Evaluate In-Vehicle Wireless Performance Using OTA To Achieve Stable Connectivity

After-market connectivity issues in new vehicles, such as automobiles and motorcycles, in various usage environments can often cause customers to lose confidence, thus hurting the brand and sales volume. As a countermeasure, this case study introduces how to evaluate a product's wireless communication quality in a near real-world environment.

Market Trend

With the spread of the connected car offering telematics and infotainment functions, vehicles increasingly use wireless communications technologies, including cellular, Wi-Fi®, and *Bluetooth*®, which are installed in telematics control units (TCU), such as the one shown in Figure 1, or navigation systems.

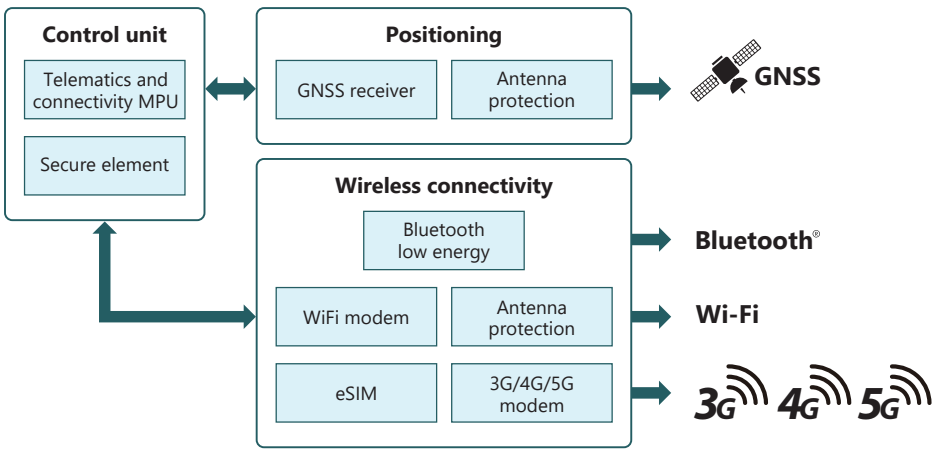

Figure 1 Example of TCU wireless function block.

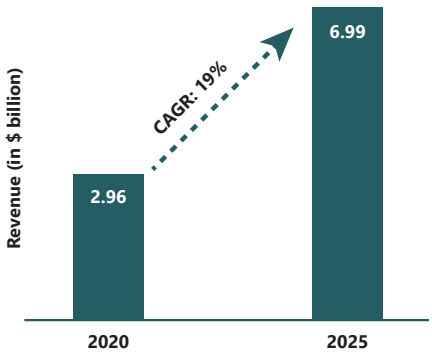

Figure 2 Global TCU shipment forecast (Source: Counterpoint).

Counterpoint Technology Market Research noted([1]), "From 2020 to 2025, global telematics control unit (TCU) shipments are expected to grow at a CAGR of 19%, and in monetary terms, the TCU market is expected to more than double to US$7 billion by 2025." (Figure 2)

The main uses of the wireless communication function include:

- Sharing traffic information and driving data.
- Viewing in-vehicle image data linked to smartphones.
- Managing driver physical condition by connecting to drive recorders and wearable devices.
- Managing operational conditions.
- Preventing accidents; supporting safe driving.

The recent appearance of telematics insurance services, such as mileage- and driving-behavior-linked services, that calculate car insurance premiums based on specific conditions, is expected to promote safe driving and reduce accidents.

Major Issues

◊ **Companies:**
Automobile and motorcycle manufacturers.

◊ **Major Issues:**
Although the wireless performance of the in-vehicle communication unit has been confirmed as a stand-alone unit, it may not perform as specified when installed in the finished product. A test solution that can evaluate actual finished-product use is required.

◊ **Solution:**
Wireless connectivity tester with the network testing mode.
Evaluation under actual use conditions using Over-the-Air (OTA) test.

◊ **Result:**
This OTA test solution allows products with wireless communication devices or modules to be tested easily in actual usage environment and shortens the development period by quick verification.

Manufacturers at every level of the connected car ecosystem must test vehicles, equipment, and components installed in or used with vehicles to internationally recognized standards. UN R10 (UN Regulation No. 10), 3GPP (3rd Generation Partnership Project), and IEEE.802.11 are examples of such standards. Furthermore, manufacturers establish separate in-house standards for vehicles used in harsh environments and test according to those custom parameters to prevent after-market issues.

The wireless performance of stand-alone TCUs, navigation systems, and other in-vehicle systems (Figure 3) incorporating wireless communication devices must be evaluated. Instability, however, may occur after the devices is installed in a vehicle, so connectivity must be verified in various test environments.

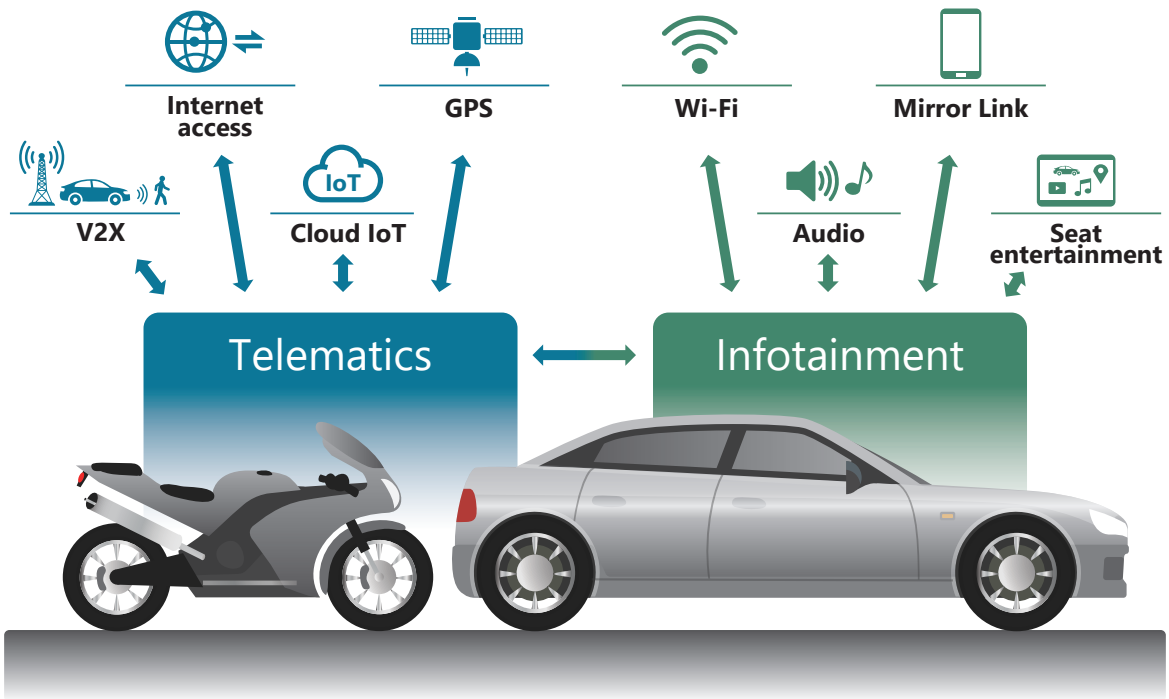

Figure 3 In-vehicle wireless communications systems.

The performance of finished products incorporating wireless communication devices must be verified to ensure that they meet the specifications, despite external factors.

1. Tx performance, Rx sensitivity, and finished-product antenna performance
Radio waves are affected easily by obstacles. Even if the stand-alone performance of the wireless communication device is guaranteed, the finished-product performance may be degraded by the antenna characteristics or mounting position.

2. Wireless communication performance due to noise in electrical and electric vehicle (EV) power systems
Modern vehicles have many electrical components and long wiring harnesses. In addition, EVs use high voltage and current. Noise from these electrical systems, as well as noise countermeasures, can degrade wireless communications quality.

3. **Noise from vehicle external sources and interference between wireless communications systems**
   Radio waves from external sources while driving or stopped can interfere with wireless communications devices and wireless communications quality. In addition, the increasing number and types of wireless communication systems may cause interference between systems.
4. **Wireless communications quality due to vibration while driving, changes in environmental temperature, etc.**
   Vibration during driving and severe environmental temperature changes may degrade wireless communications quality due to distortion within the wireless communication device and inter-unit connectivity effects.

Creating an OTA Test Environment

The various shapes of vehicles and position of the noise source for each model may affect the vehicle wireless communication performance. Therefore, it is necessary to evaluate the finished-product wireless performance during development to prevent after-market issues. Evaluating wireless connection conditions closely mimicking the actual usage environment requires OTA tests in conditions unaffected by external radio waves, such as a radio anechoic chamber. Figure 4 is an example of such an OTA test environment.

OTA measurements can test overall communication performance under real-world finished-product usage communication conditions by emitting radio waves from the antenna into the air.

The general procedure for measuring transmission and reception performance is:

1. Prepare transmission/reception test equipment.
2. Connect antenna to test equipment.
3. Measure while test equipment is communicating with device under test (DUT).

It is also possible to determine the values of parameters, such as the DUT Tx output, by using a radio anechoic chamber to calibrate the absolute values in advance.

Note: A radio anechoic chamber or shielded room is also required either for reproducible or quantitative tests, or when outputting radio waves at powers exceeding legal limits.

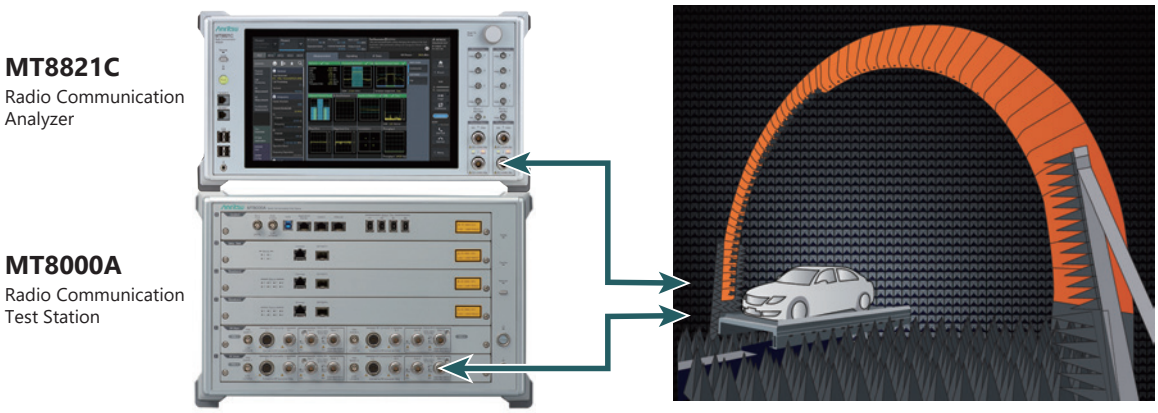

Figure 4 OTA cellular test system for vehicle

Telematics uses mobile communications systems, specifically 4G LTE and 5G. Organizations such as the U.S. Cellular Communications Industry (CTIA) and 3GPP define standards for measurement methods and RF performance requirements of these systems.

OTA regulations define the following:

- ◊ Equivalent Isotropic Radiated Power (EIRP) and Effective Isotropic Sensitivity (EIS) in beam direction including antenna characteristics.
- ◊ TRP (Total Radiated Power) to measure the total radiated power and TIS (Total Isotropic Sensitivity) to measure the total isotropic sensitivity (Figure 5).

The wireless performance of the entire vehicle with installed wireless device(s) can be evaluated by these tests.

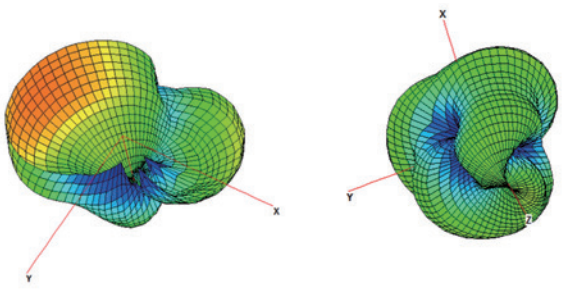

Figure 5 TIS/TRP plots (Source: https://www.tele.soumu.go.jp/resource/j/equ/mra/pdf/24/e-18.pdf)

OTA Testing Supports WLAN Product Evaluation in Real-World Environment

To verify the WLAN RF characteristics in a finished vehicle, a working connection method, such as Network Mode in the Wireless Connectivity Test Set MT8862A, using WLAN protocol messaging is superior than a test mode connection where the communications equipment is configured for testing. This is because area verification requires continuous acquisition of data on wireless characteristics. In addition, benchmark testing requires measurement of wireless communications performance under actual driving conditions.

■ Enables Efficient WLAN Area Verification

A typical vehicle OTA testing environment (Figure 6) includes WLAN area verification to evaluate whether the position of the in-vehicle WLAN unit is appropriate. This is verified in three steps:

1. Verify the distance between the vehicle and OTA antenna.
2. Replace the WLAN output power.
3. Convert the measured Rx power to distance to verify the relative signal reach.

Furthermore, the WLAN 3D signal coverage area can be captured by changing the angle of the OTA antenna and vehicle position.

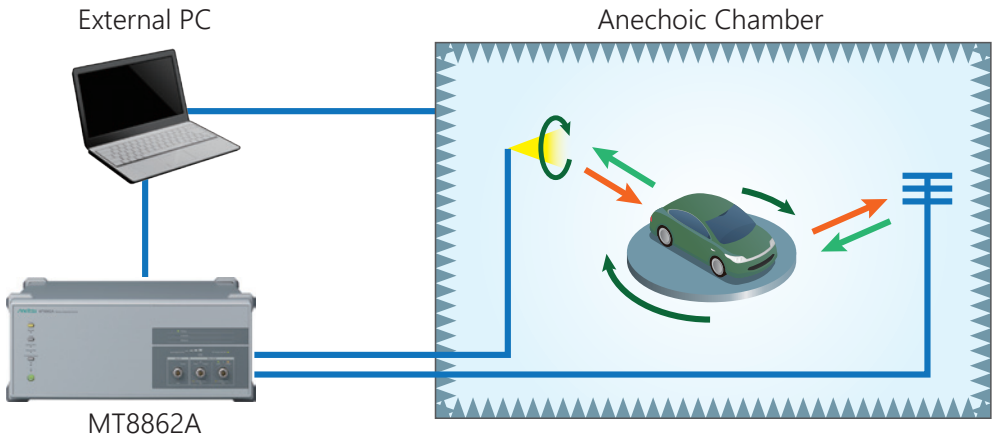

Figure 6 OTA Wi-Fi test environment

■ Enables Efficient Benchmark Test in Near Real-World Environment

Since the layout of the WLAN unit varies with the vehicle model and grade, area verification and RF performance must be measured each time. A benchmark test includes the usage environment (such as real-world noise). The ability to test under near real-world conditions without switching to a special test mode supports efficient evaluation and reduces development time.

Conclusion

Connected, Autonomous, Shared, and Electrical (CASE) technology innovation is progressing rapidly. In today's data-driven society, vehicles use various wireless devices, such as cellular, Wi-Fi, and Bluetooth, to connect to everything. Unstable communications in any area hinders safe and comfortable driving. Anritsu test solutions assure stable high-quality in-vehicle radio communications to contribute to safe and secure driving.

References

[1]: "Global Telematics Control Unit Shipments" https://www.counterpointresearch.com/global-tcu-shipments-2021/