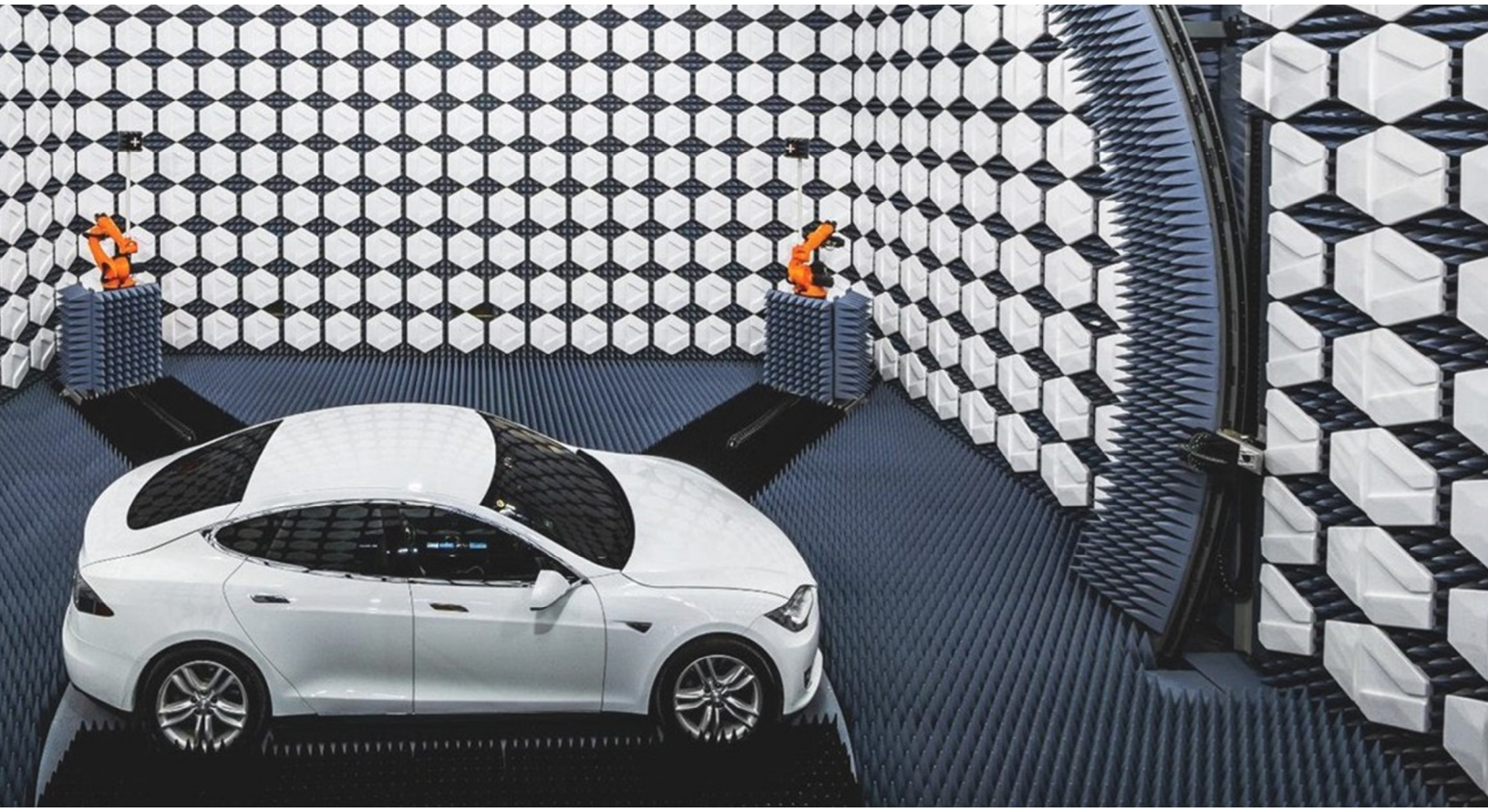
Measurement Technologies Help Shape the Mobility Society of Tomorrow



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China is the World's Largest Automobile Market. The Country has a Lofty Goal to increase the Percentage of Autonomous Vehicles (Level 4-5) sold to 10% by 2030.

In 2021, Start-Up Autox began offering Taxi Service using Unmanned Autonomous Vehicles in the City of Shenzhen.

Autonomous Vehicle Development in China

"... deploying a new wireless communication performance measurement system engineered by TOYO Corporation"

The technologies that enable autonomous driving vehicle development continue to advance at breakneck speeds, with test engineers constantly challenged to keep pace by deploying newer measurement systems. Testing and measuring the performance of wireless communication of vehicles through OTA (Over-the-Air) tests to evaluate the performance of a wireless communication environment is a crucial step to the development of reliable Advanced Driving Assistant Systems (ADAS) and Autonomous Driving (AD) vehicles.

In China, often evaluation tests become or turn into certification tests.

China's national research institute, the "China Intelligent and Connected Vehicles (Beijing) Research Institute (CICV)," was established in March 2019. CICV was formed by the China Society of Automotive Engineers (SAE), the China Association of Automobile Manufacturers (CAAM), and the China Industry Innovation Alliance for Intelligent and Connected Vehicles (CAICV). The research institute is operated by its shareholders and investors; they include OEMs, automotive equipment manufacturers, and global telecommunication industry giants.

CICV is deploying a new wireless communication performance measurement system engineered by TOYO Corporation specifically for testing intelligent connected cars. The organization is also planning to roll out an industry-first vehicle OTA test facility.

We spoke with Mr. Fang Dalong, a Senior Manager of the Platform Division at CICV, and asked him to provide us with an update on ADAS and AD technologies in China. We also talk to him at length about CICV's decision to create OTA-testing facilities, and how they see their role as test pioneers in the industry.

Imaizumi: Thank you for allowing us to speak with you. To start, can you let us know the status of autonomous driving technology development and OTA measurements in China?

Dalong: The simultaneous development of intelligence and connectivity has created unique solutions that integrate vehicles, roads, cloud computing, network infrastructure, and maps. Considerable government resources are being devoted to the development of infrastructure and connected cars. In the future, a vehicle's intelligence and connectivity (network) technologies will be important considerations for car buyers.

Full-vehicle OTA testing has just begun in China, and most testing organizations are still waiting and watching from the sidelines. However, two leading-edge research institutes in China, the China Automobile Process Research Institute, Inc. (CAERI) and China Intelligent, and Connected Vehicles (Beijing) Research Institute (CICV), have begun to make significant investments in test facilities to support OTA testing.

Imaizumi: We know private manufacturers and the Chinese authorities actively support technological and infrastructure developments; what is the role of a national certification organization such as CICV?

Dalong: As an industry leader, CICV is primarily responsible for industry-wide planning, top-level design, securing resources, and industry development. Our main areas of focus are:

Proper Evaluation of Communication Quality is Critical for the Success of Autonomous Driving Vehicles

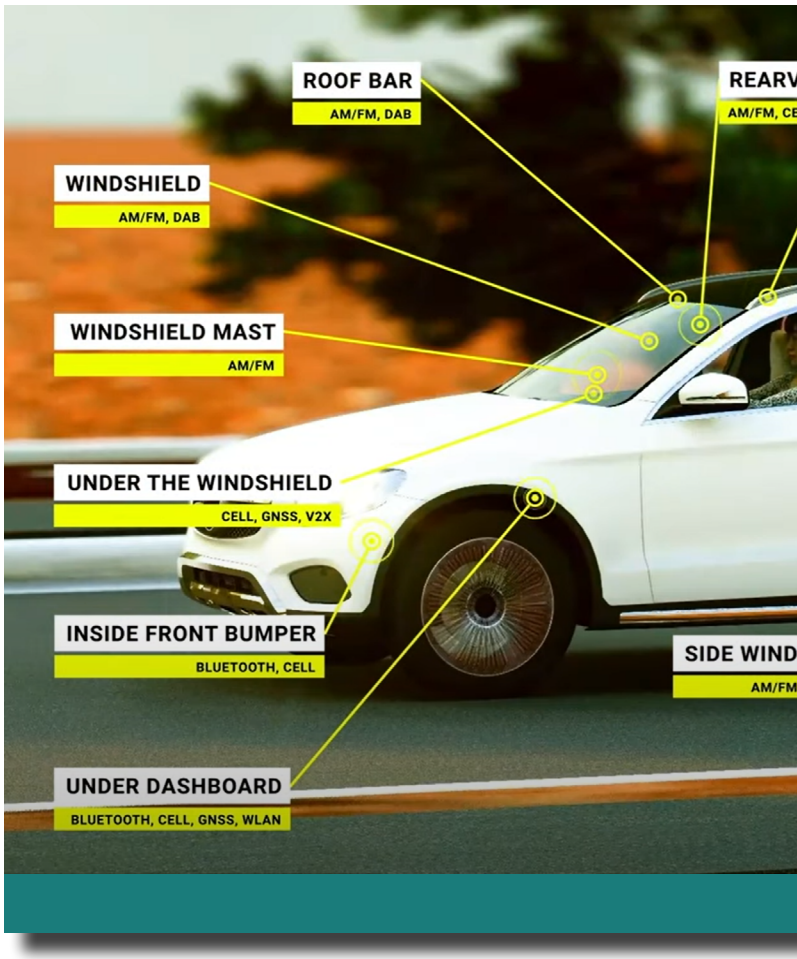
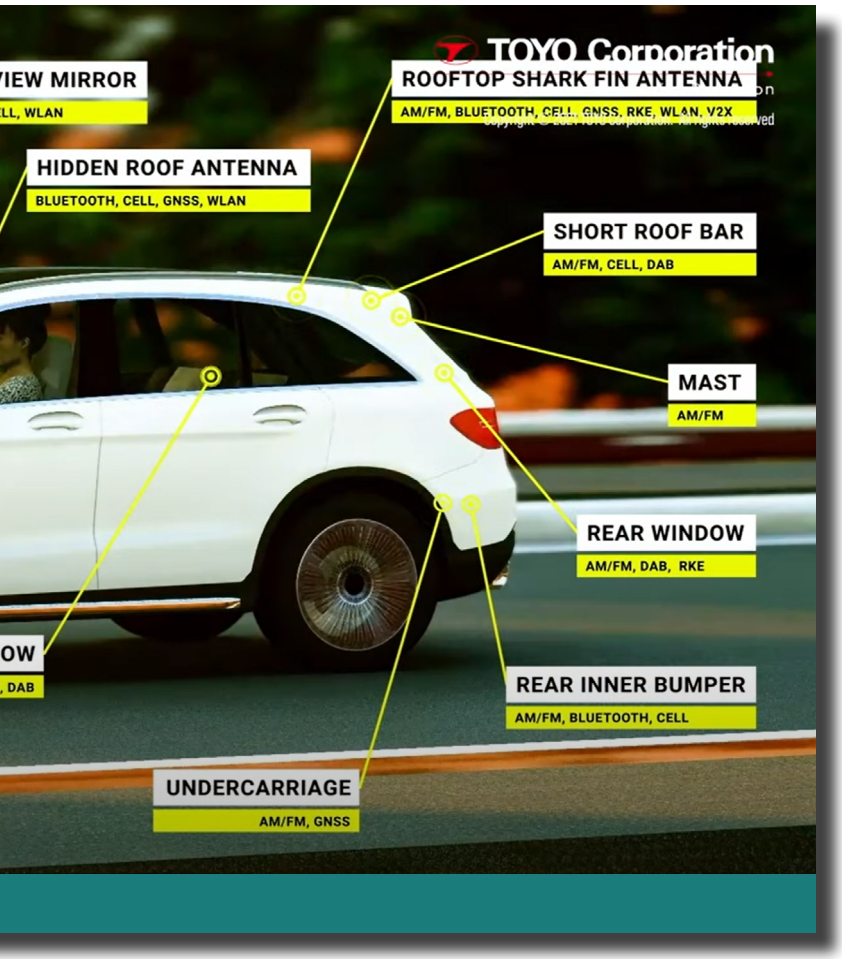


Photo (top):
Upwards of 15 or more antennas can be deployed in an intelligent connected vehicle

Photo (left):
Mr. Fang Dalong being interviewed by Mr. Yoshimichi Imaizumi



1. Establishing national development strategies and guidelines, and directing industrial development technologies and policies in response to the industrial progress.

2. Promoting basic research and advanced technology research. As an example, we released the 2.0 version of the physical platform for connected cars in 2021.

3. Conducting important basic technological research on computing infrastructure platforms, cloud control infrastructure platforms, high-precision map platforms, information security platforms, intelligent cockpit platforms, and other industry-wide needs.

4. Bridging industry, academia, and government, collecting industrial resources, converting results, promoting industrial applications, and developing industrial personnel.

Imaizumi: Needless to say, guaranteeing vehicle communication quality such as V2X (Vehicle to Everything) is very important for autonomous driving and vehicles. Could you tell us about the current status of initiatives for communication quality evaluation of autonomous driving vehicles in China? What are some of the challenges?

Dalong: At the present, tests are conducted mainly on communication terminals. Because requirements for production testing after integration have not been established, communication quality evaluations have yet to be conducted on a wide scale. Since full-vehicle testing is usually conducted outdoors, there are issues such as low repeatability, poor efficiency, and limited test scenarios. Although domestic standards for network communication testing of production vehicles have not yet been established, demand for such standards is rising rapidly. To respond to such demand, industry leaders are expected to take bold actions and initiative to establish such standards as quickly as possible.

Imaizumi: CICV is the first national research institute in China to introduce a large-scale communications evaluation system for vehicles. Could you tell us more about this introduction such as the purpose, reason, and background?

Dalong: Due to clear business needs to support the development and application of IoV (Internet of Vehicles) in the future, CICV is planning to construct a large-scale test lab as an innovation center for connected cars in the country, with an emphasis on automotive intelligence and networking. The OTA test lab is positioned as one of the key labs to spur technological growth. Looking ahead, IoV is an inevitable direction for the automotive industry, but the government has not yet prepared effective means for testing and regulating IoV. The full-vehicle OTA test lab can meet the needs of establishing benchmarks for future regulations and permits.

Imaizumi: The to-be-installed evaluation system utilizes the Radiated Two-Stage (RTS) test method for mobile terminals and base stations. Please tell us about the technical reasons why you decided to go with the TOYO system.

Dalong: First, both the RTS method and the multi-probe method (MPAC) are 3GPP[1]-approved test methods and are included in TS 37.544, a 3GPP international standard. MIMO[2] measurements on mobile terminals are all based on far-field testing. For example, MPAC must be conditioned on the far-field.

Because MPAC is a method to create a quiet zone (QZ) by superimposing waves from multiple probes, achieving a QZ large enough to cover an entire vehicle is not realistic.

The standard RTS method is based on two steps: antenna pattern measurements is the first step and throughput rate measurements is the second. Antenna pattern measurements require acquisition of the antenna pattern for far-field based on far-field conditions. However, there are two challenges in MIMO measurements of completed vehicles.

1. The vehicle is equipped with multiple antennas, which are located at different positions.
2. Measurements need to be conducted in the near-field.

In the project that prompted the use of this system, the RTS method is used to perform far-field MIMO2 measurements according to the following workflow:

1. While a DUT (device under test) antenna and a test antenna are connected via a vector network analyzer, the antenna radiation pattern (including amplitude and phase) is measured using the entire vehicle as a DUT.
2. The near-field to far-field transformation algorithm and antenna pattern of the DUT acquired in the previous step are used for conversion from near-field to far-field, and the far-field antenna radiation pattern of the DUT is calculated. The near-field/far-field transformation algorithm is used for spherical waves.
3. The vector network analyzer is disconnected from the antenna (DUT), and the DUT is switched to the communication state.
4. The calculated far-field antenna radiation pattern of the DUT is imported into a channel simulator and calculated using the channel model of the DUT to generate multi-channel throughput measurement signals.
5. The system measures the throughput rate by resolving an inverse matrix of the spatial propagation matrix and establishing one-to-one OTA correspondence to spatial propagation.

Imaizumi: What are the important considerations for the future development of autonomous driving technology? Please also share your expectations regarding test and measurement solutions developed by TOYO and our competitors.

With regards to intelligence and connectivity technologies, China has announced guidelines for connected vehicles seeking entry into the Chinese market. The requirements and test rules will be announced soon. Test requirements will include simulation tests, laboratory tests, on-road tests, information security tests, etc.

In addition, clear requirements for online upgrades have been released. And the requirements for vehicle internet connection will become crystal clear in the near future. We expect that the wireless communication performance measurement system that we have standardized on will be able to meet future market needs through updates, while also covering the current market needs.

Imaizumi: Emerging automakers such as Tesla in the US, and NIO and Lixiang in China have 100% of their fleet at Autonomous Driving Level 2 (Partial Driver Assistance). Some have achieved Level 2 with OTA upgrades. In the year 2020, Toyota led all manufacturers in the number of Level 2 (885,000) vehicles sold in China[3].

We know global automakers such as Toyota, GM, and Volkswagon as well as component manufacturers like BOSCH have invested in CICV. Please share the working relationship CICV has with its investors?

Toyota, GM, and Volkswagen enjoy substantial brand loyalty and market shares in China. These companies, like us, believe that the intelligence and networking of vehicles will advance in the future, and they expect to be able to follow China's future policy guidelines through CICV. We intend to work closely with these companies to quickly develop and apply intelligent connected cars (smart cars) and to partner on standards and regulations-making along with the industry-wide ecology. We are excited that they are also investors.

Imaizumi: Thank you for taking some time from your busy schedule to speak with us. We covered a great deal of information today and we also learned a lot about CICV and the intelligent connected vehicle industry. TOYO Corporation also believes intelligent connected vehicles are the future of mobility and we will continue to support the industry with our industry leading solutions. I wish you and CICV every success moving forward. Please come back at some point in the future and speak with us again.

Partnerships with Global Automobile Manufacturers is an must for Success. Toyota, GM, and Volkswagon are all CICV Investors

Photo (top):
Mr. Yoshimichi Imaizumi during the interview

Footnotes

[1] Third Generation Partnership Project (3GPP): An international project created in December 1998 for the popularization of third-generation mobile phones (3G) by standardization organizations in various countries. 3GPP examines and determines the specifications related to the mobile communication systems of 3G and later generations.

[2] Multiple Input Multiple Output: Wireless communication technology that uses multiple antennas simultaneously to transmit and receive data.

[3] Source: Global Information Corporation, "Analysis of the Chinese Level-2 (L2) Autonomous Vehicles Market, 2020). https://www.gii.co.jp/report/rinc984886-china-l2-autonomous-driving-market-report.html)

The China Intelligent and Connected Vehicles (Beijing) Research Institute Co, Ltd. (CICV) was established on March 2019 by Chinese automotive-related organizations China SAE, CAAM, and CAICV. CICV's shareholders include OEMs, automotive equipment manufacturers, and telecommunications leaders both in and outside China. On March 30, 2019, the Chinese Ministry of Industry and Information Technology (MIIT) approved CICV as the National Innovation Center of Intelligent and Connected Vehicles. CICV aims to strengthen global competitiveness and to build a world-class R&D platform with the objective of leading and raising the position of the Chinese ICV (Intelligent Connected Vehicle) industry and related industries in the global value chain.

Mr. Fang Dalong is a graduate of Tsinghua University, and hold a "high-grade processor (senior engineer)" national qualification. For more than 10 years, he has engaged in R&D and management of automotive products. While working at CICV, he has led or participated in the following projects: National ICV (Intelligent Connected Vehicle) Innovation Center Construction Project of the Chinese Ministry; Basic Data Services and Cloud Control Platform Construction Project; Completed Vehicles OTA and Autonomous Driving Simulation Project; and the Basic Design Project for Autonomous Driving Simulation Zone. His main research areas are autonomous driving and the Internet of Vehicles (IoV).

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