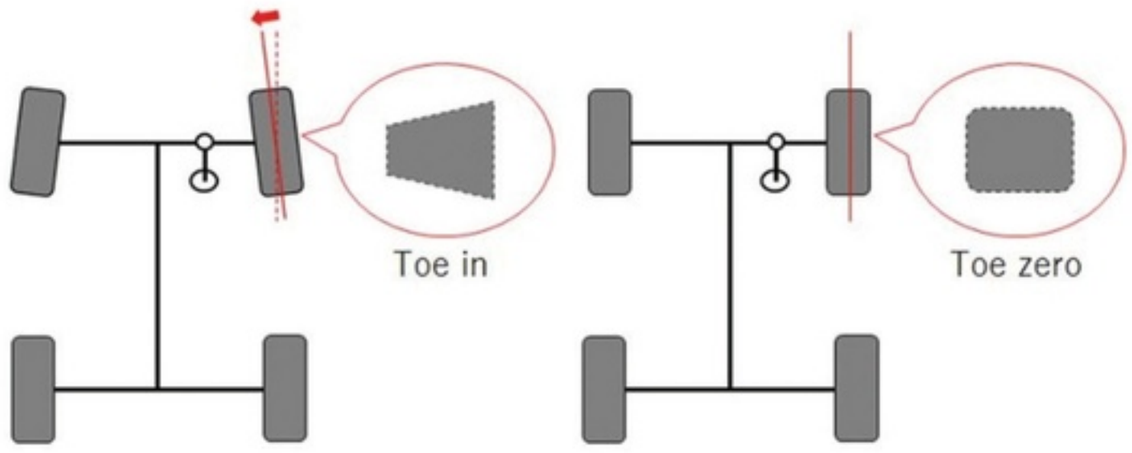
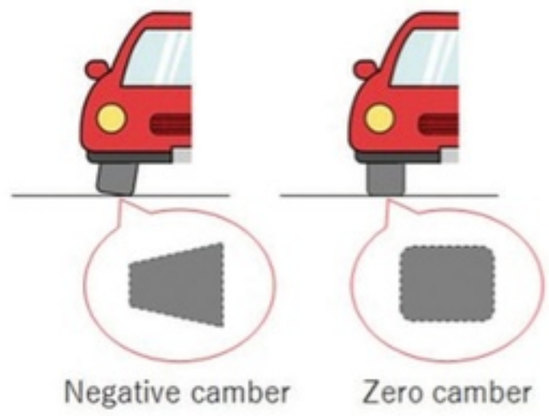


Effect of the toe on the contact patch



Effect of the camber on the contact patch

The measurement results obtained by the DCFR testing machine under various simulated real-world driving conditions are compiled into a single map. These informative tire-ground contact maps collect and organize slip and camber angle data into a graph showing the effect of wheel alignment on the tire contact state. This data shows the possibility of uneven tire wear from the left and right contact length ratio of the contact patch shape, and the contact pressure distribution. Other ground-contact testing graphs can show how running resistance is affected by cornering force, which can indicate how to alter tire alignment to reduce running resistance.

Besides the DCFR, A&D also offers other tire testing equipment such as flat-belt test rigs, rolling drum test rigs, vehicle measurement systems and a variety of other measurement, control and simulation systems. If a company needs tire testing but doesn't have the budget to invest in a rig, A&D also offers tire-testing services.

Figure 4: In the positive cornering force area on the horizontal axis of the graph, the equivalently shaped line tended to decrease the running resistance value more than the other lines, indicating the possibility of reducing running resistance by controlling tire posture

Figure 5: Understanding the impact of changes in tire posture when contacting the ground to optimize tire alignment settings

The information obtained from all these tire testing methods is essential for tire development, ensuring that tires meet regulatory standards, improving vehicle handling and stability, and enhancing overall driving safety and comfort. Moreover, the data obtained from DCFR testing is valuable for the development of new tire technologies and the optimization of tire designs for specific vehicle types and driving conditions. **tire**