

6G: From Spec-Driven to Experience-Driven — Enabled by Accurate Simulation

6G assumes that there is a shift to quality-assured operations. To enable this, the performance of devices in real-world environments should be accurately understood in advance. Anritsu’s Field Simulation Test (FST) captures real-world radio signals and reproduces them in the lab, enabling efficient, quantitative quality of experience (QoE) comparison across devices and chipsets.

Kota Kuramitsu, a manager at the Solution Marketing Department in the Mobile Solutions Division of Anritsu, says, “6G is expected to shift from best-effort to quality-assured operations and will be used for more mission-critical applications. Under such conditions, the conventional approach used up to 5G, which identifies issues and resolves them afterward, becomes insufficient.”

Accurately measuring device performance under diverse conditions and resolving potential issues in advance is essential for the quality-assured networks envisioned for 6G.

To address this, Anritsu provides FST. Keisuke Sawada, an assistant manager in the same department, explains, “The goal of this solution is to enable quantitative comparisons of end-user perceived throughput.”

FST integrates the full workflow of signal capture, analysis, and playback. It captures real-world radio signals using hardware, analyzes propagation characteristics, and reproduces the results in a laboratory environment using a tester.

Capturing Real-World Radio Conditions and Reproducing Them in the Lab for Comparisons

FST addresses a fundamental limitation of conventional field testing: Real-world environments are constantly changing due to weather conditions, crowd density, and vehicle movements, making it extremely difficult to reproduce a specific event observed at a particular time and place.

“For device and chipset vendors, the inability to quantitatively compare their products with those of competitors has been a major issue,” Sawada explains.

Traditionally, the radio conditions of each MNO were evaluated by connecting multiple smartphones to a PC and walking through urban areas while monitoring throughput. This approach is labor-intensive, and it is difficult to establish whether performance variations are from temporary environmental changes or from the device or chipset.

Kuramitsu says, “In practice, we were limited to collecting large amounts of data and presenting averaged results.”



Manager Kota Kuramitsu (left) and Assistant Manager Keisuke Sawada, Solution Marketing Department, Mobile Solutions Division, Test & Measurement Company, Anritsu

The “Field to Lab” concept of reproducing real-world radio propagation in a laboratory environment has existed for some time. According to Kuramitsu, market demand for this approach started around 2008. The introduction of smartphones rapidly increased the complexity of communication systems and radio environments. This created a need to reproduce and verify issues observed in the field under controlled laboratory conditions, bringing renewed interest in the Field to Lab concept. At the time, test vendors, including Anritsu, attempted to realize Field to Lab by using base station simulators and communication logs. However, communication logs alone were insufficient to accurately identify and reproduce issues in real-world radio environments, and these efforts did not result in products that met customer expectations.

“From the customer’s perspective, Field to Lab remained unrealized for a long time,” recalls Kuramitsu.

To overcome this limitation, Anritsu developed FST. It is a different approach that reproduces how radio signals are delivered from the base station to smartphones. A key component of the FST architecture is the signal capture hardware, the Universal RF Unit MD8190A. This unit

is equipped with four antennas, like a smartphone, and it captures 4G and 5G downlink signals as IQ data (raw radio signals represented as in-phase and quadrature components). The four-antenna configuration enables the acquisition of correlation characteristics between signals received at multiple antennas.

Anritsu’s expertise is also reflected in its data analysis. Temporal variations in propagation characteristics and other parameters are visualized through graphs, allowing intuitive selection of segments for laboratory reproduction. While generating radio propagation models is a core function, FST also enables deeper analysis. By acquiring encryption keys from smartphones, the system decodes user-specific data channels and enables objective observation of radio quality metrics, such as SINR degradation and resource block allocation.

“Data channel analysis is a key differentiator and a major strength of Anritsu,” says Kuramitsu.

Encryption keys are extracted by tools from chipset vendors or device log analysis vendors. The system currently supports Qualcomm’s chipset log analysis tool QXDM, with plans to extend support to other tools from vendors, such as Meritech and Accuver.

Playback is executed by adding optional features to the widely used Radio Communication Test Station MT8000A. Simulation incorporates fading models that reflect real-world conditions, including multipath propagation and frequency-selective reception characteristics. This enables repeatable testing under fixed radio conditions. By varying device parameters, such as the model, firmware version, and battery level, FST enables comparative evaluation of perceived throughput.

To suit multiple field-testing requirements, it is available in either a portable version or a vehicle-mounted version. The portable version integrates the MD8190A into a backpack. The minimum system, including a control PC and mobile battery, weighs approximately 6 kg, enabling rapid deployment in a variety of locations and

efficient collection of field data.

The vehicle-mounted version incorporates a high-capacity storage PC designed for continuous real-time recording of multiple bands under carrier aggregation. It supports extended data capture while driving on highways or through urban areas, enabling efficient recording of radio propagation characteristics in mobility scenarios.



An example of the propagation characteristic analysis of captured radio signals using FST. The upper graph shows the analyzed delay spread profile. The lower graph indicates temporal variations in throughput.

Revealing “True Performance” Beyond Carrier or Chip-Level Comparisons

Below are examples of specific use cases for FST. One is comparing radio conditions across carriers at the same location. In a large-scale event scenario, radio signals from shared base stations in the venue are captured. By keeping device conditions constant and varying only the carrier in the simulation, FST provides objective and straightforward comparisons of the performance of various carriers.

FST also enables comparisons of chipsets. Anritsu conducted field capture sessions in various environments, including outdoor event venues, major terminal stations, and highway service areas, and then performed simulations with only variations in the chipset. The results showed throughput differences even under identical conditions.

“When selecting a chipset, device manufacturers had no effective way to understand performance differences beyond catalog specifications. With FST, they can assess the true performance of each chipset,” says Kuramitsu.

Antenna testing is another key use case. Different antenna sizes and form factors can be evaluated within a single system, enabling straightforward A/B testing of throughput. Repeated verification against recorded propagation data improves development efficiency and accelerates antenna optimization.

Looking ahead, Anritsu anticipates a shift from specification-driven evaluation in 5G to user-perceived quality in 6G.

Emphasizing the need for measurements using FST, Sawada says, “For mission-critical applications, understanding the quality of experience in advance is essential.”

In addition, laboratory environments that accurately replicate real-world conditions allow the development and validation of new products before deployment, accelerating the time-to-market of 6G devices.

Another key aspect of 6G is the integration of terrestrial and non-terrestrial networks (NTN). FST can capture NTN reception conditions. By applying simulation-based improvements to device-side algorithms, NTN connectivity is possible even in challenging scenarios, such as indoors or inside moving vehicles.

Accurate simulation technologies such as FST will underpin communications in the 6G era.

An example of a configuration of FST.

In this photograph of the portable version, the chassis beneath the laptop PC is the Universal RF Unit MD8190A, and the black unit in the upper right is an external antenna.

