Anritsu Advancing beyond

Test Solutions for IoT Devices

Quality Assurance from Development to Manufacturing and Field Operation

IoT is expanding rapidly across manufacturing, logistics, healthcare, and infrastructure. In recent years, multiple communication technologies — including wireless LAN (WLAN), *Bluetooth*® technology, cellular IoT, and 5G and local 5G — have come to coexist, increasing the complexity of IoT system design, evaluation, and operation.

In IoT systems, stable connectivity is a prerequisite for data acquisition, control, and optimization. Meeting performance requirements — such as throughput, latency, and reliability — in actual deployment environments is critical for successful operation. However, factors such as interference, noise, installation conditions, and variations in the mass-production process often prevent communication quality from matching design expectations. To address these challenges, it is essential to quantitatively measure wireless signals and communication quality and to visualize the results throughout all phases, from development and evaluation to mass production and operation.

This document outlines IoT market trends, key technical challenges, and Anritsu's test solutions to address them. Anritsu offers comprehensive measurement solutions that enable the consistent evaluation of the wireless and network performance of IoT devices and systems—from performance verification during development and mass production testing to on-site troubleshooting in the field operation. By building optimized evaluation environments for each phase in line with evolving IoT market trends and communication technologies, Anritsu brings assured quality to IoT connectivity.

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IoT Market Trends

In recent years, IoT has evolved from simply connecting sensors and devices to networks into a foundational technology that enables the visualization of on-site conditions and supports operational decision-making, control, and automation. As a result, IoT has expanded across industries and services, including healthcare and medical IoT (Internet of Medical Things: IoMT), Industrial IoT (IIoT), smart factories, smart infrastructure, and smart agriculture. Data collected from sensors and devices can improve on-site visibility, enhance operational efficiency, and create new value. IoT is becoming established as a foundational technology supporting data-driven operations and automation across society and industry.

A key driver of this trend is the growing labor shortage caused by a shrinking workforce and stricter labor regulations. This challenge is especially significant in logistics, construction, and healthcare, where safe and efficient operations must be maintained with limited personnel. To address these challenges, IoT is increasingly being leveraged for condition monitoring, automation, and remote operation. IoT is being adopted across many fields as an effective solution for reducing labor requirements, improving efficiency, and enhancing safety by minimizing the amount of hazardous work performed by human operators. In particular, the following areas are experiencing particularly rapid adoption in response to social challenges and changes in industrial structures.



IoT Applications

Manufacturing/Smart Factory (IIoT)

In manufacturing, the adoption of smart factories is accelerating as the real-time visualization of equipment operating statuses and quality data enables higher productivity and more efficient maintenance. By collecting data from sensors and control devices, manufacturers have access to condition monitoring, anomaly detection, and predictive maintenance, helping reduce unexpected downtime and enhance maintenance operations.

IIoT serves as a foundational technology supporting these smart factories by enabling the integrated management of production line operation data, quality information, and energy usage. In recent years, the importance of communication infrastructure capable of transmitting and processing large volumes of data with low latency and high reliability has increased. As a result, factory networks are required to deliver high bandwidth, high reliability, and scalability to support future expansion.

Medical/Healthcare (IoMT)

In the medical field, the adoption of IoMT is accelerating, with medical devices and wearable sensors able to collect and utilize data over networks. Real-time monitoring, storage, and analysis of vital signs and medical data — such as heart rate, blood oxygen levels, blood pressure, and medical imaging — support more accurate patient assessment and faster clinical decision-making.

IoMT extends beyond hospital medical equipment to home healthcare devices and wearables, enabling remote monitoring and telemedicine. This helps reduce the workload of healthcare professionals, optimizes medical resources, improves patients' quality of life (QOL), and enables early intervention to prevent disease progression. In parallel, communication reliability and security are critical requirements for IoMT. The accurate transmission of medical data requires not only high-quality WLAN and Bluetooth technology connectivity, but also robust countermeasures against electromagnetic noise and interference, as well as compliance with all Electro-Magnetic Compatibility (EMC) standards.

Logistics/Construction

In the logistics and construction field, labor shortages and on-site safety have become critical challenges. Operations in these fields often involve large outdoor spaces, making the real-time monitoring of the status of vehicles, heavy equipment, and workers essential for improving efficiency and safety.

With the adoption of IoT, it has become possible to continuously monitor the operating status, utilization time, fuel consumption, and location of trucks, forklifts, and other construction machinery. This supports optimized dispatch planning, process management, and higher equipment utilization. In addition, location management using GNSS and sensors enables the accurate tracking of materials and equipment and visualizes work progress, helping reduce unnecessary movement and idle time.

To support these initiatives, a wide-area communication infrastructure and stable connectivity are indispensable. In outdoor and mobile environments, ensuring wireless communication quality and mitigating latency and disconnections are critical, requiring thorough communication environment evaluation and system design with an eye to long-term operation.

Energy/Smart Infrastructure

In the energy field, the expansion of sustainable energy and the shift toward distributed power sources are accelerating the development of smart infrastructure. This includes the remote monitoring of generating and transmission facilities, the visualization of equipment conditions, and remote meter reading using smart meters. At solar and wind power plants, sensors continuously monitor parameters such as output, equipment temperature, vibration, and early signs of failure. By centralizing this data over communication networks, operators can achieve stable operation and more efficient maintenance.

The widespread adoption of smart meters also enables the real-time, remote monitoring of electricity and gas consumption, supporting remote meter reading, demand forecasting, and highly accurate supply–demand control. IoT plays a central role by connecting these distributed assets and measurement points, supporting a stable power supply, predictive maintenance, and labor-efficient maintenance operations.

Agriculture/Environmental Monitoring (Smart Agriculture)

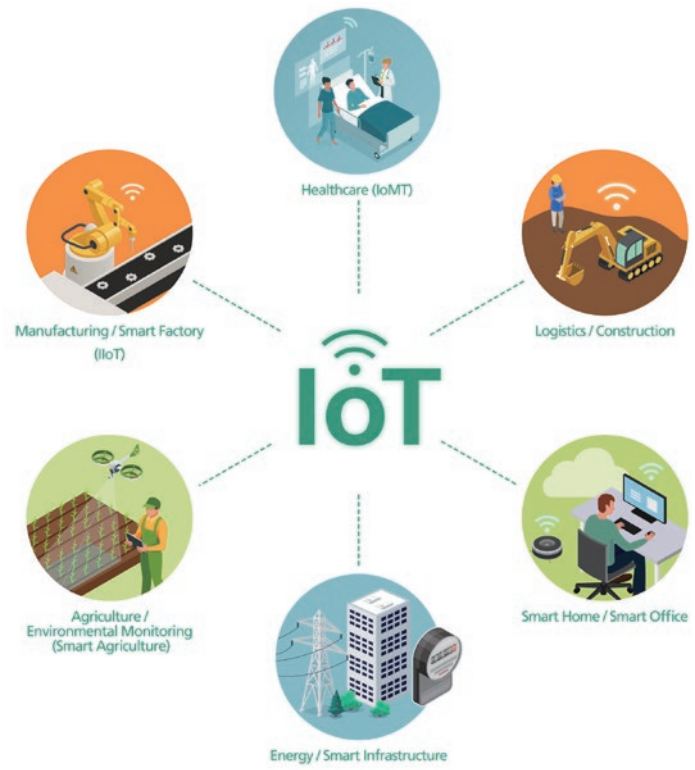
In agriculture, labor shortages and climate change are driving the adoption of smart agriculture to improve productivity and reduce manual work through data utilization. Farm sensors continuously monitor soil moisture, temperature, solar radiation, air temperature, and humidity, enabling the quantitative assessment of crop growth conditions.

By integrating IoT with agricultural machinery such as tractors, operators can monitor operating statuses and work locations, and have access to remote monitoring and operation support. This improves operational efficiency and reduces physical workload. By accumulating and analyzing this data, farming decisions are shifting from experience-based judgment to data-driven, planned operations. Because these systems are deployed over large outdoor areas, IoT designs must ensure stable communications and high environmental durability.

Smart Home/Office

In homes and offices, IoT is used for controlling HVAC, lighting, and security systems, as well as for energy management, improving comfort, safety, and energy efficiency. By integrating sensors and devices, systems can automatically adjust to indoor conditions and occupancy, reducing unnecessary energy consumption.

Remote operation and status monitoring via smartphones and cloud services further enhance user convenience. In offices, visualizing the energy consumption and equipment operating status enables the planning of energy-saving measures and operational optimization, accelerating the adoption of smart buildings. Because these environments involve a large number of concurrently connected devices, stable wireless connectivity and robust security are critical technical requirements.



Key Technologies for IoT

AIoT and Edge Computing

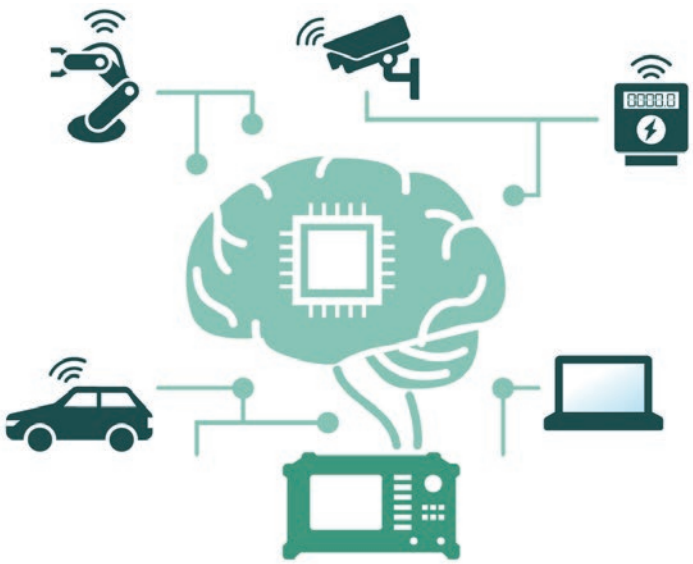
Artificial Intelligence of Things (AIoT) combines AI and IoT to analyze the data collected from IoT devices and automatically makes decisions and controls actions. While conventional IoT has primarily focused on monitoring and visualizing equipment and environmental conditions, AIoT is characterized by its ability to directly apply analytical results to operation and control. This evolution is transforming IoT from a monitoring mechanism into autonomous systems.

In recent years, edge AI — performing AI processing closer to sensors and devices without relying solely on the cloud — has gained momentum. By enabling local decision-making and control, edge computing reduces the impact of communication latency, allows a faster response, reduces the network load, and improves system reliability even during communication disruptions.

As a result, IoT systems are no longer simple collections of sensors, but intelligent systems capable of sensing, decision-making, and control at the point of operation. In fields such as manufacturing, logistics, healthcare, and infrastructure — where real-time responses and safety are critical — AIoT and edge computing are expected to address labor shortages, reduce variations in quality, and minimize downtime. IoT is increasingly positioned as a core technology that directly influences overall system competitiveness.

AIoT and edge computing are already demonstrating tangible benefits across some fields. On-site autonomous decision-making and control reduce reliance on individual expertise and improve response speed during abnormal conditions, steadily advancing digital transformation in manufacturing, logistics, and urban infrastructure. However, these benefits are not automatically achieved in all environments. Stable sensor data acquisition is essential, and communication conditions — such as latency, jitter, and packet loss — can directly affect system behavior. Unstable connectivity may lead to data loss or delayed decisions, preventing the intended automation and optimization.

For AIoT, it is critical to maintain stable communication and processing performance under actual operating conditions and to ensure continuous, reliable operation as designed. AIoT is transitioning from a tool that supports DX to a domain where success depends on certainty and verification at the design and evaluation stages.



Mobile IoT (Drones/AGVs/Mobility)

IoT has evolved primarily as a technology for continuously monitoring equipment and environmental conditions using fixed sensors. In recent years, the integration of mobile platforms — such as Unmanned Aerial Vehicles (UAVs/drones), Automated Guided Vehicles (AGVs/AMRs), and autonomous mobility — has significantly expanded both its application scope and the value of the acquired data. Mobile IoT enables a shift from point- or area-based measurements to dynamic, spatial awareness. By collecting data while moving through an environment, IoT becomes a more practical and field-ready technology.

These mobile platforms can be equipped with sensors, including cameras, temperature and humidity sensors, gas sensors, and LiDAR. This allows efficient and safe data collection in locations that are difficult or dangerous for humans to access, such as elevated areas, hazardous zones, and large indoor or outdoor spaces. Tasks such as inspection, monitoring, and materials transport — previously requiring manual work or large-scale equipment — can be automated and streamlined, which is a key advantage of mobile IoT.

At the same time, unlike fixed systems, mobile IoT is subject to changing radio conditions as the devices move. Communication quality can fluctuate due to obstacles, signal conditions, and interference. These variations directly affect control accuracy and system reliability, with a direct impact on overall performance and safety. In particular, for AGVs, mobility platforms, and drones, communication latency or momentary interruptions can lead to operational stoppages or safety risks. Ensuring communication quality — including latency and interruptions — is therefore a critical technical challenge.

In addition, mobile IoT systems are often battery-powered, making power consumption a major factor in affecting run time. Excessive communication or unnecessary data transmission can shorten battery life, driving the need for optimized data volumes through edge processing and the selection of appropriate communication systems based on the application's requirements.

Mobile IoT is already being deployed in fields such as agriculture, logistics, manufacturing, and infrastructure inspection. Applications, including environmental monitoring and infrastructure inspection using drones, as well as automated intralogistics using AGVs, are beginning to deliver improvements in labor efficiency and safety. To consistently realize these benefits, however, comprehensive design and validation — covering communication reliability under field conditions and power consumption — is essential. As mobile IoT enters the practical deployment phase, operational quality, including communication reliability and power efficiency, is becoming a key focus.



Wireless Communication Technologies Supporting IoT

Driven by the diversification of communication technologies, the growing number of connected devices, and increasingly advanced applications, IoT systems adopt different wireless communication technologies depending on the intended use and the deployment environment.

For indoor environments and limited areas, WLAN and Bluetooth technology are widely used for short-range communication. WLAN provides high speed and a large data capacity and has become the foundation for connecting large numbers of IoT devices in factories, offices, and commercial facilities. In smart factories and smart buildings in particular, stable multi-device connectivity is essential, as sensors, cameras, robots, and AGVs all operate on a shared network.

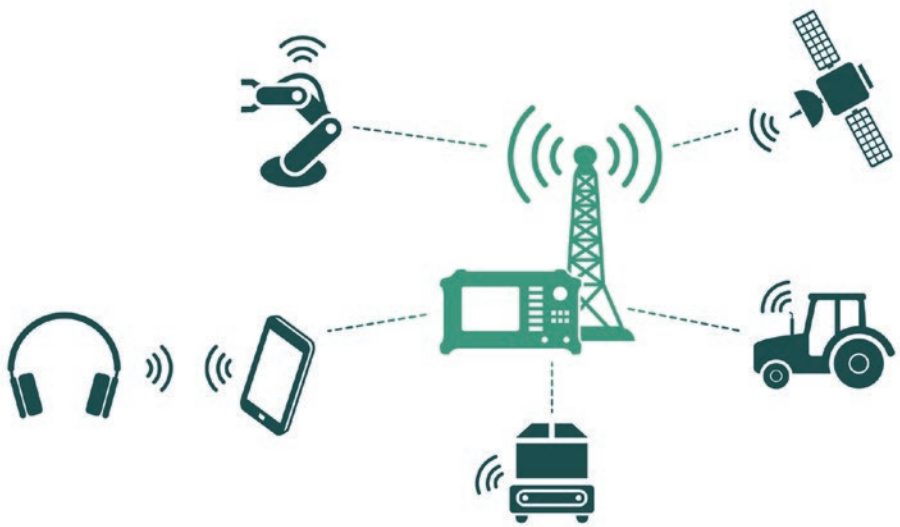
An important evolution of WLAN is Wi-Fi 7. In addition to higher throughput and lower latency, Wi-Fi 7 is designed to improve efficiency in environments where many devices communicate simultaneously. This makes it well-suited for IoT applications, offering improved reliability and flexibility. Going forward, Wi-Fi 7 is expected to play a central role in local IoT networks, gradually replacing conventional WLAN systems depending on the application requirements.

Bluetooth technology, on the other hand, has supported the widespread adoption of IoT devices as a low-power, short-range wireless technology. Bluetooth Low Energy (BLE) is widely used in sensors, wearable devices, and beacons, and is an essential communication option for battery-powered IoT devices. Recent enhancements in positioning accuracy and data transmission efficiency are also expanding its use in asset tracking and indoor location monitoring.

Complementing these local communication technologies, cellular IoT is gaining importance as a solution for wide-area connectivity. Among these, 5G-based RedCap (Reduced Capability) and eRedCap (enhanced RedCap), which simplify the communication functions for IoT use, are attracting attention as technologies that balance wide coverage and reliability with lower power consumption and cost. They are becoming strong candidates for applications such as factory monitoring, infrastructure management, and mobile IoT applications.

In addition, interest in IoT using Non-Terrestrial Networks (NTN) and satellite communications is growing as a technology to complement terrestrial network coverage. Satellite communication enables IoT connectivity in environments where conventional infrastructure is difficult to deploy, such as mountainous regions, offshore areas, and remote locations. In fields such as logistics, energy, and environmental monitoring, hybrid configurations combining terrestrial networks and satellite communications enable more continuous and global data collection.

Today's IoT systems are evolving into layered communication architectures that combine short-range connectivity using WLAN and Bluetooth technology, wide-area cellular connectivity including RedCap and eRedCap, and coverage extension through NTN and satellite communications. Selecting and combining the optimal wireless technologies based on required reliability, power consumption, and deployment conditions is a key factor in maximizing the overall value and reliability of IoT systems.



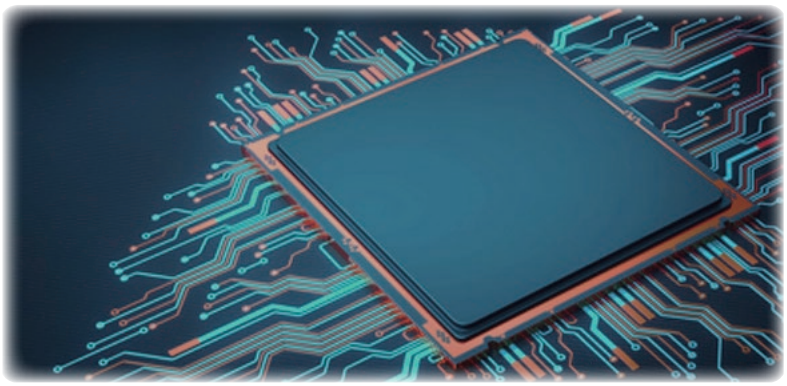
Technical Challenges and Testing Solutions for IoT Devices

Technical Challenges in R&D

Establishing a Consistent Evaluation from Development to Certification and Mass Production

IoT products are brought to market through multiple phases, including prototype evaluation in R&D, certification testing to ensure compliance with wireless standards and regional regulations, and inspection during mass production. However, evaluation conditions and pass/fail criteria can differ between these phases. Issues that do not surface during R&D may emerge for the first time during certification or mass production. Typical examples include non-compliance on specific channels during certification testing, communication performance variations under different temperature conditions after mass production, or failure to achieve the expected level of performance in the field. In many cases, these issues arise because measurement conditions were not fixed during development, and the evaluation criteria used in later phases were not sufficiently verified.

To avoid any such reworking, it is essential to evaluate products from the early development stage based on the same measurement items and acceptance criteria used in certification and mass production. By standardizing evaluation conditions and metrics across all phases and ensuring consistency from development through to mass production, manufacturers can reduce development delays and prevent unnecessary cost increases.



Reproducing Abnormal Conditions and Verifying Communication Behavior in Unstable Environments

IoT device failures often occur under conditions such as weak signal strength or increased latency when the communication load is high. However, in R&D, evaluation typically focuses on normal operation under stable radio conditions, and device behavior during temporary disconnections or repeated reconnections may not be sufficiently verified. As a result, issues such as unstable communication in specific environments may be discovered only after market deployment, leading to on-site troubleshooting and emergency firmware updates.

Ensuring Wireless Communication Quality Across a Wide Range of Operating Environments

IoT devices are deployed in various environments, including factories with densely packed machinery, logistics systems using AGVs and AMRs that move between indoor and outdoor areas, medical facilities with strict radio usage constraints, and outdoor infrastructure and agricultural applications. In these environments, factors such as reflection, shielding, noise, and environmental changes caused by mobility affect wireless communications, making stability and reliability critical design requirements.

In contrast, R&D evaluations are often conducted primarily in the laboratory, creating a gap between the test conditions and the actual operating environments. As a result, communication performance deemed acceptable during design may become unstable after deployment, appearing as unexpected interference or communication dropouts. Such issues can lead to the need for rework in later phases, incurring extra costs.

Test Requirements for Addressing Technical Challenges

To address these R&D technical challenges, the following evaluations are effective. This requires the adoption of test solutions that meet each of these requirements.

1: Establishing a consistent evaluation environment
Ensuring consistency in the evaluation criteria, reproducibility, and test methods from early development through certification, to mass production.

2: Evaluation under controlled abnormal and boundary conditions
Verifying communication behavior under controlled and reproducible abnormal scenarios and edge conditions.

3: Communication quality evaluation under real-world conditions
Assessing wireless communication quality assuming actual operating environments, including radio conditions and interference.

R&D Test Solutions

Identifying real-world communication quality risks early in the design phase

Anritsu provides solutions that enable wireless communication evaluation from the early stages of development, with real-world operating environments in mind. These solutions address technical challenges in IoT product R&D across various applications, including factories, medical facilities, logistics, construction, infrastructure, agriculture, and smart homes/offices.



Virtual Signalling Tester MX844030PC

1: Virtual Signaling Testing Enabling Consistent Evaluation from R&D, Through Certification, to Mass Production

Virtual Signalling Tester MX844030PC

The Virtual Signalling Tester MX844030PC is a PC-based solution that enables cellular signaling testing in a virtual environment. It supports protocol verification for next-generation cellular IoT technologies, including 5G and RedCap, from the pre-silicon stage. This helps identify issues early in development and reduces the need for design rework.

This solution allows flexible configuration of communication conditions and scenarios that are difficult to reproduce in real networks. Behaviors such as connection establishment and release, reconnection, and communication degradation can be evaluated during the R&D phase. This supports robust communication design for IoT devices used in a wide range of environments, including factory equipment, infrastructure systems, and mobile logistics applications.

In addition, test cases created in the virtual environment can be reused in later phases, contributing to a consistent evaluation framework from R&D, through certification, to mass production.



Radio Communication Test Station MT8000A

2: Validating Communication Reliability in R&D Under Abnormal Conditions

Radio Communication Test Station MT8000A

The Radio Communication Test Station MT8000A is a test platform supporting the latest cellular technologies, including 5G and RedCap.

It enables the controlled reproduction of abnormal conditions such as disconnections, reconnections, and increased latency, as well as various radio environments, at the R&D stage. Evaluating device behavior under communication conditions that are difficult to reproduce in real networks, it helps reduce the risk of issues after market deployment and supports the development of highly reliable IoT products.

In addition, it provides a comprehensive test environment covering both cellular IoT protocol testing and RF testing. Its flexible configuration, designed with future standards in mind, accelerates the market introduction of next-generation IoT products and supports long-term competitiveness.



Wireless Connectivity Test Set (WLAN Tester) MT8862A

3: Visualizing WLAN Communication Quality in R&D Under Realistic Operating Conditions

Wireless Connectivity Test Set MT8862A

The Wireless Connectivity Test Set MT8862A is a test solution that enables the evaluation of RF transmit and receive performance for IoT devices supporting WLAN. It supports performance evaluation under conditions that simulate real communications in complex radio environments, such as factories, medical facilities, smart buildings, and smart homes/offices, where interference and radio conditions vary significantly.

In the R&D stage, visualizing the impact of noise, interference, component placement, and enclosure design on RF characteristics enables the early identification of design issues. This helps reduce the risk of communication problems after market deployment.

Technical Challenges in Manufacturing

IoT devices commonly support communication technologies such as cellular, WLAN, and Bluetooth technology, depending on the application and deployment requirements. In manufacturing, however, ensuring stable quality while mass producing products with different communication technologies is a major challenge.

Because inspections must be completed quickly on production lines, the use of different instruments and test methods for each technology increases the operational burden. As a result, testing may be limited to basic connectivity checks, increasing the risk that products are shipped without sufficient evaluation of their transmit quality or receiver sensitivity.

On the other hand, some IoT devices are designed for a single communication technology, such as Bluetooth. While this may appear to simplify communication testing in manufacturing due to the limited scope, ensuring stable and consistent communication quality remains a critical technical challenge even for such devices in production environments.

Manufacturing inspections are repeated across operators and lines, and complex measurement procedures or test settings can lead to variability and human error. Since inspections are not always performed by communication specialists, simple, standardized test environments that enable consistent verification without specialized expertise are essential to maintaining stable mass production quality.



Test Requirements for Addressing Technical Challenges

To address these manufacturing technical challenges, the following evaluation capabilities and solutions are required.

1: Efficient visualization of wireless performance within a limited test duration

Solutions that support multiple communication technologies — such as cellular, WLAN, and Bluetooth technology — and enable efficient visualization of wireless performance within a limited test duration.

2: Stable communication testing through simple operation

Wireless performance evaluation that ensures consistent and stable inspection through simple, standardized operation.

Manufacturing Test Solutions

Stabilizing communication performance in mass production and consistently producing design-intended quality.

Anritsu's test solutions support reliable communication quality and improved manufacturing efficiency throughout the entire IoT product lifecycle.



Universal Wireless Test Set MT8870A

1: Efficient Evaluation Under Various Communication Technologies and Conditions for Real Network Operation

Universal Wireless Test Set MT8870A

The Universal Wireless Test Set MT8870A is a test solution supporting WLAN (IEEE 802.11a/b/g/n/ac/ax/be), Bluetooth technology, and cellular technologies such as LTE and 5G. Its broad support of multiple wireless standards and frequency bands enables flexible operation in manufacturing. It also supports the consistent evaluation of the power efficiency and communication stability required for IoT devices, enabling unified verification from design through manufacturing.

- Evaluation of wireless performance (transmit quality and receiver sensitivity)
- Evaluation under communication conditions that simulate real networks
- High-speed measurements optimized for production lines (supports up to four test units)

This helps prevent field communication issues while improving quality, consistency, and inspection efficiency during mass production.



Bluetooth® Test Set MT8852B

2: Simplified Evaluation of Bluetooth Technology Devices

Bluetooth® Test Set MT8852B

The Bluetooth® Test Set MT8852B is a test solution designed for evaluating IoT devices supporting Bluetooth technology. It supports quality assurance for short-range wireless IoT products, including smart home devices, medical sensors, and logistics tags.

- Wireless performance evaluation compliant with Bluetooth specifications
- Efficient evaluation from functional testing through to mass production inspection
- One button operation to reduce takt time, improve yield, and lower test costs

Ensuring Bluetooth communication reliability during manufacturing helps reduce connectivity issues in end user environments.

These solutions enable the reliable evaluation and control of communication quality during manufacturing, helping shorten development time, stabilize mass production quality, and reduce issues in the field.

Technical Challenges in Field Operations

In operational environments such as factories, medical facilities, and infrastructure sites, IoT devices are required to operate reliably over long periods and continuously collect and transmit data as part of the system requirements. In actual conditions, however, factors that are difficult to fully anticipate during design and validation — such as interference, noise, fluctuations in communication traffic, and increasing network complexity — can significantly affect communication quality. In factories and logistics sites, many wireless devices operate simultaneously, while in medical and infrastructure applications, communication latency or momentary interruptions directly impact service quality and safety. In outdoor and wide area applications, such as agriculture and infrastructure monitoring, variability in communication quality across different locations also becomes a key challenge.

Under these conditions, simply confirming connectivity is not sufficient. Quantitatively assessing communication quality — such as latency, packet loss, and throughput — in real-world operational environments, while continuously managing the communication status is critical to ensuring the overall reliability of IoT systems.



Test Requirements to Address Technical Challenges

To address these technical challenges encountered in real-world operation, the following evaluations are effective.

1: Quantitatively measure communication quality, including latency, packet loss, and throughput for a real network.

2: Visualize the impact of the wireless environment, such as the signal strength and radio interference, before deployment and during operation.

Field Test Solutions

Visualizing the causes of communication quality fluctuations and failures in the field, enabling rapid root-cause identification and corrective action.

Reliable and continuous operation in the field after deployment is essential for IoT systems. Anritsu's solutions provide objective, on-site insights to support informed decision-making.



Network Master Pro MT1000A

1: Network Quality Measurement and Quantitative Evaluation

Network Master Pro MT1000A

The Network Master Pro MT1000A enables the verification of network quality at the actual operating site where IoT devices are in use.

- Numerically identify whether communication is delayed or intermittently interrupted
- Instantly detect packet loss and throughput degradation

For example, even when data delays occur at factories or logistics sites, this enables the clear identification of whether the root cause lies in the network quality itself or in other factors.

It is effective not only for troubleshooting during failures, but also for pre-deployment verification and periodic inspections.



Field Master Pro™ MS2090A

2: Visualizing the Wireless Environment, Including Signal Strength and Interference

Field Master Pro™ MS2090A

In factories, buildings, and outdoor facilities, radio interference and installation conditions often cause communication issues. The Field Master Pro™ MS2090A is a portable measuring instrument that enables the on-site investigation of such wireless environments.

- Visualize those areas with strong and weak signal strength
- Efficiently identify interference signals that cause communication issues
- Adapt to environmental changes after installation

This enables the on-site identification of where and why communication instability occurs, facilitating the efficient optimization of access point placement and environmental improvements.

These solutions visualize real-world communication conditions and clearly identify the root causes of issues based on quantitative data, enabling more stable and reliable IoT service operation.