

Defense Radio Communication Testing with Reverberation Chambers

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Radio Performance as an Operational Capability

For more than 20 years, Bluetest has supported the efficient development and verification of some of the world's most advanced wireless products: The mobile device in your hand is very likely made by a manufacturer that uses Bluetest reverberation chambers as part of its development and validation process.

The same need for fast, objective and repeatable radio verification is becoming increasingly important in security and defense. Mission-critical communications must perform not only in ideal conditions, but in environments shaped by reflections, obstruction, mobility, spectrum congestion and intentional interference.

Bluetest reverberation chambers create a controlled over-the-air test environment in which complete radio systems can be evaluated under multipath conditions representative of real-world operation and deliberately stressed RF conditions. This allows development teams to reproduce scenarios that are difficult, costly, or impractical to create in open-field testing.

This White Paper describes how reverberation chamber technology can be applied to security and defense applications to shorten verification cycles, reduce test cost and improve confidence in operational radio communications performance. All within a safe laboratory environment.

Two principles form the basis of the approach. First, radio systems should be verified over the air, because cables bypass the antenna system and therefore exclude important parts of real device performance. Second, unobstructed line-of-sight propagation is the exception rather than the rule in real operations - particularly in dense, contested or hostile environments.

The following sections explain the Bluetest measurement principle and its use for defense communication including tactical radios, UAV control and video links, 5G networks and user equipment, live-person and body-worn equipment testing (Human-In-The-Loop, HITL), robustness against, or effectiveness of, jamming and spoofing, and assessment of unintended electromagnetic emissions related to the TEMPEST framework, where the Bluetest systems can provide useful pre-characterization.

The objective is a practical laboratory platform that makes complex RF conditions repeatable, enabling faster engineering decisions and a measurable performance baseline from development through deployment and post-mission verification.



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Faster Verification, Lower Cost and More Relevant Results

Field trials remain essential, but they are expensive, difficult to repeat and often constrained by spectrum regulation, weather, safety and operational availability. Conductive (cable connected) tests can characterize parts of a radio chain, but they bypass the antenna and therefore cannot capture the radiated performance of the complete device.

A reverberation chamber enables engineering teams to move a large part of verification into the laboratory. Realistic fading, multipath, interference and link-loss conditions can be reproduced without radiating into the surrounding environment. Test cases can be repeated after design changes, environmental exposure or field missions, making performance degradation visible before it becomes an operational problem.

Reverberation chamber technology itself is well established. Bluetest has spent decades industrializing the method into commercial systems designed for repeatable measurements, integrated instrumentation and automated workflows. This maturity is why the technology is used by leading global tech companies.

Radio systems should be verified over the air

Operational radio equipment communicates over the air (OTA), not through coaxial cables.

Conducted testing is useful for radio characterization, but a cable connection excludes the antenna system, antenna matching, platform integration, body detuning/loss and other effects that can determine real radiated performance.

OTA testing connects the device under test to the measurement system through radio waves in a controlled environment. This makes it possible to measure the complete implementation as it is intended to operate, including transmitter, receiver, antennas and their interaction with the host platform.

For mission-critical communications, reverberation chambers minimize a false sense of security!

For mission-critical communications, system-level radiated performance is the engineering target.

Real environments contain reflections, scattering, shadowing and moving objects. In buildings, dense urban areas, vehicles and complex terrain, signals arrive from many directions. In security operations or armed conflict, the environment can be even less predictable due to concealment, damaged infrastructure, spectrum congestion and intentional interference.

Bluetest reverberation chambers create a statistical rich-isotropic-multipath environment. Mechanical mode stirring continuously changes the field distribution, enabling a measurement result to represent many independent field conditions rather than one specific device orientation or arrival angle.

This is particularly relevant for diversity and MIMO systems, where performance depends on the combined behaviour of multiple antennas and the propagation channel, as well as for interference mitigation, where the device needs to handle jamming and spoofing signals regardless of orientation or angle-of-arrival.

A controlled multipath environment makes complex RF conditions repeatable - and therefore engineerable.

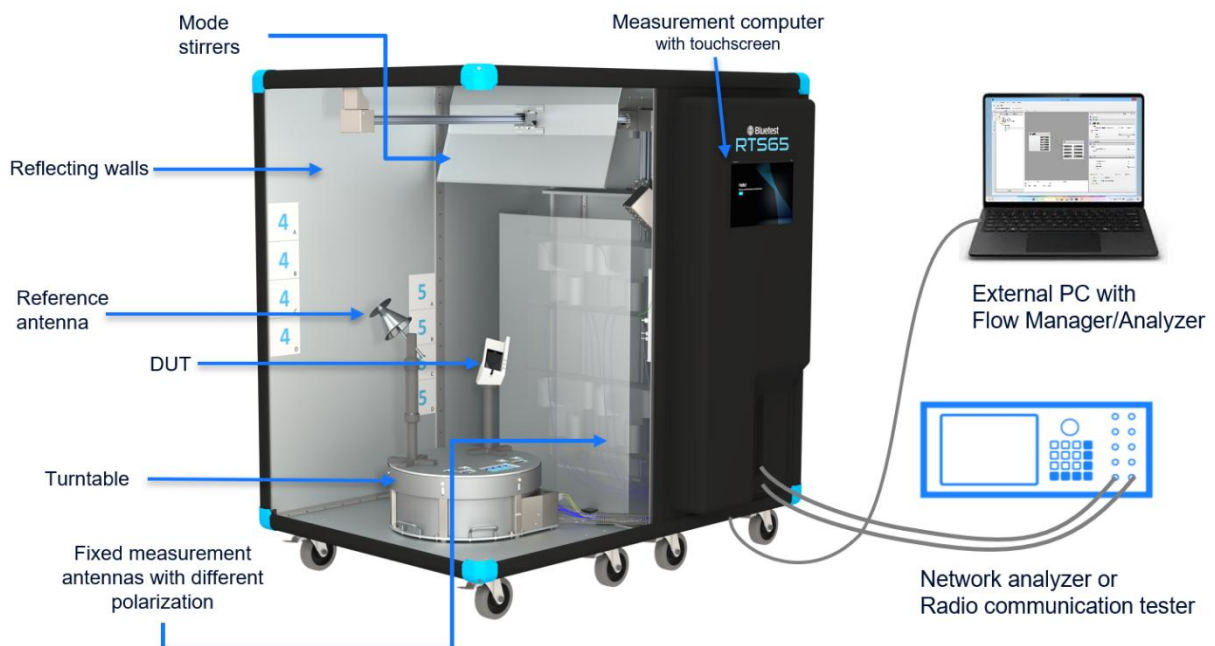
The Bluetest Reverberation Test System

An RTS is a shielded metallic chamber equipped with measurement antennas, mode stirrers, a turntable, and integrated control software. The reflective enclosure retains RF energy while the stirrers randomize the electromagnetic field. The result is a spatially statistically uniform environment with inherent multipath propagation suitable for isotropic OTA measurements, system level MIMO measurements and interference test cases, with support for:

- Passive antenna metrics such as antenna efficiency and diversity/MIMO gain.
- Active metrics including Total Radiated Power (TRP), Total Isotropic Sensitivity (TIS) and data throughput.
- Interference mitigation/effectiveness.
- Spurious emission and EMC-oriented measurements where applicable.
- All major wireless protocols, including 5G/6G, satellite communication (NTN), WiFi and Bluetooth.

Bluetest systems support a broad range of radio communication testers, vector network analyzers and signal analyzers. Flow software provides reusable test sequences, system control, batch execution and automated reporting. This reduces dependence on operators and makes it practical to use the same test logic from early development through qualification and post-mission checks.

Fast setup and repeatable automation turn RF verification into an iterative development tool rather than a late-stage gate.



UAS and Drone Communication Testing

Unmanned aerial systems depend on robust command-and-control, telemetry, payload data and navigation links. These links must be evaluated not only under nominal conditions but also when distance increases, orientation changes, multipath is severe or intentional interference is present.

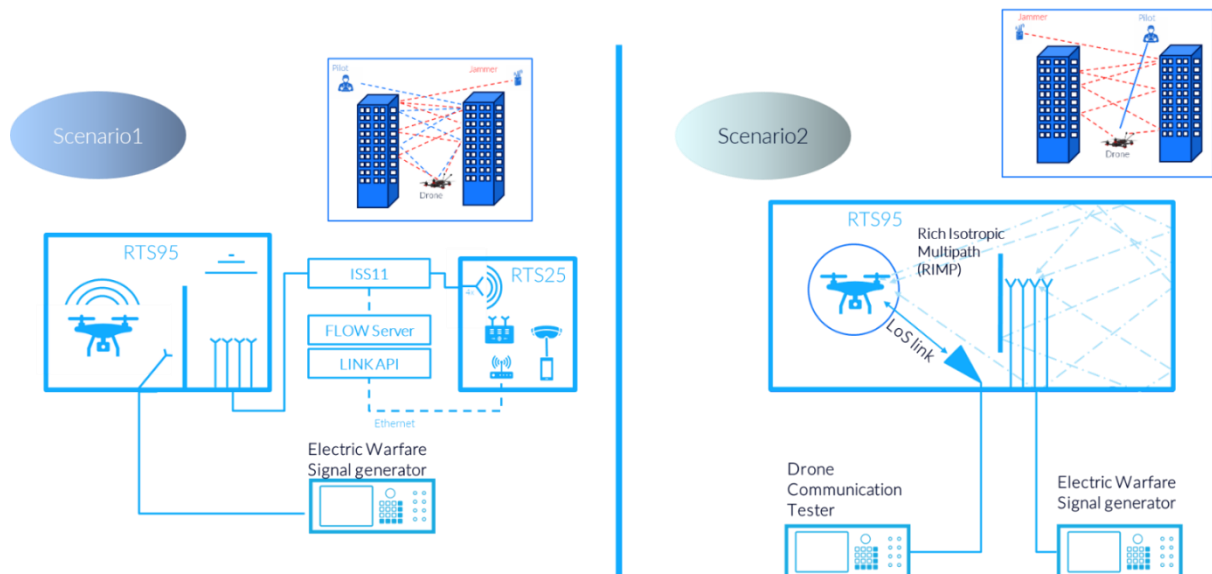
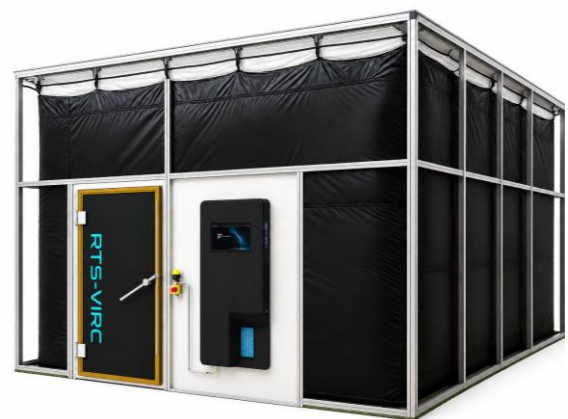
A representative base configuration uses an RTS95 for the aircraft and an RTS25 for the controller and goggles, see example setup in the left picture below. This setup enables testing even without the presence of RF connectors on the equipment. The chambers are interconnected through RF paths and an ISS11 attenuator. By varying attenuation, the setup emulates changing link margin and distance while keeping the representative small-scale multipath Rayleigh fading and the test repeatable and contained. This enables:

- Exercising of wide frequency ranges and elevated signal levels in a shielded laboratory environment.
- Creation Rich Isotropic Multipath (RIMP) conditions, depending on the test objective.
- Evaluation of throughput and link robustness while injecting CW or other interference.
- Repetition of tests with changed integration conditions to evaluate impact by the physical mounting position.

Another example scenario is shown to the right in the picture below, with a stronger line-of-sight link between controller and the aircraft.

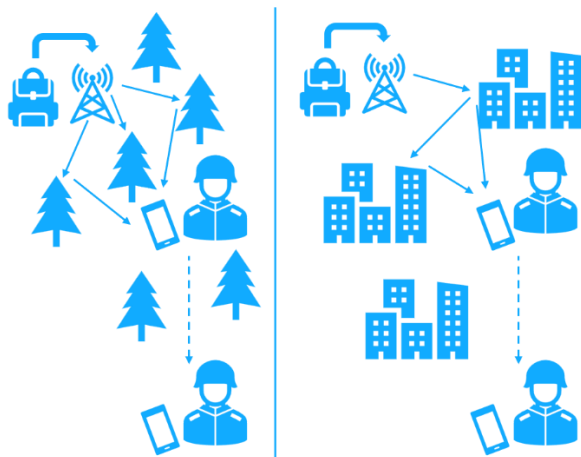
For larger unmanned aircraft, vehicles or other large platforms, Bluetest can extend the same reverberation principle using RTS-VIRC. The Vibrating Intrinsic Reverberation Chamber uses a metallized enclosure with mechanical actuation for mode stirring and can be dimensioned to suit the customer's test object and facility constraints.

From compact controllers to large air vehicles, the measurement principle can scale without abandoning the controlled and repeatable multipath methodology.



5G Networks in a Controlled RF Domain

5G is increasingly relevant where organizations require controlled coverage, local data handling, low latency and integration with edge applications. Before deployment, both infrastructure and user equipment need objective performance data under realistic propagation conditions.



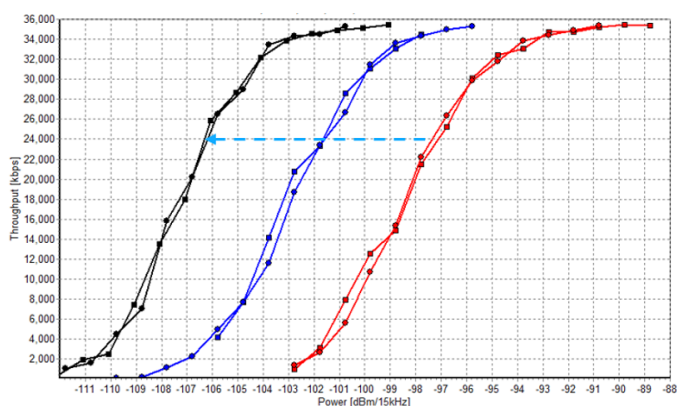
10 dB better performance in the RC means higher reliability at longer distances (or higher data rate).

Inside a Bluetest chamber, a base-station emulator can establish a contained cellular network and exercise devices under multipath, blocked-line-of-sight and interference conditions. Because the chamber is electromagnetically shielded, demanding scenarios can be developed without radiating test signals into adjacent operations.

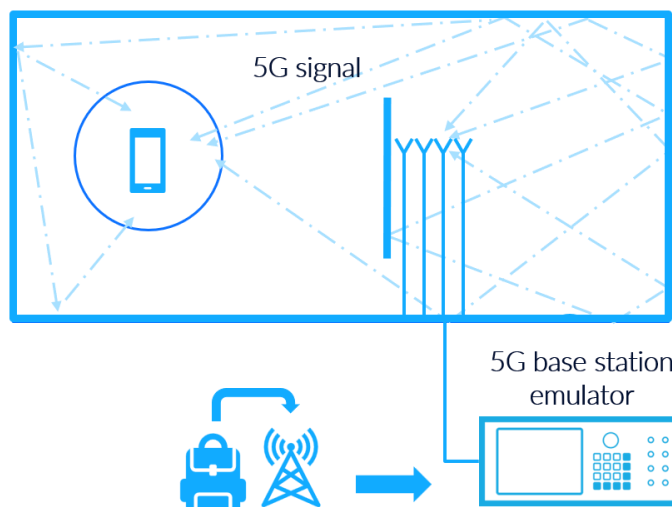
Cellular networks have been the very core of Bluetest test scenario for the past 20 years!

This is particularly valuable for electronic-warfare-oriented development and training support: engineers can reproduce interference conditions in peacetime, compare protection schemes and evaluate the effect on throughput or sensitivity without disturbing surrounding radio services.

A shielded chamber creates a RF test domain for repeatable 5G performance and resilience verification.



Accurately separate good device from bad device.
Excellent repeatability.



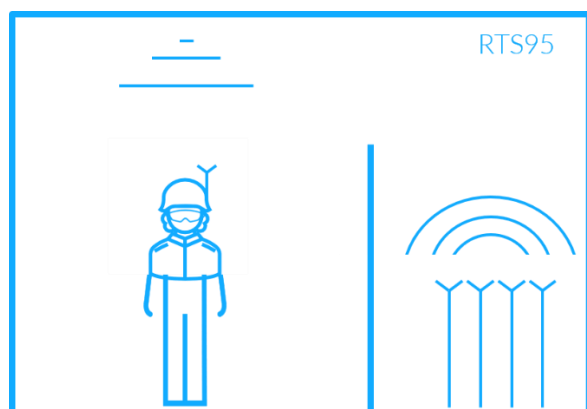
Human-In-The-Loop: Live-Person and Body-Worn Equipment Testing

Body-worn radios, antennas, phones, headsets and sensors are strongly affected by the person carrying them. The human body absorbs RF energy and detunes antennas, while clothing, armor, batteries, cables and other equipment alter the electromagnetic environment around the antenna.

Walk-in RTS chambers allow a person to be present during the measurement and do not require the subject to remain static. This enables realistic assessment of complete worn configurations and user-handling effects that are difficult to reproduce with a phantom alone.

The same capability is useful after field missions or harsh-environment testing. Equipment may appear functional while antenna, connector or cable damage has reduced link margin. A repeatable OTA baseline can reveal non-visible degradation and support maintenance decisions such as replacing antennas or cabling before redeployment.

Verify the equipment as it is actually carried - and verify that it still meets the required baseline after mission.



Robustness, Jamming and Spoofing Resilience

Resilience cannot be demonstrated by nominal link testing alone. A mission system must be characterized against representative interference, including signals arriving from arbitrary directions and across realistic propagation paths.

Bluetest chambers can combine wanted signals with controlled jamming or spoofing sources. For Navigation Systems such as GNSS, a simulated constellation can provide the wanted navigation signal while an isotropic interference field represents jamming or spoofing that may arrive from many directions. For 5G, both the wanted cellular signal and the jammer can be emulated in a three-dimensional multipath environment. This allows users to:

- Quantify the interference level at which throughput, sensitivity, positioning or link continuity degrades.
- Validate anti-jam waveforms, frequency-hopping strategies and other protection mechanisms.
- Compare design revisions using identical interference scenarios.
- Characterize the output of jamming/spoofing equipment with spectrum-analysis instrumentation or reference device where appropriate.

The value of this approach is reproducibility. Field interference is difficult to control and may create safety, regulatory or operational constraints. In the chamber, the same stress condition can be applied repeatedly while a single design parameter is changed. This makes resilience engineering measurable rather than anecdotal.

Controlled interference testing supports both defensive resilience verification and engineering analysis of electronic-warfare effects.

Assessment of Compromising Emanations

Compromising emanations are unintentional electromagnetic signals from electronic equipment or cables that may disclose information or reveal the presence and location of equipment. This is related to the TEMPEST framework, where the Bluetest RTS can provide useful pre-characterization.

For security and defense systems, the objective is to understand and reduce unintended RF emissions from both intentionally wireless and nominally non-wireless equipment. Computers, cameras, digital electronics, cables and peripherals can all radiate spurious energy and may compromise safety or disclose sensitive information. Reducing unwanted emissions also helps to reduce interference in other systems.

A reverberation chamber can support fast, repeatable spurious-emission measurements over a wide frequency range. Because RF energy is reflected within the chamber rather than absorbed, the method can provide high field-strength efficiency and useful sensitivity while maintaining a large, uniform three-dimensional test volume.

Reducing unintended emissions will lower the probability that equipment, or a person carrying it, is detected through its electromagnetic signature. This is related to the TEMPEST framework, where the Bluetest RTS can provide useful pre-characterization.

A Practical Verification Platform for Mission-Critical Wireless Systems

Security and defense organizations need wireless systems that can be trusted outside ideal laboratory conditions. Bluetest brings a measurement platform proven in demanding commercial wireless development into this domain: complete-system OTA testing, representative multipath, controlled interference, scalable test volumes and repeatable automation.

The result is a shorter path from prototype to verified capability - with objective data for performance, resilience, maintenance and electromagnetic-signature decisions.



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